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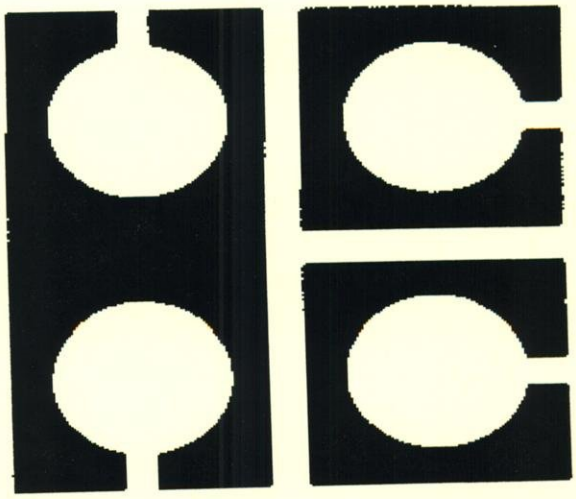

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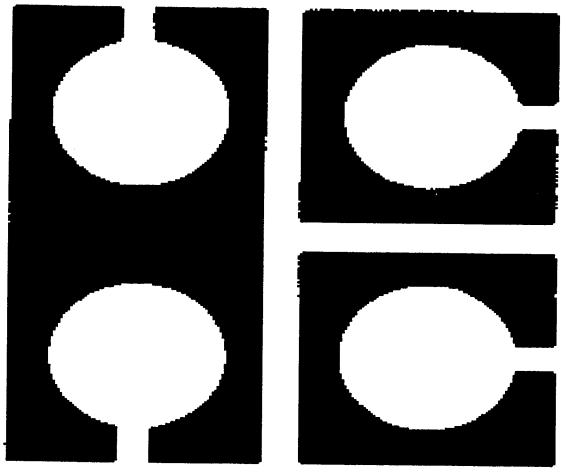

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Proceedings of

The Twenty Ninth Annual Conference on Ecosystems Restoration and Creation

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INTRODUCTION

The Annual Conference on Ecosystems Restoration and Creation provides a forum for the exchange of results of scientific research in the restoration, creation, and management of freshwater and coastal systems. The conference is designed to be of particular benefit to governmental agencies, planning organizations, colleges and universities, corporations, and environmental groups. These proceedings are a compilation of papers and addresses presented at the Twenty Ninth Annual Conference.

As in years past, this year's conference would not have been possible without the assistance and cooperation of Mr. Roy R. "Robin" Lewis, III. Mr. Lewis has been an important contributor since the very first conference twenty nine years ago. We are grateful for his help and participation. Appreciation is also extended to Fred Webb and Felix Haynes for providing administrative support for the conference.

The following people also deserve acknowledgment for contributing to the conference and assisting in the preparation of the proceedings for publication: Elaine Baskin, Peter Rossi, Charles Mason and his staff. A very special thanks to Johnnie Hurst for her untiring assistance in handling the many details of conference planning.

Thanks are extended to **Parker Keen** of the **Cargill Fertilizer** for arranging and conducting a very successful field trip to a wetland restoration site.

These proceedings could not have been completed without the time and efforts of the authors and reviewers.

To all these people, thank you.

SPOIL ISLAND RENOVATION AND HABITAT CREATION

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ABSTRACT

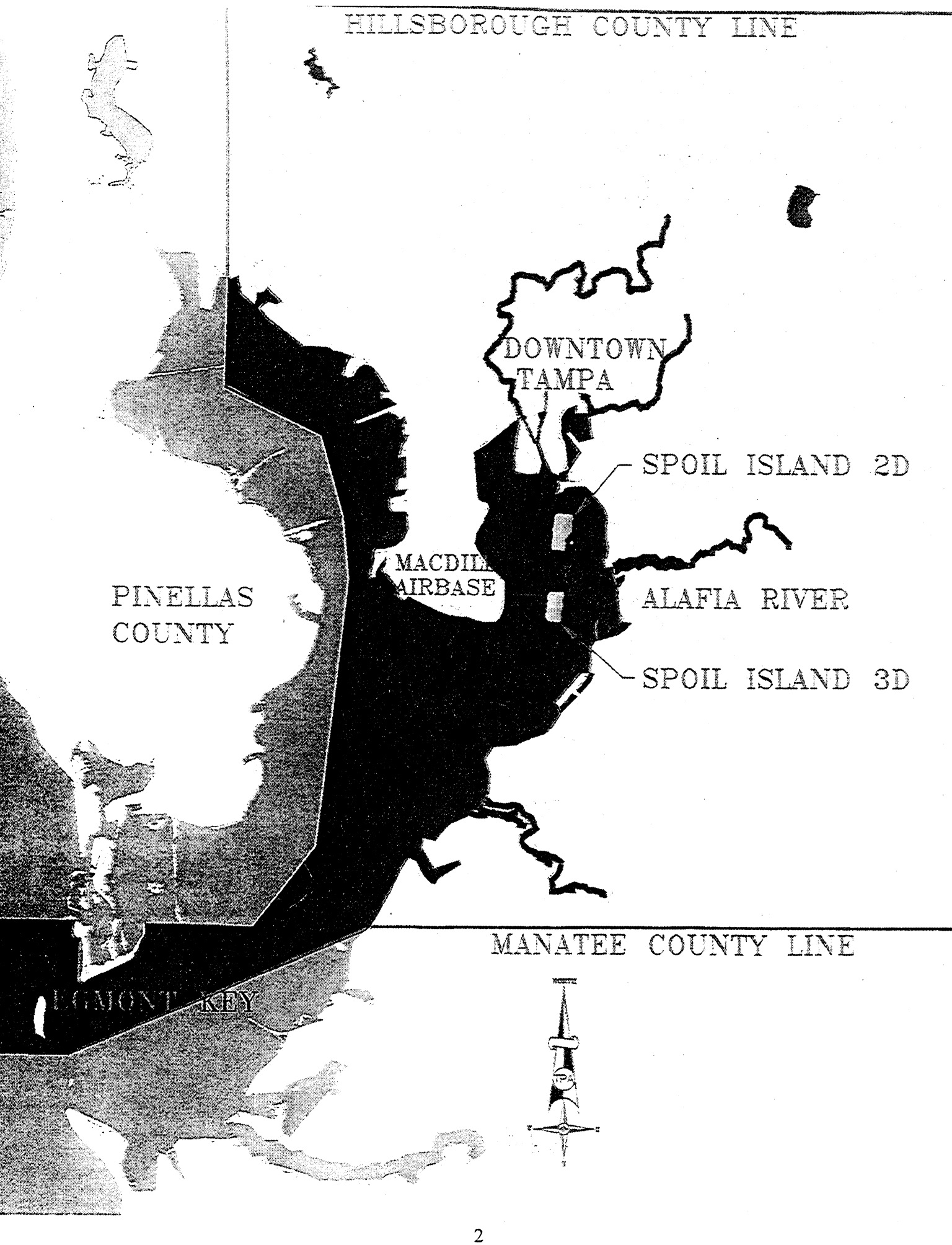
The Florida Aquarium, in partnership with the Tampa Port Authority, has initiated a renovation project on a three-acre spoil island just north of the Alafia River in upper Hillsborough Bay. The Florida Department of Environmental Protection and the Environmental Protection Commission of Hillsborough County are participating in this project by providing partial funding through the Gardinier Settlement Trust Fund. Project objectives include the removal of invasive non-native plant species and the creation of an integrated upland and shoreline native plant community. Other objectives include the construction of trails, interpretive signage, an educational shelter and boat dock to provide opportunities for future phases of the project involving extensive educational and eco-tour programs as well as monitoring and analysis projects. The renovations are expected to enhance habitat quality, demonstrate environmentally responsible landscape management to the community, and increase public awareness & appreciation of habitats found in the bay.

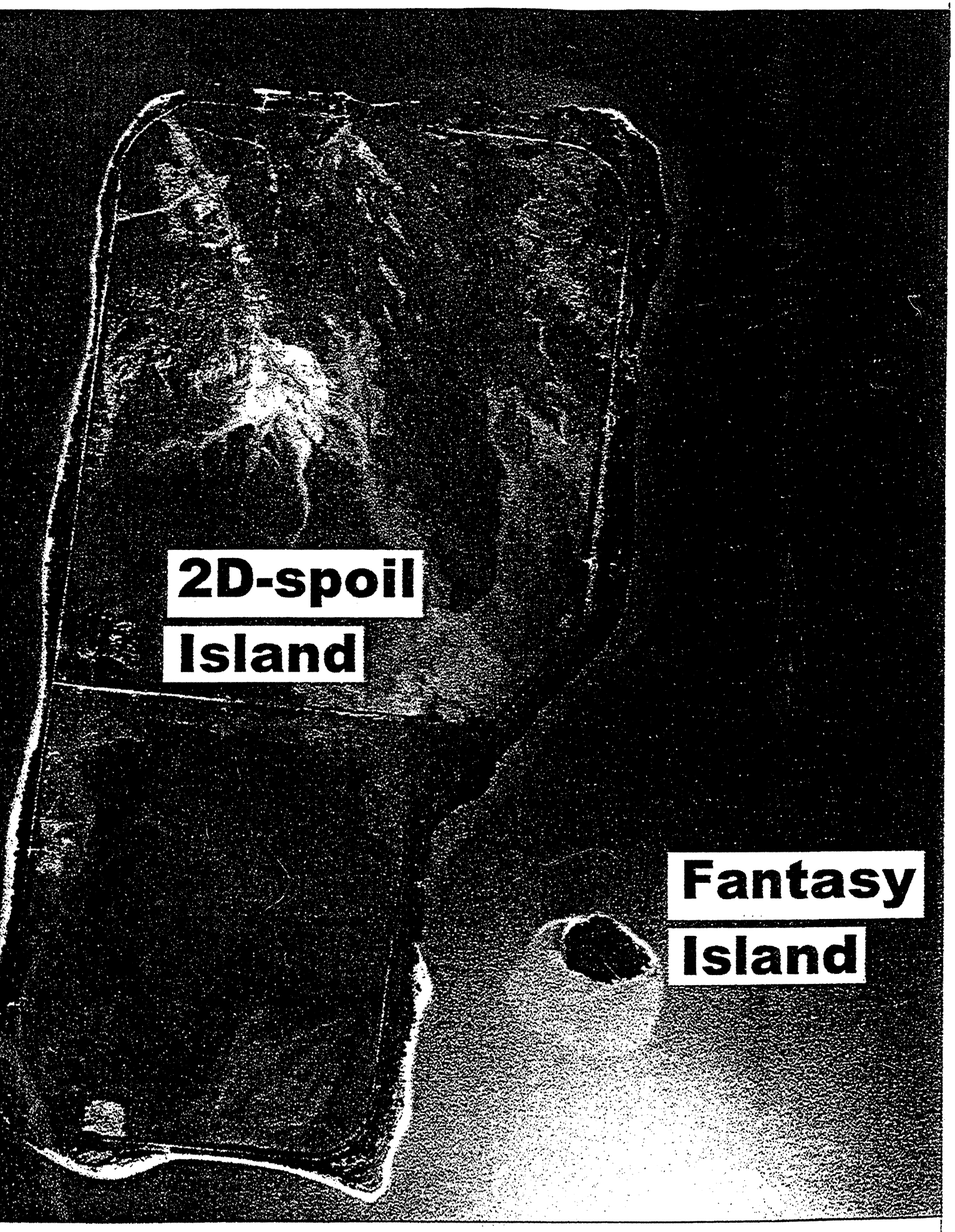
INTRODUCTION

Florida is fortunate in the richness and variety of its 8,000 miles of coastline. In the last one hundred years, Tampa Bay has lost over eighty percent of its sea grass meadows and over forty-four percent of its mangrove and salt marshes. The bay is threatened daily from nutrient loading, toxic pollution, and habitat loss and degradation. The ecological restoration of shorelines in Florida is essential as the State expands to accommodate more people. This renovation project provides an opportunity to transform an ecologically unimportant manmade spoil island into a worthwhile coastal environment that can be used as a tool to assist in maintaining the environmental quality of coastal landscapes.

PROJECT SITE AND PARTNERS

Just north of the Alafia River in upper Hillsborough Bay is a small manmade spoil island owned by The Tampa Port Authority. The island is referred to as "Fantasy Island." The Florida Aquarium, in partnership with the Tampa Port Authority, the Department of Environmental Protection and the Environmental Protection Commission of Hillsborough County are participating in the renovation of this island through partial funding provided by the Gardinier Settlement Trust Fund. Additional funding and in-kind services were


HILLSBOROUGH COUNTY LINE
DOWNTOWN TAMPA
SPOIL ISLAND 2D
MACDILL AIRBASE
ALAFIA RIVER
PINELLAS COUNTY
SPOIL ISLAND 3D
EGMONT KEY
MANATEE COUNTY LINE


2D-spoil
Island
Fantasy
Island

provided by Tampa Electric Company Bayside Project, Tampa Baywatch, and Audubon of Florida.

PROJECT DEFINITION

The project is defined as a renovation as opposed to a restoration because it occurs on a manmade spoil island. Spoil islands are composed of dredge spoil material from the construction of navigation channels. Upon creation, the islands are quickly populated by exotic plants such as Brazilian pepper (*Schinus terebinthifolius*). Invasion of these exotic species leads to lower plant and animal diversity on the islands. Renovation of this island is an effort to protect & restore valuable and diminishing habitat in Tampa Bay.

PROJECT PHASES

Phase one of the project includes the licensure agreement between the Tampa Port Authority and the Florida Aquarium, the initial vegetation survey, the design and planting plan, exotic plant removal, and planting. Phase two of the project includes the construction of a boat dock, the educational shelter, and signage. The third phase of the project will include educational programming and eco-tours.

PROJECT IMPLEMENTATION

Phase one of the project began in June of 2000 with the examination of existing plant species. The Department of Environmental Protection provided global positioning system units to collect data on the island. This data, used in conjunction with satellite images and aerial photographs, was then incorporated into a geographical information system to create computer maps that would show the location and quantity of exotic plants to be removed and native plants to remain. These maps provided a guide for the removal of the exotics and a working template for the design and installation of native plant species that would provide a mosaic of habitats typical of a central Florida island. The design also includes areas to be preserved, a series of pathways, an educational shelter for outdoor classrooms and a dock to accommodate a large eco-tour boat. Opportunities to increase salt marsh and oyster beds were indicated on the design as well.

The exotic plant removal process began in August 2001. Over eighty percent of the island was covered by a thick matt of Brazilian pepper (*Schinus terebinthifolius.)* Brazilian pepper is a pioneer of disturbed sites and these trees took root two decades ago when the spoil was dumped. One or two lead tree (*Leucaena)*, another exotic that readily invades open disturbed sites on coastal strands, were also found on the island. The goal was to remove the Brazilian pepper before November when the trees produce seed and still have time to plant the natives before the end of the rainy season of summer. There is no access to fresh water on the island to water in the new plantings. Project implementation options were limited by the carrying capacities of available boats. The

U.S. Coast Guard volunteered their services to transport the chipper needed to chip the Brazilian pepper on site once it was cut. The chipper was driven to Pendola Point and then transported via helicopter to the island. Before the actual removal process began, signage was placed on the island to inform the public about the renovation efforts taking place. Chain saws were used to cut the Brazilian pepper to ground level. The trees were fed through the chipper and the stumps were treated with Garlon herbicide. The stumps were left in place for erosion control. The removal process took two weeks.

Plant acquisition began immediately after removal of the exotics on the island. Only a few species of plants are adapted to life in this environment. This is the pioneer zone for plants and within it exists quite severe conditions of heat, drought, and high salinity. Twenty five species, over four thousand native plants, were salt acclimated in the nursery and delivered to the aquarium. The plants were sorted by species and placed onto pallets for ease in transport. Once the plants were on the pallets, they were wrapped with mesh to keep them in place during transport. The pallets were color coded to assist in proper placement once on the island. The plants were then transported with forklifts to a barge located behind the aquarium in the Port of Tampa. A crane located on the barge moved the plants from the dock to the barge. An all-terrain forklift was also craned onto the barge for use in transporting the plants once on the island. Areas to be planted on the island were color coded with spray paint to match the color codes on the plant pallets. This system enabled the forklift operator to get the plants as close to their designated areas as possible. The plants were then set out according to the planting plan and planted by groups of volunteers over several days. Pre-measured survival packs containing spores of beneficial fungi, terra-sorb hydrogel, humic acid, seaweed meal, and yucca plant extract were used to assist the plants in acclimating to their new home. Ice was also used to provide a slow release of moisture to the plants during the planting process.

The removal of exotic species provided an opportunity for other plants to grow. Solidago, Heliotrope, and Opuntia are some of the volunteer plant species that began to appear. Canavalia seeds were abundant throughout the island and soon began to sprout as well. Unfortunately, some exotic seeds are still viable. Monthly maintenance visits are required to keep the Brazilian pepper (*Schinus terebinthifolius*) and Lead tree (*Leucana*) in check.

Phase two of the project began in June of 2002. The construction of the boat dock is currently in progress. Phase three will begin upon the completion of phase two. The ultimate goal in this island renovation project is to provide a mosaic of habitats, essential information concerning those plants most valuable in protecting our coastal zone, and a basic understanding of the coastal environment in Tampa Bay.

FANTASY ISLAND RESTORATION PLANT SPECIES

Trees

Avicennia germinans	Black Mangrove	35	1-gal
Conocarpus erectus	Buttonwood	135	7-gal
Juniperus virginiana	Red Cedar	5	7-gal
Laguncularia racemosa	White Mangrove	54	7-gal
Quercus virginiana	Live Oak	3	10-gal
Rhizophora mangle	Red Mangrove	27	7-gal
Sabal Palmetto	Cabbage Palm	15	7-gal

Shrub

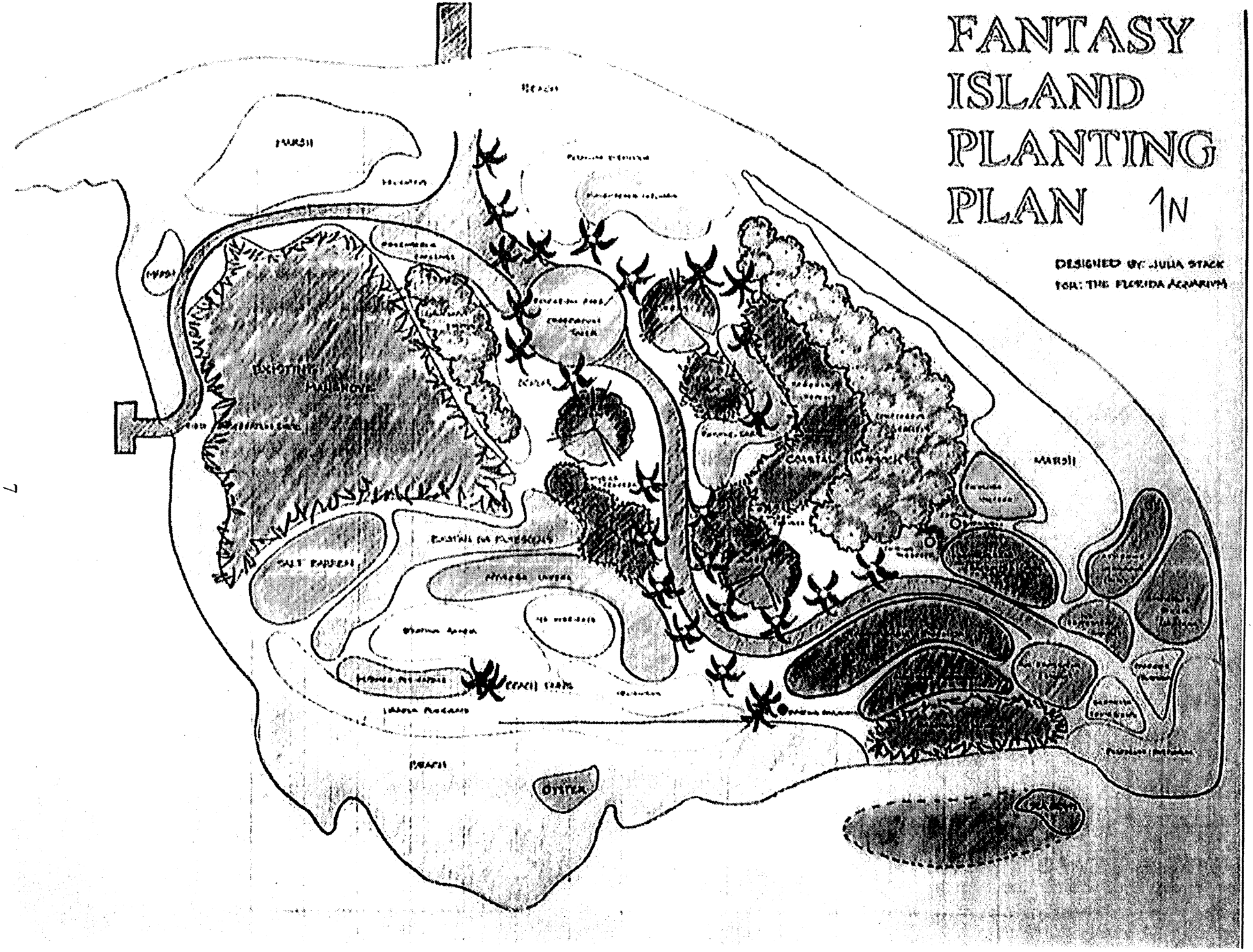
Cocoloba uvifera	Seagrape	46	3-gal
Eugenia	Stopper	60	1-gal
Forestiera segregata	Florida Privet	60	1-gal
Iva frutescens	Marsh Elder	124	1-gal
Myrica cerifera	Wax Myrtle	10	7-gal
Myrsine guianensis	Myrsine	75	3-gal
Serenoa repens	Green Saw Palmetto	190	7-gal
Sophora tomentosa	Necklace Pod	50	1-gal

Herbs

Borrichia frutescens	Sea Oxeye Daisy	124	1-gal
Helianthus debilus	Beach Sunflower	200	1-gal
Ipomea pes-capre	Railroad Vine	100	1-gal
Iva imbricata	Sea Coast Elder	142	1-gal
Muhlenbergia capilaris	Muhly grass	337	1-gal
Paspalum distichum	Salt Jointgrass	782	2"
Spartina bakerii	Sand Cordgrass	302	1-gal
Spartina patens	Saltmeadow Cordgrass	75	1-gal
Uniola paniculate	Sea Oats	500	1-gal

FANTASY ISLAND PLANTING PLAN

DESIGNED BY: JULIA STACK
FOR: THE FLORIDA AQUARIUM



FANTASY ISLAND OYSTER HABITAT ENHANCEMENT AND SALT MARSH PLANTING PROJECT IN TAMPA BAY, FLORIDA

Christine A. Klassen, Sari E. Deitche, Peter A. Clark
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St. Petersburg, Florida 33702

ABSTRACT

Tampa BayWatch initiated a community-based habitat enhancement project with The Florida Aquarium, Tampa Port Authority (TPA), Coastal Conservation Association of Florida and local community groups to create a series of new oyster bars and plant salt marsh grasses on the shoreline of Fantasy Island in Hillsborough County, FL. These habitats were created to help stabilize the island, provide habitat for fish and wildlife resources and improve water quality in the Tampa Bay estuary.

First, Tampa BayWatch, The Florida Aquarium and TPA sponsored a salt marsh planting event with Young Middle School, planting 5,000 plugs of salt marsh grasses (*Spartina alterniflora*) along one acre of shoreline. Salt marsh was planted shoreward of areas marked for oyster bar placement. Second, Tampa BayWatch and project partners organized an oyster-building event in which community groups and local volunteers shoveled fossilized oyster shell into buckets for easy transportation to Fantasy Island. Volunteer boaters then delivered the buckets of shell to the site where they were handed off to staff and volunteers who deposited the shell on the tidal flats. Tampa BayWatch staff later deployed concrete oyster reef units to stabilize a section of shoreline where mangroves were uprooted and signs of excessive erosion were evident. These newly created habitats will serve to stabilize the shifting shoreline and protect from erosion as well as provide valuable habitat and foraging area for many species of wildlife in Tampa Bay. This project also presented an opportunity for community volunteers and students to get involved in hands-on habitat enhancement and to learn about Tampa Bay's estuarine environment.

INTRODUCTION

Due to problems associated with coastal development, the Tampa Bay estuary has experienced a tremendous loss of natural communities. About 21 % of Tampa Bay's natural tidal wetlands were destroyed between 1950 and 1990 primarily due to development (Janicki *et al.* 1994). Coastal wetland losses have exacerbated shoreline erosion, decreased habitat for coastal wildlife and have contributed to reduced water quality. In response to these losses in natural habitat, the Tampa Bay National Estuary Program (TBNEP) set goals for habitat restoration and protection as well as guidelines for restoring a balance of wetland and associated upland habitats in Tampa Bay (TBNEP 1996). This comprehensive plan included the restoration of low-salinity tidal marsh,

enhancement and protection of the bay's mangrove and salt marsh communities, restoration of salt barren habitat and protection of hard-bottom (oyster reef) and soft-bottom communities. Tampa BayWatch has created several habitat restoration programs to help meet the goals of the TBNEP's comprehensive plan. Tampa BayWatch utilizes community volunteers to accomplish habitat restoration and protection activities, including salt marsh and oyster bar projects such as the Fantasy Island project. These projects restore coastal communities, enhance fish and wildlife resources and promote public involvement and education.

Eastern American oysters (*Crassostrea virginica*) occur naturally throughout the Tampa Bay estuary, centralizing around freshwater inputs, such as the Alafia River. The Alafia River flows into Hillsborough Bay and creates an estuary in which oysters grow abundantly. Hillsborough Bay has been the focus of several Tampa BayWatch oyster bar enhancement projects. Expansion of hard bottom communities creates greater surface area for settling oyster larvae and creates habitat niches for many other benthic organisms including barnacles, sea squirts, anemones, sponges, corals and algae. These sessile organisms provide a diverse food source and optimal foraging opportunities for a variety of fish species (redfish, snook, sheepshead), shorebirds (American oystercatcher, ibis, herons) and other wildlife species (blue and stone crabs, and shrimp).

Oysters provide a natural cleansing system for the bay. They are filter feeders that consume suspended particles in the water column and are able to filter up to 37 liters (9.8 gallons) of seawater every hour (Friese 1973). This process helps remove impurities from the water and improve water quality and clarity. Oysters also act as natural wave breaks by buffering and absorbing wave energy. This facilitates the stabilization of bottom sediments, which results in reduced turbidity levels and lowered shoreline erosion rates. Oyster bars protect shorelines from high levels of erosion due to boating activities and waves produced by seasonal storms.

This buffer effect provides optimum conditions for the establishment of salt marsh grasses along natural shorelines. Salt marsh habitats anchor the shoreline, minimize erosion and buffer uplands from storms. The individual salt marsh plants act as a natural filter for freshwater runoff and absorb nutrients and pollutants carried in runoff from upland urban areas. Salt marsh habitats also provide a valuable nursery area for several fish species, hiding places for invertebrates and foraging opportunities for many of Florida's wading birds (TBEP 1996). Salt marshes provide a vital habitat for many organisms in the marine food web.

STUDY SITE

Fantasy Island is a small, circular island located in Hillsborough Bay. Hillsborough Bay is in the northeast corner of the Tampa Bay Estuary and receives fresh water input from the Hillsborough, Palm and Alafia rivers. Fantasy Island is a spoil island created in the late 1970's as part of the Harbor Deepening Project. It is located just east of the CDMA-2D spoil island. Over time, Fantasy Island has severely eroded and a significant shift in

island topography has taken place. Erosion has occurred due to changes in currents and sand distribution as well as increased boat traffic to the Port of Tampa.

The southern shoreline of this island was selected for habitat enhancement efforts to coincide with an upland restoration project in process by The Florida Aquarium, Tampa Port Authority and the Florida Department of Environmental Protection. Two sections were surveyed for oyster bar creation. Sites were chosen by the hardness of substrate, preceding oyster growth and proximity to the eroding shoreline. One 100-foot section on the island's southeast corner and another 120-foot section further west were surveyed for oyster bar development (Figure 1). The shoreline behind these oyster bar areas was selected for planting salt marsh grasses. Located west of the proposed 120-foot oyster reef was an area of shoreline in which immediate protection from waves was necessary. Along a 40-foot section of shoreline, mangroves were uprooted and signs of excessive erosion were evident. Concrete Reef Balls™ were the chosen treatment for this area because of their sturdy structure and wave reducing capabilities.

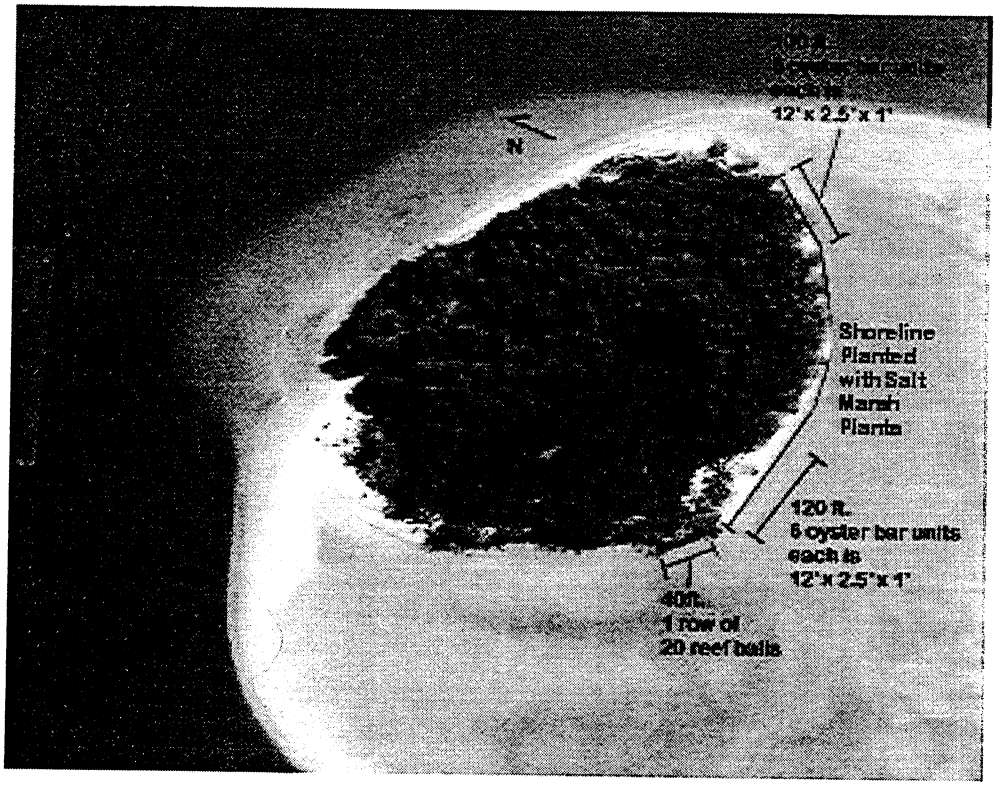

Figure 1. Location of oyster bars and salt marsh on Fantasy Island

MATERIALS AND METHODS

The first component of the Fantasy Island shoreline enhancement project was to plant salt marsh plants on the southeastern corner. Tampa BayWatch, The Florida Aquarium and the Tampa Port Authority organized a planting event for students to plant 5,000 planting units of smooth cordgrass (*Spartina alterniflora)*. Salt marsh plants were supplied from Tampa BayWatch's Bay Grasses in Classes Program. Fifteen schools throughout Hillsborough and Pinellas counties participate in this program by maintaining their own salt marsh nursery on campus. Students pull *Spartina alterniflora* from a donor site at Port Manatee Fish Hatchery and create their own 16' x 16' salt marsh nursery. Individual plants are planted into cells and placed in trays in the nursery. The plants then grow and multiply until several plants are in each cell. Once a year, after 6-8 months of growth, half of the nursery is harvested and planted into a restoration site by the students. The students then recycle the remaining portion of the nursery by separating the individual plants and replanting them into cells to refill the nursery. Once harvested, the plants are in planting units consisting of 3 to 10 individual plants (Tampa BayWatch 2001).

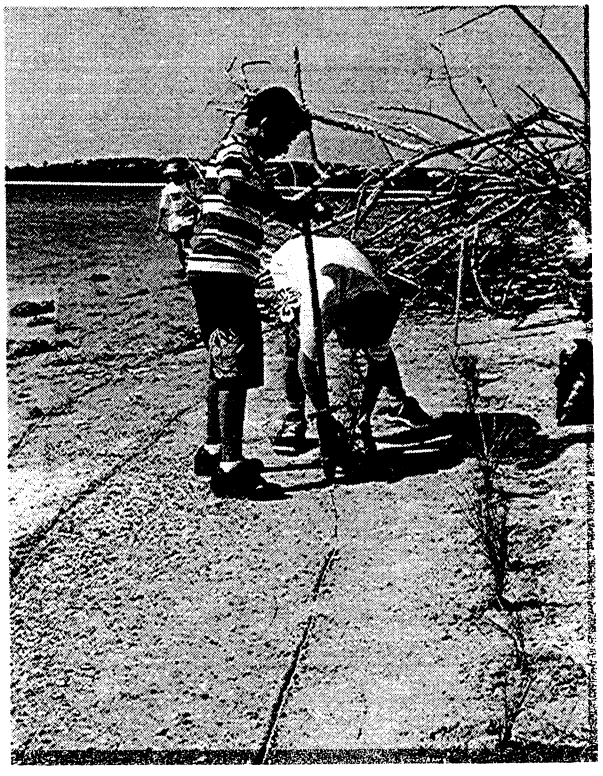

Figure 2. Students planting salt marsh on the shoreline of Fantasy Island

For the Fantasy Island site, the planting units were supplied from Young Middle School's salt marsh nursery. Young Middle School is a math, science and technology magnet school located in Tampa. For this event, 40 students received permission to participate in the planting project. Zone leaders, primarily consisting of Tampa BayWatch staff and other partners and funders, placed planting lines along the contours of the tide line, shoreward of areas marked for oyster bar placement. The planting units that were previously harvested from Young Middle School's nursery were planted 2 to 3 feet apart from each other, allowing optimal growth for each plant. To complete the planting, holes approximately 3 to 4 inches deep were dug along the planting lines using dibble bars (Figure 2). Students then placed the planting units in the holes and filled in and packed down the plants with the removed sediment.

The second step in the Fantasy Island shoreline project was to create oyster bars on the tidal flats of the island approximately 50 feet from the shoreline. This distance was determined due to factors such as water depth, hardness of substrate, and surrounding

seagrass coverage. Each oyster bar site was designed to be divided into six, one-ton, oyster bar units approximately 12' x 2.5' x 1'. The 100-foot site was planned to cover 72 linear feet with oyster shell and to be separated by spaces approximately 5.6 feet between units. The 120-foot site was also designed to cover 72 linear feet with oyster shell and allow approximately 9.6 feet of space between each unit. The individual oyster bar units were marked with PVC poles to ensure the proper placement of shell, and to alert boaters of the location of the reefs. A biodegradable jute mat was placed down in order to prevent or delay sinking of the shell into the substrate.

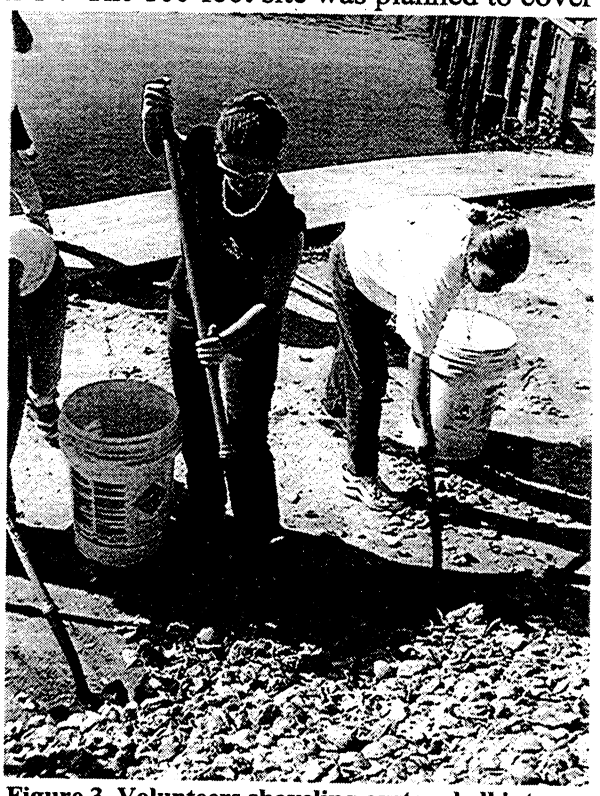

Figure 3. Volunteers shoveling oyster shell into buckets

Tampa BayWatch organized a community oyster bar-building event at Fantasy Island involving community volunteers and local boaters. Three-inch, washed, fossilized oyster shell was purchased from a local shell mine in Sarasota and delivered to the Williams Park Boat Ramp the day before the event. On the day of the event, community volunteers and the youth group from First United Methodist Church of Brandon shoveled the loose fossilized shell into 5-gallon buckets (Figure 3). The buckets were then wheeled by hand carts to boater volunteers at the dock. The buckets of shell were shuttled to Fantasy Island and handed off to volunteers and staff. The shell was then poured into the marked areas, on top of the jute mat, to create oyster bar units on the tidal flat.

A 40-foot section on the southwest corner that is exposed to heavy wave action was surveyed for a different type of stabilization reef. Plans included placing 20 concrete Reef Balls™ along the shoreline approximately 20 feet offshore. These Reef Balls™ are constructed of a mixture of non-toxic additives and concrete and are constructed with plenty of holes to provide hiding places for marine invertebrates and fishes, as well as creating a hard substrate in which oysters will attach. They are also designed with a broad base to provide a stable structure, less likely to be moved by the waves. The Lo-Pro style of Reef Balls™, manufactured by Reef Innovations, Inc. of Sarasota, were placed along this section of the island. Each Lo-Pro is approximately 2 feet in diameter and 18 inches tall. Along this 40 foot section of the island, approximately 25 feet from the shoreline, a single row of 20 Lo-Pro Reef Balls™ was placed end to end to provide a stable structure to reduce future erosion to this area of the island (Figure 4).

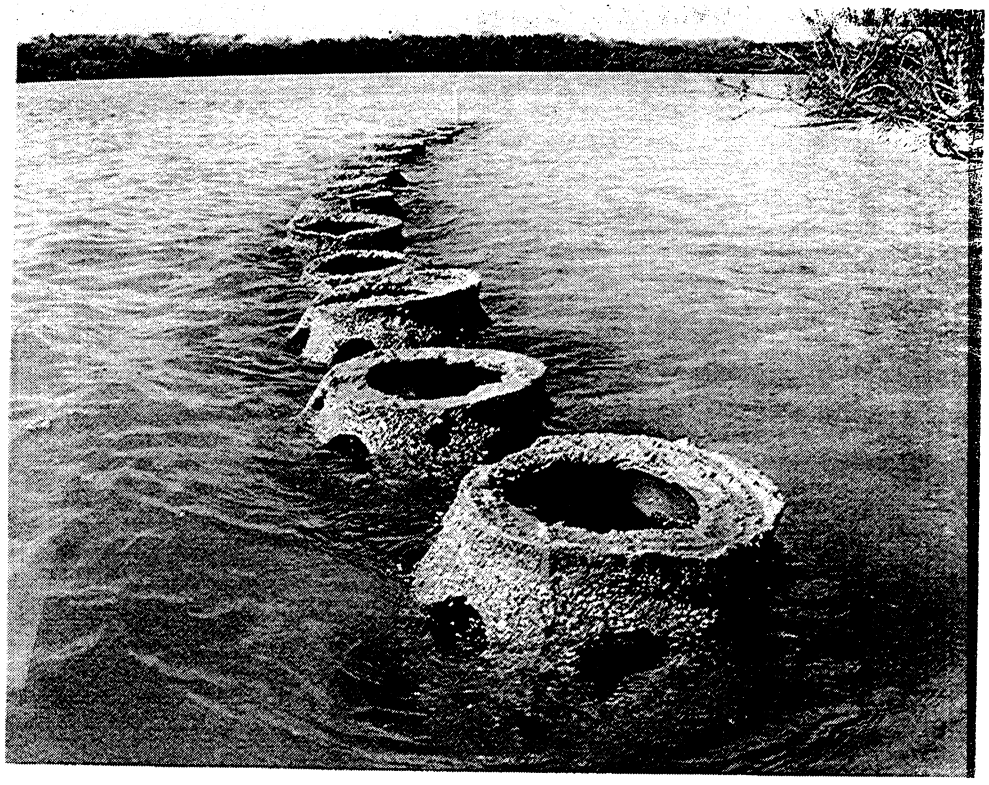

Figure 4. Oyster units placed along the shoreline

RESULTS

On November 1, 2001, Tampa BayWatch, The Florida Aquarium and The Tampa Port Authority sponsored a salt marsh planting event with Young Middle School. A total of 40 sixth grade students, along with teachers, parents and project sponsors from National Oceanographic & Atmospheric Administration/National Marine Fisheries Service (NOAA/NMFS), Florida Association for Water Quality Control (FAWQC), and the GE Elfun Organization, planted 5,000 plugs of salt marsh grasses (*Spartina alterniflora*) along one acre of shoreline on Fantasy Island (Figure 5). The salt marsh was planted shoreward of areas marked for oyster bar establishment.

On November 10, 2001, Tampa BayWatch, The Florida Aquarium, Tampa Port Authority, Coastal Conservation Association of Florida and local community groups worked together to build oyster bars on the shoreline of Fantasy Island. The event involved 11 boater volunteers, 17 youth group members (First United Methodist Church of Brandon) and 19 community volunteers, creating a total of 47 volunteers for the event. Oyster bars were created at two sites on Fantasy Island and were constructed similar to natural oyster communities found along shoreline areas throughout Tampa Bay. At each site, six oyster bar units, each measuring approximately 12 feet long, 3 feet wide and 18 inches tall were constructed out of fossilized oyster shell. They were deployed end to

Figure 5. Students raise their hands to celebrate a successful planting

end (with a space between each bar) in a row parallel to the shoreline in order to help reduce erosion and allow water flow between each unit. Six oyster bar units were installed along a straight 100-foot section on the island's southeast corner. This created 72 linear feet of oyster reef with approximately 5.6 feet of space between units. The units were placed approximately 50 feet from the shore. Another six units were installed along a section on the southwest corner of the island covering approximately 120 feet in length. This resulted in 72 linear feet of oyster reef with approximately 9.6 feet of space between each unit. The project included a total of 12 tons of oyster shell deposited on the intertidal fringe of Fantasy Island. After the building of the oyster bars, Coastal Conservation Association of Florida members provided lunch for all event participants at the Williams Park Boat Ramp.

On November 27, 2001, Tampa BayWatch deployed 20 Reef Balls™ (Lo-Pros) along a 40-foot section of shoreline where mangroves were uprooted and signs of erosion were evident. The Reef Balls™ were delivered to the Williams Park Boat Ramp where Tampa BayWatch staff loaded them onto boats and delivered them to the island. They were placed approximately 20 feet from shore in an effort to stabilize this area of the shoreline.

The newly created habitats on Fantasy Island were monitored six months after construction. The salt marsh plants were established and multiplying. Plants planted in higher elevations showed a higher survival rate than the submerged planting units.

Monitoring of the oyster bars revealed that the loose oyster shell has shifted and no oyster growth is apparent. This area receives heavy wave action, which has affected the formation of the oyster bars. Tampa BayWatch is currently examining reasons why this site has not become productive. Possibilities include the timing of oyster spawning and the effects of high wave action.

DISCUSSION AND CONCLUSION

Habitat restoration projects have become an increasingly popular tool to restore coastal communities, enhance fish and wildlife resources and to promote public involvement and education. In the Tampa Bay estuary numerous restoration programs have been initiated to restore coastal environments. Local environmental organizations have worked together to accomplish many restoration and habitat enhancement goals. The Fantasy Island Project was a combined effort of The Florida Aquarium, Tampa Port Authority, Florida Department of Environmental Protection, Environmental Protection Commission of Hillsborough County, Tampa Electric Company (TECO) Bayside Project and Tampa BayWatch to remove exotic species, primarily Brazilian pepper (*Schinus terebinthifolius*), and replant native vegetation on Fantasy Island. Plans also include the construction of an educational pavilion, interpretive nature trail and a boat dock. The Florida Aquarium plans to make regular eco-tours to the island with visitors from the Aquarium. Tampa BayWatch's contribution to this project was to create a natural shoreline environment to reduce erosion, increase productivity and create habitat to attract wildlife to the island. The newly created salt marsh and oyster habitats will serve to stabilize the shifting shoreline as well as provide valuable habitat and foraging area for many species of wildlife in Tampa Bay.

Tampa Bay is located along the transition zone between mangroves and salt marsh vegetation, allowing both habitats to coexist. Low energy tidal coastlines further north consist primarily of salt marsh species that are more freeze-tolerant than mangroves. Estuaries further south are vegetated primarily with tropical mangrove species. In Tampa Bay, many salt marsh restoration sites have evolved into mangrove habitats. By planting salt marsh plants and establishing a salt marsh community, restoration efforts further promote the formation of other natural species and habitats. The salt marsh helps secure the shoreline and attenuate wave impacts. This creates conditions ideal to the recruitment of mangroves. Red mangrove (*Rhizophora mangle*) seedlings are trapped by the salt marsh plants and take root in an area buffered from wave energy. The establishment of mangroves on the shoreline further anchors the sediments and creates a different habitat among their prop roots.

Creating oyster bars out of natural shell material on the intertidal flats of the bay encourages the establishment of oyster colonies. Juvenile oysters attach to hard substrates above bottom sediments and survive best in areas of higher relief. Up off the bottom conditions are better for feeding, waste elimination and respiration (Myatt *et al.* 1999). Oysters attached to elevated structures are also less accessible to predators. Artificial shell reefs provide such relief and supply a hard surface for the larval oysters to

attach to. Once oysters settle on a hard substrate, they continue growing and cover the individual pieces of fossilized shell. Eventually the oysters begin growing together and help cement the fossilized shell and living oysters together. These oyster reefs also provide extensive surface area for habitation by a diversity of epifauna. Many species utilize spaces between the oysters as hiding places and habitat niches. Other organisms feed on the oysters and, in turn, provide a food source for larger predators.

Monitoring results show severe shifting and movement of oyster shell that has not been observed at other oyster enhancement sites in the bay. In the spring of 2001, oyster bars were created on the shoreline of Whiskey Stump Key. Whiskey Stump Key is a natural island in Hillsborough Bay owned by Audubon of Florida and maintained as a shorebird sanctuary. The shell material at Whiskey Stump Key has shifted some, but has still maintained its bar formation and has established a living oyster reef. Oyster larvae settled on the loose oyster shell within three months of creation. Live oysters on Whiskey Stump Key have attained an average size of 43 mm.

The Whiskey Stump Key site varies from Fantasy Island in two important aspects. Whiskey Stump Key has a lower energy shoreline and the oyster bars were constructed during the spring season. Possibilities for the lack of oysters at Fantasy Island could be due to either of these differences, or other factors entirely. Oysters previously existing on the Fantasy Island shoreline and in surrounding areas may not have had a spawning event this year, or if so they spawned after the oyster shell had been moved around and distributed by the wave action so that it did not support enough relief for the oysters to attach. Other possibilities also exist and require assessment.

In order to address issues of oyster distribution after deployment a new oyster bar building technique was adopted and tested on a third island in Hillsborough Bay. In the spring of 2002, oyster bars were constructed on Green Key with loose oyster shell and shell material contained in oyster bags. The oyster bag idea and the bagging technique were adopted from the South Carolina Department of Natural Resources. The bags were deployed along the leading edge of the oyster bar units and filled in behind with loose shell. Future assessment of this new technique will determine if this option provides a more stable structure than the shell material alone. This treatment may prove to be ideal for shorelines experiencing higher wave energy impacts, such as Fantasy Island.

This project also presented an opportunity for community volunteers and students to get involved in hands-on habitat enhancement and to learn about Tampa Bay's estuarine environment. In addition to providing a work force for habitat creation, these programs attempt to cultivate an understanding and appreciation of resource stewardship within our community. Community habitat restoration and enhancement projects encourage interaction between students and local scientists and heighten student and public awareness of the problems affecting Tampa Bay. Students and volunteers who have worked to restore the bay are likely to become more enlightened bay users and advocates of resource protection and conservation.

ACKNOWLEDGEMENTS

The authors would like to acknowledge all the program participants in the Fantasy Island shoreline restoration events including The Florida Aquarium, the Tampa Port Authority, Coastal Conservation Association, the First United Methodist Church Group, students and teachers at Young Middle School, NOAA/NMFS, FAQWC and the GE Elfun Organization. The Tampa Port Authority, Fish America Foundation, Frank E. Duckwall Foundation and the National Oceanographic & Atmospheric Administration/Restore America's Estuaries (NOAA/RAE) partnership provided funding for the oyster bar events. Funding for the salt marsh planting event as part of the Bay Grasses in Classes program was provided by the GE Elfun Organization, FAQWC, NOAA/RAE, the Environmental Protection Agency (EPA) and Pinellas County Environmental Foundation/National Fish and Wildlife Foundation (PCEF/NFWF).

LITERATURE CITED

Friese, U.E. 1973. Marine invertebrates. T.F. H. Publications, Inc. ISBN 0-87666-105-3. Neptune City, New Jersey: 220.

Janicki, A.J., D.L. Wade, and DE. Robison. 1994. Habitat Protection and Restoration Targets for Tampa Bay. Tech Pub #07-93, Tampa Bay National Estuary Program. Prepared by Coastal Environmental, Inc.

Myatt, DeWitt O., G.S. Alspach Jr., M. Duva, W. Parks and C. Speir. 1999. Comparative Growth and Mortality of the American Oyster (*Crassostrea virginica*) on Artificial Reefs and Natural Substrates in the Chesapeake Bay in the Eastern United States. Proceedings Seventh International Conference on Artificial Reefs: 166-171.

Tampa Bay National Estuary Program. 1996. Charting the Course: The Comprehensive Conservation and Management Plan for Tampa Bay: 1-263.

Tampa BayWatch, Inc. 2001. Tampa BayWatch Bay Grasses in Classes-Wetland Nursery Program Operations Manual: 1-16.

RESTORATION AND HABITAT CREATION IN HUDSON RIVER PARK

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ABSTRACT

In 1998, with the passage of the Hudson River Park Act, the first major new public open space in 100 years was created on 5.5 miles along the west side of Manhattan. As part of the enacting legislation, four-fifths of the Park was designated as the Hudson River Park Estuarine Sanctuary (the Sanctuary). This designation acknowledges the importance of the Park's marine and upland habitats and the need for resource protection, restoration, and creation. An *Estuarine Sanctuary Management Plan* (ESMP) is currently under review that identifies management needs and policies in resource protection, habitat enhancement, education, and research activities. The ESMP will balance the needs of varying park uses with procedures for implementing habitat monitoring policies, rules, laws, and regulations.

HRPT has a mandate to assure that management and construction along the waterfront will result in a net overall environmental benefit. HRPT is committed to resource assessments and monitoring that will ensure this goal. The ESMP designates marine habitats and use areas as well as upland habitat to be protected, restored and created. Implementation is underway to create fishery habitat (bethnic, reefs, and emergent), shallow wetlands, shoreline strands, shoreline meadows, upland riverine forest, and unique ecological piers for species requiring isolation (shore birds, harbor seals, etc.).

INTRODUCTION

The ESMP includes a Base Plan, Three-year Action Plan and a Responsive Summary to the Public Review of the October-December, 2001. The base plan provides overall direction for the protection, management and enhancement of the Hudson River Park Estuarine Sanctuary. As is summarized following, the ESMP is composed of goals and objectives established in four key management areas: resource protection, public access and recreation, education, and environmental research. Each is summarized below.

A. Resource Protection

Respect the importance of the Hudson River's ecological health by preserving, and, where possible, enhancing the marine habitats of the Sanctuary.

The Hudson River is used by a wide variety of fish, shellfish, marine mammals, and birds. HRPT intends to minimize effects on the aquatic resources of the Lower Hudson River Estuary during both development and operation of the upland Park and the Sanctuary and, wherever possible, encourage indigenous species to use and recolonize the Park's upland and water areas. The preservation objectives are aimed at managing the Sanctuary and its public uses, as well as controlling solid waste and water pollution that may result from Park activities. Enhancement objectives focus on improving water quality, aquatics, wildlife habitat, and promoting native species and sustainable design. Through the management of public use, monitoring ecological conditions, enforcement of rules, pollution prevention, waste management programs, and integrated pest management, HRPT seeks to preserve and enhance the ecological health of the Sanctuary.

B. Public Access and Recreation

Build and operate a park that maximizes public access to the Hudson River—both visually and physically—while protecting the Sanctuary's natural resources.

The amount of publicly accessible water area will increase significantly with the park's construction. Thus, a key goal of HRPT is to balance the increasing demand for water-based access and recreation with the need to preserve and improve the area's natural resources. Public access and recreational objectives focus on providing additional opportunities for waterfront access through the development of a variety of new facilities for water play, boating, docking, fishing, and passive activities to meet the needs and uses of diverse park users; increasing the safety of concurrent in-water activities through safety training and the use of rules, regulations and schedules; and, encouraging the use of the waterfront through special events and programs.

C. Education

Capitalize on the Sanctuary's combination of important ecological values and prime regional location by promoting awareness, understanding, and stewardship of the Hudson River for the millions of visitors who will enjoy the Park each year.

Since the Sanctuary is centrally located near millions of residents and thousands of boaters and, is embedded with a rich ecology and social history, it provides the opportunity to serve as a prime educational resource for both children and adults. Through partnerships with educational and cultural institutions, the educational potential of the Sanctuary can be further realized. HRPT's educational objectives focus on expanding educational opportunities within the Sanctuary through learning facilities and special programs, and developing partnerships with local and regional educational organizations in addition to maximizing the potential of such facilities and programs.

D. Research

To promote research that will increase knowledge and understanding of the Hudson River, with the principal intent of improving the ecological values of the Sanctuary and the Hudson River Park ecosystem.

Current research goals focus on solidifying the understanding of the Sanctuary's ecology, analyzing the river's habitats and their relationships with biotic resources, evaluating issues associated with pier demolition and construction, assessing impacts of combined sewer overflows, inventorying social use, and developing methods for improving habitat. HRPT's future research objectives seek to support academic inquiry into the Park and Sanctuary that increases the understanding of the Hudson River's unique resources and environmental conditions and complements ongoing research efforts elsewhere in the estuary.

STUDY SITE

Hudson River Park extends from Battery Place on the south (excluding Battery Park City) north to Pier 99 and West 59th Street. It comprises all of the lands and water west of the Route 9A corridor to the U.S. Pierhead Line and includes most of the piers, with a few exceptions (see Figure 1). The park elements, as defined for this study and also by the Hudson River Park Act, are discussed below.

The water portion of Hudson River Park is bounded on the south by the north bulkhead of Battery Park City and on the north by the north side of Pier 99 located at the foot of West 59th Street. The eastern boundary of the water area is a continuous historic bulkhead which includes relieving platforms. The west boundary is the U.S. Pierhead Line as designated in 1856 by the Commission for the Preservation of the Harbor. This line was delineated to protect the river's navigable channel. It was subsequently adopted by the Federal Rivers and Harbor Act of 1899 (as amended), and is also identified on the official map of the City of New York. The Act specifies that DEC has jurisdiction over "underwater lands held by the State" within this water area.

MATERIALS AND METHODS

To initiate implementation of the objectives cited above, HRPT has developed an Estuarine Sanctuary Action Plan. For the ESMP to be a useful management tool, it is anticipated that the Action Plan will be updated every three years and reassessed, in conjunction with park facility timelines. The Action Plan identifies near-term, short-term, and long-term implementation actions. Near-term actions will be those completed or near completion in the current action plan (2002-2005). Short-term actions are those that are planned for completion in the next action plan (2005-2008) and are sometimes

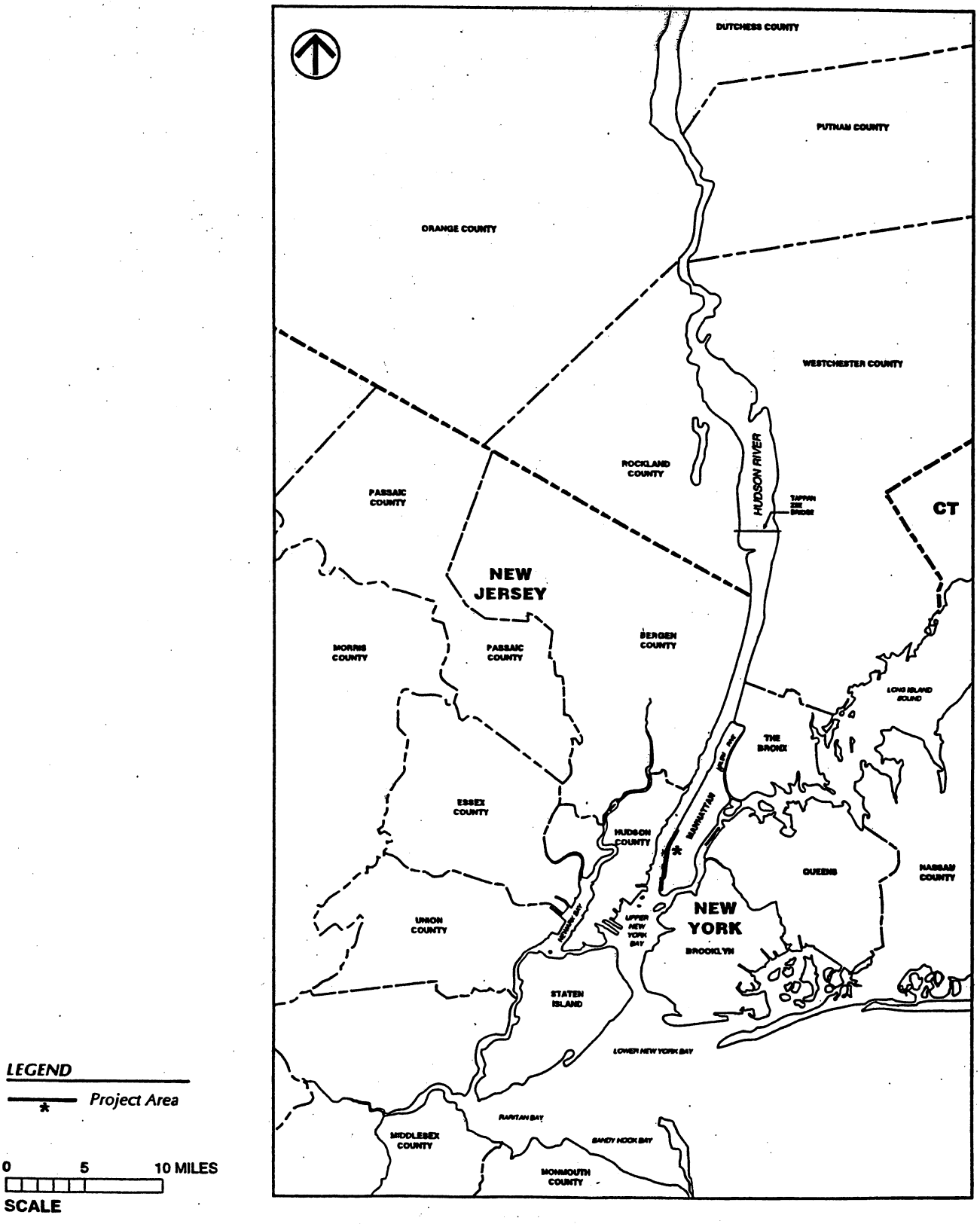

Figure 1: Hudson River Park Estuarine Sanctuary

associated with physical structures that will be developed as the park facilities are constructed. Long-term Actions have a planning horizon in Action Plan 2008-2011. The Action Plan's key implementation items are outlined as follows:

A. Resource Protection Objectives

1. Manage park sites and facilities to protect the integrity of the natural resources of the Lower Hudson River estuary.
2. Monitor and minimize public use impacts on water quality and sensitive species.
3. Prepare a status report on key species within the sanctuary.
4. Protect the seasonal use of the Sanctuary by key species.
5. Adopt policies for the use and management of pesticides, fertilizers and anti-foulants that avoid or minimize the need for chemicals and encourage organic alternatives.
6. Develop waste-management and recycling programs that minimize the waste stream and incorporate litter control.
7. Develop and enforce pollution protection programs to minimize chemical discharge.

B. Resource Enhancement Objectives

1. Work with government agencies to achieve water quality levels needed for unrestricted use of the Hudson River.
2. Coordinate habitat enhancement plans with academic and research institutions (see Figure 2).
3. Further positive trends in biological productivity, abundance and/or diversity (see Figure 3).
4. Promote landscaping with native plants (see Figure 4).
5. Research and promote use of energy efficient facilities and equipment.
6. Integrate environmentally friendly materials into park features and operations.

C. Public Access and Recreation Actions

1. Complete design and construction to facilitate participation in a broad range of activities related to the Hudson River's recreational values.
2. Continue to provide and expand safe access to the Hudson River by creating additional boating and docking opportunities.
3. Establish and manage water surface zones to maximize enjoyment and passive appreciation of the Hudson River environment and minimize in-water conflicts between different types of park activities and users.

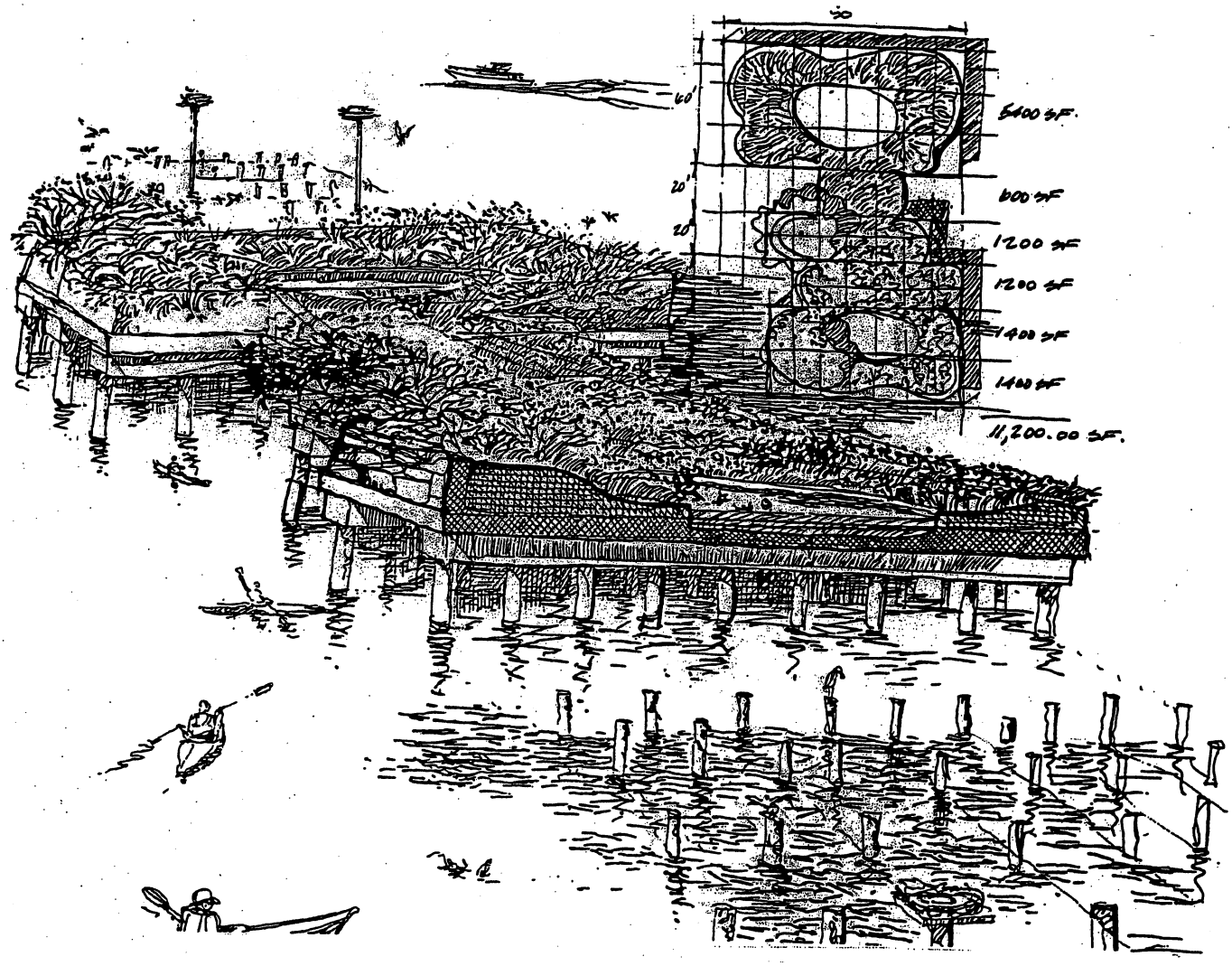

Figure 2: Habitat enhancement plans for ecological piers are based on several major research projects from Cornell and Rutgers Universities

4. Enforce and encourage diverse and safe boating activities that do not have significant adverse impacts on Sanctuary ecology, and allow recreational opportunities for non-boaters.
5. Enforce rules and safety measures for access to the water.
6. Expand opportunities for recreational fishing.
7. Maintain affiliations with local, regional, state, national and international open space organizations.
8. Provide barrier-free access to facilitate full enjoyment of the Park's water areas.

9. Limit signage to protect uninterrupted views and scenic enjoyment of the River.
10. Minimize the adverse effects of created waves on recreational activities and special park features.

D. Education Actions

1. Promote knowledge of the Hudson River's ecosystem, prehistory and history by expanding youth and adult educational programs.
2. Provide facilities where park visitors can gain an appreciation and understanding of the River's ecology, the Estuarine Sanctuary, cultural history, maritime history, and anthropogenic history.
3. Develop partnerships with educational and cultural institutions knowledgeable about the River's ecology and history to offer programs and interpretive materials for park visitors.
4. Provide ecological and historic interpretive elements.
5. Develop a range of written materials to facilitate public education.
6. Provide opportunities for students and volunteers to gain knowledge of the Hudson River through internships and training.

E. Research Actions

1. Provide opportunities for academic and research institutions to augment past and current research and develop new initiatives.
2. Utilize research to monitor the effectiveness of the Estuarine Sanctuary resource protection preservation, protection, and enhancements; public access and recreation; education; and~~,~~ research efforts.
3. Monitor recreation throughout the Park and Estuarine Sanctuary including user groups, activity locations, and the relevance of behavioral information to design planning, and management.
4. Support research that evaluates the potential for regenerated wetlands and other innovative restoration and creation projects that aid the environment.
5. Ensure that research results are publicly accessible.
6. Establish an accessible, technical library system on the Estuarine Sanctuary's data, history and environment.
7. Foster an active climate for research support and funding including grants, scientists-in-residence, internships, equipment, and facilities.

F. Monitoring and Enforcement Actions

1. Coordinate enforcement among HRPT, Local, City, State, and Federal agencies.
2. Oversee design, planning and construction activities to ensure compliance with permit conditions.

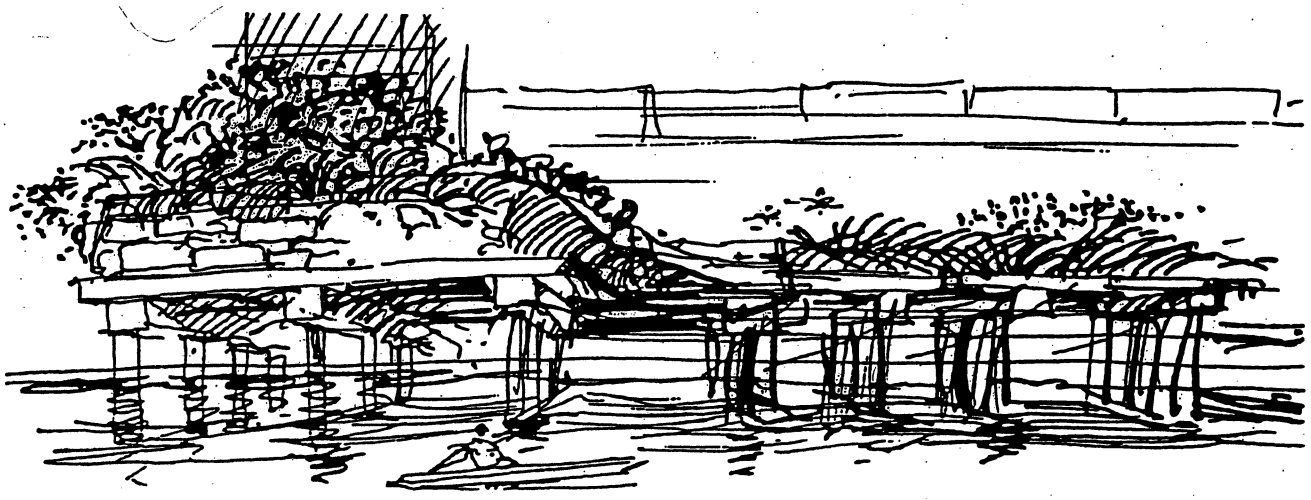

Figure 3: Ecological piers are being planned to further positive trends in biological productivity, abundance and/or diversity.

RESULTS

An ever-expanding database (almost 70 publications) exists on the Sanctuary of species history, toxins, river dynamics, and hydrodynamics and sediment transport. The ESMP is currently re-assessing the improvement of water quality and, monitoring fishery, insect and avian population due to increases in the restoration of habitat. Many natives plants presently exist on the waterfront and areas are being set aside, if necessary, to move these plants (dock, dodder, dogbane, goats beard, pig weed, pokeweed, nightshade, seaside goldenrod, etc.).

HRPT will be supplementing ferns and vines because of their past prominence on the Hudson River waterfront and their potential role as groundcovers. Plans also call for beach, marsh, and marsh meadow restoration. The high-energy situation at the beach will require some wave attenuation or a breakwater. This will also protect wetland, beach, and beach meadow plantings. Some potential energy dissipation systems also being considered include below-surface limestone breaks and oyster balls, sheet piles, floating breakwaters with hanging cages for eel grass, and tensar fencing (all with openings for fish migration).

The planting design will avoid monoculture plantings. The only exception may be the edging necessary to define the paving. The interior paths will be minimized for habitat

density. Low growing plants will build from the edge of the paving to a dense interior of medium height. The high canopy will be continuous at 75' to 100' because the first song bird activity will be high in the canopy and will remain there until the full vegetative structure develops.

HRPT is also encouraging the examination of lighting that does not significantly impair vegetation or wildlife (like the special lighting used at Jamaica Bay). The reference is EPA (publication PM-221, 1992) for light colored paving which reduces heat reflection into the habitat plant beds. Lastly, HRPT is encouraging specialized soil specifications that encourage biological activity in the soil profile (especially for earthworms and insects).

DISCUSSION AND CONCLUSIONS

HRPT is focused on habitat creation and preservation in the marine and upland habitat areas because of the park general plan (GPP), impact statement (FEIS), estuarine sanctuary management plan (ESMP), and DEC and Army Corps of Engineers permit process.

- Upland between Piers 64 and 76 will feature native waterfront plantings (GPP, page 12).
- Chelsea Section will feature native, salt tolerant plants (GPP, page 11).
- HRPT will convert 26 acres of impervious surface to native riverside plantings (FEIS, page 10-4).
- Provide a continuous ribbon of habitat (FEIS, pages 10-38).
- Maintain structural diversity in the shoreline habitat (ESPM, pages 1-14).
- Use a diversity of natives in emergent, marsh, groundcovers, shrubs, understory and canopy plants (GPP, page 8).
- Provide bird nesting, resting, and foraging habitat (ESDC Findings, page 26 and FEIS, pages 10-38).
- Consider butterfly, firefly and other insect habitat for songbirds (ESPM, page A-20).
- Preserve and where possible, enhance marine habitat (FEIS, pages 1-13 and Draft Sanctuary Plan, page 3-1).
- Construct Submerged aquatic vegetation beds and artificial substrates that range from zero to three feet of water depth and a sediment bed that is stable (FEIS, pages 10-15 and ESMP, pages 1-11 and A-20).
- There should be no net loss of granular material from the beach (ACOE Findings, page 113).
- Utilize wave attenuators or other technologies to protect high-energy wetland and beach habitats (ESMP, page 4-2).

Figure 4: Plans will encourage creation of habitat for native birds such as the Least Tern and the Peregrine Falcon.

ACKNOWLEDGEMENTS

The New York State Department of Environmental Conservation (DEC), Fish and Wildlife Division and Lands and Forests Division assists in analyzing the habitat plans for Hudson River Park. Their review and approval of plans is a crucial part of the HRPT habitat restoration process. Those participating in the DEC assessment are Joe Pane (wildlife), Tony Emmerich (urban forestry), and John Cryan (insects). We appreciate the assistance of the DEC Divisions and would like to thank Van Valkenburgh Associates for the habitat figures in this paper.

JOAN M. DURANTE PARK COASTAL RESTORATION

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ABSTRACT

The Joan M. Durante Park Coastal Restoration project consisted of the construction of the second phase of a 32 acre restoration project on Longboat Key in Manatee County. The project site incorporated several approaches to coastal restoration and enhancement. The project resulted in the creation and enhancement of tidal lagoons, transitional wetlands, coastal hammock and bay bottom. Seagrass restoration was also a component of this project. These activities were accomplished through partnerships with several governmental agencies and private donations.

INTRODUCTION

The Joan M. Durante Park Coastal Restoration project is located on the bay side of Longboat Key in Manatee County Florida. The land is under the ownership and management of the Town of Longboat Key who played a primary role in initiating and implementing the project. The site consists of approximately 32 acres of mixed communities, including mangrove swamp, high marsh, saltern and coastal hammock in and adjacent to Sarasota Bay. A linear trench (excavated in the early 1970s for a utility line placement) runs through the adjacent seagrass beds in an east-west orientation across the bay. The project site was broken out into a north and south phase. The north phase was constructed in 1997. The subject restoration activities were associated with the south phase for which construction was initiated in the Spring of 2001. The restoration project was carried out through cooperative efforts and funding from project partners which included the Town of Longboat Key, Florida Department of Environmental Protection, Sarasota Bay National Estuary Program, U.S. Fish and Wildlife Service, Southwest Florida Water Management District and private donations from Mr. James P. Durante. The project involved enhancements of coastal hammock, bay bottom, tidal lagoons and seagrass communities with a restoration goal of creating a self-sustaining system with minimal maintenance requirements (Redmond, 2000). Public access and educational components were incorporated into the project through the design and construction of boardwalks and interpretive trails.

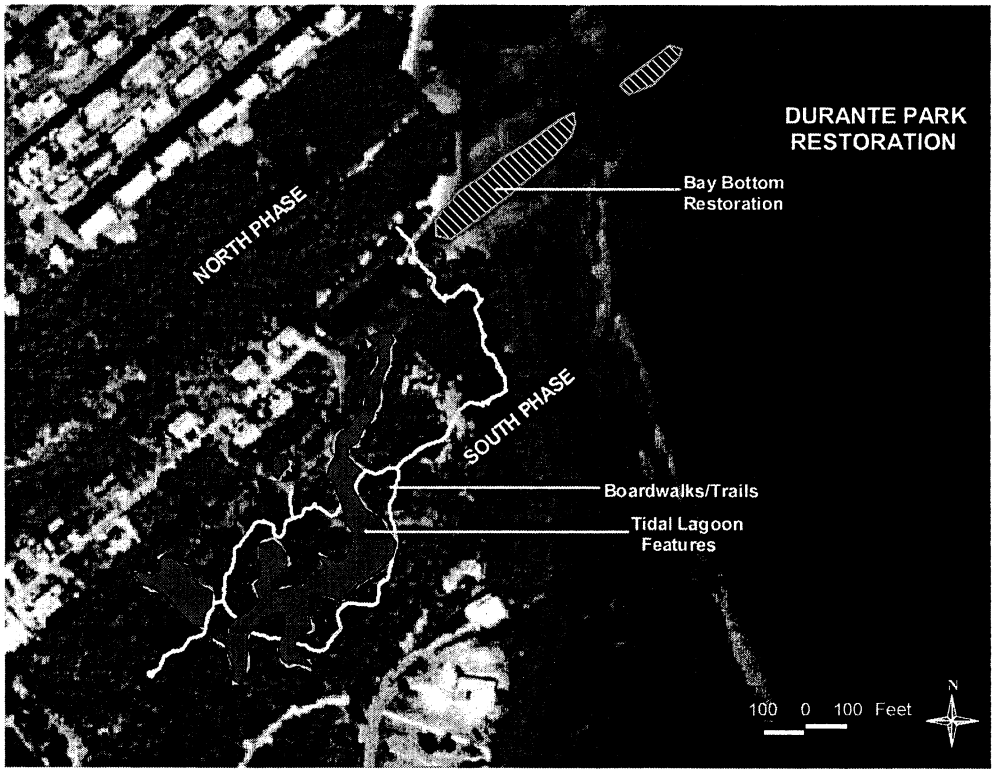

Figure 1. Project Area.

METHODS

Historical information was gathered for the site through resources such as old aerial photographs, Natural Resource Conservation Service Soil Surveys and regulatory agency files. Numerous site visits in addition to aerial photo interpretation was conducted to prepare a restoration strategy. Plans for the project were developed using methods such as sub-meter accuracy GPS for site mapping and a laser level to collect elevation data. The entire project area was mapped to determine the areas which were to be targeted for exotic control, tidal lagoon excavation limits and boardwalk/trail construction. Equipment access areas as well as buffer areas for existing native habitat were also determined and mapped.

Restoration and enhancement activities at the site were initiated in April of 2001. Approximately 1.58 acres of meandering tidal lagoons were created within the project area for this phase of the project. The areas to be excavated were located so as to minimize any impacts to existing functional communities. Tidal connections were made at strategic locations so as to maximize tidal exchange. Water depths were created which ranged from approximately –0.5 feet to –3.9 feet NGVD.

Typically, spoil generated from excavation activities would either be trucked off-site or mounded on-site. It was determined that compatible material which was to be excavated to create the tidal lagoons could be used to fill portions of the existing trench through the adjacent seagrass beds immediately waterward of the project area. This was considered a beneficial use of the material. In addition to the creation of wetlands on-site, the material would be used to repair an existing scar through the adjacent seagrass beds. Elevations were determined and mapped for both the adjacent seagrass and the trench using a laser level and GPS. As material was excavated at the site to create the lagoon features, it was trucked to a staging area and the compatible material was segregated. The selected material was then pumped to a barge which deposited the material within the trench limits. A diffuser was used to more evenly deposit material. Temporary benchmarks were set up to be able to frequently check elevations as the project progressed. Elevations were created in the trench which would support seagrass growth.

Subsequent to the filling of portions of the trench, shoal grass (*Halodule wrightii*) was planted at selected locations using two mechanical planting techniques employed by the contractor. Ten 4' x 5' units of *H. wrightii* were planted within the filled trench utilizing a mega-unit transplanting vessel and a second mechanical planting vessel installed approximately 2000 units at the site with 5-7 short shoots per planting unit. Donor material was taken from the adjacent seagrass beds for both treatments. Planting locations were staked the day before using PVC pipe. Adjustments were made the day of planting to accommodate tide conditions. Planting locations for the sod units were recorded using a Trimble Pro-XR GPS. Coordinates for the adjacent donor sites were also recorded.

Figure 2. Barge in position at bay bottom restoration site.

Exotic vegetation within the site consisted primarily of Australian pines (*Casuarina equisetifolia*), Brazilian pepper (*Schinus terebinthifolius*) and carrotwood (*Cupaniopsis anacardioides*). Mechanical equipment was used to clear vegetation within the footprint of the lagoons to be excavated. However, hand removal and herbicide treatment (Garlon 4) was a primary method of exotic control within many areas so as not to disturb the existing native vegetation. This also reduced areas of ground disturbance, which would be expected to reduce exotic colonization.

Spartina alterniflora was planted along the littoral zones of the lagoons subsequent to the completion of excavation. Staff and volunteers installed plants along approximately 3000 linear feet of lagoon shelves during the summer of 2001. Vegetation was collected from the Florida Marine Research Institute's nursery in northern Manatee County and transported to the site.

The site contained a mosaic of various habitats that included coastal hammock, mangrove swamp, high marsh and saltpan. However, significant areas were invaded by exotic vegetation. It was determined that diversity and exotic control would benefit through supplemental plantings throughout the site. During the summer of 2001, a planting palette was developed for the site and the plants were installed. An irrigation system was set up to reduce mortality during the establishment period for the plants. Vegetation planted at the site included the following:

Spartina alterniflora
Spartina patens
Eugenia axillaries
Quercus virginiana
Sable palmetto
Paspalum distichum
Cocolobo uvifera
Juncus roemerianus
Spartina bakerii
Helianthus debilus
Borrichia frutescens
Bursera simaruba
Acrostichum danaeifolium
Conocarpus erectus
Muhlinbergia capillarus
Juniperus salicicola

Boardwalks and trails were constructed so as to provide the visitor with an experience of meandering through several types of wetland and upland habitats. The boardwalk transitions from a high marsh to a mangrove community and breaks through the canopy edge to provide a view of the open bay. Bridges, gazebos and benches were placed at strategic locations within these habitats. The trail system was developed to enhance educational outreach opportunities as well as provide aesthetic views to the visitor. This was also one of the first restoration projects within Manatee County to utilize recycled plastic material for components of the boardwalk structure.

RESULTS AND DISCUSSION

Wetland loss in Sarasota Bay has been significant. It has been estimated that 39 percent of tidal wetlands in the National Estuary Program study area have been lost (Estevez, 1992). The restoration activities at the site will provide valuable habitat and will help to achieve the Sarasota Bay Comprehensive Conservation Management Plan goal of 18 acres of intertidal wetland restoration per year (Alderson, 1995). The filled trench area and planted seagrass will be monitored over time to observe both natural recruitment of submerged aquatic vegetation as well as the success of the mechanically planted material. The donor sites for the sod transplant units will also be monitored to determine extent of recovery over time for this method.

Within less than a year of construction of the tidal lagoon features, sporadic occurrences of *Caulerpa sertularioides* and *Halodule wrightii* were noted while snorkeling the site. This was considered significant as other recently created lagoon systems within Sarasota Bay have become colonized with submerged aquatic vegetation.

Maintenance events for exotic control have been conducted at the site, but it is expected that continual monitoring and maintenance for exotics will be necessary for the site due to adjacent seed sources on the island. As the planted vegetation matures and competition increases through the natural recruitment of native species, it would be expected that maintenance requirements would be reduced.

The recycled plastic material used for the boardwalks will also be observed over time. Long term cost comparisons will be made, especially in regard to maintenance and replacement requirements. This will provide valuable information relating to the type of materials to be used at restoration sites in the future for public access.

LITERATURE CITED

Alderson, M,; Roat, P.; Smith, H.; Tomasko, D.; and Walker, S. 1995. Freshwater and Saltwater Wetlands Chapter. Pp 5-1 – 5-15. In: (M. Alderson, C. Ciccolella, and P. Roat, eds.) The Voyage to Paradise Reclaimed, the Comprehensive Conservation and Management Plan for Sarasota Bay, Sarasota Bay National Estuary Program. Sarasota, FL.

Estevez, E. 1992. Tidal Wetlands Chapter. Pp. 6.2-6.20. In: (P.Roat, C. Ciccolella, H. Smith and D. Tomasko, eds.) Sarasota Bay: Framework for Action. Sarasota Bay National Estuary Program. Sarasota, FL.

Redmond, A.M., 2000. Dredge and fill regulatory constraints in meeting the ecological goals of restoration projects. Ecological Engineering 15 (2000) 181-189.

WATER, WATER EVERYWHERE?

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Miami, Florida

I. INTRODUCTION

Florida's once seemingly inexhaustible water resources are being compromised and diminished as a result of increased demand, and a lack of formalized coordination and planning between planning authorities and water management districts. Florida's re-plumbing efforts, in the form of the Comprehensive Everglades Restoration Plan ("CERP"), are insufficient on their own to address the threat to water and the environment, which ultimately threatens the habitability of Florida. I will be identifying some of the problems and obstacles to achieving a healthy environment in Florida, particularly as these relate to water resources. In addition, I will be examining the existing legislative and regulatory framework applicable to water resources and water delivery, and proposals that have been put forward to address Florida's future development and water management.

There is a notable lack of a coherent, visionary and enforceable water plan in Florida that sets limits and protects Florida's already over-tapped water resources. Currently, Florida's "plan" is a patchwork quilt of policy statements that are exhortative only, rather than enforceable provisions. Since the enactment of the Water Resources Act,[2] Florida's emphasis on regulation, as opposed to planning, has significantly contributed to Florida's water woes. A proposal to link planning and water resources management, together with a recommendation to enhance cooperation between local government and water management districts under the oversight of the state, will be discussed.[3] Although the Florida Department of Environmental Protection ("DEP") has recently issued a new report, the Florida Water Conservation Initiative Report, containing proposals to conserve water, critics have observed that these measures, even if implemented, would preserve the existing easy and free access to water by the biggest users, principally agriculture, rather than implementing measures to preserve an already over-tapped resource.[4]

II. POSTCARD FROM FLORIDA

Picture this: You sit in your deckchair in your backyard, watching the sun glisten on the canal as the palm trees gently sway in the wind while you sip on your iced tea.

This apparently idyllic scene belies the fact that, right now, the view from Florida is far from picture perfect: there is a good chance that the canal you are gazing at is man-made, the water is contaminated, and at lower levels than when you bought your house, only a few years before. As you continue to soak up the sun, enjoying the scene and the sun's warmth, millions of your fellow Floridians at the same time are irrigating their gardens

and farms, washing their cars and the sidewalks and flushing their toilets without giving a second thought to the water supply, while fully expecting that it will always be available – clean, abundant and on tap.

They are sadly mistaken. The following is a snapshot of the true state of affairs in Florida which is one of the thirstiest states in the country: "More water is withdrawn and used in Florida than in any other state east of the Mississippi River."[5] "Water use is forecast to increase 30 percent from 7.2 billion gallons per day ("BGD") in 1995 to 9.3 billion in 2020."[6] Florida has the highest per capita water consumption in the world, with on average, 171 gallons of water being consumed per day.[7] Groundwater withdrawals account for 62% of Florida's water use.[8] Inefficient and inappropriate use of groundwater, particularly by agriculture,[9] and a rising per capita water consumption, are responsible for the steep rise in water usage that we have witnessed over the past several decades. Levels of groundwater used by agriculture stood at 52% in 1995, with DEP stating that "actual agricultural water use is projected to increase from 3.7 BGD in 1995 to 4.1 BGD in 2020."[10] Aside from the nominal cost of permits, water is free in Florida.[11]

The business of making future population projections is extremely speculative. For instance, in DEP's Public Review Draft of the Florida Water Conservation Initiative, which was released in November, 2001, a projection was made that by 2020, Florida's population would increase from 16 million to approximately 20.4 million.[12] Based on those figures, DEP projected that there would be an average water use of about 9.3 BGD in 2020.[13] DEP's population projection seems to have been based on a trend that may have appeared to signal a decrease in the growth rate; however, this may not have provided a true picture of Florida's rapidly accelerating growth. One commentator has observed:

> [T]he growth from 528,542 in 1900 to 15.5 million in 2000 is an annual rate of growth of 3.44%. If this rate was to persist for the next 100 years, the 15.5 million population would grow to 455 million. This magnitude is greater than the projected population for the nation as a whole.[14]

The same commentator remarks that what appears to be a drop in growth in the 1990s may be attributable to factors other than to a real decline in Florida's growth dynamics.[15] By April, 2002, DEP had revised its population projection, made just four months earlier, from 20.4 million to 21.8 million, which DEP observed may "possibly lead to greater demands [on fresh water]."[16]

There are numerous indicators of the environmental degradation and population pressures that have occurred over the years. The Everglades are now at only one third of the original ecosystem following more than a century of wetlands drainage and development.[17] As growth and population in Florida have expanded, there has been a fanning out from the initial settlement in the northeastern and southeastern areas of the state along the Atlantic coast and in the uplands.[18] To satisfy the increased demand for

more land, inland areas were drained of surface water, thereby reducing the supply of potable water.[19]

The Floridan aquifer supplies Florida with much of its water needs. However, the pressures of population, drained wetlands, farming practices and drought are impacting water resources.[20] Miami-Dade takes most of its water from the Biscayne aquifer, "a wedge-shape subterranean sponge of porous limestone that holds huge volumes of slow-moving ground water."[21]

> The people of Florida should be aware that the south Florida ecosystem is not sustainable on our present course. Floridians, at all levels, need to recognize that we can sustain neither our existing human nor our natural systems in south Florida with regard to water if we do not change direction.[22]

Over-withdrawals of groundwater can lead to multiple and serious problems including saltwater intrusion, reduced supply, drainage of lakes and wetlands and land subsidence.[23] "In central Florida, wetlands, lakes and streams will start to dry up by 2006 if all the permits to withdraw water are granted and new supplies aren't identified," observed Kirby Green, Director of the St. John's River Water Management District, which services 16 central and north Florida counties.[24] St. John's River Water Management District is not the only region facing a grim situation regarding its water resources:

> In the Suwannee River Water Management District, the year 2000 was the fourth lowest rainfall year since 1931. In the spring of 2001, most of the gauging stations in the Suwannee, Santa Fe, and Withlacoochee rivers recorded record low flows. Fifty-two of the district's eighty-five Floridan Aquifer monitoring stations set record low levels. Many of the District's springs had either ceased flowing or had greatly reduced flows.[25]

The Wellfield Protection Zone.

The wellfield protection zones in Florida, which have typically been established by county ordinance, draw a line around wellfields, inside which industry is banned, because of the potential impact on the potability of underground water. Banned industries include airports, dry cleaners and paint manufacturers. The so-called cone of influence around a wellfield is comparable to the conical dip that forms on the surface of a milk shake when a straw is used; the stronger the suction, the wider the cone.[26]

An example of the wellfield protection zones is found in Chapter 24 of the Miami-Dade County Ordinance, which provides for protection zones around a number of wells, including fifteen Miami-Springs wells that provide drinking water to one million people in South Florida.[27] These protection zones were established by the Miami-Dade County Commission under the assumption that the wells would pump 70 million gallons per day

("MGD"). To protect the aquifer and ground water, the ordinance prohibits certain industries from contamination by chemical seepage or spill.

"A constellation of wellfields around the county sucks the water from the aquifer - - which begins just below our feet - - and powerful pumps force the water through massive pipes to treatment plants."[28] Wells in the Miami - Springs area are already pumping too much. According to DERM, as of 1994,"the Miami Springs wells [were] pumping between 100 and 125 MGD in 1994, expanding the cone well beyond the intended protection zone and into areas that are known to be contaminated - - including Miami International Airport and certain industrial areas in Hialeah."[29] The wellfield restrictions prohibit industries from being situated in a wellfield protection zone, but fail to restrict a wellfield pumping outside its zone. It has been remarked that an explanation for these inconsistencies lies in the fact that Miami-Dade is "conveniently, both the wellfield operator and the author of the wellfield protection ordinance."[30]

Additionally, continuing development pressures have resulted in the bending of the line, known as the Northwest Wellfield Protection Zone. Miami-Dade County Commissioners recently approved a new development, known as Beacon Lakes, consisting of an immense 436-acre warehouse complex, which will be situated almost entirely in a wellfield protection zone: "[I]t's at the edge of the buffer, an area where contaminants could creep toward the wells if an extreme drought or excessive pumping dropped the water table."[31]

The development was approved after DERM determined that the project did not pose a risk to the Beacon Lakes drinking supply.[32] A factor in that approval seems to have been based, at least in part, on the developer's proposal to build a canal, similar to the Snapper Creek Canal extension, situated on the Florida Turnpike in Miami-Dade County. The Snapper Creek Canal extension is described by engineers as creating a protective pressure barrier: "The canal, when held at higher levels than the surrounding groundwater, prevents tainted water from flowing back west toward the wells."[33] The Beacon Lakes project has its critics: They do not agree that the risk of contamination of the well field can be successfully contained by the construction of a canal, and question the effectiveness of this type of canal as a hydrological divide, pointing to periodic failures of the Snapper Creek Canal.[34]

III. THE RESTUDY AND THE EVERGLADES RESTORATION PLAN

The Everglades ecosystem of a century ago, with its unique combination of hydrological flows and climate, has been forever lost.[35] It has shrunk to half of its original size, largely through the initiative of the original Central and Southern Florida Project ("C&SF Project"), which implemented a wide-scale conversion to agricultural use in response to hurricane flooding in the late 1940s.[36] The sixty mile-wide sheet flow that historically flowed south, and which could take over a year to reach the ocean, insulated the Everglades from the droughts and floods that are a regular feature of Southern Florida. The wetland vegetation, which acted as a natural filter as the water slowly made its south-

bound passage, contributed to the high quality of the water.[37] This unique flow formed estuaries where the sheet flow met the ocean, supporting abundant marine and estuarine species.[38]

The Everglades ecosystem has been designated a Ramsar Convention Wetland of International Importance, an International Biosphere Reserve, and a World Heritage Site.[39] These three international environmental organizations have designated South Florida to be an area of biological importance because of the Everglades' unique hydrological pattern and the immense wealth of biological diversity that it supports. The Everglades is one of only three areas that have attained this status in the international community.[40]

In compromising the integrity of the Everglades, we have not only impacted the availability of clean, fresh water, but we have lost a number of species and are in danger of losing more as a result of both diminished water flow and water contamination, largely as a result of agricultural runoff.[41] Eighteen animal and plant species have been identified by The Fish and Wildlife Service as threatened or endangered within the study area.[42] Increased demand stresses Florida's aquifers and causes both contamination and salt water intrusion. It is imperative that we preserve and restore the health of the Everglades by protecting it and our aquifers from pollution, inappropriate development, and agricultural practices.

The C&SF Project Comprehensive Review Study ("Restudy") team, led by the Army Corps of Engineers, has proposed an experimental restoration plan that is intended to mimic the historical levels of water flow that once flowed through the Everglades.[43] It currently involves the implementation of sixty water management projects at a cost of approximately eight billion dollars.[44]

The greatest challenge to the plan's success is overcoming the inadequacies of South Florida's entire water management system, which largely depends on making significant changes to the established water management responsibility in Southern and Central Florida. Its success will also depend on institutionalizing flexible responses that will be required for effective ecosystem management. The Restudy involves adaptive management, and builds on projects implemented on an experimental basis, on which subsequent decisions are based.[45]

The Everglades Restoration Project is just one piece of the puzzle; it is the beginning of what is needed in order to ensure that we do not overburden our environment, and that our quality of life does not decline as a result of a corresponding decline in water quality, air quality, and availability of water. There are many interlocking pieces to identify and piece together to assure Florida's continuing quality of life and economic health. If we continue to approach the issue of planning, water delivery and supply water pollution as separate and segmented pieces, there is a real danger that we will fail in our efforts.

IV. INTRODUCING LINKAGE

In 1972, Florida enacted The Environmental Land and Water Management Act,[46] The Water Resources Act,[47] and the Land Conservation Act,[48] thereby becoming one of eleven growth management states.[49] While these statutes provide that regional and state issues be considered in land use and development issues, there is no linkage between land use and water use, with the exception of taking into consideration current water facilities as a concurrency issue.[50]

California has taken a lead by introducing such a linkage. "For the first time in California's history, statewide government policy has linked land-use and growth issues to water supply [with the passage of a law which requires developers] "to prove there is a 20-year supply of water *before* they are given permits to build subdivisions with more than 500 units."[51] There are no positive indications that Florida will follow California's lead in taking such a step. A coordinator with the South Florida Regional Planning, indicated that while Florida land management and water agencies were aware of the California decision, a bill considering linkage was proposed in Florida's previous legislative session, it did not pass.[52] He indicated that it "would be easy for the Regional Planning Councils to support this measure," were it to pass.[53]

One observer of the challenges faced by Florida in reconciling growth and management, has discussed the need to link land development with water permitting, and, in so doing, has supported the views of the Third Environmental Lands Management Study Committee, which identified this need as the "missing link."[54] "Except for limited provisions, Florida law does not establish a formal link between land planning and water planning . . . [which] is a significant 'missing link.'"[55] Regulatory programs predominate in Florida for both land and water use. Although permitting is an efficient tool, its function is not intended to substitute for effective local government planning. Comprehensive planning that links land development with water resources and that incorporates environmental thresholds and optimum carrying capacity, is needed. "[A] combination of good planning and other nonregulatory tools such as land acquisition, conservation easements and transferable development rights should be used to protect the important habitat and direct growth away from it."[56] This currently does not occur. The following observations have been made regarding existing land and water management deficiencies in Florida in which permitting appears to have taken the place of planning:

> Federal, State, regional, and even local wetland and water regulation programs issue permits for land development by looking at the potential adverse effects of the particular development on water resources. These programs do not plan for future land development. Also, these programs do not use and identify and implement long – range goals, objectives and policies based on a comprehensive assessment of natural resources in a particular area in light of future growth projections and community needs and desires. Using a regulatory program to attempt to achieve proper land use planning is a losing proposition. Planning decisions cannot be made

> when a developer requests a permit application. All that can be done at this point is minimize environmental impacts through engineering treatment technologies and wetland mitigation. The burden is passed on to the permitting agency, rather than being dealt with as a land use and natural resource protection policy.[57]

To better understand what is missing from Florida's approach to land development and water management, with its emphasis on regulation, the following is a description of the state's existing legislative and regulatory scheme.

A. The Environmental Land and Water Management Act (The "ELWMA").

The ELWMA established two regional planning mechanisms in addressing Florida's growth management system: The Area of Critical State Concern ("ACSC"), and Developments of Regional Impact ("DRI"). Both of these designations require that the State take specific action modifying local government authority for land development in their jurisdictions. Areas designated as ACSCs may be established pursuant to Section 380.05, Florida Statutes. An ACSC is a program providing for the identification of up to five percent of the state's land as an ACSC. It is an area that contains or has a significant impact on "environmental or natural resources of regional or statewide importance."[58] A development receives a DRI designation pursuant to Section 380.06, Florida Statutes "because . . . its character, magnitude, or location, would have a substantial effect upon the health, safety, or welfare of citizens of more than one county."[59]

B. The Florida Water Resources Act.

The principal statutory scheme governing water in Florida is contained in the Florida Water Resources Act. This statute created the regional water management districts, which were established along surface water hydrologic boundaries rather than along political boundaries. Additionally, it provided for district decision-making by governing boards, with members to be appointed by the governor and confirmed by the senate.[60] The Water Resources Act originally identified five primary programmatic areas of water management district functions. These were: (1) The construction and operation of district works; (2) planning for, management, and permitting of consumptive uses of water; (3) supervision of water well construction; (4) regulation of systems that manage or store surface waters; and (5) evaluation of water supplies and other resources within the district.[61]

Since the implementation of the Water Resources Act, the districts have been given additional responsibilities, either by the legislature or by way of delegation by the DEP. These have included responsibility for the development of groundwater basin resource availability inventories, environmental resource permitting, surface water improvement and management (SWIM) programs, acquisition and management of certain lands, and restoration of the Everglades and Florida Bay.[62]

The principal objective of the Act, which has again been amended since 1997, is to harness and provide more water for human consumption and natural systems. To that end, the Act directs water management districts to engage in active water resource development and, in so doing, to harness more water for Florida's end users.[63] That is the main shift from the earlier regulatory approach, when the focus was principally on the allocation of available water rather than the exploitation of additional sources of water. The amendments are a "product of . . . political clashes [resulting in] a statutory scheme purposefully designed to increase water resources. For the first time, the state's water policy focused on the development of water resources and water supply, rather than merely allocating water among competing users."[64]

The 1997 amendments to the Act introduced a requirement that the water management districts develop their own regional water supply plans. This was due to anticipation that sources of water would be inadequate to meet projected demands of the year 2020.

> In addition to traditional ground and surface water sources, the plans typically call for better conservation of water resources and development of more "drought resistant" water supplies including demineralization of brackish groundwater, desalination of seawater, and reuse of reclaimed water. Storage options were also evaluated in some of the plans, including water reservoirs, aquifer recharge and aquifer storage and recovery (ASR).[65]

C. Florida Water Plan

The Water Resources Act mandates that a water quality standards system be developed and coordinated with the state water use plan.[66] These two components together comprise the Florida Water Plan, pursuant to Section 373.039, Florida Statutes. The Act required that a state water use plan be formulated, which was, inter alia, to identify existing and future needs and uses of water, existing water resources, and the means for conserving and augmenting these resources.[67] While a water use plan has since been developed, it is rarely invoked to resolve a water supply issue. This is due to its lack of enforcement powers, its non-binding nature, and its failure to introduce a link between water management and land use and planning. The Plan's emphasis is on addressing water supply, maximizing the availability and capture of water, and developing alternative sources of water, rather than establishing any environmental threshold carrying capacities. In doing so, it relies on technology, rather than good planning, to respond to water pressures and to cater for increased water demand.[68] It appears to reinforce the status quo, which relies heavily on technology to extract water to meet increasing demand. This technology includes the promotion and development of wastewater recycling, desalination, and ASR injection. Such technology-dependent measures, in particular with regard to ASR's, are not risk-free.

Section 373.016(3), Florida Statutes, vests power and responsibility in the Florida Department of Environmental Protection (DEP) to conserve, protect, manage, and control Florida waters. This statute gives the DEP sufficient flexibility and discretion to accomplish these ends through delegation of appropriate powers to the various water management districts. The DEP is responsible for state level administration of the Florida Water Resources Act, and it is charged with the responsibility of developing the Florida water plan, a state water policy and a state water use plan.[69] It has delegated many of its functions to the districts, which is permitted by the Water Resources Act.[70]

D. Permitting

Water use permitting, a discretionary tool, has taken center stage in Florida and has steered water management in Florida to a much greater extent than water supply planning. This development is contrary to the intention of the authors of A Model Water Code, on which the planning provisions of the Water Resources Act are based. Consumptive use permitting ("CUP") and environmental resource permitting ("ERP") underpin Florida's regulatory environment, administered by the managers of the water management districts.

Permitting, however, does not address planning issues:

> Neither ERP nor CUP is aimed at directing types, densities or intensities of land development, determining where large tracts of land should be preserved, or addressing resource issues that relate solely to upland or non-water related concerns. Instead, water management permitting requirements frequently can be met through engineering solutions and project design regardless of whether the project is in an appropriate location or of an appropriate density or intensity.[71]

Consumptive Use Permits ("CUPs")

Consumptive use permits are one of the principal features of the Water Resources Act. The necessity of such permits for any given user is left up to the discretion of the individual water management districts.[72] It is only the South Florida Water Management District that regulates water use of less than 100,000 gallons per day.[73] A permit is required in the other four water management districts only if a user exceeds a certain threshold of water use.[74] This threshold includes any one of the following: (1) a total withdrawal capacity of one million gallons per day; (2) an annual average withdrawal equal to or in excess of 100,000 gallons per day; or (3) withdrawal from a well having an outside diameter of at least six inches.[75]

Section 373.223, Florida Statutes, sets out conditions for water permits and contains a three-pronged test. Irrespective of ecological concerns, permits are issued when they meet the following three criteria that draw upon Florida's common law tradition of

riparian rights: The use must be "a reasonable-beneficial use"; it must be "consistent with the public interest"; and it must "not interfere with any presently existing legal use of water." A determination of whether a use meets this requirement is made on a case-by-case basis.

Environmental Resource Permitting ("ERPs")

Land development over a specified size is regulated under the ERP program.[76] This program provides for jurisdiction, inter alia, over most land development systems, from buildings to roads and mines, whether occurring in uplands, wetlands, or other surface waters. There are exemptions from the ERP requirements, which are found at sections 373.406 and 403.813, Florida Statutes and Rule 40C-4.051, Florida Administrative Code Annotated - one of the most significant exemptions covers agricultural, silvicultural and horticultural activities. Rule 40C-4.301 provides, inter alia, for the prohibition of any activity that would adversely impact water quantity, violate a State water quality standard, or adversely impact wetlands and other surface waters. Engineering design solutions are often adopted to overcome water quality and quantity concerns in order to meet the applicable criteria, and mitigation to offset wetland impacts are regularly implemented to protect wetland functions.

Water management regulation, whether by way of ERP or CUP, does not address planning concerns and issues concerning densities or types of land development, or relating to upland or concerns that do not pertain to water.

> Instead, water management permitting requirements frequently can be met through engineering solutions and project design regardless of whether the project is in an appropriate location or of an appropriate density or intensity...It would a very rare case where, given enough financial resources and engineering know-how, a project could not be designed to meet the ERP criteria.[77]

E. Minimum Flows and Levels.

The Water Resources Act requires the state to establish the "minimum flow" of water and "minimum water level" in the aquifer at which "further withdrawals would be significantly harmful to the water resources or ecology of the area."[78] That requirement has been on the statute books since the enactment of the Water Resources Act in 1972. By the early 1990's, water management districts had, on the whole, failed to implement this directive, and citizens' groups litigated to force water management districts to protect minimum flows and levels, which, they claimed, were deteriorating as a result of environmental stressors, including saltwater intrusion, lowering of groundwater tables, loss of wetlands and exotic infestation. [79]

The result has been to strike a balance between water resource protection and economic growth with the amendment of the Water Resources Act, and the passage of sections 373.042 and 373.0421, Florida Statutes. In order to achieve that balance, the criteria for establishing minimum flows and levels were changed, with water management districts not being required to re-establish historic levels.[80]

Another significant amendment established a priority list by each water management district, consisting of a schedule for establishing minimum flows and levels for surface water and aquifers located in each district. Because the legislature removed language in the statute which required districts to set minimum flows and levels, water management districts are no longer subject to potential litigation seeking that a level or flow be addressed. Additionally, there is no longer a requirement to set minimum flows and levels for water bodies under twenty five acres in size.[81]

According to a Water Management District attorney, even though these statutes are more than twenty years old, "they are up for interpretation. We haven't had a lot of litigation because we haven't gotten to the point of water wars. But I think as growth increases in South Florida and we are forced to send more water to the Everglades, we're going to be going to court on these statutes."[82]

F. The Land Conservation Act.

The Land Conservation Act provides that the state may establish a system permitting it to acquire land for conservation purposes and for the public good.[83] The Conservation and Recreation Lands Trust Fund may be tapped to acquire lands pursuant to this statute and, in such acquisitions, priority is given to highly populated counties, in addition to lands designated as areas of critical state concern.[84]

V. RECENT DEVELOPMENTS

Recently, in *Tahoe-Sierra Preservation Council, Inc., v. Tahoe Regional Planning Agency,*[85] the United States Supreme Court found that a 32-month moratorium on development around Lake Tahoe did not constitute a partial taking pursuant to the categorical rule announced in *Lucas v. South Carolina Coastal Council.* [86] Takings law stems from the final clause of the Fifth Amendment,[87] which provides that "private property [shall not] be taken for public use without just compensation," and applies to states and the federal government.

In order to preserve the integrity and beauty of Lake Tahoe, California and Nevada entered into the Tahoe Regional Planning Compact ("Compact"), which was approved by Congress in 1969. This was amended extensively in 1980 to tighten controls over the new residential construction around the lake. The 1980 amendments to the Compact directed the Tahoe Regional Planning Agency ("TRPA"), the agency charged with implementing the Compact, to "coordinate and regulate development in the Basin and to

conserve its natural resources," and to develop "regional environmental threshold carrying capacities."[88] This was a broad term encompassing "standards for air quality, water quality, soil conservation, vegetation preservation and noise."[89]

The Compact provided that the TRPA would adopt such standards and ultimately adopt an amended regional plan that implemented and maintained those carrying capacities. In order to achieve this timetable, the Compact itself provided that all new subdivisions, condominiums and apartment buildings would be prohibited, and proscribed all cities and counties within the Basin from granting any additional permits.[90] A new regional plan was ultimately adopted on April 26, 1984.

Among the petitioners were approximately 2,000 owners of improved and unimproved land in the Lake Tahoe Basin, in addition to other individual land owners of vacant lots who had purchased their properties prior to the effective date of the 1980 Compact. The sole issue before the Court was "whether the rule set forth in *Lucas* applies - that is, whether a categorical taking occurred because Ordinance 81-5 and Resolution 83-21 denied the plaintiffs "all economically beneficial or productive use of land."[91] The court held that there was no such categorical taking, and upheld the decision of the Court of Appeals, finding that the actions taken by TRPA did not constitute an unconstitutional taking of petitioners' property. *Lucas* was distinguished by the Court as being confined to the relatively rare case in which a regulation permanently deprives an entire parcel of all productive use. In this instance, the moratoria were limited to only a temporal slice of the affected landowners' fee interest.

Thus, land management agencies in Florida have a new tool at their disposal to protect land and water resources in their planning process where circumstances warrant a temporary halt on development. Chapter 70 of the Florida Statutes protects private property rights where action of the state or political entities in Florida may "inordinately burden, restrict, or limit private property rights without amounting to a taking under the State Constitution or the United States Constitution" and provides for "a distinct cause of action from the law of takings...when a new law, rule, regulation, or ordinance of the state or a political entity in the state, as applied, unfairly affects real property."[92] The term "inordinate burden" expressly excludes "temporary impacts to real property."[93] Provided that the action constituted a "temporary impact," a moratorium on development similar to that implemented by the Tahoe Regional Planning Agency would be likely upheld as permissible, both under Chapter 70, and under the Florida and United States Constitutions.

Water For Sale.

Included in the DEP's Water Conservation Initiative is a recommendation to "consider the use of market principles" in the allocation of water.[94] Introducing such principles may be difficult to reconcile with the current designation of water as a public resource in Florida and may pave the way to placing water on the open market. In 1999, a subsidiary of Enron Corp., Azurix Corp. made a proposal to Governor Jeb Bush and DEP Secretary,

David Struhs, which involved an offer to pay Florida's share of Everglades restoration in exchange for the rights to sell water from the restoration project.[95] While no agreement was ever concluded, the company attempted to have bills passed in the state's legislature that would have supported limited water markets in Florida.[96] While water pricing by the state may have its merits, involving the attribution of a value to a precious resource, privatizing Florida's water may be difficult to reconcile with the conservation of water, each having opposing desired outcomes. If such a plan to privatize were implemented, the opportunity to link water planning with land planning by state agencies could thereby be lost for ever.

VI. CONCLUSION

In Florida, the continued delivery of plentiful and clean water depends on our good management and stewardship. While the Everglades Restoration Plan has the potential to reverse some of the damage to the Everglades by re-plumbing parts of the Everglades, it is debatable whether it will be successful in restoring some of the Everglades' historic flow patterns.[97] "South Florida is depending on the massive Everglades restoration project to meet part of its future demands by storing water in reservoirs and deep wells."[98] Whether successful or not, we should not be lulled into believing that we can rely on the Everglades Restoration Project to cure Florida's water woes. The proposal that land use planning be integrated with water management is one that merits consideration, but Florida's reliance on technology through its regulation program, established to meet that State's future water demand, may well be over-optimistic, and, some might say, short-sighted. There are limits to the capabilities of technology to deliver needed water and meet future demands. The implementation of comprehensive planning linking water supply with development in order to set limits, similar to those adopted by California, may be a tool Florida cannot afford to ignore.

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[2] Chapter 373, FLA. STAT.

[3] Mary Jane Angelo, *Integrating Water Management and Land Use Planning: Uncovering the Missing Link in the Protection of Florida's Water Resources?*, 12 FLA. J. L. & PUB. POL'Y 223, 224 (2001).

[4] Curtis Morgan, *State May Curb Water Usage*, MIAMI HERALD, May 13, 2002, at 5A.

[5] *Id.*

[6] Amanda Riddle, *Water Shortage Still Critical, Officials Say*, MIAMI HERALD, December 28, 2001.

[7] Angelo, *supra* note 3, at 224.

[8] *Id.*

[9] *See* FLA. DEPT. OF ENVTL. PROT., FLORIDA WATER CONSERVATION INITIATIVE, PUBLIC REVIEW DRAFT, [hereinafter FWCI DRAFT] at 3 (November, 2001) ("Forty-one percent of all water used for agricultural irrigation east of the Mississippi River is used in Florida . . . Florida is more dependent on groundwater (60% of fresh water use) than any other state east of the Mississippi River.")

[10] *See* FLA. DEPT. OF ENVTL. PROT., FLORIDA WATER CONSERVATION INITIATIVE [hereinafter FWCI] at 8.

[11] Morgan, *supra* note 4, at 5B.

[12] FWCI DRAFT at 4.

[13] *Id.*

[14] James C. Nicholas & Ruth C. Steiner, *Growth Management and Smart Growth in Florida*, 35 WAKE FOREST L. REV. 645, 647 n.12, 648 n.28. "[The] lessened pace of [population growth] may be due more to the severe and prolonged recession of the early 90s and the decrease in the number of persons nationally reaching retirement age than to any fundamental change in the growth dynamics."

[15] *Id.* at 647.

[16] FWCI, supra note 10 at 7.

[17] John J. Fumero, Column, *Environmental and Land Use Law: Everglades Ecosystem Restoration: A Watershed Approach by the Legislature*, 74 FLA. B. J. 58, 58 (2000). Fumero writes:

> As late as the 1800's, the Everglades consisted of a 60 mile-wide shallow river, seldom more than two feet deep, flowing from Lake Okeechobee to Florida Bay. That was before the U.S. Army Corps of Engineers erected 1,400 miles of dikes, dams, levees, and water control structures in the name of water supply and flood control. Now in the year 2000, more than 50 years after Marjorie Stoneman Douglas wrote about the demise of the Everglades, only 2.4 million acres of Everglades remain - - about one third of the original Everglades ecosystem. Lake Okeechobee is likewise experiencing adverse ecological impacts. Florida is now at a turning point, ready to begin reversing the effects of massive wetlands drainage, damage to our estuaries and loss of valuable storage areas.

[18] James C. Nicholas, *The Ups and Downs of Growth Management in Florida,* 12 FLA. J. Law L. & PUB. POL'Y 213, 220 (2001). Nicholas writes:

> The drainage that made much of Florida habitable also disposed of the fresh water that was a critical element of the ecosystem and the source of drinking water. The farms and subdivisions that developed in the diked and drained areas added so many pollutants to the remaining natural areas that their continued existence came into doubt. The sheer pressure of numbers extended urban development into areas that nature had not designed to be used for those purposes and created consequences . . . beyond what the natural and human systems could absorb.

[19] *Id.* Nicholas & Steiner, *supra* note 14, at 648.

[20] Riddle, *supra* note 6.

[21] *Id.*

[22] U.S. ARMY CORPS OF ENGR'S AND S. FLA. WATER MGMT. DIST., CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW STUDY B OVERVIEW, at 12 (October, 1998) (citing GOVERNOR'S COMM'N FOR A SUSTAINABLE S. FLA., OCTOBER REPORT (1995)).

[23] *Id.*

[24] *Id.*

[25] *Id.* at 4.

[26] Kirk Semple, *Running on Empty*, MIAMI NEW TIMES, October 20, 1994, at 8 of electronic document.

[27] Curtis Morgan, *Wellfield Development Still Faces Opposition*, Curtis MIAMI HERALD, June 3, 2002, at 1 of electronic document.

[28] *Running on Empty, supra note 26* at 2 of electronic document.

[29] *Id.* at 8 of electronic document.

[30] *Id.*

[31] *Wellfield Development Still Faces Opposition, supra* note 27at 2 of electronic document.

[32] *Id.*

[33] *Id.*

[34] *Id.*

[35] DAVID MCCALLY, THE EVERGLADES: AN ENVIRONMENTAL HISTORY (University Press of Florida 1999) (providing a comprehensive description of the Everglades' ecosystems).

[36] *Id.* at 140-145.

[37] *Id.* at 26-27.

[38] *See* U. S. ARMY CORPS OF ENGR'S AND S. FLA. WATER MGMT. DIST., CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW STUDY, FINAL INTEGRATED FEASIBILITY REPORT AND PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT. at 2-5 (1999) [hereinafter RESTUDY].

[39] STEVEN M. DAVIS & JOHN C. OGDEN, EVERGLADES: THE ECOSYSTEM AND ITS RESTORATION (CRC Press - St. Lucie Press 1994.)

[40] *Id.*

[41] *See* RESTUDY, *supra* note 38, at 3-19.

[42] *See Id.* at tbl. 3-1.

[43] *See Id.* at 7-15.

[44] William E. Gibson & Neil Santaniello, *Bush Brothers Agree: Ecosystem comes First; State-Federal Pact Promises Water to Area; 30 Year Project to cost $8 Billion,* SUN-SENTINEL (Fort Lauderdale,

FL), January 10, 2002, at 14A. This state/federal pact, a 30-year plan which was signed on January 10, 1992, promises water to the Everglades area at a projected cost of $8 billion. The agreement is:

> [C]onsidered to be the first such – state water compact . . . the signing was required by the Water Resources Development Act of 2000, which calls for a binding agreement in which the state promises that nature will have the first claim to new water supplies. Congress insisted on such an agreement before the federal government could pay its part of the costs.

[45] *Id. See* RESTUDY, *supra* note 38, at 5-32.

[46] *See* FLA. STAT. Section 380.012 *et seq.*

[47] *See* FLA. STAT. Section 373.013 *et seq.*

[48] *See* FLA. STAT. Section 259.01.

[49] The other growth management states are California, Georgia, Hawaii, Maine, Maryland, New Jersey, Oregon, Rhode Island, Vermont, and Washington. *See* A.C. Nelson & Terry Moore, *Assessing Growth Management Policy Implementation: Case Study of the United States' Leading Growth Management State*, 13 LAND USE POL'Y 4, 241-59 (1996).

[50] Telephone Interview with John Hulsey, DRI Coordinator of the South Florida Regional Planning Council (May 7, 2002) [hereinafter *Hulsey Interview*].

[51] *Show Me the Water*, SIERRA, March/April 2002, at 17.

[52] Hulsey Interview, *supra* note 50.

[53] *Id.*

[54] Angelo, *supra* note 3, at 235 (referring to the Envt'l. Land Mgmt. Study Comm., Building Successful Communities 6 (1992)).

[55] *Id.* at 223.

[56] *Id.* at 234.

[57] *Id.* at 232.

[58] *See* FLA. STAT. Section 380.05(2)(a).

[59] *See* FLA. STAT. Section 380.06(1).

[60] *See* FLA. STAT. Section 373.069 (2001). The 1972 statute established six water management districts, however the statute was amended in 1977 to reflect the current five districts. These comprise the South Florida Water Management District, the Southwest Florida Water Management District, the Northwest Florida Water Management District, the Suwannee River Water Management District and the St. John's River Water Management District. Section 373.073 provides that governing board appointments are made according to hydrologic basin boundaries (three districts) or county jurisdictions (two districts). The Southwest Florida Water Management District has an 11-member governing board whereas all other district have nine member boards. *See id.* Section 373.073.

[61] *See* Angelo, *supra* note 3, at 230. *See also* FLA. STAT. Section 373.086-.087 (2002) and Parts II-IV (1973).

[62] *See* Angelo, *supra* note 3, at 230. *See also* FLA. STAT. Sections 373.0395 (availability inventories); Sections 373.414, .427, .441 (resource permitting); Sections 373.453- .459 (SWIM programs); Sections 259.032, .101, and 373.59 (acquisition and management).

[63] *See* FLA. STAT Section 373.0831(3).

[64] Frank E. Matthews & Gabriel E. Nieto, *Florida Water Policy: A Twenty-Five Year Mid-Course Correction*, 25 FLA. ST. U. L. REV. 365, 366 (1998).

[65] FLA. DEPT. OF ENVT'L. PROT., FLORIDA WATER PLAN, at 14 (December 2001).

[66] FLA. STAT. Section 373.039.

[67] *Id.* Section 373.036.

[68] Jeffrey Rothfeder, *Focus*, BOSTON GLOBE, January 6, 2002, at E8 ("[W]hile richer countries like the United States have been able to cover up water shortages with engineering sleights of hand, this strategy is backfiring: Southeast Florida, Southern California, and Atlanta are all likely to be dry within 20 years if their growth patterns and mismanagement of water aren't sharply altered.")

[69] FLA. STAT. Sections 373.026, .036, and 403.061(33).

[70] *Id.* Sections 373.026, .043.

[71] Angelo, *supra* note 3, at 230.

[72] FLA. STAT. Section 373.219 . This provides that:

> (1) The governing board or the department may require such permits for consumptive use of water and may impose such reasonable conditions as are necessary to assure that such use is consistent with the overall objectives of the district or department and is not harmful to the water resources of the area. However, no permit shall be required for domestic consumption of water by individual users. (2) In the event that any person shall file a complaint with the governing board or the department that any other person is making a diversion, withdrawal, impoundment, or consumptive use of water not expressly exempted under the provisions of this chapter and without a permit to do so, the governing board or the department shall cause an investigation to be made, and if the facts stated in the complaint are verified the governing board or the department shall order the discontinuance of the use.

[73] *See* FLA. ADMIN. CODE ANN. r. 40E-20.302 (1996).

[74] *See id.* r. 40D-2.041(1).

[75] *Id.*

[76] *See* FLA. STAT. Part IV Chapter 373.

[77] Angelo, *supra* note 3, at 230.

[78] *See* FLA. STAT. Section 373.042.

[79] *See Concerned Citizens of Putnam County for Responsive Gov't, Inc. v. St. John's River Water Mgmt. Dist.*, 622 So. 2d 520, 522 (Fla. 5th DCA 1993).

[80] *See* FLA. STAT. Section 373.0421(1) (2001).

[81] *See id.* at 373.0421(1)(b)(2)

[82] Semple, *supra* note 23, at p.5 of electronic document. (Quoting Cecile Ross, South Florida Water Management District attorney).

[83] FLA. STAT. Section 259.032(3)(d) (2001)

[84] *See id.* Section 259.032(1)

[85] *Tahoe-Sierra Pres. Council, Inc. v. Tahoe Reg'l Planning Agency*, 122 S. Ct. 1465, 1470 (2002).

[86] *Lucas v. South Carolina Coastal Council*, 505 U.S. 1003 (1992).

[87] U.S. CONST. Amend. V.

[88] *Tahoe-Sierra Pres. Council, Inc.*, 122 S. Ct. at 1471-72 (internal quotations omitted).

[89] *Id.* at 1472 (internal quotations omitted).

[90] *Id.*

[91] *Id.* at 1476 (internal quotations omitted).

[92] *See* FLA. STAT. Section 70.001(1).

[93] *See id.* Section 70.001(3)(e).

[94] FWCI, *supra* note 10, at 65.

[95] Curtis Morgan, *'Marketing' of Water draw Fire*, MIAMI HERALD, at 4.

[96] *See id.*

[97] *Id.* Stuart Appelbaum, a U.S. Army Corps of Engineers ecosystems expert, and one of the authors of "The
Plan to Restore America's Everglades," commented, "It's clear to us we're not putting the system back the way it was. That would require removing 6 million people that live in South Florida, and the agriculture, and recontouring the land and putting it back the way it was. That's just not practical." Author, *Title*, SARASOTA HERALD-TRIBUNE, August 20, 2000, at A1.

[98] Riddle, *supra* note 6.

LEAST TERN CONSERVATION PROJECT: NO PLACE TO TERN

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ABSTRACT

The St. Petersburg Audubon Society has been monitoring Least Tern and Black Skimmer roof-top nesting sites in Pinellas County since 1998. Due to the gradual loss of their natural nesting sites (undisturbed sandy beaches), these birds have had to adapt to nesting on flat gravel roofs. According to a statewide Florida Fish and Wildlife Conservation Commission (FWC) survey (1998-2000), Pinellas County has the largest number of Least Tern roof-top nest sites (43) of any county in Florida. This situation is most likely caused by disturbance of their natural nesting habitat by humans, dogs, and raccoons. The roof-top sites used are bare gravel roofs that are similar to their natural nest sites. This unnatural habitat appears to meet their needs for hatching and fledging chicks, however the success rate is unknown for either natural beach or roof-top sites. As gravel roofs age and fall into disrepair, they are now often replaced with rubberized roofing materials unsuitable for nesting. So now, even the least tern's "unnatural" nesting habitat is being lost.

Goals of this project are to: 1) Protect and monitor colonies throughout the nesting season, using trained Audubon volunteers and Eckerd College students, 2) Work with FWC biologists and Audubon staff to develop census protocols to determine colony size and nesting success, and devise a means of observing inaccessible roof-tops without disturbing nests, 3) Continue to monitor and protect the few remaining natural beach colonies, such as at Shell Key, 4) Identify roofs that can be improved through conservation measures, by screening over downspouts or providing shaded protection for chicks from aerial predators, such as crows, and 5) Establish contacts with colony building owners, and provide them with information and positive publicity about the birds and the importance of these colonies.

INTRODUCTION

From 1998 to 2000, volunteers from the St. Petersburg Audubon Society (SPAS) participated in a 3-year statewide survey of roof-top nesting colonies for the Florida Fish and Wildlife Conservation Commission (FWC, J.A. Gore, unpublished report). The study focused on 2 bird species which are in trouble, because they naturally nest on bare sandy beaches. This brings them into conflict with Florida's growing human population and its

attendant development. These 2 species are the Least Tern (*Sterna antillarum antillarum*) and the Black Skimmer (*Rynchops niger*). Both species are listed in Florida at the state level: the Least Tern as Threatened, and the Black Skimmer as a Species of Special Concern. Loss of beach habitat has caused these bird species to adapt to nesting on flat gravel roof-tops which somewhat mimic the beach substrate they prefer (Krogh and Schweitzer 1999). Pinellas County had the largest number of roof-top nest colonies (43 sites) of any county in Florida.

Observations by the St. Petersburg Audubon Society during the FWC study suggested that few beach nesting colonies were successful and, each year during the survey, some roof-top colonies were lost due to re-roofing with materials unsuitable for nesting. The St. Petersburg Audubon Society is concerned about the future of these birds, as they are losing both their primary natural and their secondary man-made habitat, so we decided to continue the survey in 2001-2002 in Pinellas County and expand it into a more comprehensive conservation and protection project. This study is still in progress.

The objectives of this paper are:
1) to discuss the nesting habitats of Least Terns and Black Skimmers,
2) to document the problems causing loss of both natural and man-made habitats, and
3) to suggest opportunities for habitat restoration for these species, on roofs and on restoration sites.

Least Tern Nesting Habits

Least Terns are the smallest terns in North America, hence the name "least". There are 3 sub-species that breed in North America. This paper is concerned with the sub-species (*Sterna antillarum antillarum*) that breeds in Florida and up the mid-Atlantic coast. These terns were once almost extirpated along the Atlantic coastal states in about 1900 following commercial hunting for decorations on ladies' hats (Gore 1996). The population has since recovered from very low numbers.

Least Terns winter in South America and migrate to North America in April to breed (Gore 1996). Their courtship ritual consists of the male offering a small fish to a female. When the female accepts, they become a mated pair.

Least Terns nest in numerous sites along the Florida coast, but usually on sandy beaches on islands which have no predators. Their natural nesting habitat is on beaches with a substrate of sand and shells, above the high tide line. Sometimes they nest on other bare areas, such as construction sites, spoil islands, phosphate strip mines, and river bars (Gore 1996, Krogh and Schweitzer 1999). Paul (1999) estimated that here are about 170 nesting pairs in the Tampa Bay area

The nest is a shallow scrape in the sand, usually with 2 eggs. Colony size varies from 10-20 pairs to hundreds of nests. The nest and the eggs are camouflaged, so humans could step on them without noticing. It takes about 3 weeks for the eggs to hatch. Least Tern chicks are small and downy and it takes 3 weeks more for the chicks to fledge and begin

to fly. Once the chicks have learned to fly, the parents take them to the nearest body of water to teach them to feed. Least terns feed by hovering over the water, then plunging in to catch small fish. In September, after just 5 months, they migrate back to South America.

Black Skimmer Nesting Habits

Black Skimmers nest locally on both coasts of Florida. They also nest on bare sandy beaches, in close colonies of up to 300 birds (Loftin and Smith 1996). They have 2-5 eggs, which is unusual for seabirds, and nest from May to August (Gore 1996, Kaufmann 1996, Coburn et al. 1997). Adults, eggs, and nestlings are highly vulnerable to human disturbance (Loftin and Smith 1996, Coburn et al. 1997). Black Skimmers number about 2000 pairs in Florida, with about 1000 pairs nesting in the Tampa Bay area (Paul 1999). Because they nest later in the spring than Least Terns, they can be more affected by late summer storms.

Skimmer species are unique in the world for their long thin beak, which has the lower mandible longer than the upper mandible. This is specialized to allow them to feed by "skimming', but actually by flying slowly while slicing their long lower beak through the water, and then quickly closing the beak when a fish is encountered (Loftin and Smith 1996, Coburn et al. 1997). They feed on small fish in healthy estuaries, mainly at night.

Beach Nesting

The natural nesting sites of Least Terns and Black Skimmers are on bare, sandy beaches, preferably on small barrier islands which have no predators (Loftin and Smith 1996, Coburn et al. 1997, Paul 1999). The main threats to beach nesting colonies include disturbance, predation, flooding, and vegetative succession (Gore 1996, Coburn et al. 1997). Most beach habitat has been lost to development on Florida's barrier islands. Nesting sites on remaining beaches are often disturbed by recreational human use and vehicles (Gore 1996, Coburn et al. 1997). Dogs and predators of eggs and nests, such as Raccoons (*Procyon lotor*), Fish Crows (*Corvus ossifragus*) and Laughing Gulls (*Larus atricilla*), are favored by human presence, and they have been known to cause the failure of nesting colonies (Coburn et al. 1997, Krogh and Schweitzer 1999).

These birds are extremely vulnerable to disturbance from humans, dogs, and predators (Loftin and Smith 1996). Terns will readily mob (chase) humans, birds, mammals, or vehicles. But avian predators can take advantage and take an egg or chick while the parents are off the nest (Gore 1996, Coburn et al. 1997). A skimmer colony exposed once to strong human disturbance can cause reproductive failure (O'Meara and Gore 1988, Gore 1996, Loftin and Smith 1996). Chicks can die from the heat in a short time when the parents are off the nest, such as mobbing a predator or a person that walks too close. Erosion from storms and vegetative succession are factors in the choice of colony sites. Sparse vegetation (10-20 % cover, O'Meara and Gore 1988, Gore 1996, Loftin and Smith 1996) has a positive role in the nesting success of these birds. If there is too much

vegetation the birds will not use a site for nesting. There has to be enough cover to hide the chicks, but not enough to hide a predator (Gore 1996).

Another factor in the suitability of a natural beach site for nesting is the substrate itself (sand and <20% shell fragments; O'Meara and Gore 1988, Krogh and Schweitzer 1999). In addition to the quality and quantity of available natural nesting sites, other factors that determine nesting success in a natural area are weather, predators, and human disturbances. Spoil islands provide a great opportunity for habitat restoration, because mammalian predation and human disturbances are less likely to occur. Construction sites, with bare dirt, are only available temporarily.

Roof Nesting

Fortunately, Least Terns and Black Skimmers are somewhat adaptable and have been observed nesting at alternative sites, such as flat tar-and-gravel roofs, construction sites, spoil islands, phosphate strip mines, and river bars (Gore 1996, Loftin and Smith 1996). Both species have been observed nesting on roofs in Florida since the 1970's (Gore 1996, Coburn et al. 1997). In some areas, 70-80% of the least tern population now nests on gravel roofs (O'Meara and Gore 1988, Gore 1996, Zambrano et al. 1996, Krogh and Schweitzer 1999). These colonies are on commercial buildings, apartments, and schools, near water. Skimmers have also adapted to nesting in these roof-top sites but with less frequency and less success (Loftin and Smith 1996, Coburn et al. 1997). The white pea gravel used for roofs offers an acceptable substrate for laying eggs. The buildings chosen by these birds for nesting are typically 1-3 stories tall with flat or slightly sloped gravel roofs with no higher buildings or trees close by. Other species may also occasionally use those roofs for nesting, such as American Oystercatchers (*Haematopus palliatus),* Killdeers (*Charadrius vociferus*) and Common Nighthawks (*Chordeiles minor*).

There are some advantages to nesting on the roof-tops (O'Meara and Gore 1988, Gore 1996, Coburn et al. 1997, Krogh and Schweitzer 1999). In addition to providing acceptable nesting habitat for these terns and skimmers, gravel roof-tops eliminate mammalian predation, although avian predation can still be a problem. There is typically only minimal disturbance by humans. Vents, air conditioners, and other structures provide shade. Birds avoid flooding of their nests from high storm tides compared to low-lying beach nesting sites.

Some disadvantages of roof-nesting are that many chicks are lost when they fall off the edge of the roof or down drainpipes. Weather is also a significant factor in the nesting success of roof-top colonies due to flooding of the nests in heavy rains and chicks being washed away in downspouts. Modifications to roof-top sites can prevent these problems. Screens can be placed over drains and downspouts (Coburn et al. 1997). Protection devices can also be placed on the roofs to provide shade from the sun and cover from predators (Krogh and Schweitzer 1999), or a rim or short screen fence around the roof to keep chicks from falling off (Coburn et al. 1997).

But even though gravel roofs seem to be a viable alternative to beach nesting sites, the birds still face the problem of human disturbances on the roof, such as air conditioning maintenance and roof repairs. Roof maintenance should be avoided, especially at midday in hot weather (Coburn et al. 1997, Krogh and Schweitzer 1999). Humans can cause chicks to fall off the roof in an attempt to escape. It has even been documented that some property owners intentionally discourage these birds from nesting on their roof-tops by stringing monofilament or flags across the roofs, or other deterrents. This is perhaps understandable because the birds are noisy during the two-month nesting period and defecation on surrounding grounds and cars can be a nuisance. But these deterrents are illegal while nesting is underway.

Another problem birds face on gravel roofs is caused by future trends in the roofing industry (Gore 1996, Zambrano et al. 1996). Unfortunately, the roofing industry is slowly replacing gravel roofs for modified bitumen, a rubberized roofing material that is cheaper and easier to install (E. DeVries, Eckerd College, personal communication). As gravel roofs age and need to be repaired, they are being replaced with materials not suitable for nesting, so even the "un-natural" alternative breeding habitat is being lost (Krogh and Schweitzer 1999). It might be possible to put a patch of gravel on a rubberized roof, and still attract birds to it (Krogh and Schweitzer 1999).

St. Petersburg Audubon Research

The goals of the St. Petersburg Audubon Society's Least Tern Project are to:

1) Protect and monitor colonies through the nesting season, using trained Audubon volunteers and Eckerd College students,

2) Work with FWC biologists, Eckerd College students, and Audubon staff to develop census protocols to determine roof-top colony size and nesting success, and devise a means to observe inaccessible roof-tops without disturbing nests,

3) Identify roofs that can be improved through conservation measures, by screening over downspouts or providing shaded protection for chicks from aerial predators, such as crows, and laughing gulls,

4) Establish contacts with owners of buildings with roof-top colonies. Provide them with information and positive publicity about the birds and the importance of these colonies, so they will be more careful to not disturb the birds and will not discourage future nesting,

5) Learn about the future trends in the roofing industry,

6) Continue to monitor and protect the few remaining natural beach colonies, such as Shell Key in Pinellas County, and

7) Identify future habitat restoration projects and actively promote them.

We are implementing this project in the following manner:

Nesting Colonies

A team of volunteers from the St. Petersburg Audubon Society monitors roof-top colonies in Pinellas County. About 50 buildings are being monitored, with typically about 30 having active nesting colonies. Each site is visited at least 3 times during each nesting season.

At most roof-top colonies, it is impossible to look up on the roof without extreme disturbance to the birds. We have no way to determine how many birds, nests, or chicks are present. Methods are being devised to estimate the number of birds nesting on the roof. Counts of flying terns landing on or leaving the roof are made for 1, 3, and 5 minutes. Additional counts are made separately when a disturbance occurs, such as a crow flying over. Almost all of the terns fly up at once to mob (chase) the potential predator. At 10 selected sites, a "cherry picker" (bucket truck) was used 3 times to provide a direct count of the adults, chicks, and fledglings on the roof. This allowed one observer at a time to be lifted up to 10 m (33 feet), to allow a view of the roof. The 10 chosen sites are buildings 1-2 stories high. Two observers each counted the birds on the roof to assess differences among observers. Research is underway to see if there is a correlation between the timed counts from the ground and the actual number of birds using the roof. This could allow us to approximately estimate the number of pairs nesting on the roof without actually seeing the top of the roof. These counts will allow us to monitor population trends through the years. Another approach may be to place a remote video camera or an observation blind on the roof. This would allow the observer to watch the birds without disturbance.

Three Eckerd College students are collaborating on this project, under the direction of Dr. Elizabeth Forys.

Alisa Mazzocchi is studying the environmental conditions at beach nesting colonies, such as environment, substrate, and soil composition. She is comparing the environmental conditions at colonies that have nested successfully to those that did not. This will give us a better idea of what the habitat requirements are for tern nesting, which will be very helpful in protecting, restoring, or recreating natural habitat.

Elizabeth DeVries is studying the future trends in the roofing industry. She is interviewing local roofing contractors to learn about types of roofs being used now, and future trends. So far, she has found that few new installations are using the gravel roofs, and they predict that rubberized roofs will be used more and more in the future, due to lower short-term costs and easier installation (E. DeVries, Eckerd College, personal communication). Some predict the total disappearance of gravel roofs, others a dramatic reduction of their number. She will also be working to calibrate the counts of flying birds against the count of birds on the roof using the cherry picker.

Mark Mueller is using GPS to accurately map the locations of the 50 known recent colony sites. He will use GIS to study the environmental conditions at each site, such as the size and height of the building, distance to the nearest water, etc.

Audubon Activities

Audubon members have focused most of our efforts on the protection of the roof-top colonies. This involves establishing good public relations with the owners, residents and/or employees of buildings with colonies (Gore 1996). We have met with the managers of some of the buildings with roof colonies to inform them about the birds. We have developed a brochure to distribute when we contact them to explain the plight of these birds, why the birds have taken to nesting on roof-tops, and why it is important for people to tolerate the birds for the few months they are here. We also worked with the FWC to develop an attractive poster with a positive message to be displayed at these buildings, and a Certificate of Appreciation for their co-operation.

We are working with our local wildlife rehabilitator, the Suncoast Seabird Sanctuary in Redington Beach, Florida, where most of the chicks that fall off the roofs are taken. We are determining which buildings have the most problems with chicks falling off. We are hoping to help the owners of those buildings to install devices to prevent it. We have also developed a tool to place chicks back on the roof of a 1-2 story building, essentially a 20-foot (6.1 m) pole with a box on the end.

We will look into incentives for buildings owners to re-roof with gravel. But, faced with shrinking availability of both beach and roof-top nesting sites, we need to look at creation of new nesting habitat for Least Terns and Black Skimmers (O'Meara and Gore 1988). In Pinellas County, the City of Pasadena has restored a beach in a small park on the Intra-Coastal Waterway (Natlie Leggett, personal communication). Least Terns are nesting there for the first time in 5 years. We are looking into ways of making that nesting site more successful and creating more similar habitat, possibly on spoil islands.

It is important to protect known nesting sites. All nesting colonies should be closed and posted, to protect them from human disturbance, during the nesting season (O'Meara and Gore 1988, Loftin and Smith 1996, Coburn et al. 1997). Posts with informative signs and rope between them are a deterrent to human disturbance. Beach sites are posted by FWC or the Pinellas County Department of Environmental Management to keep people and their dogs at a safe distance. Various volunteers are monitoring those colonies and documenting nesting success.

Opportunities to improve known nesting sites include clearing vegetation, creating new sites, limiting human and vehicle access, posting existing colonies, constructing fences to deter predators, removing non-native predators, constructing nesting platforms, and fencing roof edges (O'Meara and Gore 1988, Gore 1996, Loftin and Smith 1996, Coburn et al. 1997). Increased awareness of the presence and sensitivity of nesting colonies can allow better stewardship and protection by land owners. Meanwhile we would like to urge anyone involved in habitat restoration in areas where Least Terns and Skimmers can

nest, to consider their needs and to create habitat for them. With the loss of beach and roof-top habitats they depend on, they need alternative nesting sites.

ACKNOWLEDGEMENTS

We acknowledge the small army of volunteers from the St. Petersburg Audubon Society, who locate and monitor the roof-top colonies, and make contact with the building owners.

Nancy Douglass and Jenny Novak of the Florida Fish and Wildlife Conservation Commission and Rich and Ann Paul of the Audubon of Florida's Coastal Island Sanctuaries, have provided invaluable advice and assistance. Katherine Ackerman provided artwork for the brochure.

Dr. Beth Forys and students Elizabeth DeVries, Alissa Mazzochi, and Mark Mueller of Eckerd College are doing student projects which will add to our knowledge of the terns in Pinellas County. We have received funding from the Florida Ornithological Society. The Suncoast Seabird Sanctuary raises and releases baby terns that have fallen off the roofs, and provides us with information about those locations.

LITERATURE CITED

Coburn, L., D. Cobb, and J. Gore. 1997. Management opportunities and techniques for roof- and ground-nesting Black Skimmers in Florida. Florida Game and Fresh Water Fish Commission. Final performance report. Tallahassee, Florida. 24pp.

Gore, J.A. 1996. Least terns (*Sterna antillarum*). Pages 236-246 in J.A. Rodgers, Jr., H.W. Kale II, and H.T. Smith, editors. Rare and Endangered Biota of Florida. Volume 5. Birds. University Press of Florida, Gainesville, Florida. 736 pp.

Kaufmann, K.1996. Lives of North American Birds.Houghton Mifflin Company, Boston. 675pp.

Krogh, M.G., and S.H. Schweitzer. 1999. Least Terns nesting on natural and artificial habitats in Georgia, USA. Waterbirds 22(2):290-296.

Loftin, R.W., and H.T. Smith. 1996. Black Skimmer (*Rynchops niger*). Pages 571-578 in J.A. Rodgers, Jr., H.W. Kale II, and H.T. Smith, editors. Rare and Endangered Biota of Florida. Volume 5. Birds.University Press of Florida, Gainesville, Florida. 736 pp.

O'Meara, T.E., and J.A. Gore. 1988. Guidelines for conservation and management of Least Tern colonies in Florida. Unpublishes report. Florida Game and Freshwater Fish Commission. Tallahassee, Florida. 12pp.

Paul, R. 1999. Chapter 12. Bird populations. Pages 12-1 to 12-7 in J.R. Pribble, A.J. Janicki, and H. Greening, editors. Baywide Environmental Monitoring Report, 1993-1998, Tampa Bay, Florida. Tampa Bay Estuary Program, Technical Publication 07-99. St. Petersburg, Florida. July 1999.

Zambrano, R., M.S. Robson, and D.Y. Charnetzky. 1996. Least Tern nesting survey of southern Florida. Florida Game and Fresh Water Fish Commission. Final performance report. Tallahassee, Florida. 24pp.

LAND MANAGEMENT TECHNIQUES VIA THE INTERNET

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ABSTRACT

Cargill Fertilizer (Cargill) embarked upon a large-scale restoration initiative that includes exotic and nuisance plant species removal and control, native species replanting, and habitat creation on its properties near Tampa Bay, Florida's largest open water estuary. Cargill recognized the importance of informing public land managers, adjacent landowners and environmental groups of company plans in order to allow for a comprehensive approach to restoration in the watershed. Cargill developed an Internet-based, land management plan that provides up-to-date information on the company's restoration initiative. The web site is interactive and allows for adaptive management techniques based on year-to-year restoration results. Cargill communicates on line with reviewing agencies to discuss restoration projects and can obtain "on-line approval" from regulators for permitted activities. The site provides Internet mapping capability for basic GIS functions such as printing, zooming, making maps, and querying geographic data sets. No special software is required. The site can be accessed via a standard Internet browser by typing "www.cargill-neb.com" in the address bar. Data is displayed via text documents, photographs, maps, tables, and spreadsheets. Parcel specific data includes baseline conditions prior to restoration (year 2000), proposed restoration activities, a schedule of project events, monitoring results, and a complete archive for each year as the site is updated. Site alerts are sent electronically to notify interested parties of updates, and a permit database is included for each parcel involved in the restoration effort.

INTRODUCTION

Cargill Fertilizer (Cargill) is one of the largest producers of phosphate and nitrogen fertilizers in the world. The company owns over 70,000 acres of land in Central and Southwest Florida, and it operates manufacturing and mining facilities in Hardee, Polk, and Hillsborough Counties. Cargill has been working actively with local, state, and federal regulatory agencies and the surrounding communities to restore natural conditions on its properties and throughout surrounding landscapes by utilizing a variety of innovative land management techniques. Recently, Cargill developed an interactive, public web site that is designed to replace the traditional "hard copy" land management plan (Cargill 2000). The web site represents the first successful Internet-based, environmental management initiative in Florida. The site is being used by regulatory agencies to review, approve, and monitor permitted activities. It was designed collaboratively by enforcement specialists, environmental consultants, Cargill, and members of the public who expressed an interest or concern about pending permits for the company. The web site houses information relating to exotic species eradication,

hydrologic improvements, prescribed fires, and other restoration initiatives. It also provides an electronic record of environmental permits issued to the company for a recent industrial expansion project. The resulting technology product allows anyone with a standard Internet browser the ability to monitor permit requirements and land management activities. No special software is required by users. Because the concept for the website was incorporated into company permits, Cargill is required to maintain its contents for the life of the permits.

STUDY SITE

One of Cargill's manufacturing facilities is located in Riverview, Florida at the mouth of the Alafia River. Tampa Bay, Florida's largest, open water estuary (Tampa Bay Estuary Program 2001), is located adjacent to the west side of the facility. Residential development has been increasing exponentially around the facility for the past 20 years. This area was chosen as the study site for the restoration effort due to its location near the riverine and estuarine environments.

MATERIALS AND METHODS

In the late 1990s, Cargill executives were faced with a complex business decision for the Riverview operation. To stay in business and remain profitable, the company was seeking the certainty of continued operations for a thirty-year time horizon. To do this, the company needed to match its existing phosphate reserves in Florida with its permitted ability to store the gypsum. An alternatives analysis determined that the company should seek additional stacking space in its existing phosphogypsum system in Riverview. Cargill recognized the need for a strategic plan that would be compatible with the Alafia River/Tampa Bay Ecosystem. It was critical to promote the objectives of the Tampa Bay Estuary Program and to satisfy Florida's environmental community who took a great interest in activities that could impact the estuary. Cargill also recognized that it must provide the community the assurance that the expansion of its phosphogypsum stack would not impact the people and the ecosystem. It would be important to develop an innovative means to keep the agencies and the public involved, not only during the permitting process, but throughout the long term monitoring of the permitted activities. The company was committed to designing, constructing, and operating this extended storage area in a manner that would meet or exceed all federal, state, and local laws. This was ultimately accomplished through the State of Florida's Ecosystem Management/Team Permitting Process.

Chapter 403, Florida Statutes provides the authority for the Ecosystem Management/Team Permitting Process. Chapter 403 states, "It is in the public interest and serves a public purpose that the Department of Environmental Protection take the leading role among the agencies of the state in developing and implementing comprehensive ecosystem management solutions, in cooperation with both public and private regulated entities, which improves the integration between land use planning and

regulation, and which achieves positive environmental results in an efficient and cost effective manner (qtd. in Cargill 2001)." Applicants who request the Ecosystem Management/Team Permitting process are required to provide "Net Ecosystem Benefits" (NEBs) above and beyond traditional regulatory requirements. NEBs for Cargill's expansion project included the installation of a stack liner system above and beyond the regulatory requirements, improvements to local drainage patterns to reduce flooding, installation of water quality monitors, and the reduction of air emissions above and beyond current regulatory requirements. Additional NEBs included the creation of low salinity habitat in the estuary, construction of an environmental education center, development of a community garden, restoration of environmentally sensitive properties, and capital contributions for a variety of community projects.

The most unique NEB was the development of an Internet-based, Integrated Land Management Plan (ILMP) which documents the restoration and long term management of approximately 1,600 acres of Cargill-held lands. The plan outlines the restoration and preservation of key environmental parcels including approximately 6,600 feet of estuarine shoreline. While other companies have developed "adaptive management" techniques in concert with regulatory agencies for large-scale projects, only Cargill has been willing to go one step further by making the process interactive and open for public scrutiny. The Internet was selected as the medium of choice because of its ability to reach a large number of stakeholders. It holds the potential for anyone to "log on" to participate in a large-scale, coordinated effort to manage restoration projects and mitigation areas throughout the watershed. Without the flexibility of the Team Permitting Process, Cargill would not have been given the opportunity to take a holistic approach to developing industrial operations and protecting the environment.

RESULTS

All information contained within the ILMP can be viewed by individuals who have Internet access. The site can be accessed by typing "www.cargill-neb.com" into the address line of a standard Internet Browser. Internet Explorer 4.0 or higher is recommended for optimum performance. Components of the site include (Stratton 2001):

- Details on Land Management Activities
- Secure Access for Agency Personnel
- Digital Filing Cabinet
- Paperless Environmental Permits
- Searchable Permit Database
- Real Time Communication
- Active Public Involvement
- Internet Mapping
- Geographic Data Analysis
- On line Regulatory Approvals
- Permit Monitoring
- Evaluation of Permit Success Criteria

In accordance with Florida's Sunshine Law, the site is not restricted to selected users; however, passwords are required for agency representatives in order to provide a secure means for authorized, electronic agency approval of restoration activities and permit requirements. Agency passwords also identify agency comments and allow Cargill to interact with the appropriate personnel as necessary.

The site is designed to allow users to view parcel-specific information. Each parcel is characterized visually through a variety of tools including text descriptions, maps, databases, scanned documents, and time-series photographs. To view information, users can either select a parcel name from a list on the left side of the computer screen or can "point and click" on the map. Site specific land management plans have been developed for each parcel. Land management activities associated with individual parcels can be tracked by clicking on the following buttons:

Baseline Conditions: This button provides baseline conditions for the year 2000 prior the comprehensive land management initiative.

Proposed Activities This provides a description of restoration activities that will be conducted in the future. Agencies can approve or recommend changes to the proposed plans.

Schedule: The proposed schedule for restoration activities, regulatory deadlines, and agency review dates for annual reporting activities are posted here.

Monitoring: Charts, tables, and spreadsheets present the results of soil and water sampling activities as well as the progress of land management activities. The monitoring button provides a place to track and compare the results of restoration efforts. This section also provides a "snapshot" of plants and animals encountered on each site via an easy to read table.

Site Photos: Users can follow the progress of restoration activities over time through a variety of photographs that are taken from pre-established monitoring locations.

GIS Mapping: Site conditions are depicted through a series of data layers such as existing habitat, proposed habitat, soils, exotic species, and other geographic features. Users can view site conditions, query information about each data set, calculate success criteria, measure distances, and generate maps.

Activities Permits: Additional permits for site-specific restoration activities such as dredging and filling are posted here. Cargill hopes to utilize this site to apply for the necessary permits electronically.

Agency Input: Agency representatives review, provide comments and recommendations, and electronically approve restoration activities and annual restoration reports. The public can view all agency comments and approvals.

Regulatory Requirements: Users can view permits that were issued to Cargill by regulatory agencies as part of the team permitting process. Other documents confirming the fulfillment of permit requirements are also stored here.

A navigation bar is provided at the bottom of each screen to allow web site visitors the ability to move back and forth through the site efficiently. The navigation options include:

- Home (Returns to the list of properties contained within the ILMP)
- Getting Started (On line tips for navigating the site)
- Links (Links to participating agencies)
- Comments (Enables users to view comments and submit comments)
- Site (Returns to the main page of the parcel that is currently being reviewed)
- Maps (Links to interactive GIS mapping component of the ILMP)

Each year, data from previous years is cataloged within the site for comparison with the current year. Cargill has made the commitment to maintain the electronic ILMP for a period of thirty years, which equates to the life of the phosphogypsum stack permits. The ILMP website will be the first in Florida to house thirty years of comprehensive restoration and land management projects at one, easy to access location. People who wish to review regulatory files will not be required to visit multiple agency offices to search through filing cabinets and await "cold storage" files that can become lost, misplaced, or destroyed. Thirty years of regulatory activity will be accessible via a home computer. For those without Internet access in their home, files can be retrieved via a desktop computer located conveniently within a single regulatory agency.

CONCLUSION

The Integrated Land Management Plan is used for regulatory reviews, public awareness, and communication between all the stakeholders who are interested in the management of environmentally sensitive properties owned by Cargill. The web site allows individuals to jointly track, monitor, and evaluate Cargill's land management activities. The site offers an efficient means of communication for all participants and provides an avenue for making real time recommendations for land management activities. It is an exciting new way for the public to follow land management issues in their neighborhoods and for regulatory agencies to work proactively with industry to track permit requirements and to ensure that environmental goals are reached effectively.

In May 2001, Cargill's bold initiative was awarded with the presentation of an Award of Excellence from the Council for Sustainable Florida. The fertilizer company was one of

several Sustainable Award winners who were recognized by Governor Jeb Bush and his Cabinet in November 2001. In May 2002, the Tampa Bay Regional Planning Council recognized Cargill with a Future of the Regions Award for its contribution to the environment. As one of Florida's large private landowners, Cargill is contributing to the restoration and maintenance of Florida's landscape in a new, unique way.

LITERATURE CITED

Cargill Fertilizer. "Integrated Land Management Plan Website." http://www.cargill-neb.com (March, 2001). 1.

Cargill Fertilizer. "Year 2001 Sustainable Florida Awards Application Form". Presented to the Governor's Council for Sustainable Florida. February 1, 2001. pp *5-6.*

Stratton, Trish, AICP. "Online Land Management in Florida." Holland & Knight LLP. Environmental Update. Second Quarter 2001; Volume 10, Issue 2. p 2.

Tampa Bay Estuary Program. "A One of a Kind Ecosystem." http://www.tbep.org/estuary.html. (October, 2001).

TRANSCO – DAVENPORT 1 MITIGATION RESTORATION: "FROM TITI TO WET PINE SAVANNA"

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ABSTRACT

The Davenport 1 Mitigation site is a 61.9 ha (153-acre) wetland mitigation restoration site for Williams Gas Pipeline – Transco. Comprised of 90 percent jurisdictional wetlands based on hydrology, soils, and vegetation, the site was significantly degraded from its historical condition of wet pine - sedge bog - savanna to a dense, uniform titi thicket. Restoration activities were initiated January 1998, and adaptive management methodology was used to guide restoration actions and measure success toward objective satisfaction and the desired future condition of the site. Quantitative monitoring of vegetation diversity and spatial distribution verified that the Davenport 1 mitigation site was historically a wet pine savanna interspersed with a mosaic of titi thickets and peat bogs. The desired future condition of the Davenport 1 mitigation site is an East Gulf Coastal Plain Wet Flatwood Bog, a.k.a. "wet pine savanna". The following performance standards were listed for the project; conducting at least three prescribed burns, selective understory removal, herbicide application for non-native plants, photographic and video site documentation prior to restoration and after every burn, hydrological evaluation of the field road, and a revised plant list. A comparative analysis for performance standards was conducted. Three prescribed burns were conducted, one in 1998 and two in 2001. Photographic and videographic documentation was conducted annually and after each burn. Selective understory removal was accomplished with the mechanical fuel treatment. Herbicide application was conducted in 2001 after the second burn. A revised plant list was completed after the final monitoring in 2001. A quantitative evaluation of the restoration and the success of the performance standards was done using the parameters of community structure and species richness. The plant community structure of the Davenport 1 site currently meets the desired future condition criterion. Dominance ranks demonstrate the herbaceous component of monocotyledonous perennials. Photographs provide qualitative documentation of the community structure.

INTRODUCTION

The Davenport 1 Mitigation site was significantly degraded from its historical condition of wet pine - sedge bog - savanna to a dense, uniform titi thicket. The objective of the mitigation was to restore a titi shrub woodland to its natural state of wet pine savanna. Davenport 1 is located in the eastern portion of the Grand Bay Savanna, one of The Nature Conservancy's "Last Great Places". Located just north of Bayou La Batre, in

Mobile County, Alabama, the mitigation site is part of a 1416 ha (3500 acre) contiguous tract owned by Williams Companies, Inc.

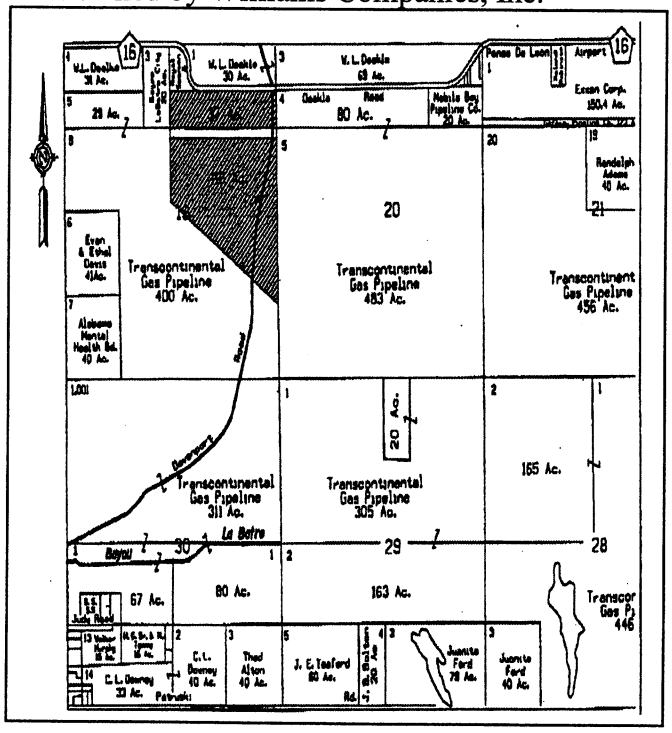

Figure 1. Exhibit 'A' wetland mitigation site.

The site is located in the northwestern portion of the tract at T 7 S, R 2 W, Section 19, Coden Quadrangle, AL (Figure 1). The parcel is bounded on the north by County Road 16, Deakle Road, and on the south by Transco's Mobile Lateral 30" pipeline. The eastern boundary is the north-south section line between sections 19 and 20. The western boundary is the north-south quarter section line of section 19. A historical county road, Davenport Road (now closed to public use), traverses north to south across the eastern portion of the site. Site selection was by Transco based on current habitat, restoration feasibility, and site accessibility.

Desired Future Condition

Quantitative monitoring of vegetation diversity and spatial distribution verified that the Davenport 1 mitigation site was historically a wet pine savanna interspersed with a mosaic of titi thickets and peat bogs. This coincides with written descriptions, photographs, and personal communications regarding the vegetation of the mitigation site. Based on the research and biological monitoring, the desired future condition of the Davenport 1 mitigation site is a "wet pine savanna". The wet pine savanna community alliance type that would occur on the mitigation site is described by The International Ecological Community Classification (Weakley et. al. 2000) as the: Feather-bristle Beaksedge – Pitcherplant species (Southern Wiregrass, Toothache Grass) Saturated Herbaceous Alliance. The community alliance is further described for type locality as a: Southern Wiregrass – Feather-bristle Beaksedge – Gulf Chaffhead – (Yellow Pitcherplant, Trumpet Pitcherplant, Whitetop Pitcherplant) Herbaceous Vegetation (a.k.a.) East Gulf Coastal Plain Wet Flatwood Bog (Weakley et. al. 2000).

> Description: This association occurs in the western Florida Panhandle and adjacent Alabama and Mississippi. It occurs in a pine flatwoods landscape, on a very gently sloping to almost level topography, and often has a scattered canopy (typically 5 – 10 percent cover) of stunted *Pinus palustris* and *Pinus elliottii* var. *elliottii*. Characteristic species include, *Aristida beyrichiana, Rhynchospora oligantha, Rhynchospora* spp.,

Sporobolus floridanus, Scleria baldwinii, Carphephorus pseudoliatris, Sarracenia leucophylla, S. psittacina, Drosera tracyi, Asclepias connivens, A. rubra, Rhynchospora plumosa, Eriocaulon decangulare, E. compressum, E. texense, Balduina uniflora, Polygala spp., *Rhexia lutea, Sabatia macrophylla, Aletris aurea, A. lutea, Eryngium integrifolium, Bigelowia nudata, Xyris scabrifolia, Carex turgescens, and Muhlenbergia expansa.* Patchy shrubs include *Gaylussacia mosieri, Ilex glabra, Morella heterophylla, Magnolia virginiana, Lyonia lucida, Clethra alnifolia, Hypericum* sp., *Cliftonia monophylla, Smilax laurifolia, Ilex coriacea,* and *Morella inodora.*

MATERIALS AND METHODS

General methods of restoration were listed in the mitigation plan. Transco's approach to the management would increase the insolation rate to the herbaceous layer through the removal of the titi shrub forest. A series of prescribed burns would be used to accomplish this restoration objective. A three-year time frame was designated for the preliminary restoration actions. Year 1 management required a reduction of understory vegetation through the use of prescribed burning. Qualitative (photographic and videographic) and quantitative monitoring would measure effectiveness and success of the restoration actions. Non-native plant species would be controlled with herbicide. Year 2 required prescribed burning and herbicide treatment of non-native vegetation. Evaluation of the hydrologic impacts of an elevated field road that traverses the southern end of the site was to be implemented in the latter part of Year 2 management. Third year management required prescribed burning and the effectiveness monitoring. Implementation of the restoration actions was enacted with adaptive management methodology. In conservation science there have been a number of ecological concepts that have had a profound effect on how conservation is now practiced. Primary among these concepts is a landscape ecosystem approach to conservation with an emphasis on biological diversity and ecological processes that occur at multiple scales. Also, there is the realization that natural systems are very complex and that it is difficult to understand and predict the future conditions of these systems. These realizations have led to the concept of adaptive management. Adaptive management is the linkage of management within a learning framework. It recognizes the low probability of predicting future states of populations or systems and uses experience to learn incrementally. Most simply, it is management followed by monitoring to assess the effect of the management. Management can be looked at as any conservation action, for example, biological management, or a protection activity. At its broadest sense, adaptive management is a learning process. At any level, monitoring is the cornerstone to adaptive management. With monitoring comes knowledge about the systems being managed.

Restoration Actions

Actions Year 1, 1998

Changing the vegetative structure of the Davenport 1 site was the primary restoration action. A prescribed burn was the initial restoration action outlined by the mitigation plan. A site review was conducted to evaluate the feasibility of conducting a prescribed burn. Three actions were selected to effect vegetation changes; fire, mechanical, and cutting. Fire was the preferred alternative because it is the primary ecological force. Conducting a prescribed burn would also comply with mitigation plan requirements. Prescribed burns in shrub fuel models have high burn complexity ratings. Because of the fuel type, loading, and urban interface concerns, a prescribed burn during the winter (dormant) season was required. The burn was enacted February 28, 1998. Baseline data was collected prior to the burn by using North Carolina Vegetation Survey monitoring protocol (NCVS) (Peet et. al. 1996).

The first prescribed burn was enacted February 28, 1998. Ground ignition was by drip torch and aerial ignition was by helitorch using aluma-gel. On the day of the burn, the north wind, the preferred burn wind, dropped out during ground ignition and was replaced by a weak, south sea breeze off the Gulf of Mexico. The resulting fire was scattered and discontinuous. Some underburning occurred but little shrub vegetation was totally impacted by flame. The outcome of the burn was subject to some speculation because few prescribed burns have been conducted in this type of habitat.

Overall, the burn was mostly ineffective and only affected approximately 4.0 ha (10 acres). Where the fire burned, however, the results were as expected, the top-killing of the titi. The areas of the site that burned, however, were a surprise. It was expected that the areas with pine straw and the shorter (1.5 – 2 m.) shrub areas would burn. Most of those areas DID NOT burn. On the contrary, the tallest titi areas, those 2 – 3 m. tall, and the very wet peat bog, DID burn. The best burn resulted in the Triangle section from ground ignition driven by the south wind. Small spot burning occurred where the aluma-gel dropped on the vegetation. The only fire advance from the aerial ignition was in the very wet peat bog. Underburning continued into the night in the heavy leaf litter of the baygall strand. Mortality of sweet bay magnolias, red maples, and swamp tupelos was quite evident several months later. Post-burn review determined that the lack of sufficient wind was the primary reason for the ineffective burn. (Shrub fuel models require steady, moderate wind speeds to push the fire through the shrub crowns.) Another prescribed burn would be conducted. Additionally, the underburning in the baygall strand demonstrated the need for a fireline for control purposes along the west side of the mitigation site.

Actions Year 2, 1999

Unexpected climatological factors influenced the restoration actions on the Davenport 1 site. March 1998 was the beginning of a three-year drought in Alabama. After the February burn, weather and site conditions quickly became too dry to conduct a burn. Burn prescription parameters required sufficient moisture in the soil to cause the flames to extinguish at the humus (H) layer where any herbaceous seed bank would occur. The KBDI remained at or above 650 the remainder of the year. The drought continued all of 1998 and through 1999. The favorable weather (warm and no winter freezes) and

available water supply (intact hydrology) created ideal growing conditions for the titi, which, by September of 1999, had now grown from 2 m. to 4 – 5 m. tall. These fuel heights and loading were unacceptable for safe prescribed burning and ecological restoration. The decision was made to effect a mechanical fuel treatment to reduce the height of the fuel. The fuel treatment would consist of bulldozers "walking down" the shrub forest. The bulldozers would carry their blade above the ground at a height to protect the radiator from puncture and the equipment would push over the vegetation and traverse over the shrubs, using them as mats to support the equipment and not churn or rut the soil layer. There would be little contact by the equipment tracks with the soil surface. This mechanical method was chosen over manual cutting because it would be safer to enact, more expedient, and cheaper. All canopy pines and pond cypress were NOT to be "walked over" if at all possible. All re-fueling and maintenance servicing with petroleum products was done off the site on Deakle Road. This "walking-down" vegetation crushing method has been used successfully on several sites in Florida (Emanuel 1998). After the entire site was "walked down", a wide fireline was to be constructed adjacent to the baygall strand on the west of the site. Two bulldozers, a D 4 and a D6 Caterpillar, worked simultaneously on the site. These dozers were equipped with extra wide tracks, an equipment feature designed for use where greater equipment weight displacement is necessary for traction because of soil type. A major concern with this method was the uncertainty of the number and the extensiveness of the peat bogs on the site. Peat bogs are unstable soils. Equipment can become mired, effectively being "swallowed" by the peat.

This action, the mechanical fuel treatment, was very successful. It began on October 20, 1999. Because of the extended drought, the site was assumed to be fairly dry. Two bulldozers, a D 4 and D 6 Caterpillar, were used. Unfortunately, but in reality fortunately, their first entry pass onto the site was into the only deep peat bog on the site . After becoming un-mired, the operation continued flawlessly, taking only two weeks to walk down 32.4 ha (80 acres), the majority of the site. This action changed the fuel structure from a shrub model to a logging slash model. The resulting fuel layer was 1 – 1.5 m. tall and loosely arranged. A prescribed burn would be conducted when the leaves had cured to the equivalent of "red slash". To facilitate containment of the fire to the "walked down" acreage, a trackhoe cleared the fireline adjacent to the west baygall strand of the site boundary. Mats were used to support the trackhoe and to prevent soil churning. The titi slash was removed from a 12.2 m. (40 ft) width and piled on the other slash to create a mineral soil fireline. This reduced the size of the effective restoration area to approximately 32.4 ha (80 acres).

It was surmised that the herbaceous vegetation would grow and recovery would begin even if a prescribed burn could not be enacted. The extent of the recovery exceeded expectations. The pushed over titi did not regrow nearly as prolifically as the burned titi did in 1998 and the leaves and finer twigs of the shrubs desiccated and crumbled in the drought conditions. Herbaceous vegetation, including grasses, sedges, and other forbs, quickly dominated any area that was not heavily covered in dense logging slash. This recovery fully demonstrated that the site was restorable and was indeed historically a wet

pine savanna prior to fire suppression and logging. In anticipation of possibly conducting a prescribed burn in early 2000, the site was monitored by video and photographs.

Actions Year 3, 2000

After the completion of the fuel treatment and fireline construction, the slash was allowed to cure until it was red. A prescribed burn was to be conducted. In February 2000, it was time to burn. Unfortunately, the drought was continuing and would not abate until November 2000. The qualitative and quantitative monitoring was conducted as outlined in the mitigation plan. Because of the drought condition, restoration efforts were extended into a fourth year.

Additional NCVS plots were scheduled to be installed after the slash burn, but the drought continued through most of 2000, ending only in November, and no prescribed burn could be enacted. The NCVS monitoring plots were established and monitored on October 12 – 13, 2000, to detect the community changes and to comply with the mitigation plan requirements to create a revised plant list prior to project termination, which was December 2000. One NCVS plot was installed in each of the three sections, Deakle, Center, and Triangle, for a total of three plots. A quantitative photo-monitoring target (for future use) was placed at the zero point of each NCVS plot 50 m. baseline (Van Horn and Van Horn 1996). Because the homogenous nature of the site remained, three plots were deemed to be adequate to assess the community.

Actions Year 4, 2001

A prescribed burn was conducted on January 24, 2001. Just as with the February 1998 burn, the forecast north wind dropped out and was replaced by a south sea breeze. The burn was held to the confines of the Triangle Section of the site. Conditions finally became favorable for a prescribed burn in early March. A prescribed burn was conducted on the site March 26, 2001. Qualitative and quantitative monitoring was conducted five months post-burn on August 14 –15, 2001. Herbicide application was completed as well. A foliar spray application of glyphosate 5% solution (Round-Up Pro) was applied to the cogongrass.

The prescribed burn January 24, 2001, was effective. Much of the dried slash was consumed and fire carried through the majority of the site on the fine fuels, the grasses and sedges. The fire extinguished at the peat surface because of ample soil moisture. Ground ignition by drip torch was very effective. Strip-head fire and point-source firing techniques were used. The wettest portion of the site did not burn, and remote ignition devices that encountered water pockets failed. The fire was contained in the Triangle Section and the burn was terminated because the south wind was out of prescription. Approximately 85 percent of the section burned. The two remaining sections of the site, Deakle and Center, and the un-burned portion of Triangle Section were burned March 26, 2001. Based on the previous burns, ground ignition with strip-head fire and point-source firing techniques were used. This burn was successful. The entire mitigation site was burned. The majority of the slash debris was consumed, with only some 1000-hour fuel

size slash remaining. The soil moisture was sufficient to extinguish the flames at the soil surface.

Monitoring Actions

Monitoring methods were outlined in the mitigation plan. The plan called for a video representation of the site prior to first-time burning and follow-up photographic documentation of the site for the first year of restoration. Videographic and photographic monitoring would be conducted prior to and following all subsequent prescribed burns. A comparative analysis was to be conducted at the end of the third year to measure the effectiveness of the restoration. A revised plant list would be included in the comparative analysis. Because the mitigation plan provided for the restoration of a plant community, the North Carolina Vegetation Survey Protocol was used for effectiveness monitoring. NCVS is a flexible, multipurpose method for recording vegetation composition and structure. With NCVS, vegetation structure and composition can be at many scales and perspectives, and because of its broad application throughout Southeastern United States, there is reference data on similar communities for possible comparison. NCVS plots are easy to establish but require the identification of all plant species within the plot).

At the onset of the project in 1998, the titi shrub forest was about two meters tall. An assessment of the site via helicopter and ground survey verified the homogeneity of the plant community. The overstory contained a few, scattered slash pines and an occasional longleaf pine approximately 15 m. tall, and one pond cypress. The herbaceous vegetation was sparse, the soil was saturated, and surface water was present on the entire site most of the year. Access into the site was extremely difficult at best and required crawling under the shrubs along the ground and clearing a path by chopping. A survey line had been chopped through the site about midway. This line afforded access to the interior of

Figure 2. Original NCVS monitoring plot, March 1998.

the site, where a NCVS permanent plot was established (Figure 2). Permanent photopoints were established around the perimeter of the site. A helicopter was used to film an aerial video. Photographic and aerial monitoring were done in 1998, 1999, 2000, and 2001.

In 1998, pipeline construction (a lease prior to the site being designated as a mitigation site) across the site impacted half of the NCVS monitoring plot. However, after the mechanical treatment of the shrub layer, the entire site was accessible. The mitigation site was now divided into three distinct sections defined by the roads and pipelines, but the overall homogeneity of the plant community remained. The three sections were designated as Deakle, Center, and Triangle. One NCVS permanent plot was established in each section in 2000. The plots were subjectively placed to avoid edge effect and to capture the homogeneous nature of the site. NCVS protocol for intensive level three sampling was used. No soil samples were taken. NCVS monitoring was done in 1998, 2000, and 2001.

The original NCVS plot was monitored March 3, 1998. The genera represented were grouped into structure categories based on plant physiology; trees, shrubs, and herbaceous. The herbaceous category was separated further into 10 sub-categories; sedges, rushes, grasses, lianas, carnivorous plants, forbs, ferns, mosses and bryophytes, aquatic plants, and fungi. These categories are representative of the structure of the desired future condition, a wet pine savanna, and can be used to assess diversity and dominance. Plant species diversity and dominance ranking will be used to measure the effectiveness of the restoration actions and progress toward the desired future condition. Thirty-three plant species were tabulated in the plot and grouped into structure categories by genera (Table 1). Trees were represented by three species in three genera. The shrub category was represented by six species in five genera. The herbaceous category was represented by 24 species: sedges - three species in one genera, grasses – two species in two genera (one genera not identified), lianas – one species only, carnivorous plants – three species in two genera, forbs – 13 species in nine genera, and mosses and bryophytes by two species in two genera (one not identified).

NCVS protocol also assesses cover. The cover is estimated visually and ascribed to the NCVS cover class. Cover classes and presence data is used to determine the dominance rank of each species as it occurs in the plot. The shrub layer had the highest dominance rank. Black titi, *Cliftonia monophylla*, was the dominant plant. It occurred in every plot and had the highest cover percentage. Spaghnum moss, *Sphagnum* sp., was the second most frequently occurring plant species. It also occurred in every plot but had lower cover percentages than the titi. The six dominant plants occurred in 6 or more of the plots. The remaining plant species occurred in fewer than six, with the majority being represented only once or twice (Table 2). The monitoring of the NCVS plot created the baseline data for the revised plant list and comparative analysis as required by the mitigation plan.

NCVS plot monitoring was conducted one year after the dozer fuel treatment, October 12 –13, 2000. Ninety-seven plant species were recorded and grouped into structure categories by genera (Table 1). Trees were represented by four species in four genera, an increase of one from 1998. The shrub category was represented by 15 species in twelve genera, an increase of nine species and seven genera. The herbaceous category exhibited the greatest increases from 1998, from 24 to 78 species. The sedges were represented by 12 species in six genera, grasses – six species in six genera, lianas – four species in four genera, carnivorous plants – eight species in three genera, and forbs – 39 species in 22 genera. The mosses and bryophytes were identical to the 1998 results, two species in two genera (one not identified). Four new categories of herbaceous vegetation were observed. The rushes were represented by 2 species of a single genera. Ferns were represented by two species in two genera. Two aquatic plant species were noted and one mushroom was observed.

The dominance ranks of the species in 2000 were different than those of 1998. The highest rank shifted from the shrub layer to the herbaceous layer. Sedges and ferns were the dominant plants in the plots. Cinnamon fern, *Osmunda cinnamomea*, and a beak rush, *Rhynchospora chalarocephala*, were the most frequently occurring plant species. The dominance rankings reflect the three-fold increases of sedge, grass, liana, and forb species from 1998 to 2000 (Table 2).

NCVS monitoring was conducted August 14 – 15, 2001. The late summer season was chosen to hopefully capture some new species two years post-dozer work, and summer growth after the spring prescribed burn. Sixty-six plant species were recorded, a decrease of 31 species from 2000, but still more than in 1998 (Table 1). Ten new species were identified, all summer forbs. The structure categories were represented as follows: The tree category had one less than in 2000 and was identical to 1998 – three species in three genera. There were ten fewer shrubs in 2001 than in 2000, and the number was identical to 1998 – six species in 6 genera. The herbaceous category contained 57 species, 21 fewer that 2000, but more than twice the number in 1998: sedges – 14 species in five genera, grasses – four species in four genera, lianas – two species in two genera, carnivorous plants – 7 species in three genera, forbs – 26 species in 11 genera, ferns – two species in two genera, and mosses and bryophytes – 1 species (Table 1). Number of species declined in all categories from 2000 to 2001, except for the sedges. The sedge category increased by two species, but were represented in two fewer genera than in 2000. The dominance ranks of the species for 2001 were different from both 1998 and 2001(Table 2). The shrub black titi, *Cliftonia monophylla*, was the most dominant, as it was in 1998. A grass, *Eragrostis refracta*, was the second most dominant plant species. The herbaceous category occurred again most frequently in the dominance ranks.

Table 1. Plant Structure Categories for the Davenport 1 NCVS Plots.

	1998		2000		2001	
Category	# species	Genera represented	# species	Genera represented	# species	Genera represented
Trees	3	*Pinus, Nyssa, Magnolia*	4	*Pinus, Nyssa, Magnolia, Quercus*	3	*Pinus, Nyssa, Magnolia*
Shrubs	6	*Cliftonia, Morella, Ilex, Lyonia, Gaylussacia,*	15	*Morella, Lyonia, Ilex, Cliftonia, Gaylussacia, Cyrilla, Ludwigia, Persea, Aronia, Callicarpa, Sambucus, Baccharis,*	6	*Morella, Ilex, Cliftonia, Gaylussacia, Cyrilla,*
Sedges	3	*Rhynchospora*	12	*Carex, Rhynchospora, Eleocharis, Fuirena, Fimbristylis, Cyperus, Scleria*	14	*Carex, , Fuirena, Scleria, Fimbrystylis, Rhynchospora*
Rushes	0		2	*Juncus*	0	
Grasses	2	*Dichanthelium,* grass (not-identified)	6	*Andropogon, Dichanthelium, Schizachyrium, Eragrostis, Panicum, Paspalum*	4	*Andropogon, Dichanthelium, Schizachyrium, Eragrostis,*
Lianas	1	*Smilax*	4	*Smilax, Parthenocissus, Vitis, Mikania*	2	*Smilax, Vitis,*
Carnivorous plants	3	*Sarracenia, Drosera*	8	*Sarracenia, Drosera, Utricularia*	7	*Sarracenia, Drosera, Utricularia*
Forbs	13	*Xyris, Coreopsis, Hypericum, Eriocaulon, Lophiola, Burmannia, Oxypolis, Chaptalia, Balduina*	39	*Xyris, Coreopsis, Hypericum, Eriocaulon, Lophiola, Burmannia, Oxypolis, Chaphalia, Balduina, Lachnanthes, Rubus, Platanthera, Helianthus, Polygala, Rhexia, Solidago, Lachnocaulon, Aletris, Eupatorium, Aster, Carphephorus*	26	*Xyris, Hypericum, Eriocaulon, Rubus, Platanthera, Helianthus, Polygala, Rhexia, Solidago, Eupatorium, Carphephorus*
Ferns	0		2	*Osmunda, Woodwardia*	2	*Pteridium, Woodwardia*
Mosses, Bryophytes	2	*Sphagnum,* a bryophyte	2	*Sphagnum,* a bryophyte	1	*Sphagnum*
Aquatic plants	0		2	*Hydrocotyle,* green algae (not identified)	0	
Fungus	0		1	mushroom (not identified)	0	

Table 2. Plant Dominance Ranks for Davenport 1 NCVS Plots.

Dominance Rank	**1998 – 33 species**	2000 – 97 species	2001 – 66 species
	Genera represented	Genera represented	Genera represented
1	*Cliftonia*	*Rhynchospora, Osmunda*	*Cliftonia*
2	*Sphagnum*	*Lyonia, Smilax, Sphagnum*	*Eragrostis*
3	*Smilax*	*Cliftonia*	*Smilax*
4	*Rhynchospora*	*Magnolia, Rhynchospora,* grass	*Rhynchospora*
5	*Gaylussacia*	*Rhynchospora, Rubus, Polygala, Gaylussacia, Hypericum, Ilex*	*Cyrilla*
6	*Magnolia*	*Panicum, Morella, Nyssa, Rhynchospora, Hypericum*	*Rhynchospora, Ilex*
7	*Drosera*	*Drosera, Hypericum*	*Rhynchospora, Magnolia, Gaylussacia, Rubus, Hypericum, Sphagnum*
8	*Lyonia*	*Dichanthelium, Hypericum, Lachnanthes, Eriocaulon, Pinus, Rhynchospora, Xyris, Eupatorium, Sarracenia, Carex, Schizachyrium*	*Morella, Eriocaulon, Rhynchospora*
9	*Rhynchospora*	*Aster, Rhexia, Lachnocaulon, Vitis, Rhynchospora, Eupatorium, Xyris*	*Zigadenus, Carex, Polygala, Dichanthelium, Rhexia, Nyssa, Rhynchospora*
10	*Eriocaulon*	*Lycopodium, Solidago, Sarracenia, Aletris, Utricularia, Xyris, Rhynchospora, Woodwardia, Morella, Rhus, Eupatorium, Cyrilla,* grass	*Eupatorium, Gnaphalium, Hypericum, Sabatia, Xyris*

DISCUSSION

Restoration Actions

The 1998 prescribed burn was not considered a success from the restoration standpoint but it was successful in other ways. The burn was not effective because of the wind change, but the success lies in the burn plan itself. In lieu of the wind change, the prescription for the fire was accurate. Until the wind changed direction, the fire burned as expected and achieved some shrub mortality through top kill and underburning, without the burn becoming uncontrollable in the highly flammable fuels and a heavy fuel load. Conducting prescribed burns in titi shrub forests or similar pocosin fuel models is extremely hazardous and the burns frequently become uncontrollable because of the fuel conditions. This prescription could serve as a model for initial burns in similar habitats and conditions.

The decision to implement a mechanical fuel treatment was based on fire management and restoration experience, project time frames, long-term climate predictions, and finances. The first two years of the drought provided ideal growing conditions for the titi shrub forest; ample water because water table levels were still high, and warm winter weather without frost or freezes to retard growth. In these favorable conditions, the shrub forest grew quickly and became approximately 2.7 – 3.7 m. (9 – 12 ft.) tall. This fuel condition would make a prescribed burn extremely dangerous. The long-term climate prediction was for a prolonged drought through the next year, the last year of the project. Because fire is the primary ecological force that maintains the wet pine savanna community, changing the structure and arrangement of the fuel would enable a safe, controllable prescribed burn to be conducted. The decision to "walk down" the shrub forest with bulldozers was based on similar experiences in Florida. It was determined that the vegetation would act as mats to support the equipment and reduce soil surface damage. This method would be expedient to hand cutting, and herbicide treatment was out-of-the question because of water contamination and possible destruction of the herbaceous community that was trying to be restored. The mechanical fuel treatment was extremely successful and appears to be a better method than fire for changing the shrub forest structure and composition in conditions like these. The community structure changed from a uniform, dense shrub forest with little sunlight reaching the soil surface to a two-tiered community structure with an open herbaceous layer and thin, widely scattered canopy of slash pine. The herbaceous vegetation responded dramatically to the increased insolation rates to the forest floor, with plants growing in every available clearing and pushing through the crushed slash. This herbaceous growth provided the fine fuel to carry a fire on the site, a fuel condition that was previously absent. Changing the burn fuel model from a heavy shrub fuel model to a combination slash-herbaceous fuel model provided for a prescribed burn with a lower complexity, increased safety, and a much larger burn window (a condition when all burn factors allow a prescribed burn to be conducted within the prescription parameters).

The prolonged drought may have resulted in an increased benefit for the herbaceous plants with respect to their restoration. By early December 1999, approximately two

months post-dozer work, the leaves of the downed titi had dried into "red slash" and were beginning to drop from the branches. This began the release of the herbaceous plant community from the shade stress created by the shrub forest. As previously stated, the herbaceous plants, with a large portion of them being sedges and grasses, re-colonized the site. Fourteen months, including one full growing season, ensued prior to the re-introduction of fire to the site in late January 2001. This growth period provided a full life cycle for the plants, with carbohydrate storage, flowering, seed production, and may have enabled the stressed plants to recover to a vigor level able to withstand the disturbance of fire. Because the fuel load for the burn was a combined grass and slash model, more heat was going to result from this burn than would be from a fire in grass fuel alone. The heat energy output from a grass fuel model that would be typical of the original site would be 200 - 300 BTU/sq. ft., whereas from the combined fuel model the projected heat energy output was 500 - 800 BTU/sq. ft. It was a concern that the increased heat output could be detrimental to the recovering herbaceous plants. The remaining titi slash consisted of 100 hour (1– 3 inch) and 1000 hour (3 – 8 inch) fuel sizes and was very dry. The smaller twigs and branches had desiccated during the dry spell. The slash would burn quickly, but enough fuel remained to create high temperatures at the soil surface in some areas where the slash was somewhat piled, especially on the west fireline that was cleared by the trackhoe. However, because ample soil moistures were present during both burns, January and March 2001, very little consumption of the peat (H soil layer) occurred. Above ground parts of perennial bunch grasses, sedge clumps, and pitcher plants were totally consumed by the fire to approximately one inch above the soil surface, a result that is not detrimental.

Monitoring

The number of plant species and diversity increased from 33 species in 1998 to 97 species in 2000. Monitoring three NCVS plots in 2000, as opposed to one NCVS plot in 1998, amounted to a greater area coverage monitored and therefore increased the likelihood of finding more species and increasing diversity. The homogeneity of the site remained however, and the increase in species and diversity was more likely due to the effect of the changed vegetation structure and the herbaceous community recovery. The majority of plant species in a wet pine savanna community are perennials. The increase is attributed to the release of suppressed plants and the sprouting of dormant root stocks. Germination from the seed bank may have also occurred. Sedges, grasses, and forbs represented 91 of the 97 species, an indication that the herbaceous layer is being restored. The time between the mechanical fuel treatment and monitoring was fourteen months, which included one full growing season.

Both dominance ranks and community structure and composition changed from 1998 to 2000. Titi shrubs were the dominant plants in 1998, reflecting the titi shrub forest, and the dominant the structure tier in 1998 was the 1 – 25 cm. (2.5 – 10 inch) shrub stem diameter comprised of titi and sweet bay (*Magnolia virginiana*). The mechanical fuel treatment changed the community structure and composition and had a direct effect on changing the dominance ranks. The community structure changed from a two-tiered dense midstory shrub forest and scattered canopy of slash pine and sweet bay magnolia to

a distinct herbaceous layer and a scattered, very sparse canopy consisting of only slash pine. Sedges (*Rhynchospora*) and ferns (*Osmunda*) were the dominant herbaceous plants in 2000, and the dominant canopy structure was the 12.7 – 25.4 cm. (5 – 10 inch) stem diameter comprised of slash pine. The midstory was totally eliminated by the mechanical fuel treatment. From a visual observation in October 2000, it could be concluded that the Davenport 1 site resembled a wet pine savanna.

The number of species declined in 2001, from 97 to 66. The decline is attributed to the burn and the timing of the monitoring, which occurred only five months after burn. The monitoring was conducted at this time period to provide a baseline for one-year post burn evaluation and because of project deadlines. Ideally, post-burn monitoring should be conducted one year after the burn to allow for a full recovery of the plants. Ten species were unaccounted for from the shrub category, and there was undoubtedly a loss of spring and summer plants due to fire. The losses should be temporary, an effect of fire, and the plants should be represented in future monitoring data. Total site species diversity increased as a result of the 2001 monitoring. Ten new species were identified. Sedges, grasses, and forbs continued to represent the majority of the species, 61 of the 66, again indicating the recovery of the herbaceous layer.

The dominance ranks changed from 2000 to 2001. The shrub black titi again regained dominance through presence and cover as short, prolific adventitious root suckers in the herbaceous structure tier, not the shrub tier. The well-developed root system of the titi is recovering from the mechanical disturbance and could possibly taking advantage of increased insulation rates and reduced competition. Frequent prescribed burning will decrease the amount of titi as carbohydrate reserves are depleted and as evaporation rates increase, reducing the saturation hydroperiod favorable for titi growth.

In the future, the Davenport 1 site will continue to have varying vegetation changes as the restoration actions and recovery continues. The sedges and grasses should remain prominent and the structure composition should remain two-tiered, with a profuse herbaceous layer and a scattered, sparse canopy of pines. The reverse hydrarch theory is entirely plausible, and it is expected that the site will become "drier", mostly through a shorter saturation hydroperiod caused by increased evaporation.

CONCLUSION

Lessons Learned

The most valuable lesson learned during this project was that heavy equipment can be used successfully in wetland restoration in certain situations without detrimental impacts to the site. The "walk-down" method used in this project is not a common practice for fuel structure changes on wetland sites. There are three key components to the success of the "walk-down" treatment.

1. Use equipment of the appropriate size and design for wetland use.

2. Use highly skilled equipment operators who are familiar with the terrain and its affect on equipment operation, and the piece of equipment they are operating.
3. Conduct the operation when the soil conditions are suitable.

The lessons learned during this project are all attributed the mechanical fuel treatment conducted on the site.

- ✓ Mechanical fuel treatment provided better results than the initial prescribed burning and may have enhanced restoration of the herbaceous layer by reducing competition.
- ✓ Mechanical treatment was an integral part of the restoration method in this dense shrub habitat.
- ✓ One growing season of herbaceous re-growth prior to the re-introduction of fire provided fuel continuity for the slash fuel model
- ✓ One growing season for previously depressed and severely suppressed plants may have provided increased plant growth, development, and vigor, and greater tolerance for ecological disturbance (fire).
- ✓ Mechanical fuel treatment delineated the location of a deep peat bog which was non-detectable with vegetation surveys.

A quantitative evaluation of the restoration and the success of the performance standards was done using the parameters of community structure and species richness. The plant community structure of the Davenport 1 site currently meets the desired future condition criterion. Dominance ranks demonstrate the herbaceous component of monocotyledonous perennials. Photographs provide qualitative documentation of the community structure. The desired future condition descriptions list 88 plant species as site indicators. Thirty-eight percent (33 species) of the species occurred on site in 1998, but 69 percent (61 of 88) have been identified in the NCVS plots since restoration began. The 88 plant species from the desired future condition descriptions are represented in 43 genera. Plants on the Davenport 1 site occur in 93 percent (40 of 43) of those genera. The revised plant list catalogues over 300 species that could *possibly* occur on the mitigation site. The list was catalogued as an inception for the development of a diversity measure. Several more years of monitoring and general site surveys should be conducted prior to developing a diversity measure. One hundred eight different plant species have been identified in the NCVS plots from 1998 to 2001.

The Davenport 1 mitigation site has achieved dramatic results from the restoration actions (Figure 3). Community restoration could be considered as reaching the maintenance phase if 80 percent (70 species) of the desired future condition species and 95 percent of the genera are present on the Davenport 1 site. It is expected that seasonal surveys in 2002 will increase the number of species and percentages, and that the site will meet the reference criteria (Figure 4).

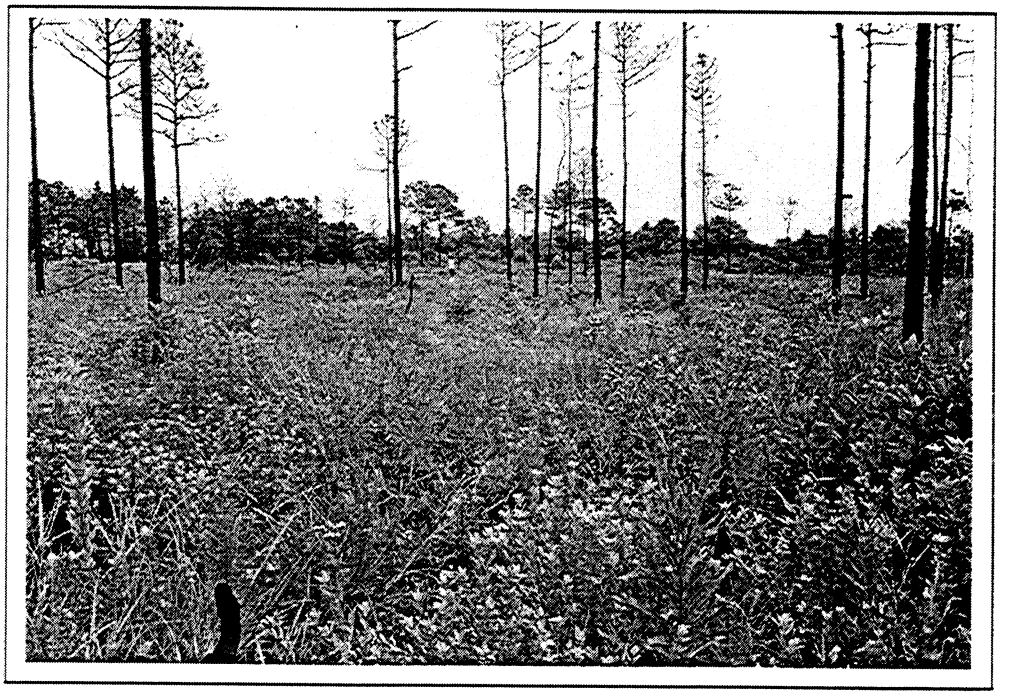

Figure 3. Deakle Section NCVS plot, August 2001.

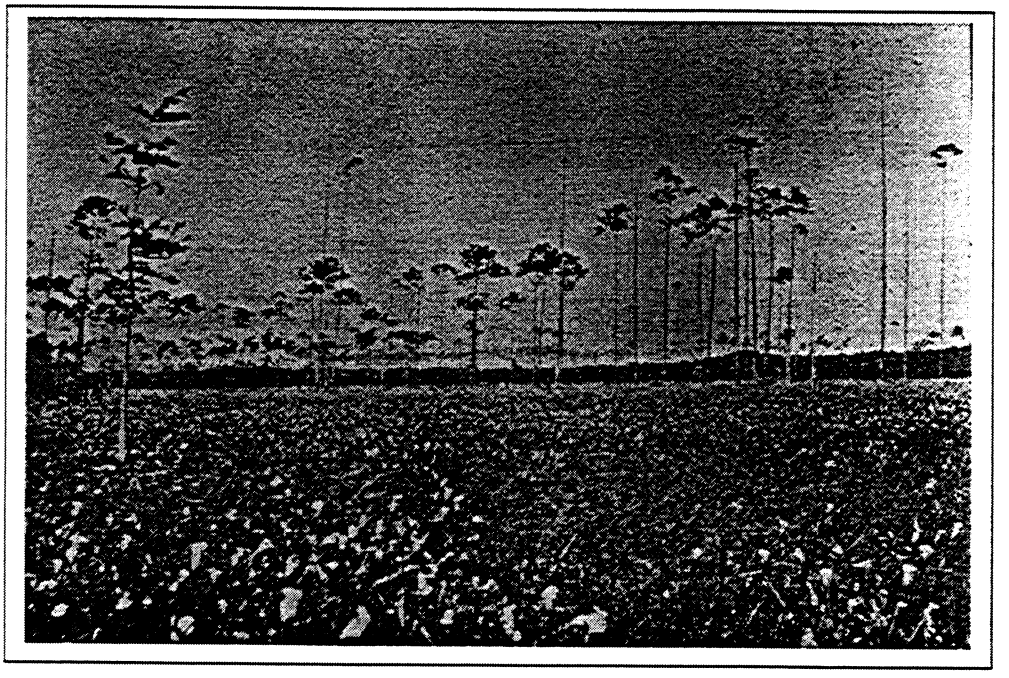

Figure 4. Desired future condition representation. Figure 22, flat wet, savanna.... about three miles north of Bayou La Batre, Mobile County, June 15, 1912, Resources of Alabama, R. Harper (1920).

LITERATURE CITED

Emanuel, L. 1998. Personal communication.

Harper, R. M. 1920. Resources of Southern Alabama. Special Report No. 11. University of Alabama.

Peet, R. K., T. R. Wentworth, R. Duncan, and P. S. White. 1996. The north carolina vegetation survey protocol: A flexible, multipurpose method for recording vegetation composition and structure. Department of Biology, University of North Carolina, chapel Hill, NC. pp. 40 & appendix.

Weakley, A. S., K. D. Patterson, S. Landaal, M. Pyne, R. E. Evans, J. A. Teague, M. J. Russo, and others (compilers). 2000. International classification of ecological communities: Terrestrial vegetation of the Southeastern United States. Repot from Biological Conservation Datasystem and Working Draft of April 18, 2000. Association for Biodiversity Information/ The Nature Conservancy, Southern Resource Office, Community Ecology Group, Durham, North Carolina.

Van Horn, M. and K. Van Horn. 1996. Quantitative photomonitoring for restoration projects. Restoration and Management Notes. 14:1. Summer 1996. University of Wisconsin Press, Madison, WI.

PLANNING FOR THE UNPLANNED: INCORPORATING ECOLOGICAL RESTORATION TECHNIQUES INTO THE PRACTICE OF LANDSCAPE DESIGN

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As the fields of landscape design and ecological restoration become increasingly intertwined, it is important to explore ways that the two disciplines can effectively interact. Landscape designers, concerned with human needs and aesthetics, and restoration ecologists, concerned with ecological function, can share numerous techniques to enhance the effectiveness of their respective practices.

From the perspective of the landscape designer, blending the traditional practices of horticulture and landscape design with the patterns and processes of native plant communities can add entirely new dimensions to their work. The thoughtful use of native plants can help to express the distinctive natural character of the regions in which they are working, while decreasing the amount of time and resources required for landscape upkeep. Considering and planning for natural processes of change to affect the designed landscape can also help decrease maintenance needs, increase long term viability, and offer an enriched experience to users.

Be they private, commercial, or public spaces, built landscapes can become ecological contributors by providing wildlife habitat, controlling stormwater runoff and reducing pollutants associated with fertilizers, herbicides, pesticides and fossil fuel consumption. The replacement of large turf areas with native meadows, woodland ground layer plantings and other native treatments alone could have a significant effect in this regard. While this approach to landscape design could have obvious ecological and practical benefits, widespread acceptance will never occur if it is not implemented with an understanding of context and aesthetics.

Exciting results can be achieved when ecological restoration is combined with the visual art of landscape design. We refer to the result as "natural design."

The elements that make a landscape design "natural" are difficult to define. In the past landscape practitioners have interchangeably used the words "natural" and "informal" to describe their work. Simply because a landscape lacks the straight lines and clipped hedges of a formal garden, it does not necessarily qualify as "natural".

The basic concept behind natural design is fairly simple—to thoughtfully incorporate native plant communities into the landscape in a manner that will encourage their self-proliferation, and allow for the natural recruitment of additional desirable species. Oversimplified maybe, but it sounds a lot like restoration ecology. The difference however, is that usually the primary beneficiary of the landscape designers efforts are

people, not flora and fauna. Consequently, the incorporation of native plants and natural processes must fit within the functional and aesthetic goals of the project, be it residential, commercial or public. Environmental benefits have increasingly become a consideration, but unless regulatory mandates are in effect, they will rarely be the primary concern.

For widespread acceptance to occur, a case must be made to the client that a natural approach will inherently enhance all aspects of the project.

Once the client is on board, a clear methodology must be in place to insure that results live up to expectations. This is why the landscape design practitioner, generally used to working in smaller scales and more controlled environments, and the restoration ecologist, usually more oriented towards wildlife than people, must share expertise.

So what are some of the specific techniques of this gray area between design and restoration? As previously mentioned, random informality often passes for "natural in the world of landscape design. In reality nature is highly ordered and anything but random. Understanding, utilizing and adapting this order is the key to making natural design workable and successful. This does not mean, however, that practitioners must attempt to copy nature exactly, or exclude the influences of other design styles. The goal is to create a framework for the overall designed landscape that has an aesthetic and ecological relationship to our indigenous landscape through the extensive use of native plants in their natural associations.

The basic considerations of natural design can be broken down into three categories: aesthetic, managerial and environmental.

The aesthetic aspect of design is highly subjective, and individual style varies greatly. Some designers may object to uniformly patterning their work on the native landscape, feeling they are homogenizing their designs or stifling their artistic expression. But, as landscape designers, our medium is the land.

Unlike a painter whose art occupies an isolated canvas, our work visually interacts with the surrounding landscape, both natural and constructed. Designers therefore have a responsibility to contribute continuity and a sense of place to the larger landscape. To successfully accomplish a marriage of art and nature, we should sometimes put our egos aside and let nature be our guide.

The managerial aspect of natural design is tied to the fact that reducing landscape maintenance is a strong priority for virtually all of our clients. Natural design techniques can make a great contribution in this regard. This does not mean that natural landscapes are maintenance-free and can be completely left to natural processes with no human guidance, however.

What natural design does mean is that landscapes that thoughtfully incorporate native plants and natural processes will require less time, money and energy for upkeep than

designs in which plants are selected and combined for ornamental effect alone. A purely ornamental garden is like a beautiful, sleek automobile with no engine. It may be nice to look at, but the only direction it will go without help is downhill. We will be perpetually required to tow these gardens up the hill with fertilizers, watering hoses and weeding forks.

The environmental considerations of natural design are equally important. Many detrimental landscape practices can be minimized or eliminated. Such landscape practices include the excessive use of pesticides, herbicides, inorganic fertilizers, fossil fuels burned while mowing large areas of turf grass, and exotic species that have aggressively naturalized in the wild.

Natural design aims not only to reduce these negative effects, but make a positive contribution to the surrounding environment as well. Naturally designed landscapes can also become functioning ecosystems capable of providing food and shelter for animals and insects, while helping to perpetuate many native plant species whose habitats are being reduced through development.

The following are ten considerations that can help achieve these goals. While they may seem elementary to a practicing ecologist, they should provide valuable insight into how the two professions can form a strong working relationship.

1. Minimize disturbance of existing native growth.
Protecting existing native growth, particularly woodlands, is easier and less expensive than trying to restore it after it's been destroyed. Even our best restoration efforts will never achieve the beauty and mystery of a mature woodland. Developers, architects and clients need to be aware of the benefits of considering ecological systems before designing the structures for the site.

Early decisions relating to the siting of buildings, topographic changes and excavation disturbance can help minimize destruction of natural growth during construction. Unfortunately, landscape designers and architects are often brought in after construction is complete and have no opportunity to influence the treatment of the existing landscape.

2. Decide how closely your design will emulate the native landscape.
The design will be determined by numerous factors, including the character of the surrounding landscape, client dictates, architectural style, site characteristics and the scale of the site.

A large site may allow for the design of a functioning ecosystem using strictly native species. A smaller site can be designed with a perimeter of site-appropriate natives, becoming more cultivated as the landscape nears the house. If adjacent properties take this approach, the possibility exists of creating a natural corridor that connects nearby natural area fragments. Native plant cultivars and selections such as 'Golden fleece' goldenrod (*Solidago sphacelata* 'Golden fleece'), 'Purple Dome' aster (*Aster novae-*

anglia 'Purple Dome') and native azalea cultivars can be very useful in making a transition from wild areas to more formal ones.

3. Allocate the location of woodlands, open spaces and transitional areas.
Natural landscape patterns found in many areas throughout the country are formed by the interplay of woodlands, open landscapes and the transitional areas where they meet (edges or ecotones). A graceful and functional mix of these features will define the design *before* any plants are selected. Even small properties can be approached in this manner, often resulting in the illusion of more space.

4. Base your design on native plant communities found in similar conditions in the surrounding areas.
Determine which plant communities would have existed on the site had it not been disturbed, and which disturbance communities would likely colonize it after disturbance. Use these as design models as is appropriate.

Determining native plants is easiest on a site that still contains remnants of indigenous growth. If this is not the case, you can obtain information by observing nearby natural areas with similar ecological conditions, analyzing the soil and hydrology of the site, obtaining geological maps and studying the natural history of the area.

If the post-disturbance soil and water conditions are no longer capable of supporting these plant communities, consider basing your design on a community adapted to the current site conditions.

5. Use and plan for natural processes of change to modify the landscape.
The indigenous landscape is a constantly changing system composed of plants, animals, insects, microorganisms and soils. Plants are not isolated entities, but participants in a system constantly in flux. Different types of systems change at different rates. The annual meadow immediately resulting from a disturbance may last for only one year, while the perennial meadow may last for 10 before yielding to pioneer forest species. By contrast, an old oak and hickory forest may last for hundreds of years if left undisturbed.

Once these changing systems are understood, the designer can decide which aspects to encourage, discourage or manipulate to fit the requirements of the client and site. Designed landscapes need not be static photographs frozen in time forever, doing battle with the forces of nature.

6. Occupy all the spaces.
A basic law of almost any native ecosystem is that if nothing is currently growing in a given space, something soon will. The more available space is filled, the less opportunity there is for an unwanted invasive plant to enter. Plants grow against each other, above each other and below each other. Even a 3-foot-tall meadow has a multi-layered structure designed to seal off the area. This is also evident below ground, where fibrous rooted plants occupy the soil surface and coexist with deep tap rooted plants "holding down the fort" below. There are obvious lessons here for the designer interested in creating

landscapes that have the ability to fight off weed invasion without the aid of mulches, fabrics and grub hoes.

Mulched beds around isolated groupings of shrubs are an open invitation to invasive plants such as Canadian thistle (*Cirsium arvense*), Japanese Knotweed (*Polygonium cuspidatum*) and Multiflora Rose (*Rosa multiflora*). A mixed, densely planted herbaceous ground cover layer, composed of plants with complementary aboveground and belowground growth habits, will be far more successful at inhibiting weed invasion than any mulch. If this ground layer is also designed for succession of bloom and contrasting foliage texture, we can create a reduced-maintenance landscape that suggests the diverse tapestry of our native ground covers while achieving an artistic and colorful composition.

7. Increase ground water recharge by preserving rainwater on-site.
Current landscape practice often considers surface water as something to be eliminated. Meanwhile, water shortages are a frequent problem in our communities, as our underground aquifers are not adequately recharged. Whenever we grade a property to direct surface runoff into the storm water system, we are sending a valuable commodity out to sea, as well as increasing erosion on the banks of our rivers and streams.

Aquifer recharge, the replenishment of our underground water tables, depends upon the absorption of rainwater into the ground. We can assist this process by using ponds, irrigation catchments, porous paving surfaces and bog gardens. Low wet areas can be converted into colorful assets by designing them as wet basins containing a range of colorful water-tolerant plants like turtlehead (*Chelone lyonii*), Joe-Pye weed (*Eupatorium purpureum*), New England aster (*Aster novae-anglia*) and blue flag iris (*Iris versicolor*).

8. Employ alternatives to high-maintenance lawns.
The American lawn has become the focus of a great deal of controversy. Great quantities of water, fertilizers and fossil fuels are expended for lawn upkeep and the amount of pollution from herbicides, pesticides and small engine exhaust is well documented.

Although there is nothing inherently evil in a blade of Kentucky blue grass (*Poa pratensis*) or the person who likes it, replacing substantial portions of mowed lawn with other, more ecologically friendly plantings would have a positive effect on our environment. A mowed lawn does serve a unique function in that you can walk, lay and play catch on it—activities that are difficult in a tall grass meadow or a cottage garden. It is possible, however, to offer alternatives that are affordable, easily sustainable, ecologically sound and aesthetically pleasing.

The first alternative to lawn is lawn. Not the resource-intensive grass monoculture that we normally plant, but a diverse ground cover of creeping broadleaf plants combined with slow-growing drought and disease-resistant grass cultivars or native grass species. These plants could include buffalo grass (*Buchloe dactyloides*), Pennsylvania sedge (*Carex pensylvanica*), wild strawberry (*Fragaria* spp.) and violets (*Viola* spp.). A lawn of this type would require little or no fertilizer or chemical application, and would need to be mowed less frequently than a traditional lawn.

Wildflower meadows are currently the most popular lawn alternative as they can provide visually stimulating, low-maintenance landscapes. However, in order for these plantings to succeed in the long run, the majority of wildflower seed producers must completely revamp their mixes. Annuals and short-lived perennials selected for immediate floral effect must give way to long-term native perennials and grasses selected for function and site-adaptability, as well as aesthetics. By patterning these landscapes after our native prairies and grasslands, their exciting potential can be fully realized.

The most neglected lawn alternative is woodland. While open space is highly valued, it can be even more appreciated when contrasted with a forest or grove. While this type of landscape takes far longer to mature, a transitional period can be filled with a meadow or grassland landscape supplemented with pioneer trees. Late stage canopy and understory trees, shrubs, and ground layer plants can be added after a sufficient canopy is developed.

9. Exclude invasive, exotic plants in the native landscape.
A number of exotic species have naturalized so aggressively into our woods, meadows and wetlands that the natural plant diversity of these areas is destroyed. These include many commonly used ornamental plants such as Norway maple (*Acer platanoides*), burning bush euonymus (*Euonymus atlatus*), privet (*Ligustrum*), Japanese barberry (*Berberis thunbergii*). Russian olive (*Elaeagnus angustifolia*) and Tatarian honeysuckle (*Lonicera tatarica).* Purple loosestrife (*Lythrum salicaria*), a European perennial that has attained enormous popularity, has completely destroyed the biodiversity of thousands of acres of wetlands. (Claims that its cultivars are sterile and therefore harmless have been proved false, as these cultivars eventually hybridize into fertile forms.) Maiden Grass, (*Miscanthus sinensis*) is just beginning to escape into the wild and could easily become a problem in the future. We should completely abandon using any plants that have become, or are likely to become invasive in the native landscape.

In addition, we should be looking into ways to identify and discontinue using any new plants that show likely potential for invading our natural areas.

10. Cultivate in your clients an appreciation of the beauty in nature.
Everyone admires the beauty in a majestic mountain range or a towering waterfall, but most of what we can create in our landscapes is more subtle. The contrasting patterns of straight and leaning tree trunks in a woodland grove, a single Turk's cap lily (*Lilium superbum*) nodding above a bed of meadow grass, or the layered branches of a pagoda dogwood (*Cornus alternifolio*) in a woodland edge may be an acquired taste.

A native old field in winter is a prime example of how learning to see the landscape anew can open a whole new vista of aesthetic possibilities. The glistening orange of little bluestem (*Schizachyrium scoparium*) in the sun, punctuated with columnar green patches of eastern red cedar (*Juniperus virginiana*) is a spectacular American scene, and a much more warming sight on a frigid February morning than a curled up, crispy bed of pachysandra (*Pachysandra terminalis*). Designers who cultivate in their clients an

appreciation of the natural world around them will find their work to be more easily accepted.

Although natural design is not new, current public interest in natural aesthetics, reduced landscape management and environmental issues is making its widespread acceptance a real possibility. In order to capitalize on this opportunity, we need to develop concrete and reliable strategies for the design, implementation and management of these landscapes based on real ecological principles.

Landscape designers and restoration ecologists influence the treatment of vast areas of land. Designers have a responsibility to treat this land as more than their personal paint canvas, and work to incorporate ecological function into their work.

Restoration ecologists can increasingly consider people as users, and in many cases, legitimate agents of change on their sites. By making an effort to truly understand the workings of our indigenous landscapes, as well as the people who share them, we can further lessen the gap between restoration ecology and landscape design.

The Natural Cities Project - A Method of Rapid Ecological Assessment for Urban Green Space

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ABSTRACT

The Natural Cities Project is a collaborative effort to develop an understanding of urban ecosystems and to create a national model for the evaluation and preservation of ecological communities in urban settings. This project combines scientific evaluation of the ecological value of various urban sites, Community value of each site, and legal assessment of protection status or potential, to prioritize conservation efforts. This procedure ensures effective use of limited resources to protect ecologically and socially significant green space, thus increasing quality of life in the urban environment. The ecological component of this Project involved the development of a rapid ecological assessment method to rank the ecological value of urban sites, and we present our methods and results here.

For the typical ecologist, significant adjustments must be made when considering urban sites. Urban environments contain many small, degraded sites that typically exhibit major signs of anthropogenic disturbance. These urban sites may be insignificant were they in a rural setting, but they can provide important ecological and social functions in urban environments. We have developed a simple survey method that can be done by individuals with minimal training to evaluate the ecological function and restoration potential of urban sites. This protocol emphasizes plot size, biodiversity, connectivity, and magnitude of alterations. The presence of impermeable surfaces, refuse, and particularly invasive exotic species are considered to be significant negative indicators for a site, while the presence of breeding birds, developed soils, high plant diversity, and connectivity with other sites are considered to be positive indicators. With the exception of four highly invasive species, exotics were considered to have biodiversity value equal to native species. This was done in recognition that urban ecosystems will never mimic native setting, and that exotic species contribute to ecological function and social value in urban settings. It is our hope that this method will be widely applicable to all urban sites.

INTRODUCTION

The protection and restoration of urban ecosystems are crucial challenges in environmental policy and urban redevelopment. In light of the American public's dramatic commitment to rebuilding our cities and to reducing the ecological impacts of sprawl, protecting and restoring urban ecosystems will be among the most important environmental issues of this century. Accompanying these urban renewal trends will be demographic shifts that will put the vast majority of Americans in cities and on the coasts, making building and rebuilding healthy and vibrant metropolitan areas a national policy priority. In the Commonwealth of Massachusetts generally, and in the Greater Boston Harbor region specifically, the amount of land used per capita has doubled over the past fifty years. Despite such pressures, urban natural resources, such as urban watersheds, can remain sources of economic, civic, and public health benefits to metropolitan area residents nationwide, provided we develop models to better understand, develop, and protect them.

Despite the increased importance of urban ecosystems to the health of urban communities and residents, very little is known about them. If we are to have a meaningful impact on the health of urban ecosystems, and consequently on the health of disenfranchised urban neighborhoods, we must do more than merely wait for long-term study results, or plant street trees, or improve vacant lots, or support the development of watershed associations, though we must of course continue to do all at these things. The Natural Cities Program will provide a national model for community-based, multi-stakeholder programs geared toward researching, restoring, and protecting urban natural assets and educating urban communities about them. The community-based restoration projects will grow from a number of long-term partnerships, ensuring community leadership. Those with the most at stake in urban environmental issues, urban residents, are often left out of efforts to protect and restore the environment; the Natural Cities Program will reverse that model with respect to urban natural resources.

As an essential step in this program, we have developed a rapid environmental assessment method for evaluating the ecological health and restoration potential of sites in an urban setting. Our method can be done in a few hours per site, and provides sufficient environmental information to rank sites effectively. Although a few methods for ranking ecological value in urban settings exist they typically reflect local goals for ecological value, and can be quite data needy (Anselin and Meire 1989, Dan and Ru-Song 1998). They also vary in the amount of local detail, ranging from remote sensing (Atkinson 1990), to relying on published databases (Goodfellow and Peterken 1981), to doing local surveys (Freeman 1999, Dana et al. 2002). We favored local surveys as being necessary to determine ecological value, in particular for assessing biodiversity. Rather than relying on the scant literature, we assembled a group of local environmental scientists and community activists to determine the important aspects of ecosystems, particularly how focusing on social values, and how they differ in urban ecosystems from other settings. From this series of discussions a new assessment method emerged. That method is the focus of this paper.

The goals of the Natural Cities Program were to build and field-test a national model for community-based urban ecosystem research and restoration. In the process, we will enhance the health of the Greater Boston Harbor ecosystem. We will build on lessons from ongoing urban ecosystem projects such as those in Baltimore, Phoenix, and New York (e.g., Sisinni and Anderson 1993, Baltimore County Department of Environmental Protection and Resource Management 2001, Cook 2002). We have developed and tested our model of urban conservation using ecological, legal and policy tools with community partners in East Boston, Chelsea, Somerville and other communities in the urban, Mystic River watershed. We will work with community organizations to restore specific sites. In our first year, we developed a community-based research model that allows local or neighborhood groups to take the lead on identifying critical urban natural resources. We hope that this Rapid Ecological Assessment model will be of interest to other cities as a methodology for bringing community partners into urban ecology research.

Survey Methods for Natural Cities Sites

The Natural Cites protocol goes through several stages of site selection and reduction for field evaluation of ecological value, and involves multiple teams with different professional expertise.

Personnel

The site selection process involves two groups that may have overlapping memberships. The ecology team will be primarily responsible for making scientific evaluations of the ecological potential of various sites under consideration. The community team will be primarily responsible for evaluating the political, financial, and local interest potential inherent to the various sites. Site surveys are to be conducted by local concerned individuals in conjunction with an interested local college. Each site was surveyed by at least two people, one of whom is an individual from either a local college or museum who is trained and experienced in conducting and designing ecological experiments. In the case of our initial survey no community team members took part in field surveys.

Site Selection

Stage 1: There are two types of sites to be identified, anchor sites, and evaluation sites. Anchor sites are those that are very large and are thought to be ecologically self sustaining and perhaps relatively intact. These sites are viewed as critical for the urban environmental landscape, and adjacency to these sites is thought to increase the value of small sites. Not all urban areas will have anchor sites. The ecological team, which consists of a mix of concerned individuals from the local communities at least one qualified field biologist (one who is trained and experienced in the design and exercise of field experiments) familiar with the local area will look at maps and aerial photographs of the region in question to select anchor sites and potential evaluation sites that may have ecological significance. The purpose of this process is to define a "universe" of potential sites for restoration or protection.

Stage 2: Social and legal data were used by the community team to narrow the number of sites to be assessed in the field. Social data were collected measuring community priorities about people's environmental and public health perceptions, and development issues and the sites relevant to those concerns. The data were collected from paper and electronic surveys distributed at targeted community meetings within the watershed. Next, lawyers, law students, or trained people assembled legal data to determine whether or not there are legal/political tools that could be used for protection and/or restoration of the sites. For example, is a site already owned by the city or state, is it protected by existing watershed agreements, or is it in private ownership with no conservation easement. Sites identified in stage 1 will be analyzed for zoning type, ownership, presence of fill and/or hazardous waste, presence of wetlands and vernal pools. Results were used to prioritize sites based on their existing protection status, potential for protection, and importance to local communities.

Stage 3: Sites in Stages 2 and 3 were cross-referenced, and a subset of sites were chosen by the ecology team for field evaluation. Available resources determined the number of sites to be visited (in this case 30 sites). In this case the top 25 sites will be selected. If the community team comes up with fewer sites than there is funding to survey the ecological team may add sites to the list.

Stage 4: The 25 sites selected in Stage 3 were surveyed on the ground for ecological value and ranked. (See below for survey methods.)

Stage 5: The community team incorporated the results of these surveys (in the form of the field sheets produced with a one page overall summary of all sites) and determined the five top priority sites for conservation.

Stage 6: The five sites selected in Stage 5 will receive more detailed analyses and reports emphasizing the current state of the sites and priorities for improvement by the ecological team. (This has not yet occurred.)

Stage 7: Site restoration will proceed on these final five sites (more if possible).

Survey Methods

Site surveys are designed to give an accurate overall picture of the ecological health of a site in a minimal amount of time (Grumbine 1992, Kerr 1995). Some aspects of the site survey (connectivity, area) are done in the lab or office, while others (breeding birds, plant diversity) may require that surveys be done at specific times of year. Site surveys can be done excluding these factors, but it must be acknowledged *a priori* that doing so will limit the accuracy and validity of the ranking system.

Connectivity: Site connectivity can be key to population persistence and ecological value (e.g., Schippers et al. 1996). Connectivity is important in that it allows sites to interact, allowing the exchange of individuals, which can be important to population persistence

(Hansson et al. 1992, Hanski 1999). We followed tradition by measuring connectivity on a map (using GIS), rather than in the field. There are many approaches to determining connectivity, but ultimately it is determined by the species living in the community. Little is known about the details of dispersal for most species (Reed et al. 1999), so we developed our own approach to defining site connectivity.

For our method, the approximate geographic center of a site should be determined. From there, draw a circle of 1km diameter. One then determines the cumulative degrees of arc that an individual dispersing from the center would encounter another identified patch of green space (Figure 1). The greater the value, the more connected a patch is. This number will serve as a functional ranking for connectivity of the site with other sites.

Area: The area of a site should be calculated from an accurate map. Any accurate and standardized method is acceptable.

Transects: Field data (described below) are gathered along sampling transects. Transects will be walked by the entire team (at least two people) simultaneously, the amount of time spent at a site will vary depending on the size of the site, but a minimum of 30 minutes must be spent on each site. (Some sites may take as much as a whole day, but most sites will probably take several hours.) At a minimum the transect should involve a walk along at least two sides of the site (at least 10 meters in from the edge) and two crossings through the center of the site (Fig. 2). A more elaborate transect is acceptable, but whatever pattern is used it must be standardized across all sites and should be determined on a map before reaching the site. The pattern may be altered in minor ways to accommodate oddly shaped sites or pre-existing paths. If in the course of conducting a survey all of the site indicators are checked (either positively of negatively) then it is not necessary to continue the transect and the survey team may move on to the next site.

Plant Species Richness: The site assessors should carry with them a selection of appropriate field guides for the site. At a minimum these should include a guide to trees and shrubs, a guide to flowers, a guide to ferns, and a guide to grasses. Along each transect, each new plant species encountered within 1 meter of the transect line should be identified and recorded. If a species cannot be identified, a clipping should be taken and it can be recorded as an additional unknown species. The total number of species encountered on the site will be used for the ranking. No weight is to be given to native vs. exotic species.

Breeding Bird Species Richness: A field guide suitable for identifying any bird potentially found in the region should be carried by the survey team. The team must include a member who is competent to not only identify the birds by sight, but also by their songs. All species found nesting, engaging in territorial behavior (e.g. singing), carrying food, etc. should be identified and recorded. The total number of species encountered will be used in the ranking. No weight is to be given to native vs. exotic species.

Trees >20cm Diameter at Breast Height: A metric diameter tape should be carried by the field team in order to make quick measurements of tree DBH. If any trees with a DBH of

greater that 20cm are found this category should be recorded positively. Alternately a pre-measured string (made of a non-stretchy material) can be used to determine whether or not trees are at least 20cm DBH.

Standing Water: This category can be determined on a map for large water bodies, but should be verified on the ground. Any standing body of water encountered during a transect will result in a positive recording for this category. Water bodies need not be located directly on the transect route to be counted, but must be visible from the transect.

Moving Water This category can be determined on a map for large water bodies, but should be verified on the ground. Any moving body of water encountered during a transect will result in a positive recording for this category. Water bodies need not be located directly on the transect route to be counted, but must be visible from the transect.

Seasonal Water: This is not a category that can be determined during the course of a transect as it is impossible to know with certainty whether a water body encountered will dry up seasonally or whether an apparently dry water body will fill up in the future. In order to make either a positive or negative finding in this category it is essential to rely on previous studies of the site. If GIS information is available for the area that is often a reliable source of information for this category.

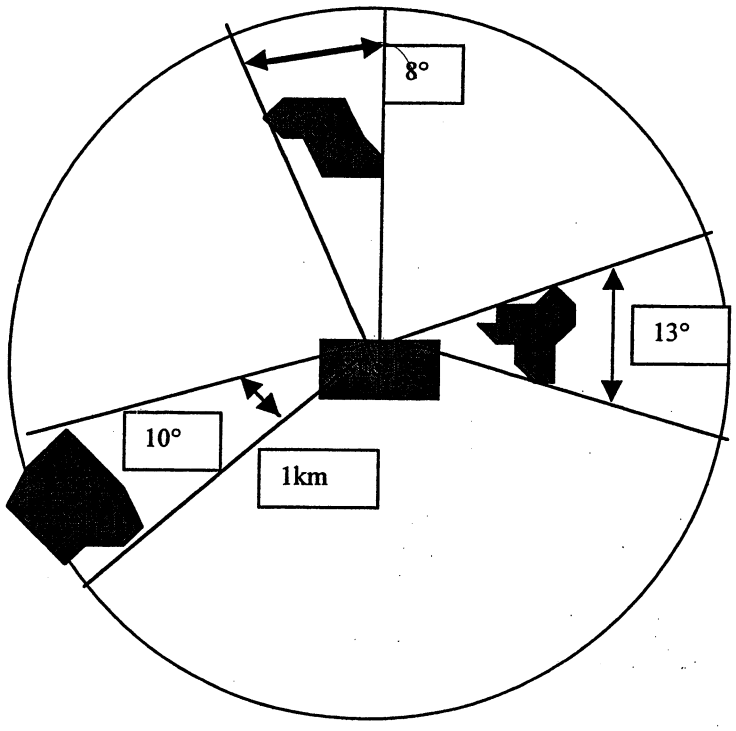

Figure 1. The total connectivity for this site equals $10^{\circ} + 8^{\circ} + 13^{\circ}$ or 31° of arc, so this site's connectivity value = 31.

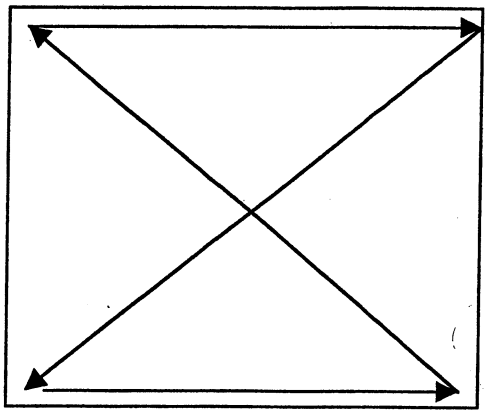

Figure 2. An example of a minimally acceptable transect path.

Impervious Surface: Impervious surfaces include any surface which will shed, rather than absorb, water. This category includes pavement, clay, densely packed earth, rock outcrops, etc. The approximate area of the site encountered during the transects should be recorded. A sketch of the overall site will be helpful in verifying these estimates. If detailed maps or aerial photos exist this area should be determined from them using the method described above under area. Accurate aerial photos are often a good means to assess the amount of impervious surface on a site, especially false infrared images.

Presence of REALLY Invasive Exotics: A few exotic species may be determined to be extremely detrimental to the ecological health of communities in an area due to their highly invasive nature. All members of the survey teams should be familiar with these species and be able to recognize them. The presence of any of these species on a site will result in a positive recording for this category.

Refuse: The presence of refuse on a site should be recorded. An occasional piece of litter need not be bothered with. This category is meant to identify the presence of large items (cars, furniture, refrigerators) or excessive amounts of litter (litter found constantly in large quantities along trails and paths).

Depth of Combined A & 0 Horizons: A soil core device should be carried by each survey team. At 10 equally spaced intervals along the transect a soil core should be taken and the combined depth of the A and 0 horizons measured. The average of these measurements will serve as the basis for the ranking in this category. These cores should be taken at least one meter away from a trail to avoid artificial soil compaction and disturbance of

the litter layer.

Presence of a 10ft High Fence: A fence that stretches from the ground to a height of 10 ft will act as a significant barrier to dispersal among many animal species and so should be noted. Thus such a fence occupying a part of a site is not of concern, but rather a fence surrounding the site or dividing it completely is of interest. If such a fence is encountered during a transect it is important to walk, or drive, along its entire length to determine whether or not it completely surrounds or divides the site. If it does then a positive finding should be recorded for this category. Significant holes (those large enough for wildlife to pass through) mean that the fence does not entirely surround or divide the site. That is why it is important to examine the entire length of the fence.

Habitat Enhancements: Enhancements include anything done to increase the suitability of the site as wildlife habitat. The primary examples in the category are bird houses and feeders, or bat boxes. If any are present a positive finding should be recorded for this category.

Presence of Tame Wildlife: If during the course of a transect the survey team is approached by birds or mammals (most likely ducks and geese and squirrels) apparently begging for food a positive finding should be recorded in this category. In most areas this category will include animals such as ducks, gees and squirrels, but may include other animals specific to the region. For instance alligators that do not flee upon the approach of the survey team should be included in Florida.

Community Specific Factors: These factors are going to vary widely from region to region based on the type of communities present. For each community that may be encountered at a site a list of several factors that are important to its ecological health should be drawn up. Specific methods for identifying the presence of these factors should also be defined. However many community specific factors are decided upon by the science team they should be assessed during the site survey. The preponderance of factors will determine whether a +1, -1 or 0 is recorded for this category rather than scoring points for each community specific factor itself.

Training: Because the survey teams will be comprised of various local citizens along with trained professionals from local colleges it will be possible to take advantage of the specialized knowledge of the individuals involved. Therefore it is not necessary for everyone to be trained in every procedure. However it will be essential to make sure that surveys can be done efficiently and accurately. To achieve this goal survey teams should conduct at least two or three practice transects on anchor sites to familiarize themselves with the methods and the area involved.

SITE DESCRIPTIONS

Below are brief descriptions of each of the 26 sites surveyed as a test for this methodology. They are all areas within the Mystic River Watershed that were identified through the process described above. Some are in urban environments while others are in

suburban environments. The site numbers are a byproduct of the GIS system we used and can be ignored.

5.6 - Woburn Landfill; Huge mountain of garbage or fill at northern end of site. Artificial wetland just south of it. Nice marsh at southern end of site and a diverse upland community. High percentage of exotic plants. Host heavily littered of all sites visited.

8.1- Burlington Native Forest: By far the most ecologically interesting site in our study. Apparently a truly untouched native forest. Warrants further study.

8.2 - Northeastern Univ. Field Station: A typical upland forest in good condition. Some abandoned buildings near road.

10.3 - Cranberry Bog Conservation Area: Apparently healthy marsh/stream system down stream from a superfund site. More mosquitoes than at any other site.

13.3 - Shaker Glenn Conservation Area: Hard to find access. Beautiful trail through nice northeastern woodlands along a slow moving stream.

14.3 - Horn Pond: Anchor Site. Most densely used site we visited. Multiple communities, extensive trails.

16.1 - Middlesex Fells East: Anchor Site. Largest site, well used, extensive trails, multiple communities.

16.3 - Boston Regional Medical Center: This site is a hospital. adjacent to the hospital and its parking lot is a meadow with Savannah Sparrows in fair condition, Most of the plant species on site are exotics brought in for landscaping,

19.1- Arlington's Great Meadows in Lexington: Large, multiple communities, mostly shrubland not meadow. Wet areas overgrown with Purple Loosestrife. Generally light usage, but there is an athletic field at one end. Lots of trails, American Chestnut Trees.

19.3- Arlington Reservoir: A reservoir. Marshy edges, wooded border. Site includes town housing for the elderly.

28.3- Fellsmere Park: Nice park with pond and woodland. excessively tame waterfowl, evidence of beaver. Fountain in the pond.

29.1- Lower Malden River: Much of the site is fenced off. Small park at southern end. Smelled like peanuts due to local factory.

33.2 - McClean Hospital: The portion of the site that is not taken up by the hospital buildings was a forest in fine condition.

34.1- Clay Pit Pond; Manicured park, fringing a large pond. More than 80% of plant

species were exotics. Canada Geese chased us away.

34.2 - Little Pond and Alewife Reservation: Mostly harmless.

34.4 - Mugar Site; Unusual site, isolated dense woodland with open patches of meadow. Former wetland now filled in naturally. Soccer fields at one end. Adjacent to Rte.2.

36.1- Mystic River Reservation: Manicured park with adjoining Phragmites marsh.

37.2 - Assembly Square Mall Waterfront: Manicured park along Mystic River with imagined soccer field.

38.1- Mary O'Malley Park: Manicured park with playgrounds adjacent to river. No bordering wetland.

38.3 - Hess Site and Urban Wild; Fenced in site with old oil pits and little else.

39.1 - Parkway Plaza; Mostly and abandoned mall with some bordering tidal wetlands dominated by *Phragmites,*

39.2 - Abandoned Field: Industrial old field entirely fenced. Some weeds .

39.3 - McClellan Highway Site (Donut Site): Small old field, much construction rubble. Tiny *Phragmites* wetland on site.

40.2. - Sell Isle Marsh: Anchor Site. Marsh/park. Park is manicured, but with some unmowed meadow communities. Marsh mostly *Phragmites*.

46.2- Wood Island Bay Marsh: Marsh adjacent to airport. Minimal use by people or wildlife. Only breeding bird was run over by a car.

46.3 - Tidal Flats: Long stretch of shoreline (beach).

RESULTS AND DISCUSSION

Table 1 is a ranking of the sites based on their survey score. Our site ranking did reflect a fair degree of variability between sites. However in future work it may be desirable to add new categories in order to create a finer scale. The most noticeable pattern that emerged was that the urban sites (those from Lower Malden River down in Table 1) all scored significantly lower than the suburban sites. This finding is hardly surprising, but does drive home the fact that a different concept of ecological value must be applied when dealing with the urban environment. The exception to this pattern was Bell Isle Marsh which is one of our anchor sites. It is approximately two orders of magnitude bigger than all the other urban sites and is managed as conservation land. It is therefore not surprising that it should score higher on our scale of ecological function.

Table 1 The Actual Ranking of Sites Based on Our Assessment Method

Site #	Site	Area	Conn	Fence	Imp	MW	StW	SeW	Plants	Birds	Soil	Trees	X	WE	Tame	Lit	Com Sp	Total
16.1	Middlesex Fells East	2	0	0	1	1	1	1	2	1	1	1	-1	0	-1	0	1	10
13.3	Shaker Glen Conservation Area	1	-1	0	2	1	1	1	2	1	1	1	-1	0	0	0	1	10
19.3	Arlington Reservoir	1	1	0	1	0	1	0	2	1	1	1	-1	0	0	0	1	9
40.1	Bell Isle Marsh	2	0	0	1	1	0	0	2	1	1	0	-1	0	0	0	1	8
34.1	Clay Pit Pond	0	1	0	1	1	1	0	2	0	1	1	-1	1	-1	0	1	8
28.3	Fellsmere Park	1	-1	0	1	1	1	0	2	0	1	1	-1	1	0	0	1	8
19.1	Arlington's Great Meadowsin Lexington	1	-1	0	2	0	1	1	2	0	1	1	-1	0	0	0	1	8
14.3	Horn Pond	2	-1	0	1	1	1	0	2	1	1	1	-1	0	-1	0	1	8
10.3	Cranberry Bog Conservation Area	1	-1	0	2	1	1	0	2	0	1	1	-1	0	0	0	1	8
36.1	Mystic River Reservation	1	0	0	1	1	1	0	2	0	1	1	-1	0	0	0	0	7
34.2	Little Pond & Alewife Reservation	1	-1	0	1	1	1	0	2	0	1	1	-1	0	0	0	1	7
33.2	McLean Hospital	1	0	0	1	0	0	0	2	1	1	1	-1	0	0	0	1	7
8.1	Burlington Native Forest	1	-1	0	2	1	1	1	1	-1	1	1	-1	0	0	0	1	7
46.2	Wood Island Bay Marsh	1	1	0	1	0	0	0	2	-1	1	1	-1	0	0	0	1	6
8.2	Northeastern Univ. Field Station	1	-1	0	1	1	0	0	2	0	1	1	-1	0	0	0	1	6
34.4	Mugar Site	0	1	0	1	0	0	0	2	0	1	1	-1	0	0	-1	1	5
5.6	Woburn landfill	1	-1	0	1	1	1	0	2	0	1	1	-1	0	0	-2	1	5
29.1	Lower Malden River	1	1	-1	1	1	0	0	0	-1	1	1	-1	0	0	0	0	3
16.3	Boston Regional Medical Center	1	1	0	-2	0	0	0	2	2	0	1	-1	0	0	0	-1	3
38.1	Mary O'Malley Park	1	-1	0	1	0	0	0	1	-1	1	1	-1	0	0	0	0	2
39.1	Parkway Plaza	1	0	0	-2	1	0	0	2	-1	-1	1	-1	0	0	-1	1	0
46.3	Tidal Flats	0	-1	0	2	0	0	0	-1	-1	-1	1	-1	0	0	0	1	-1
39.3	McClellan Highway Site	0	0	0	1	1	0	0	1	-1	-1	1	-1	0	0	-1	-1	-1
38.3	Hess Site & Urban Wild	0	-1	0	-1	0	1	0	1	-1	0	1	-1	0	0	0	0	-1
39.2	Abandoned Field	0	1	0	-1	0	0	0	1	-1	-1	1	-1	0	0	0	-1	-2
37.2	Assembly Sq. Mall River Front	0	-1	-1	1	0	0	0	1	0	-1	1	-1	0	0	-1	-1	-3

Imp = Impervious Surface
Conn = Connectivity
MW = Moving Water
StW = Standing Water
SeW= Seasonal Water

X = Invasive Exotics
WE = Wildlife Enhancements
Lit = Litter
Com Sp = Community Specific factors

Rapid Assessment Ranking Sample DataSheet

Criteria	Categories	Score
Plant species richness	<10 -1 10-25 0 25-50 +1 >50 +2	
Breeding bird species richness	<5 -1 5-10 0 10-20 +1	
Trees >20cm DBH	Yes (+1 forest, -1 otl No (-1 forest, +1 others)	
Standing water	Yes +1 No 0	
Moving water	Yes +1 No 0	
Seasonal water	Yes +1 No 0	
Impervious surface	0% +2 <10% +1 10-25% 0 25-50% -1>50% -2	
Presence of REALLY invasive exotics	Yes -1 No 0	
(purple loosestrife, *Phragmites* , oriental bittersweet, japanese knotweed, European Starling)		
Refuse	Large, leaky items -2 extensive - None 0	
Depth of combined A & O horizons	<3cm -1 3-6cm 0 >6 cm +1	
Connectivity	isolated -1 0 1	
Area	<1acre -1 1-10 0 10-100 +1100-1000 >1000 +3	
Presence of 10ft high fence	Yes -1 No 0	
Habitat Enhancements (bird or bat boxes)	Yes -1 No 0	
Presence of Tame wildlife	Yes -1 No 0	
Community specific factors	-1 0 1	
Grassland		
Litter layer	Thick +1 Sparse 0 Bare patches -1	
Invasive presence of woody plants	Yes -1 No 0	
Species of note		
Upland Sandipiper, Grasshopper Sparrow, Agrostis, Panicum		
Forest		
Litter layer	Thick +1 Sparse 0 Bare patches -1	
Multiple layers Hardwood or mixed	Solid canopy +1 Broken canopy 0	
Snags	Yes +1 No 0	
Naturally downed logs	Yes +1 No 0	
Species of note		
woodpeckers, salamanders, millipedes		

In evaluating our criteria it was found that some were much more useful than others. For example: although we expected to find invasive exotics at most sites, we originally thought that the few most invasive species might be a good indicator. It tuned out that they were ubiquitous and thus not useful. Our topsoil measurement also turned out to be useful only in distinguishing urban (poor soil) from suburban (good soil) sites, with little variability within these classes. Only two of our sites turned out to be surrounded by a fence while only two others had any wildlife enhancements. Although the plant diversity appears to be an important factor, our scale was not calibrated appropriately. We are currently evaluating different calibrations for plant diversity and are looking into increasing the categories and also narrowing them (from 25 species per category to 10 or 5).

One of the results of this study that interested us was the discovery of a new community; the park. Most of the sites we surveyed could be classed into one or more ecological community types, forest, grassland, marsh, etc. However we were perplexed over how to deal with a manicured lawn studded with large (often exotic) trees. Such environments were common and clearly had ecological value, but didn't fit into any of our preconceived notions. We are still working on a set of community specific factors to try to distinguish ecologically "good" parks from "poor" parks.

We have learned a great deal about evaluating ecosystems and rapid assessment methods from this study. Currently we are working on a year long evaluation and refinement of the method described above. All of our surveys were conducted over a four week period in late spring, so one of our first goals is to determine whether the method works at any time of year. We are also trying different survey techniques and ranking systems to make our method more effective and to better balance the speed and detail of the survey. We plan to report on these refinements at the 2003 conference.

ACKNOWLEDGMENTS

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LITERATURE CITIED

Anselin, A. ,and P.M. Meire. 1989. Multicriteria techniques in ecological evaluations: an example using the analytical hierarchy process. Biological Conservation 49:215-229.

Atkinson, S. F. 1990. A simplified habitat evaluation for use with remote sensing data. The Environmental Professional 12:122-130.

Baltimore County Department of Environmental Protection and Resource Management. 2001. A GIS-based methodology for establishing a greenway corridor system in a

fragmented forest landscape. In associatiation with Biohabitats, Inc.

Cook, E. A. 2002. Landscape structure indices for assessing urban ecological networks. Landscape and Urban Planning 58:269 - 280.

Dan, H, and W. Ru-song. 1998. An integrated approach to evaluation on ecological service functions for urban green space and its application. Journal of Environmental Sciences, China. 10:316-324.

Dana, E.D., S. Vivas, and J. M. Mota. 2002. Urban vegetation of Almeria City – a contribution to urban ecology in Spain. Landscape and Urban Planning 59:203-216.

Freeman, C. 1999. Development of a simple method for site survey and assessment in urban areas. Landscape and Urban Planning. 44:1-11.

Goodfellow, S., and G.F. Peterken, 1981. A method for survey and assessment of woodlands for nature conservation using maps and species lists. The example of the Norfolk Woodlands. Biological Conservation 21:177-195.

Grumbine, R. E. 1992. Ghost Bears: Exploring the Biodiversity Crisis. Island Press, Washington, D.C.

Karr, J. R., 1995. Ecological integrity and ecological health are not the same. In: Schulze, P. (Ed.), Engineering within Ecological Constraints, National Academy of Engineering, Washington, D.C.

Hanski, I. (1999) Metapopulation Ecology, Oxford Univ. Press, Oxford.

Hansson, L., Soderstrom, L. & Solbreck, C. (1992) The ecology of dispersal in relation to conservation. *Ecological Principles of Nature Conservation,* (ed. L. Hansson), pp. 162-200. Elsevier, New York.

Reed, J. M., T. Boulinier, E. Danchin, and L. W. Oring. 1999. Informed dispersal: prospecting by birds for breeding sites. Current Ornithology 15:189-259.

Schippers, P. S., J. Verboom, J. P. Knaapen, and R. C. van Apeldoorn. 1996. Dispersal and habitat connectivity in complex heterogeneous landscapes; an analysis with a GIS-based random walk model. Ecography 19;97-106.

Sisinni, Susan M., Marianne O'Hea Anderson, 1993. Methods and results of natural resource assessment in New York City, New York. Landscape and Urban Planning 25:95-114.

THE EFFECT OF EXOTIC SPECIES ON RIPARIAN PLANT DIVERSITY ON CONSERVATION LANDS IN THE GREATER BOSTON AREA

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ABSTRACT

As part of a long-term ecological research program instituted by the Urban Ecology Institute (UEI) in conjunction with Boston area high schools, we have conducted a research project through the Environmental Scholars Program at Boston College. We have investigated plant diversity at several conservation sites in the greater Boston area. These sites are significant to the educational programs administered by the UEI and the majority of them are also part of the Charles River watershed. At each site we investigated the effects of invasive exotic plant species on the biodiversity of the site. Our goal was to see if exotic plants were having an impact on diversity through an investigation that did not involve time series data and to create a baseline to investigate this issue over the long term.

Five fifteen-meter transects were laid out at each site. The transects were spaced evenly along the length of the river defined as the "site". All plants falling within .5m of the transect line were identified and counted. Linear regressions were conducted to analyze the effects of exotic species on the overall composition of the plant communities. Although exotic species were found at all sites, including some highly invasive species such as Phragmites *(Phragmites australis)* and Purple Loosestrife *(Lythrum salicaria),* no evidence was found to suggest that exotic species significantly reduced the diversity of native plants. There was a slight (not statistically significant) inverse correlation between the number of exotic plants and the number of native plants, but not between the numbers of exotic plants and the number of native species present. Our data represent a snapshot in time that we expect will serve as the basis for the long-term studies being carried out at these sites.

INTRODUCTION

A great deal of attention has been given to the issue of maintaining biodiversity in the environment around us. One particular issue of interest is the introduction of alien plant species into new areas and their affects on these communities. "Human induced biological invasions are occurring on a global scale and are beginning to blur the regional distinctiveness of the Earth's biota" (Westbrooks, 1988). That distinctiveness, which has developed over millions of years, is what maintains biodiversity. Many ecologists are concerned that if these invasions continue, biological systems throughout the world may become homogenized and many native species could decline or disappear altogether. To gain some insight into the matter, our research focused on several Boston area sites along the Charles River in order to explore the relationship between native and non-native plant species and determine how much of an effect, if any, these non-native plants really have on the biodiversity of the areas.

"Invasive plants are plants that have been introduced into an environment in which they did not evolve and thus usually have no natural enemies to limit their reproduction and spread" (Westbrooks, 1988). About 8,000 species or 3% of all known plants are considered to be invasive plants in agriculture (Westbrooks, 1988). They often out compete native plants for light, water and nutrients. Among the characteristics that allow them to rapidly invade are: early maturation, profuse reproduction by seeds, long life in the soil, seed dormancy, production of biological toxins that suppress growth of other plants, prickles, spines or thorns that cause injury and repel animals, the ability to parasitize other plants, roots, or rhizomes with large food reserves, survival under adverse environmental conditions, and high photosynthetic rates. Thus a combination of any number of these factors serves to increase the likelihood that such species will survive and successfully proliferate in new environments, eventually taking the place of native plants and reducing the biodiversity of such areas. Natural habitats can become degraded by multiple invasive species. However, it must be noted that most introduced species, including garden, meadow and agricultural species, are not harmful to native communities (Weatherbee et al., 1998). Thus it really just becomes a matter of using careful research and testing before intentionally introducing new species or varieties anywhere.

According to recent county-level floras and checklists, Massachusetts and Connecticut currently have the largest number of invasive plant species and observed invasions in New England (June 2000 Meeting of the New England Botanical Club). These data, along with numerous other studies, suggest that the biodiversity levels of native species in Massachusetts and elsewhere are at risk of being severely depleted (Crow, 1982). Over twenty long-term study sites have been established by the Urban Ecology Institute, which is working in conjunction with local high schools to educate and increase environmental awareness among today's youth. The six sites selected for this project are part of conservation lands that are either located directly along the Charles River or along one of its tributaries. The sites were chosen randomly for the purpose of investigating whether the natural environment of Massachusetts is really in as much danger as some experts are claiming. Some of the sites are part of local high school grounds such as Arlington and West Roxbury while others were part of public park grounds such as Nahanton Park and Leverett Pond. All of the sites studied here shared similar plant communities.

METHODS

Six sites were chosen in the greater Boston area along the Charles River, these sites were located in Brighton at the Northeastern University Boathouse, at Arlington High School, in South Boston at Leverett Pond, in Newton North at the Cheesecake Brook, at the West Roxbury High School, and in Needham at Nahanton Park. Five transects were plotted at each site perpendicular to the river or water source so as to equally divide each site. Each transect was 15 meters long and was measured with a rope marked in one meter increments. All plants that intersected each transect as well as each plant that was located within half of a meter to the right or left of the transect were keyed out and recorded. At each site the number of plants as well as the number of species were recorded. Those

numbers were later organized in a spreadsheet in Microsoft Excel and then analyzed using Statview 4.0. Linear regressions were performed to determine if there were any significant relationships between the numbers of native and non-native species.

Invasive plants were identified using A Guide to Invasive Plants in Massachusetts (Weatherbee et al., 1998) while native woody plants, trees, shrubs, etc. were keyed out using Petrides (1972) and Watts (1991) while herbaceous plants were identified using Peterson and McKenny (1968) and Newcomb (1977). Grasses were identified with (Brown, 1979). Research was conducted from early October to early April. As the weather grew colder and plants and trees began to enter dormancy, it became increasingly difficult to identify them, however resources like Levine (1995) and Trelease (1931) proved very useful.

Upon completion of the fieldwork, all the data from each transect of each particular site was compiled into an Excel spreadsheet. The plant numbers and species numbers were organized, separating native plants from non-native or exotic plants. The variables in this experiment were designated as follows; the number of plants, the number of species, the number of native plants, the number of exotic plants, the number of native species, the number of exotic species, and the number of unknown plants at each site. A series of linear regressions were conducted by compiling all the data and using different combinations of the variables to determine relationships between native and non-native plants and species.

RESULTS

A significant correlation was seen between the number of plants and diversity (Fig. 1) because as the number of plants in an area expands, the chance of coming across different species is greatly enhanced. This is evident by the close clustering of data points and the steep positive slope of the trendline. The more plants, the greater the likelihood of diversity in a given area.

Figure 2 shows the effect of the number of exotic plants on the number of native plants at the sites studied. Unlike the effects of density (Fig. 1), an increase in the number of invasive species does not have a significant effect on overall diversity. In fact, there is a slight increase in diversity as more invasives are encountered rather than the decrease that many people would predict.

The number of plants as a function of the number of species.

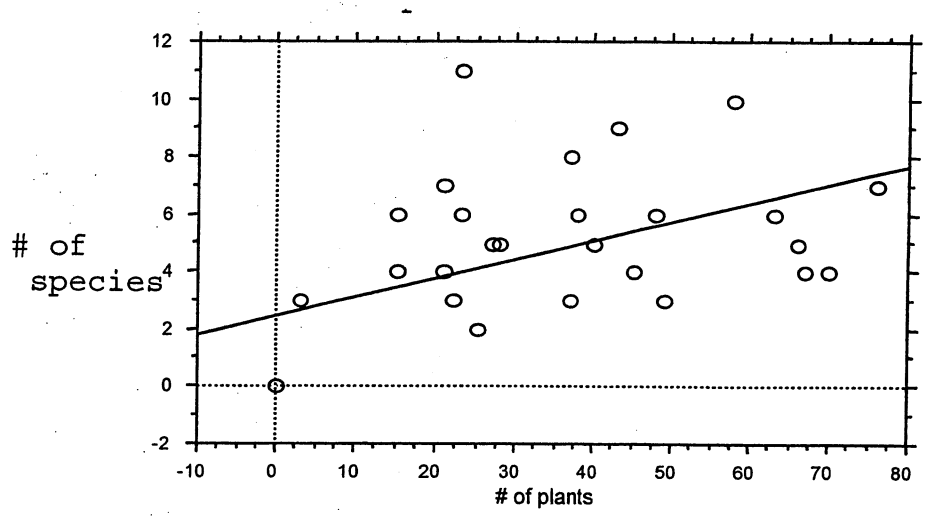

Figure 1 shows the effect of the number of plants on the number of species determined at the sites studied. As can be observed from the closely clustered data, the number of species increases as the number of plants increases.

The number of exotic species as a function of the number of exotic plants.

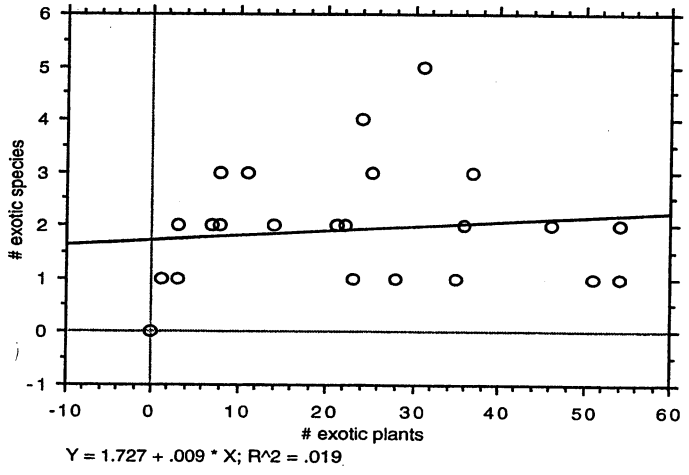

Figure 2. There is no significant relationship between the number of exotic invasive species found at a site and the overall number of plant species found at a site. The slight positive trend is not significant.

When looking solely at the native plants within a site it was found that the number of species increased with the number of plants found (Fig. 3). This trend is highly predictable and should not come as a surprise to anyone. The outlying points are easily explained by large stands of one or two species (such as *Typha*) or by intentional planting of native species.

The number of native species as a function of the number of native plants.

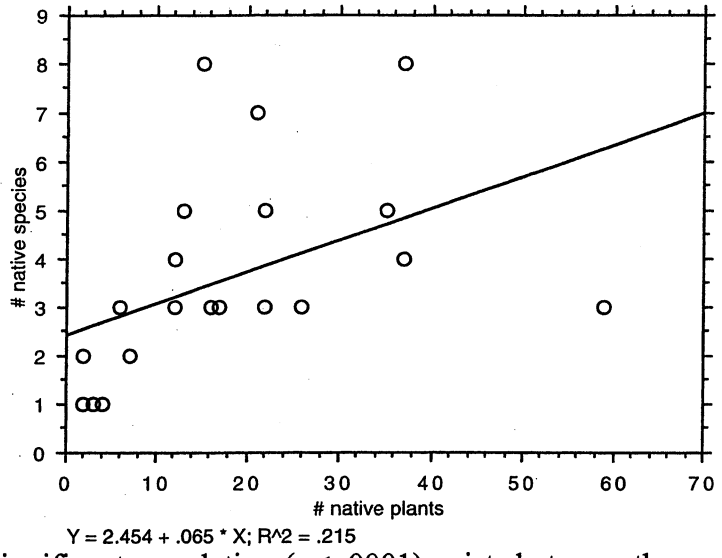

Figure 3. A highly significant correlation ($p < .0001$) exists between the number of native plants at a site and the number of species encountered. Such a pattern is expected in any environment.

There is no relationship between the numbers of exotic species the number of native species (Fig. 4). If the claims of most environmentalists that invasive exotics are detrimental to ecosystem diversity are accurate then one would predict a negative slope for this graph. Our results seem to indicate that invasive exotics do not have a significant negative impact on total plant diversity. This pattern may change in time however, and our results may speak more to trying to use a snapshot method of analysis to answer long-term problems than to the true nature of competition in the community.

A similar pattern is seen when comparing total number of invasive exotic plants to the number of native plants (Fig. 5). Although in this case there is a downward trend, it is not statistically significant ($p > .3$). Such a pattern would indicate that the exotics are not, in fact, eliminating native species from the ecosystem. The findings of these two analyses (Fig. 4 and 5) suggest that rather than reducing diversity, the exotics are adding to it.

The number of native species as a function of the number of exotic species.

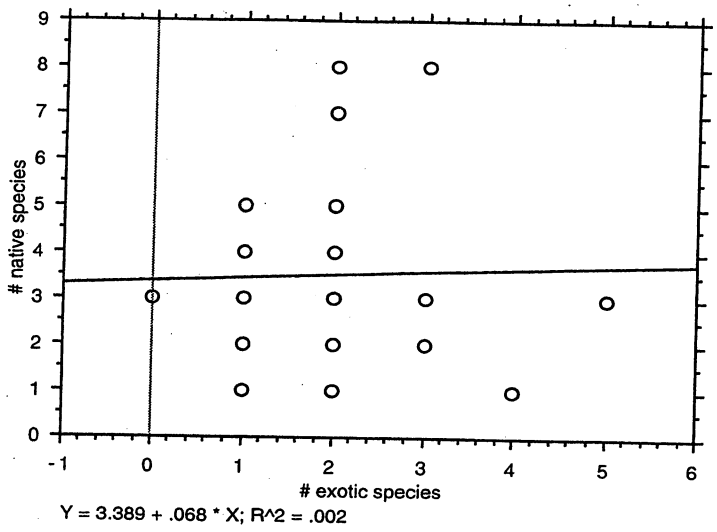

Figure 4 shows the effect the number of exotic plants on the number of native species at the sites studied. There is no correlation between these two variable, indicating that an invasive species make up a larger proportion of the community they do not reduce the diversity of native species, but rather add to it.

The number of native plants as a function of the number of exotic plants.

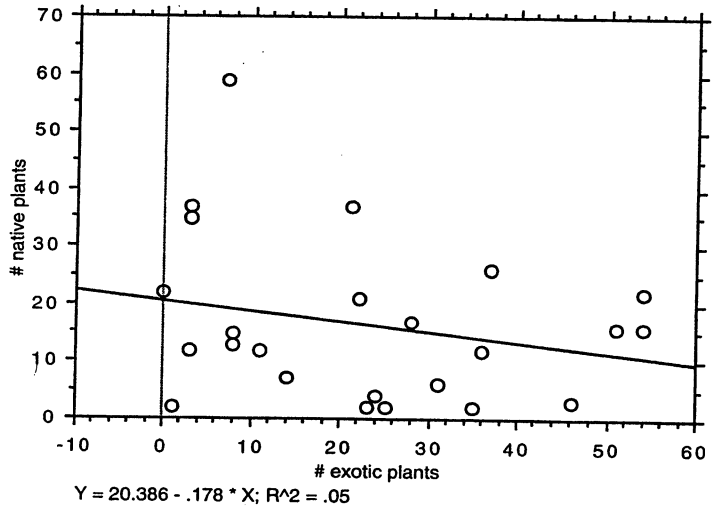

Figure 5 shows the effect of the number of exotic plants on the number of native plants at all six sites. The trendline again has a slightly negative slope, but it is not statistically significant ($p>.3$). There is no significant relationship between the number of exotic plants and the number of native plants.

When the variables of number of plants and number of species were crossed interesting patterns resulted. It was predicted that the number of native plants would decrease as the number of exotic species increased (Fig. 6) and that the number of native species would decrease as the number of exotic plants increased (Fig. 7). Although the former was found to be the case, the latter was not. The observation that exotic species seem to become dominant within the community and reduce the ecological role of native species without actually eliminating them from the environment is significant, as it implies that native communities may be hardier and easier to restore than many believe.

The number of native plants as a function of the number of exotic species.

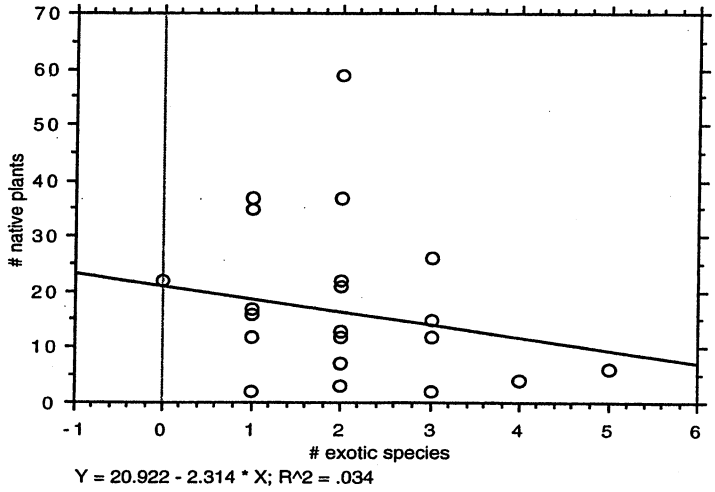

Figure 6 shows the effect of the number of exotic species on the number of native plants at the sites studied. This trend is significant ($p<.05$) indicating that the populations of native plants decrease as more invasive species move into their environment.

The number of native species as a function of the number of exotic plants.

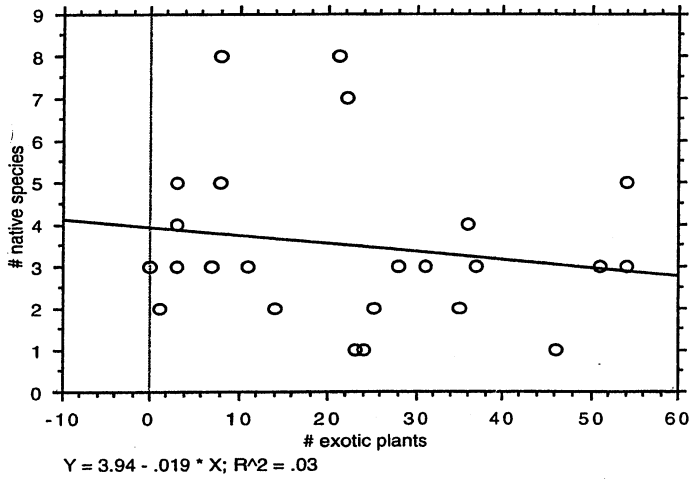

Figure 7 shows the effects of the number of exotic plants on the number of native species at the six sites There is no significant trend here indicating that even as invasive species become dominant in a community native species are able to persist.

DISCUSSION

This study was performed during the 2001-2002 academic year although most of the field data was collected from early October through mid December 2001. As the seasons shifted from autumn to winter, it was increasingly difficult to key out plants, trees and shrubs because many of them began to loose their foliage, which left fewer characteristics to use for identification. Earlier in the research process, it was quite simple to key out certain species as familiarity with the different types improved.

While the linear regressions did not support the premise that exotic species were diminishing the biodiversity of the areas they inhabited, it was interesting to note, that where some species grew, they often took up large areas forming monocultures. One prominent example was the Japanese Knotweed *(Polygonum cuspidatum).* Although it was not found intersecting every transect of every site, it was quite common. In areas where it was found, like along the Charles River in Brighton, it formed dense stands where no other species of plant could be found. So when it did grow, it took over an area and prevented the growth of any other plants. When invasive species were identified, they tended to be found in clusters. Another example is Oriental Bittersweet (*Celastrus orbiculata*) a vine that wound around young trees choking them or spread over low vegetation, smothering it. The Arlington site had a fair amount of Oriental Bittersweet, as well Japanese Knotweed (*Polygonum cuspidatum).*

It was also expected that there would be positive relationships between the number of exotic plants and the number of exotic species as well as the number of native plants and the number of native species. These relationships can be seen in Figures 2 and 3 respectively. In both plots, there was a slight increase in the slope of the line as well as a clustering of points that suggested that as the number of exotic plants increased the number of exotic species increased. This was the same for the native plants and species. These findings tie in with Figure 1 where an increase in the general number of plants causes an increase in the general number of species.

According to the data gathered throughout the experimental process, there does not appear to be a strong relationship between exotic plants and native plants. Prior research has concluded that we're losing the battle of biodiversity and that many introduced plants are becoming invasive and will cause severe damage to the biodiversity of our systems, now and well into the future. But the data from this research project denies that allegation. It is true that certain invasive species are really harmful and that they are killing off others. But in the grand scheme of things, what they may be destroying may not be that significant.

The only way to address the discrepancies is to continue our research. One likely interpretation of the data from this study is that snapshot studies (one year or less) are simply inadequate to discern the effects of long-term community transitions. This study will serve as a baseline for additional work over the upcoming decades to determine whether or not the patterns we observed are permanent or transitional. However based on

this study it appears that invasive species will occupy large areas of a community thus reducing the populations of native species, but that they will not eliminate those native species and thus increase the overall alpha diversity of the area.

ACKNOWLEDGMENTS

We would like to take this opportunity to thank Heather Langford and the VISTA members of the Urban Ecology Institute at Boston College for their time and effort in assisting with the initial setup of this research and for graciously supplying us with the essential maps and overviews of the sites studied.

LITERATURE CITED

Brown, Lauren 1979. Grasses An Identification Guide. Houghton Mifflin Co., Boston, MA, 240pp.

Crow, Garrett E. 1982. New England's Rare, Threatened, and Endangered Plants, U.S. Government Printing Office. Washington, D.C.

Levine, Carol 1995. A Guide to Wildflowers in Winter, Yale University Press, New Haven, 329pp.

Newcomb, Lawrence 1977. Newcomb's Wildflower Guide. Little, Brown and Co. Boston, 490pp.

Peterson, R, T. and Margaret McKenny. 1968. A Field Guide to Wildflowers. Houghton, Mifflin Company, Boston.

Petrides, George A. 1972. A Field Guide Trees and Shrubs, Houghton Mifflin Company, Boston.

Watts, May T. 1991. Tree Finder: Manual for the Identification of Trees. The Nature Study Guild, Rochester, NY. 64pp.

Weatherbee, Pamela B., Paul Somers and Tim Simmons. 1998. A Guide to Invasive Plants in Massachusetts. New York Botanical Garden.

Westbrooks, R. 1998. Invasive plants, changing the landscape of America: Fact Book. Federal Interagency Committee for the Management of Noxious and Exotic Weeds. Washington, D.C. 1O9 pp.

Trelease, William, 1931. Winter Botany Dover Publications, Inc. New York, NY.
http://www. huh.harvard.edu/nebc/Summaries/2000/Jun00sum.htm
1 Summary of the June 2000 Meeting of the New England Botanical Club.

APPLYING DECISION ANALYSIS METHODS TO NRDA RESTORATION PLANNING

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ABSTRACT

Restoration planning is often a complex problem characterized by the need to consider multiple project objectives, a range of alternatives, the views of all stakeholders, and the uncertainties associated with restoration performance and cost. These disparate data, ranging from cardinal numeric data to ordinal subjective opinion, must be integrated to define clear objectives, identify appropriate alternatives, and then select appropriate projects for restoration.

Both decision tree and multi-criteria decision analysis methods were used to help natural resource trustees systematically evaluate injury monitoring options, restoration technologies or projects, and public participation approaches for Natural Resource Damage Assessment (NRDA) cases. The utility of these methods is illustrated using four examples: 1) selecting coral reef structural repair technologies, 2) ranking solicited projects for river corridor restoration, 3) determining the expected value of real-time monitoring of potentially injured fish stocks, and 4) evaluating options for public participation in restoration planning.

Decision analysis methods can help planners develop, communicate, and document defensible restoration plans and reduce potential claims that the restoration decisions are arbitrary or capricious. They are especially useful in cases that involve multiple stakeholders or interdisciplinary technical teams and uncertainty with respect to restoration performance or cost.

INTRODUCTION

Developing restoration plans for a Natural Resource Damage claim, or any major restoration or mitigation project, is often a complex undertaking characterized by the involvement of multiple agencies and/or stakeholders and the need to consider multiple objectives. Restoration planning is also subject to both technical and cost uncertainties. In many NRDA cases, there is considerable controversy and even legal action to alter trustee decisions. Stakeholders with different agendas provide competing ideas as to how recovered funds should be invested. There is sometimes disagreement between technical experts or trustees who represent different disciplines or resource interests.

Restoration planners are challenged to develop restoration plans that can be defended and implemented in a timely manner. Significant implementation delays, due to controversy or protests, can result in escalated costs, delayed resource recovery, and increased economic damages due to extending the period of lost use. If selected projects are significantly altered or dropped, the credibility of the Trustee agencies may be adversely impacted.

In addition to the inherent complexity, planners need to address regulatory and administrative requirements. Restoration plans need to be consistent with the regulatory guidance provided. This guidance is often general in nature and provides no advice on how to integrate criteria or make trade-offs. The basic decision framework must also be consistent with any other related trustee agency policy or Memoranda of Agreement (MOAs) negotiated for the case.

The restoration plan must be clearly linked to the claimed injuries. A clear rationale for the proposed restoration actions showing how they relate to the injuries is needed, or the trustees are liable to claims that their selected actions are being "arbitrary and capricious."

Restoration plans should also be impartial, easy to communicate, and documented well enough to be defensible should protests or legal action arise. It is not uncommon to have active political and stakeholder involvement once trustees have obtained damages from responsible parties. Plans must be adaptable, since plans are usually initiated during ongoing injury investigations as a means of estimating damages and may require change as new information on the nature and extent of injuries or natural recovery becomes available.

DECISION ANLAYSIS METHODS

Decision analysis (DA) is a structured modeling approach well suited to providing insights to improve complex decisions where tradeoffs between completing objectives are required or when considerable uncertainty exists with respect to the performance or cost (Keeney and Raiffa, 1976). Decision analysis methods, commonly used in systems analysis and management science, can serve as a valuable aid in sorting through some of the problem issues encountered in complex restoration planning efforts. DA provides a means to explore a range of potential future scenarios, integrate disparate information, explicitly consider uncertainty, assess which information is most relevant to the decision, and demonstrate how much decision-makers should be willing to pay to obtain additional information.

We have used two decision analysis approaches, multicriteria methods and decision trees, to assist Federal and State agencies with various aspects of restoration planning. Multicriteria methods are used to help integrate information and values related to multiple objectives that cannot readily be converted into the same unit of measure. Site

selection, technology selection, and risk ranking problems are common examples for this approach. In these decisions, tradeoffs often need to be made between various environmental, economic, and socio-political factors. This approach is particularly useful when an interdisciplinary or interagency team is involved in group decision-making.

Decision trees provide a means of exploring a sequence of decisions and chance events that, at the end of the planning horizon, result in consequences. An example application might be an evaluation of alternative multi-year vegetative replanting strategies with different initial costs and reliabilities. The differential success is a result of the chance of adverse weather conditions during the period following initial planting. In this case, the probabilities of various alternatives are multiplied by the potential values to project an expected value for the each alternative branch of the tree.

Decision trees can also be used to consider the expected benefits of obtaining additional information that can be used to improve or refine the plans. Value-of-information assessments, essentially back calculations of the tree branches, can indicate how much one should be willing to pay to obtain additional information before the final decision is made. This approach can be useful in justifying the need for monitoring during the injury assessment phase of the NRDA or monitoring of restoration projects involving uncertainty.

RESULTS - NRDA CASE APPLICATIONS

The decision support applications described here were developed to aid trustee decision making, not to make decisions. Four examples are presented to illustrate the types of applications that may be useful for any type of complex restoration or habitat creation project. These include:

1. Two vessel groundings in the Florida Keys National Marine Sanctuary
2. A river corridor restoration program associated with a rail car toxic spill in the upper Sacramento River, California
3. A major marine oil spill, the *Exxon Valdez* in Prince Williams Sound, Alaska.
4. The Guadalupe Dunes site in CA, an oilfield in an undeveloped area on the California coast.

The first two projects involved group multicriteria analysis to select restoration alternatives based on multiple factors. The second two projects used decision tree analysis to explore future scenarios related to the benefits real time injury monitoring and options for stakeholder participation in restoration planning.

Example 1: Selecting Coral Reef Structural Restoration Options

NOAA pursued two NRDA claims related to the groundings of the M/V Maitland and M/V Elpis in the Florida Keys National Marine Sanctuary and recovered damages from

the responsible parties. NOAA then had to decide how to structurally restore the injured coral reefs, something that had not been attempted before. The challenge was to select a structural engineering remedy to stabilize the reef substrate so subsequent recolonization and transplanting could take place. Time was of the essence, as the site surveys indicated that further damage was occurring due to erosion and movement of loose coral debris. This decision involved a spatially distributed interdisciplinary team, composed of biologists, oceanographers, engineers, sanctuary managers, attorneys and contracting specialists.

A group multicriteria decision analysis approach was implemented using faxed and e-mail surveys to obtain initial preference information (Sheehy 1994). The decision process linked the engineering design process with the restoration planning process (Figure 1). Mitigation requirements were delineated in the tiered Environmental Assessments prepared once the preferred alternatives were identified.

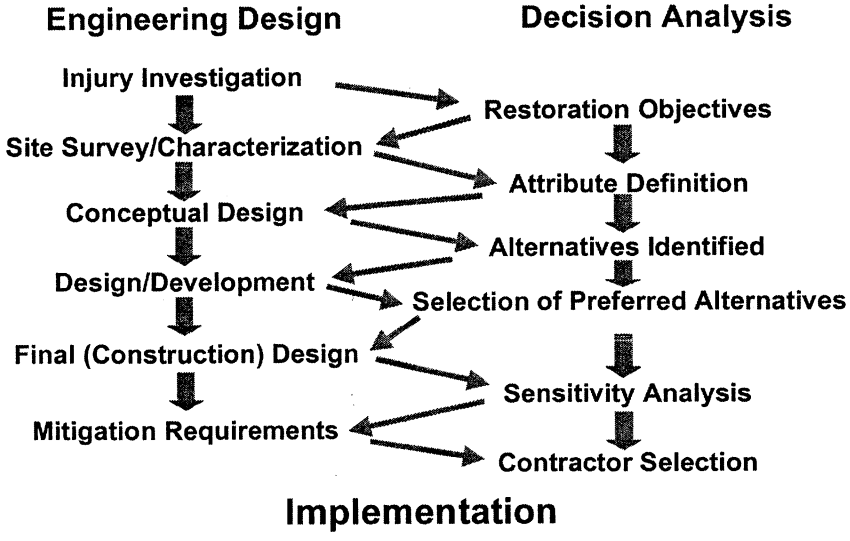

Figure 1. Linkage between engineering design and decision analysis processes in the selection and implementation of coral reef structural restoration methods.

The multicriteria approach is often presented as a matrix of criteria considered in the evaluation along the Y-axis and alternative courses of action along the X-axis (in this case potential structural remedies). When there are multiple technical experts or stakeholders being tracked, this often takes the form of a three-dimensional spreadsheet where the Z-axis is composed of separate input from the individual technical experts or stakeholder groups. The criteria are scored for each alternative using interval number scales designed to model the decision-maker's preferences. A highly simplified example of the *M/V Maitland* site evaluation matrix is illustrated in Table 1. Total scores reflect relative merits of a subset of considered alternatives. The preferred alternative in this case was the Reef Replicating Armor Unit, a prefabricated module whose upper surface was textured to look similar to coral bottom.

Table 1.
Simplified example of the M/V Maitland site evaluation

Criteria	Weight	Continuous Concrete Cap	Boulder Fill	Gabions	No Action	Armor Units
Aesthetics	49	4	2	1	4	4
Consistent with Agency Strategy	53	3	3	2	2	4
Tech. Feasibility	86	3	3	3	4	3
Potential for Collateral Injury	72	3	3	3	3	3
Public Perception	28	4	2	2	1	4
Reduce Recovery Time	81	4	3	2	1	5
Reduce Potential Additional Injury	91	4	3	3	1	4
Total cost	43	$480K	$449K	$128K	0	$470K
Total Score Range		3.2-4.0	2.7-3.5	2.2-3.1	1.8-2.7	3.5-4.4
Alternate Rank		2	3	4	5	1

The criteria were first assigned weights based on their relative importance to the decision-makers then scored for the relevant criteria. The outcomes were compiled using an additive weighting method, one of the more common multiple attribute methods. For each criterion, the weight is multiplied by the normalized score and these weighted scores are summed for each alternative. The weighted sums of all criteria reflect the relative preference for alternatives. Individual evaluator scores were combined to yield an overall group evaluation. Sensitivity analyses were conducted to assess which factors were driving the rankings or where there were significant conflicts between evaluators or stakeholder groups. This information was used to focus discussions and quickly reach a consensus. Two new engineering approaches were selected for the structural restoration of the coral reef sites.

Although commonly used, this approach is often applied incorrectly due to lack of knowledge of the underlying theory. For example, ordinal number scales are commonly used to rate criteria and these numbers can be legitimately added. As with statistical programs, you need to consider the inherent method assumptions and develop unbiased questions about scores and weights. Poor applications often create the illusion of a rational approach while in fact they mask some serious flaws.

One of the primary benefits of the multicriteria approach used in this application was its utility in integrating the trustee restoration planning with the engineering design process. This integration kept the trustees objectives in focus throughout the design process. The iterative feedback between the two processes helped identify key concerns, such as aesthetic compatibility and the potential for collateral damage, that were not considered in the initial engineering analysis.

Another benefit was that the comparative analysis of alternatives provided the ready basis for the Environmental Assessments (EAs) required for implementing the restoration. The EAs were based (tiered) on the decision analysis document thereby expediting their completion. The concerns identified during the decision analysis and discussions were incorporated as mitigation measures in the EAs.

As a consequence of the unique nature of the project and the potential for collateral damage during restoration implementation, we were able to convince trustees to adopt a "best value" procurement approach. This is really another form of the multicriteria method used to select contractors or sources when more than just minimal technical competence and cost is important.

Example 2: Restoration Project Selection - Cantara Metam Sodium Spill

The release of metam sodium, a soil fumigant, from a train upset in the upper Sacramento River killed almost everything living in a 40-mile reach of the river. The California Department of Fish and Game (CFG) was the lead trustee involved in restoration planning efforts for this case. After conducting some core projects, CFG decided to build a restoration program by seeking a broad range of restoration project proposals. A grant program was established to fund restoration and was implemented annually for five years after the case settled.

This was a controversial case with non-trustee groups involved legally in the process. Therefore the development and selection of projects had to be impartial and defensible. The process also had to be adaptable, since it would occur over a 5-year period during which recovery and the performance of initial restoration would be monitored. The decision process used to select projects was reevaluated each year and some modifications to criteria weights or project categories were made to adapt the process to restoration progress.

Multicriteria group DA methods used in this case were designed to accommodate a range of distinct project types (restoration, research, acquisition, and public education) (Sheehy *et al.* 2000). The decision analysis was based on the guidance in charter documents (Regulations, policy, MOAs etc.) and used as the basic framework for the evaluation of projects. The decision analysis process was included as an appendix to the annual grant solicitations to provide a clear picture of what the trustees were looking for and how they would evaluate proposals. A turnkey software program was developed to help a technical review team, composed of members from all of the participating trustee agencies, implement their analysis of proposals.

The trustee council issued a solicitation and established a review team to evaluate the proposals submitted using the software tool. The weights, reflecting the relative importance of the criteria were reevaluated each year by the technical panel using a pair-wise comparison algorithm. For all proposals received, each reviewer scored each criterion and the software made computations and assigned overall scores/ranks for the

group to review. The technical teams recommendations were presented to the Trustee Council, which made the final selections.

An example value hierarchy used to evaluate the restoration, rehabilitation, and enhancement category of projects is shown in Figure 2. Additional project categories included 1) study and research, 2) property acquisition and resource protection, and 3) public information and education. Each project category had a separate valuation hierarchy tailored to its specific nature. However, the overall framework for all four categories was based on three primary objectives: 1) provide the greatest practicable restoration benefit to the injured resources, communities, and habitats, 2) ensure that restoration activities were closely related to the resources injured, and 3) achieve these objectives cost-effectively and in a timely manner.

In each project category, the technical review panel assigned projects one of three tiers. Tier I were top scoring projects that provided substantial benefits and were recommended for funding. Tier II consisted of projects lower in overall benefit, but still above a minimum threshold, and Tier III did not meet this threshold and were not recommended for funding.

The technical team's recommendations, based on the decision analysis process, were well received and trustee decisions were over 90% consistent with the team's recommendations (Table 2). 94% of the projects assigned to tier I received funding while only 3% of the projects assigned to tier III were funded. The trustee's project selections were challenged by an interested stakeholder and the decision analysis proved useful in defending against claims that trustees were arbitrary and capricious in their decisions.

Example 3: Monitoring Returning Salmon Stocks- The Exxon Valdez Spill

During the preliminary restoration planning for the *Exxon Valdez* oil spill, EPA initiated efforts to get a handle on the scale of injuries and potential restoration requirements. Federal and state trustee agencies were trying to prevent further injury to fisheries. A major concern was how to best regulate the salmon fishery to protect the resource as it entered the spill impact area.

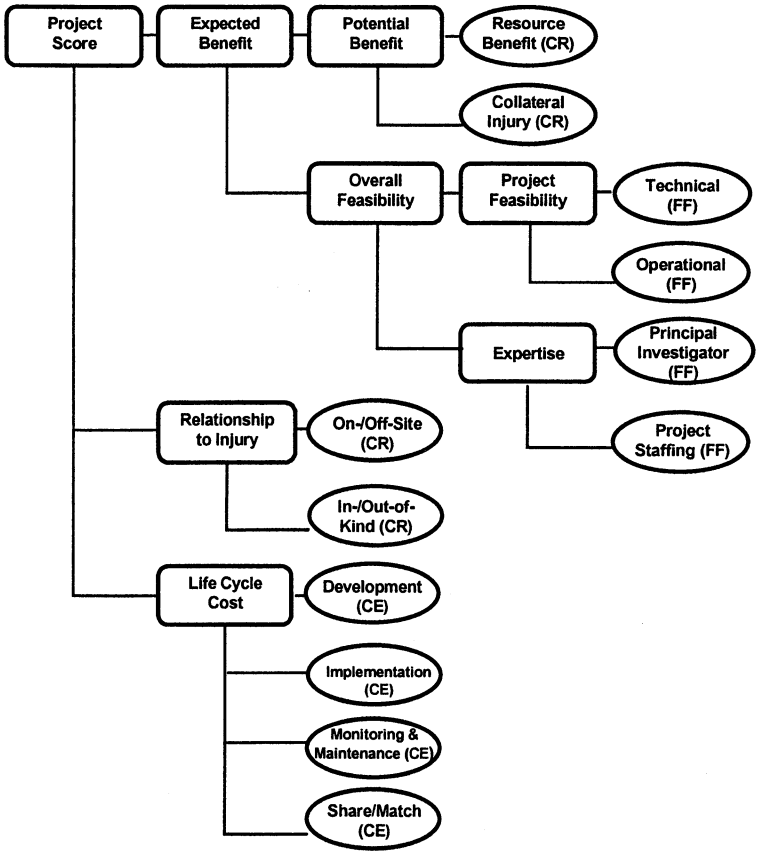

Figure 2. Value hierarchy for restoration, rehabilitation, and enhancement projects. Ovals indicate criteria (CR), feasibility factors (FF), or cost elements (CE) evaluated by the technical review panel. Feasibility factors helped consider the uncertainty in expected performance. Potential benefits were modified by the feasibility factors to provide more realistic expected benefits.

In this case, the traditional conservative approach would have been to close the fishery and thereby protect the returning adults. However, this was a culture-based fishery augmented with hatchery production. If the fishery was closed and there was limited impact due to the spill, too many fish would return to spawning areas. The resulting large population of juveniles would deplete the lake forage base and adversely impact the future stock.

A decision tree approach was used to explore alternative fishery management strategies shortly after the spill in order to protect the returning salmon stock (Sheehy 1990). The simplified core part of the decision tree is illustrated in Figure 3. The initial circle represents a chance event, the impact of the spill, and provides three example scenarios, a good year class (no spill impact), a poor year class (modest spill impact), and a very poor year class (serious spill impact). The square decision node that follows reflects the fishery management decision on how to regulate fishing to reduce further injury to the stock and subsequent damage to the fishery.

Table 2.

Relationship between technical panel recommendations (using decision support system) and Trustee Council decisions for 115 proposals received during 1996 and 1997.

Demonstrates the consistency between the Council's decisions and the panel's recommendations related to specific subtasks, funding levels, or phased implementation.

Category	Benefit Tier	Council Funding			Percent Funded	Percent Consistency
		Full	Part	None		
Restoration	I	5	1	0	100	83
	II	0	4	3	57	71
	III	1	0	15	6	94
Acquisition	I	2	2	0	100	100
	II	0	1	2	33	100
	III	0	0	5	0	100
Research	I	1	2	1	75	75
	II	0	3	11	21	71
	III	0	0	28	0	100
Education	I	0	3	0	100	100
	II	0	2	4	33	100
	III	0	1	8	11	89
Tier Totals	I	8	8	1	94	88
	II	0	10	20	33	83
	III	1	1	56	3	98
Totals		9	19	77	24	91

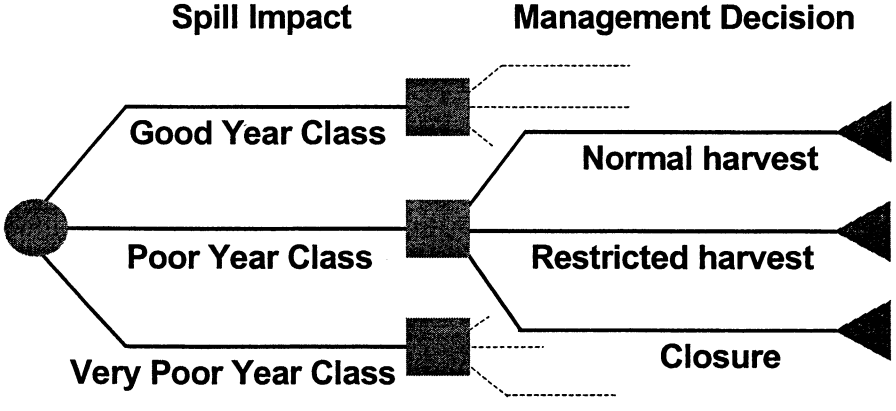

Figure 3. A simplified version of the decision tree used to evaluate alternate fishery monitoring strategies for returning salmon stocks. Chance node (circle) reflects strength of returning year class and decision (square) node indicated management decision. Triangles represent the fishery consequences in dollar value.

Three representative management choices are illustrated: normal fishing, a reduced catch, and outright closure of the fishery. Each branch of the chance node had the same set of choices, but they are just sketched in here to avoid clutter. The nine potential outcome scenarios represented in this simple example (triangles) were the expected values of the salmon harvest under each combination of spill injury and management decision.

Initial analyses were conducted using past data on the value of the harvest, stock-recruitment predictions based on the strength of the returning year class, juvenile lake forage carrying capacities, and predictions on future year class strength. Results demonstrated that the potential economic loss and subsequent damage to the fishery was highly dependent on how the returning stock was regulated

A simplified example of the results from this decision tree analysis is illustrated in Table 3. This payoff matrix is generated by multiplying probabilities by the estimated values to project an expected payoff in terms of the value of the stock across each path through the decision tree. For this example, if no spill impact occurred and normal fishing were allowed, payoff would be the greatest (+25). However, if a very poor year class occurred due to a significant impact and no special restrictions were imposed, projected losses could be very significant (-20).

Table 3.
General form of a payoff matrix for the fishery monitoring decision.
Output for each of the nine combinations considered project the relative economic value of combination of chance impact events and management decision.

Harvest Strategy	**Spill Impact on Returning Salmon Stock**		
	None, Good Year Class	**Partial, Poor Year Class**	**Severe, Very Poor Year Class**
High	25	-5	-20
Low	10	5	-5
Closure	-5	-5	-8

The results indicated the need for reducing the uncertainty in the status of the returning stock via monitoring to afford managers the opportunity to adaptively regulate the fishery. The question arose as to how to justify this preventive monitoring expenditure so that it might be recovered in the claim. To examine this issue we conducted a "value of information" analysis, which is a form of back calculation of the tree, to show how much a decision maker should be willing to pay to obtain additional information. This approach essentially established a decision node in front of the chance node that reflected the trustee decision on whether or not to implement real-time monitoring. By comparing the cumulative difference over all scenarios resulting from each new branch, we demonstrated that the cost of real-time monitoring was justified. Failure to obtain prior knowledge of the status of returning stocks could cause long-term damage to the fishery. The trustees implemented real-time monitoring and the results were used to adjust fishing pressure.

Example 4: Evaluating Public Participation Options - Guadalupe Dunes

The Guadalupe coastal dune site involved ground and surface water releases of both oil and a diluent designed to promote oil flow through oil field piping systems. Since it was an otherwise undeveloped site along the CA coast, it was rich in threatened and endangered species and rare habitats. The case was controversial and there were a number of diverse stakeholders including property owners, environmentalists, surfers, developers, and owners. Further complicating the situation, the site was in the process of being abandoned by the current operator and redevelopment opportunities were being considered concurrently with the planned remediation and restoration.

For the US Fish and Wildlife Service, we examined potential options for involving the public in the restoration process. A decision tree model was developed to explore various alternative scenarios and a retrospective study of a number of other NRDA cases was conducted to collect data to support the analysis (Sheehy and Vik 1999). The preliminary analysis clearly demonstrated the potential impacts of public controversy on restoration decisions.

The basic decision tree illustrated in Figure 4 was developed to provide insight for considering how best to involve stakeholders in the planning process. The tree describes a sequence of chance events (stakeholder actions/responses) and trustee decisions

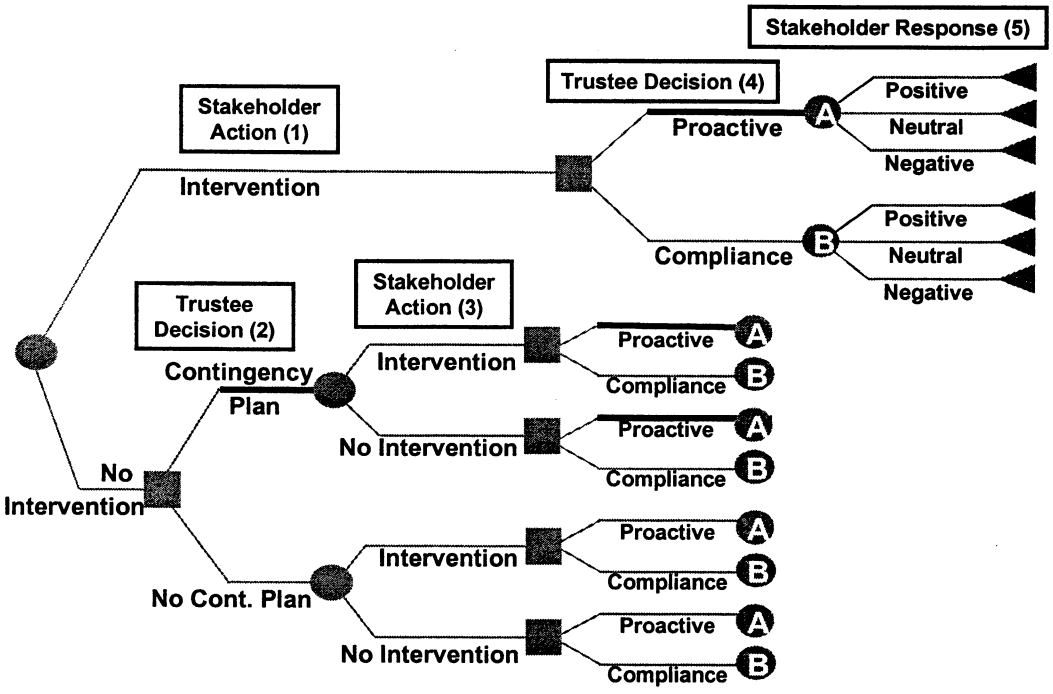

Figure 4. Public participation option analysis for the Guadalupe Dunes case. Results suggest the value of contingency planning and the adoption of a more proactive stakeholder involvement approach to increase the probability for timely and effective restoration (shown in bold).

that brackets the range of potential scenarios. Model inputs included estimated costs for planning, public involvement programs, delays in restoration implementation or changes to the plan. The estimated costs for contingency planning, proactive and compliance involvement, and potential consequences were based on information from past NRDA cases. Probability estimates for various types of stakeholder intervention were developed after consulting local experts and conducting content analysis of regional media.

This was a simplified example with only a subset of possible chances and decisions. In this case, stakeholder intervention might occur before or after the preparation of a trustee contingency plan for addressing such an action. Trustees could elect to adopt the common minimal requirement for participation (compliance) or seek a more proactive approach. The stakeholders' responses ranged from positive to negative, where a negative response might lead to delays due to legal efforts to change the plans.

For the Guadalupe case, the results clearly suggested the benefit of developing a contingency plan to provide a preplanned and coordinated response to stakeholder intervention. It also suggested the merits of using a more proactive approach than the minimal required by regulation (compliance). These recommended courses of action are shown in bold in Figure 4 and may have implications for future NRDA cases.

DISCUSSION

One of the primary benefits to applying decision analysis methods to support trustee decision-making is that the structured process provides an efficient framework for group review and analysis. Developing a decision tree reflecting the range of potential outcomes or a multi-attribute matrix of criteria, weights, and alternatives, and helps a group formulate a shared decision framework. The insights developed while quantifying judgments are extremely valuable in focusing discussions on any remaining areas of controversy or uncertainty.

During the last 15 years, we've developed some useful lessons learned in the process of applying DA to restoration and mitigation planning projects. These include:

1. **Anchor the analysis framework to charter documents** such as the regulations, agency, policy, or MOAs. The NRDA regulations generally provided little detail other than enumerating and defining criteria and no guidance on how these incommensurate criteria are to be integrated, using these starting points for analysis and shows the linkage to governing regulations.

2. **Start with values or objectives**, rather than initially focusing on alternatives. This provides the best opportunity for innovation and doesn't prematurely lock you into a limited set of options.

3. **Frame the problem and get decision-maker priorities and buy-in before collecting new data.** This reduces false starts and focuses data and information collection on those issues key to the decision.

4. Be sure you **understand the decision analysis method** selected and the assumptions inherent in its use. Many projects make basic application mistakes, which can be expensive and potentially damaging to the claim. An analyst familiar with the methods and assumptions may be useful during model development and initial application.

5. Have the **right people** opining on the values, probabilities, of weights. As with all modeling and analysis, it's Garbage In-Garbage Out. These decisions are often subjected to intense review so it is useful to obtain the best available technical experts or delegated policy makers to add credibility.

6. Use **sensitivity analyses and value of information calculations** to focus data collection. Failure to address uncertainty is a very common problem. The value of information analysis can help make monitoring more efficient.

In addition to their use in NRDA restoration, we feel that these DA methods are also useful for a range of other natural resource or environmental problems such as:

1. **Impact assessment** - Multicriteria methods are an ideal way to scope NEPA requirements, which are generally a comparative analysis of alternatives to support the selection of a preferred alternative. Sheehy (1991) developed a probability tree approach to help the State of New Jersey consider the potential risks (impacts) associated with stocking non-native fish and develop means to mitigate those risks with serious consequences.

2. **Site investigations** are classic decision tree type studies. The value of additional information assessment is commonly used to help decide how many samples to take and how much it is worth to obtain the information before assessing risk and selecting a remedy.

3. **Facility siting** is a classic example of multicriteria methods and some of the major power plant siting efforts used this approach. It can be especially useful for any Locally Unwanted Land Use (LULU) problems. Stakeholders can be profiled independently to help identify opportunities for acceptable compromises.

4. **Priority setting or risk ranking** is a common application in business and the military, but also has application in natural resource or environmental problems. Information from GIS programs can be effectively integrated using decision analysis methods (Sheehy, *et al.* 1990).

5. **Best Value Procurement** - As restoration projects become more complex, the selection of contractors should be based on more than just the lowest bid. The "best value" procurement approach recommended for the implementation of the coral reef structural restoration case is an example of a multicriteria method.

CONCLUSIONS

Decision analysis methods proved to be useful tools for supporting planning in complex restoration projects, especially where there are multiple objectives, diverse stakeholder interests, uncertainty, and/or controversy. It is a rational approach that can illuminate the decision making process for review, and help provide a defensible decision. When appropriate, it can help stakeholders understand the process and contribute useful ideas and support. The benefits derived from these applications are largely the result of the insights provided in going through the structured process and the use of the framework in communicating the basis of the decisions with decision makers, technical experts, and concerned stakeholders.

Structured decision analysis methods can provide a common framework for planning, implementing and assessing the performance of restoration projects or programs. For example, in the vessel grounding cases, decision analysis was used to support engineering design, NEPA compliance, and contractor selection. Since these methods are generally applied using software tools, they can be readily modified as conditions change at the site or new opportunities arise. The performance of implemented restoration should also be considered in terms of the original objectives and criteria. If these are found wanting, the lessons should be captured and incorporated in future planning.

For programmatic problems or common decisions, the structured approach can also provide a consistent framework to aid agency or program decision-making. The process can provide an overarching structure that can be tailored to case/project specific issues. For example, criteria rating scales and weights in a generic multicriteria approach can be adjusted locally to reflect regional or site specific priorities.

Although useful, decision analysis is not a panacea for all restoration planning problems. It is only as good as the model, data and knowledge input, and the application. It can be, either accidentally or intentionally, biased to yield a particular course of action. However, when the structure and method are clearly documented and communicated, this problem can be adequately reviewed and corrected. Properly applied, the process can provide a clear decision framework, stimulate focused thinking, and promote group communication and participation.

ACKNOWLEDGEMENTS

We would like to thank the sponsors of these studies for their support. EPA supported the salmon monitoring work as part of the preliminary restoration scoping effort for the *Exxon Valdez* spill. NOAA's Sanctuaries and Reserves Division supported the structural design efforts in the Florida Keys grounding cases. The decision support efforts for the Cantara metam sodium spill were sponsored by the California Department of Fish and Game and the Guadalupe Dunes public participation evaluation was sponsored by the U.S. Fish and Wildlife Service. We particularly appreciate the patient assistance of the technical experts who provided the essential input for these analyses and the project managers and decision-makers who were willing to consider a different approach to the planning process.

LITERATURE CITED

Keeney, R.L. and H. Raiffa. 1976. Decisions with multiple objectives: Preferences and Value Tradeoffs. Wiley, NY. 569 pages.

Sheehy, D. J., C. P. Martz, M. C. Stopher, S. M. Turek, J. W. Miller, and J. P. Milton. 2000. Restoration Planning for the Cantara Metam Sodium Spill: A Group Multiattribute Decision Analysis Approach. Calif. Fish & Game 86(1):72-86.

Sheehy, D. J. and S. F. Vik. 1999. Public Participation in Restoration Planning: A Review and Analysis of Options for the Guadalupe NRDA Site. Prepared for the U.S. Fish and Wildlife Service.

Sheehy, D. J. 1994. Selecting Restoration Alternatives for the *Maitland* and *Elpis* Grounding Sites: A Decision Analytic Approach. Prepared for the Sanctuaries and Reserves Division, NOAA

Sheehy, D. J. 1990. A Decision Analysis Approach to the Selection of Restoration Alternatives for the *Exxon Valdez* Oil Spill. Prepared for the U.S. EPA Ecosystem Research Laboratory.

Sheehy, D. J., J. Gerritson, and W. A. Richkus, 1990. The Application of Decision Analysis to Select Streams in Western Maryland for Mitigation of Episodic Acidification. Prepared for the Maryland Department of Natural Resources.

DEER PRAIRIE SLOUGH HYDROLOGIC RESTORATION PROJECT: INITIAL RESULTS AND LESSONS LEARNED

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ABSTRACT

Sarasota County biologists undertook a restoration of the historic hydrology and ecology of Deer Prairie Slough, a tributary of the Myakka River in Sarasota County. The Slough was ditched in the early 1950s to drain the area for agriculture. Approximately 12 miles of Slough ditches existed on public lands. The Deer Prairie Slough Restoration Project will enhanced approximately 2,500 acres of hydric/mesic hammock and herbaceous marsh by eliminating approximately 8.4 miles of ditches. Ditch backfilling for the wetlands in Phase I (6.7 miles) was completed between April and June 2001, prior to the 2001 wet season, with Phase II scheduled to finish prior to the 2002 Florida wet season. Benefits of this project include improving and increasing wetland wildlife habitat, reducing exotic plant coverage, improving water quality to on-site and downstream locations including estuarine habitats, and reducing flood pulses by increasing water storage and water retention times of on-site wetlands. One important goal was to create natural grades with extremely gradual slopes. The temporarily disturbed restoration areas were initially intended to voluntarily recruit desirable wetland plants. The initial changes in wetland hydrology and vegetation are summarized, with special attention to lessons learned in funding, contracting, and project management. This project received grant funding from the Charlotte Harbor National Estuary Program and the Southwest Florida Water Management District.

INTRODUCTION

The following is a case study in which a county government initiated a restoration project on public reserve lands which included contracting, monitoring, and managing multiple grants. The Deer Prairie Slough Restoration Project was cooperatively funded and designed to restore and/or enhance 2,000 acres of freshwater marsh and adjacent mesic and hydric hammocks through backfilling of historic ditches. The project was initiated and managed by Sarasota County Government biologists and received matching grant funds from the Sarasota County Pollution Recovery Trust Fund, Southwest Florida Water Management SWIM program, and the Charlotte Harbor National Estuary Program. All contracting and procurement was achieved through Sarasota County Government Procurement standards and protocols based on Florida State Statutes. The project was designed as two phases, carried out by "cradle-to-grave" management strategy, which allowed for adaptations and field changes to ensure a successful final product.

STUDY SITE

The study site, Deer Prairie Slough (Figure 1), involves a series of freshwater wetlands and wet prairies with origins in the Myakka State Park and Sarasota County's T. Mabry Carlton Jr. Memorial Reserve (CMR). South of the CMR boundary, the Deer Prairie Slough's waters converge into a seasonally flooded creek, Deer Prairie Creek, which is a tributary to the Myakka River. The Myakka River ultimately empties into Charlotte Harbor. The size of the watershed entering the slough system is estimated at approximately 10,000 acres. Immediately following World War II, a channelization, achieved via mule teams and steam dredges for nearly 15 miles of channel for agricultural purposes, disturbed natural hydroperiods by forcing an early drawdown of adjacent wetlands and shrinking wetland acreage by reducing seasonal high water elevations. The introduction of a channel into this topographically conservative system resulted in continued erosion with seasonal rains. Subsequent fire suppression and sporadic cattle grazing combined with the hydrologic impacts, resulting in a highly disturbed series of freshwater wetlands often dominated by dog-fennel (*Eupatorium capillifolium*) and wax myrtle (*Myrica cerifera.*), with mesic hammocks encroaching towards the interior. Deep areas within the channel ultimately prevented the growth of native emergent macrophytes and served as seasonal holding pools for floating exotic species such as water lettuce (*Pistia stratiotes.*) and water hyacinth (*Eichornia crassipes*). The existing wet prairie areas within the slough were frequently infested with torpedo grass (*Panicum repens*) and occasional West Indian marsh grass (*Hymenachne amplexicaulis*).

The CMR was established by Sarasota County in a series of land acquisitions and donations culminating in the mid-1980's, and currently contains an active water well-field which is operated by Sarasota County. As a part of the Southwest Florida Water Management District's requirements for operating the wellfield, an extensive system of groundwater, surface water, and precipitation monitoring sites has been in place since 1989. Hyroperiod data collected over the years, coupled with a vegetative community clearly indicative of disturbance, led to the concept of restoring the Deer Prairie Slough channel. Sarasota County biologist viewed the nearly twelve miles of channelized slough on public lands as a site offering the perfect opportunity to improve the quality of the environment.

MATERIALS AND METHODS

Design

Acknowledging a potential lack of funds for a large-scale project, the researchers began to consider various methods whereby the Deer Prairie Slough system could be restored. Historic aerials and topographic data suggested that many of the interconnected wetlands of the Deer Prairie Slough system had previously been connected via sheet-flow during maximum seasonal high water, yet remained separate for most of the year. To achieve this set of conditions would require careful attention to channel backfill elevations, particularly with regard to transitional zones between wetlands. Phasing of the project

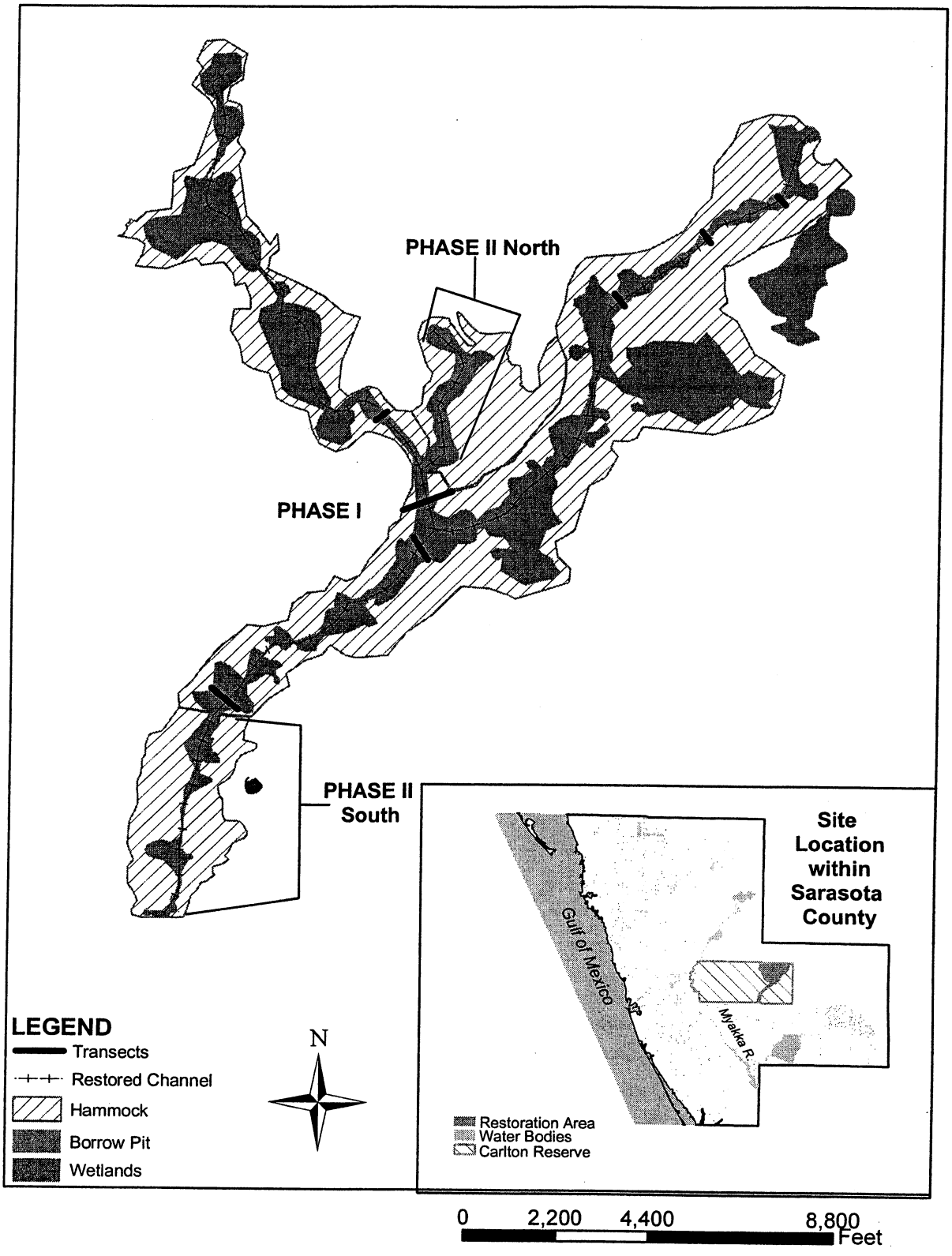

Figure 1. Deer Prairie Slough Restoration Project site location map, Sarasota County, Florida.

would allow for the work to be timed during the driest times of the year. Drawing on anecdotal and published data from other attempts involving restoration of channelized systems (Anderson and Ohmart, 1985; Evans and Allen, 1995), the use of ditchblocks as a restorative technique was discarded in favor of a comprehensive attempt to eliminate the artificial deepwater areas and provide natural transitions between historically distinct wetlands. It appeared very simple at that point – utilize the existing spoil left along the channel to backfill the ditch, and the area would be restored.

Funding

After careful research into available funds, grants were obtained from the Charlotte Harbor National Estuary Program and the Southwest Florida Water Management District's SWIM fund. Sarasota County provided the match required to obtain these funds through their Pollution Recovery Trust Fund. Additional match was realized as in-kind services provided by the biologists in the form of project management, monitoring, and reporting hours. The pre-existing data set for the project area, combined with monitoring schedules and equipment already in place, provided an opportunity to submit solid grant proposals with a guarantee of clear and measurable results as deliverables.

Contracting

With money practically in-hand, the next obstacle was to produce a construction contract that would adequately address the scope and existing conditions of the project. This was to be accomplished, under Florida Statute, by selecting the lowest bidder. Quantification then became an important factor in preparing the bid specifications; no funds were earmarked for a thorough survey whereby the earthmoving costs could be quantified. An in-house team of surveyors was utilized to provide representative cross sections which were incorporated into the bid documents as characteristic of the site, with the added caveat that all contractors would be responsible for final quantities. These surveys revealed the need for existing fill in spoil piles adjacent to the channel to be supplemented with fills from a borrow pit. Two technical provisions were written for this Contract Specifications Document following Florida Department of Transportation Standard Specifications for Road and Bridge Construction, 2000; one for mobilization and one for excavation, grading, and offsite borrow.

The clearing and grubbing provisions described removal of vegetation from existing spoil materials, as well as the site preparation for the borrow pit. The contract indicated removal of the existing shrubby oaks and wax myrtle from the spoil and subsequent scattering of dead vegetative material adjacent to the construction corridor. It was surmised that this material would quickly breakdown while providing additional structural components as temporary habitat. Exotic plants within the designated earthwork areas were targeted prior to any work to reduce transport and re-distribution of undesirable seeds.

All earthmoving costs were then contracted as "lump sum" instead of "unit cost" to circumvent the potential change orders often characteristic of low-bid contracts. The lump sum earthmoving specifications left all mobilization techniques, fill and excavation quantities, equipment and operators to the contractor's professional opinion. Specific

indications for ditch backfilling required utilization of available fill materials to "create natural grades that are characteristic of those from the surrounding wetlands." Except for designated haul routes, the contractor was restricted to operating within a 150' corridor centered on the existing channel.

Following previous design ideas, the backfilling of the DPS channels was written into an earthmoving contract as two phases representing two distinct ditch configurations. The contract allowed for both phases to be completed within the same dry season (March through late June) or for them to be accomplished during two successive dry seasons. The onset of the wet season, marked by rising water levels in the slough, was variable and difficult to address in contract language. Specific construction windows, based on recent years' hydrology, were written into the contract documents with a liquidated damages clause providing some assurance. Because the contractor was to be aware of the difficult working environment of the slough, exceptional rainfall events resulting in delays during construction were described as rainfall "greater than a five-year average for that 24 hour period."

All contractors were urged to visit the project site, and two pre-bid tours were provided for all interested contractors with biologists leading the discussion and overview of the bid specifications.

Permitting

While the design and contracting phases of the project were underway, applications for relevant permits were being prepared and submitted. Both phases of the Deer Prairie Slough involved temporary wetland impacts. Under Florida Water Management District Rules, an Environmental Resource Permit application was submitted, requesting a Noticed General Permit. As a result of numerous meetings and discussions with the Southwest Florida Water Management District, the County created a partnership with the Florida Department of Environmental Protection to apply for the SWFWMD Noticed General Permit. In this case, the representative cross sections of the project area described in the contract proved invaluable. It should be noted that the location of the restoration project within a County reserve facilitated the permitting process by reducing the project's potential for impacting adjacent landowners.

The United States Army Corps of Engineers recommended permitting under a Nationwide Permit. Once again, all data collected during the design and contract writing proved invaluable in obtaining the permit in a timely manner.

Monitoring

As stated above, numerous surface water, groundwater and precipitation monitoring locations existed on site as part of an ongoing water-use permit. This data extended back to 1989, providing a baseline for monitoring changes in hydrology and vegetative communities. Additional vegetation monitoring transects were installed at selected sites along the slough corridor to assess changes in upland, transitional, disturbed wetland, and channel areas following restoration efforts.

RESULTS AND DISCUSSION

The Deer Prairie Slough Restoration Project required an adaptive management approach. Figure 2 shows the initial two phases of the project divided into subtasks and milestones. Bids were opened in early March 2001, and the contract was awarded to the lowest bidder. One day after signing the contract, the contractor recognized that he had not had a clear indication of site conditions and extent of the project. While the confusion was quickly dissipated, the project could easily have been delayed or halted for an indefinite period. Lesson learned: Mandatory pre-bid and pre-contract signing meetings should provide clarity and consistent information regarding the scope and nature of the contract.

Two days into clearing and grubbing of the Phase I area it became clear that daily site visits and contractor discussions would be crucial. There was an emerging issue of deepwater areas with thick vegetation mats where no equipment could be safety operated, and other issues relating to final grade. It became clear that all communications with the contractor should be consistent, with particular effort made to coordinate all communications with the contractor's designated contact.

A month into the earthmoving on Phase I, a nearby prescription burn escaped its boundaries and swept eastward into the restoration area. Having set up a flexible budget with some reserve, a change order was added to the contract for subsequent fire line repair within the slough system. This change order included funds for utilization of another windfall for the project well near the end of Phase I. A major pipeline construction project crossed the slough system at the boundary between Phases I and II. The earthmoving contractor for the pipeline agreed to leave nearly 6000 cubic yards of fill stockpiled for use in the restoration project. A change order was executed to transport this material and spread to grade in eleven target locations to achieve proper transitional zones between wetlands. This additional fill material came from nearby wetlands and proved to be a valuable seed source for initial colonization of the corridor.

Phase I earthwork was completed in June 2001, and revegetation of the corridor depended entirely on natural recruitment and a small volunteer planting effort in the downstream end of Phase I, where erosion was expected. A 24 hour, 7 inch rainfall event was recorded two weeks after de-mobilization i.e., tropical storm Gabrielle. Once the high waters receded, the need for erosion and sediment rework was apparent in the unvegetated areas and at the terminal end of Phase I where a temporary earth and geosynthetic plug had been placed.

Initial hydrologic changes following Phase I of the restoration are summarized in Figure 3. While downstream erosion allowed for an earlier drawdown than expected, the hydroperiods of the northern sites demonstrated increases in wetland water depth and duration as a result of channel filling. Initial changes to vegetation are summarized in Table 1. Following initial erosion and storm damage, the backfilled sediments were stabilized, and further plant colonization continued. The initial emergence along most of the Phase I corridor consisted of smartweed (*Polygonum punctatum*) and maidencane

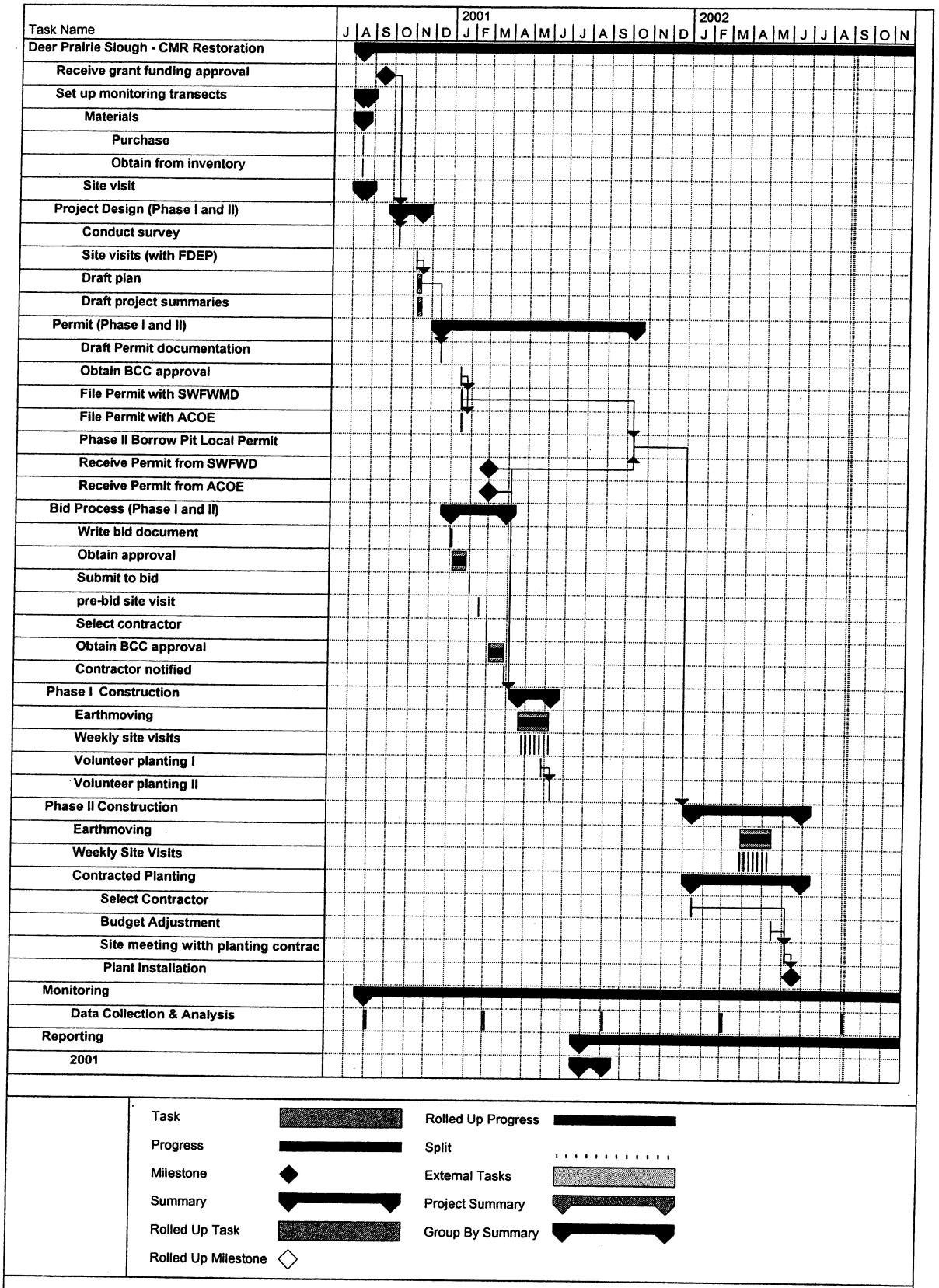

Figure 2. Deer Prairie Slough Restoration Project compressed gantt chart for phased management. Note additional plantings planned during Phase II.

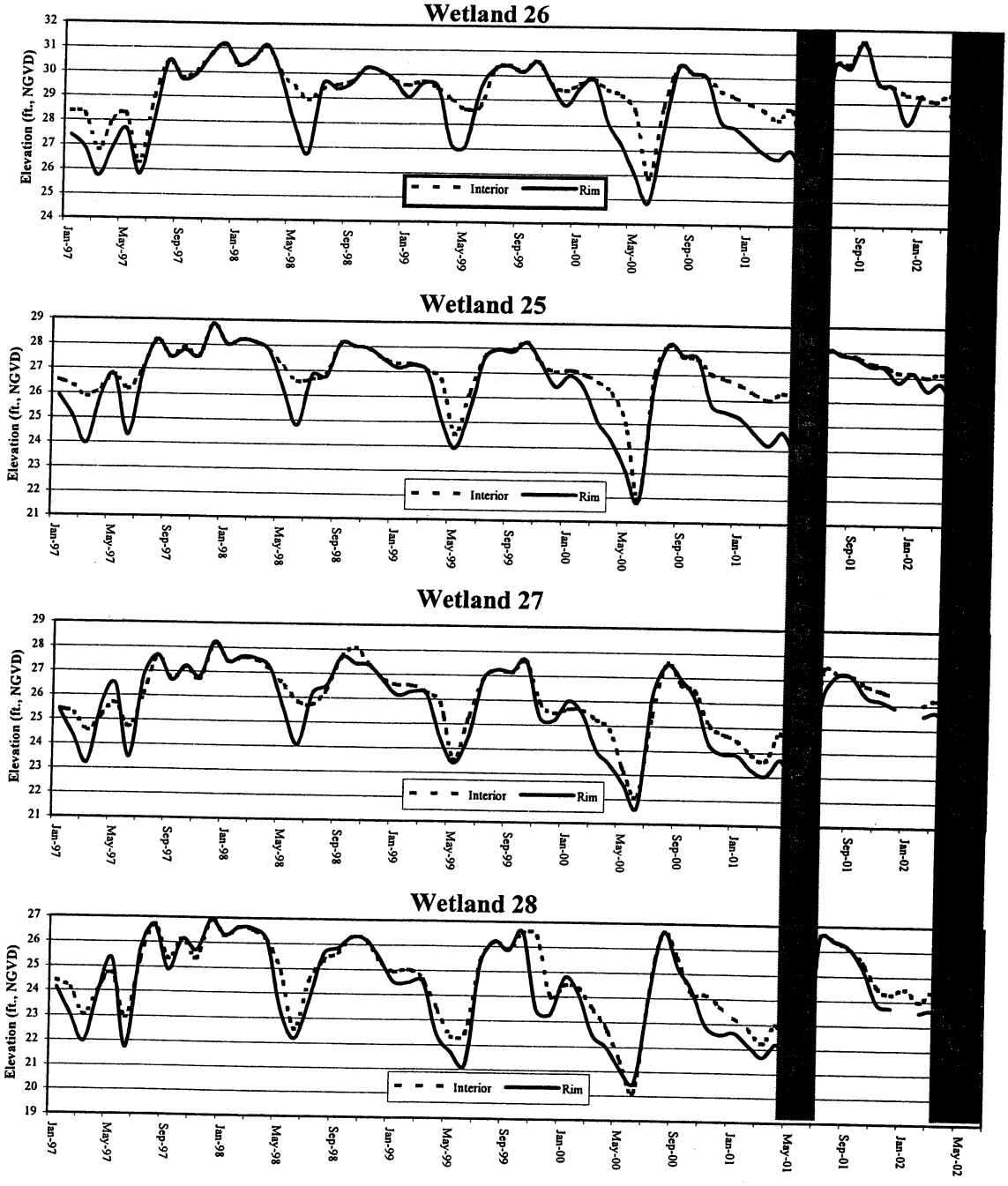

Figure 3. Deer Prairie Slough wetland hydrographs showing construction phases. Individual monitoring sites are arranged from north (upstream) to south (downstream).

Table 1. Dominant species by transect, in order of decreasing dominance, for the North Branch of the Deer Prairie Slough Restoration Project, Phase I. This area represents the first area within the corridor to recruit naturally prior to the 2001 wet season.

	Phase I Pre-restoration		Phase I Post-restoration
Transect #	August 2000	March 2001	August 2001
6	*Polygonum punctatum* *Panicum hemitomon* *Mikania scandens* *Spartina bakeri* *Eupatorium capillifolium*	*Panicum hemitomon* *Polygonum punctatum* *Centella asiatica* *Lippia nodiflora* *Andropogon virgnicus*	*Spartina bakeri* *Panicum repens* *Panicum hemitomon* *Polygonum punctatum* *Centella asiatica*
7	*Panicum hemitomon* *Panicum repens* *Sparina bakeri* *Andropogon virginicus* *Hypericum fasciculatum*	*Panicum hemitomon* *Panicum repens* *Centella asiatica* *Andropogon virgnicus* *Lippia nodiflora*	*Panicum repens* *Panicum hemitomon* *Spartina bakeri* *Polygonum punctatum* *Urtricularia foliosa*
8	*Panicum hemitomon* *Myrica cerifera* *Mikania scandens* *Centella asiatica* *Andropogon virginicus*	*Panicum hemitomon* *Ptilimnium capillaceum* *Eupatorium capillifolium* *Centella asiatica* *Lippia nodiflora*	*Panicum hemitomon* *Sacciolepis striata* *Eupatorium capillifolium* *Polygonun punctatum* *Andropogon virginicus*
9	*Panicum hemitomon* *Polygonum punctatum* *Andropogon virginicus* *Panicum repens* *Sacciolepis striata*	*Panicum hemitomon* *Polygonum punctatum* *Lippia nodiflora* *Eupatorium leptophyllum* *Galium tinctorium*	*Panicum hemitomon* *Polygonum punctatum* *Alternathera philoxeroides* *Panicum repens* *Urtricularia foliosa*

(*Panicum hemitomon*). Torpedo grass recolonized the margins of the earthwork corridor but senesced as water levels reached late summer maximums. Areas where earthwork had been kept to a 50-foot wide corridor vegetated completely by colonization from adjacent source areas. Wider corridor areas did not colonize completely prior to the peak seasonal high water. This concurs with much of the published literature regarding macrophyte emergence and recolonization in flowing systems (van der Walk, 1994; Henry, *et al.* 1996), suggesting that site conditions favoring vegetative reproduction prior to inundation would increase corridor revegetation for Phase II.

Phase II earthmoving began in late March 2002 and was completed by mid-May 2002. The following lessons learned were implemented into the adapted management plan for Phase II:

1) Coordinate construction phases carefully to gain full advantage of weather patterns and water levels to minimize down time and promote revegetation.
2) Reduce temporary impact area as much as possible.
3) Require pre-construction contractor meetings and site visits with weekly follow-ups.
4) Maintain budget flexibility.
5) Plan for temporary wildlife protection and relocation.
6) Acquire additional needed fills through creating a nearby vegetated borrow pit.

CONCLUSIONS

The Deer Prairie Slough Restoration project represents a successful restoration of channelized wetlands on public lands, utilizing public funds. Creative funding and partnering for permitting were crucial to the success of the project. An adaptive approach, combined with a flexible budget and careful attention to contract document detail customization, maximized efficiency and enhanced success. Phasing of the project and cradle-to-grave management allowed for a learning and adaptation period between phases. The channel fill method appears to provide tremendous restoration potential for linear slough projects.

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LITERATURE CITED

Anderson, B.W.: Ohmart, R.D. (1985). *Riparian revegetation as a mitigating process in stream and river restoration.* Pges 41-80. In: Gore, J.a. (ed). Restoration of Rivers and Streams: Theories and Experience. Butterworths, Woburn. 280 pp.

Evans, D.K., and Allen, H.H. (1995). Mitigated wetland restoration: Environmental affects at Green Bottom Wildlife Management Area, West Virginia," Technical Report WRP-RE-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS>

Florida Department of Transportation Standard Specifications for Road and Bridge Construction. 200. FDOT

Henry C.P., C. Amoros & G. Bornette. (1996). Specied traits and recolonization processes after flood disturbances in riverine macrophytes. *Vegetatio* January 122 (1) 13-27.

van der Valk A.G., (1994). Effects of prolonged flooding on the distribution and biomass of emergent species along a freshwater wetland coenocline. *Vegetatio,* February 110(2): 185.