ISLAND RESTORATION AND ENHANCEMENT IN BISCAYNE BAY, FLORIDA

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ABSTRACT

Dredging and filling in the early 1900s to create navigation channels and harbors in Biscayne Bay resulted in over twenty human-made spoil islands and two partially filled natural mangrove islands. Most of the islands are still under public ownership; however, eroding unconsolidated shorelines, tangled exotic vegetation, and debris build-up have discouraged use and limited habitat for birds and marine life. Further, the continual erosion of the island soils contributes to water quality degradation of Biscayne Bay. This paper reviews Biscayne Bay Island Restoration and Enhancement projects, components of which include stabilizing shorelines, removing exotic trees and fill, establishing flushing channels, and planting mangroves and native salt/drought-tolerant uplands vegetation. Over the last ten years of implementing the Biscayne Bay Restoration and Enhancement Program, Miami-Dade DERM has coordinated fourteen island projects through the cooperative efforts of federal, state, and local agencies. Cost-effective techniques were developed and used in implementing these successful projects.

Key words: Island, restoration, spoil islands, mangroves, native plants, creation, enhancement, stabilization, erosion, water quality.

I. INTRODUCTION

A large body of scientific literature exists documenting the importance of coastal habitats to local fisheries, food web relationships, habitat value, and as shoreline stabilizers (Idyll et al., 1968; Odum et al., 1982; Lewis, 1990a). Biscayne Bay and its associated coastal habitats are some of Florida's most valuable natural resources. The bay is a shallow subtropical estuary located on the southeast coast of Florida (see Figure 1). Extending approximately 56 km. (35 miles) from north to south and varying in width from less than 1.6 km. (one mile) to approximately 12.8 km. (eight miles), it covers an area of 572 km. (220 square miles). The bay is bordered on the west by the Greater Miami area and on the east by a series of barrier islands and submerged vegetated banks.

Rapid urbanization and associated coastal development over the last 100 years has severely altered natural habitats in Biscayne Bay (Harlem, 1979). The northern third of the bay (North Bay), which has been most severely impacted by development, is subdivided by six filled causeways and a major seaport facility. Low coastal wetlands have been virtually eliminated in North Bay. Over fifty percent of the existing North Bay

bottom area is barren (Harlem, 1979; Milano, 1983), caused by the creation of deep dredge holes and associated spoil placement and chronic elevated turbidity levels. High turbidity in the bay has been correlated with the re-suspension of unconsolidated bay bottom and spoil island shorelines, eroding margins of dredge banks, and un-vegetated bottom sediments (Wanless et al. 1984).

Morton (1977) contributed substantially to our understanding of the biological effects of dredging and spoil disposal on estuarine environments. During creation of the Atlantic Intra-coastal Waterway (ICW) in the early 1900s, a series of spoil-fill islands were created adjacent to the navigational channel. Wanless et al. (1984) identified these eroding islands as a persistent source of turbidity, resulting in water-quality degradation. Biologically, excessive turbidity is usually undesirable, as it reduces the amount of light penetrating the water column and often limits productivity of bottom vegetation and phytoplankton.

Most of the spoil islands in Biscayne Bay are still under public ownership. Eroding shorelines and debris accumulation have discouraged use of many of these areas. Undeveloped, filled islands are predominantly vegetated with exotic species such as Australian pine (*Casuarina equisetifolia*), Brazilian-pepper (*Schinus terebinthifolius*), Burma reed (*Neyraudia reynaudiana*), seaside-mahoe (*Thespesia populnea*) and beach naupaka (*Scaevola taccada*).

Most existing data on emergent wetlands habitat enhancement on spoil islands is limited to the temperate-zone marsh grass Spartina alterniflora (Garbisch, 1974; Lewis and Dunstan, 1974; Kruczynski and Huffman, 1978; Lunz et al., 1978; Carangelo et al., 1979; Allen et al., 1986; La Salle et al., 1981), which does not occur in lower southeastern Florida. Techniques for mangrove planting and restoration in Florida have been well documented (Savage, 1972; Pulver, 1976; Teas, 1977; Goforth and Thomas, 1980; Lewis, 1990, Markley et al., 1992), but little information is available on restoration of mangroves on spoil islands. Specific limitations of mangroves (e.g. along eroding shorelines) have also been documented (Savage, 1972; Teas, 1977; Goforth and Thomas, 1980). Fernald et al. (1985) described the limitations of planting liner-size tropical hardwood hammock species under exotic-species canopies on spoil islands. Contributions have been made on spoil-island habitat creation and enhancement for bird populations (Maxwell and Kale, 1974; Morris and Miller, 1974; Lewis and Lewis, 1978; Schreiber and Schreiber, 1978; Soots and Landin, 1978; Toland, 1992; Paul et al., 1995).

Island restoration and enhancement activities are underway to stabilize eroding shorelines, restore historical dune communities and wetlands, eradicate exotic vegetation, and create wetlands, dune, coastal strand and tropical hardwood hammock communities. Limited recreational opportunities are also intended for these areas. This paper reviews the creation of 15.2 ha (thirty eight acres) of tropical hardwood hammock community, 4.8 ha (twelve acres) of mangrove community, 4.4 ha (eleven acres) of coastal strand community and over 1.6 km (one mile) of dune community on fourteen stabilized islands in Biscayne Bay (see Figure 1).

II. METHODS

Environmental resource permits from the Army Corps of Engineers, Florida Department of Environmental Protection, Miami-Dade County Environmental Resources Management and local municipalities are required for all restoration activities; see Milano (1999b) for details associated with the environmental permit process. In addition, the Department of the Army has a perpetual easement for maintenance dredging for the majority of spoil islands along the Intra-coastal Waterway. As a result, a Department of Army Consent to Easement is required to allow shoreline stabilization and habitat restoration on a dredge disposal island. Island restoration designs are developed through review of historical documents (aerials for natural islands) and field investigations of site characteristics. Field investigations include topographical, biological, geo-technical, hydrological, and archaeological review of the prospective site. This information is used to identify and protect existing natural resources and to accurately quantify project elements. These elements are used to develop a detailed final design, an accurate cost estimate, environmental permitting applications, funding requests, and construction contract technical specifications and drawings. The final design consists of the types and areas to be stabilized, areas to be cleared of exotics, areas to be excavated, location of flushing channels and tidal creek network, species to be restored, elevation specifications, access routes, public facilities, etc.

A comprehensive biological evaluation is conducted to document on-site and surrounding biological communities, to identify environmental concerns, to define the biological goals and objectives, and to make specific recommendations concerning construction activities associated with the restoration and enhancement efforts (e.g. access route, selective clearing, environmental precautions). The biological assessment is a key element for required local, state and federal environmental resources permit applications. Observations of the surrounding natural-community (if present) assist the restoration team in developing design criteria (e.g., species, planting elevations, hydrological connections, etc.). Selective clearing of exotics is conducted to remove unwanted competitive species and promote development of existing native communities. A land and submerged water survey is performed by a certified land surveyor. This topographic survey assists the restoration team in the planning, design, and construction phases of the restoration. In addition, the topographic survey is used to obtain a precise estimate of fill quantities to be removed or added. Hydrographic evaluations are performed to obtain information for wave energy, tidal regime, current velocity, and surrounding bathymetry. Elevations are referenced to NGVD on all restoration documents (e.g., permit drawings, construction drawings). Hydrographic (wave and tidal conditions) and topographic information are used to develop cost-effective placement of lime-rock groins along eroding island shorelines. See Milano (1999b) for wetlands geo-technical evaluation information.

Shoreline Stabilization

Eroding, unconsolidated fill shorelines are stabilized using natural lime-rock boulders [30 cm to 90 cm (one to three feet) in diameter], lime-rock boulders in combination with mangroves, or mangroves alone by using a new experimental pvc encased, mangrove technique (Riley, 1995). Habitat enhancement benefits of these methods include wave abatement, which reduces erosion and re-suspension of sediments and related turbidity, and an increase in feeding, refuge, and nursery habitat. The limestone revetment also creates a variety of stable habitats for attached and motile sub-tidal and inter-tidal marine organisms. On-site physical and biological conditions may limit planting or require a temporary,

protective barrier (mangrove planter) to protect young mangroves from waves, floating detritus, and debris. Once the red mangroves have established stabilizing prop roots, the temporary protective lime-rock barrier can be reduced and recycled into other shoreline stabilization projects. On sloping unconsolidated shorelines, lime-rock boulder revetments should begin at an elevation at least 30 cm (one foot) below mean low water (or at the edge of any seagrass beds), and extend to an elevation of 60 cm (two feet) above mean high water. The slope of the revetment should not be greater than 2 horizontal to 1 vertical. The upper elevation is necessary to reduce erosion behind the structure, and to prevent trash and debris from damaging mangroves, which are routinely planted behind the protective lime-rock barrier. Filter fabric is used within the protective lime-rock structure, to contain uplands fill and soils in planted areas. Filter fabric may also be used to support boulders where the existing substrate is unstable. The width of a mangrove planter depends on upland excavation limitations, and the water-ward edge of existing seagrasses. Exact volume of lime-rock boulders per linear cm of shoreline stabilization will vary depending on the water depth and slope of the project site. Averages range from 1.15 m to 2.68 m (1.5 to 3.5 cubic yards) per thirty centimeters of shoreline.

Community Planting Groups (See Appendix II for species commonly planted with each planting group.)

Wetlands Community See Milano (1999b) for details of wetlands restoration.

Dune Community (DC) The dune community extends from the mean high-tide line +45 cm (+1.5') NGVD to the upper fore-dune. Dune community species have been planted at ten islands. Island dunes are created using on-site calcareous sand or locally available quartz sand. The Chicken Key dune system was restored successfully using on-site calcareous sand, screened from spoil fill, which was deposited on the island in the mid 1900's. All newly planted dune vegetation is planted on 45 cm (18") centers and is protected for approximately two years at popular recreational islands, using wood sand fencing. Prices range from $1.00 - $1.60 for liner-size dune plants.

Coastal Strand Community (CS) The coastal strand community extends from the back dune, to the inner island hammock zone. Coastal strand species have been introduced at ten spoil islands. The coastal strand community assemblages interface with the dune and tropical hardwood hammock communities and are planted on 90 cm to 210 cm (3 to 7 feet) centers (all species and sizes). Prices range from $4.00 - $8.00 for 3.8 liter (1-gallon) material and $5.00 - $25.00 for 11.4 liters (3-gallon) material.

Tropical Hardwood Hammock (THH) Tropical hardwood hammock community species have been introduced at five spoil islands. THH species are planted on 210 cm – 300 cm (7-10 feet) centers (all species & sizes). A 20.3 cm-30.5 cm (eight- to twelve-inch) layer of mulch is recommended for water retention over the entire planting site. Prices range from $5.00 - $20.00 for 3.8 liter (1-gallon) material and from $20.00 - $90.00 for 26.6 liter (7-gallon) material.

Contract planting specifications include the size, quality, storage limitations, excavation of plant holes, setting of plants, fertilizing, watering, and maintenance. When large quantities

of plants or unavailable species are desired, it may be necessary to contract for plant grow-out. Contracts typically specify 80% survival of planted material after 1 year. All plants are watered on a once-a-week schedule, regardless of rainfall until the completion of project construction. A maintenance performance bond for a minimum of one year is typically required from the date of final acceptance for all plantings. The terms of the maintenance or warranty period begin on the date of final acceptance of the work and continue for a minimum of one year. Vegetative monitoring is conducted at pre-established photo stations and by aerial qualitative assessments on a quarterly basis. Should the quarterly monitoring by DERM reveal that less than 80% of the plant material is surviving, the contractor is notified immediately and has fourteen calendar days to replant the total number of dead units.

Project Costs

Typical costs and contract line items for island restoration and enhancement projects are as follows:

Line item	Unit costs
Mobilization	10% of the total construction cost
Selective clearing, and removal of un-desirable vegetation	$ 5,200 - $ 9,000 per .4 ha (acre)
Excavation, and spoil disposal	$ 12.50 - $ 30.00 per .765 m^3 (cu. yd.).
Lime-rock boulders (rip-rap)	$ 24.00 - $ 50.00 per .9 metric ton (ton)
Filter fabric	$ 2.00 - $ 4.00 per .8 m^2 (sq. yd.)
Mangroves (l year old)	$ 1.00 - $ 3.00 per unit
Uplands vegetation	$ 10.00 - $ 30.00 per 11.4 liter (3 gallon) (DC) $ 1.00 - $1.60 /liner (CS) $ 20.00 - $ 90.00 per 26.6 liter (7 gallon)
(THH) Mulch	$ 15.00 - $25.00 per .765 m^3 (cubic yard)

III. PROJECT IMPLEMENTATION

The implementation of restoration and enhancement plans is achieved by selecting outside contractors through a bidding process that defines the scope of work and specifications for the project; the contract is awarded to the lowest bid by a qualified bidder. The bid and contractor selection process typically requires between four and six months to complete. This process is initiated upon securing dedicated funding and regulatory permits. Projects are scheduled to optimize planting windows (i.e. natural cycles, rainy season), and conducted in a manner to minimize environmental impacts (e.g. use periods of extreme high tides, avoid periods of bird nesting). Restoration cost savings are improved by detailing, within the bid document, cost-effective methodologies (e.g., soil turning, sand screening) for all project components and suggesting contract alternatives (e.g., contractor ownership of excavated material, recycling of materials from other sites). Site accessibility

directly affects costs for all project elements. Accessibility by water requires specialized marine vessels to transport equipment, materials and personnel, and averages out to be at least twice as expensive as land-accessible areas. The re-establishment of altered historical wetlands typically involves excavating, removing and disposing of large quantities of fill. Public restoration dollars are maximized through resourceful spoil disposal plans that reduce restoration costs. For example, a cost savings of $450,000 was realized during the Chicken Key restoration (see Appendix 1), through a resourceful spoil disposal plan that allowed the contractor to own and market all fill materials removed from the island, and through a cost-effective construction plan.

As detailed in the project descriptions (Appendix I), island stabilization and enhancement have been funded primarily through the Florida Inland Navigation District (FIND) Waterways Assistance Program and the Biscayne Bay Environmental Enhancement Trust Fund. In addition, island restoration and enhancement grant monies have been secured through the Florida Department of Environmental Protection, the South Florida Water Management District, and local mitigation opportunities.

Prior to construction, the project biologist marks all existing seagrass areas and desirable uplands vegetation within the project boundaries to minimize environmental impacts. During construction, the project construction manager inspects the site on a regular basis to ensure compliance with specifications. As-built surveys of all elevation modifications, flushing channels/culverts are required prior to approval for wetlands planting. Prior to planting, all plant material is inspected by the project biologist. Wildlife assessments are conducted by wildlife experts. Maintenance activities for exotic vegetation control (herbicide treatment) are conducted on a quarterly basis until native communities are established. Typically, tropical hardwood hammock canopy development is achieved within four years when using 11.4 to 26.6 liter (3- to 7-gallon) material placed on 7 ft. centers. Dune community development is very rapid. For example, *Uniola paniculata* (sea oats) liner material planted in April 1997 at the Chicken Key (CK) site was observed in June 1997 to be displaying seed and partial coalescence.

Fourteen islands have been successfully restored and soils stabilized using a variety of vegetative and non-vegetative techniques for approximately 3.8 million dollars. Four habitat types, consisting of approximately 90 species, have been successfully established using cost-effective techniques on these natural and dredge spoil islands in Biscayne Bay. Appendix I summarizes these projects, and Appendix II details the species planted at each island.

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APPENDIX I: PROJECT DESCRIPTIONS

(See Appendix II for species used in each project)

CHICKEN KEY BIRD ROOKERY RESTORATION (CK)

Size: 2.8 ha (7 acres) **Completion Date:** 3/97

Location: Chicken Key, located in the Biscayne Bay Aquatic Preserve, south Biscayne Bay
26° 37'12"N, 80°17'15"W

Scope of Restoration:

* Clearing and removing 1.6 ha (4 acres) of exotic vegetation, including *Casuarina equisetifolia, Neyraudia reynaudiana, Schinus terebinthifolius, Scaevola taccada, Thespesia populnea, Hibiscus tiliaceus* and *Acacia auriculiformis*
* Selectively clearing 1.2 ha (3 acres) of exotic vegetation
* Excavating 25,245 cubic meters (33,000 cubic yards) of dredge spoil from the north and central portions of the Key (spoil sold by contractor reducing restoration cost)
* Restoring 36.0 m (1200 LF) of dune community
* Planting 45 m (150 LF) of experimental mangrove in encased tubes
* Planting 1.4 ha (3.7 acres) of red mangroves (*Rhizophora mangle* on 3 foot centers)
* Installing 3 flushing channels 2.4 m – 4.5 m (8'-15') wide
* Installing a network of tidal creeks 270 m (900 LF)

Funding: (% of total) Florida Dept. of Environmental Protection (FDEP) (34%), South Florida Water Management District (SFWMD) (24%), Biscayne Bay Environmental Enhancement Trust Fund (BBEETF) (42%)

Cost: $600,000

DINNER KEY ISLAND (DK)

Size: 2.8 ha (7 acres) **Completion Date:** Ongoing

Location: Biscayne Bay Aquatic Preserve, Miami, FL, central Biscayne Bay
25°46'08"N, 80° 12'54"W

Scope of Enhancement:

* Clearing and mulching 1.6 ha (4 acres) of exotic vegetation, predominantly *Casuarina equisetifolia, Thespesia populnea, Schinus terebinthifolius,* and *Scaevola taccada*
* Creating 1.6 ha (4 acres) of coastal strand/maritime hammock
* Stabilizing shoreline with mangroves and limerock boulders
* Installing an osprey nesting platform

Funding: Miami-Dade Seaport Department (100%)

Cost: $275,000

FLAGLER MONUMENT ISLAND (FM)

Size: 1.8 ha (4.5 acres) **Completion Date: 6/94**

Location: Biscayne Bay Aquatic Preserve, City of Miami Beach, Florida, south

region of northern Biscayne Bay
25° 46'54"N, 80°9'6"W

Scope of Enhancement:

* Selectively clearing 1.8 ha (4.5 acres) of exotic vegetation, predominantly *Casuarina equisetifolia, Neyraudia reynaudiana, Schinus terebinthifolius, Thespesia populnea* and *Scaevola taccada*
* Creating 225 m (750 LF) of dune community
* Creating 1.6 ha (4 acres) coastal strand/maritime hammock
* Stabilizing 270 m (900 LF) of shoreline with lime-rock boulders
* Installing an osprey nesting platform

Funding: (% of total) BBEETF (50%), Florida Inland Navigation District (FIND) (50%).
Cost: $220,000

TEACHERS ISLAND (#1)

Size: 1.48 ha (3.7 acres) **Completion Date:** Ongoing
Location: Biscayne Bay Aquatic Preserve, Miami, Florida south region of northern Biscayne Bay
25°47'40"N, 80°12'10"W

Scope of Enhancement:

* Selectively clearing and disposing of exotic vegetation, predominantly *Casuarina equisetifolia, Schinus terebinthifolius*, and *Scaevola taccada*
* Creating 1.48 ha (3.7 acres) of dune/coastal strand community
* Stabilizing 96.3 m (320' LF) of shoreline with lime-rock groins

Funding (% of total): FIND (50%), BBEETF (50%)
Cost: $140,000

MORNINGSIDE ISLAND (#2)

Size: 1.7 ha (4.2 acres) **Completion Date:** 3/97
Location: Biscayne Bay Aquatic Preserve, Miami, FL, south central region of northern Biscayne Bay
25°45'06"N, 80° l0'15"W

Scope of Enhancement:

* Selectively clearing 1.6 ha (4 acres) of exotic vegetation, predominantly *Casuarina equisetifolia, Schinus terebinthifolius*, and*Thespesia populnea*
* Creating 1.6 ha (4 acres) of dunes/coastal strand community
* Stabilizing 150 m (500') of shoreline with lime-rock groins
* Creating .08 ha (0.2 acres) of mangrove wetlands
* Installing an osprey nesting platform

Funding (% of total): FIND (50%), BBEETF (50%)
Cost: $290,000

MANGROVE ISLANDS (#4) (2)

Size: 1.1 ha (2.8 acres) **Completion Date:** 8/96

Location: Biscayne Bay Aquatic Preserve, Miami, FL, central region of north Biscayne Bay
25° 49'30"N, 80°11'l5"W

Scope of Enhancement:

* Selectively clearing of exotic vegetation using herbicides, predominantly *Casuarina equisetifolia*, and *Thespesia populnea*
* Enhancing 1.1 ha (2.8 acres) of existing mangrove wetlands

Funding: BBEETF (100%)

Cost: $5,000

LEGION ISLAND (#6)

Size: 2.8 ha (7 acres) **Completion Date:** Ongoing

Location: Biscayne Bay Aquatic Preserve, FL, central region of northern Biscayne Bay
25° 5l'30"N, 80° 11'15"W

Scope of Enhancement:

* Selectively clearing exotic vegetation, predominantly *Casuarina equisetifolia, Neyraudia reynaudiana, Schinus terebinthifolius*, and *Thespesia populnea*
* Stabilizing 150 m (500 LF) of shoreline with pvc encased mangroves
* Creating 2 ha (5 acres) of maritime hammock/coastal strand community
* Installing an osprey nesting platform

Funding (% of total): FIND (50%) BBEETF (50%)

Cost: $150,000

PELICAN ISLAND (#8)

Size: 2 ha **(**5 acres) **Completion Date:** 1/92

Location: Biscayne Bay Aquatic Preserve, Miami, FL, central region of northern Biscayne Bay
25° 51'00" N, 80°10'00"W

Scope of Enhancement:

* Clearing and mulching 2 ha (5 acres) of exotic vegetation, predominantly *Casuarina equisetifolia, Neyraudia reynaudiana, Schinus terebinthifolius* and *Scaevola taccada*
* Creating 45 m (150 LF) of dune community
* Stabilizing 360 m (1,200 LF) of shoreline with limerock boulders
* Enhancing .06 ha (14 acres) of mangrove wetlands
* Creating 1.8 ha (4.5 acres) of maritime hammock/coastal strand community
* Installing an osprey nesting platform
* Installing a docking facility [61.2 m^2 (680 sq. ft.)]

Funding (% of total): FIND (50%), BBEETF (50%)

Cost: $300,000

QUAYSIDE ISLAND (#11)

Size: 2 ha (5 acres) **Completion Date:** 3/93
Location: Biscayne Bay Aquatic Preserve, FL, northern Biscayne Bay
25°54'35"N, 80°09'25"W
Scope of Enhancement:
* Clearing and mulching 2 ha (5 acres) of exotic vegetation, containing predominantly *Casuarina equisetifolia,* and *Schinus terebinthifolius*
* Creating 108 m (360 LF) of dune community
* Stabilizing 600 m (2,000 LF) of shoreline with mangroves .14 ha (0.34 acres) and lime-rock boulders
* Creating 1.8 ha (4.5 acres) of maritime hammock/coastal strand community
* Installing an osprey nesting platform
* Installing a docking facility [54 m^2 (600 sq. ft)]

Funding: (% of total) FIND (40%), FDEP (19%), BBEETF (41%)
Cost: $590,000

HELKERS ISLAND (#12)

Size: 1.6 ha (4 acres) **Completion Date: 4/93**
Location: Approximately 255 m (850 feet) west of the ICW and south of the 79th Street Causeway, Biscayne Bay Aquatic Preserve, North Miami, FL, northern Biscayne Bay
25°53'N, 80°09'W
Scope of Enhancement:
* Clearing and mulching 1.6 ha (4 acres) of exotic vegetation, predominantly *Casuarina equisetifolia, Schinus terebinthifolius* and *Thespesia populnea*
* Creating 144 m (480 LF) of dune community
* Stabilizing 264 m (880 LF) of shoreline with mangroves (0.27 acres) and lime-rock boulders
* Creating .2 ha (0.5 acres) of mangrove wetlands
* Creating 1.6 ha (4 acres) of maritime hammock/coastal strand community
* Osprey nesting platform

Funding (% of total)**:** FIND (50%), BBEETF (50%)
Cost: $300,000

CRESCENT ISLANDS (#13) (2)

Size: .8 ha (2 acres) **Completion Date:** 1/92
Location: Biscayne Bay Aquatic Preserve, North Miami, FL, northern Biscayne Bay
25°52'30"N, 80°08'30"W
Scope of Enhancement:
* Selectively clearing .8 ha (2 acres) of exotic vegetation, containing predominantly

Casuarina equisetifolia, and *Thespesia populnea*
* Creating 180 m (600 LF) of dune community

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* Stabilizing 297 m (800 LF) of shoreline with mangroves and natural
* limerock boulders
* Creating .2 ha (0.5 acres) of mangrove wetlands
* Creating .14 ha (0.35 acres) of coastal strand community
* Installing an osprey nesting platform

Funding (% of total): BBEETF (40%), FIND (40%)
Cost: $200,000

LITTLE SANDSPUR ISLAND (#14)

Size: .6 ha (1.5 acres) **Completion Date:** 2/99
Location: Biscayne Bay Aquatic Preserve, northern Biscayne Bay
25° 53'30"N, 80° 8'30"W

Scope of Enhancement:

· Clearing and removing .4 ha (1 acre) of exotic vegetation, predominantly *Casuarina equisetifolia*, and *Thespesia populnea*
* Creating 66 m (220 LF) of dune community
* Enhancing .2 ha (0.5 acre) of mangrove
* Creating .4 ha (1 acre) dune/coastal strand community
* Stabililizing 186m (620 LF) of shoreline with lime-rock boulders
* Installing an osprey nesting platform
* Installing a wetlands flushing channel [3.6 m (12 ft. wide)]

Funding (% of total): BBEETF (50%), FIND (50%)
Cost: $170,000

SAND SPUR ISLAND (#15)

Size: 6.1 ha (15 acres) **Completion Date:** 6/93
Location: Oleta River State Recreation Area, Biscayne Bay Aquatic Preserve, North Miami Beach, FL, north Biscayne Bay 26° 54'00"N, $80^0$08'15"W

Scope of Enhancement:

* Clearing and mulching 15 acres of exotic vegetation, predominantly *Casuarina equisetifolia, Neyraudia reynaudiana, Schinus terebinthifolius*, and *Scaevola taccada*
* Creating 1800 LF (2.1 acres) of dune community
* Stabilizing 915 m (3,000 LF) of shoreline with mangroves and lime-rock boulders
* Creating 1 ha (2.5 acres) of mangrove wetlands
* Creating 5.6 ha (14 acres) of maritime hammock/coastal strand community
* Installing an osprey nesting platforms

Funding: (% of total) BBEETF (48%), FIND (44%), SFWMD (8%)
Cost: $531,000

APPENDIX II: Planted Species by Site (See Appendix I)

Species	Island
Acacia choriophylla	15, 12, 11 8, 6, FM, DK
Acoelorrhaphe wrightii	FM
Amyris elemifera	15, 12, 11, 6
Ardisia escallonioides	15, 12, 11, 6
Ateramnus lucidus	15, 12, 11, 6
Avicennia germinans	15, 13, 12, 11, 6, DK, CK
Blutaparon vermiculare	14
Borrichia frutescens	15, CK
Bumelia celastrina	12, 11, 6
Bursera simaruba	15, 13, 12, 11, 8, 6, 2, 1, FM, DK
Callicarpa americana	15
Calyptranthes pallens	15, 12, 11, 6
Canavalia maritima	14, 2, 1, FM
Canella winterana	15, 12, 11, 6
Capparis cynophallophora	15, 14, 12, 11, 6, 2, 1, FM, DK
Capparis flexuosa	15, 12, 11, 6
Casasia clusiifolia	15, 12, 11, 6, 2, 1
Cassia sp.	15, 14, 2, 1, FM
Chiococca alba	15, 12, 11, 6
Chrysobalanus icaco	12, 11, 6, 2, 1
Chrysophyllum oliviforme	15, 12, 11, 6
Citharexylum fruticosum	15, 12, 11, 6, 2, 1, FM, DK
Coccoloba diversifolia	15, 12, 11, 8, 6, DK
Coccoloba uvifera	15, 12, 11, 8, 6, 2, 1, FM
Cocos nucifera	15, 12, 11, 6, 2, 1, FM
Coccothrinax argentata	2, 1, FM
Conocarpus erectus	15, 13, 12, 11, 8, 6, 2, 1, FM, DK
Conocarpus erectus sericeus	15, 12, 11, 6, DK
Cordia sebestena	15, 13, 12, 11, 8, 6, FM, DK
Croton punctatus	14,
Dodonaea viscosa	15, 14, 12, 11, 8, 6, FM, DK
Erithalis fruticosa	15, 12, 11, 8, 6, DK
Ernodea littoralis	14, 2, 1
Erythrina herbacea	15, 12, 11, 6, FM, DK
Eugenia axillaris	15, 12, 11, 6
Eugenia confusa	15, 12, 11, 6
Eugenia foetida	15, 12, 11, 6
Exostema caribaeum	15, 12, 11, 6
Ficus aurea	15, 12, 11, 8, 6, DK
Ficus citrifolia	15, 8
Forestiera segregata	15, 12, 11, 6, 2, 1, FM, DK
Gaillardia pulchella	14, 2, 1, FM

Guaiacum sanctum	15, 12, 11, 6
Guapira discolor	15, 12, 11, 6
Hamelia patens	14
Helianthus debilis	15, 14, 12, 11, 6, 2, 1, FM
Hymenocallis latifolia	14, 12, 11, 6, 2, 1, CK
Ipomoea pes-caprae	15, 14, 12, 11, 6, FM,
Iva imbricata	14, 2, 1, FM
Jaqaemontia reclinata	14, 2, CK
Jaquinia kevensis	15, 14, 12, 11, 6
Lantana involucrata	12, 11, 6
Lysiloma bahamensis	15, 12, 11, 6
Mallotonia gnaphalodes	2, CK
Mastichodendron foetidissimum	15, 12, 11, 6
Myrica cerifera	14, 2, 1
Myrsine guianensis	15, 12, 11, 6
Nectandra coriacea	15, 12, 11, 6
Okenia hypogaea	14
Opuntia compressa	14
Passiflora suberosa	14
Picramnia pentandra	15, 12, 11, 6
Piscidia piscipula	15, 13, 12, 11, 8, 6, FM
Pithecellobium unguis-cati	15, 12, 11, 8, 6, DK
Psidium longipes	15, 12, 11, 6
Psuedophoenix sargentii	15, FM
Psychotria nervosa	15, 12, 11, 6
Quercus laurifolia	15, 12, 11, DK
Quercus virginiana	15, 12, 11
Randia aculeata	15, 12, 11, 6, 2, 1, FM, DK
Reynosia sp	15, 12, 11, 6
Rhizophora mangle	15, 12, 11, 8, 6, DK, CK
Sabal palmetto	15, 8, 2, 1, FM, DK
Sapindus saponaria	15, 12, 11, 8, 6, DK
Scaevola plumieri	15, 14, 12, 11, 6, 2, 1, FM, CK
Schaefferia frutescens	15, 12, 11, 6
Serenoa repens	15, 14, 12, 11, 6, 2, 1,
Sesuvium portulacastrum	15, 14, 12, 11, 6, 2, 1, FM, CK
Sophora tomentosa	15, 14, 12, 11, 8, 6, 2, 1, FM, CK
Spartina patens	1, 2, FM
Spartina spartinae	15, CK
Suriana maritima	15, 12, 11, 6, 2, 1, FM, CK
Swietenia mahogani	15, 12, 11, 8, 6, FM
Thrinax morrisii	14, 2, 1
Uniola paniculata	15, 14, 13, 12, 11, 8, 6, 2, 1, FM, CK
Zanthoxylum coriaceum	15, 12, 2, 1
Zanthoxy1um fagara	15, 12, 11, 6, 2, 1