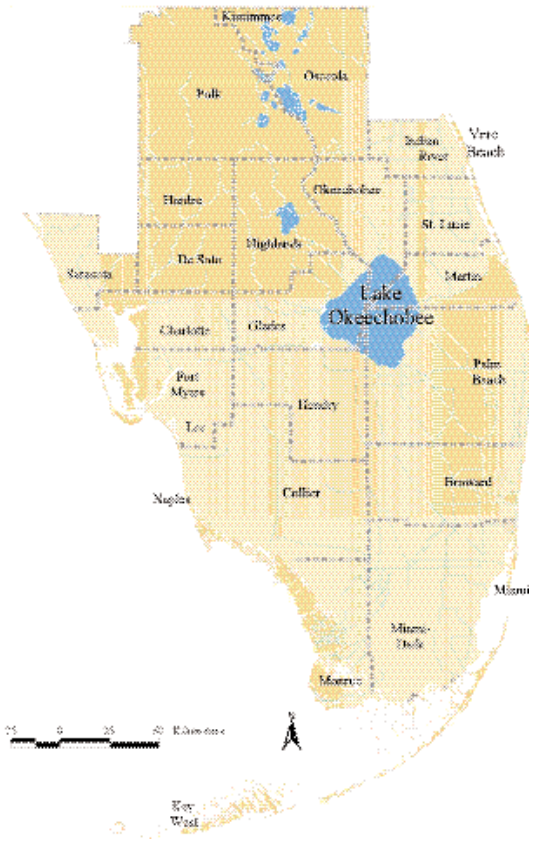
The South Florida Ecosystem

Federally Listed Species in S. FL:	**68**
State Listed Species in S. FL:	**422**

Figure 1. The counties of South Florida.



The most striking conclusion that historical research conveys about Florida and its ecosystems is that in any one area there have been immense changes.

S.D. Webb (1990)

No region reflects this more than South Florida. A unique combination of geological history, climate, geography, and environmental forces has made the South Florida Ecosystem an important reservoir of landscape, community, and species diversity. The vegetation of South Florida represents a mixture of Caribbean, southern temperate, and local influences. The South Florida Ecosystem supports the only subtropical ecological communities in the continental United States: about 60 percent of the native plant species south of Lake Okeechobee originated from the tropics. As a result of this convergence of Caribbean, temperate, and endemic influences, the South Florida Ecosystem supports substantial ecological, community, taxonomic, and genetic diversity. This chapter provides an overview of South Florida, highlighting its biodiversity, the pressing ecological issues, and ongoing management and restoration efforts.

The Watersheds and Subregions of South Florida

The South Florida Ecosystem encompasses 67,346 square kilometers (26,002 square miles) covering the 19 southernmost counties in Florida (Figure 1). From a watershed management perspective, South Florida can be described by further subdividing the region into the following subregions: Kissimmee River, Lake Okeechobee, Lake Wales Ridge, Peace River/Charlotte Harbor, Upper East Coast, Lower East Coast, Caloosahatchee River, Everglades, Big Cypress, and Florida Keys, including Biscayne Bay, Card Sound, and the lower southwest estuaries (Figure 2).

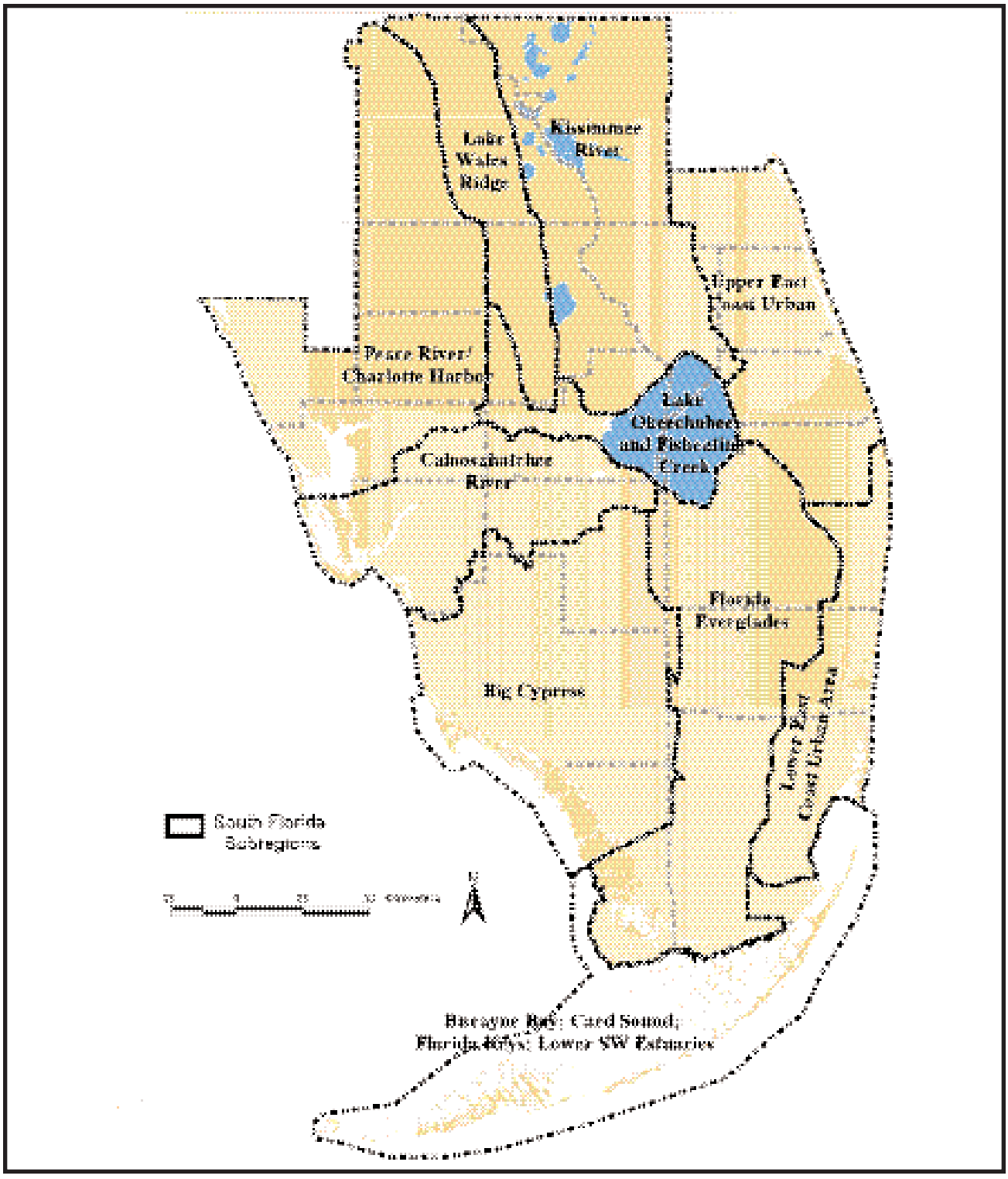


Figure 2. Subregions and watersheds of the South Florida Ecosystem.

Kissimmee River

The Kissimmee River subregion forms the upstream portion of the Kissimmee-Okeechobee-Everglades watershed. Originating near Orlando and ending at Lake Okeechobee, the subregion encompasses most of Osceola and Okeechobee counties as well as portions of Highlands, Polk, and Glades counties. There are three sub-basins within the drainage: the upper basin, with Lake Kissimmee and 18 smaller lakes; the lower basin with the Kissimmee River and its tributary watersheds (excluding Istokpoga Creek) between Lake Kissimmee and Lake Okeechobee; and the Lake Istokpoga drainage area (COE 1996, Koebel 1995). Lake Kissimmee is Florida's third largest lake, with a surface area of 140 km² (54 mi^2). Lake Istokpoga is the fifth largest in the State, covering 112 km² (43 mi^2) (Brenner *et al*. 1990). The drainage also includes the Indian Prairie/Harney Pond sub-basin south of Lake Istokpoga and the Taylor Creek/Nubbin Slough sub-basin, both of which are connected to Lake Okeechobee by drainage canals.

Although relatively flat, the Kissimmee River drainage has greater topographic relief than areas south of Lake Okeechobee. The western boundary of the Kissimmee River subregion is clearly defined by the Lake Wales Ridge. The eastern boundary is low and poorly defined, with elevations reaching up to 23 m (75 ft). The northeastern boundary is formed by the St. Johns River drainage basin. Okeechobee and Osceola Plains are two broad physiographic areas within this subregion.

The diversity of ecological community types in the Kissimmee River subregion includes high pine on hilltops and slopes, scrub scattered throughout, scrubby flatwoods on sandy coastal and interior sites, upland hardwood forests on rolling hills, dry prairie inland, forested wetlands, marshes, lakes, and rivers (blackwater streams).

Lake Okeechobee

Lake Okeechobee lies about 48 km (30 mi) west of the Atlantic Ocean and 96 km (60 mi) east of the Gulf of Mexico. Extending across parts of Highlands, Charlotte, Glades, Hendry, Okeechobee, Martin, and Palm Beach counties, this subregion covers the lake and its immediate drainage area to the west, including Fisheating Creek. This subregion does not include the Kissimmee River or Everglades drainages. Lake Okeechobee is the central feature of the South Florida Ecosystem-its liquid heart. The lake is formed by a broad, shallow, relatively circular depression in bedrock and has a surface area of roughly 1,890 km^2 (730 mi^2) (COE 1994). Land levels around the lake vary from 3 m (10 ft) to 15 m (50 ft) above sea level (McPherson and Halley 1997). The lake is ringed with levees, pumping stations and control structures to permit fluctuation of lake levels in response to drought, flood conditions and water supply demands. Major outlets are the St. Lucie Canal to the east and the Caloosahatchee Canal and River to the west. Also numerous agricultural canals release excess lake water to Water Conservation Areas south of the lake.

Lake Okeechobee formed over 6,000 years ago. Originally, the water flowed south and west from the lake. The lake was the source of the Everglades

"River of Grass" sheetflow which sustained the Everglades and nourished Florida Bay and coastal estuaries. During the last 50 years the Okeechobee subregion has been re-engineered; resulting in a much shallower and nutrient-laden lake, with a littoral zone filled with exotic species. Today, the major vegetative communities outside the lake proper are predominantly freshwater marsh with some cypress forest wetlands and small fragments of remnant pond apple forest.

Lake Wales Ridge

The Lakes Wales Ridge subregion is a unique mosaic of elevated sandy ridges encompassing an area from about the southern Highlands County boundary 160 km (99 mi) north to near Orlando. The Lake Wales Ridge averages about 7.5 km (4.6 mi) in width (Christman 1988). Though the name implies a single physiographic area, the Lake Wales Ridge actually consists of three elevated, sandy ridges that were once the beach and dune systems of Miocene, Pliocene and early Pleistocene seas (Christman and Judd 1990). These relic dunes and the deep, sandy, well-drained soils support a number of plant communities that have adapted to xeric conditions over millions of years.

Due to the elevation and geologic age of the soils of Lake Wales Ridge scrubs, it has been estimated that the highest hill tops in this area have supported upland vegetation for about 25 million years. On the Lake Wales Ridge, an estimated 200 ancient scrub islands have been identified (Christman and Judd 1990). Between ridges and at the base of hills, the soils become fine and compacted and often retain surface water, forming wetlands and lakes. Rainfall, seepage, and elevated water tables provide the sources of water for these aquatic systems. Combined with the aquatic and wetland communities that now exist between and within the ridges, this subregion consists of a complex mosaic of habitats, some unique to Florida.

Because of its complexity, the Lake Wales Ridge contains a wide diversity of plant and animal communities. However, it is the xeric upland plant and animal associations that constitute the majority of surface area. Although relatively common within the Lake Wales Ridge, these xeric communities are rare when compared to their relative distribution within the State and nation. Several major ecological communities found within the Lake Wales Ridge subregion provide important habitat for imperiled species. The most important of those are scrub, high pine, scrubby flatwoods, lakes and freshwater marshes.

Peace River/Charlotte Harbor

The Peace River/Charlotte Harbor subregion encompasses about 7,800 km^2 (3,012 mi^2) in southwest Florida and includes the Myakka and Peace River drainages. The Myakka River originates about 72 km (45 mi) inland in western Manatee and eastern Hardee counties, while the Peace River begins about 115 km (71 mi) from the coast in Polk and western Highlands counties (Taylor 1974).

Much of the Charlotte Harbor basin emerged from a shallow sea during the Miocene and Pleistocene epochs. Only the immediate coastal areas remained inundated until about one million years ago. Most of this area lies within the Gulf Coast Lowlands or DeSoto Plains physiographic regions, both of which are

composed primarily of marine sands and sediments (Southwest Florida Regional Planning Council 1995). These soils are all deep, nearly flat, and poorly drained.

Northern portions of the Charlotte Harbor subregion, primarily within the Peace River drainage, are characterized by cypress and hardwood hammocks and extensive areas of poorly drained marshes. Central and southern areas include marsh, dry and wet prairies, pine flatwoods, and estuaries (DEP 1995). Mesic flatwoods support a wide diversity of animals and represent the third highest species richness of vegetative communities in Florida (Beever and Dryden 1998). Dry prairie is one of the most widespread upland vegetative communities in the Charlotte Harbor basin. Coastal areas, including Charlotte Harbor proper, contain expanses of seagrass beds, mangrove, and coastal strand communities. There are roughly 23,675 ha (58,500 acres) of seagrass in Charlotte Harbor (CHNEP 1996); this community provides important ecological functions that benefit many threatened and endangered species as well as migratory birds. Mangroves provide a variety of habitats and food resources for a diversity of animals, serve to hold and stabilize intertidal sediments, and provide erosion protection for adjacent uplands.

Upper East Coast

The Upper East Coast subregion, which includes Indian River, St. Lucie, and Martin counties and a northern portion of Palm Beach County, covers over 5,631 km^2 (2,174 mi^2) and has an average elevation of 6 m (20 ft). Formed by the rise and fall of changing sea levels, the region is characterized by three east-to-west physiographic zones: (1) the Atlantic Coastal Ridge, (2) the Eastern Valley, and (3) the Osceola Plain (SFWMD 1994). The Atlantic Coastal Ridge, bordered on the east by the Atlantic Ocean and on the west by the Eastern Valley, consists of relic dune ridges formed by wind and wave action along the coastline. Paralleling the east coast, the Ridge varies in width from a few hundred meters to a few kilometers and ranges in elevation from sea level to 28 m (92 ft) in Jonathan Dickinson SP, the highest coastal elevation in this subregion.

A wide variety of upland vegetative communities exist throughout the subregion, including coastal dunes, coastal strand, maritime forest, scrub, hardwood hammock, and pine flatwoods. Wetland habitats are a vital component for the biodiversity of the region. Between the barrier islands and the coastal ridge (or mainland) lies the Indian River Lagoon, a linear estuarine system that extends along more than a third of Florida's east coast. Numerous freshwater wetlands and sloughs undergo a transition into riverine systems that connect directly to the Indian River Lagoon. The combination of freshwater and saltwater wetlands, seagrass and mangrove communities in particular, contribute valuable cover, foraging areas, and reproductive habitats for many fish and wildlife species in this subregion.

Lower East Coast

The Lower East Coast subregion extends approximately 160 km (99 mi) north to south through large coastal portions of Palm Beach, Broward, and Miami-Dade counties. The major topographic feature of the Lower East Coast

subregion is the Atlantic Coastal Ridge. This limestone ridge extends the length of the Atlantic Coast. Three major estuaries and marine systems occur in this subregion: Lake Worth Lagoon in Palm Beach County, Biscayne Bay in Miami-Dade County, and West Lake in Broward County.

The Lower East Coast subregion is the most highly urbanized area in Florida, containing 30 percent of the State's residents. Most urbanization occurs along the coastal portion of the subregion with substantial agriculture present south and west of the Atlantic Coastal Ridge (Science Subgroup 1996). Although the region is highly urbanized, many species of native fauna and flora continue to exist in the remnant patches of native vegetative communities. Ecological communities found in this subregion include beach dune, coastal strand, maritime and tropical hardwood hammocks, pine rocklands, scrub, pine flatwoods, mangrove swamps, coastal saltmarsh, freshwater marsh, and wet prairie (Myers and Ewel 1990, Science Subgroup 1996).

Water resources for this subregion are primarily available from rainfall and surface and groundwater storage systems such as shallow surficial aquifers. The area between Boynton Beach and Miami receives the highest amount of rainfall in the State (163 cm or 64 in). The Biscayne Aquifer is the largest of its kind, and one of the most important natural resources in the area. It extends throughout Miami-Dade County, into a majority of Broward County, and a portion of southern Palm Beach County. Public water for the Florida Keys, Broward County, and Miami-Dade County is supplied by the Biscayne Aquifer. This aquifer also depends on rainfall for recharge (Southwest Florida Regional Planning Council 1995, Science Subgroup 1996).

Caloosahatchee River

The Caloosahatchee River subregion encompasses the Caloosahatchee River watershed, the lower Charlotte Harbor estuarine system, including San Carlos Bay, Matlacha Pass (south of an east-west line from Boca Grand Inlet), and Pine Island Sound, the Estero Bay estuary and watershed, and the Immokalee Rise. This area is approximately 516,000 ha (1.28 million acres), and includes most of Lee County, the southeastern portion of Charlotte County, western Hendry County, and southern Glades County. The major physiographic provinces of the subregion are the Caloosahatchee Valley, Gulf Coast Lowlands, DeSoto Plain and the Immokalee Rise (Southwest Florida Regional Planning Council 1995). Within this subregion, the Immokalee Rise includes most of Hendry County and eastern Lee County. It is about 8 m (25 ft) in elevation, but can peak at 11 m (36 ft) and 13 m (43 ft) in some areas. All soils are deep, nearly level, and poorly drained, with a water table less than 25 cm (10 in) from the surface during at least part of the year (SWFRPC 1995).

Historically, the Caloosahatchee River was a shallow, meandering 80 km (50 mi) long system, with headwaters near Lake Hicpochee (Science Subgroup 1996). Today, however, it extends approximately 114 km (71 mi) from Lake Okeechobee to San Carlos Bay, as a channelized flood control and navigational waterway. The river is supplied by inflows from Lake Okeechobee and runoff within its own basin. It was extended to Lake Okeechobee by dredging in 1884, and was subsequently channelized to improve navigation and flood control.

The river now has three locks or water control structures: Moore Haven Lock, Ortona Lock, and Franklin Lock. The freshwater portion of the river, also called the C-43 Canal, extends eastward from the Franklin Lock and Dam toward Lake Okeechobee and the cities of LaBelle and Moore Haven. The C-43 Canal is part of the cross-state Lake Okeechobee Waterway that provides navigation between the east and west coasts of Florida. West of the Franklin Lock, from Olga to the Gulf, the river broadens into a tidally influenced estuarine system. Franklin Lock, also called S-79, serves as a salinity barrier to tidal changes and as a conveyor of freshwater into the estuary (COE 1994).

The estuarine portion of the Caloosahatchee Subregion is approximately 42 km (26 mi) long and extends from S-79 to Shell Point where it discharges into San Carlos Bay at the southern end of Charlotte Harbor (COE 1994). The average discharge is 2,000 cubic feet/second (cfs) (Science Subgroup 1996). San Carlos Bay connects the mouth of the Caloosahatchee River to Matlacha Pass and Pine Island Sound (COE 1994**)**. The Caloosahatchee River can discharge freshwater to the southern portion of Pine Island Sound during periods of large releases from Lake Okeechobee, but the primary source of freshwater is sheetflow from the surrounding islands, as well as from the small creeks and marshes on Pine island, and the Sanibel River on Sanibel Island (CHNEP 1996).

The Estero Bay estuary and watershed in southwestern Lee County, consists of Estero Bay and associated barrier islands, the Estero Bay basin, including the Imperial and Estero rivers, and the Six-Mile Cypress Slough Watershed (Science Subgroup 1996). Estero Bay is a shallow, subtropical estuarine lagoon, approximately 4,580 ha (11,317 acres) in area. Five creeks and rivers drain into the bay including Hendry Creek, Mullock Creek, Estero River, Spring Creek, and Imperial River. The Six-Mile Cypress Slough, in central Lee County, (830 ha or 2,051 acres) is an important recharge area for the watershed. Estero Bay is separated from the Gulf of Mexico by several barrier islands: Estero Island, the Lovers Key complex (Long Key, Lovers Key, Black Island), Big Hickory Island, Little Hickory Island, and Bonita Beach Island (CHNEP 1996). Estero Bay was designated a State Aquatic Preserve and its tributary watersheds are protected by the State of Florida.

Predominant ecological communities in this subregion, in addition to the Caloosahatchee River, proper, include pine flatwoods, scrubby flatwoods, coastal strand, freshwater marshes, mangroves, and seagrasses.

Everglades

The Florida Everglades is unique in the world, combining both temperate and tropical flora in a widely shifting mosaic of habitats. Historically, water connected the entire Kissimmee River-Lake Okeechobee-Everglades watershed. The system was bordered on the east by the Atlantic Coastal Ridge and on the west by the Immokalee Rise (McPherson and Halley 1997). Prior to drainage of this system of wetlands by man, the Everglades region consisted of dense, seemingly impenetrable wetlands, extending over an area approximately 64 km (40 mi) wide by 160 km (99 mi) long (Brooks 1974, Davis 1943, Parker 1974, Tebeau 1974) and covering an estimated 3.5 million

ha (8.6 million acres) (COE 1994). Today, much of the land that historically supported Everglades communities now supports a variety of land uses, ranging from intensively managed agriculture in the north (EAA), to rapidly spreading urban uses along the east and west boundaries.

Geologically, the Everglades system is young, formed 5,000 years ago as rising sea levels created pressure to contain freshwater within the shallow bedrock trough in South Florida, and allowed the accumulation of thick peat in deep areas (Gleason and Stone 1994). During the dry season and during periods of below-average precipitation, the Everglades subsists on nutrients derived primarily from the atmosphere through rainfall (Lodge 1994). The system is not directly fed by streams or rivers, but, is balanced through precipitation, evapotranspiration, and subsurface movement into and out of the aquifer (Wagner and Rosendahl 1987). It is this characteristic that gives rise to the uniqueness of the Everglades and its recognition as a system dependent on sheetflow. In contrast, most of the world's other large wetland systems that on some level resemble the Everglades, such as the Pantanal of Brazil, the Llanos of Venezuela, and the Usumacinta and Grijalva river deltas of Mexico, receive their nutrients and water from rivers that overflow their banks (Lodge 1994).

The Everglades subregion consists of a complex system of hydrologically inter-related landscapes. Because the Everglades is located on a peninsula that extends from a temperate to a subtropical climate, the associated flora consists of tropical, temperate, and endemic species (Gunderson 1994). Gunderson (1994) grouped Everglades communities into upland and wetland vegetative components based on hydro-edaphic conditions, water chemistry, and vegetative growth form. Everglades uplands are composed of rockland communities, which include rockland pine forests and tropical hardwood hammocks. Everglades freshwater wetland communities are categorized as forested wetlands, marshes, prairies, and ponds and sloughs. The periphyton community, composed of many taxa of microalgae, occurs in concert with many of the freshwater communities in the Everglades, and is an important element of the base of the food chain.

Big Cypress

The Big Cypress subregion includes all of Collier and portions of Lee, Hendry, and Monroe counties. This subregion has two watersheds: the Corkscrew Swamp from near Lake Trafford and southwest to the coast, and the Big Cypress Swamp running southwest and perpendicular to the Tamiami Canal. The South Florida Shelf runs through the subregion and generally parallels the southwest coast. The landscape is relatively flat and underlain with an uneven bedrock surface which is usually covered by a veneer of soils. The soils are relatively modern and in the process of formation from surficial sediments such as sand and calcareous marl mixing with organic peat and muck components.

The more than 320,000 ha (790,720 acres) of connected wetlands feature the Corkscrew Regional Ecosystem Watershed, Corkscrew Swamp, Camp Keais Strand, Okaloacoochee Slough, Fakahatchee and Picayune strands, Belle Meade, and a major portion of Big Cypress National Preserve. The system encompasses mostly cypress, pine, and hardwood forests, as well as prairies

and sloughs that drain into the Ten Thousand Islands and Rookery Bay estuarine systems and into other estuaries off the Everglades. Major ecological communities of the Big Cypress subregion include pinelands, hammocks, beach dune, coastal strand, prairies, cypress swamps, mangroves, and freshwater and saltwater marshes.

Florida Keys, including Biscayne Bay, Card Sound, and the Lower Southwest Estuaries

This subregion is geographically within Monroe County and a portion of Miami-Dade County. It covers the estuarine waters contiguous with Florida Bay and the Florida Keys. Biscayne Bay is at the southeast corner of the State, protected from the deeper waters of the Florida Straits and the Atlantic Ocean by the northern extent of the Florida Keys. Card Sound lies off the northern Keys. Florida Bay and Ponce de Leon Bay are located around the tip of the State up the southwest coastline.

This unique subregion began forming 100,000 years ago when the sea level was 8 m (26 ft) above the present level. Along a submerged platform, coral reefs developed in a band from present-day Miami to the Dry Tortugas. Fossil remnants of reef organisms form the exposed limestone bedrock of today's Middle and Upper Keys. What has evolved is a combination of marine and tropical upland habitats that support a wealth of biological diversity and habitats, some found nowhere else in the world. Because of the geographic isolation of the Keys, there are numerous endemic plants and animals. The natural community types of primary importance in the Keys and lower Florida coast include hardwood hammocks, pine rocklands, freshwater wetlands, mangrove wetlands, seagrasses and coral reefs.

West Indian hardwood hammocks and pine rocklands are imperiled upland communities of the Florida Keys. Of approximately 3,359 ha (8,300 acres) of Keys hardwood hammock, over 3,035 ha (7,500 acres) are unprotected. There are more than 120 species of hardwood trees, shrubs, and plants that grow in these unique, dense uplands. Only about 404 ha (998 acres) of an estimated 910 ha (2,249 acres) of pine rocklands are protected. Shoreline habitats, such as mangrove wetlands, transitional wetlands, and beach habitats are also found in this region. These habitats are all critical nursery areas for aquatic life and shelter the coasts from erosion.

The mangrove forest ecosystem along the shoreline of this subregion provides food and shelter to a myriad of marine organisms and shelter for diverse avian life. Biscayne Bay has the longest stretch of mangrove shoreline left on the east coast of the U.S. The shallow protected waters of the estuaries support clear waters and lush seagrass beds that serve as an important nursery for marine life, providing food and shelter to larvae and juveniles. Mangrove communities provide nursery areas for many fish.

The Florida Keys' coral reef tract is one of the world's major barrier reefs, the most extensive living coral reef system in North America and the third largest reef system on the planet. It extends the length of the Keys, from Biscayne Bay to the

Dry Tortugas, almost 322 km (200 mi) of subtropical islands surrounded by the Gulf of Mexico and Florida Bay to the west and Atlantic Ocean to the southeast.

The Biogeography of South Florida

A unique combination of history, climate, geography, and environmental forces has made the South Florida Ecosystem an important reservoir of landscape, community, and species diversity. The fauna of this region is extremely young and dynamic, and understanding it requires abandoning simple explanations due to historical zoogeography, ecological conditions, hydrological conditions, or human disturbance alone. Three factors mostly define the nature of southern Florida's biodiversity: the recent origin of freshwater and terrestrial ecosystems; peninsula geography and habitat diversity; and subtropical wet/dry climate and productivity.

The climate in South Florida is subtropical and humid with average annual temperatures in the mid-20s C (70s F), ranging from about 16 C (60 F) in midwinter to about 27 C (80 F) in summer. Rainfall averages about 137 cm (54 in), with 50 to 60 percent of it from June to September. High rainfall may also occur during late summer and early fall in association with tropical storms or hurricanes. Hurricane season extends from June 1 through November 30.

The ecological communities of South Florida were not established until about mid-Holocene, but this relatively short time allowed the differentiation of distinctive phenotypes and genotypes (Webb 1990). Layne (1984) suggested that much of South Florida's subspeciation is a product of isolation and changing conditions. There is a general pattern of reduced species richness as one proceeds down the Florida peninsula. This has been discussed as a "peninsula effect" due to reduced land area, decreased rates of invasion, and/or increased rates of extinction (*e.g*., Cook 1969, Duellman and Schwartz 1958, Kiester 1971, MacArthur and Wilson 1967, Robertson 1955, Simpson, 1964). Reduced species numbers and stressful conditions are not equally expressed in all ecological or taxonomic segments, however. Layne (1984) listed 32 species of native mammals (including bats) in mainland Florida south of Lake Okeechobee, as compared with 51 species for the State as a whole. Carnivores comprise a larger proportion of the mammalian fauna in southern Florida than in the rest of the State (31 percent *vs*. 20 percent). Robertson and Kushlan (1984) listed 296 species of birds regularly seen in South Florida, over 60 percent of which are migratory. These authors noted wading bird densities and species richness in South Florida that was historically as high as anywhere in North America, and they point out that the "nearly unique ability of the South Florida ecosystem to support such large numbers of 14 species of superficially similar secondary and tertiary consumers on a resource base that is reduced in species diversity by biogeographic factors is generally unappreciated." Busack and Hedges (1984) and Dalrymple *et al.* (1991) have noted no reduced species diversity for lizards and snakes in their studies, and Dalrymple (1988) noted high numbers for some amphibian and reptile species in South Florida. Of the 132 species of amphibians and reptiles known from Florida, 72 species are known from South Florida (55 percent) (Dalrymple 1988). Loftus and Kushlan (1987) found 92 freshwater fish species in South Florida. In addition, some 217

fish species have been collected from various marine and estuarine mangrove communities of South Florida. Over 600 species of fish have been noted from the Indian River Lagoon region (Indian River Lagoon National Estuary Program 1996). A total of 246 fish species have been reported from the estuarine ecosystem of Charlotte Harbor, including 18 commercially important species and 5 species that are important for recreational fisheries (Taylor 1974).

The Species of Concern

Threatened and Endangered Species

There are 68 federally listed species that occur in South Florida (Table 1). Note that this number does not include the mountain lion, peregrine falcon, or American alligator, which are listed by similarity of appearance, the whooping crane, which is considered an experimental population, or cetaceans or Johnson's seagrass which NMFS has the recovery lead for. Information on the biology, ecology, status, trends, management, and needed recovery actions for each of the 68 species are included in "The Species" section of this Recovery Plan. The ecological community accounts in "The Ecosystem" section highlight a few of the other species of concern occurring in the South Florida Ecosystem; a comprehensive list of these species by community type is given in Appendix C.

Migratory Birds

The South Florida Ecosystem is located along one of the primary migratory routes for bird species that breed in temperate North America and winter in the tropics of the Caribbean and South America. Many species of neotropical migrants have been recorded in the South Florida Ecosystem (Appendix D). In 1995, the FWS prepared a list of migratory nongame birds of management concern in the U.S. to stimulate a coordinated effort by Federal, State, and private agencies to develop and implement comprehensive and integrated approaches for the management of these selected species (FWS 1995). The South Florida Ecosystem supports 43 of these species (Table 2). Large numbers of species like the bobolink (*Dolichonyx oryzivorus*), a species of management concern, migrate through the South Florida Ecosystem as they fly from their breeding grounds in southern Canada and the northern Great Plains on their way to the marshes of Argentina and Brazil. Virtually the entire North American population of blackpoll warblers (*Dendroica striata*) migrates to South America along a route that passes through Florida to the West Indies. Other migratory species like the tanagers (*Pirange spp.*), chimney swifts (*Chaetura pelagica*), tree swallows (*Iridoprocne bicolor*), nighthawks (*Chordeiles minor*), royal terns (*Sterna maxima*), and blue-winged teal (*Anas discors*) also have major migratory pathways through the South Florida Ecosystem.

More than 129 bird species migrate to the South Florida Ecosystem to overwinter. Another 132 bird species breed in the South Florida Ecosystem. Because the South Florida Ecosystem is located near Cuba and the West Indies, it draws Caribbean species that rarely appear elsewhere in North America.

Table 1. Federally listed endangered and threatened species in South Florida.

Mammals (except whales)		
Florida panther	*Puma concolor coryi*	E
Mountain lion	*Puma concolor*	T (S/A)
Key deer	*Odocoileus virginianus clavium*	E
Key Largo cotton mouse	*Peromyscus gossypinus allapaticola*	E
Key Largo woodrat	*Neotoma floridana smalli*	E
Lower Keys rabbit	*Sylvilagus palustris hefneri*	E
Rice rat (= silver rice rat)	*Oryzomys palustris natator* (= *O. argentatus*)	E (CH)
Southeastern beach mouse	*Peromyscus polionotus niveiventris*	T
West Indian manatee	*Trichechus manatus*	E (CH)
Birds		
Audubon's crested caracara	*Polyborus plancus audubonii*	T
Bachman's warbler	*Vermivora bachmanii*	E
Bald eagle	*Haliaeetus leucocephalus*	T
Cape Sable seaside sparrow	*Ammodramus (=Ammospiza) maritimus mirabilis*	E (CH)
Everglade snail kite	*Rostrhamus sociabilis plumbeus*	E (CH)
Florida grasshopper sparrow	*Ammodramus savannarum floridanus*	E
Florida scrub-jay	*Aphelocoma coerulescens*	T
Ivory-billed woodpecker	*Campephilus principalis*	E
Kirtland's warbler	*Dendroica kirtlandii*	E
Peregrine falcon	*Falco peregrinus*	E (S/A)
Piping plover	*Charadrius melodus*	T
Red-cockaded woodpecker	*Picoides (= Dendrocopos) borealis*	E
Roseate tern	*Sterna dougallii dougallii*	T
Whooping crane	*Grus americana*	XN
Wood stork	*Mycteria americana*	E
Reptiles		
American crocodile	*Crocodylus acutus*	E (CH)
American alligator	*Alligator mississippiensis*	T (S/A)

Table 1. ***cont.***

Atlantic salt marsh snake	*Nerodia clarkii (=fasciata) taeniata*	T
Bluetail (=blue-tailed) mole skink	*Eumeces egregius lividus*	T
Eastern indigo snake	*Drymarchon corais couperi*	T
Green sea turtle	*Chelonia mydas* (incl. *agassizi*)	E (CH)
Hawksbill sea turtle	*Eretmochelys imbricata*	E (CH)
Kemp's (=Atlantic) ridley sea turtle	*Lepidochelys kempii*	E
Leatherback sea turtle	*Dermochelys coriacea*	E (CH)
Loggerhead sea turtle	*Caretta caretta*	T
Sand skink	*Neoseps reynoldsi*	T
Invertebrates		
Schaus swallowtail butterfly	*Heraclides (= Papilio) aristodemus ponceanus*	E
Stock Island tree snail	*Orthalicus reses (*not incl. *nesodryas)*	T
Plants		
Avon Park harebells	*Crotalaria avonensis*	E
Beach jacquemontia	*Jacquemontia reclinata*	E
Beautiful pawpaw	*Deeringothamnus pulchellus*	E
Britton's beargrass	*Nolina brittoniana*	E
Carter's mustard	*Warea carteri*	E
Crenulate lead-plant	*Amorpha crenulata*	E
Deltoid spurge	*Chamaesyce(=Euphorbia) deltoidea* spp. *deltoidea*	E
Florida bonamia	*Bonamia grandiflora*	T
Florida golden aster	*Chrysopsis (=Heterotheca) floridana*	E
Florida perforate cladonia	*Cladonia perforata*	E
Florida ziziphus	*Ziziphus celata*	E
Four-petal pawpaw	*Asimina tetramera*	E
Fragrant prickly-apple	*Cereus eriophorus* var. *fragrans*	E
Garber's spurge	*Chamaesyce(=Euphorbia) garberi*	T
Garrett's mint	*Dicerandra christmanii*	E
Highlands scrub hypericum	*Hypericum cumulicola*	E

Table 1. ***cont.***

Key tree-cactus	*Pilosocereus (= Cereus) robinii*	E
Lakela's mint	*Dicerandra immaculata*	E
Lewton's polygala	*Polygala lewtonii*	E
Okeechobee gourd	*Cucurbita okeechobeensis* spp. *okeechobeensis*	E
Papery whitlow-wort	*Paronychia chartacea (= Nyachia pulvinata)*	T
Pigeon wings	*Clitoria fragrans*	T
Pygmy fringe-tree	*Chionanthus pygmaeus*	E
Sandlace	*Polygonella myriophylla*	E
Scrub blazing star	*Liatris ohlingerae*	E
Scrub buckwheat	*Eriogonum longifolium* var. *gnaphalifolium*	T
Scrub lupine	*Lupinus aridorum*	E
Scrub mint	*Dicerandra frutescens*	E
Scrub plum	*Prunus geniculata*	E
Short-leaved rosemary	*Conradina brevifolia*	E
Small's milkpea	*Galactia smallii*	E
Snakeroot	*Eryngium cuneifolium*	E
Tiny polygala	*Polygala smallii*	E
Wide-leaf warea	*Warea amplexifolia*	E
Wireweed	*Polygonella basiramia* (= *ciliata* var. *b.*)	E

Examples of these species include the smooth-billed ani (*Crotophaga ani*), mangrove cuckoo (*Coccyzus minor*), Antillean night hawk *(Chordeiles gundlachii)*, white-crowned pigeon (*Columba leucocephala*), and black-whiskered vireo (*Vireo altiloquus*).

The South Florida Ecosystem has an endemic race of the yellow warbler (*Dendroica petechia*) and contains the majority of the nesting locations for the great white heron (*Ardea herodias occidentalis*), reddish egret (*Egretta rufescens*), roseate spoonbill (*Ajaia ajaja*), swallow-tailed kite (*Elanoides forficatus*), and short-tailed hawk (*Buteo brachyurus*) in the U.S.

Fifteen species of herons, storks, and ibises nest in the South Florida Ecosystem and are considered ecological indicators because of their wide foraging ranges, relatively narrow food requirements, and relatively specific habitat requirements. Their breeding success reflects the health of the wetland and coastal habitats of the South Florida Ecosystem. Wading bird populations in the South Florida Ecosystem have undergone declines far greater than the declines of their nesting habitats. According to current estimates, breeding populations of wading birds in South Florida have declined by more than 90 percent as their habitats have been reduced by 50 percent (Ogden 1994). Of the 15 species of wading birds that breed in the South Florida Ecosystem, the wood stork (*Mycteria americana*), great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), tricolored heron (*Hydranassa tricolor*), and white ibis (*Eudocimus albus*) have declined by an estimated 75 to 80 percent between the 1930s and the late 1970s. The wood stork has undergone the most serious population decline (Ogden 1994). Habitat destruction and loss have reduced the supply of fish and other food items, thus contributing to the overall decline of wading birds.

The coastal area of the South Florida Ecosystem, like the rest of Florida, provides important breeding and wintering areas for shorebirds. The beaches provide nesting habitat for 13 species of shorebirds and support one of the two largest concentrations of wintering shorebirds in Florida. The South Florida Ecosystem also contains important wintering habitat, including portions of the Key West National Wildlife Refuge (NWR), for the endangered piping plover (*Charadrius melodus*).

Land conversion for residential housing has significantly reduced the amount and quality of nesting and wintering habitat for migratory birds in the South Florida Ecosystem. Very few bird habitats in South Florida have been protected from the effects of this land conversion. Although the response of breeding and wintering populations of migratory birds to habitat losses in South Florida is uncertain, the magnitude of the habitat loss is certain to adversely affect migratory bird species. For example, Charlotte Harbor once supported large numbers of nesting black skimmers (*Rynchops niger*), snowy plovers (*Charadrius alexandrinus*), American oystercatchers (*Haematopus palliatus*), royal terns, and sandwich terns (*Sterna sandvicensis*). Because of habitat loss in Charlotte Harbor, these species now concentrate along the coast of the Panhandle and the northeast coast of Florida. (Cox *et al*. 1994).

Table 2. Migratory nongame birds of management concern in the South Florida Ecosystem.

American bittern *Botaurus lentiginosus**	loggerhead shrike *Lanius ludovicianus**
American swallow-tailed kite *Elanoides forficatus*	long-billed curlew *Numenius americanus*
Bachman's sparrow *Aimophila aestivalis**	Louisiana waterthrush *Seiurus motacilla*
barn owl *Tyto alba**	northern harrier *Circus cyaneus**
black rail *Laterallus jamaicensis*	northern flicker *Colaptes auratus*
black-capped petrel *Pterodroma hasitata*	painted bunting *Passerina ciris*
black-throated blue warbler *Dendroica co erulescens*	prairie warbler *Dendroica discolor*
black-whiskered vireo *Vireo altiloquus*	reddish egret *Egretta rufescens**
blue-winged warbler *Vermivora pinus*	seaside sparrow *Ammodramus maritimus**+
bobolink *Dolichonyx oryzivorus*	sedge wren *Cistothorus platensis*
brown pelican *Pelecanus occidentalis*+	short-tailed hawk *Buteo brachyurus*
burrowing owl *Speotyto cunicularia*	snowy plover *Charadrius alexandrinus**
common loon *Gavia immer**	Swainson's warbler *Limnothlypis swainsonii*
common ground-dove *Columbina passerina*	upland sandpiper *Bartramia longicauda*
eastern meadowlark *Sturnella magna*	veery *Catharus fuscescens*
field sparrow *Spizella pusilla*	white-crowned pigeon *Columba leucocephala*
grasshopper sparrow *Ammodramus savannarum*+	Wilson's plover *Charadrius wilsonia*
Henslow's sparrow *Ammodramus henslowii**	wood thrush *Hylocichla mustelina*
lark sparrow *Chondestes grammacus*	worm-eating warbler *Helmitheros vermivorus*
least bittern *Lxobrychus exilis**	yellow rail *Coturnicops noveboracensis*
least tern *Sterna antillarum*	yellow-billed cuckoo *Coccyzus americanus*
limpkin *Aramus guarauna*	

* = also on the FWS 1987 list of management concern.

+ = Florida population of brown pelican was removed from the list of threatened species on March 6, 1985 (Federal Register 50(23), February 4, 1985, pp 4,938-4,945).

+ = Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) was listed as endangered in July 1986 (Federal Register, July 31, 1986).

+ = Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) was listed as endangered in March 1967 (Federal Register, March 11, 1967), and critical habitat designated in August 1977.

+ = Dusky seaside sparrow (*Ammodramus maritimus nigrescens*) was removed from the endangered list as extinct on January 11, 1991 (Federal Register 55(239), December 12, 1990, pp 51,112-51,114).

Interjurisdictional Fish

Estuarine and marine fish are integral to the ecology and economy of South Florida, reflecting, to a large extent, the health of aquatic systems and the ecosystem as a whole. For example, Florida Bay fish populations are critical to the health of the wading bird colonies along the northern edge of the Bay. Also, anglers spend millions of dollars annually fishing in Florida for such species as red drum (*Sciaenops ocellatus*), spotted seatrout (*Cynoscion nebulosus*), tarpon (*Megalops atlanticus*), snook (*Centropomus sp.*), bonefish (*Albula vulpes*), jacks (*Caranx sp.*), snappers (*Lutjanus sp.*), groupers (*Epinephelus sp.*), sharks (30 to 40 species), spiny lobsters (*Panulirus argus*), and stone crabs (*Menippe mercenaria*). To further highlight the importance of such species to humans and the relevance of the South Florida Ecosystem to fish, consider that more than one-third of the fish and shellfish landed in Florida's coastal waters were caught by vessels originating from South Florida ports. In 1997, these vessels landed more than 19 million lbs (8.6 million kg) of fish and 18.9 million lbs (8.6 million kg) of shellfish. This catch was valued at $88.5 million (Josh Bennett, NOAA Southeastern Fisheries Science Center, personal communication 1999).

An estimated 96 percent (98 percent Gulf of Mexico and 94 percent southeast Atlantic) by weight of commercially and recreationally important marine fish species in South Florida are dependent upon estuarine habitats for critical life processes (Chambers 1991). The coastal, estuarine, and nearshore ecosystems of South Florida provide a nursery for a wide variety of fish and shellfish species, supporting offshore fisheries in the South Atlantic and Gulf of Mexico. Florida Bay is a key nursery area for various marine species including spotted seatrout, bonefish, red drum, tarpon, pink shrimp (*Penaeus duorarum*), and spiny lobster. Also, Charlotte Harbor is the southern range of the threatened Gulf sturgeon (*Acipenser oxyrhinchus desotoi*). The status of Gulf sturgeon in Charlotte Harbor is unclear; however, information indicates that juvenile sturgeon have been collected by commercial fishermen in the 1990s (F. Parauka, FWS, personal communication 1996).

The habitats that historically supported South Florida fish populations have declined significantly in area and quality over the past 50 years. The alteration of freshwater flows to the estuaries along the southern and southwestern coasts of Florida has reduced water quality of the estuarine habitats of the region. A 90 percent reduction in freshwater inflow and increased levels of nutrient and pesticides have contributed to an increase of algal blooms, lost seagrass beds, sponge mortality, and salinity increases. Excessive pulses of fresh water released into the estuaries over a short time frame are also very harmful. The resulting decrease in salinity, increase in suspended solids, and other water chemistry parameter changes can severely stress or kill estuarine organisms.

All of these changes have caused increased incidences of fish kills and serious losses of mangroves-all of which are directly linked to land use or land misuse in areas surrounding the Everglades as well as to South Florida's water management regime.

An April 1996 workshop, "Identification of Potentially Endangered Species in the Gulf of Mexico and Determination of Research Needs for These Species," held at the Gulf Coast Research Laboratory in Ocean Springs, Mississippi, identified the following species of concern within the contiguous areas of the South Florida Ecosystem: opossum pipefish (*Microphis brachyurus lineatus*), mangrove rivulus (*Rivulus marmoratus*), mangrove gambusia (*Gambusia phizophorae*), blue croaker (*Bairdiella batabana*), sea lamprey (*Petromyzon marinus*), striped bass (*Morone saxatilis*), key silverside (*Menidia conchorum*), small tooth sawfish (*Pristis pectinata*), and some sharks. Many of these species are tropical peripherals, following the Gulf Stream and other currents into the South Florida area. The opossum pipefish and many gobies (*Gobionellus sp.*) depend on oligohaline areas (*e.g.*, the mouth of the St. Lucie River) for reproduction, although opossum pipefish have been found in Lake Okeechobee (R. Gilmore, Harbor Branch Oceanographic Institute, personal communication 1996). These species are especially sensitive to blockages in rivers, such as dikes, dams, or weirs, that impede their movements; and they also are flushed out by instantaneous and unramped water releases. Many vegetative species targeted for herbiciding, such as panicum grass, are used by these species. Although their ecosystem roles are not fully understood or appreciated, the fact that they are diminishing signals other system imbalances.

Freshwater fish may not be faring any better than marine and estuarine species. Human health advisories are in place due to the mercury content of such fish as largemouth bass (*Micropterus salmoides*), bowfin (*Amia calva*), gar (*Lepisosteus sp.*), spotted sunfish (*Lepomis punctatus*), Mayan cichlid (*Cichlasoma urophthalmus*), warmouth (*Lepomis gulosus*), and yellow bullhead catfish (*Ictalurus natalis*) in approximately 12 rivers and 17 lakes in South Florida, as well as in the Savannas Marsh, Big Cypress Preserve, Arthur R. Marshall Loxahatchee NWR, Everglades Water Conservation Areas 2a and 3, and Everglades NP (Florida Department of Health and Rehabilitative Services 1993).

Status and Trends

The natural resource issues in South Florida are extremely complex. Human socioeconomics and demographics play a major role in the process of species recovery and habitat restoration. A majority of imperiled species in this region are habitat-limited. With an increasing human population, habitat loss, fragmentation and degradation are critical issues to overcome to effect recovery.

Human Population Trends in South Florida

Just before the turn of the 20th century, the total population of the 16 counties now included in the South Florida Water Management District was 32,000 people. Nearly 20,000 of those people lived in Key West. Only 861 people lived in the area currently occupied by Miami, Fort Lauderdale, and West Palm Beach (Intragency Working Group 1994).

Ninety years later, that situation has changed dramatically. Half of Florida's 12 million people currently live in the South Florida Ecosystem: one out of every four of Florida's population lives in Miami-Dade and Broward counties. The South Florida Ecosystem contains four of the top ten fastest-growing metropolitan statistical areas in the United States: including Naples, Fort Pierce, Fort Myers-Cape Coral, and West Palm Beach-Boca Raton-Delray Beach (the first, third, fourth, and sixth fastest-growing areas in the country, respectively).

Florida's population, fourth largest in the U.S., is expected to reach 17.8 million (331 per mi^2) by 2010 (Floyd 1997a). About half of these people will live in the South Florida Ecosystem; one third of Florida's population is projected to live in Miami-Dade, Broward, and Palm Beach counties. On the west coast, Lee, Sarasota, and Collier counties are expected to increase by more than 161,000, 102,000, and 87,000 people, respectively, by the year 2010. The population of South Florida passed one million (130 persons per km^2 or 50 persons per mi^2) in 1950, three million (391 per km^2 or 151 per mi^2) in 1970, and six million (780 per km^2 or 301 per mi^2) in 1990. The population density of South Florida has exceeded the statewide average since 1960. South Florida's population is projected to reach 8.2 million (1070 per km^2 or 413 per mi^2) by 2010.

South Florida accounted for 49 percent of Florida's residential construction starts in 1995 (Floyd 1996). Ft. Lauderdale, Miami, West Palm Beach-Boca Raton, Sarasota-Bradenton, Ft. Myers-Cape Coral, Ft. Pierce-Port St. Lucie, Lakeland-Winter Haven, Punta Gorda, and Naples, in descending order, accounted for 39 percent of Florida home sales in 1996. Ft. Lauderdale ranked third and Miami fourth statewide in total numbers of houses sold. Naples ranked second statewide in the percentage increase of houses sold. South Florida accounted for 54 percent or $336,865,920,000 of Florida's land use value in 1995 (Floyd 1996).

The Economy of South Florida

> *The Ever Glades are now suitable only for the haunt of noxious vermin, or the resort of pestilent reptiles. The statesman whose exertions shall cause the millions of acres they contain, now worse than worthless, to team with the products of agricultural industry; that man who thus adds to the resources of his country...will merit a high place in public favor, not only with his own generation, but with posterity*.
>
> T. Buckingham Smith (1848) from Johnson (1974)

South Florida has a diverse economy based on tourism, agriculture, fisheries, mining, and manufacturing.

Tourism

Tourism became the world's largest industry in 1992 and accounted for 13 percent of the world's consumer spending in 1993. Tourism nationwide generated $416 billion in expenditures and $56 billion in Federal, State, and

local tax revenues in 1994. The tourism industry, with 6.2 million direct jobs, is the U.S.'s second largest employer behind health services (Kranzer *et al.* 1995). Florida tourism employed more than 732,000 people and generated over $35 billion in taxable sales in 1995. South Florida accounted for nearly 35 percent of the jobs (Kranzer *et al.* 1995) and 40 percent of the taxable sales (Coggins 1995). In 1995, 73 percent of the tourists who arrived in Florida by air went to destinations in South Florida (Coggins 1995); almost all of those tourists traveled to destinations in Miami-Dade (Miami), Broward (Fort Lauderdale), or Palm Beach (Palm Beach) counties. Each year, about 1 million people visit the coral reefs in Pennekamp State Park and the Florida Keys National Marine Sanctuary. Each year, Everglades, Biscayne, and Big Cypress national parks receive about 1.5 million visitors.

Florida tourism began in the 1800s when fishermen came south for tarpon and other sport fish, invalids came south to a better climate per doctor's orders, and the wealthy established vacation homes or took their leisure in resorts on subtropical coasts. Boat travel gave way to rail travel when the Florida East Coast Railroad reached Miami in 1896, Homestead in 1903, and Key West in 1912. Rail travel gave way to auto travel in the 1940s and 1950s and today most visitors come by air.

Over 46 percent of Florida's licensed hotel, motel, rental condominium, and transient apartment (six month or less rental) units are located in South Florida. Some 17,530 licensed food establishments in South Florida account for 47 percent of the seating capacity statewide and are capable of seating 1.4 million people three times a day every day (Floyd 1997b). {"...The steady flow of travelers throughout the year means that in gross annual numbers the State's population is not 12 million but 56 million. Tourists, like residents, consume food, water and energy, generate garbage, and use the public parks and beaches, the roads and medical facilities, the jails, exempting the schools and most social services. The visitor's environmental impact is profound and surprisingly unexamined."} (Derr 1989).

South Florida has 28 percent of Florida's state parks (35 of 124) and hosted 44 percent of the 12.5 million visitors in fiscal year 1995 to 1996. Just 10 State parks in Monroe County hosted 14 percent of the State and 31 percent of the South Florida visitors. Visitation ranged from 1,097 at 29 ha (72 acres) San Pedro State Underwater Archaeological Preserve in Monroe County to 1,003,368 at 1022 ha (2,525 acres) John Pennekamp Coral Reef state park, also in Monroe County. Visitation by county ranged from 15,776 in Charlotte County to 1,700,072 in Monroe County (Floyd 1997a).

South Florida has 40 percent of Florida's national parks (4 of 10) and hosted 49 percent of the 10.8 million visitors in 1996. Visitation to national parks in Florida was down 12 percent from 1995 but visitation to national parks in South Florida was up 6 percent (Floyd 1997a). Each year about 1 million people visit the coral reefs in Pennekamp SP and the Florida Keys National Marine Sanctuary. Everglades, Biscayne and Big Cypress national parks receive about 1.5 million visitors per year. Big Cypress National Preserve, Biscayne NP, Dry Tortugas NP, and Everglades NP generated $163.2 million in sales and $10.6 million in taxes in 1995 (Correia 1995).

South Florida also has 55 percent of Florida's national wildlife refuges (16 of 29). The numbers of visitors to these refuges in 1998 totaled nearly 1.3 million, and ranged from 3,000 visitors at Florida Panther NWR to 821,000 at J.N. "Ding" Darling NWR.

After decades of explosive growth Florida's tourism numbers are stagnant. Auto visitor numbers have dropped as much as 10 percent per month for several years and international visitors are down 9 percent. Tourism is shifting away from theme parks to archaeological, cultural, ecological, or historical destinations. These trends suggest the only way to save Florida tourism is to save Florida itself (Hiller 1996).

Phosphate Mining

"Phosphorus, which has no natural or synthetic substitute, is an element necessary for all forms of life. Furthermore, long before carbon, nitrogen or oxygen supplies become critical, our supply of phosphorus will be exhausted. It is estimated that 3.1 million metric tons (3.5 million tons) of phosphorus are washed from the land into the seas by the world's rivers each year. And the oceans are already holding all of the largely insoluble phosphates that they can. New phosphorus simply forms sediment at the bottom of the seas and man cannot, at the present time, retrieve it". (Blakely 1973).

Florida holds 12 percent of the world reserves and 37 percent of the U.S. reserves of phosphorus (Sweeney and Hasslacher 1970 in Blakely 1973). Florida ranks first in the production of phosphate in the nation and produces 80 percent of the U.S. supply (Cates 1992). The central Florida phosphate region encompasses about 512,000 ha (1.2 million acres) in DeSoto, Hardee, Hillsborough, Manatee and Polk counties.

Florida began producing phosphate in 1888 when pebble rock was mined from the Peace River by floating barges (Blakely 1973, Long and Orne 1990). The central Florida phosphate industry has grown from small, localized operations to large, regional operations that mine an average of 2,428 ha (6,000 acres) per year. A total of 60,353 ha (149,130 acres) had been mined by 1975 and another 28,000 ha (69,000 acres) had been mined by 1990. As reserves are depleted in Polk County, phosphate mining is expected to make a dramatic shift to Hardee County (Central Florida Regional Planning Council 1997). Production in central Florida is expected to peak at 40 million metric tons (44 million tons) per year and taper off to 20 million metric tons (22 million tons) per year by 2010 because the industry cannot find enough new land to replace existing mines, and because remaining deposits are not as good as those being mined (Long and Orne 1990).

Sand tailings and the overburden are used to backfill mine cuts allowing the land to be reclaimed for industrial development, residential development, golf courses, cattle range, agricultural crops, and "wilderness restoration." Phosphatic clays are pumped to settling ponds which occupy 20 to 40 percent of the land mined. There are about 23,000 ha (57,000 acres) of existing settling ponds and a projected need for an additional 8,000 ha (20,000 acres). The settling ponds cannot be reclaimed for load-supporting construction uses but

can, after 3 to 5 years, support cattle grazing. About 53 percent of all mined lands have been reclaimed (Long and Orne 1990).

Phosphate mining has altered the headwaters, tributaries, and flood plains of the Alafia, Little Manatee, Manatee, Myakka, and Peace rivers with subsequent hydrological and downstream impacts. Mining irreversibly alters the physical and chemical characteristics of the topsoil and subsoil, thus altering the capability of the land to support a diverse native flora and fauna. Previously mined land cannot be completely restored to native condition, and more than half of the threatened and endangered species of the central Florida phosphate region are negatively impacted (Landrum 1993).

Limestone Rock Mining

Mined limestone is used primarily for infrastructure development; providing asphalt aggregate, concrete aggregate, road base, fill material and cement. The primary economic significance of the limestone rock mining industry is that this material is vital to Florida's construction industry and transportation system. The State of Florida has been adding approximately 1,000 new miles of roads per year. In addition to millions of square feet of nonresidential construction, the average pace of new residential construction has been 100,000 units per year since 1990. The significance of the industry is in both the production of a market demanded product while also generating substantial employment and income. The limestone industry, including linked activities, collectively constitutes employment of 7,089 individuals. In Florida, the limestone rock mining industry mined approximately 70 million tons in 1997 (Floyd 1997).

Of the total mined limestone, approximately half is presently mined within an 89-square mile area known as the Lake Belt region of western Miami-Dade County. Approximately 11,000 acres of wetlands have been impacted as a result of limestone mining in the Lake Belt region at a rate of nearly 300 acres per year. In addition to the loss of wet prairie and saw grass marsh communities, the large, deep excavation lakes that remain after the product is removed are of questionable quality for fish and wildlife resources (Hudy and Gregory 1984).

It is estimated that an additional 10,000 acres of wetlands will be affected as a result of limestone mining within the Lake Belt region in the future (SFWMD). Ecological concerns also include any effects on regional wetland function from increased groundwater seepage out of the Everglades as a result of excavation.

In 1992, the Florida legislature established the Northwest Miami-Dade County Freshwater Lake Plan Committee. The Committee was created as a public and private partnership to develop a plan for the design and implementation of a freshwater lake system in northwest Miami-Dade County. It is charged with developing a plan to address and balance water supply, efficient recovery of limestone, promotion of social and economic welfare, environmental protection, and public education. In concert with this effort, Federal, State, and local environmental agencies have developed a regional wetland mitigation and preservation plan for the Lake Belt area. The COE is also preparing a Programmatic Environmental Impact Statement, containing a Recommended Plan as a framework under which limestone mining will be permitted in Miami-Dade County. Project features, beneficial effects, resource impacts, and resource mitigation will be discussed in detail in this document.

Oil and Gas

Ten fields in South Florida produced 33 percent of Florida's 6.3 million barrels of crude oil and only 3 percent of Florida's 6.7 billion cubic feet of natural gas in 1996. The Bear Island and Raccoon Point fields, both in Big Cypress National Preserve, produced 77 percent of the oil and 81 percent of the natural gas extracted from South Florida in 1996. The remaining 23 percent of the oil and 19 percent of the natural gas were produced on eight private fields (Floyd 1997a).

There are four general phases of oil and gas development; exploration, drilling, production, abandonment and reclamation. In Big Cypress National Preserve, the average life span of a "typical" field is estimated to be 40 to 80 years. Reclamation after the field is abandoned generally involves filling pits, ditches, and other excavations; removing or covering all debris; and restoring the surface of the land and the access road to their former conditions. Vegetation restoration includes the use of native plant species and the reduction or elimination of exotic plant species (NPS 1991).

Agriculture

Agriculture began in the Everglades, south of Lake Okeechobee, after the drainage projects of the 1906 to 1927 era and intensified after the water control projects of the early 1950s, which created the Everglades Agricultural Area (EAA). It is possible that agriculture in the Everglades reached its zenith in the 1980s. Because virtually all of the EAA has been planted, there is no room for future expansion. Today in South Florida, more than $750 million is earned annually from the production of sugarcane, vegetables, sod, and rice and over 20,000 full-time equivalent jobs are provided. The future of agriculture in the Everglades is, however, uncertain due to possible changes in Federal farm programs, the loss of organic soils as a result of drainage, and concerns about nutrients in drainage water from the EAA. These latter concerns may be significantly alleviated by the development of agriculture more compatible with a periodic wet season, high water tables, and flooding (Davis and Ogden 1994).

Cattle - Florida has the largest herd of cattle east of the Mississippi River. The South Florida Ecosystem accounted for 54 percent of the beef and dairy cattle statewide in 1997 (Floyd 1997a). Interestingly, cattle numbers have declined 33 percent since 1995; this is attributed to an increase in citrus acreage on South Florida pastures and urbanization statewide. The dairy industry, which had substantial activity along the shores of Lake Okeechobee throught the 1980s, has been modifying its agricultural practices. State-mandated best management practices and buyouts have been effective in reducing nutrient loading into the lake; however, effects of historic nutrient runoff are still evident.

Citrus - The South Florida Ecosystem accounted for 87 percent of Florida's citrus groves and 88 percent of Florida's citrus production in 1995 to 1996 (Floyd 1997a); Polk County produces more oranges than California (Central Florida Regional Planning Council 1997). Almost 400,000 ha (1 million acres) of groves existed in South Florida in the late 1960s. Urbanization and freezes reduced citrus to a low of 253,000 ha (624,500 acres) in 1986 (Jackson 1991).

The acreage climbed back to 350,000 ha (860,000 acres) by 1996 (Floyd 1997a). Urbanization of better-drained lands, increased land values, increased taxes, and freezes have pushed citrus increasingly onto marginal, poorly drained areas in southwest Florida. Maehr (1990), and Mazzotti *et. al.* (1992) have pointed out that the expansion of the citrus industry has more than doubled in land area in southwest Florida since 1980, from 30,000 to 60,000 ha (74,130 ac to 148,260 acres). The citrus industry is expected to expand to over 80,000 ha (198,000 acres) by the year 2000 at current rates. Such land use provides only minimal habitat value for most wildlife species (Mazzotti *et al.* 1992).

Sugarcane - The tropical grass cultivated as sugarcane is a complex hybrid of two or more species of the genus *Saccharum* which is thought to have originated in southeastern Asia. Sugarcane is economically important because of its ability to accumulate high concentrations of sugars, primarily sucrose, in the stalk (Bottcher and Izuno 1994).

The first sugarcane grown in Florida was planted by the Spanish founders of St. Augustine in 1572. Attempts to establish commercial sugar production in Florida during the colonial period were short-lived. About 5,261 ha (13,000 acres) of sugarcane were grown for syrup production by the early 1900s. Large-scale sugar production began around 1925 in the Everglades region with the completion of the area's first sugar mill. A second mill was built in the 1930s and a third in the 1940s. Prior to 1960, expansion was limited by production quotas imposed by the U.S. Sugar Act (Bottcher and Izuno 1994). Political unrest in Cuba in 1960 encouraged the repeal of domestic production and acreage restrictions. Eight new mills were constructed by 1964 and the acreage planted to sugarcane increased from 20,640 ha (51,000 acres) to 90,248 ha (223,000 acres).

Over two-thirds of the dollar value of Everglades agriculture is generated by sugar production, and over 80 percent of the cropland is in sugarcane (Davis and Ogden 1994). Almost 13 metric tons (14.5 million tons) of sugarcane were harvested from 168,760 ha (417,000 acres) in Glades, Hendry, Martin, and Palm Beach counties in 1995 (Floyd 1997a).

Vegetables - In 1880, few vegetables were grown in Florida strictly for commercial production. Today over two dozen varieties are grown and South Florida produces nearly 70 percent of the nation's winter and spring vegetables (Kranzer *et al* 1995). Tomatoes are consistently the most valuable vegetable crop.

Tomatoes made up 13 percent of the vegetable acreage planted statewide in 1969 to 1970 and in 1989 to 1990. Miami-Dade and Collier counties have been the leading producers (Rose 1973, FDACS 1991). Tomato production statewide increased from 17,564 ha (43,400 acres) in 1949 to 1950 to 21,318 ha (52,675 acres) in 1969 to 1970 and 22,582 ha (55,800 acres) in 1989 to 1990. South Florida consistently produces greater than 90 percent of the tomatoes annually. The total tomato crop in 1989-90 was valued at $441 million (FDACS 1991).

Land Use Changes in South Florida

> *The last word in ignorance is the man who says of an animal or plant: "What good is it?" If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.*
>
> Aldo Leopold, *Round River*.

Dramatic population increase and economic expansion in South Florida has been accompanied by extensive land-use alteration. In the past 50 years, more than 3,237,485 ha (8 million acres) of forest and wetland habitats have been cleared in Florida to accommodate the expanding human population (Cox *et al*. 1994). Habitat loss has been particularly significant in the South Florida Ecosystem, which contains four wetland landscapes that have been reduced to remnants: the cypress strands fringing the western side of the Atlantic Coastal Ridge; the pond apple forest that occupied the southern shore of Lake Okeechobee; the extensive sawgrass prairie that formed the Everglades; and the peripheral wetlands that used to border the sawgrass prairie (Davis *et al.* 1994). Less than two percent of the original extent of pine rocklands outside of Everglades NP, remain (Snyder *et al.* 1990). Less than 10 percent of the tropical hardwood hammocks remain. Approximately 64.4 percent of the xeric habitats (scrub, scrubby flatwoods, and sandhills) on the southern Lake Wales Ridge have been lost to development or degraded (Peroni and Abrahamson 1985). Changes in the South Florida landscape since 1900 are dramatically depicted in the series of maps adapted from Costanza (1975) and USGS, BRD (1996), provided as Figures 3-6.

All of this habitat loss and fragmentation has been accompanied by dramatic alterations of the natural processes that maintained the healthy functioning of the ecosystems of South Florida. The canals and levees that crisscross South Florida have altered the natural hydrology that formed and maintained the wetlands and estuaries of South Florida. Portions of the freshwater wetlands are too dry in the dry season and too wet in the wet season. Portions of the estuaries along the coast of South Florida do not receive sufficient water to maintain their estuarine character. Most of the fire-dependent communities of the Lake Wales Ridge have been denied fire long enough to disrupt their ecology and endanger most of their endemic flora and fauna. Florida Bay has undergone a significant level of ecological degradation as evidenced by extensive algal blooms and seagrass die-off.

Upland Loss and Fragmentation

The natural upland communities of South Florida include: high pine, scrub, scrubby high pine, beach dune, coastal strand, maritime hammock, mesic temperate hammock, tropical hardwood hammock, pine rocklands, scrubby flatwoods, pine flatwoods, and dry prairie. The ecological community accounts provide an overview of these communities, and the species of concern. Refer

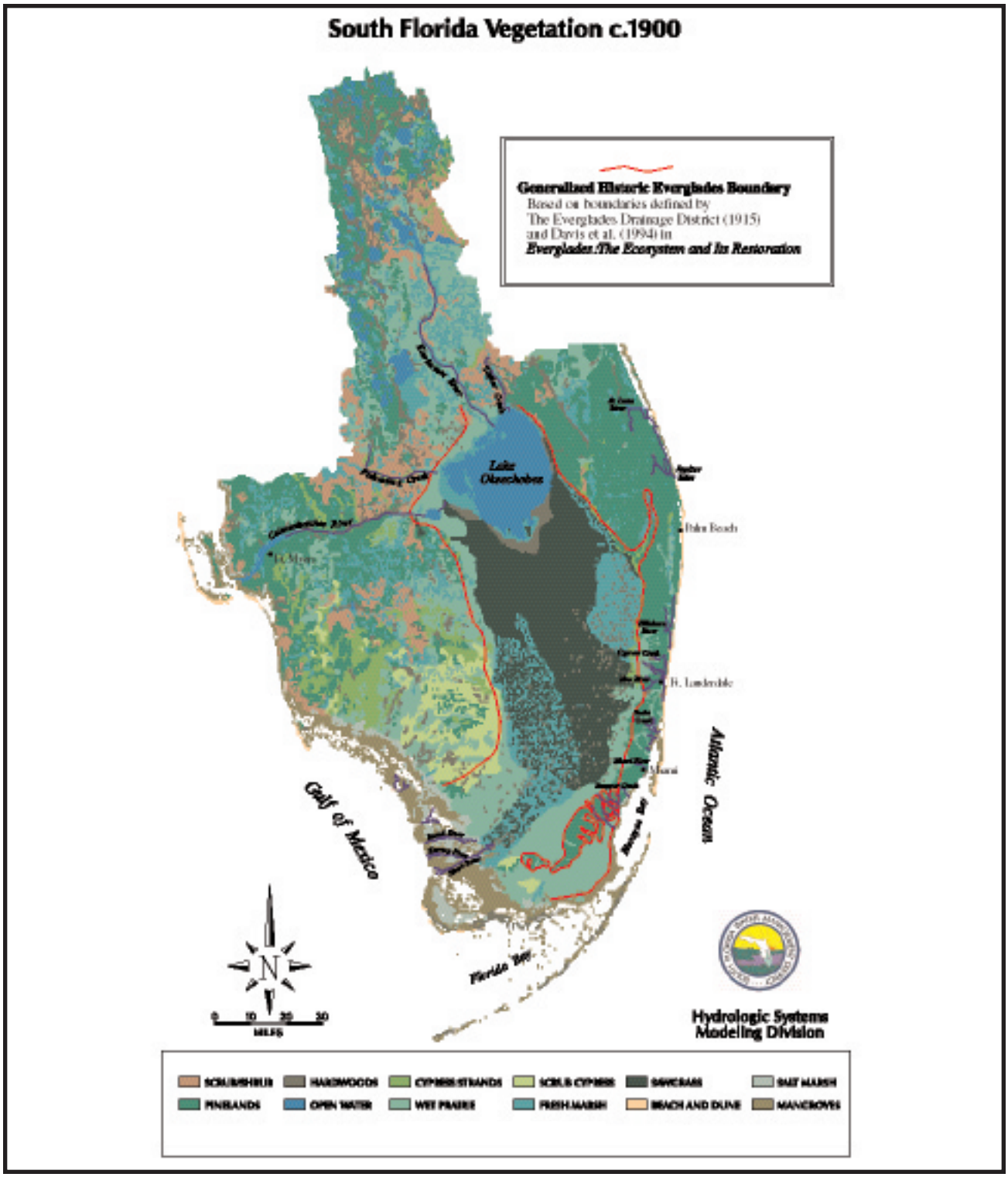


Figure 3. Vegetation within South Florida Water Management District boundaries circa 1900 (adapted from Costanza 1975).

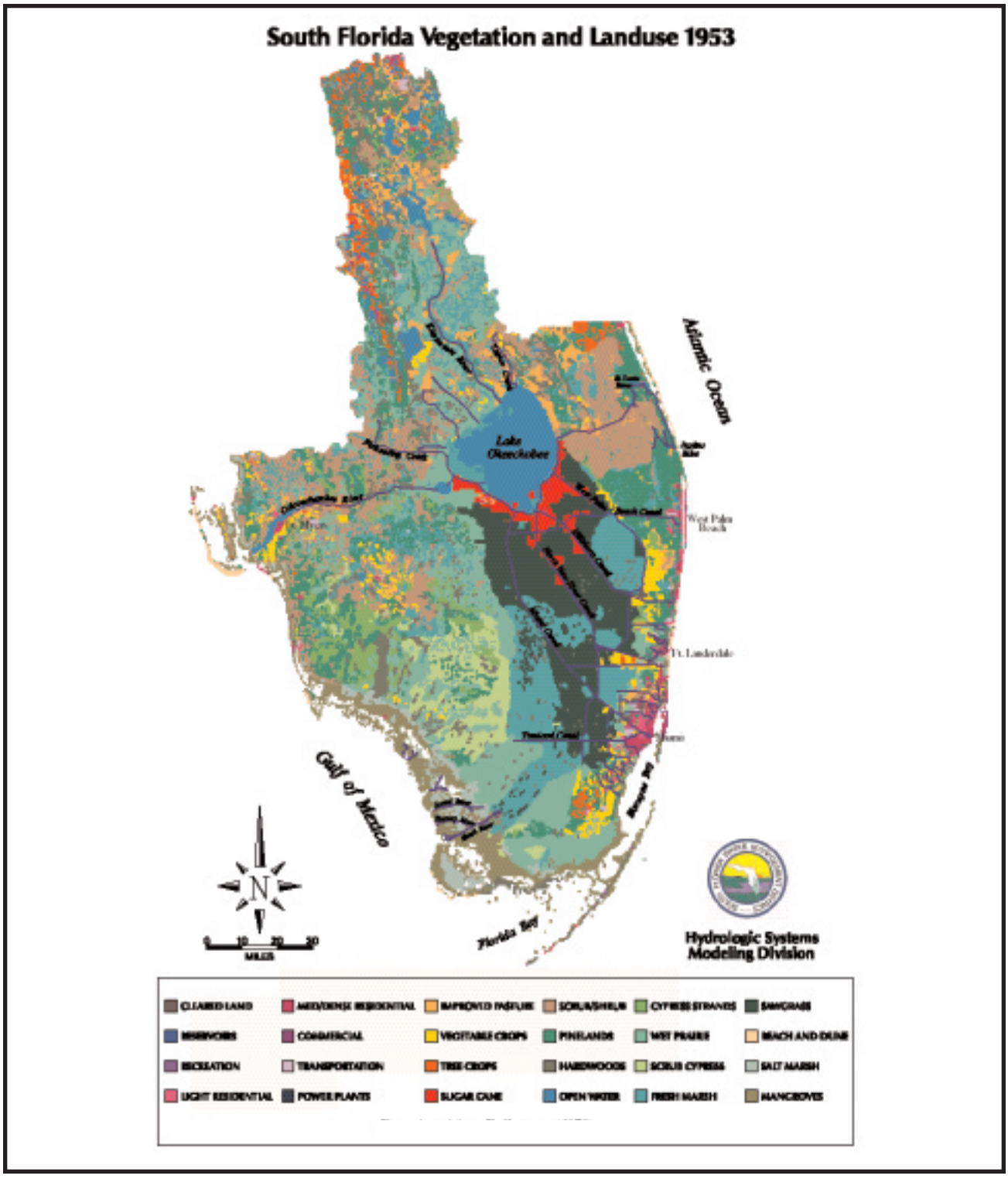


Figure 4. Vegetation within South Florida Water Management District boundaries circa 1953 (SFWMD adapted from Costanza 1975).

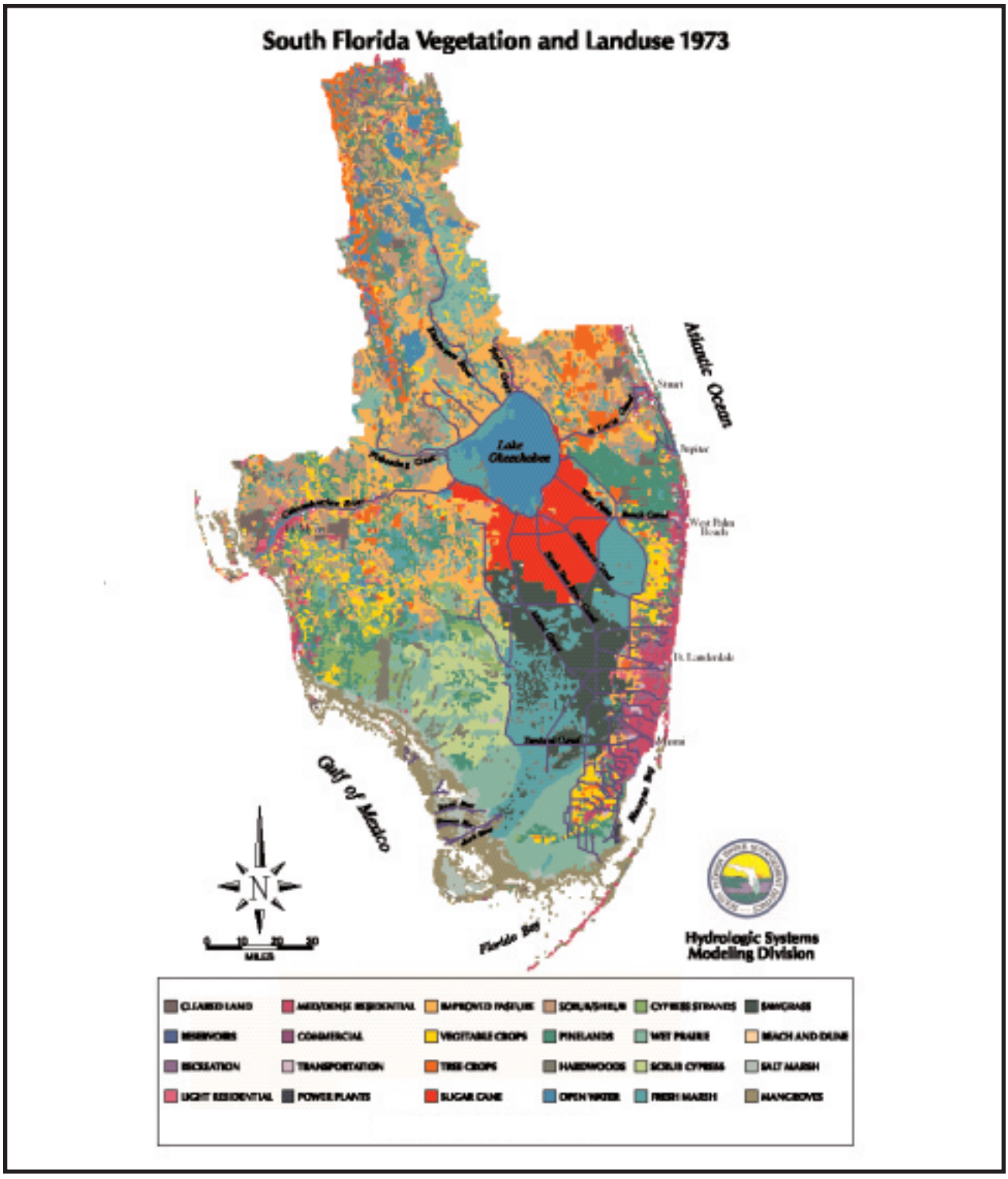


Figure 5. Vegetation within South Florida Water Management District boundaries circa 1973 (SFWMD adapted from Costanza 1975).

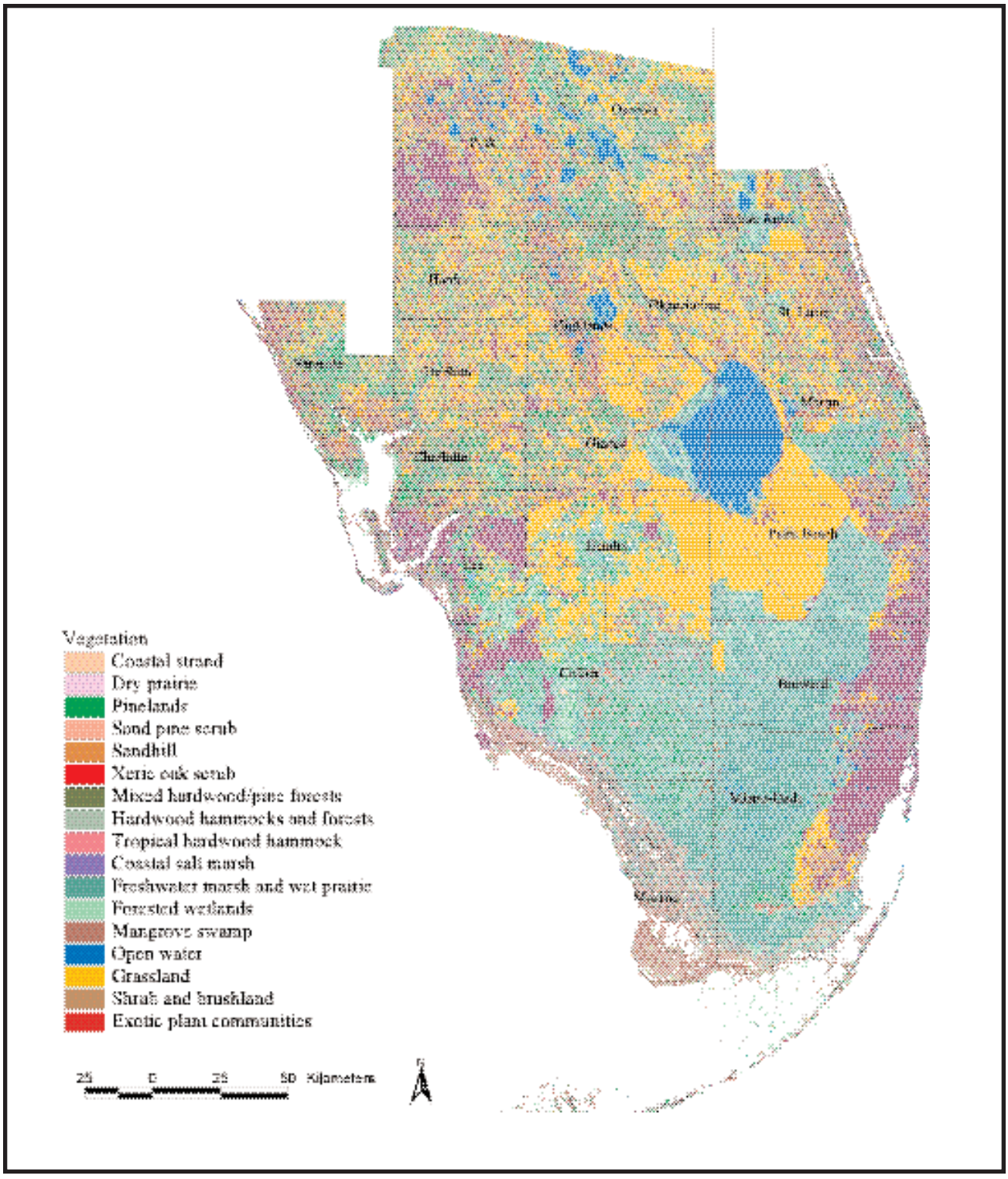


Figure 6. Vegetation in South Florida 1993/94 (adapted from USGS,BRD 1996).

to Appendix C for a more comprehensive list of imperiled species found in these upland communities.

There is an incredibly high percentage of biodiversity of endemic plant species that are unique to these upland habitats. The critical role that the interspersion of uplands with wetlands plays in the life histories of the vast majority of terrestrial and semi-aquatic animals is often overlooked by land managers because of the amount of attention wetland physiographic provinces and their associated communities receive in regional restoration planning in South Florida. The restoration of the wetlands will not be complete unless they are integrated into the matrix of swamps and upland forests and dry prairies that give South Florida its amazing diversity.

Based on rough estimates derived from Cox *et. al.*'s (1997) assessment of the map of the natural vegetation of Florida (Davis 1967) South Florida had approximately 136,500 ha (3.34 million acres) of upland habitat of all types. Currently about 33 percent of this remains in a native state, although it is stressed and fragmented. In an assessment of approximately 530,000 ha (130, 963 acres) in an area covering portions of Charlotte, Collier, Glades and Lee counties, and all of Hendry County, Mazzottti *et. al.* (1992) noted that in 1900, 92 percent of the uplands of the area were pine flatwoods, but by 1989 pinelands constituted less than 45 percent of the total land area. Likewise, in recent evaluations of uplands in Miami-Dade County, it is estimated that 99 percent of the rockland pine forests and tropical hardwood hammock uplands outside of Everglades NP have been lost to development (Snyder *et. al.* 1990). By 1984 only approximately 230 natural forest communities encompassing only 1,458 ha (3,603 acres) (Dade County 1984) remained.

In Everglades NP, the uplands have faced a complex history of fire management from winter *versus* summer burns at varying intervals. The impact of logging and fire management on the fauna are clear (Robertson 1953). The loss of wild turkey (*Meleagris gallopavo*), red-cockaded woodpeckers (*Picoides borealis*), brown headed nuthatch (*Sitta pusilla*), eastern bluebirds (*Sialia sialis*), and breeding American kestrels (*Falco sparverius*) all reflect a forest less capable of supporting diversity. This is especially true for primary and secondary cavity nesting species (Harris and Wallace 1984, Lewis 1994, Robertson 1955, Robertson and Kushlan 1984). Bobwhite quail are still present in Long Pine Key, and are occasionally seen in small coveys in hedgerows in the agricultural lands to the east of the park. Efforts are underway to re-establish brown headed nuthatches and bluebirds in the Long Pine Key area, and depending upon their success, attempts may be made to re-introduce red-cockaded woodpeckers (O. Bass, Jr., Everglades NP, personal communication 1998).

Production forestry for naval products (Abrahamson and Hartnett 1990), logging for wood products, urban and agricultural expansion for housing, citrus and rangeland, along with the ever-expanding system of roadways all contribute to continued loss of uplands and fragmentation of the last remaining uplands in South Florida.

Complicating matters is the fact that many of our larger and more mobile species have become adapted to using what might be called the "new uplands":

roadways, levees, citrus groves, rangeland, and dense forests of exotic melaleuca, Australian pine and Brazilian pepper. Many terrestrial animals and plants are capable or forced to inhabit these new uplands, which may be of marginal value. The forests of exotic trees present serious threats by replacing native upland trees and understory flora and fauna (Dalrymple 1988, O'Hare and Dalrymple 1997). The roadways and levees result in increased accidents with automobiles, and the citrus, rangelands, and other agricultural lands present problems related to ingestion of herbicides and pesticides, and becoming "nuisance species" to landowners. These "new uplands" also are a system of disturbed edges that promote inroads to natural areas for other exotic species. In many instances, these human-made upland habitats are critical as corridors for connecting larger expanses of native upland.

The major restoration objectives for most upland cover types in South Florida are land acquisition, and proper management through prescribed fire, exotic plant eradication, and restoration of proper soil and surface hydrology. Efforts to conserve the remaining uplands areas will require reserve design, land acquisition, incentives to landowners, partnerships, and an understanding of appropriate management techniques.

Wetland Loss and Fragmentation

The FWS has not conducted wetland status and trends analysis specifically for the South Florida Ecosystem area. However, there have been two status and trends surveys conducted for the State of Florida. The first report covered the period 1950s to 1970s (Hefner 1986), and the second covered the period 1970s to 1980s (Frayer and Hefner 1991). The estimates for the mid-1970s in the 1986 report do not exactly match the estimates for the same period in the 1991 report for several reasons: higher quality aerial photography was available for the 1991 study for the mid-1970s (*i.e*. color infrared *versus* black and white); improved photo interpretation techniques; and, variation in statistical analysis (*e.g.,* a reduction in the number of sample plots from 656 to 644). For these reasons, the mid-1970s data in the 1991 report is considered superior to that in the 1986 report.

For general comparison purposes, we have combined the mid-1950s data from Hefner's 1986 report with the mid-1970s and mid-1980s data from Frayer and Hefner's 1991 report. General trends in wetlands changes for selected categories are shown in the Table 3.

The combined surveys indicate that in the mid-1970s nearly a third of the land surface in Florida was classified as wetlands, or 4.5 million ha (11.3 million acres). Florida's average annual net loss of wetlands was greater than 23,000 ha (72,000 acres) for the 30-year study periods, or a total of 705,000 ha (1.74 million acres). Losses were concentrated in the Everglades region of South Florida, and most of these could be directly attributed to agricultural development.

The surveys also revealed that there were nearly seven times more hectares of palustrine (freshwater) wetlands than estuarine wetlands. The most extensive wetland in the State was the palustrine forested and scrub-shrub type. These areas included what are locally referred to as cypress heads, strands, swamps, bottomland hardwoods, and hydric hammocks. Relatively small

Table 3. Wetland trends in Florida.

WETLAND TYPE	(in thousands of hectares)			
	mid-1950s	mid-1970s	mid-1980s	percent change
All wetland types	5,172	4,572	4,467	14
All estuarine wetlands	503	551	550	+9
Estuarine intertidal emergent	155	116	116	-25
Est. intertidal scrub-shrub and forested	231	271	270	+14
Other estuarine	118	164	164	+28
All palustrine wetlands	4,468	4,007	3,903	-13
Palustrine emergent	1,820	1,204	1,160	-36
Palustrine scrub-shrub and forested	2,808	2,749	2,676	-5
Other palustrine	39	54	67	+4

losses of this type of wetland were shown. Palustrine emergent wetlands, which include freshwater marshes, wet prairies, and Everglades, experienced the largest losses. About 660,000 ha (1,065,000 acres) of this type were eliminated, which represented about 94 percent of the total wetland loss in the State. The primary cause of wetland loss was drainage for agriculture, amounting to 79 percent of the total conversion. However, loss in the estuarine areas resulted from dredging and filling for urban development and navigation. Other palustrine wetlands showed an increase over the 30 years. Many of these wetlands include small open water bodies and shallow waters less than 8 ha (20 acres), usually associated with construction of farm ponds and small lakes in residential areas.

The FWS has completed a draft of the National Wetlands Status and Trends report for 1985 through 1995. This draft is pending release awaiting a policy level review in Washington, D.C. The FWS is also drafting a wetlands status and trends report for Florida, covering the period 1984 to 1991. (T. Dahl, FWS, personal communication 1998).

Habitat Degradation

In addition to habitat loss and fragmentation, habitat quality is threatened in South Florida. Habitat degradation is occurring in uplands and wetlands as a result of anthropogenic factors: contaminants, water and air quality problems, exotic species invasion, fire suppression, soil subsidence, and changes in hydrology. A general overview of these issues is provided here; the community accounts provide a more specific discussion where appropriate.

Environmental Contaminants and Water Quality

Environmental contaminants are ubiquitous and an ever-increasing problem in South Florida. Human activities have degraded water quality in large areas of South Florida during the last century. Water in urban and agricultural canals

commonly has high concentrations of nutrients and toxic compounds compared to water in marshes that are remote from canals. Drainage of nutrients and contaminants from urban and agricultural lands has degraded lakes, streams, canals, estuaries, and bays of the region (McPherson and Halley 1997). In addition, discharge of nutrient-laden sewage and stormwater runoff into canals also carries bacteria, viruses, oil and grease, toxic metals, and pesticides. The urban canal water discharges into coastal waters or enters the groundwater system and the public water supply (Klein *et. al.* 1975). See Table 4 for a list of South Florida Superfund sites by county.

Federal and State agencies and environmental organizations have agreed that the South Florida Ecosystem, and especially the Everglades, should be protected and restored, to the extent possible, to its predevelopment conditions. Contaminants play a role in the decline of species, keeping them at suppressed levels and preventing species from recovering. Therefore, the restoration goals can be successfully accomplished only if serious consideration is given to the negative effects of contaminant loading from agricultural, industrial and urban sources on our Trust resources and their habitat. The effect of toxins in the food chain, and their long-term adverse effects on ecosystem integrity are also largely unknown. These types of scientific information would be valuable for the restoration effort in the South Florida Ecosystem.

Nutrients - Fertilizers are widely used in South Florida to maintain high levels of agricultural productivity. From July 1, 1990 through June 30, 1991, fertilizers sold in South Florida contained 127,000 metric tons (140,000 tons) of inorganic nitrogen and 50,800 metric tons (56,000 tons) of phosphate (McPherson and Halley 1997). Nutrient loading from the Everglades Agricultural Area (EAA) and urban areas has significantly increased nutrient concentrations, particularly phosphorus, in the South Florida Ecosystem (Stober *et. al.* 1996). This has resulted in increased soil phosphorus content, changed periphyton communities, loss of native sawgrass communities, increased organic matter in water, loss of water-dissolved oxygen, conversion of wet prairie plant communities to cattails and loss of important wading bird habitats (Stober *et. al.* 1996). Historically, the Everglades were nutrient-poor, with phosphorus concentrations less than 10 parts/billion (ppb). Nutrient loading from the EAA has been associated with eutrophication in the Water Conservation Areas having greater than 50 ppb phosphorus concentrations.

Atmospheric deposition also contributes to the nutrient load infiltrating the South Florida environment. The highest deposition rates for nutrients occur in agricultural and urban areas, and lowest in coastal and rural areas (Brezonik *et. al.* 1983, Hendry *et. al.* 1981). Greening (1997) estimated that 29 percent of the nitrogen and 31 percent of the phosphorus entering Tampa Bay come from wetfall and dryfall directly deposited to the bay's surface, making this source second to only stormwater as the largest bay nitrogen loading source, and the largest source of phosphorus. Overall, atmospheric nitrogen is a more important source for the nutrient budget than atmospheric phosphorus (Brezonik *et. al.* 1983).

Pesticides and Polychlorinated Biphenyls - Pesticides have also been widely used in agricultural and urban areas in South Florida for more than 50 years to control insects, fungi, weeds and other undesirable organisms. Because of year-

Table 4. Superfund national priority list sites in South Florida by county.

COUNTY	SITE NAME	SITE ADDRESS	CONTAMINANTS PRODUCED
Brevard	Harris Corp.	Palm Bay	heavy metals, volatile organic compounds
Broward	Chemform Inc.	Pompano Beach, 1410 SW 8th St.	heavy metals, oily liquid sludge
"	Davie Landfill	Davie	heavy metals, ammonia
"	Florida Petroleum Reprocessors	Ft. Lauderdale	oil and grease, volatile organic compounds, chlorinated solvents
"	Hollingsworth Solderless Terminal	Ft. Lauderdale	heavy metals, oil and grease, trichloroethylene
"	Petroleum Products Corp.	Pembroke Park	lead, polychlorinated biphenyls
"	Wilson Concepts of Florida, Inc.	Pompano Beach, 1408 SW 8th St.	organochlorines, heavy metals
"	Wingate Road Municipal Incinerator Dump	Ft. Lauderdale	pesticides, DDT, aldrin, chlordane, dieldrin
Miami-Dade	Airco Plating Co.	Miami	heavy metals
"	Anaconda Aluminum Co./Milgo Electronics Corp.	NW 76th St., Miami	
"	Anodyne, Inc.	Sunshine State Industrial Park, North Miami Beach	chromium, polychlorinated biphenyls
"	B&B Chemical Co., Inc.	800 feet N. of Miami Canal, Hialeah, Miami	chlorobenzene, dichloroethylene, dichlorobenzene

Table 4. ***cont.***

COUNTY	SITE NAME	SITE ADDRESS	CONTAMINANTS PRODUCED
"	Gold Coast Oil Corp.	Miami	lead, zinc, organic pollutants
"	Homestead Air Force Base	Homestead	heavy metals, cyanide
"	Miami Drum Services	Miami	heavy metals, organic solvents, phenols
"	Munisport Landfill	North Miami	organic pollutants, lead
"	Northwest 58th Street Landfill	Hialeah	heavy metals, phenols, halogenated organic compounds
"	Pepper Steel & Alloys, Inc.	Medley	oil and grease, polychlorinated biphenols
"	Standard Auto Bumper Corp.	2500 West 3rd Court, Hialeah,Miami International Airport	heavy metals
"	Woodbury Chemical Co. (Princeton Plant)	West side of U.S. Route 1, Princeton	aldrin, dieldrin, toxaphene, chlordane
Indian River	Piper Aircraft/Vero Beach Water & Sewer	Vero Beach	volatile organic compounds
Martin	Florida Steel Corp.	Indiantown	lead, zinc
"	Solitron Microwave	0.5 miles East of U.S. Hwy. 1, Port Salermo	tetrachloroethene, trichloroethane, xylene, acetone, vinyl chloride, methylene chloride, dichloroethene
Palm Beach	BMI-Textron	1121 Silver Beach Rd., Lake Park	nitrates, low pH, cyanide, fluoride
Polk	Alpha Chemical Corp.	Galloway	cadmium, chromium, lead

round warm temperatures and moist climate, Florida agriculture requires vigorous pest control, thus while Florida agricultural production ranks approximately 30th in the U.S., pesticide usage per acre is in the top five. The compounds used vary in their toxicity, persistence, and transport. Since the late 1960s, persistent organochlorine pesticides have been detected in fish that are part of the Everglades food chain (Kolipinski and Higer 1969, McPherson 1973, Haag and McPherson 1997). Some more persistent pesticides, such as DDT, Chlordane, Dieldrin, and Aldrin have been banned for use in the State, but their residues still occur in the environment. Although pesticides are usually applied to specific areas and directed at specific organisms, these compounds often become widely distributed and are potentially hazardous to nontarget species (McPherson and Halley 1997). Herbicides, including Atrazine, Bromocil, Simazine, 2-4-D, and Diuron, which have the highest rate of application, are among the most frequently detected pesticides in Florida's surface waters (Shahane 1994). By far the most frequently detected insecticides in surface waters are the chlorinated hydrocarbon ones that are no longer used in the State, such as DDD, DDE, DDT, Dieldrin, and Heptachlor. These insecticides are also the most frequently detected pesticides in bottom sediments (Shahane 1994).

Chlorinated chemicals, such as polychlorinated biphenyls (PCBs), dioxins, and furans, which are generated and used primarily in urban and industrial areas, pose serious concern to fish, wildlife, and human populations (Colborn *et. al.* 1993). Although most uses of PCBs have been banned since the late 1970s, these persistent chemicals are still found in the environment and continue to pose potential threats to fish, wildlife, and humans. In recent years, many organochlorine pesticides and PCBs have been linked to hormone disruption and reproductive problems in aquatic invertebrates, fishes, birds, and mammals (Colborn *et. al.* 1993).

Mercury - The evidence of mercury contamination in fish and wildlife in South Florida freshwater and terrestrial ecosystems is extensive. Trends in mercury accumulation in South Florida, as evidenced by sediment profiles, show that atmospheric mercury deposition has increased approximately fivefold since 1900 (Rood *et. al.* 1995). The deposition rate of mercury by rainfall measured today is at least double that of other remote sites in North America (Guentzel *et. al.* 1995). Piscivorous freshwater sport fish and alligators in many watersheds, especially in the Everglades, have high mercury levels in their tissues (Ware *et. al.* 1990, Eisler 1987). After discovering the extent and severity of mercury in fish in 1989 the State Health Officer issued advisories to fishermen warning against consumption of several species of fish in more than 400,000 ha (1,000,000 acres) of the Everglades, and advising restricted consumption of others over most of the State. Besides human health concerns, ecological resources may be at risk as well. In the early 1990s three Florida panthers (*Puma concolor coryi*) inhabiting the Everglades died; mercury was determined to be the proximate cause of death in one and a contributing cause of death in the other two cases (Roelke *et. al.* 1991). High mercury levels have been detected in the endangered wood stork and other birds (Sundlof *et. al.* 1994). There is concern that the 50-year decline in wading bird numbers in South Florida partially may be a result of increased mercury exposure; intensive studies are underway to further define this concern.

Exotic Species

Florida's invasion by exotic species began with the first European explorers in the early 16th century. Because of its mild climate, international seaports, cultural diversity, and lenient importation laws, Florida has been the epicenter for more exotic species than almost any other region in the country. Some species have remained localized around the release sites, some have died off, and many have extended their ranges to other states.

It is probably safe to say that the most severe exotic species threats to the South Florida Ecosystem come from plants, rather than animals (Appendix E). Therefore, the emphasis on exotics in Florida has been on flora, rather than fauna. As of 1994, at least 684,000 ha (1.69 million acres) in Florida were impacted with the top seven exotic plant species: Australian pine *(Casuarina spp),* water hyacinth *(Eichornia crassipes),* hydrilla *(Hydrilla verticillata),* Old World climbing fern *(Lygodium microphyllum),* melaleuca *(Melaleuca quinquenervia),* torpedo grass *(Panicum repens)* and Brazilian Pepper *(Schinus terebinthefolius)* (Schmitz 1994). Melaleuca affects several hundred thousand ha of upland and wetland habitat throughout the Everglades (primarily eastern), including sawgrass and cypress habitats. Brazilian pepper affects at least 40,000 ha (100,000 acres) of mangroves in Everglades NP, as well as tens of thousands of acres elsewhere in the uplands and freshwater parts of the Everglades. Australian-pine inhibits sea turtle nesting on Highland Beach, and is also a nuisance in the southeastern Everglades and along canals throughout. Old World climbing fern is a serious threat to the Arthur R. Marshall Loxahatchee NWR and will likely spread to other Everglades areas.

Some exotic animals have compounded the exotic plant problem by spreading the seeds. For example, feral hogs eat the tropical soda apple fruits and transport the seeds in their droppings. Exotic animals have been found to carry diseases that affect native fauna and humans (Layne 1997). Feral hogs have become a serious threat to native wildlife in other ways. They forage for ground-nesting animals, and will eat the eggs of birds and reptiles. Another exotic animal which forages on ground-dwelling native wildlife is the armadillo, which has recently expanded its predation on sea turtle eggs and has become a serious threat to turtle nesting success.

Many other introduced animals have become pests. One of the best-known is the imported red fire ant (*Solenopsis invicta*), which causes an estimated $1 million a year in damage to crops, livestock, *etc.*, and has caused human injury. The spike-topped apple snail (*Pomacea bridgesi*) from Brazil, is likely beginning to displace the native Florida apple snail (*Pomacea paludosa*), which is the primary food of the snail kite (*Rostrhamus sociabilis*) (Warren 1997). Snail kites apparently cannot feed on the spike-topped apple snails. In addition, Florida hosts the largest number of nonindigenous fish species in the continental U.S. (Courtenay 1997). Examples of exotic fish are cichlids, tilapia, and walking catfish (*Clarias batrachus*). While their effect on native aquatic organisms is not thoroughly known, some problems are evident. The pike killifish (*Belonesox belizanus*) preys on the native mosquitofish (*Gambusia holbrooki*), which feeds on mosquito larvae. Blue tilapia (*Tilapia aurea*) may compete with native centrarchid species, and peacock cichlids (*Cichla ocellaris*), and speckled peacocks (*Cichla temensis*) may prey on native fish (Courtenay 1997).

Fire Suppression

The dependancy of xeric upland plant communities in South Florida on periodic fire is well documented. The normal fire regime prior to European settlement is unknown, but the majority of lightning-caused fire in this region occurs between May and September, with larger fires in the early part of the wet season. The shortest fire interval could be 2 to 3 years, the longest interval 10 to 15 years, with most researchers in agreement that pine rocklands typically burn twice per decade. Today, however, many fragmented habitat patches have not been burned for some time, and many of the xeric habitats are now overgrown or have been invaded by more mesic, fire-intolerant vegetation (Givens *et. al*. 1984). In cases where fire has been excluded for long periods, the likelihood of catastrophic fire is increased from the build-up of unusually high fuel loads. As a result, when fires do occur, they are more intensive, may result in ecological damage, and cause more problems for humans than if a natural fire regime had been maintained. From an ecological perspective, the functions and values of xeric habitats have been lost, and many of the flora and fauna typical of these fire-maintained areas have been greatly reduced or extirpated. Habitat suitability, and thus the persistence of some species, may decline as soon as 5 to 10 years since last fire to as many as 100 years since last fire depending on the xeric community and affected species (Myers 1985). The role of fire in the ecology of South Florida is described in more detail in the separate ecological community accounts.

Soil Subsidence

The region south of Lake Okeechobee historically received the lake's overflow in the wet season. As the water rose in the lake, it gradually spilled over the shallow natural southern bank and followed the sloping gradient southward. The sediments carried with the water helped to create the organic soils, among the richest in the country, and to continuously accrete. The superb fertility of the soil, which was originally 12 to 14 feet deep, has attracted farmers since the early 1900s. The major canals (Hillsboro, North New River, Miami) were dug to drain this land, now known as the Everglades Agricultural Area (EAA). Since then, the soil has been subsiding at an alarming rate. A post marked in Belle Glade in 1924 showed soil subsidence of 5.5 feet in 1997 (about 1.12 inches/year).

There are several factors causing the subsidence. One is shrinkage, similar to a sponge drying. Wind erosion and fires are also caused by the dehydrated soil. A very important factor is oxidation of the soil, caused by aerobic microbiological decomposition. All of these are preventable by keeping the soil flooded or at least saturated.

A side-effect of oxidation is the release of phosphorus from the soil. This is substantial, estimated at 78 lbs/acre/year from the EAA, or 400 percent of the average rate of fertilizer applied to the sugarcane (Shih *et al*. 1997). Thus, the soil subsidence has increased the phosphorus runoff into the Everglades, which is one of the most critical problems facing the Everglades today.

Although soil subsidence is the most severe in the EAA, it is occurring in many parts of the remaining Everglades. The WCAs have been

compartmentalized, so that water drains from the north and becomes pooled in the south. As the dry season progresses, the northern sections of the WCAs usually become dry, causing subsidence. The dryness of the soil makes it more susceptible to fire. Furthermore, fires are more difficult to control in the WCAs than in the EAA (which is networked with canals). When the fire burns the dry peat, it can smolder for months (as occurred in WCA 3A in 1989).

As the soil subsides, it causes depressions to form. This changes the sheetflow patterns and vegetation composition, reducing the potential for restoring the Everglades to its natural state.

Subsidence affects wildlife directly by reducing the water storage ability of the soil in the dry season; in effect, the soil becomes compacted and cannot retain as much moisture. The peat may dry out before the next rainy season begins, adversely affecting the crayfish, snails, fish and amphibian eggs, *etc*. that can survive in the moist soil for months. Periphyton are recognized as an important primary producer in the Everglades, but their species composition may change depending on which species are more tolerant of dehydration. This affects a myriad of organisms progressing up the food chain.

Recent measurements have revealed that the subsidence rate in the EAA is decreasing (Shih *et al*. 1997). This is partially due to Best Management Practices, required by the South Florida Water Management District as part of the Everglades Forever Act. These include holding water on the farm longer, laser-leveling fields, growing moisture-tolerant crops, *etc.* Another explanation is that, as soil levels drop, the soil surface becomes closer to the water table and may be wet more often than unsubsided areas.

Soil subsidence is a fairly well-understood phenomenon. Restoring the hydropatterns to the Everglades, albeit a difficult task, will reverse the problem. Some areas of the EAA have subsided too much, however, to be restored simply by rehydrating.

Changes in Hydroperiod and Hydropattern

Water from the Everglades is vital to replenishing the Floridan and Biscayne aquifers; to supplying surface water for South Florida; to carrying essential nutrients and clean, fresh water to the estuaries; and to supporting an extremely rich and diverse assemblage of wildlife and plants. Many migratory birds from all over North America as well as avian residents depend on the Everglades during the year; the variation in the depth across the region is critical to their foraging. Changes in the hydroperiods (the duration that an area is inundated) and hydropatterns (the depth, timing, flow, and location of surface water) are major threats to the Everglades and ultimately to the South Florida Ecosystem.

Historically, the precipitation that fell on the Everglades could spread out over the entire area, more than 6,000 km^2 (4,000 mi^2) because of the lack of barriers. That same quantity of rain still falls on the region, but it is not allowed to stay over the half that has been removed from the Everglades system if it floods farmland or developments. That “homeless” water currently gets pumped onto the remaining Everglades or out to the ocean (“to tide”). The upshot is that, during the rainy season, the peak water depths in the remaining natural system are higher than they were historically, causing the Everglades to

flood. Flooding affects tree islands, eventually causing the trees to rot and die. Deer, rodents, and other terrestrial animals that live on the tree islands can drown. Alligator and turtle nests can become inundated, causing them to fail. The coastal estuaries will also suffer from the excess volumes of fresh water being dumped into them over a short period. The decrease in salinity, increase in suspended solids, and other water chemistry parameter changes can severely stress or kill estuarine organisms.

The dry season was historically not as extreme as it is now, either. Water that lingered in the marshes and sloughs remained for the benefit of the Everglades biota. Currently, that water may be stolen from the Everglades and pumped into the thirsty lands adjacent to the Everglades for irrigation and municipal water supply. The lack of water causes the obvious problems of desiccation of plants and aquatic organisms and lack of drinking water for wildlife. It also increases the potential for fire, causes fires to burn hotter, and promotes soil subsidence.

Change in hydropatterns also alters the timing of nesting wading birds. The lack of short hydroperiod wetlands available at the start of the dry season (November to January), when wood storks and other Ciconiiformes historically initiated nesting, has shifted the breeding season later by several months. The adults will wait until later in the dry season (March or April) when water levels in the longer hydroperiod wetlands are shallower. By this time, it is unlikely that the species with longer breeding cycles (*e.g.*, wood storks) can fledge their young before the wet season rains return.

The watersheds draining South Florida are large relative to the size of their receiving estuaries. Therefore, land use practices and hydrological manipulations in watersheds can substantially impact the estuaries. The alteration of freshwater flows to the estuaries along South Florida's coasts has reduced water quality, in some cases reduced quantity, and overall is changing the face of estuarine habitats in the region. The growing population of South Florida, increased need for water, and demographic changes are affecting habitats and resources of South Florida's estuaries. An illustration of this point is what has happened to Florida Bay, a key nursery area for various marine species including spotted seatrout, bonefish, red drum, tarpon, pink shrimp, and spiny lobster. By the 1990s, a 90 percent reduction in freshwater inflow and increased levels of nutrients and pesticides contributed to an increase of algal blooms, lost seagrass beds, sponge mortality, and salinity increases. These changes caused increased incidences of fish kills and serious losses of mangroves.

Some human activities that affect freshwater inflow to estuaries are diversion of freshwater for municipal and agricultural consumption, dams for irrigation, stormwater collection and treatment systems, increased paved surface areas in developed areas, drainage canals, and deforestation by development and clear-cutting practices. Diversion or drainage of water changes the natural cycle and the amount and timing of water flowing downstream to an estuary. Removing vegetation from land removes the uptake of water by vegetation, and adding impervious surface cuts percolation of water into underground aquifers. Cumulatively, our rivers and estuaries get

higher than normal freshwater input during the wet season and lower than normal fresh inputs during the dry season. As things get more and more out of balance this can spell disaster for the estuaries.

Management and Restoration

South Florida possesses a wealth of natural resources. Diverse habitats support a rich and unique flora and fauna — habitats including the seagrass beds of Florida Bay, mangrove swamps of the Ten Thousand Islands Region, the Everglades' sawgrass prairies, Lake Wales Ridge scrubs, Miami region pine rocklands, and the Florida Keys' tropical hardwood hammocks. At the same time, South Florida faces major ecological challenges and restoration opportunities. Demands on the resources are excessive, yet there are unprecedented revitalization efforts being implemented. This section provides an overview of the management and restoration efforts ongoing in South Florida; specific land management recommendations and restoration actions for conservation lands are discussed in the ecological community chapters. Habitat protection efforts through acquisition and conservation easement are also discussed, as these are key recovery and restoration tools in South Florida. Because the development of this Recovery Plan is a major element of the South Florida Ecosystem Restoration Initiative, summaries of some of the many multi-agency restoration projects associated with the Restoration Initiative are presented to provide an indication of the complexity of implementing recovery and restoration efforts in this region.

The Conservation Lands in South Florida

This overview provides a brief summary of the Federal, State, Tribal, and private conservation lands in South Florida, and highlights particular management and restoration examples of each. A list of Federal, State and privately owned conservation lands in South Florida is provided in Appendix F, and these lands are illustrated in Figure 7. Lands currently being acquired and considered for acquisition are shown in Figure 8. Adequate information to include all of the county-managed conservation lands in South Florida in this document was not available. The purposes and authorities of the Federal and State agencies that have responsibility for ecological conservation are described in Appendix G.

National Interest Lands

The South Florida Ecosystem has over 20 land areas that are managed by the Federal government (not including Miccosukee and Seminole lands) (Figure 7). The Federal holdings are managed by the FWS, National Park Service (NPS), National Oceanic and Atmospheric Administration (NOAA), and the Department of Defense (DOD) (Appendix F).

U.S. Fish and Wildlife Service - The FWS manages 16 national wildlife refuges in South Florida: Arthur R. Marshall Loxahatchee NWR and its satellite Hobe Sound NWR; Florida Panther NWR and its satellite Ten Thousand Islands NWR; J.N. "Ding" Darling NWR and satellites;

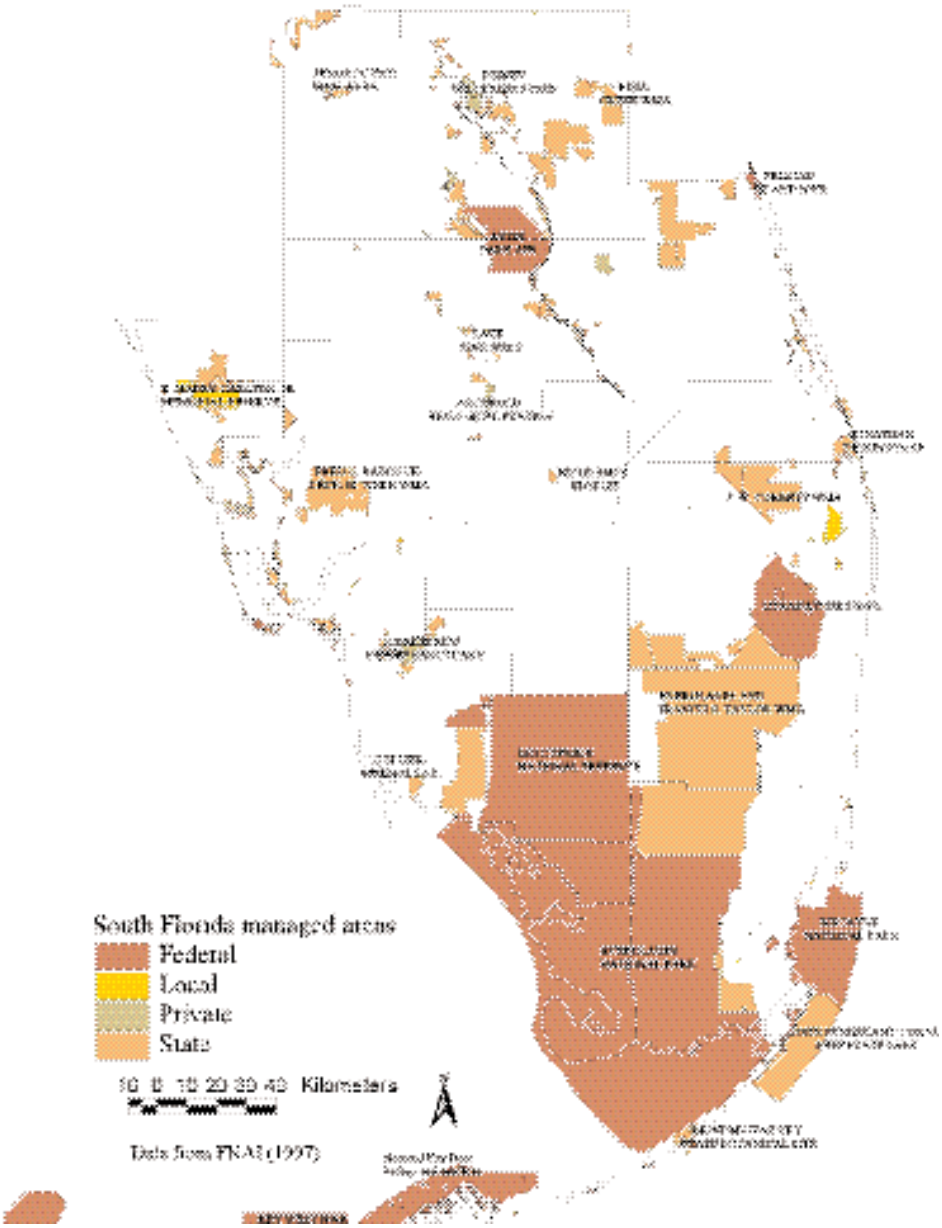


Figure 7. Public and private conservation lands in South Florida (Florida Natural Areas Inventory 1997).

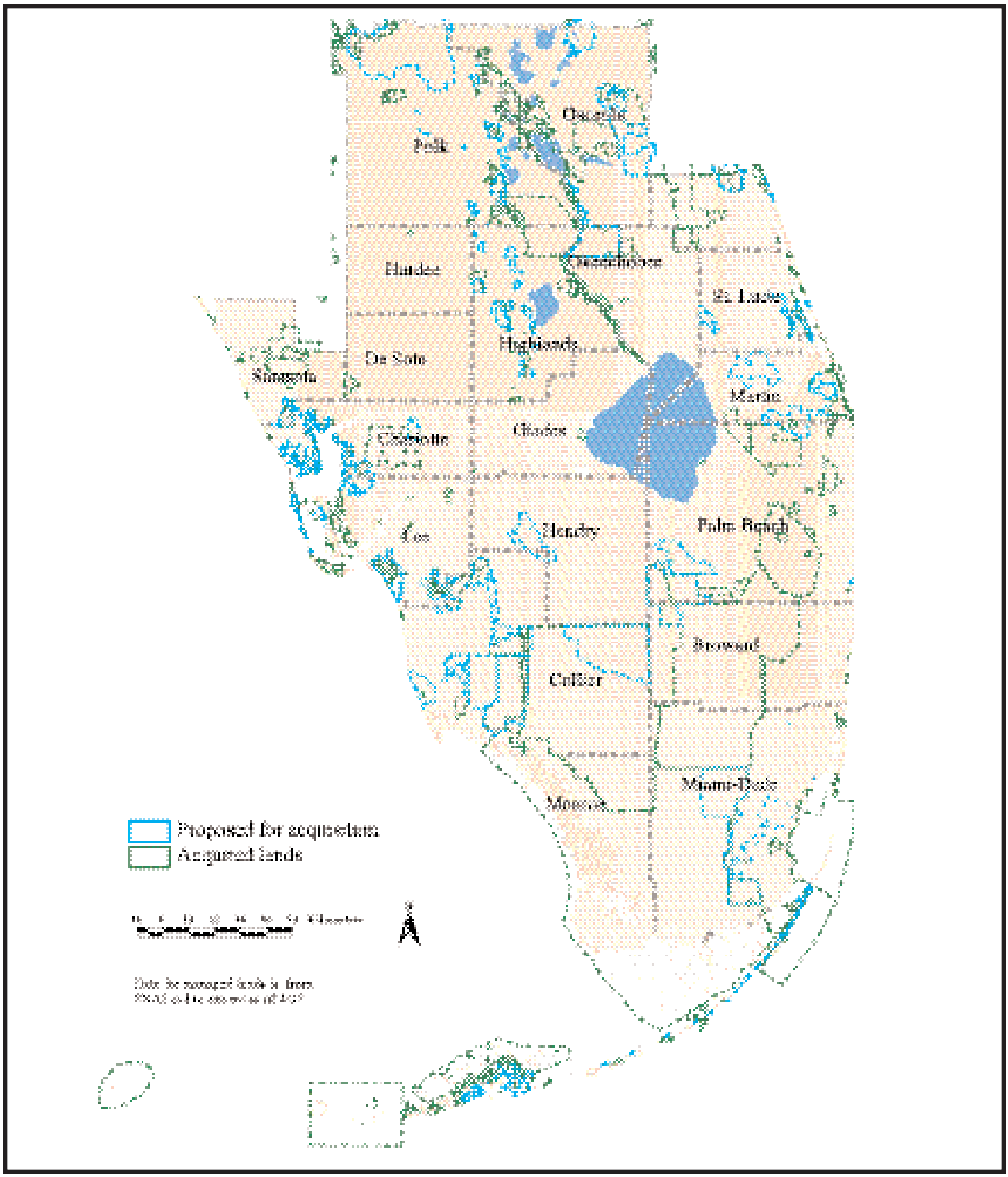


Figure 8. Conservation and recreation lands proposed for acquisition under the Preservation 2000 Act (Florida Natural Areas Inventory 1997).

Caloosahatchee NWR, Island Bay NWR, Matlacha Pass NWR, and Pine Island NWR; Archie Carr NWR, Lake Wales Ridge NWR, and Pelican Island NWR, administered as satellites of the Merritt Island NWR; and National Key Deer Refuge and satellites Crocodile Lake NWR, Great White Heron NWR, and Key West NWR. It is the intent of the FWS that refuges will acquire and subsequently provide the quantity and quality of habitat that supports America's diverse wildlife heritage. Also, refuges will serve as the cornerstone of an ecosystem approach to resource conservation that considers landscapes beyond boundaries and focuses on environmental health and biological integrity.

As an example of these management missions, the Lake Wales Ridge NWR is the first refuge designated primarily to preserve flora. It protects 26 rare plants (13 listed species), four federally listed vertebrates, and more than 40 rare, endemic invertebrate species. The refuge was authorized in November 1993, and acquisition of the proposed 7,944.26 ha (19,630 acre) refuge began in 1994. The Lake Wales Ridge is an ancient beach and sand dune system that rises sharply along the western edge of the Kissimmee River drainage basin. This habitat, the oldest ecosystem in the southeast, has been disappearing faster than any other in the United States with about 85 percent of the ridge lost to citrus groves and residential and commercial development. Many of the endemic plants, found nowhere else on earth, face extinction.

This refuge was created through a joint venture between the State of Florida, The Nature Conservancy, the Archbold Biological Station, and the FWS. The most pressing management issues are habitat fragmentation and isolation of the genetic material necessary for plant recovery. In some cases, the plants exist in only one or two locations. Other threats include off-road vehicles and trash dumping and all impacts have pushed many of the remaining scrub plants to the brink of extinction and this ancient ecosystem to a crossroads.

National Park Service - The NPS acquires land for new parks or expands existing parks with approval from the United States Congress. There are three national parks and one national preserve in South Florida**:** Biscayne NP, Dry Tortugas NP, Everglades NP, and Big Cypress National Preserve.

To illustrate NPS conservation management, perhaps the best known park in South Florida is Everglades National Park, a 609,681-ha (1,506,500-acres) area established in 1947 to preserve the southern portion of the Everglades and most of Florida Bay. In 1976, Everglades NP was designated a Biosphere Reserve. In 1979, it was designated a World Heritage Site and in 1987, it was designated a Wetland of International Importance. Only two other sites in the world are on all three lists. This park is the largest remaining U.S. subtropical wilderness and provides habitat for more than 400 species of birds, 25 species of mammals, 60 species of amphibians and reptiles, 125 species of fish from 45 families, more than 120 tree species, 1,000 species of seed-bearing plants, and numerous epiphytic plant species including 24 different orchids. Fourteen of these plant and animal species are listed as federally threatened or endangered.

Everglades NP is working in cooperation with other Federal agencies, the State of Florida, and private groups to restore the Everglades ecosystem. Additional acreage is being acquired by the State and Federal governments in the East Everglades which will add 42,123 ha (104,084 acres). Everglades NP management programs are designed to perpetuate federally listed species and their habitats. Specific techniques used are prescribed burns and exotic vegetation removal. Usually 4,856 to 6,879 ha (12,000 to 17,000 acres) are burned annually. The exotic vegetation removal program has cleared two million *Melaleuca* trees from over 36,828 ha (91,000 acres).

National Oceanic and Atmospheric Administration - To protect the diverse marine ecosystem of the Florida Keys, the Florida Keys National Marine Sanctuary (FKNMS) and Protection Act was enacted in 1990 and the FKNMS Management Plan was approved by the Florida Governor and Cabinet and U.S. Congress in 1997. The main purpose of the FKNMS is to protect the unique marine habitats of the Florida Keys, including the most extensive living coral reef system in North American waters and the third largest reef system in the world. The Key Largo and Looe Key National Marine Sanctuaries, established in 1975 and 1981 respectively, are also found within its boundaries.

Although the best known feature of the Keys marine environment is the coral reefs, the shallow waters near the shore are really a series of interconnecting and interdependent habitats. These include mangrove forests and seagrass meadows as well as hardbottom, patch reefs, and bank reefs, all of which support a wealth of marine life.

The FKNMS encompasses both State and Federal waters, and in recognition of this fact, is managed in a cooperative relationship with the Florida Department of Environmental Protection. The FKNMS boundaries extend from a stretch of the reef tract east of Biscayne Bay, around the entire Florida Keys, and westward to surround, but not include, Dry Tortugas National Park. Although it overlaps four NWR boundaries, the FKNMS encompasses approximately 3,786 km^2 (2,800 nautical mi^2) and is now the second largest sanctuary in the U.S.

In addition to the FKNMS, Congress created the National Estuarine Research Reserve System (NERRS) in 1972 to foster a system of estuary reserves that represents the range of coastal and estuarine habitats in the U.S. Rookery Bay was designated a NERR in 1978, with NOAA as the Federal partner and DEP as the State partner. Rookery Bay NERR is 12,500 acres, and features pristine mangrove forests surrounding shallow bay waters, along with an upland buffer of pine flatwoods, xeric scrub, and tropical hardwood hammocks. It is located in Collier County, and represents one of the few remaining undisturbed mangrove estuaries in North America.

Department of Defense - In South Florida, the only DOD conservation land is Avon Park Air Force Range (APAFR), managed by the Department of the Army. This Air Force Range is located in Highlands and Polk counties, and is bordered on the east by the Kissimmee River and on the west by the Lake Wales Ridge. The 42,943-ha (106,110-acres) installation is operated by the 56th Combat Support Squadron to provide a realistic environment for training Tactical Air Command aircrews and other military units. There are no plans to purchase additional land.

The natural plant communities found on APAFR include 3,3345 ha (82,393 acres) of natural plant communities, including mesic and wet flatwoods, dry and wet prairies, floodplains marsh, scrub, and seepage slope. Pine plantations account for 7,984 ha (19,728 acres), and tame grass pasture covers 724 ha (1,790 acres). The remaining 1,614 ha (3,989 acres) include the improved and semi-improved grounds of the cantonment area and the airfield. Of APAFR's 42,943 ha (106,110 acres), 90 percent is leased for cattle. About 400 Florida scrub-jays (*Aphelocoma coerulescens*) inhabit the base, as well as Audubon's crested caracaras (*Polyborus plancus audubonii*), red-cockaded woodpeckers, and grasshopper sparrows (*Ammodramus savannarum*). The military status of the land allows for protection of these habitats. The public has access to all of the habitats, but use is restricted to certain trails and campgrounds. Natural resource programs include hunting, cattle grazing, forest management, wildlife habitat management, and endangered species conservation. Prescribed burning is the primary management tool used to enhance and maintain native plant communities. Other habitat management activities are mowing, roller-chopping, and discing.

Tribal Lands

The unique and distinctive political relationship between the United States and Indian tribes is defined by treaties, statutes, executive orders, judicial decisions, and agreements, and differentiates tribes from other entities that deal with, or are affected by, the Federal government. This relationship has given rise to a special Federal trust responsibility, involving the legal responsibilities and obligations of the United States toward Indian tribes and the application of fiduciary standards of due care with respect to Indian lands, tribal trust resources, and the exercise of tribal rights.

The Departments recognize the importance of tribal self-governance and the protocols of a government-to-government relationship with Indian tribes. Long-standing congressional and administrative policies promote tribal self-government, self-sufficiency, and self-determination, recognizing and endorsing the fundamental rights of tribes to set their own priorities and make decisions affecting their resources and distinctive ways of life. The Departments recognize and respect, and shall consider, the value that tribal traditional knowledge provides to tribal and Federal land management decision-making and tribal resource management activities. The Departments recognize that Indian tribes are governmental sovereigns; inherent in this sovereign authority is the power to make and enforce laws, administer justice, manage and control Indian lands, exercise tribal rights and protect tribal trust resources. The Departments shall be sensitive to the fact that Indian cultures, religions, and spirituality often involve ceremonial and medicinal uses of plants, animals, and specific geographic places.

Indian lands are not Federal public lands or part of the public domain, and are not subject to Federal public land laws. They were retained by tribes or were set aside for tribal use pursuant to treaties, statutes, judicial decisions, executive orders or agreements. These lands are managed by Indian tribes in accordance with tribal goals and objectives, within the framework of applicable laws.

Because of the unique government-to-government relationship between Indian tribes and the United States, the Departments and affected Indian tribes need to establish and maintain effective working relationships and mutual partnerships to promote the conservation of sensitive species (including candidate, proposed and listed species) and the health of ecosystems upon which they depend. Such relationships should focus on cooperative assistance, consultation, the sharing of information, and the creation of government-to-government partnerships to promote healthy ecosystems.

In facilitating a government-to-government relationship, the Departments may work with intertribal organizations, to the extent such organizations are authorized by their member tribes to carry out resource management responsibilities.

Big Cypress Seminole Indian Reservation - The Seminole Tribe's Big Cypress Reservation lies in the northern Everglades in Broward and Hendry County. About 21,181 ha (52,338 acres) have been set aside and are managed as "trust resources" and require development for the economic benefit of the Reservation while protecting the resources for future generations. Current management is for improved pasture (irrigated), wildlife habitat, and some citrus production. This mostly undeveloped Reservation provides habitat for many wildlife species.

Brighton Seminole Indian Reservation - The Brighton Reservation of the Seminole Tribe of Florida covers 14,487 ha (35,796 acres) is in Glades County. Most of the developed land is cattle pasture and a catfish farm and processing plant are also on the Reservation. Current management is for improved pasture (irrigated), wildlife habitat, and some citrus production. This mostly undeveloped Reservation provides habitat for many wildlife species.

Miccosukee Indian Reservation - The Miccosukee Tribe of Florida owns 31,809 ha (78,600 acres) and holds another 76,488 ha (189,000 acres) in perpetual lease in Miami-Dade, Broward, and Hendry counties. Reservation lands are managed for improved pasture (irrigated), wildlife habitat, and some citrus production. The mostly undeveloped Reservation provides habitat for many wildlife species.

State Conservation Lands

The State of Florida has approximately 470,500 ha (1,162,135 acres) of managed lands in South Florida (Figure 7). State agencies with management responsibilities for conservation lands include: the Division of Forestry (DOF) within the Department of Agriculture and Consumer Services; the Florida Department of Environmental Protection (DEP), and the Florida Game and Fresh Water Fish Commission (GFC). Refer to Appendix F for a list of conservation lands in South Florida.

The Division of Forestry - "protects and manages Florida's forest resources through a stewardship ethic to assure these resources will be available for future generations." The DOF manages two State forests, Lake Wales Ridge and Picayune Strand, in the South Florida Ecosystem.

An example of this protection and management can be seen at Picayune Strand State Forest, in southwest Collier County. It is comprised of two Conservation and Recreation Lands (CARL) projects, the South Golden Gate Estates tract (22,339 ha/55,200 acres) and the Belle Meade tract (7,781 ha/19,227 acres), of which 14,165 ha (35,000 acres) have been acquired.

Commercial logging in Collier County occurred on a small scale at the turn of the century and logging of virgin cypress was mostly complete by 1960. Picayune Strand was not spared. Large tracts of cut-over land were subdivided. These were mostly wetlands and for all intents and purposes undevelopable. However, draglines and dynamite were used to excavate 275 km (171 mi) of canals and bulldozers spread the rubble to form 1,298 km (807 mi) of unpaved road. Drainage altered salinity patterns in the Ten Thousand Islands region of the Gulf of Mexico and increased the frequency and severity of wild fires in Picayune Strand thus altering historic vegetative patterns.

Today, Picayune Strand State Forest is very sparsely developed with dilapidated hunting camps and single family residences. The DOF (land manager), South Florida Water Management District (SFWMD), DEP, GFC, Natural Resource Conservation Service (NRCS), and FWS are working on a hydrological restoration plan to ameliorate problems caused by overdrainage of Picayune Strand. Many rare orchids and other endemic epiphytes are found in Picayune Strand State Forest. Animals of concern found there include: the Florida panther, Florida black bear (*Ursus americanus floridanus*), mangrove fox squirrel (*Sciurus niger avicennia*), Everglades mink (*Mustela vison mink*), American alligator (*Alligator mississippiensis*), eastern indigo snake (*Drymarchon corais couperi*), wood stork, bald eagle (*Haliaeetus leucocephalus*), snail kite, red-cockaded woodpecker, Arctic peregrine falcon (*Falco peregrinus tundrius*), and Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*). Proper management of the forest, historically under-utilized by the Florida panther, may allow for an increase in occupied range.

Department of Community Affairs' Areas of Critical State Concern - The Area of Critical State Concern (ACSC) program is administered by the DCA. An ACSC may be designated only for (1) an area containing, or having a significant impact upon, environmental or natural resources of regional or statewide importance, including, but not limited to, State or Federal parks, forests, wildlife refuges, wilderness areas, aquatic preserves, major rivers and estuaries, State environmentally endangered lands, Outstanding Florida Waters, and aquifer recharge areas, the uncontrolled private or public development of which would cause substantial deterioration of such resources; (2) an area containing, or having significant impact upon, historical or archaeological resources, sites, or statutorily defined historical or archaeological districts, the private or public development of which would cause substantial deterioration or complete loss of such resources, sites, or districts; (3) an area having a significant impact upon, or being significantly impacted by, an existing or proposed major public facility or other area of major public investment including, but not limited to, highways, ports, airports, energy facilities, and water management projects. Of four designated ACSCs

in Florida, three are in the South Florida Ecosystem: Green Swamp ACSC, Florida Keys ACSC, and Big Cypress ACSC.

An example of an ACSC and its management is Big Cypress ACSC, established in 1973, encompassing about 323,760 ha (800,000 acres) in Collier, Miami-Dade, Hendry, and Monroe counties. Its purpose is to conserve natural, environmental and economic resources and the scenic beauty of the Big Cypress Area. Collier County has adopted comprehensive plan regulations that; (1) limit site alteration to 10 percent of the area being developed, (2) restrict disturbance of permeable surface area, (3) require restoration of mining spoil areas, and (4) limit wetland drainage. Collier County has also identified the Big Cypress ACSC as a Special Treatment Area on their future land use map. While this has restricted some development, most agricultural activities are exempt.

Florida Department of Environmental Protection - The DEP conserves and manages Florida's environment and natural resources by providing stewardship of ecosystems so that the State's unique quality of life may be preserved for present and future generations. DEP also protects the public health and safety, and provides for the responsible and wise use of the State's mineral, cultural and living resources. As of January 1, 1998 the DEP manages 43 State parks, recreation areas, and reserves in South Florida (Appendix F).

One of the parks is Myakka River State Park, dedicated in 1941; the park was developed by the Civilian Conservation Corps. Today there are 11,686 ha (28,875 acres). Sarasota County where the park is located, is growing rapidly. Development outside the park is impacting hydrology and the ability to manage fire-adapted natural communities by burning. There are severe habitat disruption problems with feral hogs and exotic plant species, especially hydrilla.

Primary management concerns include the restoration and maintenance of extensive dry prairie and flatwoods habitat, the restoration of aquatic systems, and the monitoring of the Wild and Scenic portions of the Myakka River which flows for 19 km (12 mi) through the park. Myakka River State Park is considered one of the best units in the Florida State Park System for wildlife observation. Bald eagles, wood storks, sandhill cranes (*Grus canadensis*), osprey (*Pandion haliaetus*), alligators, and deer (*Odocoileus virginianus*) are numerous. There is anecdotal evidence of panther use.

The DEP also manages the Rookery Bay National Estuarine Research Reserve. Resource management efforts include prescribed burns, exotic plant removal, restoration of disturbed sites, and marine mammal recovery and rescue.

Florida Game and Fresh Water Fish Commission - The mission of the Florida GFC is to manage freshwater aquatic and wild animal life and habitats to perpetuate diverse species with sustained ecological, recreational, scientific, educational, aesthetic and economic benefits. Under Florida's constitution, the GFC is responsible for protecting freshwater and upland endangered and threatened fish and wildlife species. The GFC manages 22 Wildlife Management Areas and other conservation lands in South Florida, including

Cecil M. Webb WMA, Everglades WMA, Fort Drum WMA, Lake Harbor Public Waterfowl Area, J.W. Corbett WMA, Kicco WMA, Holey Land WMA, Rotenburger WMA, and the Southern Glades Wildlife and Environmental Area.

An example of a WMA is the J.W. Corbett Wildlife Management Area, encompassing 23,429 ha (57,892 acres) in northwestern Palm Beach County. Prior to acquisition, the primary land uses included timber harvesting, grazing and vegetable farming. The current management goals are to maintain native plant communities, maintain/restore water levels and the natural hydroperiod, manage wildlife for healthy, self-sustaining populations, and provide public recreation consistent with other goals.

The J.W. Corbett WMA includes a diversity of vegetative communities, including pine flatwoods, wet prairie and marsh areas, cypress sloughs, cypress dome and tropical hardwood hammocks. A wide variety of fish and wildlife species are known to occur there, many of which are characteristic of the pine flatwoods and cypress swamps of southeast Florida. Ten species of wildlife listed as threatened or endangered by the GFC regularly occur, or are occasionally seen, on the Corbett WMA. Federally and State listed species include the wastern indigo snake, bald eagle, and red-cockaded woodpecker, all of which nest on the area. Florida panther use has been documented there and on the adjacent Dupuis Reserve State Forest. The State listed Florida sandhill crane also nests on the area.

Water Management Districts - There are three water management districts whose boundaries overlap within the geographic boundary of this recovery plan: St. Johns WMD, South Florida WMD, and Southwest Florida WMD. In 1981 the Florida Legislature created a Water Management Trust Fund that enables the water management districts to acquire lands needed for water conservation purposes (see SOR piece in the State Land Acquisition section). The water management districts are also responsible for enhancement and management of the SOR lands. Management is designed to protect the District's proprietary rights and functioning of its canals, levees, and rights-of-way, while also providing for other appropriate and compatible public/private uses, where possible.

In addition to the SOR program, the Florida Legislature enacted the Surface Water Improvement and Management (SWIM) Act in 1987, which directed the State's five water management districts to develop and implement plans to clean up and protect specific waterbodies with the cooperation of State agencies and local governments. Affected waterbodies were thus prioritized with a common SWIM goal established for each. Essentially, each system shall be improved and managed at a level of quality "that provides aesthetic and recreational pleasure for the people of the state; that provides habitat for native plants, fish, and wildlife, including threatened and endangered species; and that attracts visitors and accrues other economic benefits." Since SWIM, many coastal communities have implemented surface water management programs which have improved the quality of the water discharging into adjacent estuaries, thereby improving water quality within the waterbody itself.

Private Conservation Lands

The FWS depends on partnerships with private, non-profit organizations and foundations for conservation of threatened and endangered species and their

habitats. In South Florida, the National Audubon Society (NAS), The Nature Conservancy (TNC), and Archbold Biological Station are dedicated to protecting and managing approximately 16,740 ha (41,348 acres) of sensitive lands (Figure 7; Appendix F); a few of these are discussed here.

Archbold Biological Station- The Archbold Biological Station is a private, non-profit organization whose primary focus is ecological research and conservation, with a major emphasis on southern Lake Wales Ridge ecosystems in south-central Florida. Research is conducted by five full-time, resident, principal investigators, five research associates, research assistants, postdoctoral fellows, support personnel, graduate and undergraduate students; and by visiting investigators.

The Station also manages a 2,000 ha (5,060 acre) property and three outlying parcels as nature reserves and operates the John D. MacArthur Agro-ecology Research Center on the 4,049 ha (10,300 acre) Buck Island Ranch located seven miles east. The Station also has an active environmental and public education program.

The main property is located in Highlands County, 12.9 km (8 mi) south of Lake Placid. Elevations range from 33 to 65 m (110 to 213 ft), and topographic features include the crest of Lake Wales Ridge, the Intraridge Valley and the 100-acre Lake Annie. The Station encompasses several globally rare Florida scrub communities, including sand pine scrub, scrubby flatwoods, and high pine. Other habitats found on the property are flatwoods, swales, bayheads, seasonal ponds, and small areas of altered habitat including old fields, a decadent ornamental tree grove, and landscaped grounds. The management objective is to maintain and enhance the natural values of the property, with emphasis on the endemic biota. The primary strategy is use of natural and prescribed fire to approximate as close as possible the pre-settlement landscape.

Archbold Biological Station supports an unusually diverse biota characterized by a high level of endemism. Native vertebrate species include 24 fishes, 17 amphibians, 44 reptiles, more than 200 birds, and 34 mammals. Federal and/or State listed species found on the property include 16 vertebrates and 21 plants. An important factor contributing to the Station's high wildlife diversity and occurrence is the fact that it is located in a region of extensive ranchlands, which extend both south to Big Cypress and north to the St. Johns River valley.

National Audubon Society's Corkscrew Swamp Sanctuary - The National Audubon Society formed an association of public and private organizations in 1954 to raise funds for acquisition of Corkscrew Swamp. The effort was driven by the intensive logging of Florida's last old growth bald cypress forest. Participants included: National and Florida Audubon Societies, Florida Federation of Garden Clubs, Florida Board of Parks and Historic Memorials, The Nature Conservancy and Collier Enterprises. Major gifts were received from Theodore Edison, John D. Rockefeller, Lee Tidewater Cypress Company and Collier Enterprises. By the end of that year a target area of 1,619 ha (4,000 acres) had been acquired or leased for future purchase with private funds. A second

phase of acquisition, also financed with private funds, enlarged the sanctuary to 4,275 ha (10,560 acres) in 1968. No further acquisition is anticipated.

Disruption of natural hydrology by residential and agricultural development is the greatest threat to the sanctuary. The hydrology of Corkscrew Swamp is monitored by a network of shallow wells and stage recorders to insure historic levels and flows are maintained. Exotic vegetation is controlled by chemical and mechanical methods. Appropriate habitats are prescribe burned. Audubon staff work with State wildlife officers to control human intrusion.

Corkscrew is the preferred nesting site of the endangered wood stork. All indigenous species of herons and egrets also nest there. Several Florida panthers have been documented using Corkscrew as part of their range. Black bear frequent the sanctuary and deer are common. It is also an important nesting and roosting area for swallow-tailed kites.

National Audubon Society's Kissimmee Prairie Sanctuary - With funding from the Katherine Ordway estate and the George Whittel bequest, National Audubon, cooperating with TNC, purchased the Kissimmee Prairie Sanctuary in 1981. This 2,794 ha (6,900 acre) purchase, plus two subsequent additions and a 130 ha (320 acre) conservation easement comprise the 3,239 ha (8,000 acre) tract situated in north-central Okeechobee County. While surrounding lands would make desirable additions to the sanctuary, no acquisitions are planned.

The sanctuary is a well-maintained example of central Florida's dry prairie community. Today, only a small fraction of the region's prairie remains in native cover. Direct and indirect threats to the sanctuary's ecology arise from landscape alteration of hydrology, conversion of land to tame pasture, citrus and dairy farms, and to a limited extent locally, by residential development. The property is located near the top of the watershed and inflow impacts are minimal; downstream drainage is mitigated by a levee which blocks historical off-site flows.

Management of the sanctuary is targeted at maintaining an open prairie community, with fire being the critical factor influencing habitat structure. Fire is prescribed to mimic the lightning season fire pattern with which the present plant community evolved. The sanctuary's biotic diversity is due to the tight interspersion of different habitats on site and the relatively benign land uses evident on adjacent ranches.

While the prairie is itself considered imperiled, few listed plants occur on the site. This inconsistency is because prairie flora is very similar to the understory of flatwoods which is the most extensive habitat in the State. Bird species commonly associated with grasslands like the sandhill crane, crested caracara, burrowing owl, and mottled duck use the sanctuary and the surrounding ranches. The federally endangered Florida grasshopper sparrow nests here and is restricted to native prairie habitat. This species is found only on a few sites statewide.

Land Acquisition Efforts in South Florida

Fee title acquisition is the most direct method of habitat preservation and is normally used when: (1) the area's natural resources and flora and fauna require permanent protection not otherwise assured, (2) a proposed land use could adversely impact the area's resources, or (3) when it would be the most

practical and economical way to assemble small tracts into viable parcels for resource management. Fee title acquisition transfers all ownership rights to the purchaser and provides the best assurance of long-term resource protection. A fee title interest may be acquired by donation, exchange, or purchase.

Less-than-fee acquisition is an option that purchases certain rights and uses of the property from the owner, but the owner retains the title or deed to the property. The first American conservation easement was written in the late 1880s to protect Boston parkways and now they are the most popular means to protect land, particularly since the Tax Reform Act of 1976 allowed them to be deducted as donations (LTA 1998). Landowners grant conservation easements to protect the property from inappropriate land uses while retaining private ownership. The easement (and protection of the natural resources, flora and fauna) may run with the land for a specified time period (term easement) or in perpetuity (perpetual easement). A landowner may receive cash payments for a "conservation lease." Overall, conservation easements may provide a means for protecting threatened and endangered species and the habitats on which they depend while allowing the landowner to retain ownership and continue traditional uses of the land.

Federal Land Acquisition

Two Department of the Interior agencies, the NPS and the FWS, own and are acquiring land in South Florida. Most recently, the FWS has acquired Archie Carr, Lake Wales Ridge, and Ten Thousand Islands NWR in South Florida (Figure 7).

National Wildlife Refuge System - The FWS acquires lands and waters consistent with legislation or other congressional guidelines and executive orders for the conservation of fish, wildlife, and their related habitats. The purpose of the land acquisition program is to: (1) Protect nationally important wetlands, (2) Protect important habitats for the preservation and recovery of federally listed endangered and threatened species and other important wildlife and plants, and (3) Provide wildlife-oriented public use for educational and recreational purposes. Funds are requested annually for land acquisition projects and for support activities associated with non-purchase alternatives. The FWS annual land acquisition budget increased from $16.5 million in 1982 to $100.6 million in 1991 and decreased to $62.3 million in 1998. The program is expected to maintain at least its current funding level in order to meet future needs for preserving wetlands and other important wildlife habitats.

The FWS's Southeast Regional Office in Atlanta, Georgia conducts an active land acquisition program. There are 29 national wildlife refuges in Florida totaling 393,640 ha (972,671 acres). This includes 35,679 ha (88,162 acres) purchased in the South Florida Ecosystem at a direct cost of $60.6 million. The remaining acreage was reserved from the public domain (1,539 ha or 3,804 acres), received as gifts (1,238 ha or 3,058 acres), acquired through agreements, easements, or leases (219,325 ha or 541,944 acres), or acquired through other Federal agencies (107 ha or 265 acres).

The relationship of Florida NWRs to endangered and threatened species is very important. For example, three South Florida refuges — National Key

Deer Refuge, Archie Carr NWR, and Florida Panther NWR — are devoted to the preservation of the Key deer, sea turtles, and the Florida panther, respectively.

State Land Acquisition

Florida has the largest state land acquisition program in the nation. The Preservation 2000 Act of 1990 provided up to $300 million annually for 10 years, contingent on annual legislative appropriations. Eighty percent of the money supplements the Conservation and Recreational Lands and Save Our Rivers programs. In 1998, voters endorsed extension of the statewide program and new state legislation; the "Florida Forever Act" was passed in 1999.

Conservation and Recreational Lands (CARL) - The CARL Program was established in 1979 and superseded the $200 million 1972 Environmentally Endangered Lands (EEL) Program. The State of Florida buys land: (1) To conserve and protect environmentally unique and irreplaceable lands that contain native, unaltered flora and fauna representing a natural area unique to, or scarce in, a region of Florida or larger geographic area; (2) To conserve and protect native species habitat, or endangered or threatened species; (3) To conserve, protect, manage, or restore important ecosystems, landscapes, and forests, if the protection and conservation of such lands is necessary to enhance or protect significant surface water, groundwater, coastal, recreational, timber, fish or wildlife resources which cannot otherwise be accomplished through local and State regulatory programs; (4) To provide access, including recreational trails for natural resource-based recreation; or (5) To preserve significant archaeological or historical sites. As of 1996, about 400,953 ha (990,741 acres) valued at $1.4 billion had been acquired through Preservation 2000, CARL and former acquisition programs. The Governor and Cabinet have approved options on an additional 22,868 ha (56,506 acres) valued at $93.6 million. Locations of active and proposed CARL projects are shown in Figure 8 and listed in Appendix F.

Save Our Rivers (SOR) - The Florida Legislature enacted the SOR program in 1981 and created the Water Management Lands Trust Fund. This fund is used to acquire fee title or less-than-fee title interest in lands needed for water supply, water management, and the protection and conservation of water resources. The fund cannot be used for the acquisition of canal and pipeline rights-of-way. Water management districts also receive $90 million (30 percent) of the annual Preservation 2000 funds as a supplement for land acquisition. SOR projects are evaluated for water management, supply, resource conservation and protection criteria. Secondary evaluation criteria include land management, habitat and species diversity, continuity, rarity, vulnerability, and recreation potential.

County Land Acquisition

The Department of Community Affairs' Florida Communities Trust helps the counties fund projects that implement local comprehensive plans. The projects are designed to conserve natural resources or resolve land use conflicts. Revenues are derived from; (1) The operation, management, sale, lease, or

other disposition of land, water areas, related resources, and facilities acquired or constructed by the Trust; (2) 25 percent of the Florida Panther license plate proceeds; (3) Donations, grants, loans, and other aid; and, (4) $30 million (10 percent) from Preservation 2000, the primary funding source. Funds are made available annually as 1:1 matching grants. Eight South Florida Ecosystem counties have land acquisition programs to garner these matching funds. Broward, Miami-Dade, Indian River, Lee, Martin, Palm Beach, Polk, and St. Lucie counties have each passed voter-approved bond and ad valorem tax increases. Charlotte and Monroe counties have acquired environmentally sensitive lands using money appropriated from their general treasury for use as matching funds.

Private Land Acquisition

Land trusts play an important role in educating the public about the value of land conservation. Protecting open space in a community can improve its quality of life, raise the value of land located near natural areas, and increase opportunities for recreation and tourism. The first land trust was founded over 100 years ago in New England. The number of land trusts in America has more than doubled, from 535 to over 1,100, since 1985 (LTA 1998). Today there are 30 in Florida and 14 in the South Florida Ecosystem. Examples of local, regional, national, and international land trusts active in South Florida are presented below.

Indian River Land Trust - The Indian River Land Trust, formed in 1990, is the successor of the McKee Gardens Preservation Society. The mission of the trust is to promote the preservation, conservation and improvement of natural resources and special places in Indian River County for the benefit of the public and future generations. The trust has established a special fund for acquisition of sea turtle nesting beaches at Archie Carr NWR, supports efforts to protect Pelican Island (America's first national wildlife refuge), conducts workshops on fund raising for land trusts, and presents informative slide-shows to the public on Indian River County's natural resources.

Corkscrew Regional Ecosystem Watershed Land and Water Trust - The Corkscrew Regional Ecosystem Watershed (CREW) Land and Water Trust is a regional non-profit organization formed in 1989 to coordinate the acquisition and management of the largest undisturbed watershed in southwest Florida (CREW 1996). The project provides for aquifer recharge, water storage, wildlife habitat (the largest wood stork rookery in the U.S. is located on National Audubon Society property in Corkscrew Marsh), flood control, and passive recreation in Collier and Lee counties. Twenty-two trustees represent local, State and Federal governments, agriculture, business, conservation and development interests. Nearly one-half of the 22,663 ha (56,000 acres) watershed has been protected thus far.

The Trust for Public Land - The Trust for Public Land, founded in 1972, is a national non-profit organization that protects land as a living resource for present and future generations. The Trust for Public Land does not permanently own or manage land, instead it works in partnership with local, State, and Federal agencies to acquire land of cultural, environmental, historic, or

recreational significance (Endicott 1993). The Trust's Southeast Regional Office in Tallahassee has protected over 54,635 ha (135,000 acres) of urban parks, historic sites, rural wildlife habitat, and coastal wetlands in Florida.

The Nature Conservancy - The Nature Conservancy, founded in 1951, is an internationally renowned non-profit organization whose mission is to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive (Endicott 1993). The Florida Chapter has helped local, State, and Federal agencies protect 51,121 ha (126,318 acres) in the South Florida Ecosystem. The Conservancy also owns and manages 24 sanctuaries in the South Florida Ecosystem totaling 3,136 ha (7,750 acres).

Multiple Agency Conservation Efforts and Partnerships

South Florida Ecosystem Restoration Initiative

On September 23, 1993, five Federal Departments and the Environmental Protection Agency signed a 5-year Interagency Agreement on South Florida Ecosystem Restoration. This agreement formally established an Interagency Task Force responsible for developing consistent policies, strategies, plans, programs, and priorities for addressing the concerns of the South Florida Ecosystem.

The purpose of the South Florida Ecosystem Restoration Initiative is to restore and maintain the elements of the South Florida Ecosystem to most resemble the natural functions of a healthy, balanced, and functioning freshwater, estuarine, and marine environment where human activities occur in a manner that supports healthy, natural conditions.

The major objectives of the South Florida Ecosystem Restoration Initiative are to: (1) Restore and maintain the biodiversity of native plants and animals in the upland, wetland, estuarine, and marine communities of the South Florida Ecosystem; (2) Recover species that are threatened or endangered; (3) Ensure that any development plans or permits for development are fully coordinated among affected governmental agencies and are compatible with the restoration of the South Florida Ecosystem; (4) Develop and manage the hydrology of the Kissimmee River, Lake Okeechobee, the Everglades, and associated waters in ways that maximize ecosystem restoration goals while providing appropriate consideration for the needs of urban, rural, and agricultural users; (5) Manage the hydrological conditions in the remaining undeveloped and potentially restorable lands in a way that maximizes natural processes; (6) Restore and sustain healthy ecosystem conditions in Florida Bay, adjacent estuaries, and coastal waters of the South Florida Ecosystem; and (7) Maintain the health and biodiversity of the coral reef ecosystem associated with Florida Bay, Biscayne Bay, and the Florida Keys.

South Florida Ecosystem Restoration Task Force

A 1993 interagency agreement established the Federal Ecosystem Restoration Task Force to coordinate the development of consistent policies, strategies, plans, programs, projects, activities, and priorities for the restoration,

preservation, and protection of the South Florida Ecosystem. Later, the Water Resources Development Act of 1996 formalized the Task Force and added Tribal, State, and local governments. The expanded Task Force is facilitating implementation of overall South Florida restoration efforts. It is a referee, information clearing house and coordinating body to keep the restoration on track with fiscal accountability. It facilitates restoration associated with the Everglades Forever Act, C&SF Restudy, Kissimmee River Restoration Project, and other efforts to re-establish natural systems functions of the ecosystem.

South Florida Ecosystem Restoration Working Group

The Task Force established the Working Group to formulate, recommend, coordinate, and implement policies, strategies, plans, programs, projects, activities, and priorities for ecosystem restoration and maintenance. The Working Group currently has 32 members, representing Federal, State and local agencies and Tribal Governments. The Working Group produces an annual report for the Task Force on interagency activities directed at the Task Force's ecosystem management goals.Information about the South Florida Ecosystem Restoration Task Force and Working Group can be found on their web site at www.sfrestore.org.

Governor's Commission for a Sustainable South Florida

The Governor's Commission is composed of 42 members of the business, government, agriculture, and public sectors in South Florida. It was established in 1994 to find ways of sustaining both human and natural systems. It calls for integrating land use with water management, linking local governments' comprehensive plans with water management districts' regional water supply plans, assessing land use and water management decisions using the principles of full cost accounting, and coordinating Federal, State, regional and local agencies' land use and water management decisions. The Commission has worked extensively with slowing urban sprawl and redeveloping urban cores. The Governor's Commission has also proposed policies to encourage sustainable development. One of their initiatives is "Eastward Ho!" that aims to pull development back from the Everglades and to the coastal ridge so that the environment is protected and older coastal cities are revitalized.

South Florida Coastal Ecosystem Program

The nation's coastal areas include some of the most rapidly growing and densely populated counties in the U.S. Florida encompasses 140,256 km^2 (54,153 mi^2) of which 85 percent or 119,218 km^2 (46,030 mi^2) is considered coastal. South Florida will have four counties in the top 10 counties nationwide in absolute population increase by 2010. As coastal populations increase throughout South Florida, the management of this growth as well as the direct and indirect effects of this growth becomes even more significant. To that end, the FWS has identified a number of opportunities to protect, conserve, and restore coastal living resources. Through the South Florida Coastal Ecosystem Program (SFCEP), partnerships with Federal and State agencies, local governments, non-governmental entities, and private property owners are formed to implement "on-the-ground" restoration projects as well as to

perform research, monitoring, and public outreach activities. Since 1995, the SFCEP has provided funding support and technical assistance to 17 ongoing habitat restoration and public outreach projects in South Florida. The FWS has "partnered" $744,000 to yield over $2,000,000 worth of projects.

South Florida Subregions Project Coordination Teams

The Kissimmee Valley, greater Lake Okeechobee, central Everglades, southeast Coast, southwest Big Cypress, and Florida Keys subregions of South Florida have project coordination teams established by the South Florida Ecosystem Restoration Task Force. Each team is expected to balance flood control, water supply, and environmental restoration by promoting cooperation and resolving conflicts among agencies and groups working in the subregion. Each team develops and maintains an integrated project coordination plan and identifies new projects, as well as following on-the-ground projects, for the South Florida Ecosystem Restoration Management and Working Group's Integrated Financial Plan. The Teams also provide assistance to other Working Group teams as needed.

Comprehensive Conservation Permitting and Mitigation Strategy

The South Florida Ecosystem Restoration Task Force has identified the development of a comprehensive plan regarding permit alteration and mitigation of wetland resource losses as a priority for restoring the health and integrity of the South Florida Ecosystem. Using geographic information system technology, the plan will assess wetland functions and values and focus on the conservation of those wetlands deemed critical for overall restoration. The use of mitigation banking, state-of-the-art mitigation techniques, establishment of wildlife corridors, among others, is being investigated.

State/Federal Mitigation Bank Review Team

The FWS is an integral component of a multi-agency team set up to ensure against adverse impacts to wetlands and other aquatic resources. Mitigation banking means the restoration, creation, enhancement, and in exceptional circumstances, preservation of wetlands and/or other aquatic resources expressly for the purpose of providing compensatory mitigation in advance of authorized impacts to similar resources. The U.S. Army Corps of Engineers (COE), Environmental Protection Agency, NRCS, and NMFS will oversee how mitigation banks are used to satisfy mitigation requirements of the Clean Water Act (CWA) Section 404 permit program and the wetland conservation provisions of the Food Security Act (FSA). Figure 9 shows the location of current mitigation banks in South Florida.

The FWS is involved in the planning, construction, and operation of approximately 30 wetland compensatory mitigation banks in South Florida. These banks are essentially wetland restoration projects, ranging in size from 81 to 5, 261 ha (200 to 13,000 acres), designed in part to support the ecosystem management concept through enhancement and protection of larger tracts of

wetlands than normally associated with mitigation for development. These projects are normally tied in with adjacent natural areas for maximum ecological benefit. Mitigation banks have the potential to complement the Multi-Species Recovery Plan because of common objectives of habitat restoration, and restoration and maintenance of the biodiversity of native plants and animals. Credit can be assigned directly for designing a restoration project which would meet elements of recovery for a particular threatened, endangered or candidate species, and which could ultimately increase the population of a species.

South Florida Greenways

South Florida's landscape has been progressively fragmented by agriculture and urban development through drainage canals and levees and utility and transportation corridors. A regional greenway network is reconnecting the fragments along these areas by reclaiming wetlands, revegetating, restoring habitat, and providing educational and recreational opportunities.

Florida Rare Plant Task Force

With its rich biological diversity and growing number of endangered species, Florida is one of five conservation priority regions identified by the Center for Plant Conservation (CPC). Since 1990, the CPC has provided a unique service to the Florida plant conservation community by facilitating and hosting a Rare Plant Task Force process. This statewide effort is dedicated exclusively to the exchange of information on Florida's imperiled plants and to the discussion, prioritization, and coordination of activities associated with rare plant conservation. The process scrutinizes plant endangerment issues, provides a meeting venue for statewide review and discussion of plant conservation projects, and oversees and coordinates implementation of priority conservation projects. Task Force participants are from diverse backgrounds and organizations statewide, and work together to mesh individual interests and perspectives with consensus-derived conservation and research objectives. The process has proven to be effective in fostering collaborative relationships and in better defining divisions of labor, thereby helping to reduce duplication of effort and foster more efficient use of scarce resources.

Florida Exotic Pest Plant Council and Task Force Exotic Plant Team

To begin the major effort of controlling exotic plants, the Florida Exotic Pest Plant Council (EPPC) was established in 1984 "to focus attention on (1) the impacts exotic plants have on native biodiversity in Florida ecosystems; (2) the impact of exotic pest plants on the integrity of native plant community functions; (3) habitat losses due to exotic plant infestations; (4) the impacts of exotic plants on endangered species via habitat loss and alteration (*e.g.*, Cape Sable seaside sparrow); (5) the need to prevent such losses by comprehensive management for exotic pest plants; (6) the socioeconomic impacts of exotic pest plants (*e.g.*, increased wildfires in *Melaleuca*); (7) changes in the seriousness of different exotic pest plants over time; and (8) the need to provide information that will help managers set priorities for management." EPPC has been growing in membership, now consisting of representatives from Federal,

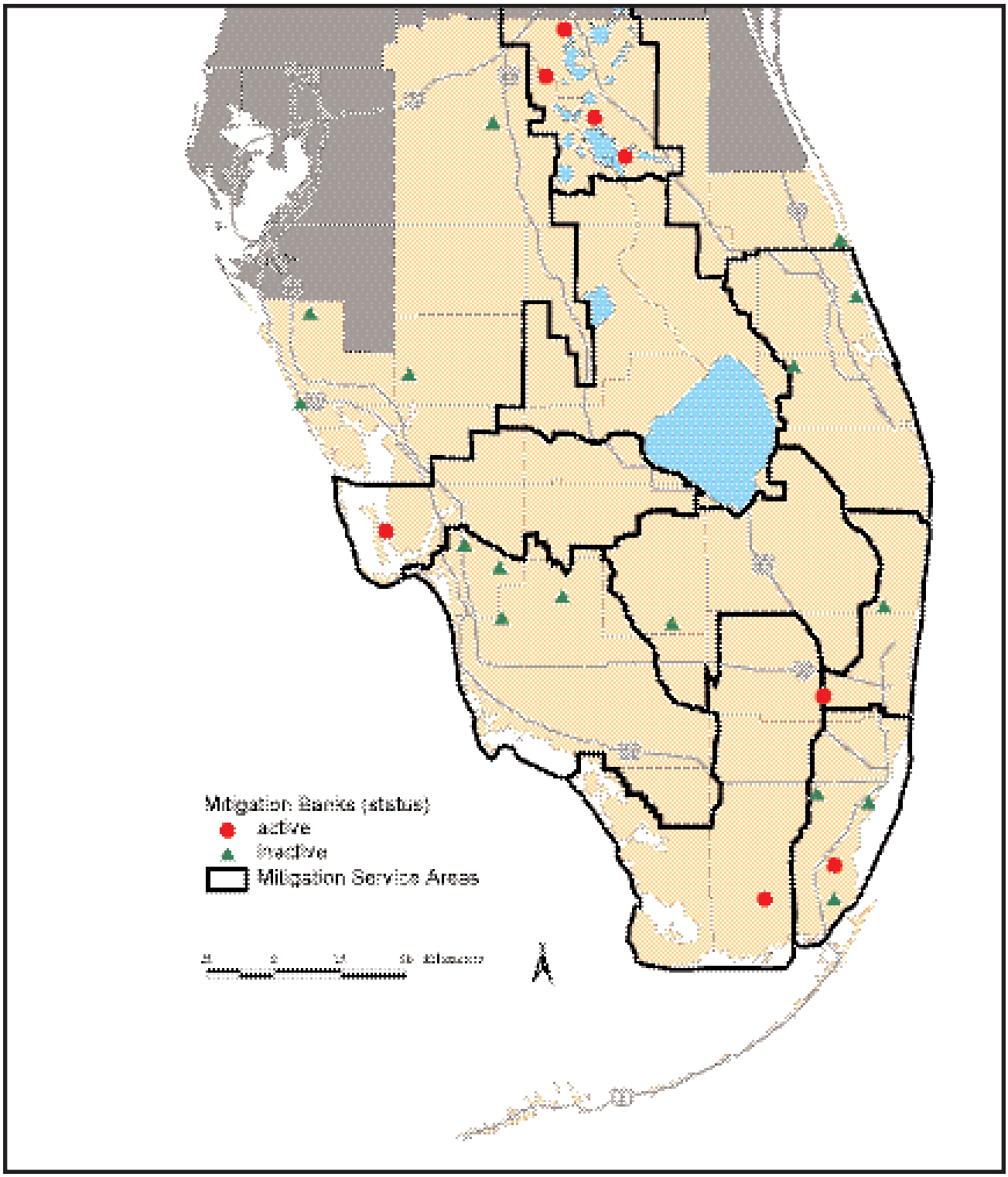


Figure 9. Mitigation service areas and mitigation banks in South Florida.

State, and local governments, as well as non-governmental organizations and private interested parties. It offers the best collective knowledge of exotic plants in the State and has been actively working toward achieving its goals. EPPC lists 62 species as Category I ("species that are invading and disrupting native plant communities in Florida") and 57 as Category II ("species that have shown a potential to disrupt native plant communities").

The South Florida Ecosystem Restoration Task Force formed a Task Team in late 1997 "to develop a comprehensive interagency strategy for eliminating and/or controlling invasive exotic plants in waterbodies, wetlands and uplands under public, tribal and private control in South Florida." The Task Force recognized that the piecemeal control efforts could be made more efficient and cost-effective with integration of programs by various agencies.

Florida Panther Interagency Committee

The Committee was established May 28, 1986, to provide a coordinated recovery effort for the Florida panther. The Committee is comprised of the Southeast Regional Directors of the FWS and the NPS, the Executive Director of the Florida GFC and the Secretary of the Florida DEP. The Committee provides the overall guidance and direction for the Florida panther recovery program.

Partners in Flight

This program is a cooperative effort of 15 Federal government agencies (including FWS), 60 State and provincial agencies, 16 forest products companies, universities, and non-governmental conservation organizations working together to maintain forest and grassland neotropical migratory birds. Biologists, educators, and policy makers are developing and implementing management strategies to restore these birds and their habitats throughout the Americas.

Partners for Fish and Wildlife

About two-thirds of our nation's land is privately owned and contains some of the most important fish and wildlife habitat in the U.S. Three-quarters of the remaining wetlands in the U.S. are privately owned. Wetlands are vital to both wildlife and people. Millions of birds, mammals, and other animals depend on wetlands for food, spawning, and nursery areas. Nearly one-third of America's threatened and endangered plants and animals need wetlands for survival. The Partners for Fish and Wildlife program restores, improves, and protects fish and wildlife habitat on private lands through alliances between the FWS, other organizations, and individuals, while leaving the land in private ownership. Normally, landowners restore unproductive areas of cropland and pasture or areas which are too wet to farm efficiently. Between 1988 and 1995, about 33,533 ha (82,859 acres) of wetlands and associated habitats were restored in the southeastern United States. Three projects restored 31 ha (76 acres) in the South Florida Ecosystem.

Lake Wales Ridge Working Group

The Lake Wales Ridge is the unique mosaic of elevated sandy ridges, relict beach and dunes, at the northern end of the South Florida Ecosystem, about in the middle of the State, in Highlands, Okeechobee, Osceola, Polk, and Orange

counties (Orange is outside South Florida Ecosystem boundaries). The Lake Wales Ridge Working Group is composed of land managers on the Lake Wales Ridge and adjacent properties. This diverse group meets quarterly and is composed of FWS, DEP, Department of Forestry, The Nature Conservancy, other non-governmental organizations, Green Horizons Private Land Trust, Archbold Biological Station, Bok Tower Gardens, GFC, Southwest Florida Water Management District, and Polk County Land Acquisition Program. What began as information exchange has grown into coordinated management for the Ridge. Archbold is developing GIS coverage for the Ridge and has habitats well defined, and the Nature Conservancy is heading up development of an overall Lake Wales Ridge interpretive plan to develop ways of presenting the Ridge and enabling ecotourism.

Lake Worth Lagoon Ecosystem Management Area Steering Committee

Lake Worth Lagoon is located in Palm Beach County along Florida's urbanized southeast coast, which is subject to a constant onslaught of environmentally degrading activities. While the health of the system has declined over the past century, significant regionally and nationally important resources remain which need to be evaluated, restored, and protected. The approximately 50-person steering committee is formed of State, local, private, and Federal representation and seeks to restore, conserve and manage the Lake Worth Lagoon ecosystem "to a level of quality to obtain measurable and significant improvements to the Lagoon's water and sediment quality; to provide habitat for native plants, fish and wildlife, and aesthetic, recreational and economic benefits for the residents and visitors of Palm Beach County; and to encourage, develop and promote a partnership of public and private interests to manage the Lagoon." The Steering Committee has developed a management plan for the Lagoon which focuses on improving water and sediment quality, attaining and maintaining biological integrity of the ecosystem, and gaining heightened public awareness and education. Plan components will be incorporated into other ongoing South Florida restoration efforts.

Loxahatchee River Management Coordinating Council

The Loxahatchee (Seminole word for turtle) River watershed covers about 338 km^2 (210 mi^2) in northern Palm Beach and southern Martin counties where nine drainage basins transport runoff to the three forks of the Loxahatchee. The northwest fork includes an approximately 11 km (7 mi) stretch of river designated as Wild and Scenic under the Federal Wild and Scenic Rivers Act. The federally designated river is administered by the State of Florida pursuant to the Loxahatchee River National Wild and Scenic River Management Plan. The River Management Coordinating Council was established by DEP and SFWMD under State law and meets at least quarterly with a representative from each of the following: U.S. Department of the Interior, DEP, DOT, GFC, DCA, DACS, Department of Forestry, Florida Department of State-Division of Archives, Treasure Coast Regional Planning Council, Martin County, Palm Beach County, Town of Jupiter, Jupiter Inlet District, Loxahatchee River

Environmental Control District, South Indian River Water Control District, Northern Palm Beach County Water Improvement District, and the Palm Beach County Farm Bureau. Also, local environmental groups and private property owners who may be affected by management are included. The Council advises DEP and SFWMD on river management matters and they play a strong role in ensuring that preservation and enhancement goals of the Management Plan are realized. They work to further protect and enhance the wild and scenic corridor by identifying and resolving conflicts among resources, users, and preservation. The Council will also be the approving and coordinating body for the Loxahatchee River Watershed Ecosystem Management Plan under preparation by DEP and others.

National Estuary Program

This is a joint Federal, State, regional, and local program. South Florida's National Estuary Program (NEP) sites are the Indian River Lagoon, Sarasota Bay, and Charlotte Harbor. The NEP is a model for examining land use, water resources, and holistic ecosystem protection with substantial public and local government participation. Also the water management districts are involved in each of the NEP's Comprehensive Conservation and Management Plans (CCMPs).

Currently, many of these management programs are having a beneficial effect on South Florida's estuaries. In some coastal embayments, seagrass coverage is increasing largely due to improved water quality conditions. Since April 1996, treated wastewater is no longer directly discharged into the Indian River Lagoon. The installation of baffle boxes designed to filter stormwater runoff has also improved water quality in the Lagoon. Treating stormwater runoff has improved water quality conditions in Sarasota Bay by reducing nitrogen and contaminant loadings. Though not within the boundaries of the South Florida Ecosystem, Tampa Bay has experienced increased seagrass coverages, again, as the result of improved water quality conditions.

National Estuarine Research Reserve System

The National Estuarine Research Reserve System (NERRS) works through Federal and State partnerships to establish, manage, and maintain reserves and to provide for their long-term stewardship, specifically through research and education. The Rookery Bay NERR is managed by DEP with NOAA as the Federal partner. Initial purchase of lands surrounding Rookery Bay was the result of combined efforts of NAS, TNC, and The Conservancy, Inc. to protect the estuary from imminent development. Program administration is guided by a three-member management board (DEP, The Conservancy, Inc., and NAS). The Friends of Rookery Bay is a nonprofit support group that provides staff assistance to DEP and conducts fundraising activities.

Florida Bay Program Management Committee

By the early 1990s, Federal and State agencies began funding large environmental monitoring and research programs in Florida Bay in response to a series of detrimental environmental changes in the Bay. The Florida Bay

Program Management Committee (PMC) was formed in 1994 to assure that the broad range of scientific activities planned for the Bay are properly focused and coordinated, with the goal of preserving Florida Bay's unique features. The Florida Bay PMC is composed of scientists representing the Federal and State agencies with lead responsibilities for protection and management of the Bay (NPS, DEP, EPA, SFWMD, COE, NOAA, FWS, and USGS). The PMC meets at least quarterly to assure critical research priorities are being addressed and adequately integrated into the overall South Florida Ecosystem Restoration activities. It also has established an annual interagency symposium series.

Florida Keys Environmental Restoration Trust Fund

Established in 1981 by a Federal judge in the Southern District of Florida, the Florida Keys Environmental Restoration Trust Fund, now administered solely by Florida Audubon Society, resulted from an innovative settlement of a legal case that established a separate mitigation fund to carry out environmental restoration projects. The Fund's established purpose is the restoration, enhancement, and management of the unique marine, wetland, and terrestrial habitats of the Keys through well-planned projects. As such, the Fund's goal is to effectuate physical changes to disturbed areas to restore and benefit natural areas and habitats, and the wildlife dependent upon them. Funds are devoted exclusively to charitable or scientific purposes that support or benefit the natural resources of the Keys.

Restoration efforts vary widely, from large-scale physical restoration of scores of acres of wetlands and one-half mile (0.8 km) of shoreline at Carysfort on north Key Largo, to seagrass revegetation in prop scars at Lignumvitae State Aquatic Preserve, to GIS mapping of invasive exotic vegetation throughout the Keys. To date, 4 km (2.5 miles) of old fill roads have been removed from Keys wetland and shallow water habitats, about 6 ha (15 acres) of these habitats restored, and hundreds of acres more have been enhanced through partnership efforts. Cooperators with the Trust Fund in the 1990s include: FWS Coastal Ecosystem Program; FWS, Crocodile Lake NWR; FWS National Key Deer Refuge; EPA, Region 4 Grants Program; Army Corps of Engineers (through formal Memorandum of Understanding); Florida DEP, Division of Parks and Recreation; and Florida DEP, Pennekamp Coral Reef State Park.

Southern Everglades Restoration Alliance

The Southern Everglades Restoration Alliance (SERA) is an interagency group overseeing implementation of several large Federal projects designed to restore the natural volume and timing of water flow in the Southern Everglades. Member agencies cooperate in development of operating criteria, performance measures and National Environmental Policy Act (NEPA) documentation necessary to implement project features. Projects within SERA's purview include the Program of Modified Water Deliveries to Everglades National Park, the Canal C-111 Restoration Project and the Experimental Program of Water Deliveries to Everglades NP.

Everglades Coalition

The Everglades Coalition is a consortium of 40 national, State, and local non-governmental organizations committed to the protection and restoration of the

Everglades. The Coalition works with legislators, interest groups, and public officials in order to advance restoration goals. It conducts quarterly business meetings, and holds an annual conference each January which brings together members of the public, government decision makers and key stakeholders to air concerns and devise strategies to help save the Everglades.

The Major Restoration Projects in South Florida

The following multi-agency restoration projects are on a landscape scale, and are critical to recovery and restoration of imperiled species and their habitats:

Kissimmee Basin Restoration

The Kissimmee River's ecosystem and its environmental values have degraded as the result of cumulative modifications for water resource development. Basin restoration is happening with a new water management schedule in the headwater lakes, which will provide the timing and flows necessary for floodplain restoration and acquisition of approximately 8,418 ha (20,800 acres) of land bordering the affected lakes. The plan for the river and its floodplain will restore the essential physical and hydrologic characteristics of the lower basin, including a more natural river channel and floodplain, with flows, depths, and hydroperiods like that of the historic condition. The plan consists of backfilling about 42 km (26 mi) of C-38; excavating about 8.7 km (11.6 mi) of new river channel; and acquiring approximately 27,115 ha (67,000 acres) of land within the basin. Restoration of these physical and hydrologic characteristics will provide the conditions necessary for natural re-establishment of an ecosystem similar to that which existed and functioned prior to construction of the basin's flood control project. The restored ecosystem will include 90 km (56 mi) of restored river, about 11,736 ha (29,000 acres) of restored wetlands, improved water quality, and restored conditions for over 300 fish and wildlife species, including waterfowl, wading birds, alligators and three federally listed endangered species.

Central and Southern Florida Project Comprehensive Review Study (Restudy)

The Restudy is a very large, very sophisticated, multi-agency effort. It is intended to provide a comprehensive re-examination of the design, operation and purpose of the original C&SF Project, and balance the needs of natural areas with pressures of agriculture and of burgeoning population and development along both coasts. The C&SF Project is touted as the largest flood control project on Earth and is a regional network of canals, levees, storage areas, and water control structures designed for water supply and flood control to allow for development of South Florida. The Restudy area includes the entire C&SF Project (Figure 10), except for the Upper St. Johns River Basin, which is a separate hydrologic basin.

The Restudy is reviewing the C&SF Project functions to determine what modifications are needed to achieve current objectives: (1) enhance ecological values, including (a) increasing the total spatial extent of natural areas, (b) improving habitat and functional quality, (c) improving native plant and animal species abundance and diversity; and (2) enhance economic and social well being, including (a) increasing availability of fresh water

(agriculture,,,municipal and industrial), (b) reducing flood damages to urban and agricultural areas, (c) providing for recreational and navigation opportunities, (d) protecting cultural and archeological resources and values.

In order to restore more natural hydrologic flow characteristics to the existing system, and thus regain many of those ecological characteristics described above and which are known to make up the pre-drainage system, the Restudy will endeavor to: (1) regain lost storage capacity; (2) restore more natural hydropatterns, and (3) improve the quality, quantity, timing and distribution of freshwater flows to the estuaries and the Everglades Protection Area.

Lake Okeechobee Regulation Schedule Study

The Lake Okeechobee Regulation Schedule Study is a State and Federal cooperative effort to identify and implement an interim regulation schedule for the lake which will optimize environmental benefits with minimal or no impact to competing project purposes *e.g.*, flood control and water supply. It will not involve structural modifications to the existing project, and will serve as the regulation schedule until the C&SF Project Comprehensive Review Study implements a long-term solution.

Key resources identified in need of protection and/or restoration and which may be effected by a regulation schedule change include the lake littoral zone and marsh, the St. Lucie and Caloosahatchee River estuaries, and the water conservation areas which receive lake water discharge. The lake, completely surrounded by the Herbert Hoover Dike, and with inadequate discharge capacity, is currently subject to prolonged high lake levels which negatively impact the diverse native vegetation mosaic, and inhibit wading birds and other fauna from foraging and breeding effectively. Flood releases to the St. Lucie and Caloosahatchee River estuaries also pose significant ecological damage to native estuarine fish, seagrasses, and aquatic invertebrates. Implementation of a more environmentally sensitive regulation schedule will hopefully begin to address these environmental problems.

Herbert Hoover Dike Major Rehabilitation Evaluation Report

The Herbert Hoover Dike (HHD) Major Rehabilitation Evaluation Report is an ongoing effort to identify problems with the structural integrity of the HHD, an approximately 230-km (143-mi) long levee surrounding Lake Okeechobee ,and which prevents the lake from overtopping and flooding surrounding urban and agricultural lands. Seepage, both under the levee and through the dike itself, has been observed over the past several years, particularly during high lake stages.

The priority area covered under this report is Reach One, a 36-km (22.4-mi) section of the HHD, extending from the St. Lucie Canal at Port Mayaca on the east side of the lake, to Hurricane Gate Structure 4, at Belle Glade. Other reaches will be addressed either individually or in subsets, in subsequent reports. Environmental concerns associated with the range of alternative plans include, migration of amphibians, reptiles, and mammals over the dike, groundwater flow between the lake and nearby wetlands wellfields, impacts to the near shore lake littoral zone and water quality, possible wetlands impacts, and direct impacts to animals and their habitat. Animals use the dike for burrowing or nesting in trees along the dike.

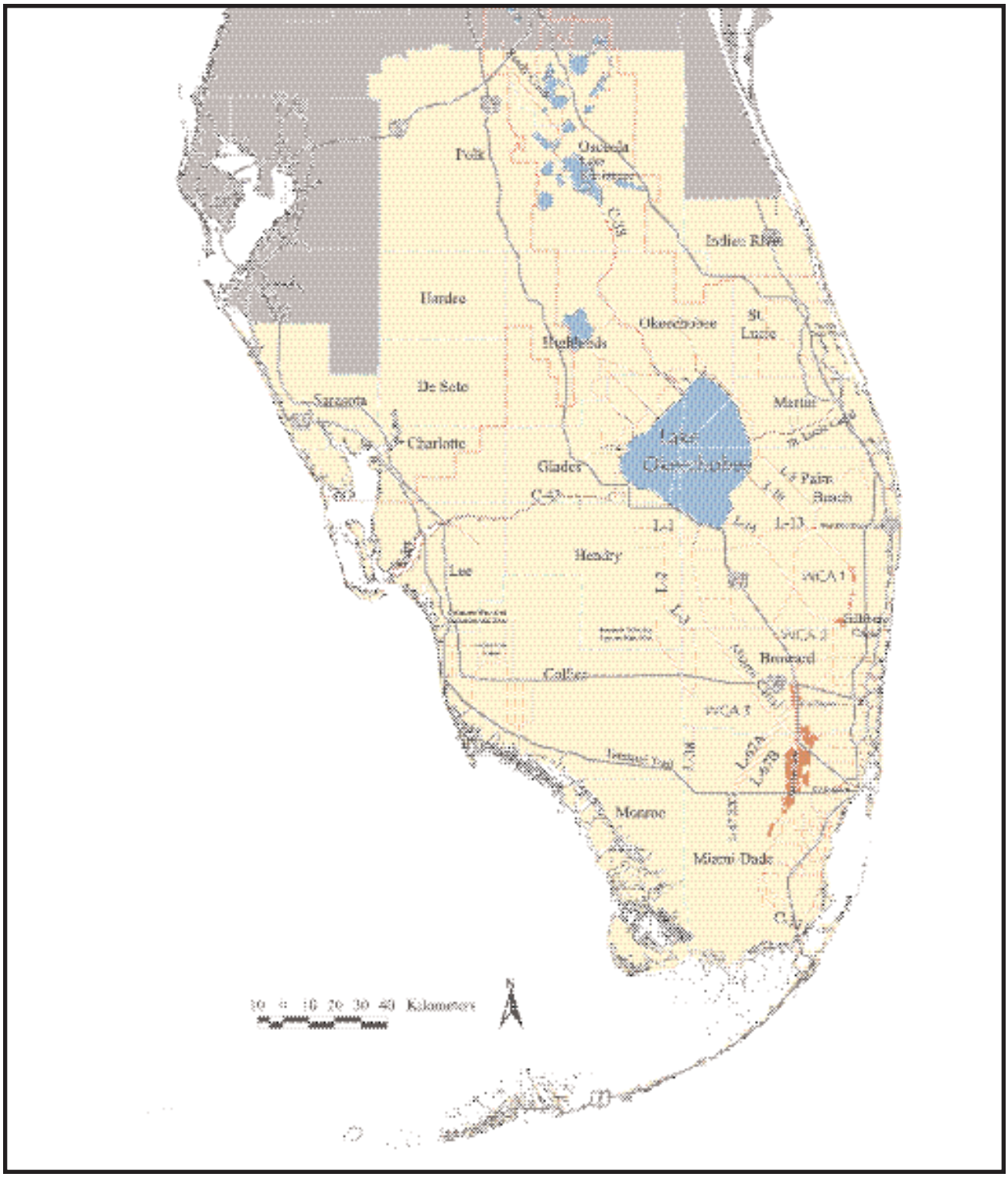


Figure 10. Geographic scope and canal systems of the South and Central Florida Restudy.

East Coast Buffer/Water Preserve Areas

The East Coast Buffer consists of approximately 26,872 ha (66,400 acres) of marshes, reservoirs, and groundwater recharge areas in Palm Beach, Broward and Miami-Dade counties. In 1997, the SFWMD Governing Board approved the expansion of the project by 2,289 ha (5,657 acres), and between 1996 and 1997, the District acquired 1,729 ha (4,271.6 acres) within the project area. Federal funding from the Everglades Ecosystem Restoration Federal Agriculture and Improvement Act of 1996 (Farm Bill) provided grant money for acquisition. The East Coast Buffer will serve as a barrier to reduce the impacts of development to the Everglades, reduce levee seepage from the Everglades, increase groundwater recharge, enhance drinking water supplies, improve the Everglade's water supply, and enhance the thousands of hectares of remaining wetlands that once comprised the Everglades. The COE incorporated the East Coast Buffer as a component of the Restudy, and refer to the area as the "Water Preserve Areas Feasibility study." Additional facilities (including water storage areas and rehydrated natural wetlands) will be built in Martin and St. Lucie counties. These areas will function largely to attenuate floodwaters currently discharged to the St. Lucie estuary and Indian River Lagoon, as well as enhancing existing and historical wetland functions for priority natural areas.

Indian River Lagoon Feasibility Study

The St. Lucie Estuary is located on the southeast coast of Florida and discharges into the Indian River Lagoon and Atlantic Ocean. The Estuary encompasses about 21 km^2 (8 mi^2)and the historic watershed was estimated to cover 673 km^2 (260 mi^2). Due to extensive agriculture and urban drainage projects, the present-day watershed has expanded to 2,007 km^2 (775 mi^2). Additionally, the estuary is linked to Lake Okeechobee by C-44, and that canal is utilized for navigation and the release of floodwaters from the Lake. C-44 is also the hydrologic linkage between this project and the overall C&SF Comprehensive Plan. The major effects of anthropogenic changes in the watershed have resulted in significant alterations in the timing, distribution, quality, and volume of freshwater entering the estuary.

The Indian River Lagoon Restoration Feasibility Study, a joint SFWMD and COE project, has the primary goals of enhancing the ecological values of the estuary and enhancing economic values and social well-being of the region. These goals will be accomplished by investigating water resource opportunities in Martin and St. Lucie counties. The focus of the study is to develop a regional plan to address multiple opportunities including environmental restoration of areas adversely impacted by the C&SF Project system, flood damage reduction, and urban and agricultural water supply. The study team for this project is a multi-disciplined team from a number of local, State, and Federal agencies and will incorporate components previously identified in the COE 1994 Reconnaissance Report. These concepts include, but are not limited to: water preserve areas, Upper East Coast Flowway (C-131), on-site detention/retention, St. Lucie Flowway, removal of the St. Lucie organic sediments, aquifer storage and recovery, and water supply alternatives.

Everglades Construction Project

Currently, stormwater runoff with elevated levels of phosphorus is being discharged from the EAA to the water conservation areas (WCA). The quality, timing and location of these discharges is contributing to adverse changes in plant and animal communities and threatens the ecological integrity of the Everglades. Implementation of the Everglades Construction Project will improve water quality through the reduction of phosphorus levels, while improving the timing and location of discharges into the Everglades Protection Area.

The Everglades Construction Project consists of six stormwater treatment areas (STA) constructed in the EAA; completion of the C-51 West flood control project; hydropattern restoration projects in WCA-2A, WCA-3A, and the Rotenberger Tract; diversion of water from the northern L-8 Basin to Lake Okeechobee; and diversion of flows from five small agricultural drainage districts away from Lake Okeechobee to STAs. Money from the Farm Bill is being used to acquire land for STAs and in the EAA. The six STAs have an effective treatment area of 17,057 ha (42,146 acres). The STAs will be located at the south end of the EAA and are designed to reduce phosphorus concentrations in the stormwater runoff from 311,417 ha (769,500 acres) of agricultural lands in the EAA and adjacent basins and Lake Okeechobee prior to discharge to the WCAs.

Modified Water Deliveries to Everglades National Park

This project will modify C&SF project features to restore the natural hydrology of Shark River Slough and ultimately restore the ecosystems of Everglades NP to the extent practicable through water deliveries. This works hand-in-hand with acquisition of the East Everglades (43,546 ha or 107,600 acres) addition for Everglades NP. The East Everglades addition contains a good part of the historic flow-way for the slough. Natural flow conditions will be restored in southern portions of WCAs 3-A and 3-B and Shark River Slough so that 2,072 km^2 (800 mi^2) will once again function naturally in timing, volume, and other flow characteristics. Completion of construction is anticipated by 2004.

Experimental Program of Water Deliveries to Everglades National Park

The COE was authorized by Congress in 1984 to "conduct an experimental program for the delivery of water to the Park from the C&SF Project for the purpose of determining an improved schedule for such delivery." This authority allowed the COE to deviate from the "minimum delivery schedule" to the park established by Congress in 1969.

The Experimental Program provides a mechanism to field-test water delivery methods to assess potential impacts on the park and other parts of the Everglades Ecosystem, as well as on the authorized C&SF project functions of flood control and water supply. It consists of a series of iterative tests, each building on the results of the previous ones. These tests are aimed at furthering the goal of restoring and maintaining, to the extent practicable through water management practices, the natural abundance, diversity, and ecological integrity of the native plants and animals within Everglades NP, including Florida Bay.

During the construction period for features of the Modified Water Deliveries and the C-111 Projects, data collection, evaluation, and ecological and hydrologic modeling are being performed as part of the Experimental Program. The ultimate objective is to identify an operational plan by the time construction is completed to optimize ecological restoration of the park while maintaining other authorized project purposes.

Experimental Program Test 7 consists of making water deliveries to Everglades NP through Taylor Slough in accordance with a rainfall/canal-stage formula developed by the park. The L-31W Canal serves as a spreader canal, recharging the adjacent Taylor Slough marsh through overbank flow or groundwater seepage, depending upon canal stage. Test 7 began on November 1, 1995 and will continue for four years, then undergo an evaluation not to exceed six months, to determine whether it should continue or be replaced by a new test. New tests can be considered under the Experimental Program at any time opportunities arise that would advance the restoration objectives.

South Florida Critical Restoration Projects

The following are projects identified as "Critical Restoration Projects" for South Florida, under the Water Resources Development Act of 1996. These are specifically designated as projects that the Secretary of the Army, in cooperation with the non-Federal project sponsor (SFWMD), and the Task Force, have determined will "produce independent, immediate, and substantial restoration, preservation, and protection benefits." There are 35 total critical projects (Table 5); this section provides a brief description of the top 11 of these.

East Canal Structures, C-4 - This project consists of the construction of two gated structures in canal C-4, one immediately southeast of the Pennsuco Wetlands and a second on C-4 just east of the intersection with C-2. The control structure G-119, which is located on the eastern edge of Water Conservation Area 3-B, will be removed to reduce head loss effects. The primary project objective is to raise surface and groundwater levels to prevent drainage of the Everglades and to re-establish natural hydroperiod patterns. The project would retain, in the Everglades, waters that now drain to the east via the primary conveyance canal system. It would increase aquifer recharge, and surface and subsurface storage of water, to enhance regional water supplies. It would also provide increased habitat for plants and animals that live in the Everglades communities by restoring wetlands and decreasing the spread of exotic plants. A project goal is to reduce seepage losses from the Pennsuco Wetlands and WCA 3-B.

Tamiami Trail Culverts - The project entails the construction of 87 additional culverts under Tamiami Trail located at 30 separate sites; per site culvert counts range from one to seven. Twenty-nine blocking plugs would also be constructed in the existing borrow canal. They would extend from the top of the road to the existing natural grade on the opposite (northern) side of the canal. Exact locations will be identified when the best locations in the natural drainage swales are identified. The project goal is to improve the natural sheet flow of surface water within the watersheds of Ten Thousand Islands NWR and Aquatic

Preserve, Picayune Strand SF, Fakahatchee Strand State Preserve, Big Cypress National Preserve, and Everglades NP. By creating a more diffuse flowway beneath the Tamiami Trail, a more natural hydropattern will be established north and south of this highway.

Melaleuca Eradication Project and Other Exotic Plants - This is a three-part project consisting of: (1) Construction of a melaleuca Quarantine and Research Facility to enable the testing of organisms for biological control of melaleuca at Fort Pierce, Florida, (2) Upgrading of existing quarantine facilities at Gainesville Florida, and (3) Implementation of biological controls. The exotic tree was introduced in the 1900s and now infests approximately 400,000 acres of South Florida's fragile wetlands. The potential range of the tree includes all of South Florida, with the exception of the saline zone (Davis and Ogden 1994). Lake Okeechobee, Everglades NP, Big Cypress National Preserve and the Everglades conservation areas are all at risk. Melaleuca reduces wildlife habitat and native vegetation and is a navigation and fire hazard. Altered hydrologic regimes within remnant wetlands have increased their vulnerability to melaleuca (Weaver *et al.* 1993). Experts agree that we are unlikely to control this pest without the aid of biological agents.

Research in Australia (melaleuca's native land) indicates that biological control agents offer immense potential to reduce the projected billion dollar impact to the South Florida Ecosystem. One melaleuca insect, *Oxyops vitiosa*, has been through the quarantine process and was released April 1997. Initial field reports indicate that this insect is very effective. Quarantine studies and release of approved candidates are being delayed due to a lack of a quarantine facility. Conventional chemical and mechanical melaleuca control continues, but incorporation of biological control agents into the management strategy is essential. A consortium of Federal, State and local agencies have funded overseas research to identify candidate biological control insects for melaleuca. Approximately ten candidates have been identified. The inavailability of quarantine space delays the testing and release of melaleuca biological control agents.

Florida Keys Carrying Capacity Study - The Florida Keys Carrying Capacity Study is a Governor-and-Cabinet ordered solution for inadequate comprehensive planning in Monroe County. The comprehensive study is directed to determine the density of human life and activity the Florida Keys ecosystem can sustain without irreversible and/or adverse impacts to natural resources. It is intended to recover and regain ecosystem and habitat integrity, as well as identify additional infrastructure needs. The study is not intended to recommend solutions, rather it will offer a foundation for making sound planning decisions by interfacing data from a multitude of agencies, organizations, and academic research sources.

Western C-11 Water Quality Treatment Project - This project will implement structural and operational modifications to the S-9 pump station and water management system that will reduce pollutant loads to the Everglades and/or reduce the design capacity and cost of future water quality treatment systems. Project features: changes to pump operation schedule to reduce sump drawdown

Table 5. Critical restoration projects.

Project Name	Rank
East Canal Structures	1
Tamiami Trail Culverts	2
Melaleuca Eradication Project and Other Exotic Plants	3
Florida Keys Carrying Capacity	4
Western C-11 Water Quality Treatment Project	5
Seminole Tribe Big Cypress Reservation Water Conservation Plan	6
Southern Golden Gate Estates Hydrologic Restoration	7
South Dade Agriculture & Rural Land Use & Water Management Plan	8
Southern Crew Project Addition/Imperial River Flowways	9
Lake Okeechobee Water Retention/Phosphorus Removal	10
Ten Mile Creek Water Preserve Area	11
L-28 Modification Report	12
Loxahatchee Slough Ecosystem Restoration	13
Geodetic Vertical Control Surveys	14
Lake Trafford Restoration	15
L-31E Flow Redistribution Project	16
Henderson Creek Belle Meade Restoration	17
Lake Okeechobee Tributary Sediment Dredging	18
Develop & Implement Agricultural BMP's in C-111 Basin	19
North Fork New River Restoration	20
L-8 Canal - Water Catchment Area - Loxahatchee Slough Infrastructure Improvements	21
Florida Keys Tidal Creek Restoration	22
Lake Worth Lagoon Restoration	23
Wetlands-Based Water Reclamation Project	24
Lake Okeechobee Project Aquifer Storage and Recovery	25
Miccosukee Water Management Area	26
Six Permanent Water Monitoring and Meteorological Stations	27
Nutrient Removal and Dosing Studies for Everglades NP	28
WCA 38 Seepage Reduction	29
Hillsborough Pilot Aquifer Storage and Recovery Project	30
Lakes Park Restoration Project	31
Town of Ft. Myers Beach	32
Palm Beach County Water Utilities Department Winsberg Farms Constructed Wetland	33
Spring Creek Reconnection and Rehydration Project	34
Restoration of Pineland & Hardwood Hammocks on Prev. Rock Plowed Land/C-111 Basin, Miami-Dade Cnty.	35

extremes; use of additional smaller electric pumps to pump seepage and reduce the frequency of high pumping rates that disturb bottom sediments; construction of a gated control structure in the western C-11 canal, west of U.S. Highway 27, to isolate seepage from stormwater runoff and maintain more consistent canal stages; changes in canal geometry and rerouting of flows during peak storm events. The project goal is to reduce pollutant loads to the Everglades Protection Area. It will reduce resuspension of solids and will isolate seepage waters from stormwater runoff so that during non-storm events, only relatively clean surface waters will be discharged into WCA 3-A. It will maintain more consistent water levels in the Western C-11 canal which will reduce the frequency of drawing in relatively low oxygen groundwater, allow particulate settling in the C-11 Canal and secondary canals, and reduce the frequency of drawing stormwater runoff from upstream in the secondary canal system.

Seminole Tribe Big Cypress Water Conservation Plan - This is a water conservation project for the west side of the Big Cypress Reservation. The project includes the design and construction of water control, management, and treatment facilities in Basins 1, 2, 3, and 4, which comprise the western portion of the Big Cypress Reservation and the major conveyance systems, including major canal bypass structures, irrigation storage cells, and water resource areas. The project goal is to improve the quality of water and runoff from all phosphorus-generating agricultural sources within the reservation. Pretreatment cells and water resource areas will remove phosphorus and other pollutants from water discharged from reservation lands and flowing to the Environmental Protection Agency through the Big Cypress National Preserve and Mullet Slough. Bypass structures built under the West Feeder Canal will re-water the Big Cypress National Preserve. Water conveyance improvements and irrigation storage cells will move and store water. A stormwater attenuation area and the rehydrated natural areas will detain water from large storm events.

Southern Golden Gate Estates Hydrologic Restoration -The recommended plan consists of a combination of spreader channels, canal plugs, road removal and pump stations. Implementation of the plan would include three major flowways that contribute freshwater input to the Ten Thousand Islands Estuary of the western Everglades watershed. The project objective is to restore the environment of the area to its natural state by re-establishing the historic flowways and reducing the shock load of freshwater discharges to the Ten Thousand Islands Estuary. Benefits will be introducing sheetflow in Southern Golden Gate Estates, re-establishing the historical flowways, reducing runoff by increased evaporation and groundwater recharge, and replacing point flow discharge through the Faka Union Canal with distributed flow along U.S. 41 into the tidal coastal marshes.

South Dade Agricultural and Rural Land Use Water Management Plan - The South Dade Agriculture and Rural Land Use and Water Management Plan is being developed by the Department of Planning, Development, and Regulation of Metropolitan Miami-Dade County to be included in the county's Comprehensive Master Plan. This critical project actually consists of two separate projects, the first of which is entitled South Miami-Dade County Agricultural and Rural Area Retention Plan. The second plan will focus on lands within the watershed of South

Biscayne Bay, including Biscayne NP, and is identified as the South Biscayne Bay Watershed Management Plan. The intent and scope of this second project are still being defined at the present time.

The South Miami-Dade County Agricultural and Rural Area Retention Plan is described as an agriculture and rural character retention initiative for the South Miami-Dade County area and will identify the major components of agricultural production and agribusiness, primarily through the use of microeconomic and analytical techniques. Agriculture industry practices associated with each major crop (or commodity) within South Miami-Dade County will be inventoried and studied in conjunction with existing surface water and groundwater hydrologic data. Information will also be collected and analyzed to establish economic strategies and incentives that may be used to strengthen and retain the agricultural industry in this region. The results of this study will be used to determine operating conditions that would optimize water supply and flood protection to these agricultural areas while minimizing adverse impacts to water quality.

Southern CREW Project Addition/Imperial River Flowways - This plan calls for acquisition of 1,890 ha (4,670 acres) of land and restoration of historic flows over the area. The project will be added to the Corkscrew Regional Ecosystem Watershed (CREW) with perpetual management to maintain natural system qualities. Project elements include the removal of existing road beds, removal of single family homes, removal of junk debris, filling of ditches, and removal of agricultural canals and berms. The Kehl Canal weir will be raised to provide more storage capacity and gates will be added to allow better water management and control. The bridge located over the Imperial River will be replaced to allow a more direct flow path. The abutment will be placed outside the channel to eliminate flow constriction.

The goal is to re-establish historical flow patterns and hydroperiods on the lands proposed for acquisition as well as CREW and Corkscrew Swamp Sanctuary wetlands to the east, to restore historical storage potential of the southern CREW lands, reduce excessive freshwater discharges to Estero Bay during the rainy season, decrease saltwater intrusion during the dry season, reduce loading of nutrients and other pollutants to the Imperial River and Estero Bay, increase aquifer recharge, and reduce flooding of homes and private lands west of the project area. The project will also reduce the potential for forcing water eastward through the CREW Project and the Corkscrew Swamp Sanctuary and harming these important areas by increasing water depth and duration.

Lake Okeechobee Water Retention/Phosphorus Removal - This project concentrates on specific land parcels located within four key basins of the Lake Okeechobee watershed-the lower Kissimmee River basins (S-65D, S-65E, and S-154) and the Taylor Creek-Nubbin Slough basin (S-191). Two land parcels have been proposed for the project; other parcels have been identified, but have not undergone design. The proposed land parcels are Palaez Isolated Wetland and Taylor Creek Diversion at Grassy Island Ranch. The project goal is to restore natural hydrology through groundwater recharge and attenuation of peak flows through the slower release of water. Phosphorous is expected to be removed naturally due to the increased amount of wetland vegetation, which would in turn result in cleaner water entering Lake Okeechobee. Large land parcels that were once part of the floodplain will be re-flooded to add adjacent and/or isolated wetlands back to the landscape.

Ten-Mile Creek Water Preserve Area - This project involves infrastructure improvements including the construction of an aboveground reservoir with a pump station for filling the reservoir from Ten-Mile Creek and a gated water-level control structure for the release of water back to the creek, as well as required planning and design activities, land acquisition, operational and best management practice plans for the basin and reservoir. The purpose of this water preserve area is the seasonal or temporary storage of stormwater from the Ten-Mile Creek Basin. Storage of excess stormwater will allow its measured release, and therefore create a more natural salinity regime. The intent of the project is to attenuate summer stormwater flows into the North Fork of the St. Lucie River Estuary which originate in the Ten-Mile Creek Basin by capturing and storing the passing stormwater. The sedimentation of suspended solids that occurs in the storage reservoir will reduce particulate loads delivered to the estuary. In addition, it is the intention that stormwater be passed through a polishing cell for additional water quality treatment before being released into the North Fork. Stored water can be released in the drier winter months to augment insufficient flows. Stabilizing the salinity concentration will greatly enhance the estuary's ability to support seagrasses, oysters, and nursery areas for marine fish.

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