COASTAL ECOSYSTEMS

Replumbing the Everglades: Large-Scale Wetlands Restoration in South Florida

Look down on South Florida from a high enough altitude and the problem is obvious. Lake Okeechobee, the liquid heart of the giant watershed that covers the lower third of Florida, stands penned behind floodproof dikes. Massive changes in the landscape have clearly altered the flow of water through the area. Below Lake Okeechobee, the original shape of the Everglades is barely recognizable arcing south for 160 km from the Lake to the mangrove shallows of Florida Bay.

Water dominates the South Florida ecosystem like few other places in North America. This was once an unbroken marshland of sawgrass and small tree islands, fed by a shallow sheet of water flowing south from Lake Okeechobee. Now the marsh is a series of disconnected tracts separated by dikes, drained by a web of major and minor canals. Croplands–mostly sugarcane–have displaced the entire northern third of the Everglades; only the southern end remains in a relatively natural state as Everglades National Park and Big Cypress National Preserve.

The benefits of these changes–and the beneficiaries–are as clear as the changes themselves. To the east of the Everglades, safe behind a levee, lies the greater Miami area–a sea of tract houses and high-rise buildings, home to 6 million people and a burgeoning center of tourism, trade, international investment, and retirement living. The levees and canals protect the populated eastern corridor from floods and effectively turn most of the remaining tracts of Everglades into reservoirs for water supply. Agriculture, which represents the other major land use in the area, depends even more on the

(continues on p. 166)

Box 3.4 Overview: Florida Everglades

In what may be the world's most ambitious effort to restore an ecosystem, U.S. government agencies, business interests, and environmentalists are combining forces—and US$7.8 billion—to reverse a century of draining and diking in the Florida Everglades. This vast inland marsh houses a rich assemblage of plants and wildlife and is the water source for the Miami area's 6 million residents and South Florida's lucrative farming sector.

Ecosystem Issues

Freshwater

The 23,000 km^2 Kissimmee-Okeechobee-Everglades watershed was once a single hydrologic system of rivers, lakes, and wetlands. Flood control and water supply structures have drastically reconfigured this once free-flowing water, reducing the water volume and disrupting the natural flooding and drying cycle. Nearly half of the wetlands have been lost; saltwater intrusion and pollution from intensive agriculture are additional problems.

Coastal

Changes in the natural water flow in the Everglades have greatly reduced the quantity of freshwater reaching the coast at Florida Bay, disrupting estuary salinity levels, and causing seagrass die-offs and turbidity in the bay. Traditional bird colonies have abandoned nearby mangrove forests and brackish marshes.

Agriculture

Croplands have displaced about one-third of the Everglades, but have made South Florida counties important producers of sugarcane, subtropical fruits, and winter vegetables. That output, however, now is threatened: agricultural acreage in Southern Florida is giving way to urban sprawl and soil subsidence.

Management Challenges

Economics

Although the restoration bill is daunting, the cost of allowing the Everglades' decline to continue could be far greater, particularly for local residents and businesses. For example, further declines in the health of Florida Bay could bring losses of more than $250 million/year in lost tourist dollars and reduced commercial fish catches. The area's $2 billion agriculture sector depends even more on the flood control and reliable water supply that the network of water control structures brings. No one has yet put an economic value on the many species whose lives hang in the balance of restoration.

Stakeholders

Sustaining the restoration effort will demand ongoing negotiations and commitment among an array of stakeholders—federal, state, and county governments; agribusinesses; environmental, sport, and recreation groups; and Native American tribes. Because restoration is intimately connected with regional patterns of land and resource use and economic expansion in Southern Florida, all of the area's 6 million residents are also ultimately affected.

Information and Monitoring

No restoration project of this magnitude has ever been undertaken; its effects on the social and biological aspects of the system are not entirely known. The many unknowns make ongoing monitoring of the ecosystem's health and productivity particularly essential: to ensure the maximum effectiveness of the $7.8 billion investment, to provide feedback to stakeholders, to guide changes in the restoration plan, and to inform similar efforts elsewhere.

Timeline

c. 0 AD Native Indian tribes—the Tequesta and the Calusa—migrate into South Florida.

1513 Spanish explorer Ponce de Leon claims Florida for Spain.

1820s Settlers from the United States begin to migrate south into Florida.

1821 U.S. purchases Florida territory from Spain.

1835–42 and 1855–58 The "Seminole Wars": Seminoles escape into the Everglades interior to avoid U.S. government troops.

1845 Florida territory is granted statehood in the United States of America.

1848 U.S. government first recommends draining Everglades for agriculture.

1855 Alligators begin to be hunted for their hides; at least 10 million killed from 1870 to 1965.

1881 Hamilton Disston finances first large-scale experiment in draining and farming in the Everglades.

1907 The Everglades Drainage District founded to fund major drainage canals.

1917 Four major canals completed from Lake Okeechobee to the Atlantic Ocean.

1926 and 1928 Hurricanes kill 2,500 people and cause more than $75 million in damages.

1928 Tamiami Trail (first road across the Everglades) is completed.

1947 Record rains flood 90 percent of southeastern Florida for 6 months. Everglades National Park is established.

1948 Central and South Florida (C&SF) Project is authorized.

1954–59 Everglades Agricultural Area created by diking and draining the northern Everglades.

1963–65 C&SF water managers stop water from flowing into Everglades National Park in order to fill new water conservation areas.

1970 Severe drought occurs.

1973 Construction complete on major elements of the C&SF Project.

1980–81 Severe drought occurs.

1983 Governor Robert Graham initiates Save Our Everglades program.

1986 Major algal bloom on Lake Okeechobee prompts state action to lower phosphorus pollution entering the lake.

1988 Seagrass die-offs and large algal blooms begin in Florida Bay. Federal government files suit against the South Florida Water Management District for releasing water polluted with agricultural runoff into the Everglades.

1991 Florida passes the Everglades Protection Act, mandating control of nutrient pollution of the Everglades.

1992 U.S. Army Corps of Engineers begins review of C&SF Project to determine how to reduce ecosystem damage.

1993 Federal government establishes the South Florida Ecosystem Restoration Task Force.

1994 Florida enacts the Everglades Forever Act to establish a comprehensive program to restore significant portions of the Everglades. Governor's Commission for a Sustainable South Florida is established.

1997 Restoration of the channelized Kissimmee River begins. Construction begins on the first of six filtering wetlands to remove phosphorus from agricultural runoff leaving the Everglades Agricultural Area.

1998 U.S. Army Corps of Engineers releases $7.8 billion plan to reconfigure the C&SF Project to restore a more natural water cycle.

flood control and reliable water supply that the network of water-control structures brings.

But the benefits that have come from bending the natural water cycle to human need have brought less welcome changes to the ecosystem. The Everglades and the whole of the South Florida ecosystem are uniquely dependent on the area's distinctive water flow pattern. When people began to disrupt this pattern, the health of the ecosystem began to deteriorate–at first slowly, but more rapidly in the last 2 decades. Wading bird populations have plunged, seagrass beds in Florida Bay have died back, sport and commercial fishing has suffered, and nonnative plants and fish have invaded, among other effects. Even the assurance of a plentiful water supply has evaporated as the urban population grew and the capacity of the Everglades to store water shrank.

Can the South Florida ecosystem be restored to health? Local powerbrokers and the public think so, and have already committed more than $2 billion to the effort over the last decade. Recently they have embraced a new $7.8 billion Everglades restoration plan proposed by the U.S. Army Corps of Engineers–the most ambitious and extensive ecosystem restoration effort in the world. With the goal of duplicating, as much as possible, the region's original water patterns, engineers are poised to rip out certain levees, refill some canals, and re-allocate water throughout the region. There are no guarantees of success, and even if some recovery occurs, scientists are not sure how much the total health of the ecosystem will improve over the long term, given that the Miami region is still developing rapidly. Yet the restoration effort has clearly generated local enthusiasm, as well as high-level support from the state and federal governments. How a contentious band of government agencies, business interests, and environmental and sporting groups came to agree on such an expensive and difficult program is a story of how convincing–and threatening–an ecosystem in distress can be.

Draining the Marsh, Stopping the Flood

Water had long been a barrier to human settlement of the Everglades region. Prior to the 19th century, a few Native Indian villages dotted the coast, but the marshy interior of the Florida Territory remained largely unpeopled until bands of Seminole and Miccosukee Indians fled to the Everglades to escape U.S. government troops in the 1830s.

Early white settlers regarded the Everglades and other seasonally flooded tracts as wasted land, inhospitable to commerce, food production, transportation, and personal safety, and fit only to be drained and "improved." At first, agriculture was the focus of these schemes. With a tiny population and no major cities or industrial base, Florida looked to its fertile muck soils for its future.

THE BEGINNING OF FLORIDA'S AGRICULTURE

In 1881, Philadelphia millionaire Hamilton Disston financed the first real attempts to drain and farm marshlands in South Florida on a 20,000 ha tract in the upper Kissimmee Basin. His success with rice and sugarcane crops on reclaimed land bore out the land's potential productivity. His canals–the area's first–opened a water route from Lake Okeechobee to the Gulf Coast. By the late 1920s, agriculture was well established around Lake Okeechobee and elsewhere in the basin and the rudiments of a drainage system–five major canals from Lake Okeechobee to the Atlantic–had been dug (Light and Dineen 1994:53-55; Light et al. 1995:120-122).

But these early canals and levees were not sufficient to protect the region from the disastrous floods that periodic hurricanes brought. Hurricanes in 1926 and 1928 claimed more than 2,500 lives and left an estimated $75 million in damages when flood waters breached the low levee protecting the farming areas south of Lake Okeechobee. These disasters intensified efforts to keep the lake safely within its bounds. The levee was raised and two flood bypass routes, to the east and the west, were created to help vent flood waters directly to the Gulf and Atlantic coasts rather than allowing the waters to flow south along their natural course (Light and Dineen 1994:55).

Unfortunately, when major hurricanes again hit the Everglades in 1947 and 1948, inundating 90 percent of southeastern Florida for 6 months, it was clear that flood protection was only partial at best. State and local representatives, backed by their powerful agricultural and urban constituents, pushed for the federal government to step in and fund a lasting solution to the area's flood problems (Light and Dineen 1994:58; USACE 1998:I-22).

THE CENTRAL AND SOUTH FLORIDA (C&SF) PROJECT

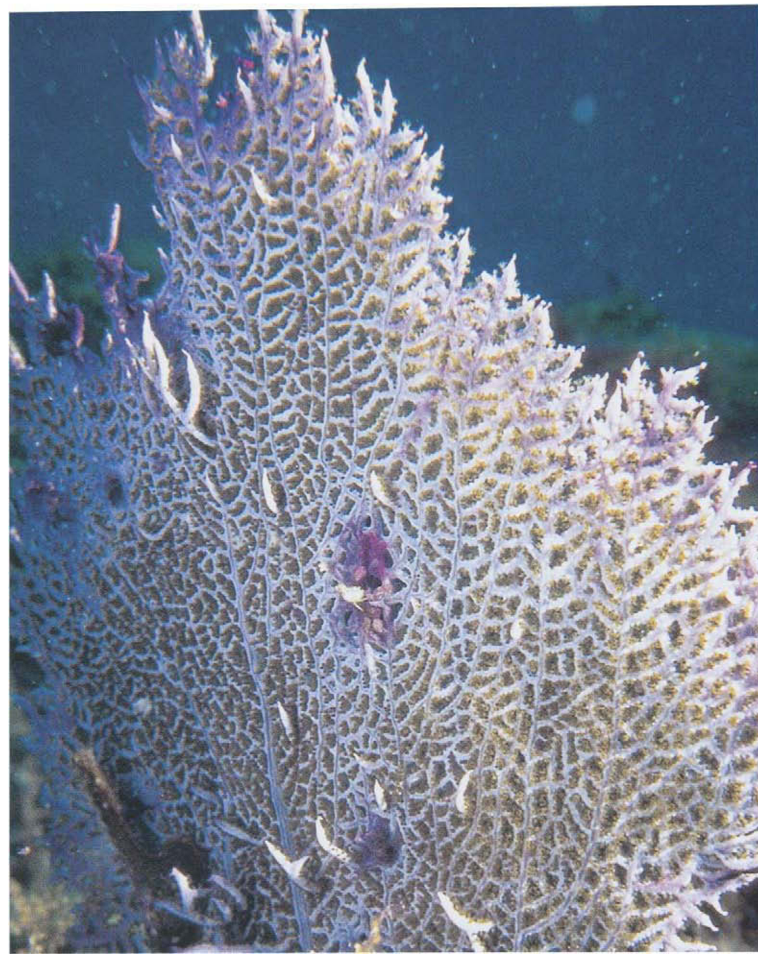
Federal officials responded with a major public works program–the Central and South Florida (C&SF) Project. It began in 1950 and took more than 20 years to complete. The C&SF Project is a large interlocked system of drainage canals, levees, pumps, water control gates, and water storage areas. The levees separated the Everglades from the urban eastern corridor to provide flood protection from Lake Okeechobee waters. As a by-product, the drainage canals and pumps allowed water tables in the area east of the levee to fall as much as 1.5 m, permitting suburban development to flourish (Light and Dineen 1994:58-76).

The intent of the C&SF Project was not just to tackle the flood threat, but also to secure an adequate water supply for both agricultural and urban users. Indeed, too little water was frequently as great a problem as too much. Drought years were not uncommon, bringing saltwater intrusion into local well fields and wildfires to the dry peat soils (USACE 1998:I-7).

To assure an ample water supply, C&SF Project engineers divided the central Everglades into three enormous tracts confined within perimeter dikes. These are the Water Conservation Areas. The Water Conservation Areas act as giant reservoirs to store water from the Kissimmee basin and Lake Okeechobee and serve as the principal recharge areas for the aquifer that supplies water to the urbanized eastern coastal strip.

A third major element of the C&SF Project was the creation of a special agricultural zone in the rich soils just south of Lake Okeechobee. The Everglades Agricultural Area, as it is called, converted about 20 percent of the original Everglades to intensive agriculture. Much of the 300,000 ha within the area is planted in sugarcane, making the sugar industry a significant economic force in the area (Light and Dineen 1994:60-66).

Providing Everglades National Park with sufficient water to keep it healthy was also on the list of project goals. In reality, this took a much lower priority than keeping human communities safe from floods and provided with water and became a sore point soon after the massive water project came on line. From the start, Everglades National Park supporters and conservationists were leery of the degree to which the C&SF plan would alter the natural water flow, but the fervor for flood control swept away their objections (Light et al. 1995:126-131).



Trade-Offs: An Ecosystem in Transition

Overall, the C&SF Project has brought huge social and economic benefits to the region. Since the Project began in 1950, urban expansion in the Miami–Palm Beach corridor has brought new neighborhoods and livelihoods along with an additional 4.5 million people (USACE 1998:V-12). In the process, it has fueled the robust expansion of the service industries and international trade sector that currently account for more than half of the South Florida economy (GCSSF 1995: Regional Overview p.2).

Agriculture, which is largely the product of wetlands drainage and flood control works, contributes at least $2 billion annually to local coffers–a small but politically significant part of the local culture and economy (SFERTF 1998a:9). South Florida counties lead the nation in production of sugarcane, oranges, grapefruit, and snap beans and produce a variety of other important winter vegetables and tropical fruits that cannot be grown elsewhere in the United States. Even the lodging and resort industry, which is vital to the area's $14 billion tourist economy (1995), relies on the water supply that the C&SF Project assures (SFERTF 1998a:9-10).

But changes in the water cycle and land-use patterns in South Florida have impaired the natural functioning of the ecosystem in a number of important ways, degrading the services that it has traditionally supplied and threatening to undermine the region's economy.

LOST WATER CAPACITY

The most fundamental physical change in the ecosystem is that it no longer has the capacity to store and release enough water to meet all the demands of the region's wildlife and human communities, particularly in dry years. Conversion of large tracts of Everglades and other marshes to farmlands and suburbs has reduced the sponge-like capacity of the watershed to retain water in the wet season and release it during the dry season. By some estimates, nearly half of South Florida's original complement of wetlands has been lost, with a concomitant loss of storage capacity (SFERTF 1998a:3).

LOST SOIL CAPACITY

Draining and lowering the water tables over much of the watershed has caused widespread land subsidence and serious soil loss in many areas, threatening the future of the region's agriculture. In some parts of the Everglades Agricultural Area, topsoil loss from drying and oxidation of the peat soils exceeds 2 m–a loss of nearly half the original depth (Davis 1998). Topsoil loss has already brought a few fields perilously close to retirement and has convinced some observers that the area's future for agriculture is limited to only a few more decades (Snyder and Davidson 1994:107-108; Davis 1998).

LOST WATER QUALITY

Runoff from farm fields and urban areas has contaminated the water cycle with pollutants, lowering water quality throughout the region. Phosphorus contamination is the

(continues on p. 170)

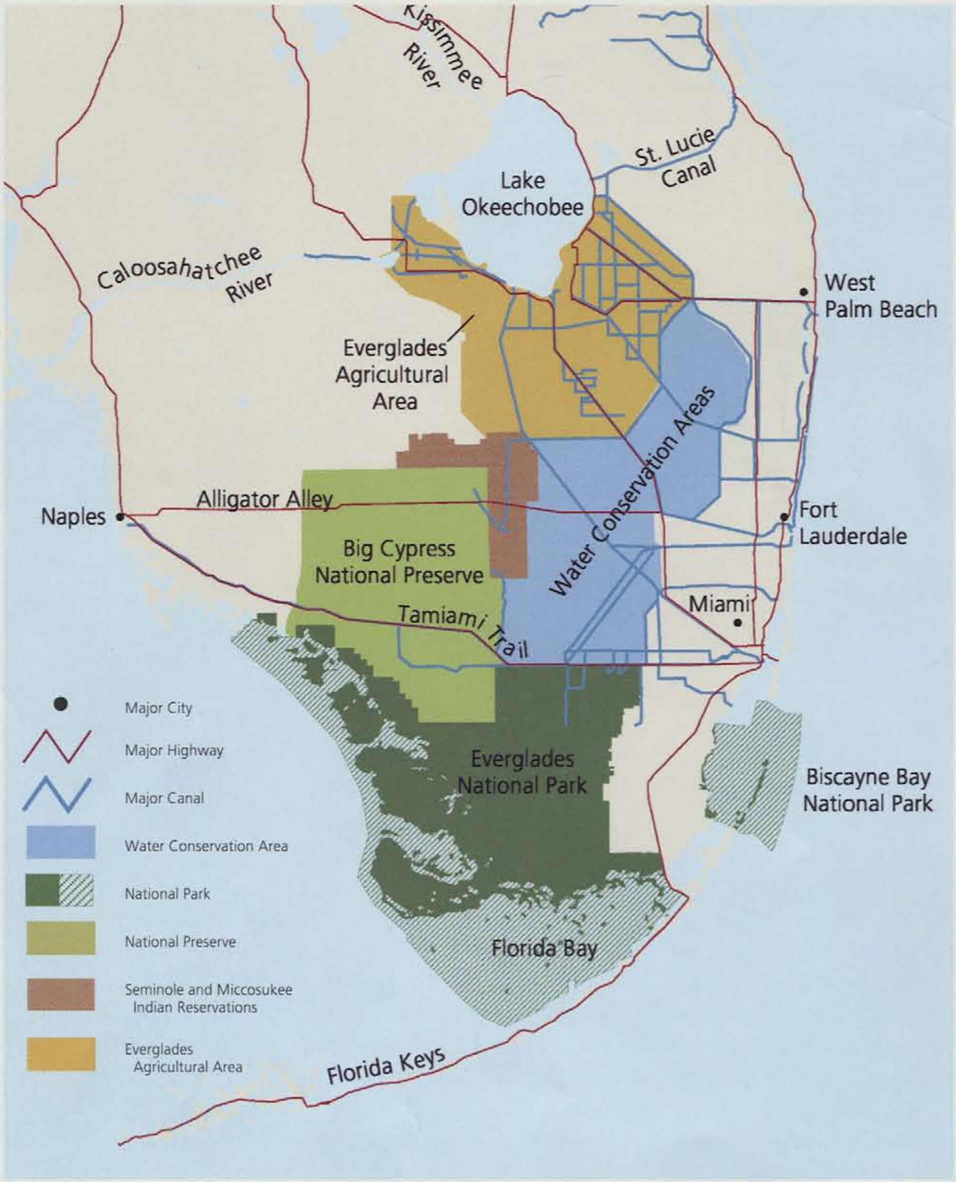
Box 3.5 The South Florida Ecosystem

The South Florida ecosystem occupies a single large watershed—the Kissimmee-Okeechobee-Everglades watershed—that covers roughly the lower third of the state and its coastal waters, an area approximately 23,000 km^2 (McPherson and Halley 1996:16). Within this enormous region are several distinct environments, including freshwater marshes, wet prairies, cypress swamps, and pine forests in the interior; coastal prairies, beaches, and mangrove forests fringing the coasts; and coral reefs and seagrass beds in the warm waters of Florida and Biscayne Bays and the Straits of Florida.

Water flow across the region and into the coastal waters is the dynamic thread that weaves these communities into a single larger system—an interconnected tapestry of wetlands, uplands, and coastal and marine areas (USACE 1998:II–2).

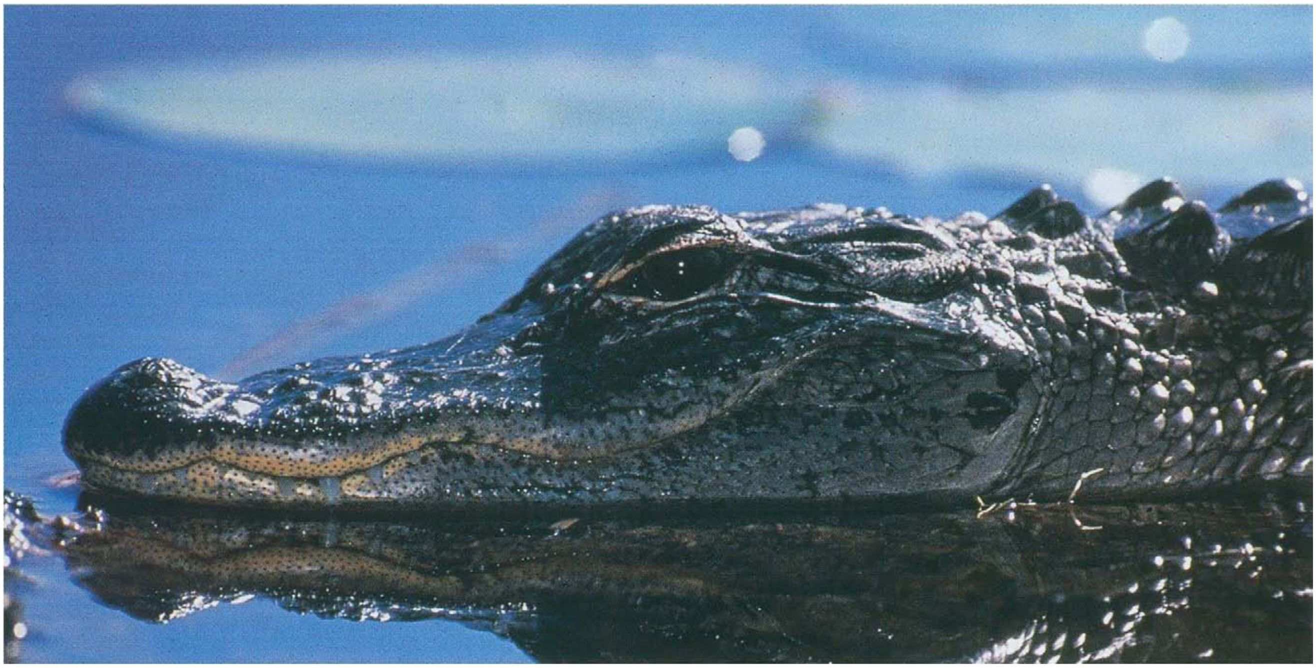
At the center of the ecosystem are the Everglades, which originally stretched in a 11,650 km^2 swath from Lake Okeechobee to Florida Bay (McPherson and Halley 1996:16). Today, the Everglades have been nearly halved in extent, with Everglades National Park in the south preserving only a fifth of the native marshlands (USACE 1998:5–4).

The dynamics of the South Florida ecosystem were—and still are—driven by a seasonal cycle of flooding and drying. Most of the region's 100–165 cm of annual rainfall occurs from May through October and, under the natural regime, much of the land was flooded during this rainy season and gradually dried out during the late fall and winter (McPherson and Halley 1996:8). Natural water flow through the system is generally from north to south, but is very slow because of the flatness of the terrain. Water originating in the Kissimmee Basin in the north, where elevations are slightly higher, gradually flowed south through wetlands bordering the Kissimmee River and into Lake Okeechobee, which acted as a giant reservoir. Under high-water conditions during the wet season, the lake overflowed its southern banks, spilling water into the Everglades in a broad sheet just inches deep over much of the marsh. This sheet flow makes of the central Everglades a shallow, vegetation-covered river—a "river of grass," as the Everglades is frequently called. Because the slope is so gentle, with elevations falling just 6 m between Lake Okeechobee and Florida Bay, it takes the water flowing through the Everglades an average of 12 months to reach the coast (Jones 1999; USACE 1998:II–3).



Sources: Birbeck 1990; Davis and Ogden 1994; ESRI 1993; Florida Department of Environmental Protection 1996a, 1996b.


LandSat Image of South Florida Ecosystem, 1994
Urban area
Sugarcane
Sawgrass marsh and tree islands
Cypress swamp
Pine forest
Mangrove forest
Historic Everglades extent



most serious problem. The level of phosphorus in Lake Okeechobee and portions of the Everglades is now well above the natural tolerance of the ecosystem, throwing the biological community out of balance. For example, phosphorus levels have doubled in Lake Okeechobee in the last 20 years resulting from manure runoff from dairies and cattle ranches, causing repeated algal blooms and at least one significant fish kill in the 1980s (USACE 1998:III-21).

Phosphorus contamination of the Water Conservation Areas and Everglades National Park is just as worrisome as the situation in Lake Okeechobee, though the contamination comes from a slightly different source. Exposure of the peat soils in the Everglades Agricultural Area to air during cultivation naturally releases phosphorus as the soils oxidize. Phosphorus-enriched irrigation water pumped out of the Everglades Agricultural Area has already allowed cattails–which thrive under high-phosphorus conditions–to begin to displace the usually dominant sawgrass vegetation in some portions of the Water Conservation Areas. Scientists worry that too much phosphorus may next change the balance of plant and animal life in Everglades National Park (Armentano 1998; SFWMD 1998b:3-6).

LOST BIOLOGICAL DIVERSITY

Populations of many species of wildlife and fishes have dramatically declined as their food sources and nesting or spawning sites have degraded or disappeared. Disrupting the water cycle has also altered the seasonal pattern of flooding and drying on which the life cycles of many Everglades species depend. Sixty-eight species in the South Florida ecosystem are now listed by the U.S. Fish and Wildlife Service as endangered or threatened with extinction (SFERTF 1998a:3).

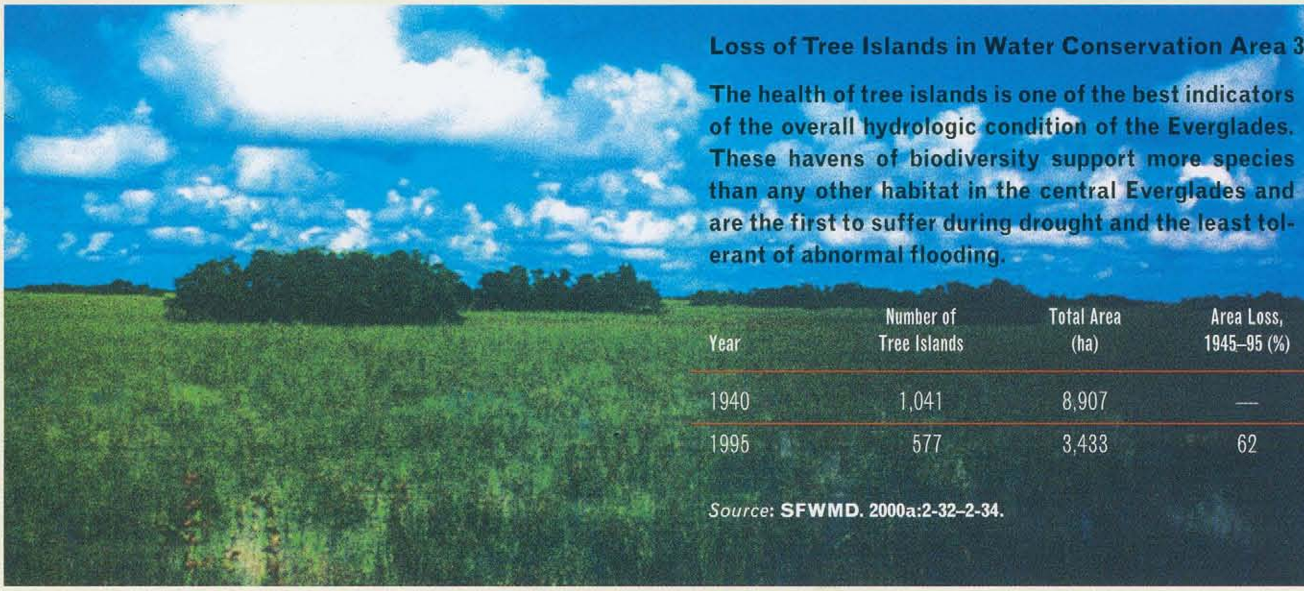
Populations of wading birds, including herons, egrets, storks, and spoonbills, have been particularly hard hit. Scientists estimate that in 1870, some 2 million wading birds crowded the marshes and estuaries of South Florida. By the 1970s that number had dropped to a few hundred thousand–about 10 percent of their historical level. The decline continues today (De Golia 1997:45).

The loss of biological diversity in the area is disturbing both from a conservation and an economic standpoint. Conservationists worldwide have recognized South Florida, and specifically Everglades National Park, for its biological richness. The Park is one of only three sites in the world to be designated a World Heritage Site, an International Biosphere Reserve, and a Ramsar Wetland of International Importance. The Park is also an important tourist destination, attracting 1 million visitors annually. If current patterns of damage continue in the Park, area officials have warned that the economic impact could be substantial. A government study calculated that if the recent declines in the health of Florida Bay at the southern end of the Park continue, economic losses could mount to more than $250 million/year in lost tourist dollars and reduced commercial catches of shrimp, lobster, snapper, and grouper (GCSSF 1995:Introduction p.2).

LOST NATIVE SPECIES

Exotic plant and animal species have invaded more than 3.7 Mha in South Florida and threaten to displace many of the native species, especially in Everglades National Park (SFERTF 1998a:3). Changes in the natural water cycle have fostered the spread of invasives such as *Melaleuca*, Brazilian pepper, and old world climbing fern, all of which thrive in dryer conditions (SFWMD 1998b:7). The system of canals,

Box 3.6 Indicators of Everglades Decline

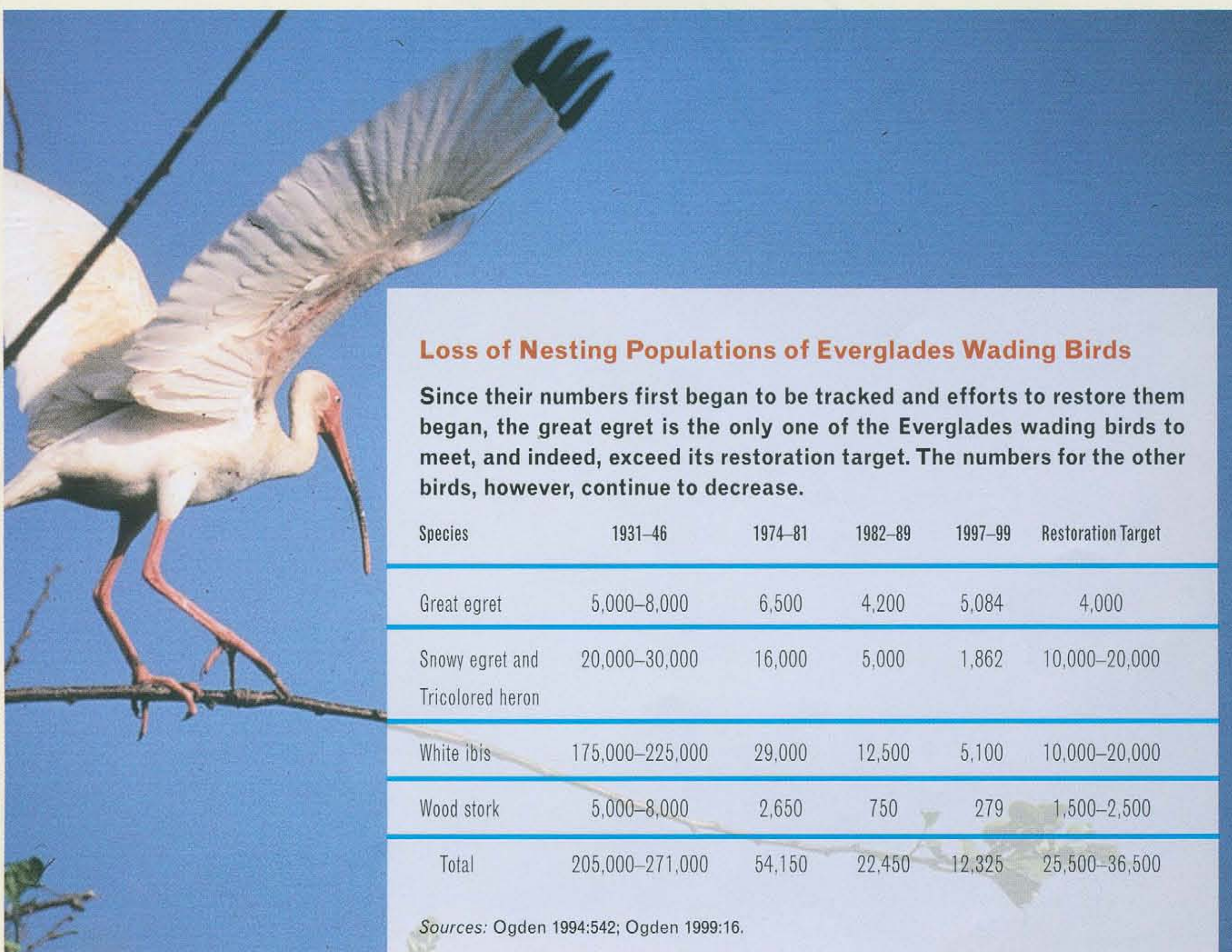


Loss of Tree Islands in Water Conservation Area 3

The health of tree islands is one of the best indicators of the overall hydrologic condition of the Everglades. These havens of biodiversity support more species than any other habitat in the central Everglades and are the first to suffer during drought and the least tolerant of abnormal flooding.

Year	Number of Tree Islands	Total Area (ha)	Area Loss, 1945–95 (%)
1940	1,041	8,907	—
1995	577	3,433	62

Source: **SFWMD. 2000a:2-32–2-34.**



Loss of Nesting Populations of Everglades Wading Birds

Since their numbers first began to be tracked and efforts to restore them began, the great egret is the only one of the Everglades wading birds to meet, and indeed, exceed its restoration target. The numbers for the other birds, however, continue to decrease.

Species	1931–46	1974–81	1982–89	1997–99	Restoration Target
Great egret	5,000–8,000	6,500	4,200	5,084	4,000
Snowy egret and Tricolored heron	20,000–30,000	16,000	5,000	1,862	10,000–20,000
White ibis	175,000–225,000	29,000	12,500	5,100	10,000–20,000
Wood stork	5,000–8,000	2,650	750	279	1,500–2,500
Total	205,000–271,000	54,150	22,450	12,325	25,500–36,500

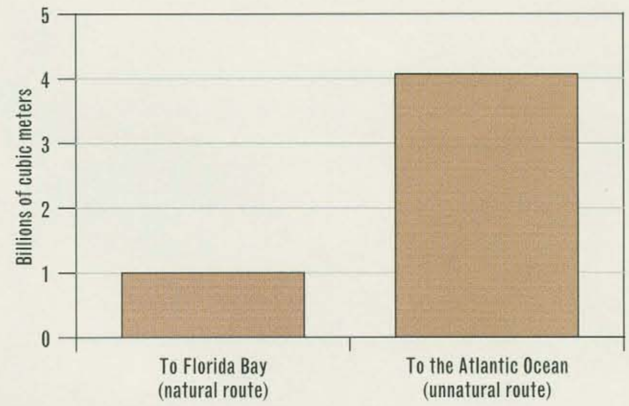
Sources: Ogden 1994:542; Ogden 1999:16.

Box 3.7 Restoration Means More Water and Clean Water

Currently, the C&SF project diverts much of the Everglades natural water flow for flood control. To prevent flooding, 3–4 times more water is released directly to the Atlantic Ocean than makes its way through the Everglades to Florida Bay. Water released to the Atlantic is lost for use by humans and wildlife. Restoration plans involve capturing some of this lost flow.

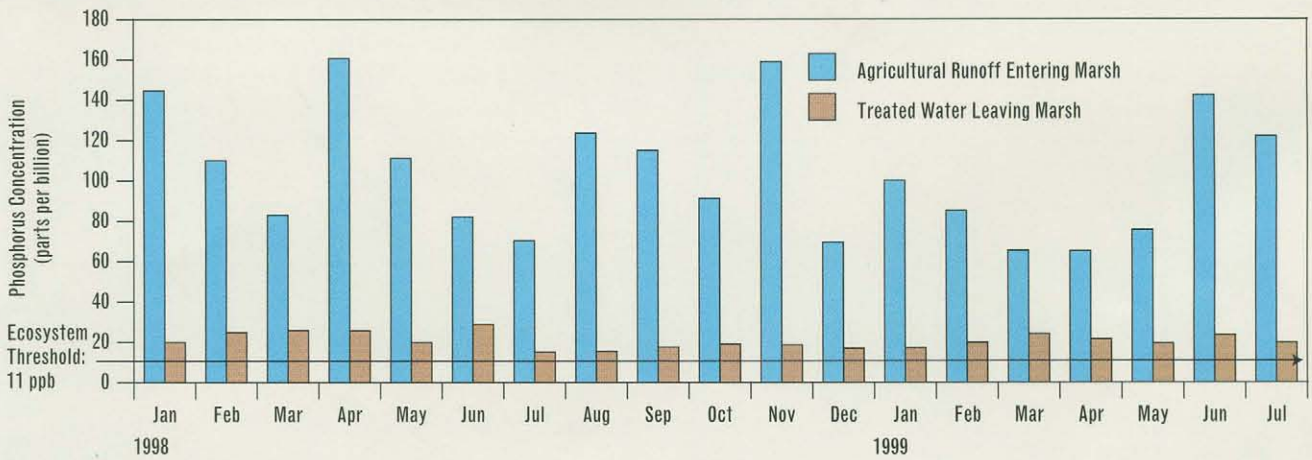
Restoration will also involve a major effort to remove phosphorus pollution from agricultural runoff by filtering it through 16,000 ha of artificial wetlands before releasing it into the Everglades. Filtering marshes reliably reduce phosphorus to 20 parts per billion (ppb) or less. Unfortunately, scientists believe that the ecosystem threshold where phosphorus begins to affect Everglades marshes is about 11 ppb, meaning an additional filtering step will be needed.

Discharge of Rainfall in the Everglades Region, 1980–89



Source: Light and Dineen 1994:82.

Everglades Nutrient Removal Project



Source: SFWMD 2000b.

which provides unnatural routes into natural areas, has also been an important pathway for the spread of invasives such as the water hyacinth and the Asian swamp eel–a relatively new introduction whose voracious appetite may threaten native fishes (Armentano 1998; SFWMD 1998a:24).

A Change in Attitudes

The decline of key features of the ecosystem took time to be noticed, and even when environmental damage was obvious, a consensus on how to tackle the problem took years to evolve. But several key events and crises moved the process forward. As always, water–or lack of it–took center stage in convincing people that the alterations they had made in the natural system were anything but perfect.

From 1963 to 1965, C&SF water managers prevented water from flowing south into Everglades National Park in order to fill the newly constructed Water Conservation Areas. Drought conditions during those years meant the Park was water starved. Breeding colonies of ibis and egrets failed to form in their traditional spots for three consecutive years. Television cameras brought the Park's plight to a national audience and drove home the point that water conflicts were likely to become more common as water demand in the rapidly urbanizing area grew. The U.S. Congress subsequently ordered water managers to deliver adequate water to the Park, but the fight over how much was "adequate" would consume many more years and eventually direct the design of the restoration plan (Light et al. 1995:127, 129).

In 1970 drought struck again. The water shortages that plagued South Florida were so intense that state politicians took action, passing landmark legislation that mandated a regionwide approach to water management (Light et al. 1995:133). Governor Robert Graham launched the Save Our Everglades program in 1983–the first attempt to address the problems of the ecosystem at a regional scale, and the first public initiative to set out the goal of restoring the components of the ecosystem to something approaching their natural state (Light et al. 1995:142).

Rather than start to improve, conditions throughout the ecosystem continued to decline. In 1988, an ecological clarion call heralded the ecosystem's precarious health. Florida Bay is a shallow, tropical estuary at the southern tip of the Florida peninsula; a rapid die-off of seagrasses and a striking decline in water clarity occurred and continued for several years. Large, sustained algal blooms began to plague the waterway and commercial and sport fishing catches suffered (Armentano 1998; USACE 1998:III-23).

At about the same time, Dexter Lehtinen, a brash U.S. government attorney, filed suit against the regional water authority, the South Florida Water Management District, for releasing water polluted with agricultural runoff into the Everglades. The U.S. government suit–based on the water district's own studies–claimed that excess phosphorus from the Everglades Agricultural Area was threatening Everglades National Park and nearby Loxahatchie National Wildlife Refuge. The immediate intent of the suit was to force the District to require farmers to clean up their effluent before releasing it. But the larger effect of the suit was to highlight the inherent contradictions in the District's traditional service to the local agricultural community–to provide irrigation water and take away runoff–and its responsibility to provide clean water to Everglades National Park (Aumen 1998; Light et al. 1995:144-146).

At first the District fought the lawsuit; but in 1991, newly elected Governor Lawton Chiles directed the agency to admit that there was, indeed, a problem and begin to collaborate with federal authorities rather than continue to waste resources fighting the lawsuit. This began a process of redefining the Water District's mission to include stewardship of the South Florida ecosystem. The District eventually became a key promoter of the idea of ecosystem restoration (Aumen 1998).

In 1993, the federal government formed the South Florida Ecosystem Restoration Task Force, which has become a central player in developing a coherent restoration plan for the entire ecosystem. The Task Force has acted as the convening body to bring together all the parties with a legal interest in the restoration–a list that includes 10 federal and state agencies, several local county governments, the Miccosukee and Seminole Indian Tribes, and the South Florida Water Management District. Agribusiness interests, environmental groups, and sport and recreation groups also participate in the public hearings where decisions on restoration matters are made (SFERTF 1998a:7).

Just as significant, the state in 1994 created the Governor's Commission for a Sustainable South Florida, which has bluntly asserted that the problems with the South Florida ecosystem are intimately connected with the larger regional patterns of land and resource use and economic expansion. Without tackling these patterns, the Commission warns, restoration activities will not be effective in the long run (GCSSF 1995:Executive Summary p.1).

Restoring the Flow, Revitalizing the Ecosystem

What does restoring the South Florida ecosystem really mean? A decade of scientific study, debate, and negotiation has led to a broad consensus on what needs to be fixed and where to begin. Current plans already include 200 projects that restore habitat, manage urban growth, realign farming practices, and reconfigure the C&SF Project's water-control structures.

Three broad goals are behind these projects (SFERTF 1998a:1, 8-10):

- Restore the area's natural hydrological patterns as much as possible; the shorthand term for this is "getting the water right."
- Increase the health and extent of wildlife habitat so that depleted species can recover.
- Relieve pressure on the ecosystem by taming suburban growth and encouraging an economy that balances the needs of humans and the biological limits of the natural system.

GETTING THE WATER RIGHT

The first goal–restoring a more natural hydrological pattern–is the foundation on which all other aspects of ecosystem recovery are built. It forms the focus of the US$7.8 billion plan put forward in 1998 by the U.S. Army Corps of Engineers to revamp the C&SF Project. The basic strategy of this ambitious plan is to increase the capacity for storing water within the watershed. This will allow water managers to quit venting so much water directly to coastal estuaries from Lake Okeechobee during high water times and make it possible to direct water flows into the Everglades at the most appropriate times and in more sufficient quantities. It will also increase the water available for urban water supply and agriculture (SFERTF 1998a:8; USACE 1998:I-ix).

Computer models of the region's water flow predict that as population and industry continue to grow over the next 30 years, water shortages could occur, on average, every other year in most of the region's urban areas if the system is not reconfigured to store more water (USACE 1998:iv). This would strike hard at the area's economic stability and quality of life, and pit urban water users against farmers and both of these against the environment. Currently more than three times as much water is discharged directly to the coast than is allowed to continue its natural flow pattern through Everglades National Park and into Florida Bay (McPherson and Halley 1996:39). This water is essentially wasted for environmental and human purposes.

To create more storage in the system, the restoration plan calls for a combination of (a) new surface reservoirs, some created from existing rock quarries; (b) marshes; and (c) the use of an innovative technique of pumping water down wells into a shallow aquifer in the wet season for temporary storage and recovery during the dry season. These three elements will be combined into an interconnected system along the eastern flank of the Everglades that will also serve as a buffer against the encroachment of suburbs (USACE 1998:v-vi). In the Everglades Agricultural Area, converted cropland will also act as surface reservoirs. To implement this strategy, federal and state officials in 1999 bought a 259-km^2 tract of sugarcane fields that will be retired from production and eventually receive overflow flood waters (McClure 1999b). Elsewhere, advanced wastewater treatment plants will allow water managers to reuse wastewater to recharge coastal aquifers.

Restoration plans will also require that farmers discharge cleaner water into the Everglades. The legal settlement of the 1988 federal lawsuit against the water district directs farmers to use cultivation practices that reduce the phosphorus they release into their drainage water. At the same time, farmers in the Everglades Agricultural Area must pay one-third of the cost of constructing some 16,000 ha of special phosphorus-scrubbing marshes–the largest constructed wetlands in the world–through which they will send their drainage water before it goes into the Everglades. Ultimately, farmers will have to extract even more of the remaining phosphorus from their effluent in order to meet new water quality restrictions due to take effect in 2003. Researchers still haven't decided how this can be done at a reasonable cost (Aumen 1998).

Removing barriers to the sheetflow of water through the Water Conservation Areas and into Everglades National Park is also an essential part of restoring a more traditional hydrological pattern in the region. Current plans call for removing approximately 800 km of canals and levees within the Water Conservation Areas and revamping a portion of a major road that cuts through the Everglades; gates and culverts are to be installed along the road to restore the sheetflow interrupted by the road since its completion in 1928 (USACE 1998:vi).

RECOVERY OF WILDLIFE

Reconfiguring the C&SF Project to restore a more natural hydrological cycle should help with the second major restoration goal–improving habitat quality and recovering wildlife populations. The original system was huge and hydrologically interconnected. Animals could typically find appropriate food supply and breeding grounds somewhere within the system under a range of natural conditions. Draining and diking the watershed broke up the system's connectivity and disrupted the ability of many animals to find suitable habitats timed to their life cycle (USACE 1998:vii-viii).

By removing internal levees and allowing the delivery of more water, more appropriately timed and directed, water managers hope to recreate many conditions that favored wildlife. They anticipate that species at every level of the food chain–from small minnows and crayfish to alligators, herons, and otters–will start to recover their original population density and distribution. Water district biologists have particular hopes that wading bird populations will rebound; these birds are perhaps most sensitive to the habitat conditions over the entire watershed (USACE 1998:vi-ix).

But just how much and how fast the living elements of the ecosystem will recover is still very much in question. Scientists have drawn up biological criteria to judge whether the system is truly recovering; but there is still controversy and concern over what to expect, especially given its high price tag. Some critics feel that the recovery plan will not recreate the original hydrological pattern sufficiently to allow large-scale recovery and will yield far smaller benefits to wildlife than advertised (McClure 1999a; Santaniello 1998; Santaniello 1999; Stevens 1999). Even government biologists are cautious. They have labored hard to draw up an integrated strategy to ensure that the restoration plan benefits as many of the area's endangered species as possible, but do not expect all of the beleaguered species to survive.

CURBING DEVELOPMENT

Modifying development and economic activities in the Miami urban corridor so that they are less environmentally destructive is probably the most challenging of all restoration goals. Biologists and water planners know that without progress on this front, their efforts to restore the South Florida ecosystem will eventually be drowned in the flood of new development still surging into the Miami urban corridor. Each year, some 29,000 people relocate to the area to take advantage of the climate, natural beauty, and expanding economy (SFERTF 1998b:iii). By 2010, officials expect the region's population to expand to 8 million; by 2050, some forecasters think the population could nearly triple to more than 15 million (GCSSF 1995:Regional Overview p.1).

Plans to manage this expected influx include a number of steps to curb the proliferation of urban sprawl. A regional program called "Eastward Ho!" is encouraging local governments to establish urban development boundaries and to redirect new growth back into already developed areas by building on unused urban parcels, redeveloping run-down sites, and cleaning up brownfields. Modifying building regulations to require higher housing density in new suburban developments is a second essential step that restoration advocates are pressing on area governments. Upgrading the area's transportation system so that it encourages denser, less automobile-dependent development is also considered an important part of the overall effort to reduce the impact of future growth.

None of these steps will be easy; they involve land-use decisions by a large number of local governments whose land-use plans currently lack much regional coordination and are subject to intense local political pressure (GCSSF 1995:Executive Summary pp.1-7).

Beyond the Everglades

It is impossible to know yet whether the effort to rejuvenate the South Florida ecosystem will ultimately succeed. On one level, the Everglades restoration effort has made an impressive start and boasts a list of accomplishments and advantages that paint a hopeful picture: it enjoys widespread popular and political support that comes from a basic understanding of the current state of the system, its vulnerability to further decline, and an acceptance of the tenet that some minimum of ecosystem health is required to support the local economy and the quality of life that people enjoy. That alone is a tremendous step forward. But the difficulty of actually bringing back healthy populations of wading birds, returning full productivity to Florida Bay, or recovering even one of the 68 endangered species whose survival hangs in the balance cannot be underestimated.

Yet regardless of the outcome, the Everglades effort has already offered many lessons. First, it shows how vulnerable ecosystems are to single-purpose management, especially when managers are ignorant of the basic workings of the ecosystem. Without knowledge of how changes in area hydrology were likely to affect the South Florida ecosystem, it was impossible for the Army Corps of Engineers to foresee the trade-offs they were making when they built the C&SF Project. And even if they had had such knowledge, it was probably outside their mandate to act on it, given their primary goals of flood control and improved water supply.

The Everglades experience also provides a thoroughly convincing economic argument for taking care to not degrade a critical ecosystem in the first place. The $7.8 billion price tag for what is just the first stage of the overall restoration effort leaves no doubt that large-scale ecosystem restoration requires a huge investment–often many times the expense of altering the system in the first place. Still, this may be inexpensive compared to the benefits that will be lost if the ecosystem continues to degrade or fails completely. The tourist trade alone is worth $14 billion annually to the South Florida economy and the ecosystem's health is directly tied to that industry's overall success.

Perhaps the most important lesson is that the idea of ecosystem restoration is extremely compelling. The public's and politicians' acceptance of a restoration program of such magnitude and expense shows that a well-articulated vision of a restored ecosystem can be a potent force for consensus and change. At the same time, the Everglades experience leaves no doubt that following through on this vision requires patience and commitment. It takes time to learn how and why an ecosystem is failing and how to put it right again; time to negotiate the inevitable controversies about how best to spend the precious dollars available to attain maximum recovery. Efforts to restore the Everglades have taken nearly 3 decades to mature to their present state, and it will undoubtedly require much longer than 3 more decades for the Everglades to heal.

Ultimately, even attaining some level of ecosystem recovery will not be enough. Keeping the restored ecosystem from failing again will be the ultimate test and will require making good on the much more ambitious vision of a regional economy that does not, through its impacts, smother the renewed life so carefully nurtured.

Managing Mankòtè Mangrove

Some people call mangroves "the roots of the sea." Mangroves are gnarled, salt-tolerant trees that grow in intertidal zones and estuaries where the ocean, land, and freshwater meet; they cling to the loose soils, sands, and muds with a maze of roots that can withstand waves and erosion. These unique, adaptable plants, of which there are about 60 species, are found along the majority of the world's subtropical and tropical coastlines.

Some coastal residents might also call mangroves "the roots of their community." The forests, swamps, and wetlands where mangroves thrive are ecosystems of great biodiversity and productivity. Coastal residents use mangroves for fuel, construction materials, food, medicines, and tannins. For fishers the mangroves' networks of roots provide breeding grounds for many kinds of sea life. The leaves, small branches, propagules, and fruit that fall from the trees contribute to production of detritus that supply the fish and other wildlife with an abundant food supply. Mangroves are also prime nesting and migratory sites for hundreds of bird species. By serving as a buffer along the coastline, mangrove forests protect coastal areas, crops, and towns from flooding during storms, shelter fishers' boats, and protect coral reefs from suspended solids. Plus, mangroves control sedimentation and coastal erosion.

But a mangrove's natural resilience and value affords it little protection against a growing number of anthropogenic threats, as communities and institutions on St. Lucia's southeast coast came to understand in the 1980s. That realization inspired an innovative program to enable local residents to reap the benefits of Mankòtè, St. Lucia's largest mangrove forest, without degrading its ecosystem services and long-term viability.

Changing Community Practices

Mankòtè was part of a U.S. military base during World War II. When the base closed and the area became public land in 1960, the 63-ha mangrove–20 percent of the total mangrove area of the country–was still covered with well-developed trees (Geoghegan and Smith 1998:1). As an open-access resource, it was soon subjected to varied and often destructive uses ranging from seasonal fishing, bird hunting, and crab catching to waste dumping and spraying of pesticides for mosquito eradication (Smith and Berkes 1993:123–124).

The greatest stress on the mangrove, however, was the extensive tree cutting by local citizens for commercial charcoal production. By the early 1980s, charcoal production had become a major source of subsistence income and an important cottage industry. The use of mangrove wood for charcoal is popular because it is cheap relative to petroleum-based fuels, can be easily transported, and is slow burning. Mankòtè became the main supply of charcoal for about 15,000 residents of Vieux Fort, a nearby community, and others in the southeast portion of the island. Although no data are available, older residents of the area observed that during those years, smaller trees in the mangrove were being harvested and large trees were becoming scarce (Smith 2000).

At about the same time, a regional NGO, the Caribbean Natural Resources Institute (CANARI), identified the Mankòtè mangrove as a priority area for conservation. CANARI soon realized that the charcoal producers themselves were key to Mankòtè's protection. Although charcoal producers' harvests were putting pressure on Mankòtè, they practiced a number of sound management measures. For example, they cut on a rotational basis, allowing time for the trees to regenerate before recutting, and left uncut the species of mangroves that make poor charcoal but provide cover to impede the evaporation of the swamp.

CANARI proposed a management strategy that was innovative and controversial for its time. They advocated that the mangrove be managed in collaboration with the harvesters–a landless, poor group with no legal right to the resource, but also the people most dependent on the mangrove and most damaging to it. With the government's tacit approval, CANARI launched what has become an ongoing effort to test ways to save the mangrove and maintain the charcoal producers' incomes (Geoghegan and Smith 1998:4, 7).

Among CANARI's key steps was to organize the harvesters into an informal cooperative of about 15 people; the cooperative is called the Aupicon Charcoal and Agricultural Produc-

The woodlot, as originally conceived, was to be managed by and benefit the group as a whole. Members would be organized for harvests and other activities. Similarly, pole production in the mangrove was meant to be a group activity. However, it has proven easier for people to continue using the mangrove and the woodlot without strict coordination of activities. Extractions are made by individuals or small teams and recorded each month.

ers Group (ACAPG). CANARI works with the group to monitor and track trends in charcoal production and the status of the mangroves. ACAPG committed to a set of sustainable harvesting practices, including a ban on cutting trees that line waterways, preservation of large trees, and cutting on a slant to preserve the tree's stump.

To reduce pressures on the mangrove, government agencies, local NGOs, and the harvesters sought to create a new wood supply for charcoal production. Between 1983 and 1985, the Department of Forest and Lands planted a 62-ha woodlot close to Mankòtè with fast-growing hardwoods, mainly *Leucaena*, and with a palm species that ACAPG members can harvest to make brooms. The government also loaned the producers a large plot of land and encouraged the producers to plant it with marketable products.

There have been significant communal harvests of plantation wood recently, although initial efforts in plantation and agricultural endeavors were plagued with problems, from fires to the charcoal producers' inexperience with agriculture, marketing, and working together. The woodlot is still far from a replacement for mangroves, but management strategies and income-diversifying opportunities continue to evolve. For example, in 1993 the harvesters began leading tourists and school groups on tours of the mangrove as an income-generating opportunity. Local NGOs have provided guide training; technical assistance grants to build interpretive signs, a boardwalk, and a viewing tower; and assisted with tour promotion and organization (Smith 2000; Brown 1996).

To limit outside threats to the mangrove, local institutions successfully protested the Department of Health's mosquito eradication program that was damaging the mangrove's fauna and hydrological functions, and secured the designation of Mankòtè as a marine reserve in 1986. That designation affords the mangrove complete protection from any extractive use without written permission of the Chief Fisheries Officer, ending years of illegal waste dumping. The charcoal producers have sole rights of use of timber resources (Smith 1999).

Like most participatory approaches to ecosystem management, the Mankòtè strategy has taken more than a decade to achieve many of its objectives. By the 1980s, the overall trend of degradation of the tree cover had been reversed. Monitoring four species of trees in each of four transects between 1986 and 1992 showed a significant increase in the number of mangrove stems larger than 25 mm/m^2–from 0.10 to almost 2 (Smith and Berkes 1993:126-127). The basal area, or total area of stems, increased fourfold. Because 1991 was a year of particularly high charcoal production, the increased regeneration of mangroves noted in the 1992 survey is especially noteworthy. Field observations and interviews indicate that preservation methods are still used rather than clear-cutting (Smith and Berkes 1993:126-127). Although the data are still limited, research in the last several years suggests that density and size of trees have continued to increase, while charcoal production has averaged 2 tons/month in early 2000, slightly less than the average in the past 15 years (Smith 2000).

Mankòtè's future is still uncertain. An economic downturn in St. Lucia could bring new pressures to the mangrove. The government continuously receives proposals for the development of the mangrove and surrounding land; fortunately, key agencies are concerned about identifying what kind of development would be possible without encroaching on the mangrove and its functions. Research is under way to ascertain other potentially significant pressures on the mangrove, including the impacts of crab hunting and fishing, and to test the effectiveness of some silviculture practices in the mangrove, with the hope of improving yields from regeneration. Nevertheless, there is agreement among all parties that the informal, collaborative arrangement at Mankòtè currently provides greater protection to the mangrove than any government agency or other institution can do on its own. The arrangement has also allowed rural families to continue to reap economic benefits.

Bolinao Rallies Around Its Reef

With its cascading waterfalls, rolling hills, white beaches, and spectacular sunsets, Bolinao has been called nature's masterpiece. But the most valuable asset in this northern Philippines municipality may be its 200 km^2 of coral reefs. About one-third of Bolinao's 30 villages and 50,000 people depend on fishing to make a living (McManus et al. 1992:43), and the Bolinao-Anda coral reef complex serves as the spawning ground for 90 percent of Bolinao's fish catch. More than 350 species of vertebrates, invertebrates, and plants are harvested from the reef and appear in Bolinao's markets each year (Maragos et al. 1996:89).

Imagine, then, the dismay among local residents, marine researchers, and NGOs who learned in 1993 that an international consortium intended to build what was claimed to be the world's largest cement factory right on Bolinao's coral reef-covered shoreline. The cement industry ranks among the three biggest polluters in the Philippines (Surbano 1998), and the plans for the Bolinao complex included a quarry, power plant, and wharf. It can take 3,500 pounds of raw materials to produce 1 ton of finished cement; pollutants commonly emitted from this energy-intensive industry include carbon dioxide, sulphur dioxide, nitrous oxide, and dust–about 360 pounds of particulates per ton of cement produced. Another by-product is highly alkaline water that is toxic to fish and other aquatic life (Environmental Building News 1993).

The ensuing debate over the plant's construction brought a new urgency and focus to local efforts to ensure the long-term viability of Bolinao's coastal resources. Pitted against a politically and economically powerful business consortium, residents successfully challenged the idea that a cement plant's short-term economic benefits would offset the risk of long-term ecosystem ruin. That outcome is an unusual and significant achievement, particularly in developing countries, where citizen advocacy and broad-based participation in natural resource management is likely to face daunting obstacles, including limited access to both environmental information and the political process.

Bolinao's Threatened Marine Ecosystem

Bolinao's environmental fragility had been recognized, in some quarters, long before a Taiwanese business group called Tuntex announced its plans to build a mammoth cement complex. A 1986 study by the Marine Science Institute at the University of the Philippines, for example, documented significant damage to Bolinao's coral reef system. Researchers found that about 60 percent of the region's corals had been killed, mostly through destructive fishing practices that relied on dynamite and cyanide to enhance catches (McManus et al. 1992:44). In 1992, Bolinao's once-booming sea urchin industry was shut down indefinitely after the urchins had been exploited nearly to extinction to satisfy export demand for roe (Talaue-McManus and Kesner 1995:229). Fishers, fish vendors, and shell craftspeople had noted diminished catches, changes in dominant species, and decreases in the size of mature fish.

But it took the possibility that a cement factory would cause further deterioration of the area's marine resources to galvanize widespread action on behalf of the ecosystem. "We launched a vigorous education campaign focused on the cement plant's potential environmental impacts," explains Liana Talaue-McManus, a researcher from the Marine Science Institute (Talaue-McManus 1999). For many, this was the first time that they fully understood the extent and richness of their community's natural resources, as well as its vulnerability.

The plant complex would be located in the middle of the reef system, within 3 km of the municipal center. This was an ideal spot from investors' perspectives, given its abundance of limestone, the deep channel for marine transport, and Bolinao's proximity to Taiwan. Investors argued that the cement production complex would not cause any pollution, but local residents soon began to suspect otherwise.

With support from the University of Philippine's researchers, a local NGO–the Movement of Bolinao Concerned Citizens–challenged the Tuntex consortium. They played a critical role in the 2-year struggle against the cement

plant, rallying opposition and raising awareness of the complex's potential impacts. Those impacts, as their research revealed, could include air pollution, erosion from the quarrying of limestone, damage to the reefs from the widening of the shipping channel, oil pollution from shipping, and the threat to their limited freshwater supply.

Their efforts were rewarded. In August 1996, the Philippines Department of Environment and Natural Resources (DENR) denied "with finality" the application for an environmental permit, citing the unacceptable environmental risks the cement plant would pose to aquatic life and coral reefs, and the conflicts that would arise with existing land and marine uses (Ramos 1996).

Crafting a Long-Term Management Plan

The hard work of ecosystem protection didn't end with the cement plant fight. In fact, for Bolinao residents and NGOs, the toughest part of ecosystem management was ahead. Local NGOs are still working toward a larger goal: developing a coastal resource management plan that empowers fishers and other community members to participate in long-term decisions about the management and health of their resources.

Consensus on how to conserve and protect the marine areas has long been elusive. Since the early 1990s, a coastal planning team composed of representatives from the Haribon Foundation and from the Marine Science Institute and College of Social Work and Development (both at the University of the Philippines) sought to mobilize Bolinao's villages on behalf of marine protection. But many issues polarized the community:

- Most of Bolinao's fish harvesters are poor, with the reefs serving as their sole source of food and income. As farmlands deteriorated, many farmers migrated to reef areas, exacerbating competition for marine resources. Increased population in the coastal areas increased the amount of organic pollution; the pollution, in turn, reduced the resilience of Bolinao's coral reef ecosystems. Because of poverty, resource depletion, tradition, and lax enforcement of bans, fishing methods known to be destructive were sometimes still used.

- The town leadership lacked adequate information about the marine ecosystem and needed technical assistance to make sound resource decisions.

- Access to milkfish fry and siganid fishing in Bolinao was governed by an inequitable but ingrained system. Those who won concessions from the local government–through a sometimes corrupt bidding process–garnered exclusive privileges to fish in an area. Subsistence fishers were banned from the area or forced to sell their catch to the concession holders at below-market prices. The result was illegal fishing and minimal incentive to regulate the harvest, but significant income for the local government.

- One survey found that the number of aquaculture pens in the Caquiputan Channel between the Bolinao mainland and the islands of Santiago and Anda had increased from 330 in December 1996 to 3,100 in July 1997 (Talaue-McManus et al. 1999). Although they produced revenues for the town's political and economic elite, they reduced fishing grounds and navigation areas, causing water quality declines and fish kills.

- Resort owners wanted the shorefront left open and free of activity, while subsistence and deep sea fishers needed navigation and docking areas.

The challenge of finding a balance between these actors and between the different uses of the coastal resources made it all the more impressive when, in 1997, NGOs successfully crafted "a collective vision for the long-term viability of Bolinao's coastal living resources" (Talaue-McManus et al. 1999). This coastal development plan drew on more than 2 decades of scientific research by investigators from the Marine Science Institute and was drafted by 21 representatives of the municipal government, the religious sector, members of the fishing industry, ferryboat operators, and environmental advocates through community workshops and meetings.

The plan divides the municipal waters of Bolinao into four zones with different use designations–"reef fishing," "ecotourism," "multiple use" (which includes milkfish pens and fish cages), and "trade and navigation." One zone includes a marine protected area. The next steps were to determine exactly what activities were to be allowed or prohibited in each zone, to ensure that the marine protected area remains truly protected, and, of course, to implement the plan. Implementation is still under way.

Most of those involved agree that local input has been a hallmark of Bolinao's ecosystem management process. They credit the participatory process with winning much greater public acceptance for Bolinao's coastal development plan than a traditional plan could have secured; most often, plans are drawn up quickly by outside consultants with little or no local input. Plus, by including direct resource users–subsistence fishers and fish vendors as well as the local government–in the zoning process, there is a greater chance of achieving conservation goals. Local stakeholders are, after all, the people who will ultimately either respect the new rules and regulations or ignore and evade them. An ongoing research program, such as that conducted by the Marine Science Institute, is an important complement to the planning effort. It serves as a source of knowledge and data that public representatives can draw on to make informed decisions.

Perhaps the best news is that Bolinao is part of a growing number of communities, organizations, and sectors of government in the Philippines that are using a "bottom up" rather than "top down" approach to natural resource management, building on a long tradition of strong citizen advocacy. And although Bolinao's coastal development plan is still very much a work in progress, one thing appears certain: more and more people will get involved as the plan is implemented. As word has spread in the Philippines about the Bolinao experience, other municipalities have turned to the University of the Philippines-Haribon team. They seek help in formulating their own coastal development plans, offering the promise of more research and monitoring on the status of coral reef ecosystems, and generating new strategies and models for reef protection and new management abilities within local communities.