Introduction to the Florida Everglades

There are no other Everglades in the world. They are, they have always been, one of the unique regions of the earth, remote, never wholly known. Nothing anywhere else is like them; their vast glittering openness, wider than the enormous visible round of the horizon, the racing free saltiness and sweetness of the their massive winds, under the dazzling blue heights of space. They are unique also in the simplicity, the diversity, the related harmony of the forms of life they enclose. The miracle of the light pours over the green and brown expanse of saw grass and of water, shining and slow-moving below, the grass and water that is the meaning and the central fact of the Everglades of Florida. It is a river of grass.

Marjory Stoneman Douglas,
_The Everglades: River of Grass, 1947_

Here are no lofty peaks seeking the sky, no mighty glaciers or rushing streams wearing away the uplifted land. Here is land, tranquil in its quiet beauty, serving not as the source of water, but as the last receiver of it. To its natural abundance we owe the spectacular plant and animal life that distinguishes this place from all others in our country.

President Harry S Truman,
Address at the Dedication of Everglades National Park December 6, 1947
Significance of the Everglades

The Everglades are a unique and important ecosystem. The survival of the Everglades is crucial because they are the:

- Largest continuous stand of sawgrass prairie in North America.
- Predominant water recharge area for all of South Florida through the Biscayne aquifer.
- Home of fourteen endangered and nine threatened species.
- Largest mangrove ecosystem in the western hemisphere.
- Largest designated wilderness in the southeast.
- Most significant breeding grounds for tropical wading birds in North America.
- Site of significant ethnographic resources.
- Site of a nationally significant estuarine complex in Florida Bay.
- Only subtropical preserve on the North American continent.
- Major "edge" area of the northern and southern limits for many species creating a unique mingling of diverse temperate and subtropical species.
- A World Heritage Site, a Biosphere Reserve, a Wetland of International Significance, and an Outstanding Florida Water.
Habitats of the Everglades

Slight changes in elevation (only inches), water salinity, and soil create entirely different landscapes, each with its own community of plants and animals.

The Everglades is a low, flat plain shaped by the action of water and weather. In the summer wet season it is a wide, grassy river. In the winter season the edge of the slough is a dry grassland. Though Everglades National Park is often characterized as a water marsh, several very distinct habitats exist within its boundaries.

**Marine/Estuarine**

Florida Bay, the largest body of water within Everglades National Park, contains over 800 square miles (2072 square km) of marine bottom, much of which is covered by seagrass. The seagrass shelters fish and shellfish and sustains the food chain that supports all higher vertebrates in the bay. The hard bottom areas are home to corals and sponges. (Additional resources for teachers are available about marine ecosystems.)

**Mangroves**

Mangrove forests are found in the coastal channels and winding rivers around the tip of South Florida. Red mangroves (*Rhizophora mangle*), identified by their stilt-like roots, and the black (*Avicennia germinans*) and white mangroves (*Laguncularia racemosa*) thrive in tidal waters, where freshwater from the Everglades mixes with saltwater. This estuary system is a valuable nursery for shrimp and fish. During the dry months, wading birds congregate here to feed. Many bird species nest in the mangrove trees.

**Coastal Prairie**

Located between the tidal mud flats of Florida Bay and dry land, the coastal prairie is an arid region of salt-tolerant vegetation periodically flooded by hurricane waves and buffeted by heavy winds. It is characterized by succulents and other low-growing desert plants that can withstand the harsh conditions.
**Freshwater Marl Prairie**

Bordering the deeper sloughs are large prairies with marl sediments, a calcareous material that settles on the limestone. The marl allows slow seepage of the water but not drainage. Though the sawgrass is not as tall and the water is not as deep, freshwater marl prairies look a lot like freshwater sloughs.

**Freshwater Slough**

The slough is the deeper and faster-flowing center of a broad marshy river. This "fast" flow moves at a leisurely pace of 100 feet (30 meters) per day. Dotted with tree-islands called hammocks or heads, this vast landscape channels life-giving waters from north to south. Everglades National Park contains two distinct sloughs: Shark River Slough, the "river of grass;" and Taylor Slough, a narrow, eastern branch of the "river." There are no surface connections between the two. A series of other sloughs through the Big Cypress Swamp supply freshwater to western Florida Bay and the Ten Thousand Islands.

**Cypress**

The cypress tree (*Taxodium* spp.) is a deciduous conifer that can survive in standing water. These trees often form dense clusters called cypress domes in natural water-filled depressions. The trees in the deep soil at the center grow taller than those on the outside. Stunted cypress trees, called dwarf cypress, grow thinly-distributed in poor soil on drier land.

**Hardwood Hammocks**

Hammocks are dense stands of hardwood trees that grow on natural rises of only a few inches in the land. They appear as teardrop-shaped islands shaped by the flow of water in the middle of the slough. Many tropical species such as mahogany (*Swietenia mahogoni*), gumbo limbo (*Bursera simaruba*), and cocoplum (*Chrysobalanus icaco*) grow alongside the more familiar temperate species of live oak (*Quercus virginiana*), red maple (*Acer rubum*), and hackberry (*Celtis laevigata*). Because of their slight elevation, hammocks rarely flood. Acids from decaying plants dissolve the limestone around each tree island, creating a natural moat that protects the hammock plants from fire. Shaded by the tall trees, ferns and airplants thrive in the moist air inside the hammock.

**Pinelands**

The slash pine (*Pinus elliottii* var. densa) is the dominant plant in this dry, rugged terrain on top of a limestone ridge. The pines root in any crevice where soil collects in the jagged bedrock. Fire is essential for survival of the community, clearing out the faster growing hardwoods that would block light to the pine seedlings. Pine bark is multi-layered, so only the outer bark is scorched during fires. Pinelands are the most diverse Everglades habitat, consisting of slash pine forest, an understory of saw palmettos (*Serenoa repens*), and over 200 varieties of tropical plants.
Water Quality Issues in the Everglades

Reduced water quality threatens the delicate chemistry of the Everglades. Most of the water quality problems can be traced back to the extreme changes in hydrology and land use that have been put into place in the last 100 years.

**Excess Nutrients**

Excess nutrients from agricultural runoff destroy mats of composite algae called periphyton. These algae are the primary producers in the Everglades food web and provide both food and oxygen for small aquatic organisms. In the dry season, these algal mats also provide the critical moisture that enables many small organisms, including some fish eggs and snails, to survive the long months until rains come again.

**Saltwater Intrusion**

Saltwater intrusion also changes water quality. When freshwater runs low, saline water penetrates aquifers and upsets the ecological balance.

**Elevated Mercury in Animals**

Mercury pollution from unknown sources is a growing problem. Although mercury (Hg) occurs naturally in the environment, it is also a dangerous pollutant. High levels of mercury were first detected in Everglades freshwater fish in early 1989, resulting in an unprecedented issuance of health advisories to Florida Fisherman. Tests show that the park's raccoons and alligators also have high levels of this toxic metal in their systems. A Florida panther found dead in December 1989 had levels of mercury that would be lethal to humans. After extensive monitoring, approximately two million acres of Florida surface waters - over half of the fresh waters of the state - are now subject to bans or restrictions on consumption of several species of fish.

**Fishing has been Banned**

The most severe problem is in South Florida, where the entirety of the Florida Everglades is covered by consumption bans. The fishing advisories have had a substantial impact on sport and subsistence angling populations in South Florida and on the economy for the state through the loss of recreation and license fees. In addition, the mercury problem places at risk a variety of wildlife within the Everglades. Most notably, the effects of elevated mercury has been implicated in the mortality and loss of fecundity in the endangered Florida Panther.
The sources, distribution, and pathways of transport and transformation of Hg through the South Florida Ecosystem are not well understood. Various explanations have been proposed to account for the unusual severity of the mercury problem in South Florida. Three potential sources or causative factors are: (1) hydrological changes resulting from the Central and South Florida Flood Control Project, (2) agricultural practices in the Everglades Agricultural Area, or (3) contamination of the Everglades ecosystem via atmospheric deposition (wet and dry) of mercury.

Methyl mercury, which constitutes a small fraction of total environmental Hg, is the predominant form of Hg present in contaminated fish (Westöö 1973) and is bioaccumulated at high rates (Boudou and Ribeyre 1985). Methyl mercury, introduced as a point source into Minamata Bay, was also identified as the compound responsible for the widespread human toxicity associated with consumption of local fish in Minamata, Japan, in the late 1960s (D'Itri 1972).

The high levels of MeHg accumulating in fish and other fauna of South Florida may result from either increasing inputs of Hg to the system or changing environmental conditions that promote formation and transport of MeHg. Although some abiotic methylation of Hg may occur, the predominant mechanism for formation of MeHg in the environment is microbial (Berman and Bartha 1986). Thus, increases in concentration of the methyl form of the element indicate either higher available concentrations of inorganic Hg or higher rates of microbial transformation activity, or both.

Mercury has been sequestered in the oligotrophic circumneutral Everglades peats through the 5,000-year period of their development. Subsidence of these soils following drainage and enhancement of their nutrient status during agricultural conversion may be mobilizing this geochemical reservoir. The natural Everglades soils were not strongly anaerobic, even though flooded for much of the year (Bachoon and Jones 1992), and increasing anaerobiosis may lead to increases in the importance of organic Hg species in Hg biogeochemical cycles. The 1400 miles of canals now in the system, with their low oxygen content, may provide a primary locale for methylation of Hg and its transport through the system in association with dissolved and finely divided organic matter.
Although there is little information about distribution and transformations of Hg in wetlands, the problem of elevated Hg in fish has been noted in lakes experiencing point source inputs of Hg, recent impoundments, acid inputs, or combinations thereof (Hakanson et al. 1988; Jackson 1988).

Potentially significant external sources include atmospheric deposition from the global and regional background and deposition from more local fossil-fuel electric power plants, garbage incinerators, paints, medical laboratories, and fossil residues from Hg-containing agricultural chemicals. The 1995 South Florida Atmospheric Mercury Monitoring Study (SoFAMMS) was carried out to investigate the potential influence of local mercury sources in the developed Southeast Florida Coast, on the atmospheric deposition of mercury to the Everglades.

More commonly, however, environmental Hg contamination cannot be attributed to external sources, but rather stems from alterations of environmental conditions that mobilize Hg and promote uptake via methylation. Widespread Hg contamination was identified in lakes in Scandinavia, eastern Canada and the north-central U.S. (Hakanson et al. 1988, Jackson 1988); surveys of affected lakes implicated acidification of poorly buffered lakes and/or recent impoundment as contributing to elevated Hg levels in fish.

The distribution of total Hg in soils and sediments of Everglades (Delfino et al. 1993) indicates an increase in the accumulation rates of Hg for the 90 years since the turn of the century, with pronounced increases dating from 1940. The similarity of these data to trends in lakes of the north-central U.S. and Sweden, despite differences in climate, hydroperiod, vegetation and location, implicates the worldwide increases in Hg inputs accompanying industrialization. However, the distribution of increases in accumulation rates within the Everglades is not uniform; WCA 1 and WCA 2 have the highest increases, implicating either localized sources or internal transport and transformation processes.

There are no historic or present measurements of Hg methylation in the Everglades; thus no direct comparisons of the rates of methylation between the Everglades and other systems, or between present-day and historic rates within the Everglades, can be made. Rather, present and past conditions in the Everglades can be compared with those factors known to control rates of Hg transformations in other surface water systems.
Sulfate Plays a Role in Methylation

The net rate of Hg methylation in the environment reflects the relative rates of two microbial processes: methylation and demethylation. Methylation is primarily carried out by sulfate-reducing bacteria in both freshwater and saltwater systems. Although many bacteria carry out methyl transfer reactions, and thus could potentially methylate Hg, the only identified species to effect these reactions to date have been sulfate-reducing bacteria (Compeau and Bartha 1985; Gilmour et al. 1992). The basis for this apparent specificity has been investigated, but is still not well understood (Choi and Bartha 1993). On the other hand, field experiments in which sulfate-reduction has been inhibited by additions of molybdate have yielded appreciable levels of Hg methylation (Mack and Nelson, unpublished data) suggesting other bacterial groups may also contribute to methylation. Demethylation can occur by two or more pathways (Oremland et al. 1991); the importance of each pathway under different environmental conditions has not been well-characterized, but may result in different net rates of methylation.

Sulfate concentrations below 1 µM in freshwater systems inhibit the rate of methylation (Gilmour et al. 1992). The increases in Hg methylation observed in acidified temperate lakes can be attributed to sulfate fertilization rather than to direct pH effects. The high levels of sulfate in marine systems also inhibit methylation (Winfrey and Rudd 1990) by promoting precipitation of Hg as sulfides. The concentrations of sulfate in the waters of the Everglade (5-170 mg/L; Stober et al. 1995) span the 20-40 mg/L concentration range thought to be optimal for Hg methylation (Gilmour and Henry 1991). Thus, although sulfate concentrations in the Everglades have probably not changed appreciably (the high concentrations relative to other fresh waters are due to underlying mineralogy rather than acid rain inputs), the high levels of sulfates may predispose the system to respond strongly to removal of other limitations on methylation.

Everglades Water Naturally Rich in SO₄

Other factors that may influence the rate of methylation include temperature, pH, DOC, and aeration status (Compeau and Bartha 1984; Miskimmin et al. 1992; Winfrey and Rudd 1990). Seasonal studies of microbial transformations of Hg indicate higher rates of methylation in summer than in winter (Bodaly et al. 1993; Korthals and Winfrey 1987). Given that most studies of microbial methylation have occurred in mid-
Drainage and Nutrient Overloads May Play a Major Role in Methylation

High-latitude lakes, the higher temperatures of the Everglades suggest potential rates of methylation in this system are unlikely to be limited by temperature as they are in temperate systems.

The aeration status of areas in South Florida may have changed in response to changes in hydrology and oxygen demand, as mediated by loadings of inorganic nutrients. Drainage of peat soils causes oxidation of organic matter from the soils, especially when microbial respiratory activity is enhanced by nutrient additions. The fate of any Hg associated with such soil loss in the Everglades is not known. Canalization and eutrophication may also have increased the extent of anaerobic zones within the water column, giving rise to areas of potentially high methylation activity. Additionally, eutrophication may increase activity of sediment microbial populations, making the sediments more strongly anaerobic. Such conditions favor activity of the sulfate-reducing bacteria responsible for methylation of Hg. Thus, eutrophication may affect the rate of methylation by both direct and indirect mechanisms.

Alteration of hydrology and nutrient status may also change the nature and composition of the organic matter cycled and transported within the system. In oligotrophic wetlands, much organic carbon is tied up as lignocellulose, or plant detrital material, which cycles slowly. Under more eutrophic conditions, algal growth and higher microbial activity increase the lability of the carbon. Increases in organic matter generally support higher microbial activity but may also complex the Hg, decreasing its availability for methylation. It is difficult, therefore, to predict the direction of change that may result from changes in character, amount, and distribution of organic matter.
A Multi-Agency Effort

Evolution of Ecosystem Restoration Efforts  In response to public concern about development and continued ecosystem degradation, all levels of government have organized efforts to work towards a balanced and sustainable South Florida ecosystem.

In 1972 the Florida legislature passed several environmental and growth management laws, including the Land Conservation Act, which authorizes the issuance of state bonds for the purchase of environmentally endangered and recreation lands. In 1983 Florida Governor Bob Graham launched the "Save Our Everglades" program — a partnership between the South Florida Water Management District and federal and state governmental agencies. Its goal is to work toward restoring the ecosystem so that by 2000 it looks and functions more like it did in 1900. The program affects a 9,000-square-mile area that includes the Kissimmee River Basin, Lake Okeechobee, the Everglades, the Big Cypress swamp, and the estuaries of Florida Bay, Biscayne Bay, and the Ten Thousand Islands. With strong public and political support, this program established the Kissimmee River Restoration Project and facilitated the congressional expansion of Big Cypress National Preserve in 1988 and Everglades National Park in 1989.

In 1985 the state of Florida also strengthened existing planning laws by adopting the "Local Government Comprehensive Planning and Land Development Regulation." This regulation focuses on integrated approaches that foster orderly and sustainable state growth. It also requires that each local jurisdiction prepare a comprehensive plan that conforms to the goals and policies of the state law. The local plans must include the general distribution, location, and extent of general land uses, and they must be linked to the comprehensive plans of adjacent cities, counties, the region, and the state.

The 1987 Surface Water Improvement and Management Act (SWIM) requires each Florida water management district to develop plans to clean up and preserve rivers, lakes, estuaries, and
bays affected by water districts. SWIM plans for Lake Okeechobee and Biscayne Bay were completed and implemented.

In contrast, the Everglades SWIM plan became the focus of intense litigation. In 1988 the United States, on behalf of Everglades National Park and Loxahatchee National Wildlife Refuge, filed a lawsuit against the state of Florida and the South Florida Water Management District. The suit alleged that federally owned or leased lands in the Everglades were being damaged by agricultural runoff containing excessive phosphorous. The suit was largely settled in 1991. However, litigation continued when agricultural interests challenged the Everglades SWIM plan. A mediated solution addressing these competing concerns was incorporated into Florida’s Everglades Forever Act, enacted in 1994. The act established a restoration plan and provides for a program of construction, research, and regulation. The plan also calls for designs to restore clean water in critical periods (hydroperiod) and to control the growth of exotic species. Finally, the act requires farmers to minimize the amount of nutrient-rich pollutants used on or discharged from farms (referred to as best management practices) and includes a schedule for constructing stormwater treatment areas (man-made marshes) that filter phosphorous from agricultural runoff before it reaches the Everglades.

In 1993 the South Florida Ecosystem Restoration Task Force was founded through an interagency agreement between the six federal departments involved in restoring and protecting the ecosystem. Congress formally established the task force in 1996 and broadened its membership to include federal and state agencies, local governments, and Miccosukee and Seminole tribal representatives. Chaired by the Department of the Interior, the task force coordinates and develops consistent policies, strategies, plans, programs, and priorities for restoring the South Florida ecosystem. The task force has appointed a Management and Coordination Working Group to assist it in restoration activities. This Florida-based group coordinates programs developed by the task force, resolves technical issues, and implements a wide variety of restoration programs.

The Governor’s Commission for a Sustainable South Florida was established in 1994 to "make recommendations for achieving a healthy Everglades ecosystem that can coexist and be mutually supportive of a sustainable South Florida economy and quality communities." The commission consists of 42 members from the business, agriculture, government, environmental, and public sectors. In 1995 the commission recommended an initiative
The Corps of Engineers
"Restudy"

Currently, the U.S. Army Corps of Engineers is conducting a comprehensive restudy of the Central and Southern Florida Project. This effort is examining the feasibility of modifying water deliveries to repair damaged natural systems, while still providing for urban and agricultural water and flood control needs.

National Park Service

The National Park Service participates in these ecosystem restoration efforts at both the park level and at the regional level. Staff from the four South Florida parks are members of the Management and Coordination Working Group and the Governor’s Commission for a Sustainable South Florida, as well as other restoration groups. NPS park staffs also play a significant role in establishing goals for ecosystem restoration, evaluating the design and implementation of restoration projects, conducting scientific research, and monitoring conditions in the field to measure progress toward restoration goals. The South Florida parks also are equally committed to educating the public about the need for restoring the ecosystem through ongoing interpretive and outreach education programs.