# 1.0 INTRODUCTION

## 1.1 Change in the Everglades Ecosystem

The Everglades ecosystem has been greatly altered during the last century to provide for urban and agricultural development. Since 1880, 50% of the historic Everglades wetlands have been drained, and an expanding South Florida human population of nearly 6 million competes for this ecosystem's water and land (Davis and Ogden 1994).

At present, most of the remaining Everglades are found in the US Fish and Wildlife Service's Loxahatchee National Wildlife Refuge (LNWR), the National Park Service's Everglades National Park (ENP), or in the Water Conservation Areas (WCA), specifically, WCA2 and WCA3 (Figure 1.1). Today, the ENP includes only one-fifth of the original Everglades that once encompassed over 2 million acres (7,800 $km^2$). One-fourth of the historic Everglades is now in extensive agricultural production within the 2,600 $km^2$ (1,000 $mi^2$) Everglades Agricultural Area (EAA), where sugar cane and vegetables are grown on drained Everglades soils. Big Cypress National Preserve (BCNP) located in western South Florida, protects forested swamp resources within the Everglades watershed. Although one-half of the 41,000 $km^2$ (16,000 $mi^2$) Everglades watershed is in public ownership, a number of environmental issues must be simultaneously resolved to protect and restore the remnant Everglades ecosystem. These issues include hydropattern modification; water supply conflicts; eutrophication; mercury (Hg) contamination of gamefish, wading birds, and other top predators; habitat loss and alteration; endangered species protection; and exotic species introductions.

## 1.2 Everglades Restoration Efforts and Scientific Studies

A series of efforts are underway to protect and restore the South Florida Everglades ecosystem. In 1994, Florida's governor established the Governor's Commission for a Sustainable South Florida to make recommendations for achieving a healthy Everglades ecosystem that can coexist with and be mutually supportive of a sustainable South Florida economy and quality communities. The federal Water Resources Development Act of 1996 established the South Florida Ecosystem Restoration Task Force, composed of representatives of federal agencies, state

agencies, indian tribes, and local governments, to coordinate the development of consistent strategies for restoration, protection, and preservation of the South Florida ecosystem (US Congress 1996). The Science Subgroup of this task force has developed integrated scientific information needs for the ecosystem restoration effort (Science Subgroup 1996) along with success criteria for South Florida ecosystem restoration (Science Subgroup 1997). The US Army Corps of Engineers (USACE) is currently conducting a restudy of the Central and Southern Florida Project to evaluate the feasibility of structural or operational modifications to the project, and identify those modifications that are essential to restoration of the Everglades and Florida Bay ecosystems while providing for other water-related needs (USACE 1994). The state of Florida has many other ecosystem restoration efforts underway (SFWMD 1997a) including a comprehensive plan to address Everglades eutrophication through land acquisition, construction projects, research, and regulation, as required by Florida's 1994 Everglades Forever Act (SFWMD 1997b). In addition other federal and state agencies and universities, including the US Environmental Protection Agency (EPA), the US Geological Survey (USGS), US National Park Service (NPS), Florida Department of Environmental Protection (FDEP), and South Florida Water Management District (SFWMD), currently are conducting studies within the Florida Everglades to evaluate the condition of Everglades resources and restoration alternatives.

## 1.3 South Florida Ecosystem Assessment Project

This report summarizes the data collected and the efforts of the EPA's South Florida Ecosystem Assessment Project. The South Florida Ecosystem Assessment Project is an innovative, large-scale monitoring and assessment program designed to measure the current and changing conditions of ecological resources in South Florida using an integrated, holistic approach. Using the EPA (1992) ecological risk assessment framework as the foundation (Figure 1.2), the ultimate goal of this program is to provide decision makers with sound ecological data needed to improve environmental management decisions for the restoration of the Everglades ecosystem. Furthermore, through an ecological risk assessment approach, the South Florida Ecosystem Assessment Project addresses the multiple issues that are thought to be critical to the restoration of the Everglades ecosystem and also addresses the interactions among these issues.

The South Florida Ecosystem Assessment Project is guided by seven policy-relevant assessment questions:

1) **Magnitude** - What is the magnitude of the problem(s) in the Everglades?
2) **Extent** - What is the extent of the problem(s)?
3) **Trend** - Is the problem(s) getting better, worse, or staying the same?
4) **Cause** - What factors are associated with or contribute to the problem(s)?
5) **Source** - What are the source(s) and what is the contribution and importance of each source to the problem(s)?
6) **Risk** - What are the risks to different ecological systems and species from the stressors or factors causing the problem(s)?
7) **Solutions** - What management alternatives are available to ameliorate or eliminate the problem(s)?

These policy-relevant questions are applicable to each major issue identified by the Science Subgroup as impacting the Everglades ecosystem (i.e., hydropattern modification, Hg contamination, eutrophication, habitat alteration, and endangered and exotic species). Initial conceptual models and testable hypotheses were developed around these key issues and policy-relevant questions.

A number of studies will be required to test all of the hypotheses and to refine the conceptual models and complete the ecological risk assessment in the Everglades. Initially, the South Florida Ecosystem Assessment Project has focused on a subset of hypotheses that are directly related to the first four policy-relevant assessment questions identified above. These hypotheses are discussed in Chapter 8.0. Additional coordinated studies directed at addressing other high priority elements of the interagency program will be conducted and merged with this project as additional resources are made available.

Unlike other studies in support of the Everglades restoration effort, the South Florida Ecosystem Assessment Project is unique in a number of ways.

(1) Scale - The South Florida Ecosystem Assessment Project is a multimedia study being conducted on over 41,000 $km^2$ (16,000 $mi^2$) in South Florida extending from the EAA in the north to the Florida Bay in the south. Few ecological studies have been conducted at this scale. This large-scale, multimedia approach will improve

the ability to assess patterns in individual resources throughout the whole Everglades ecosystem and the interactions among these resources or patterns.

(2) Study Design - The South Florida Ecosystem Assessment Project uses a unique probability-based, statistical survey design to select sample locations throughout the Everglades marsh and canals. This sampling design permits the development of unbiased population estimates of resource condition with known confidence. Furthermore, this design also permits spatial analyses and associations that provide insight into functional relationships among observed ecological effects and multiple stressors.

(3) Risk Based Approach - The South Florida Ecosystem Assessment Project evaluates multiple impacts and stressors on the Everglades ecosystem simultaneously using an ecological risk based approach. By using a risk based approach, issues that are critical to the restoration efforts and the interaction among these issues and stressors will be identified for decision makers.

(4) Complementary Interagency Efforts - This project was designed to address critical policy-relevant questions in a complementary manner not previously used by other agencies or studies. Not only will the South Florida ecosystem assessment project contribute to the Interagency Task Force on Ecosystem Restoration efforts, the results of this project will be closely coordinated with the State of Florida and other agencies findings to provide the scientific information needed to assess restoration efforts proposed for the Everglades ecosystem. For example, the data collected will be used by other agency scientists and engineers to calibrate hydrodynamic, water quality, and landscape ecology models that are being used to predict responses of the Everglades to various management alternatives.

## 1.4 Purpose and Organization of This Report

The purposes of this report are to (1) present and summarize the data collected in the Everglades ecosystem by the EPA, (2) to provide preliminary answers to the first four policy relevant assessment questions pertaining to the magnitude and extent and current conditions within the Everglades canal and marsh ecosystems, and (3) to establish a baseline for assessing future trends in resource condition. This report provides the results of the data collection efforts conducted within the Everglades from 1993 through 1996. The information provided by this project will be critical to the South Florida Interagency Ecosystem Restoration Task Force to determine if the precursor and ecological restoration success criteria identified by the task force are being achieved.

This report is organized into two volumes. In this volume (Volume I) the background information, study design, data and results, management implications, and research recommendations relevant to the specific ecosystem restoration issues identified earlier in this chapter (i.e., hydropattern modification, eutrophication, habitat alteration) are provided. All figures have been placed at the end of their respective chapter. Supporting data and background information are either provided in appropriate chapters or included in Volume II, which contains the appendices to this report. Appendices include the following: Appendix A - Sampling Apparatus; Appendix B - Data Quality Objectives; Appendix C - Summary of Data Review Findings; Appendix D - Eastern Mosquitofish Studies; and Appendix E - Response to Peer Review Comments. Volume II also contains peer review comments received on the draft report and responses to the comments.

## 1.5 Key Everglades Restoration Issues

Several issues have been agreed on by the numerous agencies as key Everglades restoration issues. These include hydropattern modification, Hg contamination, eutrophication, habitat alteration and loss, and endangered and exotic species. Each of these issues and the interaction among them is more fully described in the following sections.

### 1.5.1 Hydropattern Modification

Change in natural hydropattern (i.e., depth, timing, duration, and distribution of surface water) of the Everglades is one of several key issues to be addressed for the restoration of the Everglades ecosystem. Canal drainage systems, levees, flood control structures, and water supply diversions have collectively contributed to large-scale changes in hydropattern and resultant changes in structure, function, and nutrient cycling of the Everglades ecosystem. The USACE Central and Southern Florida Project Restudy (USACE 1994) is evaluating the modification of canals and levees to return the hydropattern to a more natural regime. Determining the natural flow regime and hydropattern and subsequently implementing the required flows in the Everglades are major restoration activities.

### 1.5.2 Florida Mercury Problem

Since the initial detection of elevated levels of total mercury in freshwater fish (THgF) in 1989, it has become increasingly apparent that South Florida has an extensive THgF problem. The state of Florida has issued a human health fish consumption advisory due to THgF contamination that either bans or restricts the consumption of largemouth bass and other freshwater species from about 2 million acres of water encompassing the Everglades and BCNP (Figure 1.1). In 1995 the advisory was expanded to cover several fish species in Florida Bay. The maximum THgF concentrations found in largemouth bass (4.4 ppm) and bowfin (over 7 ppm) collected from an Everglades canal within WCA3A are the highest concentrations found in Florida to date. The maximum concentrations found in bowfin are the highest reported nationwide. While THgF contamination has been found to be greatest in the Everglades, it is also found at levels of concern in largemouth bass throughout Florida's surface waters. Transformation of inorganic Hg into methylmercury (MeHg), which is the most toxic form of Hg, and its subsequent bioaccumulation in predatory game fish, is a cause for concern for human health. Human consumption of MeHg contaminated game fish can lead to neurotoxicological risk to human populations, especially to the developing nervous system of fetuses and infants (EPA Mercury Report to Congress 1997). Food serves as the primary source of MeHg absorbed by humans, and fish typically have the highest Hg concentrations of foods consumed by humans. The intake of inorganic Hg from air or water ranges from one-hundredth to one-tenth of the intake of MeHg from food (EPA 1997).

In addition to the potential risks to human health, the ecological health of the South Florida ecosystem also is at potential risk from Hg transformations and cycling. Elevated levels of MeHg have been found in various Everglades biota, including fish, the endangered Florida panther, raccoons, wading birds, and alligators. A Florida panther (a federally and state listed endangered species) found dead in ENP in 1989 had an extremely high liver MeHg concentration of over 110 ppm. MeHg contamination not only poses a potentially serious threat to the continued existence of the Florida panther, but also many other species in South Florida ecosystems.

While Everglades MeHg contamination has received widespread attention since 1989, and atmospheric deposition of Hg as a potential dominant source of Everglades Hg are well studied

(Delphino et al. 1993; Pollman et al. 1995; Guentzel 1997; USGS ACME), the extent and magnitude, transport, transformation, and pathways of Hg and MeHg through South Florida ecosystems, particularly in peat, are still largely unknown. Atmospheric emissions from global, regional, or local sources, such as fossil fuel fired electrical generating plants, solid waste incinerators, and medical waste incinerators, and subsequent transport and wet and dry deposition are known to be one source of Hg to the Everglades ecosystems. However, it is unknown what portion of the atmospherically deposited Hg is methylated and accumulated through the food chain. Other possible sources of Hg in Florida include natural mineral and peat deposits, and paint and agricultural operations (Science Subgroup 1995).

Although there are multiple interactions among these sources and several possible pathways for Hg transport and MeHg bioaccumulation through the Everglades ecosystem, none of these individual sources appears to adequately explain the vast area with MeHg contamination. Various degrees of uncertainty still remain in the quantitative understanding of sources, transport, and transformation that limit the ability to make fully informed management decisions at this time. These uncertainties are expected to be reduced substantially over the next 2 years as the monitoring, research, modeling, and assessment data collected over the last 5 years are further analyzed, synthesized, and integrated into a more complete, accurate, and precise predictive quantitative model. The South Florida ecosystem assessment project is expected to make an important contribution to this effort.

### 1.5.3 Eutrophication

Nutrient loading from the EAA and urban areas has significantly increased nutrient concentrations, particularly phosphorus, in the downstream WCAs and ENP (Scheidt et al. 1989; Walker 1991; Walker 1995) and major eutrophic impacts to wetland systems downstream have occurred (Nearhoof 1992). Among the progressive eutrophic impacts are increased soil phosphorus content (Doren et al. 1996; DeBusk et al. 1994), altered natural periphyton communities (Raschke 1993; McCormick et al. 1996), loss of water column dissolved oxygen (DO) and changed community metabolism (Belanger et al. 1989; McCormick et al. 1997), conversion of wet prairie and sawgrass (*Cladium Jamaciensis*) plant communities to cattails

(*Typha domingensis*) (Davis 1994; Jensen et al. 1995), and subsequent loss of important wading bird foraging habitat (Fleming et al. 1994, Hoffman et al. 1994). These collective changes are systemic and impact the structure and functions of the aquatic ecosystem (Belanger et al. 1989; Nearhoof 1992; McCormick et al. 1997).

FDEP concluded that eutrophication of the Everglades resulted in the violation of four Florida water quality standards protecting fish and wildlife and created an imbalance in natural populations of aquatic flora and fauna, with a resulting loss in biological integrity (Nearhoof 1992). Some eutrophic impacts, such as periphyton community changes, are thought to be short-term and reversible if nutrient additions can be significantly decreased. Other impacts are considered long-term (decades or centuries), such as loading peat soil with excess phosphorus that triggers the loss of native plant communities and foraging habitat. The nutrient levels required to sustain the natural balance of oligotrophic plants and animals into future decades and centuries are currently under debate. There are still many marsh areas where total phosphorus (TP) concentrations in surface water are near natural concentrations (i.e., 10 ppb and less) and recent studies have shown that TP concentrations entering ENP are lower than concentrations recorded in 1986 (Walker 1997). It is unknown however, how much changing hydrological conditions and flow patterns in the Everglades have confounded these lower recorded TP concentrations since 1986.

Nevertheless, a combination of agricultural best management practices (BMPs) and construction of approximately 43,000 acres (174 $km^2$) of wetlands known as stormwater treatment areas (STAs) (Figure 1.1) is being implemented in the EAA in an attempt to control phosphorus loadings to the Everglades. The goal of Phase I of the phosphorus control program is to decrease total phosphorus (TP) concentrations in the water discharged to the Everglades to at least 50 $\mu$g/L. The effectiveness of these controls in reducing nutrient concentrations to near natural TP concentrations of 10 ppb is not yet known.

### 1.5.4 Habitat Alteration and Loss

Over 1 million acres of the original “River of Grass” have been drained and altered for other uses since the turn of the 20th century. In addition to the habitat lost, much of the remaining

habitat has been altered because of unnatural flooding and drying, groundwater removal, or similar perturbations. This habitat alteration is still ongoing as the population of South Florida continues to expand. Unlike eutrophication and Hg contamination, habitat loss is, for the most part, irreversible. In addition, habitat alteration aggravates other environmental problems, and these interactions are poorly understood.

### 1.5.5 Endangered and Exotic Species

The South Florida ecosystem is known for its great diversity of plants and animals, many of which are endangered (SFWMD 1997a). Florida also has a large number of introduced and nonnative fish and birds, which compete with the native species. These introduced or exotic species are not restricted to fauna; there are also significant numbers of nonnative plants. The melaleuca tree (*Melaleuca quinquenervia*), for example, has taken over large areas of the Everglades. This species was originally introduced because of its ability to transpire water and help drain the wetland areas (Bodle et al. 1994). Eliminating introduced species altogether is unlikely. Practices for minimizing their impact on native habitat and preventing continued expansion into the Everglades are needed to sustain native Everglades communities, elements, sensitive, threatened, or endangered species, and to maintain overall biological diversity of the Everglades ecosystem.

### 1.5.6 Interaction Among Issues

None of the issues discussed above are independent of the others. These issues are all intertwined, each problem affecting other problems. For example, hydropattern modification affects the fate and transport of both TP and Hg within the South Florida ecosystem, as well as habitat for endangered species. Addressing these issues requires a large-scale perspective. Integrated, holistic studies of the multiple issues impacting the Everglades need to compare the risks associated with all impacts and their interactions.

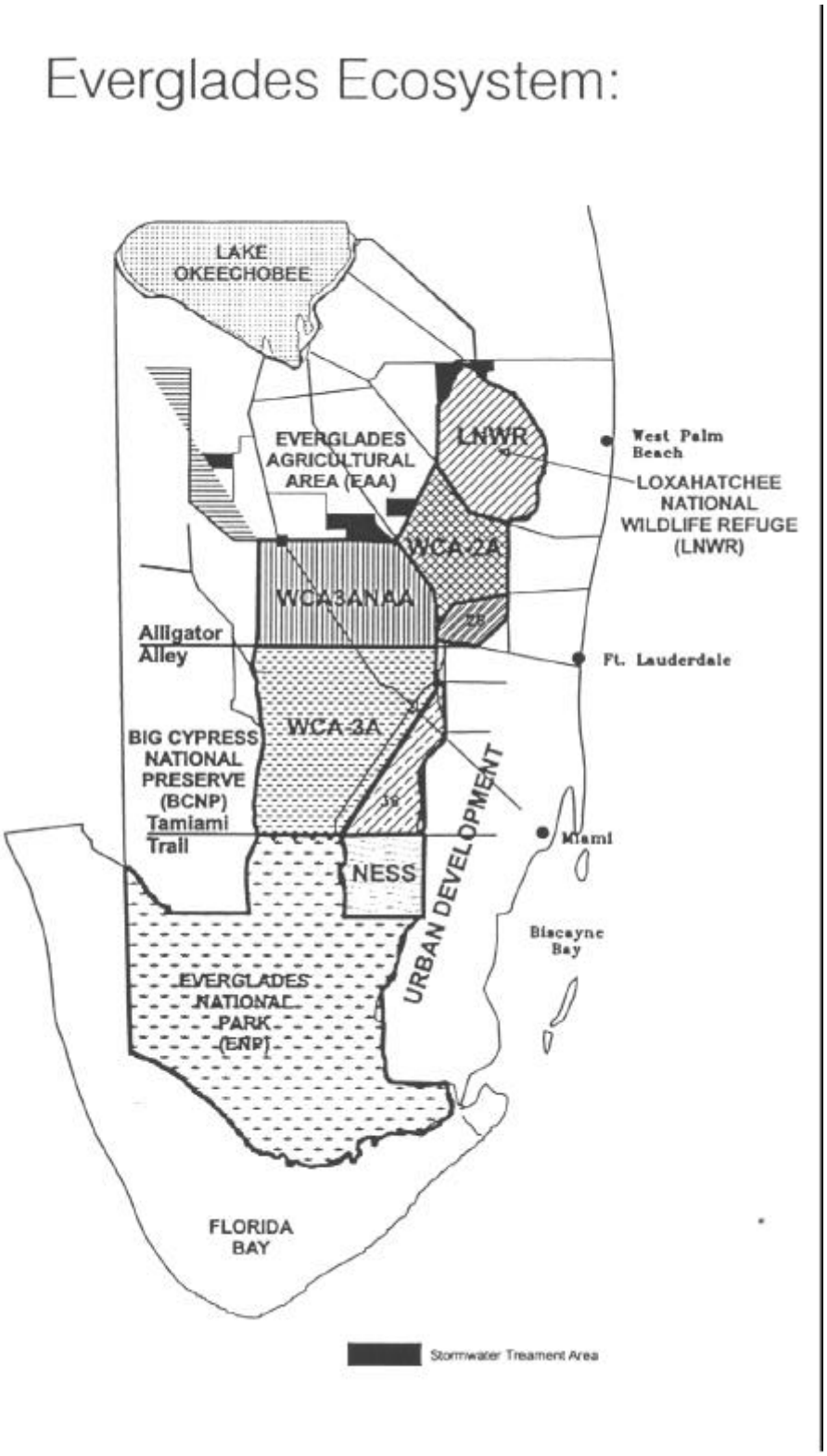


Figure 1.1 South Florida study area.

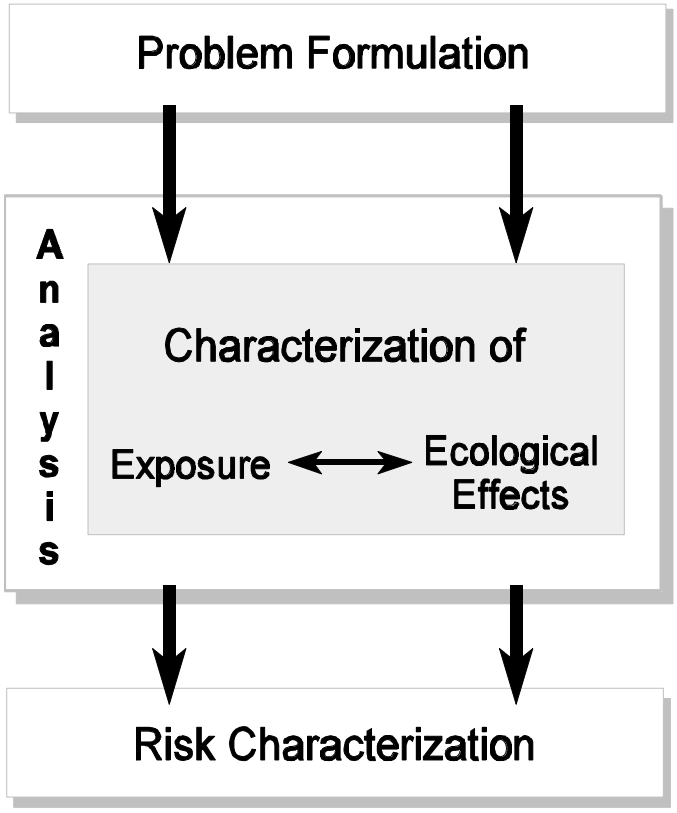


Figure 1.2 Ecological risk assessment framework.