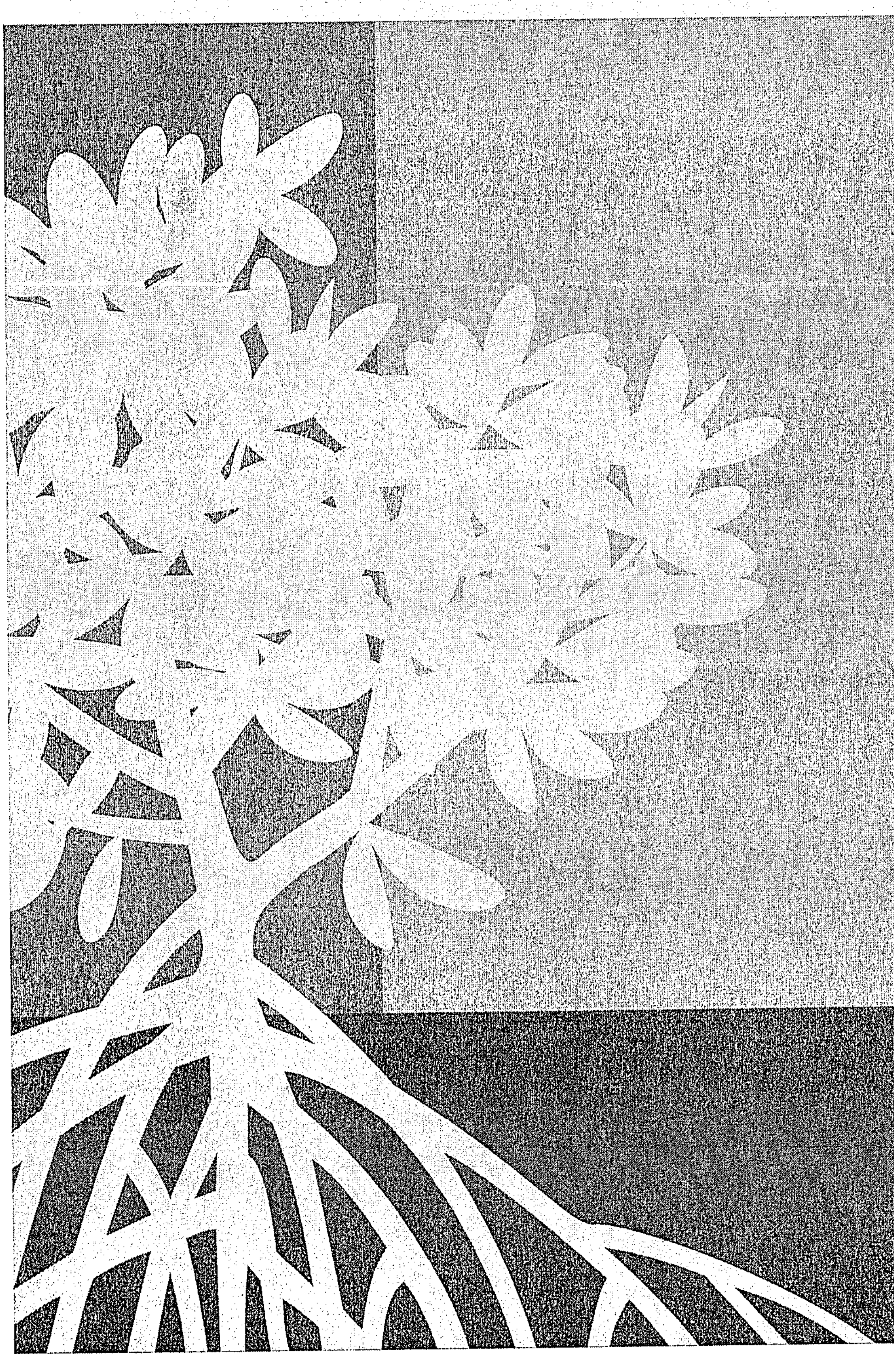
U.S. Geological Survey Program on the South Florida Ecosystem

Proceedings of South Florida Restoration Science Forum, May 17-19, 1999, Boca Raton, Florida

For participating USGS projects



U.S. GEOLOGICAL SURVEY
Open-File Report 99-181

U.S. Geological Survey Program on the South Florida Ecosystem—Proceedings of South Florida Restoration Science Forum, May 17-19, 1999, Boca Raton, Florida

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U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

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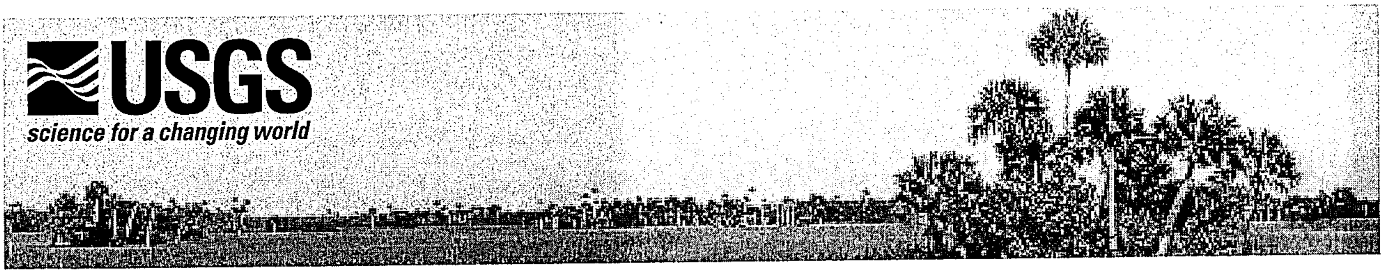

Executive Summary

(Published as U.S. Geological Survey Fact Sheet FS-061-99)

INTRODUCTION

As land and resource managers see the value of their resources diminish, and the public watches the environments they knew as children become degraded, there are increasing calls to restore what has been lost, or to build productive ecosystems that will be healthy and sustainable under the conditions of human use. The U.S. Geological Survey's (USGS) Placed-Based Studies Program was established to provide sound science for resource managers in critical ecosystems such as South Florida (fig. 1). The program, which began in south Florida in 1995, provides relevant information, high-quality data, and models to support decisions for ecosystem restoration and management. The program applies multi- and interdisciplinary science to address regional and subregional environmental resources issues.

ENVIRONMENTAL RESTORATION: A PARTNERSHIP

A consensus has emerged among Federal and State agencies and environmental groups that south Florida and the Everglades (fig. 1) ecosystem should be restored as much as possible to its original condition. Following the settlement of a lawsuit on Everglades water quality, a Federal task force, chaired by the Department of the Interior (DOI), was formed in 1993 to oversee restoration efforts (fig. 2). The task force was enlarged in 1995 to include 25 representatives of Federal and State agencies and Indian tribes. A Science Coordination Team (SCT), consisting of representatives of these agencies

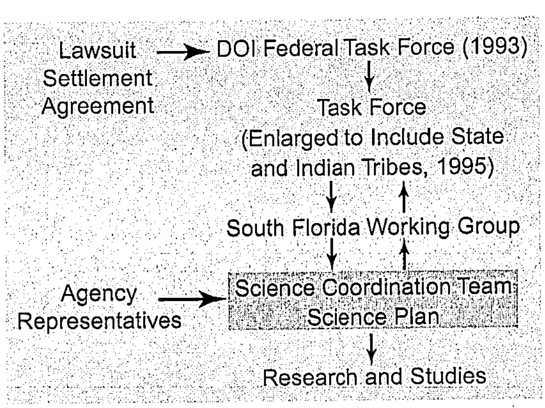

Figure 2. Diagram of science development for the restoration of south Florida.

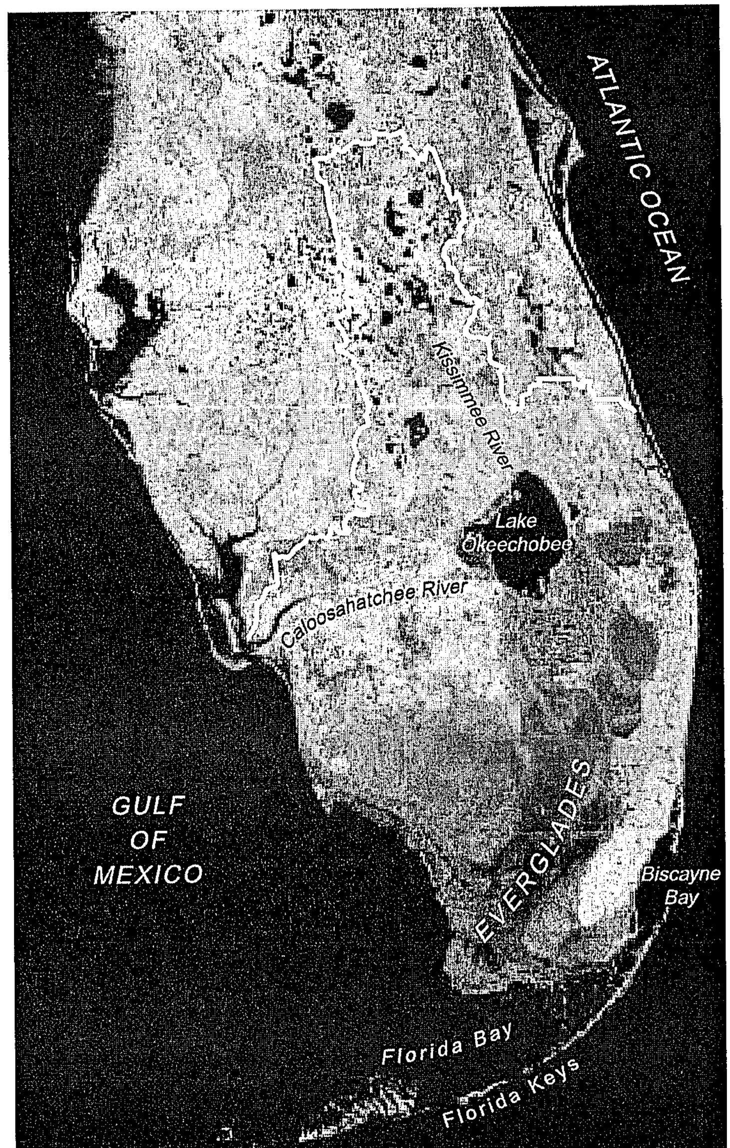

Figure 1. Satellite image of south Florida showing boundary of the South Florida Ecosystem Program.

and tribes, advises the task force (fig. 2) on scientific investigations needed to support restoration. These investigations include characterizing and comparing the predrainage system with the present system, determining key characteristics of the predevelopment ecosystem, providing natural science input to and assessment of the redesign of

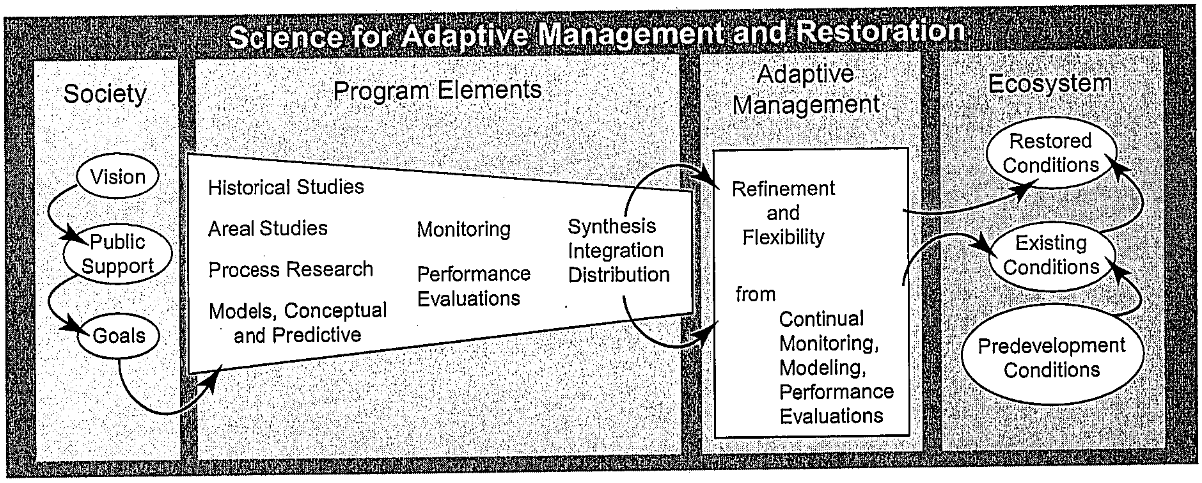

Figure 3. Diagram of science for adaptive management and restoration in south Florida.

structures and operations of the Central and Southern Florida Project Comprehensive Review Study (the Restudy), assessing the hydrologic and ecological results of the Restudy modifications through pre- and postmodification monitoring and modeling, modifying the design of the modifications to make improvements based on monitoring and modeling results, and characterizing the potential effect of the project on mercury accumulation. Many of the scientific activities are carried out by the USGS, which is the principal science agency of the DOI. The USGS works and collaborates with researchers in academia, State Government, and elsewhere in the Federal Government to bring the right mix of expertise needed for the scientific task.

SOUTH FLORIDA ECOSYSTEM PROGRAM

The South Florida Ecosystem Program is one of the Nation's Placed-Based Studies. The program began with a diverse body of projects encompassing cartographic, geologic, and hydrologic disciplines, and was guided from the start by scientific demands of ecosystem restoration. Projects have been selected based on the ranking of proposals by agencies involved in restoration, or based on the results of scientific review processes which highlighted additional scientific needs. Recently, the SCT has assumed the major responsibility for coordinating and selecting scientific studies needed for restoration.

An important part of the program is the facilitation of scientific linkages between disciplines. The multi- and interdisciplinary approach brings together scientists from appropriate operational units to apply their diverse expertise to common problems. Information from one discipline is designed to be used by scientific colleagues in other disciplines. When the National Biological Survey joined the USGS and became the Biological Resources Division in 1997, the USGS was able to provide a more integrated and comprehensive scientific service for land and resource managers.

Many studies in the program are nearing completion. As studies are completed, emphasis is shifting to completing research reports, archiving data from the ongoing projects, and preparing topical synthesis documents. Synthesis documents will summarize and integrate USGS accomplishments and understanding to date, as well as describe the relevance of the program's research to management issues. Synthesis will also identify unanswered questions and make recommendations for continuing research directions.

Program Elements

The program in south Florida has several broad work elements that contribute to science for adaptive management and restoration (fig. 3). The elements include:

- **Historical Studies of the Ecosystem**—The objective of historical studies is to better define recent (last few hundred years) climatic and environmental conditions in south Florida. Techniques include review of historical records and analysis of sediment cores by using charcoal, pollen, spores, and invertebrate skeletons as indicators of past environments. Results from these studies help managers define goals for restoration based on predevelopment conditions.
- **Areal/Site Studies**—Multidisciplinary studies, which are confined to specific areas or sites such as Florida Bay, Biscayne Bay, and the southern inland coastal systems in southern and eastern Dade County, provide biologic, cartographic, geologic, and hydrologic information that focuses on the needs associated with restoration activities.
- **Geochemical Process Research**—Research on the biological and chemical processes that affect and control the cycling of nutrients, sulfur, mercury, and other contaminants improves understanding of the south Florida ecosystem and its response to restoration activities.
- **Model Development**—Robust models of ecological processes and the hydrologic system provide predictive capabilities for managers of the ecosystem and improve understanding of probable ecosystem responses to restoration activities. Development and applications of models of sheetflow, ground-water movement, evapotranspiration in different vegetative communities, and ecological interactions are all underway.
- **Data Synthesis and Information Dissemination**—Topical syntheses will analyze, summarize, and integrate USGS research and understanding, and describe the relevance of this research to management issues. Synthesis is also planned at the interagency level, incorporating multidisciplinary information collected by all agencies involved in south Florida restoration. The USGS World Wide Web site, **http://sflwww.er.usgs.gov** (fig. 5) allows easy access to program information by the public, interested scientists, and resource managers. The web site includes access to scientific data and metadata, information on current projects and investigators, and reports.

Hydrologic Exchange of Surface Water and Ground Water and Its Relation to Surface Water Budgets and Water Quality in the Everglades

By Judson W. Harvey[1], Steven L. Krupa[2], Jungyill Choi[1], Cynthia Gefvert[1], Robert H. Mooney[3], Paul F. Schuster[4], Ann L. Bates[1], Susan A. King[5], Michael M. Reddy[4], William H. Orem[1], David P. Krabbenhoft[5], and Larry E. Fink[2]

Concerns about the flow and chemical quality of water in the Everglades have opened new discussion on how best to manage the conveyance of surface water through this ecosystem. Plans call for improving chemical quality of water entering the compartmentalized basins of the north and central Everglades, called Water Conservation Areas (WCA's), as well as maintaining surface flows through WCA's to Everglades National Park. Several restoration efforts are already underway, including the construction of large constructed wetlands called Stormwater Treatment Areas (STA's) at the northern terminus of the Everglades to intercept agricultural drainage and to remove excess nutrients. Evaluating the success of ongoing restoration efforts and planning for future restorations depends on reliable hydrologic information, including a better understanding of the role of interactions between surface water and ground water. The purpose of the present project is to (1) quantify hydrologic fluxes between surface water and ground water in areas where limited prior information exists, and (2) use new estimates of hydrologic fluxes to improve the accuracy of hydrologic budgets and chemical mass balances for constituents such as mercury, sulfate, and nutrients. Investigations are underway in three principal areas. The first area is the 4,000-acre Everglades Nutrient Removal (ENR) area, a prototype STA; the second area is WCA-2A, a 105,000-acre basin with a long history of accumulating excess nutrients; and the third area is central Taylor Slough, where the goal of ongoing restoration efforts is to maintain southerly flows through the slough to Florida Bay while protecting chemical quality and increasing flood protection for the agricultural and residential areas to the east of the Park. The main users of the data are the Everglades Restoration Department and Planning Department of SFWMD (South Florida Water Management District).

Our findings are summarized below:

1. Management of water levels in the compartmentalized WCA's has enhanced interactions between surface water and ground water by establishing and maintaining water-level differences across levees that drive substantial underflow beneath the levee through the permeable limestone of the surficial aquifer. We know from published work that water fluxes are significant through the permeable bottoms of canals immediately adjacent to levees, but our results are some of the first to indicate significant fluxes through the less-permeable wetland peat. Although lower in magnitude than hydrologic fluxes through canal bottoms, vertical fluxes through peat are important because they occur over a much larger area of the wetlands, extending miles from the levee. For example, the relatively high water levels that are maintained in WCA-1 drive ground-water flow under the L-7 and Hillsboro levees and upward into the eastern part of the ENR and the northern part of WCA-2A, respectively. Downward flow occurs in central and western ENR, central and eastern WCA-2B, and central WCA-2A.

2. In addition to man's influence on interaction of surface water and ground water, another major control is the distribution of transmissive and restrictive zones for ground-water flow in the aquifer. A limestone layer near the top of the surficial aquifer is the main conduit that links recharge areas in WCA-1 with discharge areas in the ENR and WCA-2A. The transmissive limestone layer is located

between +10 and -30 feet NGVD (1929 National Geodetic Vertical Datum) and has horizontal hydraulic conductivities ranging between 150 cm/d (centimeters per day) in the denser parts of the limestone to greater than 6500 cm/d in well-indurated parts. Underlying the limestone is coarse sand to -70 feet NGVD grading to fine sand at the base of the surficial aquifer at -180 feet NGVD. Horizontal hydraulic conductivities in sands range from 30 cm/d in the fine sands to greater than 6,500 cm/d in the coarsest sands. At the top of the surficial aquifer is 2 to 4 feet of organic wetland sediment (peat) that acts as a hydraulically restricting layer that impedes vertical flow. The median estimate of vertical hydraulic conductivity of peat in northern Everglades sites was 17 cm/d, which is similar to that of a very fine sand, but lower by several orders of magnitude lower than hydraulic conductivities of the limestone and sand aquifer that underlies the peat.

3. Measured vertical fluxes through peat in the northern Everglades ranged from less than 0.04 cm/d (detection limit) to 10 cm/d, which, at the upper limit, is more than an order of magnitude higher than average daily precipitation or evapotranspiration (approximately 0.5 cm/d). Fluxes generally decreased with distance from levees toward central areas of the compartmentalized WCA's, where the direction and magnitude of vertical fluxes responds more to regional influences. The net, long-term interaction between ground water and surface water in the WCA's appears to be a small downward flux from surface water to ground water. The net downward flux is most likely a response to the long-term effect of storing water and maintaining relatively high water levels within the WCA's. Outside the Everglades, water levels have tended to decline over the past 50 to 80 years due to ground-water withdrawals and subsidence in some areas.

4. Vertical hydrologic fluxes between surface water and ground water were determined by direct measurements using seepage meters and indirect estimates based on modeling of vertical transport of chloride in peat. Neither measurement technique worked at all study sites. Seepage-meters were most reliable at sites where vertical hydraulic gradients in the peat were greater than 0.1. The average uncertainty of vertical flux estimates determined from replicate seepage-meter measurements was 50 percent. Modeling vertical transport of chloride in porewater to estimate hydrologic fluxes was generally a less reliable technique, due to difficulties in specifying fluctuations in chloride concentrations in surface water for the upper boundary condition. Currently we are quantifying the role of vertical hydrologic fluxes as sources and sinks for sulfate and mercury in WCA-2A and ENR, respectively.

5. Surface flow in Taylor Slough in the eastern part of Everglades National Park is augmented by surface water and shallow ground-water flowing southeasterly from the pine islands into Taylor Slough. Some of the southerly flow of water becomes ponded behind the Old Ingraham Highway, but there is clear evidence that at all times of the year a substantial amount of water flows beneath the highway through the porous road bed and aquifer, emerging in Taylor Slough. A historical canal usually referred to as the Rookery Canal also plays a role in distributing the shallow drainage across Taylor Slough. Environmental chemical tracers are being used to estimate the volumetric rate of ground-water inflow to Taylor Slough.

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