

Global Climate Change in Everglades National Park

South Florida Research Center
Everglades National Park, Florida
United States of America

Report of an Internship

by Twan Rosmalen
Loek Stalpers

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Department of Watermanagement
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1 Introduction

An internship (practical training) of three months is an obligatory part of the study program "Cultuurtechniek" (Land and Water Use) of the Agricultural University Wageningen, the Netherlands.

After some discussion with Eric Westein (also student Land and Water Use of A.U.W.), who did his practical training at the Research Center of Everglades National Park (National Park Service), we decided to write a letter to Gordon Anderson of the Research Center and to ask for possibilities to do our practical training in the Everglades.

This is the report of our practical training period which took place from may 1993 until august 1993 at the Research Center. It contains some general information about the National Park Service (section 2), the South Florida Research Center (section 3) and the Everglades (section 4). In section 5 the activities during our stay are discussed as well as the larger framework in which these activities fit.

2 The National Park Service

The National Park Service is a bureau of the U.S. Department of the Interior. Created in 1916, its mandate is to preserve, protect and manage the natural, cultural, historical and recreational areas of the National Park System. Through a variety of programs, the National Park Service accomplishes two primary functions:

- * to conserve natural and cultural resources
- * to provide the public with recreation, inspiration and educational experience

3 South Florida Research Center

3.1 Organisation of the South Florida Research Center (basic functions)

Everglades National Park is engaged, through its work, in the conservation of its natural ecosystems where humans represent a significant ecological element. Goals for the research program are designed to complement and support research, monitoring and resource management.

The South Florida Research Center (SFRC) is structured to reflect Everglades' functions and inter-relationships. The SFRC addresses long-term issues of water resources, adjacent urban development, exotic species control, restoration of wildlife and vegetation on regional, ecosystem and biological community levels. This includes additional basic research on fire effects on pinelands, wetland productivity, water-delivery impacts on the hydrology of wetlands and the downstream estuaries, the production of a park-wide vegetation map and establishment of contaminants monitoring. Resource management support is available to deal effectively with long-term issues such as exotic vegetation and recreational fishing impacts, as well as assessments of proposals that could impact the system. In-house modelling expertise is being developed to better simulate the dynamics of key species and community interactions and will facilitate effective restoration efforts. The SFRC concentrates its efforts in addressing these research needs within four basic functions - best carried out by four programs:

- 1) Inventory and Monitoring,
- 2) Data Management and GIS Applications,
- 3) Ecosystem Research and Modelling, and
- 4) Resource Management and Science Applications.

The Inventory and Monitoring group provides data for hypothesis testing, model development, model verification and trend assessment. The priorities and protocols for long-term monitoring will be determined through consultation with the other programs.

The Data Management and GIS Applications group receives all inventory and monitoring data and provides the relational framework, including spatial array (GIS), so that the data can be used by SFRC scientists.

The Ecosystems Research and Modelling group conducts field research and tests hypotheses. Modelling is the inevitable methodology for making impact assessments or for evaluating restoration alternatives for Everglades National Park.

The Resource Management and Science Applications group translates information into action. This group implements and directs resource

management activities and coordinates program activities with other SFRC programs and park divisions.

The SFRC also maintains scientific collections and archives. All cultural and natural artifacts are maintained to Park Service standards for reference and specimen collections.

3.2 Organisation of SFRC based on different disciplines

The following staff place various aspects of their studies under their appropriate group:

- 1) hydrological staff
- 2) marine research staff
- 3) vegetation staff
- 4) data management staff

The role of the hydrological staff is to provide professional expertise and research and management capabilities to address a broad scope of area-wide hydrological issues including surface water deliveries, water quality, groundwater impacts, canal diversions, municipal wellfield development and agricultural influences.

The role of the marine research staff is to provide professional expertise and research and management capabilities to address a broad scope of coastal and marine management issues including such factors as upland runoff effects on park estuarine ecosystems, boater impacts, fisheries harvests and resource impacts, oil spill contingency plans and protection of endangered marine species.

The role of the vegetation staff is to provide professional expertise and research and management capabilities to develop a basic understanding of Everglades plant ecology sufficient to address the full range of vegetation management issues including such factors as hydrological effects on community composition and plant productivity, nutrient uptake, storage and cycling abilities and processes, long term vegetational changes, exotic plant research and management, visitation impacts on vegetation, fire history, fire effects and prescribed fire needs and rare plant studies.

The role of the wildlife staff is to provide professional expertise and research and management capabilities to address a broad scope of freshwater fish, invertebrate and wildlife issues such factors as population status and dynamics of important wildlife species (e.g. wading birds, alligators, deer), endangered species monitoring and management, impacts of hydrological alterations on park fauna and habitat needs, aircraft overflight impacts, visitor activity impacts, factors influencing nesting success of wading birds, control of exotic species and control of problem wildlife.

The role of the data management staff is to provide technical support to the SFRC, as well as to other park divisions and administrative staff. This group is responsible for maintaining GIS and database management computer facilities and research and resource management data archives.

4 Everglades National Park

Everglades National Park is situated in the most southern part of Florida. The 1.4-million-acre park encompasses only about one-seventh of the area that comprises the entire Everglades. The park is famous for its wildlife, such as alligators, turtles, panthers and many wading birds. The term Everglades refers to the vast system of marshes, sloughs, tree islands and cypress forests that historically covered most of southeastern Florida. Nowadays only a small part of Florida consists of this type of vegetation and the most southern part is preserved in the Everglades National Park. Everglades National Park is made up of vast saw-grass prairies, deep mangrove swamps, subtropical jungle, and the warm waters of Florida Bay.

The Florida peninsula is a great flat sponge of porous limestone. This sedimentary rock derived from the shells and skeletons of animals was deposited in the warm seas that covered Florida during recent glacial periods. The limestone consists mostly of calcium carbonate. Over the limestone only a thin mantle of marl and peat provides soil for rooting plants. Soluble in water having a slight degree of acidity, it is often characterized by caverns, and in the Everglades, by a very pitted surface (pinacle rock). The rock underlying the park is called Miami Oölite. Oölite limestone is composed of tiny round concretions, only indirectly derived from marine shells. The limestone is holding a huge volume of fresh groundwater.

Both coasts of south Florida are slightly elevated and the great trough of the Everglades acts as a broad, shallow, grass-clogged river from Lake Okeechobee to the sea (see figure 1). The natural drainage of the Everglades has been altered by canals, mostly dug from 1905-1960. Less water from the northern Everglades now enters the park. Growing agriculture and urban water usage places increased demands on the finite quantity of water in the Park, making it more difficult to maintain the wetlands ecosystem. Apart from problems caused by the changed water quantity, there is the degradation of the waterquality due to the discharge of agricultural and urban runoff into the wetlands. The drainage (and withdrawal of groundwater) also resulted in intrusion of salt water into aquifers and an increase of wildfires.

Salt water intrusion can take place in two more or less different ways:

- 1) Intrusion via surface water
- 2) Intrusion via groundwater

Studying the extent of intrusion of salt water caused by the rising of the sea and the impacts on the Everglades is one of the subjects in the framework of the Global Climate Change research program (GCC). In the next chapter the GCC program in general and our contribution to it for Everglades National Park, will be discussed.

5 NPS Global Change Research Program (GCC)

5.1 Why study Global Change in National Parks

In recognition of the ecological, economic and social implications of global change, the Working Group on Global Change of the Committee on Earth and Environmental Sciences has instituted a comprehensive research program. The focus is on seven scientific areas:

- ecological systems and dynamics,
- earth system history,
- biogeochemical dynamics,
- solid earth processes,
- climate and hydrologic systems,
- human interactions and
- solar influences.

The National Park Service contributes substantially to the national program through active research in the first five of these areas.

In order to understand and predict the potential impacts of global change, scientists need to study different geographic areas on the ecosystem, landscape, regional and global levels. National parks are ideal laboratories in which to study global change because of their diversity and their comparatively well-preserved ecosystems. Units of the National Park Service (NPS) were established to preserve their natural and cultural resources unimpaired for future generations. Consequently, this system of relatively undisturbed areas across the nation is ideal for the long-term ecological research necessary to study global change and its effects at various scales. National parks contain portions of representative ecosystems in each of the major biogeographic areas of the United States. Furthermore, many parks have site-specific, long term natural resource data sets that provide the historical framework necessary to interpret existing conditions and predict changes.

Altogether, the NPS global-change network consists of 20 biogeographic areas (including 63-plus NPS units) representing all of the United States' major biomes, and three thematic initiatives (involving 15-plus additional units).

Florida has 4 biogeographic areas within its borders including 6 - plus NPS units. These are listed in table 1.

biogeographic area	NPS unit	status
Gulf Coast Plain	Big Cypress	National Preserve
Coastal Barriers	Canaveral	National Seashore
South Florida	Big Cypress	National Preserve
	Everglades	National Park
Coral Reefs	Biscayne	National Park
	Fort Jefferson	National Monument

Table 1: Biogeographic areas and NPS units in Florida (GCC-program)

5.2 Global Change in South Florida

Covering more than two million acres, Everglades National Park and Big Cypress National Preserve contain the largest remaining subtropical wilderness in the contiguous United States. Extensive wetlands range from saline mangrove forests to freshwater cypress swamps and sawgrass marshes.

These south Florida ecosystems lie within a few meters of sea level. Small changes in global temperature, with corresponding sea level rises, may have dramatic effects. They might inundate freshwater areas and lands near sea level with salt water, dramatically altering the hydrologic balance and delicate ecosystems of the Everglades and Big Cypress. The growing population along the edges of the system depends on water supply from the freshwater wetlands. These conditions make these south Florida NPS units ideal for the study of global change. Global-change research may help determine how to manage the fragile relationship between humans and nature in coastal environments.

The low-lying coastal wetlands of south Florida are threatened with rapid and extensive degradation by the changes projected for sea level and climate in the next forty years. Everglades National Park focuses on changes to be expected along the inland boundary of the mangrove fringe, where mangroves give way to the freshwater marshes of the Everglades. The working hypothesis is that changes here will be driven by modification in local hydrologic conditions, such as hydroperiod and salinity. This hypothesis will be tested through a two step approach. First, field studies of hydrology in the vicinity of the mangrove/marsh ecotone will be conducted, to establish what hydrologic conditions control the transition from mangrove to freshwater marsh. Second, a model of the coastal hydrology along the south Florida coast will be formulated and

calibrated to relate changes in sea level and climate to changes in local hydrologic conditions that affect the vegetation. Through this approach it will be possible to quantify the sensitivity of the vegetation in the vicinity of the mangrove/marsh ecotone to changes associated with the coastal hydrology and it will be possible to project the effects of future sea level and climate scenarios [Nuttall W.K. and Cosby, B.J.]

The hydrologic model will be setup first for transect nr. 1 (see figure 2) and later (when data are available) calibrated and verified with help of data of the transects nr. 2, 3 and 4.

The objective of the first phase of study with the hydrologic model is to assess the relative influence of atmospheric water fluxes, surface and groundwater discharged into the Everglades Park from South Florida Water Management District facilities and fluctuations in sea level on local hydrologic conditions. A one dimensional, finite difference model is being constructed for this purpose. The model is based on a single water balance equation that combines surface water flow and horizontal groundwaterflow into a single flux. It is assumed that both subsurface flow and surface flow through vegetation are adequately represented by a linear function of the slope of free surface multiplied by a "conductance" coefficient. Further, it is assumed that percolation through the soil and into the aquifer is instantaneous and that vertical head gradients are zero; these assumptions are defensible on the grounds of the large spatial scale of the model and the multi-decade period of simulations. Changes in the depth of surface water, including periodic drying of the surface, are handled by making both the conductance and the storage coefficient functions of water depth [Nuttall, 1989].

5.3 Monitoring stations in the coastal mangrove forests

To achieve the goals as described in the previous section, 15 monitoring stations will be placed at the west coast of Everglades National Park. The objectives for the hydrologic monitoring stations are:

- 1) to collect essentially continuous records of depth of surface water and hydraulic head in the underlying limestone aquifer and
- 2) monitor changes in salinity in the soil and in the limestone aquifer.

Each monitoring station will consist of a well for monitoring surface water levels and elevation of the water table in the soil, a piezometer for measuring hydraulic head in the limestone aquifer and two sampling tubes for salinity measurements in the soil.

The water table well will be cased with slotted casing through the full depth of the soil profile and the bottom of the well will be sealed where it meets the interface with the limestone.

The piezometer will be drilled by coring 3 feet (1 meter) into the limestone. The limestone core will be retained. The piezometer will be lined with a casing screened only over the bottom 1 foot (33 cm.), and the hole will be backfilled with sand to above the screen then with bentonite to the surface.

Water sampling tubes will be constructed of pvc tubes, screened only at the bottom and augered to 1 foot below the surface and just above the soil/limestone interface. The tubes will be backfilled with sand around the screens, then sealed to the surface.

Each station will be equipped with a Campbell datalogger to record water levels and salinities. Water table levels and water levels in the piezometer will be measured with a float and pulley system or other appropriate device. Salinities will be measured for water samples pumped from the piezometer and the two soil water sampling tubes. Salinity measurements will be made using a salinity sensor and a device to sequentially pump water from the three sample locations.

Each transect will consist of at least four hydrologic monitoring stations, two in mangroves and two in the sawgrass marsh. One station on each transect will have a raingage. Also a deep piezometer will be installed at one of the inland, marsh stations on each transect to try to locate the position of the fresh-saline interface in the limestone aquifer. This deep piezometer will be constructed in a way to allow water samples for salinity measurements to be taken near the upper surface of the limestone aquifer and at the bottom of the piezometer.

5.4 Activities during our stay

During our stay at the South Florida Research Center we mainly worked for the GCC project. With our supervisor Gordon Anderson we made a start with 11 of 15 stations as described in the previous section. The locations are denoted in figure 2 (c1, c2, c3, 11, 12, 13, 14, s1, s2, s3, s4). "Making a start" consisted of the following:

- * preparing field-trips
- * transportation to the sites
- * finding appropriate locations in the field to built the stations
- * basically building the stations

Transportation to the sites was the most difficult task by far, because of the fact that heavy materials and heavy equipment had to be moved to and through rather inaccessible, remote areas. As a result of the isolation and remoteness, as well as the heat, thunderstorms and mosquitos, it wasn't always easy to get the job done. Even after flipping a boat, an overnight stay in the mangroves and a swimming game with alligators to reach the "normal" world we continued and finished 11 stations.

Literature

Craighead George, Jean (1988). Everglades Wildguide, Handbook 143 of the National Park Service. Department of the Interior, Washington D.C.

Nuttall, W.K. 1989. Comment on "A model for wetland surface water dynamics" by D.E. Hammer and R.H. Kadlec. Water Resources Research 25:1060-1062

South Florida Research Center, Orientation.

Appendix 1

Personal Notes

However they say that the summertime is not the best season to visit South Florida, my stay there has been a very pleasant one. The Everglades really is an impressive area. I've learned more about animals, plants and trees than I ever did before. The work I've done was sometimes hard but I am sure I will never forget the feel and bite of the mangrove forests. I want to thank Gordon "Watson" Anderson for his supervising activities and making it possible for me to come and enjoy the Everglades.

Loek Stalpers
July 1993

Appendix II

Personal notes

Experiencing the Everglades National Park has been a real adventure for me. Working in this area with the mosquitos and the burning sun has not always been easy, but the beauty of the Everglades makes it all worthwhile. The fishlife of Florida Bay, the alligator nests in the Shark River Slough and the mosquitos in the mangroves of Johnson's Creek are things that I will remember all my life. I like to thank Gordon "Captain" Watson for making all this possible for us.

Twan Rosmalen
July 1993