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## FCE II Year One Annual Report for NSF Award DBI-0620409 (2007)

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FCE II YEAR ONE  
ANNUAL REPORT FOR NSF AWARD DBI-0620409

FLORIDA COASTAL EVERGLADES LTER  
Florida International University

Submitted October 2007

Principal Investigators

Evelyn Gaiser  
Mike Heithaus  
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# **I. PARTICIPANTS**

## **A. PARTICIPANT INDIVIDUALS**

### **Principal Investigators:**

Evelyn Gaiser

### **Co Principal Investigators:**

Mike Heithaus, Rudolf Jaffé, René Price

### **Senior personnel:**

William Anderson, Anna Armitage, Mahadev Bhat, Joseph Boyer, Henry Briceno, Randolph Chambers, Daniel Childers, Ligia Collado-Vides, Tim Collins, Carlos Coronado, Susan Dailey, Stephen Davis, Frank Dazzo, Bob Doren, Vic Engel, Sharon Ewe, Jack Fell, Carl Fitz, James Fourqurean, Jose Fuentes, Jennifer Gebelein, Hugh Gladwin, Anne Hartley, Gail Hollander, Krish Jayachandaran, Lynn Leonard, Julie Lockwood, William Loftus, Jerome Lorenz, Christopher Madden, Melissa Memory, Greg Noe, Steve Oberbauer, Laura Ogden, Tom Philippi, Mark Rains, Jenny Richards, Victor H. Rivera-Monroy, Mike Robblee, Michael Ross, Rinku Roy Chowdhury, Dave Rudnick, Colin Saunders, Margo Schwadron, Len Scinto, Marc Simard, Fred Sklar, Ned Smith, Helena Solo-Gabriele, Gregory Starr, Serge Thomas, Joel Trexler, Tiffany Troxler-Gann, Robert Twilley, Kevin Whelan, Joseph Zieman

### **Post-docs:**

Tom Frankovich, Robinson Fulweiler, Jay Sah, Tiffany Troxler-Gann, Jeff Wozniak, Yunping Xu, Youhei Yamashita

### **Graduate students:**

Jose Bazante, Robin Bennett, Edward Castaneda, Meilian Chen, Josh Cloutier, Bryan Delius, Kim de Mutsert, Kendra Dowell, Katherine Dunlop, Sam Evans, Min Gao, David Green, Rebecca Garvoille, Patrick Gibson, Daniel Gomez, Noemi Gonzalez-Ramirez, Erin Hanan, Kelly Henry, David Iwaniec, Greg Koch, Josette La Hee, Michael Laas, Laurel Larsen, Lauren McCarthy, Danielle Mir-Gonzalez, Ron Mossman, Jay Munyon, Amy Omae, Oliva Pisani, Amanda Quillen, David Reed, Adam Rosenblatt, Clifton Ruehl, Michelle Sanchez, Rahul Shrivastava, Travis Thyberg, Matthew Toro, Matt Tymchak, Raul Urgelles, Ania Wachnicka, Clayton Williams, Xavier Zapata

### **Research Experience for Undergraduates:**

Ashley Bulp, Tatiana Marquez, Regina Perry, Jeremy Gifford, Kardi Greaves, Jennifer Stine, Natalie Basma Naassan

### **Undergraduate students:**

Ashley Bulp, Roger Lopez, Greg Losada, Carrie Rebenack, Srikumar Roy, Mary White

### **Pre-college teachers:**

Nicolas Oehm, Teresa Casal, Carlos Escobar

### **High school students:**

Brian Aguilar; Nia Brisbane; Sara Claro; Magaly Dacosta; Jorge Delase; Sebastian Diaz; Rebecca Fonseca; Ben Giraldo; Oscar Marti ; Christopher Sanchez

**Technician, programmers:**

Robin Bennett, Daniel Bond, Michelle Calvo, Alex Croft, Kevin Cunniff, Amanda Dean, Lisa Giles, Chuck Goss, Imrul Hack, Steve Kelly, Mark Kershaw, Greg Losada, Amanda McDonald, Jennifer Mellein, Alaina Owens, Linda Powell, Damon Rondeau, Mike Rugge, Pablo Ruiz, Timothy Russell, Kristy Sabo, Brooke Shamblin, Adele Tallman, Christine Taylor, Franco Tobias, Rafael Travieso, Josh Walters

**B. PARTNER ORGANIZATIONS**

- College of William & Mary: Collaborative Research; Personnel Exchanges
- Ecology and Environment, Inc.: Collaborative Research; Personnel Exchanges
- Everglades National Park: Collaborative Research; Personnel Exchanges
- Florida Gulf Coast University: Collaborative Research; Personnel Exchanges
- Harbor Branch Oceanographic Institute: Collaborative Research
- Louisiana State University: Collaborative Research; Personnel Exchanges
- Miami-Dade County Public Schools: Collaborative Research; Personnel Exchanges  
Two of our Education and Outreach coordinators (Susan Dailey and Nick Oehm) have taught and given FCE LTER presentations at Miami-Dade County Public Schools. Our Research Experience for Teachers (RET) and Research Experience for Secondary Students (RESSt) programs have included teachers and students from Miami-Dade County Public schools.
- Michigan State University: Collaborative Research; Personnel Exchanges
- National Aeronautics and Space Administration: Collaborative Research; Personnel Exchanges
- National Audubon Society: Collaborative Research; Personnel Exchanges
- Nova Southeastern University Oceanographic Center: Collaborative Research; Personnel Exchanges
- Rutgers University New Brunswick: Collaborative Research
- South Florida Water Management District: Financial Support; In-kind Support; Collaborative Research
- Texas A&M University Main Campus: Collaborative Research; Personnel Exchanges  
Collaborations with Stephen Davis.
- Texas A&M University at Galveston: Collaborative Research; Personnel Exchanges
- U.S. Department of the Interior: In-kind Support; Facilities; Collaborative Research
- Department of Interior U.S. Geological Survey: In-kind Support; Collaborative Research
- University of Alabama: Collaborative Research; Personnel Exchanges
- University of Colorado: Collaborative Research; Personnel Exchanges
- University of Florida: Collaborative Research; Personnel Exchanges
- University of Miami: Collaborative Research; Personnel Exchanges
- University of Miami Rosenstiel School of Marine & Atmospheric Science: Collaborative Research; Personnel Exchanges  
Jack Fell through a separately funded NSF grant.

- University of North Carolina at Chapel Hill: Collaborative Research; Personnel Exchanges
- University of North Carolina at Wilmington: Collaborative Research; Personnel Exchanges
- University of South Florida: Collaborative Research; Personnel Exchanges
- University of Virginia: Collaborative Research; Personnel Exchanges

### **C. OTHER COLLABORATORS**

We have maintained important collaborative partnerships with 5 federal agencies (Everglades National Park, USGS, NOAA, EPA, and NASA-JPL) during the first year of the FCE II LTER Program. We also partner with 1 state agency (South Florida Water Management District), 1 NGO (National Audubon Society), and 15 other universities (Louisiana State University, College of William & Mary, and Texas A&M University through subcontracts).

Examples of specific collaborations include:

- FCE Education and Outreach has maintained its relationships with Miami Dade County Public Schools (MDCPS) and Miami Dade College (MDC). Both MDCPS and MDC students receive frequent lectures and a variety of curriculum materials from our Education and Outreach Coordinator and frequently serve as the testing grounds for many of our products.
- At the present time, FCE Education and Outreach is awaiting decisions on two different proposals. The first proposal lists FCE as collaborator in an NSF ITEST proposal with Dr. Ali Whitmer of Santa Barbara Coastal LTER. As proposed, FCE will host one three GIS workshops for K-12 teachers along with SBC LTER and VCR LTER. In our second proposal, Ft. Lauderdale Museum of Discovery and Science will use FCE in developing International Polar Year activities.
- Dr. Adelwale Alonge has been consulting FCE in developing his Japanese Fullbright project in comparing Japanese wetlands with the Florida Everglades. Dr. Alonge will implement his project with students at Homestead Middle School and at a companion school in Japan.
- Linda Amaral-Zettler at International Census of Marine Microbiology, (ICoMM) ([icomm.mbl.edu](http://icomm.mbl.edu)), Marine Biological Laboratory. Received NSF funding to support massively-parallel, 454-based tag sequencing strategy that allows extensive sampling of marine microbial populations (PNAS 103: 32 p. 12115-12120). Strategy based on sequencing of hypervariable regions of the SSU rRNA gene allows measurement of both relative abundance and diversity of dominant and rare members of the microbial community thereby allowing efficient comparison of the structure of microbial populations in marine systems. This will be started this fall on aquatic component at 4 sites in FCE during wet and dry season.

- Linda Amaral-Zettler at International Census of Marine Microbiology, (ICoMM) (icomm.mbl.edu), Marine Biological Laboratory. Funding from the W.M. Keck Foundation to established a facility for generating V-6 tag rRNA gene sequences from Bacteria and Archaea. Sequencing of microbial eukaryotes will be forthcoming upon the upgrade of our 454 pyrosequencing machine slated for Spring 2007. Slated to sample sediments from 8 sites in FCE next spring.
- Colin Saunders continued a collaboration with Dr. Deborah Willard (USGS, Reston, VA), Dr. Christopher Craft (Indiana University), Dr. Jason Lynch (North Central College), Dr. Brian Beckage (University of Vermont), Drs. Susan Newman and Shili Miao (South Florida Water Management District) on a paleoecological research project to characterize pre-drainage conditions within Everglades National Park.
- Sharon Ewe began a collaboration with FCE LTER colleagues (Jennifer Richards, Colin Saunders, Tiffany Troxler) started a collaboration with Dr. Vic Engel (Everglades National Park) to apply physiological and paleoecological research to quantify vegetation changes in the mangrove ecotone of Taylor Slough. This will also involve future collaboration and coordination with ecotone research currently conducted by SFWMD and other FCE LTER personnel.

## II. ACTIVITIES AND FINDINGS

### A. RESEARCH AND EDUCATION ACTIVITIES

The second phase of Florida Coastal Everglades (FCE) research (FCE II) focuses on understanding how dissolved organic matter (DOM) from upstream oligotrophic marshes interacts with a marine source of phosphorus, the limiting nutrient, to control estuarine productivity in the estuarine ecotone. Our 15 research sites are located along freshwater to marine transects in the Shark River Slough (SRS), and the Taylor Slough/Panhandle (TS/Ph) regions of Everglades National Park. FCE II research is organized into 5 working groups (Primary Production, Organic Matter Dynamics, Biogeochemical Cycling, Trophic Dynamics and Community Structure, Hydrology) and 3 cross-cutting themes (Human Dimensions, Climate and Disturbance, Modelling and Synthesis). Although most of these groups existed during FCE I, the Hydrology, Human Dimensions, and Climate and Disturbance groups were established during the first year of FCE II. We've included summaries of the first year of FCE II working groups, cross-cutting theme groups, education, and information management activities below.

#### 1. Primary Production

##### *Periphyton*

We continue to measure periphyton biomass and composition among sites in the FCE LTER. We are interpreting long-term trends in relation to those gathered from joint large-scale monitoring projects in the Everglades and Florida Bay. These data are being combined into models that predict changes in periphyton biomass, composition and nutrient content from hydrologic, water chemistry and other abiotic and biotic variables. The National Park Service has recently contracted with Gaiser to support a post-doctoral associate to interface with the FCE LTER and SFWMD in order to join the growing databases and develop more spatially explicit

predictive models. Current models are being tested experimentally, including two graduate student projects occurring at or near FCE sites that investigate interactions of hydrology, light, nutrients, vegetation and consumers in controlling periphyton production. Laboratory experiments conducted in chemostats are ongoing to determine causes for the negative relationships of periphyton production to nutrient availability observed at FCE sites. A new grant from DOE (NCCR) will be manipulating periphyton and plant production to determine controls on CO<sub>2</sub> sequestration or evasion in peat and marl-forming environments, and these findings will be interpreted with respect to atmospheric eddy covariance data obtained from two new flux towers supported off this grant (to new FCE collaborator Steve Oberbauer). ILTER-supported comparisons of periphyton in the FCE to that of similar wetlands in the Yucatan peninsula and Belize are revealing similar very high production rates by compositionally identical communities, suggesting unusual patterns observed in the FCE are not unique to the Everglades but more broadly representative of subtropical, calcareous wetlands. Paleocological investigations interpreting rates of change from fossil periphyton assemblages are ongoing in the Everglades, Florida and Biscayne Bays and have been useful in interpreting fluctuations in modern FCE datasets.

### *Seagrass ecosystems*

We continue to assess primary production of the seagrass ecosystems in the FCE-LTER domain every 2 months. On these trips, we have been measuring seagrass leaf productivity using standard hole punch methods and periphyton productivity as described above since 2000. This year, we initiated measurements of below-ground production of seagrasses, as well as macroalgal production. In addition to the monitoring, we concluded a couple of experiments on controls of primary production. A 1.5 year study of the effects of manipulation of sediment iron and organic matter on seagrass productivity was completed, and the results of that study are now in press (Ruiz-Halpern et al, in press). We also concluded a study of the impacts of resting schools of fish on nutrient availability and primary production of seagrasses; this study formed a student's MS thesis (Dewsbury 2006) and is being prepared for publication. We also completed surveys of the biomass, species composition and elemental and isotopic composition of benthic plants from the Shark River, this MS thesis (Cornett 2006) is also being reworked for publication.

We initiated a new study of the effects of fertilization on ecosystem function 20 years after the fertilization had been discontinued, building on the experiments of Fourqurean Powell and others (Powell et al 1989, Fourqurean et al 1995). We also continued to support a study of the dynamics of submerged vegetation in the mangrove-lined embayments of northern Florida Bay. This study was funded by Everglades National Park in collaboration with the FECE-LTER. We also began a new Everglades-funded project examining the long-term effects of fertilization and freshwater delivery on Florida Bay seagrass beds using experimental manipulations very near the FCE-LTER focal monitoring sites in Florida Bay.

### *Mangroves*

We continue monitoring mangrove litter dynamics in three mangrove sites (SRS4, SRS5, SRS6) along the freshwater-estuarine fertility gradient of the Shark River estuary. Litterfall was collected in 0.25 m<sup>2</sup> wooden baskets supported approximately 1.5 m aboveground, and the bottom of each basket was constructed of fiberglass screening (1 mm mesh). Litterfall has been collected monthly since January 2001. In each mangrove site ten litter baskets were placed systematically in two 20 by 20 m permanent plots (5 baskets per plot). Plant material within each basket is dried for 72 h at 60 °C. Material is separated into leaves, fruits, flowers, stipules, wood,



and miscellaneous and weighed to within 0.1 g. Litter fall rates of each component is expressed in  $\text{g m}^{-2} \text{ day}^{-1}$ . In addition, we continue our soil biogeochemical properties monitoring program along the Shark River estuary to understand the factors controlling patterns of primary productivity in mangrove forests.

## **2. Organic Matter Dynamics**

### *Dissolved organic matter (DOM) studies*

We have wrapped up several on-going LTER-1 sub-projects dealing with the characterization of DOM in the Everglades. These studies are primarily based on the application of optical parameters to characterize and determine environmental dynamics of DOM in the FCE and are discussed below in the ‘findings’ section. In addition, we have continued the monthly monitoring of DOM at all active FCE-LTER sites using optical properties, including Excitation Emission Matrices (EEM or 3D fluorescence) in combination with parallel factor analysis (PARAFAC). Thus we have now completed a three year survey, and are processing the data. This activity is expected to continue throughout the LTER-2 period, generating an eight year long continuous database on DOM dynamics.

To better define DOM end-member components as defined by EEM-PARAFAC, we have started analyzing biomass leachates from the main aquatic vegetation in the Everglades (sawgrass, spikerush, mangroves, periphyton and seagrass) and have exposed these to solar simulation and biodegradation. This project will expand to real, surface water DOM (i.e. photo- and bio-degradation studies) as well as for soil leachates. As part of this end-member characterization study, we are in the process of analyzing DOM in groundwater samples using the EEM-PARAFAC technique. Thus far we have been able to clearly distinguish between surface and ground water DOM, and are trying to determine the possible differences between oxic and anoxic groundwater DOM components.

### *Particulate (POC) and soil organic matter*

We have wrapped up three on-going LTER-1 sub-projects dealing with the origin, fate and transport of particulate and sedimentary OM in the Everglades. These studies are all based on molecular marker analyses (biomarkers, lipids) and are discussed in the ‘findings’ section shown below. The work on OM source characterization of ‘floc’ has been expanded to include a seasonal component as well as periphyton characterizations using biomarkers (lipid fingerprints) and pigments (for chemotaxonomy).

We also continue to work on the paleo-environmental aspects of Everglades’ freshwater wetlands and mangrove swamps, where biomarker distributions are used to assess possible organic matter source changes. Organic matter preservation is assessed in the same cores using a variety of analytical techniques ( $^{13}\text{C}$ -NMR, UV-Vis of extractable humic acids, etc) along a hydroperiod/nutrient gradient for the wetland sites and a salinity/nutrient gradient for the mangrove sites.

### *Soil nutrients and organic matter*

We continue our long-term collection and analysis of soil samples along Everglades and Florida Bay transects. In addition to acute, hydrologic pulses of water flow associated with storms, the Everglades ecosystem also is impacted by hydrologic changes driven by drought, freshwater diversion or addition, and sea-level change. These longer-term drivers of the

structure and function of wetland ecosystems are changing in somewhat predictable fashion (i.e., sea-level is indeed rising, and wetland restoration efforts eventually will allow for greater freshwater inflows), but the ramifications of saltwater intrusion from the seaward end and freshwater additions from the landward end of the Everglades have not been determined. We plan to use our ongoing, seven-year data set to identify long-term changes in soil nutrients and organic matter that are related to these hydrologic changes.

### **3. Biogeochemical Cycling**

#### *Baseline Water Quality*

For SRS1(a,b,c), SRS2, and SRS3 collections of samples for water quality, primary productivity, soil nutrients/physical characteristics, and physical data (rainfall/water level) are used to help answer key FCE-LTER questions. For SRS4, SRS5, and SRS6 collections of samples for Water Quality and physical data (water level) are used to help answer key FCE-LTER questions. Dissolved and total nutrient analyses were carried out at all LTER sites in conjunction with SERC Water Quality Monitoring Network.

#### *Microbial Dynamics*

Three procedures were performed each month for all FCE II sites: bacterial production, bacterial enumeration, and the measurement of pigment, quantum yield, and excitation characteristics of phytoplankton using Phyto-PAM. Heterotrophic bacterial production is determined using tritiated thymidine uptake within 24 hours of collection. We incubated each of the duplicate samplings per site with 3 replicates and one blank of 10 ml for each sample, with the blank being killed by 20% phosphate-buffered formalin. After stopping the incubation period with 50% TCA after one hour, and triple rinsing the filters with 5% TCA and 80% EtOH, we added scintillation cocktail and ran the samples 24 h later using a Beckman scintillation counter. Bacterial enumeration was determined through epifluorescence microscopy using DAPI DNA stain after preservation with 2 percent bacterial free phosphate buffered formalin and dark storage. Slides were made within 14 days of collection and counted immediately after they were prepared. Algal dynamics were determined through PAM (pulse-amplitude modulation) fluorescence within 24 hours of collection. Algal energetics samples were analyzed using PAM fluorimetry for chl a content and productivity irradiance curves. Samples for microbial analyses were collected in washed, acid-rinsed, ADDIH<sub>2</sub>O-rinsed, sample-rinsed brown, 250 ml, Nalgene bottles. Depth of sampling was 10 cm below the water surface.

#### *Microbial Metagenomics of Floc*

Floc samples have been collected for DNA analysis at 6 LTER sites: SRS 1, 2, and 6, and TS 1, 2, and 6. The projected plan is to collect samples 4 times per year in wet, dry, and transitional seasons. Thus far, samples have been collected in May and September of this year. DNA is extracted from the samples using a FastDNA SPIN kit (for soil) and the extracted DNA is then amplified through PCR with forward and reverse primers attached. After amplification, the PCR products are purified and a product check is performed to confirm that clean amplification has occurred. For T-RFLP analysis, DNA concentration is determined, followed by a restriction enzyme digestion. After the digestion, the samples are desalted and then prepared for analysis at the DNA Core Lab.

#### **4. Trophic Dynamics and Community Structure**

We continued gathering fish and macroinvertebrate density estimates at SRS 2 and 3 and TS 2 and 3 to contribute to the growing FCE-LTER database on consumer density. Samples were collected in February, April, July, October, and December, similar to all past years of the project. We put special emphasis on data QA/QC this year and are submitting updated versions of all of our data with some minor errors corrected. Also, we worked with Jennifer Rehage and Bill Loftus to evaluate sampling methods to quantify littoral-zone fish standing crops in the Shark River transect. This has proven to be a challenging problem because the currents typical of this area preclude use of many net types that enclose areas of appropriate size for fish quantification. We also examined the use of a Dual frequency IDentification SONar (DIDSON) instrument to produce near-video quality streaming images of fishes (Moursund et al. 2003) in the channel of the Shark and Taylor River.

Telemetry studies are about to be initiated. During this year, we purchased VR2 monitoring stations and positioned them throughout the Shark River Slough. We have conducted several range test to optimize the spatial cover of the array. In October, we will begin deploying transmitters on Florida gar, American alligators, bull sharks, and snook.

Throughout the year we have continued longline fishing for juvenile bull sharks and collected tissue samples for stable isotopic analysis.

#### **5. Hydrology**

The Hydrology Working group was formed at the FCEII ASM 2007 meeting in March. At that time, an oral presentation of the future activities and objectives of the Hydrology Working group were giving to the entire FCE II group. In addition, members of the Hydrology Working group met at a break-out group to further refine the group's activities and objectives. Objectives of the Hydrology Working Group include 1) quantifying the major water balance parameters (precipitation inputs, evapotranspiration, surface water flow rates, and groundwater discharge); 2) estimating the water residence times across the various ecotones of Shark and Taylor Slough; and 3) observing changes in the position of the groundwater mixing zone due to changes in water flow across Tamiami Trail. Projects aimed at addressing each of these objectives were initiated during this first year of FCE II. By the end of this first year, three eddy-flux towers will be installed. Two new towers will be installed, one in northern Shark Slough near SRS-1 and one in northern Taylor Slough near TS/PH-1, The third tower was rebuilt at SRS-6 following damage from Hurricane Wilma in Oct. 2005. This tower became operational again in late October 2006. In addition, an evapotranspiration station will be installed in year 1 in southern Taylor Slough at TS/PH-6b. Surface water velocity meters were installed at three sites in northern Shark Slough to detect the initial changes in flow across Tamiami trail once the road is raised. Additional surface water velocity meters will be installed by the end of year one in the mangrove ecotone regions of Shark Slough (SH-3, SH-4) and Taylor Slough (TS/PH-3).

For the purposes of exploring the relationships between the movement of water, nutrients, and energy fluxes in the Everglades ecosystem, three studies were initiated, two in tree islands and the other in the mangrove ecotone. The first study is an intensive investigation of hydrologic

fluxes on a tree island in northern Shark Slough. On this island, pressure transducers were installed in 3 piezometers to compare groundwater levels in tree islands to the surface water level in the surrounding slough. Transpiration sensors were deployed on 12 trees on this island to provide data on canopy water use and to investigate the role of trees in generating the hydraulic gradients observed between the island and the adjacent slough. This information is being used in conjunction with stable isotope data to investigate the seasonal controls on groundwater versus surface water uptake by trees and the role this differential uptake may play in nutrient budgets. In a second project, sap flow probes were installed on two other tree islands in Shark Slough. Together, the three islands outfitted with the transpiration sensors lie along a hydrologic gradient ranging from wet to dry conditions, and the sap flow data collected on these islands will provide information on the physiologic response of tree species to changing water levels and environmental conditions. The third study is taking place in the mangrove ecotone. For this project, a set of nested automated soil-water tensiometers were installed in July 2007 near the eddy covariance flux tower at SRS-6 in order to: 1) ascertain seasonal variations in soil-water content of the forest peat down to 1 m, and 2) determine soil-water flowpaths based on changes in hydraulic head gradients. In addition to the above information, tensiometer data will be used in conjunction with mangrove sapflux and eddy flux data to evaluate the effects of soil moisture variations on single tree and canopy-level transpiration and evapotranspiration. Two tipping bucket automated rain gauges were installed at this site; one above and one below the mangrove canopy. These rainfall measurements will help to understand changes in throughfall as the canopy regenerates following Hurricane Wilma. All tensiometers and rain gauges were set to record data every minute.

A surface water tracer experiment was performed in December 2006 to investigate flow patterns in the Everglades ridge and slough environment. An inert gas tracer SF<sub>6</sub> was injected into the water column and its progression through the wetland environment was tracked for 7 days. The objective of the project was to quantify surface water flow rates, and advection and dispersion patterns in the slough and adjacent ridges.

Two additional projects were initiated in this first year of FCEII with funding from state and federal partners, the SFWMD and USGS. The objectives of these projects were to provide estimates of nutrient transport in brackish groundwater discharge to the mangrove ecotone of Shark Slough and into Florida Bay. One project was focused on sampling groundwater within the bedrock and sediments along the mangrove ecotone of Shark Slough. The other project was focused in Florida Bay and involved sampling surface water, and groundwater in both the bedrock and sediments for nutrient concentrations. In an effort to identify “hot-spot” areas of groundwater discharge in Florida Bay, streaming resistivity surveys along with flow-through <sup>222</sup>Rn, conductivity and temperature measurements were conducted along transects across northeast Florida Bay. The data from these projects are being synthesized at this time.

Undergraduate students conducted two laboratory based studies into the adsorption/desorption of phosphorus on limestone rock from the Everglades. One student digested rock core samples from the Everglades and Florida Bay and subjected them to a serial extraction procedure to provide estimates of loosely adsorbed, iron bound, organic bound, and total phosphorus. The other student performed a series of adsorption/desorption tests on a 20 cm by 20 cm cube of Key Largo limestone. This second experiment involved sealing the limestone

cube in a permeameter, and then flowing either a dionized water or seawater solution through the stone with varying concentrations of phosphorus. Concentrations of both phosphorus and chloride, along with temperature, pH and salinity were monitored throughout the course of each test, and breakthrough curves of both phosphorus and chloride were produced.

Modeling and synthesis for the FCE II will take advantage of the TIME model simulations being run at Everglades National Park. The TIME model was developed by the USGS and the domain covers all of the LTER study zones and surrounding areas (<http://www.time.er.usgs.gov>). The model is a finite element, surface/groundwater and hydrodynamic model with a variable size grid mesh. It simulates all the components of the hydrologic cycle in the Everglades, including tidal inputs and density driven flow in the coastal zones. The simulations cover the period from 1996-2000, and new simulations covering the period from 2000-2004 are being developed. Output from this model will be stored on the ENP database. For the application to FCE II, the model will be used to calculate surface water residence times in relation to physiographic and boundary conditions for each of the LTER sites. Relationships between easily measured field parameters and hydrologic residence times will be sought in the model environment. These relationships will then be used for the interpretation of nutrient biogeochemistry and trophic interactions along the LTER transects and salinity gradients.

## 6. Human Dimensions

The goal of FCE Human Dimensions working group is to investigate the processes and dynamics of land use/land cover change for lands adjacent to the FCE study site. We are examining the social and economic processes driving regional land use change; linking this data to biophysical data produced by other FCE working groups (particularly long-term nutrient and hydrologic data sets); and producing maps and models of the societal-ecological characteristics of land use change. In particular, we are interested in understanding the factors that drive residential landscape management decisions such as the use of water, pesticides and fertilizers. Our activities for year-one of the project include:

- 1) **Developed Framework for Investigation:** We hypothesize that the processes driving land use/land cover change in the buffer lands adjacent to Everglades National Park (FCE study site) are both localized and transnational. To understand the dynamics of these processes, we have chosen three study sites within the greater Everglades watershed as study locations. These study sites represent differing historic land usage patterns, cultural and demographic variables, and patterns of land use change. The study sites are:
  - a. **The Everglades Agricultural Area**—historic agricultural sector, particularly for sugarcane, at the northern end of the ecosystem;
  - b. **Central Miami**—currently site of urban renewal projects and volatile real estate prices;
  - c. **Southern Dade County**—mixed use of row-crop agriculture, plant nurseries and residential properties.
- 2) **Identified Specific Research Questions:** Specific sub-questions developed for this investigation include:

- What are the social dynamics (political/policy, economic, cultural, demographic) that shape land & water decisions and patterns at each of the sites?
- How have they changed over time?
- In what ways (if at all) does what is happening at one site shape land & water use decisions and patterns at the other sites?
- How are these patterns (localized at a variety of scales) transnational?

**3) Identified Stage One of Project (The “Lawn” Study):** As a first step for the project, we are focusing our research on land use/land cover change in southern Dade County. We are calling this stage of the project the “lawn study” since the location is undergoing rapid suburbanization characterized by a transition from agricultural, and other working lands, to residential development. Lawns are an important lens for understanding one type of “envisioned” landscape, or a landscape that reflects contemporary attitudes and perceptions of the environment (its domestication and relationship to wilderness, for example). Some very interesting research is being done on lawns, including at the CAP and BES LTER sites, providing us with critical cross-site comparisons.

In a broad sense, we are using a political ecological approach to the study of lawns, treating lawns as any other “crop” and applying models from agricultural economics to characterize the inputs, costs and labor markets associated with this land use. To understand the ecological impacts and processes driving this change, investigators will conduct qualitative and quantitative studies examining zoning characteristics, housing, real estate, and labor markets, as well as the economic, social and policy dynamics of regional land management.

While land use changes may alter ecological functioning at an ecosystem scale, land use change decisions take place at much smaller scales - households, local zoning boards, etc. We have operationalized the lawn study to account for the multiple scales relevant to the political ecology of lawns. Project methodologies follow:

- **Identify a “transect” for sampling within the South Dade Study Site.** The transect will cross the southern Dade County study site, forming a linkage between the non-residential areas within Everglades and Biscayne National Parks. The transect allows us to focus our qualitative and quantitative research within an area that includes gradients of zoning and land use (historic and contemporary) and neighborhood/demographic characteristics.
- **Develop GIS maps of the transect.** Land use classificatory, demographic, LIDAR, and real estate/property data will be used to produce GIS layers. Decadal maps will be produced for the transect area from 1928 to 2008. Aerial photographs and historic photographs of the transect will be linked to GIS data.
- **Investigate community perceptions of land use change and lawn practices.** Researchers will develop a survey and conduct interviews within the transect to document residents’ environmental attitudes, attitudes toward land use and change, and specific attitudes and practices about lawns. This

perceptions data will allow us to determine the extent (if at all) that neighborhood-level and household environmental behaviors and attitudes are spatialized.

- **Sample grass.** In coordination with the Schoolyard LTER program, researchers will collect grass samples from lawns within the transect and analyze these samples to characterize inputs. A multi-variable vegetation and lawn management field survey will be administered to document lawn practices and characteristics.
- **Analyze remotely-sensed data.** Remotely-sensed data will be used to quantify regional gradients in net primary productivity, characterize land cover, set up landscape structure for linkages to hydrological and nutrient footprints of diverse land covers within the study site.
- **Develop Commodity Chain Research of Turf Grass.** The production, transportation and consumption of turf grass represents a key socioecological linkage and driver within the larger Everglades ecosystem. Turf grass is grown in the northern end of the watershed (south of Lake Okeechobee), is then transported to residential and commercial properties within the study site where it then is installed by homeowners and landscaping companies. We will produce a model that documents the economic and ecological inputs, costs and benefits of this commodity. These variables include labor costs and job opportunities, soil subsidence rates, habitat benefits for wildlife, fossil fuels, fertilizers and pesticides, and water.
- **Link socio-economic data and to FCE biophysical research.** Documentation of land use change will then be correlated with historical changes in variables (such as urban storm water, sewer water, and fresh water flow into FCE transects) in adjacent urban-rural areas that have undergone land use changes. This analysis will help to link the human dimensions of land use change with the ecological investigations conducted by other FCE sub-groups. In particular, we will use this data to model the connections between human-driven change and water quality/quantity models.

## 7. Climate and Disturbance

The Climate and Disturbance Working Group is new to the FCE organizational structure and after the 2007 ASM, we presented our immediate research goals for the next year. These goals including securing supplemental funding for LIDAR transects to be flown and processed for all FCE sites. Submission of supplemental funding request to NSF were approved for LIDAR (Zhang and Anderson, FIU) and for a disturbance study of the mangrove ecotone to evaluate the effects of Hurricane Wilma (Rivera-Monroy, LSU). Additionally, the repairs are now complete to the eddy-flux tower deployed at SRS-6, which was severely damaged during Hurricane Wilma in 2005. Two additional flux towers will be deployed at stations TS1 and SRS 2 by Oberbauer (FIU) with funding from DOE NICCR.

In October of 2005, Hurricane Wilma, a category 3 storm directly impacted mangrove forests in southeast Florida, resulting in a large-scale carbonate sediment deposition (over 3 cm) and catastrophic damage to the forest canopy. Riera-Monroy and others, examined the post-hurricane effects in several mangrove sites in southwestern Florida (Shark River, Broad River, Harney River) and Florida Bay (Taylor River). In each of these sites, transects of different lengths (ranging from 150 to 700 m) were established perpendicular to the water edge to evaluate the distribution of woody debris and the magnitude of disturbance in the forest canopy. In addition, sediment cores were collected with a piston corer at different intervals along each transect. Cores were used to determine the chemical properties, distribution and depth of new deposited sediment. A sequential fractionation method was used to determine inorganic and organic pools of phosphorus (P) in the sediment.

In order to further understand the affects of tropical storms on near shore terrestrial systems, Anderson (FIU), Ross (FIU), Sternberg (U. of Miami) and Grissino-Mayer (U. of Tenn.) submitted a proposal to DOE NICCR program to use tree-ring isotopic geochemistry from slash pine (*Pinus elliottii* var *densa*) to better understand these disturbance events, e.g. storm surge effects (salt water stress). Sea-level has been increasing at a rate of 2.54 mm per year as measured at National Water Level Observation Network station at Key West . By 2100, if rates remain constant, sea level will rise 24 cm, and if the rate of sea-level rise were to increase to levels observed during the last Deglaciation, then this rate would more than double. FCE data severs now have all sea-level (tidal gauge) data stations available to the community from Florida Bay and Keys West Stations. These data will not only help with long term changes in sea-level forcing, but will also help investigators to consider how tidal cycles are affecting the system.

With the support of the Hydrology Working Group, the oxygen and hydrogen isotopic composition of precipitation is now being measured by Price (FIU) to support the efforts of the Climate and Disturbance Working Group.

A paleoecological project lead by Saunders (SFWMD) is being conducted to understand the dynamics of sawgrass over the last century. The overall goal of this project is to integrate plant growth and biomass data from the FCE LTER program (2000 to present) with paleoecological and soil data in order to (1) understand long-term changes in vegetation and hydrologic conditions over the past several centuries to millenia and (2) to develop and use a plant-soil-cohort model that simulates long-term (decadal to century scale) vegetation change, soil development and elevation change and feedbacks between plant and soil processes via altered hydrology. Specific objectives included (1) quantifying seed-biomass relationships of Everglades plant species; (2) quantifying vegetation changes through dated soil profiles of macrofossils (mainly seeds) and biomarkers; (3) quantifying spatial and temporal changes in Everglades fire patterns through dated soil profiles of charcoal; (4) utilizing isotopic variation in fossil *Cladium jamaicense* seeds as an independent proxy of hydrologic stress; and (5) data synthesis through modeling and mapping our data.

## **8. Modelling and Synthesis**

We have completed a dynamic model (coded in STELLA modeling software) that simulates P standing stocks (g P m<sup>-2</sup>) and net P fluxes for the major ecosystem components (i.e., water, algal, plant, consumer, and detrital pools) along the freshwater transect of FCE LTER



sites in Shark Slough. These models were calibrated with site-specific FCE data (and data from related studies) for sawgrass-dominated (shallow water) and spikerush-dominated (deep water) plant communities. We determined model sensitivity of P dynamics (e.g., long-term P accumulation and net P flux through the system) to slight changes in individual model parameters (e.g., turnover rates of P in periphyton), initial conditions (e.g., initial standing stocks of periphyton), and environmental conditions (e.g., annual average water depths). An important result of this research was to show the importance of aquatic processes (e.g., cycling of P in periphyton, fish and invertebrates, and floc) in controlling water TP and P accumulation in deepwater as well as Cladium marshes. In addition, we found improved predictions of water TP by including exchanges of waterborne- and particulate-P (floc-P) between the two habitats, and that parameters governing floc-P exchanges and the aerial cover of the two plant communities were more sensitive than within-habitat processes. The lack of information on P exchanges and the potential for changes in habitat and floc-transport with restoration of sheetflow and water stages highlight these areas of research priorities.

We are also developing a simulation model to hindcast historic vegetation in historic Shark Slough (including two FCE LTER sites, SRS-2 and SRS-3). The model is based on previous 1-D models that incorporate vertical soil accretion and its feedbacks on hydrology, plant productivity, and long-term system stability (Rybczyk et al., 1998; Saunders, 2003; Nungesser, 2003). Process-level data from FCE LTER sampling (e.g., plant productivity, SOM decomposition) and data from ongoing paleo-ecological FCE LTER research are being used to validate and test model predictions for ridge-and-slough marshes in Shark River Slough.

An Independent Expert Panel completed a review of (greater Everglades regional domain, 1-km grid resolution) Everglades Landscape Model (ELM), indicating that the model should be used for applications involving Everglades restoration projects.

Mitsch, W. J., L. E. Band, and C. F. Cerco. 2007. Everglades Landscape Model (ELM), Version 2.5: Peer Review Panel Report. Submitted January 3, 2007 to the South Florida Water Management District, West Palm Beach, FL. <http://my.sfwmd.gov/elm> (Peer Review: Comments tab).

We developed sub-regional, fine-scale (125 m grid resolution) Everglades ridge & slough application of ELM, demonstrating the biological-physical feedback mechanisms that maintained landscape patterns at century time scales in this peat soil environment. An application is available for exploring hypotheses regarding maintenance and restoration of patterned Everglades landscapes. We also developed a prototype of a fine-scale regional (greater Everglades, 500 m grid resolution) ELM application which will be available (Dec. 2007). This will support other research and modeling activities that require regional analyses at spatial resolutions that are finer than 1 km.

## **9. Information Management**

The Florida Coastal Everglades (FCE) Information Management System (IMS) continues to facilitate the site's scientific work and to ensure the integrity of the information and databases resulting from the site's coastal Everglades ecosystem research. The primary focus of the FCE Information Management (IM) team this past year has been to completely redesign the FCE web site (<http://fcelter.fiu.edu>). The web site serves as the primary portal for dissemination of information about the FCE LTER program, for distribution of datasets, to coordinate our

Education and Outreach activities, and to aid FCE scientists and students in their research. With the second phase of FCE research (FCE II) beginning this year, it was important that the FCE web site not only contain results of prior research (FCE I) but also a comprehensive explanation of FCE II research.

New web site features, such as 'What We Do', were added to the web to deliver information to the general public about what services and products our team of scientists, students and technical staff contribute to the FCE LTER program, the broader ecological community and South Florida residents. A new 'About the Everglades' section provides FCE web site visitors with information and outside internet links on four general categories: 1) Everglades General Information, 2) Everglades History & Culture, 3) Everglades Nature & Science and 4) Everglades Issues & Restoration. Old web site features, such as 'Data', 'Research', and 'Education and Outreach', have been redesigned to be more informative and user-friendly for both the scientific community and general public.

The FCE Information Management (IM) team continues to provide total support of the site and network science by: 1) collecting and archiving both FCE and historical Everglades data, 2) providing comprehensive metadata for data interpretation and analysis, 3) designing and implementing tools that facilitate data management, data discovery and data access and 4) contributing to LTER network informatics activities. A web-based query interface tool, which is linked to FCE physical and chemical research results stored in the FCE Oracle10g database, is currently being built and is expected to facilitate data discovery and data access for FCE and LTER network scientists.

The FCE IMS is an active participant in LTER network level activities. Data contributions have been made regularly to the following LTER network databases: 1) ClimDB, 2) SiteDB, 3) All Site Bibliography, 4) Personnel, 5) Metacat XML database and 6) Data Table of Contents. The FCE IMS group is also a data contributor to the EcoTrends project managed by the Jornada Basin LTER.

The FCE information manager, Linda Powell, was elected by the LTER Information Management committee to serve as an IM representative on the LTER Network Information Systems Advisory Committee (NISAC) during the annual LTER Information Management Committee meeting held in San Jose, California this past August (2007). She was also a member of the NSF's Niwot Ridge LTER site review team (June 2007). Additionally, Linda Powell, was an invited keynote speaker at the RED-MEX ILTER All Scientists Meeting in March of 2007, held in Autlán de Navarro, Jalisco, Mexico. She talked about the importance of establishing a strong information management system and gave examples of how the FCE LTER program handled different aspects of project and information management.

## **10. Education and Outreach**

During the initial year of FCE II we have continued to expand our Research Experience for Secondary Students (RESSt) program. Nearly half of our RESSt interns returned for a second and third year while the total number of concurrent participants rose to 14 interns, an increase of nearly 50% over the previous year.

Our greatest success stories in 2007 were those of our second year interns, Nia Brisbane and Sebastian Diaz of Felix Varela Senior High School in Miami. Brisbane and Diaz have worked as RESSt interns with Dr. Colin Saunders, studying the seed morphology of *Cladium jamaicense* in soil profiles found along the Everglades estuarine ecotone. In February, Diaz and Brisbane presented their results in the *South Florida Regional Science and Engineering Fair* held in Miami. Brisbane earned a *superior* rating for her poster, *Tiny seeds present the big picture in Everglades restoration*. Brisbane's awards include: Frey Scientific Award (\$25); Ricoh Sustainable Development Award; Sierra Club's Outstanding Project; US Army Award; Beckman-Coulter, Inc Award; and Runner-up for Best Biological Sciences Award (\$250). After competing at the 53<sup>rd</sup> *State Science and Engineering Fair of Florida* held in April 2007 in Naples, FL, Brisbane became the first RESSt intern to advance as a finalist at the *Intel International Science and Engineering Fair in Albuquerque, NM*.

Diaz won awards for Outstanding Project by the Sierra Club, and an award from US Army at the *South Florida Regional Science and Engineering Fair* held in Miami. He also advanced to the State Fair to compete for a spot at the International competition with his poster *The use of Cladium jamaicense seeds as indicators of historical changes in the Everglades estuarine ecotone*. Brisbane is currently studying Biology at the University of Florida and Diaz is enrolled as an Engineering student at Miami Dade College and preparing the first RESSt manuscript of their results with Saunders.

FCE's third year intern, Magaly Dacosta presented a joint poster with her FCE mentor Jeff Wozniak entitled *Isotopic values for southern Everglades marshes: C and N natural abundance study* at the 2006 FCE-ASM meeting. At the 2007 FCE-ASM meeting Dacosta read her essay *Our Responsibility to the Natural World* for which she won *First Place in Prepared Public Speaking* at the Future Farmers of America (FFA) District Convention and advances to compete at the FFA State Convention. Magaly also led a team of students from her high school in winning a \$500 award as the *Grand Champion* in Native Plant Landscape Design at the 2007 Miami-Dade County Fair and Exposition.

First year intern, Ben Giraldo, has been working with Dr. Tiffany Troxler-Gann. In a joint presentation of their poster *Bacterial diversity, enzymatic activities, and soil CO<sub>2</sub> flux along a soil P gradient in a coastal peatland, Panama*, Ben received First Place and \$100 book award at the 2007 FCE-ASM. In addition, each of the remaining RESSt interns gave a short progress report of their projects at the annual FCE LTER ASM March 19 and 20.

We have begun working with the Department of Geology and Regional Studies at the University of Miami through our collaborator Dr. Rinku Roy Chowdhury. Our Education and Outreach Coordinator has been working closely with Dr. Chowdhury in developing GIS workshops for high school science and social studies teachers. Dr. Chowdhury will be providing school site instruction and will also host workshops at the University of Miami's GIS lab during the summer months. Participating teachers will receive continuing education credits for their participation and developing LTER GIS activities for use within their classrooms.

In our Extended SLTER program, we have developed a two-part FCE LTER film documentary featuring three community types. The purpose of these short films is to encourage the use of FCE LTER datasets in student projects and other classroom activities. Collecting nearly one hundred hours of footage, the series begins with an introduction to FCE LTER, its mission and the Everglades landscape. The first film highlights our biotic datasets and includes a variety of interviews with FCE plant, algal, and fish researchers. In the second film we explore the FCE abiotic datasets and interview many of our climatic and water quality researchers. Both films conclude with a short demonstration on the navigation and downloading procedures necessary for acquiring and using the datasets.

A secondary goal of these films is to encourage teachers to develop their own classroom activity that focuses on a portion of the datasets or use them to demonstrate the similarities and differences between the abiotic and biotic factors between Everglades communities. Understanding such comparisons are included as one of the Annually Assessed Benchmarks in the Sunshine State and National Science Standards in the Secondary Science Curriculum. To further address this benchmark we are currently developing an accompanying classroom activity with questions and an answer key and a further film edit will incorporate its use as a supplemental activity. In this way, students and their teachers will become familiar with the scope of research for the FCE LTER, the research significance and some of the methodology of the data collections and will be implemented during the Spring 2008 semester at Miami Dade College.

Another objective of our extended SLTER proposal was to create an English to Spanish translations of our Education and Outreach webpage. We have completed and posted the translation of our most frequently downloaded “Foreverglades” presentation/script and will be releasing the translated introduction, purpose and research description to in an updated FCE webpage currently under development by our FCE Program and Information Manager.

Our second major product was developed and is being tested in the classroom by our RET Teresa Casal. This activity engages students in using actual FCE data to explore science as a process. In addition, Ms. Casal has worked closely with MDCPS District Supervisors and plans to include the activity in a newly developed, county-wide Integrated Science Curriculum.

## **B. FINDINGS**

### **1. Primary Production**

#### *Periphyton*

High rates of periphyton productivity have been measured in the freshwater marsh that results in thick floating and epilithic mats that average 4800 ml m<sup>-2</sup> in wet biovolume, 210 g m<sup>-2</sup> in dry mass and 60 g m<sup>-2</sup> ash-free dry mass. Rates of periphyton ANPP were lower in the predominantly floating mats of SRS than for the epilithic mats of TS (mean 2001-2004 = 21 g m<sup>-2</sup> yr<sup>-1</sup> vs. 1400 g m<sup>-2</sup> yr<sup>-1</sup>, respectively).

Within the SRS transect, the highest rates of periphyton production occurred during the wet season of each year, with values being highest in the central slough (SRS 2, 3) and lowest at

the SRS 1a and b, close to the Tamiami Canal. Movement of this site in 2005 and 2006 to areas further from the S-12 water delivery structures dampened this trend. There was a general negative relationship between periphyton production and phosphorus availability, a trend reported extensively in this study and throughout the Everglades (Gaiser et al., 2006).

Within the TS transect, periphyton production is highly variable, with highest rates occurring just after seasonal inundation of previously dry mat (Iwaniec et al., 2006). The relationship of periphyton production to P availability along this transect is positive, but the gradient was within the natural range of variation exhibited in the Everglades rather than reflecting excess P income that instigates the disintegration of the mat matrix (Gaiser et al., 2005).

Epiphyte accumulation rates in Florida Bay were lower than those for the marsh. Rates are significantly higher at TS/Ph-11 than TS/Ph-9 and 10 at all times of the year and these epiphytes contain a higher concentration of phosphorus than those at the two upstream sites. Compositional differences in the epiphytic diatom flora were also pronounced among the three Florida Bay sites and were related to gradients in salinity and phosphorus availability (Frankovich et al., 2006).

#### *Seagrass ecosystems*

Seagrass primary production monitoring - The purpose of this work is to measure *Thalassia testudinum* shoot demographics and estimate aboveground and belowground primary production of the species at the Florida Bay LTER sites, including Trout Creek, Little Madiera, Duck Key, Bob Allen Keys, and Sprigger Bank. Aboveground productivity and leaf emergence rates have been measured by a leaf marking technique on a continuing basis at these sites for 4 – 6 years. Demographic reconstructions of shoot populations provide an estimate the number of new shoots produced in a year. The age of individual shoots are estimated from the number of leaf scars on a shoot and the average annual leaf emergence rate. Belowground productivity is then estimated on the basis of rhizome, root and shoot biomass on a per-shoot basis, and seasonality of productivity is based on seasonal patterns of leaf emergence rates throughout the year.

Data collections and analyses are nearly complete. In general, the population age-frequency distributions follow a reverse J-shape at all sites. Sprigger Bank has a high leaf emergence rate and a young population with the oldest individual shoots rarely exceeding four years in age. Bob Allen Banks has a slower average leaf emergence rate and the population includes shoots exceeding nine years of age. Duck Key and Trout Cove populations are intermediate in their leaf emergence rates and the population ages, which reach eight years. Little Madiera, located between Duck Key and Trout Cove, is different. A high leaf emergence rate at Little Madiera is comparable to the rate measured at Sprigger Bank and the population age structure is young, including no individual shoots that exceed 4 years in age. It is possible that seasonal variability in salinity, which has been measured as low as 3 ppt, is affecting the population age structure.

*Seagrass primary production monitoring , Macroalgal components:* The main macroalgae in the region are calcareous green species (*Halimeda*, *Penicillus*, *Rhipocephalus* and *Udotea*), in significant less amount calcareous red articulated species (*Amphiroa*) and in some occasions floating masses of red and brown macroalgae can be found intermingled on seagrass or other

macroalgae, however they do not stay in each site but move driven by winds and currents all along the bay. There is a gradient in diversity and biomass of macroalgae from west to east in Florida Bay: Standing crop ( $\text{g/m}^2$ ) of macroalgae varied seasonally. Productivity per plant ( $\text{mg/day}$ , and number of segments/day) has been measured successfully for *Halimeda incrassata* at Sprigger using the Alizarin red technique. Productivity varied seasonally, with productivity peaks that coincide with biomass peaks..

*Mangrove Lakes submerged aquatic vegetation:* The ongoing investigation into the controls on benthic vegetation distributions within the Mangrove Lakes region of the Florida Everglades and Florida Bay has described a highly dynamic zone within the Florida Bay estuarine ecosystem. The Mangrove Lakes region is characterized by spatially distinct submerged aquatic vegetation communities dominated by *Chara hornemanni* in the inland "lakes" and the seagrass *Halodule wrightii* in the more marine embayments downstream. The spatial distribution of SAV species composition relates to salinity and the variability thereof. Both *Chara* and *Halodule* exhibit sinusoidal seasonal variation but abundance patterns of both species are not temporally synchronized. Peak *Chara* abundance has occurred in the winter months, during periods of reduced salinity following the wet season. *Halodule* abundance peaks during summer months in synchrony with other marine seagrasses occurring in Florida Bay and the nearshore Florida Keys.

*Long-term effects of short-term fertilization on ecosystem function:* An oligotrophic phosphorus (P) limited seagrass ecosystem in Florida Bay was experimentally fertilized in a unique way. Perches were installed that promoted the roosting of seabirds, which through the act of defecation functioned as an external nutrient source. Two treatments were examined; (1) a chronic 23 year fertilization, and (2) a 28 month fertilization that was discontinued 23 years ago. Because of the low mobility of P in carbonate sediments we hypothesized long-term changes to ecosystem structure and function in both treatments. Structural changes in the chronic treatment include a shift in the dominant seagrass species from *Thalassia testudinum* to *Halodule wrightii*, large increases in epiphytic loads and sediment chlorophyll-a, and a decline in species richness, while functional changes include increased ecosystem metabolism and quantum efficiency. Initially there were similar changes in the short-term discontinued fertilization but after 23 years of nutrient depuration *T. testudinum* has reestablished itself as the dominant species. However, P remains elevated in the ecosystem and *H. wrightii* has maintained a presence. Functionally the discontinued treatment remains altered. Biomass exceeds that in the chronic treatment and indices of productivity, elevated relative to control, are not different from the chronic fertilization. Cessation of nutrient loading has resulted in a superficial return to the pre-disturbance character of the ecosystem but because of the nature of P cycles functional changes persist.

### *Mangroves*

*Litter Dynamics:* There was a consistent seasonal pattern of litterfall production in all sites compared to previous years. Higher rates were observed during the wet season (June-November) compared to the dry season. Leaf fall comprised most of the total litterfall in all sites ranging from 69% (SRS4) to 83% (SRS5). Wood fall contribution to total litterfall ranged from 9% (SRS5) to 13% (SRS6), while reproductive parts had the smallest contribution varying from 5% (SRS5) to 9% (SRS6). Mean annual rates were consistently higher in SRS6 and decreased with

distance from the mouth of the estuary. Overall, the estimated values for the Shark River sites are within the range of values reported for other mangrove sites in the Neotropics.

*Soil Biogeochemical Properties:* The seasonal variation in porewater salinity across sites followed the same pattern than previous years. Mean salinity values were higher during the dry season than in the wet season. The freshwater-estuarine salinity gradient along the Shark River was consistent with previous years (SRS4 < SRS5 < SRS6) ranging from < 5 to 30 g kg<sup>-1</sup>. Overall, we can conclude that porewater salinity along the Shark River is below levels of stress (< 60 g kg<sup>-1</sup>) for mangrove forest development and growth. Porewater sulfide concentrations along the Shark River sites were < 0.4 mM and also indicative of low stress. Redox potential values were consistently higher at 0 and 10 cm depth (100-180 mv) compared to 45 cm depth (50 to -40 mv). Overall, redox potential values in the Shark River sites indicate slightly reducing soil conditions at all depths.

*Impacts of hurricanes:* Hurricanes Irene (1999) and Wilma (2005) deposited a significant layer of carbonate (bay-derived) sediment in the mangrove ecotone of our TS/Ph transect. Since this area is not well-flushed with daily tides, these deposits persist for extended periods and may affect long-term patterns in mangrove productivity. In Year 1 of FCE II, collaborators from TAMU, LSU, and FIU initiated a small-scale sediment amendment experiment to better understand how carbonate sediment deposition--a potential source of inorganic P--controls dwarf *R. mangle* productivity and biomass allocation. Specifically, we selected 6 tree clusters at the TS/Ph-6 ecotone site. Of those, half received sediment addition at the base of the tree. Sediment thickness was maintained at 3-4 cm--an average thickness measured from multiple cores taken near TS/Ph 8 (Figure 2). The remaining trees will serve as un-amended controls. We will also track seedling growth in response to sediment deposition--through fertilization of seedlings--relative to control (un-amended) seedlings. We will observe aboveground responses of tree clusters and seedlings for 1-2 years. Results of this pilot study will be used to design and implement a large-scale sediment amendment study that will track patterns of biomass allocation both above and belowground.

## **2. Organic Matter Dynamics**

(a) *Mangrove tannins in aquatic ecosystems: their fate and possible role in dissolved organic nitrogen cycling:* We describe the fate of mangrove leaf tannins in aquatic ecosystems, and their possible influence on dissolved organic nitrogen (DON) cycling. Tannins were extracted and purified from senescent yellow leaves of the red mangrove (*Rhizophora mangle*) and used for a series of model experiments to investigate their physical and chemical reactivity in natural environments. Physical processes investigated included aggregation, adsorption to organic matter-rich sediments, and co-aggregation with DON in natural waters. Chemical reactions included structural change, which was observed by excitation-emission matrix fluorescence spectra, and the release of proteins from tannin-protein complexes under solar simulated light exposure. A large portion of tannins can be physically eliminated from aquatic environments by precipitation in saline water and also by binding to sediments. A portion of DON in natural water can co-precipitate with tannins, suggesting that mangrove swamps can influence DON cycling in estuarine environments. The chemical reactivity of tannins in natural waters was also very high, with a half-life of less than 1-d. Proteins were released gradually from tannin-protein

complexes incubated under light conditions but not under dark conditions, suggesting a potentially buffering role of tannin-protein complexes on DON recycling in mangrove estuaries. Although tannins are not detected at a significant level in natural waters, they play an important ecological role by preserving N and buffering its cycling in estuarine ecosystems through the prevention of rapid DON export/loss from mangrove fringe areas and/or from rapid microbial mineralization.

(b) *Physical and microbial processing of dissolved organic nitrogen (DON) in the Florida Coastal Everglades*: More than 90% of the terrestrial N loading from the Florida Everglades to Florida Bay is in the form of dissolved organic nitrogen (DON). A better understanding of the biogeochemical cycling of nutrients entering Florida Bay is a key issue regarding the restoration of the Everglades. The chemical nature and microbial bioavailability of this DOM are not well known. Should this DOM be readily available, any increased load as a function of restoration activity might have an impact on internal nutrient cycling and phytoplankton bloom dynamics. To better understand this issue, experiments were conducted which addressed the effect of increased salinity on flocculation of DOM, the effect of photolysis on the chemical structure of DOM, and on the microbial bioavailability of the DON component from sawgrass marsh, mangrove forest, and seagrass beds. No significant flocculation or precipitation of DOM occurred with increased salinity. Therefore, terrestrial DOM remains in the water column where it is subjected to extended photolysis, estuarine mixing, and transport. Simulated sunlight had a significant effect on the chemical characteristics of DOM. While the DOM concentration did not change significantly during photo-exposure, its optical characteristics were modified. The environmental implications of this are conflicting as photo-induced polymerization may stabilize DOM by reducing its bioavailability while photolysis may make the DOM more labile. The DON bioavailability was relatively low in this region. Under estuarine salinity conditions, the percent of bioavailable DON (BDON), from the freshwater wetland was higher (9.2%) than from both mangrove (4.8%) and seagrass sites (3.5%). This implies that faster DON transport from freshwater wetlands to the bay may have a more pronounced impact on the N cycle than is currently the case. Although the BDON is low, the DON concentrations are high relative to the DIN pool. Therefore, if the median DIN concentration for the estuarine site is 4.6  $\mu\text{M}$  while amount supplied by BDON is 1.6  $\mu\text{M}$ , then amount of N supplied by DON recycling may become a significant portion of the total DIN pool in the estuary.

(c) *Generation and quality characterization of DOM in seagrass enclosures in Florida Bay*: We have just concluded a seagrass enclosure experiment (NOAA), where seagrass production of DOM was measured over a 24 hour cycle. The study clearly demonstrates that the seagrass communities in Florida Bay make a significant contribution to the DOM pool of this shallow estuary. The freshly produced DOM from these mixed communities is more bioavailable than the aged, ambient DOM, probably due to microbial and photochemical reworking, and a larger load of terrestrially derived DOM in the ambient samples. The terrestrial input seems in part to be derived by leaching from sedimentary OM, but is also controlled by hydrological forcing as part of Everglades wetlands runoff during the wet season. In contrast, DOM sources are more determined by seagrass and planktonic primary productivity during the peak summer season. Much of the variability in the DOM quality in space and time, as determined through optical means, seems controlled by the DOM fraction with molecular weight below 1000 Dalton.



(d) *Lipid biomarkers in suspended particulates from a subtropical estuary: Assessment of seasonal changes in sources and transport of organic matter:* Temporal and spatial variations in the composition of particulate organic matter (POM) from Florida Bay, USA were examined. The predominance of short chain homologues for *n*-alkanes, *n*-alcohols and *n*-fatty acids as well as relatively high abundance of C<sub>27</sub> and C<sub>28</sub> sterols suggested that an autochthonous/marine source of OM was dominant bay-wide. Several biomarker proxies such as *Paq* [(C<sub>23</sub>+C<sub>25</sub>)/(C<sub>23</sub>+C<sub>25</sub>+C<sub>29</sub>+C<sub>31</sub>) *n*-alkanes], short/long chain *n*-alkanes, (C<sub>29</sub>+C<sub>31</sub>) *n*-alkanes and taraxerol indicated a spatial shift in OM sources, where terrestrial OM rapidly decreased while seagrass and microbial OM markedly increased along a northeastern to southwestern transect. Regarding seasonal variations, POM collected during the dry season was enriched in terrestrial constituents relative to the wet season, likely as a result of reduced primary productivity of planktonic species and seagrasses during the dry season. Principal component analysis (PCA) classified the sample set into sub-groups based on PC1 which seemed to be spatially controlled by OM origin (terrestrial-mangrove vs. marine-planktonic/seagrass). The PC2 seemed to be more seasonally controlled suggesting that hydrological fluctuations and seasonal primary productivity are the drivers controlling the POM composition in Florida Bay.

(e) *Occurrence and distribution of botryococcones in the Florida Everglades:* A high abundance of isoprenoid hydrocarbons, the botryococcones, with carbon skeletons from 32 to 34 were detected in the Florida Everglades freshwater wetlands. These compounds were present in varying amounts up to 106 µg/gdw in periphyton, 278 µg/gdw in floc, and 46 µg/gdw in soils. Their structures were determined based on comparison to standards, interpretation of their mass spectra and those of their hydrogenation products, and comparison of Kovats indexes to those reported in the literature. A total of 26 cyclic and acyclic botryococcones with 8 skeletons were identified, including those with fewer degrees of unsaturation, which are proposed as early diagenetic derivatives from the natural products. This is the first report that botryococcones occur in the Everglades freshwater wetlands. Their potential biogenetic sources from green algae and cyanobacteria were examined, but both contained no botryococcones. Thus, the source implication of botryococcones in this ecosystem needs further study.

(f) *Photochemical alteration of 3-oxy-triterpenoids: Implications for the origin of des-A-triterpenoids in aquatic sediments and soils:* The reactivity of higher plant-derived 3-oxy-triterpenoids to sunlight was investigated using a series of pure reference standards both under simulated and real solar exposure. The majority of the exposed compounds showed reactivity to light, particularly to simulated sunlight and among others generated *seco*-derivatives. While photochemical processes have been suggested for the formation of such compounds, their abundance in some in aquatic sediments and soils and have often been assumed to be the result of diagenetic reworking of parent triterpenoids. Analyses of mangrove leaves, an important known source of taraxerol in coastal ecosystems, showed the presence of the *seco*-derivative dihydrolacunolic acid, and as such could represent an important biotic source for des-A-triterpenoid precursors to sediments and soils, which is unrelated to aquatic organic matter diagenesis.

(g) *Environmental assessment of vegetation cover and hydrological conditions in the Everglades freshwater marshes using multiple geochemical proxies:* Reconstruction of environmental change in the Everglades freshwater system has become important to better design restoration

strategies. In this study several geochemical proxies such lipid biomarker distributions were shown to provide biomass-specific organic matter (OM) source information. Vertical profiles of such biomarkers and vegetation seeds in soil cores from the FCE-LTER showed that the vegetation community shifted from an earlier *Eleocharis*-domination to more recent *Cladium*-domination, which may be a result of the decrease in water level (shorter hydroperiods) induced by water management. Paleo-assessments in wet prairies or sloughs of the Shark River Slough and Taylor Slough showed that *Eleocharis* remained dominant at same locations over the last century, while vegetation shifts from waterlily to *Eleocharis* were also observed during that period. The recent increases in abundance of C<sub>20</sub> HBIs and botryococenes in all of the cores might be attributed to increased levels of periphyton as a result of the increasing nutrient levels caused by human activities over the last century. In general, the data shows that most wetland environments in the Everglades have shifted to a shorter hydroperiod regime since the start of anthropogenic influences in the region.

(h) *Variation in soil nutrients and organic matter related to storm events:* Our data have demonstrated rapid changes in soil nutrients and organic matter from storm deposits and erosion events associated with Hurricane Wilma in 2005. Although soil parameters tended to “recover” to pre-storm levels within two years, longer-term changes in nutrients and organic matter may accrue with changes in differential seedling recruitment and plant success driven by storms—a landscape-level feature we observed in 2007.

(i) *Variation in wetland response to iron amendments:* We have successfully used reactive iron additions in Florida Bay sediments to stimulate seagrass growth and elucidate the relationship between organic matter processing and phosphorus availability. In 2002 we began a long-term experiment testing the addition of reactive iron to sediments in the freshwater Everglades, for comparison with seagrass ecosystems. Rather than stimulating plant growth, however, plants in iron-addition plots in the Everglades are significantly smaller than plants from control plots, and the pool of plant-bound phosphorus has decreased significantly. Concomitant with the decrease in plant phosphorus has been an increase in soil phosphorus not specifically associated with iron-phosphorus sorption. Plants in iron-enriched plots, however, exhibit no obvious signs of iron toxicity other than reduced growth, and tissue concentrations of iron, carbon, nitrogen, phosphorus from control and iron-enriched plots are not significantly different. Reactive iron acts as a buffer to sulfide toxicity in seagrass ecosystems (organic matter decomposition dominated by sulfate reduction), but as an apparent toxin in the freshwater Everglades (organic matter decomposition dominated by oxic respiration and other anaerobic pathways beside sulfate reduction). Given these results, we are hopeful of initiating an iron-addition experiment in the dwarf mangrove habitat along Taylor Slough, where sulfide toxicity is one of the suspected causes of stunted tree growth.

### **3. Trophic Dynamics and Community Structure**

Data analysis for most aspects of our study are ongoing. However, during this year, we found that DIDSON shows promise for quantification of fish standing crops in channel habitats, which is a major goal of our working group. We are planning to rent the instrument in the coming year to conduct calibration studies and further determine the feasibility of its use for our project. We also found that we can detect acoustic transmitters 400-800m from our VR2 listening stations. This allows us to set up several acoustic gates throughout the Shark River

Slough to determine the impacts of freshwater flow and other factors on movements of large consumers.

Studies of the distribution and trophic position of bull sharks revealed minor impacts of salinity and season on the abundance of sharks. However, sharks were concentrated approximately 20km from the river mouth. Regardless of their capture location, stable isotopic analysis suggests that they are feeding primarily in marine-derived food webs despite being captured in freshwater. Further studies of shark movements will help to elucidate whether sharks are actively transporting marine nutrients upstream.

We examined spatial and temporal dynamics in the fish community of ecotonal mangrove creeks along the SRS transect, particularly between SRS3 & 4. Our sampling reveals a highly dynamic community composed of freshwater fishes, resident estuarine species, and transient marine taxa. Community composition varies seasonally, and to a greater extent for the larger-bodied fish species, reflecting a pulse of freshwater taxa into creeks as marshes upstream dry seasonally (Rehage & Loftus 2007). The timing of this pulse is closely tied to the pattern of dry-down in upstream marshes, and may have important ramifications for wading bird foraging and nesting success. We hypothesize a shift in the path of energy flow from wading bird predators to piscine predators depending on the timing and severity of dry-down. Three years of data collected at creeks show that if marshes dry early, prey fishes are forced into creeks, where they may be subject to heavy predation from both estuarine and freshwater predators, and no longer available to wading bird predators on the marsh surface.

#### **4. Hydrology**

Drought conditions have prevailed during this first year of FCE II. Surface water levels in Everglades National Park are at a 17 year low for September which is when water levels are often at their highest. Tropical cyclones typically add significant amounts of rain to south Florida in September and October. However, the 2006 El Nino event significantly reduced the number of tropical cyclones that formed in the tropical Atlantic in the previous wet season, and the current hurricane season has not resulted in tropical cyclones delivering significant rainfall to south Florida.

We find that Florida Bay is an evaporative basin with long-term (30-year) estimates of evaporation of 166 cm/yr as compared to the average rainfall amounts of 106 cm/yr (Price et al., 2007). On an annual basis evaporation from Florida Bay can vary from 148 to 181 cm/yr, while rainfall can vary widely from 62 to 152 cm/yr. Evaporation rates vary seasonally within Florida Bay with the highest rates occurring in the late spring and summer (April through October), and the lowest rates occurring in the late fall and winter (November through March). Evaporation is highest in May corresponding with the highest measured values of net radiation, and then decreases slightly during the rainy season months of June through October due to an increased presence of cloud cover. On a similar topic, preliminary results show that latent energy fluxes as a proportion of the total energy budget are higher after Hurricane Wilma at SRS6.

Preliminary results of adsorption/desorption tests on limestone rock suggest that average concentrations of loosely adsorbed P range from 0.9 to 9 $\mu$ g of P/g of rock with an average of 2.3

$\pm 2.1$   $\mu\text{g}$  of P/g of rock. Total concentrations of P in the limestone rock range from 40 to 90  $\mu\text{g}$  of P/g of rock with an average of about 60  $\mu\text{g}$  of P/g of rock. The transport of phosphorus through the Key Largo limestone cube was significantly retarded due to adsorption when compared to a chloride in deionized water. However when using seawater, there was little adsorption of the phosphorus onto the limestone cube, and at low concentrations of P, there was even some release of P from the cube.

The surface water tracer experiment showed that average flow rates recorded using SF6 agree with nearby, point-based measurements using acoustic Doppler velocimeters (Judson Harvey, USGS). The results suggest that high spatial resolution (< 20 m length scale) is necessary to adequately characterize flow patterns in sloughs, and that flow patterns differ significantly in adjacent sloughs as a function of bathymetry and vegetation. The experiment showed that fluctuations in whole-basin water balance may cause variance in flow patterns at small spatial scales, and that slough surface water penetrates into adjacent ridges. Finally, the results showed that longitudinal dispersion plays a significant role in ridge and slough habitats, which has implications for modeling nutrient loading and sediment dynamics. Additional tracer experiments are planned in October 2007.

## **5. Human Dimensions**

Much of our work this year has focused on refining our research approach (as outlined in the “activities” section of this report). We have completed the following products for year-one:

- 1) Completed a literature review of the relevant land use/land cover research (for the study site, and more generalized), as well as the social science and landscape architecture literature on lawns. Annotated bibliographies were produced from this literature review and are available on the FCE website.
- 2) Located and acquired data layers for the larger study site. This data enables us to locate properties with lawns in relation to other properties in the south Miami-Dade county area. Land use classification of properties (from the County Tax Assessor data—1992-94 pre/post Hurricane Andrew and current 2007) allows analysis of both changes in land use between agricultural and residential (mapping growth/sprawl, among other variables) and GIS positioning of properties in relation to other data layers we are adding. These layers include 2000 census blocks and block groups, the coverage of the 2006 American Community Survey (Census) sample over the area, canal/hydrological features locations, and LIDAR elevation coverage for identifying potential sites of lawn chemical runoff and sinks.

## **6. Climate and Disturbance**

### *Mangrove ecotone hurricane disturbance*

Preliminary results from the post-Hurricane Wilma study indicate that the Ca bound-P fraction is the largest P fraction in these carbonate deposited sediments. These results highlight the importance of this P fraction in controlling productivity patterns in mangrove forests of south Florida, as demonstrated along the freshwater-estuarine transect of Shark River estuary. Since in estuaries of the Everglades, P is supplied by the Gulf of Mexico, and not the oligotrophic upstream areas, this study will contribute to our understanding of how different soil P fractions,

specifically the Ca bound-P fraction is tightly coupled to productivity and biomass allocation gradients in mangrove forests of south Florida. Moreover, Hurricane Wilma provided an excellent opportunity to evaluate how these pulsing events regulate productivity of mangroves in south Florida and how resilient the system is to these types of events. We are planning a large sampling of mangroves sites along Shark River in October-November 2007 to assess how mangrove forest have responded to wind damage since 2005

#### *Flux tower*

A flux tower located at SRS-6 has been monitoring net ecosystem exchange on this mangrove island since June, 2003. In October, 2005, Hurricane Wilma destroyed approximately 30% of the trees at this location, deposited 3 cm of carbonate mud on the forest floor, and while the tower remained standing, it was damaged beyond repair. Reconstruction of the tower was completed in October, 2006, and flux studies were commenced to evaluate post-hurricane ecosystem response and function. Initial results from the study reveal greatly reduced carbon dioxide assimilation rates throughout the day following the hurricane, likely a result of reduced canopy biomass. Energy partitioning studies in the post-hurricane forest find greatly reduced sensible heat fluxes, while the latent heat fluxes are not found to be significantly altered following the hurricane. Nighttime respiration rates are not significantly different following the hurricane to date, but are expected to increase in the future as there is greater decomposition of the biomass brought down by the hurricane.

#### *Isotopic Composition of Precipitation*

Ten years of stable isotopic rainfall data collected from 5 sites in south Florida indicate a strong seasonal and regional variation, despite the relatively limited geographic coverage and low-lying elevation of each of the collection sites. Based upon the weighted-mean stable isotope values, the sites were classified as coastal Atlantic, inland, and lower Florida Keys. The coastal Atlantic sites had weighted-mean values of  $\delta^{18}\text{O}$  and  $\delta\text{D}$  of -2.86‰ and -12.85‰, respectively, and exhibited a seasonal variation with lower isotopic values in the summer wet-season precipitation ( $\delta^{18}\text{O} = -3.381\text{‰}$ ,  $\delta\text{D} = -16.57\text{‰}$ ) as compared to the winter-time precipitation ( $\delta^{18}\text{O} = -1.66\text{‰}$ ,  $\delta\text{D} = -3.2\text{‰}$ ). The inland site was characterized as having the highest *d*-excess value (+13.34‰), signifying a contribution of evaporated Everglades surface water to the local atmospheric moisture. In spite of its lower latitude location, the lower Keys site located at Long Key had the lowest weighted mean stable isotope values ( $\delta^{18}\text{O} = -3.64\text{‰}$ ,  $\delta\text{D} = -20.29\text{‰}$ ) as well as the lowest *d*-excess value of (+8.83‰). Extremely low stable isotope values ( $\delta^{18}\text{O} < -6\text{‰}$ ,  $\delta\text{D} < -40\text{‰}$ ) were observed prior to the passage of hurricanes from the Gulf of Mexico as well as from cold fronts from the north-west. These results suggest that a source region to the west, possibly the western Pacific, may be responsible for the extremely low values observed during some tropical storms and cold fronts.

#### *Paleoecological Research*

Results from our soil cores analyzed to date show substantial vegetation change in historic Shark Slough over the past century or more. In general, they show increasing *Cladium* and the reduction or disappearance of water lily sloughs, starting mostly in the early 20<sup>th</sup> Century and possibly reflecting drainage due to water use by humans and the completion of the Tamiami Trail by 1940. Some of the cores also indicate a return to wetter conditions, including increased water lily abundance, in the 1990s, consistent with higher rainfall and water stages observed in

the 1990s relative to previous decades. Additional soil proxies provide a complementary environmental context to these vegetation changes, including charcoal concentrations (a proxy for fire) and fossil seed  $\delta^{13}\text{C}$  signatures (a proxy for waterlogging stress). Finally, our preliminary modeling work suggests that mechanistic 1-D models predicting vertical soil accumulation stand to benefit from the inclusion of equations governing fossil seed production/accumulation as a means to calibrate and test models' long-term predictions of vegetation change under past and future environmental changes. The development of more mechanistic models are the focus of our final year of study and will be potentially valuable to Everglades managers and to Everglades restoration by providing a means to understand future vegetation/soil responses to altered climate and hydrology.

## C. TRAINING AND DEVELOPMENT

### Education, Outreach, and Diversity Activities

During the initial year of FCE II we have continued to expand our Research Experience for Secondary Students (RESSt) program. Nearly half of our RESSt interns returned for a second and third year while the total number of concurrent participants rose to 14 interns, an increase of nearly 50% over the previous year.

Our greatest success stories in 2007 were those of our second year interns, Nia Brisbane and Sebastian Diaz of Felix Varela Senior High School in Miami. Brisbane and Diaz have worked as RESSt interns with Dr. Colin Saunders, studying the seed morphology of *Cladium jamaicense* in soil profiles found along the Everglades estuarine ecotone. In February, Diaz and Brisbane presented their results in the *South Florida Regional Science and Engineering Fair* held in Miami. Brisbane earned a *superior* rating for her poster, *Tiny seeds present the big picture in Everglades restoration*. Brisbane's awards include: Frey Scientific Award (\$25); Ricoh Sustainable Development Award; Sierra Club's Outstanding Project; US Army Award; Beckman-Coulter, Inc Award; and Runner-up for Best Biological Sciences Award (\$250). After competing at the 53<sup>rd</sup> *State Science and Engineering Fair of Florida* held in April 2007 in Naples, FL, Brisbane became the first RESSt intern to advance as a finalist at the *Intel International Science and Engineering Fair in Albuquerque, NM*.

Diaz won awards for Outstanding Project by the Sierra Club, and an award from US Army at the *South Florida Regional Science and Engineering Fair* held in Miami. He also advanced to the State Fair to compete for a spot at the International competition with his poster *The use of Cladium jamaicense seeds as indicators of historical changes in the Everglades estuarine ecotone*. Brisbane is currently studying Biology at the University of Florida and Diaz is enrolled as an Engineering student at Miami Dade College and preparing the first RESSt manuscript of their results with Saunders.

FCE's third year intern, Magaly Dacosta presented a joint poster with her FCE mentor Jeff Wozniak entitled *Isotopic values for southern Everglades marshes: C and N natural abundance study* at the 2006 FCE-ASM meeting. At the 2007 FCE-ASM meeting Dacosta read her essay *Our Responsibility to the Natural World* for which she won *First Place in Prepared Public Speaking* at the Future Farmers of America (FFA) District Convention and advances to compete at the FFA State Convention. Magaly also led a team of students from her high school in winning a \$500 award as the *Grand Champion* in Native Plant Landscape Design at the 2007 Miami-Dade County Fair and Exposition.

First year intern, Ben Giraldo, has been working with Dr. Tiffany Troxler-Gann. In a joint presentation of their poster *Bacterial diversity, enzymatic activities, and soil CO<sub>2</sub> flux along a soil P gradient in a coastal peatland, Panama*, Ben received First Place and \$100 book award at the 2007 FCE-ASM. In addition, each of the remaining RESSt interns gave a short progress report of their projects at the annual FCE LTER ASM March 19 and 20.

### **Graduate Student Activities and Productivity**

The FCE Affiliated Students Group includes over 40 graduate, undergraduate, and high school students who are members. The group meets once a month for meetings. They receive funding from the FIU Graduate Student Organization and host seminars and social activities with other graduate student organizations. FCE students earned 4 MS theses and 1 Ph.D. dissertation from December 2006 to October 2007.

Bryan K. Delius, FIU, MS, Distribution and trophic position of juvenile bull sharks in an oligotrophic estuary.

David P. J. Green, FIU, MS, Community structure and physiological stresses of oligohaline zone fishes in south florida

Min Gao, PhD summer 2007 Chemical characterization of soil organic matter in an oligotrophic, subtropical, freshwater wetland system: Sources, diagenesis and preservation

MS Danielle Lara Mir-Gonzalez, Groundwater nutrient availability controls on nearshore benthic community structure in Biscayne Bay, Florida

MS David L. Reed

Effects of hydrology and light on seedling establishment and growth of four wetland tree species in tree islands of northern Shark Slough, Everglades National Park

### **D. OUTREACH ACTIVITIES**

There are many ways in which FCE scientists, students, and staff interact with the greater public. Outreach often takes the form of presentations at forums such as community group meetings, publicized events, and secondary schools, or of specific training activities for students, teachers, or others. If a FCE scientist discusses their LTER research in such a presentation, we record that presentation as FCE outreach. The FCE Education and Outreach staff (including FCE high school interns) gave numerous presentations to schools in south Florida. FCE researchers also gave 58 presentations from December 2006 - September 2007.

The FCE LTER Program also reaches out to the public is through our web site and web statistics have shown that we have been reaching a steadily growing number of new web clients, suggesting a strong positive trajectory for our web-based public outreach. We continue to receive general questions from our visitors and requests for schoolyard visits and presentations. Additionally, visitors to the data section of our website downloaded 193 datasets from December 2006 - September 2007.

Finally, all FCE scientists and students are, to some degree, also involved with Everglades restoration. Several FCE scientists participated in preparation of the Interim Operations Program report to Congress with scientists and managers at Everglades National



Park. FCE researchers have also been involved with RECOVER (Everglades Restoration planning) with scientists and managers at the South Florida Water Management District.

Dr. René Price served as a Science Summit Judge, at F. C. Martin International K-8 Center, Miami, FL, April 11, 2007

Dr. René Price participated in Career Day, as a hydrogeologist, at F. C. Martin International K-8 Center, Miami, FL, Nov. 16, 2007

Dr. Colin Saunders presented a seminar “Paleoecological Detective Work in the River of Grass” to middle-school students at Palm Beach Community College. Boca Raton, FL. June, 2007.

### **III. PUBLICATIONS AND OTHER SPECIFIC PRODUCTS**

#### **A. PUBLICATIONS**

##### **Book chapters**

Hall, R.O., S.E. Thomas, and E.E. Gaiser, 2007. Measuring primary production in freshwater ecosystems . Pages 175-203 In T.J. Fahey and A.K. Knapp, (eds.) Principles and Standards for Measuring Net Primary Production in Long-Term Ecological Studies. Oxford University Press.

Knapp, A.K., J.M. Briggs, and D.L. Childers, 2007. Estimating aboveground net primary production in grassland and herbaceous dominated systems . Pages 27- 48 In T.J. Fahey and A.K. Knapp, (eds.) Principles and Standards for Measuring Net Primary Production in Long-term Ecological Studies. Oxford University Press.

##### **Journal articles**

Boyer J.N., Dailey S.K., Maie N. and Jaffé R. (In review) Physical and microbial processing of dissolved organic nitrogen (DON) in the Florida Coastal Everglades, USA. *Hydrobiologia*.

[Davis, S.E. and D.L. Childers, 2007. Importance of water source in controlling leaf leaching losses in a dwarf red mangrove \(\*Rhizophora mangle\* L.\) wetland. \*Estuarine, Coastal and Shelf Science\*, 71\(1-2\): 194-201.](#)

Dorn, N.J. and J.C. Trexler, 2007. Crayfish assemblage shifts in a large drought-prone wetland: the roles of hydrology and competition. *Freshwater Biology*, 20(1): 113-115.

[Ewe, S.M.L. and L.d.S.L. Sternberg, 2007. Water Uptake Patterns of an Invasive Exotic Plant in Coastal Saline Habitats. \*Journal of Coastal Research\*, 23\(1\): 255-264.](#)

Frankovich, T.A., A.R. Armitage, J.W. Fourqurean, A.H. Wachnicka, and E.E. Gaiser. (In review) P enrichment of seagrass meadows causes changes in epiphyte community structure at Division level and within diatom communities. *Journal of Phycology*

- Gao M., Simoneit B.R.T. and Jaffé R. (In press) Occurrence and distribution of botryococcanes in the Florida Everglades. *Chemosphere*.
- Herbert, D.A. and J.W. Fourqurean (In review) Ecosystem structure and function still altered two decades after short-term fertilization of a seagrass meadow. *Ecosystems*.
- Ikenaga, M., and J.N. Boyer. (In review) Changes in sediment bacterial community structure along the Florida Coastal Everglades marsh-mangrove-seagrass gradient. *Applied Environmental Microbiology*.
- Jochem, F.J., M.T. Rogers, and J.N. Boyer. (In review) Bacterial abundance, growth rates, and grazing losses in Florida Bay. *Aquatic Microbial Ecology*.
- [Maie, N., N.M. Scully, O. Pisani, and R. Jaffe, 2007. Composition of a protein-like fluorophore of dissolved organic matter in coastal wetland and estuarine ecosystems. \*Water Research\*, 41: 563-570.](#)
- Maie N., Pisani O. and Jaffe R. (In press) Mangrove tannins in aquatic ecosystems: their fate and possible role in dissolved organic nitrogen cycling. *Limnology & Oceanography*.
- [Noe, G.B. and D.L. Childers, 2007. Phosphorus budgets in Everglades wetland ecosystems: The effects of hydrology and nutrient enrichment. \*Wetlands Ecology and Management\*, 15: 189-205.](#)
- Poret, N., R.R. Twilley, V.H. Rivera-Monroy, and C. Coronado-Molina, 2007. Belowground Decomposition of Mangrove Roots in Florida Coastal Everglades. *Estuaries and Coasts*. *Estuaries and Coasts*, 30(3): 491-496.
- Rehage, J.S. and W.F. Loftus, 2007. Seasonal fish community variation in headwater mangrove creeks in the southwestern Everglades: an examination of their role as dry-down refuges. *Bulletin of Marine Science*, 80(3): 625-645.
- Rivera-Monroy, V.H., R.R. Twilley, J.E. Mancera, A. Alcantara-Eguren, E. Castaneda-Moya, CasasO. Monroy, P. Reyes, J. Restrepo, L. Perdomo, E. Campos, G. Cotes, and E. Villoria, 2007. Adventures and Misfortunes in Macondo: Rehabilitation of the Cienaga Grande. *Ecotropicos*, 19(2): 72-93.
- Rivera-Monroy, V.H., R.R. Twilley, K. de Mutsert, E. Castañeda-Moya, M. Romigh, and E. Davis, III. (In press) Patterns of nutrient exchange in a riverine mangrove forest in the Shark River Estuary, Florida, USA. *Hydrobiologia*.
- Ruiz-Halpern, S., S.A. Macko and J.W. Fourqurean. (In press) The effects of manipulation of sedimentary iron and organic matter on sediment biogeochemistry and seagrasses in a subtropical carbonate environment. *Biogeochemistry*.

- Saunders, C.J., Childers, D.L., Anderson, W.T., Lynch, J.A., and Jaffe, R., 2007, Understanding *Cladium jamaicense* dynamics over the last century in ENP using simulation modeling and paleoecological data - 24 month Report. Everglades National Park, National Park Service (#EVER-00278), 47p.
- Saunders C. J., M.J. Blum, J. McLachlan, C. Craft, and J. Herrick. (In review) Genetic variation in salinity tolerance within a coastal marsh sedge population resurrected from a seed bank spanning 110 years (1885 to 1995). *Global Change Biology*
- Simoneit, B.R.T., Y. Xu, R. Neto, J. Cloutier, and R. Jaffe (In Review) Photochemical alteration of 3-oxy-triterpenoids: Implications for the origin of des-A-triterpenoids in aquatic sediments and soils. *Journal of Photochemistry and Photobiology*
- Stanaway, K., J.N. Boyer, J.W. Louda and P. Mongkrons. (In review) Effects of flocculent microbial mats and seagrass roots and rhizomes on sediment nutrient fluxes in a shallow estuary. *Estuaries and Coasts*.
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## **B. OTHER SPECIFIC PRODUCTS**

### **Presentations at Professional Conferences**

The FCE LTER Program has not generated any tangible economically-valuable products to date. However, we view the dissemination of our results at professional scientific conferences as a tangible intellectual product. FCE scientists and students have made 68 such presentations during the first year of FCE II.

We continue to dedicate FCE resources to provide travel support for FCE scientists, students, and educators to attend professional conferences. This is important for their professional development, but is also important as a mechanism for disseminating products of FCE LTER research. Disseminating this intellectual product is critical to helping guide the science of Everglades Restoration.

### **Data or databases**

We have 290 FCE and historical Everglades datasets. Datasets include climate, consumer, primary production, water quality, soils, and microbial data as well as other types of data. An Oracle10g relational database has been designed to accommodate the diverse spatial and temporal heterogeneous core data and accompanying metadata submitted by the FCE researchers. Datasets are available for public download from the data section of the Florida Coastal Everglades LTER website at <http://fcelter.fiu.edu/data>.

## **C. INTERNET DISSEMINATION**

The url of the main FCE LTER Program website is <http://fcelter.fiu.edu>.

## **IV. CONTRIBUTIONS**

### **A. CONTRIBUTIONS WITHIN DISCIPLINE**

Several FCE scientists participate in large-scale high-density monitoring programs in the Everglades compliment FCE-LTER research. This includes the REMAP program of the Environmental Protection Agency, which collects and analyzes periphyton, vegetation and consumer data from 125 sites throughout South Florida every 3 years in conjunction with abiotic and other biotic data. Similar mapping occurs through support through the Comprehensive Everglades Restoration Monitoring and Assessment Program funded through the South Florida Water Management District. Gaiser and Trexler are collecting periphyton, consumers and plants from >400 sites per year, distributed throughout the Everglades, and analyzing patterns relative to water quality and hydrology gradients. Monitoring in Biscayne Bay, Florida Bay and the Florida Keys continues through support from the Southeast Environmental Research Center, University of Virginia and South Florida Water Management District.

J.S. Rehage, along with K. Petren (University of Cincinnati) co-organized an oral session at the Ecology Society of America annual meeting in San Jose, CA titled “The behavior of invasions:

Is there a path from mechanism to prediction?” (August, 2007). At this session, J.S. presented a talk titled “[Examining behavioral interactions between non-native predators and native prey: a tale of two cichlids](#)”

J.S. Rehage and W.F. Loftus gave a poster presentation at the South Florida & Caribbean Cooperative Ecosystem Unit Semi-Annual Science Meeting, February 2007 titled “Seasonal fish dynamics in mangrove creeks of the coastal Everglades.”

The Hydrology Working Group organized a meeting entitled “Tree Island Investigations and Observations” held on June 28, 2007. Scientists working on tree island research in the Everglades gave short presentations of their work to the group.

Dr. Joe Boyer attended the following meetings/workshops:

- Southeast Florida Coral Reef Initiative Technical Assessment Committee. Ft. Lauderdale, May 24-25, 2007.
- Association of Marine Laboratories of the Caribbean Meeting. St. John, USVI, June 14-17, 2007.
- SECOORA Meeting. Jacksonville, FL, June 12, 2007
- FL-COOS Caucus. Florida Institute of Technology, June 19, 2007.
- Gulf of Mexico Alliance meeting. St. Petersburg, FL, July 9-12, 2007.
- FKNMS Steering Committee Meeting. Key Colony Beach, FL, July 24, 2007.
- FKNMS Sanctuary Advisory Committee. Marathon, FL, Aug. 21, 2007.

Dr. Joel Trexler co-chaired the a symposium entitled “Setting goals and targets for restoration and management of large-scale ecosystems” at the Ecological Society of America Meeting in San Jose, CA. He also lead a symposium entitled “Everglades Water Quality: On the Critical Path to Restoration” at the North American Benthological Society Meeting in Columbia, SC.

## **B. CONTRIBUTIONS TO OTHER DISCIPLINES**

Several FCE scientists participate as advisors to the South Florida Ecosystem Restoration Task Force for establishing Vital Sign Indicators of Everglades restoration. This team is using FCE LTER and other large, long-term datasets to assess and evaluate the trajectory of Everglades restoration projects. This includes participation in bi-monthly workshops, modeling efforts and synthesis of long term datasets. The group plans to publish findings in a special issue of the journal *Ecological Indicators* in 2008.

Several FCE scientists participate as advisors to the REstoration COordination and VERification (RECOVER) team for the Comprehensive Everglades Restoration program. This includes participation in quarterly workshops, reading and evaluating annual reports and proposals and synthesizing data for use in Everglades monitoring and protection.

Several FCE scientists participate as advisors to the South Florida Water Quality TOC Water Quality Evaluation Team which evaluates the compliance to water quality standards set for Everglades National Park and other federally protected land in South Florida. Participation includes presence at biannual meetings, reporting on water quality data (including FCE LTER findings) and evaluating reports to congress.

Gaiser represented the FCE LTER at the annual meeting of the South Florida and Caribbean Cooperative Ecosystems Studies Unit which facilitates research funding for ecological sciences in South Florida.

Gaiser is a collaborator on an NSF Research Coordination Network grant for the Global Lakes Ecological Observatory Network. This is a grassroots network of limnologists, engineers and information specialists who aim to equip lakes and wetlands with high-resolution sensors and real-time global conveyance to evaluate large-scale patterns in ecological change in aquatic ecosystems. Participation in GLEON will facilitate future high-resolution sensor data collection and communication within the FCE LTER and a site at the head of the FCE watershed at Archbold Biological Station. She attended and presented at the following meetings:

Gaiser, E. E., N. Deyrup, R. Bachmann, L. Battoe and H. Swain. 2007. Long-term shifts in water transparency alter thermal responses to climate change in a subtropical, monomictic seepage lake. 30<sup>th</sup> Congress of the International Association of Theoretical and Applied Limnology. Montreal, Quebec.

Gaiser, E. E., N. Deyrup, R. Bachmann, L. Battoe and H. Swain. 2007. A 23-year record of cascading limnological effects of a shifting light environment in a monomictic seepage lake in central Florida. Global Lakes Ecological Observatory Network meeting. Lammi Biological Station, Finland.

Fourqurean, Gaiser, Ogden and Price represented the FCE at LTER planning grant activities and participated on the LTER Science Coordination Committee at the annual meetings.

The FCE-LTER was part of two responses to the NSF RFI for the National Ecological Observatory Network. FCE scientists attended conferences to facilitate participation in NEON and are awaiting news about participating as a gradient site.

International LTER supplemental funding from 2006/07 was used to support cross-system comparisons in the Sian Ka'an Biosphere Reserve in Quintana Roo, Mexico and New River Lagoon, Belize. The extensive wetlands occur on calcareous bedrock and support wet prairie habitat very similar to the Everglades. Trexler, Gaiser and Loftus took FCE students J. LaHee and C. Ruehl to these sites in Fall 2006 and Spring 2007 to compare the Eltonian biomass structure of these wetlands to that of the Everglades. Preliminary analyses show that these wetlands also support a very high biomass of periphyton which does not translate up the food web. The consumer community was depauperate and dominated by reduced community of gastropods and small fish as in the Everglades. Community analyses show a great deal of compositional overlap in the algal and plant communities but less so with the consumers, although biomass structure does appear consistent among sites. The following presentation resulted from this work:

Gaiser, E. and J. LaHée. Taxonomic and morphological variability in diatoms endemic to modern stromatolitic microbial mats of Caribbean wetlands. North American Diatom Symposium. Pellston, MI.

J.S. Rehage and W.F. Loftus attended several meetings of the CERP MAP Greater Everglades Module throughout 2006. They also contributed data to the 2007 System Status Report for RECOVER and gave a presentation before the RECOVER Assessment Team title “Integrative Trophic Sampling in the Greater Everglades.”

Dr. René M. Price serves as a science advisor to the SFWMD, Miami Dade County Water and Sewer Dept., as well as to Everglades and Biscayne National Parks on issues related to groundwater quality.

Dr. Vic Engel is co-chair of the Greater Everglades module of the CERP Monitoring and Assessment Program. He is also a member of the Decentralization Project Team administered by the SFWMD and the ACOE.

Dr. Joe Boyer participated in the following workshops:

- South Florida Ecosystem Restoration Task Force Science Coordination Group – Ecosystem Indicators Group. Miami, FL, June 13, 2007.
- South Florida Ecosystem Restoration Task Force Science Coordination Group – Ecosystem Indicators Group. Miami, FL, Aug. 20, 2007.

Dr. Carl Fitz - For the Comprehensive Everglades Restoration Plan, Interagency Modeling Center, trained twelve representatives of State and Federal agencies in the use and application of the Everglades Landscape Model.

Human Dimensions members contributed to Everglades Restoration and climate change/ risk assessment modeling and planning.

Ogden, Laura. Writing Team, *LTER Integrated Research Plan*.

Ogden, Laura. LTER Ecosystem Services Workshop, Portland State University, Oregon, May 16, 2007.

Ogden, Laura. Member. South Florida Ecosystem Restoration Task Force, Human Ecology Ad-Hoc Team.

Gladwin, Hugh. Miami-Dade Climate Change Advisory Task Force (2006-Present)

Gladwin, Hugh. Steering Committee, Local Mitigation Strategy, Office of Emergency Management and Homeland Security, Miami-Dade County, 1997-Present.

Gladwin, Hugh. Disaster Reduction—Theory and Practice Workshop. Hazards and Vulnerability Research Institute, University of South Carolina, 2007.

### **C. CONTRIBUTIONS TO EDUCATION AND HUMAN RESOURCES**

The FCE Schoolyard LTER program and the FCE EdEn Venture effort, joint with Environmental Education at Everglades National Park and several local schools, highlight our K-12 human resource development. We detail these programs elsewhere in this report.

We have continued to expand the offering of new curriculum materials on our Education webpage. New offerings include: an LTER site mapping and classification exercise; ForEVERGLADES Presentation script in Spanish; Animals of the Everglades Activity; Energy Transfer Through an Everglades Ecosystem; and a population dynamics exercise “Oh Deer! Everglades Lab”. In addition, we have posted several general exercises that will be incorporated into existing presentations and those in current development. Our hope is to increase website traffic by posting exercises that can be used throughout any discipline within the science curriculum.

FCE Education and Outreach is also currently working with the University of Miami Department of Geology and Regional in developing GIS workshops for teachers and in GIS curriculum development for the high school classroom. Another product on the horizon is our first video projects. In its final stages of production, we will begin testing its use in MDCPS classrooms in October 2007.

J.S. Rehage developed a new Everglades Ecology and Conservation course at NSU, which will be taught to undergraduates for the first time in Winter 2008.

Six undergraduate students at FIU gained experience in field sampling techniques working with bull sharks.

Graduate education is a very important component of the FCE LTER program, and our graduate students maintain their own very active FCE Affiliated Student Group. We currently have over 40 graduate students, from more than 6 different universities, who are affiliated with FCE. Between December 2006 and October 2007, 5 graduate degrees (4 MS theses and 1 Ph.D. dissertations) were conferred from FCE-based thesis/dissertation research. Our student group (which also includes interested undergraduate and high school students) meets monthly to discuss their LTER research. They receive funding support from the FIU Student Government Association.

### **D. CONTRIBUTIONS TO RESOURCES FOR SCIENCE AND TECHNOLOGY**

#### **Research sites**

Our research plan focuses on 15 permanent sampling sites located on 2 large transects that cover most of Everglades National Park. At each site, we have constructed platform, boat dock, and boardwalk facilities that are available to any permitted researcher who wishes to use them (after requesting permission). To date, many academic and agency scientists are taking advantage of these field facilities, and the FCE LTER Program continues to support expanded use of our facilities through Letters of Support for proposals (8-10 such formal letters are written each year).



We are currently participating in a large mangrove monitoring program with our colleagues from the Mexican LTER program (<http://www.mexlter.org.mx/>). Our FCE-LTE mangrove sites is now part of a network of sites distributed along the Gulf of Mexico coast, including Florida and the Mexican states of Veracruz, Tabasco, Campeche, Yucatan, and Quintana Roo. This program will be funded by the Mexican Agency CONABIO (*Comision Nacional para el Conocimiento y Uso de la Biodiversidad*, <http://www.conabio.gob.mx/>) and will be the framework for the *Red de Monitoreo de los Manglares de Mexico*. The FCE-LTER sampling scheme (productivity and forest structure) has been incorporated in this monitoring network and Victor H. Rivera-Monroy and Robert R. Twilley will participate as advisers on sample protocols and data analysis. In addition VHRM, as part of the Mexican LTER program Executive Committee is collaborating in initiatives to expand the monitoring program to other sites in the Caribbean. It is expected that the collaboration with the Mexican LTER program will help to consolidate our collaboration and allow FCE-LTER scientists to perform collaborative research in Mexican coastal ecosystems in the Gulf of Mexico and the Mexican Caribbean. In addition we are developing a mangrove rehabilitation program in Celestun Lagoon in collaboration with the Mexican LTER group ECOPEY (*Ecosistemas Costeros de la Peninsula de Yucatan*). Research results from mangrove studies in Shark and Taylor River and Celestun Lagoon are now being applied to develop programs to develop techniques in mangrove restoration and rehabilitation in Latin America.

### **Website**

The FCE LTER website provides a variety of information, including data, educational activities, maps, project information, site information, publications, presentations, and photos. Visitors to the data section of our website downloaded 193 datasets from December 2006 - September 2007.

### **E. CONTRIBUTIONS BEYOND SCIENCE AND ENGINEERING**

We have an active Human Dimensions group, headed up by Laura Ogden (Anthropology, FIU) that includes social scientists from several universities. The FCE Human Dimensions group submitted a 2007 Social Science Supplemental Request for cross-site activities that would allow us to 'jump-start' our FCE research by taking advantage of the depth and breadth of social science expertise across the LTER Network.

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