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FCE III Year Five Annual Report for NSF Award DEB - 1237517

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FLORIDA COASTAL EVERGLADES LTER

FCE III YEAR FIVE ANNUAL REPORT

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Accomplishments

Major goals of the project

The goal of the Florida Coastal Everglades Long Term Ecological Research (FCE LTER) program is to conduct long-term studies to understand how climate change and resource management decisions interact with biological processes to modify coastal landscapes. Our focus is on the oligohaline ecotone of the Florida Everglades, integrating marine and freshwater influences. Long-term data show that the ecotone is highly sensitive to increasing marine pressures, driven over longer-time scales by sea level rise (SLR) and over shorter-time scales by storms and tidal exchanges. Freshwater flow, controlled by climate variation and upstream allocation decisions, interacts with marine pressures to affect water supplies to the ecotone. FCE is in its third phase of research (FCE III), focused on linking long-term dynamics in freshwater and marine water supplies to transformations in the ecotones of two major drainages, Shark River Slough (SRS) and the Taylor Slough/Panhandle (TS/Ph).

The overarching goals of this reporting year included: (1) continue to constrain the sources of variance in the short and long-term dynamics of water supply to the ecotone, and socioecological and hydrological politics of freshwater restoration in the face of SLR, (2) continue to collect long-term data across the five core areas and integration with results from mechanistic experiments and spatial scaling studies to address the causes and consequences of long-term dynamics of the oligohaline ecotone relative to changes in fresh and marine water supplies, (3) continue studies of the legacies of climate and disturbance as drivers of change through alterations in ecotone salinity, phosphorus (P) supplies and inundation, (4) complete modeling and synthesis efforts linking climate and disturbance legacies to future projections, (5) complete revisions on FCE synthesis book and synthesis papers for publication, (6) continue updates of FCE data to the Network Information System (PASTA), (7) integrate core findings across through LTER network-wide collaborations, (8) advance education (FCE Schoolyard) and outreach activities through expanded partnerships directed toward goals of the Strategic Implementation Plan for LTER.

FCE III research is conducted within the context of four major working groups (WG): *Biogeochemical Cycling*, *Primary Production*, *Organic Matter (OM) Dynamics*, and *Trophic Dynamics*. Integration is accomplished through four Cross-Cutting Themes (CCT): *Hydrology and Water Policy*, *Carbon (C) Dynamics*, *Climate and Disturbance Legacies*, and *Modeling and Scenarios*. Further synthesis was driven by our contributions to a holistic synthesis book that is in final editorial stage, and in several synthesis papers that have been submitted or accepted for publication. Here, we report progress integrating across each of these categories relative to the themes set in our proposal using data from long-term studies and experiments, while also addressing the feedback from our mid-term review team.

Major Activities

Hydrology and Water Policy: Activities in our Hydrology and Water Policy Theme address how climate change and SLR interact with water management practices to control hydrologic conditions in the oligohaline ecotone through two hypotheses: (1) variable inflows from upstream sources, SLR, and storm surge interact to alter surface water residence time, salinity, and groundwater intrusion in the oligohaline ecotone, and (2) stakeholder uncertainties over SLR will increase conflicts over Everglades restoration implementation and will affect freshwater delivery to the oligohaline ecotone. We addressed the first hypothesis through continued ground- and satellite-based observations of hydrology and geochemistry, and a synthesis of 16-years of these data to determine impacts of sea level rise on water levels and water chemistry of the oligohaline ecotone. We coupled this analysis with a variable density groundwater flow model SUTRA to simulate seawater intrusion in Taylor Slough. Activities addressing the second hypothesis included surveys and interviews with farmers in the Everglades Agricultural Area – these are stakeholders-actors who are critical to the target, objectives and implementation of Everglades restoration. Farms of diverse types and sizes were assessed for their individual and collective contributions to water quality improvements, and related to the degree of shared management among farms in the area. Semi-structured interviews with respondents were conducted to understand the extent and significance of collaboration and information-sharing within the farming community as well as between farmers and other stakeholder groups.

Carbon Dynamics: Activities in our Carbon (C) Dynamics Theme addressed how changing freshwater inflows, tidal and storm cycles, and climate patterns influence the magnitude, rates, and pathways of C sequestration, loss, storage and transport across the land-water continuum through two hypotheses: (1) temporal variability in C cycling reflects the presses and pulses of the balance of marine and freshwater supplies, and (2) landscape patterns of C reveal legacies of this balance. We continued to address the first by coupling long-term data with field and laboratory experiments to address mechanisms, and the second through scaling plot-based long term measurements using remote imagery.

Long-term data collection and synthesis. Following the advice of our mid-term review team, we are driving synthesis of our long-term data through the production of papers that synthesize 17 years of FCE biogeochemical, primary production, organic matter, and consumer research. The synthesis of biogeochemical synchrony, submitted by Kominoski et al. to *Ecosystems*, tests the hypothesis that surface water, porewater, plant, and soil C, nitrogen (N), and P dynamics along freshwater-ecotone-marine gradients in SRS and TS/Ph express decreasing freshwater and increasing marine connectivity; a complimentary paper analyses over 27 years of biogeochemical data from Florida Bay. The synthesis of our primary production data integrates long-term hydrological and biogeochemical data to determine how water balance regulates plant composition and primary productivity. In addition, we completed studies on the impact of a changing water balance on the quality and fate of C through synthesis of organic matter reactivity, long-term inorganic and organic C accumulation rates, particulate organic matter mobilization, and C dioxide efflux to surface water. Finally, we are examining how changes in water balance, and resultant shifts in organic matter source and quality, manifest in the movements and trophic interactions of consumers. We continued to synthesize our data from our consumer movement array to determine how short and long-term changes in marsh-ecotone-

estuary connectivity modify the behavior and trophic structure of consumers (American alligators, bull sharks, common bottlenose dolphins, common snook and Atlantic tarpon).

Experiments. To understand the mechanisms of how the balance of fresh and marine water supplies influence the C balance through interacting effects on P availability, salinity and water residence time we have continued several scales of experiments. We submitted a manuscript from a mesocosm experiment manipulating P and mangrove leaf loss to quantify above- and belowground changes in C storage; completed a 2-year mesocosm experiment manipulating surface and porewater salinity and P loading on plant-soil and periphyton C loss from freshwater marshes; finalized analyses and a draft manuscript for a mesocosm experiment testing subsidy-stress gradients in salinity and P concentrations on freshwater and brackish water peat soil C loss; and began a 1-year freshwater restoration manipulation in experimental mesocosms.

Climate and Disturbance Legacies: We hypothesize that changes in land-use and water allocation in the FCE have hydrodynamic consequences in the Everglades landscape that explain changes in the oligohaline ecotone. We investigated these legacies broadly using biophysical and integrated socio-ecological approaches including: (1) examining biogeochemical and productivity legacies of SLR and tropical storms in a press-pulse framework; (2) the legacies of extreme cold episodes on the responses of temperate and tropical species to changing fresh and marine water supplies, and (3) ongoing evaluation of the economic legacies of restoration decisions in retrospective and scenario analyses of the effects of decisions on ecosystem services.

Scenarios and Modeling: Our modeling and synthesis efforts continue to span both local and landscape spatial scales and instantaneous to multi-decadal temporal scales, while addressing both hydrodynamic, geochemical, and hydro-ecological dynamics. Our hydrodynamic and geochemical modeling continues to improve our fundamental understanding of pattern and process, and serve to inform our scenarios modeling; our scenarios modeling is underscoring the need for improved understanding of vegetation-peat responses to altered salinities and water depths. We made progress on geochemical and hydrodynamic modeling efforts to better understand the geochemistry, transport, and fate of dissolved constituents, with a focus on P and C, in the mangrove ecotone of the Everglades. Having developed a framework of climate scenarios for use in FCE modeling efforts, we simulated hydro-ecological responses to three of these climate scenarios for 2060 using the Everglades Landscape Model (ELM v2.8.6) with a focus on the Everglades National Park.

Specific Objectives

Hydrology and Water Policy: Specific objectives of this past year included understanding how climate change and sea level rise interact with water management practices to control hydrologic conditions in the oligohaline ecotone, and understanding how stakeholder uncertainties over SLR will increase conflicts over Everglades restoration implementation and will affect freshwater delivery to the oligohaline ecotone. We planned to complete long-term ground-based and satellite observations of hydrology and geochemistry to understand change in the oligohaline ecotone, improve our ability to track and understand implications for hydrologic change in the TS/Ph ecotone through the modeling efforts, and complete the analysis of our ethnographic and stakeholder surveys.

Carbon Dynamics: Specific objectives were directed toward two hypotheses: (1) temporal variability in C cycling reflects the presses and pulses of the balance of marine and freshwater supplies, and (2) landscape patterns of C reveal legacies of this balance. We planned continued long term data collection and coupled with field experiments to address the patterns and causes for change, and analysis of our ability to detect change at different scales by combining interpretations from long term measurements with those provided via remote imagery.
Long-term data collection and synthesis. We continued to collect and synthesize over 17 years of FCE biogeochemical, primary production, organic matter and consumer data to determine how the balance of fresh and marine water supplies influence components of the C cycle. We have completed several collaborative synthesis papers to this end, including an analysis of dynamics and controls of stoichiometric variability across ecosystem components along the freshwater-marine gradients, and an analysis of salinity threshold responses in long-term primary production along our transects (SRS, TS/Ph). We analyzed 17 years of periphyton data to determine roles of foundation algae species in regulating community dynamics and production along water supply gradients. We also worked on determining linkages between molecular character and reactivity of dissolved organic matter (DOM), drivers of optical properties measurements on spatial and temporal scales, and effects of climate and management on DOC export. In the past year, we continued analysis of food webs in the freshwater Everglades using new biomarkers (fatty acids). This work will lead to new food-web descriptions based on assimilated food and food quality, building on two book chapters that provide graphical representation of structural food webs documenting trophic linkages, addressing a concern of our mid-term review. We have continued our long-term datasets to determine spatio-temporal dynamics, a critical element to understand ecosystem function in the Everglades and that make it an excellent ecosystem to reveal novel yet widely important ecological dynamics. We have performed juvenile bull shark fishing to obtain a minimum of 12 longline sets per yearly quarter. In addition, we tagged and measured approximately 40 juvenile bull sharks as well as sampled multiple tissues for stable isotope analysis in the last year. We deployed an additional 20 bull shark acoustic tags and 15 alligator tags in 2016. Also, we have performed regular downloads of the Shark River acoustic array. These long-term datasets of movements and trophic interactions will give us insights into the ecological roles of consumers and to determine the interplay of these roles with changing environmental conditions.

Experiments. To understand the mechanisms of how the balance of fresh and marine water supplies influence the C balance through interacting effects on P availability, salinity and water residence time we planned to continue our experiments, including evaluation of how pulses of salinity and P associated with storm surges affect C losses from freshwater wetlands. We also planned to complete mesocosm (salinity x inundation and salinity x P) and field (salinity) experiments with freshwater and brackish plant-soil peats. We planned to complete analyses of data from 2013 (soil microbial community data forthcoming) and 2015-2016 REU projects, and complete a 1-year freshwater restoration manipulation in experimental mesocosms, and submit manuscripts associated with these efforts. We planned to continue to meet as a team to synthesize research findings from manipulative experiments (field and mesocosm).

Landscape scaling. In addition to the aforementioned syntheses of spatio-temporal patterns of biophysical change at our long term research sites arrayed along long landscape gradients, we planned to complete a first generation landscape-scale map of coastal ecotone vegetation to

determine how plant composition and primary productivity express legacies of fresh and marine water supplies. We also planned an assessment of spatial representativeness of sites along our transects using these remotely sensed data. We are awaiting news about several leveraged proposals to increase our landscape scaling research to address these questions about transect representativeness.

Climate and Disturbance Legacies: We planned to complete our paleoecological work to measure 100-year rates of organic C burial along this gradient on the SRS in addition to our synoptic surveys of bulk soil properties to evaluate connections between long-term vegetation patterns (above-and belowground), efficiencies in soil C storage, and soil C burial rates in mangrove sites along the SRS and TS/Ph transects. Our consumer research focused on synthesizing the legacies of extreme events on consumer populations, movements, and trophic interactions, extending long-term datasets to determine the importance of freshwater delivery to connectivity between marsh and estuarine systems through movements and trophic relationships of fish and other large consumer, synthesizing datasets to determine patterns of niche overlap and separation among the top predator guild, and extending long-term datasets on the movements and trophic interactions of large estuarine predators to predict impacts of freshwater delivery and SLR on their role in connecting ecosystems. Lastly, we aimed to achieve a better understanding of human dimensions of the ecosystem by examining: a) institutions of landscape change; b) institutions of water management; and c) geographic patterns of environmental attitudes among the South Florida population.

Scenarios and Modeling: We had three specific objectives of our modeling work in the past year: (1) to publish our second and third papers on geochemical laboratory experiments of water-rock interactions accompanying saltwater intrusion, and use these results to further develop our geochemical model in which we can investigate nutrient release under various climate and sea level rise scenarios. (2) to complete our hydrodynamic model of coastal Shark River with a particle tracking component, which required acquiring final data necessary as input (ie., bathymetric surveys, remote sensing, and water level data), and (3) to finalize and publish our Everglades Landscape Model (ELM) simulations of hydro-ecological responses in the Everglades National Park to future climate scenarios. We also coordinated synthesis efforts to (1) compare seasonal changes and environmental drivers of black carbon export in the Altamaha River, GA (GCE LTER) and lakes in McMurdo (MCM LTER), and (2) develop a new testable conceptual model for understanding ecosystem development after disturbance across long-term research platforms.

Significant results

Hydrology and Water Policy: Analysis of the combined effects of water management, climate, and sea level rise on water levels and chemistry of SRS over the last 16 years of the FCE concluded that freshwater delivery can have the greatest impact on reducing salinity and nutrients in the oligohaline ecotone if it is delivered year-round as opposed to only during the wet season as commonly occurs (Figure 1; Dessu et al., in prep). This delivery is dependent on freshwater inflows meeting P concentration limits. An analysis of the impact of farm water management on P loading indicates that the shared pollution cap generated effective participation with a preference for group compliance rather than individual regulation. Analysis of water

management outcomes at the basin level from 2000-2015 (Figure 2a, b) indicates the largest land managers (Florida Crystals) are significant players in leading the overall basic-wide reductions in P loads. Third, analysis of temporal trends against baseline data highlight clear drawbacks of the shared pollution cap, since basins are allowed to increase their loads relative to their baselines and farm management trends indicate that future reduction may not be as strong as past reductions if farms continue to have increasing P concentrations.

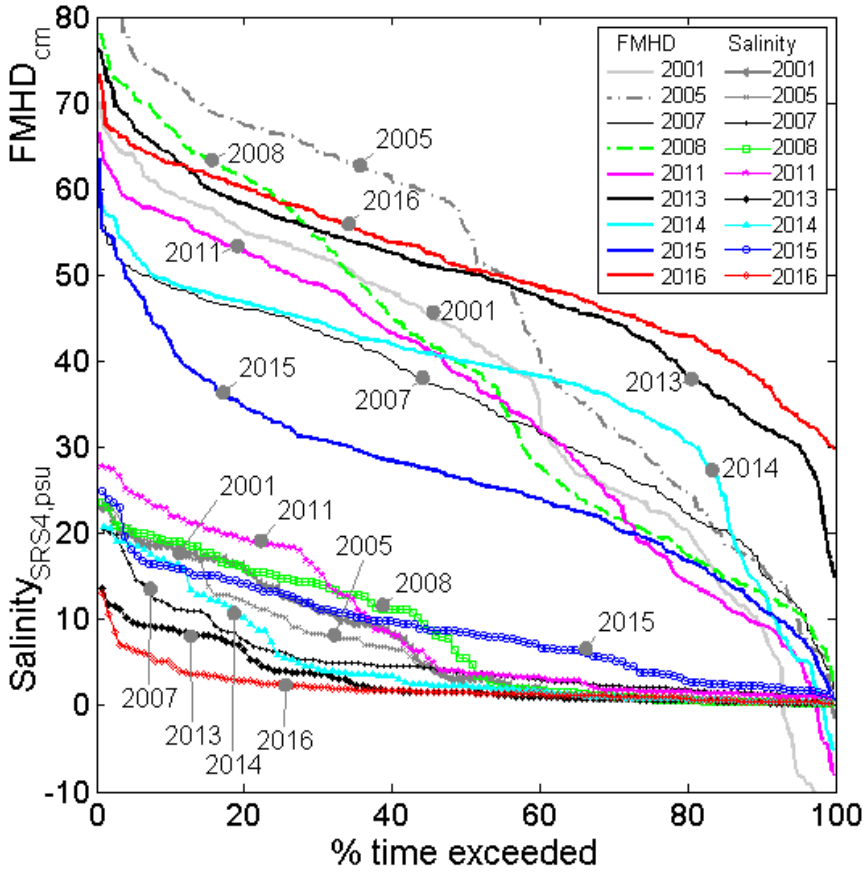


Figure 1. Exceedance curve analysis of 16 years of FCE data. Freshwater to Marine Head Difference (FMHD) as determined by the difference in water level at SRS3 and sea level at Key West was found to be the dominant factor in determining salinity in the

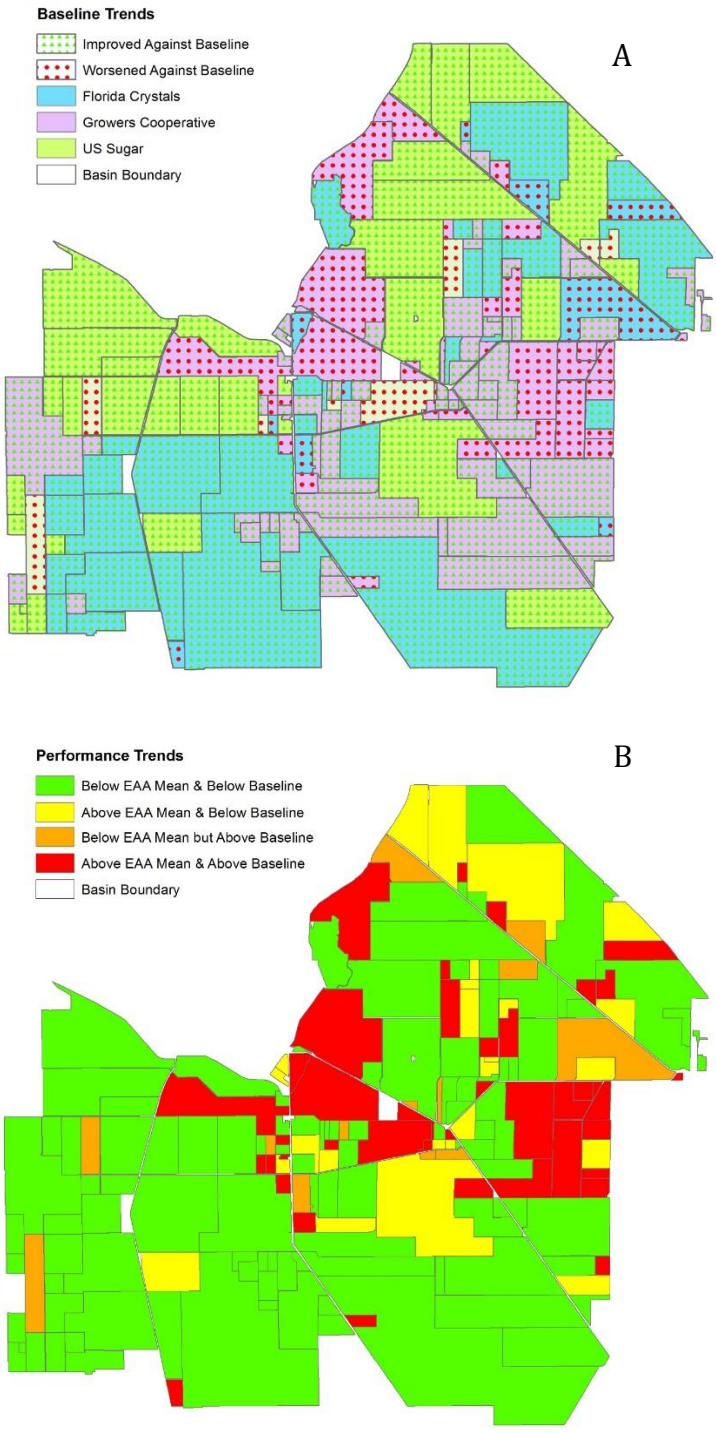


Figure 2. (A) Average annual P loads by company (2000-2015) relative to pre-regulatory baseline P load for each basin published in the South Florida Environmental Reports. Map shows basins by company management, in which the indicated farm business manages the majority of the land in the basin. **(B)** Basin performance in annual mean total P loads below or above the Everglades Agricultural Area's 15-year mean of 0.98 pounds per acre combined with baselines.

Carbon Dynamics: *Long-term data collection and synthesis.* Syntheses of long-term (up to 17 years) of surface water, plant (periphyton, sawgrass, mangrove) and soil chemistry data showed that episodic disturbance events have the capacity to mineralize and mobilize internal sources of nutrients over varying scales of space and time (Figure 3). Increases in P inputs, retention and allocation, and synchronization among ecosystem compartments was greater in riverine than micro-tidal mangrove forests and in long- than short-hydroperiod freshwater marshes due to higher connectivity to water-mediated sources of P. In upstream freshwater marshes, long-term patterns of primary productivity and the net C balance are largely controlled by the effects of seasonal and interannual cycles of freshwater and P availability driven by large-scale meteorological teleconnections and water management operations (Kominoski et al., in review). Calcareous periphyton mats can account for up to half of C fluxes, but exposure to above-ambient P concentrations causes abrupt dissociation of periphyton mats through a loss of foundation algal species (Marazzi et al. 2017; Figure 4). Our models show that increasing delivery of freshwater that meets the P criterion will maintain integrity and function of these mats while increasing their nutritional quality and palatability to consumers (Naja et al. 2017; Beerens et al. 2017; Figure 5). In the marsh-mangrove ecotone, reduced freshwater flows and SLR are increasing marine supplies of salt and P, as well as indirectly influencing P availability through salinity-mediated desorption from carbonate-rich sediments and bedrock (Flower et al. 2017a,b). Conspicuous organic C flux in tidally riverine mangroves represents only ~10% of the C from mangrove net ecosystem production, while the remaining is inorganic C lost to the atmosphere or delivered downstream to the ocean (Ho et al. 2017). Long-term spatio-temporal patterns of estuary DOM and POM concentrations reflect the influence of tidal pulsing on OM flushing (Regier et al. 2016; Regier and Jaffe, 2016), with the majority of DOM being from freshwater sources while the POM is primarily mangrove-derived (Chen and Jaffe 2016). Long term declines in above-ground net primary production appear related to increased salinity exposure, except in regions more directly connected to marine sources of P (Figure 6). However, our recent work in seagrass beds has shown that small-scale increases in P availability do not increase C storage (Armitage and Fourqurean 2016). Interestingly, given that burial rates of autochthonous inorganic C are 4-10 times higher than burial rates of organic C across much of the FCE domain, it is likely that much of the landscape could have been acting as a source of CO_2 to the atmosphere over the last 5,000 years, despite having high rates of net primary productivity (Howard et al. 2017). Long-term tracking of consumers shows that fish, mammals, wading birds, and crocodilians seek resources trapped in upstream freshwater reaches during the dry season, while also relying heavily on seasonal pulses of prey into the upper estuary (Botson et al. 2016), creating temporally-variable trophic linkages between mangrove and freshwater food webs (Matich et al. 2017).

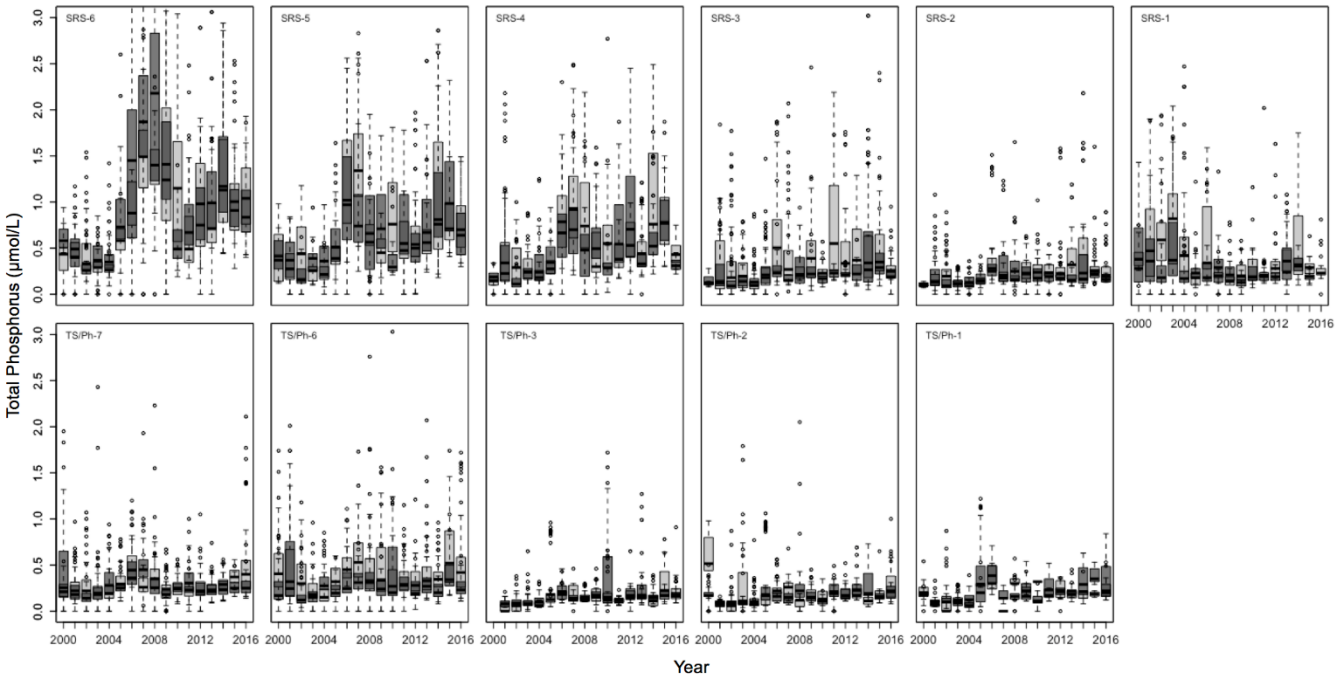


Figure 3. Long-term median surface water total P along estuarine to freshwater gradients in Shark River Slough (SRS) and Taylor Slough/Panhandle (TS/Ph) during subtropical wet (dark grey; June – November) and dry seasons (light grey; December – May) from 2000 to 2016. Figure from Kominoski et al., in review.

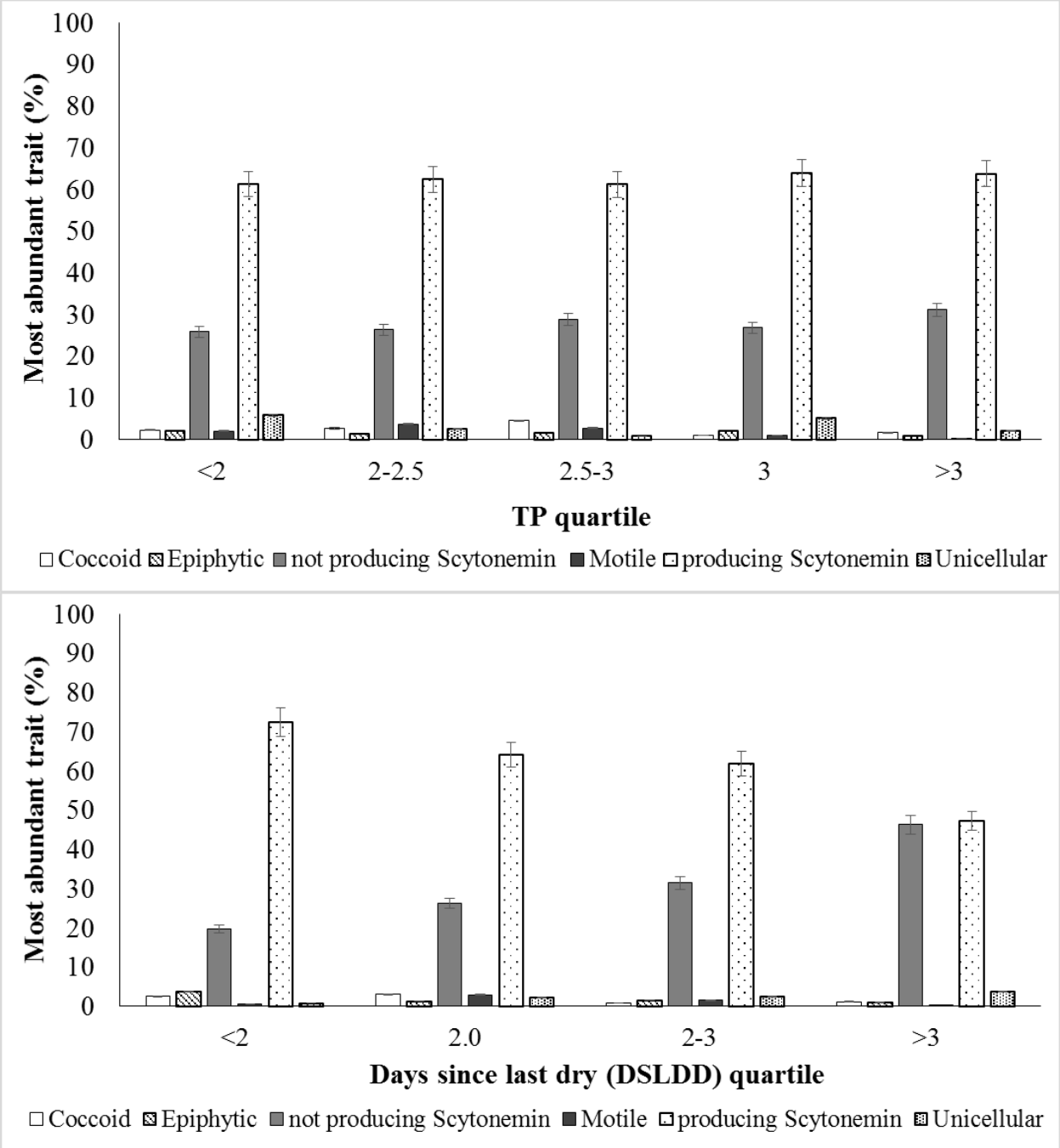
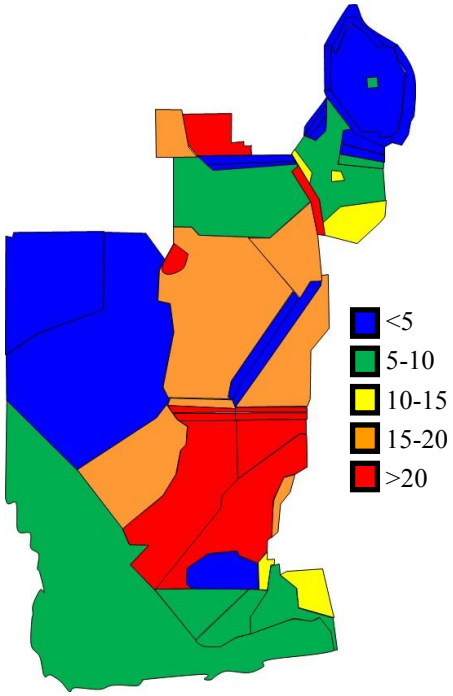


Figure 4. Mean frequency of algal traits (%) in relation to quartiles of (A) periphyton mat TP content; (B) days since last dry (DSLDD). From Marazzi et al. (2017)



Periphyton Edibility (%)
Difference between "business as usual" and full CERP restoration scenarios.

Figure 5. Map shows results of Everglades Landscape Model inputs to the Periphyton Edibility Model for the difference between a "do nothing" scenario and full Comprehensive Everglades Restoration Program (CERP) for the final year of the 36 year run averaged across 51 Everglades Landscape Units.

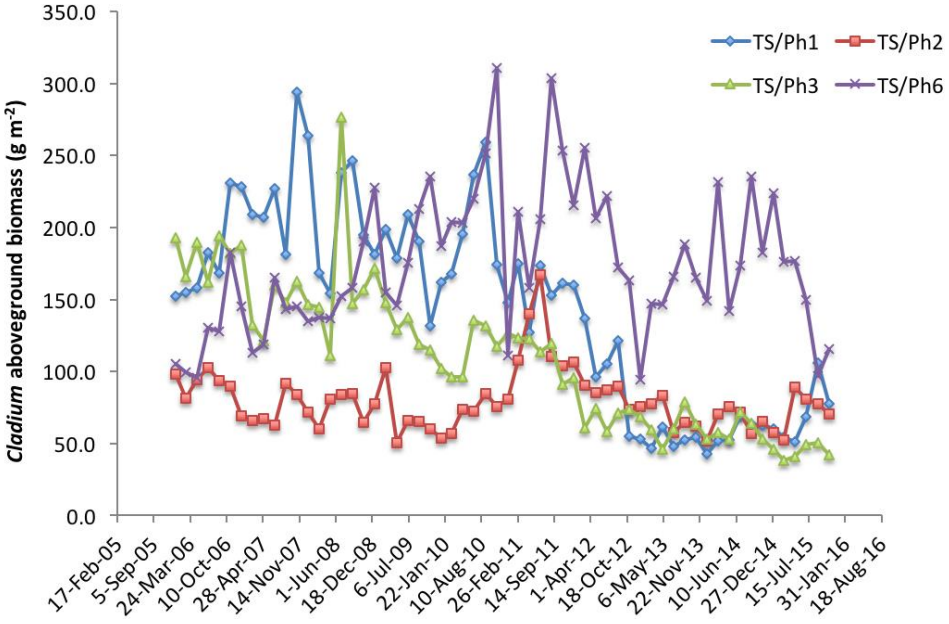


Figure 6. Long-term variation in *Cladium* aboveground biomass along TS/Ph sites.

Experiments. In salinity and P manipulative studies of freshwater sawgrass (*Cladium jamaciense*) marshes, we observed consistent increases in surface, porewater, and plant (periphyton and sawgrass) TP, not soil TP after 2 years. P increased soil C gains (2x increase in root productivity > 15% increase in litter *k*), but elevated salinity reduced peat soil elevation by nearly 3x (Figure 7). Elevated salinity decreased soil microbial extracellular enzyme activities by up to 4x (Figure 8). By experimentally elevating water flow velocity, we demonstrated nutrient loading that changed biofilm and periphyton species and biochemical composition, which was transferred to an herbivorous fish (both tissue fatty acid composition and stoichiometry) but not an omnivorous fish or shrimp (Bornhoeft 2016).

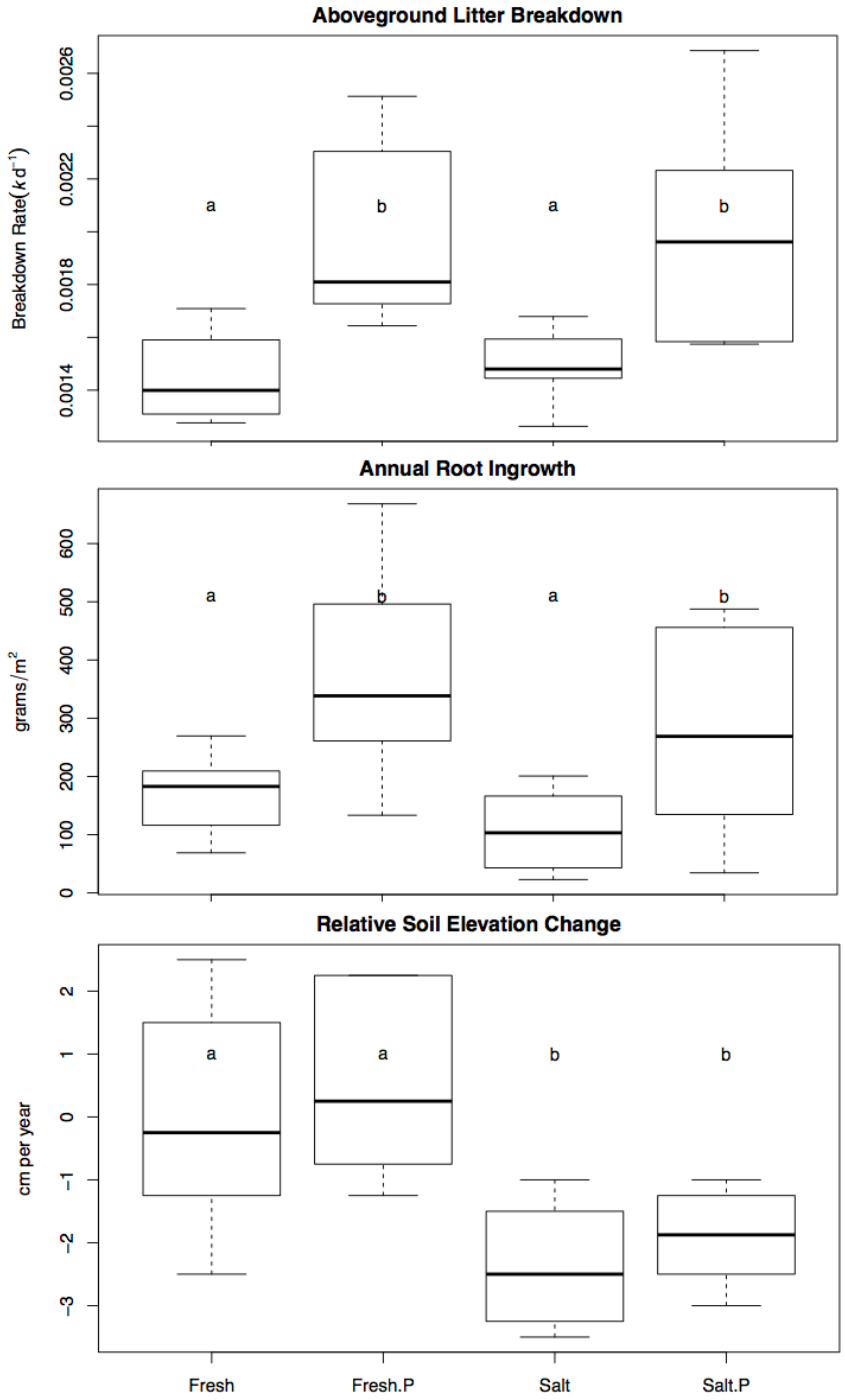


Figure 7. Aboveground litter breakdown rates (*k*), root productivity (0-7.5, 7.5-15 cm depth), and changes in soil elevation in artificial wetland mesocosms after 1 year. Responses were assayed from experimental mesocosm wetlands exposed to four treatments: freshwater (fresh), freshwater with added P (fresh.P), elevated salinity (salt), and elevated salinity with added P (salt.P). Responses were compared using an ANOVA followed by a Tukey HSD for comparison. P-values less than 0.05 were considered significant.

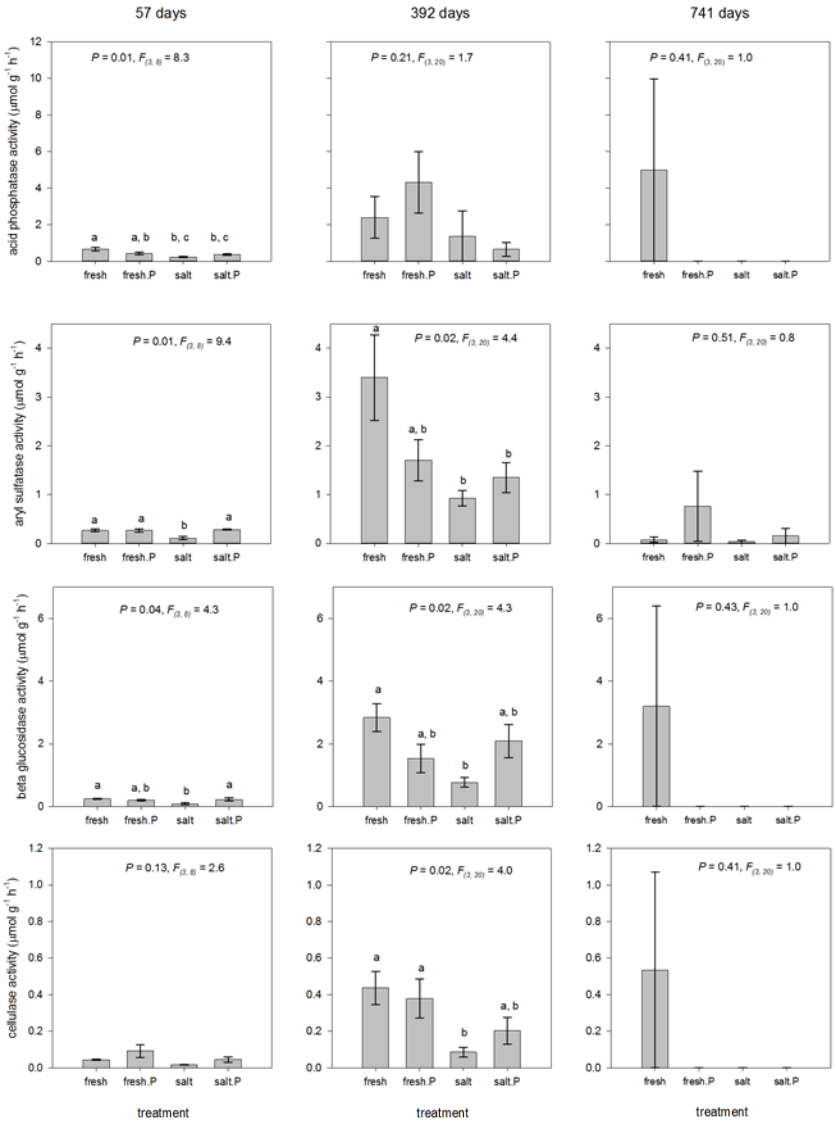


Figure 8. Microbial extracellular enzyme activities from surficial soils (0-7.5 cm) in artificial wetland mesocosms after 57, 392 and 741 days. Enzyme activities (acid phosphatase, aryl sulfatase, beta glucosidase, and cellulase) were assayed from experimental mesocosm wetlands exposed to four treatments: freshwater (fresh), freshwater with added P (fresh.P), elevated salinity (salt), and elevated salinity with added P (salt.P). Responses were compared using an ANOVA followed by a Tukey HSD for comparison. P-values less than 0.05 were considered significant.

Climate and Disturbance Legacies: Our paleoecological work is showing that the rate of soil organic matter accumulation is the best predictor of accretion rates (Figure 9a). Based on soil accretion rates observed in mangrove forest over the past century, some sites may be able to keep pace with the lower future SLR estimate, but there is no evidence that any of these sites can match the higher estimates. Burial of organic carbon relative to primary productivity is least efficient in the oligohaline ecotone region (Figure 9b). Forest production continues to reflect the

legacies of Hurricane Wilma (2005), although initial recovery was very rapid (Figure 10). We are also showing the capacity for specific habitat patches within a landscape to modulate stressors from extreme climate events, and for variation in consumer distribution to influence vulnerability to cold spells (Boucek et al 2017). These rare glimpses at biological responses can be instrumental in expanding our understanding of key ecological and evolutionary processes operating in our study systems, and of the drivers and constraints of recovery and overall system trajectories (Figure 11).

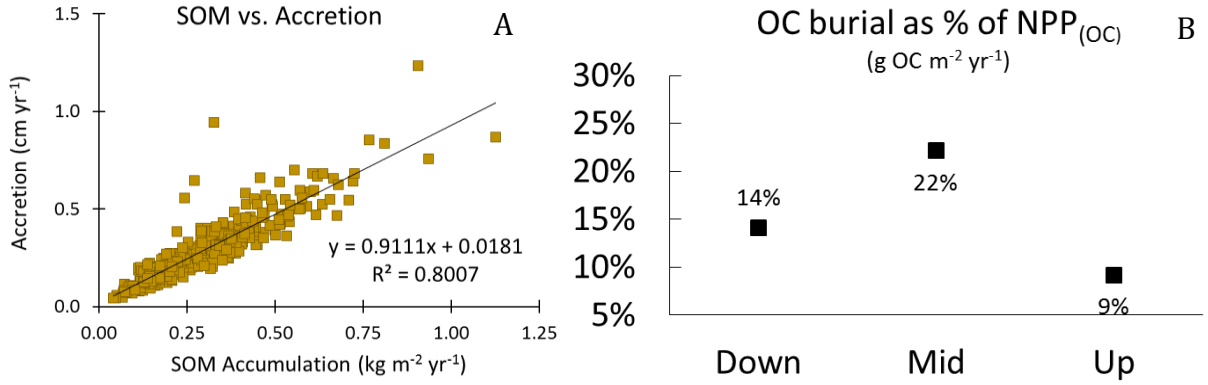


Figure 9. (A) Relationship between soil organic matter (SOM) accumulation and accretion rates, and (B) the percent of net primary productivity (NPP) buried as organic carbon as a function of estuary location (downstream, midstream (ecotone) and upstream).

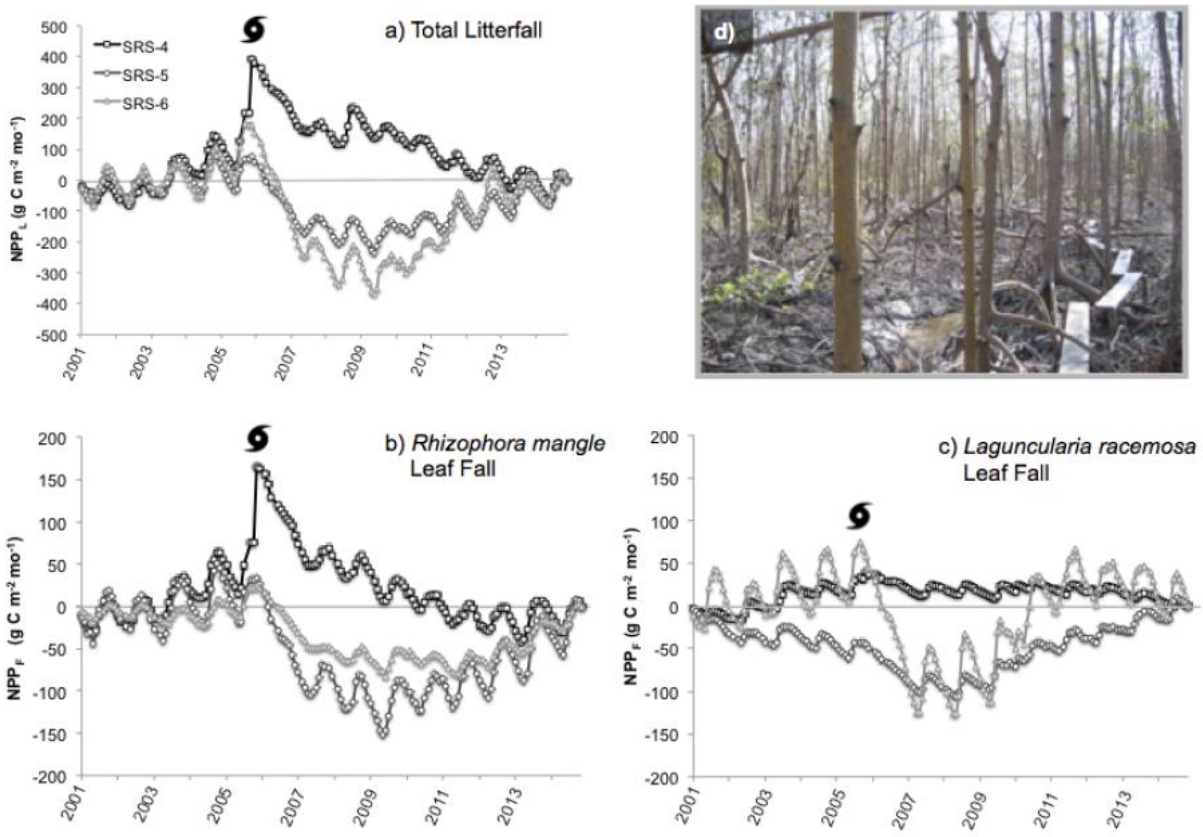


Figure 10. Cumulative sum (cusum) graphs for a) total litterfall (NPP_F), b) *Rhizophora mangle* leaves (NPP_L), and c) *Laguncularia racemosa* leaves (NPP_F) in mangrove sites along Shark River estuary. A segment with a positive slope in a cusum graph indicates a period when values in the original time series were above average, and vice-versa; whereas a horizontal segment represents at-average value. The insert photo depicts canopy defoliation at SRS-6 from Hurricane Wilma.

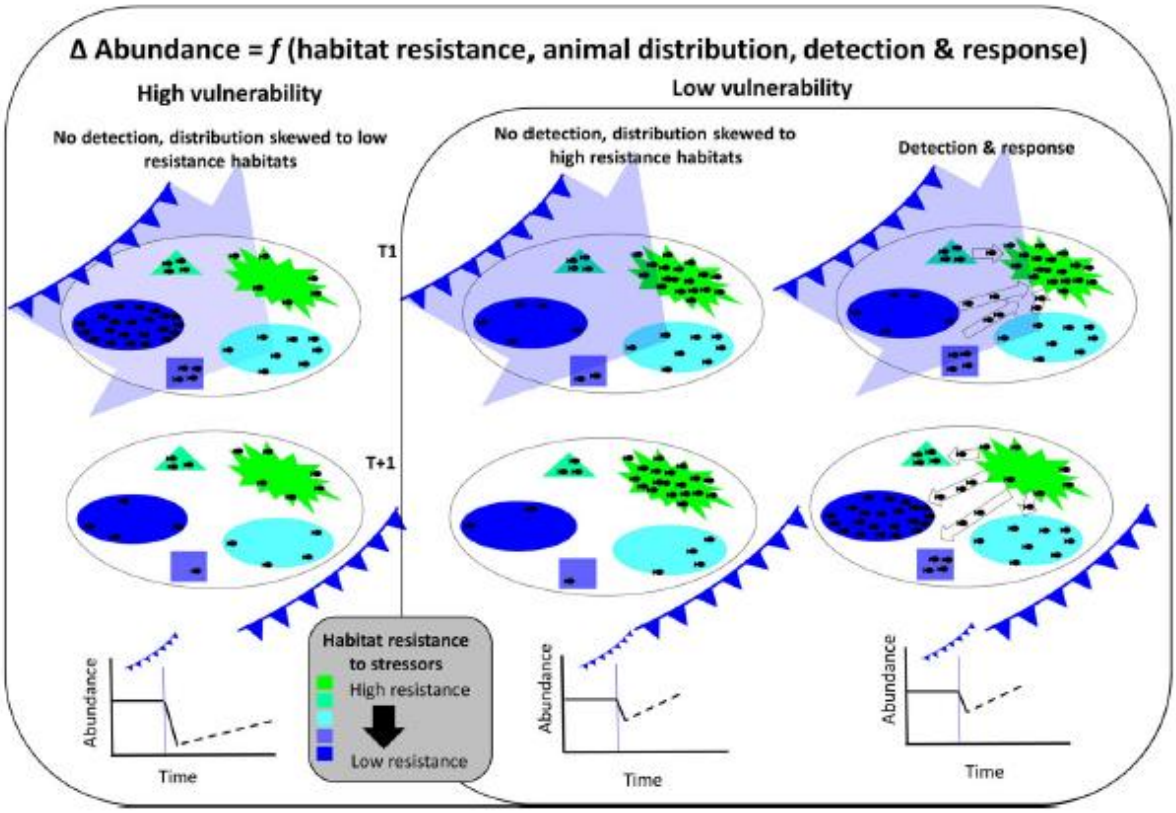


Figure 11. Conceptualization of the interaction between animal habitat use and spatially explicit nature of Extreme Climate Events (ECEs). Consider a population that moves freely between habitat patches (shaded shapes) that differ in their capacity to mitigate stressors from ECEs, represented by the color of the shape. In the high vulnerability scenario, animal density is high in habitats that cannot modulate stressors from the disturbance (blue circle), and population losses are high. In the low vulnerability scenarios, population densities are either higher in a habitat that mitigates stressors of climate disturbance (green symbol), or individuals have the capacity to detect and rapidly move to refuge habitats, and population losses are lessened. The lower figures illustrate population changes under the three scenarios over time.

Scenarios and Modeling: We succeeded in developing a geochemical model that simulates seawater-induced desorption of P accompanying seawater intrusion. We also successfully installed an ADCP at SRS-6 and geo-referenced the stations at SRS-4 and SRS-6 so that the data collected at those stations would be compatible with our modeling efforts. The topobathymetric surface was completed for Shark River and Little Shark River between Gunboat Island and the mouths of the rivers. This model domain is currently being used for hydrodynamic and particle tracking models. Development of a new particle tracking model is approaching completion (Figure 12). Our 40-yr ELM simulations provide screening-level analysis of plausible Everglades ecosystem response by 2060 to sea level rise (0.50 m) interacting with macroclimate change (1.5 ºC warming, 7% increase in evapotranspiration, and rainfall that either increases or decreases by 10%). The landward boundaries of mangrove forest and saltwater transgressed up to 15 km inland in response to sea level rise; contrary to expectations, rainfall did not mitigate against this. Our increased rainfall scenario provided a significantly milder

salinity regime both spatially and temporally, however it introduced a greater risk of open water expansion. There was substantial change in land-cover, including an expansion of open-water habitats under both increased and decreased rainfall scenarios (Figures 13, 14).

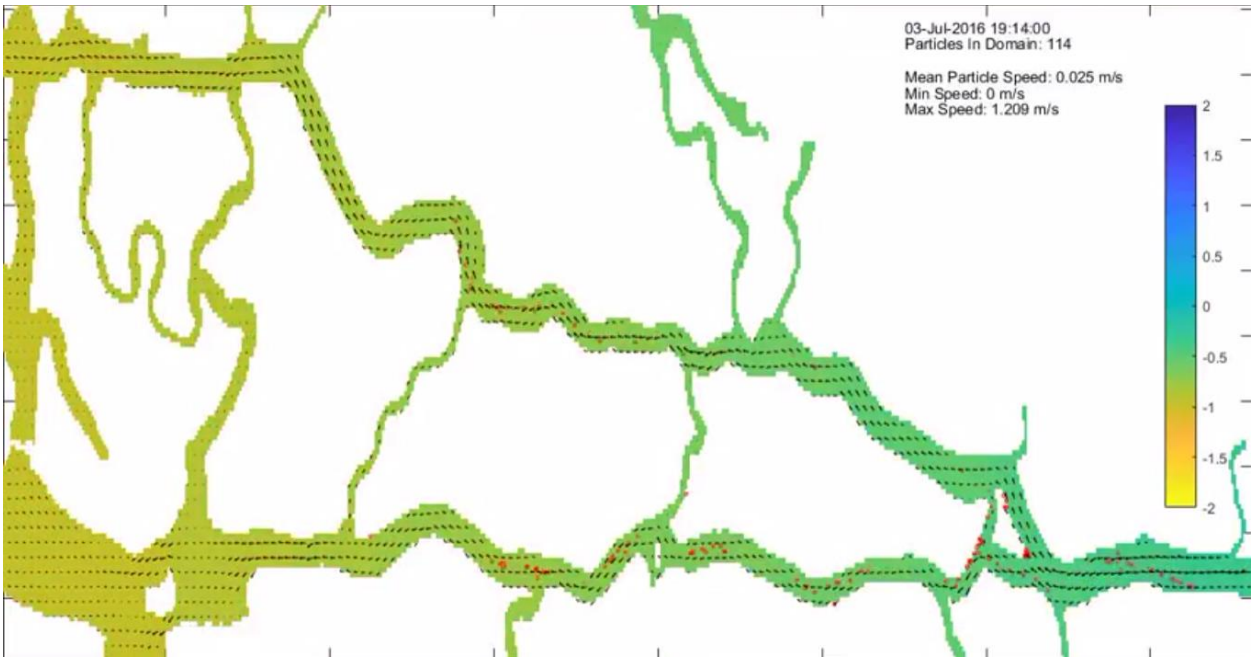


Figure 12. Screen shot of model run with particles depicted in red (using data from July 3rd through 9th of 2016).

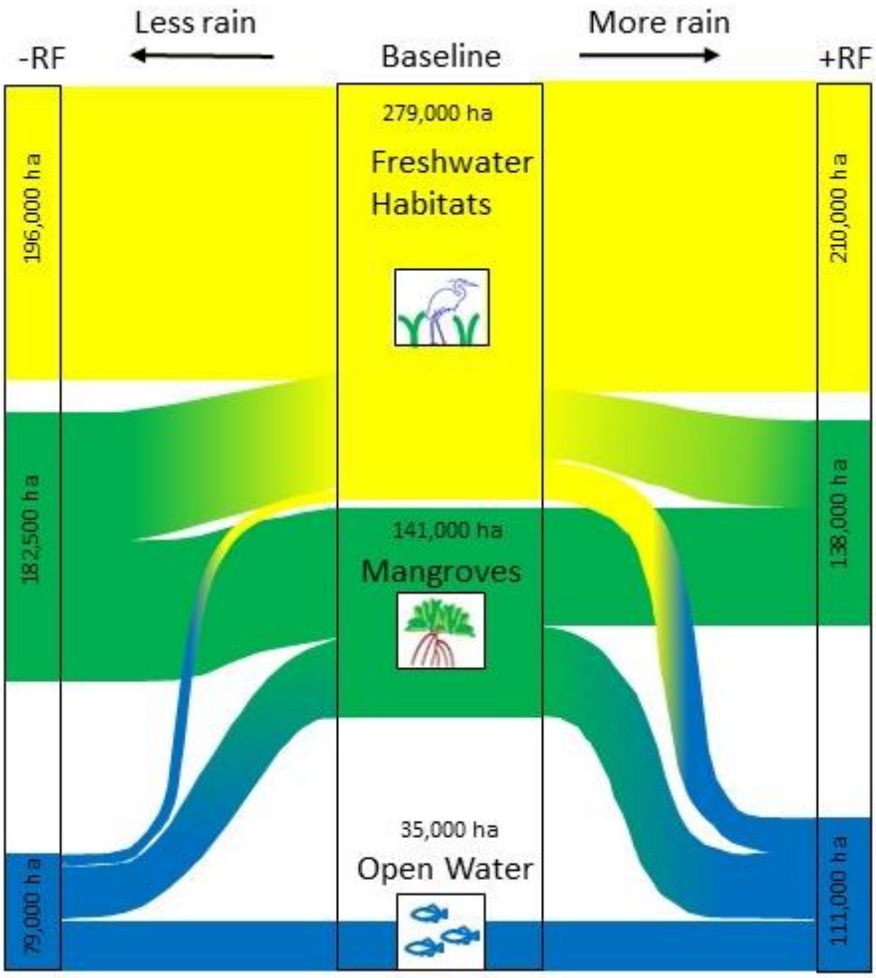


Figure 13. Sankey diagram showing areal coverage of the three habitat classes for the Baseline scenario condition (center column), the decreased rainfall scenario (-RF, left column) and the increased rainfall scenario (+RF, right column) with estimated exchanges illustrated

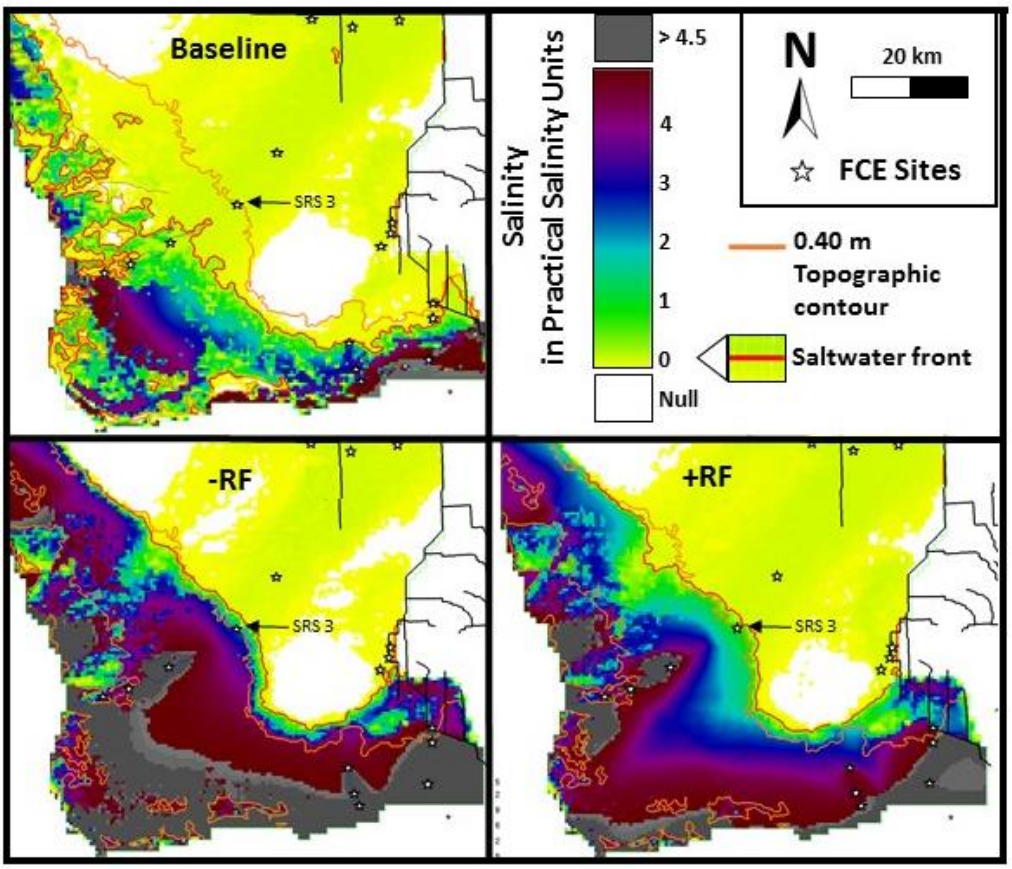


Figure 14. Simulation maps of daily mean surface water salinity for the Baseline scenario (top left), the decreased rainfall scenario (-RF, bottom left), and the increased rainfall scenario (+RF, bottom right).

Key outcomes or Other achievements

Hydrology and Water Policy:

- Fresh water delivery to the upstream end of SRS can have the greatest impact on reducing salinity and nutrients in the oligohaline ecotone when delivered year-round as opposed to only during the wet season as commonly occurs.
- Analysis of institutional governance in the EAA shows that the regulatory regimes in combination with agricultural land manager operations strongly shape collective participation in better management practices, and consequently, the P-loads in the EAA. The largest land managers in the EAA (e.g., Florida Crystals) are critical drivers of overall basic-wide reductions in P loads.
- The future efficacy of the shared pollution cap is uncertain, since basins may increase their loads relative to their baselines and farm management trends indicate that future reduction may not be as strong as past reductions if farms continue to have increasing P concentrations.

Carbon Dynamics:

- After 2-years of adding continuous elevated P and salinity to freshwater sawgrass mesocosms, we found that P increased soil carbon gains while elevated salinity decreased soil microbial extracellular enzyme activities and decreased soil elevation.
- DOC export from the Shark River has been steadily declining over the past decade. Regardless of the expected climate scenarios predicted for South Florida, DOC export Is expected to continue to decline, likely as its main source (the Everglades Agricultural Area) becomes more depleted of soil OM.
- High-resolution DOC determinations clearly show that management can have significant effects on water quality in the Shark River estuary at relatively short time frames. In addition, pore-water associated DOC in the mangrove marsh represents an important component of the total DOC export.
- Fatty acids can be used as markers of food quality in the Everglades; by manipulating stoichiometry of biofilms we were able to track responses in fatty acid biomarkers of herbivores and omnivores.
- Trophic linkages and resource partitioning of C sources in a community of consumers are both temporally and spatially variable. In addition, consumer populations exhibit degrees of plasticity in response to environmental change, as well as individual-level variability in movements and foraging behavior.

Climate and Disturbance Legacies:

- Soil organic matter and soil inorganic matter do not contribute additively to soil volume. This is contrary to findings from North American coastal wetlands broadly, and suggests a unique characteristic of carbonate platform mangrove soils that lack a regular, substantive supply of terrigenous soil inorganic matter.
- Juvenile bull shark population size and body size structuring continues to recover from an extreme temperature event in 2010.
- Differential sensitivity to changes in presses and pulses of water quality from marine and freshwater sources are detectable from long-term repeated measures throughout a large coastal landscape.

Scenarios and Modeling:

- Our modeling efforts show that the landward boundaries of mangrove forest and saltwater transgressed up to 15 km inland in response to SLR; contrary to expectations, rainfall did not mitigate against this and there was substantial change in land-cover, including an expansion of open-water habitats under both increased and decreased rainfall scenarios. Increased rainfall scenario provided a significantly milder salinity regime both spatially and temporally, however it introduced a greater risk of open water expansion.
- Collaborative research with McMurdo LTER lead to results indicating the accumulation of combustion-derived products In lakes of Antarctica, and indicating a shift from mainly wildfire-derived black carbon (long-range transport) to fossil-fuel derived (with possible local sources).

Opportunities for training and professional development

Luca Marazzi participated in the LTER Metacommunity working group led by Eric Sokol at the National Center for Ecological Analysis and Synthesis (NCEAS) in Santa Barbara on March 6-10, 2017. The ecologists involved worked on defining and investigating metacommunity stability in a LTER cross-site and cross-organism framework. This was an excellent opportunity for postdoctoral associate Marazzi to develop his statistical and R programming skills in collaboration with experienced quantitative ecologists. The working group has a plan to write and publish 2-3 peer-reviewed journal articles on metacommunity theory using data from multiple ecosystems and LTER sites, including the FCE (in particular using data on algae and fish).

Luca Marazzi has also attended a number of interactive discussion sessions on career development for early career researchers led by Dr. Eric von Wettberg at FIU on topics such as job interviews and talks, grant writing, time management, and academic service.

Edward Castaneda traveled to Penn State University for eddy covariance and flux tower training with Dr. Jose Fuentes in February 2017. The training helped Edward to maintain and repair the flux towers at FCE's mangrove sites in Shark River Slough and Taylor this year.

Communicating results to communities of interest

Disseminating Results to Communities of Interest
FCE LTER actively disseminates the results of our research to communities of interest, including decision makers and members of our community who are not usually aware of our research. We accomplish this by working directly with decision makers, NGOs, formal and informal science educators, community groups, media, citizen science, and collaborating in the arts and humanities.

Decision Makers & NGOs
FCE has a long history of including decision makers and NGOs as our collaborators. These partnerships improve our communication with policy makers and enable us to report our results directly to governmental agencies such as: the US Environmental Protection Agency; US Geological Survey; NASA Goddard Space Flight Center; National Park Service (NPS) Everglades National Park; NPS South Florida/Caribbean Network Inventory and Monitoring Program; and the South Florida Water Management District.

In addition to working with decision makers, we also collaborate with scientists at the Everglades Foundation. Over the last year, this partnership has given us the opportunity to share our results with high profile/impact individuals such as: Former Prime Minister David Cameron; U.S. Representative Francis Rooney; Jay Faison (World Resources Institute); FL Senator Rooney; Congressman Joyce; Congressional Staff; Martha Stewart; and Sea World executives.

Informal Science Education Venues & Community Groups
FCE Education & Outreach also partners with Informal Science Education (ISE) venues and community groups to enhance the public understanding, and increase the interest in learning and

careers in science, technology, and the humanities. These ISE partnerships improve our ability to engage with the members of our community that are not typically aware of our research and allow us to maintain a consistent presence in our community.

Our scientists are actively engaged with the public and our broader community. Since our last report, 21 of our researchers have participated in 142 events, to 91 community organizations. These events have covered nearly 23% of the calendar (n=83 d) and have included: 23 panels; 50 tours; 67 presentations; 9 exhibitions; 5 trainings, 13 tabling events; and they have served as competition judges. FCE researchers have also given a reported 32 presentations, to an estimated 585 members of our community.

Informal Science Education Partners

Our ISE partners fill an important role by connecting us with the community, providing a venue to share our work, and assisting with the interpretation our work for the general public. Over the last year, these partnerships have given us access to an audience of over 750,000 visitors to The Deering Estate at Cutler, ZooMiami, Phillip and Patricia Frost Museum of Science, and the Ft. Lauderdale Museum of Discovery and Science.

Each year, FCE participates in several large events hosted by our ISE partners. Tabling at these special events is valuable for increasing our visibility across our community. In March 2017, over 8,300 residents attended the Deering Seafood Festival, where FCE staff presented educational activities such as the *Marine Macroalgae Mobile Lab* and the *Coastal Angler Science Team (CAST) Fishing Tournament*. The *CAST Fishing Tournament* was also included as part of ZooMiami's *Bird Fest* and *Party for the Planet* Earth Day celebration with estimated 6,900 visitors in attendance.

Our newest partner, The Phillip and Patricia Frost Museum of Science, opened its doors on May 8, 2017, in Miami's Museum Park. The 250,000 square foot structure includes a 500,000 gallon Gulf Stream Aquarium, with 30 additional aquariums on *The Dive* level. As visitors take "a journey from the ocean to the Everglades", they learn about the coastal Everglades and the work of Dr. Jim Fourqurean in the *Seagrass Communities: Marine Meadows* exhibit. In the first two months (May-June), the museum has exceeded expectation with over 283,400 visitors. If this trend continues, our partnership with The Frost will give us the potential to engage with nearly 1.7 million visitors over the next year.

Citizen Science

The FCE Citizen Science program consists of two major initiatives: Predator Tracker (http://tracking.fiu.edu) and CAST: Coastal Angler Science Team (http://cast.fiu.edu**)**. Since 2011, an estimated 2.7 million guests (450,000/year) have visited the Ft. Lauderdale Museum of Discovery and Science where they can learn about the coastal Everglades and the movement of alligators, snook, and bull sharks in the Living in the Everglades exhibit. Featuring the work of Drs. Jennifer Rehage and Mike Heithaus, visitors can select an individual animal and view their movement over time. The tracking data are updated monthly and integrated with the web-based Predator Tracker which allows visitors to continue monitoring their favorite animal long after they have left the museum. Additional details can be seen at https://www.youtube.com/watch?feature=player_embedded&v=klgIaR27ziI# .

Traditional and Social Media
FCE research also maintains an active presence in both traditional news and social media. Over the last year, our research was discussed in 64 media events, on 51 calendar days, and has highlighted 18 of our researchers. This news media has been distributed across 21 international, national, and local media outlets including: *CBS News and CBS This Morning; BBC; Japan Times; Miami Herald; NPR; PBS Newshour; and NSF News.*

FCE social media content is due in large part to the regular contributions by graduate students and Dr. Luca Marazzi. Together, they have made 61 Facebook posts that have been displayed 11,985 times and have increased our outreach to include 9750 unique engagements over the lifetime of the page. Our blog, *Wading Through the Research* (http://floridacoastaleverglades.blogspot.com), provides richer content and in-depth look at the work of our scientists. Over the last year, Dr. Marazzi and our graduate students have added 23 new posts, including the "Diatom of the month". In our second blog, the *Heithaus Lab* (http://heithauslab.blogspot.com) have posted 5 additional entries and their work was featured on the Discovery Channel's annual Shark Week in *Devil Sharks*.

Plans to accomplish goals during the next reporting period

Hydrology and Water Policy: Hydrological and geochemical assessment will continue using ground-based and satellite measurements. Density-dependent flow modeling will continue to determine restoration efforts on the water delivery to and the water quality in the mangrove ecotone. We are planning to conduct spatial statistical, basin-level analyses of farm contributions to meeting water quality targets, and develop an explanatory spatial model that investigates spatiotemporal trends in water management outcomes (such as for P) in the Everglades Agricultural Area as it relates to site specific biophysical factors (e.g. soil type and depths), climate trends (e.g. precipitation variability), and farm characteristics (e.g., size, crop choice, management and location in the EAA/adjacency effects).

Carbon Dynamics: We will complete the freshwater restoration mesocosm experiment (spring 2018), analyze data, generate products, and continue to mentor a REU student. We will submit a synthesis manuscript for the 27-year water chemistry data from Florida Bay. We will submit all manuscripts from the elevated salinity and P mesocosm experiment and the pulsed salinity field experiment to peer-reviewed journals. We will submit manuscripts from the 2015 and 2016 REU, and 2016 RET projects to peer-reviewed journals. We will present results at the 2018 FIU Biology Research Symposium, 2018 FCE All-Scientists Meeting, the 12th International Symposium on the Biogeochemistry of Wetlands, and 2018 Ecological Society of America Meeting. We will continue to publish finding on burial rates in mangrove forest soils, compare accretion rates across multiple timescales with other coastal wetlands, continue developing the collaborative project with the GCE-LTER and BNZ-LTER on high-resolution determinations of fDOM, publish work completed during 2016-2017 period on DOM optical properties synthesis, flow-Induced POC transport, and continue measurement of DOM optical properties at selected FCE sites. In the next reporting period, we will continue field and laboratory manipulations of physical drivers to document their impacts on food webs as revealed by fatty acid biomarkers. We are also completing a landscape-scale survey of stoichiometry and fatty acid

biomarkers in periphyton by evaluating within and among site variation. We are also comparing these data to stoichiometry and fatty acids in fish collected in the same space as periphyton samples. Alligators are apex predators in the Everglades ecosystem that affect food webs by both direct consumption and nutrient regeneration (excretion and suspension from physical disturbance). In the next reporting period we will initiate analysis of their effects as environmental engineers by analysis of food webs (stoichiometry and fatty acid biomarkers) in areas where they are common, including small depressions alligators use for feeding, nesting, and dry-season refuge (alligator ponds). We will also continue collection of data on movement, trophic interactions, and population dynamics of multiple consumers. We plan to add additional stomach samples of juvenile bull sharks to get taxa specific diet information. We also plan to expand our bull shark tissue analysis to include total mercury analyses. In addition, we will deploy another round of 15 alligator and 20 bull shark acoustic tags to get additional information on movements and possible food web linkages across seasons including inter-annual variation. In response to midterm reviews, we are adding multiple tissues stable isotope analysis and stomach contents work on marine catfishes to get a better picture of the food web that includes highly abundant, lower level predators that may have significant ecosystem effects.

Climate and Disturbance Legacies: This year, we will refocus our plans for this working group to address the impacts of Hurricane Irma (10 September 2017) on trajectories of ecosystem development and resilience. We will submit our manuscript suggesting a new theoretical framework for driving synthesis of ecosystem development across long-term ecological research programs, and lead the cross-site effort to test this model through networked synthesis.

Scenarios and Modeling: We plan to complete geochemical model development and publish a paper on the mechanism governing seawater-induced P desorption, first in a series of papers that will investigate how future climate and sea level rise scenarios may affect P availability. We will publish results from our reach-scale particle-tracking hydrodynamic model of an 8 km portion of coastal SRS and develop model to include P and ecologically significant particles such as mangrove propagules and fish eggs under climate scenarios. We will also use our published scenarios-based simulations with ELM as a basis for initiating several FCE papers on the future of the Everglades, from peat to periphyton to wildlife. We will begin developing a "soft linkage" between the ELM and the Seagrass and Submerged Vegetation Community Model (SEACOM) so as to simulate hydro-ecological responses in Florida Bay to scenarios of climate change and sea level rise, and continue to work with the South Florida Water Management District to improve the downscaling of precipitation data for future scenario development.

Products

Publications

Journal Articles

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Wachnicka, A. and L. Wingard, 2017. Multiple ecological regime shifts in the south Florida estuaries as a result of climate change and 20th century water management of the Everglades wetlands. Annual Meeting of the American Society for Limnology and Oceanography, Honolulu, Hawaii, February 28, 2017.

Wendelberger, K.S. and J.H. Richards, 2017. Halophytes Can Salinize Soil When Competing with Glycophytes, Intensifying Effects of Sea Level Rise in Coastal Communities. Greater Everglades Ecosystem Restoration Meeting, Coral Springs, Florida, April 20, 2017.

Wilson, B.J., S. Servais, S.P. Charles, J. Kominoski, and T. Troxler, 2017. Biogeochemical effects of a freshwater marsh experiencing simultaneous saltwater intrusion and nutrient enrichment: A stress-subsidy experiment . Ecological Society of America Annual Meeting 2017, Portland, Oregon, August 7, 2017.

Wilson, B.J., S. Servais, V. Mazzei, T. Troxler, F.H. Sklar, J. Kominoski, E.E. Gaiser, S.E. Davis, and D.T. Rudnick, 2017. Biogeochemical and physiological effects of simulated sea level rise in the coastal Everglades. Greater Everglades Ecosystem Restoration Meeting, Coral Springs, Florida, April 20, 2017.

Wilson, B.J., S. Servais, V. Mazzei, S.E. Davis, E.E. Gaiser, J. Kominoski, J.H. Richards, F.H. Sklar, and T. Troxler, 2017. Testing mechanisms of plant-soil carbon loss in coastal ecosystems: insights from simulated saltwater intrusion in wetland mesocosms. Society of Wetland Scientists Meeting, San Juan, Puerto Rico, June 6, 2017.

Zhai, L., R. Travieso, J. Kominoski, L. Zhang, E.E. Gaiser, and L.S.L. Sternberg, 2017. Separating increases in salinity due to saltwater intrusion from that due to evaporation. Greater Everglades Ecosystem Restoration Meeting, Coral Springs, Florida, April 19, 2017.

Zhao, J., S. Oberbauer, P.C. Olivas, J. Schedlbauer, J. Moser, and G. Starr, 2017. Photosynthetic Activity of C3 and C4 Graminoids in Response to Water Table Change in a Short-Hydroperiod Wetland of the Florida Everglades . Greater Everglades Ecosystem Restoration Meeting, Coral Springs, Florida, April 18, 2017.

Zhao, J., S. Oberbauer, P.C. Olivas, J. Schedlbauer, J. Moser, and G. Starr, 2017. Photosynthetic activity of C3 and C4 graminoids in response to inundation in a short-hydroperiod wetland. Plant Biologists of South Florida Meeting, Miami, Florida, March 18, 2017.

Dissertations and Theses

Ph.D. Dissertations

Breithaupt, Joshua L. 2017. Spatio-temporal Dynamics of Soil Composition and Accumulation Rates in Mangrove Wetlands. Ph.D. dissertation, University of South Florida.

Bush, Michael Ross. 2017. Experimental analysis of the effects of hydroscape structure on fishes in a dynamic wetland. Ph.D. dissertation, Florida International University.

Regier, Peter. 2017. Linking organic matter dynamics to management, restoration and climate in the Florida Everglades. Ph.D. dissertation, Florida International University.

Master's Theses

Hill, Gregory. 2017. Examining Movement and Habitat Selection of Everglades Fishes in Response to Seasonal Water Levels. Master's thesis, Florida International University.

Reio, Dillon N. 2017. Investigating the Effects of Land-Cover Change on the Hydrologic Conditions of a Restored Agricultural Area in Everglades National Park. Master's thesis, Florida International University.

Websites

Florida Coastal Everglades LTER Program Website
http://fcelter.fiu.edu/
The Florida Coastal Everglades LTER Program Website provides information about FCE research, data, publications, personnel, education & outreach activities, and the FCE Student Organization.

Coastal Angler Science Team (CAST) Website
http://cast.fiu.edu/
The Coastal Angler Science Team (CAST) Website, created by FCE graduate student Jessica Lee, provides information about how researchers and anglers are working together to collect data on important recreational fish species in Rookery Branch and Tarpon Bay in the Everglades and invites anglers to participate in this project.

Predator Tracker
http://tracking.fiu.edu/
The Predator Tracker website has information about the Predator Tracker application and a link to download the application. Predator Tracker is a stand alone application based on a kiosk at the Museum of Discovery and Science in Ft. Lauderdale. The application allows one to learn how researchers at Florida International University track and study big predators in the Shark River Estuary in Everglades National Park and explore their predator tracking data.

Wading Through Research
http://floridacoastaleverglades.blogspot.com/
A blog created by FCE graduate students which focuses on the experiences of graduate students conducting research in the Everglades.

Other products

Databases
The FCE Information Management System contains 159 datasets which are publicly available online at FCE LTER web site (http://fcelter.fiu.edu/data/FCE/) or the LTER Network Data Portal (https://portal.lternet.edu/nis/home.jsp). Datasets include climate, consumer, primary production, water quality, soils, and microbial data as well as other types of data. A table of FCE LTER data sets in PASTA with the data set titles and DOIs is included in the Appendix.

The database "Periphyton and Associated Environmental Data From the Comprehensive Everglades Restoration Plan (CERP) Study (FCE)" and the "Diatom Abundance Data From the Comprehensive Everglades Restoration Plan (CERP) Study (FCE)" covering the period February 2005 - November 2014 have been completed by postdoctoral associate Luca Marazzi and are available upon request.

Participants & Other Collaborating Organizations

Group photo from the 2017 FCE LTER All Scientists Meeting

Participants*

*People who worked at least 1 person month on the project

Name	Most Senior Project Role
Gaiser, Evelyn	PD/PI
Heithaus, Michael	Co PD/PI
Jaffe, Rudolf	Co PD/PI
Kominoski, John	Co PD/PI
Price, Rene	Co PD/PI
Briceno, Henry	Faculty
Childers, Daniel	Faculty
Collado-Vides, Ligia	Faculty
Malone, Sparkle	Faculty
Oberbauer, Steven	Faculty
Oehm, Nick	Faculty

Name	Most Senior Project Role
Rains, Mark	Faculty
Rehage, Jennifer	Faculty
Richards, Jennifer	Faculty
Rivera-Monroy, Victor	Faculty
Roy Chowdhury, Rinku	Faculty
Schwartz, Katrina	Faculty
Smoak, Joseph	Faculty
Starr, Gregory	Faculty
Staudhammer, Christina	Faculty
Trexler, Joel	Faculty
Troxler, Tiffany	Faculty
Wdowinski, Shimon	Faculty
Casal, Teresa	K-12 Teacher
Laroche, Catherine	K-12 Teacher
Flower, Hilary	Postdoctoral (scholar, fellow or other postdoctoral position)
Lee, Dong Yoon	Postdoctoral (scholar, fellow or other postdoctoral position)

Name	Most Senior Project Role
Marazzi, Luca	Postdoctoral (scholar, fellow or other postdoctoral position)
May, Jeremy	Postdoctoral (scholar, fellow or other postdoctoral position)
Santos, Rolando	Postdoctoral (scholar, fellow or other postdoctoral position)
Fitz, Carl	Other Professional
Rugge, Michael	Other Professional
Serna, Alexandra	Other Professional
Vanderbilt, Kristin	Other Professional
Absten, Michael	Technician
Bauman, Laura	Technician
Bornhoeft, Sarah	Technician
Duquesnel, Jim	Technician
Garriga, Marbelys	Technician
Gastrich, Kirk	Technician
Hines, Adam	Technician
Kline, Michael	Technician
Kuhn, Paul	Technician

Name	Most Senior Project Role
Robinson, Michelle	Technician
Standen, Emily	Technician
Stumpf, Sandro	Technician
Tobias, Franco	Technician
Travieso, Rafael	Technician
Viadero, Natasha	Technician
Castaneda, Edward	Staff Scientist (doctoral level)
Davis, Stephen	Staff Scientist (doctoral level)
Frankovich, Tom	Staff Scientist (doctoral level)
Kiszka, Jeremy	Staff Scientist (doctoral level)
Allen, Joshua	Graduate Student (research assistant)
Bush, Mike	Graduate Student (research assistant)
Charles, Sean	Graduate Student (research assistant)
Clasen, Hunter	Graduate Student (research assistant)
Eggenberger, Cody	Graduate Student (research assistant)
Gann, Daniel	Graduate Student (research assistant)
Kunwor, Sujit	Graduate Student (research assistant)

Name	Most Senior Project Role
Mazzei, Viviana	Graduate Student (research assistant)
Paz, Valeria	Graduate Student (research assistant)
Regier, Peter	Graduate Student (research assistant)
Reio, Dillon	Graduate Student (research assistant)2
Roebuck, Alan	Graduate Student (research assistant)
Sanchez, Jessica	Graduate Student (research assistant)
Sarker, Shishir	Graduate Student (research assistant)
Servais, Shelby	Graduate Student (research assistant)
Strickland, Bradley	Graduate Student (research assistant)
Unthank, Kalli	Graduate Student (research assistant)
Wilson, Ben	Graduate Student (research assistant)
Maxberry, Imani	Undergraduate Student
Nanez, Steven	Undergraduate Student
Sanon, Sonicah	Undergraduate Student
Simon, Matthew	Undergraduate Student
Howarth, Marina	Research Experience for Undergraduates (REU) Participant
Roebling, Suzy	Research Experience for Undergraduates (REU) Participant

Partner Organizations

Name	Location
Clark University	Worcester, MA
College of William & Mary	Williamsburg, Virginia
Dartmouth College	Hanover, NH
Encounters in Excellence, Inc.	Miami, Florida
Everglades Foundation	Palmetto Bay, Florida
Everglades National Park	Homestead, Florida
Florida Atlantic University	Boca Raton, Florida
Florida Gulf Coast University	Fort Meyers, Florida
Florida State University	Tallahassee, Florida
Indiana University	Bloomington, Indiana
Louisiana State University	Baton Rouge, Louisiana
Miami-Dade County Public Schools	Miami-Dade County, Florida
National Aeronautics and Space Administration	Pasadena, California
National Audubon Society - Tavernier Science Center	Tavernier, Florida
National Oceanic and Atmospheric Administration - AOML	Miami, Florida
National Park Service - South Florida/Caribbean Network	Palmetto Bay, Florida
Sam Houston State University	Huntsville, Texas
South Florida Water Management District	West Palm Beach, Florida

Name	Location
The Deering Estate	Miami, Florida
The Pennsylvania State University	University Park, Pennsylvania
University of Alabama	Tuscaloosa, Alabama
University of California, Los Angeles	Los Angeles, California
University of Central Florida	Orlando, Florida
University of Florida	Gainesville, Florida
University of Hawaii at Manoa	Honolulu, HI
University of Miami	Coral Gables, Florida
University of North Florida	Jacksonville, Florida
University of South Carolina	Columbia, South Carolina
University of South Florida	Tampa, Florida
University of South Florida St. Petersburg	St. Petersburg, Florida
USGS	Reston, Virginia
Zoological Society of Florida	Miami, Florida

Impacts

Impact on the development of the principal disciplines

FCE science is integral to understanding the long-term dynamics of coastal estuaries, and we have particularly advanced comparative coastal ecosystem studies through research in the tropics. Our studies of disturbance dynamics are informing general models, and we have led two synthesis efforts across LTER sites to populate those models with long-term data to test core disturbance theory. In addition, through two leveraged grants from NASA, we are contributing the global blue carbon assessment and relating those assessments to biodiversity patterns across wetland types. Studies of organic matter processing in FCE have especially advanced these estimates because of our more thorough understanding of the relative importance of nutrients in controlling net carbon storage in reduced and oxidized environments in the face of sea level rise. In addition, our intensive experimental research on carbon stability is helping inform mechanisms of peat collapse, a phenomenon being recognized recently in wetlands around the world. Our global studies have helped reveal how natural and human disturbances influence the stability of coastal wetlands not only in the neotropics, but also in other tropical and subtropical latitudes around the world through comparative projects from Mexico to Africa.

Impact on other disciplines

FCE science is informing socio-ecological solutions to global challenges, such as sea level rise and current interdisciplinary research of urban resilience to extreme events. Through the Sea Level Solutions Center at FIU and an NSF Sustainability Research Network grant (Urban Resilience to Extremes), FCE researchers are working closely with architects, designers, communications specialists, and computer scientists to develop user-friendly tools for the resource managers and the general public to use to visualize the outcomes of decisions under different future scenarios. FCE hydro-ecological models are being translated into augmented reality platforms to provide experiences that guide decision-making to create a more resilient South Florida. Social scientists will be studying the impact of these next generation tools on policy decisions.

Impact on the development of human resources

Research, Training and Mentoring
Exposing Teachers, Young People, and the Public to Science
Combining the research at FCE LTER with training and mentoring across the K-20 spectrum is critical for impacting human resource development in science, engineering, and technology. We continue to offer a variety of opportunities for pre- and professional service teachers, K-12 students, undergraduates, and graduate students, to expose them to our research, and to provide with training and mentoring.

Professional and Pre-Service Teachers
Partnering with the STEM Transformation Institute and the FIUteach program, we have worked with The National Tropical Botanical Garden (NTBG) to offer the *Kampong's Science Teachers*

Enrichment Program (K-STEP) as professional development. This year, 18 middle and high school science teachers, from 15 Miami Dade County Public Schools (MDCPS), participated in K-STEP 2017 at NTBG's mainland garden, The Kampong.

During the week-long K-STEP program, participants had the opportunity to work with botanical experts in conservation biology, ethnobotany, and economic botany. FCE's Dr. John Kominoski gave an overview of FCE research, examined some of the key FCE datasets, and led the group on a tour of the coastal Everglades. The tour made several stops along the salinity transition zone of the southern Everglades where they made observations, discussed Everglades ecology, FCE research, and many of the issues facing the Everglades ecosystem.

After returning to The Kampong, the teachers used the remainder of the week to work with the FCE Education & Outreach Coordinator to develop inquiry-based, environmental science lessons to use in their classrooms and received a $500 stipend for submitting a completed lesson plan.

RAHSS and K-12 Programs

Our scientists are also mentoring exceptional K-12 students through the Research Experience for Secondary Students (RESSt) and RAHSS program. Over the last year, five of our scientists have formally mentored five Miami Dade County Public Schools students and one from Altholton Senior High School (Columbia, MD) totaling 12 semester units (SU) of mentoring.

FCE Graduate Student, Vivi Mazzei mentored RAHSS Andres Leon (Felix Varela Senior High School), who received a *Superior* rating and *The American Meteorological Award* at the *South Florida Regional Science and Engineering Fair*. Andres Advanced to the *State Science and Engineering Fair of Florida* where he received the *Society of Mining, Metallurgy and Exploration ($300)* and the *Palm Beach Regional Science and Engineering Fair Award ($50)*. RAHSS Katarzyna Bezen (Coral Reef Senior High School) was mentored by Dr. Anna Wachnicka. She also received a *Superior* rating *South Florida Regional Science and Engineering Fair*.

In July 2016, FCE donated 52 copies each of *One Night in the Everglades* and *Una Noche En Los Everglades* to the Miami Dade Public Library System (MDPLS). Over the last year, pre-service teachers from the FIUteach program have been providing programming related to the book. A total of 12 FCE-related programs have been provided as part of the *Full STEAM Ahead with FIU* program, at 12 libraries, in underserved communities, across the Miami Dade Public Library system.

REU and Undergraduate Mentoring

In 2016, Dr. John Kominoski mentored RET Marco Fernandez in his research project *Comparing effects of saltwater intrusion on soil microbial carbon use in freshwater and brackish coastal wetlands using experimental gradients of salinity and phosphorus*. He presented the results in a poster at the annual *Florida International University Biology Symposium* and the *FCE LTER All Scientists Meeting* where he was recognized as the *Best Undergraduate Poster*. Since his REU, Marco has also been awarded the *2017 McNair fellowship* and had continued to working in the Kominoski lab focusing on the effects of Fire and phosphorus cycling in intermittent wetlands at the Archbold Biological Station. Earlier this year, he received the *SWS*

Multicultural Mentoring Program (SWaMMP) Award and traveled to Puerto Rico to present his poster *Quantifying changes in soil microbial carbon use in coastal wetlands exposed to crossed gradients in salinity and phosphorus: Implications for sea-level rise* at the *2017 Society for Wetland Sciences (SWS)* meeting.

Also in 2016, Katherine Castrillon and Andrew Fuentes shared an REU with Dr. Mike Ross to conduct an analysis of forest dynamics within the Cutler Slough Rehydration Project. Located within the Deering Estate in southern Miami-Dade County, the project is a site-specific restoration effort which reintroduces seasonal water flow into a historic slough. An aerial photo indicates that the slough was completely forested in 1926, but does not allow determination of the forest's pre-development composition. Restoration planners believe that, prior to drainage, swamp forest trees predominated, and have subsequently been encroached on by upland hardwood hammock vegetation, and predict that the restoration will initiate hardwood hammock tree species mortality over wetland tree species at low elevations. Katherine and Andrew collected data on tree species along three transects that crossed the mosaic of hardwood hammock and wetlands of the Cutler Slough, and determined how tree species, size and survival were related to elevations derived from Light Detection and Ranging (LiDAR). They found that in fact there was little mortality among wetland tree species, but that mesophytic tree species suffered high mortality at low elevations. The trees found to have the highest percent mortality were: *Bursera simaruba, Sideroxylon foetidissimum, Nectandra coriacea, Coccoloba diversifolia,* and *Calyptranthes pallens*. Katherine and Andrew's work establishes an important baseline for adaptive management of the restoration of an important urban watershed.
This year, Suzy Roebling is working as our 2017 REU and focusing her on research related to freshwater restoration of previously salt- and phosphorus-exposed freshwater sawgrass peat monoliths. Suzy has learned how to measure gas flux from plant-soil mesocosms under varying light and temperature levels, and she is working on using these data to develop annual estimates of GPP and ER. She plans to present her results at the 2018 FCE LTER All Scientists Meeting.
In addition to REUs, FCE continues to provide a range of opportunities for research, teaching and mentoring in science. Over the last year, FCE scientists have also provided 62 semester units (SU) of undergraduate mentoring to 40 undergraduates, in 9 FCE labs. The majority (93%) of the students mentored can be identified as traditionally underrepresented in STEM, consisting of 70% are female (n=28) and more than 80% (n>32) are considered ethnic minorities.
FCE scientists are also sharing our research results through the educational materials that they are using in their courses. Over the last year, 19 scientists report discussing FCE research, in 62 courses where 2217 students have learned about our work.

Improving Retention of Underrepresented Groups

FCE is working with our university partners in the Herbert Wertheim College of Medicine to improve retention of underrepresented groups in STEM through the *Florida Science Training and Research Student (Florida-STARS) Fellowship*. In 2016 and 2017, participants from underserved populations toured the Everglades by airboat with FCE scientists. During the excursion they learned about the public health issues associated with the Everglades restoration. The goal of the program is to encourage students to continue their STEM education and to assist with their matriculation into medical school through career counseling, mentoring, and preparing them for medical school application and matriculation. The 2017 cohort was

composed of 13 students between the ages of 18-20 from Xavier University of Louisiana, Bethune -Cookman University, Florida Memorial University, and FIU.

Impact on information resources that form infrastructure

The IM team (K. Vanderbilt and M. Rugge) continue to support site and network level science by making high quality FCE data and metadata accessible through the FCE LTER website and the LTER Network Data Portal. Updates to long-term data sets are regularly published in both locations in compliance with the FCE Data Management Policy and LTER Data Access Policy. FCE LTER now has 159 data packages in PASTA. The FCE IM also contributes to cross-site LTER databases ClimDB, HydroDB, and PersonnelDB to keep them current. The FCE IM team lends its expertise to researchers by providing assistance with metadata development, data submissions, individual project database design, collaborations on GIS work and research graphics.

IT Infrastructure

The FCE information management system (IMS) Web server, Oracle 12C database and FTP server are loaded on four (4) virtual servers housed on Florida International University Division of Information Technology's (UTS) equipment. The FCE III Disaster Recovery Plan calls for data to be backed up offsite at the Northwest Florida Regional Data Center (NWRDC) located on the campus of Florida State University in Tallahassee, Florida. This allows the FCE website and Oracle 12c database to be continuously available throughout disaster events such as hardware failures and hurricanes.

FCE III Website and Data Archives

The FCE web site provides outstanding support for site and network science. FCE project information and minimal research data metadata are stored in an Oracle12c database that drives the FCE website. The site's homepage (http://fcelter.fiu.edu) design provides a simple, user-friendly gateway to a wealth of information ranging from the FCE LTER project overview to a searchable database of FCE publications. Scientists seeking data may select from FCE LTER Data Products, LTER Network Data, and Outside Agency Data, where links are available to multiple external databases. FCE Core Research Data are searchable through a sophisticated interface. The FCE Data Summary Table for each data set displays a link to complete metadata and a link to download the data. The data set citation, including the DOI as generated by PASTA, is also displayed. This summary table also links to a web-based data visualization tool that allows researchers to rapidly visualize complex data streams and to efficiently process and annotate data.

In response to the implementation of four new metadata quality checks in PASTA+, the FCE's EML generation tool (Excel2EML) was updated by Mike Rugge. The EML created by the Excel2EML tool now includes a checksum value to validate the uploaded data entity. It also automatically includes the PIs' ORCIDs, if they exist, and has increased support for adding keywords from the LTER Controlled Vocabulary.

Other contributions
IM Vanderbilt contributed to two book chapters and two journal articles published in 2017. All relate to LTER information management. She also chaired the LTER Information Management Committee's subcommittee to revise and update the *LTER Information Management System Guidelines* document. This document is a reference for new LTER information managers and primary investigators, as well as a tool for planning at existing LTER sites.

Impact on society beyond science and technology

Arts & The Humanities
Engaging with the arts and humanities remains an important priority for FCE Education & Outreach. Our collaborations with the Tropical Botanic Artists, Eco Artist Xavier Cortada, and more recently with Artists in Residence in Everglades (AIRIE), have given us the opportunity to broaden the spectrum of our outreach to include communities who may not otherwise be aware of our research activities.

Tropical Botanic Artists
The Tropical Botanic Artists (TBA) have long been as the cornerstone to FCE STEAM initiatives. Since our last report, the *The Trail: In the Beginning. . .Tamiami Trail 100th Anniversary* exhibit has been on display at three new venues and is currently on display through October 2017, with the Florida Keys Arts Council, Key West. The exhibition features 31 portraits of native plants found in the various vegetation zones, across the breadth of South Florida, from Miami-Dade to Collier County, at the time the Tamiami Trail documentation was signed on May 15th 1915. The group has artistically depicted a variety of plants, many of which are still there today, but now bordering on the rare or endangered, or their predominant locations have shifted due to a change in water flow and man's intervention.

The importance of TBA's collaboration with scientists is also being recognized beyond our community in south Florida. TBA Pauline Goldsmith was invited to display her portrait of *Amorphea proteus* in an exhibition celebrating the NPS centennial. The portrait was on loan to the National Park Service Headquarters, in Atlanta, and on exhibit at Hartsfield-Jackson Atlanta International Airport until June 2017.

EcoArtist Xavier Cortada
Eco Artist Xavier Cortada continues to collaborate with Dr. Evelyn Gaiser as Artist In Residence for FIU's School of Environment, Arts, and Society and FCE. Last year, Cortada's exhibit *CLIMA 2016* featured new works and participatory, from November 28, 2016 through January 14, 2017, at the Milander Center for Arts and Entertainment. The exhibit was presented by the City of Hialeah, in partnership with FIU Sea Level Solutions Center (SLSC), FIU College of Arts, Sciences & Education (CASE) School of Environment, Society and the Arts (SEAS), the FIU College of Communication, Architecture + The Arts (CARTA).

CLIMA 2016 featured the following science-inspired art works by Cortada including:
- "Do Not Open," a participatory work aimed at connecting present-day South Florida residents and political refugees with climate refugees in the future.
- Hot for Hialeah and the Psychoanalysis of Climate Change

- Works created at three Long Term Ecological Research (LTER) sites: Florida Coastal Everglades LTER, Hubbard Brook Experimental Forest LTER, and H.J. Andrews Experimental Forest.
- A showcase of two prior participatory eco-art projects: FLOR500 (a wildflower reforestation effort commemorating Florida's quincentennial) and the Reclamation Project (a mangrove reforestation eco-art project launched a decade ago in 2006 and now based at the Frost Science Museum).

Currently, CLIMA 2017 is in the final stages of planning and due to open October 12th, 2017 at Pinecrest Gardens. Developed as a partnership between FIU College of Arts & Sciences School of Environment, Society and the Arts, the College of Communication, Architecture + The Arts, the Honors College and the Sea Level Solutions Center, the exhibit addresses Global Climate Change and Sea Level Rise and will feature a flood prediction app, developed by the School of Communication + Journalism and Code for Miami, that will allow participants to see how sea level rise will affect their neighborhood by entering their address.
Cortada also hosted a *FLOR 500* participatory, eco-art, Earth Day event with FCE LTER for Sweetwater Elementary's 2017 Earth Day Celebration. During the event, FCE Volunteers read *One Night in the Everglades* to the entire school, in 35 classrooms, reaching 721 PreK-5 students. Several of the students received a copy of the book and/or wildflower seeds to grow in the classroom and plant at home after they germinate.

AIRIE: Artists in Residence in Everglades
In a new partnership, we are working with AIRIE to provide their fellows with an opportunity to view the Everglades through the eyes of FCE scientists. Residents stay in a live/work studio provided by Everglades National Park, and make new work for a month in the wilderness with support from AIRIE staff and board members, as well as Everglades rangers and scientists. In June 2017, AIRIE Fellow Cherry Pickman shadowed FCE scientist Cody Eggenberger in the field, absorbing knowledge about the Everglades ecology and the work of the Rehage Lab.

More recently, the AIRIE-FCE STEAM professional development was due to launch on September 9, 2017, but was postponed due to Hurricane Irma. The AIRIE-FCE STEAM PD was designed for Miami Dade County Public School teachers, in high need elementary and middle schools to fill a void in the understanding of the natural wetlands of South Florida and the challenges faced. Once rescheduled, the three, day-long workshops, will be led by FCE Scientists, FCE RETs, and AIRIE Fellows, and will focus on central elements that play a critical role in the makeup of the Florida Everglades—Water, Habitat, Man and Community.

Each day will be divided into two sessions. The environmental and scientific concepts will be taught in the morning followed by an artist-led activity in the afternoon. Teachers will be instructed on how to use the information and skills they acquire to communicate the story of the Everglades and directed on how to engage their students through social media. On alternate dates, an airboat tour of Conservation Area 3A with *Love the Everglades Movement (LTEM)* will be available to all participants and will count as additional professional development points.

The ARIE-FCE STEAM professional development sessions will be held in the *AIRIE NEST*, located at the Ernest F. Coe Visitor Center in the Everglades National Park and is open to 20

Teachers per day (60 total). The AIRE-FCE STEAM Lab with LTEM will be offered for up to 45 total participants at Tigertail Airboat Tours, on the Miccosukee Reservation.

Appendix: Table of FCE LTER Data Sets in PASTA

FCE DATA SET TITLE	DOI
Relative Abundance Diatom Data from Periphyton Samples Collected for the Comprehensive Everglades Restoration Plan (CERP) Study (FCE) from February 2005 to November 2014	doi:10.6073/pasta/cb0f7e88d28075a6ff1f59d008bb732c
Periphyton and Associated Environmental Data From the Comprehensive Everglades Restoration Plan (CERP) Study from February 2005 to November 2014 (FCE)	doi:10.6073/pasta/8d7141338c38cd75a5c75383cb790579
Fluxes of dissolved organic carbon from the Shark River Slough, Everglades National Park (FCE), South Florida from May 2001 to September 2014	doi:10.6073/pasta/02cf0405c4f560746a5e5275ef6e225b
Mangrove soil phosphorus addition experiment from July 2013 to August 2013 at the mangrove peat soil mesocosms (FCE), Key Largo, Florida	doi:10.6073/pasta/3dda94cbf11483f7ae9c48f255fb9787
Mangrove soil phosphorus addition experiment from June 2013 to August 2013 at the mangrove peat soil mesocosms (FCE), Key Largo, Florida	doi:10.6073/pasta/983b021dc50ac84755806b07f3c65dc3
Biomarker assessment of spatial and temporal changes in the composition of flocculent material (floc) in the subtropical wetland of the Florida Coastal Everglades (FCE) from May 2007 to December 2009	doi:10.6073/pasta/e84cc609ffbc63bb45bd484810e6746b
Monthly water balance data for southern Taylor Slough Watershed (FCE) from January 2001 to December 2011	doi:10.6073/pasta/1fb384a7c943af6f367dbdc46493f566
Cross Bank sediment characteristics, Everglades National Park (FCE), South Florida from 2014	doi:10.6073/pasta/8a665416247299616dfd90a9feca8dcd
Cross Bank Benthic Aboveground biomass, Everglades National Park (FCE), South Florida from 1983 to 2014	doi:10.6073/pasta/8e96bfec4be54df2a5e0d4a1741d4dab
Percentage of Carbon and Nitrogen of Soil Sediments from the Shark River Slough, Taylor Slough and Florida Bay within Everglades National Park (FCE) from August 2008 to Present	doi:10.6073/pasta/3665add421ff8cbfda25519464523ad8
Cichlasoma urophthalmus cytochrome b sequences collected from the Florida Everglades (FCE) and Central America from January 2012 to May 2014	doi:10.6073/pasta/406058160f1adb10a2ec578c56db5df8

FCE DATA SET TITLE	DOI
Cichlasoma urophthalmus microsatellite fragment size collected from the Florida Everglades (FCE) and Central America from June 2010 to March 2013	doi:10.6073/pasta/de1ec3c490268a9b3d784a9266fa2ebf
Trophic transfer of Everglades marsh consumer biomass to Everglades Estuaries (FCE), Everglades National Park, South Florida from December 2010 to Present	doi:10.6073/pasta/bb567fd4066fa2866419a1a200a89c92
Common snook (Centropomus undecimalis) movements within the Shark River estuary (FCE), Everglades National Park, South Florida from February 2012 to Present	doi:10.6073/pasta/58414574e57fd558d71cfab0952c0dc1
DIC and DOC 13C tracer data from Shark River Slough and Harney River (FCE), Everglades, South Florida in November 2011	doi:10.6073/pasta/dd9da92e48b2506cc0c2a352a5cbea8f
Mangrove Litterfall from the Shark River Slough and Taylor Slough, Everglades National Park (FCE), South Florida from January 2001 to December 2004	doi:10.6073/pasta/76f67d0aa478a133fe95b18655414412
Fish trap catch, set, and environmental data from Shark Bay Marine Park, Western Australia from May 2010 to July 2012	doi:10.6073/pasta/4a273aa566c090cd059f5f8780f566be
Stationary camera observations, set, and environmental data from Shark Bay Marine Park, Western Australia from July 2011 to June 2012	doi:10.6073/pasta/351008458935802ef0436d43bfb487ba
Marine turtles captured during haphazard at-sea surveys in Shark Bay, Australia from February 2008 to December 2013	doi:10.6073/pasta/0ae2eafe1fd94702a8471a80741b8cb1
Count data of air-breathing fauna from visual transect surveys including water temperature, time, sea and weather conditions in Shark Bay Marine Park, Western Australia from February 2008 to July 2014	doi:10.6073/pasta/fac4bf481caf8149f86ea357455abb86
Capture data for sharks caught in standardized drumline fishing in Shark Bay, Western Australia, with accompanying abiotic data, from January 2012 to April 2014.	doi:10.6073/pasta/3f664bf54f492e77fe408543f9eeafa8
Capture data for sharks caught in standardized drumline fishing in Shark Bay, Western Australia, with accompanying abiotic data, from February 2008 to July 2014.	doi:10.6073/pasta/5541d081239577c69c87c0df5ff3a52e

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Fish community data obtained from Antillean-Z fish trap deployment in the Eastern Gulf of Shark Bay, Australia from June 2013 to August 2013	doi:10.6073/pasta/3eed6e46081423861d71e6d6a6ee3194
Percent cover, species richness, and canopy height data of seagrass communities in Shark Bay, Western Australia, with accompanying abiotic data, from October 2012 to July 2013	doi:10.6073/pasta/272c332a1c3d83dd522c5ed6324e0df9
FCE Redlands 1994 Land Use, Miami-Dade County, South Florida	doi:10.6073/pasta/e7856aad78610c7c365cf620f47a5ef5
FCE Redlands 2001 Zoning, Miami-Dade County, South Florida	doi:10.6073/pasta/e6e6563f64ae6d6aa4cb07b294f1ec95
FCE Redlands 2008 Slope Mosaic, Miami-Dade County, South Florida	doi:10.6073/pasta/f0c0fcaaca44b472112745262c372628
FCE Redlands 2001 Land Use, Miami-Dade County, South Florida	doi:10.6073/pasta/b1c64a9c7c616829ace724de8d41785b
FCE Redlands Flood Zones, Miami-Dade County, South Florida	doi:10.6073/pasta/54138174a44f11a0000279a7e480b632
FCE Redlands 2006 Roads, Miami-Dade County, South Florida	doi:10.6073/pasta/c1e2b4bdf4d5a1ad441e69b7417cdfab
FCE Redlands 2006 Land Use, Miami-Dade County, South Florida	doi:10.6073/pasta/b7e35d8321a2db2138748b869993dacd
FCE Redlands 1998 Roads, Miami-Dade County, South Florida	doi:10.6073/pasta/f5831e56dffab52a99bbe8a1a2563b1d
FCE Redlands 1998 Land Use, Miami-Dade County, South Florida	doi:10.6073/pasta/ab8e1dea7bc3301919512575093460fc
FCE Redlands 1994 Land Use, Miami-Dade County, South Florida	doi:10.6073/pasta/1d696e0668ed238469adeaed24dd7bc1
Shark catches (longline), water temperatures, salinities, and dissolved oxygen levels, and stable isotope values in the Shark River Slough, Everglades National Park (FCE) from May 2005 to Present	doi:10.6073/pasta/b545e1df777df9ebaa16ddc950e5bc77
Large shark catches (Drumline), water temperatures, salinities, and dissolved oxygen levels, and stable isotope values in the Shark River Slough, Everglades National Park (FCE) from May 2009 to May 2011	doi:10.6073/pasta/0f02b8eb2fa3c0751be63d67cccb2000

FCE DATA SET TITLE	DOI
Monthly monitoring fluorescence data for Shark River Slough and Taylor Slough, Everglades National Park (FCE) for October 2004 to February 2014	doi:10.6073/pasta/e168b11ab498c8532a7144aba064db92
Subsurface Water Temperatures taken in Shark River Slough and Taylor Slough, Everglades National Park, South Florida (FCE) from May 2010 to Present	doi:10.6073/pasta/56a7c2c88e4e20dc8c2b0100c3de9a1d
Standard Lengths and Mean Weights for Prey-base Fishes from Taylor River and Joe Bay Sites, Everglades National Park (FCE), South Florida from January 2000 to April 2004	doi:10.6073/pasta/73c32ad91eddd1843338e4081754d41e
Monitoring of nutrient and sulfide concentrations in porewaters of mangrove forests from the Shark River Slough and Taylor Slough, Everglades National Park (FCE), South Florida from December 2000 to December 2004	doi:10.6073/pasta/6f537d738ac1cdb246f8795d4da95e90
Global Climate Change Impacts on the Vegetation and Fauna of Mangrove Forested Ecosystems in Florida (FCE): Nekton Mass from March 2000 to April 2004	doi:10.6073/pasta/beb355c2f21efc3653f888709cf49637
Abiotic monitoring of physical characteristics in porewaters and surface waters of mangrove forests from the Shark River Slough and Taylor Slough, Everglades National Park (FCE), South Florida from December 2000 to May 2004	doi:10.6073/pasta/c368af399950f050ce218a718063f51d
Water Levels from the Shark River Slough and Taylor Slough, Everglades National Park (FCE), South Florida from May 2001 to Present	doi:10.6073/pasta/96730deb08e9a150633771afc965f106
Bull shark catches, water temperatures, salinities, and dissolved oxygen levels in the Shark River Slough, Everglades National Park (FCE) , from May 2005 to May 2009	doi:10.6073/pasta/04a8792fed9ceed4237bd3273a97e8f8
Fish and consumer data collected from Northeast Shark Slough, Everglades National Park (FCE) from September 2006 to September 2008	doi:10.6073/pasta/4eda63d153f0859a70c4398c3762be9e
Minnowtrap Data from Rookery Branch and the North, Watson, and Roberts Rivers National Park (FCE) from November 2004 to April 2008	doi:10.6073/pasta/91d7c7dd18e2580c7b1523c562db8021
Seasonal Electrofishing Data from Rookery Branch and Tarpon Bay, Everglades National Park (FCE) from	doi:10.6073/pasta/4cc7a504b072f661f9b82c7c4536bd30

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November 2004 to Present	
Bulk Parameters for Soils/Sediments from the Shark River Slough and Taylor Slough, Everglades National Park (FCE), from October 2000 to January 2001	doi:10.6073/pasta/435f4c70788b8199849b43c5445d3367
Greenhouse mixed culture experiment from August 2002 to April 2003 (FCE): Evaluate the effect of salinity and hydroperiod on interspecific mangrove seedlings growth rate (mixed culture) / Morphometric variables	doi:10.6073/pasta/c559309bdc4b90e325b1e8772e1de60a
Greenhouse experiment (FCE) in April and August 2001: Responses of neotropical mangrove saplings to the combined effect of hydroperiod and salinity/Biomass	doi:10.6073/pasta/b4200968cd7c84d47fd59a3d271e11b8
Periphyton data from LTER Caribbean Karstic Region (CKR) study in Yucatan, Belize and Jamaica (FCE) during 2006, 2007, 2008	doi:10.6073/pasta/f3a6a99aa7dacb1d338cf2d6d1698482
Diatom Species Abundance Data from LTER Caribbean Karstic Region (CKR) study (FCE) in Yucatan, Belize and Jamaica during 2006, 2007, 2008	doi:10.6073/pasta/84241f5358c01c8dacd832b42d3fc736
Periphyton Net Primary Productivity and Respiration Rates from the Taylor Slough, just outside Everglades National Park, South Florida (FCE) from December 1998 to August 2002	doi:10.6073/pasta/6b1a16e33753fdd17053c94d3e69c044
Florida Bay, South Florida (FCE) Seagrass Epiphyte Light Transmission from December 2000 to February 2002	doi:10.6073/pasta/393fd3bbbd5a520e5cf372483113f2ce
Thalassia leaf morphology and productivity measurements from arbitrary plots located in a Thalassia seagrass meadow in Rabbit Key Basin, Florida Bay (FCE) from March 2000 to April 2001	doi:10.6073/pasta/bf798892c1105cb3a157f7132165c732
Seagrass Epiphyte Accumulation: Epiphyte Loads on Thalassia testudinum in Rabbit Key Basin, Florida Bay (FCE) from March 2000 to April 2001	doi:10.6073/pasta/5aadc198730a74b48ae27b6c1e11f3a8
Mean Seagrass Epiphyte Accumulation for Florida Bay, South Florida (FCE) from December 2000 to September 2001	doi:10.6073/pasta/0d88f0cd8f29d6f227e19050bde91896
Seagrass Epiphyte Accumulation for Florida Bay, South Florida (FCE) from December 2000 to September 2001	doi:10.6073/pasta/2bf2a1f1d9c7904b12b137ba58956203

FCE DATA SET TITLE	DOI
Gastropod Biomass and Densities found at Rabbit Key Basin, Florida Bay (FCE) from March 2000 to April 2001	doi:10.6073/pasta/e9498a3ecfd1d497c6b4c266901c9d4b
Flux measurements from the SRS-6 Tower, Shark River Slough, Everglades National Park, South Florida (FCE) from January 2004 to August 2005	doi:10.6073/pasta/aec87311dc582fde9adf4a11a198e0aa
Light limited carboxylation rates of Red mangrove leaves at Key Largo, Watson River Chickee, Taylor Slough, and Little Rabbit Key, South Florida (FCE) from July 2001 to August 2001	doi:10.6073/pasta/d6bea805dbfa2dca53bfd60735de1af8
Rubisco limited photosynthesis rates of Red mangrove leaves at Key Largo, Watson River Chickee, Taylor Slough, and Little Rabbit Key, South Florida (FCE) from July 2001 to August 2001	doi:10.6073/pasta/6a3a958ec35ea159a935be9ceb214fe8
Mangrove leaf physiological response to local climate at Key Largo, Watson River Chickee, Taylor Slough, and Little Rabbit Key, South Florida (FCE) from July 2001 to August 2001	doi:10.6073/pasta/7390d5ffed6b06f0b881a8942a53e880
Meteorological measurements at Key Largo Ranger Station, South Florida (FCE) for July 2001 to August 2001	doi:10.6073/pasta/d0950d21f1ba78c9e91ae08d867174be
Radiation measurements at Key Largo Ranger Station, South Florida (FCE) for July 2001	doi:10.6073/pasta/7682f3f1180f6048716b39531328a0b4
Water Temperature measured at Shark River, Everglades National Park (FCE) from July 2007 to June 2011	doi:10.6073/pasta/a50dd41d188c25bc122deee65c2c73a9
Water Temperature, Salinity and other physical measurements taken at Shark River, Everglades National Park (FCE) from February 2010 to Present	doi:10.6073/pasta/65bf262c4bfd8ab956effc63f920c4d3
Water Temperature measured at Shark River, Everglades National Park (FCE) from October 2007 to August 2008	doi:10.6073/pasta/274fb25dec72d09d8226f147cdfbecb1
Groundwater and surface water phosphorus concentrations, Everglades National Park (FCE), South Florida for June, July, August and November 2003	doi:10.6073/pasta/2b42a17496155b8a7ce2191ae90e193b
Non-continous meteorological data from Butternut Key Weather Tower, Florida Bay, Everglades National Park	doi:10.6073/pasta/93ac051825af8798aaee03fcc37acb57

FCE DATA SET TITLE	DOI
(FCE), April 2001 thru Present	
Non-continuous TS/Ph7b Weather Tower Data, Everglades National Park (FCE), South Florida from May 2008 to Present	doi:10.6073/pasta/bb9d0f577959f2c73b9268002681372a
Water flow velocity data, Shark River Slough (SRS) near Satinleaf Island, Everglades National Park (FCE) from July 2003 to Present	doi:10.6073/pasta/c63a5d588755fa961bcd0dfc041e6d19
Water flow velocity data, Shark River Slough (SRS) near Gumbo Limbo Island, Everglades National Park (FCE) from October 2003 to Present	doi:10.6073/pasta/cd0a790f883c8f0f6e988d36bec58e00
Water flow velocity data, Shark River Slough (SRS) near Frog City, south of US 41, Everglades National Park (FCE) from October 2006 to Present	doi:10.6073/pasta/eb350d627455e94f0566adea2a7c65e8
Water flow velocity data, Shark River Slough (SRS) near Chekika tree island, Everglades National Park (FCE) from January 2006 to Present	doi:10.6073/pasta/a6ac11e4f8a552db3c744605b8a47e9a
Water flow velocity data, Shark River Slough (SRS) near Black Hammock island, Everglades National Park (FCE), South Florida from October 2003 to Present	doi:10.6073/pasta/d14efe4f113f59a36e4af3c63041ec3b
Flux measurements from the SRS-6 Tower, Shark River Slough, Everglades National Park (FCE), South Florida from October 2006 to Present	doi:10.6073/pasta/da2dd08561a8df482d64180735e416dc
Florida Bay Seagrass Canopy Temperature Data, Everglades National Park (FCE), South Florida from September 2000 to Present	doi:10.6073/pasta/3e4b3c5dafeb488d96abb756521f9add
Florida Bay Physical Data, Everglades National Park (FCE), South Florida from September 2000 to Present	doi:10.6073/pasta/71e031011df956555758ad9f94cac835
Florida Bay Stable Isotope Data Everglades National Park (FCE), South Florida from January 2005 to Present	doi:10.6073/pasta/3f76f8426e7322bc0b923bec5877771b
Florida Bay Productivity Data, Everglades National Park (FCE), South Florida from September 2000 to Present	doi:10.6073/pasta/f7f933443f6117bdd0ce8d4baf1e362a
Florida Bay Braun Blanquet, Everglades National Park (FCE), South Florida from October 2000 to Present	doi:10.6073/pasta/750f9687efb27af816eb882234c9c0c5
Florida Bay Nutrient Data, Everglades National Park	doi:10.6073/pasta/34e6683b4907b10002bde6

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(FCE), South Florida from August 2008 to Present	cacebe7045
Physical and Chemical Characteristics of Soil Sediments from the Shark River Slough and Taylor Slough, Everglades National Park (FCE) from August 2004 to Present	doi:10.6073/pasta/b5b9528aa9e1f8c85b96091c4c90a945
Isotopic Variation of Soil Macrofossils from Shark River Slough, Everglades National Park (FCE) in December 2004	doi:10.6073/pasta/2bcdb06ad4018aac1783c25701fa086b
Macrofossil Characteristics of Soil from Shark River Slough, Everglades National Park (FCE) from July 2003 to February 2006	doi:10.6073/pasta/e8f697869b4be3ac9c0cecff377d94d8
Radiometric Characteristics of Soil Sediments from Shark River Slough, Everglades National Park (FCE) from 2005 and 2006	doi:10.6073/pasta/c0cb8ff0f150e429674ecf0db15bedc5
Physical Characteristics and Stratigraphy of Deep Soil Sediments from Shark River Slough, Everglades National Park (FCE) from 2005 and 2006	doi:10.6073/pasta/43f9e2156680db7372e8ad4db497eb0d
Evaporation Estimates for Long Key C-MAN Weather Station, Florida Bay (FCE) from July 1998 to May 2004	doi:10.6073/pasta/c40d320f5d15fdd36a65ef7a2ef93f17
Physical Hydrologic Data for the National Audubon Society's 16 Research Sites in coastal mangrove transition zone of southern Florida (FCE) from November 2000 to May 2015	doi:10.6073/pasta/2e14523fe0a3b759b16b97e5f24ef7fa
Global Climate Change Impacts on the Vegetation and Fauna of Mangrove Forested Ecosystems in Florida (FCE): Nekton Portion from March 2000 to April 2004	doi:10.6073/pasta/7b0e0c1a9a93965c79fd66bd4bbae46d
Environmental data from FCE LTER Caribbean Karstic Region (CKR) study in Yucatan, Belize and Jamaica during Years 2006, 2007 and 2008	doi:10.6073/pasta/5a01d59e5f7d73bd1f7baee2c71af765
Florida Bay Physical Data, Everglades National Park (FCE), South Florida from January 2001 to February 2002	doi:10.6073/pasta/f0e13c236606c1ed6efe5618e3eee8c0
Mangrove Soil Chemistry Shark River Slough and Taylor Slough, Everglades National Park (FCE), from December 2000 to May 23, 2002	doi:10.6073/pasta/542c044a50f7081beb454d1314fddff2
Soil Characteristics and Nutrient Data from the Shark	doi:10.6073/pasta/b159b26b251d40494258f3

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River Slough, within Everglades National Park (FCE), from March 2003 to March 2004	d4430f4dfc
Mangrove Forest Growth from the Shark River Slough, Everglades National Park (FCE), South Florida from January 1995 to Present	doi:10.6073/pasta/bec6c029df692768f349106c69162df7
Macroalgae Production in Florida Bay (FCE), South Florida from May 2007 to Present	doi:10.6073/pasta/6e69036588a3b161593ad320a2e900fd
Periphyton Biomass Accumulation from the Shark River and Taylor Sloughs, Everglades National Park (FCE), from January 2003 to Present	doi:10.6073/pasta/d773a9573ce77c9b8548d921ef98d864
Periphyton Accumulation Rates from Shark River Slough, Taylor Slough and Florida Bay, Everglades National Park (FCE) from January 2001 to Present	doi:10.6073/pasta/7b42451d4737f90883d60ee58bf61c71
Periphyton data collected from Northeast Shark Slough, Everglades National Park (FCE) from September 2006 to Present	doi:10.6073/pasta/03e9d26feab9b1eb156477057aa587b7
Macrophyte count data collected from Northeast Shark Slough, Everglades National Park (FCE) from September 2006 to Present	doi:10.6073/pasta/effd9e98134913af21b670febebd6233
Periphyton Productivity from the Shark River Slough and Taylor Slough, Everglades National Park (FCE), from October 2001 to Present	doi:10.6073/pasta/1a235d9f1737f26fde0401fd3ea3afa6
Characterization of dissloved organic nitrogen in an oligotrophic subtropical coastal ecosystem (Taylor Slough and Shark River Slough) for December 2001 in Everglades National Park (FCE), South Florida, USA	doi:10.6073/pasta/cc9f23891b8bb977eaf5d7eb6f76005f
Physical and microbial processing of dissolved organic nitrogen (DON) (Photodegradation Experiment) along an oligotrophic marsh/mangrove/estuary ecotone (Taylor Slough and Florida Bay) for August 2003 in Everglades National Park (FCE), South Florida, USA	doi:10.6073/pasta/da883a9edecd3c2a2be661531b16a780
Physical and microbial processing of dissolved organic nitrogen (DON) (Salinity Experiment) along an oligotrophic marsh/mangrove/estuary ecotone (Taylor Slough and Florida Bay) for August 2003 in Everglades National Park (FCE), South Florida, USA	doi:10.6073/pasta/07272b339cff887abca38b8676789a56
Chemical characteristics of dissolved organic matter in	doi:10.6073/pasta/76696c297746734756f827e

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an oligotrophic subtropical wetland/estuary ecosystem, Everglades National Park (FCE), South Florida from December 2001 to January 2002	c748eb20f
Quantitative and qualitative aspects of dissolved organic carbon leached from plant biomass in Taylor Slough, Shark River and Florida Bay (FCE) for samples collected in July 2004	doi:10.6073/pasta/22916d1d52d8a756020b8c7537b1bd87
Monthly monitoring fluorescence data for Florida Bay, Ten Thousand Islands, and Whitewater Bay, in southwest coast of Everglades National Park (FCE) for February 2001 to December 2002	doi:10.6073/pasta/1bb7981116c89e6f414964b0a113b294
Examination of protein-like fluorophores in chromophoric dissolved organic matter (CDOM) in a wetland and coastal environment for the wet and dry seasons of the years 2002 and 2003 (FCE)	doi:10.6073/pasta/6d2e26bc8c8cd2322981d22a095ab968
Monthly monitoring of Fluorescence, UV, Humic and non-Humic Carbon, Carbohydrates, and DOC for Shark River Slough, Taylor Slough, and Florida Bay, Everglades National Park (FCE) for January 2002 to Present	doi:10.6073/pasta/09d51db8543d43cb6f8f4e21f9630611
Water Levels from the Taylor Slough, Everglades National Park (FCE), South Florida from August 1999 to Present	doi:10.6073/pasta/c66a3111977828c21b6fa31cc9d25bcf
Precipitation from the Taylor Slough, Everglades National Park (FCE), South Florida from July 2000 to Present	doi:10.6073/pasta/965a0fb564ebbb56ae1a2ff94ec32de9
Water Levels from the Taylor Slough, just outside the Everglades National Park (FCE), South Florida from October 1997 to December 2006	doi:10.6073/pasta/2bb421d19f71704ed7476ca128bacb72
Precipitation from the Taylor Slough, just outside Everglades National Park (FCE), South Florida from August 2000 to December 2006	doi:10.6073/pasta/6581a4898452afd4bc1f6665b44aeb4f
Water Levels from the Shark River Slough, Everglades National Park (FCE), South Florida from October 2000 to Present	doi:10.6073/pasta/d756577ebf1b9a2bad4aea1b6c594787
Water Levels from the Taylor Slough, Everglades National Park (FCE), South Florida from April 1996 to Present	doi:10.6073/pasta/c6f897f83cf418015657eab9bcc4a6b4

FCE DATA SET TITLE	DOI
Precipitation from the Shark River Slough, Everglades National Park (FCE), South Florida from November 2000 to Present	doi:10.6073/pasta/9d61464601c0a485e067d462456a2262
Soil Characteristic and Nutrient Data from the Taylor Slough, within Everglades National Park (FCE), from March 2002 to April 2004	doi:10.6073/pasta/6040a745baed01378e215c8070d0126d
Soil Physical Data from the Taylor Slough, within Everglades National Park (FCE), from September 1999 to November 2006	doi:10.6073/pasta/ac54452865f50d6ca972a4c196522e4f
Soil Physical Data from the Taylor Slough, just outside Everglades National Park (FCE), from October 1998 to October 2006	doi:10.6073/pasta/81e0fc75f420c948340b17715a4d78a5
Soil Physical Data from the Shark River Slough, Everglades National Park (FCE), from November 2000 to January 2007	doi:10.6073/pasta/903576c777c0b7dc6bf87cd86f9fbc05
Periphyton Net Primary Productivity and Respiration Rates from the Taylor Slough, just outside Everglades National Park (FCE), South Florida from December 1998 to December 2004	doi:10.6073/pasta/6cd7783c4871eaf3527ab177deacd035
Sawgrass above ground biomass from the Taylor Slough, Everglades National Park (FCE), South Florida from August 1999 to Present	doi:10.6073/pasta/247ce69e445fb7b80c64c51d9eccbb92
Sawgrass above ground biomass from the Taylor Slough, just outside Everglades National Park (FCE), South Florida from October 1997 to December 2006	doi:10.6073/pasta/e6640b978d38e54d88f2231ebc7db92d
Sawgrass above ground biomass from the Shark River Slough, Everglades National Park (FCE), South Florida from November 2000 to Present	doi:10.6073/pasta/b28039119d1a48d51ee9563343b341f7
Sawgrass Above and Below Ground Total Nitrogen and Total Carbon from the Taylor Slough, Everglades National Park (FCE), South Florida for March 2002 to Present	doi:10.6073/pasta/792a7c68dfb410462bbedac3549a6c51
Sawgrass Above and Below Ground Total Phosphorus from the Taylor Slough, Everglades National Park (FCE), South Florida for March 2002 to Present	doi:10.6073/pasta/5609c84fe54d7ceab4cd755c5cde0c08
Water Quality Data (Porewater) from the Taylor Slough, Everglades National Park (FCE), South Florida from	doi:10.6073/pasta/d4e923e473d693cce2a896d82348e112

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September 1999 to December 2006	
Water Quality Data (Grab Samples) from the Taylor Slough, Everglades National Park (FCE), South Florida from September 1999 to Present	doi:10.6073/pasta/4363952963663bcd233b22e959876366
Water Quality Data (Extensive) from the Taylor Slough, Everglades National Park (FCE), South Florida from July 1999 to Present	doi:10.6073/pasta/241bc3e309edcb2aaaa4328d99bf0680
Water Quality Data (Porewater) from the Taylor Slough, just outside Everglades National Park (FCE), from August 1998 to October 2006	doi:10.6073/pasta/1c4f9019e3dc4306b17a067f455430ad
Water Quality Data (Grab Samples) from the Taylor Slough, just outside Everglades National Park (FCE), for August 1998 to November 2006	doi:10.6073/pasta/cd96927a753e84af3d9d2a07b02fa322
Water Quality Data (Extensive) from the Taylor Slough, just outside Everglades National Park (FCE), from August 1998 to December 2006	doi:10.6073/pasta/3a668167984681792eb010cd334d19af
Water Quality Data (Grab Samples) from the Taylor Slough, Everglades National Park (FCE), from May 2001 to Present	doi:10.6073/pasta/841a276afdf1c45f25b9f00a15532e9e
Water Quality Data (Extensive) from the Taylor Slough, Everglades National Park (FCE), from April 1996 to Present	doi:10.6073/pasta/c3971619b22e1ded0f9a258e95f4e2a7
Water Quality Data (Grab Samples) from the Shark River Slough, Everglades National Park (FCE), from May 2001 to Present	doi:10.6073/pasta/bb732e1e254c2a797afee65e6c21d535
Water Quality Data (Extensive) from the Shark River Slough, Everglades National Park (FCE), from October 2000 to Present	doi:10.6073/pasta/4606a6abdda742225de953d079934ce4
Sawgrass Above and Below Ground Total Phosphorus from the Shark River Slough, Everglades National Park (FCE), from September 2002 to Present	doi:10.6073/pasta/b1428041c71c70931a89a5c55e92f2fa
Sawgrass Above and Below Ground Total Nitrogen and Total Carbon from the Shark River Slough, Everglades National Park (FCE), from September 2002 to Present	doi:10.6073/pasta/1fbc5e6770502b93d70db006f604025f
Water Quality Data (Porewater) from the Shark River Slough, Everglades National Park (FCE), from January	doi:10.6073/pasta/d4828e6bf3f27761065392f428a49f0c

FCE DATA SET TITLE	DOI
2001 to Present	
Overnight Shark River Surveys from Shark River Slough, Everglades National Park (FCE), South Florida from October 2001 to March 2002	doi:10.6073/pasta/8b6e429fb37dbeaeaa22f962af725a42
Rainfall Stable Isotopes collected at FIU-MMC (FCE), Miami Florida, from October 2007 to Present	doi:10.6073/pasta/3a820d8e2e5d34f57bf9c8ee7125920c
Consumer Stocks: Wet weights from Everglades National Park (FCE), South Florida from March 2003 to April 2008	doi:10.6073/pasta/7ff817fdf10aac0ad84a64acd6ca1c95
Consumer Stocks: Fish Biomass from Everglades National Park (FCE), South Florida from February 1996 to March 2000	doi:10.6073/pasta/4c6f16f6825cc77204ef76f21e86b75a
Consumer Stocks: Fish Biomass from Everglades National Park (FCE), South Florida from February 2000 to April 2005	doi:10.6073/pasta/b0e2ae3fb140447717b8dd9fdc3f4ac5
Consumer Stocks: Physical Data from Everglades National Park (FCE), South Florida from February 1996 to April 2008	doi:10.6073/pasta/bc7e38fe4b8f5f976f1adb9e6395a8f8
Consumer Stocks: Fish, Vegetation, and other Non-physical Data from Everglades National Park (FCE), South Florida from February 2000 to April 2005	doi:10.6073/pasta/354b4b6ac638551cc947a9e83e17805d
Pond Cypress C-111 Basin, Everglades (FCE), South Florida Dendroisotope Data from 1970 to 2000	doi:10.6073/pasta/9e929b1d4c7ab02e3afd12652391f3a3
Biogeochemical data collected from Northeast Shark Slough, Everglades National Park (FCE) from September 2006 to Present	doi:10.6073/pasta/ee08228027fd32182996ce39cfde7e22
NOAA Monthly Mean Sea Level Summary Data for the Key West, Florida, Water Level Station (FCE) (NOAA/NOS Co-OPS ID 8724580) from 01-Jan-1913 to Present	doi:10.6073/pasta/4fca540ab6a8146f26b97c4eb1186a80
Temperatures,salinities, and dissolved oxygen levels in the Shark River Slough, Everglades National Park (FCE LTER) , from May 2005 to Present	doi:10.6073/pasta/b6a32d593cf8810a59a4ff519358ef8e
Large consumer isotope values, Shark River Slough, Everglades National Park (FCE LTER), May 2005 to Present	doi:10.6073/pasta/ff377333dfe23ed096f8ff732c5be61d

FCE DATA SET TITLE	DOI
Microbial Sampling from Shark River Slough and Taylor Slough, Everglades National Park, South Florida (FCE) from January 2001 to Present	doi:10.6073/pasta/c4057d056a2d6acd1439fcf91bf89f9a
Surface Water Quality Monitoring Data collected in South Florida Coastal Waters (FCE) from June 1989 to Present	doi:10.6073/pasta/ecc72ed682eb6d0e1481bdf0b88b7b57
NOAA Daily Surface Meteorologic Data at NCDC Tavernier Station (ID-088841)(FCE), South Florida from June 1936 to May 2009	doi:10.6073/pasta/dd507279ead6dab518823bdcafec8071
NOAA Daily Surface Meteorologic Data at NCDC Royal Palm Ranger Station (ID-087760)(FCE), South Florida from May 1949 to Present	doi:10.6073/pasta/4fd84503fa9cb81fe9f7f30b0c8e41cd
NOAA Daily Surface Meteorologic Data at NCDC Miami International Airport Station (ID-085663)(FCE), South Florida from January 1948 to Present	doi:10.6073/pasta/a5ba3ca4e949c16a95825fc1620c93d0
NOAA Daily Surface Meteorologic Data at NCDC Flamingo Ranger Station (ID-083020) (FCE), South Florida from January 1951 to Present	doi:10.6073/pasta/7bae64d38e108bd316c0e4b0058df94e
NOAA Daily Surface Meteorologic Data at NCDC Everglades Station (ID-082850)(FCE), South Florida from February 1924 to Present	doi:10.6073/pasta/a27e3e1a20d6aa9f1dc827a5c25069c7