TITLE:

Understanding and predicting global climate change impacts on the vegetation and fauna of mangrove forested ecosystems in Florida (FINAL PROJECT REPORT).

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INTRODUCTION:

Mangrove forests are a dominant part of coastal ecosystems in the world's tropical and sub-tropical areas. Mangroves provide many ecosystem goods and services to humans, such as: shoreline and flood protection, commercial and recreational fisheries, water quality improvement, and tourism. Coastal development and conversion from forest to fish ponds, housing developments and port facilities, has resulted in tremendous losses of mangrove forests worldwide. Mangroves are now considered one of the globe's most threatened tropical coastal ecosystems. Global climate change in general, and sea level rise in particular, is another factor which could adversely affect these productive and important environments. The objective of our research was to examine the impact of potential global climate change on the plants, animals, and hydrology of the mangrove forests in south Florida.

OVERVIEW OF PROGRESS & RESULTS:

Our project is addressing six key hypotheses related to global change impacts on the fauna, flora, and hydrology of the mangrove forest ecosystems that lie at the downstream end of the greater Everglades. We are conducting studies along upstream-downstream gradients on three tidal rivers that drain the Everglades. Furthermore, at many of our sites, other investigators are also conducting research. This co-location of work provides for more valuable sets of data for the entire ecosystem.

Faunal Component:

H_1: Fishery productivity (as inferred from standing stocks) is positively related to flooding duration, negatively related to salinity variability.

H_2: Patchy habitat conversion from forest to mudflat enhances fishery productivity (as inferred from standing stocks).

Vegetation Component:

H_3: Fires along the mangrove / marsh ecotone promote invasion of mangroves into adjacent marshes.

H_4: Shifts in the position of the mangrove / marsh ecotone are linked to the passage of major tropical storms and hurricanes.

***Hydrology component*:**

H_5: There is a unique set of hydrologic conditions that characterize the position of the mangrove – marsh ecotone along the freshwater – marine hydrologic gradient.

H_6: The hydrologic conditions that characterize the mangrove – marsh ecotone are sensitive to fluctuations in sea-level and freshwater inflow from upstream areas.

This project allowed us to continue previously funded work in the coastal Everglades pertaining to vegetation and hydrology. We have accumulated over a decade of data pertaining to mangrove forest dynamics and their recovery from large-scale catastrophic disturbance. This type of disturbance, in this case from Hurricane Andrew, is predicted to be more frequent by several climate change scenarios. Data from the hydrology sampling network are providing crucial information from a previously un-sampled region of Everglades National Park. Funding during this cycle of the GCC program allowed us to initiate sampling of estuarine fauna at sites where we have data for hydrology and vegetation.

All of our data are relevant to the Comprehensive Everglades Restoration Plan (CERP). CERP is one of the largest ecosystem restoration programs in the world today. Global climate change will affect the progress of the restoration and climate change has not been considered in the various restoration scenarios for the Everglades. For example, our analyses have indicated that the historic pattern of vegetation, that is being used as a restoration goal, had already undergone change as a result of rising sea-level. Continuing climate change is expected to influence the hydrology, vegetation and fauna of the greater Everglades ecosystem.

SPECIFIC ACCOMPLISHMENTS & RESULTS:

Faunal Component:

1) Mangrove rivulus, a small (<2 inches) specialized fish largely restricted to mangrove forests, is common all along the salinity gradient sampled in Shark River. Unlike most other fish, this species remains on the damp forest floor even at low tide when the forests drain. Its abundance in the forests independent of salinity regime, suggests it is unlikely to be affected by salinity changes associated with global change. Its abundance along Shark River also has implications for the considered listing of this species under the Endangered Species Act: it is presently a species of special concern. Our work demonstrates that the species is not rare, but is rather a habitat specialist not captured in traditional fishery surveys. It thrives wherever mangrove forests are relatively intact.

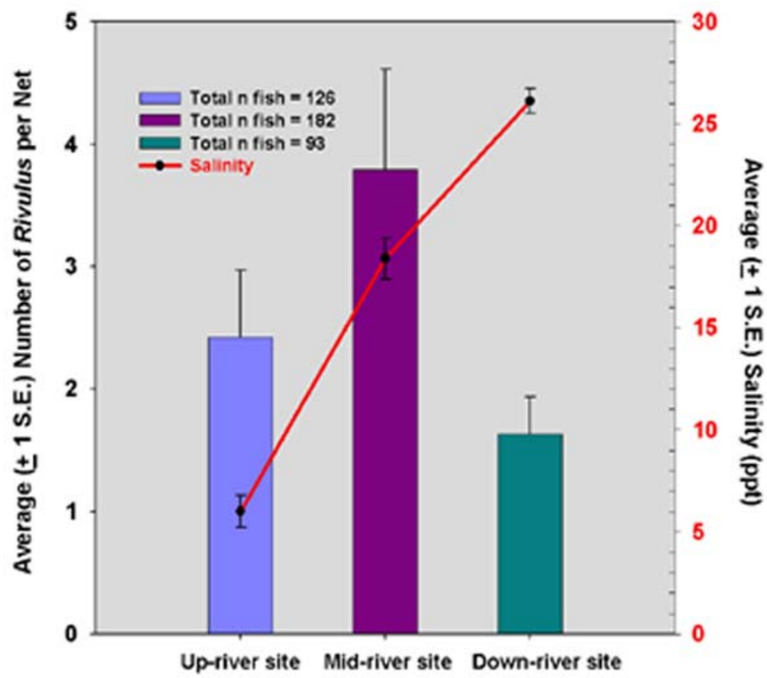

Figure 1F. Mangrove rivulus are common in mangrove forests along Shark River, and are distributed, seemingly independent of site salinity.

Relevance to resource managers: Mangrove rivulus are not a good indicator species for salinity changes associated with global change. Consideration for listing under the Endangered Species Act should take into account the species' abundance along Shark River in Everglades National Park.

This study supports Question and Product: Q2, P2; Table of Milestones, Products, and Payoffs.

2) <u>The distribution of Frillfin goby (*Bathygobius soporator*), the most abundant fish captured in tidal mangrove forests along Shark River, is closely and positively correlated with average salinity along the sampled gradient.</u> Frillfin gobies are apparently primarily a marine species. Coupled with their abundance in tidal forests, they could serve as a good indicator species for salinity changes associated with rising sea level.

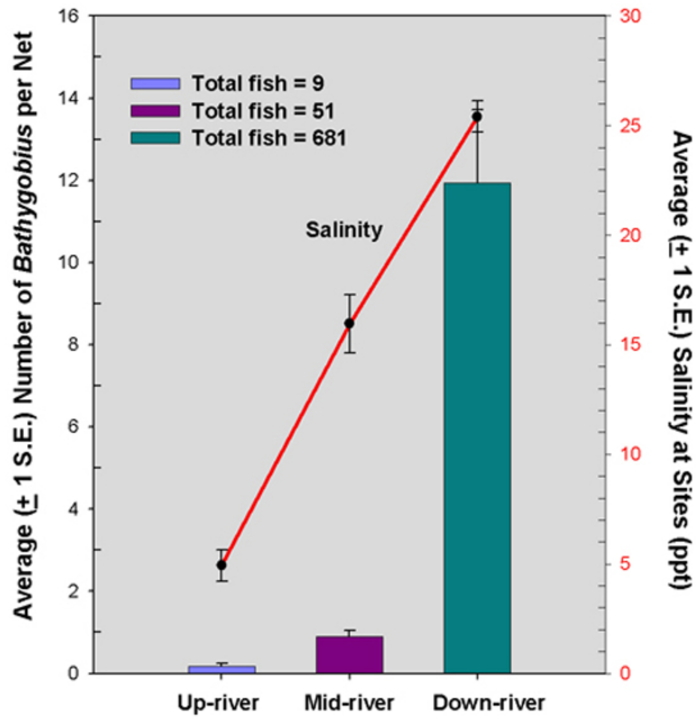

Figure 2F. Frillfin gobies are common in mangrove forests along Shark River, and their distribution is closely correlated with site salinity.

Relevance to resource managers: Frillfin gobies may be a good indicator species for salinity changes associated with global change or other factors.

This study supports Question and Product: Q2, P2; Table of Milestones, Products, and Payoffs.

3) The species composition of fish samples taken from intertidal rivulets draining forests and mudflats in the Big Sable Creek complex differs substantially. Briefly, although many common estuarine species occur in both habitats, mudflat samples are overwhelmingly dominated by water-column schooling fishes (herrings, anchovies), species rare or absent in forest samples. Cluster analysis, a statistical technique that groups objects based on their similarity, consistently groups mudflat and forest samples into different clusters, a reflection of their different species composition.

4) Mudflat sites have generated more than twice the number of species than have forested ones. From the perspective of the entire complex of six interconnected creeks, it is clear that the combination of forests and mudflats results in an increase in fish diversity at this locale.

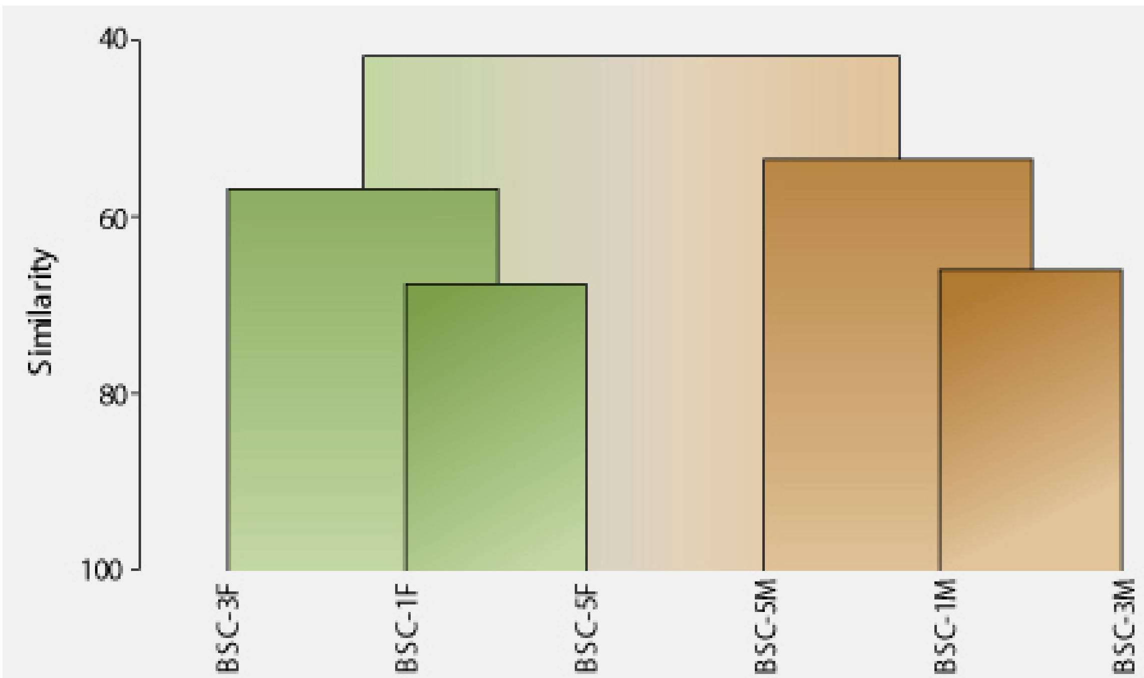

Figure 3F. Simplified plot from cluster analysis of fish samples collected from replicate mudflats (brown shading) and forests (green shading) in the Big Sable Creek complex. Based on estimates of similarity of species composition, fish samples from forests and mudflats are distinct from each other.

Studies 3 and 4:

Relevance to resource managers: Resource managers can judge whether documented differences in fish communities from mangrove forests versus mudflats warrants intervention to promote forest regeneration.

This study supports Question and Product: Q2, P2; Table of Milestones, Products, and Payoffs.

5) The dead wood so abundant in headwater creeks in the Big Sable Creek complex provides important habitat for federally listed diamondback terrapins. These large logs apparently resulted from the category 4-5 hurricanes of 1935 and 1960. They likely serve two roles for terrapins: refuge from predators, and a place to forage. Diamondback terrapins are estuarine turtles that occur in salt marsh and mangrove habitats. Their populations are threatened in many locales from habitat loss, nest predation, and mortality from bycatch in the blue crab fishery.

Figure 4f. Log jams in headwater creeks of the Big Sable Creek complex appear to be favored habitat for diamondback terrapins in this system.

Relevance to resource managers: Resource managers can use this information on habitat association to target these or similar areas for long-term monitoring of an endangered species.

This study supports Question and Product: Q2, P2; Table of Milestones, Products, and Payoffs.

SPECIFIC ACCOMPLISHMENTS & RESULTS:

Vegetation component:

1) Mangrove forest ecosystems may not be able to survive the combination of large-scale disturbance and sea level rise. – This study shows that the combination of large-scale disturbance, such as that from hurricanes, and sea level rise can cause the conversion of mangroves to intertidal mudflat. Hurricane disturbance can cause wide spread tree mortality which in turn leads to a lowering of sediment surface elevation. With the wetland surface becoming lower the forest becomes much more susceptible to the influence of rising sea level (Fig. 1V).

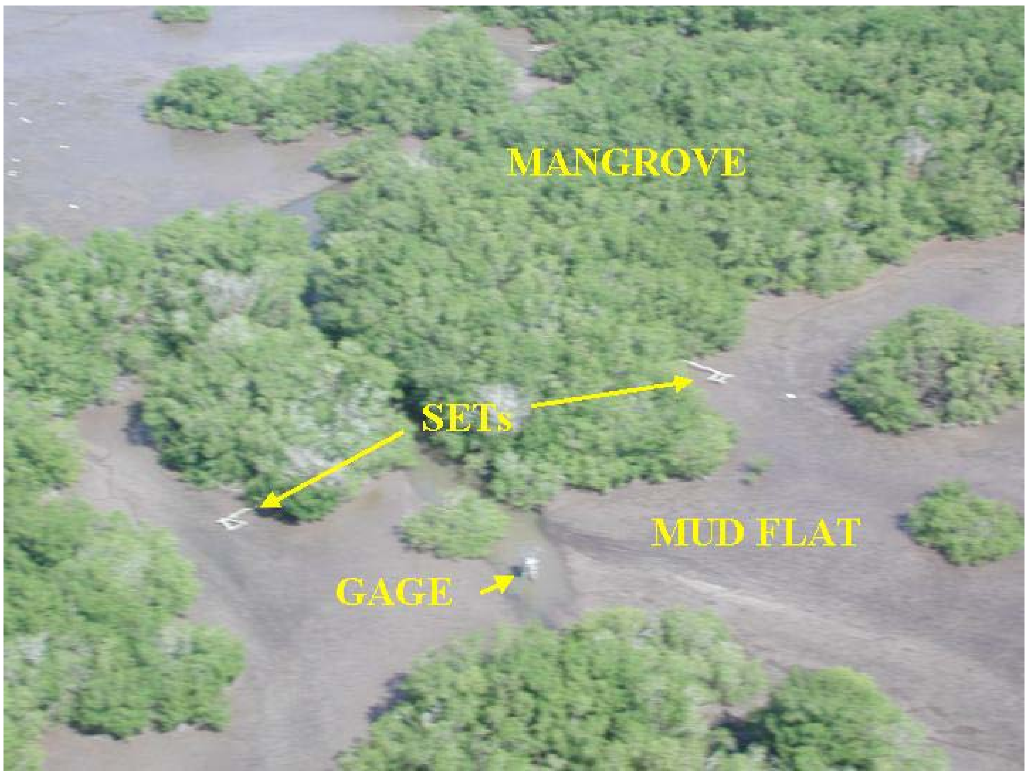

Figure 1V. Mangrove forest and barren mud flat located in the Big Sable Creek region of Everglades National Park. Prior to the Great Labor Day Hurricane of 1935, the mud flat was in fact a mangrove forest. The forest failed to recover from the storm disturbance. Our sampling of Sediment Elevation Tables (SETs) in both habitats has shown that the mud flat is continuing to lose elevation, some 70 years after the storm.

Relevance to resource managers: Resource managers need to consider ways to re-forest mangrove areas following large scale disturbance.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

2) Dead wood is generated in large pulses by disturbance events such as hurricanes. The dead wood plays an important role in the cycling of carbon, nitrogen and phosphorus. – In the immediate aftermath of a large-scale disturbance, massive quantities of woody debris and leaves begin decomposition. This can lead to a pulse of nutrients being released. This is followed by a period during which the wood actually serves as a sink. Decaying wood remains in the ecosystem for a century or more.

Relevance to resource managers: In any mangrove clearing or trimming exercise, the wood should be left in place rather than placed in an aquatic environment.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

3) Vegetation has been changing in the coastal Everglades prior to 1940, the year used as the "base condition" for the Comprehensive Everglades Restoration Plan. – This study demonstrates that vegetation change in the coastal Everglades was underway prior to the 1940 baseline assumed in the Comprehensive Everglades Restoration Plan. This is true in areas such as the C-111 basin, Cape Sable, and the southwest coastal areas of Everglades National Park.

Relevance to resource managers: Restoration goals or targets for some areas of the park need to be re-examined.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

4) <u>The phenomenon of "vegetation die off" observed in Florida Bay appears to be a long term, cyclical process, not related to freshwater runoff, but possibly to sea level variation.</u> – Initially it was felt that the die-off of mangroves and herbaceous vegetation on the islands and northern coastline of Florida Bay was related to upstream water management and reduced inflows leading to hyper-salinity. Our study has shown that hyper-salinity on the islands occurs as a result of natural hydrological and biological processes and had been documented long before canals were dug in south Florida. Our current working hypothesis is that the cyclical nature of the die-off is related to the 19.6 year periodicity of perigean spring tides.

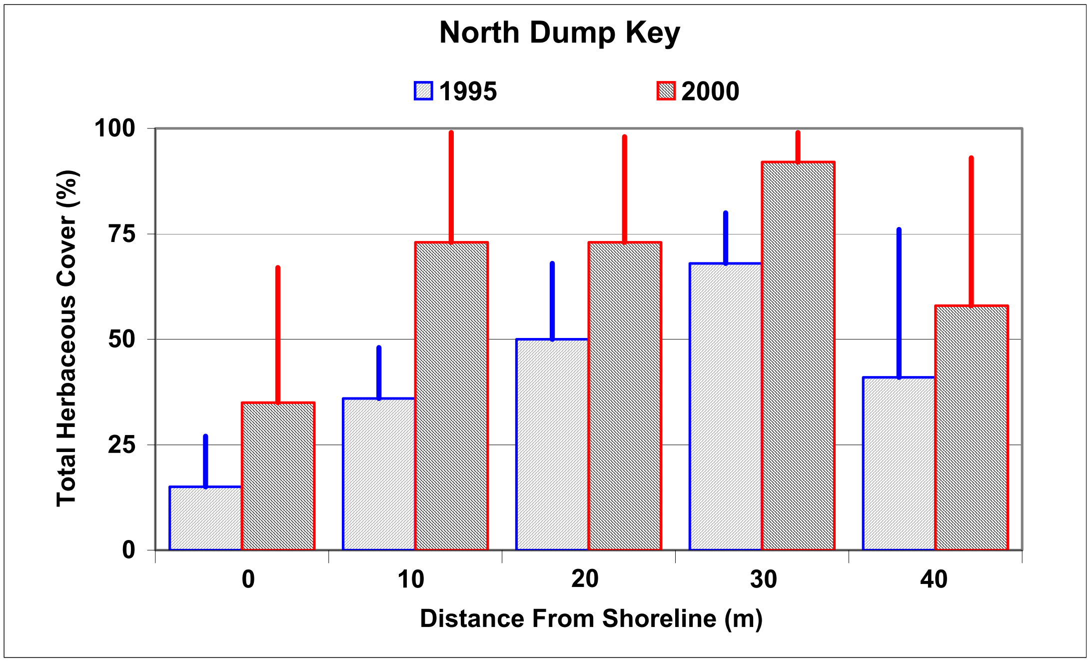

Figure 2V. Percent cover of herbaceous vegetation on North Dump Key, Florida Bay. The data represent the average (± 1SD) of six 1 m^2 quadrats. The period from 1995 to 2000 was marked by lower average sea level and higher than normal rainfall. This resulted in decreased soil salinities and increased herbaceous vegetation cover.

Relevance to resource managers: This is a naturally occurring process that managers need to be aware of, but not necessarily concerned about. Monitoring needs to occur to make sure that human factors do not alter the natural pattern.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

5) <u>The three species of mangroves in Florida have well defined allometric relationships that can be used to predict biomass and productivity.</u> – Our results have demonstrated that simple linear regression models can use tree diameter to accurately predict biomass and productivity in the mangrove forests of Everglades National Park.

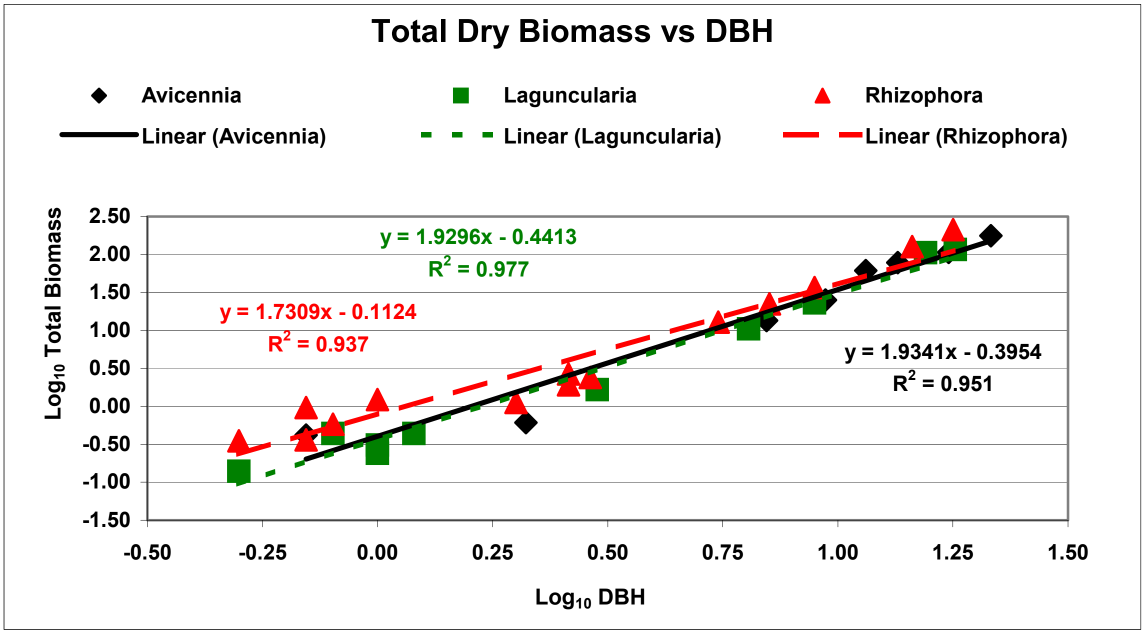

Figure 3V. Log-log (base 10) relationship of total dry biomass as a function of diameter at breast height for three species of mangroves in Florida.

Relevance to resource managers: Resource managers have a new tool for use in assessing restoration success.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

5) <u>Important elements for plant growth show marked gradients across the coastal zone. For example, ammonium, a form of nitrogen, is present in low concentrations in mangrove forests, but relatively high concentrations in adjacent sawgrass prairies.</u> Reasons for these patterns are unknown at present but they might be a result of differences in hydrology and/or fire regime between communities.

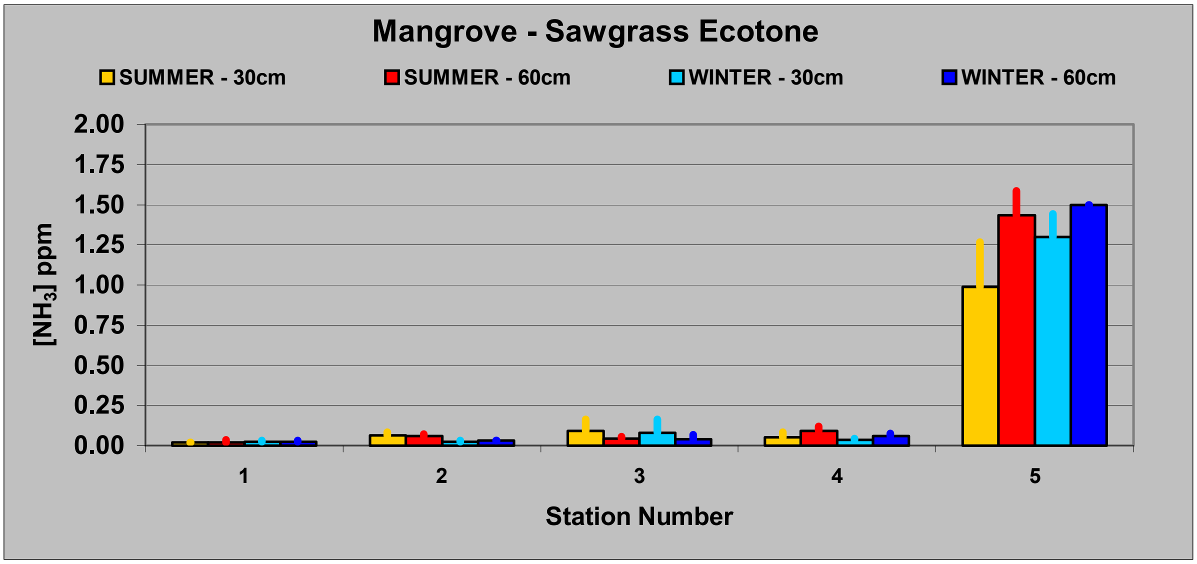

Figure 4V. Concentrations of ammonium (mean ± 1 standard deviation) in the sediment along a transect from the edge of a coastal tidal river, into a sawgrass prairie. Data are shown for two depths in the sediment (30 and 60cm) and for two seasons (summer and winter). Station 1 = tall mangrove forest adjacent to the river, Stations 2 and three = shorter mangrove forest some 100m and 200m respectively, away from the river. Station 4 = mixed short mangrove forest with sawgrass, 270m from the river. Station 5 = sawgrass prairie some 350m from the river.

Relevance to resource managers: The influence of hydrologic and fire regimes on nutrient dynamics is poorly understood. As CERP alters the hydrology of the Everglades, and also the fire regime, studies are needed on how this will influence plant available nutrients.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

6) <u>The concentration of iron (Fe) in sediment porewater appears to be related to density and distribution of the mangroves *Avicennia germinans* and *Rhizophora mangle*.</u> - The relationship is a positive one for *Rhizophora*. As Fe increases in the sediment, stem density of *Rhizophora* increases. For *Avicennia*, the relationship is inverse, increasing iron concentrations result in decreasing stem density.

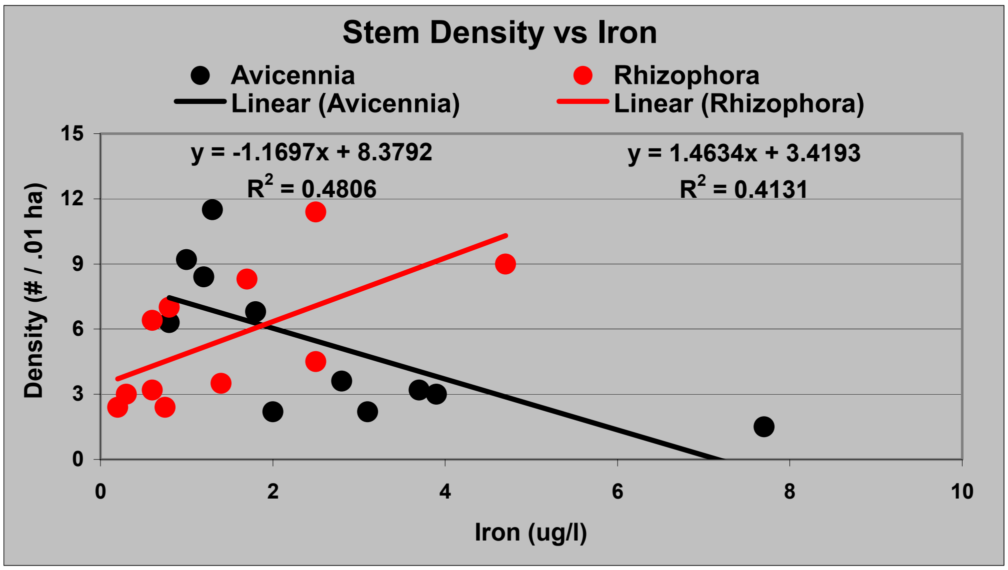

Figure 5V. Relationships between stem density and sediment porewater iron concentration for *Avicennia* and *Rhizophora*.

Relevance to resource managers: The concentration of nutrients and other compounds in the sediments of mangroves and marshes is influenced by a number of factors, including hydrology and salinity. As CERP progresses, it will alter both the hydrology and salinity regimes of the coastal Everglades, and also the concentrations of nutrients and other elements. Studies are needed on how this will influence sediment porewater chemistry and plant community structure and composition.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

SPECIFIC ACCOMPLISHMENTS & RESULTS:

Hydrology component:

1) <u>The large coastal islands of the southwest Everglades appear to be hydrologically disconnected from upstream freshwater inflows, but not to groundwater. Their response to sea level rise is still a matter of debate.</u> – Surface water hydrology of the large islands found on the southwest coast of Everglades National Park (those lying between the tidal rivers) appears to respond independently of upstream hydrology or even the river hydrology. However, there does appear to be a similarity in groundwater hydrology across the coastal zone of the Everglades.

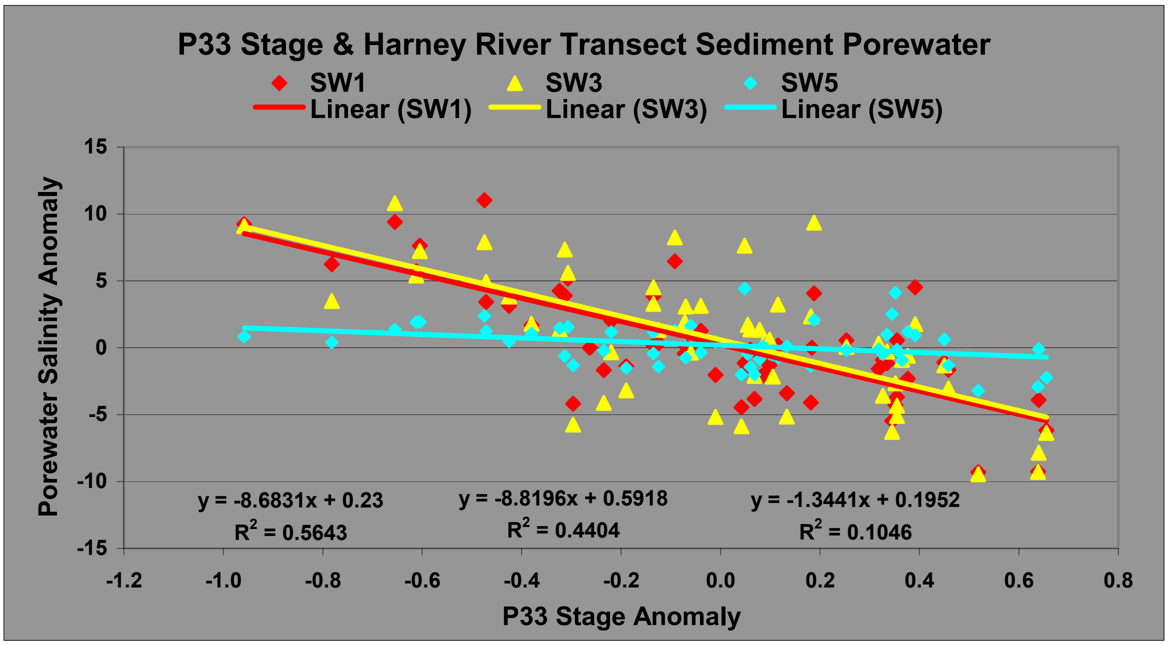

Figure 1H: Relationships of stage anomalies at gauge P33 in central Shark River slough in Everglades National Park and sediment porewater salinity anomalies at three locations downstream from P33. The data have been adjusted by subtracting the monthly mean from each monthly observation. Thus, above average stage (positive anomalies) lead to below average salinities (negative anomalies). Site SW1 is located approximately 20m from the edge of the Harney River, a large tidal distributary of Shark River Slough. SW3 is 150m inland from SW1. SW5 is located 350m away from the river and is in a sawgrass prairie.

Relevance to resource managers: Management of the coastal marshes and prairies on these islands will depend on prescribed fire rather than hydrologic manipulation.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

2) <u>Sediment surface elevation in freshwater and saltwater wetlands respond differently to water level changes. As stage decreases in freshwater wetlands, sediment elevation increases, whereas, when stage decreases in saltwater wetlands, elevation also decreases.</u>

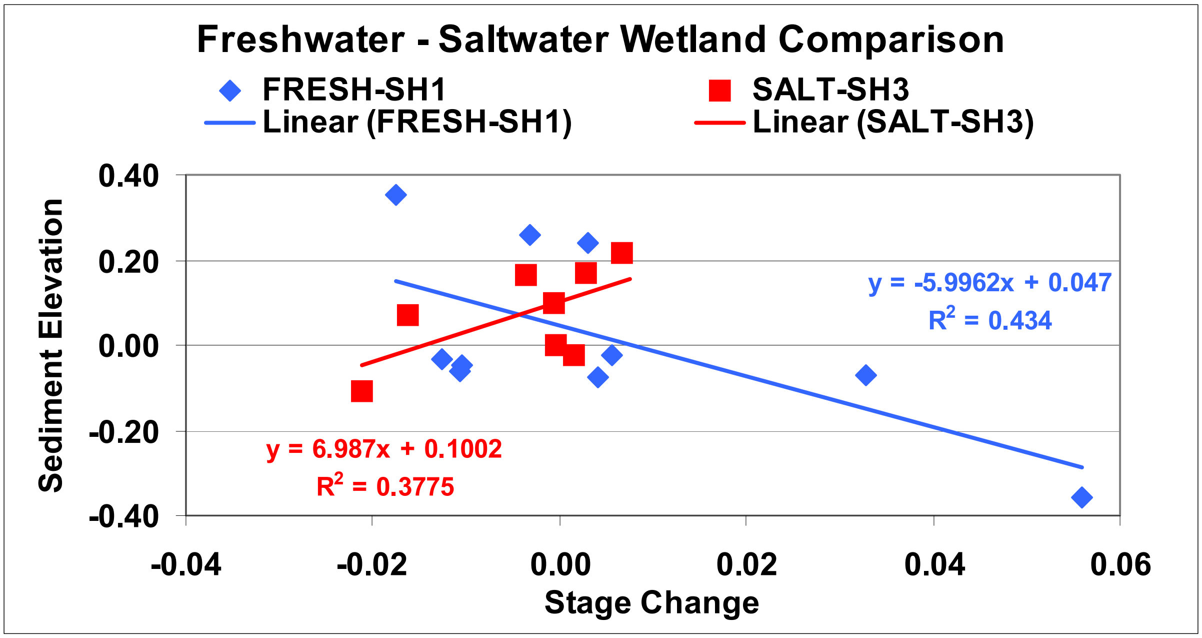

Figure 2H. Relationship between water level (stage) change and sediment surface elevation for freshwater and saltwater wetlands. The relationships are opposite.

Relevance to resource managers: All wetlands in the Everglades are NOT equal! The response of wetlands to the hydrologic restoration of CERP will vary depending on location along the salinity gradient.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

3) The berm removal project on the C-111 canal was only partially successful at restoring water levels in downstream marshes. - Our analysis indicates that the removal of the berm has resulted in pre-canal marsh water levels in the western portion of the C-111 basin, but not the eastern portions. Marsh water levels in the Highway Creek drainage are still below those of the pre-canal period.

Relevance to resource managers: Further structural modifications to the C-111 levee may be required to adequately redistribute surface water and flow to downstream marshes.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

4) Marsh water columns in the Florida Everglades experience a daily turnover that is driven by the pattern of daily solar heating and nighttime cooling. The spring and fall vertical mixing of the water column in lakes and ponds has a profound influence on nutrient dynamics and productivity. We found that the shallow water column of the Everglades marshes experience a daily turnover (mixing) that is driven by rapid temperature changes. This mixing extends into the upper layers of the sediment. And is dependent on water depth.

Relevance to resource managers: This mixing of the water could have profound impacts on the cycling of nutrients and contaminants (e.g. mercury) in the Everglades. The dynamics of this process will most likely be altered by increasing water depths and flows under the current restoration scenario, but we do not know by how much.

This study supports Question and Product: Q2, P2; Table – Feasibility of Milestones, Products and Payoffs.

PRODUCTS:

Data Sets

Anderson, G.H. & T.J. Smith III. 2004. Hydrological Data Report for Water Years 1995 – 2002 for the Lower Shark River Monitoring Network, Everglades National Park. U.S. Geological Survey, Open-File Report 02-457. St. Petersburg, Fl.

Faunal Component:

Fisheries datasets, all Excel files (March 2000 – December 2002):

- ENP data biomass-2000.xls
- ENP data biomass-2001.xls
- ENP data biomass-2002.xls
- ENP data numbers-2000.xls
- ENP data numbers-2001.xls
- ENP data numbers-2002.xls
- ENP data sitesums-2000, 2001,2002.xls
- ENP detrital export from rivulets.xls

Reports, Abstracts, and Presentations

Faunal component:

Hart, K. Microsatellite DNA variation in Diamondback terrapins: Using molecular techniques to figure out those Terps. Talk at Duke Marine Laboratory, March 2004.

McIvor, CC. Invited speaker to the Interagency Ecology Program for San Francisco Bay and the Delta, Asilomar, California, Feb 26, 2003: ***Challenges and Goals for Everglades Restoration*.**

McIvor, CC & N. Silverman. Assessing the Consequence of Hurricane-Induced Conversion of Mangroves to Mudflats on Fish and Decapod Crustacean Assemblages in the Big Sable Creek Complex of Southwest Florida, poster, GEER Conference, April 2003. Poster.

Hart, K.M., C.C. McIvor, & G.L. Hill. Distribution, abundance, and population structure of a broadly-distributed indicator species, the diamondback terrapin (*Malaclemys terrapin*), in the mangrove-dominated Big Sable Creek complex of Southwest Florida, Everglades National Park. GEER Conference April 2003. Talk.

McIvor, C.C., N. Silverman & G.L. Hill. Fish assemblages of tidally flooded mangrove forested habitat along a salinity gradient in Shark River. Geer Conference April 2003. Talk.

Hart, K. Declines in diamonbacks: Terrapin population modeling and implications for management, Ecological Society of America annual conference, August 5-10, 2001, Madison, WI. Poster.

McIvor CC & S. Whaley. Patterns of Distribution and Abundance of Mangrove-Associated Fishes and Crustaceans along a Salinity Gradient in Shark River, Everglades National Park, December, 2000. Talk.

McIvor, CC. Mangroves as Nursery habitat: A Review of the Paradigm. Seminar to Marine Sciences, USF, Spring 2000. Invited talk.

McIvor, CC., JJ Lorenz, JA Ley, CH Faunce, & JE Serafy. Patterns of fish use of mangrove prop root habitat, South Florida, USA. Conference on mangrove macrobenthos, Mombassa, Kenya, September 2000. Talk.

McIvor, C.C., T.J. Smith III, M.B. Robblee & L. Lefebvre. Impacts of hydrological restoration on three estuarine estuarine communities of the southwest Florida coast and on associated animal inhabitants. U.S. Geological Survey Program on the South Florida Ecosystem – 2000 Proceedings. 11-15 December 2000. Naples, FL. Open File Report 00-449, pgs. 123-125.

Waddle, J.H., Whelan, K.R.T., Rice, K.G. & Smith, T.J., III. Anuran dynamics in a fringing riverine mangrove habitat. Estuarine Research Federation, 16th Biennial International Conference. 4-8 November 2001. St. Petersburg Beach, FL.

Vegetation component:

Coffin, A.W., H. Mounts, H. Henkel, A.M. Foster, P.R. Briere, T.J. Smith III and R.R. Wertz. 2003. Creation of a Geodatabase of the Digital Aerial Photography Archives for the Greater Everglades of South Florida and the Southern Inland and Coastal System, 17th Biennial Conference of the Estuarine Research Federation Conference, Program with Abstracts, Seattle, WA.

Coffin, A.W., H. Mounts, H. Henkel, P.R. Briere, A.M. Foster, T.J. Smith III & R.R. Wertz. 2003. Creation of a Geodatabase of the Digital Aerial Photography Archives for the Greater Everglades of South Florida and the Southern Inland and Coastal System. Presentation: Joint Conference on the Science and Restoration of the Greater Everglades and Florida Bay Ecosystem "From Kissimmee to the Keys", Program with Abstracts, Palm Harbor, FL.

Foster, A. & Smith, T.J., III. 2003. Distribution of mangroves in the western Florida Everglades, 1927 to present. 17th Biennial Conference of the Estuarine Research Federation, Program with Abstracts, pg 46.

Marshall, C.H., Jr., Pielke, R.A., Sr., Steyeart, L.T., Cronin, T.M., Willard, D.A., Jones, J.W., Smith, T.J., III & Irons, J.R. 2002. Impact of land management practices in Florida on the regional climate of South Florida and the Everglades. 13th Symposium on Global Change and Climate Variations. Annual Meeting of the American Meteorological Society. 14-17 January 2002. Orlando, FL

Smith, T.J., III, L. Fahrig, P. Carlson, T. Armentano & G. Peery. 2003. Mangrove Die-off in Florida Bay: A recurring natural event? Pgs 14-15 in Florida Bay Program and Abstracts, Joint Conference on the Science and Restoration of the Greater Everglades and Florida Bay Ecosystem.

Smith III, T.J. & A. Foster. Global change effects on tropical coastal ecosystems, with special reference to the Florida Everglades. Presented at: The Big Unknowns in Global Change: Climatic, Biotic & Human Systems. A "State of the Art Conference" sponsored by University of Georgia. 5-6 April 2001. Athens, GA.

Smith, T.J., III & McIvor, C.C. Understanding and predicting the effects of global climate change on the mangrove forested ecosystems of Florida. Annual Meeting of the Society of Wetland Scientists. 3-7 June 2002. Lake Placid, NY.

Walker, C., T.J. Smith III & K.R.T. Whelan. 2003. Short term dynamics of vegetation change across a mangrove – marsh ecotone in the southwest coastal Everglades: Storms, sea level, fires and freezes. Joint Conference on the Science and Restoration of the Greater Everglades and Florida Keys, Program with Abstracts, pp 571-573.

Whelan, K.R.T., Smith, T.J., III & Van Leth, I. A preliminary investigation of gap dynamics in the mangroves of south Florida. . Estuarine Research Federation, 16th Biennial International Conference. 4-8 November 2001. St. Petersburg Beach, FL.

Hydrology Component:

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Anderson, G.H. & T.J. Smith III. 2003. Long-Term Data from the USGS-BRD Mangrove Sampling Network in Everglades National Park.. April 2003. 2003 Greater Everglades Ecosystem Restoration Conference, Palm Harbor, FL

Anderson, G.H., F. Ilami, T.J. Smith III, S. Chwala & C. Walker. 2002. Pore Water Sampling Methods of Water Quality Parameters in the Everglades Mangrove Estuaries. USGS 3rd National Conference on Water-Quality Field Activities. Orlando, FL., 18-22 November 2002.

Anderson, G.H. & T.J. Smith III. 2002. Hydraulic Conductivity of Riparian Mangrove Peat Adjacent to the Harney River, Everglades National Park: A Comparative Field Study of Field Saturated and Saturated Hydraulic Conductivity Methods. EOS Trans. AGU, 83(19), Spring Meet. Supple., Abstract H31A-02.

Anderson, G., W.K. Nuttle & T.J. Smith. 1999. Restoration of Sheetflow to Florida Bay: An Assessment of Modifications to the C-111 Canal. ERF 15th Biennial International Conference. New Orleans, LA., 25-30 September 1999
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Anderson, G.H., A. van de Lockant, C. Walker, T.J. Smith III & T. Mullins. A spatial analysis of seasonal surface, soil and groundwater salinity variations from April 1997 to April 2000 across the coastal mangrove - freshwater marsh ecotone near the Harney River in Everglades National Park. Greater Everglades Ecosystem Restoration Science Conference. 11-15 December 2000. Naples, FL

Nuttle, W.K., T.J. Smith III & G. Anderson. 1999. Hydrologic Exchange Processes in Mangroves Downstream of Shark River Slough, Florida. ERF 15th Biennial International Conference. New Orleans, LA. 25-30 September 1999.

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Saiers, J.E. & T.J. Smith III. Hydrologic variation and ecological processes in the mangrove forests of south Florida: Response to restoration. U.S. Geological Survey Program on the South Florida Ecosystem – 2000 Proceedings. 11-15 December 2000. Naples, FL. Open-File Report 00-449, pg. 136.

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Hydrology Component:

Jenter, H.L., R.W. Schaffranek & T.J. Smith III. In Review. Diel temperature cycles dominate vertical mixing in a marsh water column. Wetlands.

Latitude and Longitude of Study Sites: **(NAD 83, GPS positions)**

Chatham Transect

Chatham 1 (CH1) lat 25, 43, 44, long 81, 09, 30 (Gulf Coast District)
Adjacent the Big Cypress/Everglades National Park boundary and within Everglades National Park (stair-step region), near the stairstep airboat trail. The site is open rush and open sparse sawgrass short-hydroperiod prairie with a few nearby dwarf red mangrove bushes. Accessible by helicopter or airboat.

Chatham 2 (CH2) lat 25, 43, 01, long 81, 11, 22 (Gulf Coast District)
East of Deer Island in a salt marsh/white mangrove scrub habitat. Accessible only by helicopter

Chatham 3 (CH3) lat 25, 42, 23, long 81, 14, 43 (Gulf Coast District)
Across from Watson Place Campground on the south side of the Chatham River. Site is located in a red/black mangrove forest. Trees range in height from 3 m to 10 meters. 10 m boardwalk from River to station. Accessible by boat.

Lostmans Transect

Lostmans 1 (LO1) lat 25, 36, 49, long 81, 01, 25 (Tamiami District)
Adjacent to the Big Cypress/Everglades NP boundary airboat trail and within Everglades National Park (south of Coconuts camp) and the south side of a circular 10 ha hardwood hammock. Site is rush/sparse sawgrass short hydroperiod prairie. Accessible by helicopter or airboat.

Lostmans 2 (LO2) lat 25, 35, 39, long 81, 02, 28 (Gulf Coast District)
East of Rocky Creek Bay and Campsite Willy Willy by 800 meters in a mixed marsh of spike rush, sawgrass, red mangrove fringe shrubs along narrow creeks. Accessible by Helicopter, boat/walking 300 meters.

Lostmans 3 (LO3) lat 25, 32, 19, long 81, 11, 02 (Gulf Coast District)
At the terminus of Johnson Mound Creek (a tributary creek to Lostman River). Site is located in mature Black/Red mangrove forest. Accessible by motorboat on high tide.

Lostmans 4 (LO4) lat 25, 30, 23, long 81, 10, 00 (Gulf Coast District)
On Key McLaughlin, in at small clearing of Spartina, nearby Black Mangroves and Florida Holly bushes. Accessible by Helicopter or one really long walk from Johnson Creek.

Shark Transect

Shark 1 (SH1) lat 25, 28, 19, long 80, 50, 42 (Tamiami District)
In the Shark Slough, .5 miles NE of the Rookery branch in a medium dense sawgrass communities near the Shark Slough airboat trail. Accessible by airboat or Helicopter.

Shark 2 (SH2) lat 25, 24, 35, long 80, 57, 49 (Flamingo District)
Adjacent the east side of Tarpon Bay in a open marsh of sawgrass and rush. Boardwalk through a fringe mangrove community of 100 ft to reach the site. Accessible by motorboat.

Shark 3 (SH3) lat 25, 21, 49, long 81, 04, 43 (Flamingo District)
On the South edge of the Shark River, in the Shark River Delta islands, near Ponce de Leon Bay in a mature stand of Red Mangroves. Little understory or ground vegetation with a daily tidal flood. Accessible by motorboat.

Shark 4 (SH4) lat 25, 25, 23, long 81, 03, 38 (Flamingo District)
On the South edge of the Harney River, across from ENP hydro site "HR". In a mature fringe forest of Red Mangroves. Understory a mixture of ferns and freshwater plants. Little daily tidal flooding. Accessible by motorboat or Helicopter/walking.

Shark 5 (SH5) lat 25, 25, 17, long 81, 03, 35 (Flamingo District)
Located at Lat/Long. In an interior marsh, 300 meters from the Harney River. Boardwalk connects Shark 4 and Shark 5. Fringe mangrove forest of Red/Black/White community approximately 250 meters wide from the Harney River. Accessible by motorboat/walking or Helicopter.

Cape Sable

Big Sable Creek (BSC) lat 25,15,58, long 081,09,44 (Flamingo District)
Located at the terminus of the right fork of Big Sable Creek, north end of Cape Sable. Accessible by motorboat.

Big Sable Creek complex (BSC) nekton sampling sites. F= forested, M= mudflat.

BSC - 1F;	N 25 16.159' W 81 09.668'
BSC - 1M;	N 25 16.338' W 81 09.549'
BSC - 3F;	N 25 16.691' W 81 09.408'
BSC - 3M;	N 25 16.682' W 81 09.408'
BSC - 5F;	N 25 17.042' W 81 09.426'
BSC - 5M;	N 25 17.212' W 81 09.319'

C111 Transect

Upper Joe Bay (UJB) lat 25, 15, 49, long 80, 31, 54 (Key Largo District)
In a dwarf red mangrove flood plain, near a small creek. Accessible by Helicopter or a really long walk. Concurrent site with National Audubon.

Lower Joe Bay (LJB) lat 25, 14, 42, long 80, 31, 56 (Key Largo District)
In a dwarf red mangrove flood plain, nearby a small creek on the Northern end of Joe Bay. Accessible by motorboat/jon boat or Helicopter. Concurrent site with National Audubon.

Upper Highway Creek (UHC) lat 25, 16, 05, long 80, 27, 29 (Key Largo District)
In a dwarf red mangrove flood plain site near a small creek. Accessible by Helicopter or a really long walk from US1. Concurrent site with National Audubon.

Lower Highway Creek (LHC) Lat 25, 15, 08, long 80, 27, 33 (Key Largo District)
In a dwarf red mangrove flood plain, nearby a small creek on the Northern end of Long Sound. Accessible by motorboat/jon boat or Helicopter. Concurrent site with National Audubon.

WEB PAGE REVIEW

The project web page has been reviewed and the needed revision / updates have been noted and passed to the web page coordinator.