Annual REPORT
Task Agreement J5284060020

Submitted to:
Department of the Interior
National Park Service
Everglades National Park

PROJECT TITLE: SYNTHESIS OF EXISTING DATA ON AQUATIC COMMUNITIES IN EVERGLADES NATIONAL PARK IN A FRAMEWORK FOR ECOSYSTEM ASSESSMENT AND EVALUTION

PRINCIPAL INVESTIGATOR:

Joel Trexler
Department of Biological Sciences
Florida International University
11200 SW8th Street
Miami, Florida 33199
Phone: (305) 348-1966
Fax: (305) 348-1986
Email: trexlerj@fiu.edu

ADMINISTRATIVE CONTACT:

Roberto Gutierrez
Office of Sponsored Research Assistance
Florida International University
11200 SW 8th Street
Miami, FL 33199
Phone: (305) 348-2494
Fax: (305) 348- 4117

October 30, 2007

Annual Report

I. Summary of Overall Progress

Over the first year of this project we have completed creation of our database, including updates through the end of 2006 and assemblage of extensive metadata. All data types (fish, invertebrate, crayfish, vegetation, physical and biomass) are in their finished forms and ready for analysis and interpretation.

Using the finalized data sets, we continued to update our analyses to determine the effects of the Interim Operating Plan (IOP) on the biota of the Everglades. To illustrate the impacts of IOP, we analyzed time-series of the population dynamics of both fish and crayfish before IOP and after IOP. We used species that vary in their sensitivity to hydrology to illustrate how changes in water management practices (i.e. IOP) impact Everglades' animal communities. These data were then used for presentations at the Krome Center and other venues (see presentations list, below). We are currently working to build models to predict fish population dynamics, given that the change in water management (IOP) did not occur. To accomplish this we are creating models that use rainfall to predict water depths at a given site, under pre-IOP water management conditions (1992-1999). These models will then be used to predict fish densities assuming that pre-IOP conditions remain, but using the observed rainfall data (2000-2006). We will then compare the results from the model simulation to the observed data and quantify the differences between the observed data and the predicted data. This analysis will yield insights into the ramifications of IOP and will potentially be of future use to inform water management decisions. I have appended to description of this work to the end of the report. A version of this description was used by Doug Donalson in his DECOMP Performance Measures Documentation Sheet produced in September this year.

II. Current Problems

None.

III. Publications and Presentations

No publications have been produced during the first 6 months of this project. However, we have made the following presentations:

Meetings with So Florida Environmental Managers and Science Coordinators:

South Florida Natural Resources Center (ENP)	April 16, 2007
South Florida Natural Resources Center (ENP)	Sept 12, 2007
Indicator Program (DOI Task Force, led by Bob Doren)	April 9, June 13, Oct 22, 2007
SCG Meeting, Presentation of Indicator Tool	Oct 18, 2007

Presentations of Results from this project to professional groups:

Ecological Society of America, Symposium on setting targets for restoration

		August 8, 2007
Estuarine Research Federation		Nov 8, 2007
Florida Institute of Technology		Oct 11, 2007

IV. Collaborators

We have sent data to William F. Loftus, Shawn Liston, Jennifer Rehage, Jerry Lorenz. Trexler met with Don DeAngelis and Doug Donaldson to discuss development of a new fish model for use in evaluation projects. Don is giving a presentation of early aspects of this model at the 2nd National Conference on Ecosystem Restoration in April, 2007.

VI. FUTURE DIRECTIONS

We are currently working on completion of indicator metrics and assessment protocol. This tool will be illustrated through our analysis of the Interim Operating Plan (IOP) on long-term monitoring sites in Shark River Slough and Taylor Slough. We are currently preparing a manuscript to be published in a special issue of the journal Ecological Indicators that is being put together by Bob Doren with funding from the Federal Task Force and USGS. I am co-editing the issue with Bob and Ronnie Best. This article, along with the database, will be two major products of this project. An additional line of work is further refinement of restoration metrics based on analyses of existing data.

There is also a need to modify the current contract terms. The recent award of year 2 funds was sent with an ending date that terminates the project with several months less than the full two years of work time. The following text was included on the title page of the contract coming from the South Florida Natural Resources Center:

TASK AGREEMENT NO:	**COOPERATIVE AGREEMENT NO:**	**EFFECTIVE DATES:**
J5284060020	H5000 06 0104 – FIU	7/10/06 – 7/10/08

TASK AGREEMENT NO:	**COOPERATIVE AGREEMENT NO**:	**EFFECTIVE DATES**:
J5284060020	H5000 06 0104 – FIU	7/10/06 – 7/10/08

MODIFICATION ONE 6/1/07 – 5/30/08

I request that the ending date be modified to 9/10/08 from 5/3/08. This is two months longer than the original two year time frame, which permits us some extra time to complete our final report.

Text Submitted to Doug Donalson for inclusion in report on Krome Center Performance Measures used in Modeling for Scenario Evaluation

***Modeling Performance Measures for Assessment*.-** Assessing management success requires a criterion for defining success. Ideally, reference sites with little or no impact from human intervention will be used to establish target values for performance measures (Karr and Chew). We used pre-project time periods to establish phenomenological relationships between water depths measured at our study sites and rainfall from gauge upstream (Fig.). These relationships were then used to estimate what water depth would have been in the post-implementation period based on rainfall IF managers had not changed the water delivery pattern. In turn, these hydrological data were used to estimate fish performance measures at each monitoring site if no change in water delivery had taken place. These estimates were used as targets for comparison to actual monitoring data in order to assess how implementation of new operations had affected aquatic system function.

We used a 10-year time series (1996-2006) of aquatic consumer data to identify relationships between Performance Measures indicative of aquatic food-web dynamics and hydrological management. The data were gathered with a 1-m^2 throw trap and standard sampling protocol carried out at 20 monitoring sites in Taylor Slough, Shark River Slough, and Water Conservation Areas 3A and 3B (map of sites in Trexler et al. 2001). Samples were collected at each study site in five months of each year (February, April, July, October, December), yielding over 17,000 community samples with over 250,000 fish records for establishing relationships between biota and hydrological conditions. Quantitative data on fish and aquatic invertebrates (crayfish, shrimp, snails, and aquatic insects) were recorded from all samples, along with environmental data on emergent-plant stem density, floating mat volume (periphyton and floating vascular plants and macroalgae), and water depth. The methods, including estimates of sampling efficiency and evaluation of sources of bias, are described in several papers (Jordan et al. 1997; Wolski et al. 2002; and papers cited therein). The study sites and sample design are also described in detail in other publications (Trexler et al. 2001, 2003, 2005).

Statistical analyses have revealed taxon-specific relationships between biota and hydrological parameters linked to management of the Everglades. Three general patterns have been observed for species lacking tolerance of marsh-surface drying (fish and grass shrimp). These relationships can be characterized as species with multi-month to multi-year asymptotic accumulation of individuals (e.g., bluefin killifish, grass shrimp), highest density soon after re-flooding and decrease thereafter (e.g., flagfish), and no relationship (only eastern mosquitofish) (Trexler et al. 2001; DeAngelis et al. 2005). Probably because of their ability to burrow when the marsh surface dries, crayfish show very different patterns to hydrological parameters than fish and grass shrimp (Dorn and Trexler, 2008). These organisms have been identified as the basis for performance measures of Everglades management and restoration because of their role as key food items for higher trophic levels, notably wading birds (Ogden 2005; Davis et al. 2005).

We have been working on approaches using monitoring data to derive statistical relationships between biotic performance measures and hydrological parameters for ecological assessments of management. At present, we have developed models for several performance measures of aquatic consumers indicative of Everglades trophic dynamics. We discuss two here: total fish density (all species summed, number per meter square) and bluefin killifish (number per meter square). Both of these performance measures display strong monotonic relationships with the number of days between the time of sampling and re-wetting of the site after the most recent drying event (Fig 1). Certainly, other factors also influence the values of these performance measures (e.g., Trexler et al. 2005; Chick et al. 2004), but generally more than 60% of the sampling variation (and often more that 70%) can be explained by this single parameter (hereafter, days since dry [DSD]). We have used the logistic equation to model this relationship and found that separate parameterization is desirable for data from Taylor Slough, Shark River Slough, and Water Conservation Areas 3A and B; separate parameterization was not needed for the data we have gathered within these sloughs. Further discussion of the biology of these fits is beyond the scope of this document, however, a key caveat is that caution should be exercised in using these relationships at sites with a history of substantially shorter hydroperiods than those where the data were gathered (Table 1). There is no particular reason to use a logistic model to describe these relationships, though this and related non-linear models better described the data than simple polynomials. Ecologists have often used the logistic equation to describe population growth and the parameters have traditional interpretations (r and K). Possibly an argument against using such a model is the temptation to interpret our parameter estimates in this way when caution is necessary because we have not independently accounted for immigration and emigration, which are certainly important factors influencing aquatic animals in the Everglades. However, we have found excellent data descriptions from a phenomenological fit of this model. Future work may lead to replacing the logistic model with a Gompertz model, because of limitations in the former (assumes symmetrical population growth at low and high ends of the relationship), but current work has revealed only minor benefit to the latter and only in some data sets. The general model form is:

$$PM = K/1+((K-D_O)/D_O)*EXP((-r*DSD)))$$

Where PM is the performance measure, K is the asymptotic density, D_O is the y-intercept, r is the rate of increase, and DSD is the days since the site last reflooded following drought. For total fish density (all species summed), we found that natural log-transformed density (plus one to account for zeros) provided the best metric for PM in the equation above, and the best-fit parameters were:

Shark River Slough K=2.7146022964, r=0.0068834763, D_O=1.4325116104;
Taylor Slough K=2.6253956732, r=0.0034866067, D_O=1.0827433951; and
WCA 3A and B K=2.900783331, r=0.0967567859, D_O=0.3000990931.

For bluefin killifish density, we found that natural log-transformed density (plus one to account for zeros) provided the best metric for PM in the equation above, and the best-fit parameters were:

Shark River Slough K=1.6441744817, r=0.0071475116, D_O=0.2323561381;
Taylor Slough K=1.5816599905, r=0.0103409613, D_O=0.076502961;
WCA 3A and B K=1.4909374223, r=0.006288146, D_O=0.4013239014.

We retained all decimal places generated from the modeling program because small differences may ramify to relatively large effects in some solutions of non-linear models, though we have not examined their importance for any particular application (i.e., drop them at your own risk).

In order to test how well our models for Shark River Slough, Taylor Slough and Water Conservation areas perform when confronted with independently collected data, we used data gathered from the CERP MAP monitoring project, and our logistic equations, to predict log total fish density. The data gathered for the CERP MAP project (Oct. of 2005 and 2006) sampling design has more locations within a given region, thus gives more comprehensive coverage of a given region and provides an opportunity to test the robustness of our model across large spatial scales.

To explore the model fits, we plotted the observed values (CERP MAP data) and the predicted values (from the previously generated logistic equation) and calculated the coefficient of determination (R^2) for each model. The models for Shark River Slough (SRS) and Water Conservation Areas (WCA) 3A and 3B explained about 17% and 3% of the variation in the data respectively. Although the model fits are relatively poor, we were able to capture the general pattern in fish response to a drying event, with low densities following a disturbance and increase until densities eventually stabilize at an asymptotic density (Fig. 1). However for the Taylor Slough Region (TSL), the model does not describe the data as well ($R^2 < 0$, Fig. 20). This poor fit may arise for one of several couple reasons: the range of DSD in the data used to generate the model was much greater than the range in the CERP MAP data, 2,478 days in the long-term monitoring data compared to 153 for the CERP data. Additionally the data from the long-term monitoring study did not have DSD values that were as low in the CERP map data set (min of 35 for the long-term monitoring data and min of 0 for CERP data). The latter may be an artifact of EDEN data fitting. We are currently waiting on updated hydrology data from EDEN, which could improve our model fits.

In addition to using the models generated from our long-term data, we estimated new models for two different regions in the CERP map project: Loxahatchee and Water Conservation Area 2A. The model fits for our performance measure equation for these regions was:

Loxahatchee: K= 3.1020683649, r = 0.0258691536, D_0= 2.5485746033
WCA 2A: K= 2.7452663486, r = 0.1040699853, D_0= 1.4913607721

As with the models for WCA 3A and B and SRS, the Loxahatchee and WCA 2A were able to predict when fish density dropped and when it stabilizes at an asymptotic density; these models explained about 12% and 20% of the variation, respectively (see Fig 20). While more work needs to be done to test these models, our modeling effort provides a step forward in using baseline data to set targets for management. Also, it seems likely that these fits will improve as more data are gathered.

We used these models to illustrate their application to spatial data. We calculated an adjusted residual as a fraction of the mean for each region (residual/mean) and plotted them on maps with simple kriging to interpolate a color-coded surface (Fig. 2). In this case, the maps simply indicate residuals from the region mean in each year of study. For example, in both years there is a gradient of wet-season fish density in Loxahatchee NWR with higher than average values in the southern end of the refuge and lower values in the northern region; this pattern corresponds with a hydrological gradient in that ecosystem. A similar northeast to southwest gradient was present in Shark River Slough in 2005, but a more complex pattern is visible in 2006. Maps of this type can be useful in illustrating within-region spatial-temporal patterns. However, we see a more useful application for assessment purposes of CERP. By using hydrological targets generated by scenarios, such as the D13R alternative enshrined in the Everglades Restudy program that led to approval of CERP, it is possible to solve statistical models such as our logistic equations to create landscape-scale targets for performance measures of aquatic communities identified in the Trophic Conceptual Model (Davis et al. 2005). We can then calculate residuals between observed values from CERP monitoring and these targets to assess progress in management toward targets. These residuals can be mapped with kriging and color coded to identify areas that are closer to and farther from targets in a report-card format. We expect to generate expectations under a variety of ‘alternative futures’ scenarios because no single target is likely to be attained for the entire ecosystem. For example, it might be desirable to compare data to expectations generated by the Natural System Model to illustrate an ideal goal and evaluate if parts of the ecosystem may already be attaining aspects of ecosystem function similar to a best-guess of historical conditions (Trexler et al. 2003).

Table 1. Range of average hydroperiod in days between 1996 and 2006 at our long-term monitoring sites. There were 6 sites in Shark River Slough, 3 in Taylor Slough, and 11 in Water Conservation Areas 3A and B. Averages are over the 10-year interval and minimum and maximum are the shortest and longest average annual hydroperiods at the sites where aquatic consumer data were collected.

	Region		
	Shark Slough	Taylor Slough	Water Conservation Areas 3A & B
Minimum	306	244	318
Maximum	362	357	365

Figure 1. Model fits to data from five regions sampled for CERP MAP. Models fit to Shark River Slough, Taylor Slough, and WCA 3A and 3B were derived from independent data, while the models fit to WCA 2A and Loxahatchee NWR were parameterized by fitting a logistic equation to the MAP data.

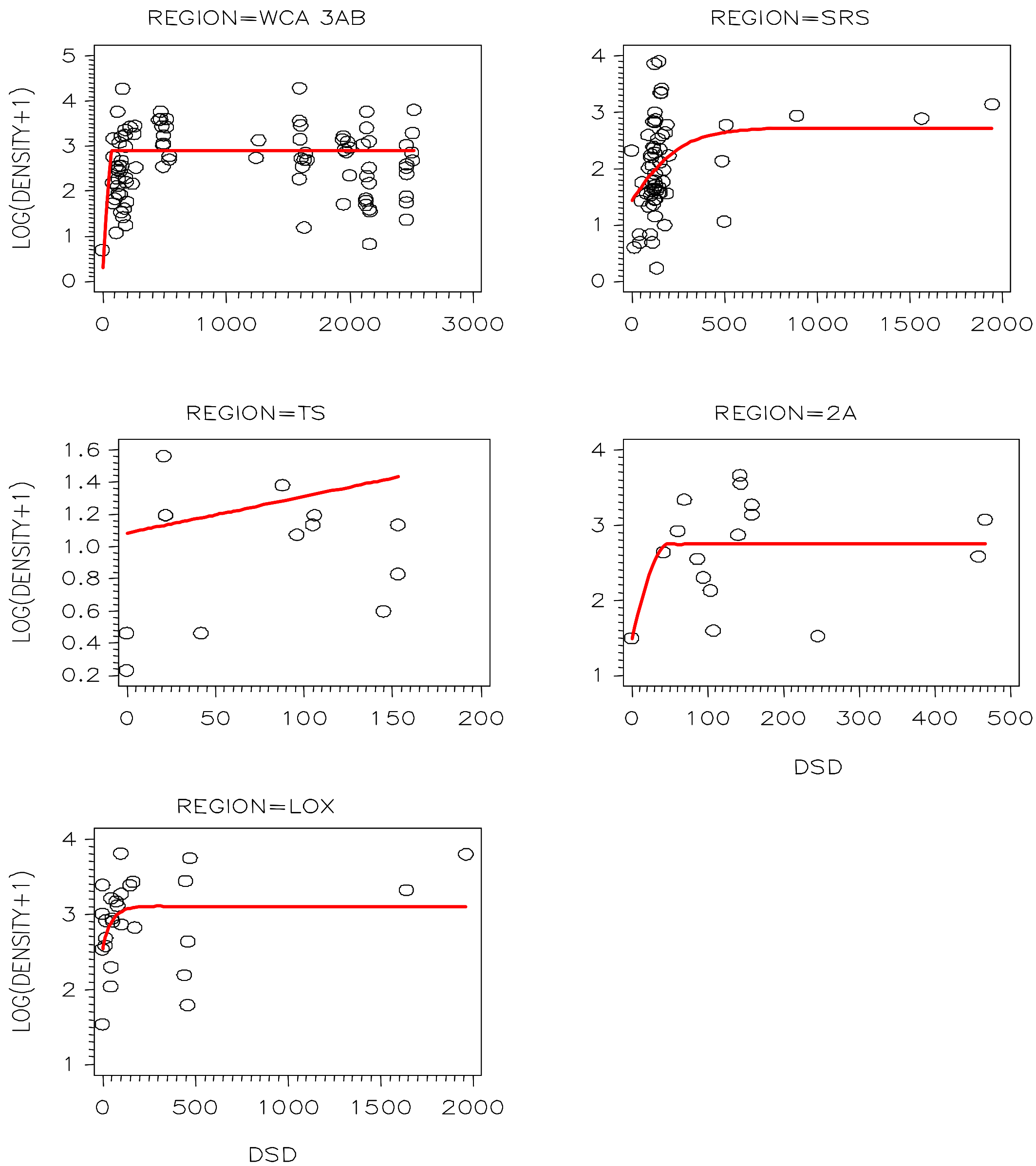

Figure 2. Map of residuals from regression of fish density (#/m^2) in 2005 and days since each PSU most recently re-flooded. Logistic models were fit to data from each region. Parameters for the logistic in WCA-3A, 3B, Shark River Slough, and Taylor Slough were derived from independent data, while those for WCA 2A and Loxahatchee NWR were derived from the pooled 2005 and 2006 data collected for this project. Simple kriging, restricted by regions, was used to colorize the map.