Aquatic Fauna as Indicators for Everglades Restoration: Applying Dynamic Targets in Assessments for CERP-MAP

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http://www.fiu.edu/~trexlerj/publications.htm
Everglades Restoration Science Strategy and Dynamic Targets

- Assessment requires a target
- Targets need to adjust for factors affecting performance measures but out of the control of managers
  - Example: Inter-annual variation in rainfall
Aquatic fauna are monitored because of their role linking environmental drivers controlled by management and wading birds. Annual or semi-annual life cycles yield real-time responses to management.
Data for Assessment
Six Performance Measures

- Four species selected as Performance Measures to represent different life histories related to effects of marsh drying
- Total fish as a measure of fish availability for higher trophic levels
- Frequency of non-native fish species
Hydrological PMs

- Recover slowly (years), effected by local drying - bluefin killifish
- Recover quickly (months), decline as site remains flooded – flagfish
- Recover quickly (months), effected by local and regional drying – eastern mosquitofish
- Not effected by short drying events, average depth past 6 months, regional drying – Everglades crayfish
Assessing Impacts of Hydrological Management

models to predict fish density

- Identify goals for hydrological management
  - Baseline period: Jan 1993 – Nov 1999
- Assessment period: Dec 1999 – 2006
- Can we detect an effect of hydrological operations on biological indicators beyond rainfall-driven hydrological variation?
  
  \[ \text{Residual effects} = (\text{Old operating} + \text{rainfall}) - (\text{New operating} + \text{rainfall}) \]
Steps for Assessment

- Model water depth from rainfall during baseline period (1993 – 1999)
- Project water depths for assessment period (late 99 - 2006) under old operating rules
- Model PM from hydrology
- Project PM during assessment period from for projected hydrology
- Compare projected PM values to observed
Sampled by throw trap
Plots A-C

Plots approx 100m x 100m
5-7 throws

Legend
- WCA3
- Shark Slough
- Taylor Slough
Hydrological Forecasting Model

- Regional rainfall data (Cumulative rainfall by season)
- Observed depths at monitoring site/plots

Split data set

- Training data set 50% of data
- Test data set 25% of data
- Validation data set 25% of data

Compare Nested linear polynomial models

Predicted depths at monitoring site if no change in operations (Days since Re-wetting DSRW)

Compare ASE values
Data for Assessment

- Inter-annual variability in ‘baseline period’ needs to span range in assessment.
- If not, predictions (targets) will be extrapolations beyond observed conditions.
Depth vs. Cumulative Rain (Before Period)

Shark River Slough
Site 7

\[ y = 1.2765x + 7.4286 \qquad R^2 = 0.5707 \]

CUMULATIVE RAIN LAST 5 MONTHS (INCHES)

SITE DEPTH (CM)

Taylor Slough
Site TS

\[ y = -0.0308x^2 + 2.299x + 1.1568 \qquad R^2 = 0.6954 \]

CUMULATIVE RAIN LAST 4 MONTHS (INCHES)

SITE DEPTH (CM)
Observed and Predicted Hydrology

Shark River Slough  Plot 6C

Begin Assessment Period

Days Since Re-Flooded

Date

1/96 1/97 1/98 1/99 1/00 1/01 1/02 1/03 1/04 1/05 1/06 1/07

- Observed
- Predicted
Ecological Model

Observed PM values

Nested linear polynomial and non linear models

Select error structure and link

Observed Hydrology (Local and Regional)

Compare AIC and choose

Please see the poster by Goss and Trexler for more details on these models
Examples of PMs

1. Log (total fish density + 1)
   Number of Days Since Flooding (Local)

2. Log (bluefin killifish density + 1)
   Number of Days Since Flooding (Local)

3. Log (flagfish density + 1)
   Number of Days Since Flooding (Adjusted)

4. Log (Everglades crayfish density + 1)
   Number of Days Since Flooding (Regional)
Shark River Slough  Plot 6C

Begin Assessment Period

Bluefin Killifish (#/m²)

- Observed
- Predicted
- Model with obs hydrology
Assessment

Forecast PM values using ecological model and hydrological forecast if no change in operations

Observed PM values

Compare PM values: Observed and predicted if no change in operations
Criteria for Red Stoplights

• Type A: one year at least three standard errors above/below limits of objective interval

• Type B: two out of three consecutive years at least two standard errors above/below limits of objective interval

• Type C: four out of five consecutive years with at least 1.5 standard errors above/below limits of objective interval
Bluefish Killifish Fish

- Model Prediction (Observed Hydrology)
- Model Prediction (Projected Hydrology)
- End of baseline period

- Observed

Target:
- 1.5 std. err
- 2.0 std. err
- 3.0 std. err.

- Upper Objective
- Lower Objective
# Stoplight Annual Assessments

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>2000</th>
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Total Fish

- Model Prediction (Observed Hydrology)
- Model Prediction (Projected Hydrology)
- ISOP/IOP Implementation

- Observed

Target: 1.5 std. err
2.0 std. err
3.0 std. err.

Upper Objective
Lower Objective

Fish Density (log #/m²)

Residual (obs - exp)

**Total Fish**

- **Model Prediction (Observed Hydrology)**
- **Model Prediction (Projected Hydrology)**
- **ISOP/IOP Implementation**

- **Observed**

**Target:**
1.5 std. err
2.0 std. err
3.0 std. err.

**Upper Objective**

**Lower Objective**

**Residual (obs – exp)**

```
-2 -1.5 -1 -0.5 0 0.5 1
```
Future Assessments Using CERP MAP

Illustration

PM: Total Fish 2005
Goal: Experimental NSM for 2005 rainfall
Target: Shark River Slough ecological model

Legend
- Caution (too few)
- Caution (too many)
- Does not meet target (too many)
- Does not meet target (too few)
- Meets target
- CANALS
Summary and Conclusions

• Assessment involves comparing monitoring data for performance measures to targets
• We recommend use of ‘dynamic targets’ for assessments in CERP when possible
  – Dynamic targets are adjusted for environmental variation outside the controls of managers
• Rainfall is a key environmental driver outside of the control of managers that effects hydrological conditions critical to aquatic fauna
• Hydrological Models for assessment (those routinely updated with contemporary rainfall) are currently lacking
• ‘Getting the water right’ should be captured in one or more hydrological models that can be used as standards for assessments
Acknowledgments

- Cooperative Agreements from the Everglades National Park and Jeff Kline
- CERP MAP program contract and Jana Newman
- Thanks to Bob Doren for including us in the Restoration Indicator Program

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