Food Webs, Interaction Webs, and Monitoring: Using a Trophic Conceptual Model to Select Ecological Indicators

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• Adaptive management

• Performance measures link societal values to actions

• Targets adjust for factors out of the control of managers
  - Example: Inter-annual variation in rainfall
Selecting Ecological Indicators

- Respond at an applicable scale?
- Feasible to implement?
- Sensitive to system drivers with predictable responses?
- Readily interpretable to general audience and scientifically defensible?
- Can a target be identified and deviations from it be documented and assessed?
- Are there situations where a positive trend is negative for restoration?
- Does the indicator have specificity?
- Does the indicator provide an early warning of ecological change?
• Wading bird population size is food limited

• Aquatic fauna links environmental drivers controlled by management and wading birds

• Annual or semi-annual life cycles yield real-time responses to management
Wading Birds and Monitoring Aquatic Fauna

- We have established link between hydrological drivers and periphyton
- ...and periphyton to fish and macroinvertebrate density dynamics
- SEM, field and lab mesocosm studies (citations available upon request)

**Regional-scale environment**
- Vegetation structure
- Landscape configuration

**Local-scale environment**
- Frequency of drought
- Time since end of last drought
- Duration and severity of last drought event

**Periphyton standing stock and composition**
- Dry season
- Prey concentration

**Prey population size**
- High-quality food patches
- Food intake, foraging aggregation size, spatial and temporal nesting patterns

**Wading Bird breeding population size**
- Large fish population size
- Wading bird characteristics
  - Morphology
  - Foraging Behavior
We have established link between wet-season prey biomass and prey biomass in drying pools.

Dale Gawlik and Bryan Botson studied aquatic animals in dry-season pools.

Prey biomass predicted by wet-season biomass, water recession rate, local microtopography.
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
Examples of PMs
• Identify goals for hydrological management
  – Baseline period: Jan 1993 – Nov 1999

• Assessment period: Dec 1999 – present

• Can we detect an effect of hydrological operations on biological indicators beyond rainfall-driven hydrological variation?
  > Residual effects = (Old operating + rainfall) – (New operating + rainfall)
Steps for Assessment

• Select Performance Measures and report temporal pattern 1995 – present

• Model water depth from rainfall during baseline period (1993 – 1999)

• Project water depths for assessment period (late 99 - present) under old operating rules

• Model PM from hydrology

• Project PM during assessment period from for projected hydrology

• Compare projected PM values to observed
Plots approx 100m x 100m

5-7 throws

Sampled by throw trap
Plots A-C
Bluefin Killifish (#/m²)

Begin Assessment Period

Observed
Predicted
Model with obs hydrology

Shark River Slough  Plot 6C
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.

Observed

Fish Density (log #/m²)

Residual (obs - exp)

- Upper Objective
- Lower Objective

Model Prediction (Observed Hydrology)
Model Prediction (Projected Hydrology)
End of baseline period
# Annual Stoplight Assessments

## Shark River Slough

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<td><strong>Bluefin Killifish</strong></td>
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<td><strong>Flagfish</strong></td>
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<td><strong>Eastern Mosquitofish</strong></td>
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<td><strong>Everglades Crayfish</strong></td>
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American alligators are food limited in freshwater Everglades.

Aquatic fauna links environmental drivers controlled by management and alligators.

Alligators may create positive feedbacks on prey production (red arrows).
Trophic Hypothesis

- Trophic hypothesis is completely bottom-up
- Ignores top-down control, indirect effects, and trophic cascades

**Regional-scale environment**
- Vegetation structure
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**Basal Resources**
- Algae in periphyton and flocculent benthic detritus, bacteria

**Primary Consumers**
- Invertebrates <<1 cm living in periphyton and benthos

**Intermediate Consumers**
- Small fish, crayfish, and shrimp (<1-8 cm)

**Large Predators**
- Fish >8 cm and similarly-sized herpetofauna
Periphyton Infauna

• Midge larvae, amphipods, nematods live inside periphyton mats

• SEM preferred model includes bottom-up and top-down effect
Planorbid snails

- Ramshorn snails are most abundant in the Everglades.
- Density does not vary along nutrient gradients though algal quality does.
- Hypothesis that predation risk and food resources balance near and far from canals.
- Tested with reciprocal transplant of periphyton.
Summary and Conclusions

• The CERP Monitoring and Assessment Plan links management actions to societal values.

• We illustrated MAP implementation and Performance Measure selection and application for the trophic hypothesis for wading birds.

• Recovery and sustenance of healthy alligator populations is a societal value captured in the CERP Monitoring and Assessment Plan.

• A ‘trophic hypothesis’ for alligators reveals key positive feedbacks to their prey by their role as ecosystem engineers.

• Positive feedbacks may mask trophic linkages observable in descriptive data.
Acknowledgments

http://www.trexlerlab.com/

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