An Integrated Framework for Linking Ecosystem Services Valuation with Freshwater Flow in the Florida Everglades

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Outline

- Background
- Conceptual Model
- Flow-Fisheries Relationship
- Willingness to Pay
- Penalty Function
Linking Flow and Ecosystem Services

Recreational fisheries context: Estimate economic value in response to changes in various fishery attributes, which could occur as a result of changes in freshwater management flows in Everglades National Park.
Florida Everglades

Source: Everglades Foundation
Conceptual Model

Flow Rate at Water Structures
  Snook, Snapper, Red Drum, Tarpon, & Bonefish
  Salinity
  Water Depth in the Marsh

Sea Trout Survival Rate
  Bass Survival Rate

Fishing Experience
  Catch Rate
  Largest Keeper
  Boat Travel Distance
  Overall Ecosystem Health

$/unit Fishing Experience
  Discrete Choice Model

Angler Population
  Change in $ Value of Recreation
  Penalty Function
Flow-Fisheries Relationship

Estimating a seasonal catch-flow function for each species:

\[ C = \beta_0 + \beta_1 F + \beta_2 \ln R + \beta_3 \text{Month}_1 + \beta_4 \text{Month}_2 \]

- \( C = \) CPUE
- \( F = \) Flow at structures
- \( R = \) Rainfall
- Monthly dummy variables

Winter (Dec, Jan, Feb)
Spring (Mar, Apr, May)
Summer (Jun, Jul, Aug)
Fall (Sept, Oct, Nov)
Flow-Fisheries Relationship

The relationship between water delivery and fishery habitat quality is modeled based on existing data sets.

**Fisheries**
- Creel surveys
- Species survival
- Habitat productivity

**Water delivery**
- S12, S333, S334, and other structures
- Seasonal dummy variables (reflecting stage and temperature)
- Precipitation
### Willingness to Pay

#### Discrete Choice Experiment
We asked anglers to value a **percent change** in various attributes from the **current level**.

#### Scenario I
- **“Status quo”**
- Low/no additional per-trip cost

#### Scenarios II & III
- Maintain or improve current levels
- Increased per-trip cost

<table>
<thead>
<tr>
<th>Effects of Future Scenarios on Recreational Fishing Experience</th>
<th>Do Nothing or Do the Bare Minimum Scenario I</th>
<th>Protect or Improve the Current Status Scenario II</th>
<th>Protect or Improve the Current Status Scenario III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catch rate</td>
<td>20% lower than your current catch rate</td>
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<tr>
<td>Size of the largest keeper</td>
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<tr>
<td>Additional cost paid by you on each trip ($ in terms of either higher boat launching fee, boat registration fee or tour guide fee)</td>
<td>No additional cost per trip</td>
<td>$30 more per trip</td>
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Willingness to Pay

Discrete Choice Experiment
We asked anglers to value a percent change in various attributes from the current level.

Let’s say $C^k$ for current catch

Any given flow-related catch can be expressed as % change from the current catch

$$\Delta C = 100 \left[ \frac{C - C^k}{C^k} \right] = 100 \left[ \frac{C(F) - C^k}{C^k} \right]$$
Willingness to Pay

Discrete Choice Experiment
We asked anglers to value a percent change in various attributes from the current level.

Mixed logit WTP estimates
- Catch: $1.28
- Largest keeper: $1.64
- Travel distance: $1.58
- Ecosystem health: $3.44

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Penalty Function

Penalty = loss of $ value in catch for not meeting target flow, $F^t$

For example, the penalty for not meeting the target catch is expressed as

$$P_c(F) = 100AW_c \left[ \frac{C(F^t) - C(F)}{C^k} \right]$$

The proportionate loss in catch in relation to the current catch as a reference, monetized at the WTP estimate of a percent change in catch ($W_c$)
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Penalty Function

Weighted catch penalty function

\[ P_a = \sum_{i=1}^{N} \omega_i \left\{ T W_c \times 100 \left[ \frac{C_i(F^t) - C_i(F)}{C_i^{k_0}} \right] \right\} \]
Penalty Function

Weighted catch penalty function

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Penalty Function

Combined penalty function

Summer Months - Catch & Harvest

Penalty ($)

Flow (KAF)

May
June
July
Applications & Future Work

- Contribute to broad-sector hydro-economic optimization model for south Florida as part of the South Florida Water, Sustainability, and Climate Project
- Scenario analysis for both past and future water management decisions
- Framework to estimate loss of benefits in other ecosystem services (carbon storage) and/or regions (Caloosahatchee and St. Lucie River Estuaries)
Acknowledgments

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Questions?