Adaptive management in a learning environment

A case study of hydrology & water quality in the A.R.M. Loxahatchee National Wildlife Refuge

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Some Tenets of Adaptive Management

• Learning happens

• Learning incorporated into decision processes

• Learning can increase management flexibility

• Directed knowledge can be used for assessing potential consequences & risks of decisions

• Combination of focused monitoring, modeling & experimentation leads to successful AM
Refuge Background

- Established in 1951
- 144,000 acres

Purposes:
- Conservation
- Water Supply
- Flood Protection
- Soft-water system
- Historically rainfall-dominant
- Formerly sheet-flow
- Water Regulation Schedule
- Consent Decree for WQ
Current Refuge Inflows and Outflows

Current Inflow

Current Outflow
Managing Refuge Resources Involves:

- Maintaining **water quantity** & **water quality**
- Identifying water management strategies to maximize ability to achieve desired conditions
How Does Water Management Influence the Refuge Marsh?

- Water Management Operations
- Canal Flow and Stage
- Water Intrusion
  Canal $\leftrightarrow$ Marsh
- Water Quality and Hydrology in Marsh
- Marsh Ecology
Refuge’s Enhanced Water Quality Monitoring & Modeling Program

• Field activities:
  – Marsh WQ characterization
  – Canal water intrusion
  – Ecological effects

• Modeling exercises:
  – Water budget
  – Hydrodynamic
  – Water quality
Water Quality Gradients in the Refuge

Conductivity

Conductivity (µS cm⁻¹) vs. Distance into marsh (km)
Canal Water Intrusion

- Conductivity transects used to track canal water penetration into the marsh

- Conductivity sondes recording hourly along gradient transects throughout the marsh
Learning & Resource Management

- Pumped inflow should be of short duration when canal and marsh stages are similar.
- Inflow can be higher when marsh stages are greater than 0.5 ft higher than canal stages.
- Inflow should cease (or have comparable or greater outflows) when canal stages are greater than 0.25 ft higher than marsh stages.
- If greater volume or duration of inflows are needed, maintain high outflows.

★ Adaptive Management ★

in a Learning Environment
Utilizing Knowledge for Management Decision Within an AM Framework

Case Study Scenario: (February, 2008)

• STA-1E discharges usually limited to < 550 cfs

• Rapid increase in water entering STA-1E (rain, inflows)

• Possible resource management questions:
  – What are options for minimizing impacts?
  – What is likely outcome based on learned knowledge?
  – What can be done to learn from the event?
  – Is risk acceptable enough to receive additional discharges from STA-1E?
Proposed Increased Inflows

Previous Conclusion:
“If greater volume or duration of inflows are needed, maintain high outflows.”

Timing/Extent Outflows

Conclusion: “If greater volume or duration of inflows are needed, maintain high outflows.”
Learning from AM experiment

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<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Inflows</td>
<td>Low</td>
<td>Inflows</td>
</tr>
<tr>
<td>Outflows</td>
<td>High</td>
<td>Outflows</td>
</tr>
</tbody>
</table>

Feb. 2008: High Inflows, High Outflows
Mar. 2005: Low Inflows, High Outflows

Inflow (red) and Outflow (black) for Jan-05, Mar-05, May-05, 31-Jan-08, 10-Feb-08, 20-Feb-08, 01-Mar-08, 11-Mar-08.
Learning from AM experiment

<table>
<thead>
<tr>
<th>Distance from canal (km)</th>
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<tbody>
<tr>
<td>0.0</td>
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Intrusion by STA-1E

- 500 µS/cm
- 350 µS/cm

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<tbody>
<tr>
<td>High Intrusion</td>
<td>Moderate Intrusion</td>
</tr>
<tr>
<td>0.5 – 1.25 km</td>
<td>0.25 – 0.6 km</td>
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Distance from canal (km)

- 31-Jan-08
- 10-Feb-08
- 20-Feb-08
- 1-Mar-08
- 11-Mar-08
## Science for Resource Management

<table>
<thead>
<tr>
<th>Information</th>
<th>Then</th>
<th>Now</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Structure Operations</td>
<td>Available</td>
<td>Available</td>
</tr>
<tr>
<td>• Canal &amp; Marsh Stage</td>
<td>Available</td>
<td>Available</td>
</tr>
<tr>
<td>• Tracking Canal Water Movement</td>
<td></td>
<td>Transects at inflows</td>
</tr>
<tr>
<td>• Water Quality in Marsh</td>
<td>14 stations</td>
<td>&gt; 52 stations</td>
</tr>
<tr>
<td>• Modeling</td>
<td>Limited</td>
<td>More extensive</td>
</tr>
<tr>
<td>• Ecological Effects</td>
<td>Limited</td>
<td>More extensive</td>
</tr>
<tr>
<td>• Management Recommendations</td>
<td>Present</td>
<td>Continued to be refined</td>
</tr>
</tbody>
</table>
Key Messages

- Science-based approach fosters expert knowledge
- Directed knowledge plays integral role in better assessing consequences & risks
- Resource management flexibility can be increased
- Increased flexibility provides additional opportunities for learning
Thank You & Questions

Snail kite chicks – July, 2008

Photo: Ed Bullington

Oliver Ray Baranski – July, 2008