Loxahatchee Hydrologic Performance Measures

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Acknowledgements

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• Refuge PM development is ongoing. Colleagues have reviewed the work shown here, and given constructive suggestions.
Example PMs

- Many examples of PMs in common use – Stock market index, Sports, ...
- Ecology (and gardening) uses **degree-days**
  - Definition
    - sum of daily \( (T - T_{base}) \)
  - Uses
Design of Performance Measures (PMs)

A habitat PM is a calculated value that is:

• Strongly related to a desirable or undesirable habitat characteristic

• Quantifiable

• *and May be* - constant, time variable, spatially variable (map), both spatial and time variable
Design of Performance Measures (PMs)

A habitat PM:
• may have a value relative to alternatives
• or have a set target where above the target
  – All alternatives are equally acceptable (constraint)
  – Acceptable alternatives are ranked by PM
Application of PMs

• Assessment (historical, retrospective)
  – Use monitoring data
  – May use modeling to establish a target, or reduce variability from extraneous factors

• Evaluation (hypothetical alternative)
  – Use models to calculate PMs
  – Models should be demonstrated to be reliable in predicting PMs
General Refuge hydrological needs

- Marsh stage to be at top of regulation schedule 3-4 weeks 4 out of 5 years
- Appropriate stage recession each year between January and April to encourage wading bird foraging success without excessive drying
- Limit stage reversals during this time
- Interannual stage variability that mimics natural patterns as much as possible
How can we measure meeting Refuge hydrologic need?

• **Total annual inflow** as a PM is problematic
  – Inflow and rainfall are correlated so there is a danger of improper conclusions
  – Timing is VERY important
  – Higher inflow years dominate statistics of central tendency
  – Higher inflow years often simply have larger releases
  – Operational decisions are important

• Conclusion – Use performance measures (PMs) based on stage not inflow

• A suite of PMs is being developed for evaluating alternative inflow scenarios under the current regulation schedule
More History, and What We Know

- There have been 4 regulation schedules in Refuge
- 1975-1994 schedule had high-stage too low
- Refuge regulation schedule was revised in 1995 to raise highest stage
- Refuge has had higher Oct-Jan stages since 1995
- 1995-2001 high-stage conditions were likely adequate; no studies show that stages were excessive
- In 2001, S-6 pump was diverted
- 2001-present high-stages reduced in magnitude & duration
Refuge Hydrologic Performance Measures

• PM suite currently proposed measure
  1. Reaching & holding high-stage (most years)
  2. Nesting Season Stage Target (appropriate recession)
  3. Reversals

• Select #1 as primary PM to identify potentially acceptable alternatives (i.e. PM 1 is a constraint)

• Other PMs then are used to rank alternatives that are acceptable under PM 1
Narrative: PM 1 – High-Stage

- Higher water (Oct-Jan) needed to:
  - Mimic natural hydropattern in timing & duration
  - Inhibit woody plant expansion in marsh
  - Inhibit wet prairie encroachment into slough
  - Inhibit expansion of non-native plants
  - Store water for ecological & water supply needs
  - Reduce canal water intrusion
  - Reduce phosphorus concentration

- Constraint: For most of the Refuge most years
  - depth $>\frac{1}{2}$ ft 3-4 weeks (21-28 days) in almost all of Refuge
  - Occur at least 3 out of 4, or 4 out of 5 years
Candidate Annual High Water #1 PMs – Sum daily scores through each water year

a. Number of days in Florida water year that stage exceeds 17 feet
   – that is, daily score is 0 when stage is below 17 ft, 1 otherwise – target 3-4 weeks in 3 in 4 or 4 in 5 years

b. Alternative smooth transition similar to a.
   – days above 17.4 ft score 1, days below 16.4 ft score 0, otherwise score = stage-16.4 ft – target derived from relationship to 1.a target
Daily Scores for 1.a and 1.b

![Diagram showing daily scores for 1.a and 1.b](chart.png)
Annual PMs from Observed Canal Stage


1a 21 to 28 days is approx.
1b 50 to 55
PM 1.b Percentile Target

From analysis of historical data:
Target: PM 1.b – 4 year return (25 percentile) > 55
Model Performance Testing

Before using models to evaluate inflow alternatives for the Refuge, we should test if the models’ predicted PMs reliably match observed PMs.

Evaluate 3 Refuge models:

- SFWMM – South Florida Water Management Model v5.4
- SRSM – Simple Refuge Screening Model v4
- MF – DHI MIKE-FLOOD Refuge model v2
\[ y = 0.9565x \]

\[ R^2 = 0.5169 \]

\[ y = 1.0031x \]

\[ R^2 = 0.6749 \]
Conclusion – Use High Stage PM 1.b

- PM 1.b provides values which are consistent with qualitative assessments
  - The one historic period believed to have adequate stage is above target
  - Other periods are below target
- Model results are more reliable for 1.b than 1.a
- Various models acceptably project PM 1.b
Recommendation - alternative evaluation

- Use PM 1.b as first metric for alternative evaluation as a constraint
  - Exceed 55 at 25\textsuperscript{th} annual percentile (longer than 4 year return)
  - No upper constraint is known
- Provisionally acceptable alternatives should be further reviewed using other PMs & professional judgment
Conclusions

• The intended use for a PM should guide its design
• Evidence that PM measures desired habitat characteristics
• Evaluation and assessment PMs are often different
• Reliability of model prediction should be demonstrated for proposed evaluation PMs
Questions?
Appendix – Model PM Evaluation

Comparison of Model Predicted to Observed Performance Measures – SFWMM, SRSM, and MF
$y = 0.9565x$

$R^2 = 0.5169$

SFWMM 1a

- SFWMM 1a
- Linear (SFWMM 1a)
$y = 1.0031x$

$R^2 = 0.6749$
SRSM 1a

\[
y = 1.0556x
\]

\[
R^2 = 0.6076
\]
SRSM 1b

$y = 0.9871x$

$R^2 = 0.565$
y = 0.9725x
$R^2 = 0.7715$

**MF 1b**

- **Model**
- **Observed**

- MF 1b
- Linear (MF 1b)