Model analysis of eutrophication constraints on an Everglades restoration project

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Presentation:

• Context – (some) Everglades issues
• Model – design & performance, to address issues
• Model application – Everglades Decompartmentalization
  • ? Modify water flows & loads → eutrophication concerns ?
• Answer – no significant concerns for this project
People surrounded the Everglades, which became fragmented by levees and canals, restricting water flows.
Comprehensive Everglades Restoration Plan (CERP)

Goals:

- Input more water
- Where it is needed,
- When it is needed…
- using CLEAN water
- And multiple other goals….
Complex spatio-temporal issues – use of models

- **Water management**
  - South Florida Water Management Model (*SFWMM*) - used to design CERP; used to evaluate multiple CERP projects
  - Regional Simulation Model (*RSM*) – 2nd generation model, now also used to evaluate multiple CERP projects

- **Ecology/water quality**
  - Everglades Landscape Model (*ELM*) – used to evaluate ecology/water quality for CERP “DECOMP” project (and other restoration projects)
ELM Design: Integrating ecological interactions

- Ecosystem model, integrating dynamic processes of hydrology, biogeochemistry, & plant biology

- Arrows denote flows of carbon, water, & phosphorus, and information feedbacks among modules
Model Performance:
1981-2000, 500 m resolution
ELM v2.8.4

Simulated vs. observed stage:
Median bias = 0 cm
Median NS Efficiency = 0.60

Hydrologic gradients:
- water ponds in downslope regions of impounded WCAs
- deeper regions along Shark & Taylor sloughs, finer-scaled slough features
ECOLAND Review

  - Stressed overall need for integrated hydrologic, ecological, & water quality models for CERP evaluations

- Mitsch, Band, & Cerco (2007) – internationally-recognized panel, review of ELM for application to CERP
  - Model is “...robust and will produce a unique contribution, with an integrated ecosystem paradigm, to understand and predict potential outcomes of Everglades restoration projects...”

- CERP Interagency Modeling Center review of ELM (2008)
  - “…IMC suggests using ELM as the primary water quality model...” for DECOMP

- ELM is Open Source, w/ comprehensive, hierarchical documentation
  - Peer-reviewed manuscripts in journals, books
ELM application:

Evaluating CERP WCA-3

Decompartmentalization Project, Phase 1

February 2011 – 2012: Contracted by US Army Corps of Engineers to apply ELM in support of CERP “Decomp” Project, Phase 1

(Related model research publication) --
ELM application for CERP Decomp Phase 1 Project

• Water quality is a formal constraint on Project Objectives
  § Project may not degrade water quality in currently-unimpacted areas
  § Apply integrated hydro-ecological ELM to evaluate that constraint

• Hydrologic water management models drove ELM
  § SFWMM v6.0 (~10 km² grid) provided regional flow boundary conditions
  § RSM v2.3.1 (avg ~2 km² grid in WCA-3) used SFWMM inflows, applied water management rules to distribute water
  § ELM v2.8.4 (0.25 km² grid) was driven by SFWMM and RSM (point) water control structure flows, simulating landscape/canal flows of water and phosphorus
Decomp Phase 1 Planning Alternatives

WCA3A water management:
- Generalized Baseline flows.
- Generalized Decomph flows.

(Background water depth map same in both diagrams: red=deep)
Decomp Phase 1 Planning Alternatives

Hydropattern restoration—distribute point inflow sources more widely
- Full spread of inflows along north boundary, or
- Combinations of less spread of inflows, or
- No action

Miami Canal modification—presence is flow barrier, and/or accelerates drainage
- Fill—completely, or
- Fill—partial (one or more sections), or
- Plugs—multiple plugs along canal, or
- No action

Future CERP projects will remove levees, input more water... towards restoration
Model setup & assumptions

- **Water management**
  - 7 Alternatives (Alts): “A” – “H”
  - 2 Bases: Future WithOut (FWO), Existing Condition Base (ECB)
  - **Common**: All were 36-year future simulations, 1965-2000 climate
  - **Differences**: Infrastructure and operations varied among runs

- **Water quality**
  - **Common**: All but ECB** simulations assumed 10 ug l\(^{-1}\) P inflow concentration from STAs (Stormwater Treatment Areas)
  - **Common**: All simulations have same (relatively high) P inflow concentrations from other basin sources

- **Performance Measures/Indicators**
  - **RSM**: Many metrics used to evaluate hydrologic benefits of Alts relative to FWO base
  - **ELM**: Eight metrics used to evaluate water quality/ecology of Alts relative to FWO base

** unused ECB assumed recent P inflow concentrations from STAs, overall mean 23 ug l\(^{-1}\)
Primary Performance Indicator:

P accumulation rate

FWO_Base

AltA – FWO_Base

AltA

Blue shades in Difference-Map =

AltA less P accumulation than FWO_Base

Ecological Landscape Modeling

http://ecolandmod.ifas.ufl.edu
Relative to FWO, ECB had significantly more marsh area with excessive P accumulation (> 50 mg P m$^2$ yr$^{-1}$).

None of the Alts (A-H) showed meaningful differences in eutrophication relative to FWO (Base used in planning).
Conclusions

• **Eutrophication risk**
  - Relative to FWO base, no Alternative had meaningful overall differences in future eutrophication risk – but all Alts showed somewhat less risk than FWO
  - Localized spatial differences were found among Alternatives, including benefits of full backfill of Miami Canal (and to some extent, full-plugging of Miami Canal)
  - Hydropattern restoration features distributed (“diluted”) P inputs along wide area, tending to reduce localized ecosystem eutrophication (compared to point inflows)
  - Alternative A, with Full Hydropattern restoration and complete backfill of Miami Canal, was one of the, if not the, preferred Alts regarding localized eutrophication risk – but all differences were small

• **Preferred Alternative**
  - RSM showed that most hydrologic benefits occurred in northern WCA-3A, supported by ELM hydro-ecological results
  - Project Development Team used RSM and ELM results to inform the evaluations of best performing plans for Decomp Phase 1

• **http://ecolandmod.ifas.ufl.edu/Projects/**
  - History-matching ELM performance documentation
  - ELM Decomp application assumptions, inputs, and results
Ongoing application/research

- **CERP Aquifer Storage & Recovery (ASR)**
  - Evaluate downstream Everglades sulfate distributions under different ASR configurations/operations

- **Florida Coastal Everglades - LTER**
  - Integrate recent multi-disciplinary research results into ELM
  - Apply ELM as landscape framework for multi-model assessments of climate change & sea level rise

- **Water resource sustainability en España**
  - Develop ecological-economic module to assess land & water management practices in the Segura basin (with N. Guaita, others)