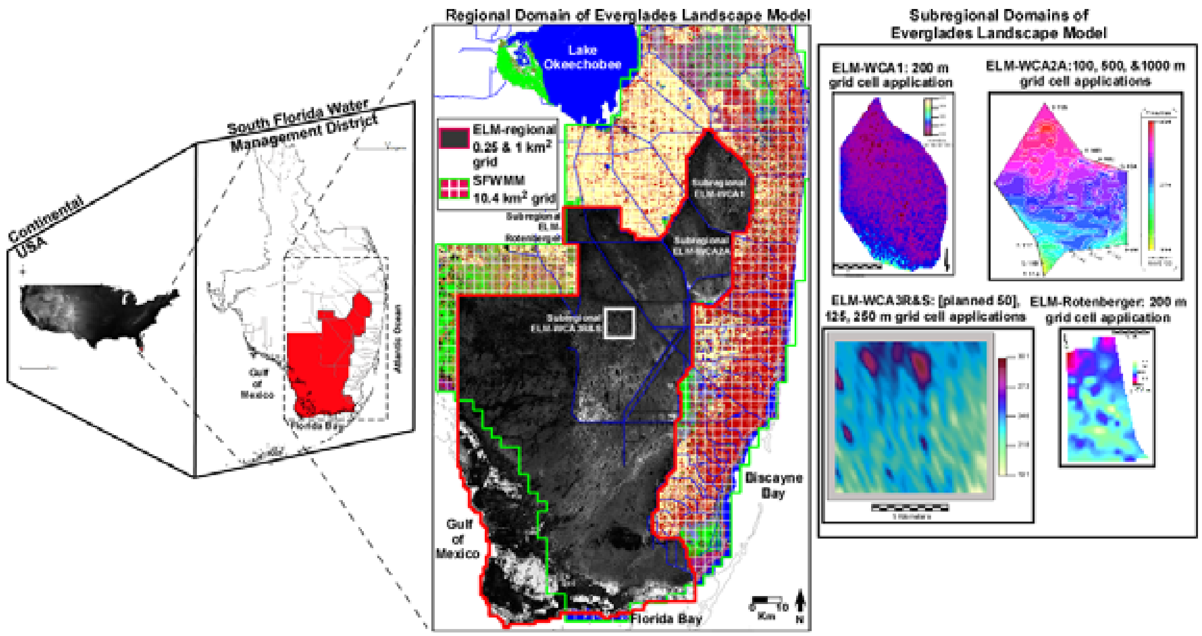
Integrated Ecological Modeling and Decision Analysis within the Everglades Landscape



GEER
2008

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Presentation:

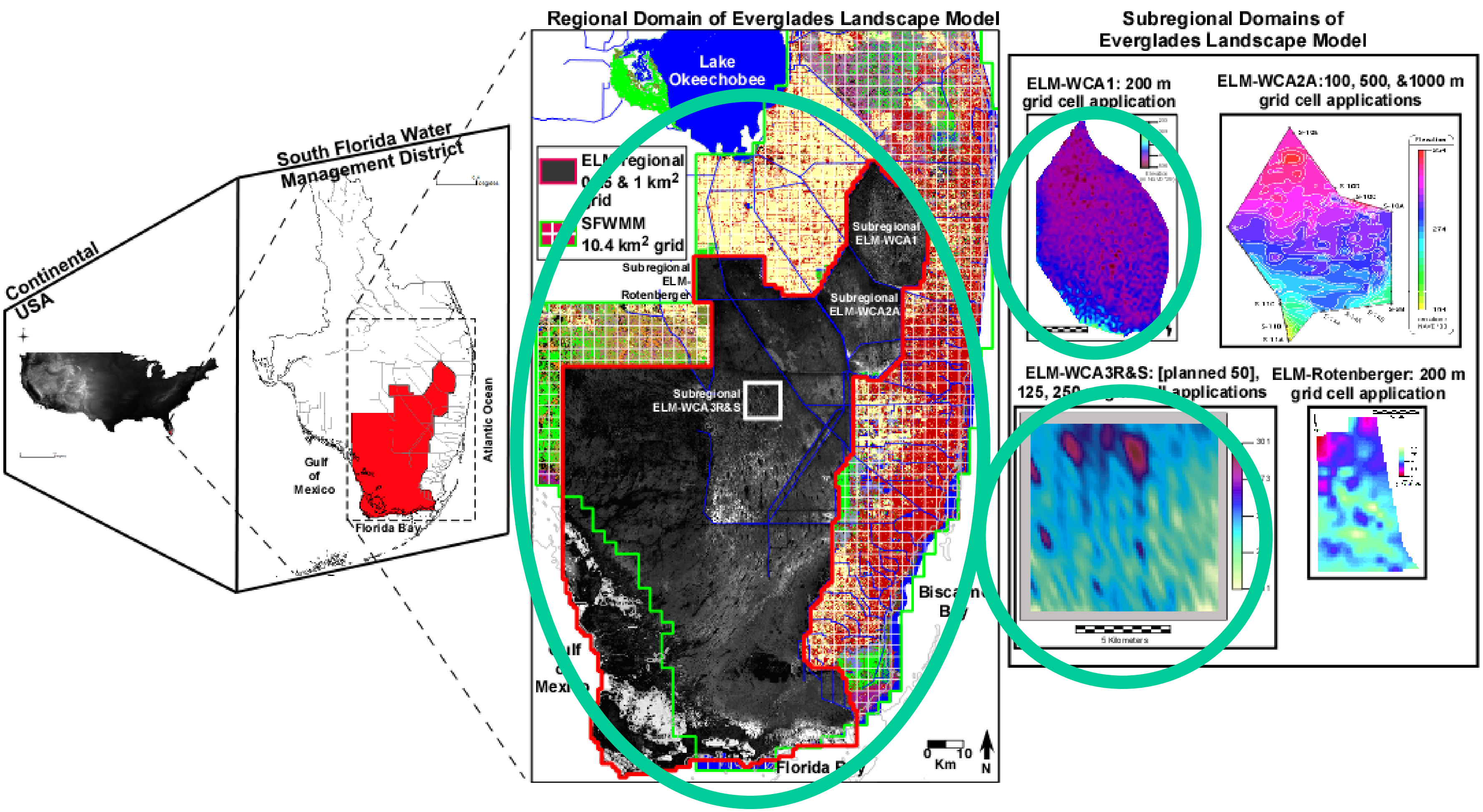
1. The ecological landscape models
2. Model applications
3. Decision analysis

Everglades Landscape Model (ELM) Goals:

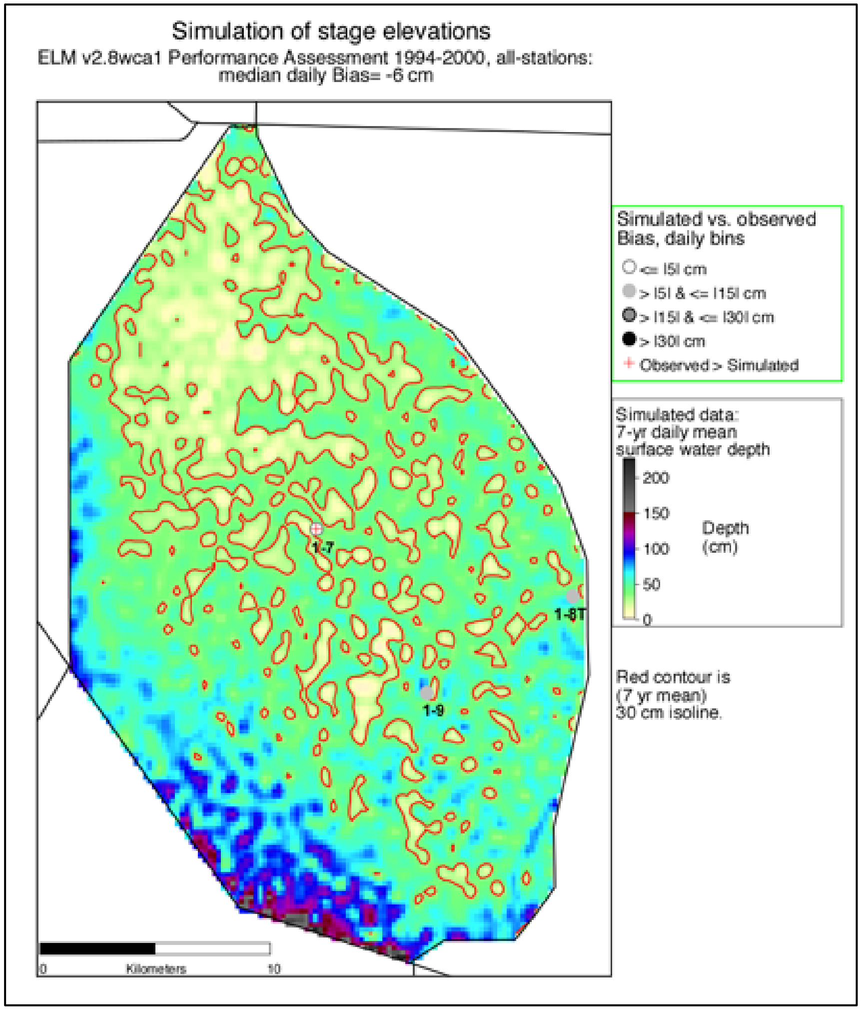
Develop a modeling tool for integrated ecological assessment of water management scenarios for Everglades restoration

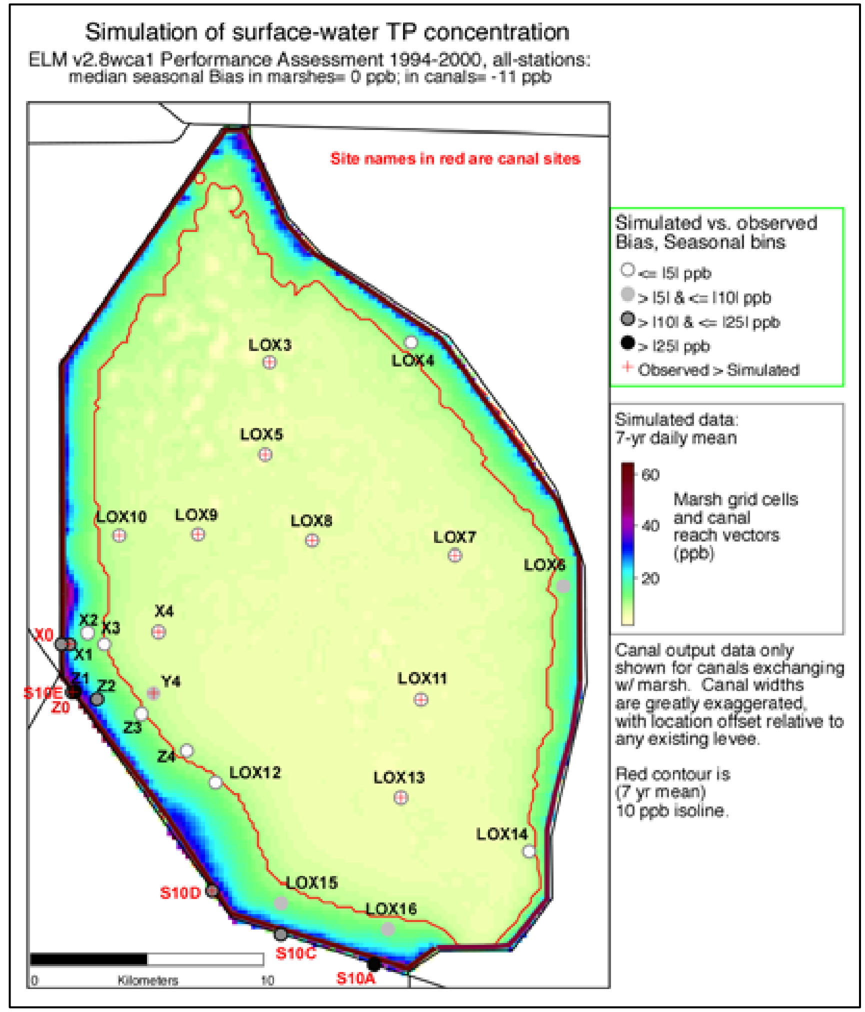
- **Integrate hydrology, biology, and nutrient cycling in spatially explicit, dynamic simulations**
- **Synthesize these interacting hydro-ecological processes at scales appropriate for regional assessments**
- **Understand and predict the relative responses of the landscape to different water and nutrient management scenarios**
- **Provide a conceptual and quantitative framework for collaborative field research and other modeling efforts**

Integrated ecological landscape models at multiple scales



Performance of ELM v2.8, 200m resolution app (being used to evaluate restoration scenarios)





Median stage bias: -6 cm in marsh

Median TP bias: 0 ppb TP in marsh

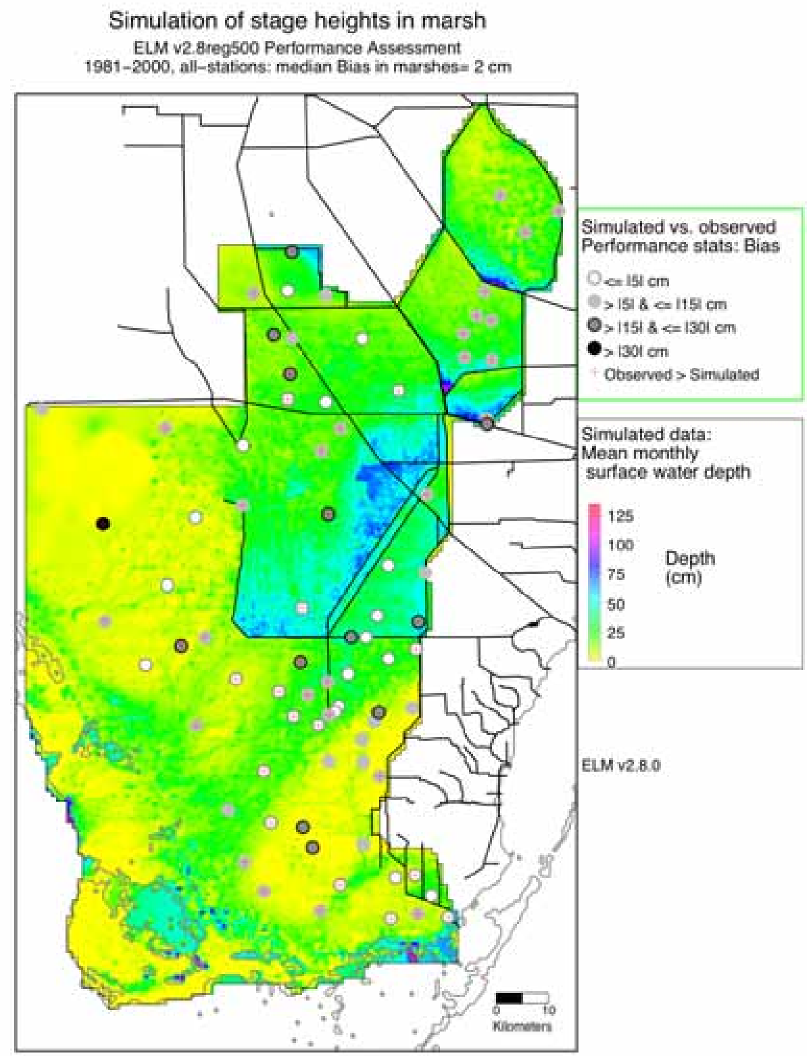
Regional ELM v2.8 application at 500 m grid resolution

<u>Stage</u>:

Median bias = 2 cm

Median NS Efficiency = 0.60

Performance of the v2.8 500m regional application exceeds that of ELM v2.5, for stage and water quality

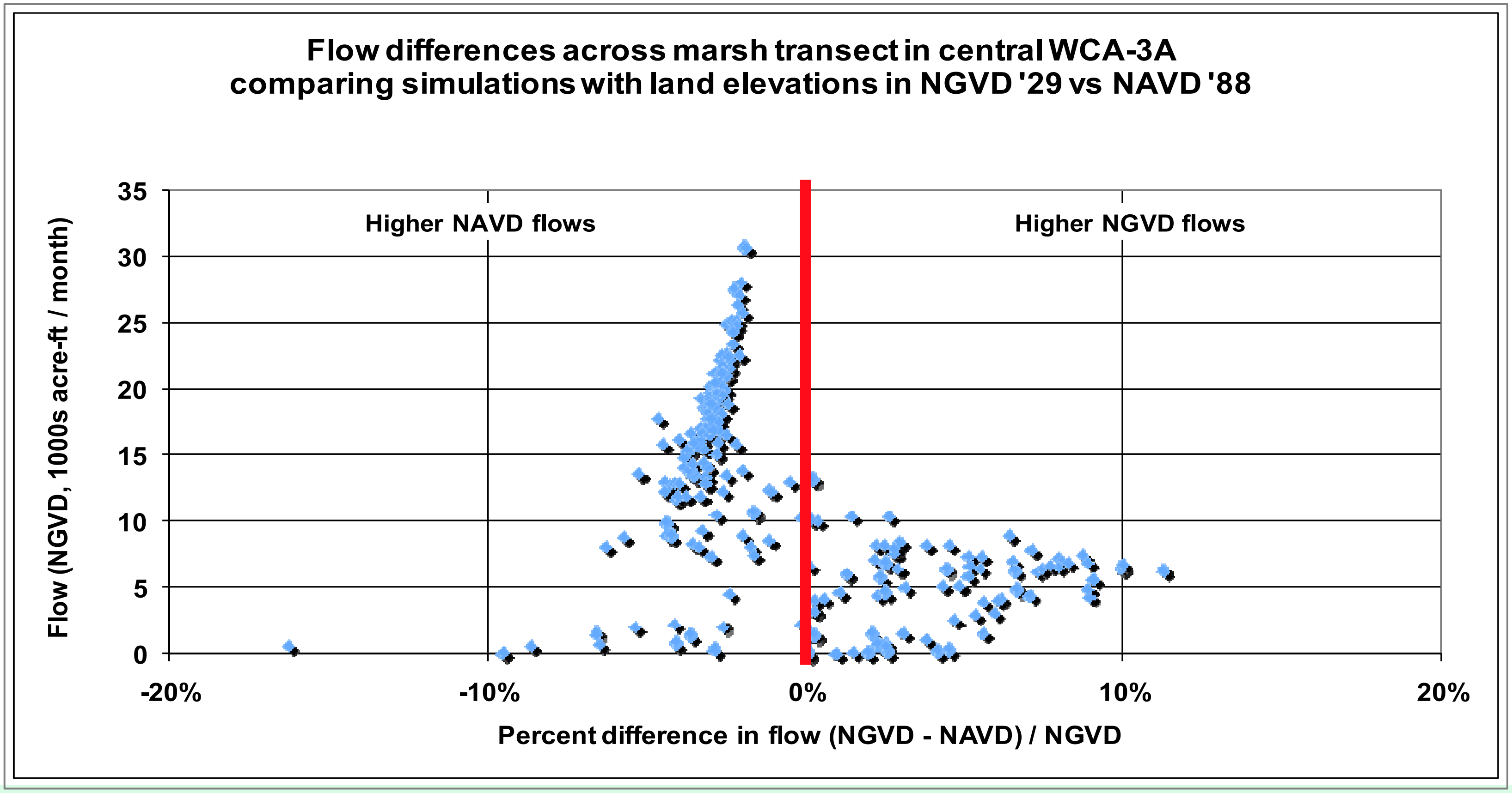


ELMreg500m
v2.8.0

ELM v2.8, 500m app

1. Comparing/integrating w/ Everglades Depth Estimation Network (EDEN)
2. Available for supporting other ecological models (e.g., ATLSS)

3. <u>Can use more accurate NAVD 1988 vertical datum:</u> little effect on stages, but flows were different from equivalent sim using older datum



Peer Reviewed…

Six-month review of ELM v2.5 (1 km) application

- **Expert Panel**
  - **W. Mitsch (chair): wetland hydro-ecology, ecological modeling**
  - **L. Band: hydrologic and ecological modeling**
  - **C. Cerco: hydrologic and water quality modeling**

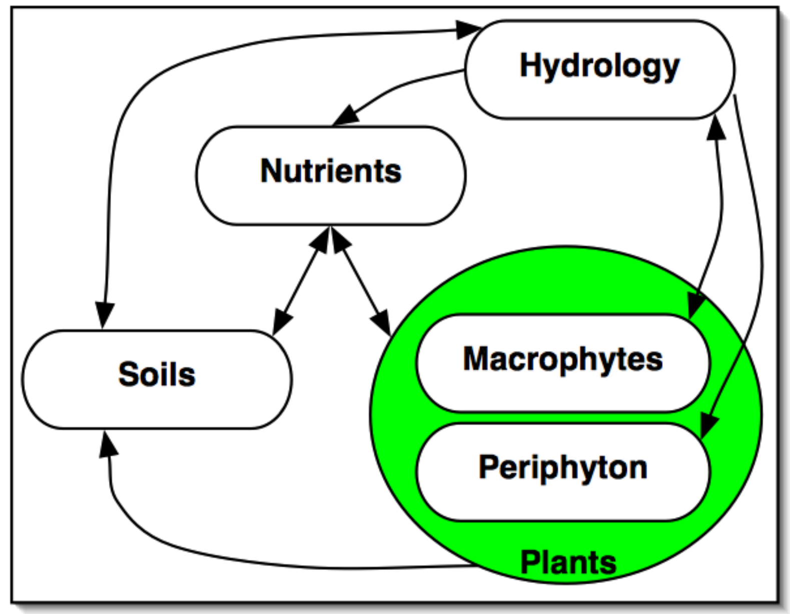
- **Panel's Report posted Jan 2007**
  - **Model is ready for application**
  - **Model is "...*robust and will produce a unique contribution, with an integrated ecosystem paradigm, to understand and predict potential outcomes of Everglades restoration projects*..."**

Open Source code and data

Extensive documentation - see web site (below)

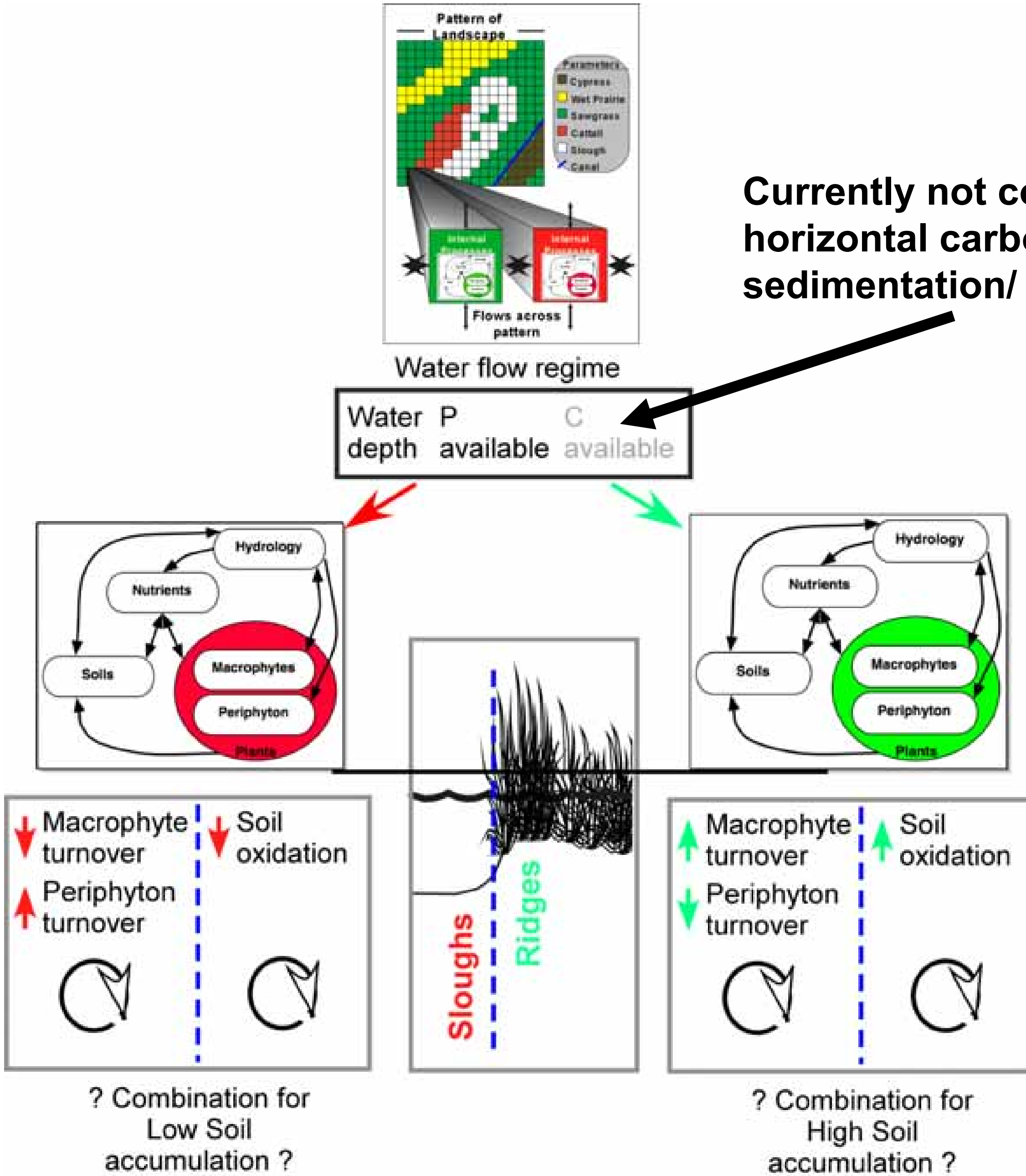
ELM Design:
Integrating ecological interactions

1. Boxes change in response to each other
2. Arrows denote <u>simple model "mechanisms" of WHY</u> things change
3. Using simple "WHYs", model is not restricted to statistical "fits" of past behavior
4. Thus, <u>apply understanding to predict relative</u> performance of future restoration scenarios



General Ecosystem Model

Currently not considering horizontal carbon transport & sedimentation/ resuspension



Presentation:

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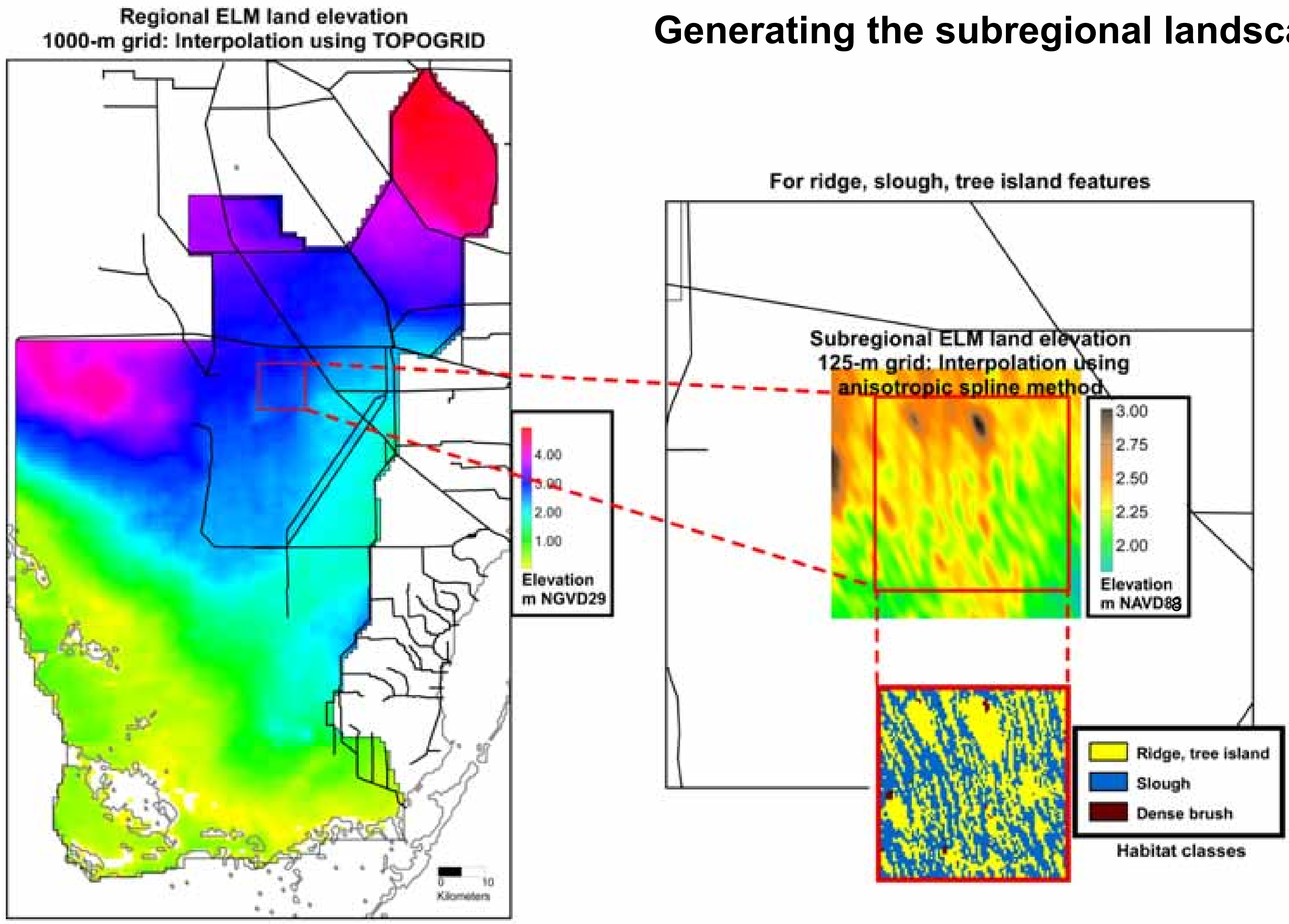
Application: Process-Pattern interactions
at century time scales

1. Apply current algorithms & parameters
2. Utilize available data on habitats, topography
   a) Central WCA-3A Ridge & Slough classified habitats (Rutchey et al.)
   b) Generate “synthetic” topography from USGS HAED survey points
3. “Nominal” conditions over 108 year simulation
4. Evaluate process - pattern interaction at century-scales
   a) An exploratory research application
   b) … to stimulate discussions and collaborations

Generating the subregional landscape…

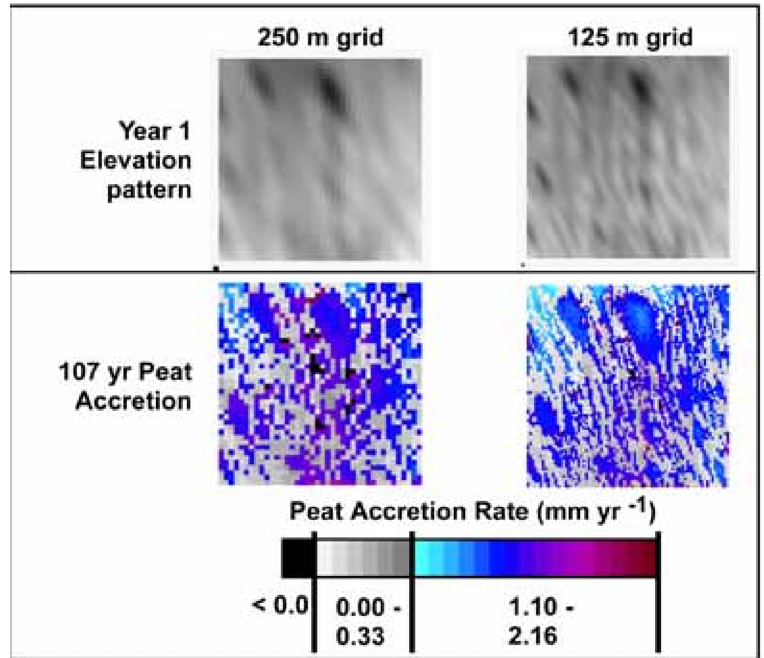


Question:
Can we simulate how the landscape pattern is maintained?

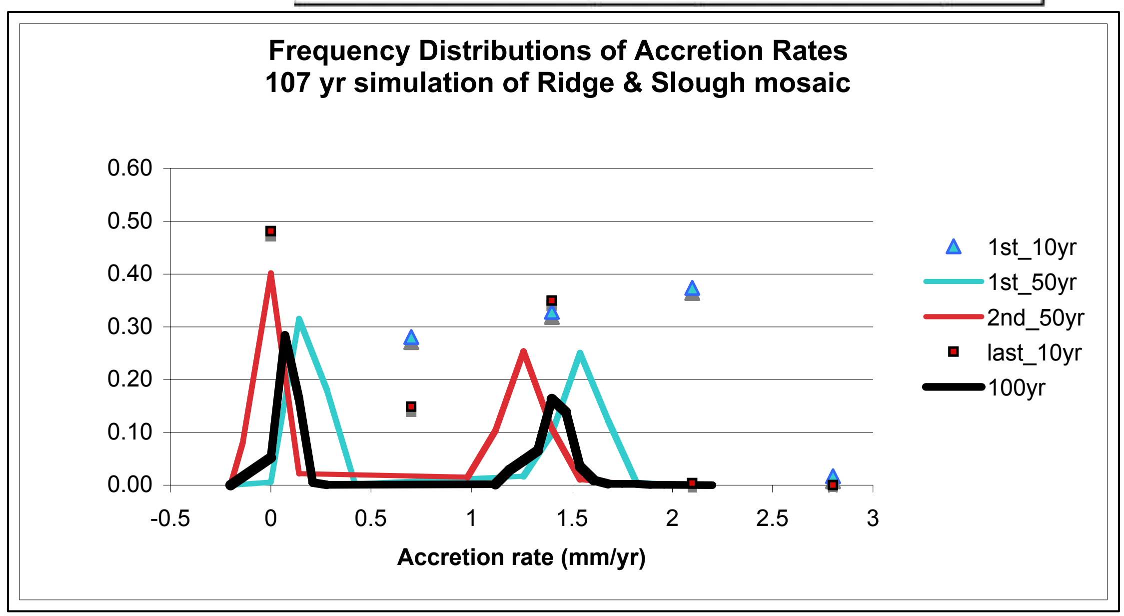
Model Experiment Results

Elevation change:

Strong differential peat accretion between sloughs and ridges/tree islands



Bimodal (ridge vs. slough) accretion rates evolved over long time scales, tending towards equilibrium under these synthetic conditions



Application: Decompartmentalization

1. CERP Project to restore sheet flow, ecology
   a) Phase I focused on Miami Canal within Water Conservation Area 3-A
   b) Backfill entire canal, plugs along canal, or some intermediate method
2. Apply ELM v2.8 at 500 m resolution (> 40x finer than SFWMM)
   a) Sensitivity of hydro-ecological patterns to different canal configs
   b) Investigate novel Performance Measure variables
3. Use Multi-Criteria Decision Analysis tools for relative comparisons
   a) 3 scenarios, multiple spatial gradients, 5 Performance Measures
   b) Organize a complex decision
   c) Stimulate stakeholder discussion

Scenarios (36 yr)

1) **Base run** = LORS07, w/ all structure flows from SFWMM v5.5 output

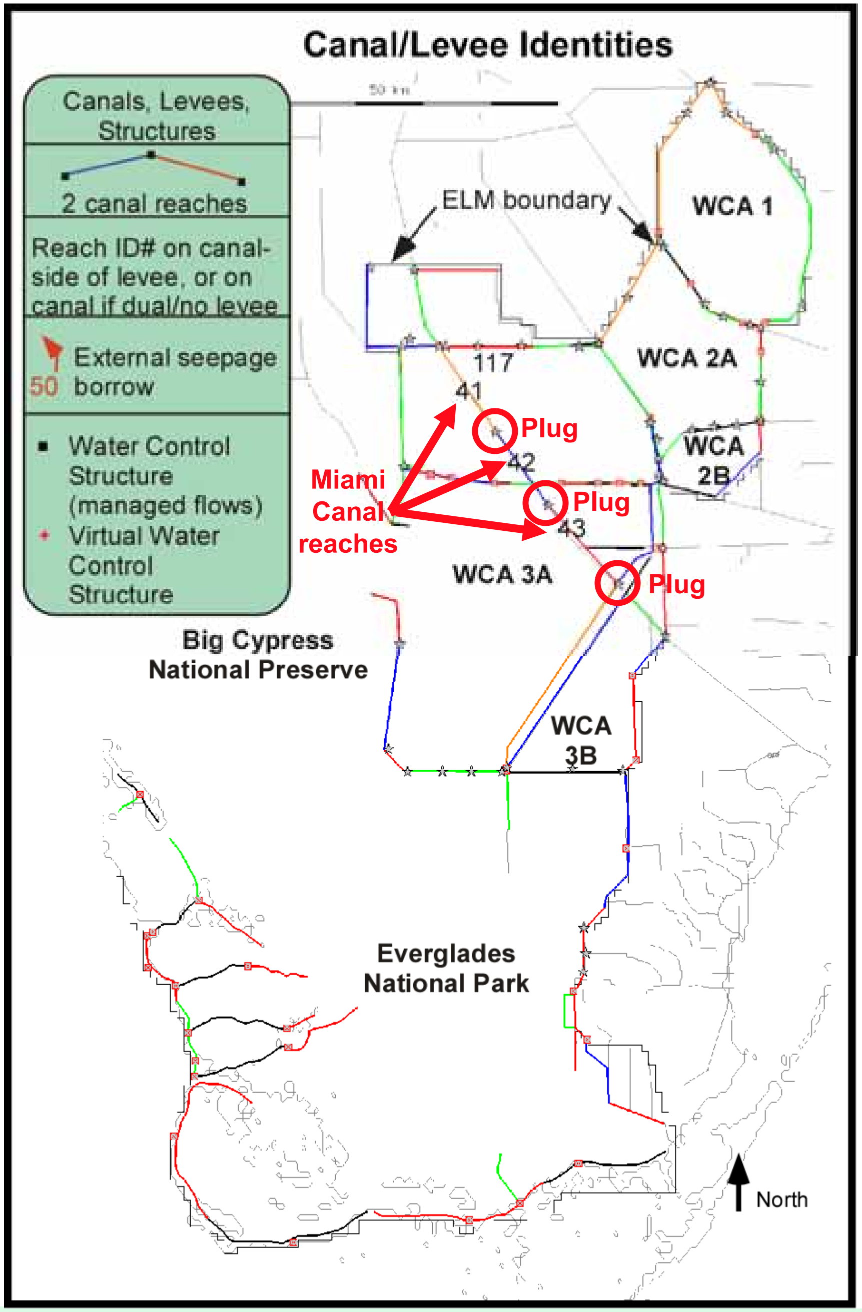
2) **Operationally remove** Miami Canal, and put 3 **plugs** at existing structure locations

3) **Backfill** entire Miami Canal within WCA-3A (reaches 41, 42, 43)

<u>For Scenarios 2) and 3):</u>

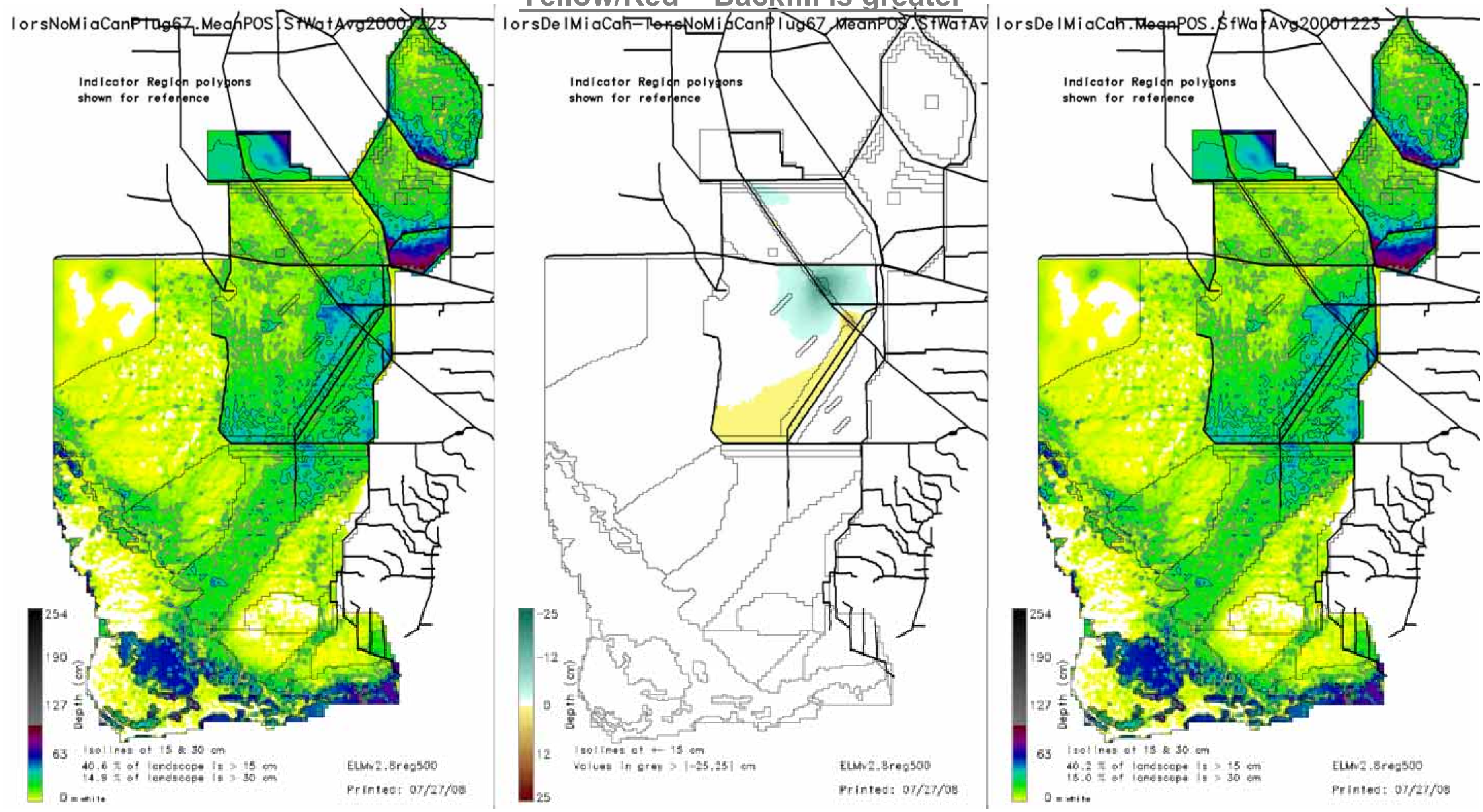
Divert Miami Canal inflows to "new" distribution canal (# 117) along northern edge

No other operational changes from Base run (i.e., not "restoration" analysis)



Scenario Comparisons: 36-yr Mean Ponded Surface Water Depths
… some redistribution within WCA-3A (< ~6”)

Yellow/Red = Backfill is greater

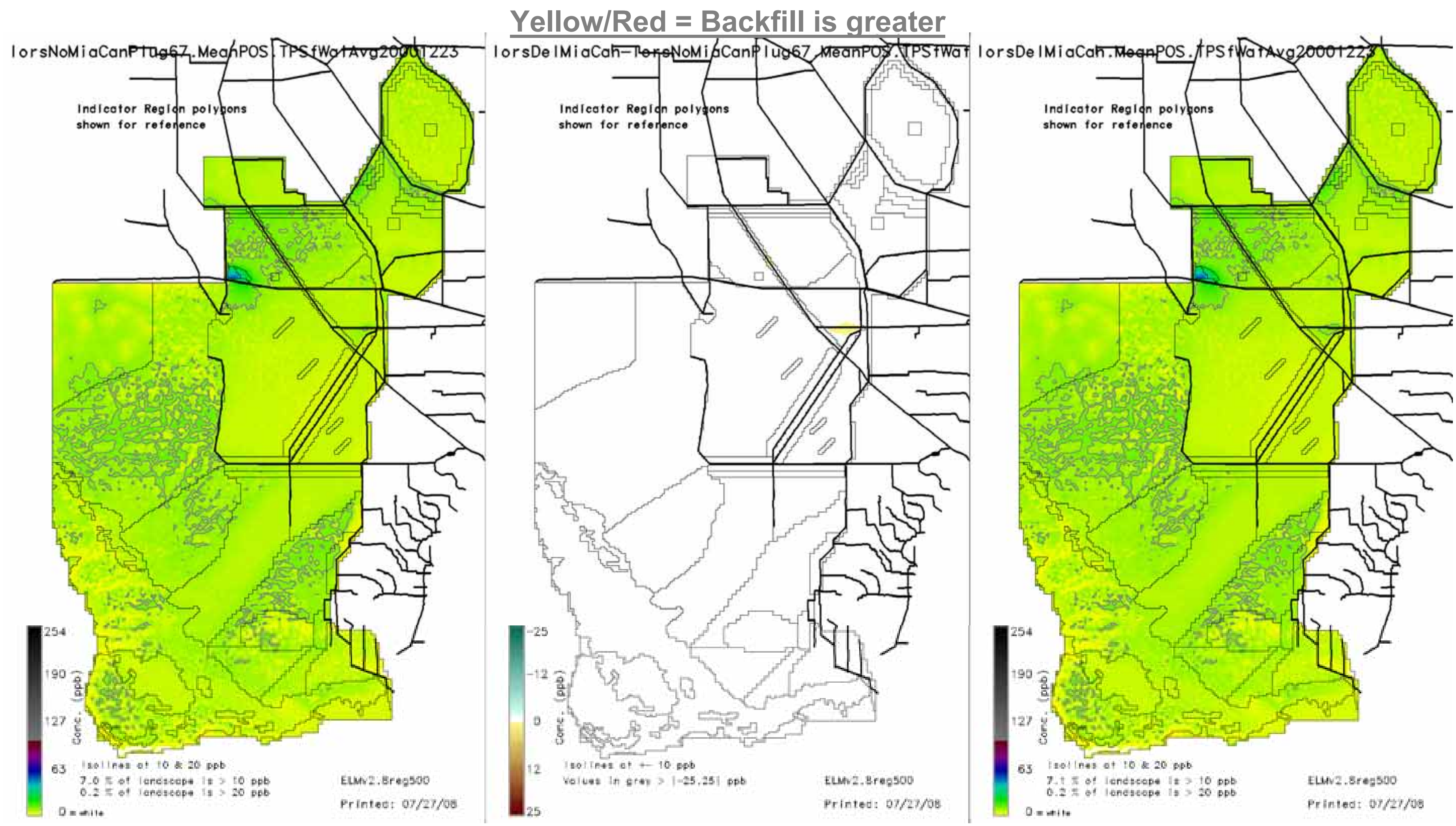


Plug Miami Canal

Backfill minus Plug

Backfill Miami Canal

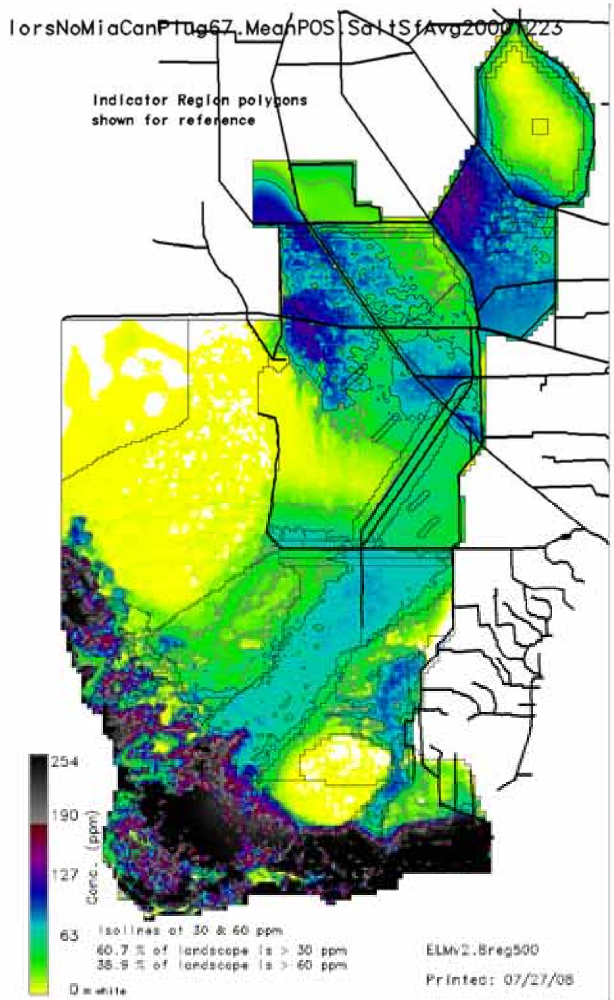
Scenario Comparisons: 36-yr Mean TP Concentrations in Surface Water
… almost no difference



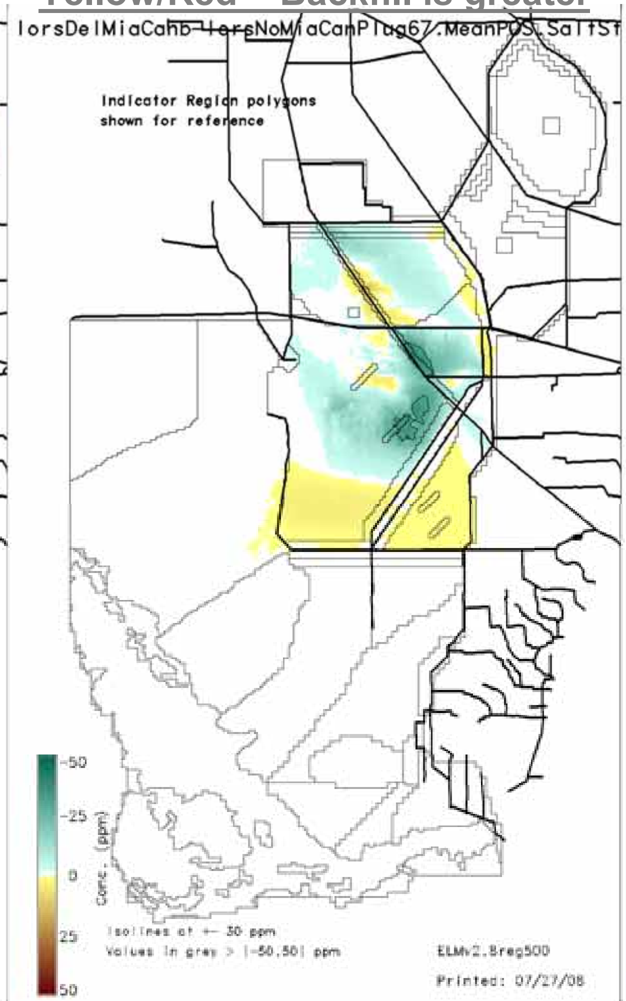
Plug Miami Canal | **Backfill minus Plug** | **Backfill Miami Canal**

Scenario Comparisons: 36-yr Mean Chloride Concentration in Surface Water
… redistributions within WCA-3A, some within 3B

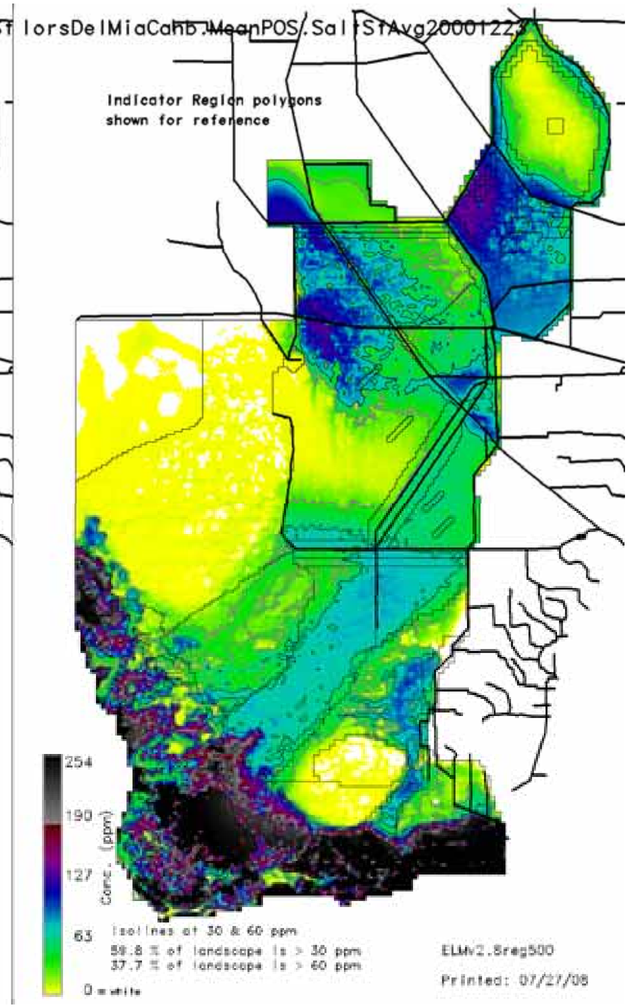
Yellow/Red = Backfill is greater



Plug Miami Canal



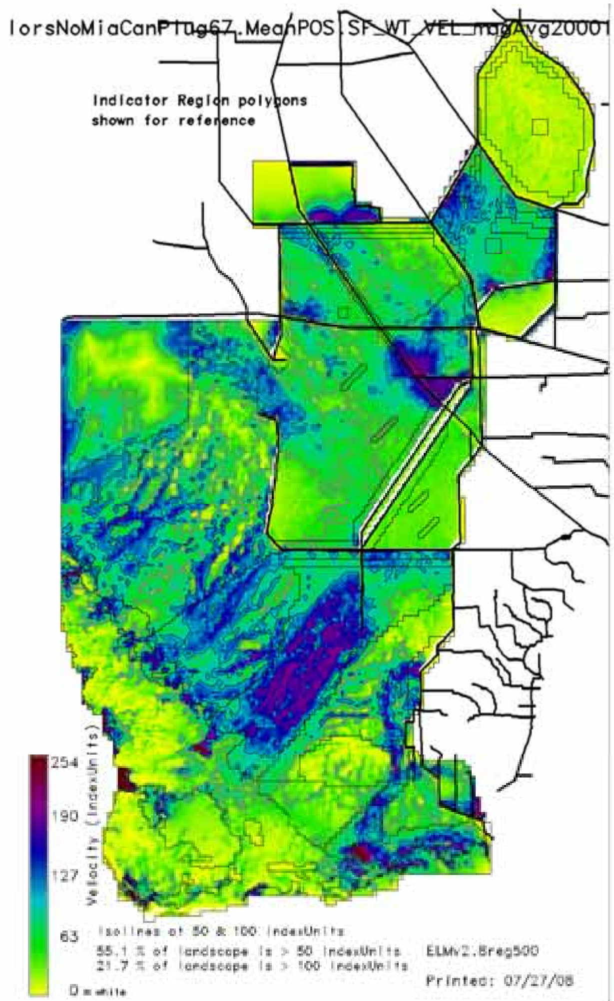
Backfill minus Plug



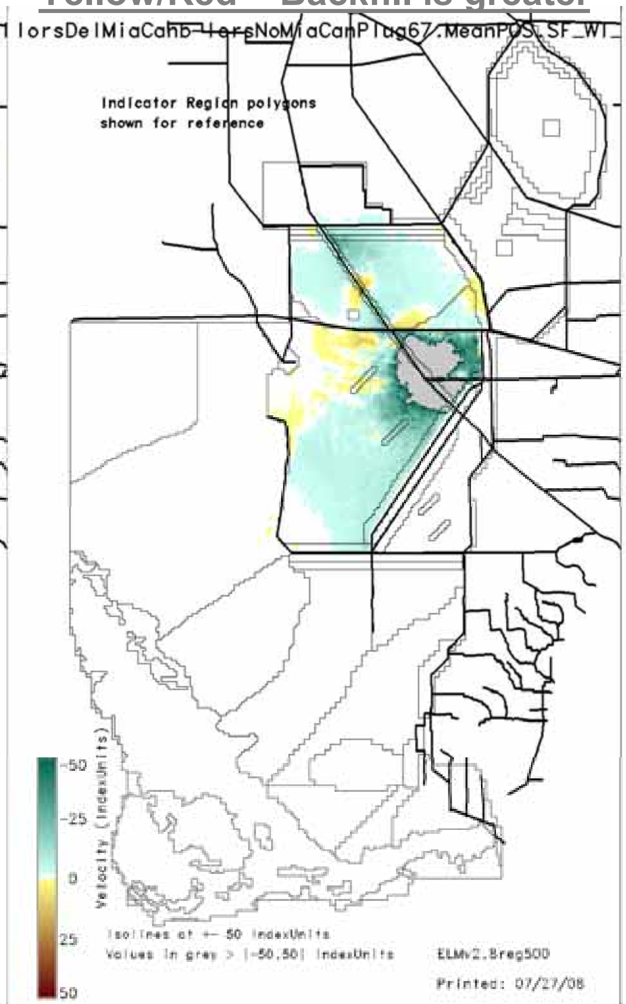
Backfill Miami Canal

Scenario Comparisons: 36-yr Mean Surface Water Flow Velocities
… substantial redistribution within WCA-3A

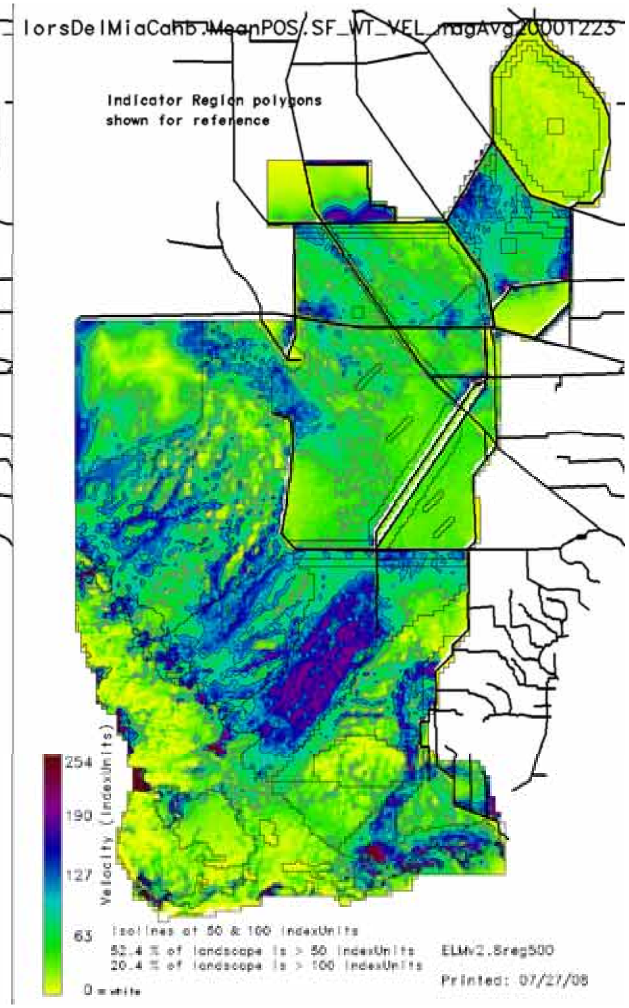
Yellow/Red = Backfill is greater



Plug Miami Canal



Backfill minus Plug



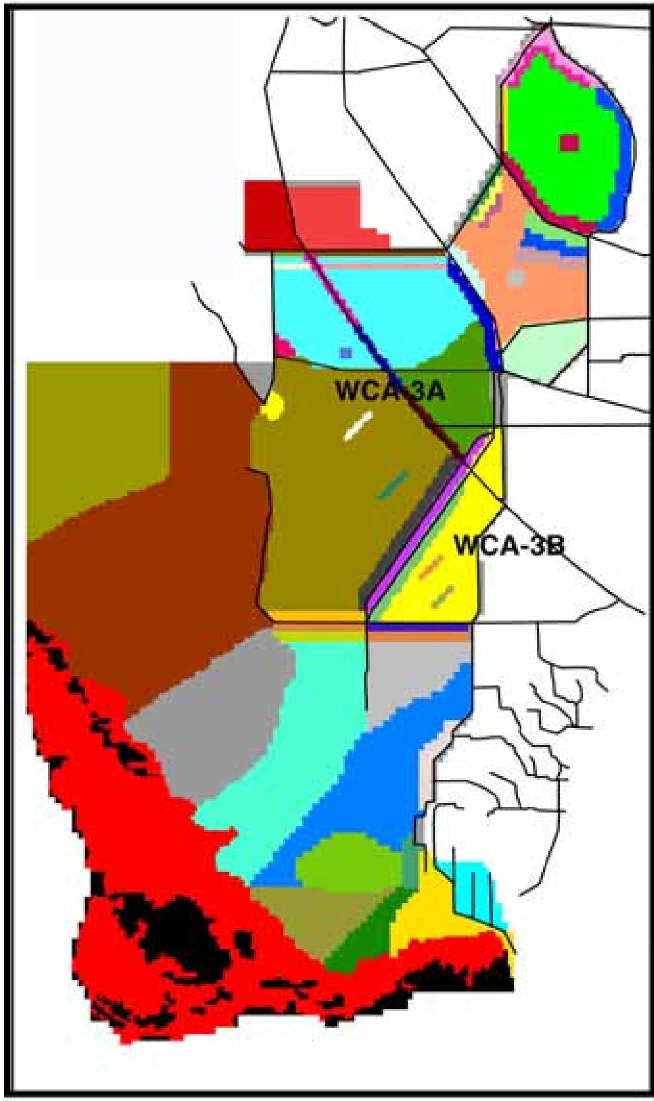
Backfill Miami Canal

Surface water velocity - LORS07 Base Run

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

ELM Basins & Indicator Regions

For evaluating Performance Measures along gradients



WCA-3A, 3B Indicator Regions

Color	ID#	Location
	15	3A - North
	16	3A - S9
	17	3A- L67
	18	3A-Tamiami
	41	3A - NEast L5_1
	42	3A - NEast L5_2
	43	3A - NEast L38
	44	3A - Alley N
	45	3A - NWest 1
	46	3A - NWest 2
	47	3A - NWest S140
	48	3A - L28I
	49	3A-N. Miami C.
	50	3A-Mid Miami C.
	51	3A-S. Miami C.
	52	3A-TransA
	53	3A-TransB
	54	3B - S349s
	55	3B-TransC
	56	3B-TransD

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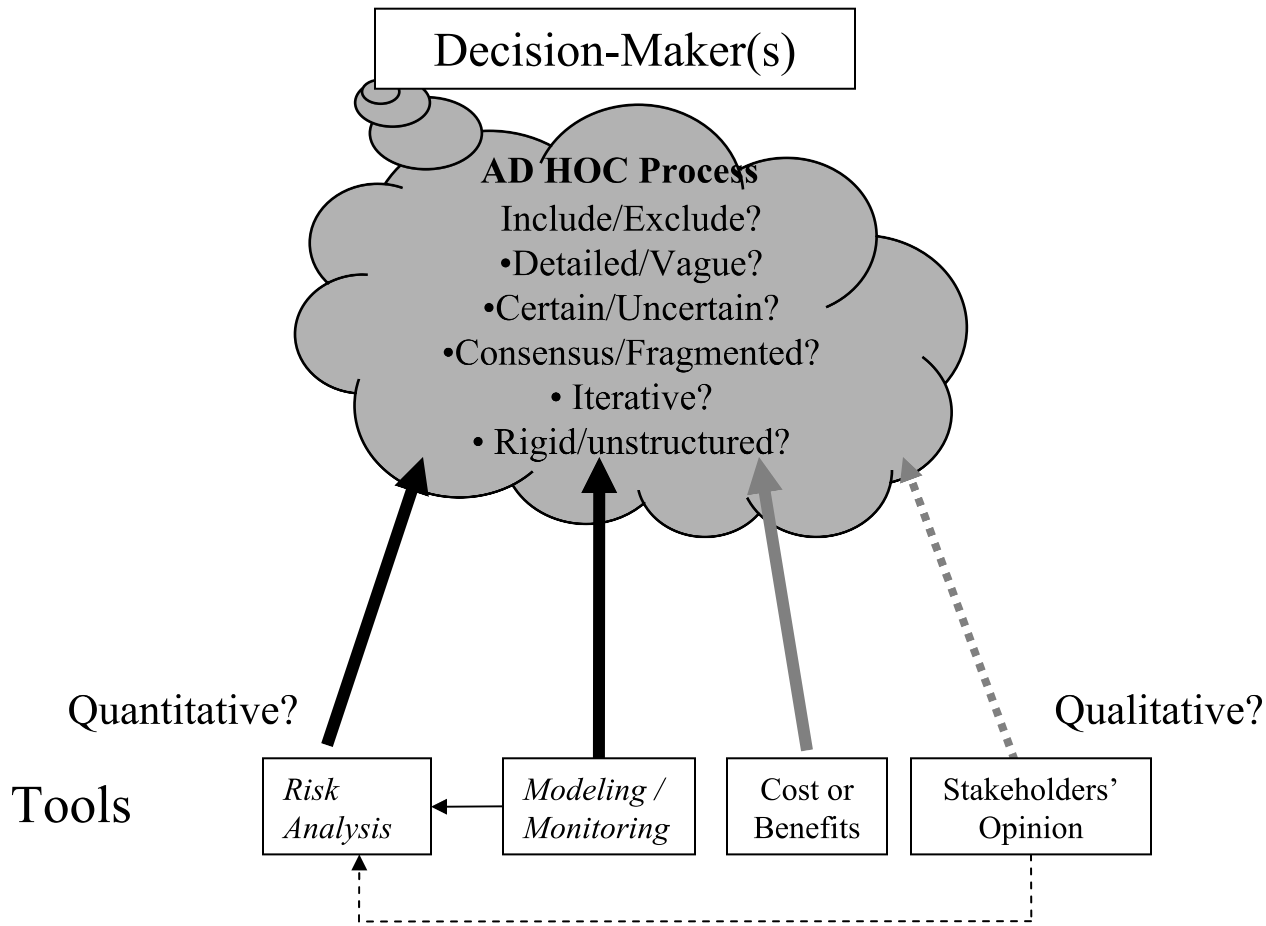
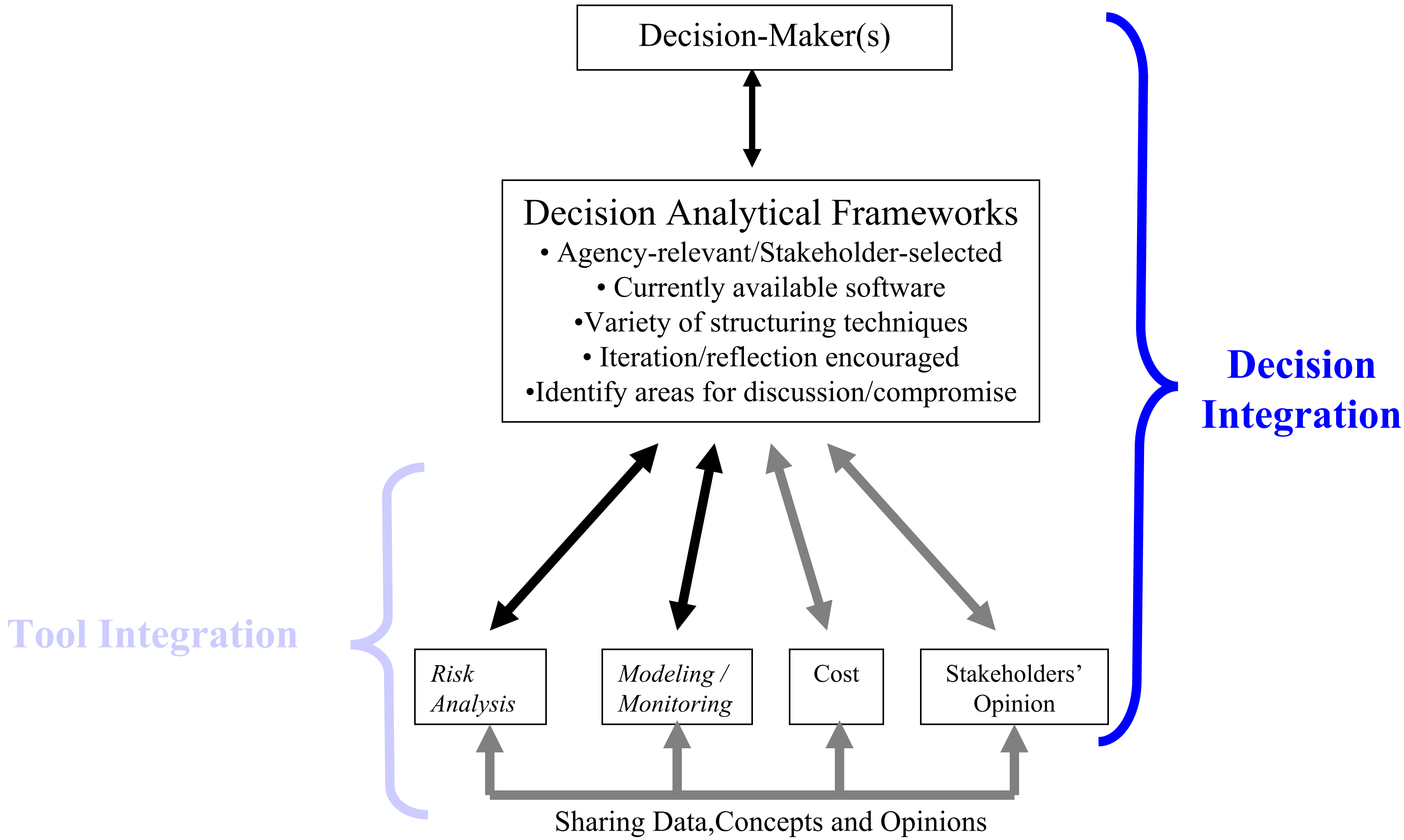
Challenges in Current Decision-Making Processes

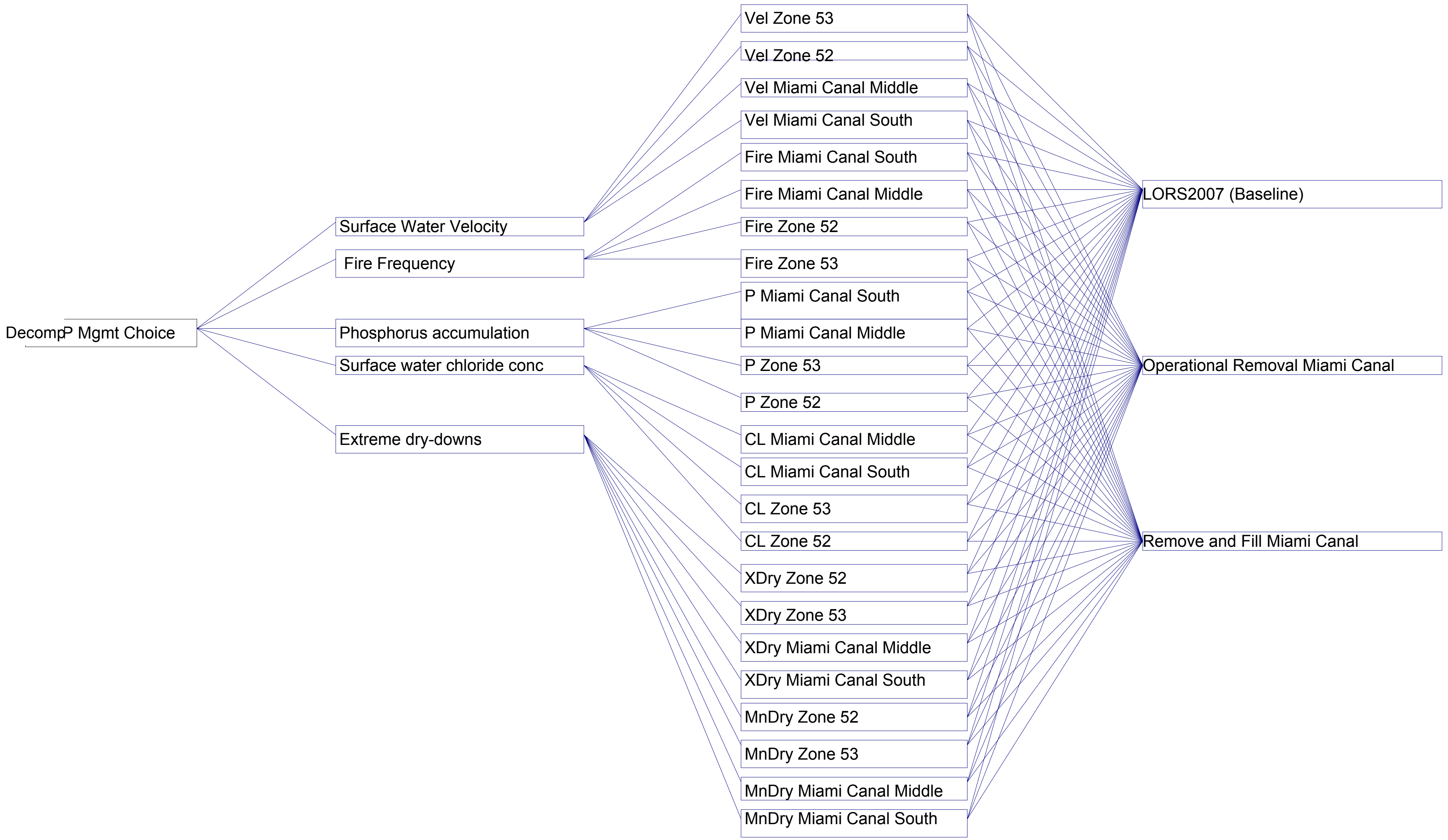


Evolving Decision-Making Processes



ELM-Decision Analysis Example

- **Alternatives**
  - Lake Okeechobee Regulation Schedule 2007 (Baseline)
  - Operationally remove the Miami Canal
  - Delete the Miami Canal from WCA-3A (Backfill)
- **ELM-Simulated Decision Criteria**
  - Surface Water Velocity - water flow velocity index (Velocity)
  - Dry Index - Mean daily duration of dry soil in upper horizon (days)
  - Mean daily surface water chloride concentration (CL, g/L)
  - Phosphorus accumulation ($mg/m^2/yr$)
  - Extreme "Dry Downs"
    - Maximum unsaturated zone depth (m)
    - Mean unsaturated zone depths that exceeded a threshold (m)
- **Four Spatial Zones: WC3A-Flow Transects 53 and 52, Miami Canal (Middle), Miami Canal (South)**

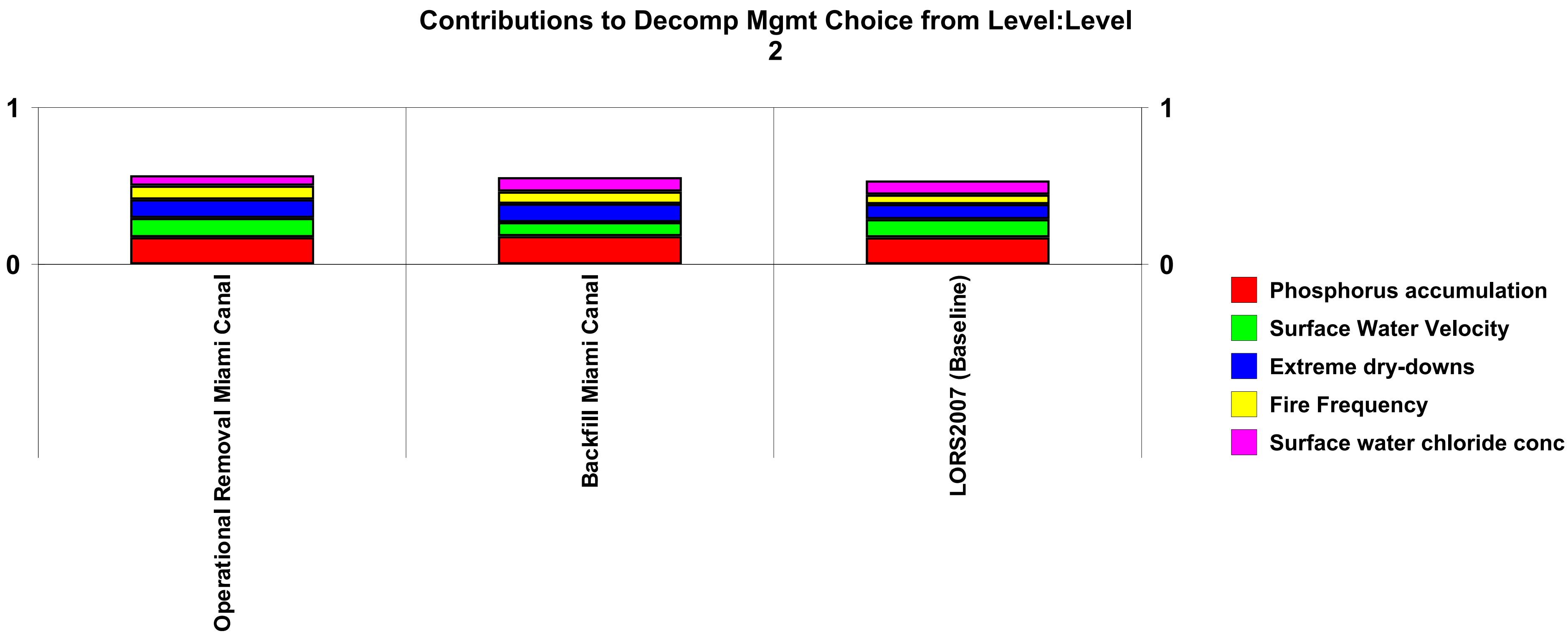


Hierarchy Rating Technique: **Weights**

Alternatives Rating Technique: SMART with linear value functions

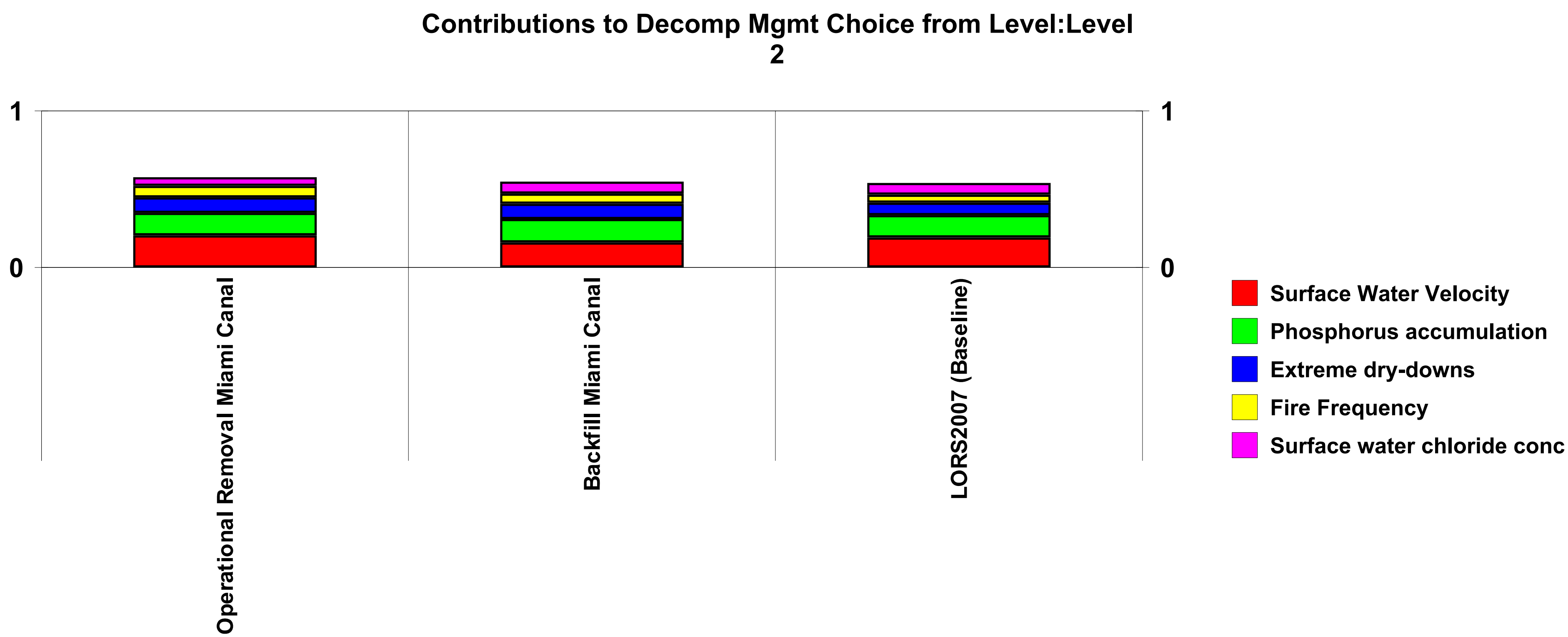
Example Decision Analysis Results

Equal weights for objectives, equal weights for zones, linear value functions



Example Decision Analysis Results

Surface Water and Marsh Area emphasis on weights, linear value functions



Discussion

- Modeling experiment to integrate different sets of ecosystem data:
  - Our “decision” was quite sensitive to criteria weighting and spatial zone choice.
  - ELM can provide useful information into structured decision analysis.
  - Cost was no object! (Proof of concept)
- Next steps: evaluate altered managed flows under different canal configurations