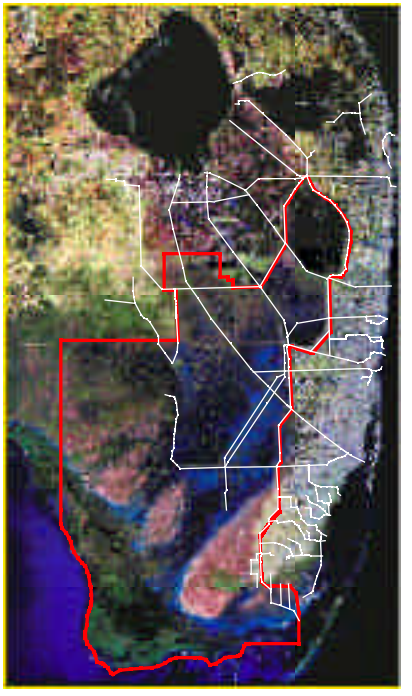
Status of the Everglades Landscape Model

Everglades Landscape Model

ELM

April 24, 2002



http://www.sfwmd.gov/org/wrp/elm

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Basin Feasibility Study
ELM Presentation Goals

Inform: Just what is this ELM thing?

- **Part I: Overview of Model Development & Performance**
- **Part II: Details of Model Calibration using ELM web site**

- **Questions and Discussion "As-We-Go"**

Everglades Landscape Model (ELM) Objectives

Integrate hydrology, biology and nutrient cycling in spatially explicit simulation

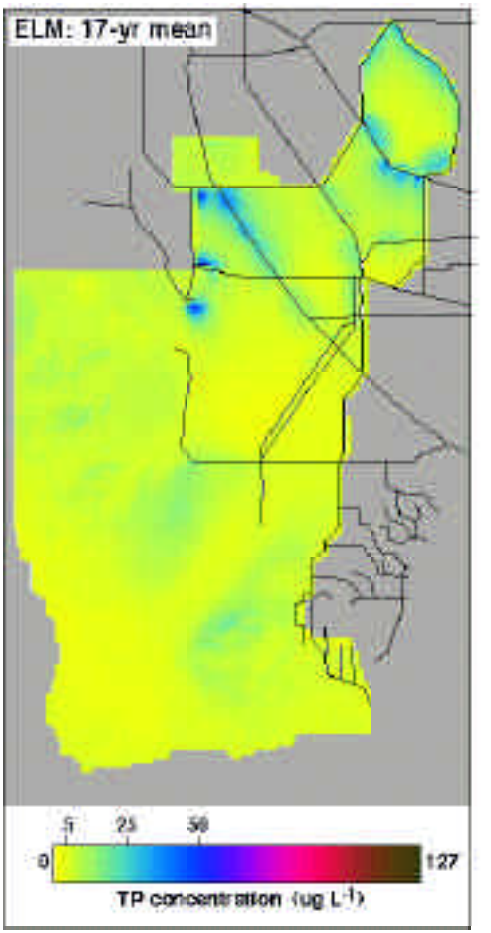
- **Understand ecosystem dynamics at regional scale**
- **Develop predictions of landscape response to altered water & nutrient management**
- **One tool to aid in Everglades restoration**

Part I: Model Development and Performance

- ELM overview
- Initial calibration (ELM v1.0)
  - Well-studied northern Everglades wetland (WCA-2A)
  - Small scale, integrated- ecosystem calibration
- Code revisions (ELM v2.1)
- Evaluation, application to full Everglades region (ELM v2.1)
  - Hydrologic calibration
  - Surface water quality calibration

Performance measures (web-enabled)

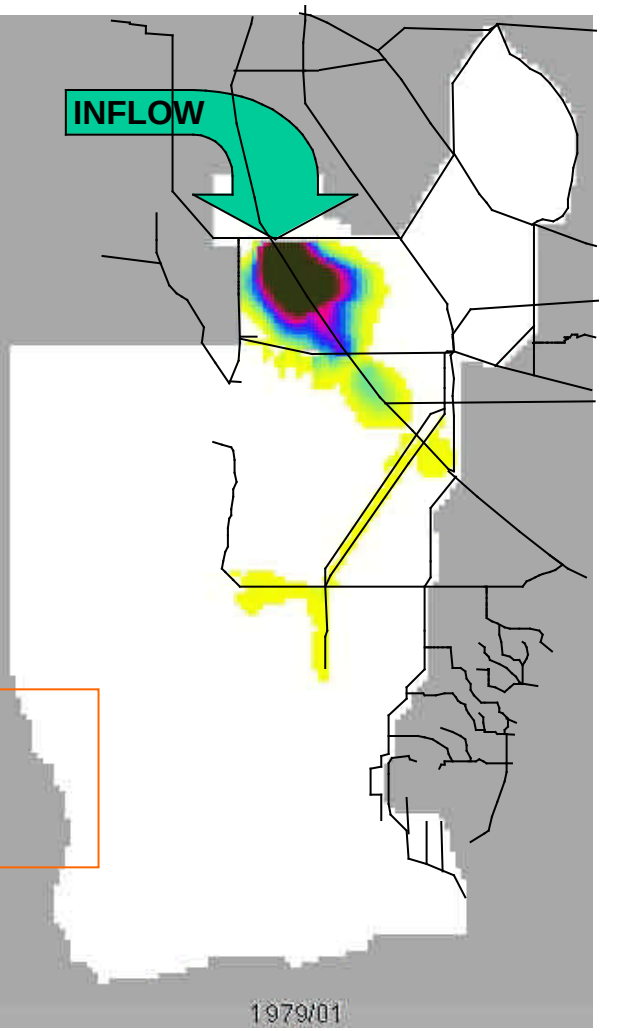
- **Regional maps**
  - § **Multi- year summaries: TP, periphyton, vegetation, ...**
  - § **Animations (annual or monthly)**
  - § **Difference maps**



http://www.sfwmd.gov/org/wrp/elm

Example: tracer flow in surface water

- Track inflows from S-8
- Monthly mean concentrations
- Distribution via overland and canal flows

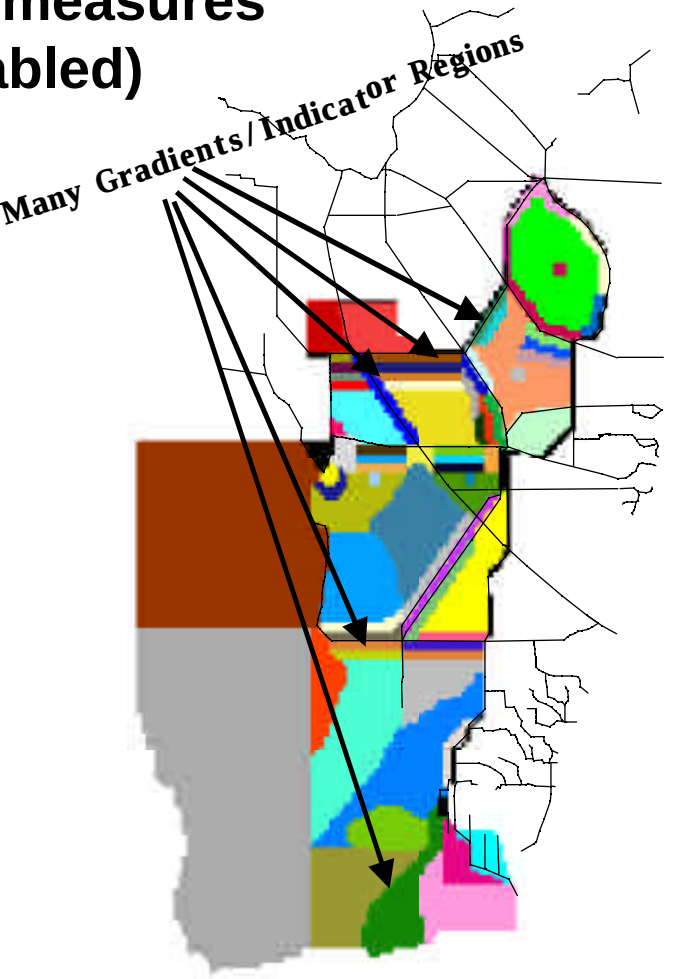


For this animation, go to:
http://www.sfwmd.gov/org/wrp/elm/results/cal_ver/elm2.1/maps/tracer/tracer_maps.htm

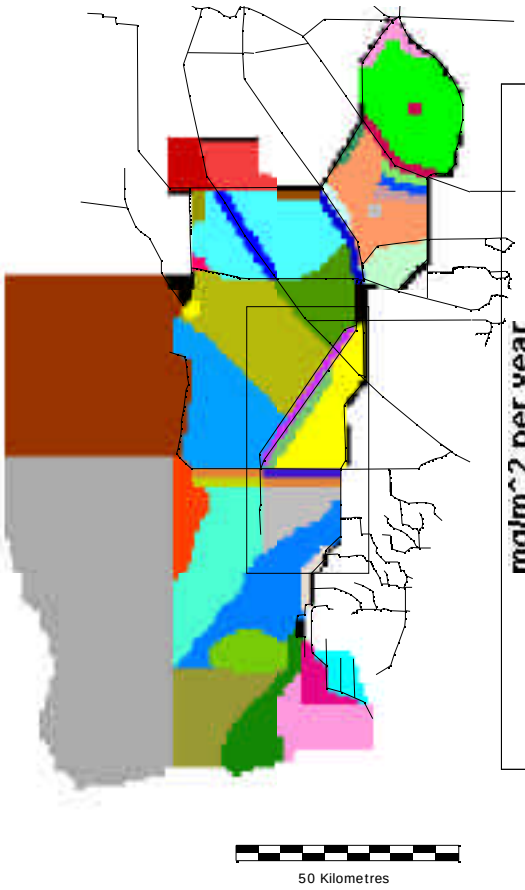
Performance measures (web-enabled)

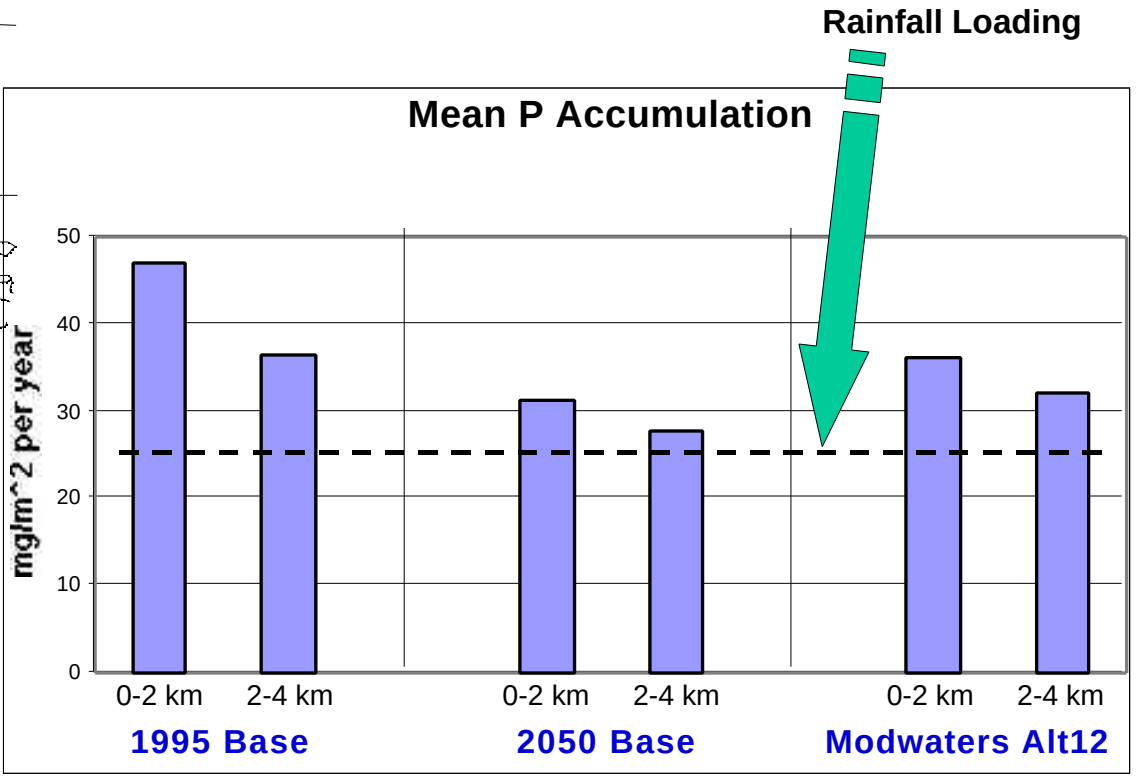
Subregional summaries

- *Water quality*
  - TP concentration & load
  - LOK water tracer
- *Soils*
  - peat accretion
  - TP concentration
- *Periphyton*
  - biomass & community type
  - tissue TP concentration
- *Macrophytes*
  - biomass & community type
  - tissue TP concentration

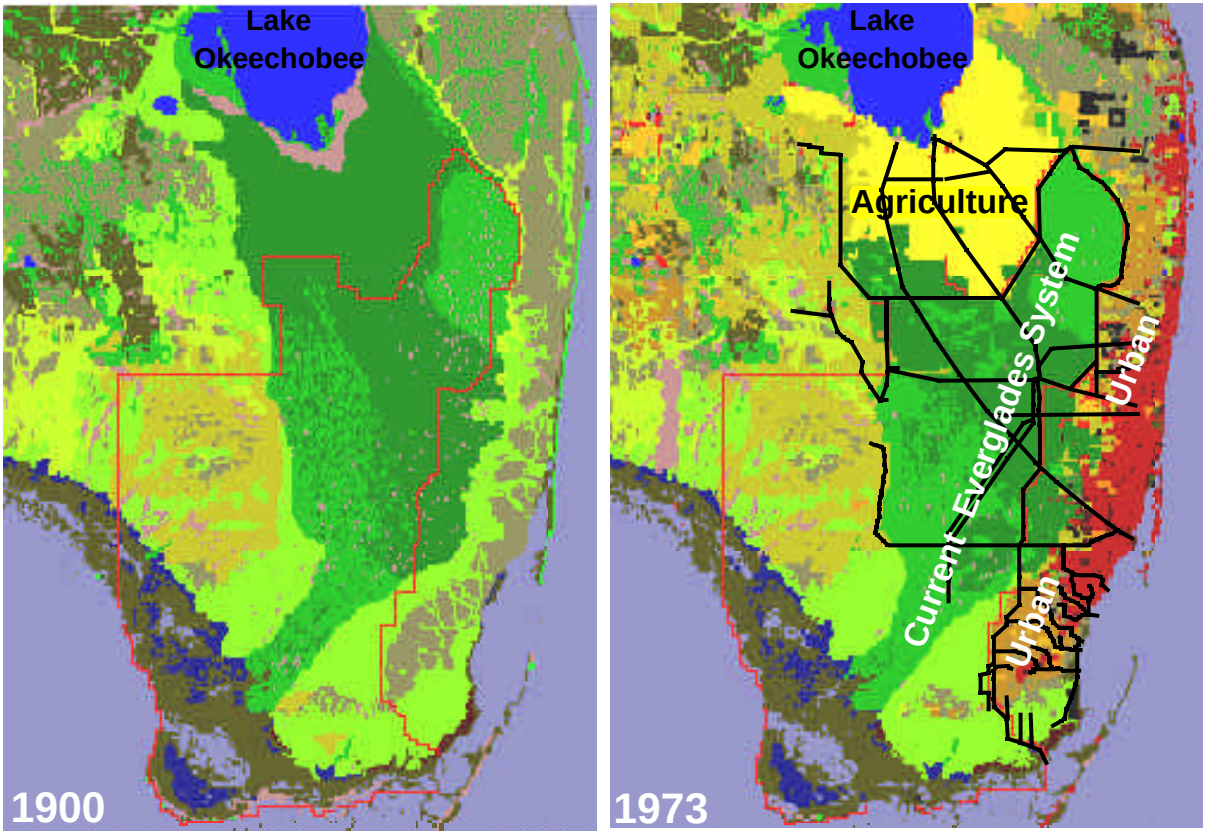


Example: P Accumulation in upper NESS



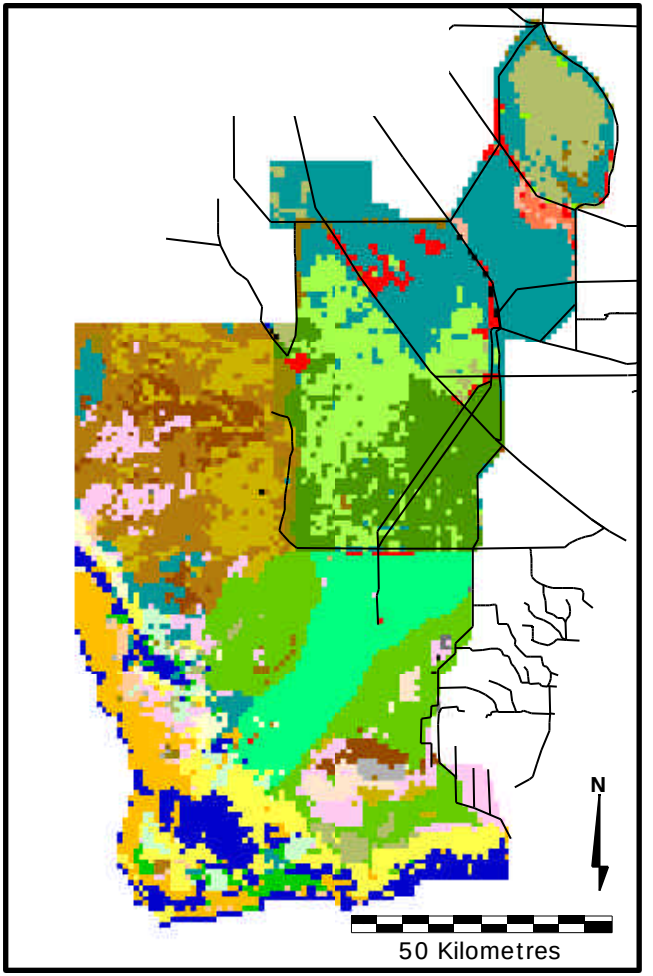


Land use change:
South Florida



http://www.sfwmd.gov/org/wrp/elm

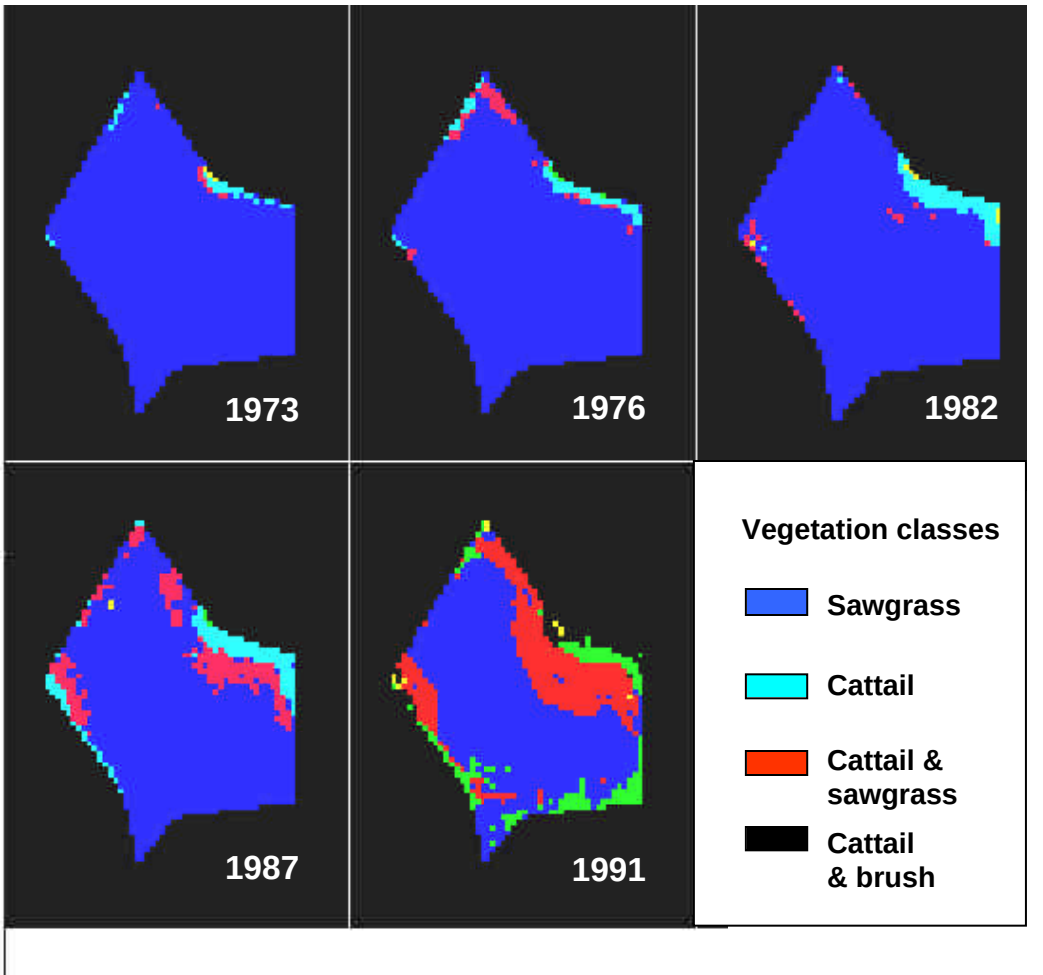
ELM vegetation classes, ca. 1995



Habitat Code	Area (km^2)	Description
1	556	Open Water
2	1705	Sawgrass plain
3	802	Sawgrass ridge
4	834	Sawgrass slough deep
5	848	Sawgrass slough shallow
6	982	Sawgrass marl prairie
7	518	Gramminoid mix
8	475	Wet prairie
9	9	Slough w/ gramminoids
10	26	Slough w/ non-gramminoids
11	157	Cattail (high density)
12	43	Cattail (med density)
13	35	Cattail (low density)
14	90	Muhly grass
15	58	Salt marsh
16	25	Hardwood-mixed
17	861	Swamp forest
18	477	Mangrove forest
19	99	Buttonwood forest
20	290	Pineland savannah
21	594	Cypress savanna
22	89	Brush
23	95	Hardwood Scrub
24	59	Cypress scrub
25	489	Mangrove Scrub
26	121	ButtonWood Scrub
27	35	Brazilian Pepper
28	9	Melaleuca
29	13	Human Influence

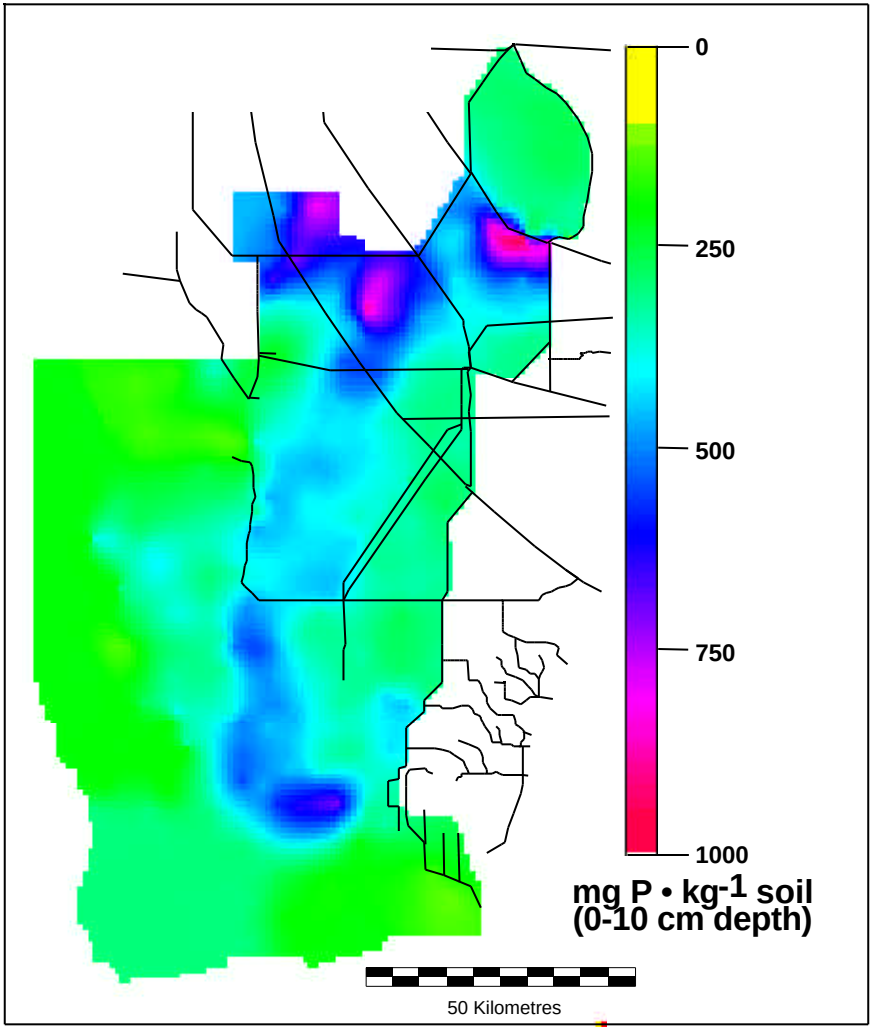
http://www.sfwmd.gov/org/wrp/elm

Cattail invasion:
Water Conservation Area 2A



http://www.sfwmd.gov/org/wrp/elm

Soil Total Phosphorus (ca.1995)



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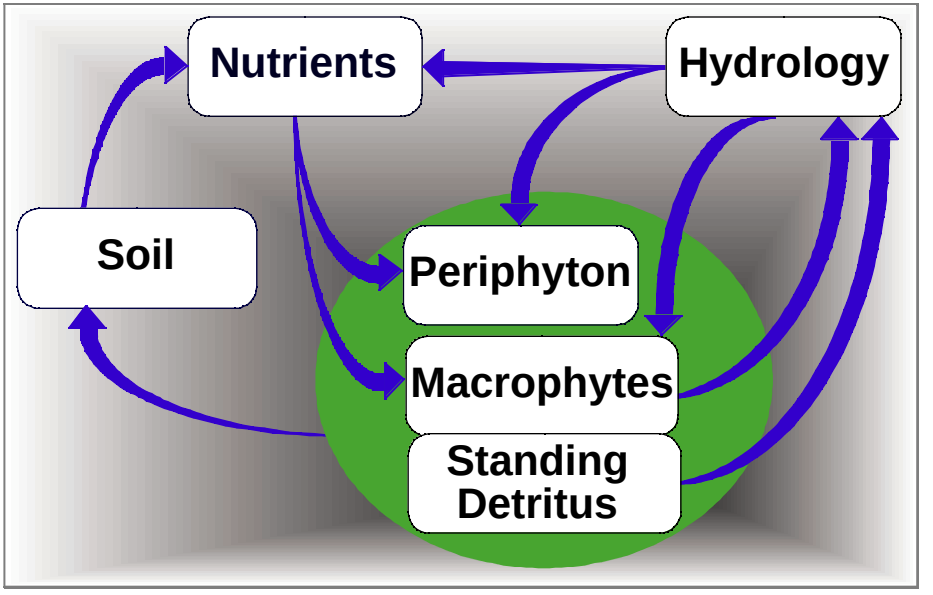
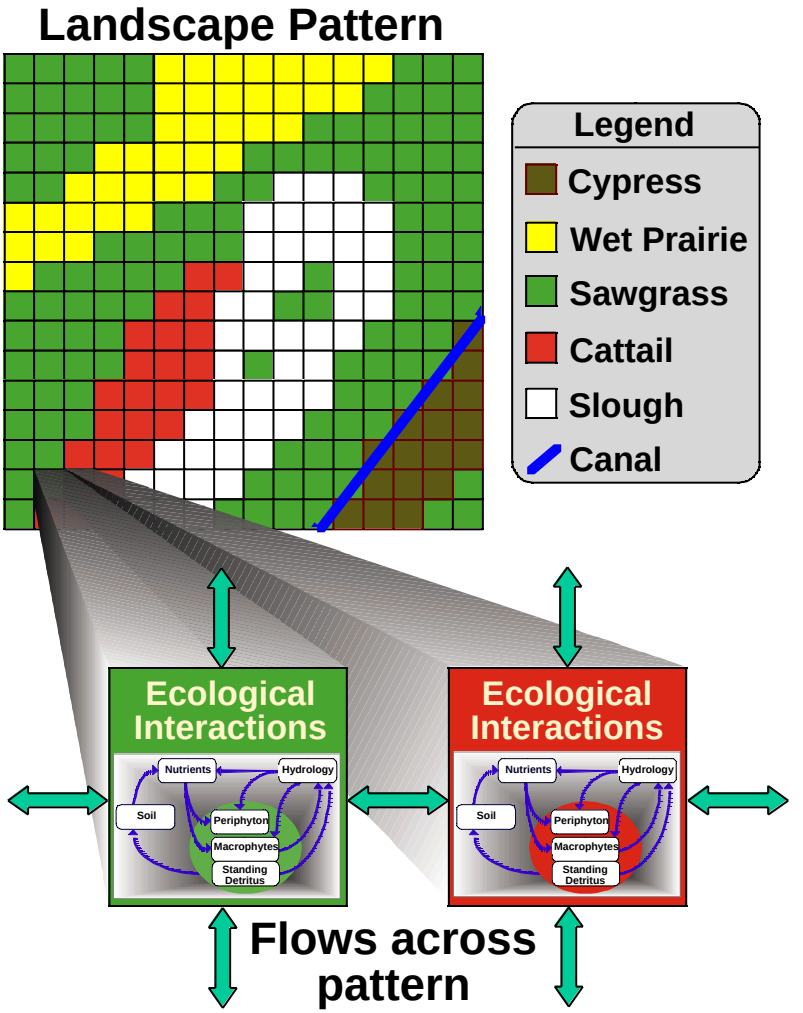
Ecological interactions



SFWMM (&ELM) hydrology

+ ELM water quality + ELM ecology

Spatial interactions



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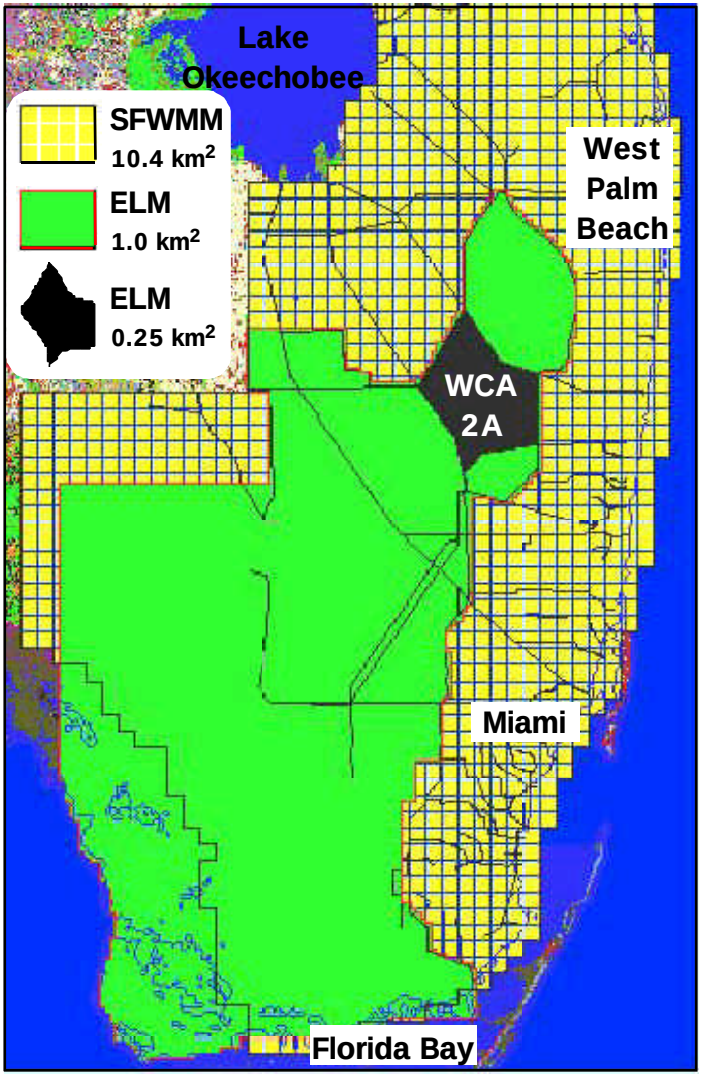
Model domains



http://www.sfwmd.gov/org/wrp/elm

Model Structure

Integrated spatial and non-spatial modules of hydrology, biology and nutrient cycling

- **Flows:**
  - **Spatial: similar in general algorithmic structure to SFWMM**
  - **Incorporate explicit feedbacks and altered canal network/scales**
- **Ecology**
  - **13 physical, chemical, biological modules; selectable at runtime**
- **Utilities**
  - **Water, phosphorus budgets**
  - **Summary stats**

Hydrologic data

- **Data shared with SFWMM**
  - **Elevation: filtered from 10 to 1 km^2 resolution**
  - **Hydraulic conductivity: filtered to 1 km,**
  - **Rainfall: direct application of 2x2 mi daily data**
  - **Other meteorological: dynamic interpolation of cloud, dew pt, etc**
- **Canal/levee vectors managed in GIS using precise coordinates**
- **Water control structure attributes managed in relational database**

Hydrologic modules

- **Vertical solutions (1 day time step)**
  - **ET from evap model, solar rad model, daily data on temp, dewPt, cloud, wind; variable LAI**
  - **Rainfall directly from daily spatial time series from SFWMM**
  - **3 layers: infiltration, percolation, upflow**

Hydrologic modules (con't)

- **Horizontal solutions (explicit, 2 hr. step)**
  - **Overland: finite difference, Manning's equation, ADE**
  - **Groundwater: finite difference, simple Darcy's, ADE**
  - **Surface-groundwater interaction: every time step, solve for available storages**

Hydrologic modules (more)

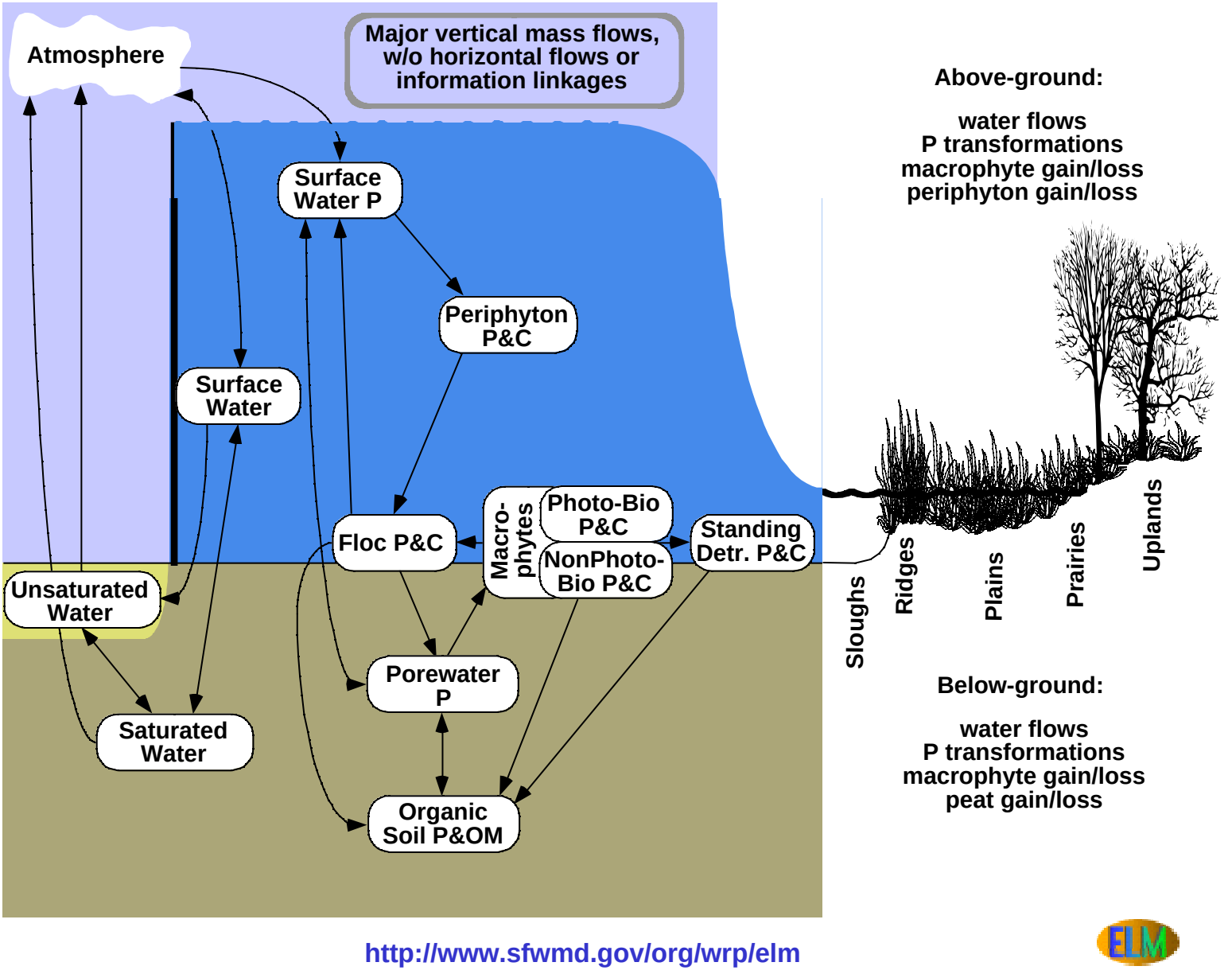
- **Water management network (2 hr step)**
  - **Canal reaches: mass balance, iterative solution as in SFWMM**
  - **Water control structs: daily flows for all structures, from observations or SFWMM**

Hydrologic modules (con't)

- **Mass balance and budget**
  - **Basin & domain-wide budgets & error-checks**
- **Post-processing**
  - **Consistency checks with SFWMM (maps and budgets, stage hydrographs)**

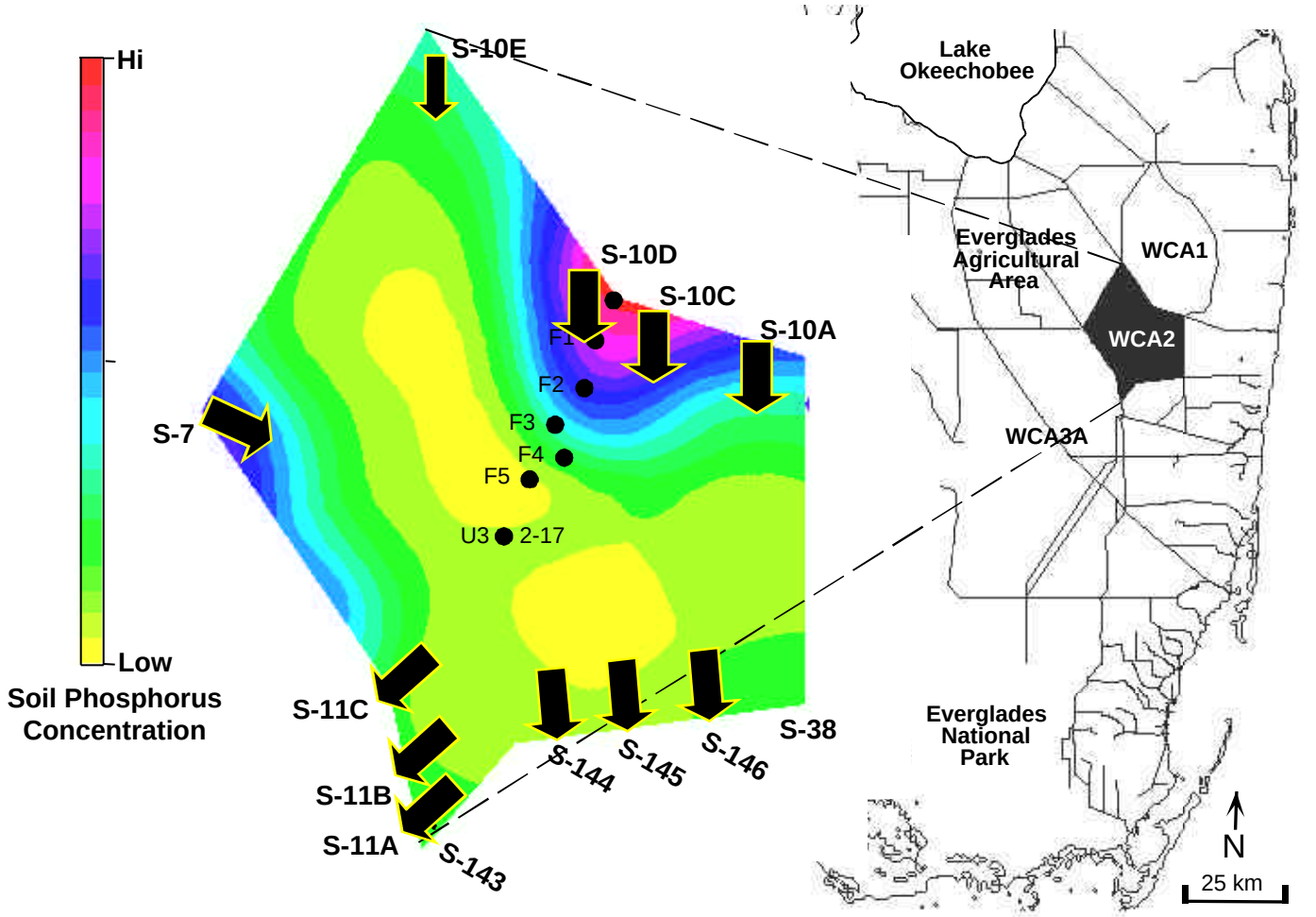
Phosphorus modules

- Overland, groundwater, and canal transport flows
- Choice 1: Strict net settling rate module (poor performance, unused)
- Choice 2: Ecological dynamics
  - P uptake, mineralization, particulate settling
  - Periphyton, macrophytes, soil dynamics
  - Surface water - soil interactions


Major vertical mass flows, w/o horizontal flows or information linkages
Atmosphere
Surface Water P
Periphyton P&C
Surface Water
Floc P&C
Macro-phytes
Photo-Bio P&C
NonPhoto-Bio P&C
Standing Detr. P&C
Unsaturated Water
Porewater P
Saturated Water
Organic Soil P&OM
Above-ground:
water flows
P transformations
macrophyte gain/loss
periphyton gain/loss
Sloughs
Ridges
Plains
Prairies
Uplands
Below-ground:
water flows
P transformations
macrophyte gain/loss
peat gain/loss

Start out “small”...

Water Conservation Area 2A



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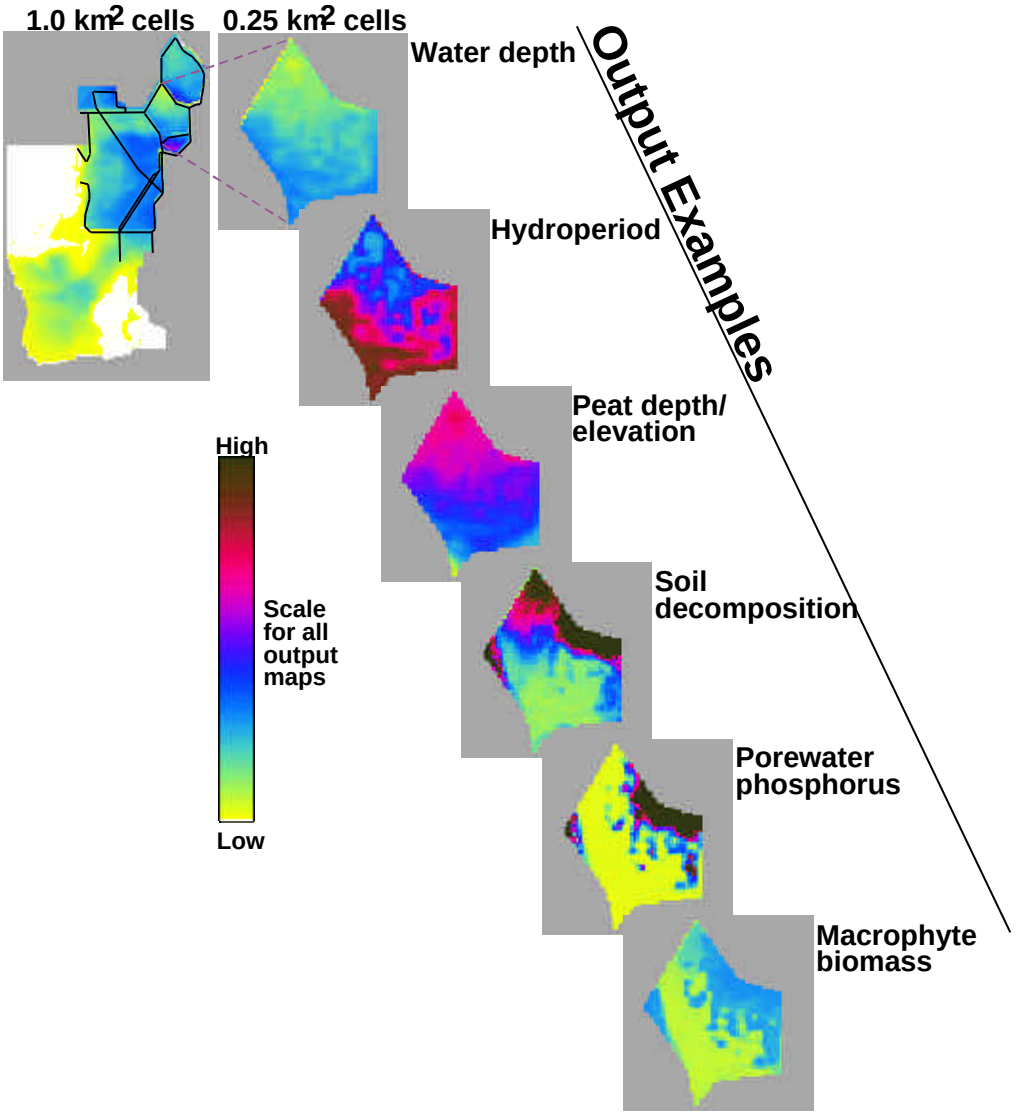

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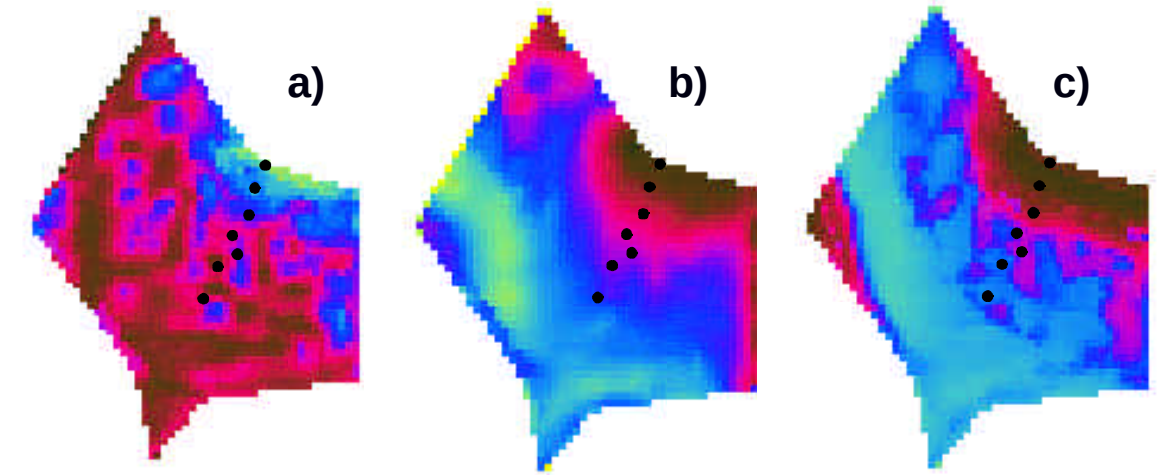
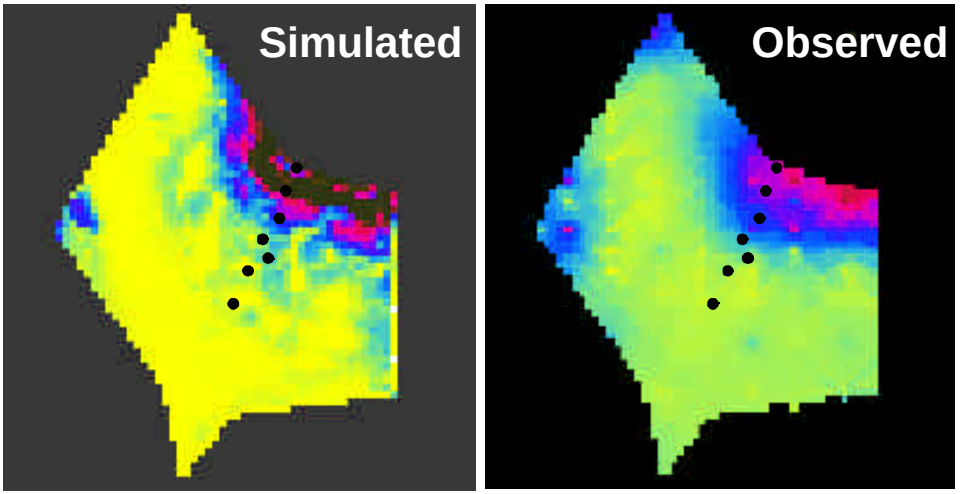
Periphyton, phosphorus, and macrophyte patterns



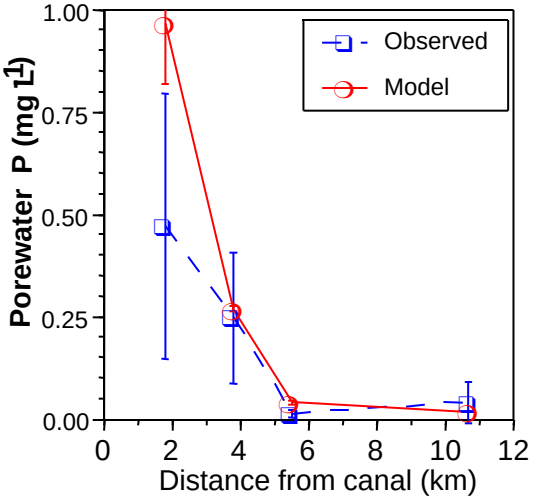
Soil porewater P calibration

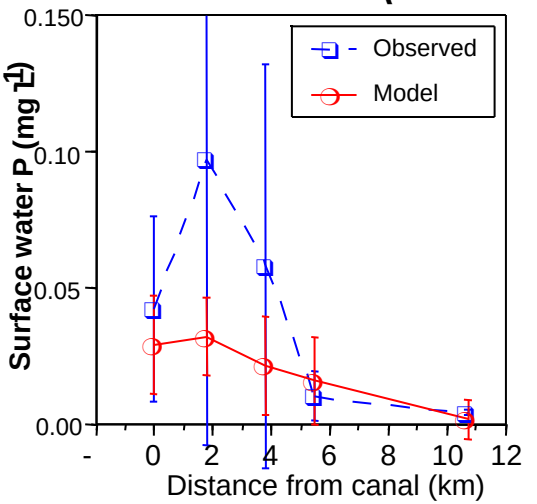


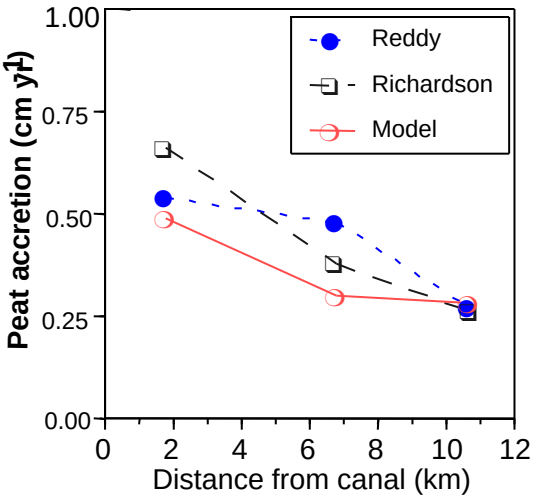
(ELM version 1.0)

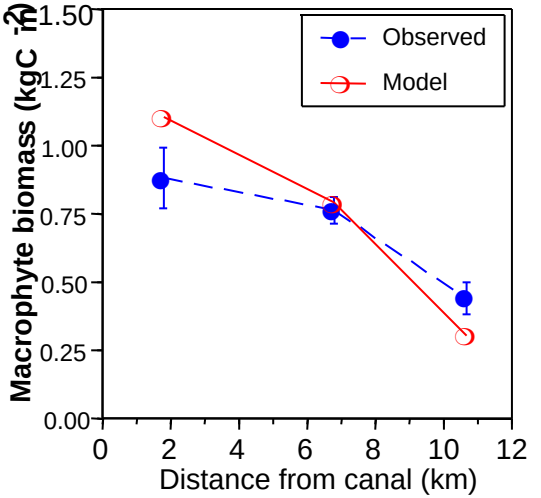
P, accretion, macrophytes calibration

(ELM version 1.0)





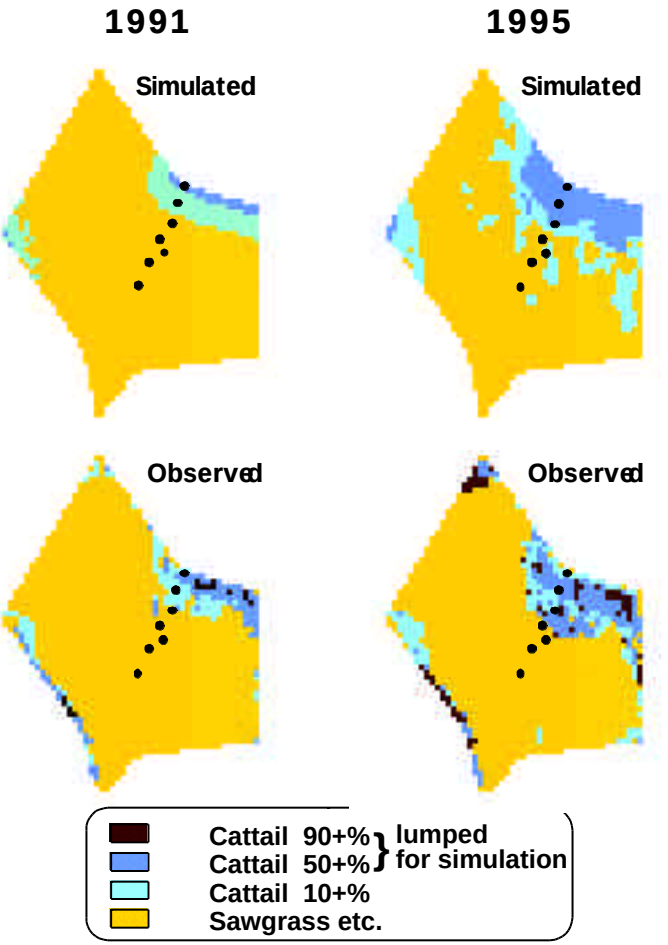




http://www.sfwmd.gov/org/wrp/elm

Vegetation change calibration

(ELM version 1.0)



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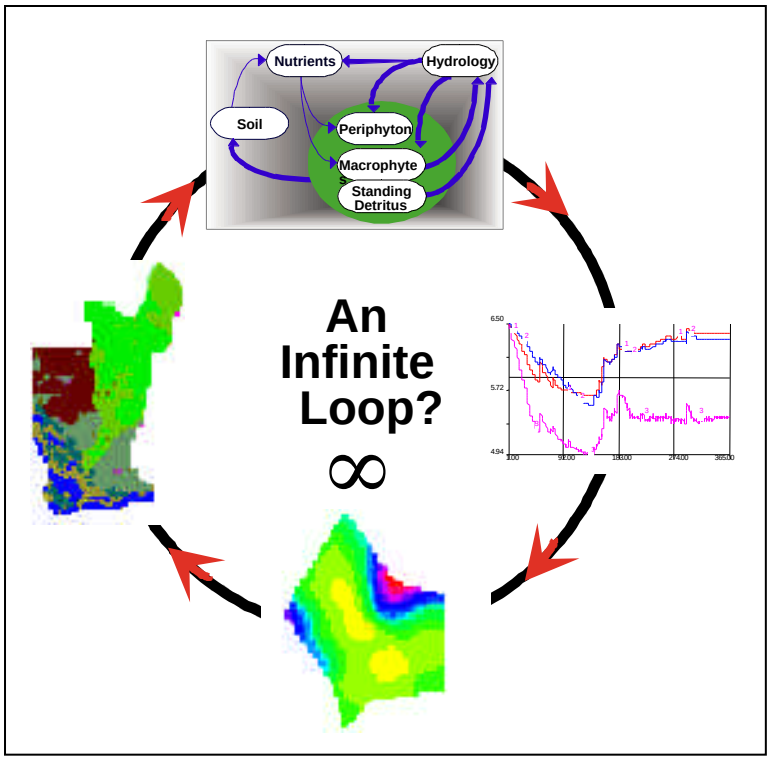
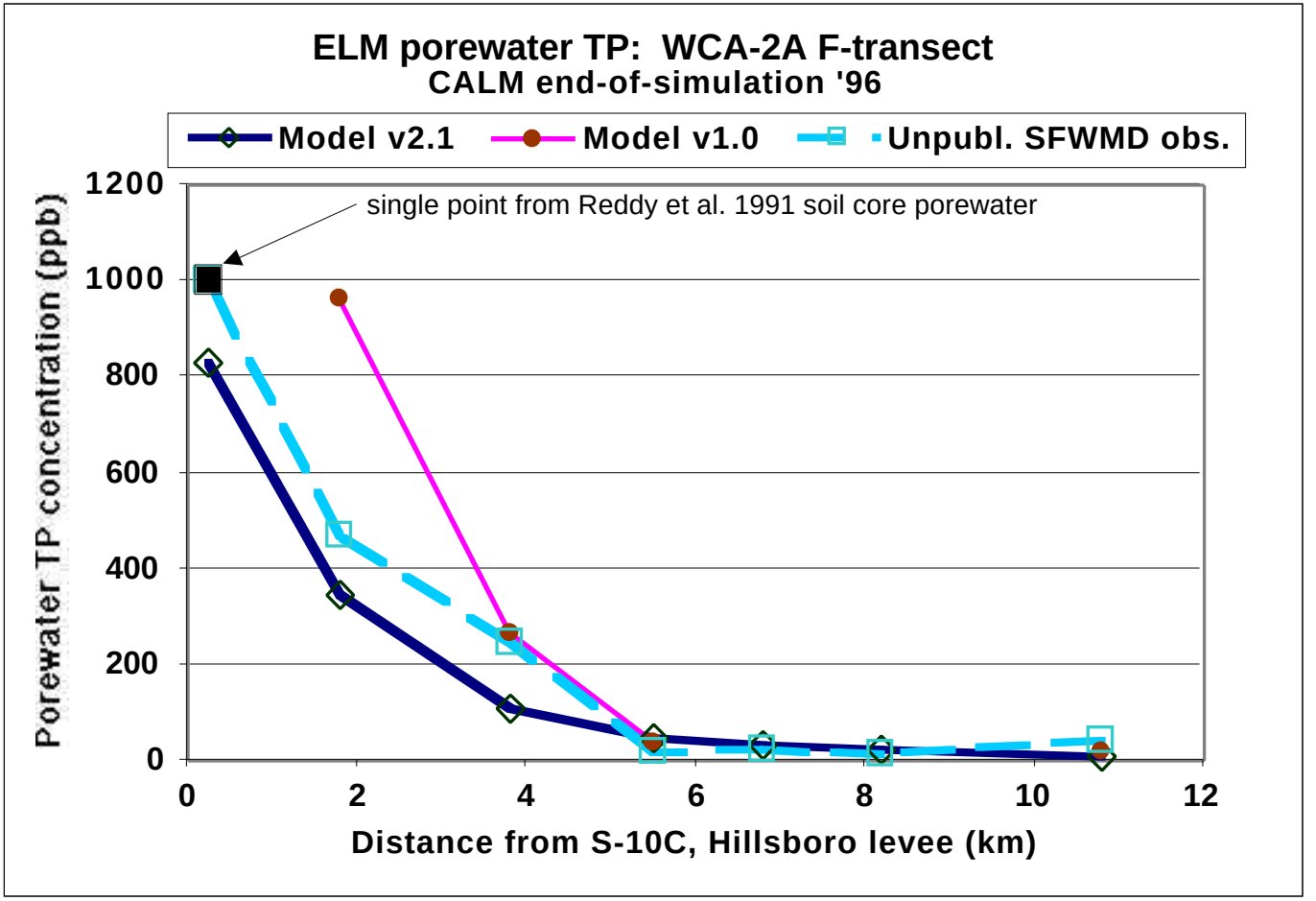
Model refinement...

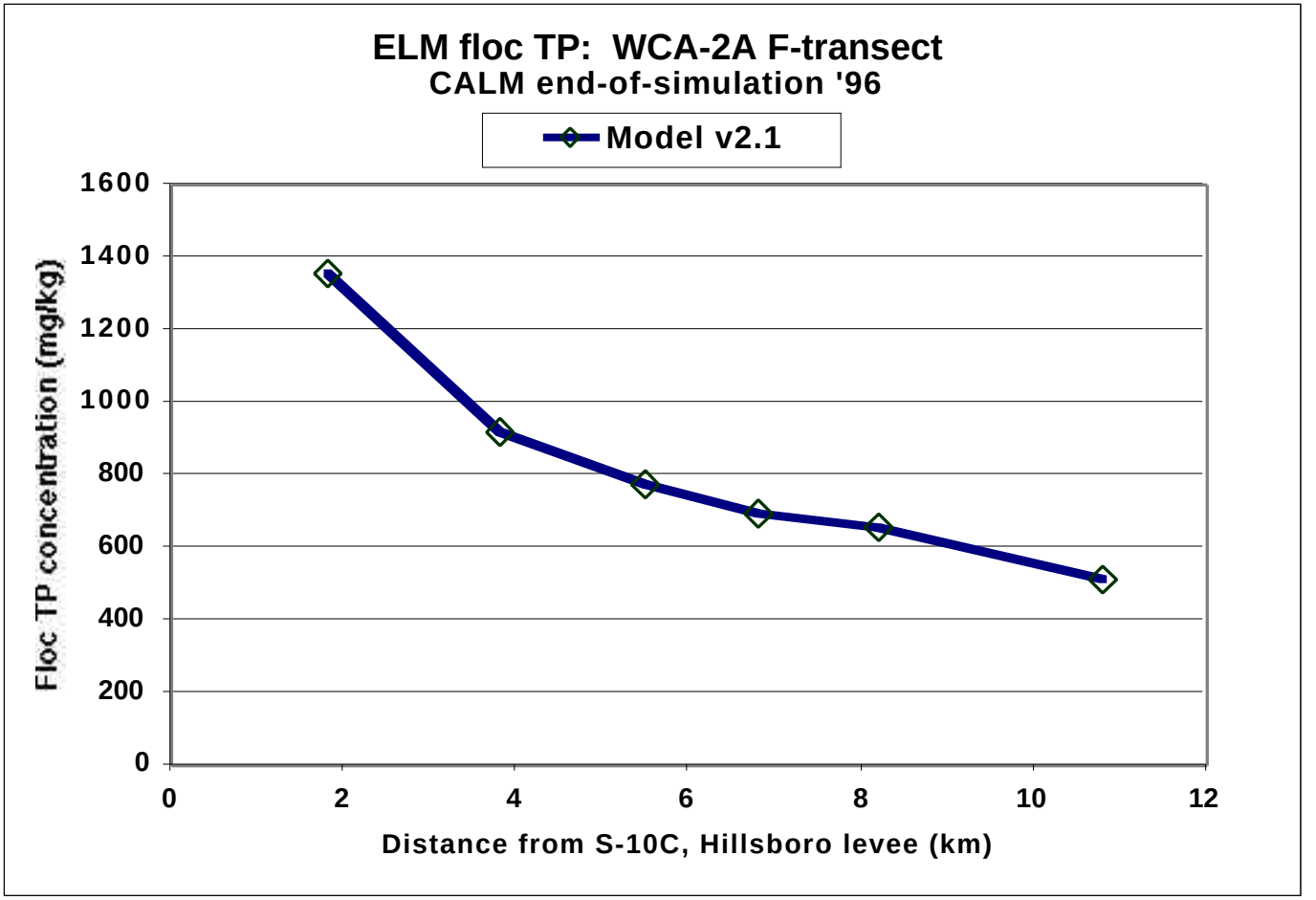


- **Modified:**
  - § **surface-ground water integration**
  - § **plant/soil nutrient kinetics**
  - § **others....**
- **Added:**
  - § **soil organic P storage**
  - § **variable C:P stoichiometry**
  - § **soil flocculent layer**
- **Calibrated v2.1:**
  - § **WCA-2A ecosystem dynamics**
  - § **Everglades-wide hydrology and surface water quality**

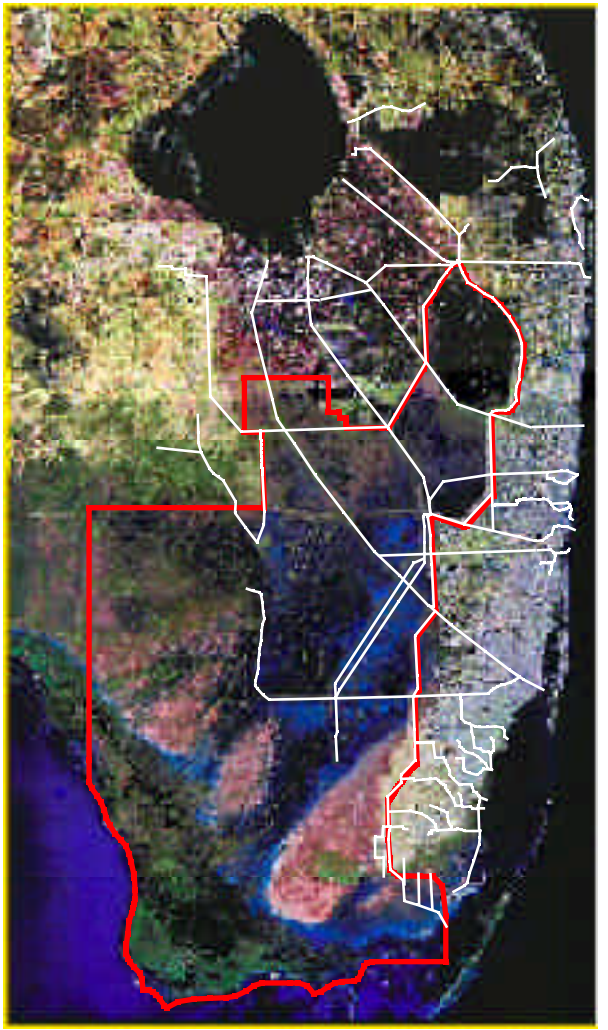
Better Performance

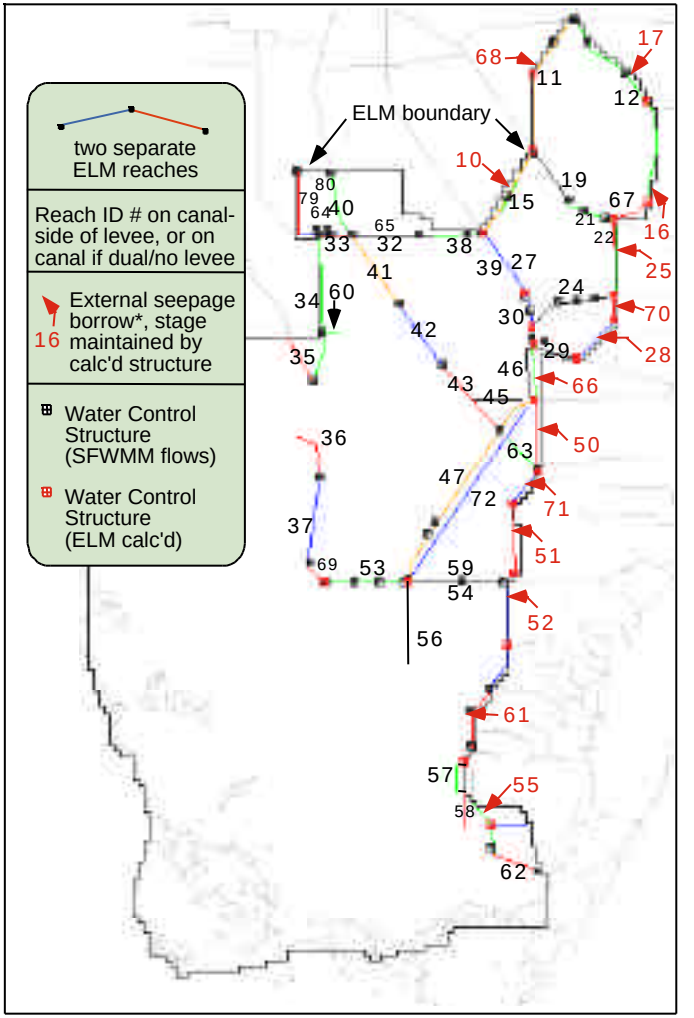


New Dynamics



ELM water management





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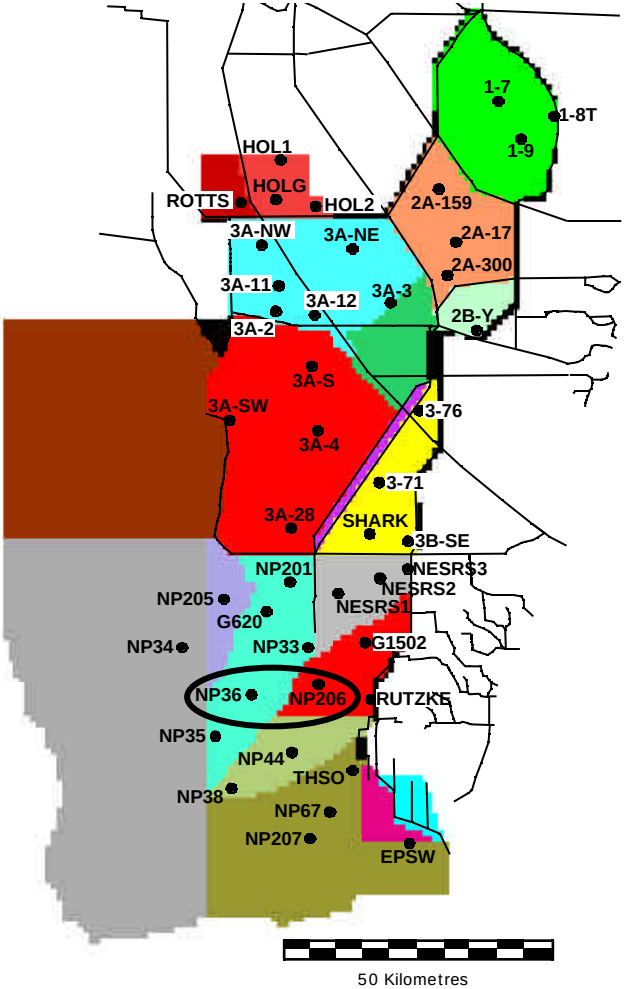
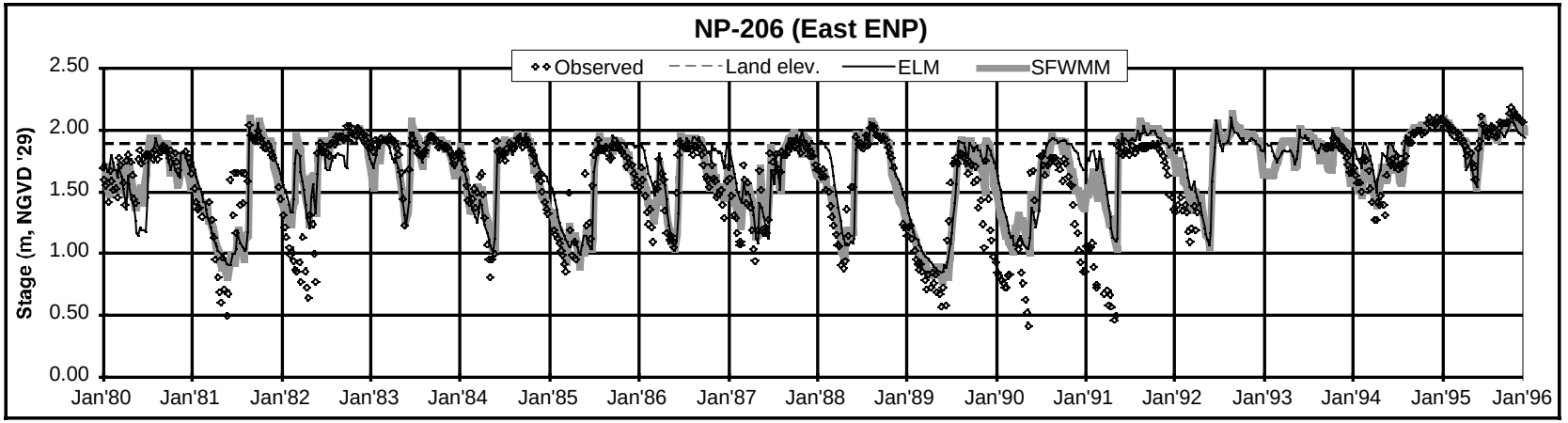
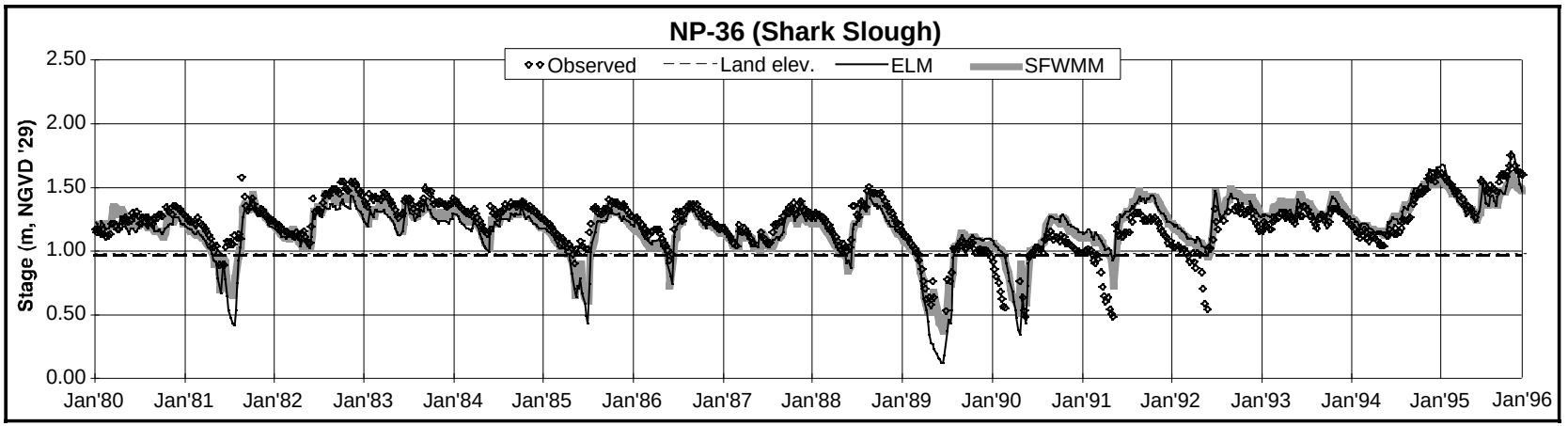
Stage monitoring regions/points



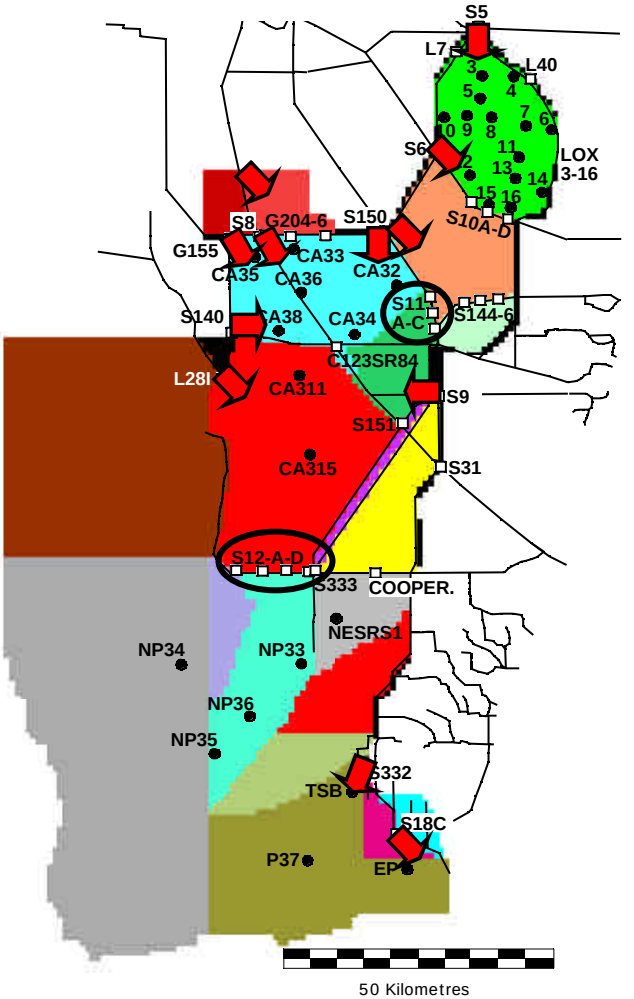
http://www.sfwmd.gov/org/wrp/elm

Stage calibration examples (v.2.1)





Surface water TP monitoring regions/points



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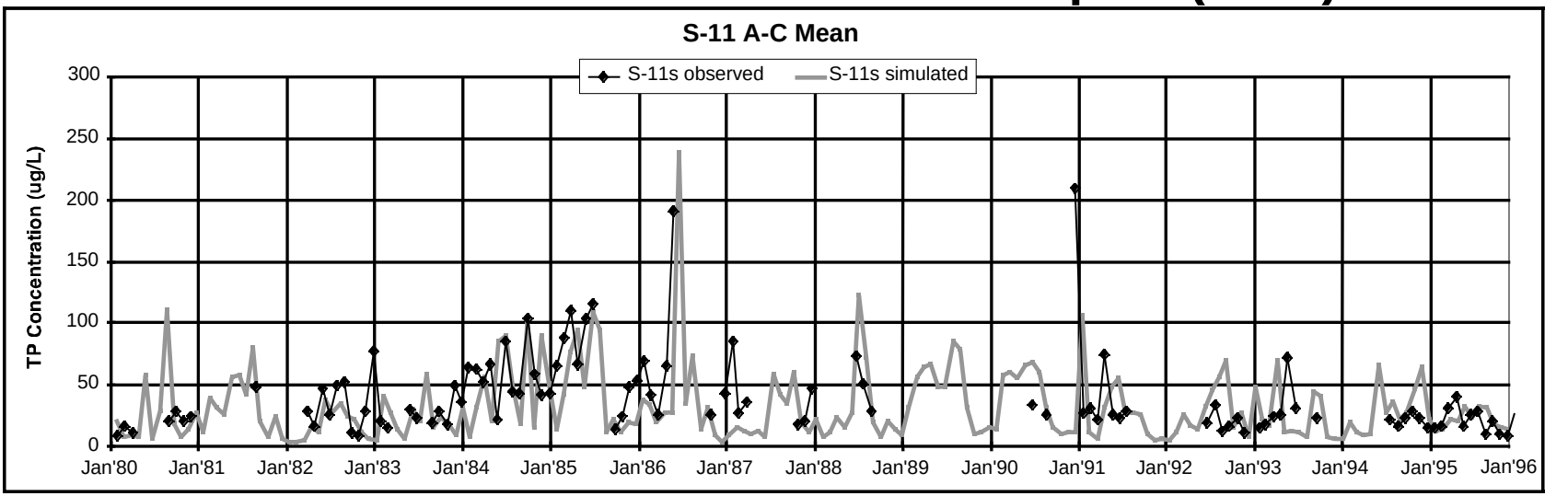
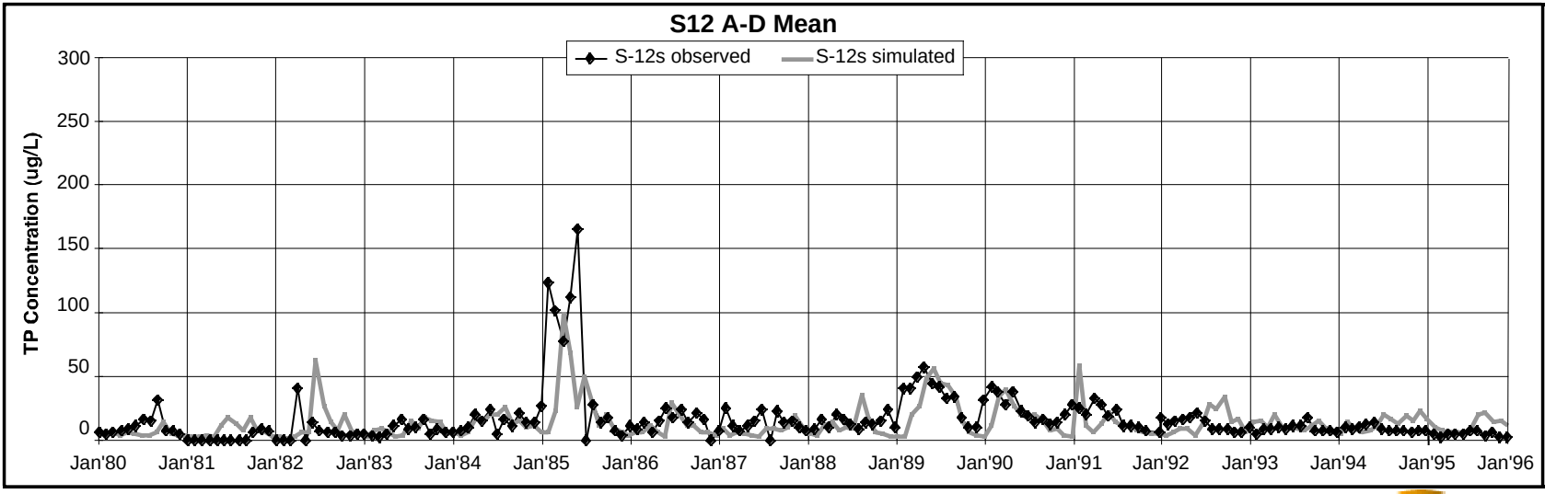
Surface water TP calibration examples (v.2.1)





http://www.sfwmd.gov/org/wrp/elm

Hierarchical Sensitivity Analysis

- **Large number of parameters**
- **1) Evaluate many- parameter response at local (non-spatial) scale of "unit" model**
- **2) Evaluate subset of parameters in simple (WCA-2A) spatial basin**
- **3) Evaluate subset of parameters in entire Everglades domain**

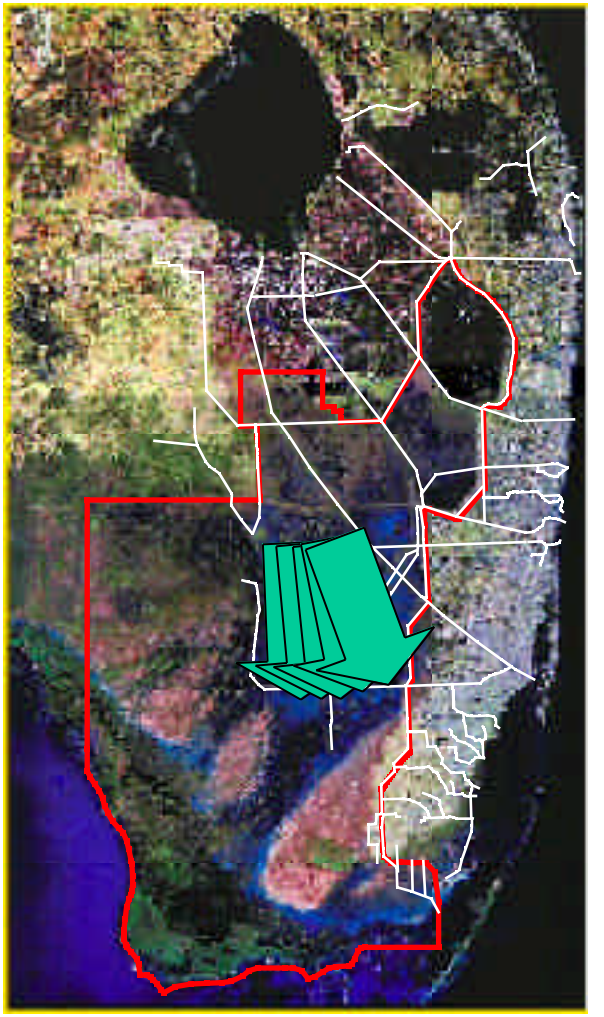
Summary: Model Development

- **Evaluate ecological process/mechanisms in subregions with high data (spatial & temporal) quality**
- **Calibrate both targets (e.g., stage, TP conc.) and rates (e.g., ET, TP uptake)**
- **To extent possible, extend subregional understanding to other regions with comparable antecedent conditions & dynamics**

Model Application

- Modified water deliveries...
- changes nutrient distributions… and influences soils and plants.

- How will the landscape pattern of periphyton and macrophytes respond?

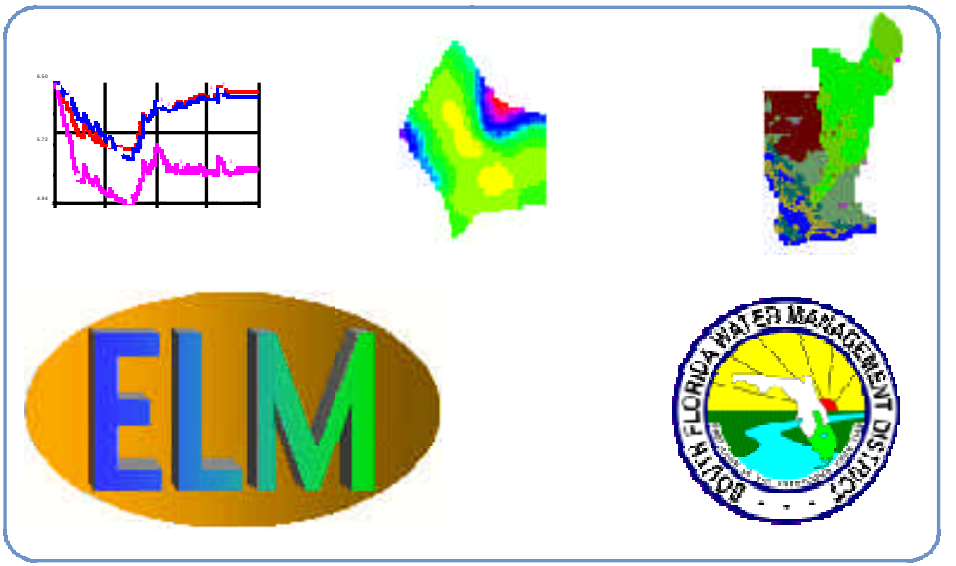


Project Alternative Evaluation: Hydrologic Considerations

- **For each Alternative, SFWMM provides (via scripted procedures)**
  - **daily input data on managed flows through water control structures**
  - **daily stages at boundary cells**
- **ELM hydrology (overland, groundwater, canal flows, etc) otherwise independent of SFWMM**
- **ELM uses SFWMM data on rainfall, topography, others**
- **Verify that ELM hydrology is consistent with SFWMM (stage, hydroperiod, budgets)**

Conclusions

- **Effectively simulated spatial and temporal interactions in complex ecological system**
- **Calibrated ecological processes in WCA-2A, calibrated hydrology and water quality throughout domain**
- **Confidence in current ELM dynamics allows evaluation of regional surface water quality**

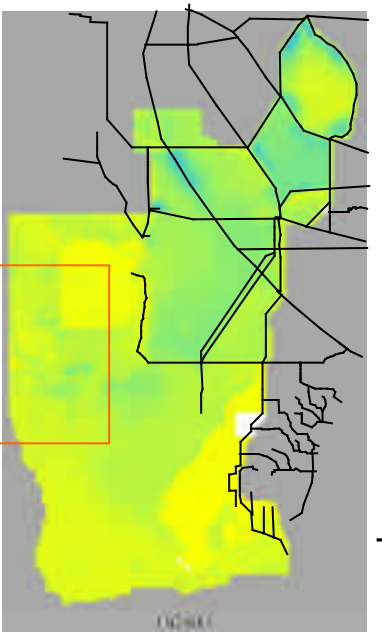


http://www.sfwmd.gov/org/wrp/elm

Status

- **Available NOW for evaluations of surface water quality throughout the Everglades**

For this animation, go to:
http://www.sfwmd.gov/org/wrp/elm/results/cal_ver/elm2.1/maps/tp/tpmaps.htm



TP in surface water:

monthly, 1979-1995

- **Finalizing calibration/refinement to evaluate other ecological (soils, periphyton, macrophytes) responses**
- **Extending Period-of-Record for calibration/verification thru 2000**

Documentation & Review

- **Web site**
  - **Data used in model development and model application**
    - **Descriptions of most data available**
    - **Organized, complete listing forthcoming**
    - **All data (& source code) to be on ftp link at web site**
  - **Model structure**
    - **Documented in manuscripts and conceptual diagrams at web site**
    - **Update on newer versions to come**
    - **Source code to be on ftp link at web site**
  - **Model results**
    - **Post-processed performance measures**
    - **Raw output data to be on ftp link at web site**
- **Peer Review**
  - **May 9: USGS Informational Workshops, including ELM**
  - **Aug 2: tentative target for formal, independent peer review for CERP-RECOVER applications**