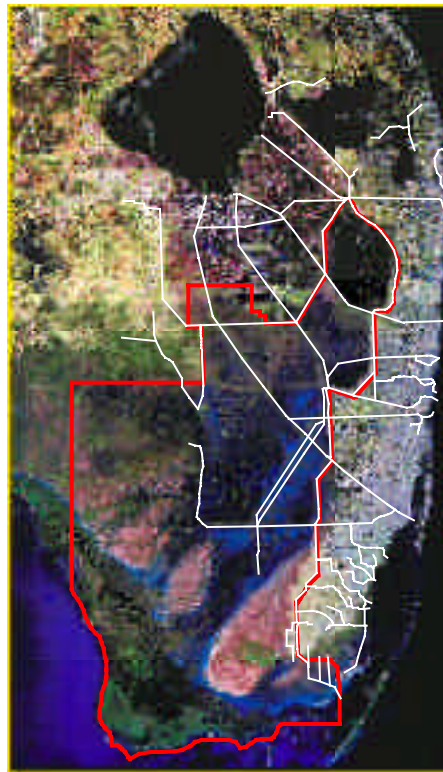


Status of the Everglades Landscape Model

Everglades Landscape Model



Aug 7, 2002



Carl Fitz
Naiming Wang
Jason Godin

*Fred Sklar & others
in the
Everglades Division*



August 7 Goals

Background for detailed review of ELM

- **Part I: Overview (this slide show)**
 - § **Model objectives**
 - § Model structure
 - § Calibration performance
 - § Application performance measures
- **Part II: Details (using web site)**
 - § Model tools
 - § Code
 - § Data
 - § Performance (calibration)

Everglades Landscape Model (ELM) Objectives

Integrate hydrology, biology and nutrient cycling in spatially explicit simulation

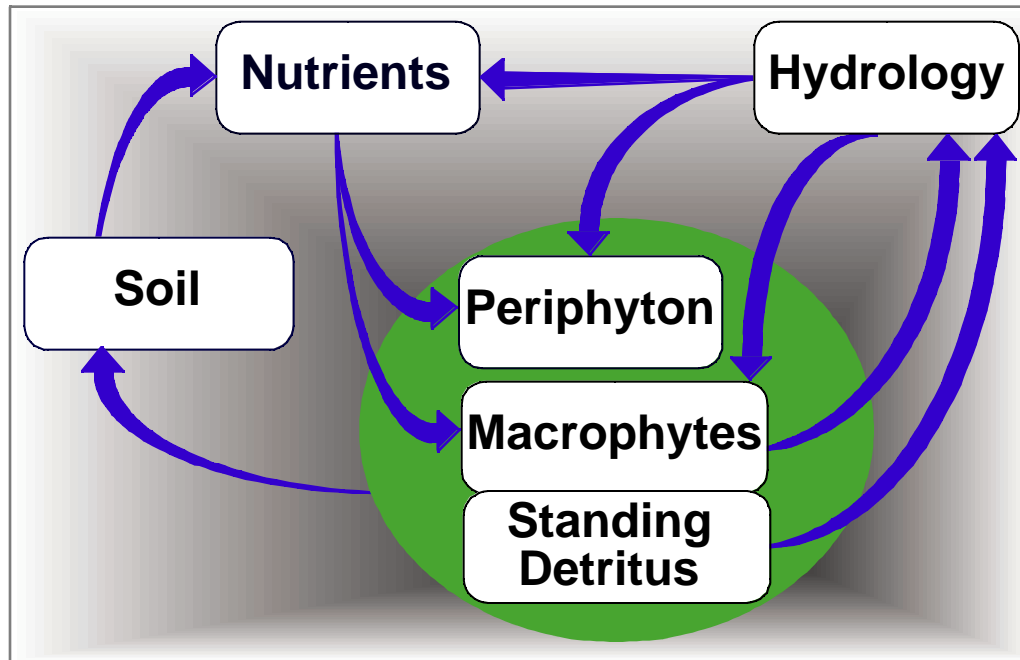
- **Understand ecosystem dynamics at regional scale**
- **Develop predictions of landscape response to altered water & nutrient management**
- **One tool to aid in Everglades restoration**

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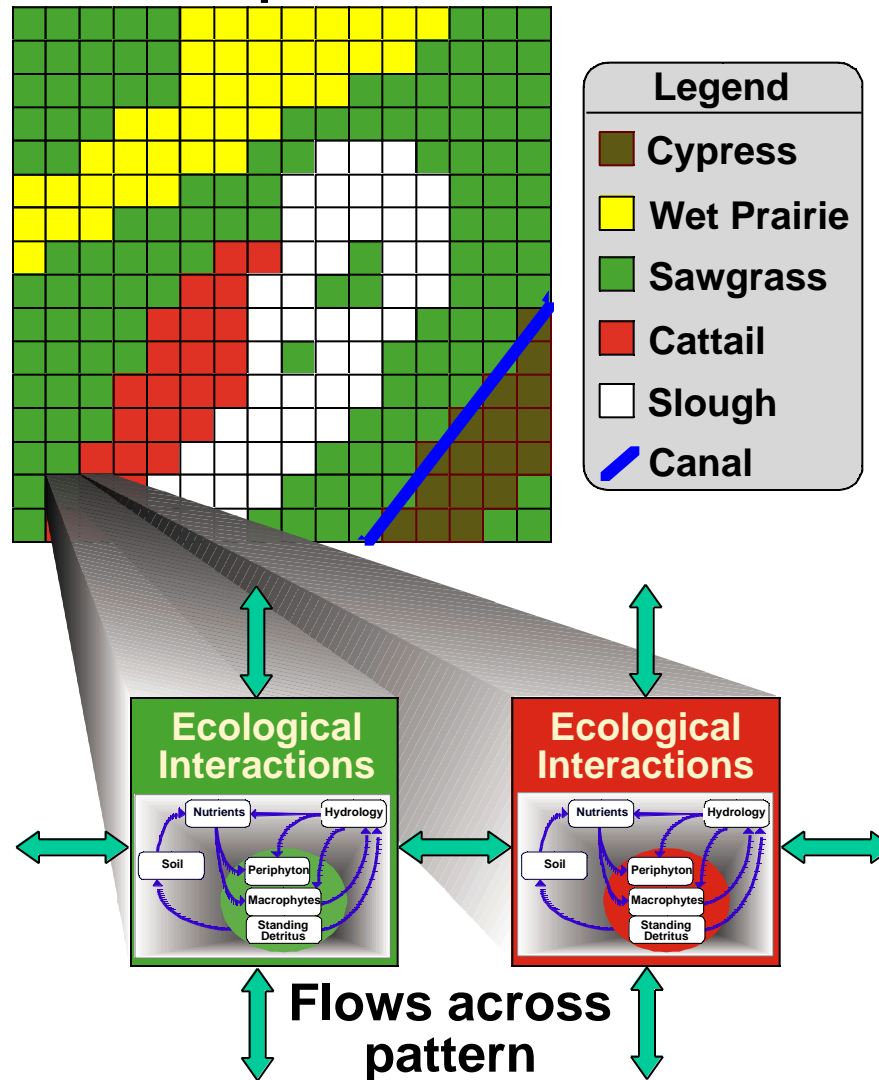
Ecological interactions



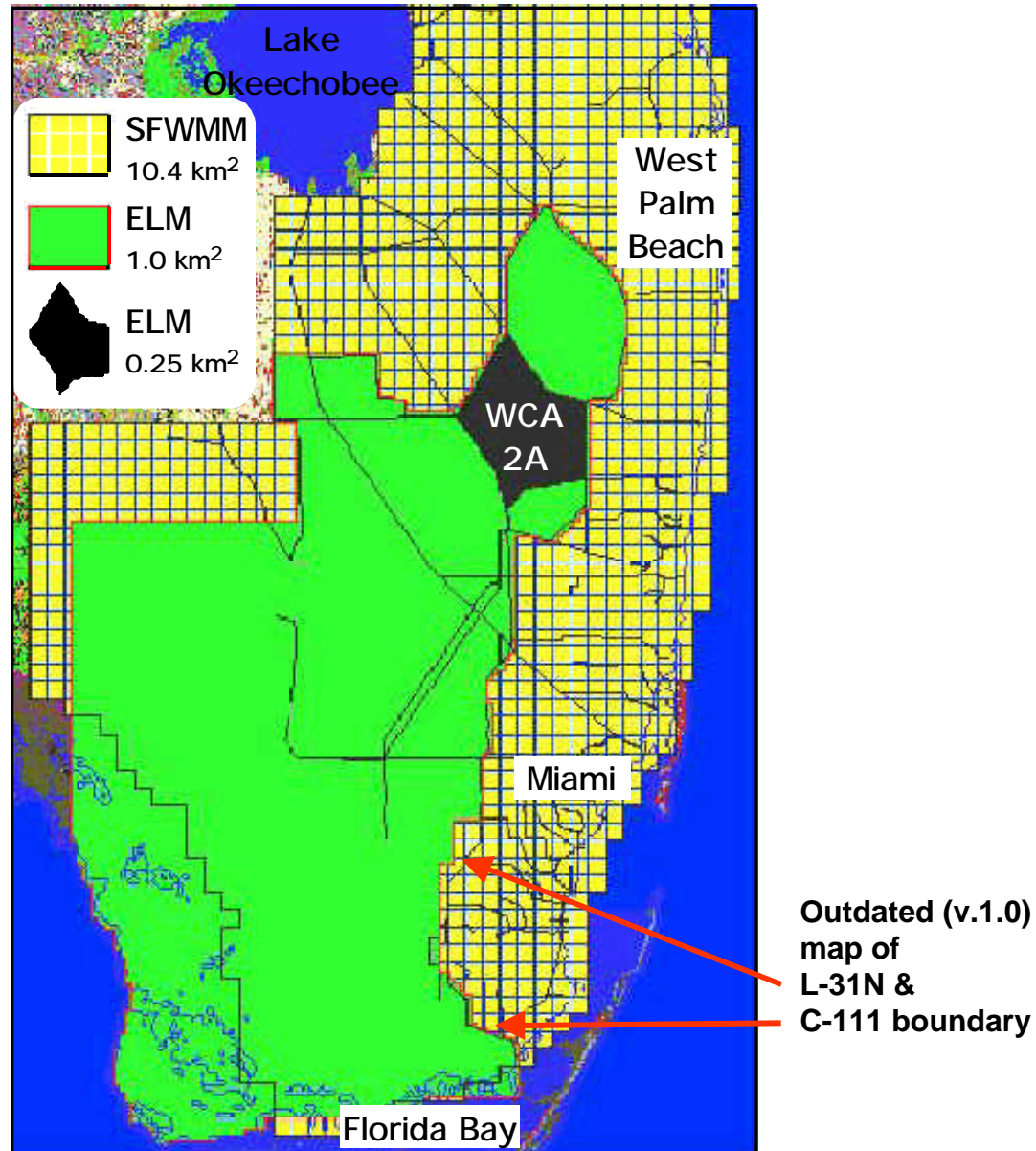
**SFWMM (&ELM) hydrology
+ ELM water quality + ELM ecology**

Spatial interactions

Landscape Pattern



Model domains



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 km² 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)

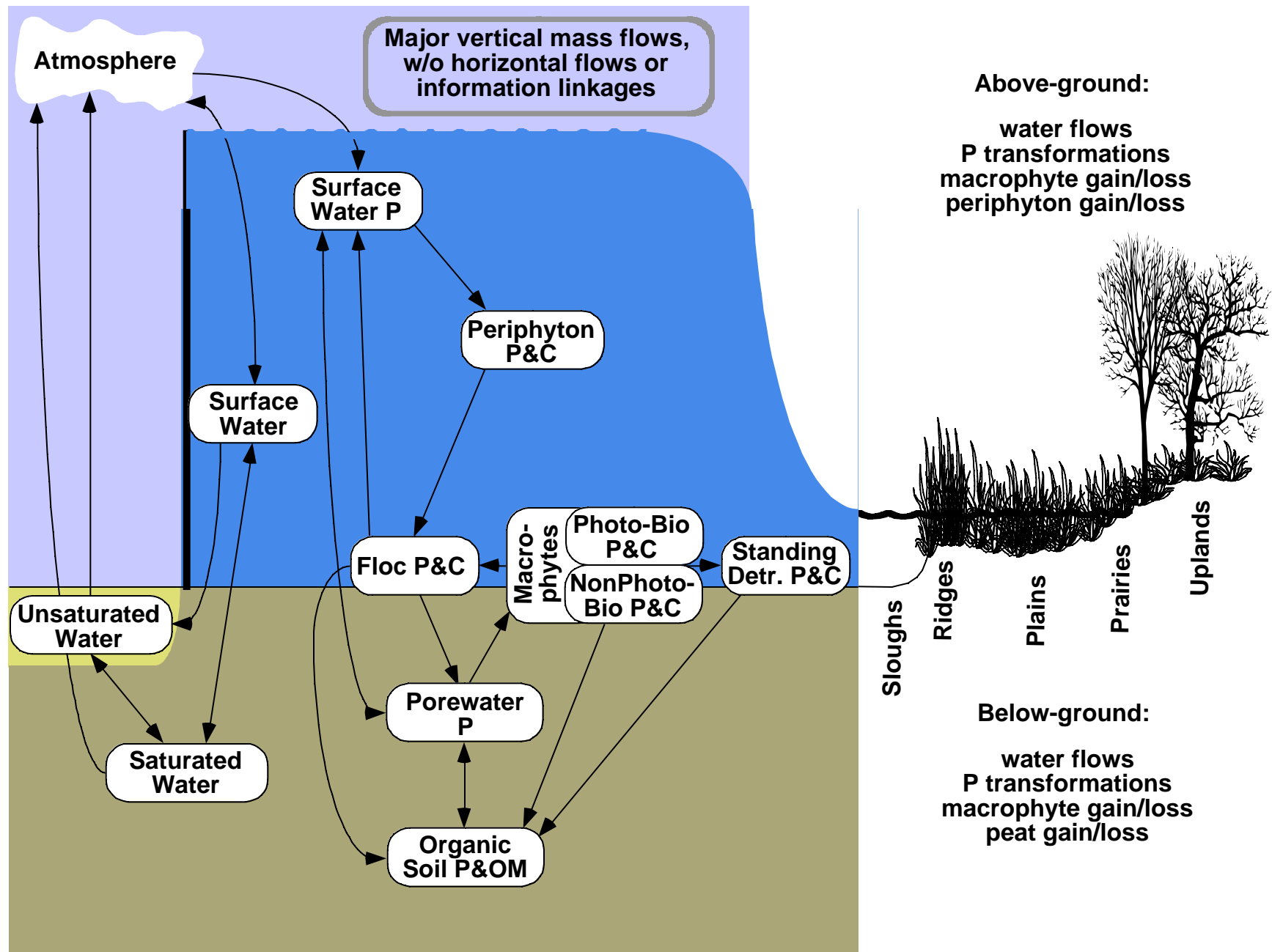
- **Water management network (2 hr step)**
 - § **Canal reaches: mass balance, iterative solution as in SFWMM**
 - § **Water control structs: daily flows for all structures, from observations or SFWMM**

Hydrologic modules (con't)

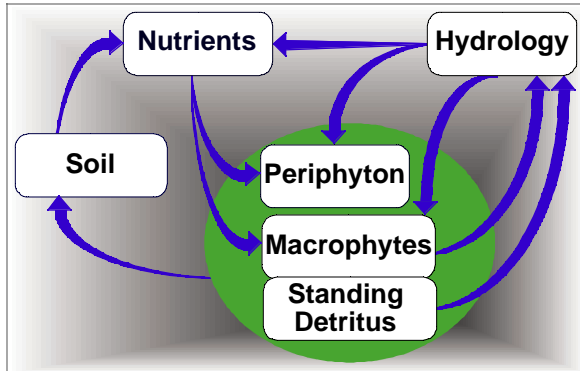
- **Mass balance and budget**
 - § **Basin & domain-wide budgets & error-checks**
- **Post-processing**
 - § **Consistency checks with SFWMM (maps and budgets, stage hydrographs)**

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



Refinement & Calibration Process

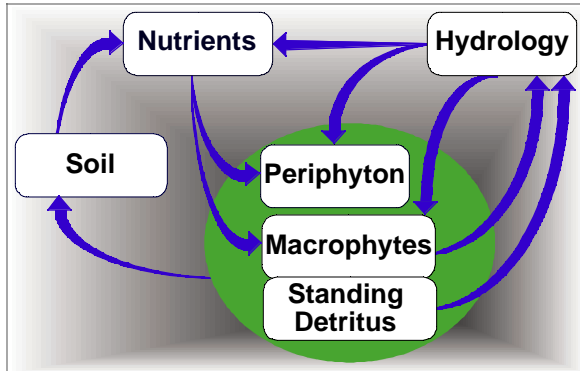


Simple modules,
complex spatio-temporal
interactions

- **integrated ecosystem approach**

- process-orientation avoids statistical “lock-in” of model application
- significant efforts in balancing mechanistic complexity vs. parameter availability
- when stocks and rates of multiple variables perform well, indicative of effective model structure and parameterization
- mass balance among fully integrated complex system provides checks on system function
 - can “calibrate” surface water quality,
 - but does not arrive at that calibration at expense of excessive soil accretion, plant growth, etc.

Refinement & Calibration Process

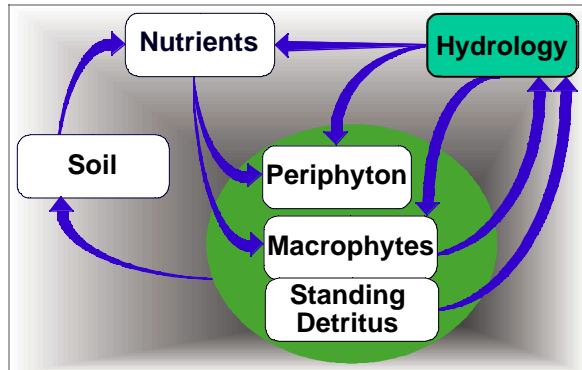


Levels of calibration

- **Level 1:** “Nirvana”, w/ hi quality & quantity of data across space & time
- **Level 2:** “Common”, with varying data quality/quantity across space & time
- **Level 3:** “Ballpark”, with sparse or poor data across space and time
- **Level 4:** “None”, with little/no effort to compare model to observations

- 2 critical **Landscape Drivers** are 1) hydrology and 2) surface water quality
- PROVIDED that other **Landscape Attributes** are in **Level 3 to 2** calibration:
 - low-intermediate model sensitivity to feedbacks between surface water quality and soils & biota
 - calibrate hydrology to **Level 1 to 2**
 - calibrate surface water quality to **Level 2 to 1**
 - AND verify performance of other variables to **Level 3 to 2**

Calibration Evaluation Process



Levels of calibration

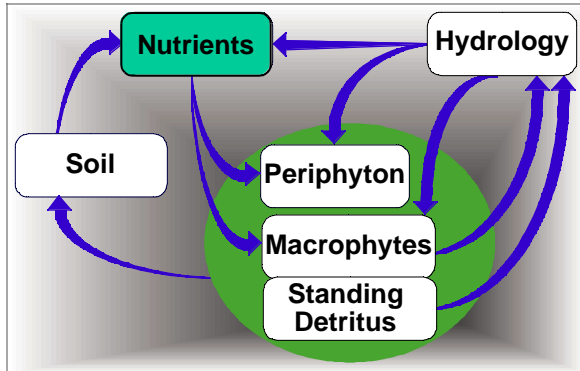
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1: Hydrology

- **ecological modules OFF**
 - model-observed stages: CALM*
 - model-observed stages: ELM
 - SFWMM-ELM basin flow budgets
 - SFWMM-ELM spatial depth & hydroperiod
- if “OK”, turn on all ecological modules
 - repeat above steps for ELM
 - (generally relatively little regional diffs)
 - aim for **Level 1-2**
- if “OK”, evaluate surface water quality & ecology

*CALM (Conservation Area Landscape Model)
= ELM implemented at finer scale in WCA-2A

Calibration Evaluation Process



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2: “Water Quality”

- surface nutrients
 - model-observed TP concentrations: CALM*
 - model-observed TP concentrations: ELM
 - aim for **Level 2-1**
- other ecological dynamics
 - soil, periphyton, macrophytes
 - at minimum, ensure **Level 2-3** in CALM*
 - at minimum, ensure **Level 3-2** in ELM
- if “OK”, fully evaluate/refine system dynamics

ELM V.2.1 IS AT THIS STAGE

*CALM (Conservation Area Landscape Model)
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August 7 Goals

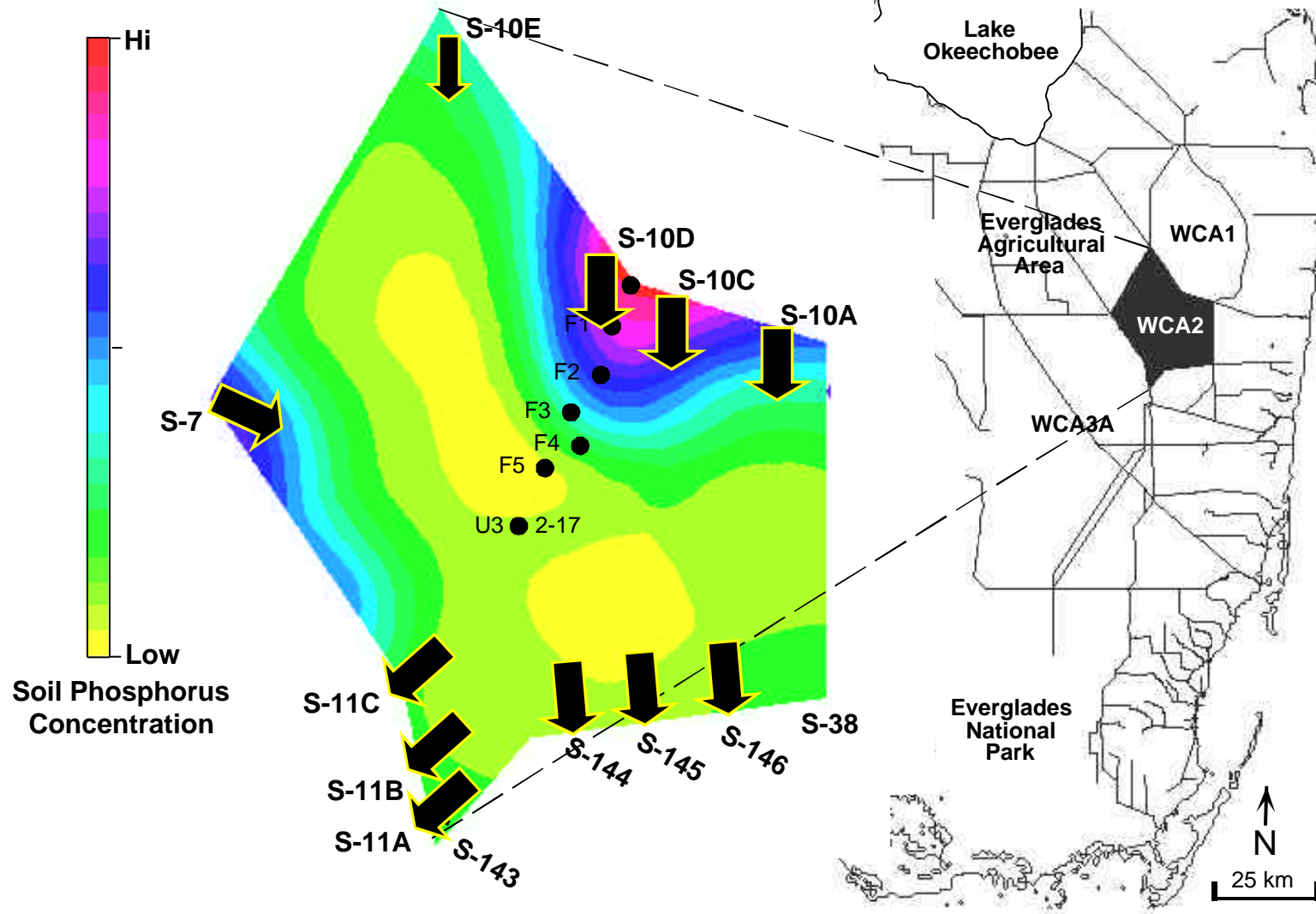
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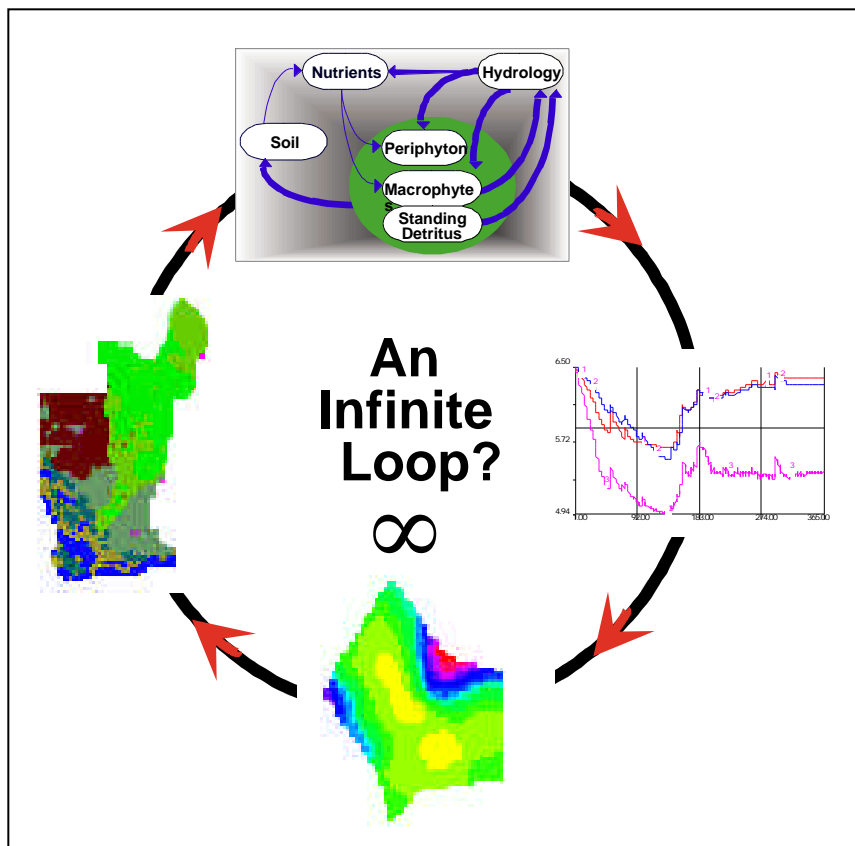
Start out “small”...

ELM is scalable in spatial grain and extent

Water Conservation Area 2A

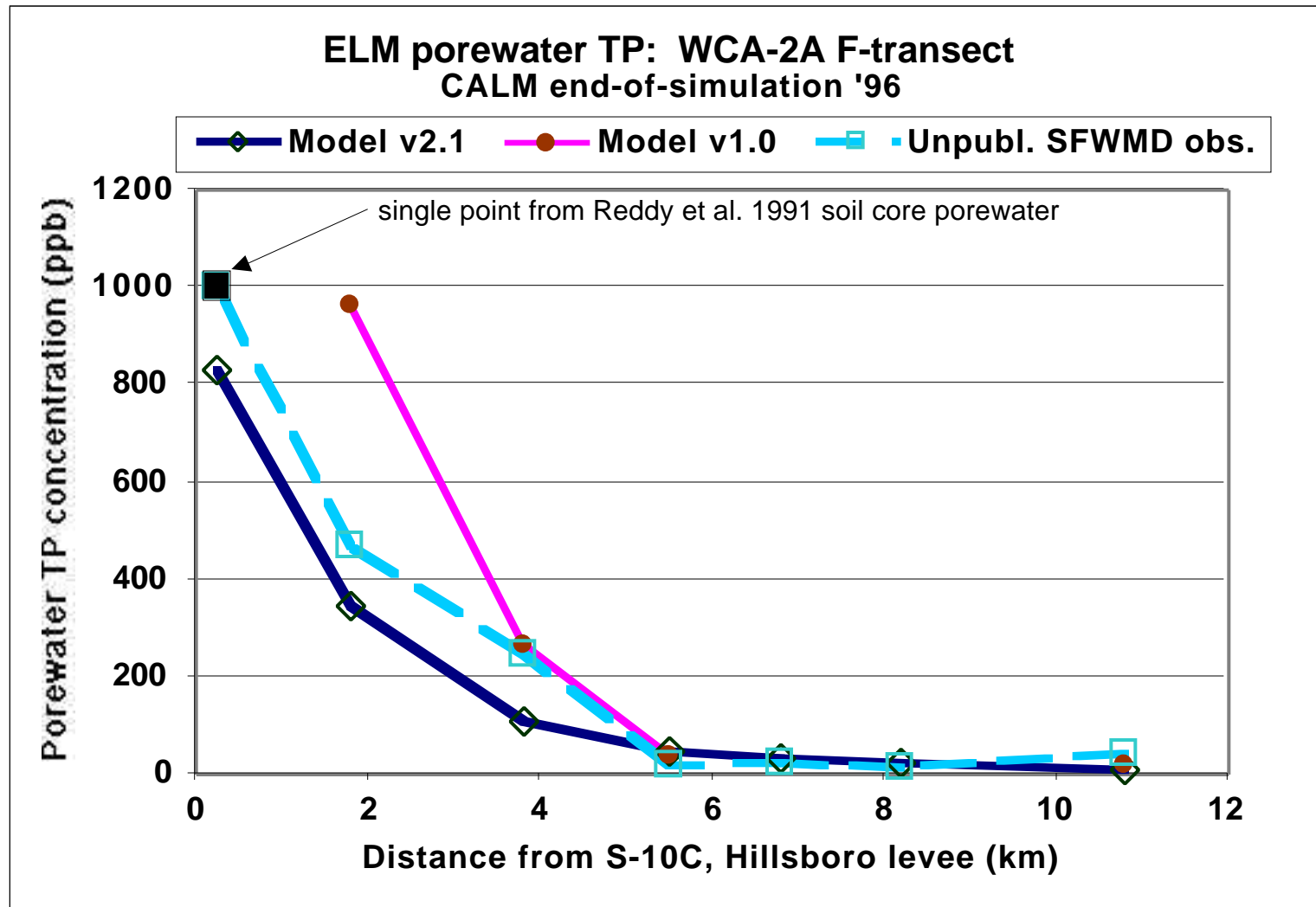


Model refinement...

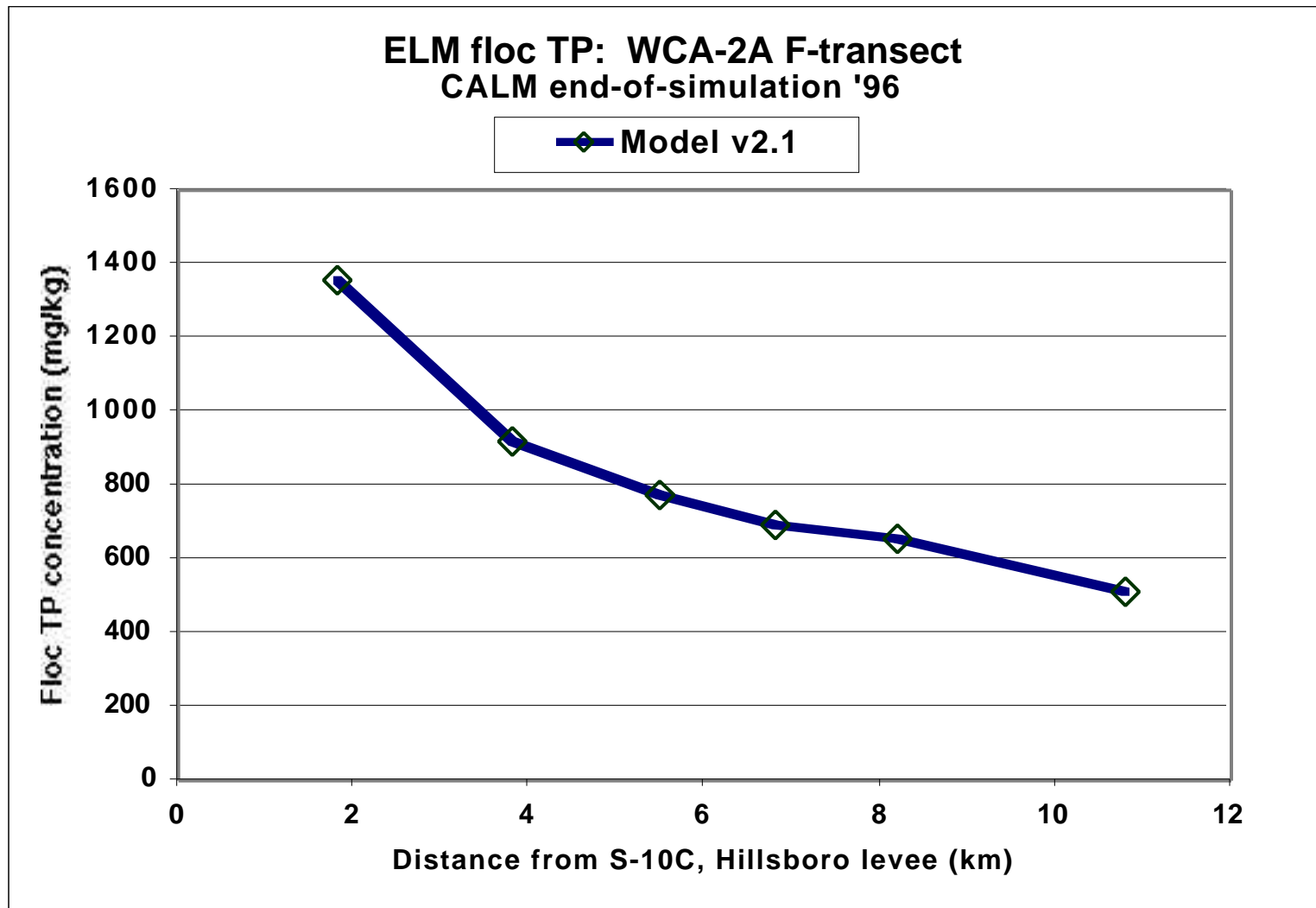


- **Modified:**
 - § surface-ground water integration
 - § plant/soil nutrient kinetics
 - § others....
- **Added:**
 - § soil organic P storage
 - § variable C:P stoichiometry
 - § soil flocculent layer
- **Calibrated v2.1:**
 - § WCA-2A ecosystem dynamics
 - § **Everglades-wide hydrology and surface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

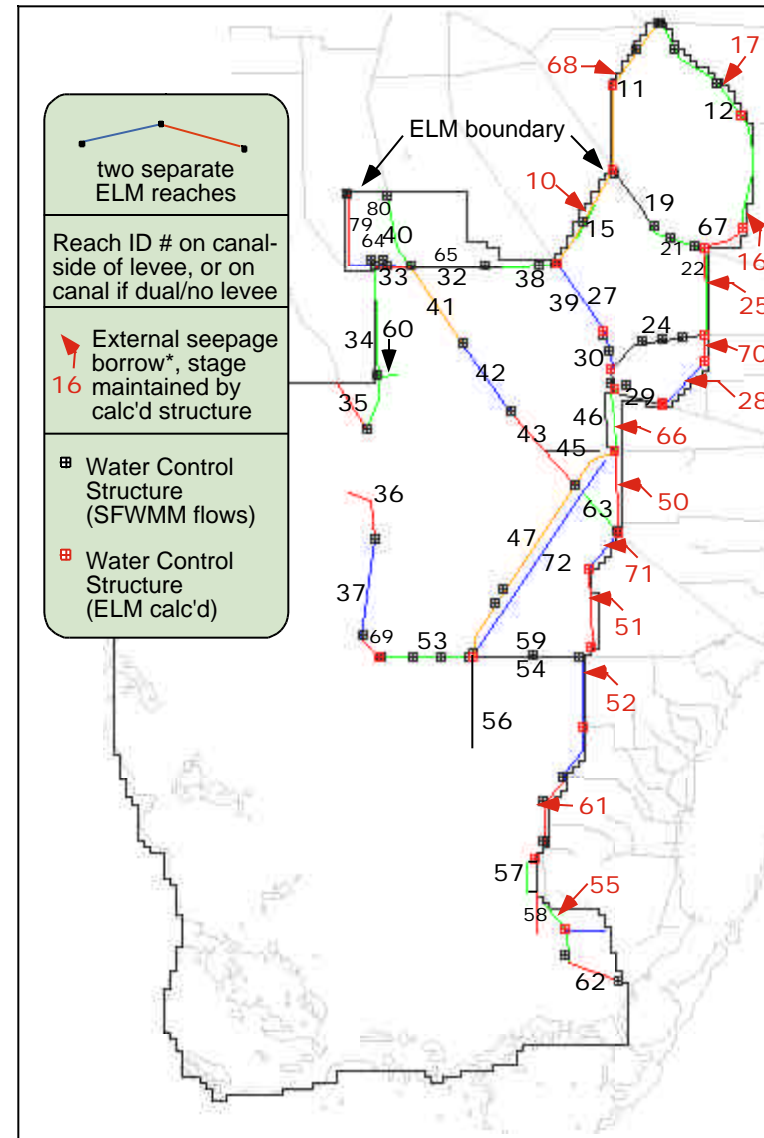
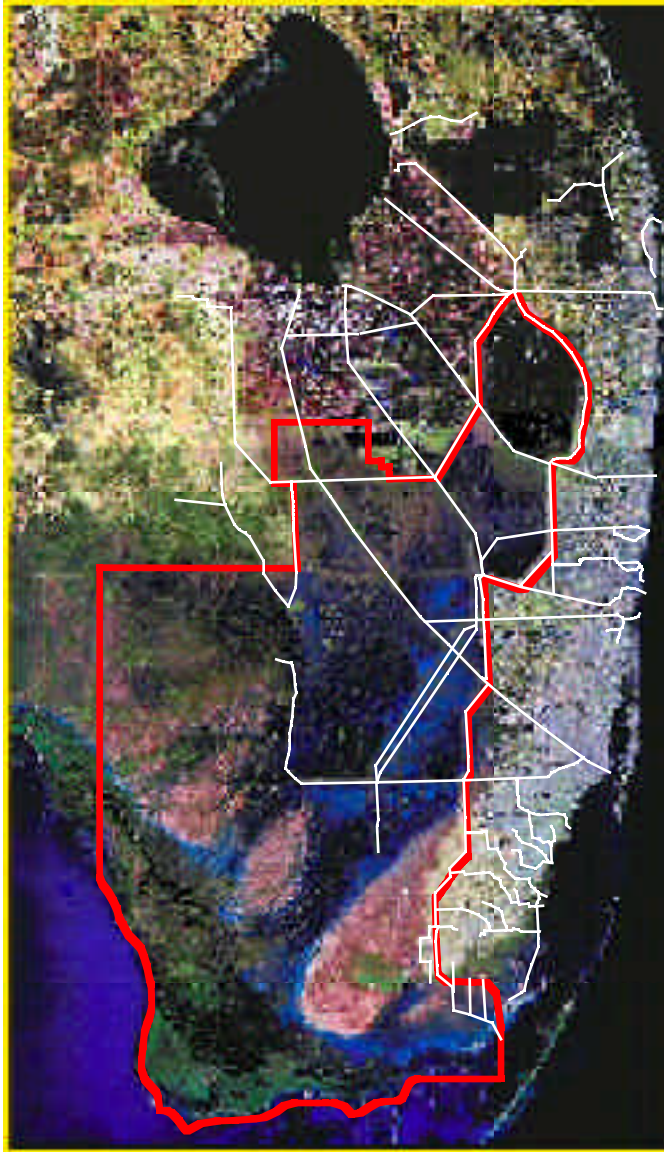
Better Performance



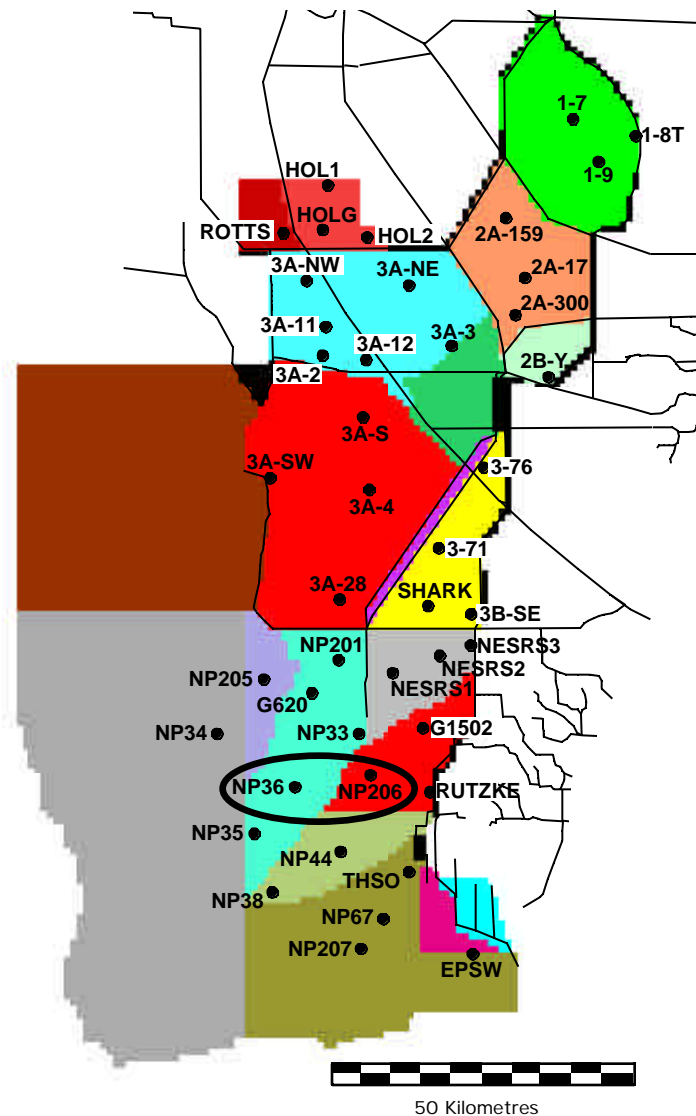
New Dynamics



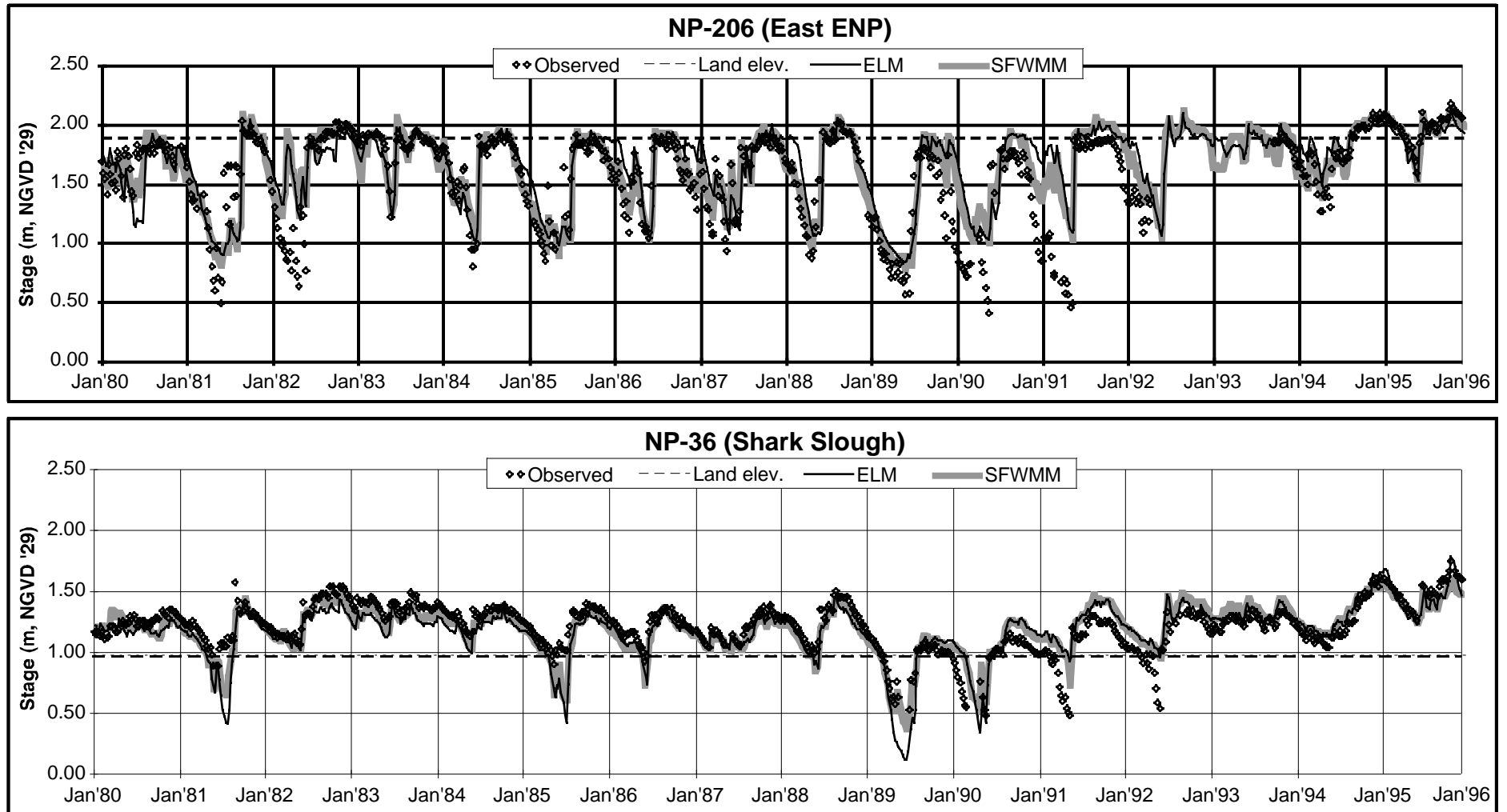
ELM water management



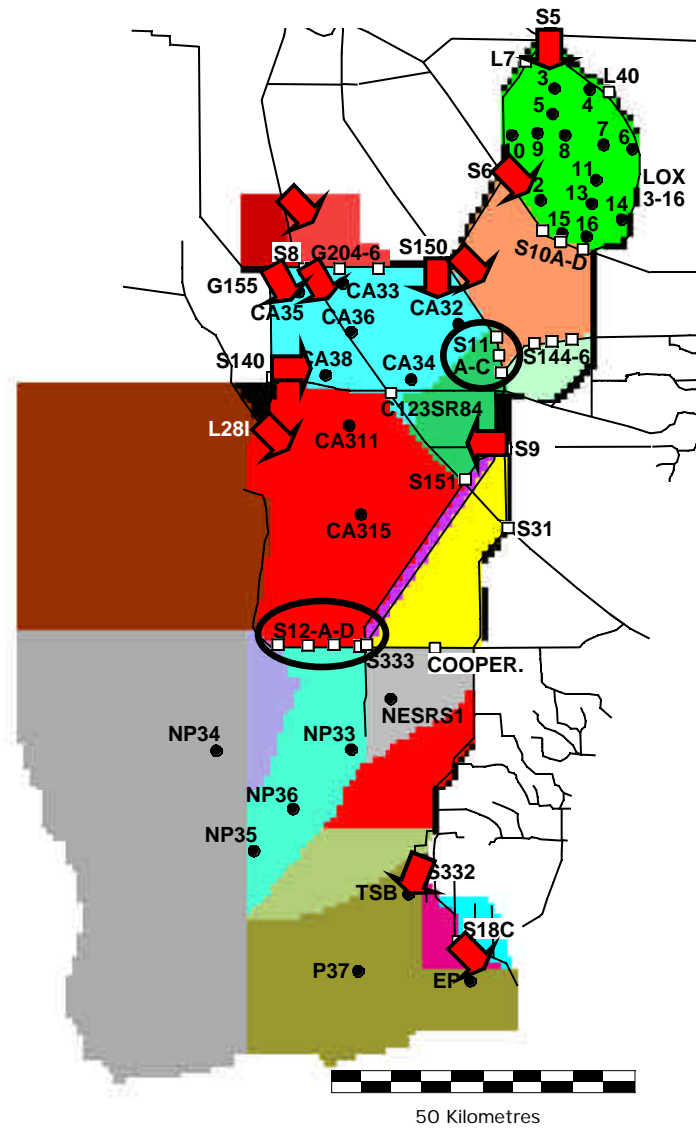
Stage monitoring regions/points



Stage calibration examples (v.2.1)

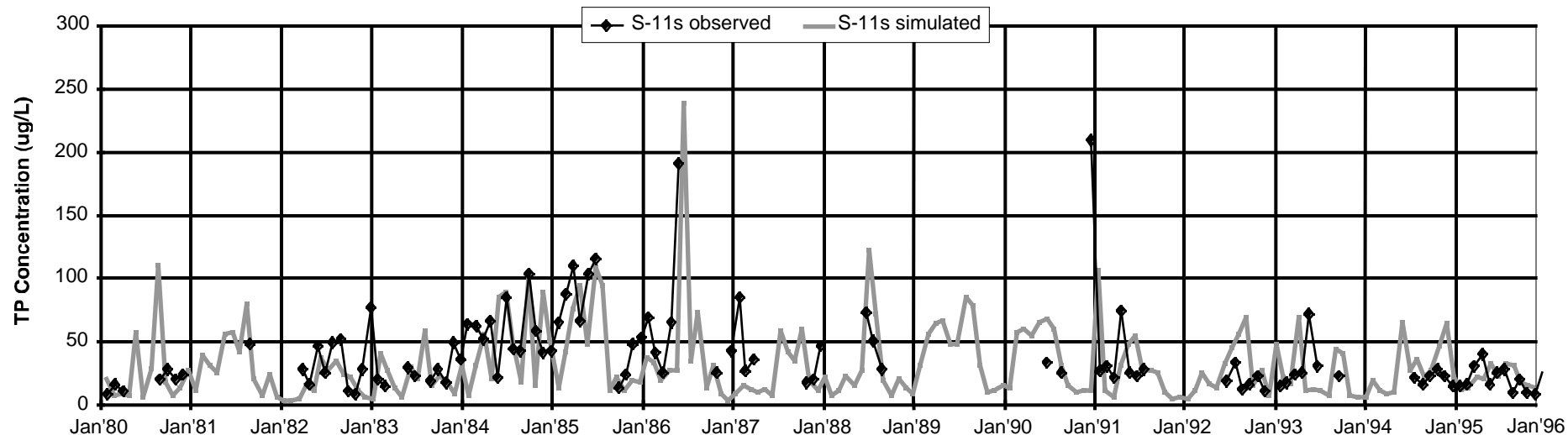


Surface water TP monitoring regions/points

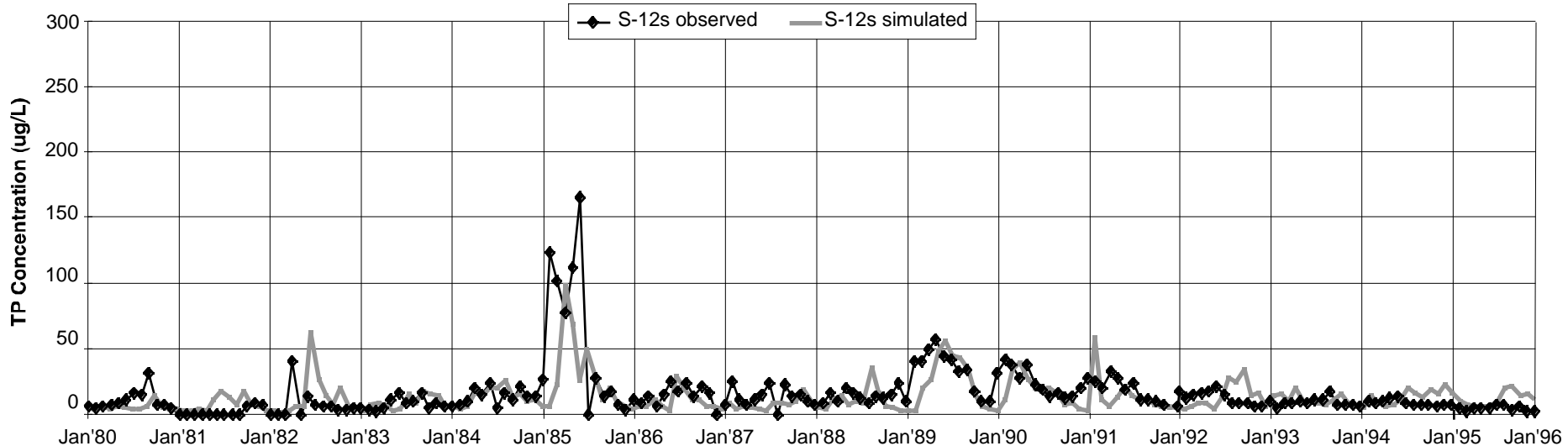


Surface water TP calibration examples (v.2.1)

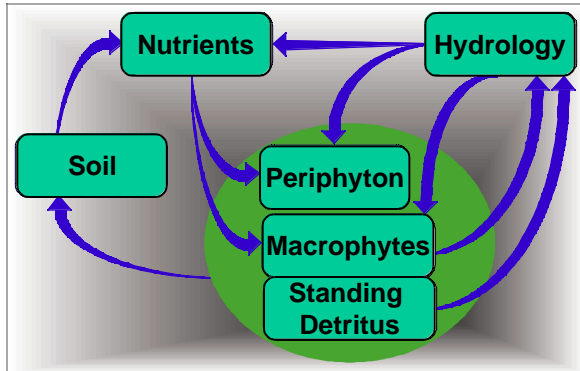
S-11 A-C Mean



S12 A-D Mean



Calibration Evaluation Process



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3: Complex system

- integrated assessment
 - data dependent, varying Levels depending on region and on simulation time period
 - aim for **Level 2** in general, **Level 1-2** in subregions, Level 3
- communicating uncertainty
 - show users at least qualitative level of confidence for different Performance Measures across space
 - taking advice of “Model Uncertainty Workshop” (Jan 02) panelists on analysis
- when “OK”, release ELM v3.0

*CALM (Conservation Area Landscape Model)
= ELM implemented at finer scale in WCA-2A

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 Performance

- **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**

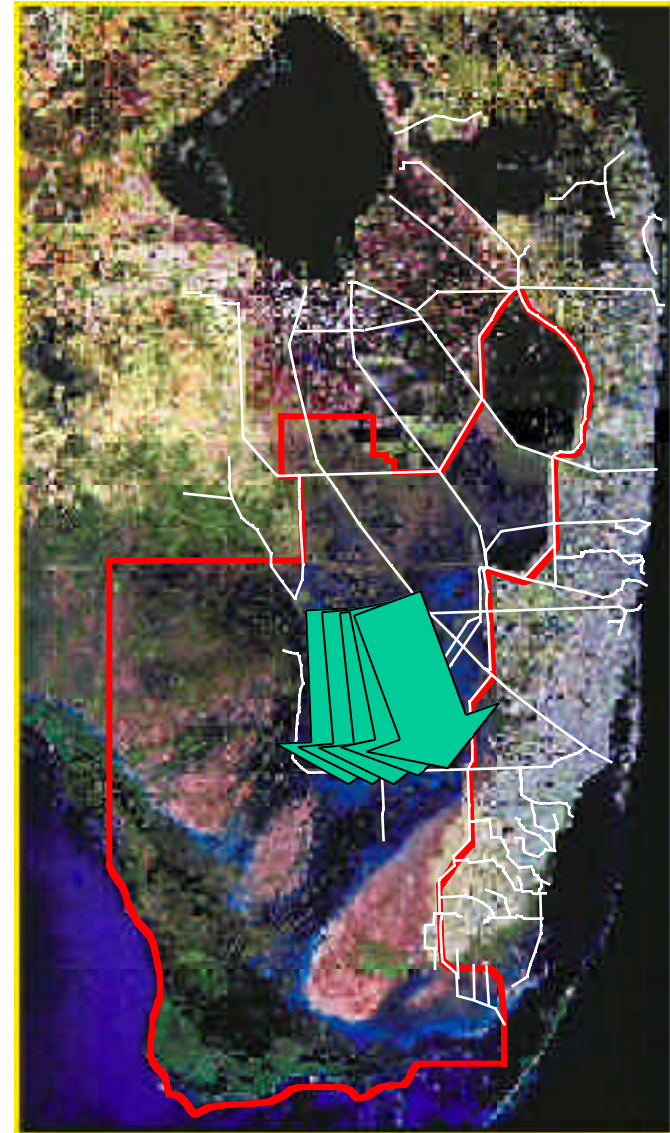
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Model Application

- **Modified water deliveries...**
- **changes nutrient distributions... and influences soils and plants.**
- **How will the landscape pattern of periphyton and macrophytes respond?**

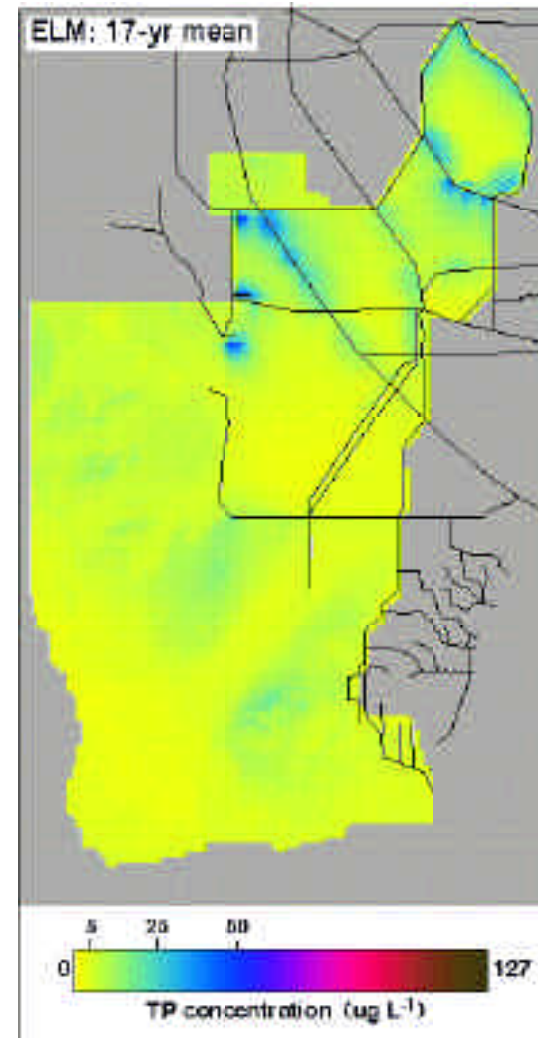


Project Alternative Evaluation: Hydrologic Considerations

- **For each Alternative, SFWMM provides (via scripted procedures)**
 - § **daily input data on managed flows through water control structures**
 - § **daily stages at boundary cells (ELM code not final for this)**
- **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)**

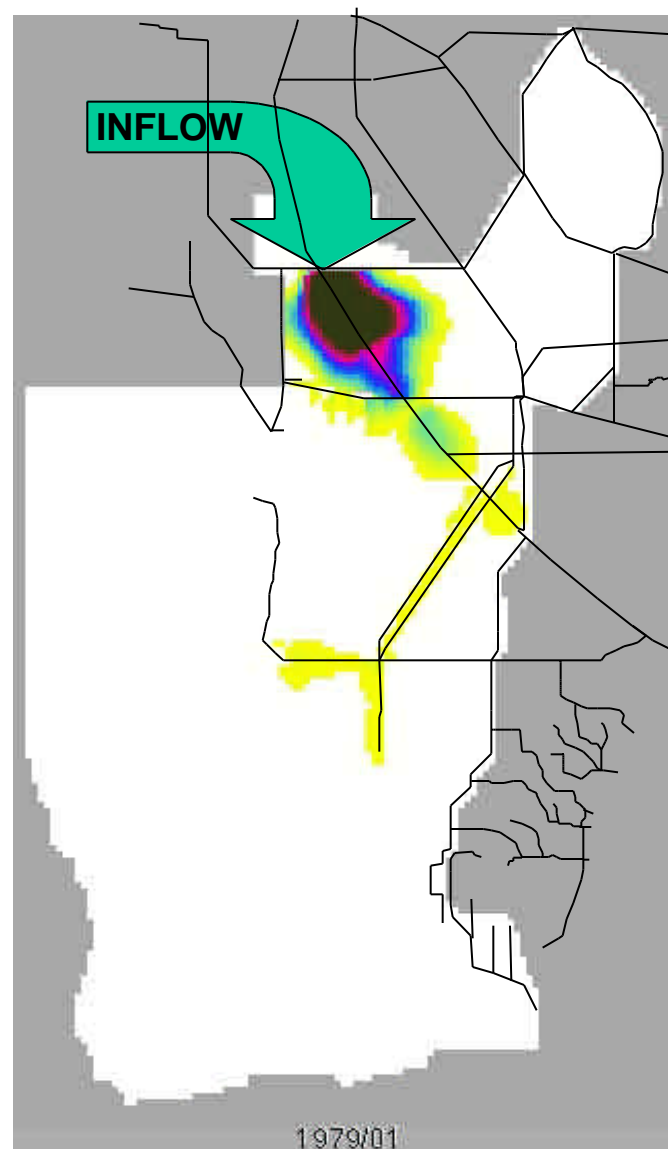
Performance measures (web-enabled)

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



Example: tracer flow in surface water

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



Performance measures (web-enabled)

Subregional summaries

§ *Water quality*

- TP concentration & load
- LOK water tracer

§ *Soils*

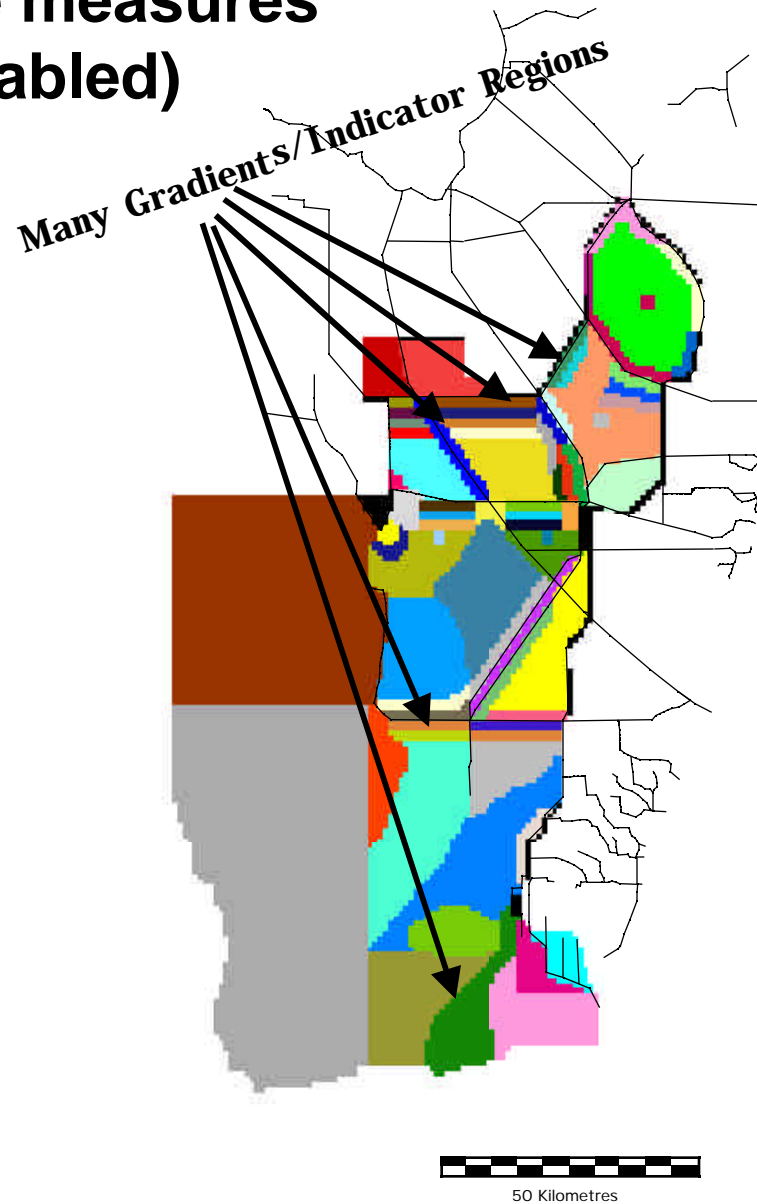
- peat accretion
- TP concentration

§ *Periphyton*

- biomass & community type
- tissue TP concentration

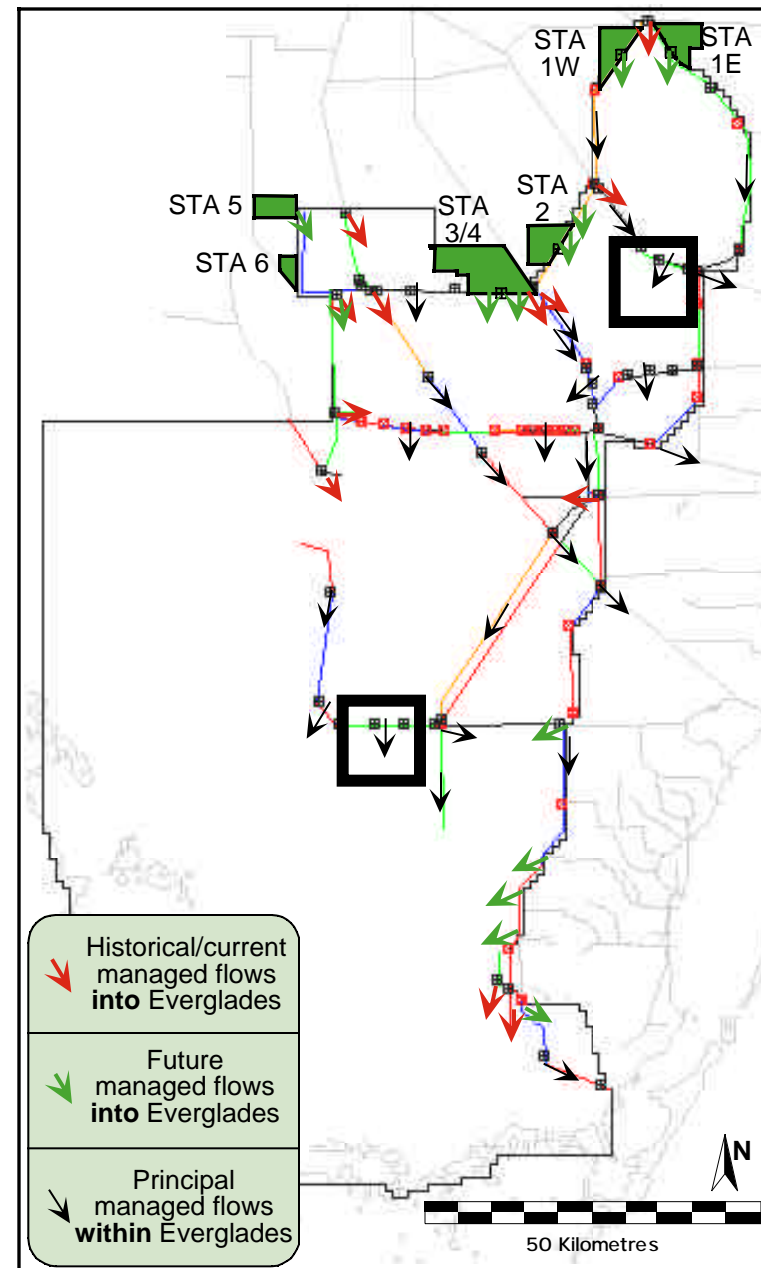
§ *Macrophytes*

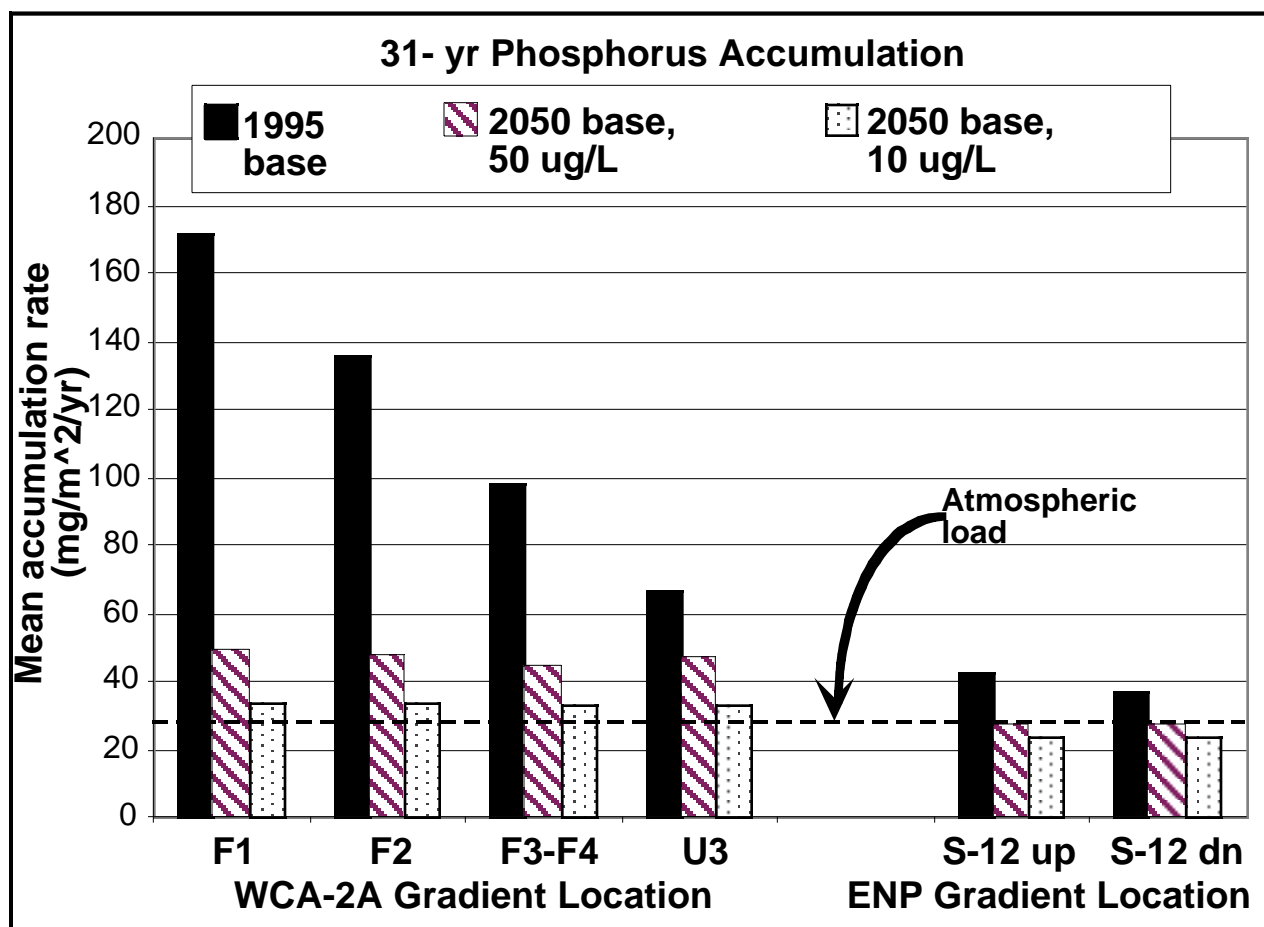
- biomass & community type
- tissue TP concentration



Model Application

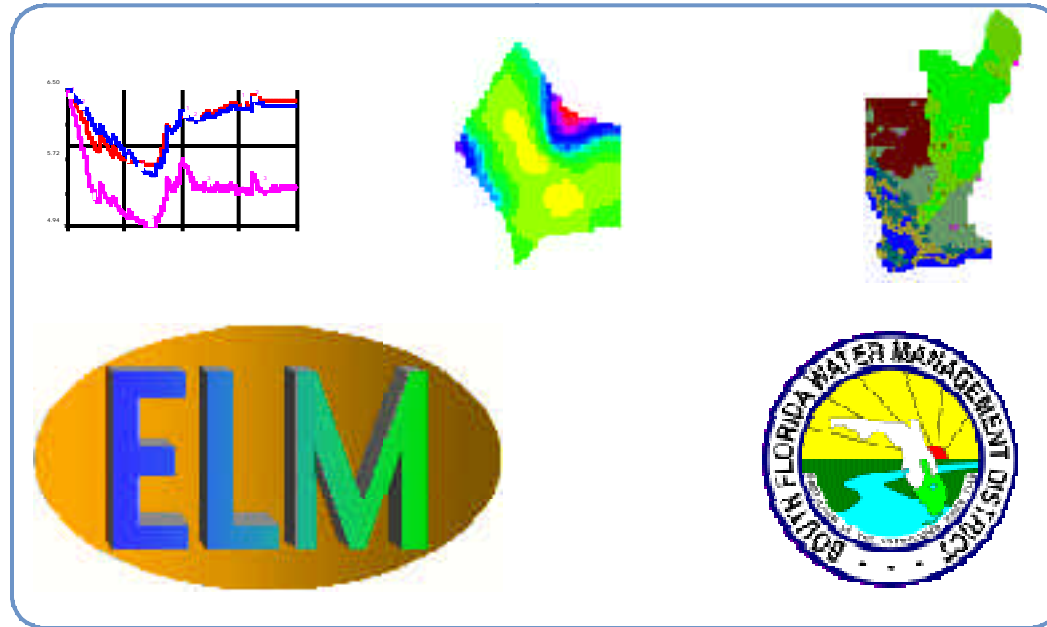
- Stormwater Treatment Areas
- Decreased P loading
- Altered flows
- Landscape response





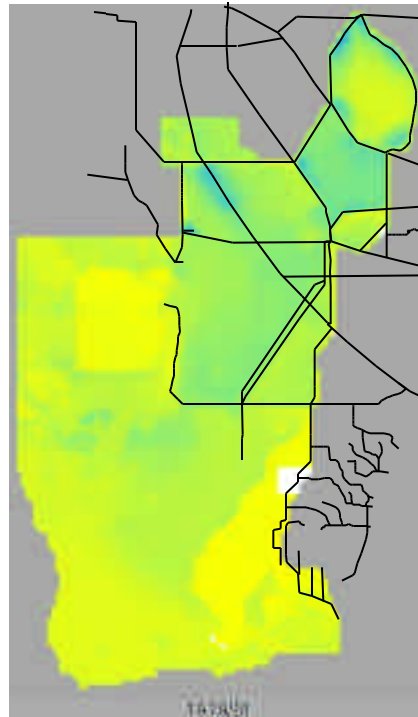
Conclusions

- 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



Status

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



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

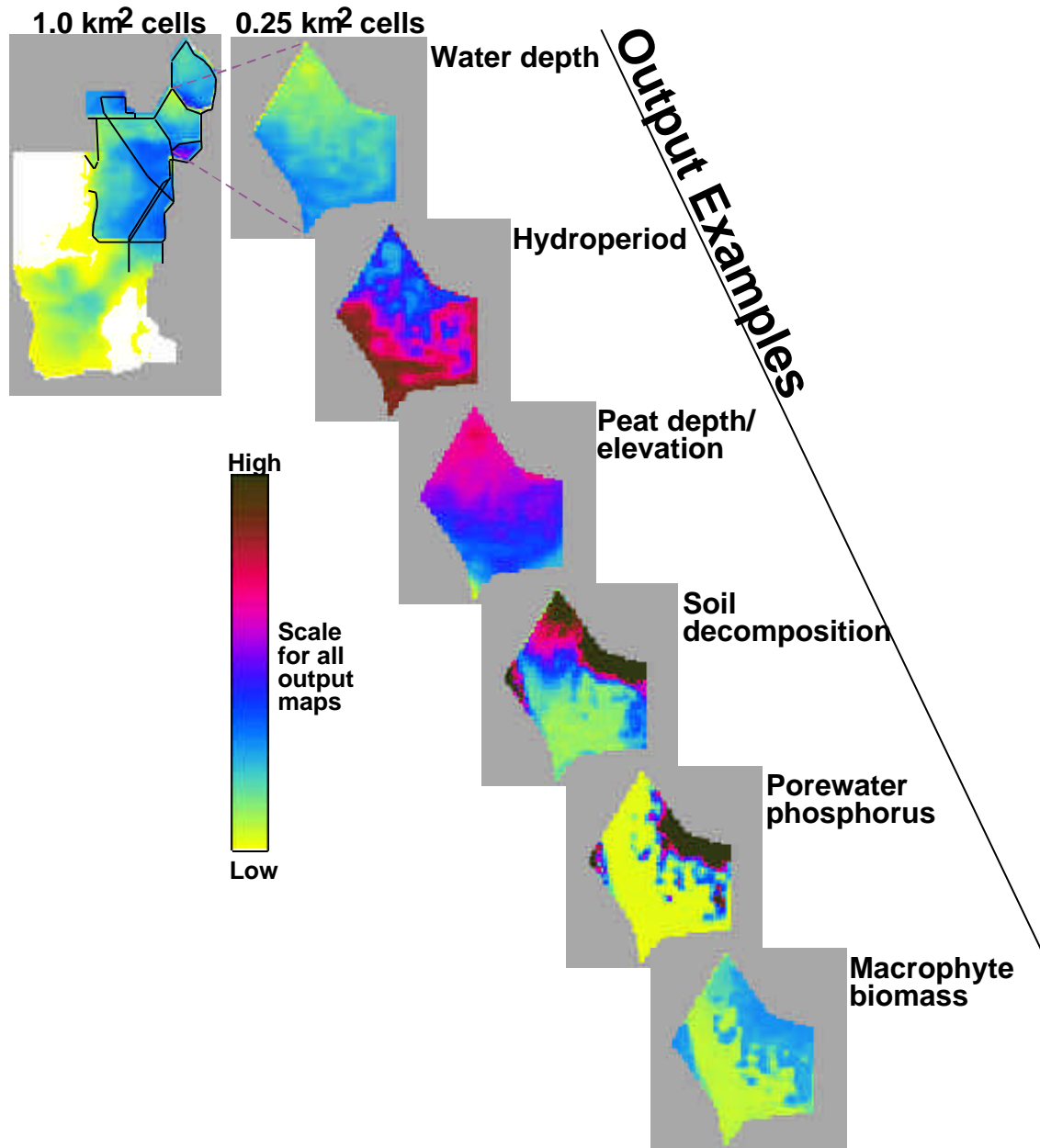
Documentation & Review

- **Web site**
 - § Data used in model development and model application
 - Descriptions of data on web site
 - All data on ftp link at web site
 - § Model structure
 - Documented in manuscripts and conceptual diagrams at web site
 - Detailed code descriptions on web site
 - All source code 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 Model Informational Workshops, including ELM
 - § Aug 7: Inter-agency review, organized by CERP-RECOVER Model Development and Refinement Team
 - § Soon?: SCT/RECOVER sponsoring independent peer review

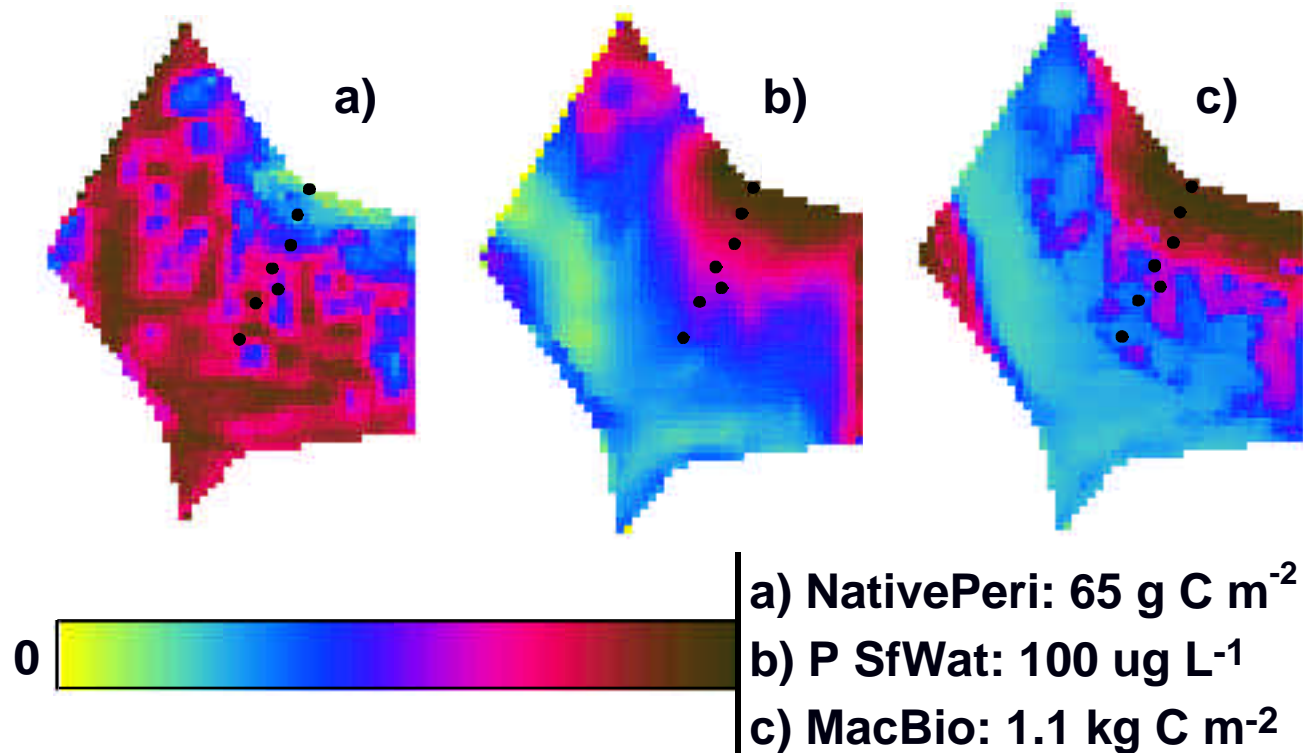
August 7 Goals

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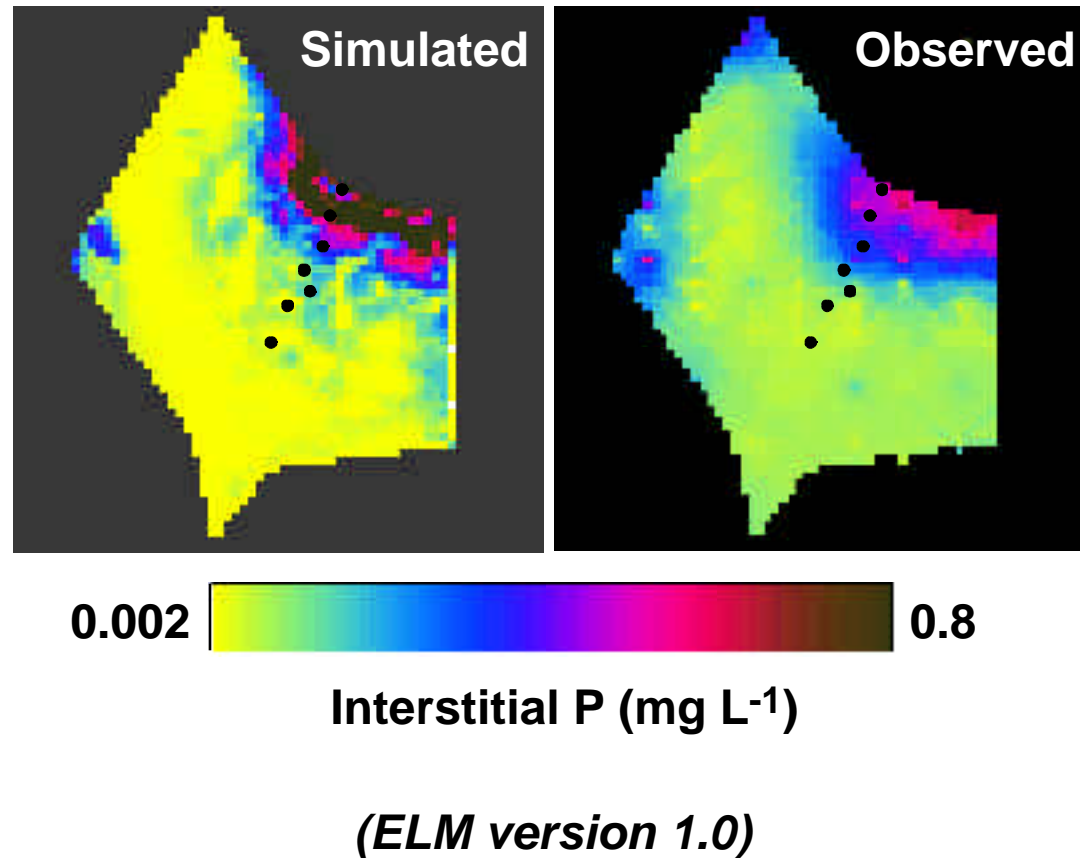
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Periphyton, phosphorus, and macrophyte patterns

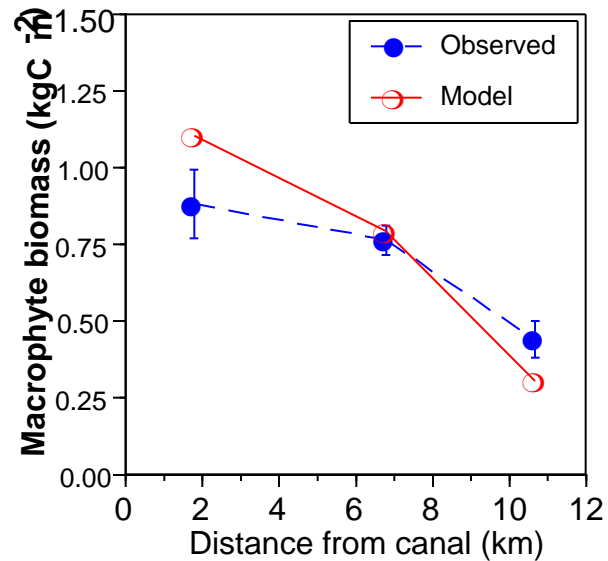
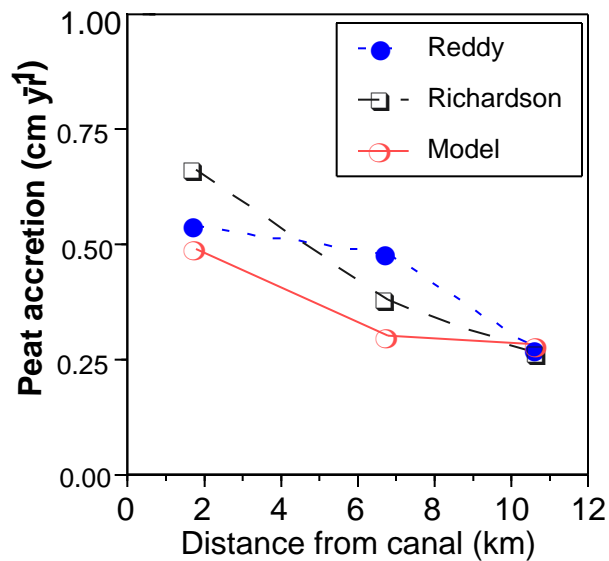
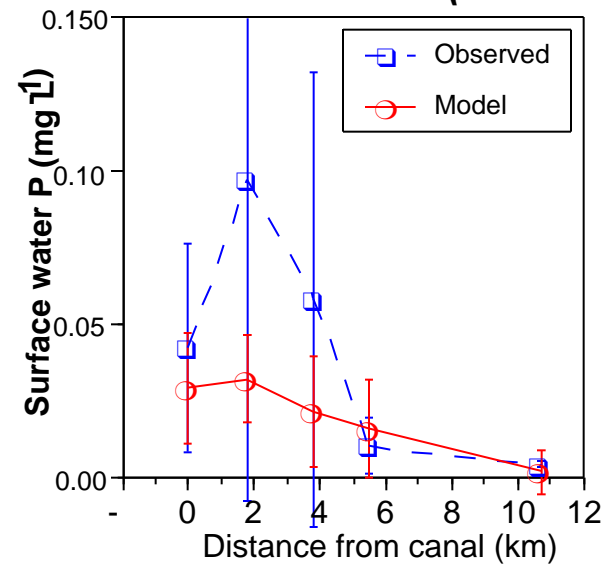
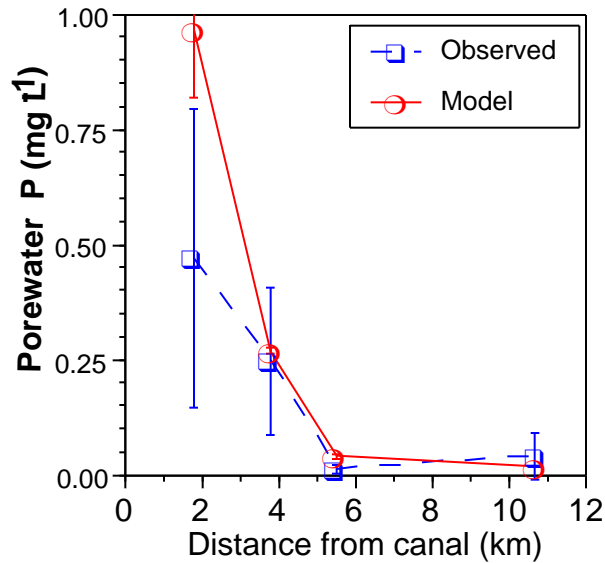


Soil porewater P calibration

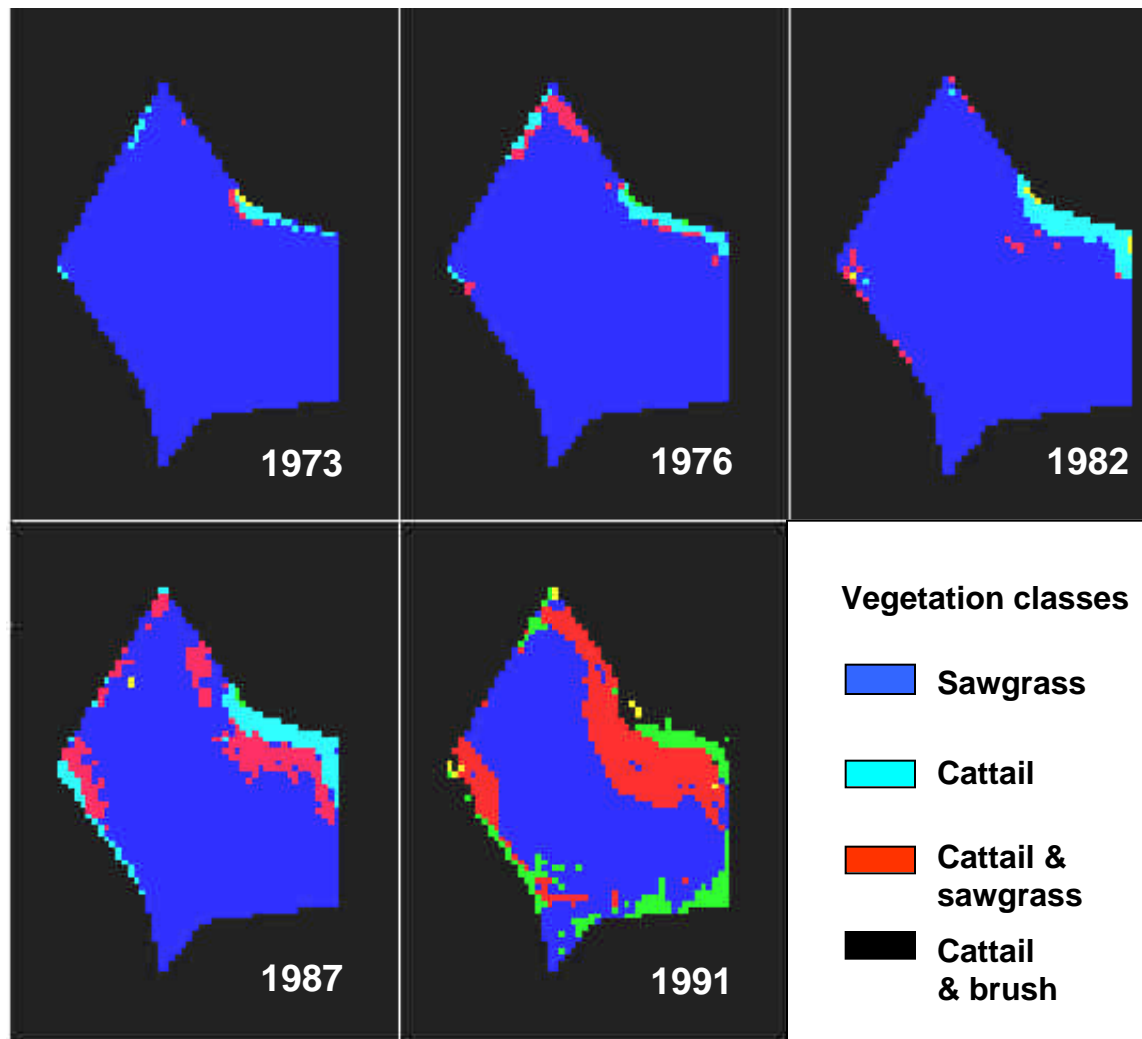


P, accretion, macrophytes calibration

(ELM version 1.0)

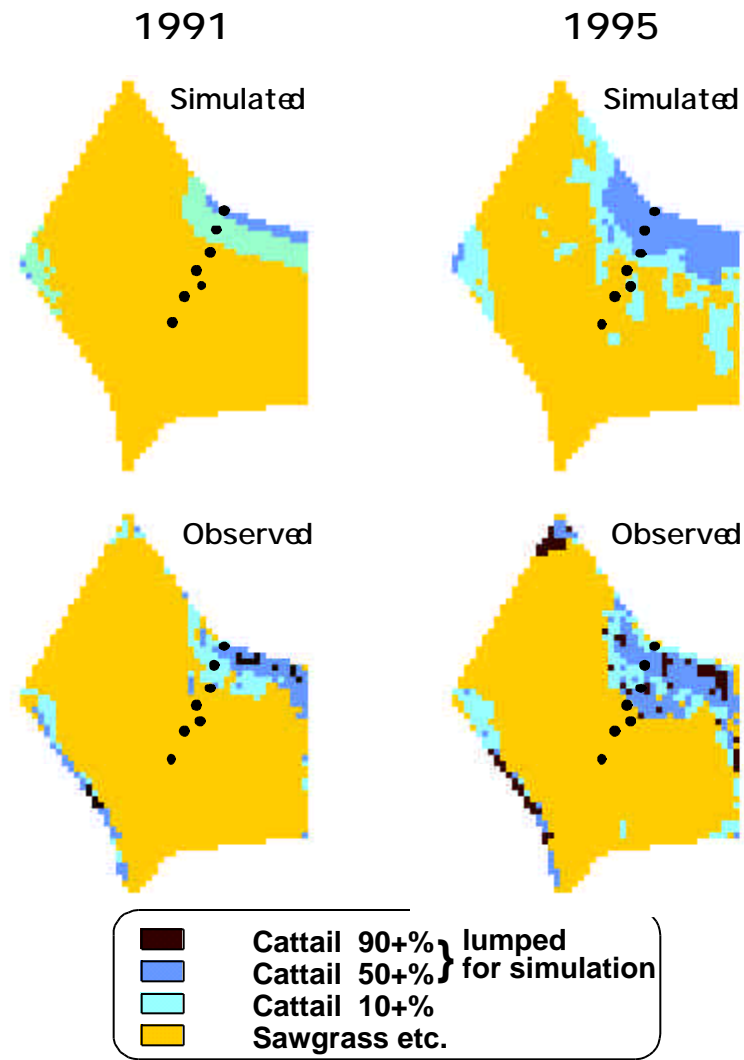


Cattail invasion: Water Conservation Area 2A

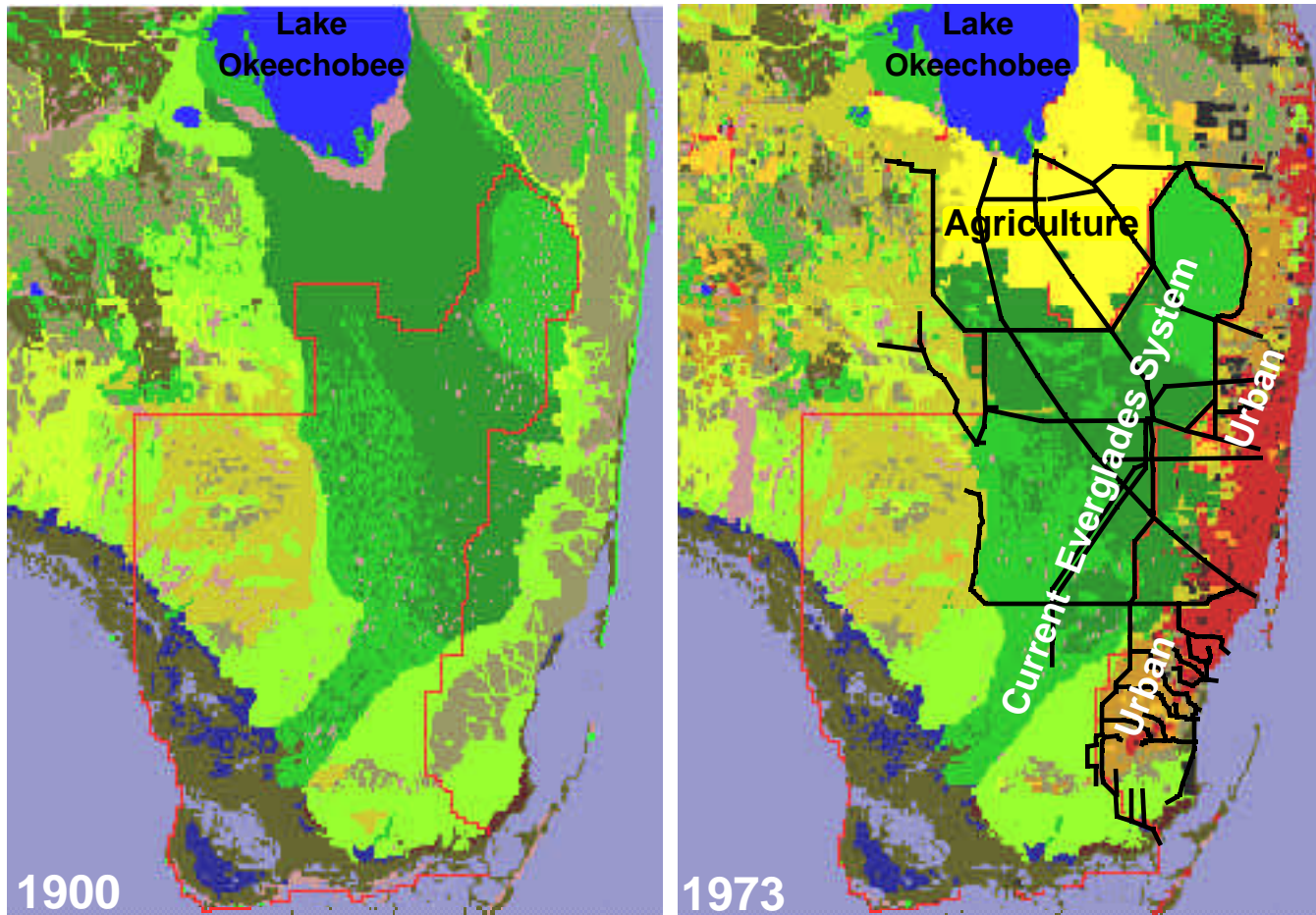


Vegetation change calibration

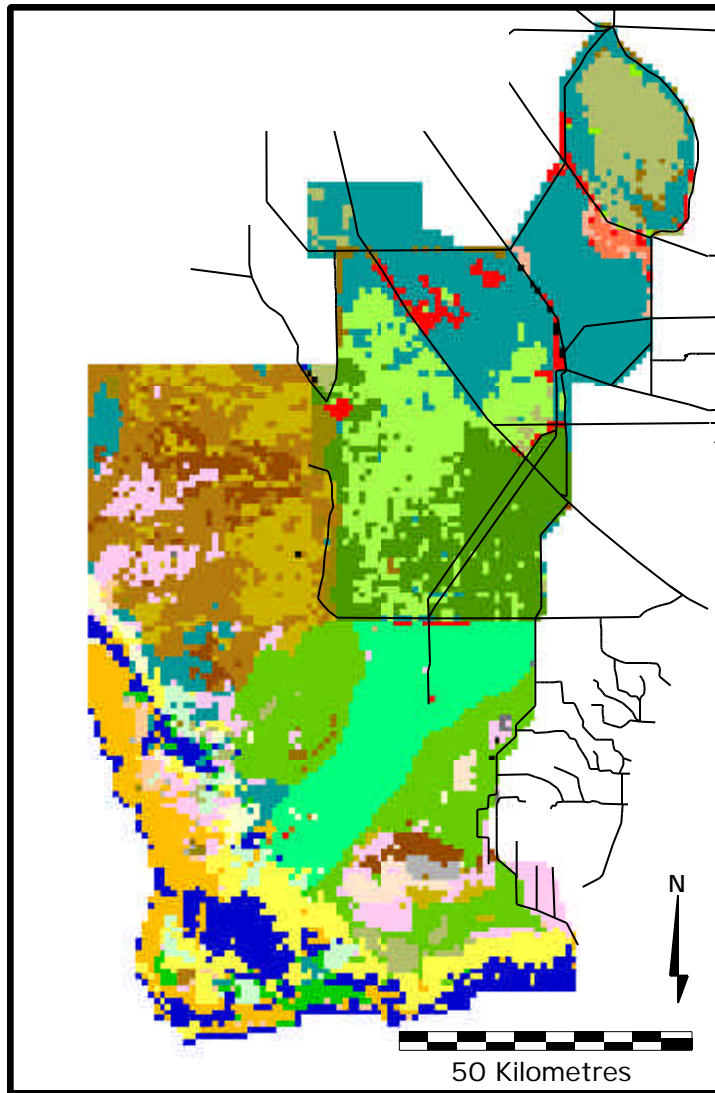
(ELM version 1.0)



Land use change: South Florida

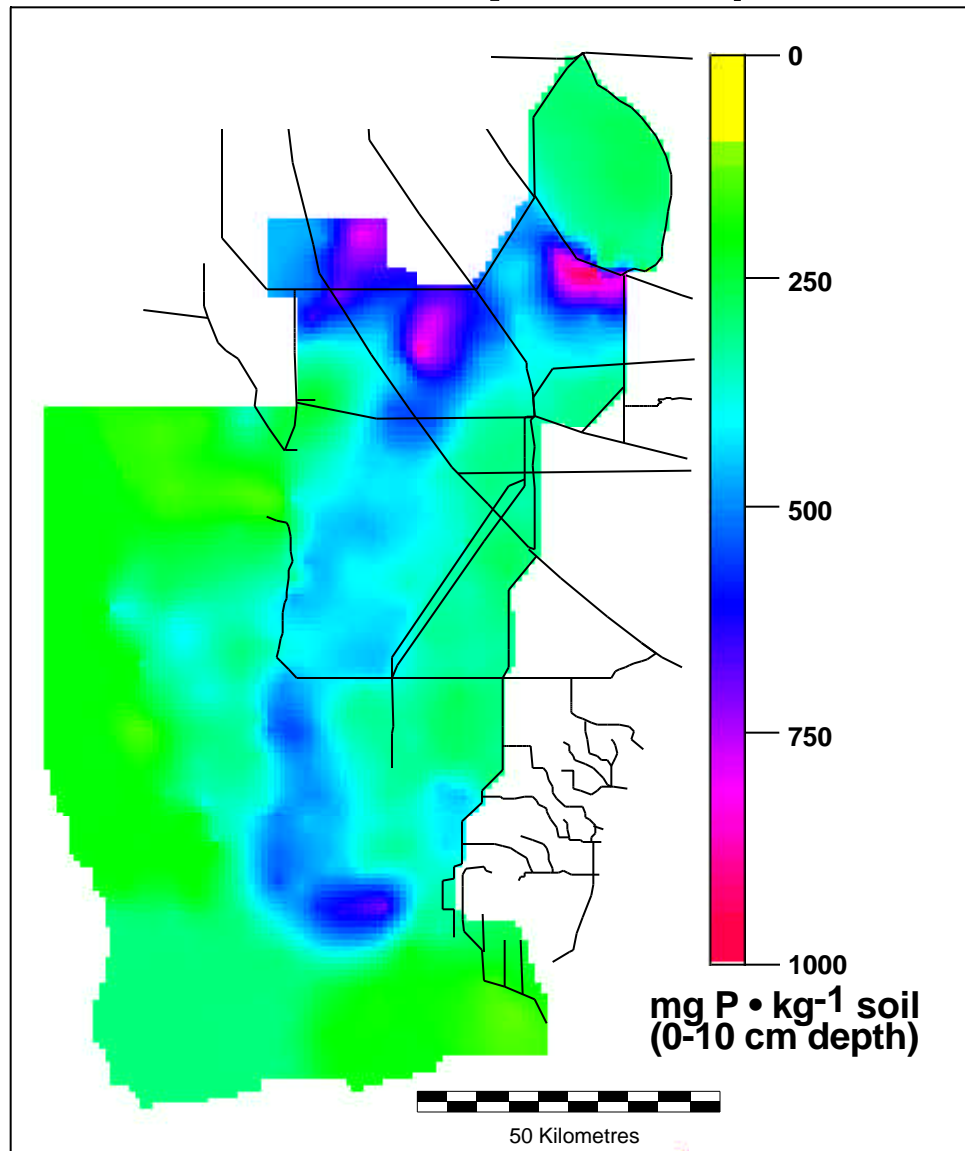


ELM vegetation classes, ca. 1995



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

Soil Total Phosphorus (ca.1995)



Example: P Accumulation in upper NESS

