Research Associated with the 1992 Settlement Agreement

Presentation to the Technical Oversight Committee
February 2008

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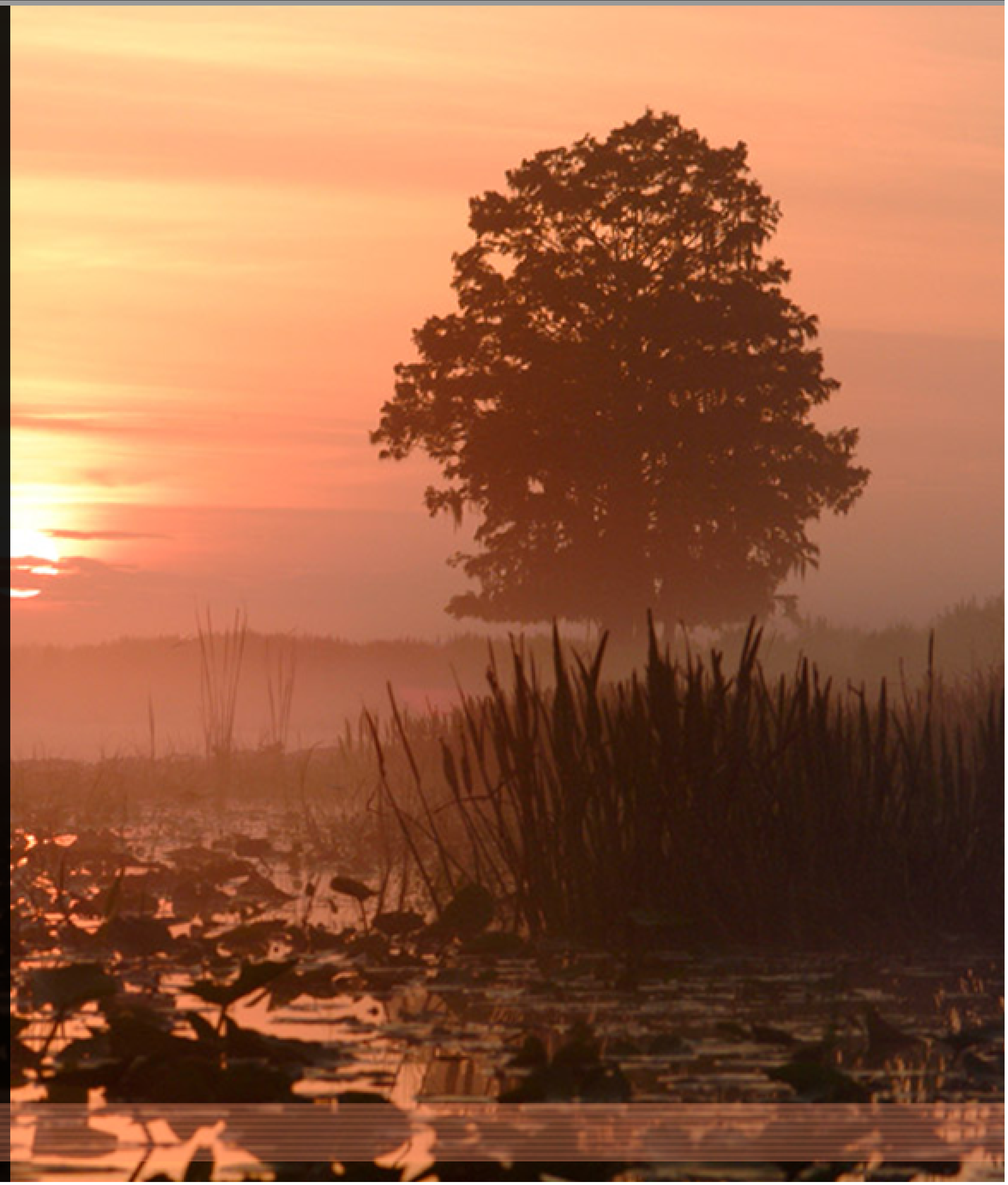
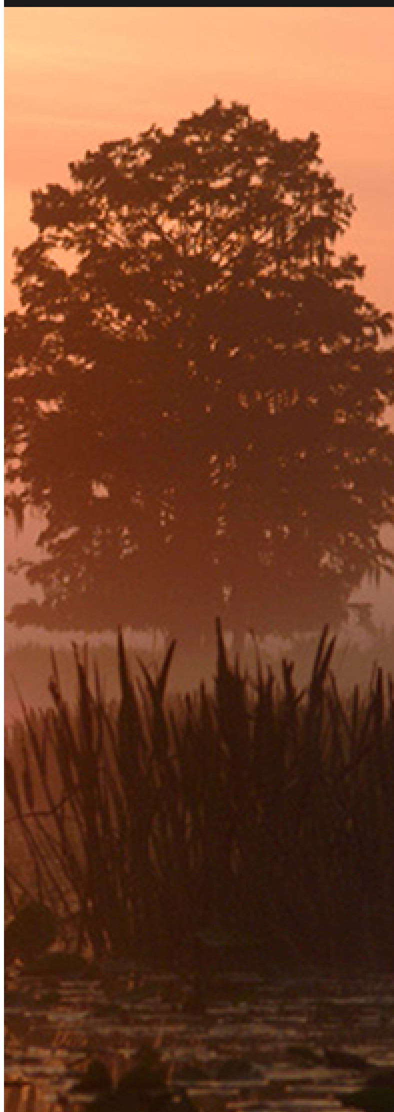
&
Dr. Fred Sklar, Dir.
Everglades Division



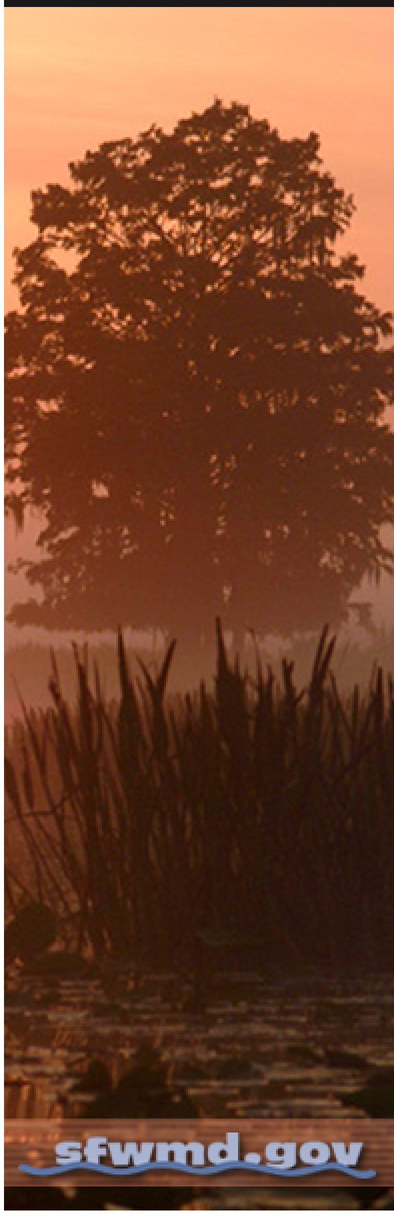
Research Objectives Specified in 1992 Settlement Agreement



- **1. “Numerically interpret the narrative Class III nutrient water quality criteria (i.e., the nutrient levels which cause an imbalance of flora and fauna in the units of the EPA);”**

- **2. “Assess current and continuing responses of the EPA to nutrient input levels resulting from the efforts to achieve interim and long-term concentration limits and levels.”**

Research Objectives of Everglades Systems Research Division, SFWMD 1992



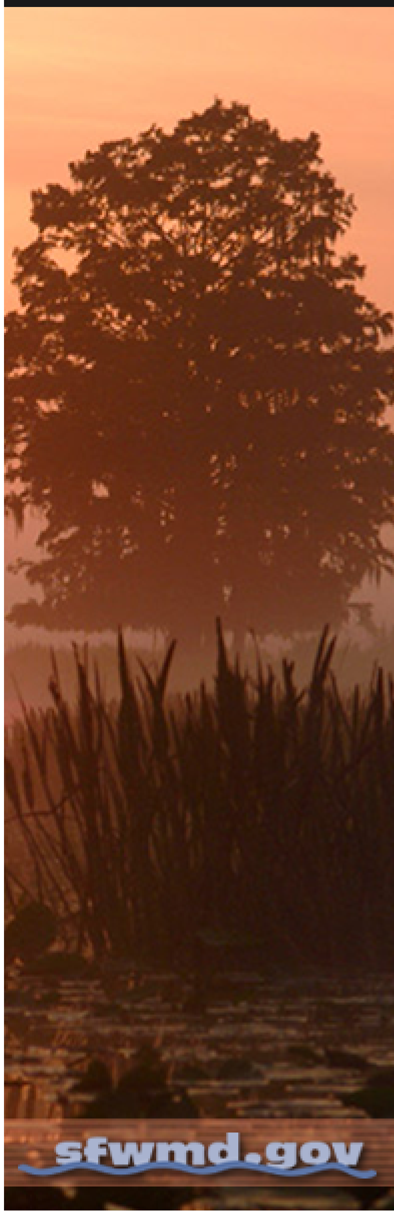
1. Conduct research to understand and predict hydrological, chemical, and ecological dynamics of the Everglades region.

2. Provide information and tools to decision makers for ensuring the restoration, protection, and enhancement of the Everglades.

3. Disseminate research findings through peer-reviewed scientific literature.

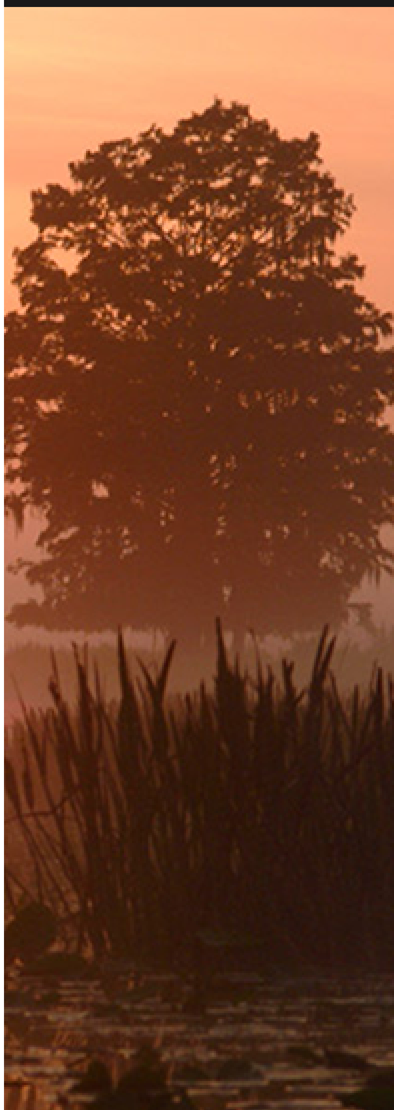
4. Coordinate research with outside agencies.

Research Components Specified in 1992 Settlement Agreement (Appendix D)



- **SA-1 Modeling Component**
- **SA-2 Existing Conditions Component**
- **SA-3 Imbalance Criteria Component**
- **SA-4 STA's & BMP's Components**

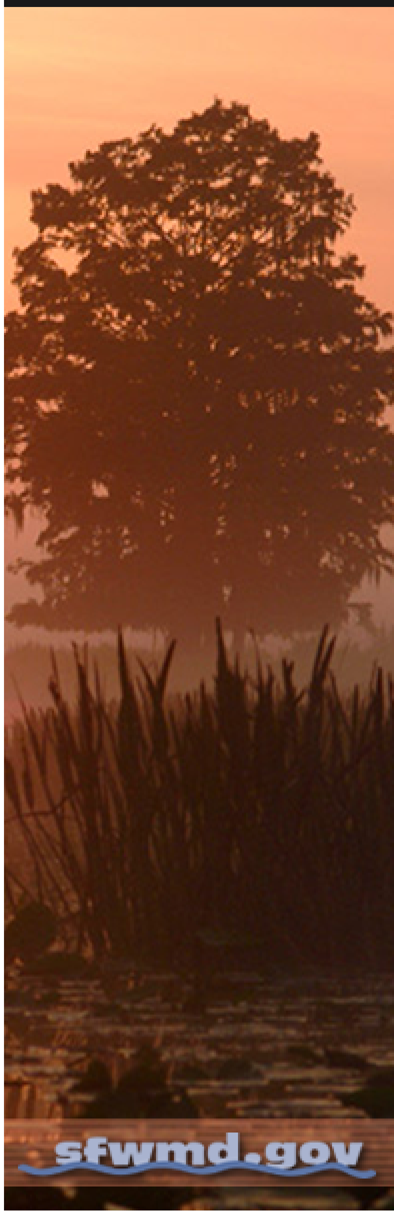
Peer Review of Research Approach and Results



Scientific panels were created to review both the experimental design phases and the final results, e.g.

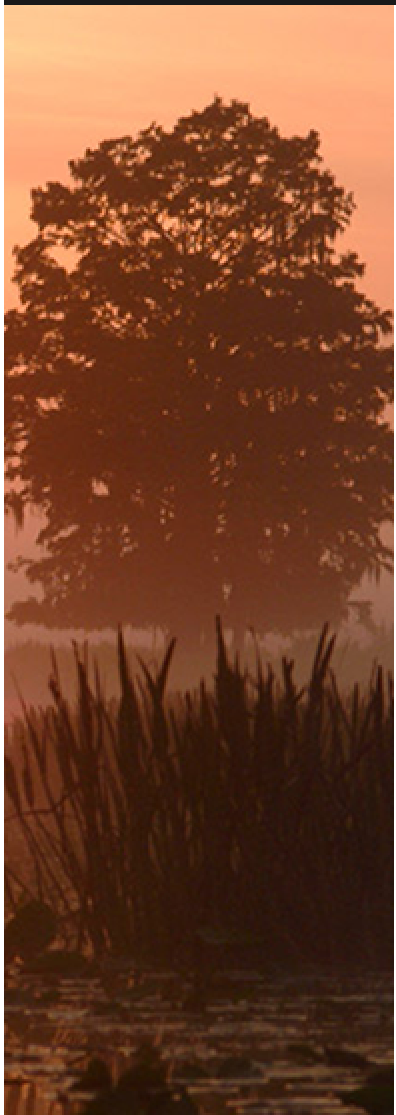
1. **Nutrient Threshold Panel (TOC)**
2. **South Florida Environmental Report**
3. **ELM Evaluation Panel**
4. **Peer Reviewed Publications**

SA-1 Modeling Component



- **"Initiate, develop, collect appropriate additional data for and complete detailed modeling efforts to measure quality and quantity impacts of system operation and alternatives for the purpose of improving water quality in the Everglades system."**

Examples of Numerical Modeling of the Everglades: 1) SAWCAT 2X2 Probability Model

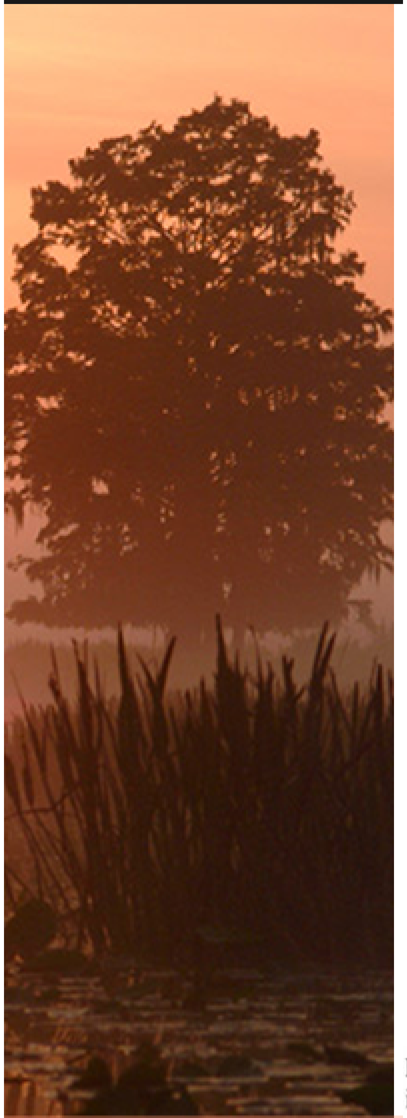


	Cattail	Sawgrass
Sawgrass	Probability of cell changing to cattail from sawgrass	Probability of cell remaining sawgrass if current cell is sawgrass
Cattail	Probability of cell remaining cattail if current cell is cattail	Probability of cell changing to sawgrass from cattail

$$P = e(P_{Adjacent} + P_{Depth} + P_{TP})$$

Source: Wu, Y., F.H. Sklar and K. Rutchey. 1997. Analysis and simulations of fragmentation patterns in the Everglades. Ecol. Application. 7(1):268-276

SAWCAT Model Results



FRAGMENTATION PATTERNS IN THE EVERGLADES

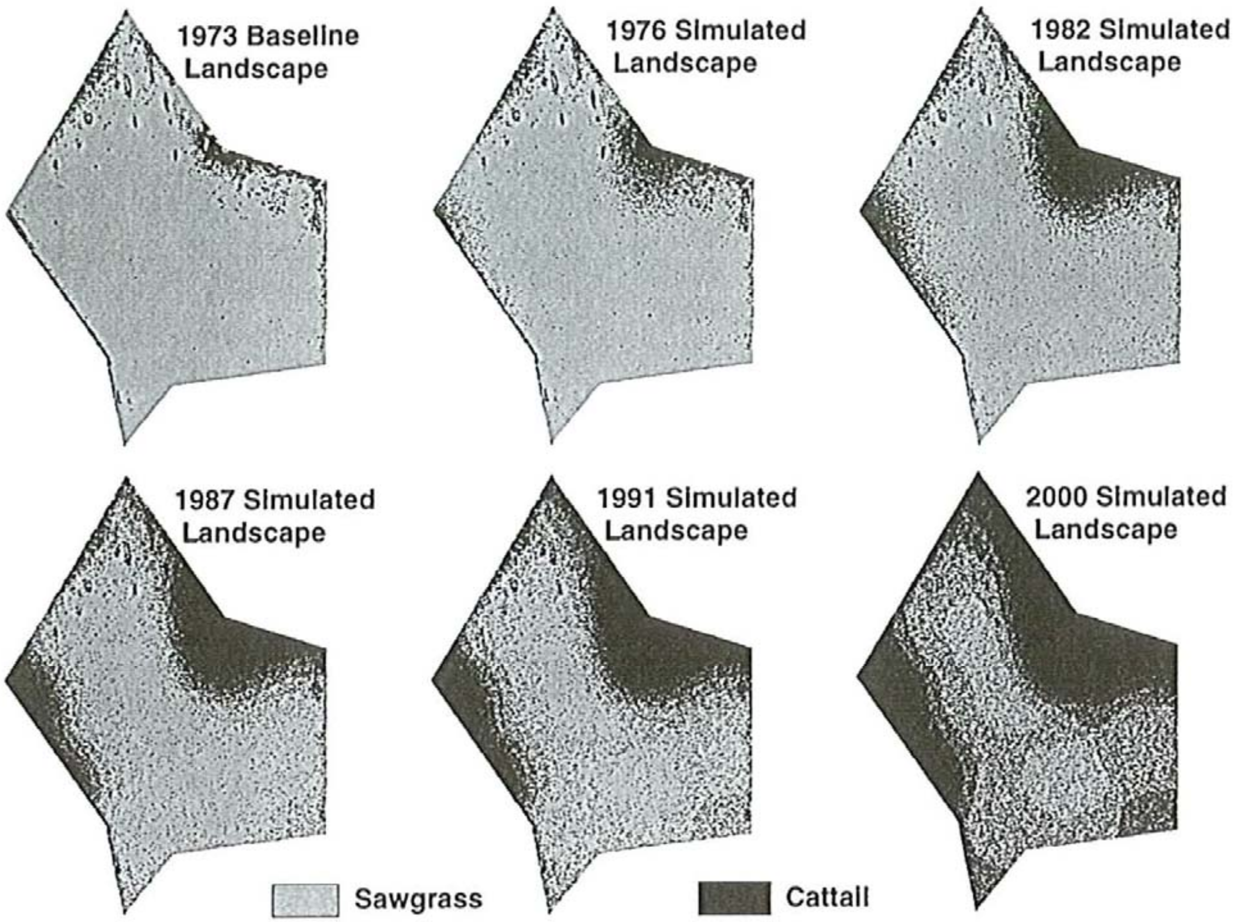
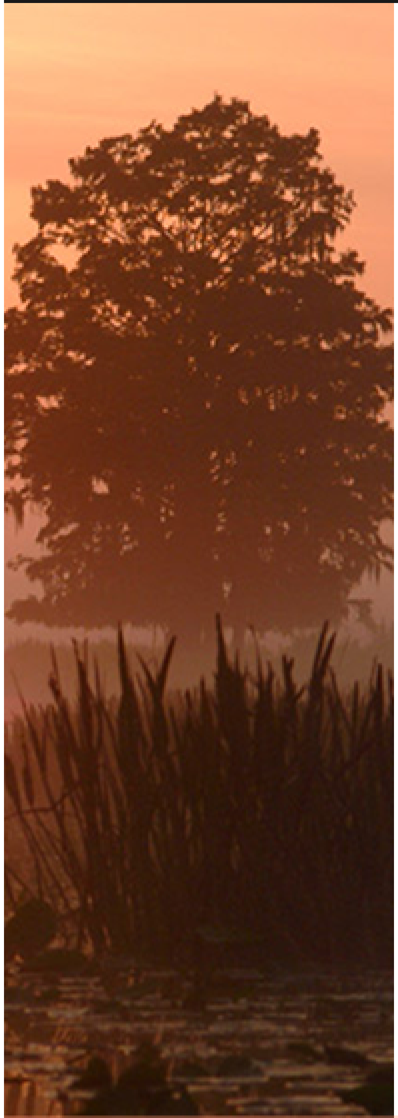


FIG. 4. Simulated landscapes of 1976, 1982, 1987, 1991, and 2000. Note that the 1973 landscape was used as the initial landscape. The spatial patterns match the actual landscapes with an overall accuracy of 0.728 compared to the actual landscape in Fig. 2.

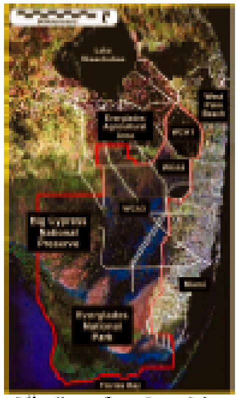
Source: Wu, Y., F.H. Sklar and K. Rutchey. 1997. Analysis and simulations of fragmentation patterns in the Everglades. Ecol. Application. 7(1):268-276

Examples of Numerical Modeling of the Everglades: 2) The Everglades Landscape Model



Everglades Landscape Model (ELM)

Documentation of the
Everglades Landscape Model:
ELM v2.5



http://my.sfwmd.gov/elm

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Beheen Trimble

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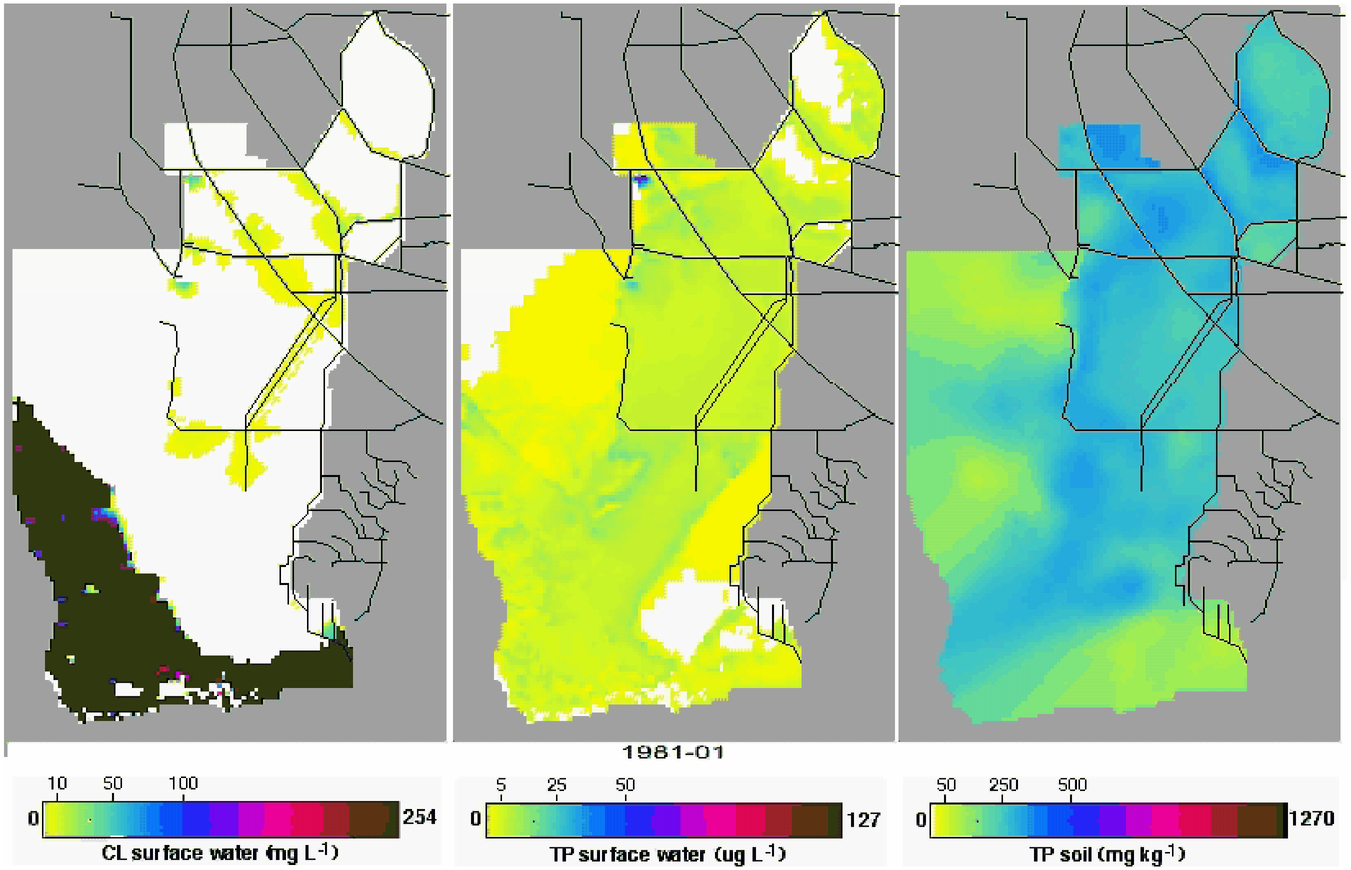
West Palm Beach, FL 33406

[1] 7512 Model Application Support Unit
Hydrologic & Environmental Systems Modeling Dept.

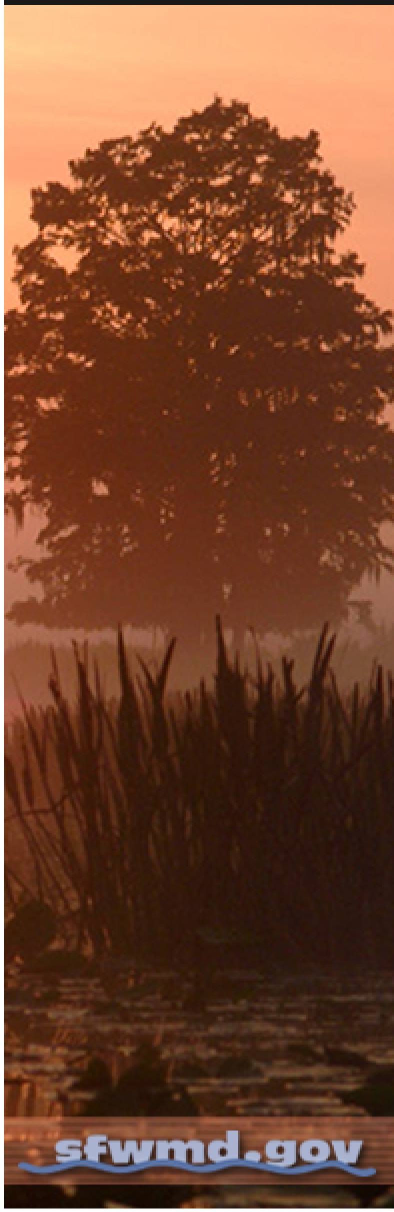
July 10, 2006

ELM v2.5 Simulation- Cl, TP and soil TP
(Monthly 1981-2000)



Source:www.sfwmd.gov/elm

SA-1 Modeling Component

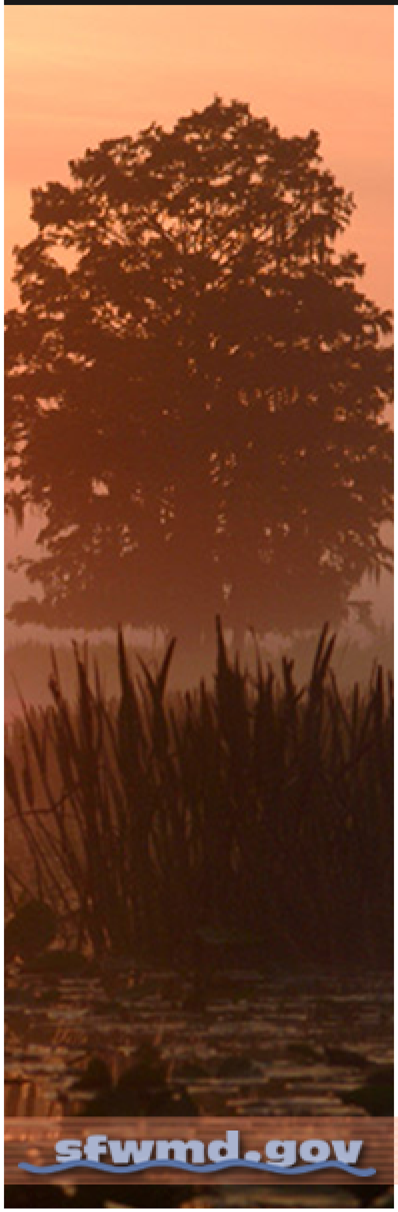


The District's 1994 research plan created a program to enhance the SFWMM and the NSM, while developing/or contributing data to new spatially-explicit ecosystem models including the:

- **Everglades Landscape Model (ELM)**
- **Sawgrass/ cattail probability model (SAWCAT)**
- **Everglades Water Quality Model (EWQM)**
- **Wetlands Water Quality Model (WWQM)**

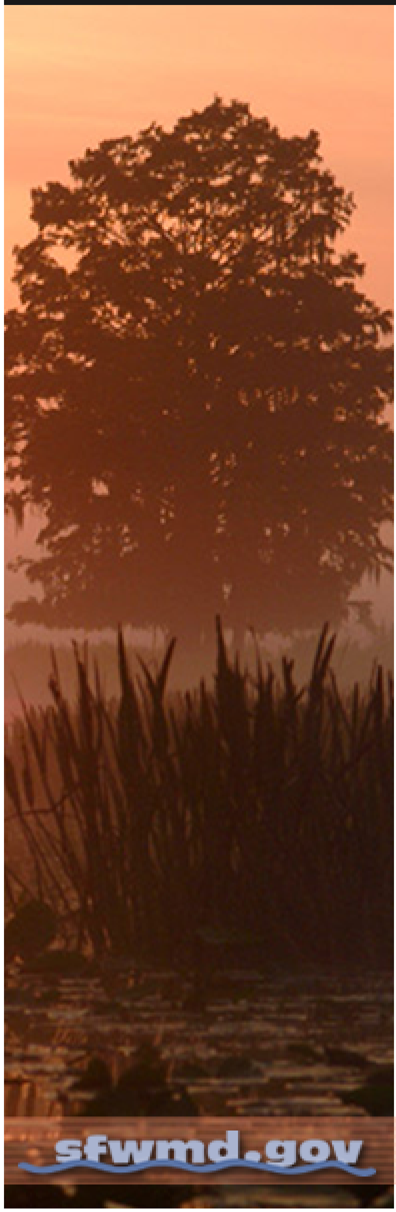
- **Dynamic Model for Stormwater Treatment Areas (DMSTA)**
- **Everglades Phosphorus Gradient Model (EPGM)**

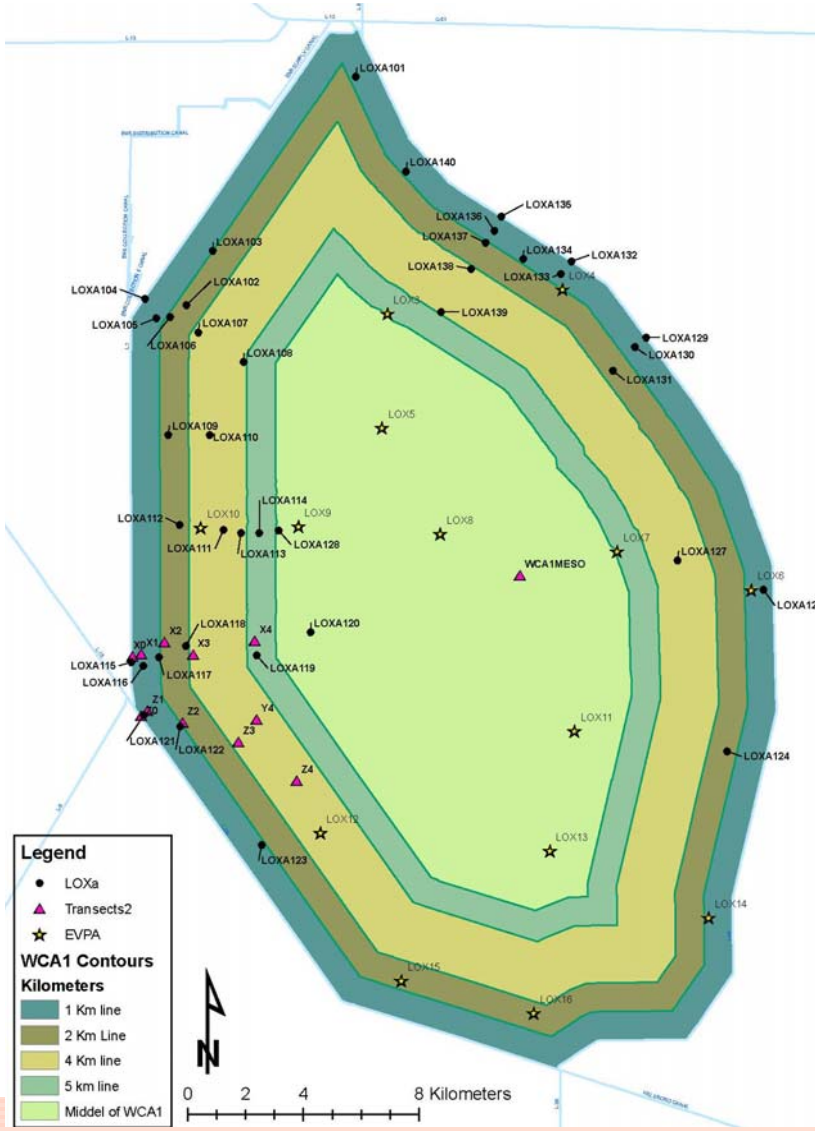
SA-2 Existing Conditions Component



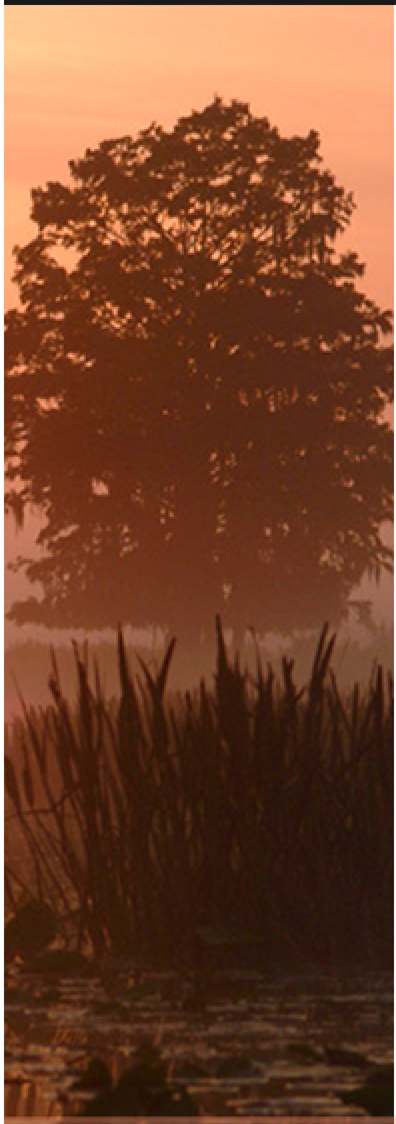
- **"Develop a research program to determine the existing conditions and if additional damage to the Refuge and Park marshes has occurred due to interim delivery levels of total phosphorus or if reversal of damage are evident."**

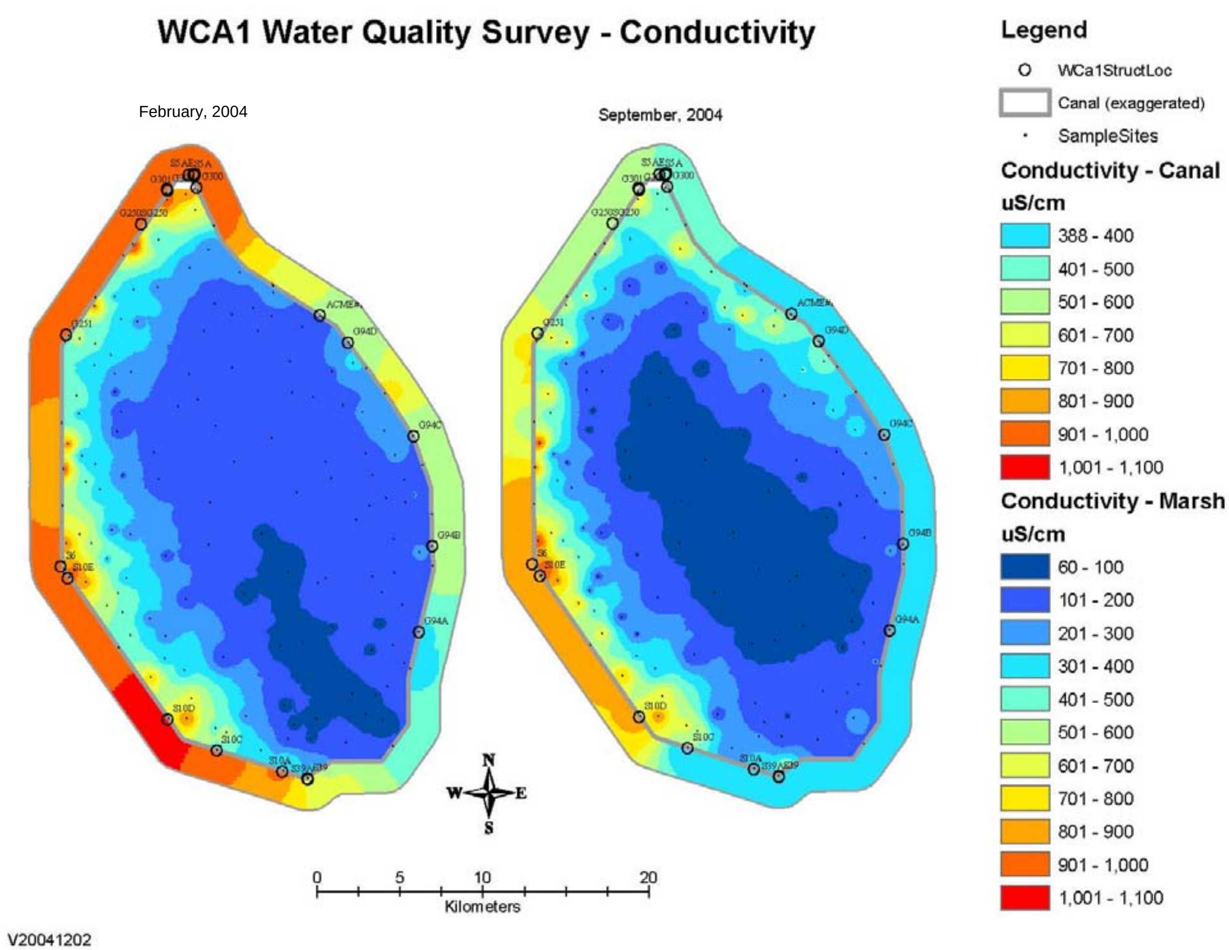
SA-2: Water Quality Monitoring throughout the Everglades Protection Area: e.g., WCA1



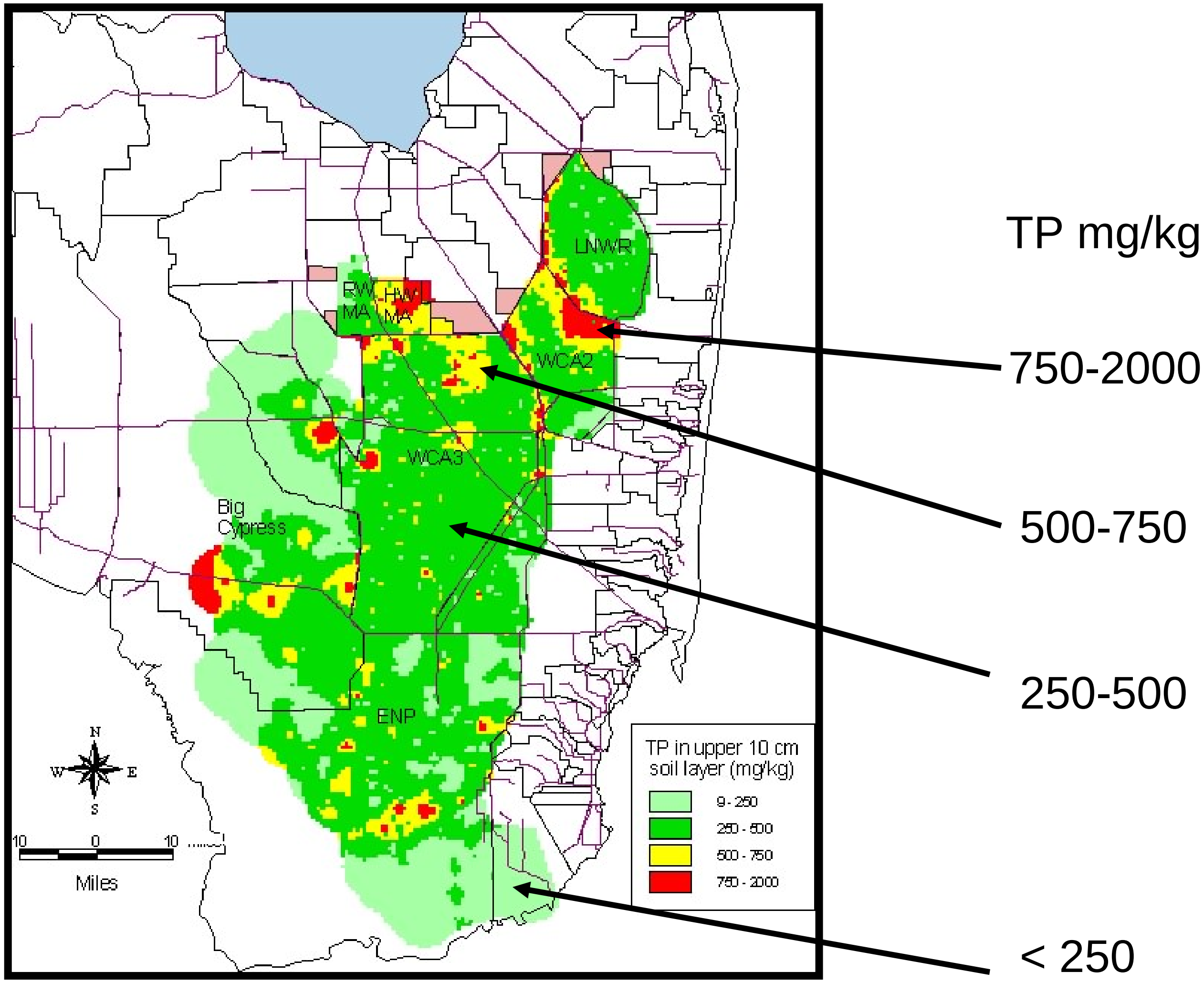


SA2- Continued Evaluation of Water Quality Effects



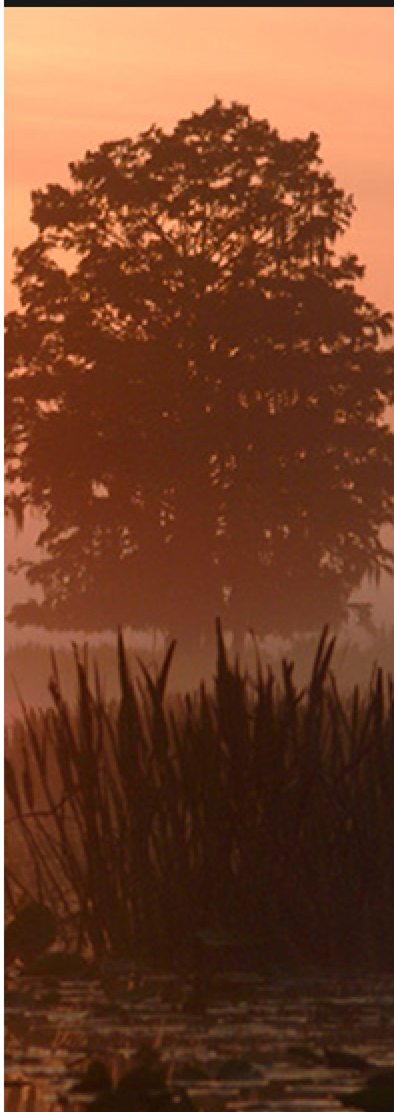


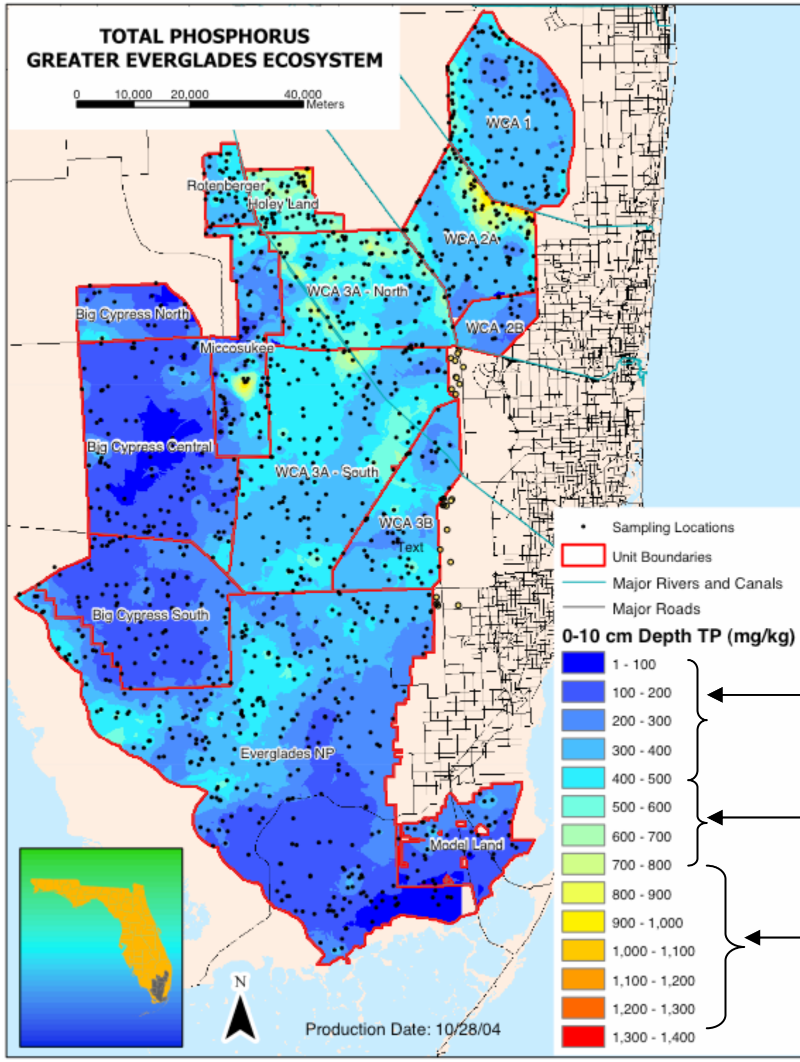
SA-2 Existing Conditions: Surface 0-10 cm Total Phosphorus 1992-1995



Data sources: REMAP 1999; Reddy et al., 1991,1994; DeBusk et al., 2001, S.M. Smith unpublished data; S. Newman, unpublished data Pink areas reflect locations of Stormwater Treatment Areas

SA-2 Current Conditions: Soil 0-10 cm Total Phosphorus 2003





TP mg/kg

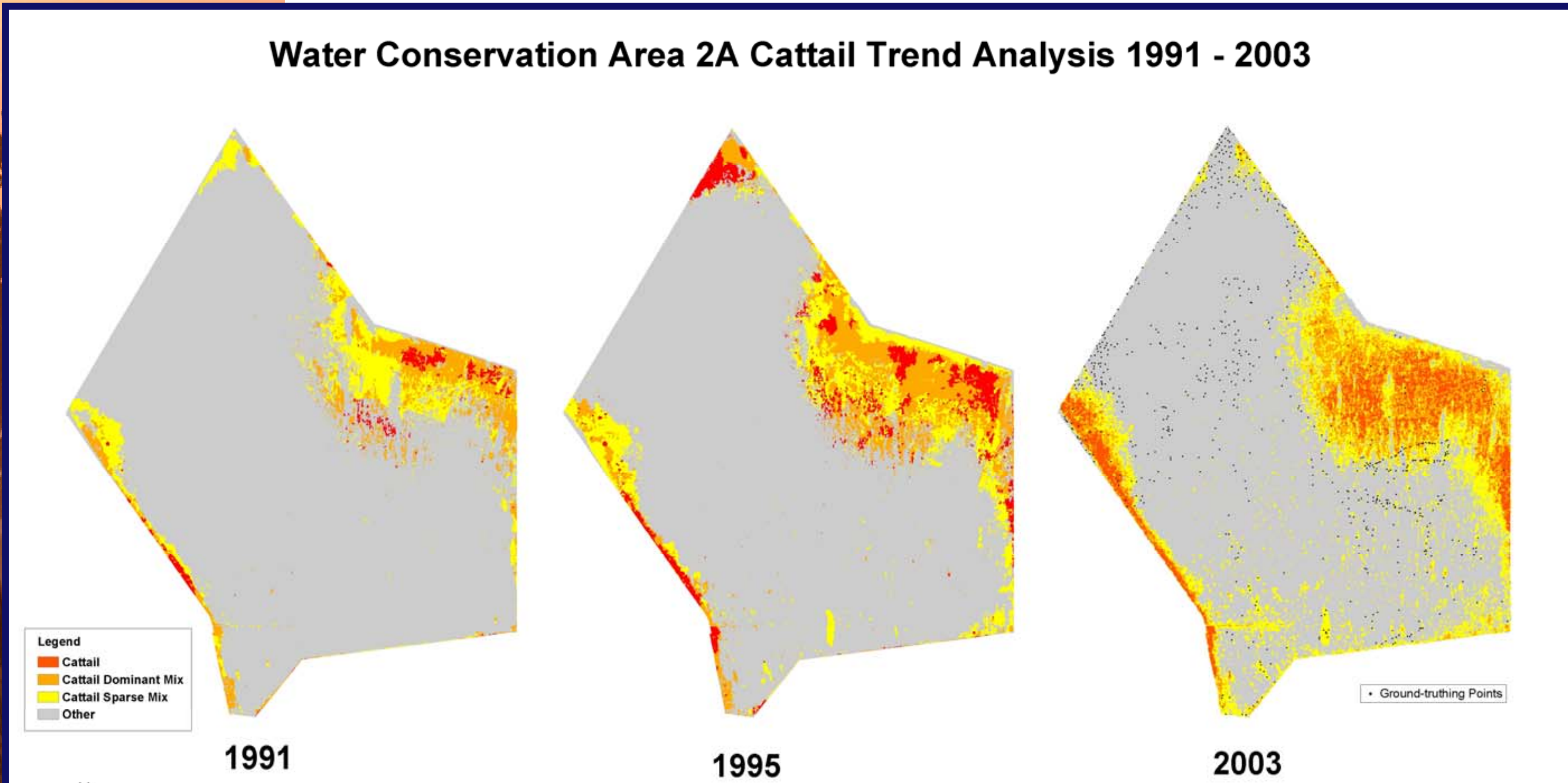
<500

500-800

800-1400

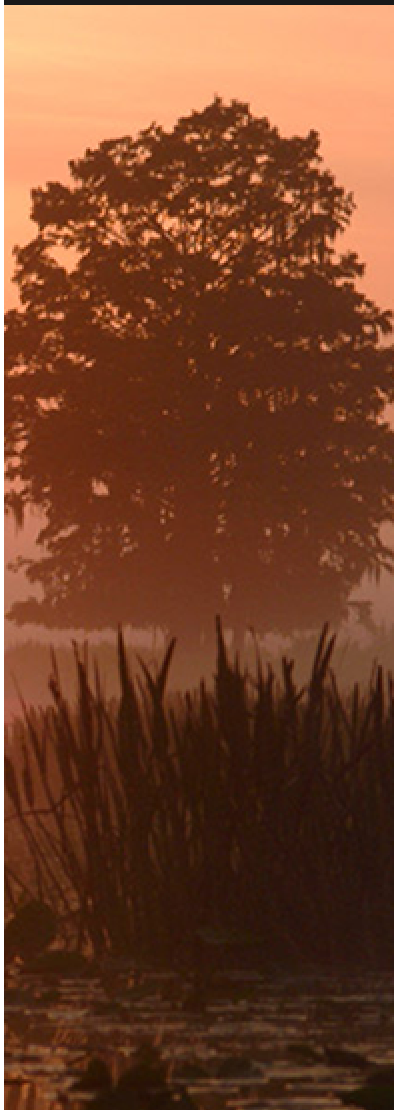
Source: Newman, Reddy & Osborne. Publications: Grunwald et al., 2004; Corstanje et al., 2006; Bruland et al., 2006, 2007; Rivero et al., 2007

SA-2 Existing and Changing Conditions



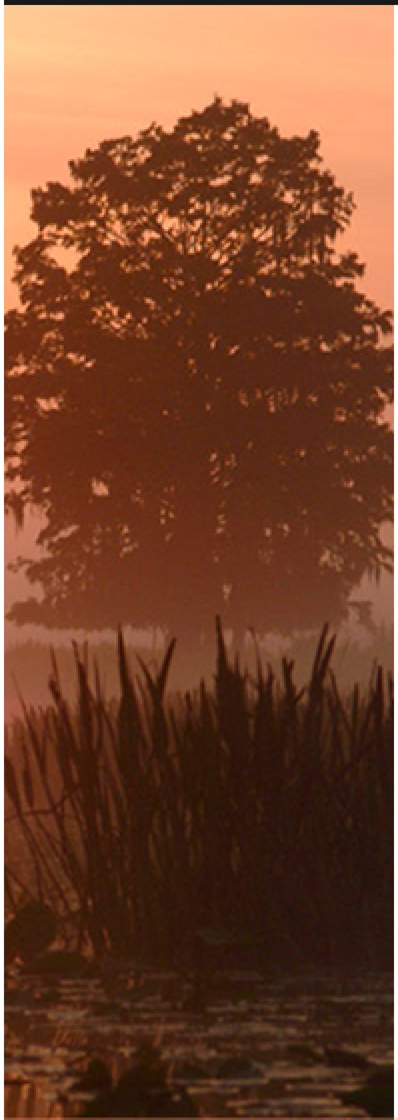
Source: Rutchey, Schall and Sklar (in review)

SA-3 Imbalance Criteria Component



- “Develop a program that will include experimental approaches to interpret the Class III nutrient criterion regarding imbalances of flora and fauna.”

SA-3
Research Program to Interpret Class III Water Quality Criteria



Approach:

- Gradient Studies
- Field Dosing Studies
  - District Mesocosms
  - FIU Flume Dosing Study
- Greenhouse & Laboratory Studies

Collaborators:

DEP, USEPA, UF, FAU, LSU, FIU

SFWMD Approach to Phosphorus Threshold Research

Experimental Type	Realism	Scale	Experimental Control	Statistical Power
Natural Expts (Gradient)	High	Large	Low	Low-Moderate
Field Mesocosms	Moderate	Medium	Moderate-High	Moderate
Greenhouse Expts	Moderate-Low	Small	High	Moderate-High
Microcosm/ Laboratory Expts	Low	Small	High	High

Duration and Frequency of Phosphorus Threshold Research Program

Gradient

- 1994 , 1996, 1999

•Diel, monthly, quarterly, semi-annually, annually, bi-annually

Field Mesocosms

- Dosing 1995, 1996, 1999 1-5 yrs
- Diel, weekly, bi-weekly, monthly, quarterly,semi-annually, annually

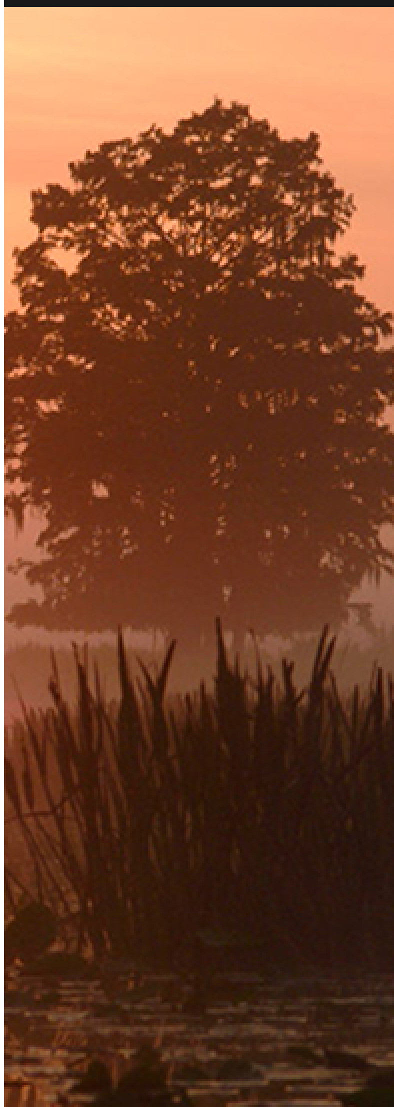
Greenhouse Expts

- Months - 2 years
- Daily, weekly, monthly

Microcosm/lab Expts

- Weeks - months
- Daily, weekly, monthly

Specifics of Gradient and Dosing Studies

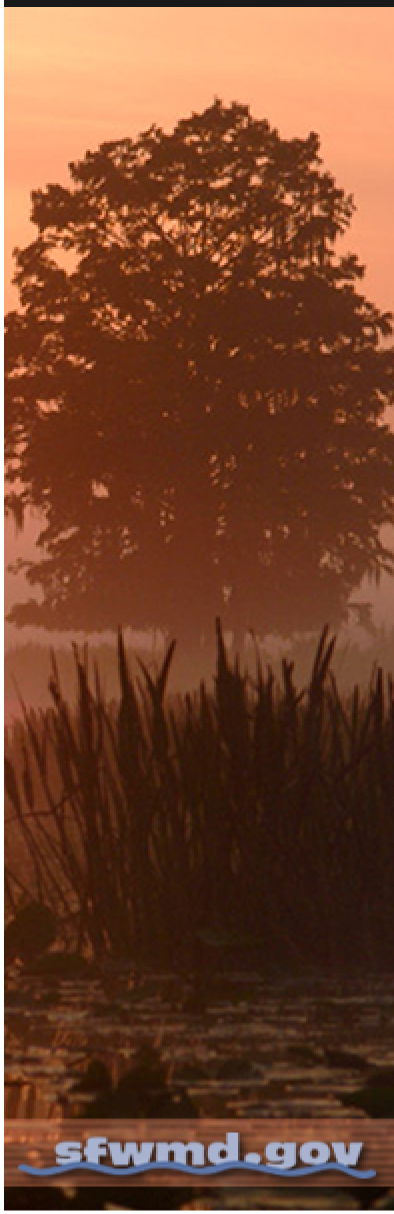


- **WCA-2A transects 1994-present.**
- **WCA-2A mesocosms June 1995; dosing ended April 2000. Monitored recovery through 2007.**

- **WCA1 transects 1996- present**
- **WCA1 mesocosms May 1996; dosing ended Nov 2000. Monitored recovery through 2007.**

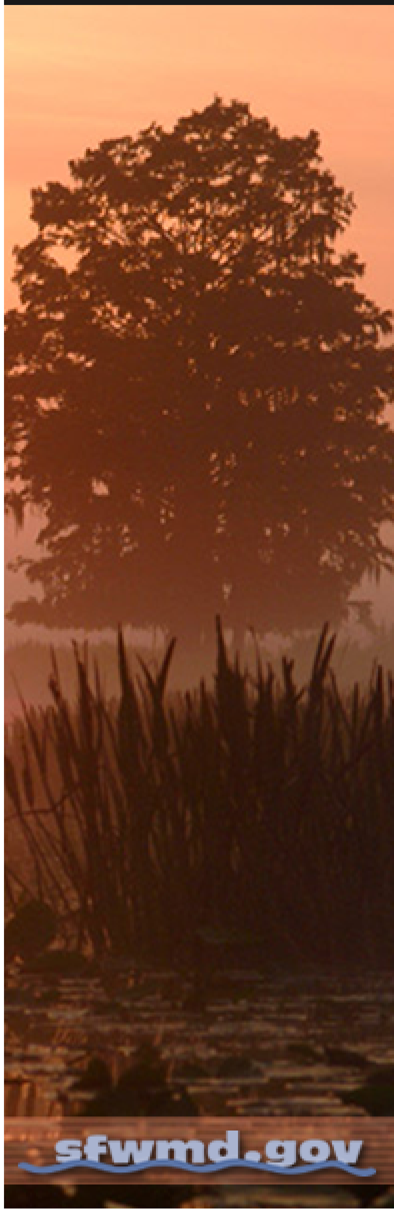
- **WCA-3 and Taylor Slough transects & mesocosms Nov 1999; dosing ended Nov 2000**

Chemistry

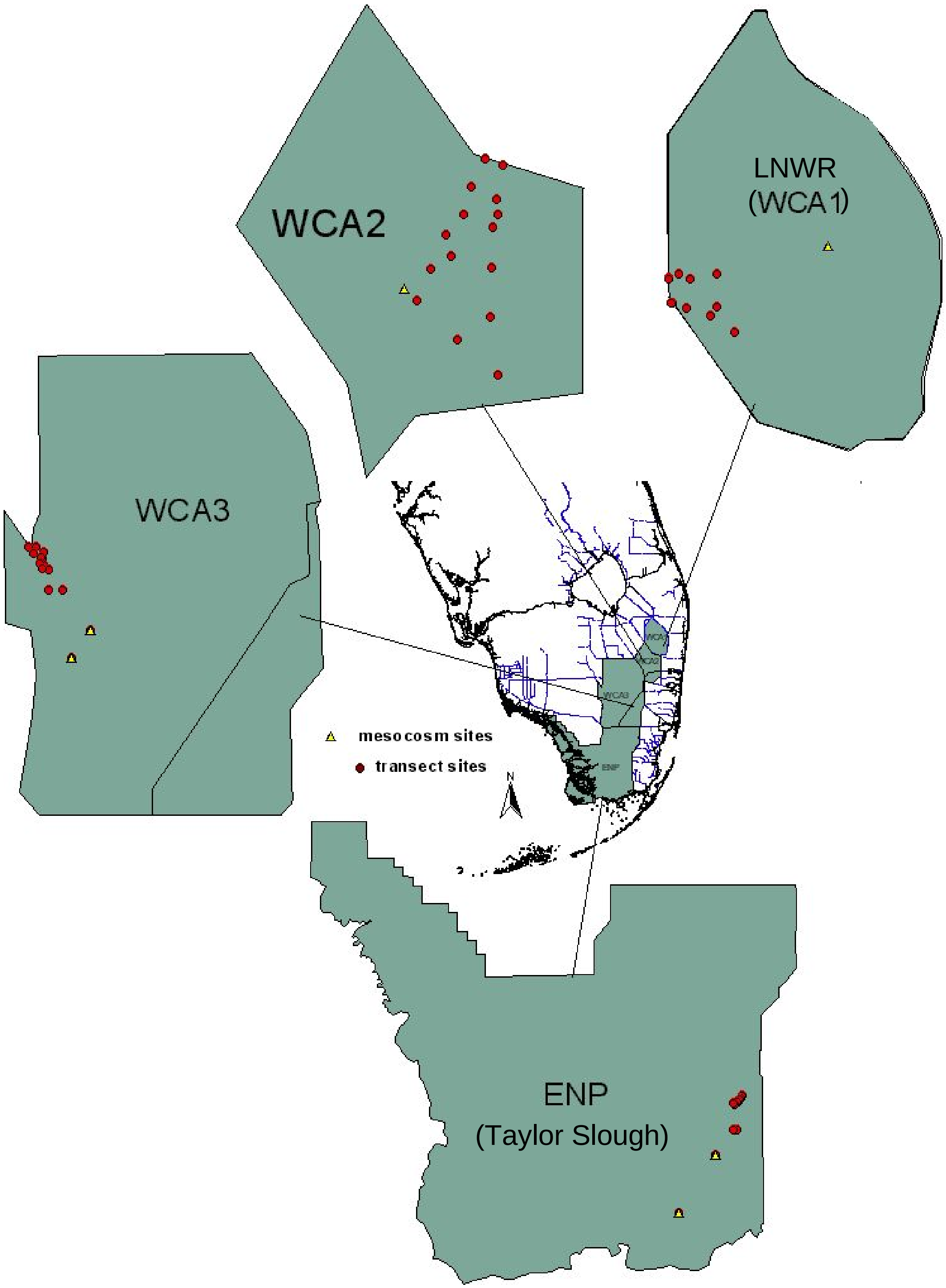


- Field/Laboratory/Internal QA/QC
  - SOPs
  - QA/QC -blanks, duplicates (triplicates, composites), spikes
- Surface and porewater analyzed by DEP using standard methods
- Soils/macrophytes-State-approved contract labs using standard methods
- Fixed sites

Biology



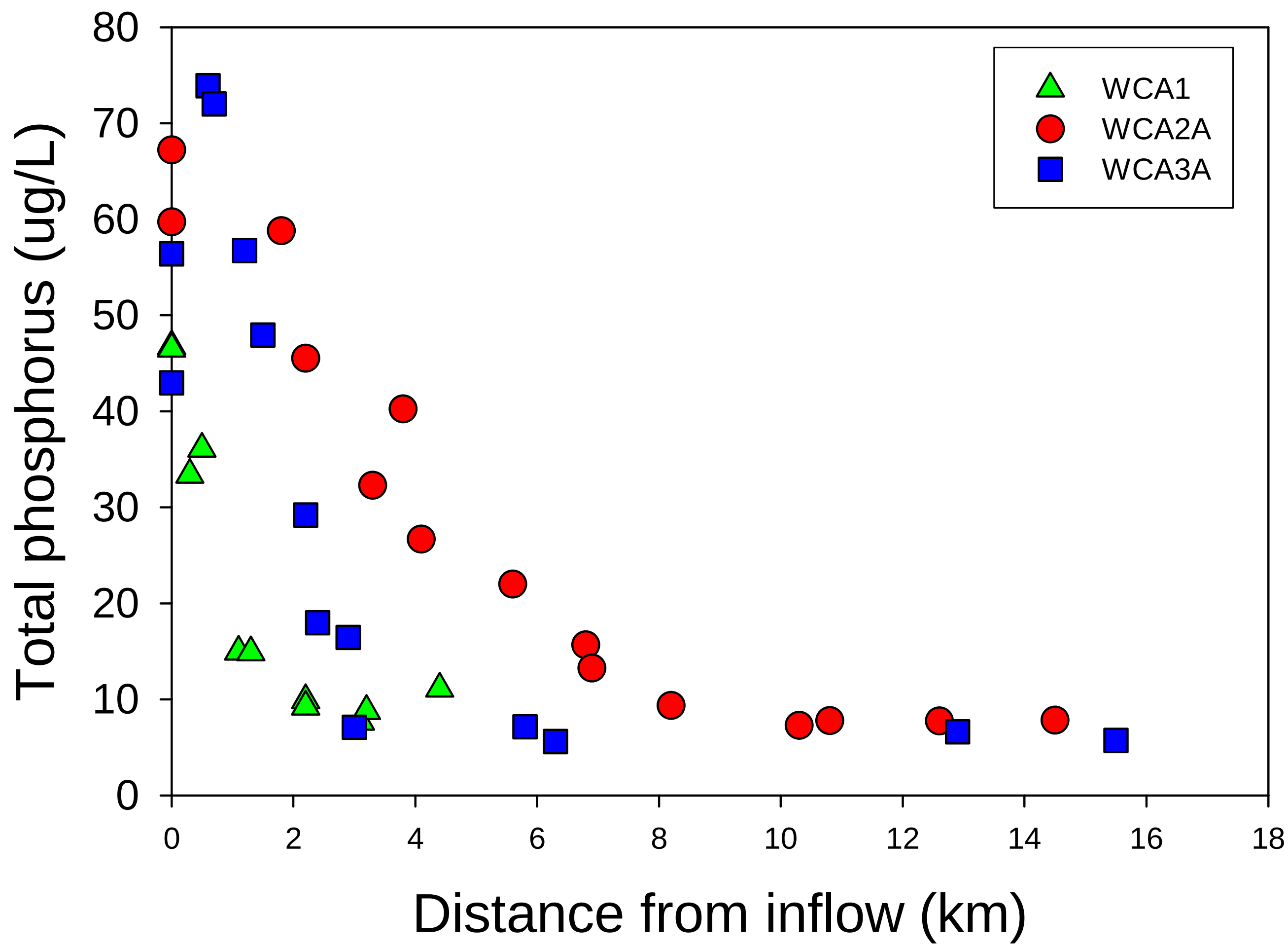
- Periphyton Taxonomy – District and DEP
  - cross training
  - permanent slide record
  - >1500 taxa
- Invertebrate Taxonomy- ID and QA/QC by DEP
  - > 400 taxa



Gradient Studies

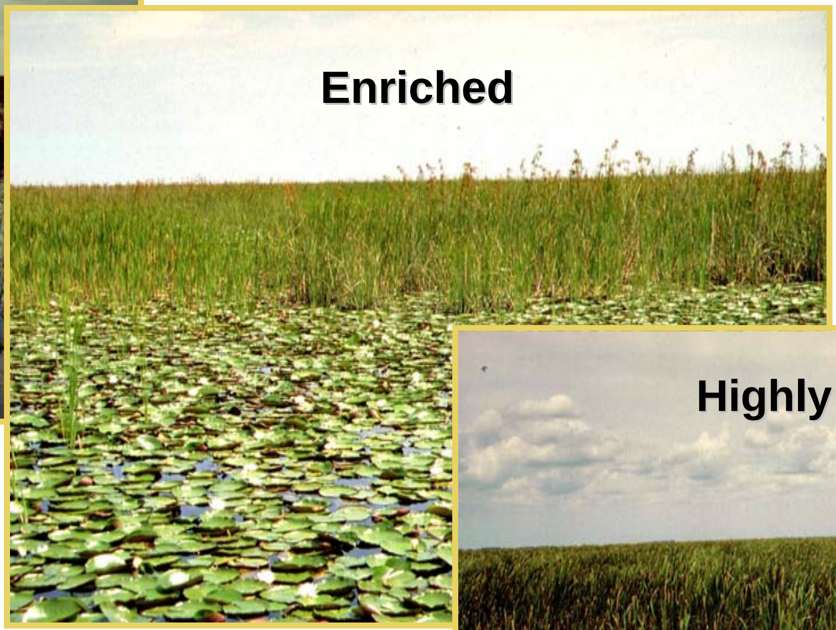
Surface Water Phosphorus Gradients within the Everglades

(Geometric Mean for Period of Record)

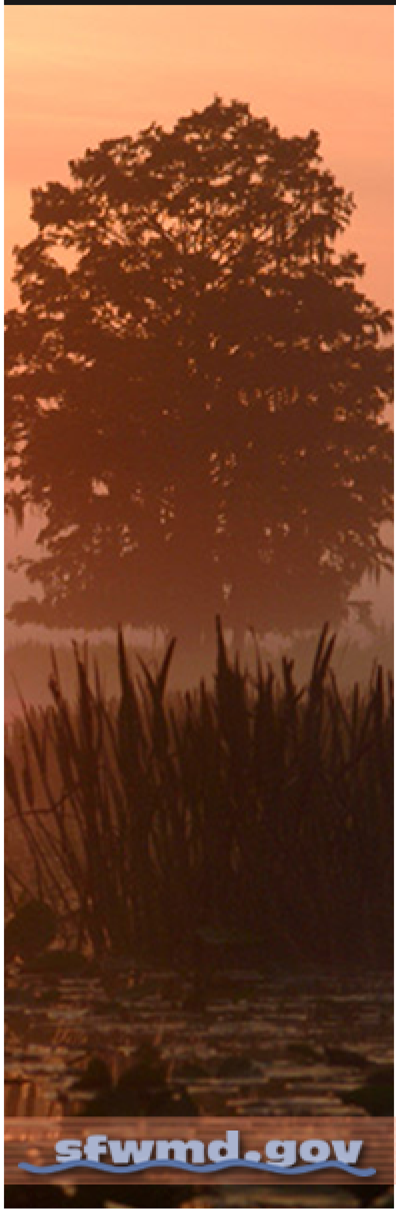


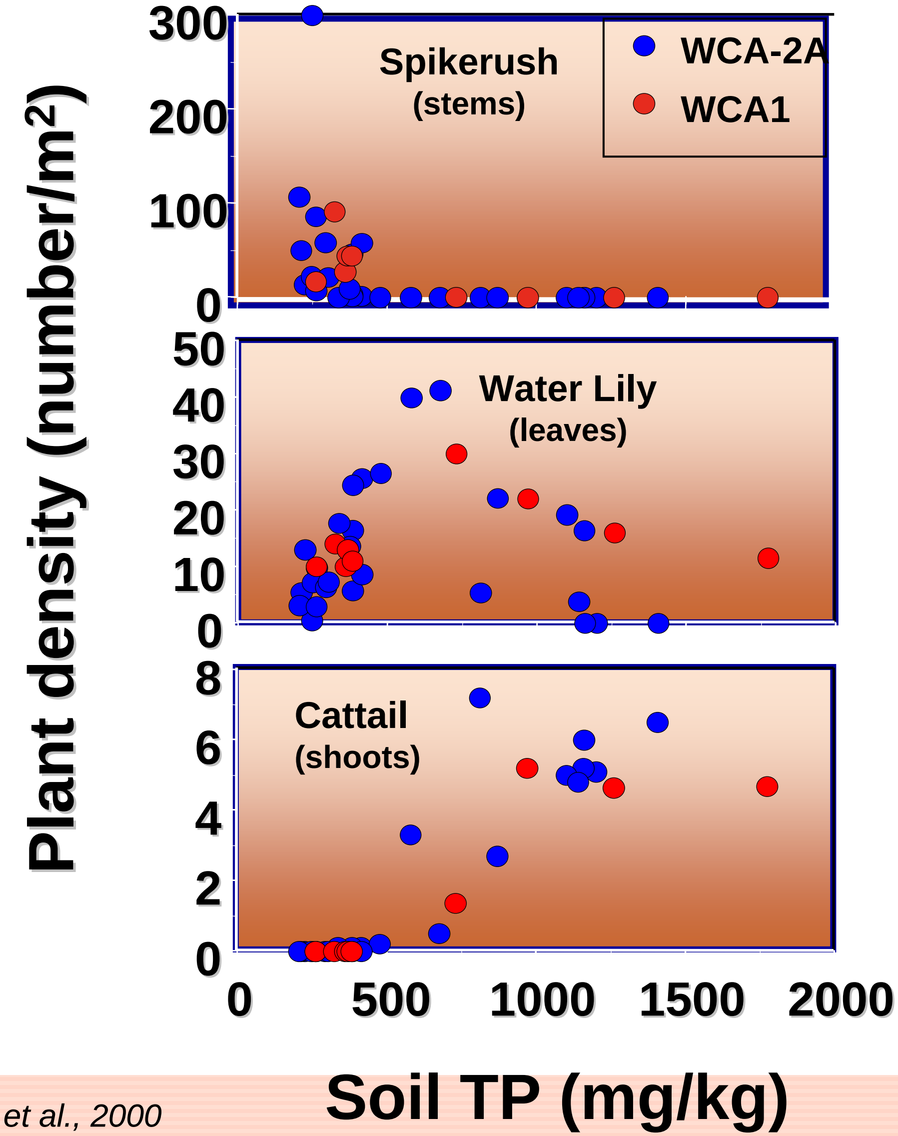
Source: Everglades Division, SFWMD

Vegetation Response to Phosphorus Enrichment



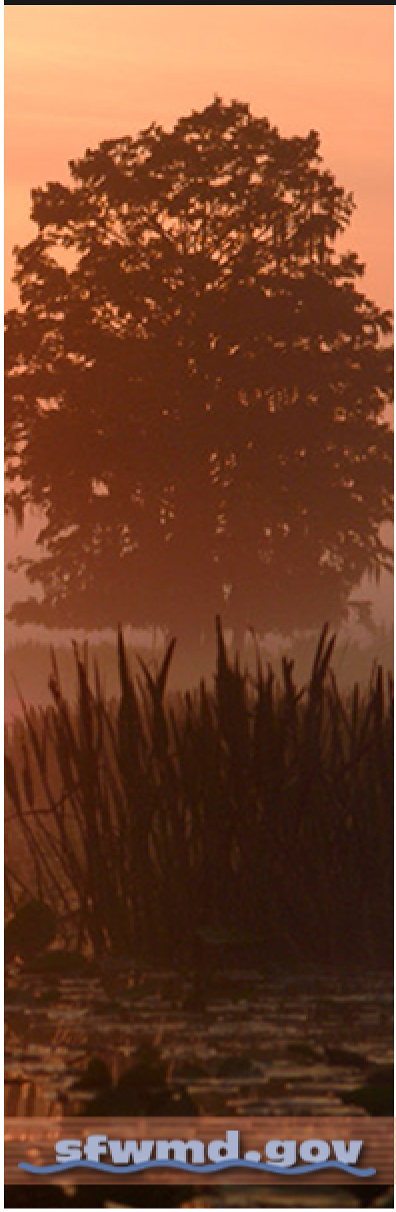
Vegetation Density changes along Nutrient Gradients

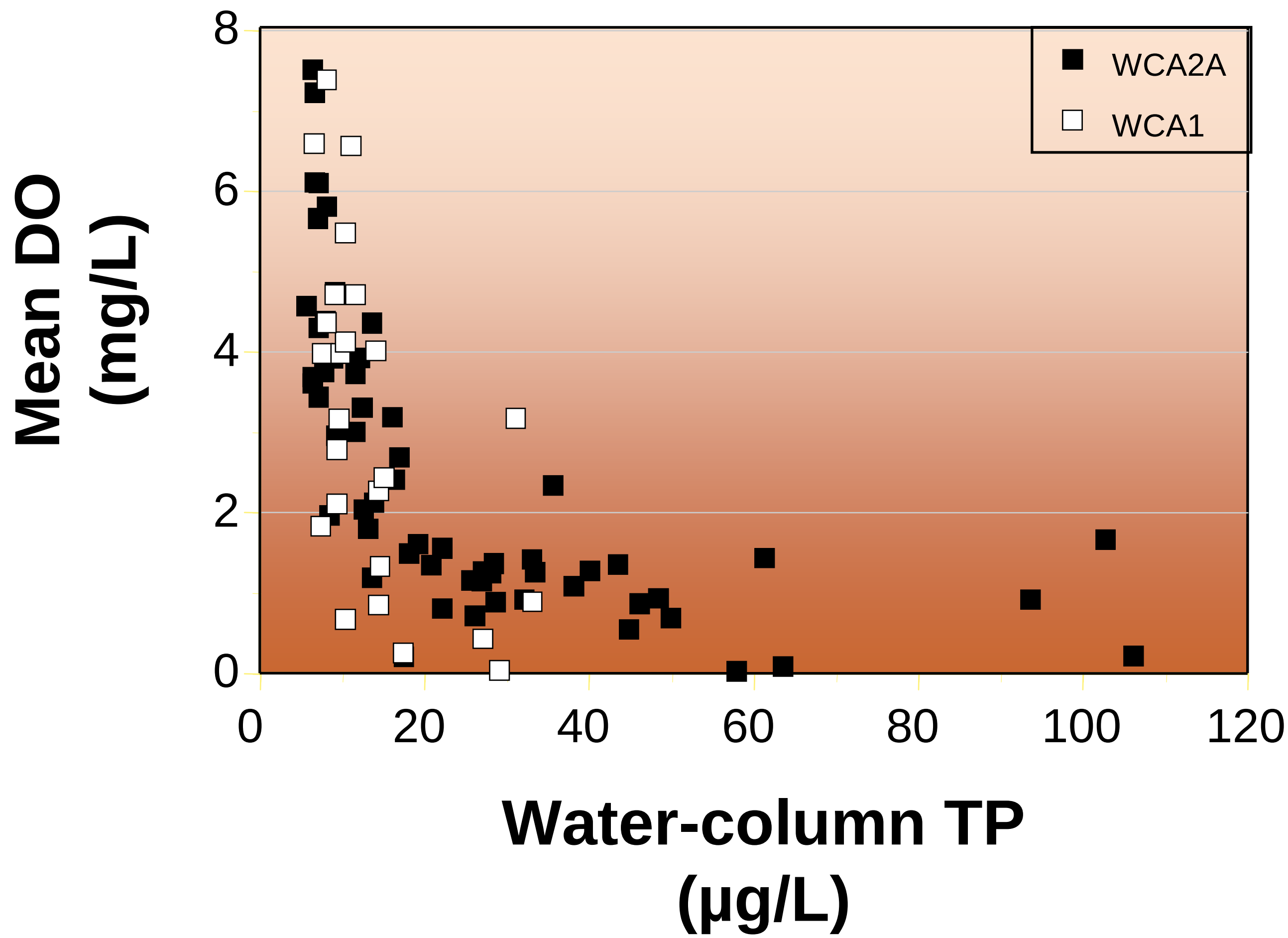




Source: McCormick et al., 2000

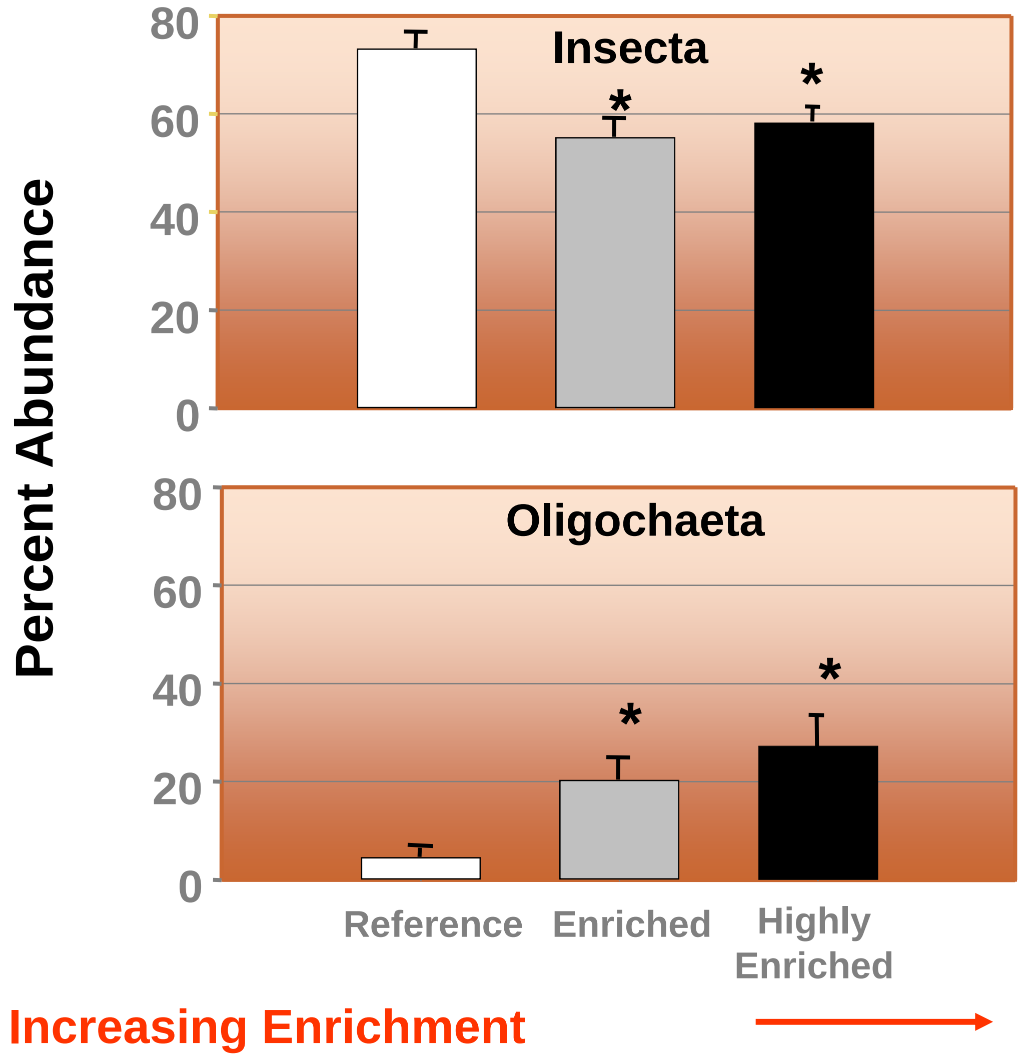
Change in Oxygen Status along Nutrient Gradients





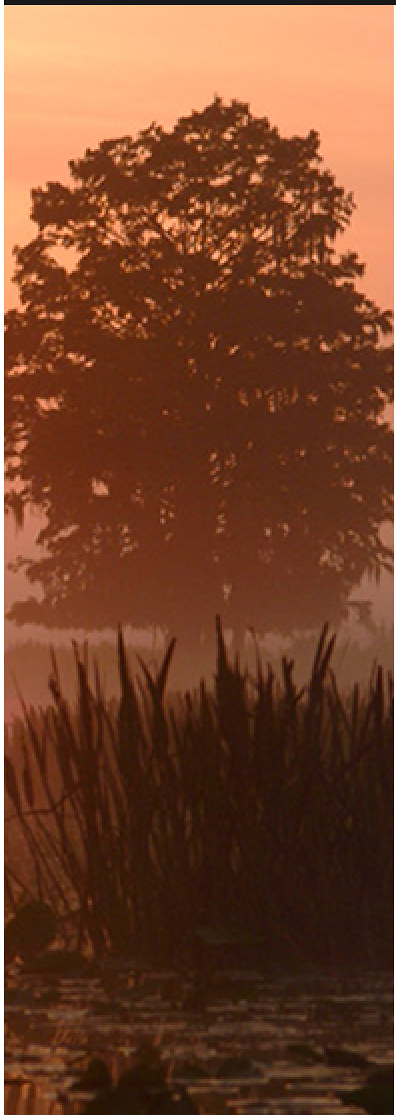
Source: McCormick et al., 2000

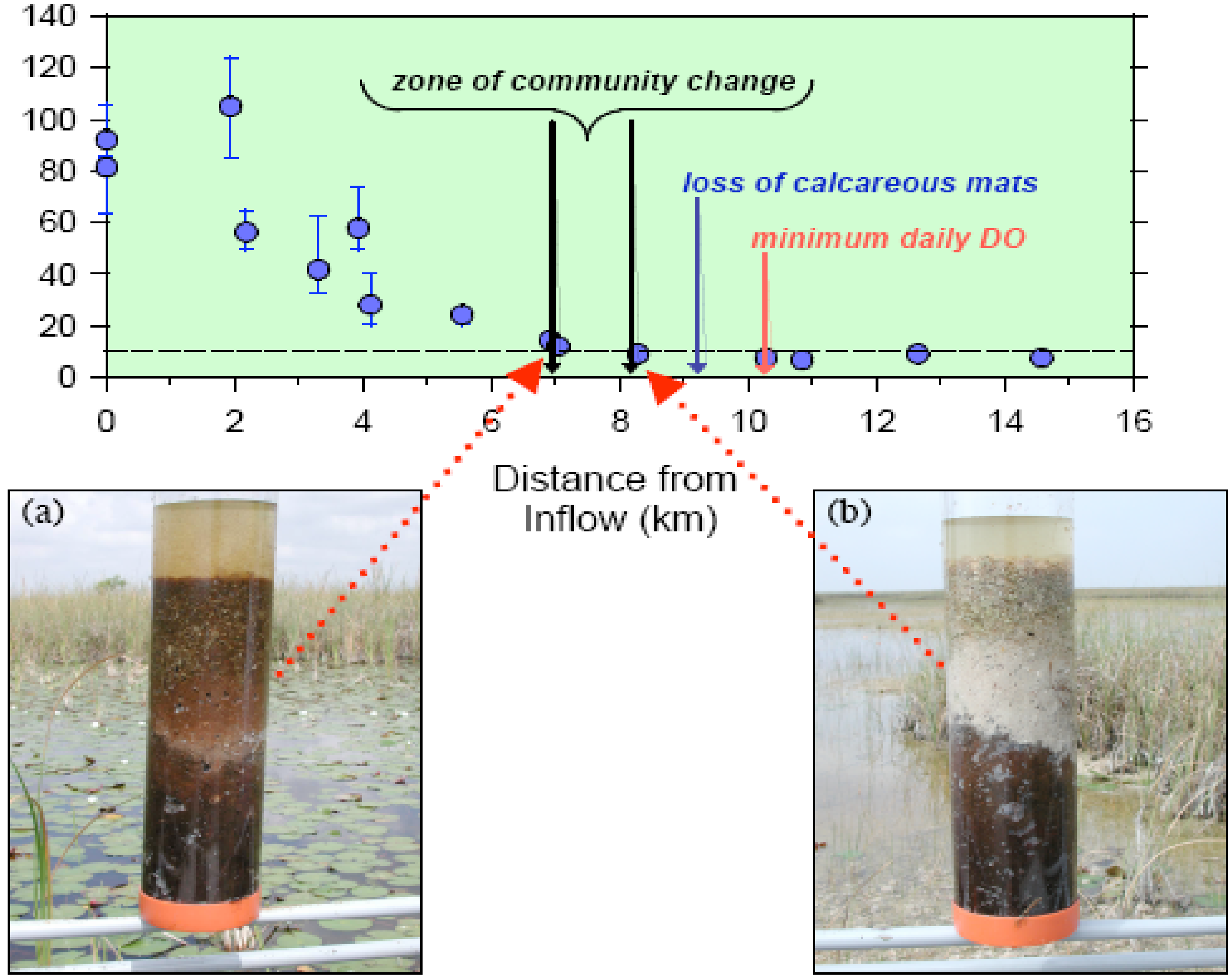
Macroinvertebrate Community Composition



Modified from McCormick et al., 2004

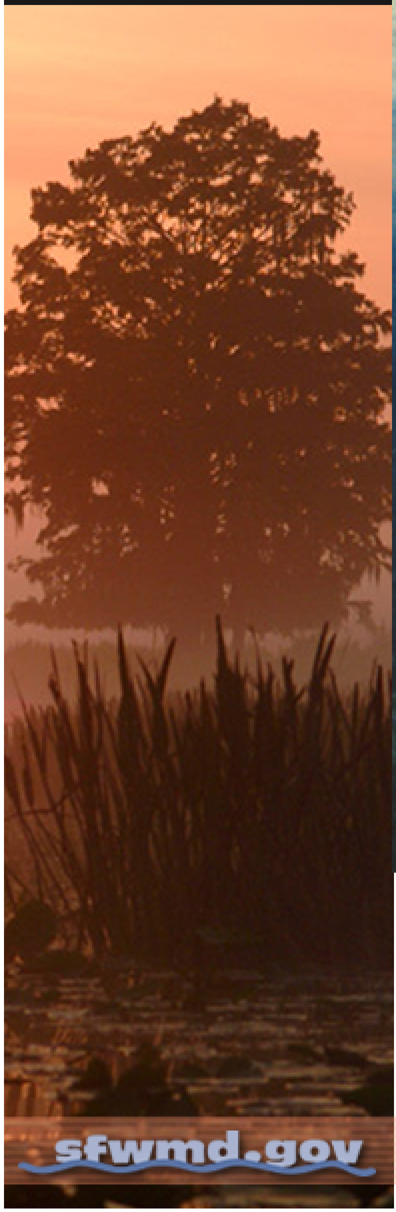
Summary of Ecological Changes Along the WCA2A Nutrient Gradient



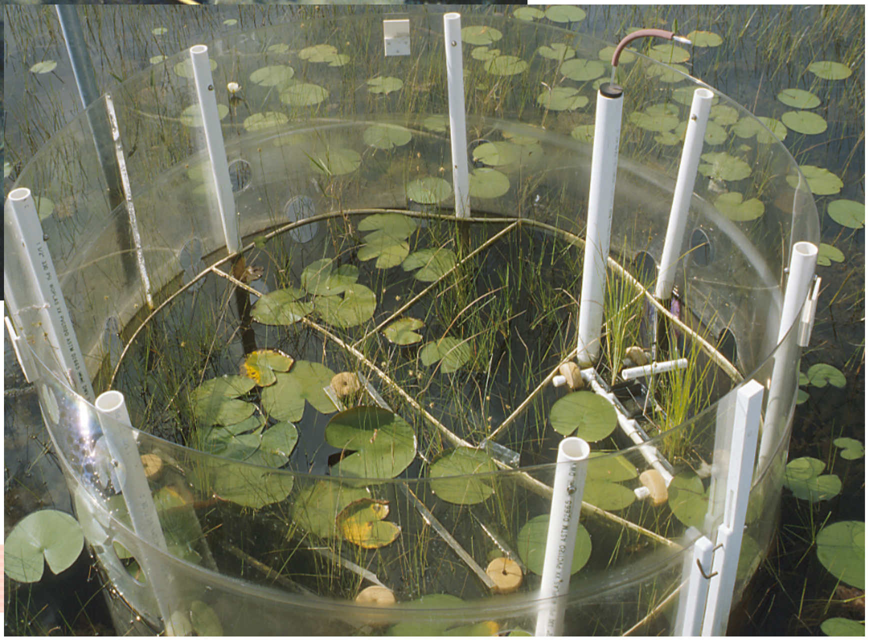


Source: Sklar et al., 2005

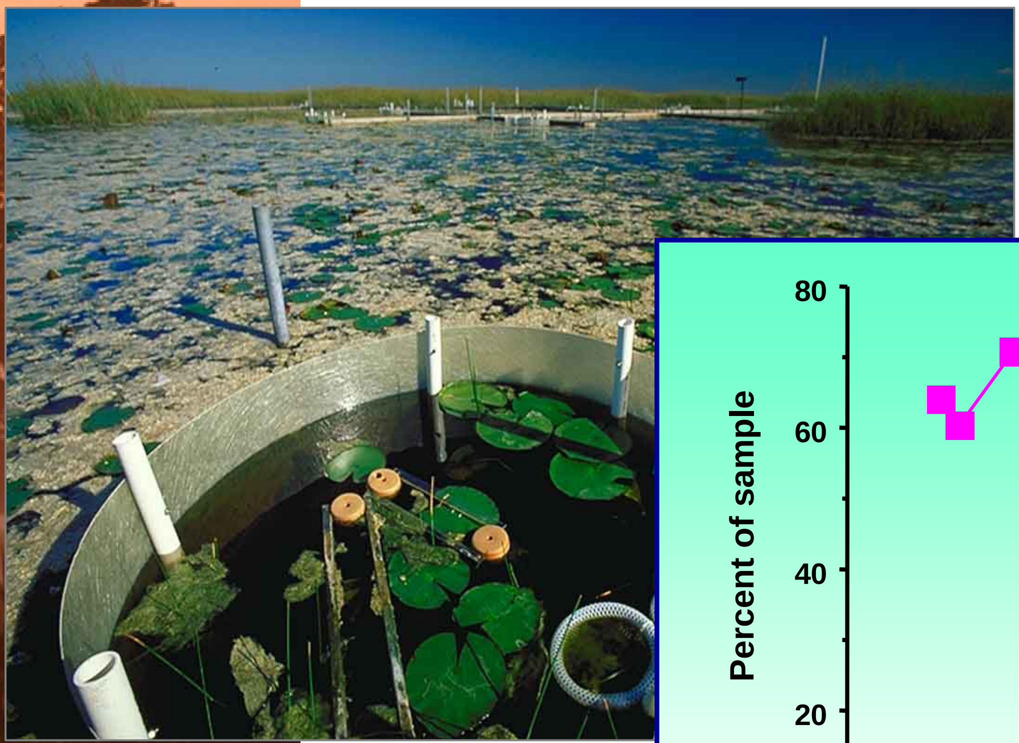
Identifying Phosphorus Specific Responses

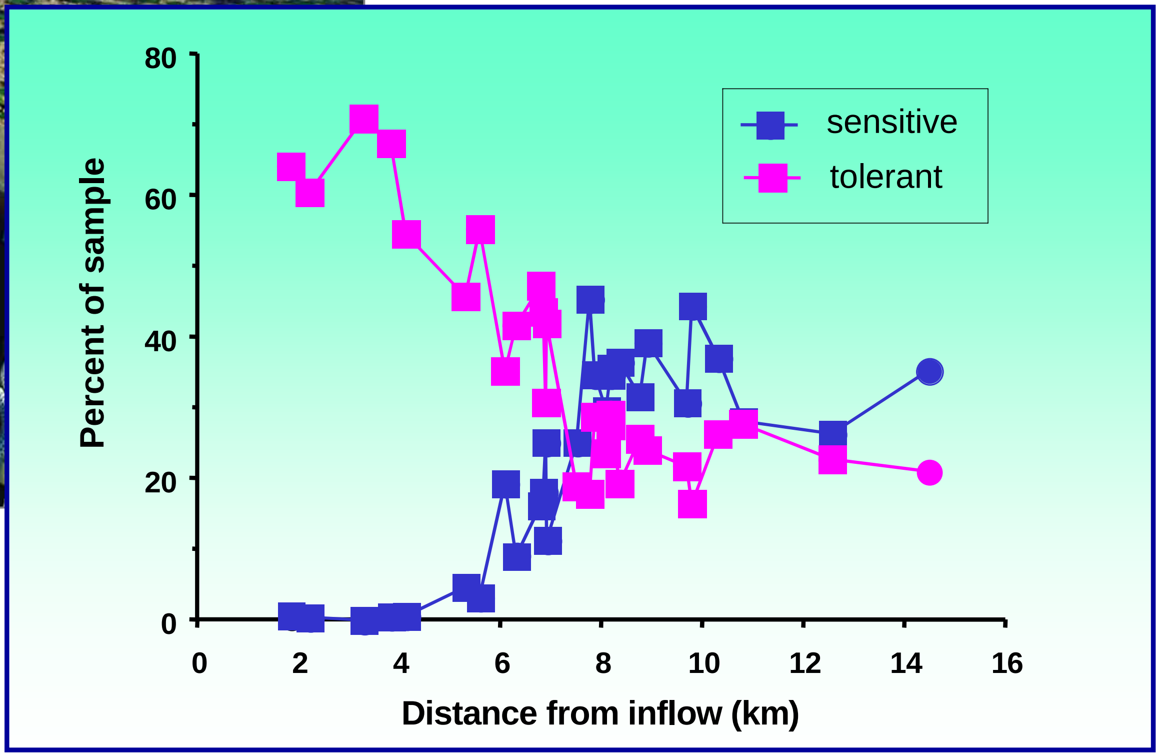


Mesocosms in WCA1



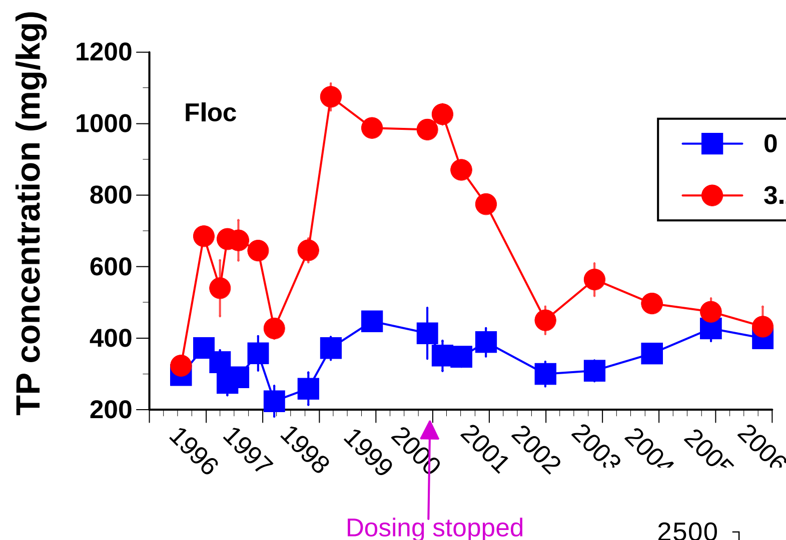
Loss of Native Periphyton Community in Response to Phosphorus in WCA2A



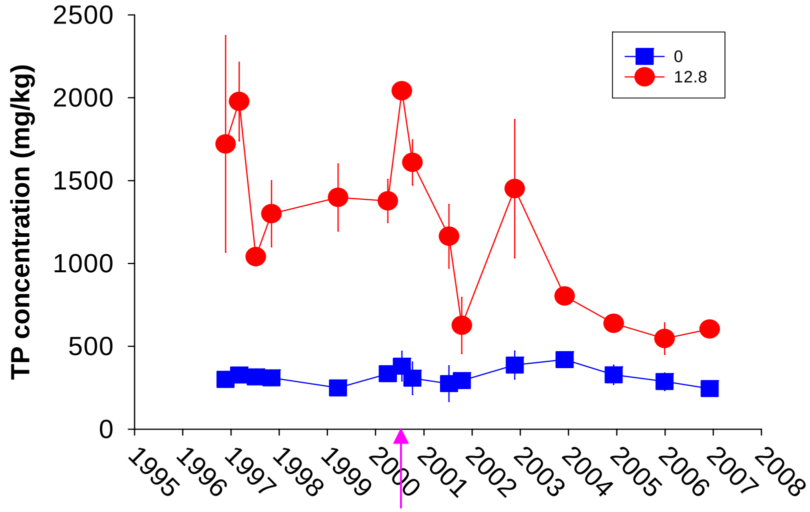


Source: McCormick et al., 2000

Recovery from Short-Term Phosphorus Enrichment: Mesocosm Studies

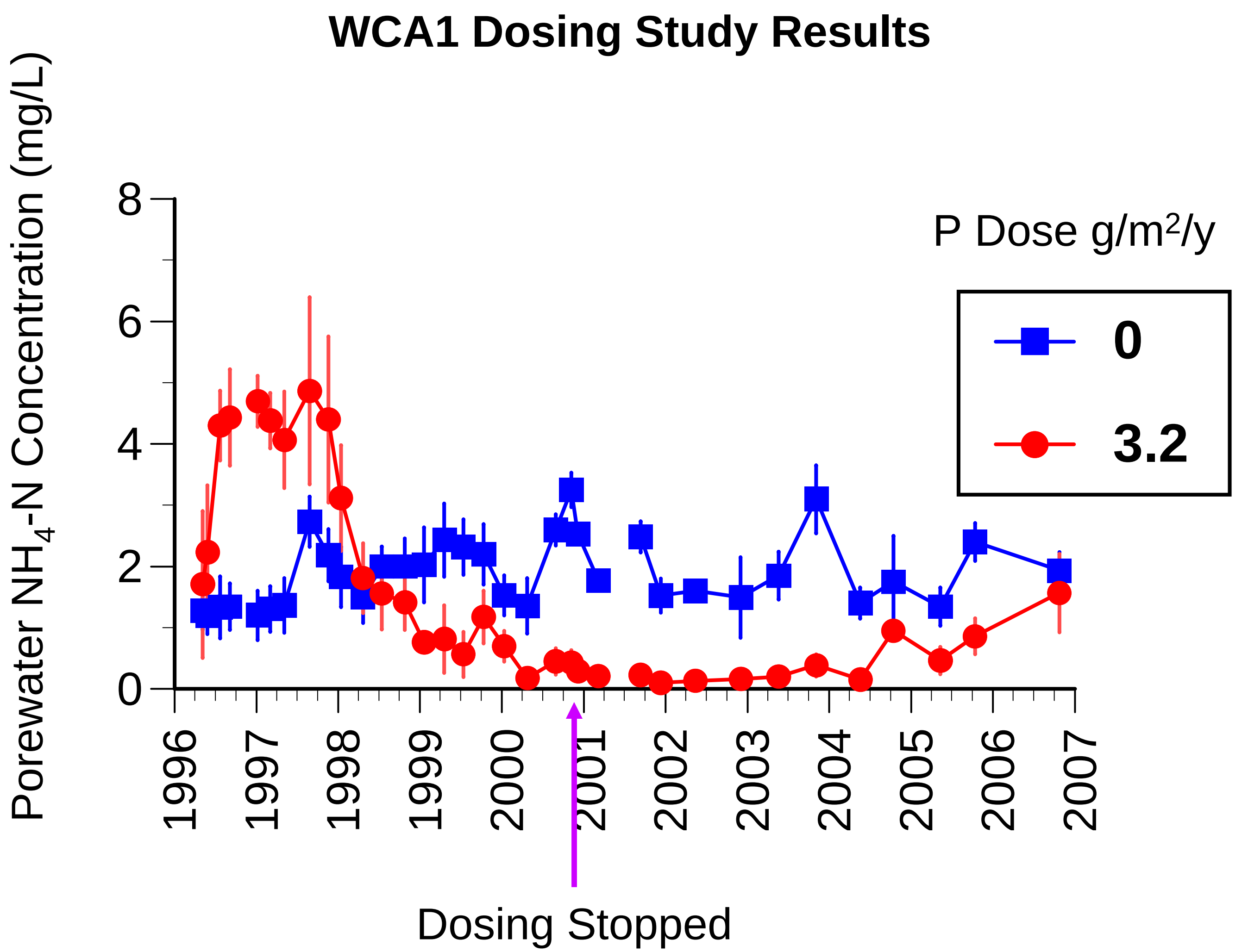


P Dose g/m^2/y



Modified from: Newman et al.; 2004

Porewater Nitrogen Availability Increases then Decreases in Response to Phosphorus Enrichment



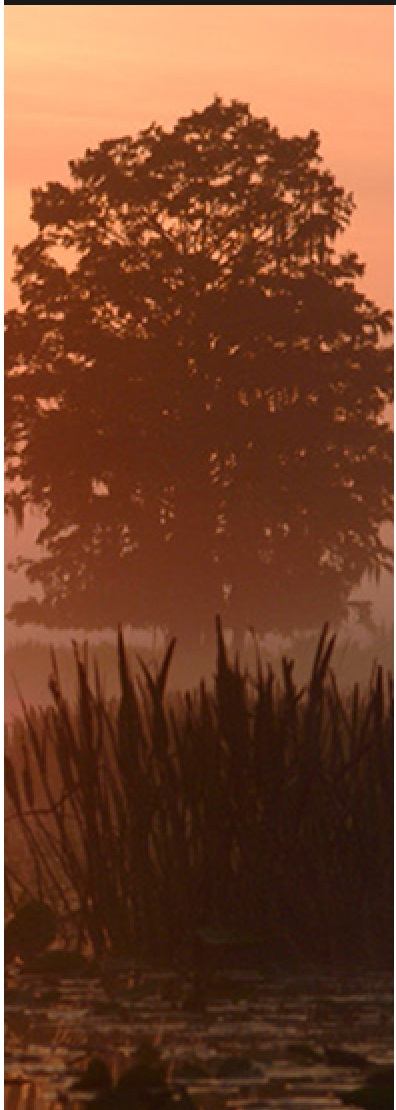
Modified from: Newman et al.; 2004

Greenhouse Expts

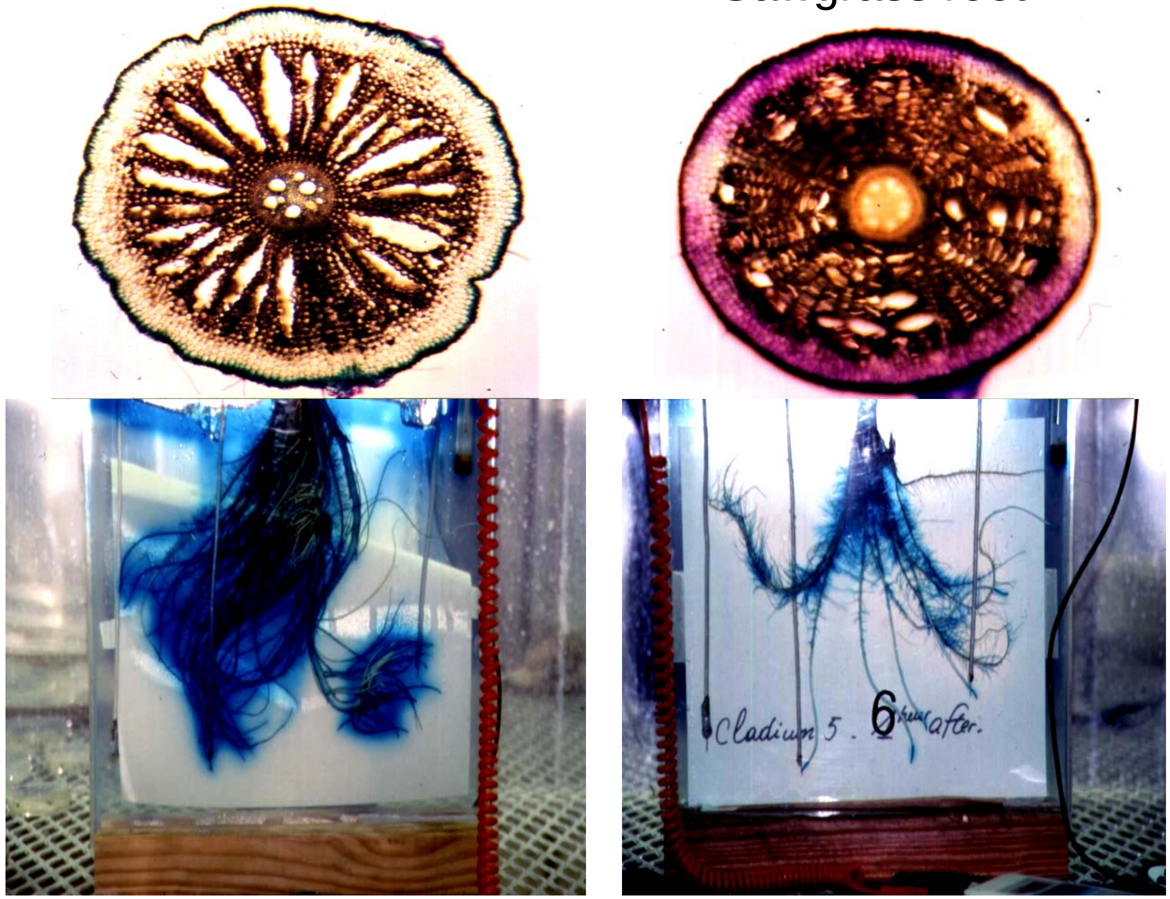
Mechanisms underlying vegetation replacement

- **Early regeneration - seed biology**
- **Growth and ecophysiology- vegetative expansiom**
- **Recovery after leaf disturbance**

Flooding Tolerance: Competitive Advantage of Cattail over Sawgrass



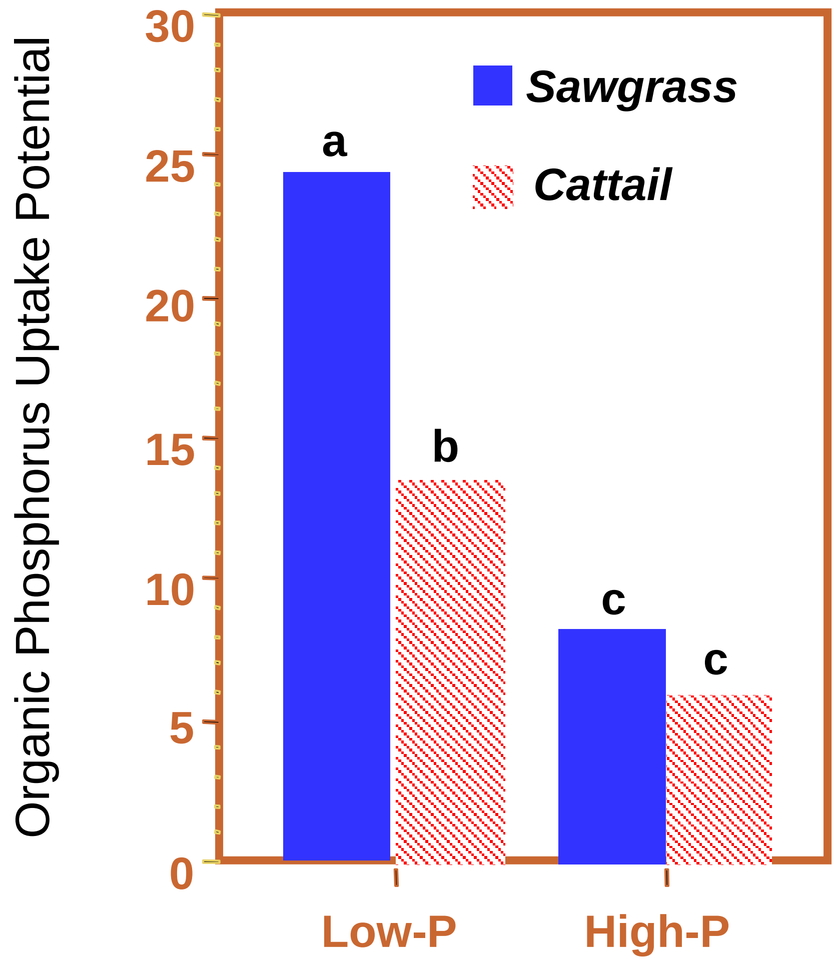
Cattail root | Sawgrass root



Blue coloration is caused by the leakage of oxygen from the roots which oxidizes the leuco-methelene blue in the rhizosphere.

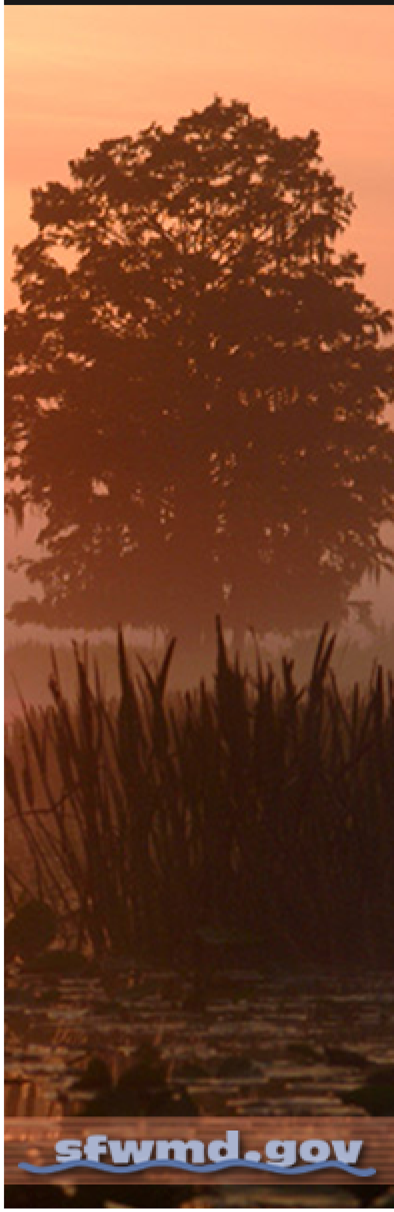
Source: Chabbi et al., 2000

Sawgrass has Greater Ability to Scavenge Phosphorus when it is Limiting



Source: Kuhn et al., 2002

Summary of Effects of P on the Everglades



➢ **Relationships between multiple measures of the structure and function of Everglades biological communities at multiple trophic levels and phosphorus enrichment.**

- **Periphyton:**
  - **Calcareous blue-green taxa eliminated**
  - **Abundance of phosphorus sensitive taxa decrease**
  - **Pollution tolerant taxa increase**

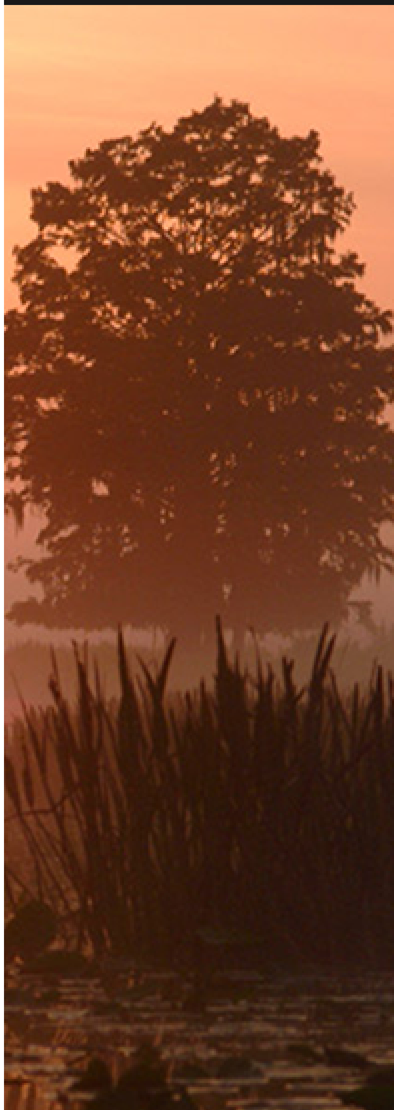
- **Macrophytes:**
  - **Increased spatial distribution of cattail**
  - **Loss of native sawgrass and slough vegetation**
  - **Decreased Eleocharis biomass and frequency**
  - **Increased cattail biomass and frequency**

- **Macroinvertebrates:**
  - **Altered invertebrate community structure (may be related to changes in D.O., food, habitat)**
  - **Reduced FI and LCI values (decreased sensitive taxa)**
  - **Decreased Chironomidae taxa richness**

- **Dissolved Oxygen:**
  - **Depressed dissolved oxygen regime (lower daily average and daily minimum).**

Source: SFWMD data for the DEP presentation to ERC Aug 2002

Conclusions



- More Everglades biogeochemistry research has been conducted in the last 15 years than in all previous years combined.
- There was a significant shift from grey literature to peer-reviewed articles after the Settlement Agreement.
- The SFWMD created the organizational structure, resources, and staff to fully implement the TOC-approved 1994 Everglades Research Plan.
- The quality of the Everglades research was found to be critical for: 1) establishing a P-associated definition of imbalance, 2) describing existing conditions, 3) separating hydrologic impacts from P impacts, and 4) demonstrating the importance of periphyton

Acknowledgements

- Everglades Division- SFWMD
- Florida Department of Environmental Protection
- US EPA- Gulf Breeze
- University of Florida
- Florida International University
- A.R.M. Loxahatchee Wildlife Refuge
- Everglades National Park
- Miccosukee Tribe
- Florida Atlantic University