South Florida Ecosystem Assessment
Everglades Stressor Interactions: Hydropatterns, Eutrophication, Habitat Alteration & Mercury Contamination

ABSTRACT

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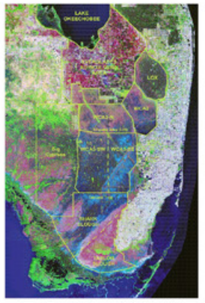
The US Environmental Protection Agency (EPA) Region 4 initiated a project in 1992 to assess the effects of mercury contamination on the South Florida Everglades Ecosystem. This project used a large scale statistical survey design to conduct synoptic marsh surveys during the wet and dry seasons in 1995, 1996 and 1999. Surface water, pore water, soil, tissue (periphyton, macrophyte and fish) and plant community parameters were sampled at about 750 sites throughout the 5800 km² central marsh system to assess the effects of hydropattern, phosphorus loading, habitat alteration and mercury contamination on the ecosystem.

Significant north to south agricultural stormwater gradients high in TOC, TP, SO_4, S^{2-} were found across the system. Mercury methylation in the marsh generated higher concentrations in water and soil in the north but occurred in all subareas. Significant interactions of these parameters occurred with water depth, food web dynamics and fish mercury concentrations. These interactions exhibited different spatial patterns in the area north of Alligator Alley (I-75), between Alligator Alley and Tamiami Trail (US-41), and south of Tamiami Trail into Everglades National Park. Three conceptual models were developed, one for each of these three areas, to describe the pathways and interactions among factors affecting fish mercury concentrations. A mercury "hot spot" in mosquitofish was found in the southwestern part of Water Conservation Area 3 extending into Everglades National Park where the interacting variables (TOC, TP, SO_4, S^{2-}) were lower and bioaccumulation was optimal. Numerous management implications have been developed from this initial monitoring.



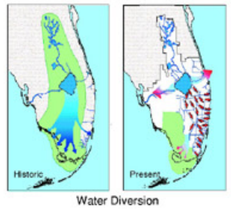
The Ecosystem and Subareas

Objectives

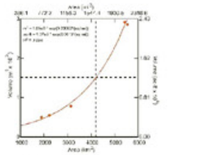
- Assess Effects & Risks of Hg Bioaccumulation
- Assess the Interactions of Hydroperiod, Nutrient Loading, Habitat Alteration & Hg
- Improve Monitoring Design & Reporting
- Provide Periodic Management Information on Restoration Issues
- Determine Ecosystem Status & Trends

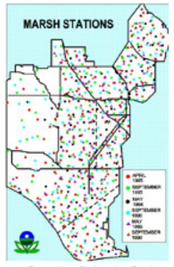
Policy Assessment Questions

- MAGNITUDE- of problem
- EXTENT- of problem
- TREND(S)- better, worse or same?
- CAUSE(S)- associated with or contribute to
- SOURCES (S)- importance of sources
- RISK(S)- risks to systems or species
- MANAGEMENT- alternatives to ameliorate

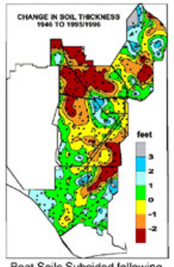


Water Diversion

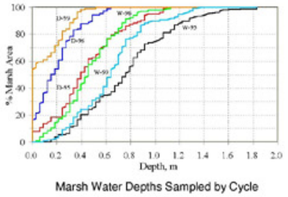

Volume to surface area defines long vs. short hydroperiod.



Sampling Points by Cycle

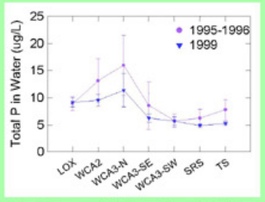


Peat Soils Subsided following Water Diversion



Marsh Water Depths Sampled by Cycle

Total Phosphorus (TP)

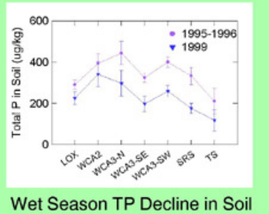


Wet Season TP Decline in Water

Change in spatial extent (%) of TP in water (wet seasons marsh).

Year	1995	1996	1999
% <10 ppb	41	78	87
% <15 ppb	65	87	93
% >50 ppb	3	2	2

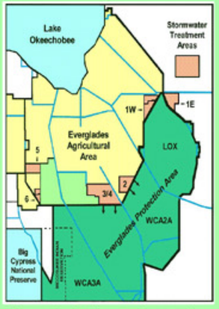
Change in TP extent with Time
Agricultural BMP's Initiated 1995



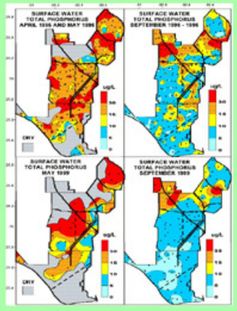
Wet Season TP Decline in Soil

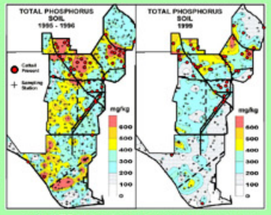
Macrophyte Community Indicators

- **Total of 136 taxa**
- **Four major clusters**
  - **Sawgrass = ubiquitous**
  - **Water lily/Purple Bladderwort = Stable Water Sloughs**
  - **Spikerush = requires low soil TP**
  - **Cattail = requires high soil TP**

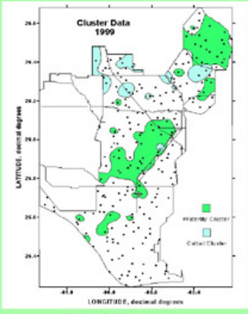


Restoration STA's under Construction to reduce TP in stormwater


Spatial Extent of TP in marsh- Nominal concentrations for ultra-oligotrophic system ranges from 6-10ppb

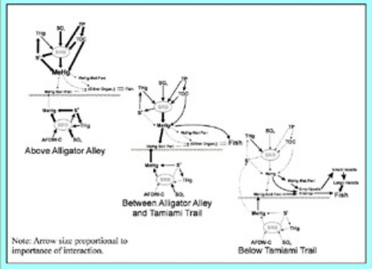


- Soil TP higher in northern subareas due to stormwater inflow.
- Reductions observed in 1999 may be a result of initiation of BMPs in 1995.
- Presence of cattails is associated with high soil TP.

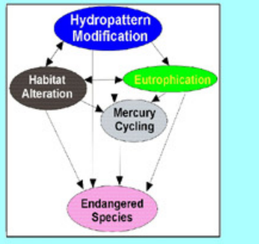


Habitat Indicators
Water Lily = long hydroperiod
Cattail = high soil TP

Interactions

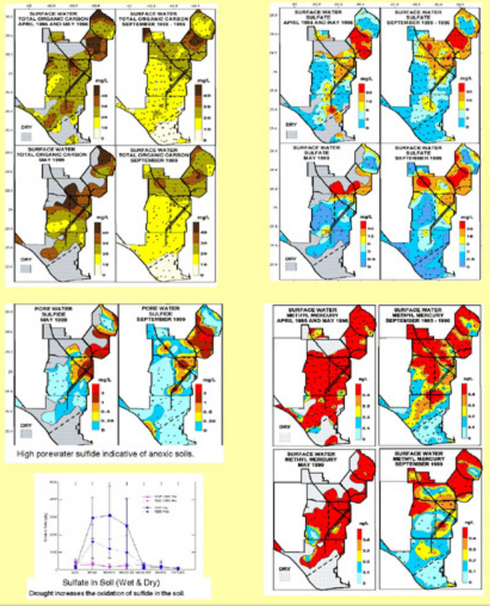


Mercury Interactions: Conceptual Models



Restoration issues are highly interdependent and must receive integrated management.

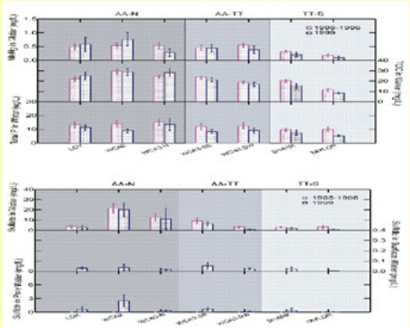
Water & Soil Quality



High porewater sulfide indicative of anoxic soils.

Sulfate in Soil (Wet & Dry)
Drought increases the oxidation of sulfide in the soil.

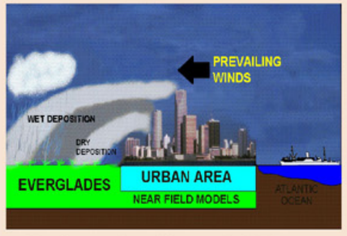
Wet Season (Mean +/- 95% C.I.)



North to South Stormwater Gradients

- Key water quality interactions occur with flow
- Stormwater from north is high in TP, TOC & SO_4
- The bacterially mediated reduction of SO_4 to S^{2-} under anoxic conditions in the presence of abundant organic matter stimulates methylation of mercury
- Methyl mercury in surface water is higher in northern subareas and occurs in all subareas during the dry season

Mercury (Hg)

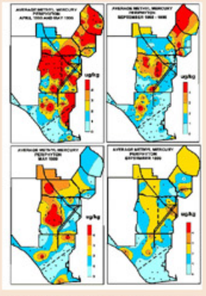


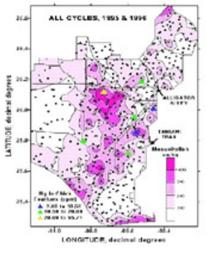
Wet Season Local Atmospheric Sources

Atmospheric vs. surface water mercury loading.

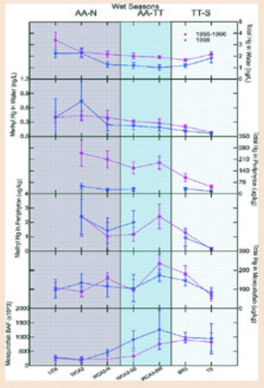
Year	Atmospheric Deposition (kg/yr)	EAA Water (kg/yr)
1994	140	2
1995	155	3-4

Air vs. Water Sources


Methyl Mercury in Periphyton



Mercury Hotspot in Mosquitofish & Great Egret Chick Feathers—USFWS Predator Protection Limit = 100 ug/kg



Total & Methyl Mercury by Media

Change in ecosystem total mercury mass (kg) in different media with time

Media	1995	1996	1999
Atmospheric Wet Deposition	153	116	146
Water	6.0	4.7	3.8
Mosquitofish	0.64	0.41	0.39

Comparisons of processes and patterns between oligotrophic and eutrophic systems

Ecological Attribute	Oligotrophic Systems	Eutrophic Systems
Controlling Factors	"Top-Down"	"Bottom-up"
Nutrient Cycling	Tightly coupled nutrient cycles-algae-grazers-microbes, regenerated in water column	Loose nutrient cycling-decoupled from higher food chain, supplied from inflow, sediment cycling
Forcing Functions	Biotic-abiotic interactions	Physical factors-inflow, hydrodynamic mixing
Temporal Patterns	Relatively small biomass variability	Large biomass variability
Nutrient Requirements	Seasonal Renewal	Continuous Supply
Predictability	Low-multivariate relationships among biomass & controlling factors not well understood	High-statistical relationships between nutrient loads & biomass

General Conclusions

- Atmospheric deposition is predominate Hg source
- Agricultural stormwater creates significant gradients in water & soil from north to south (TP, TOC, SO^4, S^{2-})
- Nutrient loading, habitat alteration & hydropattern modification influence patterns of Hg contamination
- Mosquitofish mercury "hotspot" is in subarea WCA3-SW between eutrophic northern and oligotrophic southern zones
- Both bottom-up (north) and top-down (south) controls in the ecosystem are needed to explain effects of nutrient loading and mercury contamination
- Restoration issues are highly interdependent and must receive integrated management

References: EPA 904-R-01-001, EPA 904-R-01-002, EPA 904-R-01-003, http://www.epa.gov/region4/sesd/reports