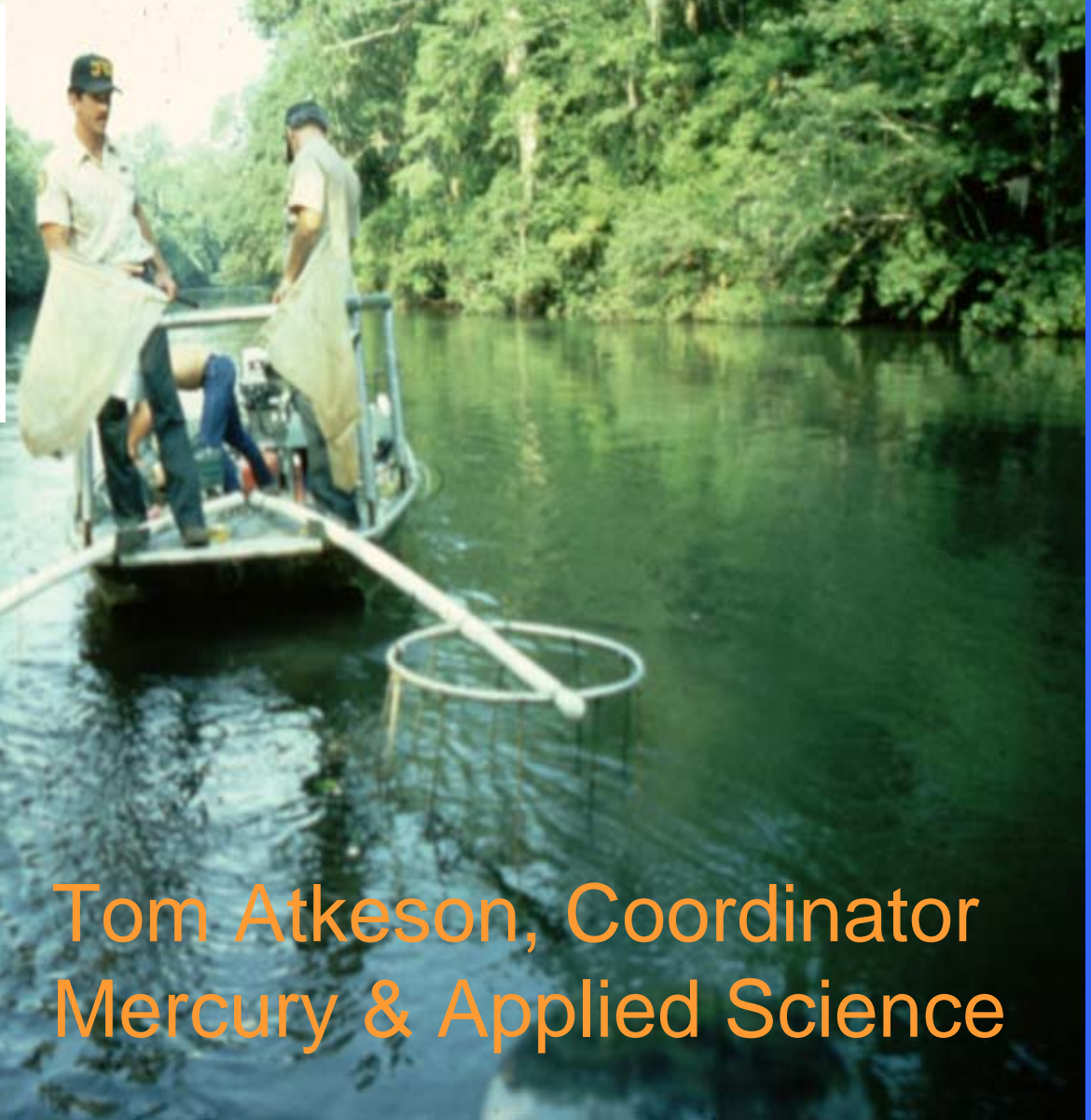
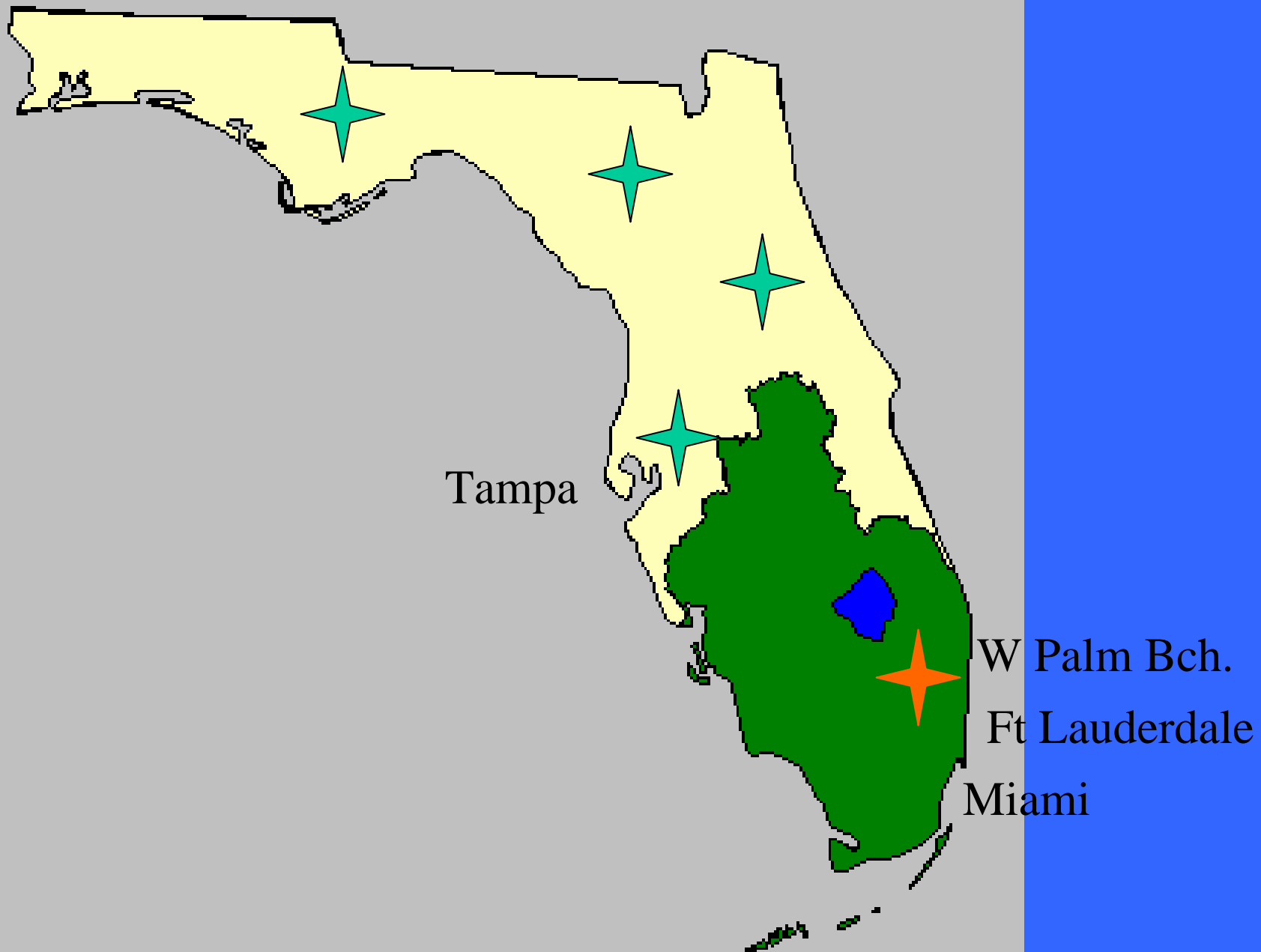


# The Florida Mercury Science Program



Tom Atkeson, Coordinator  
Mercury & Applied Science



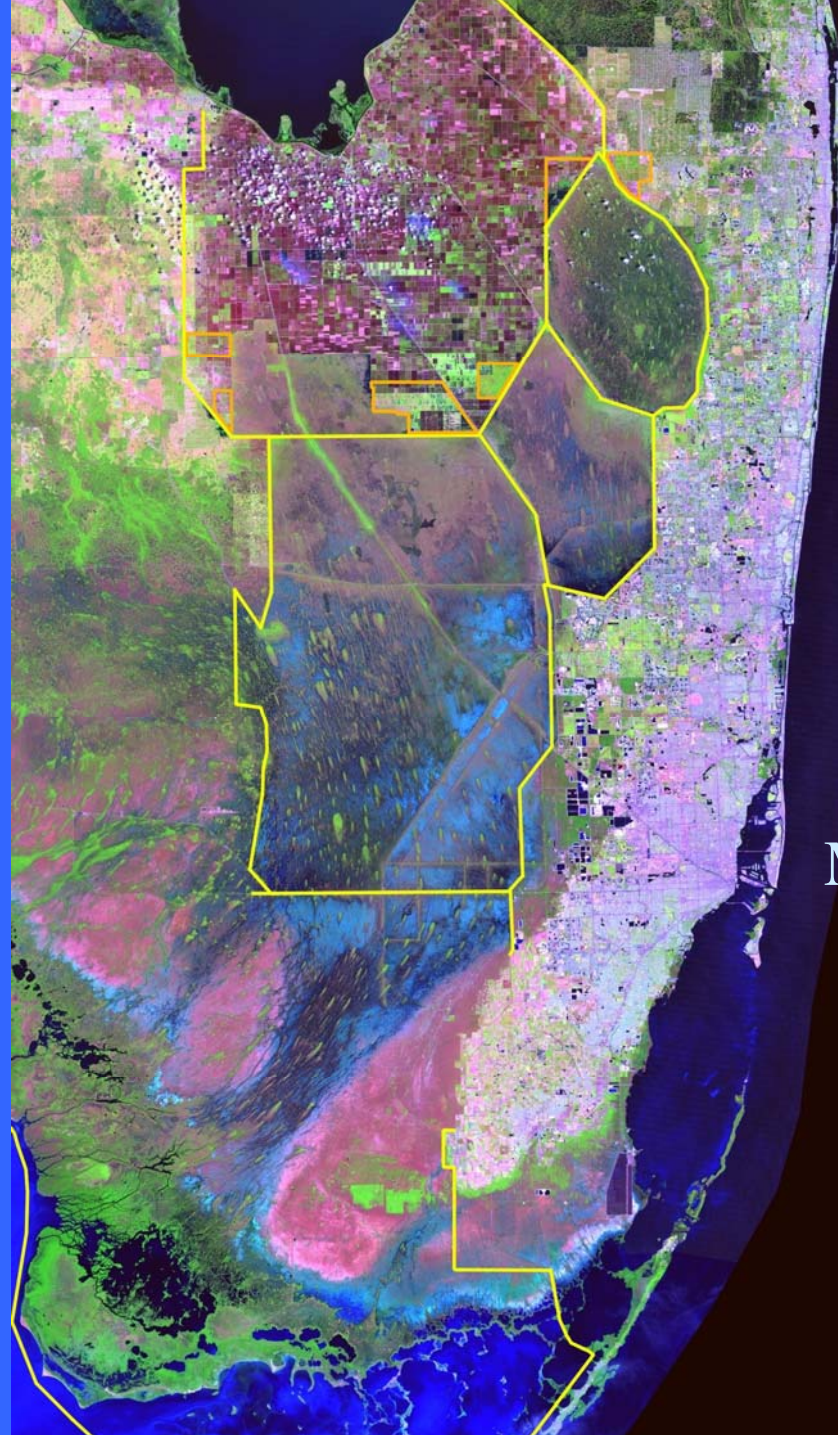


An aerial photograph of the Everglades wetlands. The landscape is a vast, flat expanse of water and marshland. The water is a dark, still blue-grey color, reflecting the sky. Interspersed among the water are numerous patches of yellowish-brown vegetation, likely sawgrass or similar wetland plants. The horizon is a straight line in the distance, with a few small white structures visible. The sky is filled with large, white, fluffy clouds, and the overall lighting suggests a bright, sunny day.

# The Everglades



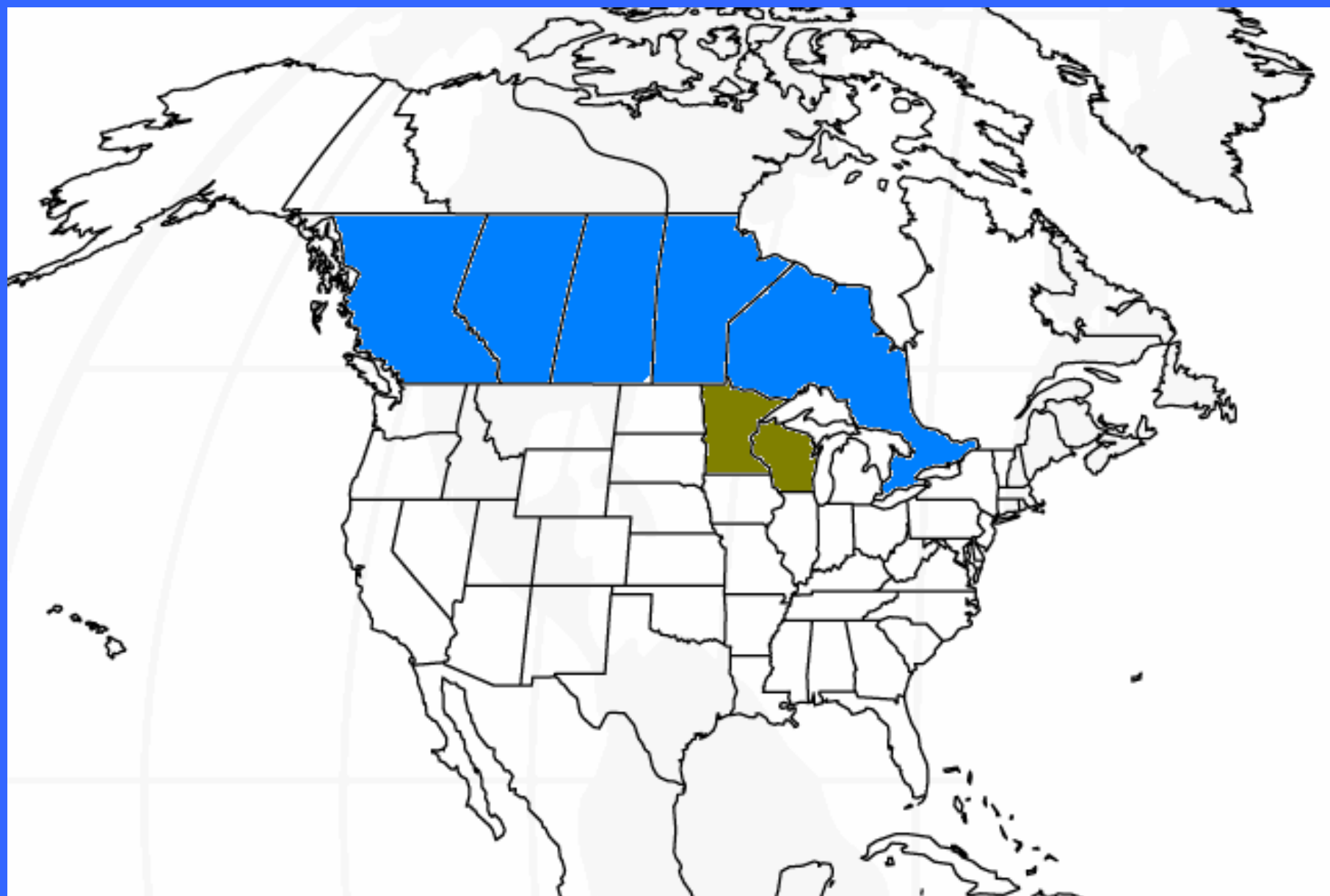
L. Okeechobee

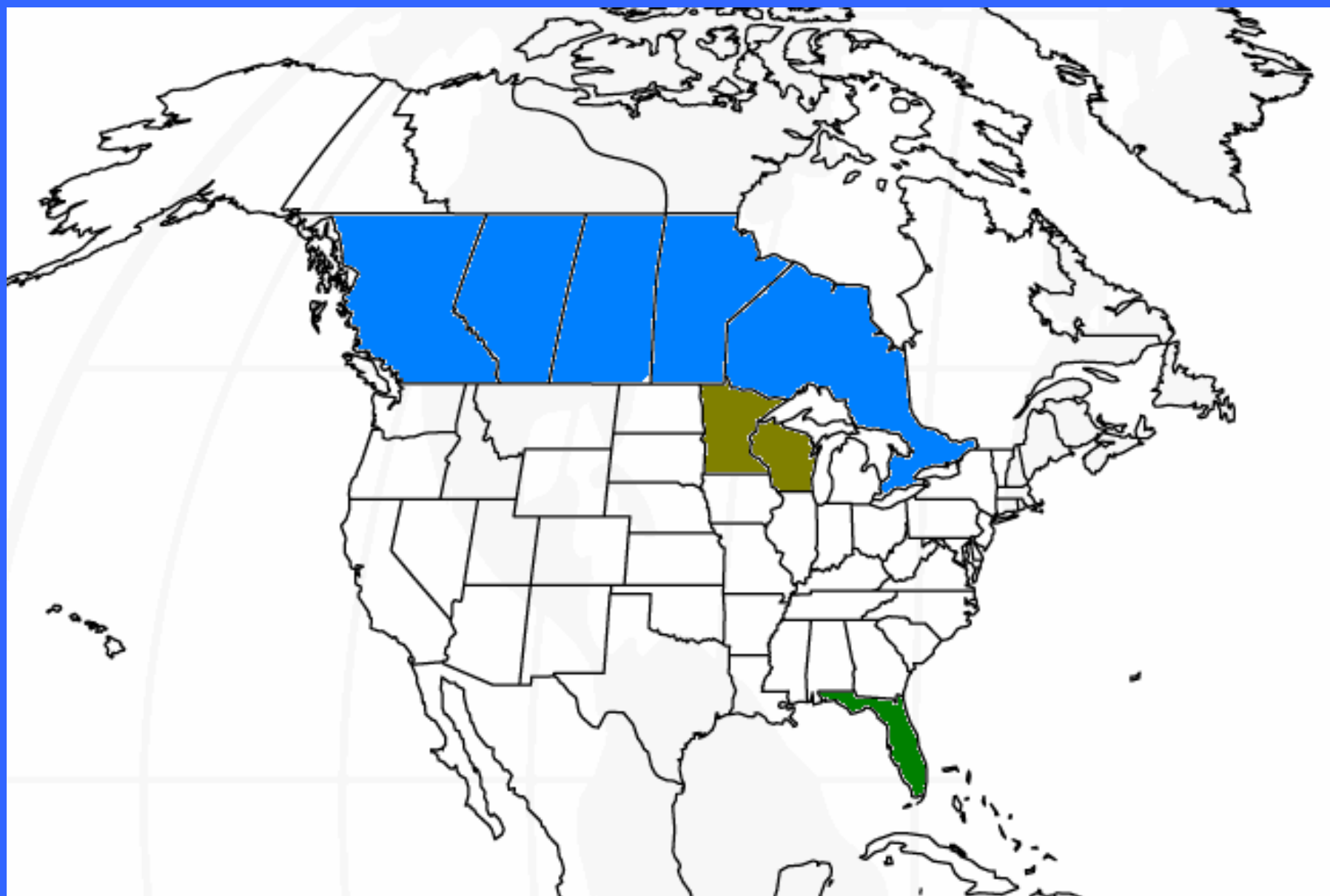


W. Palm Beach

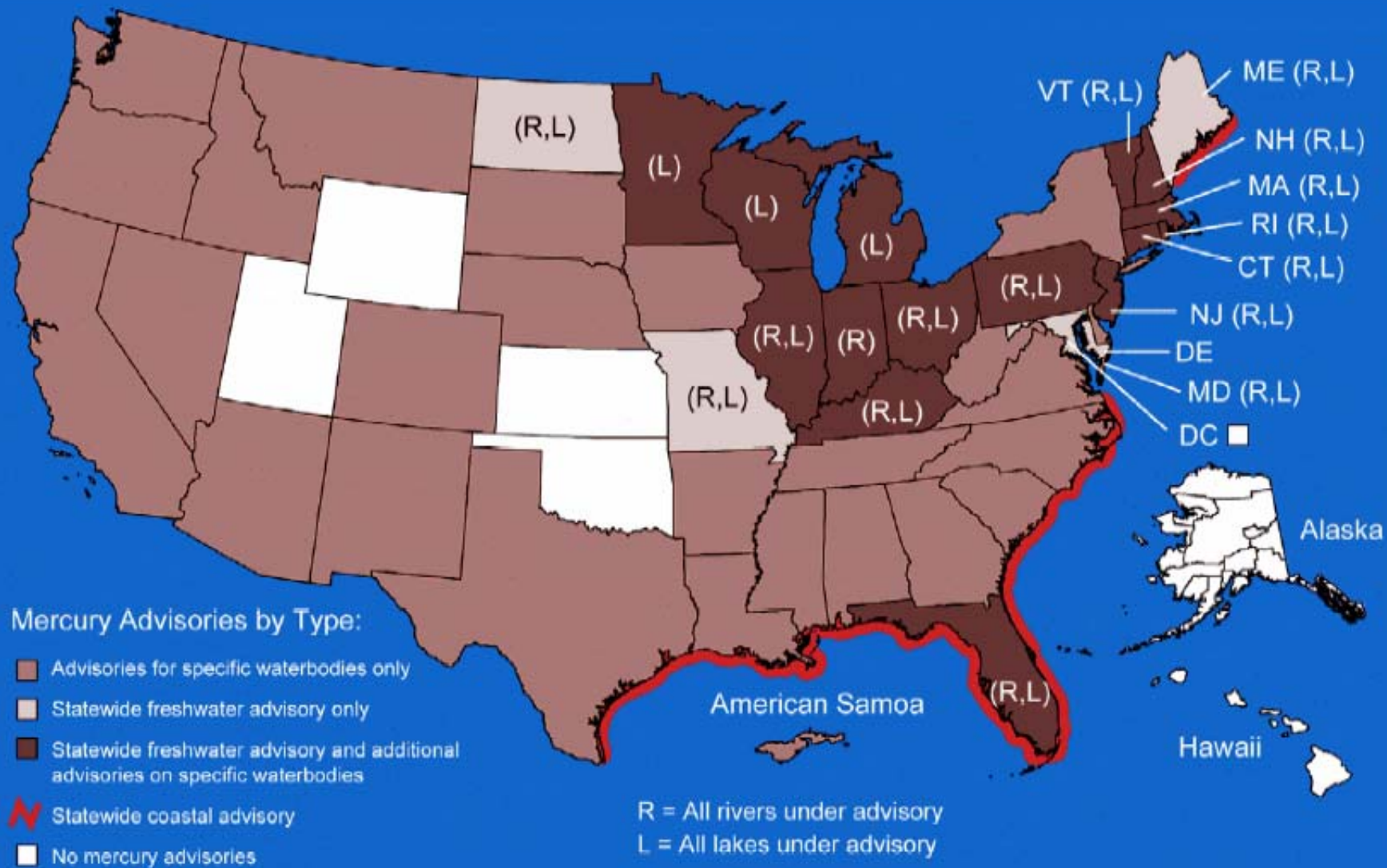
Ft. Lauderdale

Miami











# MERCURY

# ~1990 THE PROBLEM





# MERCURY

## The Problem

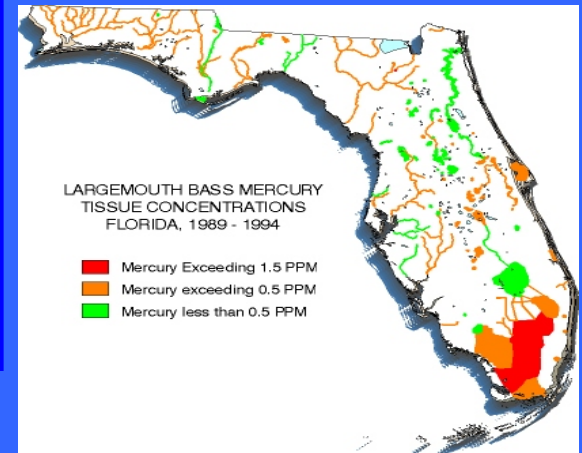


### WARNING

The Florida Department of Health and Rehabilitative Services has issued a health advisory urging limited consumption of largemouth bass and warmouth caught in certain portions of the Everglades due to excessive accumulation of the element mercury.

- Fish caught in Arthur R. Marshall Loxahatchee National Wildlife Refuge (Water Conservation Area 1) should not be eaten more than once per week by adults and not more than once per month by children under 15 and pregnant women.
- Fish caught in Water Conservation Areas 2a and 3 should not be eaten at all.

For additional information, contact the Florida Department of Health and Rehabilitative Services at (405) 355-3018.

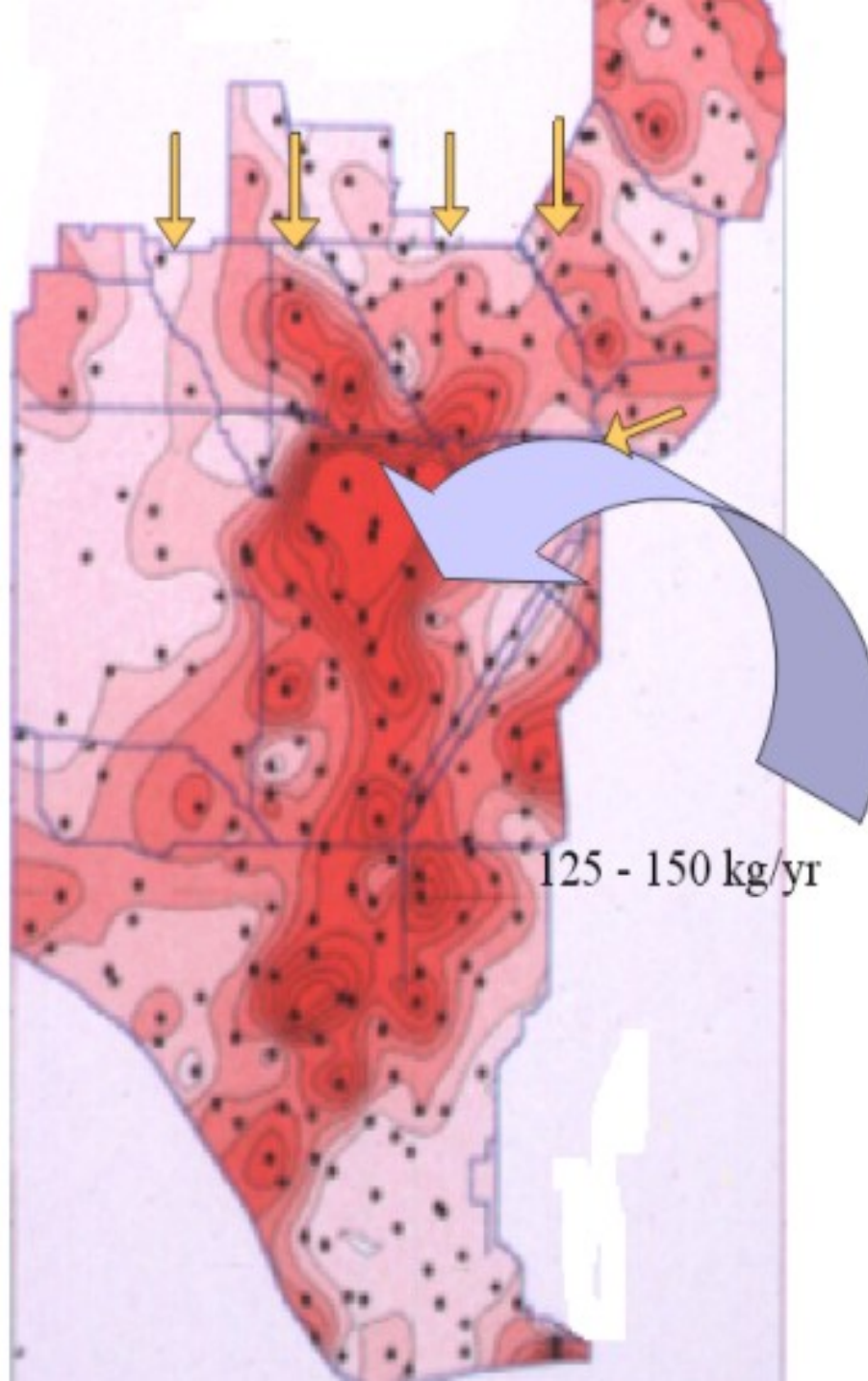


# Science Partners









~ 98 %  
Atmospheric



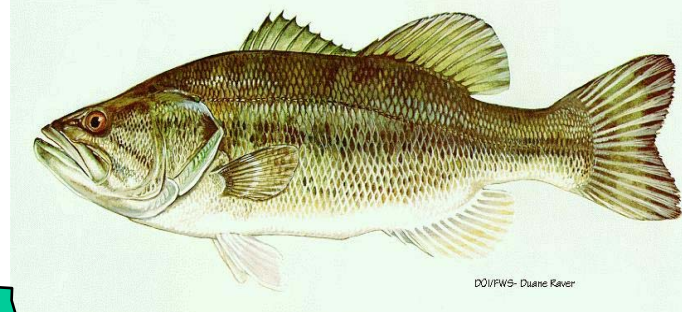
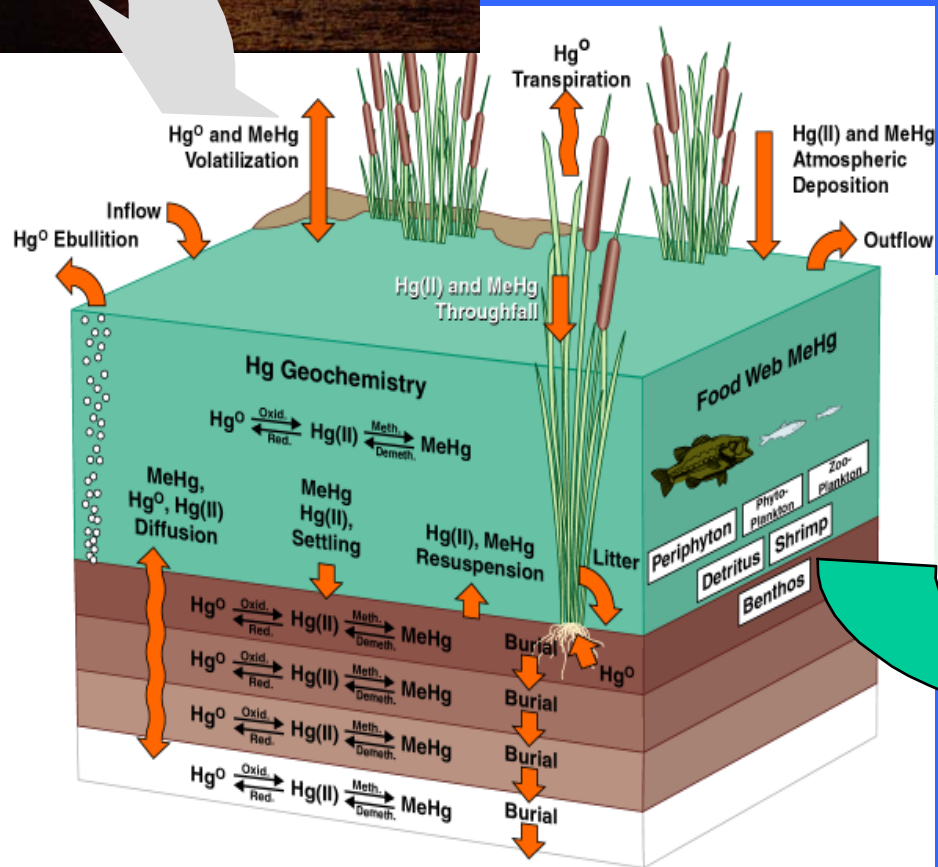


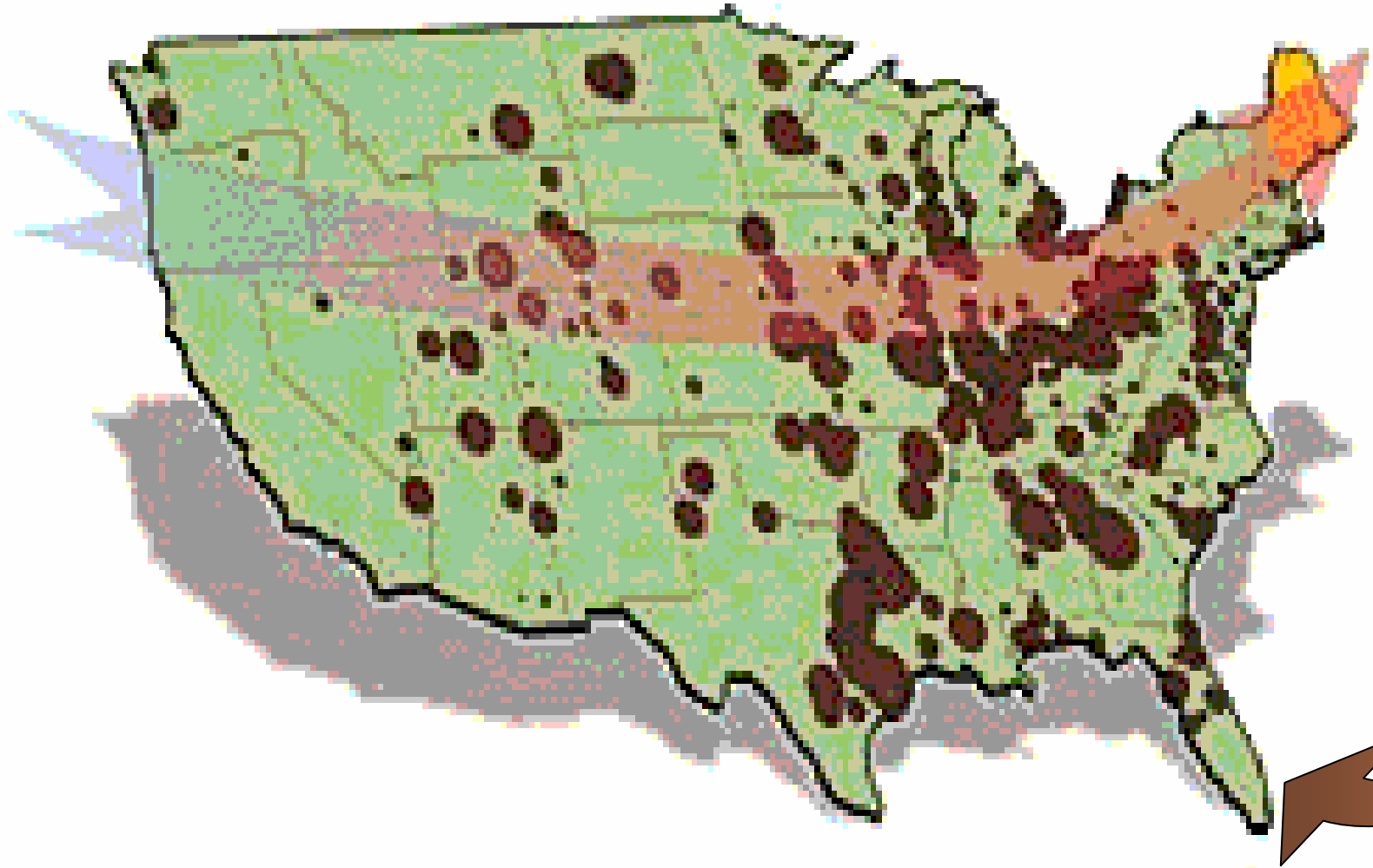
Figure 1. Conceptual model of Hg cycle in Everglades Hg Model

# The Mercury Problem

Where does the mercury come  
from?



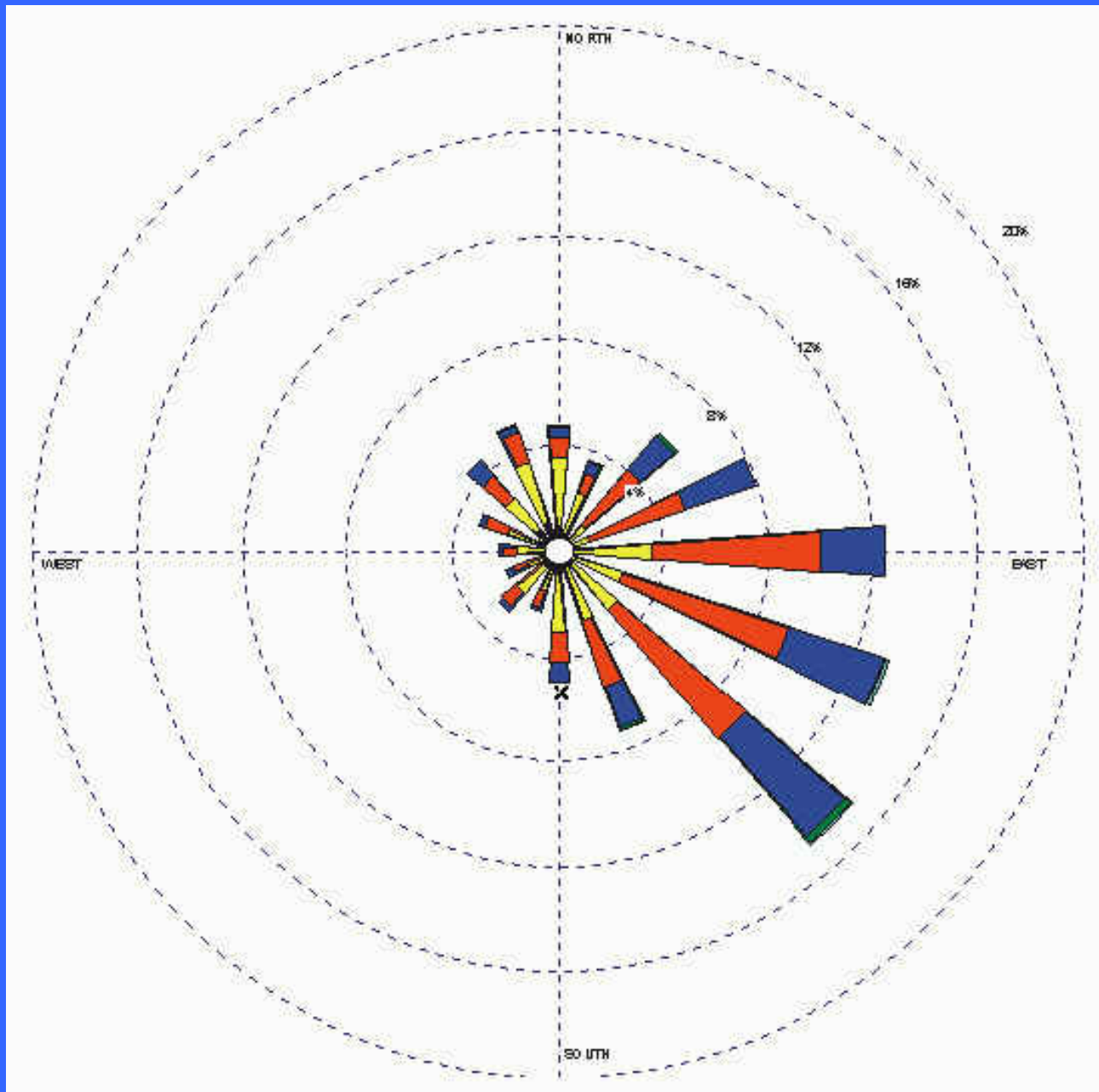
## Mercury Emission and Transport



**~ 60% Local Sources**







Wind Rose: Miami, Fla., Summer 6 mos., 1992

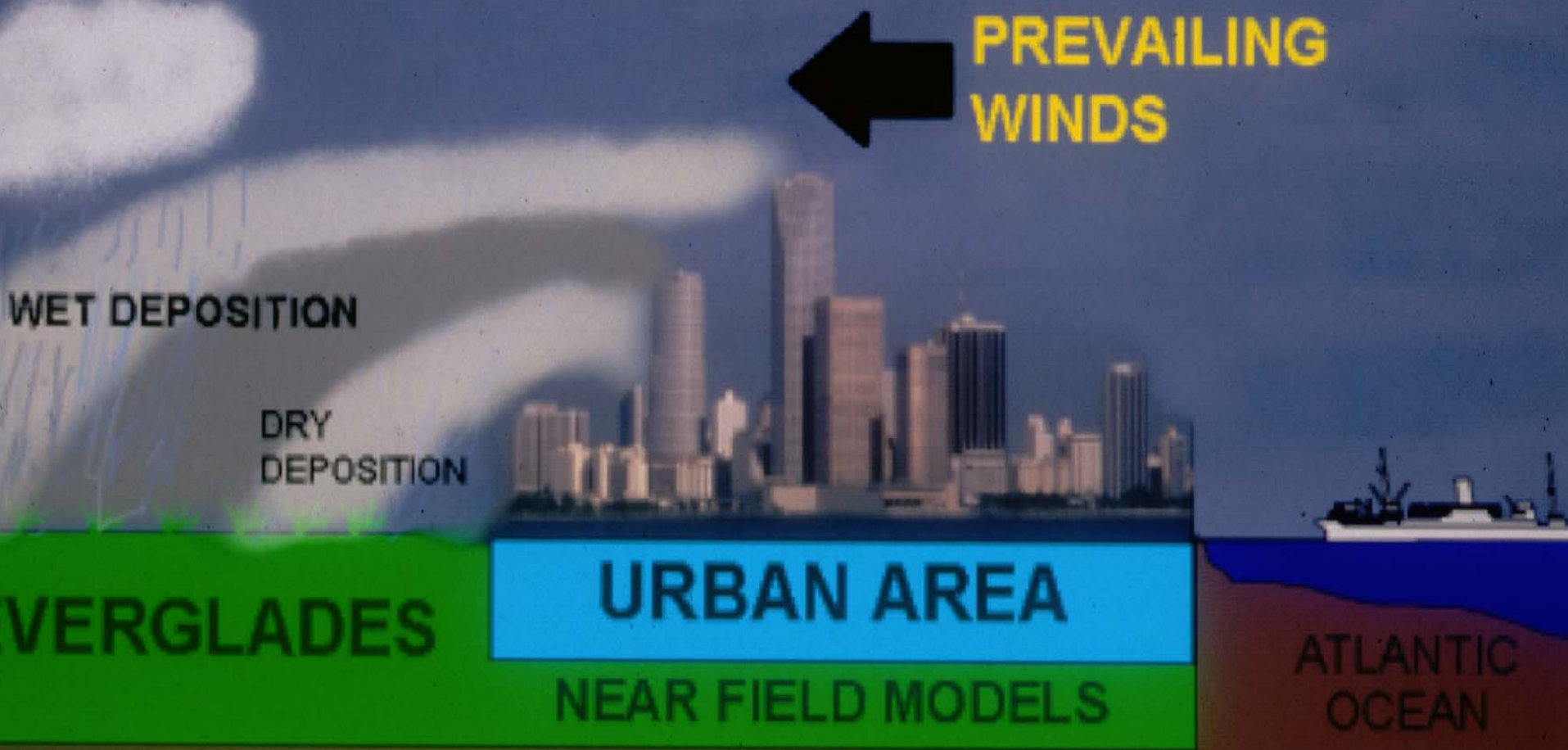


Municipal Waste Combustor



W

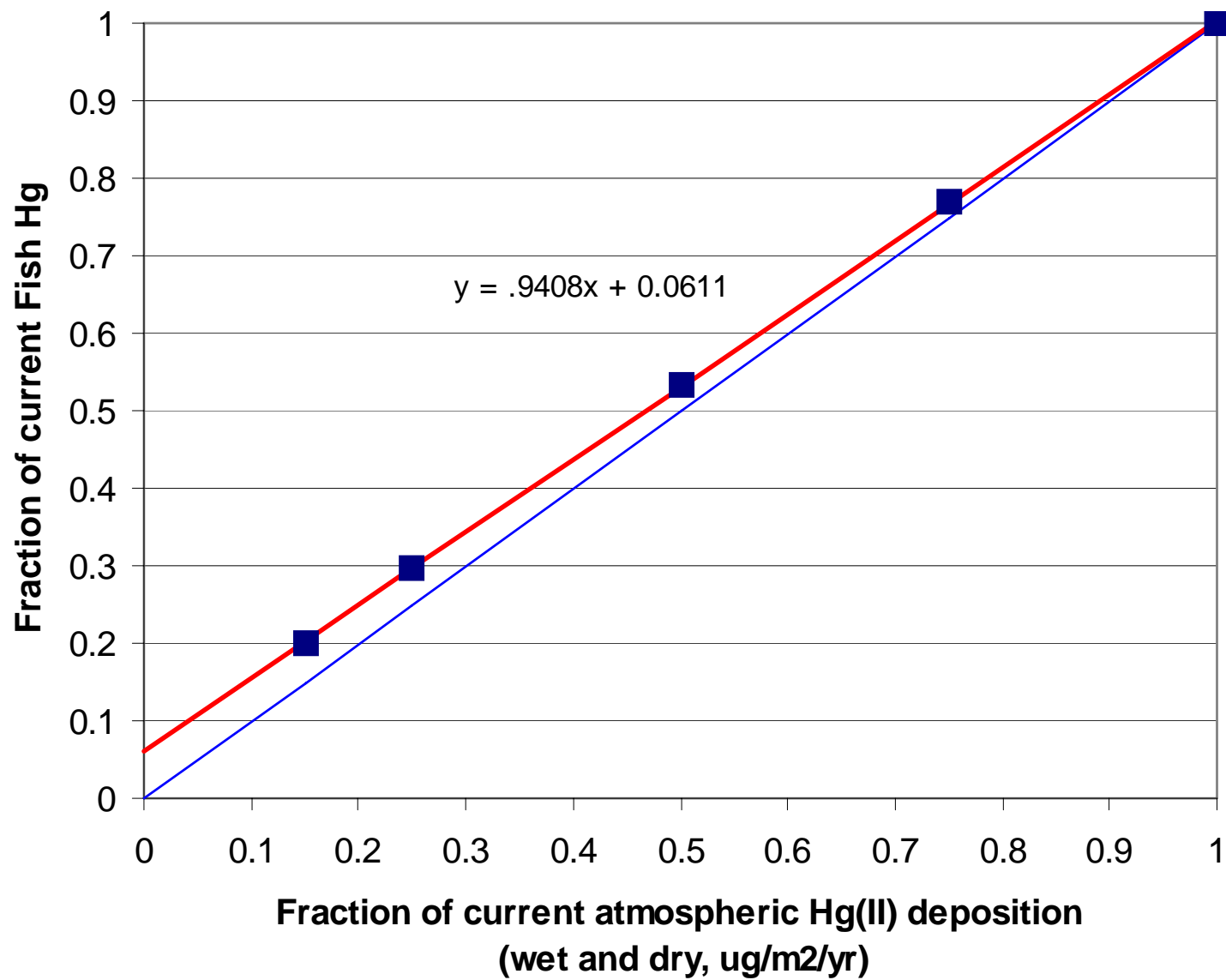
E



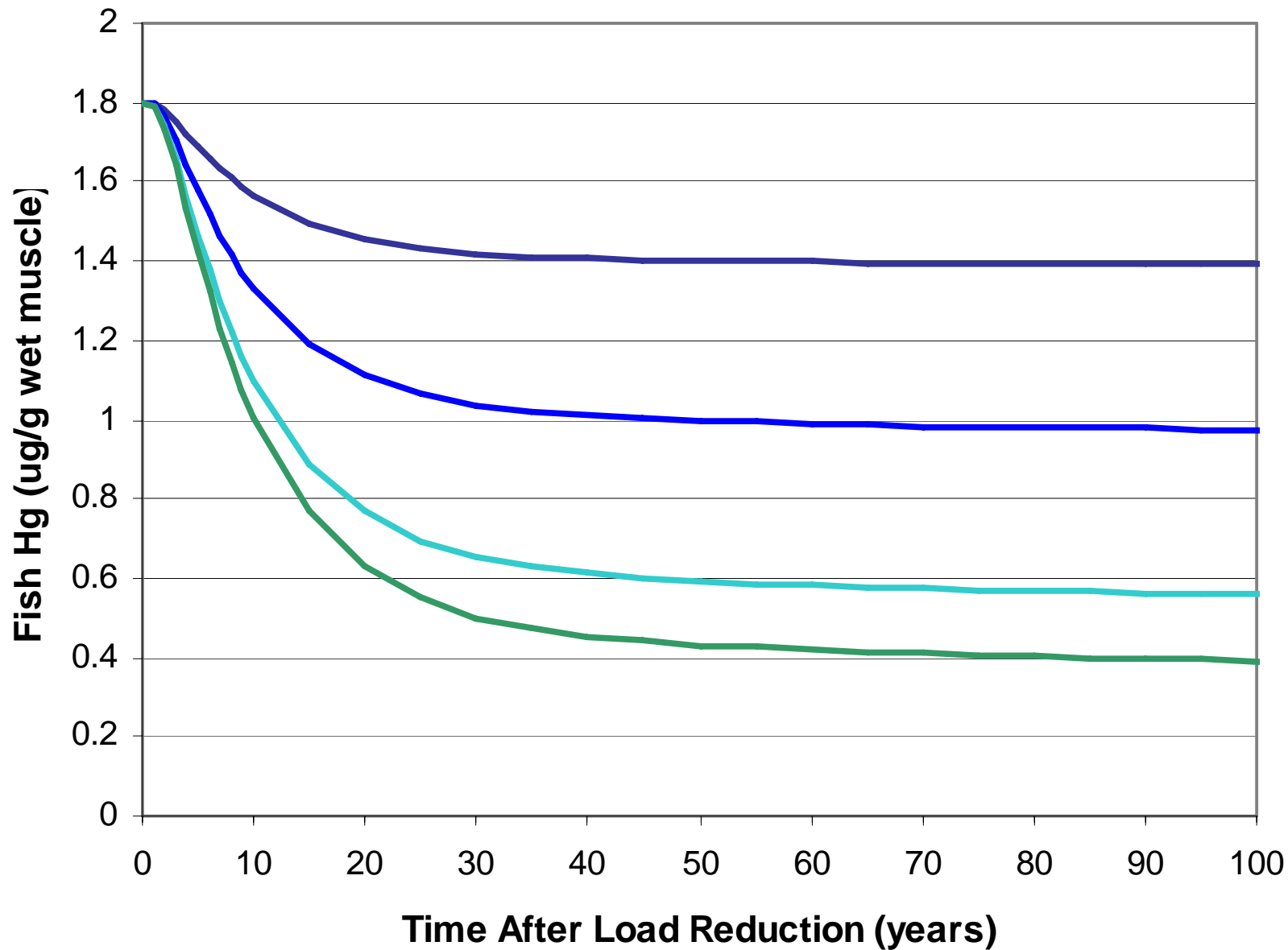
# Mercury Trends

Recent Data From Florida





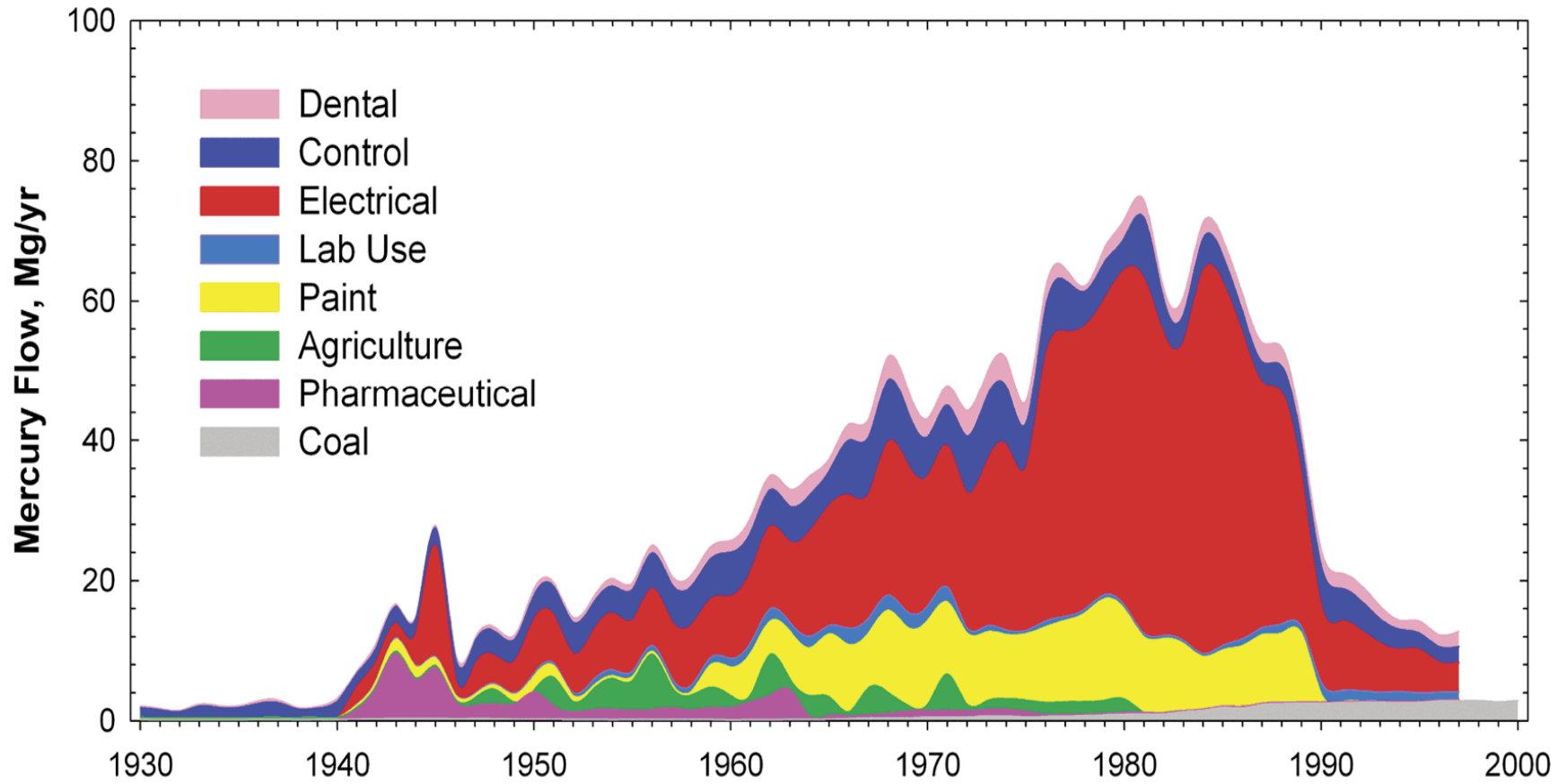
— Proportional response    ■ E-MCM predicted    — Linear fit of E-MCM results



— 25% Reduction — 50% Reduction — 75% Reduction — 85% Reduction

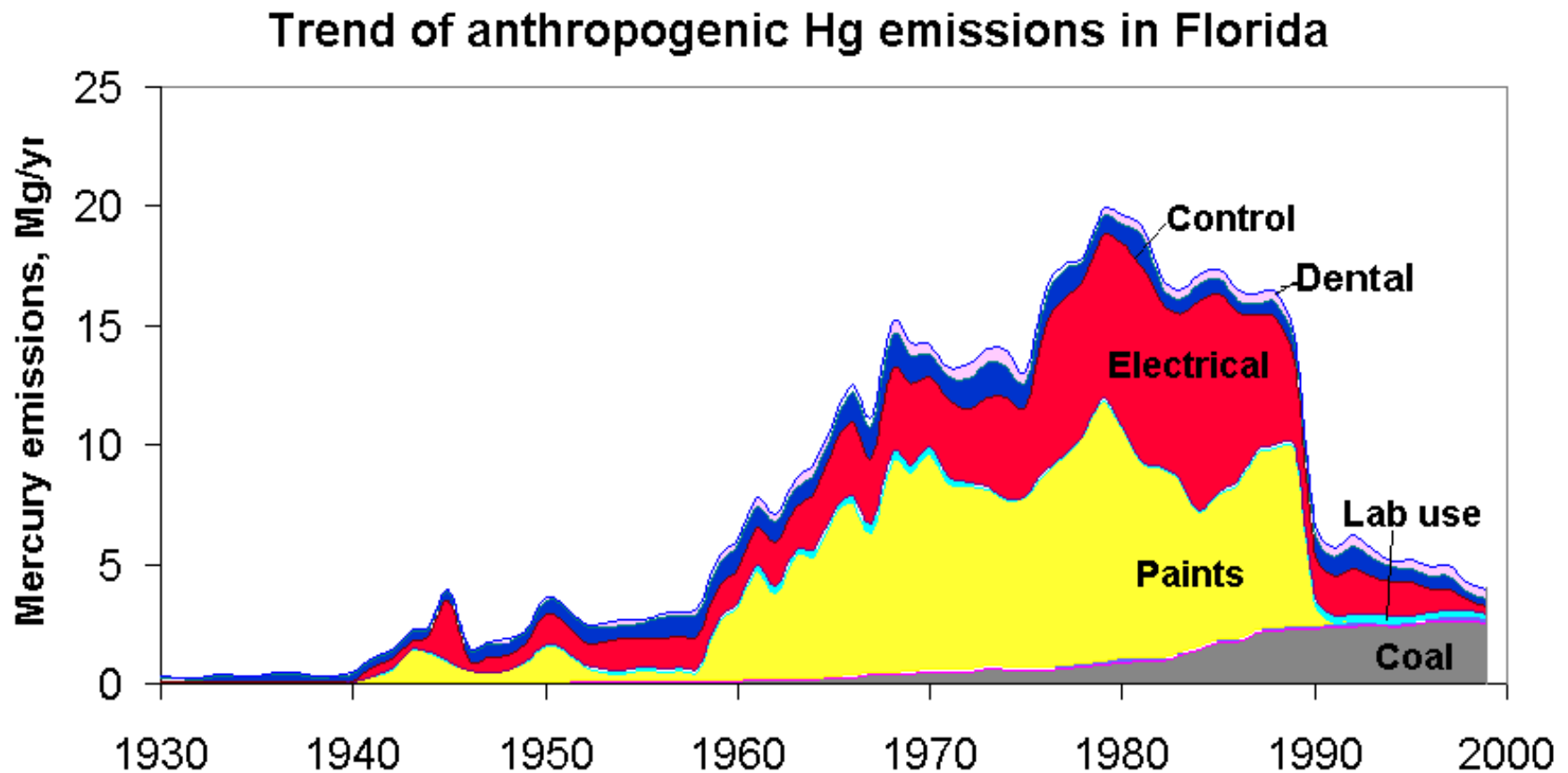
# MERCURY

## Material Flows in Florida





# MERCURY Retrospective Emission Inventory



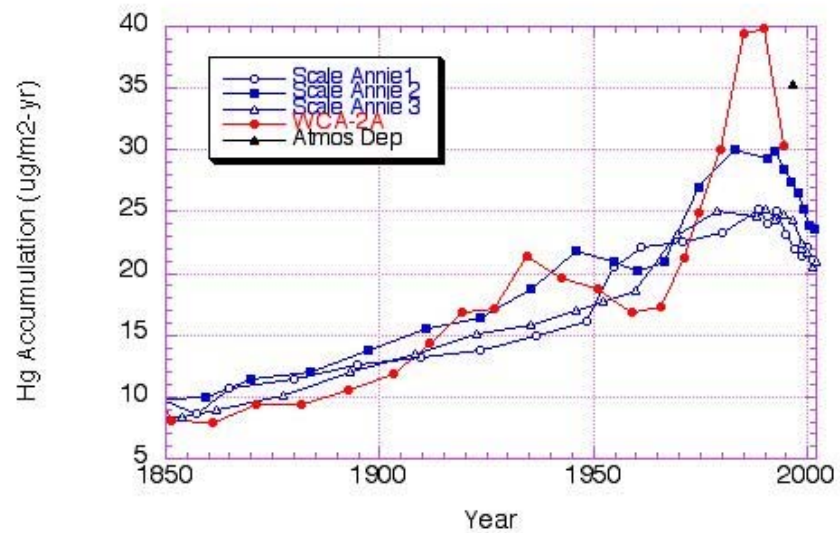
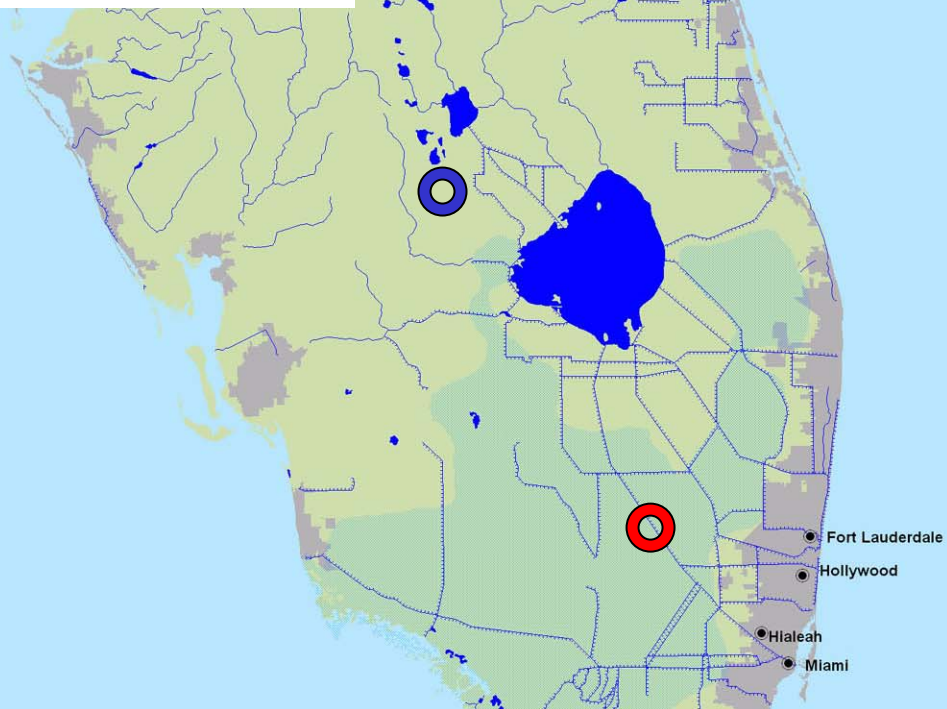
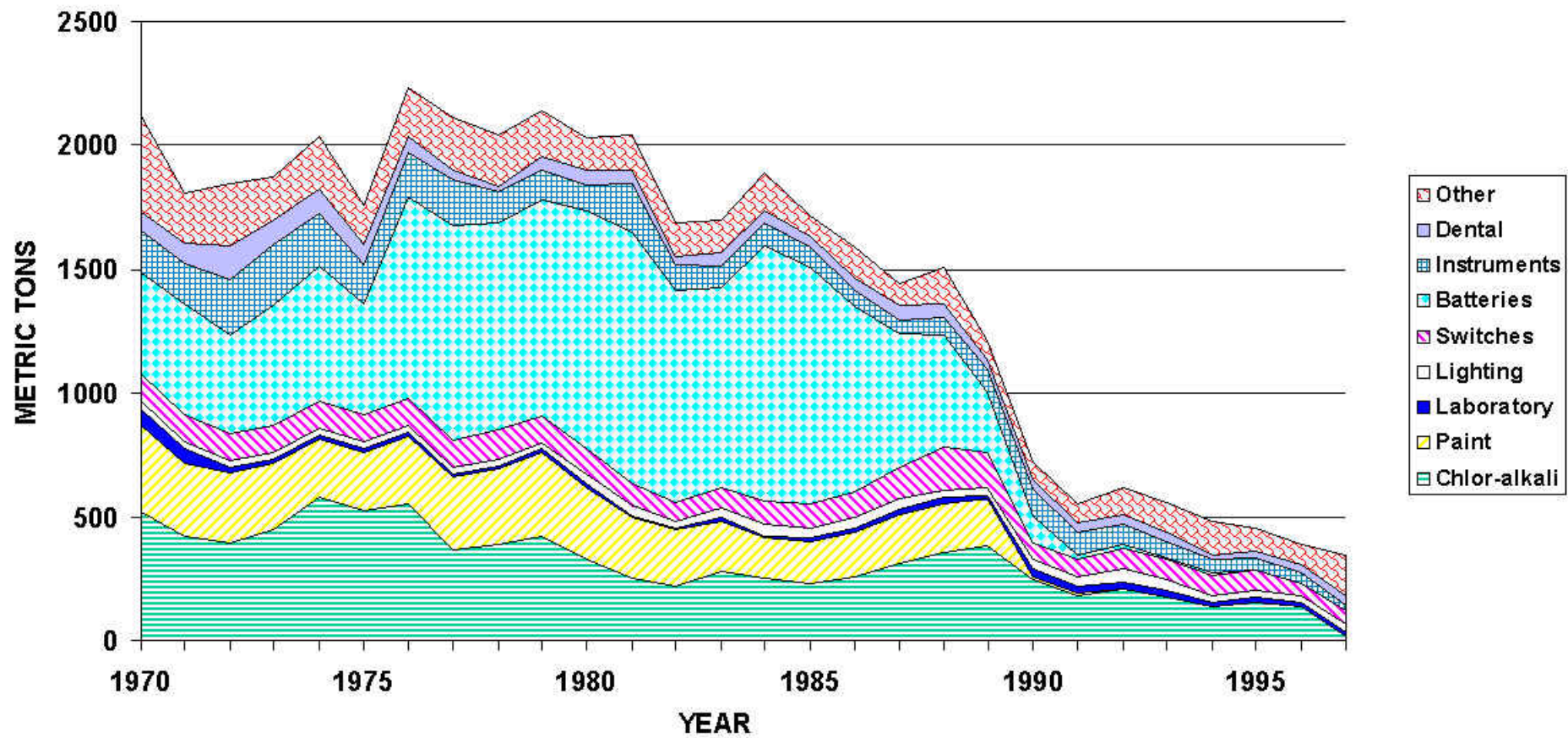


Figure 2. Same as Figure 1, except that the Lake Annie fluxes have been normalized to yield similar baseline (pre-1850) fluxes as Site F3.

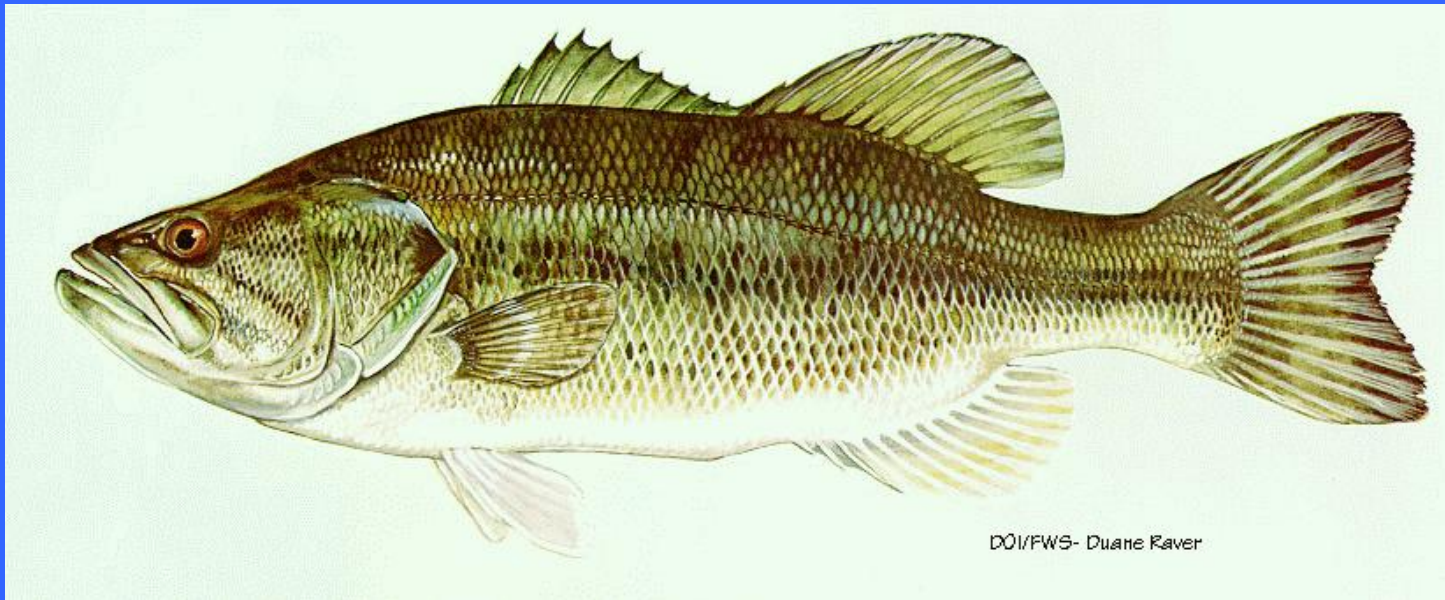
### Legend

- City
- Urban Area
- Wetland





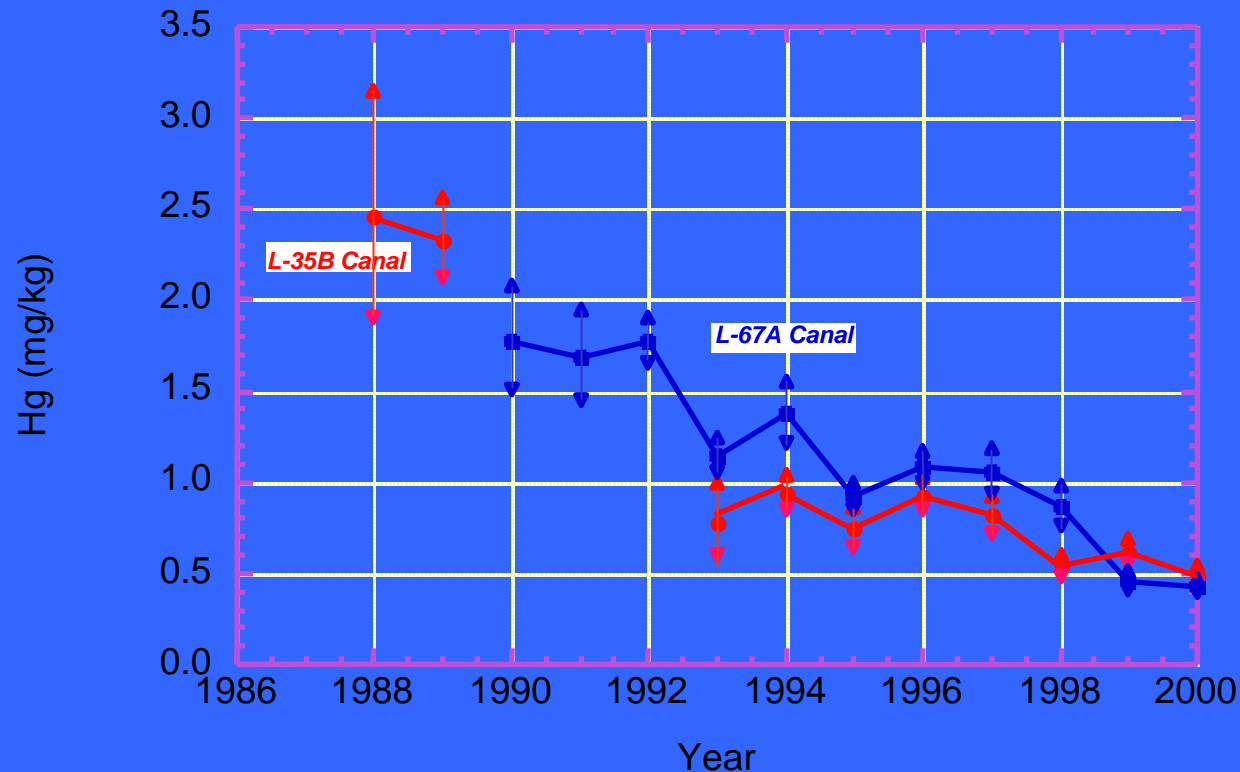




DOI/FWS- Duane Raver

# Hg Concentrations in Largemouth Bass Everglades Canals L-37B and L-67A

Geometric mean by year. Diamonds show  $\pm 1$  SE of the Mean



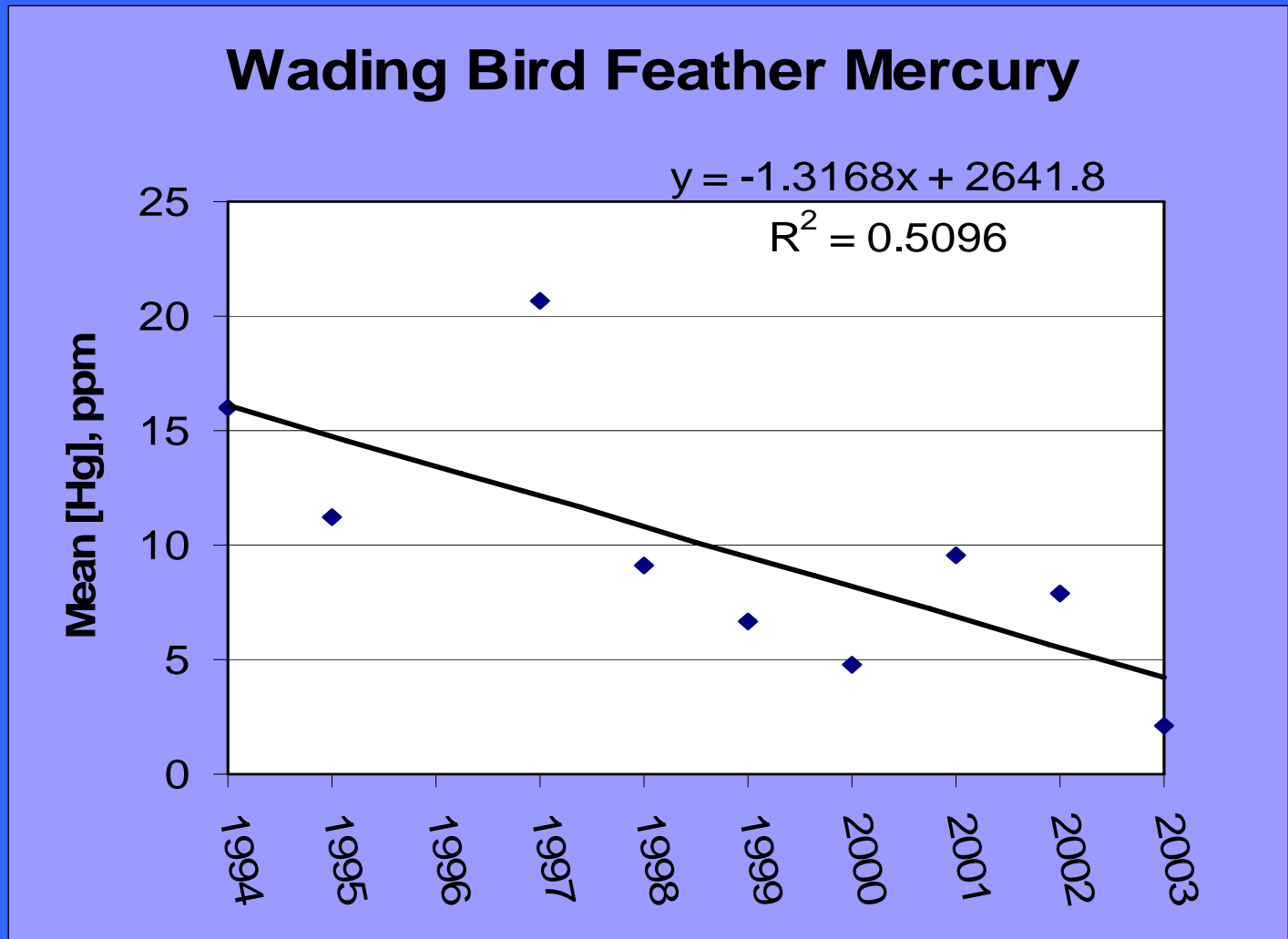
Data courtesy of Ted Lange.



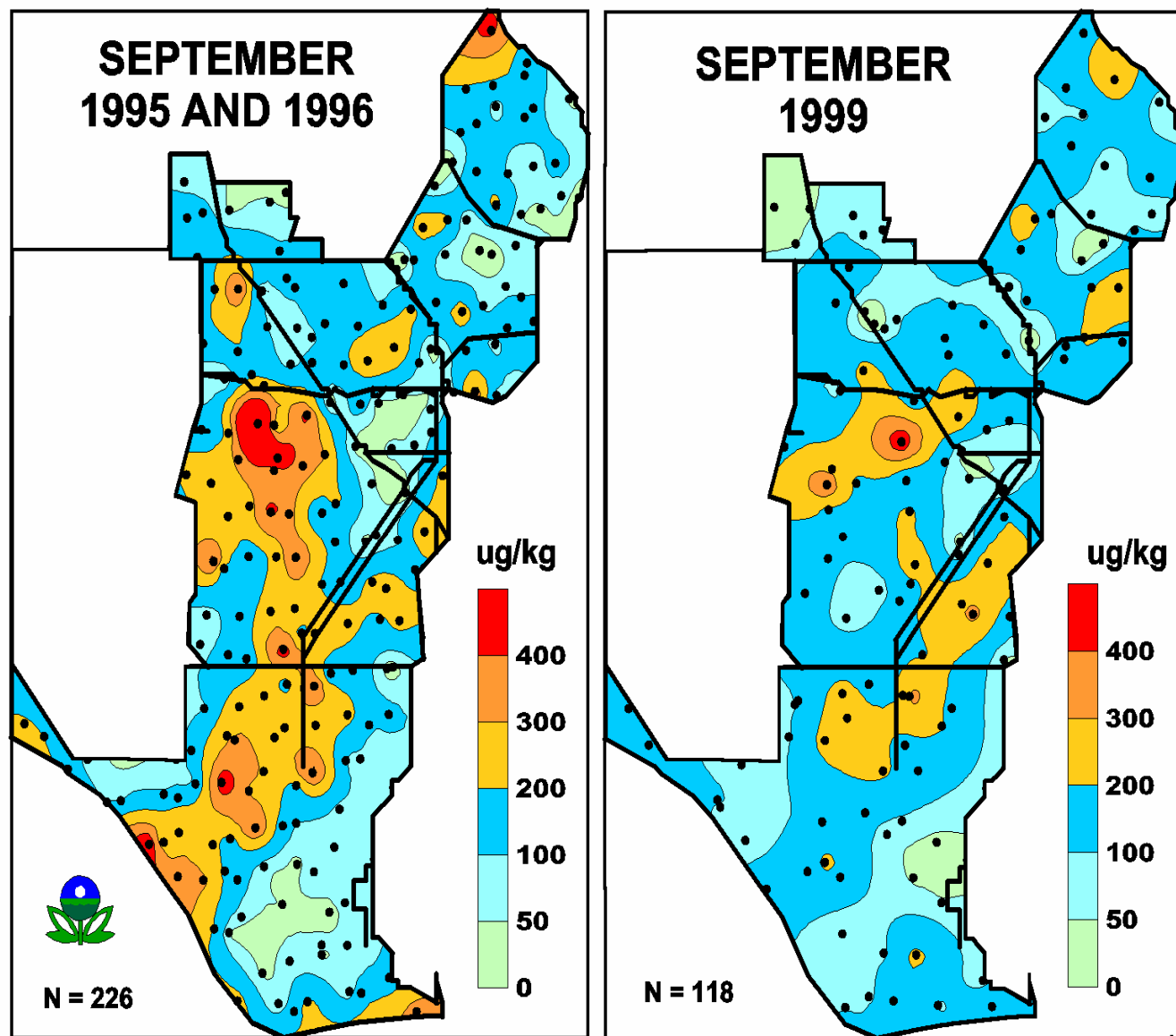


# MERCURY

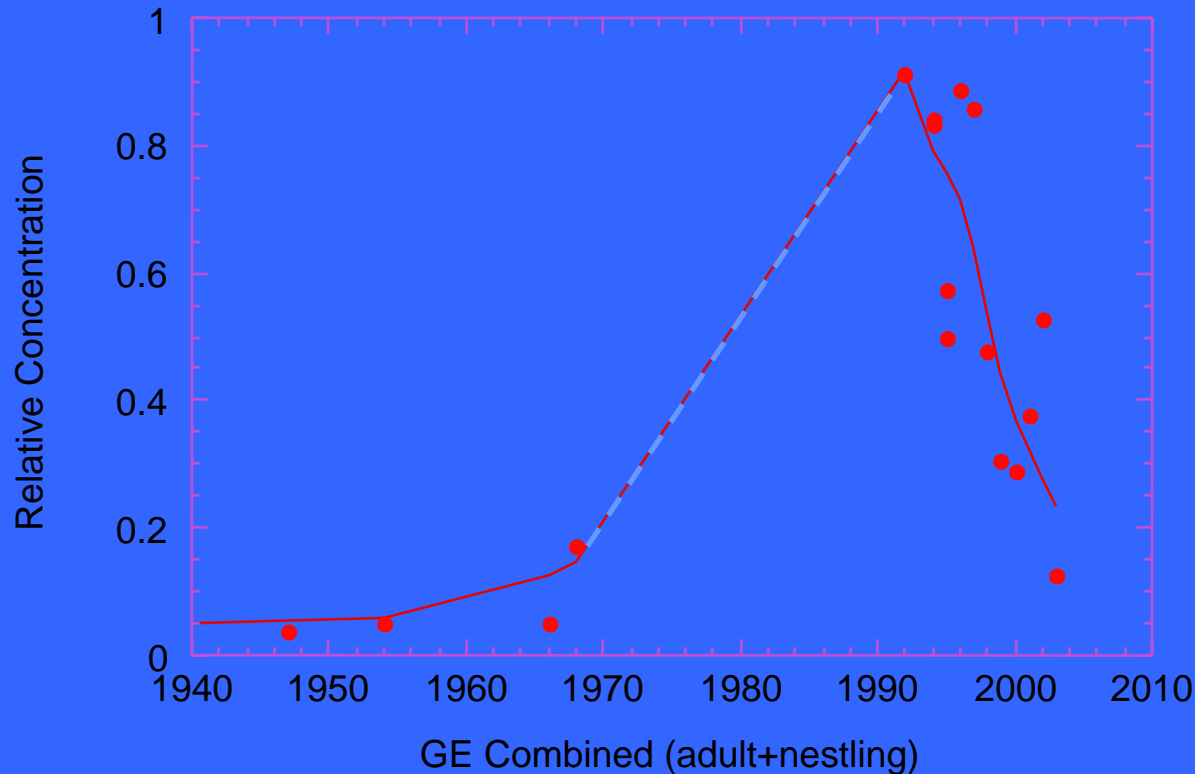
## Great Egret Feathers, 94 - 03 All Active Nesting Colonies



# MOSQUITOFISH Hg TREND

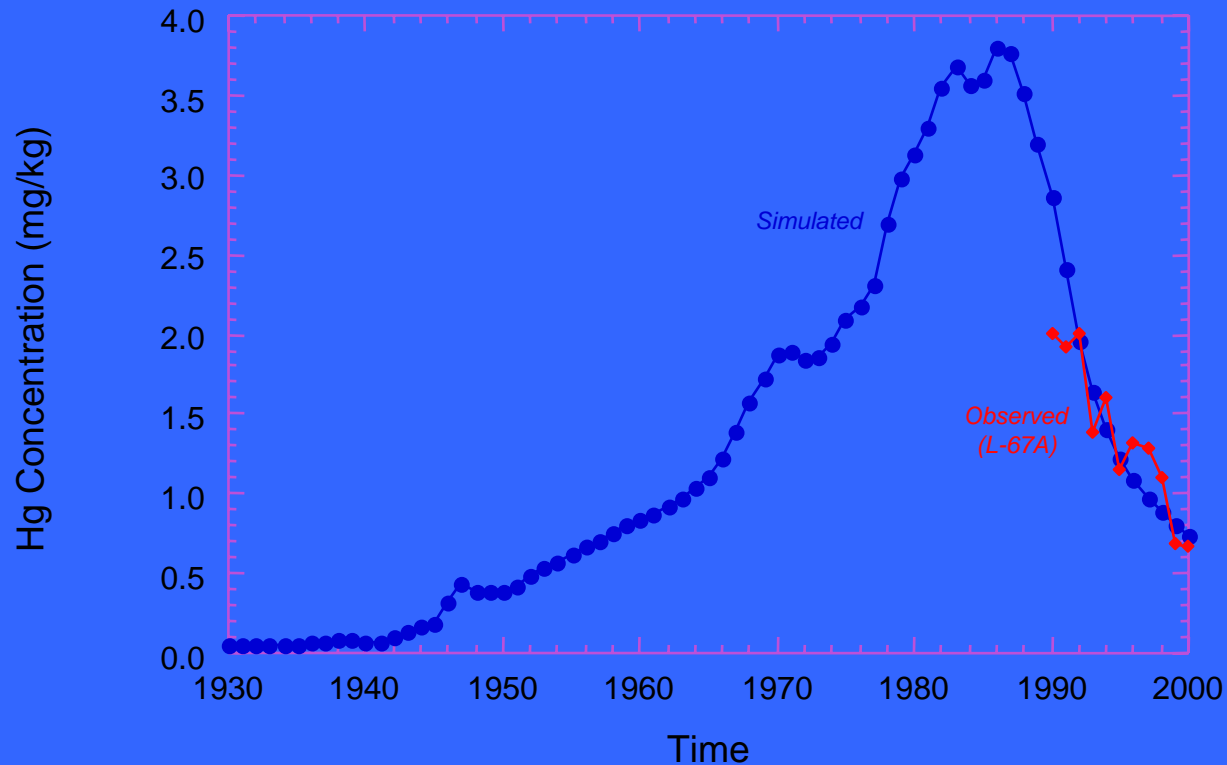


Concentrations of Hg in Great Egret Feathers (adults and nestlings). Data normalized to facilitate comparison. Data courtesy of P. Frederick (2003).





# Preliminary E-MCM Model Hindcast of Changes in Hg Concentrations in Age 3 LMB Due to Inferred Changes in Atmospheric Deposition

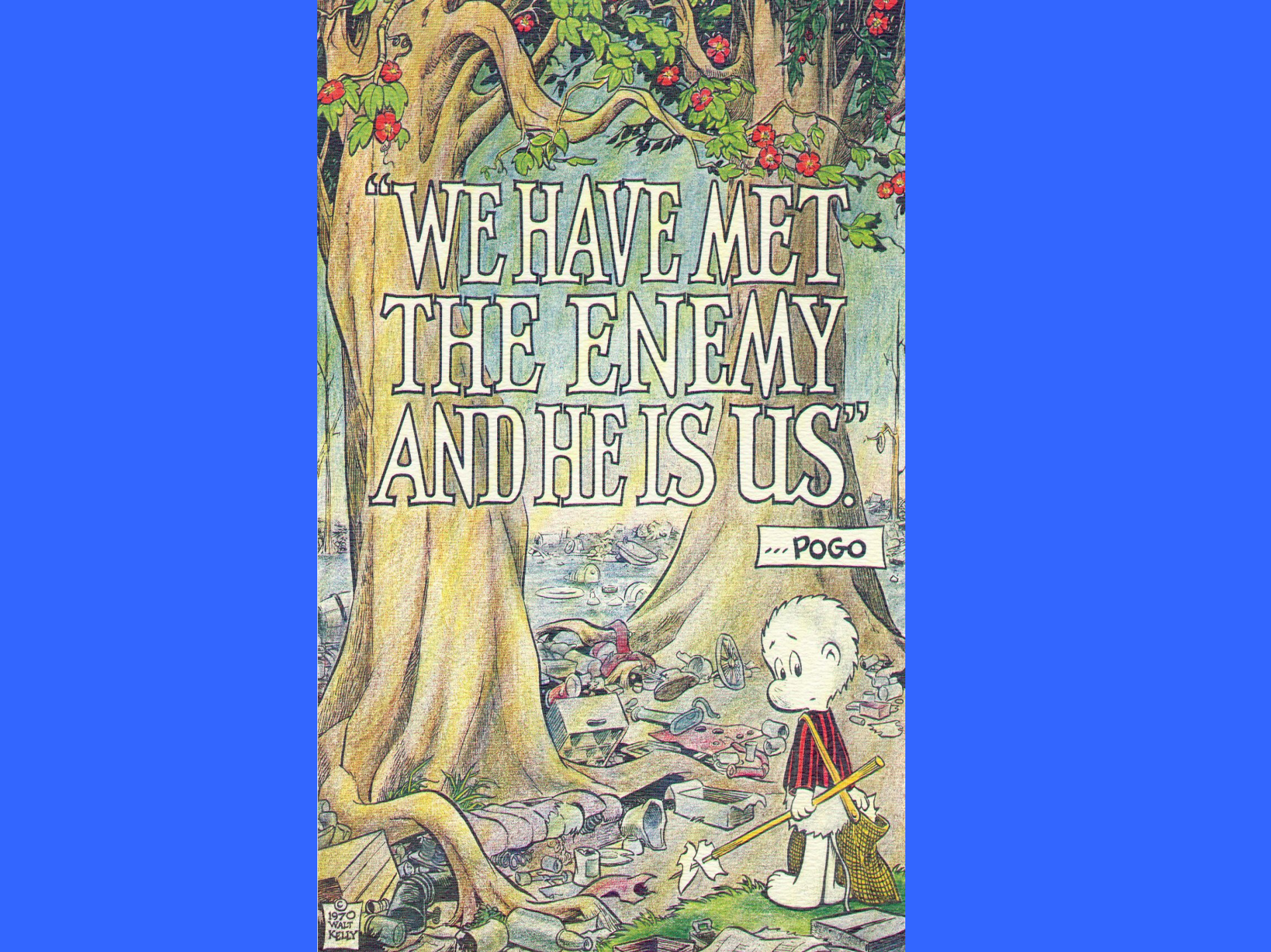




# MERCURY : The Bottom Line

- Reduction of atmospheric sources of mercury within Florida has led to > 60% declines in mercury in Everglades fish and wildlife in less than 15 years since peak deposition.
- To the extent that mercury emissions are in the reactive form (RGM), reductions will yield local-scale benefits within a few years, and near equilibrium in decades.
- The main driver of the Everglades mercury problem is mercury load – overwhelmingly from atmospheric deposition.
- There is synergy between Hg & Sulfate, which combine to exacerbate Hg methylation.

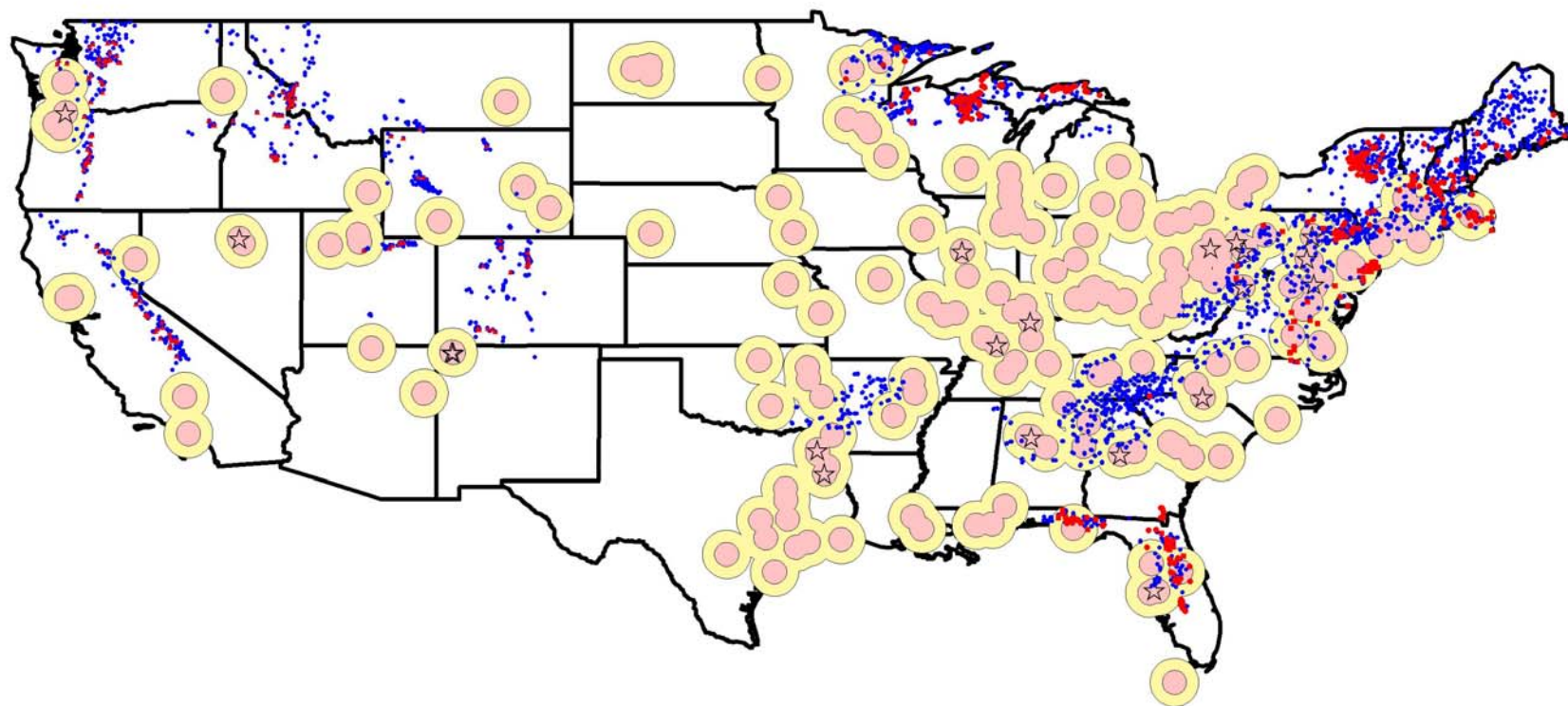




“WE HAVE MET  
THE ENEMY  
AND HE IS US.”

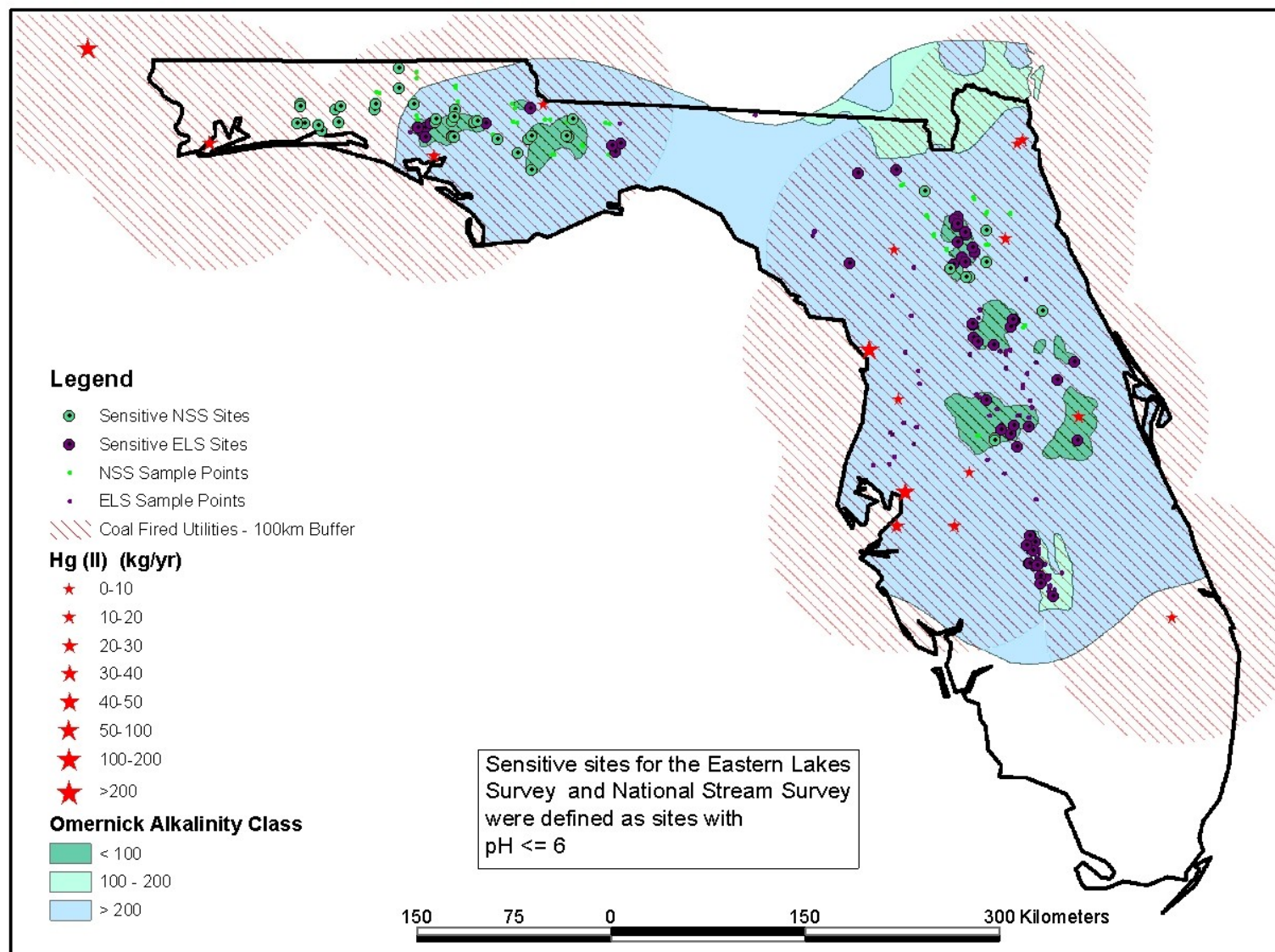
...POGO





- ▲ WLS - Sensi
- NSS - Sensi
- ELS - Sensi
- ELS WLS and NSS sample points
- Top 200 Hg Emissions
- 50 km
- 100 km
- ☆ Top 20 Hg Emissions

Sensitive sites were selected from ELS and NLS by either  $\text{pH} < 6.0$  or  $\text{ANC} < 20$ . NSS sites were selected with the same above criteria with an additional filter of  $\text{DOC} > 3 \text{ mg/l}$ .



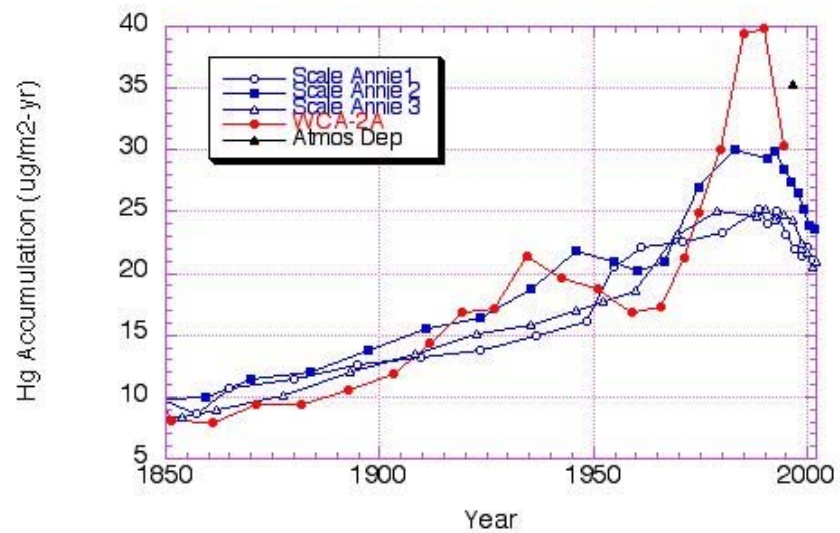
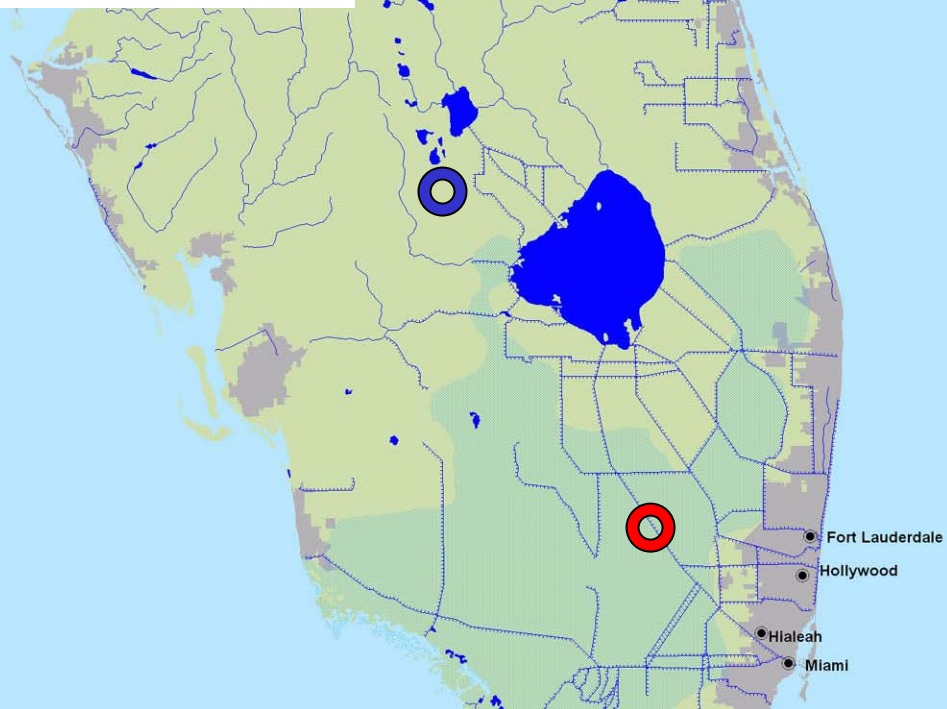
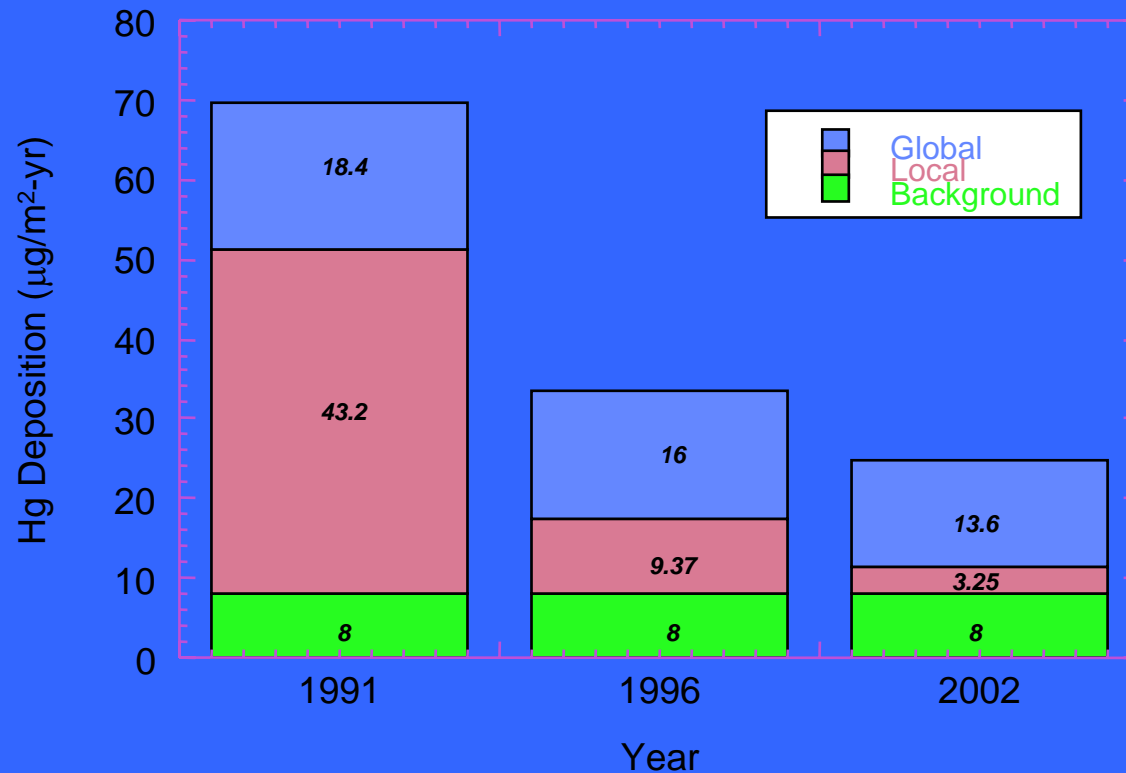


Figure 2. Same as Figure 1, except that the Lake Annie fluxes have been normalized to yield similar baseline (pre-1850) fluxes as Site F3.

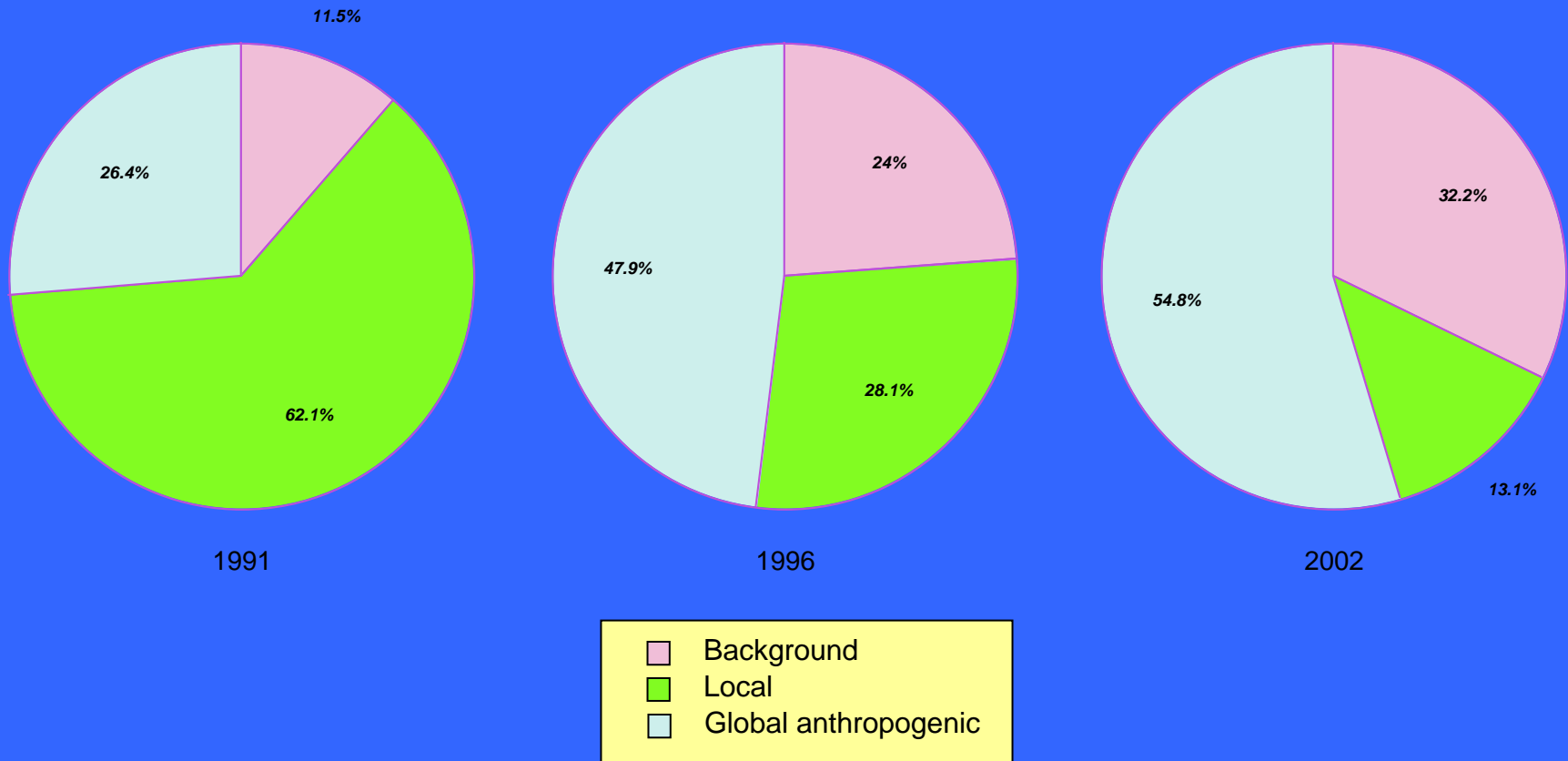




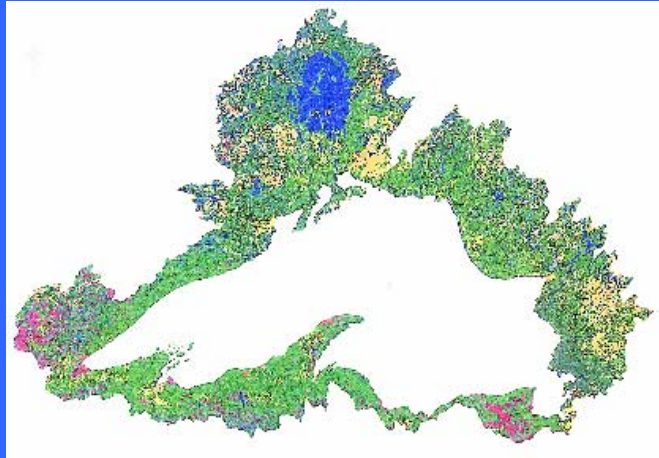
# Changes in Local Emissions Contributions to Atmospheric Deposition Fluxes of Mercury in South Florida



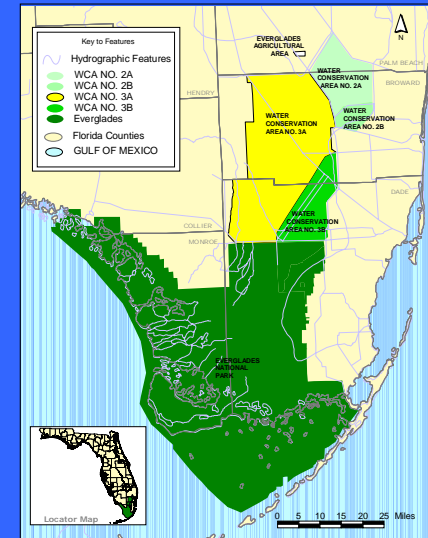
# Changes in Local Emissions Contributions to Atmospheric Deposition Fluxes of Mercury in South Florida



# End-members of mercury vulnerability



Vs.



## Lake Superior:

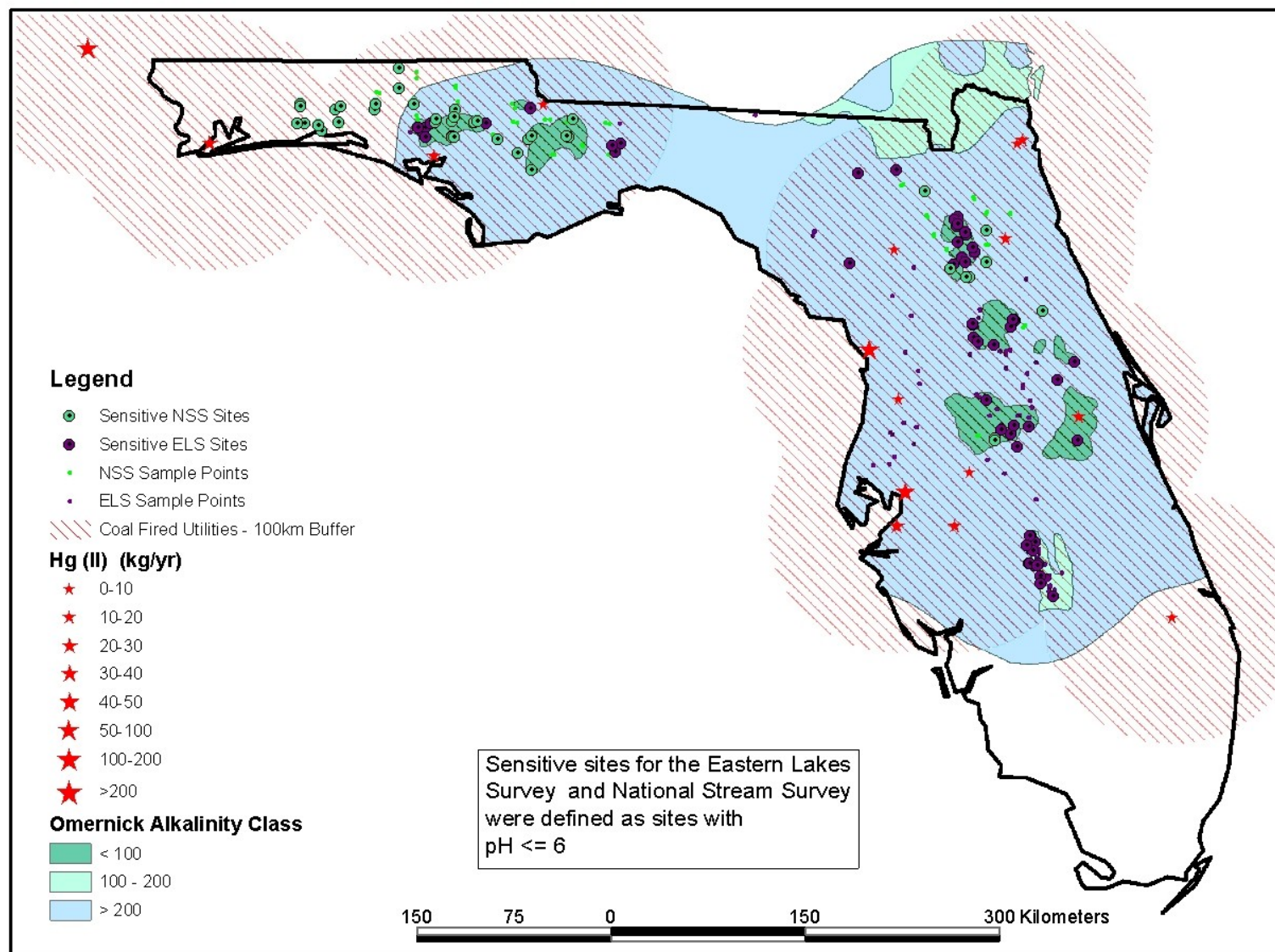
- Cold, prolonged ice-up
- Low photon flux
- Deep
- Disconnect w/ overlying epilimnion
- Low Surface to vol. Ratio
- ~ 100% wetlands
- Low surface roughness to trap atm. gases & particles

## Everglades:

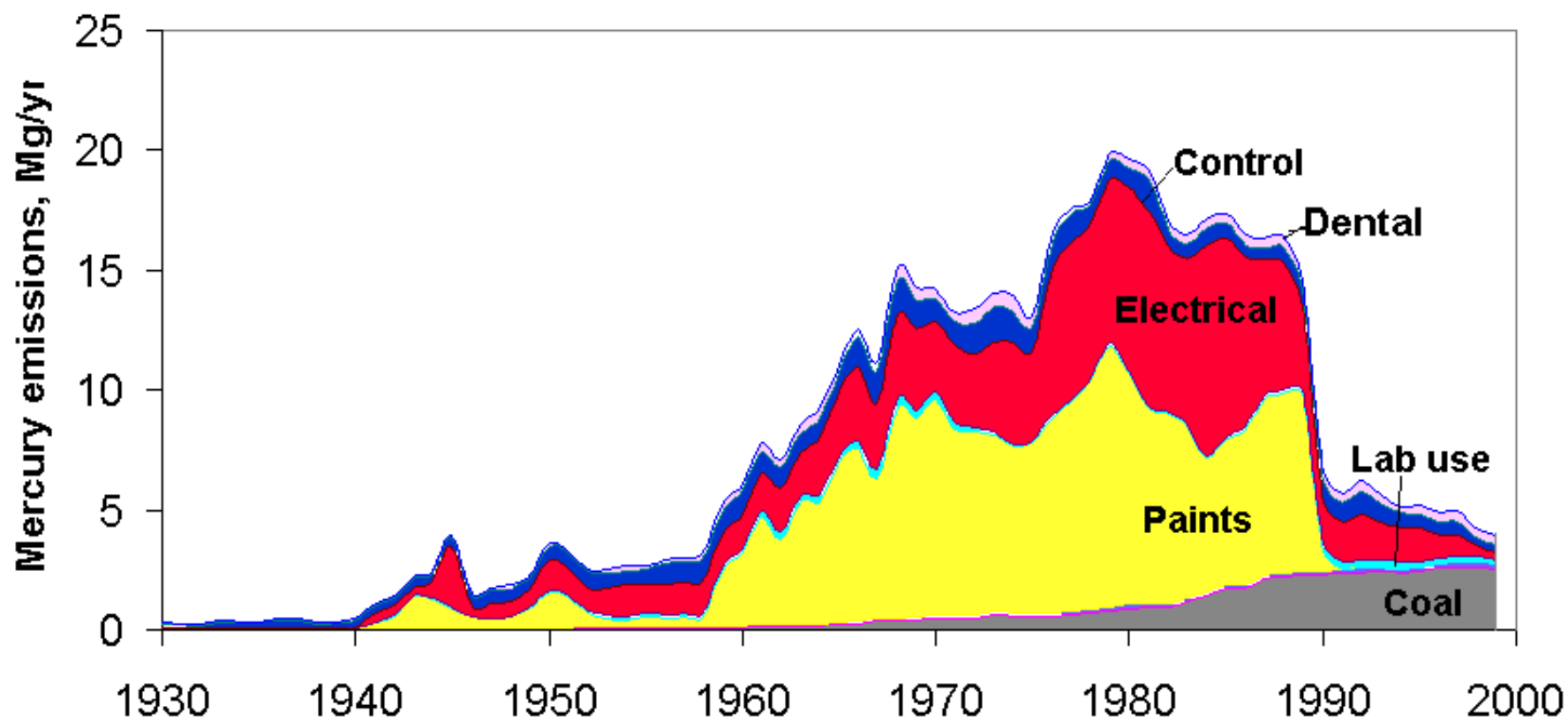
- Hot year-round
- High Photon Flux
- Shallow
- Close apposition of water surface & sediments
- High Surface to vol. Ratio
- High % wetlands
- High surface roughness

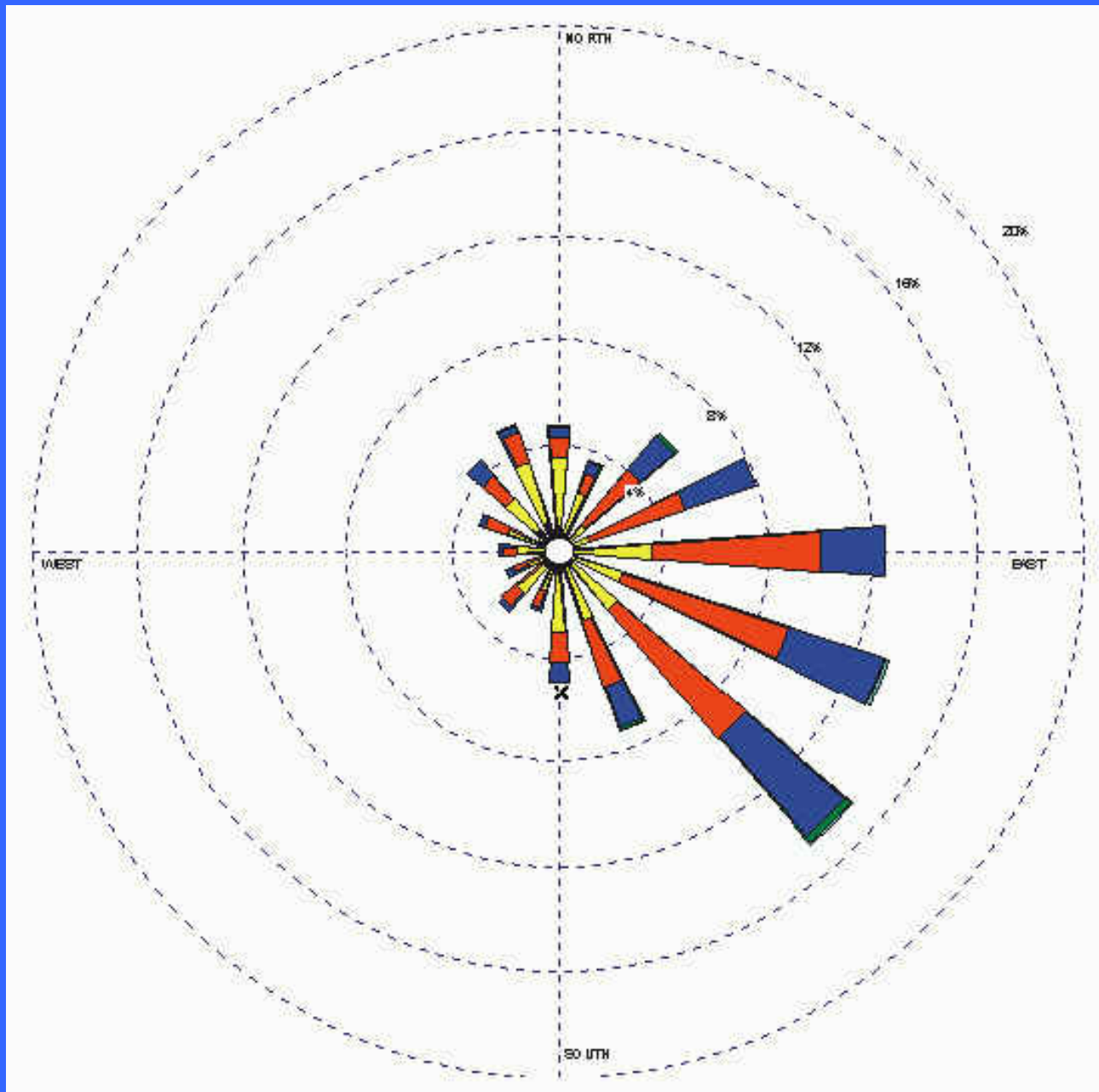






## Trend of anthropogenic Hg emissions in Florida





Wind Rose: Miami, Fla., Summer 6 mos., 1992







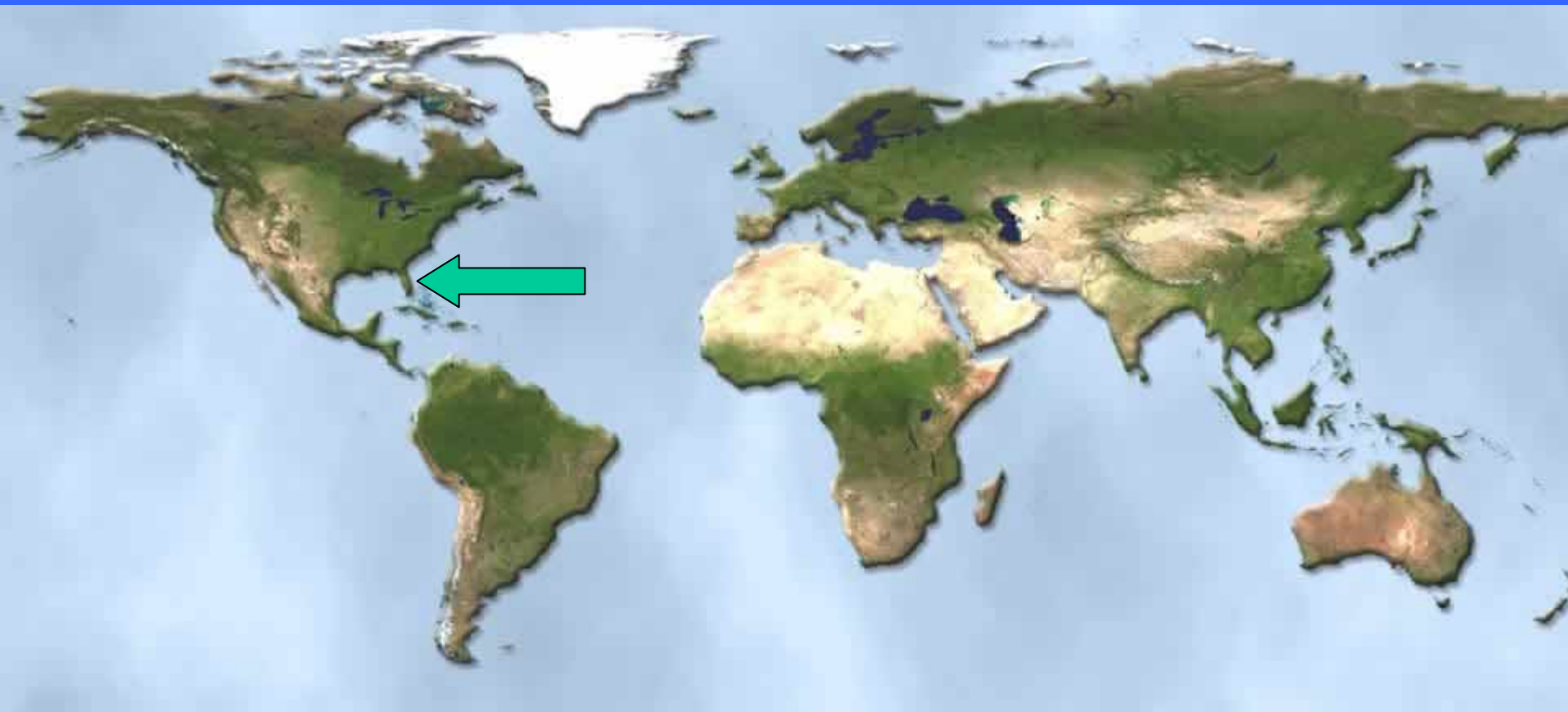
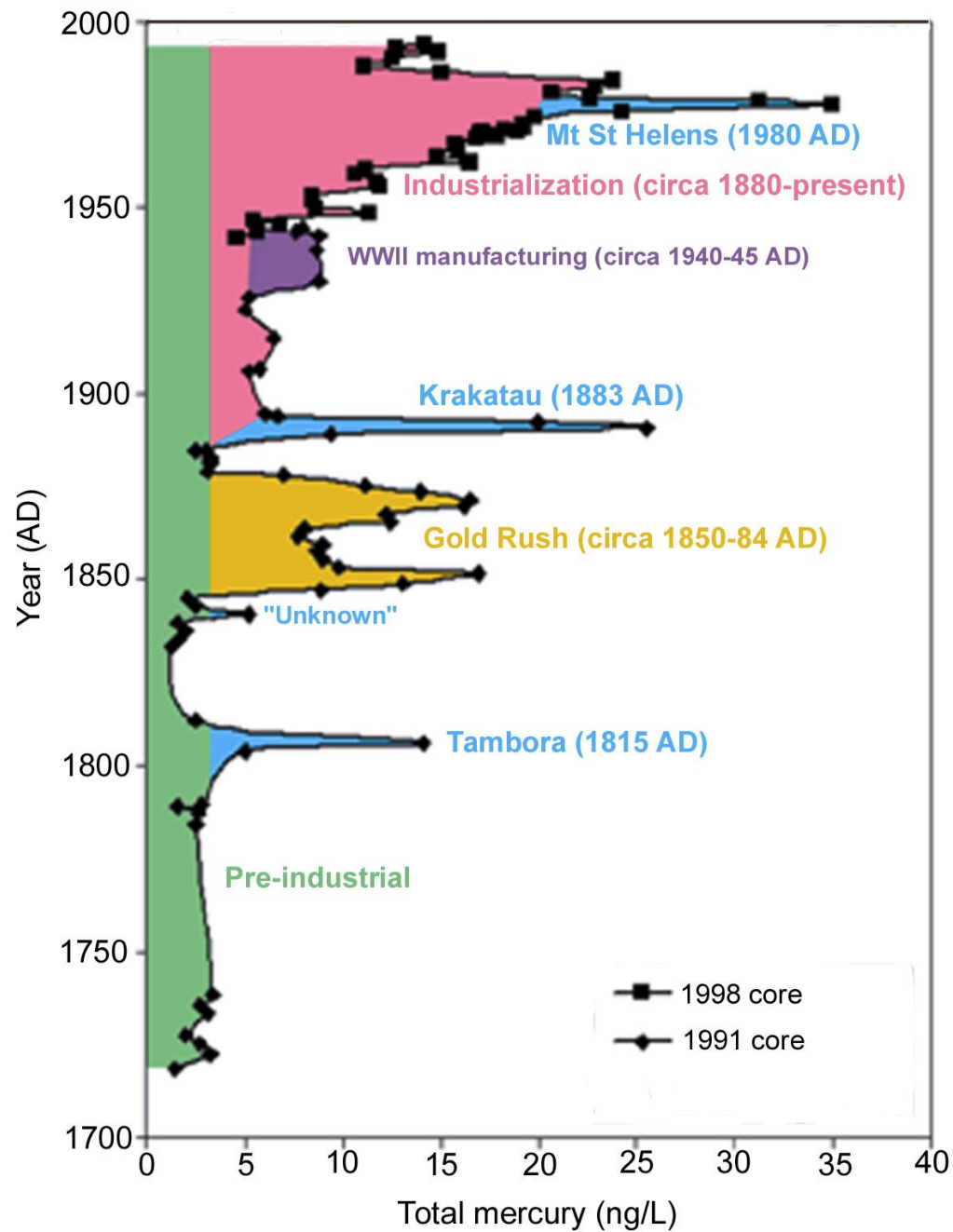


Figure 2



Science has a face, a house, and a price;  
it is important to ask who is doing science, in  
what institutional context, and at what cost.

Understanding such things can give us  
insight into why scientific tools are sharp for  
certain types of problems and dull for others.

— Robert Proctor, *Cancer Wars*

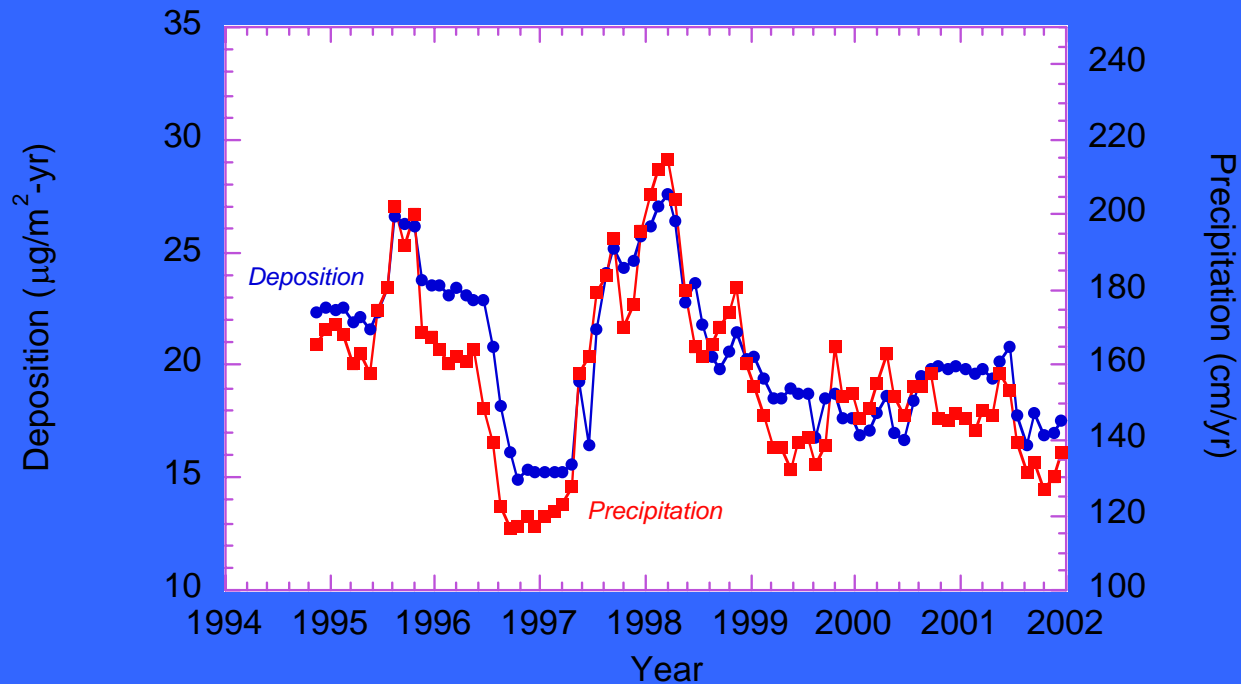
Truth crushed to earth  
shall rise again;  
the eternal years of God are hers.

But error, wounded,  
writhes with pain,  
and dies among his worshipers.

— *Bryant*



Annual Hg Wet Deposition and Precipitation Fluxes at Everglades National Park, 1994 - 2002. Data from Guentzel et al. (2002) and MDN. Data expressed as 12 month running total.



# Medical Waste Incinerators

## Varying sizes

