



The Great Lakes Environmental Indicators (GLEI) Project in Lake Superior

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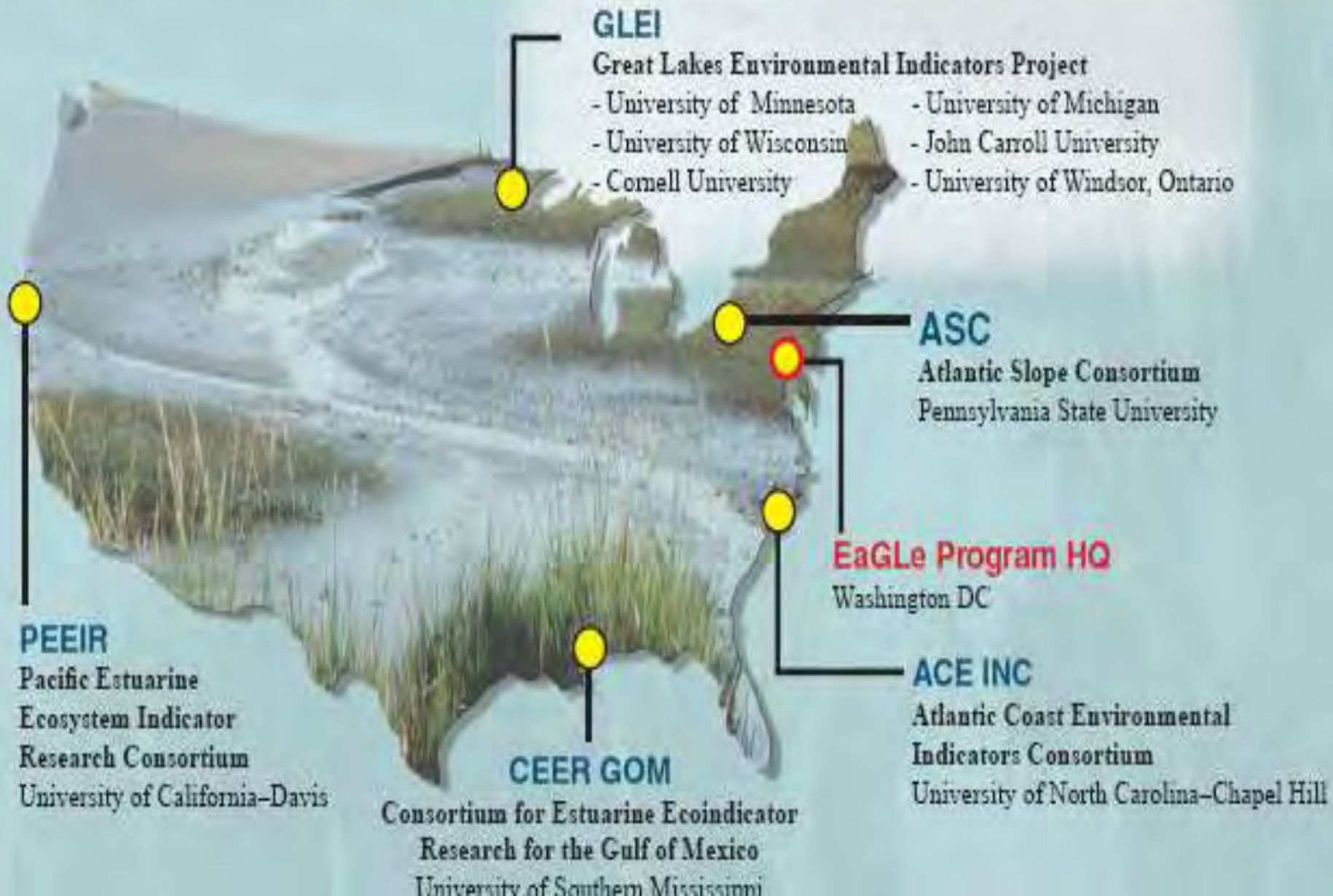
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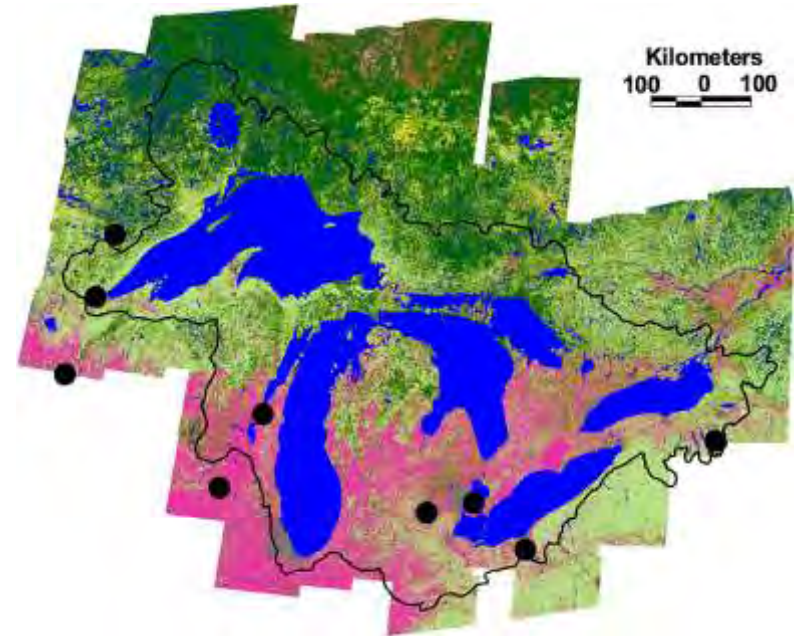
Joy Zedler, University of Wisconsin, Madison

John Brazner, John Kelly, Anett Trebitz, Peder Yurista, Gary Ankley, Dave Mount, Steve Diamond, U.S. EPA's Mid-Continent Ecology Division

EPA's Science to Achieve Results (STAR) Estuarine and Great Lakes (EaGLE) Program

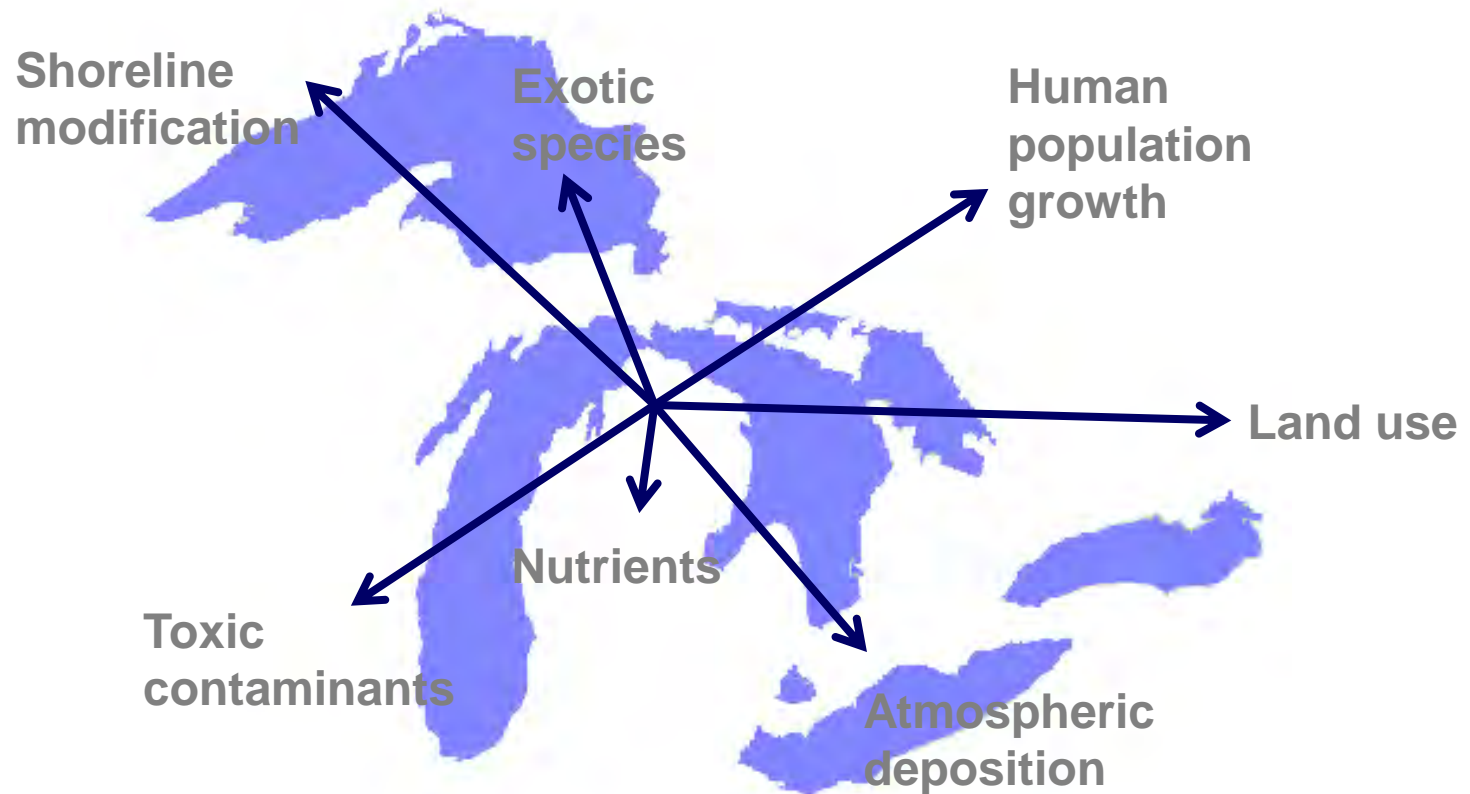


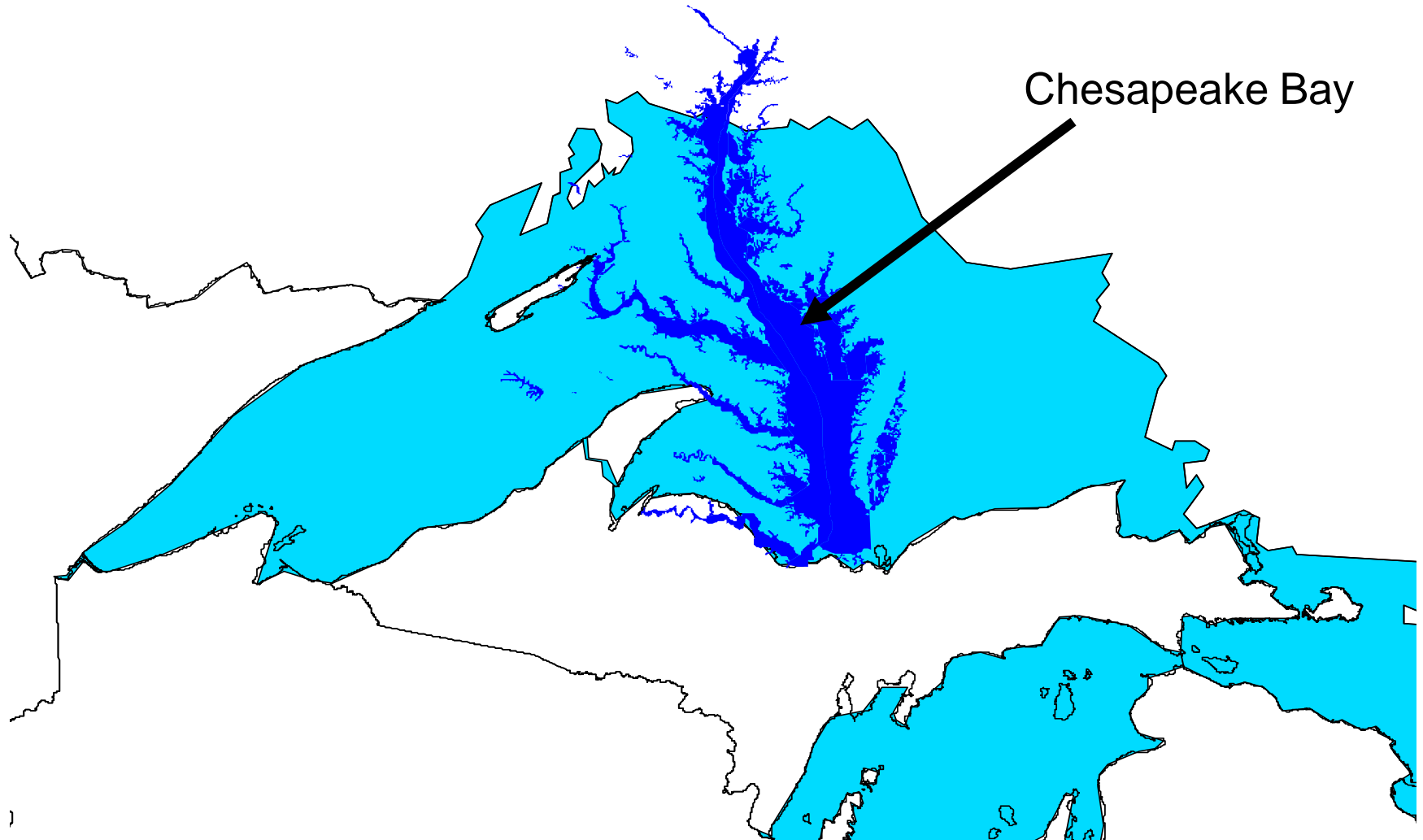
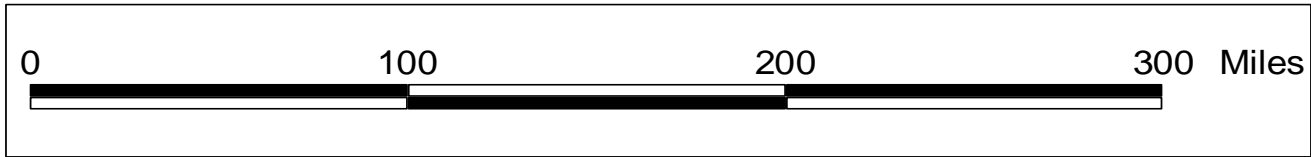
- **Develop indicators that assess the ecological condition of the U.S. Great Lakes coastal region AND point to causes of impairment**
- **Indicators examined**
 - Birds and amphibians
 - Diatoms
 - Contaminants
 - Fish and macroinvertebrates
 - Wetland vegetation
 - Land use and landscapes – NASA
- **Basic questions – how are these biological communities related with human disturbances across the Great Lakes coastal region?**



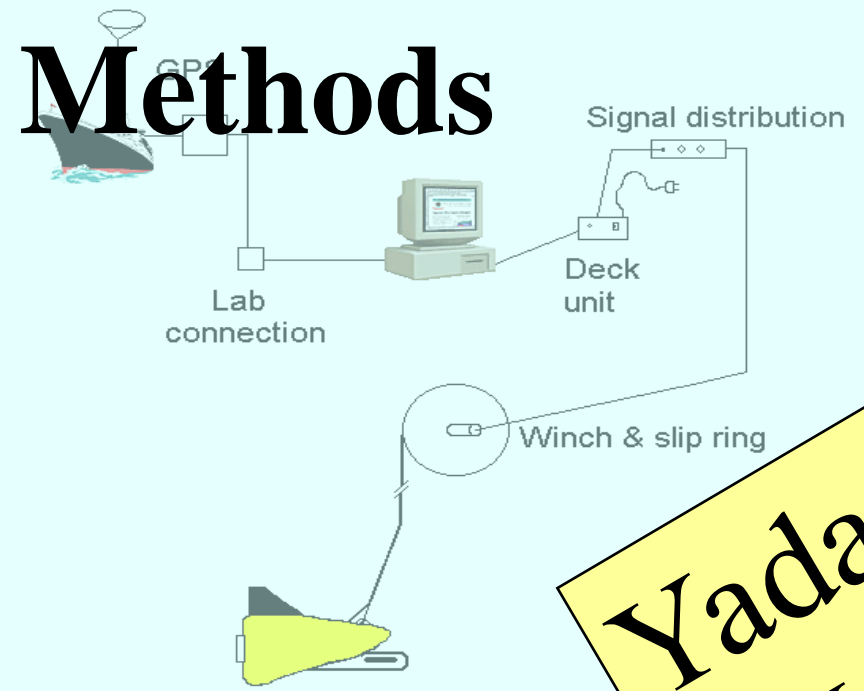
U.S. Great Lakes Stressor Gradient

- Large geographic extent (> 6500 km of coastline; > 750 wetlands)
- Many important human disturbances – overlapping in space and time





Methods



Yada ...
Yada ...
Yada.

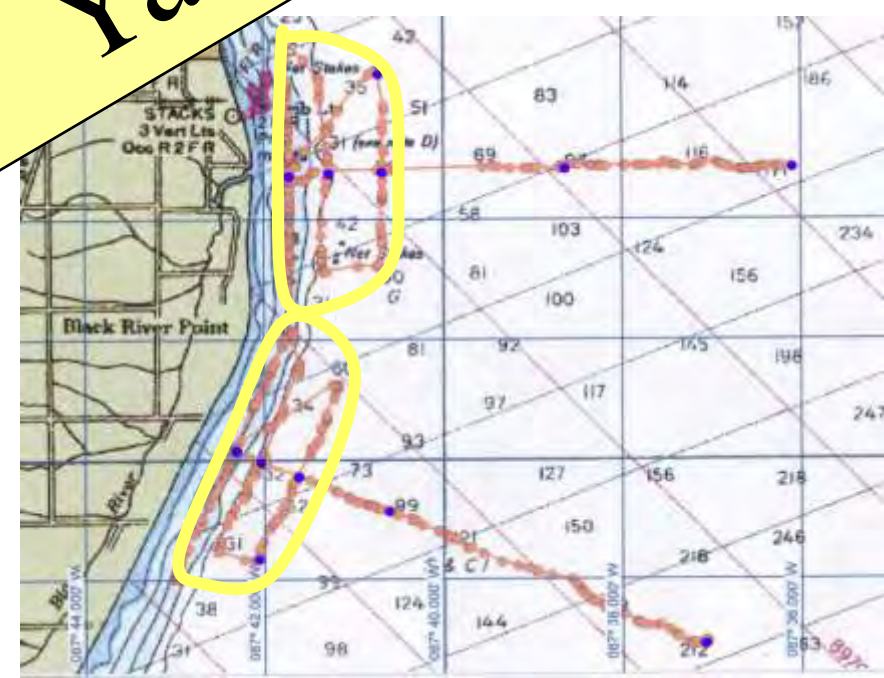
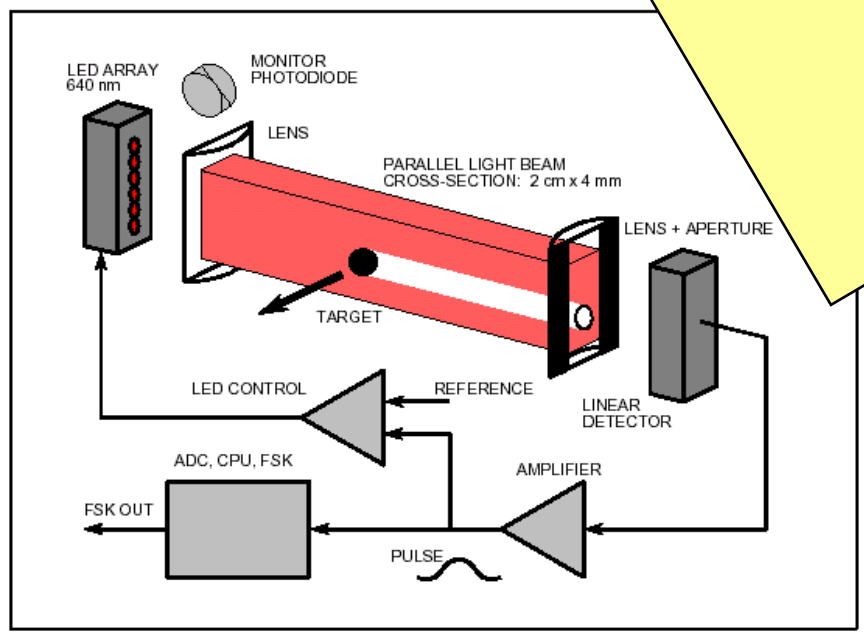
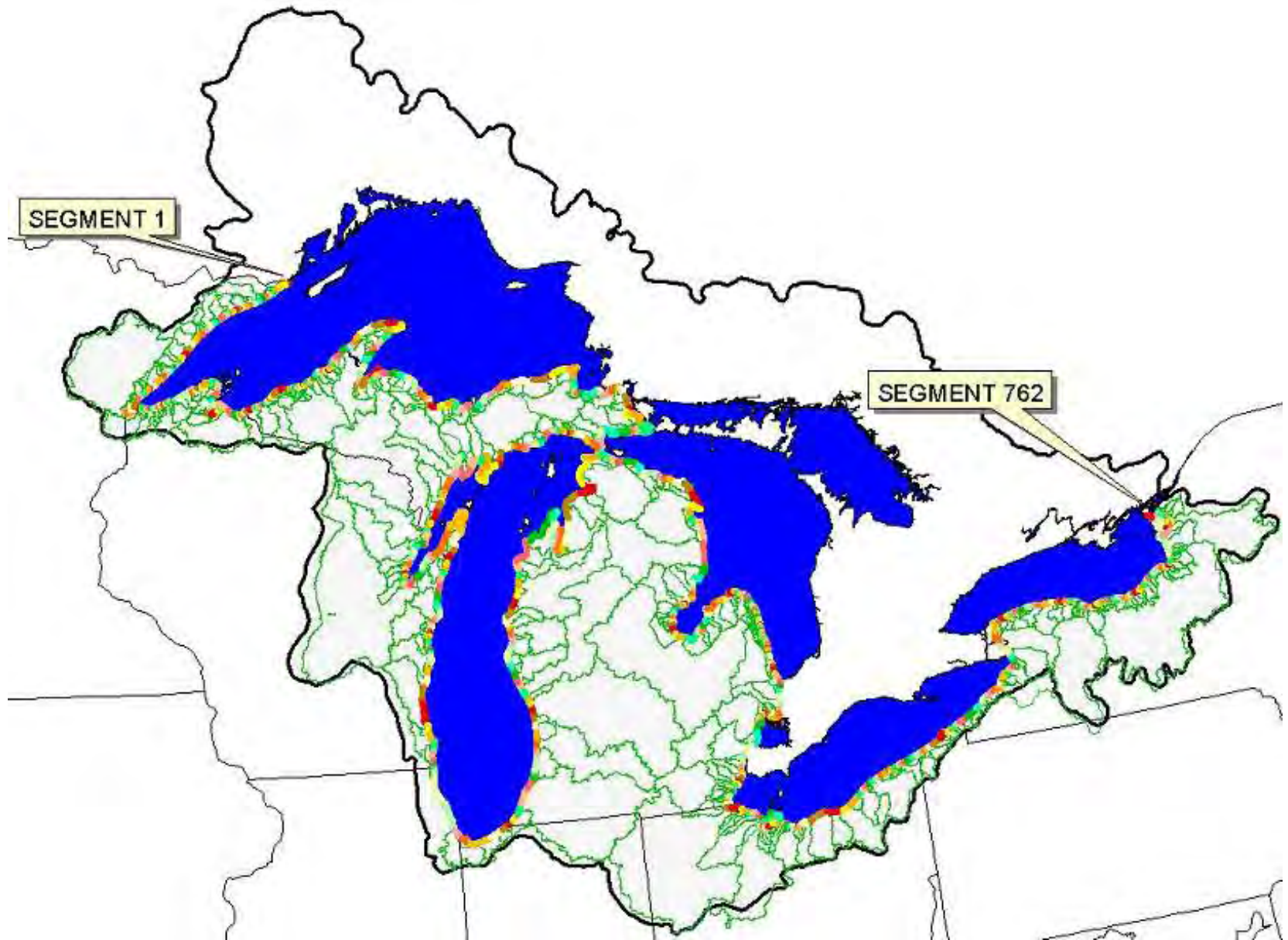


Figure 1 - Schematic of Operating Principle

762 Segment-sheds



Stress Data Used

- Over 200 variables from 19 data layers were available as GIS coverages
- Existed prior to sampling
- Required substantial processing effort
- Used to partially characterize stress regime for segment-sheds



Envirofacts



National Atmospheric Deposition Program



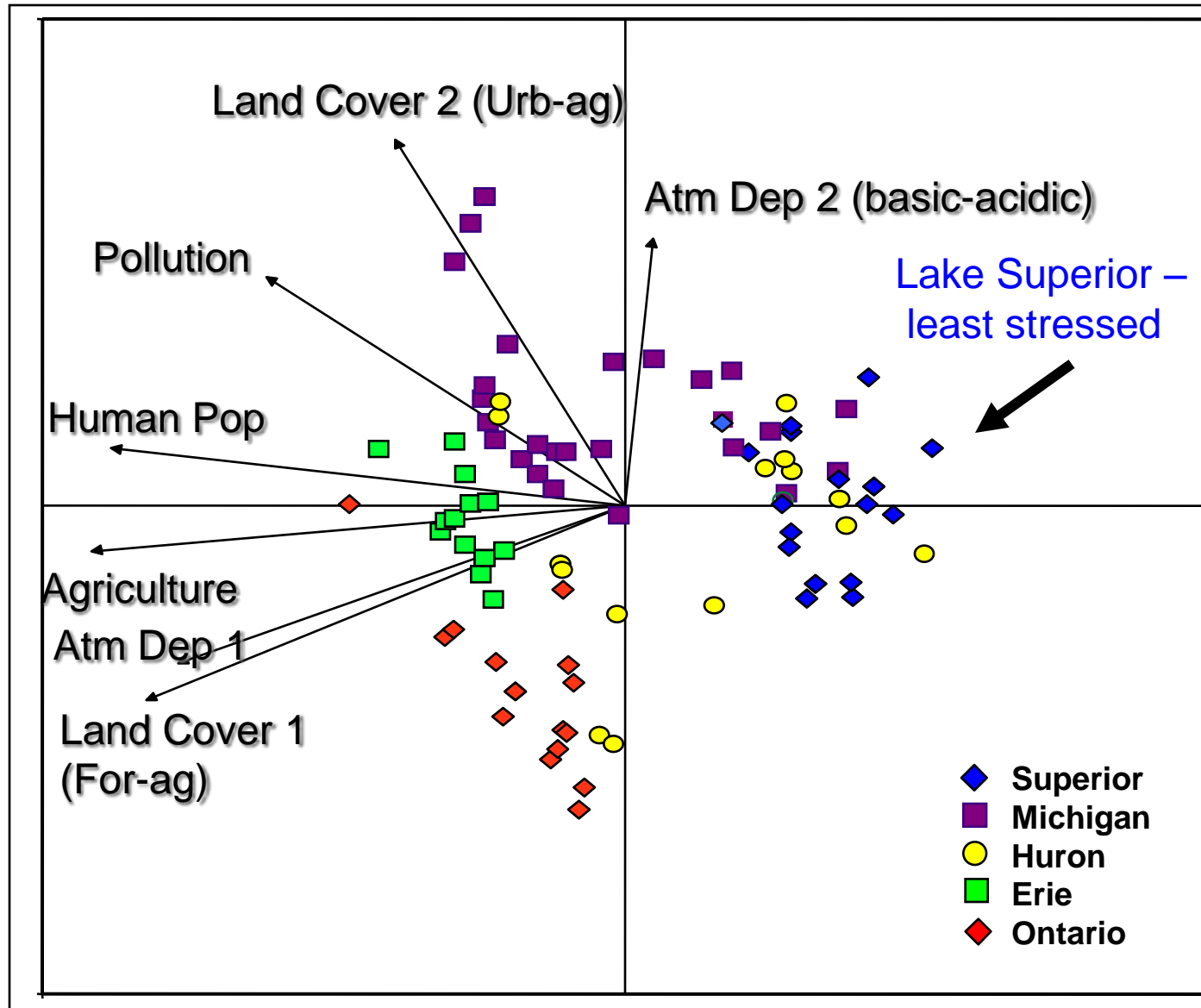
7 Categories

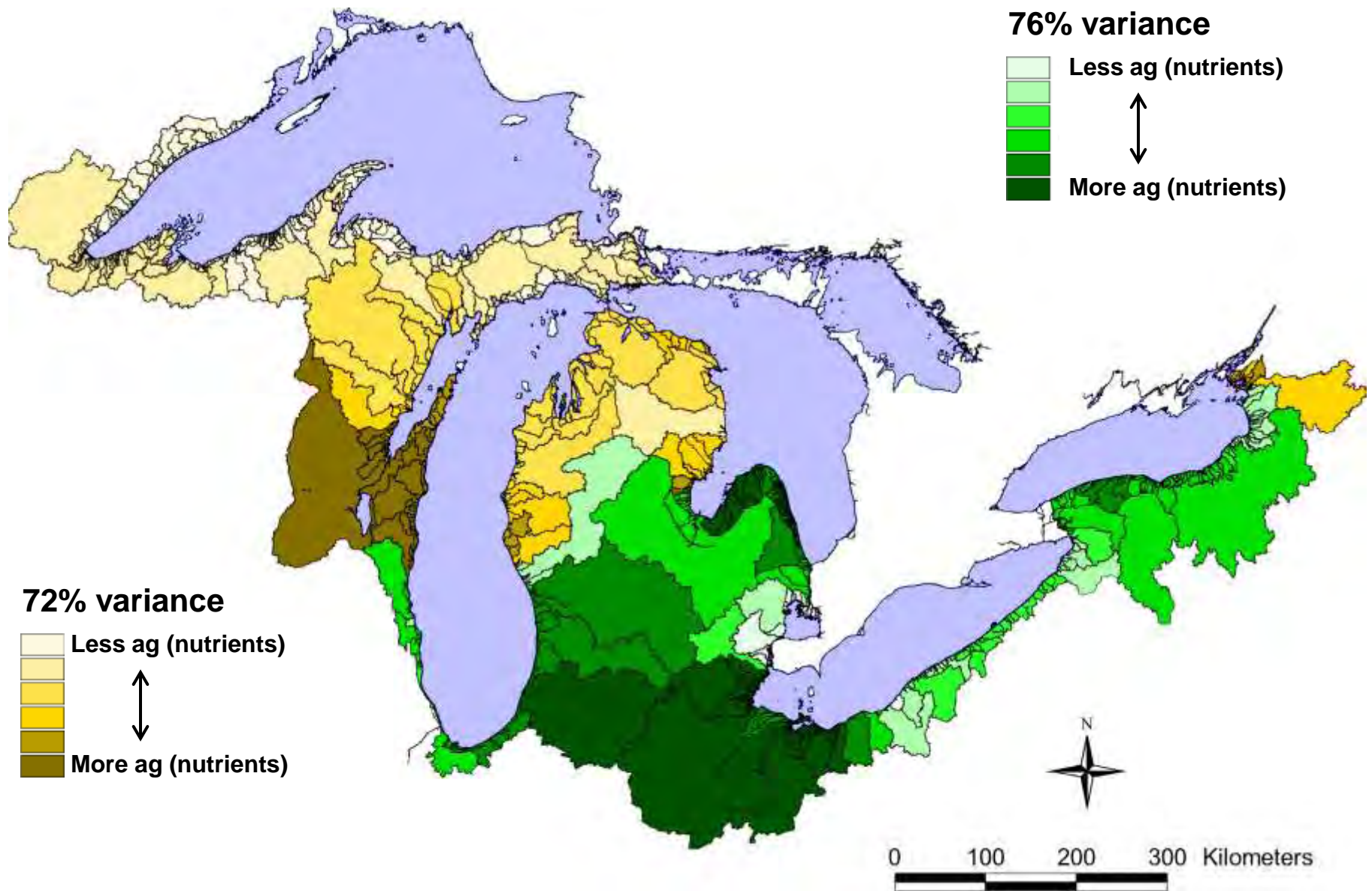
n Variables

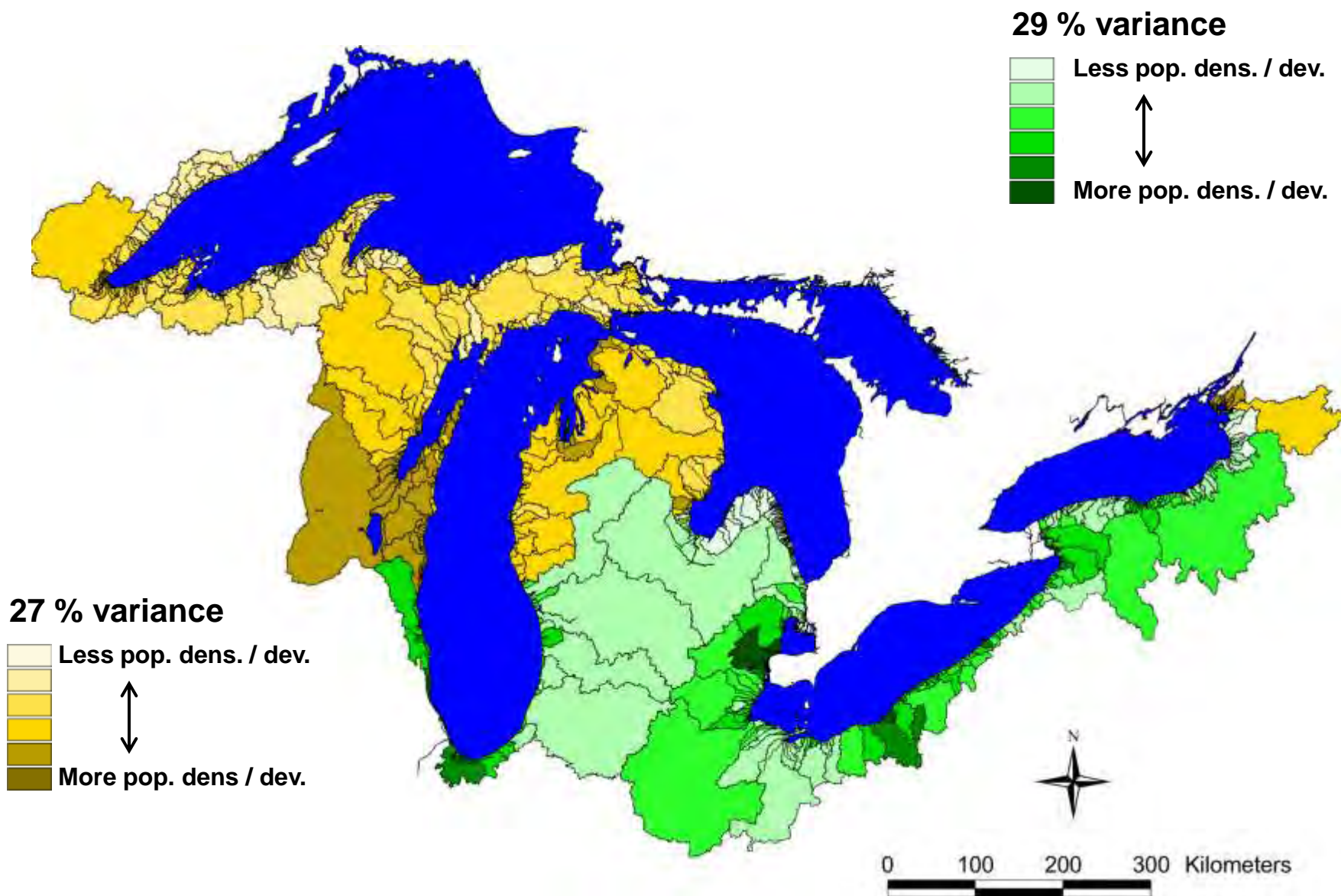
Agricultural / Ag. Chemical	21
Atmospheric Deposition	11
Land Cover	23
Human Population / Development	14
Point and Non-point Pollution	79
Shoreline Protection	6
Soils	53

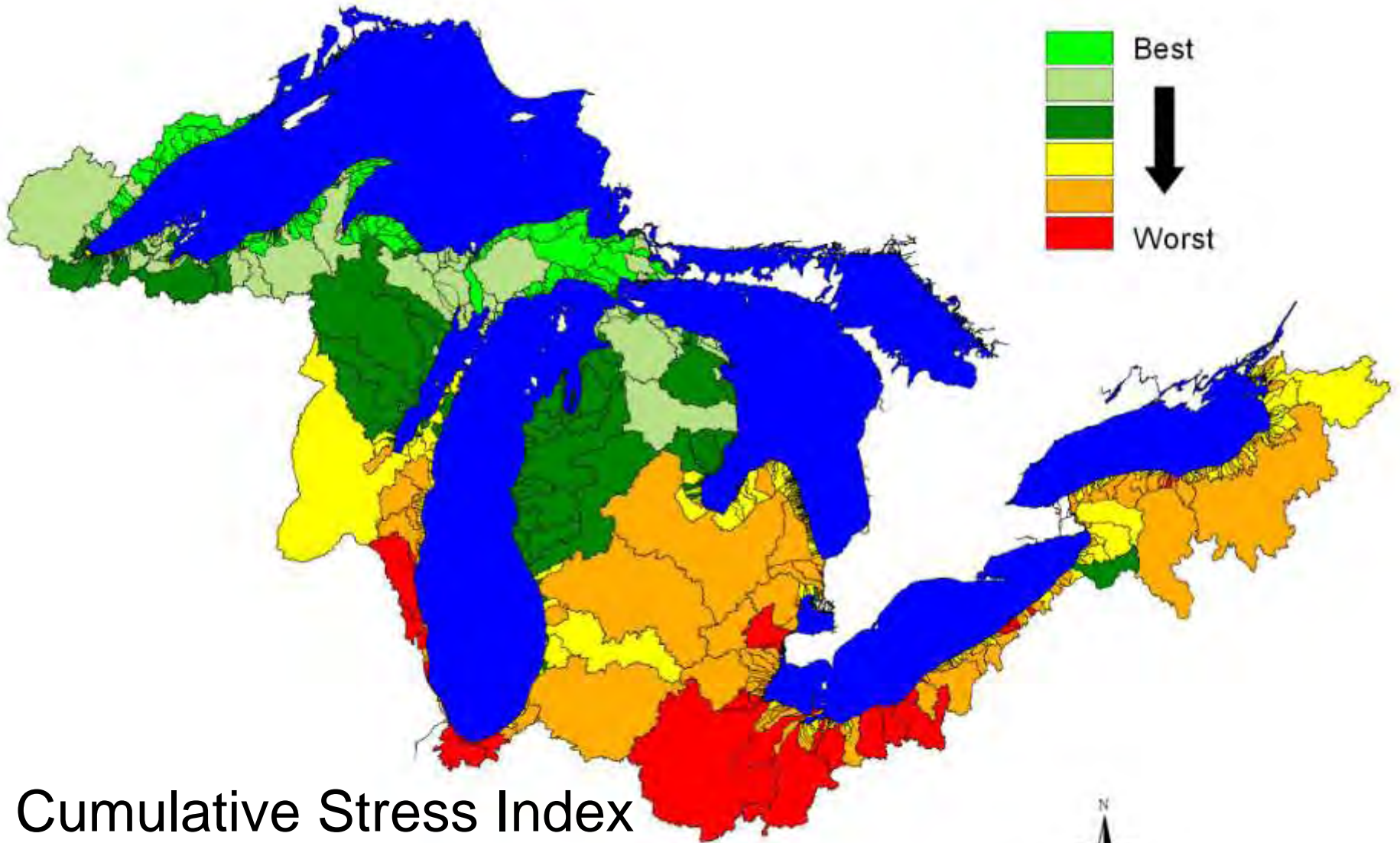
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Stressor gradients are organized by lake



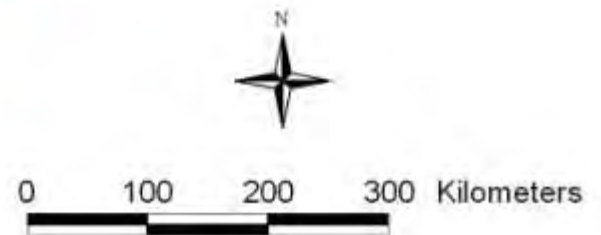




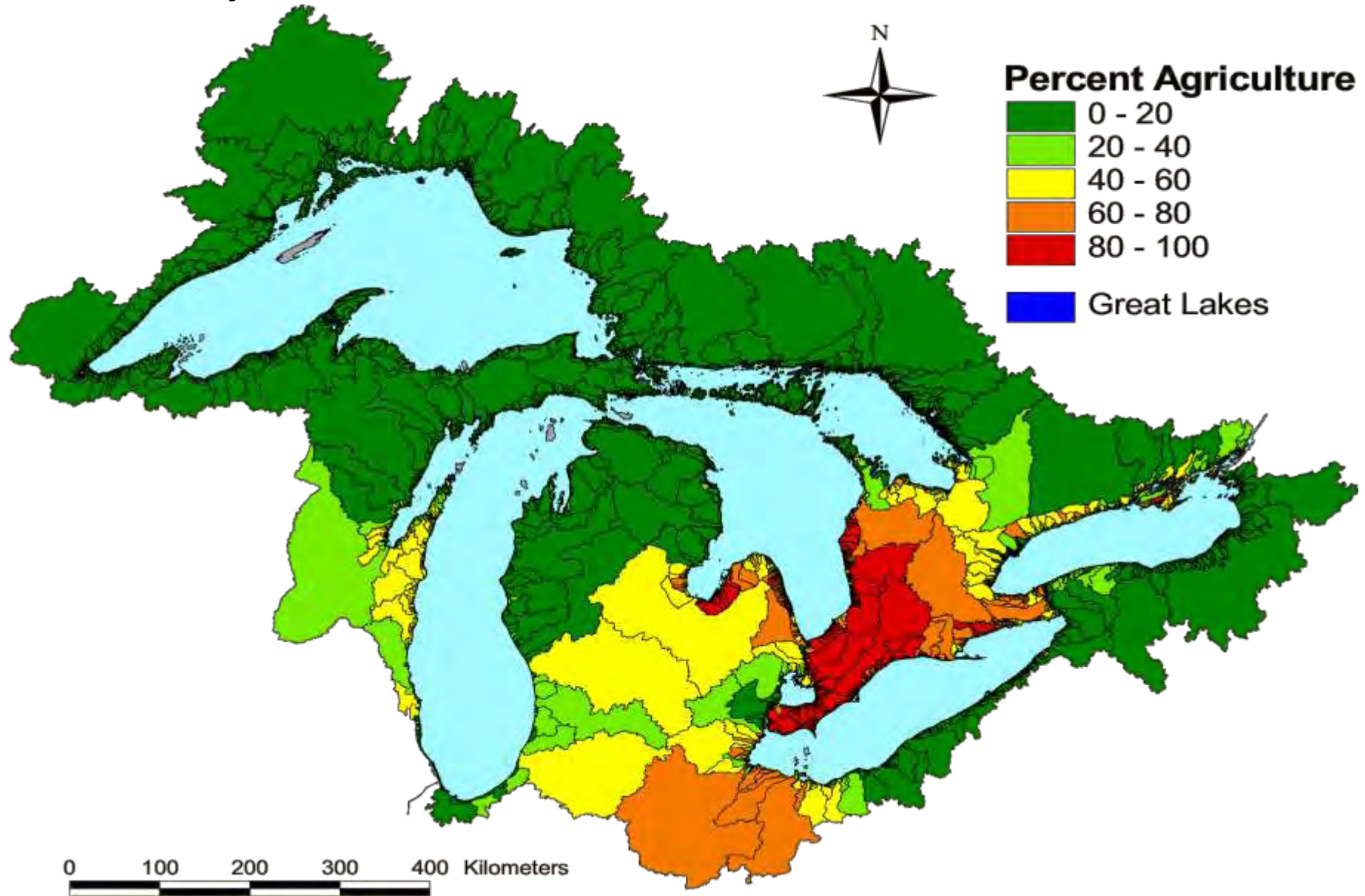


Cumulative Stress Index

Danz *et al.* 2007. *Env. Manage.*



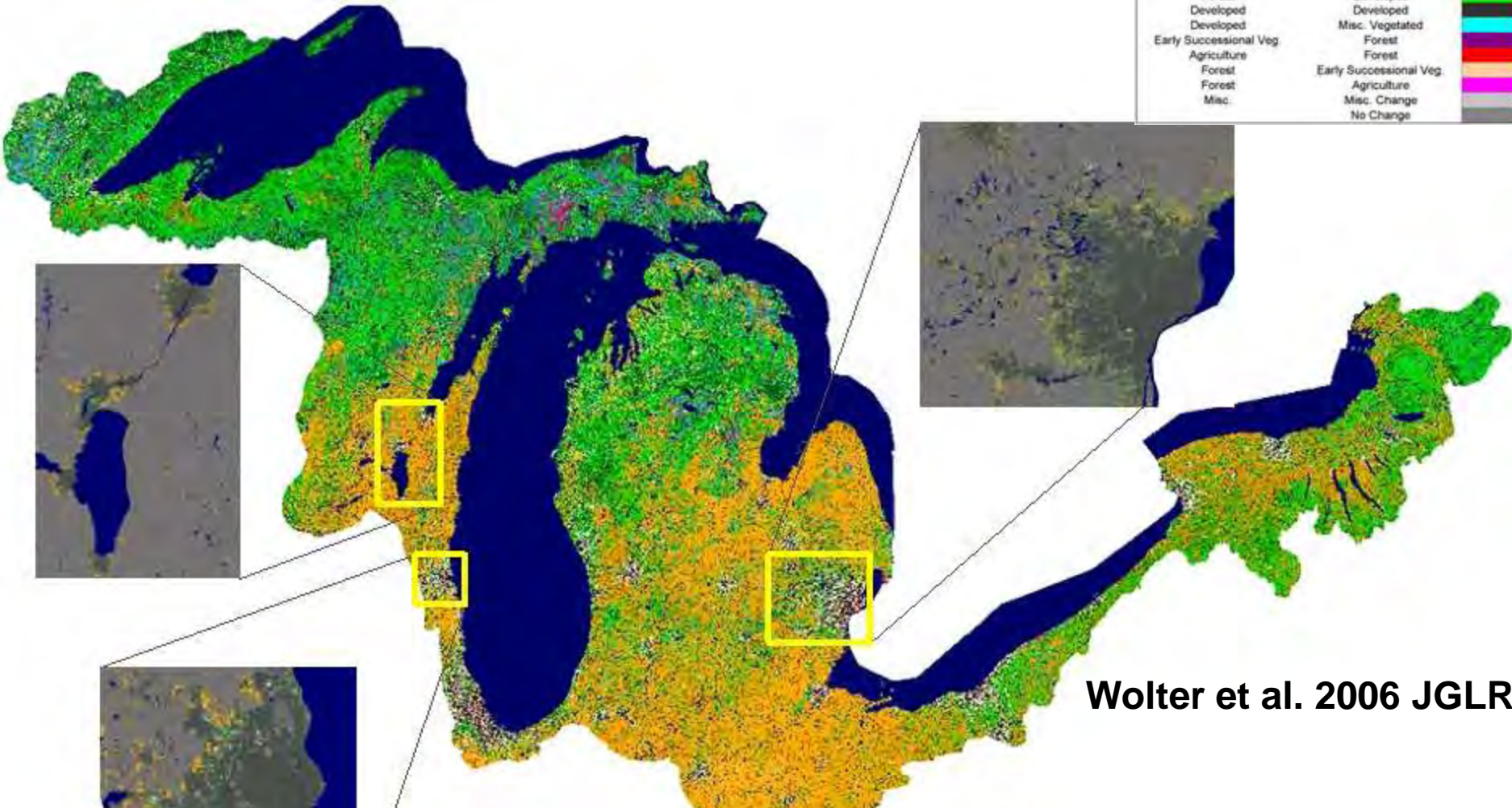
Agricultural land use gradient for entire watershed with Archydro units across the entire basin



Land Use Change Detection: NLCD-1992 to NLCD-2001

Change Legend

1992	2001	
Water	Water	
Misc. Vegetated	Flooded	
Wetland	Developed	
Early Successional Veg.	Developed	
Agriculture	Developed	
Forest	Developed	
Developed	Developed	
Developed	Misc. Vegetated	
Early Successional Veg.	Forest	
Agriculture	Forest	
Forest	Early Successional Veg.	
Forest	Agriculture	
Misc.	Misc. Change	
	No Change	



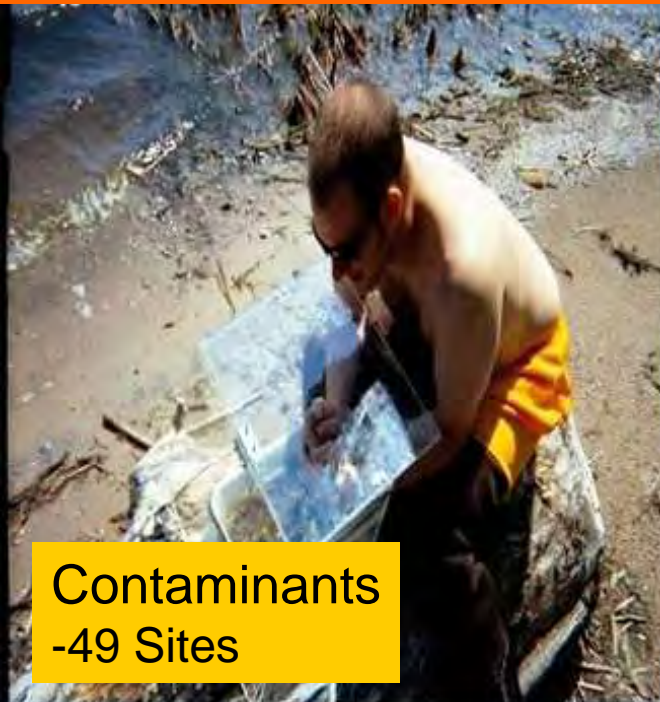
Wolter et al. 2006 JGLR

	1992 (ha)	2001 (ha)	Change (ha)	Percent
Forest	14,226,538	13,868,107	-358,430	-2.6%
Agriculture	11,600,037	11,289,356	-310,680	-2.8%
Residential	2,543,187	2,945,169	401,983	13.6%

Western End of Lake Superior - Duluth-Superior - 1995



GLEI components – Extensive Field Efforts!



Contaminants
-49 Sites



Diatoms and WQ
-237 sites; > 1500 spp.
-52,376 ++ individuals



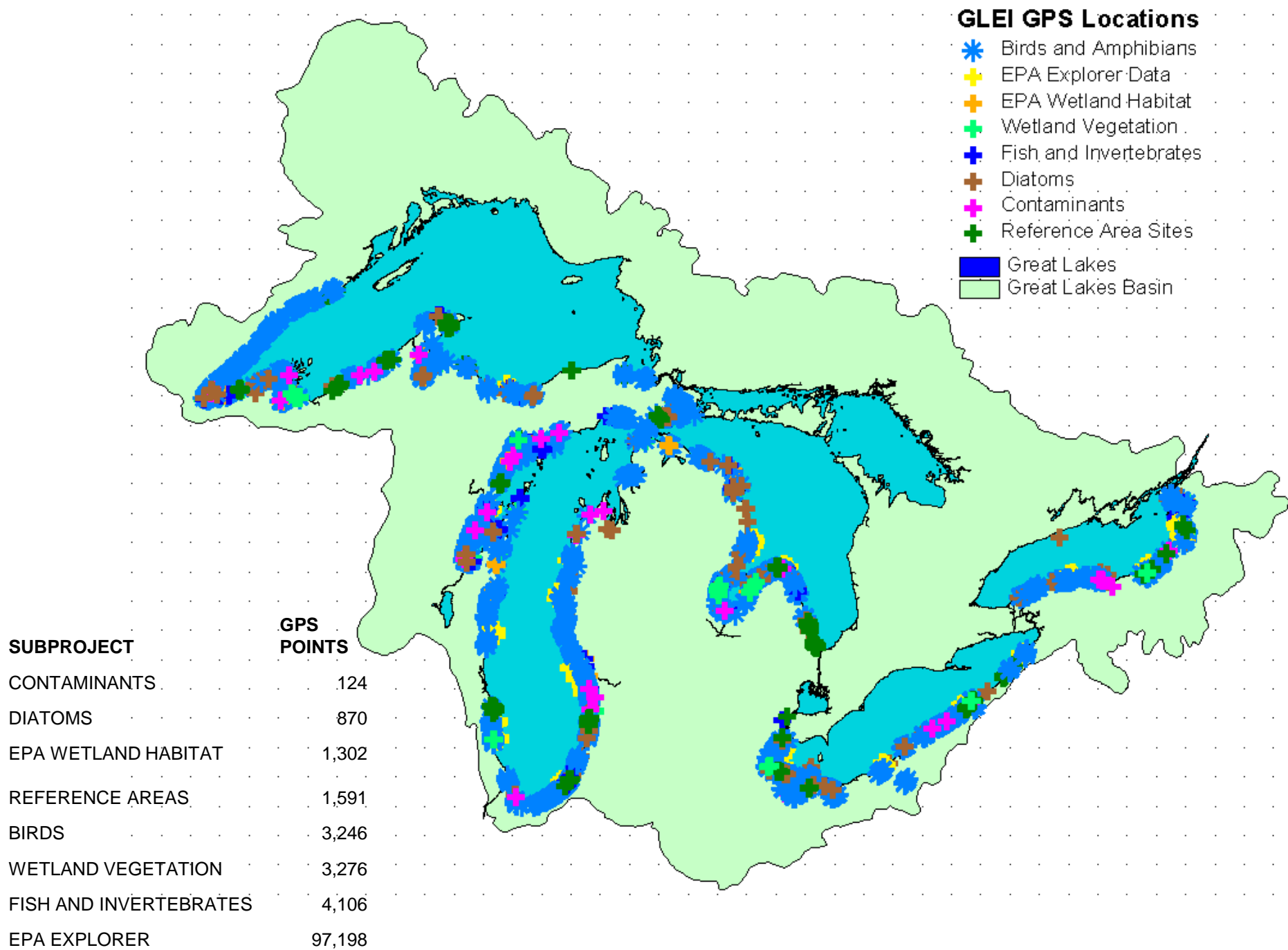
Birds and amphibians
- >3,000 points; >250 sites;
-195 bird spp;
-120,909 individual birds
-12 spp. amphibians;



Wetland vegetation
-91 complexes
-526 taxa
-20,560 observations



Fish & Bugs – 145 sites
- 104 fish spp, 104,476 individuals
- 337 bug taxa, 240,334++ individuals



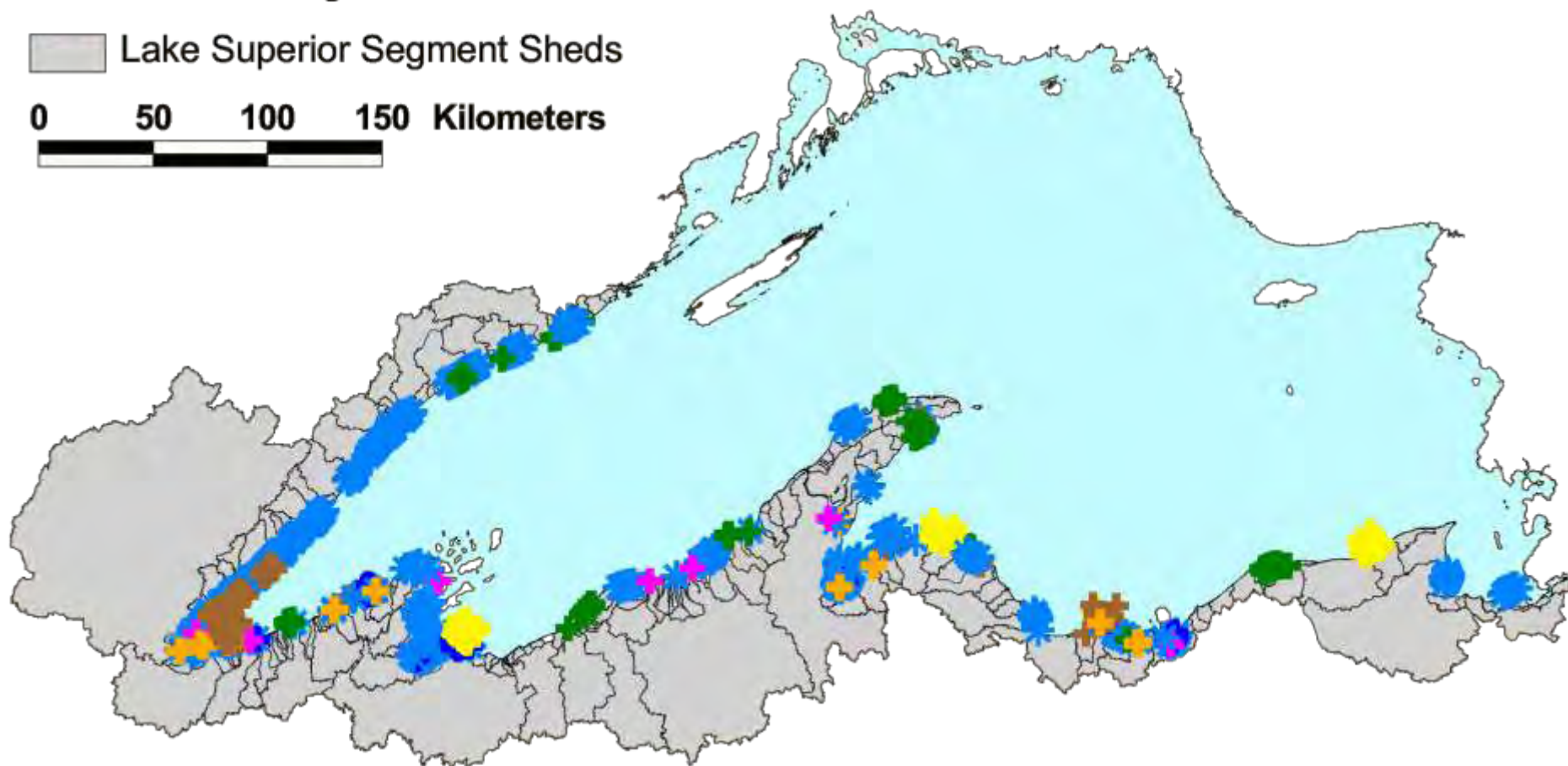
GLEI Lake Superior Sites

- ✱ Birds
- ✚ EPA Explorer
- ✚ Contaminants
- ✚ Diatoms
- ✚ EPA wetland Habitat
- ✚ Fish & Invertebrates
- ✚ Reference
- ✚ Wetland Vegetation



☐ Lake Superior Segment Sheds

0 50 100 150 Kilometers



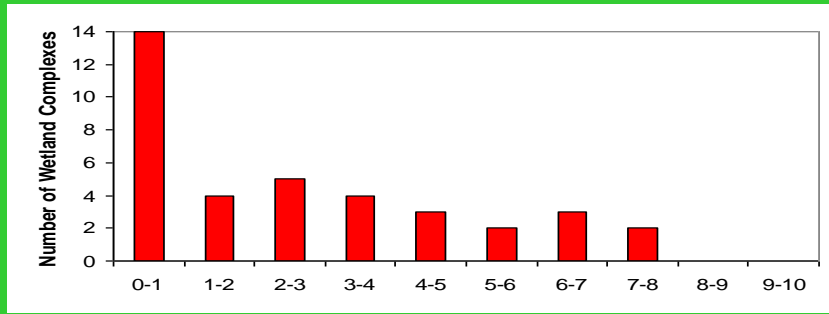
Environmental Indicators

- 14 to 20 “groups of indicators” developed

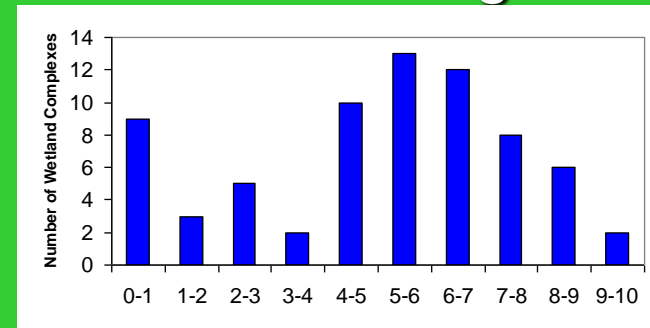
1. Amphibians (frogs) – not very useful
2. Breeding birds – very useful in wetlands and upland areas
3. Polycyclic aromatic hydrocarbons (PAHs) – combination of light transmission and PAH in sediment – estimates toxicity to larval fish
4. Diatoms – very useful – water quality; also provides a historical context
5. Fish and macroinvertebrates – very useful
6. Wetland vegetation – four to ten taxa; invasive plant species are very important
7. Land use and land cover – essential

Distribution of bird community condition

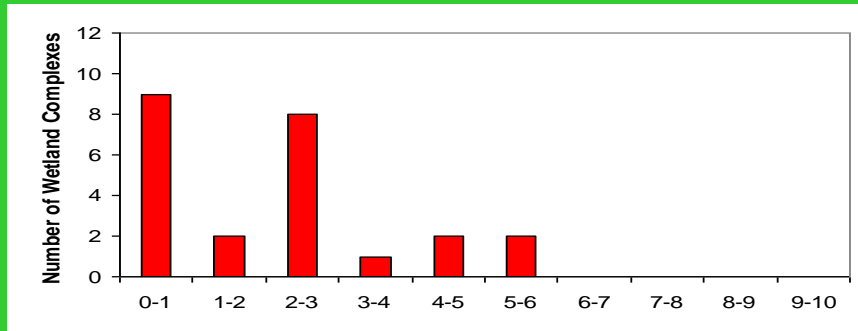
Lake Ontario



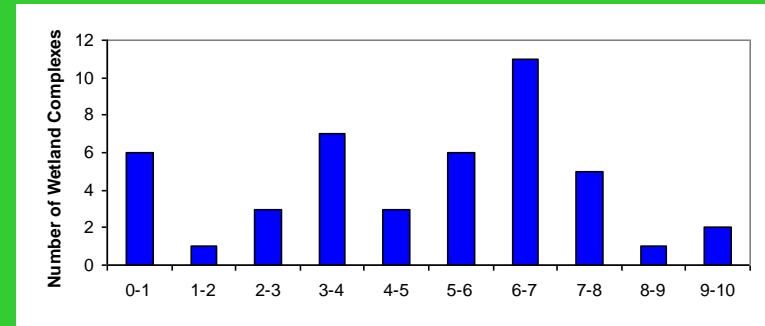
Lake Michigan



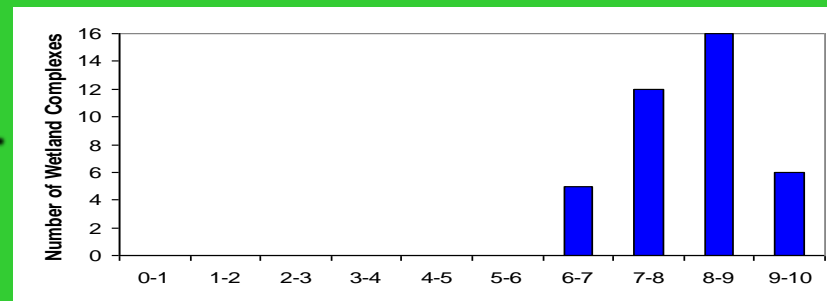
Lake Erie



Lake Huron

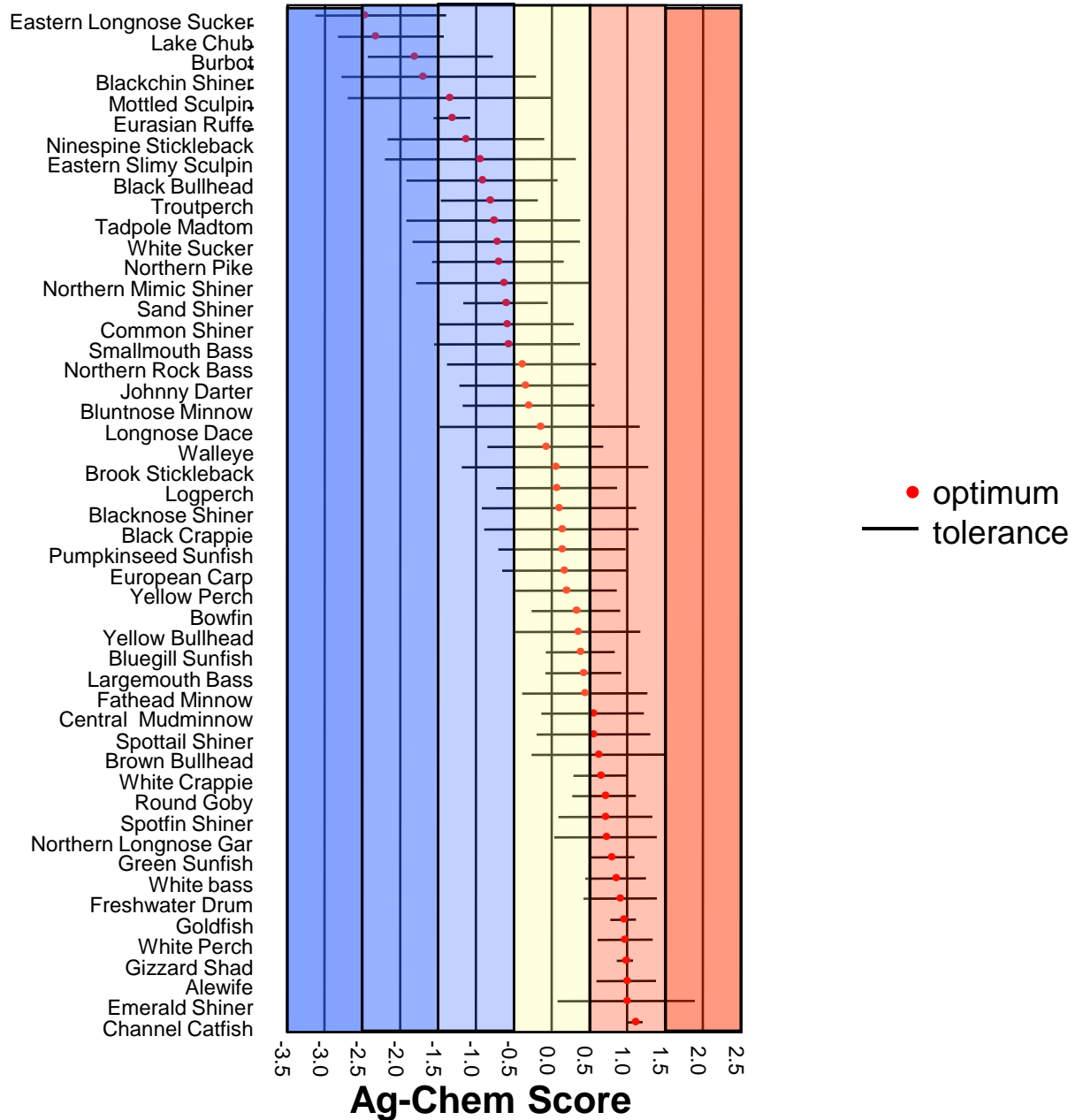


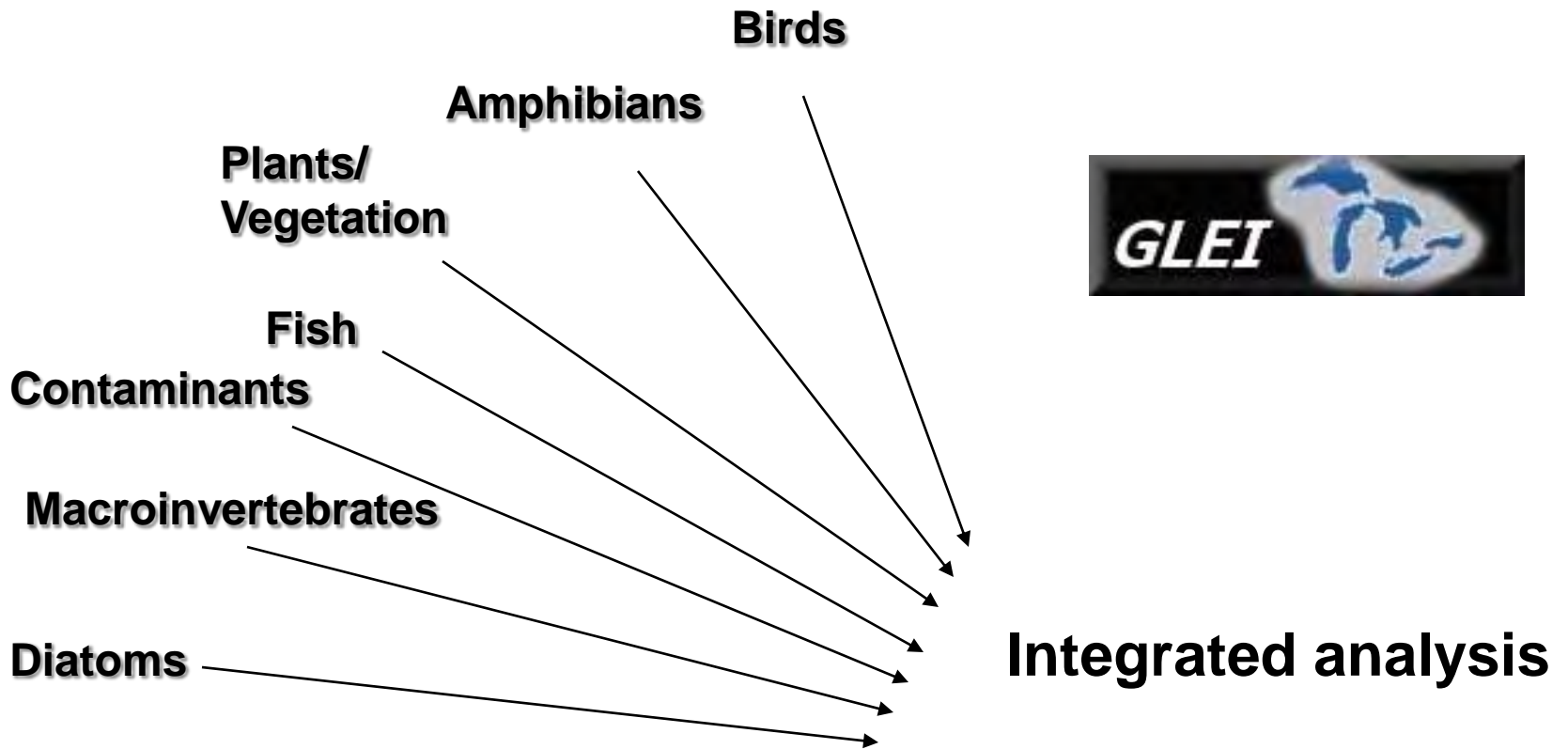
Lake Superior



---- Increasing Breeding Bird Condition →

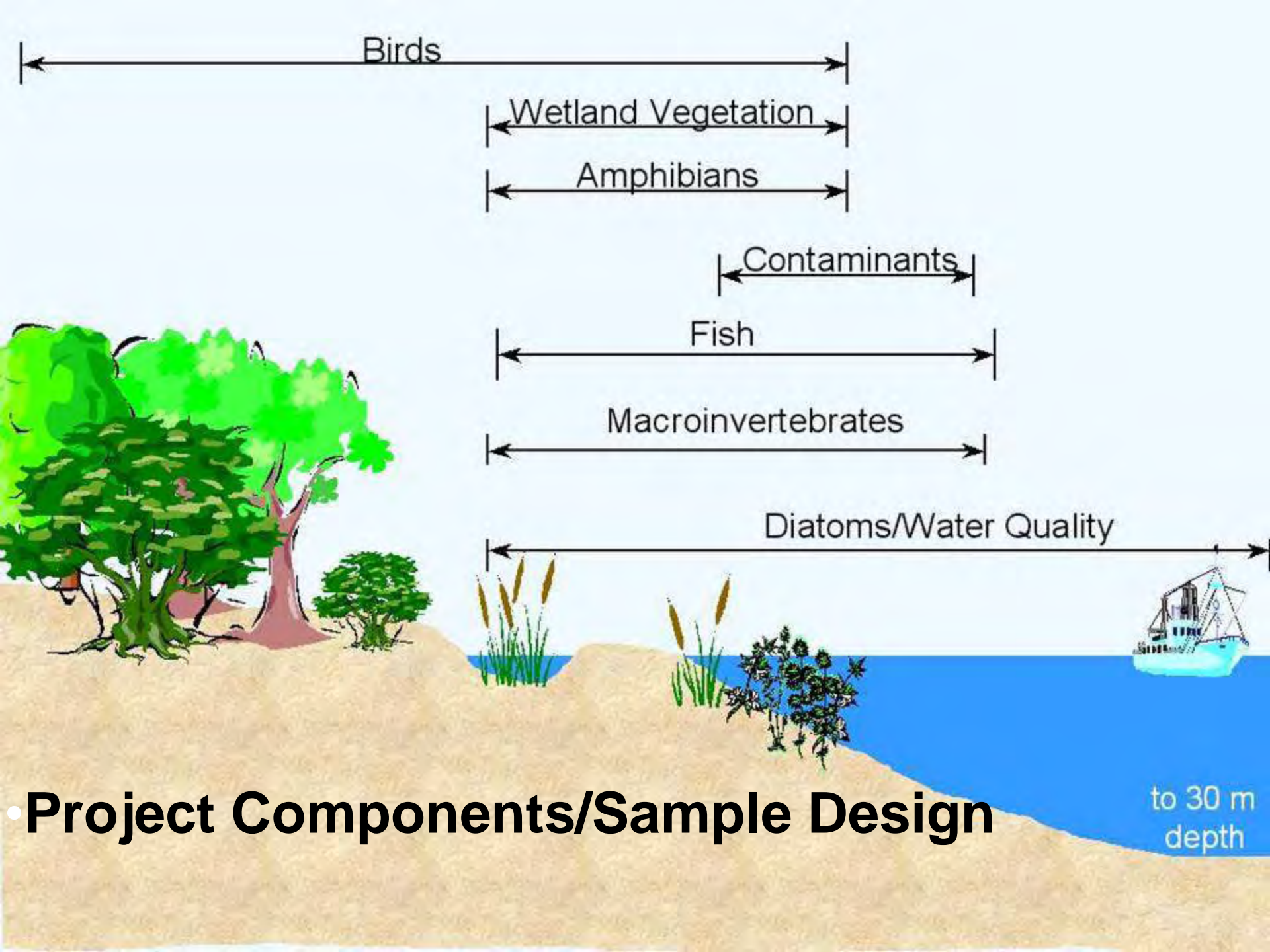
Fish species tolerances with respect to Agricultural Stressor





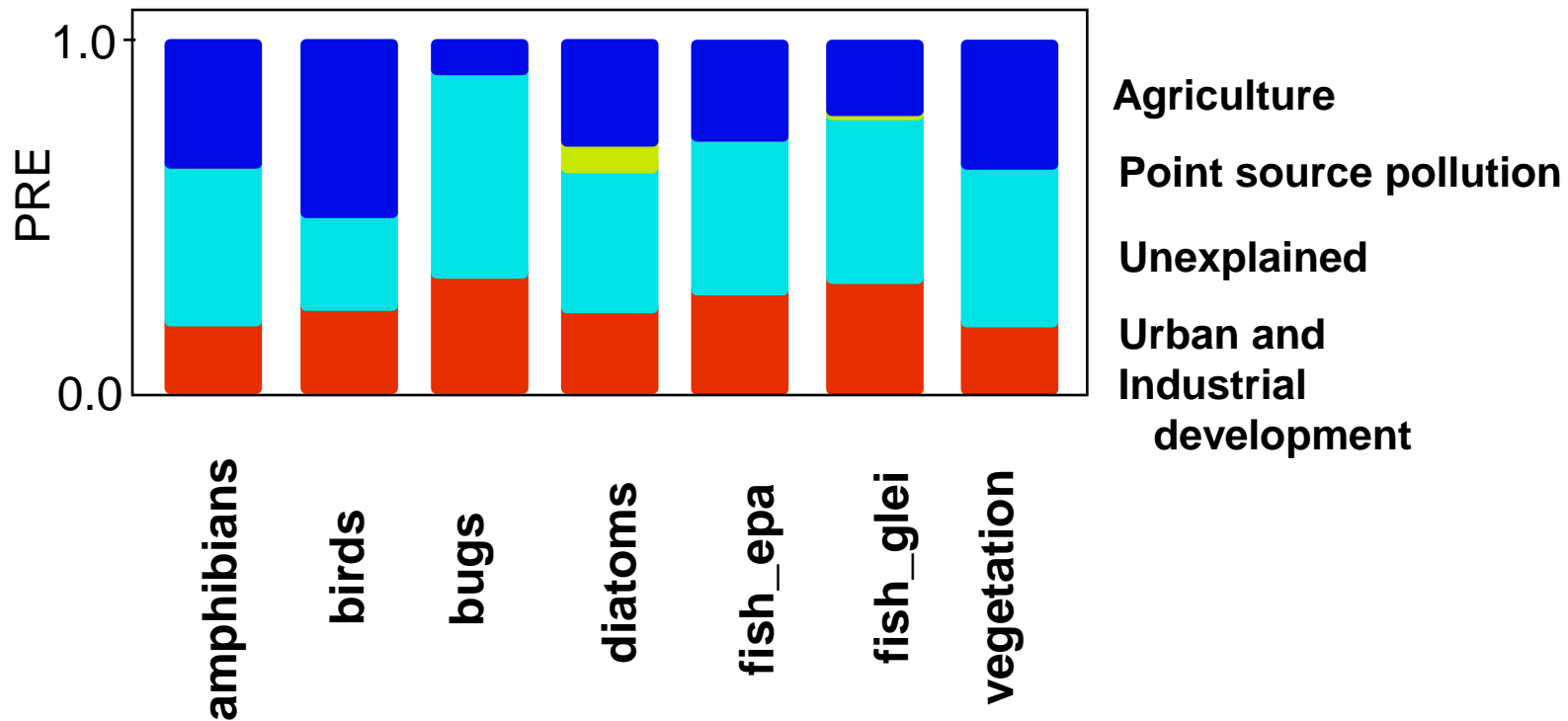
Multiple Stressors

- What is the relationship between these taxa and the primary stressors of human disturbance?
 - agriculture (row crop)
 - urbanization (population density), and
 - point source pollution



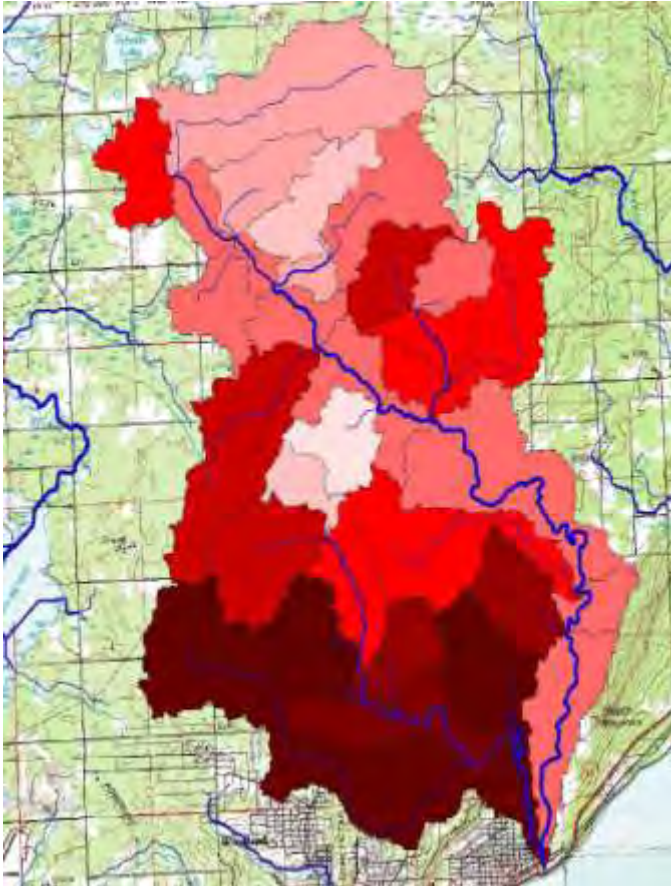
- Project Components/Sample Design**

Relating stress to the biological indicators through classification and regression trees (CART).....



Stressor Gradients

Lester River Watershed



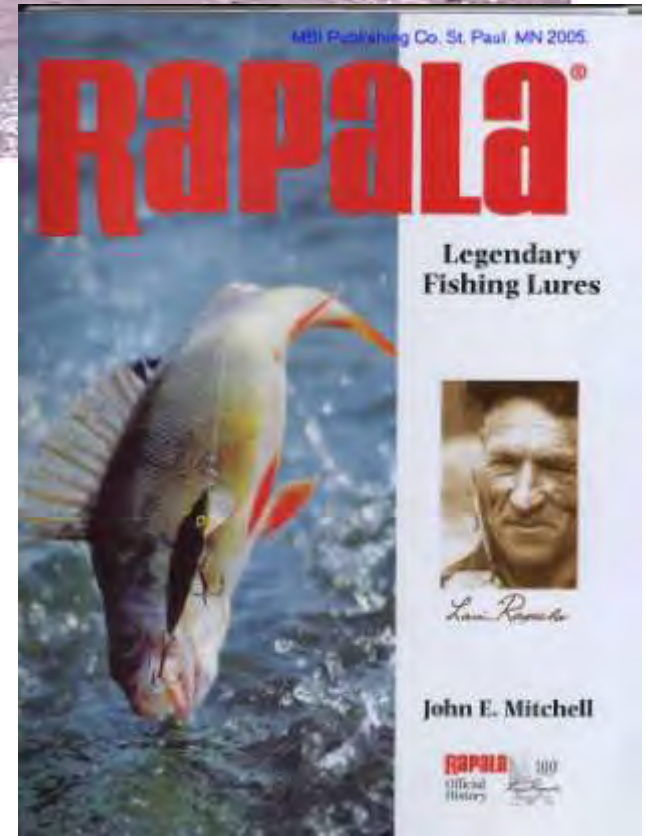
St. Louis River Watershed



Colors graded according to a combination of population density, point sources, and urban/agricultural land. Used to identify indicators of condition and to prioritize management / conservation / restoration.

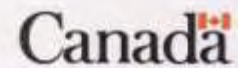
Weber Stream Restoration Initiative

- Assessment
- Restoration
- Cooperation with partners
- Improved water quality



State of the Great Lakes 2005

Highlights



SOLEC

Limited development
of coastal indicators

Summary

- Human disturbance gradient provides a framework for sampling across the Great Lakes coastal region – an independent variable(s) or the **x-axis (“dose”)**
- Primary stressors – agricultural activity, human population density, and point sources (primarily in industrial areas)
- What can we do about it? – implement best management practices (maintain effective riparian areas, reduce erosion, reduce use of fertilizers, etc.)

Acknowledgements

Research supported by a grant from the U.S. EPA's Science to Achieve Results (STAR) Estuarine and Great Lakes (EaGLE) Coastal Initiative through funding to the Great Lakes Environmental Indicators (GLEI) project, U.S. EPA Agreement EPA/R-8286750 and STAR EPA/R-82877701.

Also funding from NASA – NA G5 – 11262





Welcome to the Great Lakes Environmental Indicators Project Website

Visit our website

<http://glei.nrri.umn.edu>