Great Lakes Environmental Indicators

Lucinda B. Johnson
Director, Center for Water and the Environment,
Natural Resources Research Institute,
University of Minnesota Duluth

Co-Principal Investigators
29 individuals from 10 institutions

Acknowledgements

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Also funding from NASA – NA G5 – 11262

Great Lakes Region: Lights at Night

Three Complementary Projects

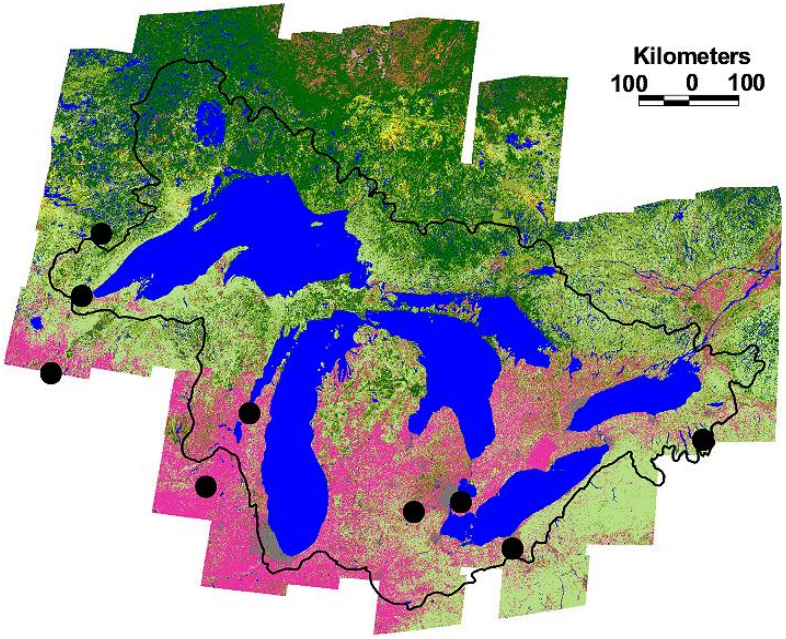
Project	PIs	Sponsor
Great Lakes Coastal Wetlands Consortium (GLCWC)	Burton, Uzarski & 6 others	EPA GLNPO ($1.8M) (2000 – 2007)
Great Lakes Environmental Indicators (GLEI)	Niemi & 28 others	EPA STAR ($6M) (2001 – 2005)
Defining & Quantifying the Reference Condition (RefCond)	Johnson & 5 others	EPA STAR ($0.7M) (2001 – 2004)

Great Lakes Environmental Indicators (GLEI) Contributors

Project Emphasis

- **Develop indicators that assess the ecological condition of the US Great Lakes coastal region AND point to causes of impairment**

- **Indicators examined**
  - Birds & Amphibians
  - Diatoms
  - Contaminants
  - Fish & Macroinvertebrates
  - Wetland Vegetation
  - Land use and landscapes ($ NASA)



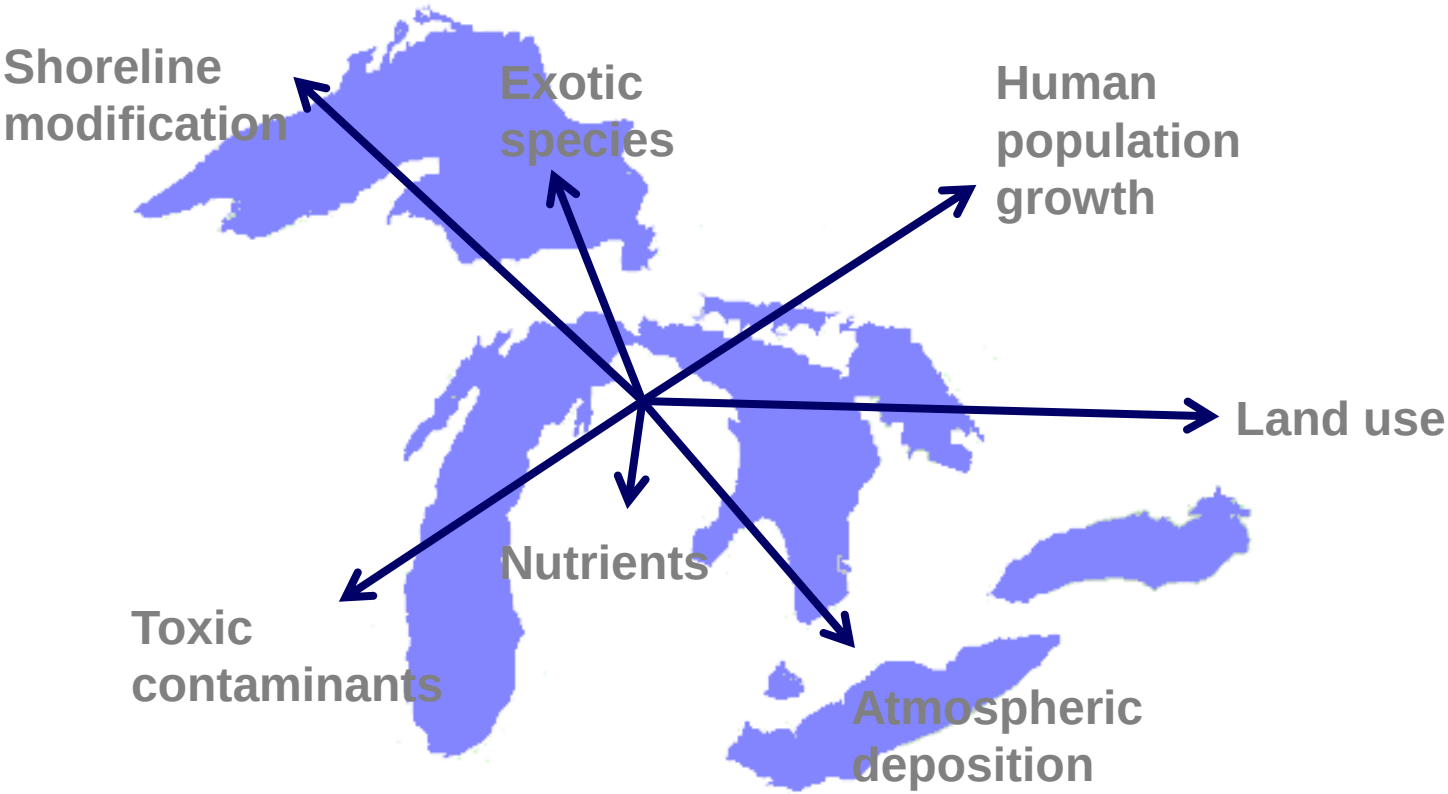
- **Basic questions – how are these biological communities related to human disturbances across the Great Lakes coastal region?**

Stressors

US Great Lakes Stressor Gradient

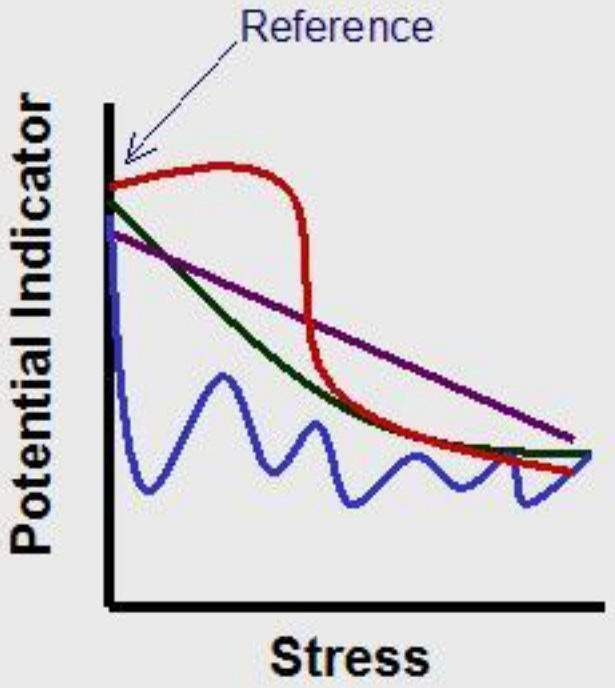
large geographic extent (> 6500 km of coastline; > 750 wetlands)

many important human disturbances – overlapping in space and time



Disturbance Gradient

Key Issue: How do we characterize the primary human disturbance gradients in US Great Lakes, and then distribute samples across that gradient?



Details available in: Danz, et al. 2005. Environmental stratified sampling design for development of Great Lakes Environmental Indicators. Environmental Monitoring & Assessment 102: 41–65

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

USDA

United States Environmental Protection Agency

United States Department of Agriculture
NRCS Natural Resources Conservation Service

National Land Cover Data

USGS science for a changing world

National Atmospheric Deposition Program

U.S. Census Bureau

TIGER

USGS science for a changing world

United States Census 2000

National Oceanic and Atmospheric Administration
Great Lakes Environmental Research Laboratory

Stress Data Used

GLEI Stress Categories: (212 georeferenced variables)

Land cover

Agriculture

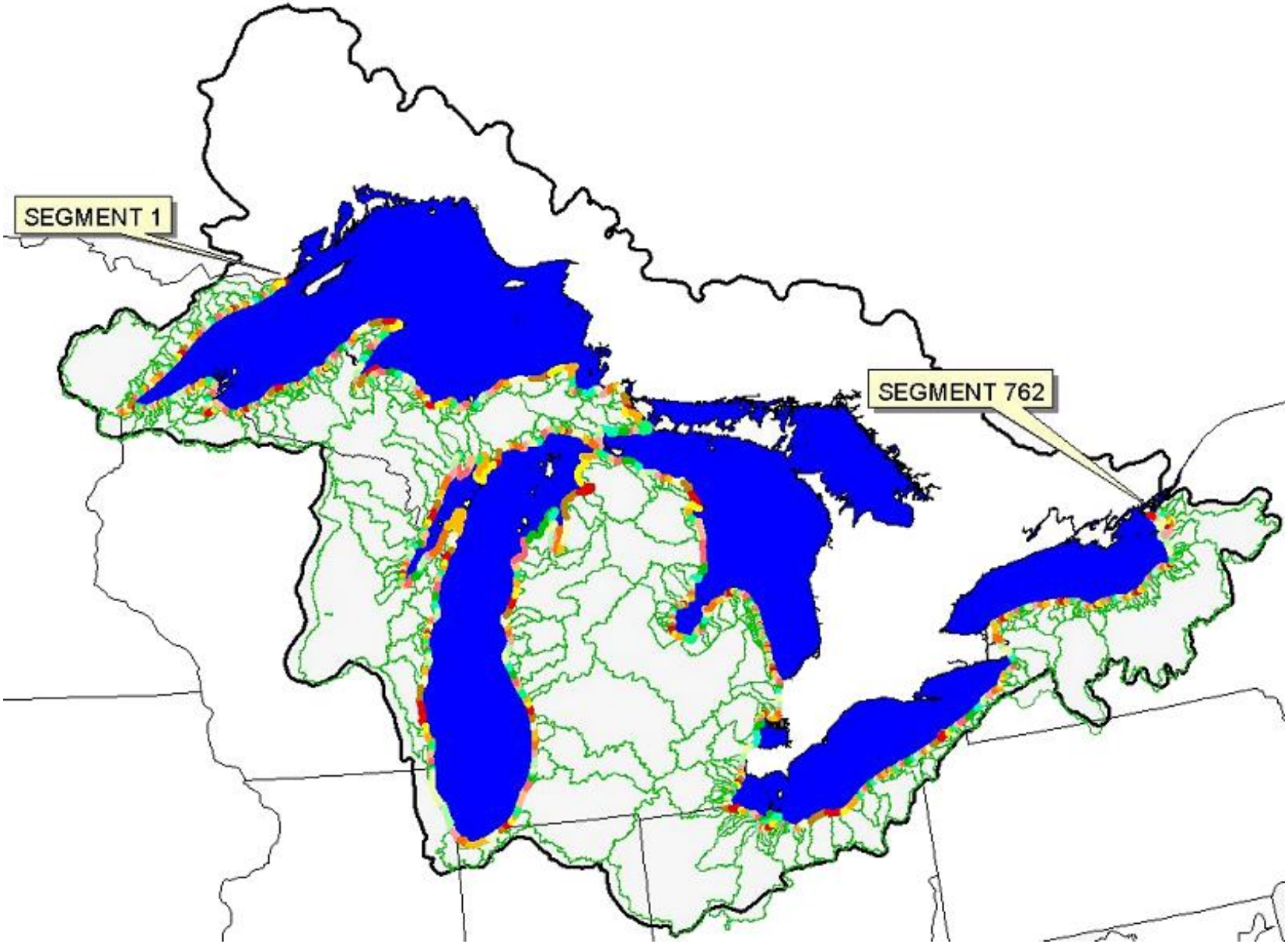
Population density

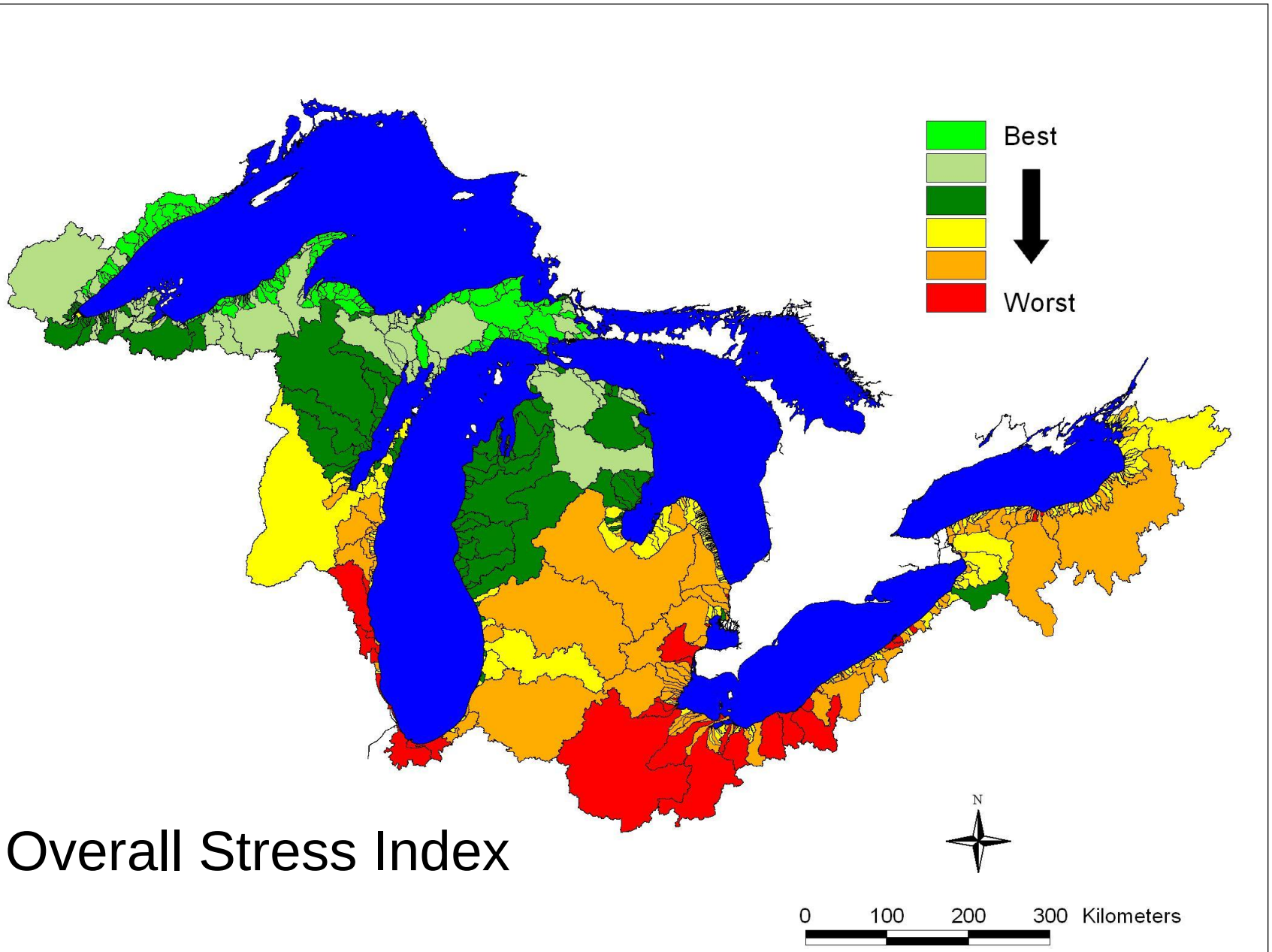
Atmospheric deposition

Shoreline modification

Point source discharge

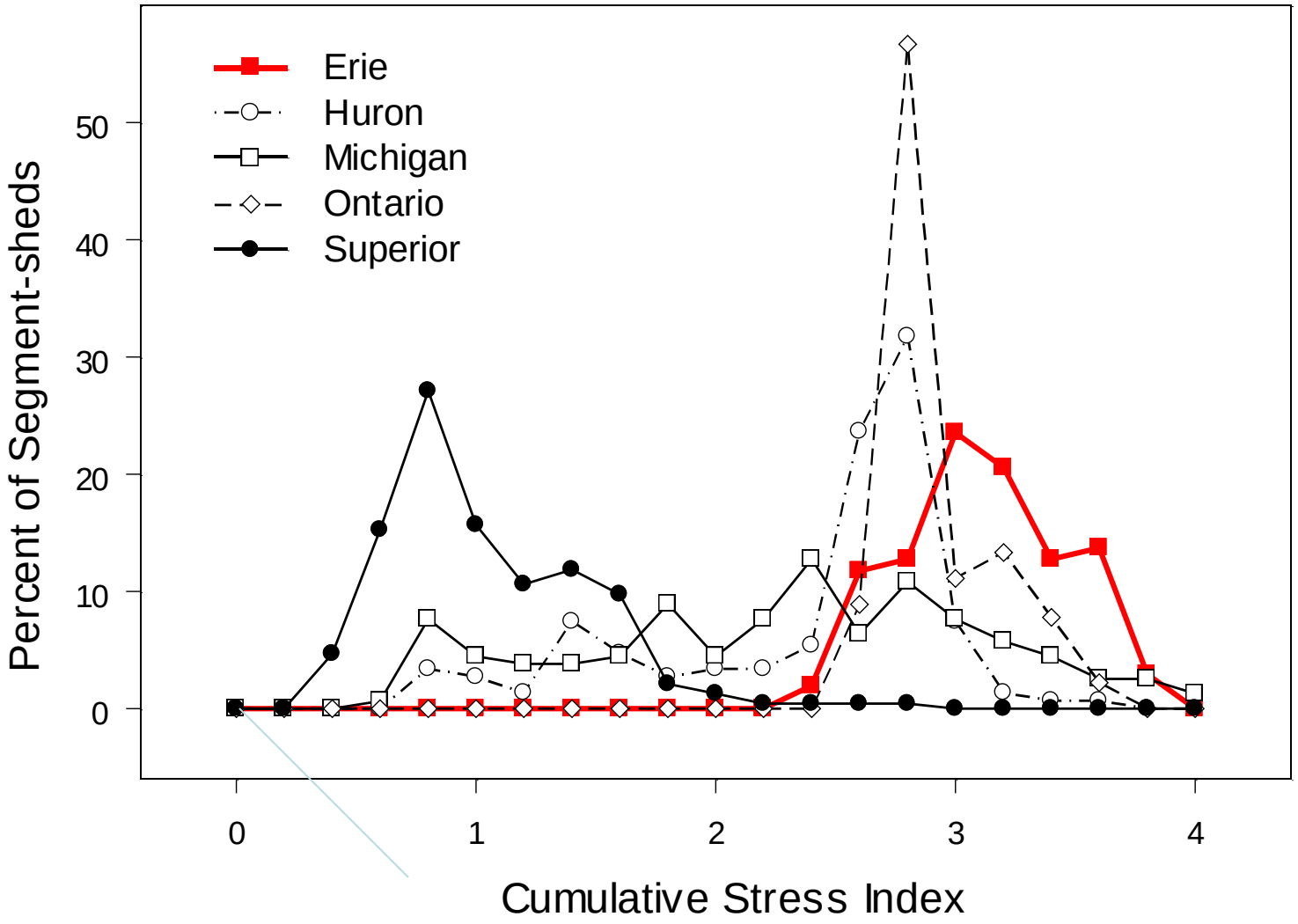
762 Segment-sheds



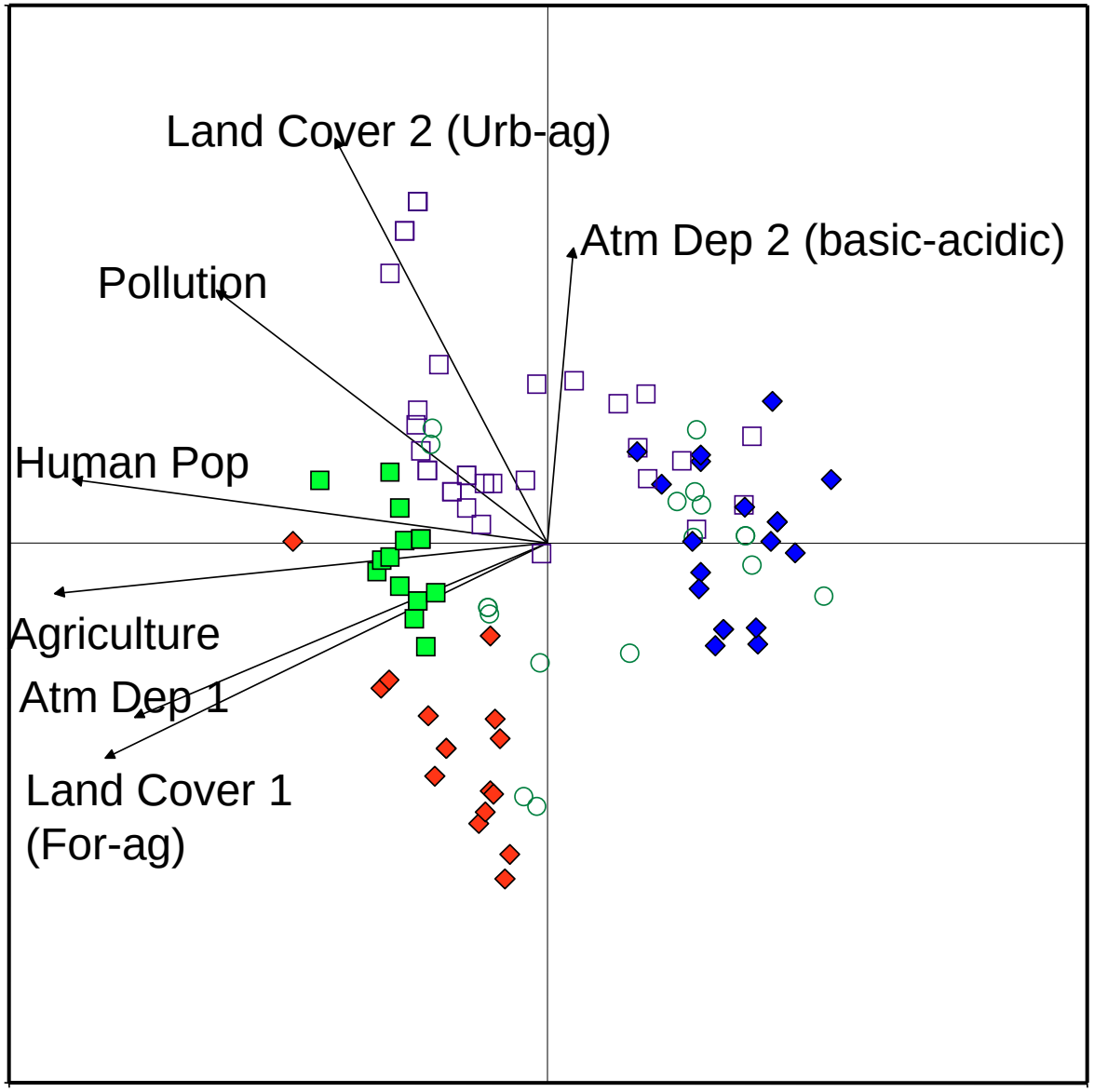


Overall Stress Index

Cumulative Stress By Lake



Stressor regime is organized by lake



Superior
Michigan
Huron
Erie
Ontario

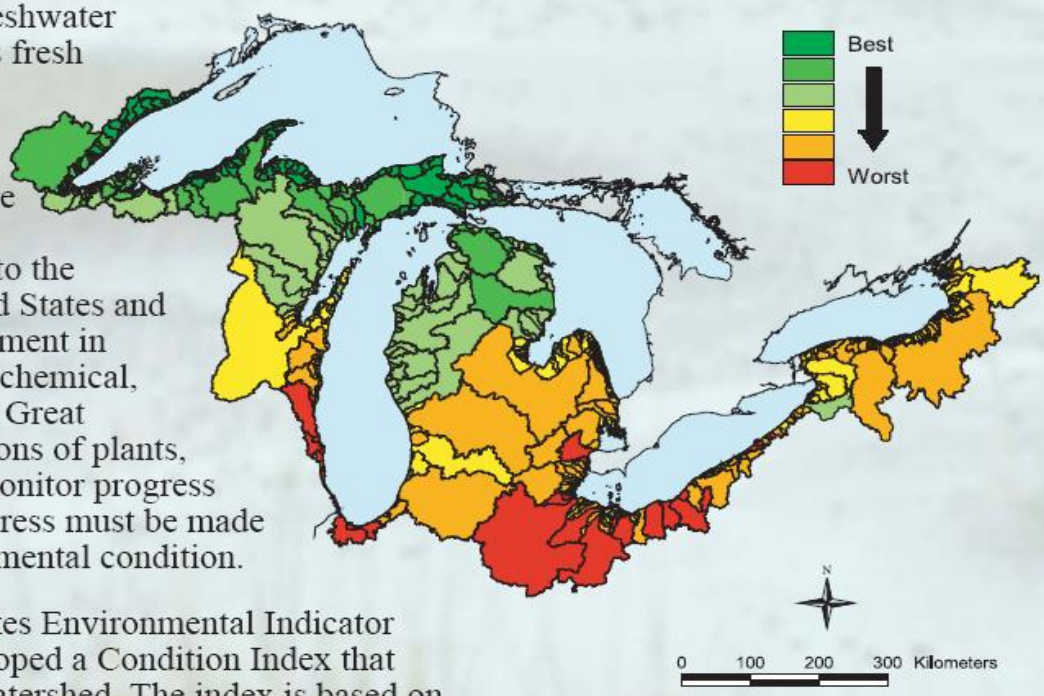
Morrice, et al, in preparation

EPA
United States
Environmental Protection
Agency

New Index of Environmental Condition for Coastal Watersheds in the Great Lakes Basin

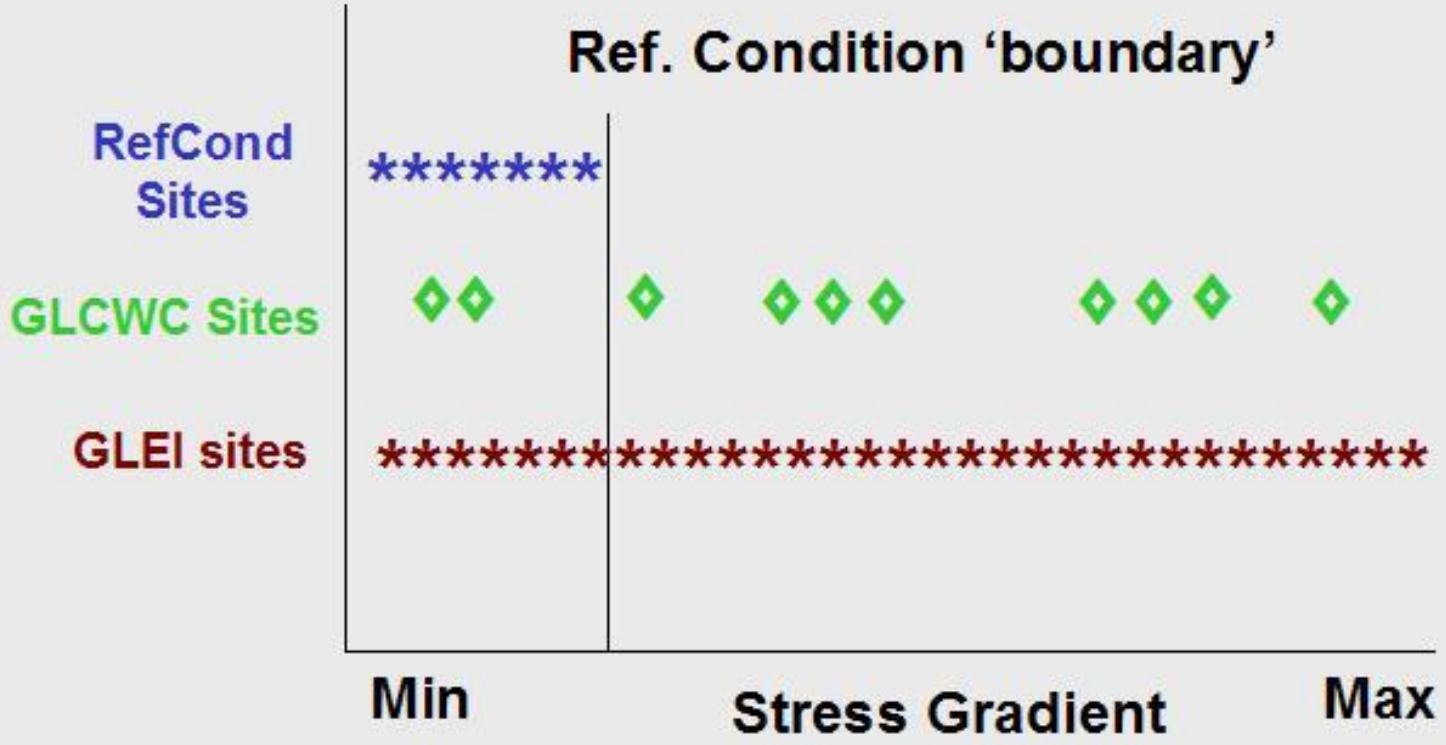
Introduction

The Great Lakes are the largest system of surface freshwater on the Earth. They contain about 20% of the Earth's fresh water and about 90% of the freshwater in the United States. The wealth of natural resources has made this area a center of economic activity for the United States. From mining, forestry, and agriculture to recreation and shipping, human activities have taken a toll on the natural environment. In response to the continued degradation of the Great Lakes, the United States and Canada signed the Great Lakes Water Quality Agreement in 1972. The goal of this agreement was "restoring the chemical, physical and biological integrity of the waters of the Great Lakes Basin ecosystem" to achieve healthy populations of plants, fish, and wildlife and to protect human health. To monitor progress towards this goal, measurements of human caused stress must be made over a period of time to evaluate changes in environmental condition.

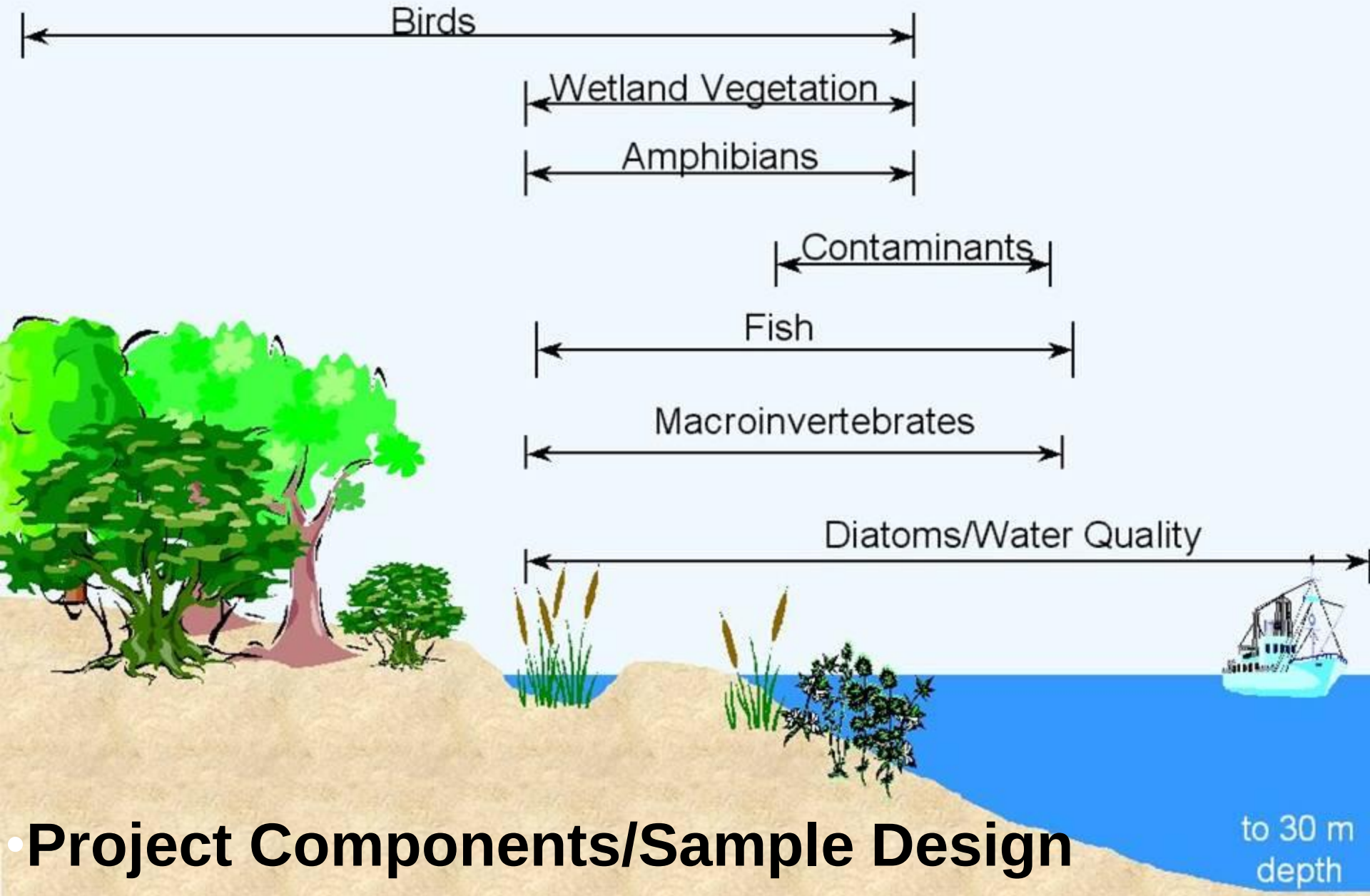


Ecological Indicator: Scientists with the Great Lakes Environmental Indicator (GLEI) Project (http://glei.nrri.umn.edu) have developed a Condition Index that indicates the region's environmental condition by watershed. The index is based on 207 individual stressors that fall into five dominant human-derived stresses to ecological condition: 1) type of land use, 2) amount of agricultural activity, 3) point sources of pollution, 4) atmospheric deposition, and 5) human population density. The stresses in each watershed were summarized and the resulting scores were distributed over a gradient from worst (red) to best (green) indicating the Environmental Condition of each coastal watershed, as depicted on the map below of the U.S. Great Lakes basin (Figure 1).

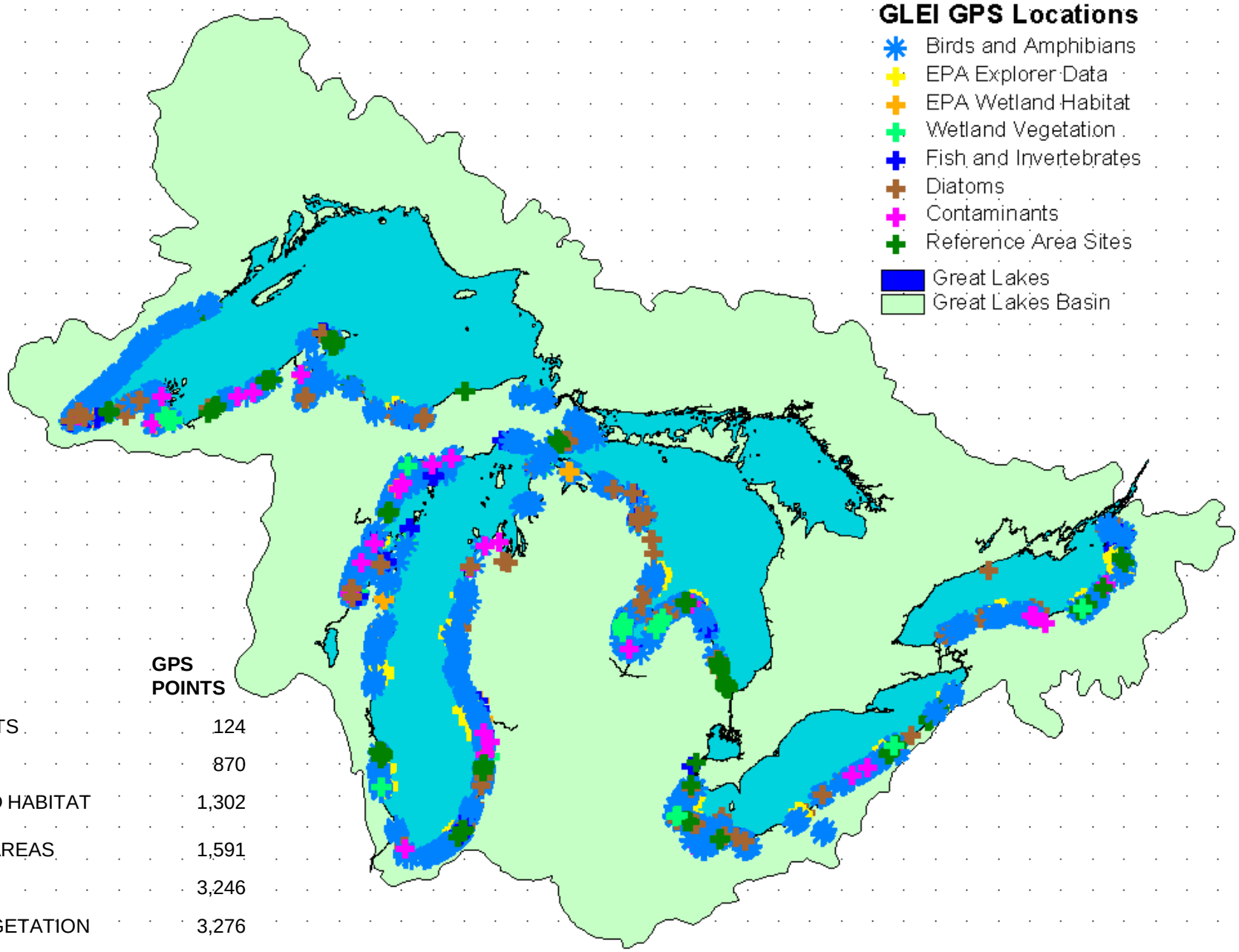
Identifying sampling sites



GLCWC sites were selected to fall along an independently derived urban+agricultural gradient – later matched to GLEI



- **Project Components/Sample Design**



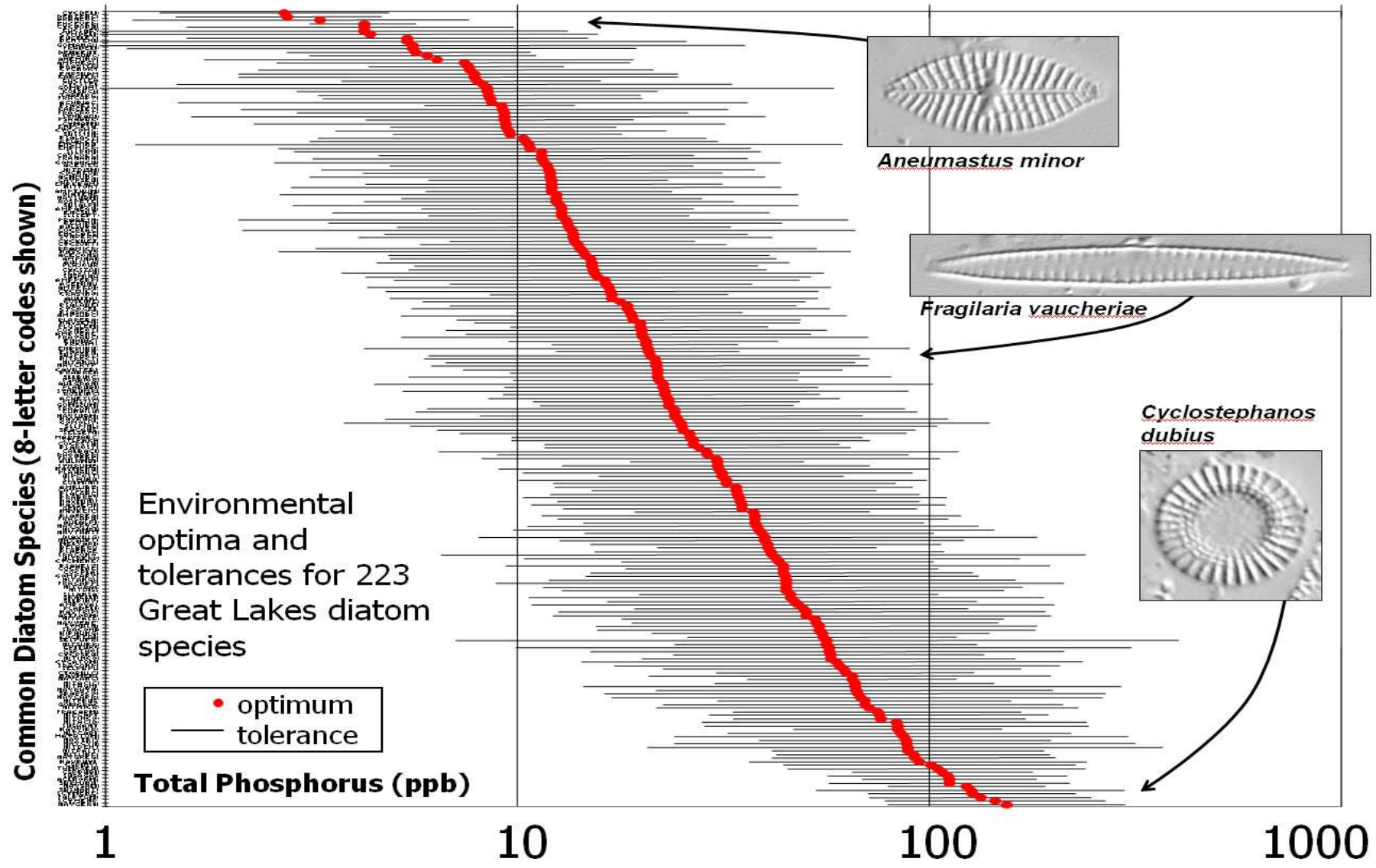
SUBPROJECT	GPS POINTS
CONTAMINANTS	124
DIATOMS	870
EPA WETLAND HABITAT	1,302
REFERENCE AREAS	1,591
BIRDS	3,246
WETLAND VEGETATION	3,276
FISH AND INVERTEBRATES	4,106
EPA EXPLORER	97,198

Environmental Indicators

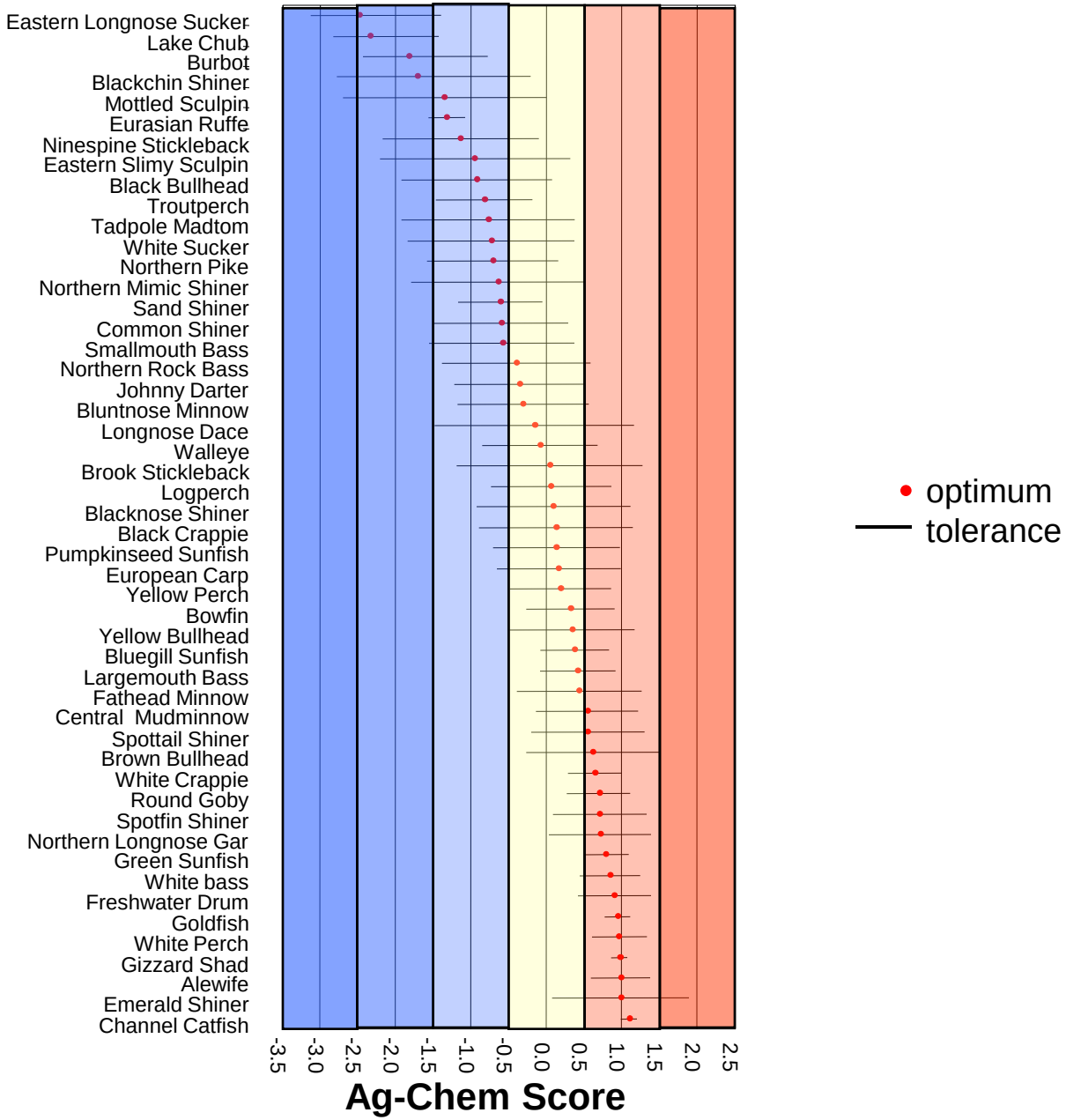
- 14 to 20 “groups of indicators” developed

1. Amphibians (frogs) – not very useful
2. Breeding birds – very useful in wetlands and upland areas
3. Polycyclic aromatic hydrocarbons (PAH’s) – 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

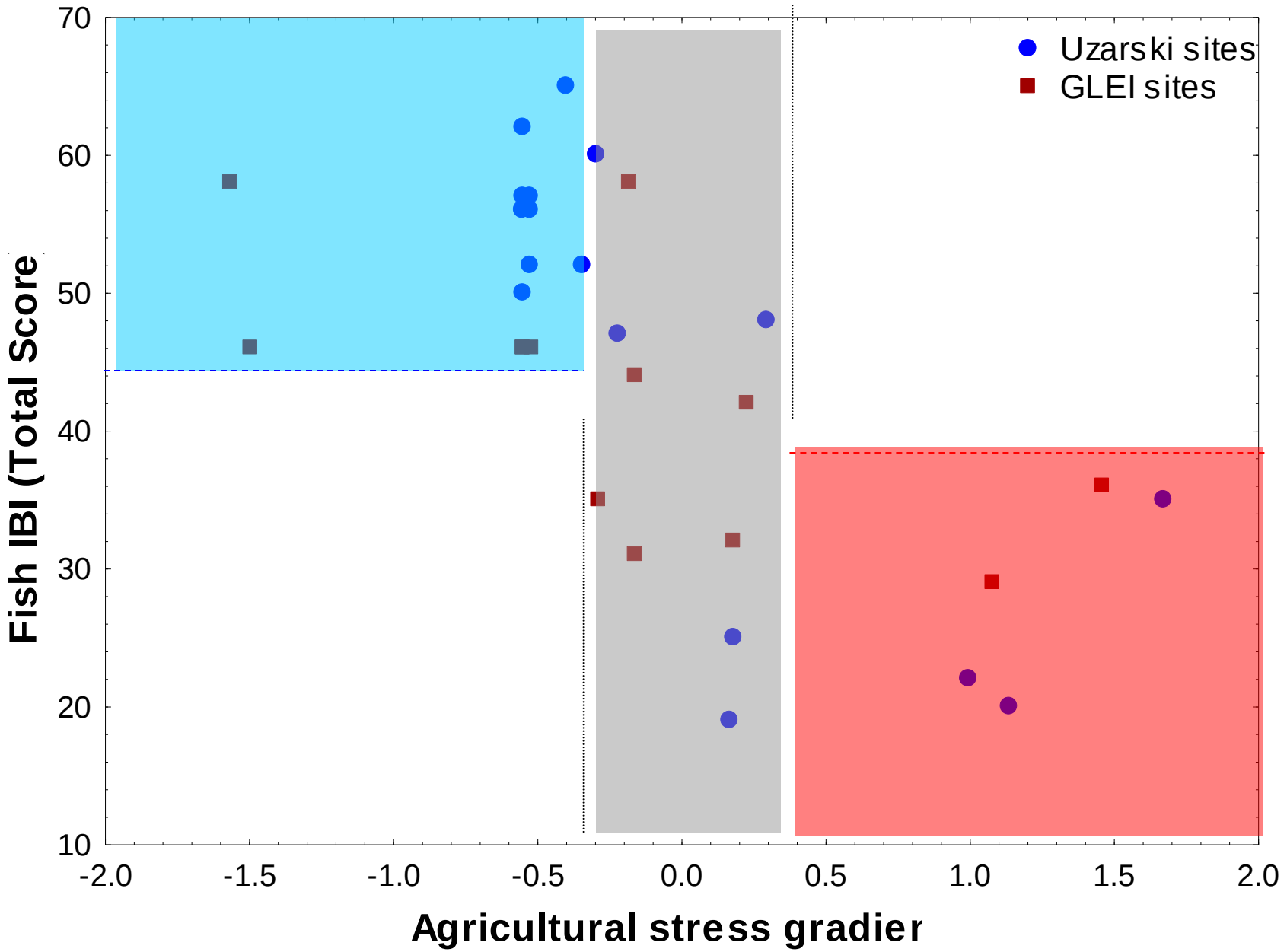
Diatoms – are excellent indicators of water quality



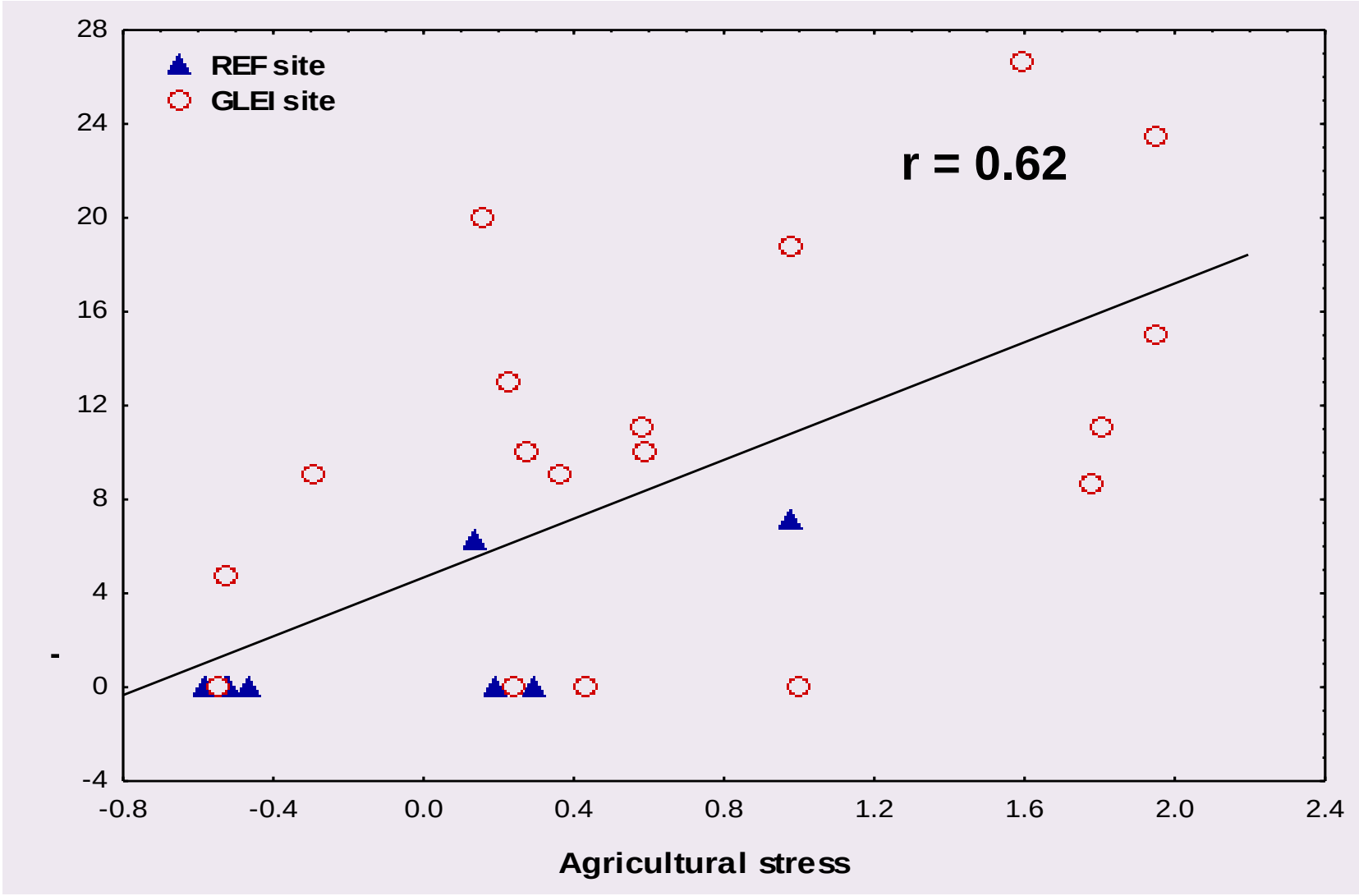
Fish species tolerances with respect to Agricultural Stressor



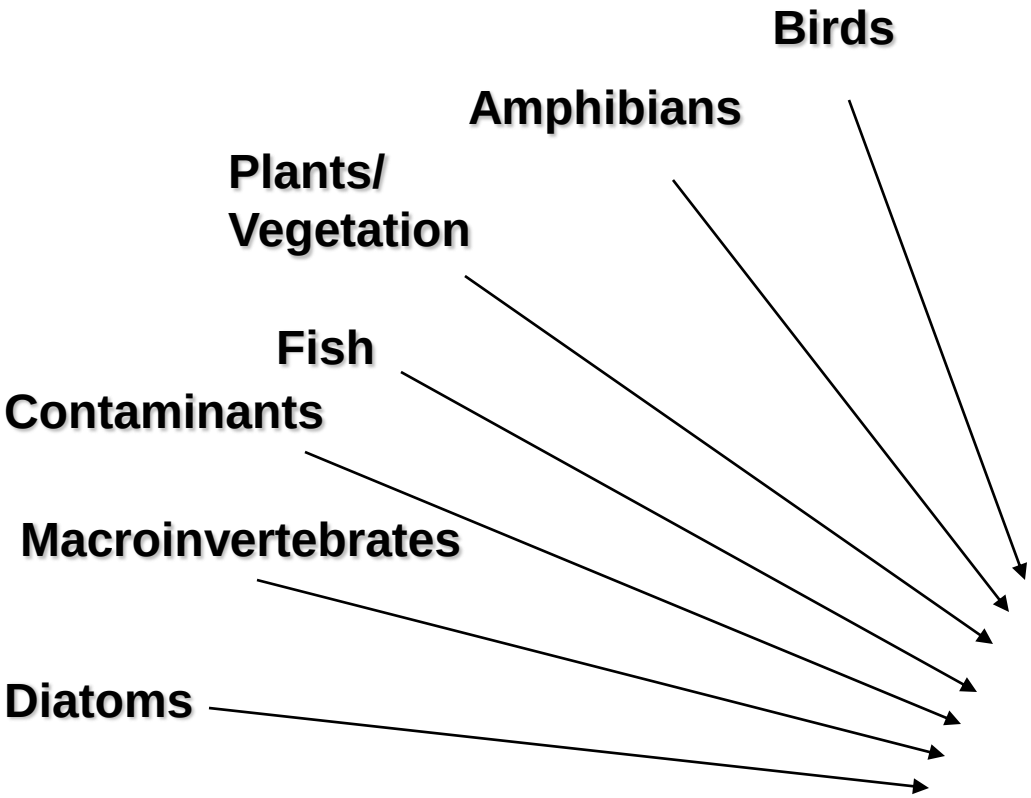
Combined data – *Scirpus* sites



Results – a few examples



From: Baghat, 2005. M.S. Thesis. University of Windsor.



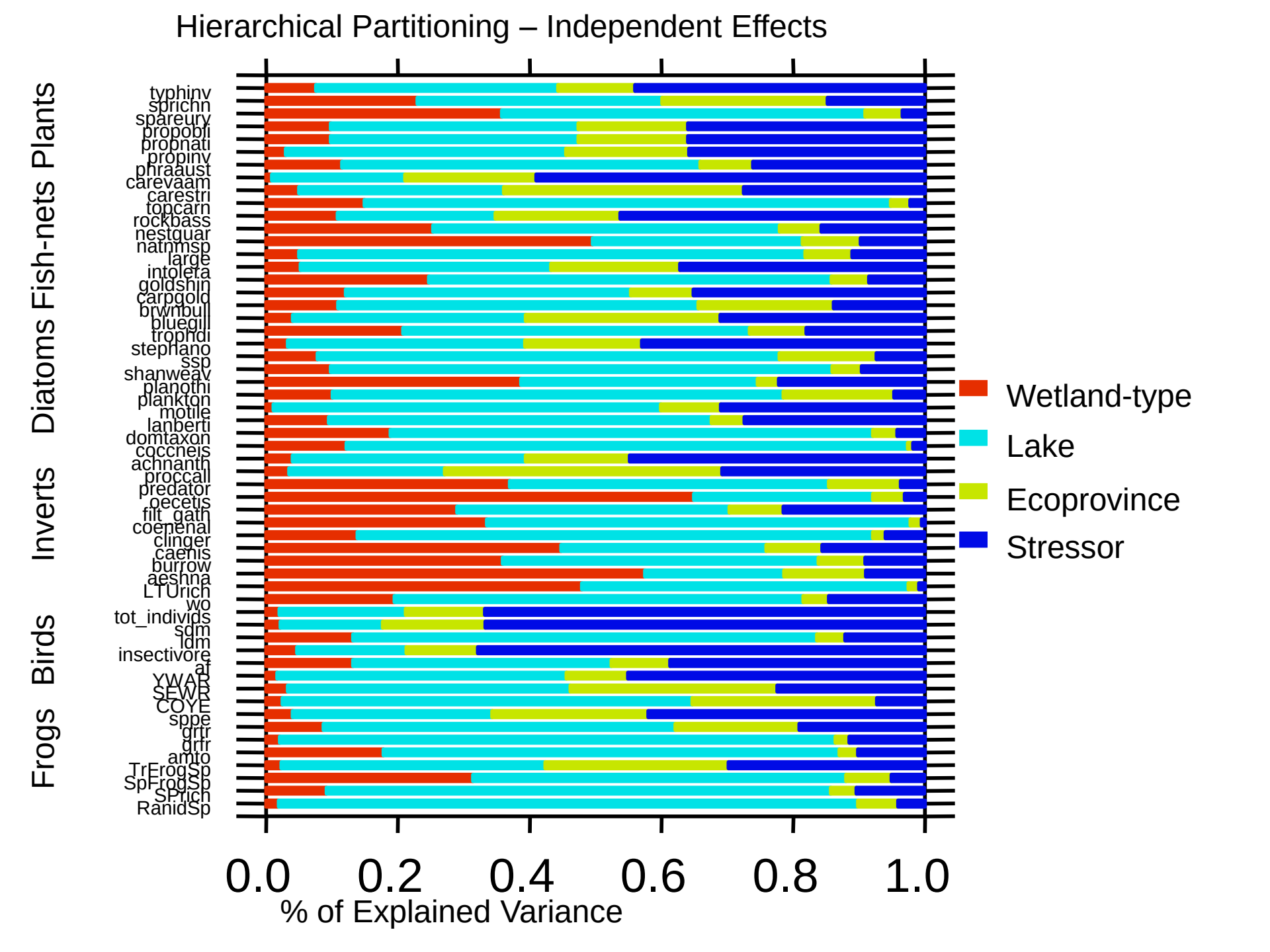
GLEI

Integrated analysis

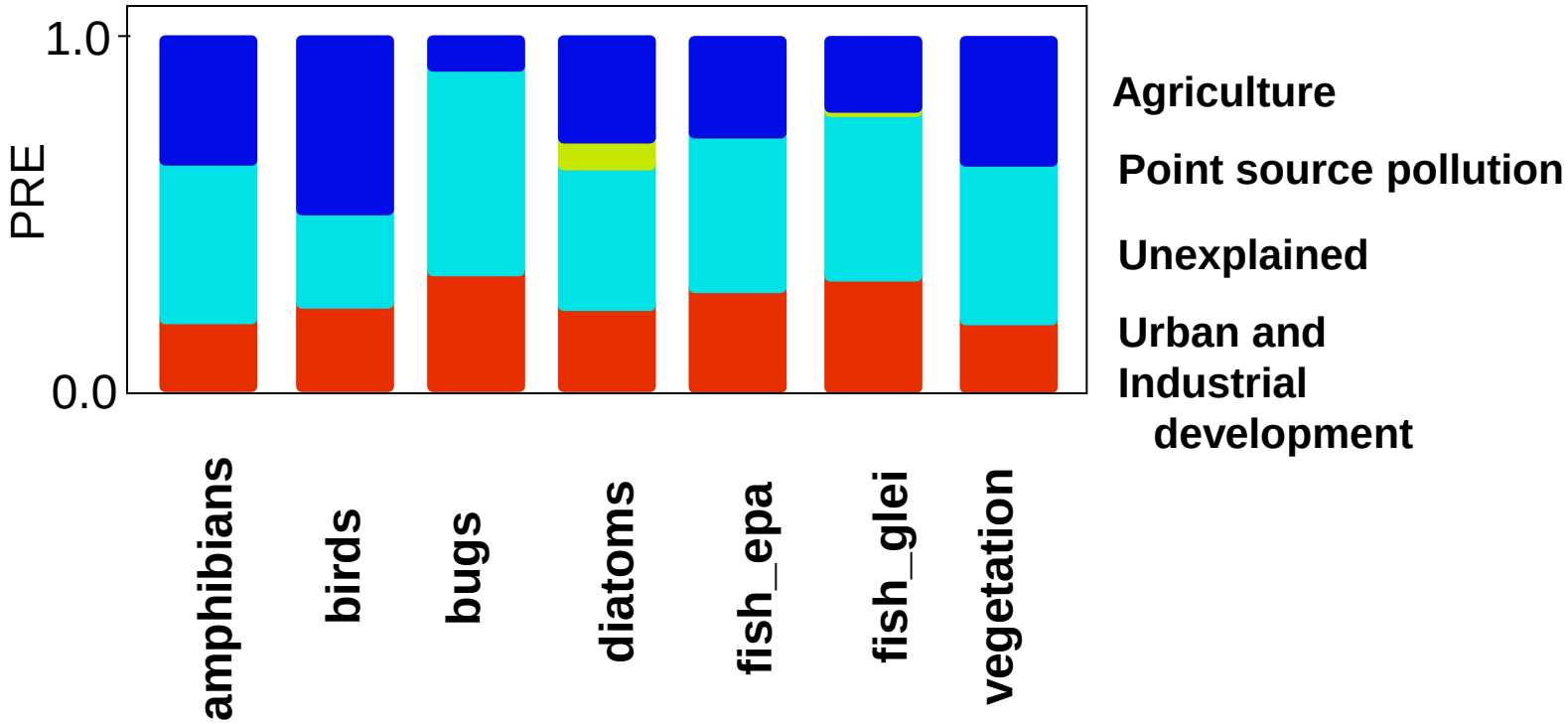
Indicators with Strongest Stressor-Response

Candidate Indicator	R^2
- % rock bass (electrofishing)	0.33
- % *Carex lasiocarpa*	0.30
- % Stephanodiscoid diatoms	0.26
- % invasive wetland taxa	0.22
- # of birds	0.21
- % bluegills (fyke-nets)	0.21
- % carp and goldfish (electrofishing)	0.20
- # insectivorous birds	0.20
- spring peepers (presence)	N/A

Brazner et al. (2007)


Hierarchical Partitioning – Independent Effects
Plants
Fish-nets
Diatoms
Inverts
Birds
Frogs
typhinv
sprichn
spareury
propobli
propnati
propinv
phraaust
carevaam
carestri
topcarn
rockbass
nestguar
natnmsp
large
intolera
goldshin
carpgold
brwnbull
bluegill
trophdi
stephano
ssp
shanweav
planothi
plankton
motile
lanberti
domtaxon
coccneis
achnanth
proccall
predator
oecetis
filt_gath
coenenal
clinger
caenis
burrow
aeshna
LTUrich
wo
tot_individs
sqm
ldm
insectivore
af
YWAR
SEWR
COYE
sppe
grtr
grfr
amto
TrFrogSp
SpFrogSp
SPrich
RanidSp
0.0
0.2
0.4
0.6
0.8
1.0
% of Explained Variance
Wetland-type
Lake
Ecoprovince
Stressor

Relating stress types to the biological indicators

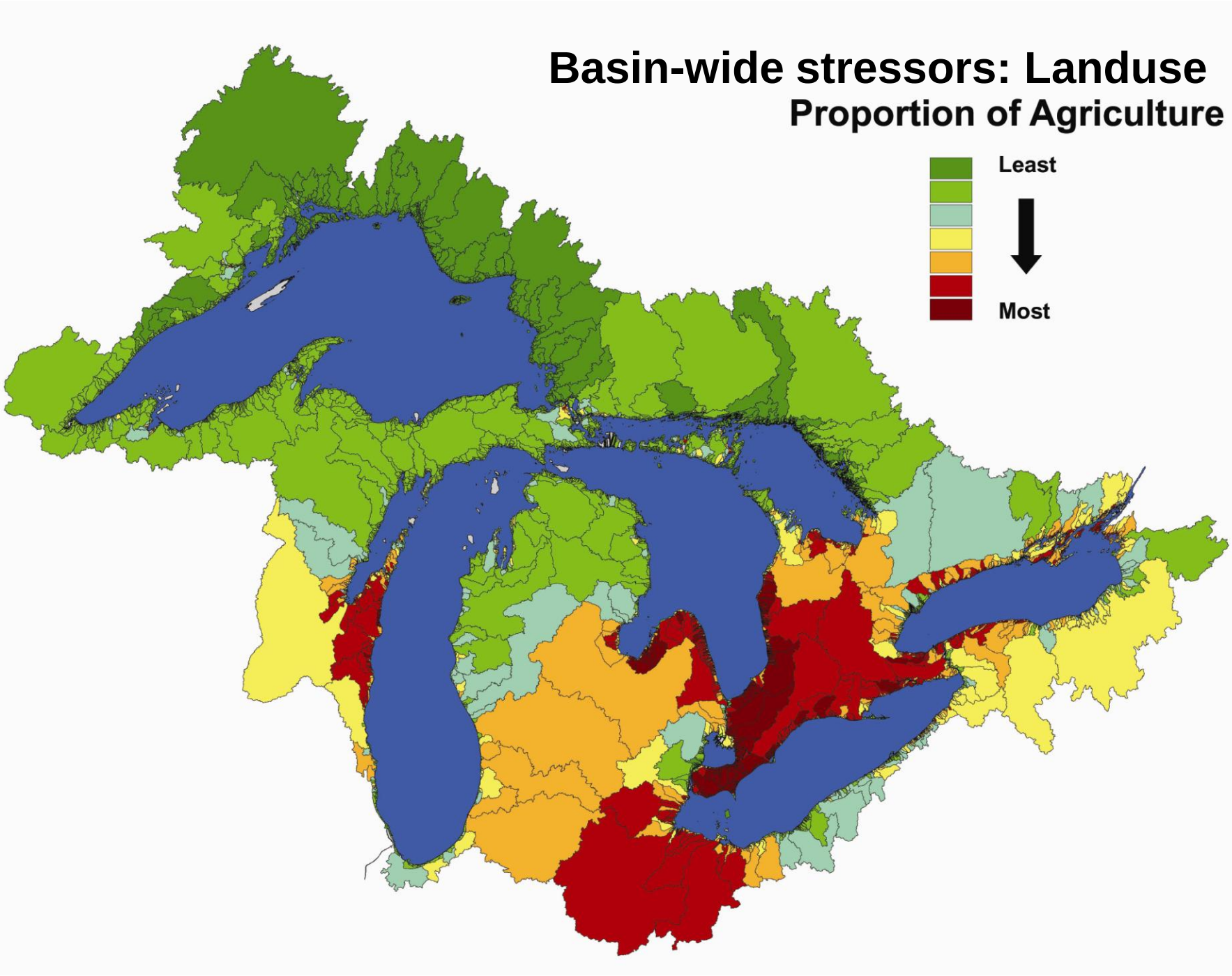


(CART analysis)

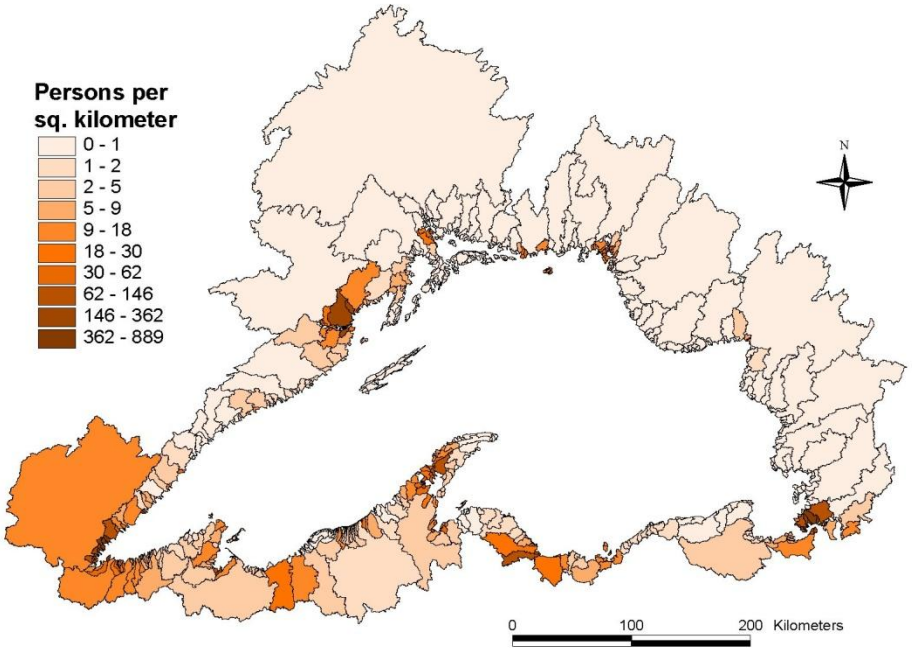
From Brazner et al. (2007) *J. Great Lakes Res. in review*

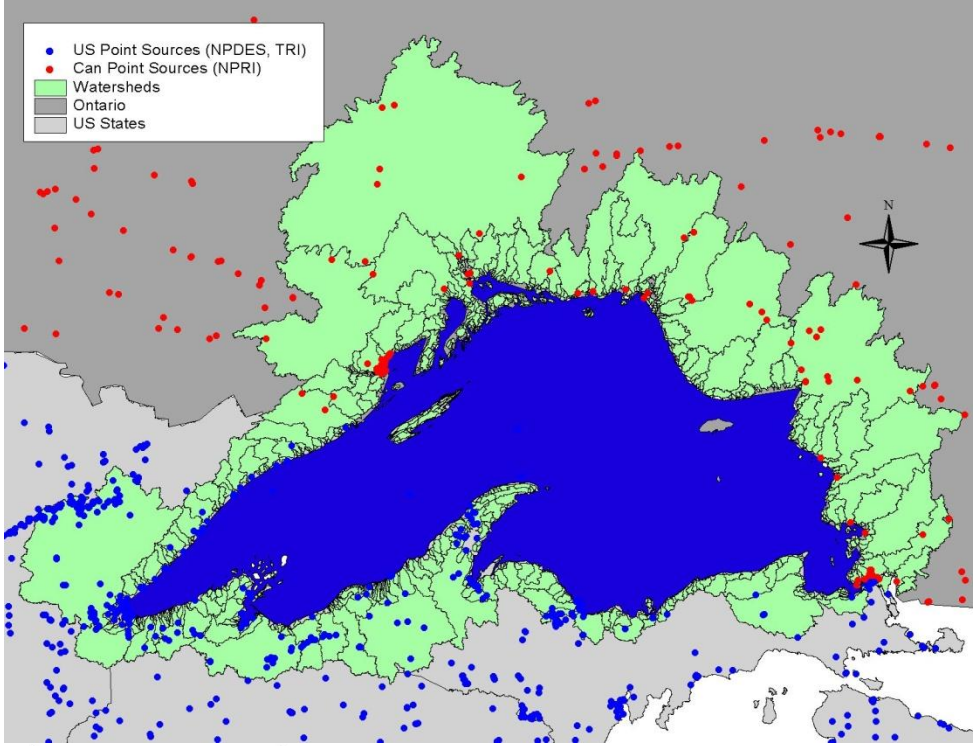
Continued Activities

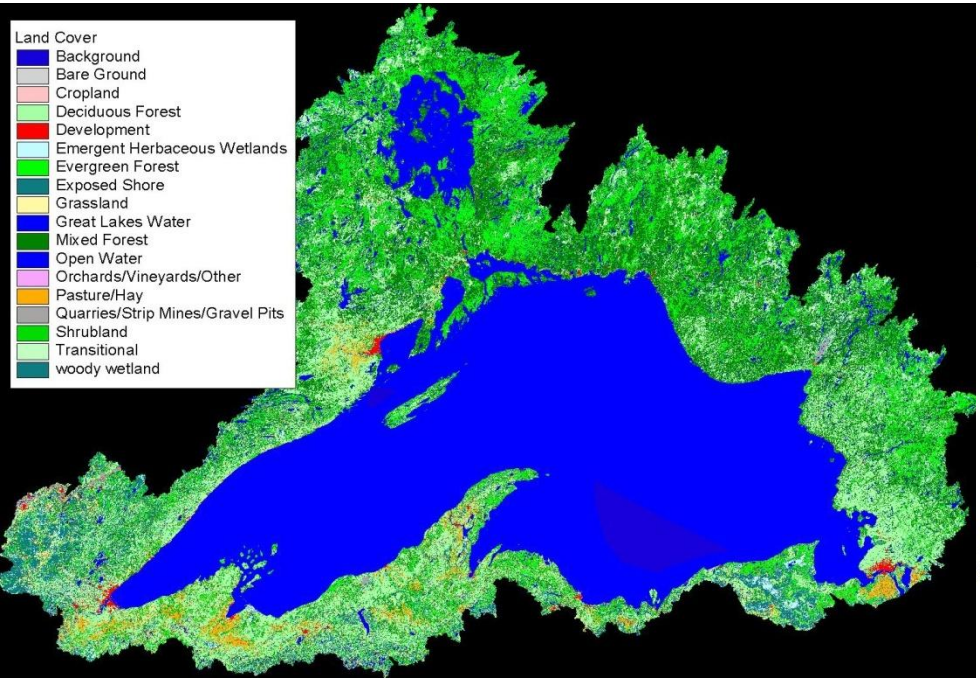
- Stressor Gradient:
  - Expanded to the Great Lakes Basin
  - Cross-walked stressors across US-Canada
  - High-resolution sub-catchments delineated for Lake Superior.
  - Integrating non-stressor data into gradient
  - Refining data delivery tools (watershed thermometer)

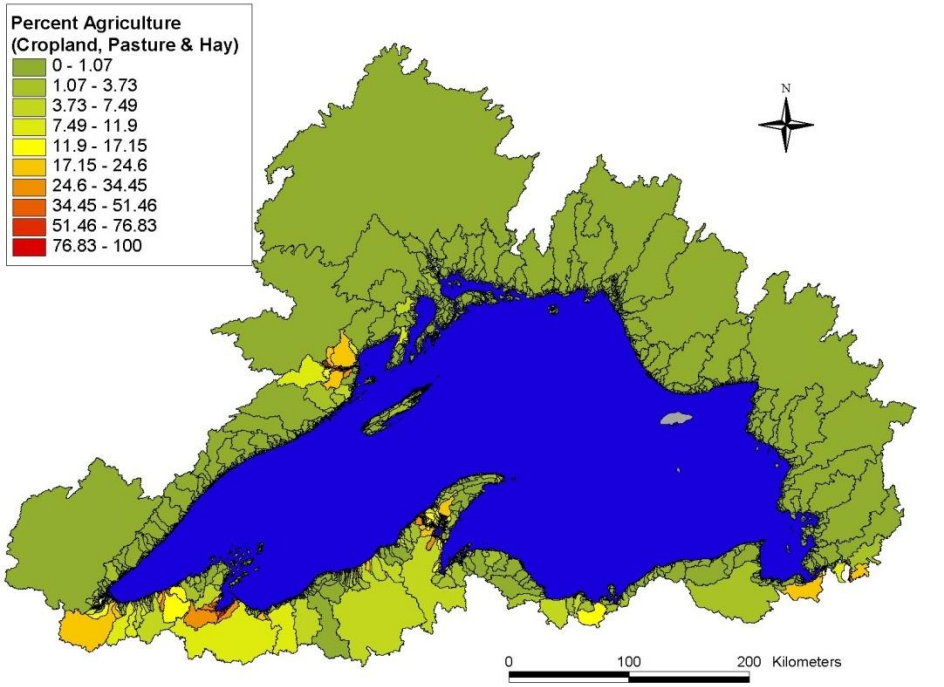

Basin-wide stressors: Landuse
Proportion of Agriculture
Least
Most

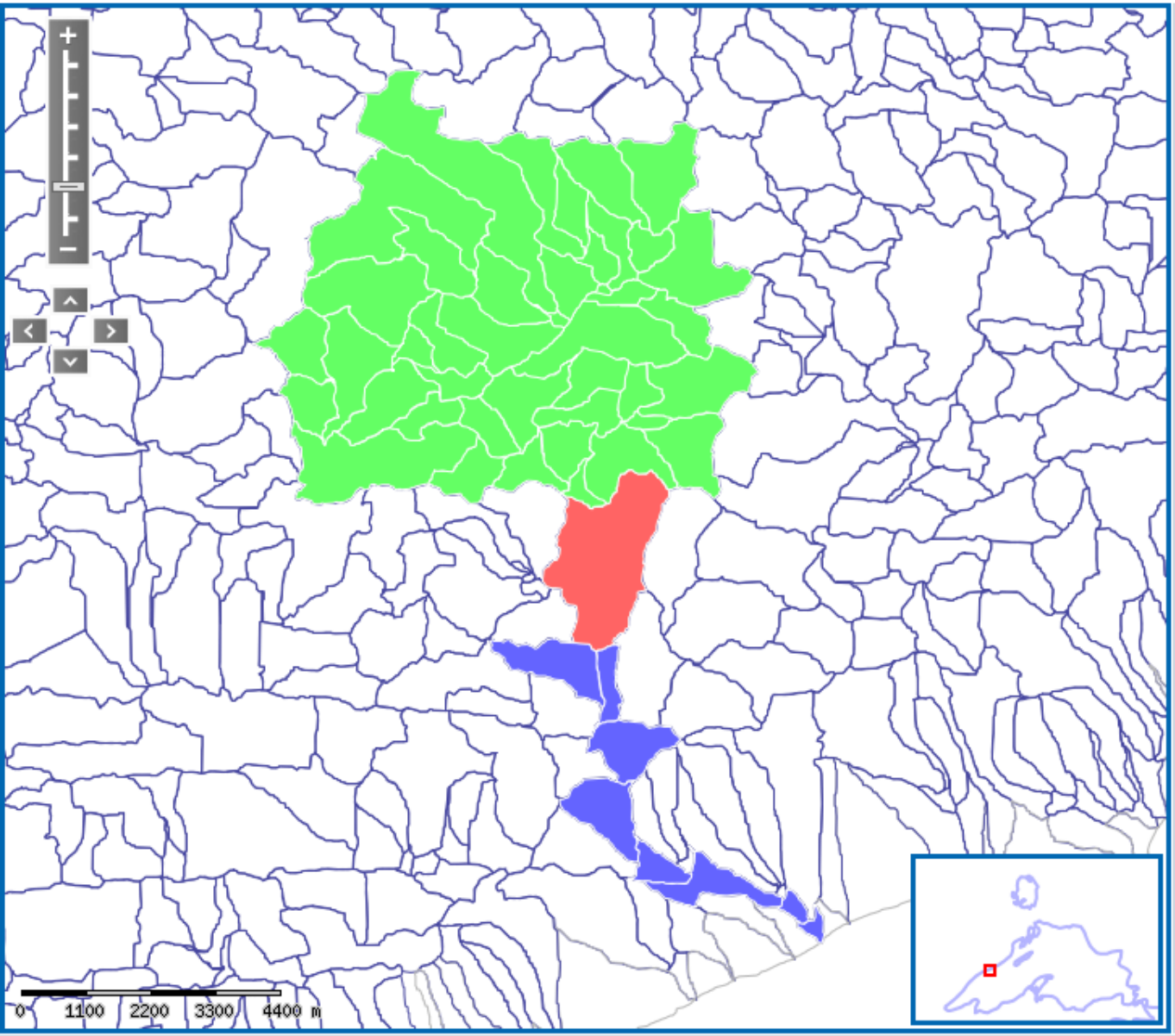
Lake Superior Basin Stressors











Jump To:

Map Layers | Information

INFORMATION

Catchment 90007589

Area: **903** acres
Agr.%: **31**

Agr. relative stress

Total relative stress

Downstream

Downstream catchments: **8**
Downstream area: **1233** acres
Agr.%: **48**

Agr. relative stress

Total relative stress

Upstream

Upstream catchments: **42**
Upstream area: **10401** acres
Agr.%: **11**

Agr. relative stress

Total relative stress

The GeoMOOSE Project **X,Y:** 420578.32,2772759.56 **Lat, Long:** 25.0684,-93.7874

Scale 1: 77,633 Go! Moose Powered

GLRI: Indicator Development & Testing

- What does the measurement indicate? (i.e., what is the story? Is the story accurate?)
- Is it reliable (through time / through space)?
- Repeatable by different sampling crews?
- Overlap with other metrics?
- Cost effective?
- Recommended suite of indicators for coastal ecosystems

GLCWC Fish IBI Correlation with GLEI Stressors

Stressors	*Typha* Zone IBI	*Scirpus* ZONE IBI
Agriculture	0.02	-0.64
Land cover: Forest	-0.38	0.15
Population/development	-0.70	-0.21
Point source discharge	-0.09	-0.57
Atmospheric deposition	0.60	0.04
Shoreline modification	-0.24	-0.13

Bhagat et al. (2007)

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.)

GLEI
Home
FAQs
Links
What's New
Outreach
Intranet
A multi agency project funded by US EPA's STAR Program
Toxins
Birds
Plants
Frogs
Bugs
Fish
Algae
Water
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