



# Evaluation of the Lake Macroinvertebrate Integrity Index (LMII) and Alternate Indices for Eastern US Lakes and Reservoirs

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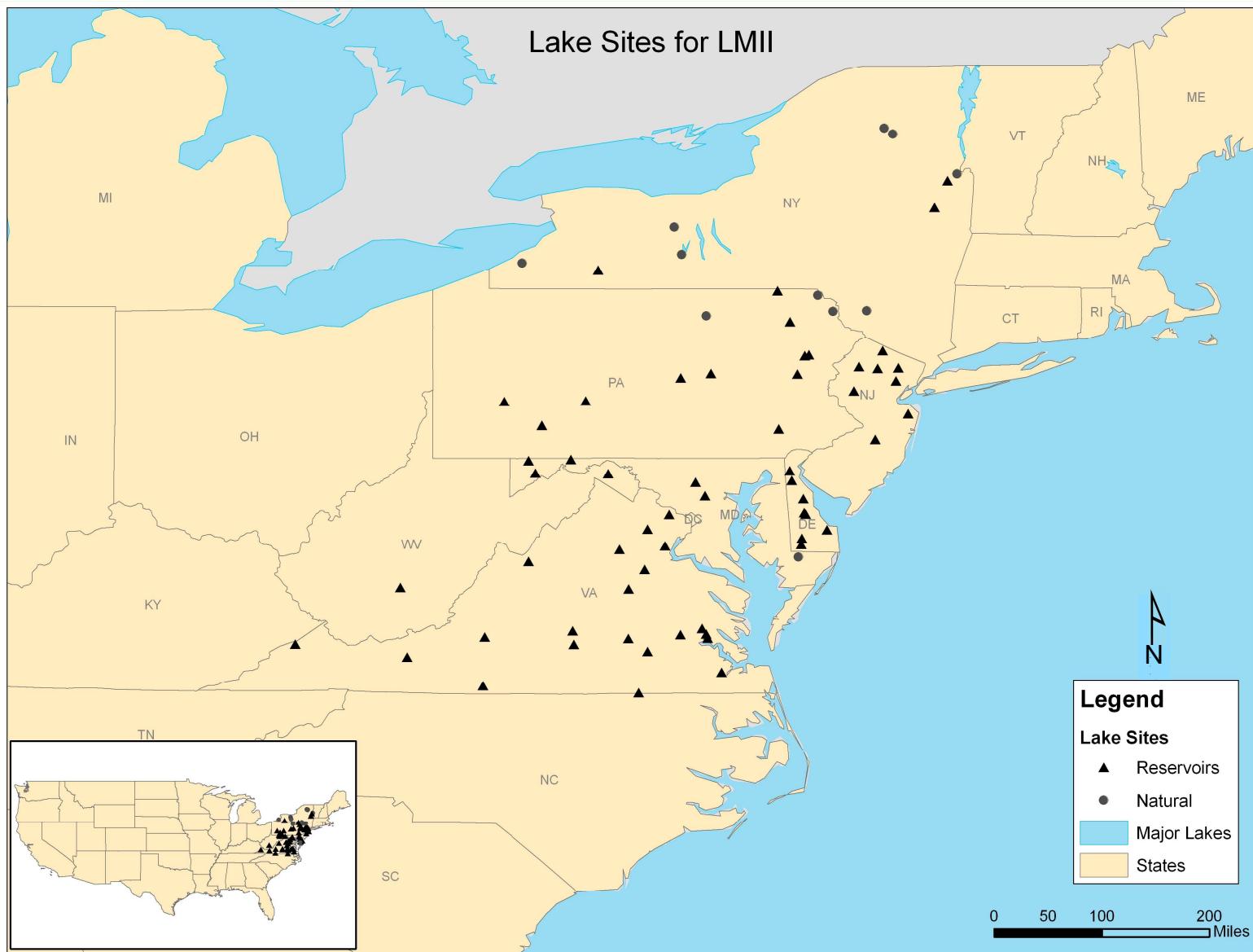
# Study Objectives

- Field validate a genus-level, sub-littoral **Lake Macroinvertebrate Integrity Index (LMII)**.
  - The LMII originally created by Blocksom et al. (2002) using species data from muck and mixed-sediment New Jersey lakes.
- Determine relationships between the LMII, water quality, and physical habitat.
- Examine the regional applicability of the LMII.
- Examine alternate indices using candidate metrics.

## The National Lakes Assessment

**The 1<sup>st</sup> ever nationally-consistent assessment of U.S. lakes, ponds, reservoirs**

- *Reasons:*
  - Clean Water Act Section 305(b) reports do not tell a comprehensive national water quality story
  - States cannot directly compare their conditions to those of adjoining states or in relation to regional conditions
- *Benefits:*
  - EPA: Yield complementary assessments of condition in light of broad national initiatives; promote consistency in cross-jurisdictional assessment of water quality
  - States: National Aquatic Resource Surveys (NARS) provide regionally explicit statements of condition against which state conditions can be compared
  - All: Establish new monitoring approaches and assessment tools

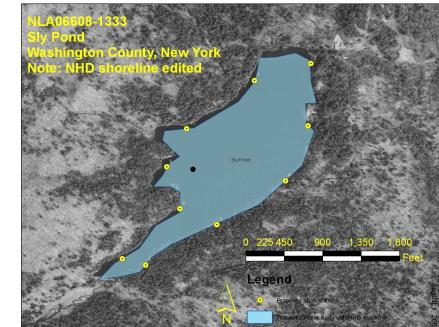




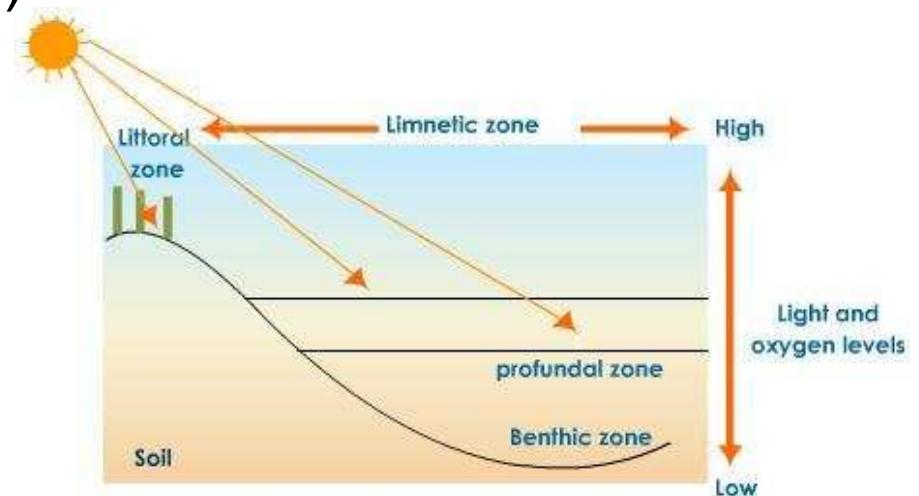
# Benthic Field Collection

- Sub-littoral macroinvertebrate assemblage
- Petite ponar grab samples
- Ten randomly-selected locations, composited into a single sample
- Samples wet sieved through wash bucket with 500-µm screen
- Specimens preserved with 95% ethanol or 10% formalin
- 100 organism sub-count for lab identification

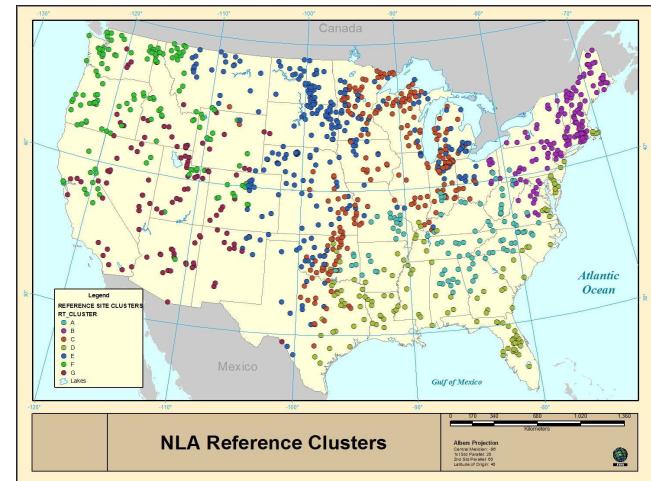
# Lake Data Collected



- *Riparian Zone:* Habitat, Substrate, Macrophytes
- *Littoral Zone:* Habitat, Substrate, Macrophytes, NLA Benthos Sampling
- *Sub-littoral Zone:* Region/State Benthos Sampling
- *Profundal Zone:* Water Chemistry, Nutrients
- Land Use/Disturbance (GIS)
- Lake Level Fluctuations



# Step 1: Identify Reference & Impact Sites



- National Lake Assessment (NLA) chemical and land disturbance-based reference/intermediate/impact lake criteria\* used to designate impairment thresholds (\* = by hydrogeomorphic cluster)
- Impairment thresholds used to evaluate sub-littoral biotic index discriminatory power

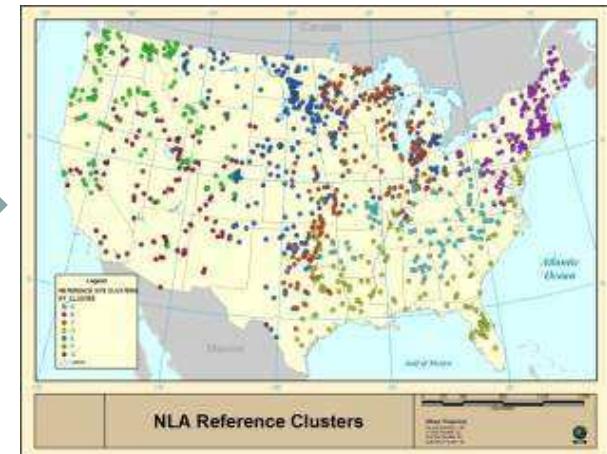


## Setting the Bar: Biological Reference Lake Screening Process

Step 1



Cluster analysis:  
 Elevation  
 Lat-Long  
 Precipitation  
 Mean ann. temp.  
 Shoreline dev.  
 Lake size/depth



Step 2

- TP
- TN
- CL
- SO<sub>4</sub>
- Turb
- ANC (given DOC)
- Euphotic Zone DO
- Shoreline disturbed by Ag
- Shoreline disturbed by non-Ag
- SD – Intensity and extent

7

	PTL	NTL	CL
<b>A</b>	12	400	200
<b>B</b>	10	300	250
<b>C</b>	1, 2	15	500

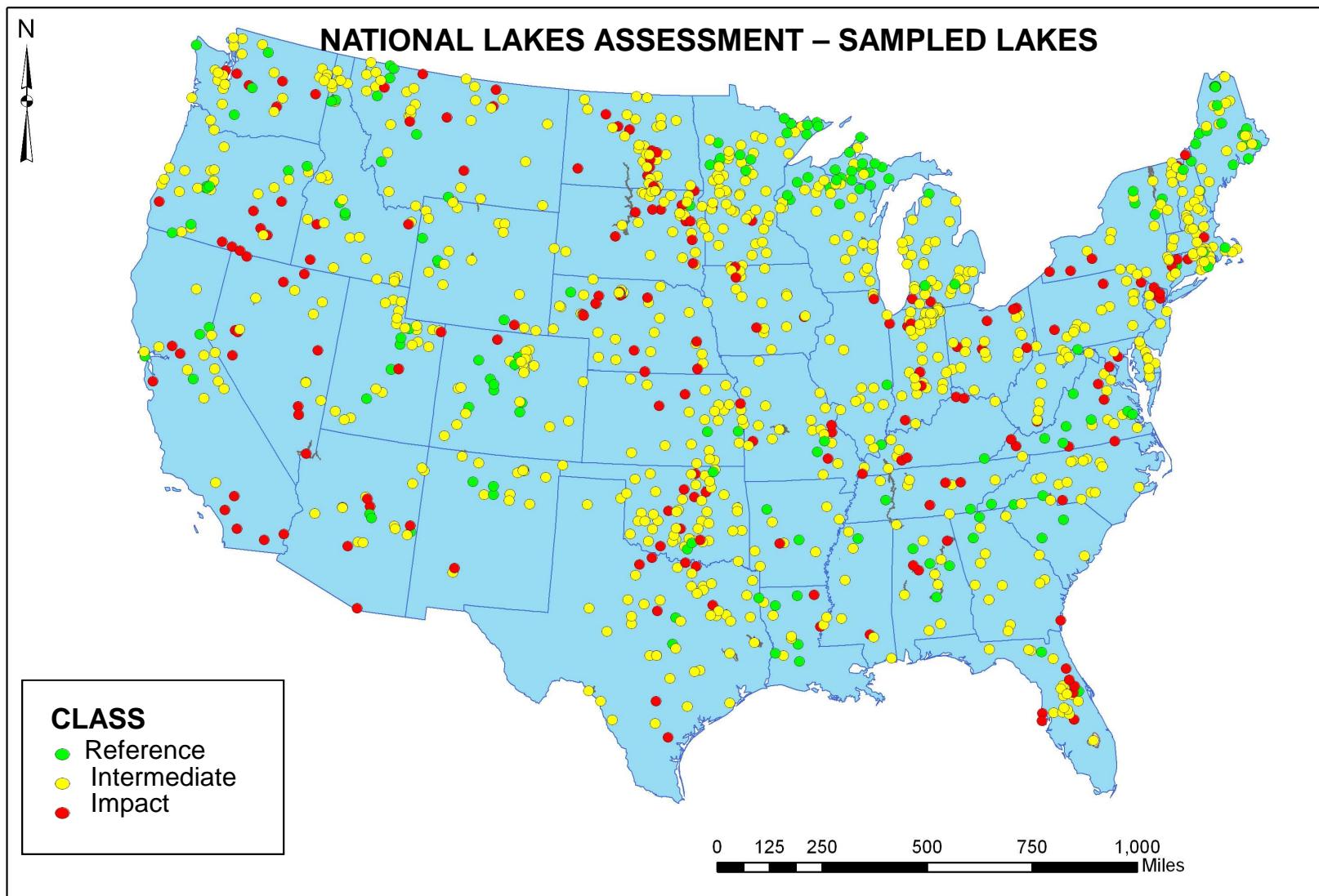
Pass all = ref



Cluster	Total Phos. µg/L	Total Nitrogen mg/L	Chloride µeq/L	Sulfate µeq/L	Turbidity NTU	ANC µq/L (@ DOC <5 mg/L)
A	12 / 100	400 / 1500	200 / 10,000	400 / 1000	5 / 50	<50 / <0
B	10 / 100	300 / 1500	250 / 10,000	250 / 1000	2 / 50	<50 / <0
C <sup>1, 2</sup>	15 / 125	500 / 1500	250 / 10,000	250 / 1000	5 / 50	<50 / <0
C <sup>1, 3</sup>	50 / 125	750 / 1500	250 / 10,000	NA / 1000	10 / 50	<50 / <0
D <sup>1</sup>	75 / 750	750 / 2500	NA / 2000	250 / 1000	10 / 50	<50 / <0
E <sup>1</sup>	100 / 500	1500 / 5000	600 / 10,000	1500 / 10,000	10 / 50	<50 / <0
F	10 / 100	300 / 1500	250 / 10,000	250 / 1000	2 / 50	NA / <0
G	50 / 250	750 / 1500	500 / 10,000	500 / 4000	10 / 50	NA / <0

Cluster	Diss. Oxygen (Euphotic Zone)	Proportion of Lakeshore, Agricultural	Proportion of Lakeshore, Non- agricultural	Overall Disturbance Intensity and Extent	Number of Reference Lakes	Number of Impact Lakes
A	>4 / <3	0 / 0.5	0.6 / 0.80	0.5 / 0.85	17	23
B	>4 / <3	0 / 0.5	0.5 / 0.75	0.4 / 0.85	30	21
C <sup>1, 2</sup>	>4 / <3	0 / 0.3	0.6 / 0.8	0.5 / 0.85	30	25
C <sup>1, 3</sup>	>4 / <3	0 / 0.3	0.6 / 0.8	0.5 / 0.85	30	25
D <sup>1</sup>	>4 / <2	0 / 0.5	0.6 / 0.75	0.6 / 0.85	19	18
E <sup>1</sup>	>4 / <3	0.1 / 0.5	0.6 / 0.75	0.6 / 0.85	24	51
F	>4 / <3	0 / 0.5	0.5 / 0.75	0.4 / 0.85	40	12
G	>4 / <3	0.1 / 0.5	0.5 / 0.75	0.5 / 0.85	10	35





## Step 2: Evaluate LMII Performance

LMII scores analyzed for:

- Ability to discriminate NLA impairment
- Relationship to habitat, chemistry, and land use

Findings:

- LMII discriminated NLA impairment poorly
- Generally, few significant relationships

## LMII

### Metrics:

# Diptera taxa

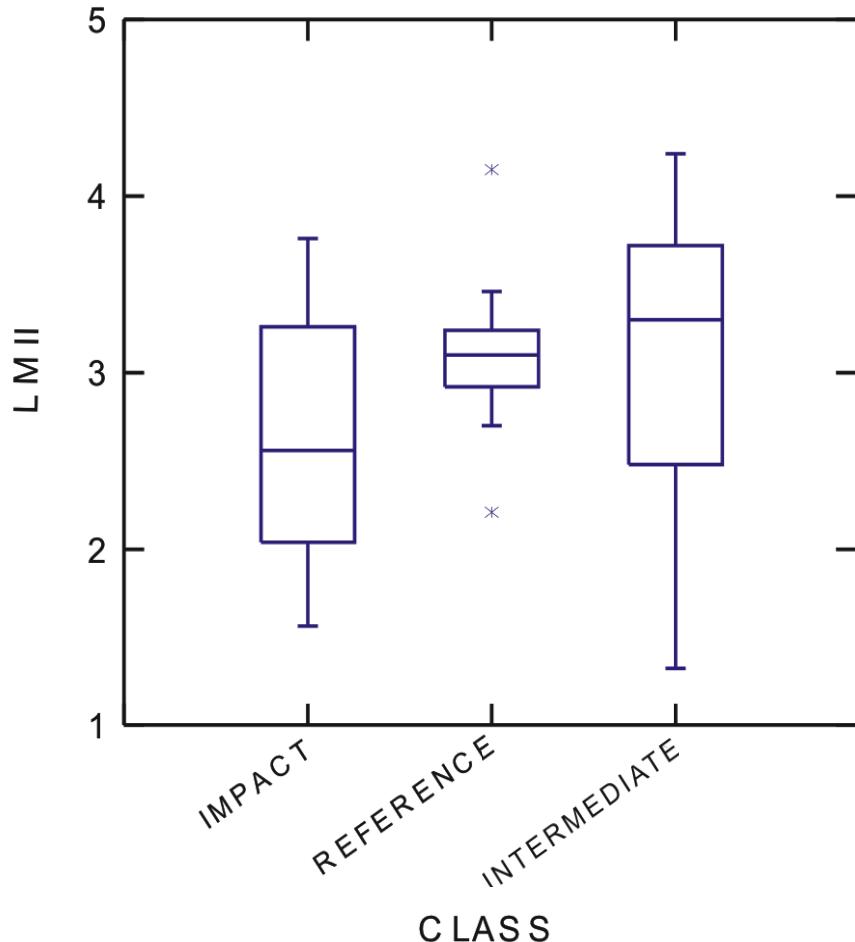
% chironomid individuals

% oligochaetes/leeches

% collector-gatherer taxa

Hilsenhoff Biotic Index

(Blocksom et al. 2002)

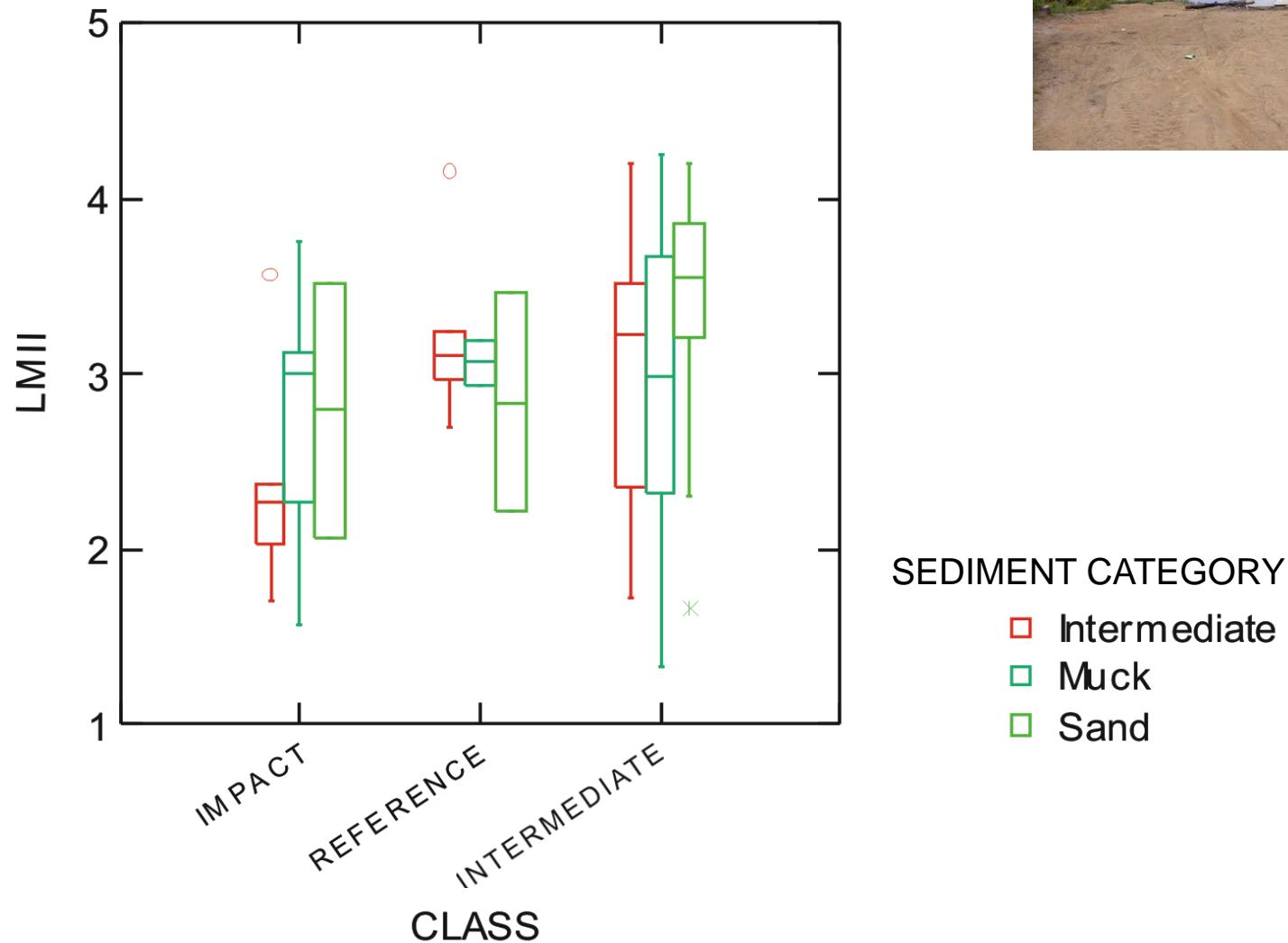


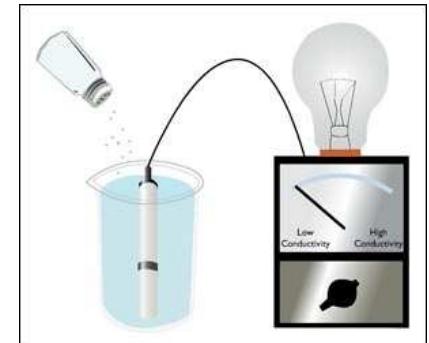
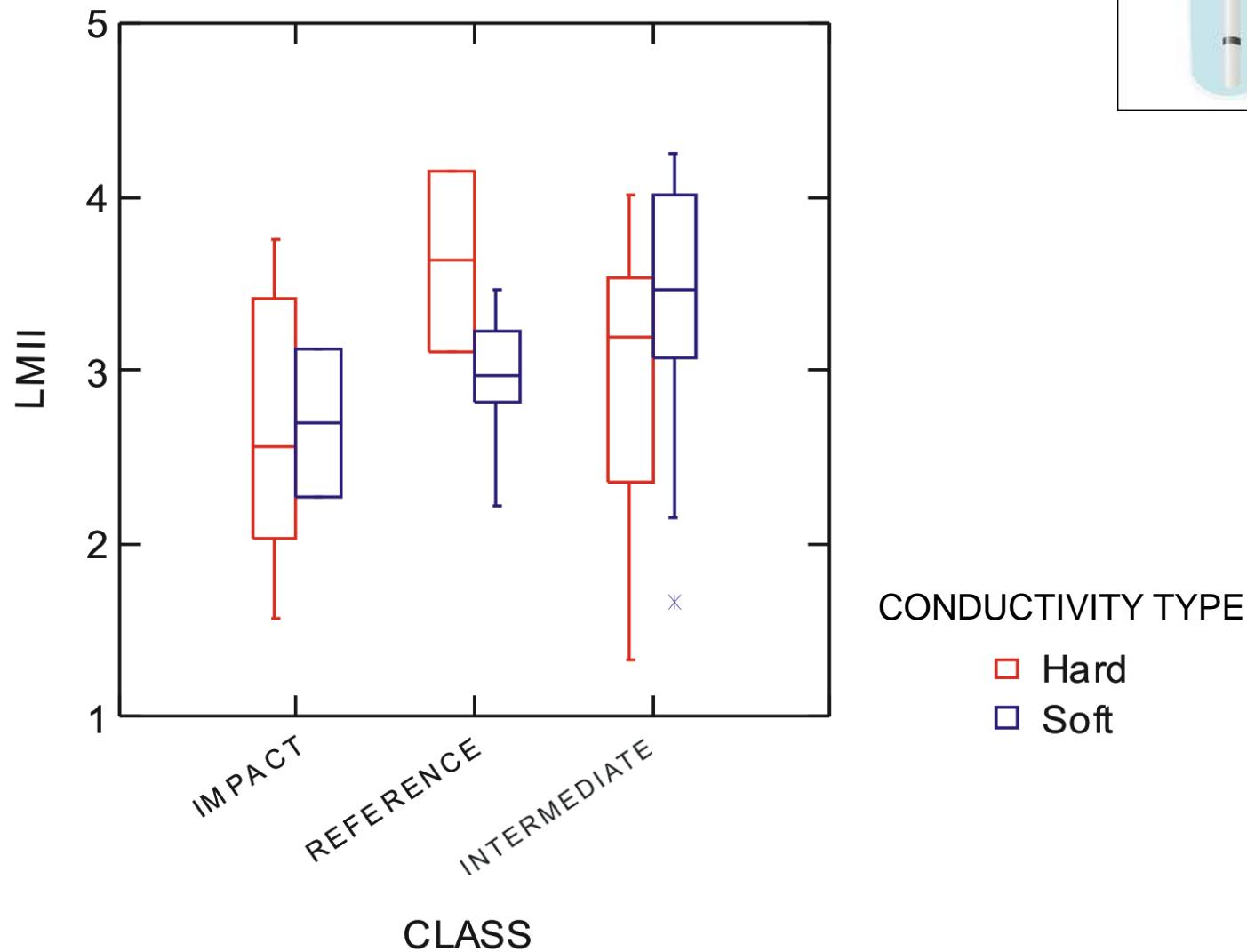
## Step 3: Evaluate LMII with Lake Classification

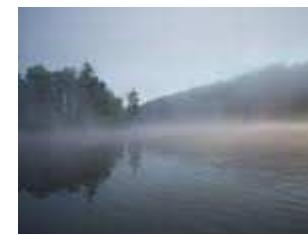
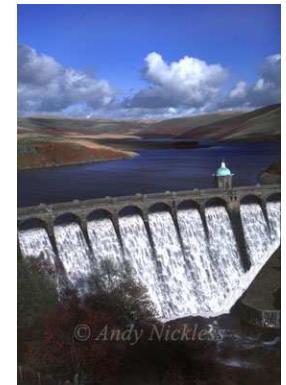
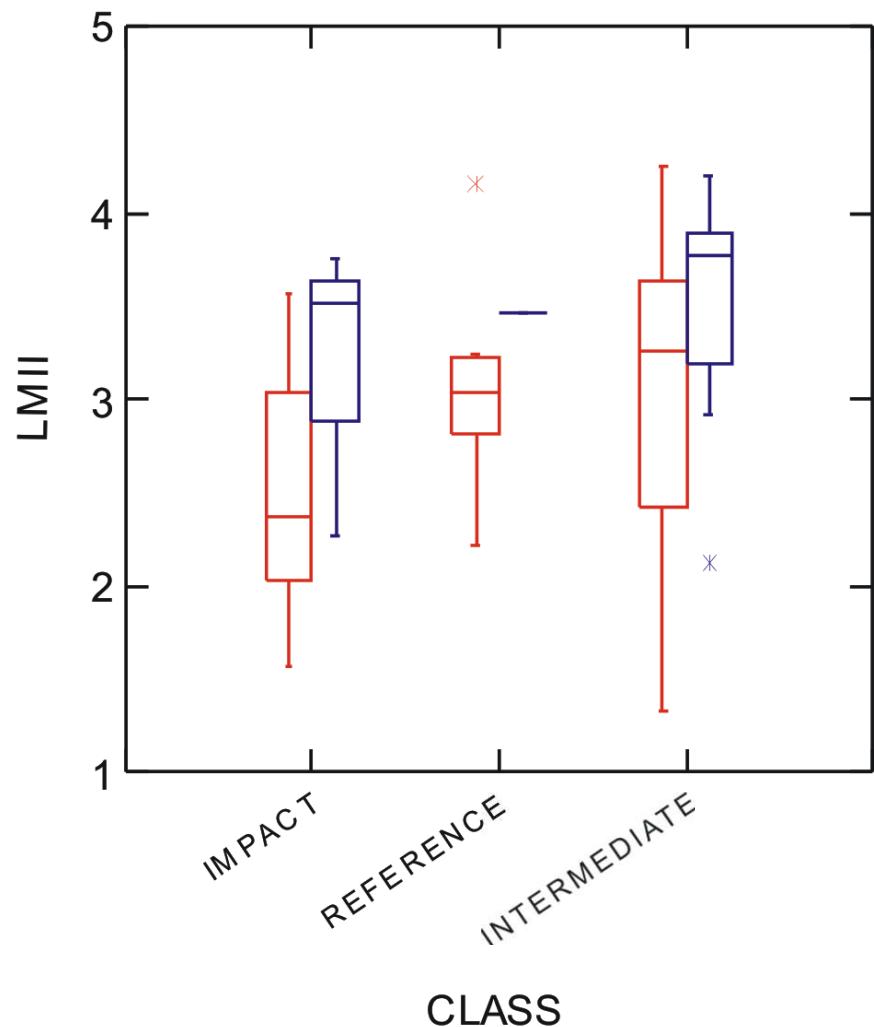
Boxplot analysis split by lake types:

- Sediment (sand, muck, or mixed/intermediate)
- Conductivity (hard or soft)
- Origin (natural or reservoir)
- USEPA Region II or III



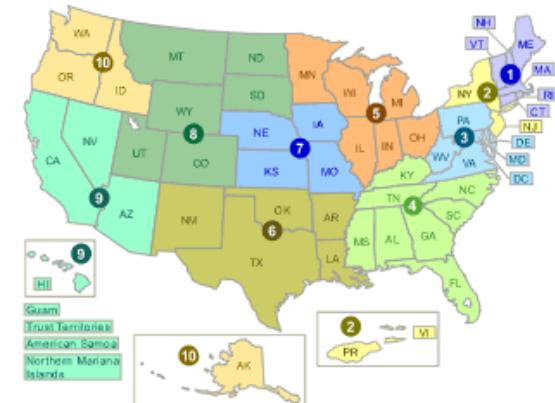
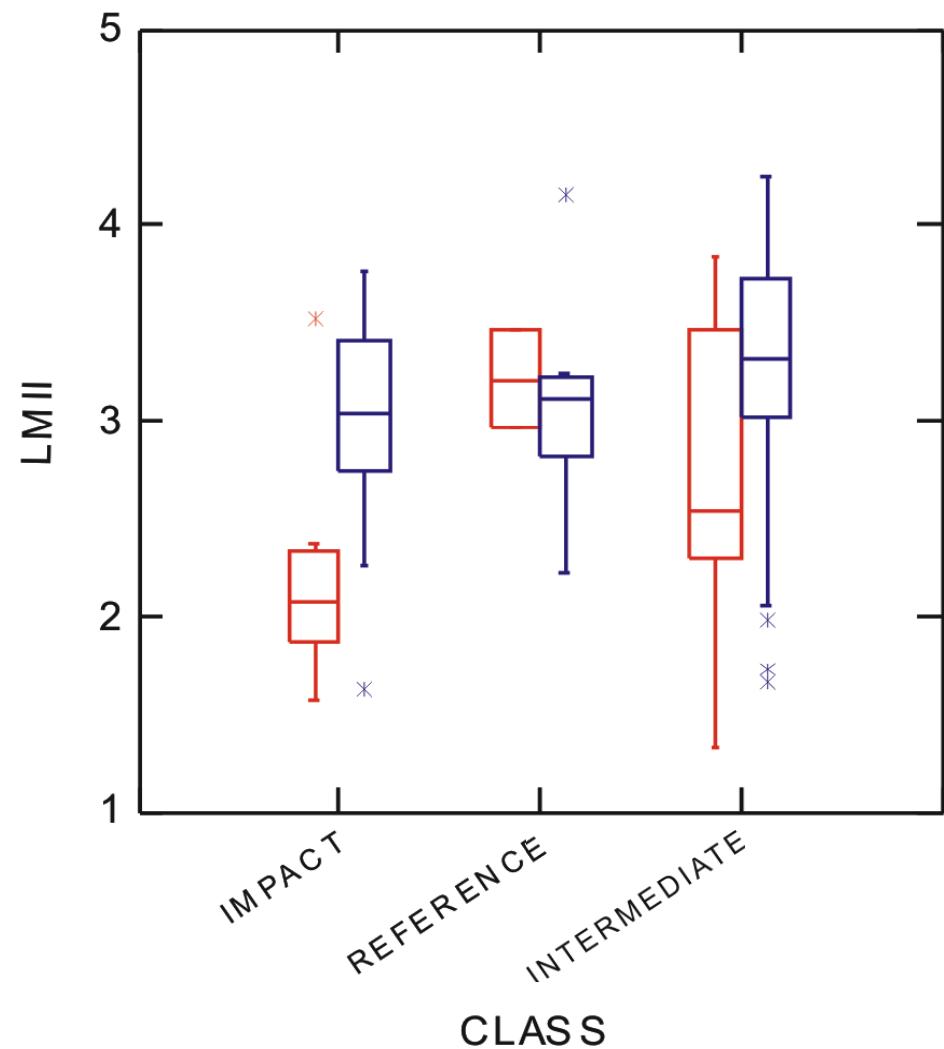






#### STATUS

- Man-made
- Natural



EPA REGION

- Region 2
- Region 3



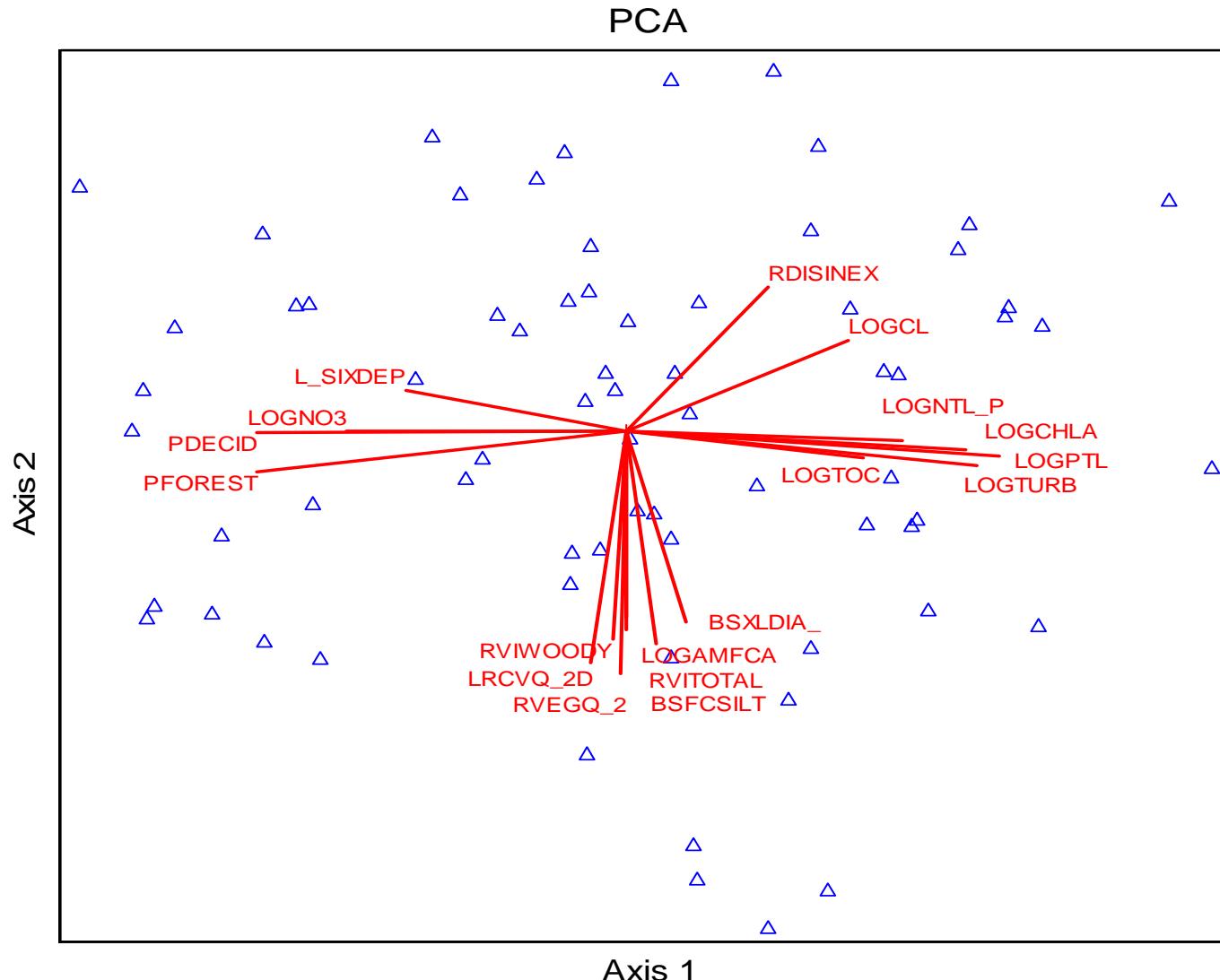
## Step 4: Analysis of Candidate Metrics

- Richness measures (e.g., total number of taxa)
- Tolerance measures (e.g., % intolerant taxa)
- Composition measures (e.g., % non-insects)
- Trophic measures (e.g., % predator taxa)



# Environmental Data Analysis

- Principal components analysis (PCA) used to detect major patterns of environmental variation
- Spearman Rank correlations used to determine strength of associations between metrics and PCA scores + original parameters
- Non-metric multidimensional scaling (NMS) used to look at species gradients; environmental joint plot overlays



# Step 5: Alternate Index Development

Metrics selected by:

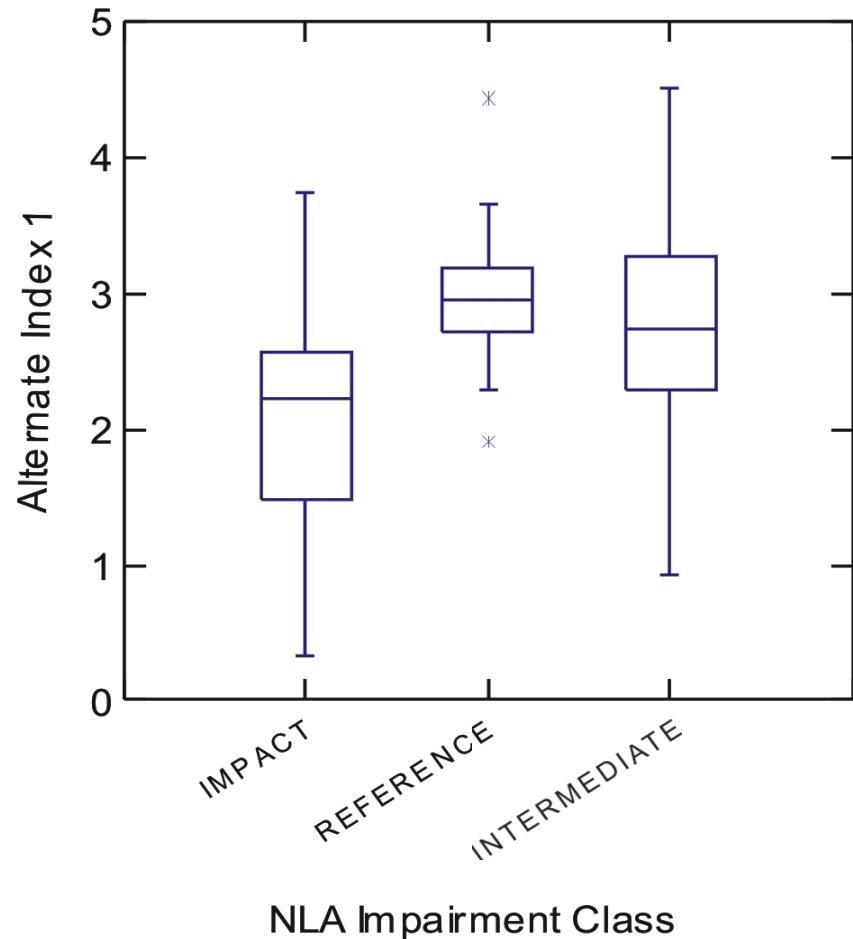
- Distributional relevance
- Discriminatory power
- Relationships to stressors
- Lack of redundancy



# Alternate Index 1

## Metrics:

- Avg. score per taxon (ASPT)
- % facultative individuals
- % predator taxa
- # Diptera taxa
- % tolerant taxa



# Alternate Index 2

## Metrics:

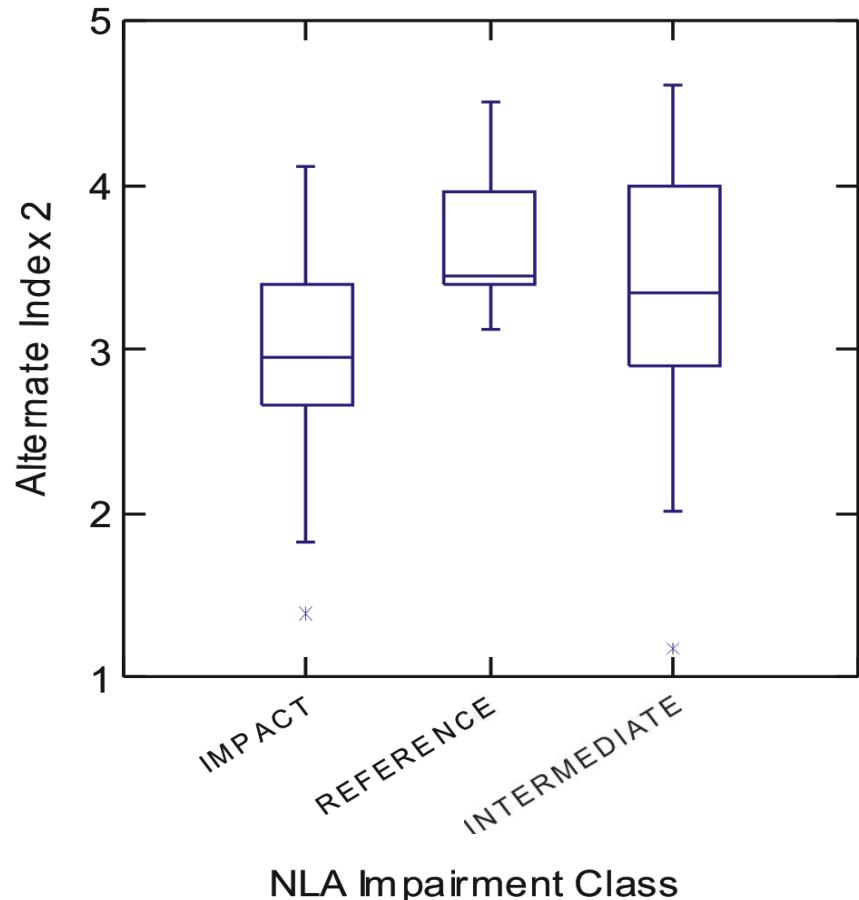
HBI

# chironomid taxa

# individuals per taxon

# predator taxa

Simpson diversity



# Spearman Correlations (p<0.01)

## LMII:

riparian substrate, lab pH, conductivity, ANC, SiO<sub>2</sub>, PCA Axis 1

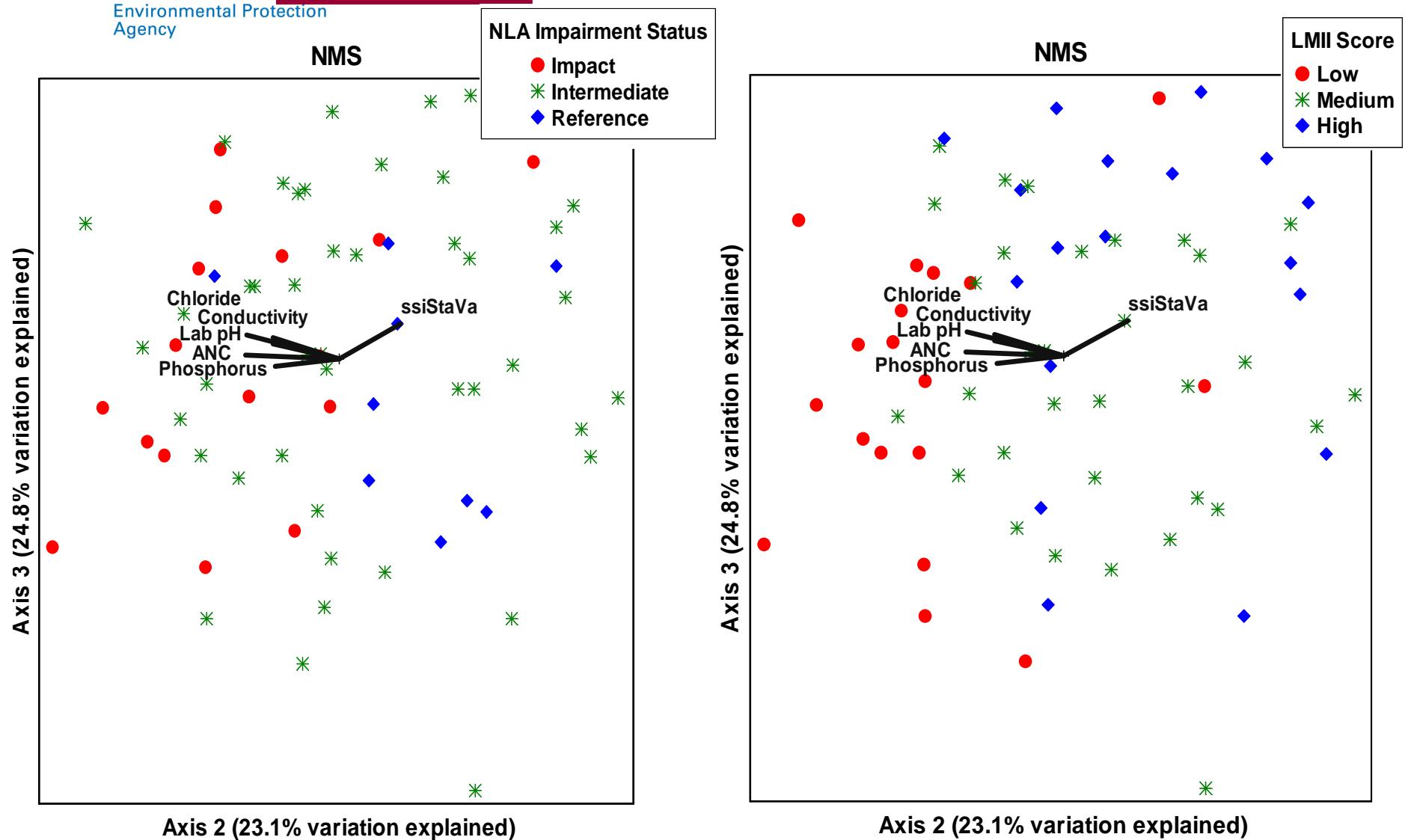
## Alternate Index 1:

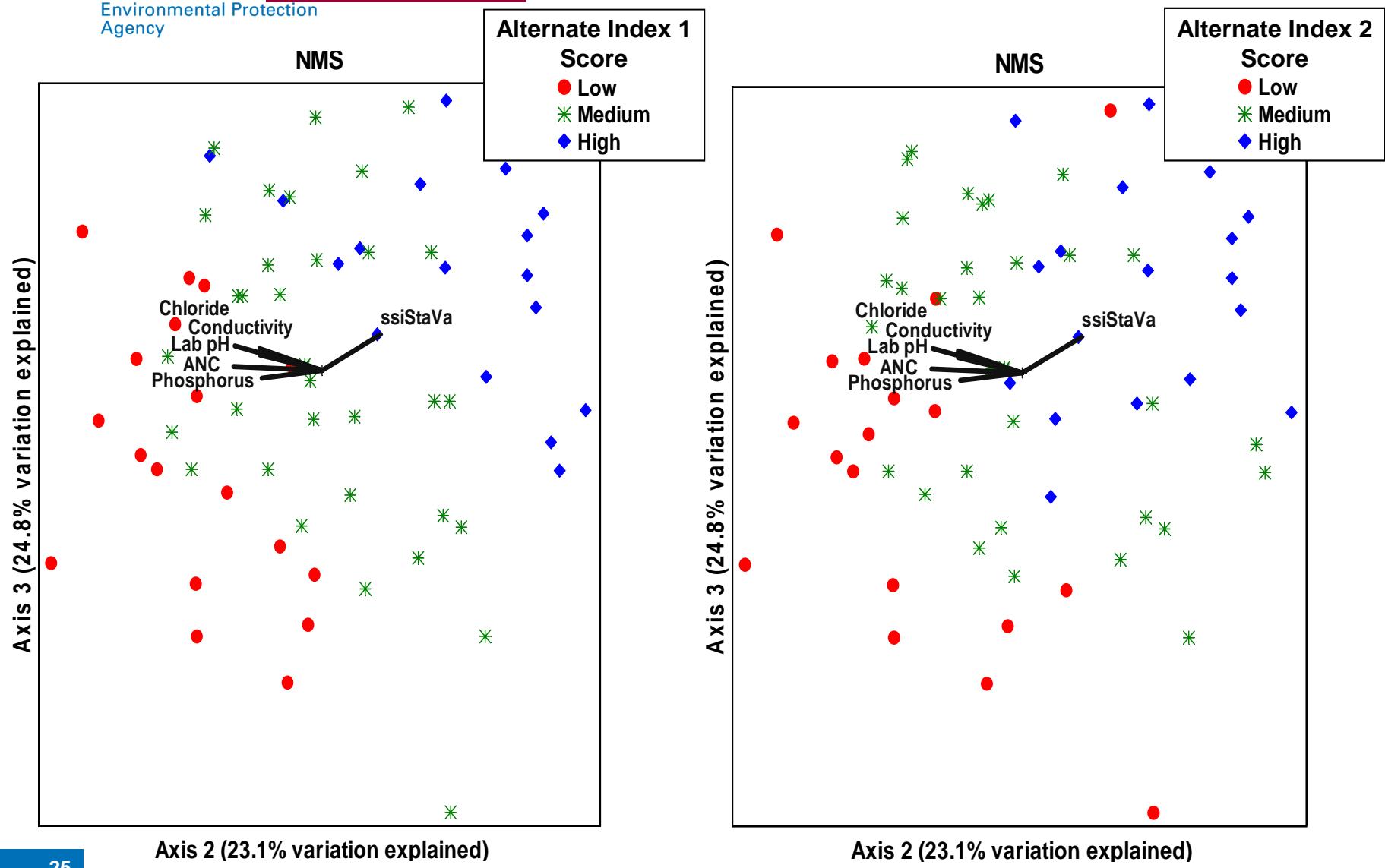
riparian substrate, littoral substrate, ANC, turbidity, TOC, DOC, PTL, SiO<sub>2</sub>, Chl-a, secchi, PCA Axis 1

## Alternate Index 2:

riparian substrate, littoral substrate, turbidity, TOC, DOC, PTL, SiO<sub>2</sub>, Chl-a, secchi, PCA Axis 1

ANC = Acid Neutralizing Capacity; SiO<sub>2</sub> = Silica; TOC = Total Organic Carbon; DOC = Dissolved Organic Carbon; PTL = Total Phosphorus

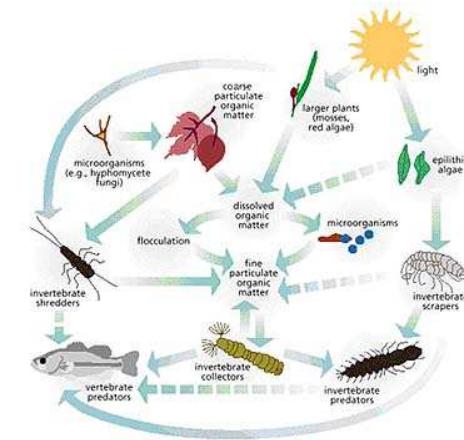




# Conclusions

- Alternate Indices superior to LMII across the study area; LMII performance in Region II > Region III
- Sub-littoral macros link to water chem and substrate
- Alternate Index 1 best differentiates biological reference status; heavy pollution focus
- Boxplots discriminate NLA impact and reference lakes; intermediate distributions unclear
- Variability could be attributed to broad typology of lakes included in the NLA

# Recommendations



- Use these indices and NLA reference criteria thresholds as a starting point in developing - or advancing - your lake bioassessment program
- Selection of which index to use currently depends on known gradients and study objectives
- Future sampling and research will advance our understanding of zonal community interactions and the natural environmental variables to which lake macroinvertebrates respond



## Feedback?

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Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

A scenic landscape featuring a calm lake in the foreground. A wooden dock extends from the bottom center into the water. In the background, there are rolling hills and mountains under a clear blue sky.

*Thank you!*