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

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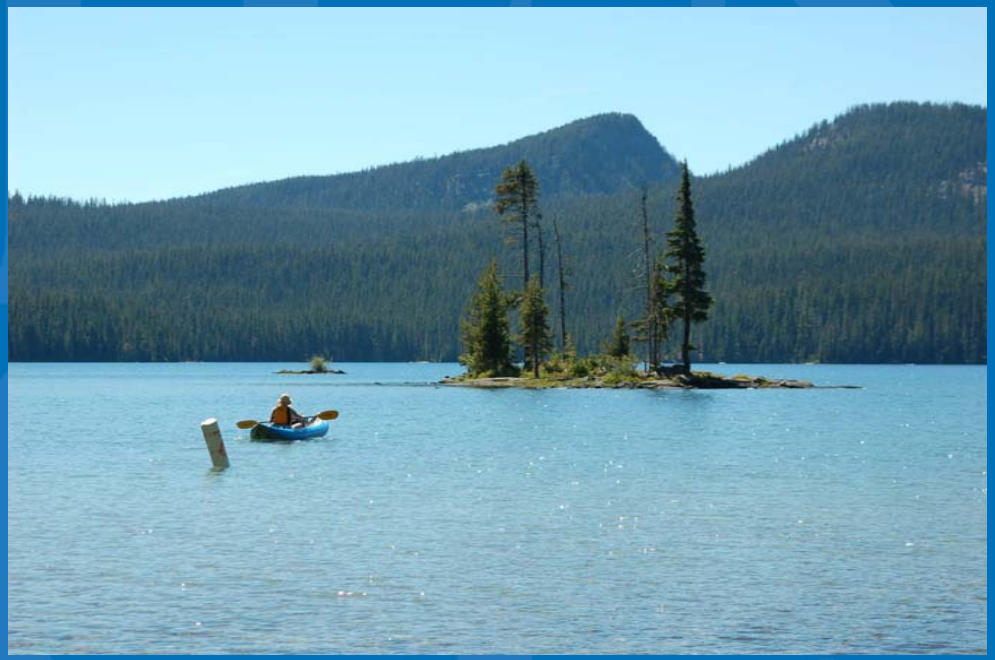

Office of Research and Development
National Environmental Exposure Research Laboratory

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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.

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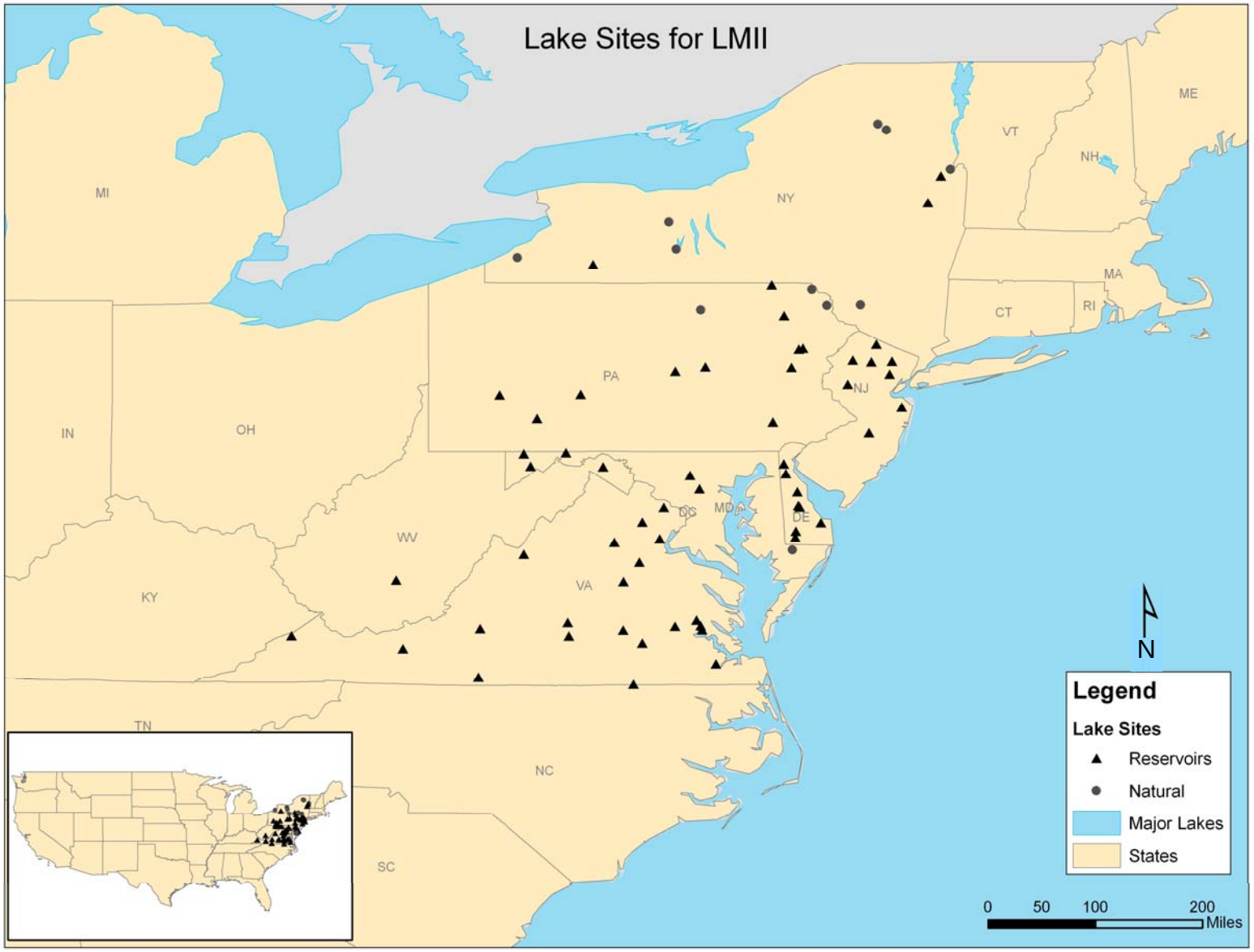

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Benthic Field Collection

- 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

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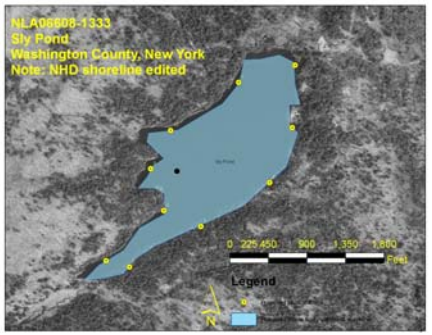
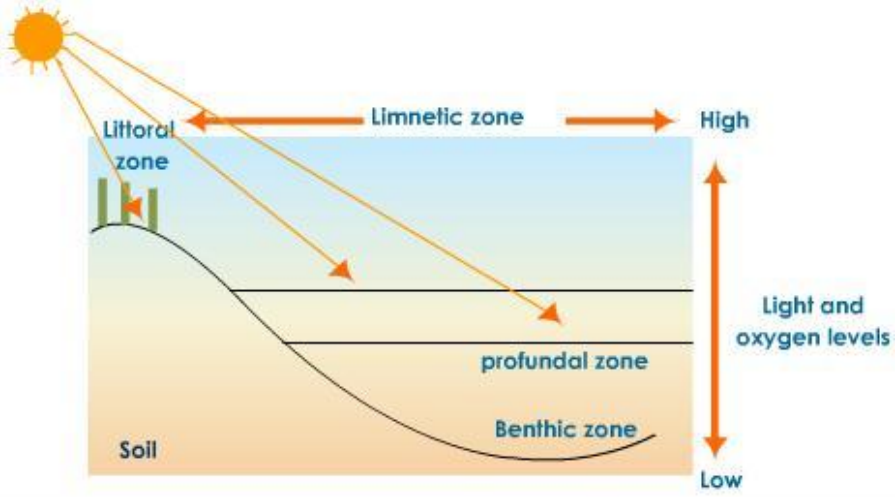


Lake Data Collected

- *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



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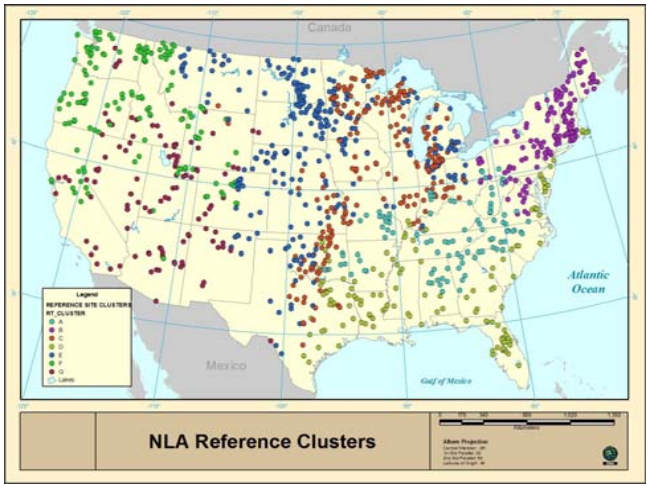
Step 1: Identify Reference & Impact Sites



- 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

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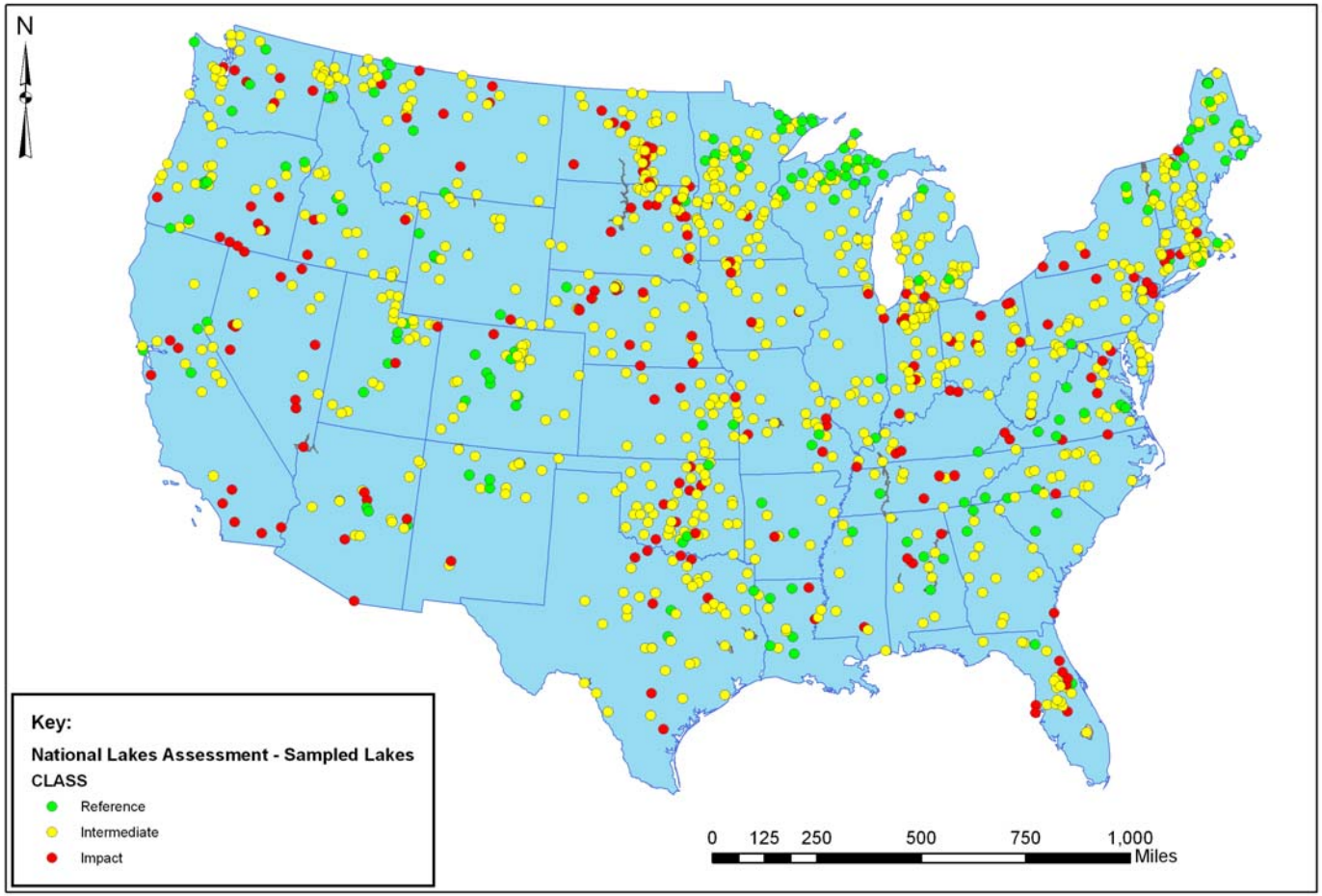


Step 2:
Evaluate LMII Performance

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:

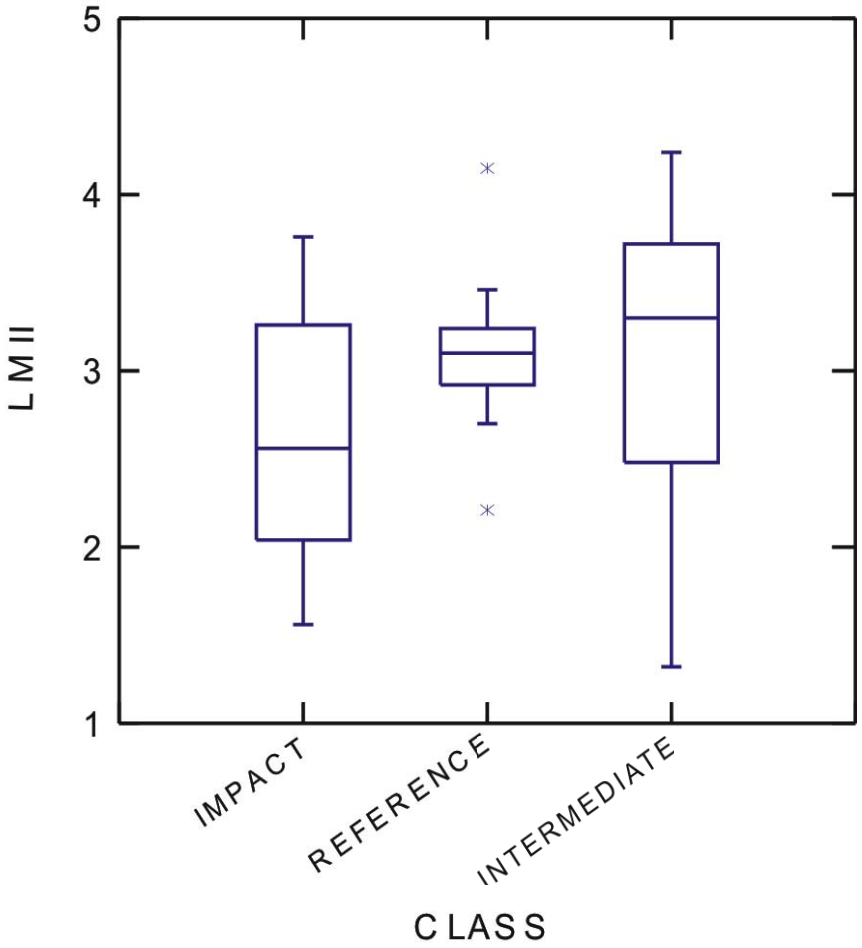
Diptera taxa

% 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

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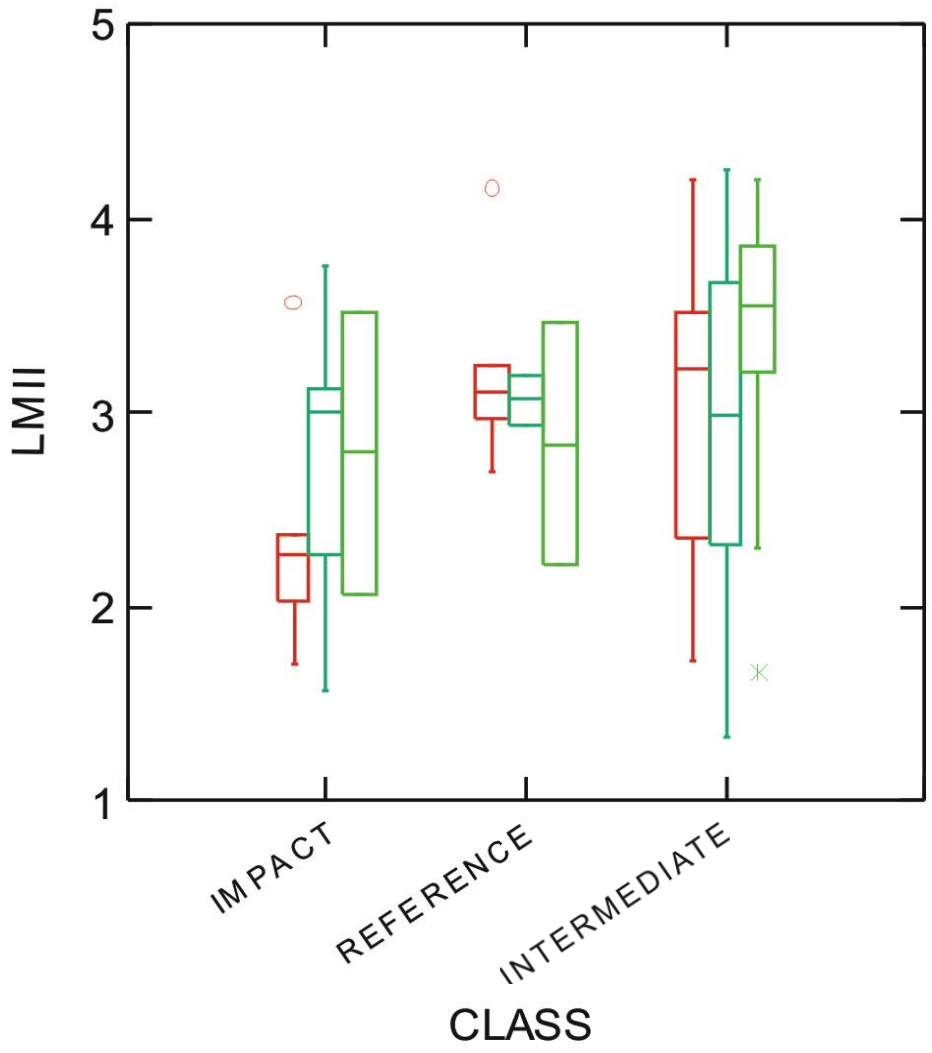
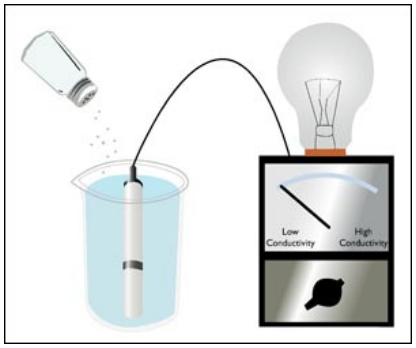
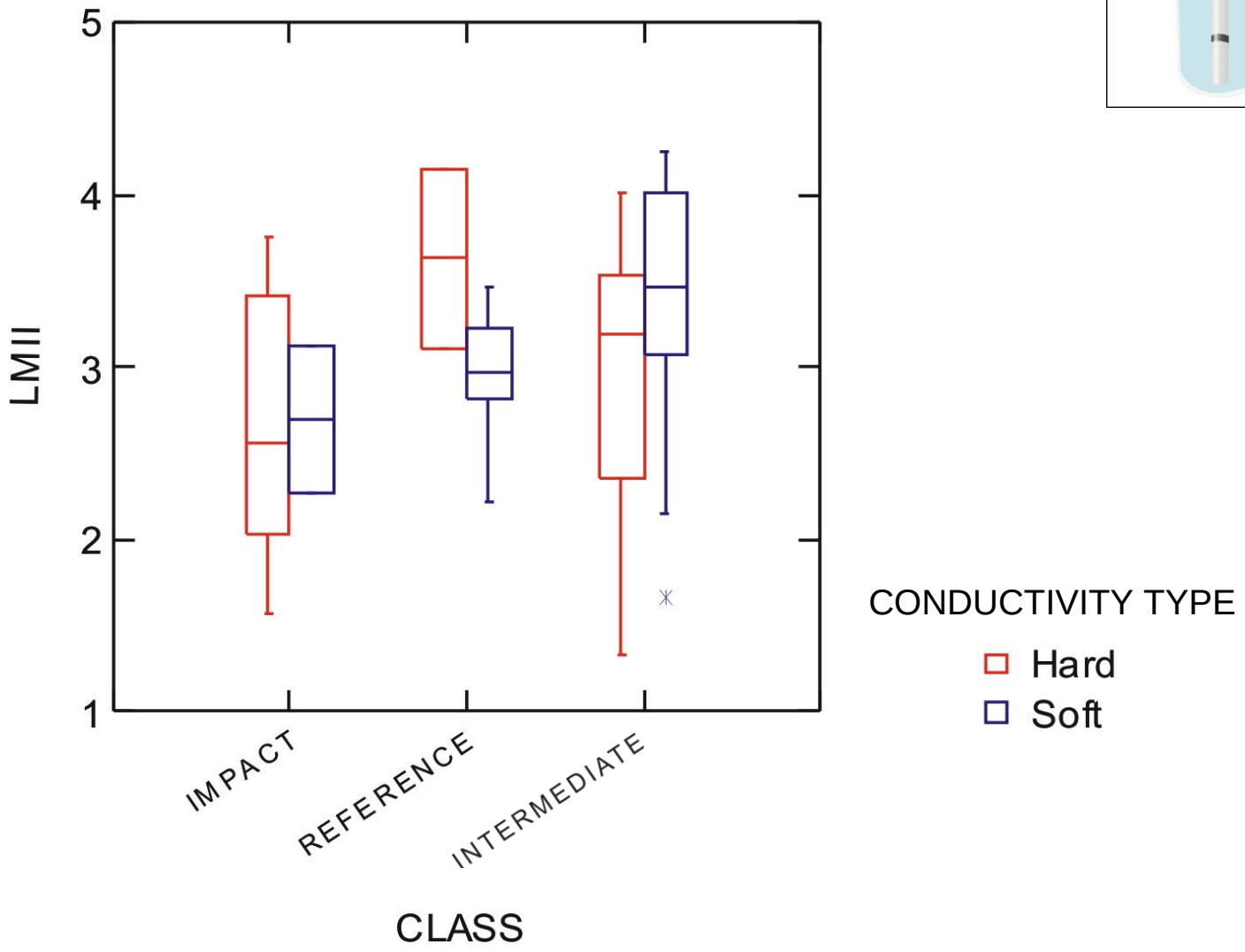


SEDIMENT CATEGORY

- Intermediate
- Muck
- Sand


Low Conductivity
High Conductivity


LMII
5
4
3
2
1
IMPACT
REFERENCE
INTERMEDIATE
CLASS
CONDUCTIVITY TYPE
Hard
Soft

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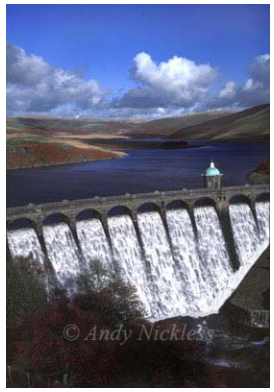
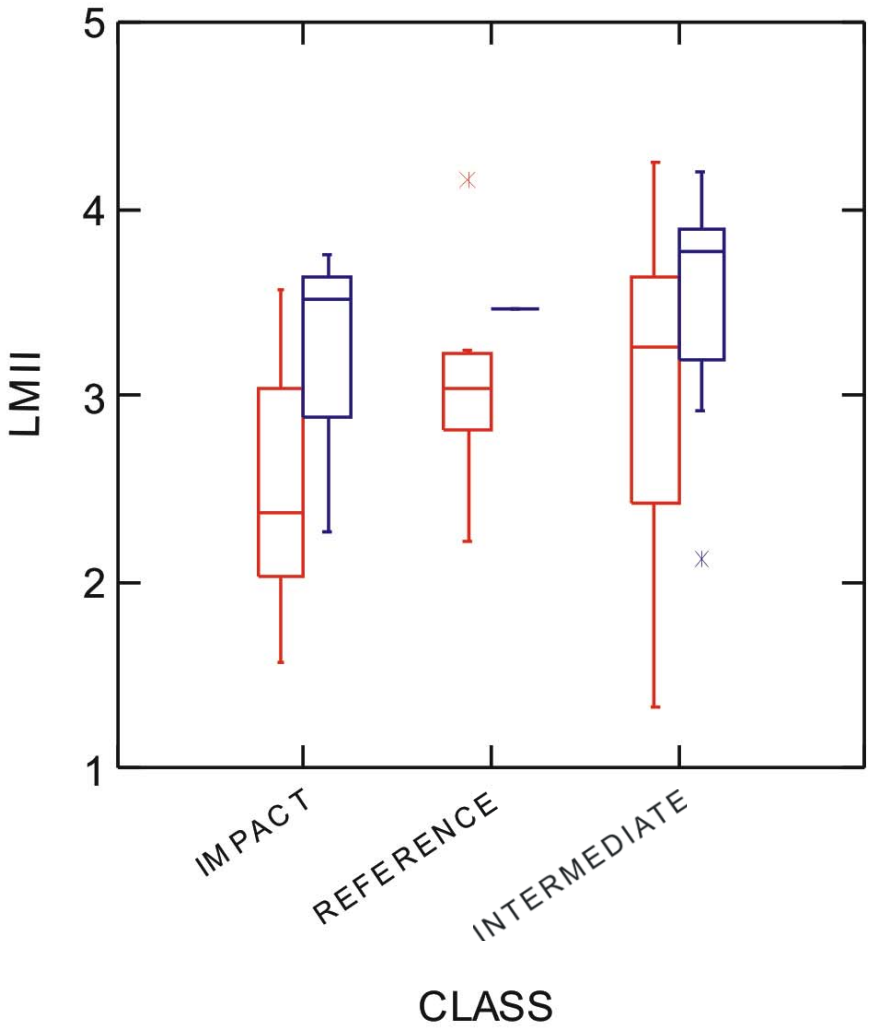
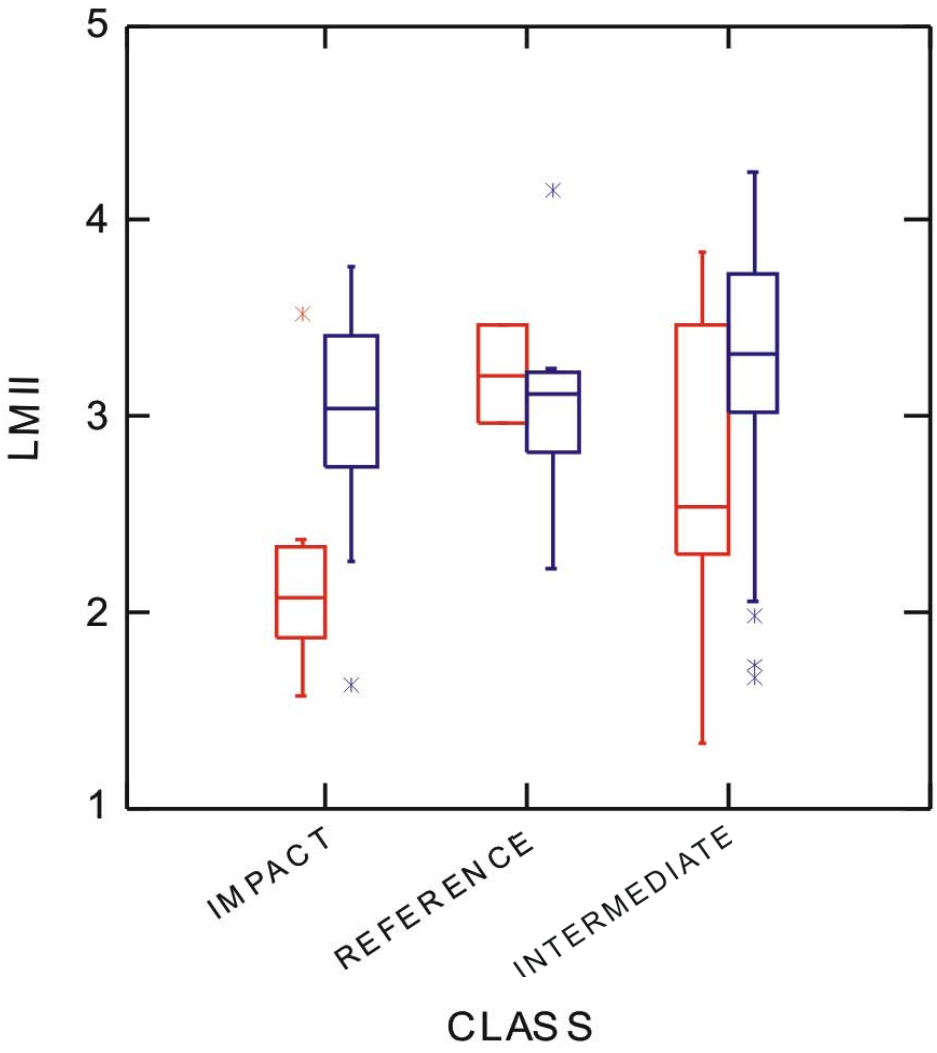
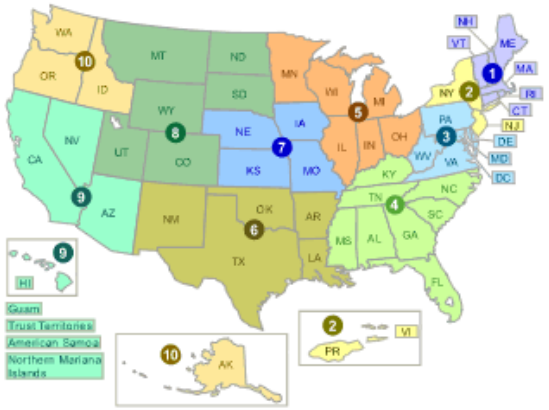




STATUS

- Man-made
- Natural





EPA REGION

Region 2

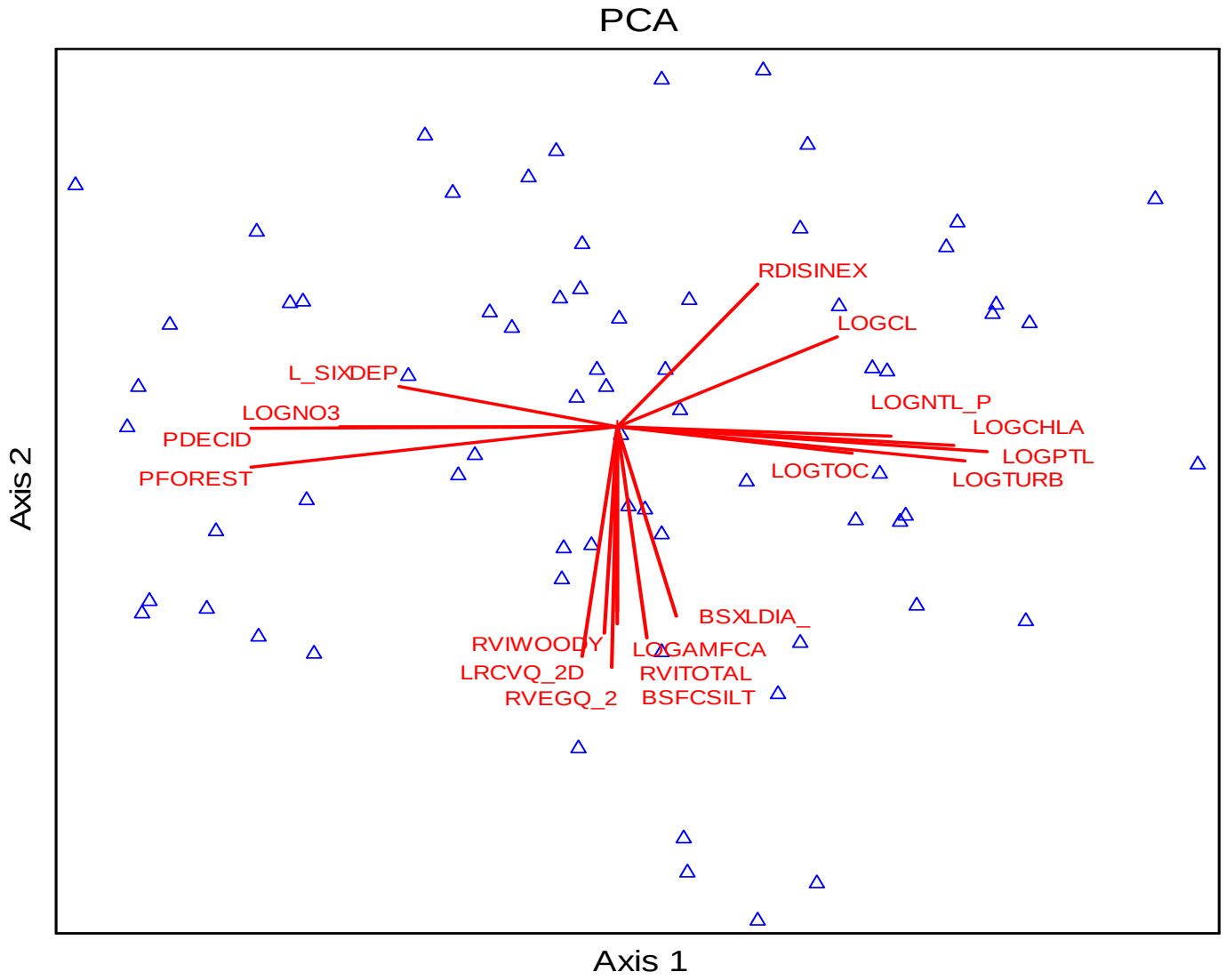
Region 3

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


PCA
RDISINEX
LOGCL
L_SIXDEP
LOGNTL_P
LOGNO3
LOGCHLA
PDECID
LOGPTL
PFOREST
LOGTOC
LOGTURB
BSXLDIA_
RVIWOODY
LOGAMFCA
LRCVQ_2D
RVITOTAL
RVEGQ_2
BSFCSILT
Axis 2
Axis 1

Step 5:
Alternate Index Development

Metrics selected by:

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

Alternate Index 1

Metrics:

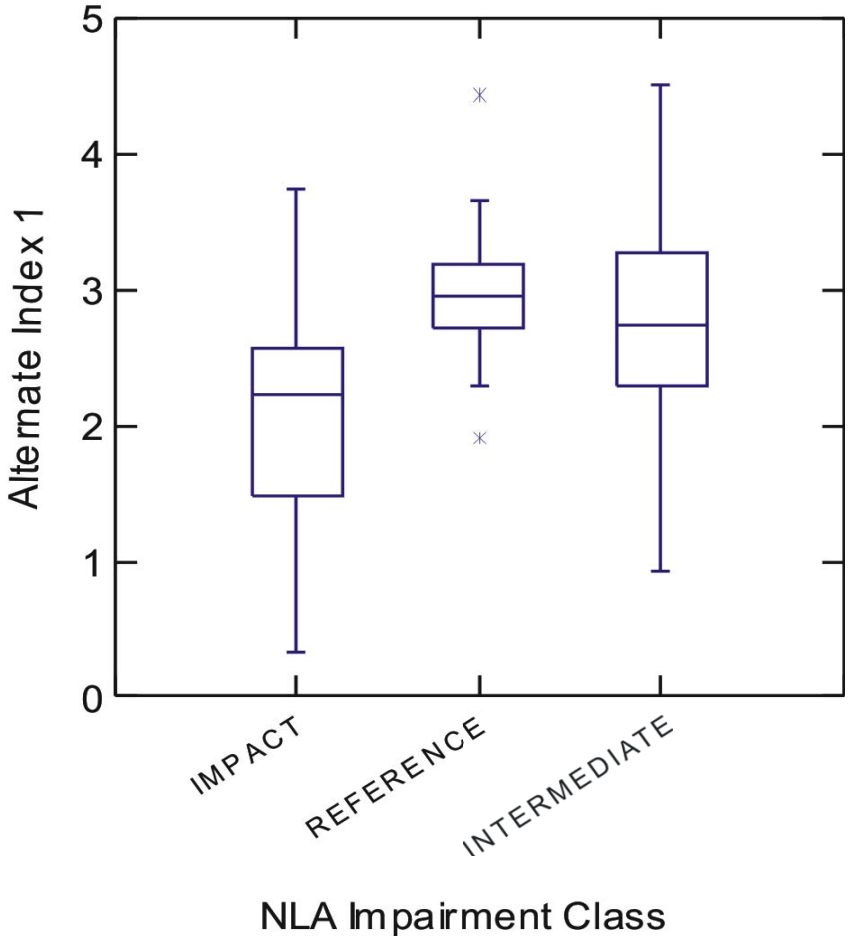
Avg. score per taxon (ASPT)

% facultative individuals

% predator taxa

Diptera taxa

% tolerant taxa



Alternate Index 2

Metrics:

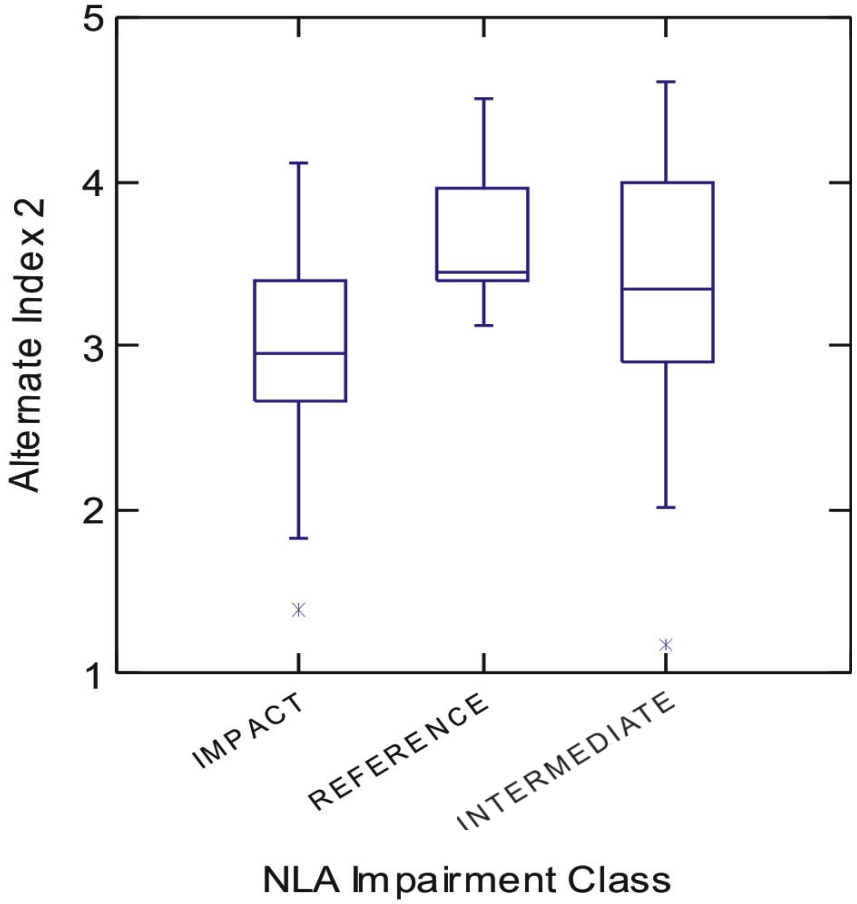
HBI

chironomid taxa

individuals per taxon

predator taxa

Simpson diversity



Spearman Correlations (p<0.01)

LMII:

riparian substrate, lab pH, conductivity, ANC, SiO2, PCA Axis 1

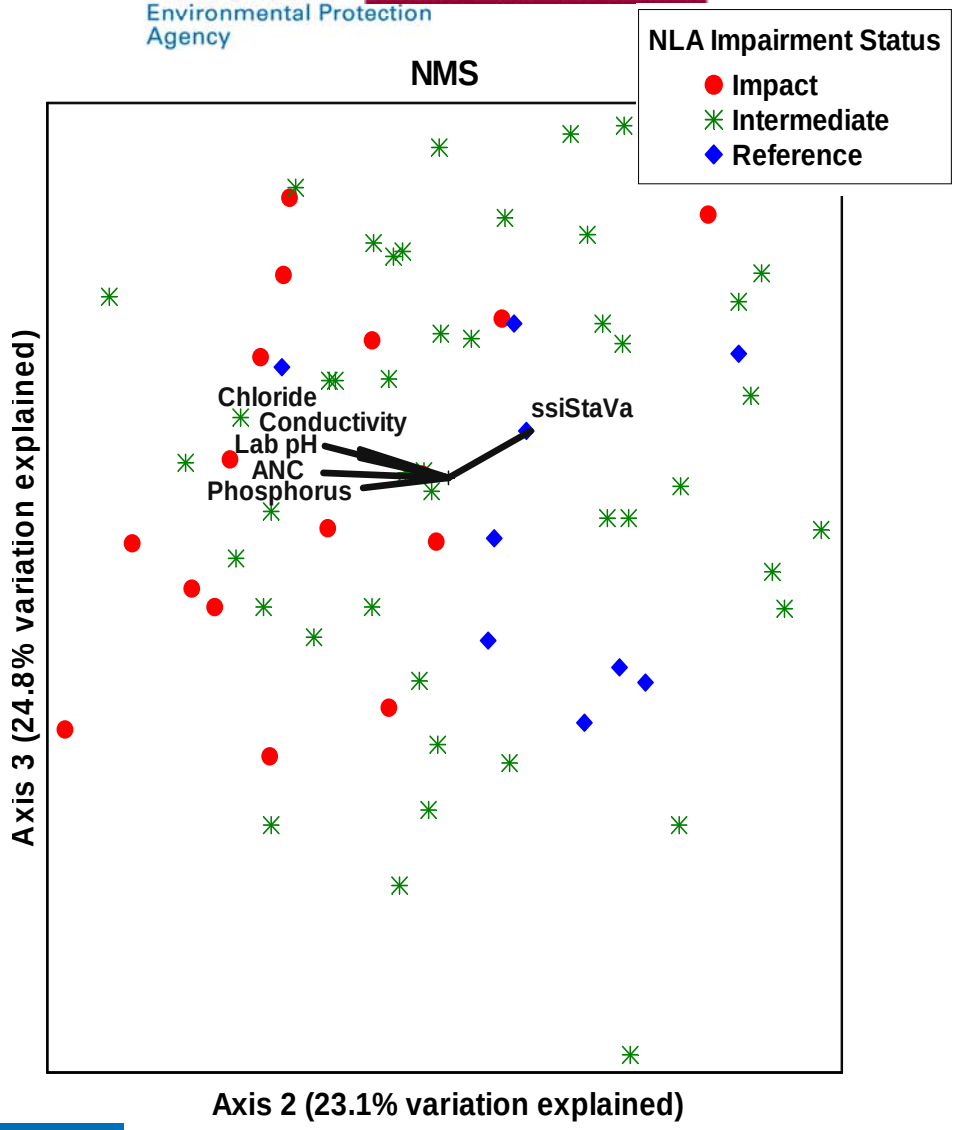
Alternate Index 1:

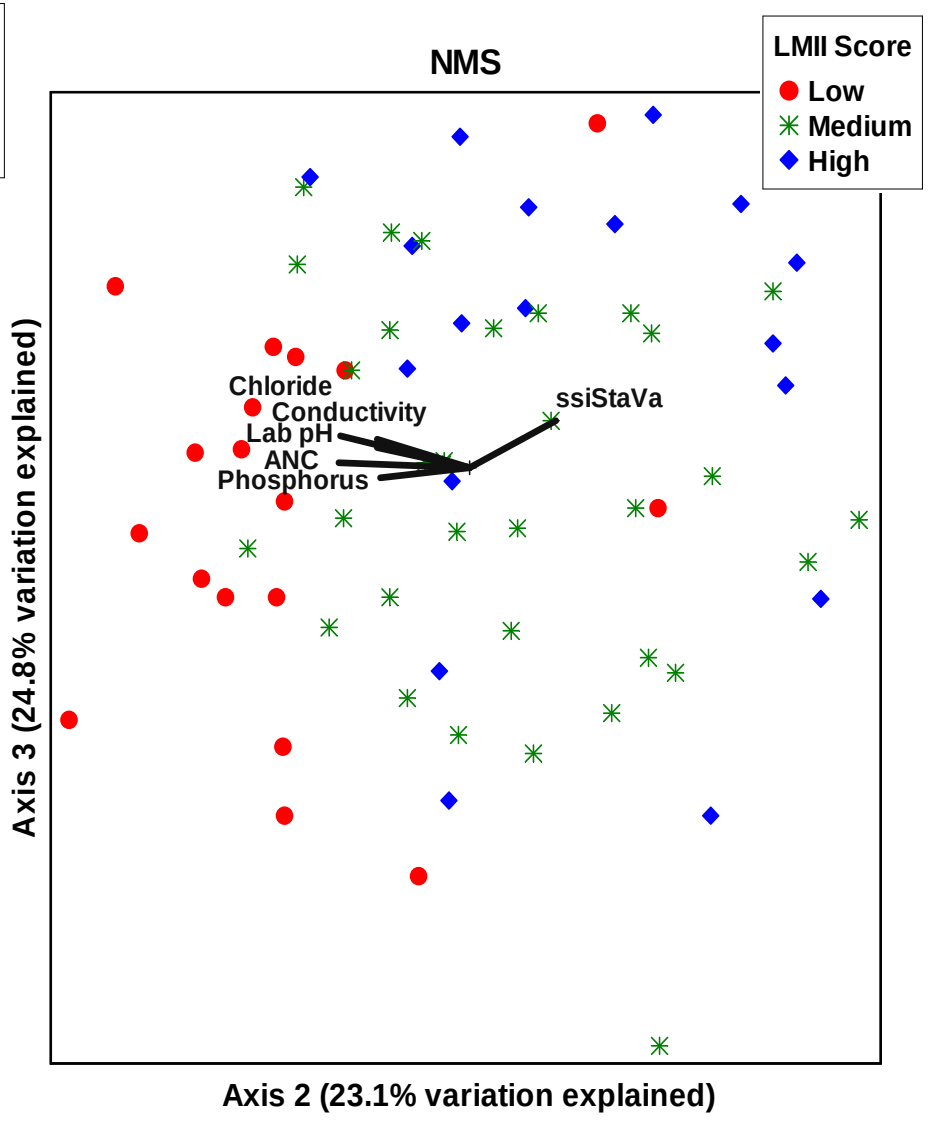
riparian substrate, littoral substrate, ANC, turbidity, TOC, DOC, PTL, SiO2, Chl-a, secchi, PCA Axis 1

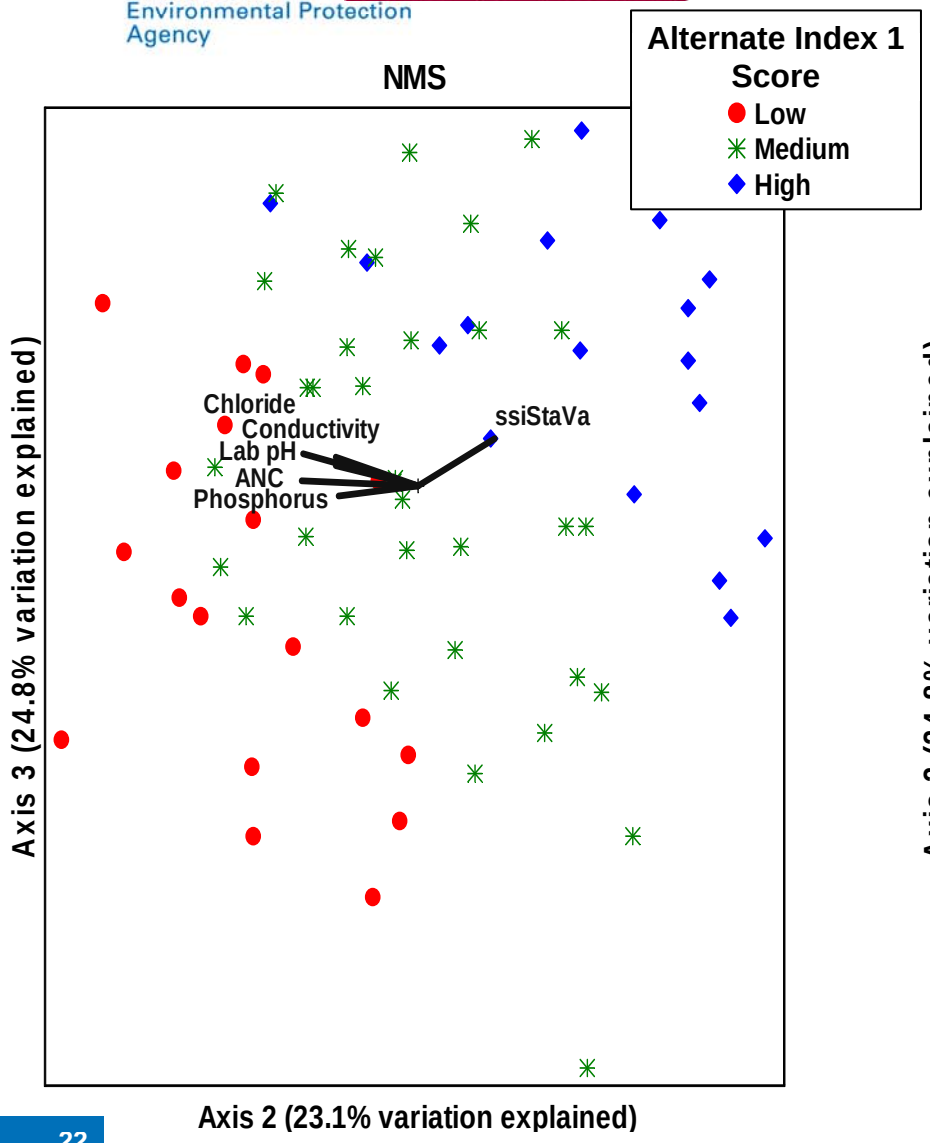
Alternate Index 2:

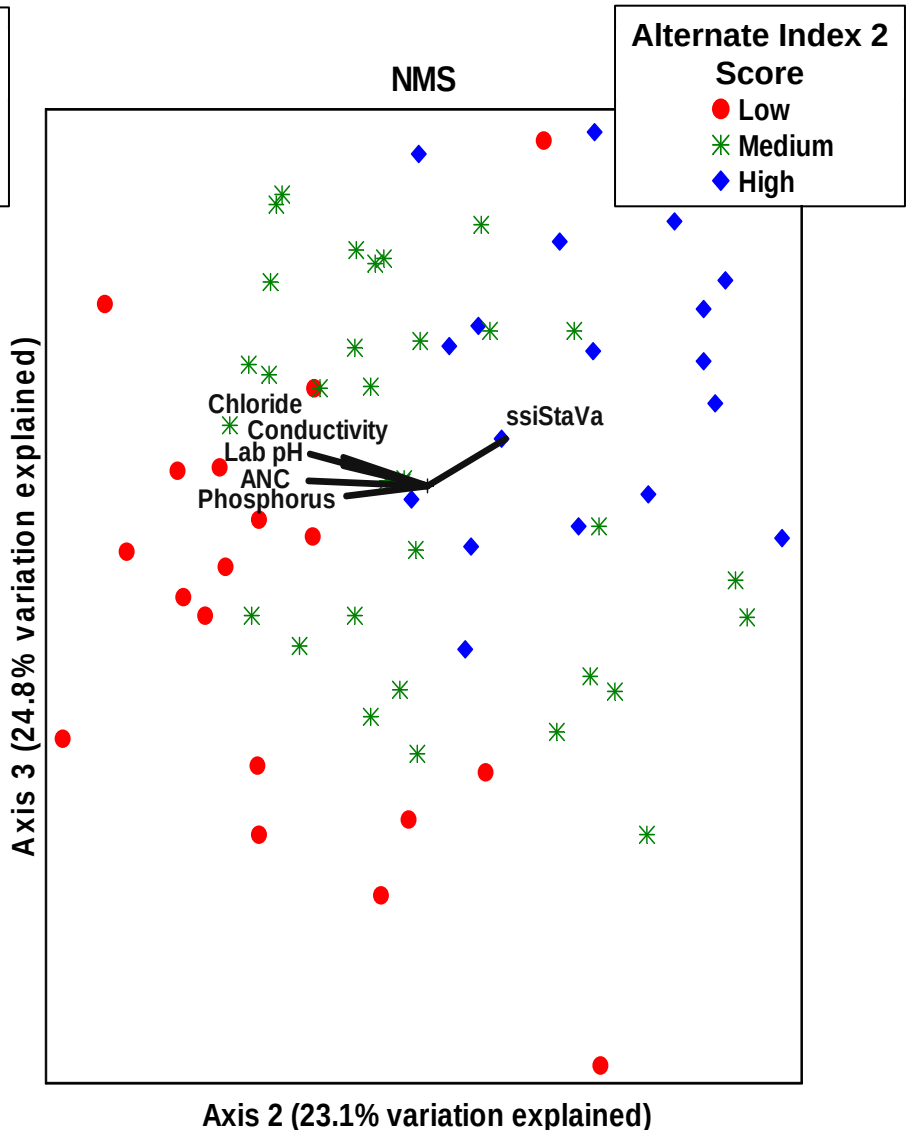
riparian substrate, littoral substrate, turbidity, TOC, DOC, PTL, SiO2, Chl-a, secchi, PCA Axis 1

ANC = Acid Neutralizing Capacity; SiO2 = Silica; TOC = Total Organic Carbon; DOC = Dissolved Organic Carbon; PTL = Total Phosphorus


NMS
NLA Impairment Status
Impact
Intermediate
Reference
Chloride
Conductivity
Lab pH
ANC
Phosphorus
ssiStaVa
Axis 3 (24.8% variation explained)
Axis 2 (23.1% variation explained)

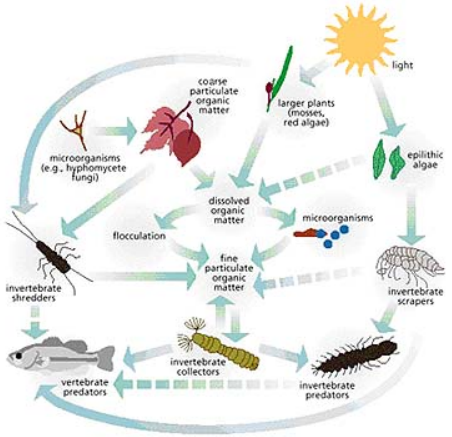

NMS
LMII Score
Low
Medium
High
Chloride
Conductivity
Lab pH
ANC
Phosphorus
ssiStaVa
Axis 3 (24.8% variation explained)
Axis 2 (23.1% variation explained)


NMS
Alternate Index 1 Score
Low
Medium
High
Chloride
Conductivity
Lab pH
ANC
Phosphorus
ssiStaVa
Axis 3 (24.8% variation explained)
Axis 2 (23.1% variation explained)


NMS
Alternate Index 2 Score
Low
Medium
High
Chloride
Conductivity
Lab pH
ANC
Phosphorus
ssiStaVa
Axis 3 (24.8% variation explained)
Axis 2 (23.1% variation explained)

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 as a starting point in developing 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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Thank you!