The Relative Significance of Environmental and Anthropogenic Factors Affecting Zooplankton Community Structure in Southeast Wisconsin Lakes

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In Memoriam
Zooplankton are a diverse group of organisms.
Lake managers define water quality using aquatic organisms.

Agricultural Wetland Ponds

From Dodson and Lillie 2001.
Land-use strongly correlated with zooplankton diversity.

Dane County Retention Ponds

$R^2 = 0.41$

From Dodson Et al 2009.
Riparian zone disturbance directly affects organisms.
Does watershed land-use best explain aquatic community structure?
What relationships exist between land-use and zooplankton community?
Site Selection

Lake Selection
• N = 29
• All dimictic lakes

Zooplankton Collection
• Every three months
• Zooplankton counted and placed into ordinal rankings (1-4)
Data Collection

Lake Morphology
- Watershed Size
- Surface area
- Max Depth
- Lake Order
- Watershed Size
- Watershed:Lake

Water Quality
- Total Phosphorus
- Total Nitrogen
- Chlorophyll-a
- Secchi depth
- Chloride
- Conductivity
- pH
- Sulfate

Watershed Land Use
- Urban
  - Residential
  - Commercial
  - Transportation
- Agricultural
  - Pasture
  - Cropland
- Natural
  - Forest
  - Wetland
- Barren/Open
- Recreation
- Industrial
Data Analysis

- Variables transformed
  - Land-use proportions arcsin sq-rt transformed
  - Variables with skewness >1 log-transformed
- Forward selection of explanatory variables
- Variance partitioning (with select variables.)
- Redundancy analysis (with select variables.)
- Pearson correlation with species richness
Results
Forward Selection

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Forward Selection (p < 0.01)

**Lake Morphology**
- Watershed Size

**Watershed Size**
- Surface area
- Max Depth

**Water Quality**
- Summer TP

**Land Use**
- Urban buffer
- Forest buffer
- Natural watershed
Species richness increases with watershed agriculture.
Community relationship with land-use not simple.

Explained Variation in Zooplankton Community
- Water Quality = 18%
- Land-use = 19%
- Lake morphology = 15%

$R^2 = 0.49$
Environmental Relationships

[Graph showing relationships between various environmental factors and taxa]
Cladoceran Community Relates to Multiple Factors

**Taxa Key**
- Cladoceran
- Calanoid
- Cyclopoid
Calanoid Copepods Relate to Trophic Status

RDA1 (31%)

RDA2 (9%)

Taxa Key
Cladoceran
Calanoid
Cyclopoid
Species specific interactions explain much of the community variability.
Size selective predation determines species composition.
*Daphnia* species composition is likely related to planktivory and urban land-use.
Small cladocera are linked with productivity and lack of *D. pulicaria*.
Conclusions

• Important to understand covariance between predictor variables.

• Larger relationship with water quality and land-use than in other regions (Dodson et al 2009, Gelinas et al 2008).

• Specialist zooplankton species may serve to assess lake ecosystems.
  – Changes in Daphnia species most likely indicate a change in planktivory.
  – Changes in dominant calanoid copepod or small cladoceran community indicate an increase in nutrient concentrations.
Implications for Lake Assessment and Management
Cladoceran community is correlated with trophic state.
Relationships with Water Quality
Lake nitrogen levels have decreased in the region.

Total Precipitation

1974 = 32”
2007 = 37”

Southeast Wisconsin Lakes

Total Nitrogen (ug/L)
Lake chloride concentrations have risen dramatically.
Land-use affects water quality

• An environmental gradient representing summer total phosphorus and chlorophyll-a was positively correlated with watershed agriculture and urban land-use in the buffer zone, while negatively related to watershed natural land.

• Chloride concentration is positively correlated with transportation and negatively correlated with forest.
Land-use has cascading effects on aquatic community structure
Acknowledgements

Dr. Stanley Dodson
Southeast Wisconsin Regional Planning Commission

Ashley Derr    Sarah Foltz
Eric Moody     Katie Lee
Heather Kreft  Sara Jelen
James Thoyre   Bill Feeny
Math Heinzel   Jeff Maxted
Questions?