Protozoa: Augmenting the Headwater Bioassessment Toolbox

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Project Goal, Hypothesis and Focus

The **Project Goal** is to provide quantitative evidence that supports the use of protozoan assemblages as a bioindicator of stream water quality across selected spatial and temporal scales.

The **Central Hypothesis** is protozoan diversity, taxonomic similarity, and trophic complexity will create a "biological response signature" as a function of representative abiotic environmental conditions (water chemistry, physical, and landscape/landuse parameters) present in the test locality.

Today's **Focus** is metric building and selection for a protozoan bioassessment tool in targeted headwater streams.
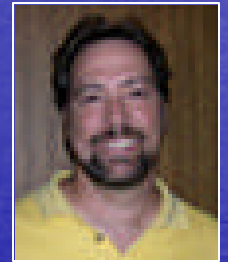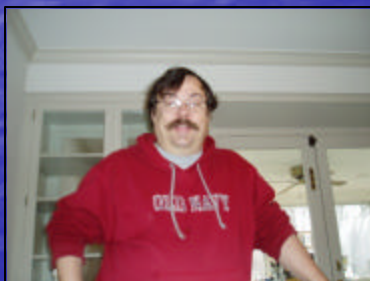
Acknowledgements

Dr. Lance Williams

THE OHIO STATE UNIVERSITY
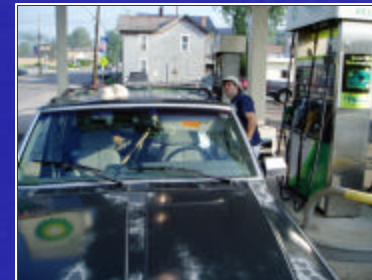
The OARDC Graduate Research Enhancement Grant

Alumni Grant for Graduate Research
OSU Graduate Department

Special "Thanks"
to
Ed Rankins

Lon Hersha

Jeremy Pritt

Rich Ciotola

Ed Moore

Hector Santiago

Kelli Hull

Headwater Stream Attributes
(if naturally intact and functioning properly)

- Headwater streams comprise **80%** of the nation's stream network
- Source of initial nutrients downstream
- Natural flood control
- Recharge groundwater
- Trap sediments and pollutants from fertilizers
- Recycle nutrients
- Create/maintain diversity
- Sustain biological productivity downstream

Tight interface between land and water

BOTTOMLINE…Foundation for the entire water system

Protist Importance in Stream Ecology

Condition leaves for macroinvertebrate consumption (Allan 2003)

In closed canopy headwater streams, microbial colonization of litter leaf is essential in conditioning the leaf for consumption by macroinvertebrates
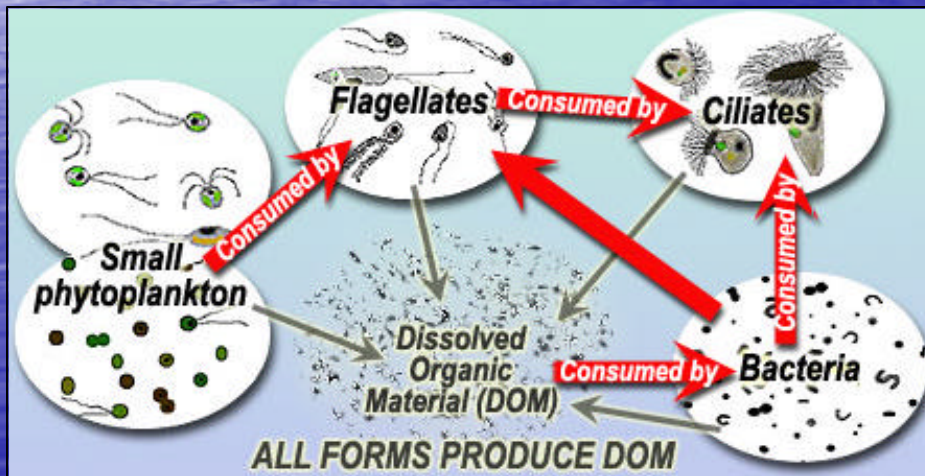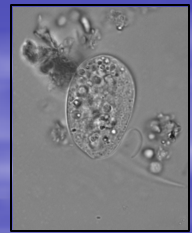

Nutrient Recycling and mineralization
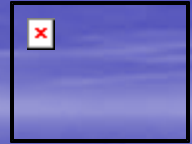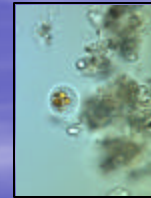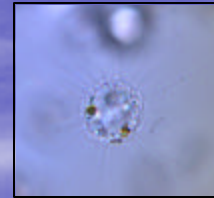
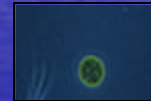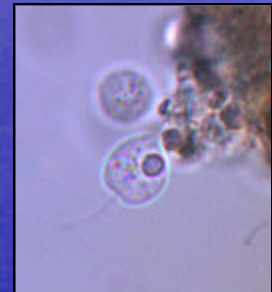**Possible energetic link to the upper food web**
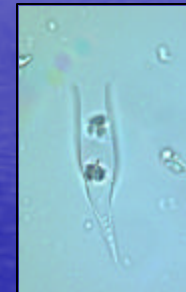
"Link or Sink?"
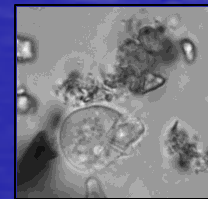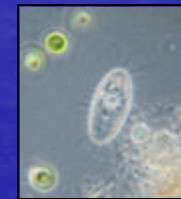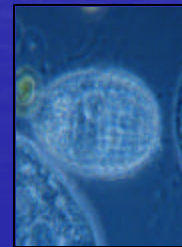
Community Bioassessment Tool
(Cairns et al. 1992, Angermeier and Karr 1994)

- Communities with short generation times respond more rapidly to acute stress making them good indicators for more persistent contaminants.

- Communities fill several roles in the ecosystem (e.g., herbivores, predators, scavengers) making them better integrators of various forms of stress as opposed to species that are perform a similar role (e.g., phytoplankton that are more diagnostic of a particular kind of pollutant such as phosphorus).

- Community approach illuminates the disconnect of functional processes that maintain the integrity of an ecosystem

- Benthic communities are good indicators of local conditions while planktonic communities may integrate conditions over a greater spatial scale.

- More representative of ecosystem functionality as a whole

Amoeba

Flagellates

Ciliates

Diatoms /Algae
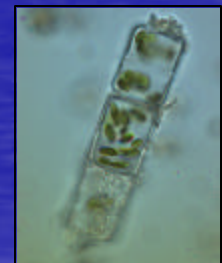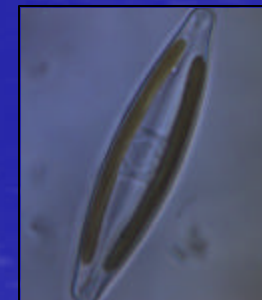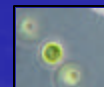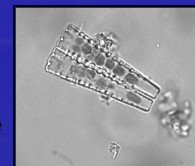
Ubiquitous and Cosmopolitan

Sugar Creek Project
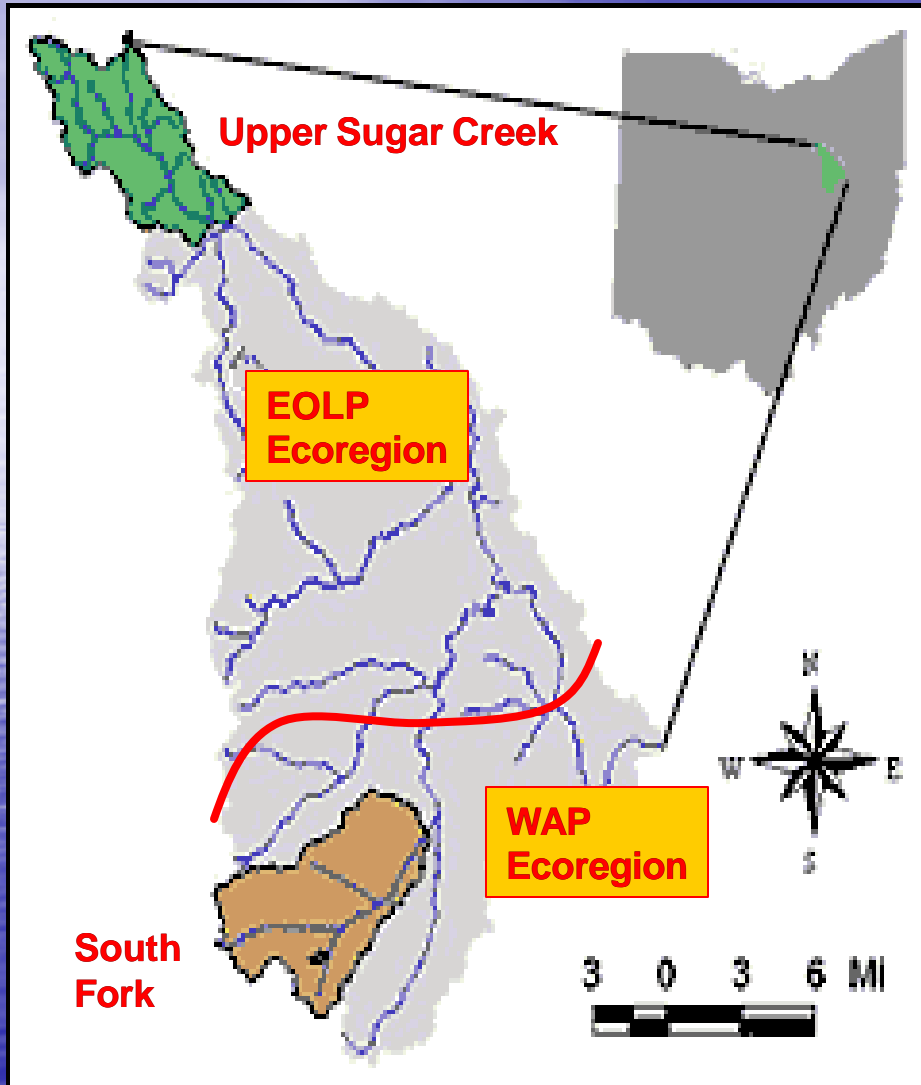
Upper Sugar Creek

- German heritage
- Conventional and conservation farming practices
- Glaciated, end moraine
- Rolling plain, slightly hilly
- Boulder, cobble, gravel, sand, silt substrate

South Fork

- Old Order Amish heritage
- Conventional farming practices
- Unglaciated
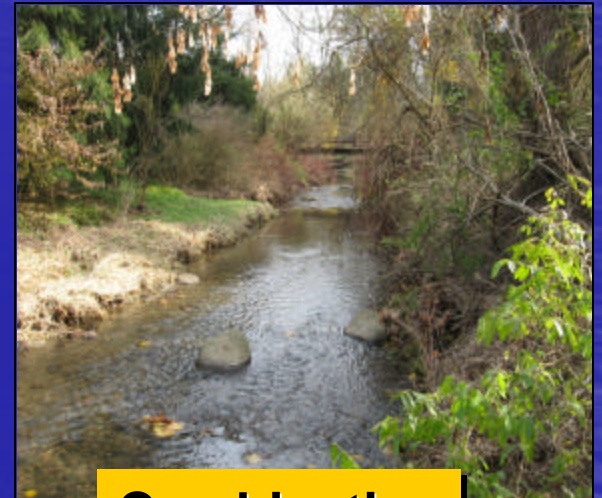- Rolling plain, slightly hilly
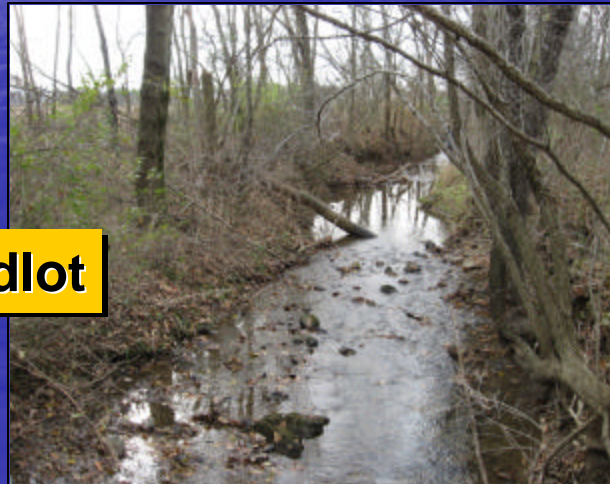- Sand and silt substrate

Upper Sugar Creek Sample Reaches
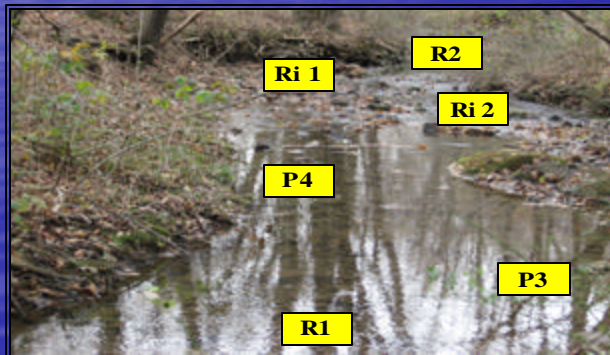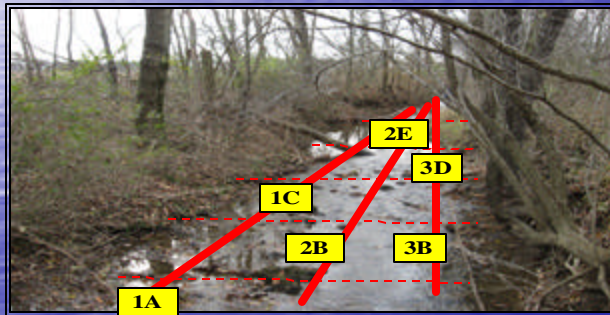
Urban

Row Crop

Woodlot

Combination

Sample Design and Gear

Collection Goals

- Cost-effective representation of the protozoan assemblage (Patterson, personal communication)

- "Biological response signature" (Yoder and DeShon 2003) that reflects land use parameters

Criteria for Multimetric Index Selection

- Significantly (= 0.05) correlate with at least 3 of the standard indices (QHEI, HHEI, IBI, B_IBI)

- Significantly (= 0.05) correlate with at least 4 of disturbance measures (e.g., turbidity, dissolved oxygen, mixed forest, %landuse evergreen)

- Significance holds in seasonal samples

- Not redundant

Pearson's R Correlation Results
Candidate Metrics

Biotic (N=15)

Indices
- IBI
- B_IBI

Tolerance/Intolerance

Community
- Species Richness** †
- Total Abundance** †
- Shannon's Diversity Index* ‡

Autecological Guild
- Autotrophic Flagellate Species Number* †
- Heterotrophic Flagellate Species Number** ‡
- Total Autotrophic Species Number* †
- Total Heterotrophic Species Number** ‡
- Autotrophic Flagellate Abundance* ‡
- Total Autotrophic Abundance* ‡

Morphological Guild
- Amoeba Species Number* ‡
- Flagellate Abundance** †
- % Flagellate Abundance* ‡
- Flagellate Species Number** †

Reduced from an initial 37 possible candidates

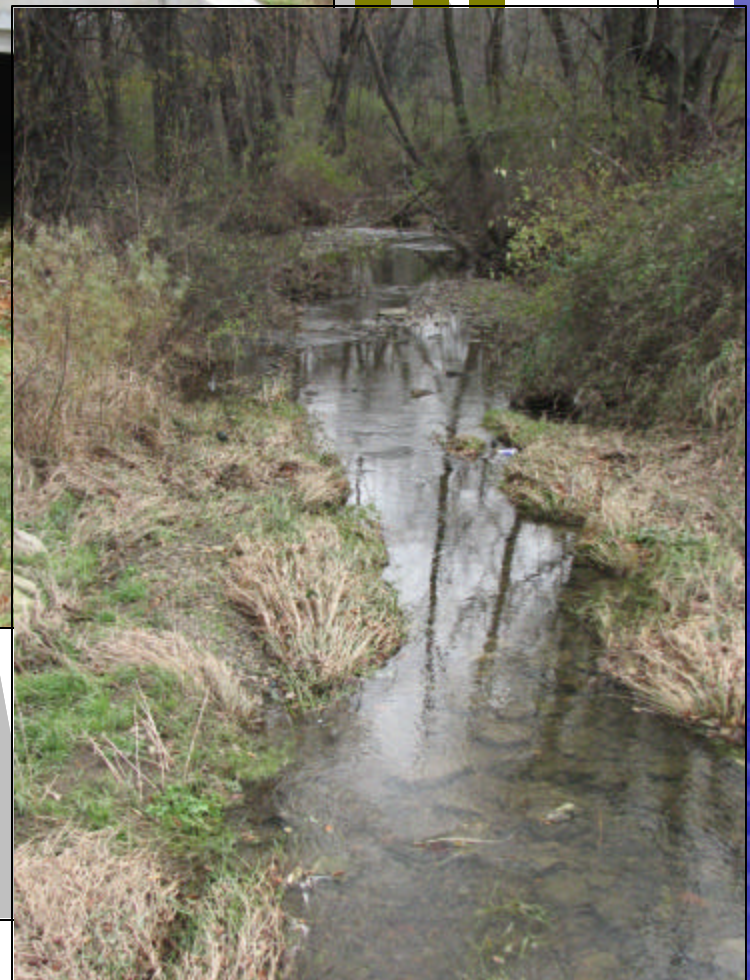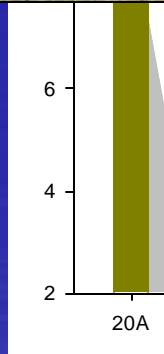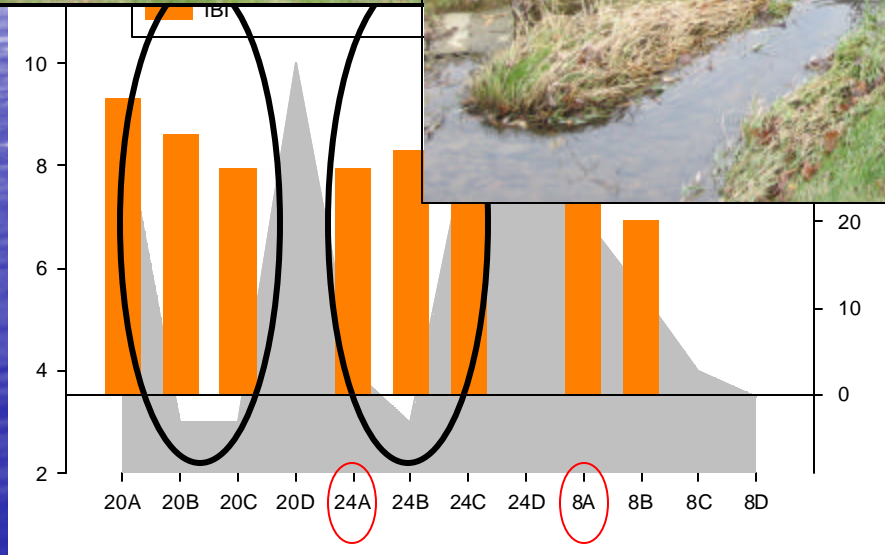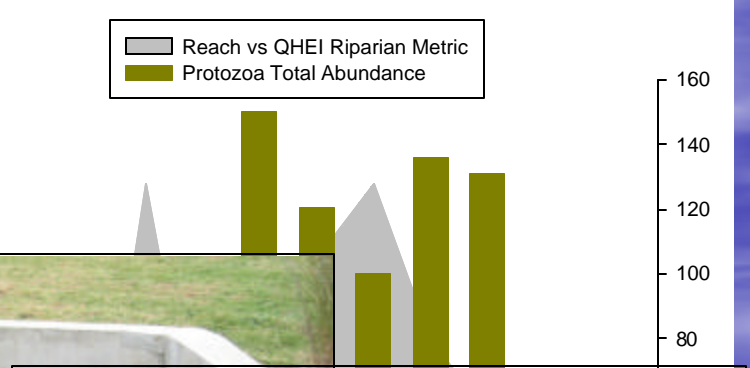### Abiotic (N=18)

Habitat Indices
- QHEI
- HHEI

Habitat Measures
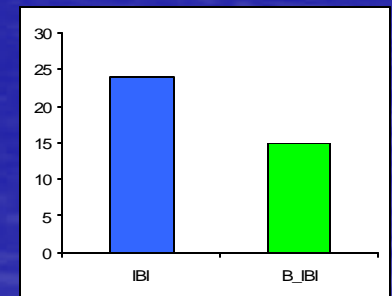- HHEI substrate *
- QHEI substrate *
- QHEI instream cover *

Physical Measures
- Dissolved Oxygen *
- Turbidity **

Landscape Measures
- Deciduous Forest *
- Evergreen Forest *
- Mixed Forest **
- Pasture/Hay *
- Row Crop *
- Cumulative Deciduous Forest *
- Cumulative Evergreen Forest *
- Cumulative Mixed Forest *
- Cumulative Pasture/Hay *
- % Landuse Evergreen Forest **
- % Light Intensity Residential

Reduced from an initial 36 possible candidates

** Correlates with all 4 Indices
* Correlates with 3 out of 4 Indices
‡ p = 0.05
† p = 0.01

IBI

10
8
6
4
2

20
10
0

20A 20B 20C 20D 24A 24B 24C 24D 8A 8B 8C 8D

6
4
2

20A

U8 Lutheran Church

U24C Oil Rig

HHEI   QHEI

IBI   B_IBI

Species Richness
Total Abundance

Luthern   Oil Rig

HHEI   QHEI

IBI   B_IBI
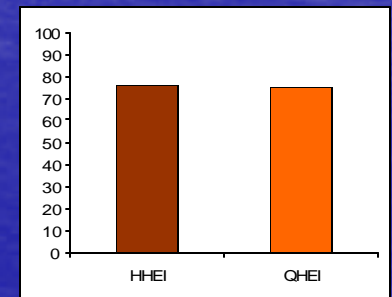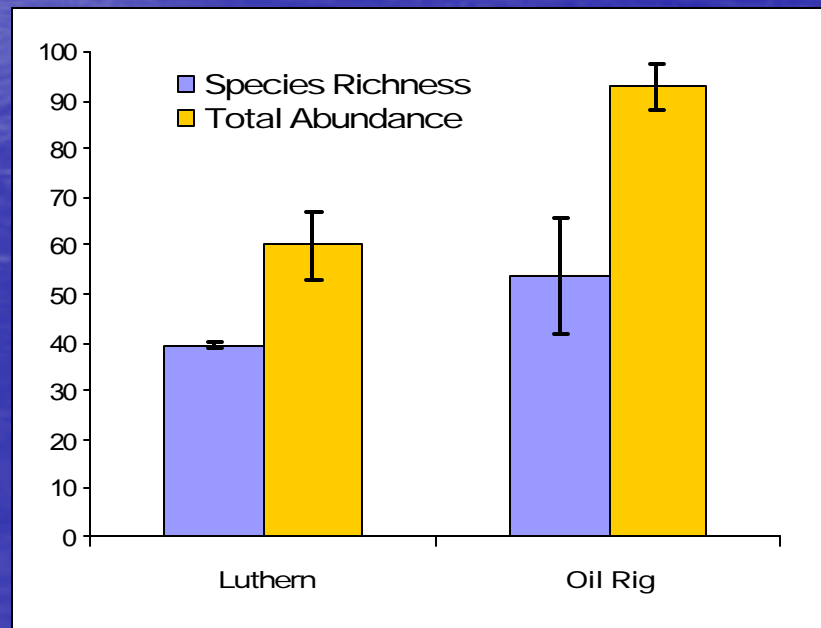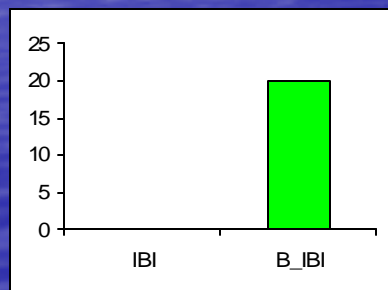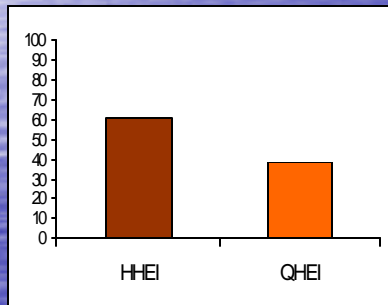
Metric Correlations

- **Only one habitat measure and one physical measure correlated with candidate metrics**

- **All candidate metrics correlated with HHEI substrate metric**
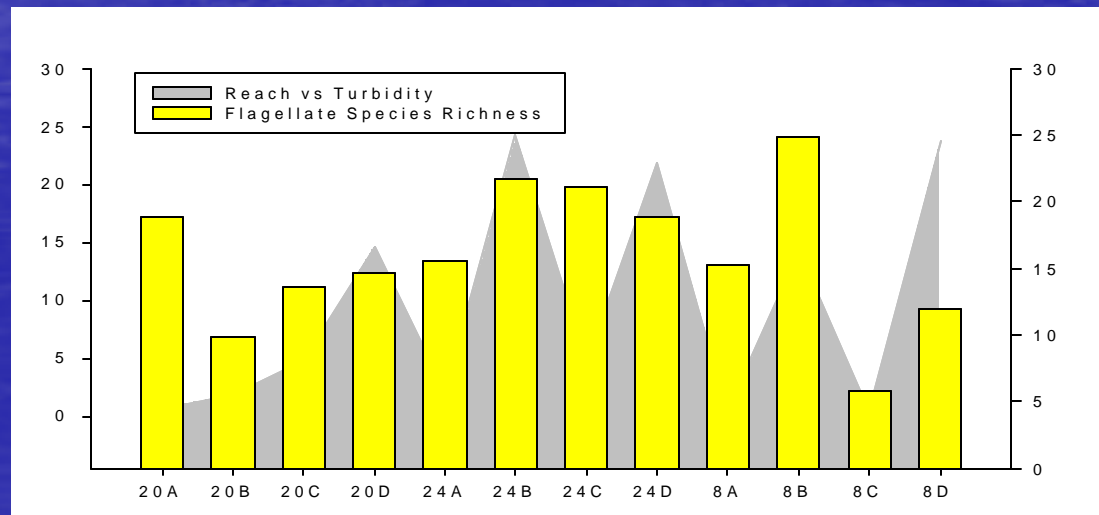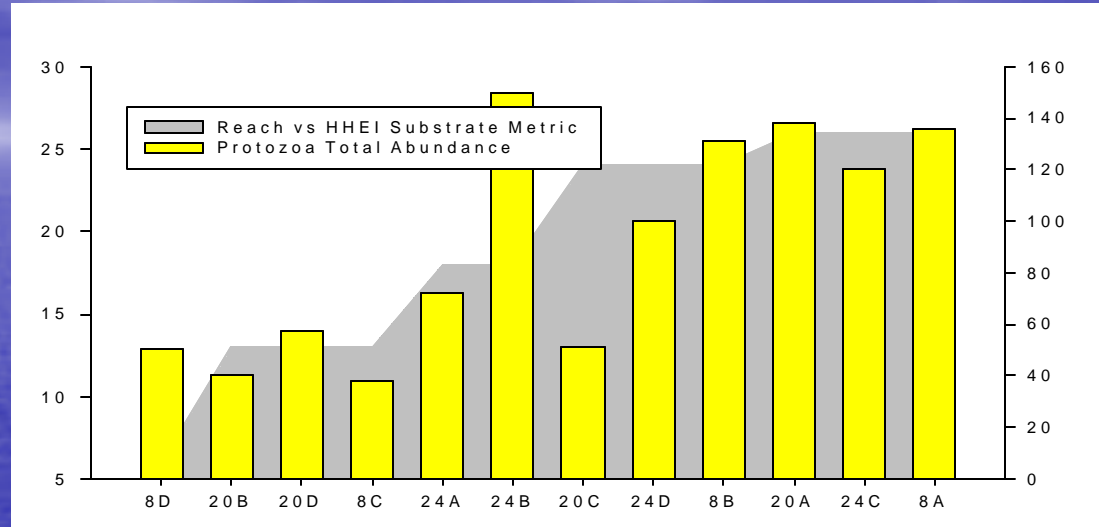
More Metric Correlations

- **Eight Landscape measures** correlated with various candidate measures
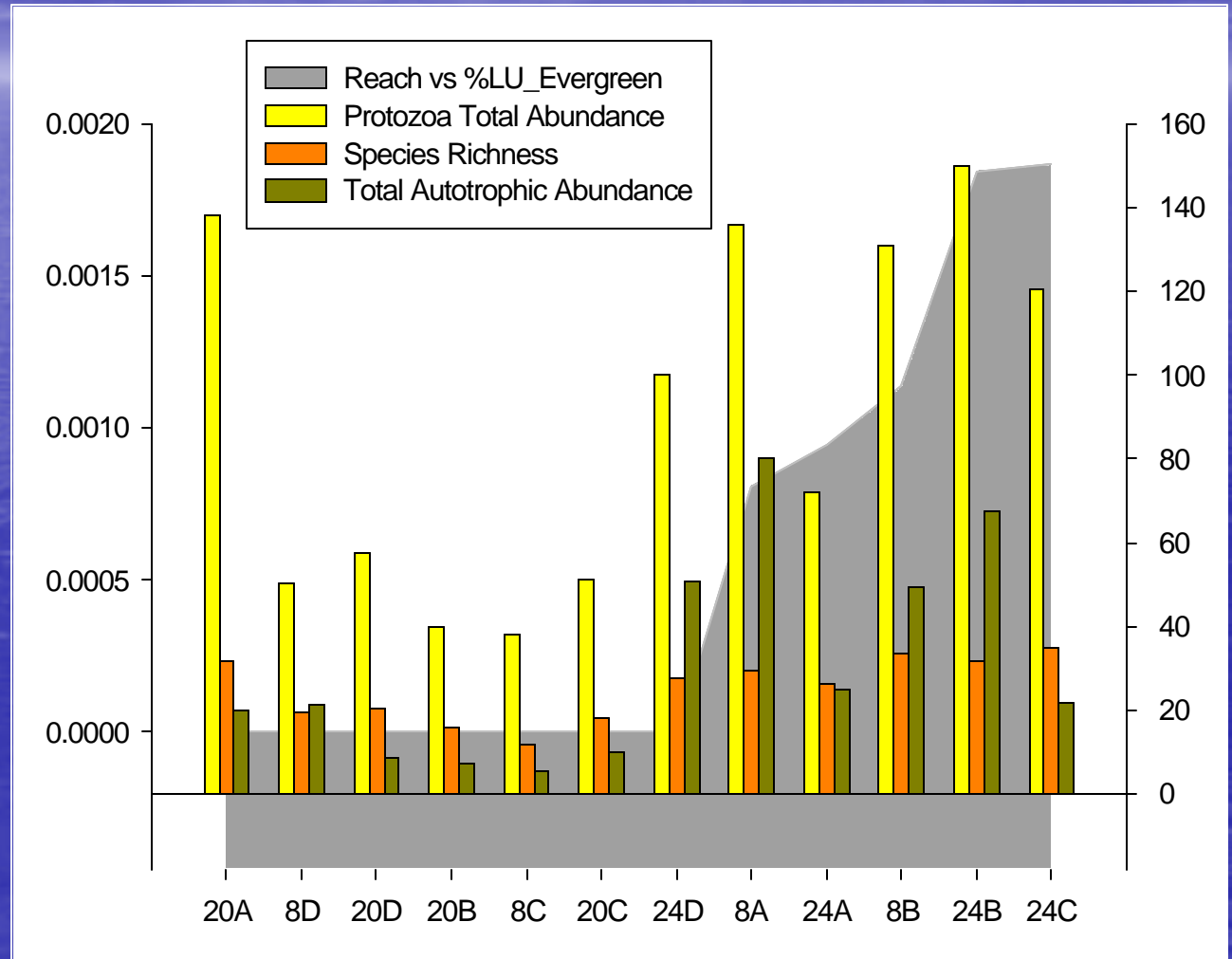
- **% Evergreen Landuse** correlated with **all** candidate measures

Concluding Remarks

- Protozoa provides a strong "biological response signature" in respond to environmental measures.

- Protozoa appears to respond to the driving forces within the system

- Protozoa may offer a more stable assessment in comparison with standard tools.

Directions

Immediate Goals

- Continue analysis, focusing on compositional compartment

- Compare response and utility of assessment metrics across the two ecoregions (EOLP and WAP) and between two sample seasons (Spring and Fall)

Future Goals

- Apply molecular studies to aid in protozoan identification and adding a necessary dimension (Angermeier and Karr 1994) to assessment of biotic integrity of a system

- Examine protistan metrics based on functional processes in comparison to structural components

- Examine the functionality and utility of protistan bioassessment tool in coastal marine waters and estuaries