

# Indicators of Ecological Change

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A SERDP Ecosystem Management Project (SEMP)  
being implement at Fort Benning, GA

Brief to the Science Advisory Board  
June 13, 2001

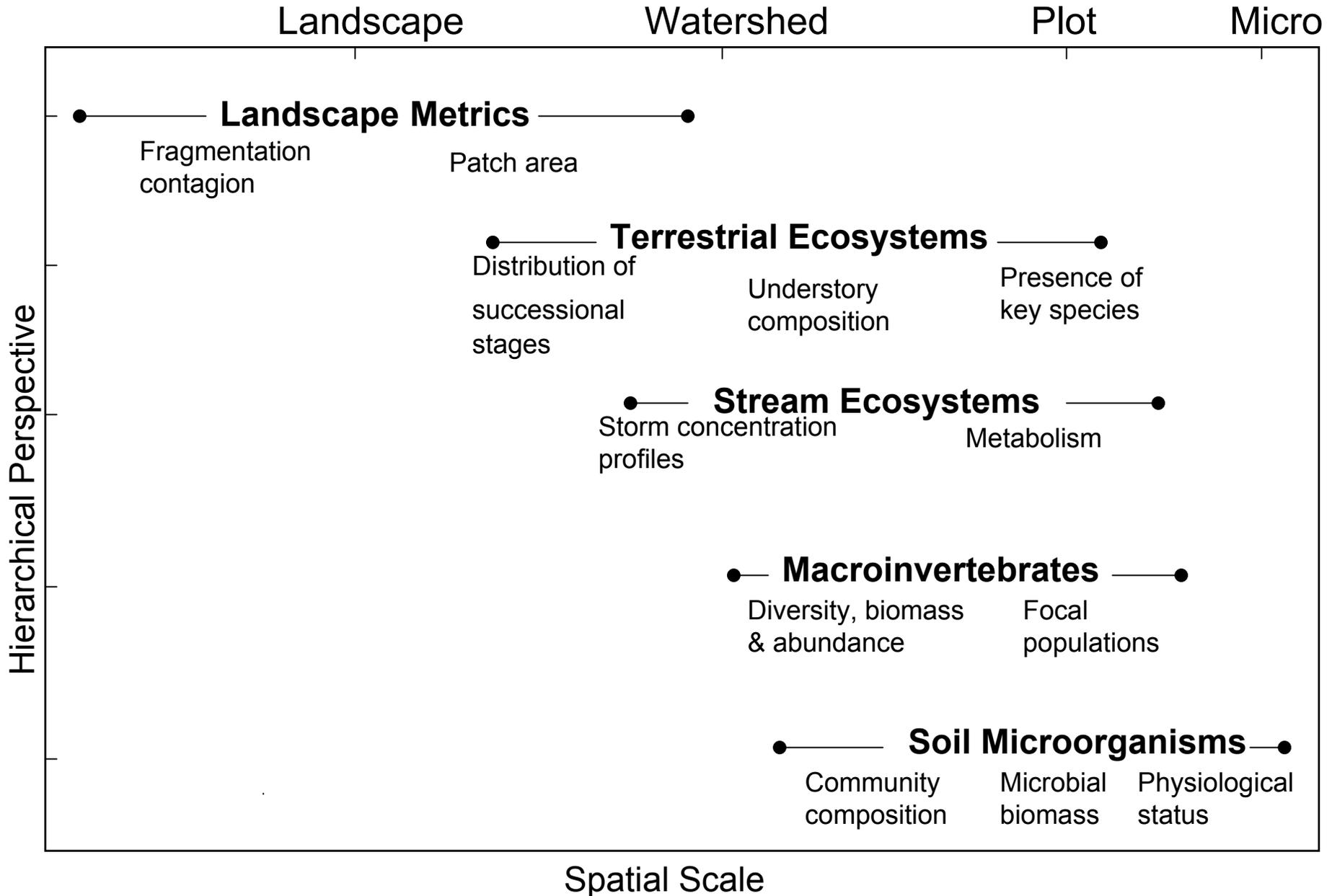
# Participants

- Jack Feminella and Ken Fritz, Department of Biological Sciences, Auburn University — [Stream macroinvertebrates](#)
- Thomas Foster, Anthropology Department, Pennsylvania State University — [Historical land cover](#)
- Patrick Mulholland, Environmental Sciences Division, Oak Ridge National Laboratory — [Aquatic ecology](#)
- Lisa Olsen, Environmental Sciences Division, Oak Ridge National Laboratory -- [Geographic information](#)
- David White, Aaron Peacock, and Sarah McNaughton, Center for Environmental Technology, University of Tennessee — [Soil microbiology](#)
- Suzanne Beyeler, Institute for Environmental Studies, Miami University, Ohio — [Terrestrial indicators](#)

# Technical Approach

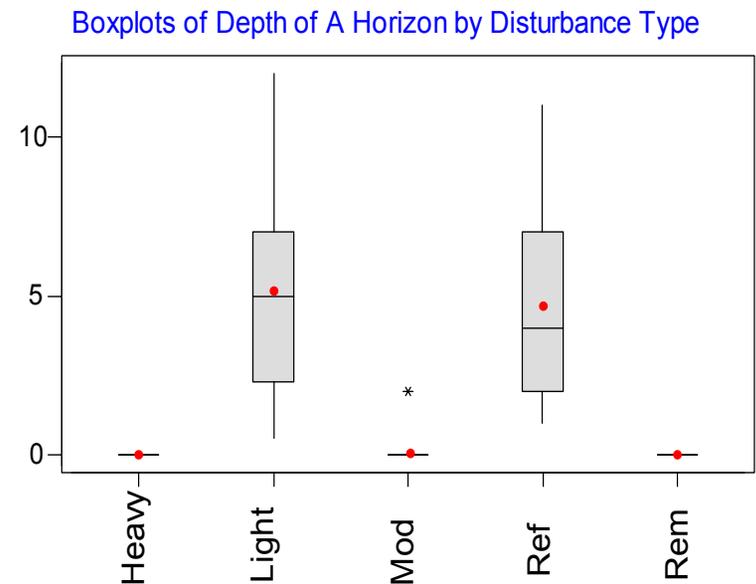
- (a) Analyze historical trends in environmental changes to identify potential indicators;
- (b) Collect supplemental data relating to proposed indicators (building upon existing data);
- (c) Perform experiments to examine how training affects indicators;
- (d) Analyze resulting set of indicators for appropriateness, usefulness, and ease of taking the measure;
- (e) Develop and implement a technology transfer plan.

# Hierarchical Overlap of Suite of Ecological Indicators

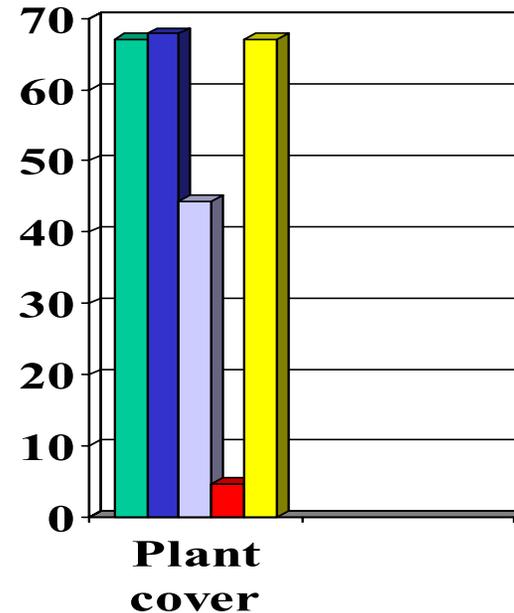
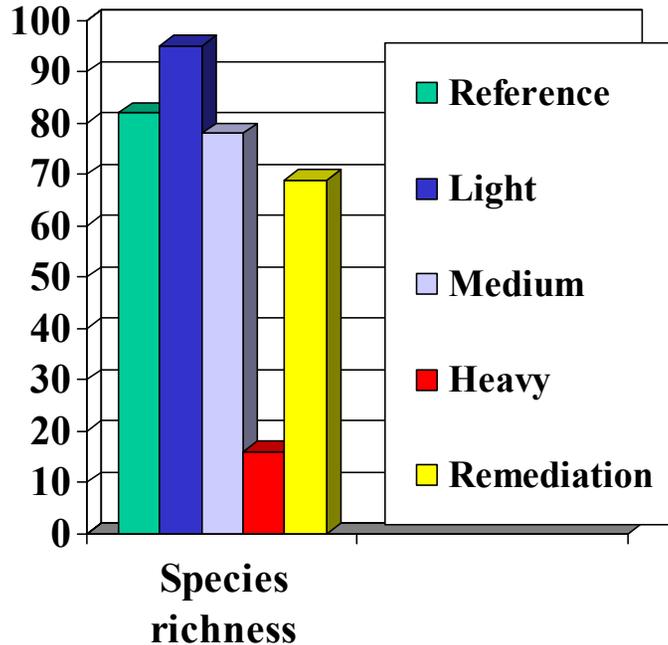


# Technical Approach: Terrestrial Studies

- Objective
  - Determine indicators of ecological change due to military training
- Approach
  - Establish 5 plots along 3 transects in reference, low, moderate and high disturbance sites
  - Establish 5 plots along 2 transects in remediated sites
  - Measure understory vegetation and microbiology
  - Determine differences and patterns



# Understory characteristics of sites with different training intensities



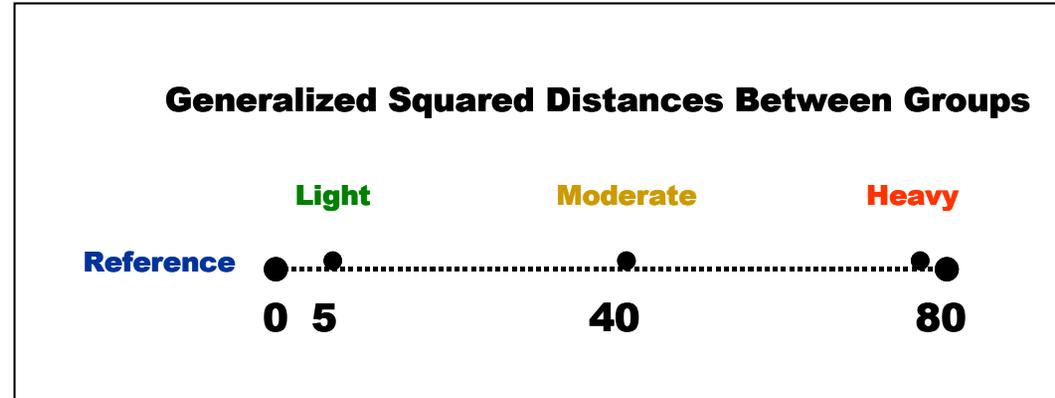
## Other results:

- Dendrograms group treatments using species occurrence
- Principle components analysis separate species according to treatments

# Analysis of soil microbial community

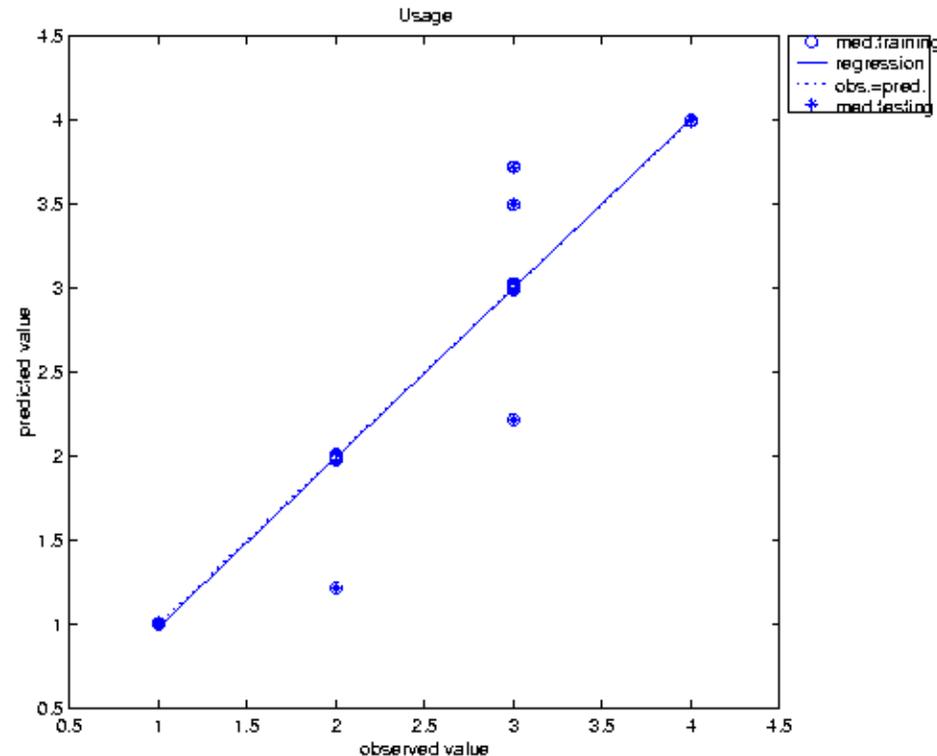
Linear discriminant model using 17 PLFA predictor variables

- Reference and light transects were very similar
- Moderate and heavy transects greatly differed



## Non-linear Artificial Neural Network Analysis

- Correctly predict classification 66 of the time (25% chance only)
- Showed that remediated transect are very different from all other treatments



# Technical Approach: Stream Studies

## Objective

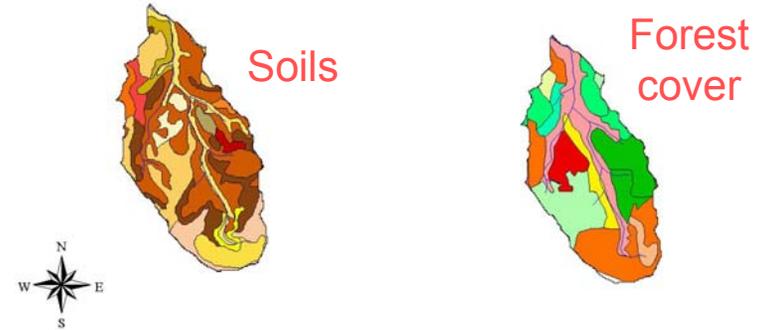
Develop and evaluate potential indices of disturbance effects on catchment biogeochemistry and stream ecosystems

## Approach

Disturbance gradient analysis (disturbance severity quantified at catchment scale as % land denuded)

- Stream sites (2nd-3rd order) over range of disturbance severity
- Measure potential indices across disturbance gradient
- Develop relationships between indices and disturbance severity\*

## Watershed Characterization- ECMI data base (GIS)



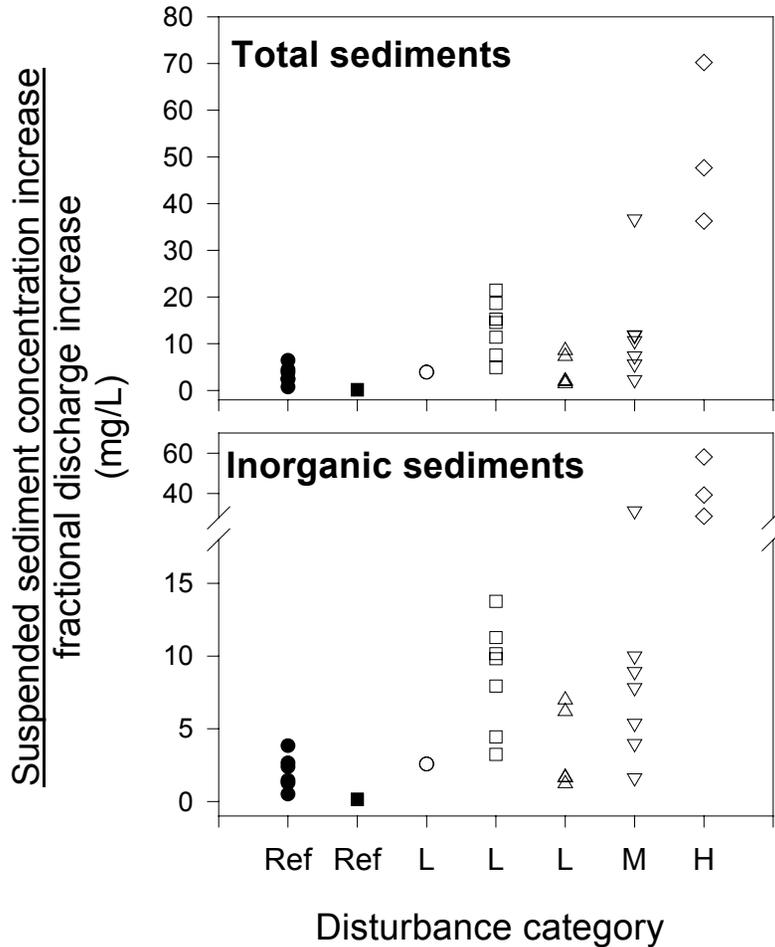
K11w-3D image

## Other coverages:

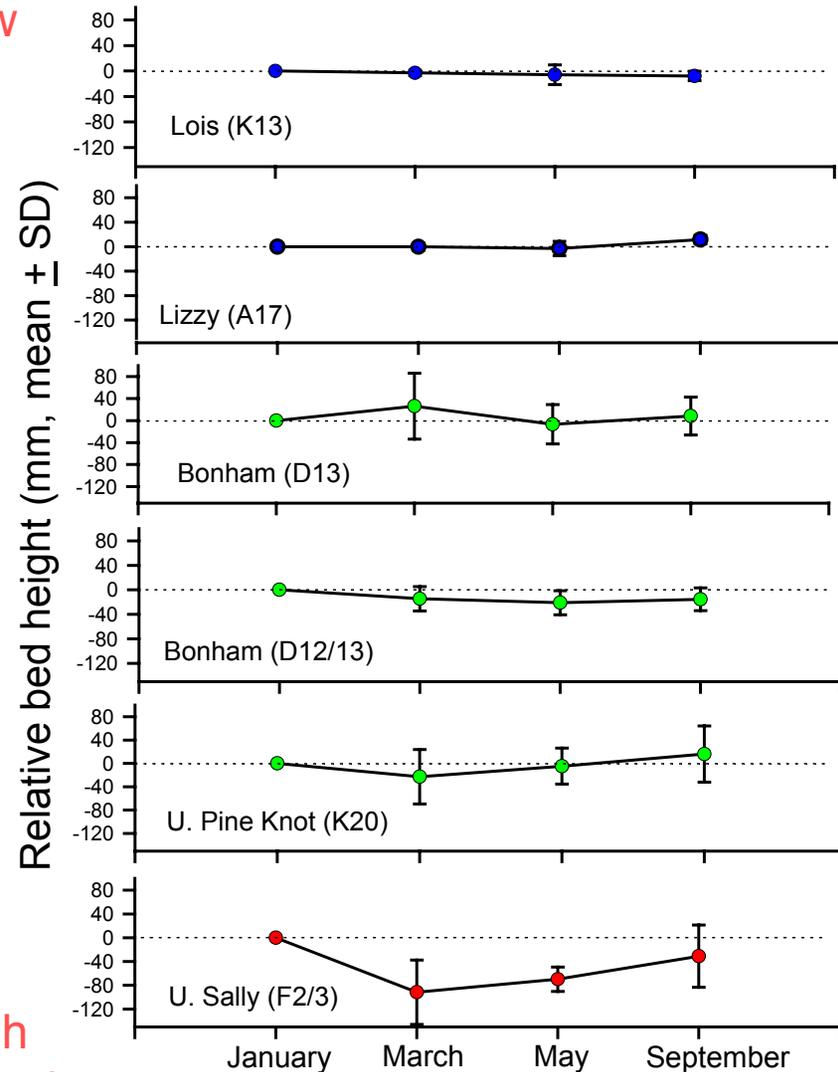
- riparian zone
- roads
- road-stream crossings
- aspect / topography
- denuded ground

# Storm suspended sediment concentration increases and bedload sediment movement indicate disturbance severity

Symbols represent different storms.

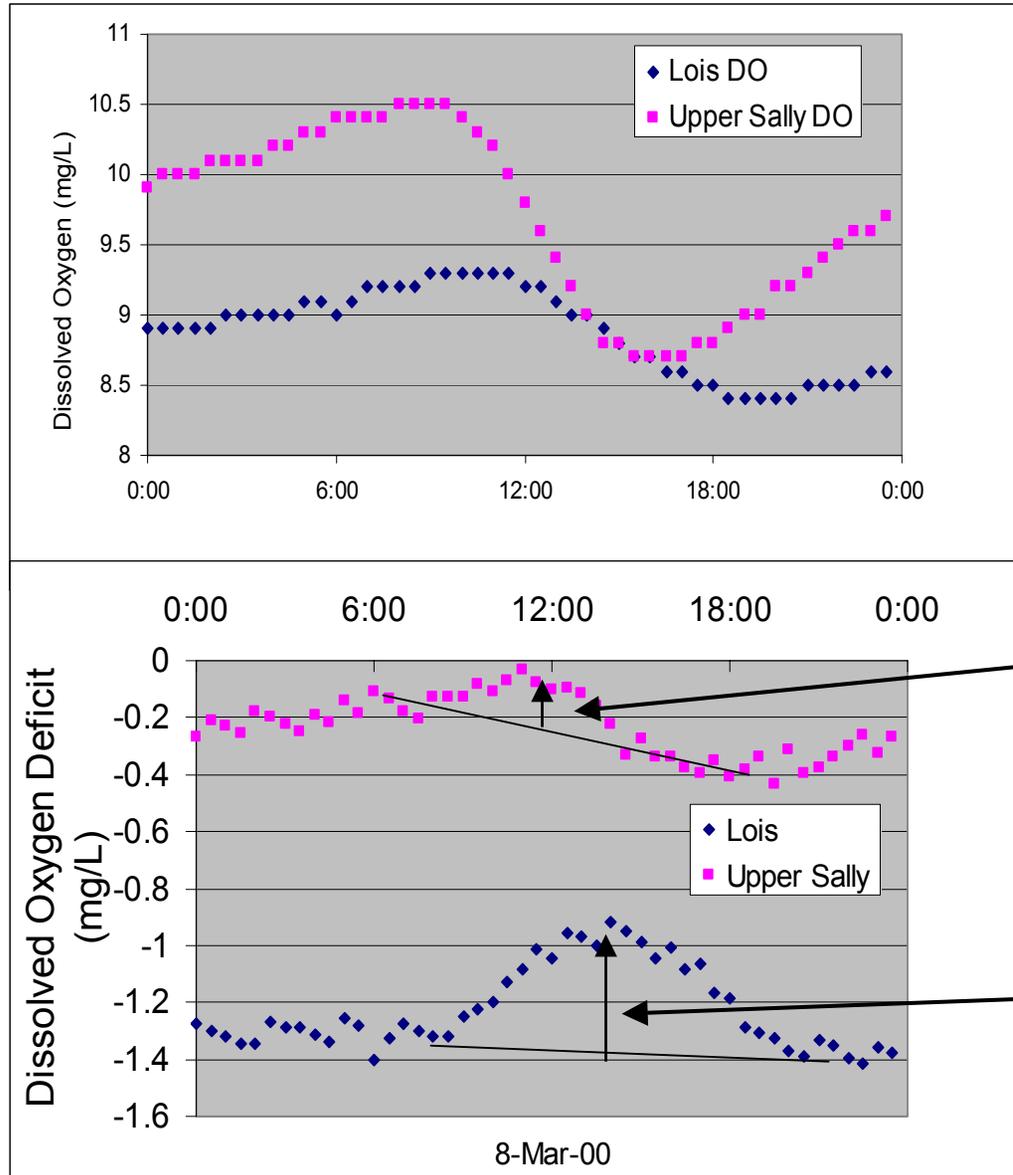


Low



High disturbance

# Diurnal dissolved oxygen profiles appear a useful disturbance indicator



Low daytime primary productivity in highly disturbed stream (Upper Sally)

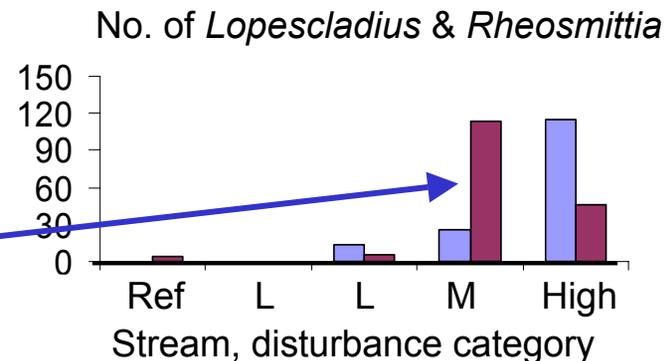
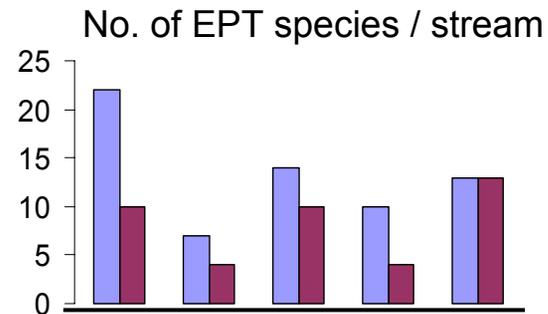
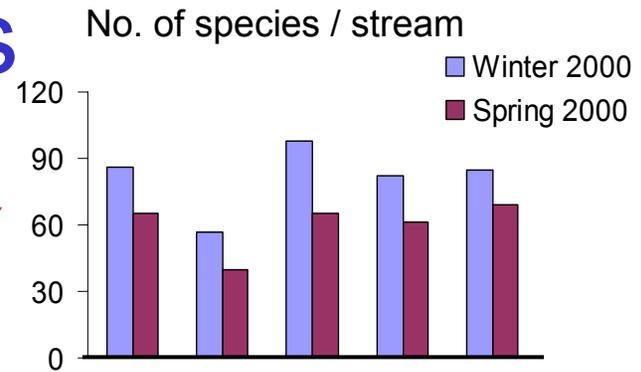
High daytime primary production in reference stream (Lois)

# Benthic Invertebrates (Winter & Spring 2000)

Number of total species and  
EPT not generally indicative  
of disturbance across  
seasons

But abundance of focal  
populations appears to  
be a useful indicator

High numbers of  
sediment-tolerant midges  
in disturbed streams

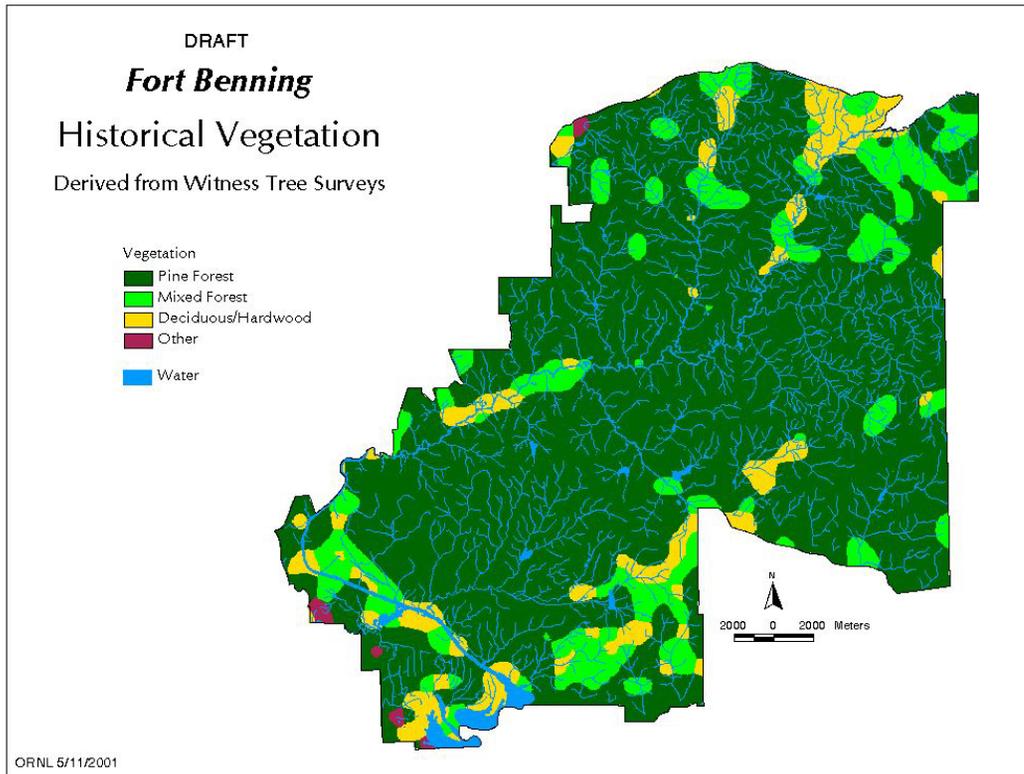
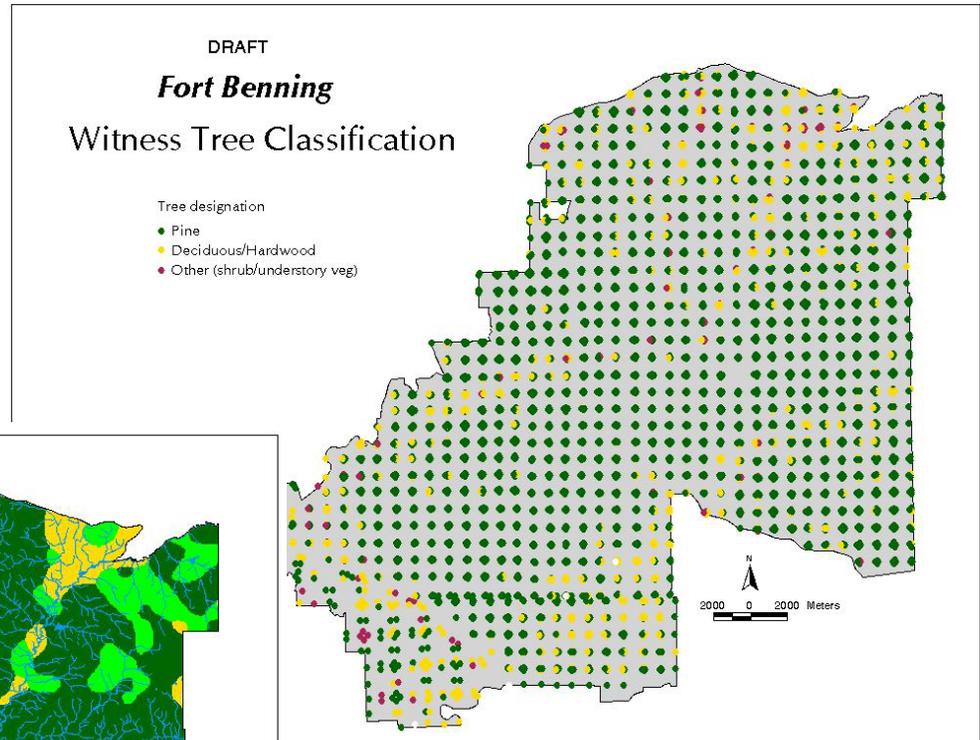


## Technical Approach: Landscape Studies

- Explore data availability
- Develop comparable data sets over time
- Analyze changes in pattern and distribution of land cover over time
- Determine which landscape metrics are most useful for indicating change

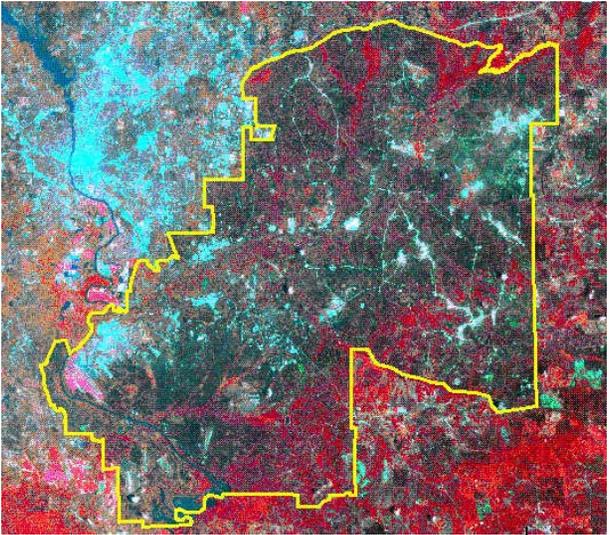
# Fort Benning Historical Vegetation

1. Obtain witness tree data
2. Classify trees
3. Interpolate surface

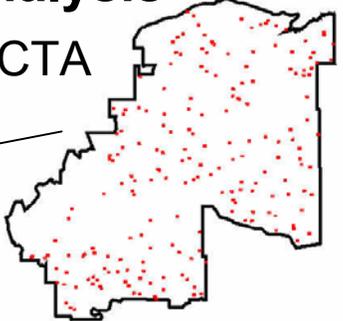


# Fort Benning - Land Cover Classification/Analysis

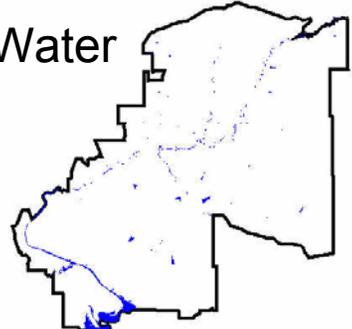
TM - July 1999



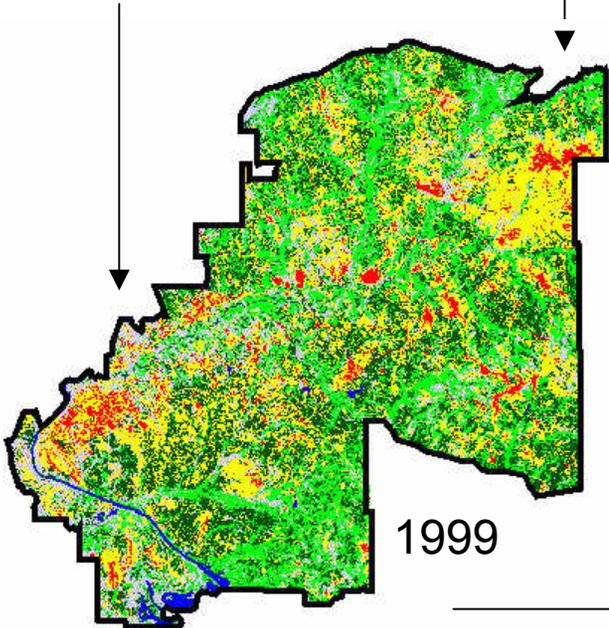
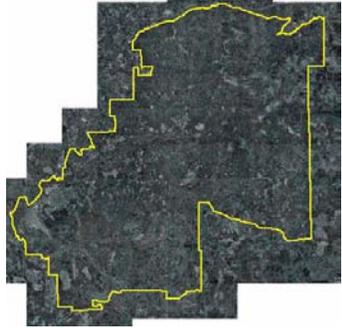
LCTA



Water



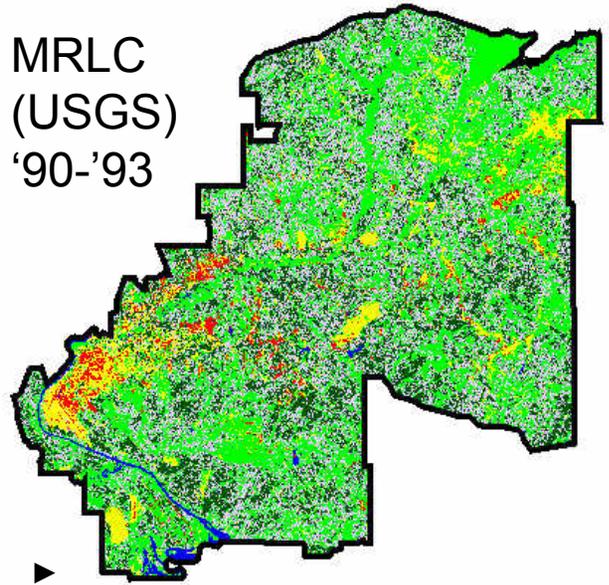
Digital-Color Orthophoto 1999



1999

- Barren/Developed
- Non-forest/Cleared
- Mixed Vegetation
- Deciduous Forest
- Pine Forest
- Water
- Wetlands

MRLC (USGS) '90-'93



Change analysis

# Next Steps

- Complete ongoing analysis
- Conduct experiment designed to test indicators
- Re-evaluate candidate indicators
- Work with Benning staff in transfer of technology

## Publications:

- Beyeler, S.C. 2000. Ecological indicators. Master's thesis. University of Miami in Ohio.
- Dale, V.H. and Beyeler, S.C. In press. Challenges in the development and use of ecological indicators. Ecological Indicators. Vol. 1.
- Dale, V.H., Olsen, L. and Mann, L.K. In review. Contributions of federal lands to protection of endangered and threatened species. Natural Areas Journal.
- Dale, V.H. , Beyeler, S.C., and Jackson, B. In review. Vegetative indicators of anthropogenic disturbance in longleaf pine forests. Ecological Indicators.
- Dale, V.H. and Beyeler, S.C. In review. Selecting Ecological Indicators for Resource Management: An Application for Department of Defense Lands. Ecological Indicators.
- Foster, H.T., II and Abrams, M.D. In review. Physiographic analysis of the pre-European settlement forests in east-central Alabama. Canadian Journal of Forest Research.
- Peacock, A. D., S. J. MacNaughton, J. M. Cantu, V. H. Dale and D. C. White. In review. Reversible shifts in viable microbial biomass and microbial community composition along an anthropogenic disturbance gradient within a longleaf pine habitat. Ecological Indicators

# Posters and Presentations

## **Posters:**

- Dale, V.H. and Beyeler, S.C. Ecological indicators: Tools for ecosystem management. SERDP Annual Meeting, December 1999, Washington, DC
- Dale, V.H. Ecological indicators. Workshop on Ecological Models for Resource Management. October 2000, Oak Ridge TN.
- Dale, V.H. "Ecological indicators for land management. Ecological Society of America Annual Meeting, August 6, 2001, Madison, WI.

## **Presentations:**

- Dale, V.H. Views from the Ridge: Considerations for Planning at the Landscape Scale, sponsored by the Pacific Northwest Research Station, USDA Forest Service, Vancouver, Washington, Nov. 2-4, 1999.
- Dale, V. H. Symposium on "Urban landscape ecology" at the 15<sup>th</sup> Annual US Landscape Ecology Symposium, Fort Lauderdale, FL., April 15-19, 2000.
- Dale, V.H. EcoSummit 2000: Integrating the Science. Halifax, Nova Scotia, Canada, June 18-22, 2000.
- Dale, V.H. Using indicators for restoration and management. Ohio State University. November 2, 2000.
- Dale, V.H. Lessons for Ecosystem Management. Fall Line Workshop. March 6-7, 2001, Aiken, S.C.
- Dale, V.H. Use of indicators. Workshop on "Climate Change and Species Survival: Implications for Conservation Strategies," February 19-21, 2001, The World Conservation Union (IUCN) in Gland, Switzerland.
- Dale, V.H. "Top Ten Issues in Landscape Ecology" session at the 16<sup>th</sup> Annual Symposium on Landscape Ecology, Tempe Arizona, April 2001
- Foster, T. "Evolutionary Ecology of Creek Residential Mobility," Southeastern Archaeological Conference, Macon, Georgia, November 2000.
- Olsen, Lisa M. and Virginia Dale. Landscape Patterns as Indicators of Ecological Change at Fort Benning, GA. ESRI User Conference, July 9-13, 2001, San Diego, CA.

# Integration

## Contributions to Other SEMP Projects

- Criteria for selecting a suite of indicators
- Protocol for selecting indicators
- Data from our studies on indicators: terrestrial, stream, and soil microbes
- Historical vegetation map

## Coordination with Other SEMP Projects

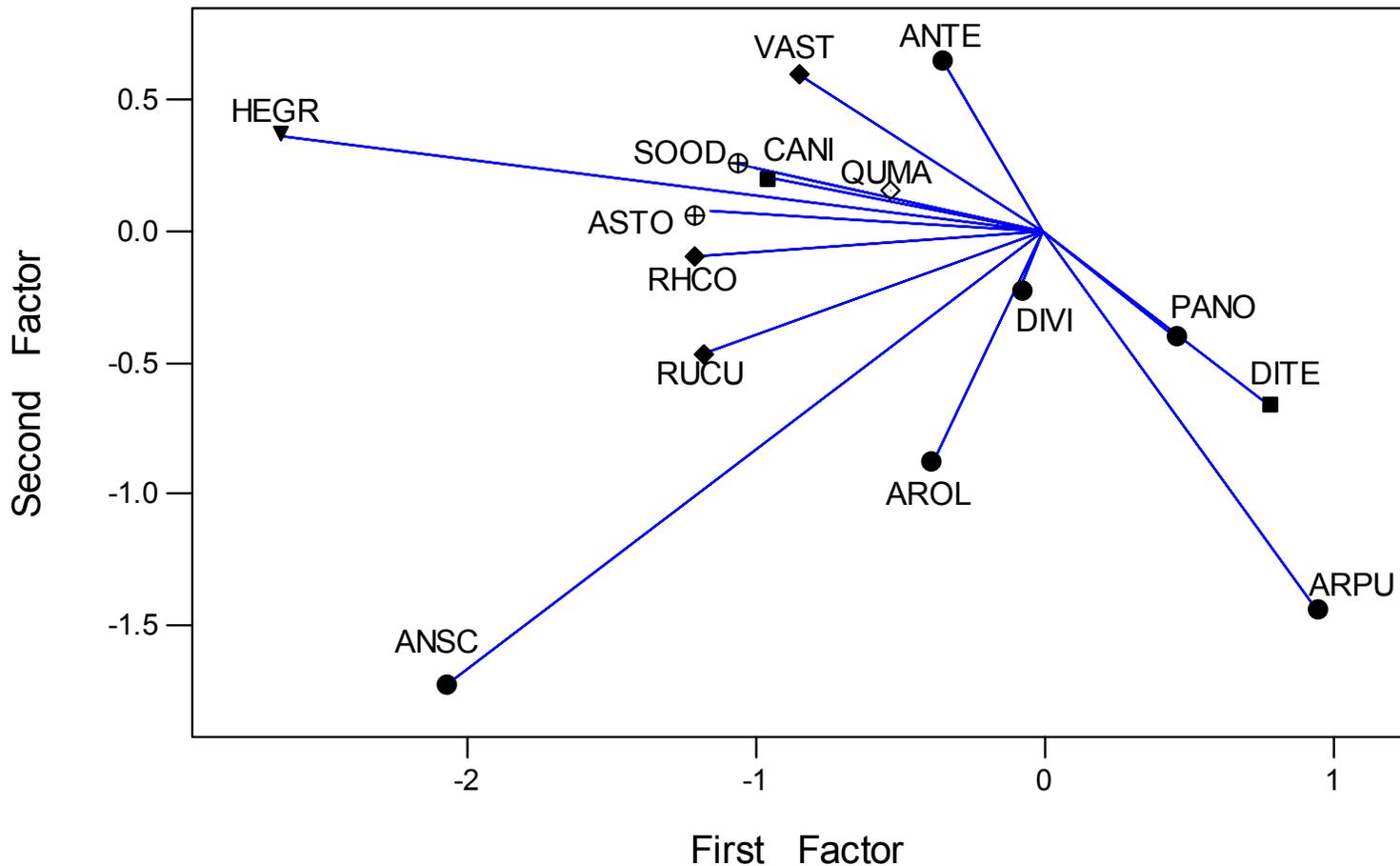
- Baseline information provided by ECMI and LCTA
- Co-location of sampling sites and sharing of data with other SEMP projects
  - Storm hydrological chemistry
  - Stream macroinvertebrates
- A comprehensive picture of changes in microbial community structure



# *BACK UP*

## Principle components separate species according to treatments

- ◇ Phanerophyte: tree
- ◆ Phanerophyte: shrub
- ▼ Hemicryptophyte
- Therophyte
- Geophyte: graminoid
- ⊕ Geophyte: composite



## *BACK UP*

# Potential Stream Indices of Disturbance

## **1. Storm chemistry profiles**

Measurements:  $\text{NH}_4$ ,  $\text{NO}_3$ ,  $\text{PO}_4$ ,  $\text{Cl}$ ,  $\text{SO}_4$ , electrical conductance, suspended sediments over storm hydrographs

Analyses: concentration vs. discharge relationships, peak concentrations

## **2. Diel dissolved oxygen profiles (metabolism indicator)**

Measurements: dissolved oxygen concentrations and deficits at 30-min intervals during baseflow

Analyses: diurnal amplitude, night-time minima

## **3. Macroinvertebrate communities and habitats**

Measurements: numbers, biomass & diversity of benthic macroinvertebrates, bedload sediment movement

Analyses: EPT index, sensitive species abundance, NCBI index, similarity indices, sediment movement over time