



United States Department of Interior



Assessing nutrient eutrophication in streams using fish, invertebrate, and algal indices in the Cornbelt and Northern Great Plains and Mostly Glaciated Dairy Region Nutrient Ecoregions (MRB 3)

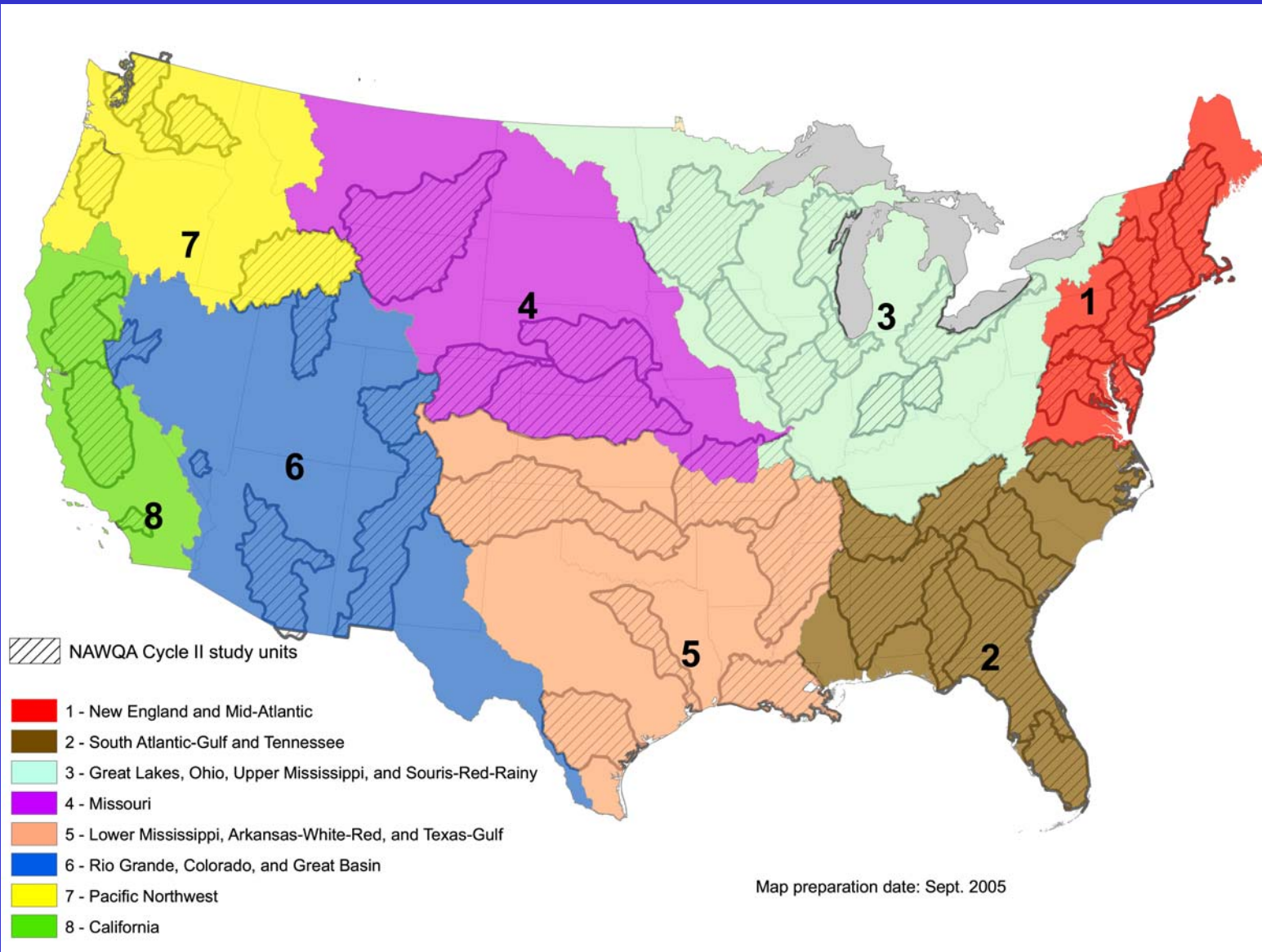
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October 30, 2007





Why is this topic important?

1) Major issue

- Nutrient enrichment – a leading cause of streams being listed on the 303(d) list

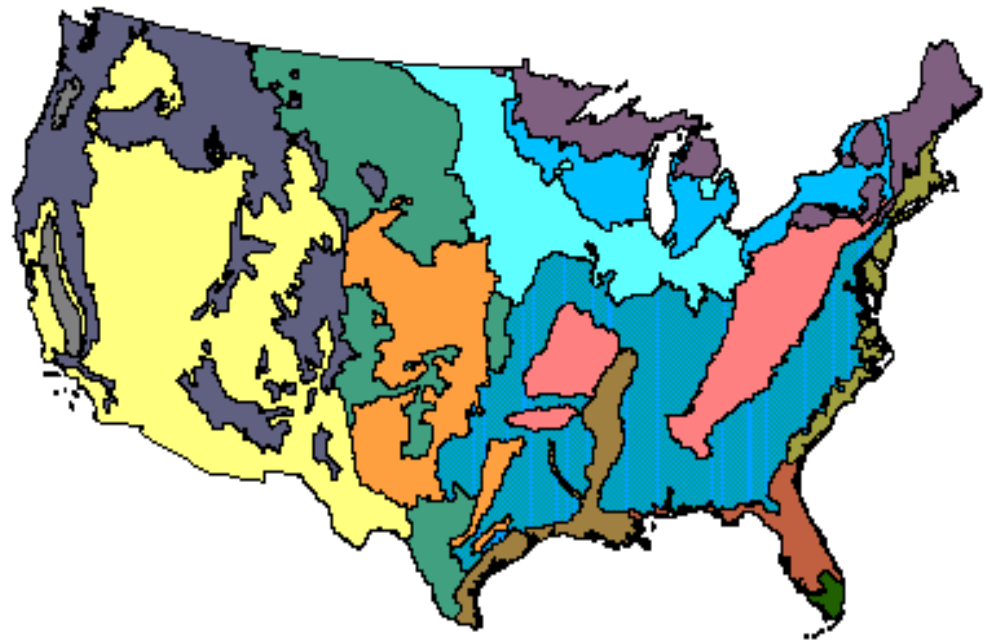
2) Pertinent and timely

- Nutrient Criteria must be developed by States by 2007- 09



Nutrient Criteria: Waterbody Types and Ecoregions

- Waterbody Types
 - Rivers and Streams
 - Lakes, Reservoirs
 - Wetlands
 - Estuaries
- Nutrient Ecoregions
 - Multiple Omernik Level III Ecoregions





USEPA Requirements for States

Numerical criteria

- **Causal variables**
 - TP
 - TN
- **Response variables**
 - Algal biomass: Chl *a*
 - Transparency: turbidity

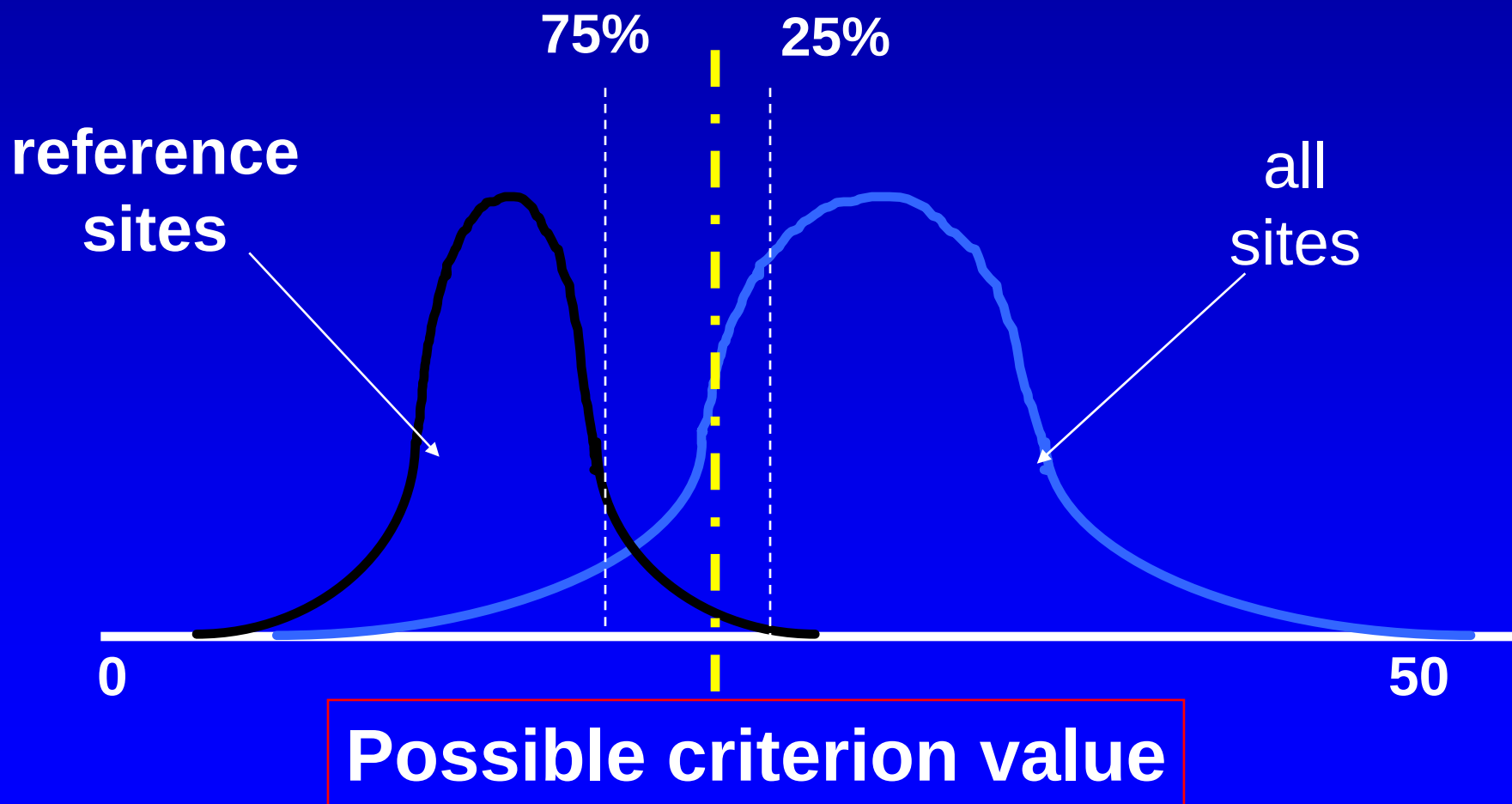


Options for States/auth. Tribes

- develop State/Tribal nutrient criteria that reflect localized conditions and protect designated uses
 - **frequency distribution approach**
 - **effects threshold approach**
- adopt EPA's regional 304(a) criteria in the absence of any better data
- develop criteria protective of designated uses using other scientifically defensible methods

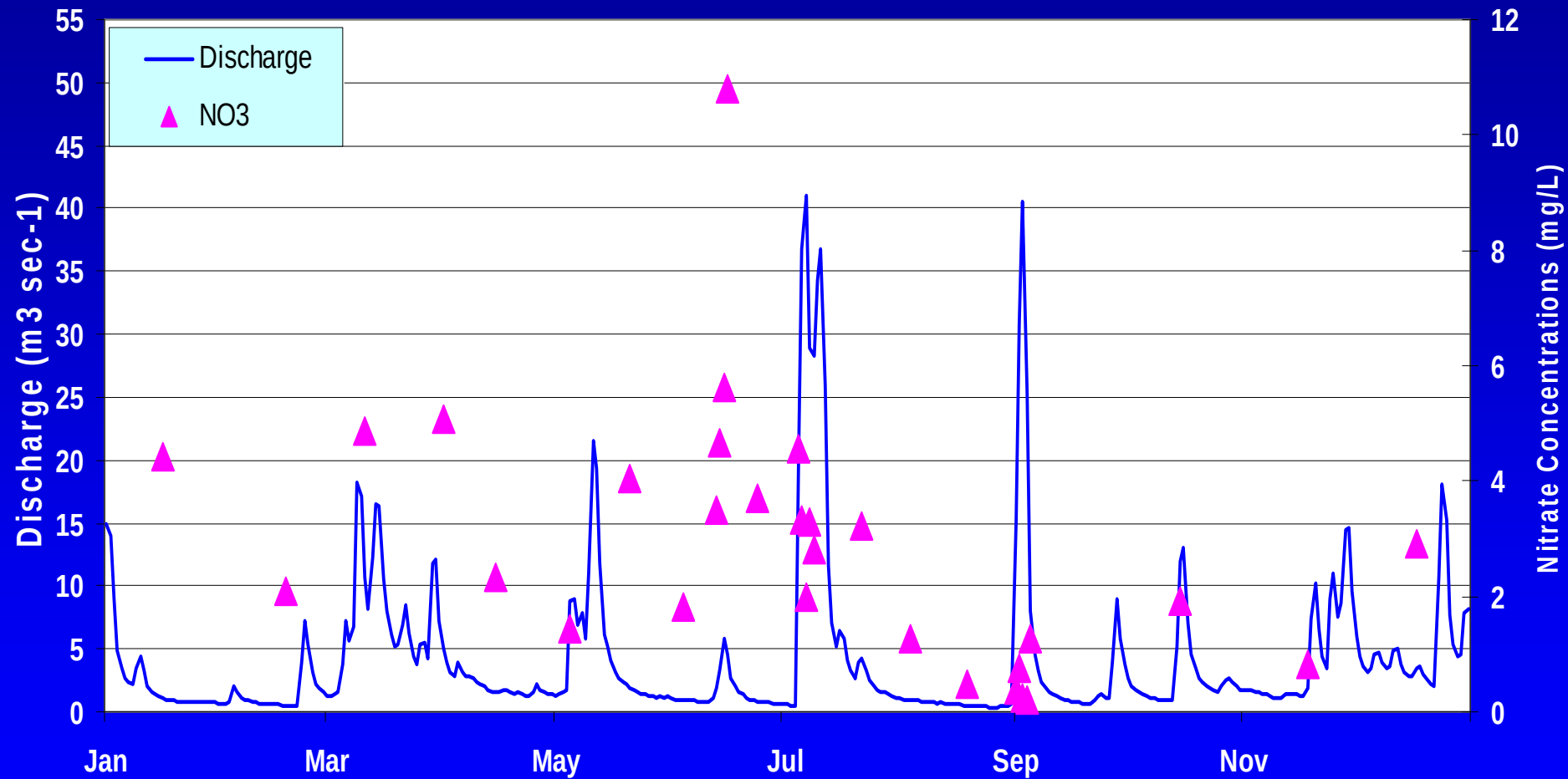


Frequency Distribution Approach



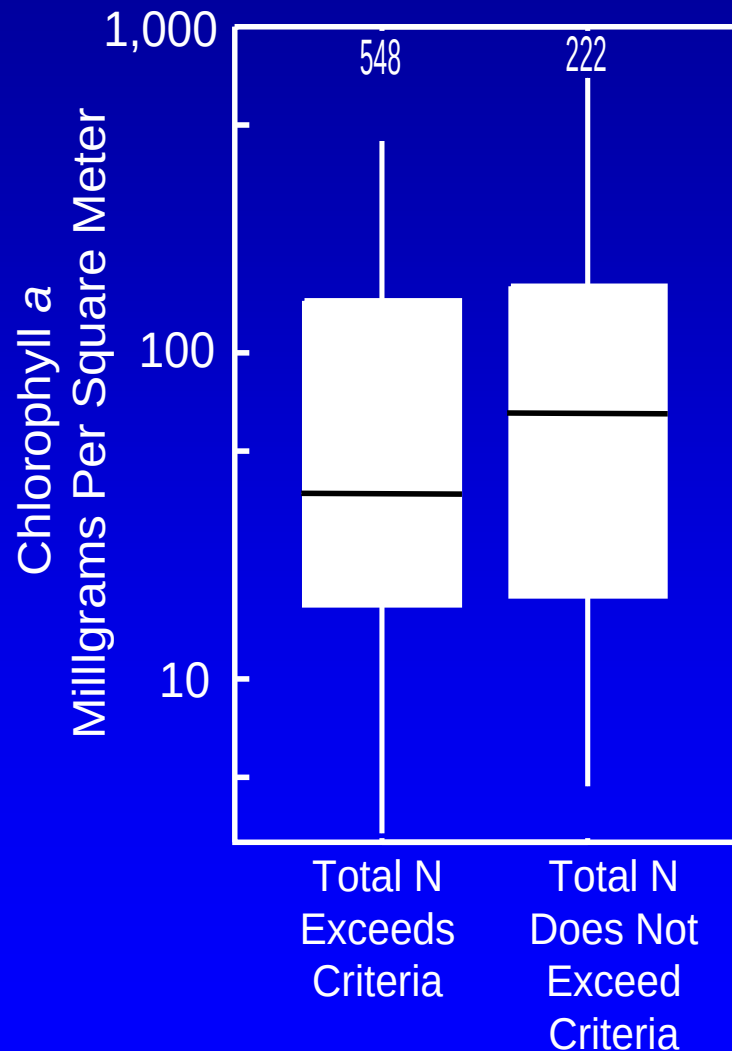


Seasonal Nutrients Changes Make Them Difficult for Use as Sole Nutrient Criteria

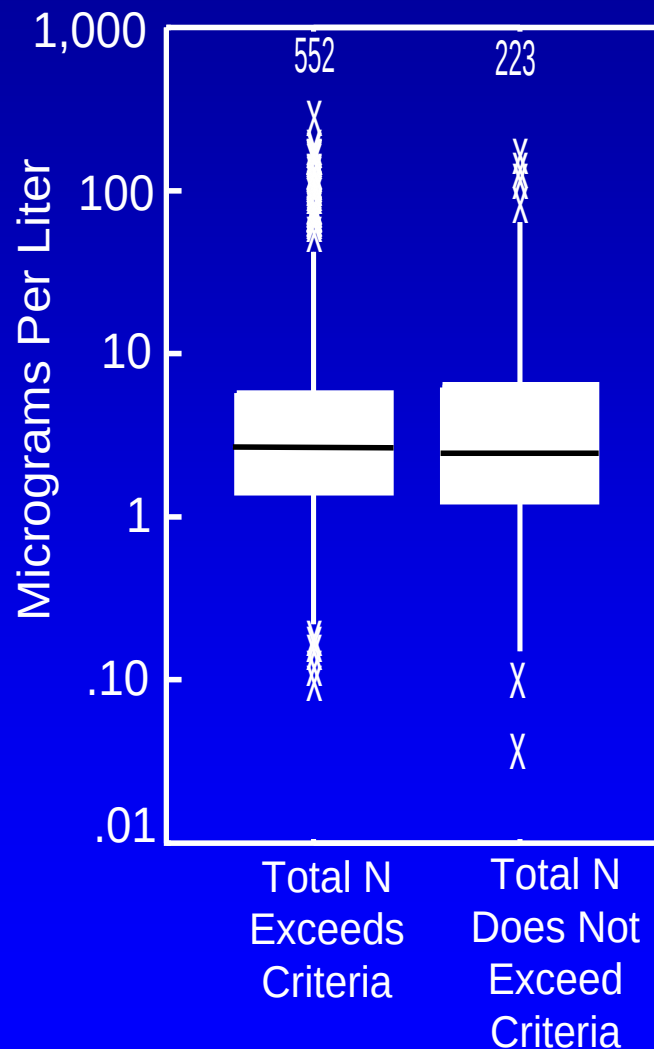


Chlorophyll *a*:Total Nitrogen Criteria

Periphyton



Seston



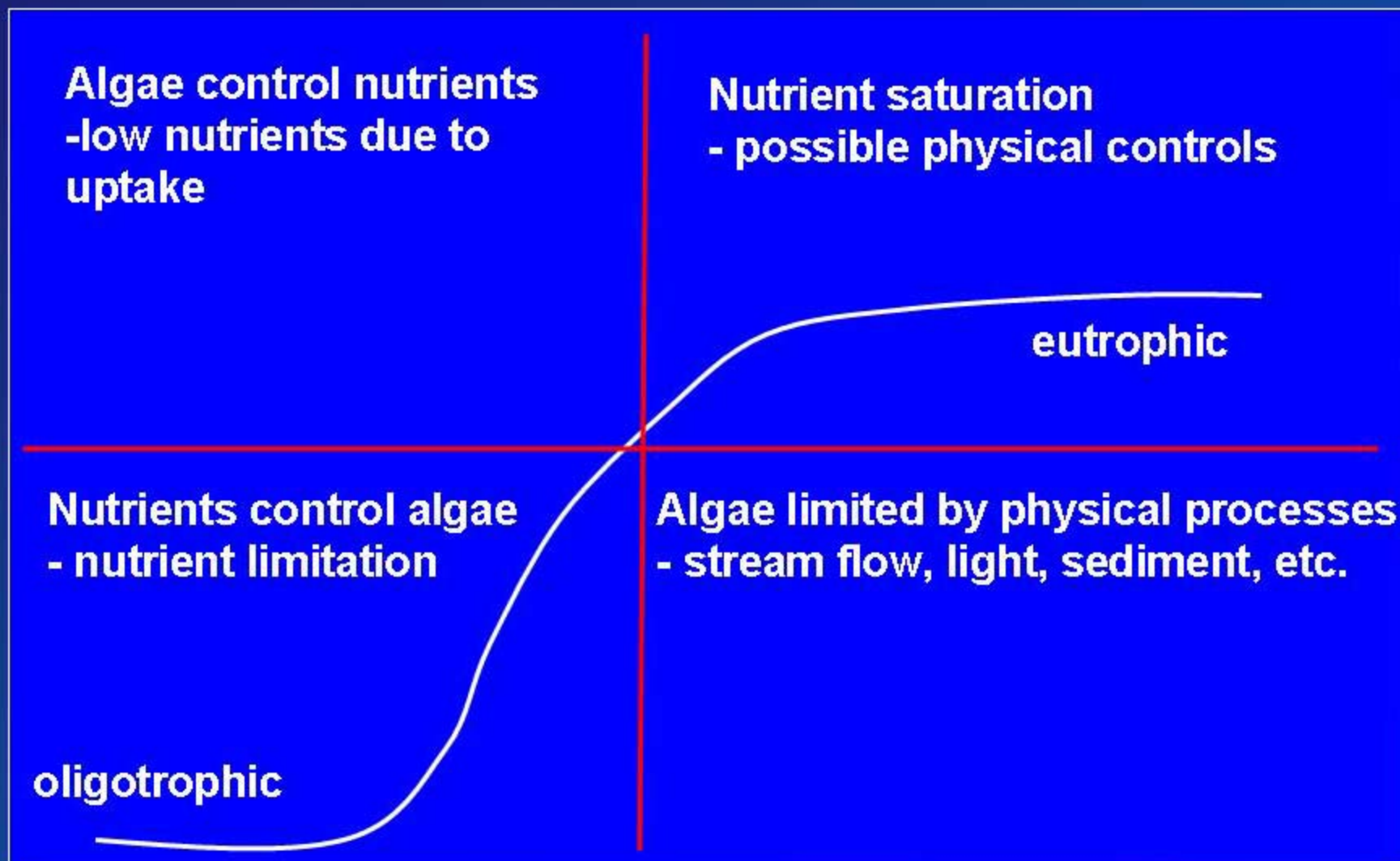
EXPLANATION

30 number of values

x upper outside
upper adjacent
75th percentile
median
25th percentile
lower adjacent
x lower outside

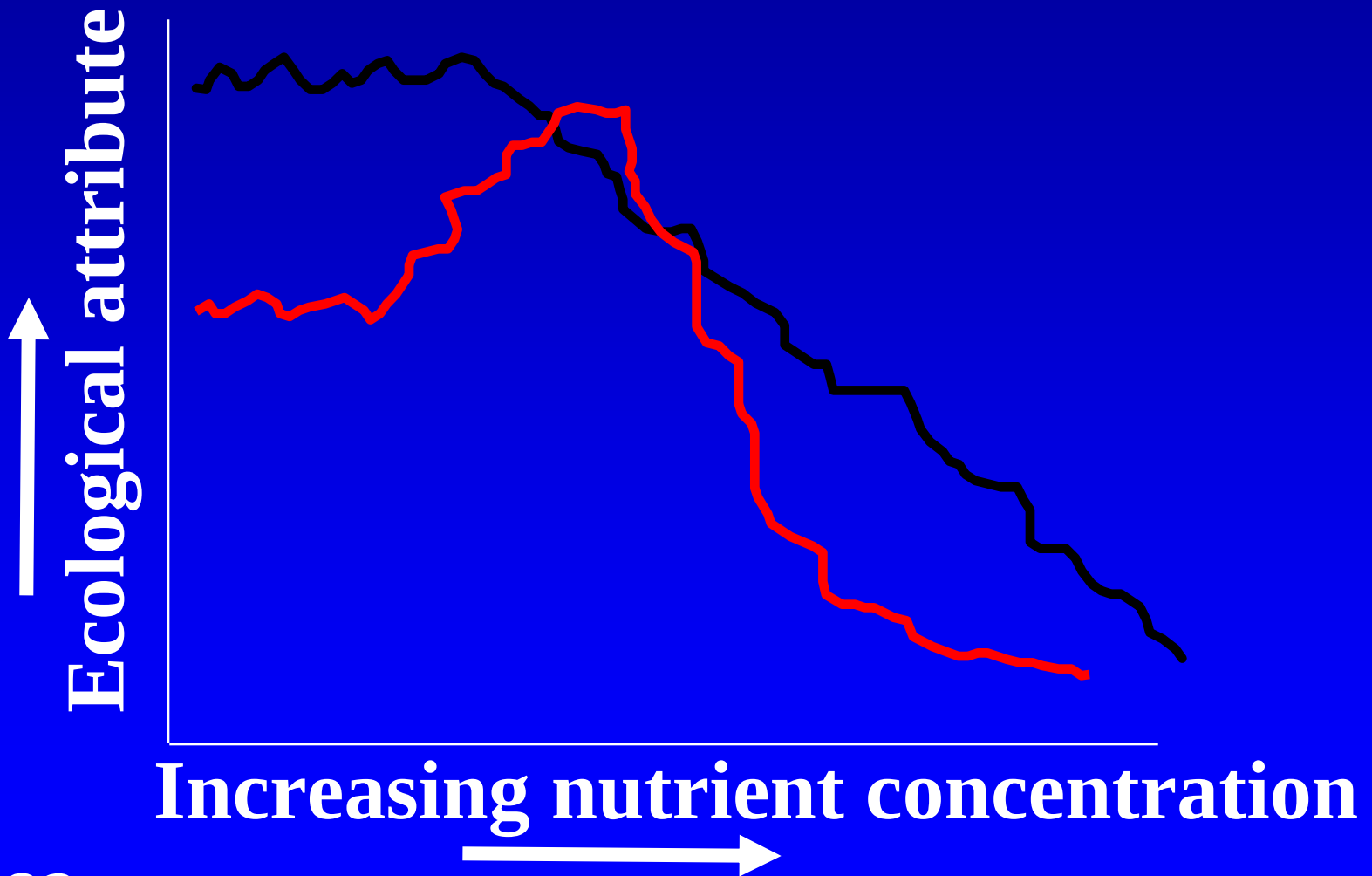
Confounding Nutrient:CHL a Effects

CHLOROPHYLL A





Effects Threshold Approach





Why should NAWQA address this topic?

- 1) NAWQA has one of few data sets with water chemistry, habitat, and fish, invertebrate, algal community data**
- 2) Provides needed links between nutrients and biological communities on regional scale**

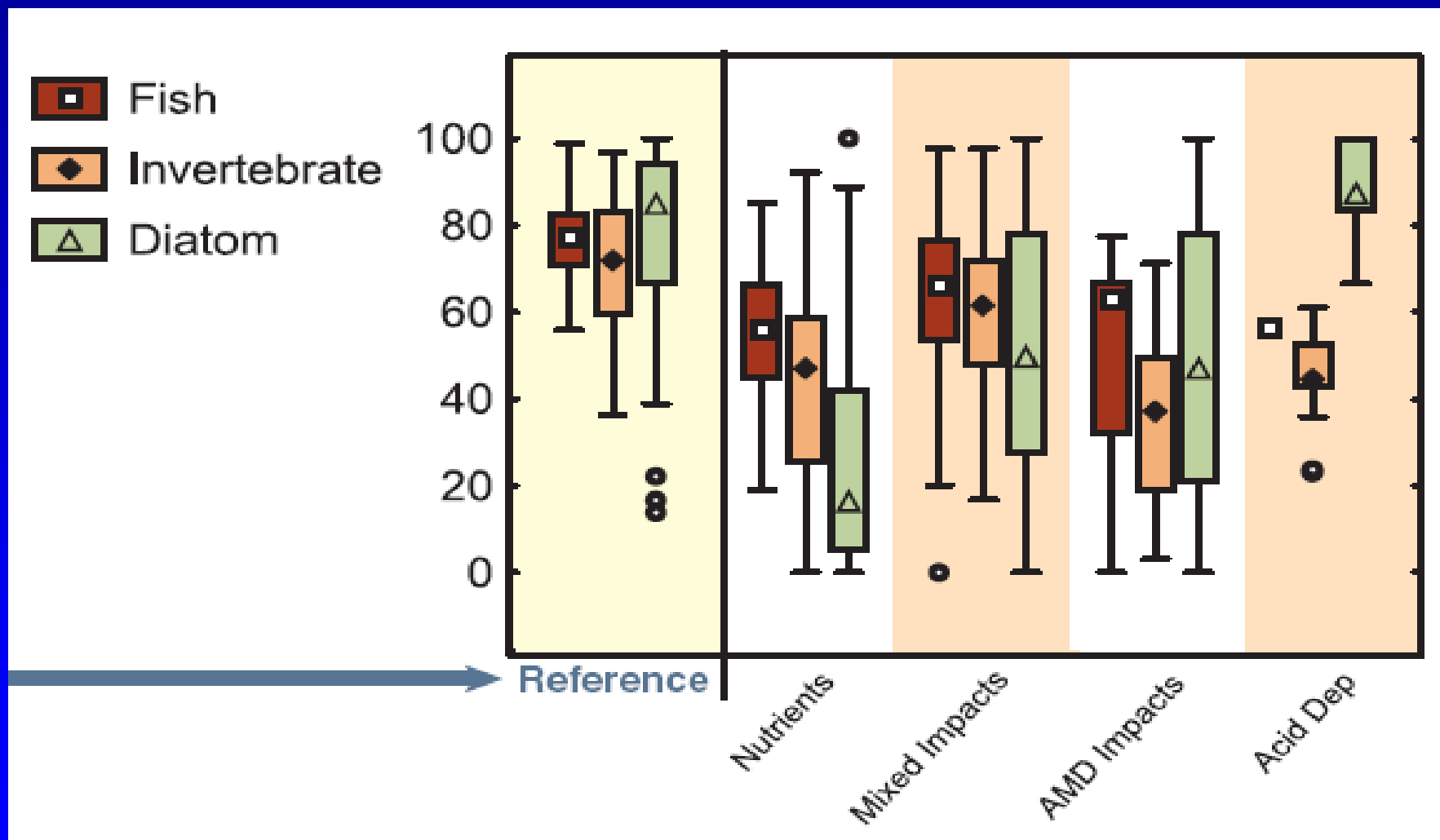


Why should NAWQA address this topic? (cont.)

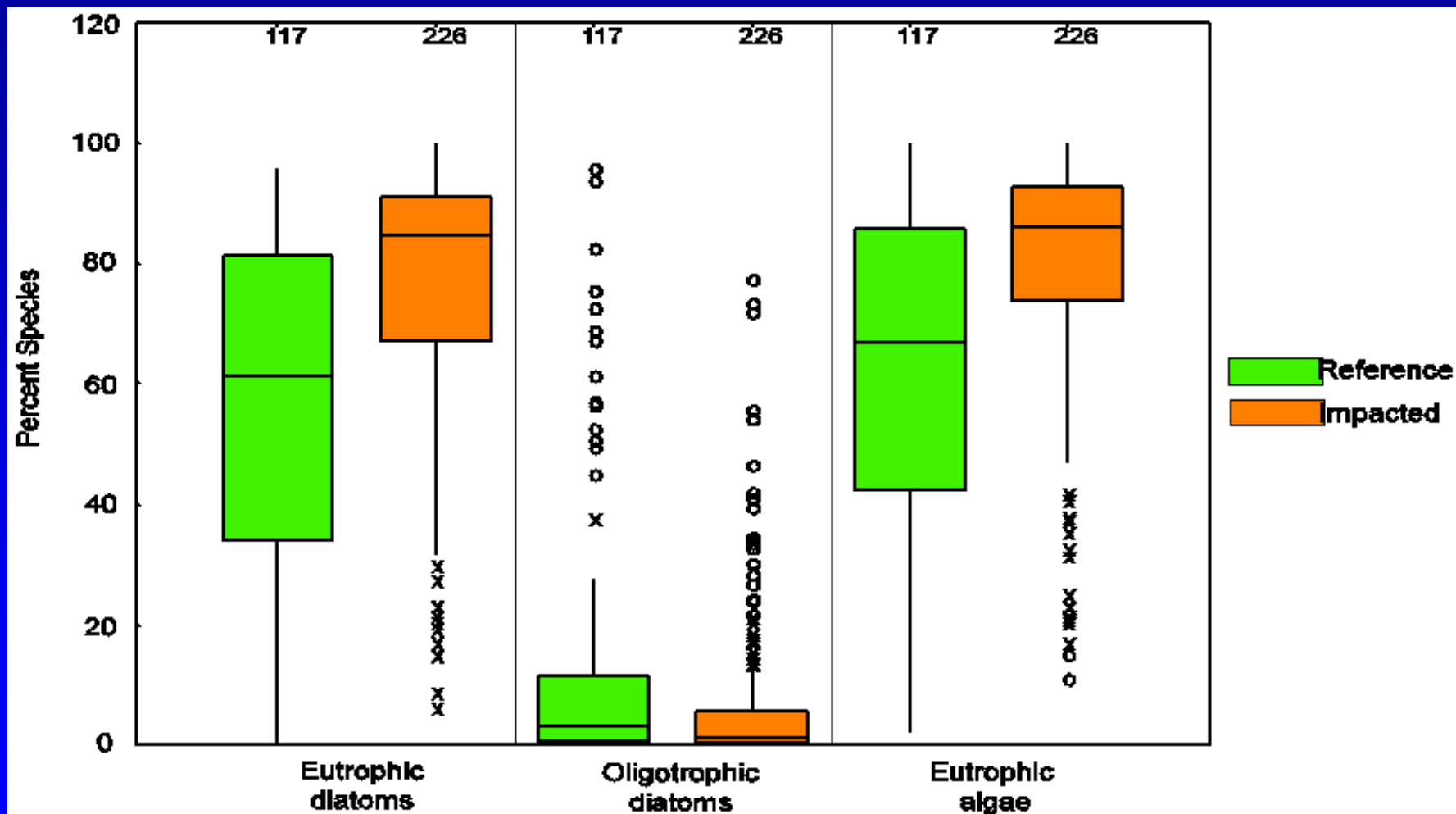
- 3) Some States feel their ecological sampling design using fish and invertebrates metrics/indices effectively measures impairment, however, fish and invertebrates cannot always distinguish specific stressors (Miltner and Rankin, 1998)**



Can Metrics/Indices Measure Human Disturbances



Can Algal Metrics/Indices Measure Nutrient Effects





Case Study 1: Clear Creek, Texas

Reference site

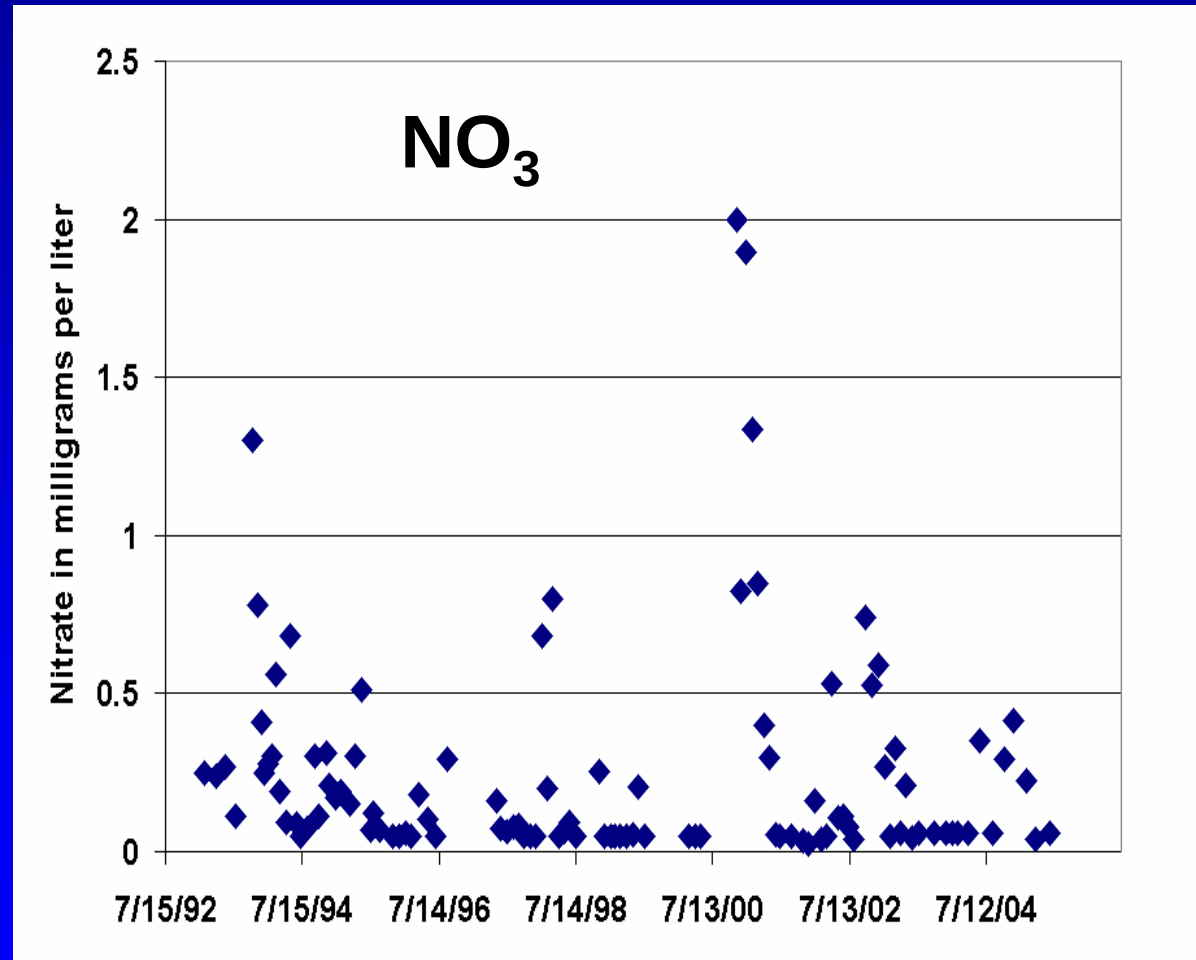


Clear Creek



Nutrient Concentrations in Clear Creek

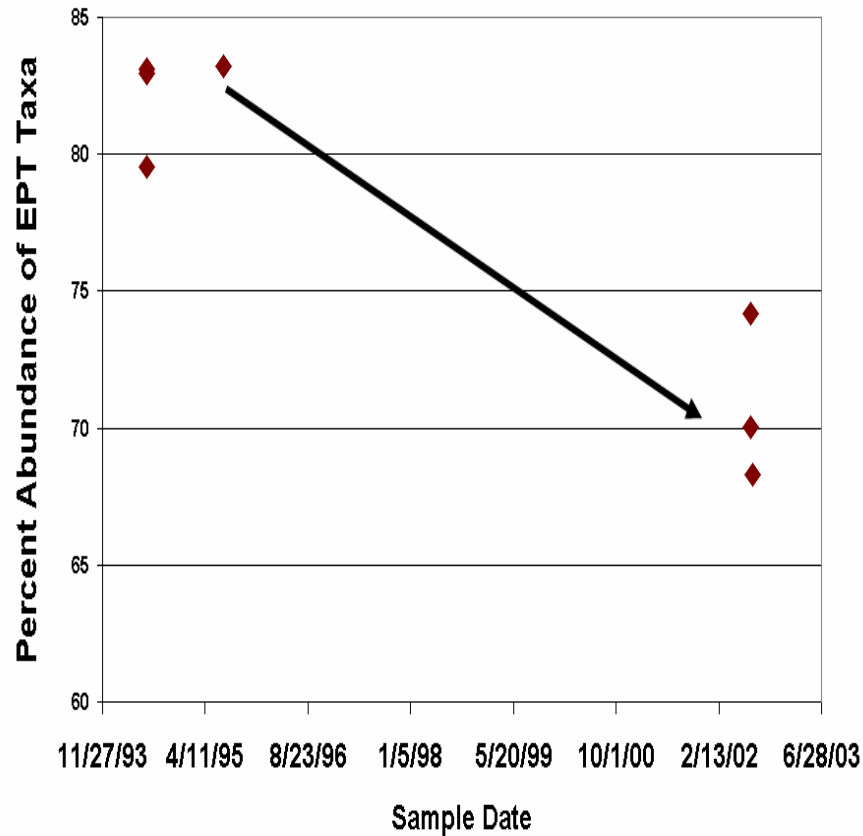
- No trends:
 - NO_3
 - Total N
 - SRP
 - Total P



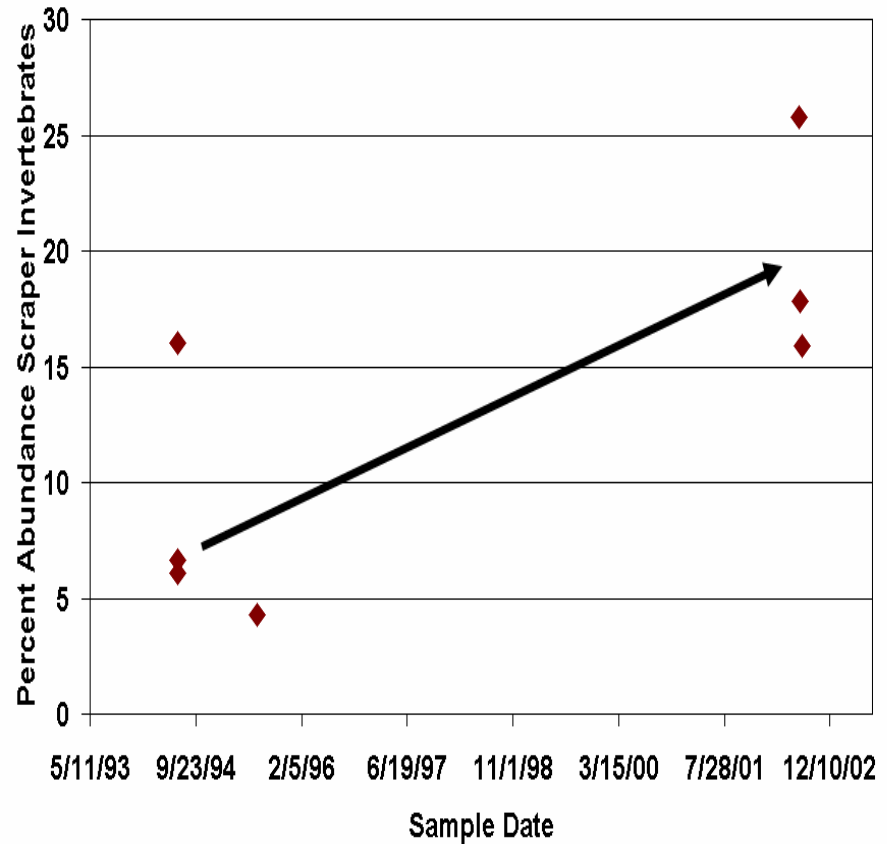


Invertebrate metrics suggest a decline in water quality

EPT Taxa



Invertebrate Scrapers

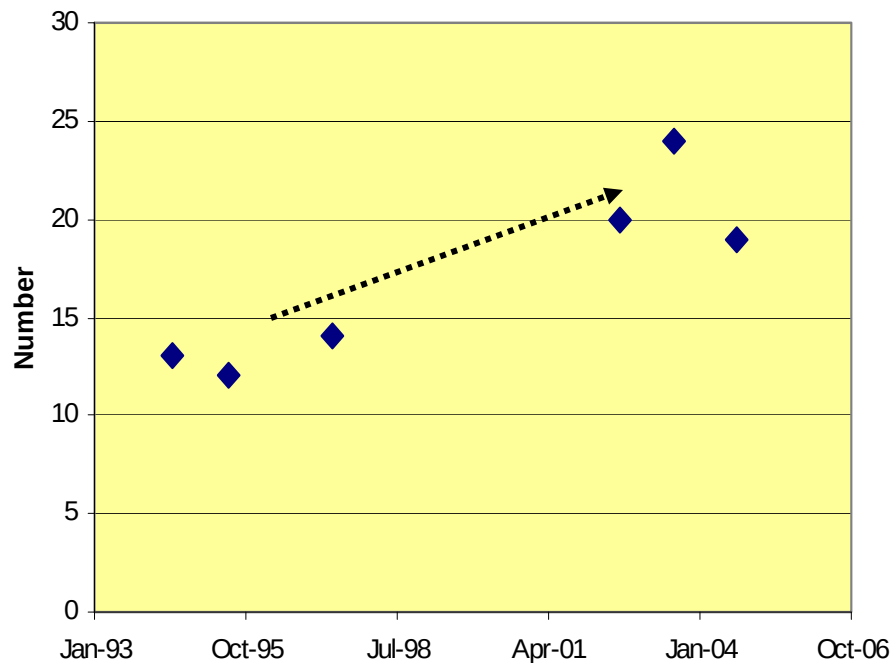




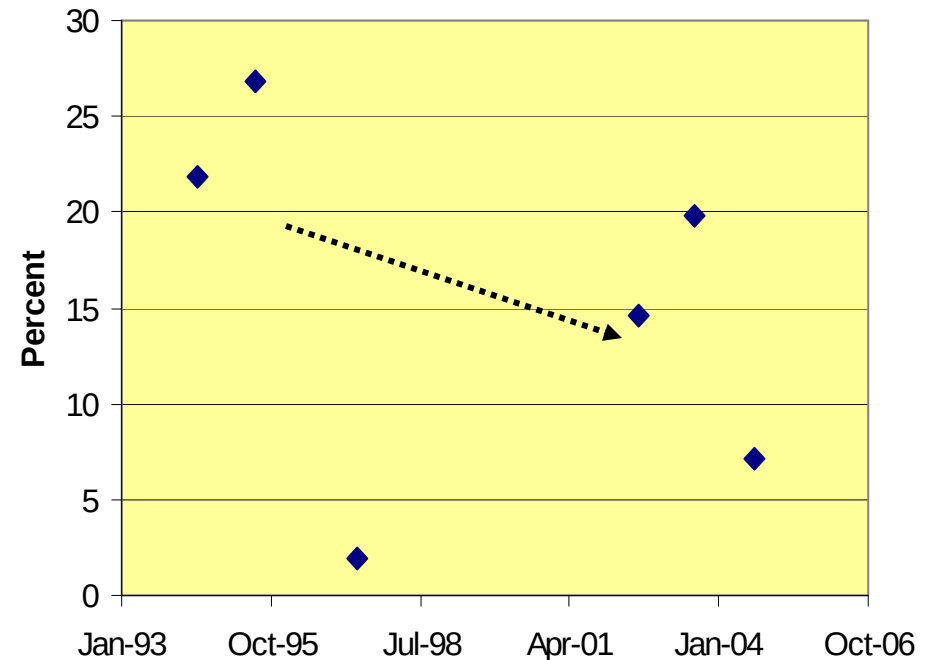
Fish Data

suggest increasing productivity

Number of fish species

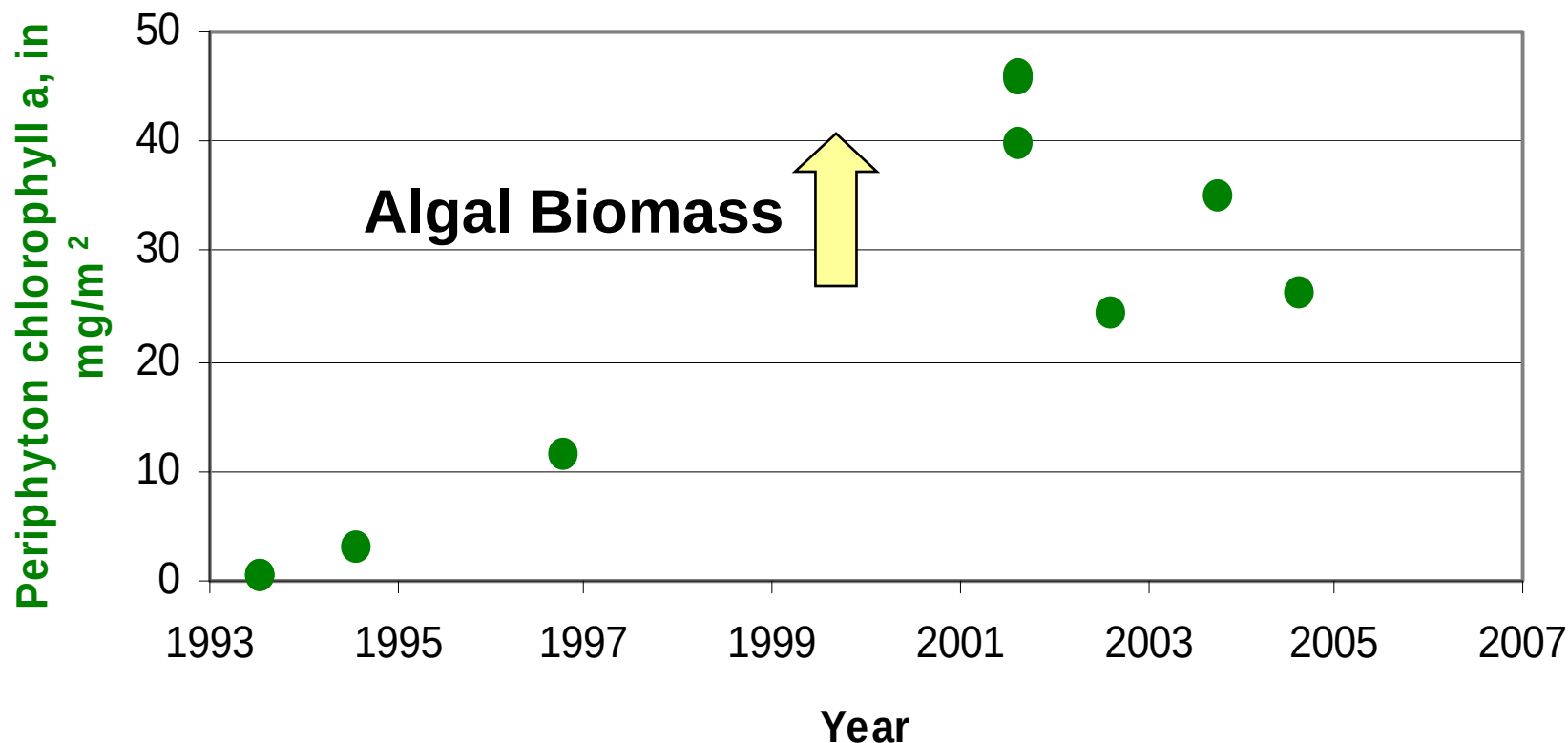


Percent carnivorous fish



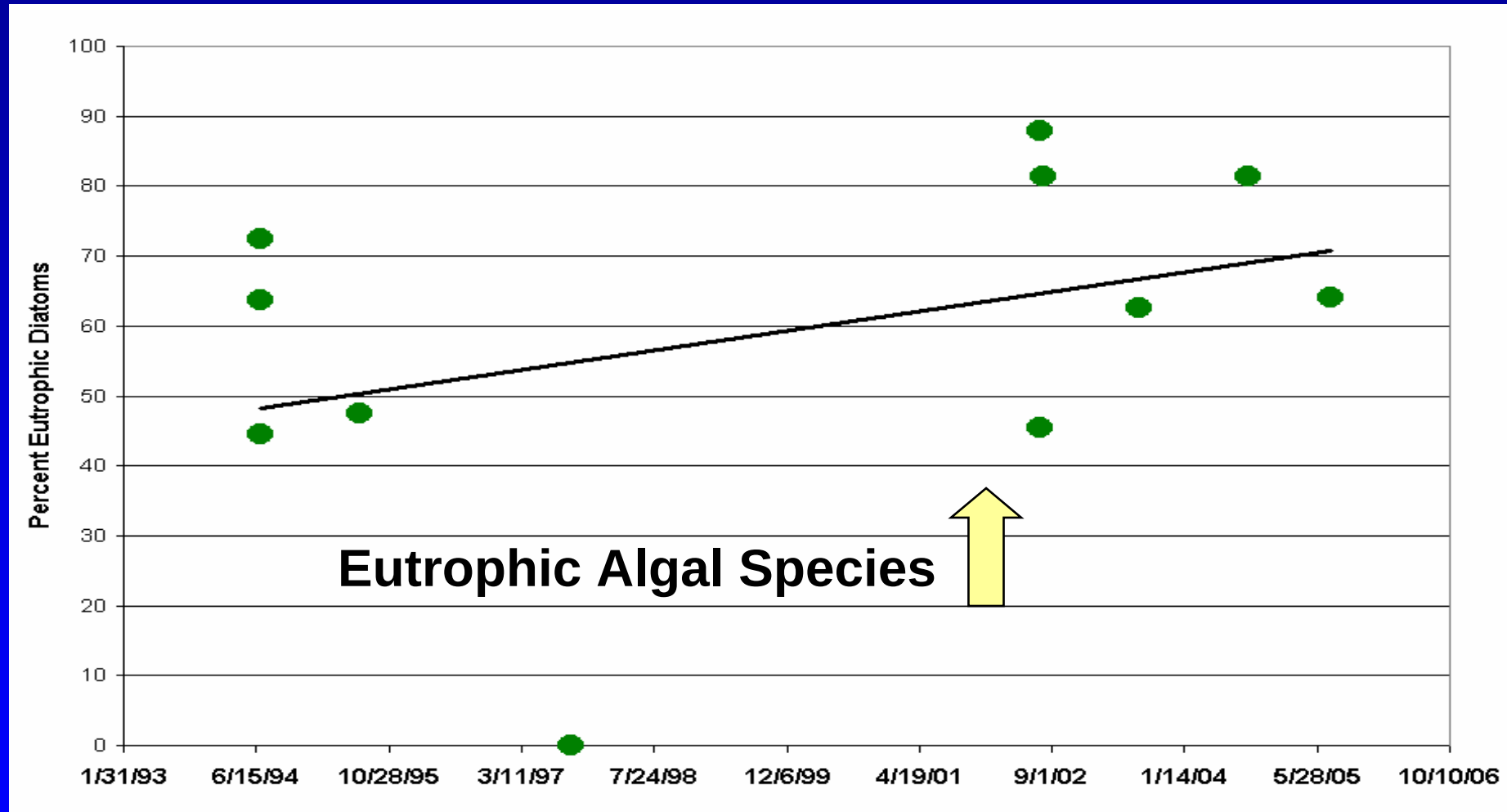


Chlorophyll a shows higher productivity





Increase in eutrophic diatoms supports increased nutrients



Which Biological Communities Best Reflect Nutrient Impacts?

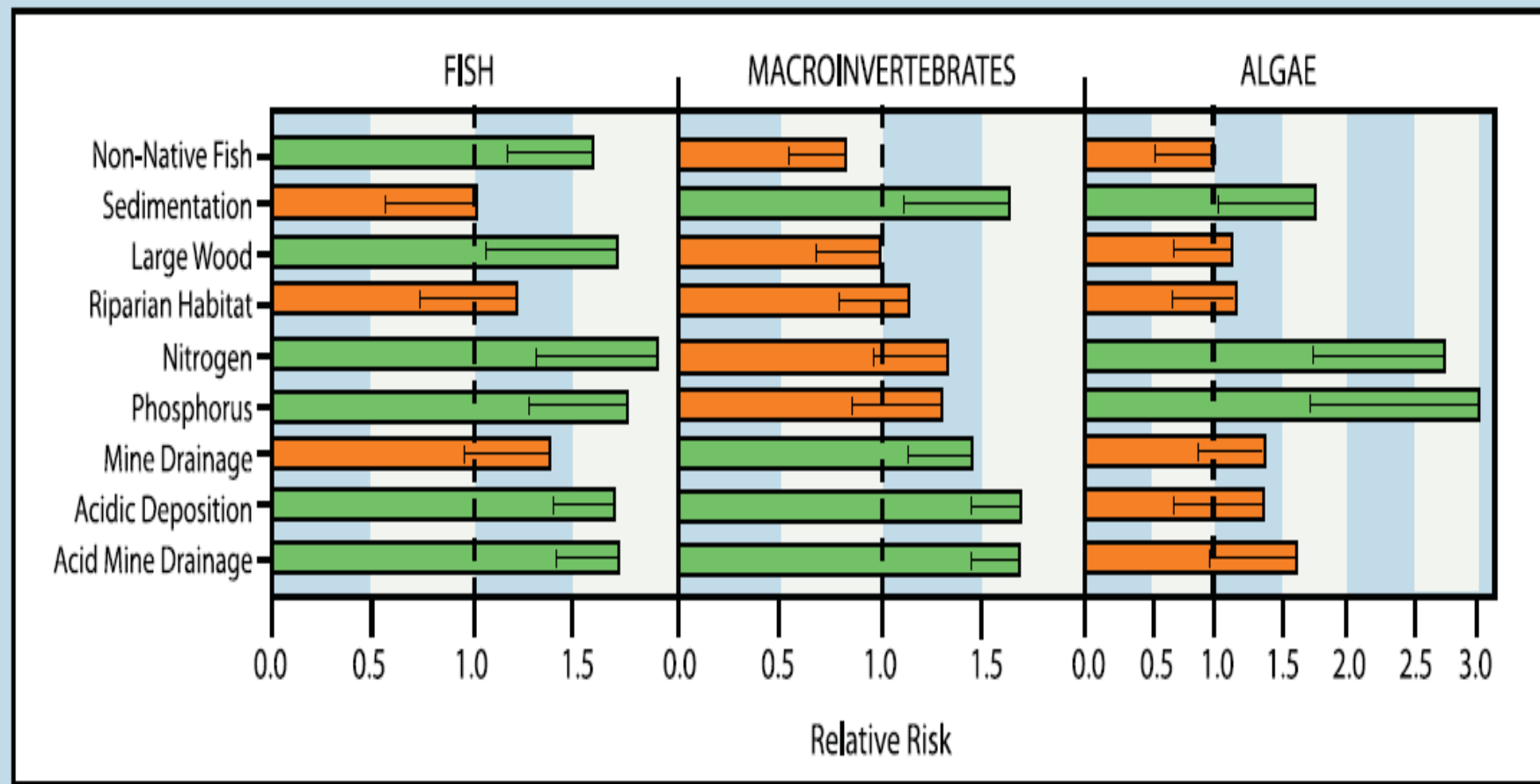


Figure developed by John Stoddard based on data from the Mid-Atlantic Highlands Streams Assessment (EPA 2000, EPA/903/R-00/015)



Objective

Which fish, invertebrate, and periphyton diatom metrics best reflect the effects of excess nutrients in the Cornbelt and Northern Great Plains and Mostly Glaciated Dairy Region Nutrient Ecoregions (MRB 3)?

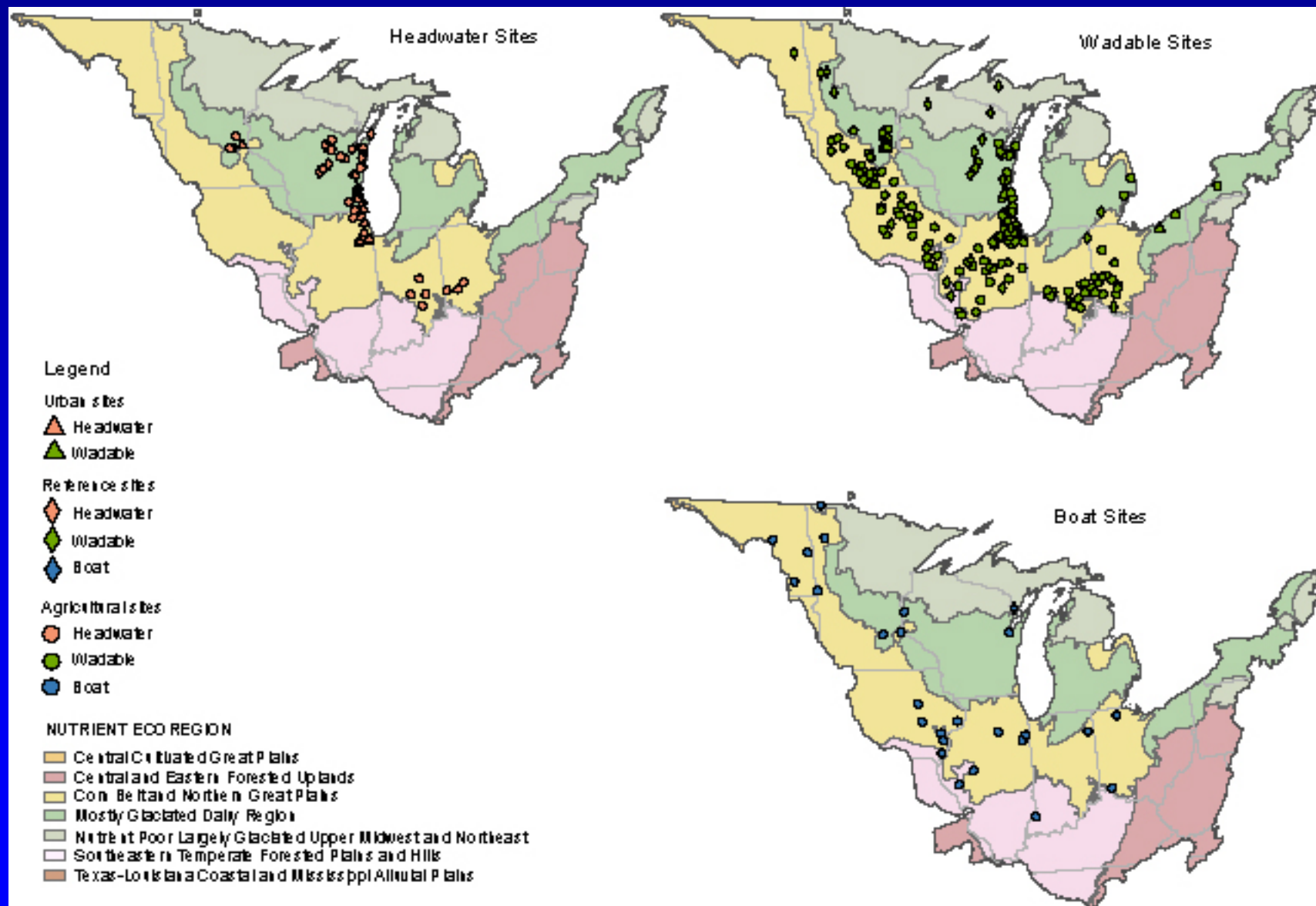
Hypotheses

- **H₁:** The fish, invertebrate, and periphyton diatom metrics/indices will effectively differentiate between impaired and unimpaired sites
- **H₂:** The periphyton diatom metrics will indicate a stronger correspondence with nutrients than fish or invertebrates

Methods

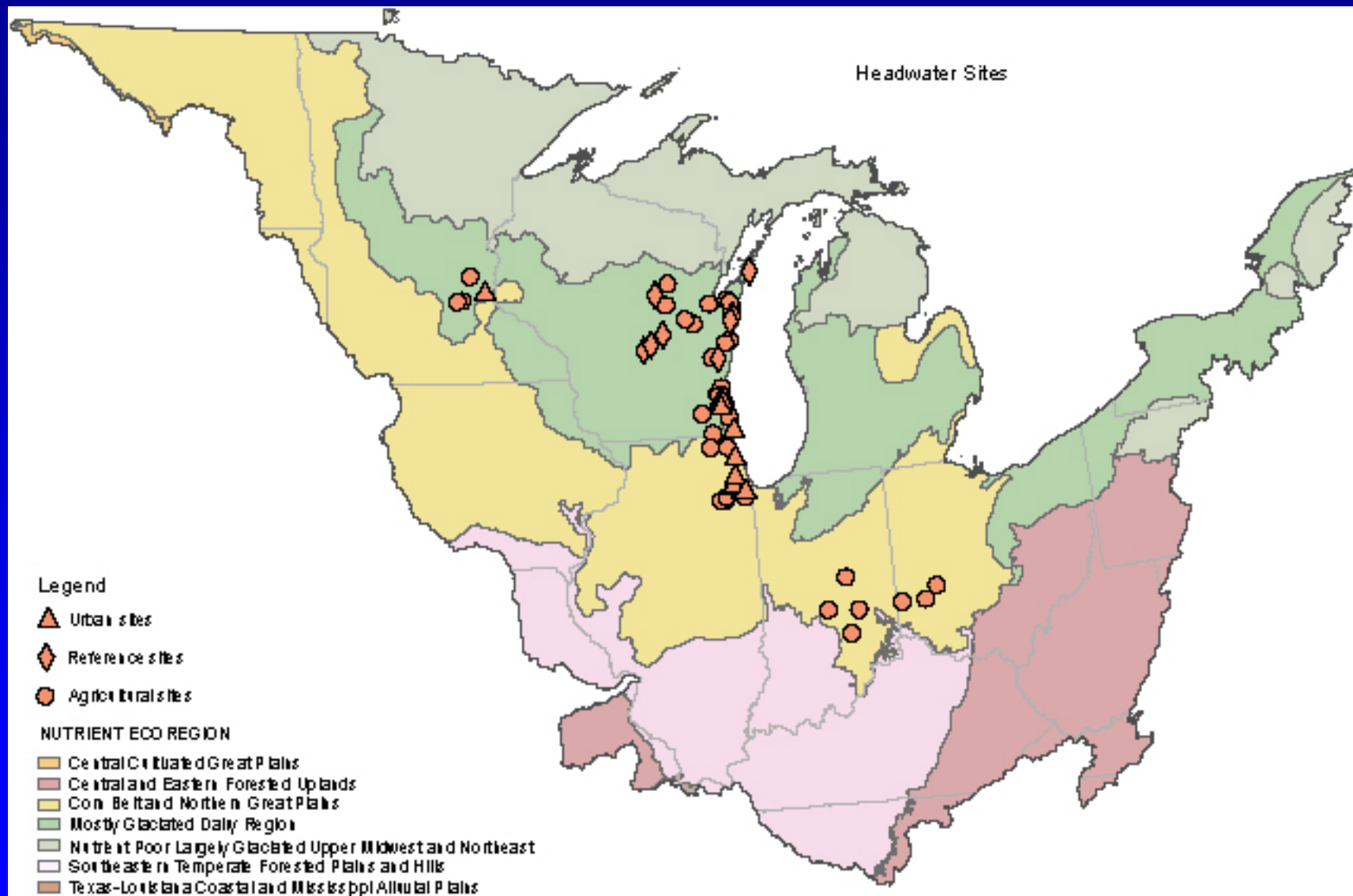
- **Building the database for analysis –**
 - **Begin with all possible NAWQA sites**
 - **Select those with nutrient, algal, invertebrate and fish data**
 - **Separate sites by drainage basin size**
 - **Headwater, Wadeable, and Boat streams**
 - **Nutrient gradient (reference to impacted)**

Potential MRB3 Sites

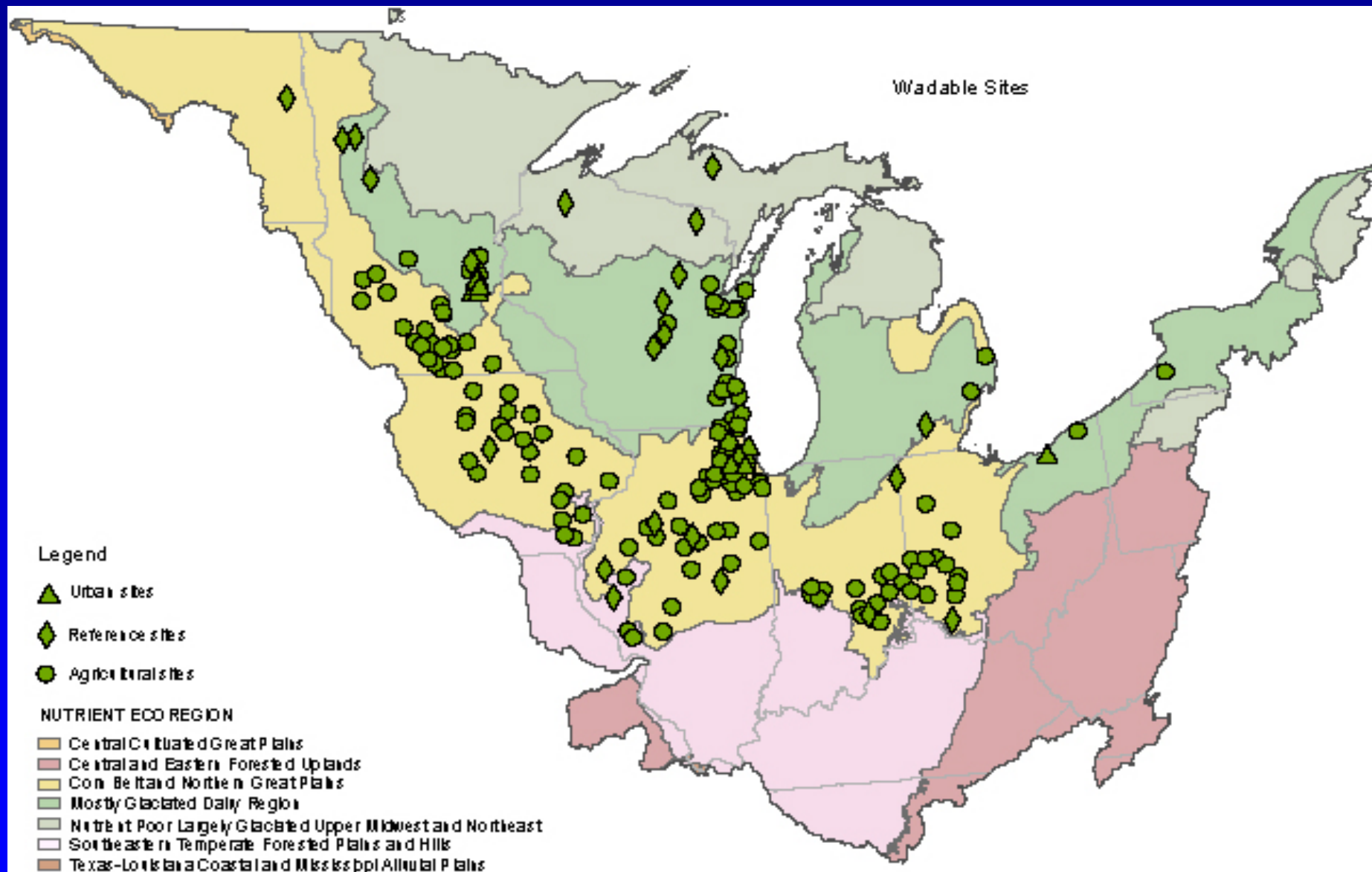




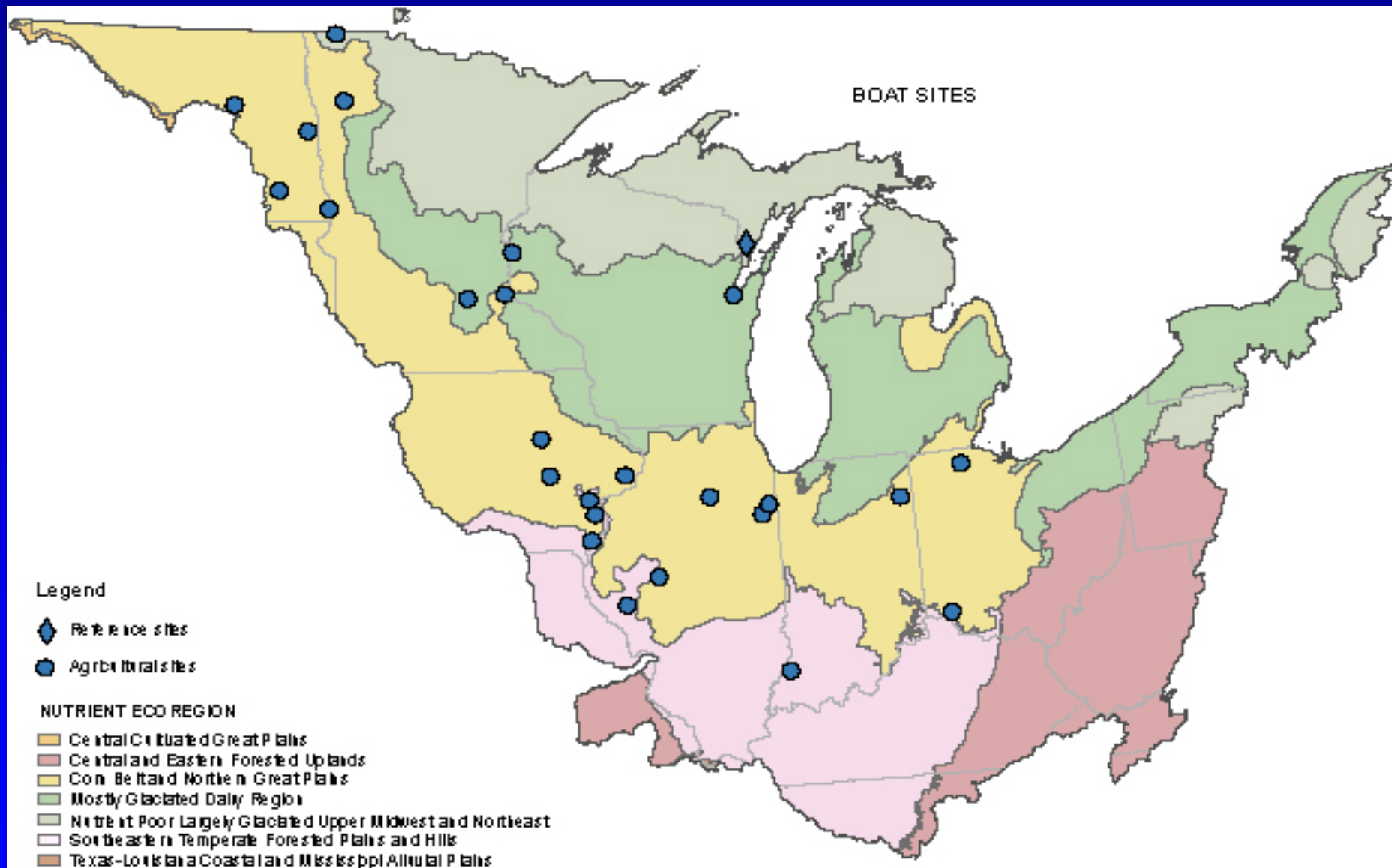
Potential MRB3 Sites - Headwater



Potential MRB3 Sites - Wadable



Potential MRB3 Sites - Boat





Methods

Determine reference sites

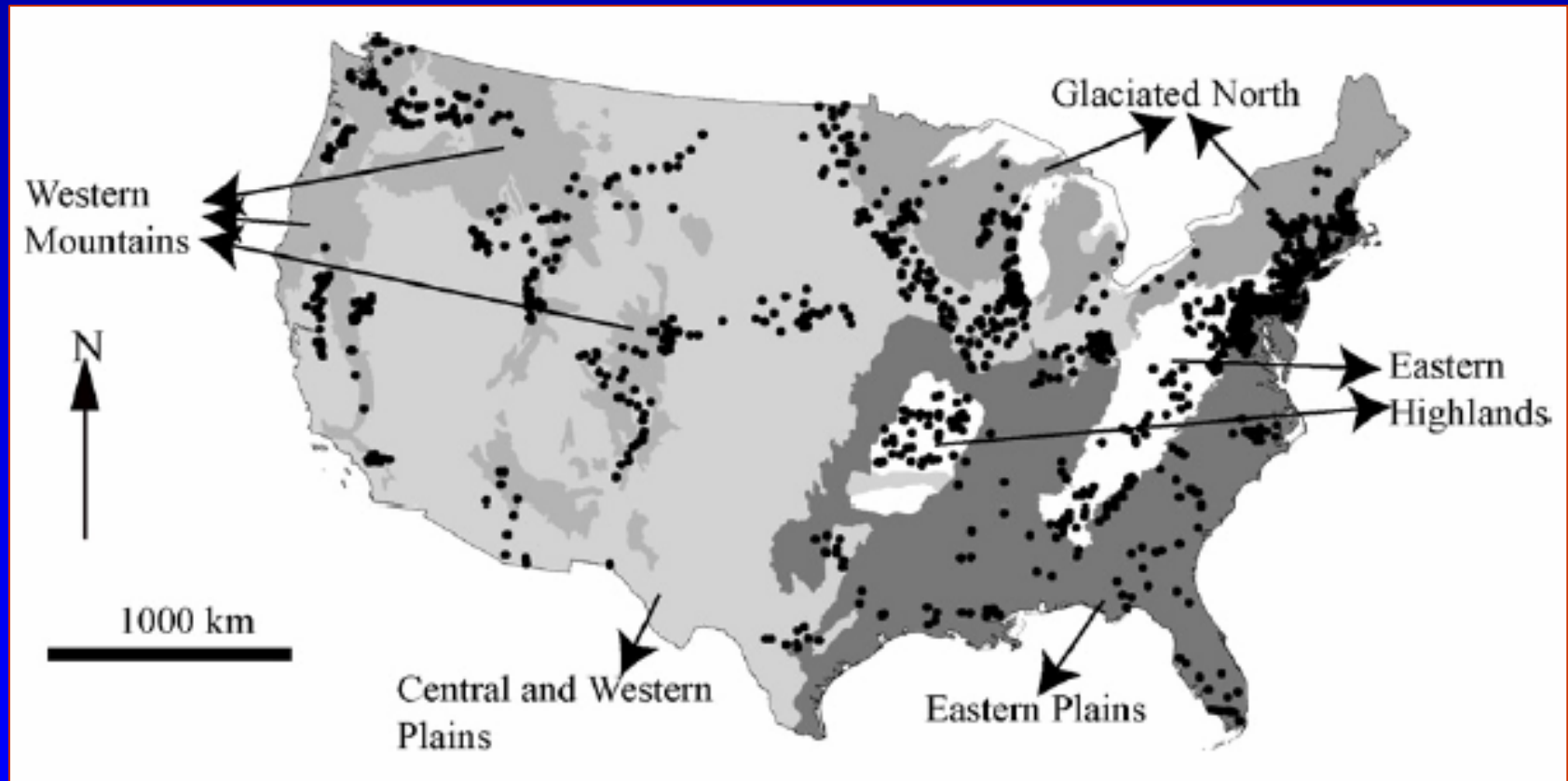
Total disturbance score: Based on sum of 0 (low) – 2 (high) level of disturbance in each of the following:

- URBAN: housing unit density, 2000, housing units/sq km
- URBAN: percent urban landcover, 1992
- URBAN: road density, 2000, km/sq km
- AG: all pesticides, 1997, kg/sq km
- AG: nitrogen from fertilizer and manure, 2002, kg/sq km
- AG: phosphorus from fertilizer and manure, 2002, kg/sq km
- FLOW: total dam storage, megaliters/sq km
- FLOW: percent streams "Canal/Ditch/Pipeline"
- FLOW: NPDES density, all point locations/100 sq km
- MINING: density of 2003 Mineral Operations locations/100 sq km
- MINING: percent mining/transitional landcover, 1992



Methods-regions within MRB3

Five Diatom Ecoregions based on national-scale
NAWQA dataset from 1340 sampling sites



Western and Central Plains Diatom Ecoregion Calibration Sites



- 127 sites
- 11 Reference
- 92 Agricultural
- 18 Mixed land use
- 6 Urban

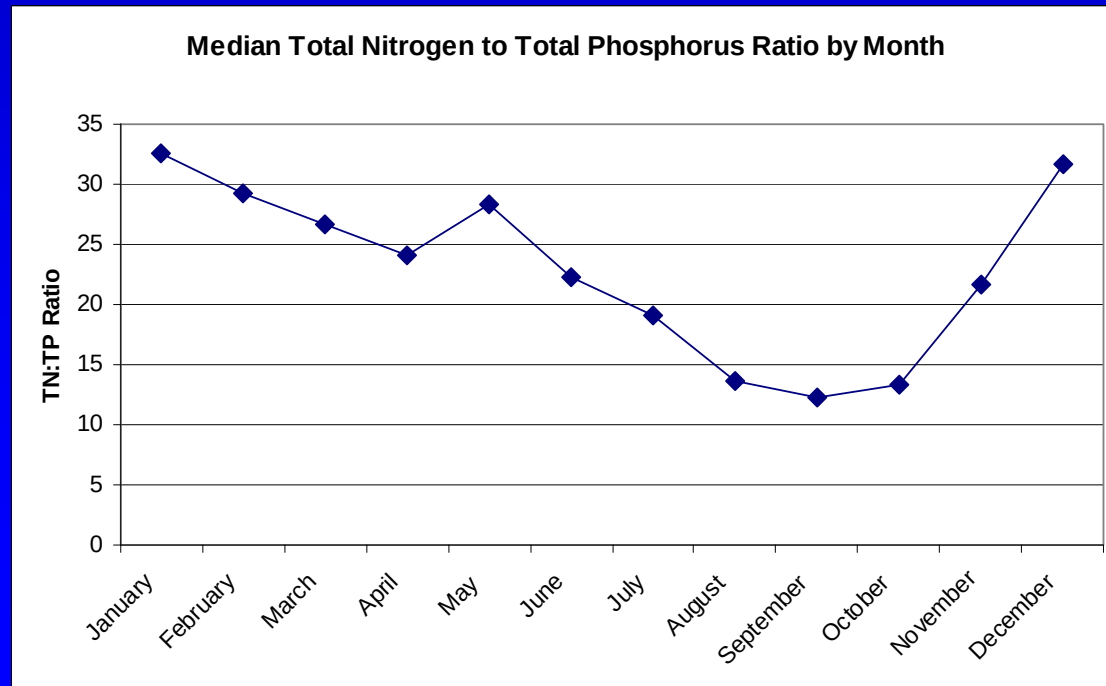
Glaciated North Diatom Ecoregions Calibration Sites



- 48 sites total
- 12 Reference
- 13 Agricultural
- 17 Mixed land use
- 6 Urban

Methods (cont.)

- Determine which nutrients have the strongest relations with the algal, invertebrate, and fish community metrics
 - Seasonal (fall, spring)
 - TN, TP, TN:TP ratios



Methods (cont.)

- Calculate metrics
 - Fish: OEPA, Goldstein and Meador, Simon
 - Inverts: IDAS. Cuffney
 - Algae: ADAS, Porter, Potopova, Bahls,...

Methods (cont.)

- Refinement of metrics
 - metric screening following Spaulding's Colorado model
 - evaluate the use of 286 algal, 171 invertebrate, and 56 fish metrics
 - compare all metrics for separation
 - maximize difference between reference and impacted sites
 - calculate signal (difference between sites) to noise (difference among sites) ratio
 - remove metrics that are redundant (Spearman *rho* correlation matrix)

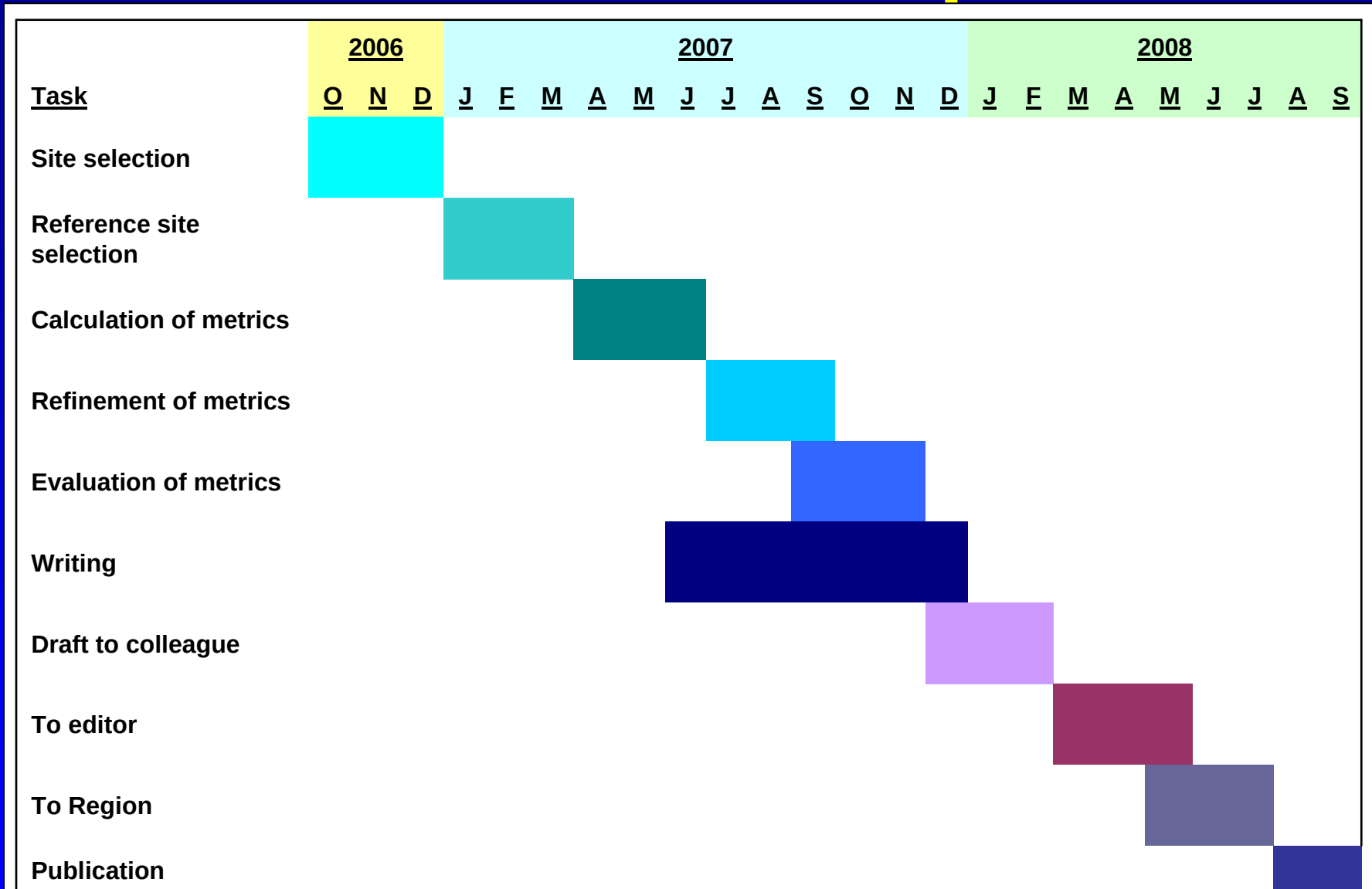
Methods (cont.)

- **Cluster Analysis (CA)** – to view how sites cluster together by regions, reference sites ...
- **Detrended Correspondence Analysis (DCA)** - to explore the structure and relations of the biological assemblages
- **Principle Components Analysis (PCA)** – a multivariate analysis to explore which nutrient variables have the strongest relations with selected biological metrics

Methods (cont.)

- **Summarize the best combination of biological metrics for evaluating nutrient impairment**
- **These metrics could be the focus for States when developing Nutrient Criteria**
 - **using threshold analysis**
 - **Nutrient Index of Biotic Integrity**

Timeline for report





W. Central & SE Plains Diatom Ecoregions Calibration Sites



- 130 sites
- 11 Reference sites
- 92 Agricultural sites
- 18 Mixed land use
- 6 Urban sites