USING COMPLEMENTARY TOOLS FROM THE ECOLOGICAL TOOLBOX TO ESTABLISH AND APPLY NUTRIENT CRITERIA

R. Jan Stevenson, Steve Rier, & Rich Schultz
University of Louisville/Michigan State University

Mike Wiley & Catherine Riseng
University of Michigan

Joe Holomuzki
Ohio State University at Mansfield

Brian Hill, Alan Herlihy, Sue Norton, Lester Yuan
U. S. Environmental Protection Agency

Objectives

- To develop nutrient criteria to support Clean Water Act goals
  - To Evaluate Rationale for Tiered Aquatic Life Use Criteria & Corresponding Tiered Nutrient Criteria
    1. Interim Goal of CWA - Fish Shellfish & Wildlife
    2. Ultimate Goal of CWA – Biological and Ecological Integrity
- To determine effects of nutrients on algal communities in streams
  - To relate effects of nutrients on algae in streams to CWA goals (Aquatic Life Uses)

Complementary Tools

1. Aquatic Life Use Criteria and Stressor Criteria
2. Tiered Uses
   1. e.g., 1) Support natural structure and function vs.
   2. e.g., 3-4) Constrain nuisance algal growths (*Cladophora*))
3. Frequency Distributions & Stressor-Response Models
   1. Characterizing Natural Condition
   2. Valued Attribute Response to Stressor
4. Lowess Regression and Regression Tree for Threshold Analysis
5. Stressor Measurement and Biological Inference Models (e.g., Diatom Indicator of TP)
6. Standard Deviation vs Standard Error of the Mean
7. Guidelines for Use (to minimize misuse and abuse)

Developing Environmental Criteria: Restoration Goals and TMDL Targets

Two Basic Questions:

1. What is natural or expected condition?
2. How do human activities affect natural or expected condition?

Developing Environmental Criteria: Methods

Two Basic Questions:

1. What is natural or expected condition?

   "Frequency-Distribution Approaches"

   "Modeling Approach"

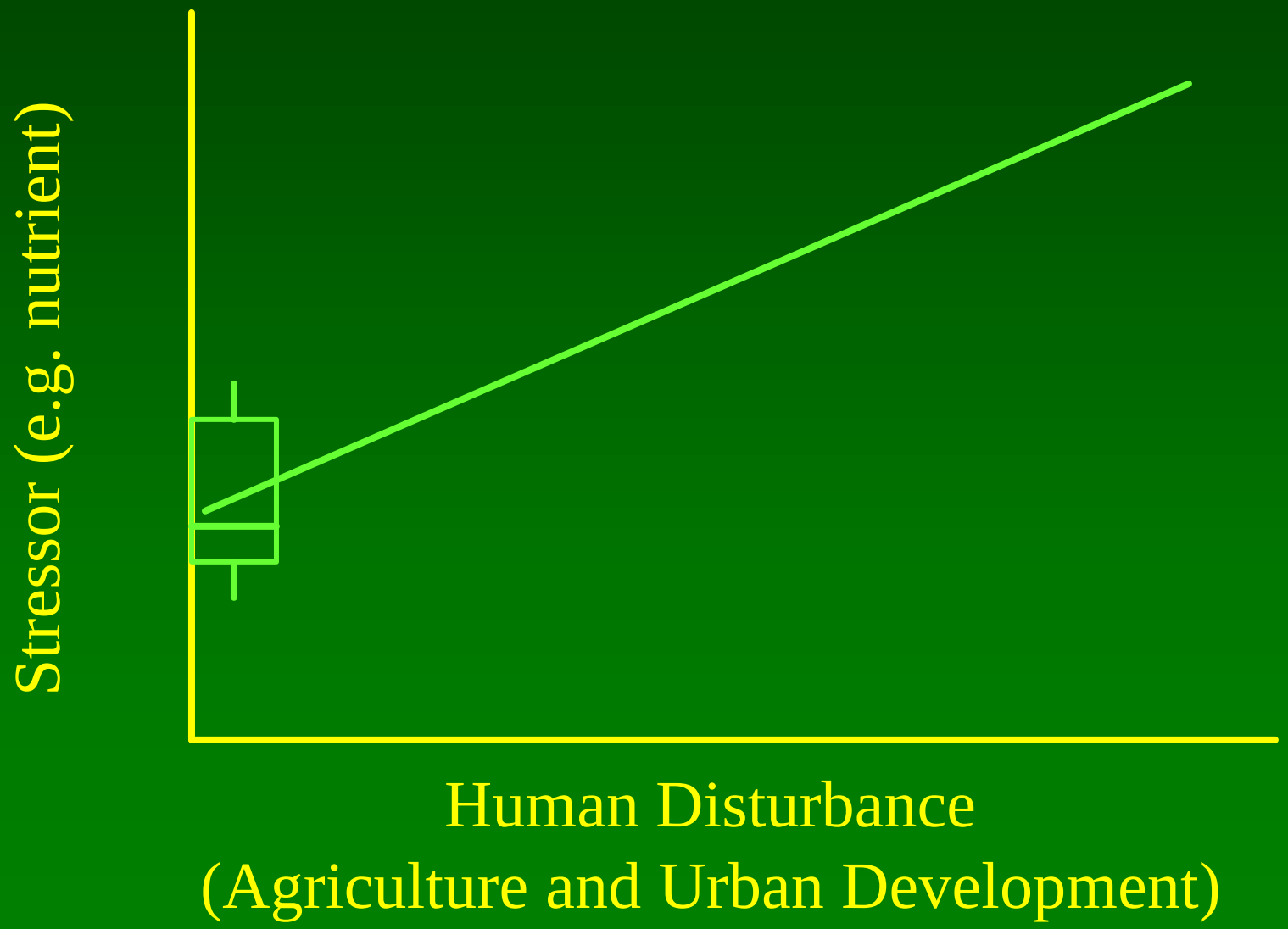
2. How do human activities affect natural or expected condition?

   "Stressor-Response Approach"

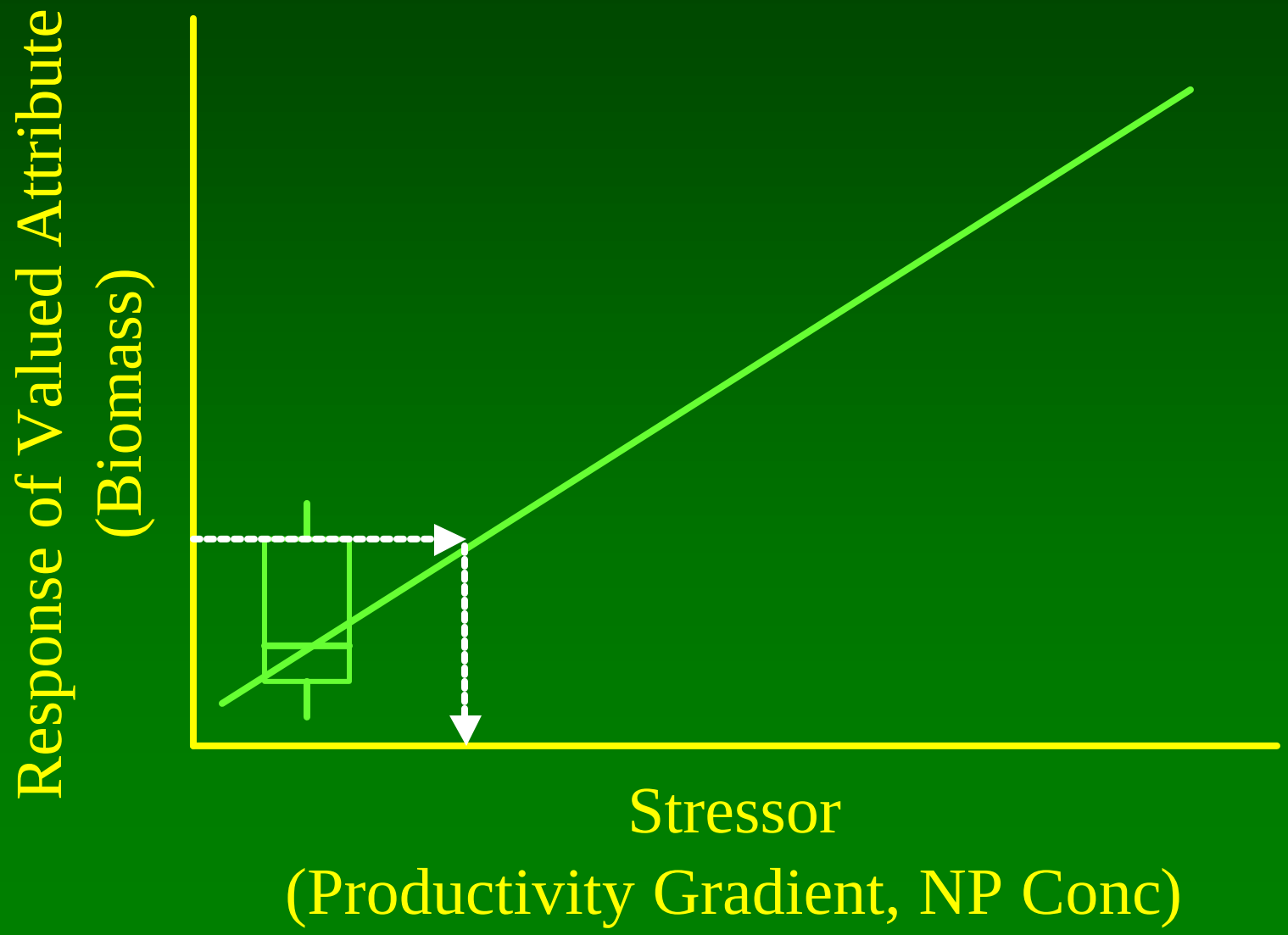
3. What level of contaminants sustainably support uses?

   "Stressor-Response Approach"

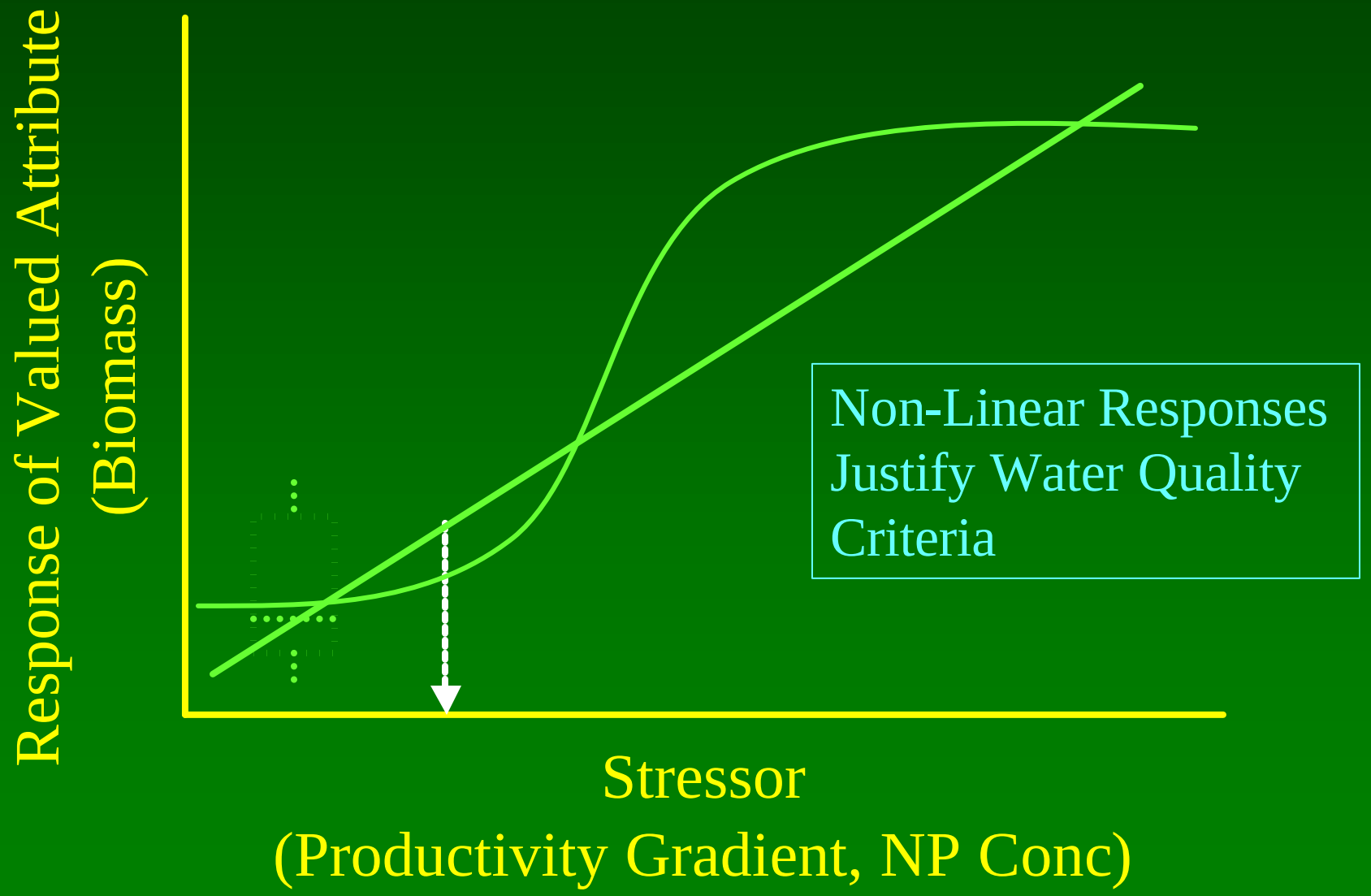
Modeling: Determine Predicted Level of Stressor with 0 Human Disturbance



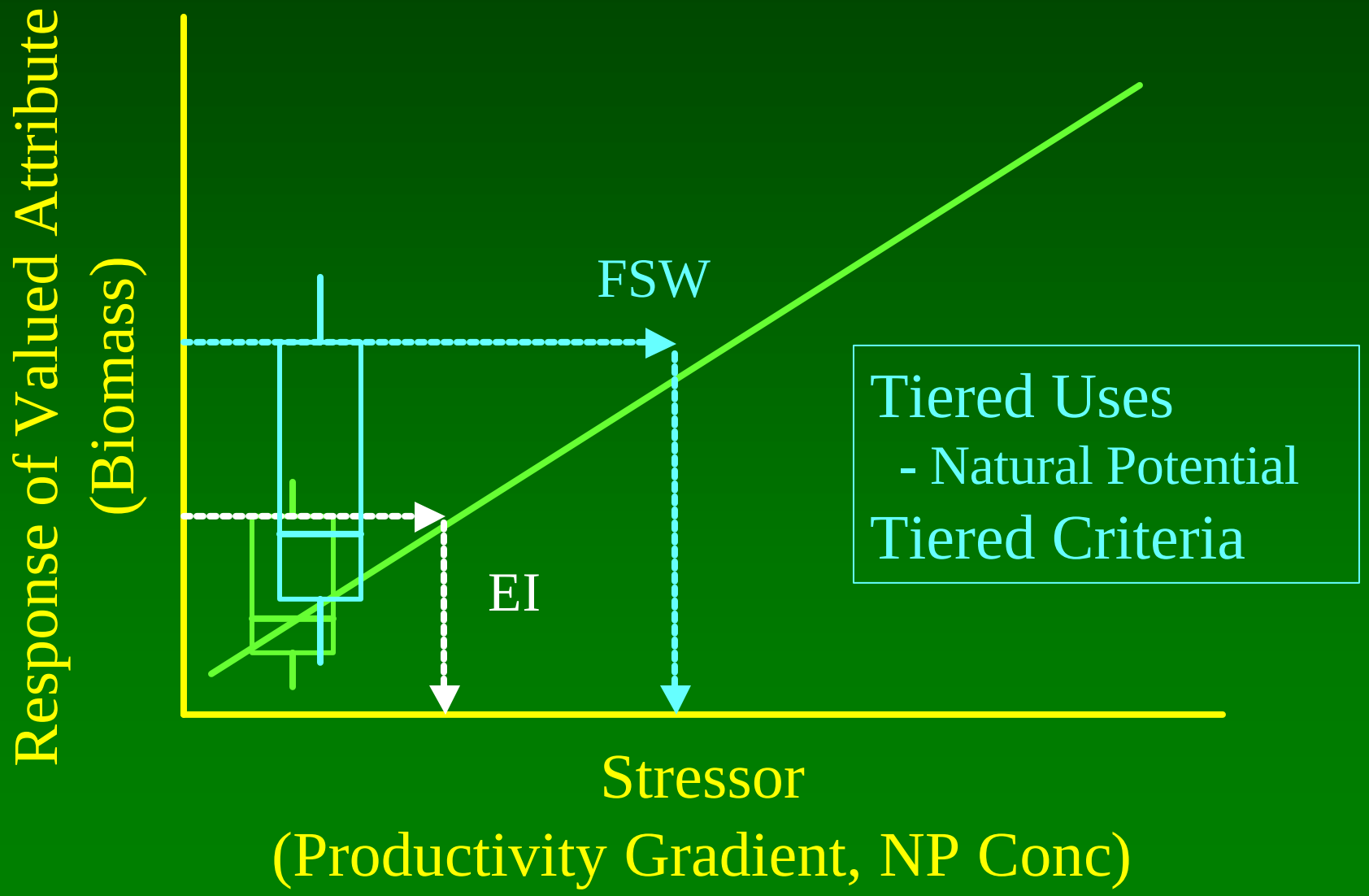
Integration of Frequency Distribution and Stressor-Response Approaches for Establishing Criteria



Integration of Frequency Distribution and Stressor-Response Approaches for Establishing Criteria

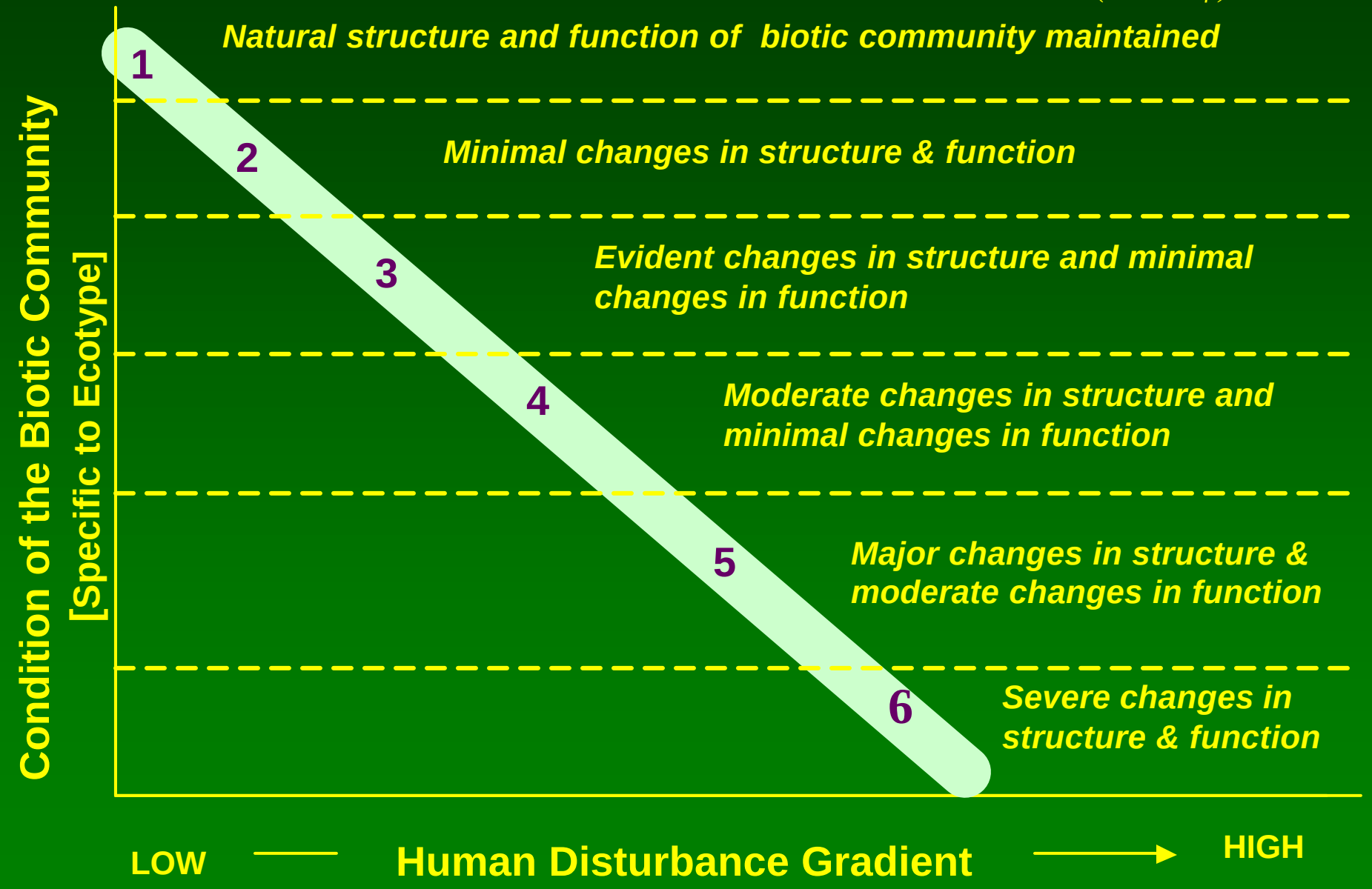


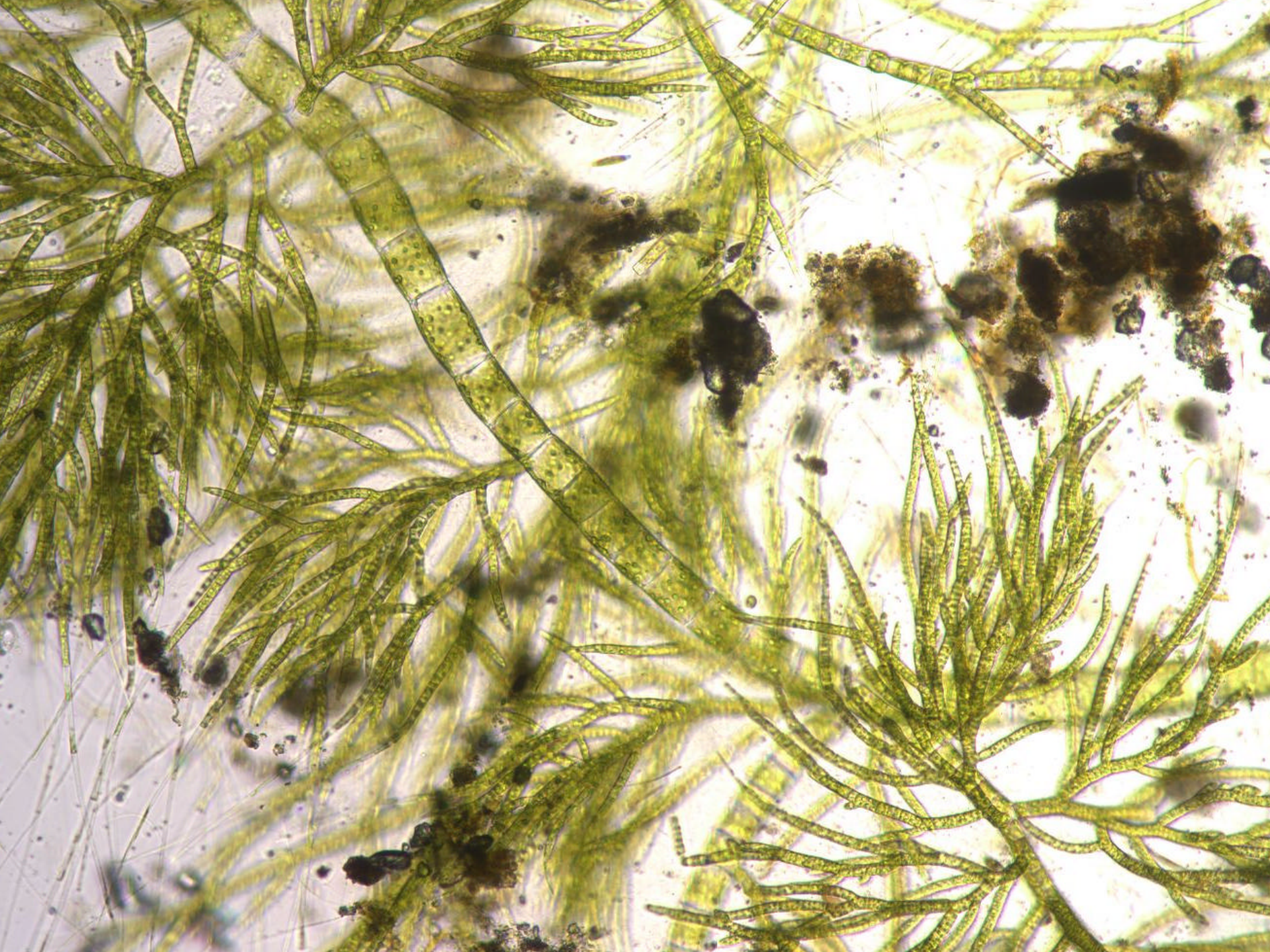
Integration of Frequency Distribution and Stressor-Response Approaches for Establishing Criteria



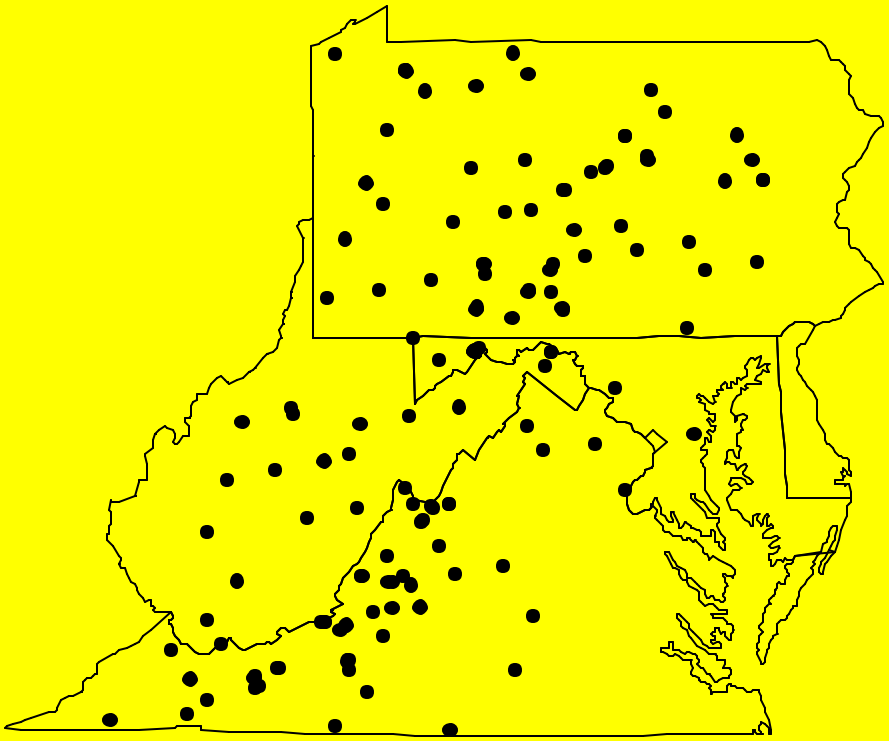
USEPA Tiered Aquatic Life Use Conceptual Model

(10/22 draft)



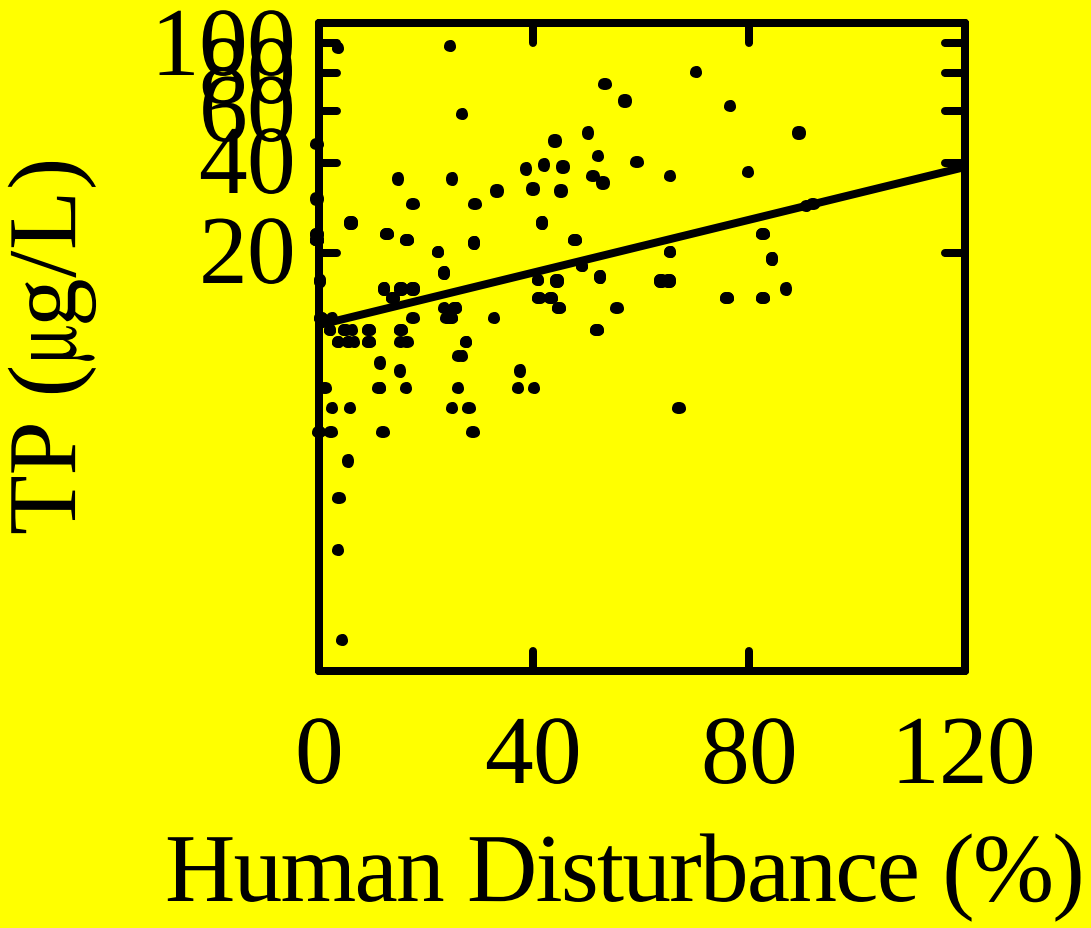


MAHA EMAP Study (‘93-’96)

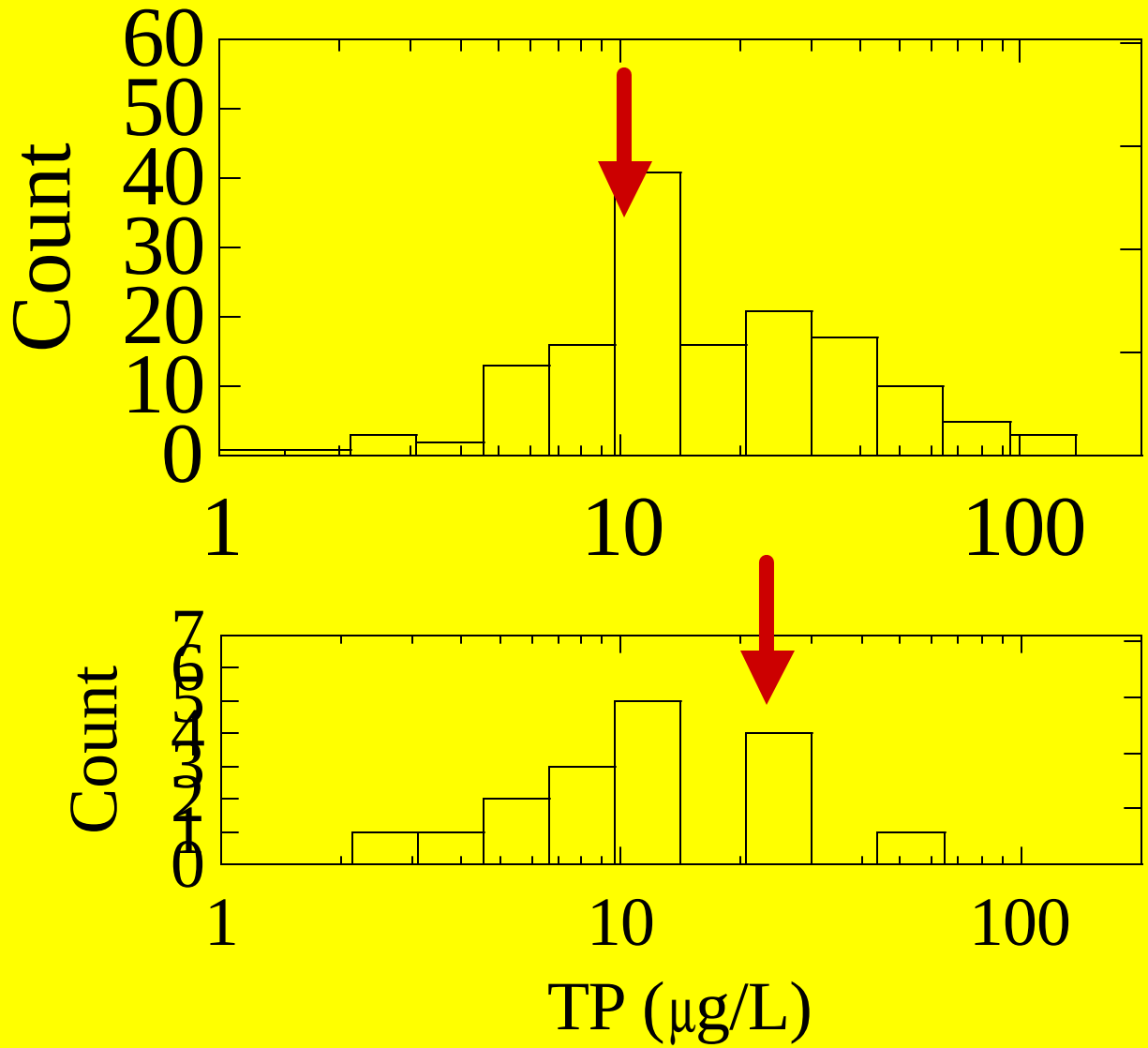


- Classified Streams by Expected Condition
- Diatoms Respond Greatly to Conductivity/pH Gradient in Reference Streams
- Selected 291 Well-Buffered Streams

9.6 µg TP/L is natural



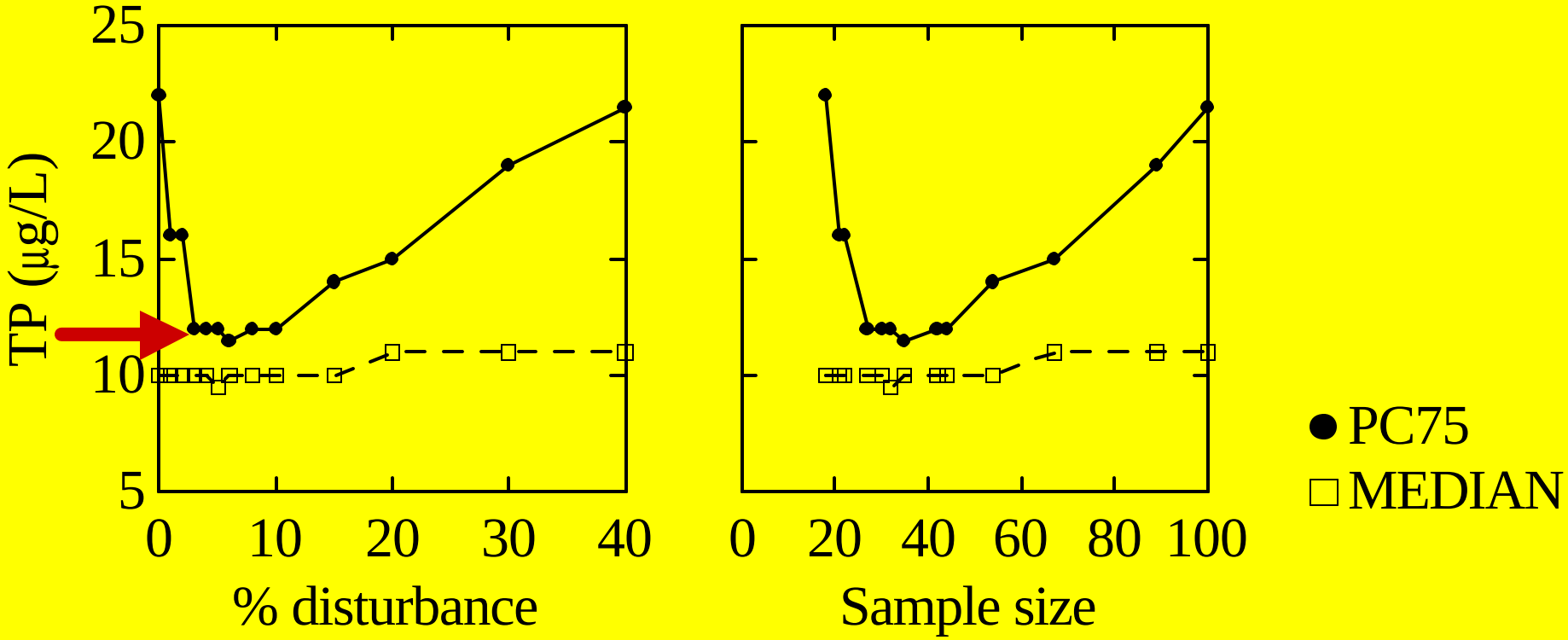
Frequency Distributions Approaches For Developing Criteria May Be Misleading



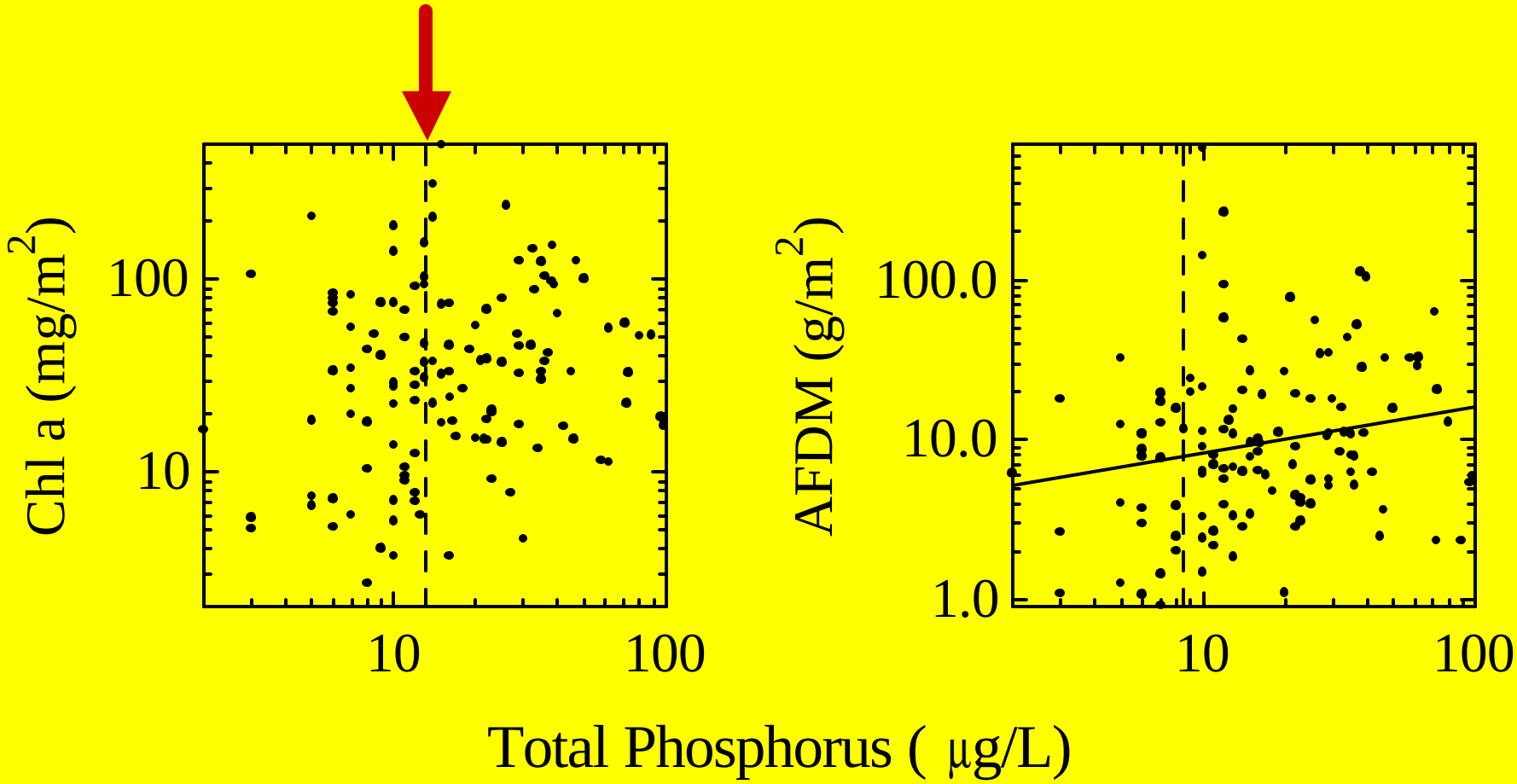
25th percentile of all well-buffered streams in the MAHA.

75th percentile of all well-buffered streams in the MAHA with 0% human disturbance.

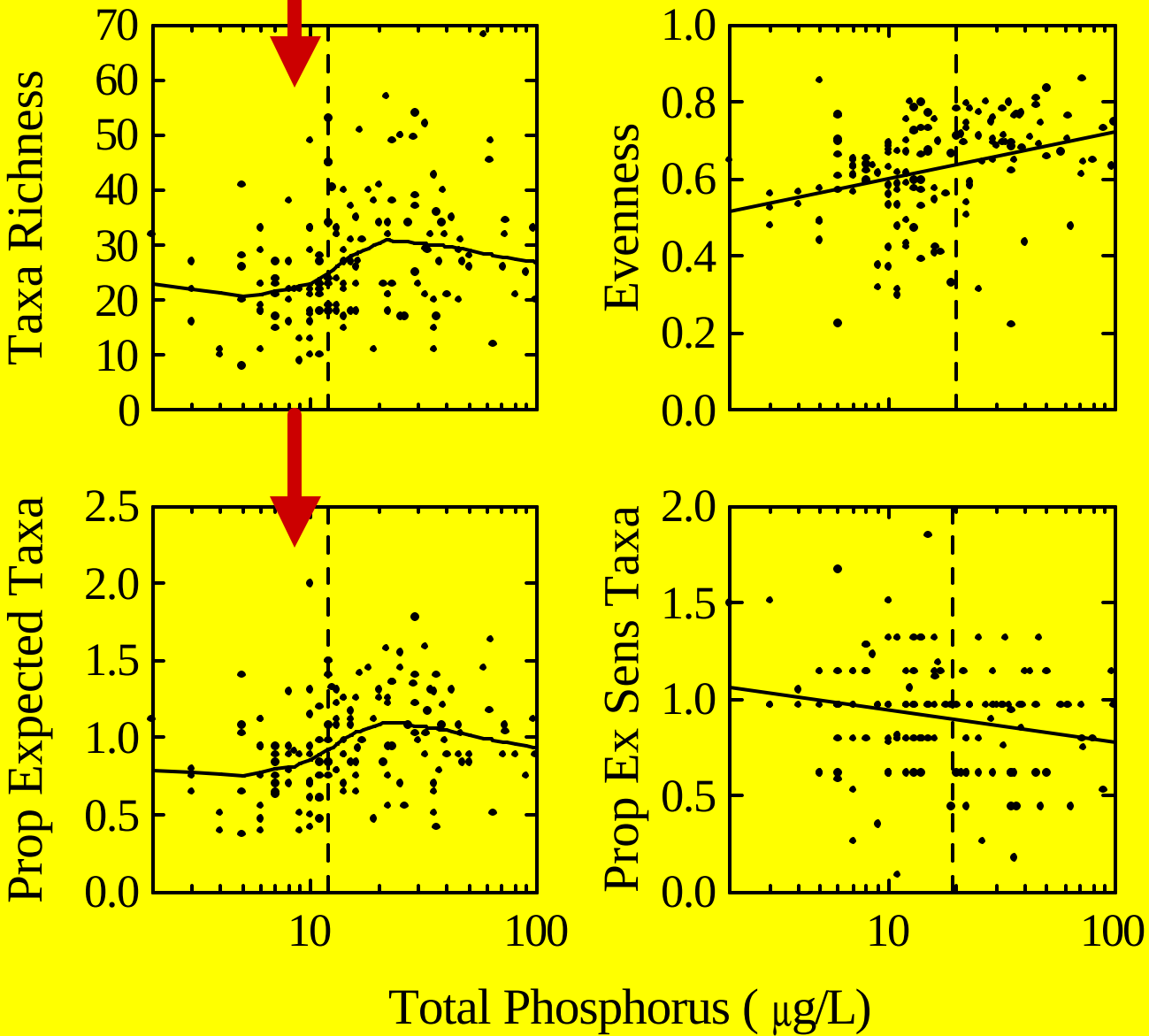
Low Sample Sizes May Constrain Precise Characterization of Reference Condition



Periphyton Biomass is Poorly Related to Nutrients When Sampled at Small Scale

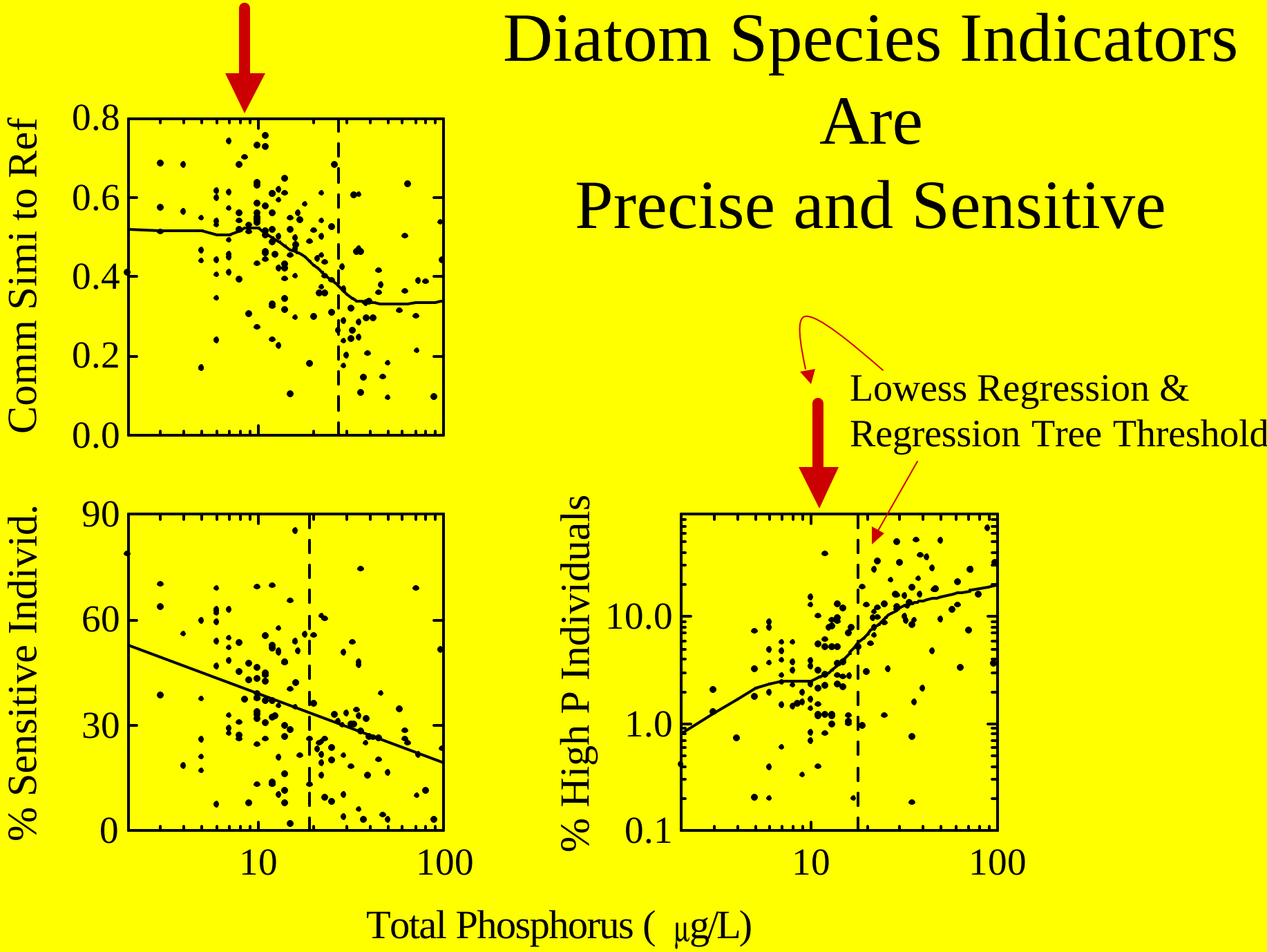


Total Algal Diversity Increases With TP, But Not Sensitive Native Taxa

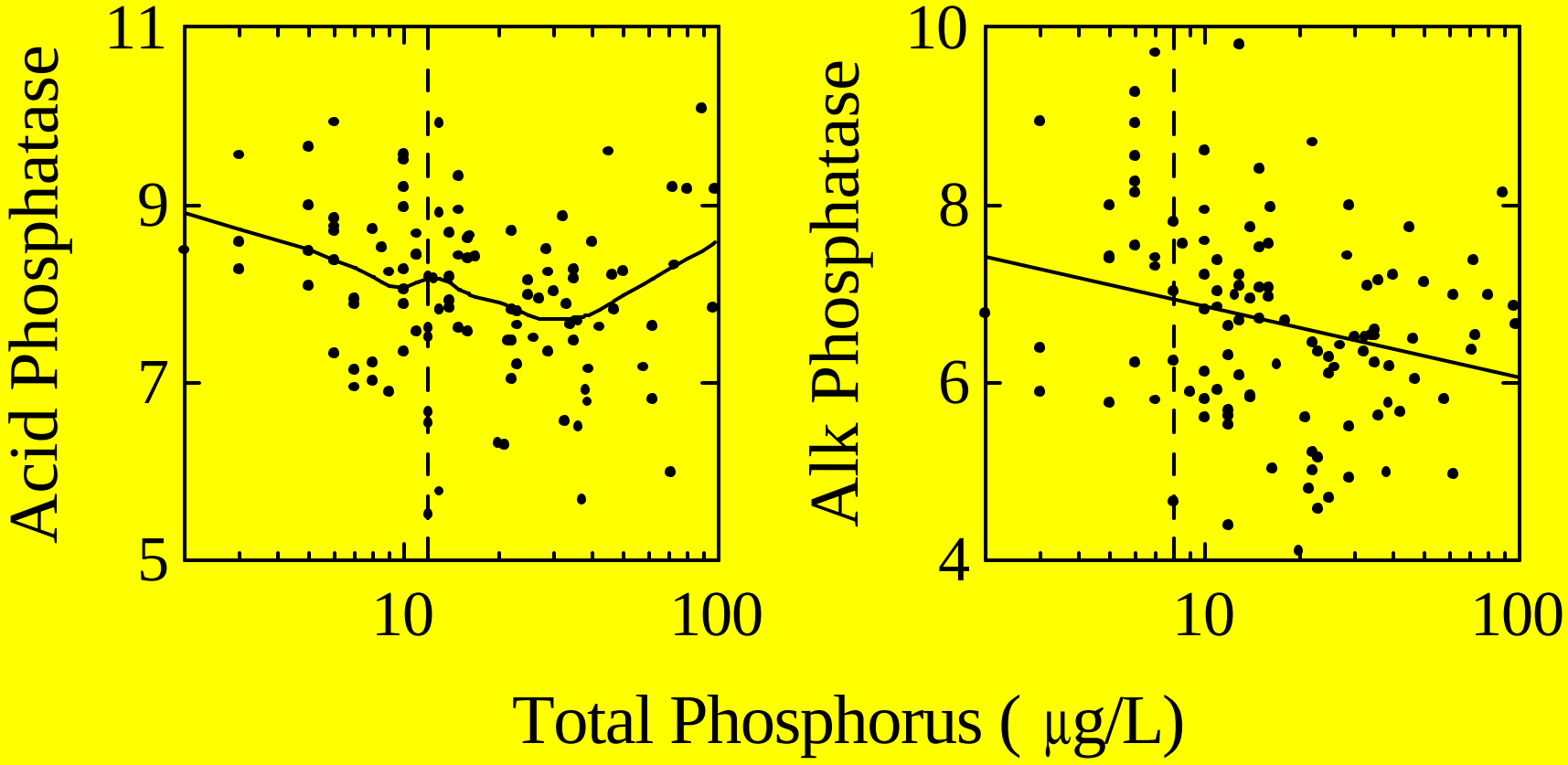


Lowess and regression tree thresholds are observed in many responses to TP enrichment between 10 and 12 µg/L.

Diatom Species Indicators Are Precise and Sensitive



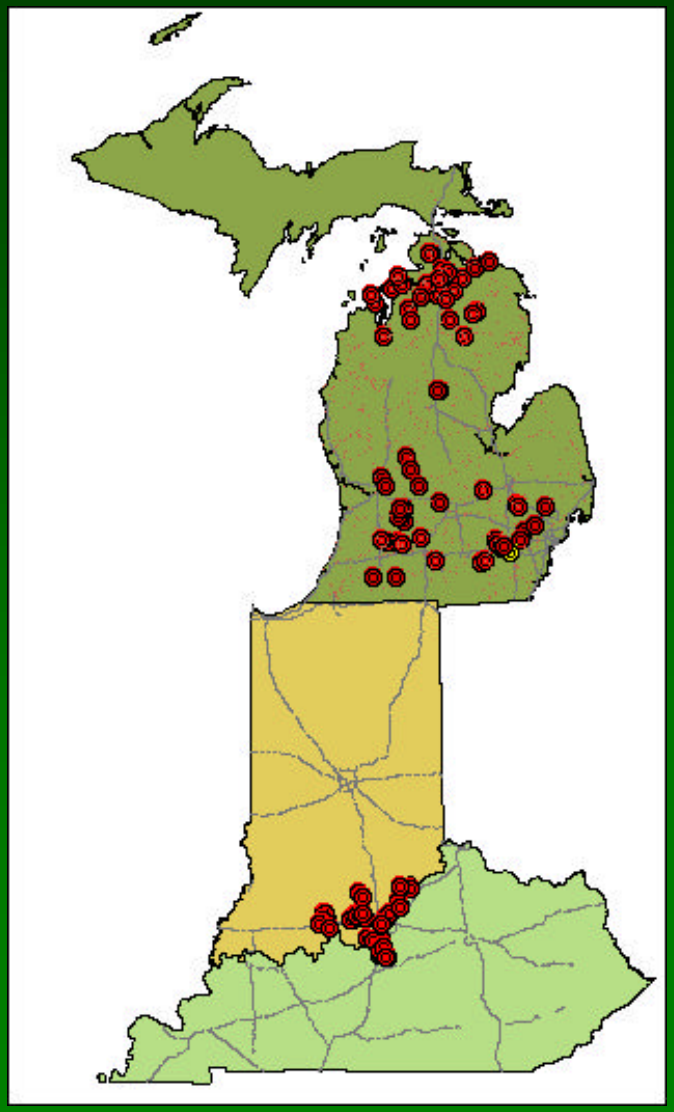
Enzyme Activity Indicates Release from P Limitation in Low P Range



Take Home Messages from MAIA

- Natural TP concentrations are about 10 µg/L
- That just happens to match 25th percentile of TP of all sites
- That is slightly less than 75th percentile of reference sites, after accounting for sample size
- Diatoms diversity responds TP increases in low range of TP concentrations
- Many threshold responses around 10 µg/L in diatom assemblages

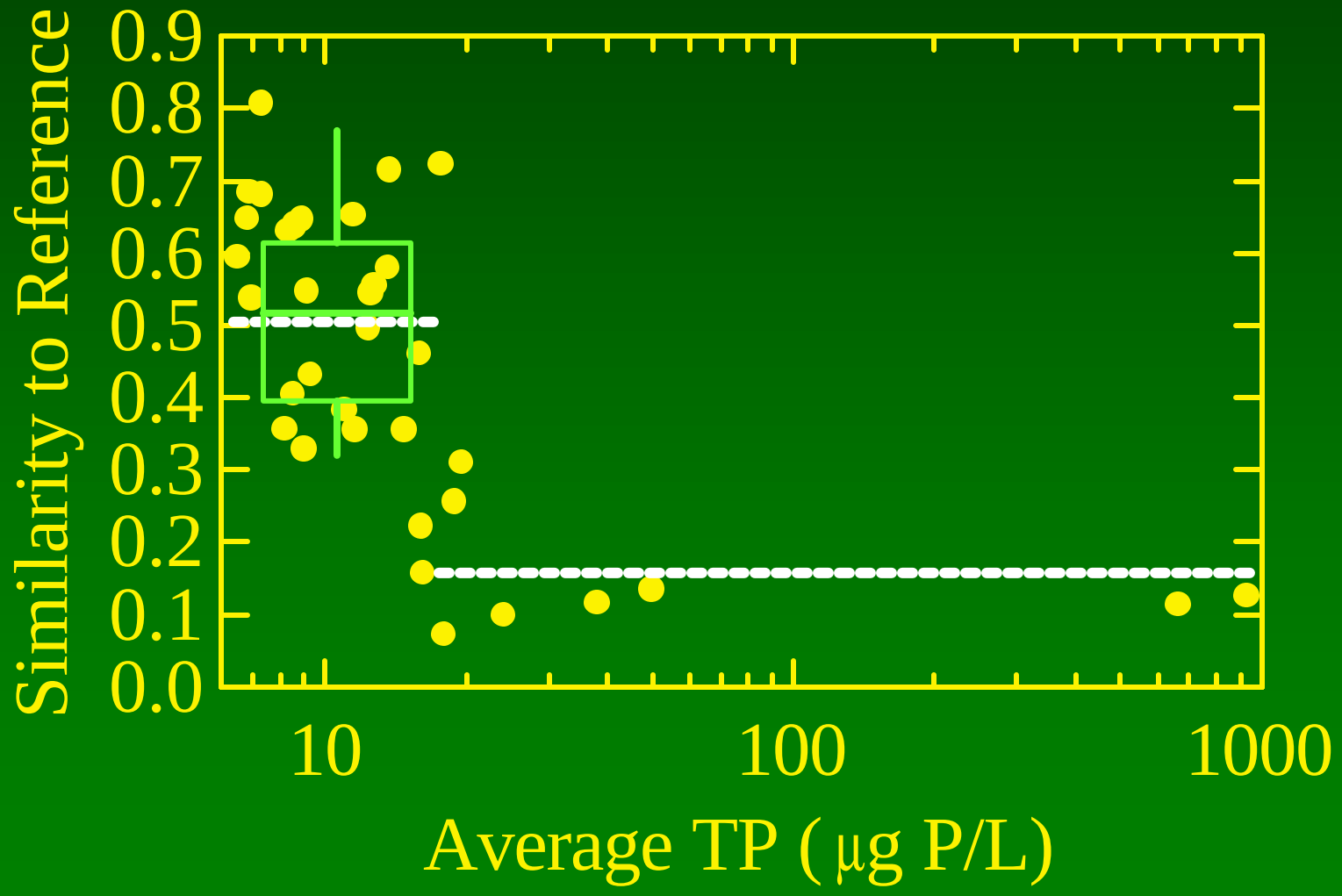
SAIN Sampling Sites



Parameters Assessed

- Discharge
- Temperature
- Canopy Cover
- Conductivity
- pH, alkalinity
- NO_3+NO_2, NH_4, TN
- PO_4 (SRP), TP
- Silica
- Chloride
- Total Suspended Solids
- Water Column Chl a
- Periphyton Cover and Thickness
- 9-rock composite samples for algal biomass & species composition **
- Inverts on 10 rocks5
- 5-rock clusters for invertebrate biomass & species composition **
- ** Only sampled 1/8 wk.

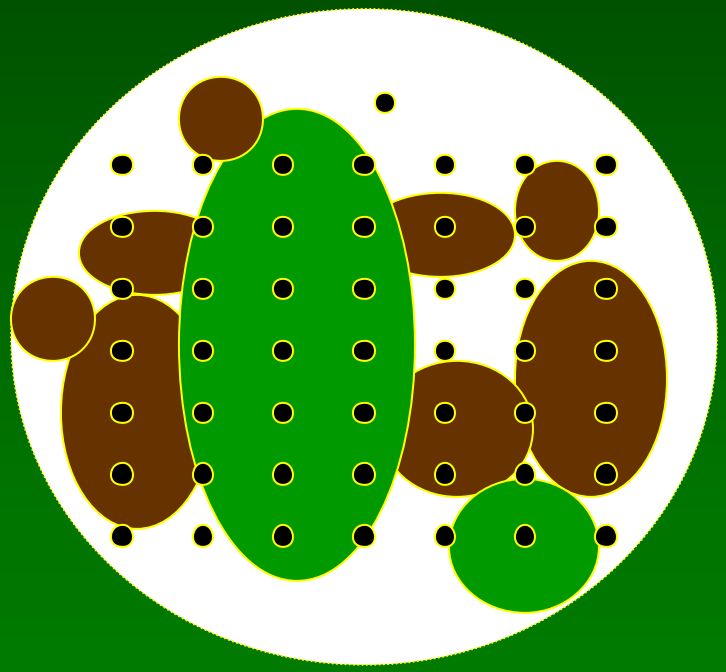
Similarity of Diatom Composition Between Test and Reference Assemblages



Rapid Periphyton Survey (in RBP Manual)

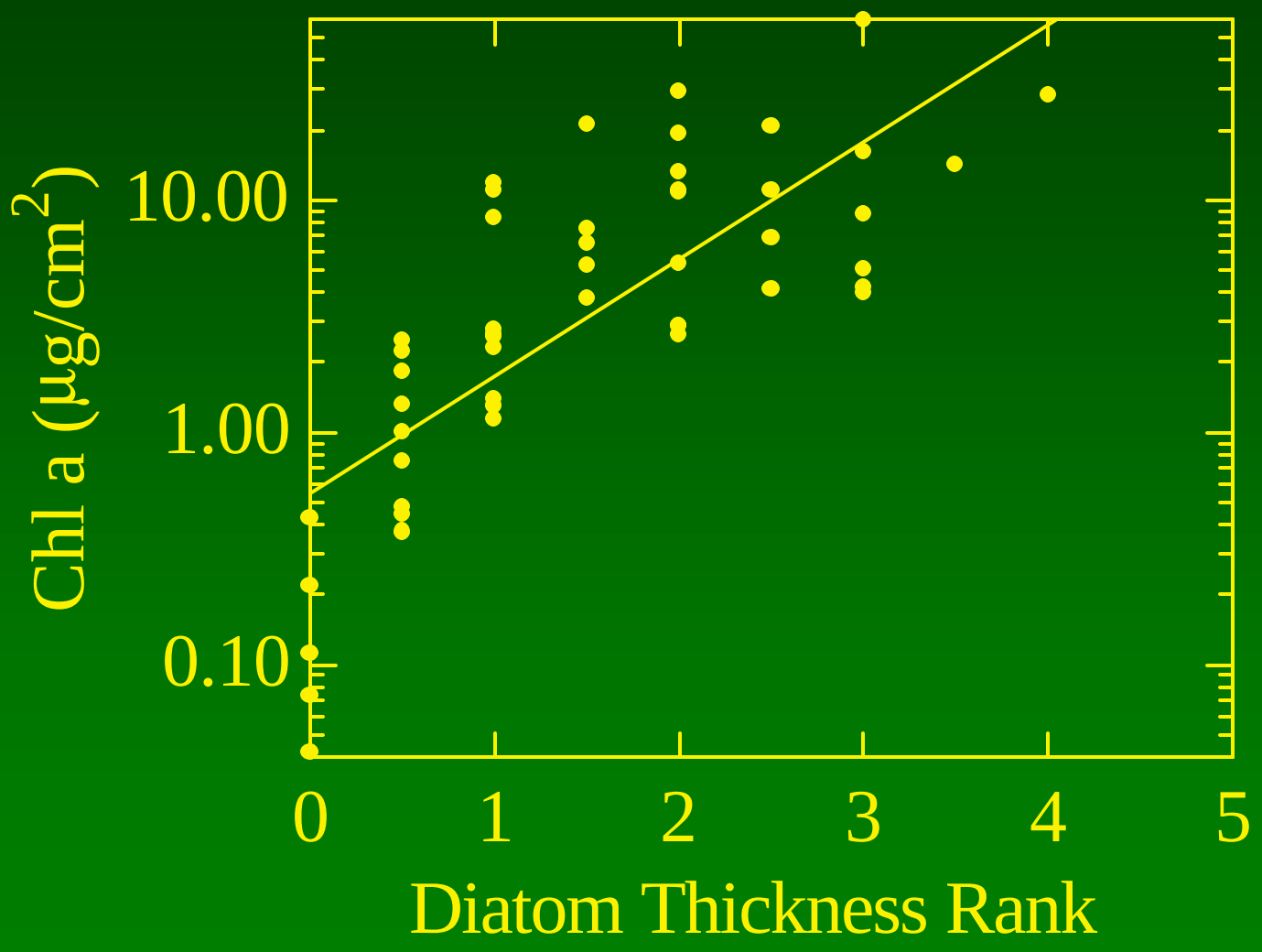
- View Bottom at Sites along Transects
- Characterize % Cover of Different Algal Types
- Characterize Thickness of Each Algal Type

Rapid Periphyton Survey

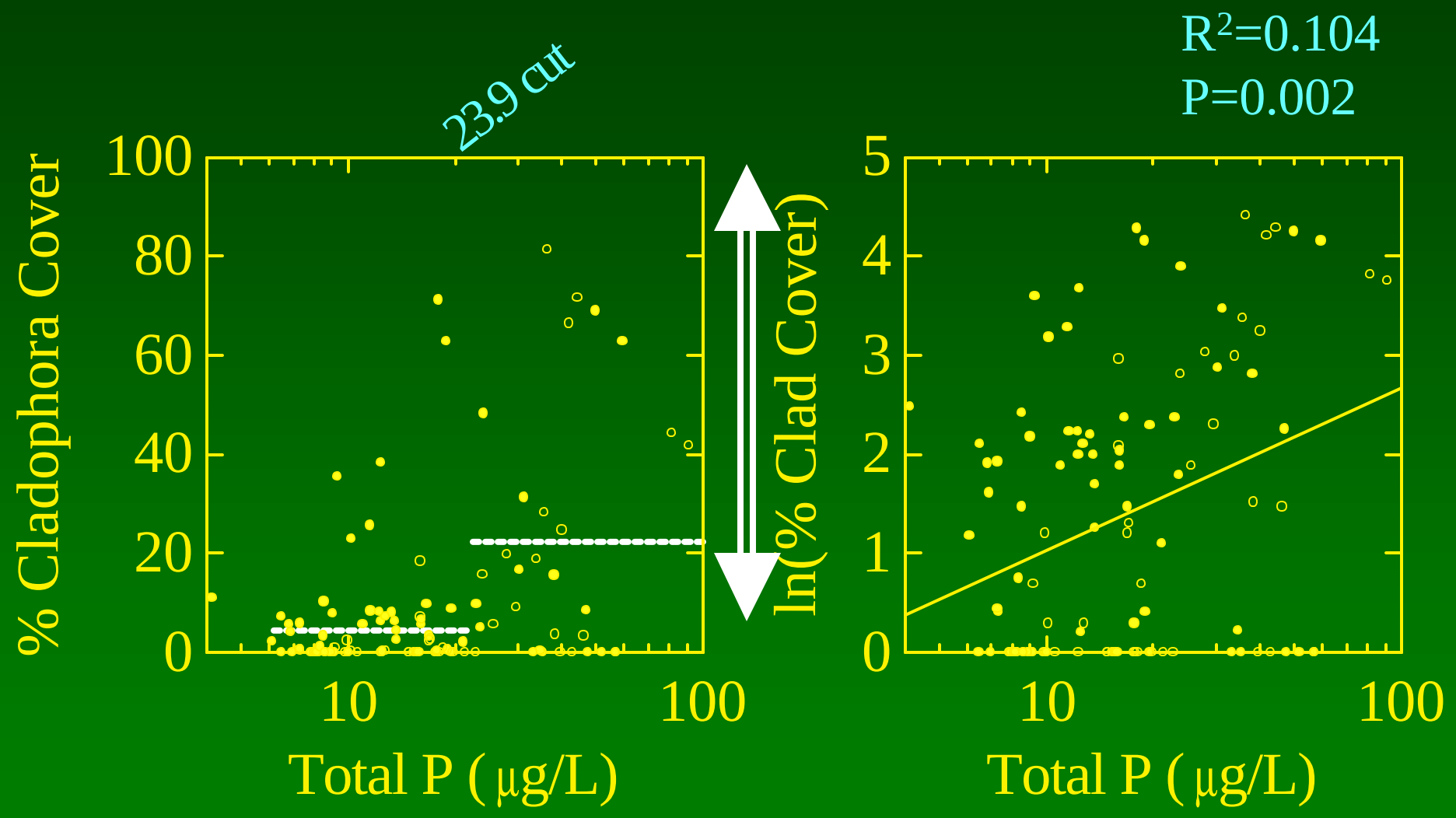


- Assess % suitable substratum
- Assess % green filament cover
- Assess % microalgal cover by division
- Assess thickness of microalgae
- See RBP manual for details

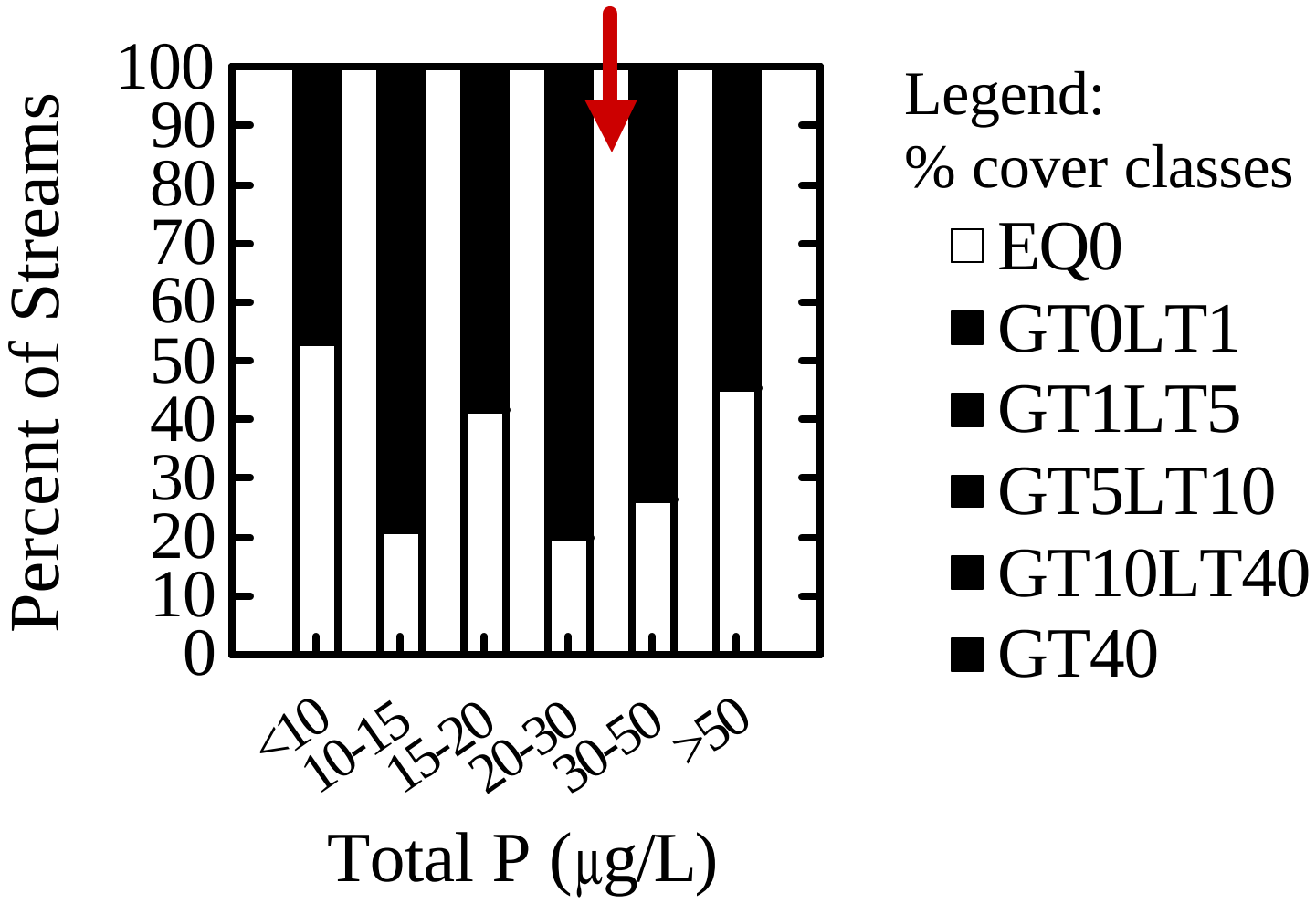
Chl a = f (Diatom Rank)



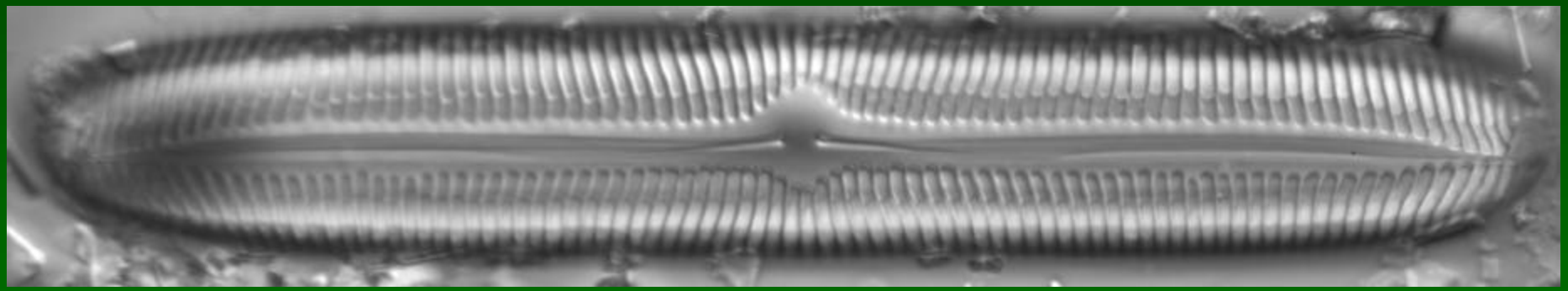
Peak Cladophora Biomass & Sources of Error



Probabilities of High Peak Cladophora Biomass in Specific P Ranges



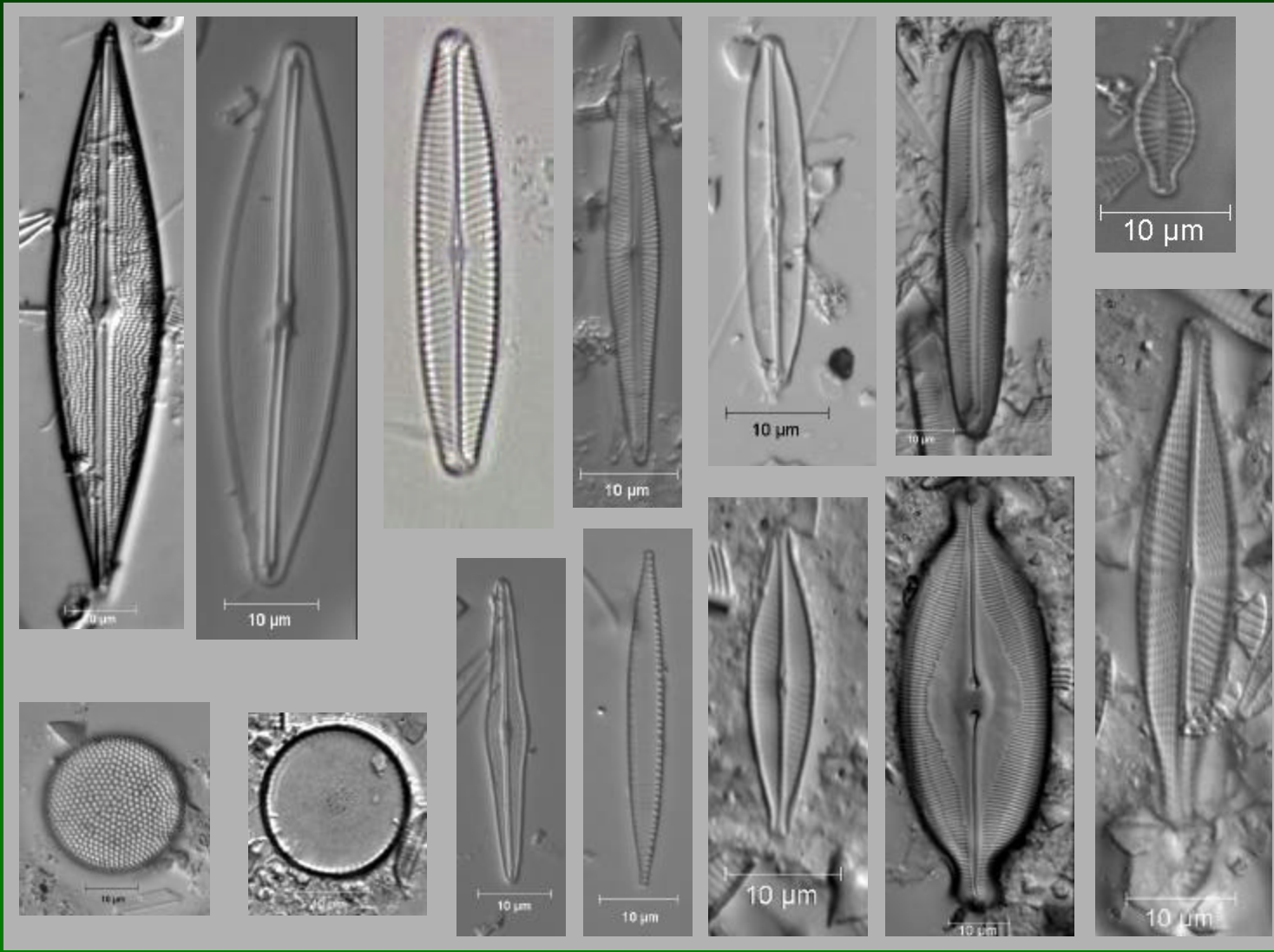
Diatoms



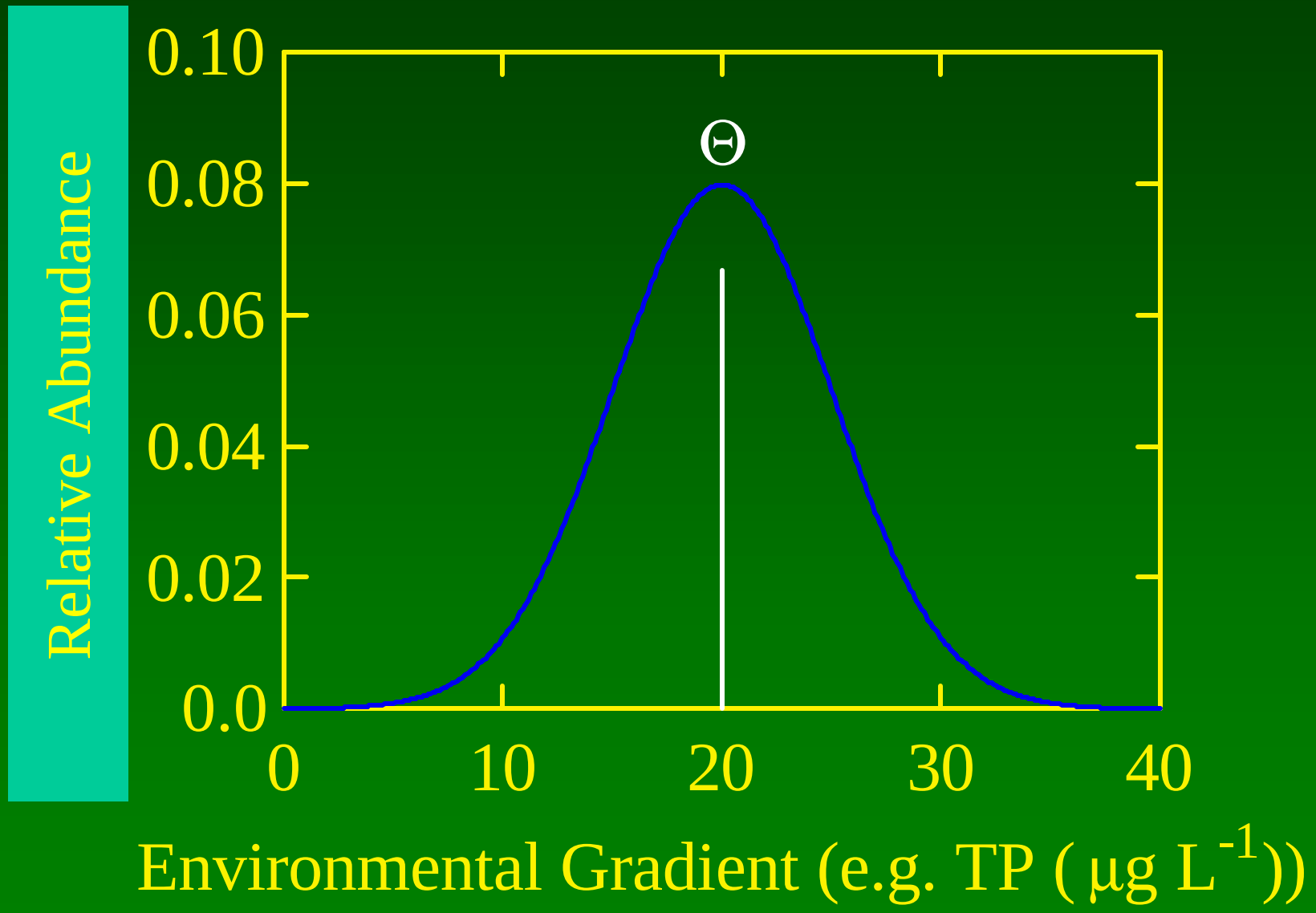
Distinguishing Differences Among Assemblages

Sensitive Taxa

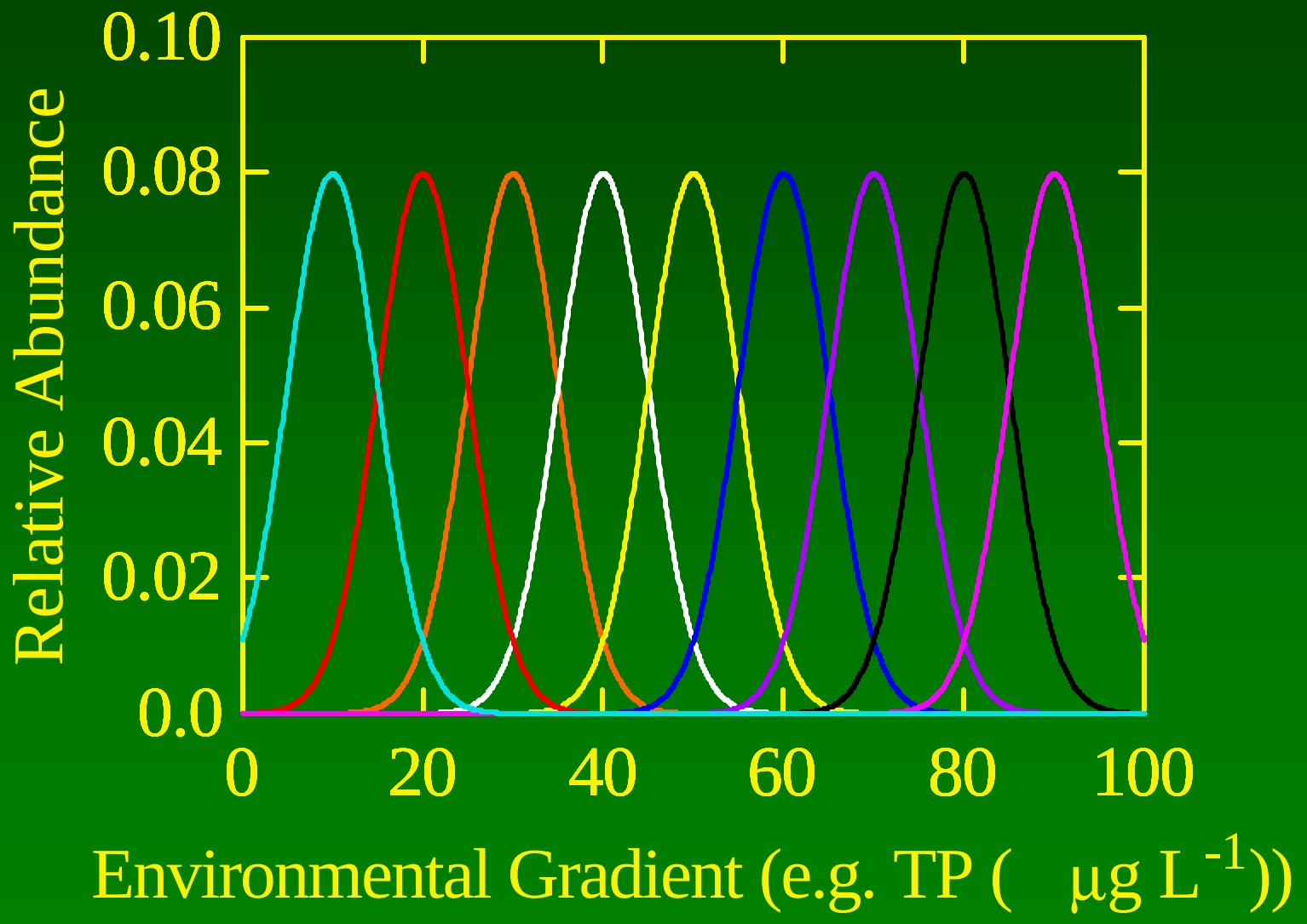
Tolerant Taxa



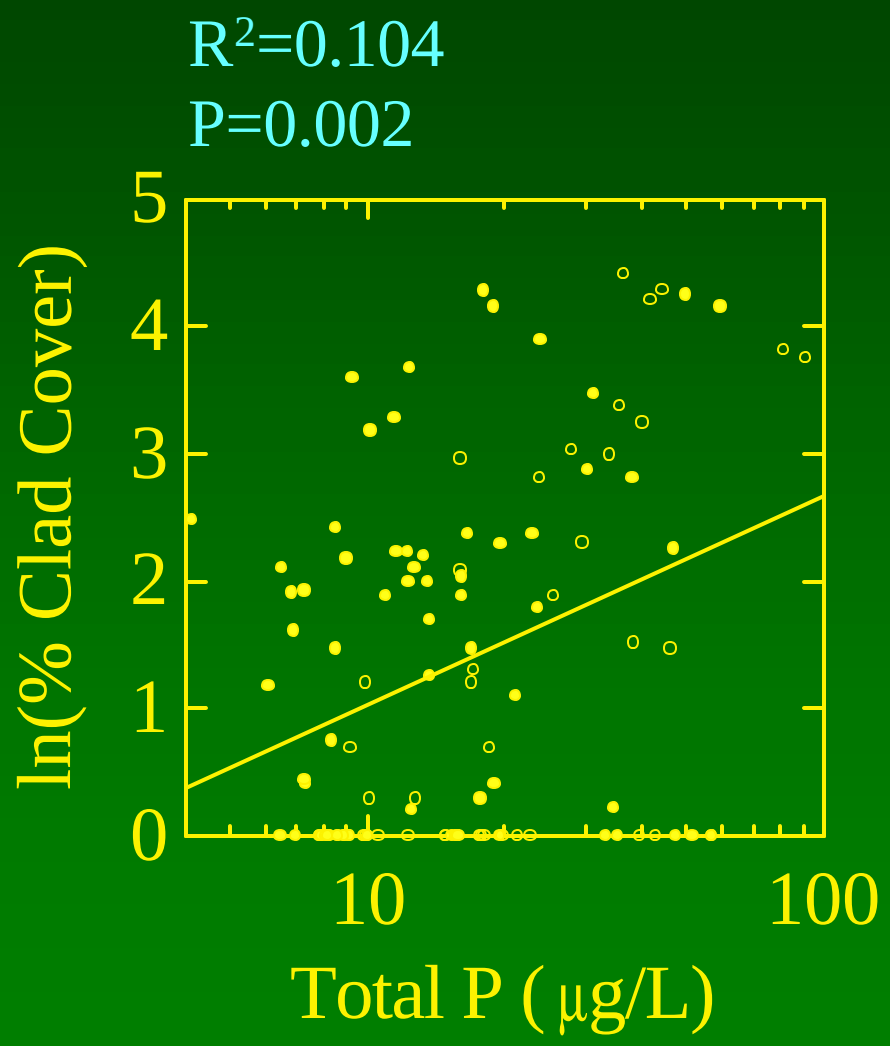
Determine Species Environmental Optimum

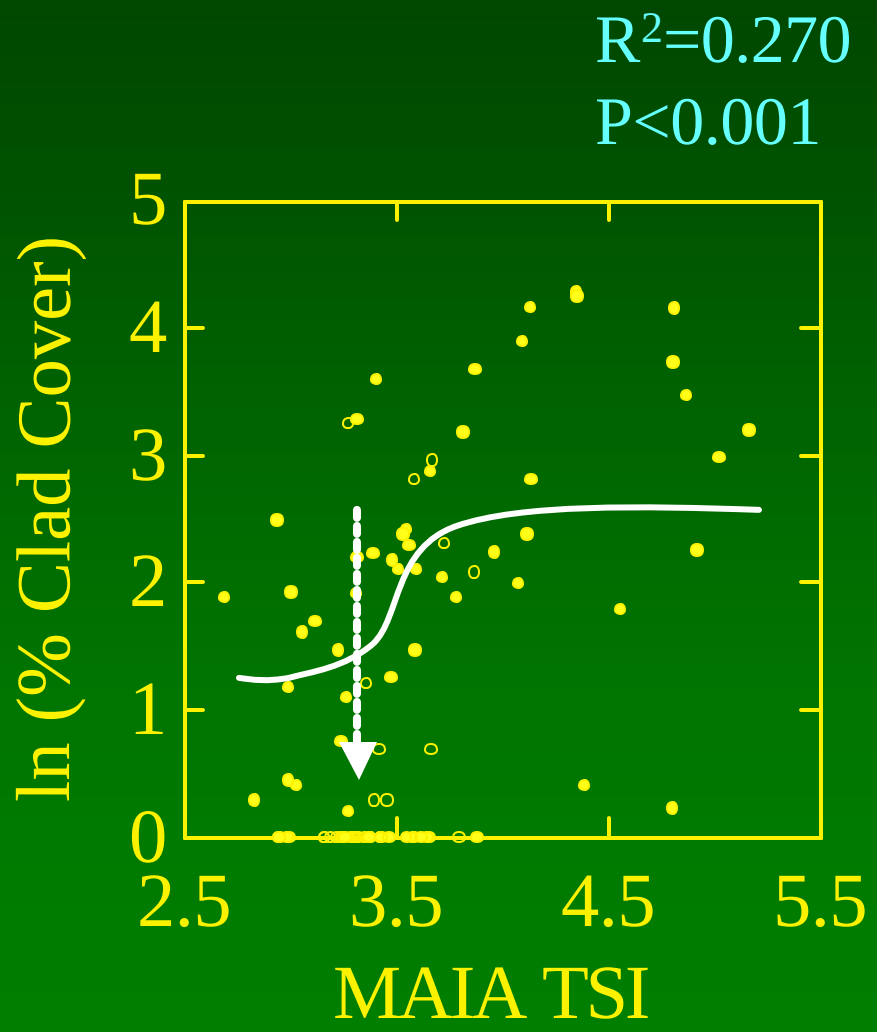


Species Abundances Along Environmental Gradient

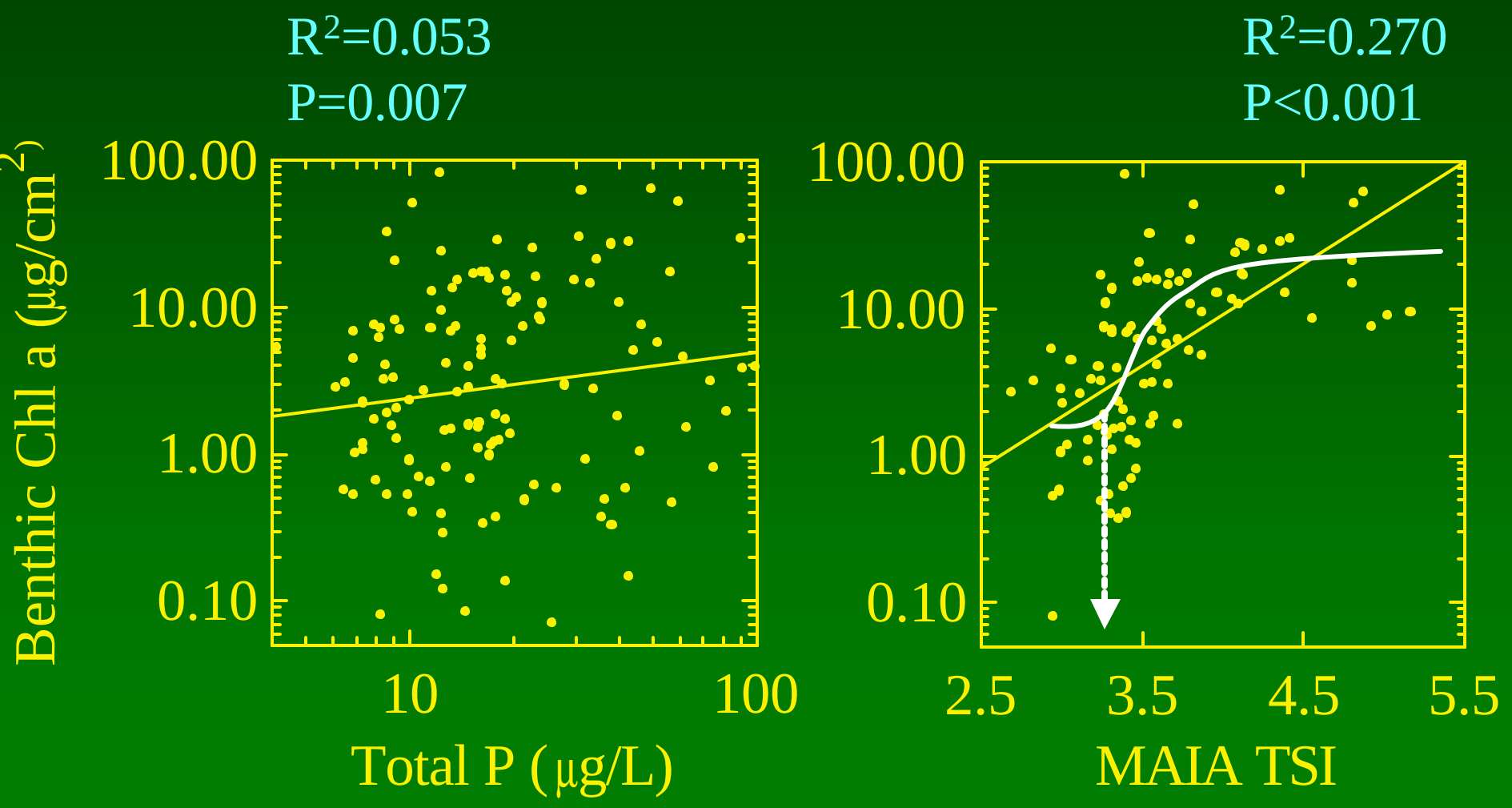


Cladophora/Nutrient Model Improves with Diatom Inferred TSI

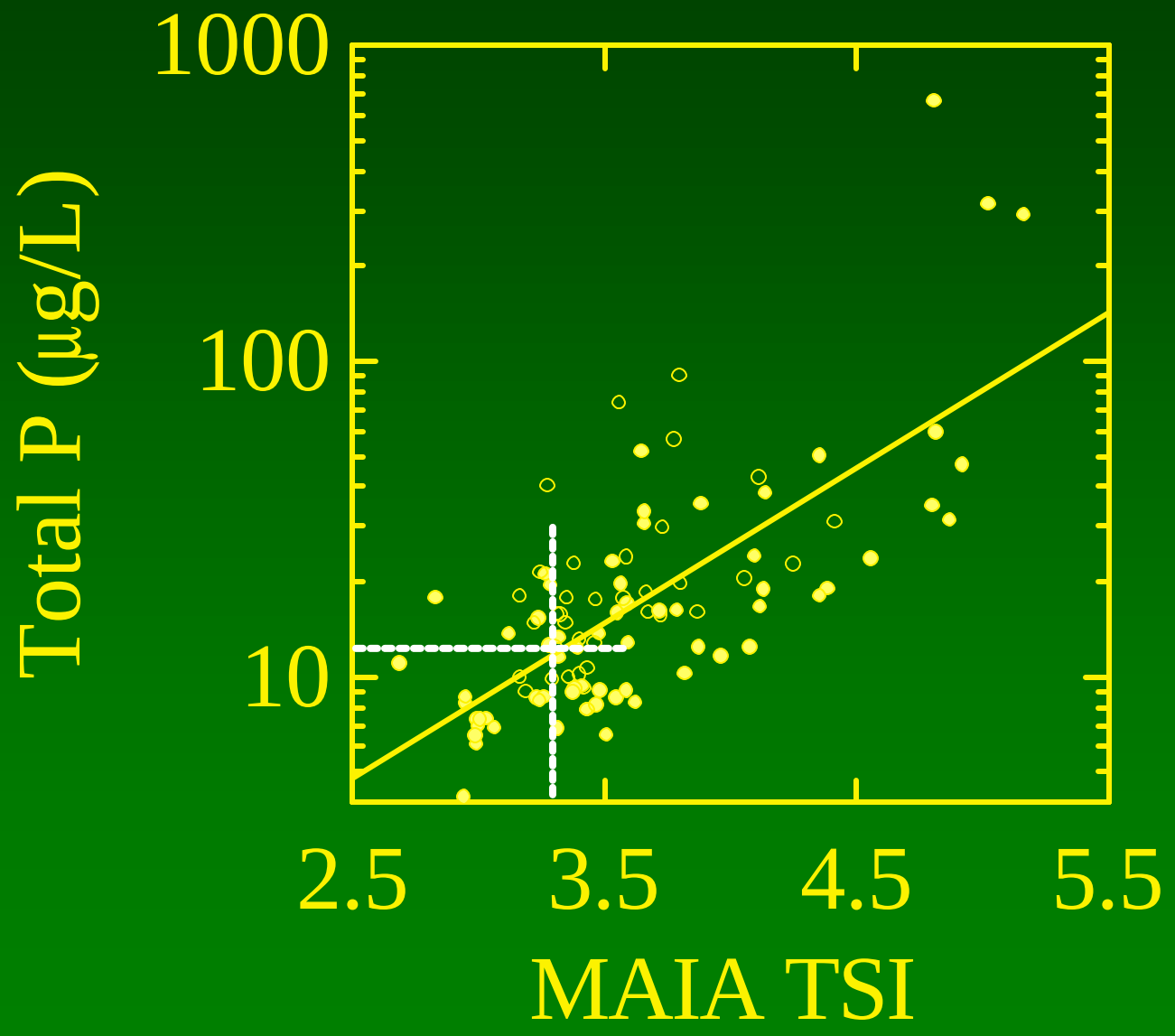




Chl a/Nutrient Model Improves with Diatom Inferred TSI



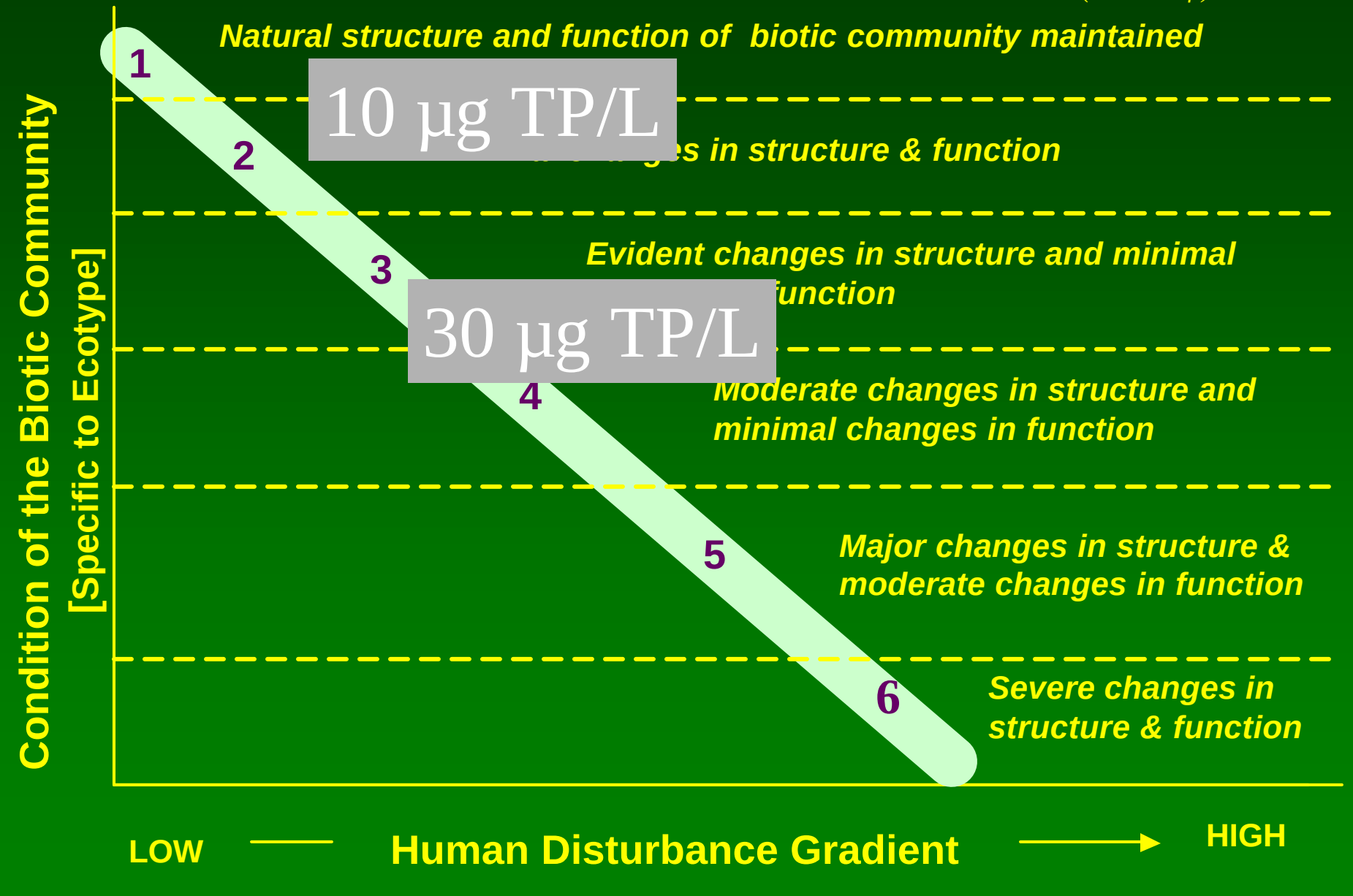
Translating TSI to Nutrient Criterion



Policy Implications

USEPA Tiered Aquatic Life Use Conceptual Model

(10/22 draft)



Complementary Tools

1. Aquatic Life Use Criteria and Stressor Criteria
2. Tiered Uses
   1. e.g., 1) Support natural structure and function vs.
   2. e.g., 3-4) Constrain nuisance algal growths (*Cladophora*))
3. Frequency Distributions & Stressor-Response Models
   1. Characterizing Natural Condition
   2. Valued Attribute Response to Stressor
4. Lowess Regression and Regression Tree for Threshold Analysis
5. Stressor Measurement and Biological Inference Models (e.g., Diatom Indicator of TP)
6. Standard Deviation vs Standard Error of the Mean
7. Guidelines for Use (to minimize misuse and abuse)