Incorporating Species Optima and Inference Models into Biological Assessments

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Introduction

- Developing new algal biocriteria for streams and rivers based on:
  - Maine's Water Classification System
  - EPA's Biological Condition Gradient.
- Need a way to calculate tolerance values for stream algae.
- Want some metrics that can help diagnose potential stressors.

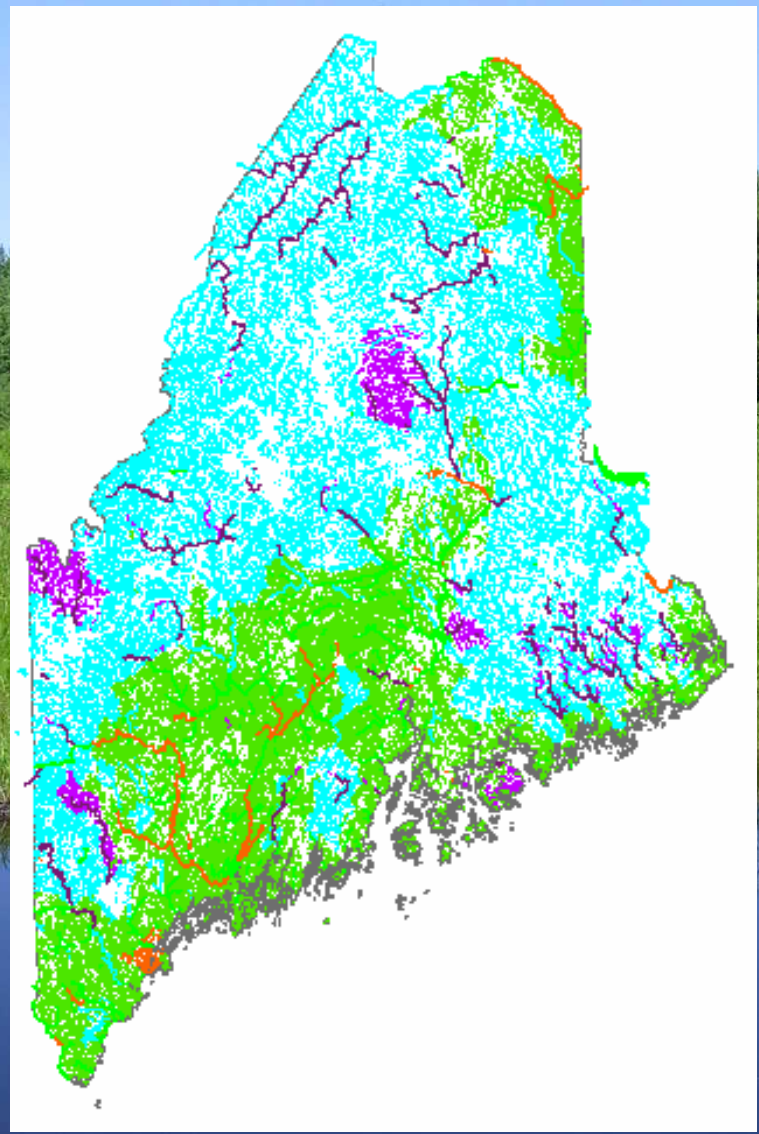
Stream Classes

AA

A

B

C



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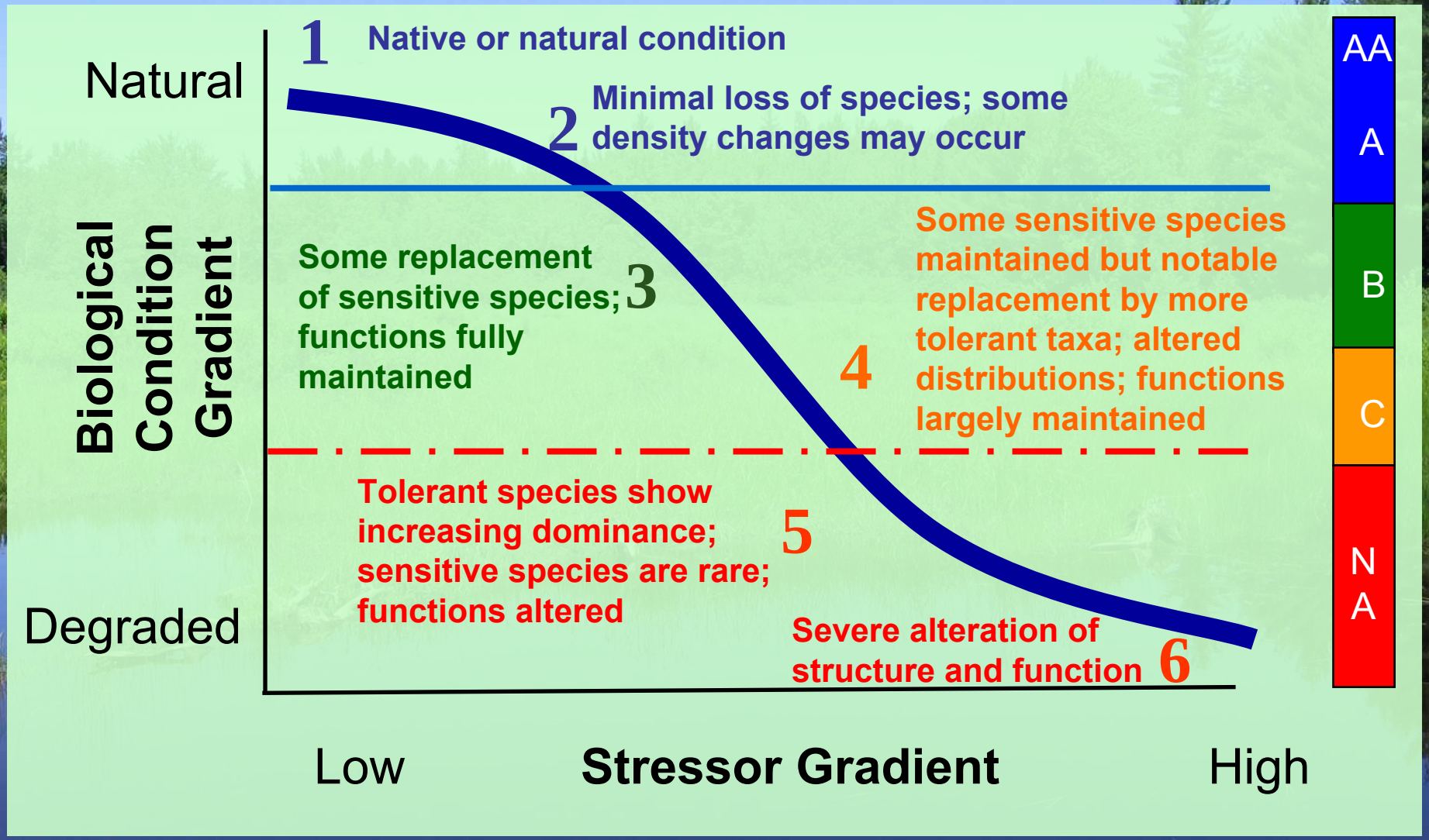
Classes and Criteria

	Numeric Criteria		Narrative Criteria	
	Dissolved Oxygen	Bacteria (*E. coli*)	Habitat	Aquatic Life (Biological)
Class AA	as naturally occurs	as naturally occurs	free flowing and natural	as naturally occurs
Class A	7 ppm or 75% sat.	as naturally occurs	natural	as naturally occurs
Class B	7 ppm or 75% sat.	64 per 100 ml (geo. mean) 236 per 100 ml (instantaneous)	unimpaired	support all aquatic species indigenous to the receiving water; no detrimental changes to the resident biological community
Class C	5 ppm or 60% sat.	126 per 100 ml (geo. mean) 236 per 100 ml (instantaneous)	habitat for fish and other aquatic life	maintain the structure and function of the resident biological community

Non-attainment (NA) stream does not meet minimum criteria

Biological Condition Gradient (BCG) and Tiered Aquatic Life Use (TALU)



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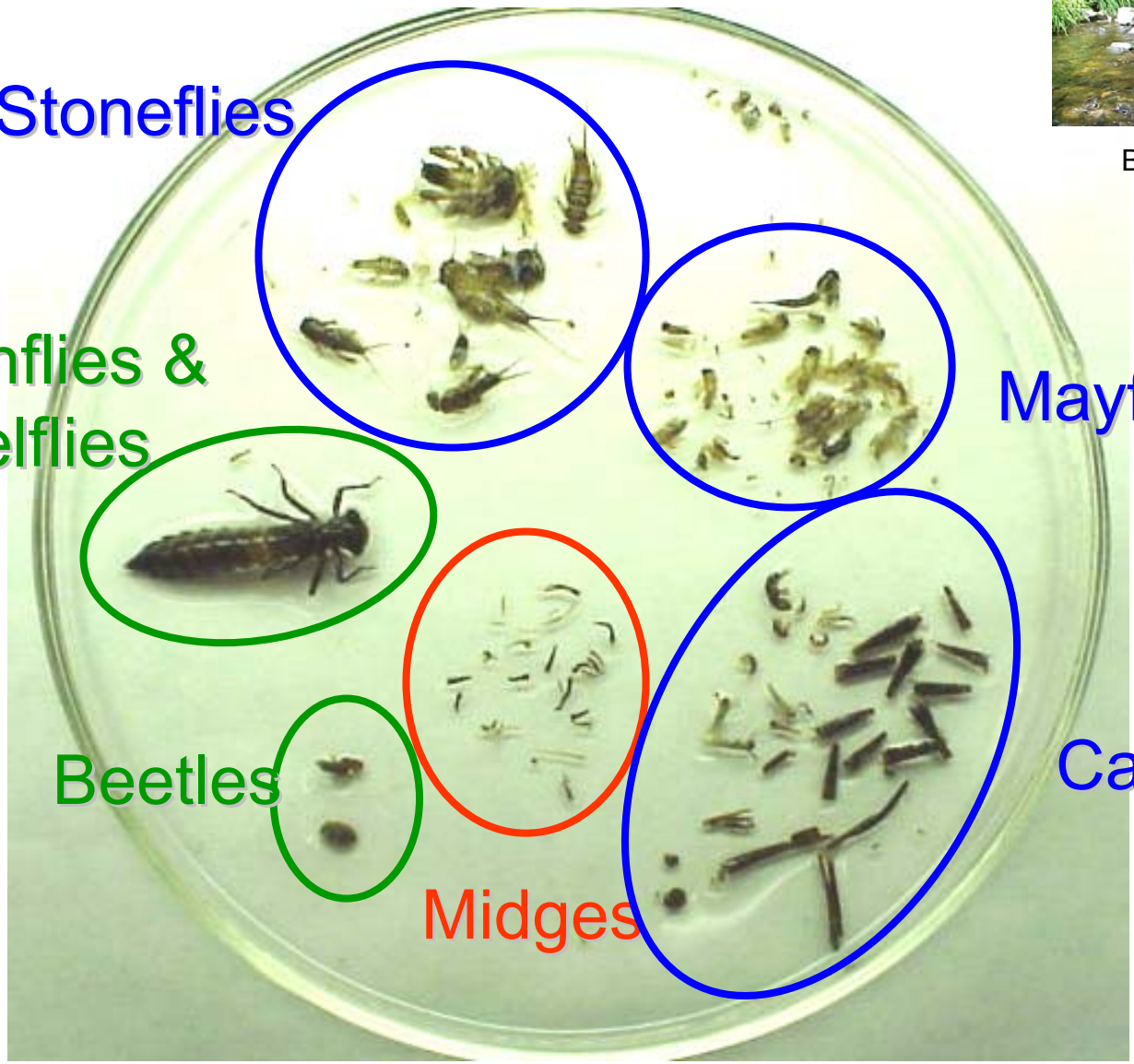
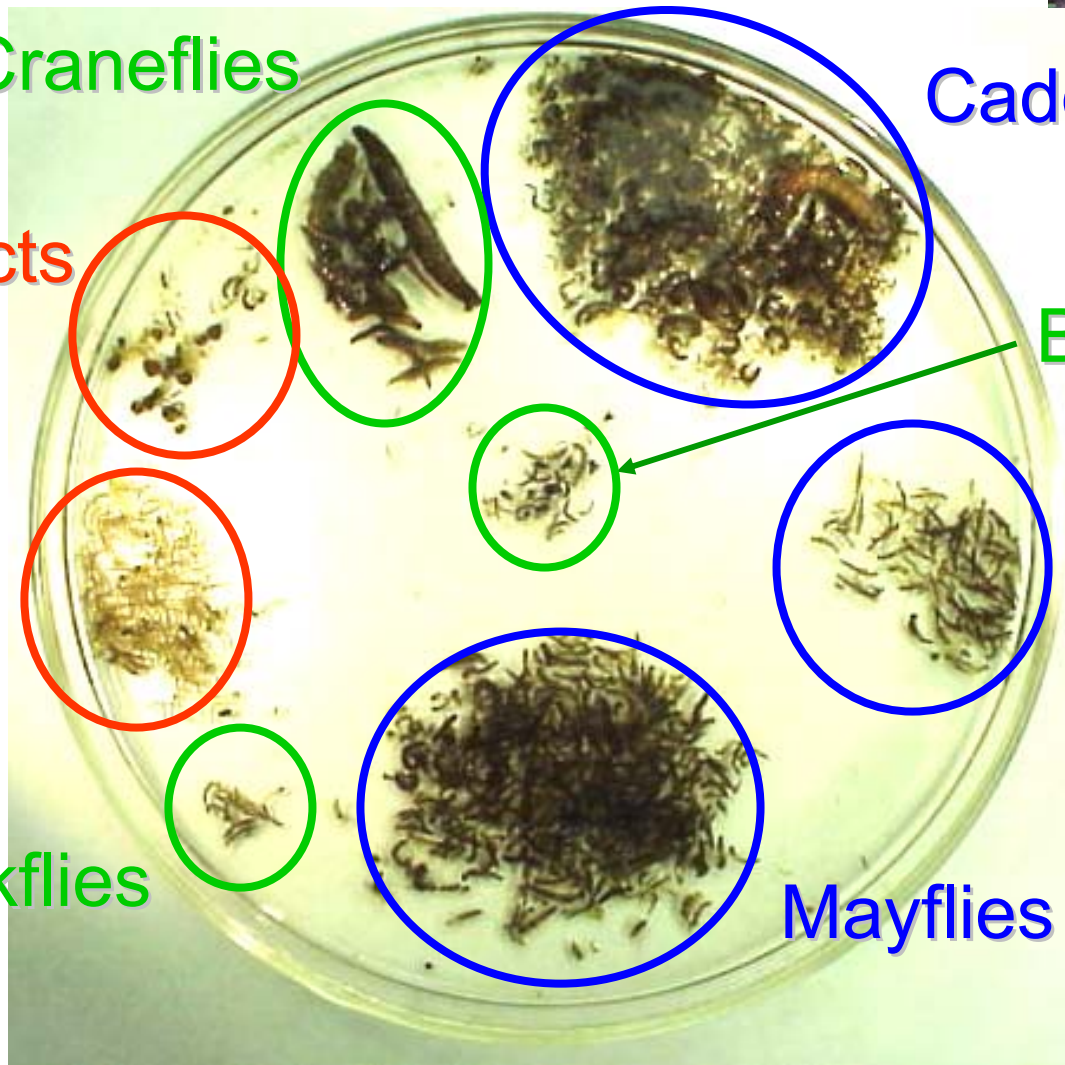
Class A Stream (Tier 2)

Babel Brook, T5 R9 NWP



Class B Stream (Tier 3)

Eddy Brook, New Gloucester



Non-Attainment Stream (Tier 5)

Penjajawoc Stream, Bangor

Scuds

Snails

Dragonflies & Damselflies

Leeches

Caddisflies

Midges

Beetles

Craneflies

1 inch

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What tolerance values do we use for stream algae?

- Tolerance values from Europe
  - van Dam, Mertens, and Sinkeldam (1994)
  - Numerous trophic and saprobic systems
- Montana Pollution Tolerance Index (Bahls 1993)
- Kentucky Pollution Tolerance Index (KDEP 2002)

- Do they work for Maine?

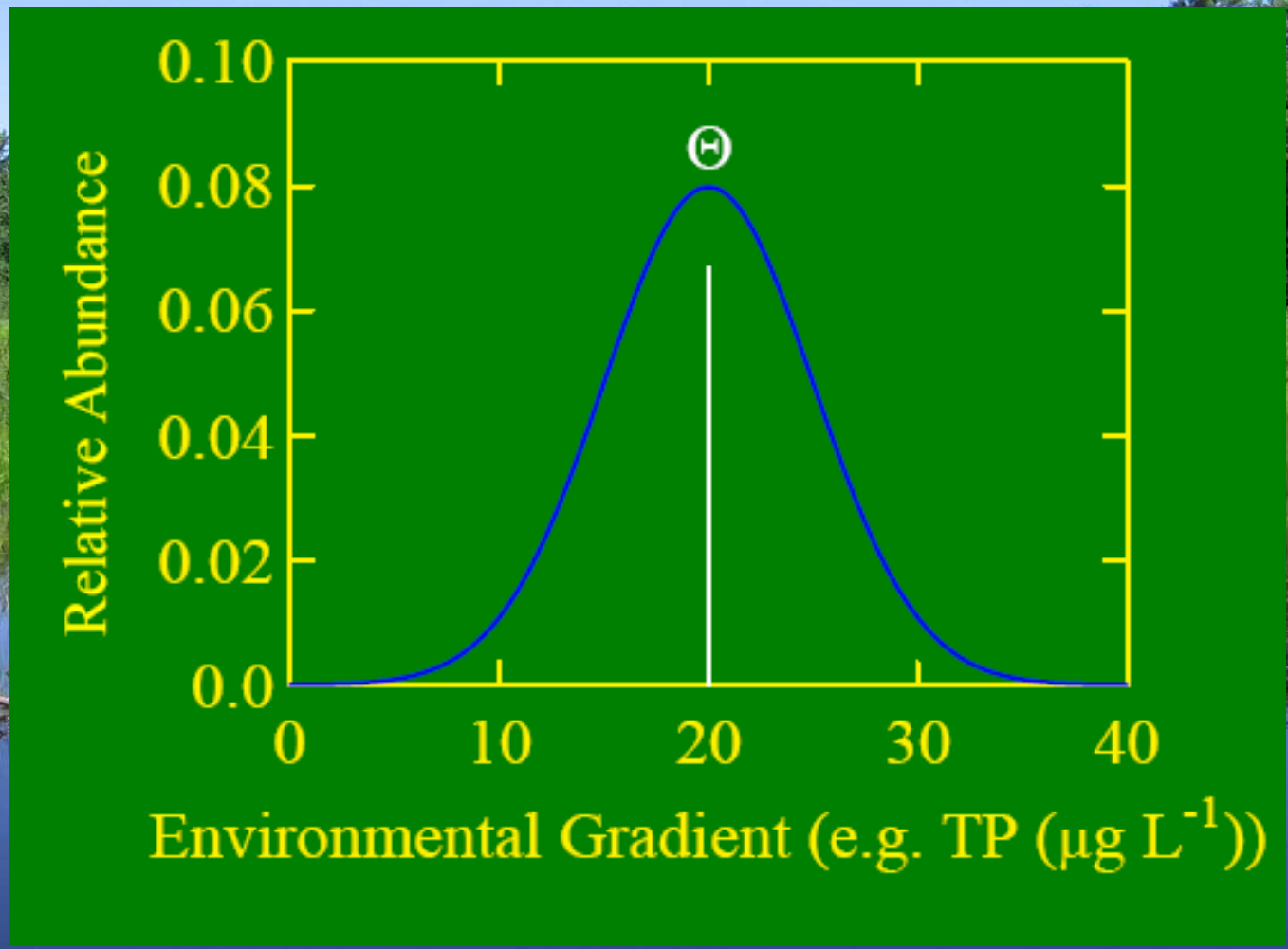
Inference Models

- Species "optima" and inference models for stream algae:
  - NAWQA diatoms (Potapova and Charles 2002)
  - NAWQA soft algae (Potapova 2005)
  - Northern Piedmont diatoms (Potapova et al. 2004)
  - NJ diatom nutrient models (Ponander et al. 2005)
- Comparisons have shown that locally derived species "optima" have worked better in models than national or international tolerance values.

Goals

- **Use species optima to calculate a Maine Tolerance Value to help build a statistical model that predicts attainment of Class A, B, or C biocriteria.**
  - **Does the stream attain its assigned class?**
- **Use inference models to help identify major stressors damaging the stream.**
  - **What's damaging it and how do we target limited resources to try and fix it?**

Species Optimum (θ)



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Courtesy Jan Stevenson

Weighted Average Optima

$$\theta_k = \frac{\sum_{i=1}^{n} y_{ik} x_i}{\sum_{i=1}^{n} y_{ik}}$$

where: θ_k **= optima of species k**

y_{ik} **= abundance of species *k* in sample *i***

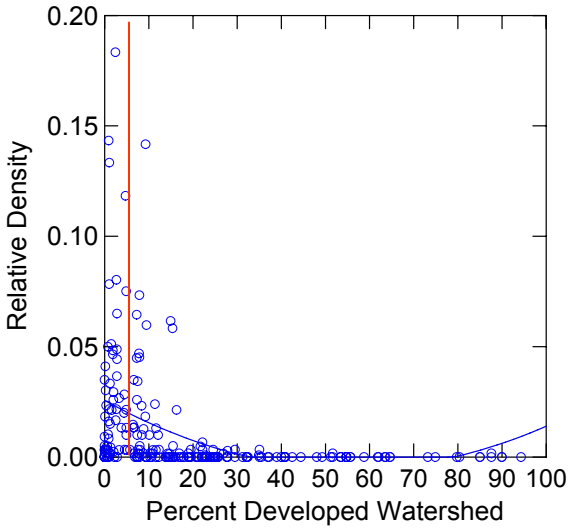
x_i **= value of environmental parameter in sample *i***

Example Calculation (*Achnanthes conspicua*)

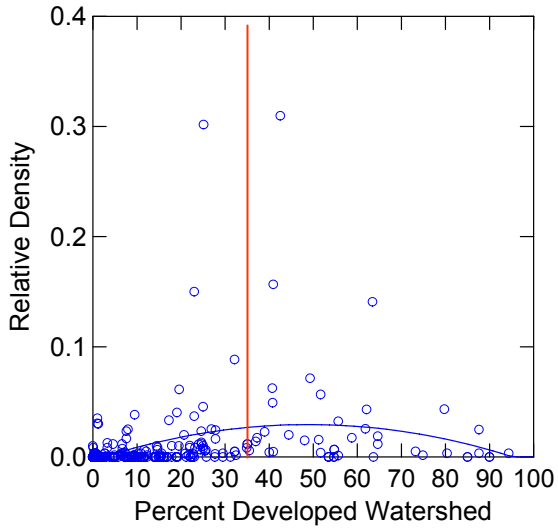
Sample	Abundance	TP (ppb)	Log (TP)	Log(TP) x Abundance
Sucker Brook	16,273	21	1.322	21,512.9
Rocky Brook	7,018	20	1.301	9,130.4
Little Ossippee River	1,048	10	1.000	1,048.0
Togus Stream	29	77	1.886	54.7
Penjajawoc Stream	6	21	1.322	7.9
Carrabassett River	5	6	0.778	3.9
	Sum = 24,379			Sum = 31,757.8

Examples of Optima

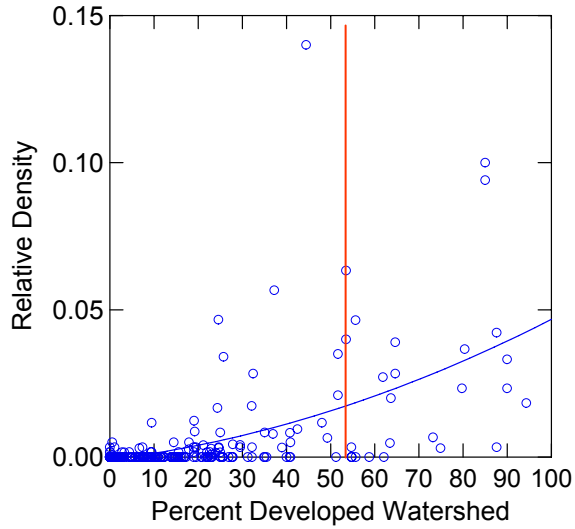
Brachysira microcephala



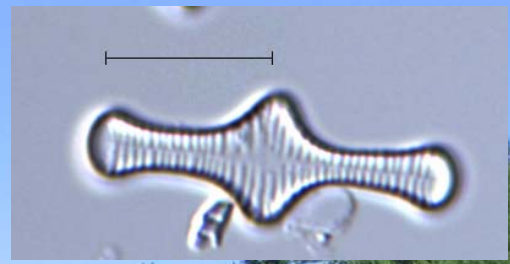
Reimeria sinuata



Navicula gregaria



Tabellaria flocculosa



Percent of Watershed that is Forest or Wetland	98%
Percent of Watershed that is Impervious Surface	1%
Specific Conductance	22 μS/cm
Total Nitrogen	14 ppm
Total Phosphorous	8 ppb

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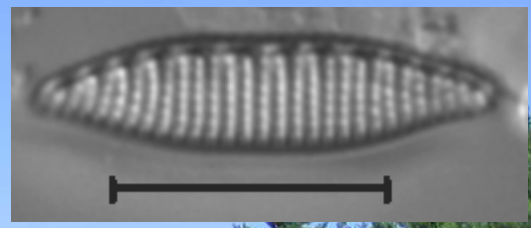
Nitzschia amphibia



Percent of Watershed that is Forest or Wetland	16%
Percent of Watershed that is Impervious Surface	40%
Specific Conductance	475 μS/cm
Total Nitrogen	109 ppm
Total Phosphorous	39 ppb

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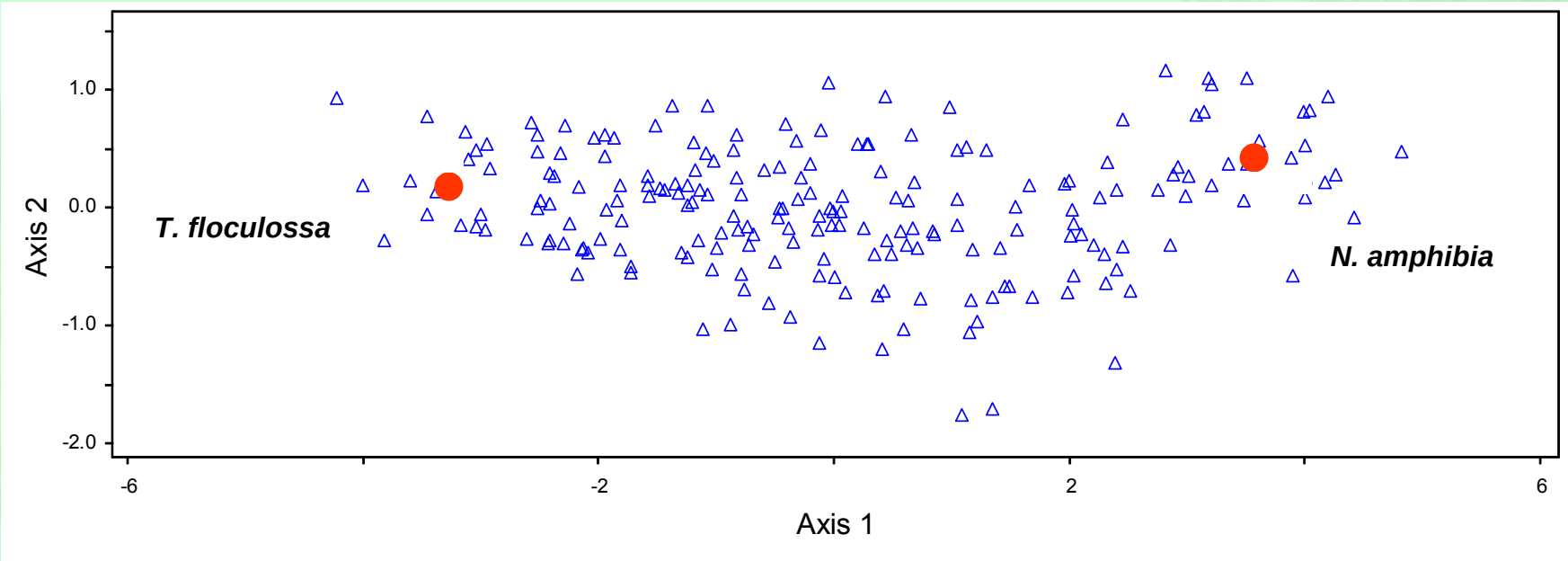
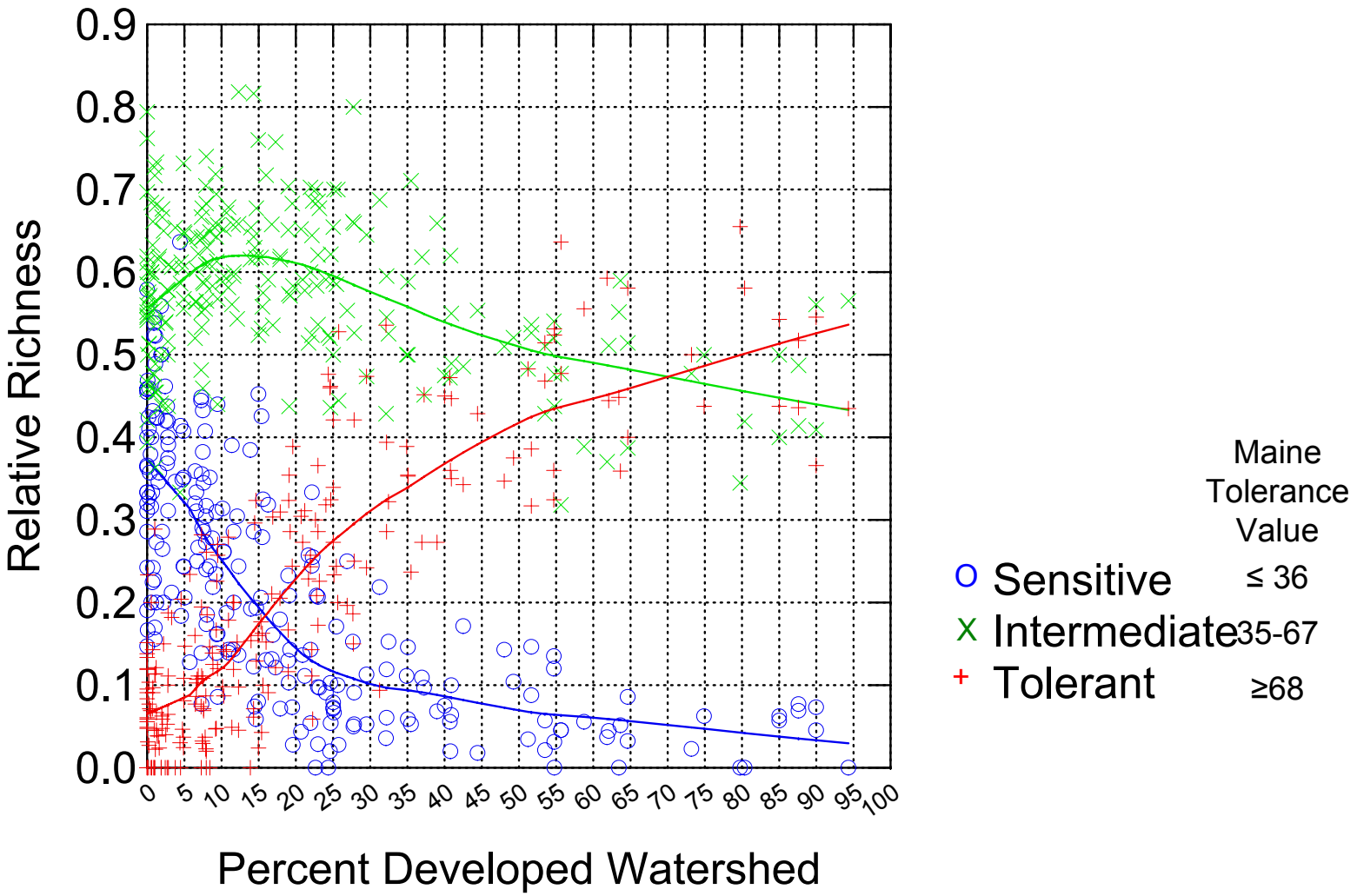
PCA Ordination Identified Major Pattern in Species Optima



- **Axis 1 represents 86% of variance**
- **Rescaled axis to 1 (most sensitive) to 100**

Relative Richness of Sensitive, Intermediate, and Tolerant Algae



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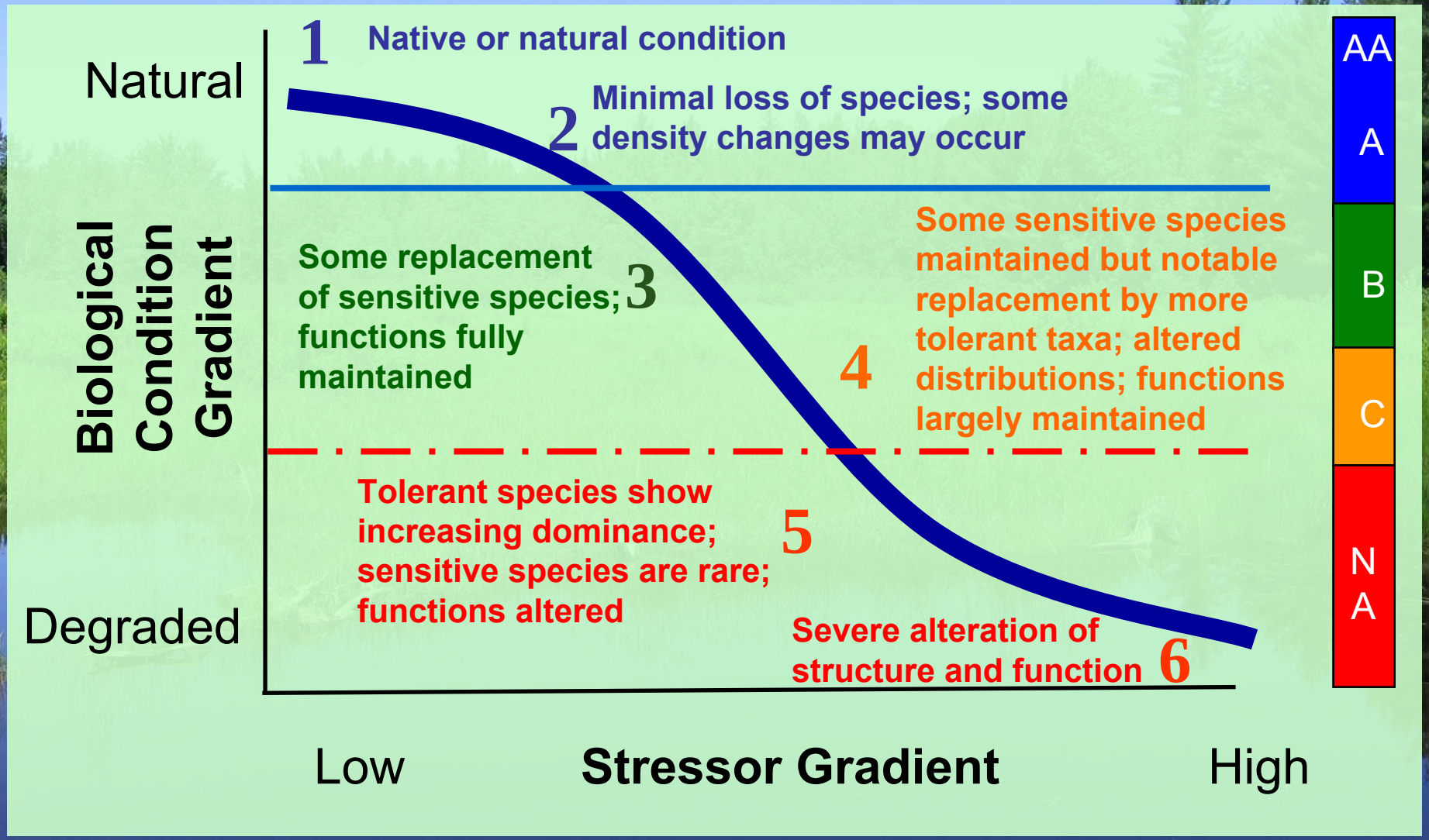
Biological Condition Gradient (BCG) and Tiered Aquatic Life Use (TALU)



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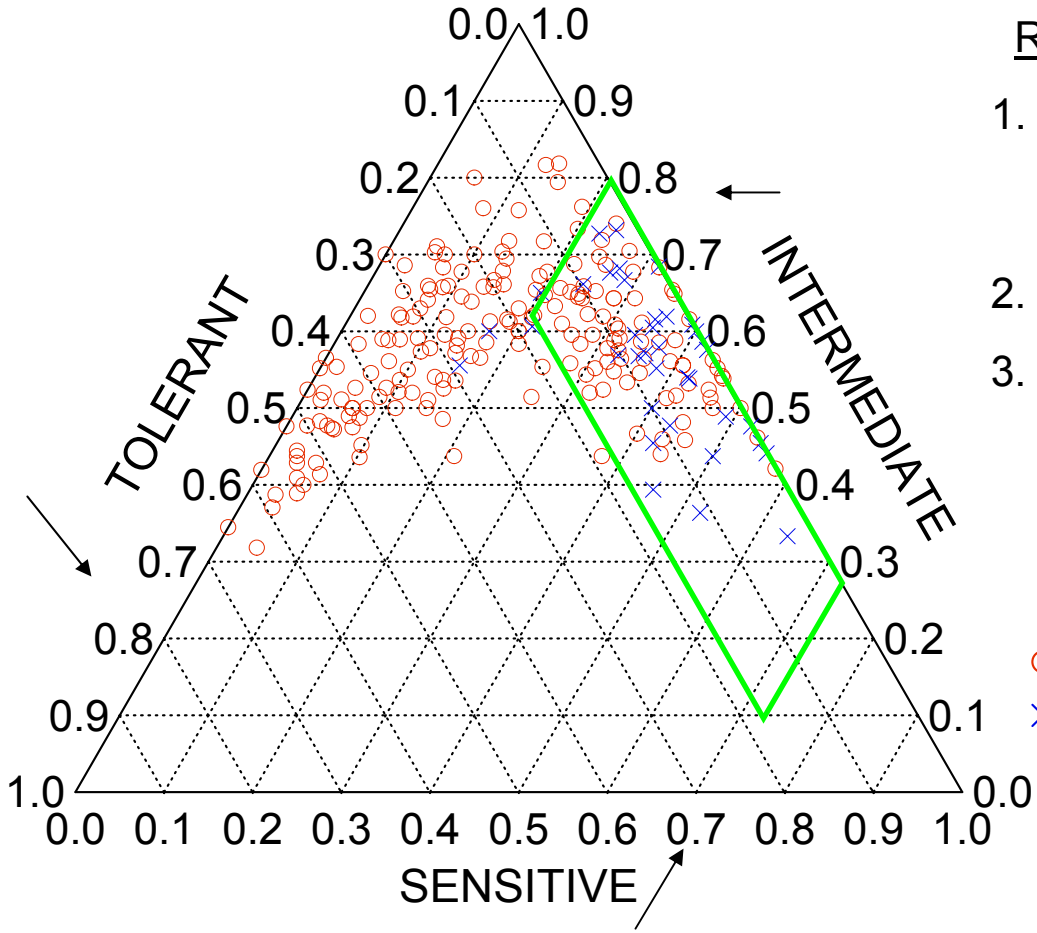
Relative Richness of Sensitive, Intermediate, and Tolerant Algae



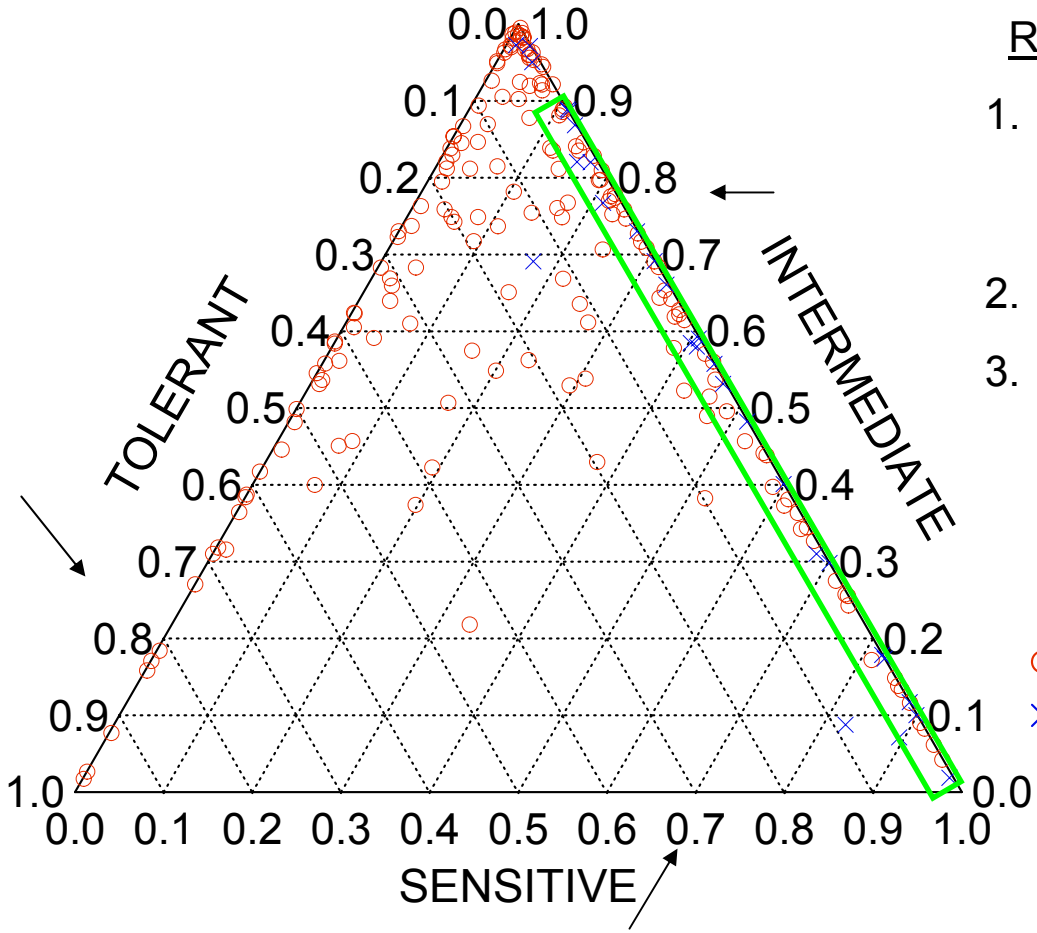
Reference Criteria

1. >95% Forest or Wetland in Watershed
2. No dams
3. No point-source discharges

REFERENCE

○ No
× Yes

Relative Biovolume of Sensitive, Intermediate, and Tolerant Algae



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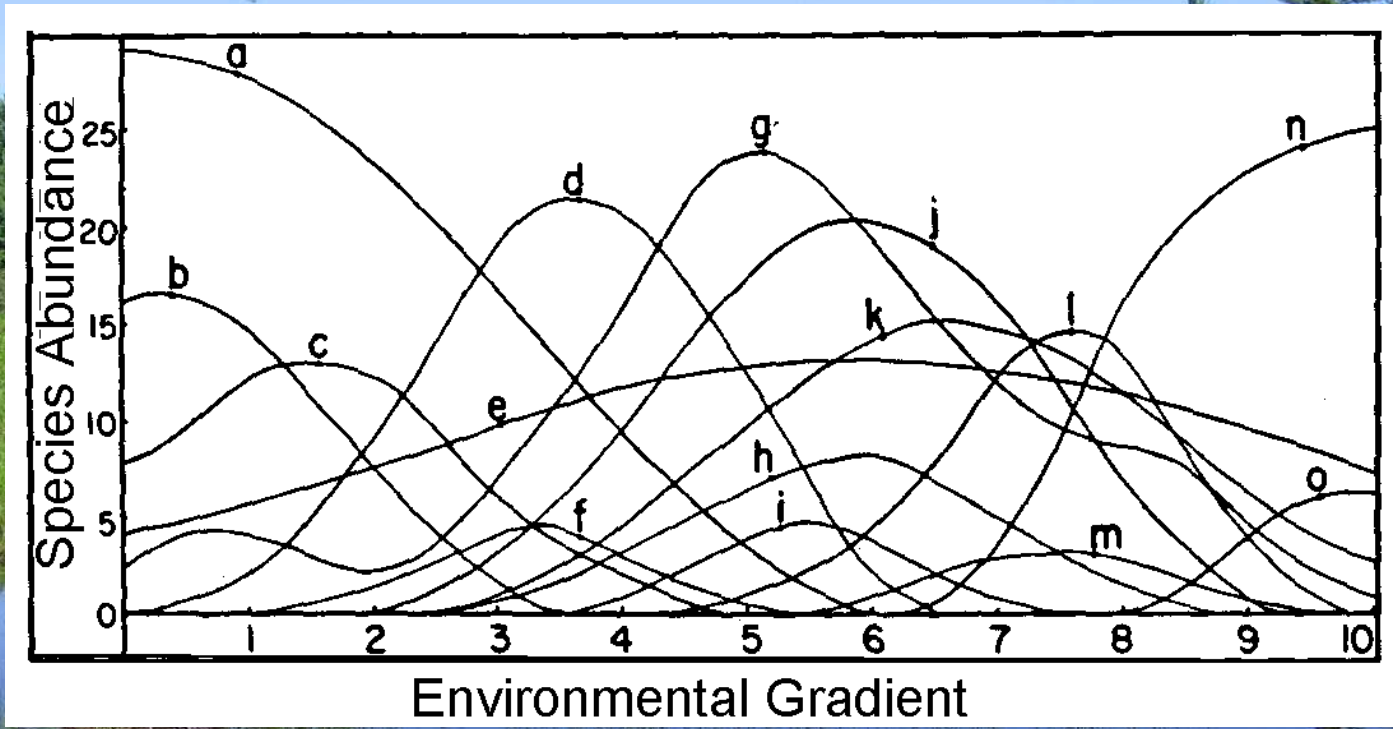
Overlapping Species Response Curves

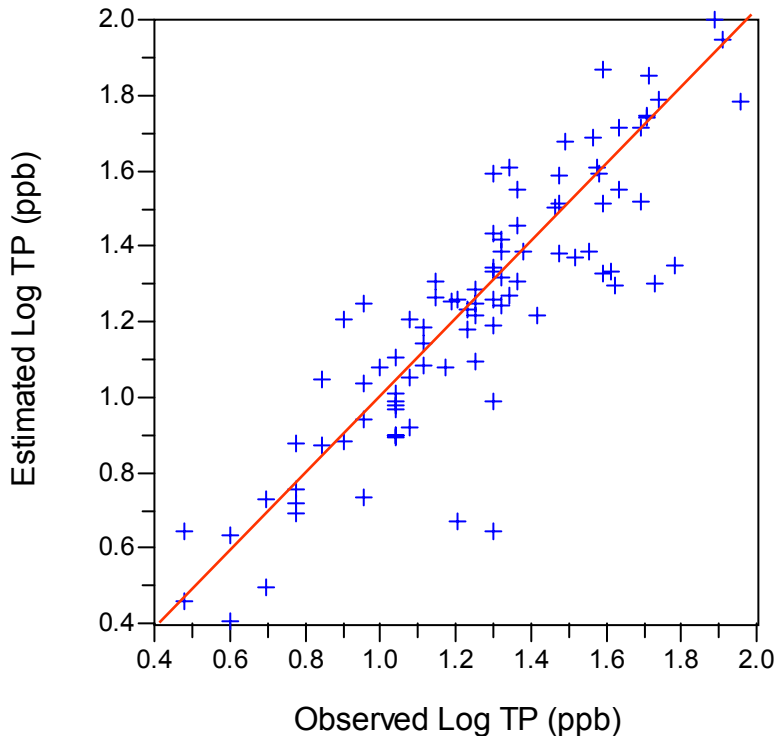


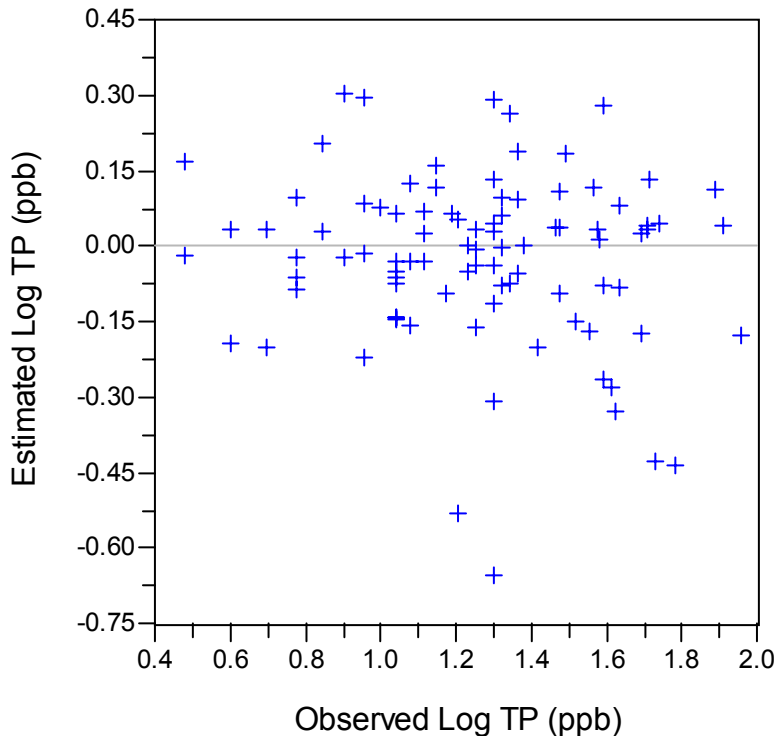
From: McCune, B. & J. B. Grace. 2002. *Analysis of Ecological Communities*. MjM Software Design, Gleneden Beach, Oregon http://www.pcord.com

Types of Ecological Inference Models

- **Weighted averaging (WA)**
  - **Inferred TP = Σ (Rel. Abun. x TP Optimum)**
  - **with classical or inverse deshrinking**
- **WA - tolerance downweighting**
  - **with classical or inverse deshrinking**
- **WA - partial least squares**
- **Maximum likelihood**
  - **based on Gaussian response curves**

Diatom TP Inference Model





RMSE	0.17097
R2	0.77027
Ave_Bias	0.02437
Max_Bias	0.095575
Boot_R2	0.55407
RMSEP	0.24401

Applications of Inference Models

- **Assess condition of stream.**
- **Diagnose potential stressors.**
- **Target limited resources to more effectively fix the stream.**
- **Measure incremental improvements in stream condition.**

Putting it all together

Variable	Tier 2	Tier 3	Tier 4	Tier 5
% Richness Sensitive Algae	41	25	3	6
% Biovolume Sensitive Algae	92	7	0	0
% Richness Tolerant Algae	9	25	48	54
% Biovolume Tolerant Algae	0	2	3	97
% Rich. N-autotrophic diatoms	41	52	0	3
% Density Eutraphentic diatoms	10	25	75	95
% Density Motile diatoms	7	22	64	40
Diatom Developed Watershed Index	6	21	52	81
Diatom Conductivity Index	17	102	321	939
Diatom TP Index	8	22	22	38

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Conclusions

- We are using optima to calculate a Maine Tolerance Value for algal taxa.
- We are using the Maine Tolerance Values in determining the Class (A,B,C) and BCG tier.
- We intend to use the inference models to help diagnose potential stressors, target restoration, and monitor recovery.

For More Information

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