

US EPA ARCHIVE DOCUMENT



# **Incorporating Species Optima and Inference Models into Biological Assessments**

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Maine DEP**

# 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.**

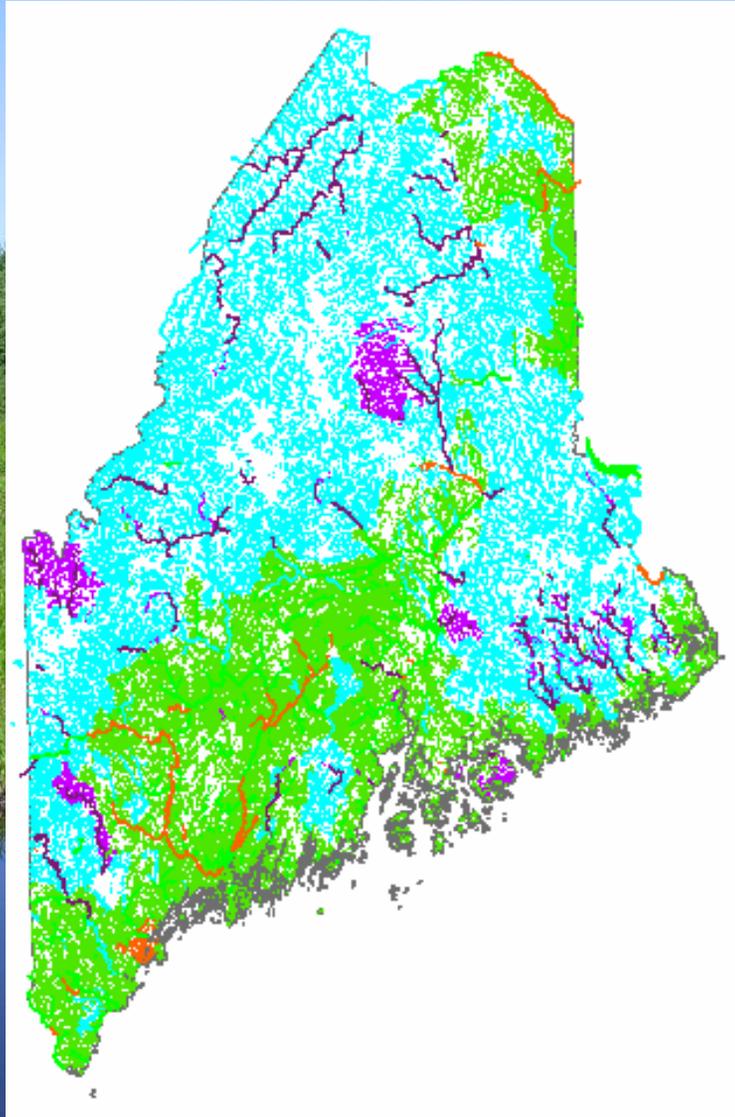
# Stream Classes

AA

A

B

C

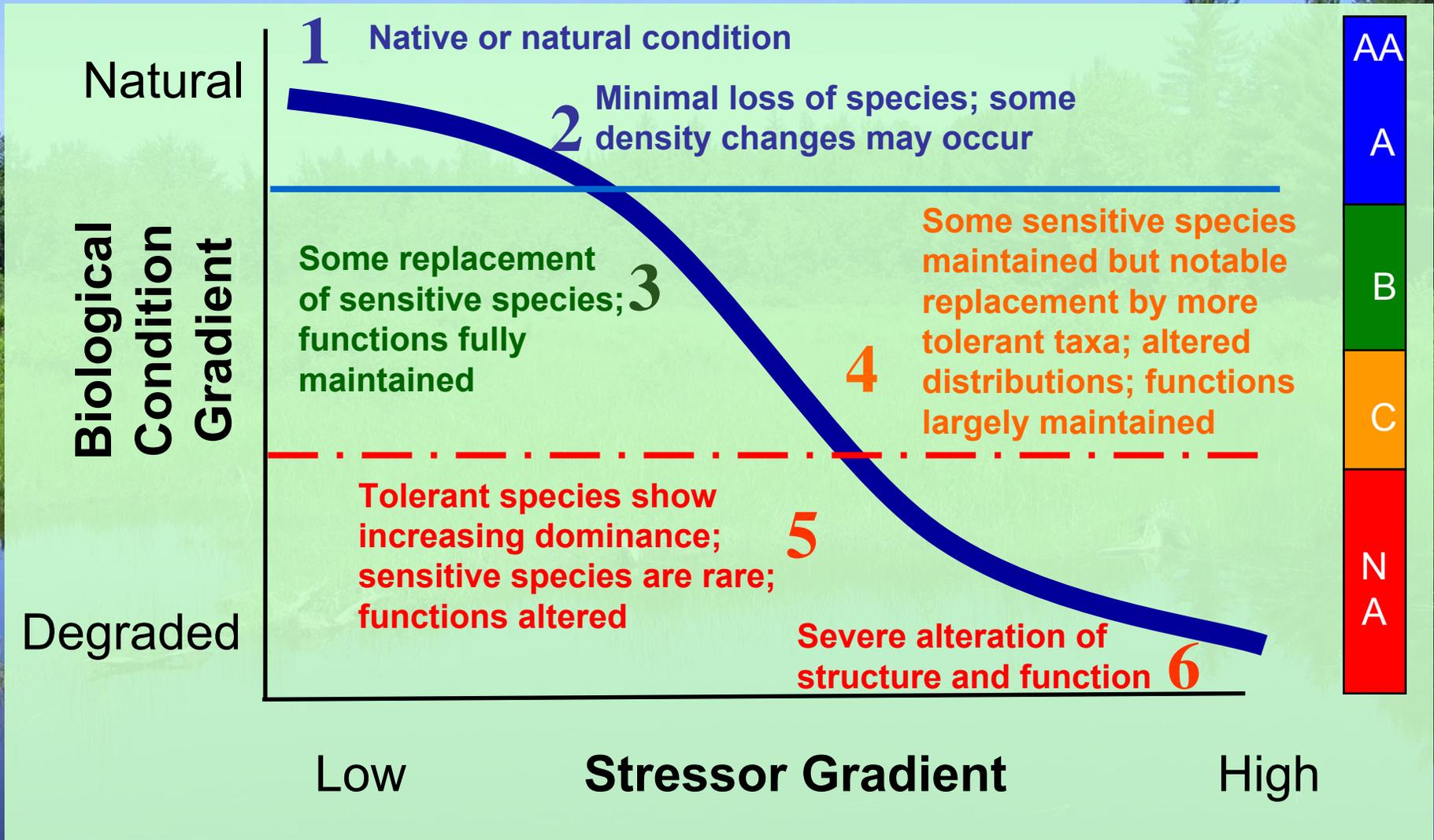


# Classes and Criteria

	<u>Numeric Criteria</u>		<u>Narrative Criteria</u>	
	Dissolved Oxygen	Bacteria ( <i>E. coli</i> )	Habitat	Aquatic Life (Biological)
<b>Class AA</b>	as naturally occurs	as naturally occurs	free flowing and natural	as naturally occurs
<b>Class A</b>	7 ppm or 75% sat.	as naturally occurs	natural	as naturally occurs
<b>Class B</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
<b>Class C</b>	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)



# Class A Stream (Tier 2)



Babel Brook, T5 R9 NWP

Stoneflies

Dragonflies &  
Damselflies

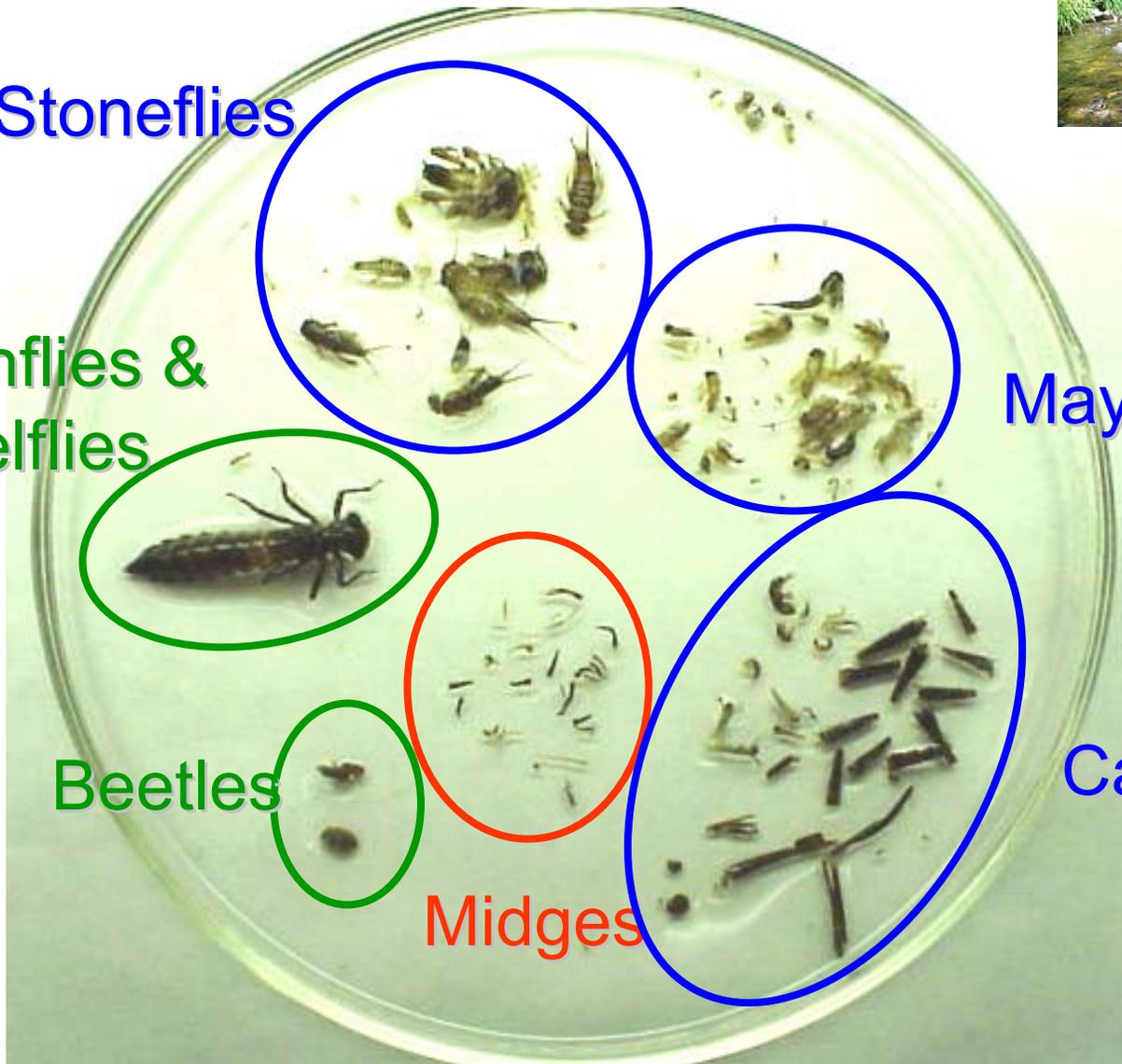
Beetles

Midges

Mayflies

Caddisflies

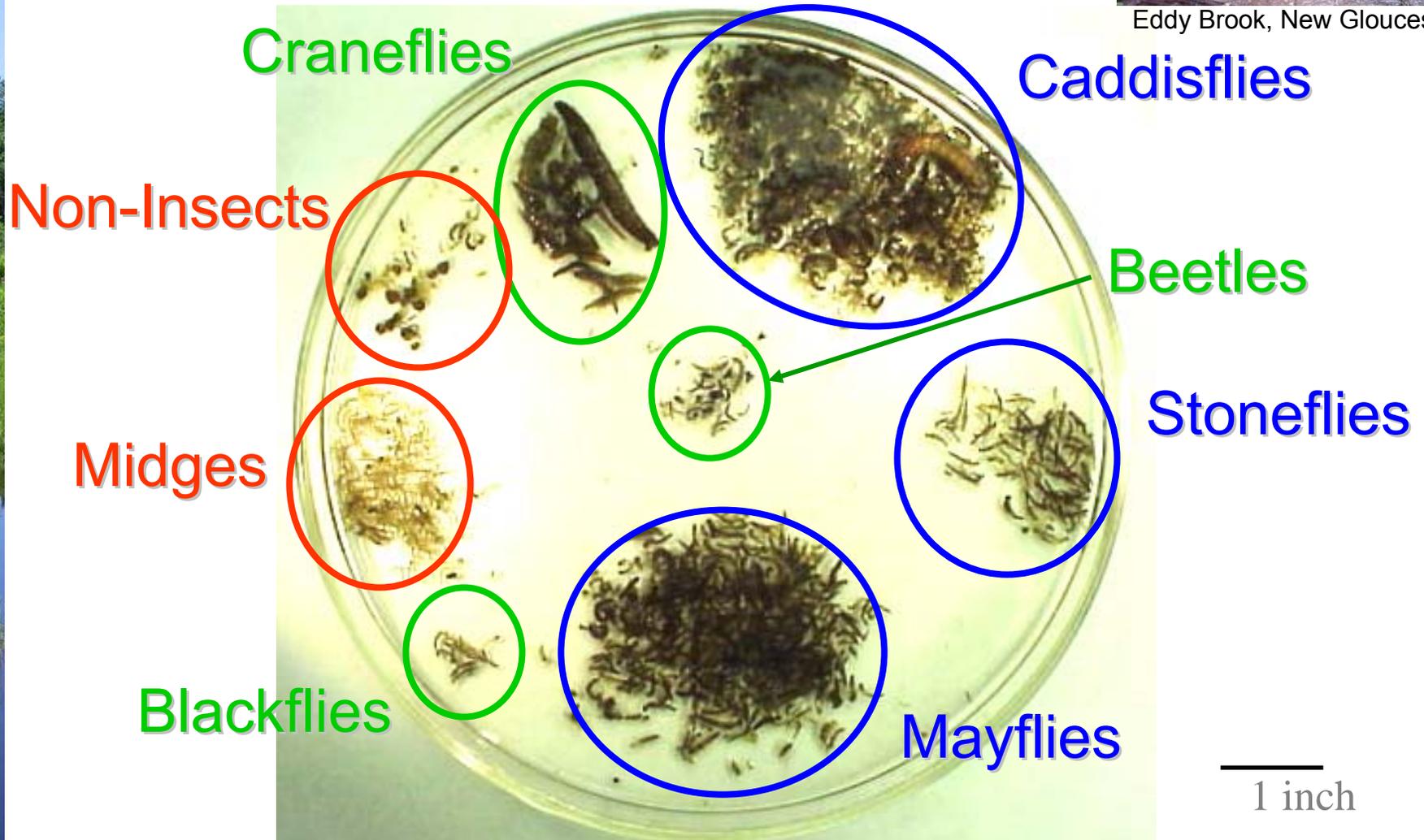
1 inch



# Class B Stream (Tier 3)



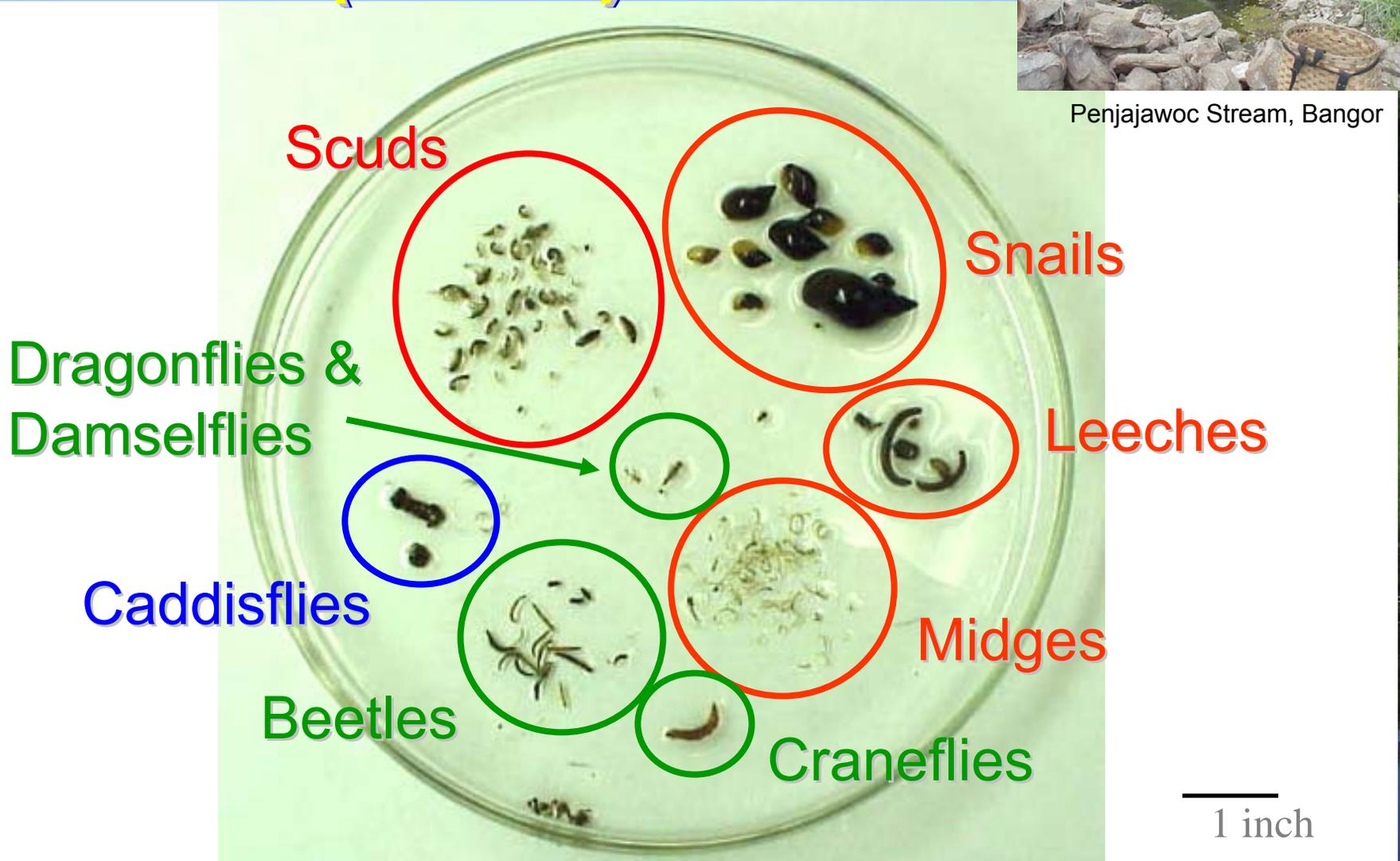
Eddy Brook, New Gloucester



# Non-Attainment Stream (Tier 5)



Penjajawoc Stream, Bangor



# 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?**

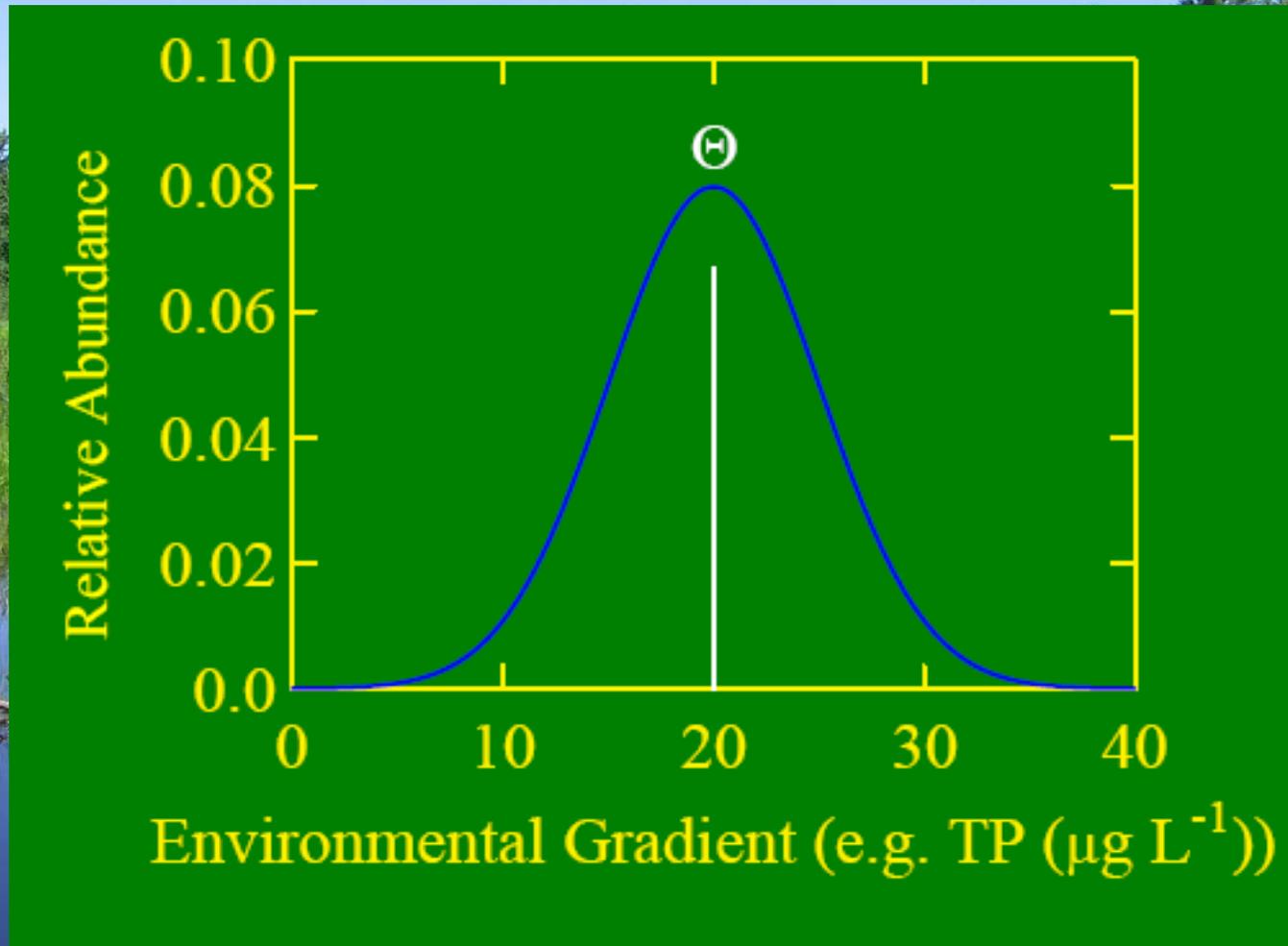
# Inference Models

- **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 ( $\theta$ )



# Weighted Average Optima

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

where:  $\theta_k$  = optima of species  $k$   
 $y_{ik}$  = abundance of species  $k$  in sample  $i$   
 $x_i$  = value of environmental parameter in sample  $i$

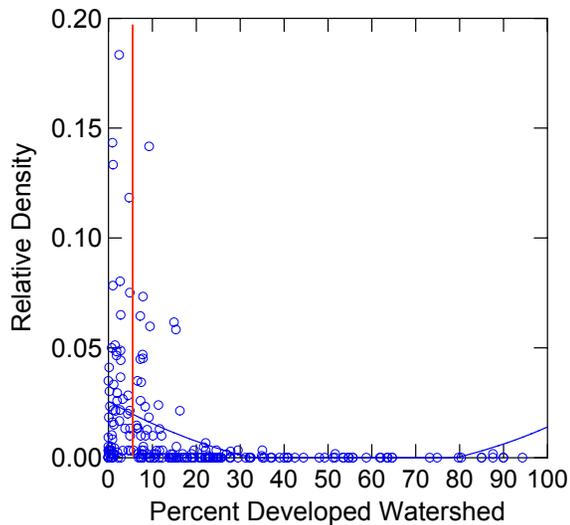
# Example Calculation (*Achnanthes conspicua*)

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 Ossipee 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

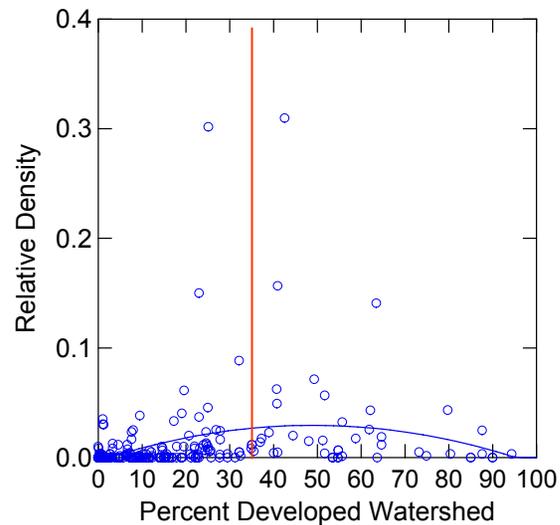
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# Examples of Optima

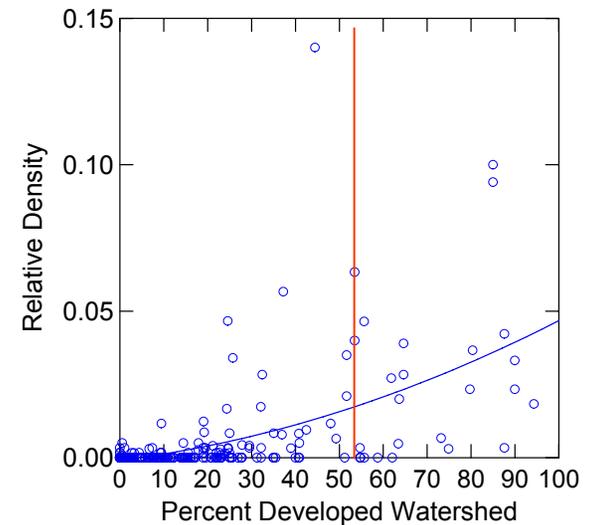
## *Brachysira microcephala*



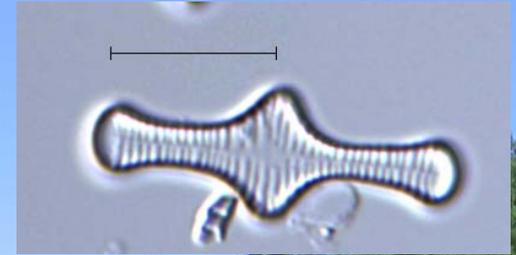
## *Reimeria sinuata*



## *Navicula gregaria*

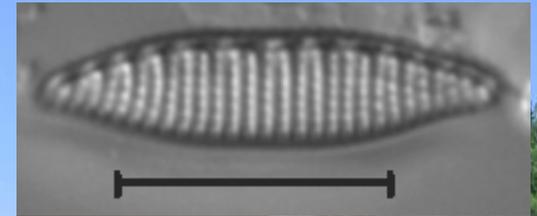


# *Tabellaria flocculosa*



<b>Percent of Watershed that is Forest or Wetland</b>	<b>98%</b>
<b>Percent of Watershed that is Impervious Surface</b>	<b>1%</b>
<b>Specific Conductance</b>	<b>22 <math>\mu</math>S/cm</b>
<b>Total Nitrogen</b>	<b>14 ppm</b>
<b>Total Phosphorous</b>	<b>8 ppb</b>

# *Nitzschia amphibia*



**Percent of Watershed that  
is Forest or Wetland**

**16%**

**Percent of Watershed that  
is Impervious Surface**

**40%**

**Specific Conductance**

**475  $\mu$ S/cm**

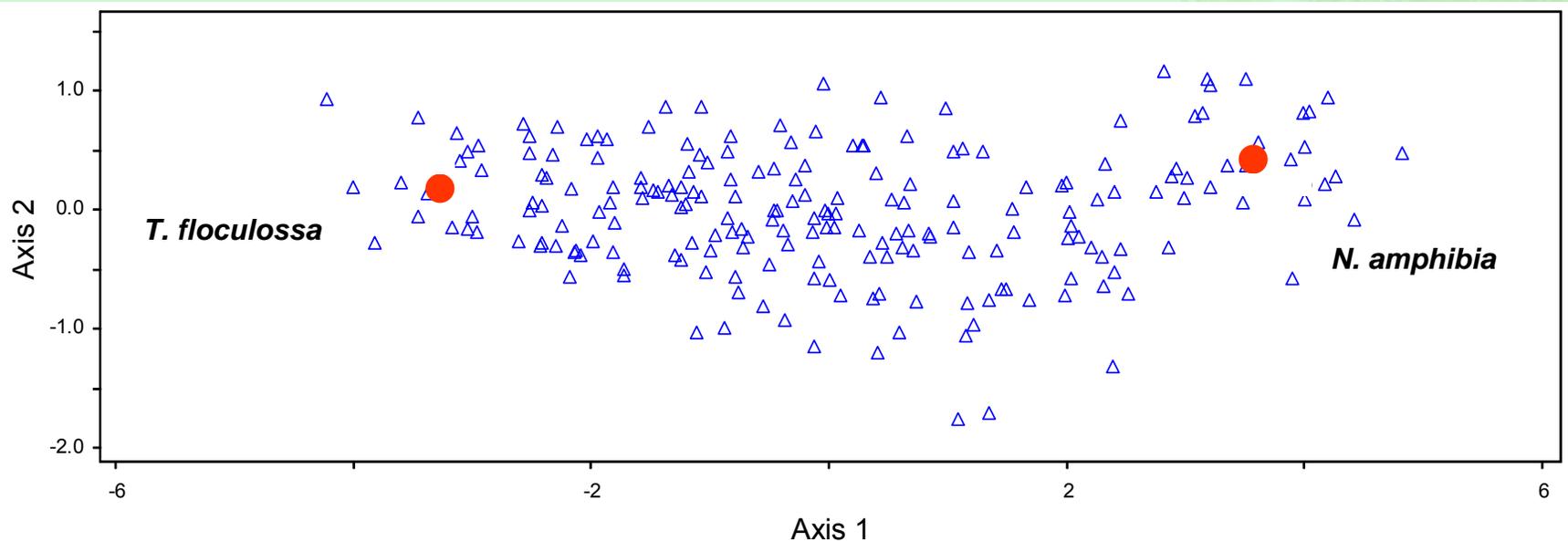
**Total Nitrogen**

**109 ppm**

**Total Phosphorous**

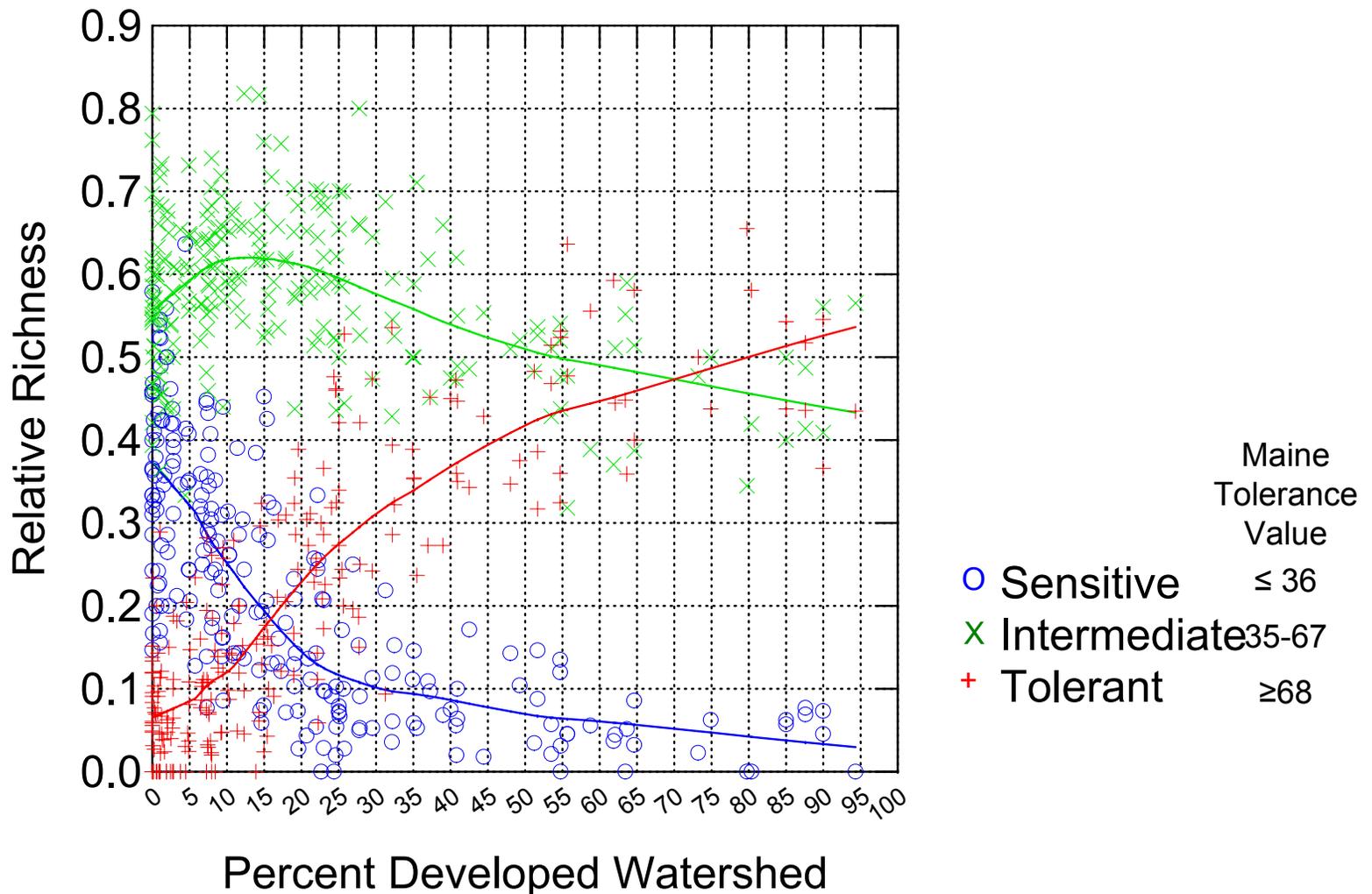
**39 ppb**

# PCA Ordination Identified Major Pattern in Species Optima

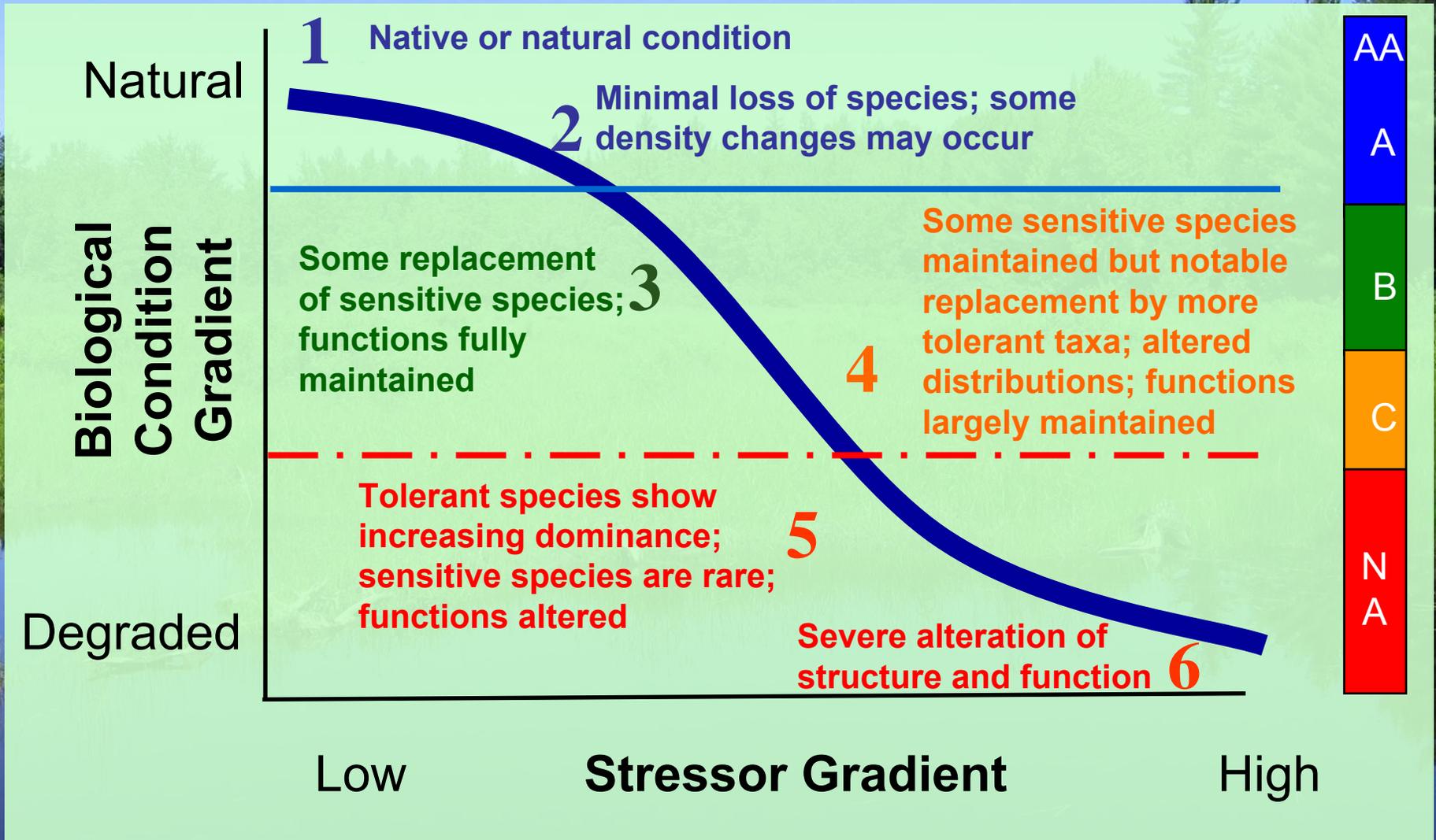


- **Axis 1 represents 86% of variance**
- **Rescaled axis to 1 (most sensitive) to 100**

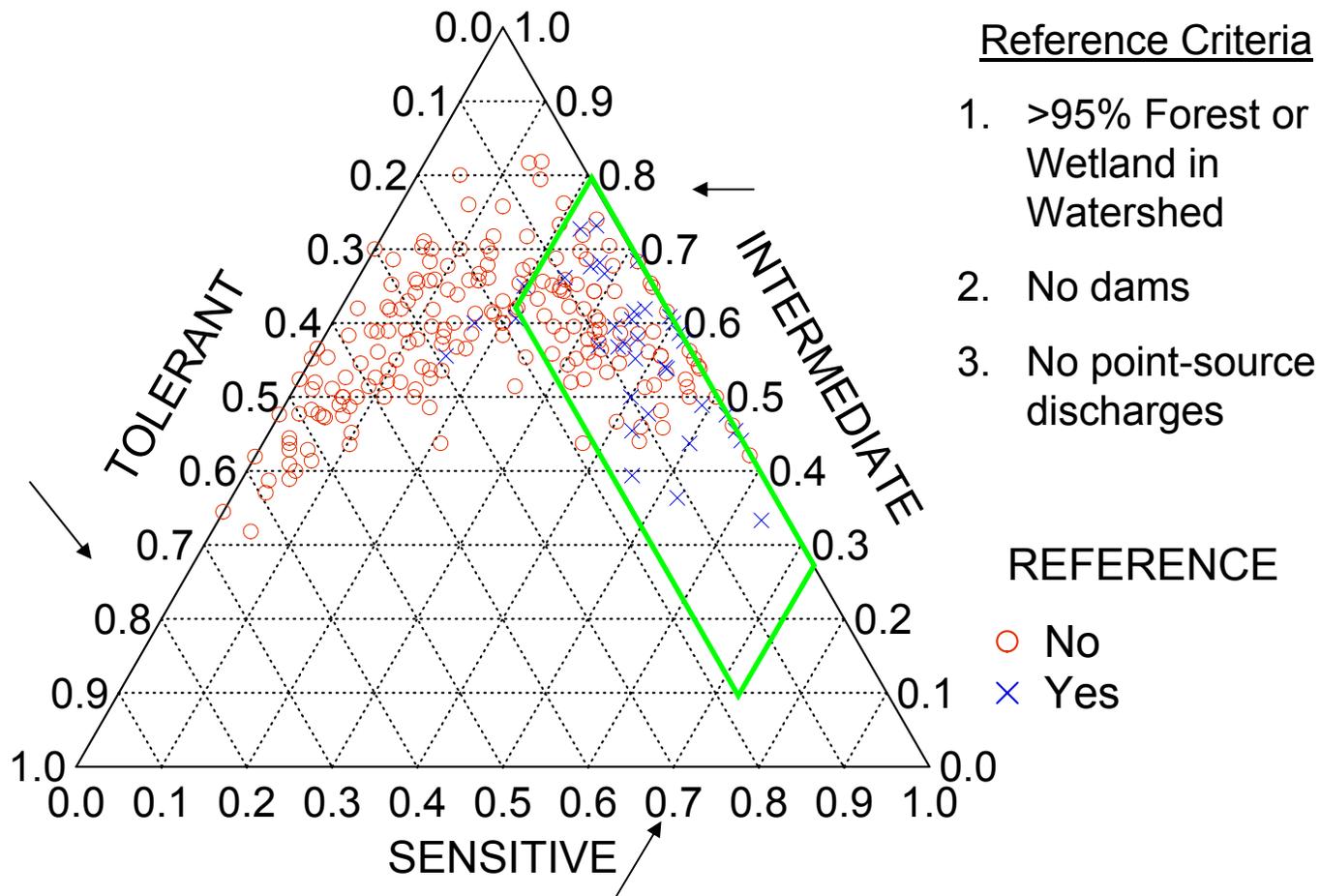
# Relative Richness of Sensitive, Intermediate, and Tolerant Algae



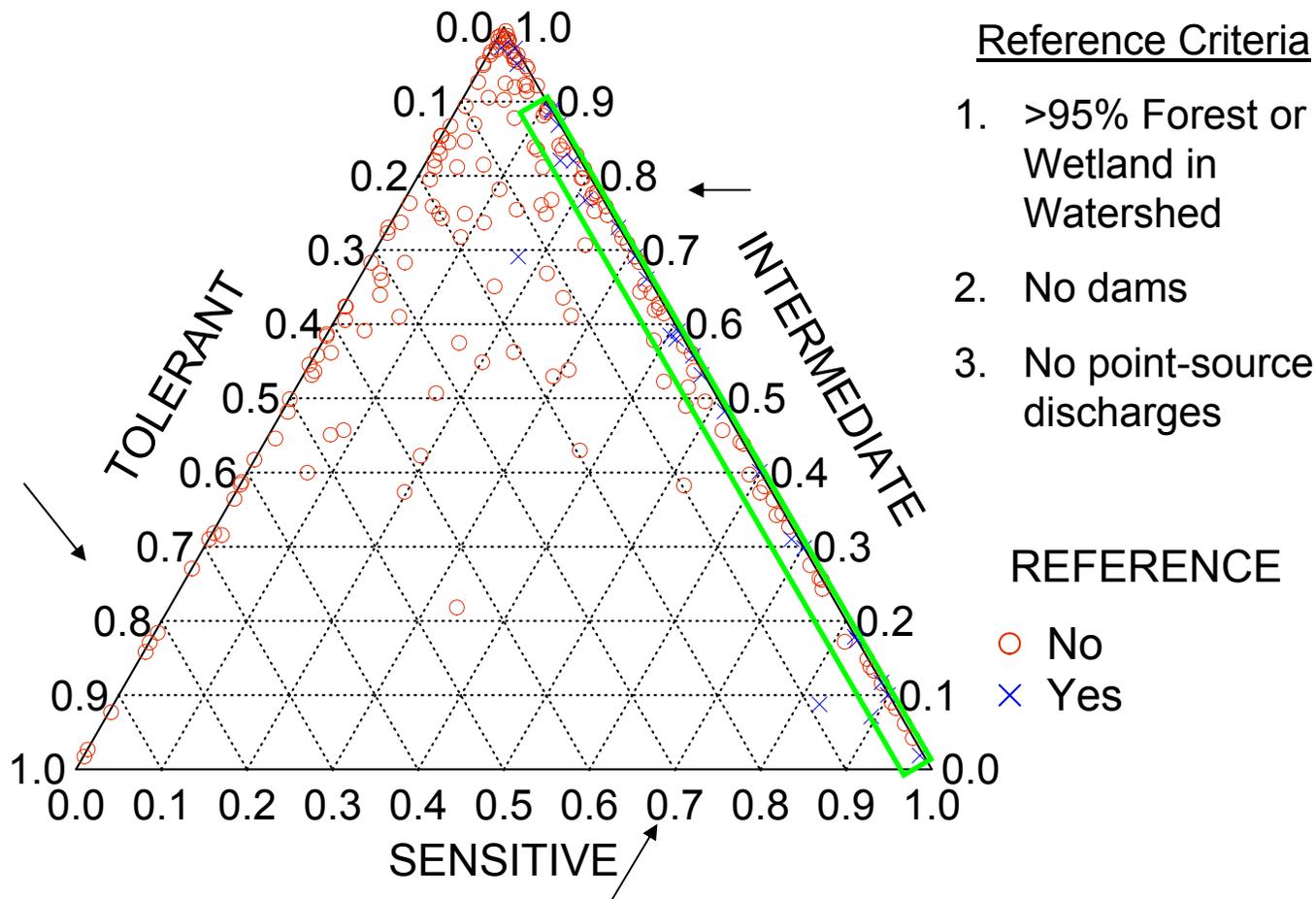
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# Relative Richness of Sensitive, Intermediate, and Tolerant Algae



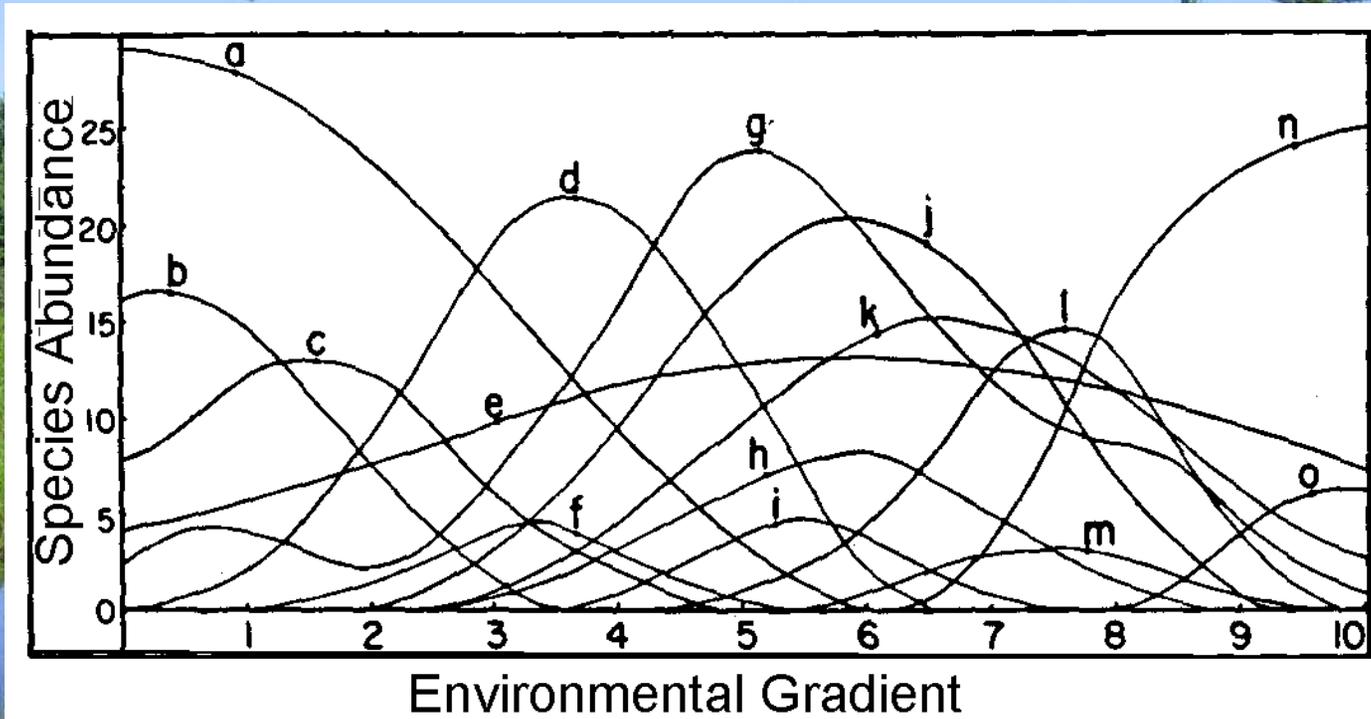
# Relative Biovolume of Sensitive, Intermediate, and Tolerant Algae



# 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?**
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# Overlapping Species Response Curves

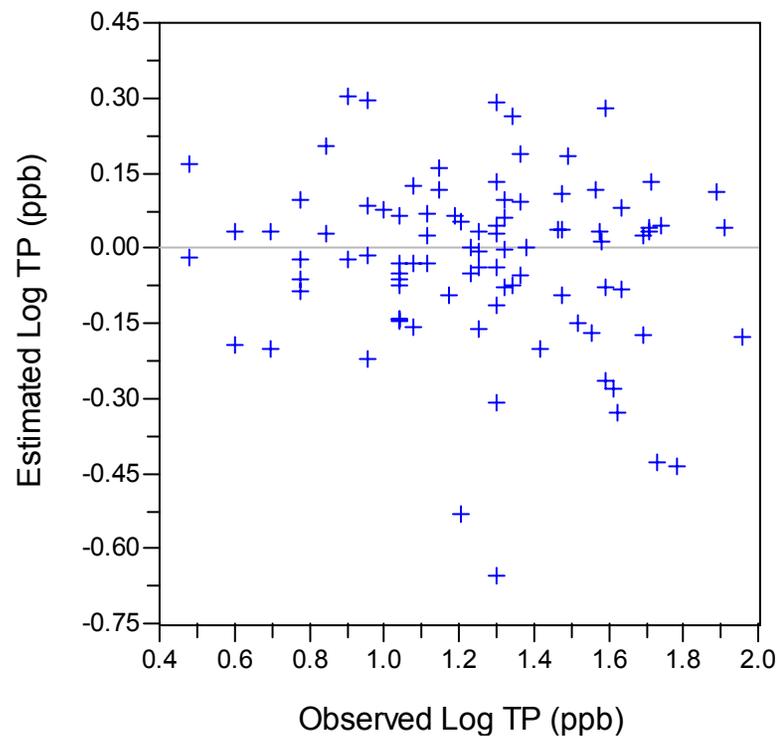
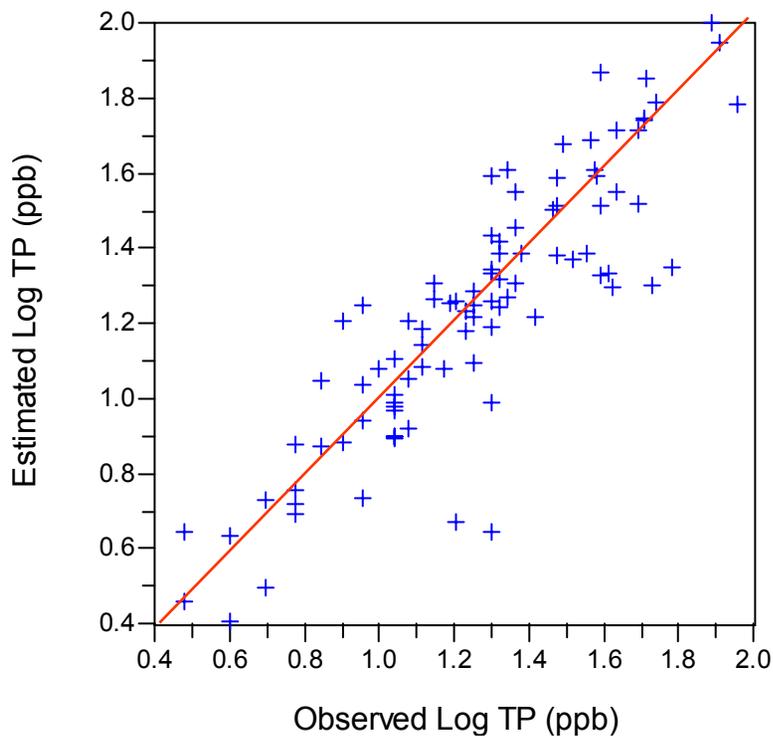


From: McCune, B. & J. B. Grace. 2002. *Analysis of Ecological Communities*. MjM Software Design, Gleneden Beach, Oregon <http://www.pcord.com>

# Types of Ecological Inference Models

- **Weighted averaging (WA)**
  - Inferred TP =  $\Sigma$  (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

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

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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

- [thomas.j.danielson@maine.gov](mailto:thomas.j.danielson@maine.gov)
- [www.maine.gov/dep/blwq/docmonitoring/biomonitoring/](http://www.maine.gov/dep/blwq/docmonitoring/biomonitoring/)

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