

# Accounting for Confounders Leads to Clearer Effects-Thresholds for Some Stressors



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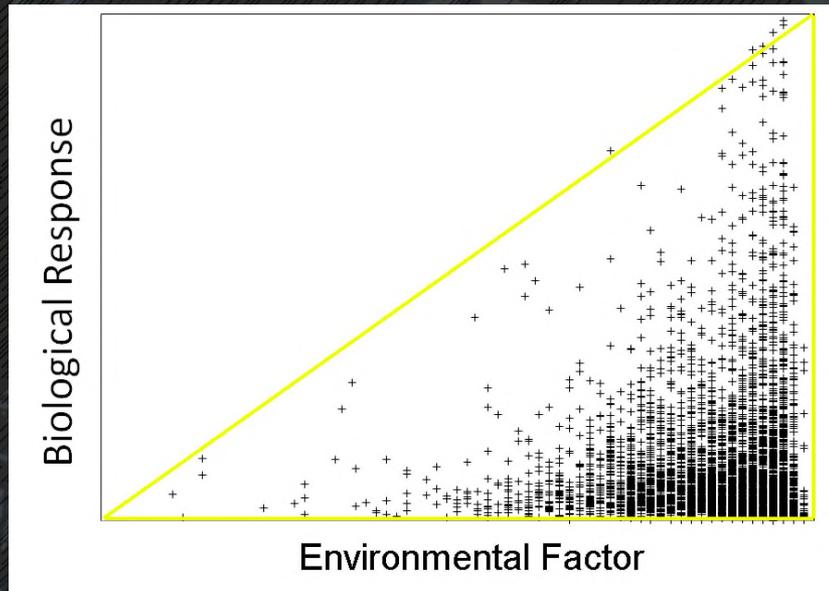
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30 W. Gude Dr., Rockville MD 20850, [www.potomacriver.org](http://www.potomacriver.org)

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## “Classic Wedge”



Highly  
Stressful  
Habitat

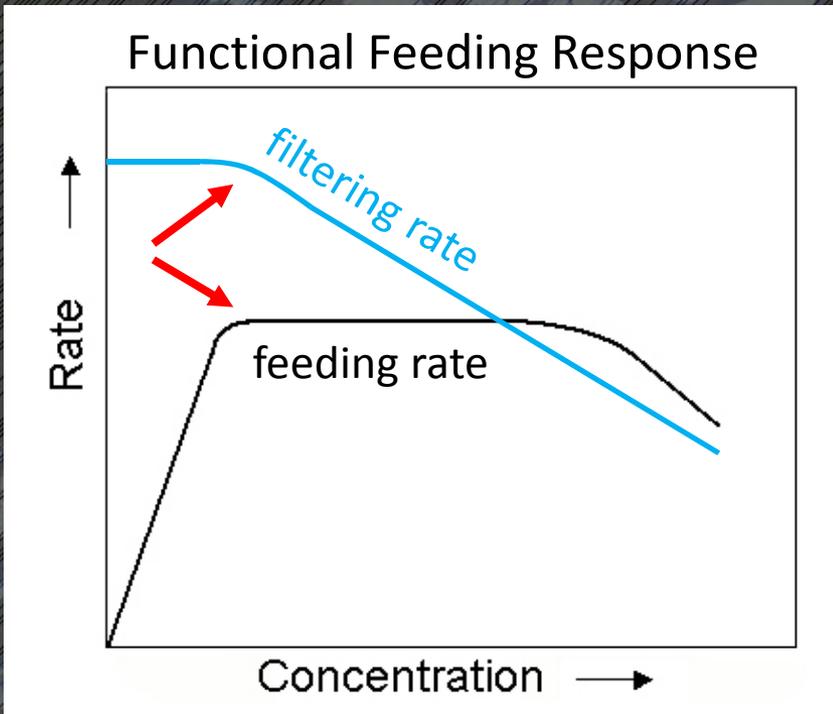


Not  
Stressful  
Habitat

- **Confounders**

Environmental factors or ecological processes that interfere with or mask an ecosystem response to a particular stressor.





- Effect-Threshold

The point at which an additional, small change in an environmental factor produces a large, non-linear response in a key ecosystem property or state.



# Chesapeake Bay region

- 1) Recursive Partitioning  
splitting
- 2) Quantile Regression  
bounding
- 3) Binning  
grouping



# Recursive Partitioning (RPART, CART)

a non-parametric **decision tree** technique that **splits the data** into increasingly distinct groups based on which independent variables optimally differentiates observations in the dependent (response) variable ... provides **thresholds**

## Example

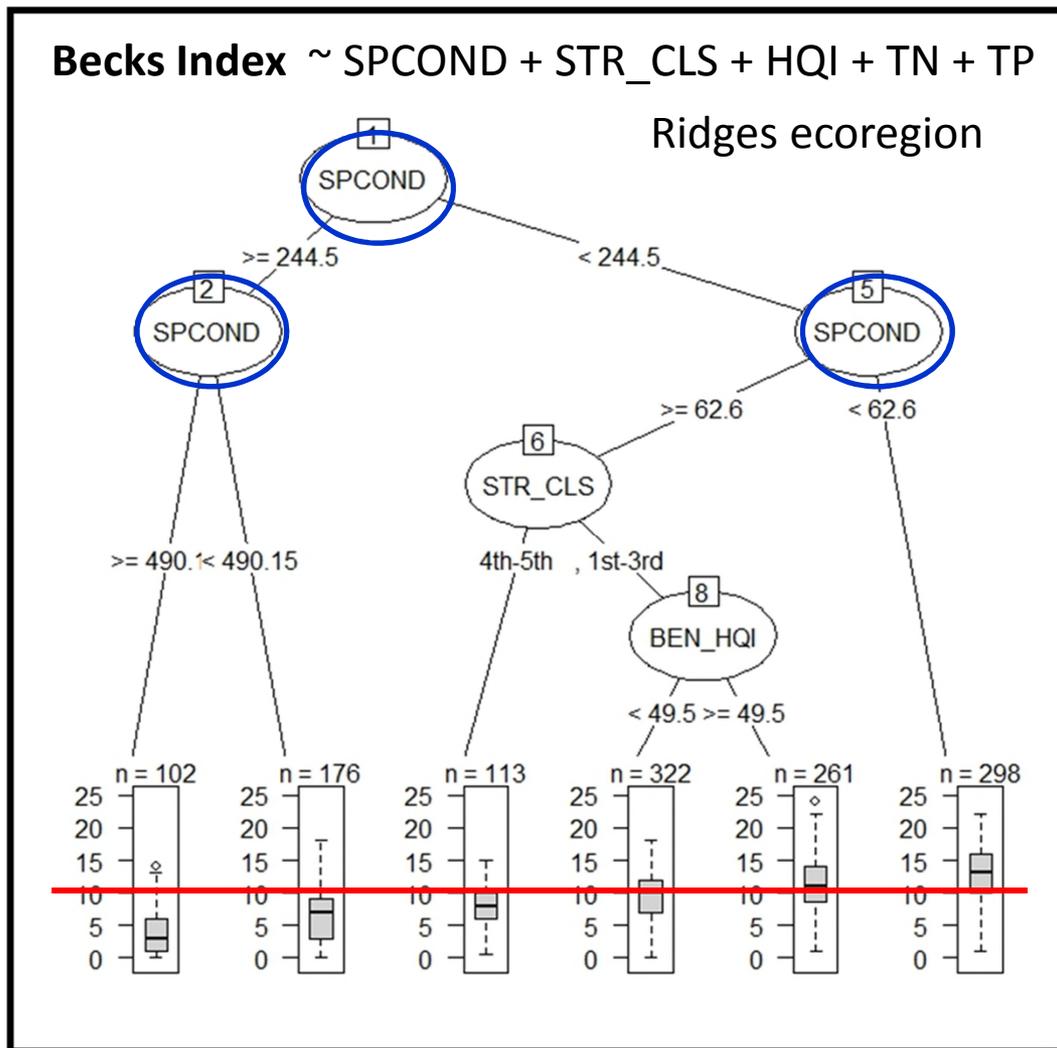
Looking for nutrient effect-thresholds in streams and ran into confounders

Response variable:

- Beck's Index (stream macroinvertebrates; high values = sensitive taxa)

Independent variables:

- Conductivity (SPCOND)
- Stream class (STR\_CLS)
- Habitat condition (HQI)
- Total nitrogen (TN)
- Total phosphorus (TP)



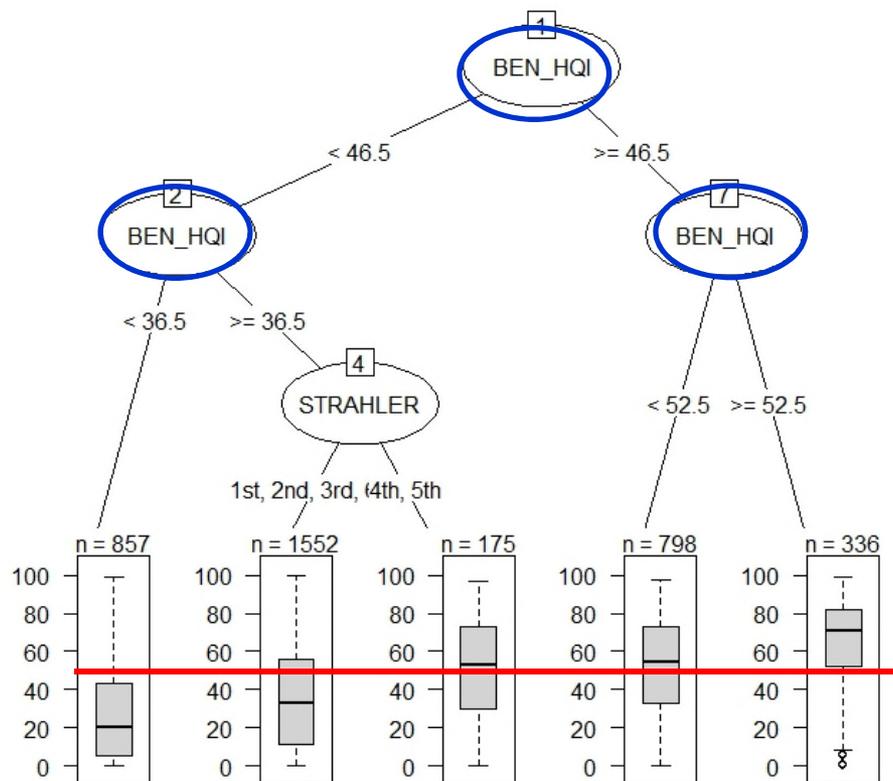
# Recursive Partitioning (RPART, CART)

%EPT ~ BEN\_HQI + TP + TN + Strahler Order  
Piedmont ecoregion

## Example (cont.)

Remove from data analysis  
samples affected by high  
conductivity

**In-stream habitat quality**  
appears as primary  
explanatory variable for many  
stream macroinvertebrate  
metrics



BEN\_HQI: epifaunal substrate, embeddedness,  
and either riffle-frequency or riffle-quality metric

# Recursive Partitioning (RPART, CART)

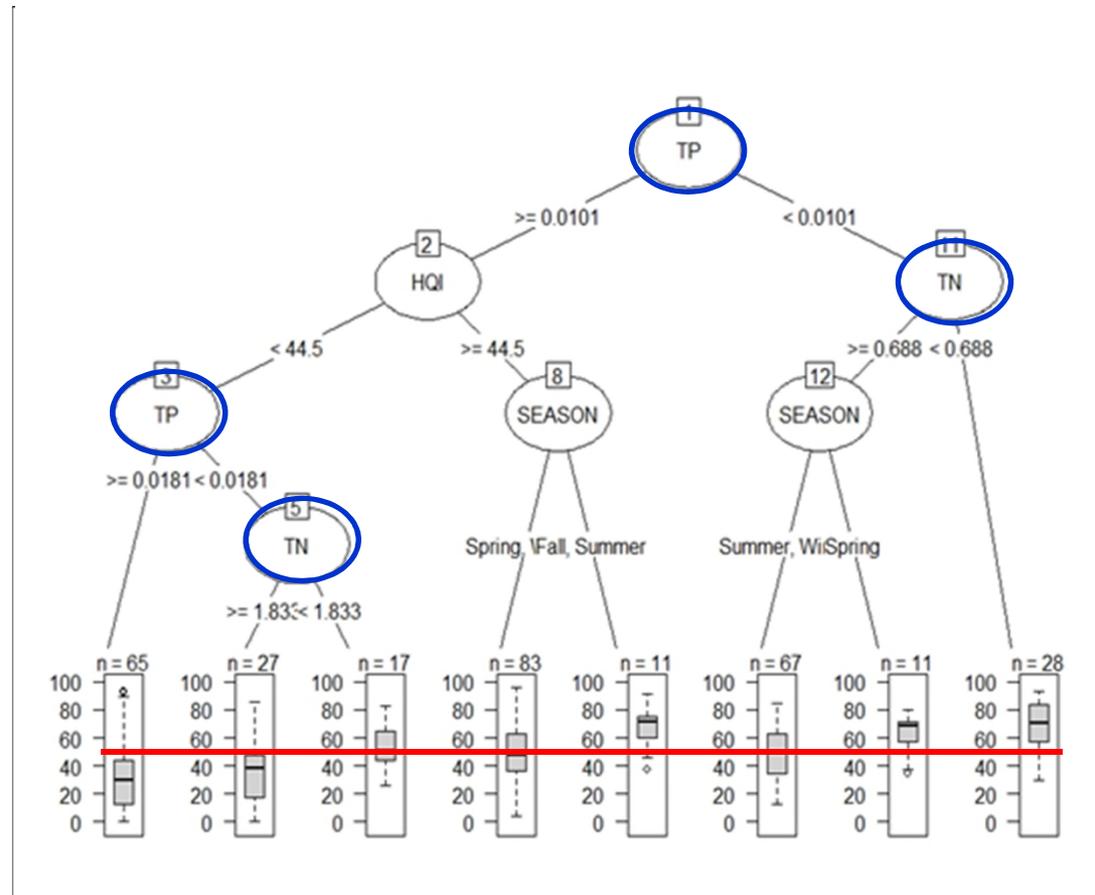
## Example (cont.)

Remove from data analysis samples affected by high conductivity **and** poor habitat quality

**Nutrients** begin to appear as primary explanatory variables for many stream macroinvertebrate metrics

**Note:** streams in this abbreviated analysis data set are relatively undisturbed

$\%EPT \sim TP + TN + HQI(>30) + \text{Season} + \text{Strahler Order}$

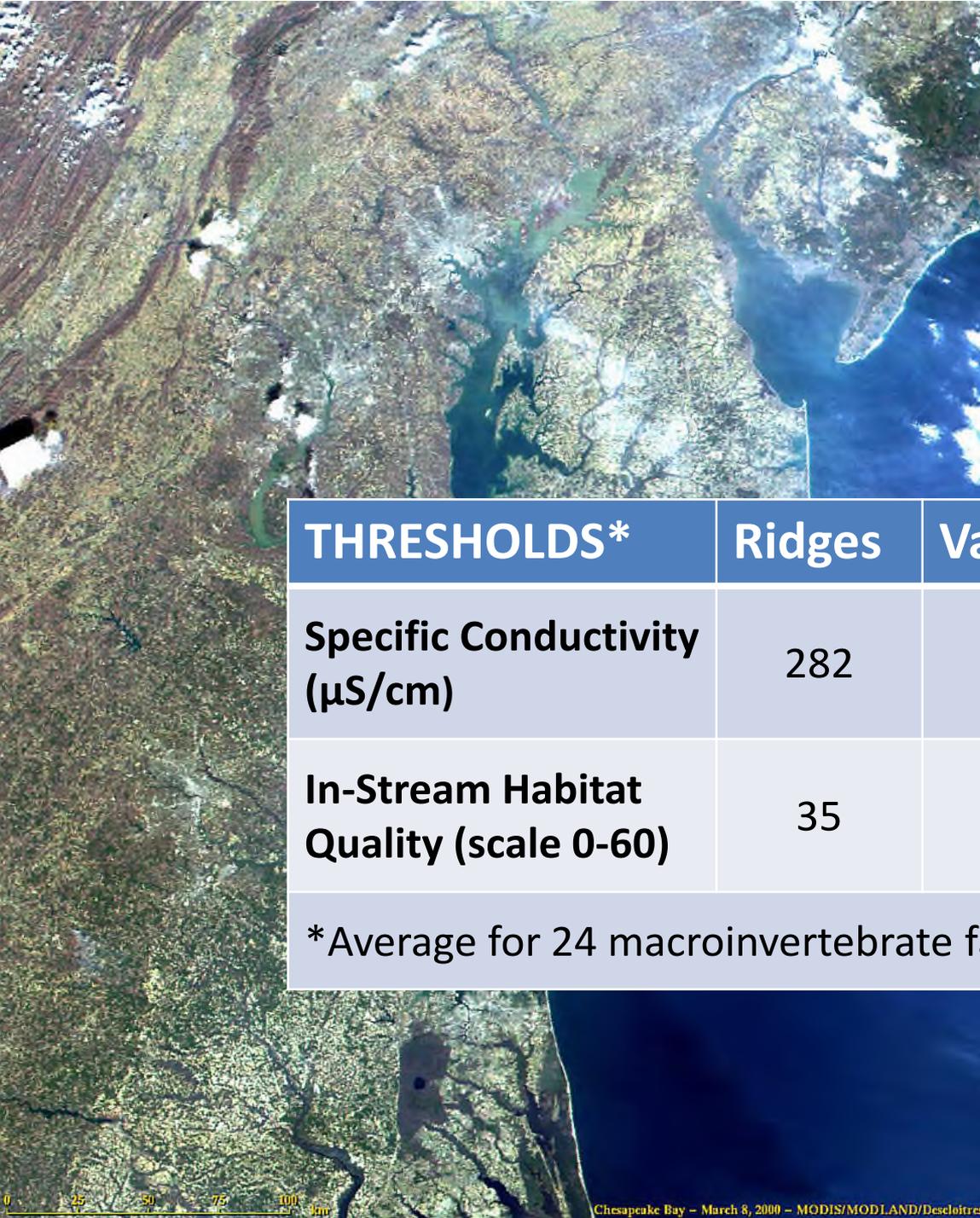


**Effect-thresholds for one factor can be masked by stronger, confounding factor(s)**

<b>THRESHOLDS*</b>	<b>Ridges</b>	<b>Valleys</b>	<b>Piedmont</b>	<b>Coastal</b>
<b>Specific Conductivity (<math>\mu\text{S}/\text{cm}</math>)</b>	282	329	200	200
<b>In-Stream Habitat Quality (scale 0-60)</b>	35	30	30	25

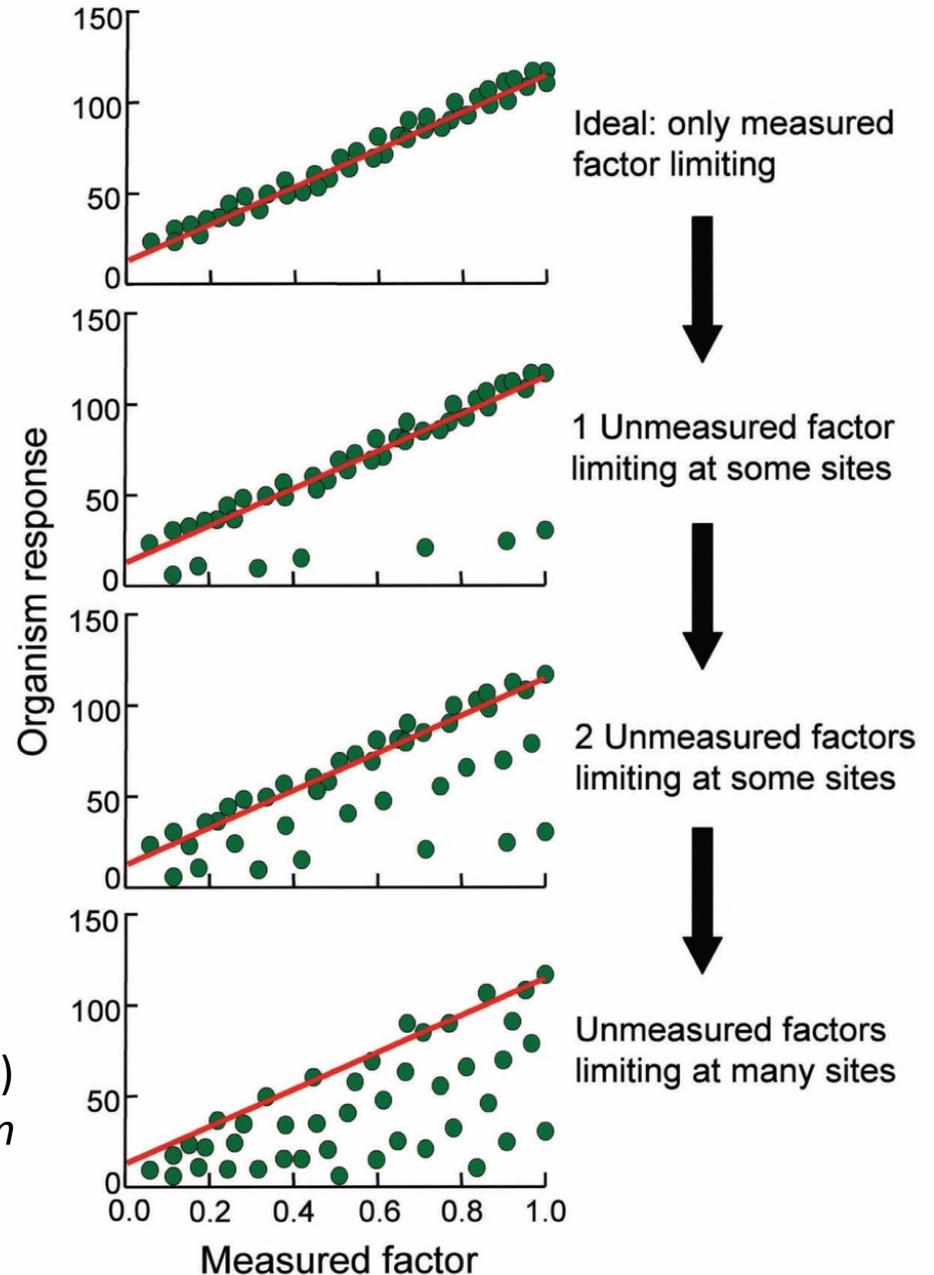
\*Average for 24 macroinvertebrate family-level metrics

**Recursive partitioning results are data-driven**



# Quantile Regression

delineates the outer edge of a data cloud



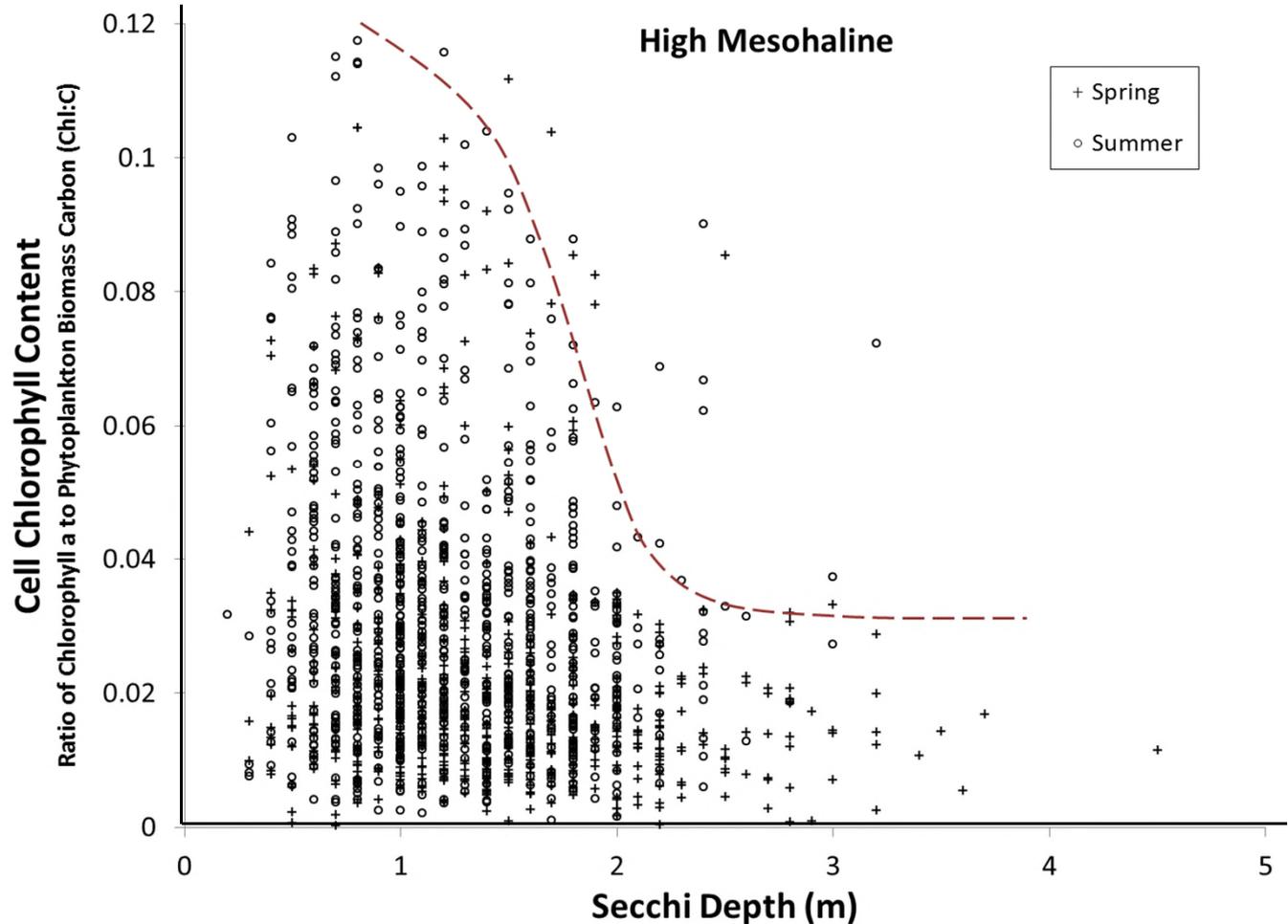
**Figure 2** from Cade B.S. & Noon B.R. (2003) *A gentle introduction to quantile regression for ecologists*. *Frontiers in Ecology and the Environment* 1(8):412–420.

# Quantile regression

Water clarity effect-thresholds for chlorophyll cell content of tidal phytoplankton

Dark-adapted  
(light-limited)

Light-adapted  
(adequate light)



Water clarity has a bigger impact on phytoplankton than phytoplankton (Chla) have on water clarity a lot of the time in Chesapeake Bay

# Light attenuation (Secchi depth) effect-thresholds for tidal phytoplankton

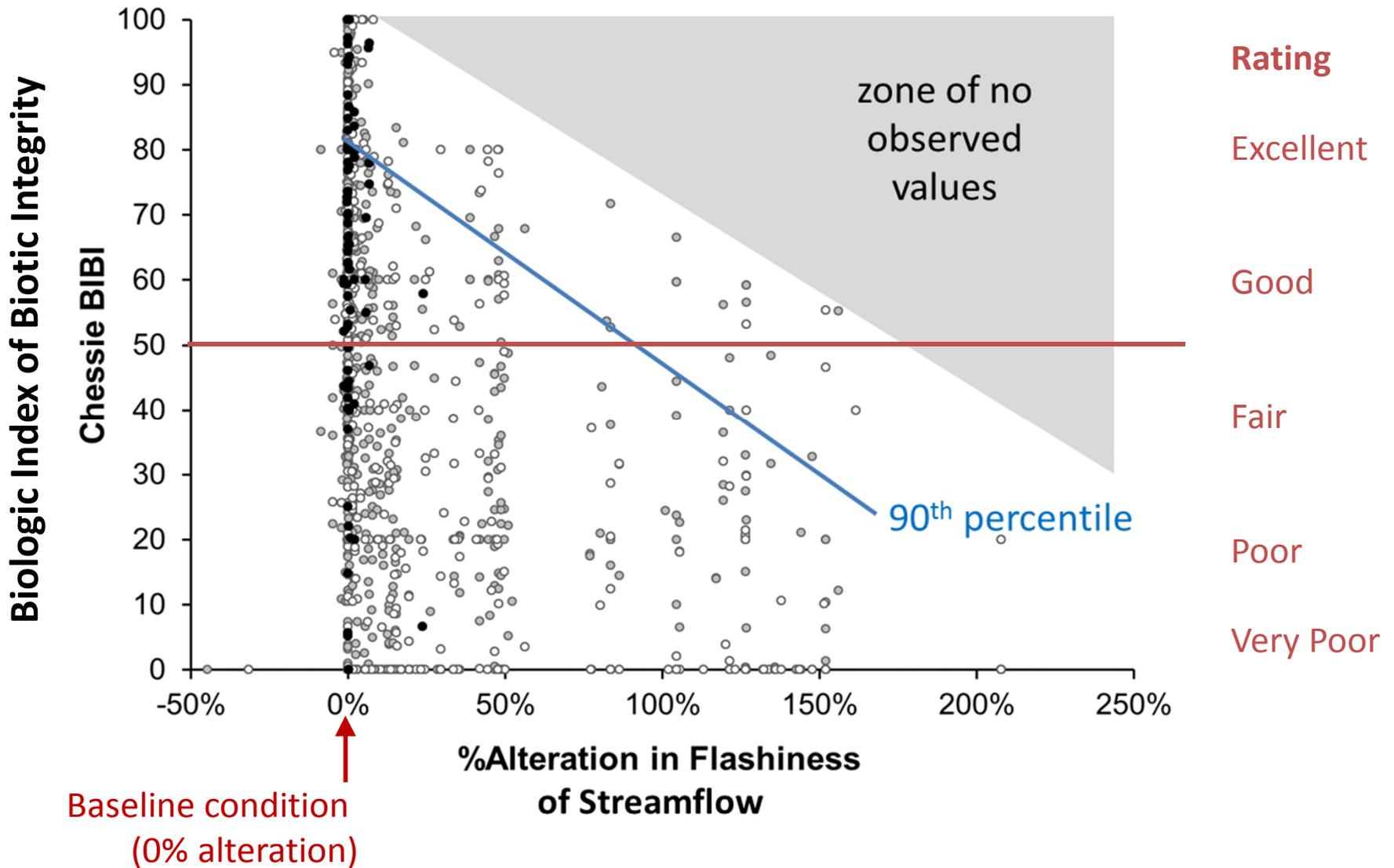
Salinity Zone	Spring (Mar-May)	Summer (Jun-Sep)
Tidal Fresh	(> 0.9)	(> 0.8)
Oligohaline	(> 0.7)	(> 0.6)
Mesohaline	(> 1.8)	(> 1.45)
Polyhaline	(> 2.15)	(> 1.85)

Currently being updated



# Quantile Regression

Flow alteration effect-thresholds on 20 stream macroinvertebrate metrics



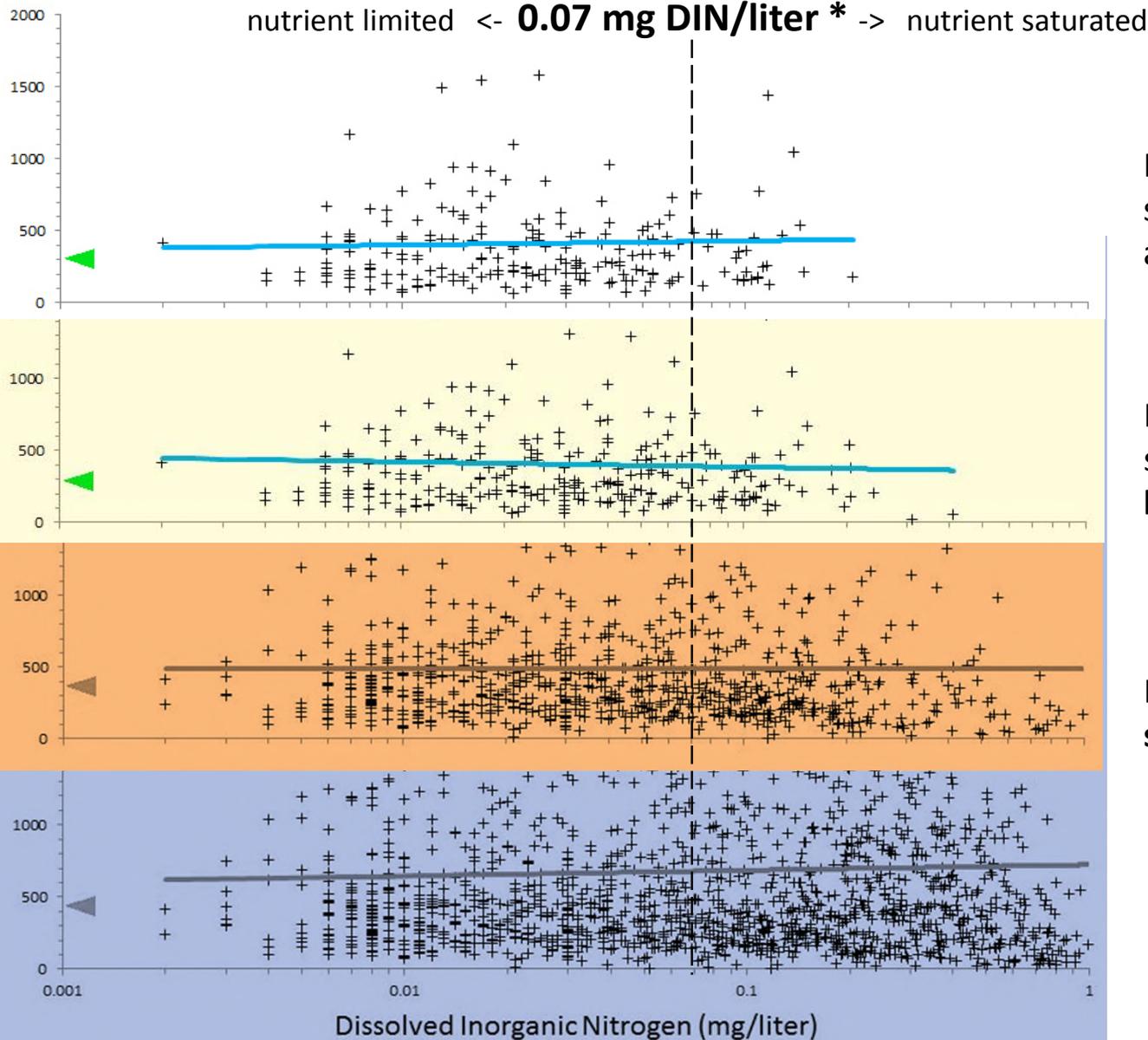


**Small changes from  
baseline in many  
streamflow metrics  
begin to impact  
macroinvertebrates  
immediately and  
negatively**

**Quantile regression  
results are data-driven**

# Phytoplankton Biomass vs Dissolved Inorganic Nitrogen (DIN)

Phytoplankton Total Biomass ( $\mu\text{g Carbon/liter}$ )



High mesohaline, summer, adequate light, and **low/limiting**  $[\text{PO}_4]$

High mesohaline, summer, and **adequate light** (Secchi > 1.45 m)

High mesohaline, and **summer** (Jul-Sep)

All **high mesohaline** (10 – 18 ppt) records

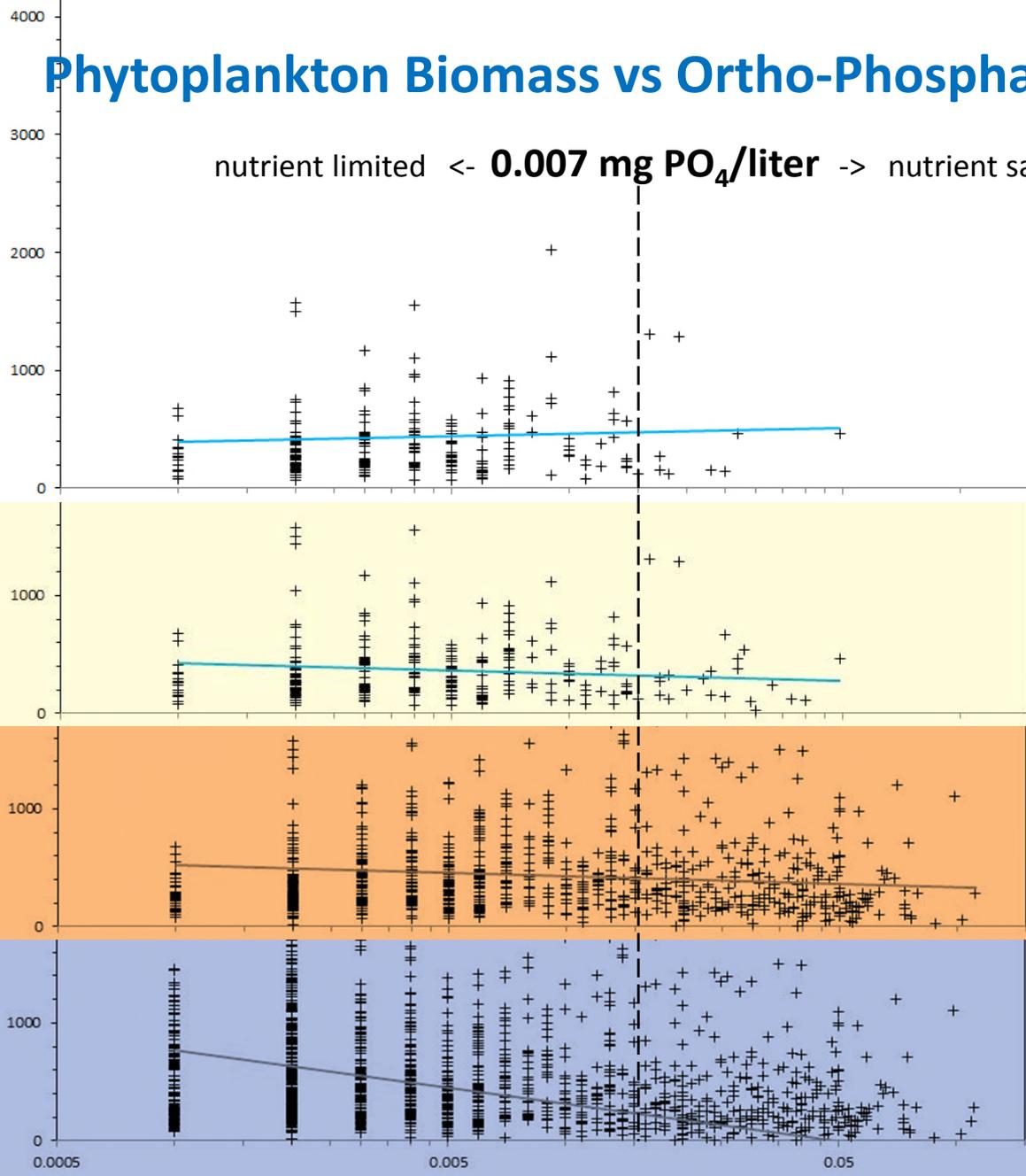
\* Fisher & Gustafson (2003)



# Phytoplankton Biomass vs Ortho-Phosphate ( $\text{PO}_4$ )

nutrient limited <- **0.007 mg  $\text{PO}_4$ /liter** -> nutrient saturated

Phytoplankton Total Biomass ( $\mu\text{g Carbon/liter}$ )



High mesohaline, summer, adequate light, and **low/limiting [DIN]**

High mesohaline, summer, and **adequate light** (Secchi > 1.45 m)

High mesohaline, and **summer** (Jul-Sep)

All **high mesohaline** (10 – 18 ppt) records



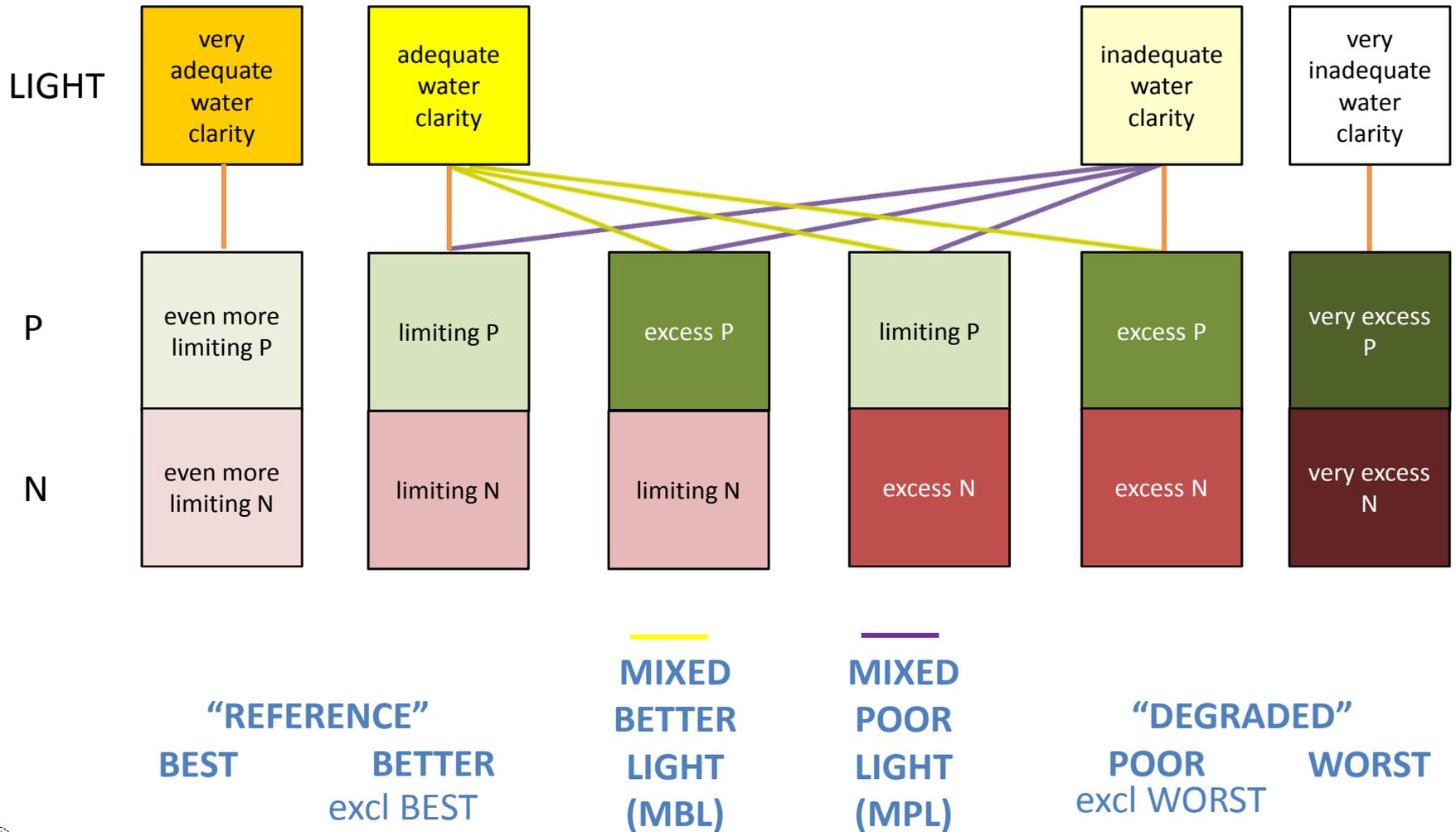
**Nutrient  
effect-thresholds  
for tidal  
phytoplankton  
observed in  
controlled  
experiments ...**

**but not in *in situ*  
populations**



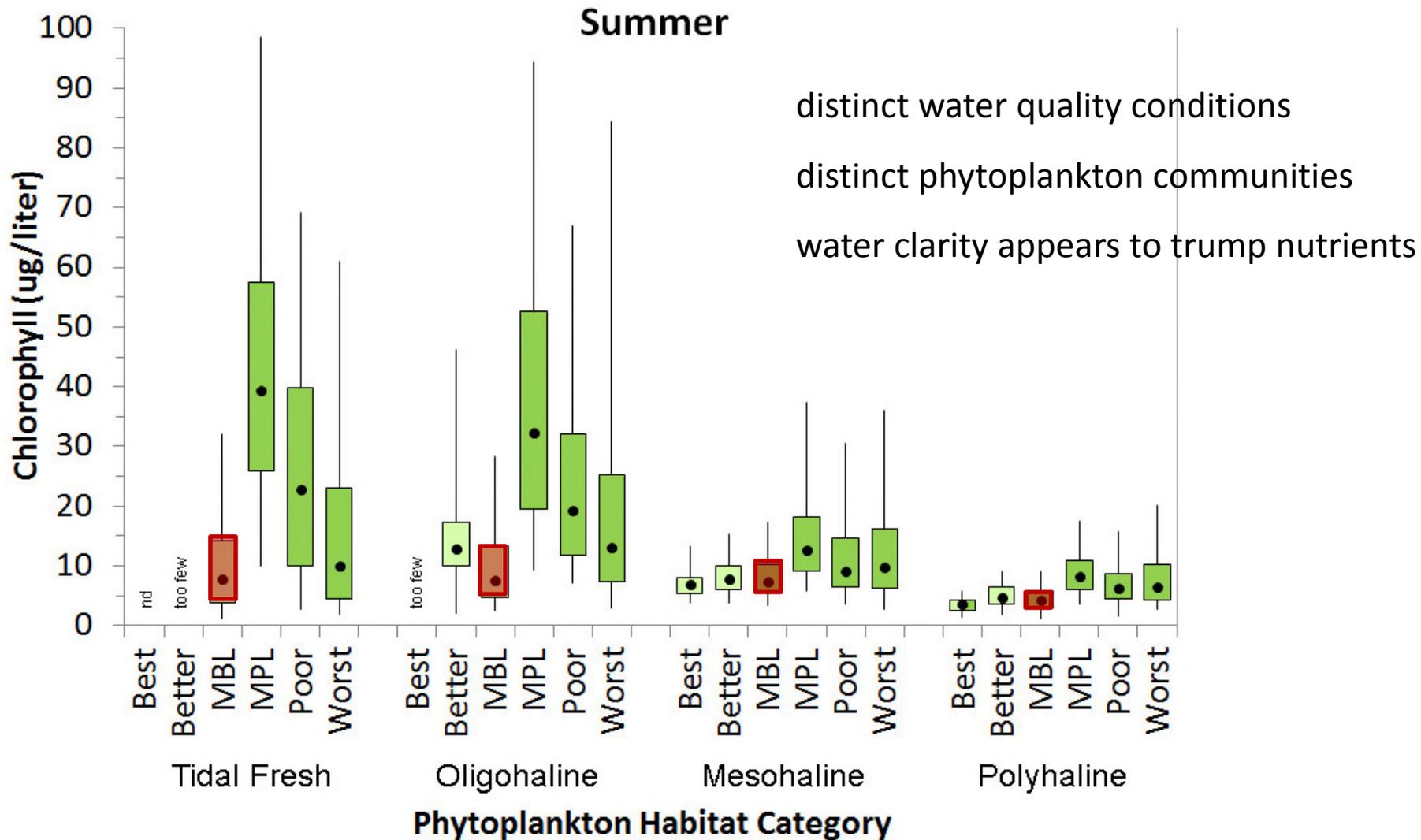
# Binning Approach

group multiple environmental factors to characterize distinct aquatic habitats  
(commonly called “reference-based” approach)



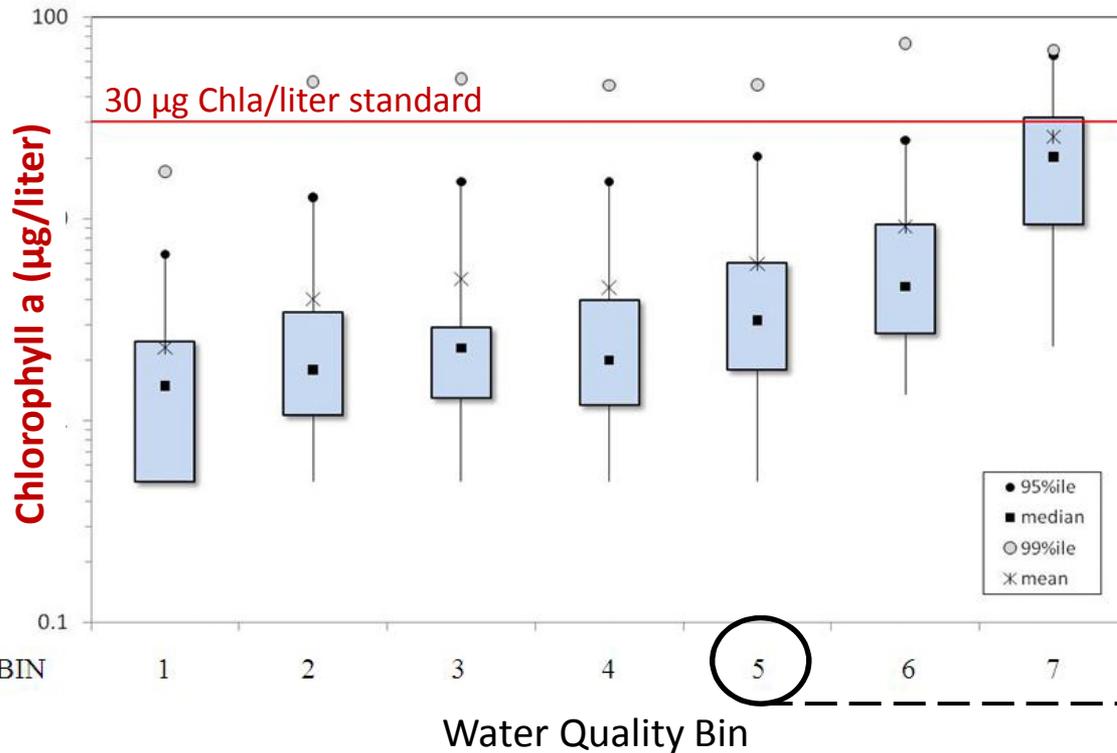
# Binning Approach

## Tidal Phytoplankton Communities



# Binning Approach

## Maryland Large Free-Flowing Rivers



Median levels at or below the following are protective of Maryland Chla standard:

	Lo DOC	Hi DOC
TP (mg/liter)	0.036	0.087
TN (mg/liter)	2.44	2.37
Turbidity (NTU)	10	10

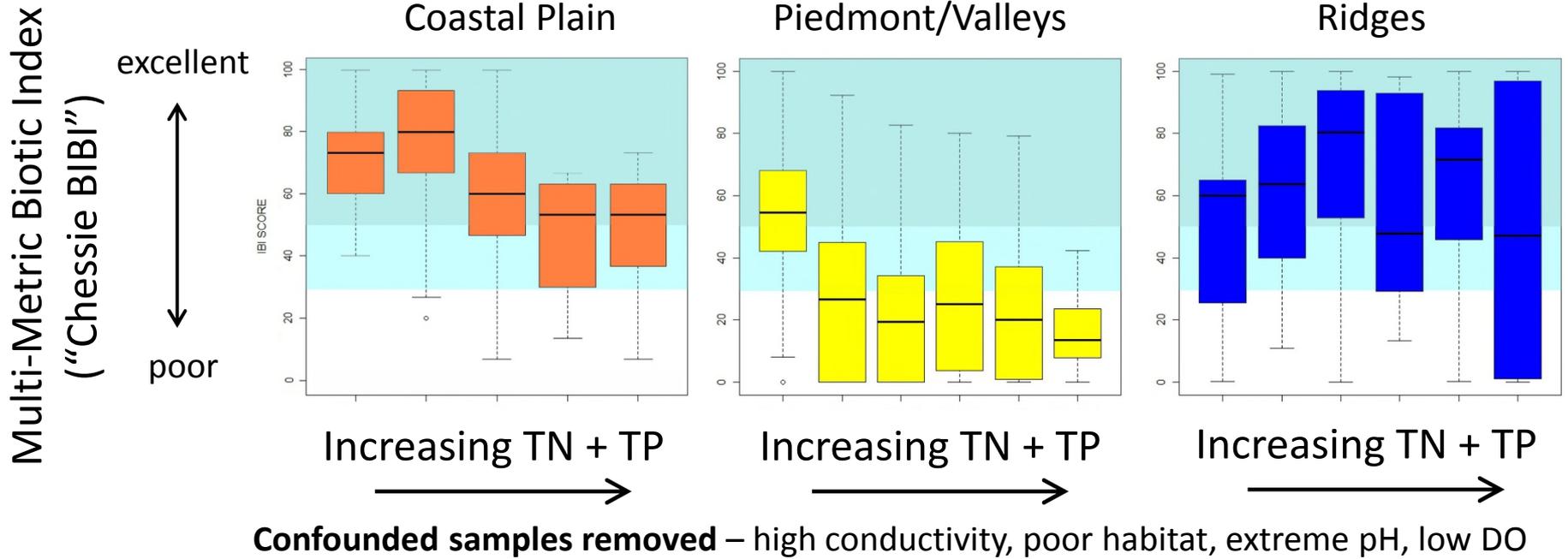
Very low  
TN, TP &  
turbidity  
("best")

Very high  
TN, TP &  
turbidity  
("worst")



# Binning Approach

Macroinvertebrates in 1<sup>st</sup> – 4<sup>th</sup> order Maryland streams



Median levels at or below **both** of the following are “protective” thresholds:

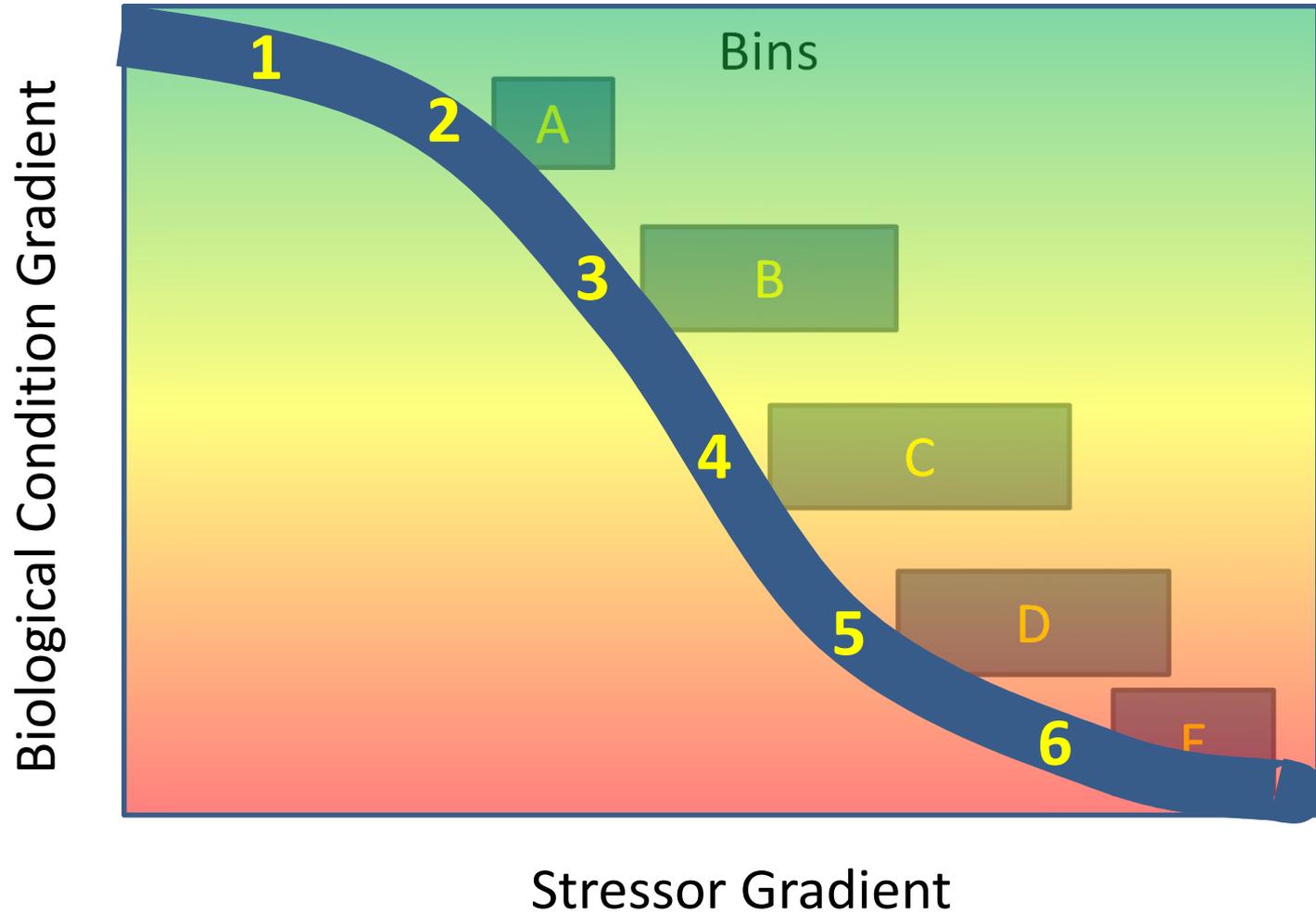
Maryland	Coastal Plain	Piedmont/Valleys	Ridges
TP (mg/liter)	0.029	0.012	0.013
TN (mg/liter)	0.58	1.13	0.85

**Binning approach  
clearly separates  
Reference & Degraded  
biological  
communities**

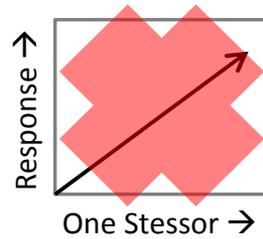
**...nutrient effect-  
thresholds are not  
evident in tidal waters  
and more evident in  
1<sup>st</sup> – 4<sup>th</sup> order streams**



# Tiered Aquatic Life Use Framework



# Resist linear thinking!



“Algae blooms are a response to increased nutrients”



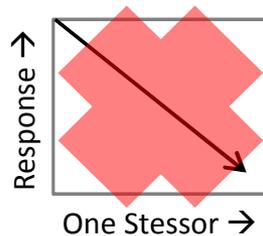
WV DEP



MD Dept. Env.

“Fish kills are a response to anoxia/hypoxia events”

Education and perception tend to make us think linearly...



Questions?

