Development of Nutrient Water Quality Standards for Ohio Surface Waters

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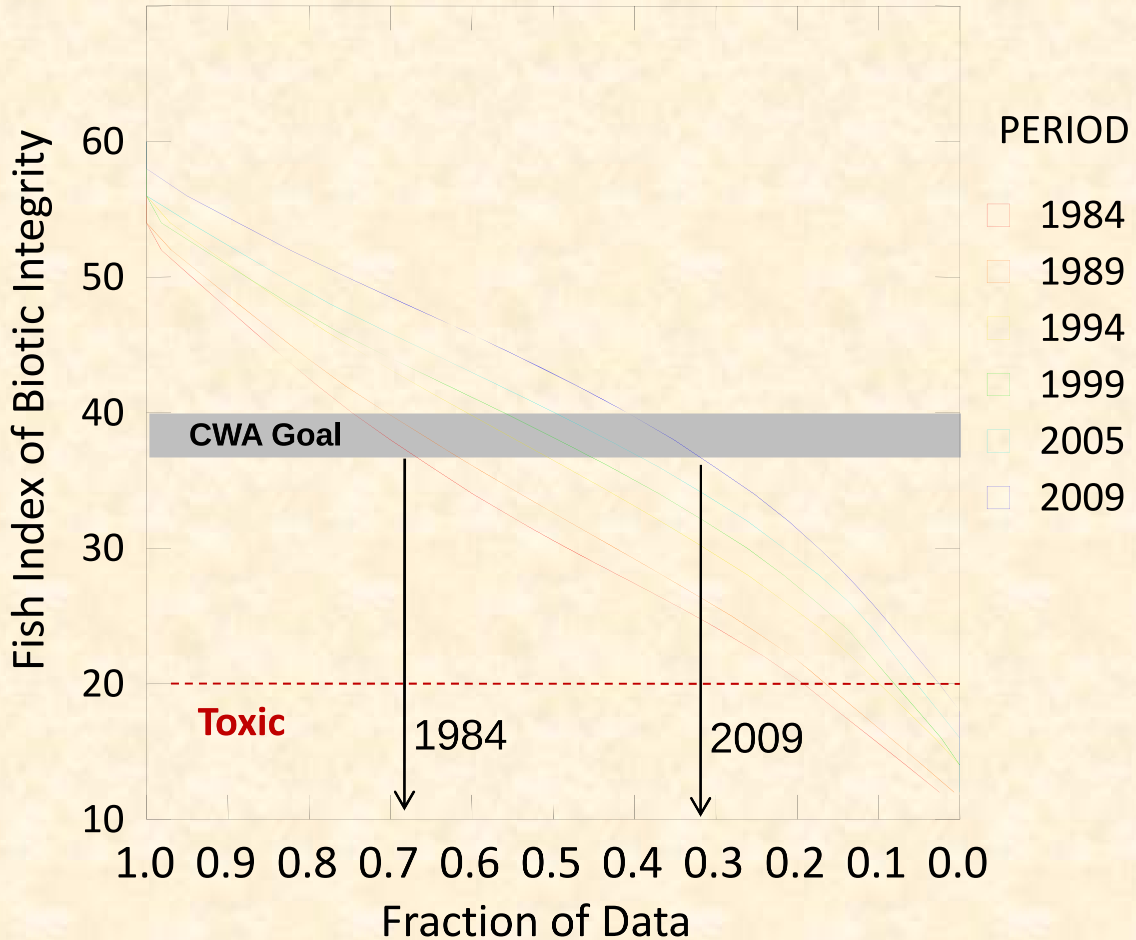
Nutrient Pollution
Scope and Magnitude

- Nutrient over-enrichment is one of the top 5 causes of impairments to Ohio streams
- Many inland lakes were posted with advisories for harmful algal blooms during 2010
- Resurgence of anoxia in the Western Basin of Lake Erie, plus harmful algal blooms

Percentiles of IBI scores by Time Period

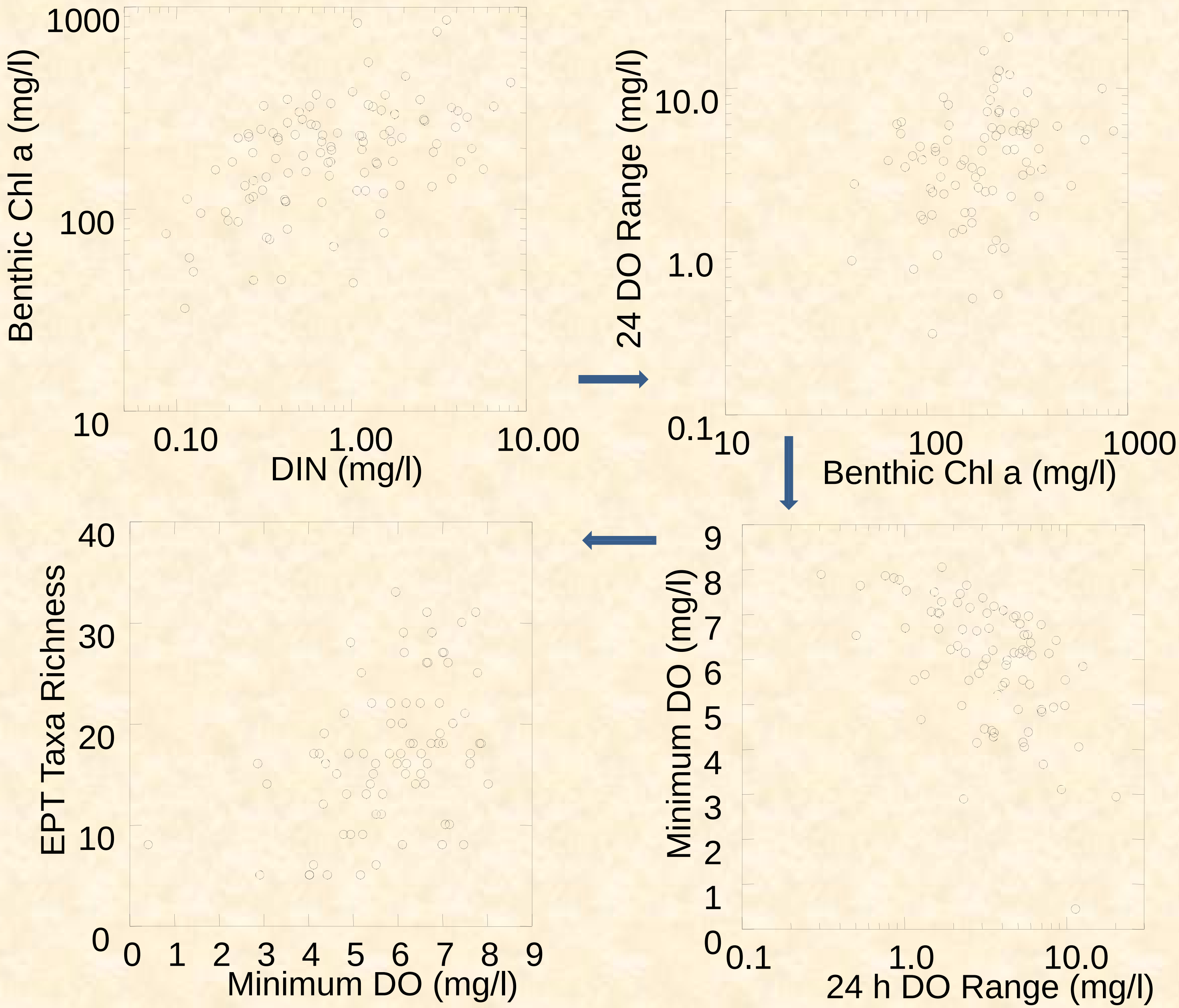
- Prior to 1985 <35% of waters were meeting CWA goal; 1 in 5 chronic or acute toxicity
- 2009 > 65% of water were meeting the CWA goal; toxicity rarely observed
- Achieved through regulation and investment



Outline of Ohio Criteria Development

- Observational study tracing effects of nutrients
  - Nutrients to benthic chlorophyll
    - as mediate by canopy cover
  - Benthic chlorophyll to dissolved oxygen
    - 24 hour range
    - absolute daily minimum
  - Dissolved oxygen to macroinvertebrates and fish
    - existing WQS for D.O.
- Identify change points/thresholds at each step
  - CART with bootstrapping, linear regression
- Reconcile thresholds with implementation

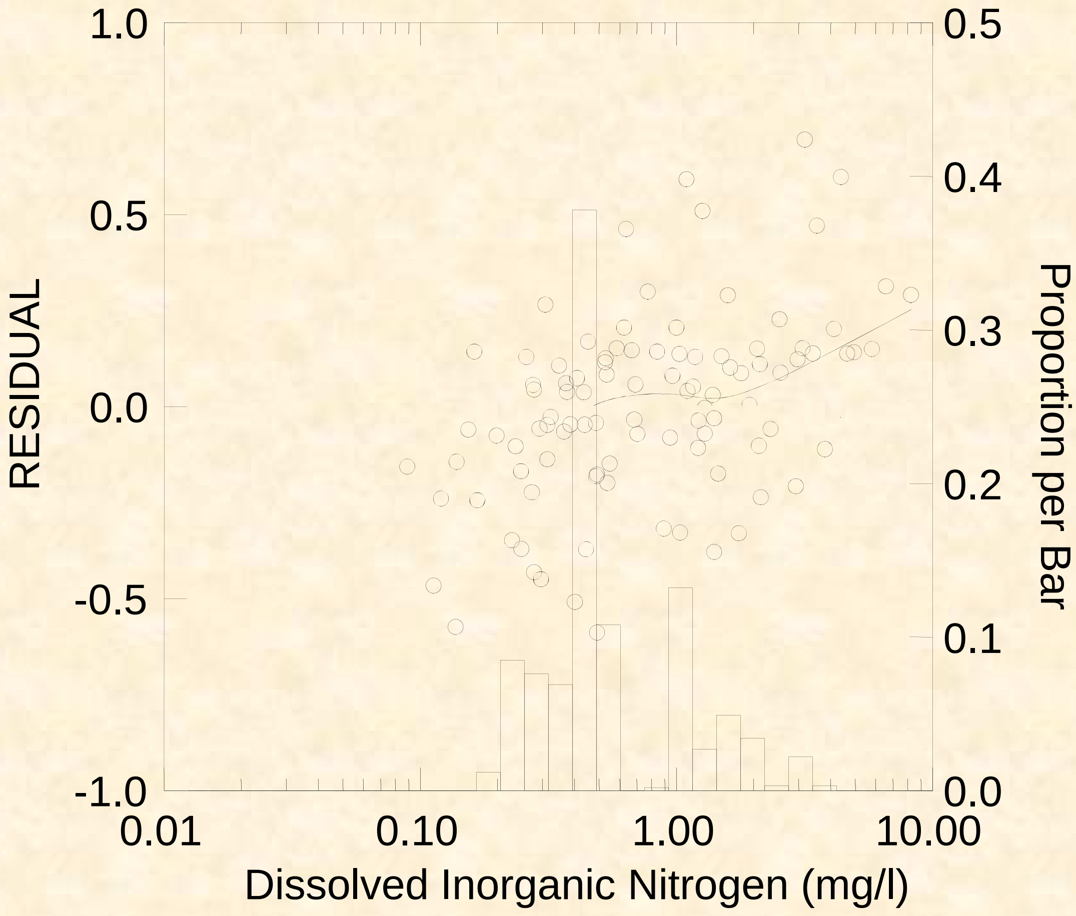
Ohio Nutrient Study - Bivariate Representation



Change Point in Benthic Chlorophyll Over Nitrogen

Based on Residual Variation Following Regression to Canopy and Percent Ag Land Use

Bootstrap Statistics
Median = 0.44 mg/l
75^{th} % = 1.09 mg/l
90^{th} % = 1.56 mg/l



Change Points and Thresholds Identified in Nutrient Study of Ohio Rivers and Streams

Drainage Areas < 1000 mi^2

	DIN (mg/l)	TP (mg/l)	Chl a (mg/m2)	DO Range (mg/l)	DO Min (mg/l)	Canopy (degree open)
Protection	0.44	0.04	120	6	6	<45
Management	1.0	0.10	183	9	5	<45

Now the Hard Part - Implementation

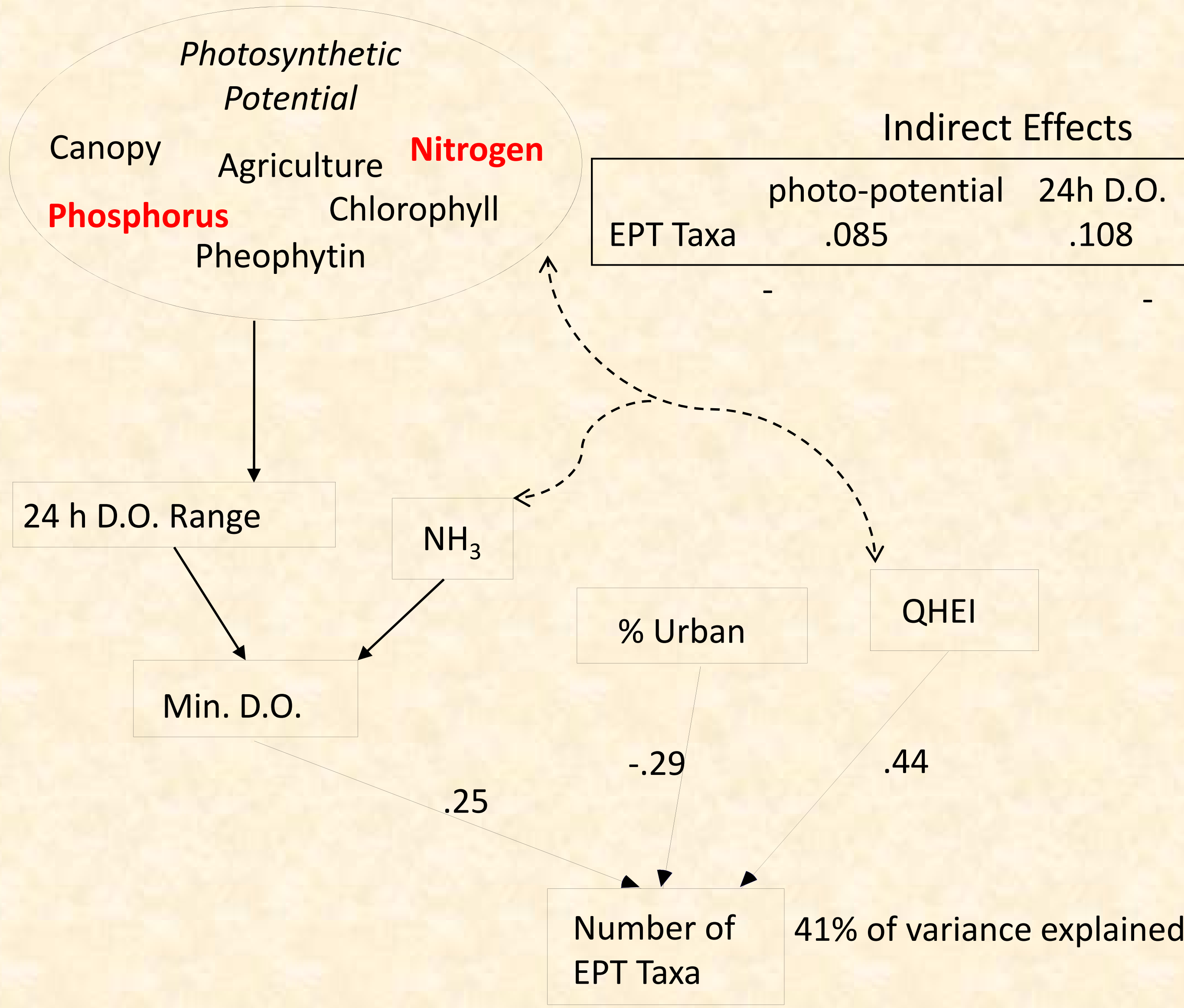
- Weight of evidence and independent application
  - How to balance the two
  - Reasonable potential
- Permits
  - Averaging period, seasonality, variance, dilution, antidegredation, WQBELs, TBELs
- TMDLs
  - Model selection, scope, allocations

Reasonable Potential

- Identifying a concentration that represents a
  - Structural equation modeling
  - Logistic regression
    - requires large data sets - Ohio is fortunate in this regard
  - Quantile Regression
  - Threshold Indicator Taxa Analysis (TITAN*)

* Baker and King (2010)

Structural Representation Incorporating all Measured Variables

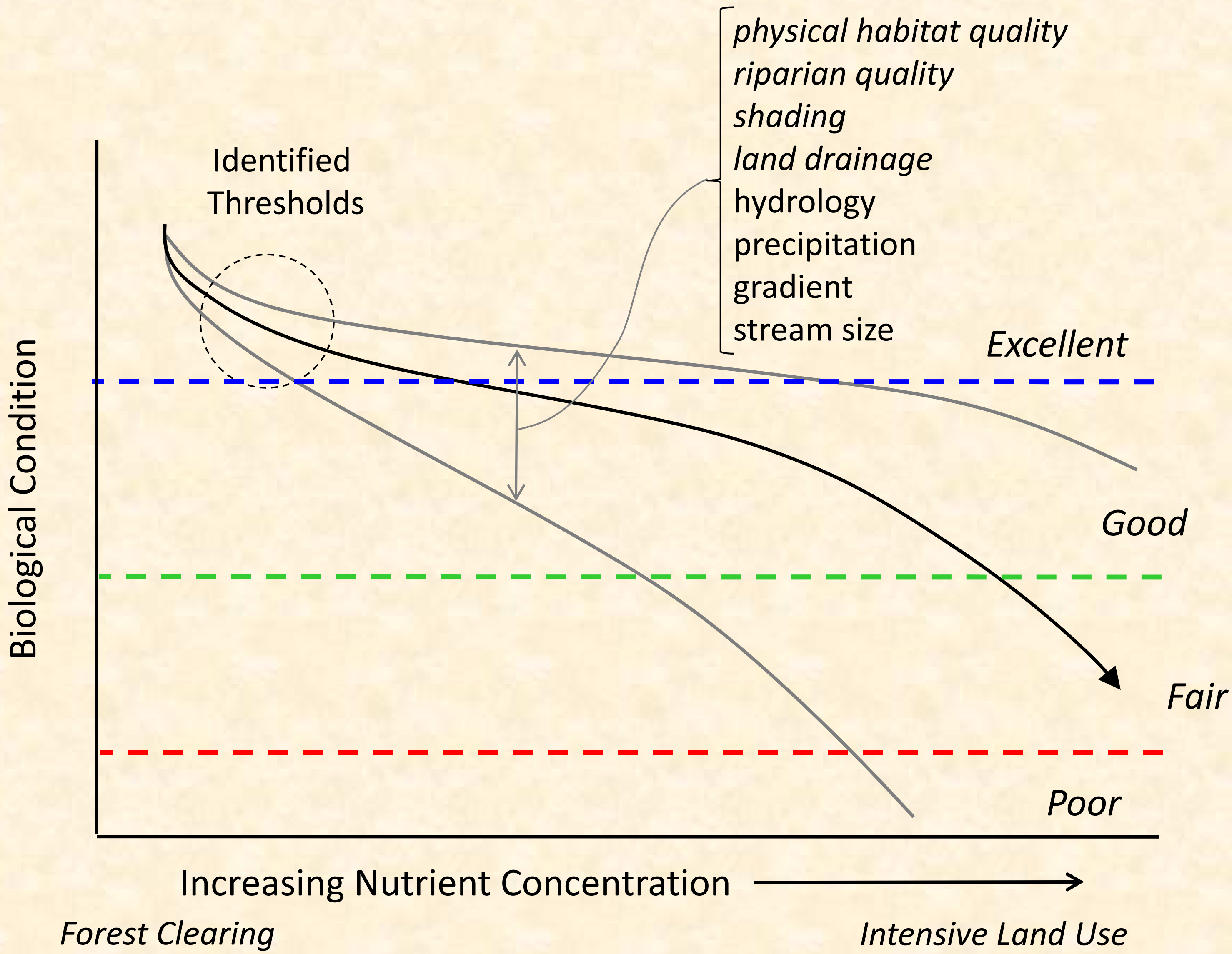


Indirect Effects

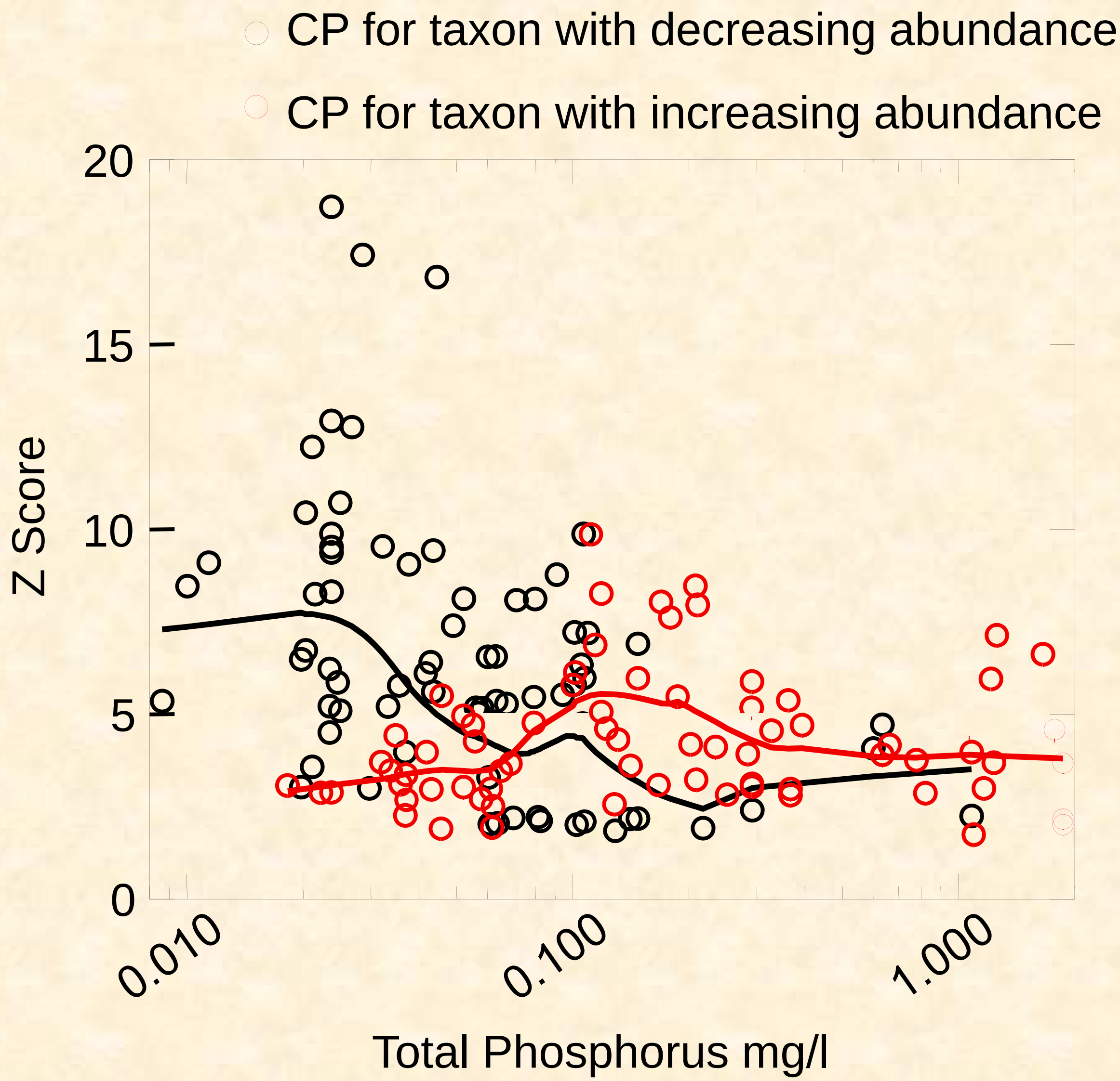
	photo-potential	24h D.O.	NH3
EPT Taxa	.085	.108	.085
	-		-

Biological Condition and Nutrient Concentration

Rivers and Streams



Community Composition Along a Nutrient Gradient
TITAN* (Threshold Indicator Taxa Analysis)



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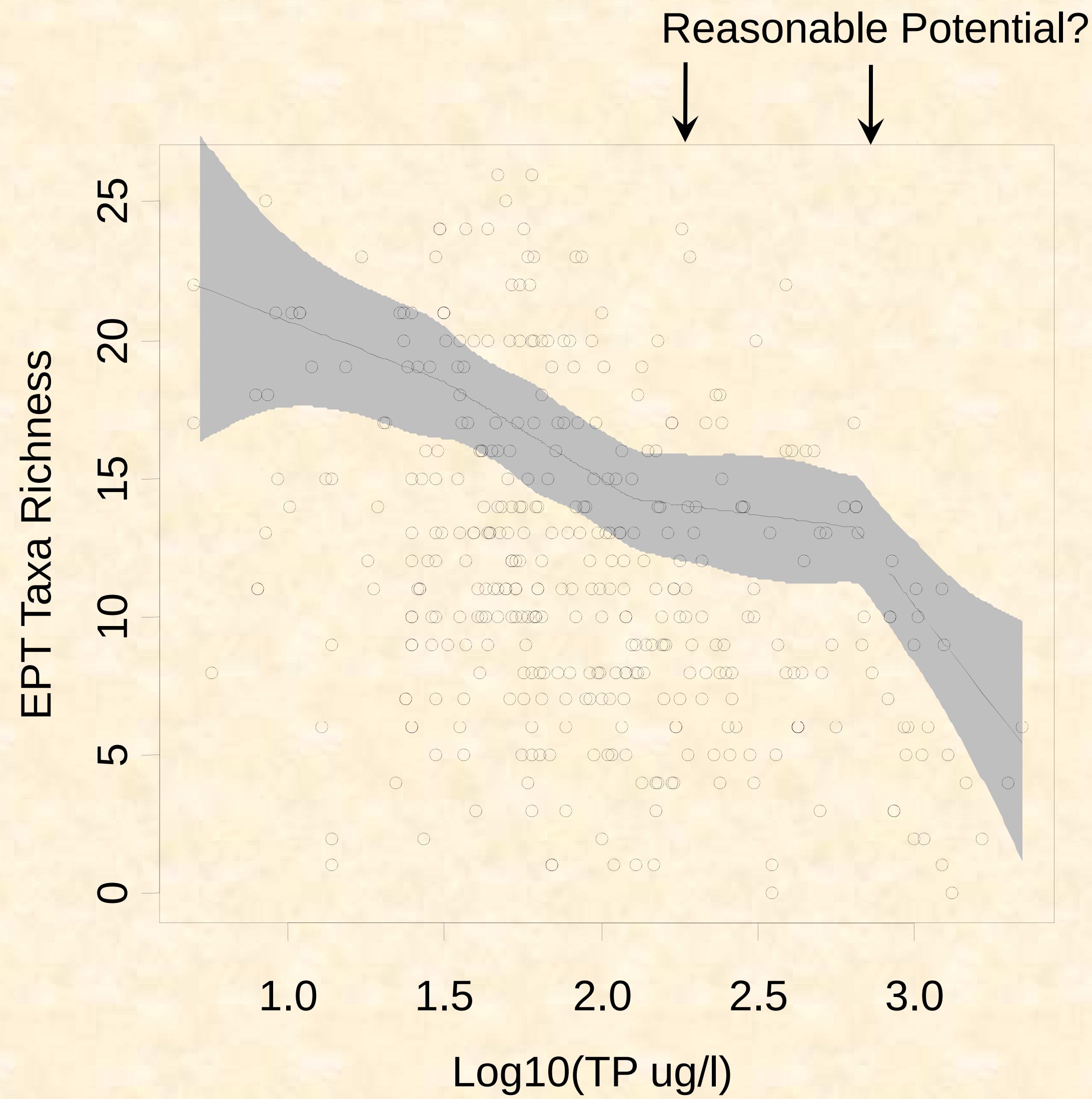
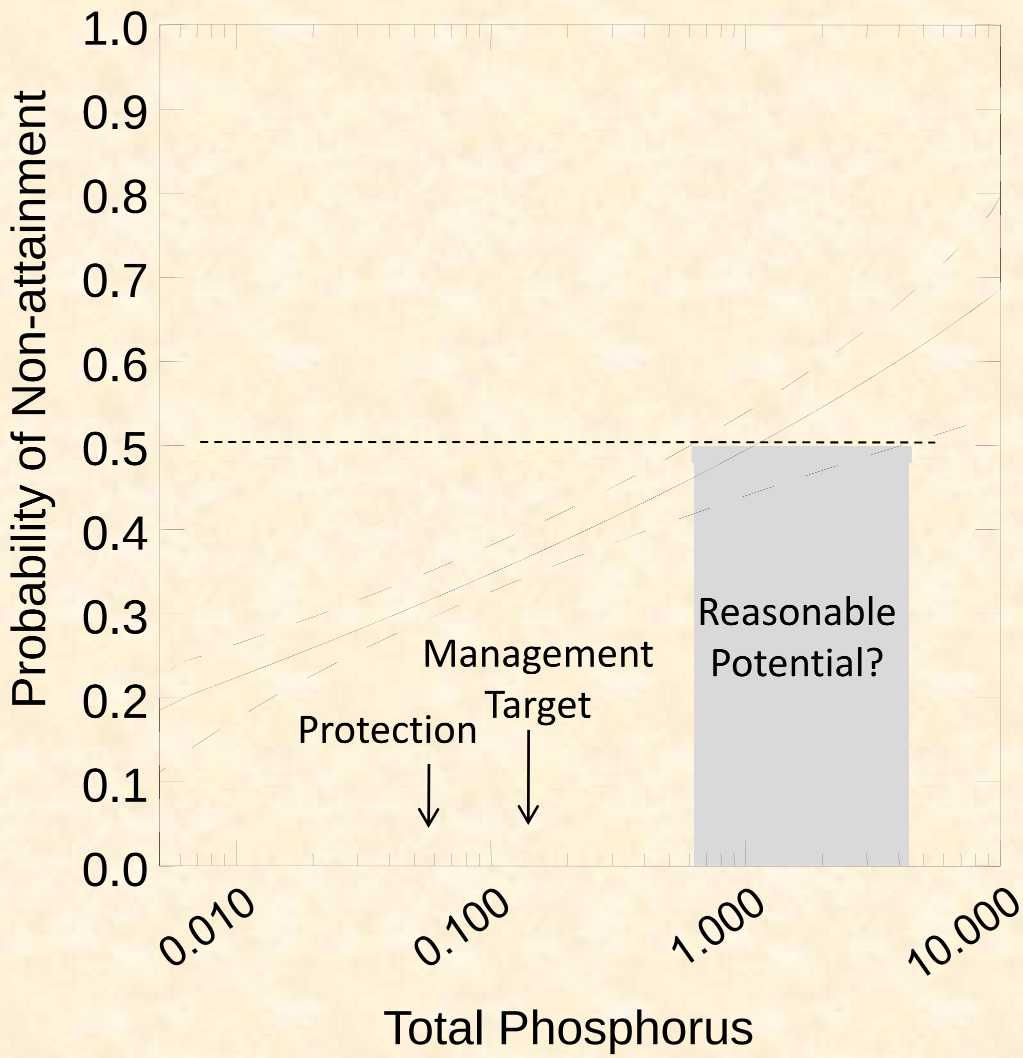
Quantile Regression
EPT Taxa Richness and Total Phosphorus



Logistic Regression

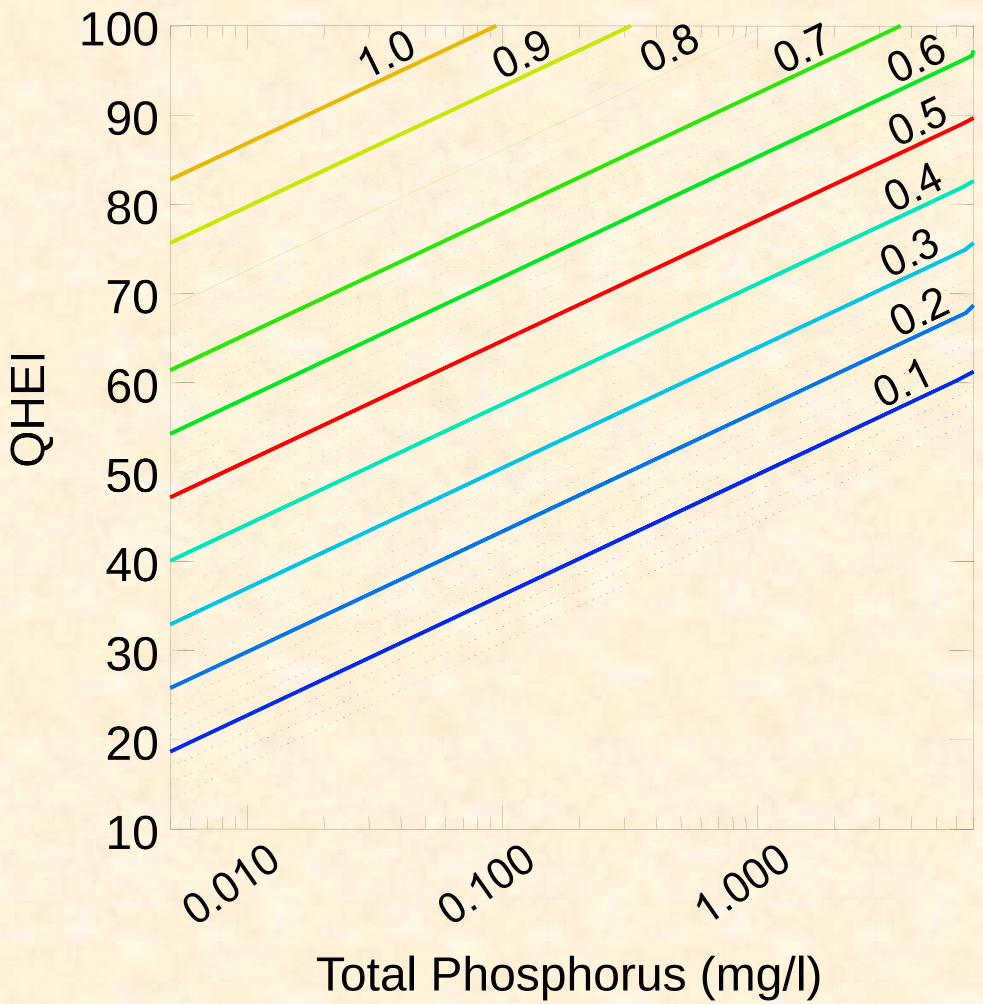
Probability of an ICI Score < WWH as a Function of Total Phosphorus Concentrations

Available historic data, 1981-2009. Data culled for NH3>0.1. Drainage area < 500mi^2.



Logistic Regression

Probability of IBI Meeting WWH
Given Habitat Quality and Total Phosphorus



Streams with good to excellent habitat quality have less potential for impairment due to phosphorus concentrations exceeding background levels.

Matrix of Reasonable Potential Thresholds

	ICI	EPT	IBI
DIN (quantile)	3.2	3.1	2.91 mg/l
DIN (logistic)	NS	NS	Varies by QHEI[1]
TP (logistic)	Varies by QHEI[2]	Varies by QHEI[3]	Varies by QHEI[4]
TP (quantile)	0.31	0.13	0.159 mg/l

1 For QHEI < median, probability of non-attainment > 0.5 when DIN> ~ 2.1 mg/l ;
when QHEI > 74, probability of non-attainment > 0.5 when DIN > ~ 9.5 mg/l;
2 For QHEI < median, probability of non-attainment > 0.5 when TP > ~ 0.6 - 3.0 mg/l
3 For QHEI < median, probability of non-attainment > 0.5 when TP > ~ 0.3 mg/l
4 For QHEI < median, probability of non-attainment > 0.5 when TP> ~ 0.159 mg/l ;
when QHEI > 74, probability of non-attainment > 0.5 when TP > ~ 0.457 mg/l

Weight of Evidence Implementation of Draft Water Quality Standards

Integrating Multiple Benchmarks & Thresholds into a Single Numeric Scale - The Trophic Index Criterion

Causal Link or Rationale for Nutrient WQS	TP	DIN	Chl a	24 H & Min D.O.	Fish & Bugs	TIC	Narrative
Nutrients to Chlorophyll	≤0.04	≤0.44	≤120	≤6 range >5 min	≥50	19	Acceptable (8 - 19)
Chl a & D.O. to Aquatic Life	>0.1	<1.0	>182	>7 range >4 min	>38	7	Threatened (4 - 7)
Logistic & Quantile Regression	>0.3	>3.0	>320	>9 range >4 min	36	1	Impaired (0 - 3)
Respective sub-scores	4		4	5	6	19	Acceptable
	1		1	1	4	7	Threatened
	0		0	0	1	1	Impaired

Summary and Conclusions

- Measurable changes to stream systems occur along a
  - Complexity of relationship precludes adoption of a single numeric criterion and independent application
  - Exceeding a threshold or change point does not equate to impairment
  - Necessitates inclusion of response indicators (e.g., benthic chlorophyll, dissolved oxygen) in standard

Final Thoughts

- Significant restoration of surface waters has occurred since the 1980s
  - Toxins and organic matter
  - Regulation
  - Funding
- Remaining problems are comparatively intractable
  - Nonpoint
  - Habitat, flow
  - Non-toxic (e.g., nutrients)
  - Less funding
  - Little or no regulation

Nutrient Loads - In Large Part a Landscape Issue