

Using structural and functional indicators to develop numeric nutrient criteria for Utah's wadeable streams

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Which Path Forward?

Nutrient Indicators

- Identify sites with nutrient related problems
 - Allows resource prioritization
- Triggers monitoring response by DWQ

OR

Nutrient Criteria

- CWA Requirement
 - Provides regulatory certainty
- Less flexible and difficult to change

Numeric Indicators

N

P

Response Indicators

Primary
Production

Compositional
Indicators

Functional
Indicators

Chl a

DO

Social Values

Macroinvertebrates

Algae

Stream
Metabolism

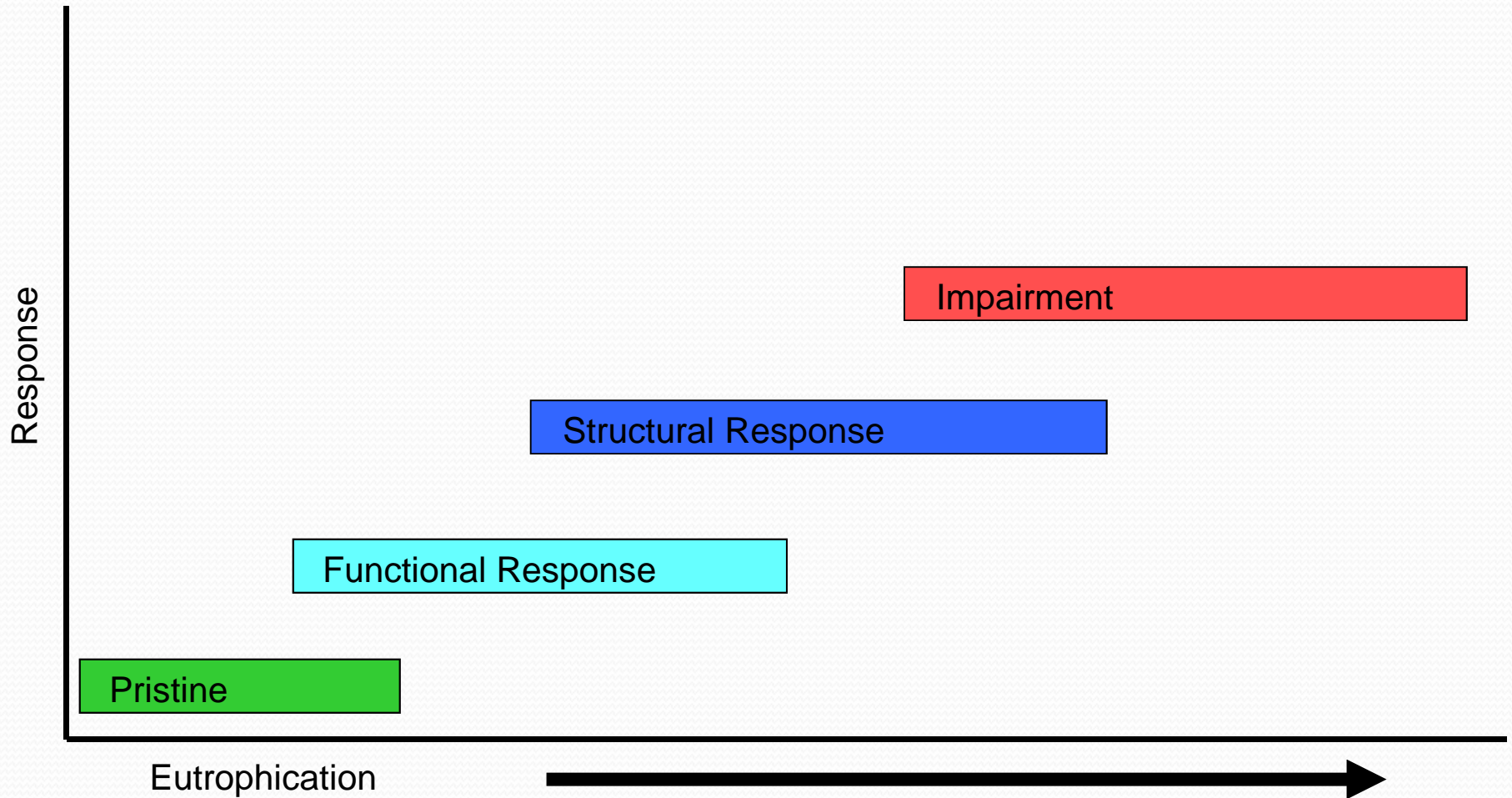
Nutrient
Limitation

Organic Matter
Storage

Decomposition

Mechanistic Models

Why use multiple indicators?



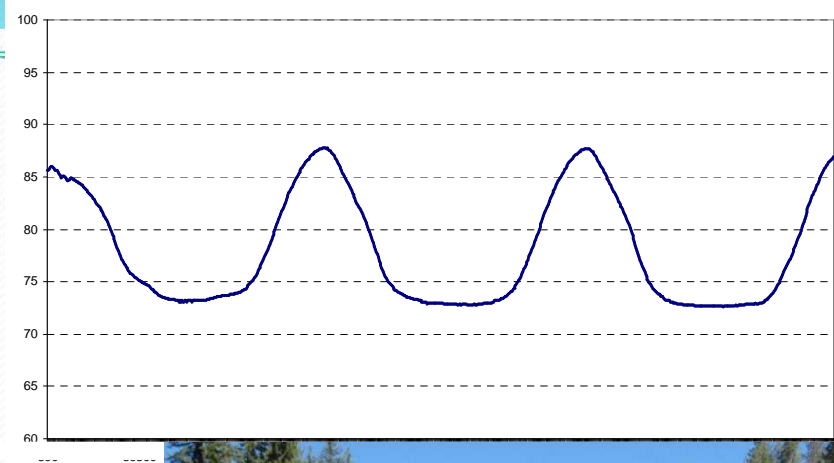
Indicators

- **Functional Indicators**
 - Stream Metabolism
 - Nutrient Limitation
 - Organic Matter Storage
 - Decomposition Rates
- **Compositional Indicators**
 - Macroinvertebrates
 - Diatoms
- **Statewide Snapshot**

Whole Stream Metabolism

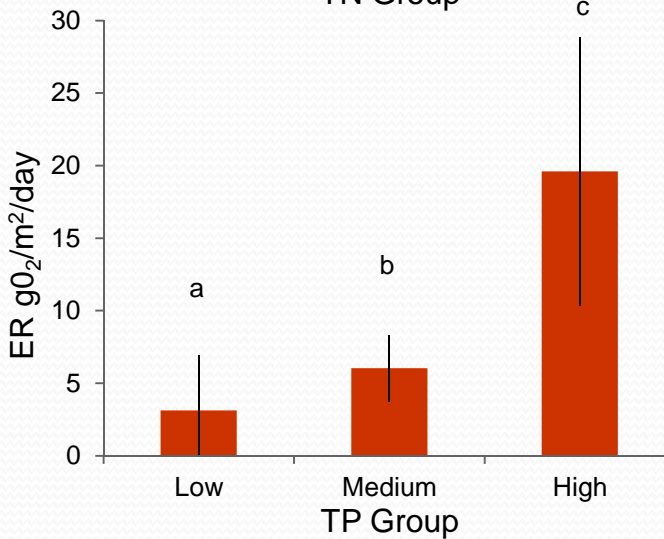
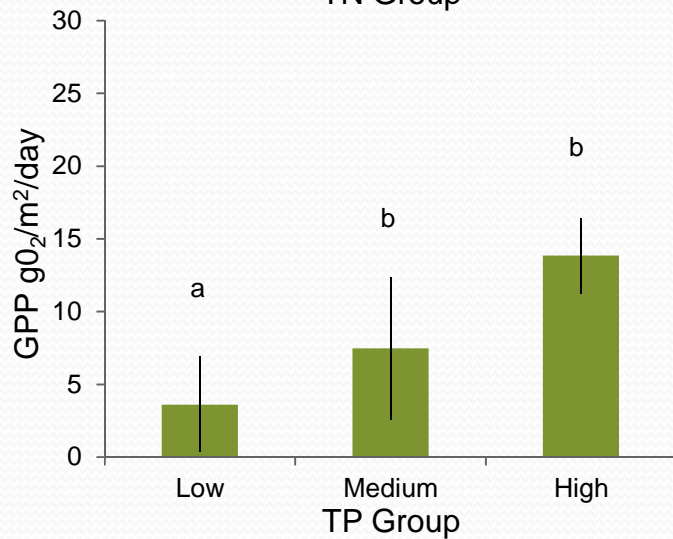
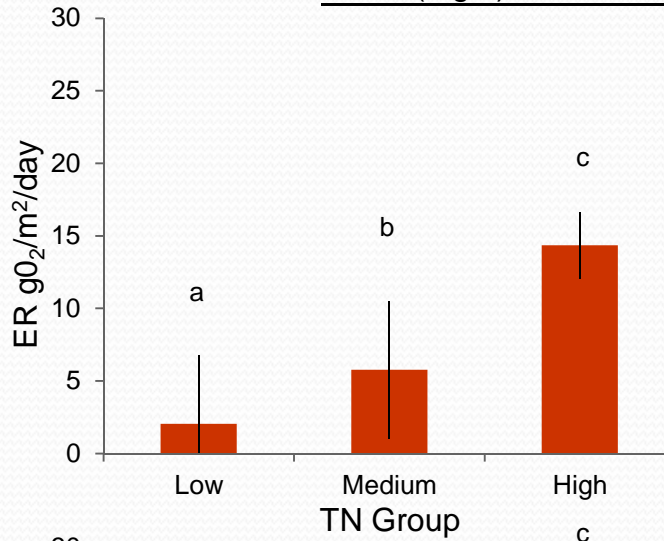
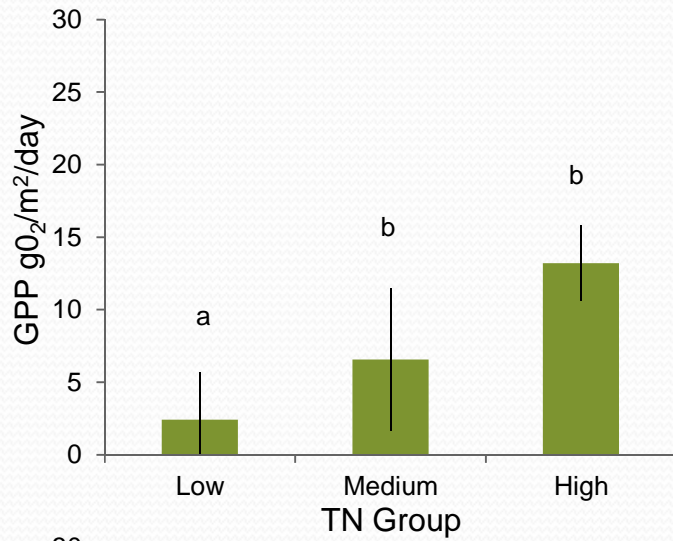
$$\Delta DO = GPP - ER \pm K$$

- Measures daily production & consumption of oxygen



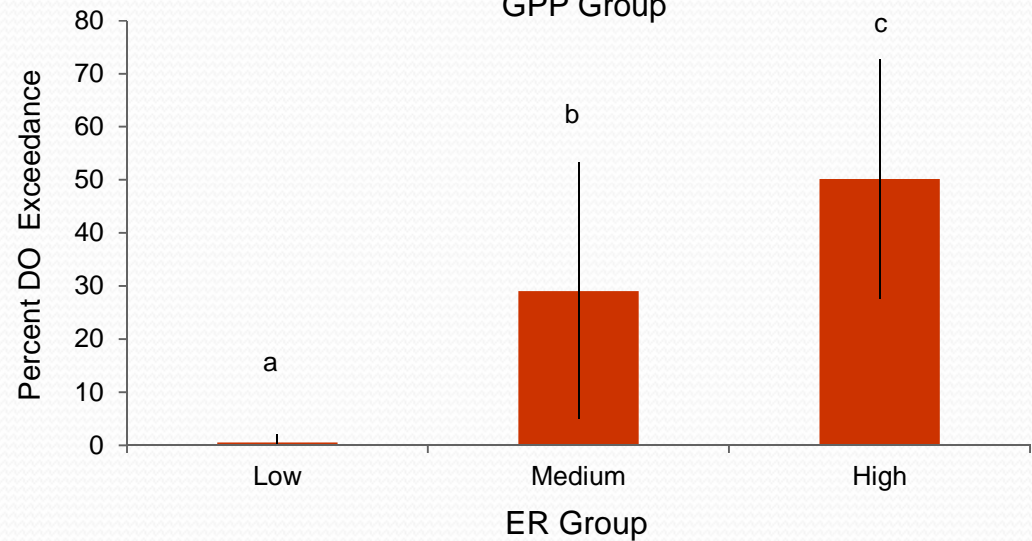
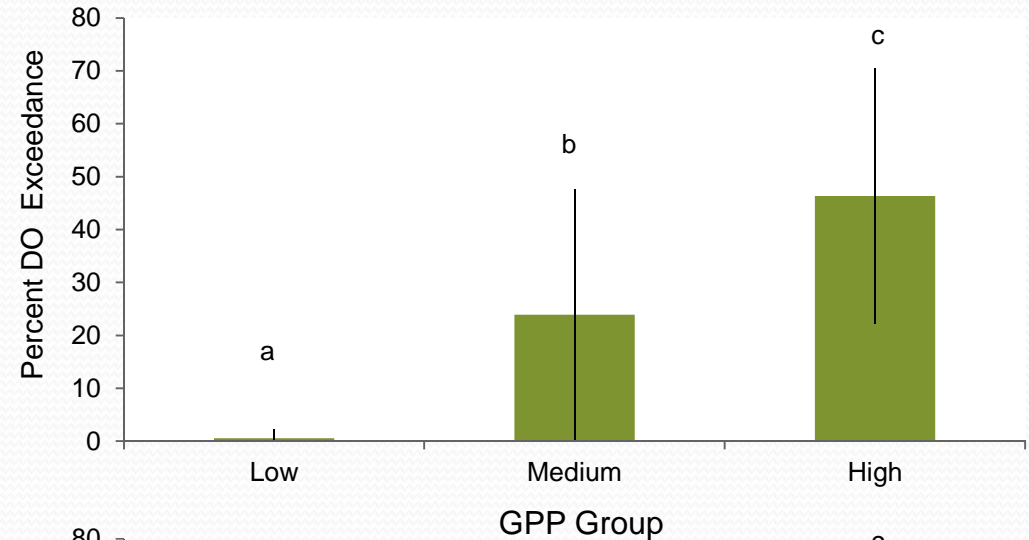
Stream Metabolism

Nutrient	Nutrient Group Thresholds
TN (mg/L)	Low < 0.24 > Medium < 1.28 > High
TP (mg/L)	Low < 0.02 > Medium < 0.09 > High



- Nutrients increase rates of GPP and ER
- High rates of GPP and ER lead to more minimum DO impairments
- Direct tie to aquatic life uses

Functional Indicator	Indicator Group Thresholds
GPP ($\text{gO}_2/\text{m}^2/\text{day}$)	Good < 6.0 > Fair < 10.0 > Poor
ER ($\text{gO}_2/\text{m}^2/\text{day}$)	Good < 5.0 > Fair < 9.0 > Poor



Nutrient Limitation

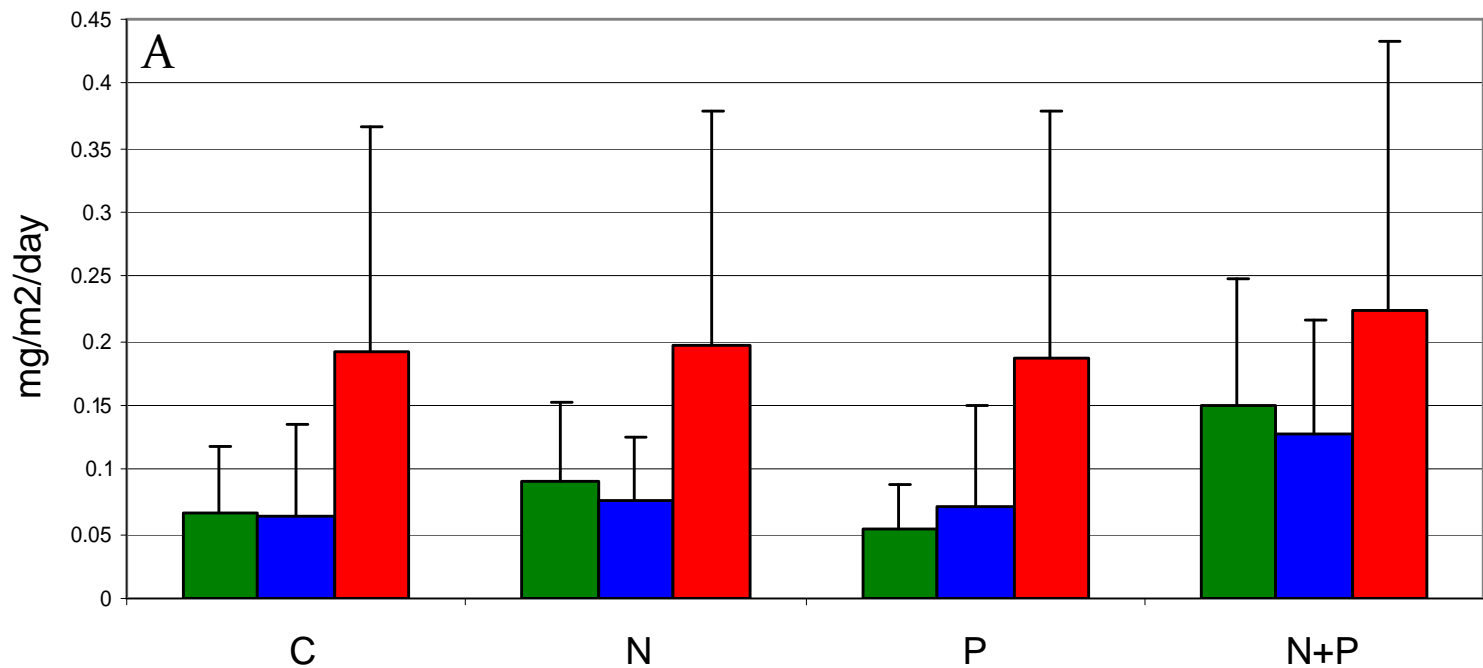
- Adding the limiting nutrient will have the greatest effect on algal growth
- Nutrient Diffusing Substrates (NDS)
- Control, N, P, & N + P
- Analyze algal growth under different nutrient additions



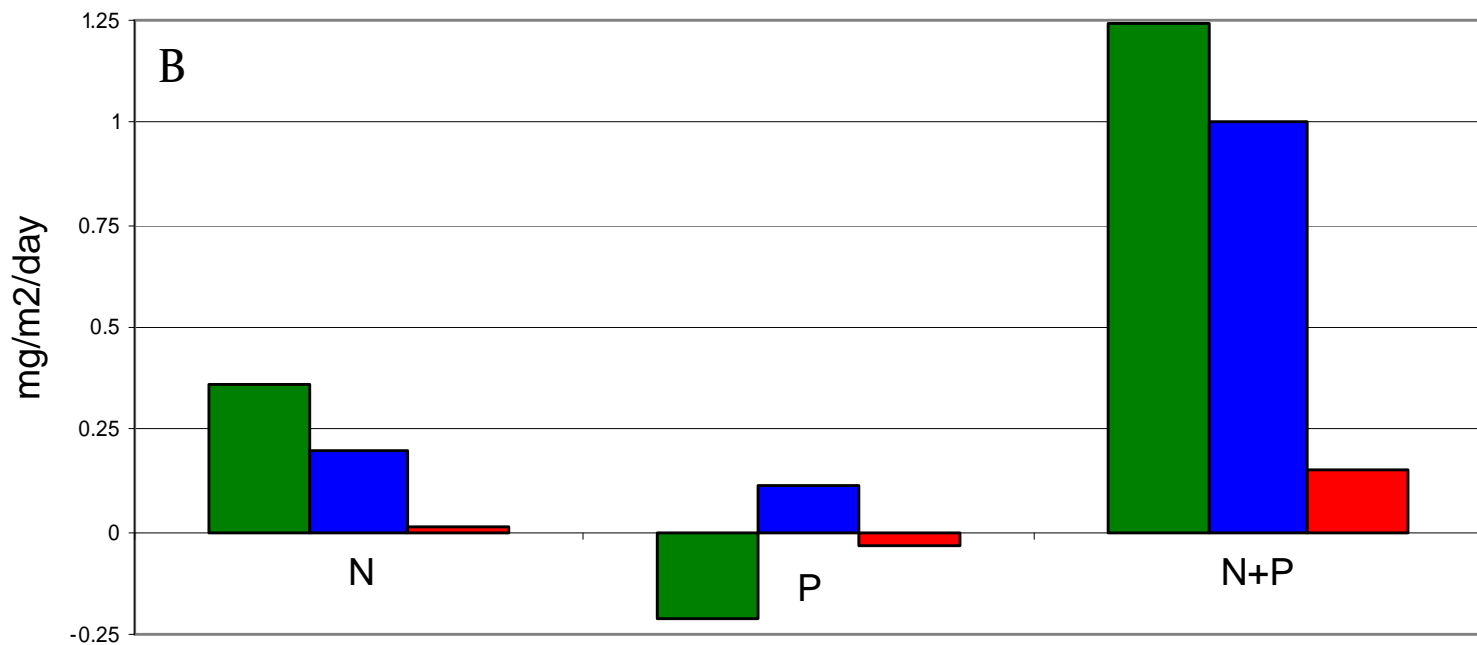
NDS Results

A) Mean Chl a growth rate per treatment

Reference
Moderate Impact
High Impact



B) Mean Chl a growth rate per treatment, relative to control



Nutrient Limitation Results

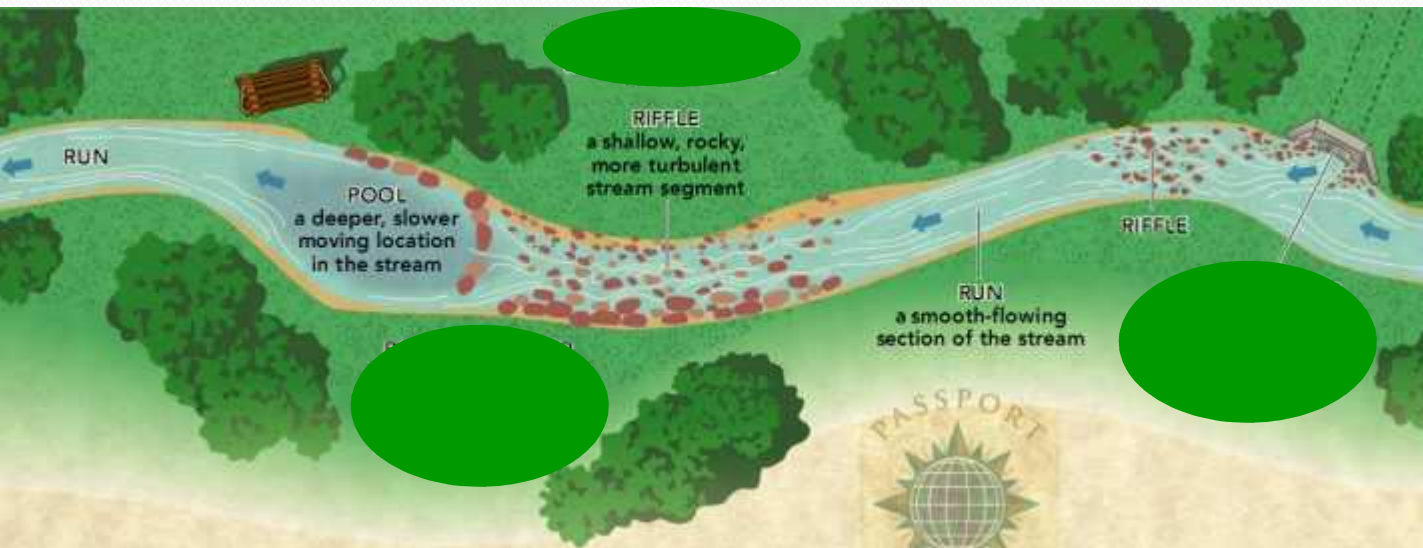
Nutrient Limitation

Site	Nutrient Limitation							
	None	N	P	N&P	N1	P2	P1	N2
Reference	3	5	0	5	2		0	
Moderate Impact	2	1	2	1	1		0	
High Impact	6	0	0	0	1		0	

- 80% of reference sites have some form of Nitrogen limitation
- 6 of 7 High Impact sites are not limited by nutrients
- No limitation likely to occur > 0.42 mg/L TN and > 0.08 mg/L TP

Organic Matter Storage

- Standing stock of all organic matter
 - Autotrophs, heterotrophs & detritus
- Analysis in progress



Decomposition

- Heterotrophic response to nutrients
 - Invertebrates excluded
- Leaf packs and wood veneers
- measured at 0, 3 & 6 weeks
 - Analysis in progress



Indicators

- Functional Indicators
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 - Nutrient Limitation
 - Organic Matter Storage
 - Decomposition Rates
- **Compositional Indicators**
 - Macroinvertebrates
 - Diatoms
- Statewide Snapshot

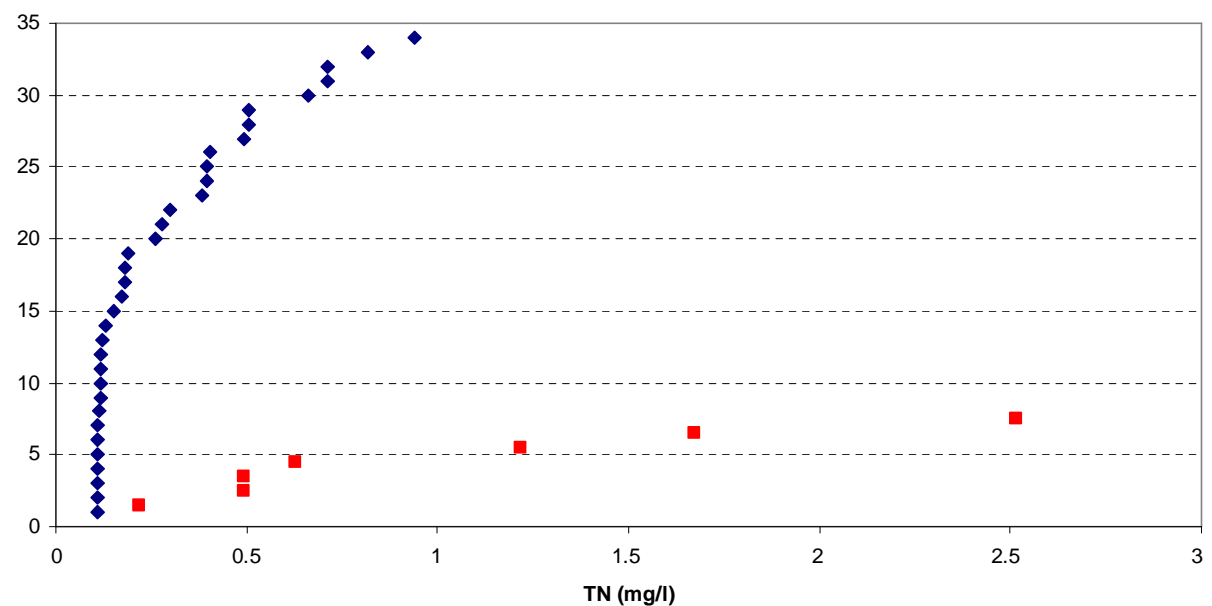
Taxonomic Indicator Threshold Analysis

-TITAN

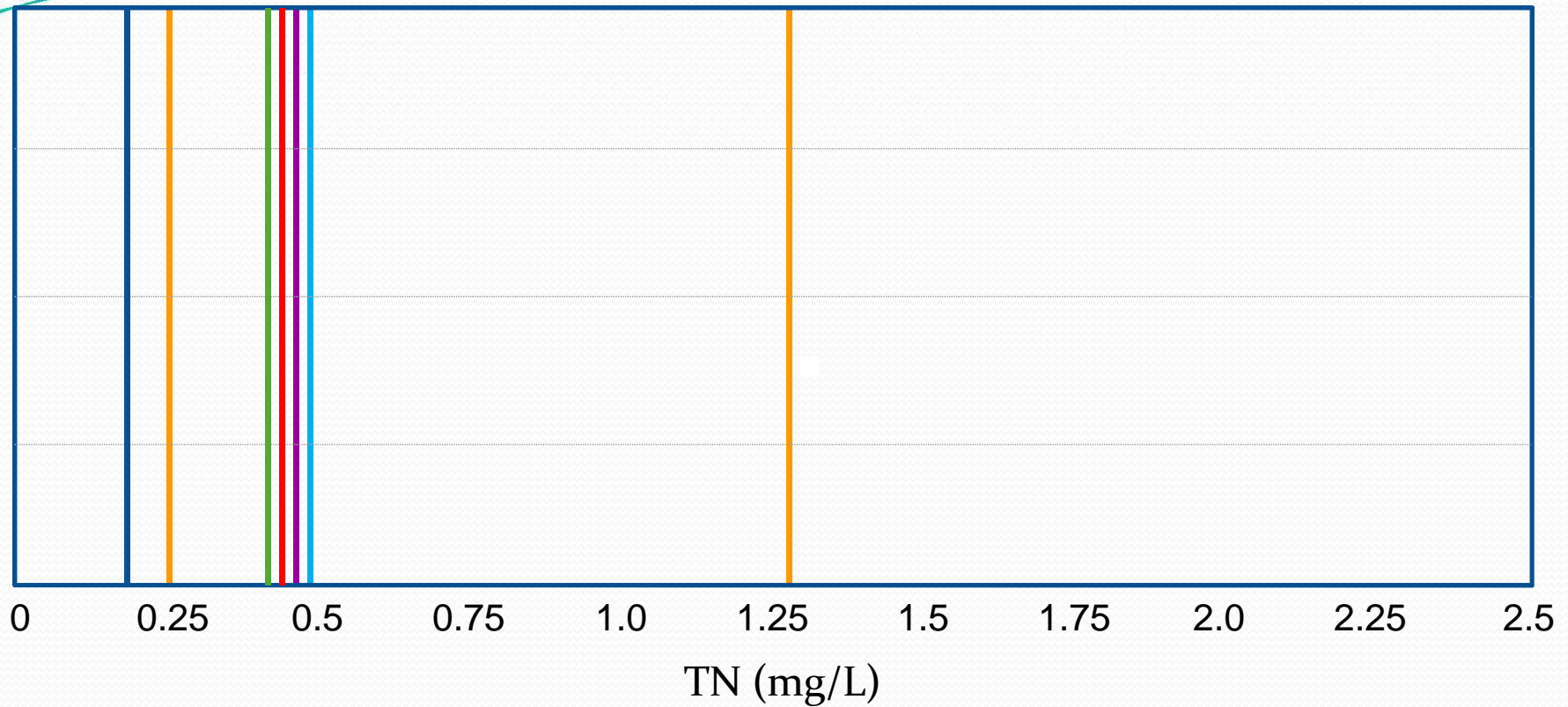
- Uses individual taxon responses instead of community metrics/composition
- Identifies and categorizes taxa into two categories
 - Negative responders (sensitive)
 - Positive responders (tolerant)
- Ideal for developing numeric criteria

◆ Respond negatively to increasing nutrients

■ Respond positively to increasing nutrients



Multiple Lines of Evidence TN



TITAN-Sensitive inverts - 0.18 mg/L

TITAN-All significant inverts – 0.40 mg/L

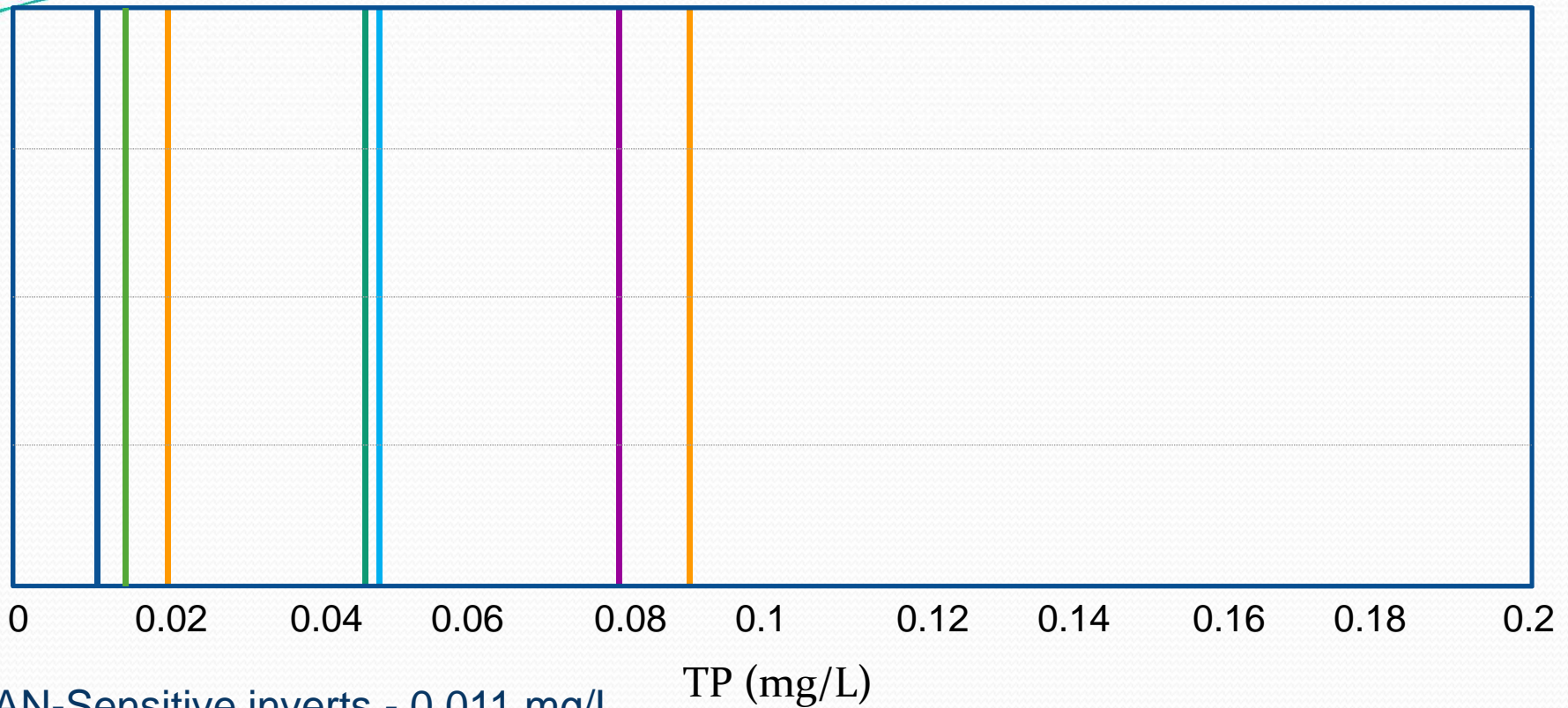
TITAN-Tolerant inverts – 0.41 mg/L

O/E biologic impairments – 0.43 mg/L

Stream Metabolism 0.24 & 1.28 mg/L

Nutrient Limitation - 0.42 mg/L

Multiple Lines of Evidence TP



TITAN-Sensitive inverts - 0.011 mg/L

TITAN-All significant inverts – 0.015 mg/L

TITAN-Tolerant inverts – 1.8 mg/L

Diatom TITAN – 0.045 mg/L

O/E biologic impairments – 0.045 mg/L

Stream Metabolism 0.02 & 0.09 mg/L

Nutrient Limitation - 0.08 mg/L

Indicators

- Functional Indicators
 - Stream Metabolism
 - Nutrient Limitation
 - Organic Matter Storage
 - Decomposition Rates
- Compositional Indicators
 - Macroinvertebrates
 - Diatoms
- **Statewide Snapshot**

What's the Number ???

● TN

Possible Criteria (mg/L)	Percent Impaired	Stream Miles Impaired	
Min 0.24	50%	~6700	<i>Too Low??</i>
Medium 0.45	30%	~4000	<i>Maybe??</i>
Max 1.2	10%	~1300	<i>Too High??</i>

● TP

Possible Criteria (mg/L)	Percent Impaired	Stream Miles Impaired	
Min 0.011	60%	~8000	<i>Too Low??</i>
Medium 0.045	25%	~3400	<i>Maybe??</i>
Max 0.08	10%	~1300	<i>Too High??</i>

Which Path Forward?

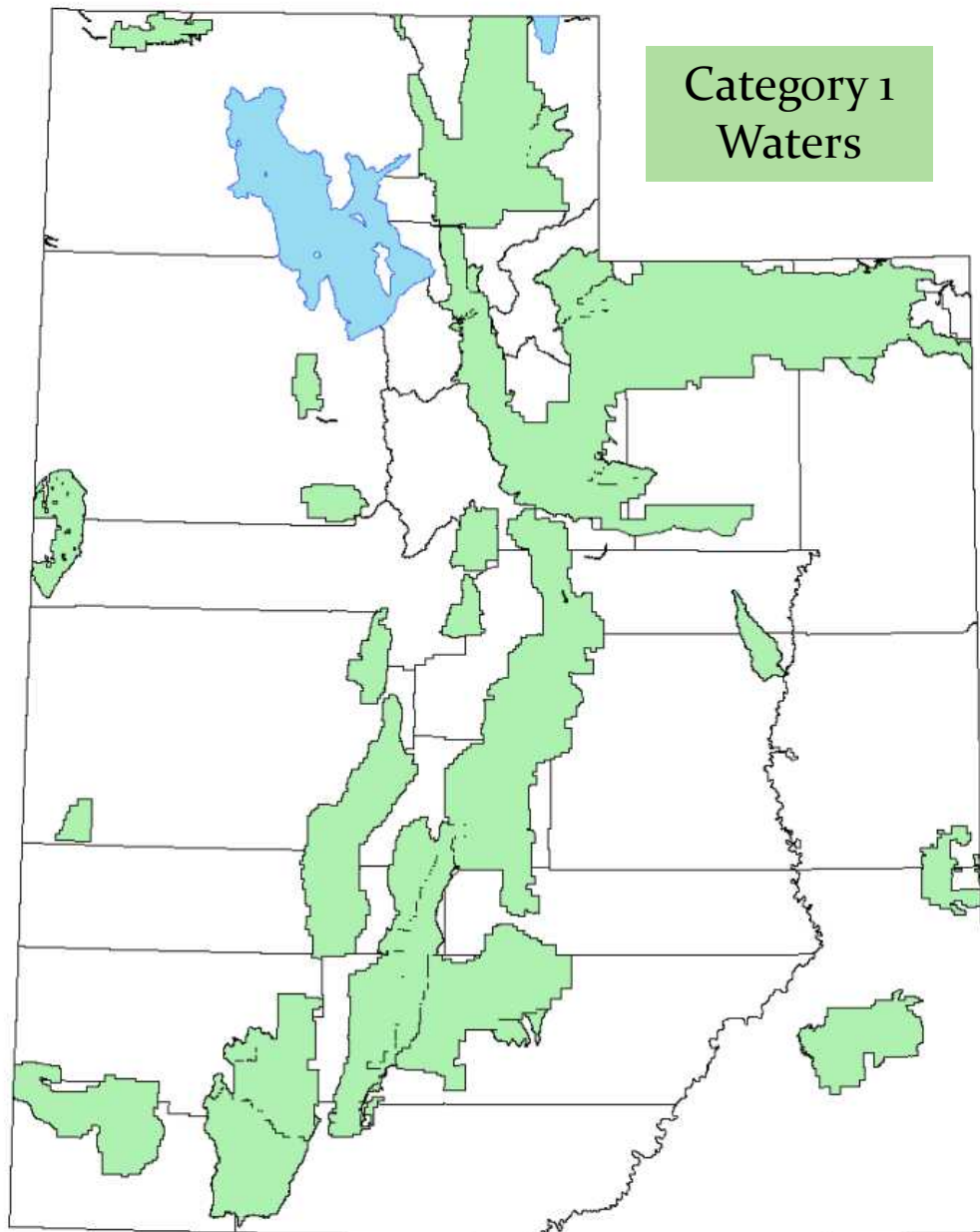
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- Apply numeric nutrient ***criteria*** to all category 1 antidegradation waters
 - Cat 1 are mostly high elevation waters on USFS land
 - Immediate protection of high quality waters
- Apply numeric nutrient ***indicators*** to all other waterbodies
 - Make certain nutrients are cause of impairments in multi stressor waterbodies
 - Consider economic impacts in nutrient reduction strategies
 - Consider appropriate uses and best attainable conditions
 - Allows time for additional investigations

Questions?

- Special Thanks
 - Utah DWQ
 - Emilie Flemer
 - Suzan Tahir
 - Jared Terry
 - Emily Bartusek
 - Kate Tipple
 - Alex Anderson
 - Ben Holcomb
 - USU
 - Michelle Baker
 - Bethany Neilson
 - Andrew Hobson



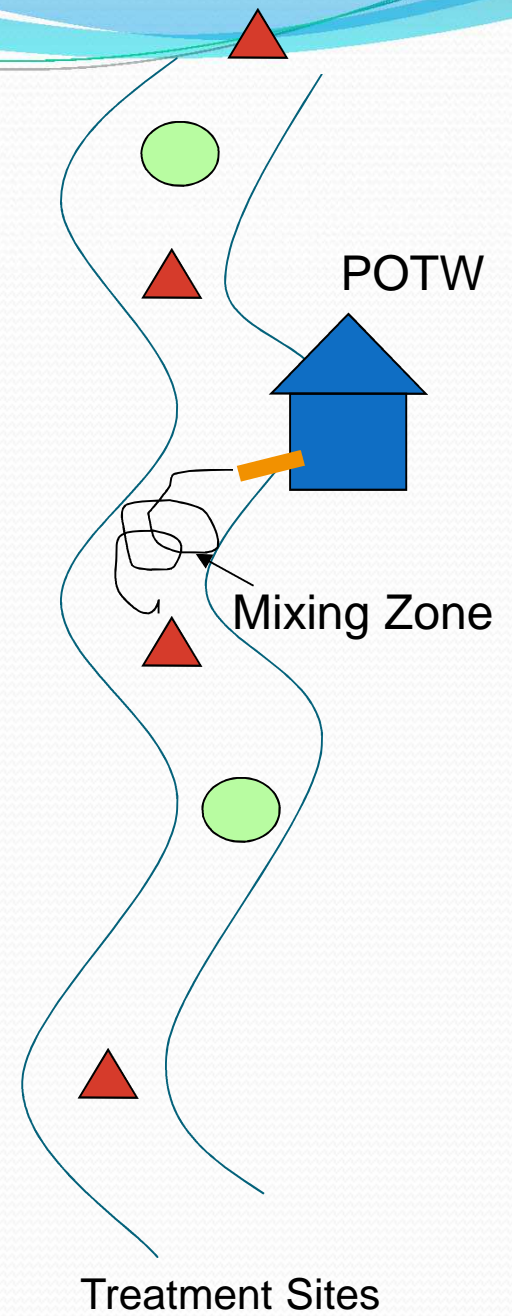
Study Design

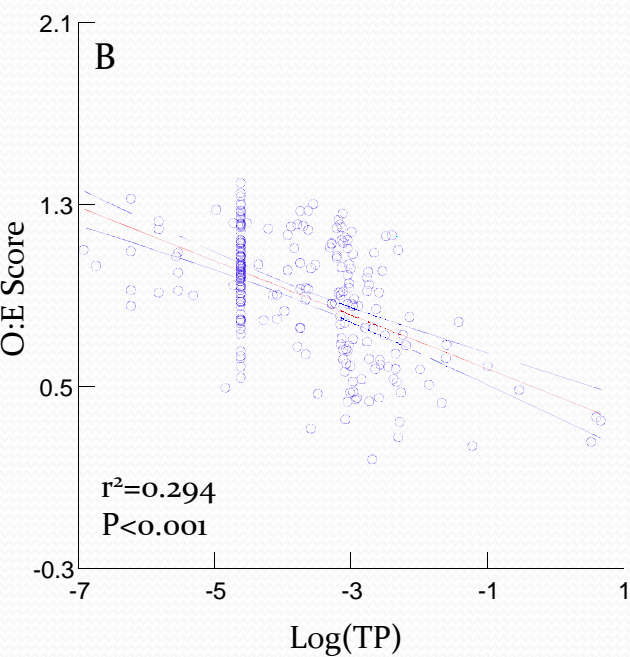
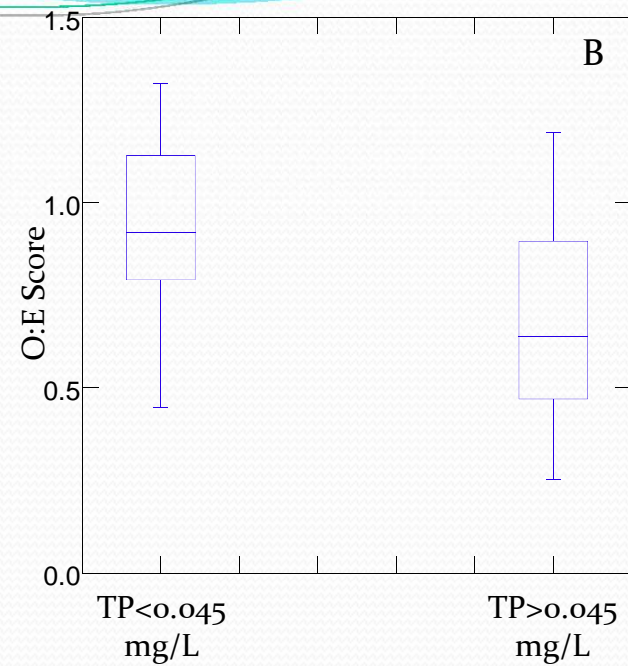
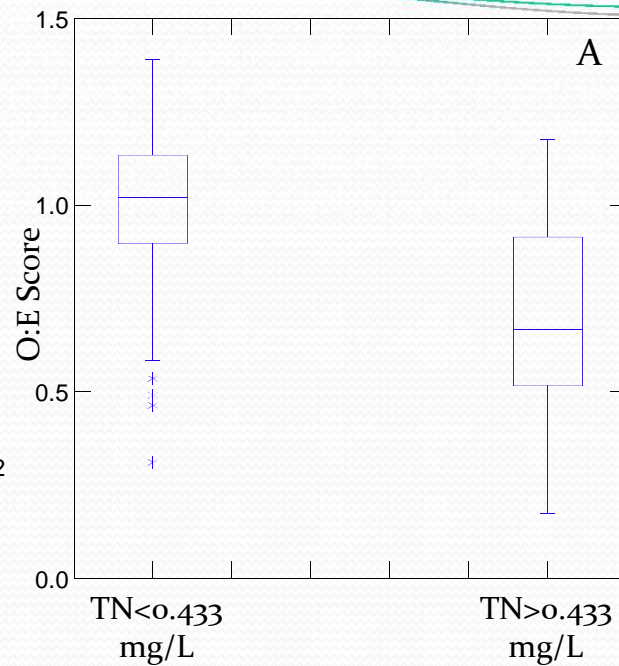
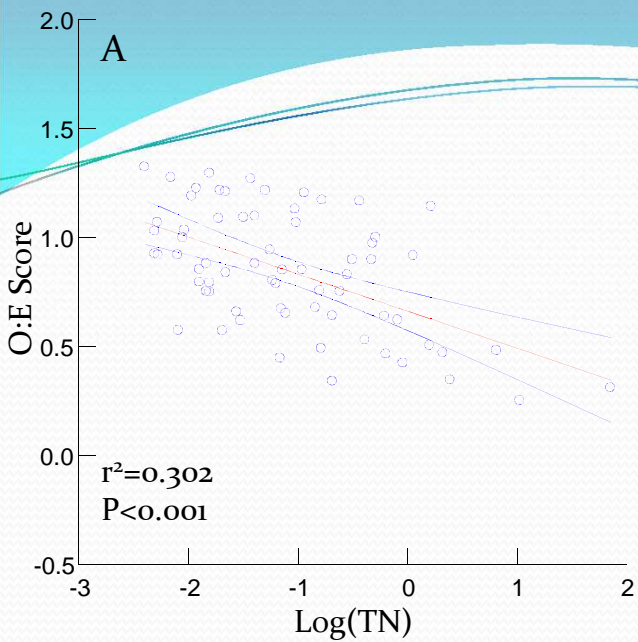
Probe & Water Chemistry

Compositional & Functional Measurements

Probe & Water Chemistry

Reference Sites

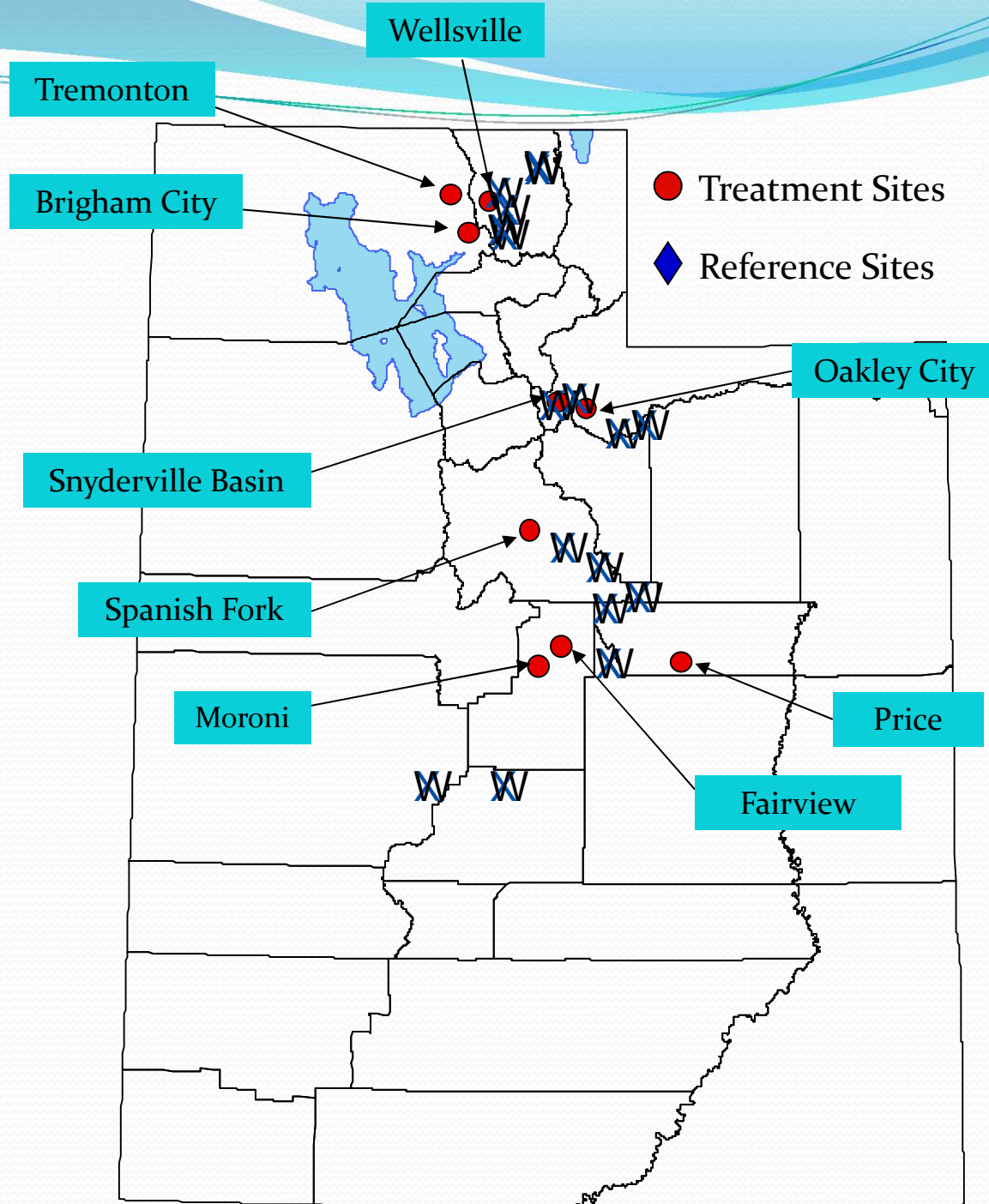


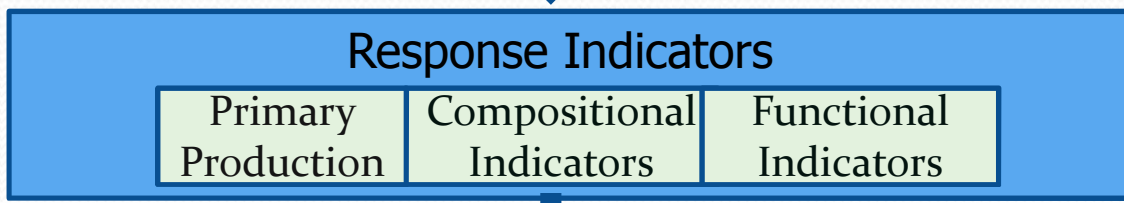
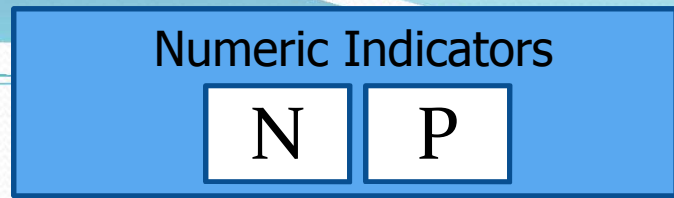


Thresholds determined by nonparametric deviance reduction among binary response data of O:E impairment indicator

Site Locations

- 9 POTW's
- 17 Reference Sites





Identify potential nutrient-related problems

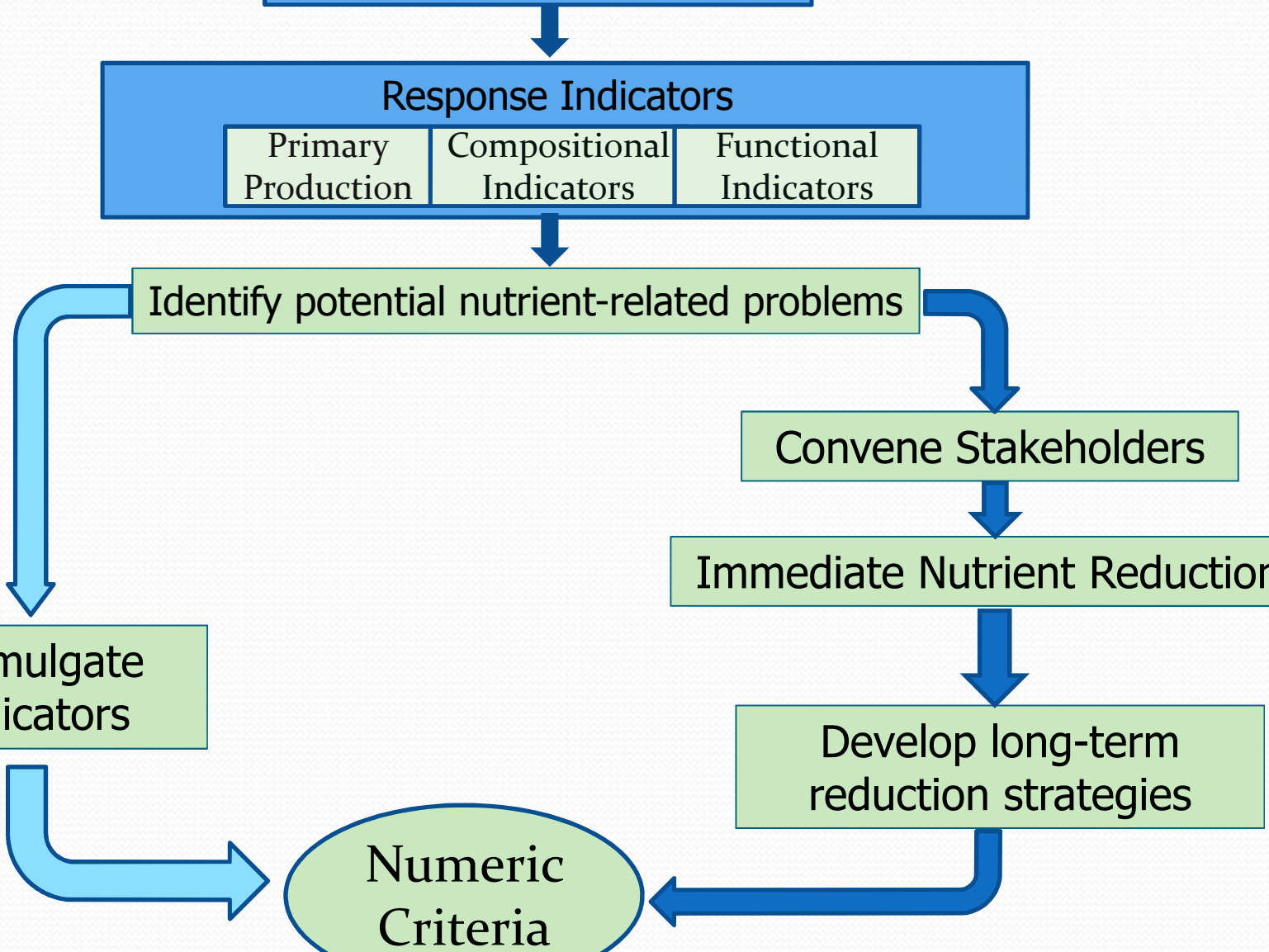
Convene Stakeholders

Immediate Nutrient Reduction

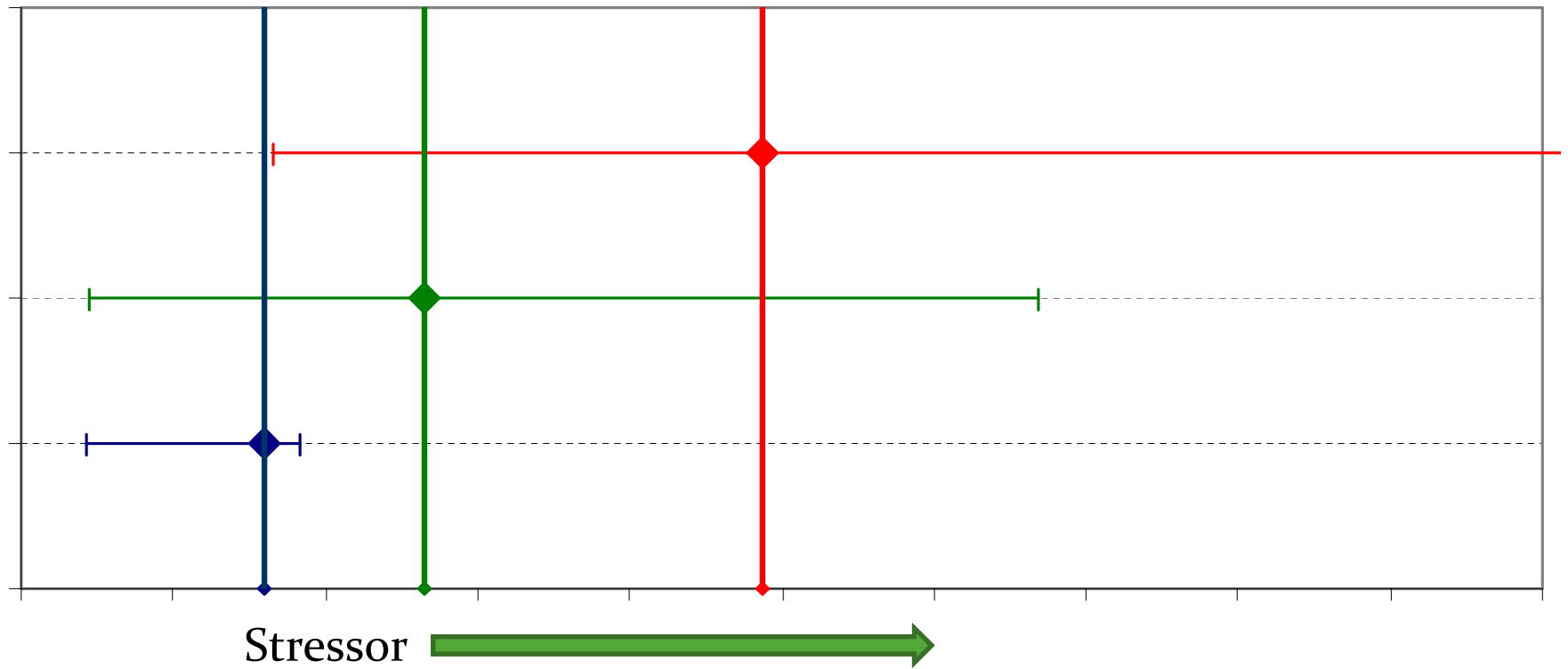
Develop long-term reduction strategies

Promulgate Indicators

Numeric Criteria



TITAN Example Data



Negative responding taxa

All significant taxa

Positive responding taxa

Numeric Indicators

N

P

- In stream/lake concentrations of nitrogen and phosphorus that suggest nutrient impairment

Response Indicators

Primary
Production

Compositional
Indicators

Functional
Indicators

- Biological or Ecological responses that confirm or reject suggested impairment

DWQ would only promulgate numeric nutrient criteria when numeric AND response indicators suggest an impairment