Numeric Nutrient Criteria for Utah's Headwater Streams

Jeff Ostermiler

Presentation for Nutrient Core Team

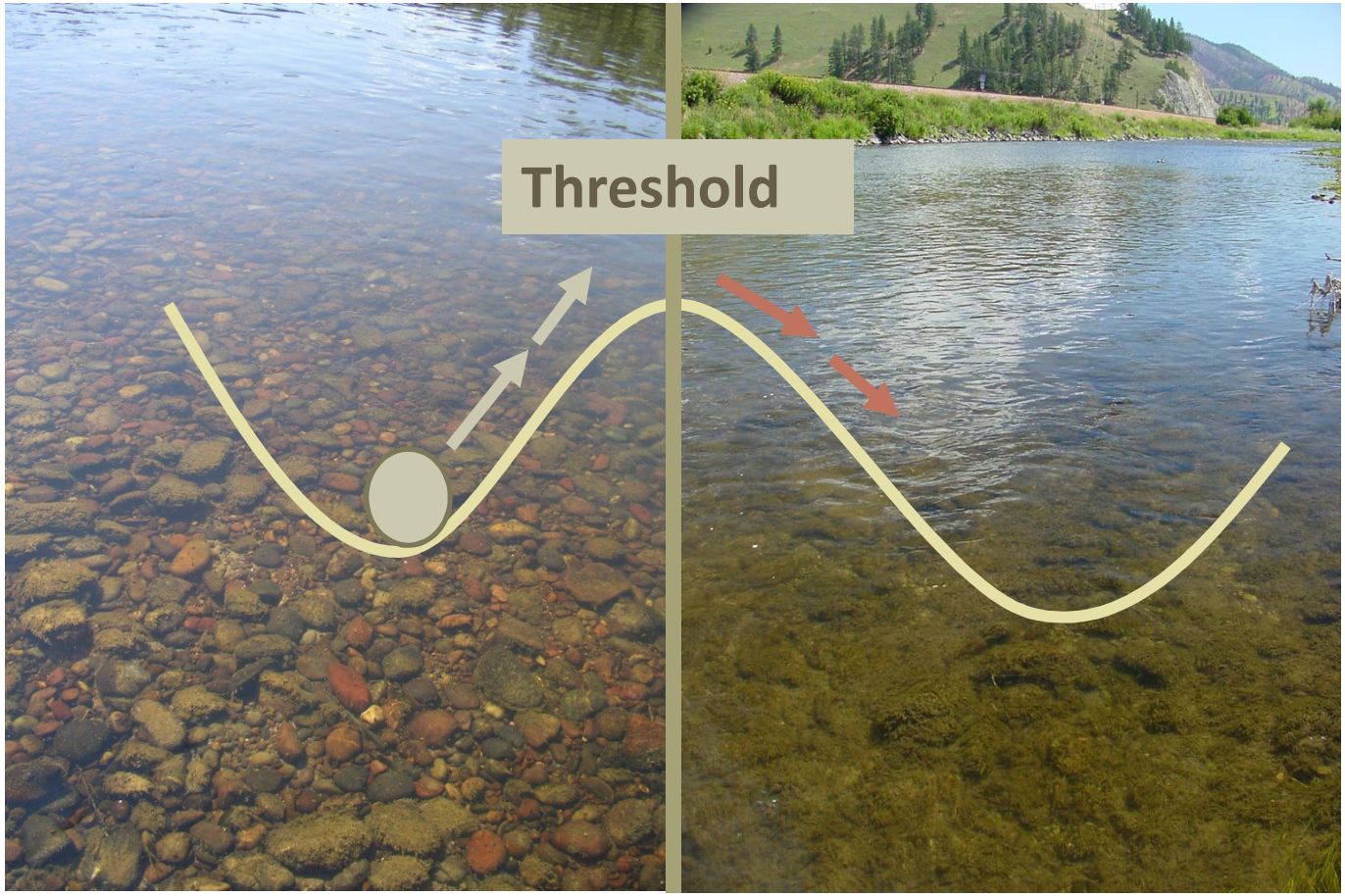
3/30/2015

Presentation Outline

- Brief Review of the Technical Basis for Proposed Criteria (DWQ)
- Headwater Criteria Proposal (DWQ)
- Combined Criteria: Guiding Principles (EPA)
- Application of Headwater Criteria: Monitoring and Assessment
- What's next? Timeline and Process

Nutrient Pollution Threatens Utah Waters

Managing Risk

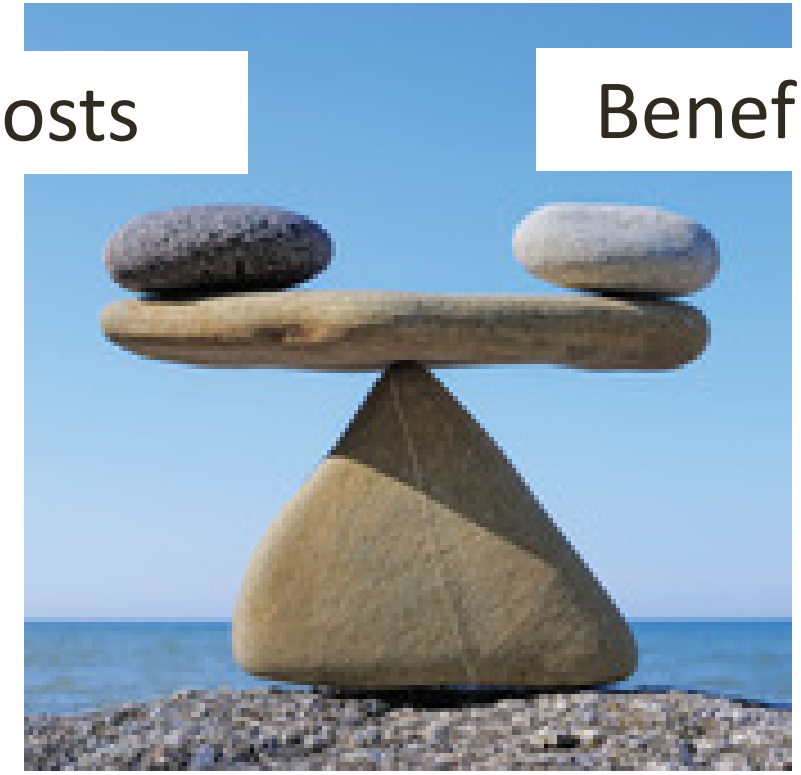


Avoid Regime Shifts

Managing Risk

Costs

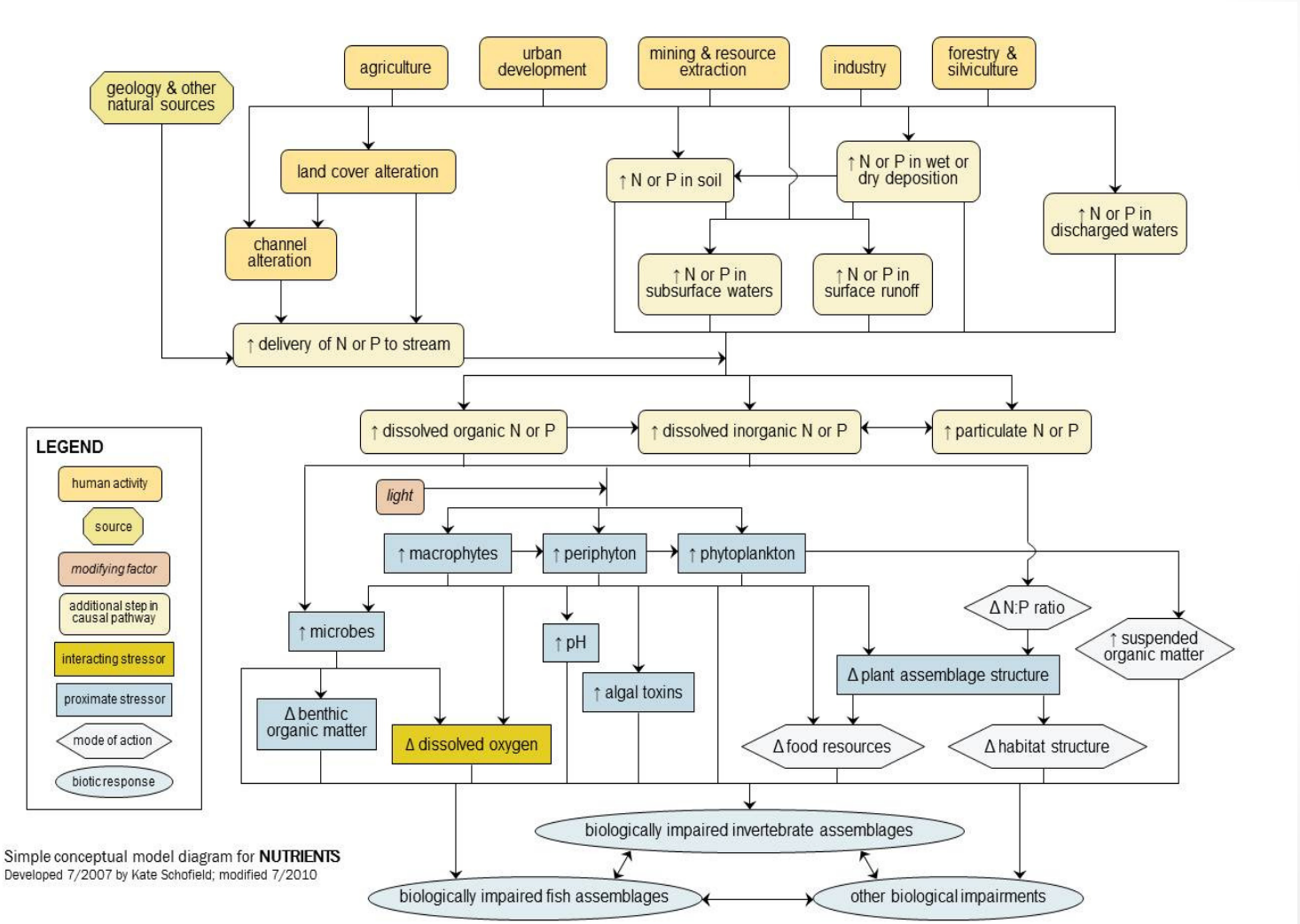
- Economic
- Degraded Uses



Benefits

- Economic
- Ecological Resilience

Complex linkages…



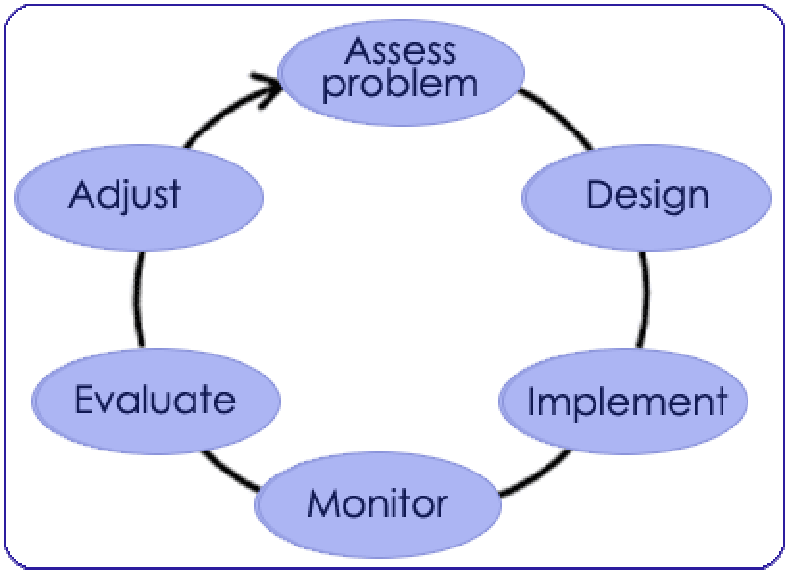
Simple conceptual model diagram for **NUTRIENTS**
Developed 7/2007 by Kate Schofield; modified 7/2010

Can lead to uncertainty.

Decisions are Needed

- Increasing demand for a scarce resource
  - 2nd driest State in USA
  - Utah's population doubles by 2050
- Climate Change
  - Long-term uncertainty for water resources
  - Need for resilience
- Develop solutions that make sense for Utah.

Adaptive Management



- "Learn by Doing"
- Identify areas of relative uncertainty In both problem elicitation and program implementation
- Resource prioritization

Headwater Criteria Development

- Develop Nutrient-Related Water Quality Indicators
- Review Existing Data
- Benchmark
  - Scientific Literature
  - Existing WQ Benchmarks

Technical Team Review

Technical Review Team

Theron Miller: Jordan River, Farmington Bay Watershed Management Council
Jesse Stewart: Salt Lake City
Darwin Sorensen: Utah State University
Erica Gaddis: SWCA then DWQ
Thomas Bosteels: Great Salt Lake Artemia Association
Tina Laidlaw: Environmental Protection Agency
Craig Walker: Utah Division of Wildlife Resources

More Recent Members

David Richards: Oreo Helix
Michelle Baker: Utah State University
Charlie Condrat: USDA Forest Service
Mark Muir: USDA Forest Service

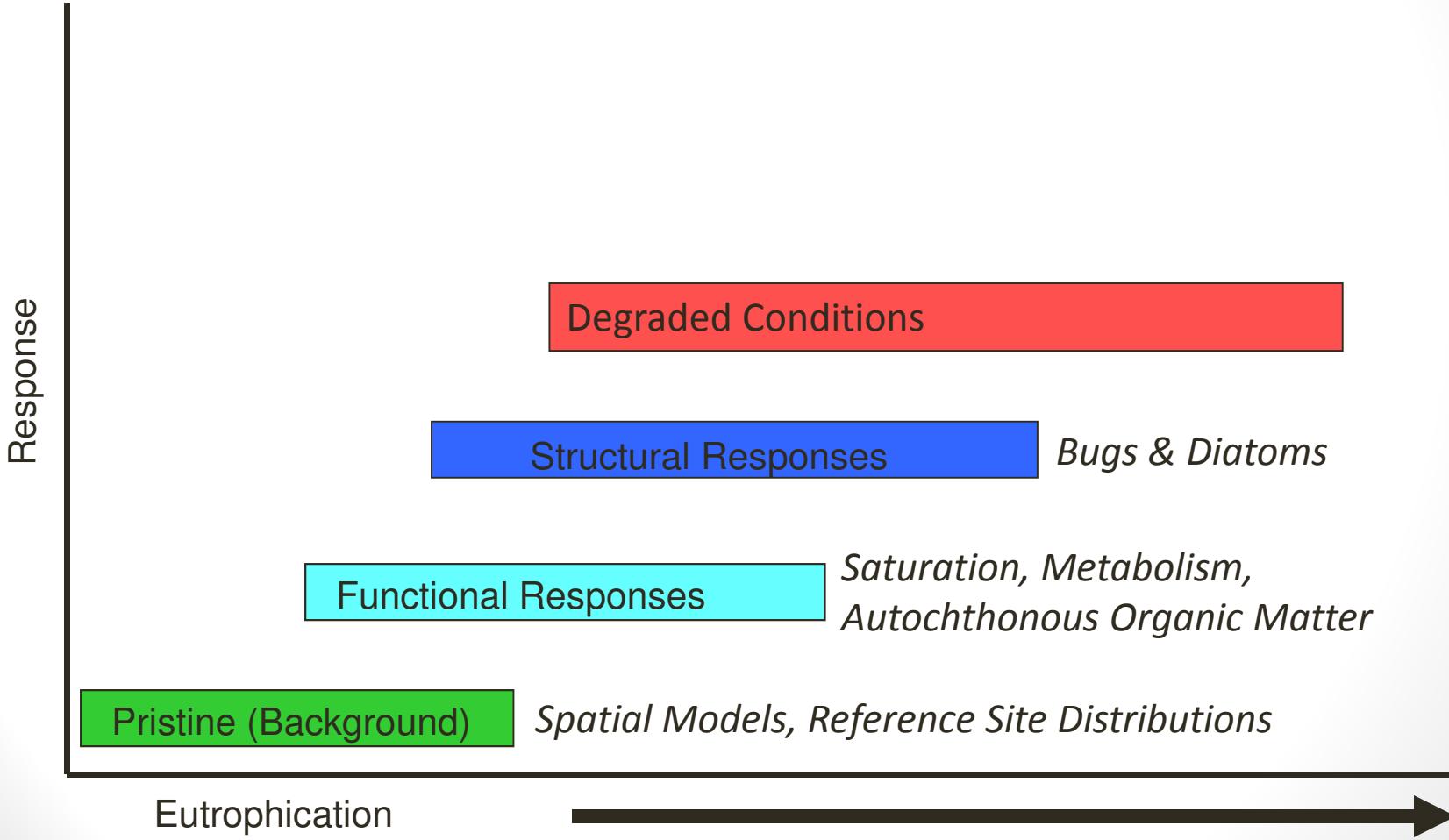
Many Thanks!

Technical Review Findings

The technical basis that underpins the headwater criteria proposal is technically sound, provided that…

- It is understood that the resulting indicators are strictly applicable to headwater streams
- Continued adaptive management is followed with implementation:
  - DWQ should continually evaluate data and make adjustments to headwater criteria where appropriate
  - New indicators should continue to be evaluated, especially for streams where nutrient-related impairments are identified
  - Collaborative management should be followed throughout all aspects of standard implementation

Developing New Indicators



Results: Response Thresholds

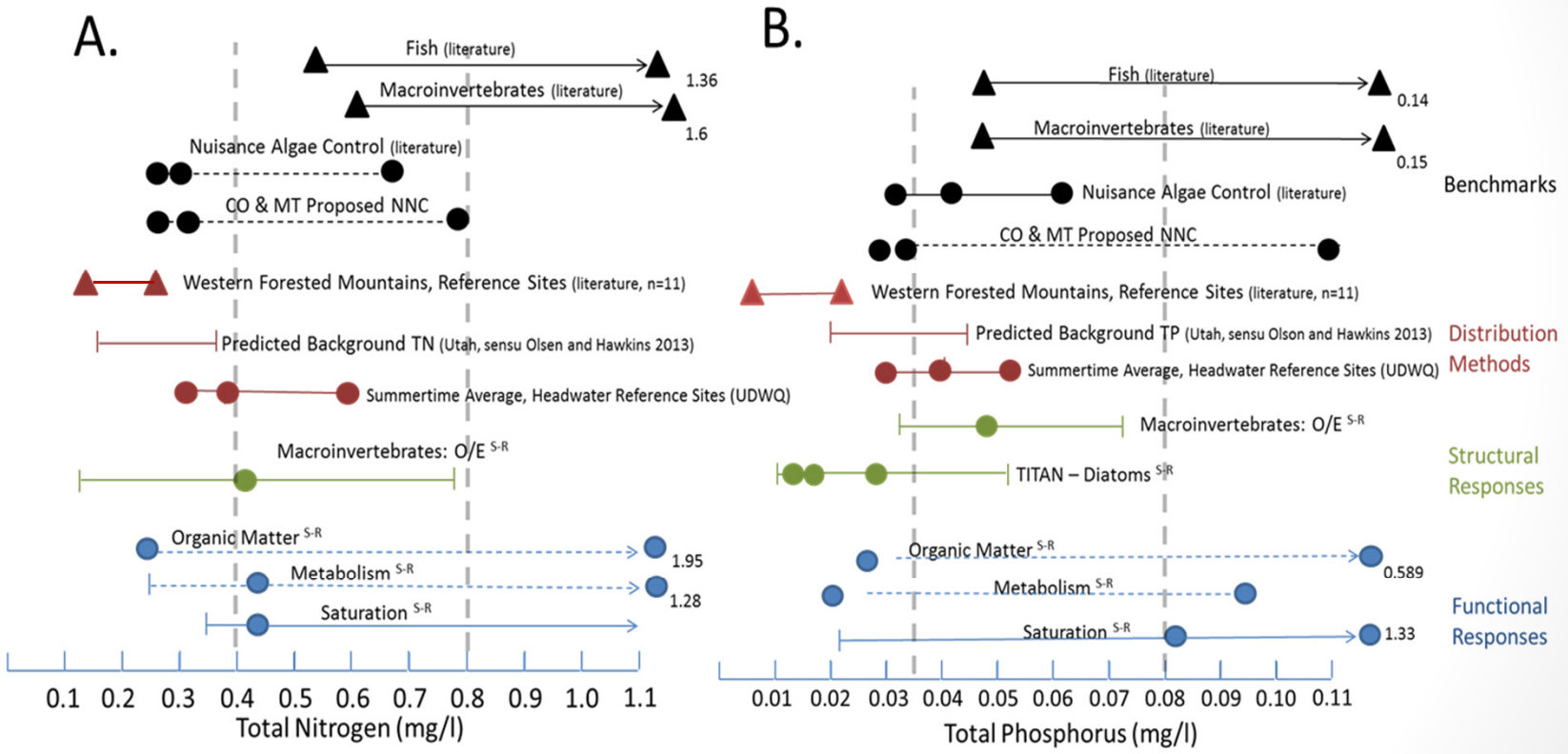
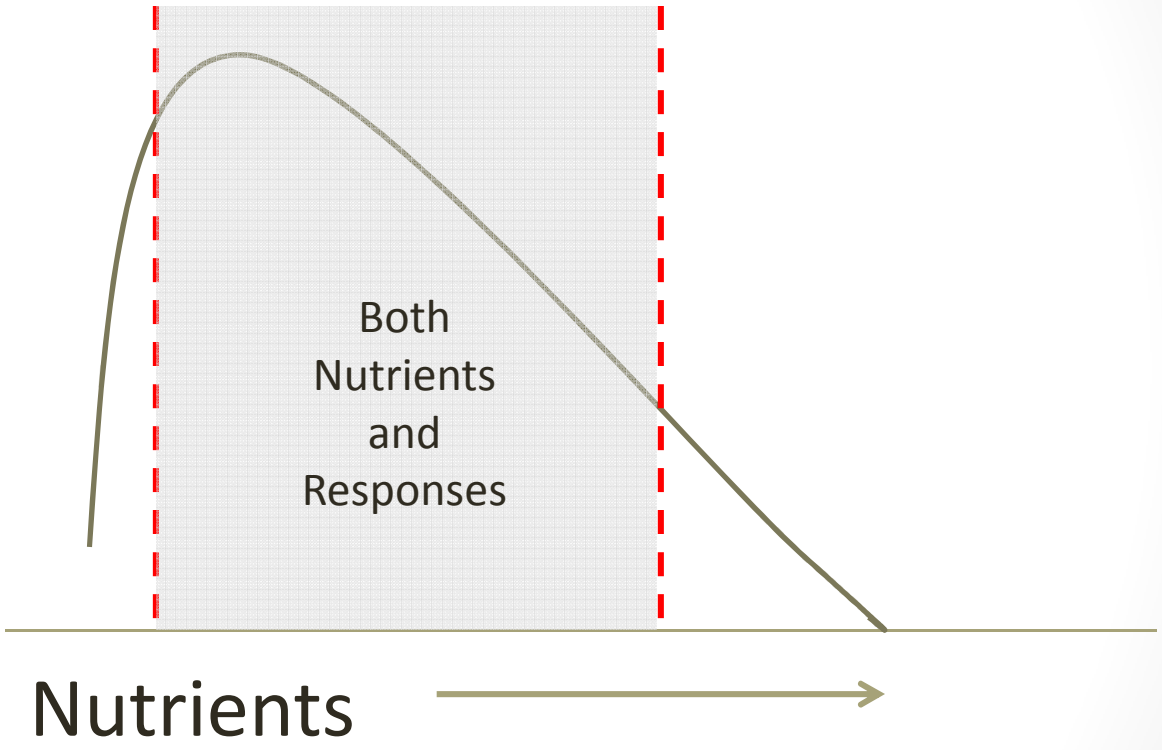


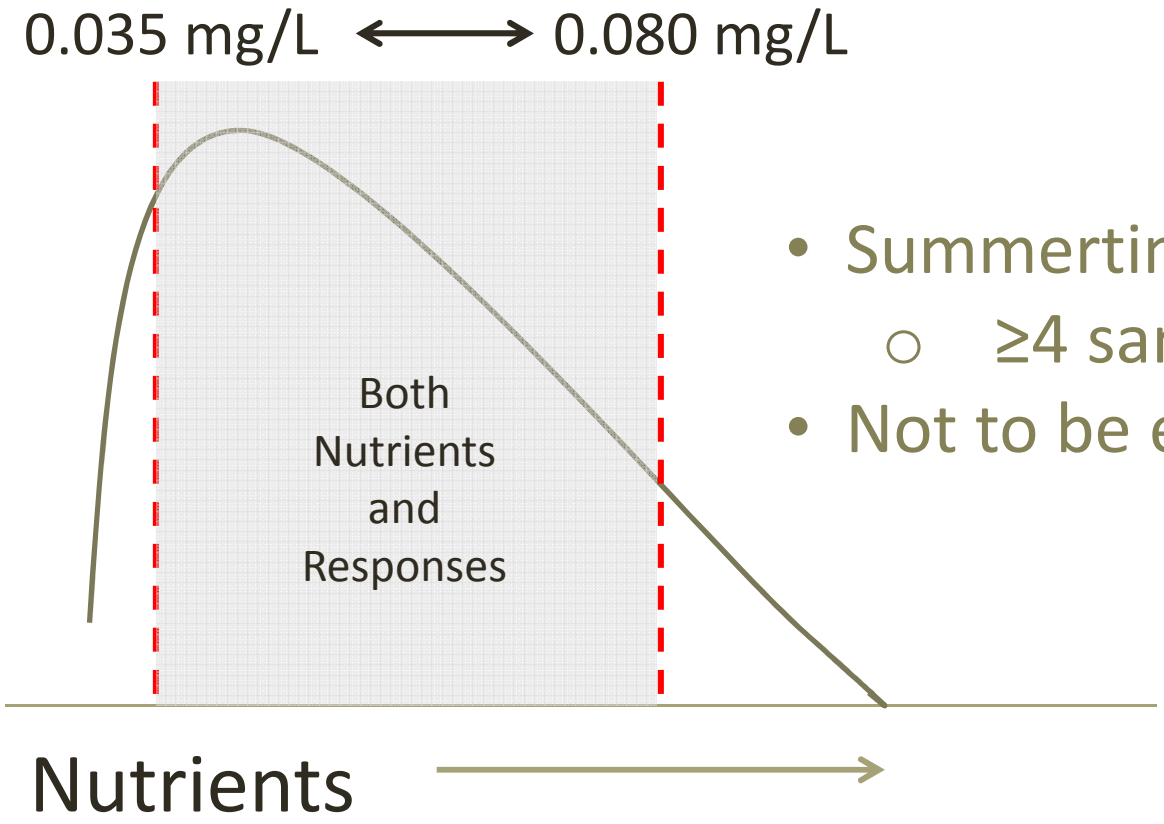
Figure 7. Thresholds for Total Nitrogen (Panel A) and Total Phosphorus (Panel B) along with proposed headwater criteria (dashed vertical lines).

Part 2
NNC for Utah's Headwaters

In a nutshell…

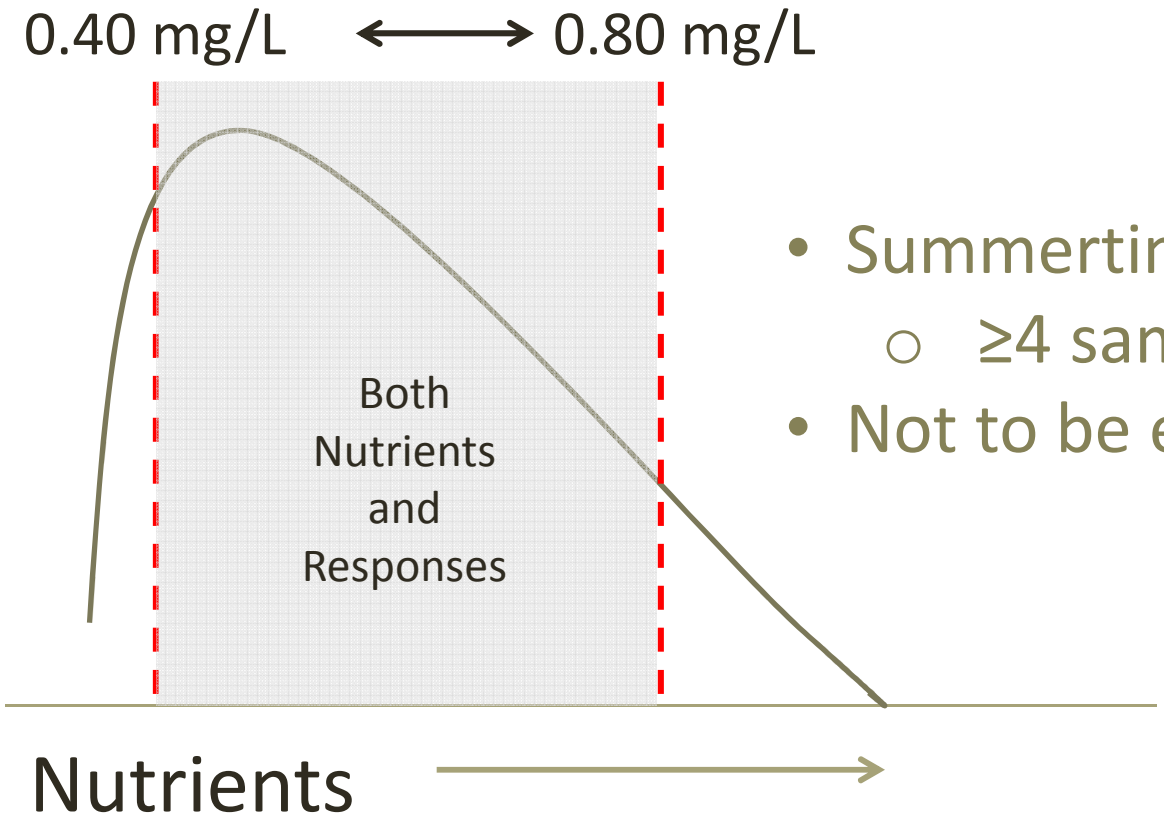


Total Phosphorus



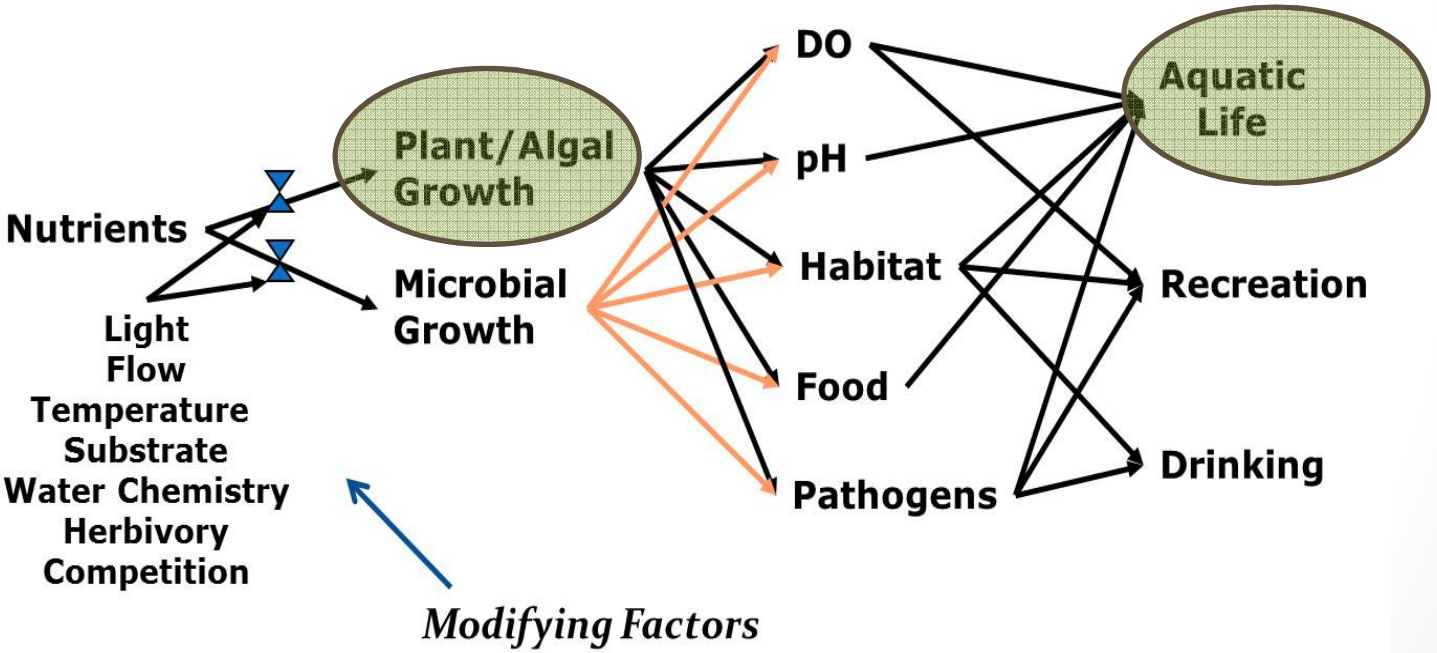
- Summertime average
  - ≥4 samples
- Not to be exceeded

Total Nitrogen



- Summertime average
  - ≥4 samples
- Not to be exceeded

Ecological Responses



The "Green Path"

The "Green Path": WQ Goals

Gross Primary Production (GPP)

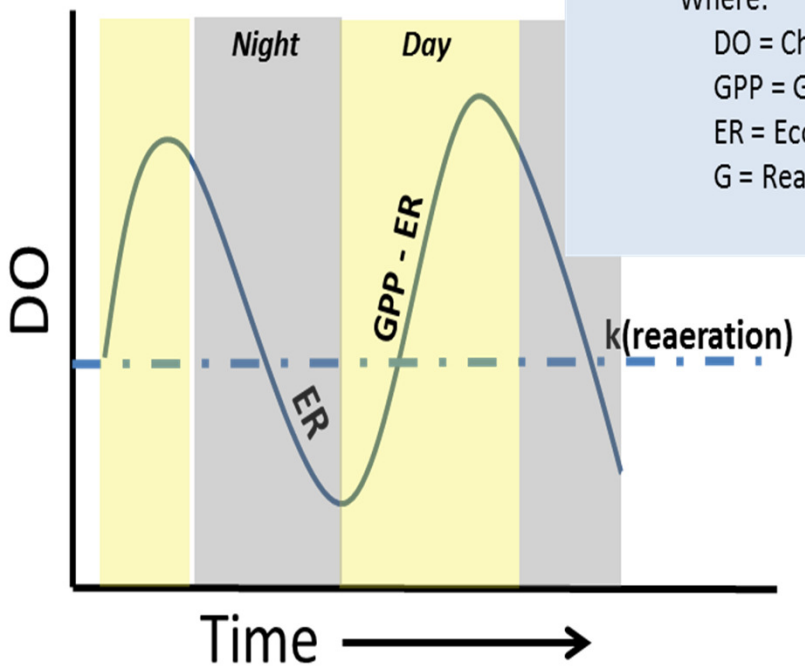
< 10 g O2/m2/day

OR

Filamentous Algae Cover

< 1/3 of Stream Bed

Ecosystem Metabolism



For each time step the amount of DO in the stream can be expressed as:

DO = GPP – ER ± G

Where:

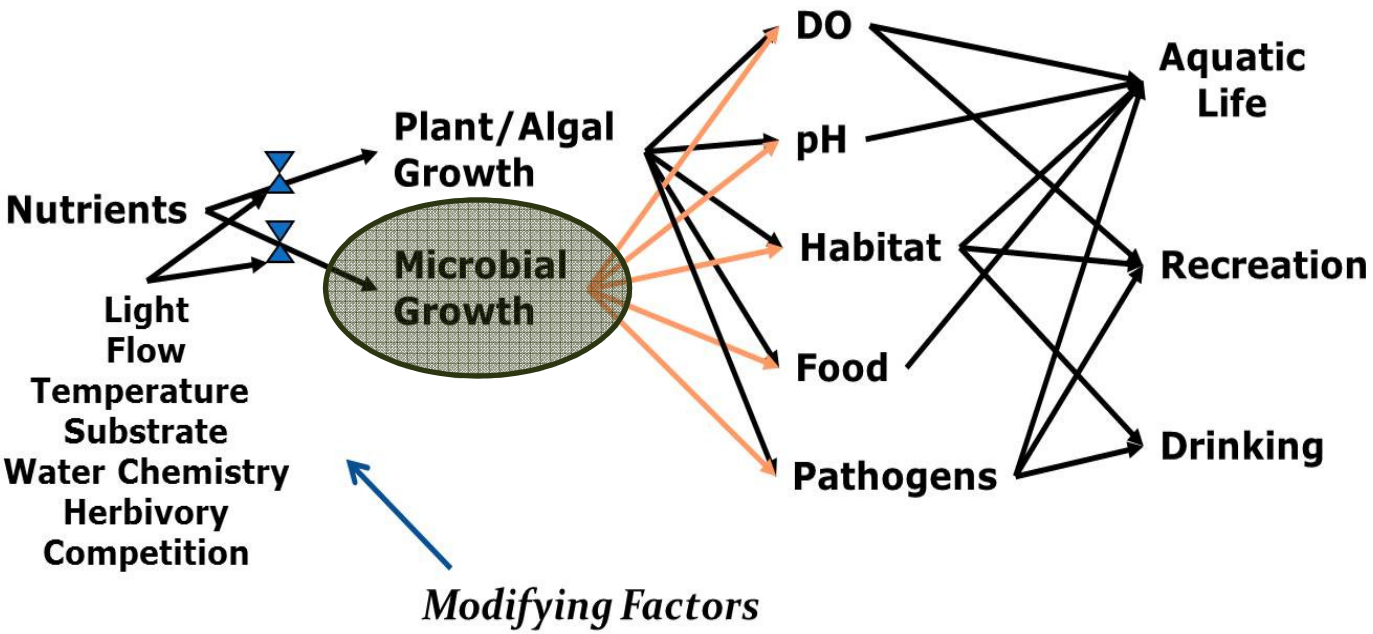
DO = Change in DO concentration

GPP = Gross Primary Production

ER = Ecosystem Respiration

G = Reaeration (k) x DO Deficit (saturation – current conditions)

Ecological Responses



The "Brown Path"

The Brown Path: WQ Goal

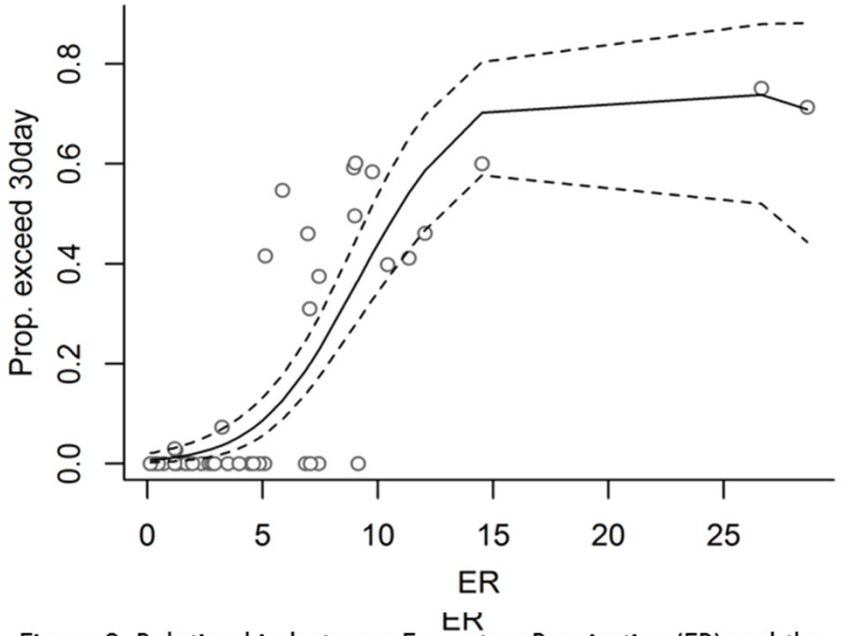


Figure 8. Relationship between Ecosystem Respiration (ER) and the proportion exceed 30-day Dissolved Oxygen criterion for all life uses (6.5 mg/l).

Ecosystem Respiration

< 9 g $O_2/m^2/day$

Table 1. Numeric nutrient criteria and associated ecological responses (bioconfirmation criteria) proposed to protect aquatic life uses in Antidegradation Category 1 and 2 (UAC R317-2-12) headwater perennial streams[1].

Low Nutrient Headwater Streams: Ecological Responses not Proposed

Summertime Average Nutrients		Assessment Notes
TN <0.40[2,5]	TP <0.035[2,5]	Fully supporting biological uses if ≥4 summertime samples fall within the range; sites with fewer samples will not be assessed for nutrients. If available response data suggest that more protective criteria are needed, site-specific standards will be developed.

Intermediate Nutrient Concentrations with Proposed Ecological Responses

Summertime Average Nutrients		Ecological Response	Assessment Notes
TN 0.41-0.80[2]	TP 0.036-0.079[2]	**Plant/Algal Growth[3]** 1/3 or more filamentous algae cover[4,6] OR GPP[3] of >10 g O_2/m^2/day OR **Plant and Microbial Growth** ER[3] >9 g O_2/m^2/day	Headwater streams within this range of nutrient concentrations will be considered impaired if <u>any</u> response exceeds defined thresholds. Streams <u>without response data</u> will be listed as having <u>insufficient data</u> and prioritized for additional monitoring if either TN or TP falls within the specified range.

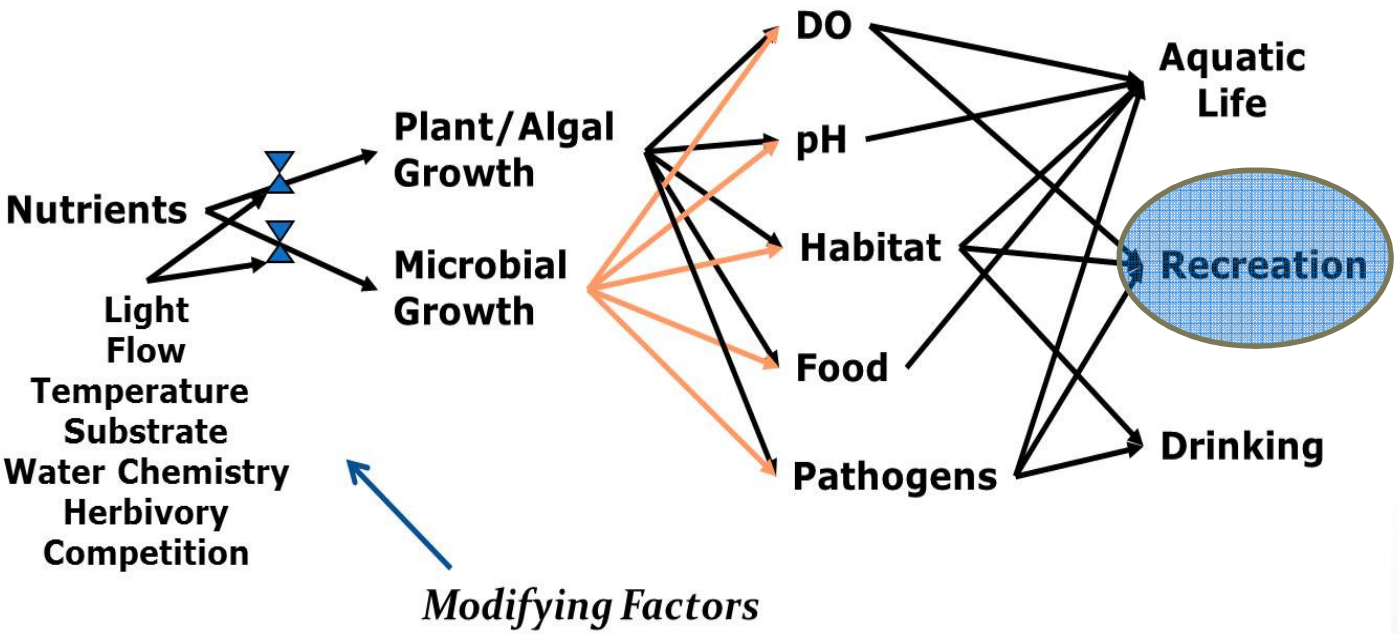
Upper Threshold Nutrient Concentration: No Proposed Ecological Responses[6]

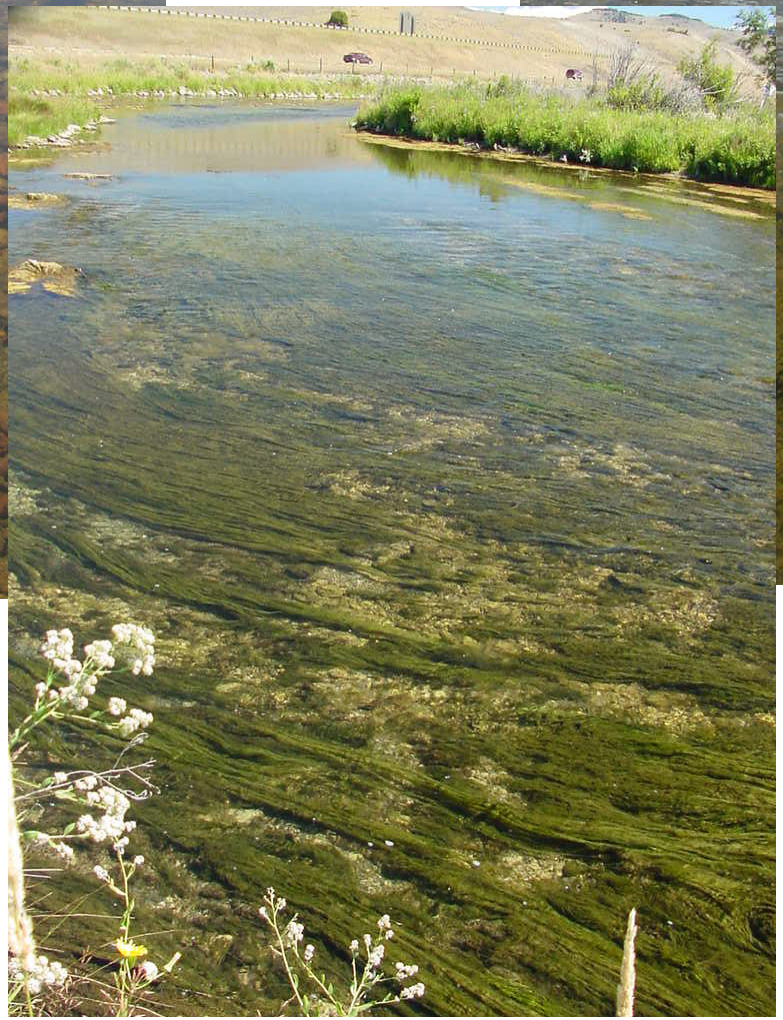
Summertime Average Nutrients		Assessment Notes
TN > 0.81[2,5]	TP > 0.080[2,5]	Streams over these thresholds will initially be placed on Utah's 303(d) list as threatened. Threatened streams will be reclassified as impaired the following assessment cycle unless additional data such as nutrient responses, biological assessments and nutrient-related water quality criteria (e.g., pH and DO) demonstrate that aquatic life uses are fully supporting; in which case, site-specific standards will be developed unless downstream resources are threatened.

FOOTNOTES:

1. *Applicable unless more restrictive Total Maximum Daily Load (TMDL) endpoints have been established to protect downstream waters.*
2. *Seasonal average of ≥4 samples collected during the summertime growing season (June 1 – September 30). Not be exceeded. TP means Total Phosphorus and TN means Total Nitrogen in mg/L.*
3. *Daily whole stream metabolism obtained using open channel methods. GPP means Gross Primary Production. ER means Ecosystem Respiration. Daily values are not to be exceeded on any collection event.*
4. *Filamentous algae cover means patches of filamentous algae >1 cm in length or mats >1 mm thick. Daily values are not to be exceeded at any time during the growing season (June-September).*
5. Response data, when available, will be used to confirm impairments or support the need for site-specific criteria.
6. *Quantitative estimates based on reach-scale averages with at least 3 measures from different habitat units (i.e., riffle, run) made with quantitative visual estimation methods.*

Protecting Recreational Uses

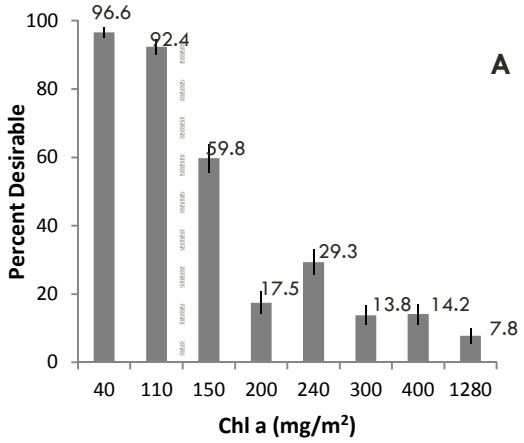


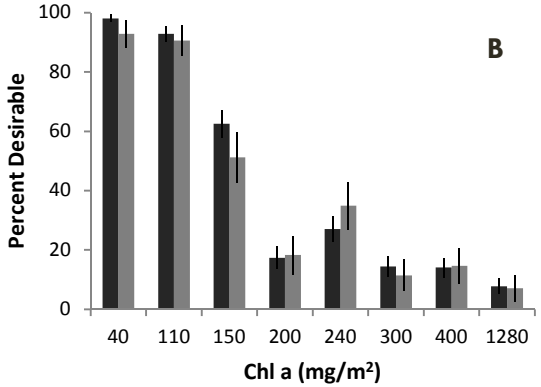


How green is too green?

Recreation Survey

Tie to Recreation Uses





Water Quality Criteria

- <125 mg chl-a/m^2

OR

- <49 g AFDM/m^2 to protect recreation uses

Excess algae degrades stream aesthetics!

Part 3
Combined Criteria: Guiding Principles

Guiding Principles for Developing and Implementing a Numeric Nutrient Criterion That Integrates Causal and Response Parameters

(EPA-820-F-13-039)

Utah Water Quality Standards Workgroup
March 23, 2015

Presented by: Lareina Guenzel
Water Quality Standards Unit
U.S. Environmental Protection Agency, Region 8
guenzel.lareina@epa.gov

Presentation Outline

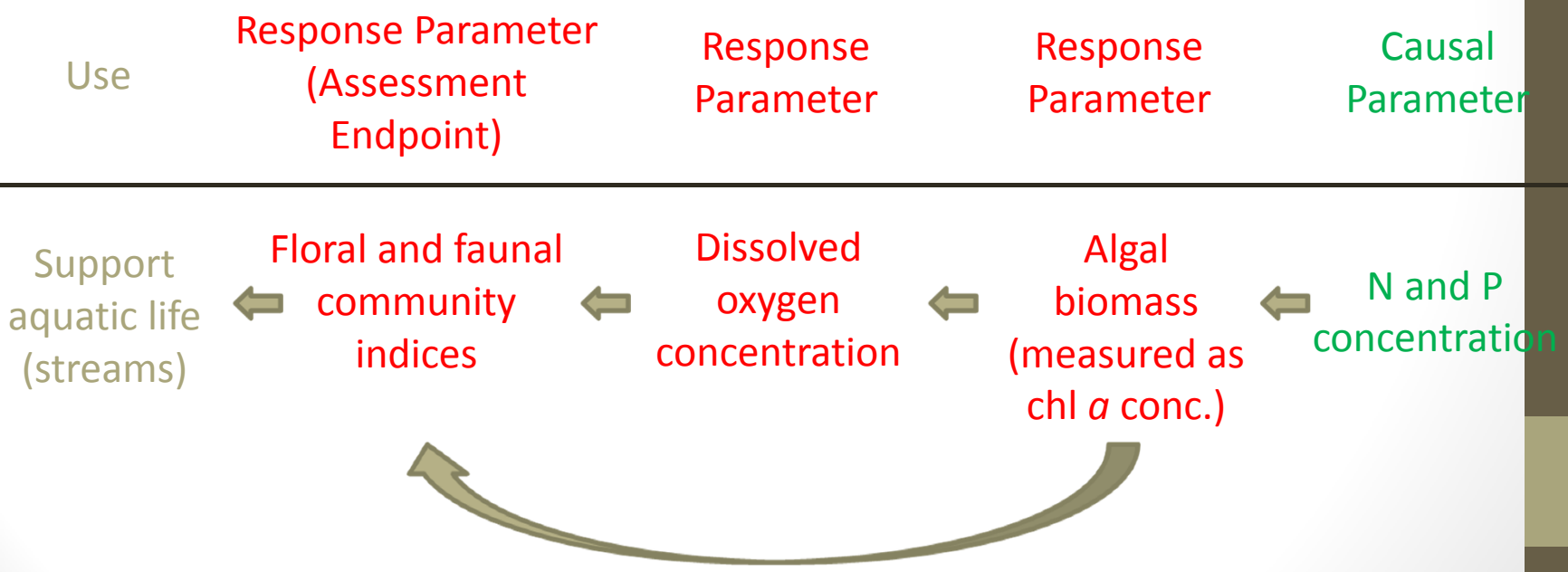
- **Background – Nutrient Criteria Development**

- **Guiding Principals**
  - I. Applicability
  - II. Criterion Science and Expression
  - III. Implementation

Development of Numeric Nutrient Criteria

40 CFR 131.11 (a)(1) – States must adopt those water quality criteria that protect the ***designated use*.** Such criteria must be based on *sound scientific rationale* and must contain sufficient parameters or constituents to protect the designated use.

40 CFR 131.3(b) – "*Criteria* are elements of State water quality standards expressed as constituent concentrations, levels or narrative statements, representing a quality of water that supports a particular *use*."



Note: Nutrients generally affect designated uses of water bodies through cascading effects

EPA's Guiding Principles (GP) for Integrated Criteria

Areas Covered include:

I. Applicability
II. Criterion Science and Expression
    A. Protectiveness
    B. Sound Scientific Rationale
    C. Expression of the Criterion
III. Implementation
    A. Section 303(d) Assessment and Listing
    B. Permitting

Guiding Principles – I. Applicability

1. GPs apply only for nutrients

2. GPs apply when states/tribes wish to rely on response parameters to indicate that a **designated use is protected, even though N and/or P are above an adopted threshold**

3. States/tribes should have a robust biological assessment program

Guiding Principles – II. Criterion Science and Expression
A. Protectiveness

1. Per 40 CFR 131.11(a), a criterion must protect the designated use of the water.

2. Numeric values for all parameters must be set at levels that protect uses (i.e., before adverse conditions that will require restoration).

3. Per 40 CFR 131.10(b), states must ensure that WQS provide for the attainment and maintenance of the WQS of downstream waters.

Guiding Principles – II. Criterion Science and Expression
B. Sound Scientific Rationale

1. Detailed documentation that identifies applicable nutrient pathways AND pathways that are not accounted for and why.

2. Select biological response parameters that are indicative of nutrient pollution.
   a) Measures of primary productivity (e.g., benthic chlorophyll *a*, percent cover of macrophytes)
   b) Measures of the algal assemblage (e.g., algal assemblage indices)
   c) Measures of ecosystem function (e.g., continuously monitored pH and dissolved oxygen).
   d) Higher trophic levels may be used in a suite of response variables, but should not be the predominant indicator

Guiding Principles – II. Criterion Science and Expression
B. Sound Scientific Rationale

3. It is important to have sufficient data to allow the development of quantitative relationships (e.g., via regression models).

4. States should clearly and thoroughly document in their WQS (or supporting documentation)—for public review and submission to the EPA—how the criterion was developed and the technical aspects of their biological assessment protocols (including the assessment endpoints).
   - reproducibility, transparency, and defensibility (See 40 CFR 131.6(b), 131.20(b))

Guiding Principles – II. Criterion Science and Expression
C. Expression of the Criterion

1. Causal and response parameters must be combined into one criterion. (CWA §303(d)(1)(A) and 40 CFR 130.7)
2. All causal and response parameters should be expressed numerically.
3. Duration and frequency components for all parameters should be included in the criterion in the state's WQS.
4. Decision framework when a state adopts a range of numeric values.

Guiding Principles – II. Criterion Science and Expression
C. Expression of the Criterion

		Response Parameters		
		Met	**Not Met**	**No Data**
Causal Parameters (N & P)	**Met**	 Uses attained!	 Uses not attained; Additional studies	 Not Assessed
	Not Met	 Uses attained! > Site-specific N&P?	 Uses not attained	 

Guiding Principles – III. Implementation
A. Section 303(d) Assessment and Listing

1. The CWA Section 303(d) assessment methodology should be consistent with the criterion.
2. CWA Section 303(d) requirement that states identify water quality-limited segments still requiring TMDLs where pollution controls are not stringent enough to implement any WQS still applies.
3. If a causal parameter is significantly exceeded but no response parameters are exceeded, then the state should pursue additional studies to determine whether site-specific criteria are appropriate.
4. States should have a process for monitoring response parameters downstream when assessing upstream conditions.

Guiding Principles – III. Implementation
B. Permitting

1. States should develop NPDES permitting implementation procedures to ensure a consistent application of the criterion.
2. NPDES permits must contain limits for any pollutants or pollutant parameters that are or may be discharged at levels that will cause, have reasonable potential to cause, or contribute to an excursion above any WQS. (40 CFR 122.44(d)(1)).
   - Such limits must be sufficiently stringent to achieve all applicable WQSs.
   - Where reasonable potential exists, permit writers must include limits in permits to achieve the WQS and, in doing so, should develop WQBELs based on the numeric nutrient causal parameters.

Questions and comments:

Tina Laidlaw (R8 Nutrient Coordinator) laidlaw.tina@epa.gov
Lareina Guenzel (R8 WQS Coordinator) guenzel.lareina@epa.gov
Mario Sengco (OW) sengco.mario@epa.gov

EPA's guiding principles document is available at:

http://www2.epa.gov/nutrient-policy-data/guiding-principles-integrated-nutrient-criteria-bioconfirmation

Part 4
Application of Headwater Criteria

Monitoring

Tier 1: Probabilistic (spatially explicit, stratified, random sample design)

- **One chemistry sample** (TN and TP)
  - Screen sites (lower threshold)
- **Quantitative algal biomass sample**
  - Assess recreational use support
- **Other independent measures of condition**
  - Bugs, fish and habitat
  - Informs where site-specific modifications are needed

Monitoring

Tier 2: Intensive (≥monthly water chemistry)

- **Multiple Chemistry Samples**:
  - At least 4 water chemistry samples collected during growing season
  - Obtain season average indicators

- **Multiple Quantitative Visual Algal Cover**:
  - Can be used as measures of percent cover responses;
  - Addresses seasonal temporal variation.

- **Proposed**: **~4 weeks of metabolism** data at high priority sites

Assessment

Figure 10. Decision matrix that will be used to assess support of headwater aquatic life uses for nutrient-related water quality problems. Associated *Integrated Report* categories are in parentheses.

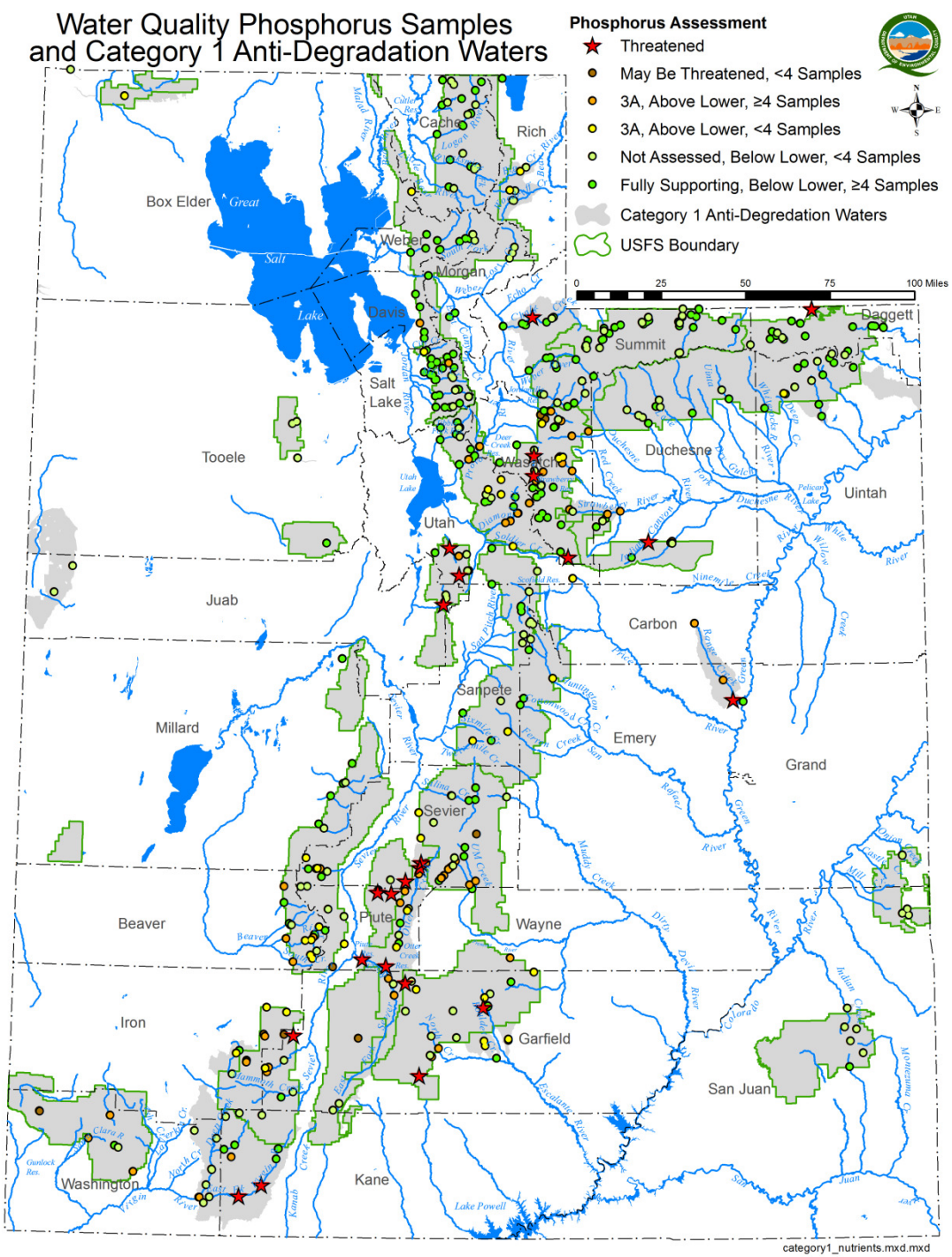
		Ecological Responses		
Nutrient Data (TN or TP)		**No Data**	**< All Criteria**	**> Any Criterion**
	No Data or < 3 Samples	Not Assessed[1]	Not Assessed	Insufficient Data (3A)[2]
	< Low Threshold	Not Assessed	Fully Supporting (1 or 2)[3]	Insufficient Data (3A)[2,4]
	Between Lower and Upper	Insufficient Data (3A)[2]	Fully Supporting (1 or 2)[3]	Impaired (5)[6]
	Above Upper Threshold	Threatened (5)[5,6]	Threatened (5)[4,5,6]	Impaired (5)[6]

FOOTNOTES:

1. There are insufficient nutrient-related data to assess whether or not aquatic life uses are supported; however, aquatic life uses may be assessed with other water quality parameters.
2. Sites where TN or TP fall below the upper threshold, but above the lower threshold, and lack measures for at least one response variable will not be assessed with respect to nutrients. These sites will be prioritized for follow-up monitoring.
3. The integrated report distinguishes between sites where at least one parameters has been evaluated for all uses (Category 1) and sites where some uses are supported, whereas others are either not supported or not assessed (Category 2).
4. Sites where nutrient and ecological response data are in conflict may be candidates for site-specific criteria.
5. Sites designated as threatened will automatically become impaired in the next assessment cycle unless it can be demonstrated that biological uses are fully supported both locally and downstream.
6. TMDL required unless an alternative remediation (TMDL alternative) plan or a site-specific standard has been approved by UDWQ and USEPA.

How do headwater streams compare?

- **~70% appear to be in good condition**
- **~9% are potentially impaired for TP and ~6% for TN**
  - **Exceed upper threshold**
  - **~1/2 have <4 samples**
- ~20% need follow-up investigation with responses
  - Above lower threshold
  - About ½ have <4 samples


Water Quality Phosphorus Samples
and Category 1 Anti-Degradation Waters
Phosphorus Assessment
Threatened
May Be Threatened, <4 Samples
3A, Above Lower, ≥4 Samples
3A, Above Lower, <4 Samples
Not Assessed, Below Lower, <4 Samples
Fully Supporting, Below Lower, ≥4 Samples
Category 1 Anti-Degredation Waters
USFS Boundary
0 25 50 75 100 Miles
Box Elder
Cache
Rich
Weber
Morgan
Davis
Salt Lake
Tooele
Utah
Wasatch
Summit
Daggett
Duchesne
Uintah
Juab
Carbon
Sanpete
Millard
Emery
Grand
Sevier
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane
Great Salt Lake
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Responding to Nutrient-Related Impairments

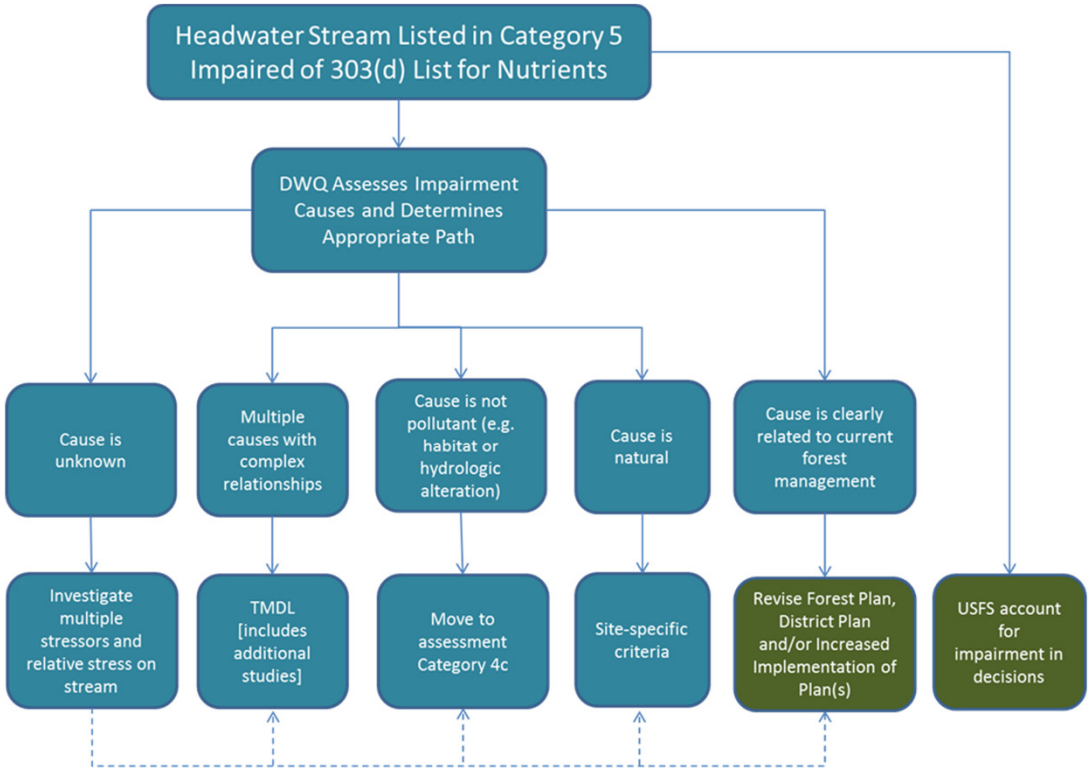


Figure 11. Summary of pathways that DWQ will follow after a headwater stream is listed as impaired for nutrients.

Next Steps

- Address specific comments & revise documentation
  - Edits to the technical basis report
  - Edits to the headwater criteria proposal
    - Assessment matrix (if appropriate)
    - Additional clarifications
- Convene another Technical Team Meeting
  - Discuss any changes to the proposal
  - Review algae cover SOPs
- Monitoring
  - Collect response data for sites where historic data suggests the potential for nutrient-related impairments
- Rulemaking
  - Develop specific rule language
  - To Water Quality Standards Workgroup for comment, then
  - To Water Quality Board for permission to proceed with rulemaking
  - 60-day public comment period and assoc. public hearings
  - To Water Quality Board for Approval
  - To EPA for Approval

Is there a need to formally involve the Core Team further in this process?


THE
END

“Back Pocket” Slides

Maine

- **Proposal includes TP criteria and the following response parameters :**
  - **Percent algal cover**
  - **Water column chlorophyll a concentration**
  - **Secchi disk depth (for lakes only)**
  - **Presence/absence of bacteria and fungi**
  - **pH**
  - **Dissolved oxygen concentration**
  - **Aquatic life**
- **EPA worked closely with ME to clarify and strengthen its draft nutrient WQS.**
- **EPA Letter to Maine DEP, December 22, 2011**
- **ME legislature has yet to adopt the criteria**

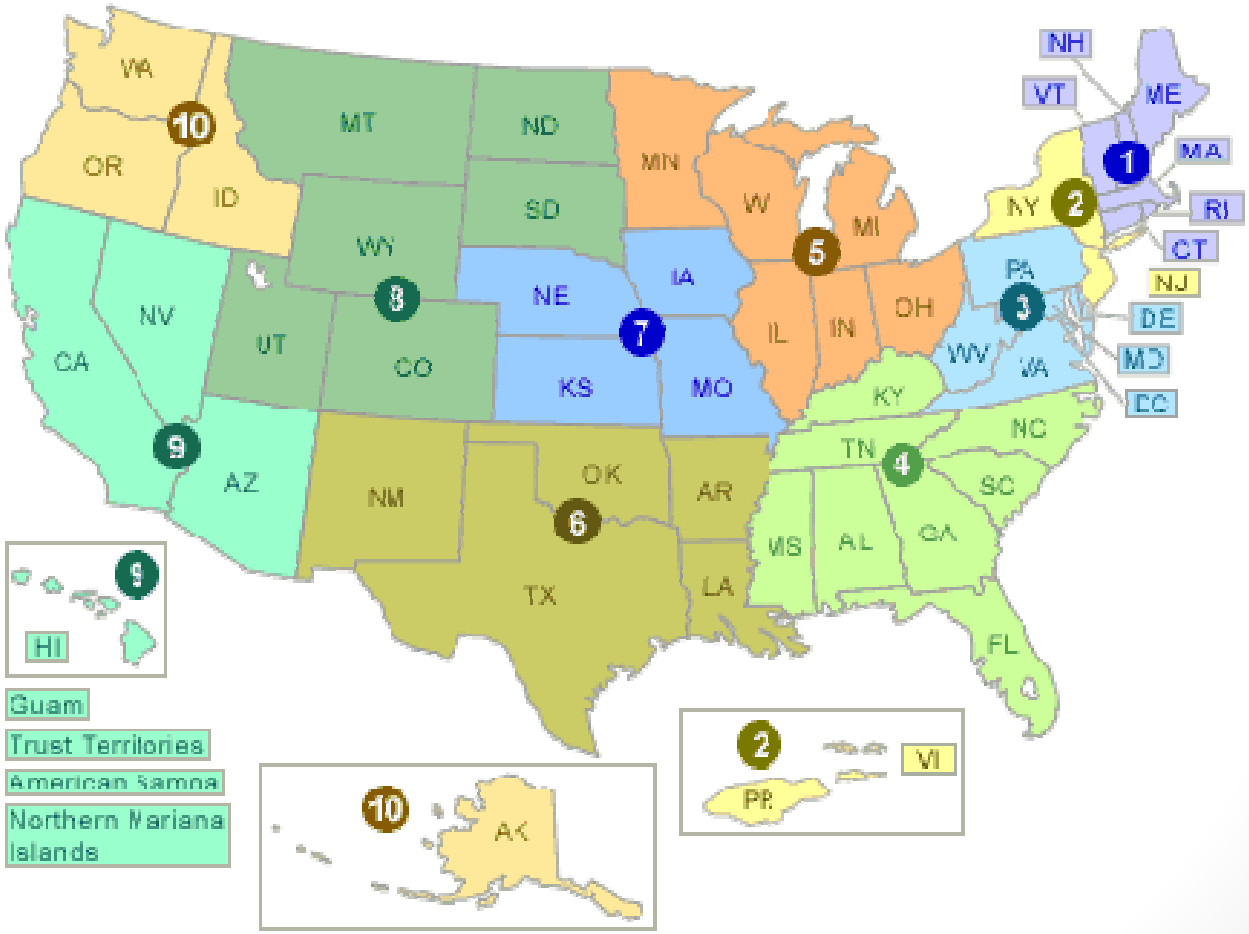
Florida

- **FL adopted and EPA approved numeric TN and TP thresholds along with numeric response parameter (for streams) within a decision framework:**
  - **Chlorophyll *a;***
  - **Periphyton coverage (measured via Rapid Periphyton Survey);**
  - **Nuisance macrophyte growth (measured via Linear Vegetation Survey);**
  - **Algal taxa dominance;**
  - **Stream Condition Index to measure flora and fauna**

- **FL provided additional technical details on how each parameter would be sampled and analyzed, and the quantitative targets to be used for each response parameter**
  - ***Implementation of Florida's Numeric Nutrient Standards* (March 2013).**
  - **Incorporated by reference and approved by EPA on June 27, 2013.**

Polling Question - Geographic Location

Please respond to the polling question on your screen

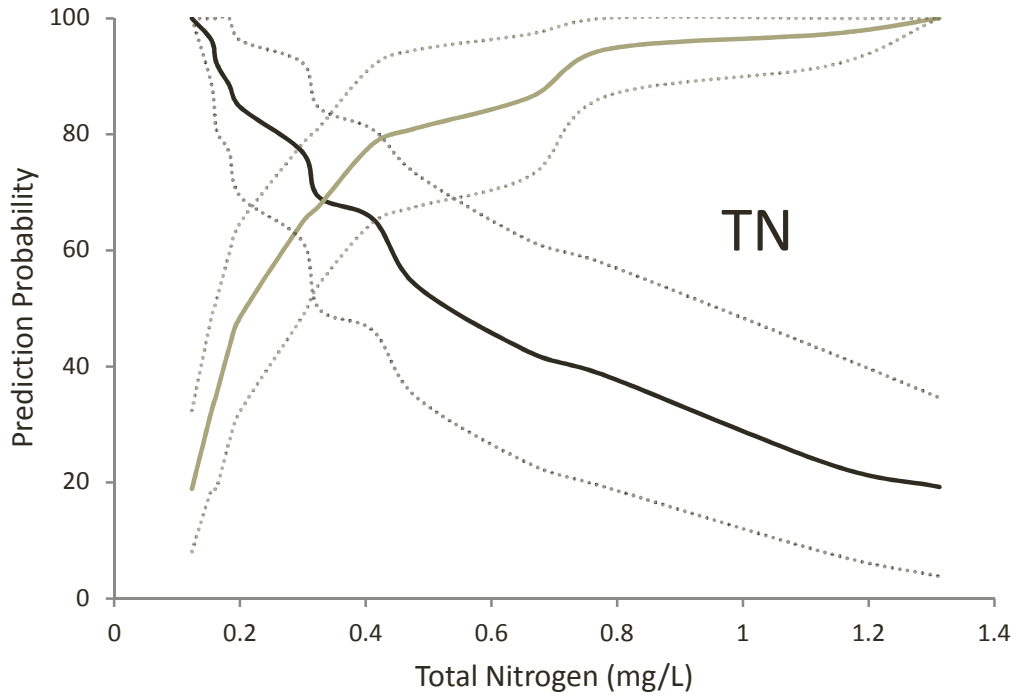


More Information

Questions and comments after the webinar:
sengco.mario@epa.gov
Use "Bioconfirmation" in the subject line.

Obtaining copies of this presentation, guiding principles and additional resources:

"Toolkit of Resources to Provide States with Flexibility in Adopting and Implementing Numeric Nutrient Criteria"
Available online at:
http://www2.epa.gov/nutrient-policy-data/toolkit-resources-provide-states-flexibility-adopting-and-implementing-numeric

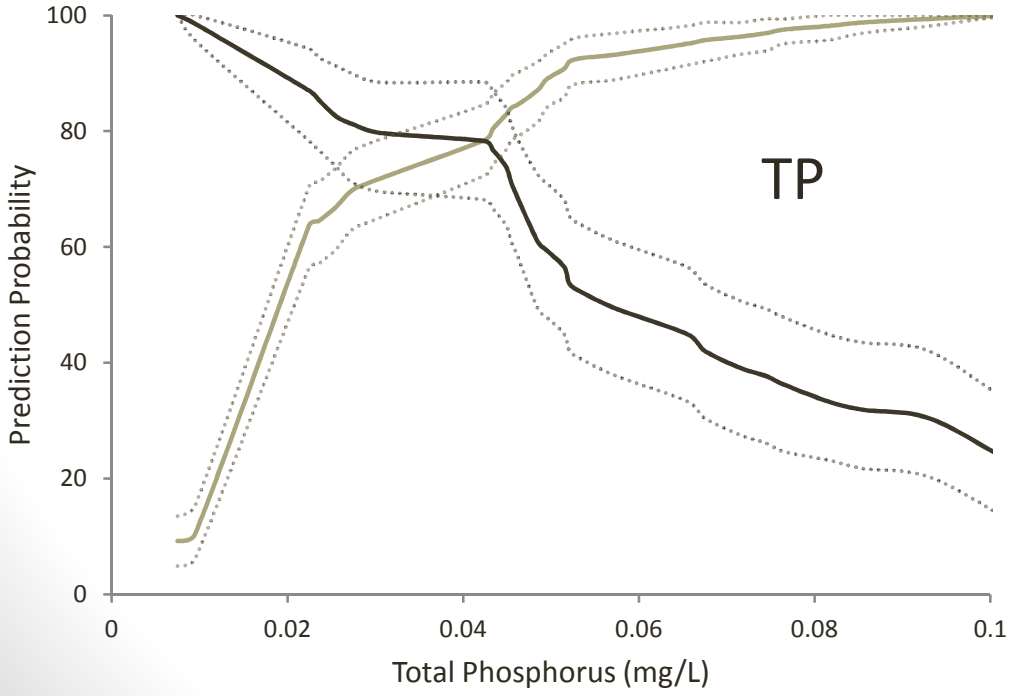


Threshold Diagnostics

TN-0.5	TN-OE	5th CI	95th CI
AUC	72.6	60.21	82.9
RR	2.09	1.57	2.95

True Positives (impaired)

True Negatives (not impaired)



Threshold Diagnostics

TP-0.045	TP-OE	5th CI	95th CI
AUC	79.6	72.7	85.6
RR	3.66	2.66	5.01

Receiver Operating Characteristics

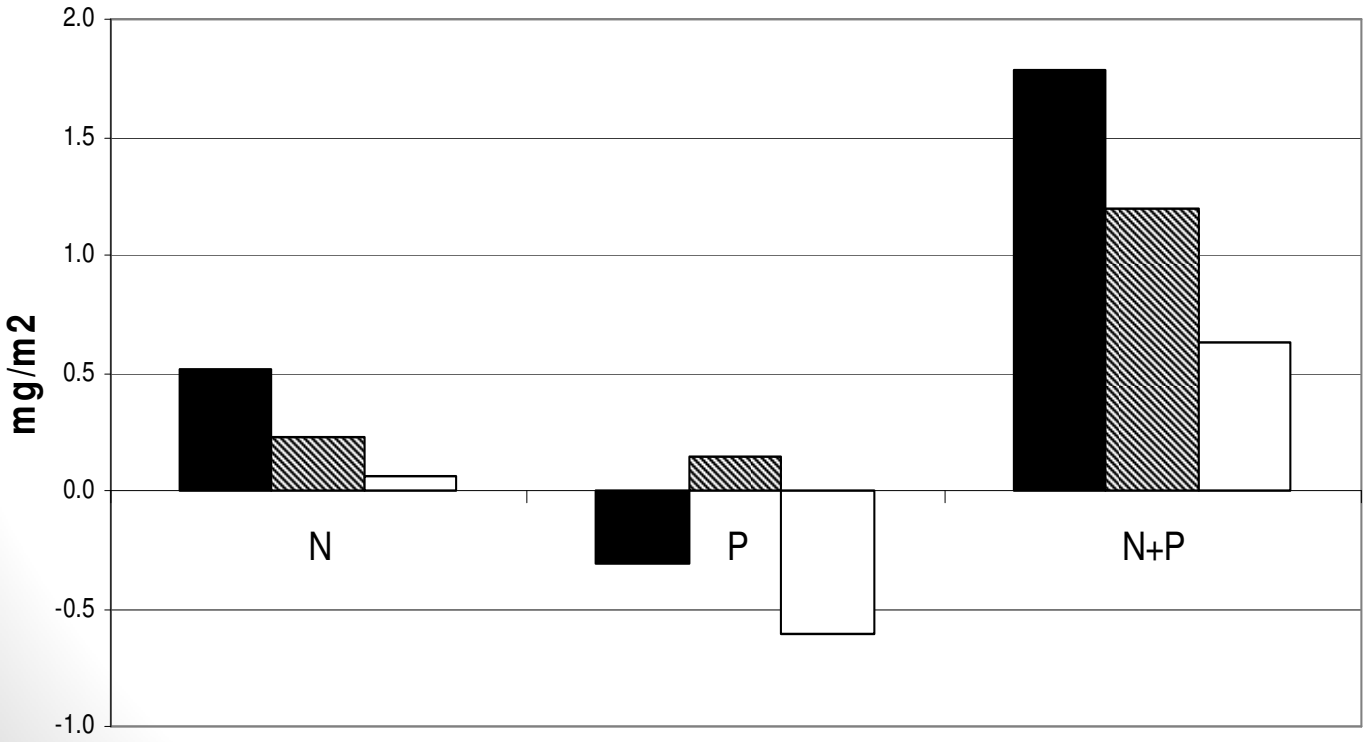
Functional Indicators: NDS

- 3 Replicates, 3 Treatments (P, N, N&P) and Controls
- Saturation Thresholds
  - TN = 0.042 (95%: 0.33-1.41)
  - TP = 0.078 (95%: 0.017-1.33)
- Confirmed accuracy of classifications with ROC:
  - TN = 82% (AUC)
  - TP = 72%

Limiting Nutrients

Data Relative to Controls

High Variation! Site-Specific (time-specific?) factors seem important.

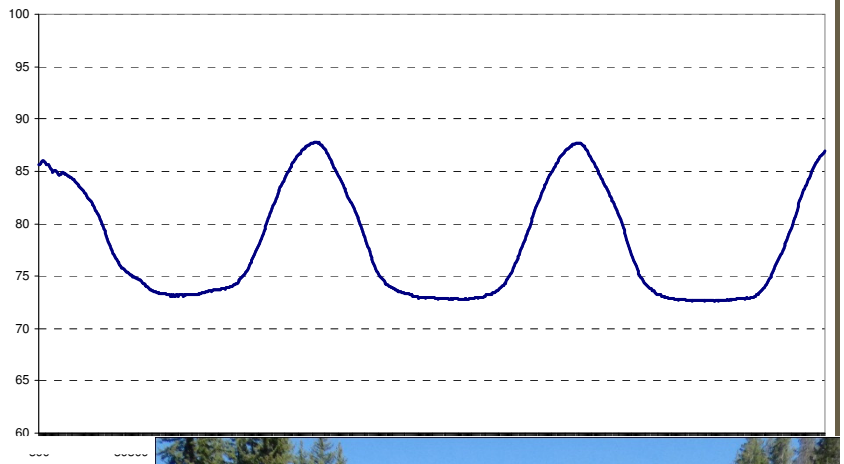


Whole Stream Metabolism

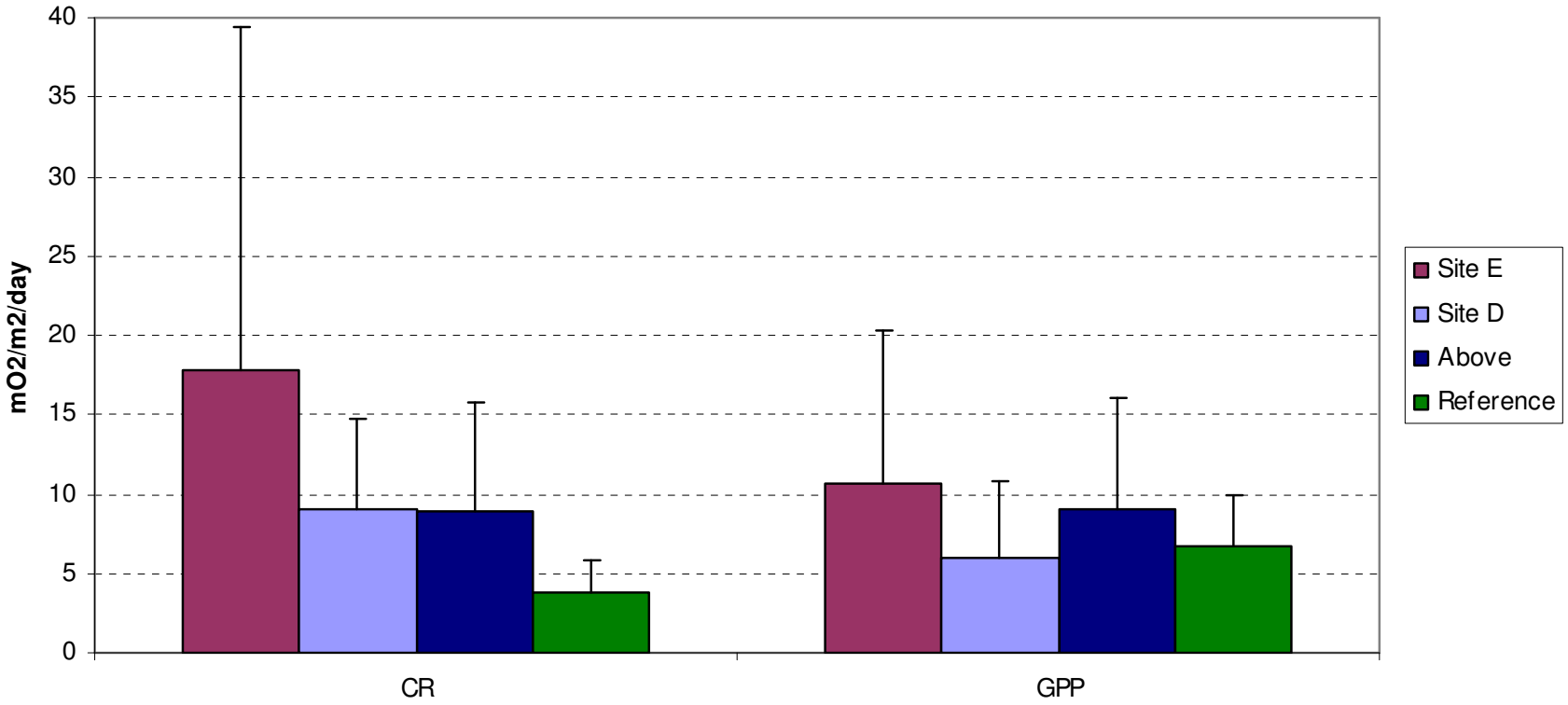
$\Delta DO = GPP - CR \pm E$

- Measures daily production & consumption of oxygen
- Promising initial results
- Continuing analysis on low productivity streams

Probes are now ~$1K!



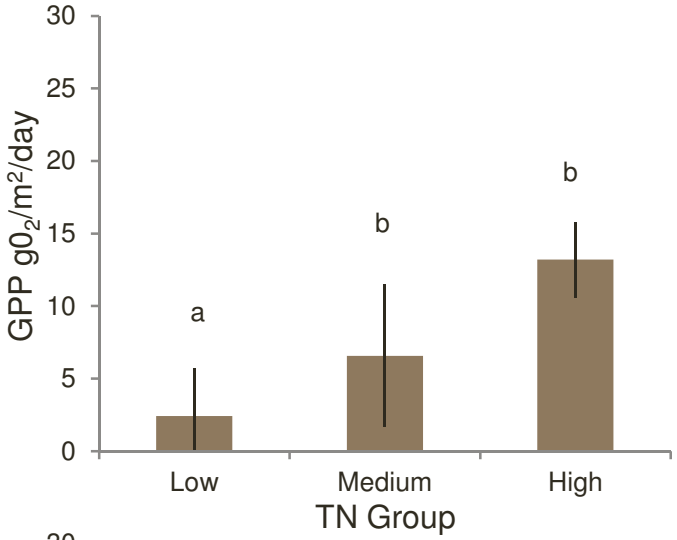
Stream Metabolism

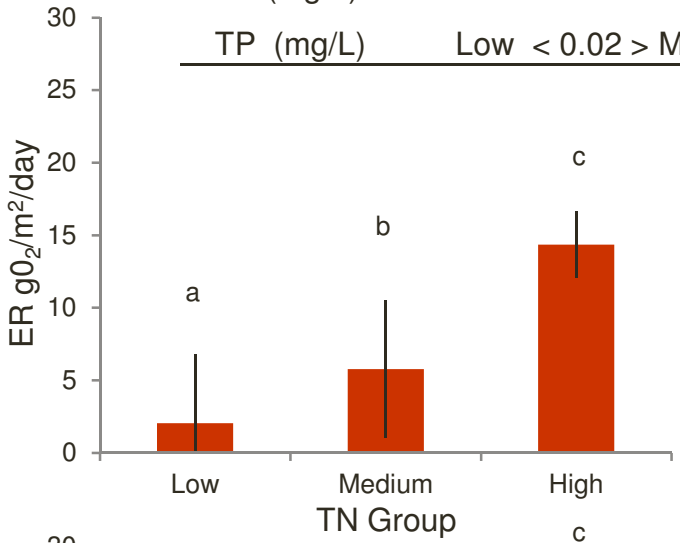


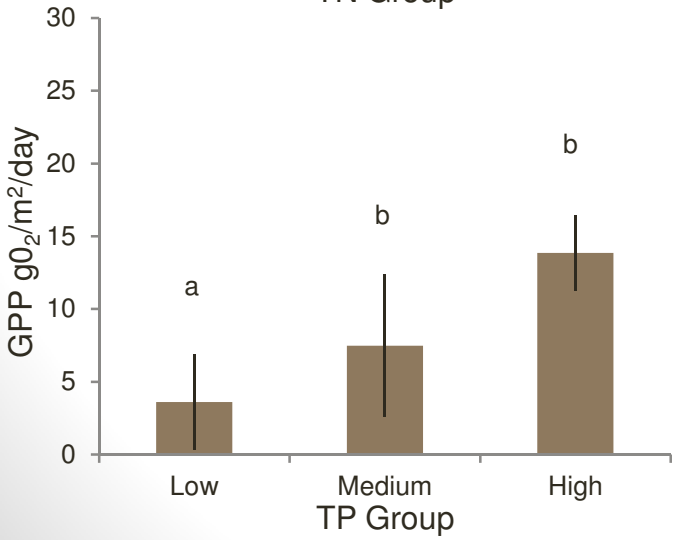
Take Home: Look for metabolism responses considerably downstream from point sources.

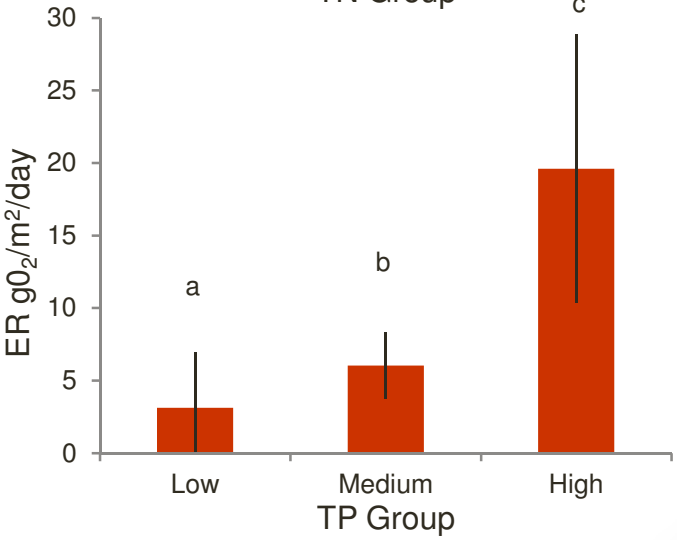
Relative Sensitivity of GPP and ER

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





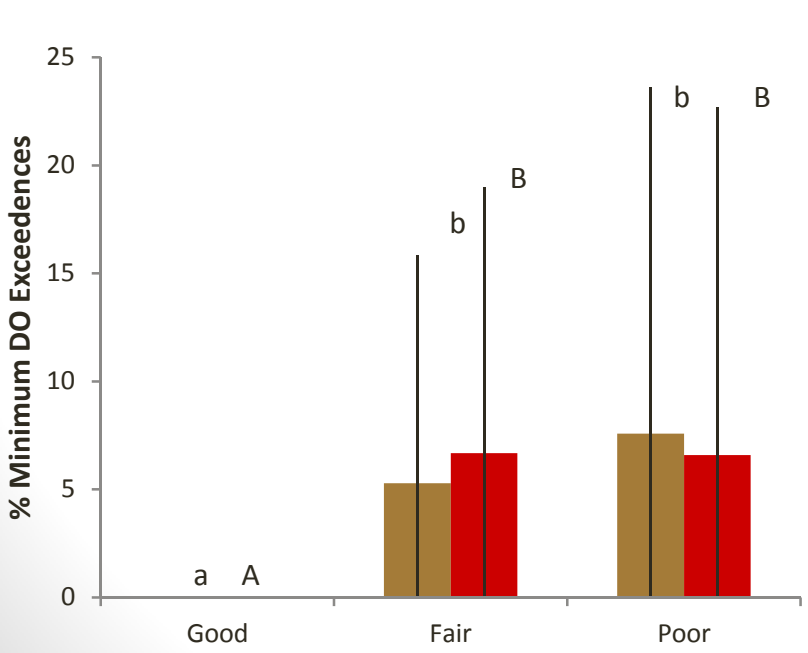


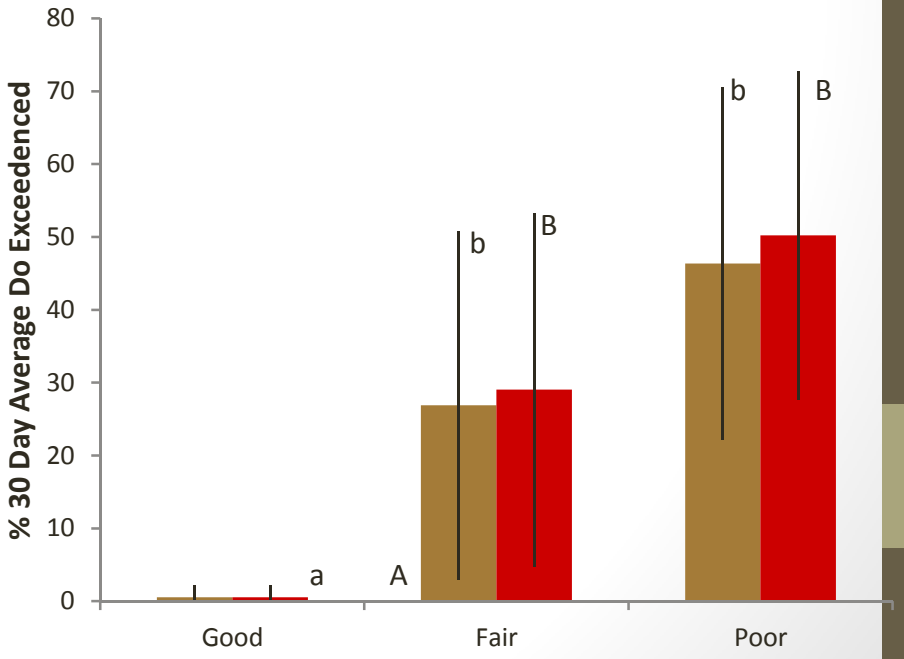


Relationship to DO Criteria

Functional Indicator	Indicator Group Thresholds
GPP ($gO_2/m^2/day$)	Good < 6.0 > Fair < 10.0 > Poor
ER ($gO_2/m^2/day$)	Good < 5.0 > Fair < 9.0 > Poor

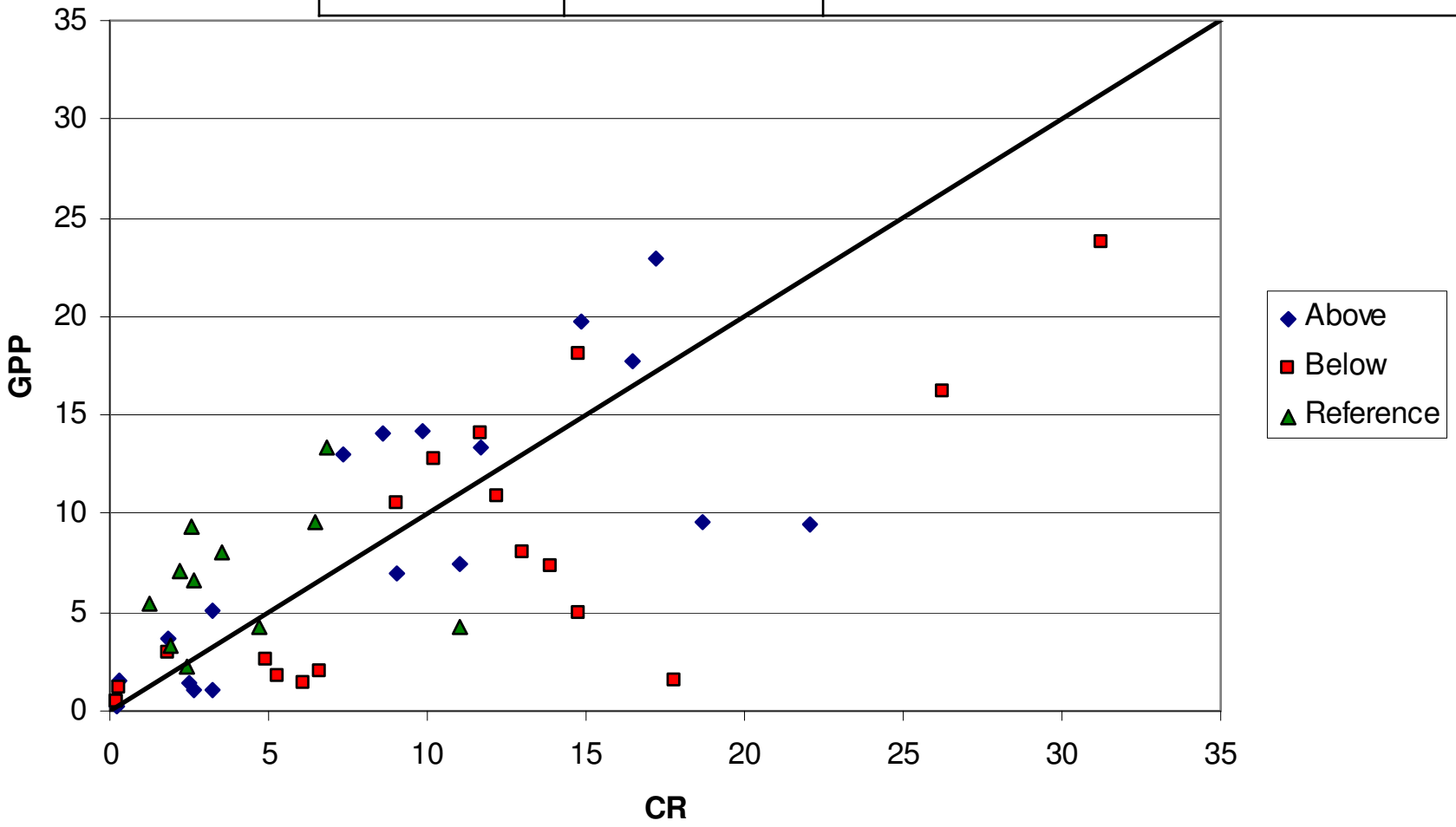
- Nutrients -> Metabolism -> Aquatic Life



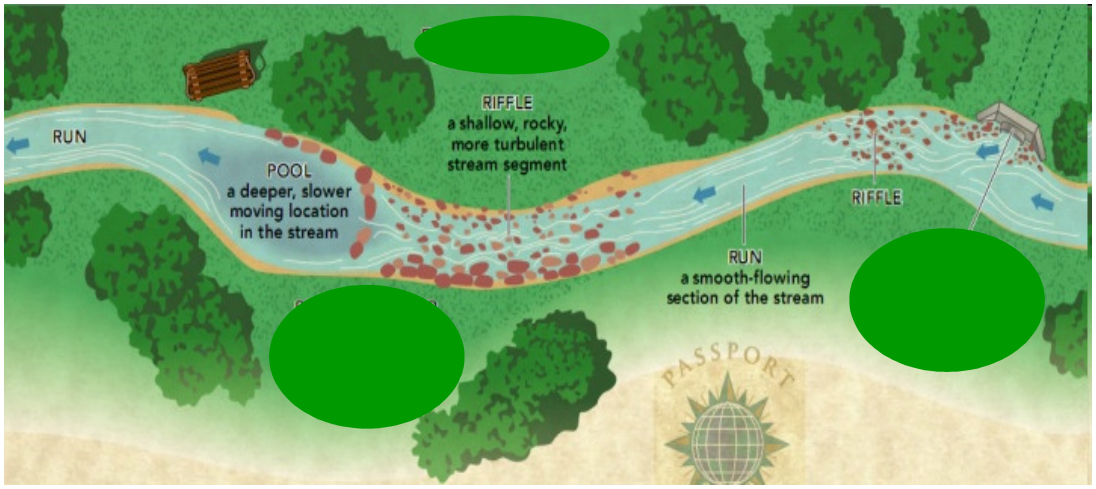


Caveats

Number of Stations		
	Completed	Bad Regression
Treatment	38	3
Reference	11	19

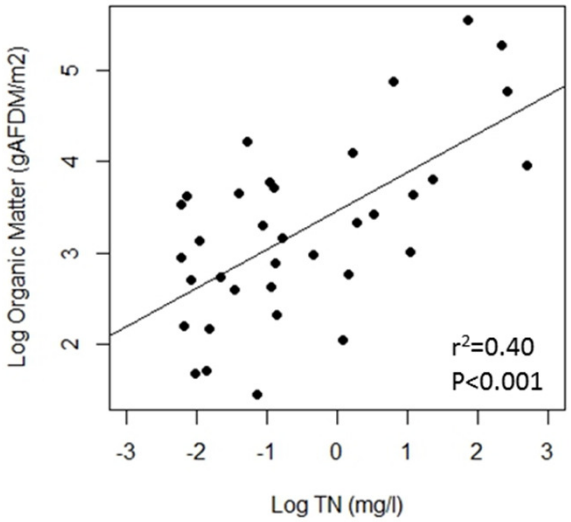


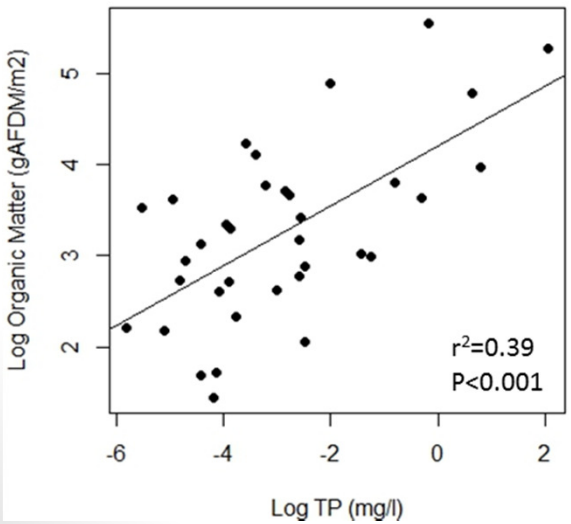
Organic Matter Standing Stocks



- Depending on the ecological response of interest, carbon may be as important, or more important than N or P.
- Consider DO: what is the covariate? C or N/P?

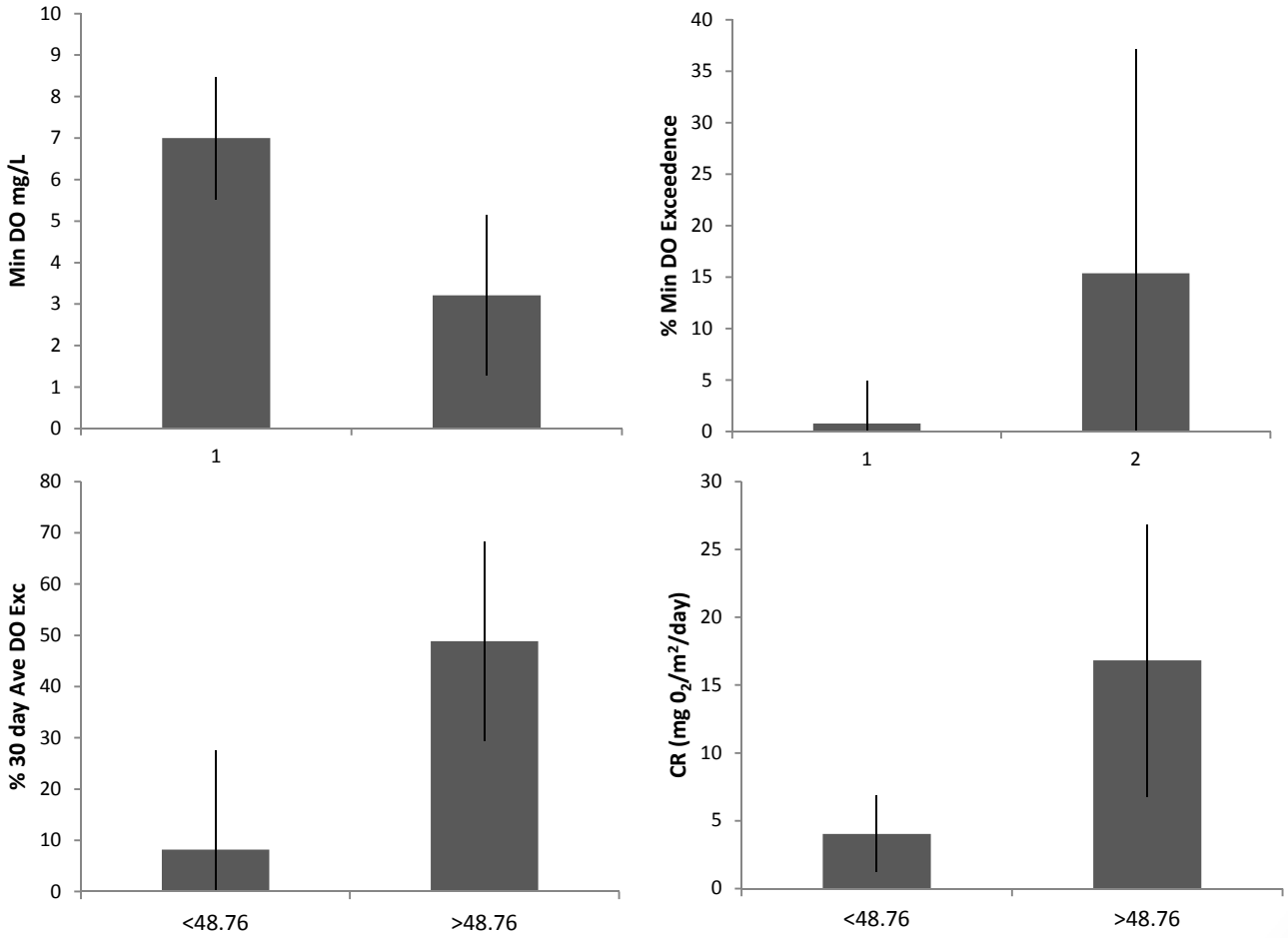
The Carbon Picture



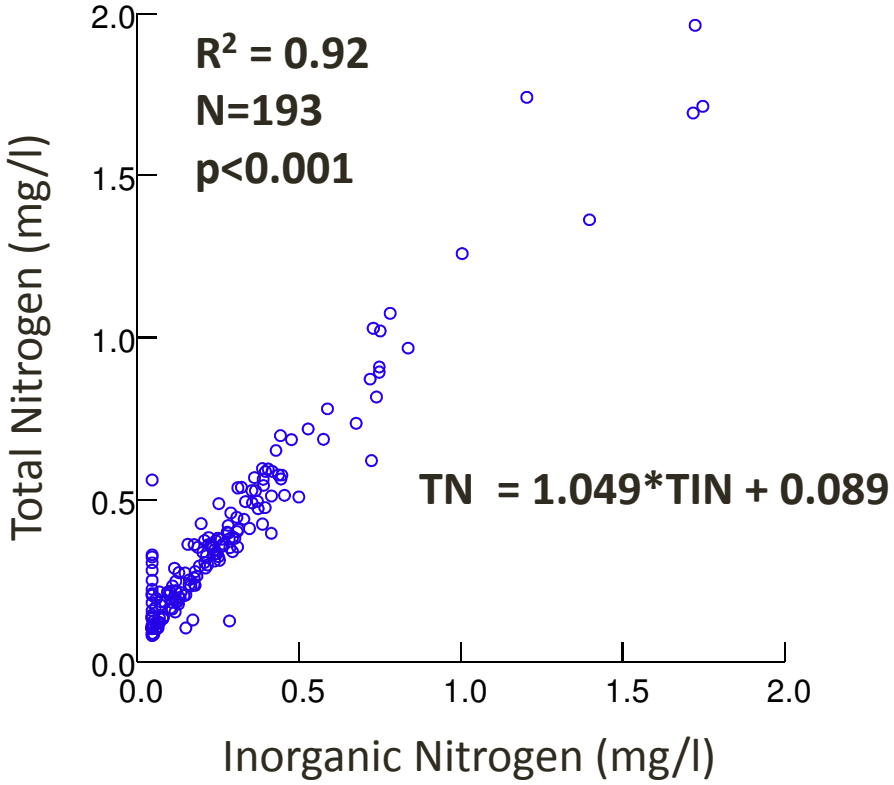


- Methods: Distinguish between autochthonous and allochthonous carbon standing stocks
- Focus on sources associated with GPP

OM Standing Stocks & DO Criteria



TN vs. TIN: Category 1 & 2 Waters



Among headwater stream, TIN varies predictably with TIN.