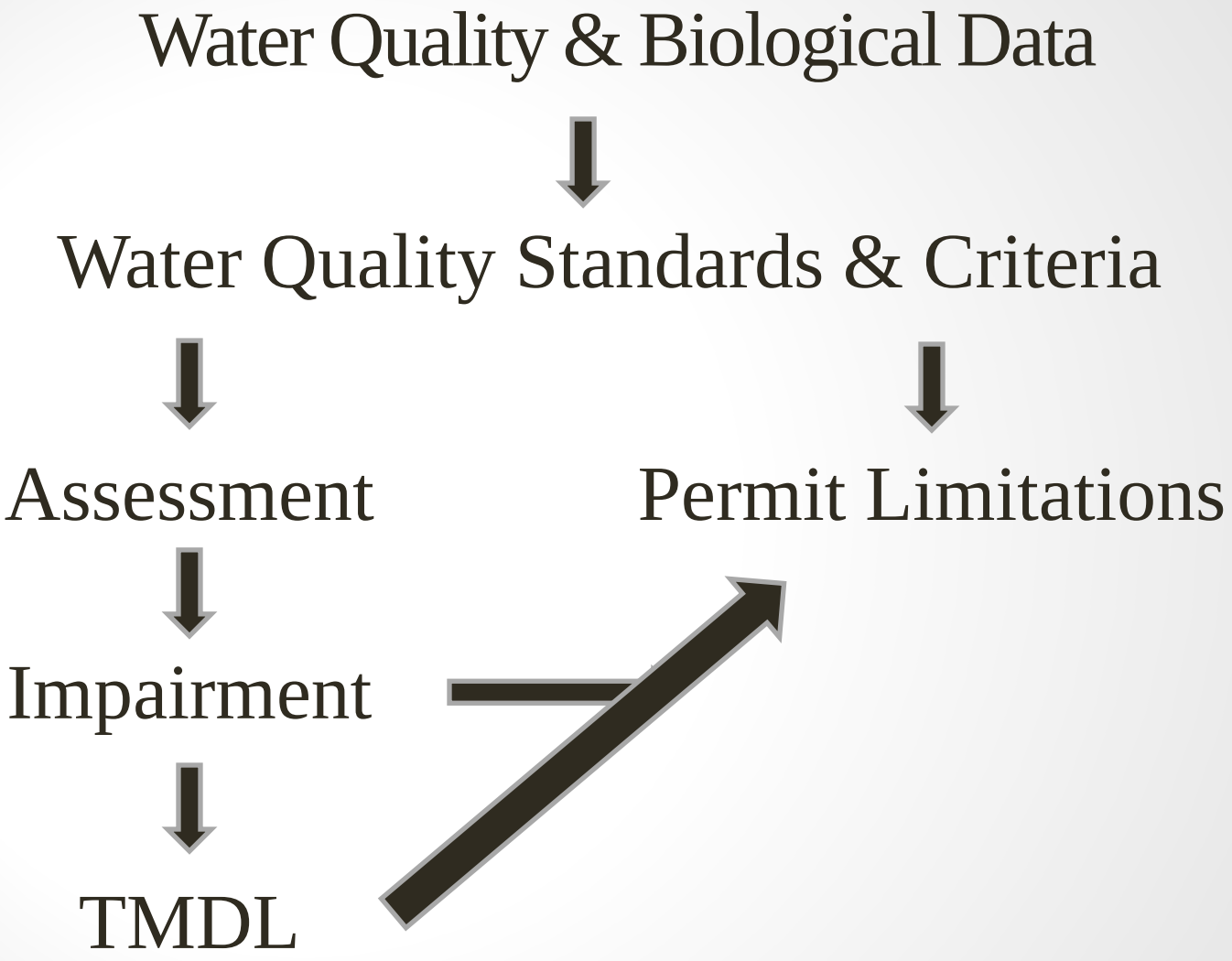
Nutrients

Water Quality Planning Branch
Water Division
Arkansas Department of Environmental Quality



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EPA Comments on ADEQ's Assessment Methodology

Illinois and Kings (Osage Creeks) were listed by EPA in 2002, but first appeared on EPA's 2004 list

2004 303(d) ROD

> EPA concluded "that Arkansas did not provide a reasonable rationale for not considering listing due to potential exceedances of narrative standards absent of approved implementation procedures."

2004 EPA Illinois River and Kings River Report "Parson's Report" Recommendations

- USEPA Region 6 and the Region 6 states should develop and make available more definitive assessment procedures and translators for assessing narrative criteria and aquatic life use attainment.
- A more thorough characterization of the daily and seasonal dissolved oxygen fluctuations, storm water sampling and phosphorus resuspension in each river basin would provide much needed data to understand the relationship between point source and nonpoint source loading.
- A clear need exists to develop unambiguous methods of assessing biotic and habitat conditions in these and similarly impacted stream systems in Arkansas and across USEPA Region 6.
- The most common and potentially dramatic stressor for these streams, sediment, was not explicitly considered in this assessment. Total suspended solids, sediment oxygen demand, and other sediment related parameters should be investigated throughout both river basins.
- Future monitoring in the watersheds should be considered to better account for the degree or intensity of the processes causing changes in stream substrate.
- The use of "minimally impacted" sites as acceptable reference sites used for investigations of this type should be evaluated and resolved between states and USEPA Region 6.
- USEPA Region 6 should work with the states to develop a consistent, quantitative methodology for a weight-of-evidence approach when using chemical, physical and biological data to determine beneficial use attainment status.

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2004 ADEQ updated Reg. 2.509 Nutrients

2005 ADEQ submitted the State of Arkansas Draft Nutrient Criteria Development Plan (NCDP) to EPA Region VI

2008 Arkansas's plan was mutually agreed upon

2008 USRPP initiated

2011 USRPP Completed

2011 NCDP Updated

2013 Ozark Highland ERW initiated

2013 EPA Guiding Principles on an Optional Approach for Developing and Implementing a Numeric Nutrient Criterion

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2010-2012 Draft 303(d) ROD

> C. Review of Arkansas's Submission
>
> > 3. Missing or Incomplete Assessment Methodology
> >
> > > b. Nutrients (Reg. 2.509): The state's Assessment Methodology did not include any information about how data are assessed and interpreted to determine attainment of the narrative criteria for Nutrients.

Assessment Methodology

Historic Assessment of Nutrient Narrative Criteria

2006-2008

Waters will be assessed as “non-support” when violation of any narrative water quality standard has been verified by ADEQ. Waters will be assessed as “non-support” if any associated numeric standard is violated pursuant to ADEQ’s assessment methodology.

2010-2012

Waters will be assessed as “non-support” when violation of any narrative water quality standard has been verified by ADEQ. This will be accomplished by use of reports documenting a water quality standards impairment caused by exceedance of a narrative criterion. The validity of the report must have been verified by an ADEQ Water Division Planning Branch employee. In addition, waters will be assessed as “non-support” if any associated numeric standard of a narrative criterion is violated pursuant to this assessment methodology.

2014

Ecoregion Screening Criteria

Nutrient Assessment Criteria (flowchart)

- Reg. 2.509 Nutrients

Materials stimulating algal growth shall not be present in concentrations sufficient to cause objectionable algal densities or other nuisance aquatic vegetation or otherwise impair any designated use of the waterbody. Impairment of a waterbody from excess nutrients is dependent on the natural waterbody characteristics such as stream flow, residence time, stream slope, substrate type, canopy, riparian vegetation, primary use of waterbody, season of the year and ecoregion water chemistry. Because nutrient water column concentrations do not always correlate directly with stream impairments, impairments will be assessed by a combination of factors such as water clarity, periphyton or phytoplankton production, dissolved oxygen values, dissolved oxygen saturation, diurnal dissolved oxygen fluctuations, pH values, aquatic-life community structure and possibly others. However, when excess nutrients result in an impairment, based upon Department assessment methodology, by any Arkansas established numeric water quality standard, the waterbody will be determined to be impaired by nutrients.

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2014 Assessment Methodology

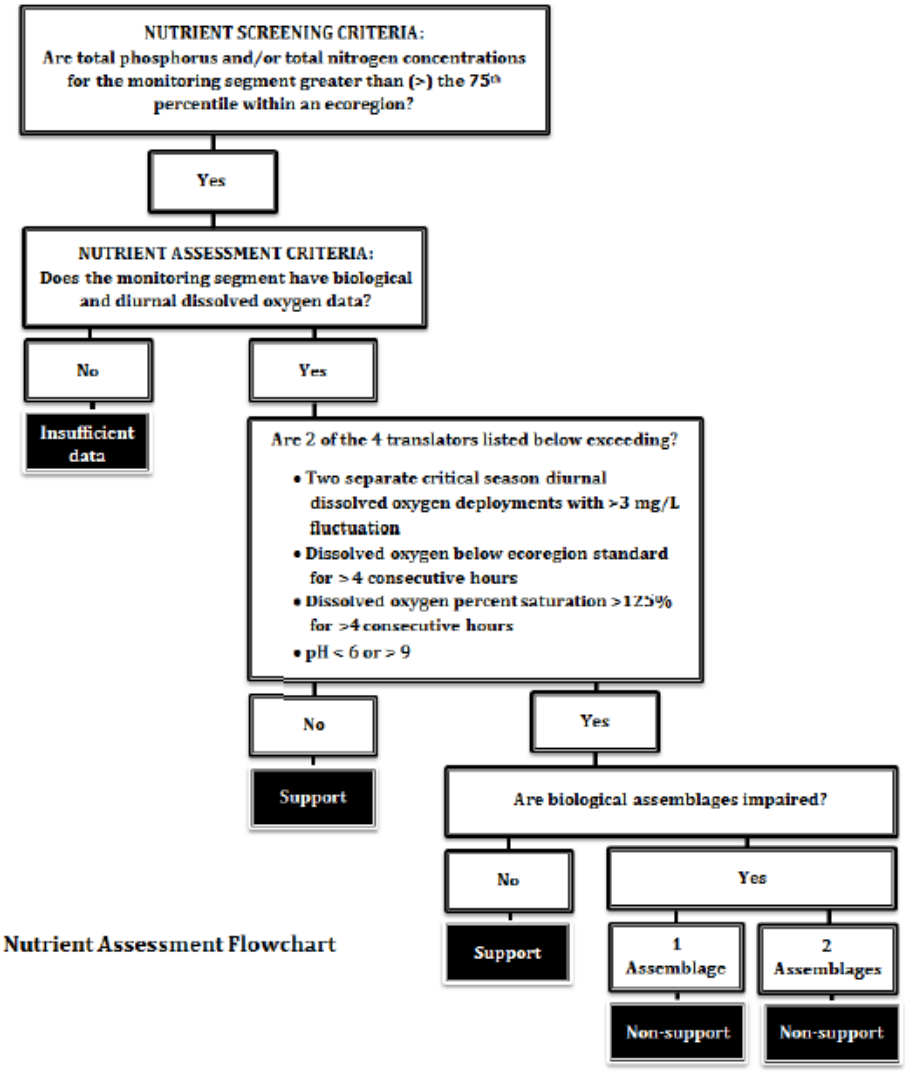
ASSESSMENT METHODOLOGY FOR NUTRIENTS

LISTING METHODOLOGY:

Monitoring segments will be listed as non-support for total phosphorus or total nitrogen if two (2) of the four (4) water quality translators are exceeded and one (1) or both biological assemblages are impaired. Water quality translators for total phosphorus and total nitrogen are two (2) separate critical season diurnal dissolved oxygen deployments (May-September) which indicate a greater than three (>3) mg/L fluctuation in concentration, dissolved oxygen saturation is >125% for four (4) consecutive hours, dissolved oxygen concentrations are below ecoregion standard for greater than four (4) consecutive hours, or pH varies from the standard of between 6.0 and 9.0 standard units. Monitoring segments that are greater than the 75th percentile for total phosphorus and total nitrogen concentrations within each ecoregion will serve as the screening criteria.

DELISTING METHODOLOGY:

Monitoring segments will be listed as support for nutrients if there are fewer than two (<2) exceedances of nutrient translators and biological assemblages are fully supported.

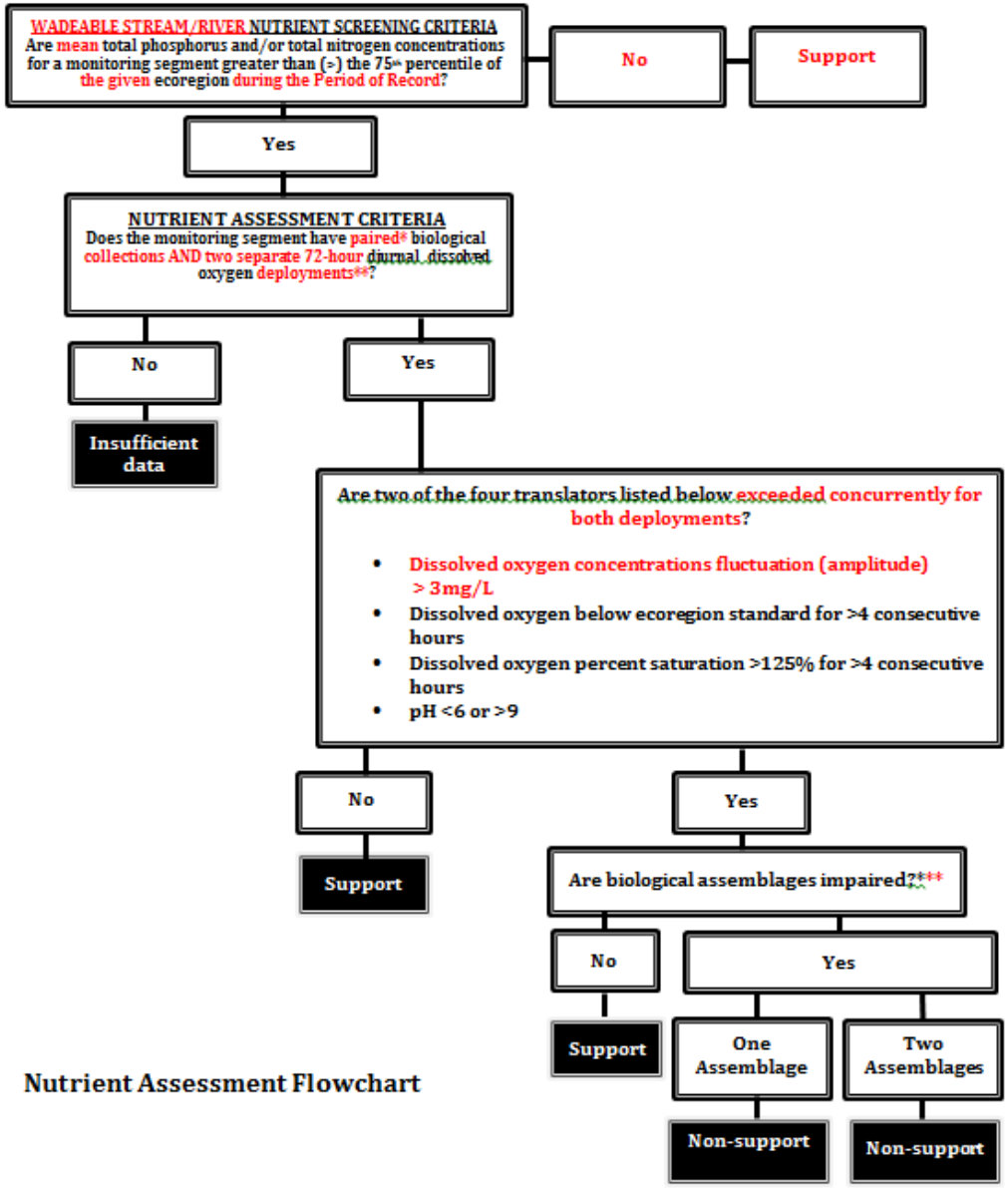


Nutrient Assessment Flowchart

[1]Section 5.1 discusses the determining factors for biological impairment.

2016-18 Assessment Methodology

- Clarification of text
- Addition and/or refinement of translators
  - Periphyton
    - Benthic chlorophyll *a*
    - Biomass



Nutrient Assessment Flowchart

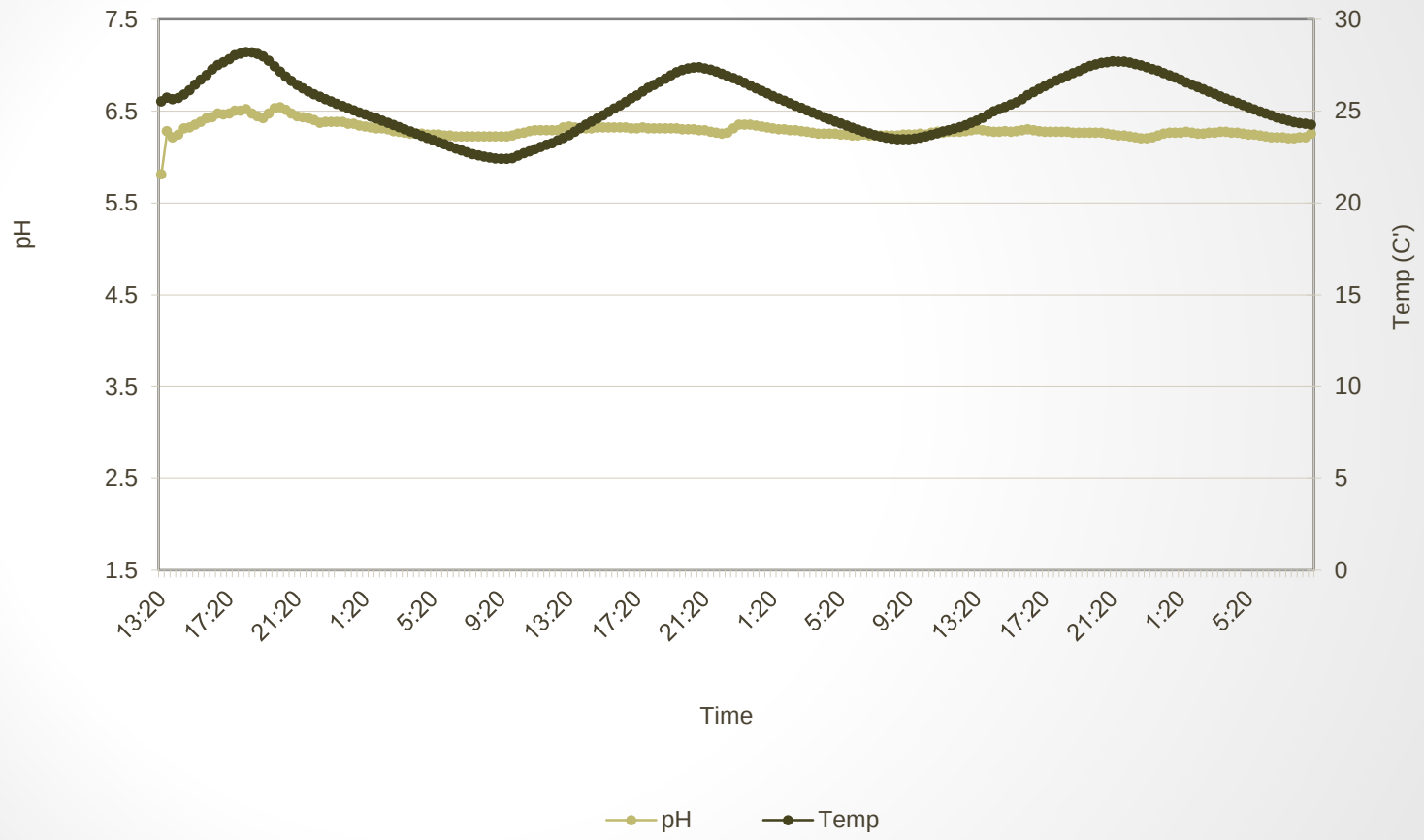
*Paired data/collections are defined as combined physical, chemical, and biological collections within the same calendar year and/or season.

**72-hour diurnal dissolved oxygen deployments must occur during the same critical season (water temperature is >22ºC)

***Section 5.1 discusses the determining factors for biological impairment.

Nutrient Translators

- Previously accepted by EPA
  - EPA utilized same translators for the 2004 Illinois River Parson's Report
  - Nutrient Criteria Development Plan
  - Upper Saline River Pilot Study
  - Currently utilized in the Ozark, Boston, and Ouachita ERW Projects
- Dissolved oxygen and pH are protecting Aquatic Life designated use


7.5
6.5
5.5
4.5
3.5
2.5
1.5
pH
30
25
20
15
10
5
0
Temp (C')
13:20
17:20
21:20
1:20
5:20
9:20
13:20
17:20
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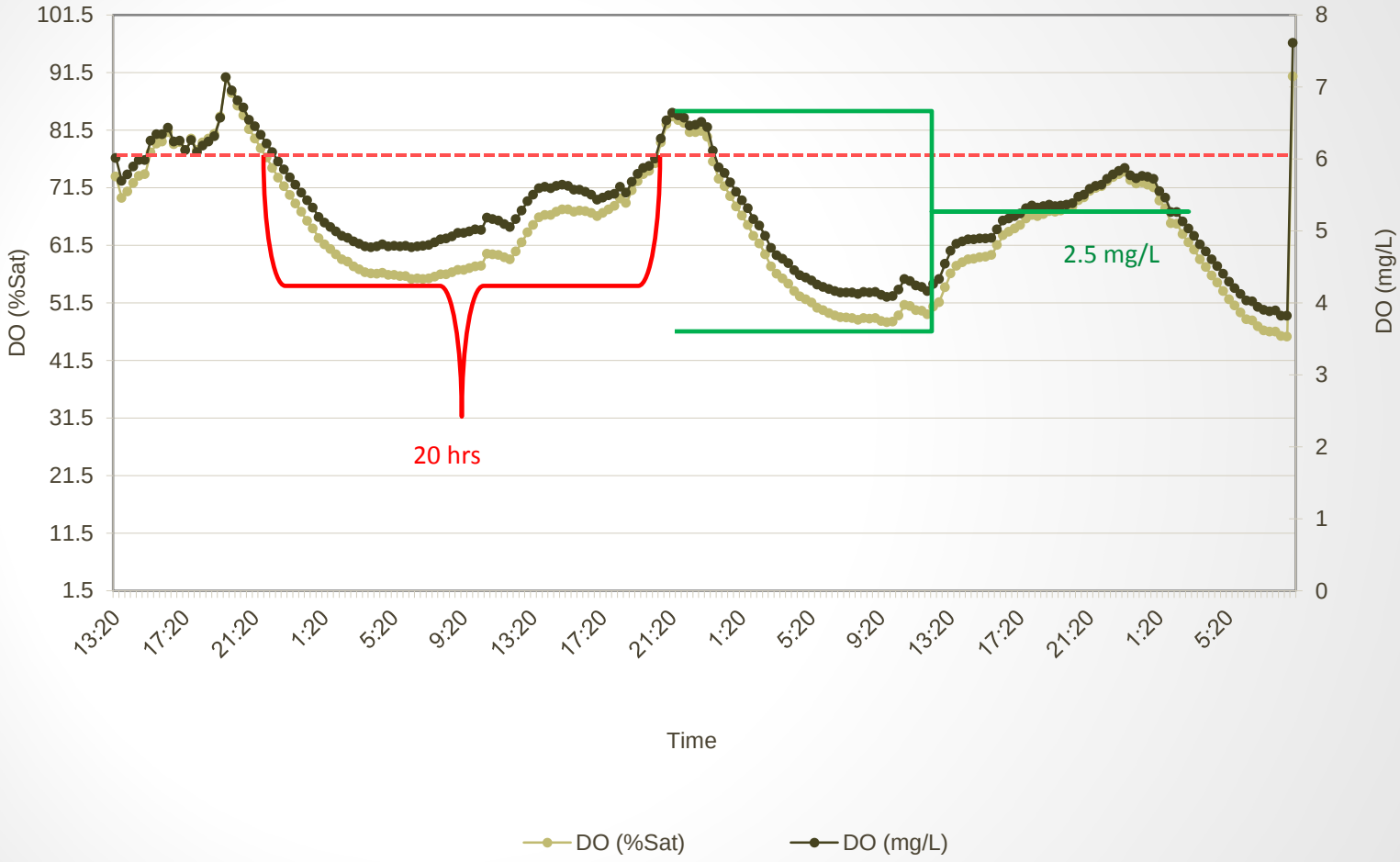
17:20
21:20
1:20
5:20
Time
pH
Temp



Biological Impairment

- Reg. 2.302(F) Aquatic Life and Reg. 2.405 Biological Integrity

The aquatic life designated use is evaluated based on the biological integrity (macroinvertebrate and/or fish communities) of the waterbody, where biological data exist to make an assessment. At a minimum, biological and chemical/physical data must have been collected over two seasons (preferably a minimum of two years) using methods outlined in a Quality Assurance Project Plan with requirements equal to or more stringent than that of ADEQ or USGS (See Section 3.4 Biological Integrity Data for additional information on data requirements). Results from acute and chronic toxicity tests of vertebrates and invertebrates will also be evaluated, when available, but are not required to make a use determination.

Biological Impairment

LISTING METHODOLOGY:
Stream and river monitoring segments will be listed as non-support when one or both of the evaluated biological communities (macroinvertebrates and/or fish) indicate perturbation/degradation, or when one or both of the toxicological test organisms (vertebrate and/or invertebrate) fail more than one acute or chronic toxicity test in a three year period.

DELISTING METHODOLOGY:
Stream and river monitoring segments will be listed as support when evaluated biological communities (macroinvertebrates and/or fish) do not indicate perturbation/degradation, and when there have been no acute or chronic toxicity test failures in a three year period.

Biological Impairment

Table IX. Biological Assemblage Assessment Determination

Data Type	Support	Non-Support
Macroinvertebrate Community Data Available	Macroinvertebrate community structure analysis indicates comparable to reference or supporting	**Macroinvertebrate community structure analysis indicates partially supporting or non-supporting***
Fish Community Data Available	Community Structure Index score is either mostly or generally similar; general presence of sensitive and indicator species	**Community Structure Index score is either somewhat or not similar; absence of sensitive and indicator species***

Biological Impairment

Table VII. Macroinvertebrate Community Structure Analysis

Attainment Status	% Comparable Estimate	Attribute
Comparable to reference	≥90%	Expected to support the community structure present at the reference site
Supporting	75-88%	Should support a diverse community similar to the reference site
Partially Supporting	60-73%	Difference in the biological community may be due to the poor habitat. Comparisons may be difficult
Non-supporting	<58%	Should not be expected to support the community present at the reference site

Biological Impairment

Table VIII. Fish Community Structure Index Ecoregion Values

Ecoregion	Total Score	Category	Attribute
Ozark Highlands **Boston Mountains** **Ouachita Mountains** **AR River Valley** **Typical Gulf Coastal** **Spring-Influenced** **Gulf Coastal**	25-32	Mostly Similar	Comparable to the best situation to be expected. Balanced trophic structure and optimum community structure present.
	24-17	Generally Similar	Community structure less than expected. Taxa richness lower than expected. Some intolerant taxa loss. Percent contribution of tolerant forms may increase.
	16-9	Somewhat Similar	Obvious decline in taxa richness due to the loss of tolerant forms. Loss of Key and Indicator taxa.
	0-8	Not Similar	Few taxa present and normally dominated by one (1) or two (2) taxa.
Channel Altered Delta **Least-Disturbed Delta**	22-28	Mostly Similar	Comparable to the best situation to be expected. Balanced trophic structure and optimum community structure present.
	21-15	Generally Similar	Community structure less than expected. Taxa richness lower than expected. Some intolerant taxa loss. Percent contribution of tolerant forms may increase.
	14-8	Somewhat Similar	Obvious decline in taxa richness due to the loss of tolerant forms. Loss of Key and Indicator taxa.
	0-8	Not Similar	Few taxa present and normally dominated by one (1) or two (2) taxa.

Impairments

- 75th %tile Screening Criteria

	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
Ozark Highlands	0.10	2.56
Ouachita Mountains	0.05	0.54
Boston Mountains	0.05	0.45
Arkansas River Valley	0.12	1.13
Gulf Coastal Plains	0.27	1.37
Mississippi Alluvial Valley	0.12	1.12

Impairments

- The 2014 AM resulted in no new impairments for total phosphorus or total nitrogen
- However, many streams exceeded screening criteria, but lacked sufficient data (Category 3 Insufficient Data).

	Total Phosphorus	Total Nitrogen
Ozark Highlands	19%	21%
Ouachita Mountains	33%	21%
Boston Mountains	18%	15%
Arkansas River Valley	21%	20%
Gulf Coastal Plains	28%	28%
Mississippi Alluvial Valley	35%	40%

If impaired for nutrients, will I get a new limit?

- Numerical vs. Narrative

Reg. 2.509 Nutrients

- All point source discharges into the watershed of waters officially listed on Arkansas' impaired waterbody list (303d) with phosphorus as the major cause shall have monthly average discharge permit limits no greater than those listed below.

Facility Design Flow – mgd	Total Phosphorus discharge limit – mg/L
= or > 15	Case by case
3 to <15	1.0
1 to <3	2.0
0.5 to <1.0	5.0
<0.5	Case by Case

- For discharges from point sources which are greater than 15 mgd, reduction of phosphorus below 1 mg/L may be required based on the magnitude of the phosphorus load (mass) and the type of downstream waterbodies (e.g., reservoirs, Extraordinary Resource Waters). Additionally, any discharge limits listed above may be further reduced if it is determined that these values are causing impairments to special waters such as domestic water supplies, lakes or reservoirs or Extraordinary Resource Waters.

If impaired for nutrients, will I get a new limit?

- Numerical vs. Narrative
- Municipality vs. Industry
  - Background Flow, Background Concentration
- New vs. Existing
  - New – limit effective with issuance of permit
  - Existing – 3 year schedule of compliance
- Nutrient Surplus Area
- TMDL

Summary

- Stringent effluent limits may provide only incremental water quality benefits
  - But may result in permit compliance issues
- Advanced treatment increases
  - Capital and O&M Costs
  - Energy use
  - Chemical use
  - Atmospheric emissions

Summary

- Nutrient management is critical in many waterbodies
- Appropriate nutrient effluent limits should be based on:
  - Protection of aquatic life and designated uses
  - Realistic capabilities of treatment technologies
  - Balanced consideration of sustainability

Questions

Nutrient Criteria Development

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EPA Guidance for Criteria Development

2000 EPA Nutrient Criteria Technical Guidance Manual: Rivers and Streams

Approach 1

Use reference stream conditions

-Assumes a large portion of streams are impaired

Approach 2

Predictive models and biocriteria

-Difficult to replicate across ecoregions

Approach 3

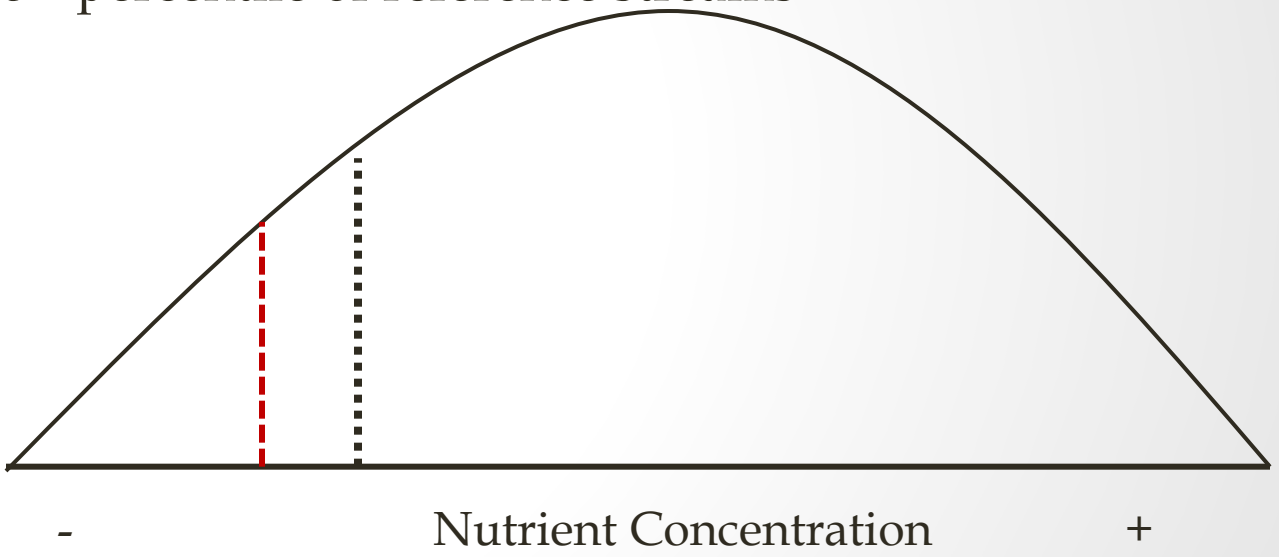
Established nutrient thresholds and stressor-response relationships

- Most protective of aquatic life
- Most data intensive

EPA Guidance for Criteria Development

Approach 1

- Set criteria at 25th percentile of all data OR
  75th percentile of reference streams



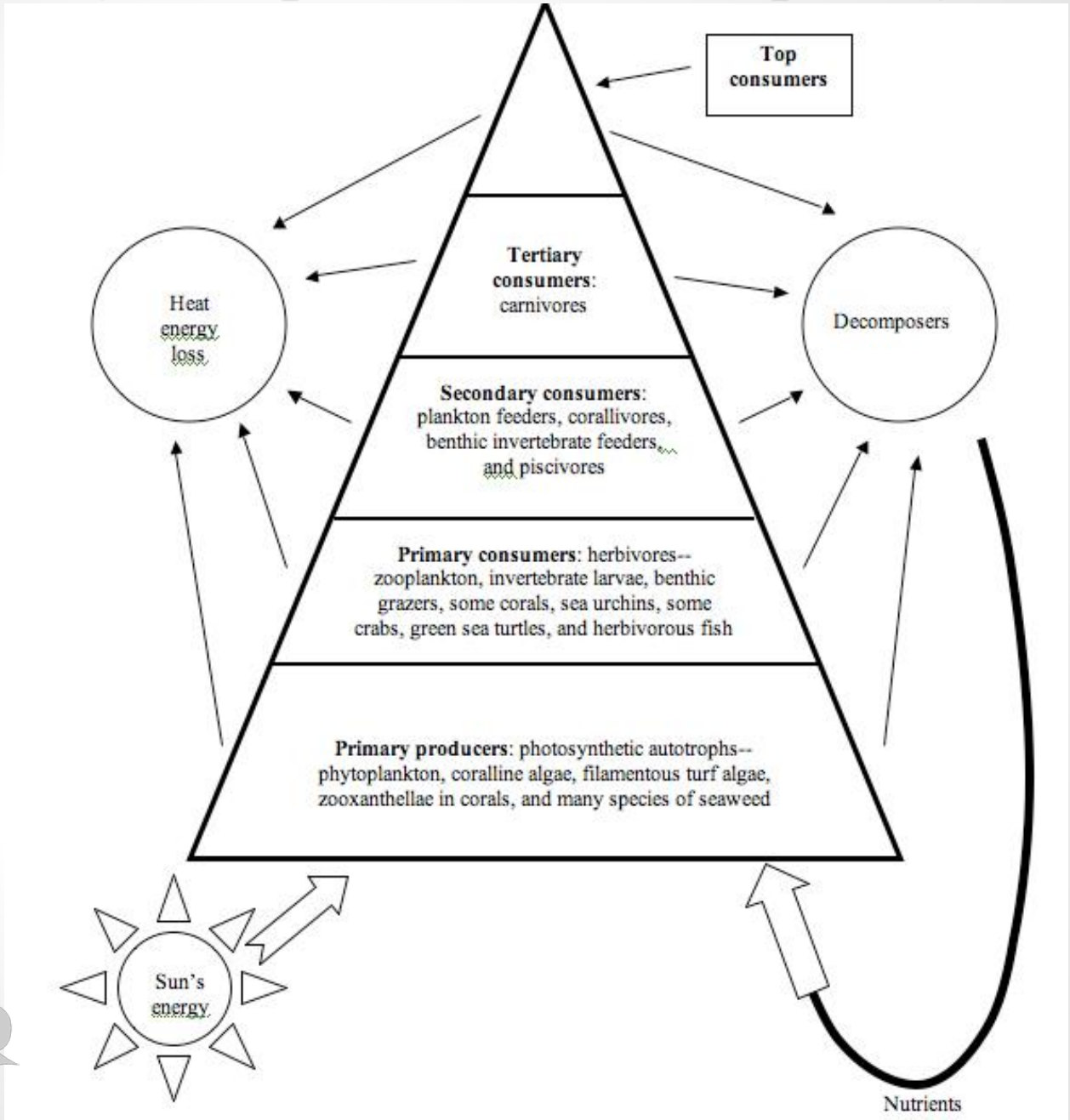
- More involved, based on reference conditions
- Difficult to define least-disturbed conditions, thus use <25th percentile as least-disturbed

EPA Guidance for Criteria Development

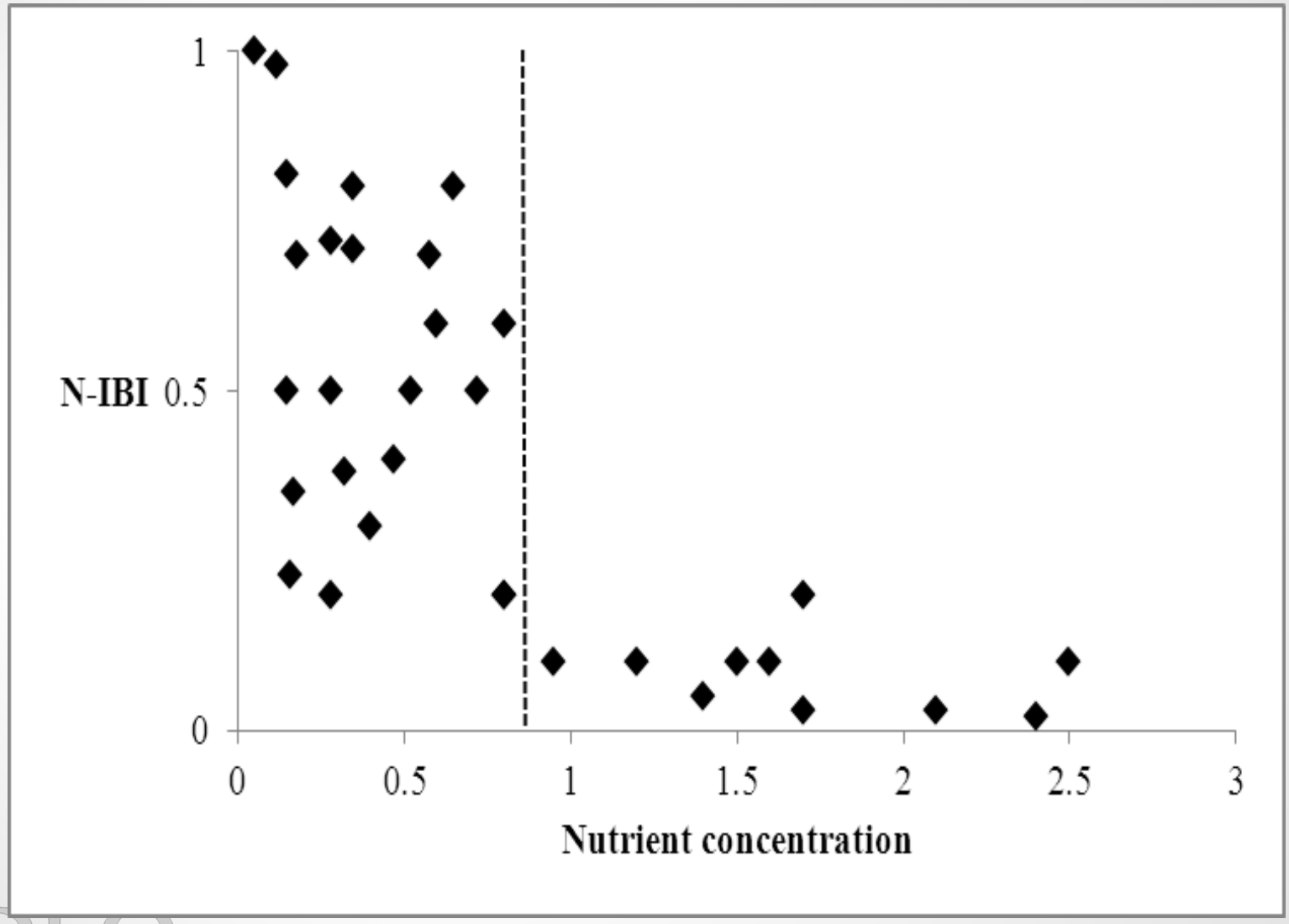
Approach 2 (Development of Biocriteria)

- Based on the assumption that as nutrient concentrations increase, certain biological assemblages will be negatively impacted
  - Develop Nutrient Index of Biotic Integrity (N-IBI)
    - Allow ADEQ scientists to identify any potential relationships between nutrient concentrations and biotic assemblages
      - If relationships exists, ADEQ scientists will then attempt to determine at what point biotic assemblages are negatively impacted (thresholds)
        - These thresholds can be used to set numeric criteria along with values from Approach 1

Approach 3 (Concept of Stressor-Response)



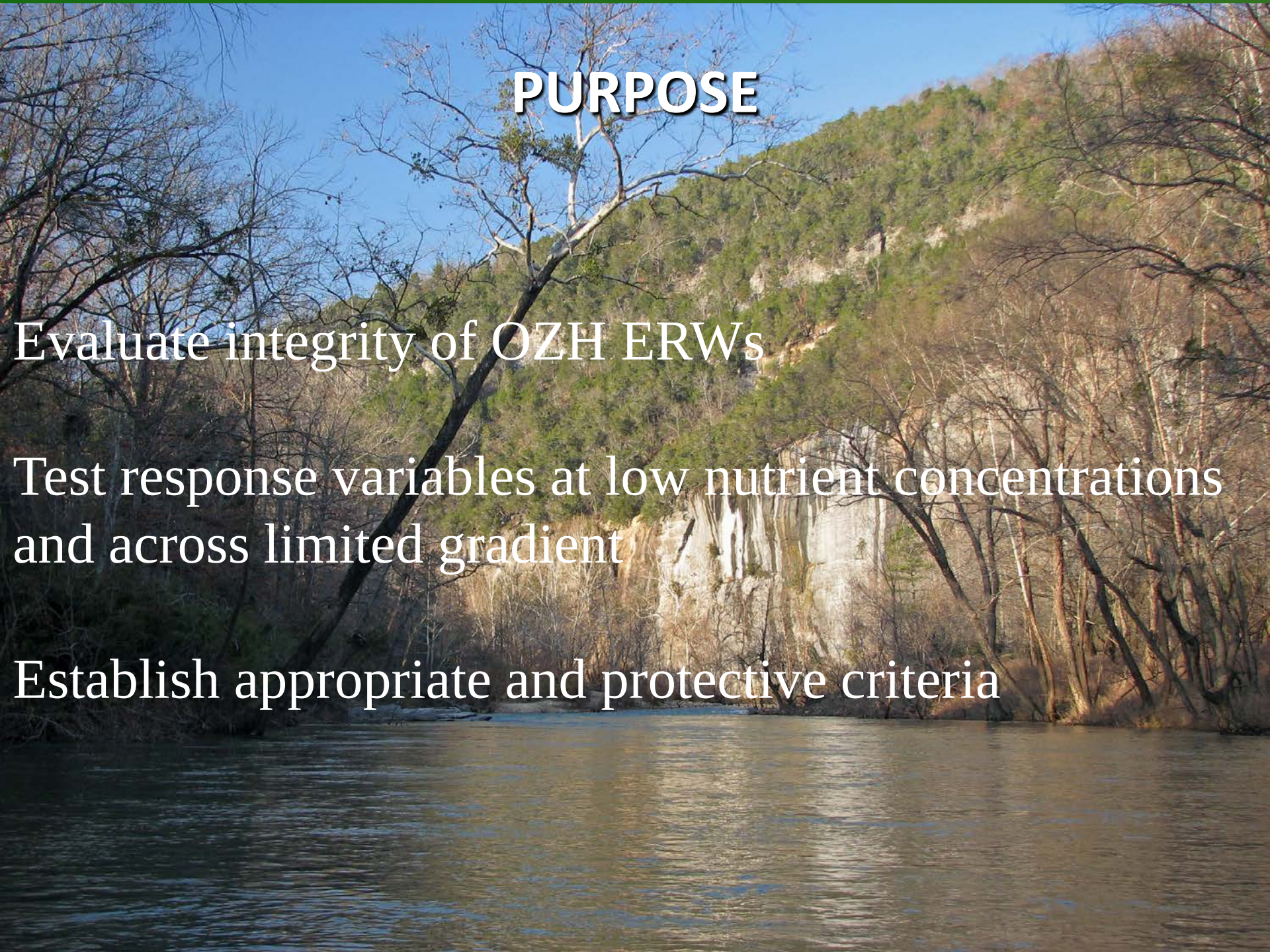
Approach 3 (Hypothetical Stressor-Response)



Nutrient Criteria Development

- Lakes/Reservoirs
  - Pilot Project – Beaver Lake (Type A)
    - Growing season geometric mean chlorophyll a
      - 8 ug/L
      - Secchi depth 1.1m
  - Type B, C, and D Lakes
- Rivers/Streams
  - Pilot Project – Upper Saline River Watershed
  - Ozark Highland ERW
  - Boston Mountain ERW
  - Ouachita Mountain ERW

Development of Nutrient Criteria for Extraordinary Resource Waterbodies (ERWs) in the Ozark Highlands



PURPOSE

Evaluate integrity of OZH ERWs

Test response variables at low nutrient concentrations and across limited gradient

Establish appropriate and protective criteria

Methodology

- Compile and analyze historic water quality data
  - Fourteen (14) Ozark Highland ERWs
    - Five (5) no water quality or biological data
    - One (1) reservoir
    - Watershed sizes range from 6.52 to 2611 mi^2
      - Wadeable ERW Streams (10)
        - 6.52-540mi^2

Methodology

Water Quality Assessments

A minimum of twelve collections made over two years

- In-situ parameters
- Water chemistry
- Diurnal dissolved oxygen assessments
  - Deploy continuous read meters twice during critical season
    - pH
    - Temperature
    - Conductivity

Physical Habitat Assessment

(Two-Tiered Approach)

Tier One: Quantitative Assessment of:

Bank Stability, riparian corridor, channel morphology, embeddedness, substrate size class, in-channel cover, canopy cover, depth profiles, discharge

Tier Two: Qualitative Assessment following Barbour et al. 1999

Periphyton Assemblage Assessment

Quantitative Assessments of Periphyton

Spring (primary season) and Summer (critical season)

Biomass (Ash Free Dry Mass AFDM)

Chlorophyll a

Data Analysis

Descriptive Statistics (SigmaStat)

Spearman Correlation (SigmaStat)

Physical	Chemical	Biological
Canopy Cover	Total Phosphorus	Benthic Chlorophyll a
Pebble Size D25	Total Nitrogen	Periphyton Biomass
Pebble Size D50	Total Kjeldahl Nitrogen	
Discharge	Nitrite-Nitrate Nitrogen	
Riffle Surface Area	Turbidity	
Watershed Size	TN:TP	
Percent Forest		
Percent Urban		
Percent Pasture		

Approach 1

	Ozark Highlands				
	5th	25th	50th	75th	EPA 2001
Total Nitrogen (mg/L)	0.32	0.67	1.3	2.56	0.31
Total Phosphorus (mg/L)	0.02	0.03	0.05	0.10	0.01

2008-2013, n=2611

	Ozark ERWs				
	5th	25th	50th	75th	EPA 2001
Total Nitrogen (mg/L)	0.21	0.39	0.68	1.16	0.31
Total Phosphorus (mg/L)	0.02	0.03	0.04	0.05	0.01

2012-2013, n=217

Approach 3

Water Quality Assessments
One-time Spring Collection
n=16

	Min	Max	Median
Total Phosphorus (mg/L)	0.01	0.041	0.03
Total Nitrogen (mg/L)	0.13	2.06	0.76
Total Kjeldahl Nitrogen (mg/L)	0.08	1.32	0.22
Nitrate-Nitrite Nitrogen (mg/L)	0.04	1.86	0.47
Total Nitrogen : Total Phosphorus	31:4	206:3	29:1
Periphyton Biomass (mg/cm^2)	0.52	5.85	2.58
Benthic Chlorophyll a ($\mu g/cm^2$)	2.81	63.4	14.3

Spring Habitat Assessment

	Min	Max	Median
Canopy Cover (% Open)	43	98	76
Pebble Size D25 (mm)	12	58	28
Pebble Size D50 (mm)	24	2048	47.5
Discharge (m^3/s)	0.06	29.7	1.7
Riffle Surface Area(m^2)	60.9	1830.1	417.8
Percent Forest	55.7	98.2	68.4
Percent Urban	0	6.2	4.0
Percent Pasture	1.3	40.4	26.8
Turbidity (NTU)	0.6	6.7	3.2
Watershed Size (mi^2)	6.5	540	108.1

Spearman Correlation

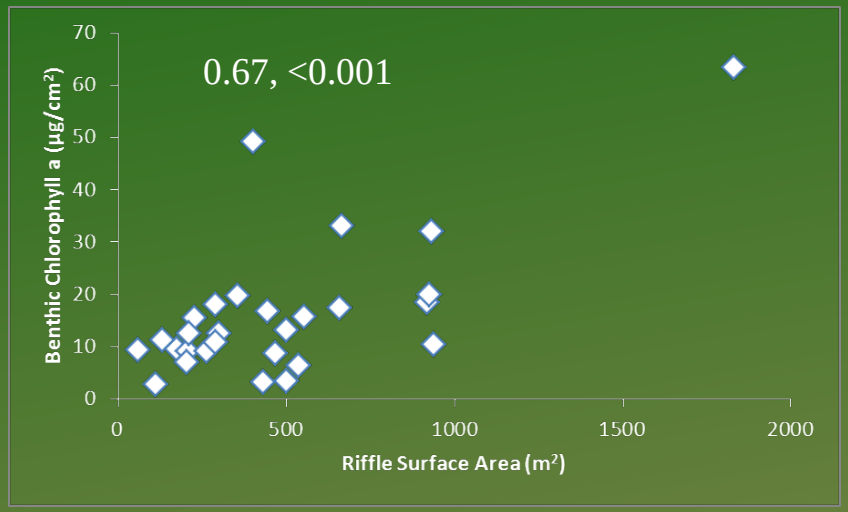
Physical
Canopy Cover
Pebble Size D25
Pebble Size D50
Discharge
Riffle Surface Area
Watershed Size
Percent Forest
Percent Urban
Percent Pasture
Turbidity
RBP Score

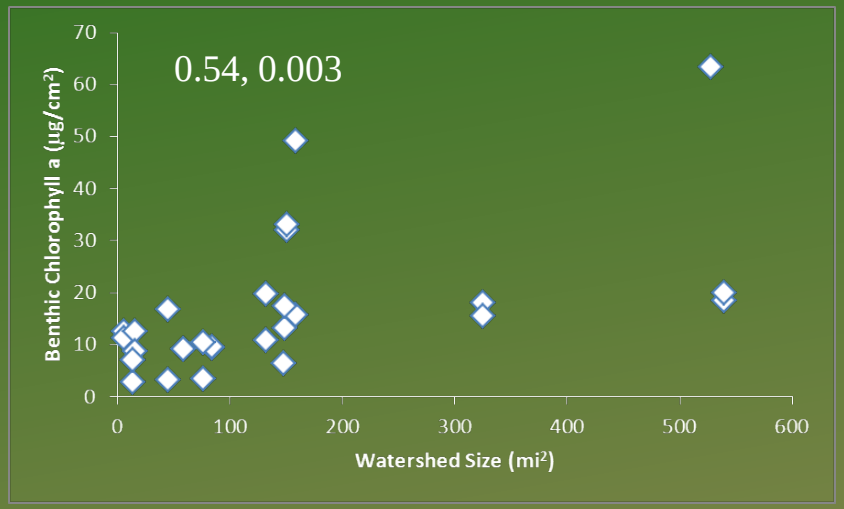
Chemical
Total Phosphorus
Total Nitrogen
Nitrite-Nitrate Nitrogen
TN:TP
Total Kjeldahl Nitrogen

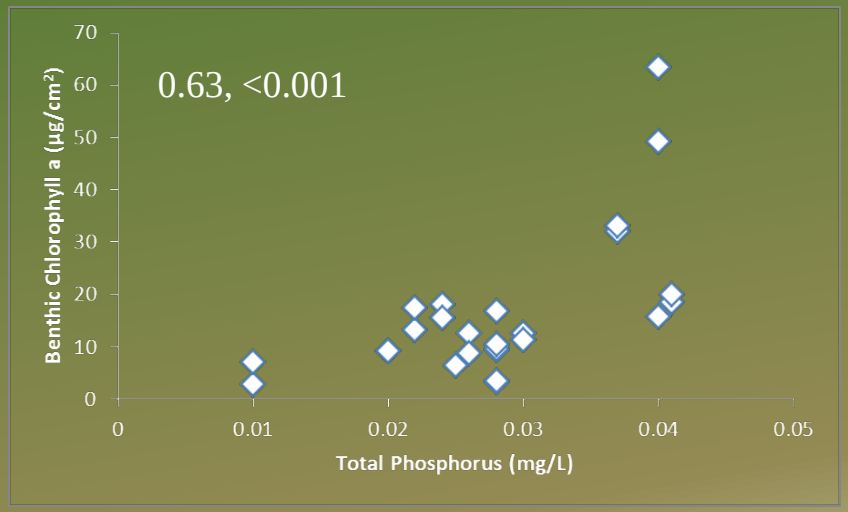
Biological
Benthic Chlorophyll a
Periphyton Biomass

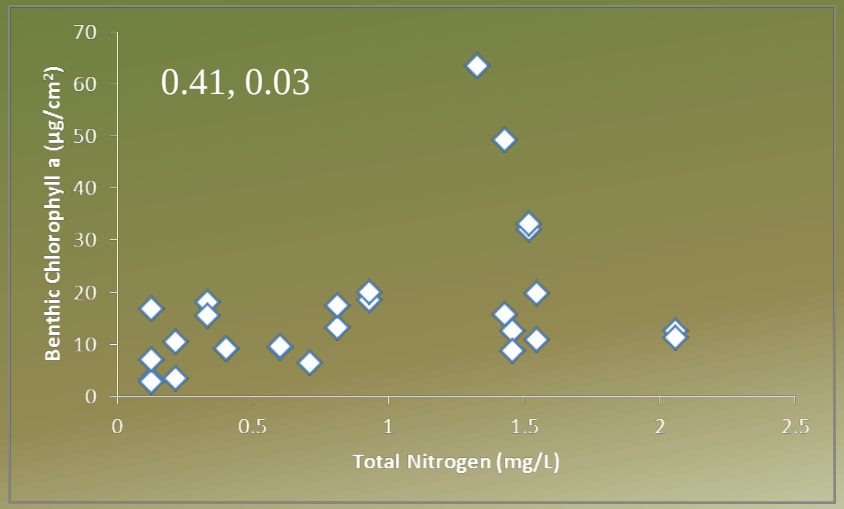
rho=0.50, p-value<0.05

Spearman Correlation

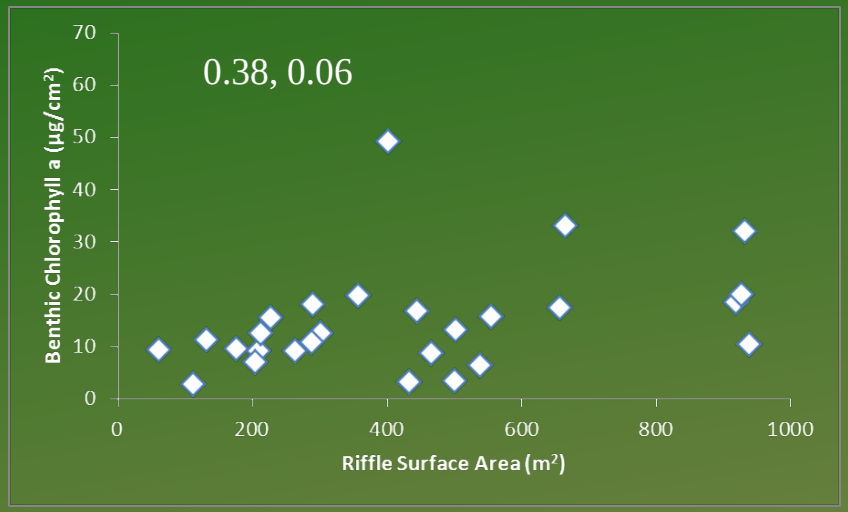


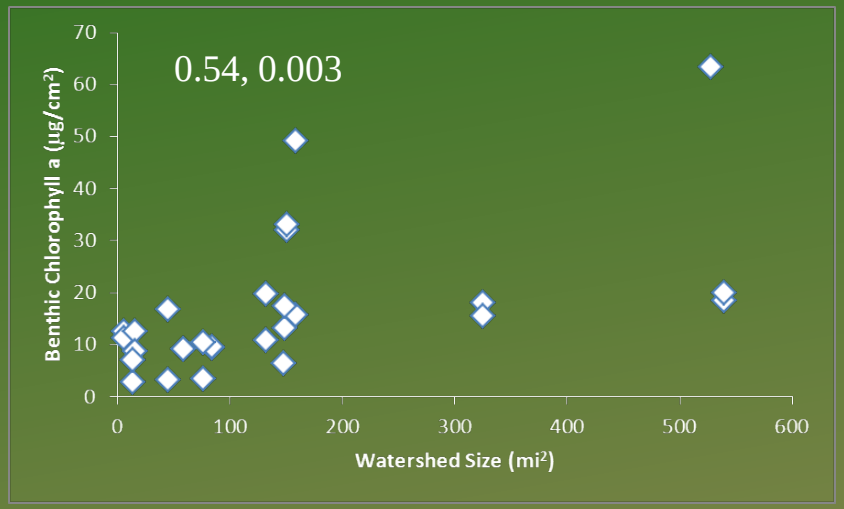


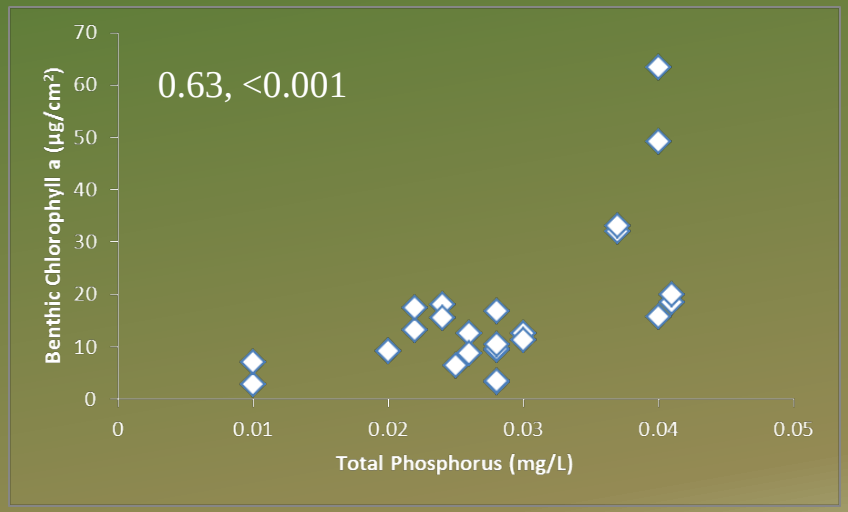


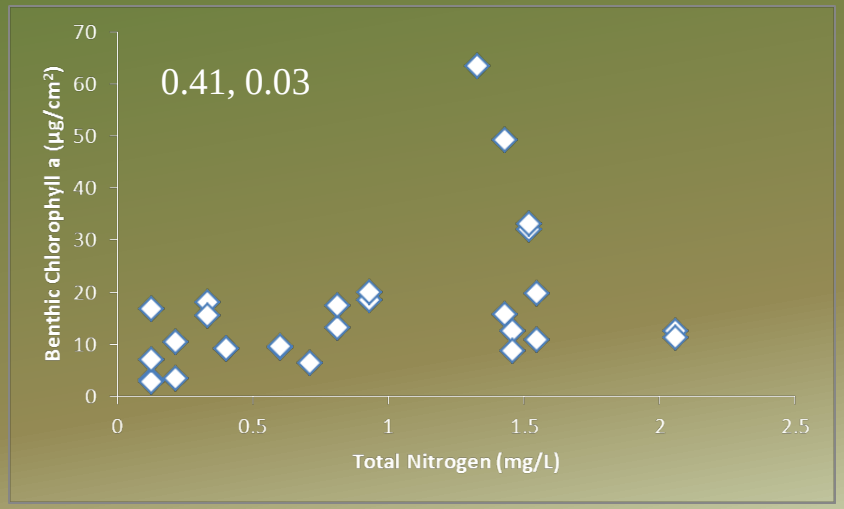


Pearson Correlation

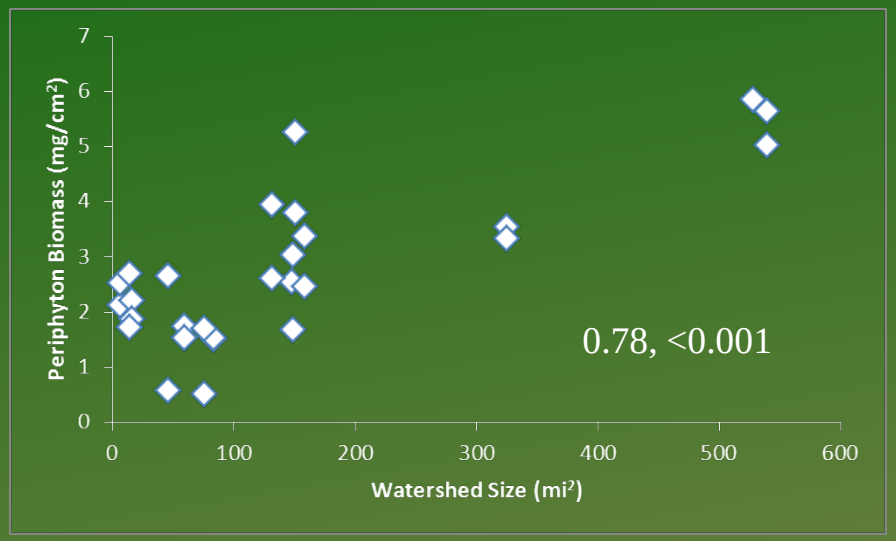


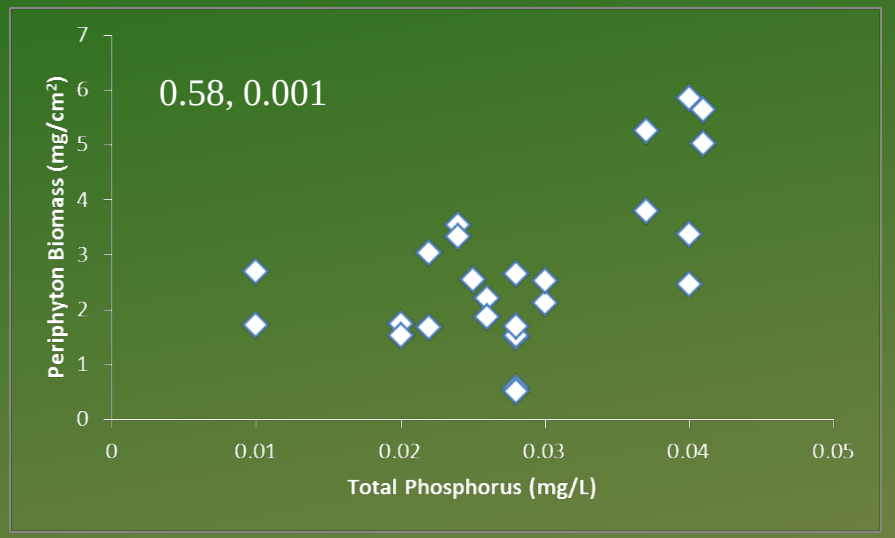


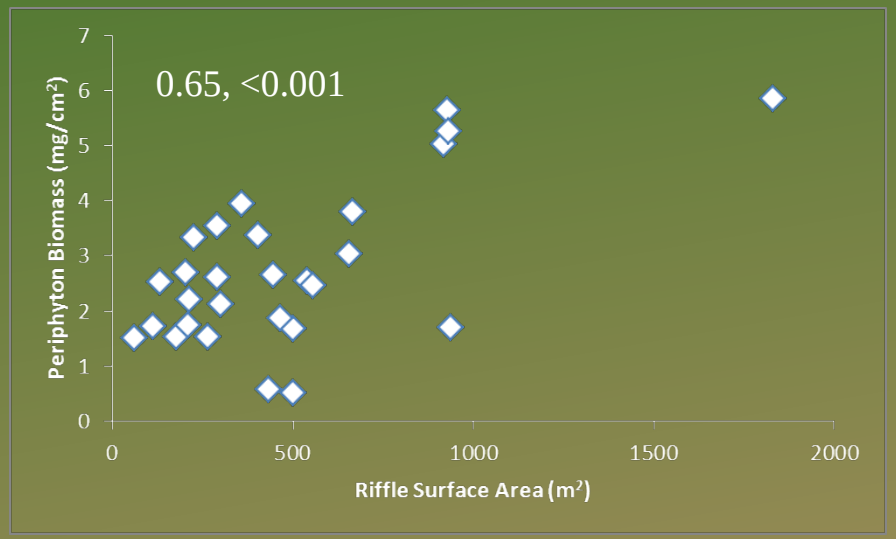


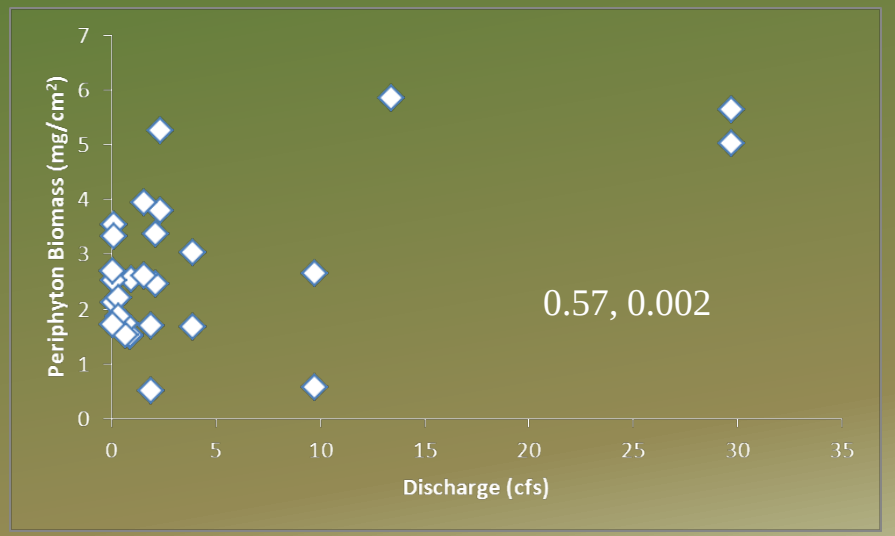


Spearman Correlation

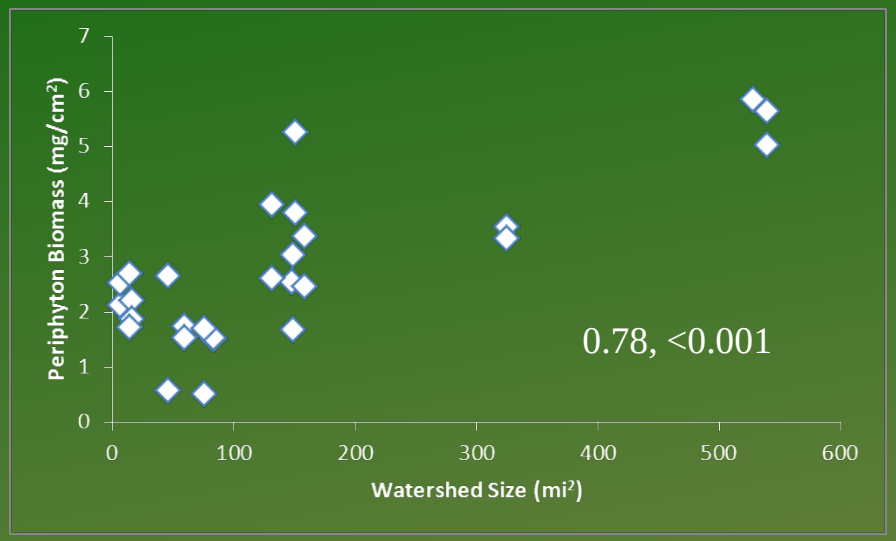


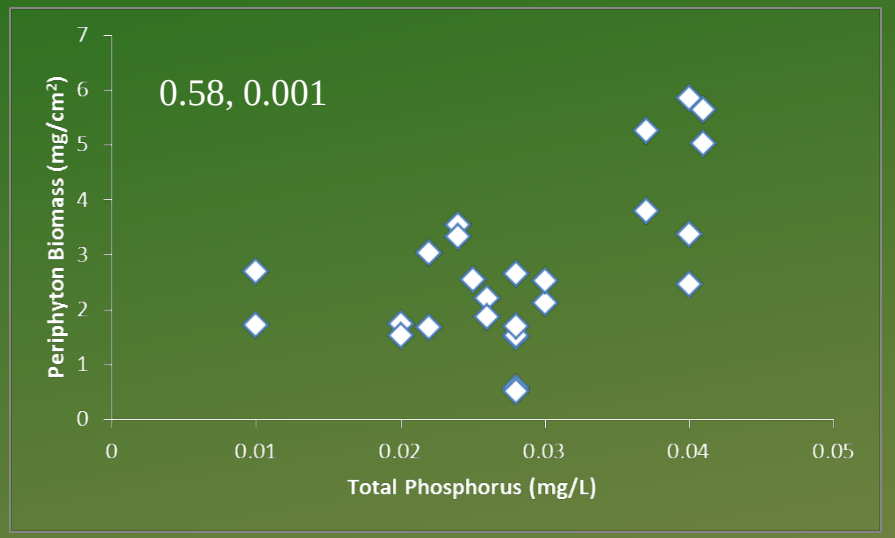


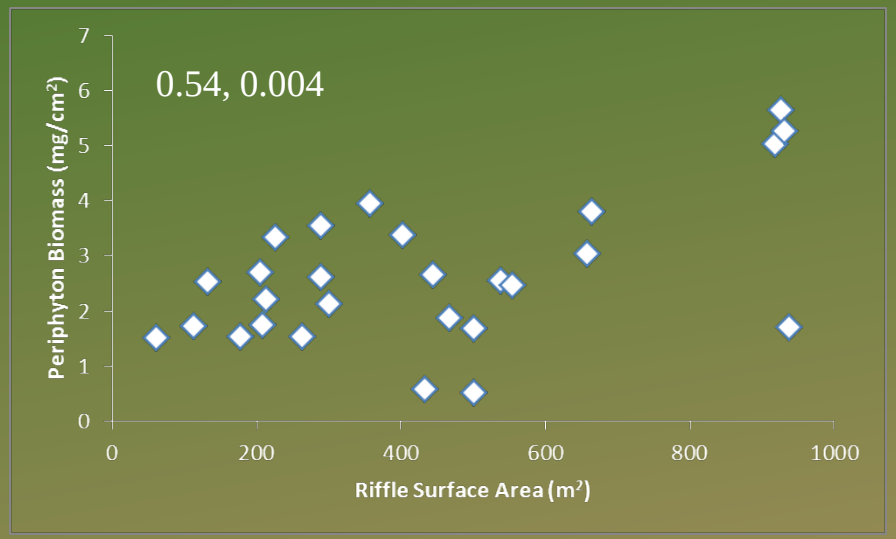


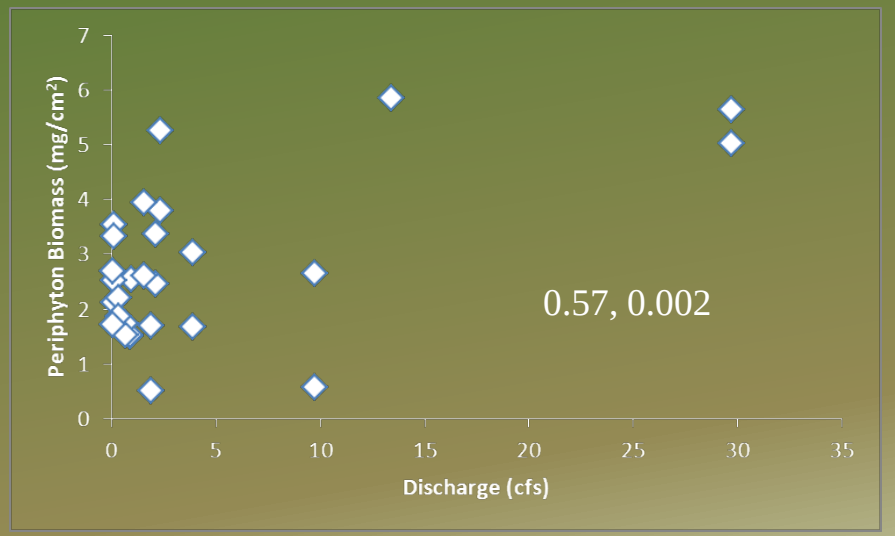


Pearson Correlation





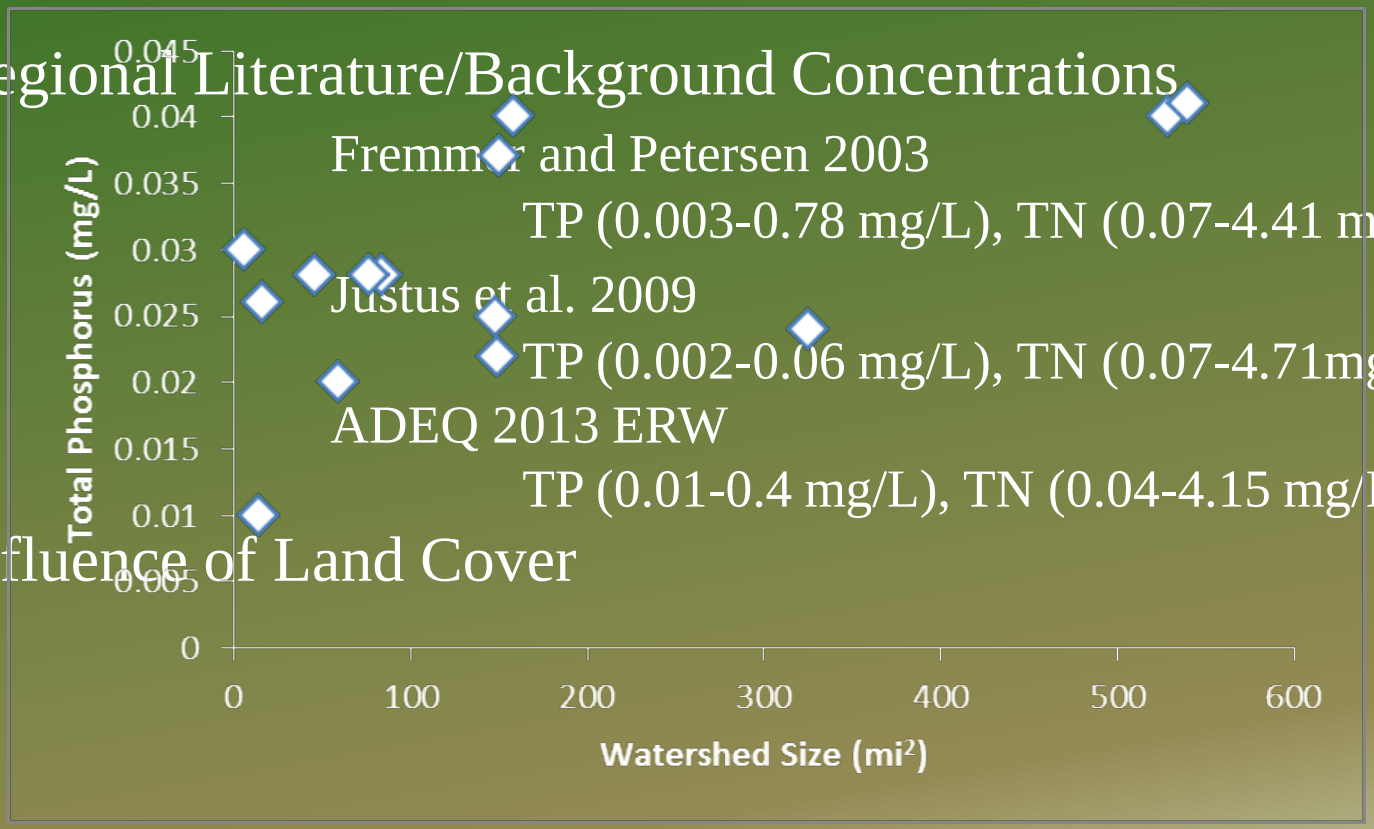




What's Does All This Mean?

Criteria for Ozark ERWs

Regional Literature/Background Concentrations



Fremmer and Petersen 2003

TP (0.003-0.78 mg/L), TN (0.07-4.41 mg/L)

Justus et al. 2009

TP (0.002-0.06 mg/L), TN (0.07-4.71mg/L)

ADEQ 2013 ERW

TP (0.01-0.4 mg/L), TN (0.04-4.15 mg/L)

Influence of Land Cover

What's Next?

Seasonal Differences

Review Primary and Critical Seasons

Diurnal Dissolved Oxygen

Fish and Macroinvertebrate Assemblage Response

Data from nutrient enriched stations

Implementation

Boston Mountain ERWs

"To protect, enhance, and restore the natural environment for the well-being of all Arkansans."