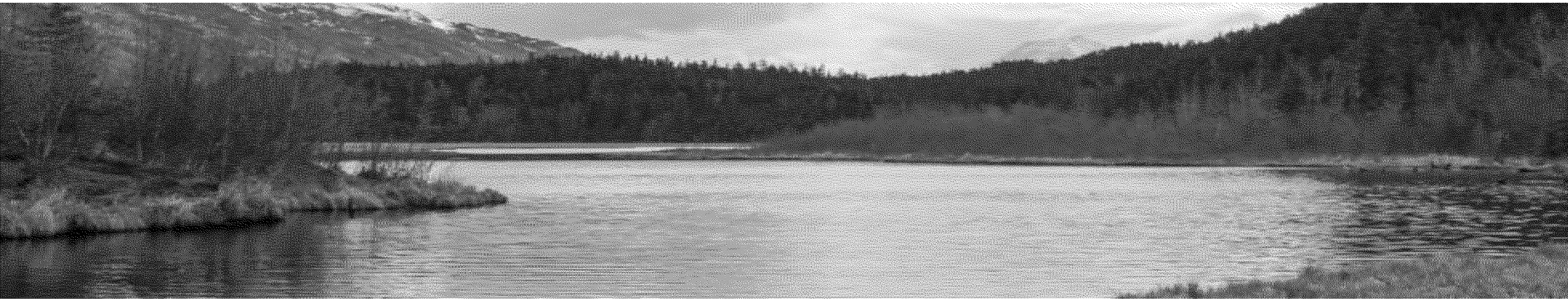

Numeric Nutrient Criteria Webinar Series

The Oklahoma-Arkansas Joint Phosphorus Study: A Framework for Developing Numeric Criteria for Nutrients in Rivers and Streams

Wednesday, June 21, 2017

3:00 PM Eastern

EPA
United States Environmental Protection Agency

Ryan King,
Baylor University

Webinar Logistics

- **To Ask a Presenter Question** – Type your question in the “Presenter Questions” pod on the right side of your console and click “Send.”

- **To Report any Technical Issues** (such as audio problems) – Type your issue in the “Adobe Connect Help” pod on the right side of your console and click “Send.” We will respond by posting an answer in the same box.

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BAYLOR
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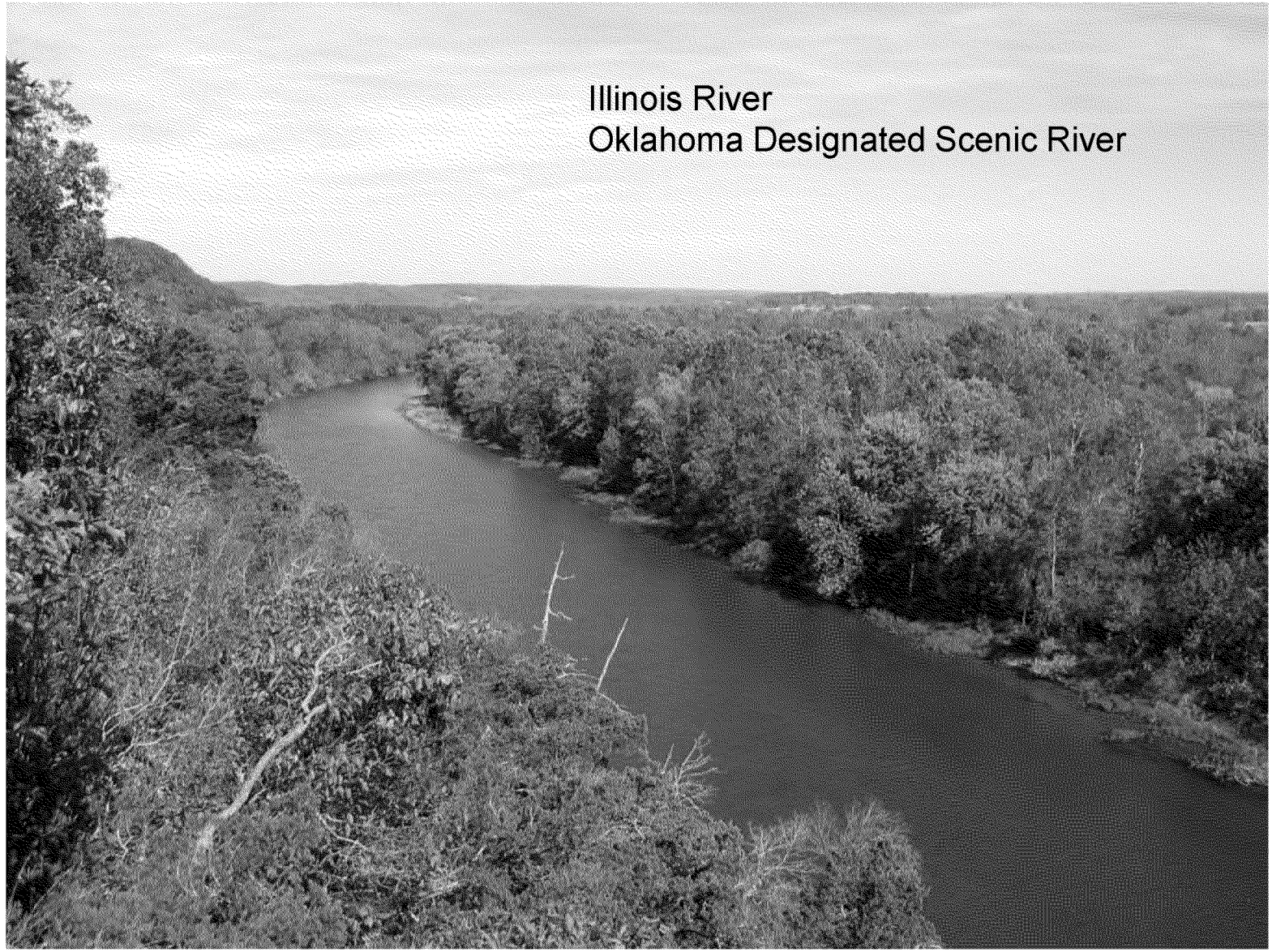
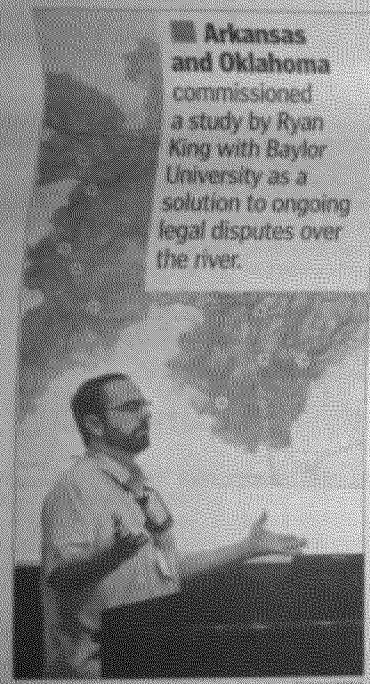
The Oklahoma-Arkansas Joint Phosphorus Study: A Framework for Developing Numeric Criteria for Nutrients in Rivers and Streams

Ryan S. King
Professor, Department of Biology, Center for Reservoir and Aquatic Systems Research, Baylor University, Waco, TX 76798
www.baylor.edu/aquaticlab

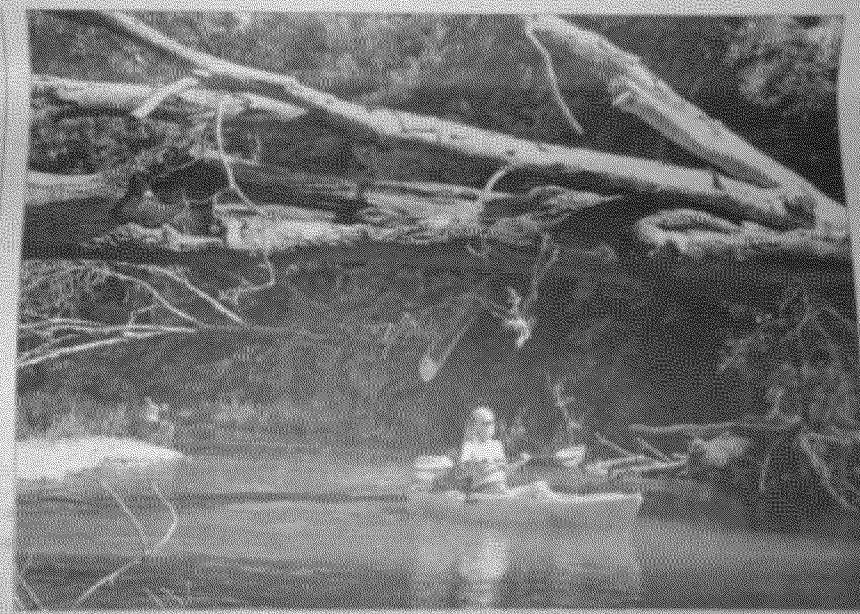

Illinois River
Oklahoma Designated Scenic River

THE NORTHWEST ARKANSAS TIMES



Arkansas and Oklahoma commissioned a study by Ryan King with Baylor University as a solution to ongoing legal disputes over the river.

FILE PHOTOS



Phosphorus levels in the river have gone down in recent years, monitoring by both Arkansas and Oklahoma show.

FIGHT OVER ILLINOIS

School Looks Ahead

HAAS HALL PLANS BENTONVILLE CAMPUS

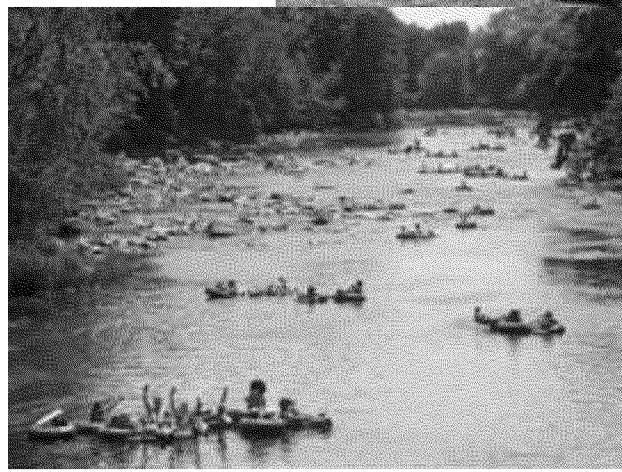
By Dave Parsons
news@nwacomm.com | @nwatimes

BENTONVILLE — Haas Hall Academy has received hundreds of applications from potential students for the Bentonville school it plans to open next fall, founder and superintendent Martin Schoppmeyer said.

Hundreds have applied for faculty positions as well.

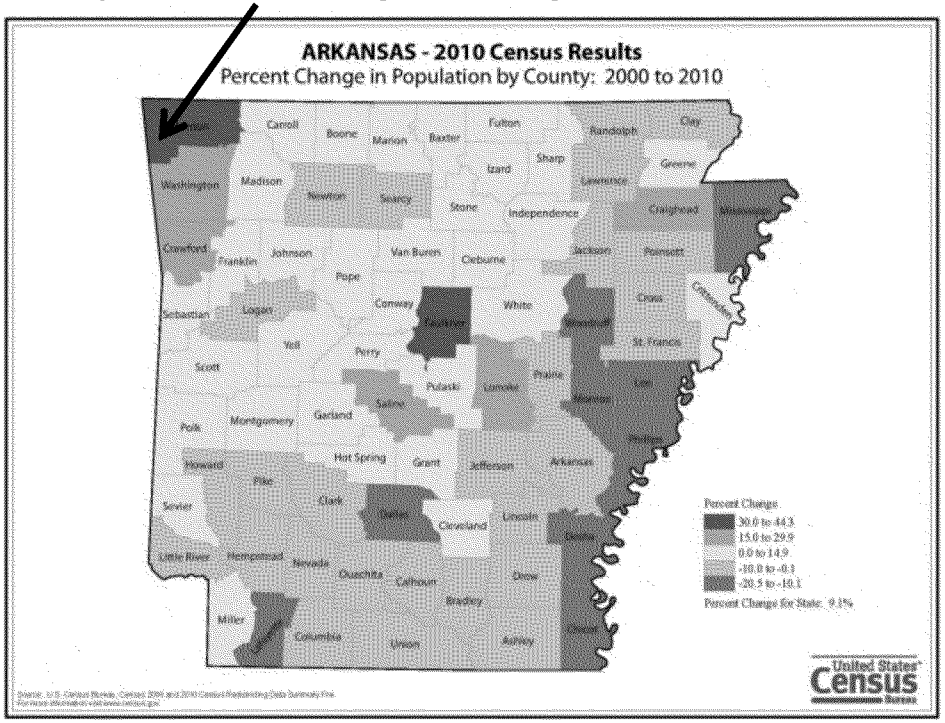
"We're getting phone calls every day about Haas Hall Bentonville," Schoppmeyer said.

Haas Hall is an open-enrollment charter school in Bentonville for students in grades eight through 12. It has been rated the best high school in Arkansas by U.S. News & World Report for three consecutive years.



Upper 50% of Illinois River watershed area falls in NWA metro area

Northwest Arkansas Metropolitan Area
Fayetteville-Springdale-Rogers



Population

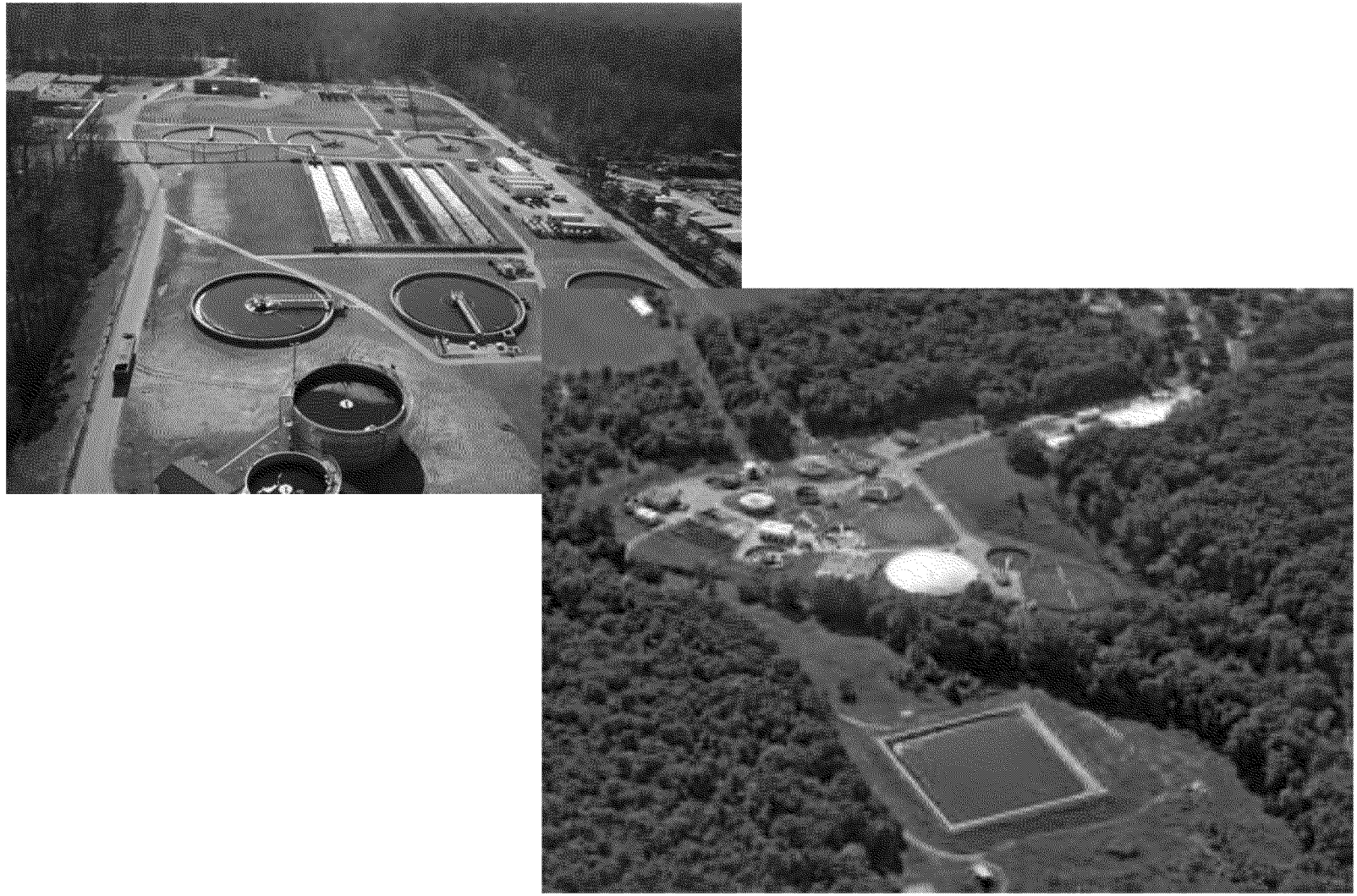
1980: 178,609

1990: 238,378

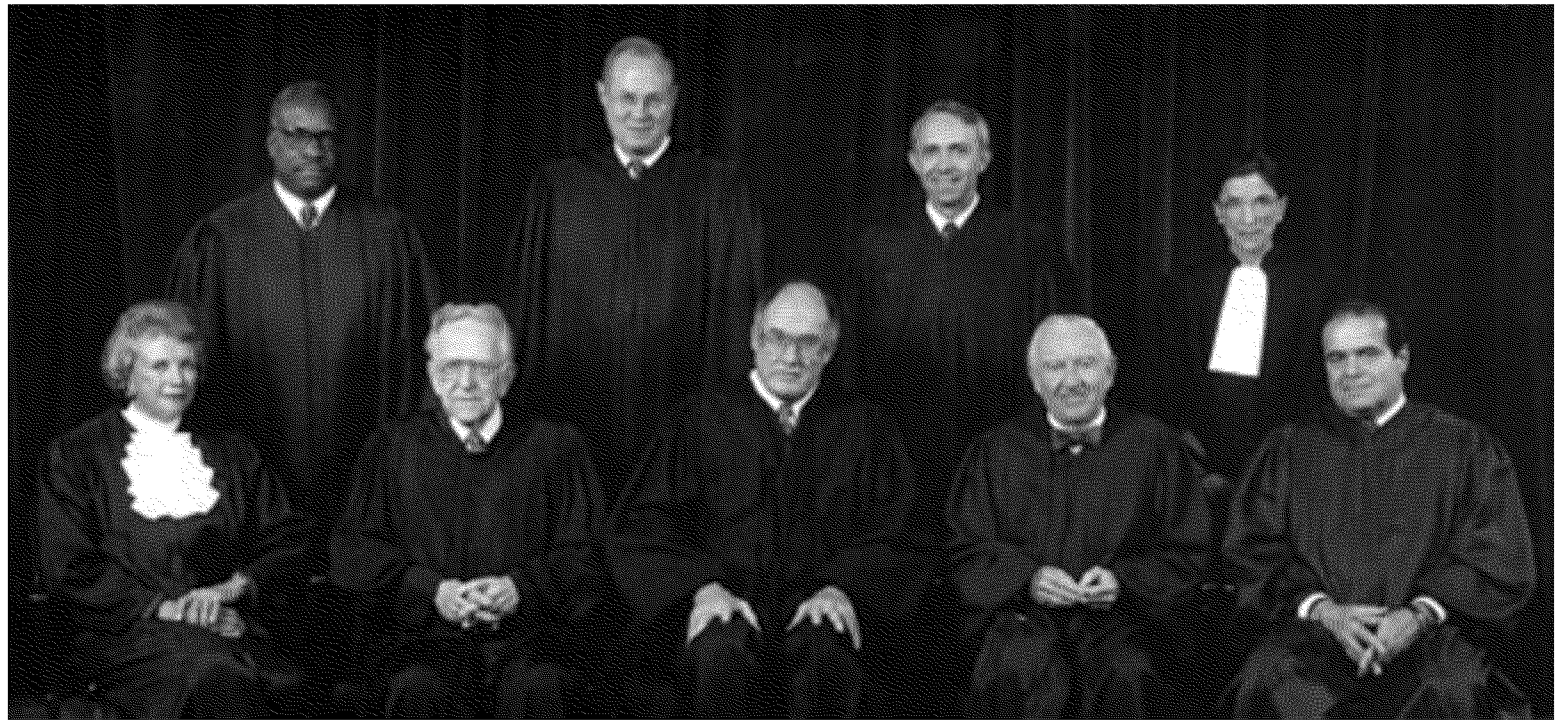
2000: 347,045

2013: 487,525

Growth expected to exceed 60% over next 20 years



US Supreme Court, ca. **1992**



503 U.S. 91 (1992)

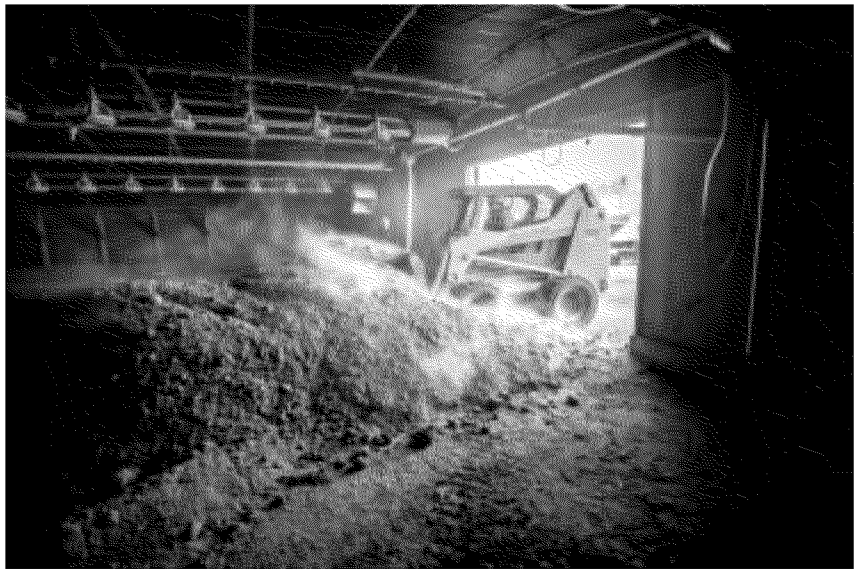
ARKANSAS et al.
v.
OKLAHOMA et al.

No. 90-1262.
United States Supreme Court.

Argued December 11, 1991.
Decided February 26, 1992.[*]
CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE TENTH CIRCUIT

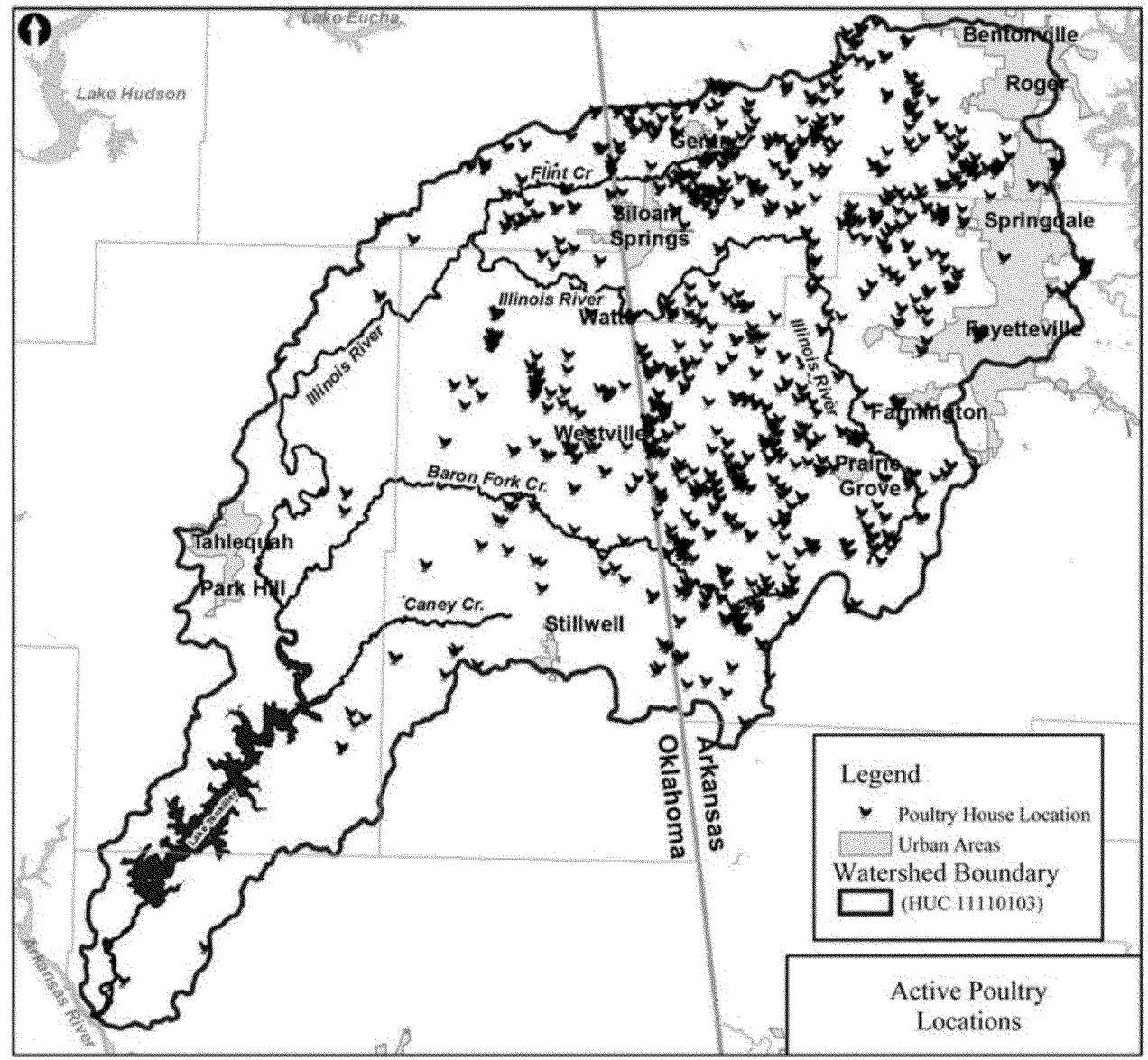
Stevens, J., delivered the opinion for a unanimous Court.

up to 25,000 birds ("broilers") *per house*



FED UP WITH ALL THE ARKANSAS CHICKEN POOP?

JOIN S.T.I.R. WWW.ILLINOISRIVER.ORG



Other Significant Events

- 2003: Oklahoma establishes a numerical criterion for total phosphorus (TP) of 0.037 mg/L (37 ppb) for the Designated Scenic Rivers based on frequency distributions of TP data
- 2005 Oklahoma Attorney General sues poultry companies over chicken waste polluting OK waterbodies
- 2009 lawsuit goes to trial, no decision rendered to date
- Late 2012 Arkansas and Oklahoma governors agree to stressor-response study to be conducted by 3rd party

Study Framework

"to determine the total phosphorus threshold response level....at which any statistically significant shift occurs in

1. algal species composition or
2. algal biomass production

...resulting in undesirable

1. aesthetic (i.e., nuisance conditions) or
2. water quality

...conditions in the Designated Scenic Rivers."

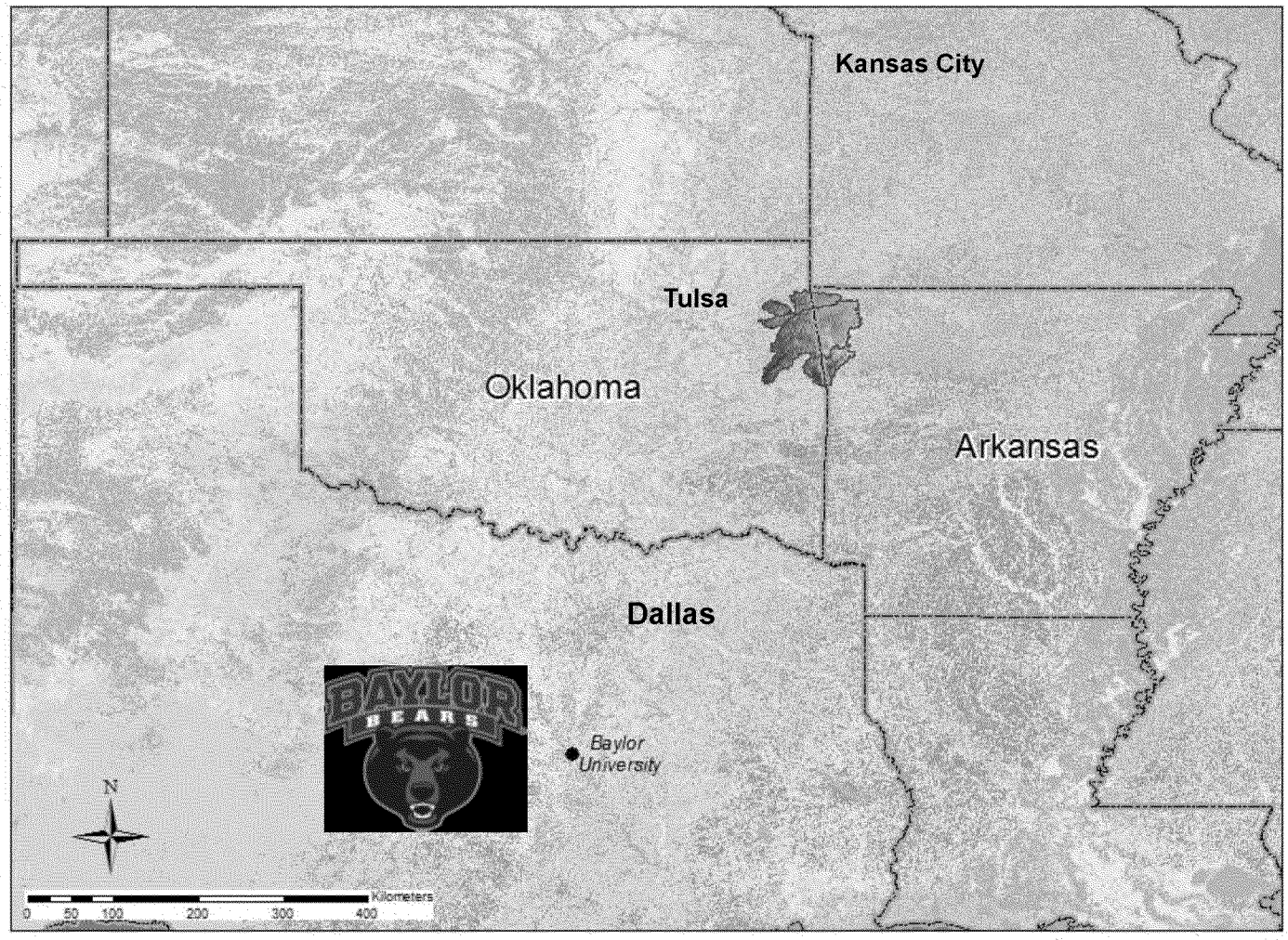
Second Statement of Joint Principles and Actions, p.2, Mandatory Study Components

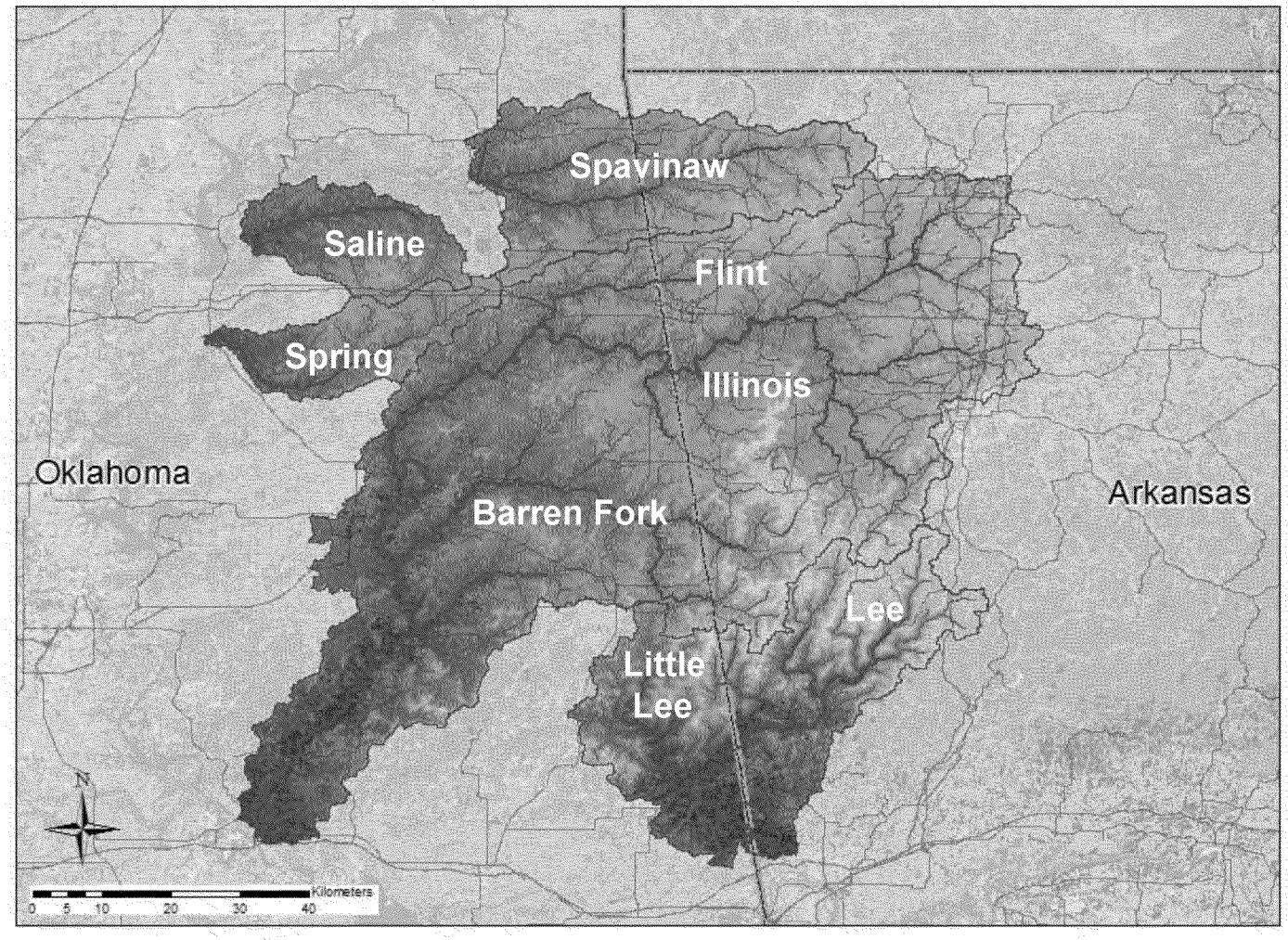
"Nuisance algae"

Predominantly *Cladophora glomerata*

Key elements of a numeric criterion field study

- Extensive and intensive ***spatial coverage*** of region
- ***Frequent*** sampling over ***multiple years***
- Spans a ***gradient*** of conditions from reference to highly enriched
- Minimizes ***confounding factors*** (channel unit, light, substrate size)


Kansas City
Tulsa
Oklahoma
Arkansas
Dallas
BAYLOR
BEARS
Baylor University
N
Kilometers
0 50 100 200 300 400


Spavinaw
Saline
Flint
Spring
Illinois
Oklahoma
Arkansas
Barren Fork
Lee
Little
Lee
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Kilometers
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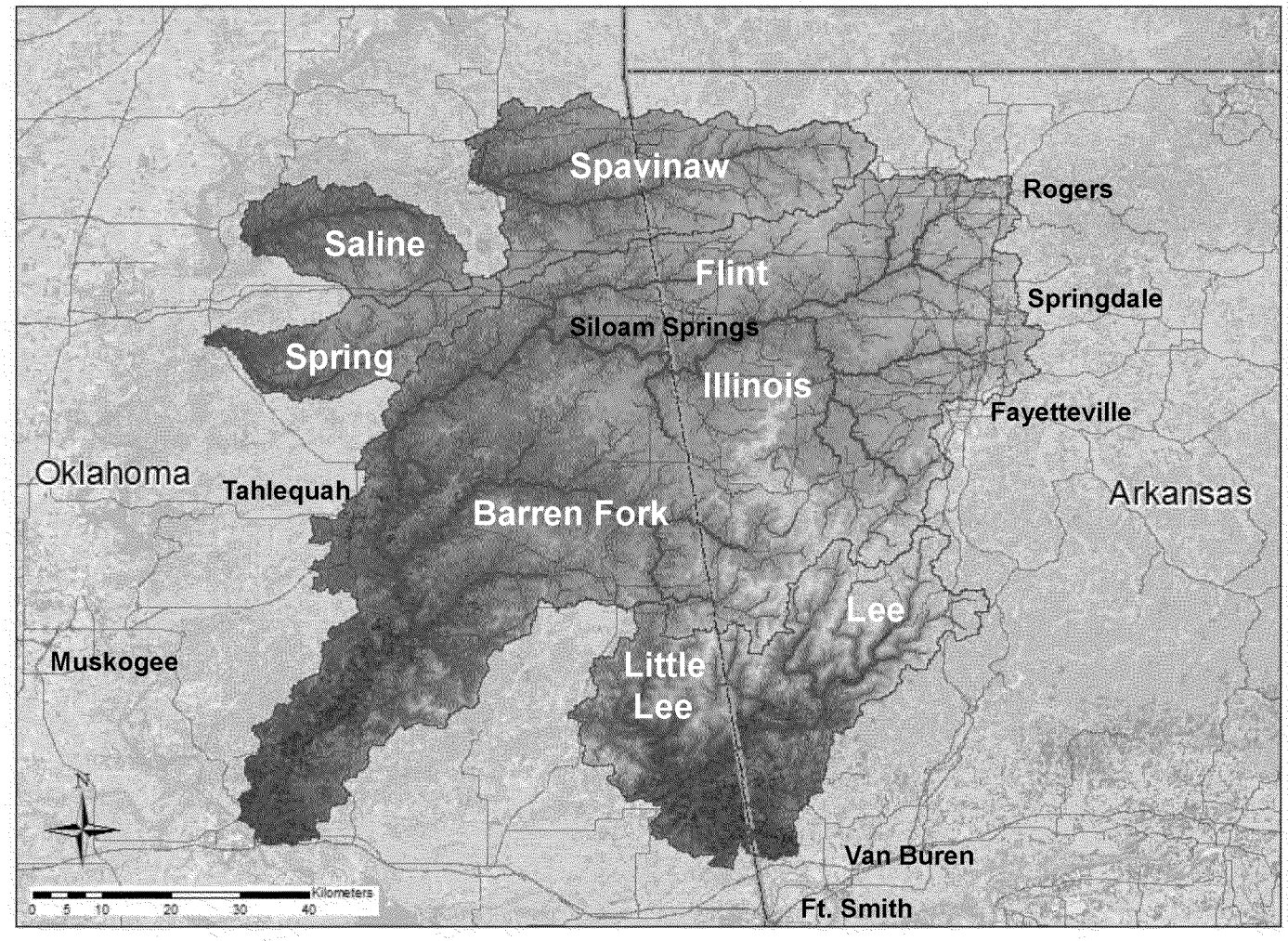
Spavinaw
Rogers
Saline
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Springdale
Siloam Springs
Spring
Illinois
Fayetteville
Oklahoma
Tahlequah
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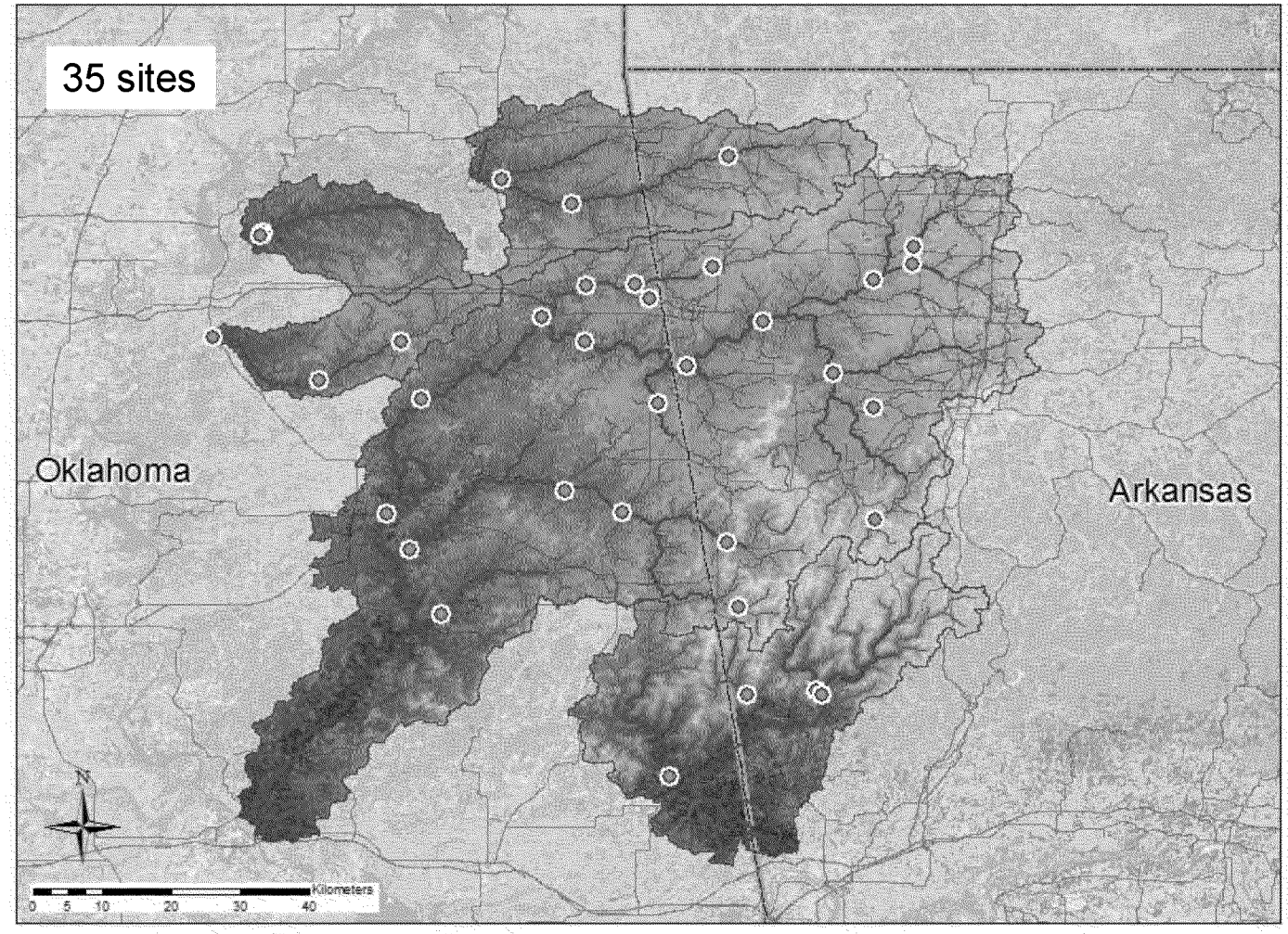
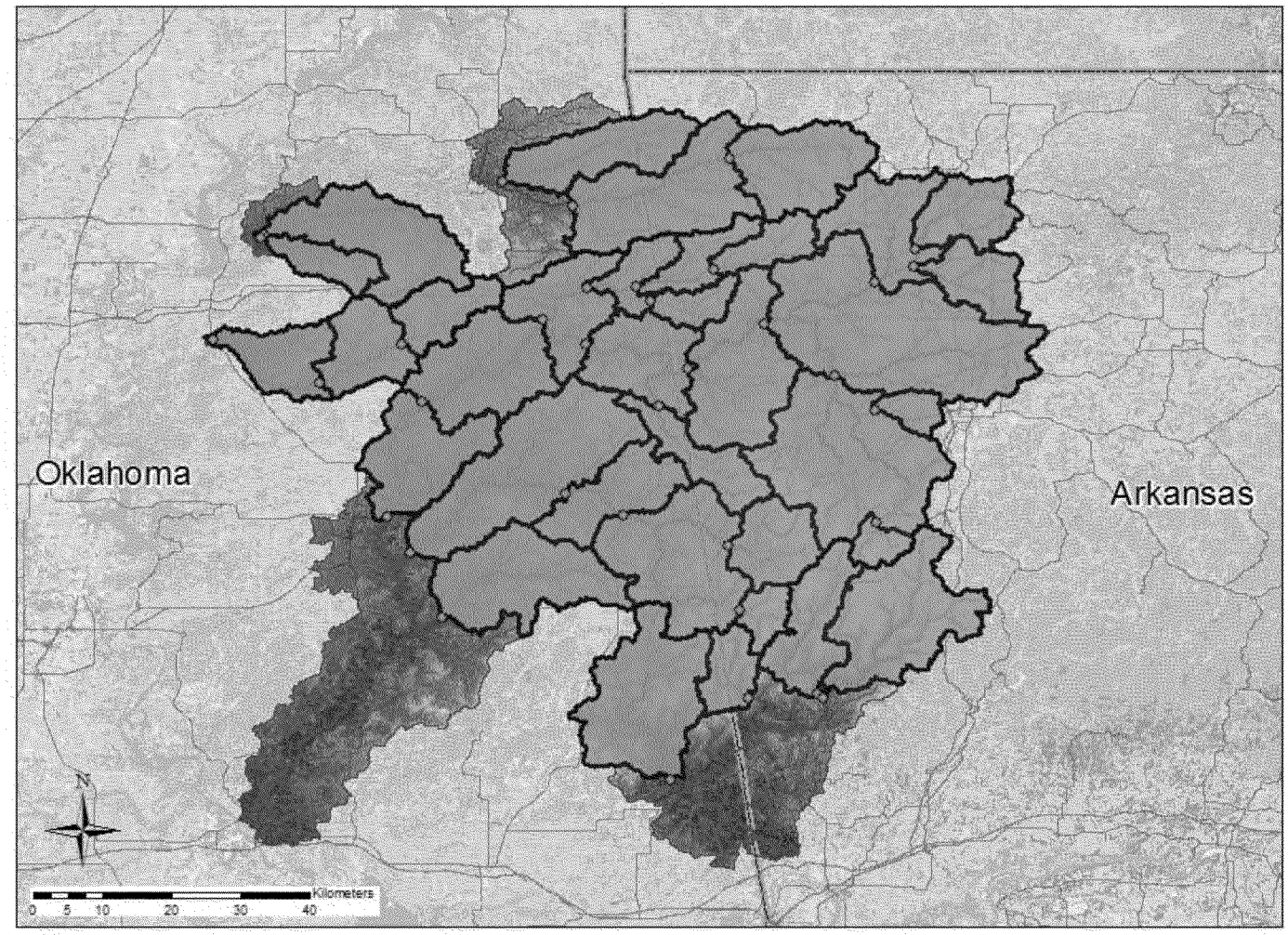
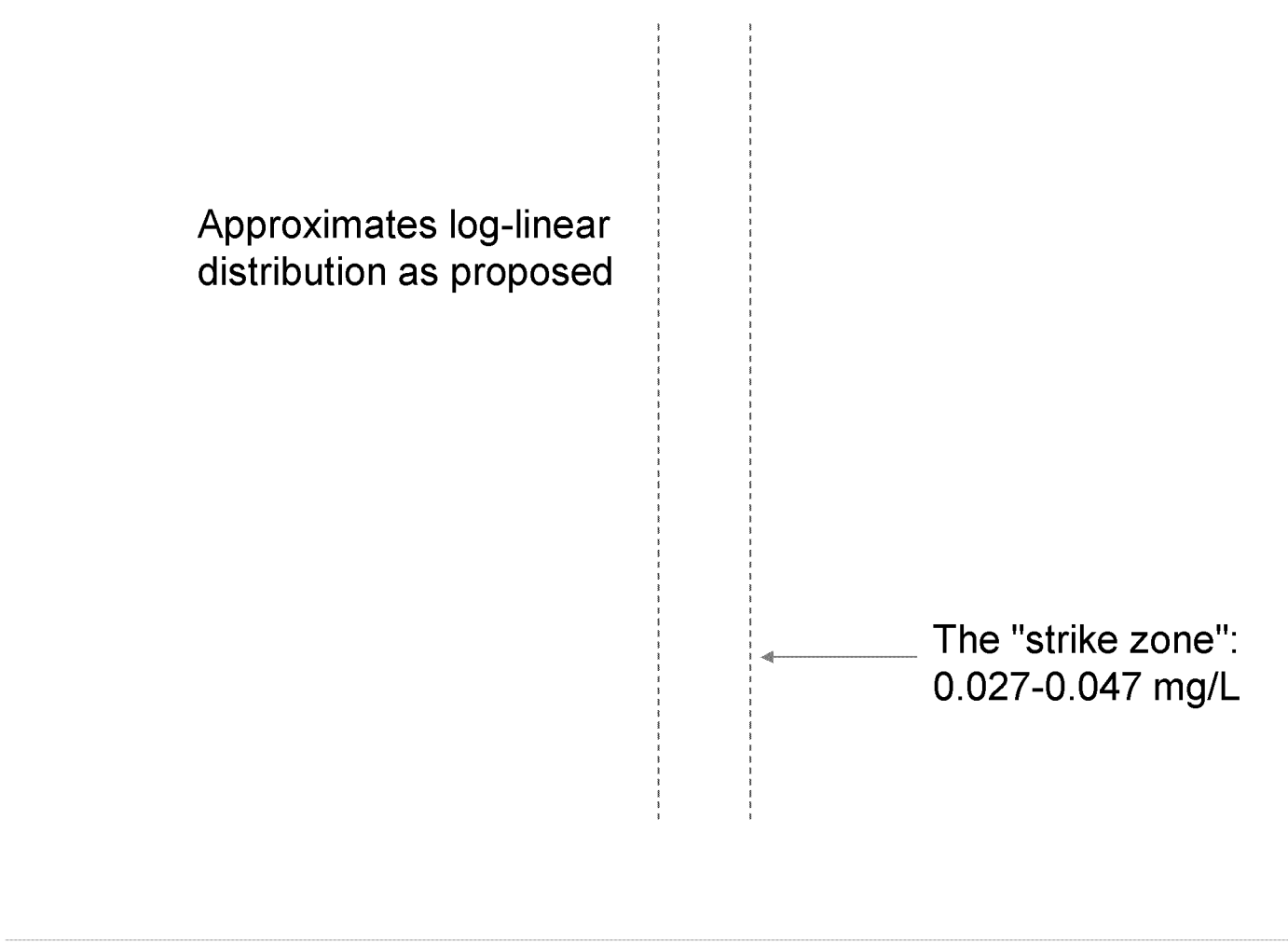
Ft. Smith


35 sites
Oklahoma
Arkansas
N
Kilometers
0 5 10 20 30 40


Oklahoma
Arkansas
N
Kilometers
0 5 10 20 30 40

Cumulative Frequency Distribution, Total Phosphorus, Log Scale



Schedule

Sampling scheduled bimonthly. Proposed sampling was to result in 12 events in 2 years. All 12 sampling events have been completed.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014				Site selection		X		X		X		X
2015		X		X		X		X		X		X
2016		X		X	Final analyses & report writing							

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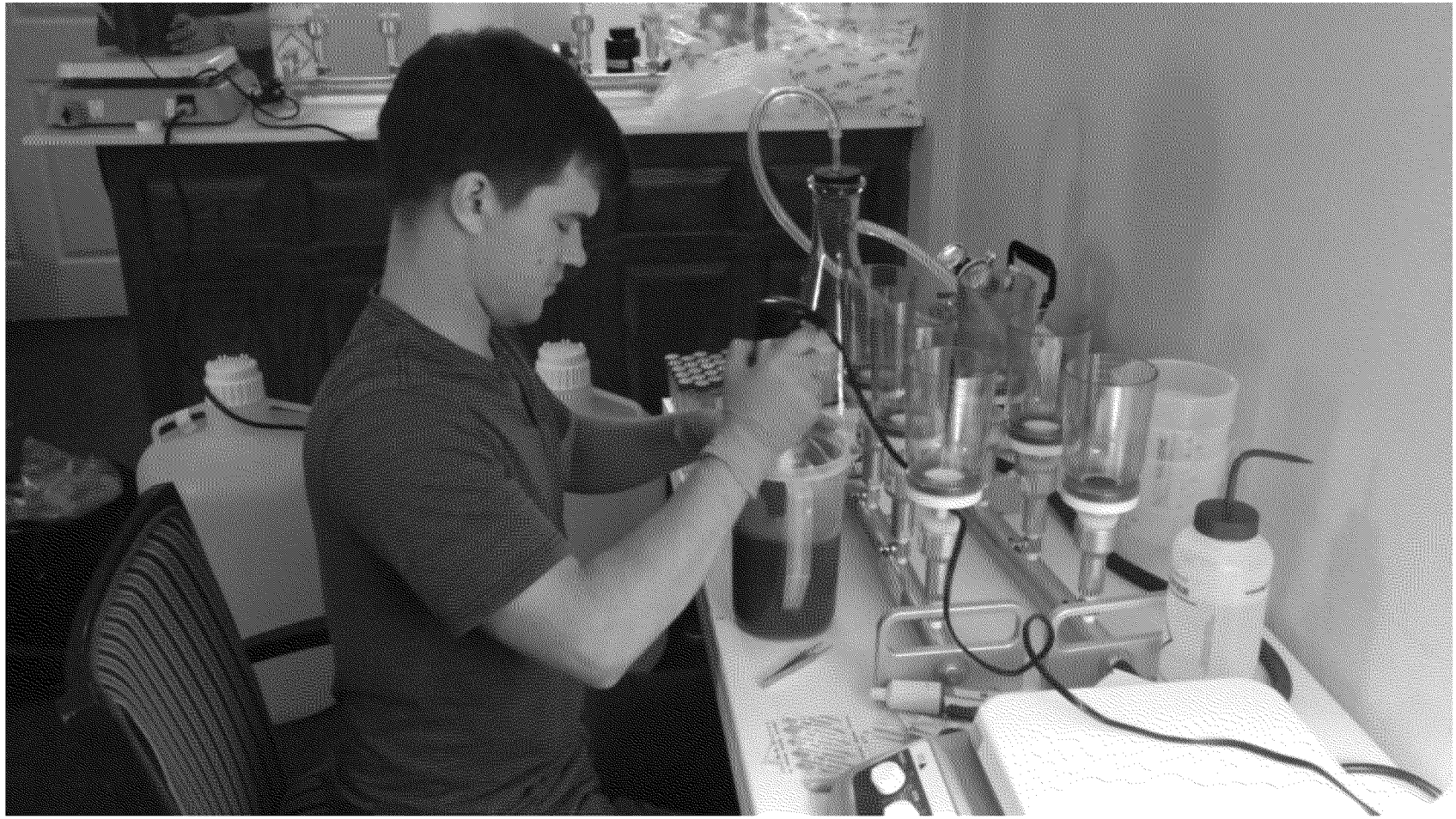
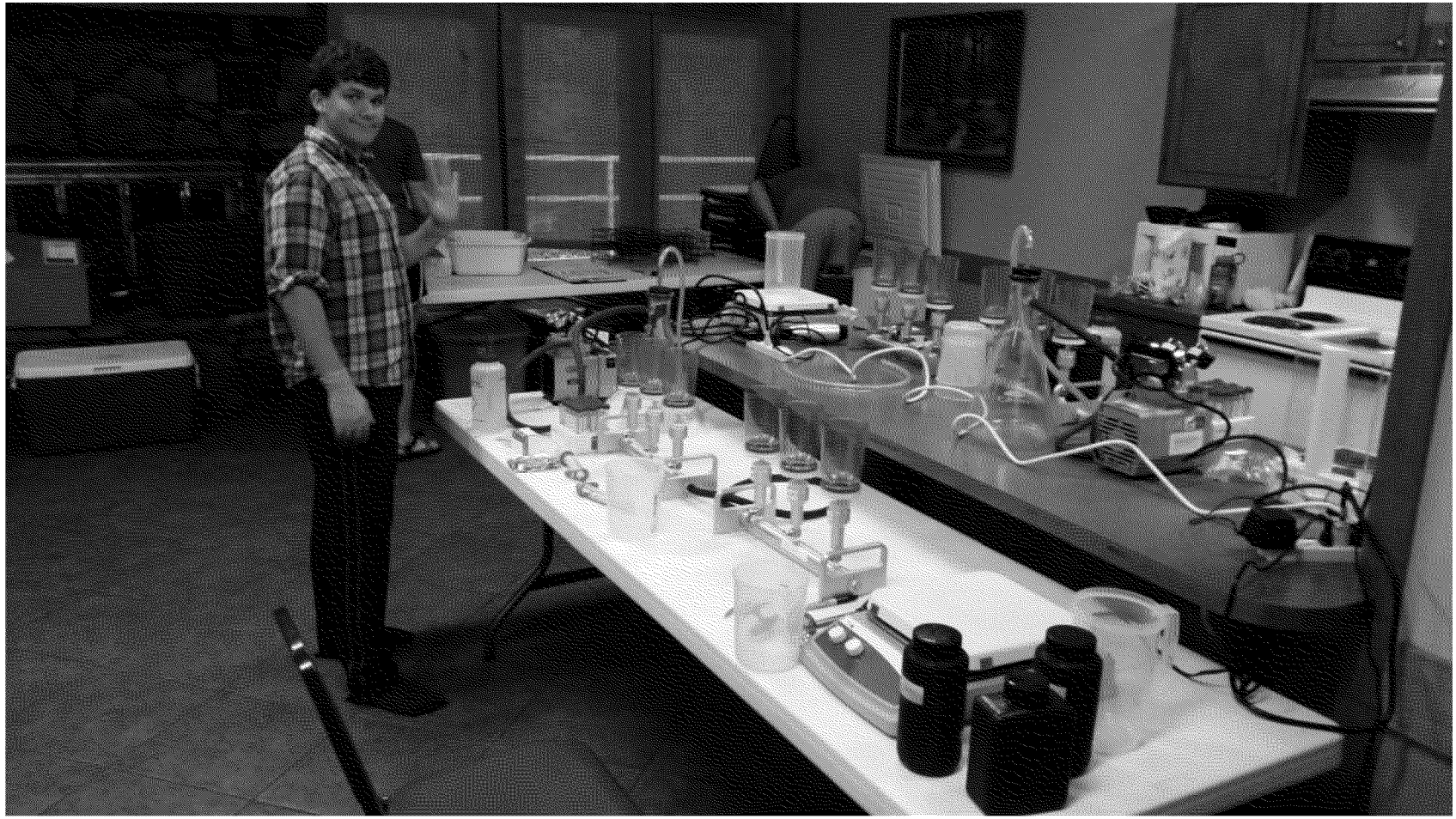
TEXAS





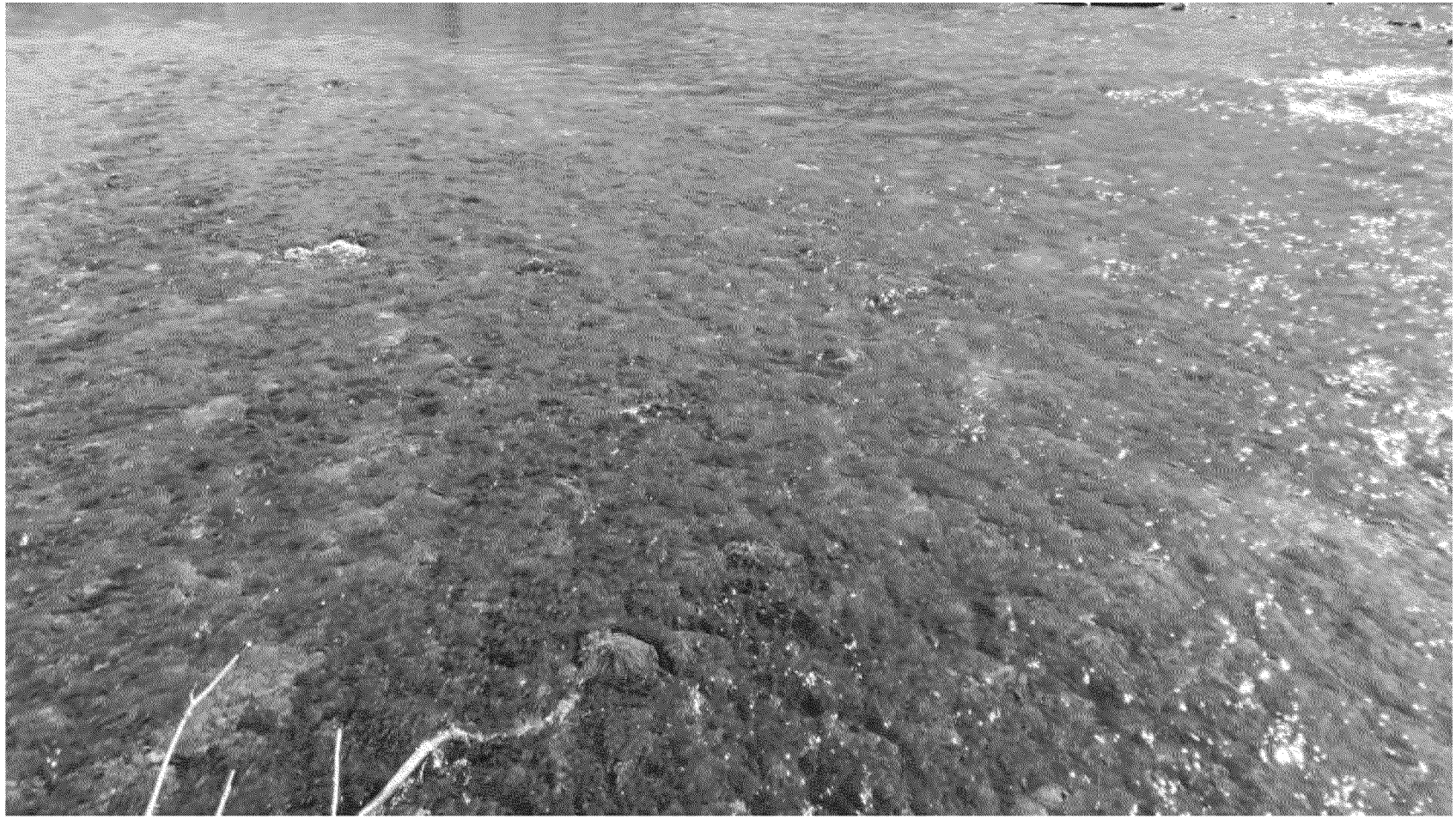
Discharge on the Illinois River at Tahlequah, 2014-16

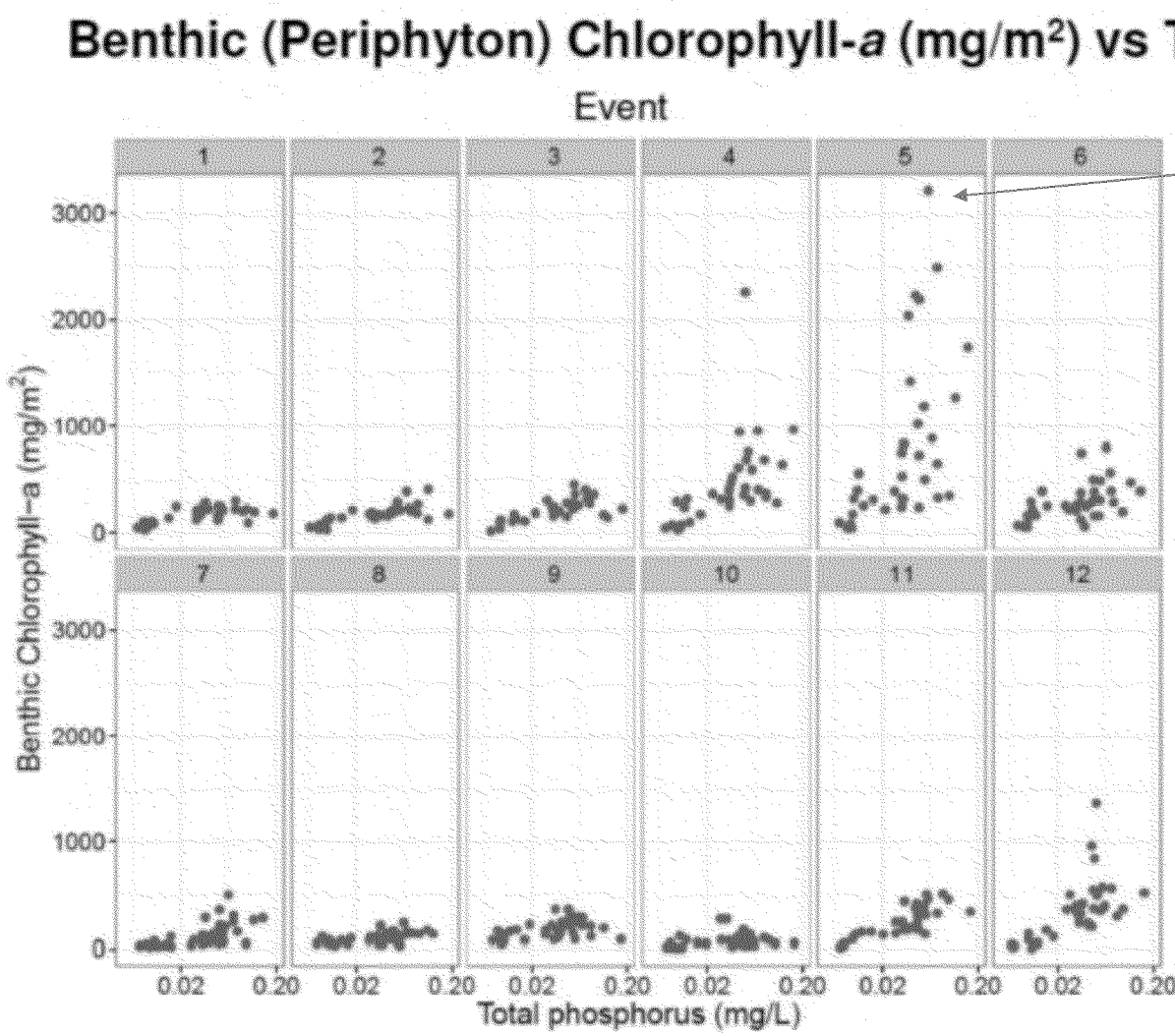
Stars correspond to sampling events (n=12 over 2 years)

Historic flood,
late December
2015

Relatively stable flows for several
months in 2014

Benthic Chlorophyll-*a*





Massive *Cladophora* bloom in late 2014, early 2015.

Peaked in Feb 2015.

What led to the bloom?

Illinois River (ILLI-5), Low-water crossing, October 2014
0.04-0.06 mg/L TP

Freshwater Science, 2012, 31(2):451–462
© 2012 by The Society for Freshwater Science
DOI: 10.1899/11-055.1
Published online: 3 April 2012

Grazing minnows increase benthic autotrophy and enhance the response of periphyton elemental composition to experimental phosphorus additions

Jason M. Taylor[1], Jeffrey A. Back[2], AND Ryan S. King[3]
Center for Reservoir and Aquatic Systems Research, Department of Biology, Baylor University, Waco, Texas 76798 USA

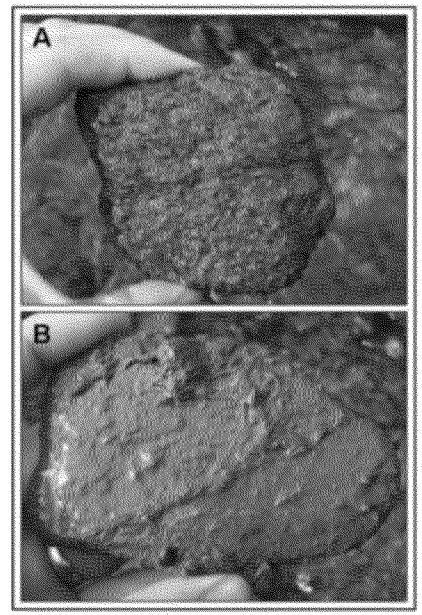
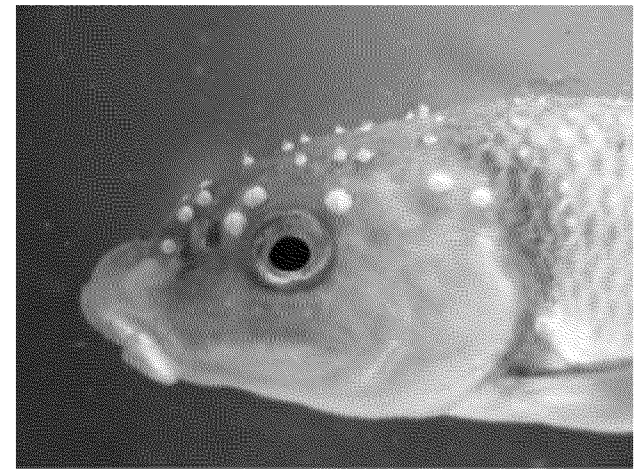


FIG. 4. *Cladophora glomerata* growth on grazed (A) and ungrazed (B) substrates on day 28 of the experiment.

Campostoma anomalum
Central stoneroller

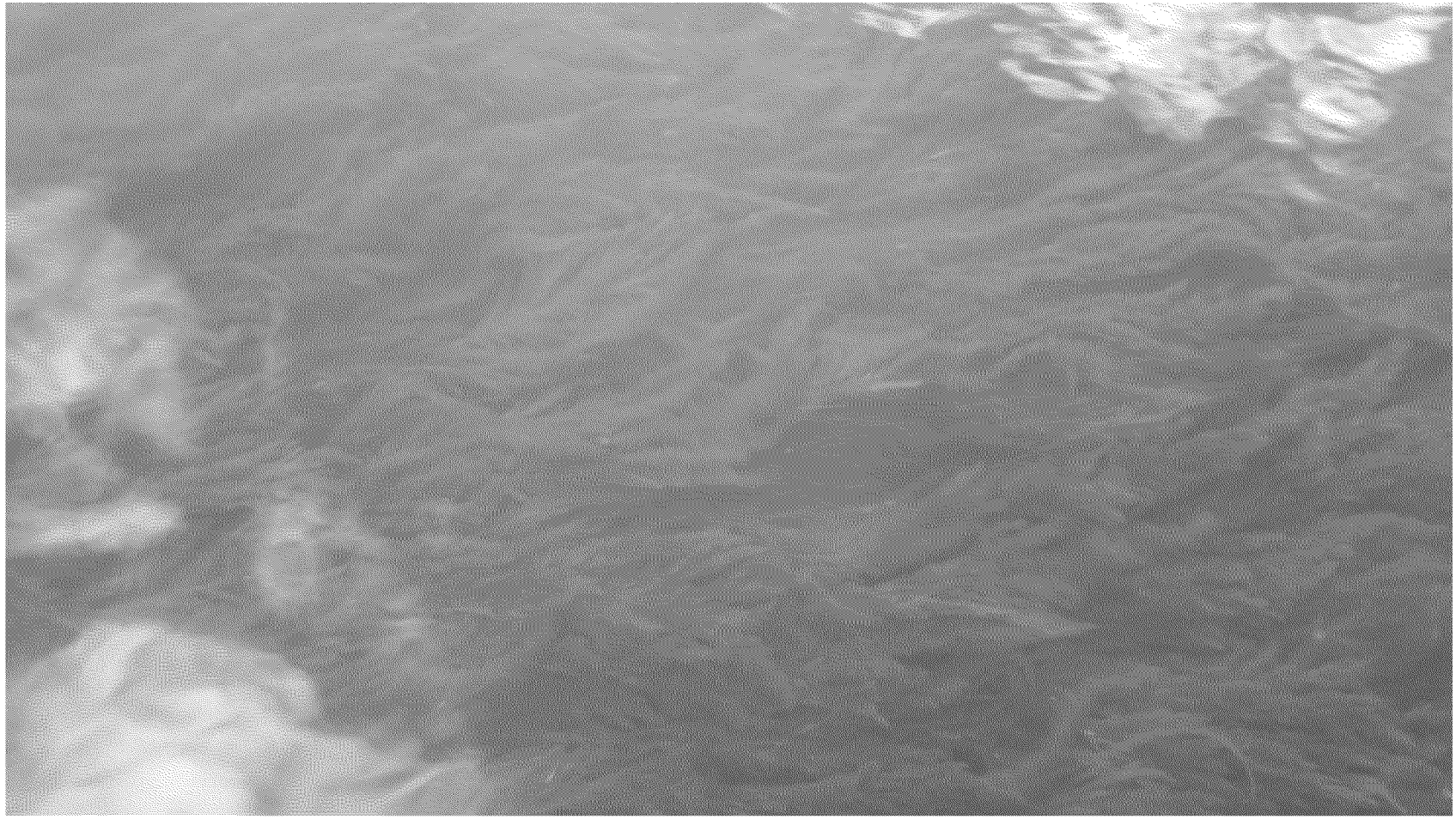


http://youtu.be/rnlzhjaV2Xc 2:18

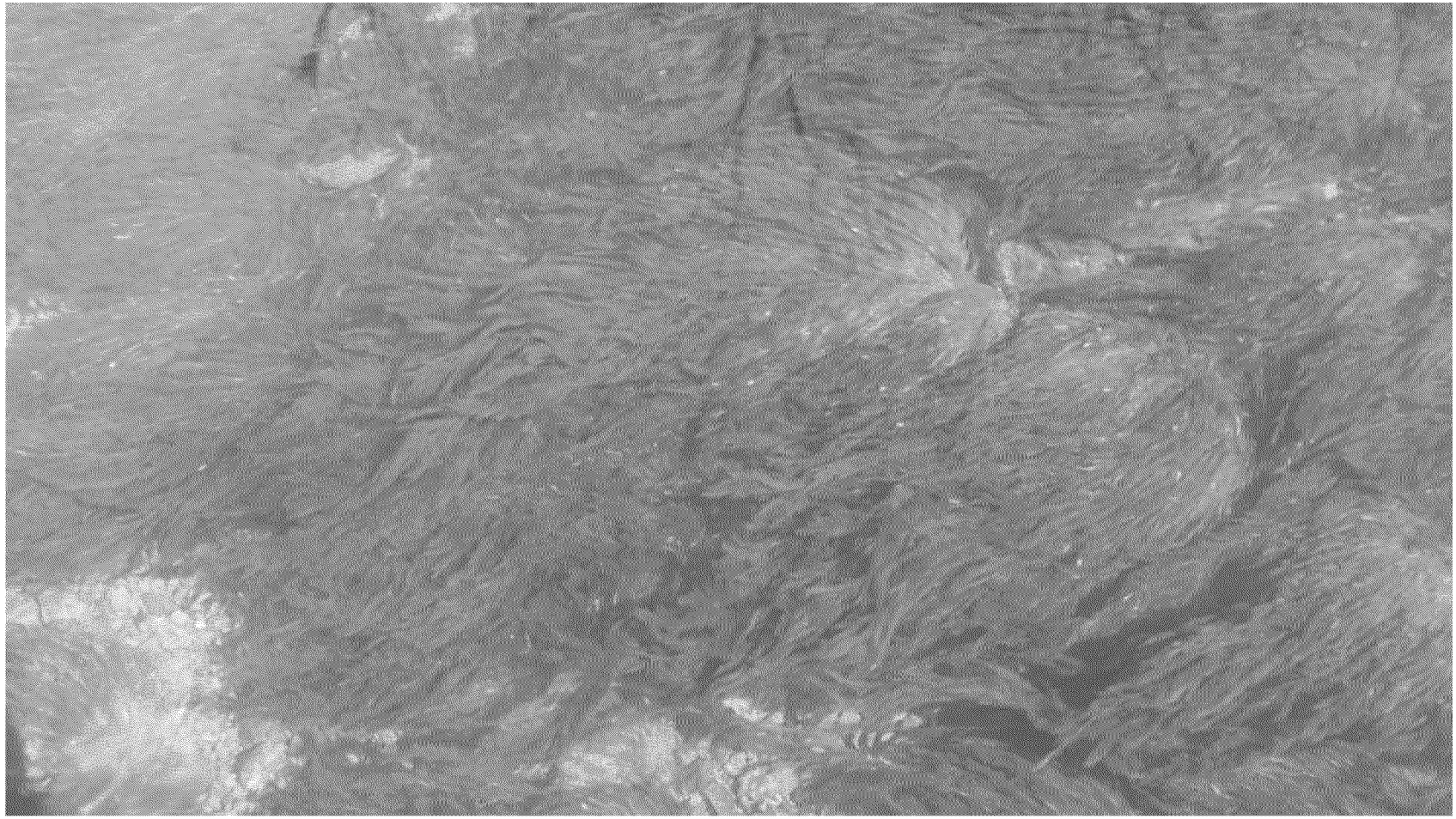
Illinois River (ILLI-5), Low-water crossing, December 2014

Illinois River (ILLI-4) @ AR 59, Feb 2015

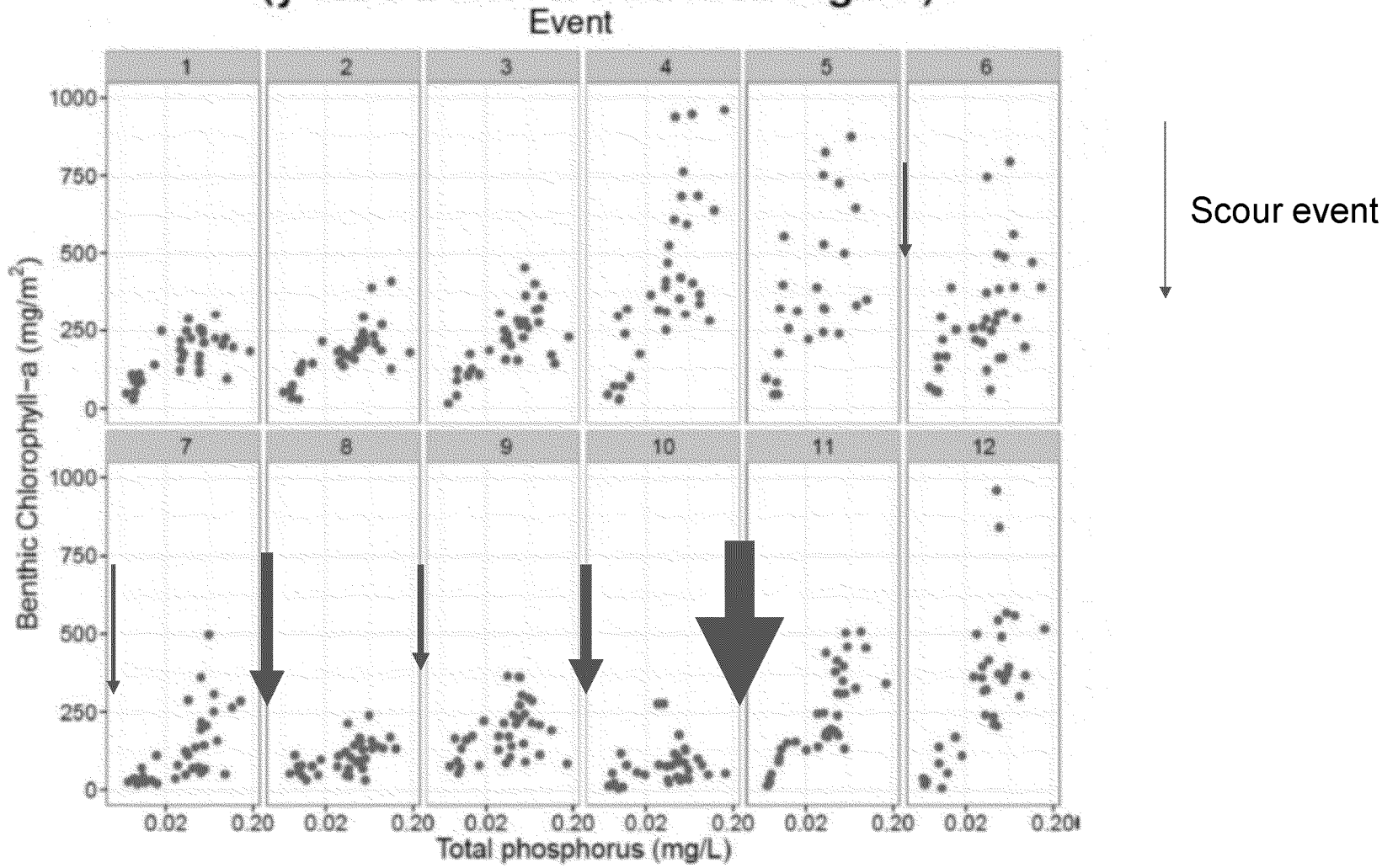
Illinois River (ILLI-8), Tahlequah, Feb 2015



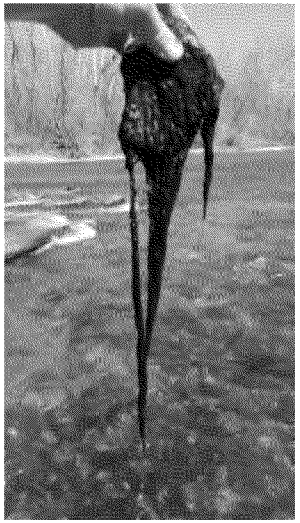
Illinois River (ILLI-3), Chambers Springs Rd, Feb 2015

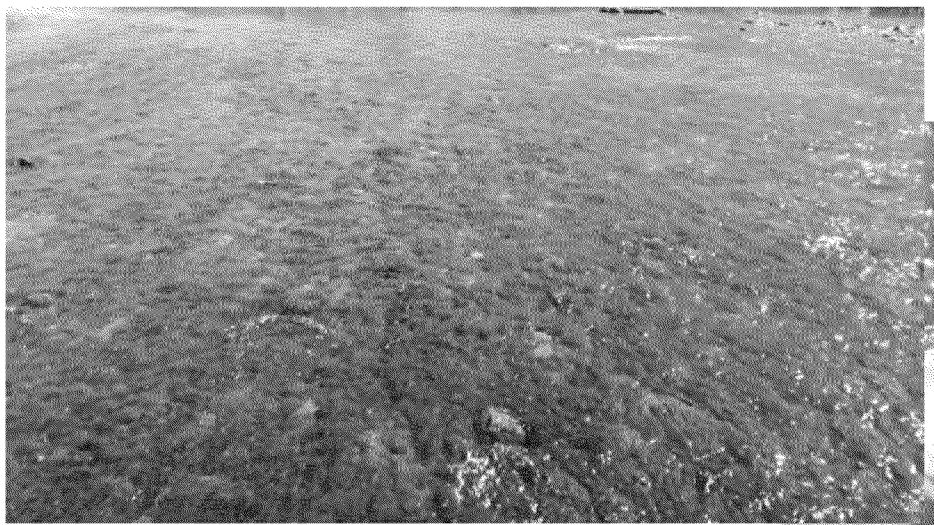


Benthic (Periphyton) Chlorophyll-*a* vs TP
(y-axis truncated at 1000 mg/m²)



Cladophora glomerata biovolume (mm^3/m^2) vs TP

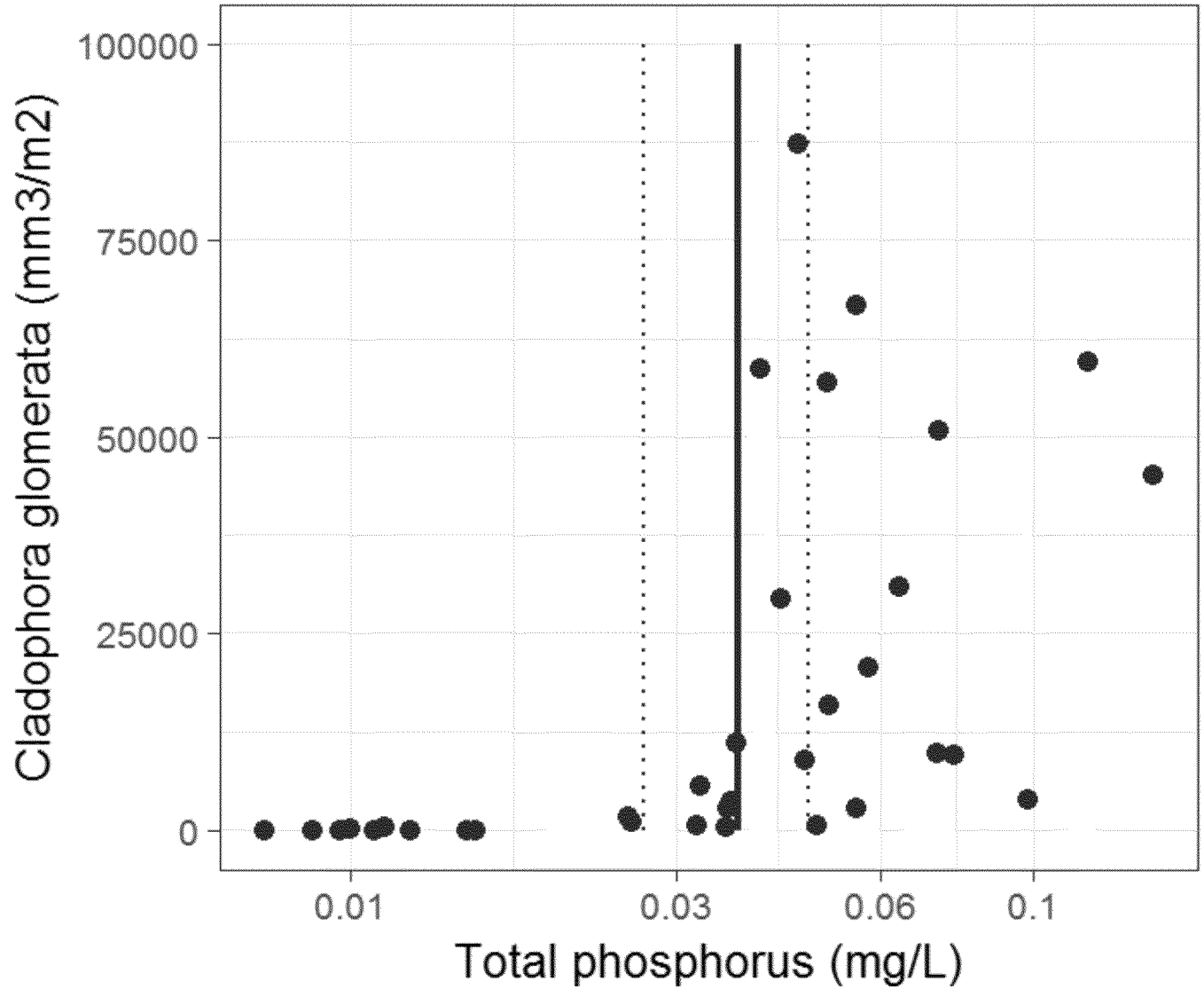




Year 1

Mean *Cladophora* biovolume sharply increased above 0.035 mg/L TP.

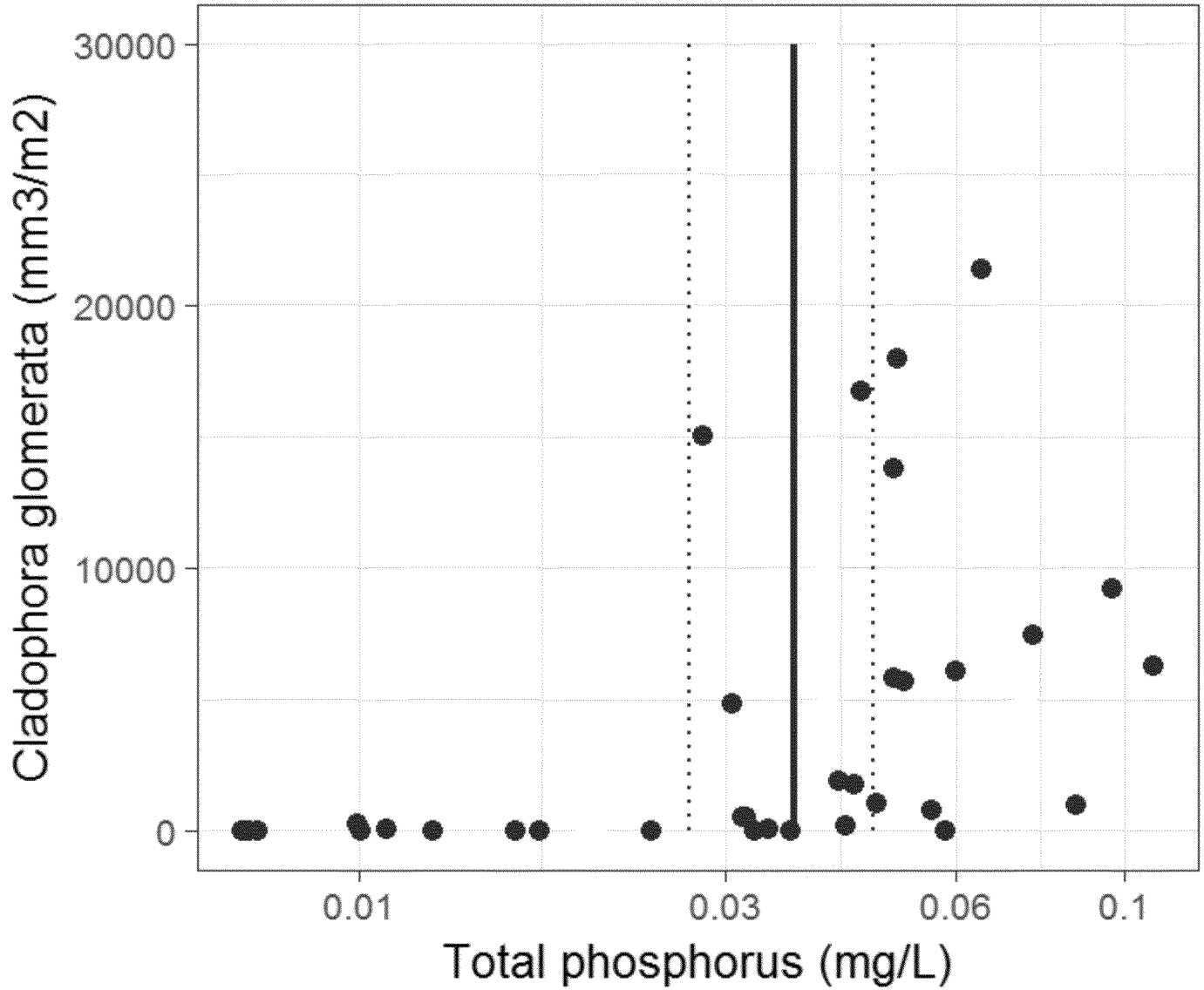
Cladophora was either not present or very low biovolume at low levels of TP.



Year 2

Mean *Cladophora* biovolume again sharply increased above 0.035 mg/L TP.

Only 2 sites below 0.035 mg/L TP had a bloom, whereas 16 of 19 had blooms above this threshold.



Final Report to Governors from the Joint Study Committee and Scientific Professionals

Summary and Recommendations

The committee met between October 2013 and December 2016, selected qualified scientific professionals, developed a scope of work, completed the 2-year joint study, reviewed the results and used a weight of evidence approach to recommend a six-month average total phosphorus level of not to exceed 0.035 milligrams per liter based on water samples collected during critical conditions was necessary to protect the designated [Oklahoma] Scenic Rivers.

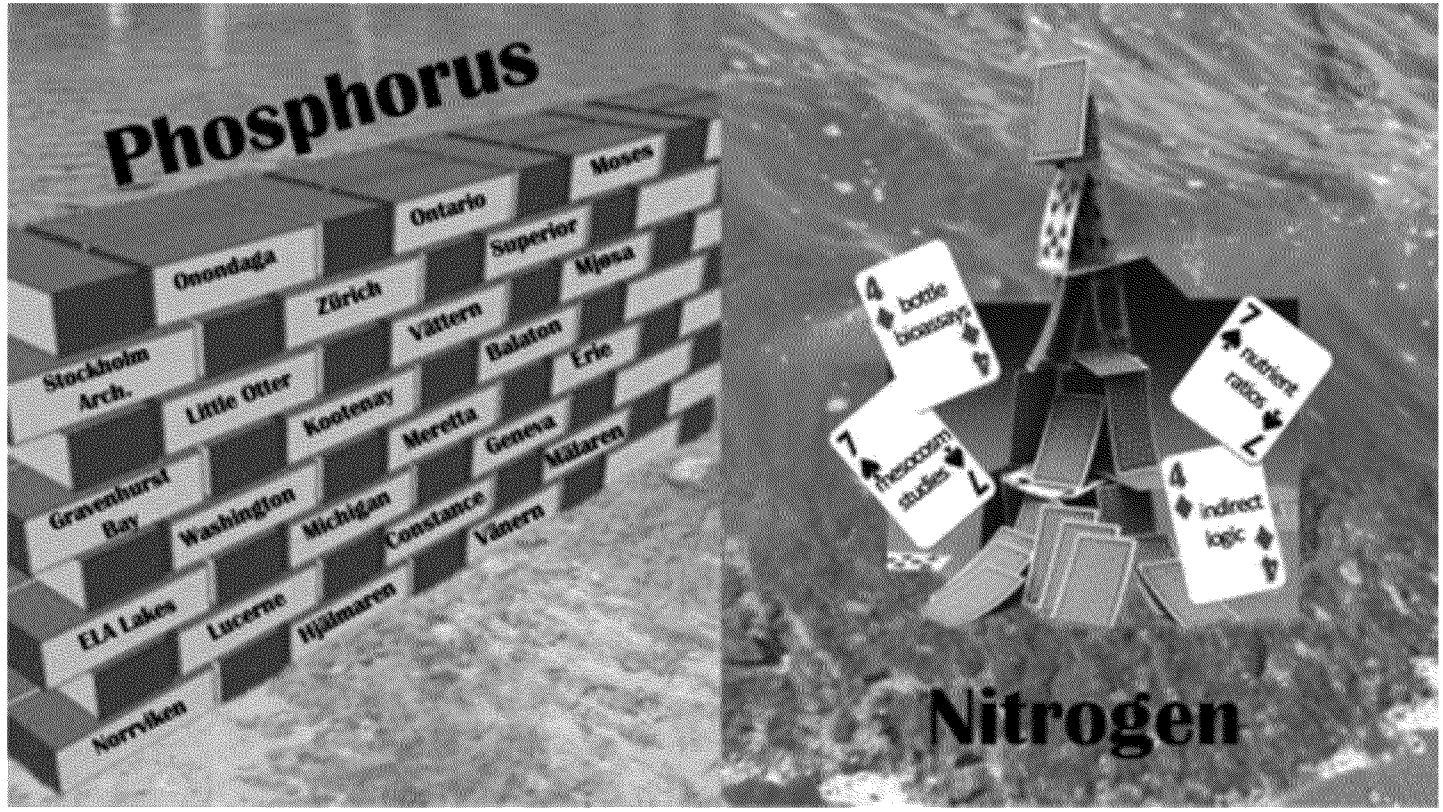
Respectfully Approved December 19, 2016

All flows vs. critical flows?

- All-flow TP is strongly predicted by critical (non-storm) flow TP

- TP criterion based on all flows would have been 2-3x higher than agreement (0.035 mg/L TP)

Reducing Phosphorus to Curb Lake Eutrophication is a Success



Environ. Sci. Technol., Article ASAP
DOI: 10.1021/acs.est.6b02575
Publication Date (Web): September 26, 2016
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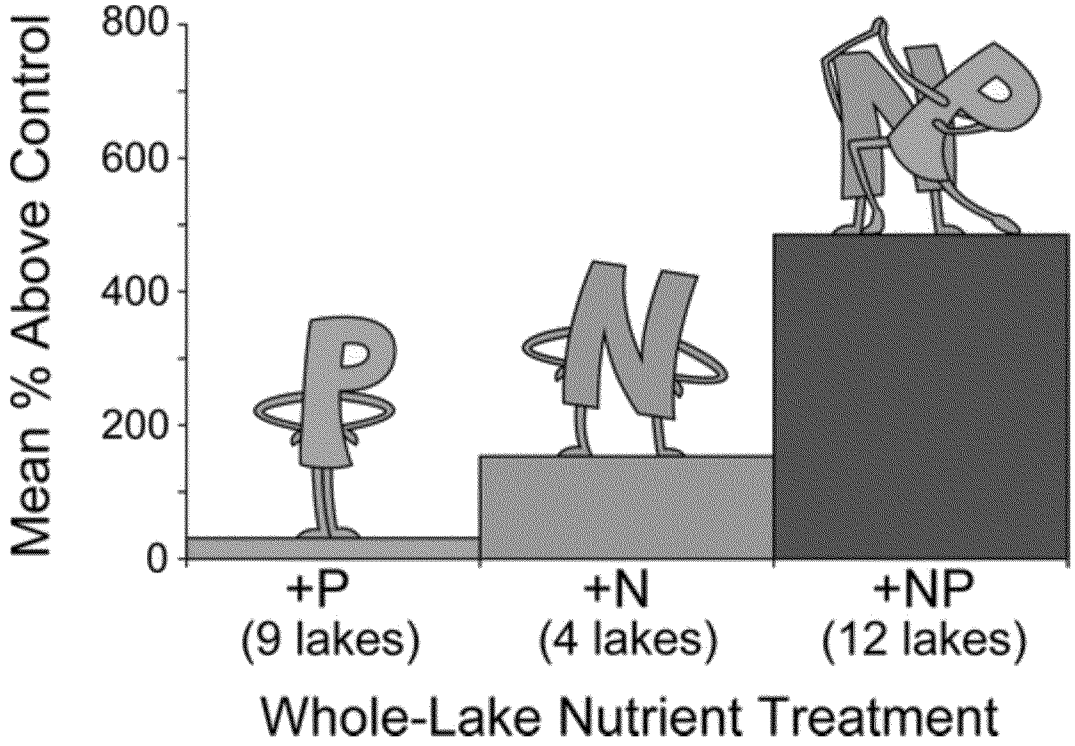
It Takes Two to Tango: When and Where Dual Nutrient (N & P) Reductions Are Needed to Protect Lakes and Downstream Ecosystems



Environ. Sci. Technol., Article ASAP
DOI: 10.1021/acs.est.6b02575
Publication Date (Web): September 26, 2016
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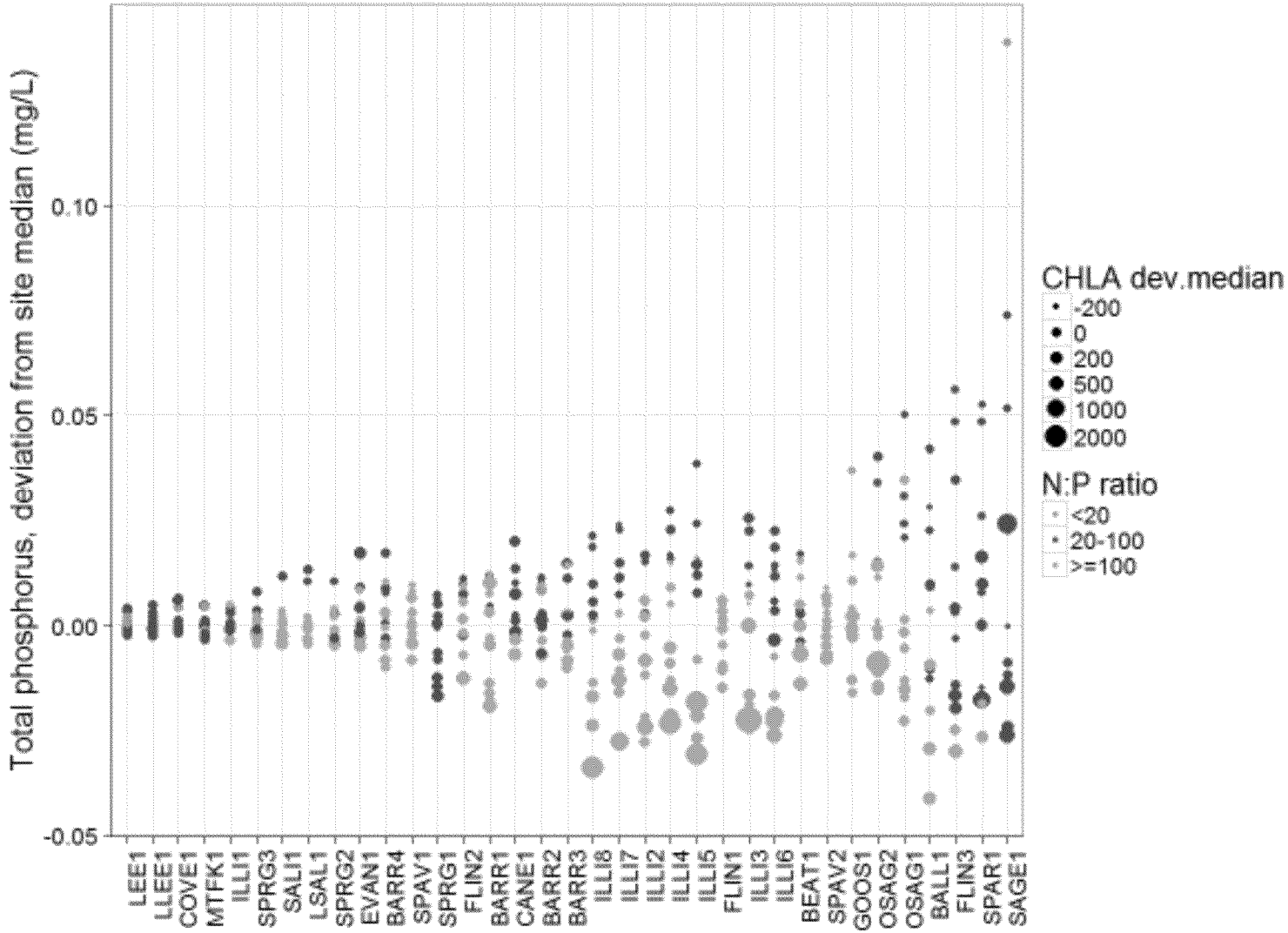
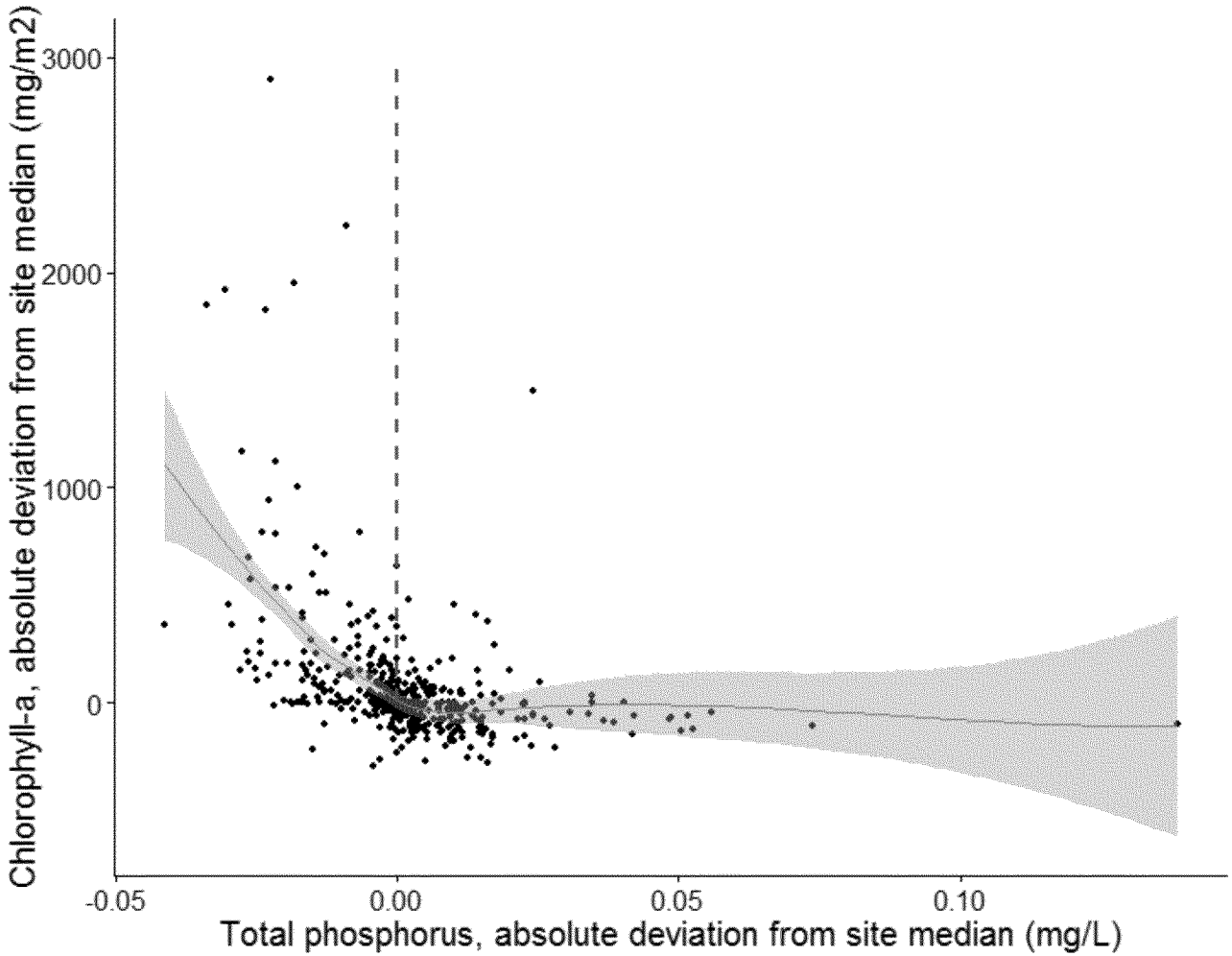
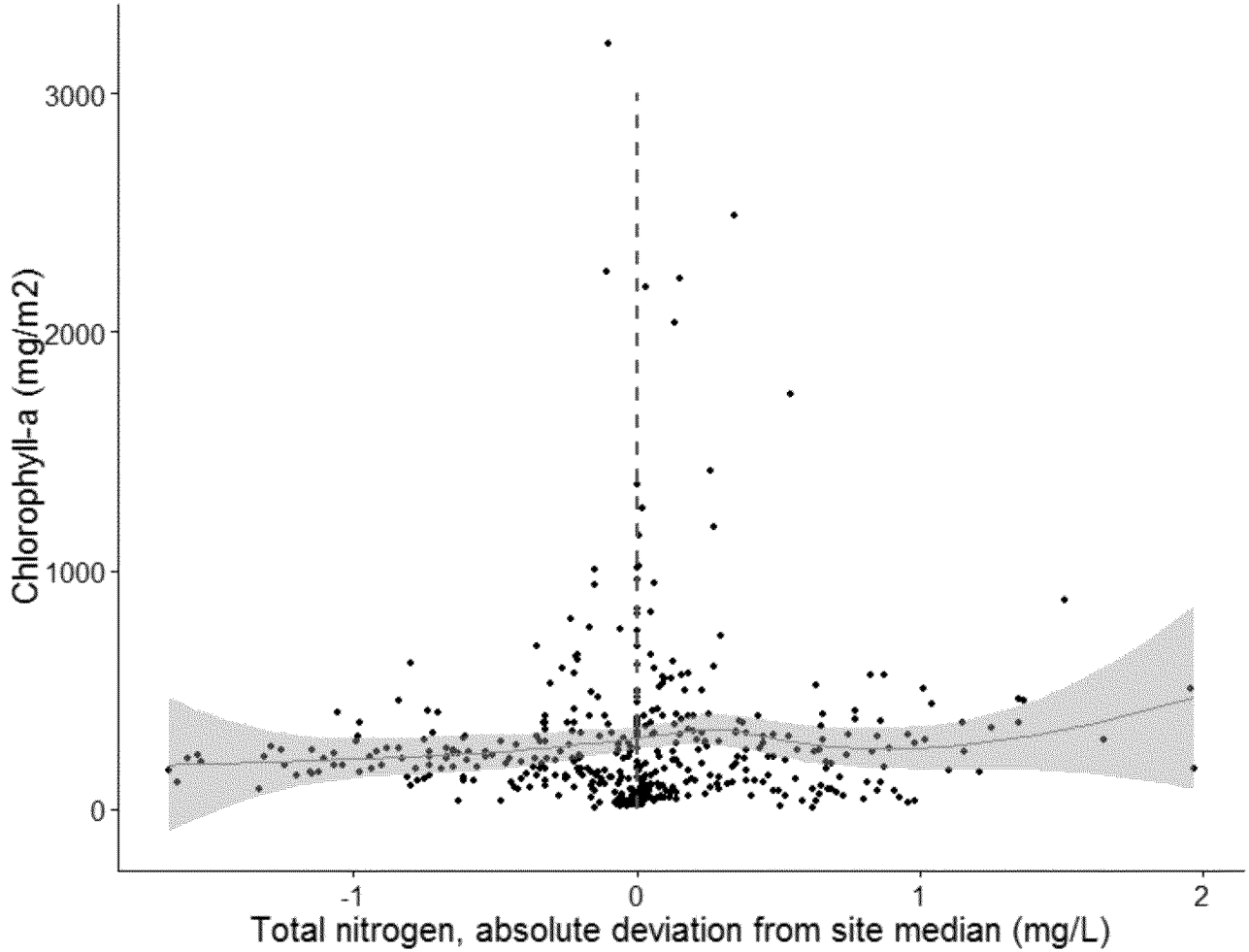
When chlorophyll-a is high, does TP go up, down, or show no definitive change?



When chlorophyll-a is high, does TP go up, down, or show no definitive change?



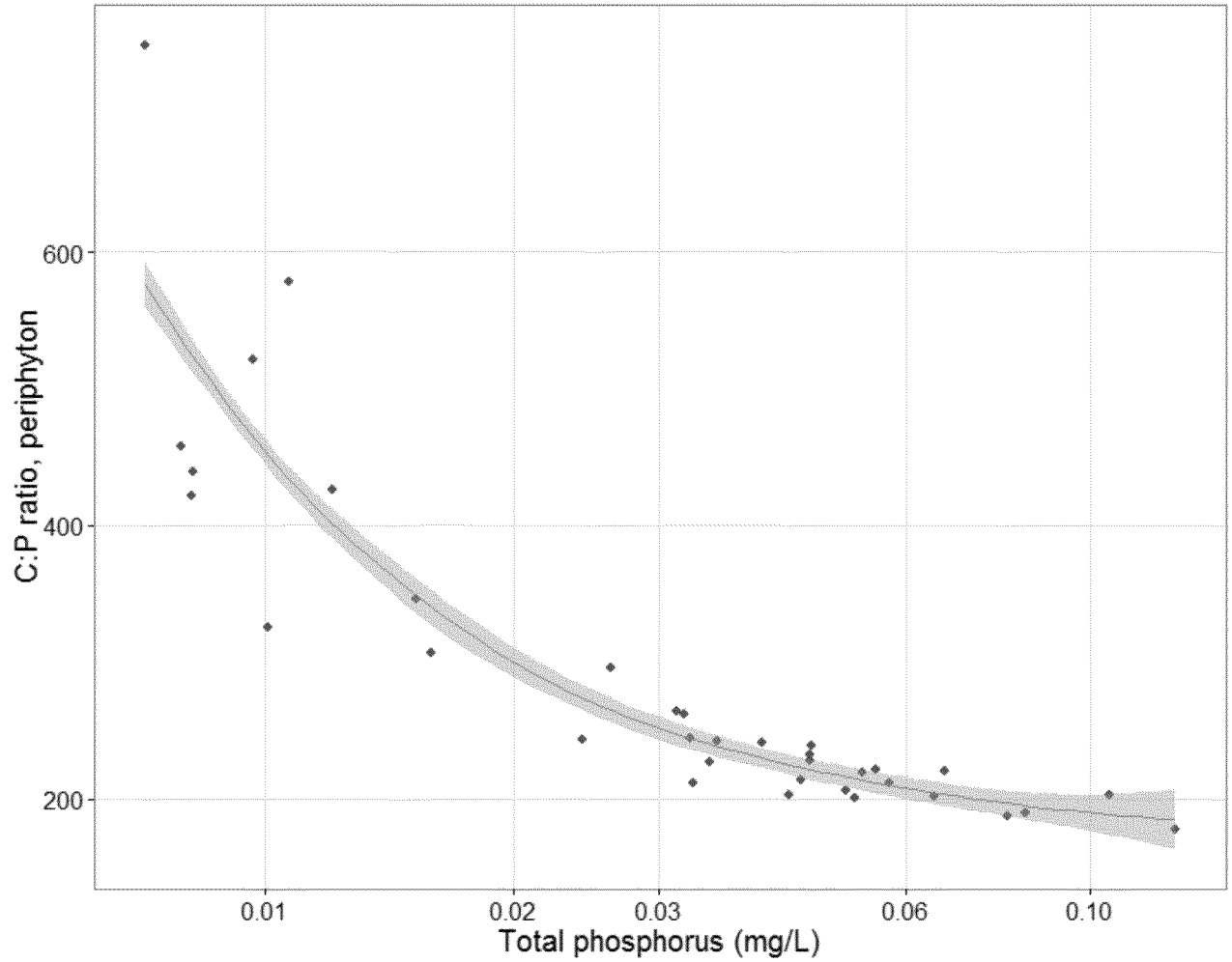
What about total nitrogen?



Periphtyon C:P ratio (lower values equate to more P per unit carbon) strongly, nonlinearly declined with increasing surface-water TP.

Relatively small declines in C:P above 0.035 mg/L TP, indicating the periphyton was nearly saturated, leading to ideal conditions for *Cladophora* blooms.

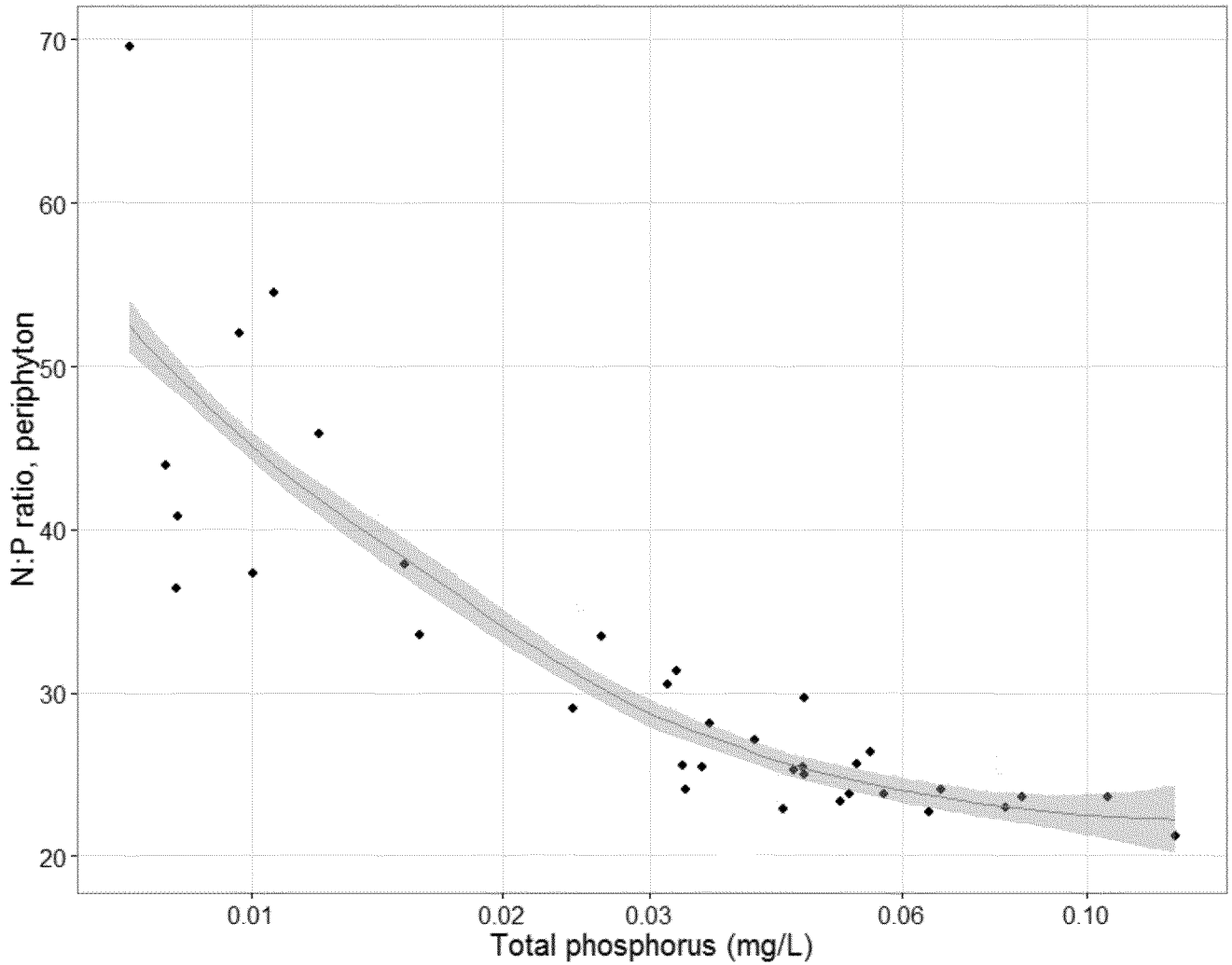
C:P ratio, periphyton, 2 year mean vs. TP



Periphyton N:P ratio (lower values equate to more P per unit nitrogen) also nonlinearly declined with increasing surface-water TP.

In other words, N content was not increasing very much with increasing dissolved N in streamwater, but P increased dramatically.

N:P ratio, periphyton, 2 year mean vs. TP



Summary

- Nuisance algae, specifically *Cladophora*, is very likely to bloom when surface-water TP averages > 0.035 mg/L TP during critical flow conditions.
- Critical flow TP is a very strong predictor of all-flow TP, but all-flow TP averages 2-3x higher than critical flow. Criterion assessment is much easier and defensible using critical flow data.
- Nitrogen is important because it also has to be available for blooms to occur, but it is in much higher supply than P, thus P was controlling blooms.

Implications for other studies

- Gradient design with minimal confounding factors is critical to identify nutrient thresholds. I cannot emphasize this enough. Large substrates! Open canopy (no more than 50% cover). Fast, broken water. Very similar flow regimes.
- Nuisance algal blooms resonate as "problem" with managers/public much more than changes in diatoms, algal metrics, etc., but require repeated sampling to "catch" blooms.
- Existing monitoring data may be helpful, but typically not collected for this purpose and too noisy/confounded, which is why so many states struggle to identify relationships.

Acknowledgments

- Baylor SRJS core team
  - Dr. Jeffrey Back, instrument specialist
  - Katherine Hooker, research technician (BU '14)
  - Morgan Bettcher, research technician
  - Stephen Elser, research technician
  - Caleb Robbins, Ph.D. student, BU
  - Stephen Cook, Ph.D. student, BU
  - Lauren Housley, M.S. student, BU
- Algal taxonomists
  - Dr. Stephen Porter (soft algae)
  - Dr. Barbara Winsborough (diatoms)
- Joint Study Committee
  - Derek Smithee, co-chair (OK)
  - Brian Haggard, co-chair (AR)
  - Shellie Chard (OK)
  - Ryan Benefield (AR, year 2)
  - Shanon Philips (OK)
  - Marty Matlock (AR)
  - Thad Scott (AR, year 1)

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Baylor University

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254-710-2150

Next Numeric Nutrient Criteria Webinar:

Effectiveness of Chlorophyll-based Water Quality Criteria for Protecting Aquatic Life Designated Uses: A Case Study for the James River Estuary

August 16, 2017
3:00 PM Eastern

Paul Bukaveckas,
Virginia Commonwealth University