The Condition of U.S. Lakes and Streams: Findings from the National Aquatic Resource Surveys

Webcast sponsored by EPA's Watershed Academy

Thursday, March 23, 2017 - 1:00pm – 3:00pm Eastern

Instructors:

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- **Dr. Amina Pollard,** Ecologist, Monitoring Branch, U.S. EPA's Office of Water, Washington, DC
- **Dr. Richard Mitchell,** Biologist, Monitoring Branch, U.S. EPA's Office of Water, Washington, DC
- **Dr. John Stoddard,** Research Scientist, U.S. EPA's Office of Research and Development, Corvallis, OR

Webcast Logistics

- **To Ask a Question** – Type your question in the "Questions" tool box on the right side of your screen and click "Send."
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Speakers

- **Sarah Lehmann**, Team Leader for National Aquatic Resource Surveys, Monitoring Branch, U.S. EPA's Office of Water, Washington, DC
- **Dr. Amina Pollard,** Ecologist, Monitoring Branch, U.S. EPA's Office of Water, Washington, DC
- **Dr. Richard Mitchell,** Biologist, Monitoring Branch, U.S. EPA's Office of Water, Washington, DC
- **Dr. John Stoddard,** Research Scientist, U.S. EPA's Office of Research and Development, Corvallis, OR

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Overview of Today's Webcast

- Overview of the National Aquatic Resource Survey (NARS)
- Key findings of the National Lakes Assessment (NLA) 2012
- Key findings of the National Rivers and Streams Assessment (NRSA) 2008/09
- Findings from a supplemental analysis that found widespread increases in the amount of phosphorus in oligotrophic lakes and streams in the U.S.

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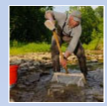
The National Aquatic Resource Surveys – An Overview

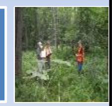
Lakes

Coastal



Rivers and Streams

Wetlands



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Presentation Outline

- Background
- NARS Approach
- Accomplishments
- Status

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What is NARS?

Coastal *Streams and Rivers* *Wetlands* *Lakes*

- Series of surveys implemented by EPA and our state and tribal partners addressing 4 waterbody types
- Program to assess all surface waters within the 48 conterminous states
- A cost effective, nationally consistent, regionally relevant means of tracking status and trends
- Program that builds from almost 20 years of research and pilots

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Purpose of the National Aquatic Resource Surveys

- **Assess biological and recreational condition and change over time**
- **Document associations between indicators of condition and indicators of stress**
- **Build/enhance state monitoring and assessment capacity**

Why is NARS important?

Provides national assessments

- Address gaps in information about the condition of the nation’s waters with statistical confidence.
- Reports used as water quality outcome measures of progress tracking protection and restoration nationally.

Supports national priorities

- Reports and ancillary analyses support nutrient pollution and habitat protection efforts
- Supplemental analyses shows increases in phosphorus in our least impacted rivers/streams and lakes
- Critical data set for identifying and responding to concerns about algal toxins

Complements state and local monitoring

- Reports extent of degradation and risk key stressors pose to water quality at national and regional scales.
- State and local monitoring are key to informing local priorities for site specific restoration actions and watershed protection.

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National Consistency: NARS Approach

- Randomized design to report on condition of each resource nationally and regionally
  - 1,000 sites in lower 48

- Standard field and lab protocols
- National QA and data management
- Nationally consistent and regionally relevant data interpretation and peer-reviewed reports

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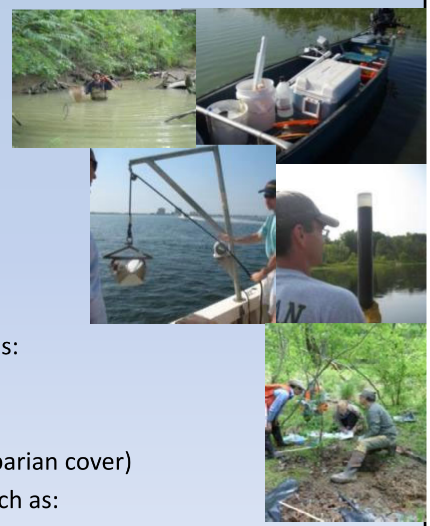
Types of Survey Indicators and Measures



Biological indicators such as:
- Benthic macroinvertebrates
- Plants
- Fish community

Public health indicators such as
- Fish tissue
- Pathogens (e.g., enterococci)
- Microcystins and other algal toxins

Occurrence and extent of key **stressors** such as:
- High levels of nutrients
- Excess sediment
- Physical habitat characteristics (e.g. riparian cover)

May include pertinent **research indicators** such as:
- Sediment enzymes
- Contaminants of emerging concern

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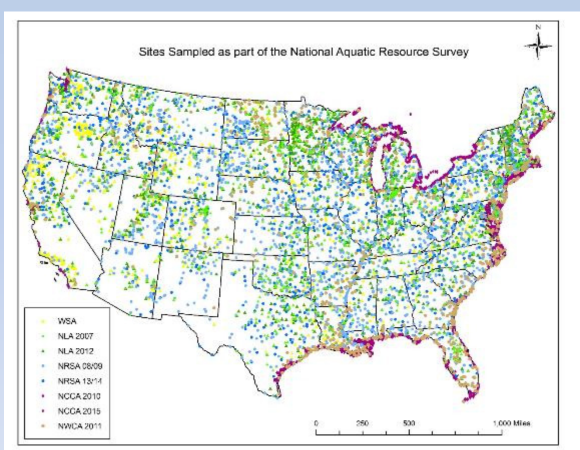
Accomplishments



- First ever, nationally consistent assessments of coastal waters, lakes and reservoirs, rivers and streams, and wetlands including information on changes.
- Assessments address ecological and human-health indicators; stressors; and changes over time
- Expanded/strengthened state, tribal and interagency partnerships

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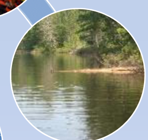
Comprehensive, consistent, and statistically-valid assessments

Results: Increased ability to report on the condition of our waters

Coastal: >35,000 square miles a **40% increase** from 2004



Lakes: >110,000 lakes which **substantially increases** the assessed acres since 2004

Rivers/streams: >1.2 million miles more than **doubling the assessed miles** since 2004

Wetlands: >60,000,000 acres resulting in a **30 fold increase** since 2004

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Status

Analysis/Reporting

- NRSA 2013-14 – Draft Report Development Underway
- NCCA 2015 – Data Analysis getting started

Data Collection/Laboratory Efforts

- NWCA 2016 – Finished field season, samples being processed by labs
- NLA 2017 – Field training is starting in preparation for summer sampling
- NRSA 2018-2019 – Planning and preparations have already begun. Design completed and indicators selected

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Acknowledgements

- State and Tribal partners
- Federal partners
  - Fish and Wildlife Service
  - NRCS Soil Survey
  - U.S. Geological Survey
  - National Park Service
  - U.S. Forest Service, Army Corps of Engineers, NOAA
- Academic Institutions
- EPA Office of Research and Development and EPA Regions

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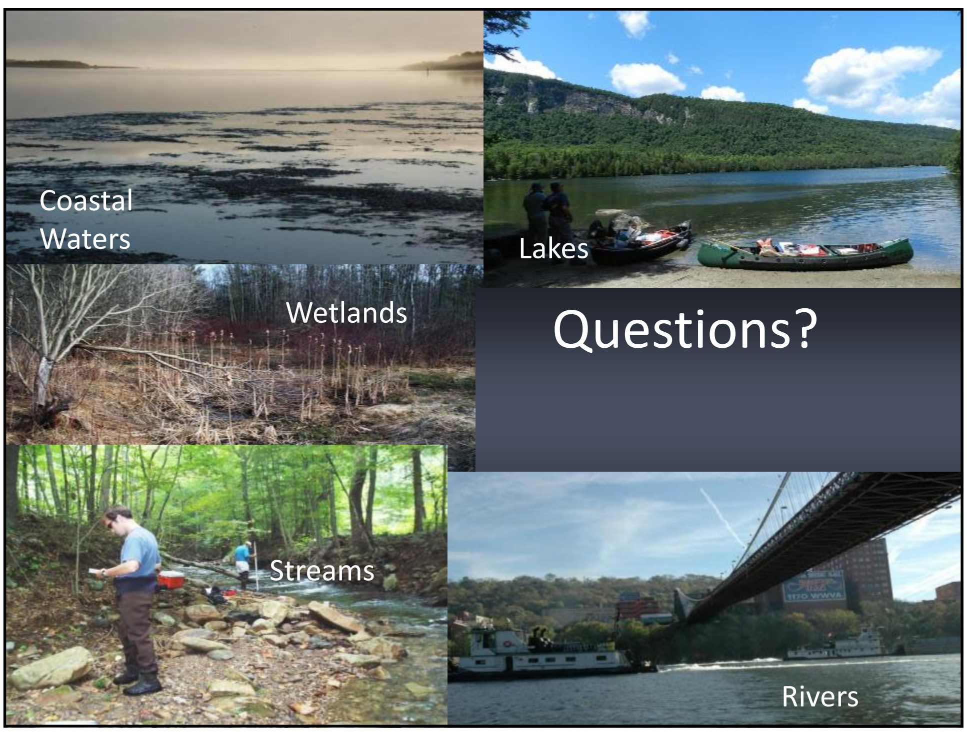

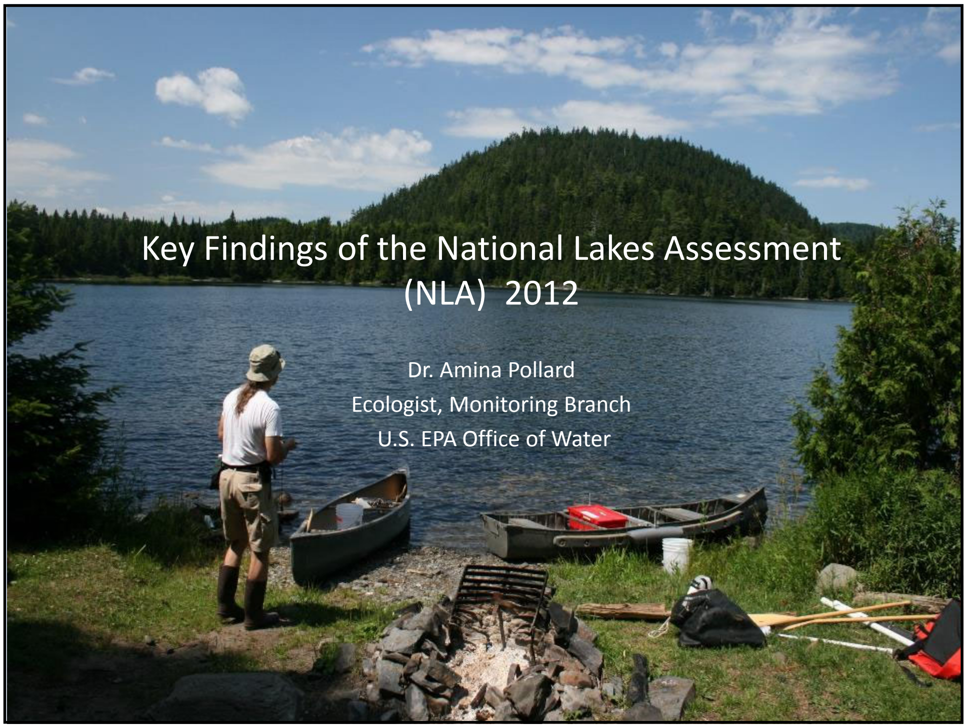

Presentation Outline

1. Introduction to the National Lakes Assessment 2012 (NLA)
   - ✓Objectives and design
2. Findings for key indicators
   - ✓Phosphorus, benthic macroinvertebrates, riparian vegetation, microcystin
3. Data and dashboard

National Lakes Assessment 2012

Objectives of the NLA:

- What is the current biological, chemical, physical, and recreational condition of U.S. lakes?
- How is the condition changing over time?

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NLA 2012 Assessment Design

- Using a statistically representative process, selects 1,000 lakes, ponds and reservoirs across the conterminous U.S. from the national map of waterbodies (NHDPlusv2)
  - ✓ Size: greater than or equal to one hectare
  - ✓ Depth: greater than or equal to one meter
- Represents 111,800 lakes across the nation

- Excludes Great Lakes; coastal lakes; treatment, disposal or stock ponds; ephemeral lakes

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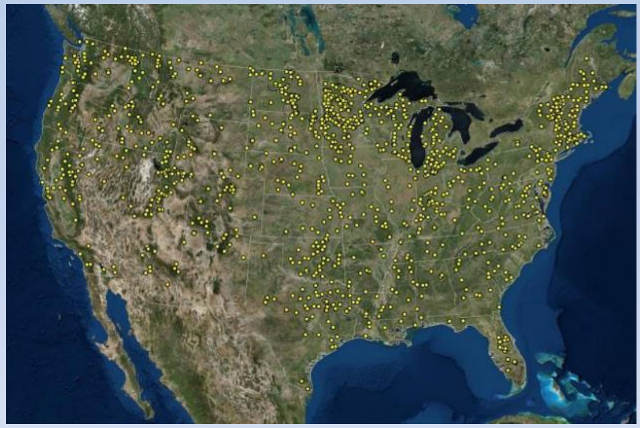
Sites Sampled for the NLA 2012



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NLA 2012 Assessment Indicators

- **Water chemistry**
    - Phosphorus, nitrogen, dissolved oxygen, acidification, trophic state
- **Biological assemblages**
    - Benthic macroinvertebrates and zooplankton
- **Physical habitat**
    - Riparian vegetation cover, shallow water habitat, lakeshore disturbance, lake habitat complexity, lake drawdown exposure
- **Recreation**
    - Algal toxins (e.g., microcystin risk and detected), atrazine pesticide screen, chlorophyll a (risk), mercury (methyl and total)

Assessment Benchmarks

Two types of benchmarks were used to determine condition:

1. Nationally-consistent, literature-defined
   Screening benchmarks (WHO for algal toxins)

2. Regionally-relevant, NLA-defined
   Minimally-disturbed condition
   Fixed percentiles define condition designation
   Applied to biological, habitat, and nutrient indicators

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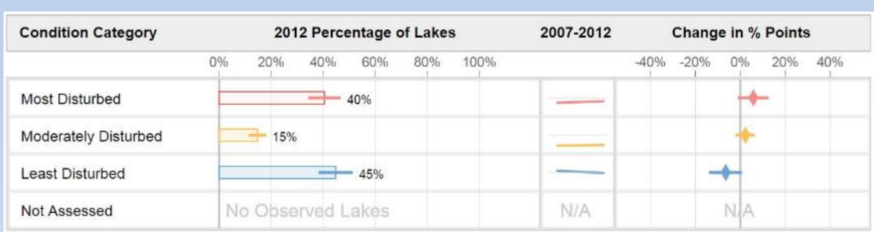
Phosphorus (Total)

2012 National Estimates and Change from 2007

Percentage of lakes in each condition category



USEPA NLA 2012

- 40% of the population shows signs of phosphorus pollution; no change in the proportion in most disturbed condition

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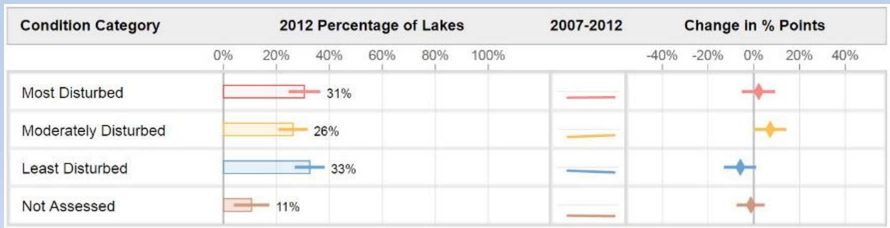
Benthic Invertebrates

2012 National Estimates and Change from 2007

Percentage of lakes in each condition category



USEPA NLA 2012

- 31% of the population is in degraded biological condition; no change in the proportion in most disturbed condition
- Lakes with phosphorus pollution are 2.2 times as likely to have degraded benthic invertebrate communities

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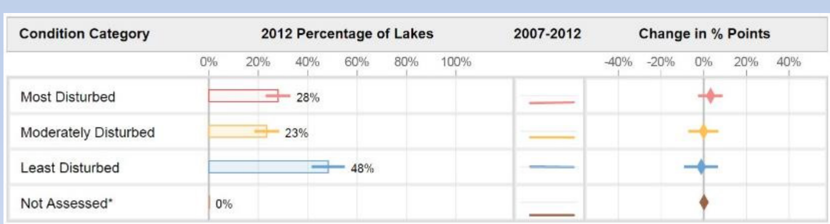
Riparian Vegetation Cover

2012 National Estimates and Change from 2007

Percentage of lakes in each condition category



USEPA NLA 2012

- 28% of the population is in most disturbed condition; no change in the proportion of the population in most disturbed condition

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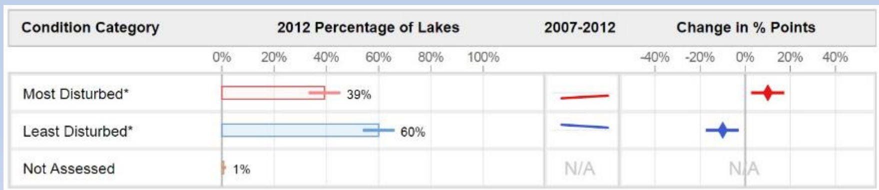
Microcystin (Detected)

2012 National Estimates and Change from 2007

Percentage of lakes in each condition category



USEPA NLA 2012

- 39% of the population had detections; statistically-significant increase (+9.5%) in detections
- Although detections are common, concentrations reach WHO risk to recreation levels in 0.7% of the population, which is similar to NLA 2007 findings

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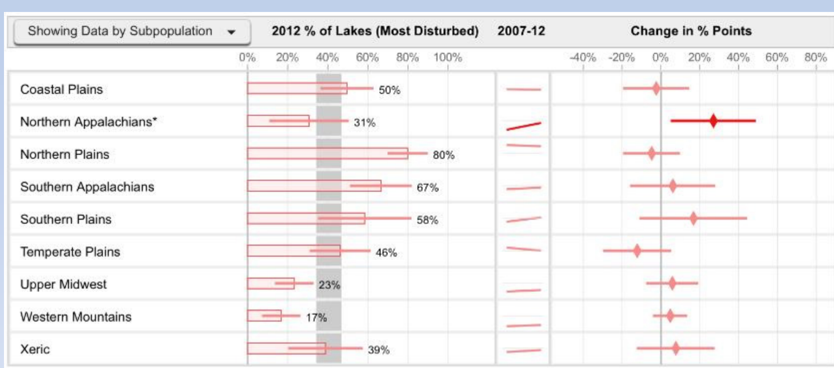
Phosphorus (Total)

2012 Estimates and Change from 2007

Percentage of lakes in most disturbed condition – NLA Ecoregions



USEPA NLA 2012

- Conditions vary across the country

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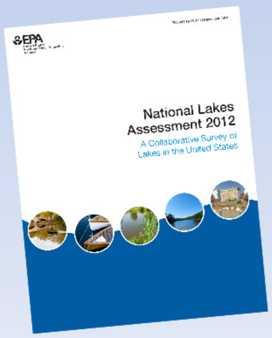
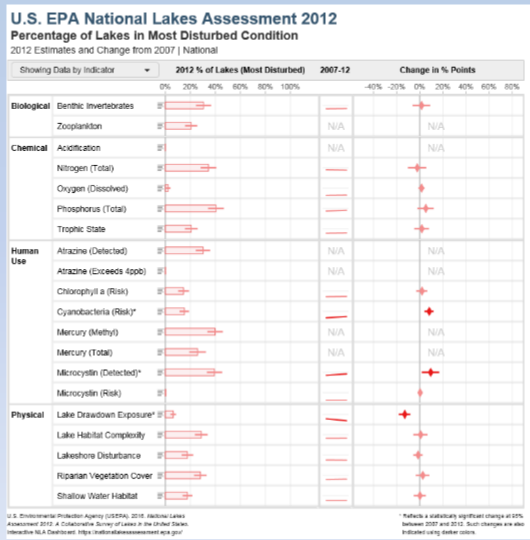
Read, Explore and Analyze

- The NLA report
- Data – including a new file with the "top 50" NLA data elements
- New interactive dashboard for exploring results





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For more information on the NLA 2012

National Lakes Assessment:

- https://www.epa.gov/national-aquatic-resource-surveys/nla

Ecoregional Results:

- https://www.epa.gov/national-aquatic-resource-surveys/ecoregional-results-national-lakes-assessment-2012

NLA Data Dashboard

- https://nationallakesassessment.epa.gov/

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National Rivers and Streams Assessment: 2008/2009 Final Results

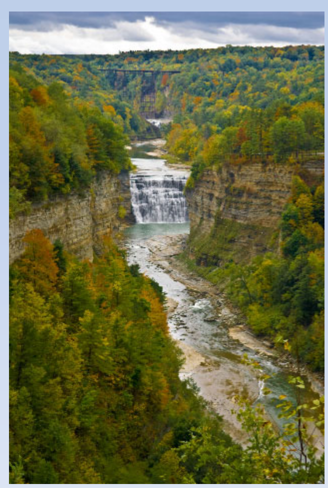
Dr. Richard Mitchell
Biologist, Monitoring Branch, U.S. EPA Office of Water

Presentation Outline

- Overview of NRSA 2008/09
- Summary of key findings
  - National and ecoregional results: benthic macroinvertebrates, total nitrogen, total phosphorus
  - Change analysis
  - Relative/Attributable risk

NRSA 2008/2009 Results

- Indicators
  - Biological
    - Benthic macroinvertebrates
    - Fish
  - Chemical
    - Nutrients (total nitrogen and phosphorus)
    - Acidification
    - Salinity
  - Physical Habitat
    - Excess streambed sediments
    - In-stream fish habitat
    - Riparian vegetation cover
    - Riparian disturbance
  - Enterococci
  - Mercury in fish tissue



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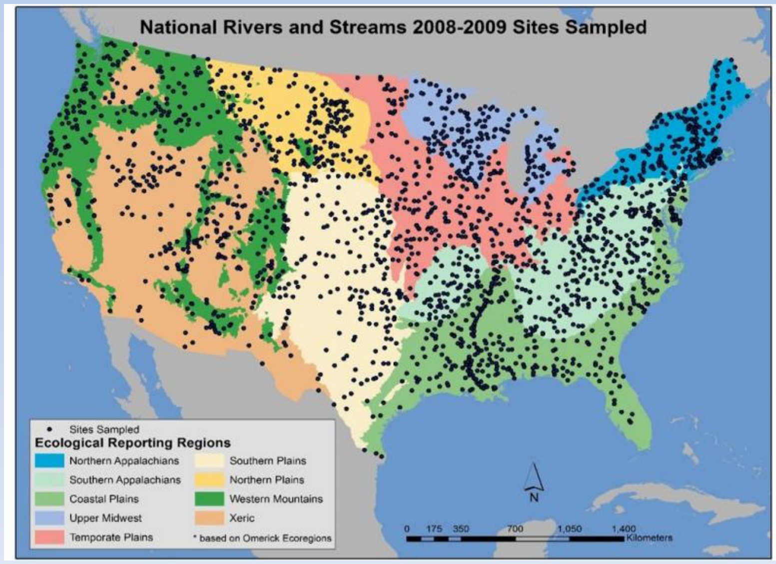
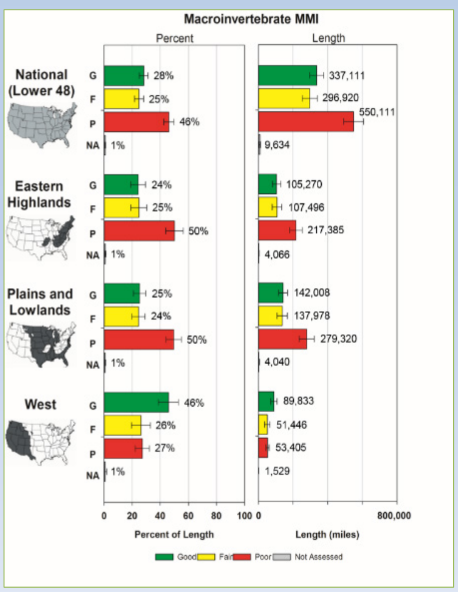
Sites Sampled for the NRSA 2008/09

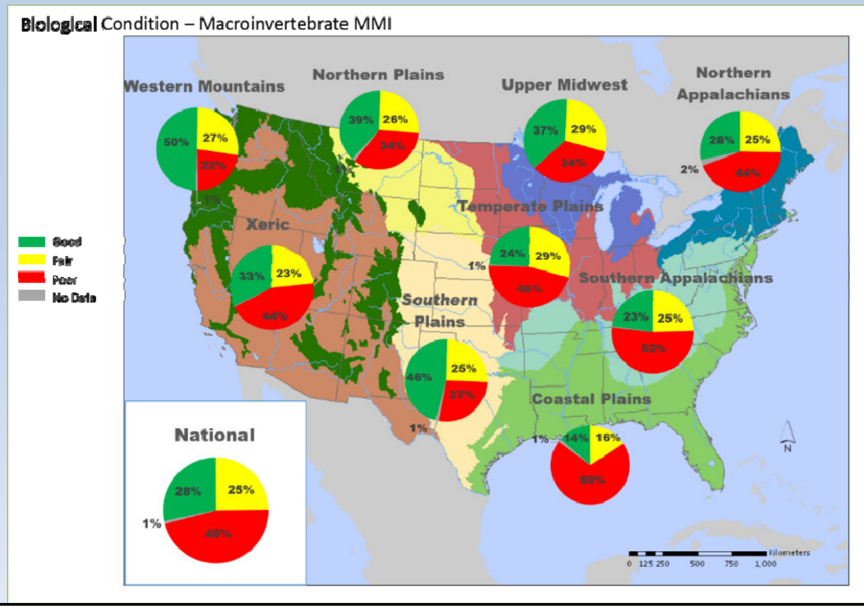


Benthic Macroinvertebrates MMI

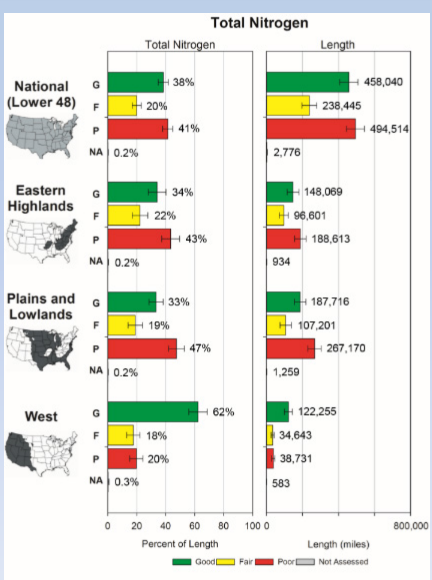


- 46% of river/stream miles are rated poor for biology
- Similar results in the Eastern Highlands and Plains
- Only 27% of river/stream miles are rated poor for biology in the West

Benthic Macroinvertebrate MMI



Total Nitrogen



- Nationally, 41% of river/stream miles are rated poor for total nitrogen
- Similar results in the Eastern Highlands and Plains
- Only 20% of river/stream miles are rated poor for total nitrogen in the West

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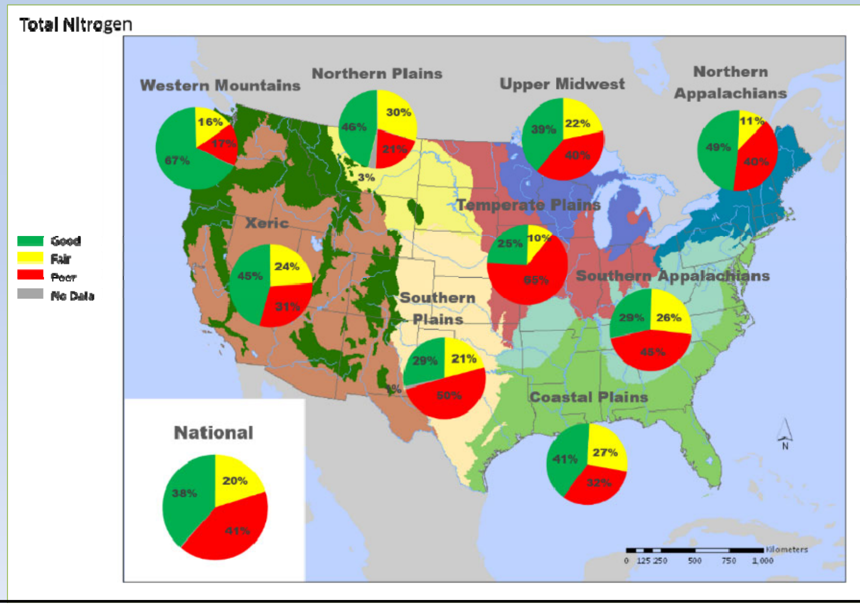
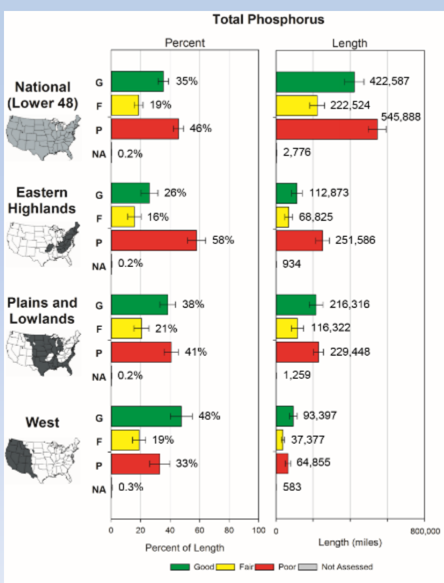
Ecoregion Total Nitrogen



Total Phosphorous



- Nationally, 46% of river/stream miles are rated poor for total phosphorus
- Eastern Highlands had the highest percentage (58%) of miles in poor condition, and the West had the lowest percentage (33%)

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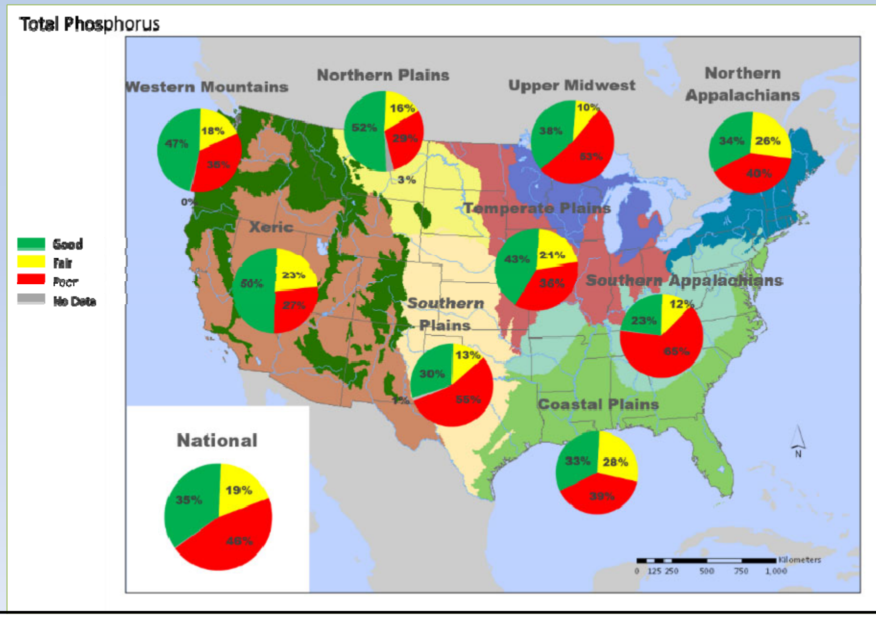
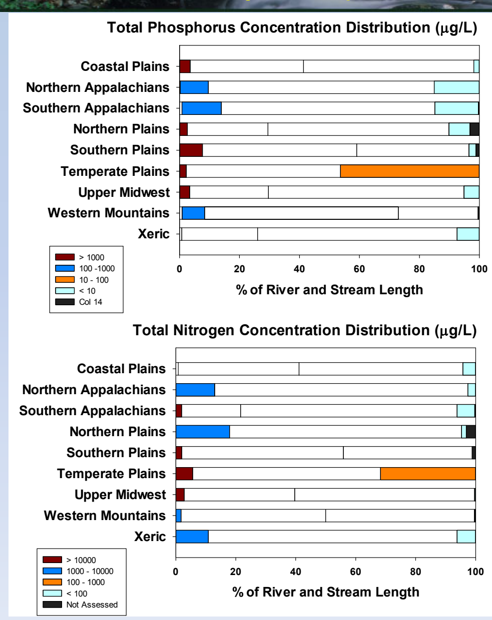
Ecoregion Total Phosphorus



Comparing Ecoregions by Concentrations (Nitrogen and Phosphorus)



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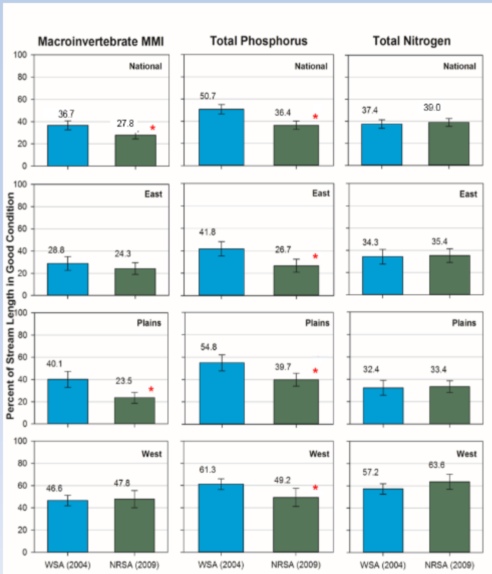
Change in Stream Condition 2004 to 2008/2009; Percent of Streams Rated As Good



- Biology showed significant decreases in stream miles rated as good between 2004 and 2008/2009
- Total phosphorus showed a significant decreases in stream miles rated as good between 2004 and 2008/2009
- Total nitrogen showed no significant change between 2004 and 2008/2009, either nationally or regionally

*Statistically significant

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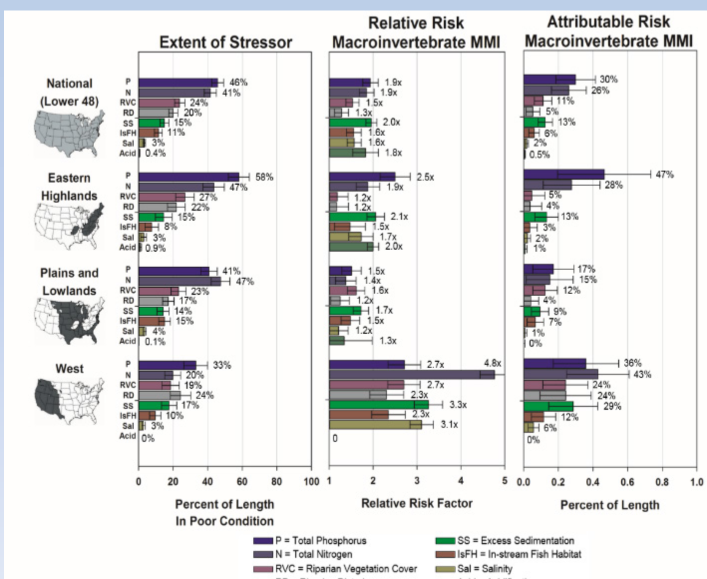
Relative Stressor Extent and Relative and Attributable Risk for Benthic Macroinvertebrates



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Continental-Scale Increase in Lake and Stream Phosphorus: Are Oligotrophic Systems Disappearing in the U.S.?

EPA

John L. Stoddard, John van Sickle, Alan T. Herlihy, Janice Brahney,
Steven G. Paulsen, David V. Peck, Richard Mitchell, Amina Pollard

March 23, 2017

Stoddard, J. L., J. Van Sickle, A. T. Herlihy, J. Brahney, S. Paulsen, D. V. Peck, R. Mitchell, and A. I. Pollard. 2016. Continental-Scale Increase in Lake and Stream Phosphorus: Are Oligotrophic Systems Disappearing in the United States? *Environmental Science & Technology* **50:3409-3415.**

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What You Need to Know about Phosphorus

- Phosphorus is a required nutrient for life
- It is generally considered THE limiting nutrient in freshwaters
- Common element in soils and bedrocks, particularly those derived from marine sediments
- It tends to stay put, unless mined (source of most P for fertilizers and industrial use) or eroded
- Movement of phosphorus through the environment is mostly as particulates
- Common anthropogenic sources of phosphorus to freshwaters:
    - Agricultural runoff
    - Stormwater runoff
    - Wastewater runoff

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Why do we care? Phosphorus limits algal growth in most freshwaters

Lake 226, Experimental Lakes Area – Whole Lake Phosphorus Addition

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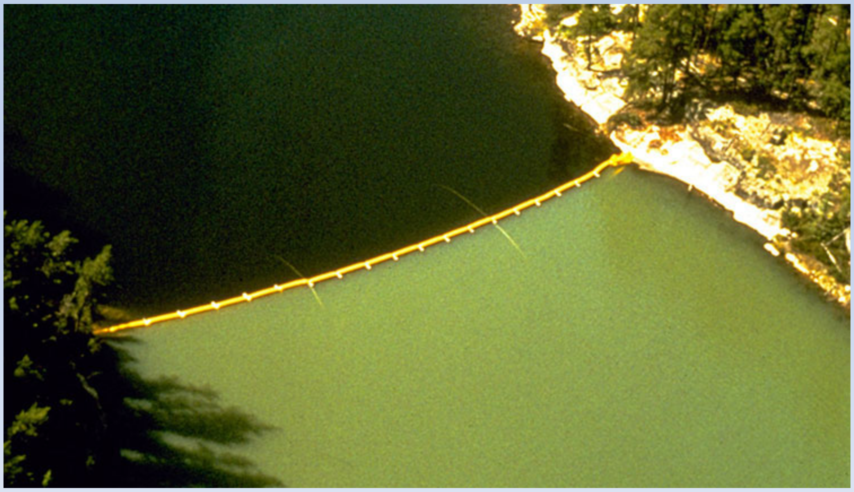
Why do we care? Phosphorus limits algal growth in most freshwaters

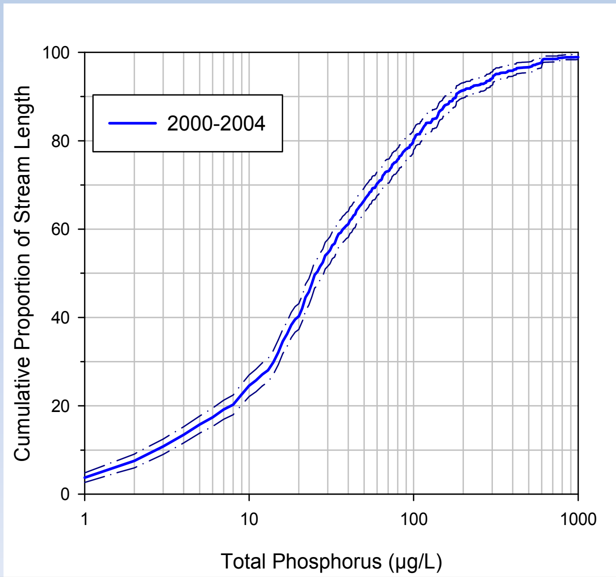


Lake 226, Experimental Lakes Area – Whole Lake Phosphorus Addition

Why do we care? Phosphorus limits algal growth in most freshwaters

Lake Erie, 2011

Total Phosphorus in NARS Stream Surveys



2004 median = 26 µg/L

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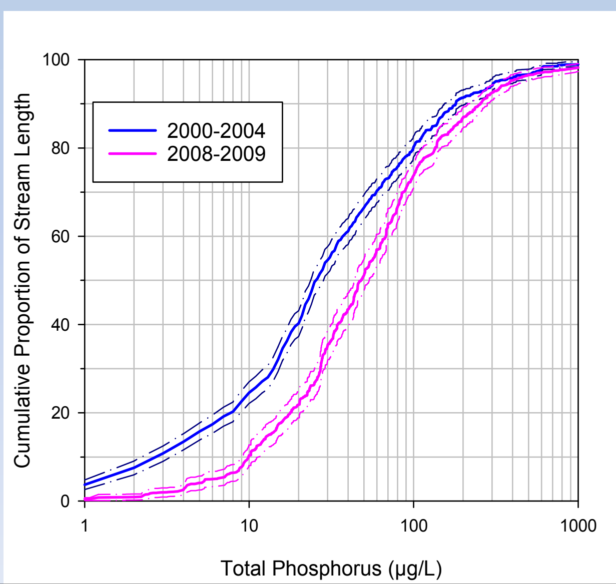
Total Phosphorus in NARS Stream Surveys



2004 median = 26 µg/L
2009 median = 48 µg/L

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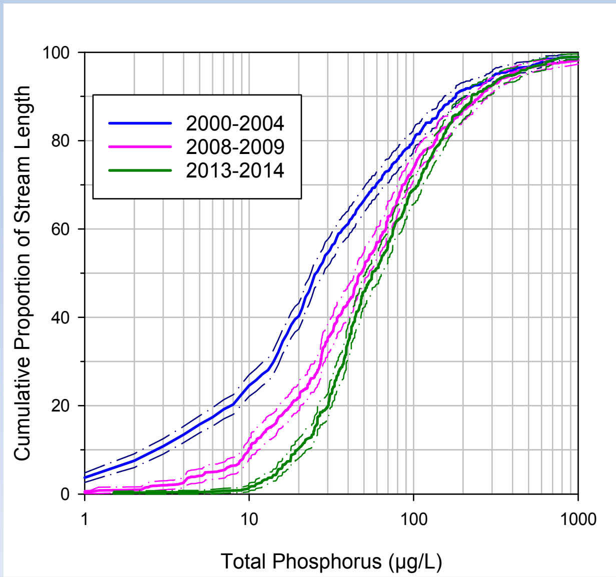
Total Phosphorus in NARS Stream Surveys



2004 median = 26 µg/L
2009 median = 48 µg/L
2014 median = 56 µg/L

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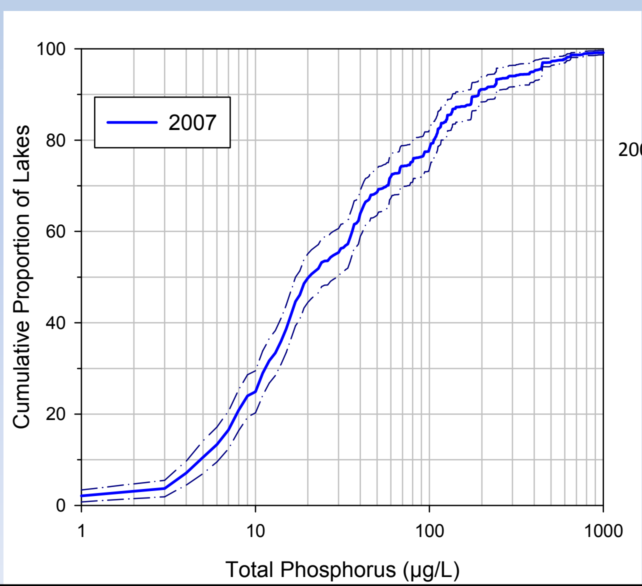
Total Phosphorus in NARS Lake Surveys



2007 median = 20 µg/L

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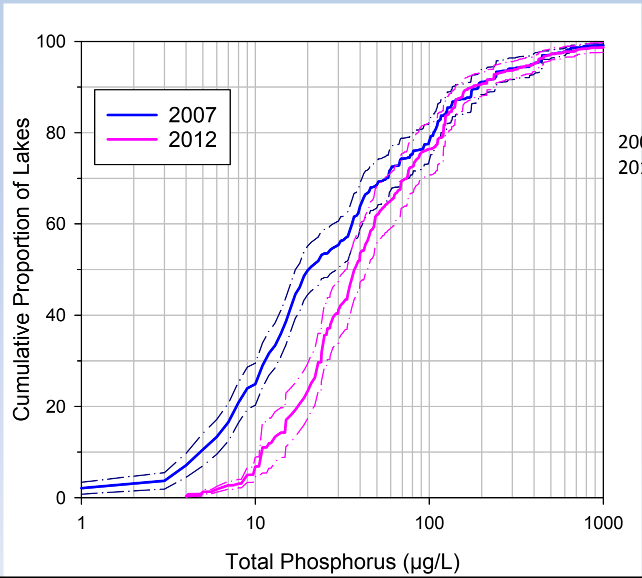
Total Phosphorus in NARS Lake Surveys



2007 median = 20 µg/L
2012 median = 37 µg/L

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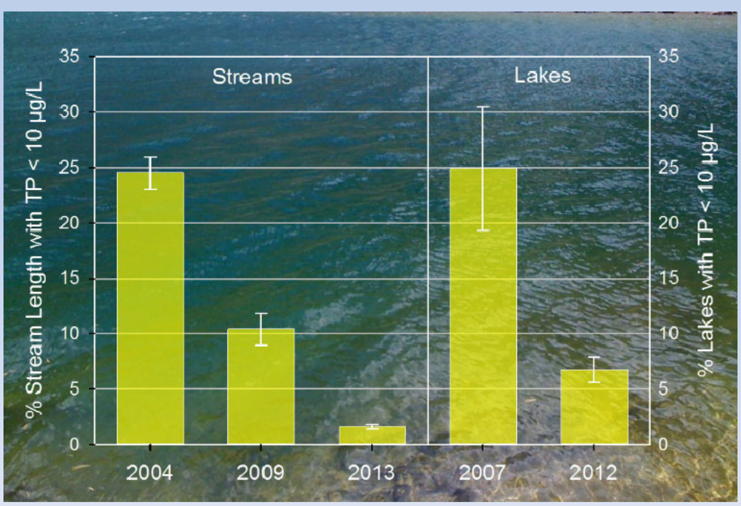
Oligotrophic Systems – Population Estimates



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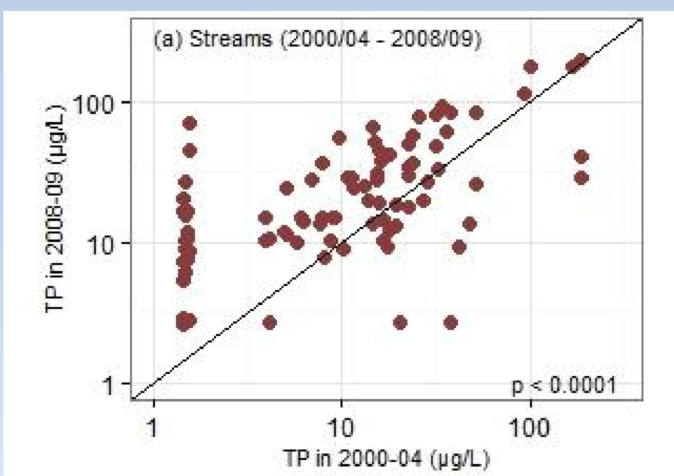
Creation of Reference Site Dataset

Least-Disturbed catchments from each survey:

- < 5% agricultural land use
- < 1.5% urban land use
- < 2 km km^{-2} road density
- riparian disturbance index values < 1.25

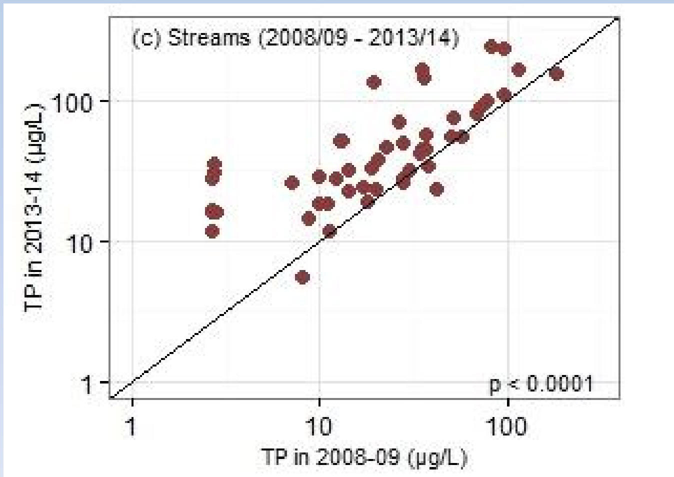
Focused analysis on re-surveyed (overlap) sites located in catchments that pass all of these criteria

Reference Site Comparisons



Median change = +2.2 μg L^{-1} yr^{-1}

Reference Site Comparisons



Median change =
+2.9 $\mu g\ L^{-1}\ yr^{-1}$

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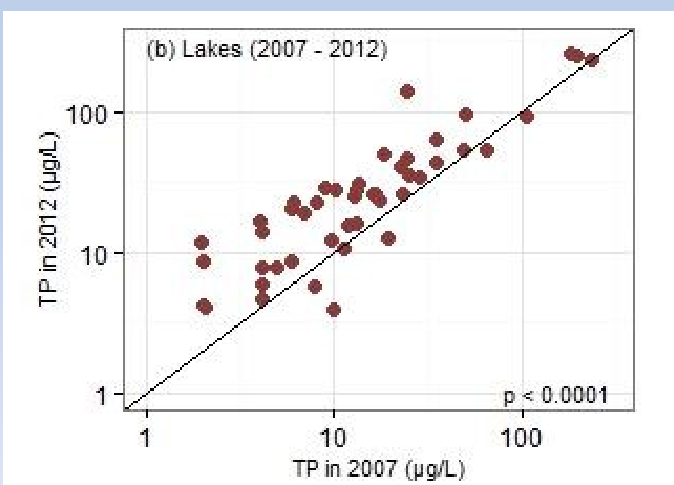
Reference Site Comparisons



Median change =
+1.6 $\mu g\ L^{-1}\ yr^{-1}$

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Oligotrophic Systems – Detectable Phosphorus

	Years	Method Detection Limit (MDL) (μg L^{-1})	% of population<MDL
Streams	2000-2004	3.1	10.8%
	2008-2009	5.5	0.4%
	2013-2014	4.0	0.3%
Lakes	2007	3.9	7.1%
	2012	2.9	0%

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Potential Mechanisms

Possible reasons for phosphorus changes:

- Data Quality
  - One lab analyzed all samples
  - No methods changes in lab or field
  - Quality assurance is extensive and thorough

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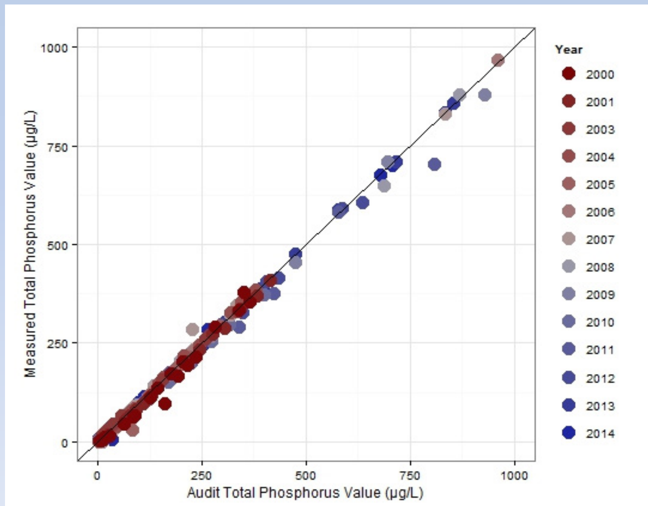
Potential Mechanisms

Results of Blind Audit Analyses, 2000-2014



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Potential Mechanisms

Possible reasons for phosphorus changes:

- Data Quality
  - One lab analyzed all samples
  - No methods changes in lab or field
  - Quality assurance is extensive and thorough
- Increases from agricultural/wastewater/stormflow runoff (the classics)
  - Not consistent with notable increases in reference sites
  - Should increase both N and P (but doesn't)

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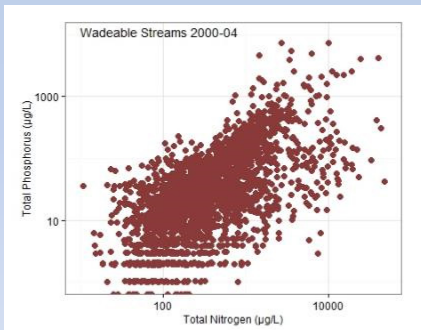
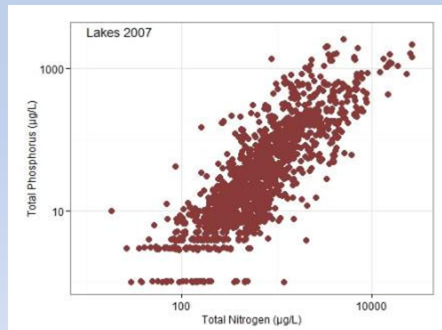
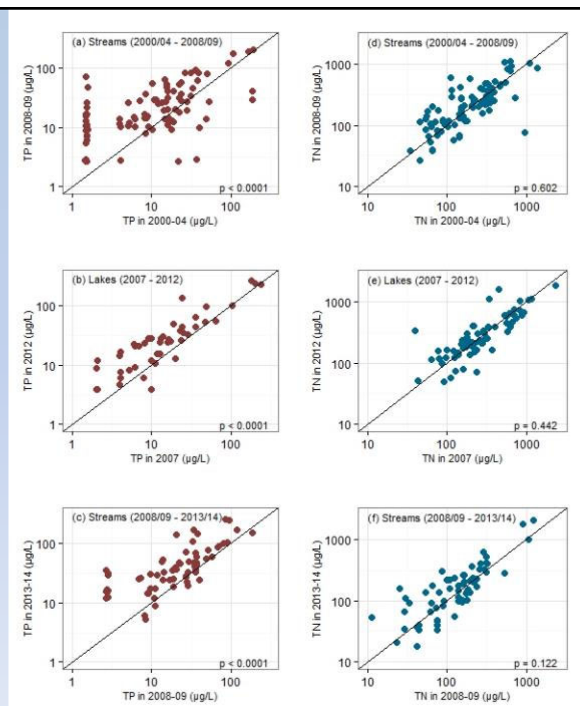
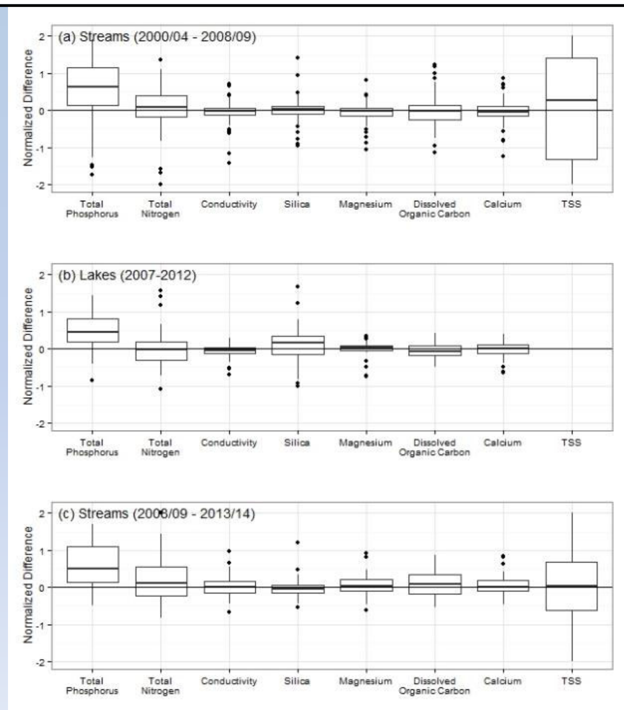
Potential Mechanisms

N and P usually very correlated with one another:









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Potential Mechanisms

Possible reasons for phosphorus changes:

- Data Quality
  - One lab analyzed all samples
  - No methods changes
  - Quality assurance is extensive and thorough
- Increases from agricultural/wastewater/stormflow runoff (the classics)
  - Not consistent with notable increases in reference sites
  - Should increase both N and P (but doesn't)
- Changes in hydrology
  - Because Total P is associated with particulates, increased flow might explain differences between N and P
  - But . . . .

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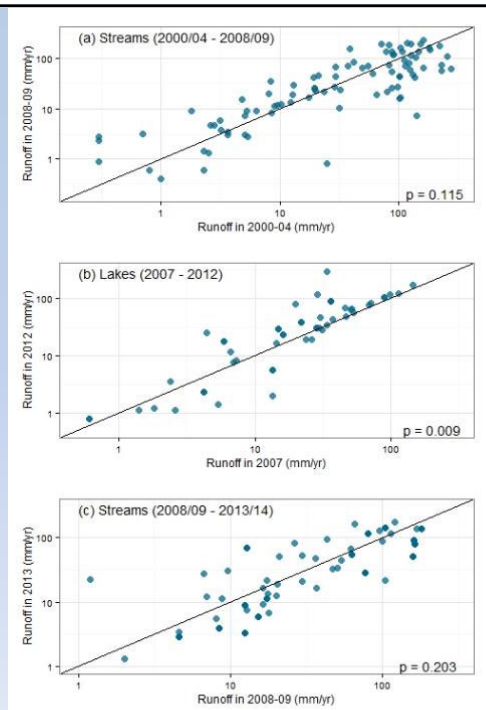
- Quarterly runoff for each HUC8 Modeled by USGS
- Years, Seasons matched to sampling dates for each overlap sample
- No significant changes in streams
- Small, but significant increase in lakes



Potential Mechanisms

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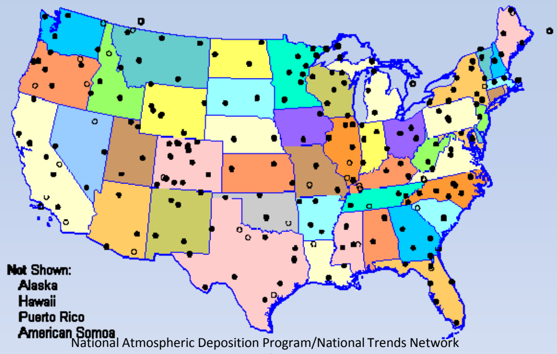
- Changes in hydrology
  - Because Total P is associated with particulates, increased flow might explain differences between N and P
- Forest Dieback, Migratory Birds, Recovery from Acidification
  - All operate at small scales (if at all), not continentally
- Atmospheric Deposition
  - Wet Deposition data very problematic
  - Dry Deposition more likely source of Phosphorus
  - Dust??

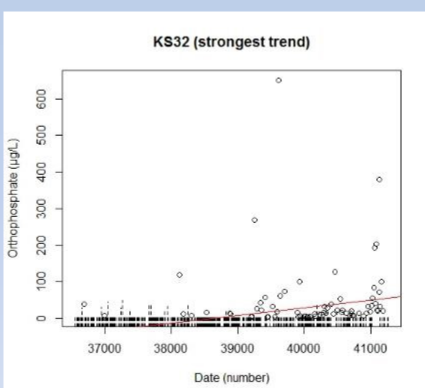
Atmospheric deposition of Phosphorus



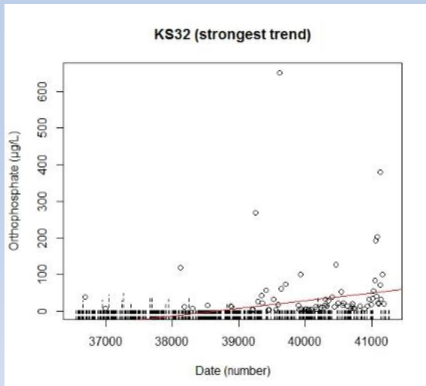
National Atmospheric Deposition Program/National Trends Network
NADP/NTN

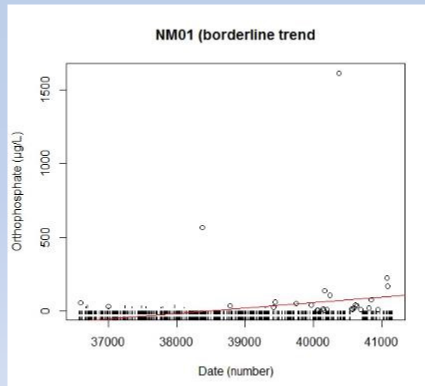
- Roughly 200 NADP sites collect long-term data on phosphorus in rain
- NADP does not measure Total Phosphorus
- 95% of the 100,000 observations are below detection

Atmospheric deposition of Phosphorus

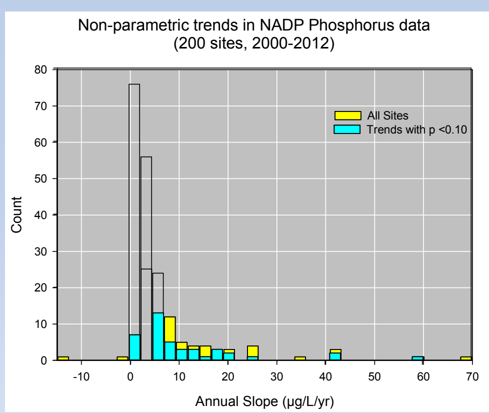


Atmospheric deposition of Phosphorus





Atmospheric deposition of Phosphorus



- 98% of sites had upward slopes
- 67% of sites had trends with p<0.10 (all positive)
- Mean trend = +5.8 µg/L/yr
- Median trend = +3.1 µg/L/yr
- Translates to ca. 15-30 µg/L over 5 years

Phosphorus deposition in dust?


Biogeochemistry
DOI 10.1007/s10533-014-9994-x

Dust mediated transfer of phosphorus to alpine lake ecosystems of the Wind River Range, Wyoming, USA

J. Brahney · A. P. Ballantyne · P. Kociolek · S. Spaulding · M. Otu · T. Porwoll · J. C. Neff

Aeolian Research

ELSEVIER

Increasing Ca^{2+} deposition in the western US: The role of mineral aerosols

J. Brahney, A.P. Ballantyne, C. Sievers, J.C. Neff

ARTICLE INFO

ABSTRACT

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Long-term trends in the chemistry of atmospheric deposition in Northwestern Italy: the role of increasing Saharan dust deposition

By M. ROGORA, R. MOSELLO and A. MARCHETTO

ABSTRACT

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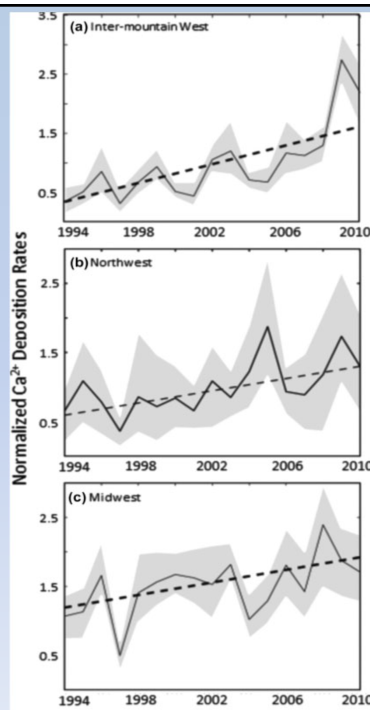
- Ca^{2+} deposition increasing in the West
- A surrogate for dust deposition?

(from Brahney et al. 2013, *Aeolian Research*)



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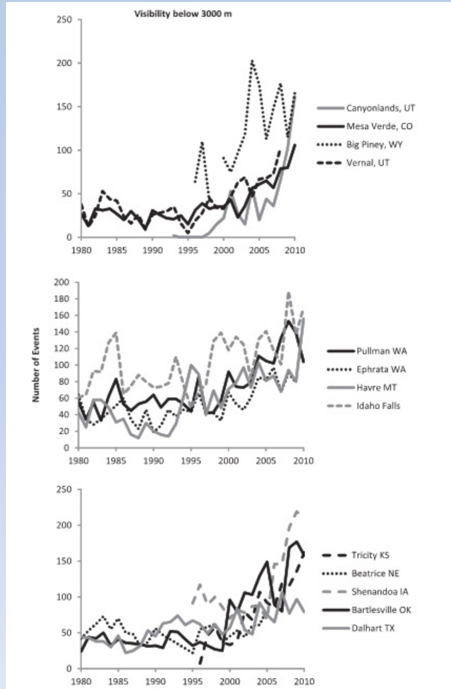
- Trends in “low visibility events” in the West
- A surrogate for dust storms?

(from Brahney et al. 2013, *Aeolian Research)*



Conclusions

- Strong evidence that Total P is increasing nationally in both lentic and lotic systems
- Especially evident in reference sites
- Streams with TP < 10µg/L:
  - 25% in 2004
  - 10% in 2009
  - 2% in 2014
- Lakes with TP < 10µg/L:
  - 25% in 2007
  - 7% in 2012
- Likely cause needs to be:
  - Very large in scale (continental)
  - Operating in remote, undeveloped areas (as well as everywhere else)
- Potential mechanisms driven by climate change?:
  - Extreme hydrologic events
  - Atmospheric Deposition (dust?)

Questions?

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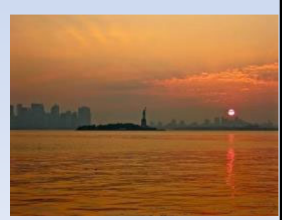

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You can type each of the attendees names into the PDF and print the certificates.

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Questions?

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