Long-term trends in the quality of US streams and rivers

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USGS National Water-Quality Assessment (NAWQA) Project

1. **Status**—What is the current quality of the Nation's surface water and groundwater?
2. **Trends**—Is water quality getting better or worse?
3. **Understanding**—What are the natural and human factors that control water quality?

NAWQA Trend Analysis

- Largest-ever evaluation of trends in U.S. stream quality between 1972 and 2012
  - Over 20,000 trend results
  - 51 chemicals and 38 measures of aquatic life
  - 1,400 sites with at least one trend result
- Leverages the power of monitoring data collected by the USGS and 73 other monitoring organizations
- On-line interactive map provides easy access to trend results
- Results are the foundation for answering critical questions about the causes and effects of changes in stream quality

NAWQA Trend Analysis

- Scope
  - Stream and river trends in nutrients, pesticides, sediment, carbon, salinity, fish, invertebrates, and algae
  - Four time periods: (1) 1972-2012, (2) 1982-2012, (3) 1992-2012, and (4) 2002-2012
- Data sources
  - NWIS, STORET, and other Federal, State, and local databases
  - 185 million water-quality records from 480,000 sites and over 600 organizations

The U.S. Geological Survey sampling the Missouri River. Photo by Kelly Brady, U.S. Geological Survey.

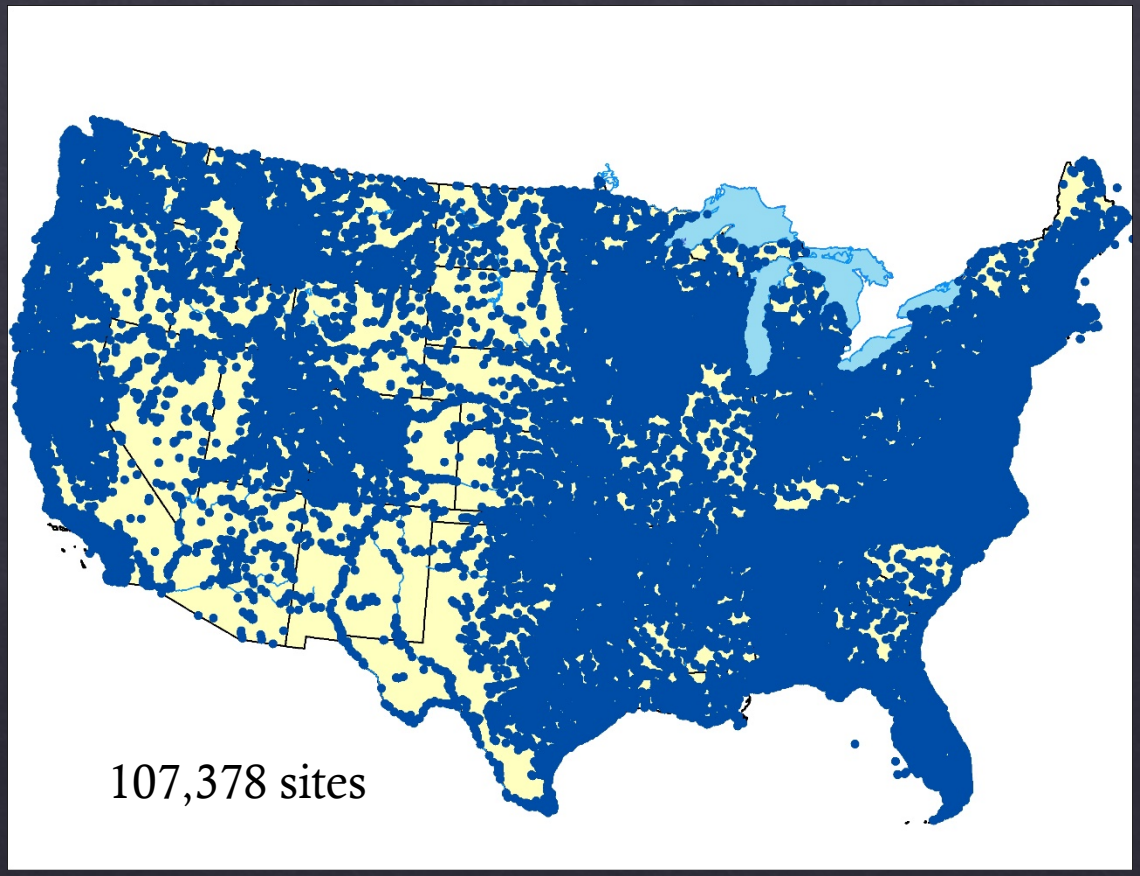
Data processing and screening

Data Processing and Screening for Trend Analysis

1. Harmonize data and address metadata gaps
2. Ensure adequate data coverage over the trend period
3. Obtain streamflow data

Orthophosphate Example

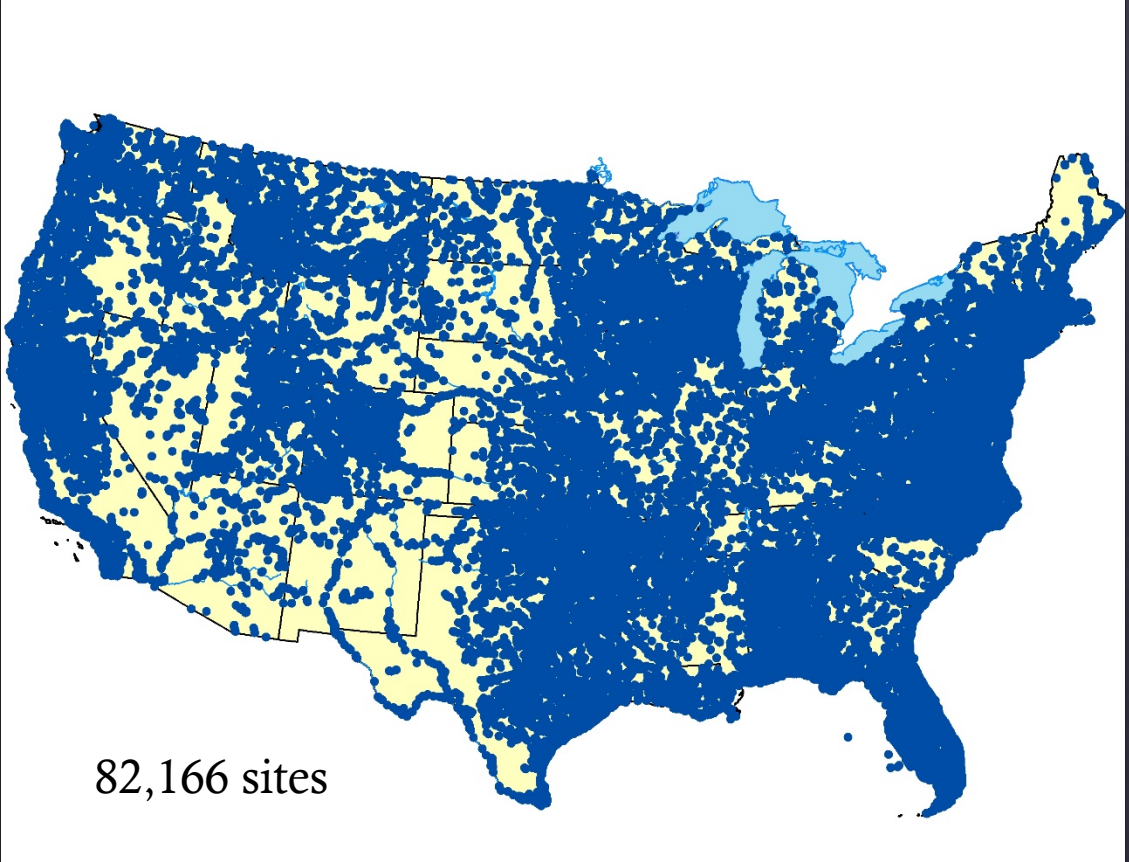
- 1+ sample



PROVISIONAL DATA – SUBJECT TO REVISION

Orthophosphate Example

- 1+ sample
- Complete metadata



PROVISIONAL DATA – SUBJECT TO REVISION

Evaluation of Multi-source Nutrient Records

- Of the 25,125,379 original nutrient records, 14,453,492 had missing or ambiguous information for one or more of the key metadata elements

Starting records	Affected records					
	Parameter name	Filtration status	Chemical form	Units	Remark codes	Zero, negative, missing
25,125,379	3,557,821	11,946,455	4,265,615	1,311,096	124,523	636,454

Sprague et al., 2017, Challenges with secondary use of multi-source water-quality data in the United States. Water Research, Volume 110, http://dx.doi.org/10.1016/j.watres.2016.12.024

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The Importance of Metadata

- Individual monitoring organizations understand their own data very well
  - Their data can become ambiguous when combined with data from other organizations
  - Different data users may make different assumptions about the same ambiguous data

- Ambiguous data could be worth billions of dollars to secondary users
  - We can maximize this added value by developing and implementing standardized metadata in the US

Data Processing and Screening for Trend Analysis

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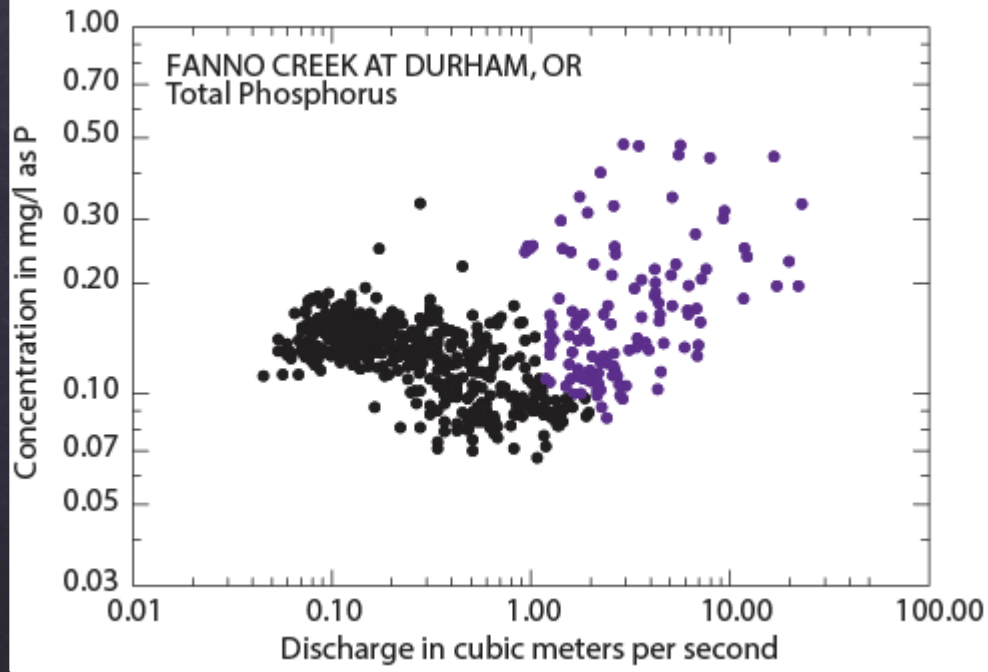
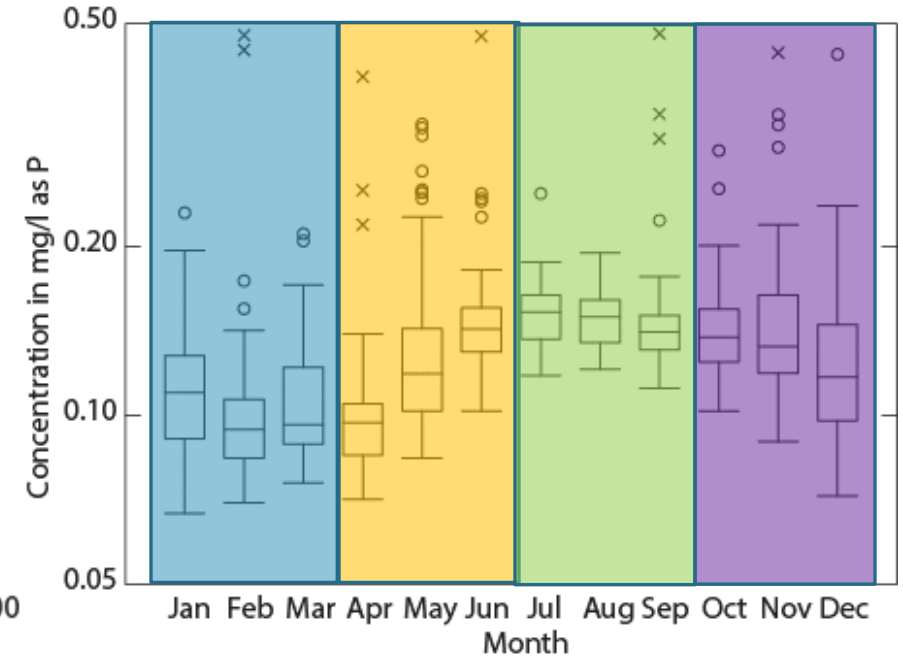
Ensure adequate data coverage over the trend period





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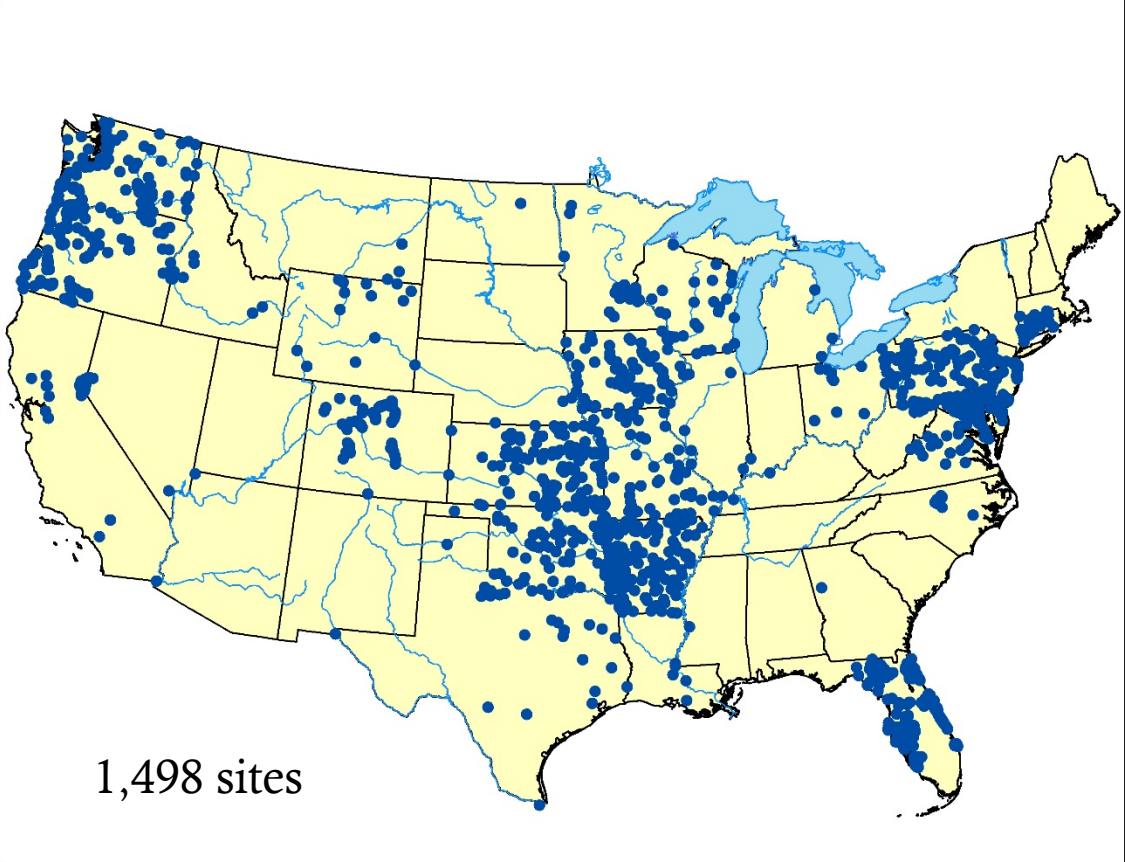
Orthophosphate Example

- 1+ sample
- Complete metadata
- Meets trend criteria
  1. Start and end years within one year of specified trend period (shortest case 2003-2011)
  2. At least quarterly sampling



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Data Processing and Screening for Trend Analysis

1. Harmonize data and address metadata gaps
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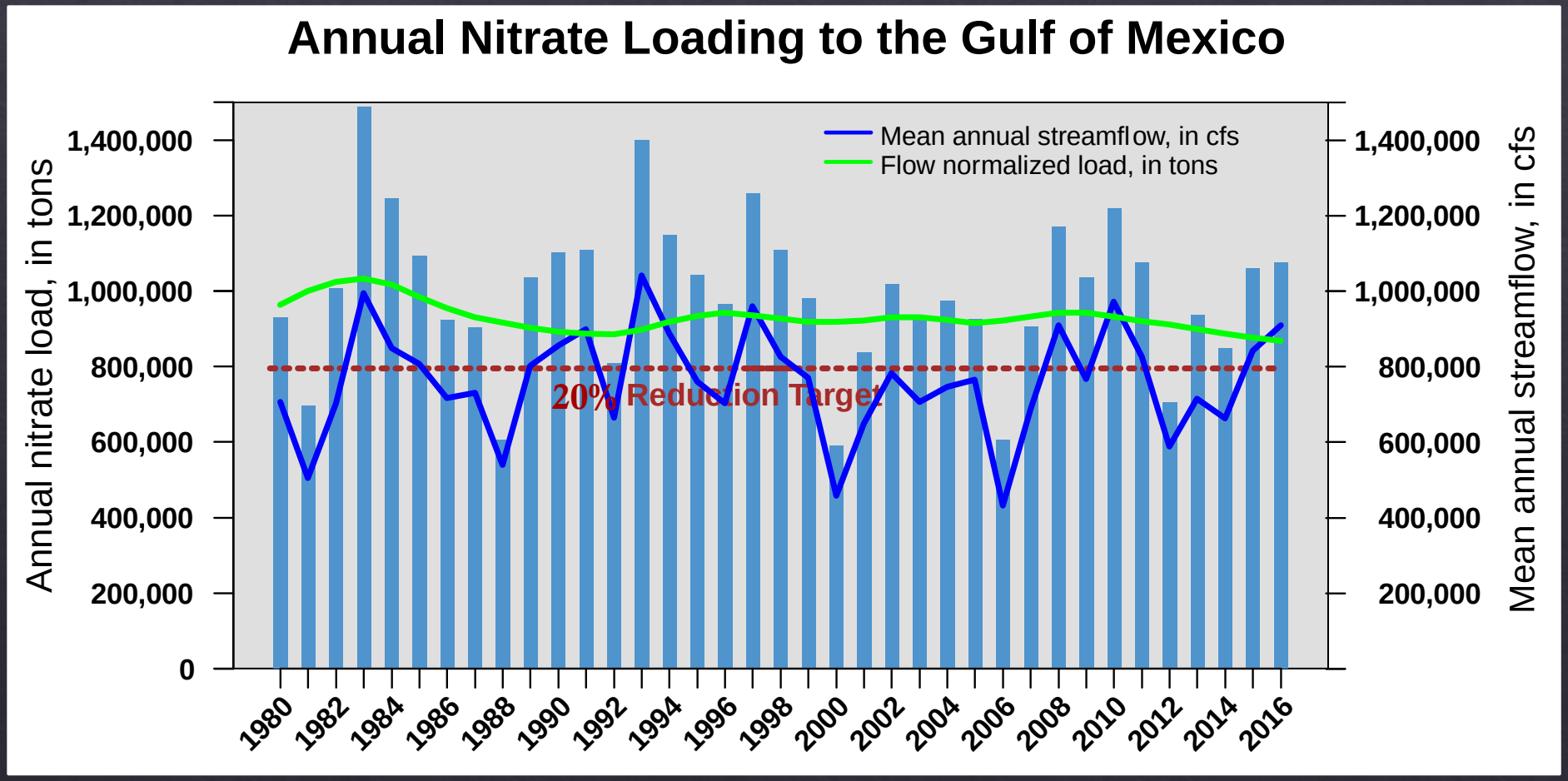
Importance of Streamflow Data



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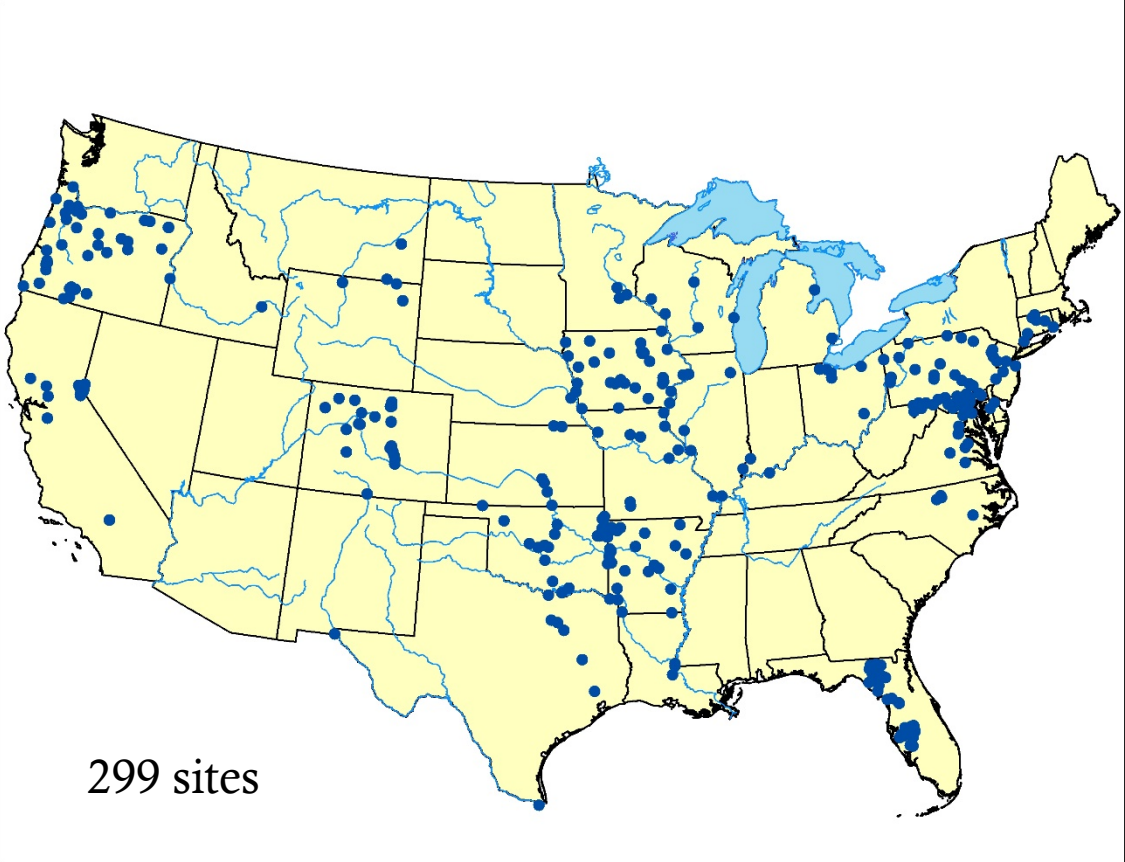
PROVISIONAL DATA – SUBJECT TO REVISION

Orthophosphate Example

- 1+ sample
- Complete metadata
- Meets trend criteria
  1. Start and end years within one year of specified trend period (shortest case 2003-2011)
  2. At least quarterly sampling
- Paired with gage
- Meets high-flow screen



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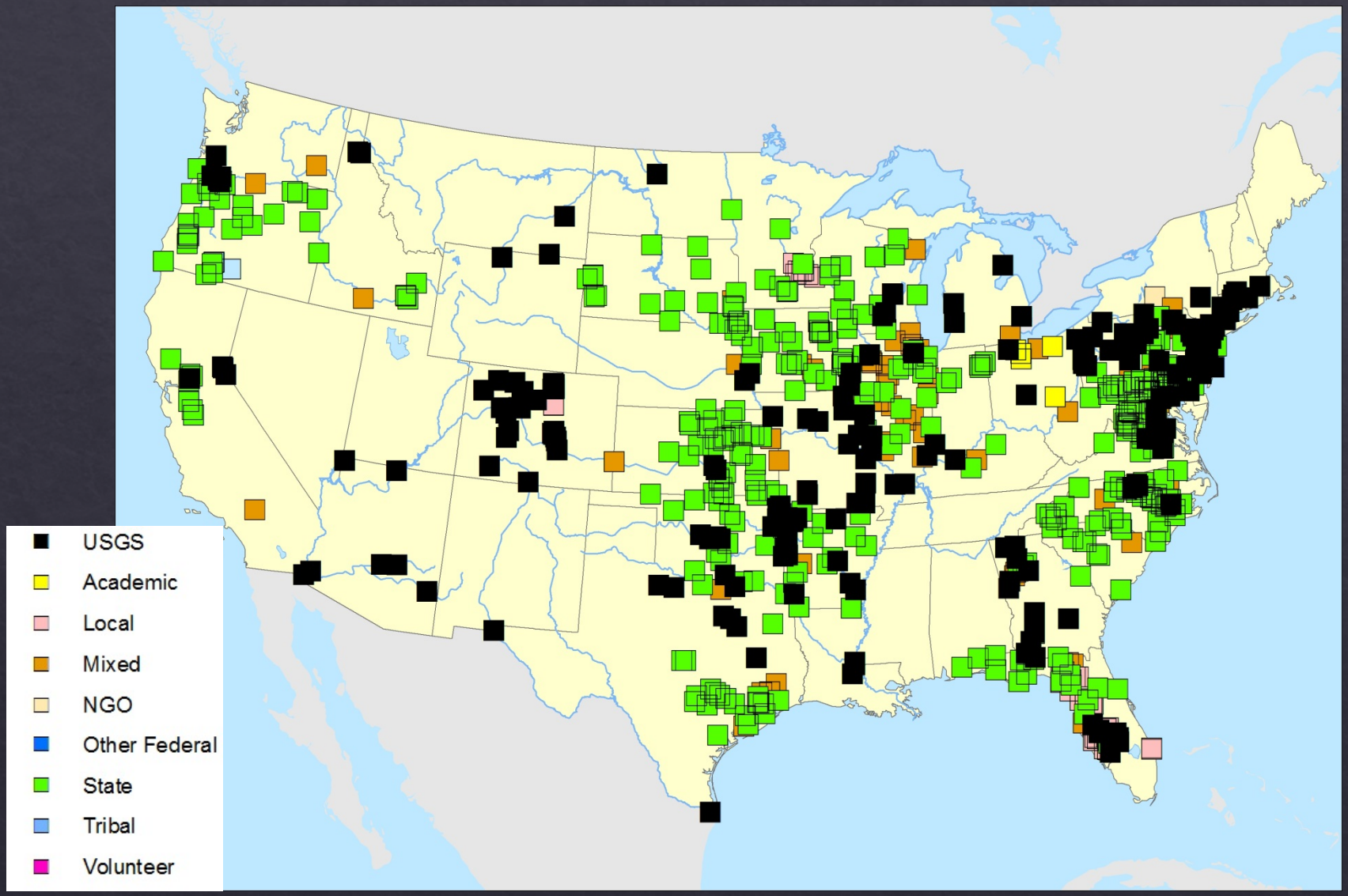
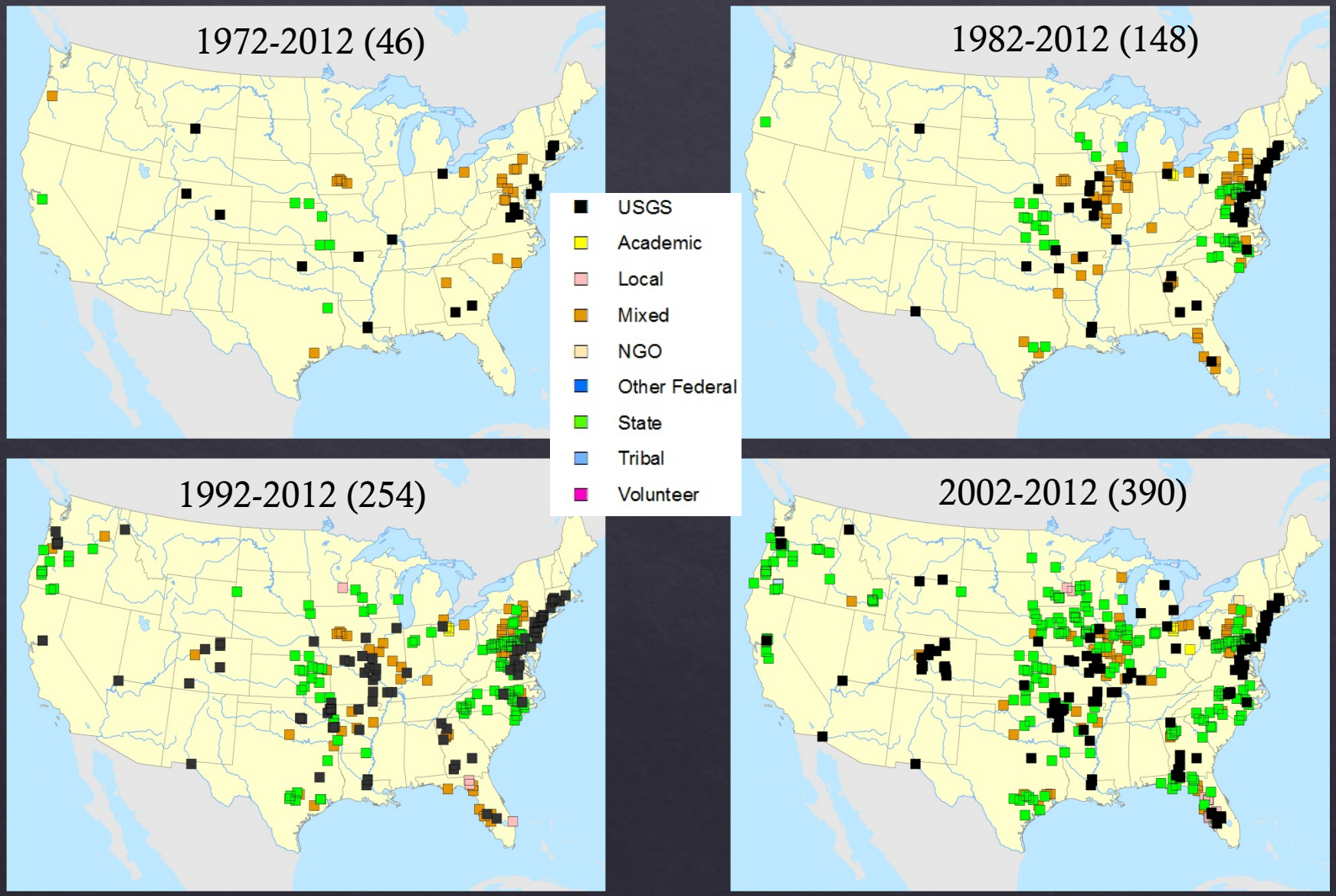
Farm fields near Fort Dodge, IA

Some of our final trend sites and results

Nutrient sites in all trend periods (762 sites)



Nitrate sites in each trend period



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Phase out of the insecticide diazinon led to widespread reductions in U.S. streams

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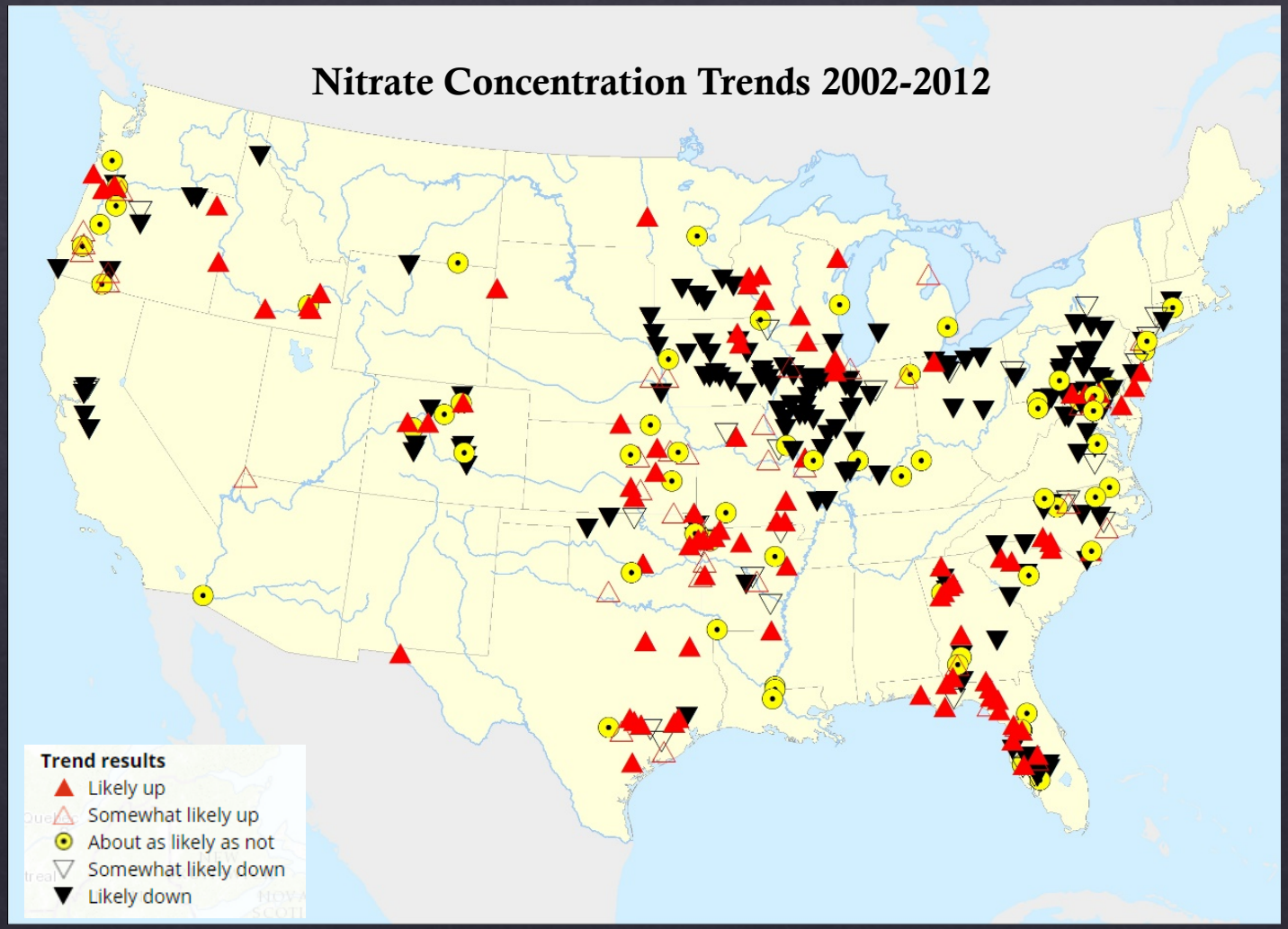
Nutrient trends are much more complicated



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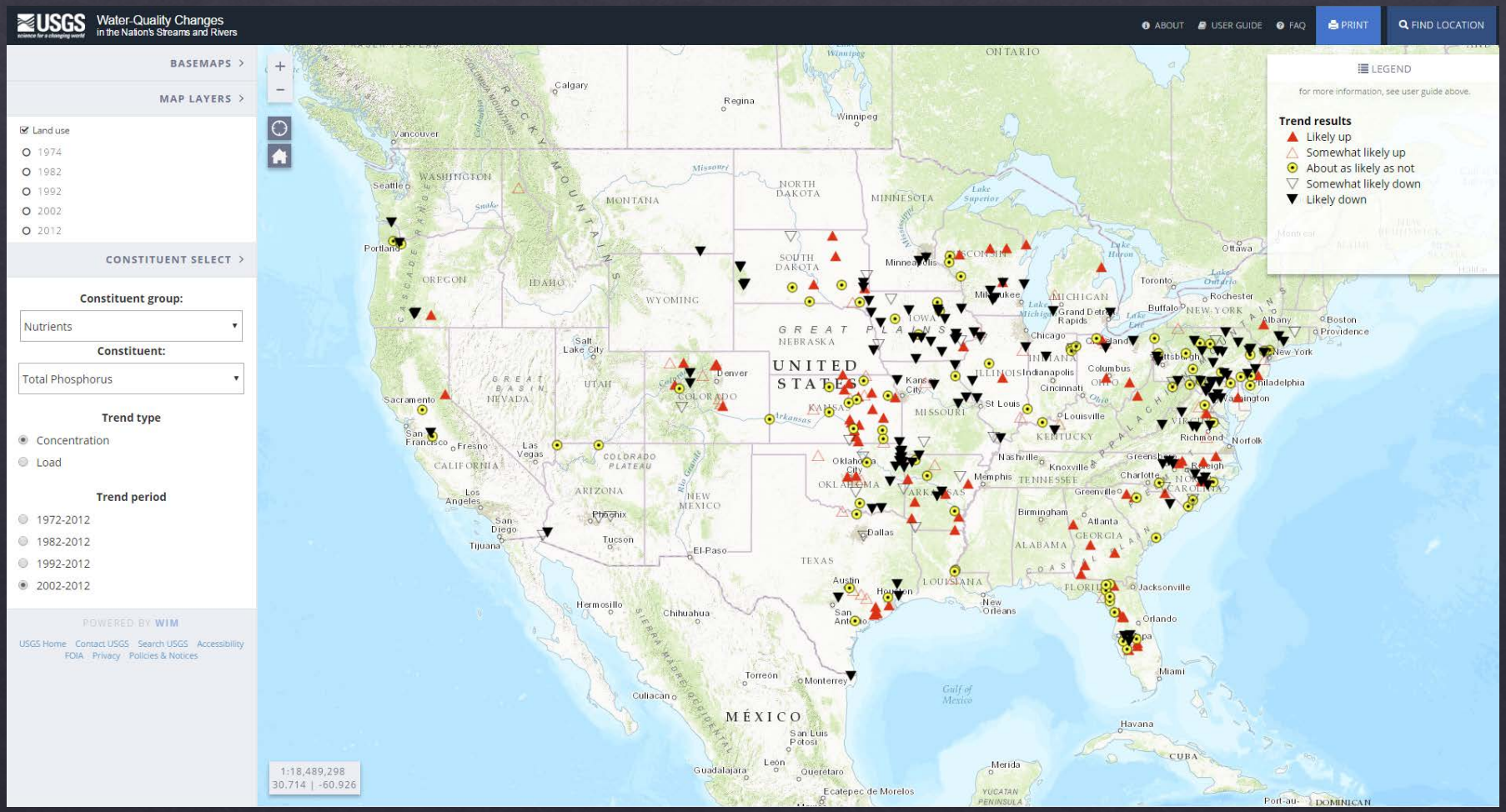
On-line interactive mapper



Photograph from Franklin D. Roosevelt Presidential Library Museum

Critical questions this study will answer in the next 4 years

- What are the major causes of trends in U.S. stream quality?
- Where have we seen the biggest changes?
- Which chemicals have changed the most?
- Have investments in pollution control been effective?
- What's been the relative role of climate vs purposeful land-use and management changes?
- Where have trends been large enough to potentially compromise the health of humans or aquatic life?
- What are the trends through 2017?

Additional Resources and Upcoming Work

- On-line mapper: https://nawqatrends.wim.usgs.gov/swtrends/
- Published reports
  - Oelsner et al., 2017, Water-quality trends in the Nation's rivers and streams 1972-2012—Data preparation, statistical methods, and trend results: U.S. Geological Survey Scientific Investigations Report 2017-5006, http://dx.doi.org/10.3133/sir20175006
  - Sprague et al., 2017, Challenges with secondary use of multi-source water-quality data in the United States. Water Research, Volume 110, http://dx.doi.org/10.1016/j.watres.2016.12.024
- Selected upcoming reports
  - Geographic summary of US river quality trends
  - Comparing US river quality trends to environmental and human health benchmarks
  - Modeling drivers of changing phosphorus loads in Chesapeake Bay tributaries
  - Increasing chloride in US rivers and its link to potential corrosivity of source waters
  - Over 15 more reports planned in the next 4 years