

Nutrient Characteristics for Streams in North Dakota

By Joel M. Galloway
Associate Director

USGS North Dakota Water Science Center

Background

- Study completed in 2012 examined data from various agencies that have conducted water-quality sampling programs and projects for streams in ND for a number of years for various purposes.
- The purpose of the study was to:
 1. Provide descriptive statistics and summaries of water-quality data from sites throughout the State;
 2. Determine trends and loads for selected constituents and sites with sufficient concentration and streamflow data;
 3. Determine an efficient state-wide network sampling design for monitoring future water-quality conditions



Prepared in cooperation with the North Dakota State Water Commission and the North Dakota Department of Health

Evaluation of Water-Quality Characteristics and Sampling Design for Streams in North Dakota, 1970–2008



Scientific Investigations Report 2012–5216

U.S. Department of the Interior
U.S. Geological Survey

<http://pubs.usgs.gov/sir/2012/5216/>

By Galloway, Vecchia, Vining
Densmore, Lundgren

(analyzed a lot more than nutrients;
today's focus is on nutrients)

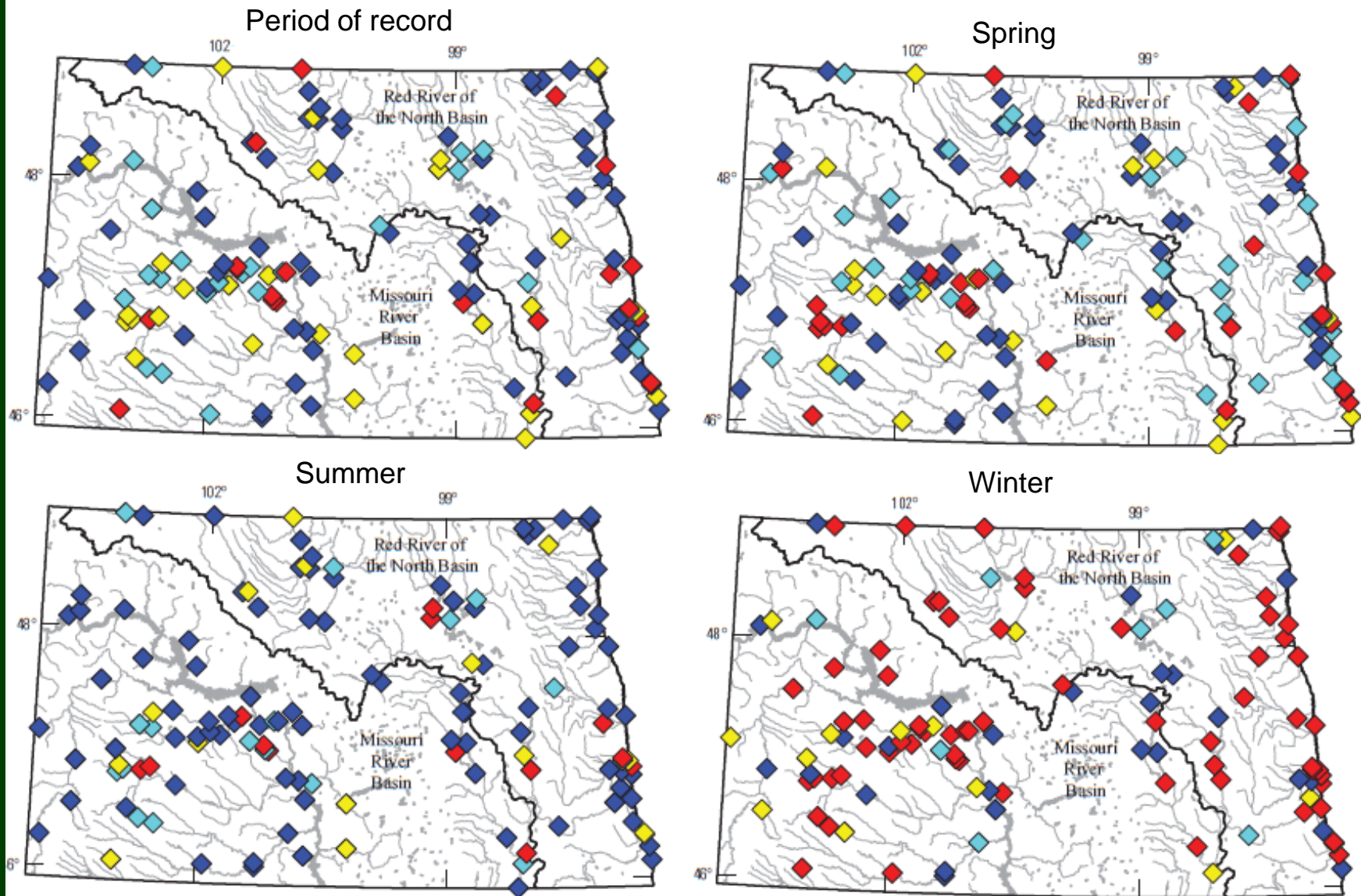
Nutrient Data and Analysis

- Examined all data available from 1970-2008 -
Data obtained from USGS NWIS database, USEPA STORET database, and electronic files from NDDH
- Data screening yielded 186 sites across the State with 10 or more samples for most constituents
 - Nutrients – 50,880 values after data was processed

Nutrient topics covered

- Spatial distribution of concentrations
 - Yields
 - Trends
- Not covered today: spatial/temporal sampling design for future monitoring

SPATIAL DISTRIBUTION - MEDIAN AMMONIA CONCENTRATIONS

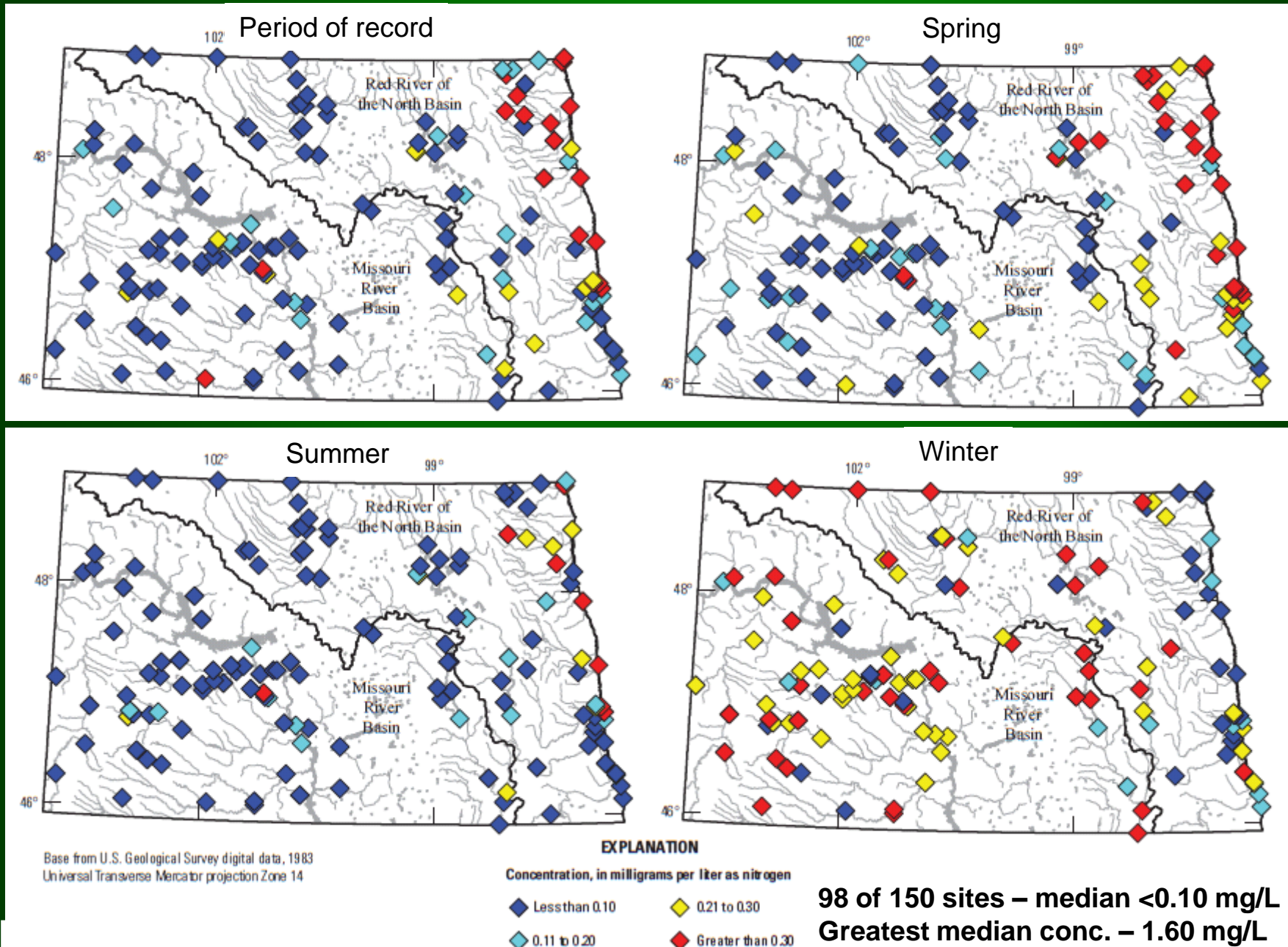


Base from U.S. Geological Survey digital data, 1983
Universal Transverse Mercator projection Zone 14

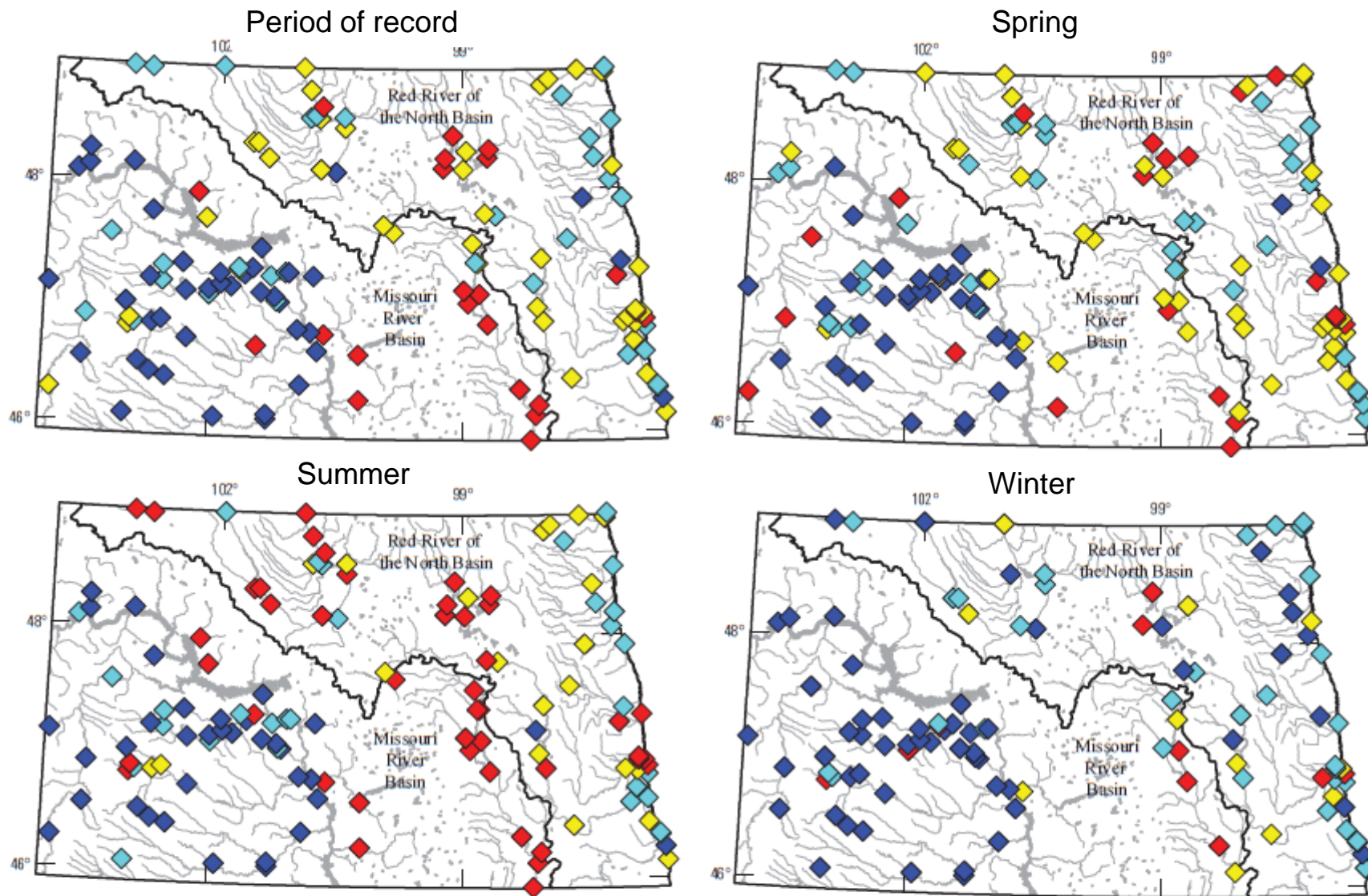
64 of 139 sites – median <0.04 mg/L
Greatest median conc. – 0.59 mg/L



SPATIAL DISTRIBUTION - MEDIAN NITRATE PLUS NITRITE CONCENTRATIONS



SPATIAL DISTRIBUTION - MEDIAN TOTAL PHOSPHORUS CONCENTRATIONS



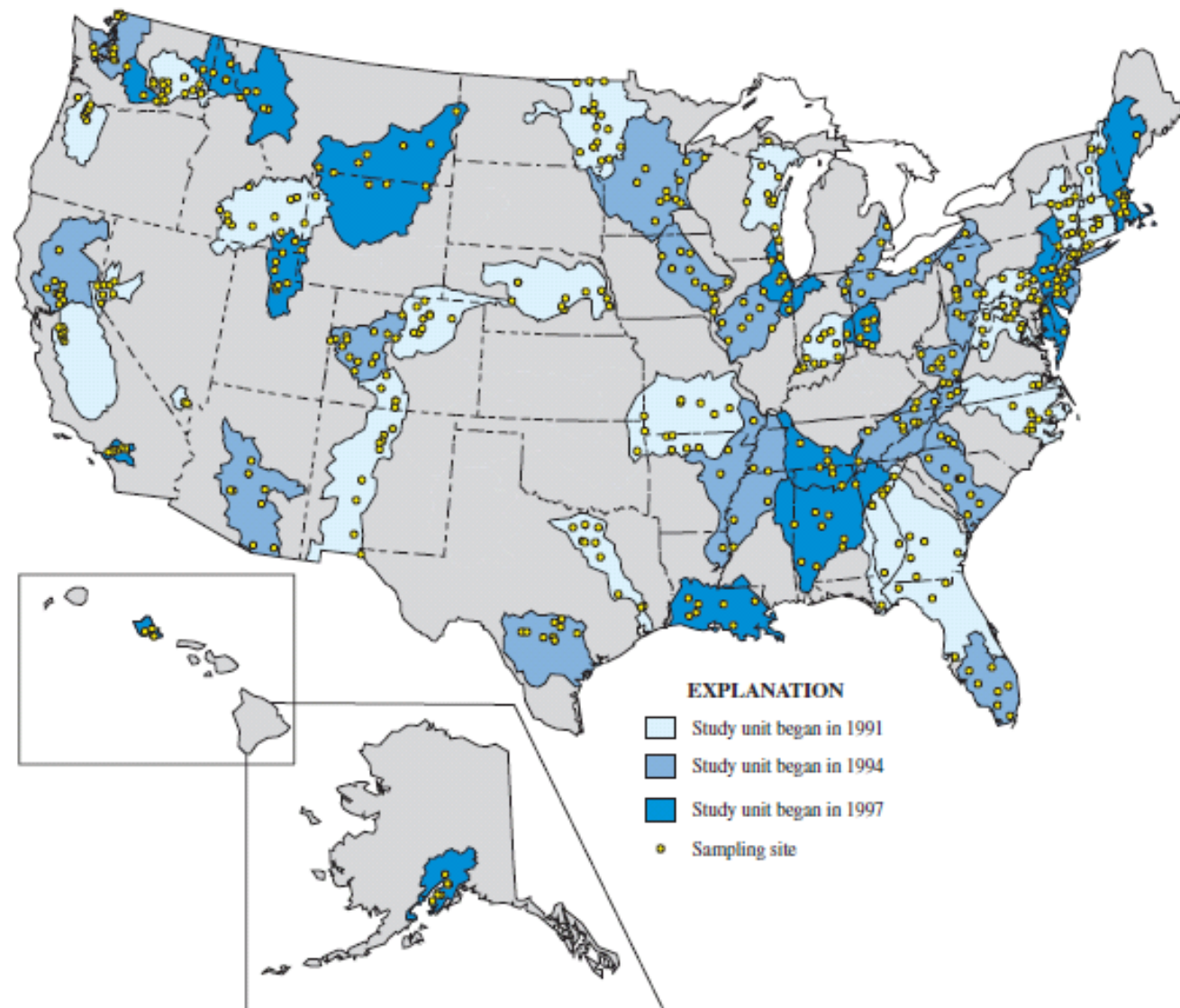
Base from U.S. Geological Survey digital data, 1983
Universal Transverse Mercator projection Zone 14

EXPLANATION

Concentration, in milligrams per liter as phosphorus

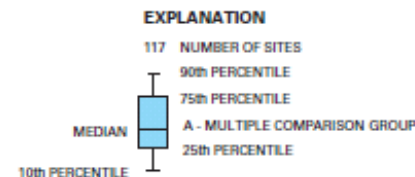
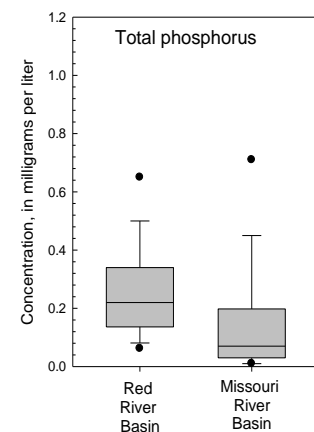
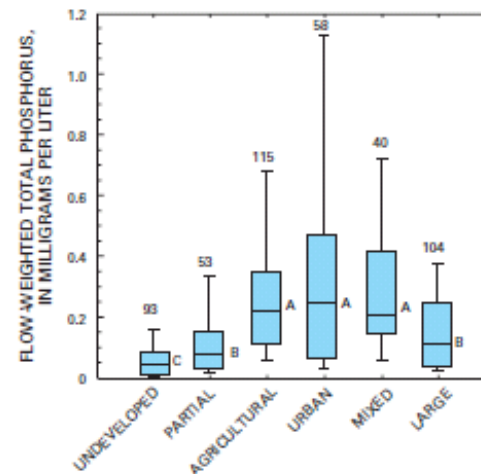
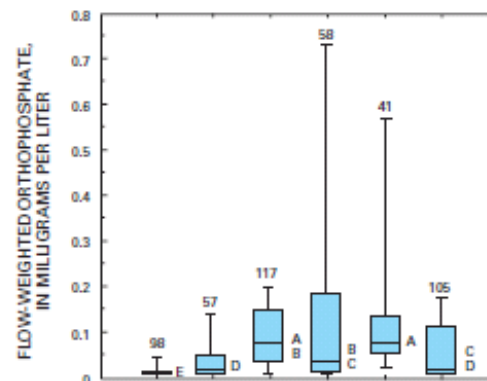
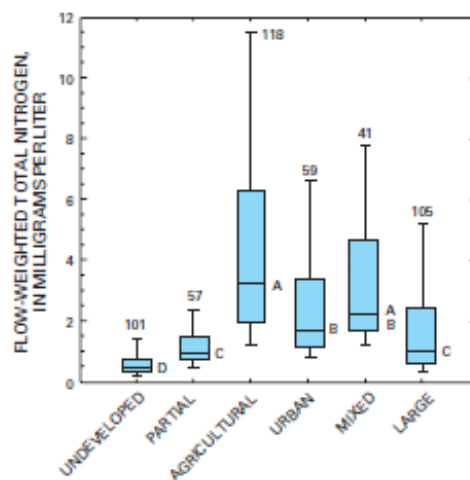
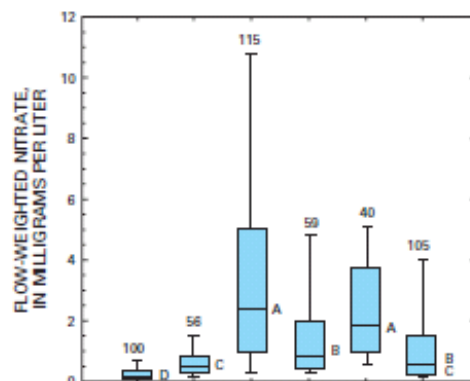
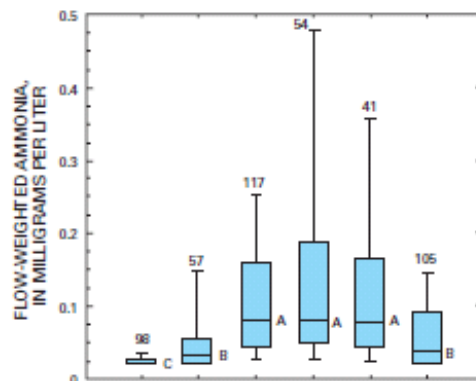
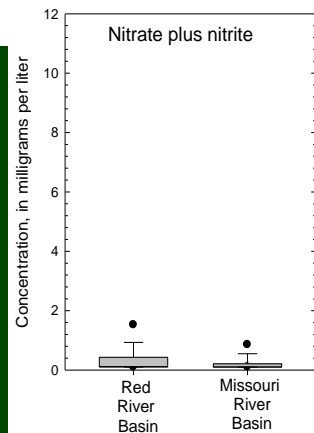
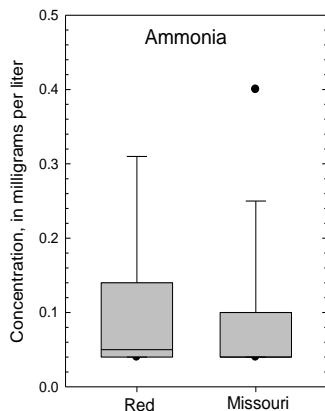
- ◆ Less than 0.01 to 0.10
- ◆ 0.11 to 0.20
- ◆ 0.21 to 0.30
- ◆ Greater than 0.30

1 of 128 sites – median <0.01 mg/L
Greatest median conc. – 0.51 mg/L



From Mueller and Spahr (2006)

Figure 2. Location of the 481 National Water-Quality Assessment sampling sites with adequate data for analysis of nutrient concentrations and loads.



From Mueller and Spahr (2006)

Figure 14. Box plots showing the distribution of flow-weighted nutrient concentrations by land-use category.

Loads and Yields

- Loads and Yields were estimated for nitrogen and phosphorus
- 34 sites were selected with sufficient data to determine reasonable estimates of load
- Loads (lbs/yr) were estimated using LOADEST to determine regression models:

$$\ln(\text{Load}) = \beta_0 + \beta_1 \ln(\text{Daily Streamflow}) + \beta_2 (\text{Time}) + \beta_3 \sin(2\pi \text{Time}) + \beta_4 \cos(2\pi \text{Time})$$

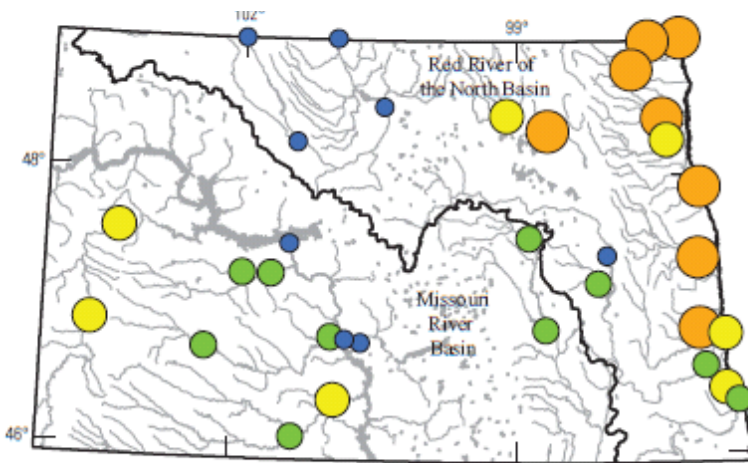
Seasonality

- Yields (lbs/yr/mi²) were calculated from the estimated loads:

$$\text{Load (lbs/yr)} / \text{Drainage area (mi}^2\text{)}$$

Nutrient Yields

Nitrate plus nitrite (total and dissolved)

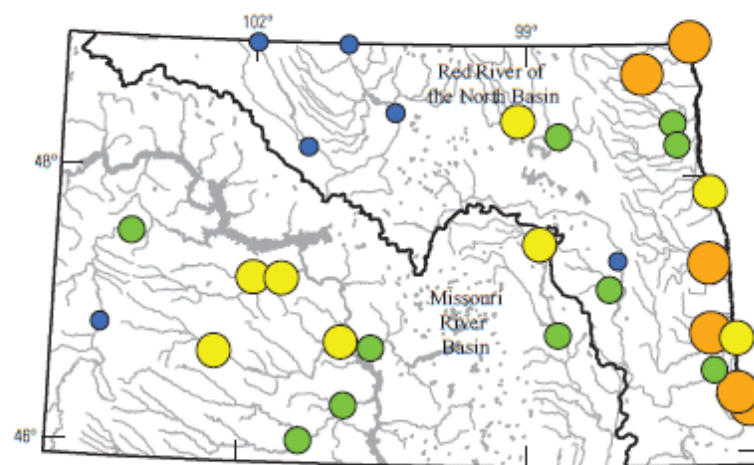


EXPLANATION

Normalized annual yields, in pounds per year per square mile



Ammonia (total and dissolved)

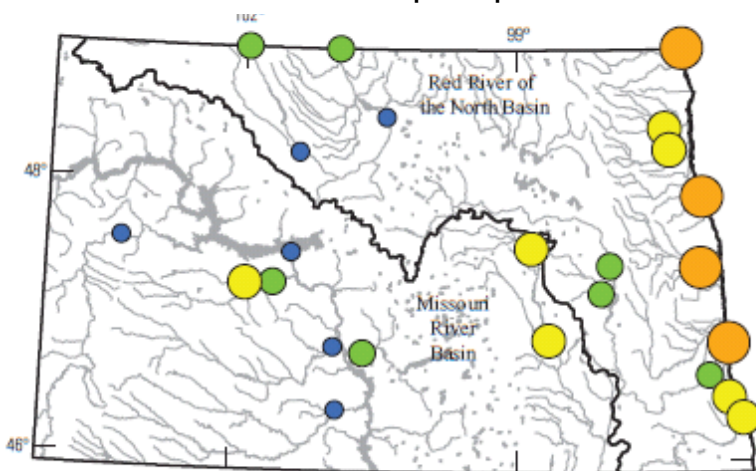


EXPLANATION

Normalized annual yields, in pounds per year per square mile



Dissolved phosphorus

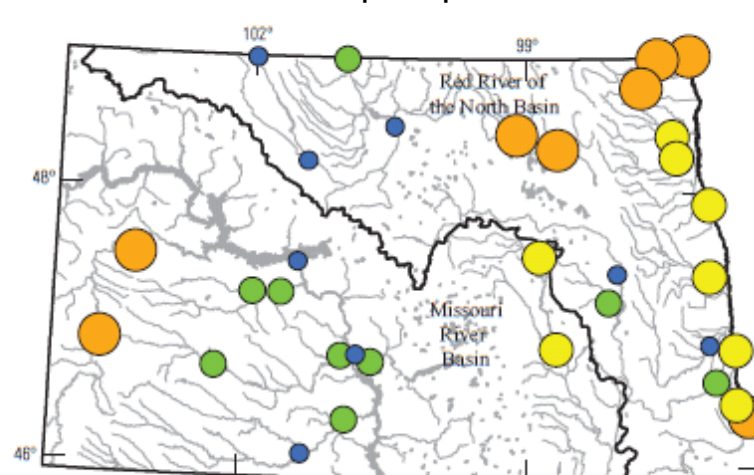


EXPLANATION

Normalized annual yields, in pounds per year per square mile



Total phosphorus



EXPLANATION

Normalized annual yields, in pounds per year per square mile



Nitrate plus Nitrite

MRB:

25 to 120 lbs/yr/mi²

RRB:

2 to 1,260 lbs/yr/mi²

Ammonia

MRB:

6 to 22 lbs/yr/mi²

RRB:

4 to 62 lbs/yr/mi²

Dissolved phosph.

MRB:

<1 to 35 lbs/yr/mi²

RRB:

5 to 47 lbs/yr/mi²

Total phosphorus

MRB:

<1 to 167 lbs/yr/mi²

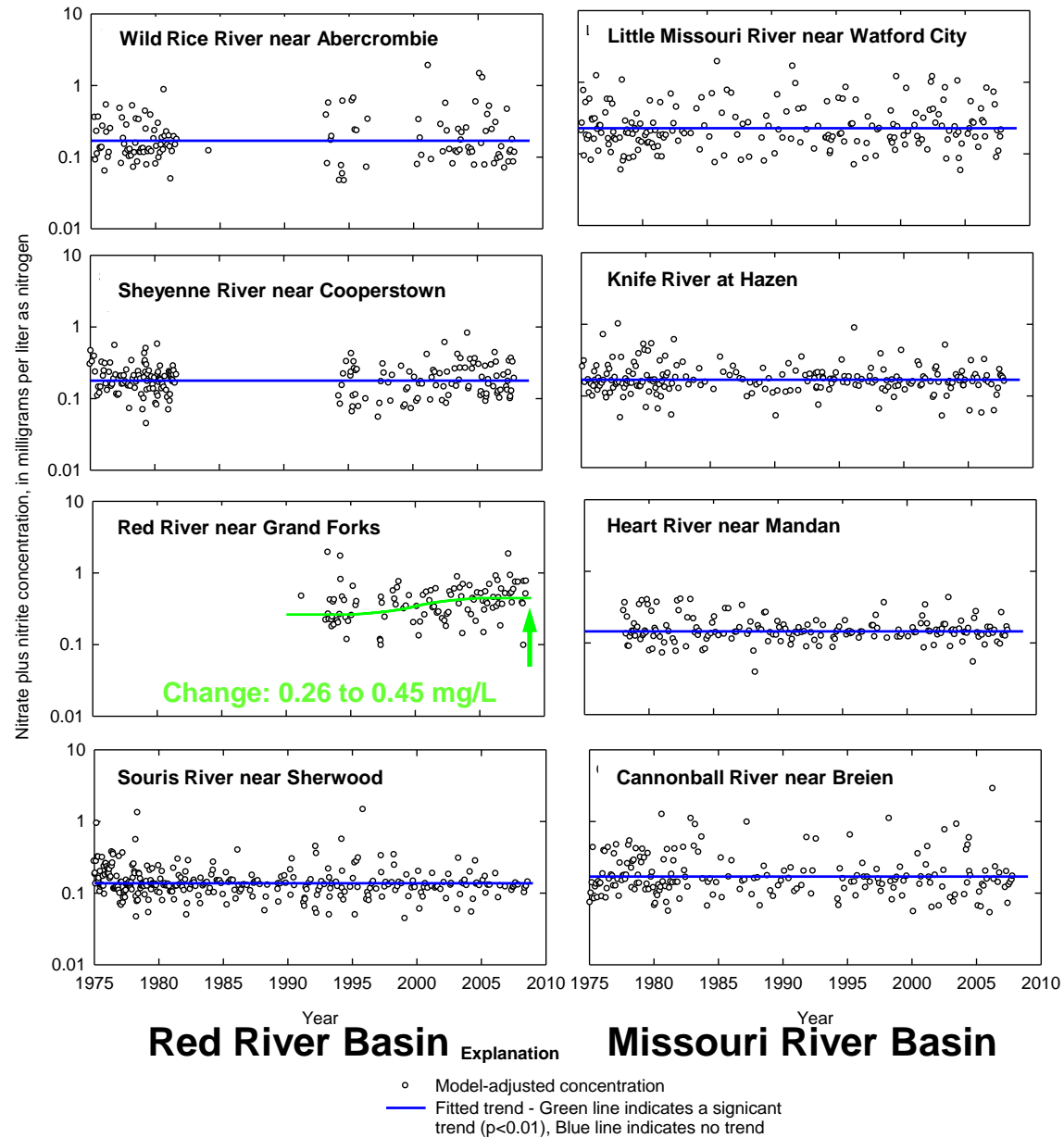
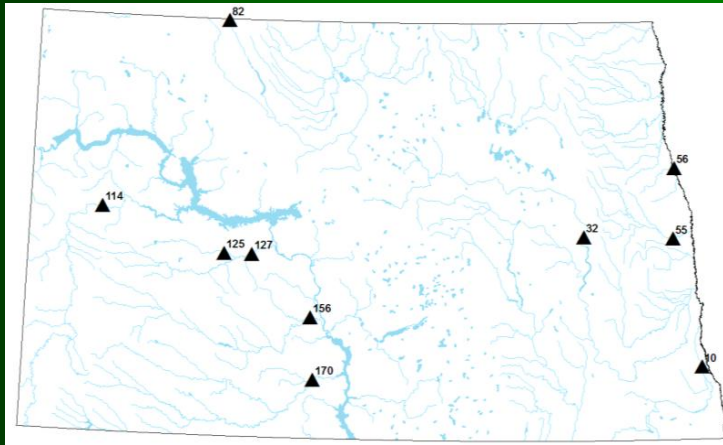
RRB:

6 to 76 lbs/yr/mi²

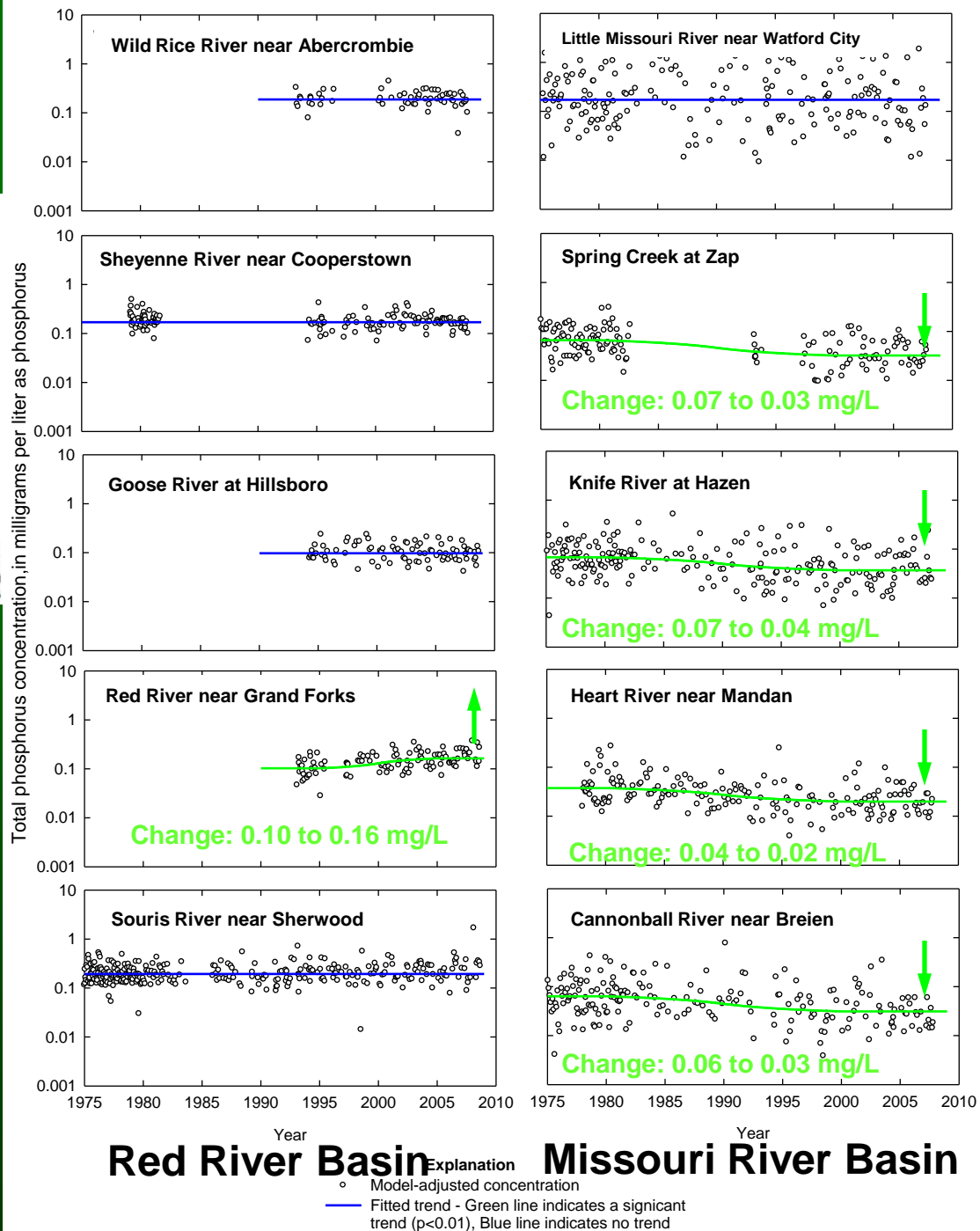
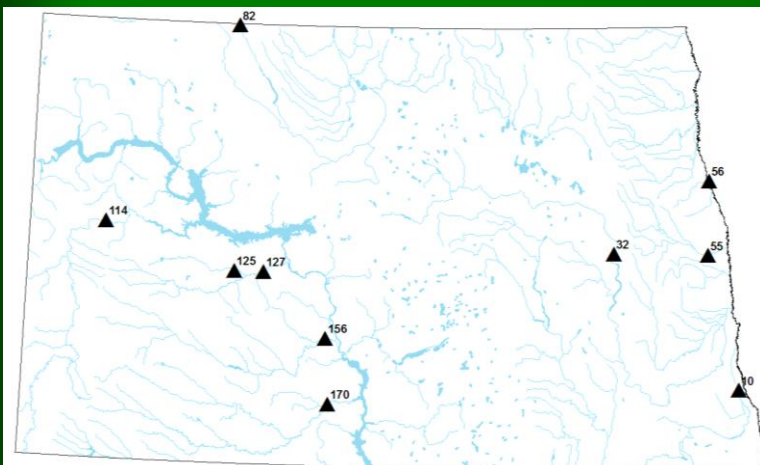
Trends

- Time-series model (QWTREND) used to evaluate flow-related variability and trends in historical concentrations. Significant trends were determined using maximum likelihood estimation and generalized likelihood ratio tests
- Selected 10 sites with sufficient data
 - Sites had to have:
 - » At least 15 years of data
 - » At least 4 samples per year
 - » Have both major ion and nutrient data
- Trends were evaluated for nitrate plus nitrite and total phosphorus

Nitrate plus Nitrite Trends



Total Phosphorus Trends



Summary

- Spatial Distribution:
 - Ammonia conc. higher in winter
 - No distinct spatial pattern
 - Nitrate plus nitrite - higher conc. in Red River Basin
 - Higher in winter in the Missouri Basin, lower in winter in Red River basin
 - Total phosphorus – highest median concentrations in James and Souris Basins, highest yields in Little Mo and Red River Basin
 - Highest in summer
- Nutrient yields generally higher in Red River Basin
- Nutrient Trends:
 - Nitrate plus Nitrite – no trend at most sites, upward trend in Red River mainstem
 - Total phosphorus – 4 sites in Missouri Basin had downward trend, 1 site had upward trend (Red River), others had no trend

ANY QUESTIONS?

Data and analysis are from:

Evaluation of Water-Quality Characteristics and Sampling Design for Streams in North Dakota, 1970–2008

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