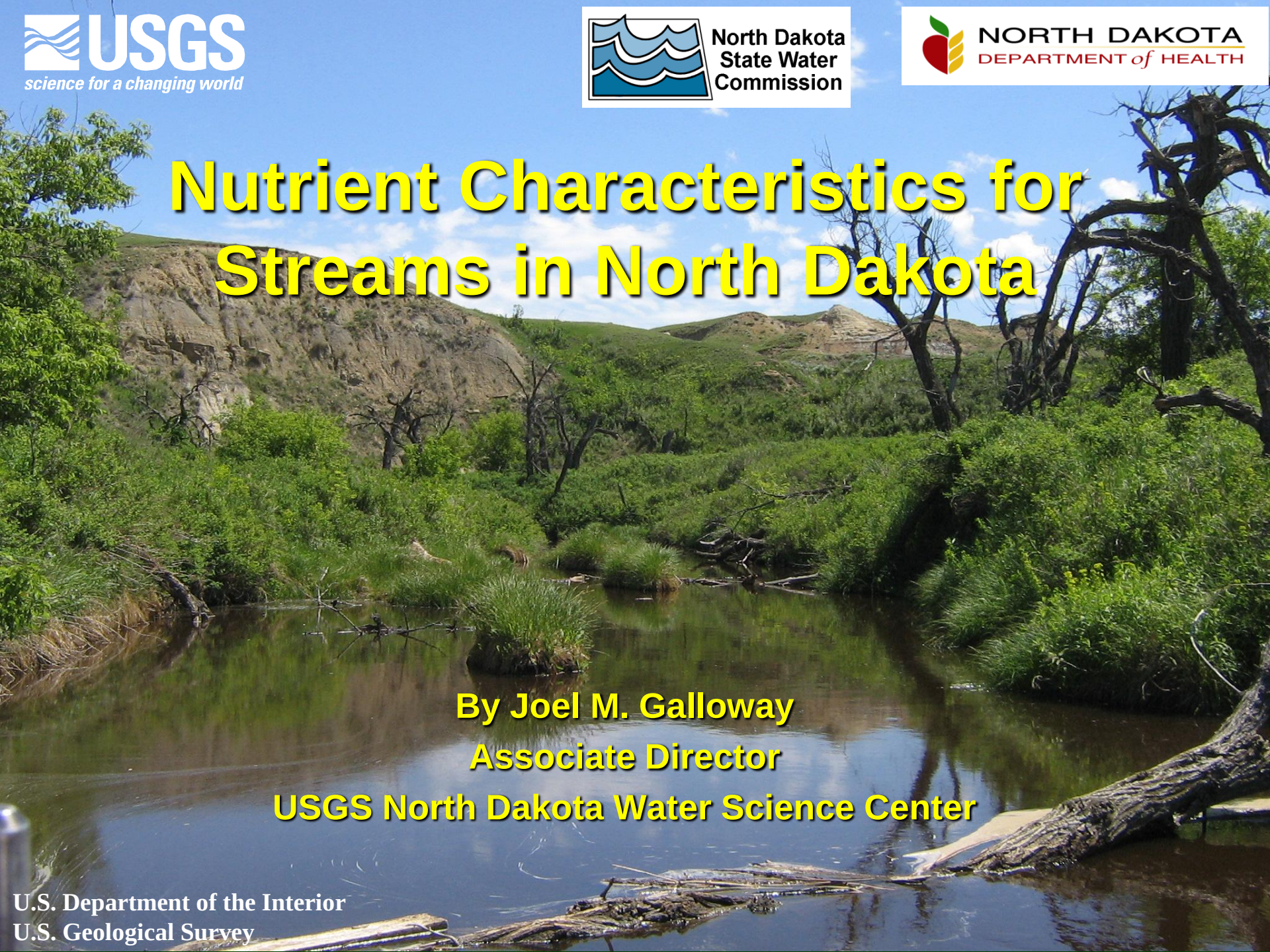
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science for a changing world
North Dakota State Water Commission
NORTH DAKOTA
DEPARTMENT of HEALTH
Nutrient Characteristics for Streams in North Dakota
By Joel M. Galloway
Associate Director
USGS North Dakota Water Science Center
U.S. Department of the Interior
U.S. Geological Survey

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

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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)

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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

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Nutrient topics covered

- Spatial distribution of concentrations
- Yields
- Trends

➢ Not covered today: spatial/temporal sampling design for future monitoring

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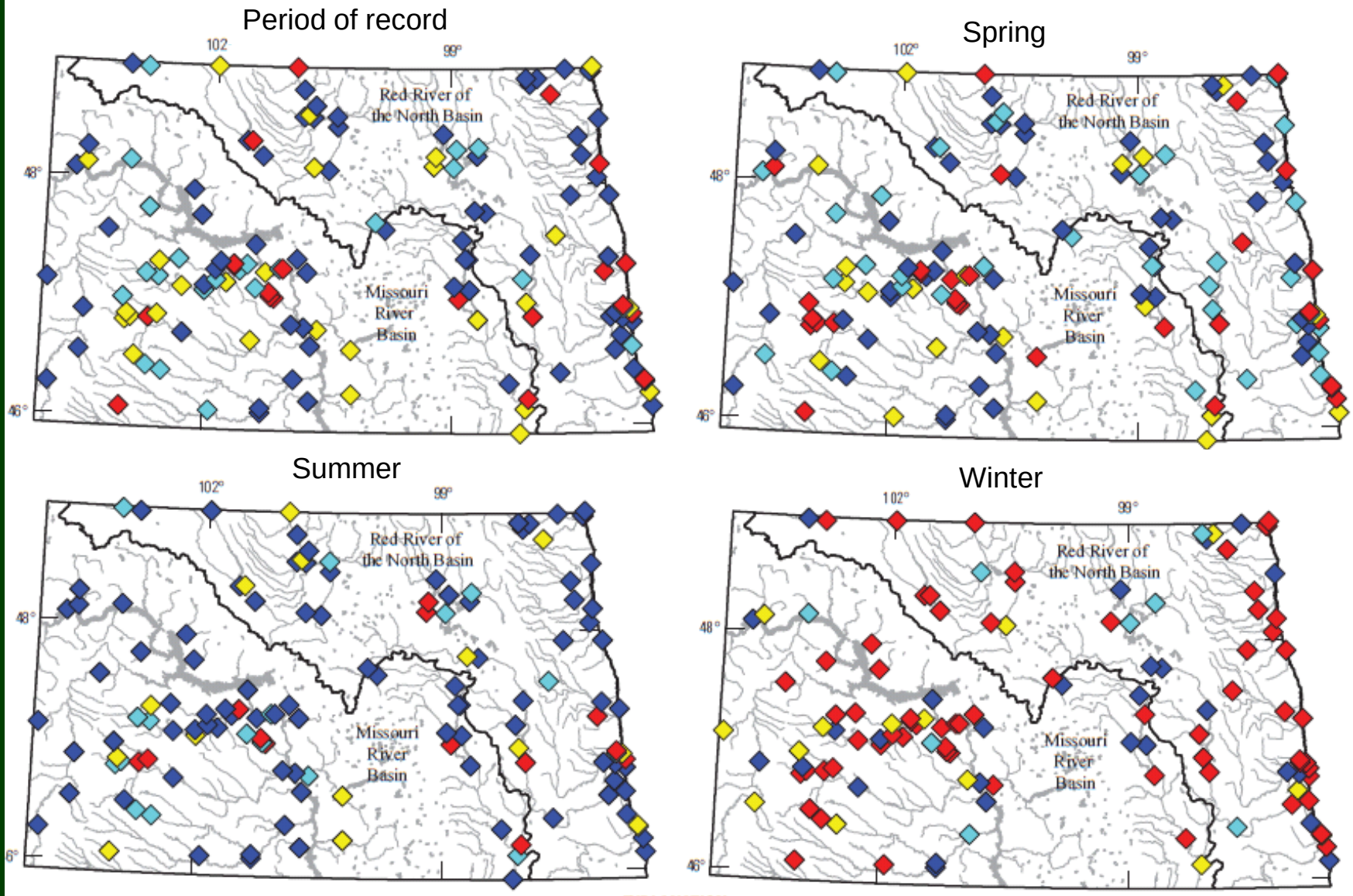
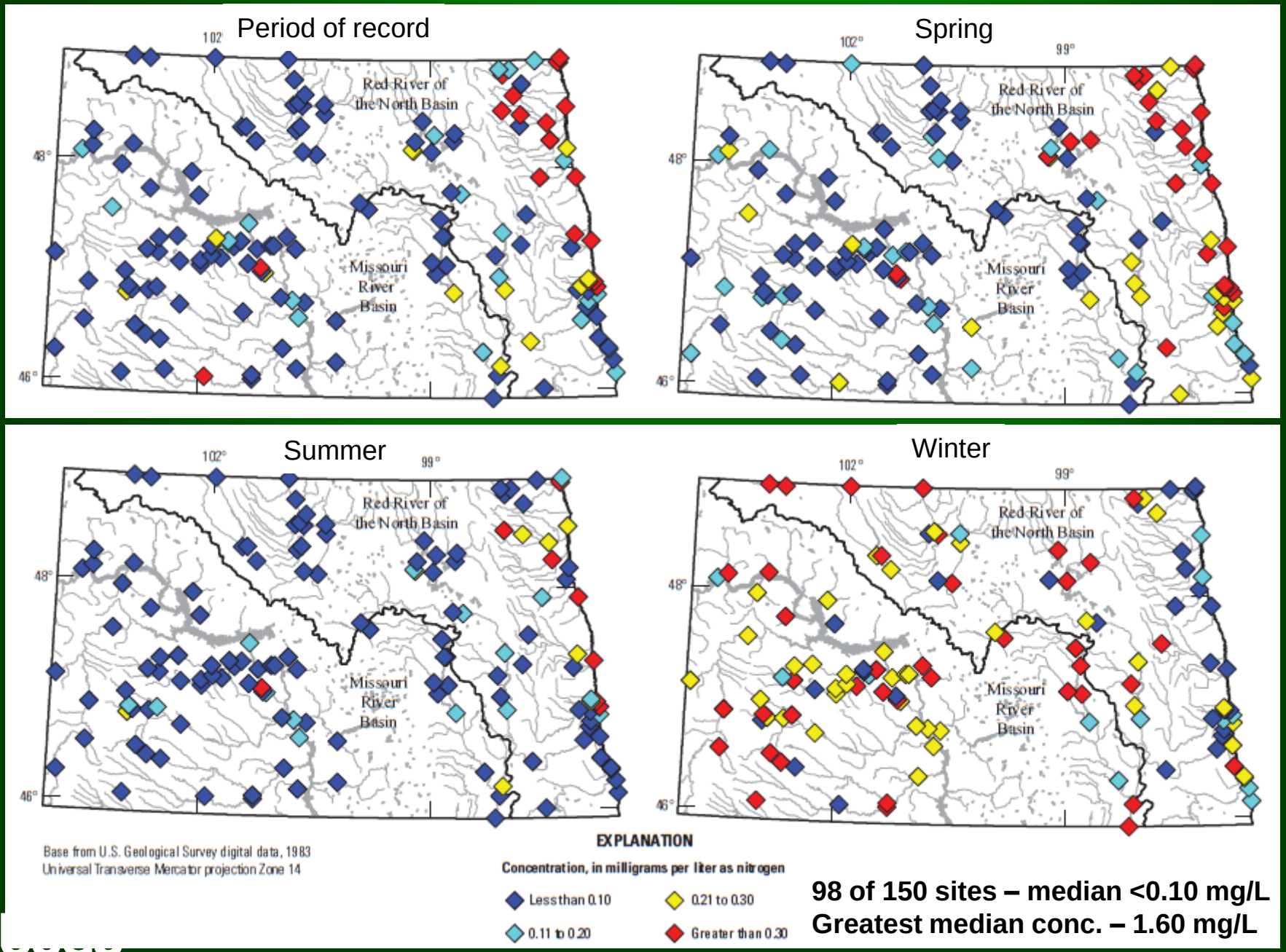
SPATIAL DISTRIBUTION - MEDIAN AMMONIA CONCENTRATIONS



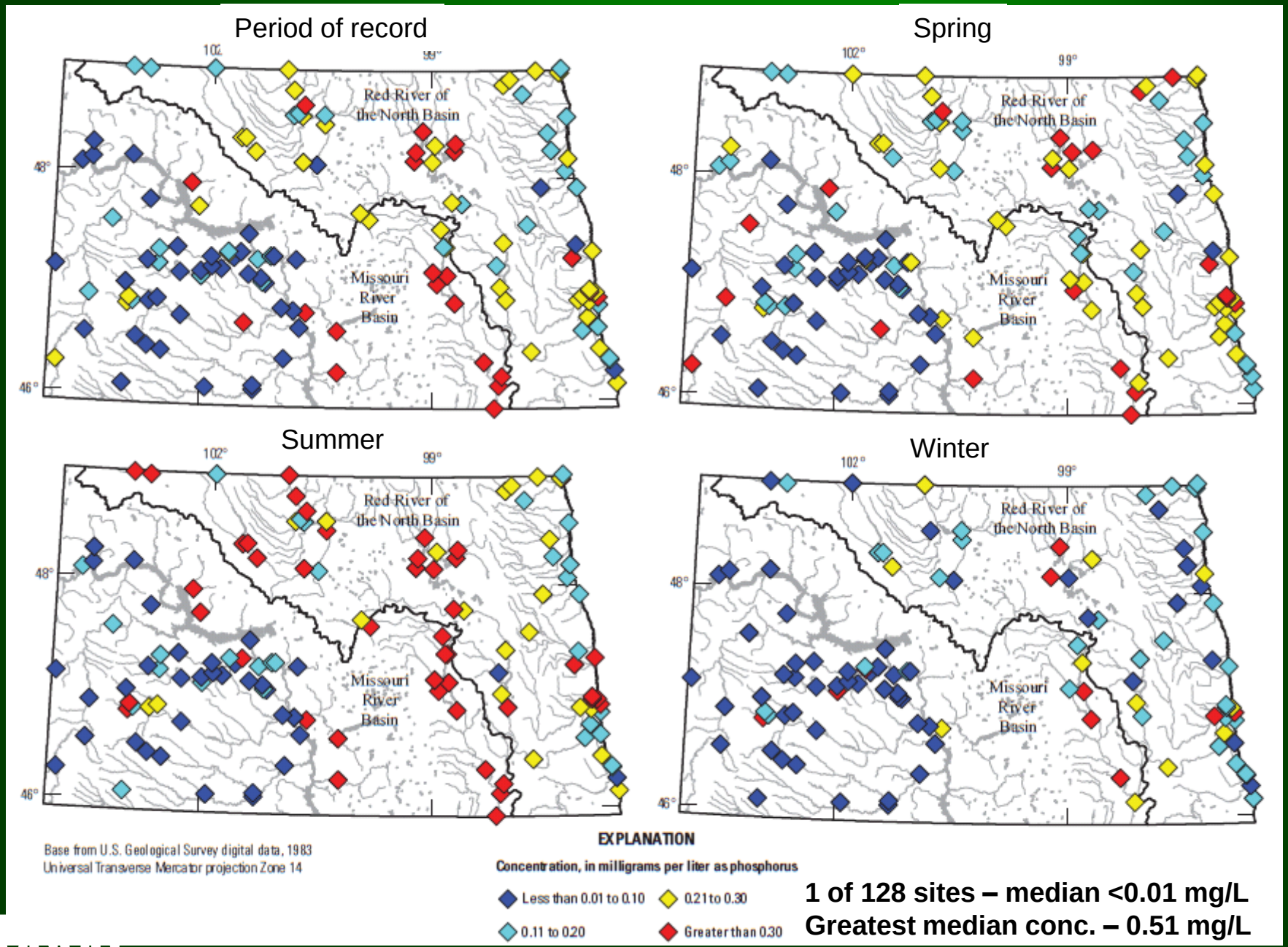
64 of 139 sites – median <0.04 mg/L
Greatest median conc. – 0.59 mg/L

SPATIAL DISTRIBUTION - MEDIAN NITRATE PLUS NITRITE CONCENTRATIONS

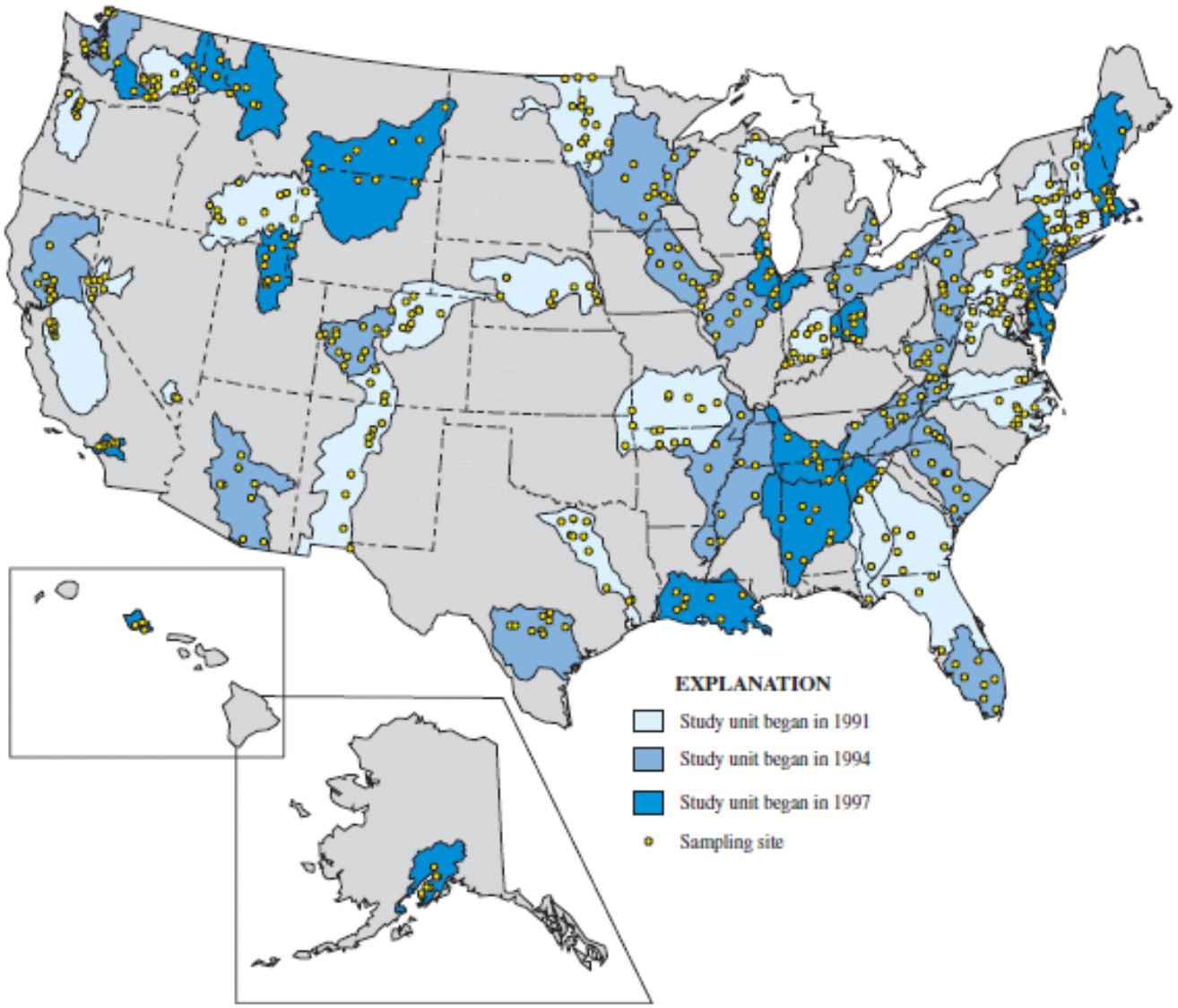


98 of 150 sites – median <0.10 mg/L
Greatest median conc. – 1.60 mg/L

SPATIAL DISTRIBUTION - MEDIAN TOTAL PHOSPHORUS CONCENTRATIONS



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.

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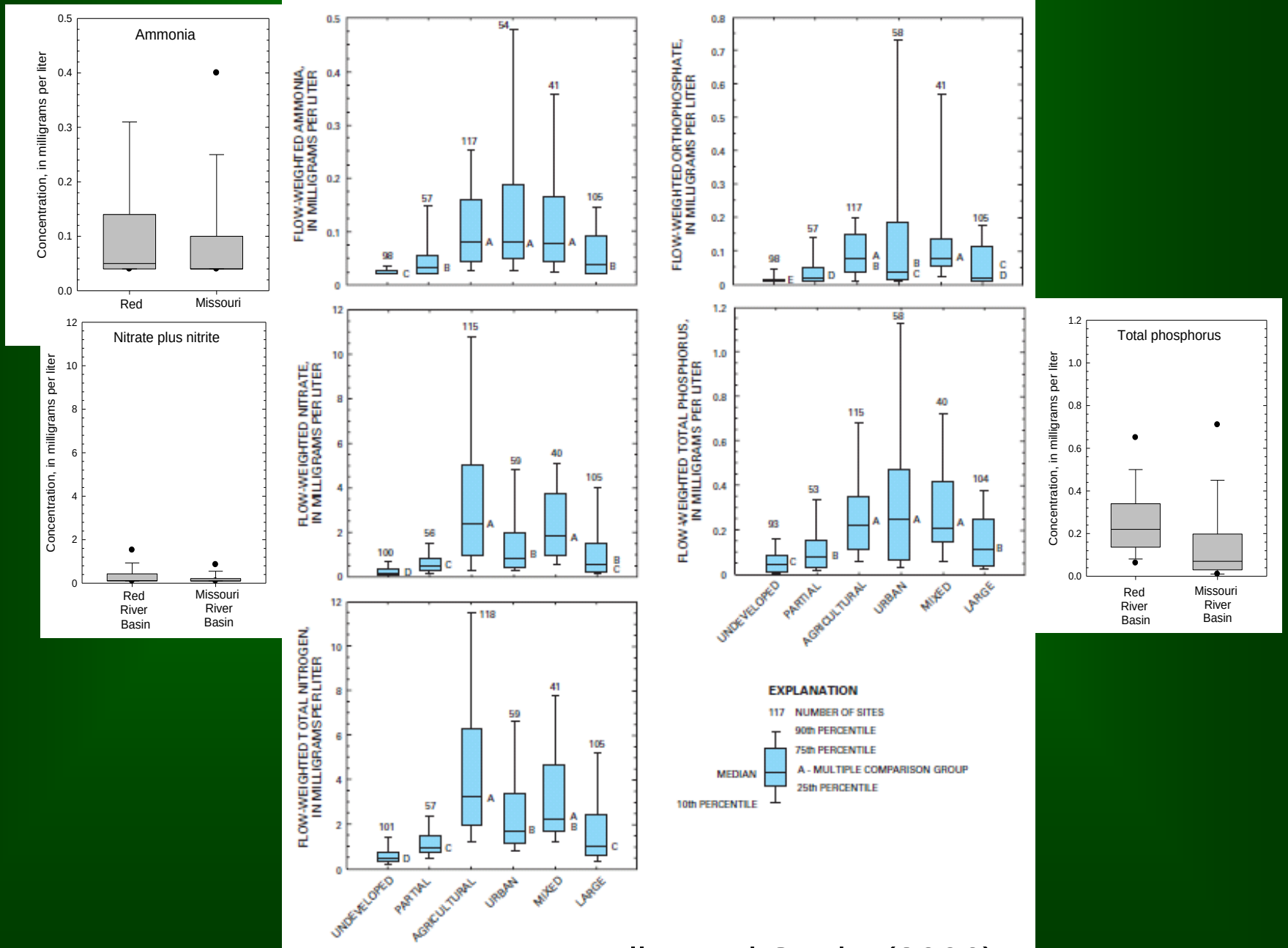

From Mueller and Spahr (2006)

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

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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/mi^2) were calculated from the estimated loads:

Load (lbs/yr) / Drainage area (mi^2)

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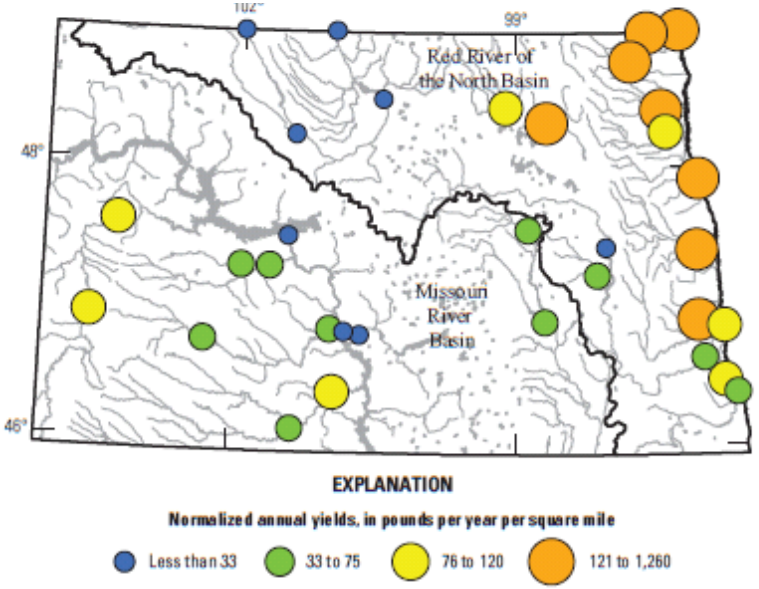
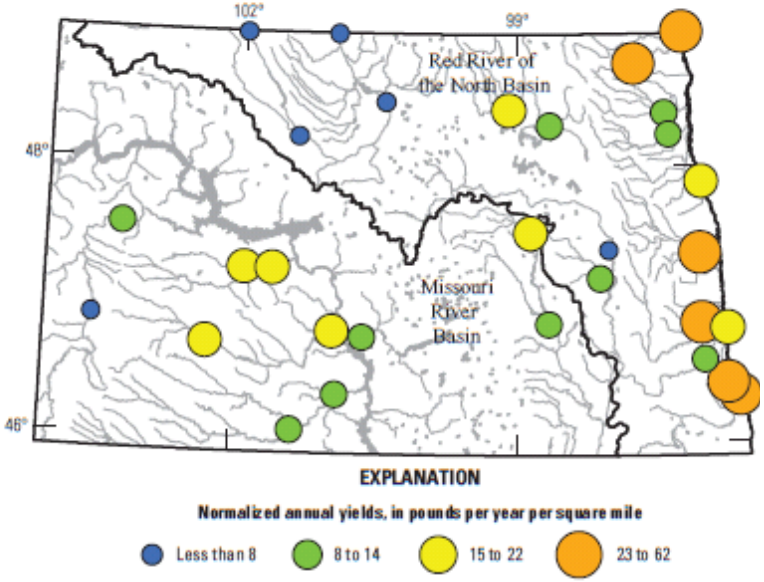
Nutrient Yields

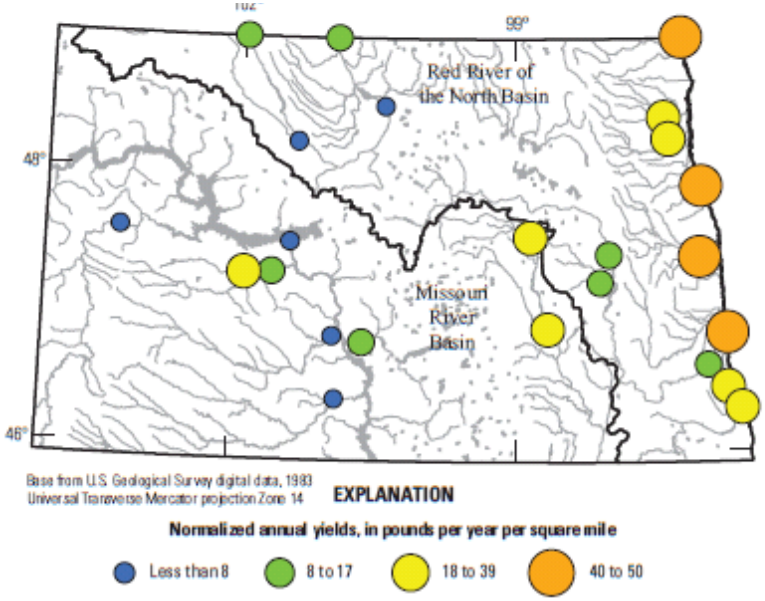
Nitrate plus nitrite (total and dissolved)



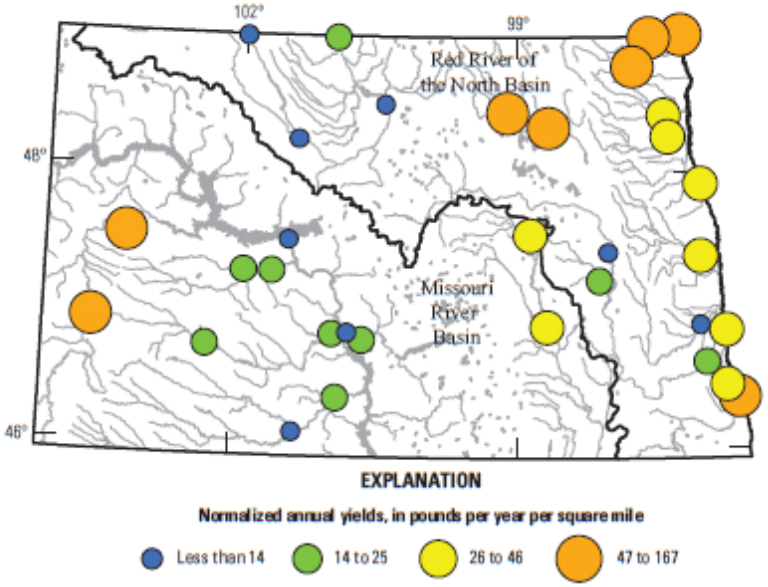
Ammonia (total and dissolved)



Dissolved phosphorus



Total phosphorus



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 phos.
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

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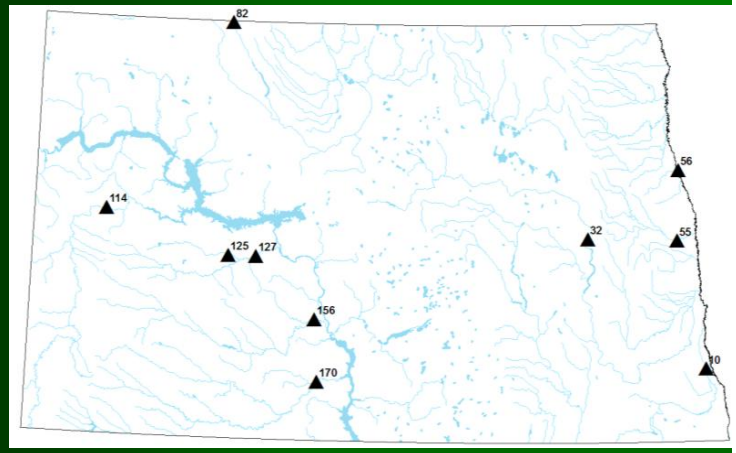
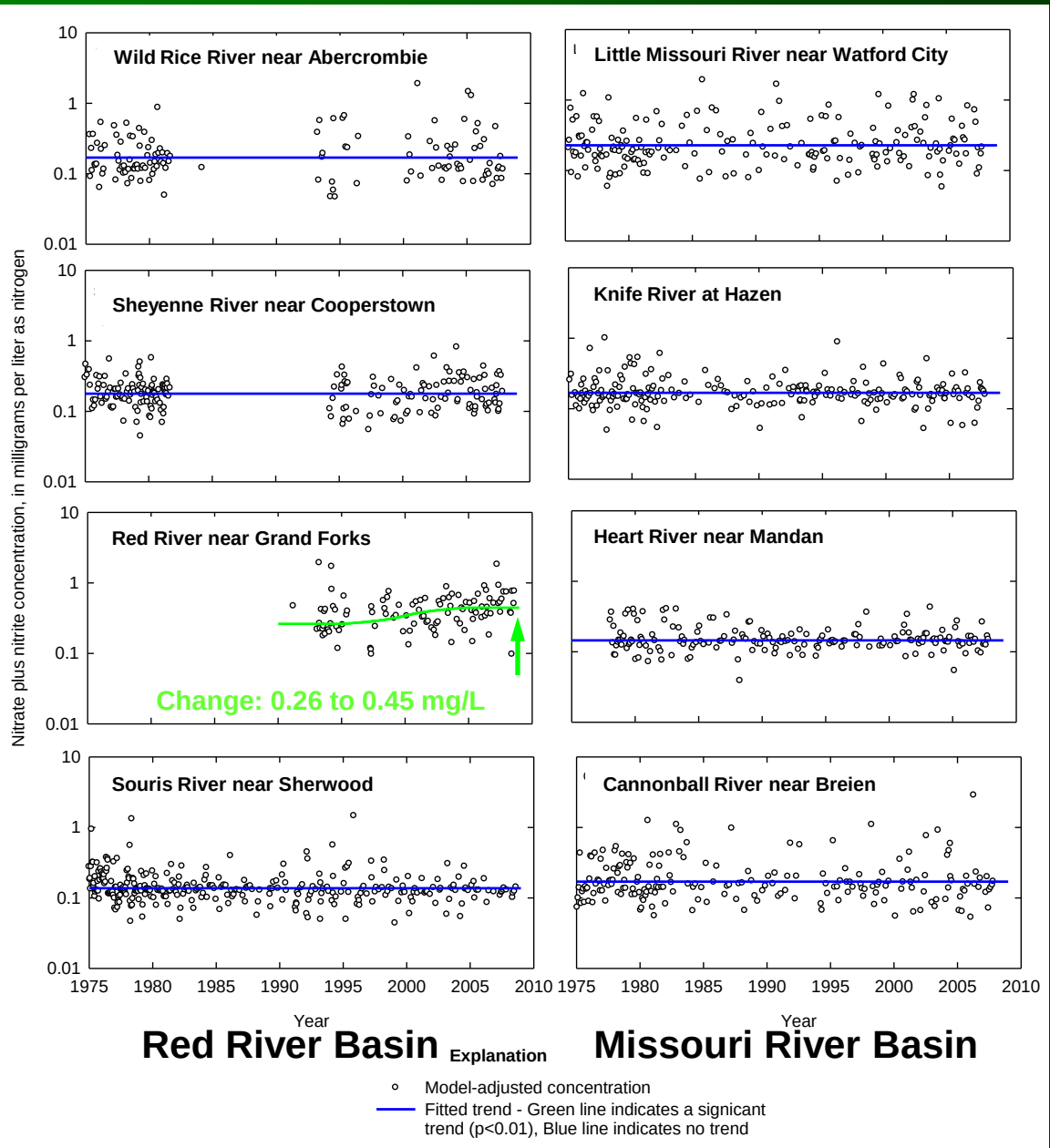
Nitrate plus Nitrite Trends





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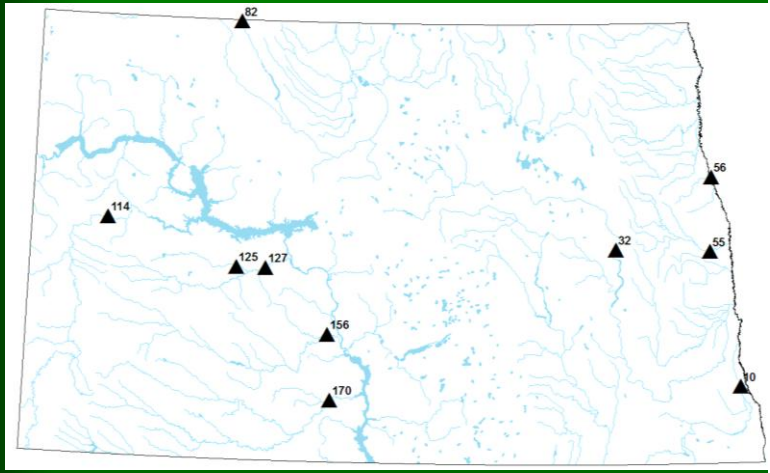
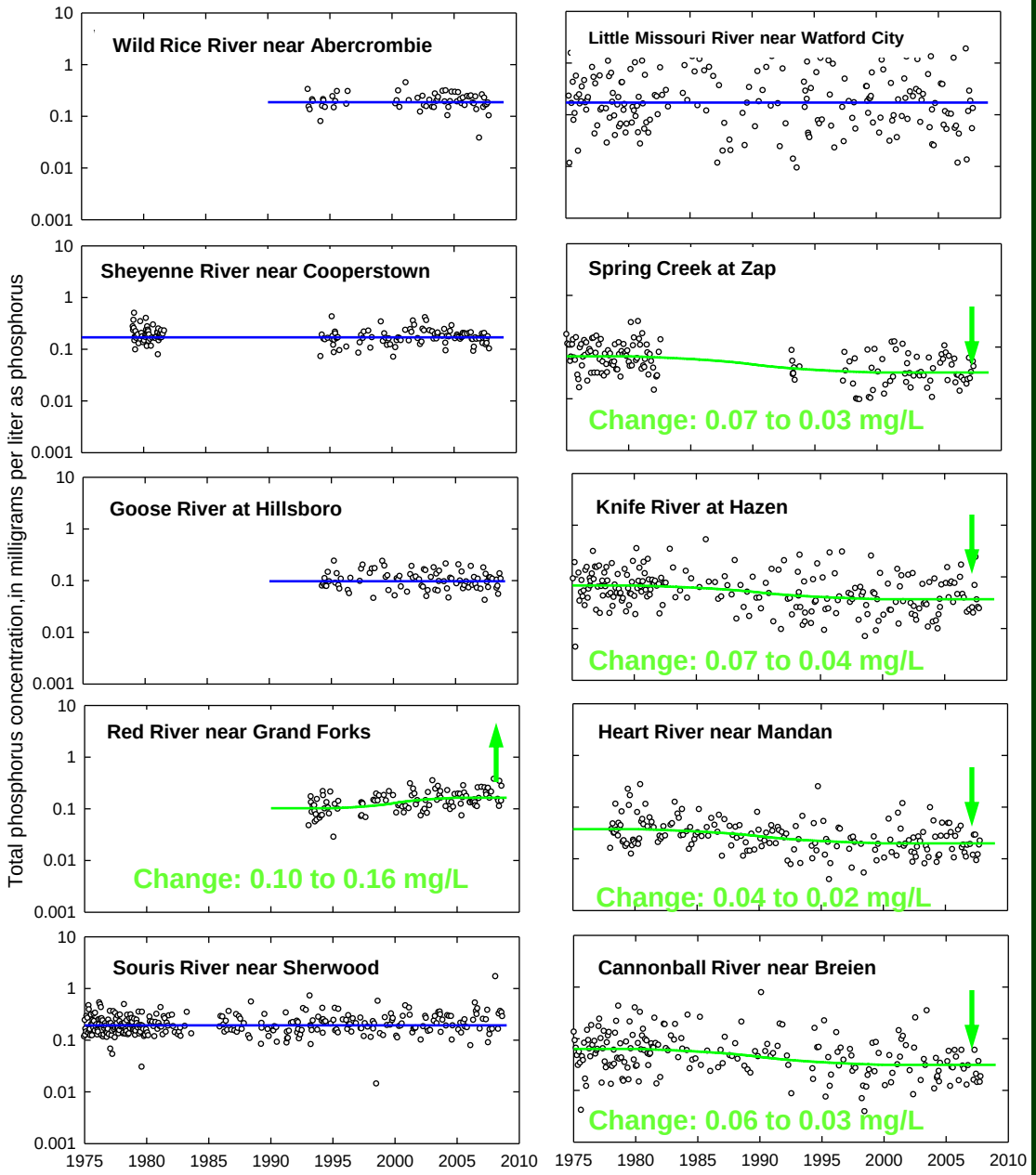
Total Phosphorus Trends





Red River Basin **Missouri River Basin**

Explanation
- Model-adjusted concentration
- Fitted trend - Green line indicates a signicant trend (p<0.01), Blue line indicates no trend

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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 Missiouri Basin had downward trend, 1 site had upward trend (Red River), others had no trend

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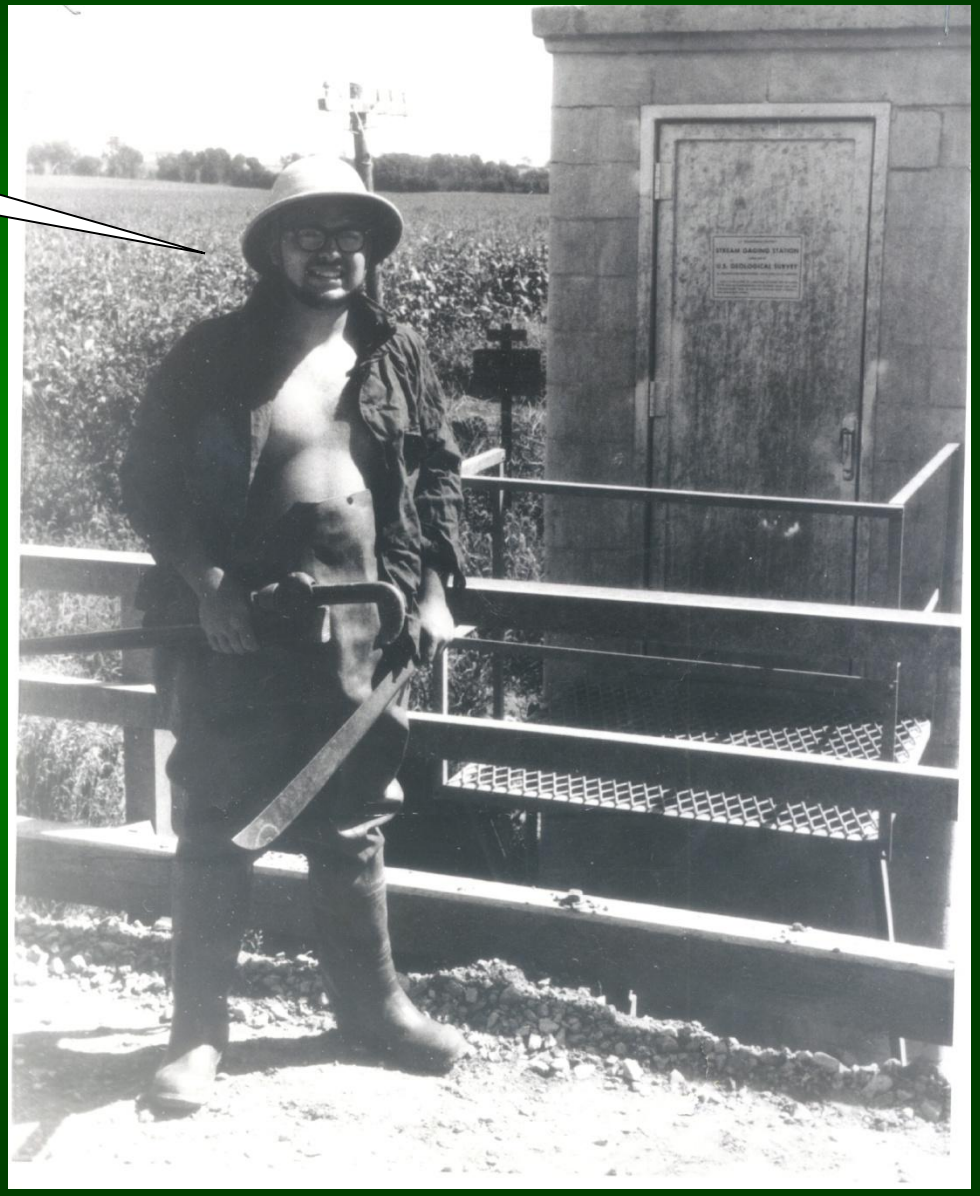
ANY QUESTIONS?



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