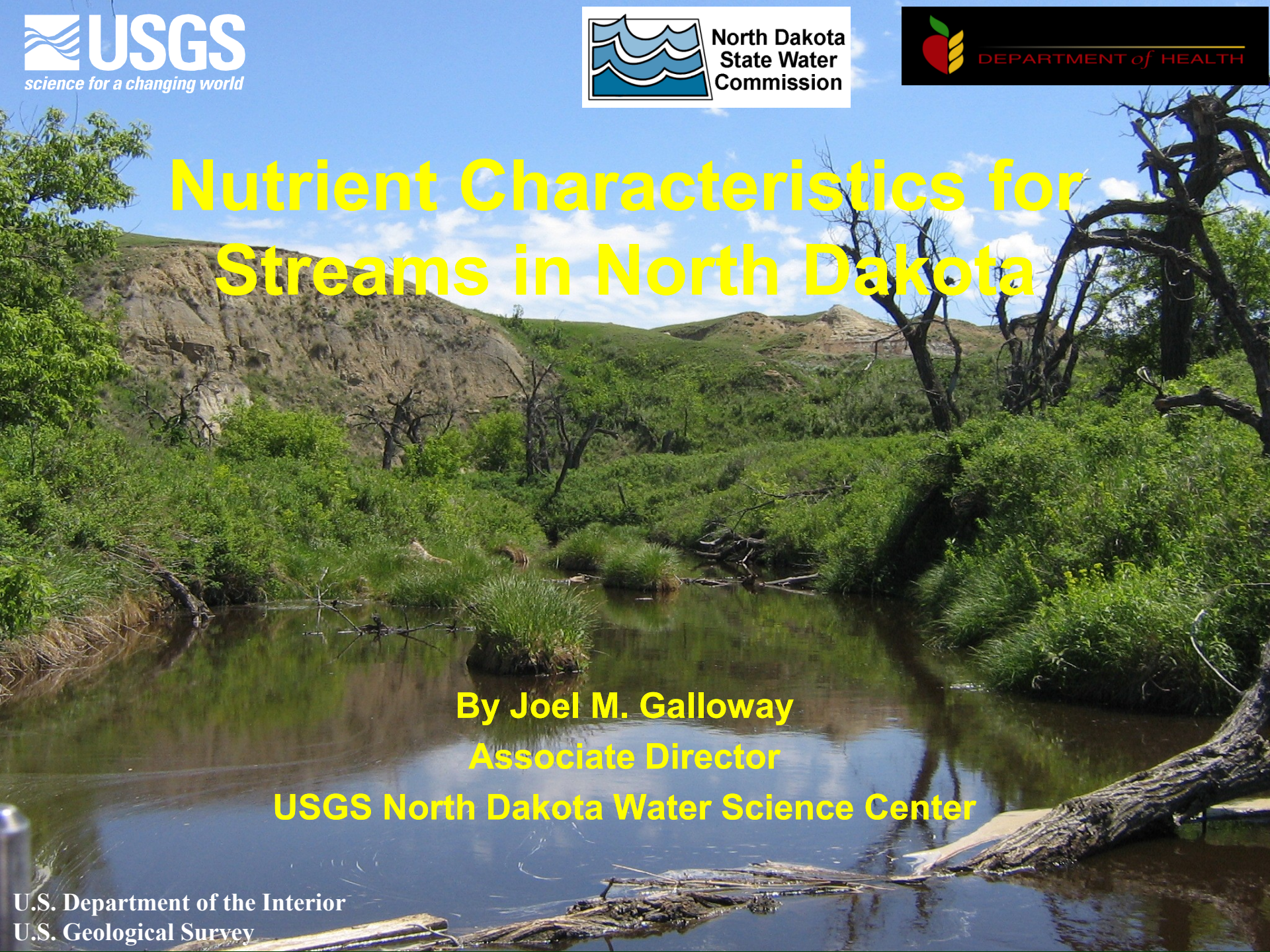
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science for a changing world
North Dakota
State Water
Commission
DEPARTMENT of HEALTH
Nutrient Characteristics for
Streams in North Dakota
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Background

- 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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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 Characteristics

- Spatial distribution of concentrations
- Yields
- Trends

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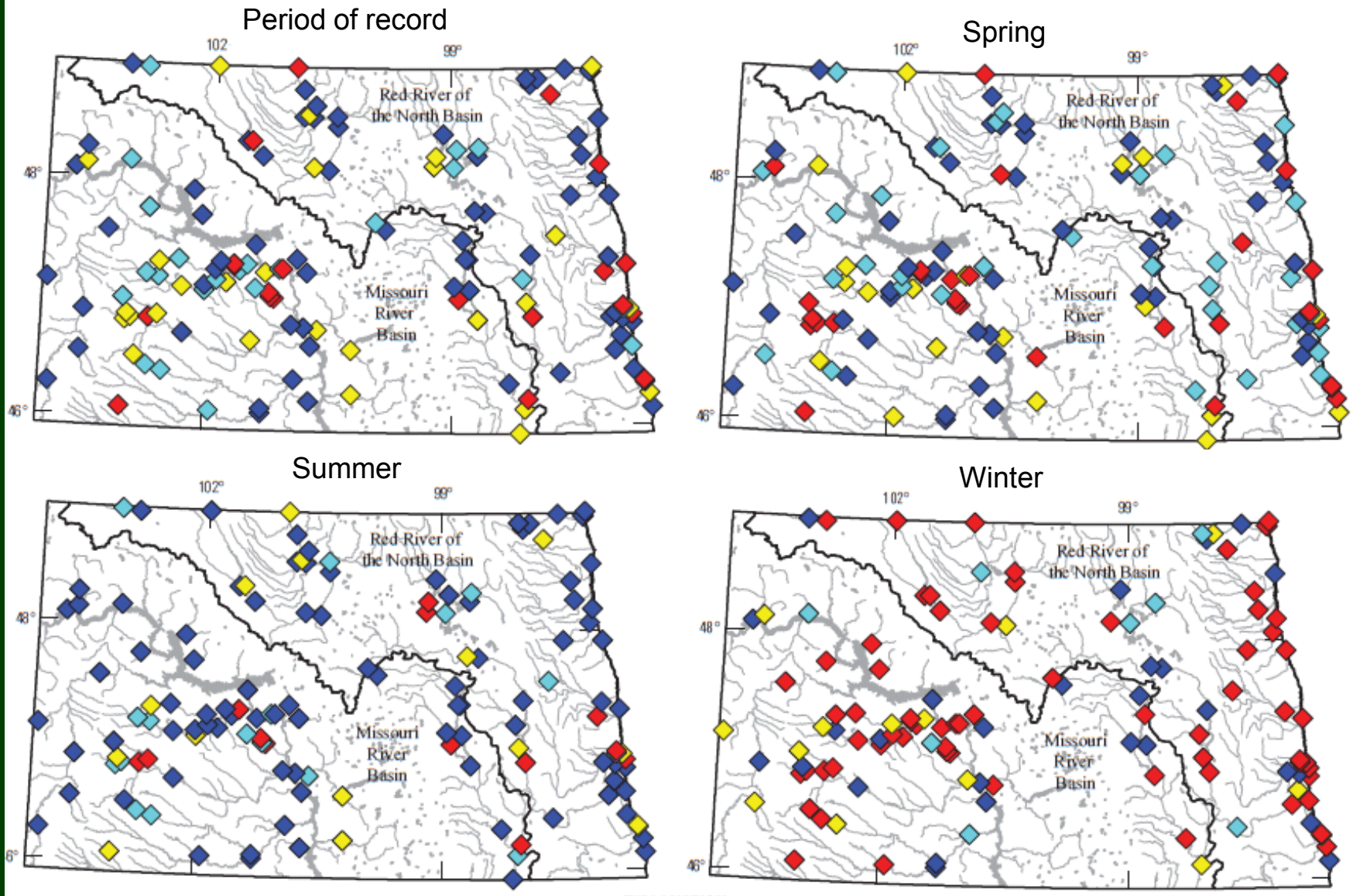
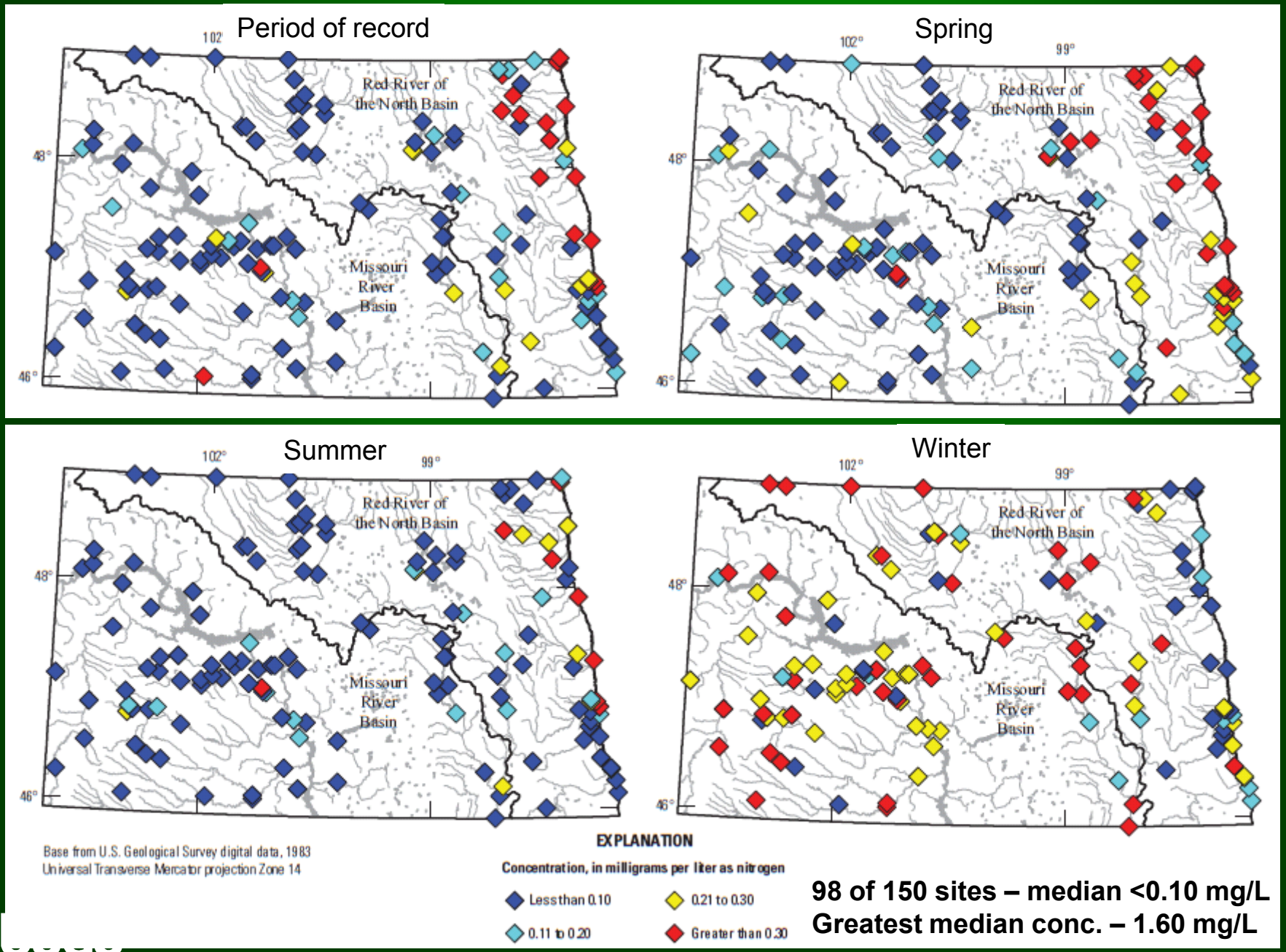
SPATIAL DISTRIBUTION - MEDIAN AMMONIA CONCENTRATIONS



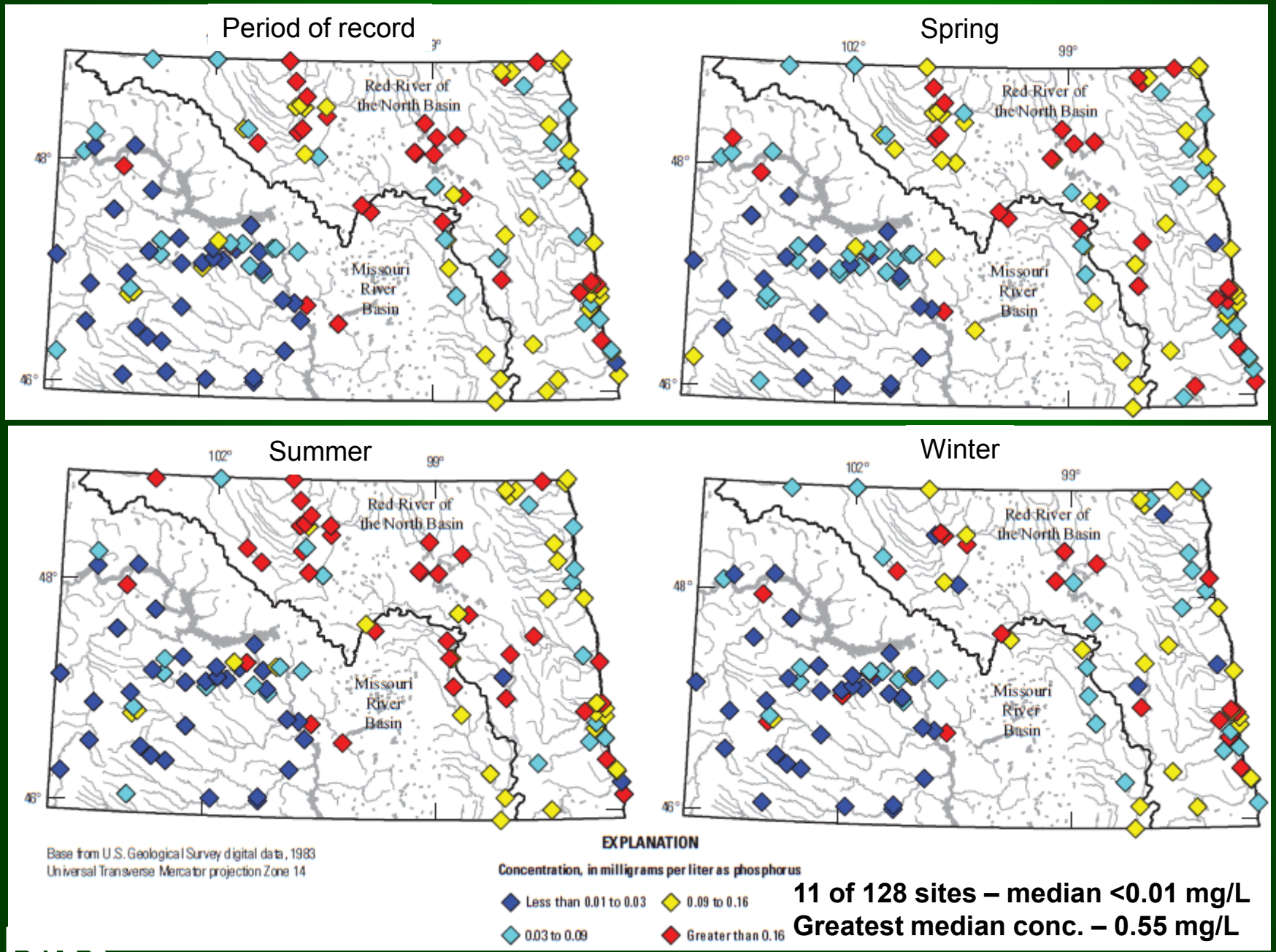
64 of 139 sites – median <0.04 mg/L
Greatest median conc. – 0.59 mg/L

SPATIAL DISTRIBUTION - MEDIAN NITRATE PLUS NITRITE CONCENTRATIONS



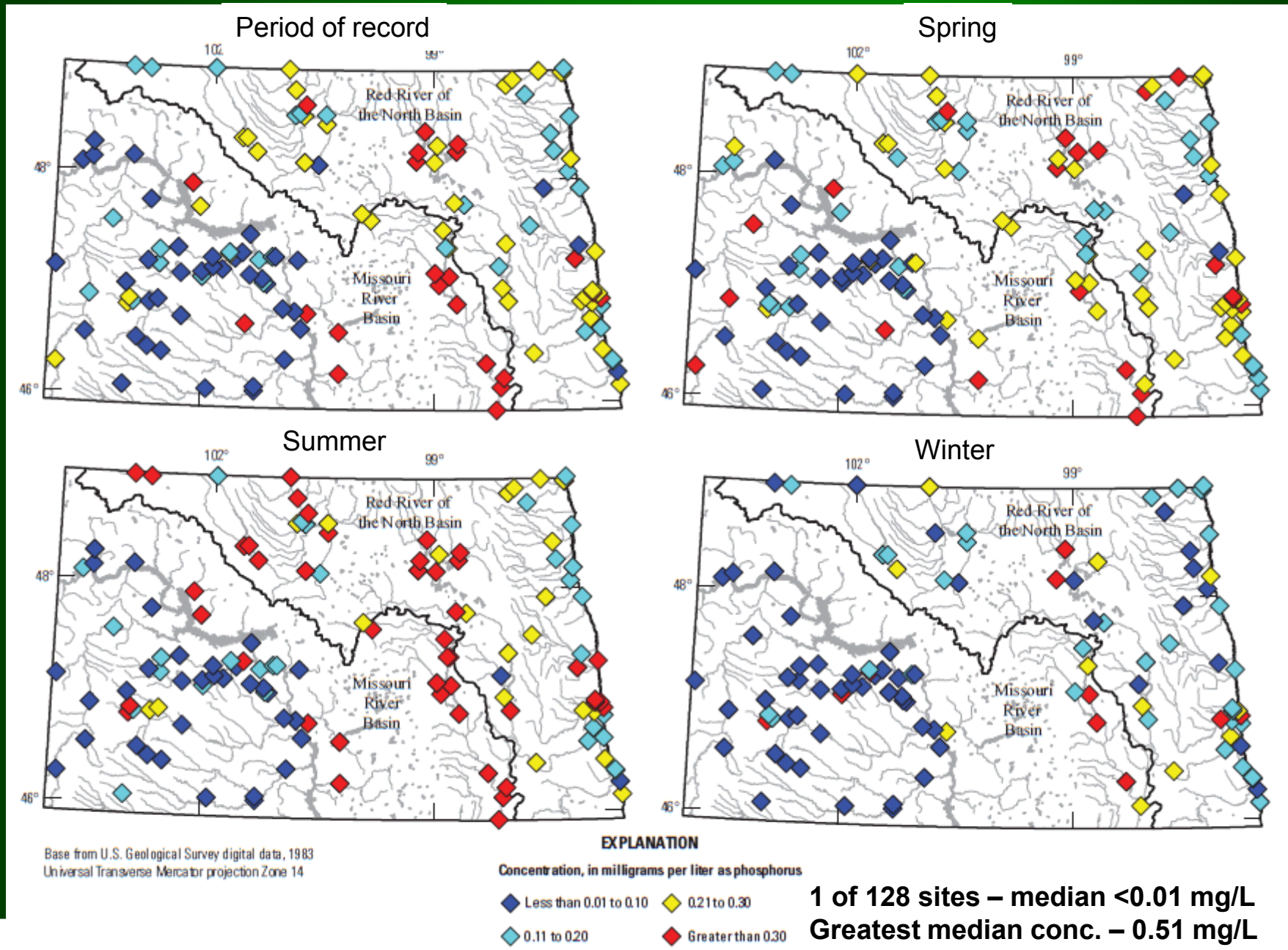
98 of 150 sites – median <0.10 mg/L
Greatest median conc. – 1.60 mg/L

SPATIAL DISTRIBUTION - MEDIAN DISSOLVED PHOSPHORUS CONCENTRATIONS

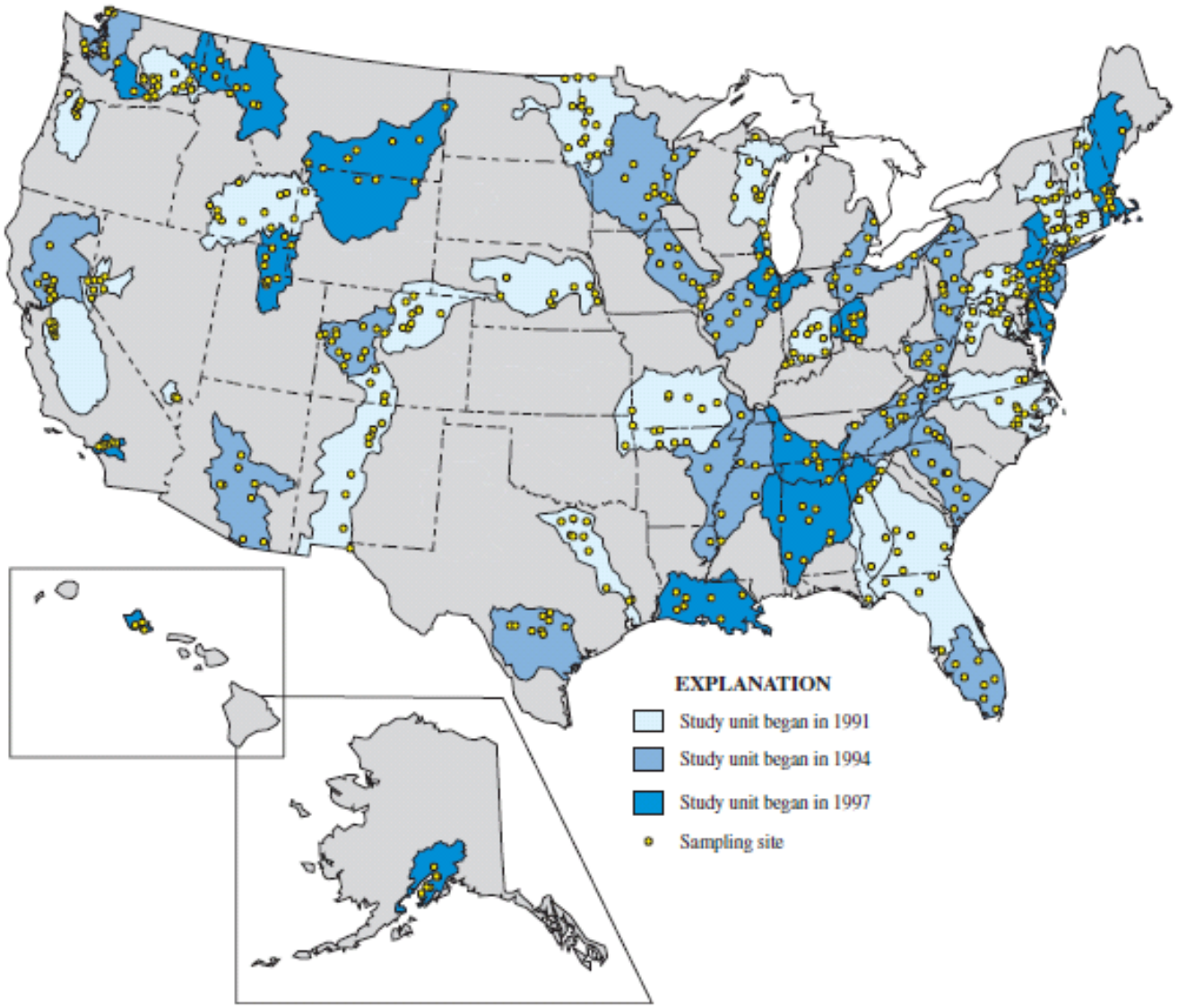


11 of 128 sites – median <0.01 mg/L
Greatest median conc. – 0.55 mg/L

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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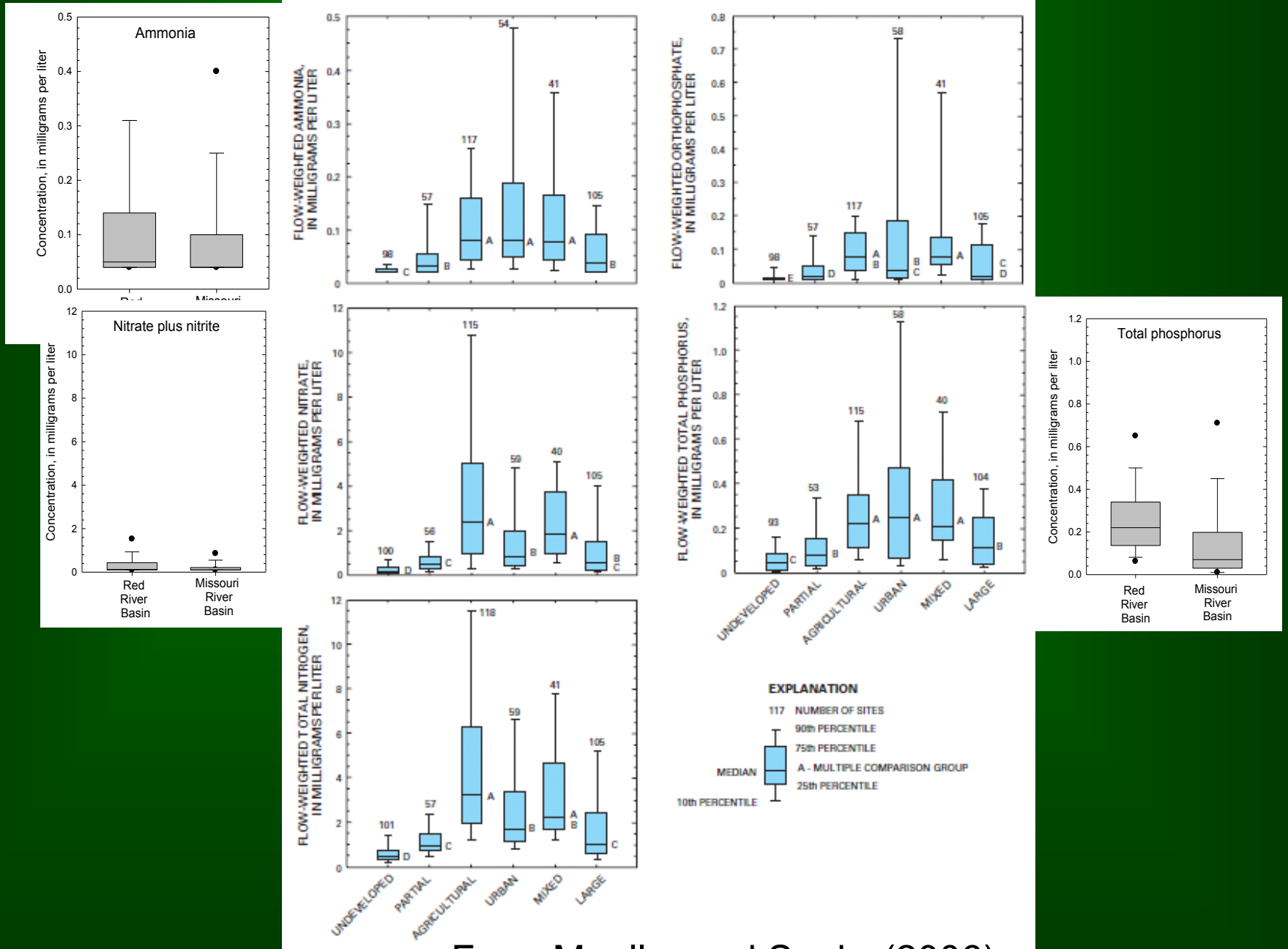

From Mueller and Spahr (2006)

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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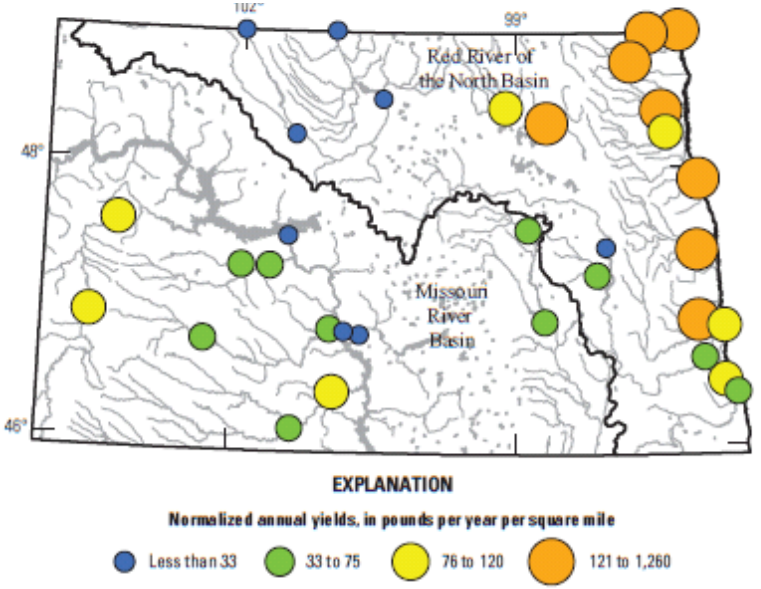
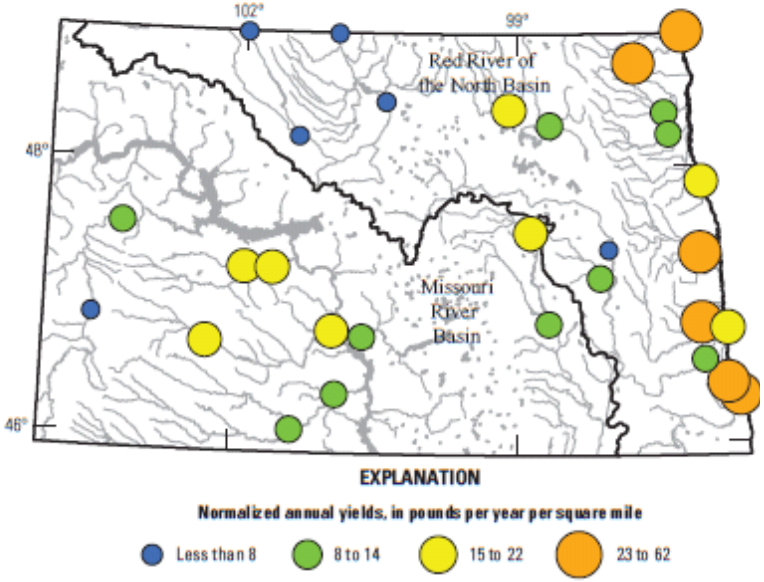
Nutrient Yields

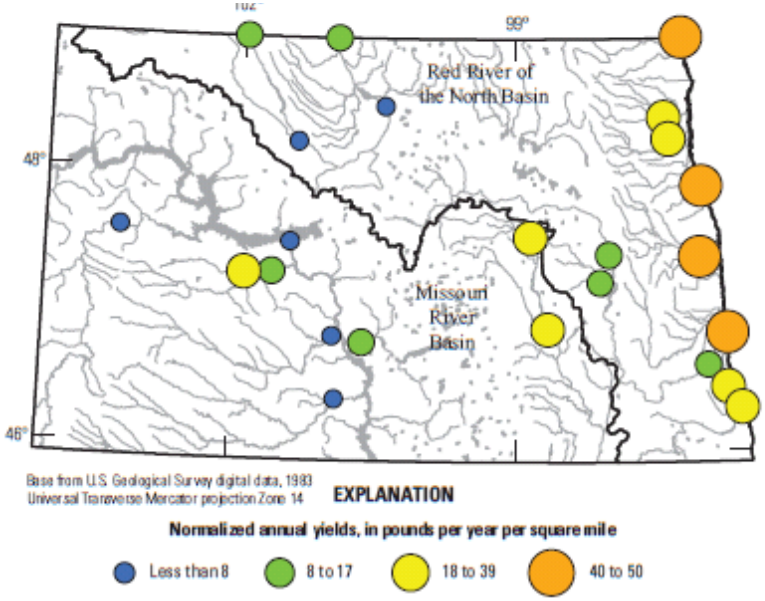
Nitrate plus nitrite (total and dissolved)



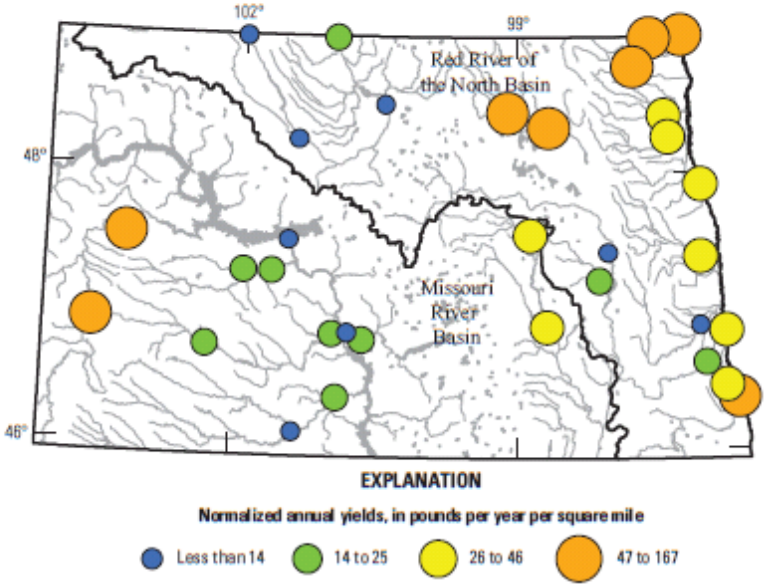
Ammonia (total and dissolved)



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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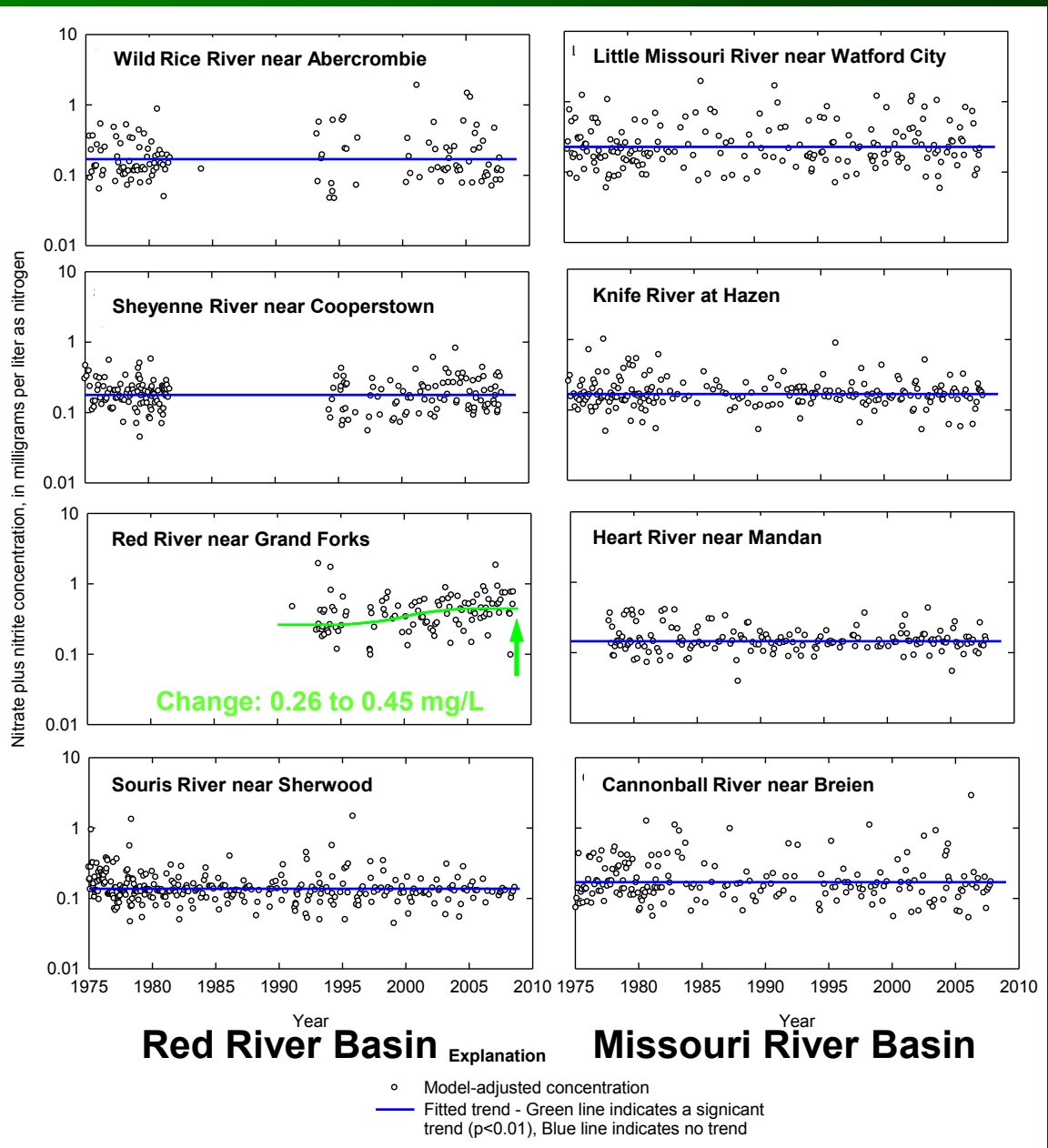
Nitrate plus Nitrite Trends



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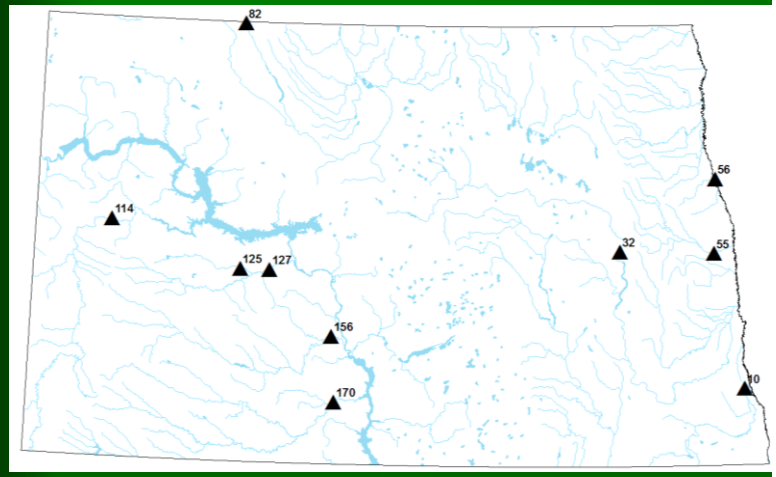
Total Phosphorus Trends



Total phosphorus concentration, in milligrams per liter as phosphorus

Wild Rice River near Abercrombie

Little Missouri River near Watford City

Sheyenne River near Cooperstown

Spring Creek at Zap
Change: 0.07 to 0.03 mg/L

Goose River at Hillsboro

Knife River at Hazen
Change: 0.07 to 0.04 mg/L

Red River near Grand Forks
Change: 0.10 to 0.16 mg/L

Heart River near Mandan
Change: 0.04 to 0.02 mg/L

Souris River near Sherwood

Cannonball River near Breien
Change: 0.06 to 0.03 mg/L

10 | 1 | 0.1 | 0.01 | 0.001

1975 1980 1985 1990 1995 2000 2005 2010

Year

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
  - Diss. phosphorus - higher in Red River Basin
    - No distinct seasonal pattern
  - Total phosphorus - higher in Red River Basin
    - Highest in summer
  - Total organic carbon – higher in Missouri Basin
- Nutrient yields generally higher in Red River Basin
- Nutrient Trends:
  - Nitrate plus Nitrite – no trend at most sites, upward trend in Red River
  - Total phosphorus – 4 sites had downward trend, 1 site had upward trend (Red River), others had no trend

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ANY QUESTIONS?

Data and analysis are from:

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

By Joel M. Galloway, Aldo V. Vecchia, Kevin C. Vining, Brenda K. Densmore, and Robert F. Lundgren

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

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