# Distribution and Sources of Nutrients in the Illinois River Basin in Comparison to Other Areas of the Upper Mississippi River Basin

(*Through the Use of SPARROW Models*)

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Illinois River System (13th Biennial Meeting)
October 6, 2011

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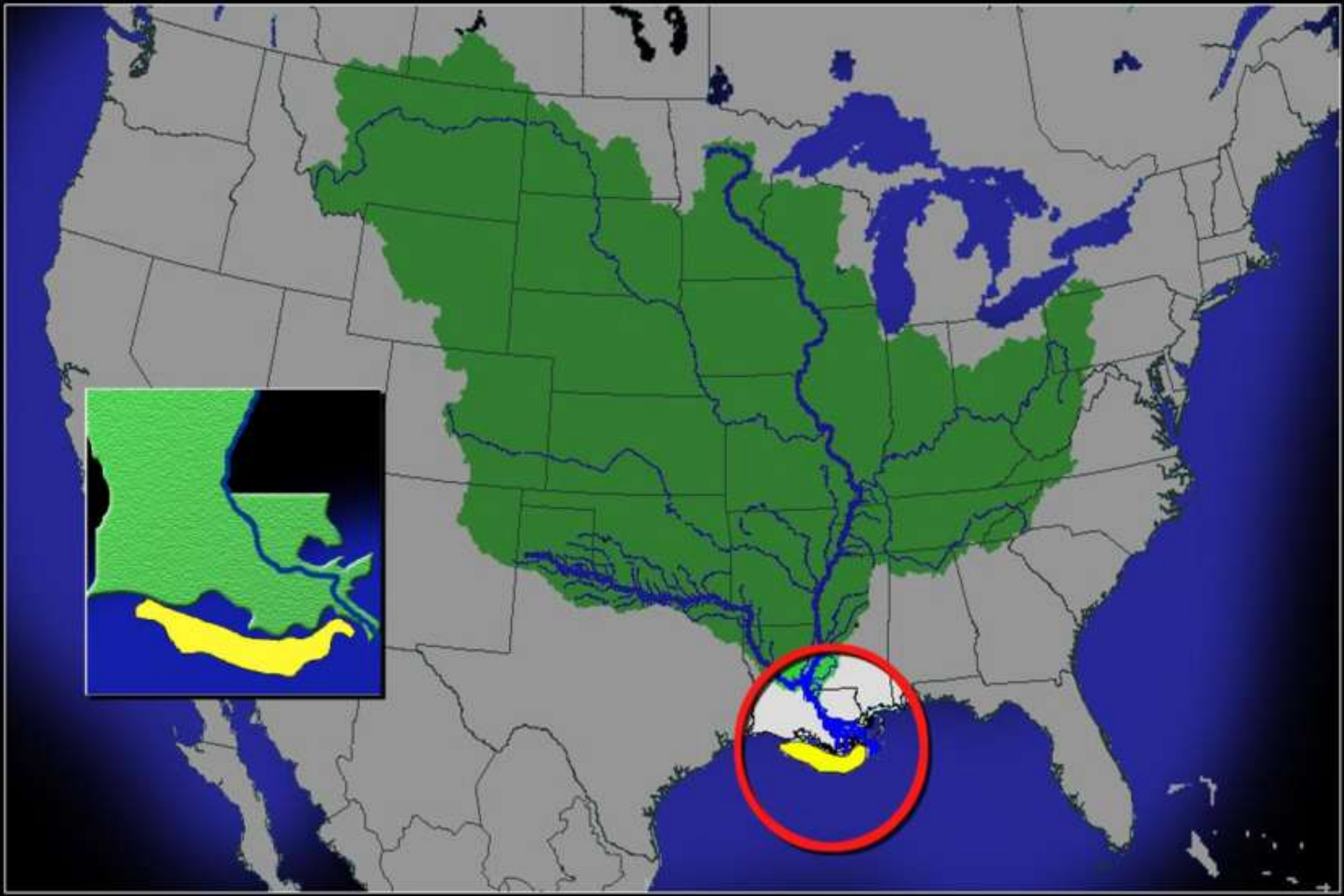
# The Importance of Nutrient Loading to Lakes is Well Known
# And is One of the Primary Reasons for Impairment Across the Country

Delavan Lake, Wisconsin

# Gulf Hypoxia



Early results suggested this was driven by Nitrogen Loading from the basin, now maybe both Nitrogen and Phosphorus

*Illinois River (Peoria Area) TMDL and LRS Development*

*Watershed Characterization and Source Assessment Report (Stage 1)*

**REVIEW DRAFT**

August 4, 2010

Prepared for

U.S. Environmental Protection Agency -- Region 5
Illinois Environmental Protection Agency

Prepared by

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The project is intended to address water quality problems in the watershed associated with bacteria, phosphorus, total suspended solids, sedimentation / siltation, dissolved oxygen, chloride, aquatic algae, pH, alteration in streamside vegetative cover, manganese, and total dissolved solids identified on the State of Illinois §303(d) list.

# Goals of SPARROW Modeling:

1. Determine N and P loading over large geographical areas.

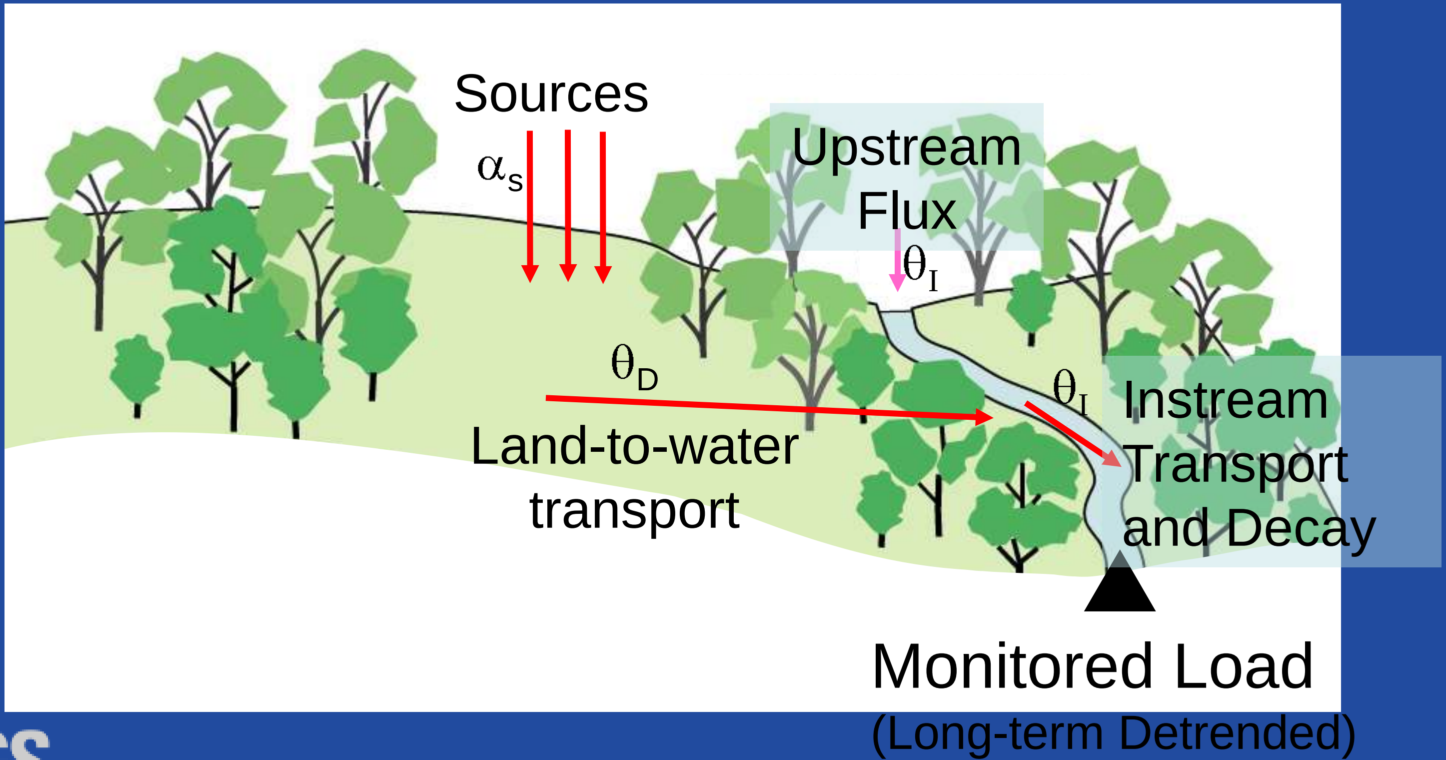
2. Rank the contributing areas based on loads and yields (prioritizing efforts).

3. Determine relative importance of nutrient sources (what type of efforts).

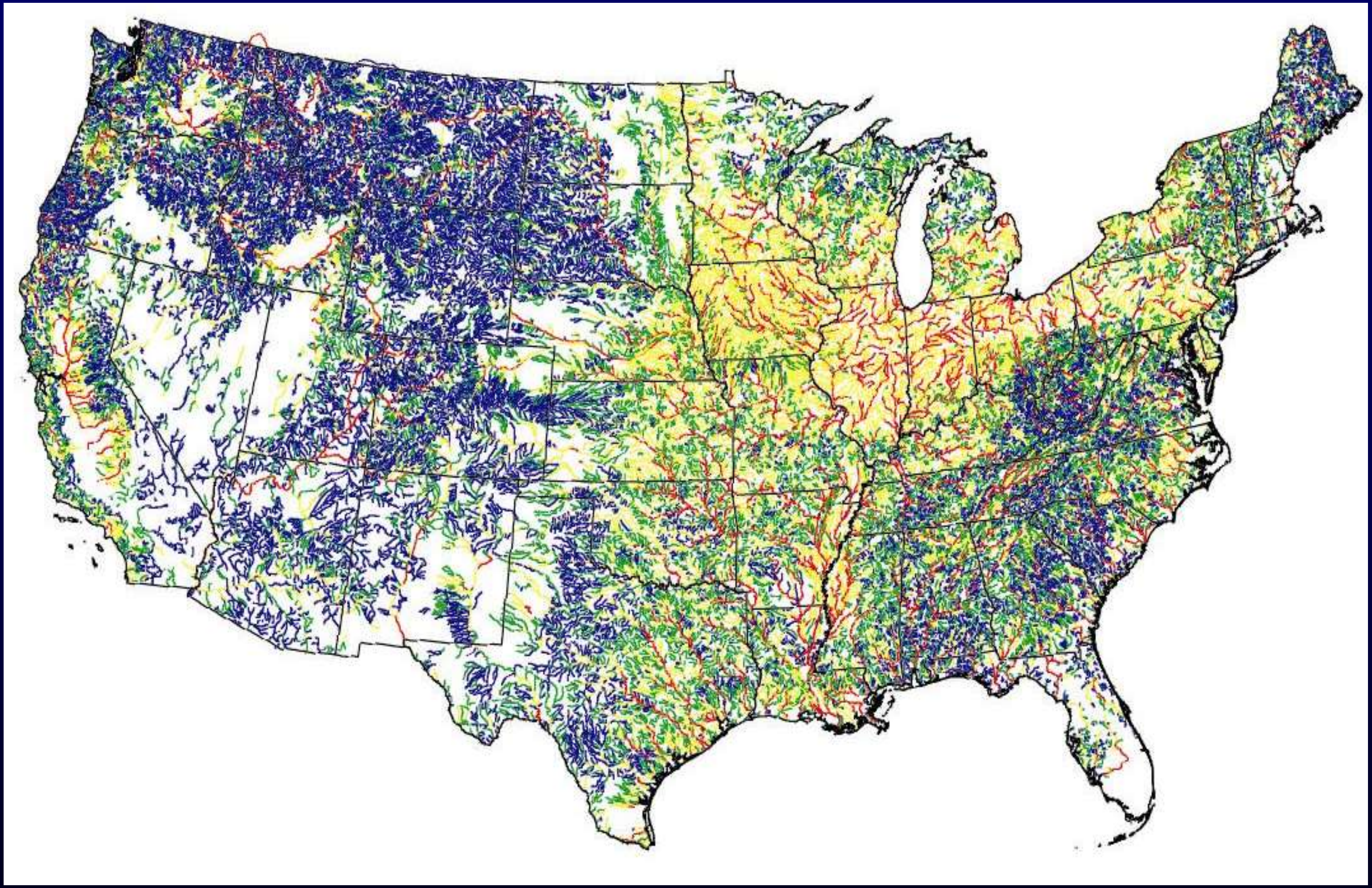
# SPARROW Mass Balance Modeling Approach

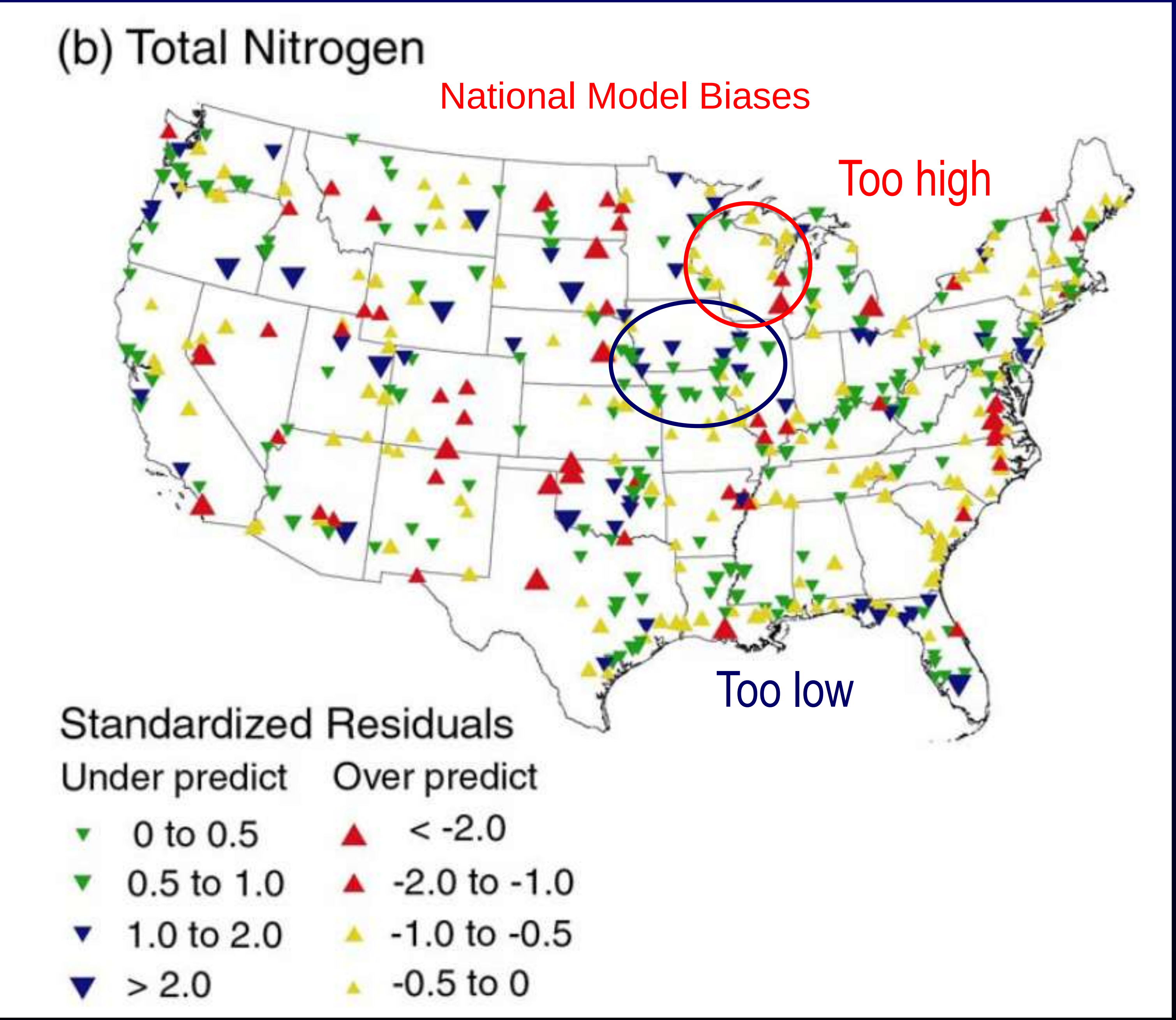
## SPAtially Referenced Regression on Watershed Attributes

- Regress water-quality conditions (long-term average detrended monitored loads) on upstream sources and factors controlling transport



# Predictions from a National SPARROW Model

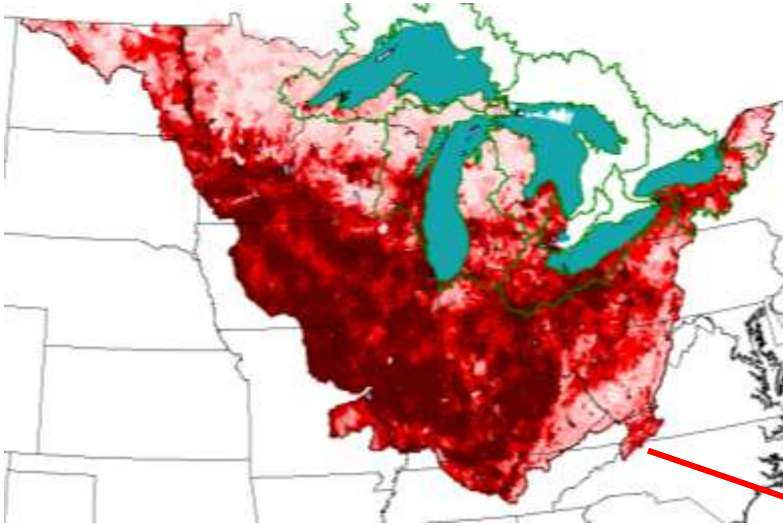




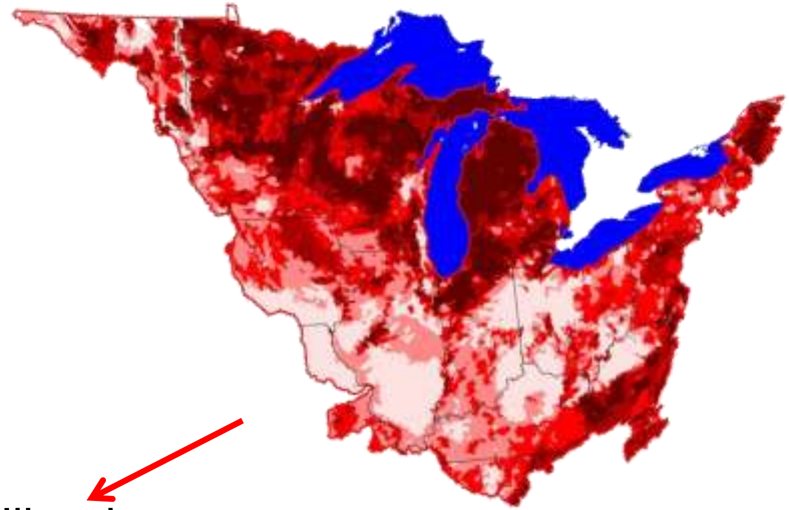
(b) Total Nitrogen
National Model Biases
Too high
Too low
Standardized Residuals
Under predict
0 to 0.5
0.5 to 1.0
1.0 to 2.0
> 2.0
Over predict
< -2.0
-2.0 to -1.0
-1.0 to -0.5
-0.5 to 0

# Upper Midwest SPARROW Model Calibration

One Source: 2002 Farm Fertilizer TP inputs, kg



One Land-to-Water Delivery: Soil Permeability



Calibration

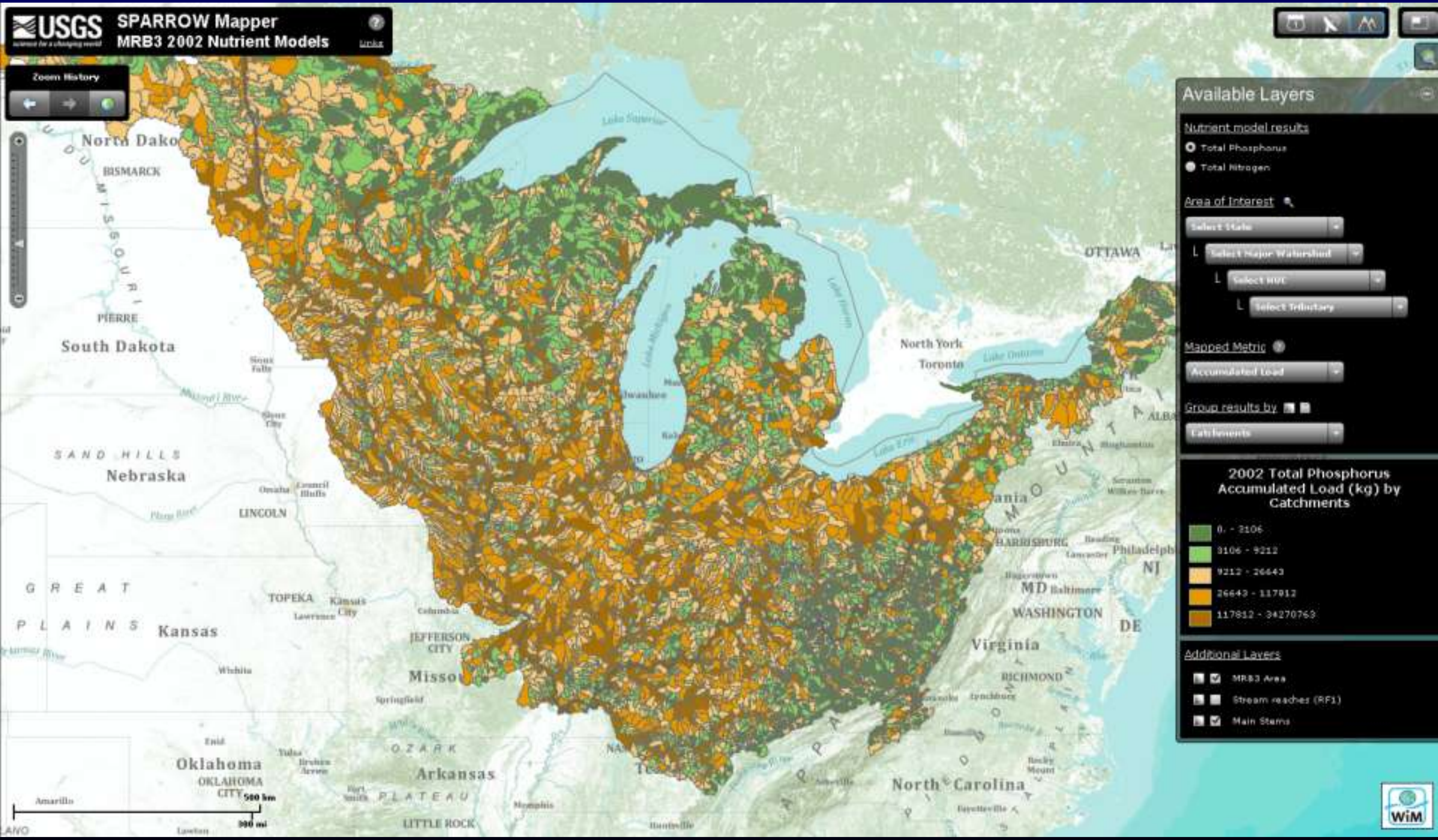
River Network – RF1

Long-term detrended Loads for 810 sites

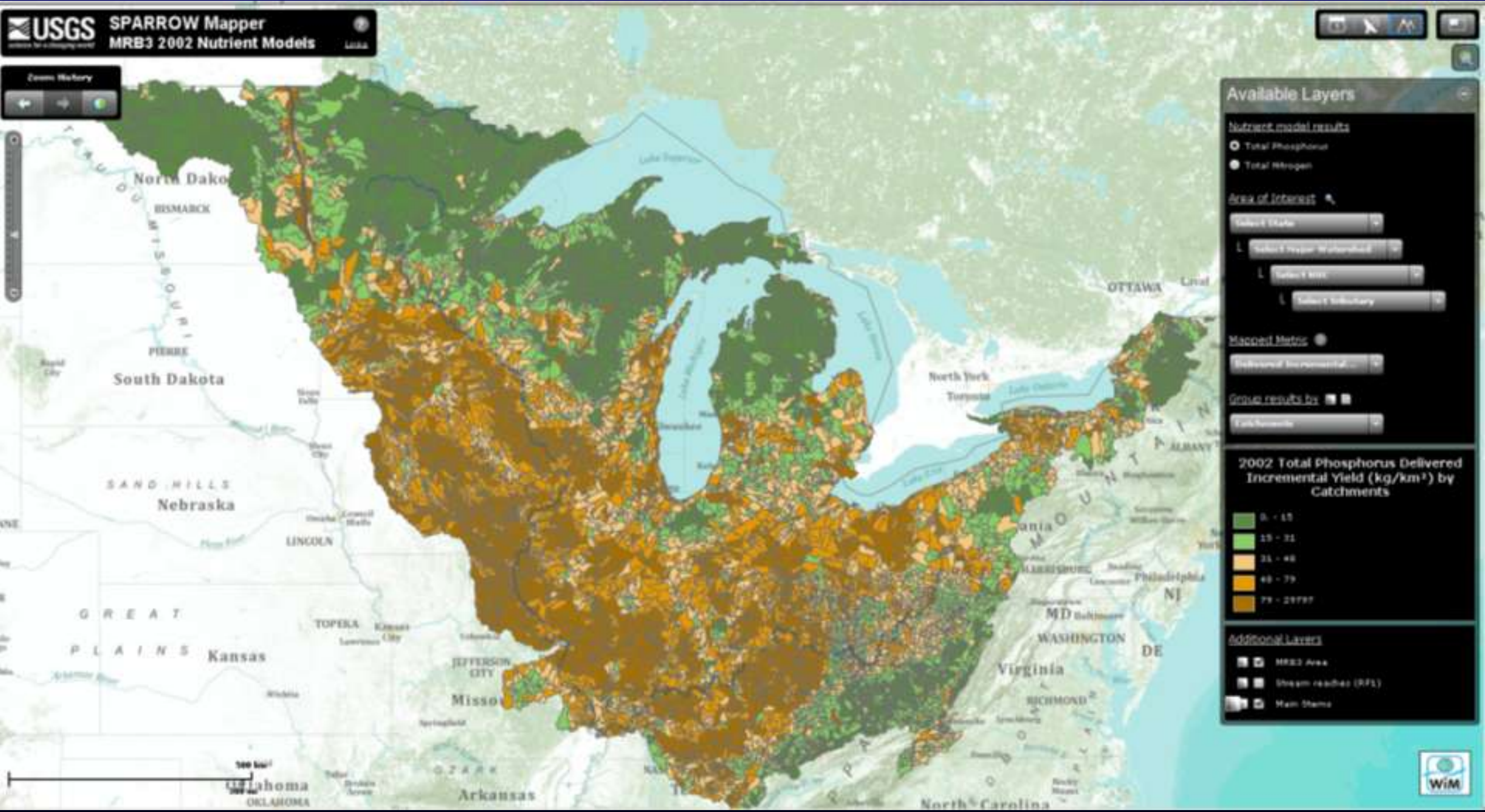
| MRB3 - SPARROW TP Model | | | | |
|---|---|---|---|---|
| Parameter | Coefficient units | Parameter values | Standard error | P value |
| **Sources** | | | | |
| Point Sources (total) | fraction | 1.068 | 0.142 | 0.0000 |
| Manure (confined) | fraction | 0.086 | 0.011 | 0.0000 |
| Manure (unconfined) | fraction | 0.032 | 0.010 | 0.0009 |
| Fertilizers (farm) | fraction | 0.029 | 0.004 | 0.0000 |
| Forest,Wetland,Scrub | $kg/km^2/yr$ | 14.700 | 0.017 | 0.0000 |
| Urban, Open | $kg/km^2/yr$ | 52.300 | 0.144 | 0.0001 |

*Robertson and Saad, 2011*

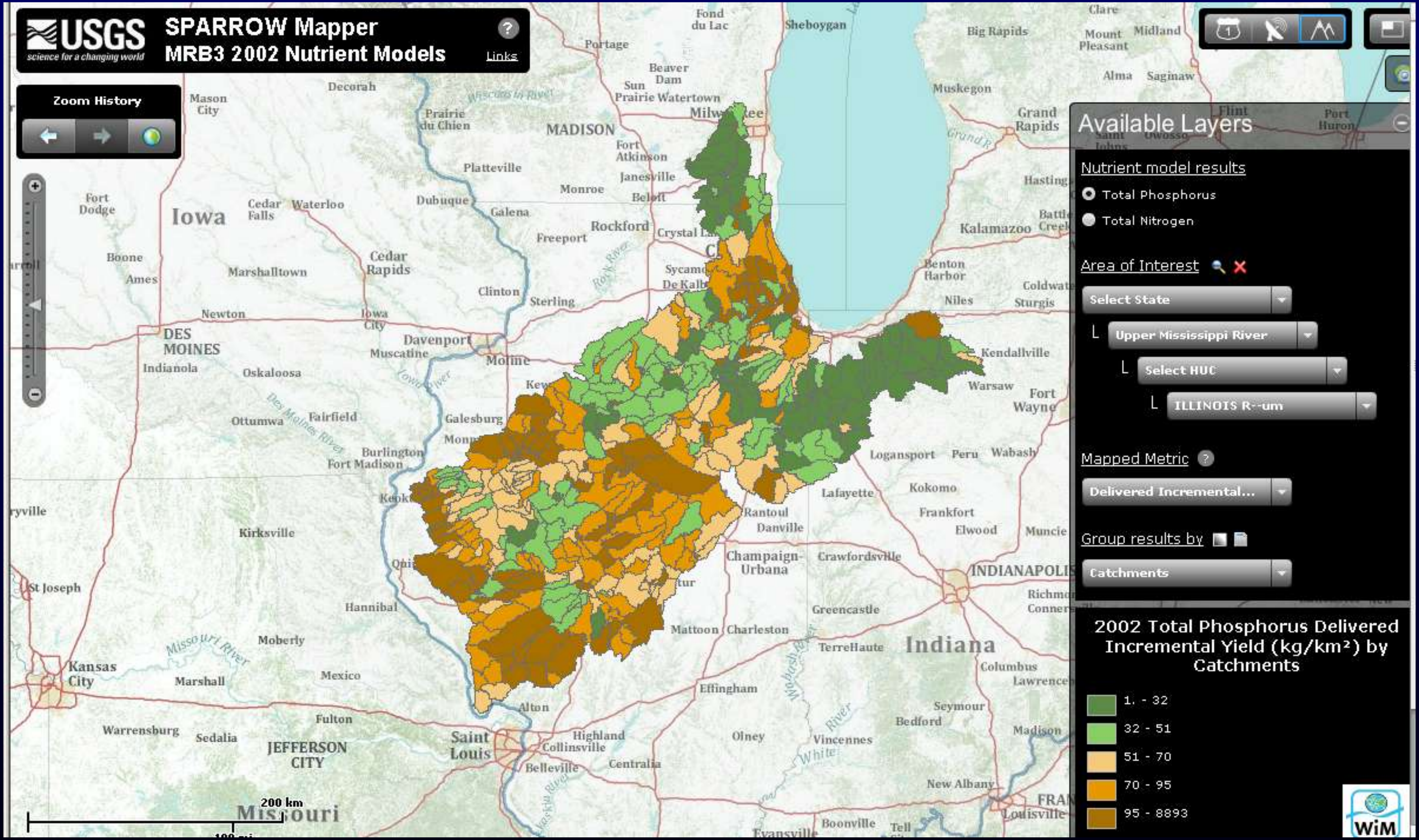
# Phosphorus Loading throughout the Upper Midwest from the TP SPARROW Model



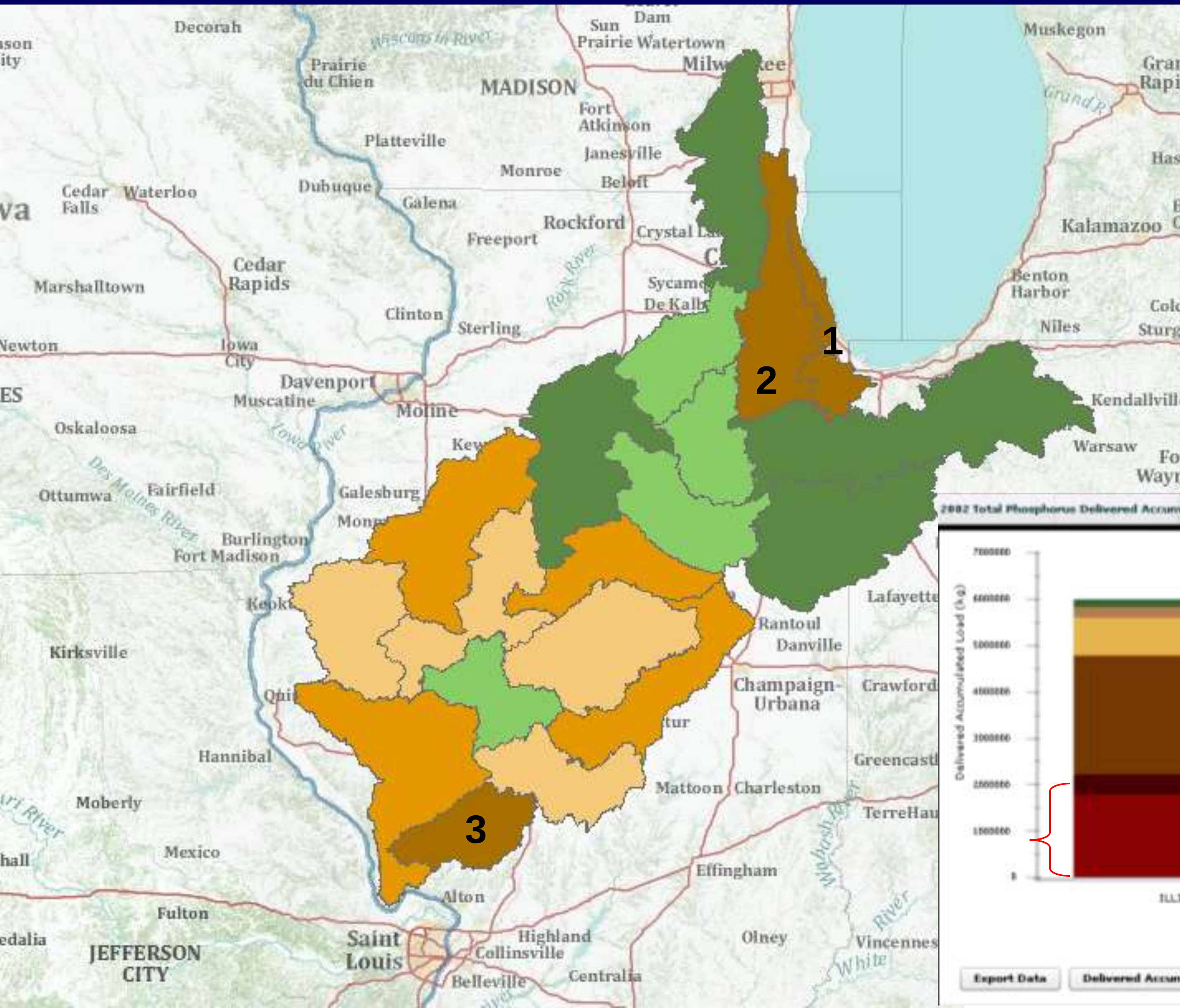
# Incremental Phosphorus Yields in the Upper Midwest from the TP SPARROW Model

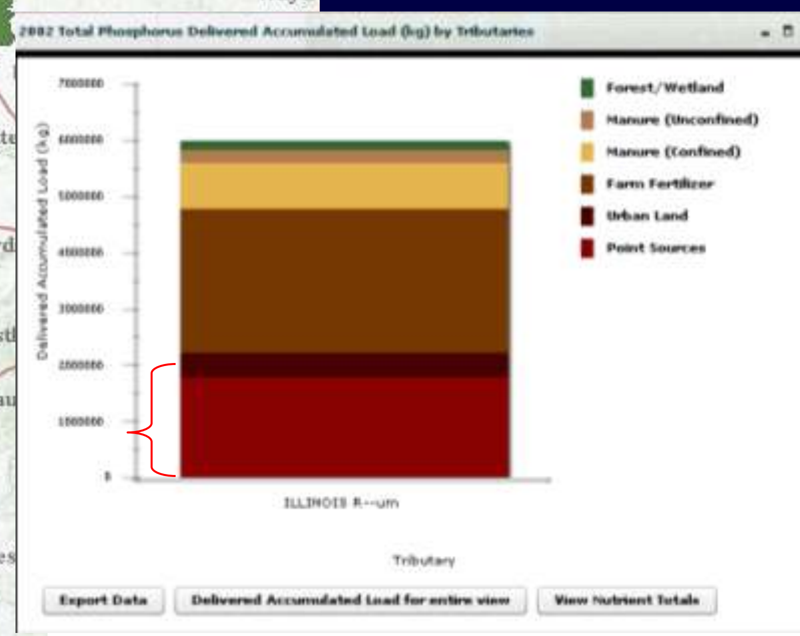


# Incremental Phosphorus Yields from throughout the Illinois River Basin

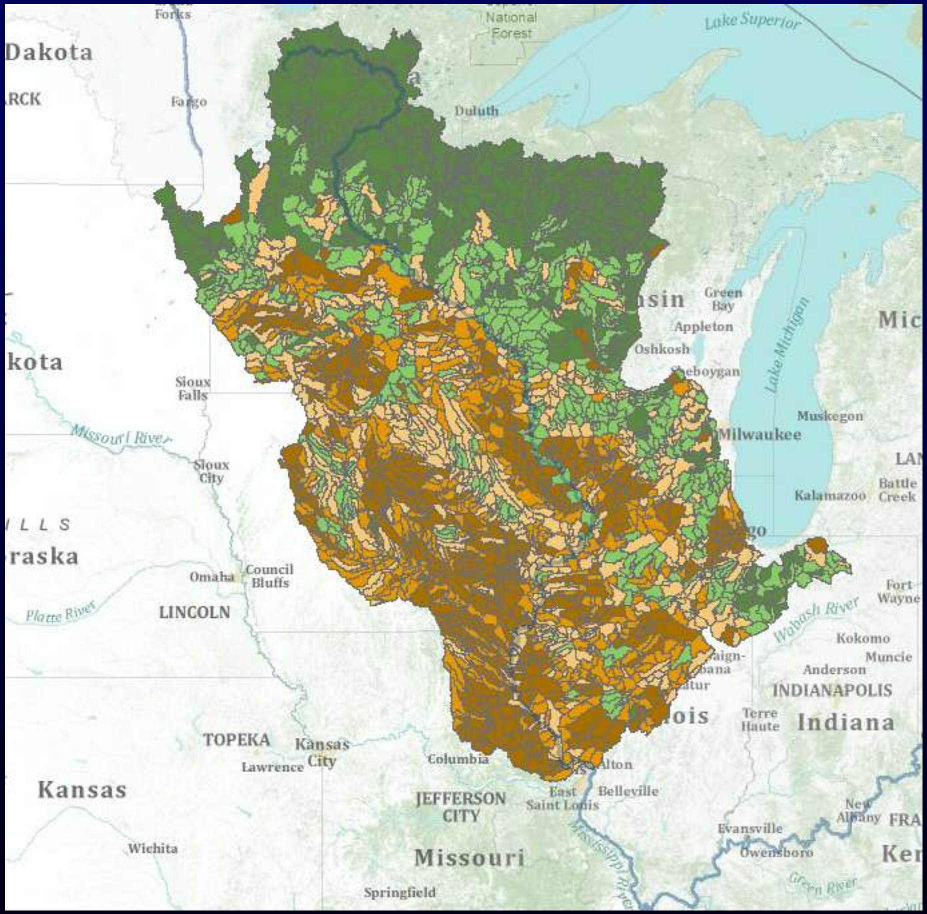


# Incremental Phosphorus Yields from HUC8's in the Illinois River Basin

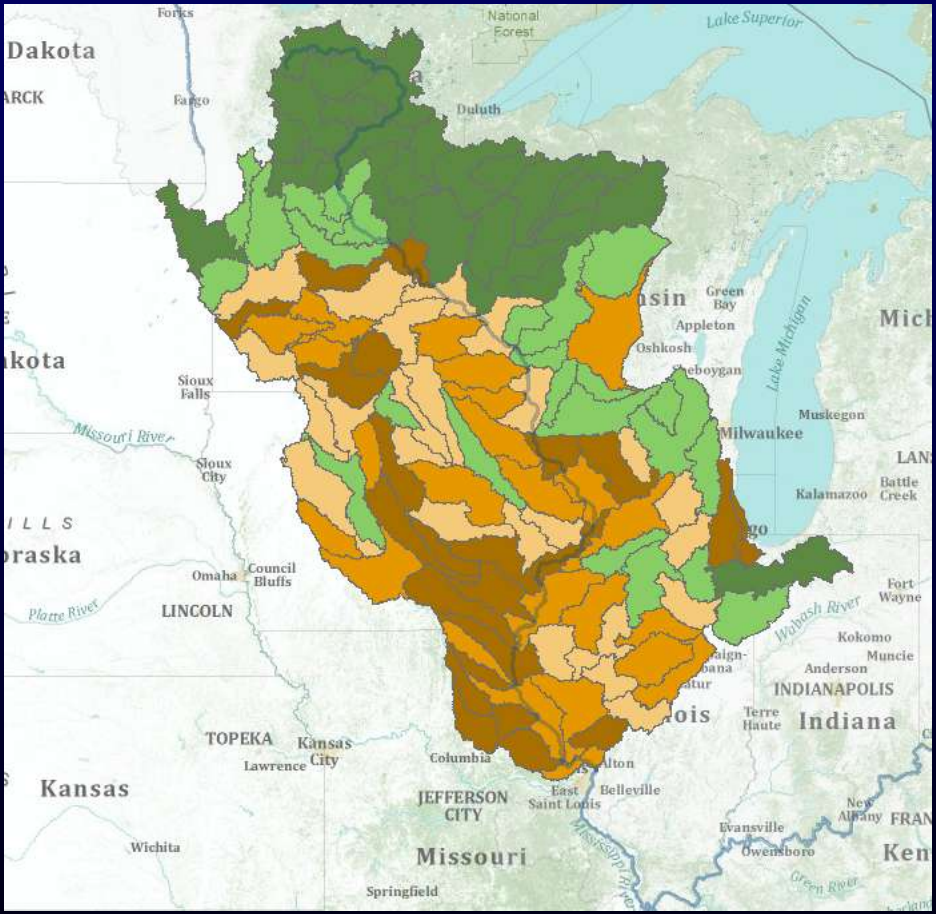


# How do P Yields from the Illinois River Basin compare with others in the Upper Mississippi River Basin

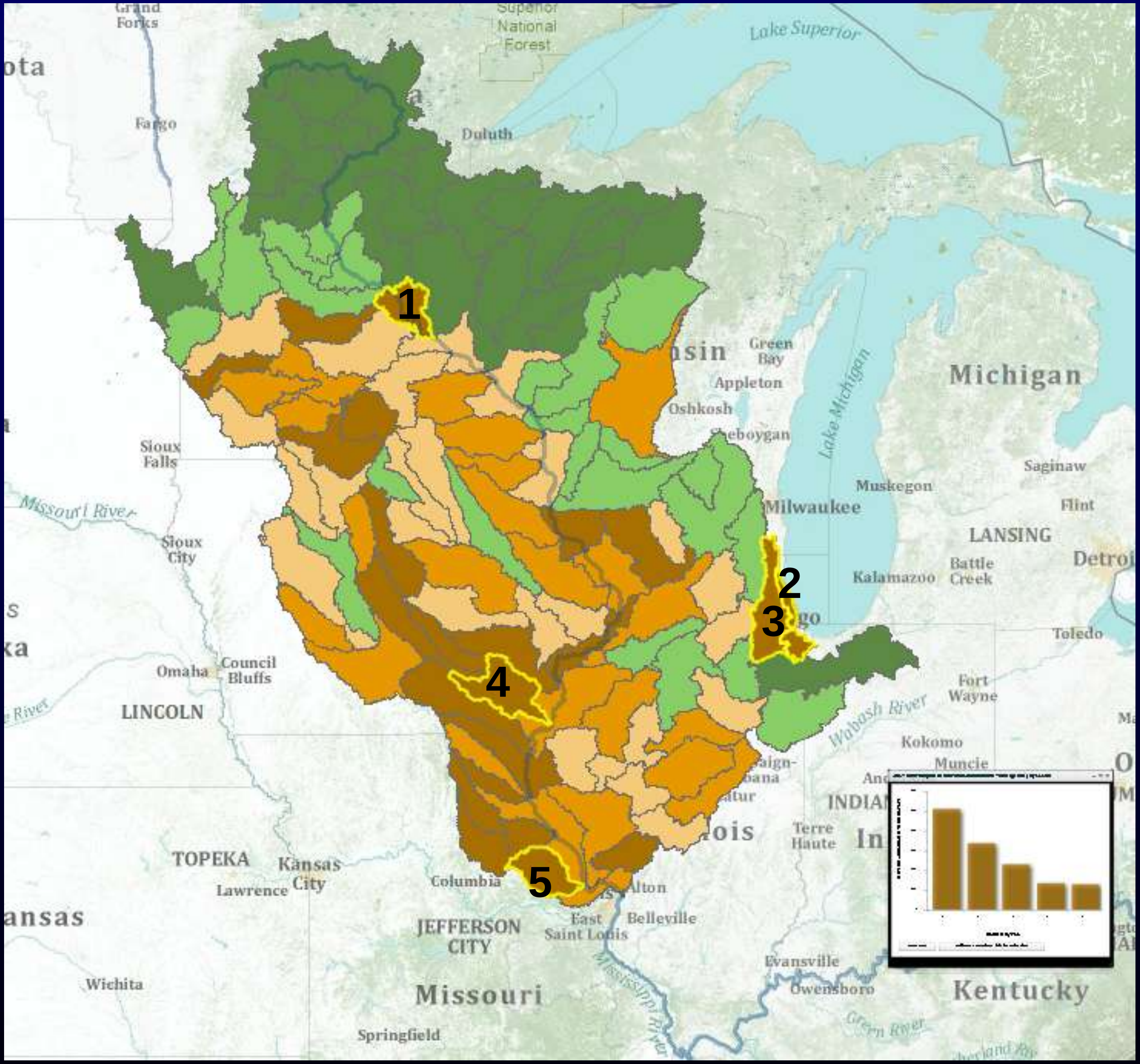


Catchments



HUC8s

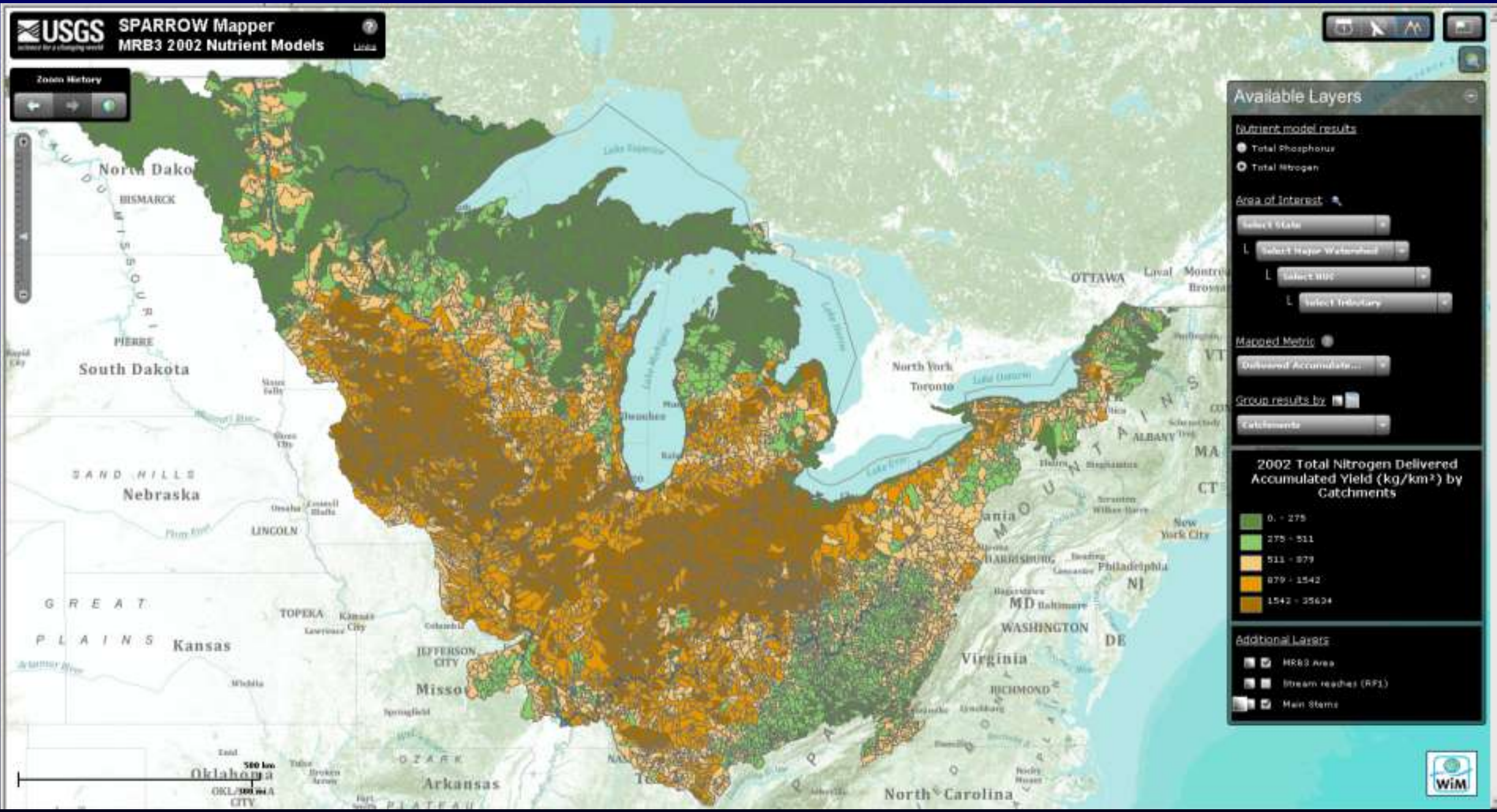
# How do Incremental P Yields from the Illinois River Basin compare with others in the Upper Mississippi River Basin?



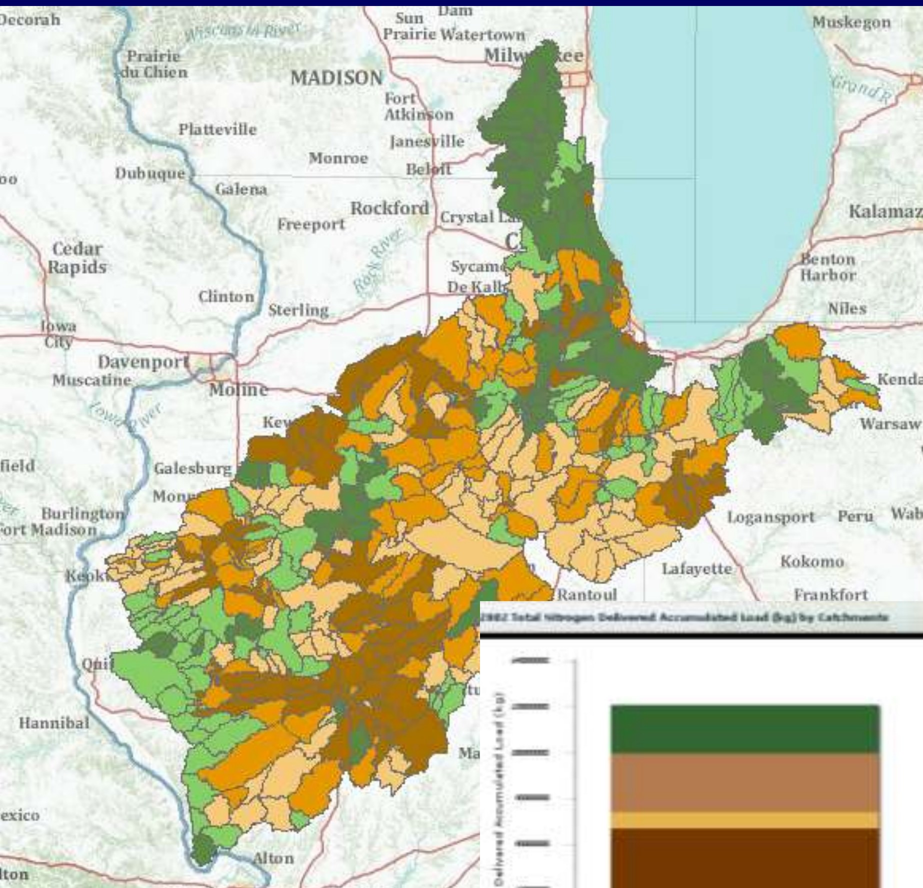

HUC8s

| MRB3-SPARROW TN MODEL | | | | |
|---|---|---|---|---|
| **Parameter** | **Coefficient units** | **Parameter values** | **Standard error** | **P value** |
| **Sources** | | | | |
| Atmosphere (Total) | fraction | 0.513 | 0.040 | 0.000 |
| Point Sources (Total) | fraction | 0.789 | 0.113 | 0.000 |
| Manure (confined) | fraction | 0.291 | 0.055 | 0.000 |
| Fertilizers (farm) | fraction | 0.131 | 0.038 | 0.000 |
| Additional agricultural sources | $kg/km^2/yr$ | 62.506 | 2.967 | 0.018 |
| **Land-to-Water Delivery** | | | | |
| Drainage Density (log) | $km/km^2$ | 0.134 | 0.057 | 0.018 |
| Precipitation | mm/yr | 0.002 | 0.000 | 0.000 |
| Air Temperature | C | -0.041 | 0.020 | 0.035 |
| Tiles (percentage of area) | % | 1.133 | 0.127 | 0.000 |
| Clay (percentage of soil) | % | 0.014 | 0.004 | 0.001 |
| **Stream and Reservoir Decay** | | | | |
| Stream Decay (CMS < 1.1) | m/yr | 0.424 | 0.100 | 0.000 |
| Stream Decay (1.1 < CMS < 2.0) | m/yr | 0.233 | 0.096 | 0.016 |
| Reservoir Decay | m/yr | 6.710 | 1.453 | 0.000 |
| RMSE | 0.405 | | | |
| Adj $R^2$ | 0.953 | | | |
| Yld $R^2$ | 0.851 | | | |
| N | 708 | | | |

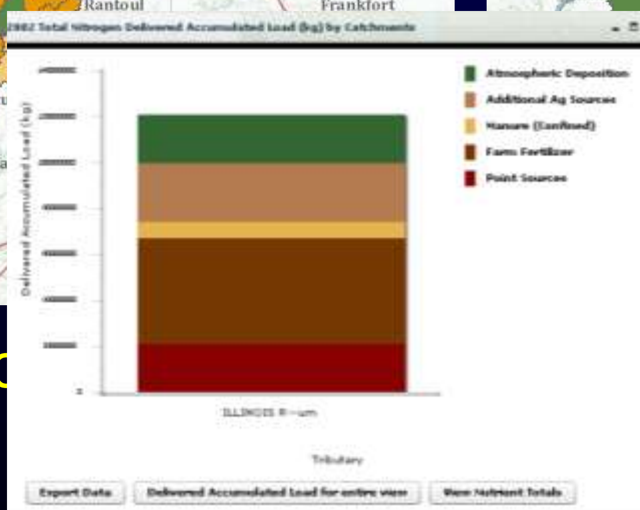
# Incremental Nitrogen Yields the Upper Midwest SPARROW Model

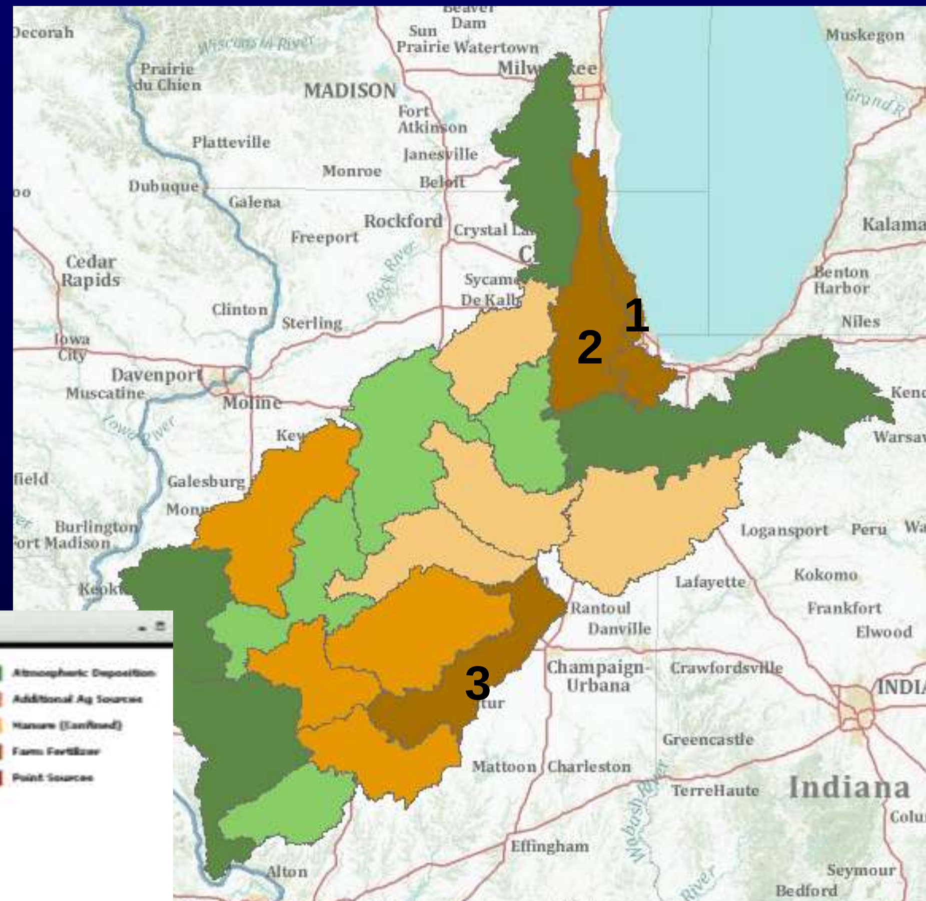


# Nitrogen Yields from throughout the Illinois River Basin



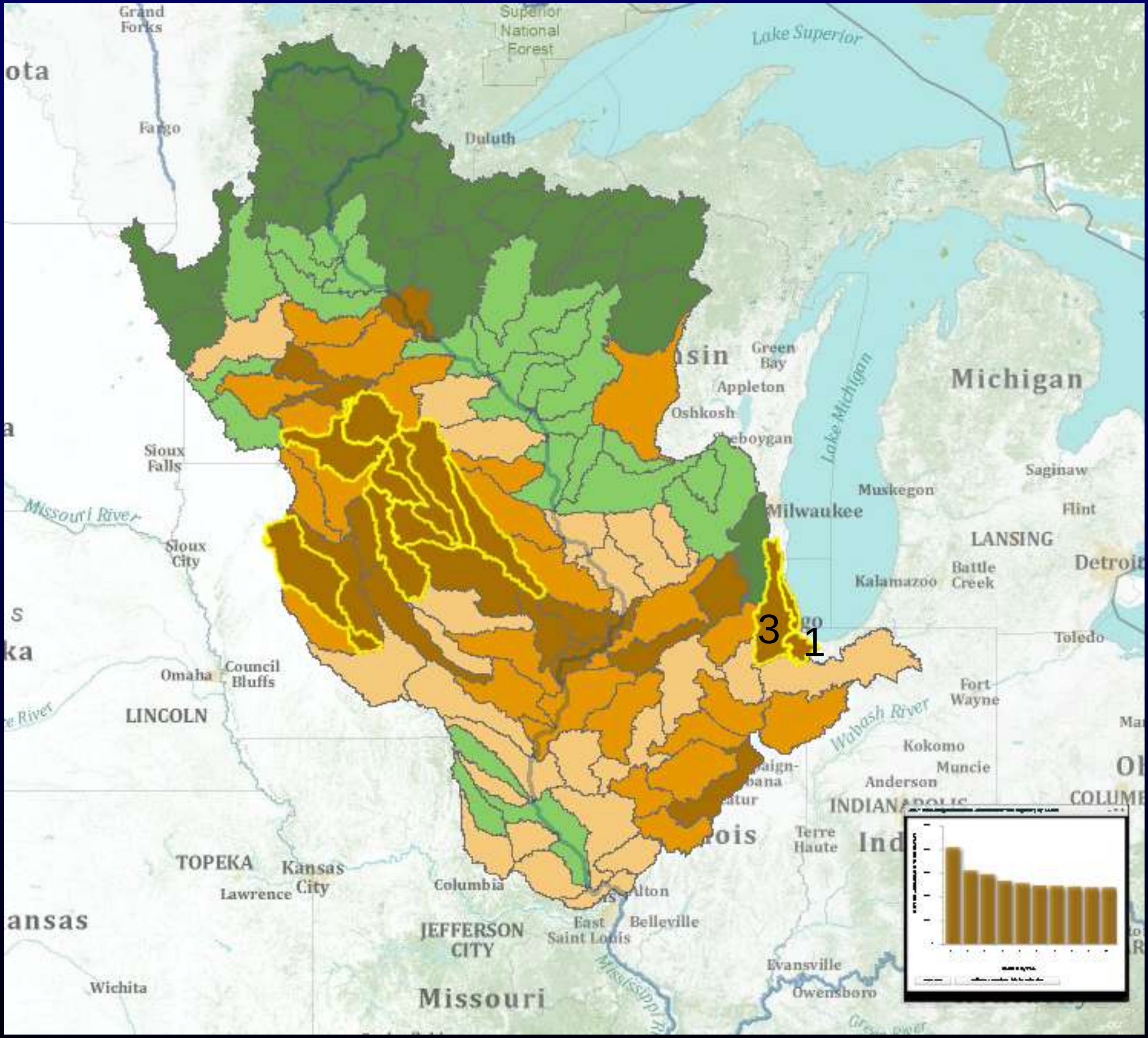

Catc



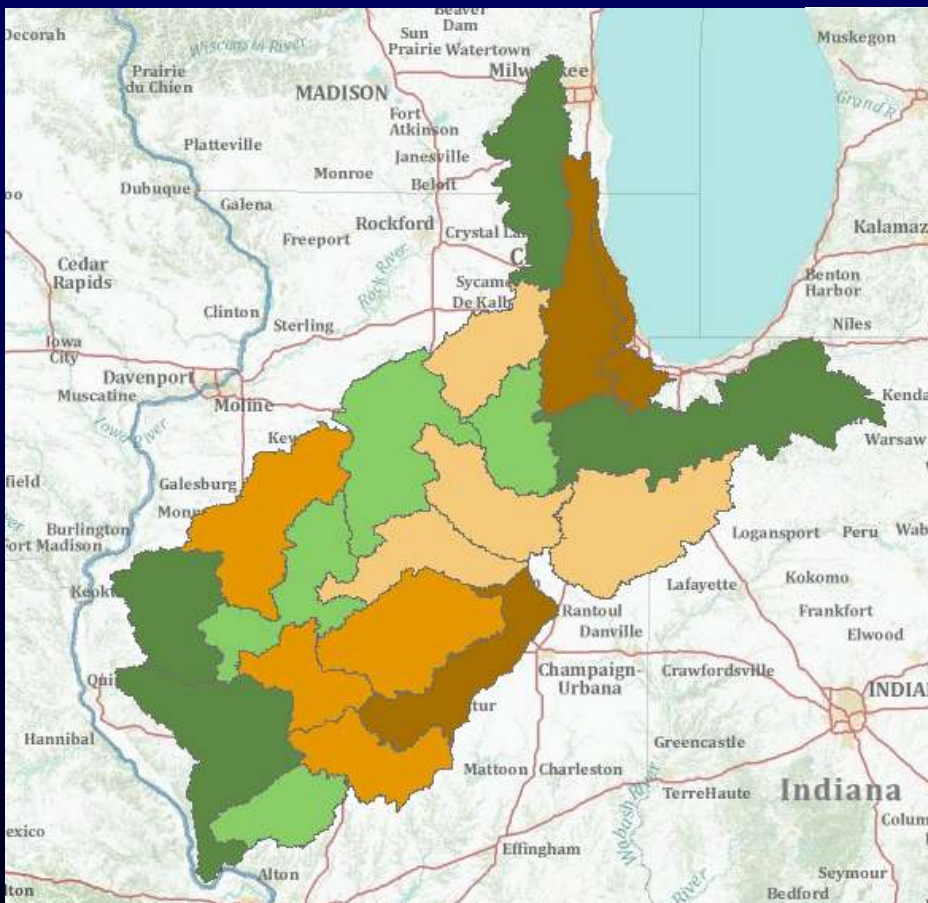

HUC8s

# How do N Yields from the Illinois River Basin compare with others in the Upper Mississippi River Basin?

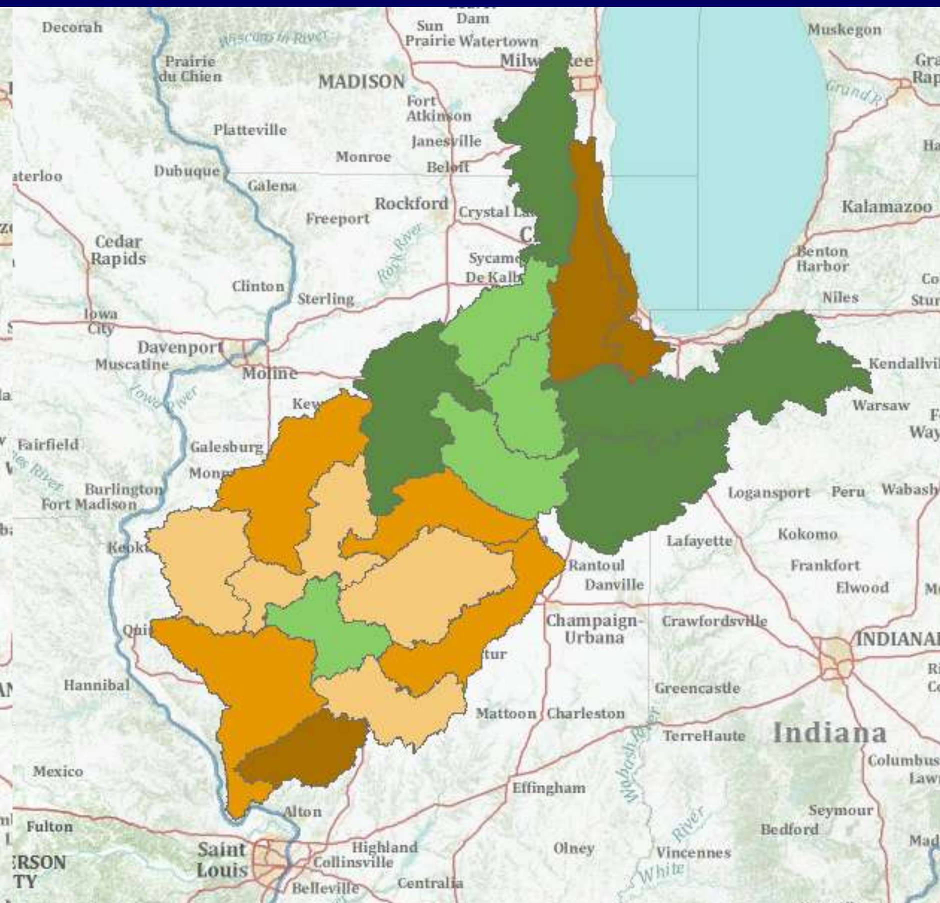


# Comparison of N and P Yields throughout the Illinois River Basin

Total Nitrogen Yields




Total Phosphorus Yields




HUC8s

HUC8s

# Demonstrating Results

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- Groundwater networks
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- Climate Response

**Water-Quality**
- Real-time Data
- Historical Data
- Water-Quality Watch

**Precipitation**
- Real-time Data

**Other**
- Annual Data Reports
- Instantaneous Data Archive
- USGS WaterAlert

**Most requested links**

- SLAMM
- Mercury Cycle
- GWCOMP

### Water Resources of Wisconsin

The Wisconsin Water Science Center provides current ("real-time") stream stage in Wisconsin and streamflow, water-quality, and groundwater levels for over 200 sites.


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### Wisconsin Annual Water Data Reports

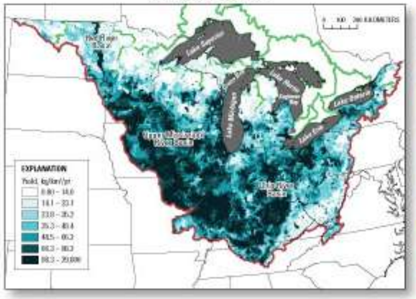
**Streamflow, precipitation, ground-water levels, and water quality for Wisconsin:**
- Water Years 2006-2010
- Water Years 1961-2005

**Lake stage and water quality in Wisconsin lakes:**
- Water Year 2007
- More years

**Water use in Wisconsin (every 5 years):**
- 2005 Wisconsin Summary
- Other Wisconsin water-use summaries

### Featured Projects

**MRB3 SPARROW Nutrient Models and Results Released**




NEW Throughout the country, declining water quality in rivers and streams has been linked to excessive quantities of nutrients, particularly nitrogen and phosphorus. The SPARROW nutrient modeling project recently released results for Major River Basin 3 (MRB3), which includes the Great Lakes and the Ohio, Upper Mississippi, and Souris-Red-Rainy River basins. Three journal articles were published in August detailing the data, model, and decision support system. In addition, two online mapping tools are also available: the MRB3 SPARROW Mapper provides load and yield data and displays rankings; and the SPARROW Decision Support System, which can be used to predict water-quality conditions, track nutrient transport downstream, and evaluate management source-reduction scenarios. Click here to learn more.

**WiM Hurricane Irene mapper tracks storm surge and flooding**

NEW As part of the larger USGS Hurricane Irene response effort, the Wisconsin Internet Mapping group (WiM) developed the Hurricane Irene Storm Surge Tracking Map to provide up-to-date information for emergency responders. During the storm event, the map linked to real-time streamflow and tidal data. Additional data, including storm surge, wave heights, and site photos, will be uploaded as post-storm conditions allow for data retrieval and processing. For more information about the USGS response to Hurricane Irene, click here.

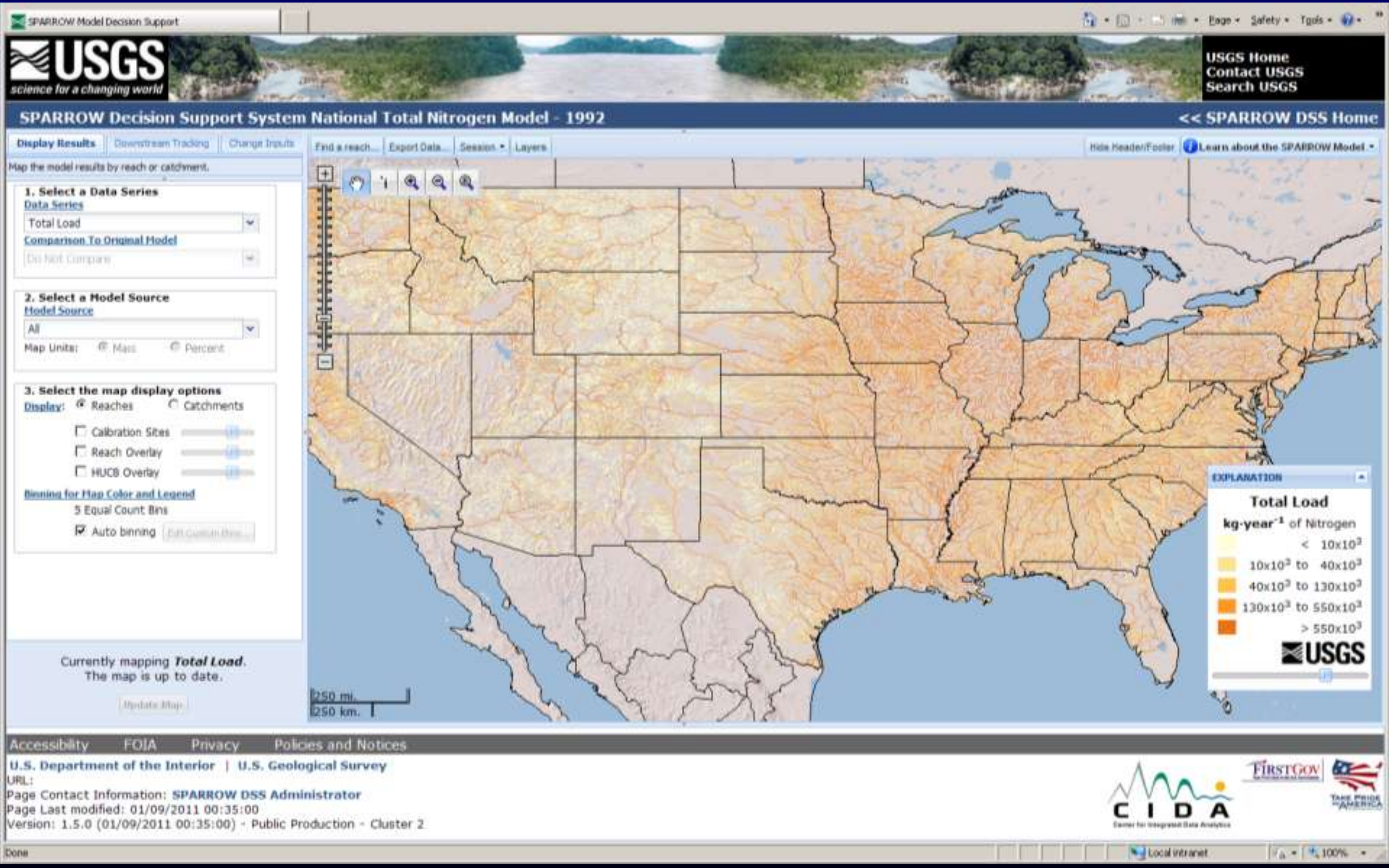
### Recent Publications

**The MRB3 SPARROW nutrient modeling project recently had three new journal articles published:**

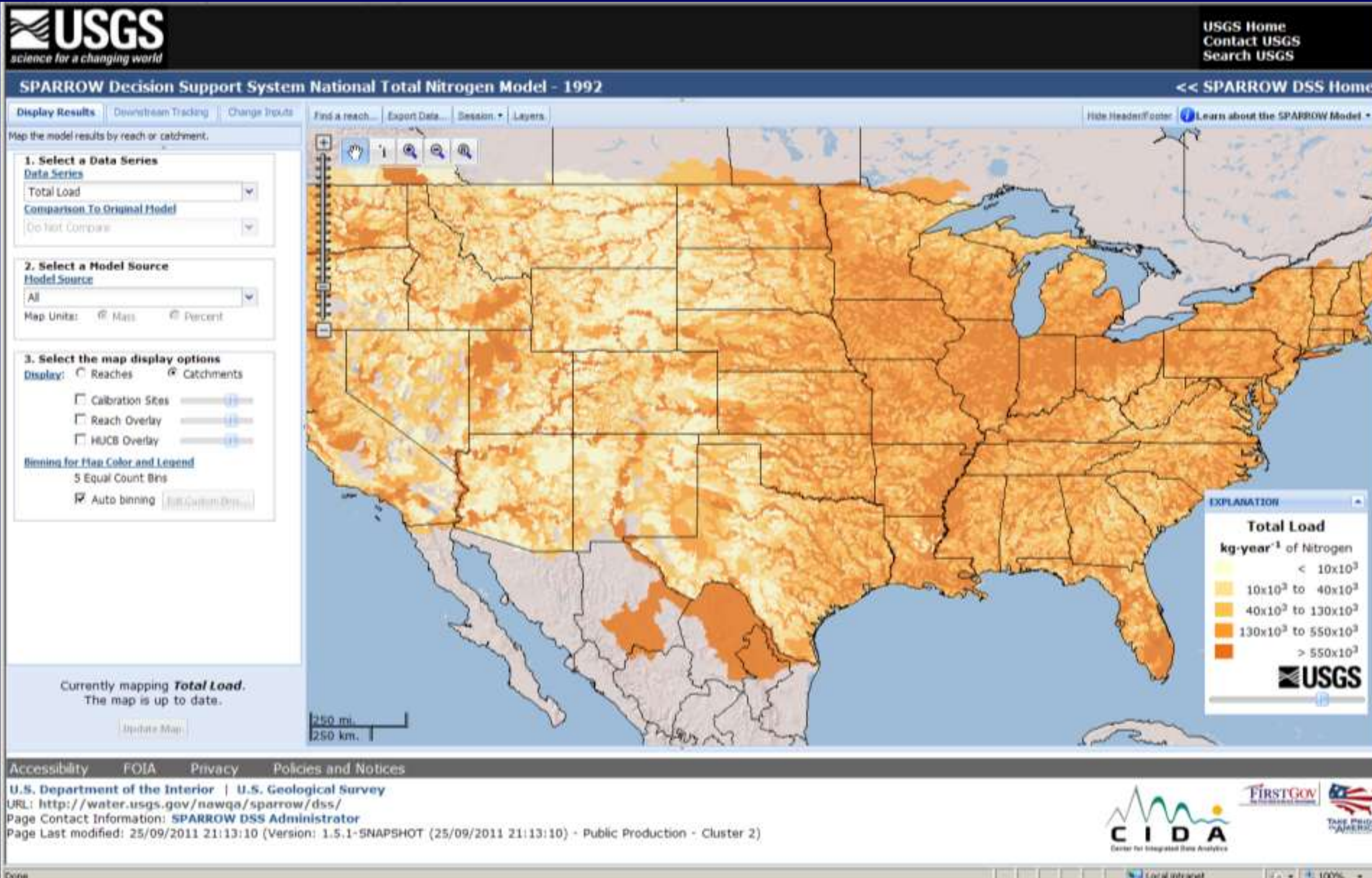
NEW **Journal of the American Water Resources Association**

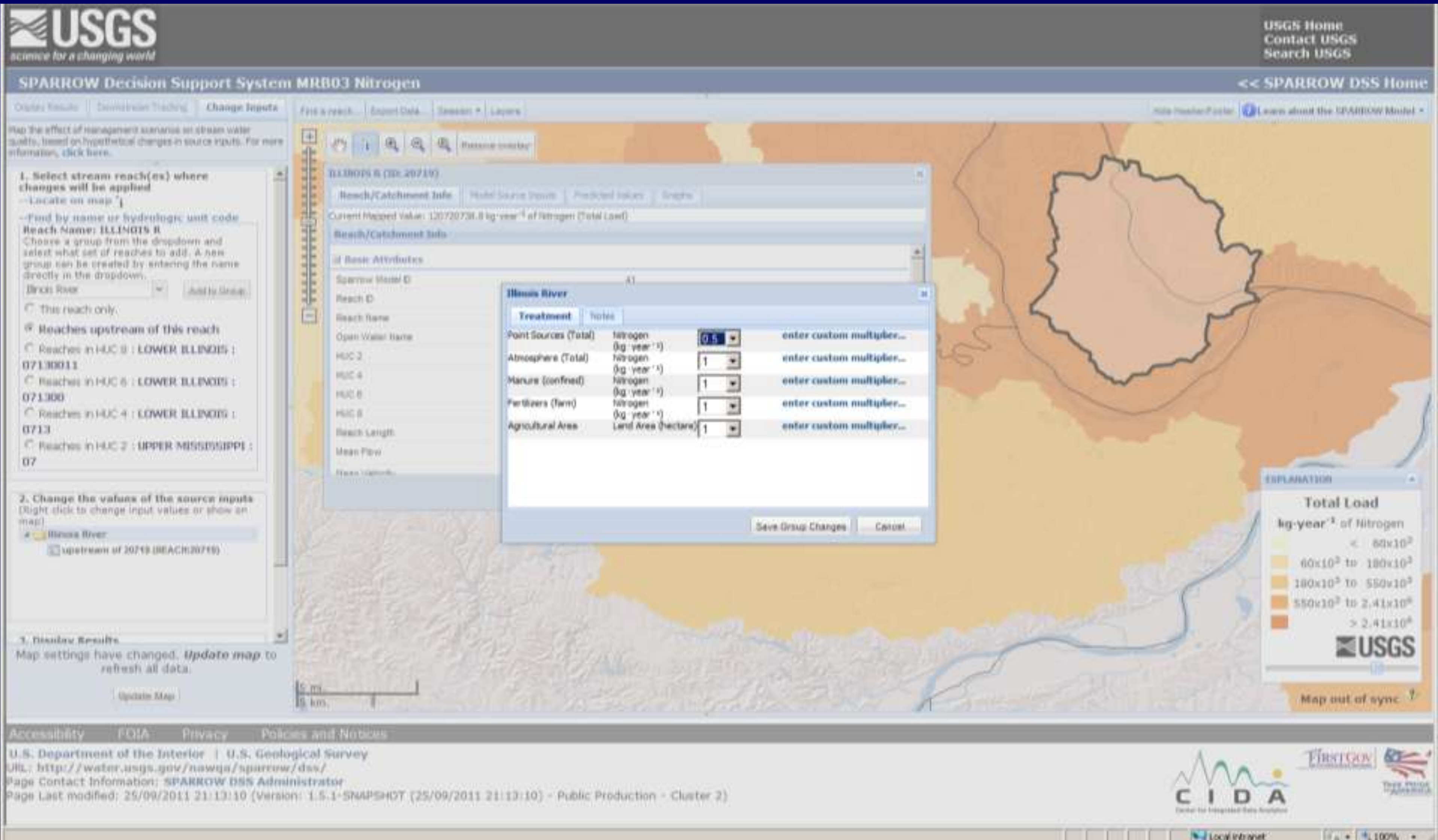
Nutrient Inputs to the Laurentian Great Lakes by Source and Watershed Estimated Using SPARROW Watershed Models. To see the results of the MRB3 model, check out the online MRB3 SPARROW mapper.

# SPARROW Decision Support System



# SPARROW Decision Support System

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SPARROW Decision Support System MRB03 Nitrogen
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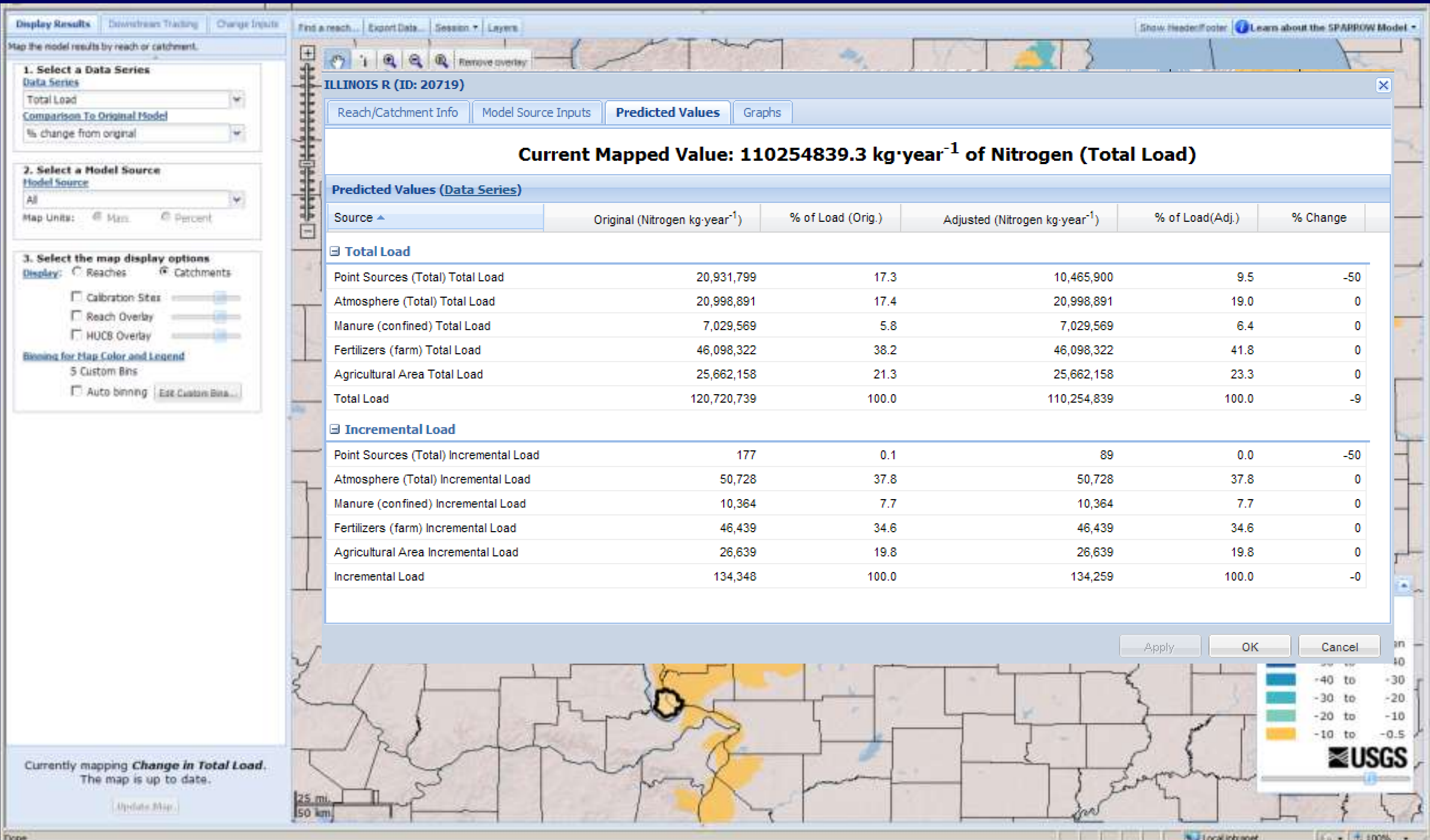
Change Inputs
1. Select stream reach(es) where changes will be applied
Reach Name: ILLINOIS R
This reach only
Reaches upstream of this reach
Reaches in HUC 8 : LOWER ILLINOIS : 07130011
Reaches in HUC 6 : LOWER ILLINOIS : 071300
Reaches in HUC 4 : LOWER ILLINOIS : 0713
Reaches in HUC 2 : UPPER MISSISSIPPI : 07
2. Change the values of the source inputs
Illinois River
upstream of 20719 (REACH:20719)
3. Display Results
Map settings have changed. Update map to refresh all data.
Update Map
Illinois River
Treatment
Notes
Point Sources (Total)
Atmosphere (Total)
Manure (confined)
Fertilizers (farm)
Agricultural Area
Nitrogen
Land Area (hectare)
enter custom multiplier...
Save Group Changes
Cancel
Total Load
kg·year⁻¹ of Nitrogen
Map out of sync
Accessibility FOIA Privacy Policies and Notices
U.S. Department of the Interior | U.S. Geological Survey
URL: http://water.usgs.gov/nawqa/sparrow/dss/
Page Contact Information: SPARROW DSS Administrator
Page Last modified: 25/09/2011 21:13:10 (Version: 1.5.1-SNAPSHOT (25/09/2011 21:13:10) - Public Production - Cluster 2)
CIDA

# SPARROW Decision Support System

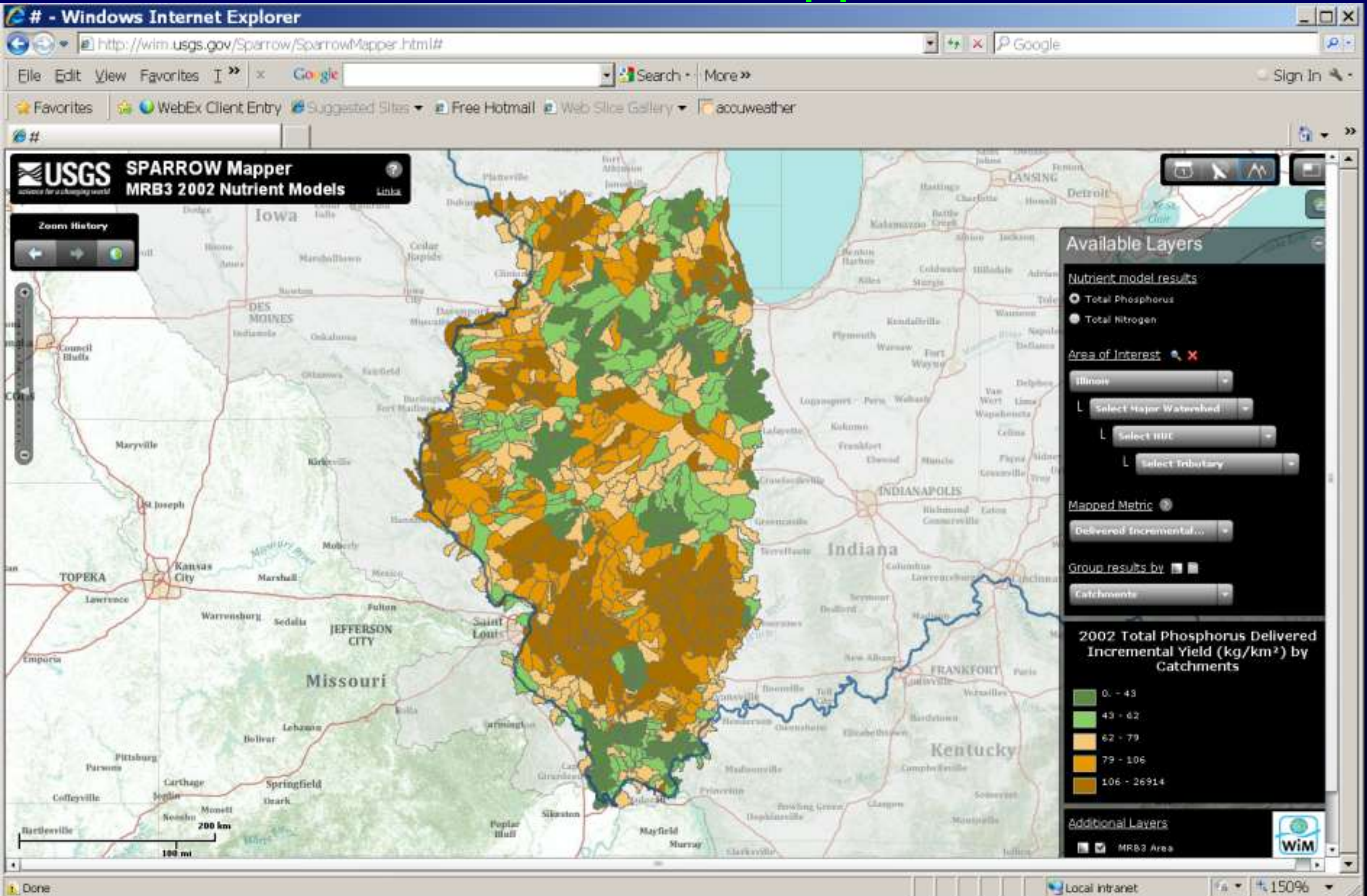
## Simulate Effects of Specific Scenarios




| Source | Original (Nitrogen kg·year$^{-1}$) | % of Load (Orig.) | Adjusted (Nitrogen kg·year$^{-1}$) | % of Load(Adj.) | % Change |
|---|---|---|---|---|---|
| **Total Load** | | | | | |
| Point Sources (Total) Total Load | 20,931,799 | 17.3 | 10,465,900 | 9.5 | -50 |
| Atmosphere (Total) Total Load | 20,998,891 | 17.4 | 20,998,891 | 19.0 | 0 |
| Manure (confined) Total Load | 7,029,569 | 5.8 | 7,029,569 | 6.4 | 0 |
| Fertilizers (farm) Total Load | 46,098,322 | 38.2 | 46,098,322 | 41.8 | 0 |
| Agricultural Area Total Load | 25,662,158 | 21.3 | 25,662,158 | 23.3 | 0 |
| Total Load | 120,720,739 | 100.0 | 110,254,839 | 100.0 | -9 |
| **Incremental Load** | | | | | |
| Point Sources (Total) Incremental Load | 177 | 0.1 | 89 | 0.0 | -50 |
| Atmosphere (Total) Incremental Load | 50,728 | 37.8 | 50,728 | 37.8 | 0 |
| Manure (confined) Incremental Load | 10,364 | 7.7 | 10,364 | 7.7 | 0 |
| Fertilizers (farm) Incremental Load | 46,439 | 34.6 | 46,439 | 34.6 | 0 |
| Agricultural Area Incremental Load | 26,639 | 19.8 | 26,639 | 19.8 | 0 |
| Incremental Load | 134,348 | 100.0 | 134,259 | 100.0 | -0 |

# SPARROW Mapper

# SPARROW Mapper



# Conclusions

1. Nutrient loadings and yields are quite variable throughout the Illinois River Basin, but very representative of the Upper Mississippi River Basin

2. Highest nutrient yields are from basins with most intense agriculture and most point sources.
>> Enables better prioritization of where rehabilitation efforts should be conducted.

3. Sources of nutrients varies greatly. High in the basin, it is from point sources. Low in the basin, it is from agricultural sources.
>> Enables better definition of what types of efforts are needed.

# Distribution and Sources of Nutrients in the Illinois River Basin in Comparison to Other Areas of the Upper Mississippi River Basin

*Questions??*

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