Use of SPARROW Models to Determine the Spatial Distribution and Sources of Nutrients in Streams in the Upper Midwest and Mississippi/Atchafalaya River Basins

By

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USGS
science for a changing world

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

Eutrophication Issues in the Great Lakes

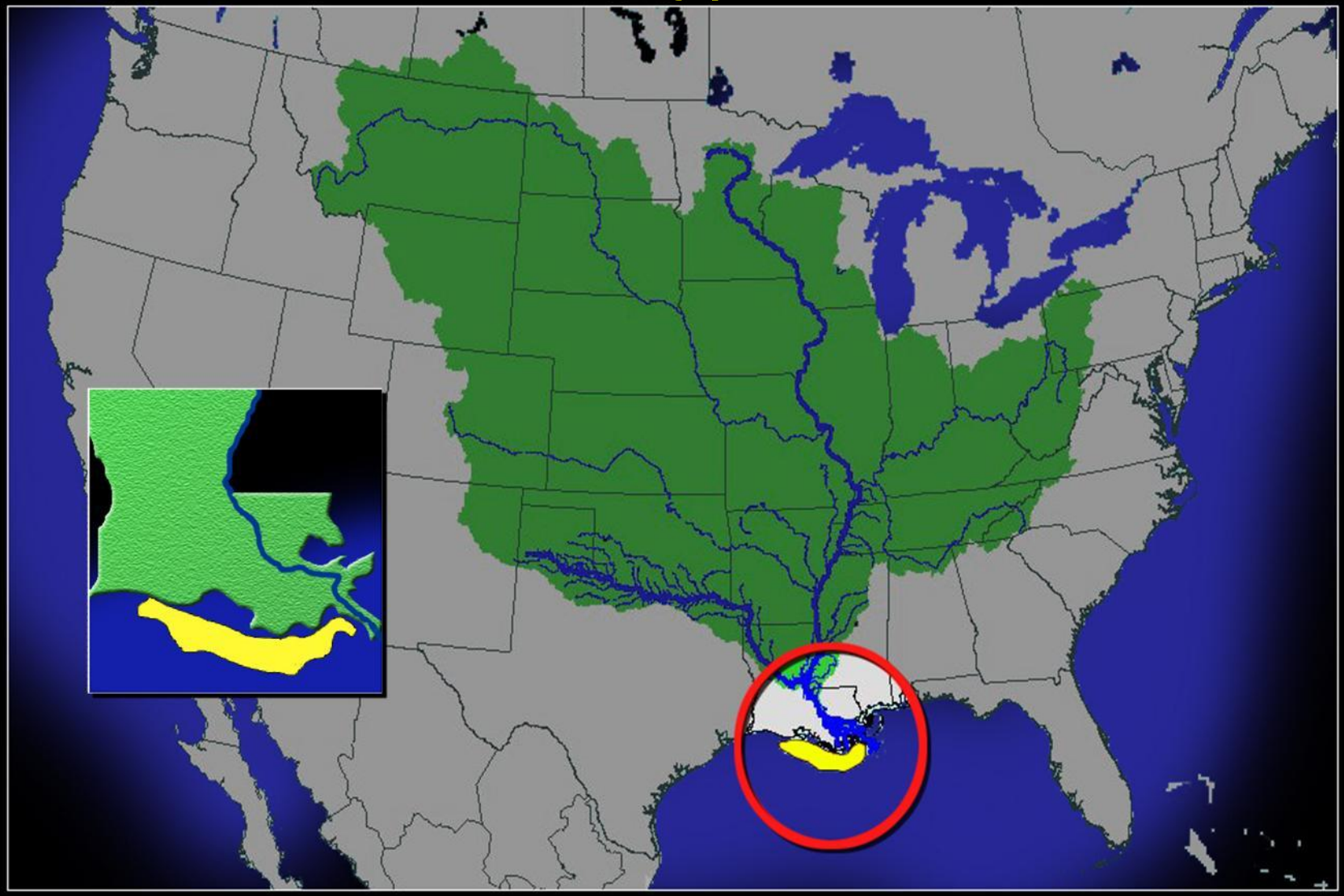

Lake Erie


Pelee Island, Lake Erie


Manitowoc, Lake Michigan


Cladophora on Beaches

Gulf Hypoxia



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

Typical Goals of SPARROW Modeling:

1. Determine P and N loading to various receiving waters over large spatial scales.

2. Determine where are the main contributing basins (Rank contributing basins based on loads and yields).

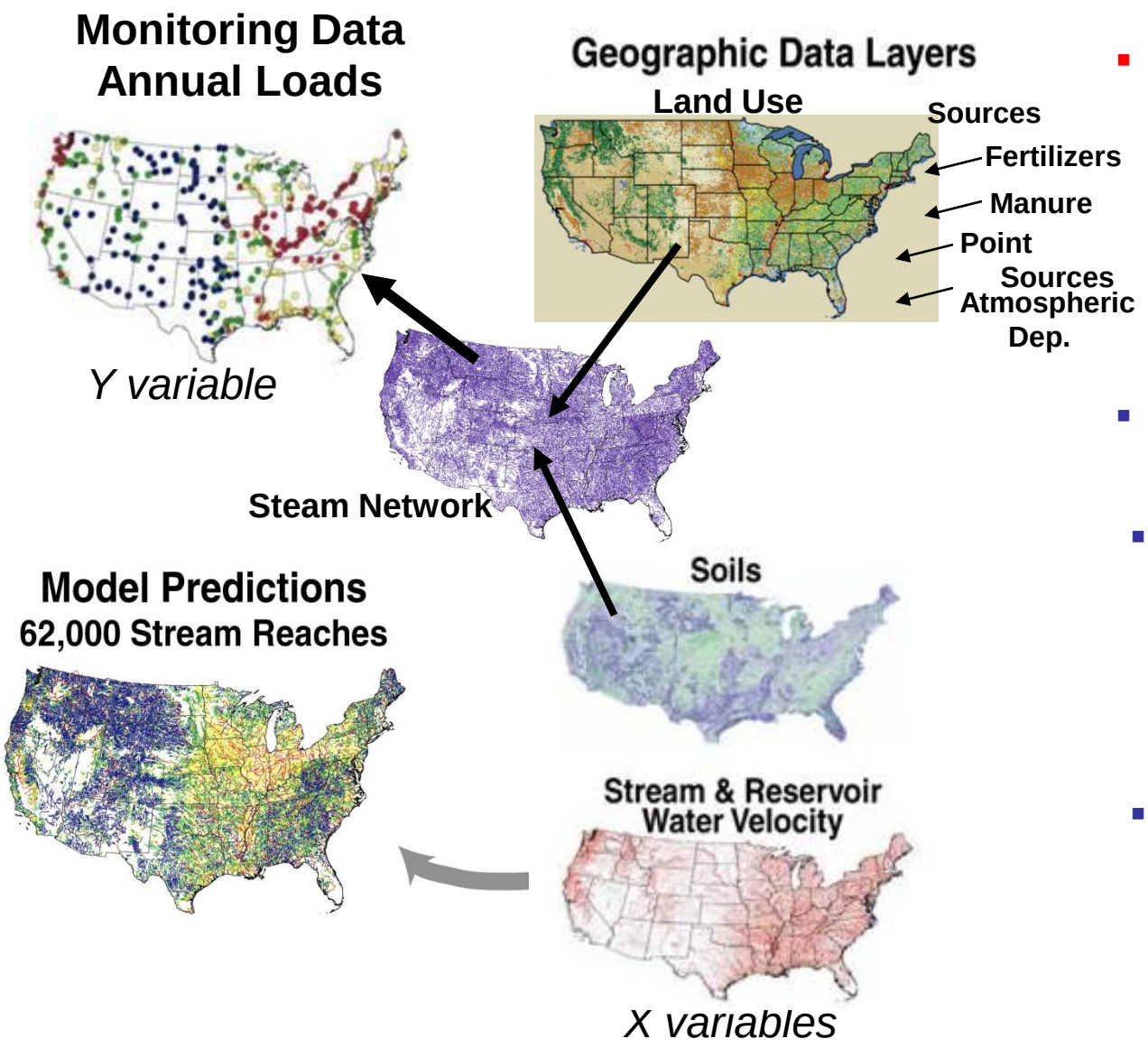
3. Determine what are the main causes of the high loads (Describe the relative importance of nutrient sources).

4. Provide information to various states and regional organizations to support regional interpretation and guide local, more indepth studies.

Approach - SPARROW Water-Quality Model -

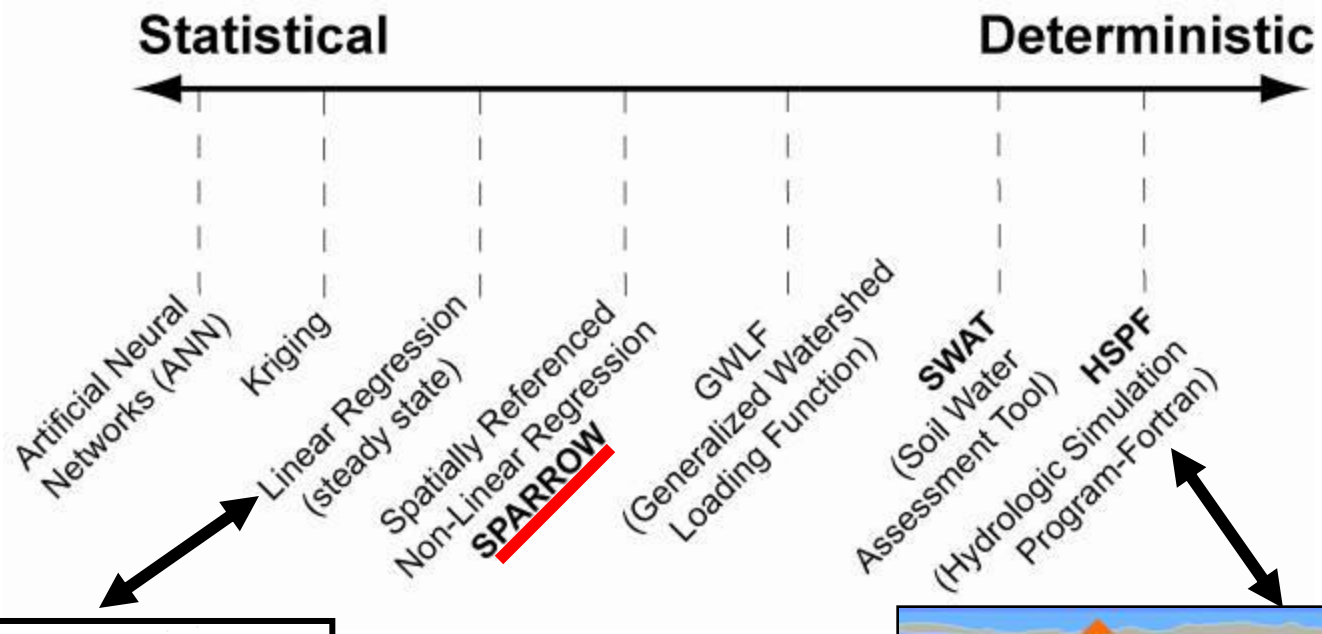
SPAtially Referenced Regression on Watershed Attributes

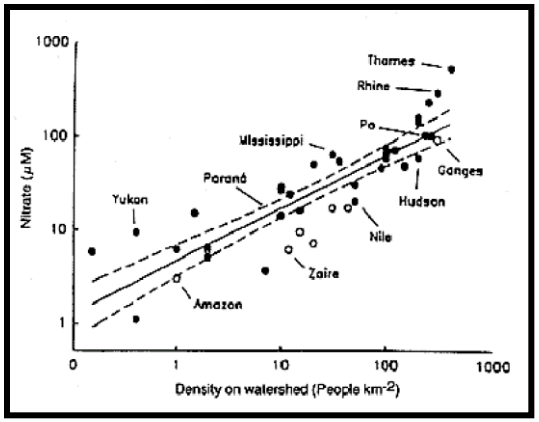
http://water.usgs.gov/nawqa/sparrow



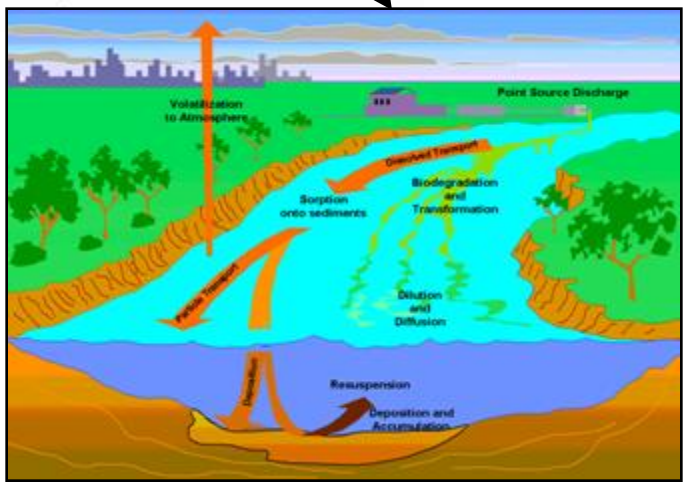
- Mass Balance Model with spatially variable deliveries. Hybrid statistical/ mechanistic process structure. Data-driven, nonlinear estimation of parameters
- Separates land and in-stream processes
- Predictions of mean-annual flux reflect long-term, net effects of nutrient supply and loss processes in watersheds
- Once calibrated, the model has physically interpretable coefficients; model supports hypothesis testing and uncertainty estimation

Watershed Modeling Continuum





Cole et al. 1997

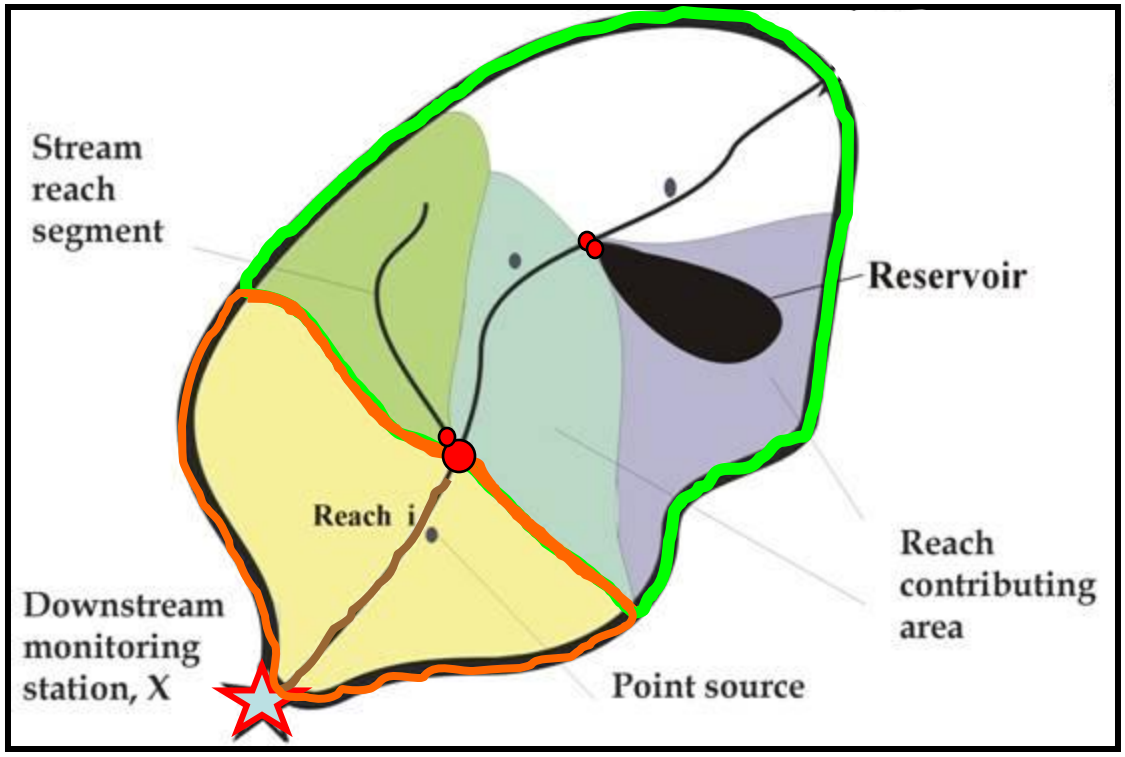


SWAT Users Manual

SPARROW's Reach-Scale Mass Balance

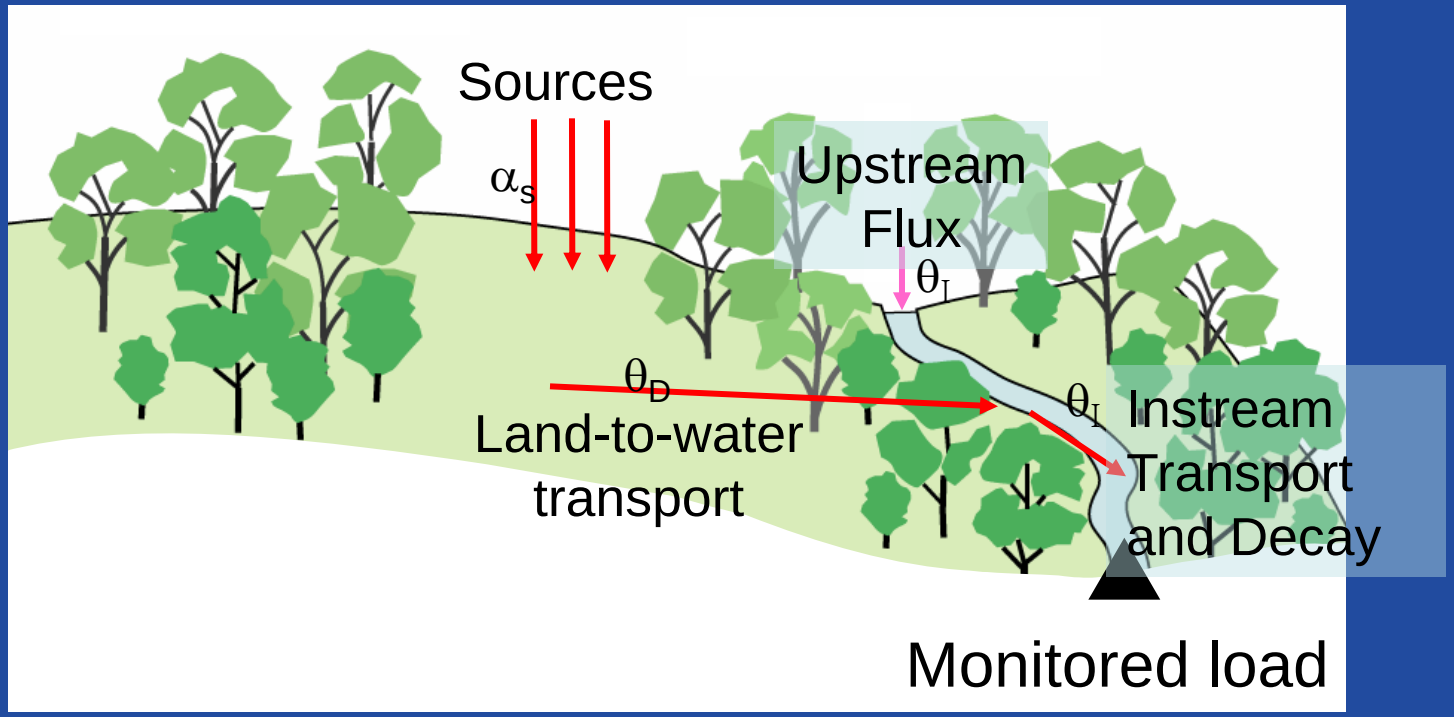
Reach network relates watershed data to monitored loads

Load leaving a reach = **Load generated within upstream reaches** and transported to the reach via the stream network + **Load originating within the reach's incremental watershed** and delivered to the reach segment - **In-stream Losses**



SPARROW Mass Balance modeling approach:

- Regress water-quality conditions (monitored load) on upstream sources and factors controlling transport
- Incorporates in-stream decay of nutrients



USGS

Regression Equation behind the SPARROW Model Mass Balance

Load at a specific site

Flux from Within a SPARROW Watershed

Flux from Upstream SPARROW Watersheds

$$F_i^* = \left(\sum_{n=1}^{N_S} S_{n,i} \alpha_n D_n\left(\mathbf{Z}_i^D;\boldsymbol{\theta}_D\right) \right) T'\left(\mathbf{Z}_i^S, \mathbf{Z}_i^R;\boldsymbol{\theta}_S,\boldsymbol{\theta}_R\right) + \left(\sum_{j \in J(i)} F_j' \right) \delta_i T\left(\mathbf{Z}_i^S, \mathbf{Z}_i^R;\boldsymbol{\theta}_S,\boldsymbol{\theta}_R\right)$$

Sources

Land-to-Water Delivery

Transport/Decay

Transport

Calibration Coefficients

Calibration of National model was based on using 425 sites with coinciding loads and GIS information for the Midwest Model ~900 sites;

Estimating Loads at EACH Monitoring Site – with Fluxmaster

Concentration = f (flow, seasonality, time trend)

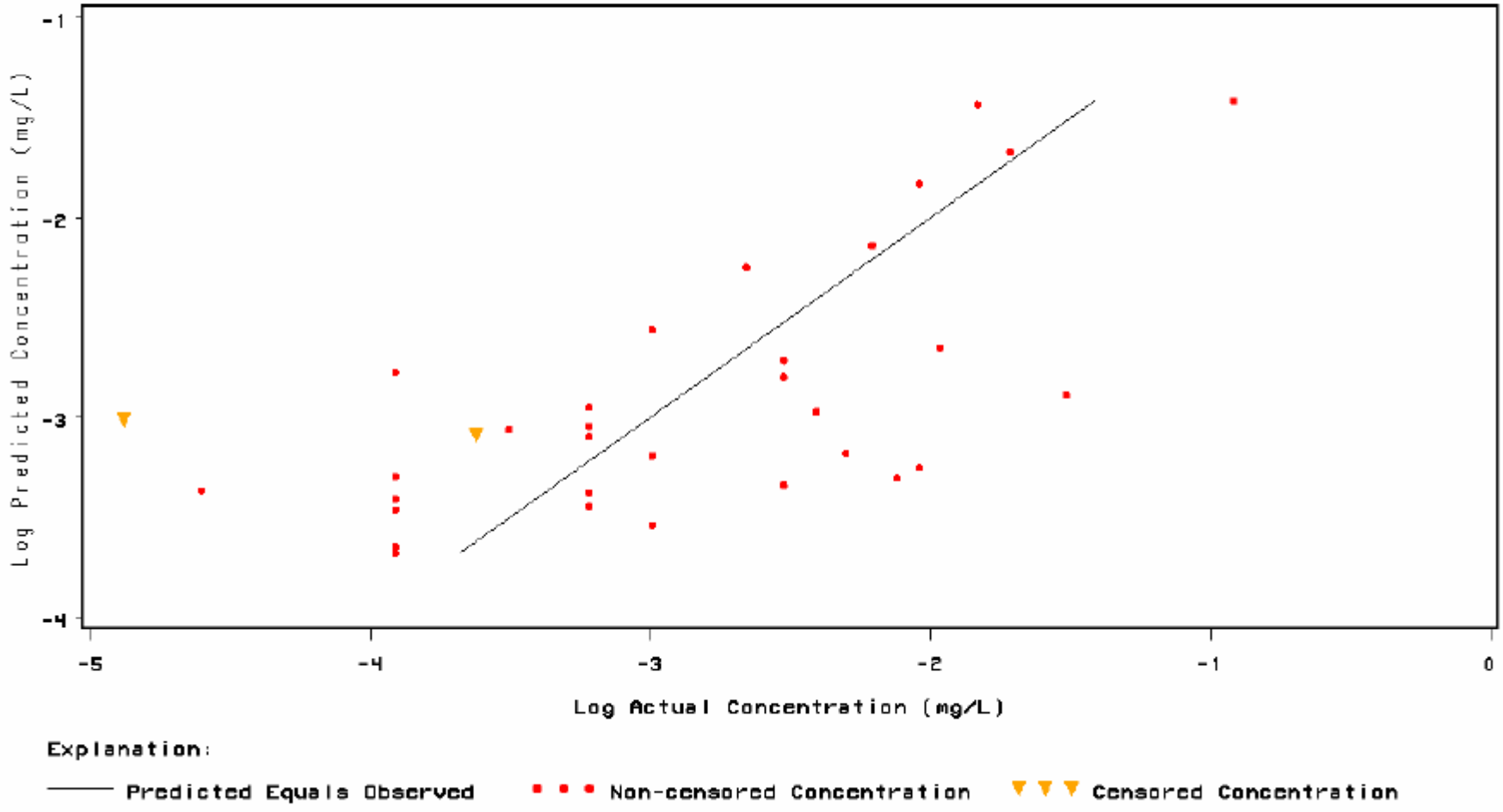
Form of the Fluxmaster Conc Model

$$\ln(\text{Conc}) = a \ln(Q) + b \sin(\text{jday}/365) + c \cos(\text{jday}/365) + d\,(\text{decimal year}) + e$$

For each site at least 25 coinciding flow (Q) and Conc. days, over at least 2 years, with all seasons represented.

Predicted versus Observed Ammonia total Concentrations for the Tangipahoa River at Robert, LA

(Parameter 00610 at Station 07375500)

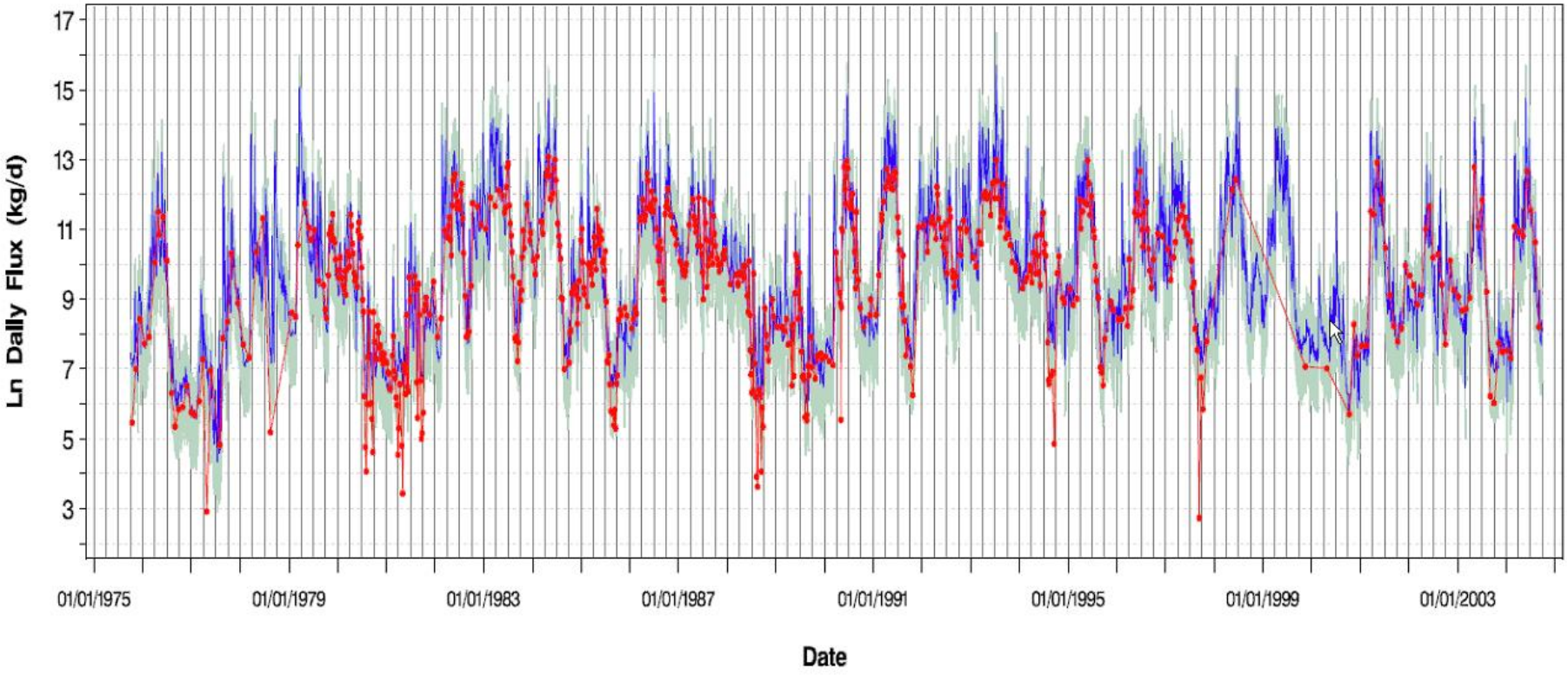


Note: actual censored values are estimates conditioned on the model and knowledge that the value is censored.

Actual and Predicted Nitrate + nitrite total Flux

for the Raccoon River at Van Meter, IA

(Parameter 00630 at Station 05484500)



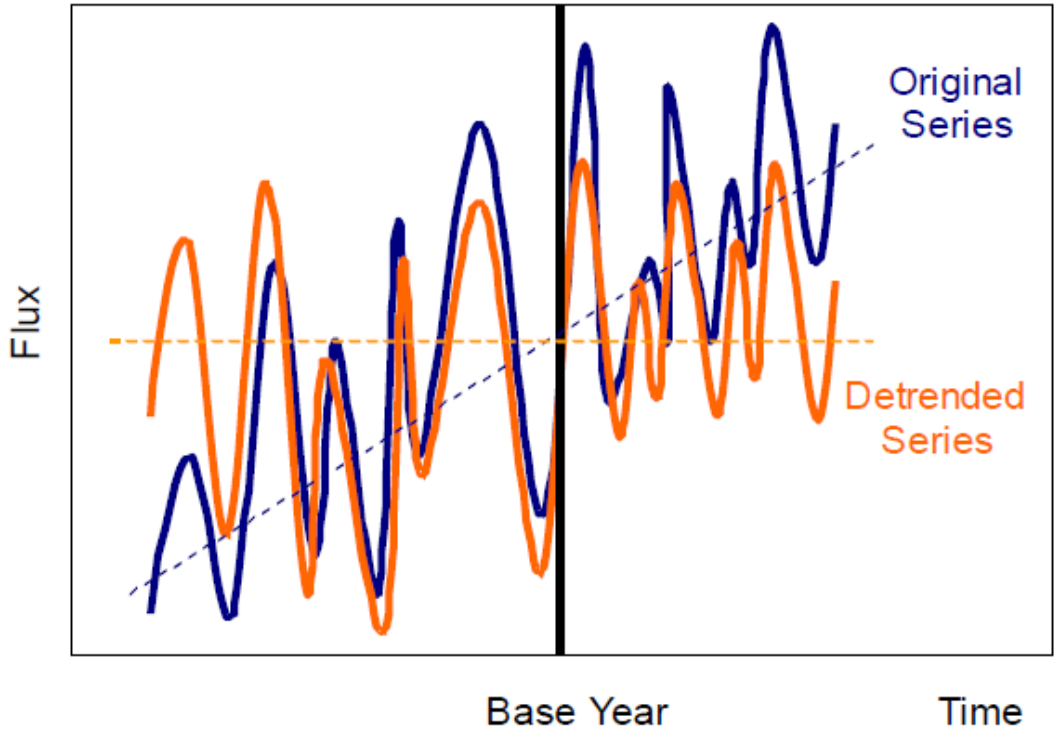
FLUX: period for avg.: 10/01/1975 – 09/30/2004 [29 prediction years], method: 2 SE avg. flux as pct.: 5.81%, end: 3.33% [not sig.];
WQ: N: 674 [0 censored], RMSE: 0.717, reference concentration: 4.36 mg/L; **FLOW:** trend: 1.26% [not sig.], variation[WQ sample/flow record]: 1.05

Predicted values are adjusted for retransformation bias, making them upward biased in log space.

Only use the site in SPARROW IF SE < 50%

Detrending

- Concept: What would flux be in year *t* if we experienced the hydrology of year *t* with the sources/management of base year T_0.



Estimating Detrended Loads at the Monitoring Sites – with Fluxmaster

Form of the Fluxmaster Load Model

$$\ln(\text{Load}) = 0.20 \ln(Q_{\text{Detrended}}) + 0.15 \sin(\text{jday}/365) + 0.36 \cos(\text{jday}/365) + 0.01 (\text{Base Year}.5) + \text{detrended flow}$$

Long-term average annual load = average of all detrended annual loads

SPARROW Sources and Transport Attributes – for the 1992 National SPARROW Models

NUTRIENT SOURCES (1992)

- **Population**
- Atmos. N deposition
- Farm fertilizer use allocated to major crops:
  - County fertilizer sales and expenditures; crop acreage
  - NLCD agricultural land use
  - State appl. rates (rotational, corn, soybeans, cotton, wheat, other crops)
- N_2 fixation – cultivated lands
- Animal manure:
  - Confined/Unconfined Animals
  - Confined > to crops & lost
- Natural and residual sources (lands in forest, barren, shrub)

LAND-TO-WATER DELIVERY

- Climate (precipitation, temperature)
- Soils (permeability)
- Topography/subsurface (slope, specific catchment area)
- **Artificial drainage (tiles)**

AQUATIC ATTENUATION

- Streams
  - First-order decay ~ f(water travel time, flow and depth)
- Reservoirs
  - First-order decay ~ f(areal hydraulic load—ratio of outflow to surface area)

Alexander and others, 2008

Regression Equation behind the SPARROW Model Mass Balance

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Sources

Land-to-Water Delivery

Transport/Decay

Transport

Calibration Coefficients

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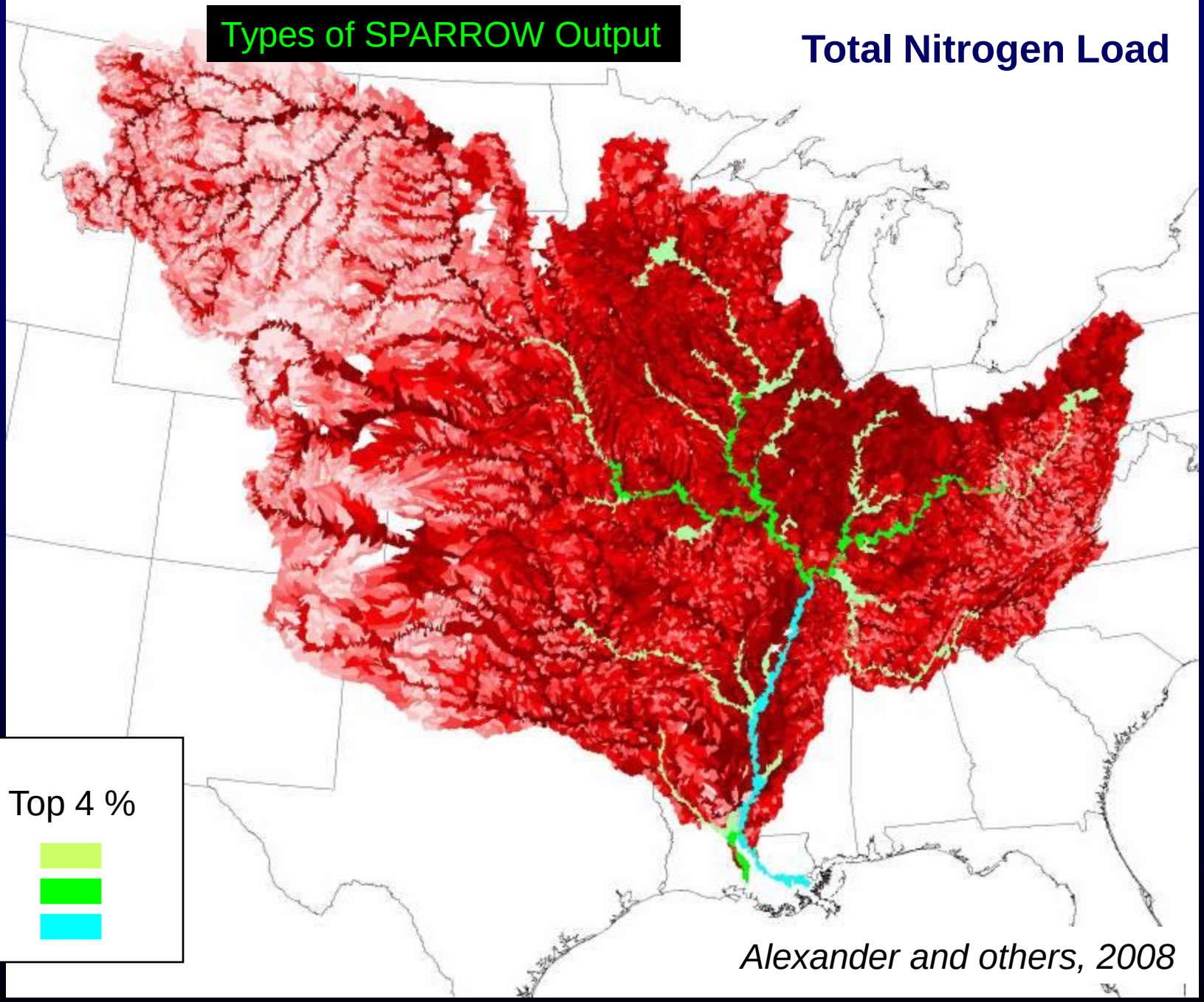
Outputs and Conclusions from the 1992 Mississippi River Basin Model

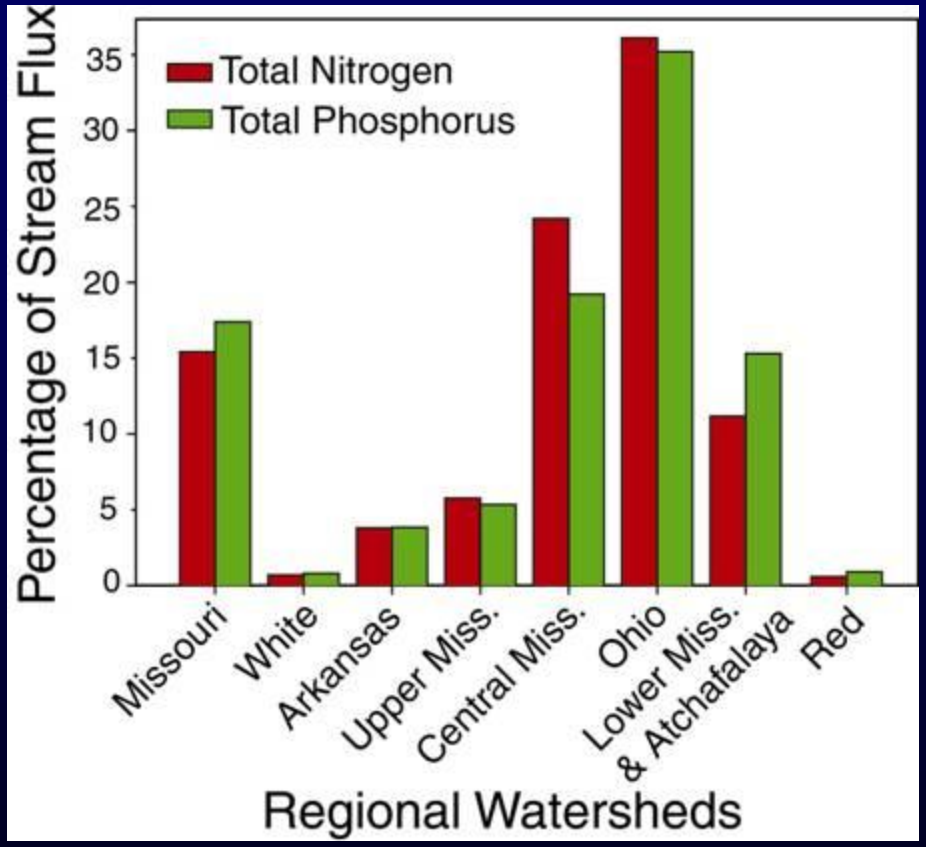
Types of SPARROW Output

Total Nitrogen Load

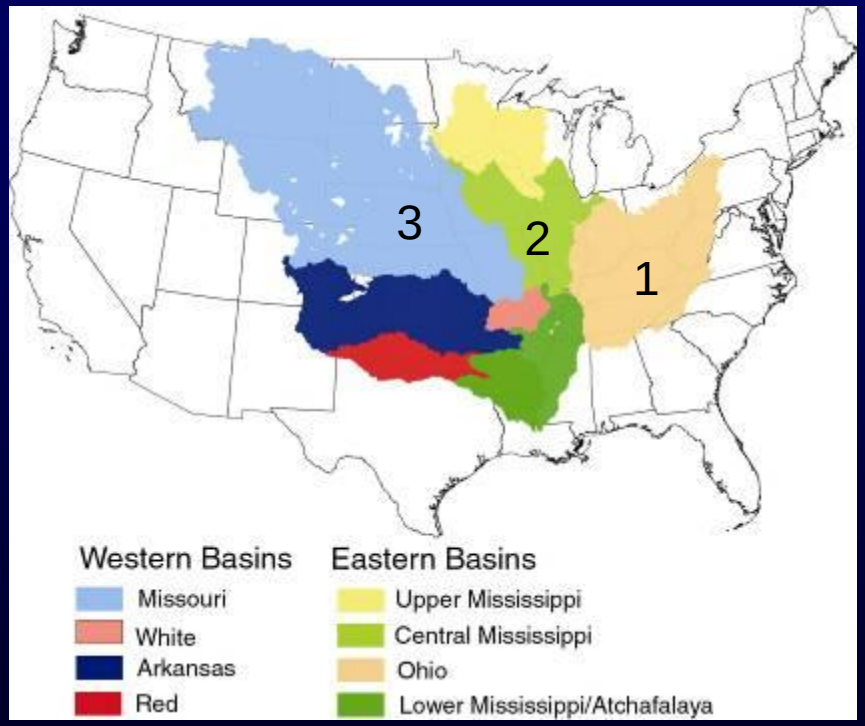


Alexander and others, 2008

Regional Contributions to the Stream Nutrient Flux to the Gulf of Mexico



Regional Watersheds

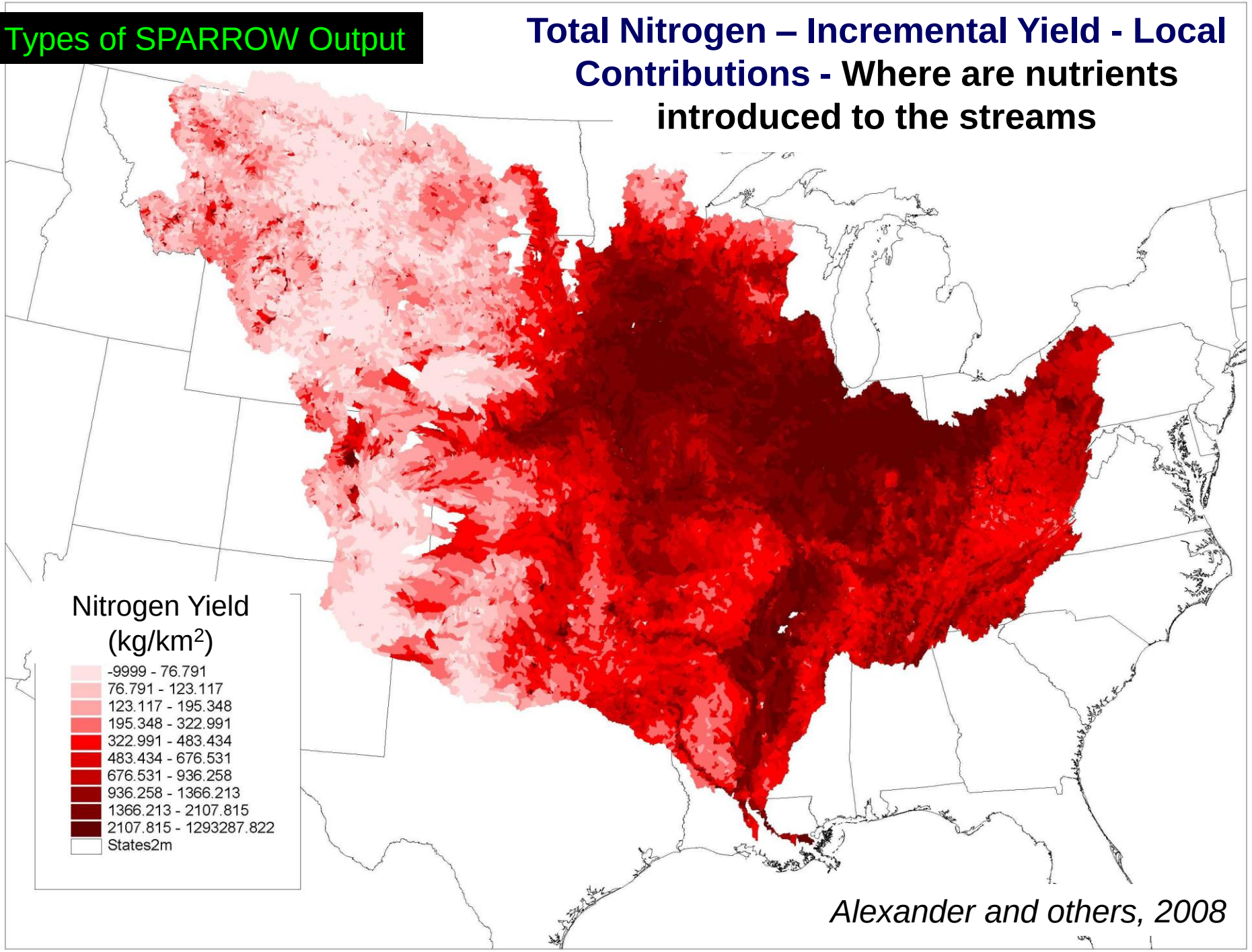


Conclusions from the 1992 National SPARROW model applied to the Miss. River Basin With loading estimated for inputs similar to 2002.

Alexander and others, 2008

Types of SPARROW Output

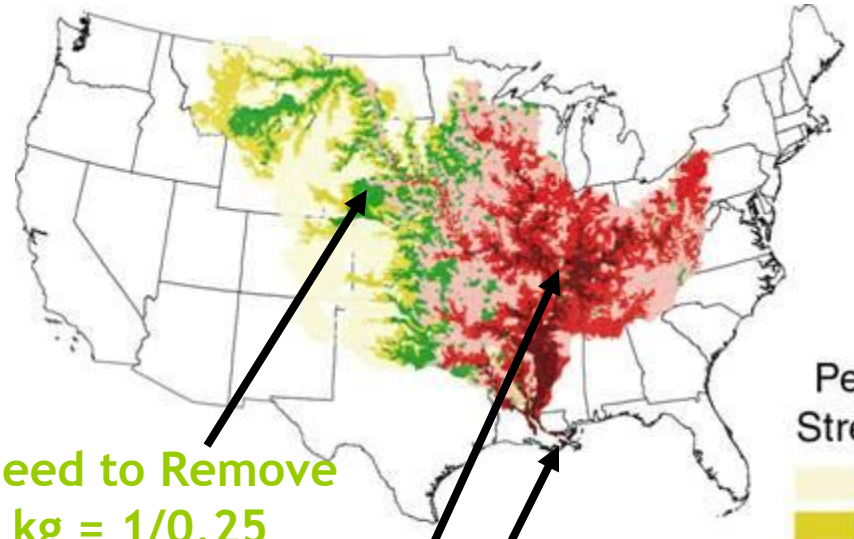
Total Nitrogen – Incremental Yield - Local Contributions - Where are nutrients introduced to the streams



Alexander and others, 2008

Not all of the Nutrients are Delivered to the Gulf of Mexico – How much makes it downstream? (incorporating in-stream and in-reservoir decay)

Total Nitrogen



Need to Remove
4 kg = 1/0.25
from these streams

To Remove
1 kg at
Gulf outlet

Need to Remove
1.1 kg = 1/0.9
from these streams

Percent of Stream Flux

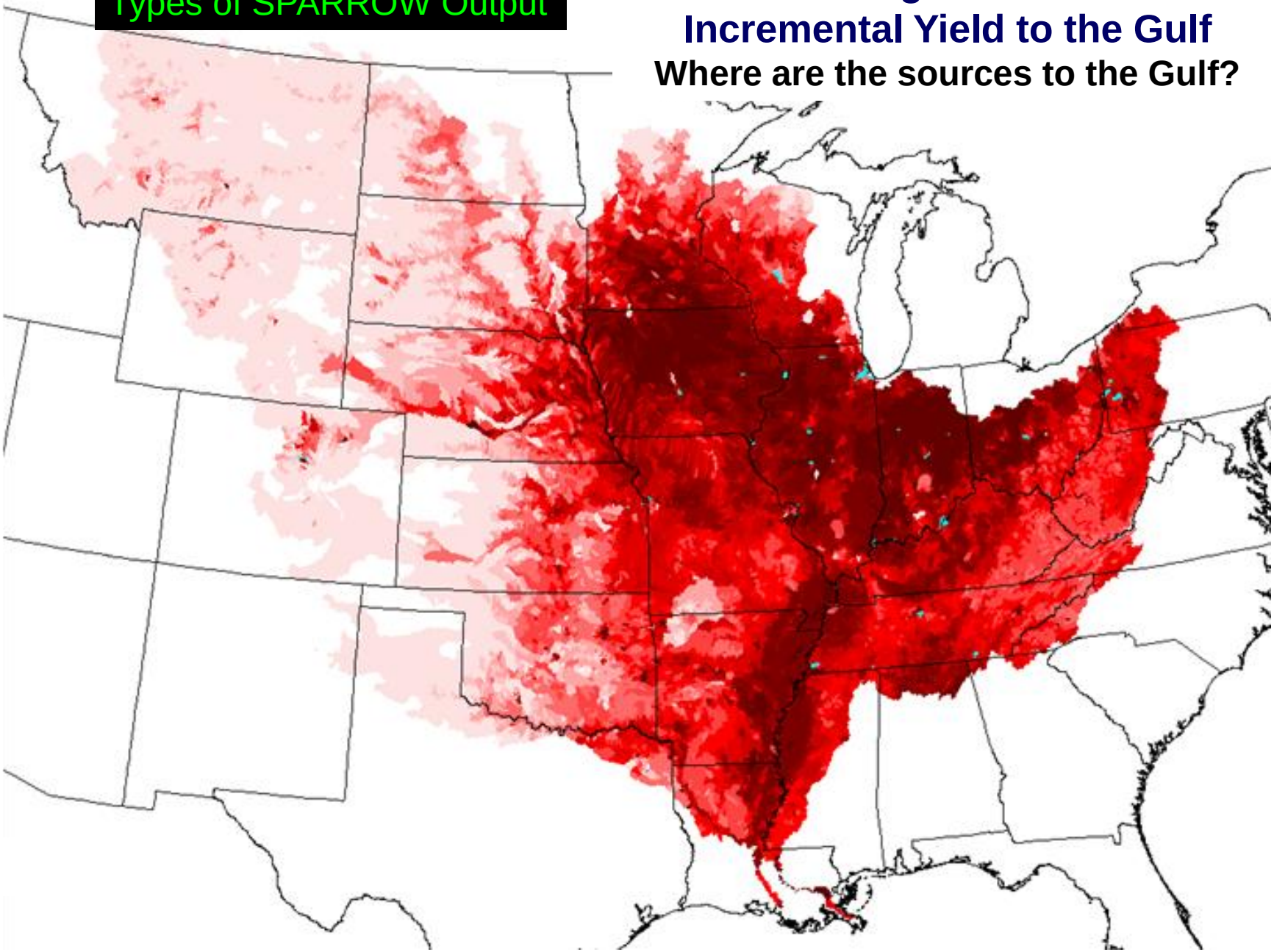
- <10
- 10 to 25
- 25 to 50
- 50 to 75
- 75 to 90
- 90 to 100

Total Phosphorus

Types of SPARROW Output

Total Nitrogen – Delivered Incremental Yield to the Gulf

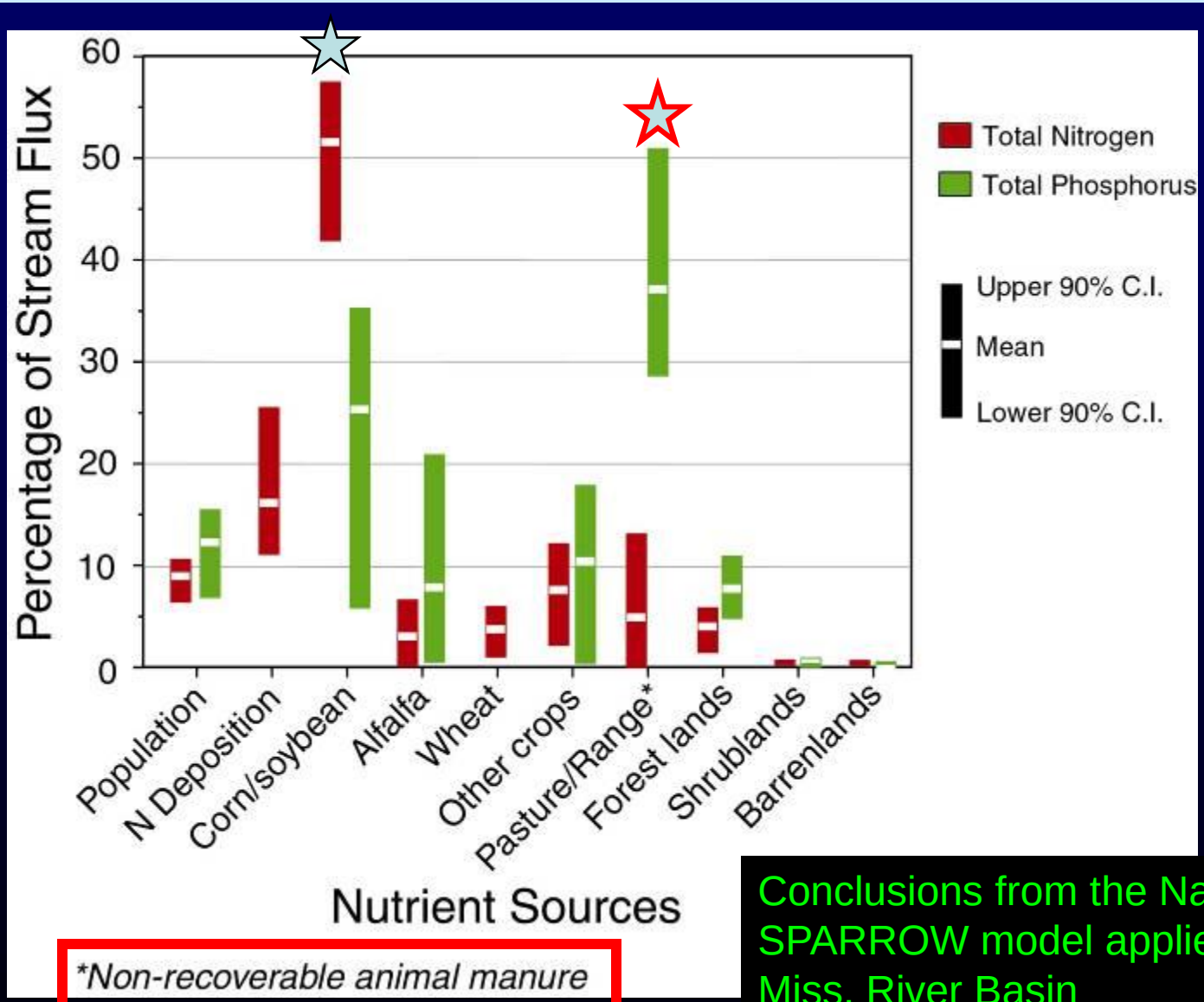
Where are the sources to the Gulf?



Nutrient Source Contributions to Stream Flux:

What are the Sources of the Nutrients?

Sources Contributions to Stream Nutrient Flux



Conclusions from the National SPARROW model applied to the Miss. River Basin

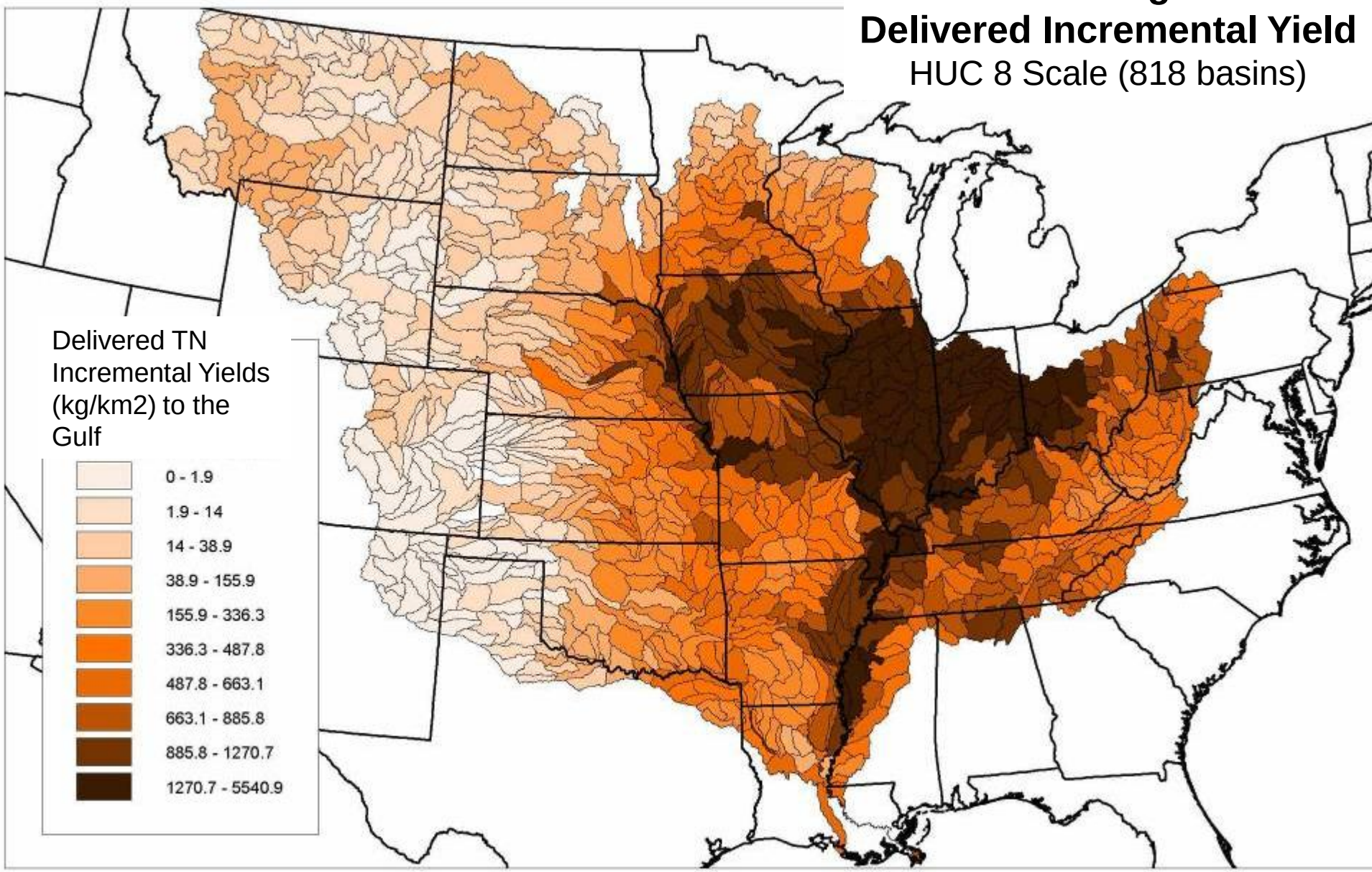
Where are the Greatest Sources of the Nutrients?

Or

Can we rank the watersheds throughout a large basin and determine which are the "TOP 150" HUC8 basins?

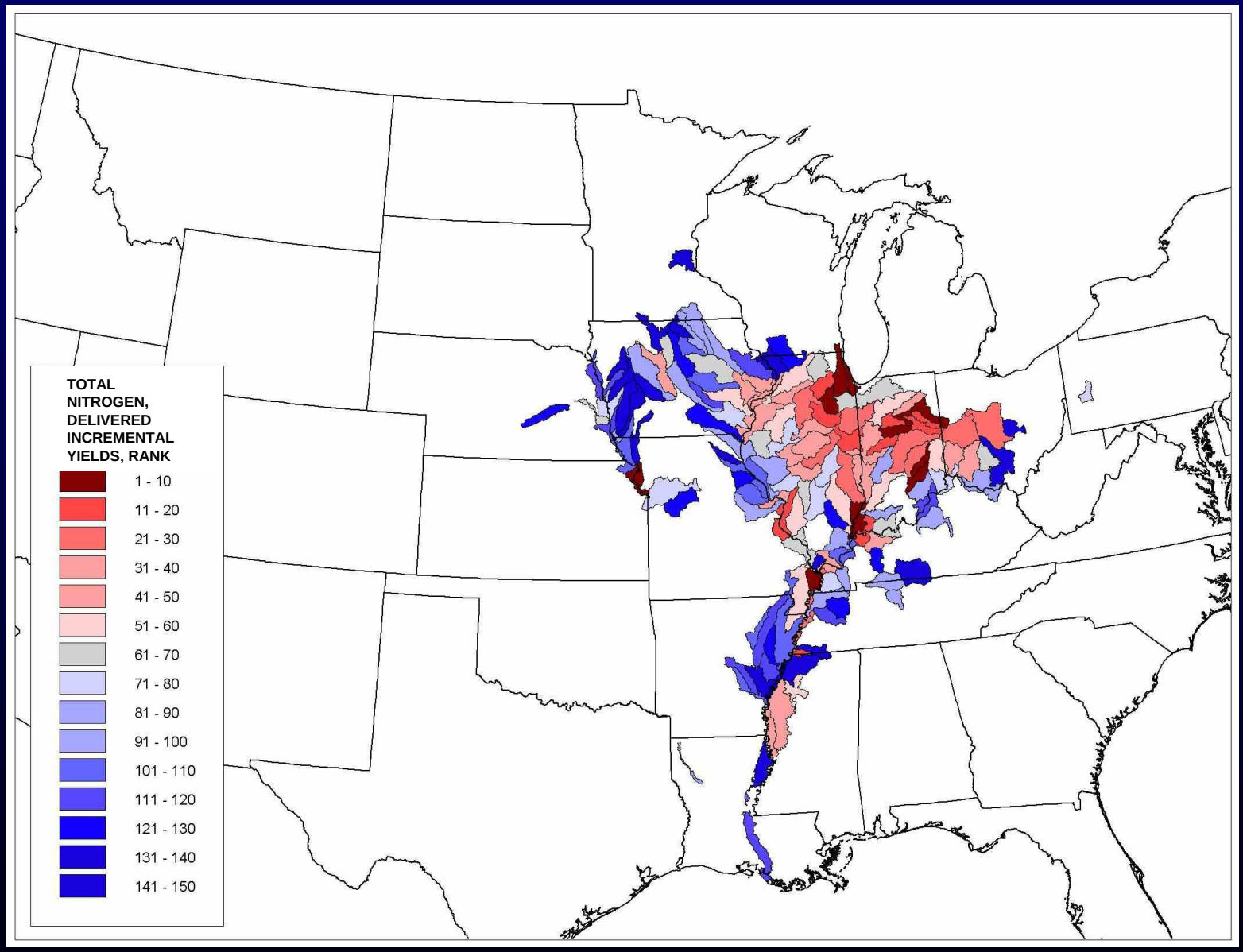
Total Nitrogen – Delivered Incremental Yield

HUC 8 Scale (818 basins)

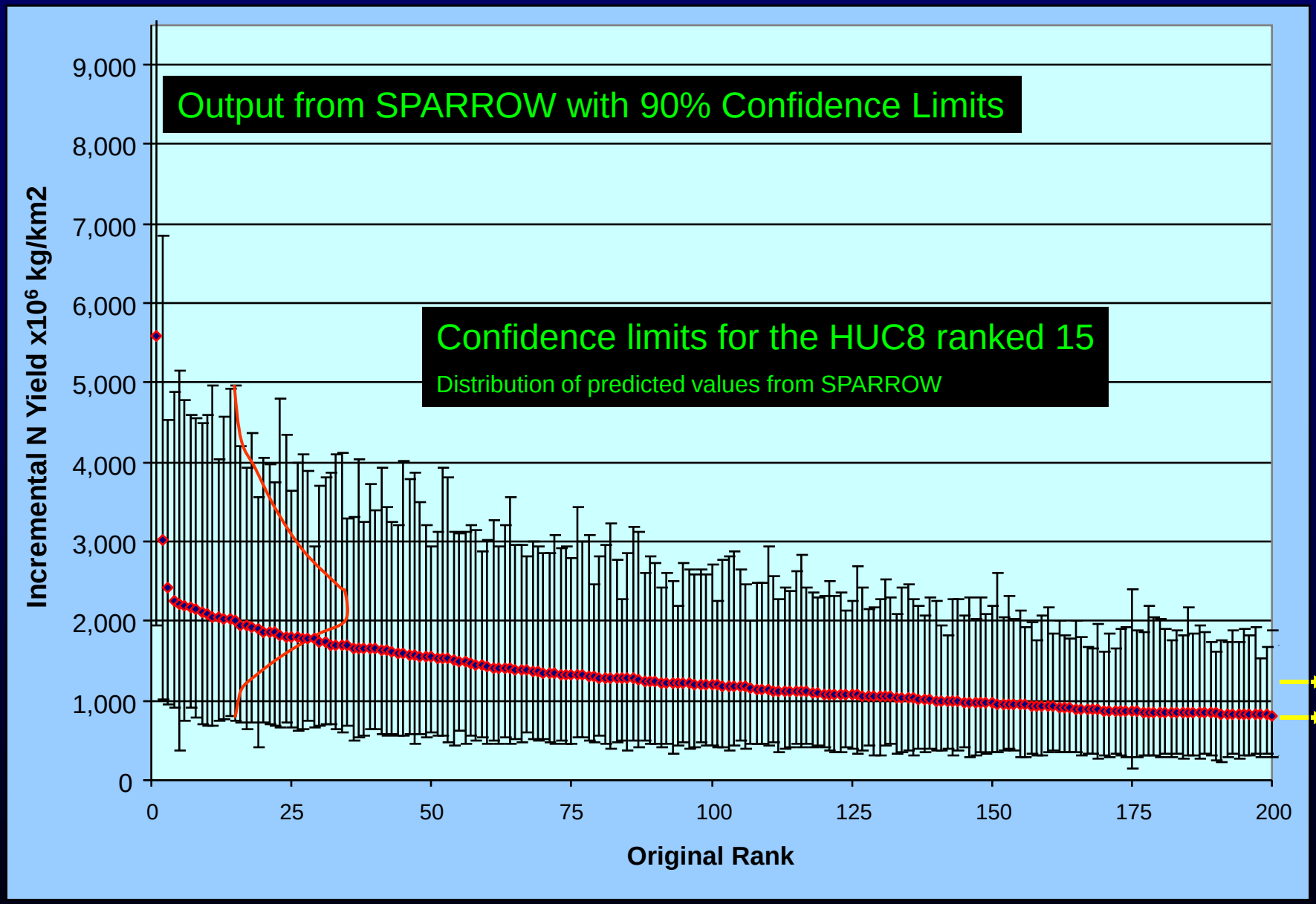


Robertson, et al. 2009

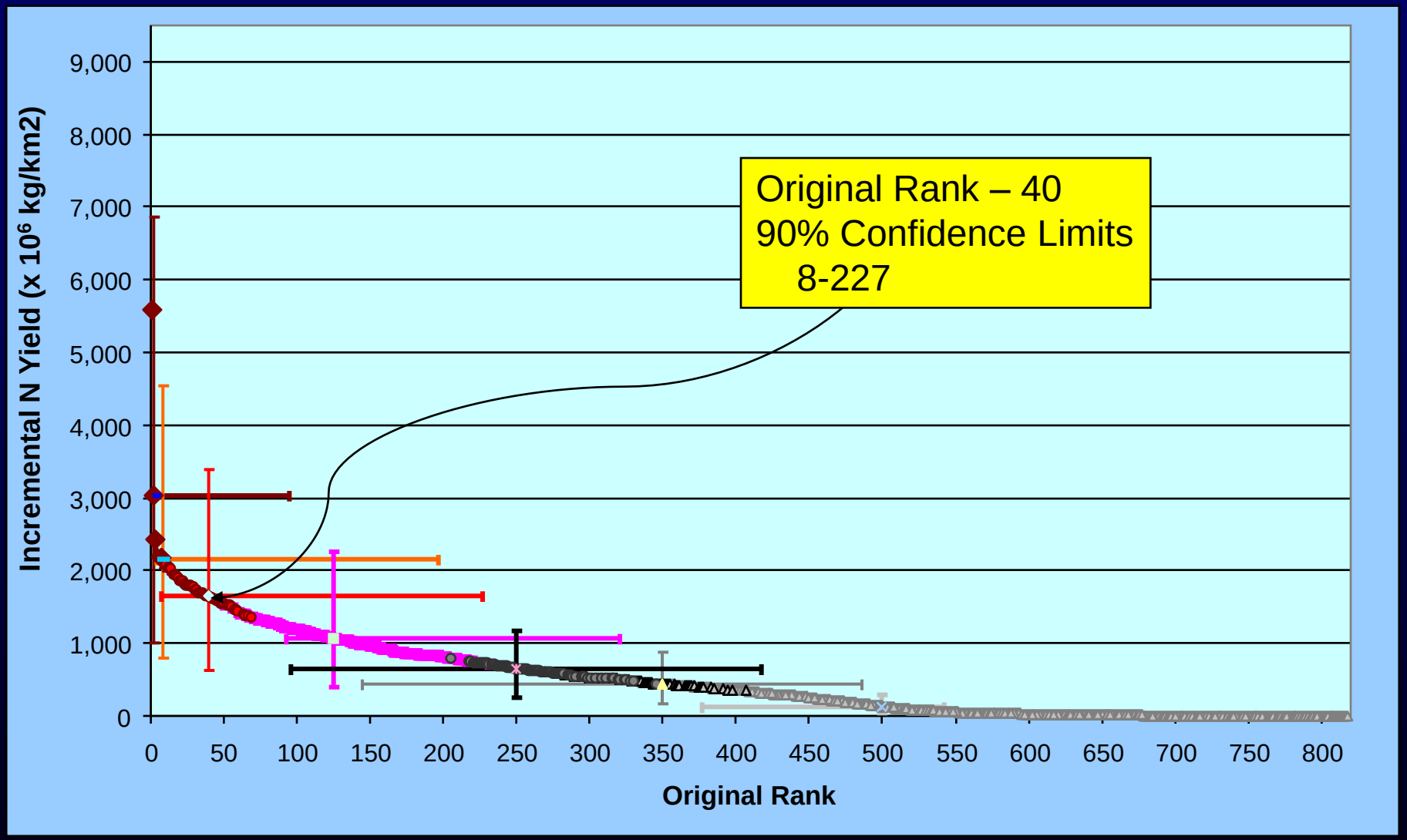
Top 150 contributors of Nitrogen to the Gulf



Ranked Incremental Nitrogen Yields From the HUCS, with 90 % CI's



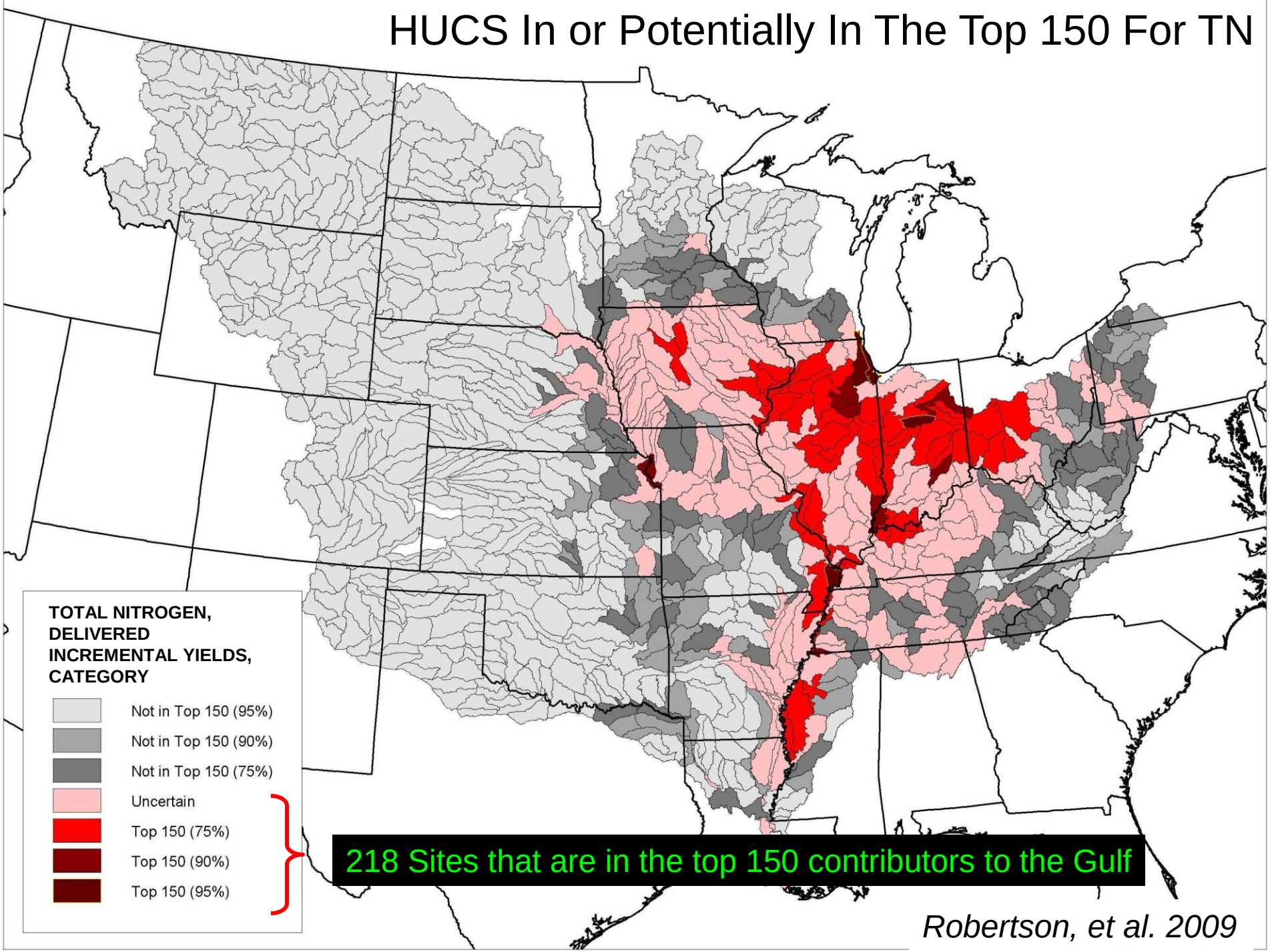
90% Confidence Intervals for Yields and Ranks



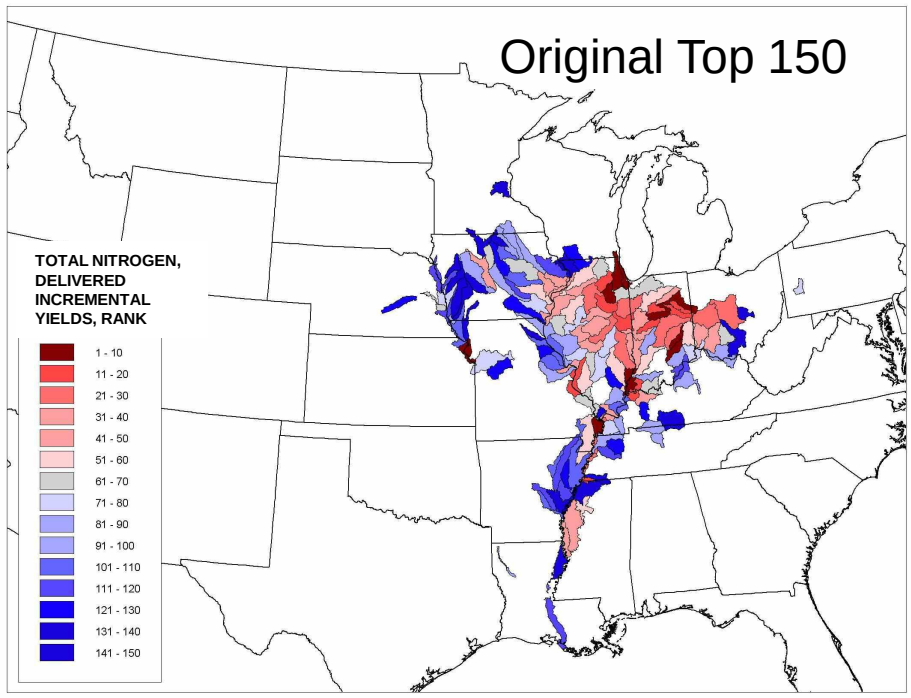
Horizontal Bars demonstrate the 90% confidence limits on the individual ranks

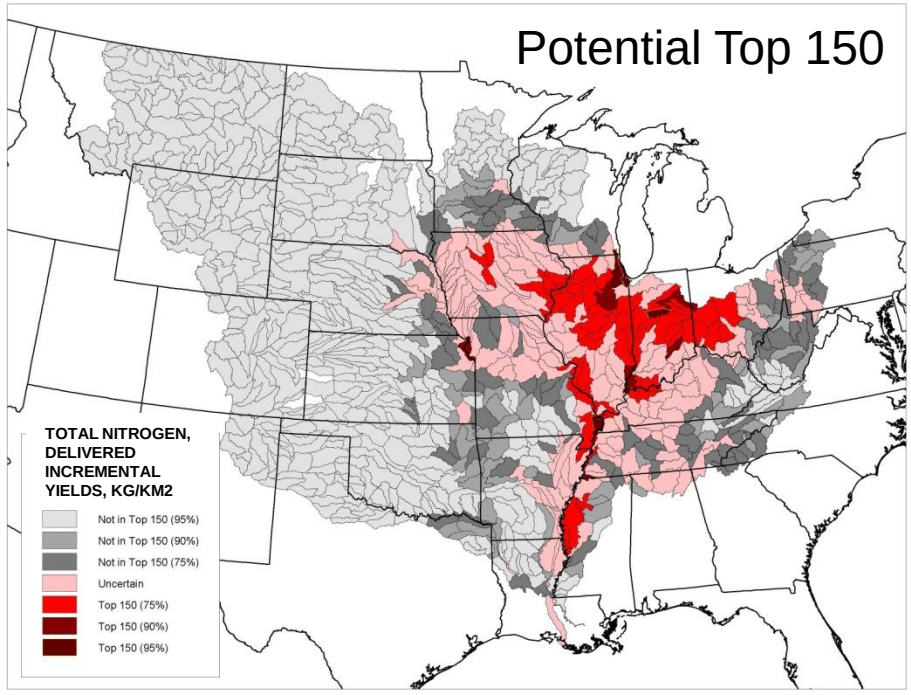
Robertson, et al. 2009

HUCS In or Potentially In The Top 150 For TN



Robertson, et al. 2009

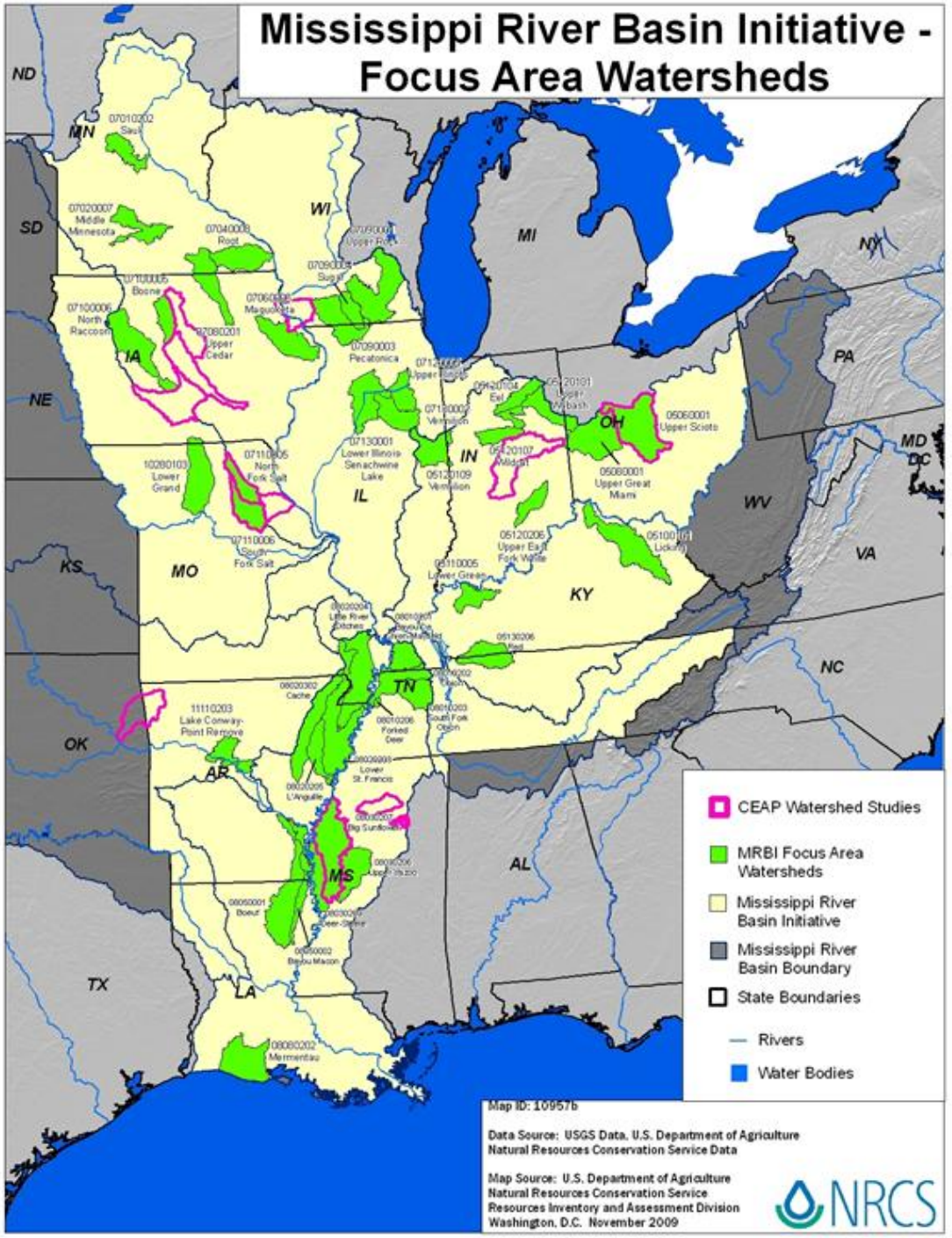




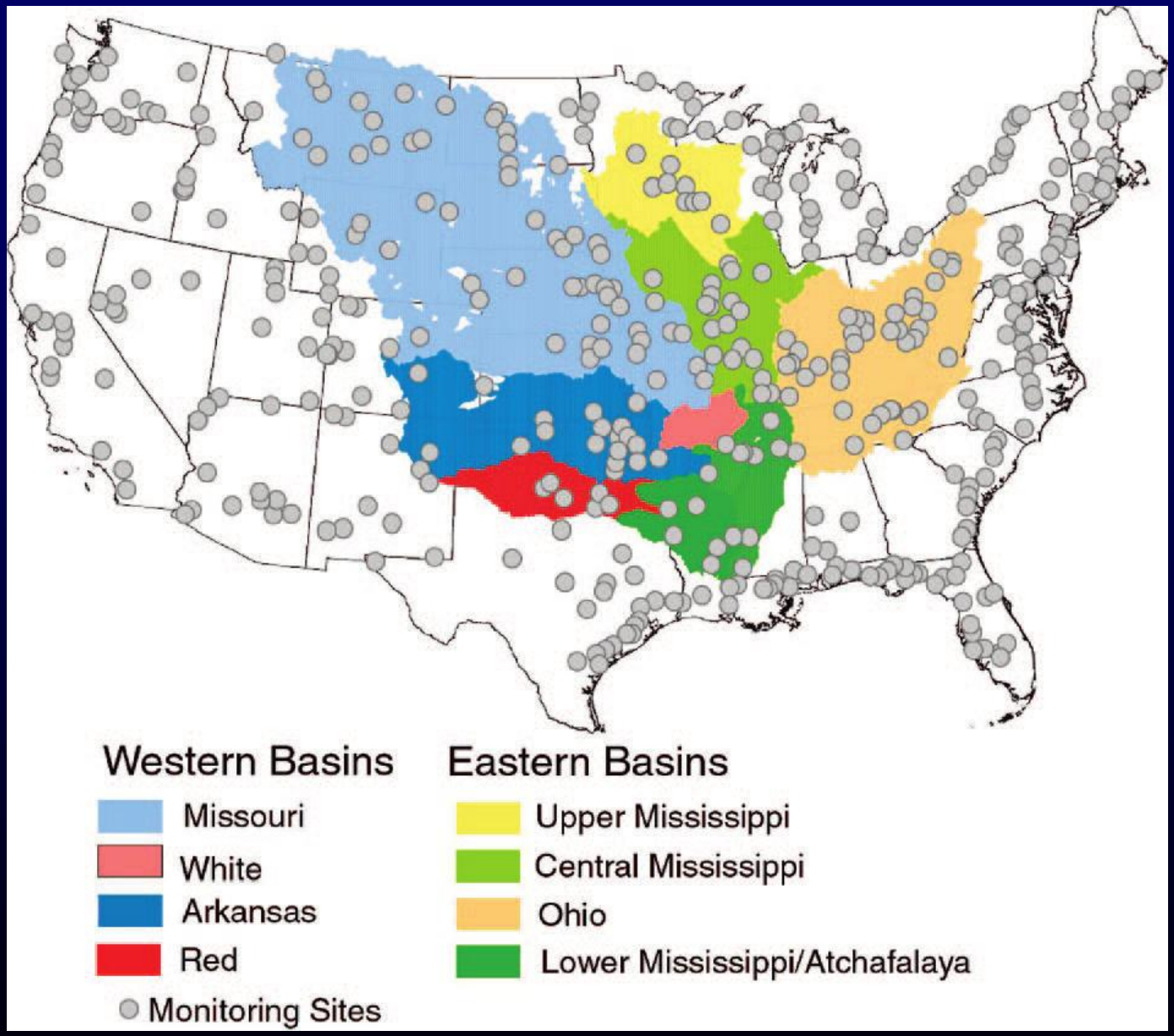
Comparison of Original Top 150 HUCs with Potential Top 150ish HUCs

Many areas in Iowa, Kentucky, and Tennessee are hard to say with confidence are in or out of the top 150

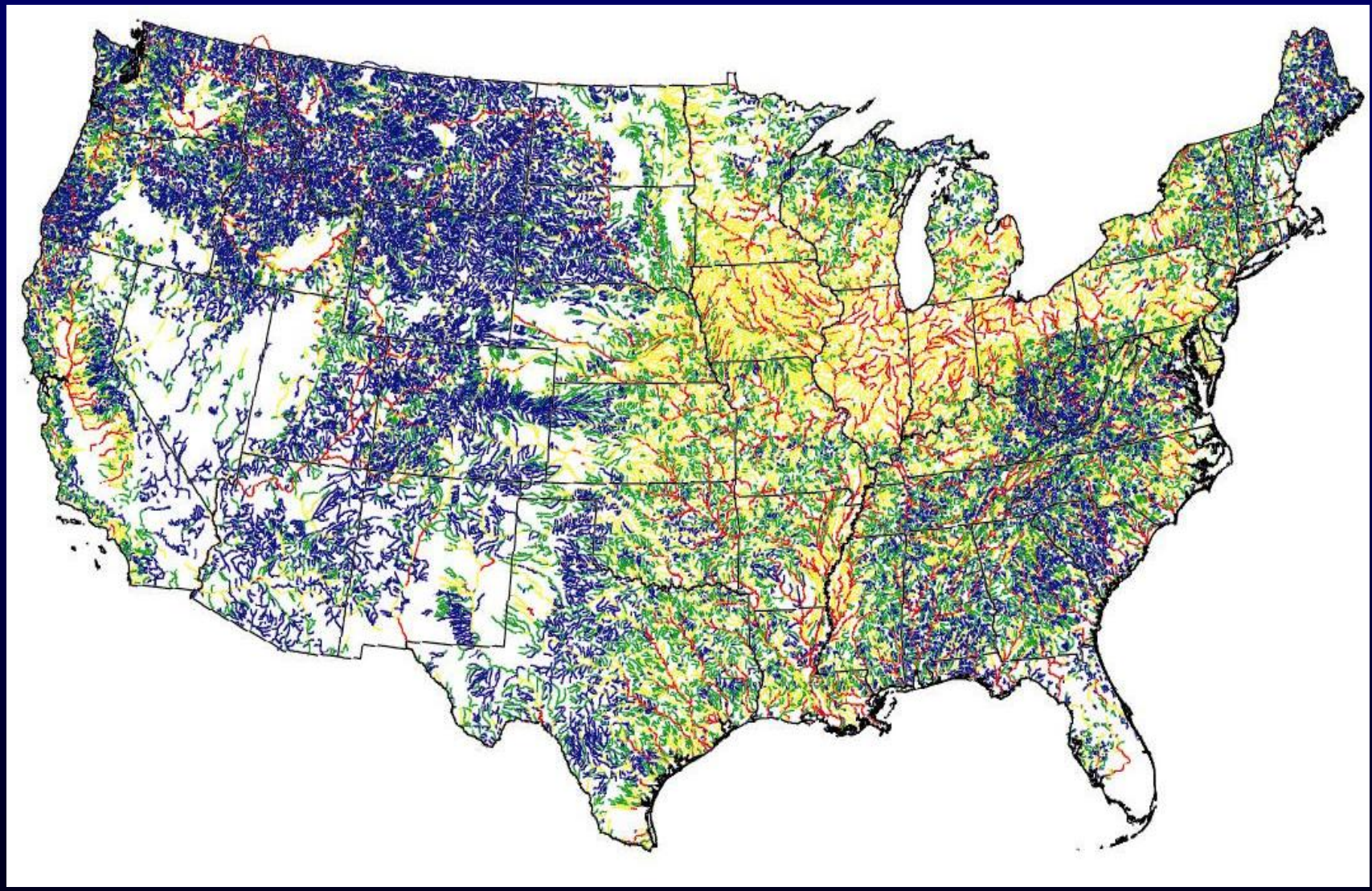
U.S. Dept. of Agriculture's Mississippi River Basin Healthy Watershed Initiative



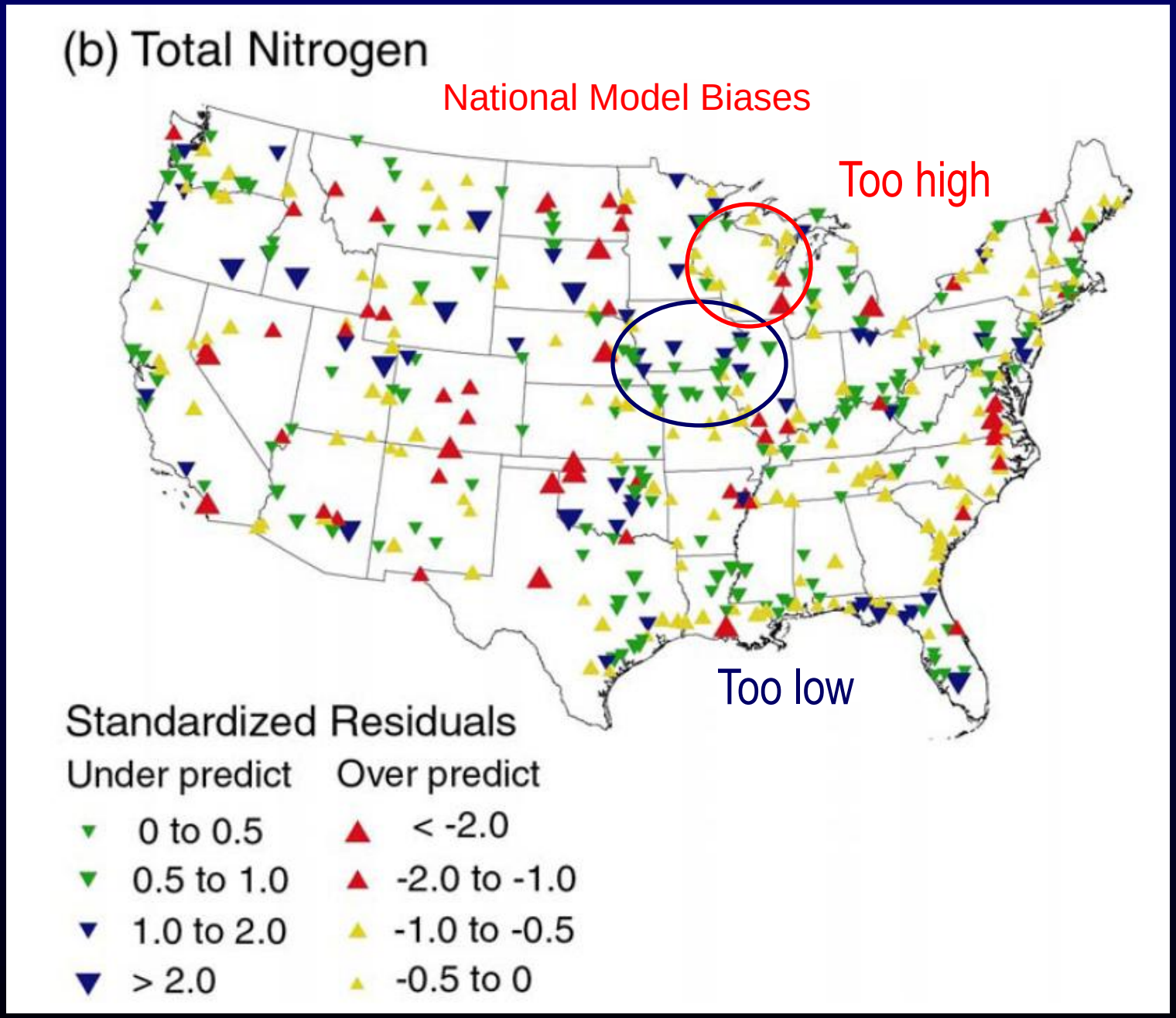
National SPARROW Models were based on approximately 450 sites



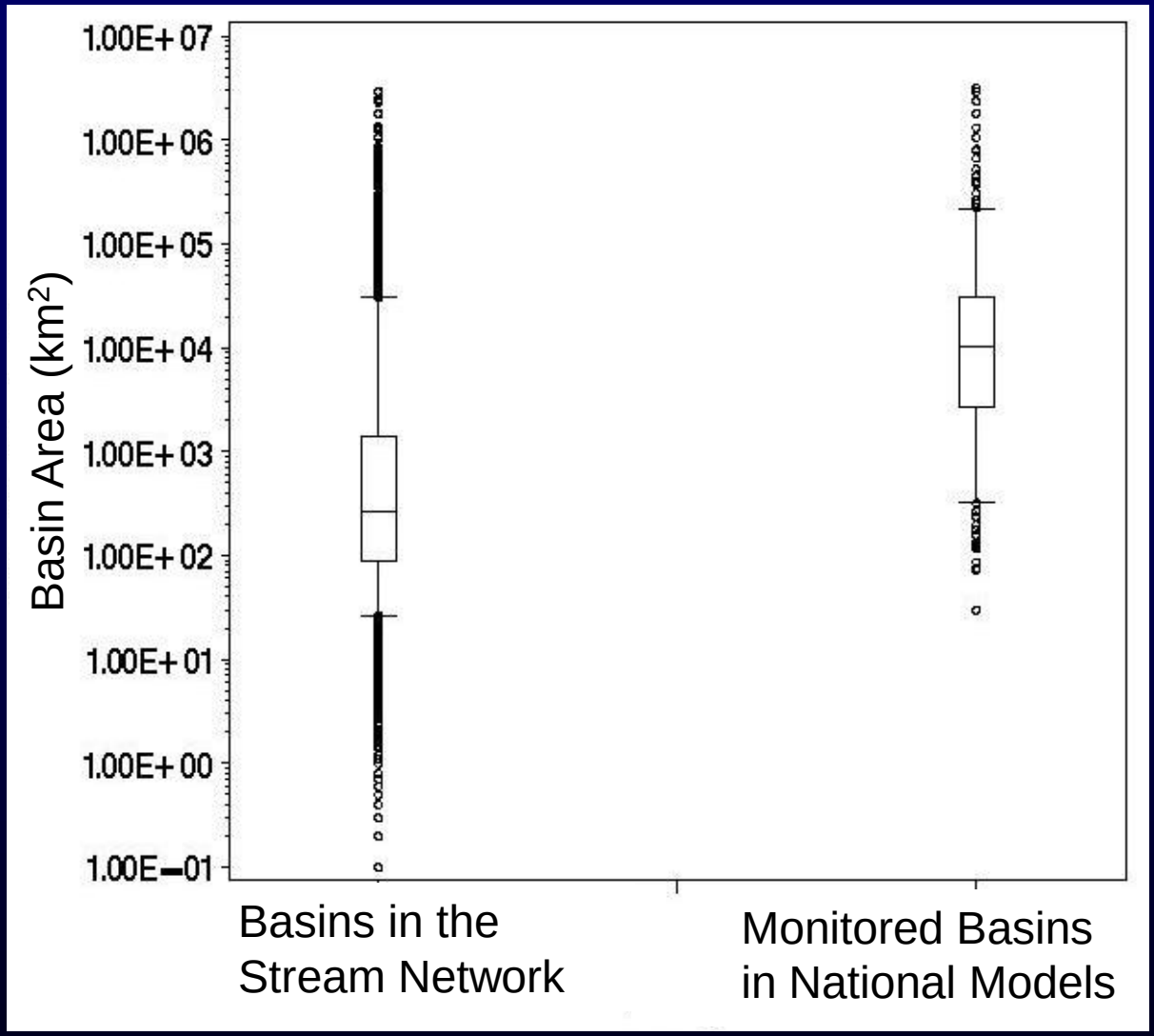
Predictions from a National SPARROW Model



With a National SPARROW model available, why would you want any other SPARROW models?

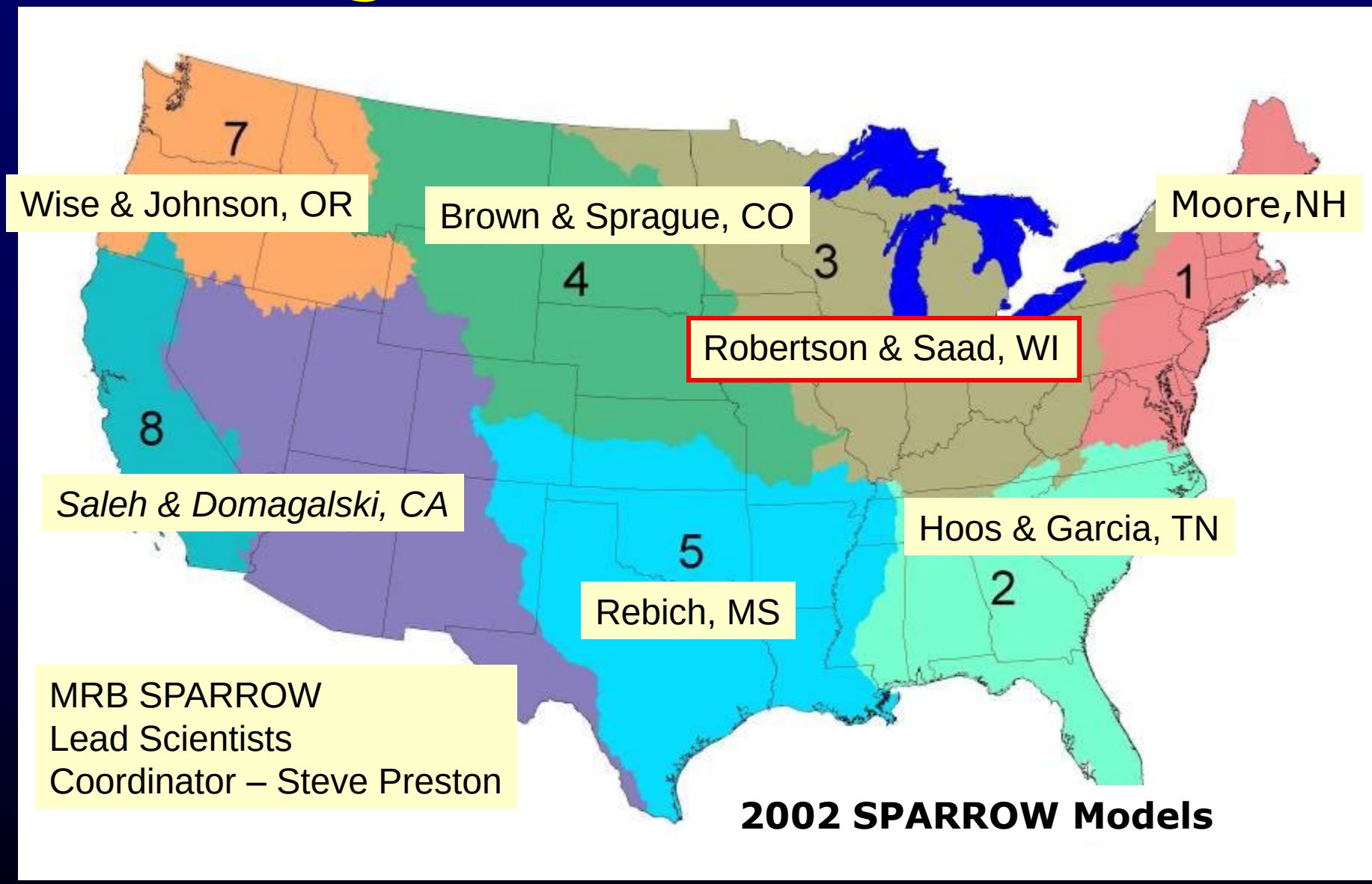

(b) Total Nitrogen
National Model Biases
Too high
Too low
Standardized Residuals
Under predict
Over predict
0 to 0.5
0.5 to 1.0
1.0 to 2.0
> 2.0
< -2.0
-2.0 to -1.0
-1.0 to -0.5
-0.5 to 0

Distribution of Basin Areas in the Model and in the Calibration Data Set

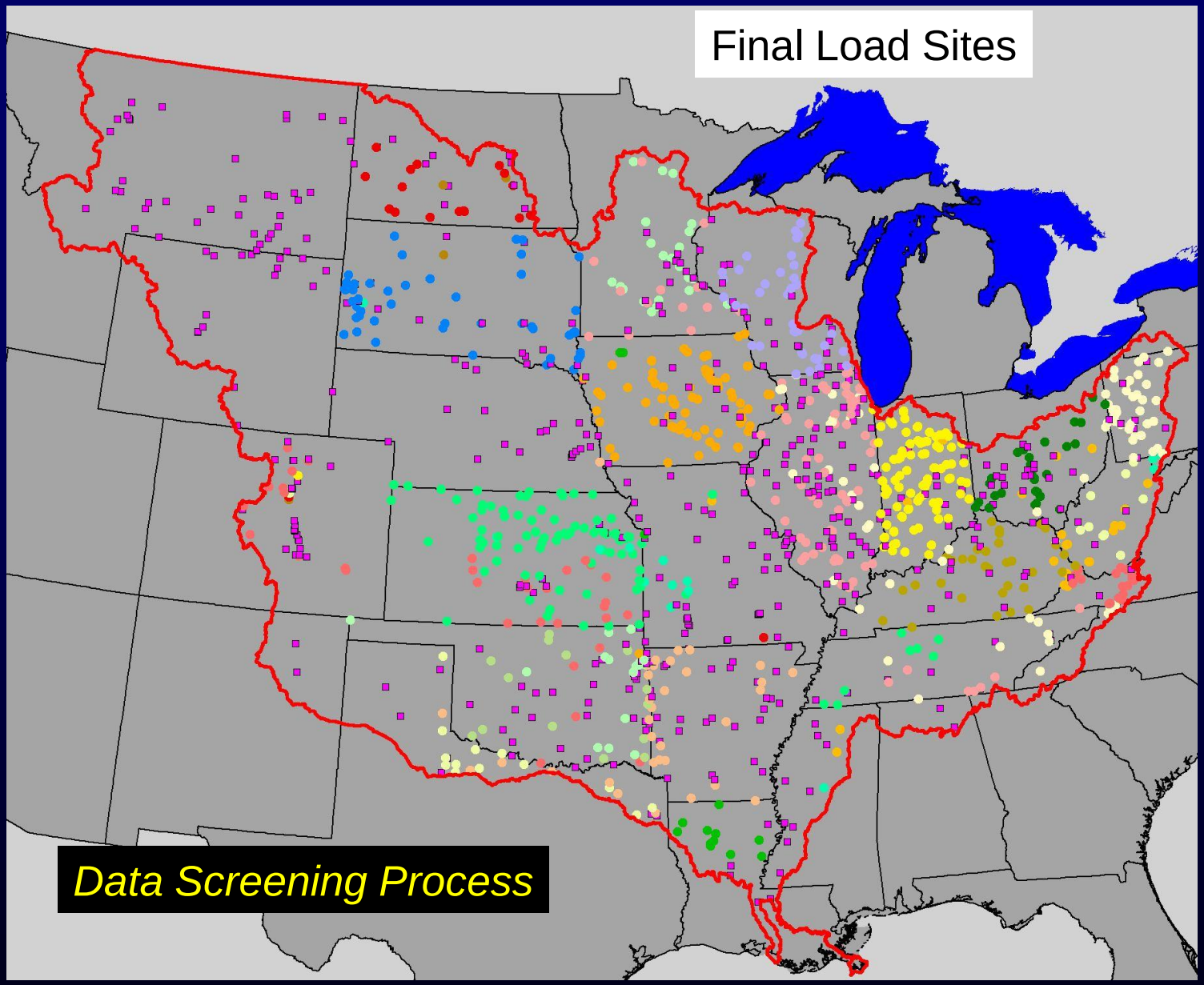


Not really sure how well the model estimates for areas that are smaller than the sites used for calibration

Regional Nutrient Models

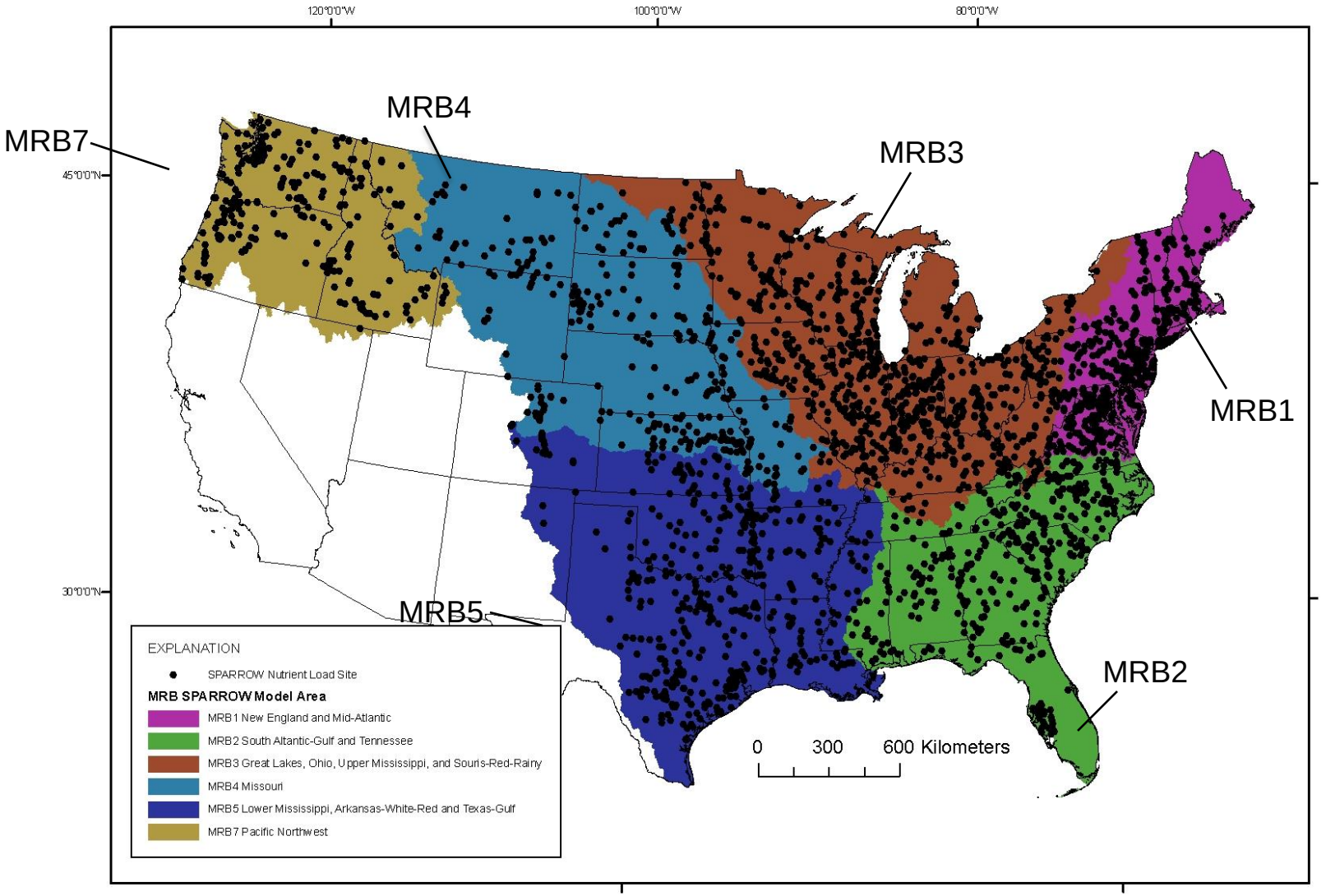


All, but MRB8, NOW published in JAWRA

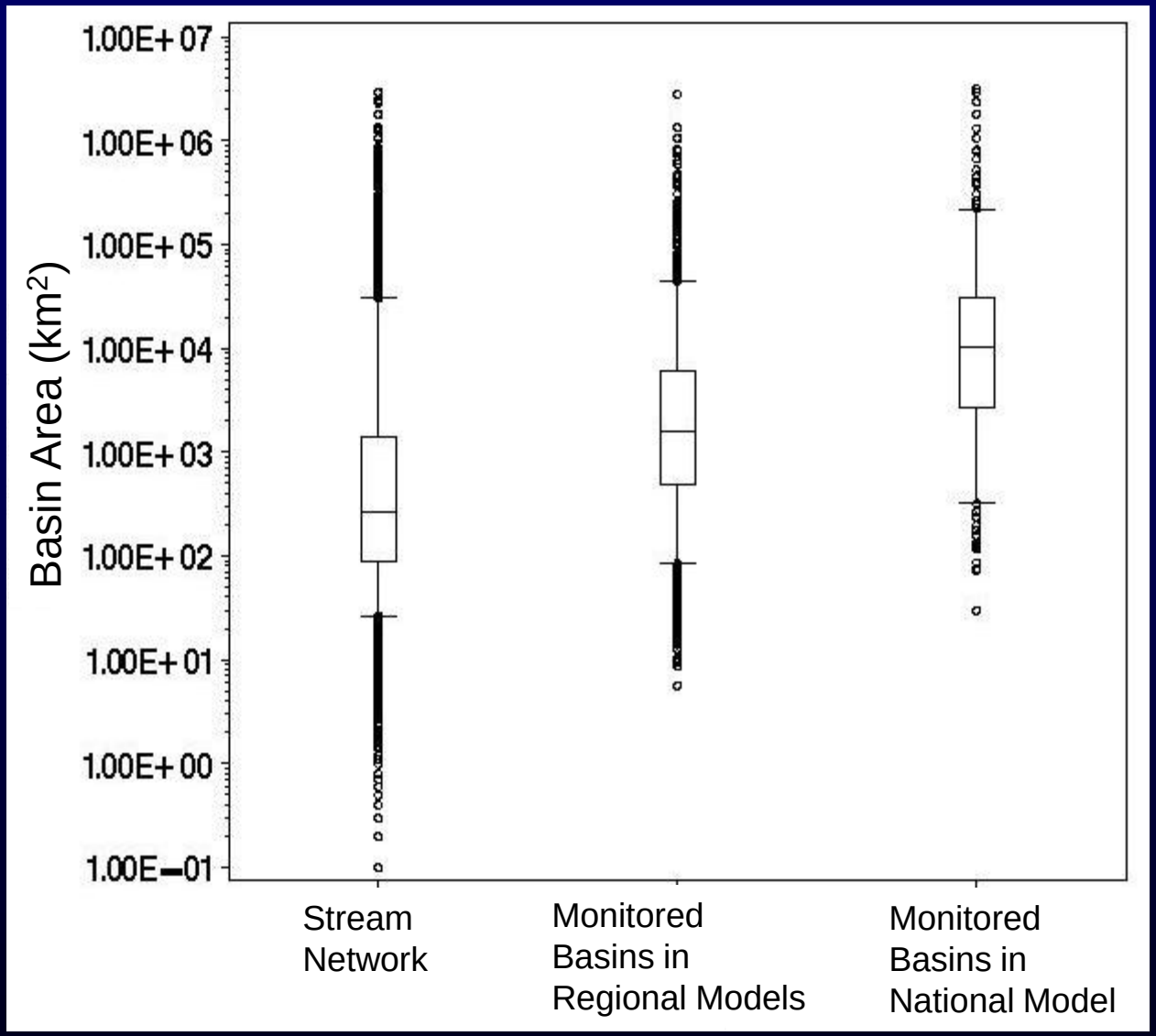


Although there is a massive amount of water quality data, only limited sites have data adequate to estimate an average annual load

Saad et al., 2011

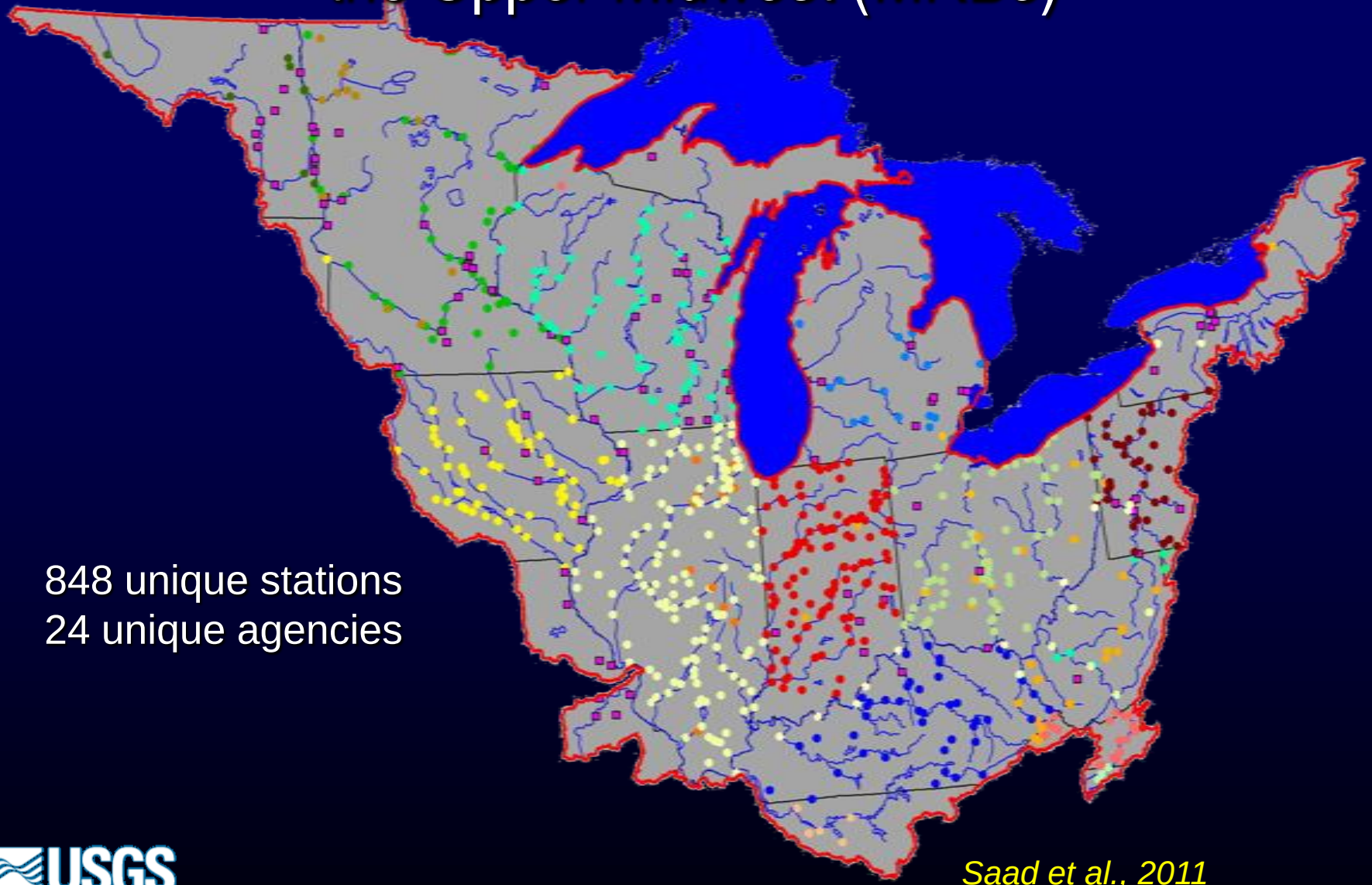

120°0'0"W
100°0'0"W
80°0'0"W
45°0'0"N
30°0'0"N
MRB7
MRB4
MRB3
MRB1
MRB5
MRB2
EXPLANATION
SPARROW Nutrient Load Site
MRB SPARROW Model Area
MRB1 New England and Mid-Atlantic
MRB2 South Altantic-Gulf and Tennessee
MRB3 Great Lakes, Ohio, Upper Mississippi, and Souris-Red-Rainy
MRB4 Missouri
MRB5 Lower Mississippi, Arkansas-White-Red and Texas-Gulf
MRB7 Pacific Northwest
0 300 600 Kilometers

Distribution of Basin Areas in the Model and in the Calibration Data Sets



Have a much better idea of how models estimate conditions in smaller streams, but still not the smallest basins

2002 SPARROW Nutrient Load Sites For the Upper Midwest (MRB3)



848 unique stations
24 unique agencies

USGS
science for a changing world

Saad et al., 2011

SPARROW Sources and Transport Attributes

NUTRIENT SOURCES (2002)

- **Point sources and other urban contributions**
- Atmos. N deposition – (NADP/CMAQ)
- Farm fertilizer use allocated to major crops:
  - County fertilizer sales and expenditures; crop acreage
  - NLCD agricultural land use
  - State appl. rates (rotational, corn, soybeans, cotton, wheat, other crops)
- N_2 fixation – cultivated lands
- Animal manure:
  - Confined/Unconfined Animals
  - Confined > to crops & lost
- Natural and residual sources (lands in forest, barren, shrub)

LAND-TO-WATER DELIVERY

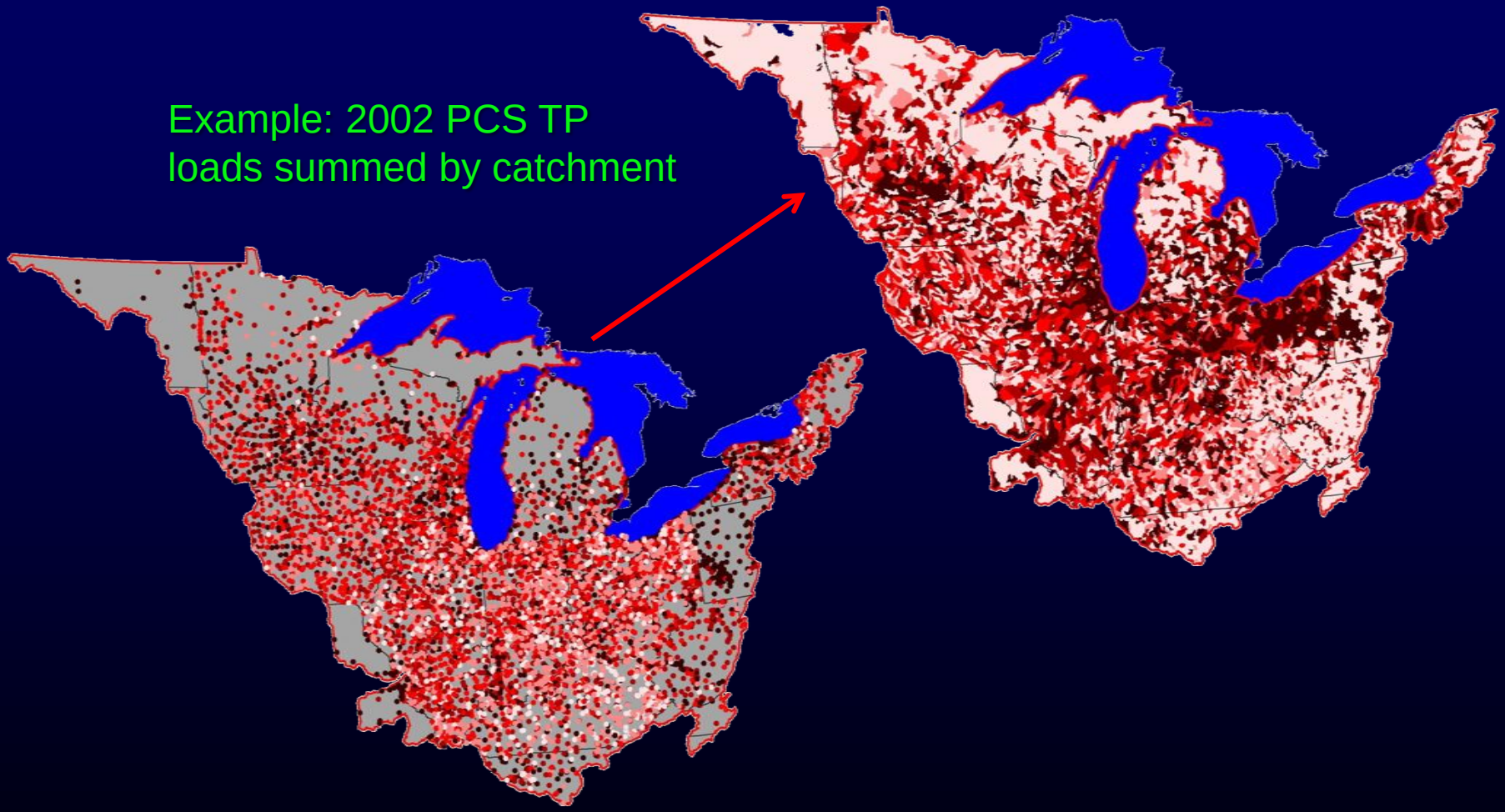
- Climate (precipitation, temperature)
- Soils (permeability)
- Topography/subsurface (slope, specific catchment area)
- **Artificial drainage (tiles, ditches, new ARSC coverage)**

AQUATIC ATTENUATION

- Streams
  - First-order decay ~ f(water travel time, flow and depth)
- Reservoirs
  - First-order decay ~ f(areal hydraulic load—ratio of outflow to surface area)

MRB3 SPARROW model input

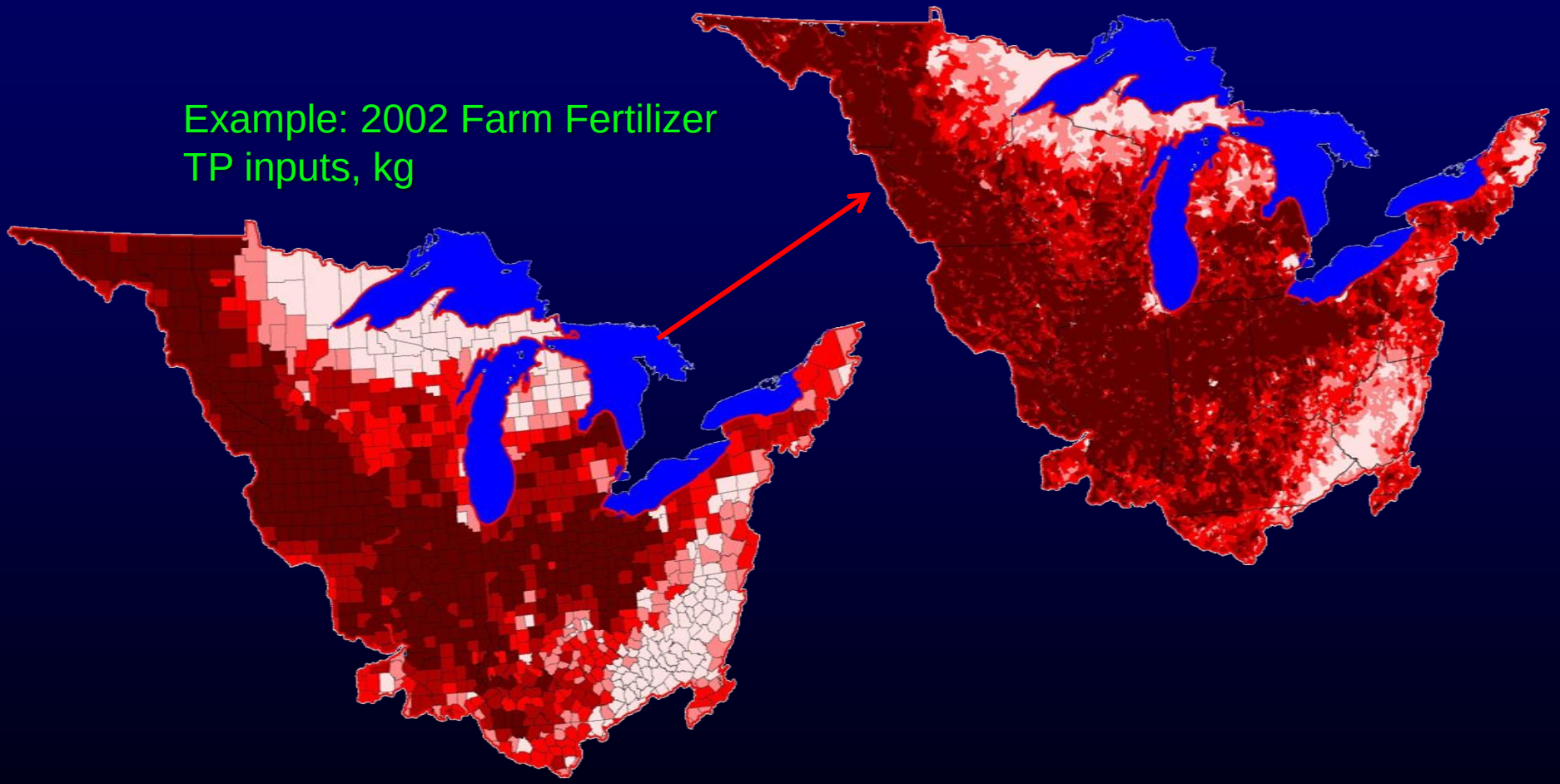
Nutrient Sources: Point Sources



Source: USEPA Permit Compliance System (PCS) database + States

MRB3 SPARROW model input

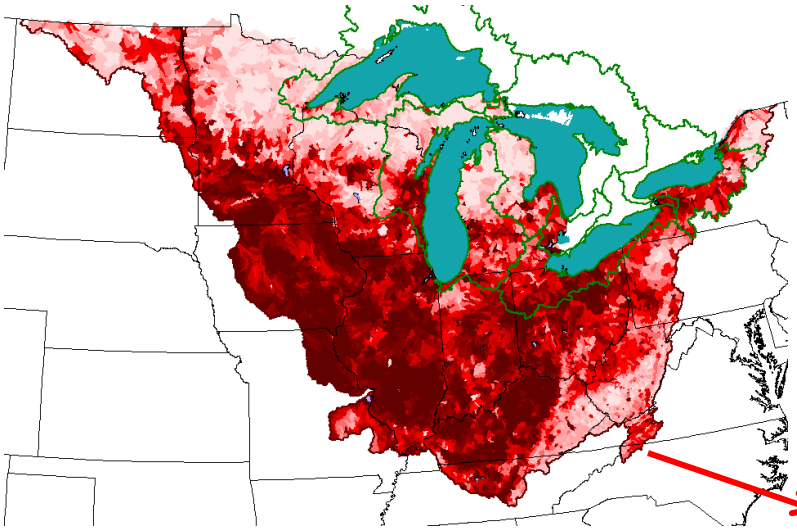
Nutrient Sources: Fertilizer and Manure



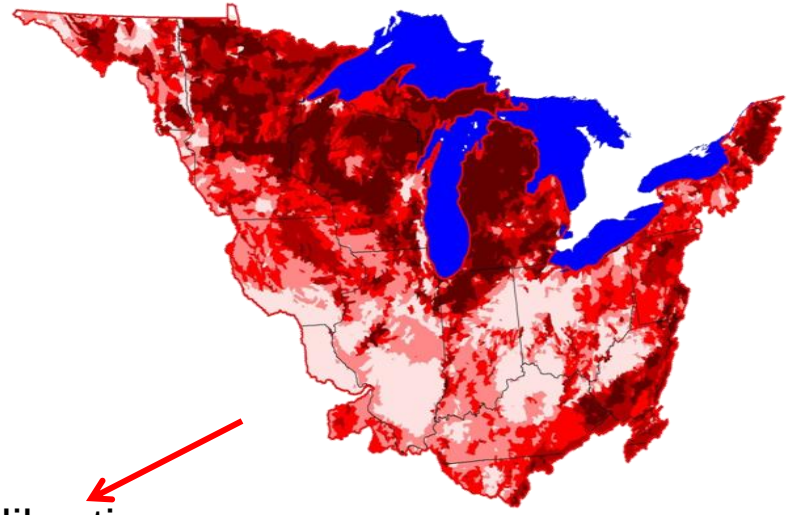
Source: Ruddy and Others, 2006 (SIR 2006-5012)
Fertilizer (sales)—AAPFCO; Manure (Animal #s)—Census of Agriculture

Upper Midwest SPARROW Model Calibration

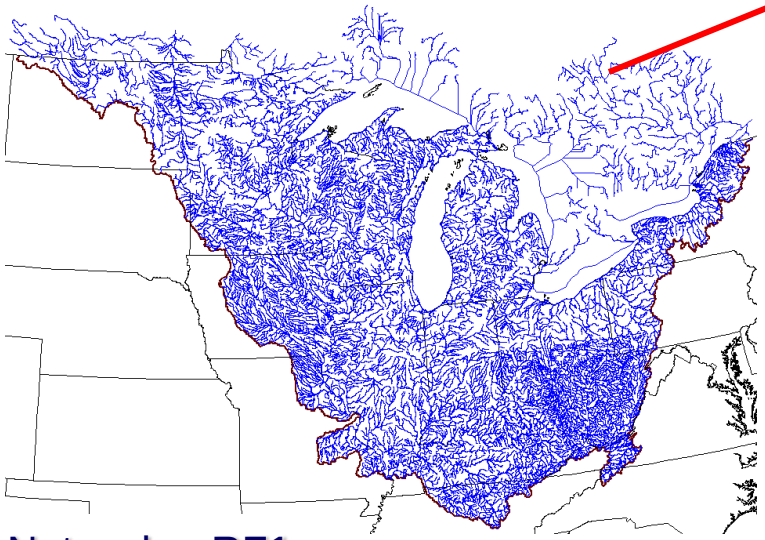
One Source: 2002 Farm Fertilizer TP inputs, kg



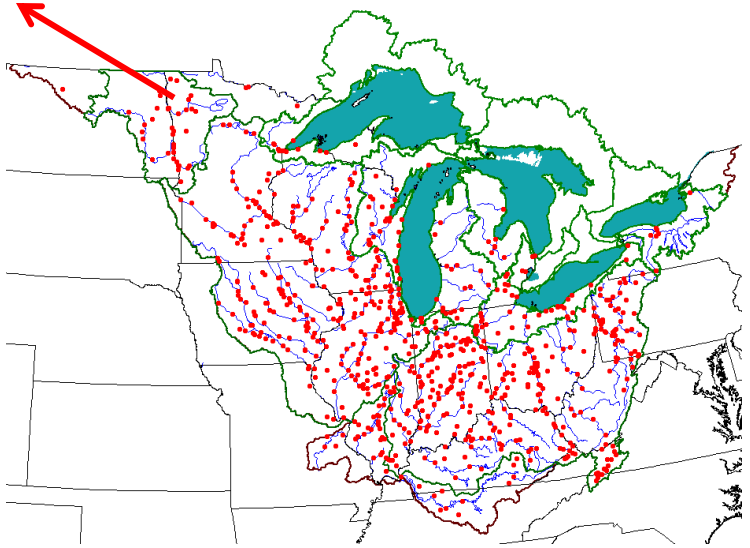
One Land-to-Water Delivery: Soil Permeability



Calibration



River Network – RF1



Long-term detrended Loads for 810 sites

Regression Equation behind the SPARROW Model for MRB#3

Load at a specific site

Flux from Within a SPARROW Watershed

Flux from Upstream SPARROW Watersheds

$$F_i^* = \left(\sum_{n=1}^{N_S} S_{n,i} \alpha_n D_n \left(\mathbf{Z}_i^D ; \boldsymbol{\theta}_D \right) \right) T' \left(\mathbf{Z}_i^S , \mathbf{Z}_i^R ; \boldsymbol{\theta}_S , \boldsymbol{\theta}_R \right) + \left(\sum_{j \in J(i)} F_j' \right) \delta_i T \left(\mathbf{Z}_i^S , \mathbf{Z}_i^R ; \boldsymbol{\theta}_S , \boldsymbol{\theta}_R \right)$$

Sources

Land-to-Water Delivery

Transport/Decay

Transport

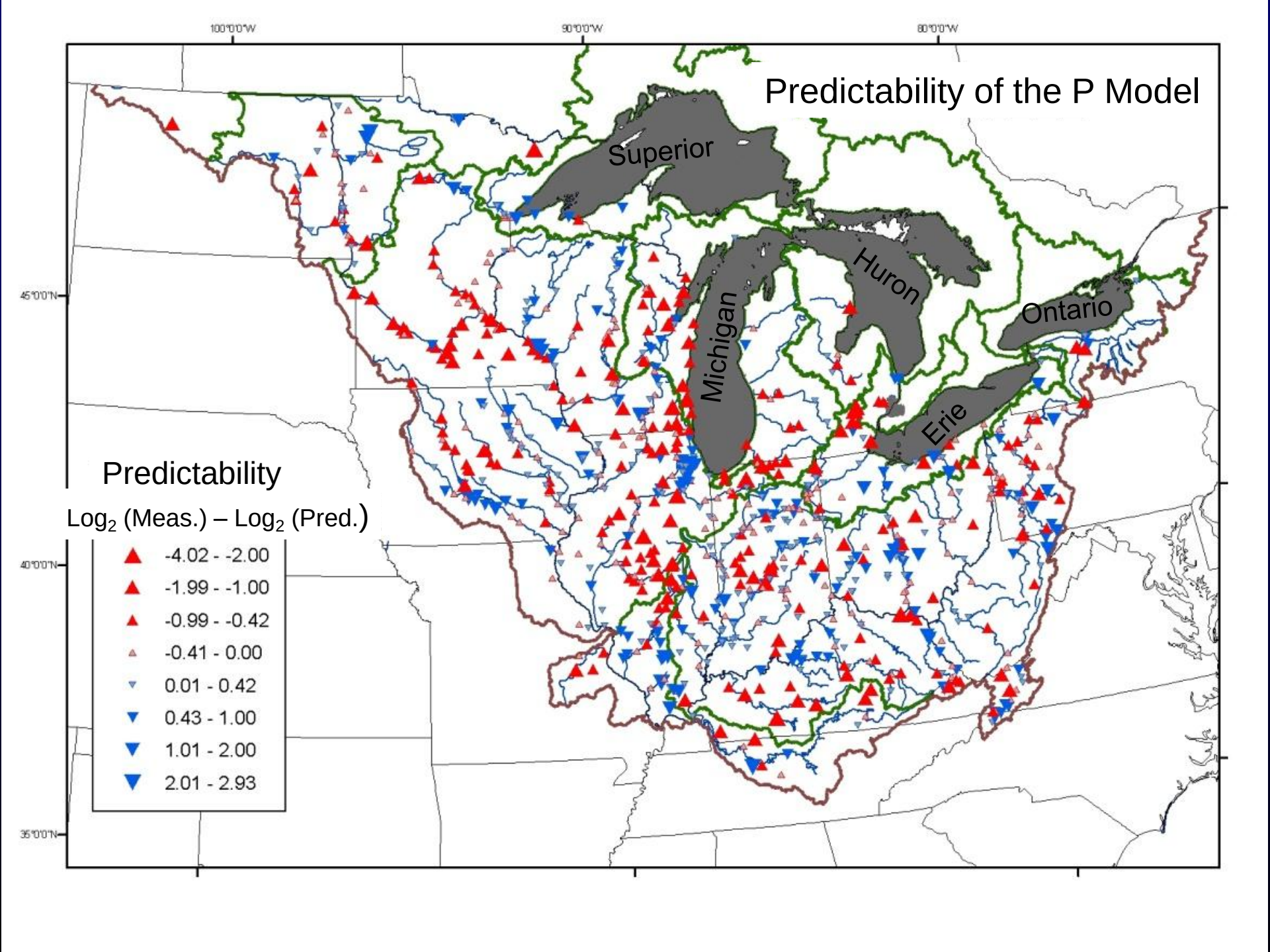
Calibration Coefficients

Calibration based on ~850 sites;

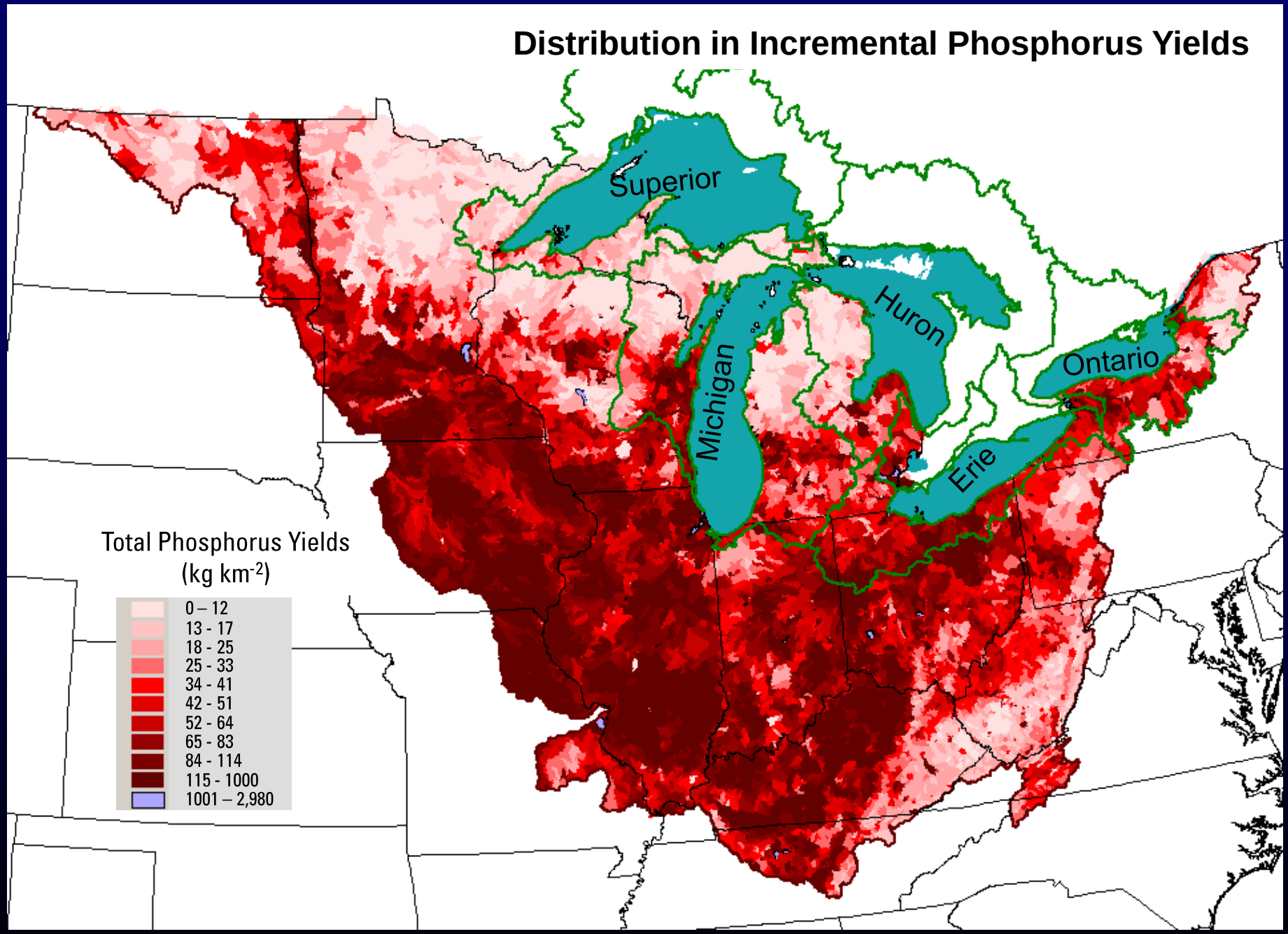
Summary of Upper Midwest SPARROW model and calibration results for TP.

Parameter	Coefficient units	Coefficient value	Coefficient Standard error	P value	Coefficient value (mean bootstrap estimate)	Coefficient 90% Confidence Limits (NLLSR) Low	High
Sources ←							
Point sources (total)	fraction, dimensionless	1.068	0.142	0.0000	1.083	0.835	1.302
Manure (confined)	fraction, dimensionless	0.086	0.011	0.0000	0.085	0.068	0.104
Manure (unconfined)	fraction, dimensionless	0.032	0.010	0.0009	0.033	0.015	0.049
Fertilizers (farm)	fraction, dimensionless	0.029	0.004	0.0000	0.029	0.023	0.036
Forested areas	kg km^{-2} yr^{-1}	14.700	1.723	0.0000	14.600	11.800	17.500
Urban areas	kg km^{-2} yr^{-1}	52.300	14.400	0.0001	48.900	28.600	76.000

Robertson and Saad, 2011


Predictability of the P Model
Superior
Michigan
Huron
Erie
Ontario
100°0'0"W
90°0'0"W
80°0'0"W
45°0'0"N
40°0'0"N
35°0'0"N
Predictability
Log2 (Meas.) – Log2 (Pred.)
-4.02 - -2.00
-1.99 - -1.00
-0.99 - -0.42
-0.41 - 0.00
0.01 - 0.42
0.43 - 1.00
1.01 - 2.00
2.01 - 2.93

Distribution in Incremental Phosphorus Yields

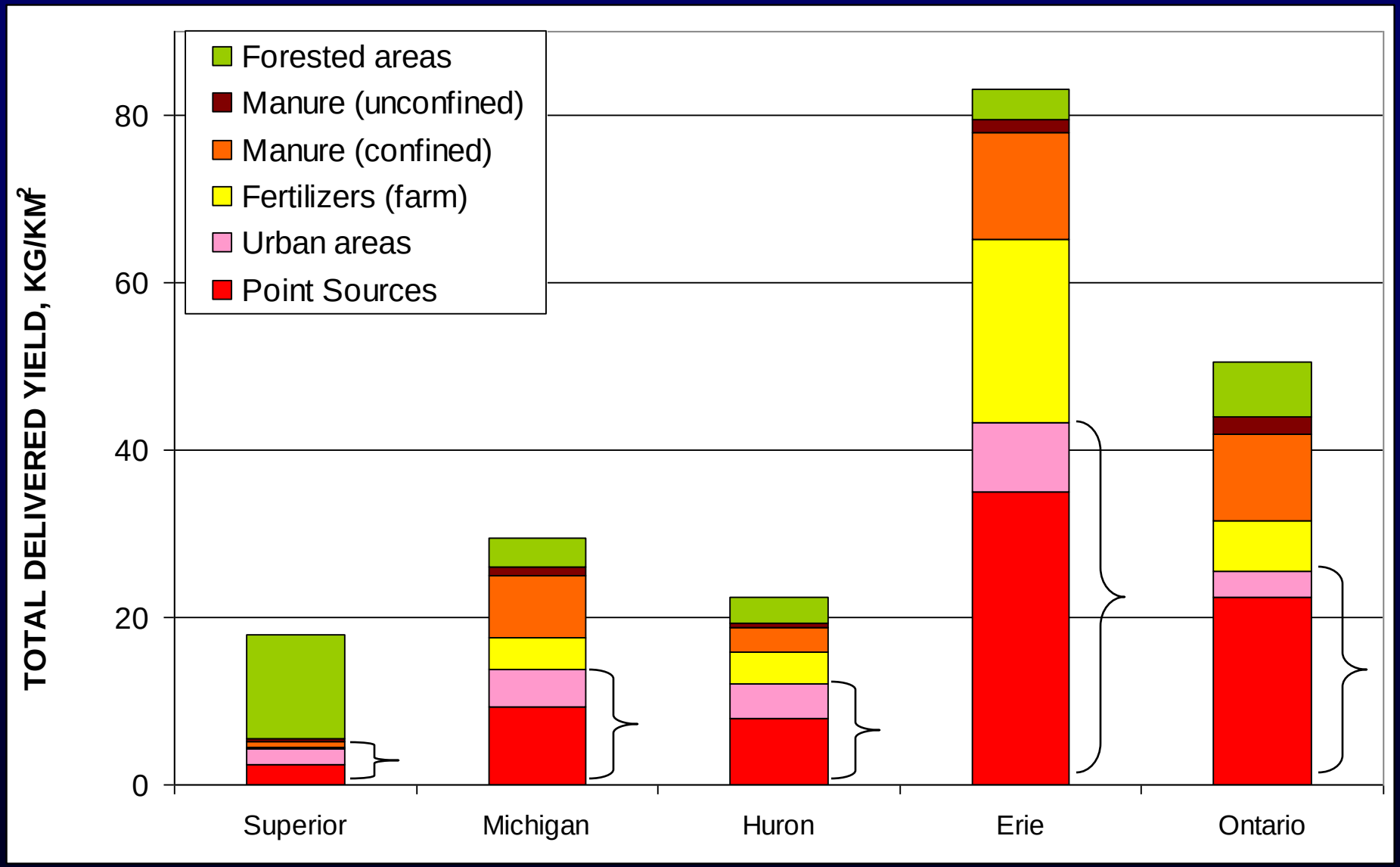


Has there been changes in phosphorus loading?

Annual TP loading and yields into each Great Lake and the nearby major river basins.
[NA, not available]

Great Lake/ River Basin	U.S. Drainage Area (km^2)	Total U.S. Load (Tonnes)[a]	Total U.S. Yield ($kg\ km^{-2}$)[a]
Superior	43,594	782	17.9
Michigan	116,395	3,431	29.5
Huron	41,369	927	22.4
Erie	55,488	4,611	83.1
Ontario	35,661	1,803	50.6

*SPARROW models only used to estimate loading from unmonitored areas

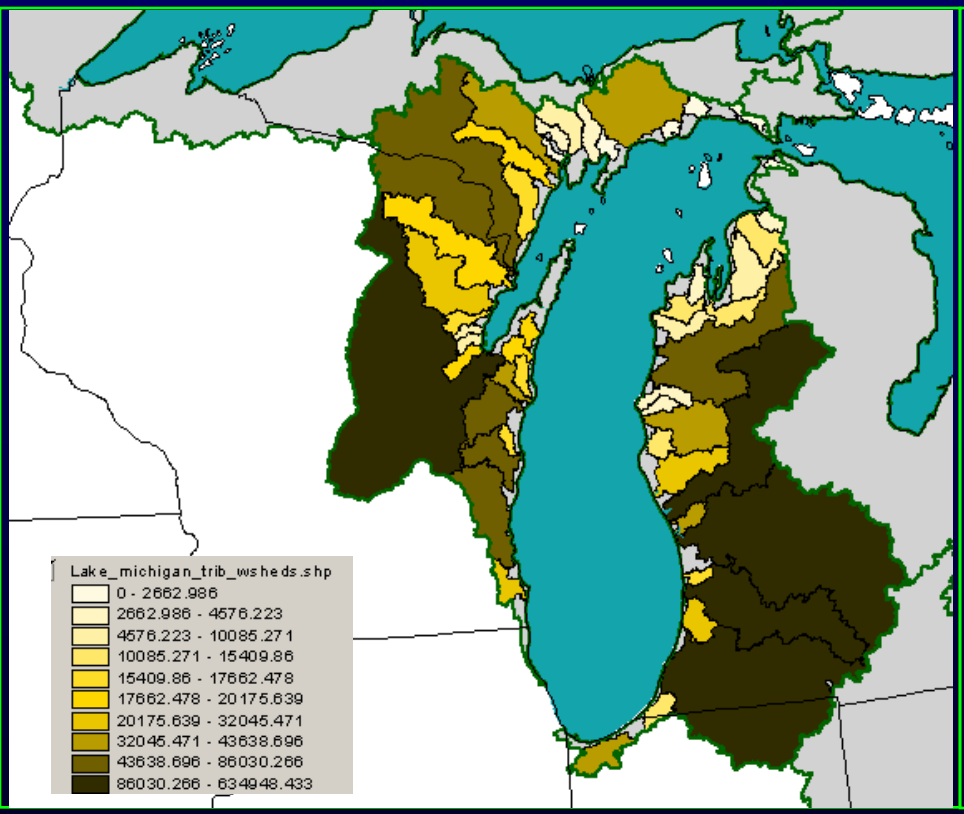


Phosphorus Yields from the U.S. Portion of the Basins by Source

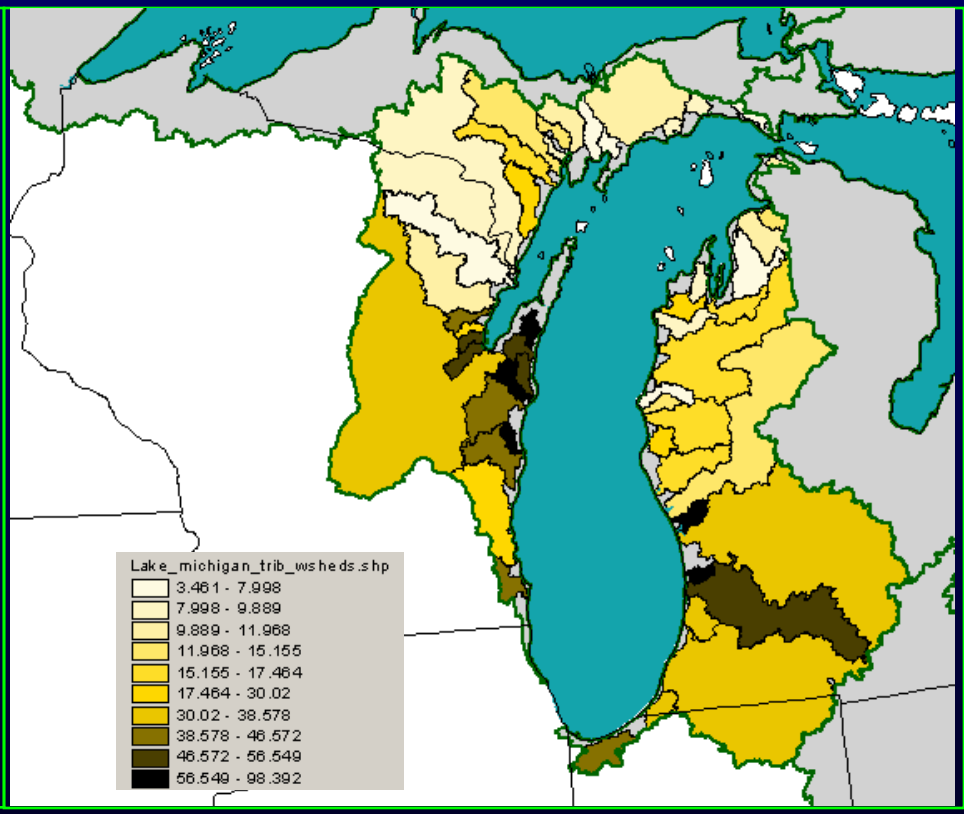
Robertson and Saad, 2011

Ranking the Lake Michigan Tributaries Based on :

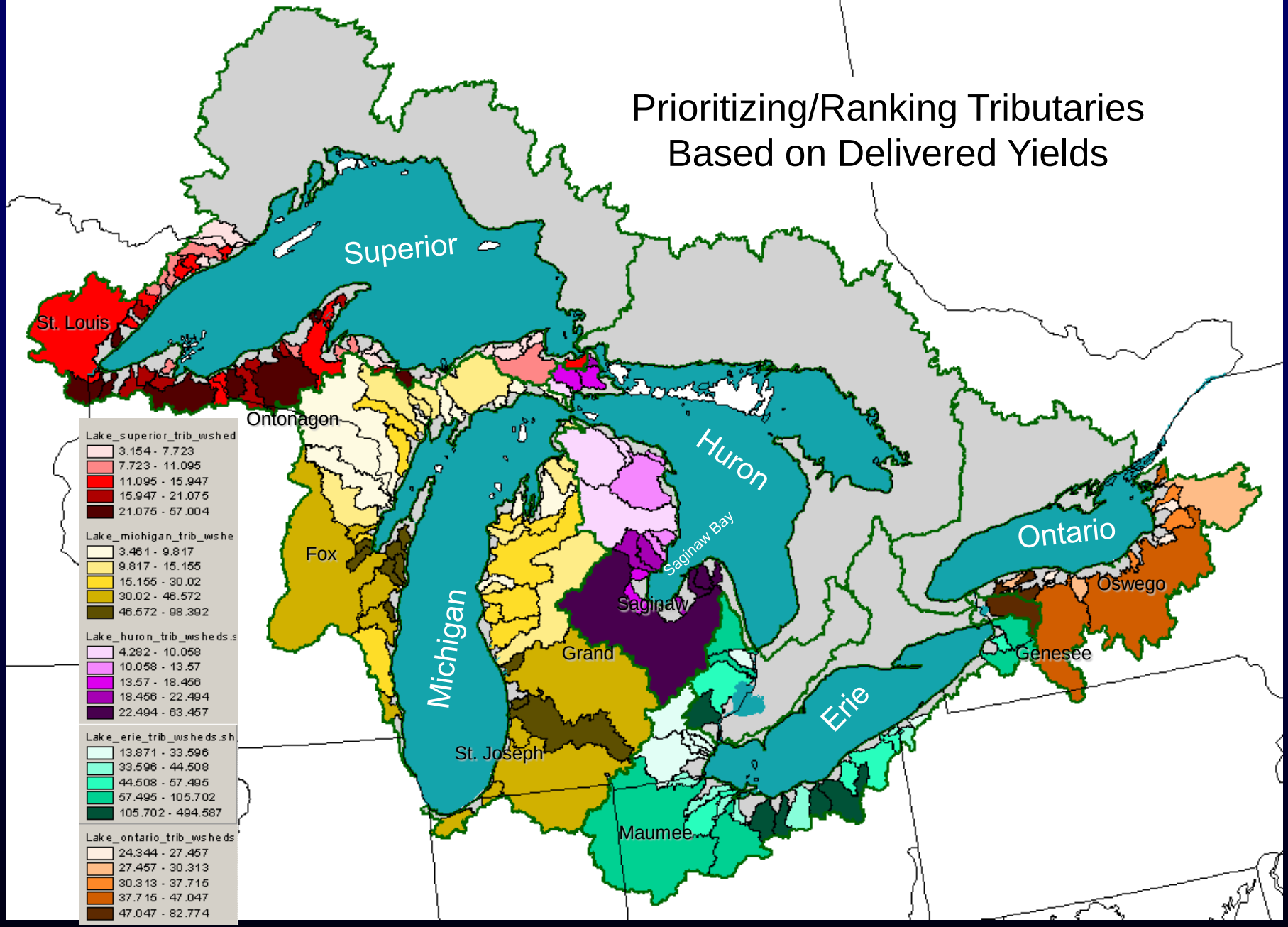
Phosphorus Loads



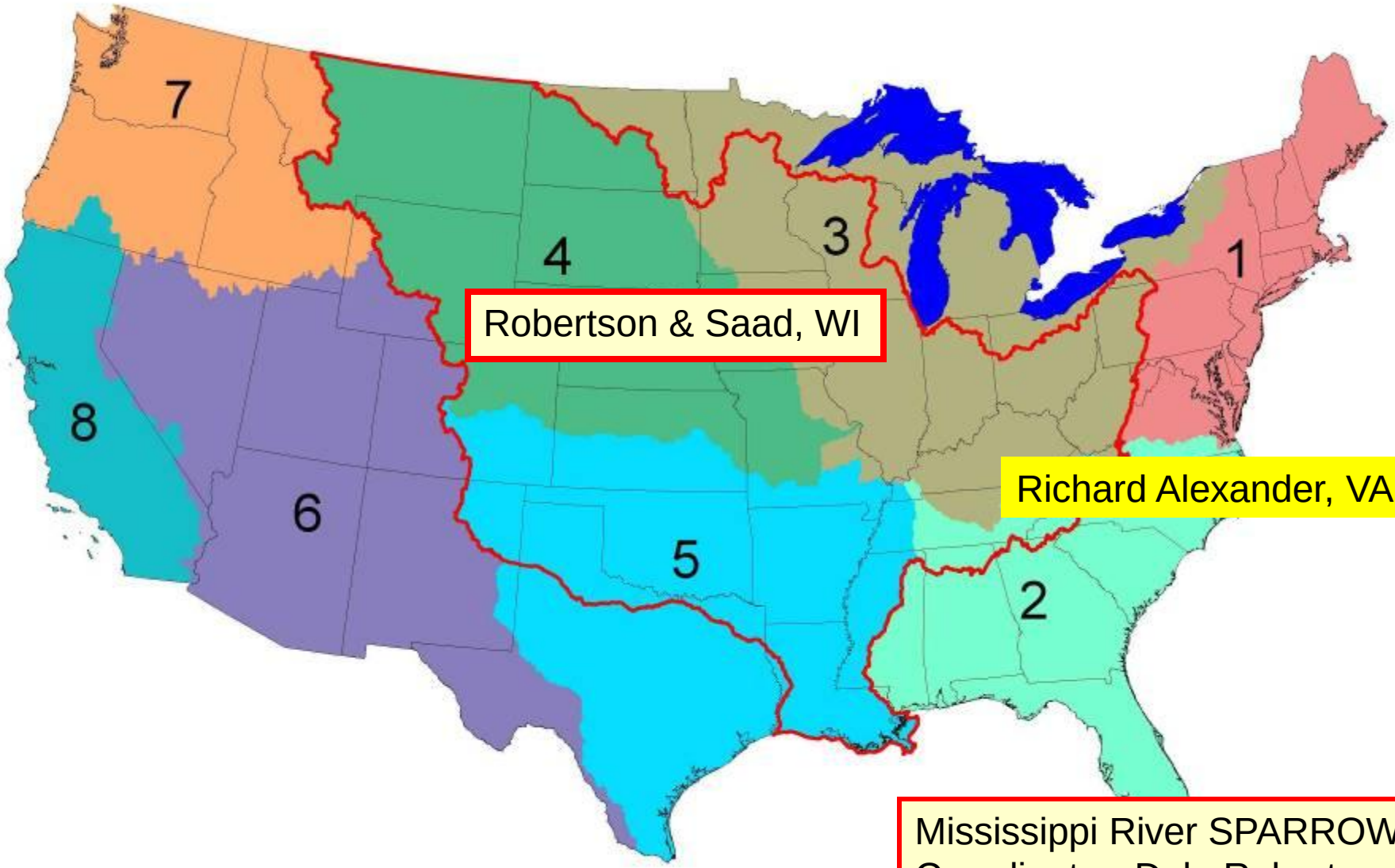
Phosphorus Yields



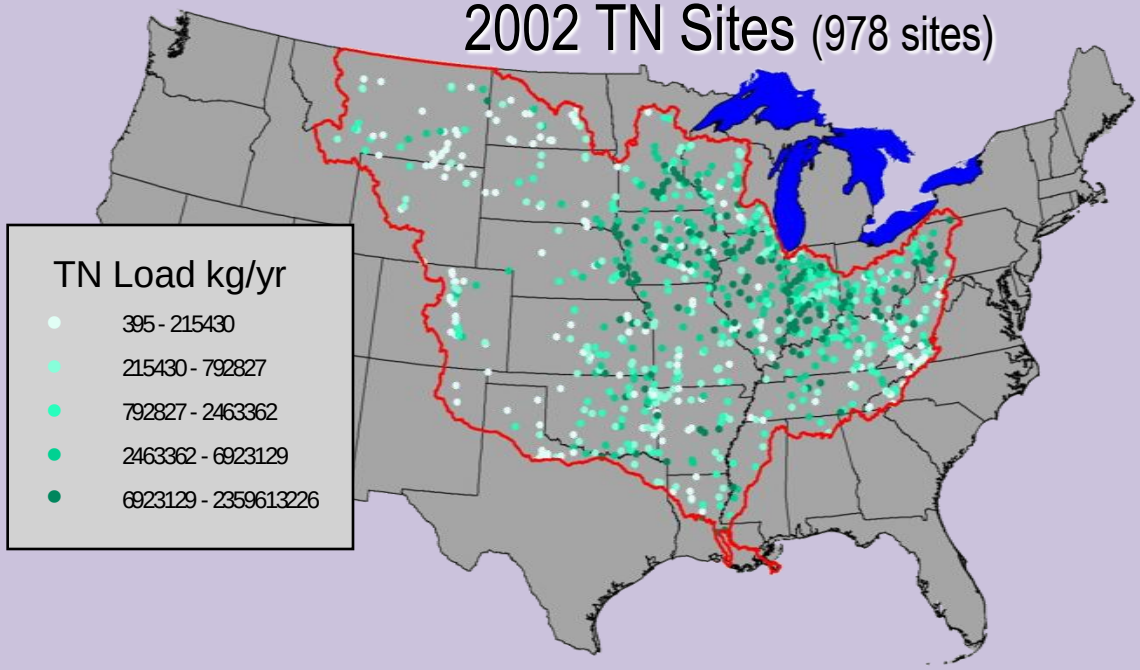
Prioritizing/Ranking Tributaries Based on Delivered Yields

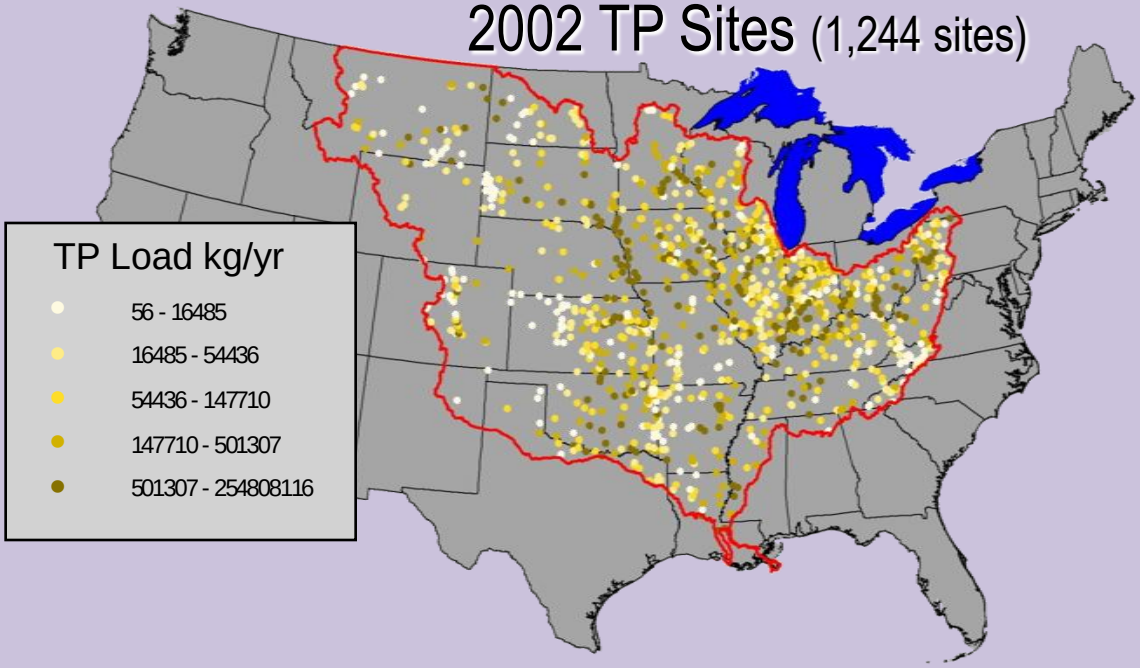


Mississippi River SPARROW Model



Mississippi River SPARROW
Coordinator: Dale Robertson



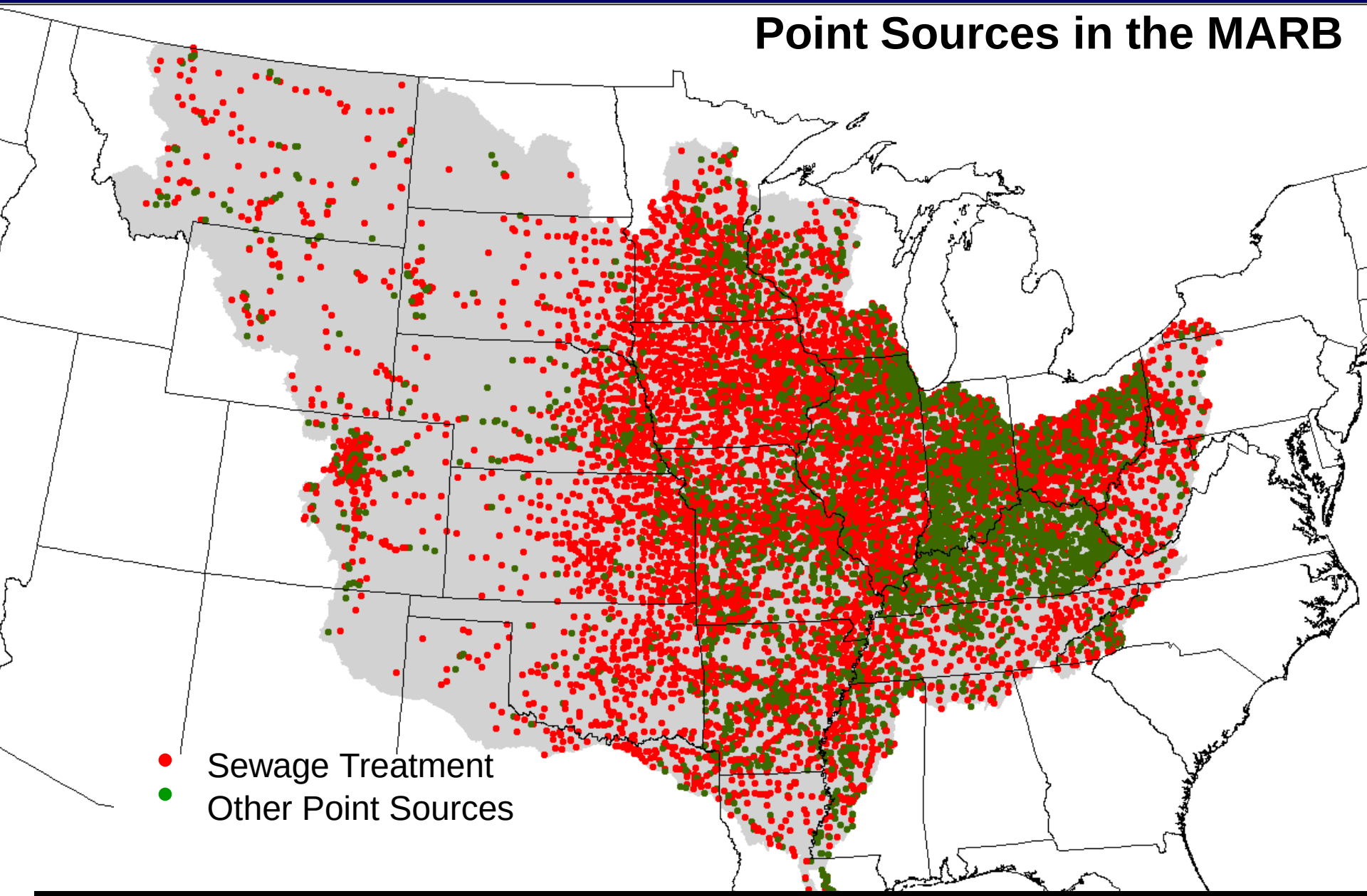


Modeling Sites

2002 load estimates for SPARROW model

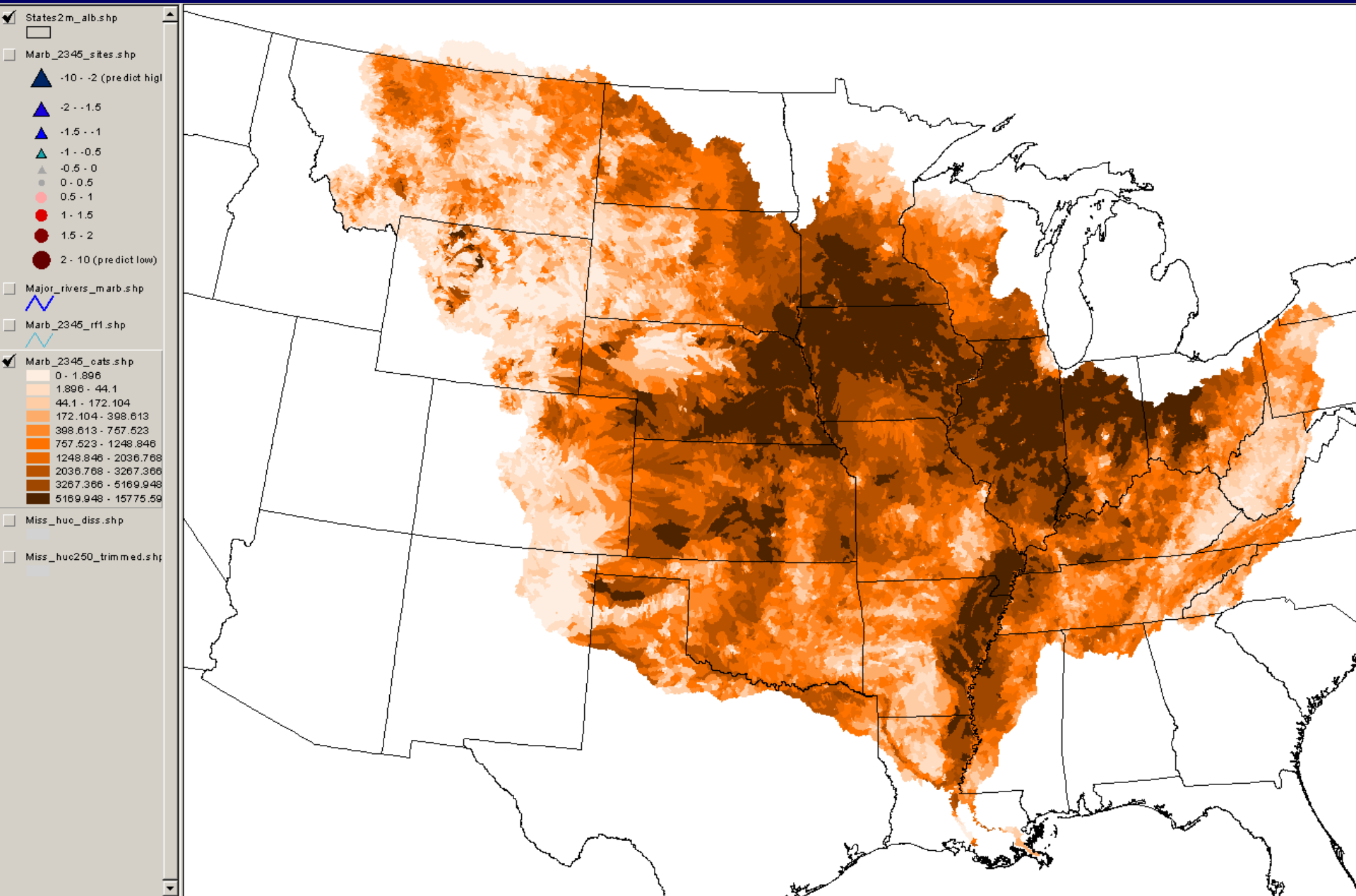
USGS
science for a changing world

Point Sources in the MARB

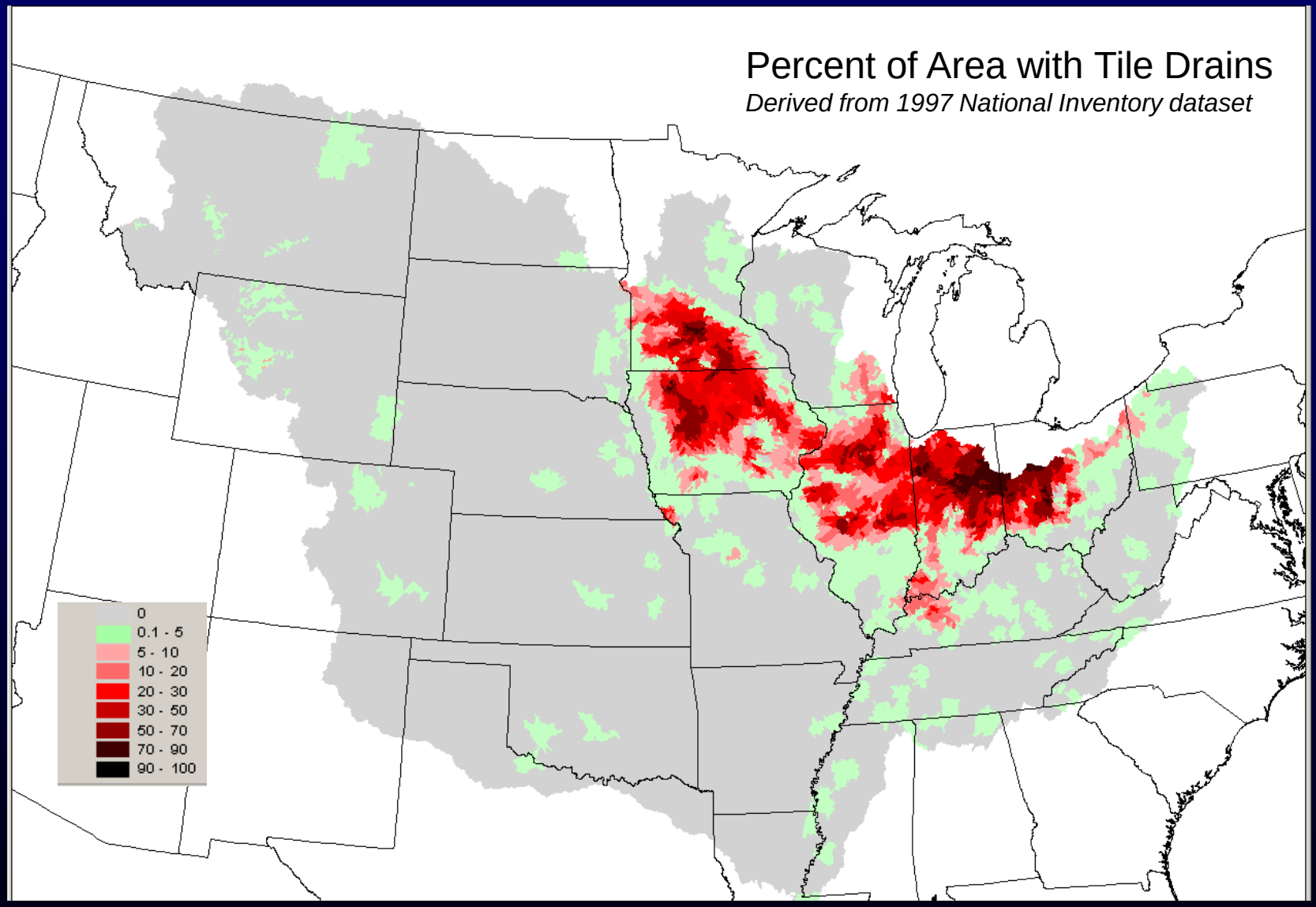


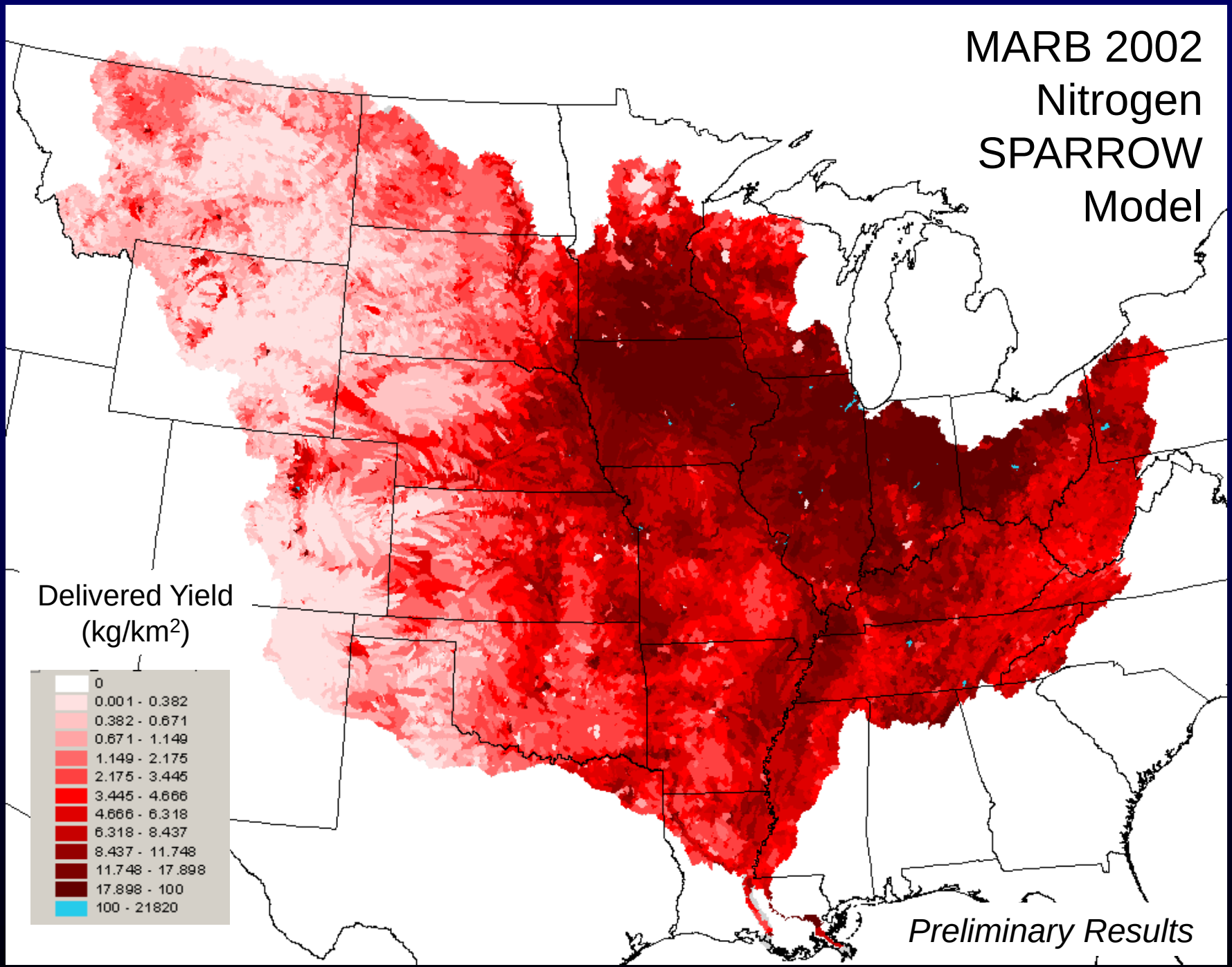
Beware: Many States and Agencies do not put their data in National Databases.
Very little measured nitrogen available.

Nutrient Inputs: Fertilizer Input Rates

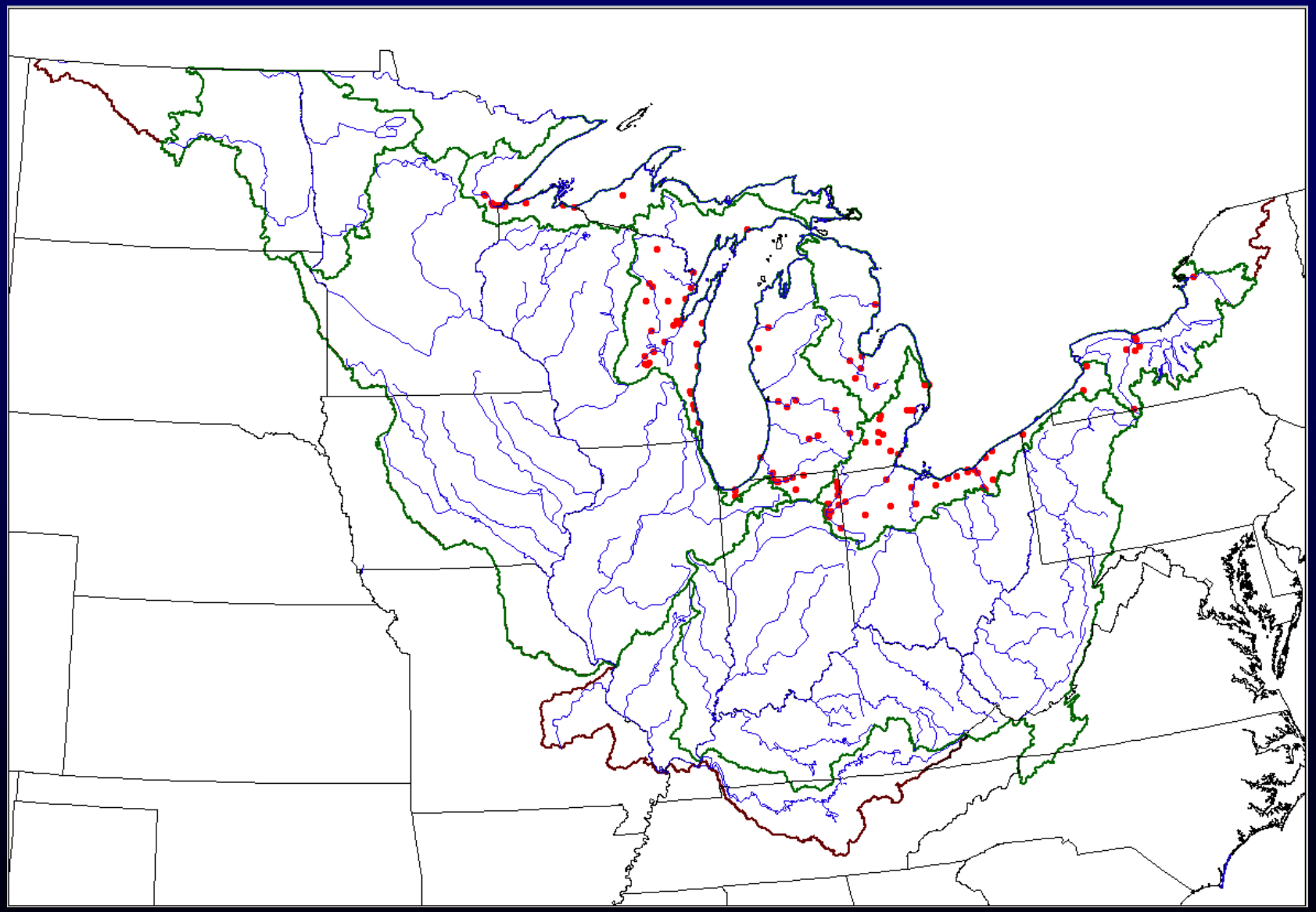


Land-to-Water Delivery Factors: Tile Drains




MARB 2002
Nitrogen
SPARROW
Model
Delivered Yield
(kg/km2)
0
0.001 - 0.382
0.382 - 0.671
0.671 - 1.149
1.149 - 2.175
2.175 - 3.445
3.445 - 4.666
4.666 - 6.318
6.318 - 8.437
8.437 - 11.748
11.748 - 17.898
17.898 - 100
100 - 21820
Preliminary Results

Should SPARROW Models be developed for smaller areas (Great Lakes Basin, River Basin, Individual State)?



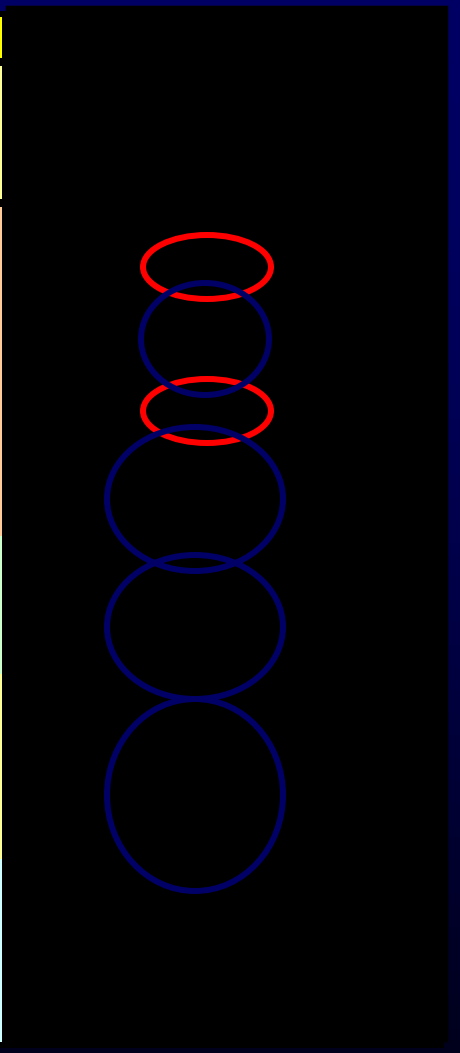
Scale of Model Development

Model Development and Interpretation of Coefficients

MRB3 - SPARROW Model

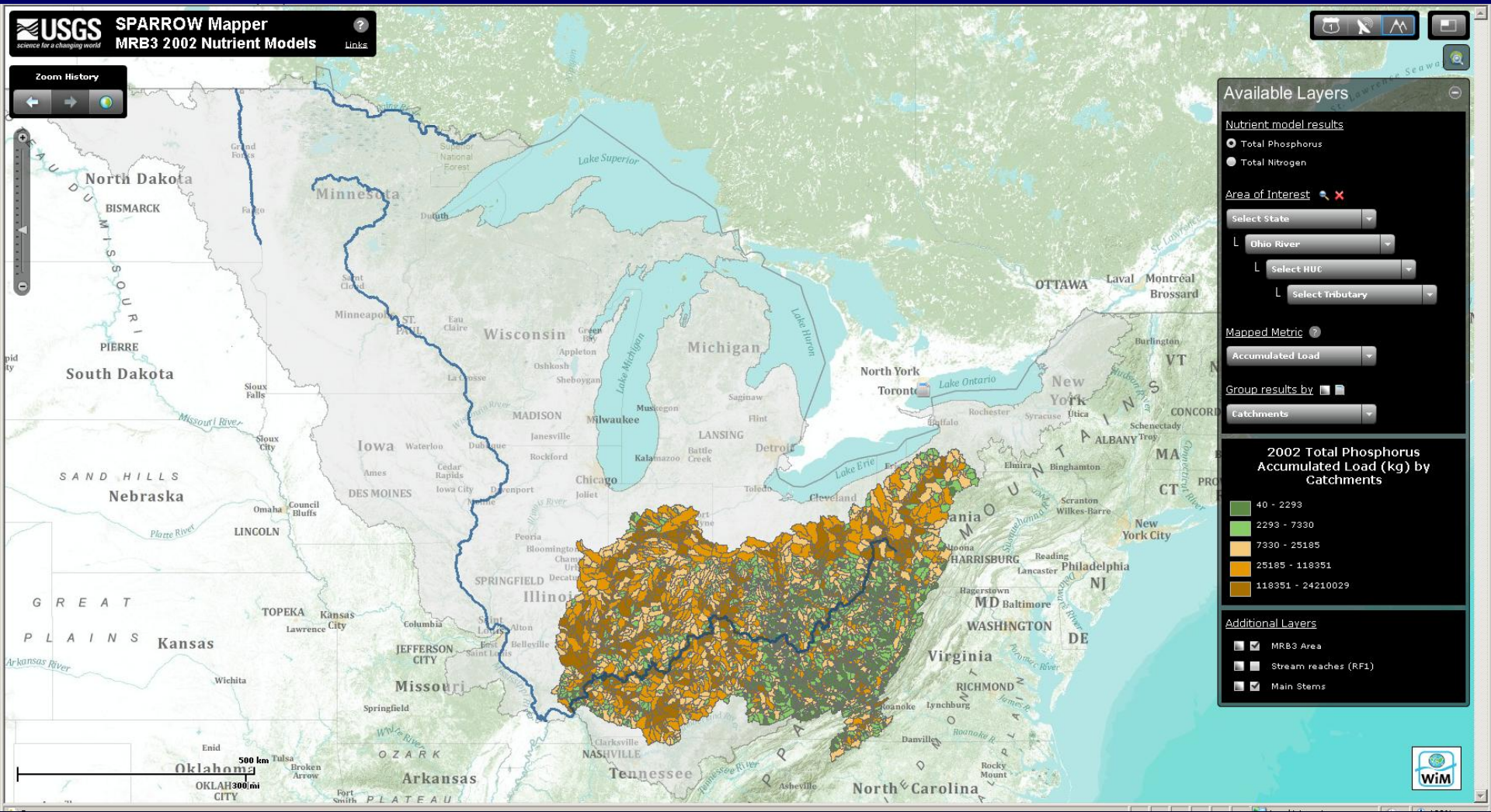
Parameter	Coefficient units	Parameter values	Standard error	P value
Sources				
Point Sources (total)	fraction	1.068	0.142	0.0000
Manure (confined)	fraction	0.086	0.011	0.0000
Manure (unconfined)	fraction	0.032	0.010	0.0009
Fertilizers (farm)	fraction	0.029	0.004	0.0000
Forest,Wetland,Scrub	kg/km^2/yr	14.700	0.017	0.0000
Urban, Open	kg/km^2/yr	52.300	0.144	0.0001
Land-to-Water Delivery				
Soil Permeability (log)	cm/hr	-0.652	0.064	0.0000
Tiles (percentage of area)	percent	-1.164	0.190	0.0000
Stream and Reservoir Decay				
Stream Decay (CMS<1.4)	m/yr	0.198	0.072	0.0064
Stream Decay (1.4< CMS < 2.3)	m/yr	0.298	0.100	0.0029
Reservoir Decay	m/yr	4.837	1.118	0.0000
RMSE	**0.493**			
Adj R2	**0.927**			
Yld R2	**0.729**			
N	**810**			

Robertson, et al. 2011 – In Press



With insufficient monitoring sites and spatial variability, it may be very difficult to develop useful regression models for smaller areas

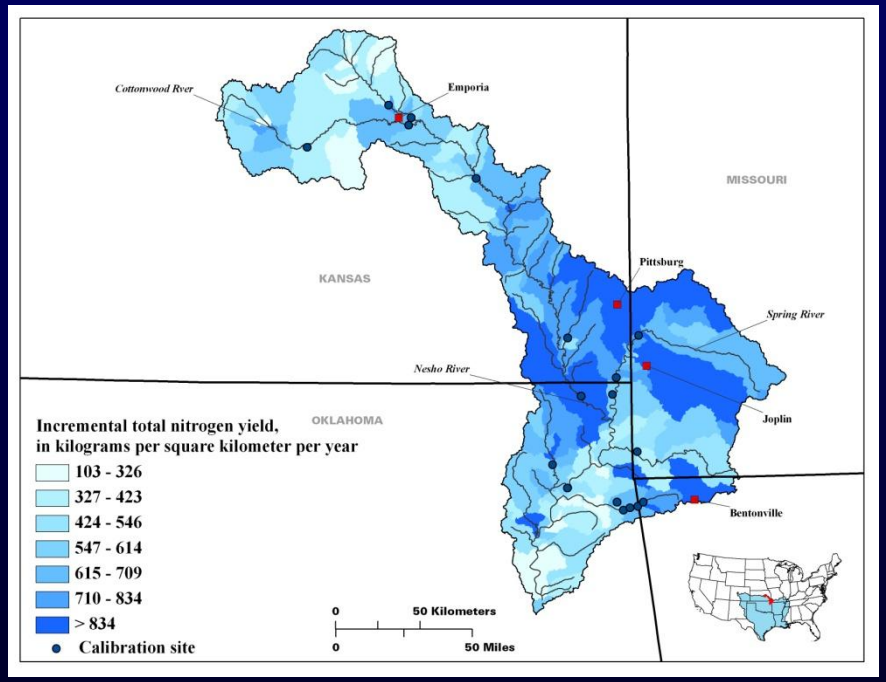
Results Extracted for the Ohio River Basin



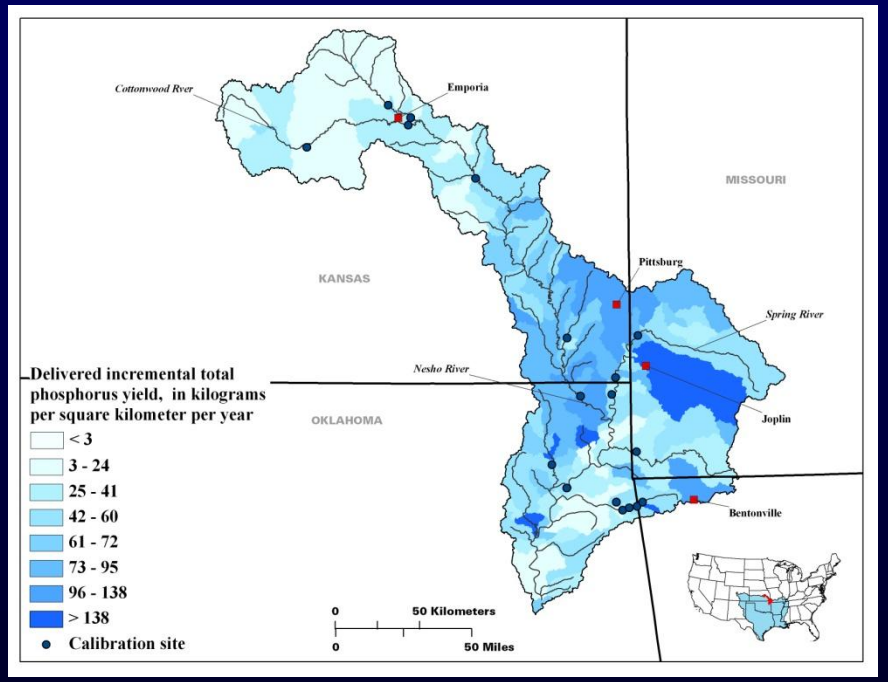
For estimating loads and concentrations at a subbasin level, it may be best to extract results from a larger scale model.

Neosho River results - phosphorus

Delivered to local streams

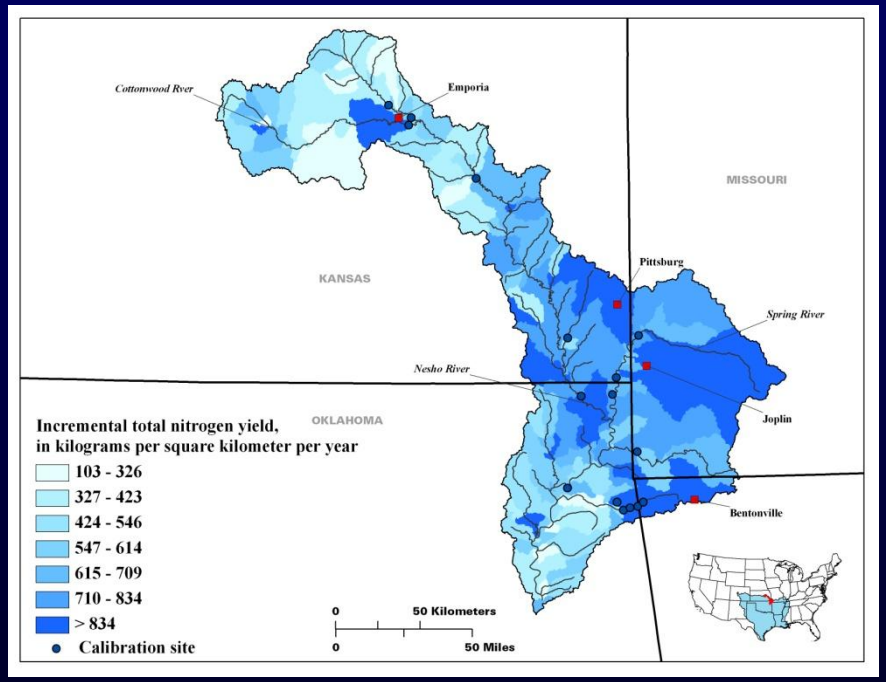


Delivered to the outlet of the Neosho River

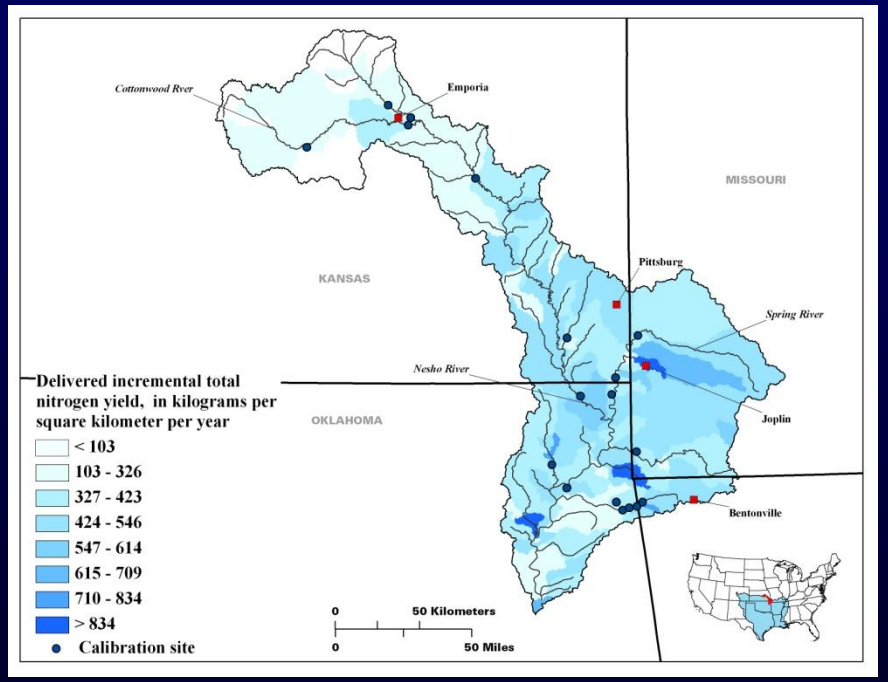


Neosho River results - nitrogen

Delivered to local streams



Delivered to the outlet of the Neosho River



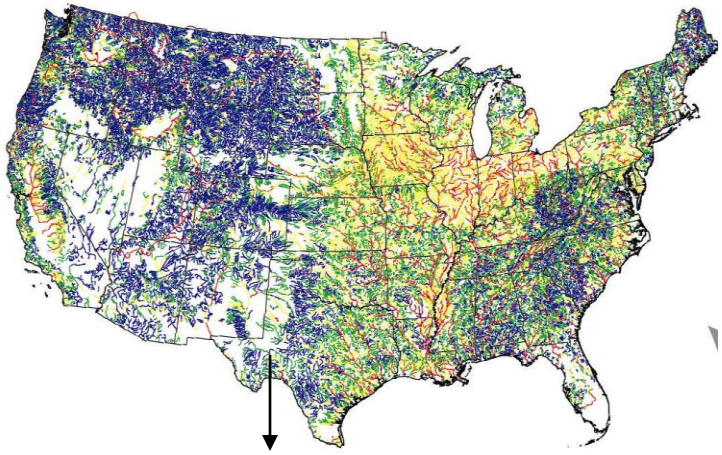
HydroSPARROW:

A GIS Regional Modeling Approach for Estimating Nutrient Loading to the Great Lakes Under Current and Future Climate and Land-Use Conditions

USGS

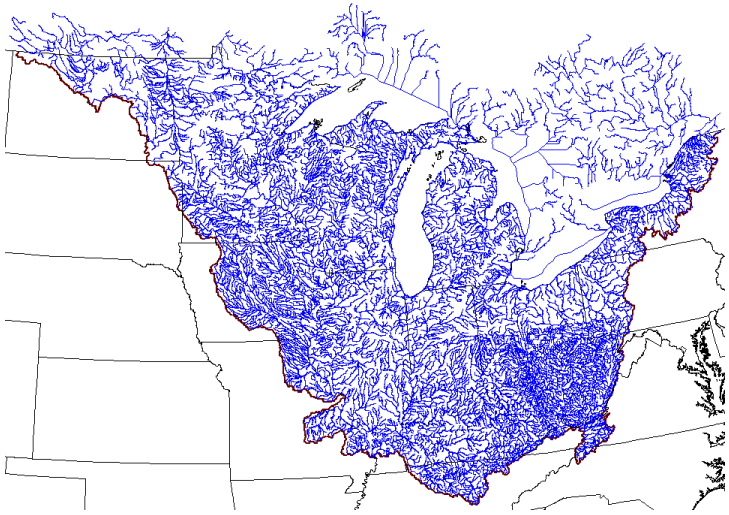
HydroSPARROW

SPARROW

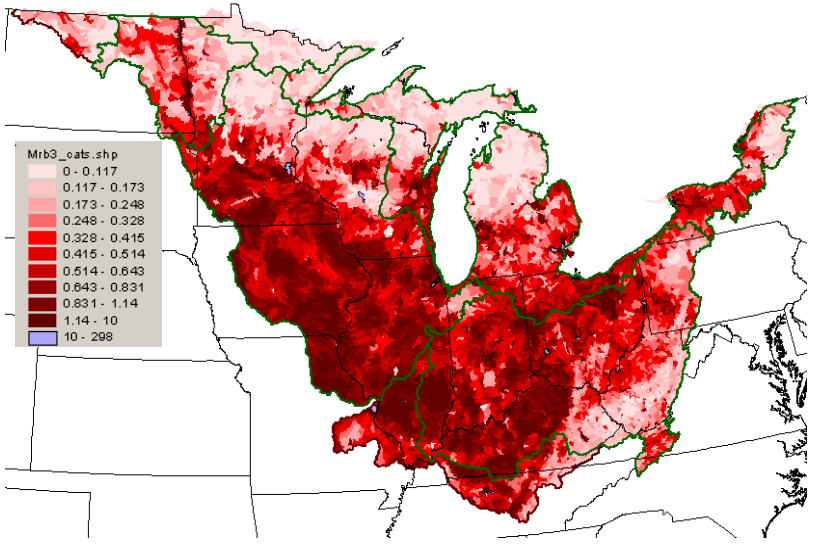


Total P and Total N Concentrations by Reach

PRMS/ TOPMODEL



Streamflow by RF1/NHD reach



Demonstrating Results

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Real-time Data
Historical Data
USGS WaterWatch
Floods
Droughts

Ground Water
Real-time Data
Historical Data
Groundwater networks

Active Water Levels
Climate Response

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

Precipitation
Real-time Data

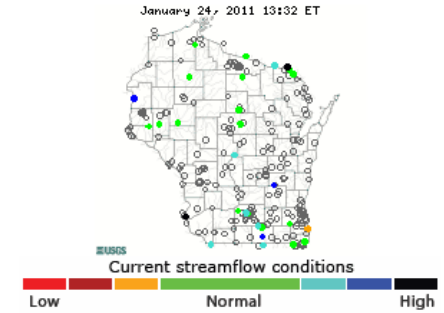
Other
Annual Data Reports
Instantaneous Data Archive
USGS WaterAlert

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.



find gage by NUMBER | find gage by COUNTY

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:

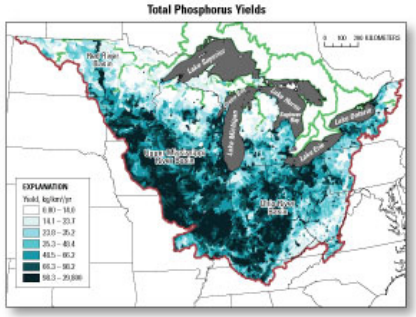
- Water Year 2007
- More years

Water use in Wisconsin (every 5 years):

- 2005 Wisconsin Summary
- Other Wisconsin water-use summaries

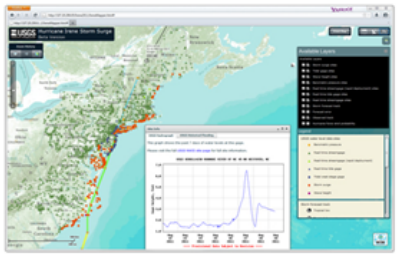
Featured Projects

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.

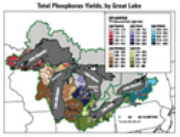
WiM Hurricane Irene mapper tracks storm surge and flooding



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.

Methods to demonstrate results and help guide decisions

1. Decision Support System

Scientists/Managers – Capable of using to visualize SPARROW output and run various scenarios.

Booth et al., 2011

Decision Support System

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SPARROW Model Decision Support

Find a Model by Geographic Location:

Select a region or state. When a state is selected, all models containing that state are listed.

Texas

Find a Model by Modeled Constituent:

Any

Models matching your criteria (Click a model to show details)

- National Total Nitrogen Model - 1992
- National Total Phosphorus Model - 1992
- Total Dissolved Solids Model for the Rio Grande, Colorado, and Great Basin Region - 2006
- Total Nitrogen Model for the Lower Mississippi, Arkansas-White-Red, and Texas-Gulf Region - 2002
- Total Phosphorus Model for the Lower Mississippi, Arkansas-White-Red, and Texas Gulf Region - 2002

Documentation and Further Reading

- What is SPARROW?
- What is SPARROW Decision Support?
- SPARROW Applications & Documentation
- SPARROW FAQs

Tutorial Videos

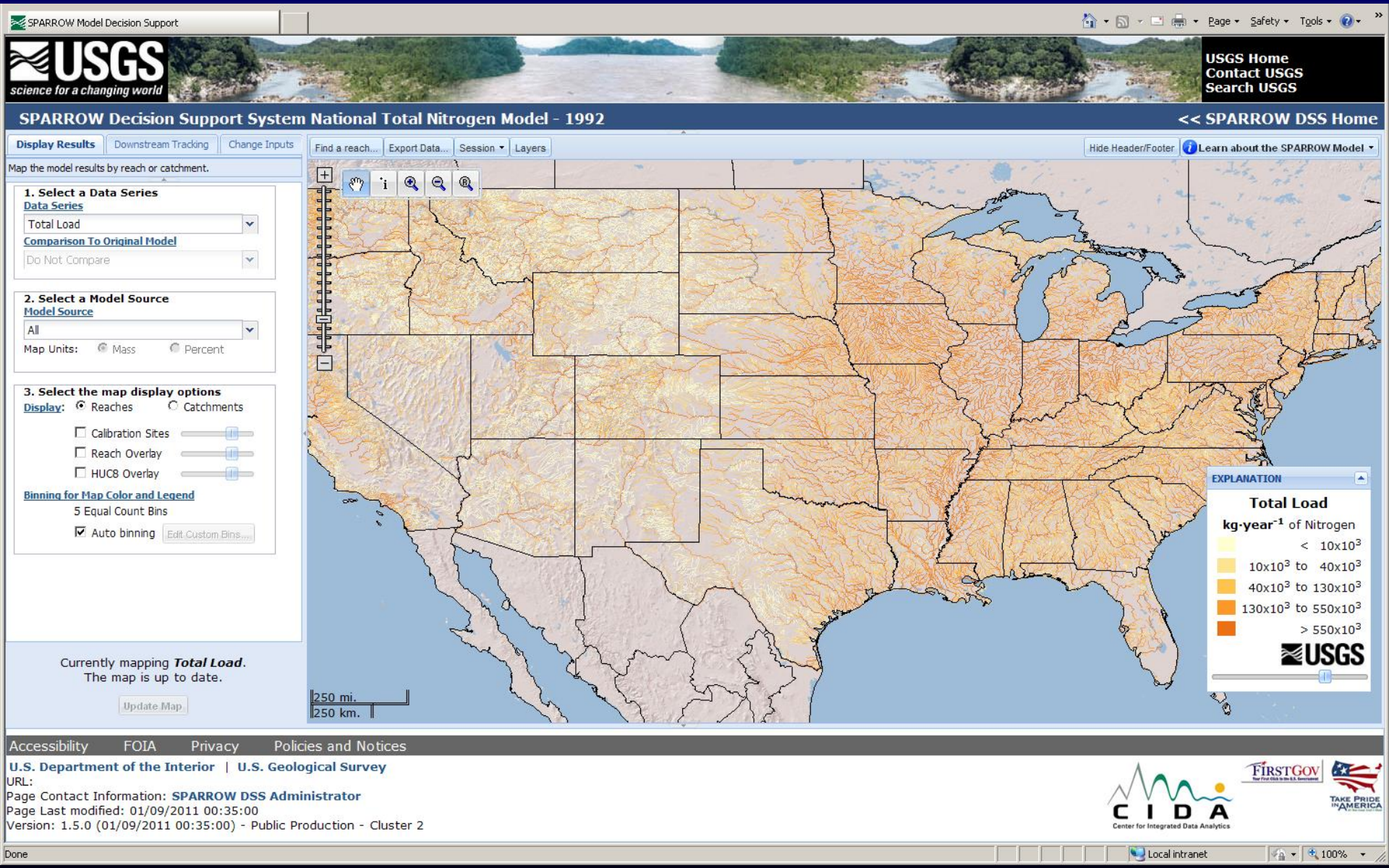
Select a video... | Watch now >>

Found a bug or have a comment?

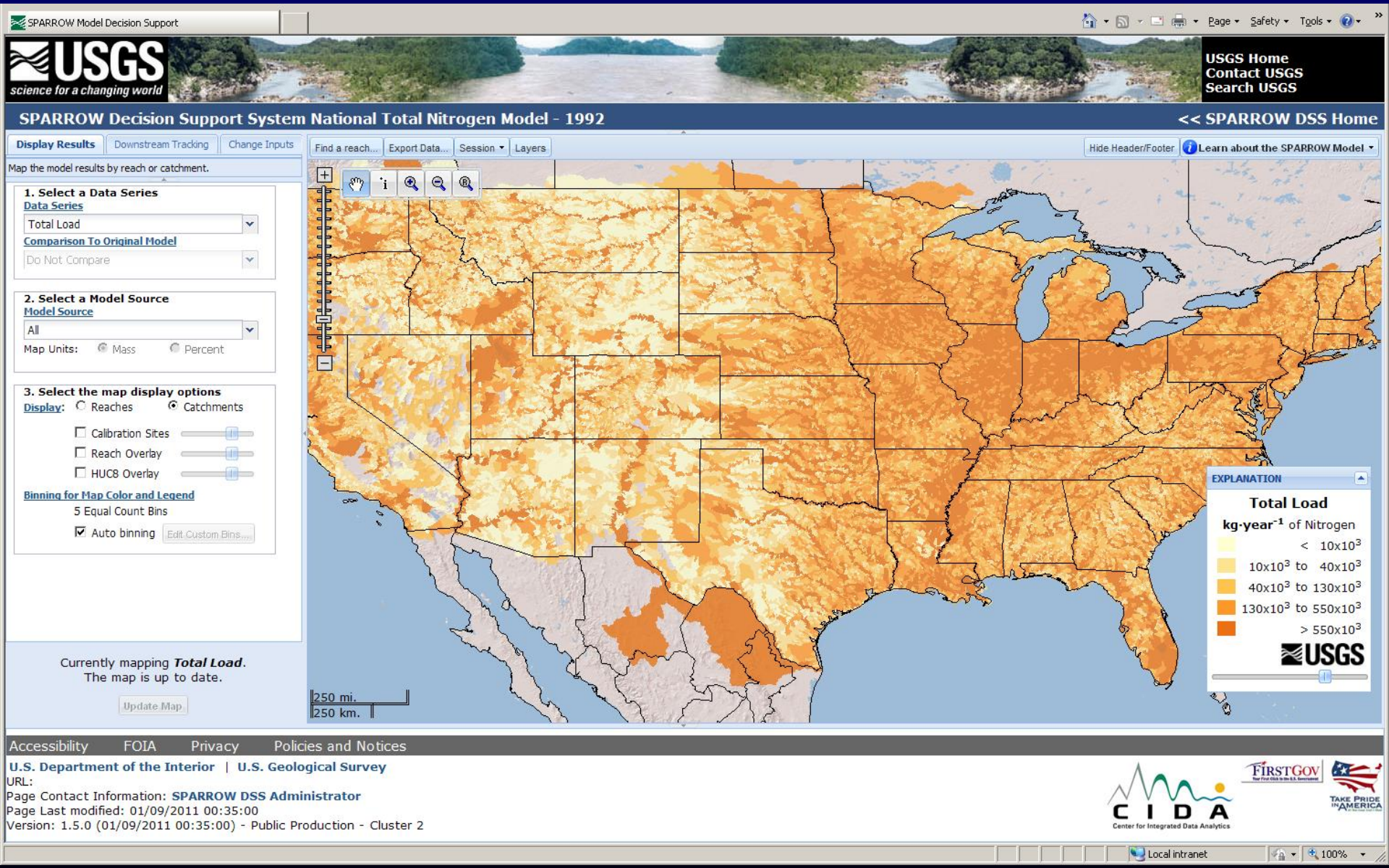
Please send bugs, suggestions and questions to the SPARROW DSS Administrator.

Selected Model

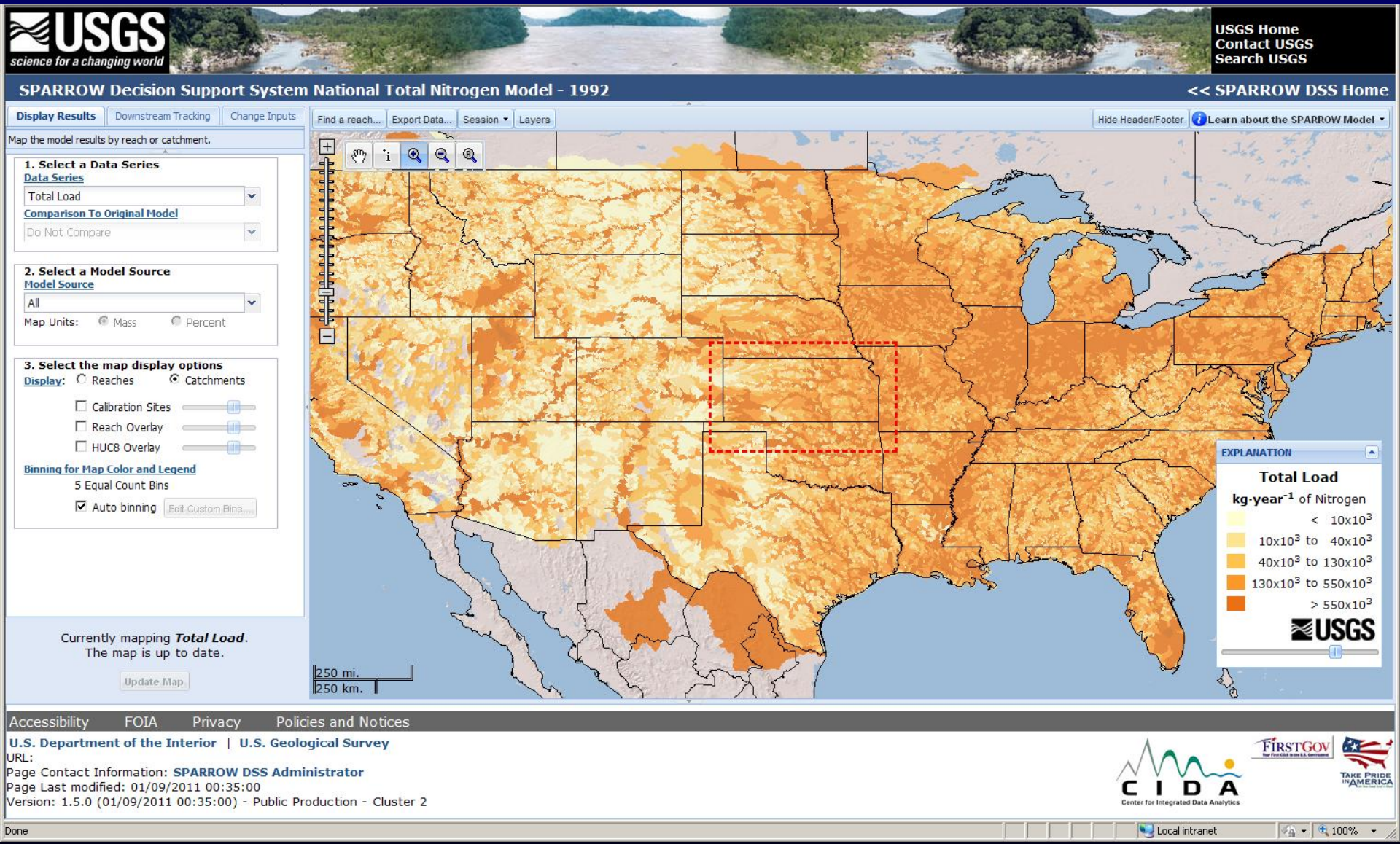
Display Reach Information

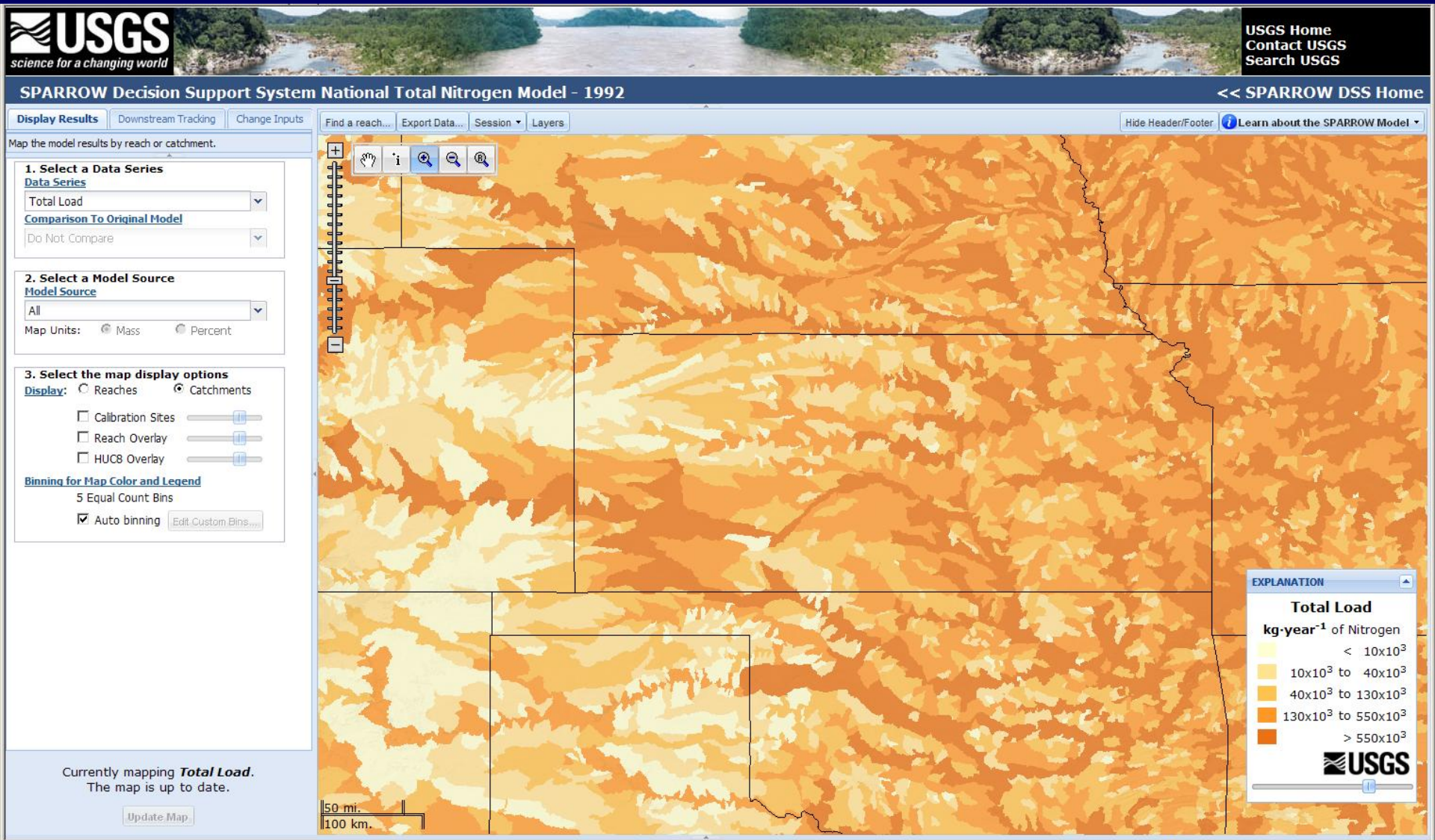


Display Catchment Information



Zoom into Selected Areas

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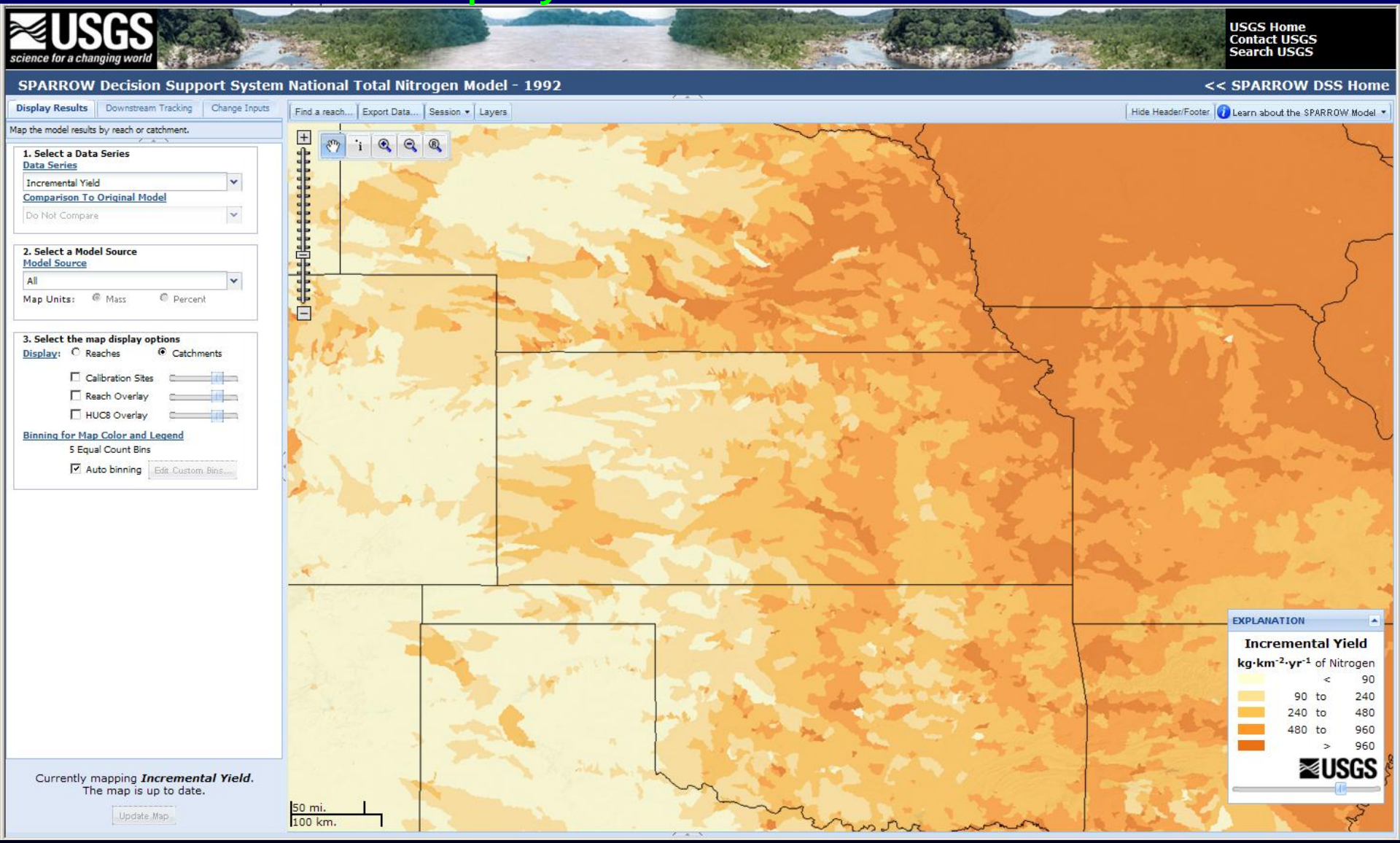
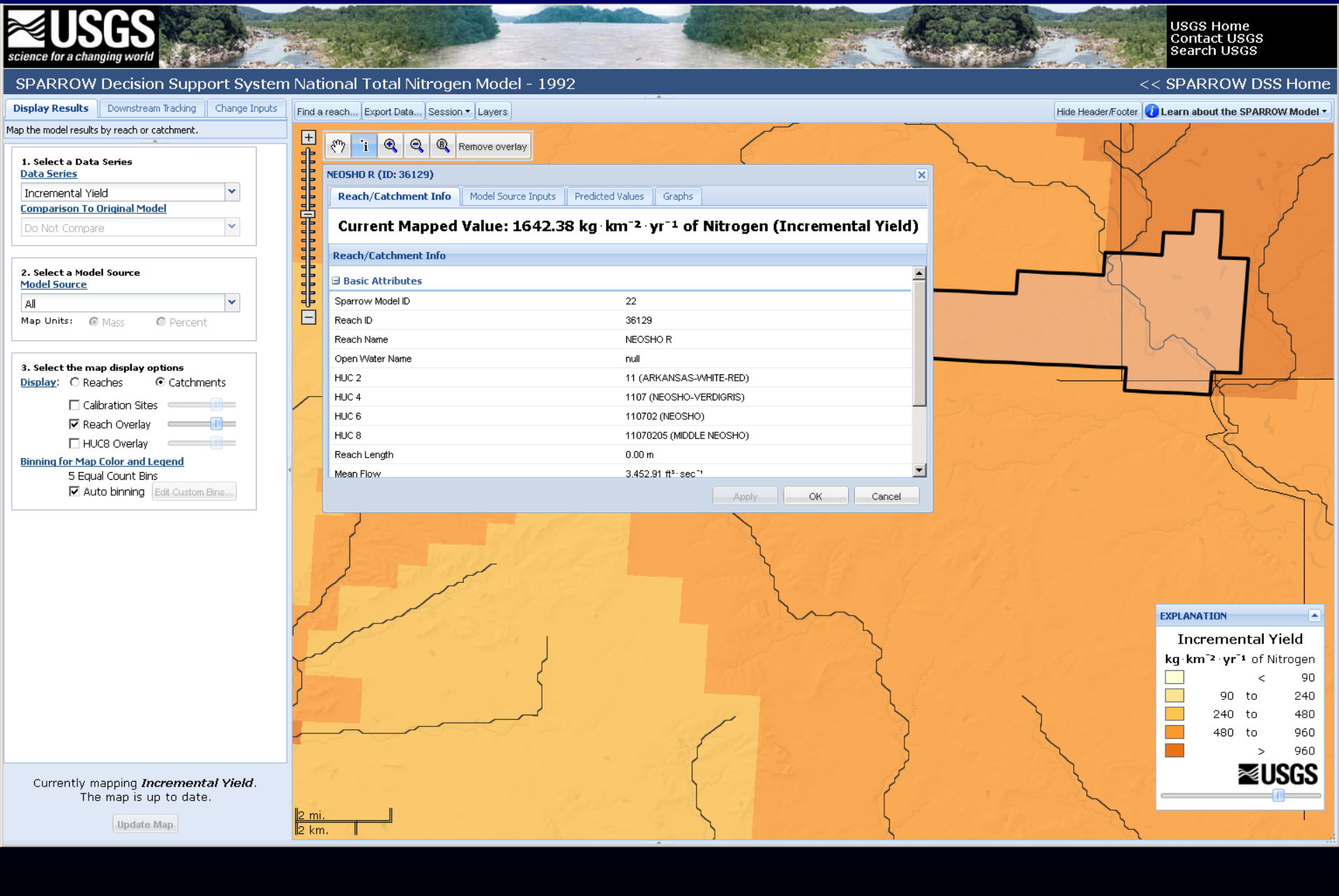
SPARROW Decision Support System National Total Nitrogen Model - 1992
<< SPARROW DSS Home
Display Results
Downstream Tracking
Change Inputs
Map the model results by reach or catchment.
1. Select a Data Series
Data Series
Total Load
Comparison To Original Model
Do Not Compare
2. Select a Model Source
Model Source
All
Map Units: Mass Percent
3. Select the map display options
Display: Reaches Catchments
Calibration Sites
Reach Overlay
HUC8 Overlay
Binning for Map Color and Legend
5 Equal Count Bins
Auto binning
Edit Custom Bins...
Currently mapping Total Load.
The map is up to date.
Update Map
Find a reach...
Export Data...
Session
Layers
Hide Header/Footer
Learn about the SPARROW Model
EXPLANATION
Total Load
kg·year-1 of Nitrogen
< 10x10^3
10x10^3 to 40x10^3
40x10^3 to 130x10^3
130x10^3 to 550x10^3
> 550x10^3
USGS
50 mi.
100 km.
Done
Local intranet
100%

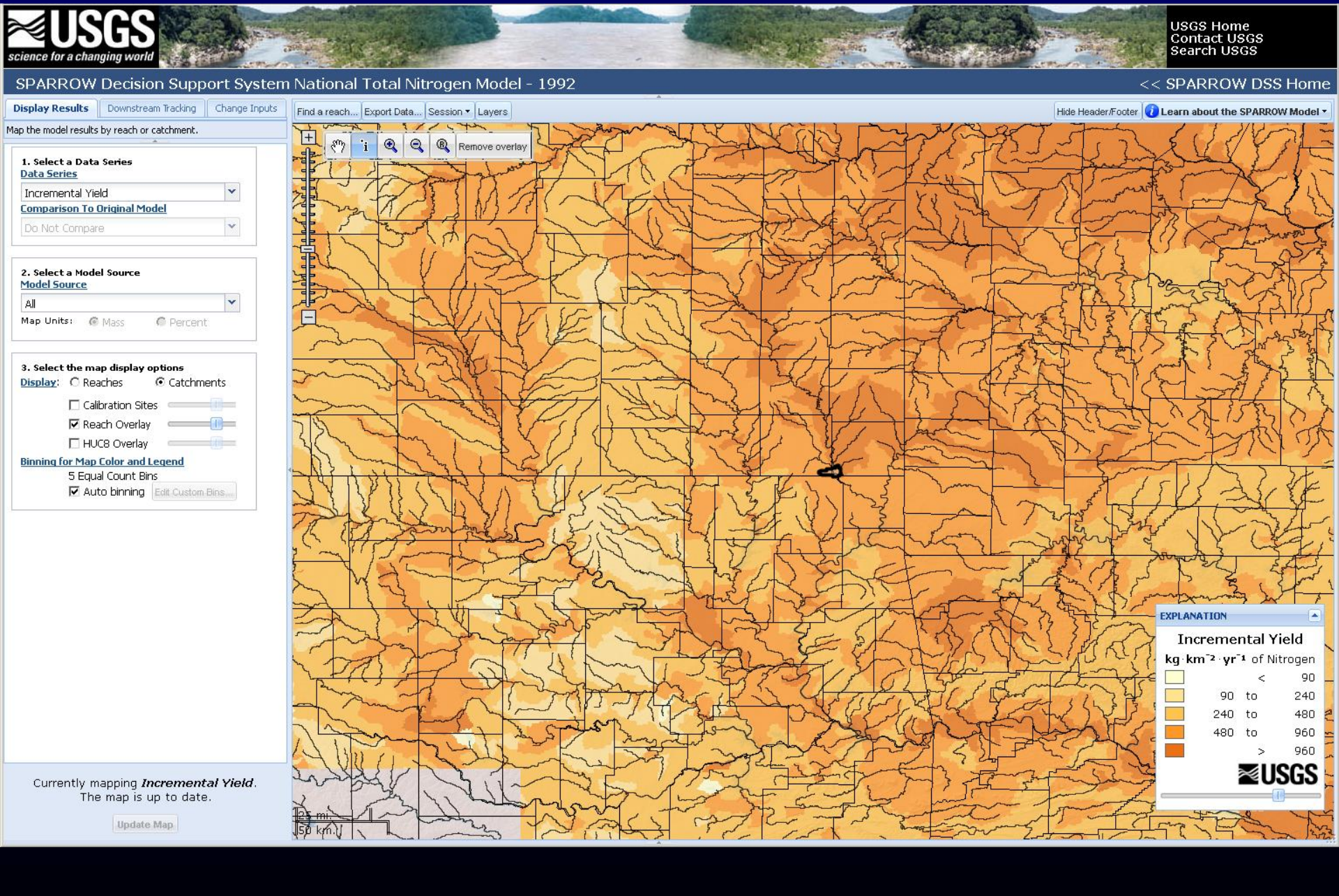
Display Incremental Information



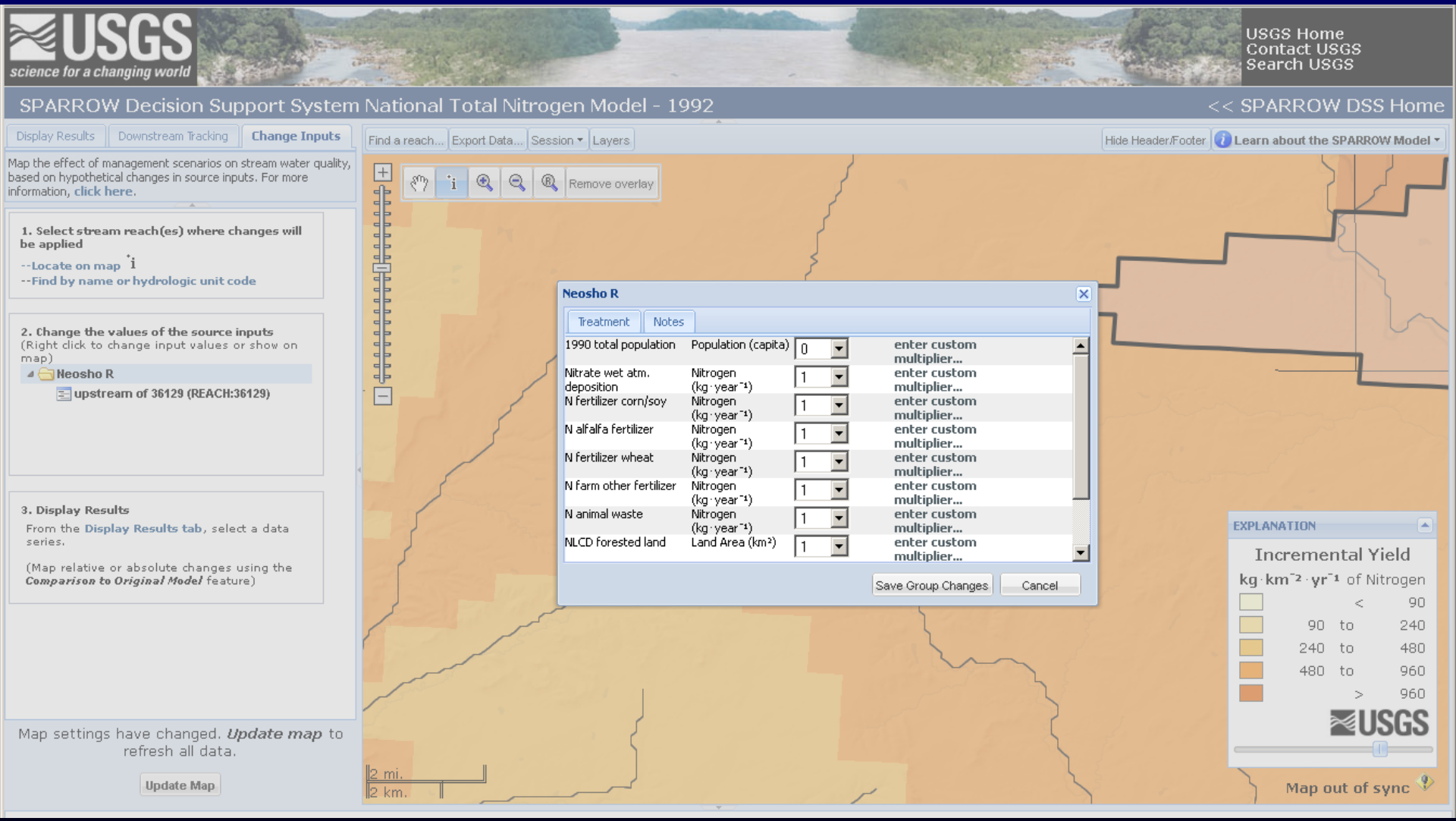
Display Detailed Information



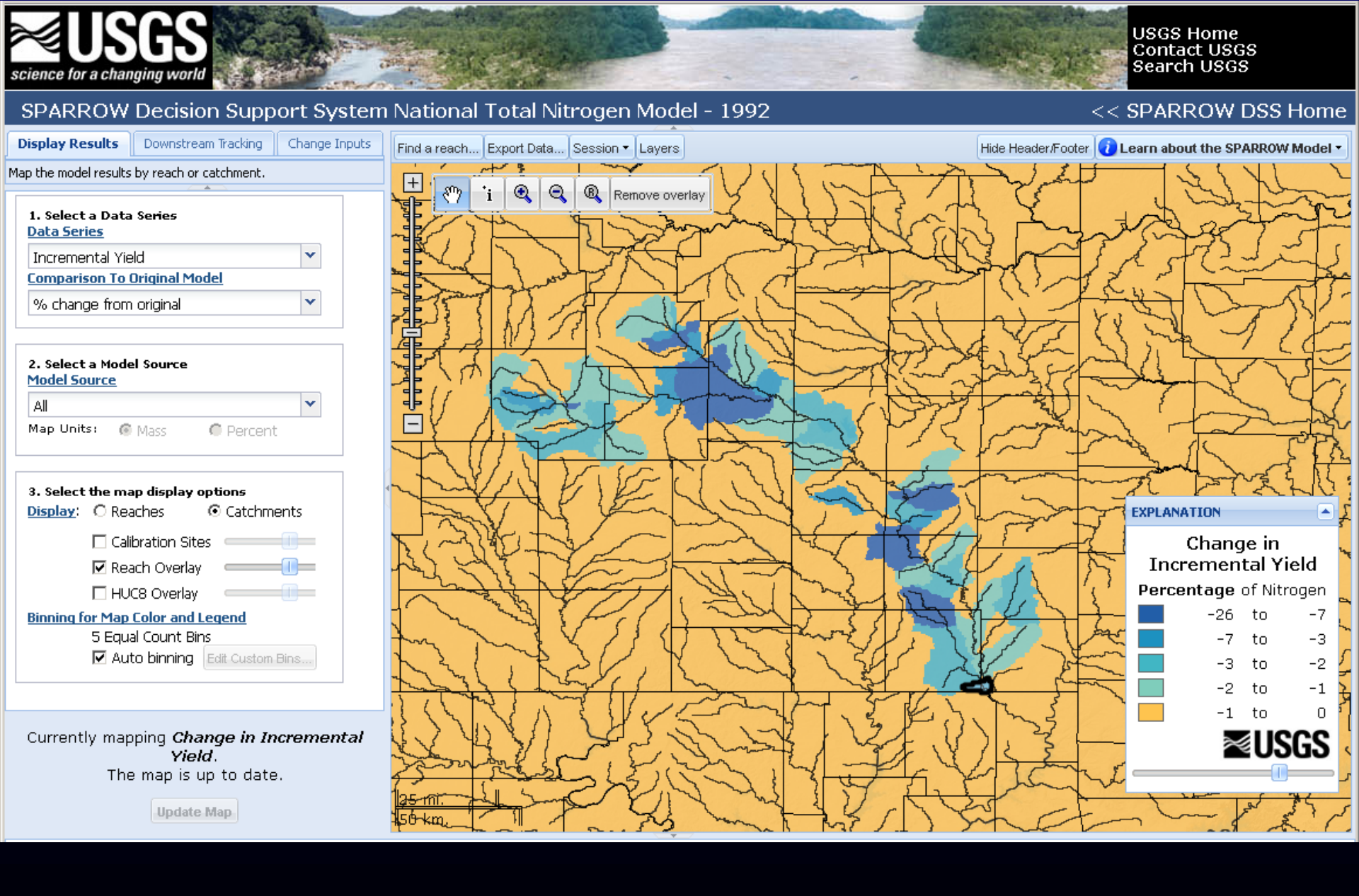
Display Detailed Information



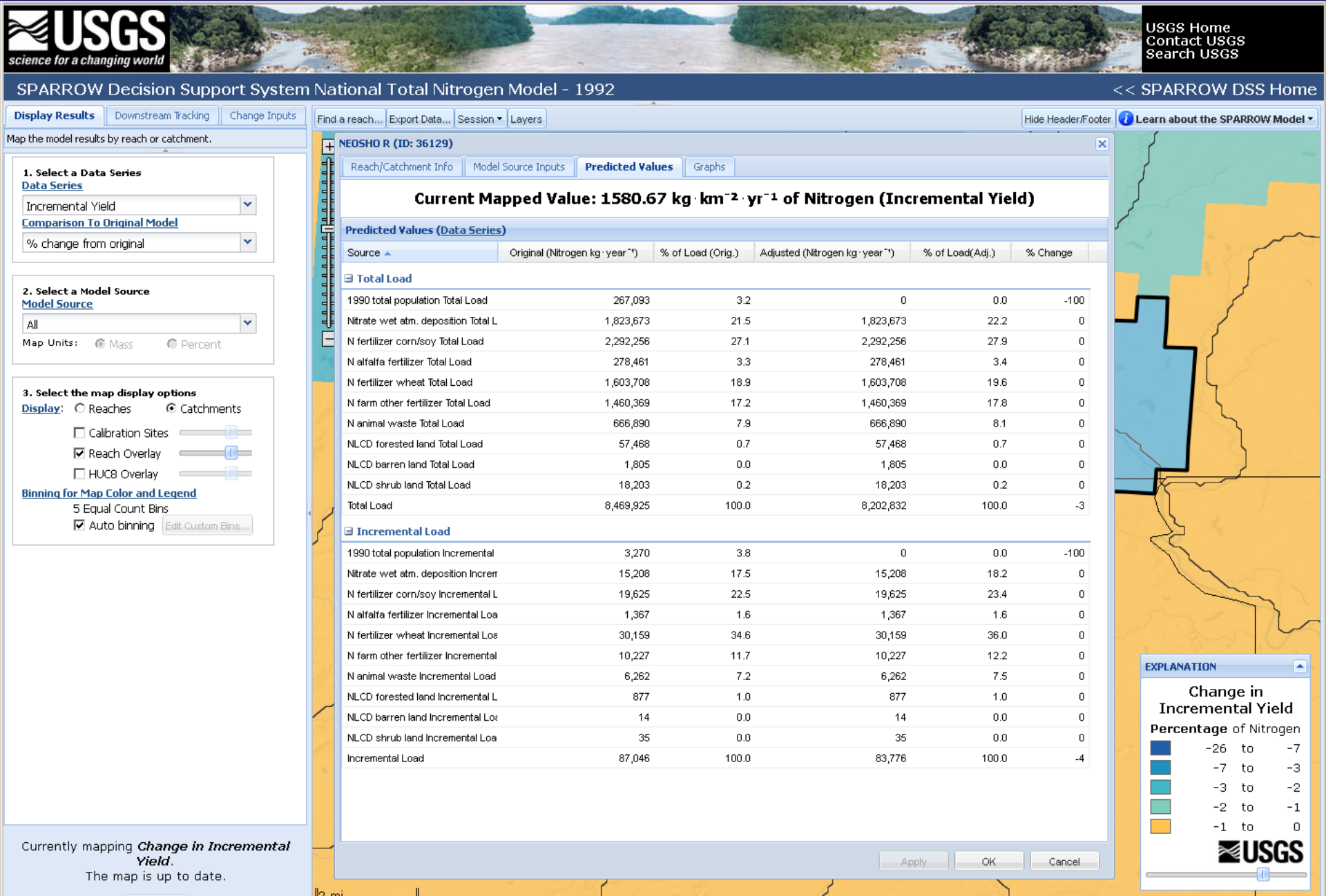
Scenario Testing



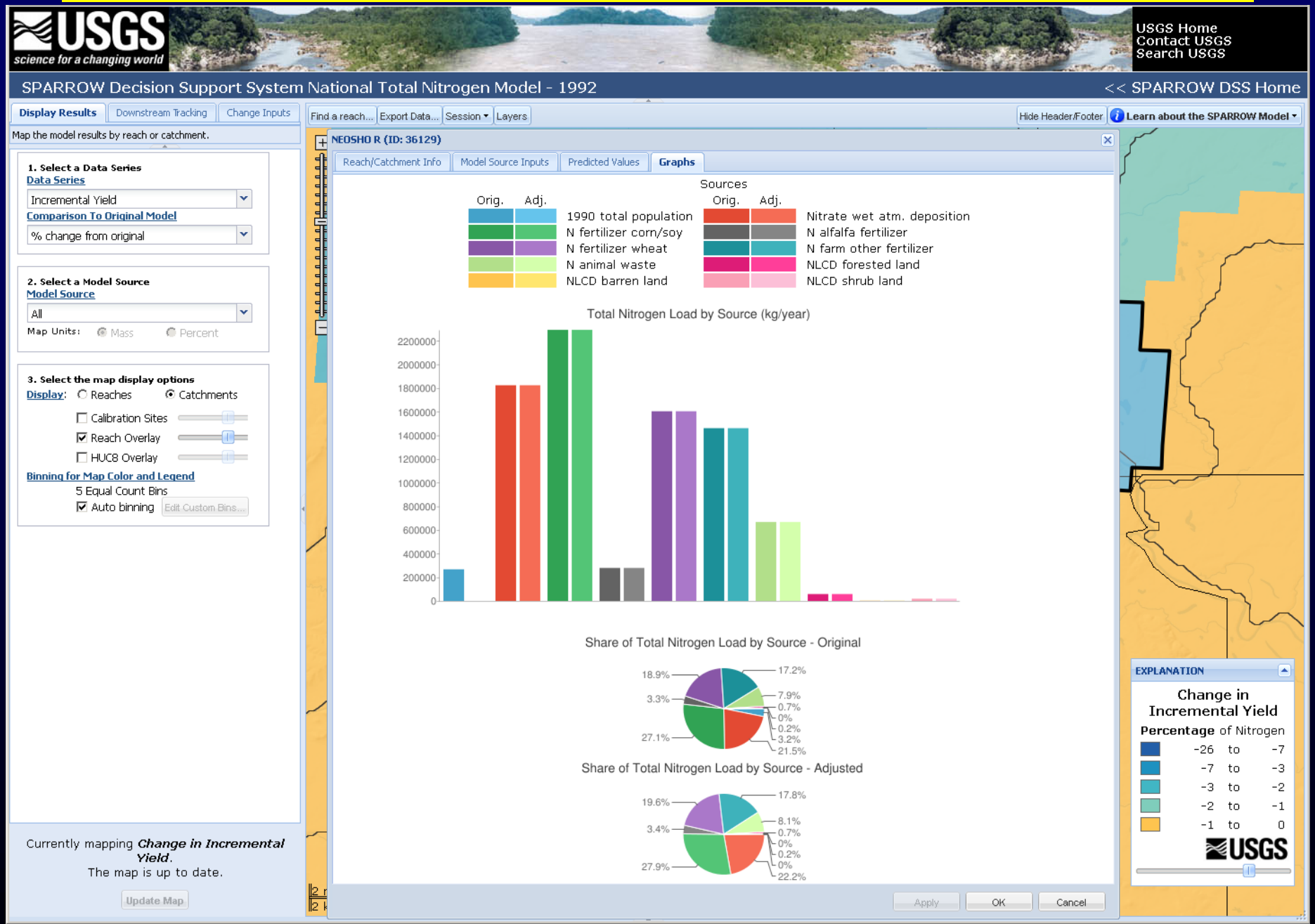
Scenario Results - Percent Changes in Incremental Yields



Scenario Results – Detailed Changes in Sources



Scenario Results – Graphical Presentation of Changes

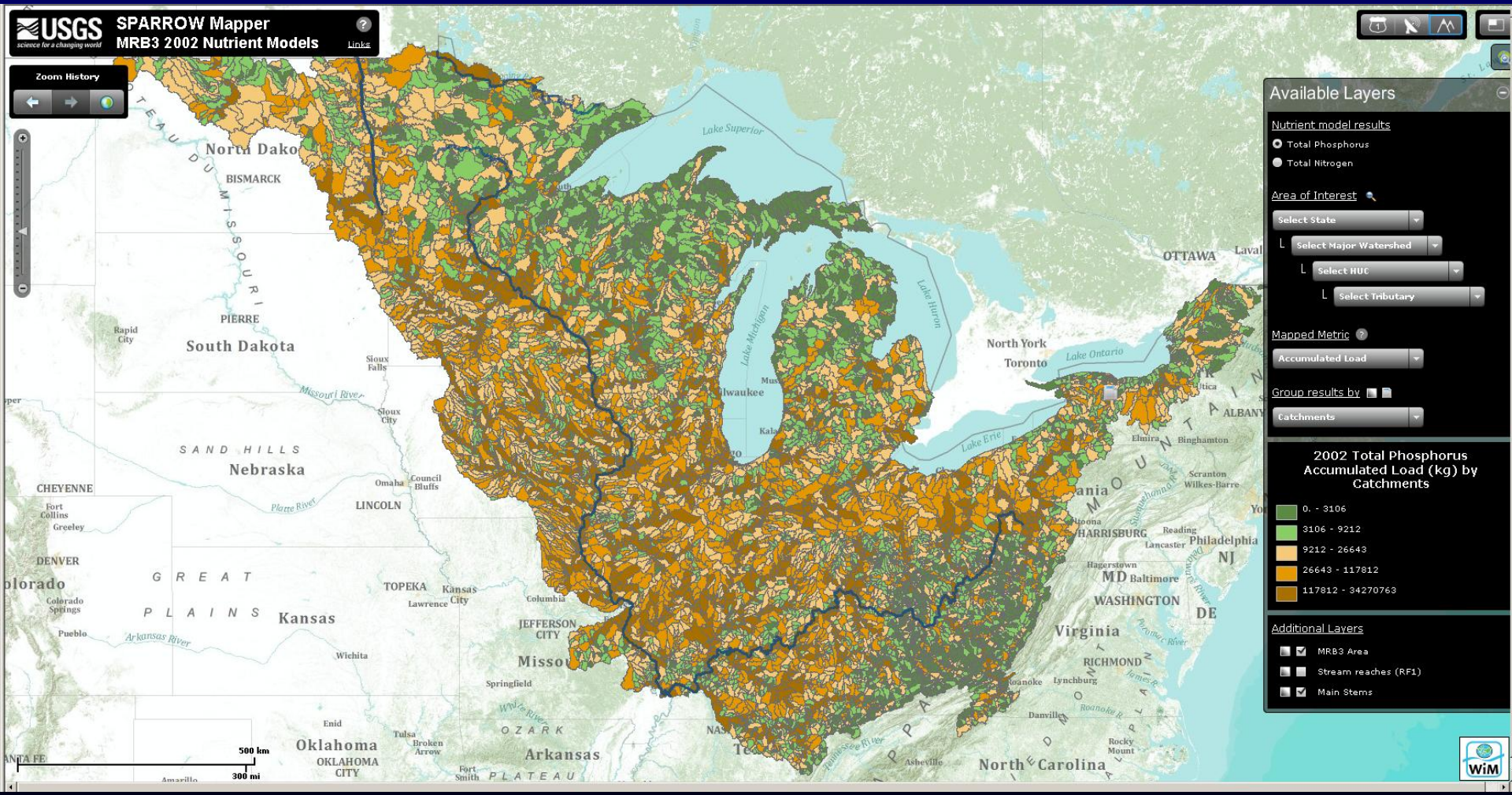


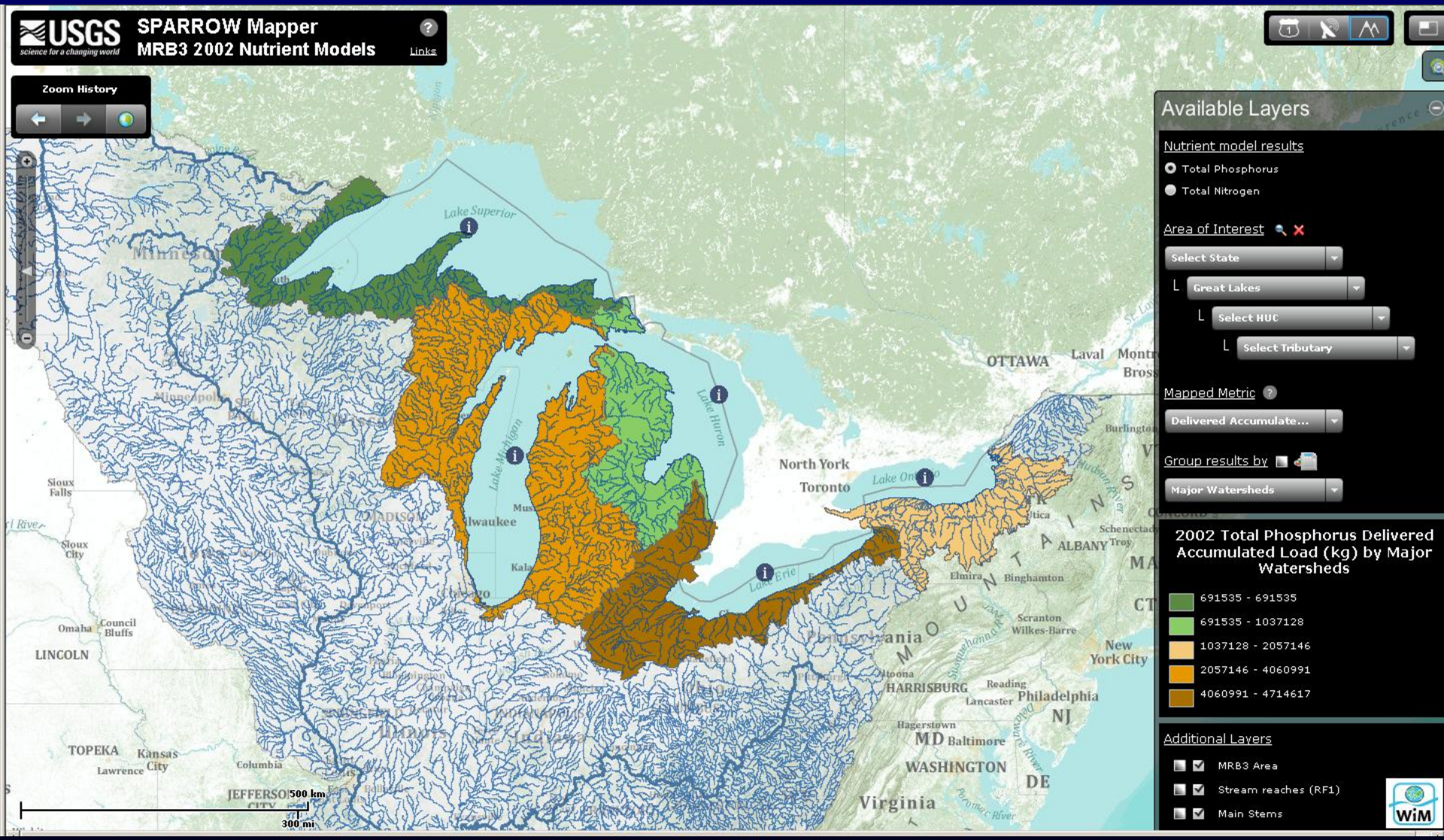
Methods to demonstrate results and help guide decisions

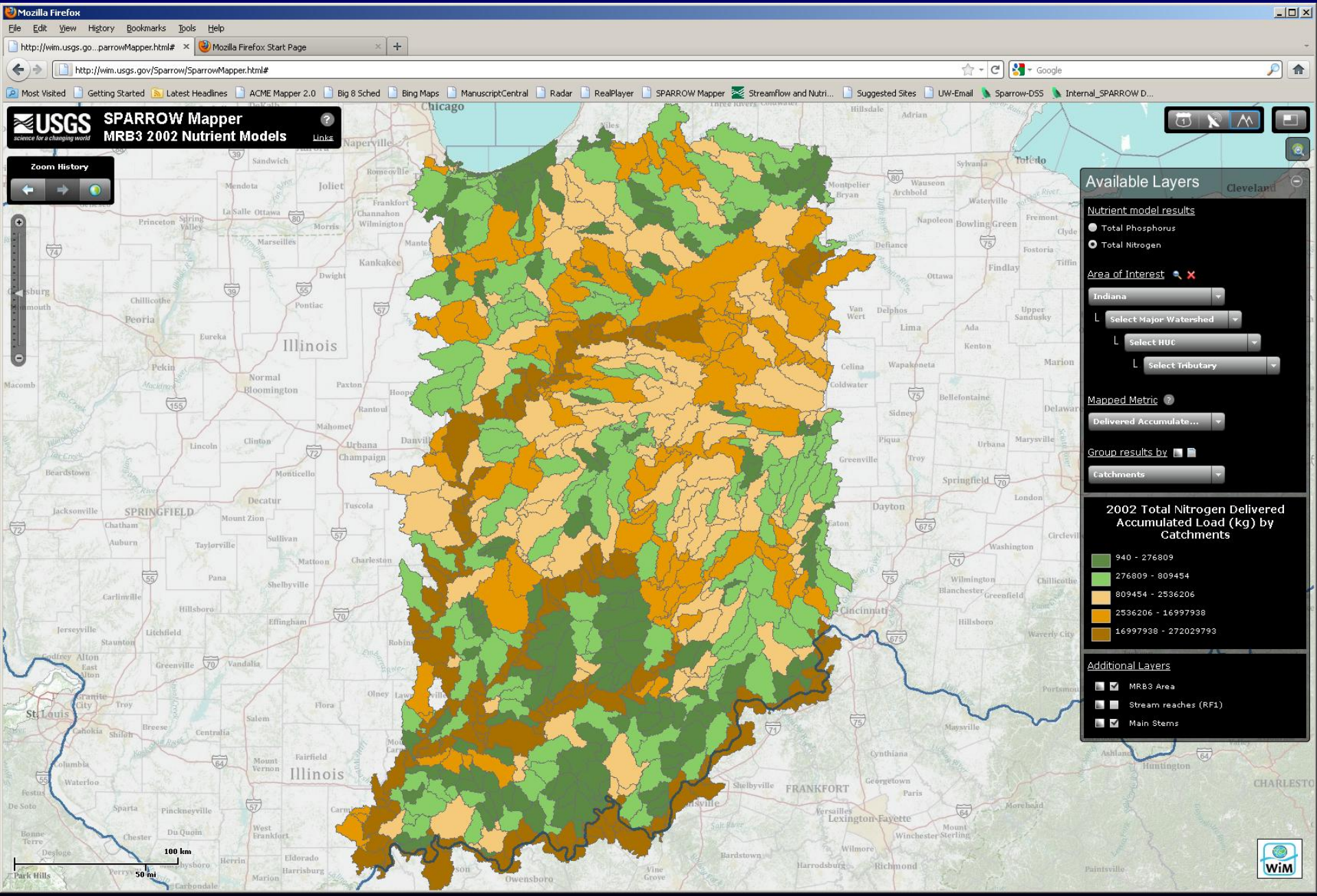
1. Decision Support System

2. SPARROW Mapper – Easy and simple way to get SPARROW results

SPARROW MAPPER




USGS
science for a changing world
SPARROW Mapper
MRB3 2002 Nutrient Models
Links
Zoom History
Available Layers
Nutrient model results
Total Phosphorus
Total Nitrogen
Area of Interest
Select State
Great Lakes
Select HUC
Select Tributary
Mapped Metric
Delivered Accumulate...
Group results by
Major Watersheds
2002 Total Phosphorus Delivered Accumulated Load (kg) by Major Watersheds
691535 - 691535
691535 - 1037128
1037128 - 2057146
2057146 - 4060991
4060991 - 4714617
Additional Layers
MRB3 Area
Stream reaches (RF1)
Main Stems
WiM
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
OTTAWA
Laval
North York
Toronto
Sioux Falls
Sioux City
Omaha
Council Bluffs
LINCOLN
TOPEKA
Kansas City
Lawrence
Columbia
JEFFERSON CITY
ALBANY
Elmira
Binghamton
Scranton
Wilkes-Barre
HARRISBURG
Reading
Lancaster
Philadelphia
NJ
MD
Baltimore
WASHINGTON
DE
Virginia
New York City
500 km
300 mi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http://wim.usgs.gov/Sparrow/SparrowMapper.html#
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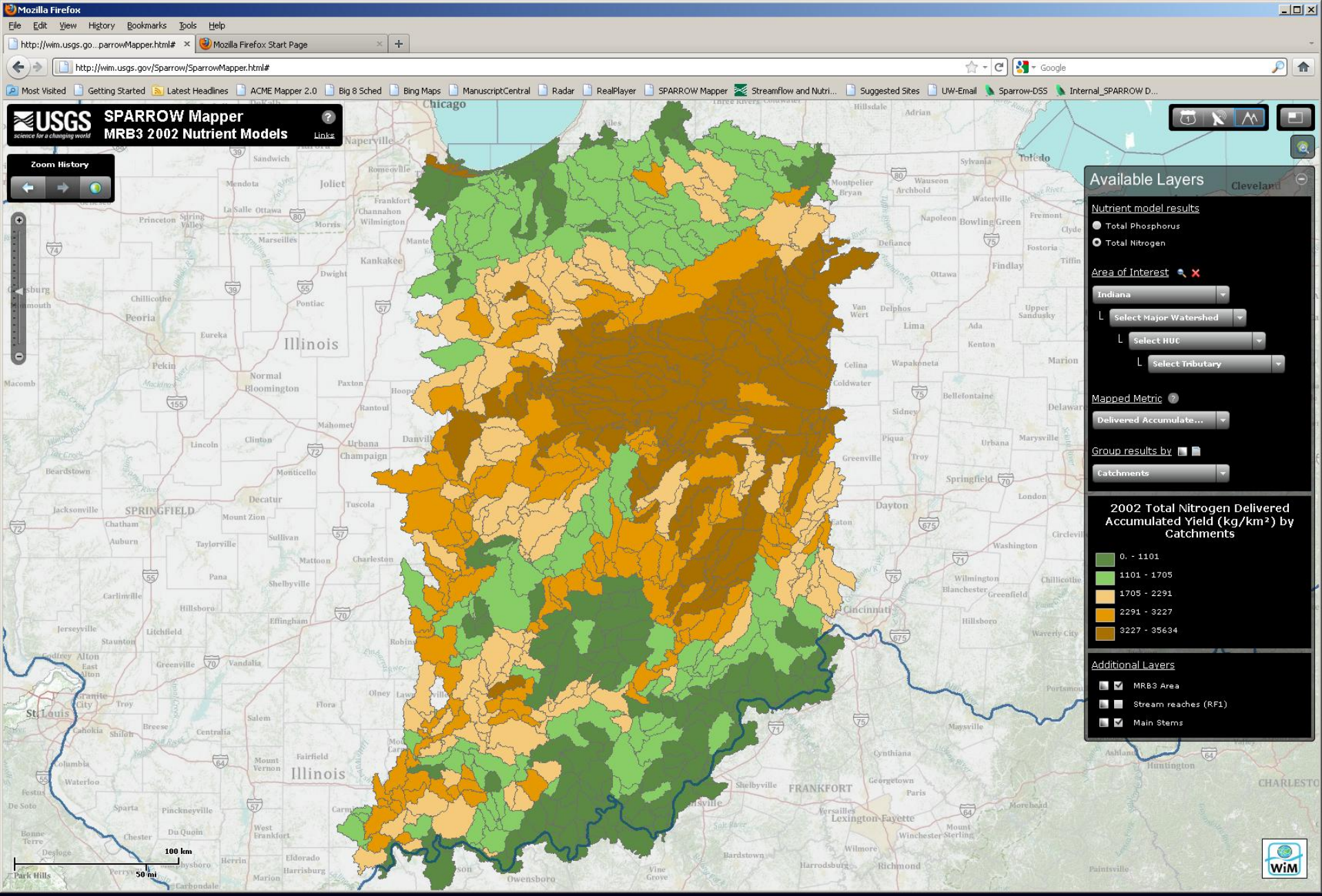
USGS science for a changing world
SPARROW Mapper
MRB3 2002 Nutrient Models
Links
Zoom History
Available Layers
Nutrient model results
Total Phosphorus
Total Nitrogen
Area of Interest
Indiana
Select Major Watershed
Select HUC
Select Tributary
Mapped Metric
Delivered Accumulate...
Group results by
Catchments
2002 Total Nitrogen Delivered Accumulated Load (kg) by Catchments
940 - 276809
276809 - 809454
809454 - 2536206
2536206 - 16997938
16997938 - 272029793
Additional Layers
MRB3 Area
Stream reaches (RF1)
Main Stems
100 km
50 mi
Chicago
Indianapolis
Illinois
Cincinnati
Dayton
Cleveland
Toledo
Lexington-Fayette
FRANKFORT
SPRINGFIELD
St Louis
WiM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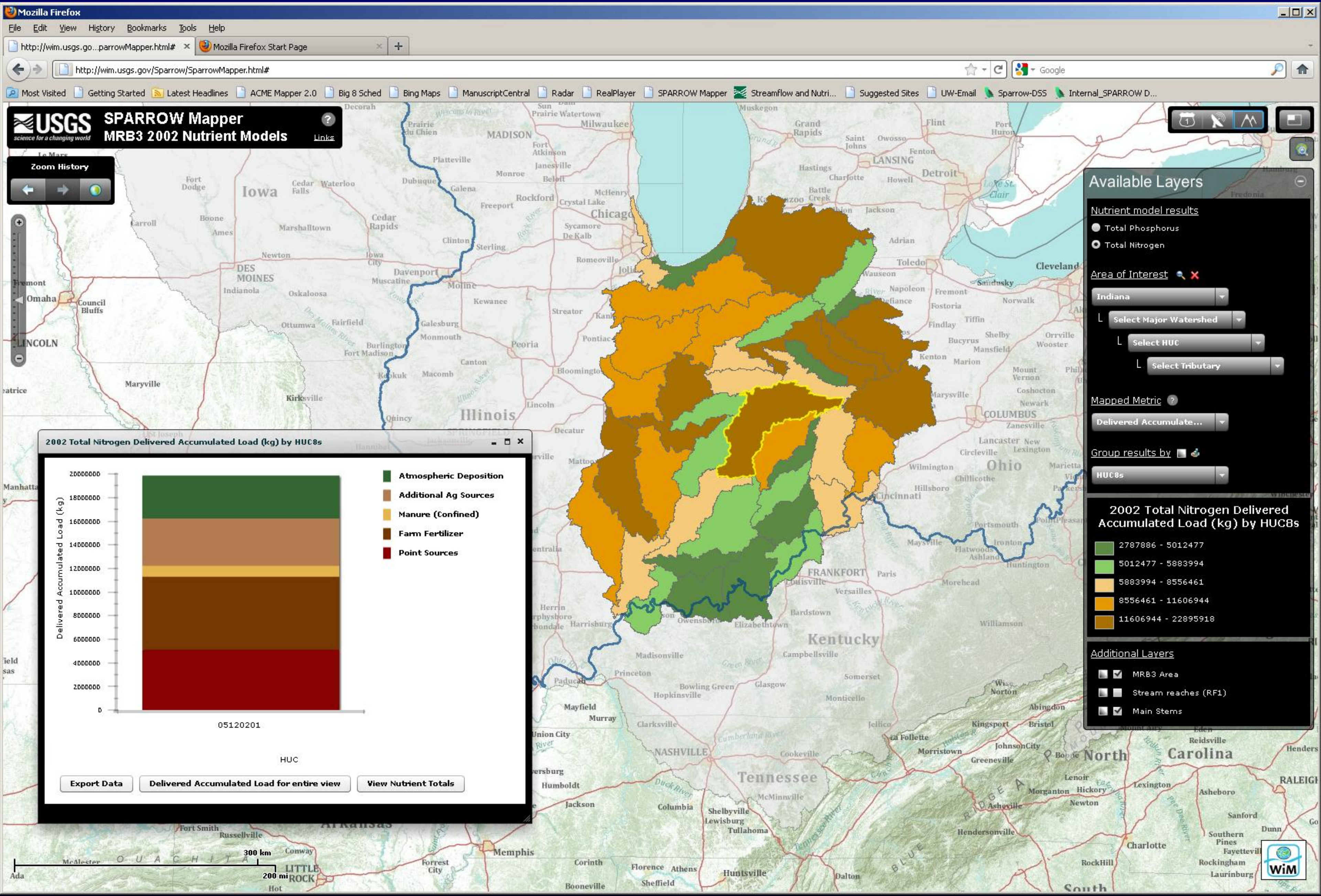
SPARROW Mapper
MRB3 2002 Nutrient Models
Links
Zoom History
Available Layers
Nutrient model results
Total Phosphorus
Total Nitrogen
Area of Interest
Indiana
Select Major Watershed
Select HUC
Select Tributary
Mapped Metric
Delivered Accumulate...
Group results by
Catchments
2002 Total Nitrogen Delivered Accumulated Yield (kg/km²) by Catchments
0. - 1101
1101 - 1705
1705 - 2291
2291 - 3227
3227 - 35634
Additional Layers
MRB3 Area
Stream reaches (RF1)
Main Stems
Chicago
Illinois
SPRINGFIELD
Cincinnati
Dayton
FRANKFORT
Lexington-Fayette
St. Louis
100 km
50 mi
WiM



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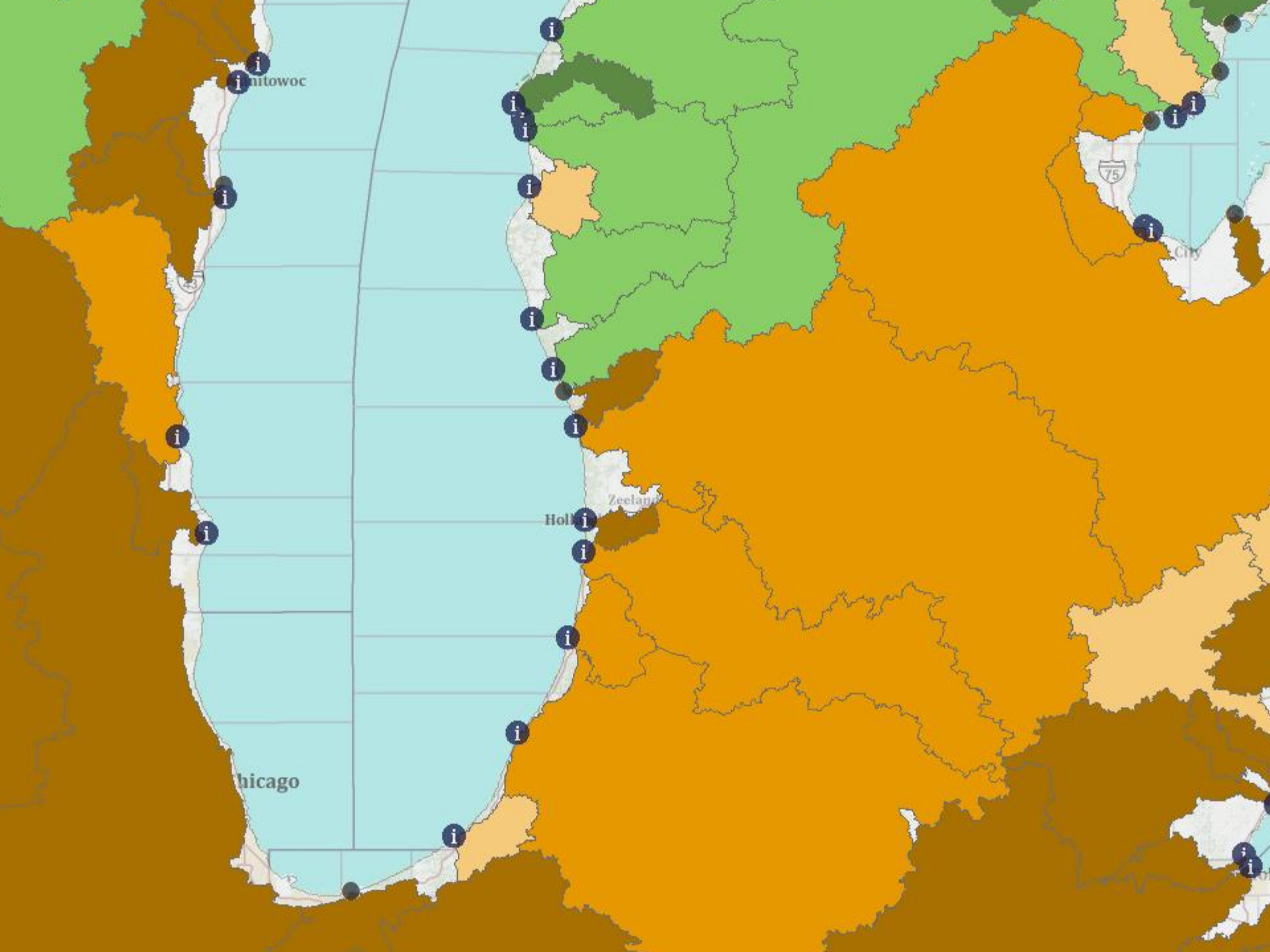
File Edit View History Bookmarks Tools Help
http://wim.usgs.gov/Sparrow/SparrowMapper.html#
USGS science for a changing world
SPARROW Mapper
MRB3 2002 Nutrient Models
Links
Zoom History
Available Layers
Nutrient model results
Total Phosphorus
Total Nitrogen
Area of Interest
Indiana
Select Major Watershed
Select HUC
Select Tributary
Mapped Metric
Delivered Accumulate...
Group results by
HUC8s
2002 Total Nitrogen Delivered Accumulated Load (kg) by HUC8s
2787886 - 5012477
5012477 - 5883994
5883994 - 8556461
8556461 - 11606944
11606944 - 22895918
Additional Layers
MRB3 Area
Stream reaches (RF1)
Main Stems
2002 Total Nitrogen Delivered Accumulated Load (kg) by HUC8s
Delivered Accumulated Load (kg)
20000000
18000000
16000000
14000000
12000000
10000000
8000000
6000000
4000000
2000000
0
05120201
HUC
Atmospheric Deposition
Additional Ag Sources
Manure (Confined)
Farm Fertilizer
Point Sources
Export Data
Delivered Accumulated Load for entire view
View Nutrient Totals
300 km
200 mi


Manitowoc
Zeeland
Holl
hicago
75

Galien River

From Wikipedia, the free encyclopedia

Coordinates: 41°48'04"N 086°44'57"W

The **Galien River** is a 30.0-mile-long (48.3 km)[2] stream in the southwest region of the U.S. state of Michigan. The river begins at the outlet of Dayton Lake and flows in a predominantly westerly direction until it enters southeastern Lake Michigan at New Buffalo. The South Branch Galien River rises just north of the border with Indiana, at the confluence of Spring Creek and the Galena River, the latter rising in LaPorte County, Indiana.[3][4]

Contents [hide]

Galien River	
river	
Country	United States
State	Michigan
Region	Berrien County
Tributaries	
- left	Dowling Creek, South Branch Galien River
- right	Blue Jay Creek, East Branch Galien River, Kirktown Creek
Source	Dayton Lake
- location	East of Galien, Michigan, Berrien County, Michigan, United States
- elevation	720 ft (219 m)
- coordinates	41°47'47"N 086°26'33"W [1]
Mouth	Lake Michigan
- location	New Buffalo, Berrien County, Michigan
- elevation	581 ft (177 m) [1]
- coordinates	41°48'04"N 086°44'57"W [1]

History [edit]

The river was named after René Bréhant de Galinée, a French missionary, mapmaker and explorer.[5] The name was changed to Galien by legislative action in 1829.[6]

Ecology [edit]

The Galien River passes through Warren Woods State Park which supports the last climax beech-maple forest in the state of Michigan. The Galien River watershed supports the state's largest breeding population of Yellow-throated Warblers (*Dendroica dominica*), and a substantial population of breeding Cerulean Warblers (*Dendroica cerulea*). Also supports a high diversity of bottomland forest obligate bird species.[7]

Designated coldwater streams in the watershed include: the main stem of the Galien River, east branch Galien River, Blue Jay Creek, south branch Galien River, and a portion of Spring Creek.[8]

Watershed [edit]

The watershed encompasses approximately 180 square miles (470 km^2) in portions of La Porte County, Indiana, and Berrien County, Michigan. The main branch of the Galien rises from the outflow of Dayton Lake in the northwest corner of Bertrand Township and flows west to the village of Galien, Michigan. It then flows northwest into Weesaw Township and north to near New Troy, where it is joined by the East Branch and begins to flow west and then southwest to New Buffalo.[9]

Agriculture is the dominant land use in the watershed and the majority of the water bodies have been dredged or channelized to facilitate the rapid conveyance of water from the relatively flat landscape.

Tributaries (from the mouth):

- South Branch Galien River, rises just north of the stateline with Indiana and flows mostly north until joining the main branch north of New Buffalo
  - Squaw Creek[10], rises south of New Buffalo and flows north around the east side of town
  - Blood Run[11], rises in Springfield Township in LaPorte County, Indiana, and flows north and east
  - Spring Creek[12], rises in Hudson Township in the northeast corner of LaPorte County, flows north into Galien Township then east into Three Oaks Township and south into the South Branch on the Michigan-Indiana border
  - Galena River, rises in LaPorte County, Indiana, near Springville
- Kirktown Creek[13], rises in Lake Township and flows mostly south into the main branch west of New Troy
- East Branch Galien River[14], rises in the northwest corner of Buchanan Township and flows mostly west and south into the main branch southeast of New Troy
  - Judy Lake Drain[15], rises from the outflow of several lakes in western Buchanan Township
- Blue Jay Creek[16], rises in southeast Weesaw Township and flows northwest to the main branch in eastern Weesaw
- Dowling Creek[17], rises on the southern edge of Galien Township, near the Indiana border where LaPorte and St. Joseph counties meet.
  - Beaverdam Creek[18], rises in southwest Galien Township.

See also [edit]

Local and Regional SPARROW applications

Local Applications

1. State of Minnesota – Nitrogen Loading
2. St. Croix River Basin (Wis.)
3. Wisconsin River Basin (Wis.)
4. Lake Winnebago and Fox/Wolf River Basin (Wis.)
5. Maumee River Basin (OH)

Local and Regional SPARROW applications

Regional Applications

1. Explanation for distribution of Phragmites

2. HydroSPARROW – Effects of future climate change

3. Seasonal load allocations in the Upper Midwest

Use of SPARROW Models to Determine the Spatial Distribution and Sources of Nutrients in Streams in the Upper Midwest and Mississippi/Atchafalaya River Basins

Questions??

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(608) 821-3867

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