

# A Spatially Detailed Assessment of Total Nitrogen Loads in the Delaware River Basin

Jeffrey M Fischer<sup>1</sup> and Richard B Moore<sup>2</sup>,

<sup>1</sup> U.S. Geological Survey,  
New Jersey Water Science Center,  
[fischer@usgs.gov](mailto:fischer@usgs.gov), 609-771-3953

<sup>2</sup> U.S. Geological Survey,  
New Hampshire Water Science Center,  
[rmoore@usgs.gov](mailto:rmoore@usgs.gov), 603-226-7825



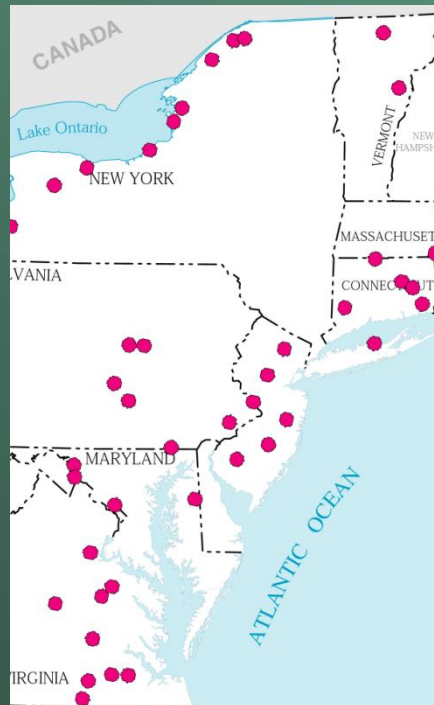
# Today's Objective

- Overview of SPARROW Nutrient Model Developed for Northeastern US
- How to Obtain Data on the Web
- Selected Nitrate Results for the Delaware Estuary
- (Phosphate results are also available, but will not be shown today)

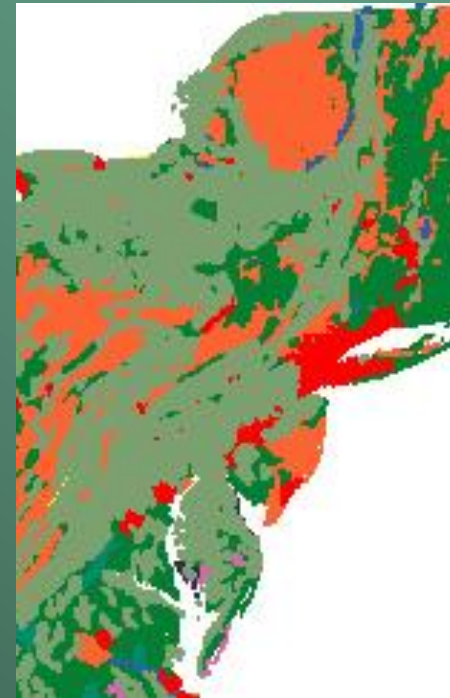
# SPARROW\* uses a stream network to relate loads at monitoring stations to sources and stream or land attributes

\*Spatially Referenced Regression On Watershed Attributes

Stream Network



Monitoring Data



Sources

Atmospheric,  
Agricultural,  
& Urban



Landscape Features

Geology,  
Topography,  
Land Use,  
and others



Model predictions are made for every reach (not just monitored reaches)

- **Load, yield, concentration**
- **Contribution from each source**
- **In-stream losses**
- **Statistical measures of uncertainty**



# Northeast SPARROW Nitrogen Model

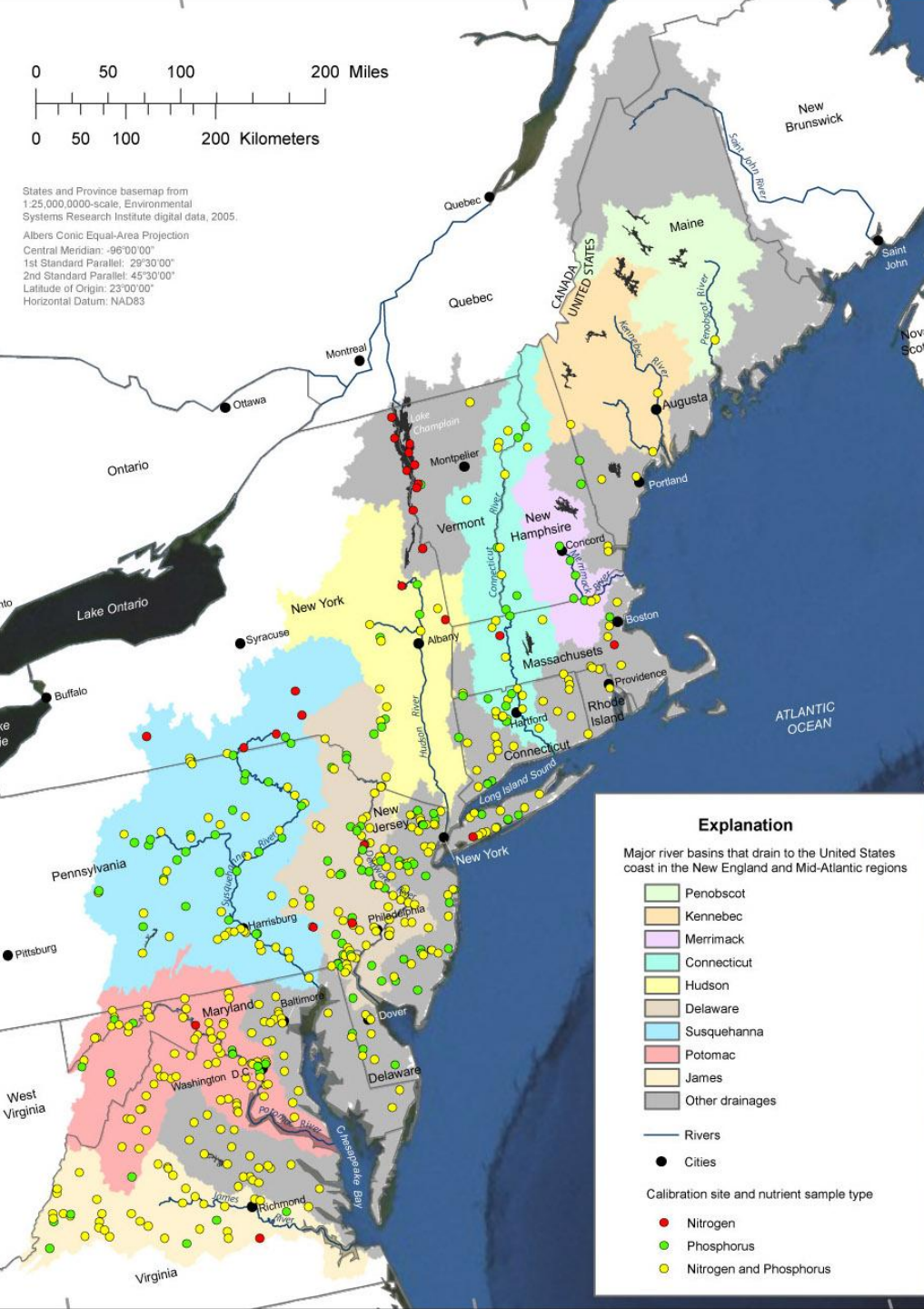
Calibrated to 363  
nitrogen monitoring  
sites

6 source terms

5 land-to-water delivery

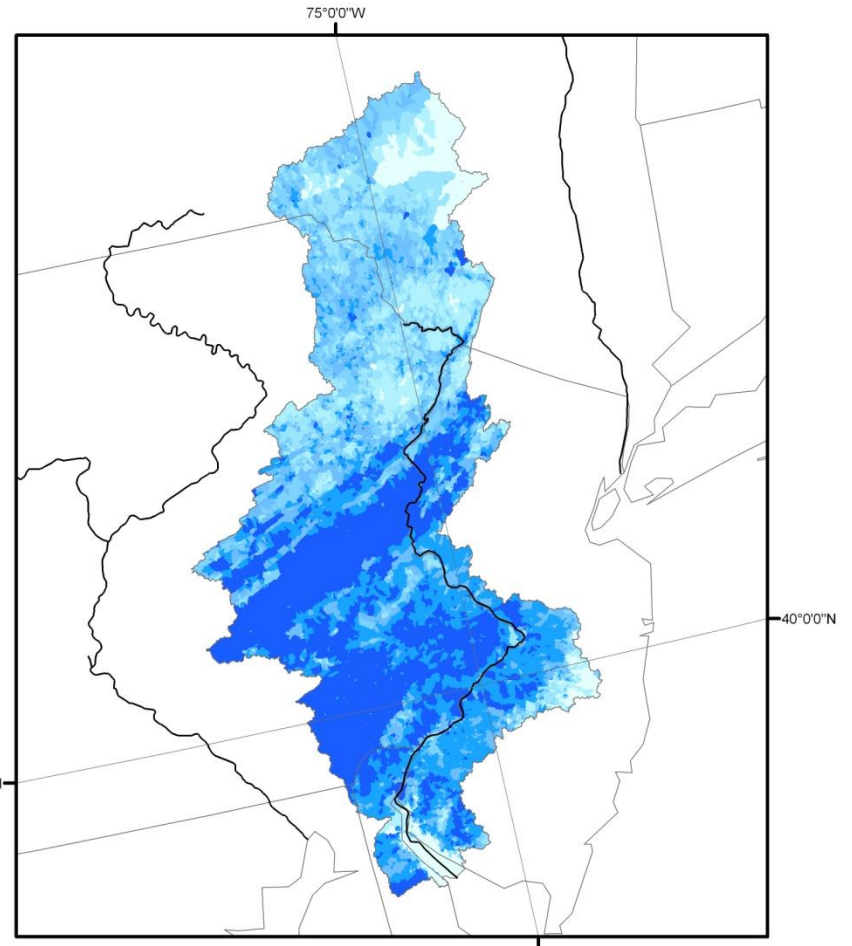
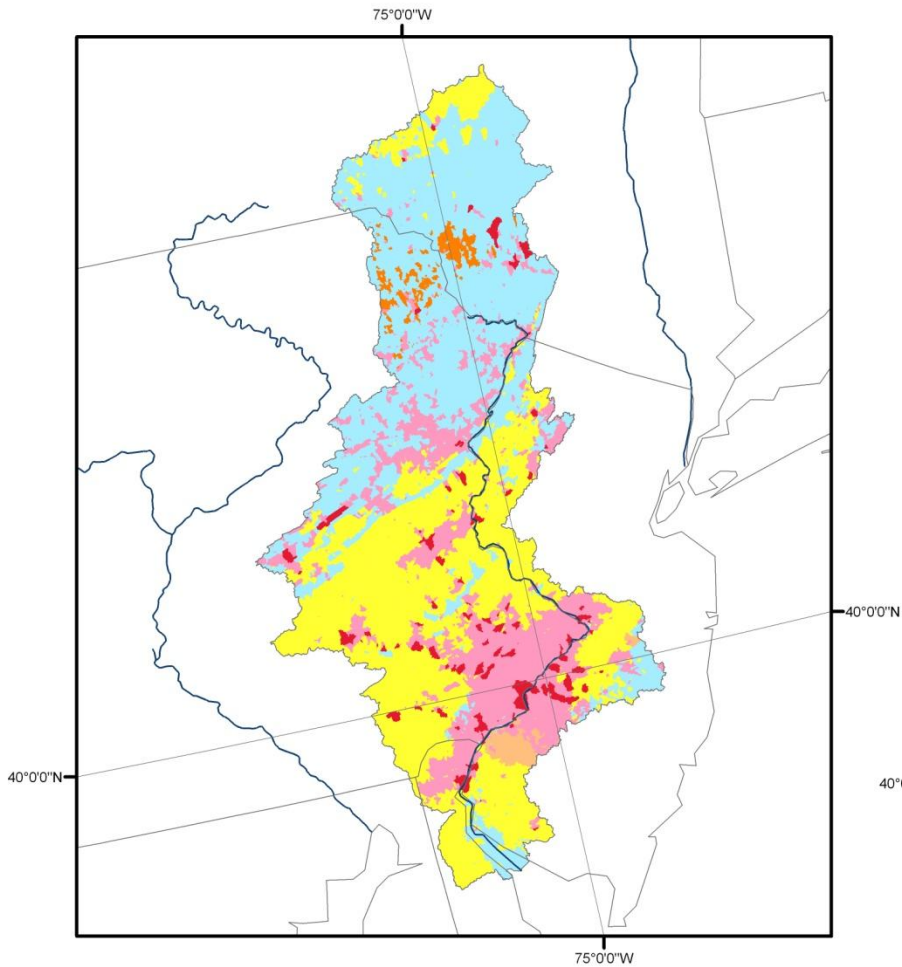
1 stream loss term

Predictions made for  
187,171 stream path  
segments (plus 6,156  
coastal segments)

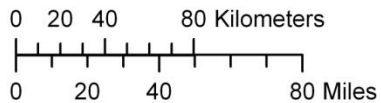


# Primary Sources

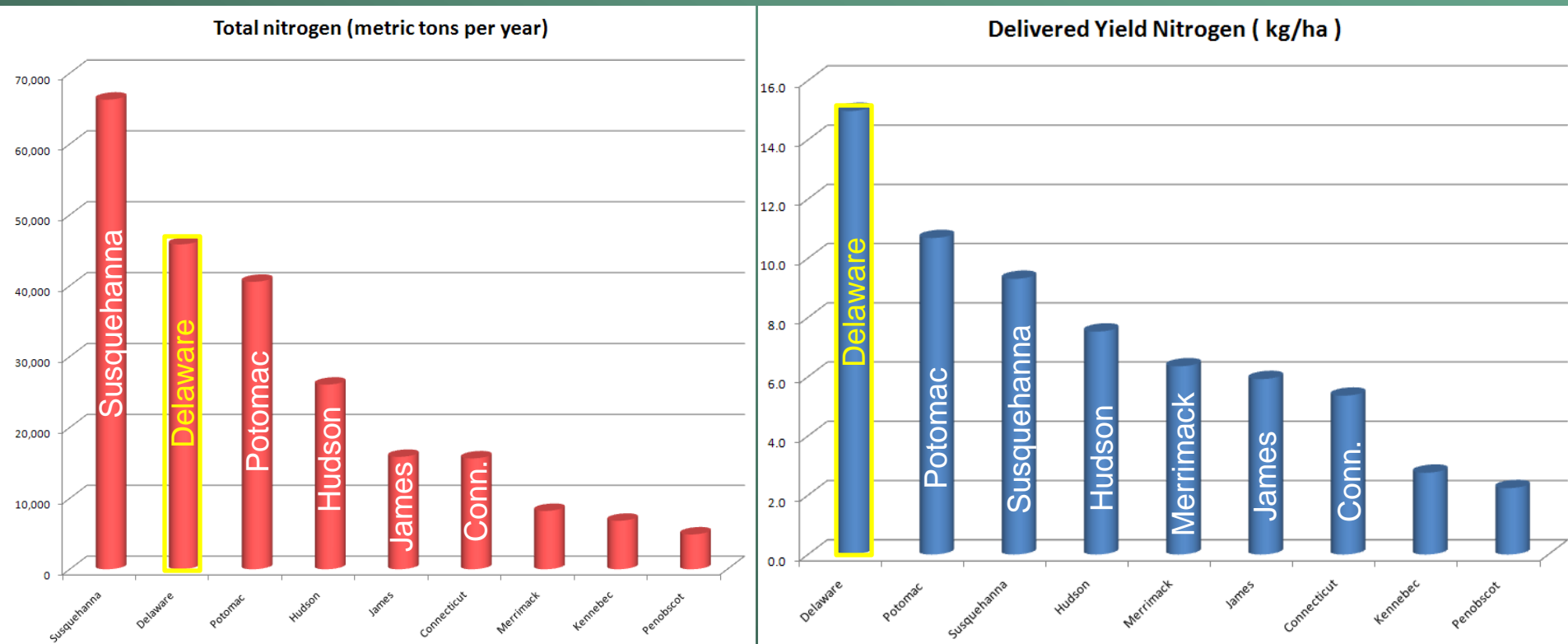
# Yield



Delivered nitrogen yield  
in kilograms per hectare per year



# How does the Delaware compare to other estuaries in the northeast?



It has the highest yield (nitrogen delivered per unit area) for estuaries in the northeast.

# SPARROW Webpage

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



USGS Home  
Contact USGS  
Search USGS

## SPARROW Surface Water-Quality Modeling

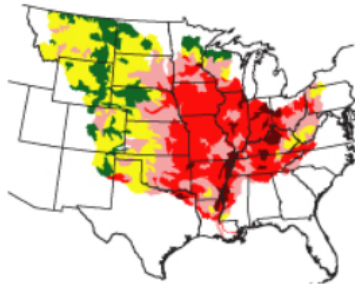
[NAWQA Home](#) [Model Description](#) [Fact Sheet](#) [Decision Support System](#) [FAQs](#) [Documentation](#) [Software](#) [Publications](#) [Contacts](#) [Training](#)

[Regional MRB Studies](#)

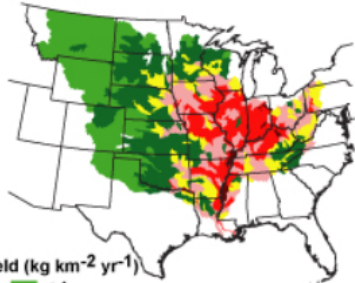
**SPARROW**, a modeling tool for the regional interpretation of water-quality monitoring data. The model relates in-stream water-quality measurements to spatially referenced characteristics of watersheds, including contaminant sources and factors influencing terrestrial and aquatic transport. SPARROW empirically estimates the origin and fate of contaminants in river networks and quantifies uncertainties in model predictions.

### Mississippi/Atchafalaya River Basins

Phosphorus yield delivered to local waters



Phosphorus yield delivered to the Gulf of Mexico



Yield (kg km<sup>-2</sup> yr<sup>-1</sup>)

< 1  
1 to 25

### RECENT ACTIVITIES

## Accessing the on-line tool

- [NEW: Regional SPARROW model assessments for the United States](#)
- [NEW: SPARROW Online Decision Support System](#)
- [NEW: SPARROW Featured Collection](#) in the Journal of the American Water Resources Association
- A model of [organic carbon](#) in streams of United States
- Sources of [suspended sediment](#) in streams of the Chesapeake Bay watershed

[Chesapeake Bay](#)  
[modeling capabilities](#)

### APPLICATIONS

#### The National Models

- [Organic carbon](#) in U.S. streams
- [Suspended sediment](#) in U.S. streams
- [Natural background concentrations](#) of nutrients in U.S. streams
- [Atmospheric sources of nitrogen](#) to estuaries of the United States

## Publications and data used in models

#### The Regional Models

- [Summary of the major results and enhanced modeling capabilities](#)
- [Regional SPARROW model assessments for the United States](#)
- [SPARROW Featured Collection in the Journal of the American Water Resources Association](#)



# Using the Decision Support Tool

## SPARROW Decision Support System

### Find a Model by Geographic Location:

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



Any Region or State

### Find a Model by Modeled Constituent:

Any

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

[Chesapeake Bay Total Nitrogen Model -2002](#)

[Chesapeake Bay Total Phosphorus Model - 2002](#)

[National Suspended Sediment Model - 1992](#)

[National Total Nitrogen Model - 1992](#)

[National Total Organic Carbon Model](#)

[National Total Phosphorus Model - 1992](#)

[Total Dissolved Solids Model for the Rio Grande, Colorado, and Great Basin Region - 2006](#)

### Documentation and Further Reading

- [What is SPARROW?](#)
- [What is SPARROW Decision Support?](#)
- [SPARROW Applications & Documentation](#)
- [SPARROW DSS FAQs](#)

### Tutorial Videos

Select a video...

[Watch now >>](#)

### Found a bug or have a comment?

Please send bugs, suggestions and questions to the [SPARROW Decision Support System Administrator](#).

### Selected Model

#### 2002 Total Nitrogen Model for Northeast and Mid Atlantic Regions



[Explore this model in the Decision Support System >>](#)

**Modeled Constituent:** Nitrogen

**Base Year:** 2002

**Stream Network:** [National Hydrography Dataset Plus](#)  
*Geometry and additional reach and network attribute data are available with the stream network data, which is available as a separate download.*

**Reference:** [Source and Delivery of Nutrients to Receiving Waters in the Northeastern and Mid-Atlantic Regions of the United States](#)

### Watershed Based Sessions

To start the DSS with the outlet river reach of a major watershed selected for downstream tracking, select a watershed and click [Go](#).

[Delaware River Watershed](#)

[Go >>](#)

# The DSS Map Interface

1. Select Data Series
2. Select Source Type
3. Update Map

## SPARROW Decision Support System MRB01 Nitrogen

Display Results | Downstream Tracking | Change Inputs | Find a reach... | Export Data... | Session | Layers | Hide Header/Footer

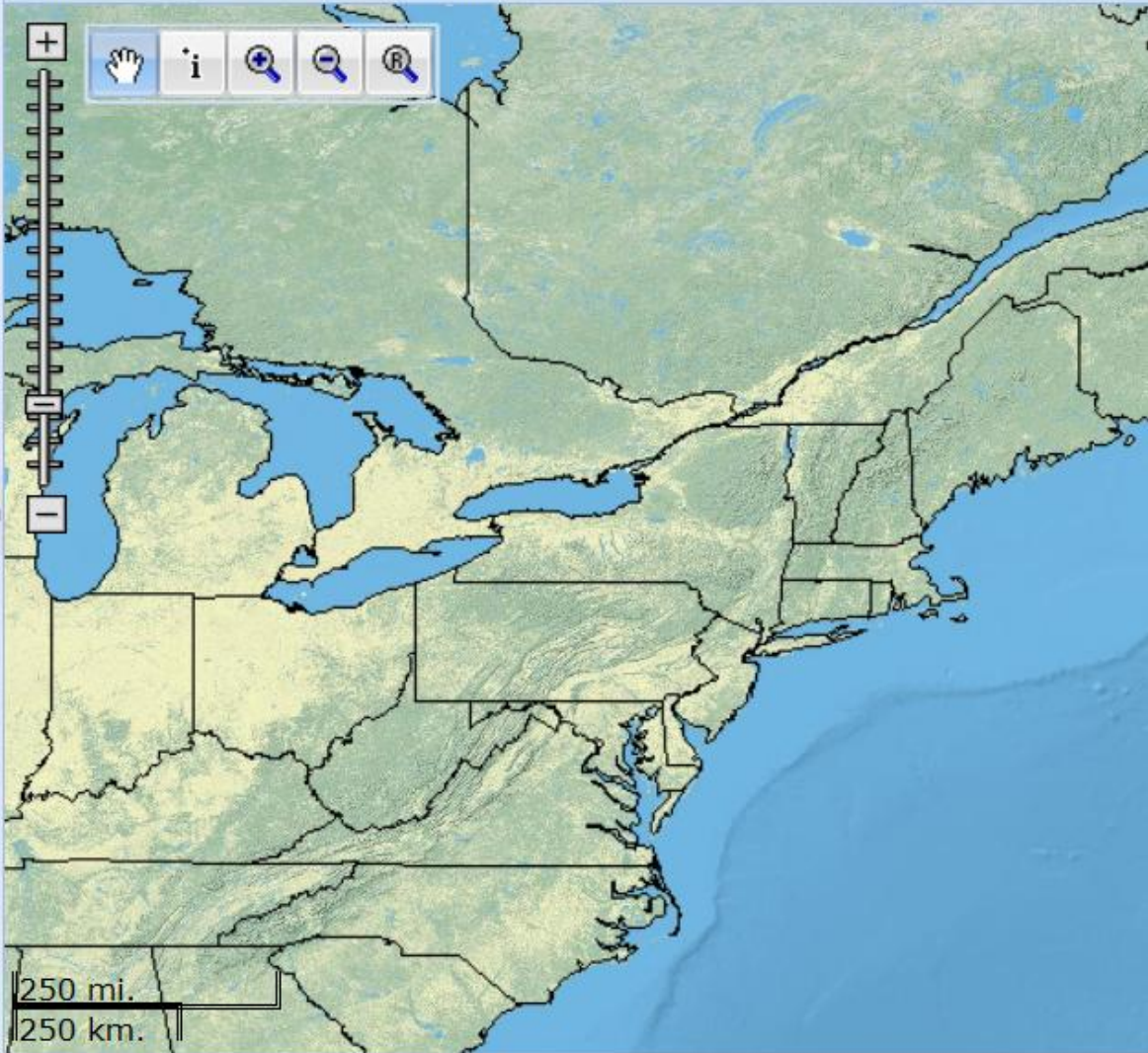
Map the model results by reach or catchment.

**1. Select a Data Series**  
Data Series  
Incremental Delivered Yield  
**1.**  
Comparison To Original Model  
Do Not Compare

**2. Select a Model Source**  
Model Source  
All  
**2.**  
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

Update Map **3.**



The map displays the MRB01 Nitrogen region, showing reaches and catchments. The map includes a scale bar (250 mi., 250 km.) and a toolbar with navigation and information icons.



# 1. Selecting Data

## SPARROW Decision Support System MRB01 Nitrogen

Display Results | Downstream Tracking | Change Inputs | Find a reach... | Export Data... | Session | Layers | Hide Header/Footer

Map the model results by reach or catchment.

### 1. Select a Data Series

**Data Series**

Total Load

**Model Estimates**

Total Load

Incremental Load

Flow-weighted Concentration

Total Yield

Incremental Yield

**Model Inputs**

Model Input Sources

**Stream Network**

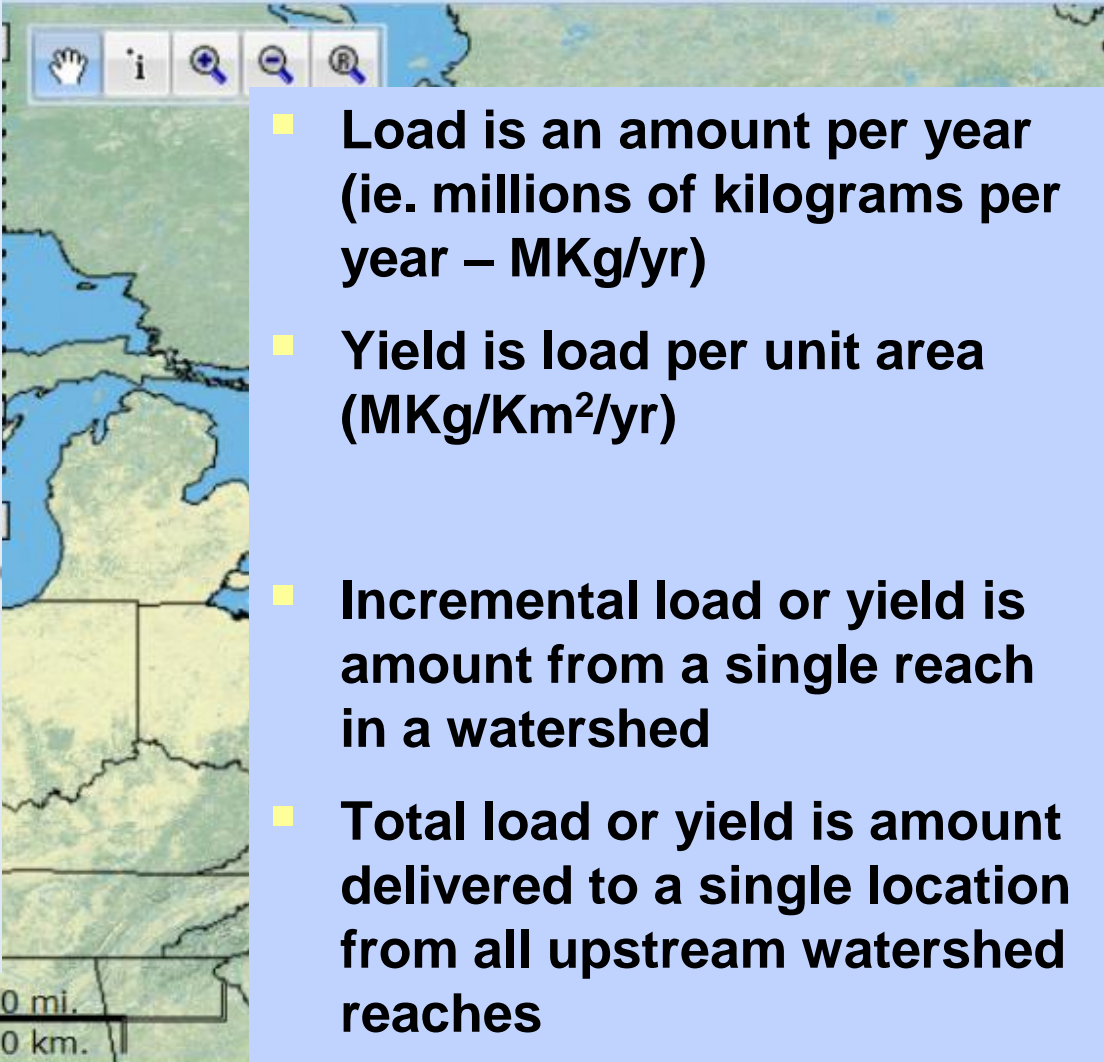
Streamflow

**Model Uncertainty**

Standard Error of Total Load

Standard Error of Incremental Load

**Downstream Tracking**



- Load is an amount per year (ie. millions of kilograms per year – MKg/yr)
- Yield is load per unit area (MKg/Km<sup>2</sup>/yr)
- Incremental load or yield is amount from a single reach in a watershed
- Total load or yield is amount delivered to a single location from all upstream watershed reaches

Update Map

# 2. Selecting Sources

## SPARROW Decision Support System MRB01 Nitrogen

Display Results   Downstream Tracking   Change Inputs

Find a reach...   Export Data...   Session ▾   Layers

Hide Header/Footer

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 ▾

All

Municipal Point Source

Fertilizer Corn Soy

Atmospheric TIN

Manure

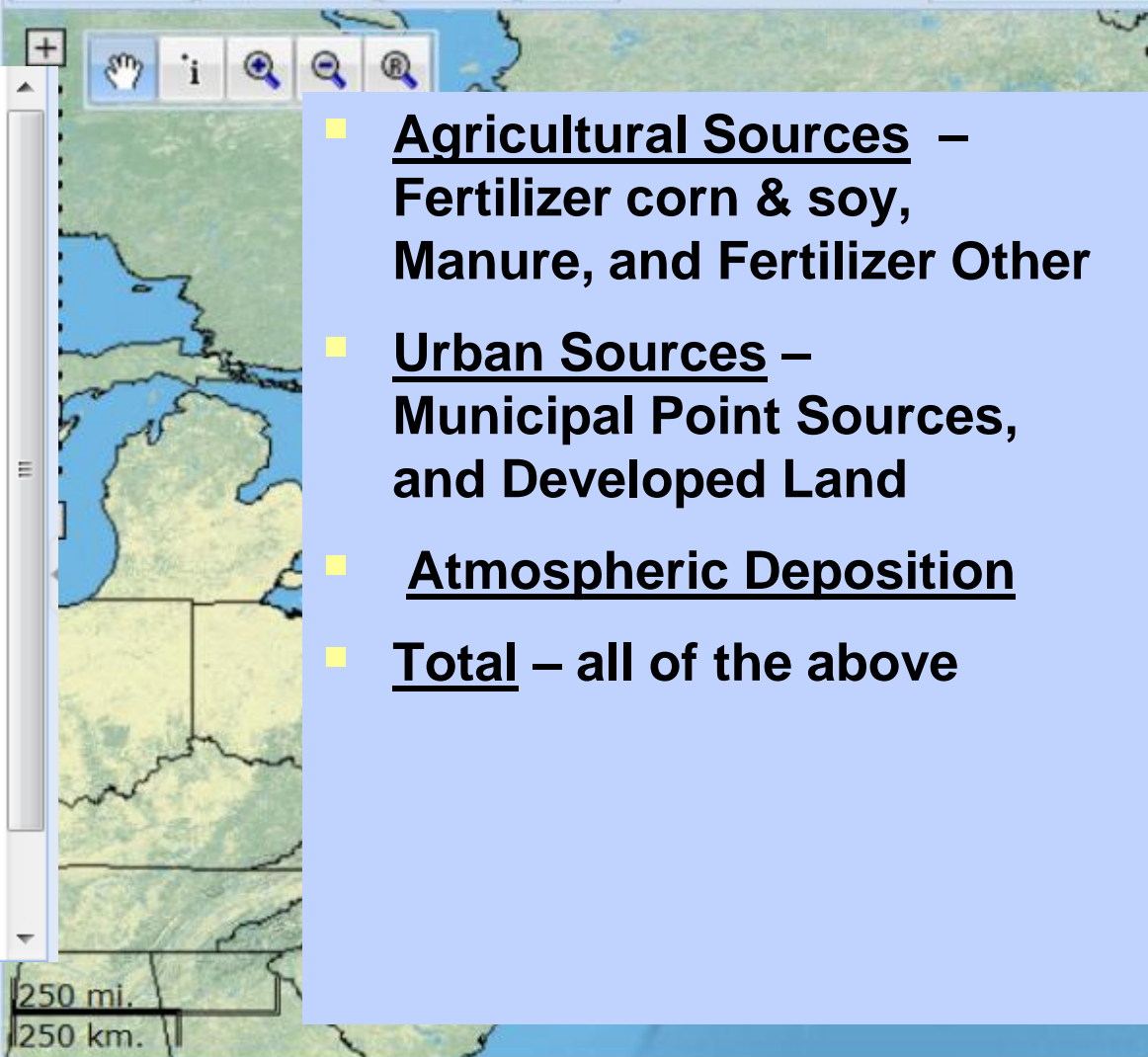
Developed Land

Fertilizer Other

#### Binning for Map Color and Legend

5 Equal Count Bins

Update Map



- **Agricultural Sources** – Fertilizer corn & soy, Manure, and Fertilizer Other
- **Urban Sources** – Municipal Point Sources, and Developed Land
- **Atmospheric Deposition**
- **Total** – all of the above



# Updating Map – Total Nitrogen Load

Decision Support System MRB01 Nitrogen

<< Home

Stream Tracking Change Inputs

Find a reach... Export Data... Session Layers

Hide Header/Footer SPARROW Model / Videos

ch or catchment.

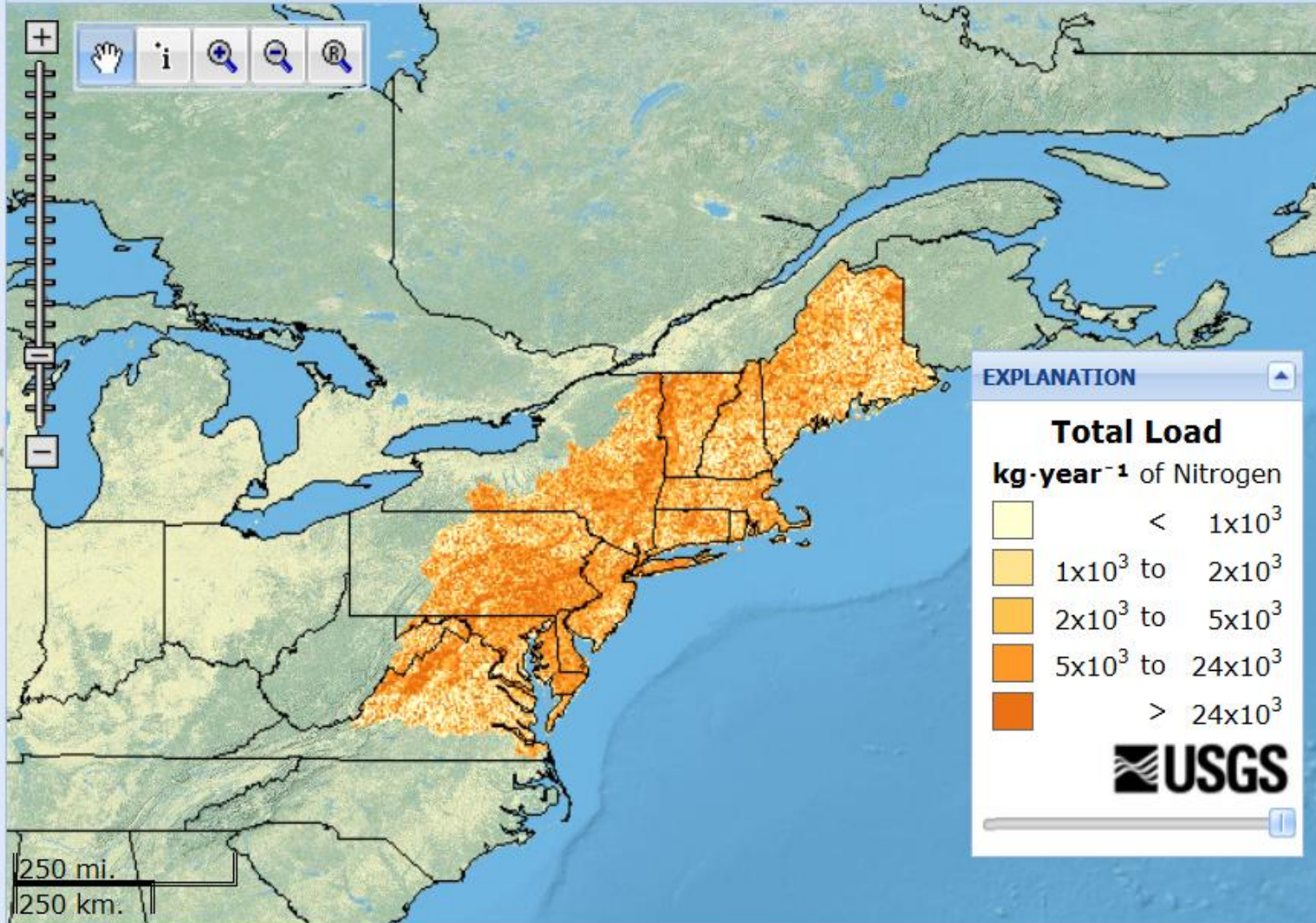
Model

Force

Display options  
 Catchments  
Sites  
Overlay  
Overlay

Updating **Total Load**.  
is up to date.

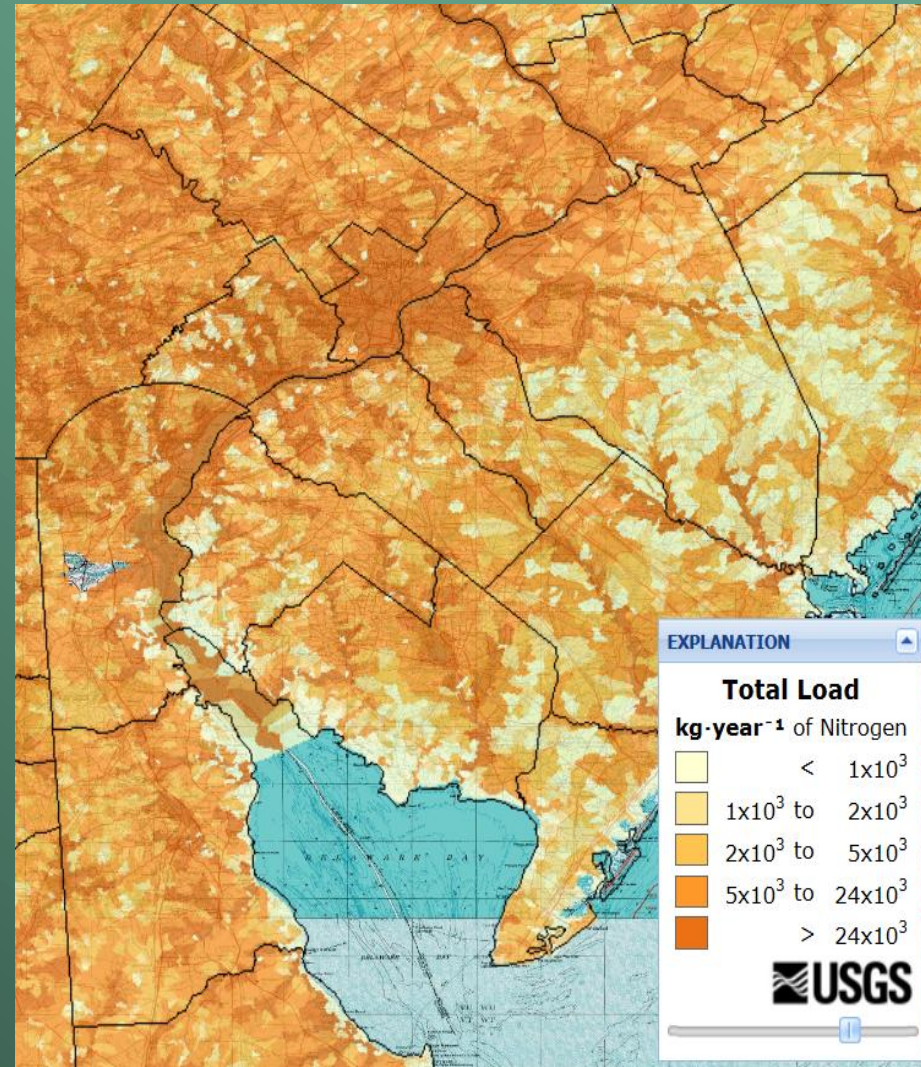
Update Map





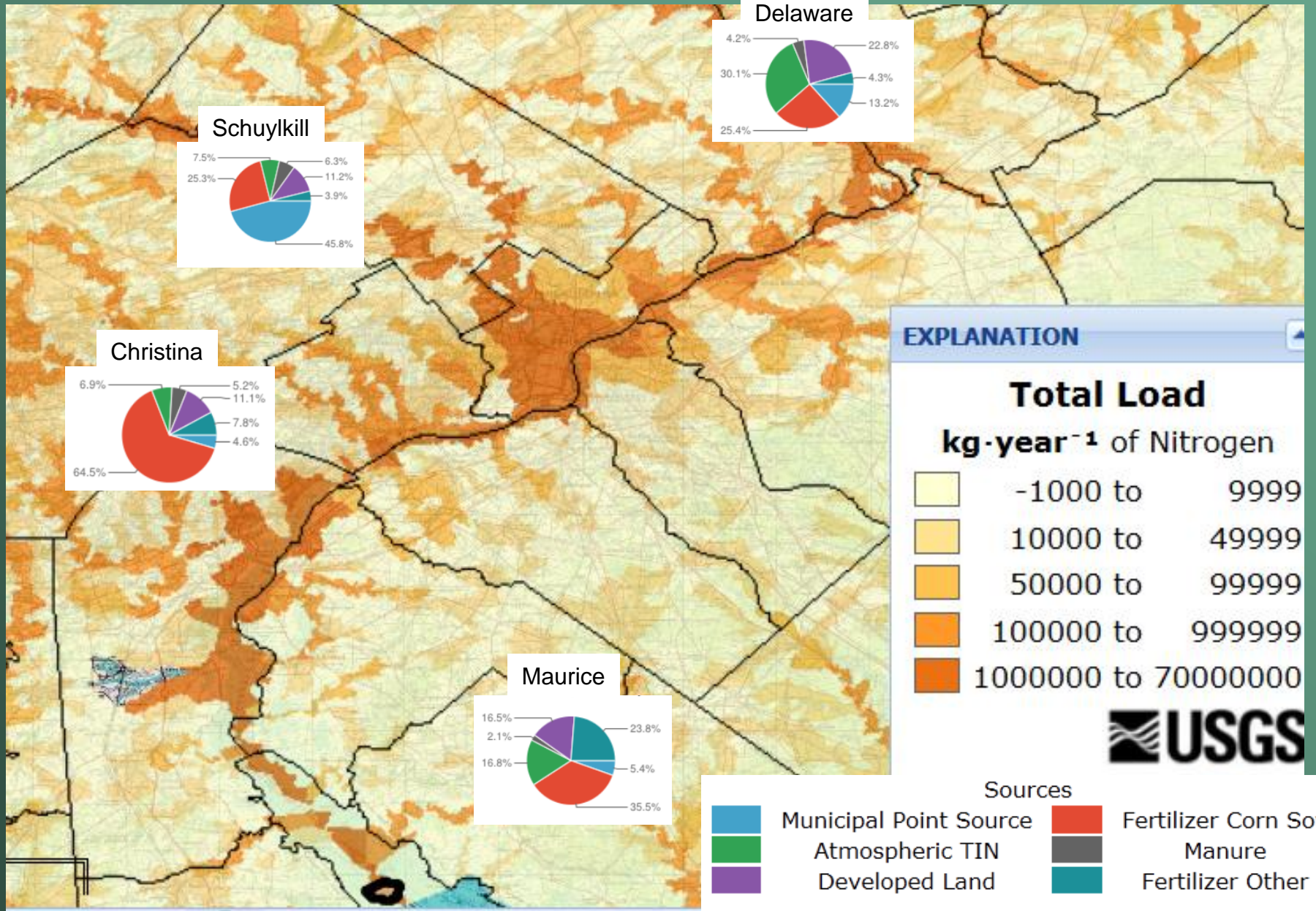
# Using SPARROW in the Estuary

- Model is calibrated for all non-tidal streams and makes predictions of loads and decay.
- Model is not calibrated in estuary and only accumulates inputs, but makes no predictions of losses (decay)
- Data is not accumulated in lower bay

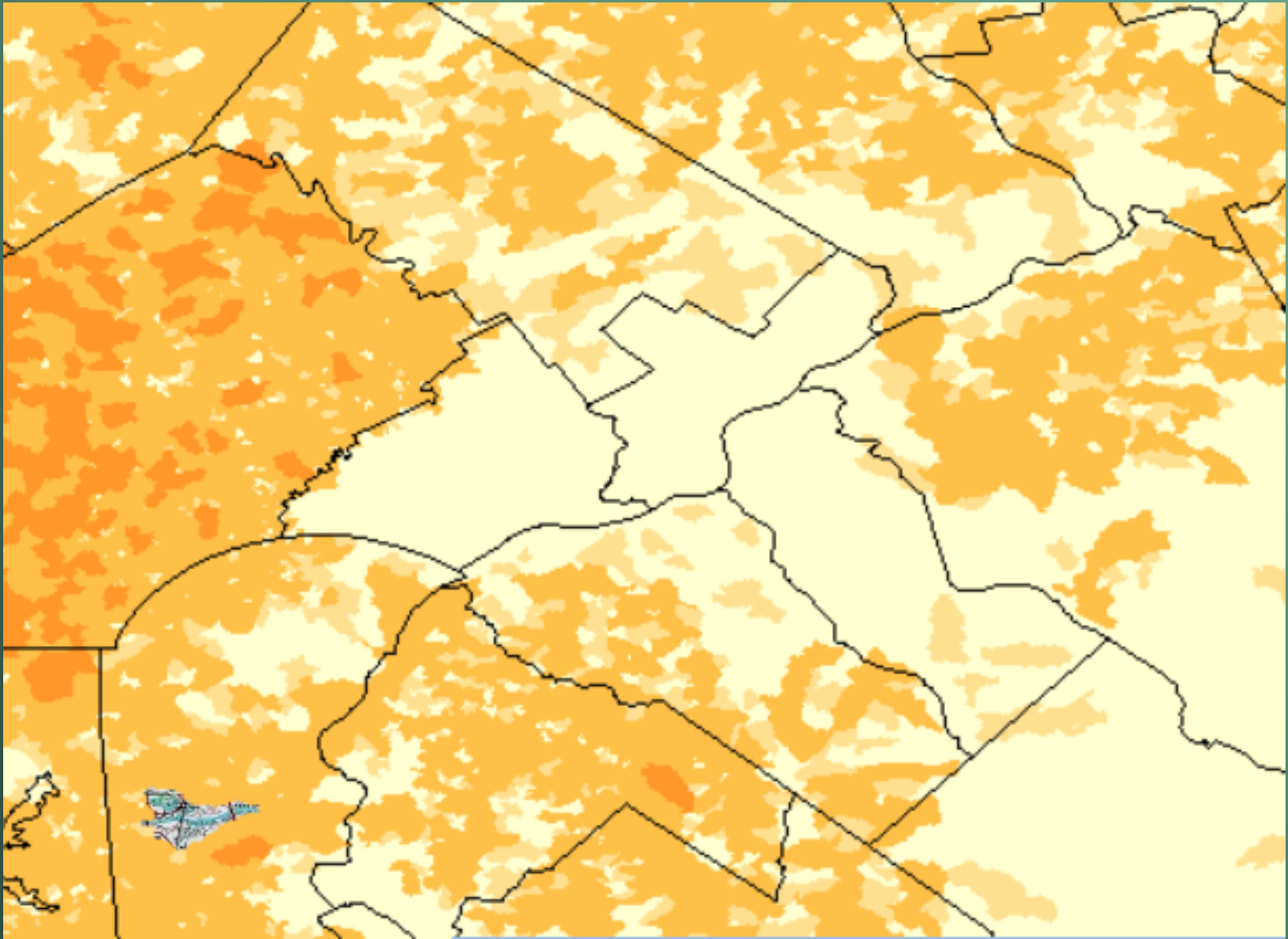




# Estuary Total Nitrogen – all Sources

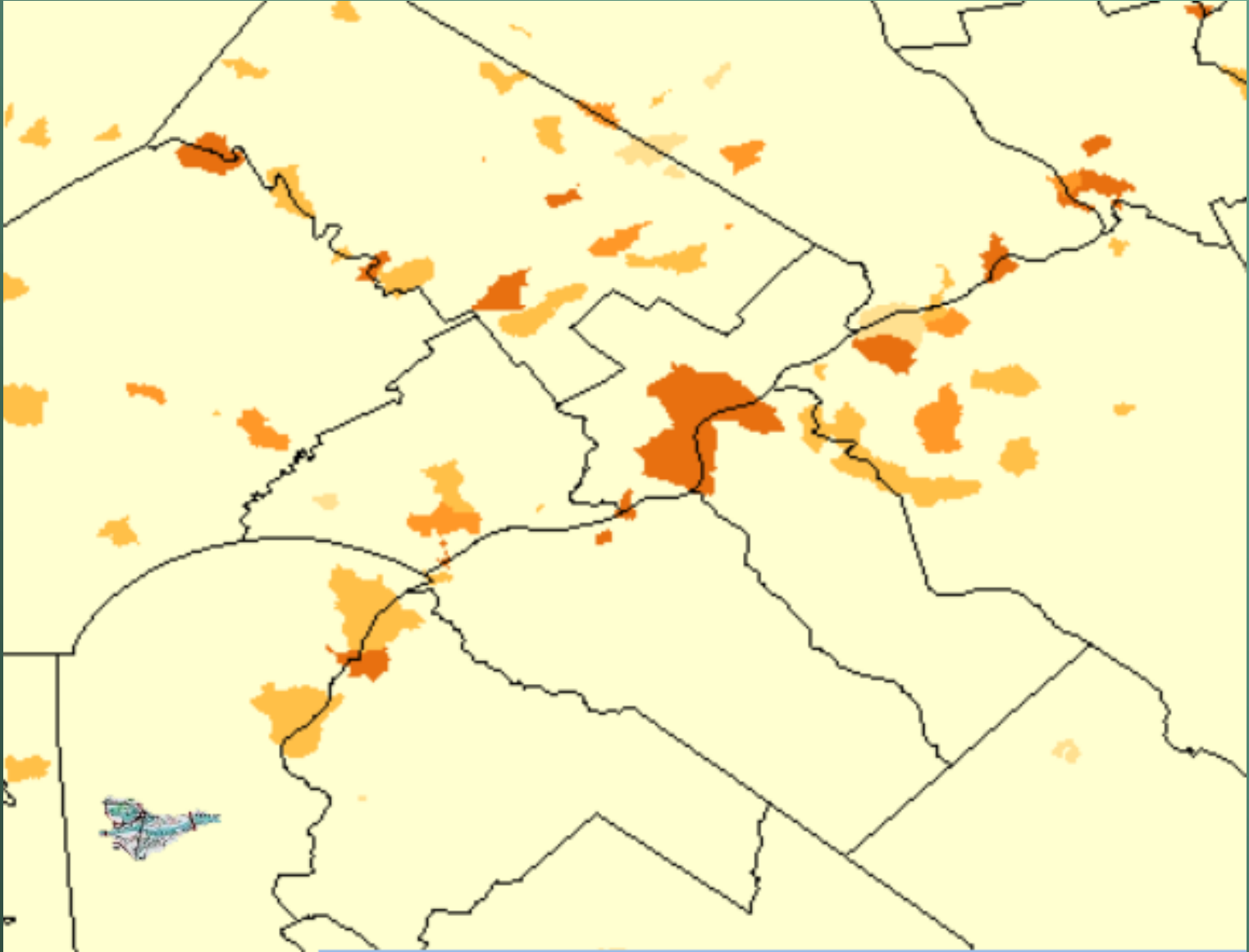


# Incremental Yields from Corn and Soy Fertilizer

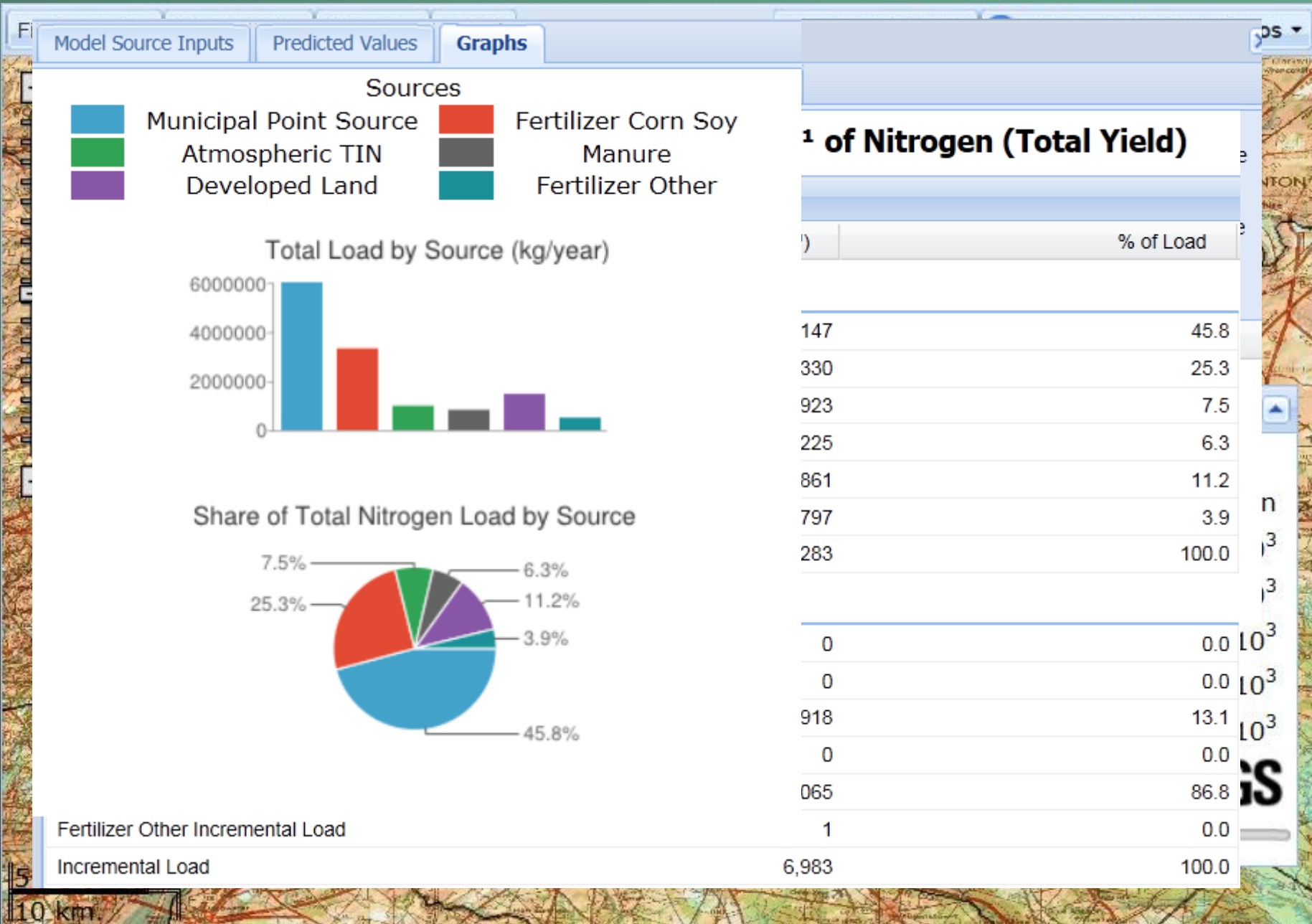





# Incremental Yields from Point Sources



# Selecting Reach Provides Information

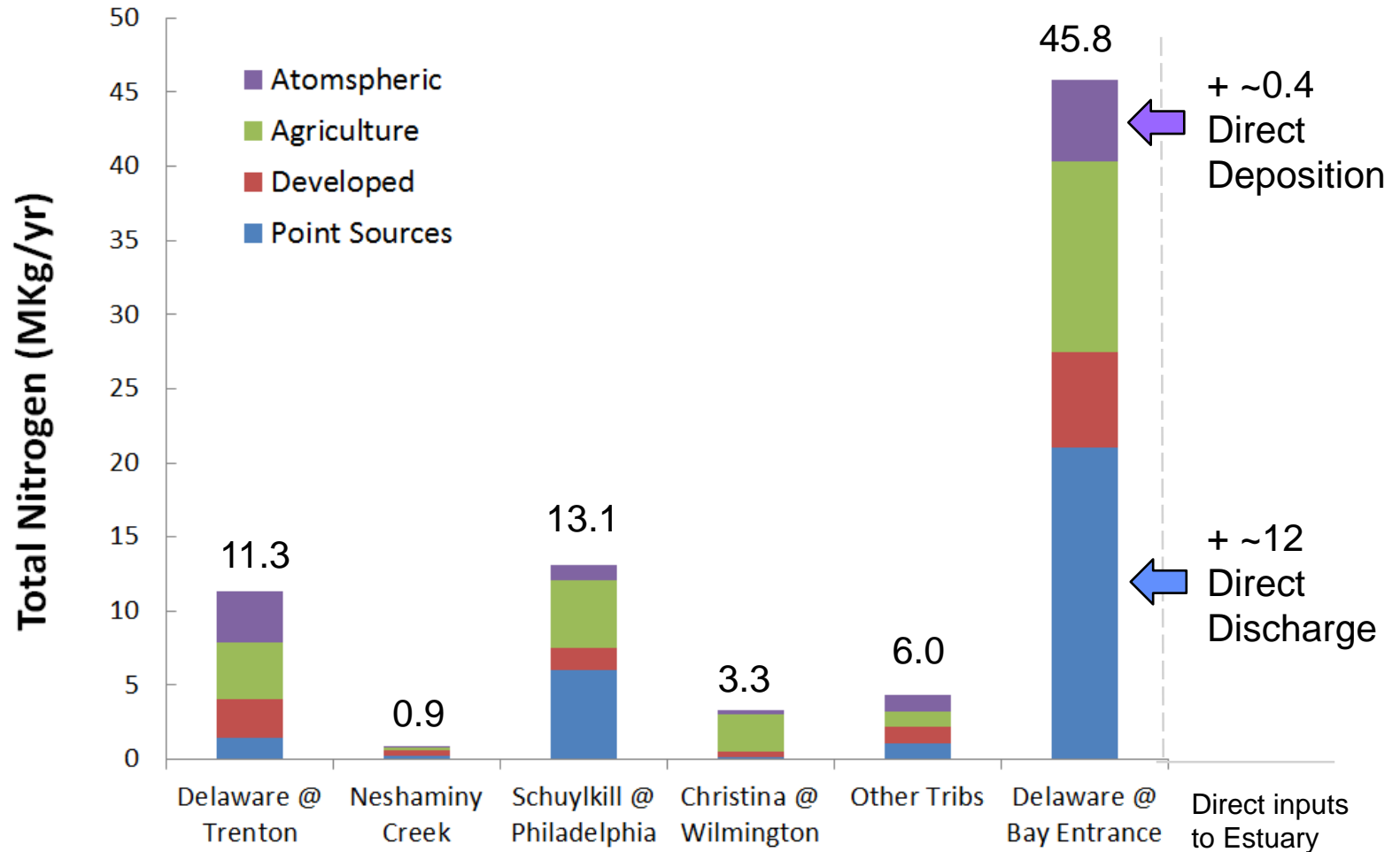


# Exporting Data

Tracking
Change Inputs
Find a reach...
Export Data...
Session ▾
Layers
Hide Header/Footer
 SPARROW Model / Videos ▾

id	Watershed Area (km <sup>2</sup> )	Manure Decayed Incremental Load (kg-year <sup>-1</sup> ) (Original)	Developed Land Decayed Incremental Load (kg-year <sup>-1</sup> ) (Original)	Fertilizer Other Decayed Incremental Load (kg-year <sup>-1</sup> ) (Original)	Incremental Load (kg-year <sup>-1</sup> ) (Original)	Atmospheric TIN Total Load (kg-year <sup>-1</sup> ) (Original)	Manure Total Load (kg-year <sup>-1</sup> ) (Original)	Developed Land Total Load (kg-year <sup>-1</sup> ) (Original)	Fertilizer Other Total Load (kg-year <sup>-1</sup> ) (Original)	Total Load (kg-year <sup>-1</sup> ) (Original)	HUC8	Reach Name	EDACODE
2785638	457.043	32.88671	807.9708	86.22368	1400.354	84786.11	16329.09	219901.5	38262.77	723168.4	2040201	Neshaminy Creek	
2785643	457.846	9.049757	852.4537	23.72666	1113.943	84949.52	16338.14	220754	38286.5	724282.3	2040201	Neshaminy Creek	
2785647	458.028	7.275988	113.6031	19.07673	227.9475	84989.97	16345.42	220867.6	38305.57	724515.2	2040201	Neshaminy Creek	
2785648	5.941	7.530968	49.42114	19.74576	170.3233	1220.715	188.4451	4294.556	494.0802	7557.579	2040201		
2785646	464.095	4.912335	40.44025	12.87936	122.2955	86239.31	16538.77	225202.6	38812.53	732195.1	2040201	Neshaminy Creek	
2785896	25.59	1031.579	12128.14	2704.664	28055.34	4747.283	1031.579	12128.14	2704.664	28055.34	2040201	Core Creek	
2785650	489.83	4.511381	28.87963	11.82942	110.4151	91019.23	17574.86	237359.6	41529.03	760360.8	2040201	Neshaminy Creek	
2785649	1.804	39.48627	1279.461	103.5289	2102.526	395.1249	39.48627	1279.461	103.5289	2102.526	2040201		
2785666	496.074	112.7366	2557.123	295.58	4712.176	92347.61	17727.09	241196.2	41928.14	767175.6	2040201	Neshaminy Creek	
2786222	1.806	35.63372	2013.69	93.42793	2776.221	376.3429	35.63372	2013.69	93.42793	2776.221	2040201	Mill Creek	
2786227	9.622	57.03207	7422.481	149.531	9538.375	1861.52	91.47081	9368.642	239.8259	12221.49	2040201	Mill Creek	
2786230	4.287	25.18005	5101.411	62.35452	6211.923	846.0724	25.18005	5101.411	62.35452	6211.923	2040201		
2786253	4.862	5.296242	802.7515	13.88698	980.858	966.7791	30.47629	5904.163	76.2415	7192.781	2040201		
2786229	7.316	24.97658	1993.044	65.48571	2742.001	1429.435	54.96072	7801.863	140.496	9818.628	2040201		
2786228	17.469	10.64953	404.7009	27.92087	633.9743	3387.588	156.3146	17485.33	406.2521	22558.73	2040201	Mill Creek	
2785687	19.507	31.6219	1494.31	82.90846	2239.364	3752.265	186.1984	18785.21	484.6432	24547.26	2040201	Mill Creek	
2786209	4.103	126.2049	3870.482	330.8921	6056.509	818.2607	126.2049	3870.482	330.8921	6056.509	2040201	Ironworks Creek	
2786210	1.975	61.25943	2126.461	160.6144	3215.728	425.3577	61.25943	2126.461	160.6144	3215.728	2040201		
2786215	6.883	14.63928	855.7486	38.38258	1183.603	1405.601	201.0158	6817.894	527.0371	10402.04	2040201	Ironworks Creek	
2786214	2.447	80.71099	2318.399	211.6131	3698.874	505.7553	80.71099	2318.399	211.6131	3698.874	2040201		

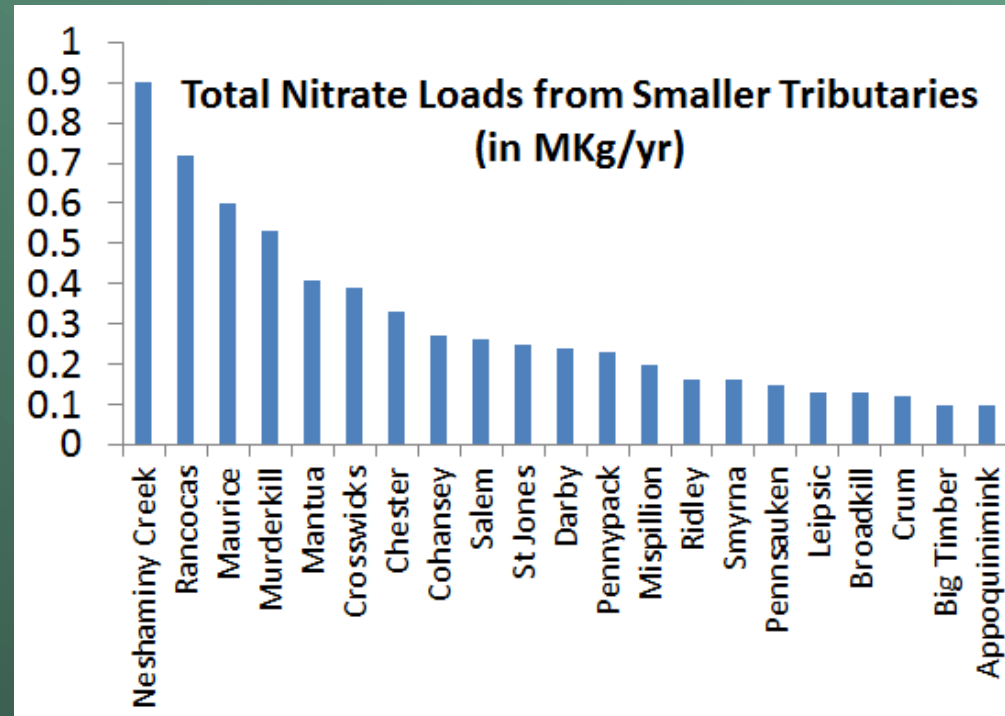
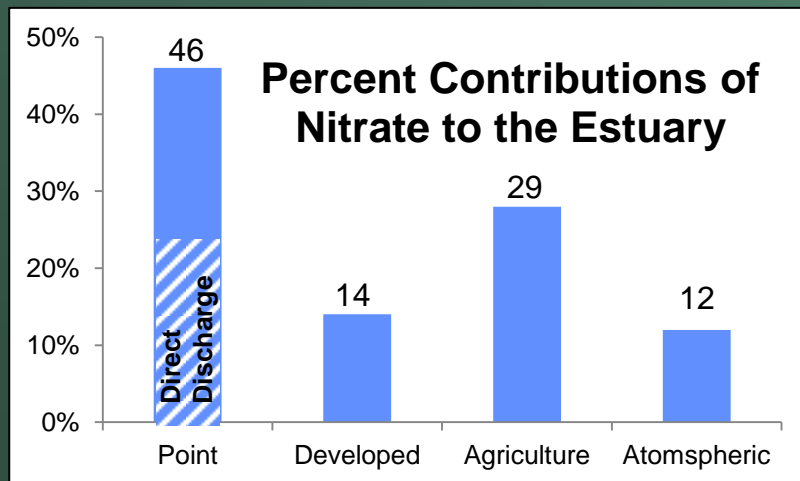
# Predicted Nitrate Loads to Upper Delaware Estuary





# Total Nitrate Budget for Delaware Estuary

- ~28 MKg/yr from Major tribs (Del R, Schuylkill, & Christina)
  - ~12 MKg/yr from direct point-source discharge to estuary
  - ~7 MKg/yr from smaller tributaries
  - <1 MKg/yr from direct atmospheric deposition to estuary
- 
- ~48 MKg/yr TOTAL



# Summary

- SPARROW nitrate and phosphorus models developed for northeastern US at 1:100,000 scale.
- On-line DSS allows user to explore and download data on loads and yields from varying sources for watersheds of interest.
- Examples were shown for nitrate in the Delaware Estuary, but similar analyses could be conducted at large or small watersheds throughout the basin.
- Phosphorus model not shown, but available.

# For More Information

## SPARROW Webpage

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

- Publications and input data for N and P models
- On-line DSS tool

## Contacts

### Rich Moore

- USGS New Hampshire Water Science Center
- [rmoore@usgs.gov](mailto:rmoore@usgs.gov), 603-226-7825

### Jeff Fischer

- USGS New Jersey Water Science Center
- [fischer@usgs.gov](mailto:fischer@usgs.gov), 609-771-3953