

# Nitrogen in Wisconsin's Environment

- surface water, groundwater and air; status and relative sources of contribution

# Speakers

- Dale Robertson, USGS
- Matt Diebel, DNR
- Jill Jonas, DNR
- Roy Irving, DHS
- David Panofsky, DNR

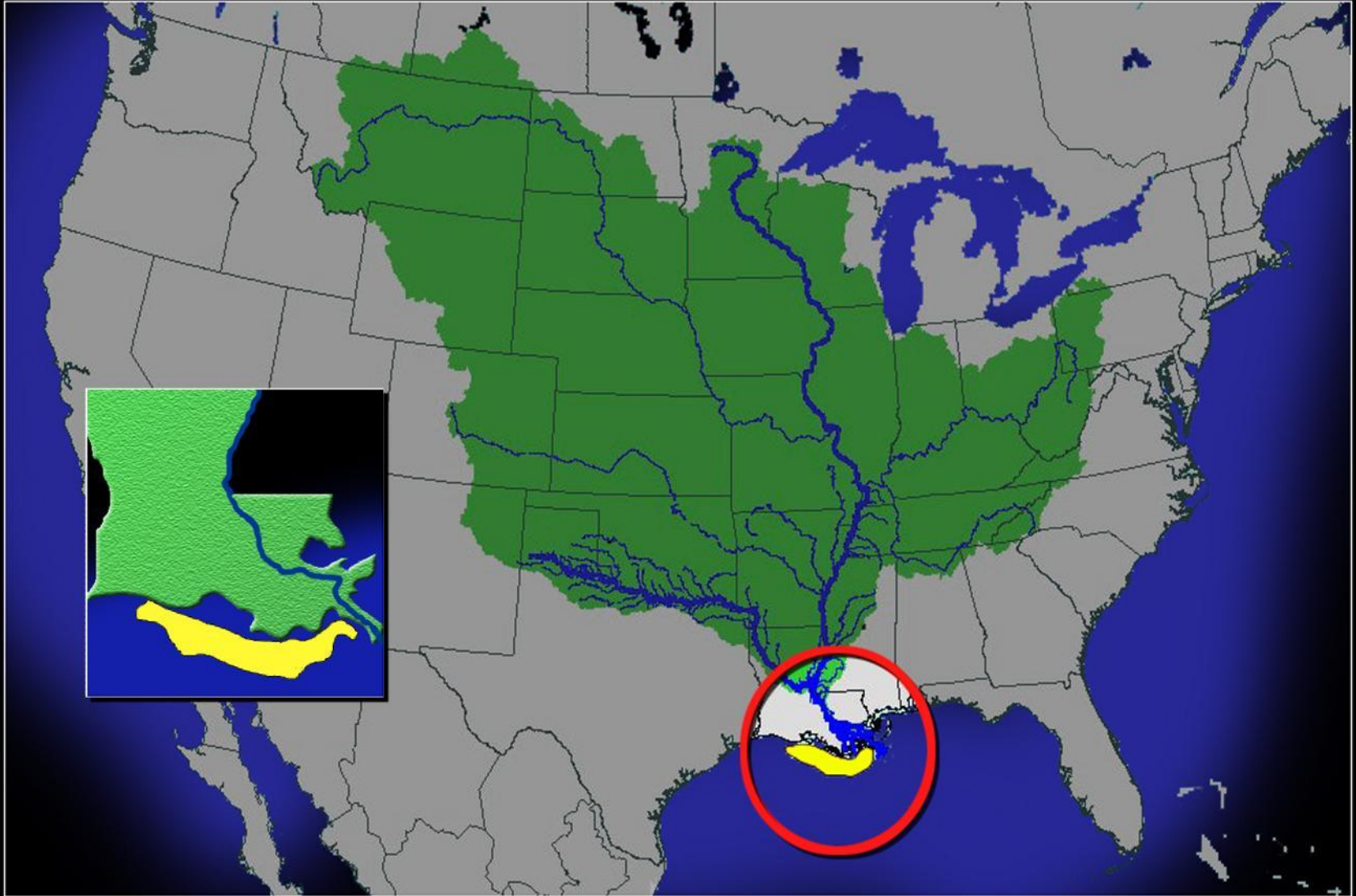
# **Dale M. Robertson**

## **U.S. Geological Survey, Wisconsin Water Science Center**

Wisconsin Nitrogen Science Summit  
Madison, Wisconsin  
March 28, 2014  
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(608) 821-3867



# Gulf Hypoxia



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

# Approach - SPARROW Water-Quality Model -

SPAtially Referenced Regression on Watershed Attributes

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

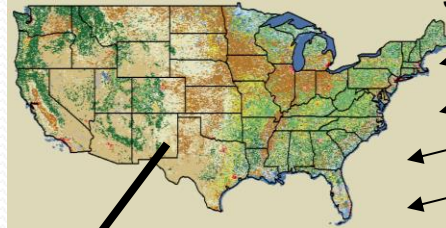
Monitoring Data  
Annual Loads



*Y variable*

Geographic Data Layers

Land Use



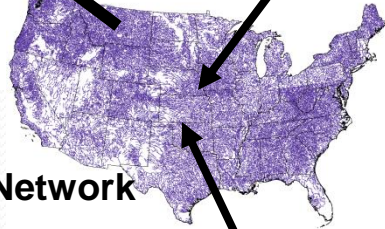
Sources

Fertilizers

Manure

Point  
Sources  
Atmospheric  
Dep.

Stream Network



Soils



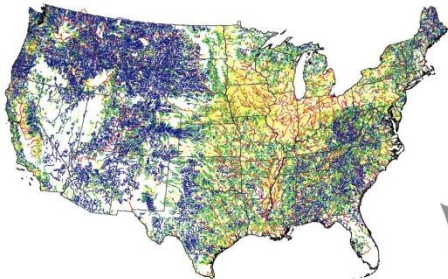
Stream & Reservoir  
Water Velocity



*X variables*

Model Predictions

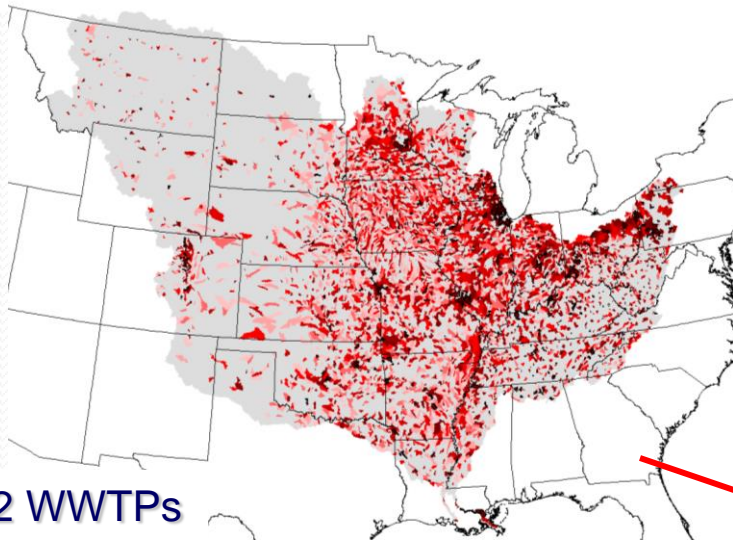
62,000 Stream Reaches



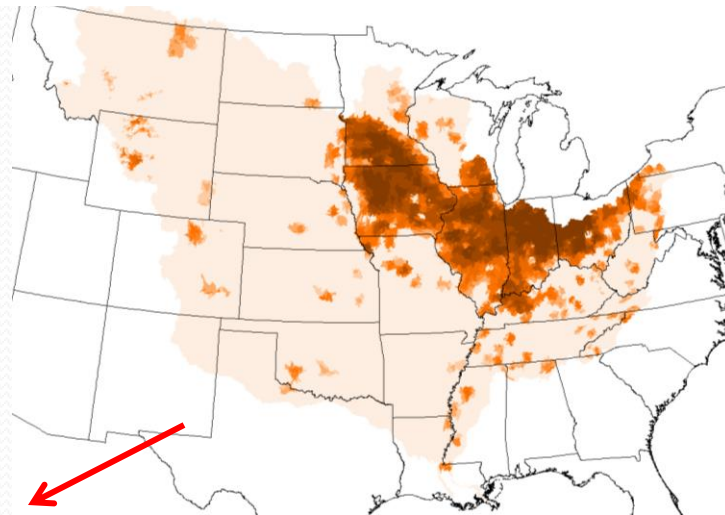
- Mass Balance Model with spatially variable deliveries. Hybrid statistical/mechanistic process structure. Data-driven, nonlinear estimation of parameters
- Separates land and in-stream processes
- Predictions of mean-annual flux reflect long-term, net effects of nutrient supply and loss processes in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

# MARB SPARROW Model Calibration

One Source: 2002 Point (WWTP) TN inputs, kg



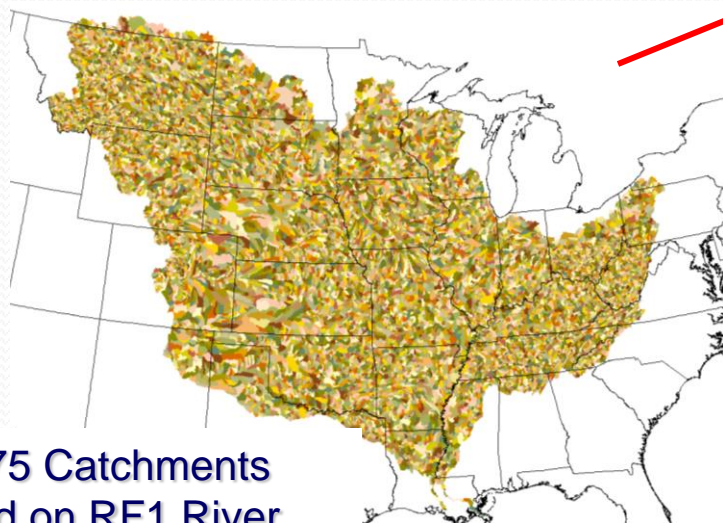
One Land-to-Water Delivery: Tile Drains



9,182 WWTPs

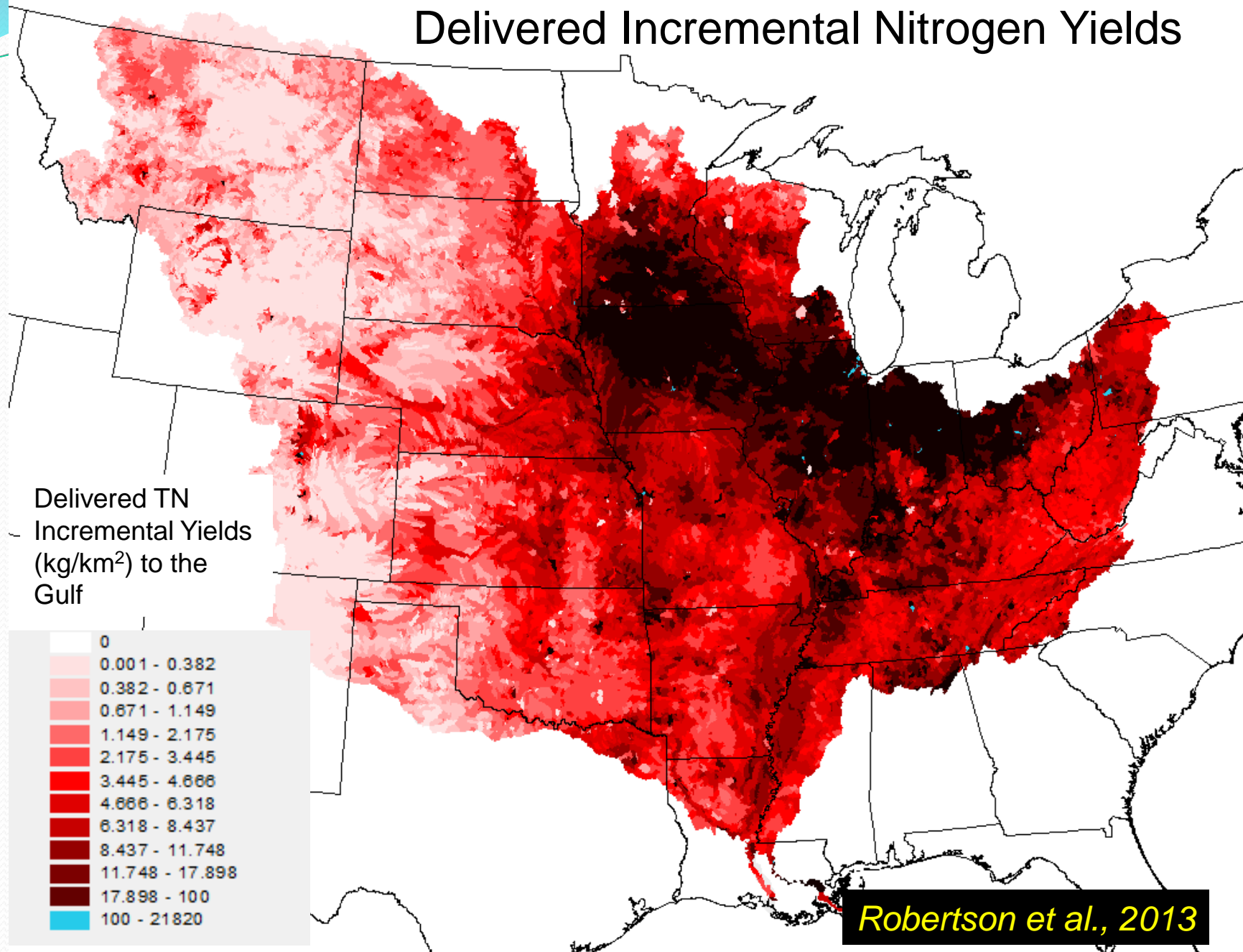
Calibration

24,475 Catchments  
based on RF1 River  
Network



Long-term detrended Loads for 856 sites

# Delivered Incremental Nitrogen Yields



Zoom History



Available Layers

Nutrient model results

- ☐ Total Phosphorus
- ☐ Total Nitrogen

Area of Interest

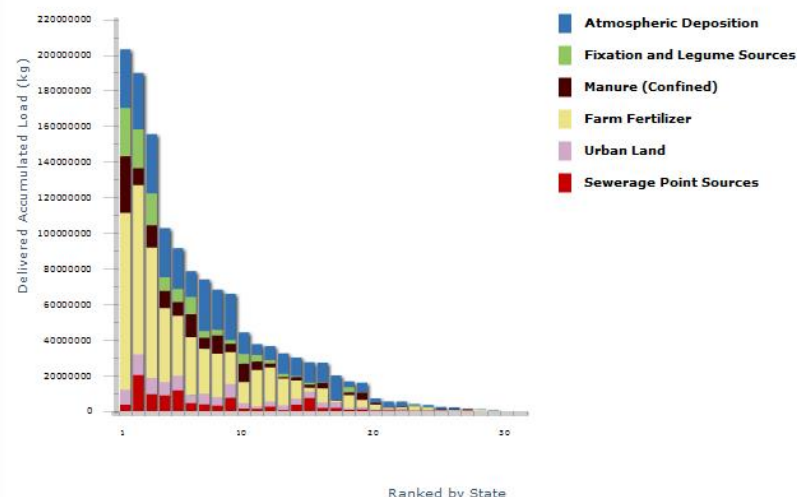
Select State

Select Main Watershed

Select HUC8

Select Tributary Outlet

2002 Total Nitrogen Delivered Accumulated Load (kg)

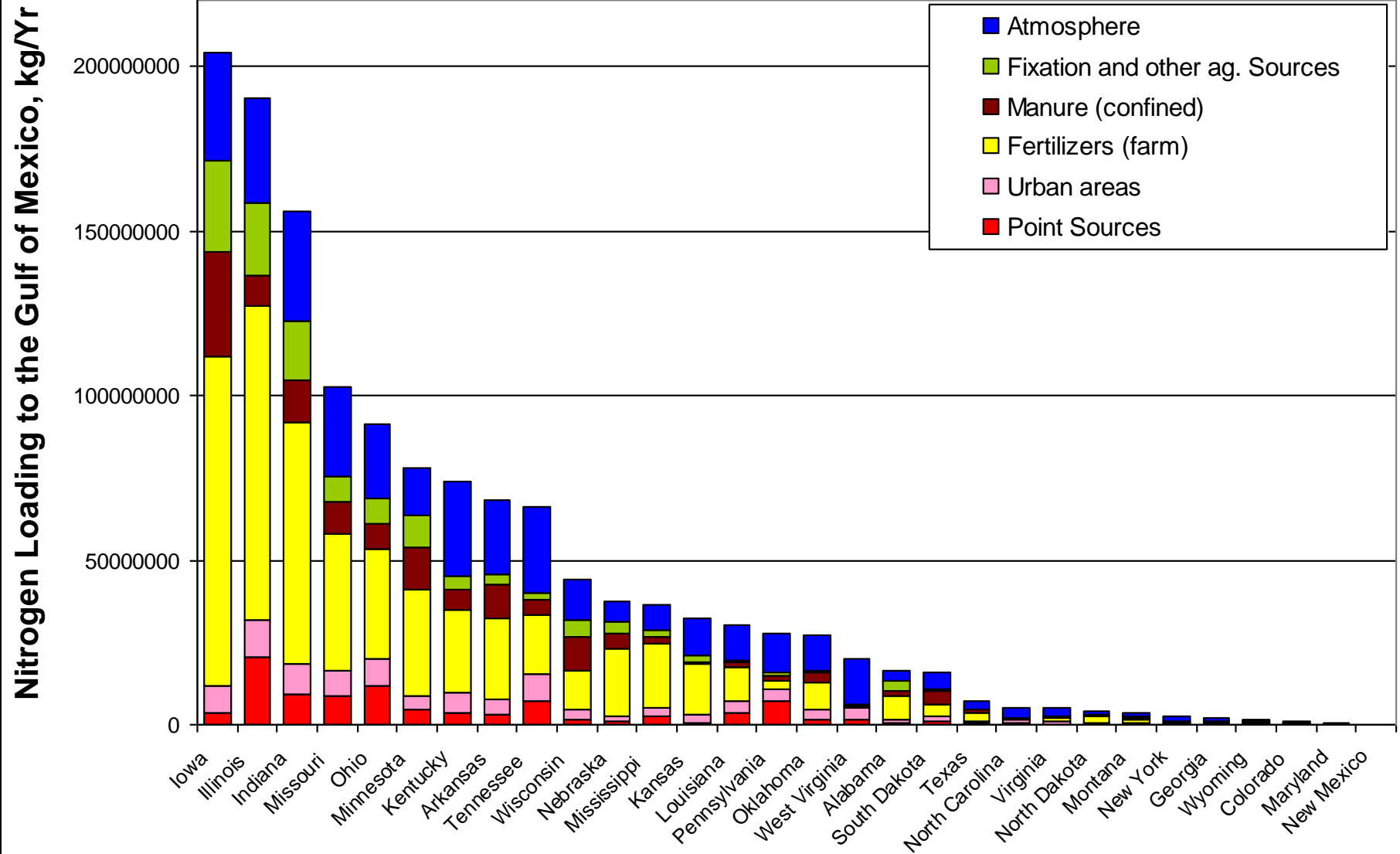


Export Data

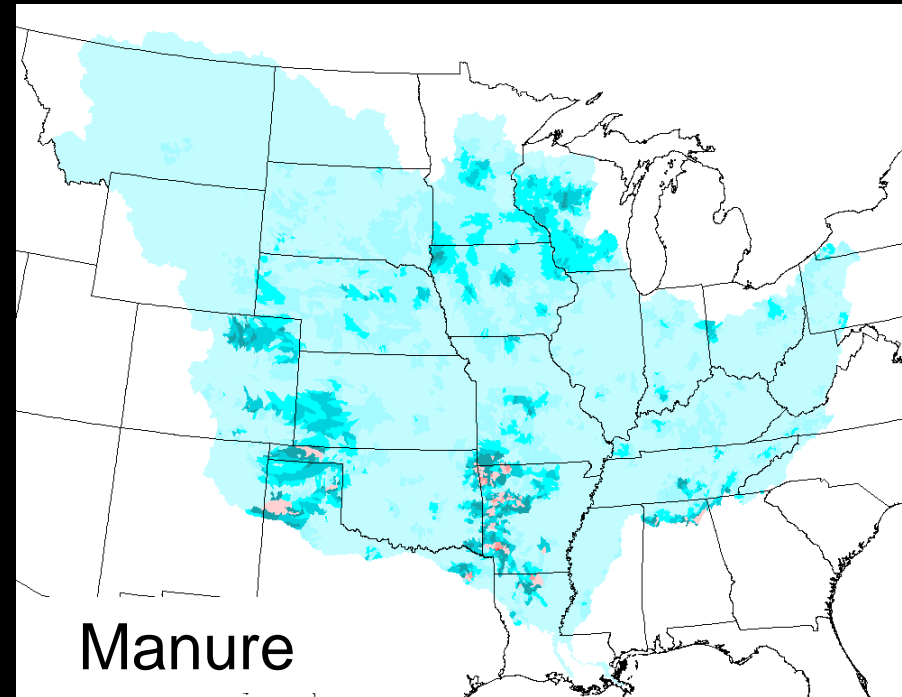
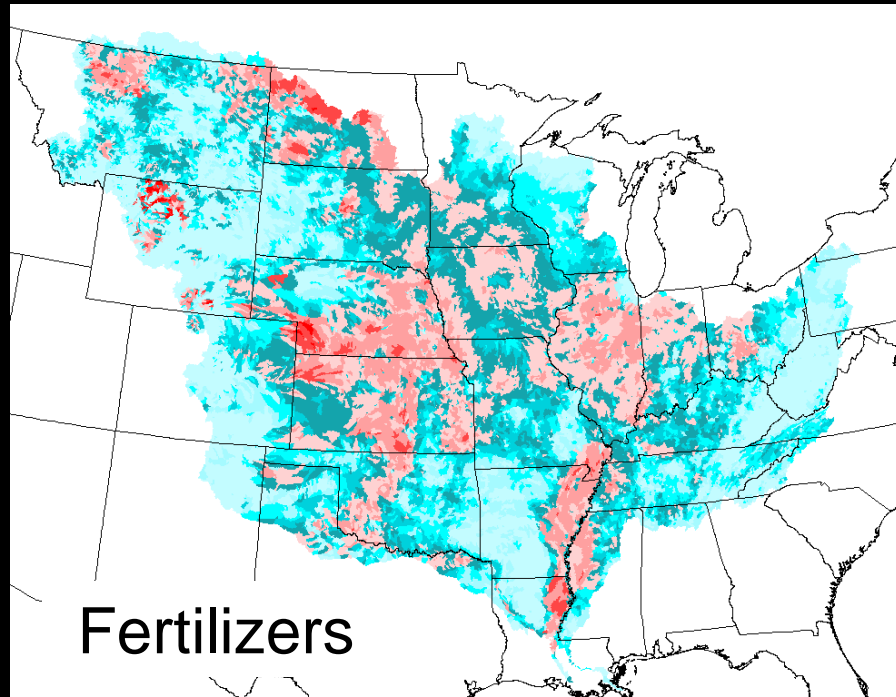
Delivered Accumulated Load for entire view

View Nutrient Totals

# Preliminary Ranking of State Contributions to the Gulf of Mexico from the MARB



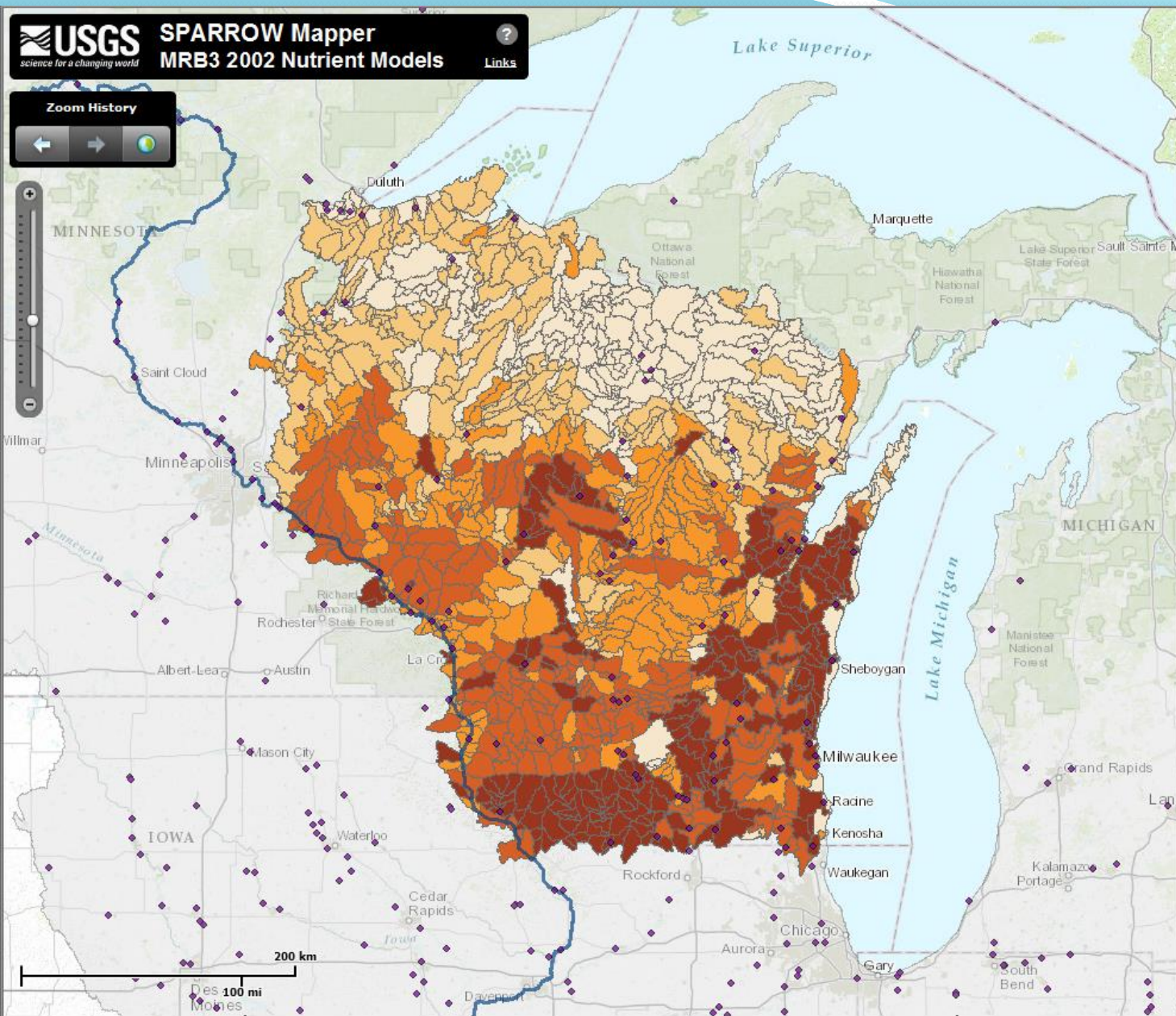
# Nitrogen Sources



Percent of  
Source to Total  
Incremental  
Load



Zoom History



Available Layers

Nutrient model results

- ☐ Total Phosphorus
- ☒ Total Nitrogen

Area of Interest

Wisconsin

Select Major Watershed

Select HUC

Select Tributary

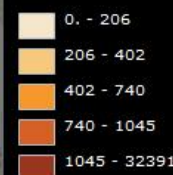
Mapped Metric

Accumulated Yield

Group results by

Catchments

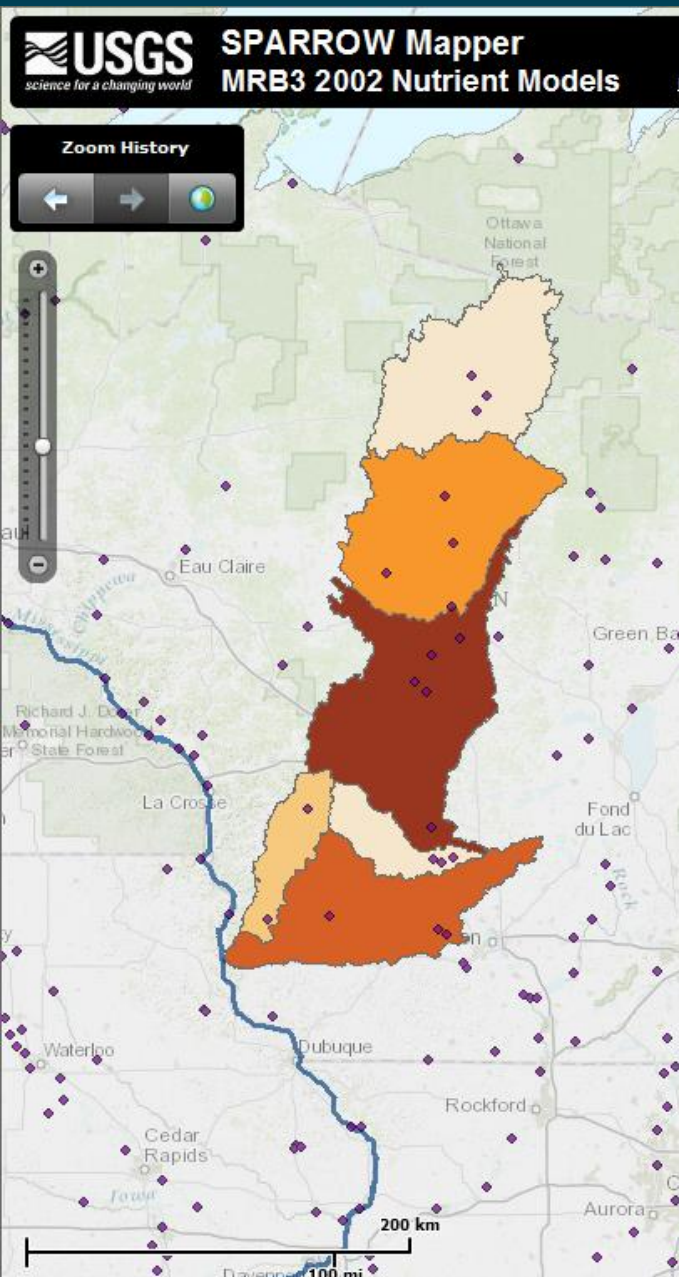
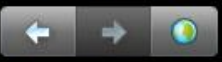
2002 Total Nitrogen Accumulated Yield (kg/km²) by Catchments



Additional Layers

- ☒ MRB3 Area
- ☒ Stream reaches (RF1)
- ☒ Main Stems
- ☒ SPARROW calibration sites

Zoom History



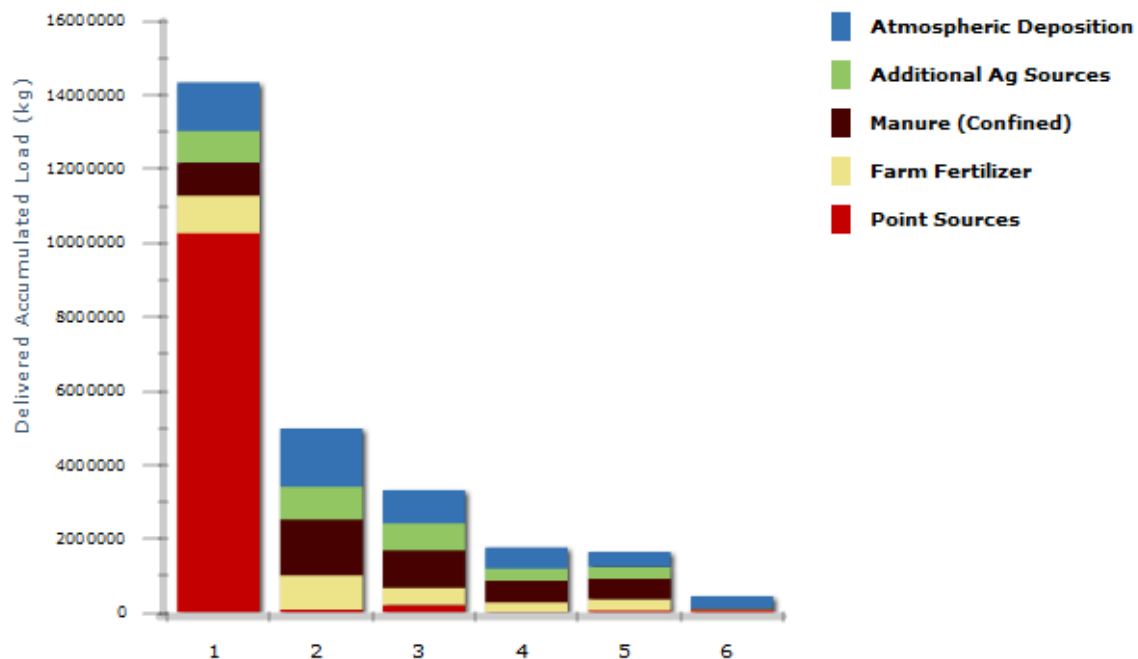
Available Layers

Nutrient model results

- ☐ Total Phosphorus
- ☒ Total Nitrogen

Area of Interest

**2002 Total Nitrogen Delivered Accumulated Load (kg) by HUC8s**



Ranked by HUC

Export Data

Delivered Accumulated Load for entire view

View Nutrient Totals

# Nitrogen in Wisconsin Streams

A photograph of a rural landscape. In the foreground, a small stream flows through a grassy field. Several black and white cows are grazing in the field. In the background, there is a dense line of trees and a clear sky.

Matt Diebel, Wisconsin Department of Natural Resources  
Nitrogen Science Symposium, March 28, 2014

# Topics

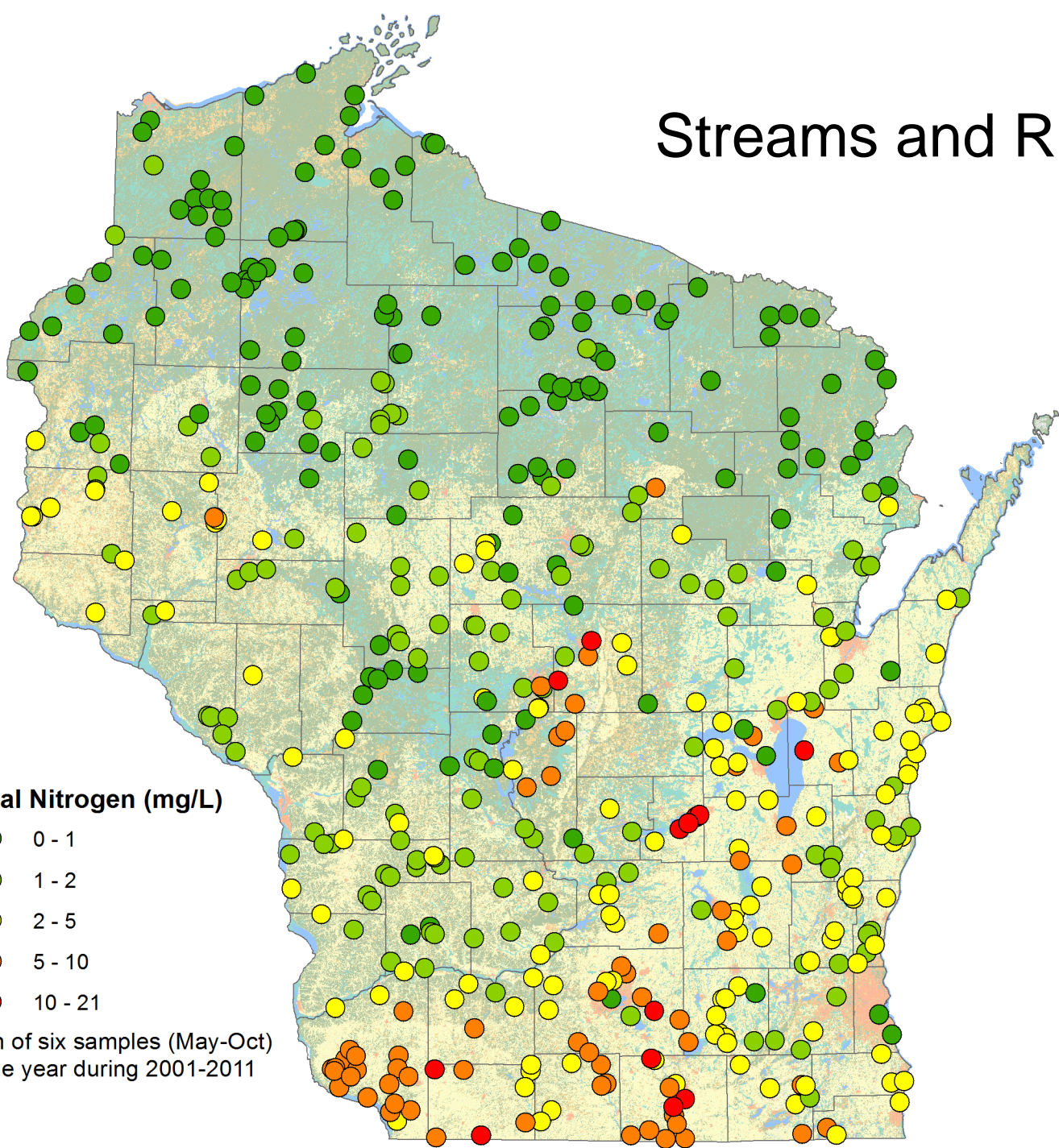
1. Spatial patterns in nitrogen in Wisconsin streams
2. Temporal trends in nitrogen in Wisconsin rivers
3. Effects of nitrogen on aquatic biota

# Streams and Rivers

**Total Nitrogen (mg/L)**

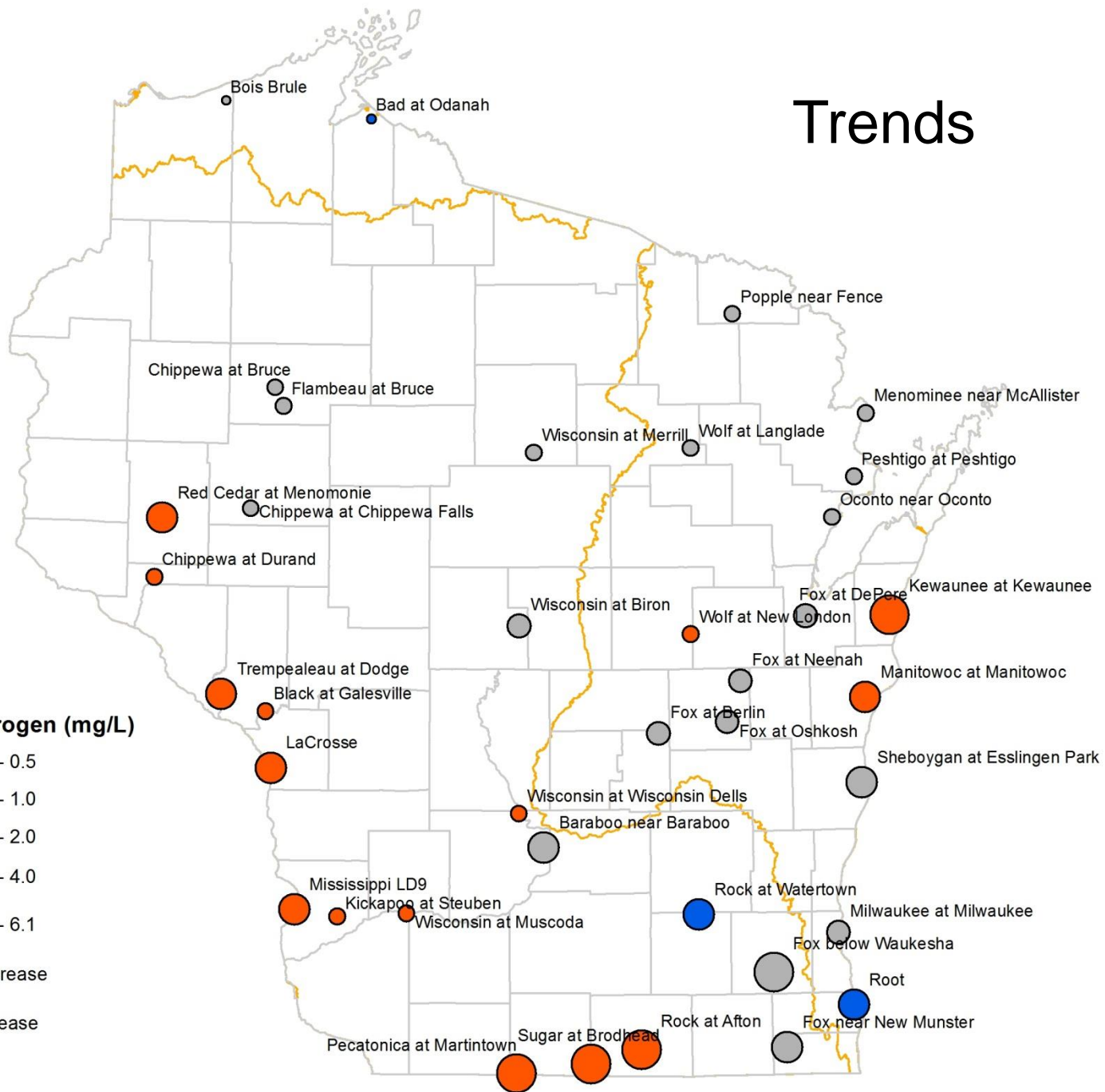
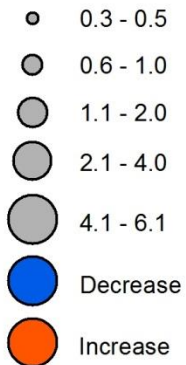
- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 21

Median of six samples (May-Oct)  
in one year during 2001-2011

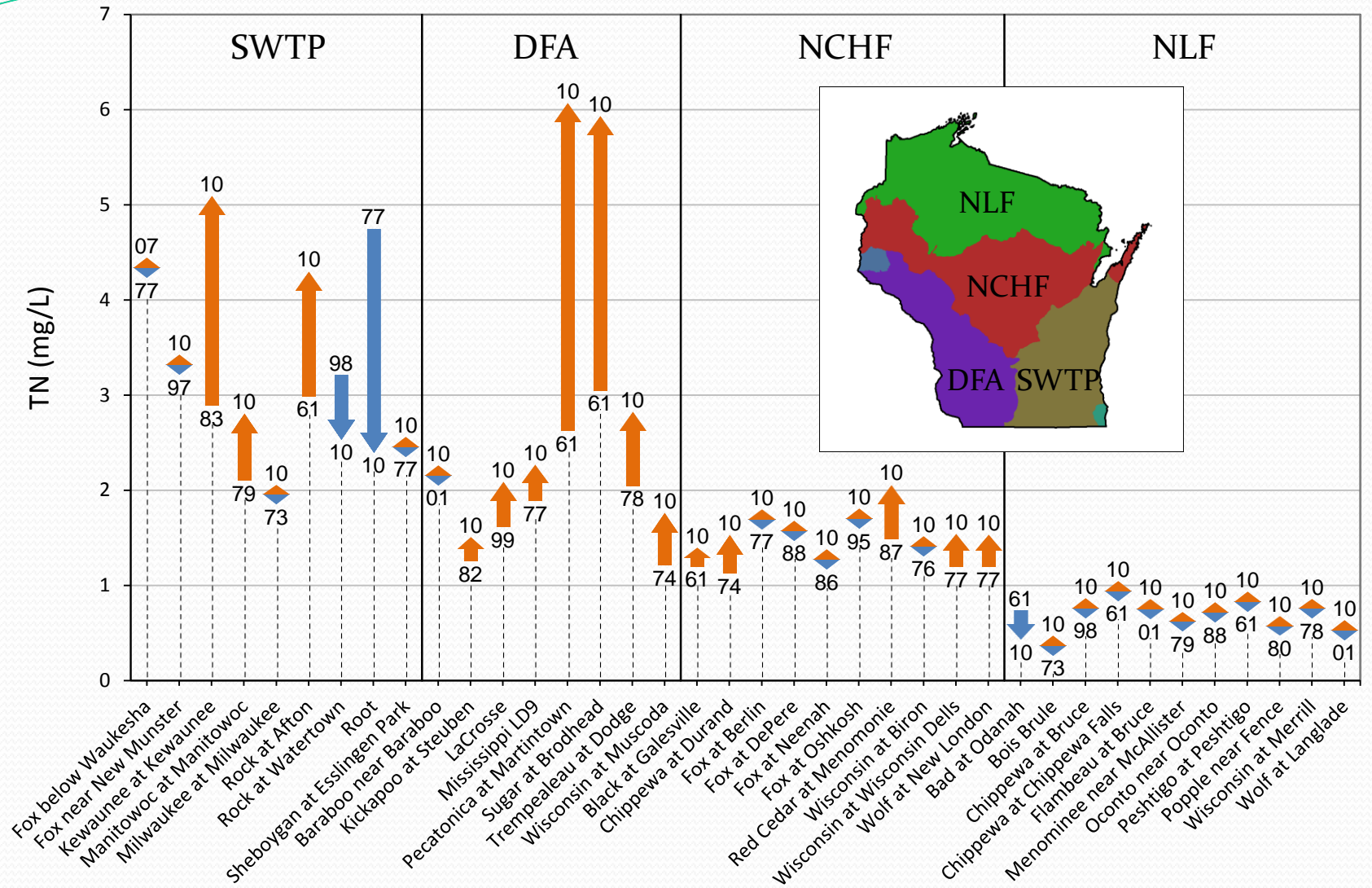


# Trends

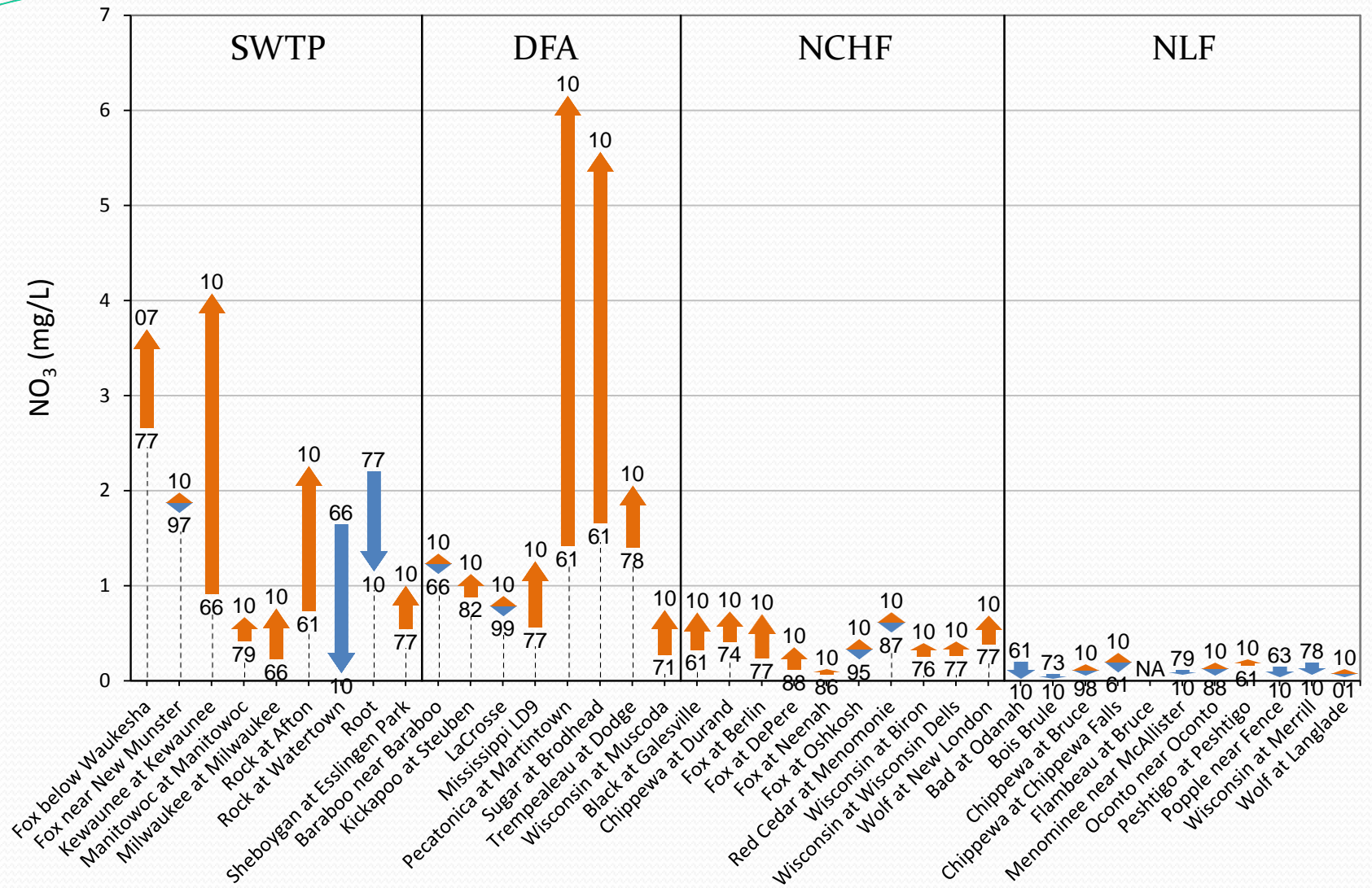
## Total Nitrogen (mg/L)



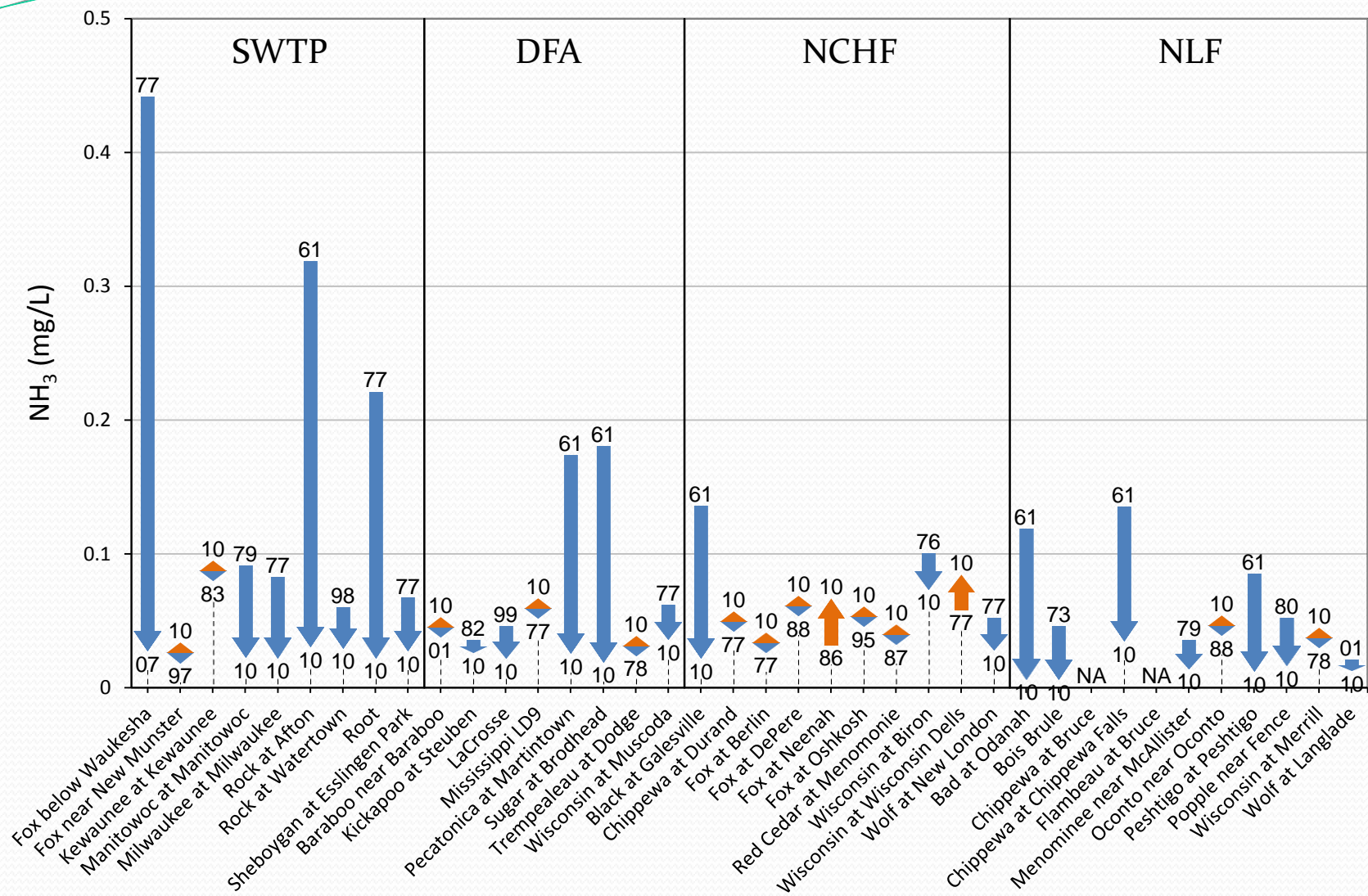
# Total Nitrogen



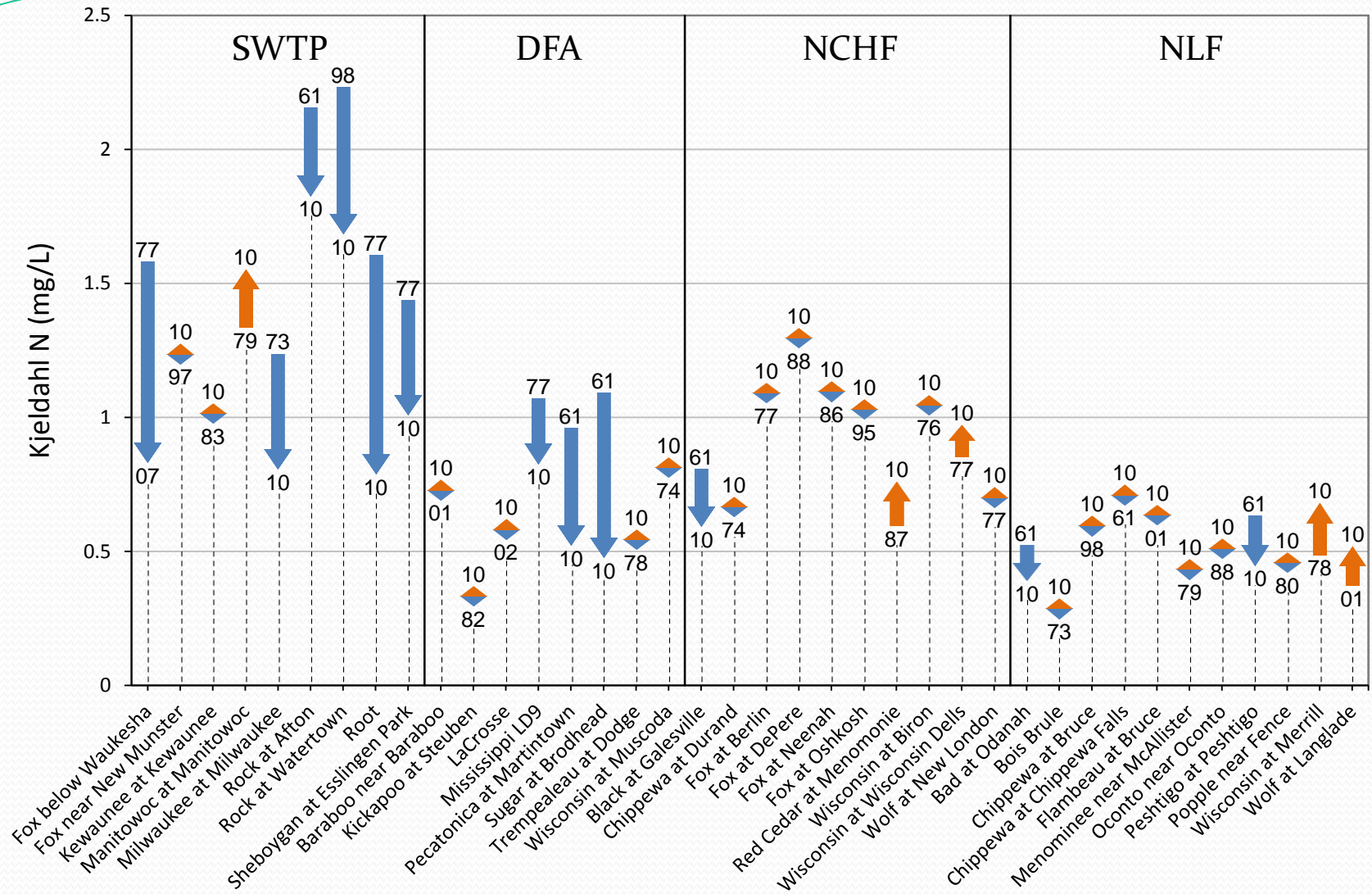
# Nitrate



# Ammonia

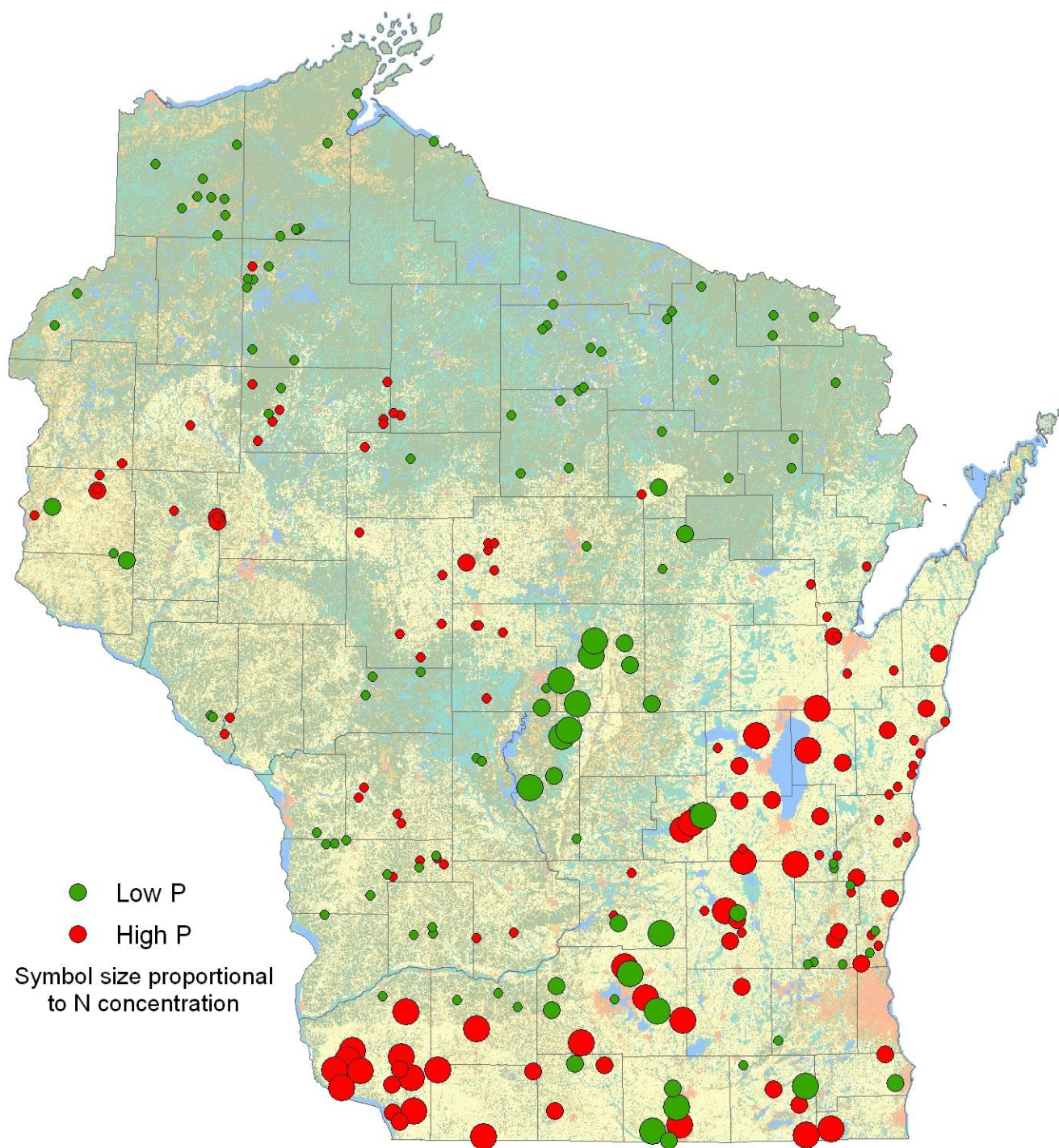


# Kjeldahl Nitrogen



Is too much nitrogen a problem here?





# Preliminary Models

Group	Metric	TP	TN	Substrate	Size
Diatoms	DNI				
	DSI				
	DBI				
Invertebrates	HBI				
	EPTN				
	EPTTX				
	SCRAP				
	SHRED				
	TAXAN				
Fish	IBI				
	CARN				
	INSECT				
	OMNI				
	INTOL				
	TOL				
	FISHN				
	FISHSPEC				

# Summary

## 1. Spatial patterns in nitrogen in Wisconsin streams

- Intensive row crop agriculture
- Permeable soils

## 2. Temporal trends in nitrogen in Wisconsin rivers

- Nitrate increasing
- Ammonium has decreased

## 3. Effects of nitrogen on aquatic biota

- Preliminary results indicate that stream diatoms, invertebrates, and fish are more sensitive to P than N



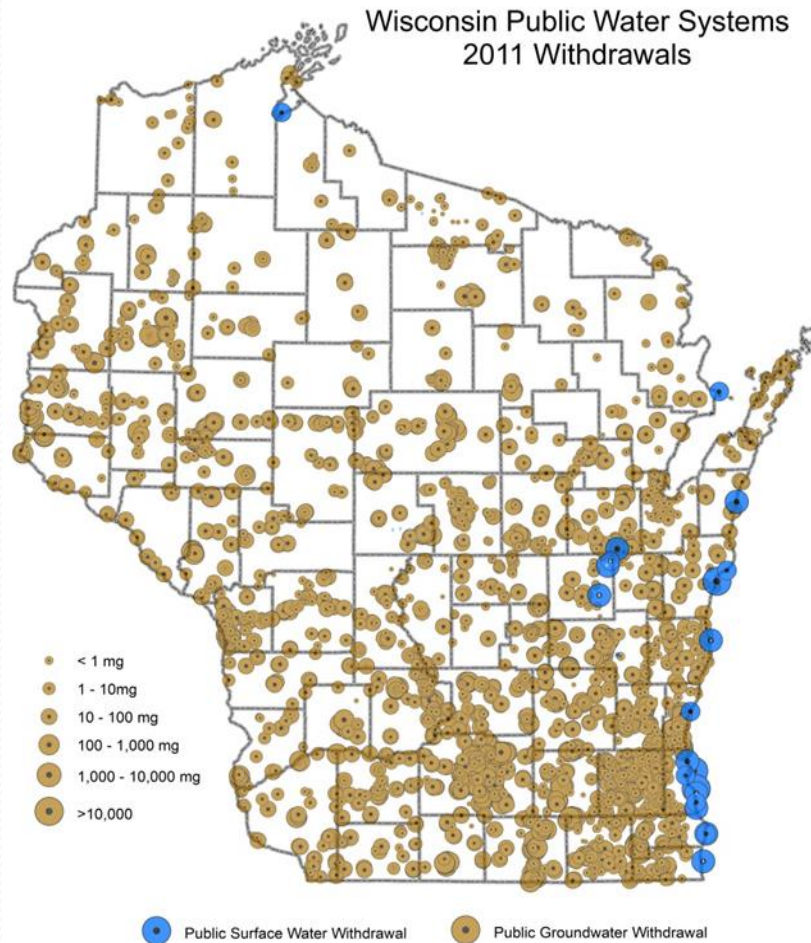
# Nitrate in Drinking Water & Groundwater

Jill Jonas

Director, Drinking Water & Groundwater

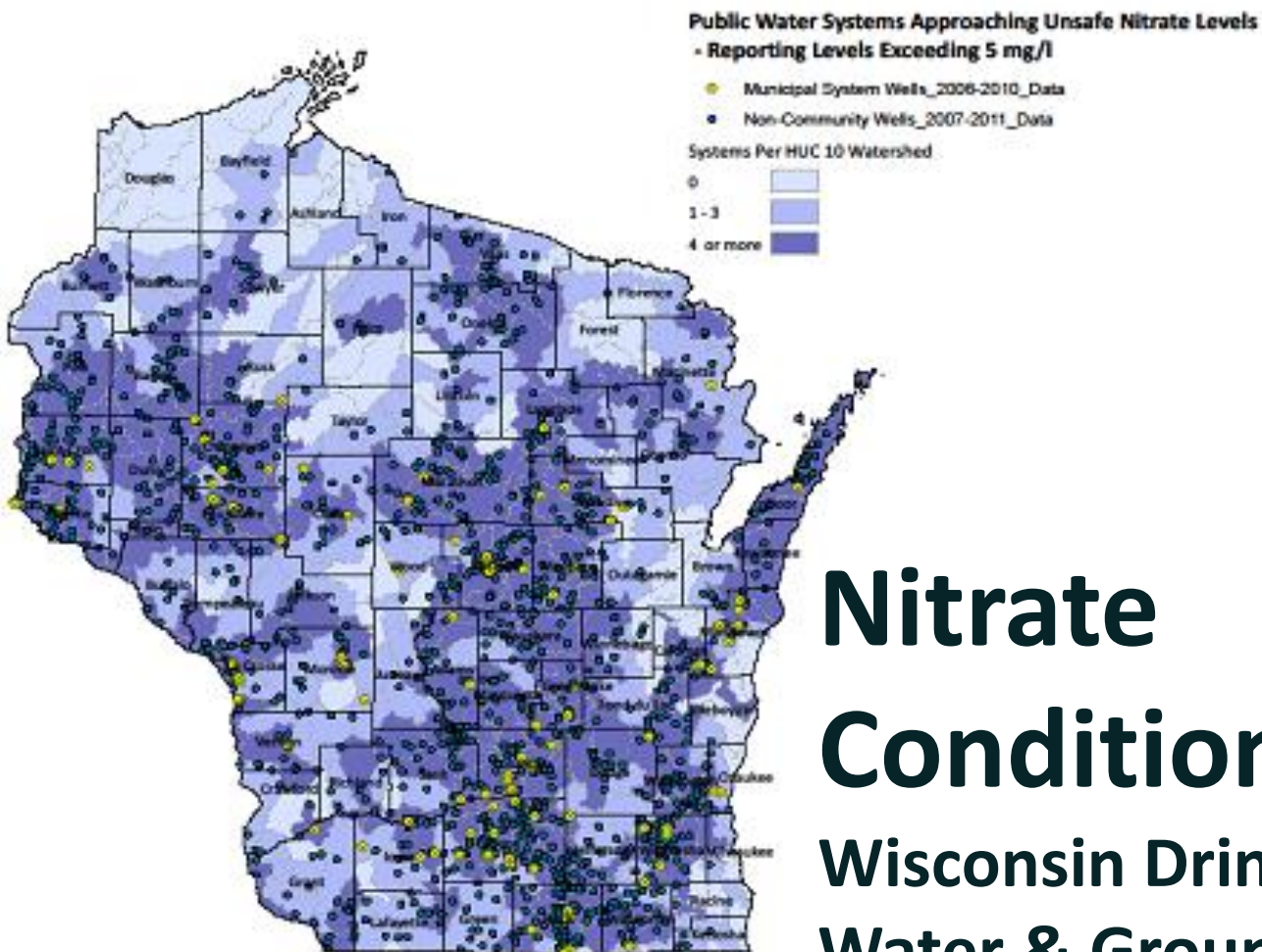


# Wisconsin depends on groundwater



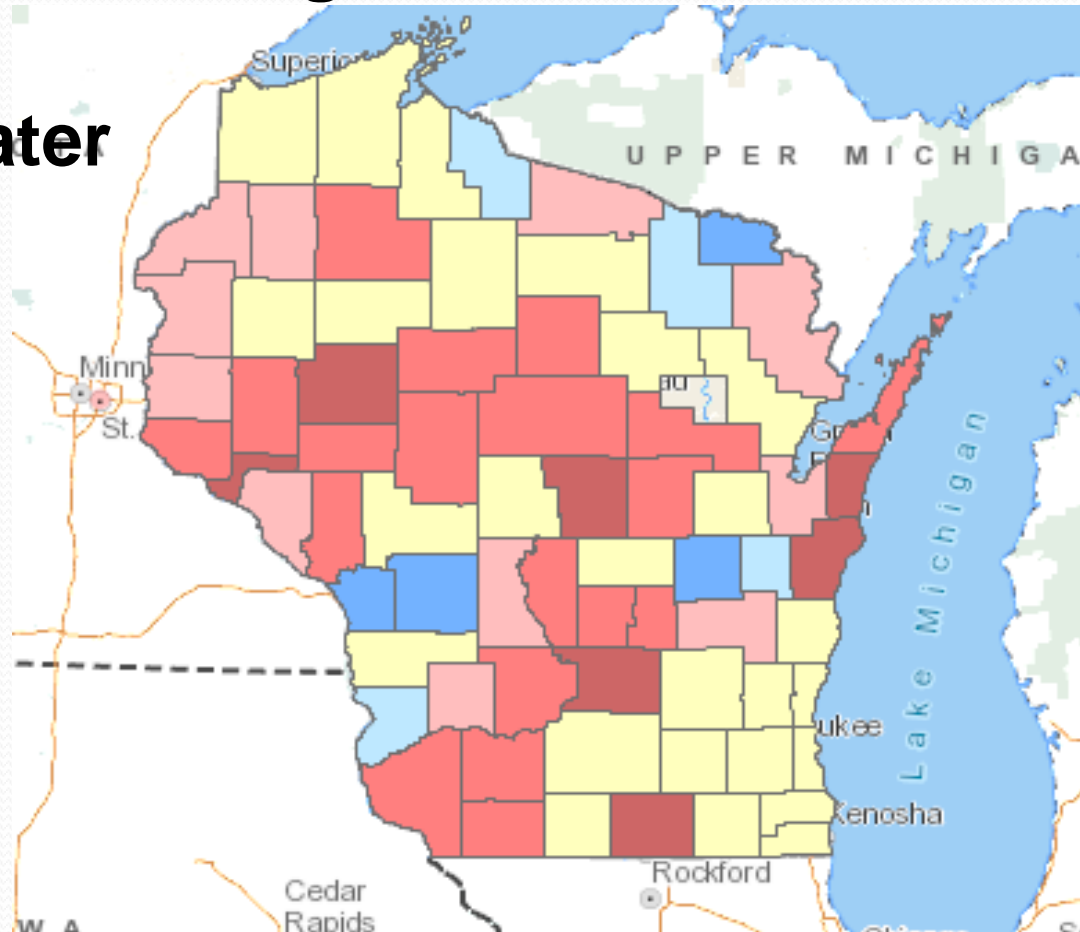
# What happens at 10





# Nitrate Condition of Wisconsin Drinking Water & Groundwater

# Nitrate Trends in Wisconsin Drinking Water & Groundwater



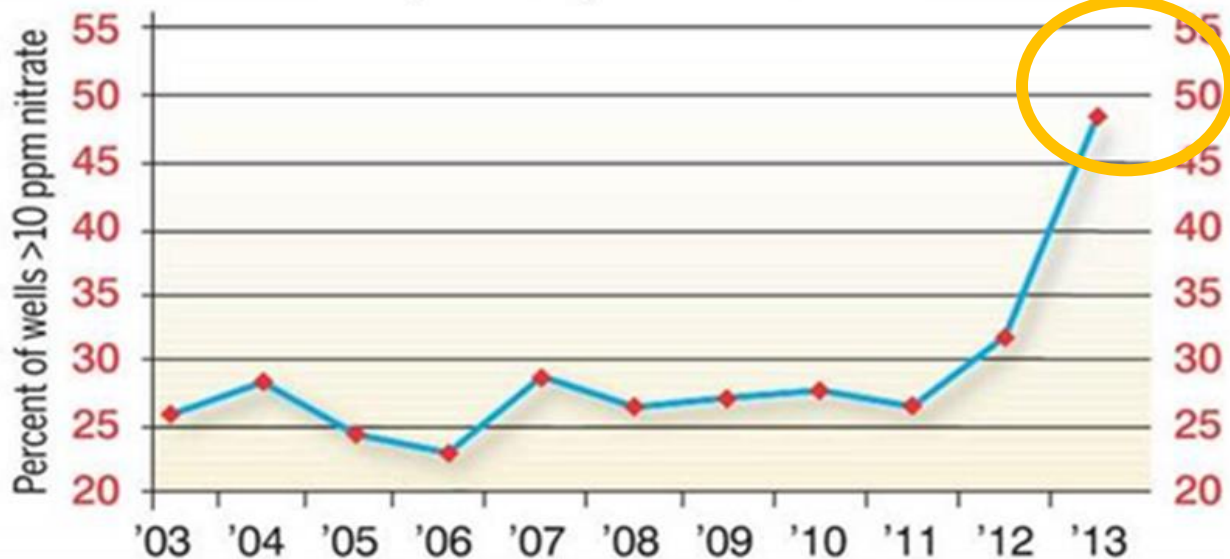
# The Gazette

SERVING JANESVILLE, ROCK AND WALWORTH COUNTIES

ROCK COUNTY

## Percent of wells with unsafe nitrate levels

Samples analyzed at RCHD lab



SOURCE: Rock County Health Department Tony DiNicola/[tdinicola@gazettextra.com](mailto:tdinicola@gazettextra.com)



# Potential Public Health Impacts from Nitrate in Drinking Water



Roy Irving, PhD  
Toxicologist

Wisconsin Department of Health Services  
Division of Public Health

March 28, 2014

# Three Key Points

- Nitrate exposure poses a serious health risk to infants and pregnant women.
- Long-term exposures to all other people may pose a health risk.
- Possible public health impacts directly inform current DHS recommendations for nitrate in drinking water:
  - Know your well water quality.
  - Water should not be consumed by infants less than 6 months of age or pregnant women.
  - All other people should reduce long-term consumption.

# Methemoglobinemia: A Serious Risk to Infants and Pregnant Women

- Nitrite can convert hemoglobin to methemoglobin (metHb).
- metHb cannot be used for oxygen transport in blood.
- Increasing levels of metHb can lead to tissue hypoxia, cyanosis, coma or death.
- Formula-fed infants are most susceptible to methemoglobinemia.

# Other Potential Health Impacts of Nitrate

- Thyroid Effects
- Neural Tube Defects
- Evidence for these impacts comes from:
  - Some (but not all) of the human epidemiological studies on these effects
  - Animal studies (for thyroid effects only)

# Conclusions: Current DHS Recommendations for Nitrate in Drinking Water

- Know your water quality – Test your well or find your water utility's annual report.
- If nitrate concentrations in water exceed state and federal standards:
  - Infants less than 6 months of age and pregnant women should not consume the water.
  - Everyone else should reduce long-term consumption.

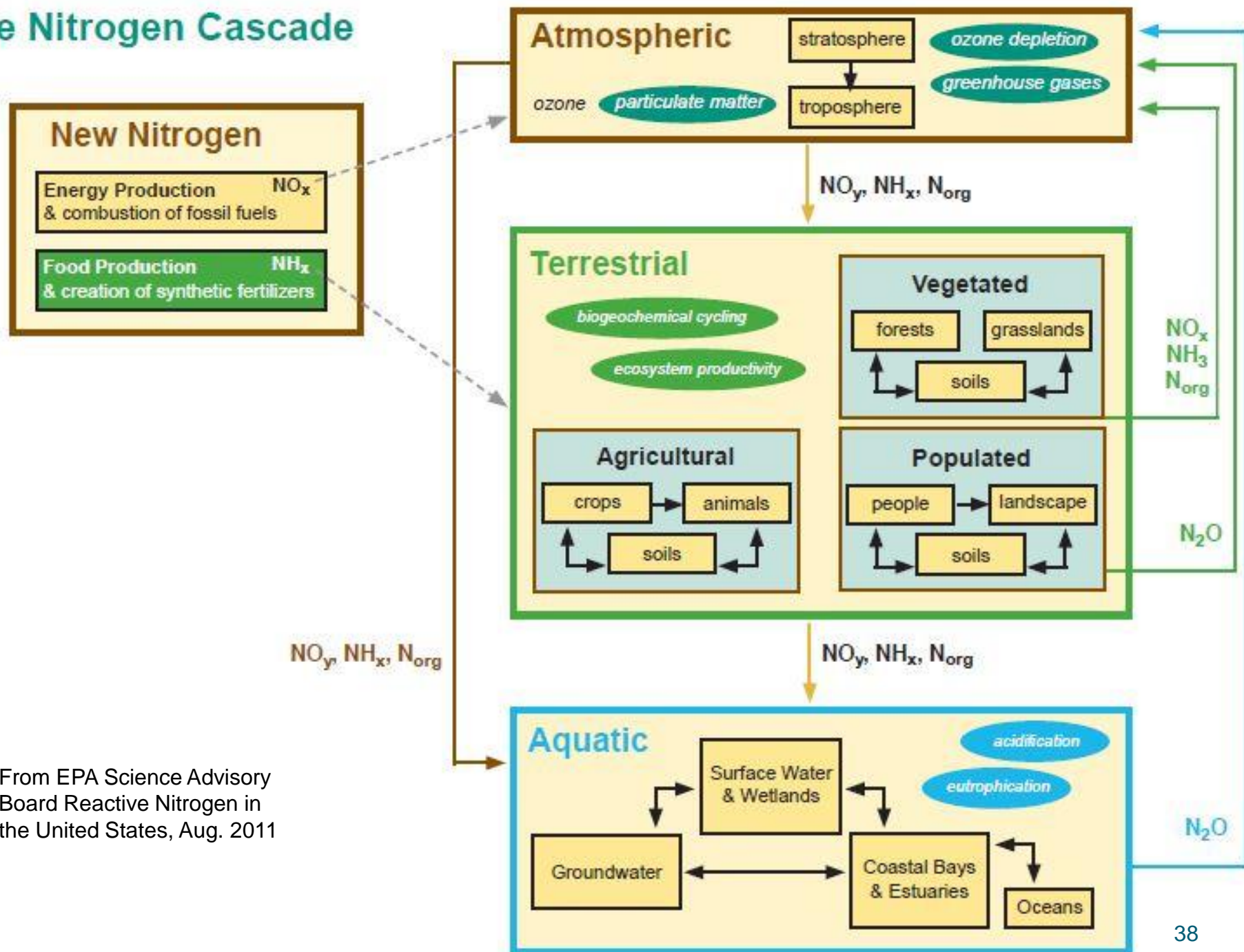
# Air Management Program Perspective

## Nitrogen Summit

March 28, 2014

David S. Panofsky, P.E.  
Bureau of Air Management

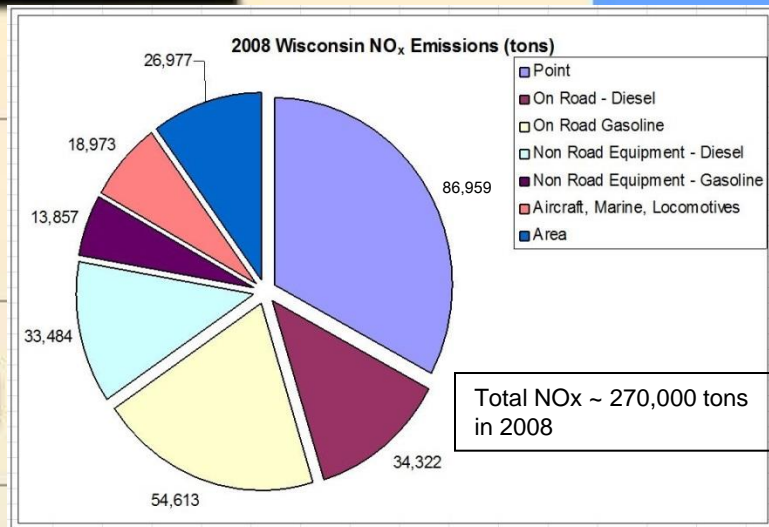
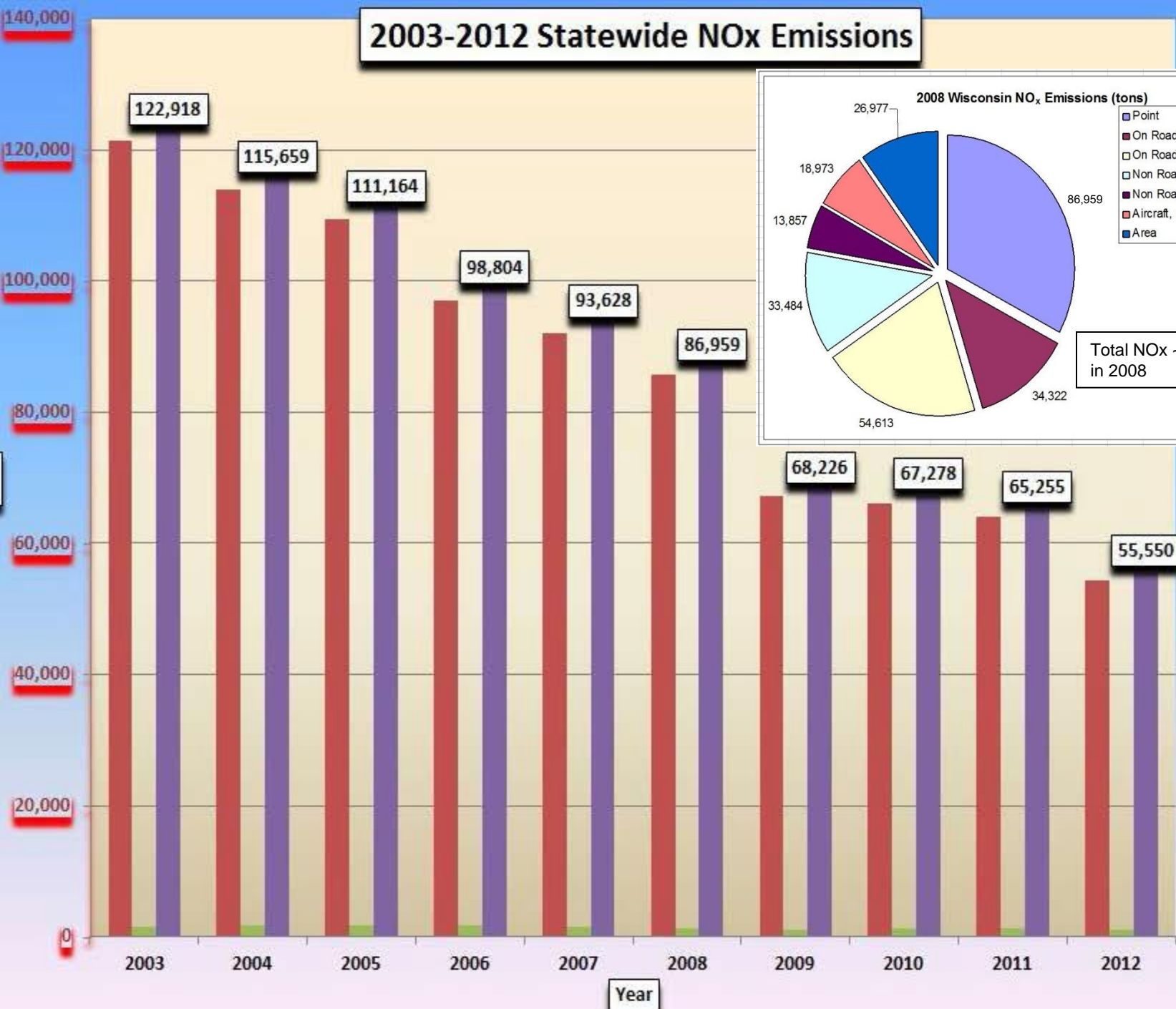
# The Nitrogen Cascade



From EPA Science Advisory Board Reactive Nitrogen in the United States, Aug. 2011

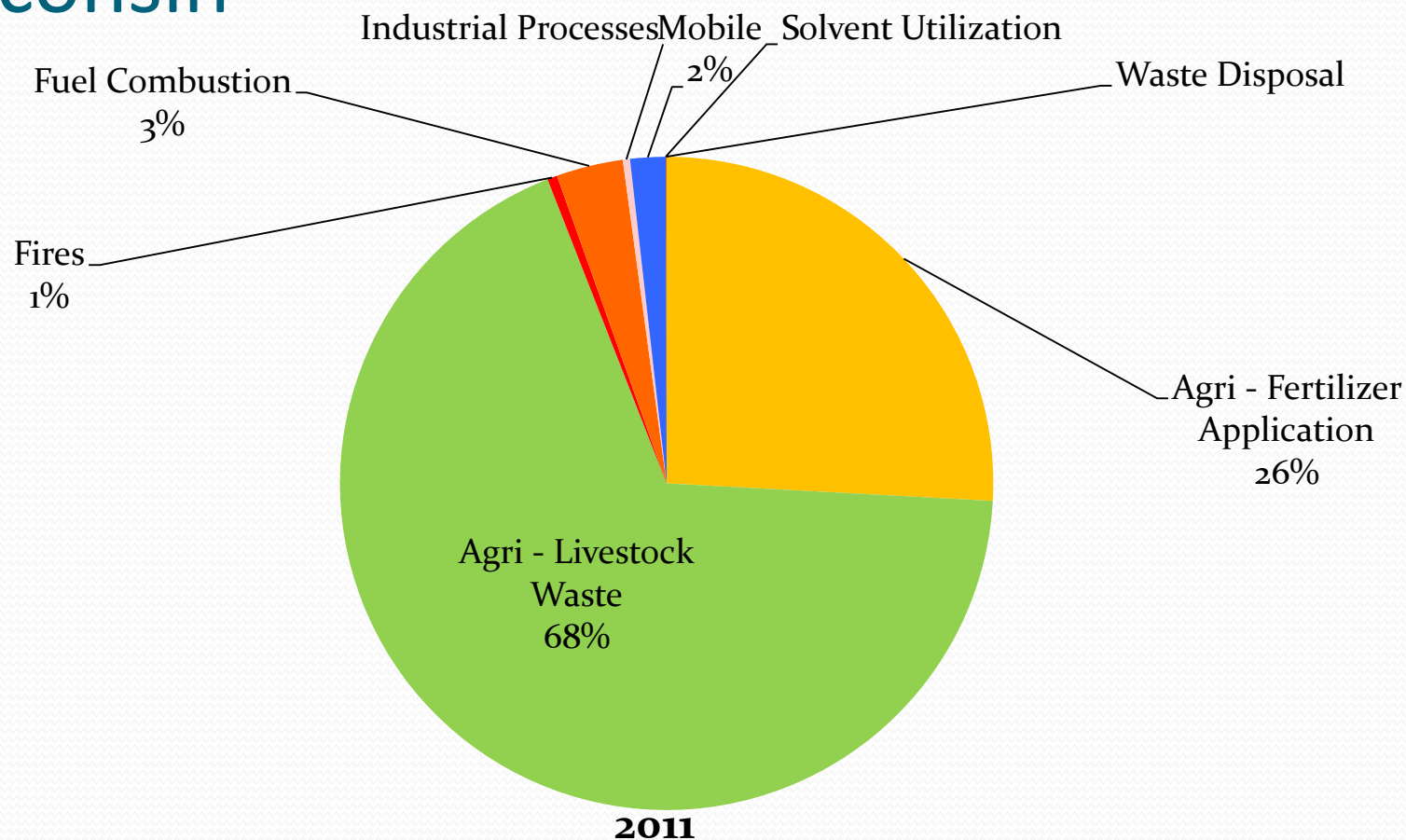
# 2003-2012 Statewide NOx Emissions

Tons



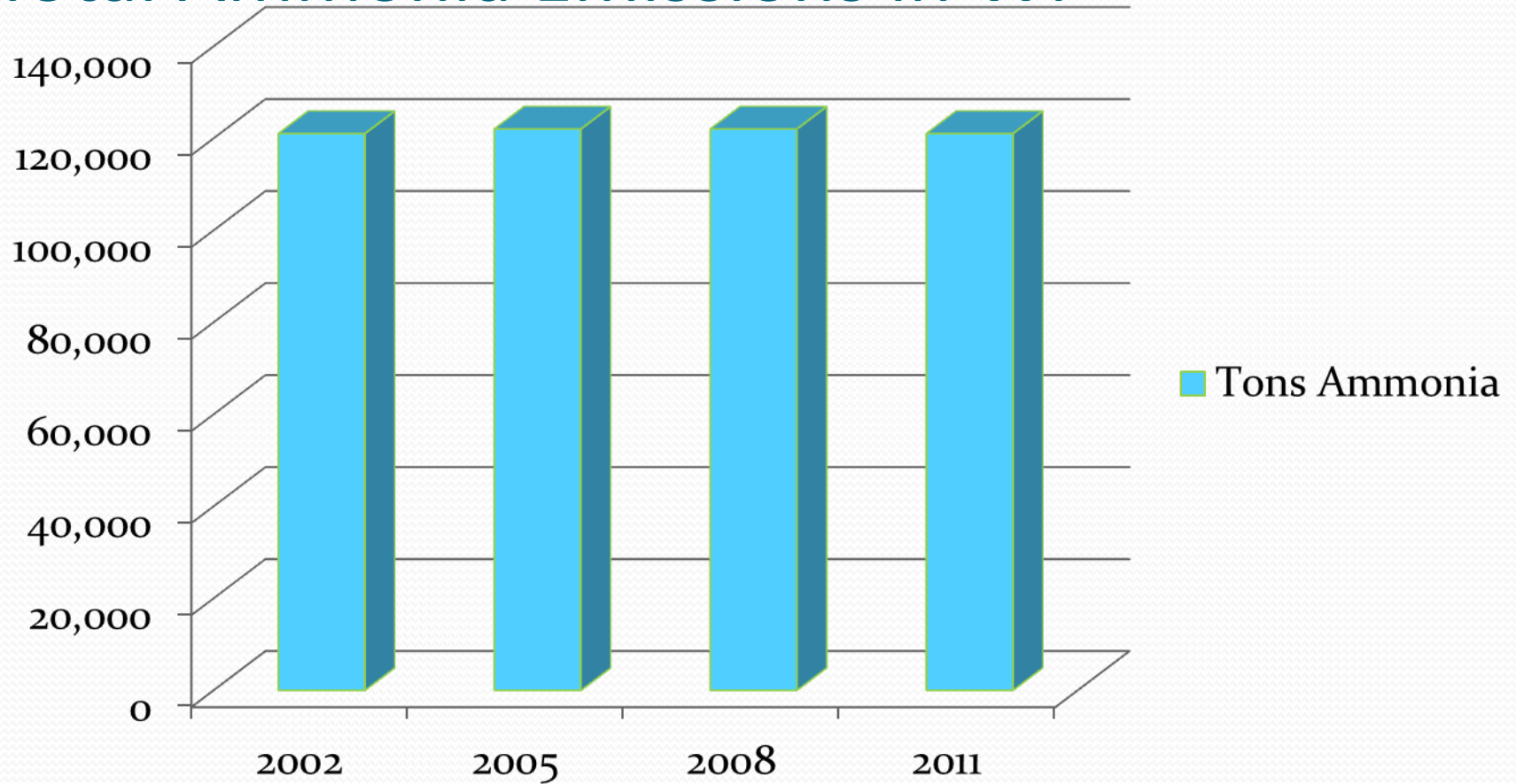
Stationary  
Portable  
Total

# Total Ammonia Air Emissions Sources in Wisconsin



Source: <http://www.epa.gov/ttn/chief/eiinformation.html>

# Total Ammonia Emissions in WI



# Why does this matter?

- Reactive nitrogen (Nr) impacts are magnified through the ecosystem resulting in multiple effects.
- For example, ammonia deposition, both wet and dry, can have local and regional effects on water and land:
  - Eutrophication
  - Acidification
  - Biodiversity loss



# Ammonia and human health impact

- Ammonia reacts with nitrogen oxides (NO and NO<sub>2</sub> -NO<sub>x</sub>) and sulfur dioxide (SO<sub>2</sub>) to form fine particulate pollution in the atmosphere which impacts human health, decreases visibility.
- As NO<sub>x</sub> and SO<sub>2</sub> emissions decline, ammonia becomes key in terms of reductions in fine particulate pollution.

## Good News

### Reducing ammonia loss can increase profitability

- Nitrogen is an important (and expensive) resource – In 2011-2012, 362,000 tons of nitrogen fertilizer were purchased and applied in Wisconsin.
- Keeping nitrogen in the soil and used by crops, as opposed to losing nitrogen via volatilization, can provide economic and environmental benefit.
- DNR, in coordination with stakeholders, published a list of voluntary beneficial management practices to minimize ammonia emissions from dairy, egg laying, broiler, swine, and beef operations and this report is available on our website.

# Thank You

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