

SPARROW: A Model Designed for Use With Monitoring Networks

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Presentation Outline

- Objectives of SPARROW modeling
- Brief description of SPARROW
- Example applications of the national-scale model
- Selected current and near-future activities
- Announcements

Objectives of SPARROW Modeling

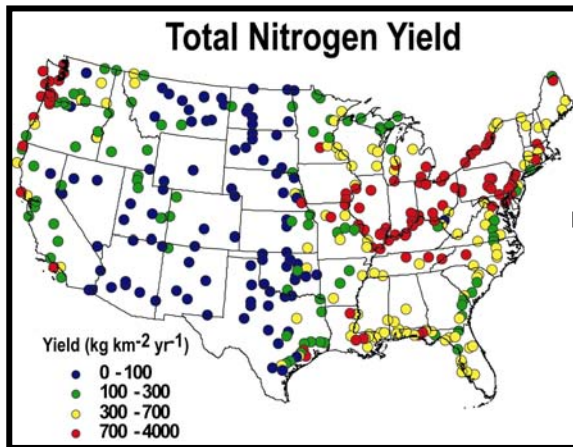
1. Describe national and regional water quality conditions (status and trends) based on “targeted”* sampling.
2. Investigate factors controlling water quality.
3. Predict water quality under alternative scenarios.
4. Analyze and optimize sampling designs.

* Non-randomized sampling

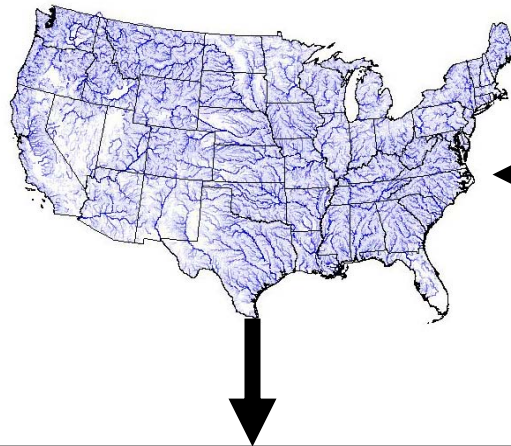
SPARROW (SPAtially Referenced Regression on Watershed Attributes)

A model relating water quality monitoring data to watershed attributes using a spatial reference frame based on a stream-channel network

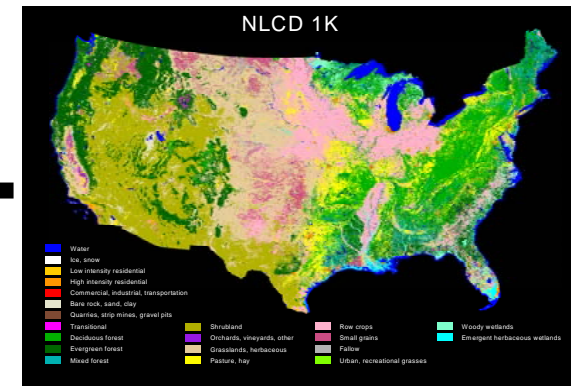
Monitoring Data



Stream Network:
Spatial Reference Frame



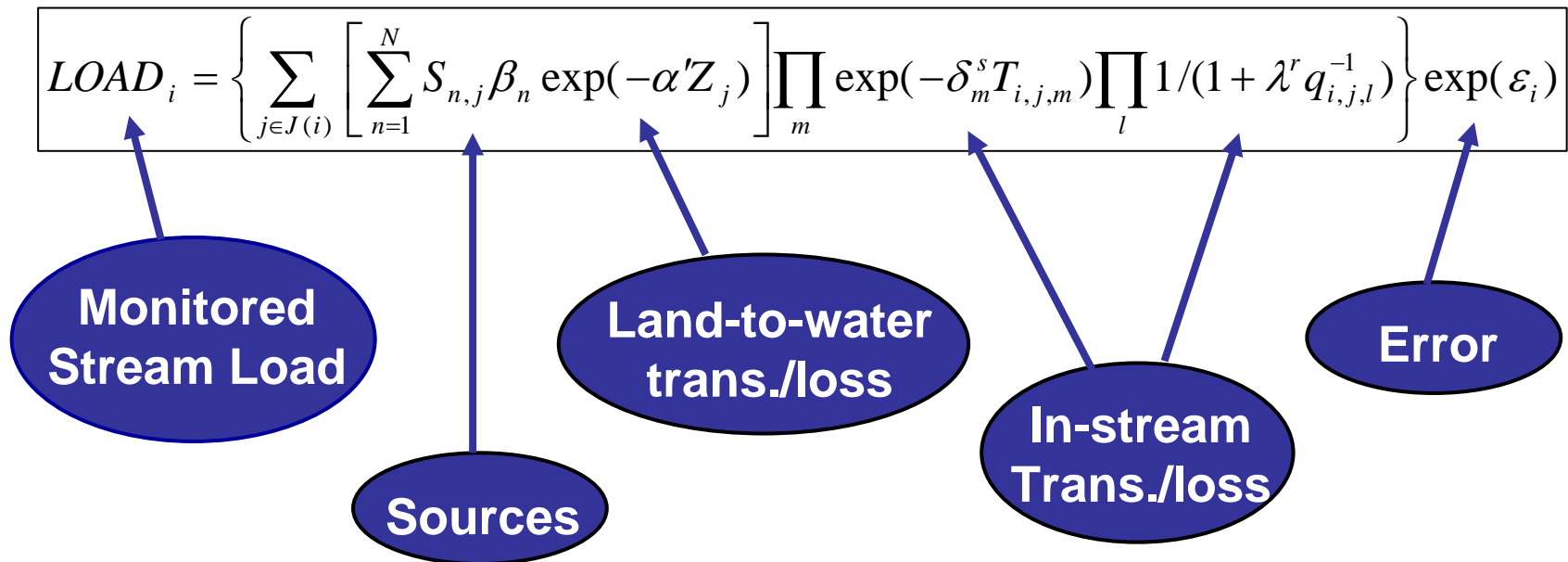
Watershed Attributes



SPARROW Model

SPARROW Model

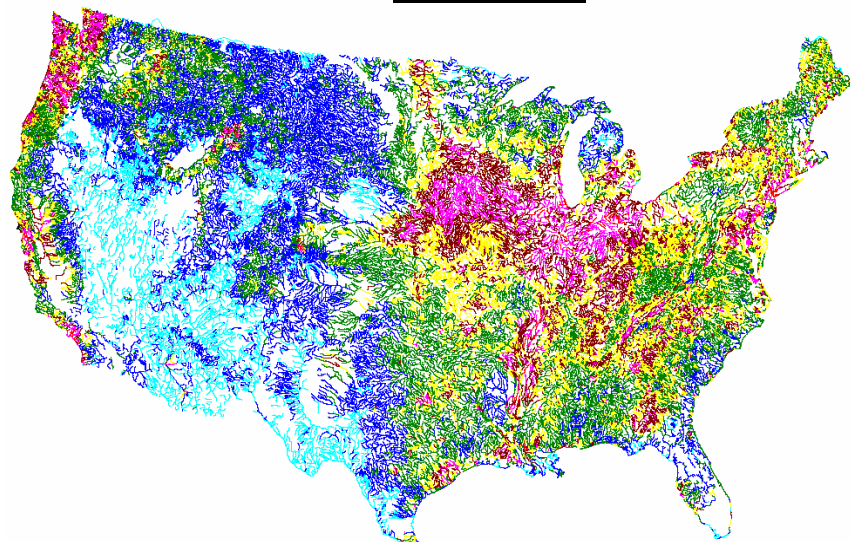
Describes the mass balance between the rate of contaminant supply from sources and the rate of contaminant transport past monitoring stations



Model Output (reach-level):

- transport rate, yield, concentration
- contributions from sources, downstream delivery
- uncertainty (error) measures

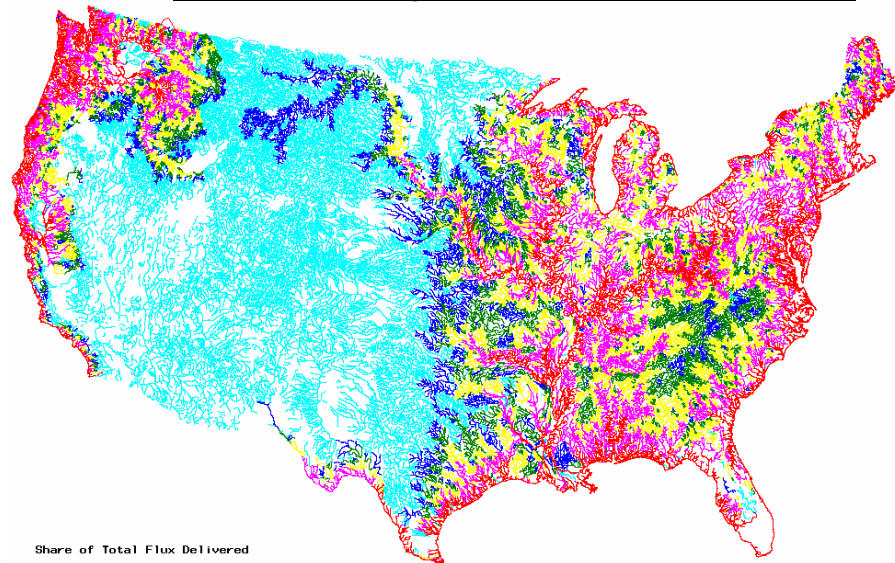
TN Yield



Total Incremental Yield (kg/ha/yr)

Missing	< 2
2 to 5	5 to 10
10 to 15	15 to 25
25 to 50	>= 50

TN Delivery to Coastal Waters



Share of Total Flux Delivered

< 0.1
0.1 to 0.3
0.3 to 0.5
0.5 to 0.7
0.7 to 0.9
>= 0.9

Applications of SPARROW Modeling

1. Describe national and regional water quality conditions based on “targeted”^{*} sampling
2. Investigate factors controlling water quality
3. Predict water quality under alternative scenarios
4. Analyze and optimize sampling designs

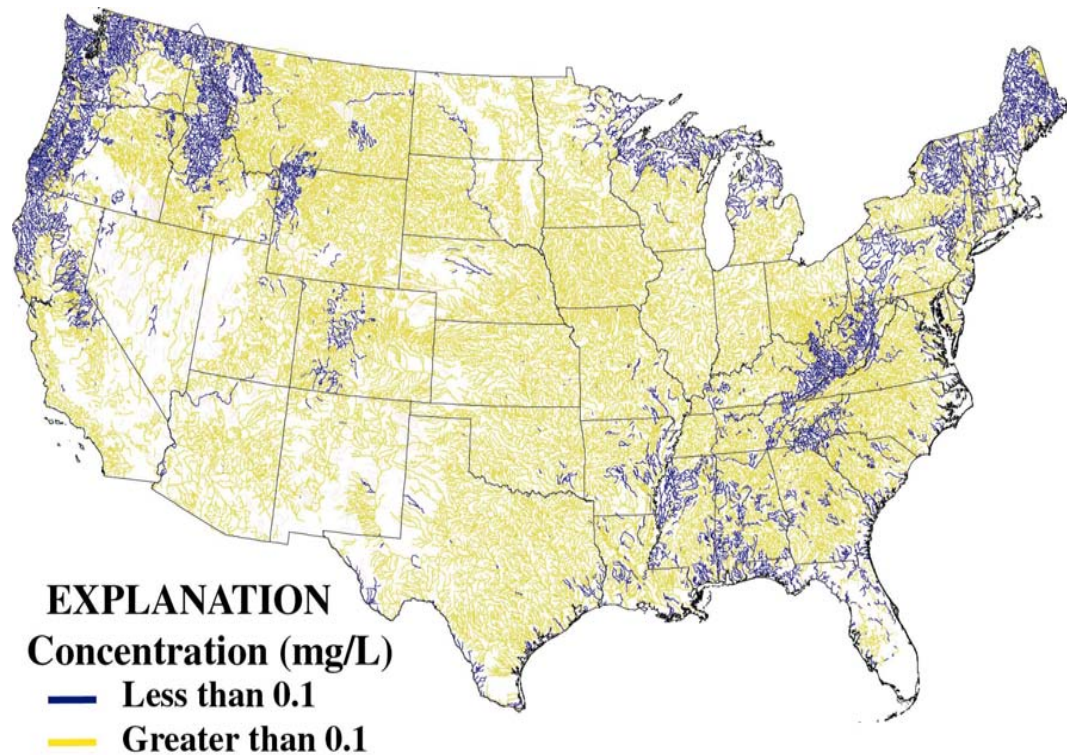
^{*} Non-randomized sampling

An Example of Objective 1: Model-Based Assessment

Percent of Stream Miles in With Total Phosphorus Concentrations Below a Criterion

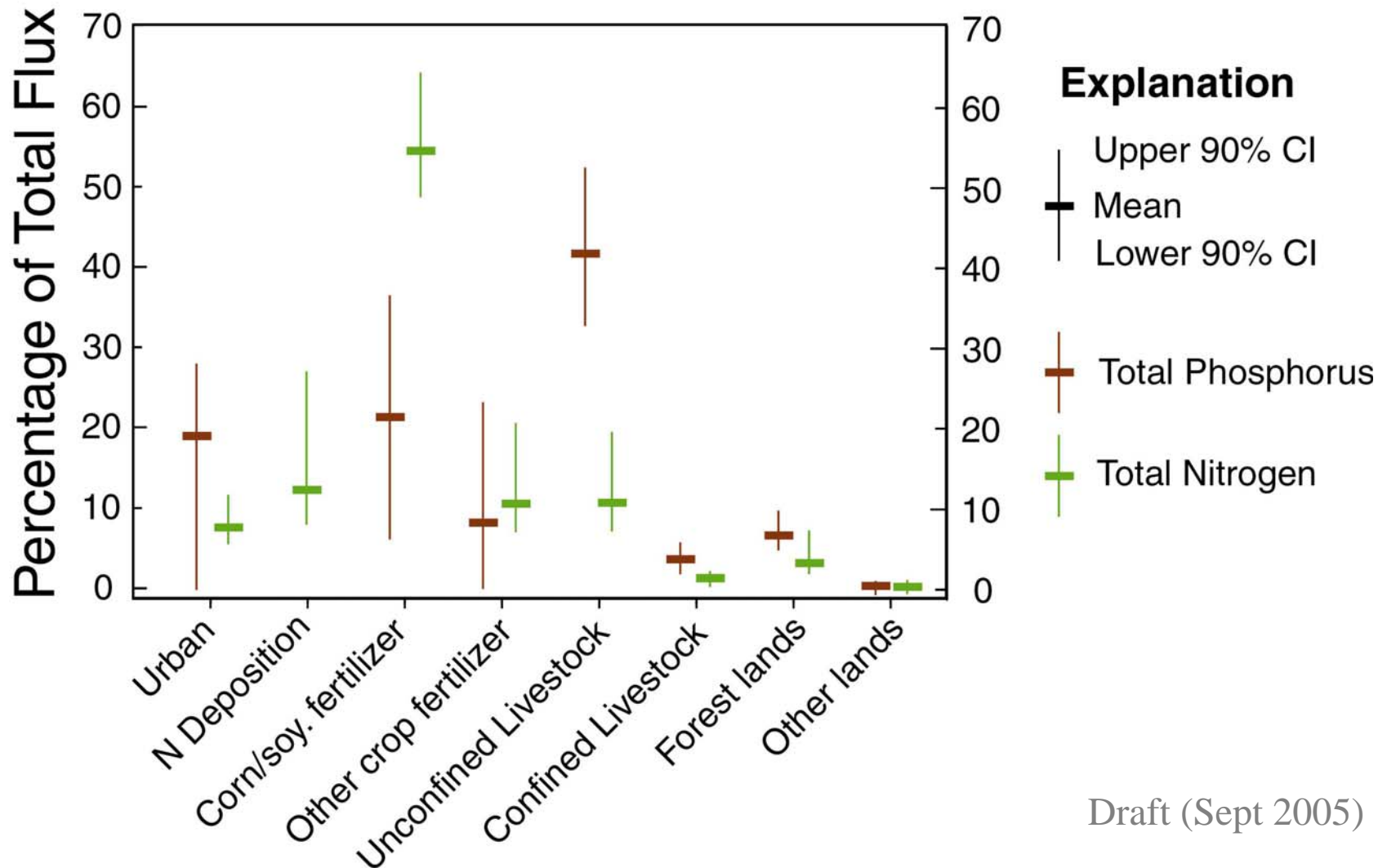
Percent of watersheds with
TP concentrations < 0.1 mg/L
for selected regions

Region	Percent	Margin of Error
United States	39	2.5
Upper Miss.	19	3.8
Mid-Atlantic	60	6.8
New England	84	7.5



Objective 2: Investigate Controlling Factors

Nutrient Source Contributions From the Mississippi River to the Gulf of Mexico



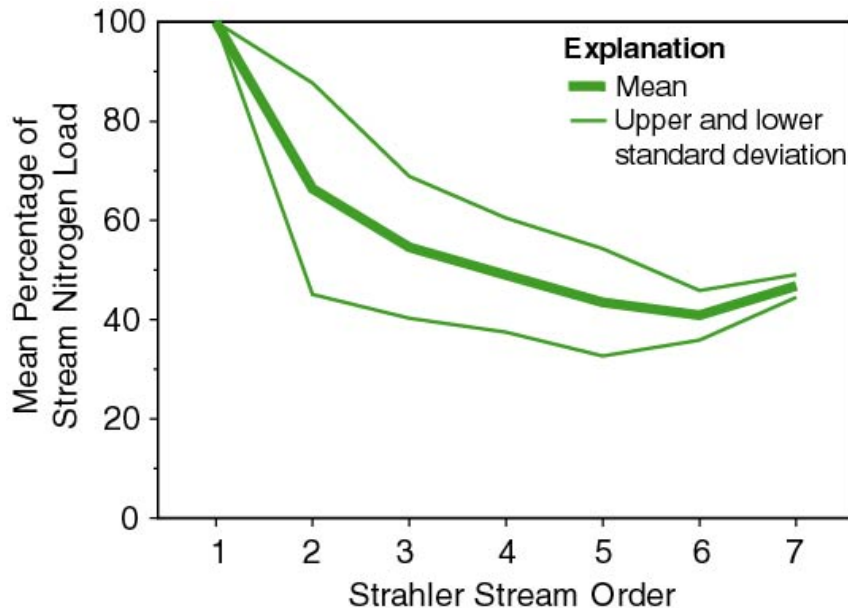
2nd Example: Investigate Controlling Factors

Headwater Streams and the Clean Water Act

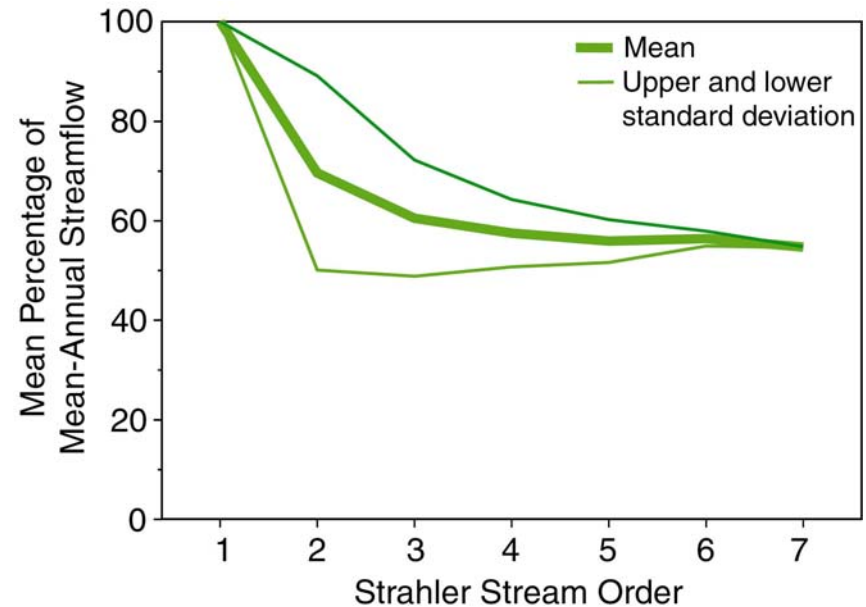
- In 2005, the U.S. Supreme Court agreed to hear a case on the regulatory limits of the Clean Water Act (specifically, tributaries (?) to the “navigable waters”).
- In preparation, the EPA and AWWRA invited papers for a conference on the importance of headwater streams to water quality.
- One paper in this conference (Alexander, Boyer, Smith, Schwarz, and Moore: in rev. JAWRA) used the New England SPARROW model to quantify the contribution of headwater streams to nitrogen loads and streamflow in Northeastern streams of varying stream order.

Headwater Stream Contributions to Mean-Annual N Load and Streamflow in the Northeastern Region

Nitrogen Load



Streamflow

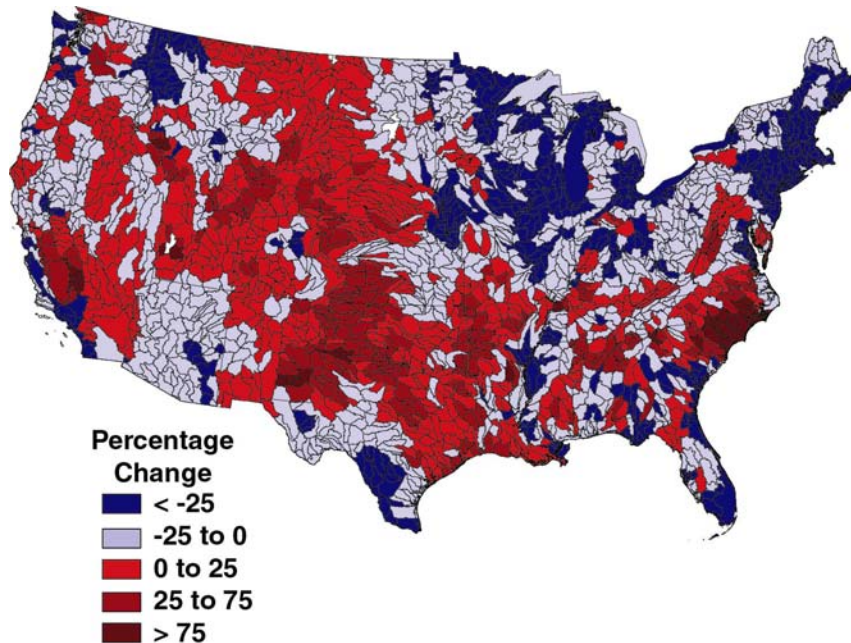


Conclusion: A large percentage of the nitrogen (and streamflow) present in higher order streams and rivers comes from headwater (first order) streams.

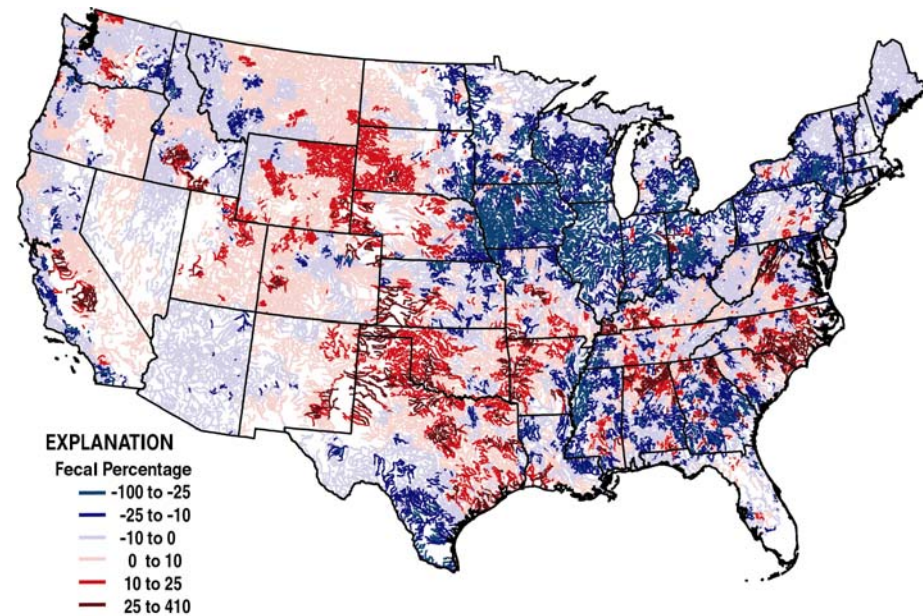
Objective 3: Predict Water Quality Under Alternative Scenarios

Assessing the water-quality response to changes in pollution sources using SPARROW

Change in Total (Confined and Unconfined) Livestock Waste, 1982-97



Predicted changes in fecal coliform bacteria in response to changes in livestock wastes, 1982-97



Objective 4: Analyze and Optimize Network Monitoring

Effect of More Monitoring Data on Model Accuracy

<u>Model</u>	<u>Stations</u>	<u>Parameters</u>	Needed to Reduce Parameter Error by 1%: <u>Stations</u> <u>(Cost Per Year)</u>	
National	379	18	7	(\$700,000)
Ches. Bay	79	10	2	(\$200,000)
N. England	65	6	1	(\$100,000)
N. Carolina	44	7	1	(\$100,000)
Tenn./Ken.	36	7	<1	(<\$100,000)

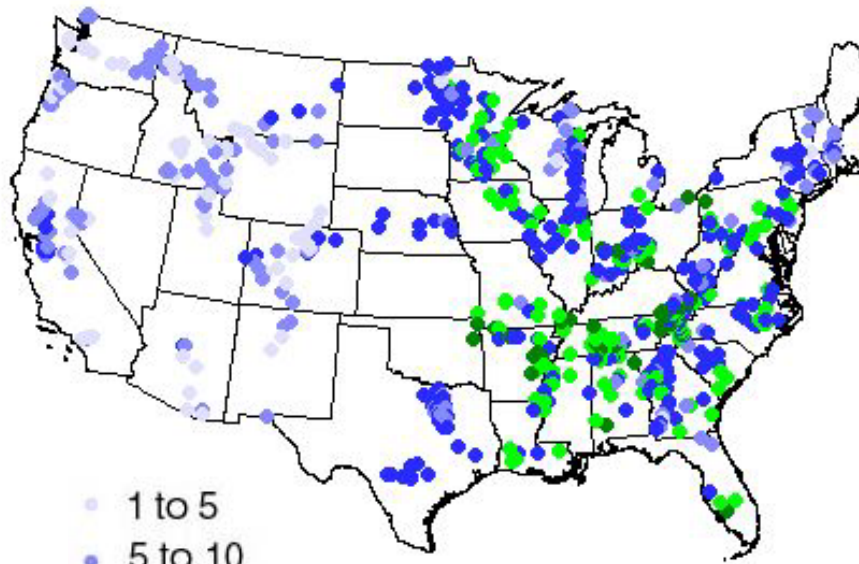
- Notes:
1. New stations are similarly located.
 2. Based on total nitrogen models.
 3. Other models would also improve with more monitoring.

Selected Current and Future Activities

- National suspended sediment model
- Trends in nutrient loads to estuaries
- Suite of models of stream metabolism (organic carbon, chlorophyll, D.O.)
- Model of mercury in fish tissue
- Models of biological metrics

Preliminary SPARROW Model of Fish Species Richness

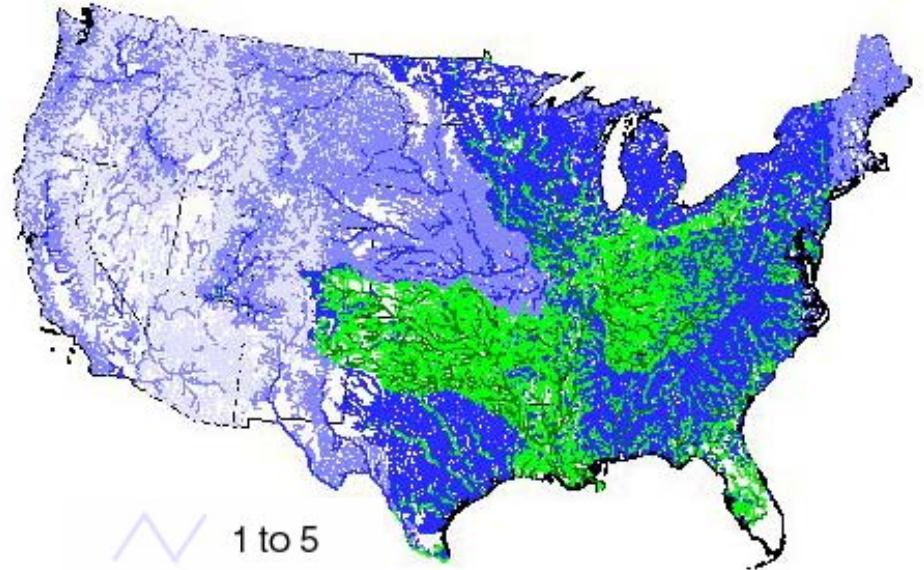
695 NAWQA Sampling Sites



- 1 to 5
- 5 to 10
- 10 to 20
- 20 to 30
- > 30

← Richness: # species present →

SPARROW Predictions for 62,000 stream reaches



- 1 to 5
- 5 to 10
- 10 to 20
- 20 to 30
- > 30

Announcements

Publication Imminent!

SPARROW Documentation

- Schwarz, Hoos, Alexander, and Smith, 2006, *The SPARROW Surface Water-Quality Model - Theory, Application, and User Documentation*: U.S. Geological Survey Techniques and Methods book 6, chapter B3.
 - Detailed description of the theoretical foundations of the SPARROW model.
 - Extensive practical discussion of appropriate SPARROW model specifications.
 - Guide for the recently developed ‘user-oriented’ SPARROW program code.

SPARROW Training Course

Late October, 2006

Denver Training Center

Open to USGS and non-USGS attendees

SPARROW Website:

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

Objective 4: Analyze and Optimize Network Monitoring

Effect of More Monitoring on Model Accuracy:

Estimated Contribution of Nitrogen Sources to Gulf of Mexico

Current Network and Model		+100 Sta. (+ \$10M/yr)	+379 Sta. (+\$38M/yr)	
Source	Contribution (percent)	90% Confidence Interval		
Corn cropland	55	48 - 64	49 - 63	50 - 58
Atmosphere	12	8 - 27	8 - 25	9 - 22
Other cropland	11	8 - 20	9 - 19	9 - 17
Unconfined animals	11	8 - 19	9 - 18	9 - 16
Urban sources	8	5 - 12	5 - 11	6 - 11

- Notes:
1. Assumes stations are selected randomly.
 2. All model predictions improve with more monitoring; these are only important examples.

Objective 4: Analyze and Optimize Network Monitoring

Marginal Cost of Improving TN Model Accuracy

