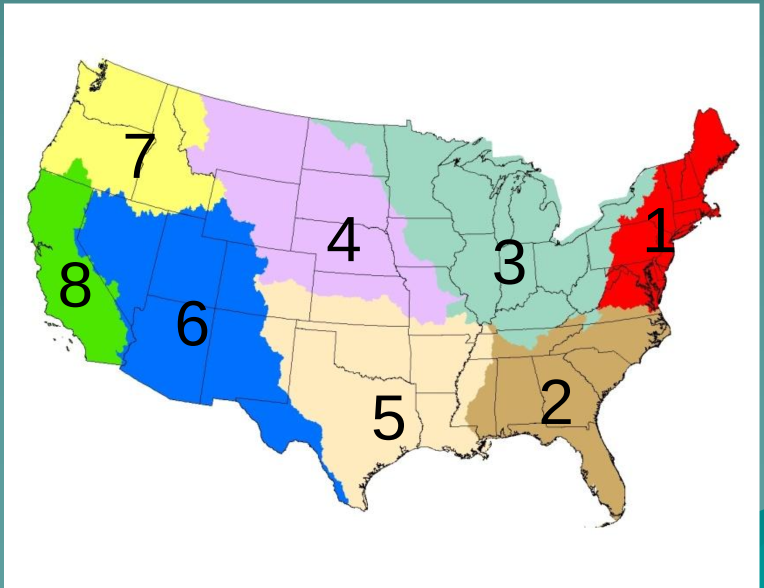
Application of a Regional Regression Model of Nitrogen Transport to Water-Quality Assessments in the Southeastern U.S.

Anne Hoos, Ana Garcia, Silvia Terziotti

U.S. Geological Survey

National Water-Quality Assessment (NAWQA)

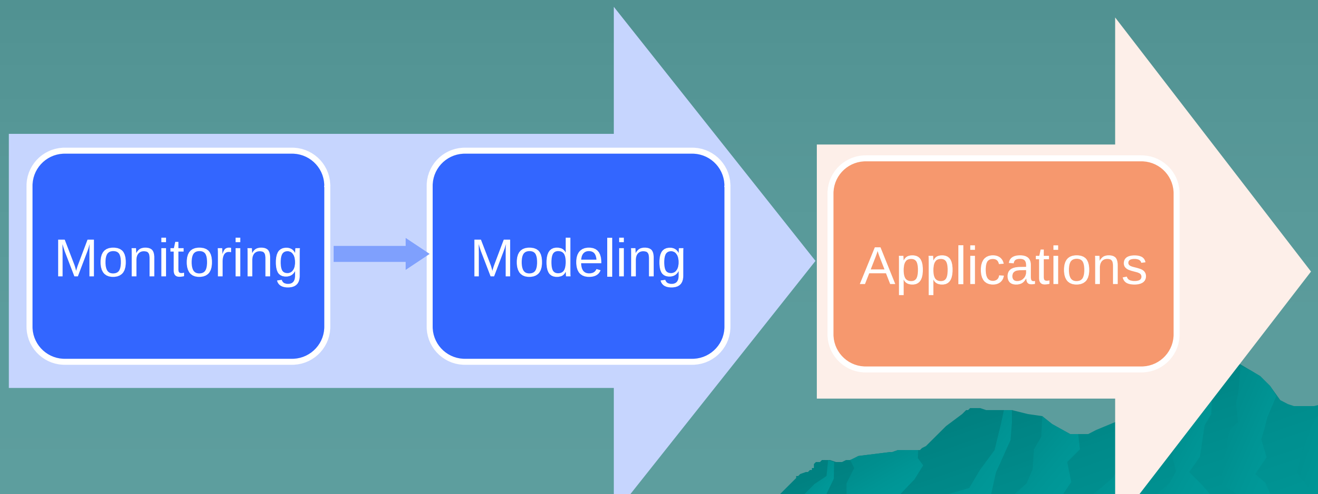


USGS

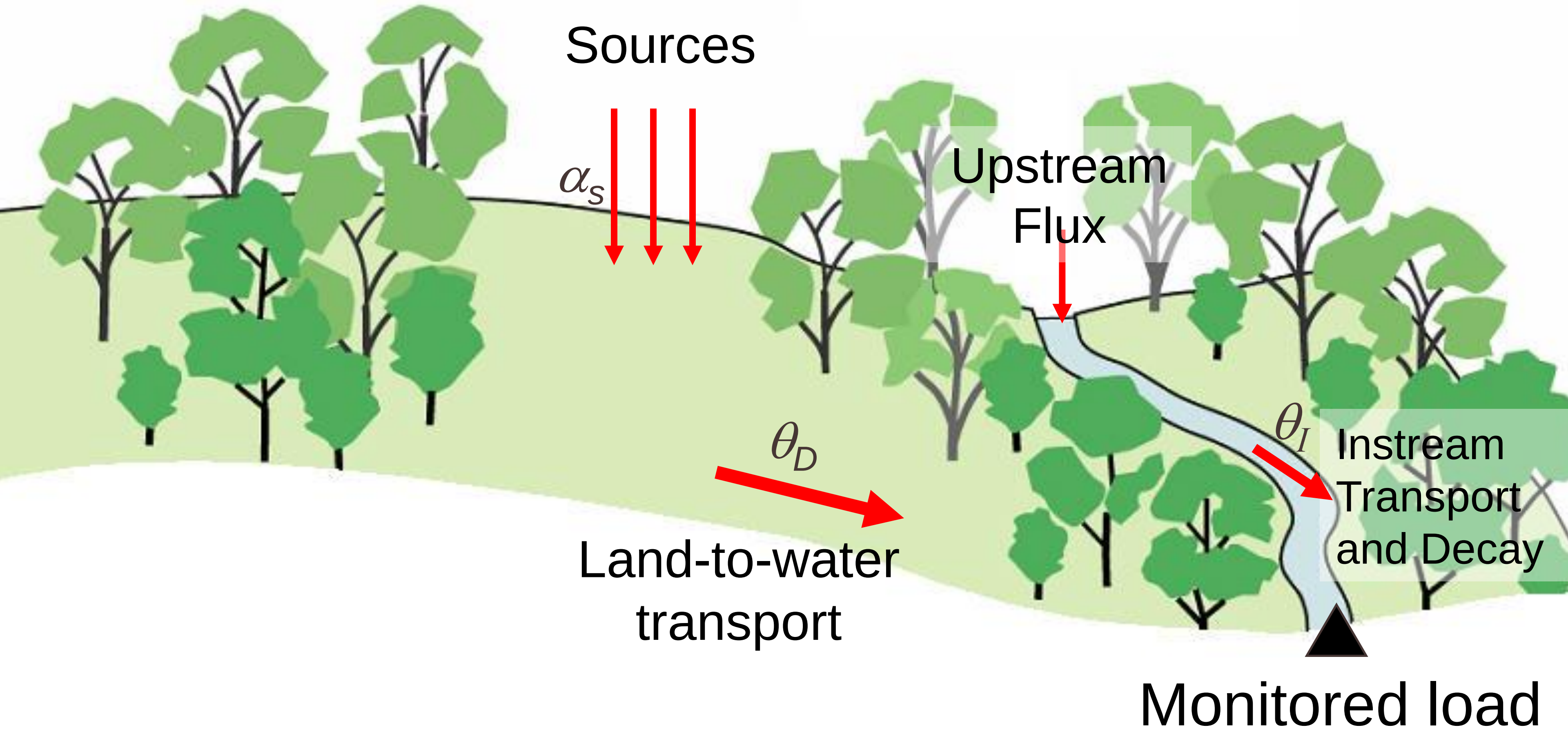
NAWQA Regional assessments of nutrient sources and transport

Objective: Build understanding of how human activities and natural features influence nutrient conditions in streams, support resource decisions

Approach: Integrate monitoring and watershed data within a regional model framework (SPARROW)



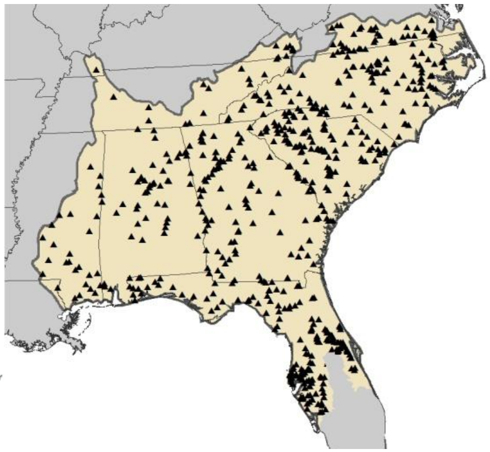
SPARROW* Model Concept



*SPAtially Referenced Regression On Watershed Attributes

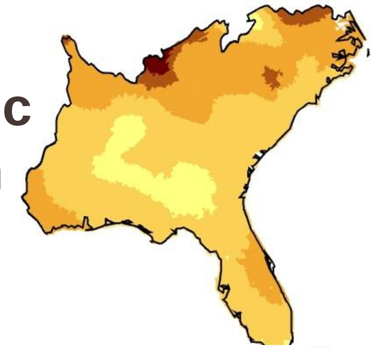
SPARROW Model Framework

Monitoring Data
804 Sites

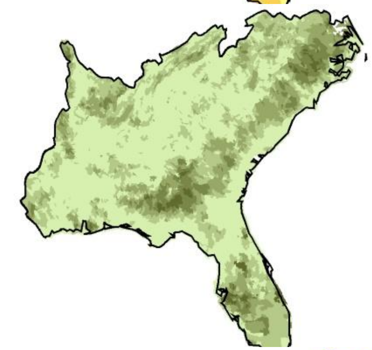


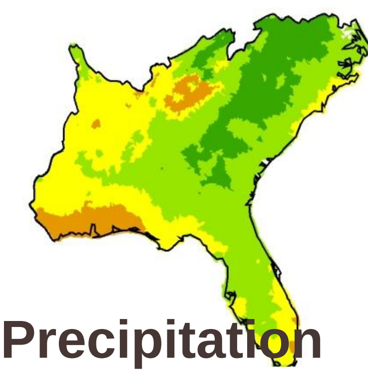
Spatial Data Layers

Atmospheric deposition

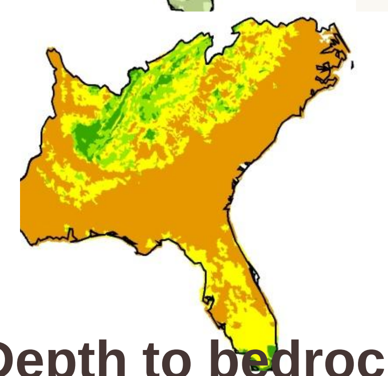


Fertilizer applied to farmland



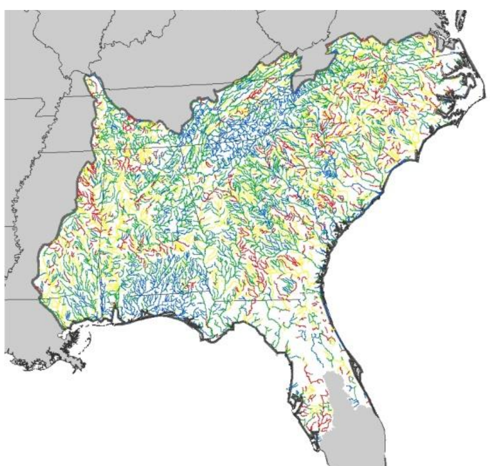


Precipitation

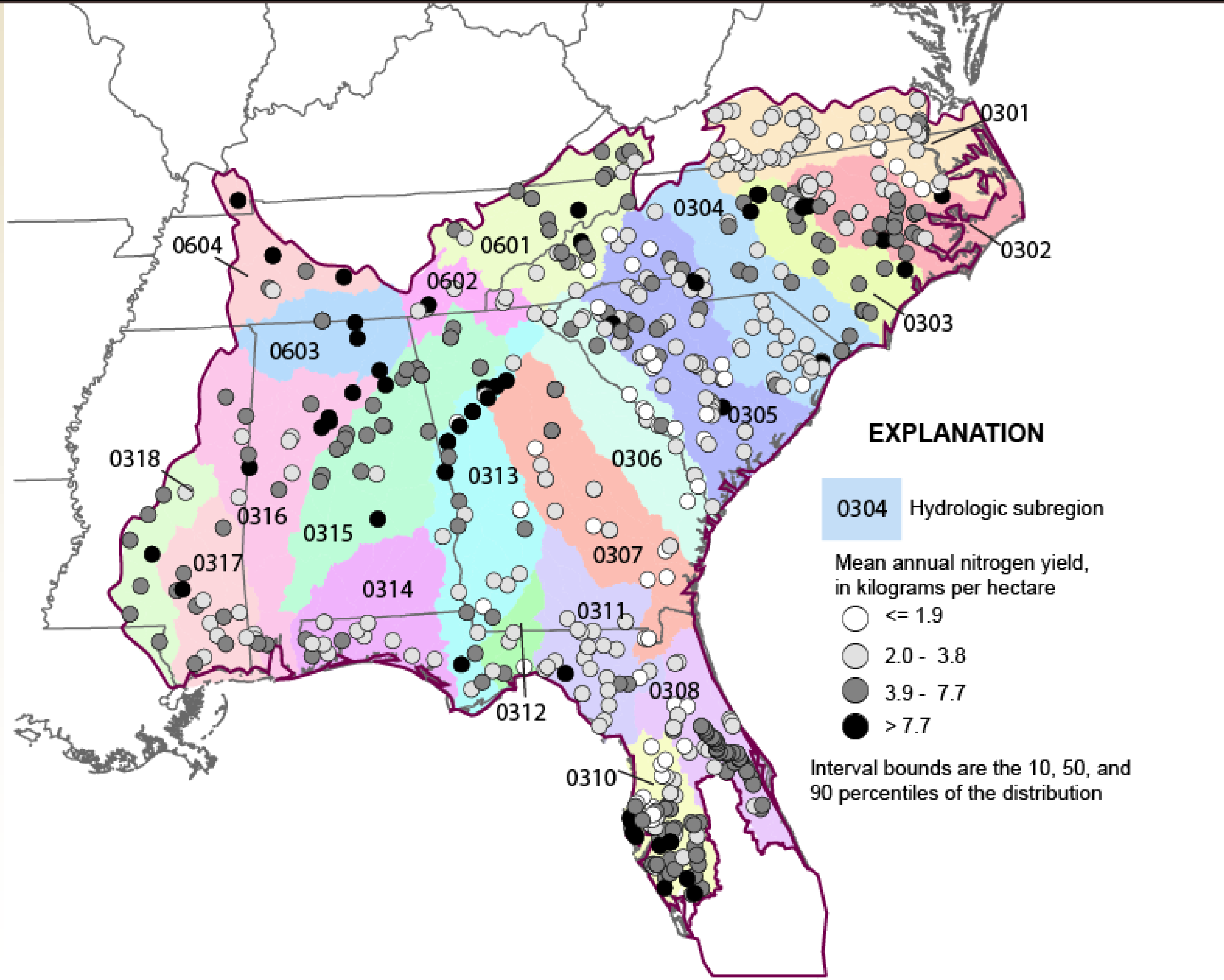


Depth to bedrock

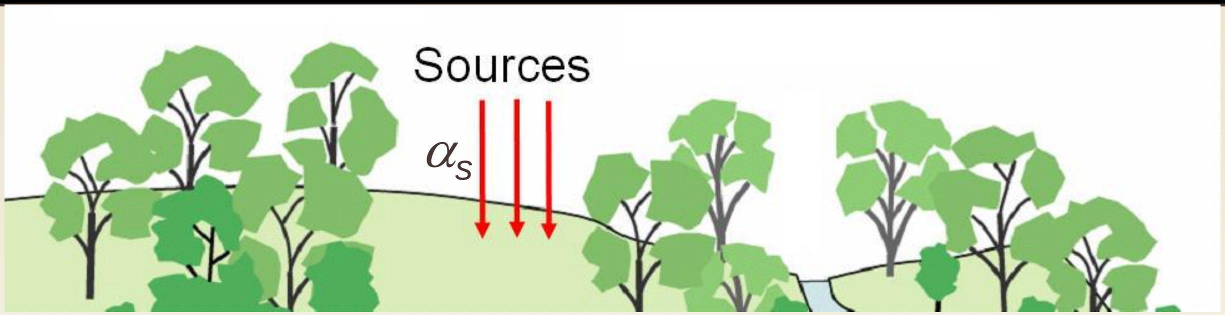
Model Predictions
8,321 Stream Reaches

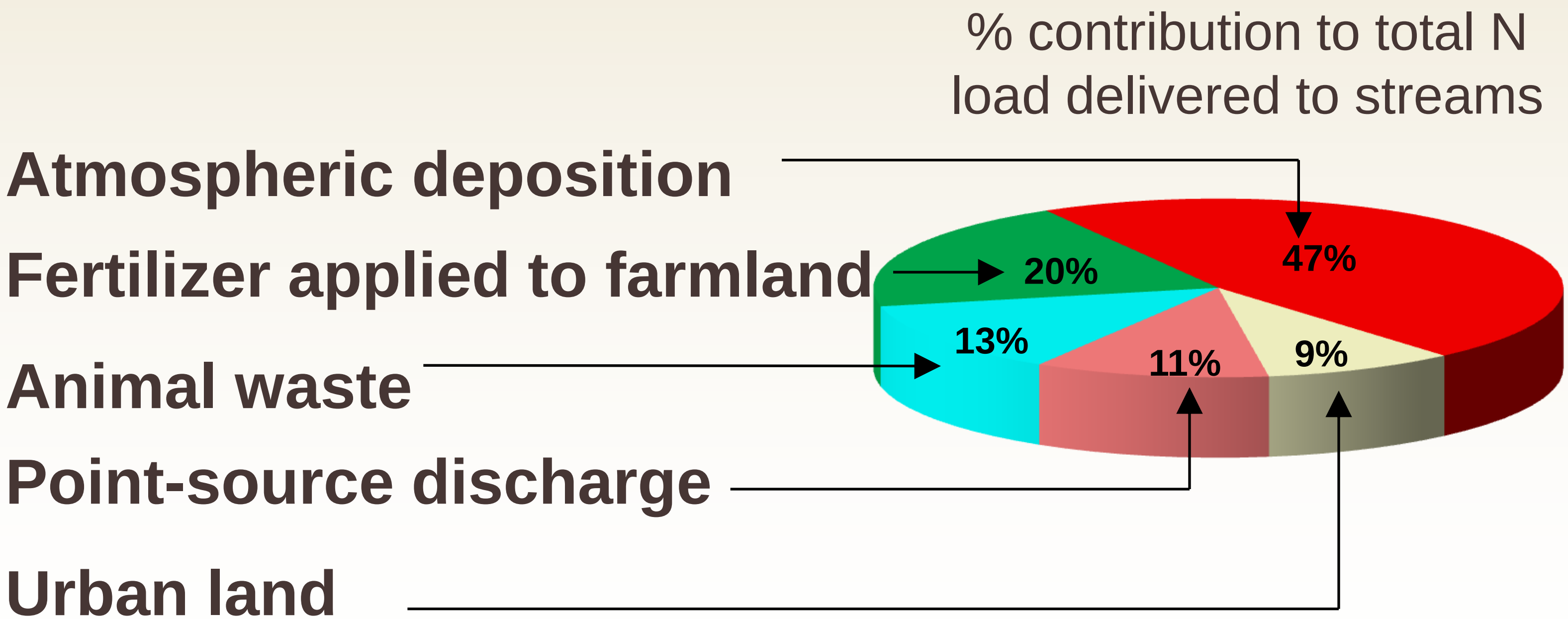


Spatial pattern of monitored instream nitrogen load, 2002

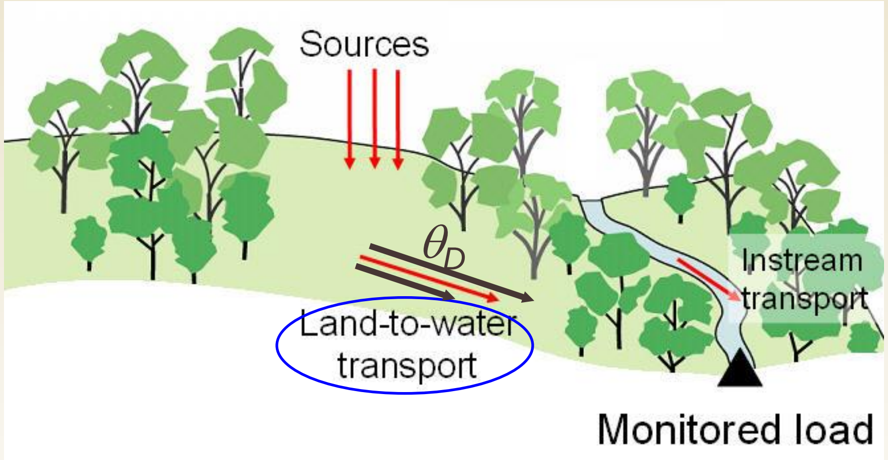


Sources accounting for instream nitrogen load in the Southeast



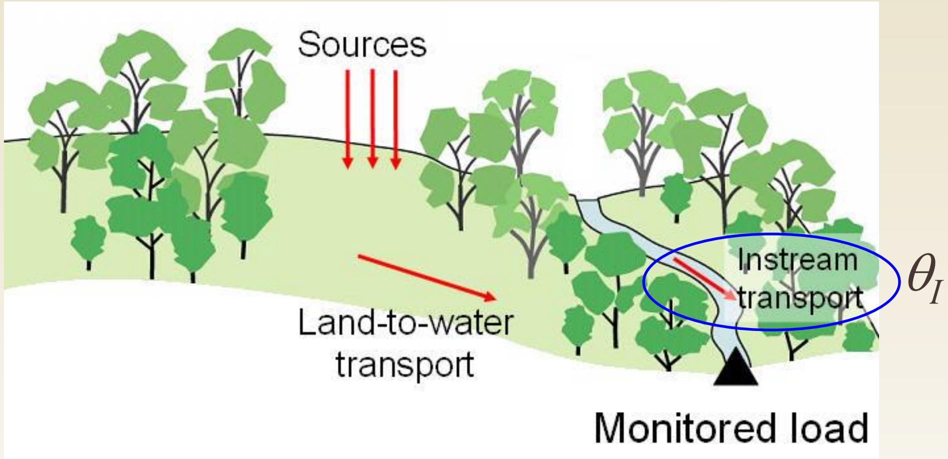


Factors controlling variation in rate of land-to-water transport



- Soil permeability
- Soil thickness
- Annual precipitation
- Primary hydrologic pathway

Factors controlling removal/assimilation of nitrogen in streams and reservoirs



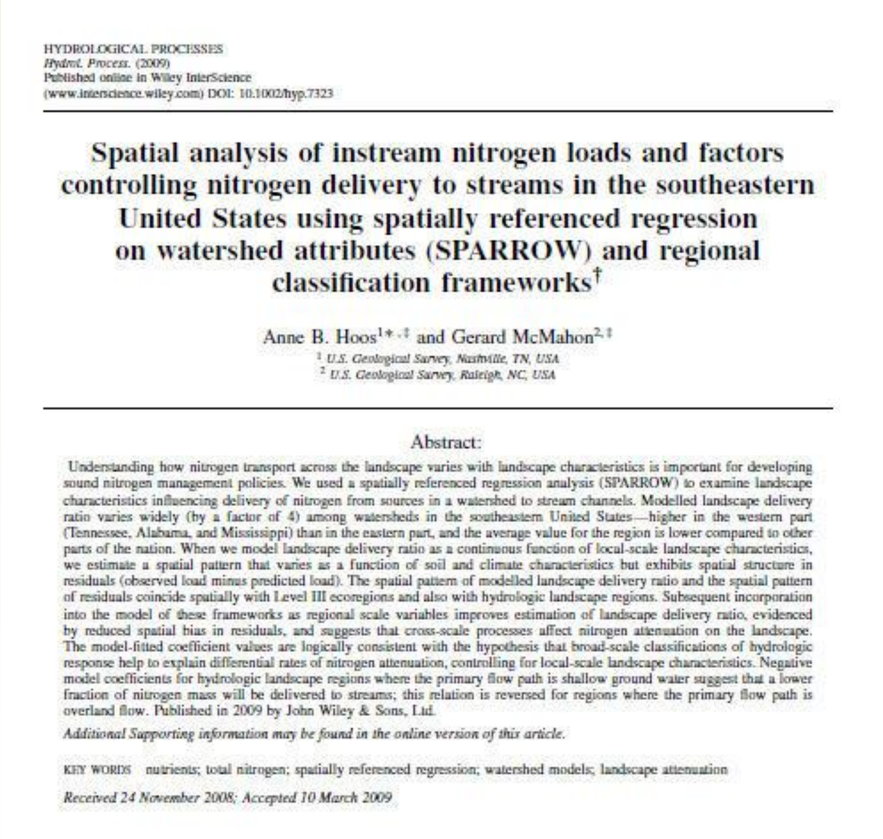
- Travel time in small streams (mean flow < 1,000 cfs)
- Retention time in reservoirs

Fit statistics for 11-variable regression model:
Explains 70% of variability in instream yield
Average prediction error = ±35%

Online access to model report and data files of model predictions

Nitrogen model paper available online at
http://water.usgs.gov/nawqa/pubs/nitrogen_loads

Contact for more information:
Anne Hoos
abhoos@usgs.gov



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Spatial analysis of instream nitrogen loads and factors controlling nitrogen delivery to streams in the southeastern United States using spatially referenced regression on watershed attributes (SPARROW) and regional classification frameworks†

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[2] *U.S. Geological Survey, Raleigh, NC, USA*

Abstract:

Understanding how nitrogen transport across the landscape varies with landscape characteristics is important for developing sound nitrogen management policies. We used a spatially referenced regression analysis (SPARROW) to examine landscape characteristics influencing delivery of nitrogen from sources in a watershed to stream channels. Modelled landscape delivery ratio varies widely (by a factor of 4) among watersheds in the southeastern United States—higher in the western part (Tennessee, Alabama, and Mississippi) than in the eastern part, and the average value for the region is lower compared to other parts of the nation. When we model landscape delivery ratio as a continuous function of local-scale landscape characteristics, we estimate a spatial pattern that varies as a function of soil and climate characteristics but exhibits spatial structure in residuals (observed load minus predicted load). The spatial pattern of modelled landscape delivery ratio and the spatial pattern of residuals coincide spatially with Level III ecoregions and also with hydrologic landscape regions. Subsequent incorporation into the model of these frameworks as regional scale variables improves estimation of landscape delivery ratio, evidenced by reduced spatial bias in residuals, and suggests that cross-scale processes affect nitrogen attenuation on the landscape. The model-fitted coefficient values are logically consistent with the hypothesis that broad-scale classifications of hydrologic response help to explain differential rates of nitrogen attenuation, controlling for local-scale landscape characteristics. Negative model coefficients for hydrologic landscape regions where the primary flow path is shallow ground water suggest that a lower fraction of nitrogen mass will be delivered to streams; this relation is reversed for regions where the primary flow path is overland flow. Published in 2009 by John Wiley & Sons, Ltd.

Additional Supporting information may be found in the online version of this article.

KEY WORDS nutrients; total nitrogen; spatially referenced regression; watershed models; landscape attenuation

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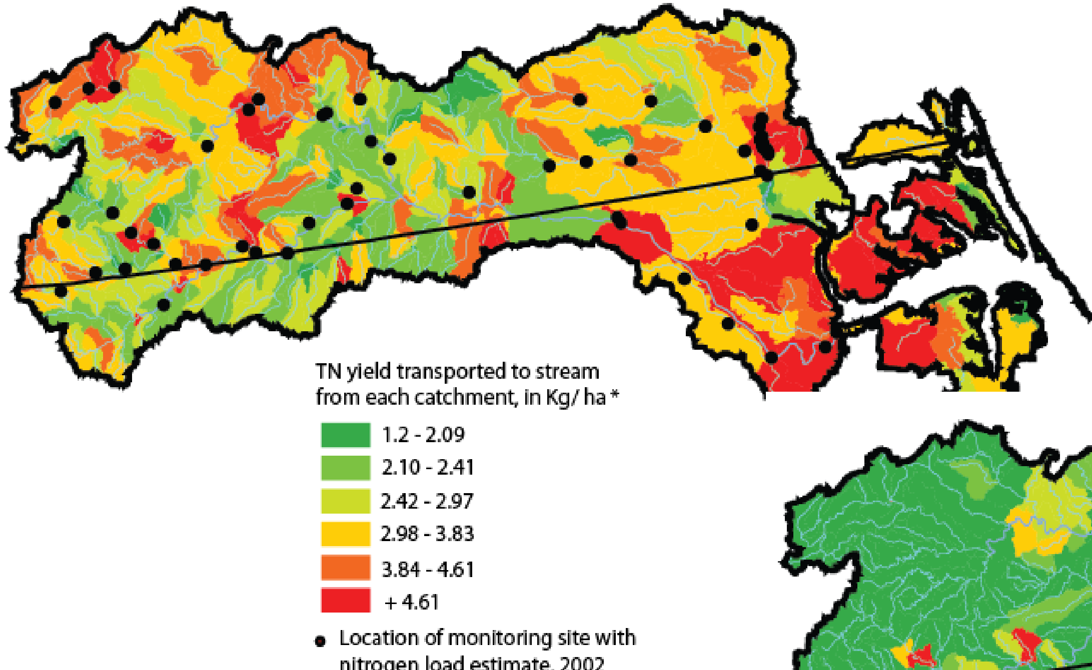
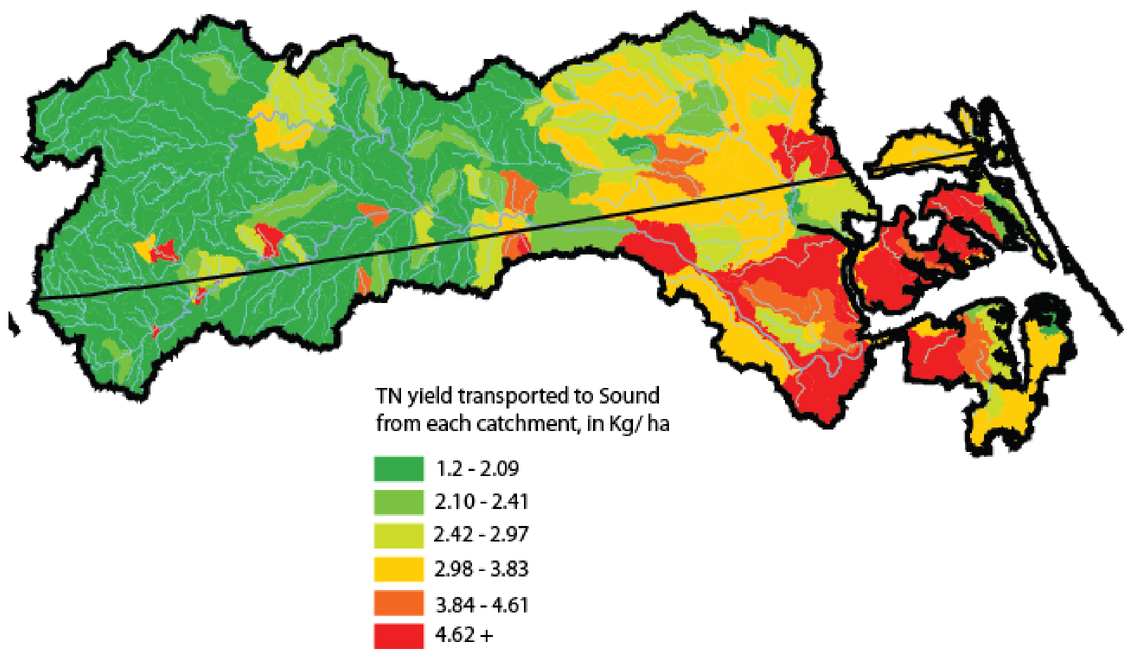
Possible applications: 1. Which areas contribute the largest amounts of total nitrogen annually…

to local streams?



to Albemarle Sound?



Possible applications: 1. Which areas contribute the largest amounts of total nitrogen annually…

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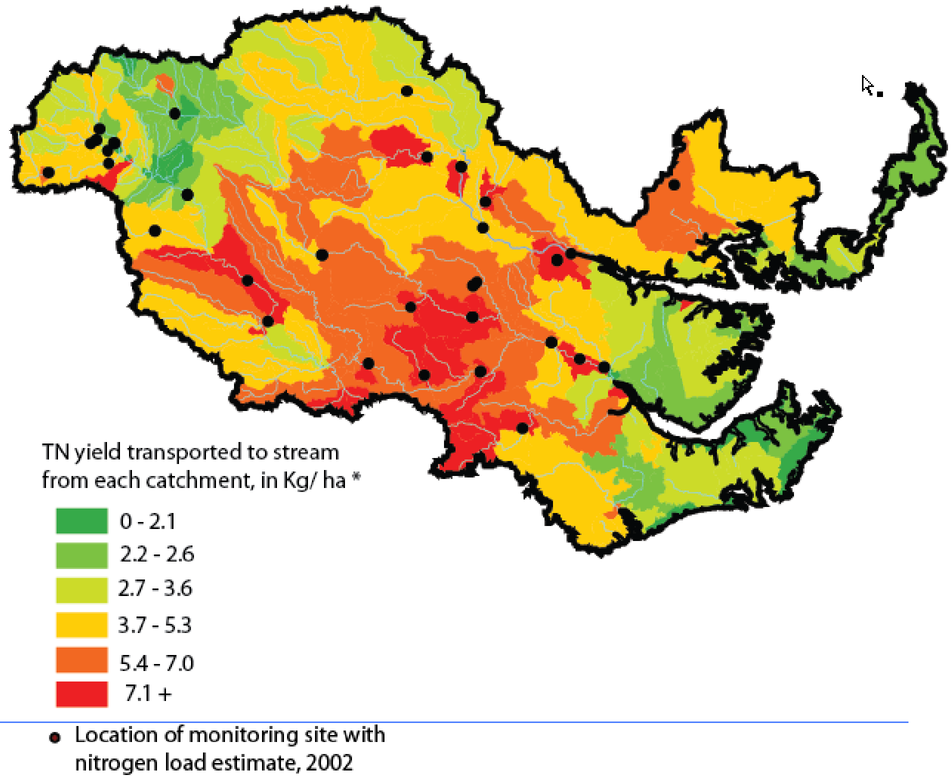
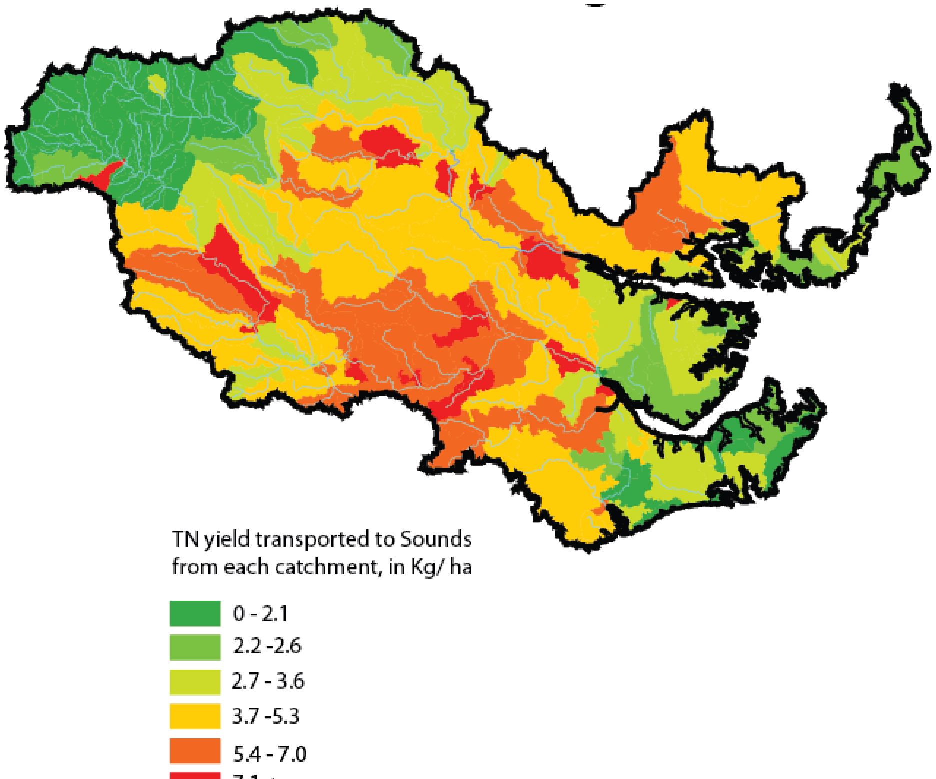
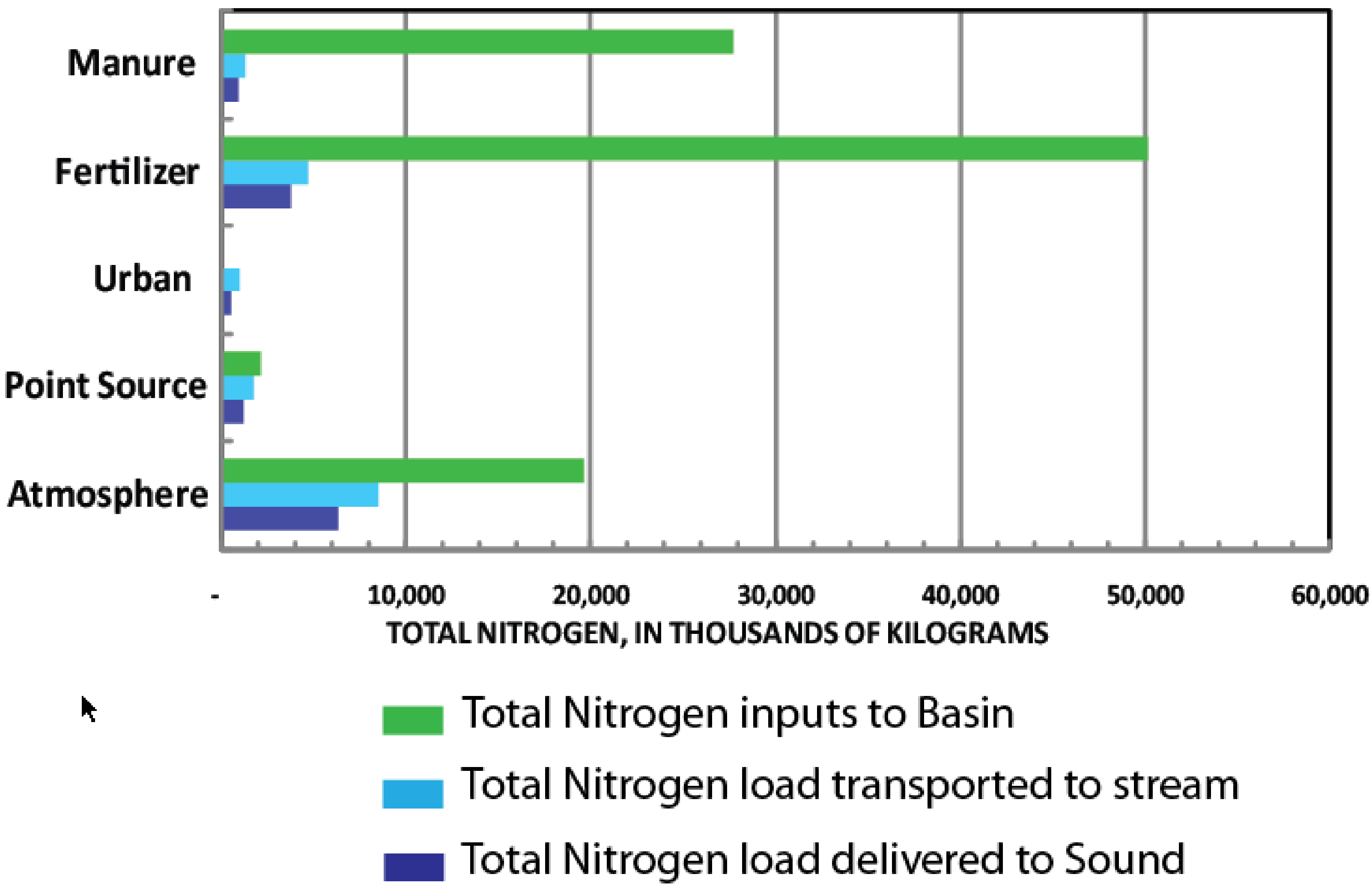


to Pamlico Sound?

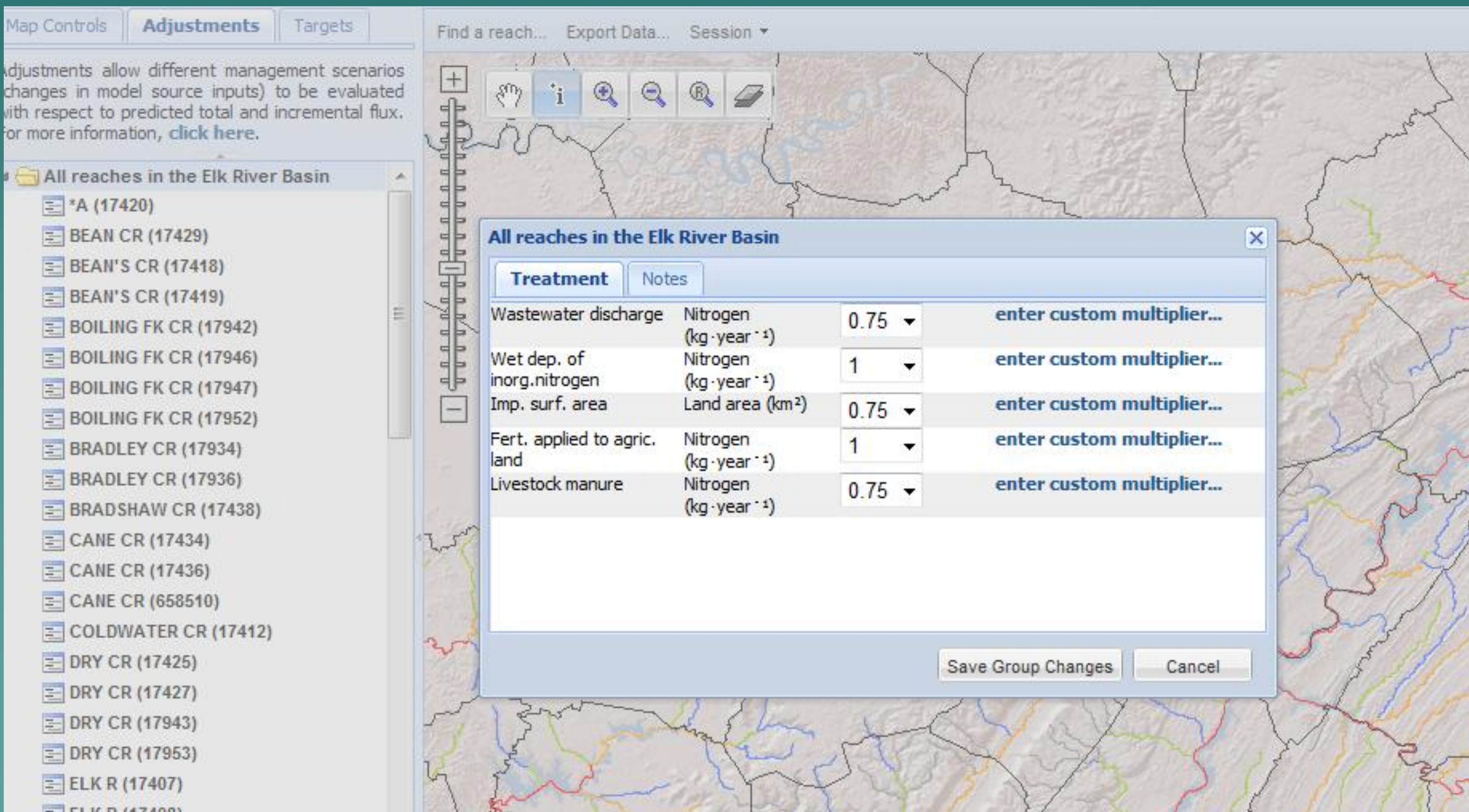


2. Which sources contribute the largest amounts of total nitrogen annually to Albemarle Sound?

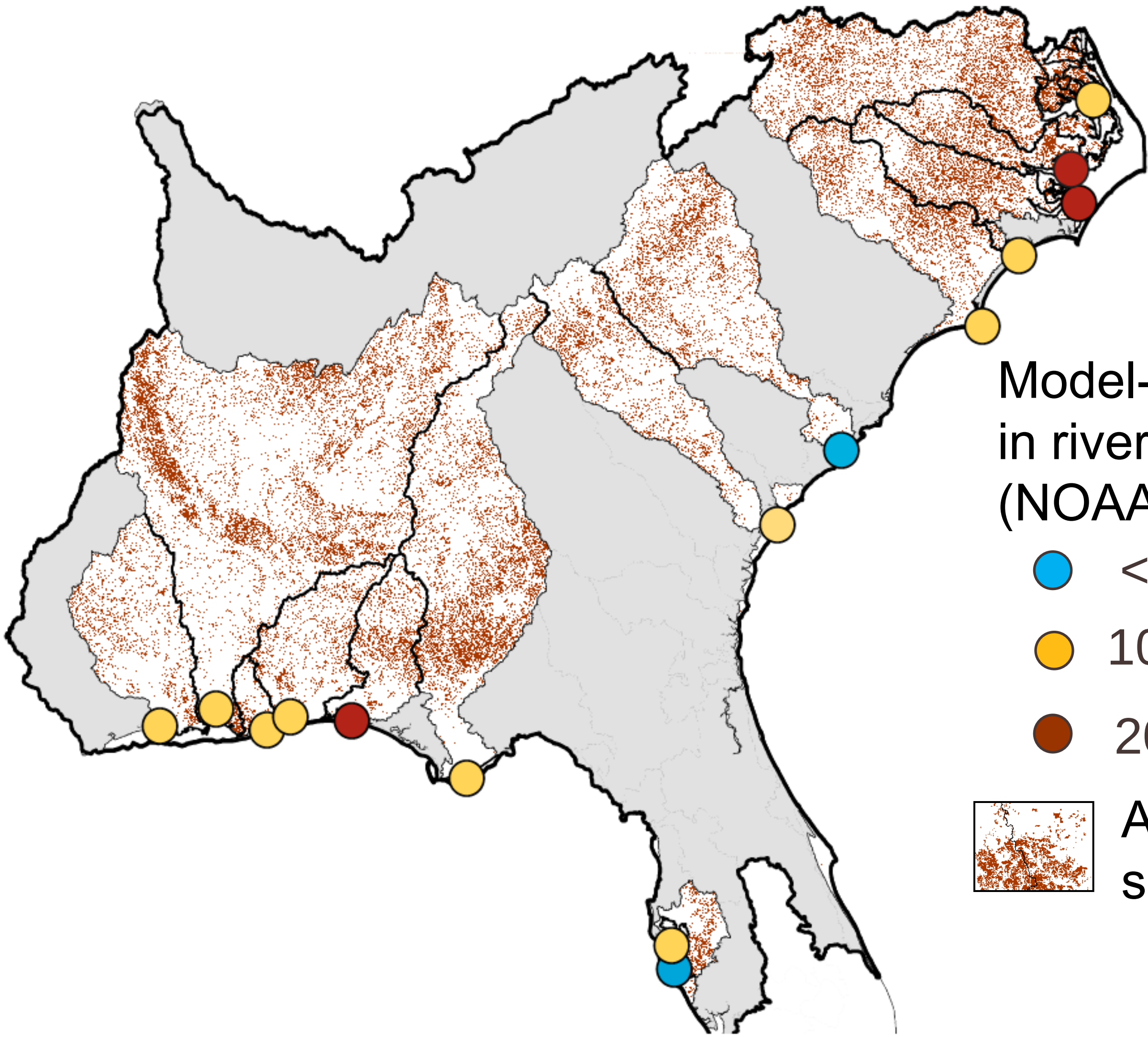


Coming Spring 2011 - Online Decision Support System for NAWQA SPARROW models

- Adjust input loads – scenario testing



3. 50% reduction in agricultural sources of N → → ?? reduction in N loading to estuaries??



Model-simulated percent reduction in riverine N loading to a eutrophic (NOAA 1999) estuary

- <10
- 10-20
- 20-25

Agricultural land use in water-sheds of eutrophic estuaries

Application to Actual Water-Quality Assessments in the Southeast

Type of application	Who and where?
1. Validate a watershed model	Tennessee water-quality agency (Beaver Creek)
2. Evaluate change in nutrient delivery to target from proposed changes in input	EPA, RTI (Neuse River estuary)
3. Calculate instream loads to match desired delivery rate to target	EPA (Florida streams)
4. Evaluate nutrient trading scenarios	NSF, UNC and Georgia State (Upper Neuse River)
5. Framework for collecting additional data	Mississippi water-quality agency (Ross Barnett Reserv)

#1. Validation of watershed models for Beaver Creek, TN

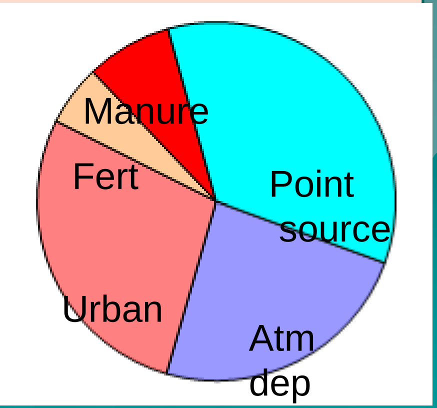
Tennessee Division of Water Pollution Control Sherry Wang (sherry.wang@tn.gov)

	HSPF	A-W (GWLF)
Total Nitrogen Load	12 kg/ha (35% PS)	7.2 kg/ha (60% PS)

- HSPF is based on simulated streamflow and limited TN sampling (20 samples)
- A-W (accumulation-washoff) is an empirical model

#1. Validation of watershed models for Beaver Creek, TN (contd.)

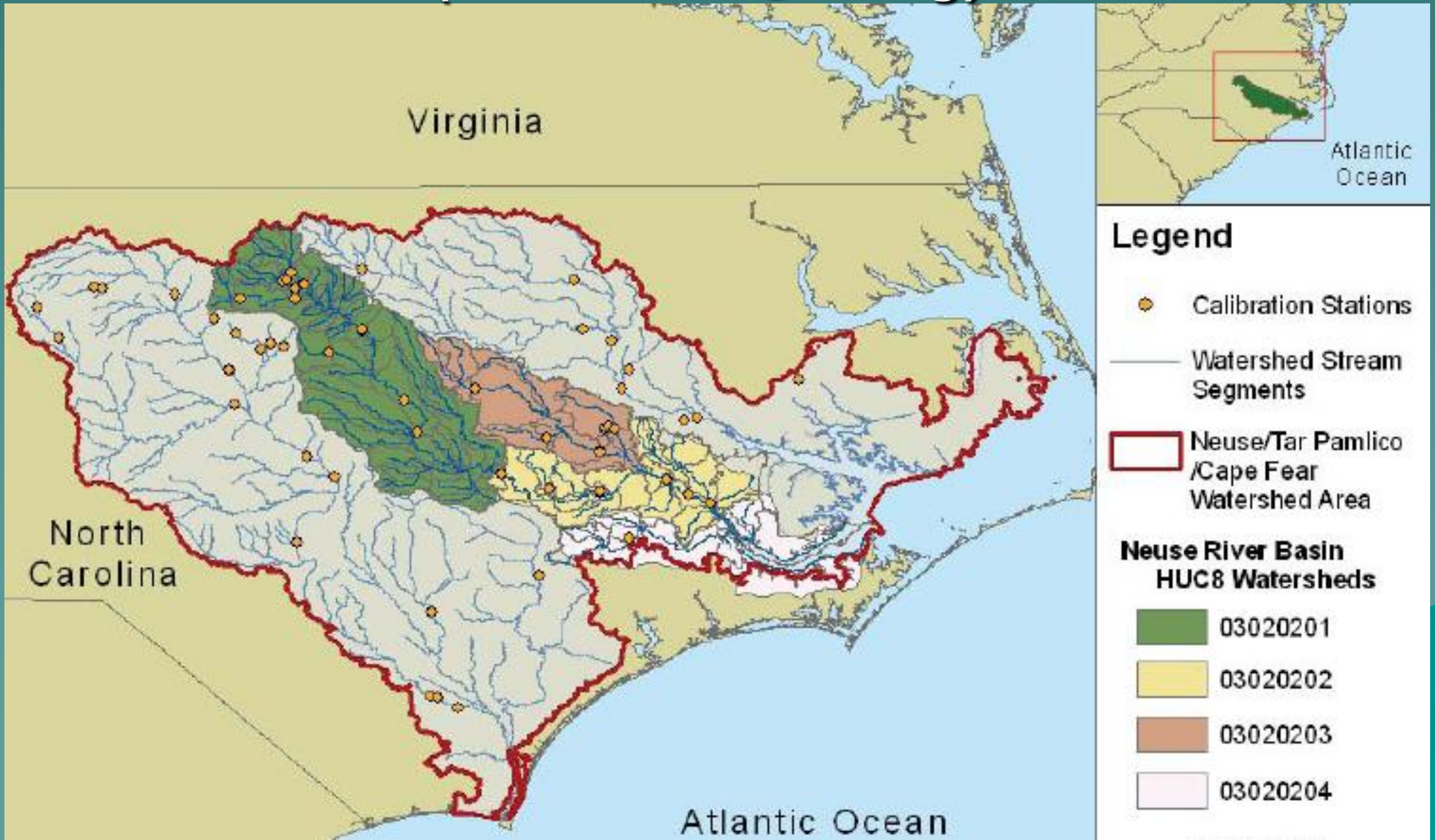
	HSPF	A-W (GWLF)	SPARROW
Total Nitrogen Load	12 kg/ha (39% PS)	7.2 kg/ha (60% PS)	13 kg/ha C.I. 8-23 (36% PS)



(sherry.wang@tn.gov)

#2. Evaluate change in nitrogen delivery to target from proposed changes in input Neuse River estuary

US EPA/OAQ Planning and Standards – Randy Waite
Research Triangle Institute - Marion Deerhake and Michele Cutrofello (mcutrofello@rti.org)



40% reduction NOx deposition → → ?? change in eutrophic status of estuary

- Prove-out of methodology to be applied nationally
- Linked three models
  - CMAQ atmospheric deposition model (EPA)
  - SPARROW watershed model (USGS)
  - ASSETS eutrophication assessment of estuary (NOAA)

40% reduction NOx deposition → → ?? change in eutrophic status of estuary

40% reduction in NOx deposition →
?? % reduction in atmos TN input to watershed

CMAQ: 18%

18% reduction in TN deposition →
?? % reduction in riverine loading to estuary

SPARROW: 5% (1.11 mg/L → 1.06 mg/L)

5% reduction in loading to estuary →
?? change in eutrophic condition (OEC score)

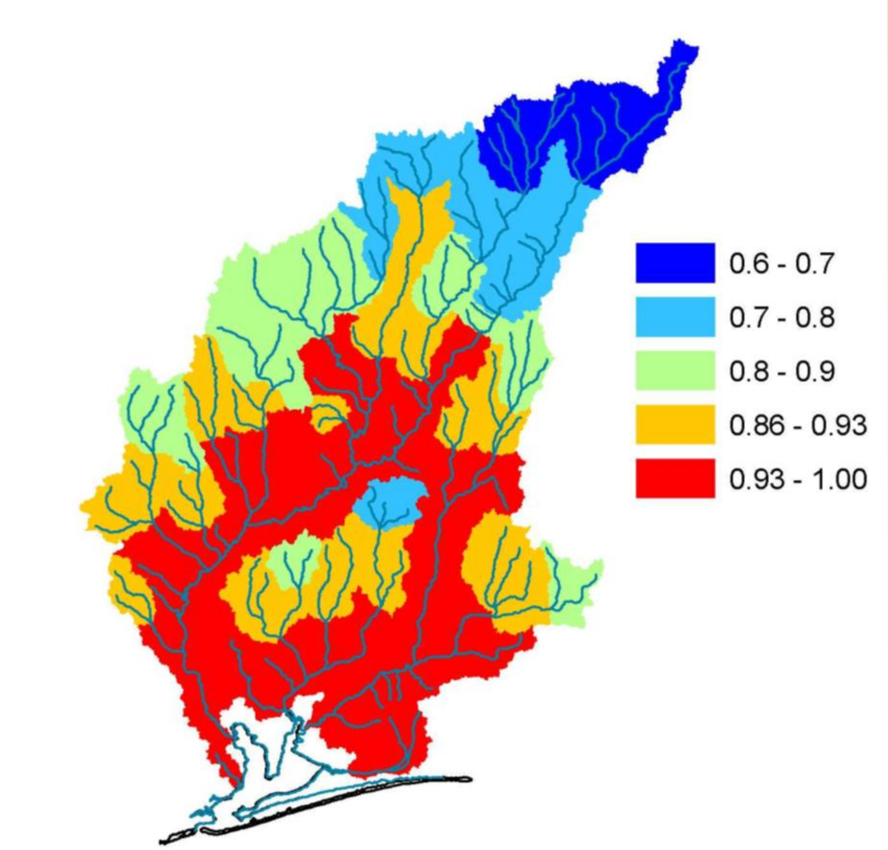
ASSETS/RTI: No change (remains highly eutrophic)

Type of application	Who and where?	Model components
1. Validate a watershed model	Tennessee water-quality agency (Beaver Creek)	Predicted load and source shares
2. Evaluate change in nutrient delivery to target from proposed changes in input	EPA, RTI (Neuse River estuary)	Calibrated model and input scenarios
3. Calculate instream loads to match desired delivery rate to target	EPA (Florida streams)	Model-fitted coefficients of instream and reservoir decay
4. Evaluate nutrient trading scenarios	NSF, UNC and Georgia State (Upper Neuse River)	Model-fitted coefficients of instream and reservoir decay
5. Framework for designing additional data collection	Mississippi water-quality agency(Ross Barnett Reservoir)	Predicted load and source shares, residuals

#3. Calculate instream load and concentration to match a desired delivery rate to target – Florida streams

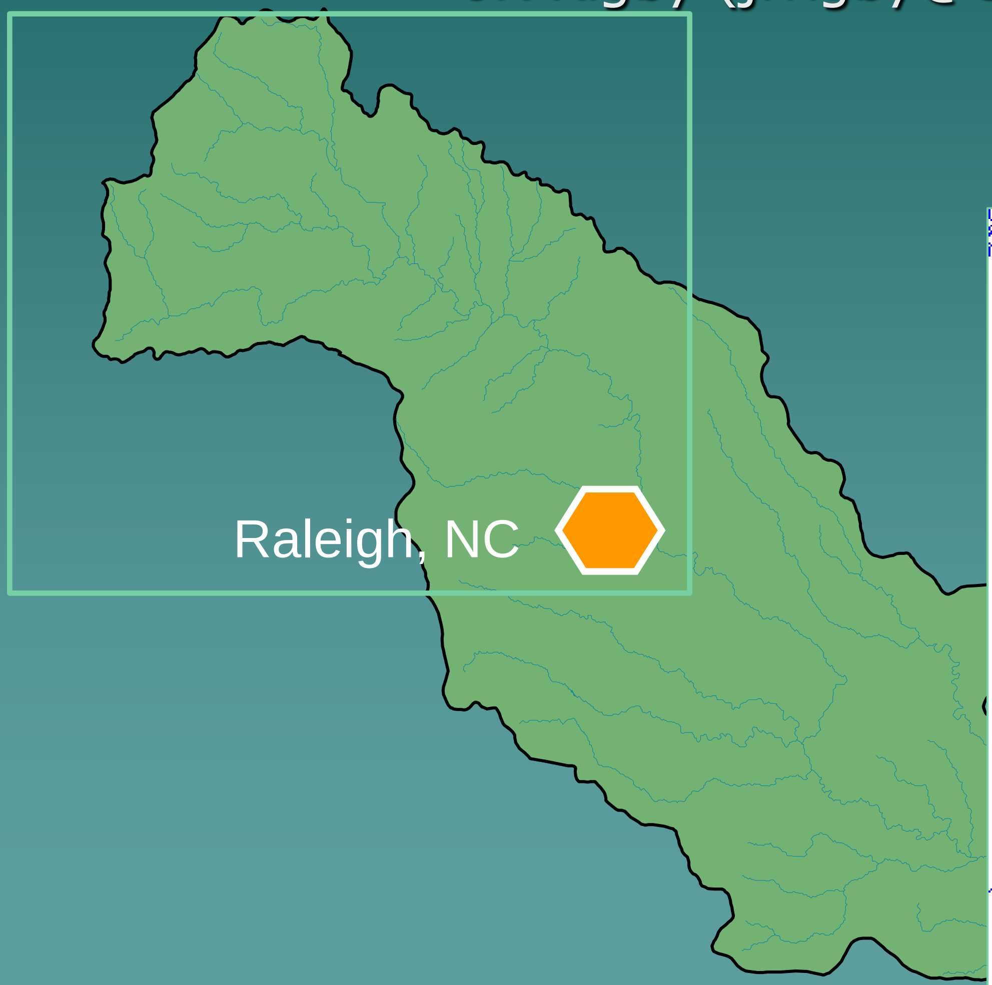
U.S. EPA Gulf Ecology Division – Richard Greene, Jim Hagy
greene.rick@epa.gov, hagy.jim@epa.gov,

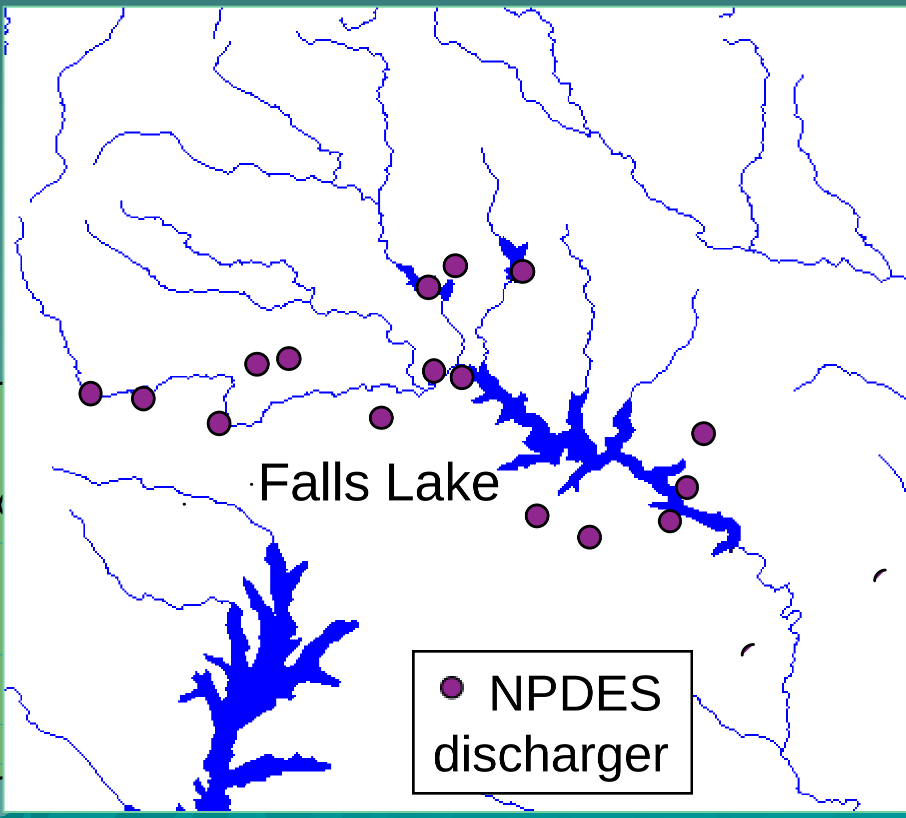
Uses SPARROW estimates of fraction of nitrogen delivered to Pensacola Bay



#4. Evaluate nutrient trading scenarios Upper Neuse – Falls Lake

NSF, Georgia State University, UNC-Chapel Hill –
JR Rigby (jrrigby@email.unc.edu)





SPARROW-Southeast is used to support water-quality assessments …

- that need to be extrapolated/applied across a large region (need consistent data and methods over wide areal extent)

- in basins with limited monitoring data (SPARROW results constrained by nearby monitoring data and at defined scale)

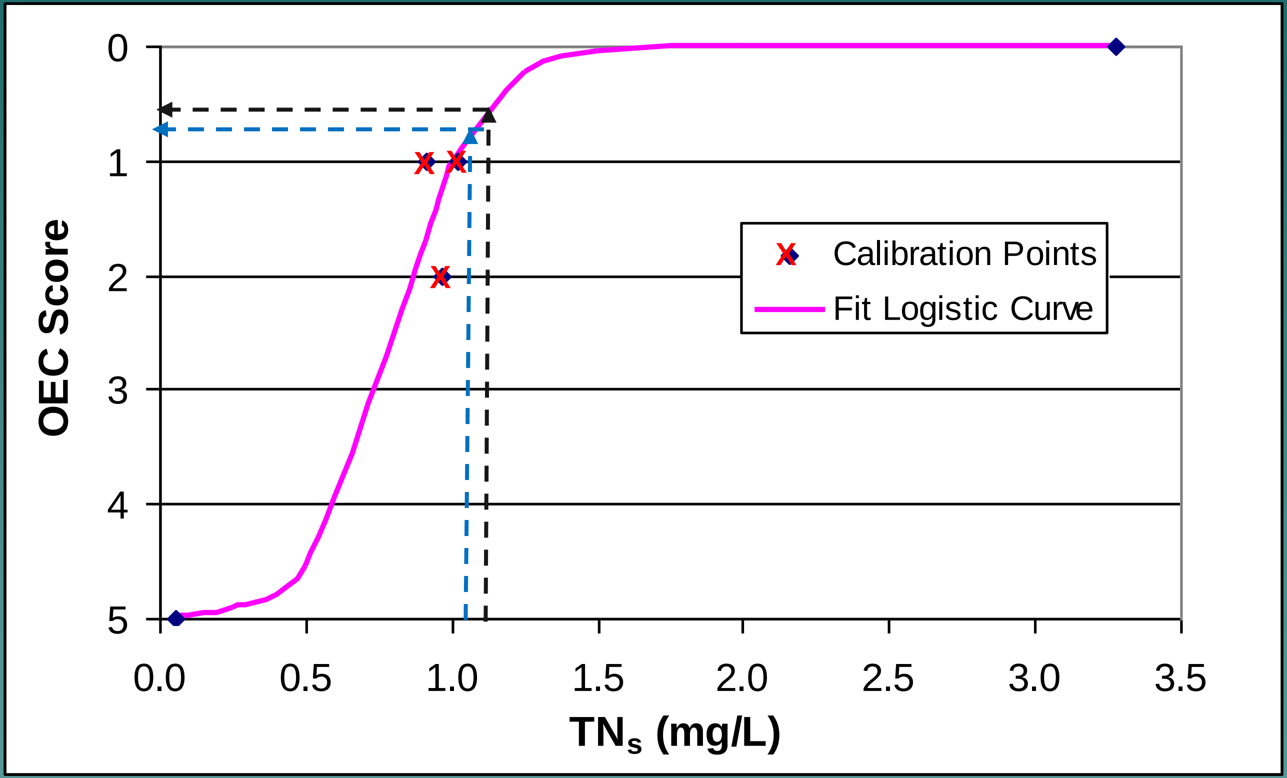
Diverse use of model components (predicted load, residuals, model-fitted coefficients)

Response curve relating inflow TN concentration to estuary eutrophic condition

Highly eutrophic

Overall Eutrophic Condition

Not eutrophic



2002 condition: Inflow TN concentration = 1.11 mg/L

OEC = highly eutrophic

Michele Cutrofello, RTI