Nutrient Loading: NAWQA Regional SPARROW model

Pee Dee River Basin and Winyah Bay Estuary
Waccamaw Water Quality Data Conference
Wednesday, September 19, 2013

Celeste Journey, Water-Quality Specialist
USGS South Carolina Water Science Center
Columbia, SC

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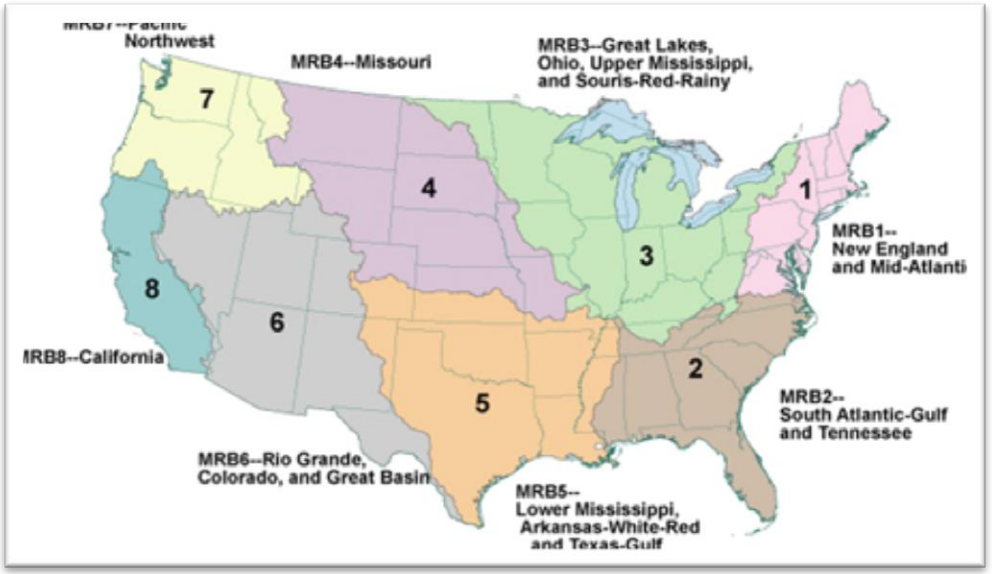
Topics of Discussion

- General Overview of the SPARROW model and online Decision Support System
- Update on better resolution, dynamic SPARROW modeling in the Pee Dee River basin
- Discussion and Input

Regional SPARROW Model Assessments of Streams and Rivers



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

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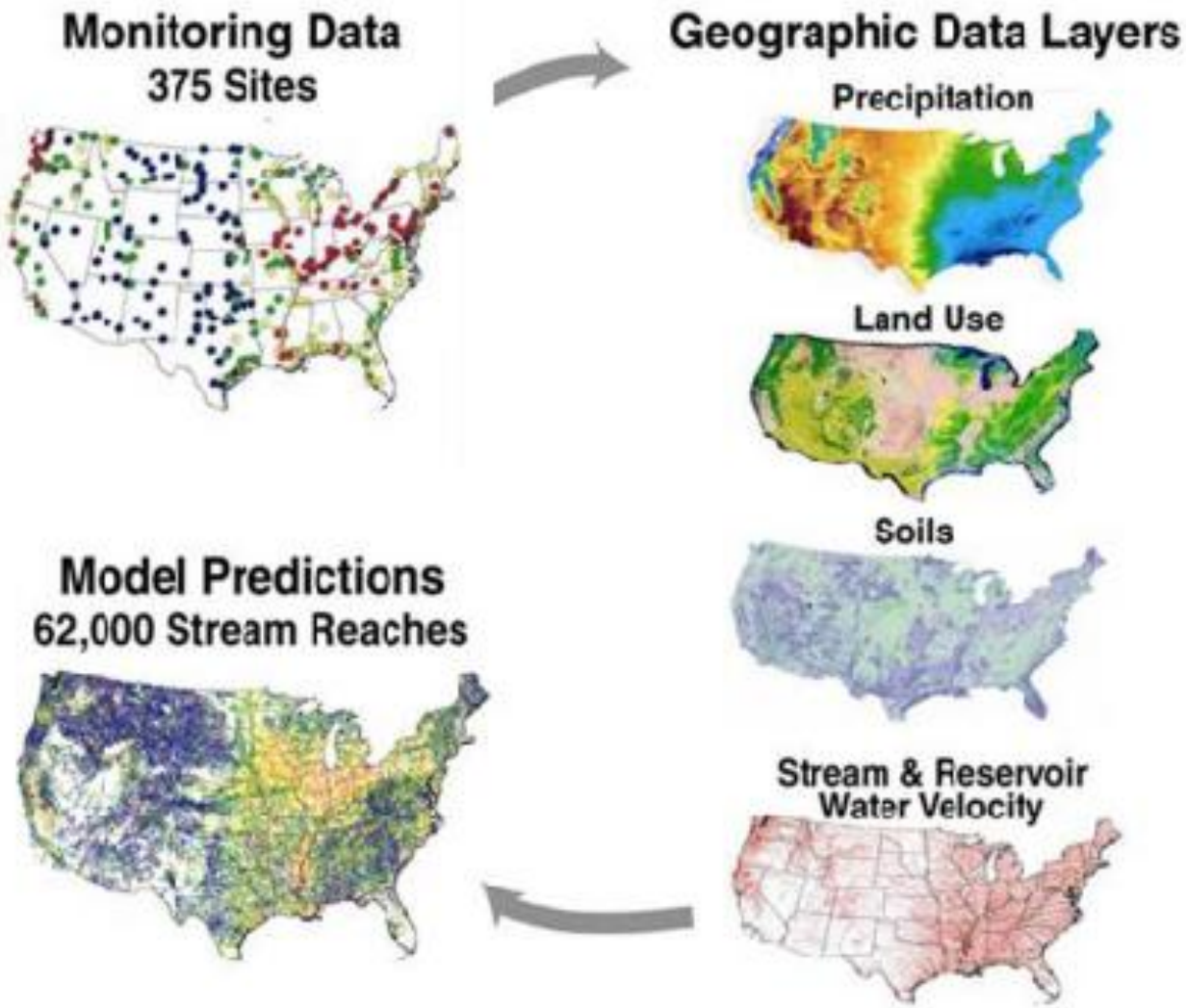
Spatially Referenced Regression on Watershed Attributes (SPARROW) Model

- Nutrient models were funded by the USGS National Water Quality Assessment (NAWQA) Program
  - More details at http://water.usgs.gov/nawqa/sparrow/

- **Applications specific to SPARROW Model**
  - Contribute to State assessments
    - beneficial uses and impaired waters
    - strategies for source water protection and management
    - nutrient management plans
  - Prioritize watersheds
    - Vulnerable to contamination
    - Benefit from improved treatment or management

SPARROW Model Elements



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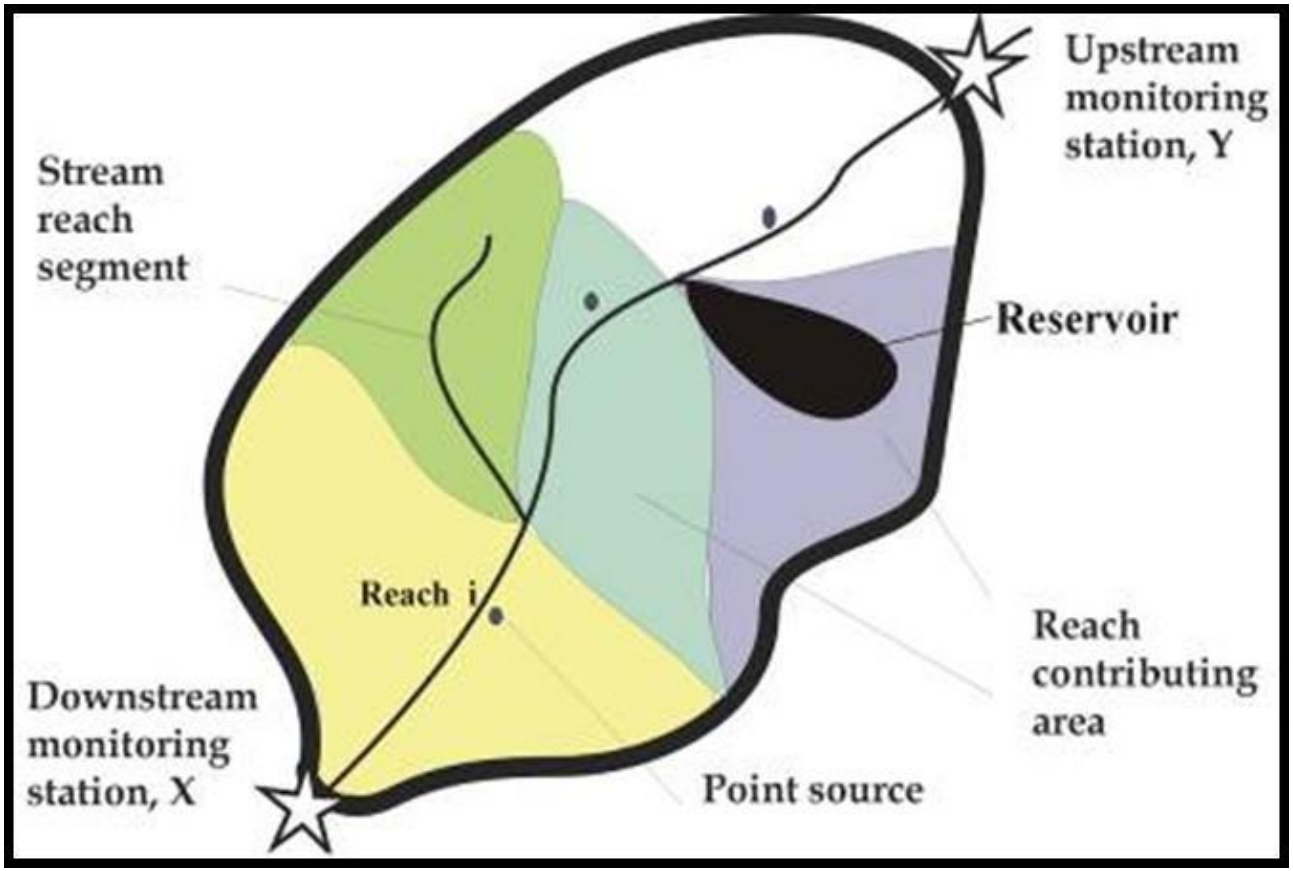
Conceptualization of model



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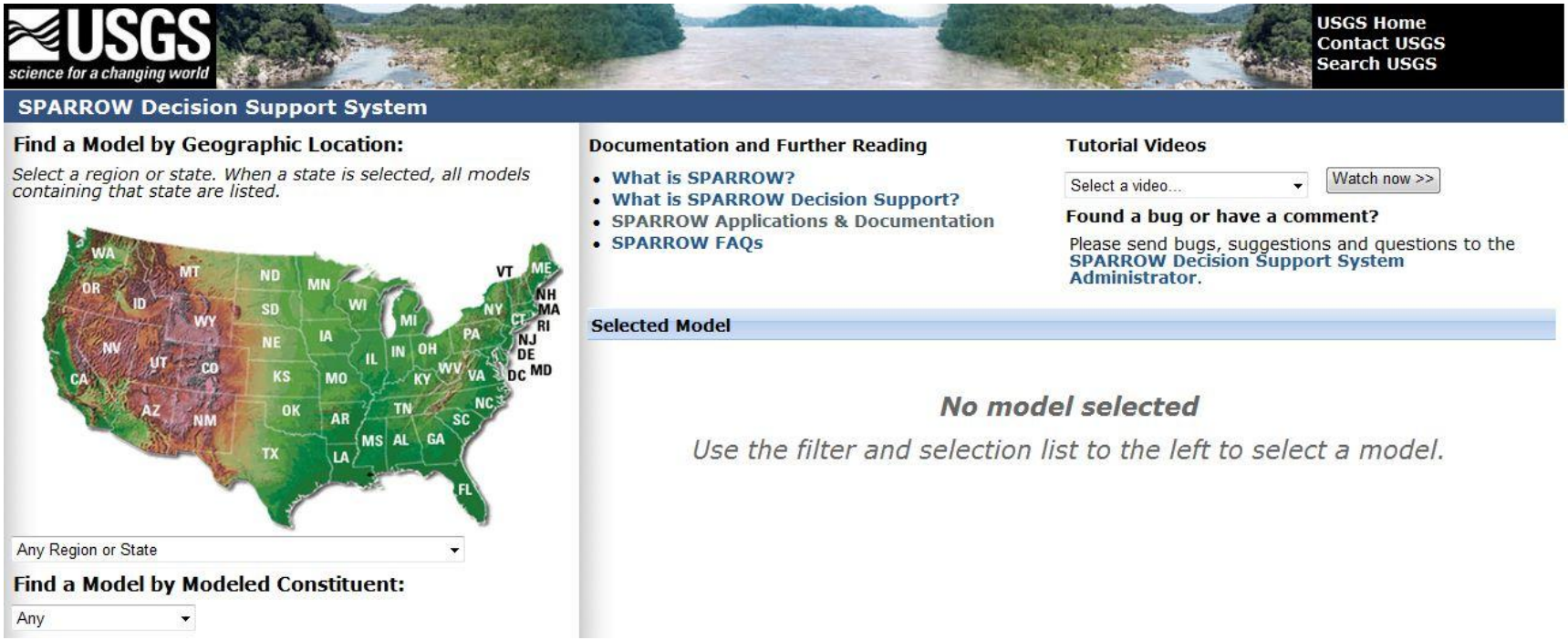
SPARROW-based User Friendly Decision Support System

- In South Carolina regional area, available models are for Total Nitrogen and Total Phosphorus

http://cida.usgs.gov/sparrow/



SPARROW-based User Friendly Decision Support System

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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.

South Carolina

Find a Model by Modeled Constituent:

Phosphorus

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

National Total Phosphorus Model - 1992

Total Phosphorus Model for the South Atlantic-Gulf and Tennessee 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 Decision Support System Administrator.

Selected Model

2002 Total Phosphorus Model for the Southeastern U.S. (MRB2)

Explore this model in the Decision Support System >>

Modeled Constituent:	Phosphorus
Base Year:	2002
Stream Network:	Enhanced River Reach File 2.0
Reference:	A Regional Modeling Framework of Phosphorus Sources and Transport in Streams of the Southeastern 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*.

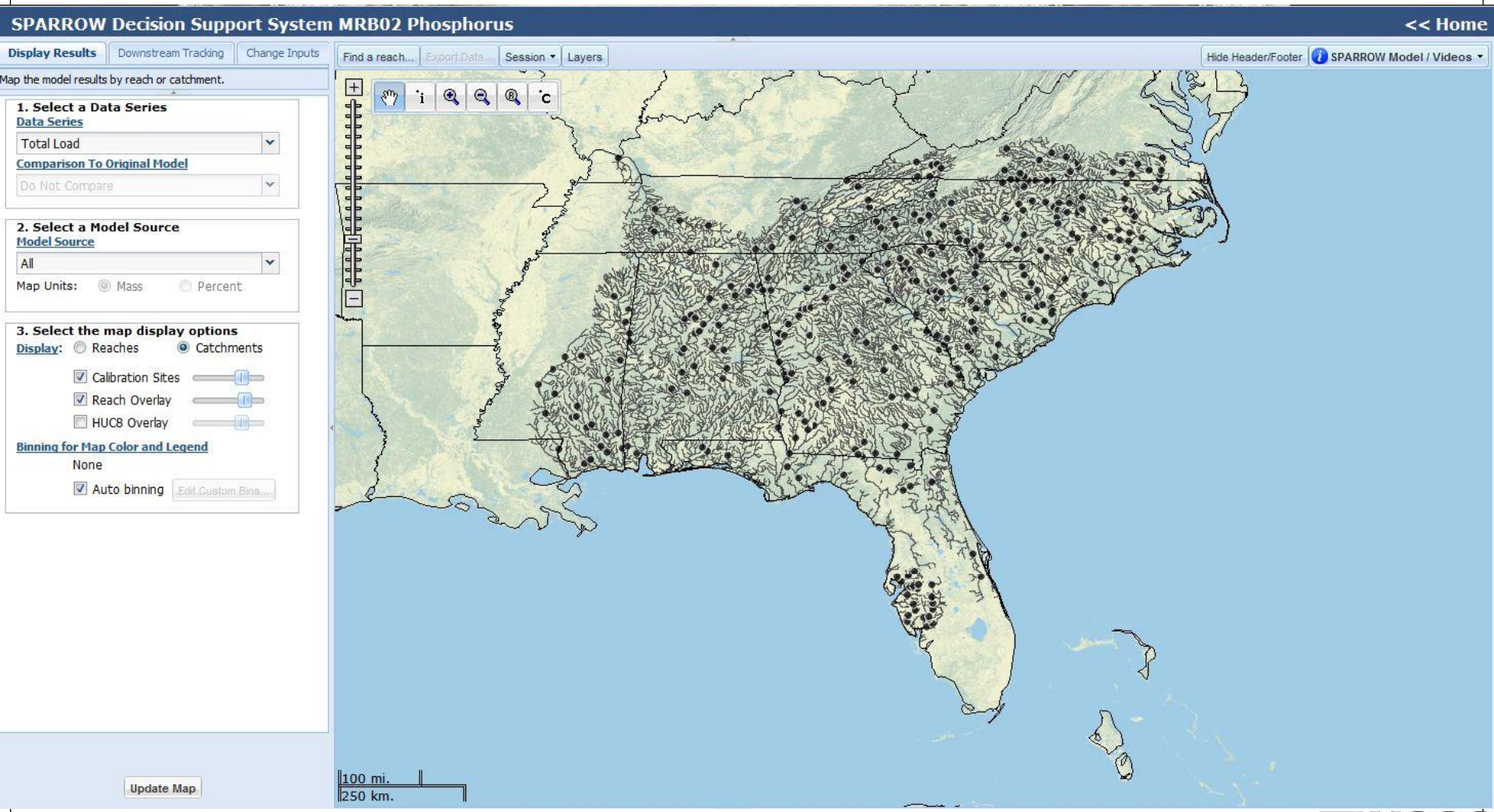
Pearl River Watershed Go >>

Scenario Based Sessions

To start the DSS with a predefined scenario, click on the link for one of the scenarios below.

Source Changes in Neuse River Basin	Example scenario showing changes in the total load of phosphorus due to a 25 percent reduction of manure sources in the Neuse River Basin.

SPARROW-based User Friendly Decision Support System



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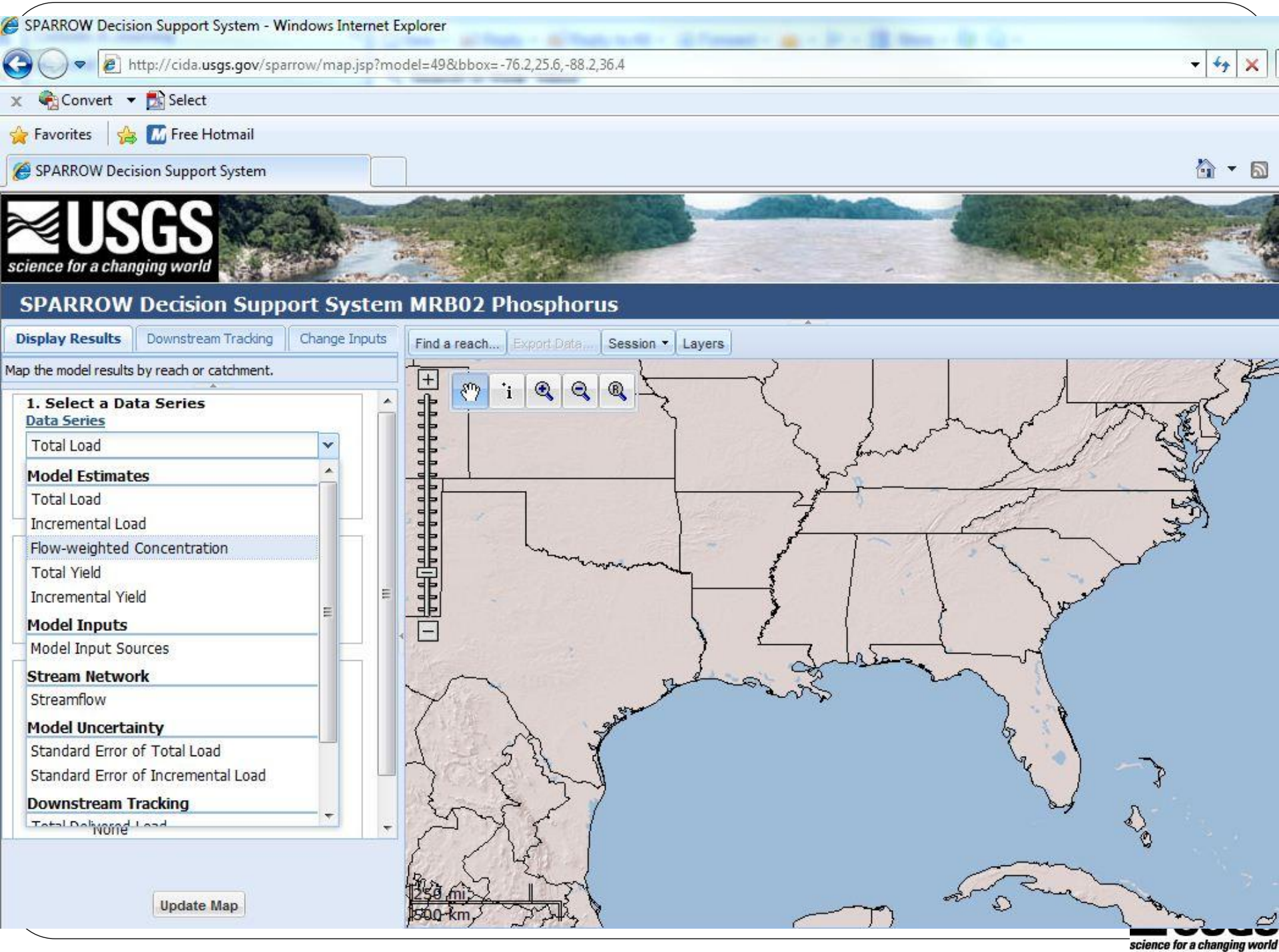
SPARROW Decision Support System - Windows Internet Explorer
http://cida.usgs.gov/sparrow/map.jsp?model=49&bbox=-76.2,25.6,-88.2,36.4
Convert
Select
Favorites
Free Hotmail
SPARROW Decision Support System
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SPARROW Decision Support System MRB02 Phosphorus
Display Results
Downstream Tracking
Change Inputs
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
None
Update Map
Find a reach...
Export Data...
Session
Layers
250 mi
500 km
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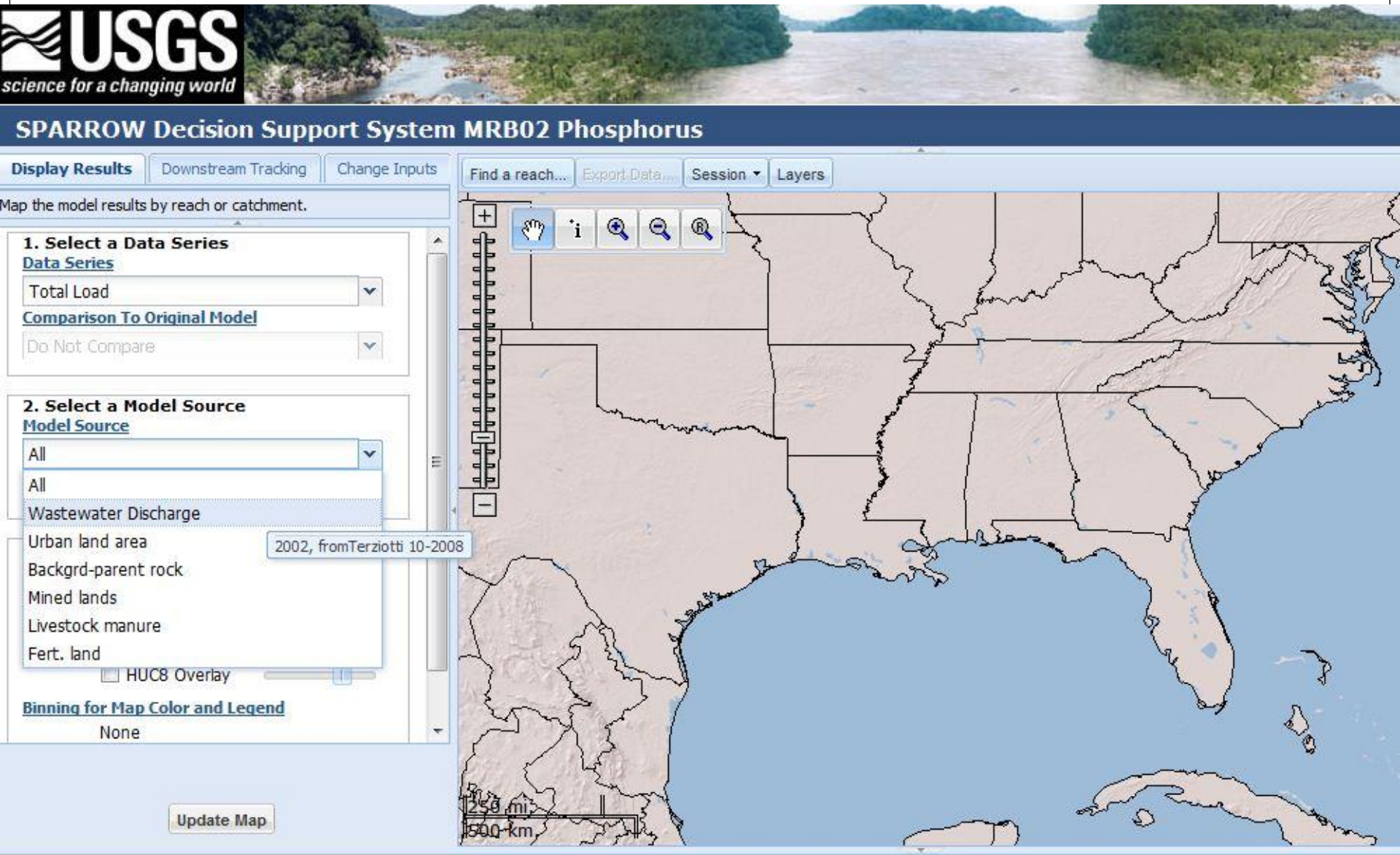
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SPARROW Decision Support System MRB02 Phosphorus
Display Results
Downstream Tracking
Change Inputs
Map the model results by reach or catchment.
1. Select a Data Series
Data Series
Total Load
Comparison To Original Model
Do Not Compare
2. Select a Model Source
Model Source
All
All
Wastewater Discharge
Urban land area
Backgrd-parent rock
Mined lands
Livestock manure
Fert. land
2002, fromTerziotti 10-2008
HUC8 Overlay
Binning for Map Color and Legend
None
Update Map
Find a reach...
Export Data...
Session
Layers
250 mi
500 km
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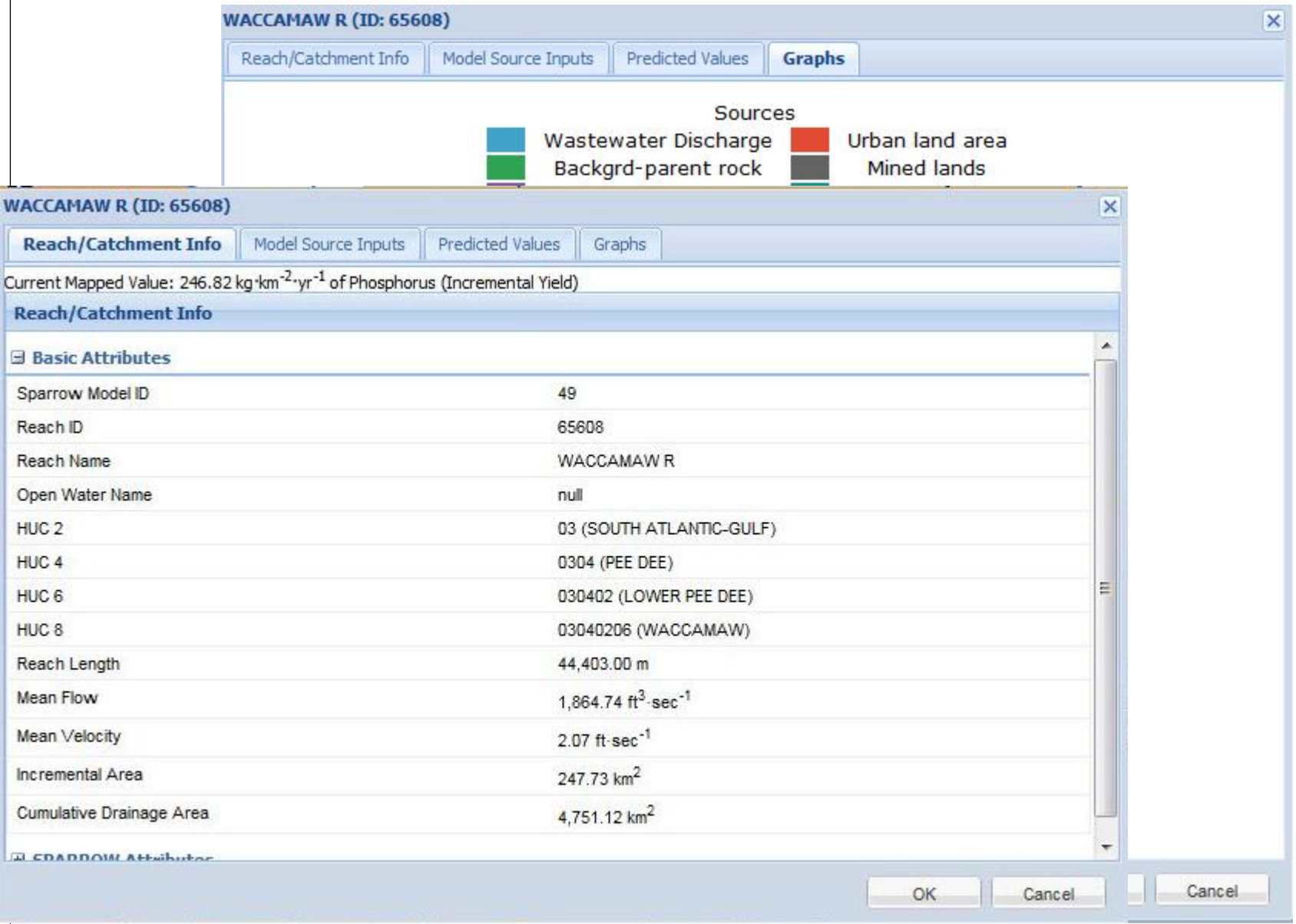

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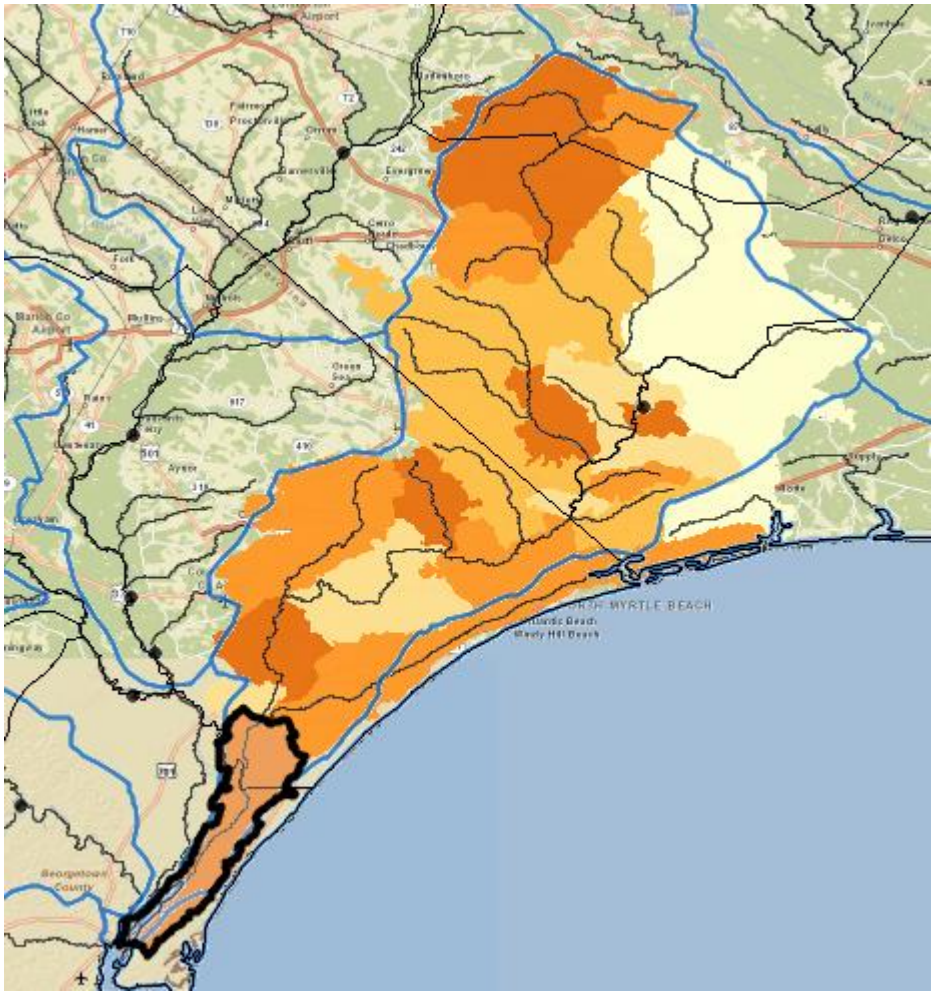
Waccamaw River Basin: Incremental Total Phosphorus Yield



EXPLANATION

Incremental Delivered Yield

kg·km^{-2}·yr^{-1} of Phosphorus

		<	29.610
	29.610	to	36.271
	36.271	to	44.769
	44.769	to	55.241
		>	55.241

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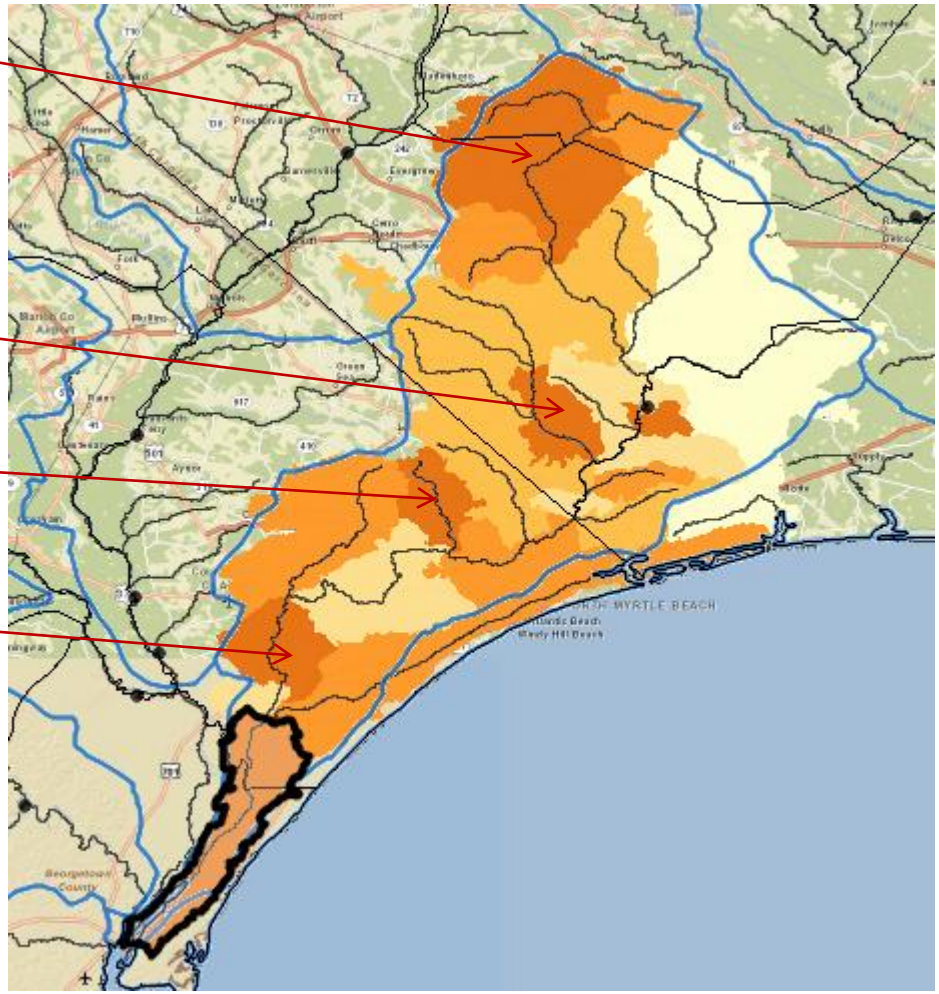
Waccamaw River Basin: Incremental Total Phosphorus Yield

White Marsh Creek (near Whiteville, NC)
Brown Marsh Creek (near Clarkton, NC)
[Livestock Manure, Fertilized Land]

Seven Creeks (near Pineway, NC)
[Fertilized Land, Livestock manure]

Simpson Creek (near Fremont, SC)
[Fertilized Land]

Waccamaw River (below Conway, SC)
[Fertilized Land, Livestock Manure, Urban]



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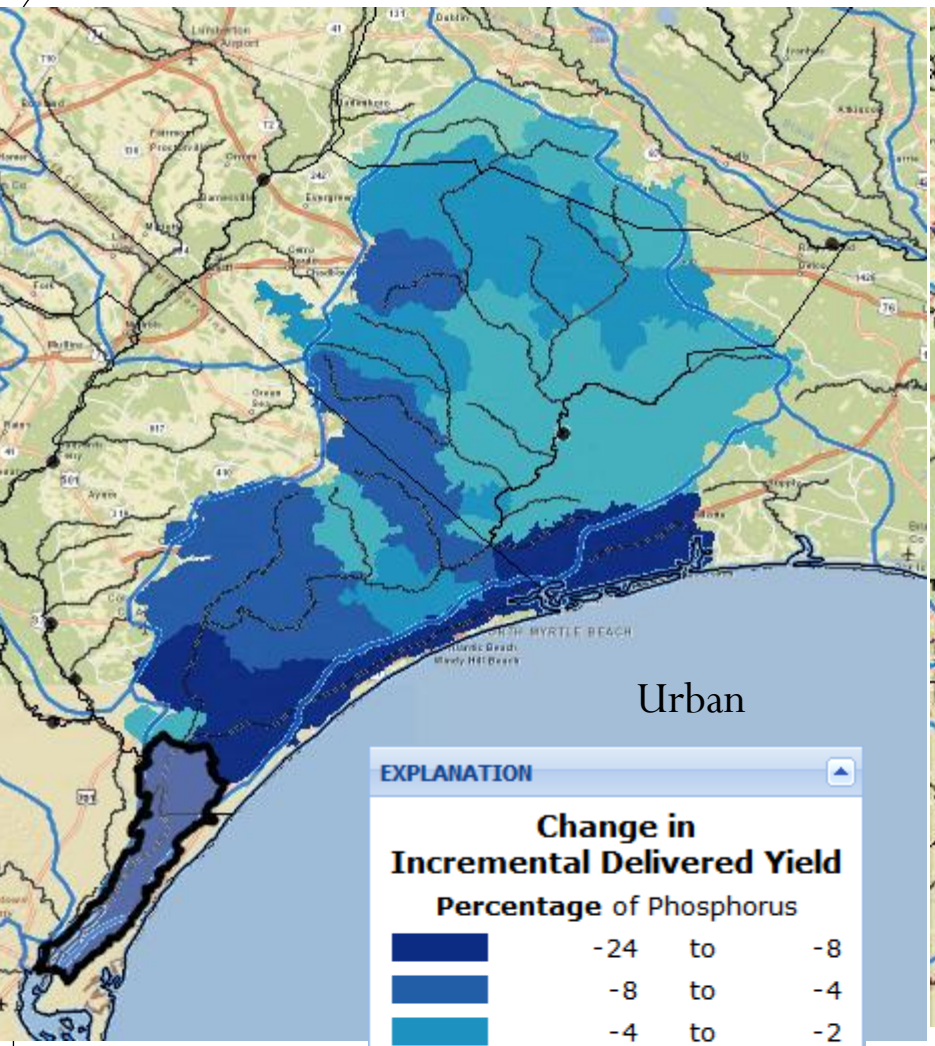

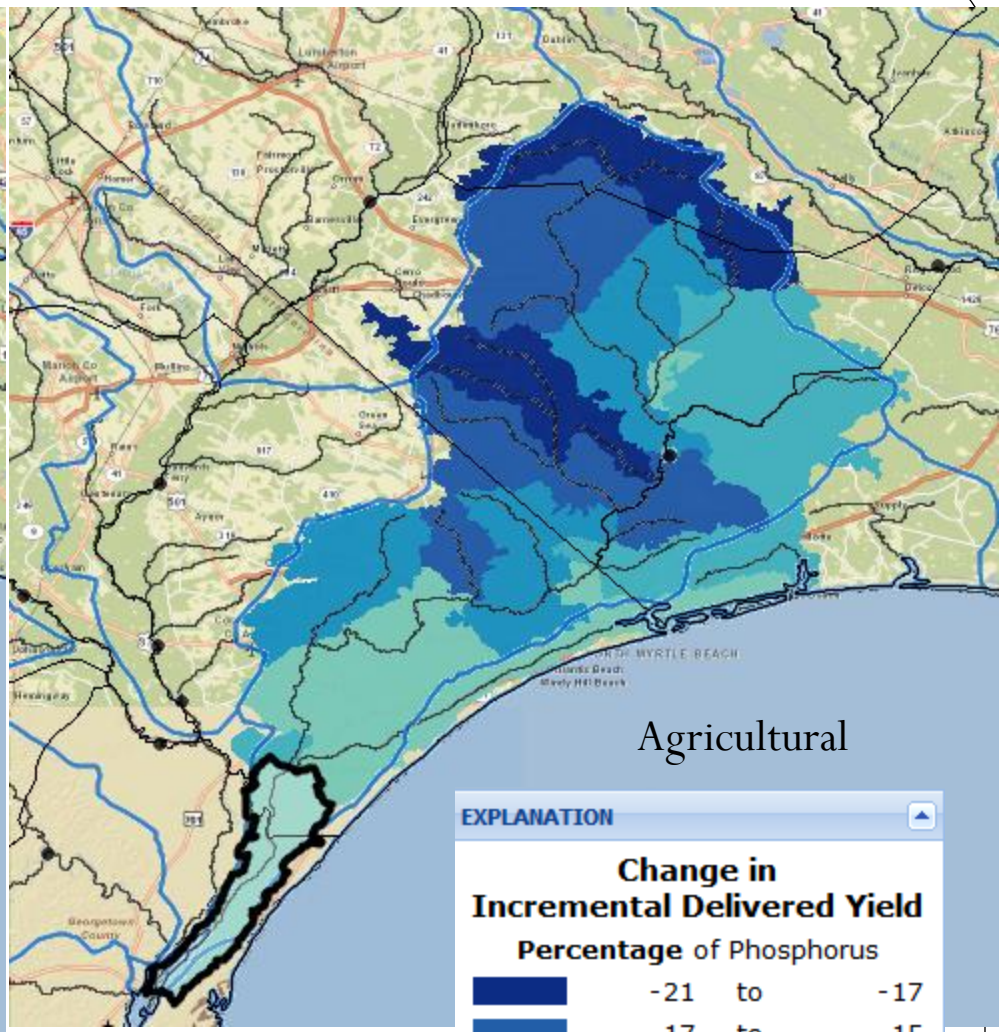

Scenario 1:
25% reduction in urban runoff

Scenario 2:
25% reduction in fertilized land

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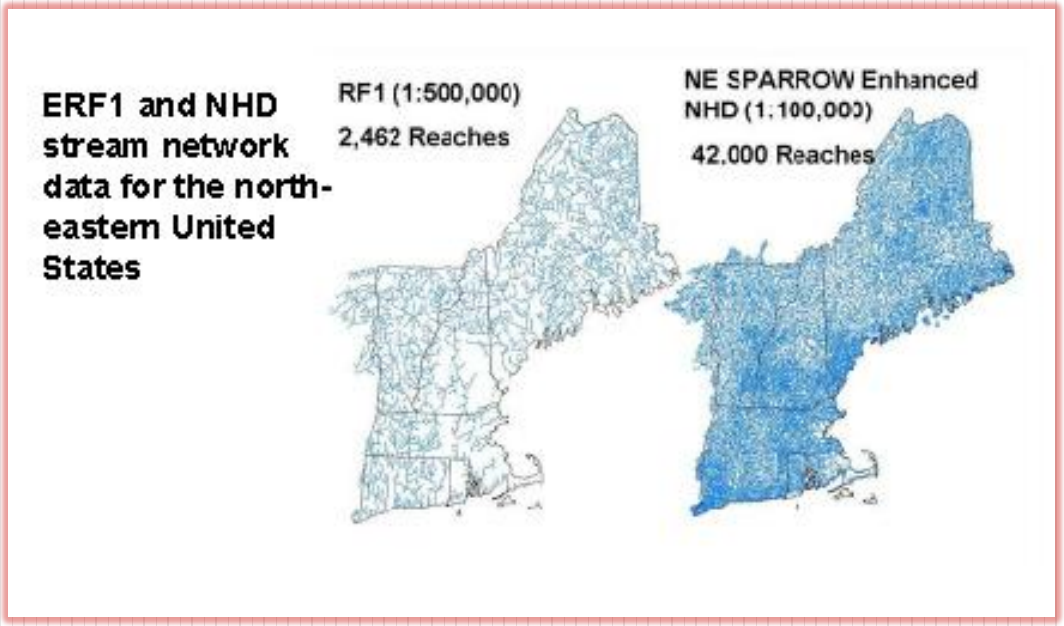
Scenario based questions

- What is the nutrient contribution from individual subbasins or catchments in the watershed of interested?
  - Look for "hot spots"
- What fraction of the total load is delivered to a downstream site from upstream subbasins or catchments?
  - Evaluates how much of the load from upstream catchments "makes it" to the downstream site.
- What happens if the source inputs change?
  - Determine the effects on a downstream site if present day sources are reduced by a certain fraction.
  - Consider point and nonpoint source

Enhancement to SPARROW modeling in South Carolina

- Better resolution of hydrology
- Seasonal rather than annual loads
- Multiple climatic conditions
- Improved "land-to-water" transport term



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Dynamic SPARROW Modeling for South Carolina

- Funding from Resources for the Future (RFF) and NASA
- Timeline FY 2012 - 2014
- Team involved in Model Development
  - Anne Hoos, USGS TN WSC
  - David Ladd, USGS TN WSC
  - Celeste Journey, USGS SC WSC
  - John Brakebill USGS MD WSC and Richard Smith, USGS HQ, Reston, VA
    - Involved in Potomac modeling

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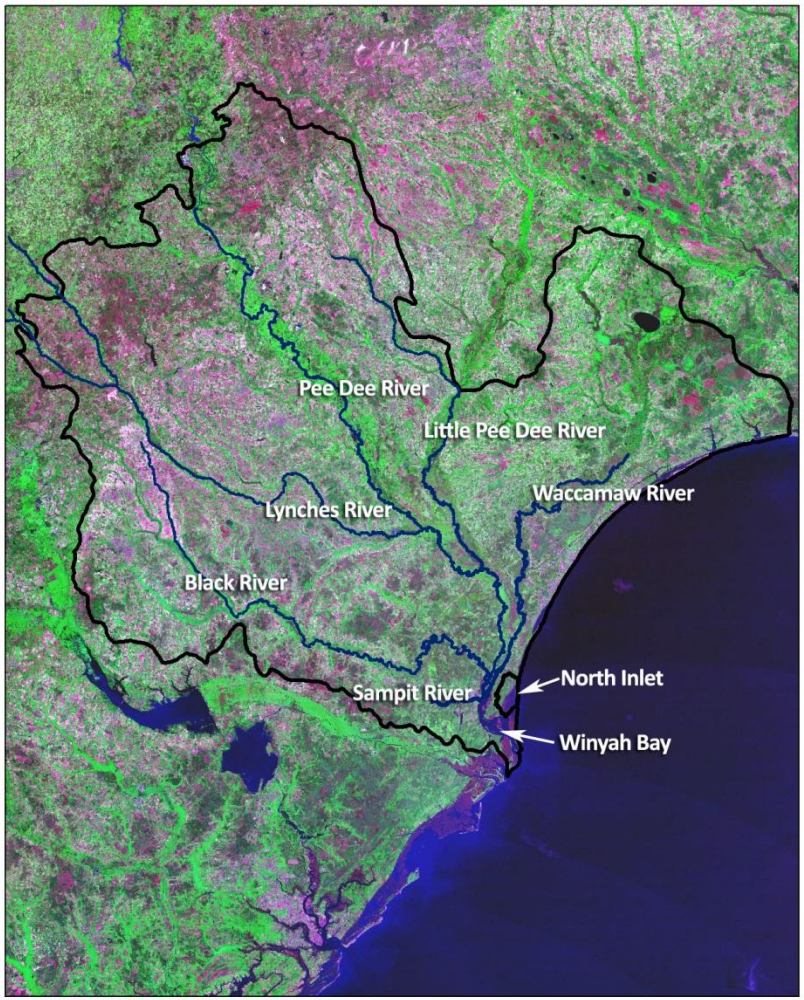
Dynamic SPARROW Model for South Carolina

- Pee Dee River basin
- Seasonal time step
- 4-year period (include average, dry, & wet conditions)
  - 2001 - 2004



Major Rivers of the Watersheds of the North Inlet and Winyah Bay Estuaries

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NERR Long-term Water Quality Monitoring Sites

North Inlet- Winyah Bay National Estuarine Research Reserve

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Winyah Bay Water-Quality Data

- http://cdmo.baruch.sc.edu
- Downloaded data from Thousand Acre station (TA)
- Weather and continuous WQ data available
- Only total phosphorus, nitrate plus nitrite, ammonia, and chlorophyll a are available for download.
  - Combined nitrate plus nitrite and ammonia to get total inorganic nitrogen.

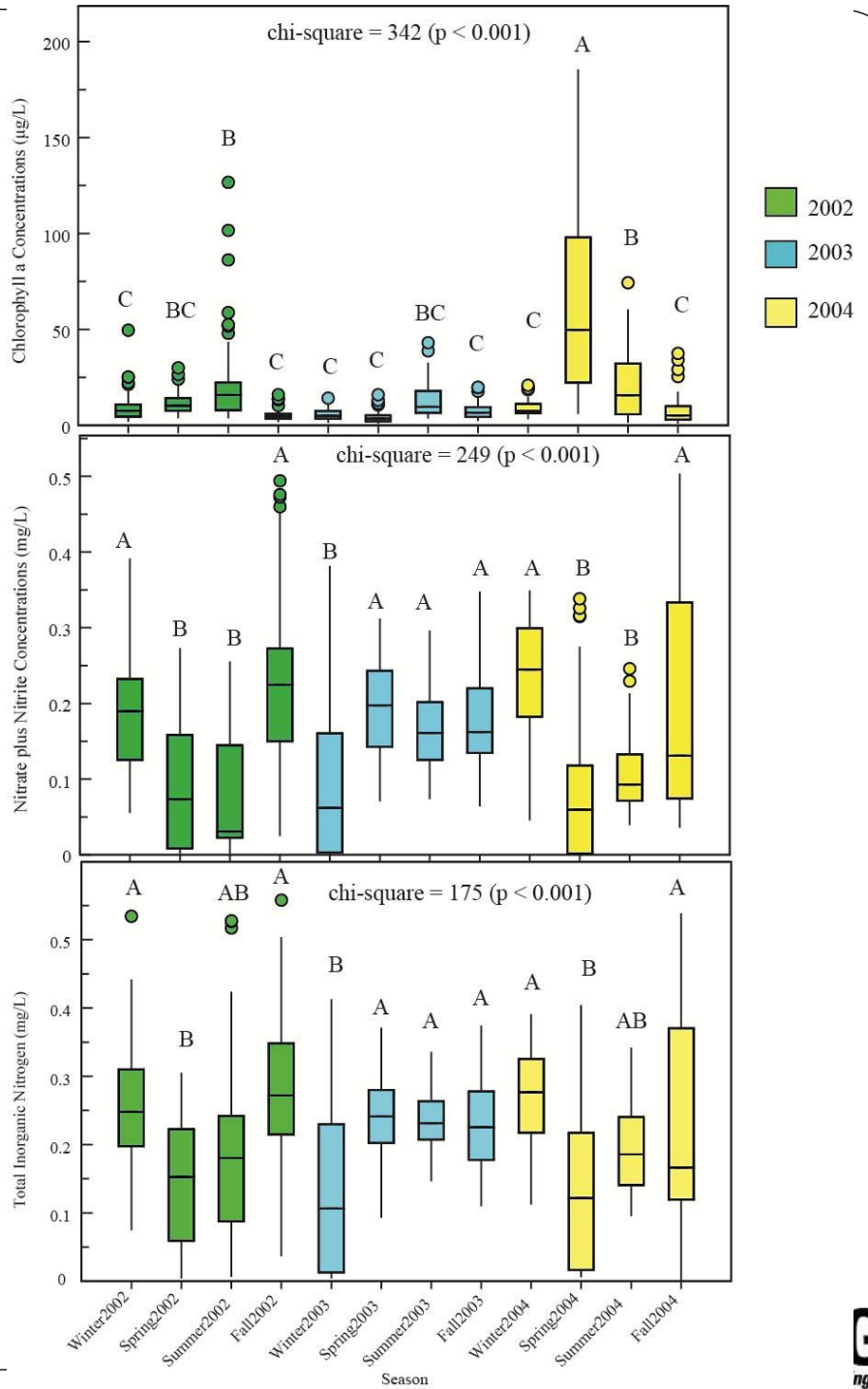
Seasonal Distribution Nitrogen and Chlorophyll Concentratins at Thousand Acre Station in Winyah Bay

Greater chlorophyll occurs in the spring and summer months in Winyah Bay.

Greatest chlorophyll levels occurred in the spring of 2004.

Greater Total Inorganic Nitrogen (mainly nitrate plus nitrite) occurred during Winter 2002, Fall 2002, Spring – Fall 2003, Winter 2004, and Fall 2004.

Lower nitrogen occurred during Winter 2002 and 2003, and in Spring 2002.



Great Pee Dee River (Station 21SC60WQ.PD-076) basin

SPARROW MODEL STATIONS

Waccamaw River (Station 21SC60WQ.MD-124) basin

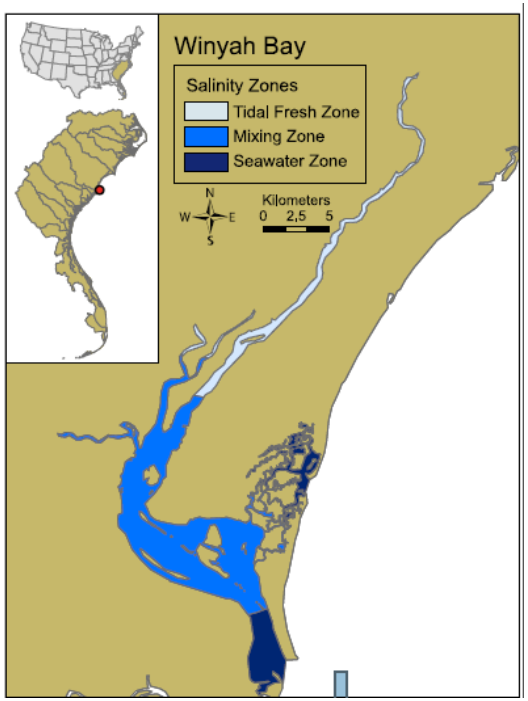
Waccamaw River basin

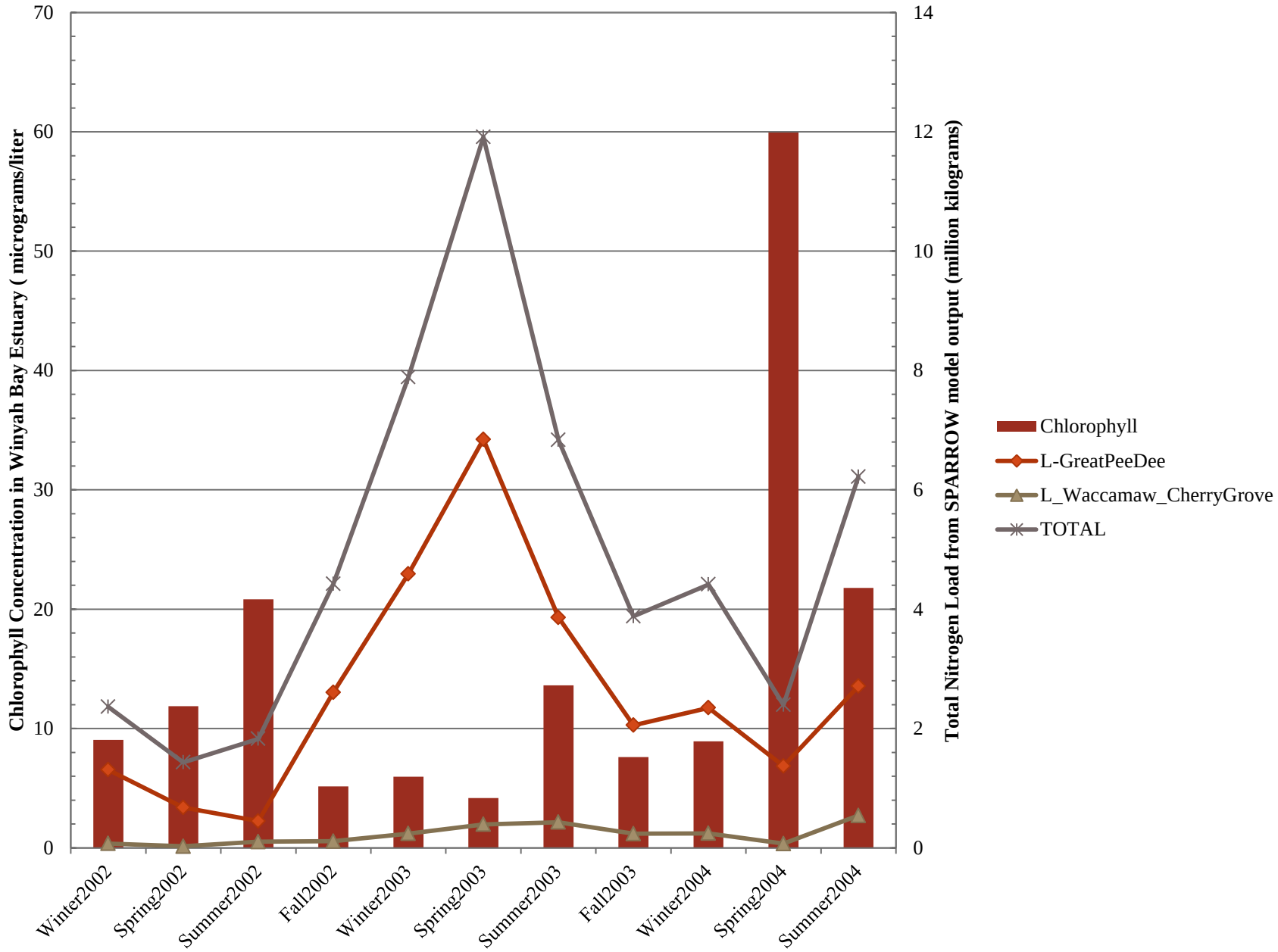
Great Pee Dee River

Waccamaw River

Thousand Acre
NERR Station

Winyah Bay





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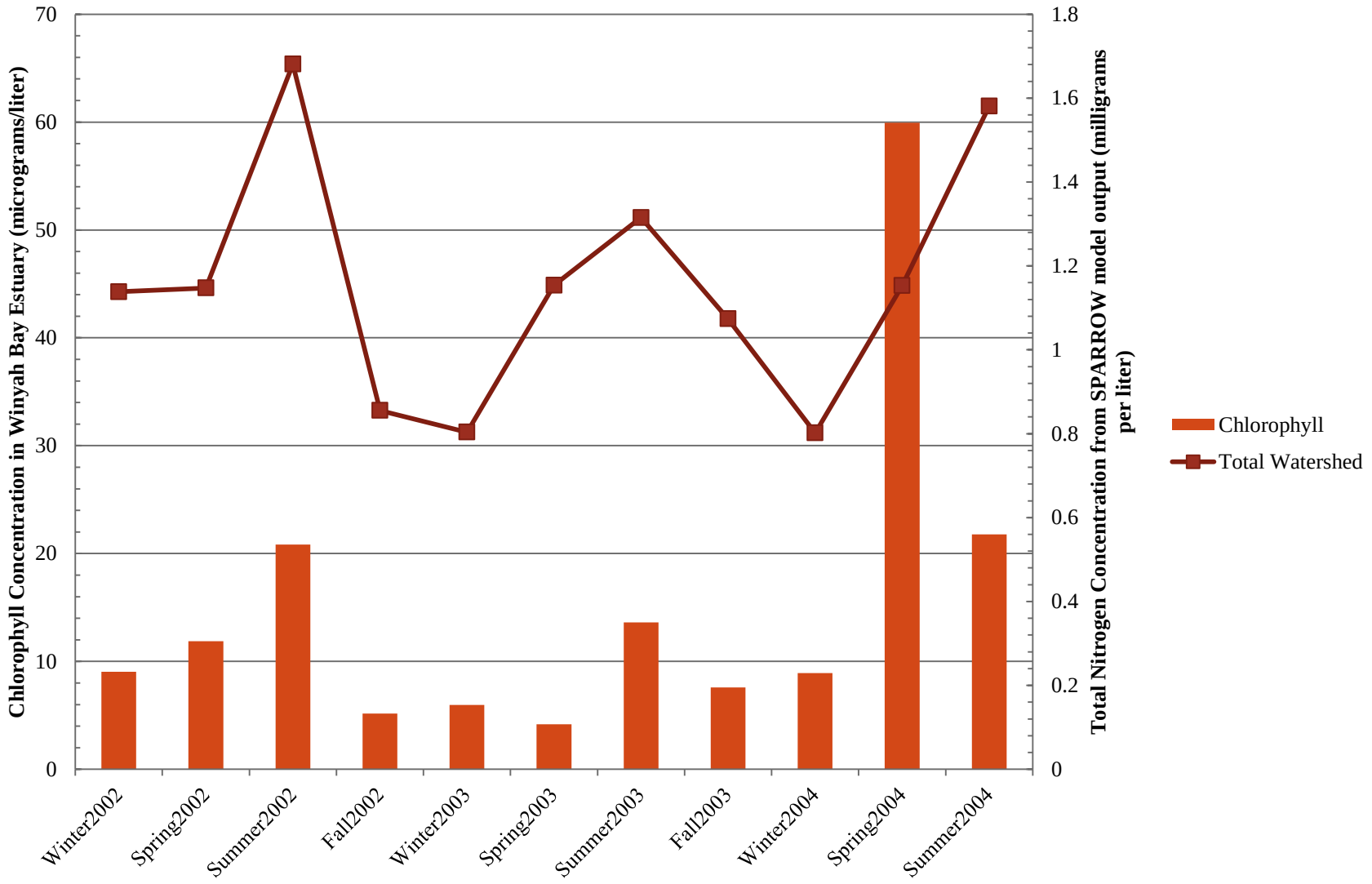

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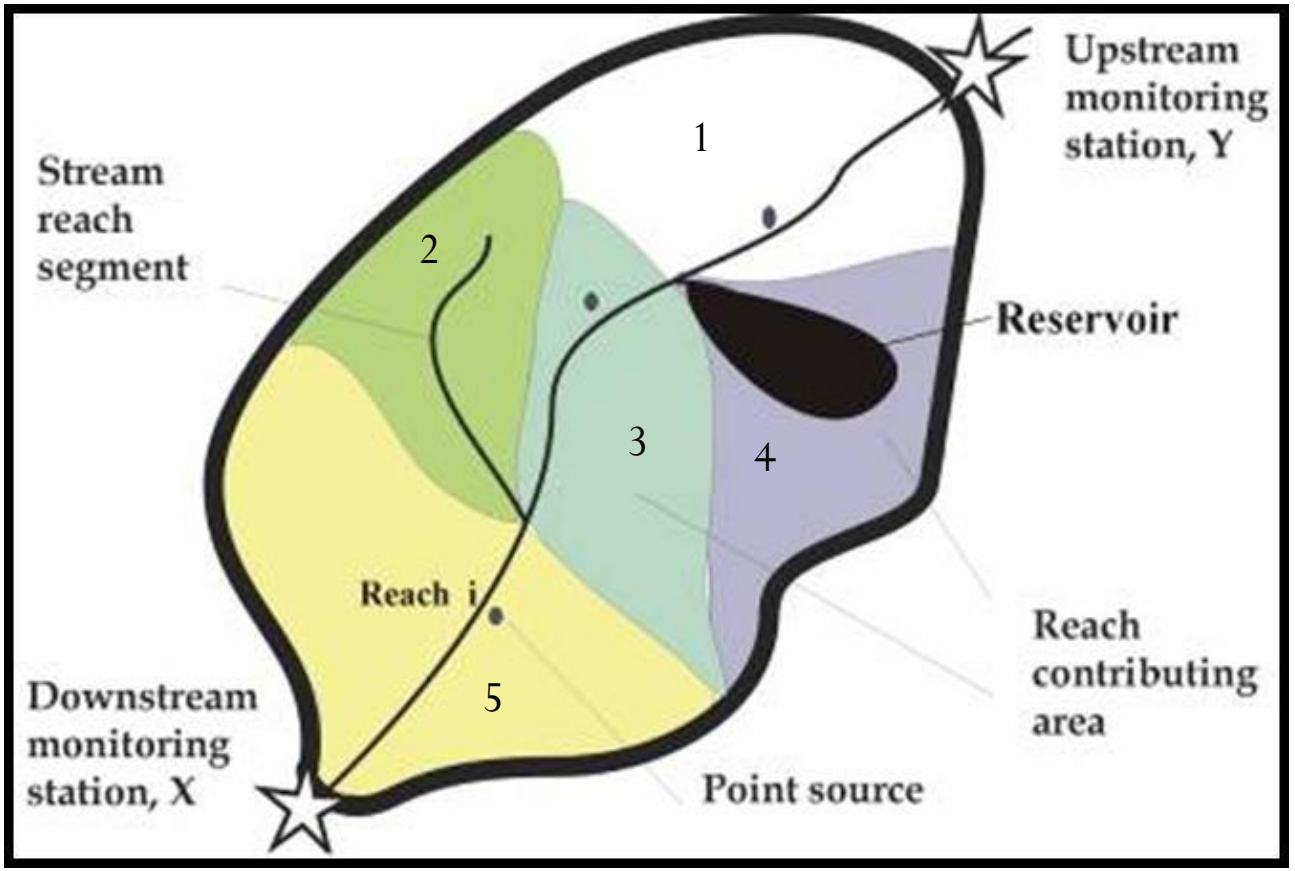
Questions?

Please contact me if you need additional information.

cjourney@usgs.gov

(803)750-6141

Total Load vs. Incremental Load



Total Load at X = L1+L2+L3+L4+L5

Incremental Load at X = L5 only

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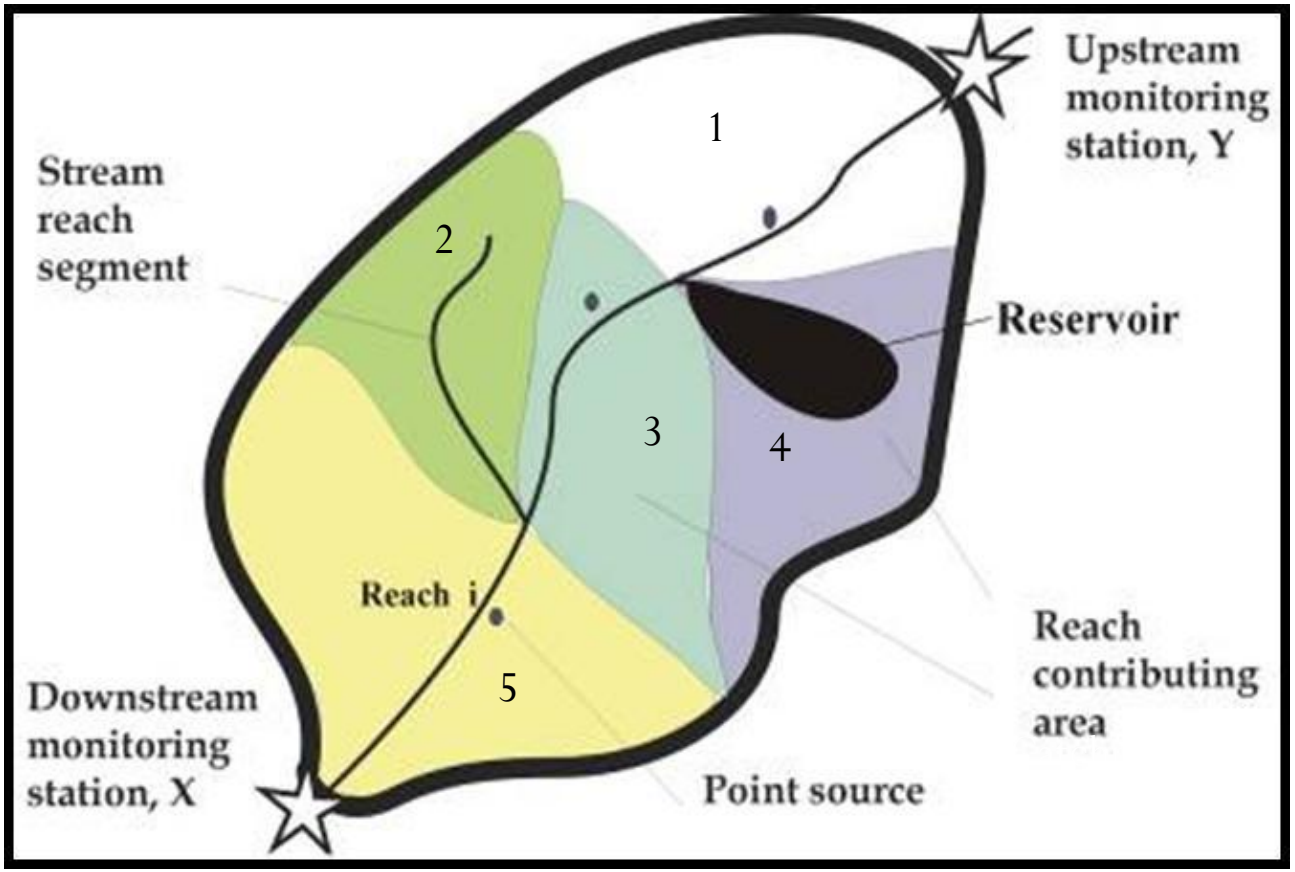
Total Yield vs. Incremental Yield



Total Yield at X = (L1+L2+L3+L4+L5)/(Catchment Area 1+2+3+4+5)

Incremental Yield at X = L5/Catchment Area 5 (yellow) only

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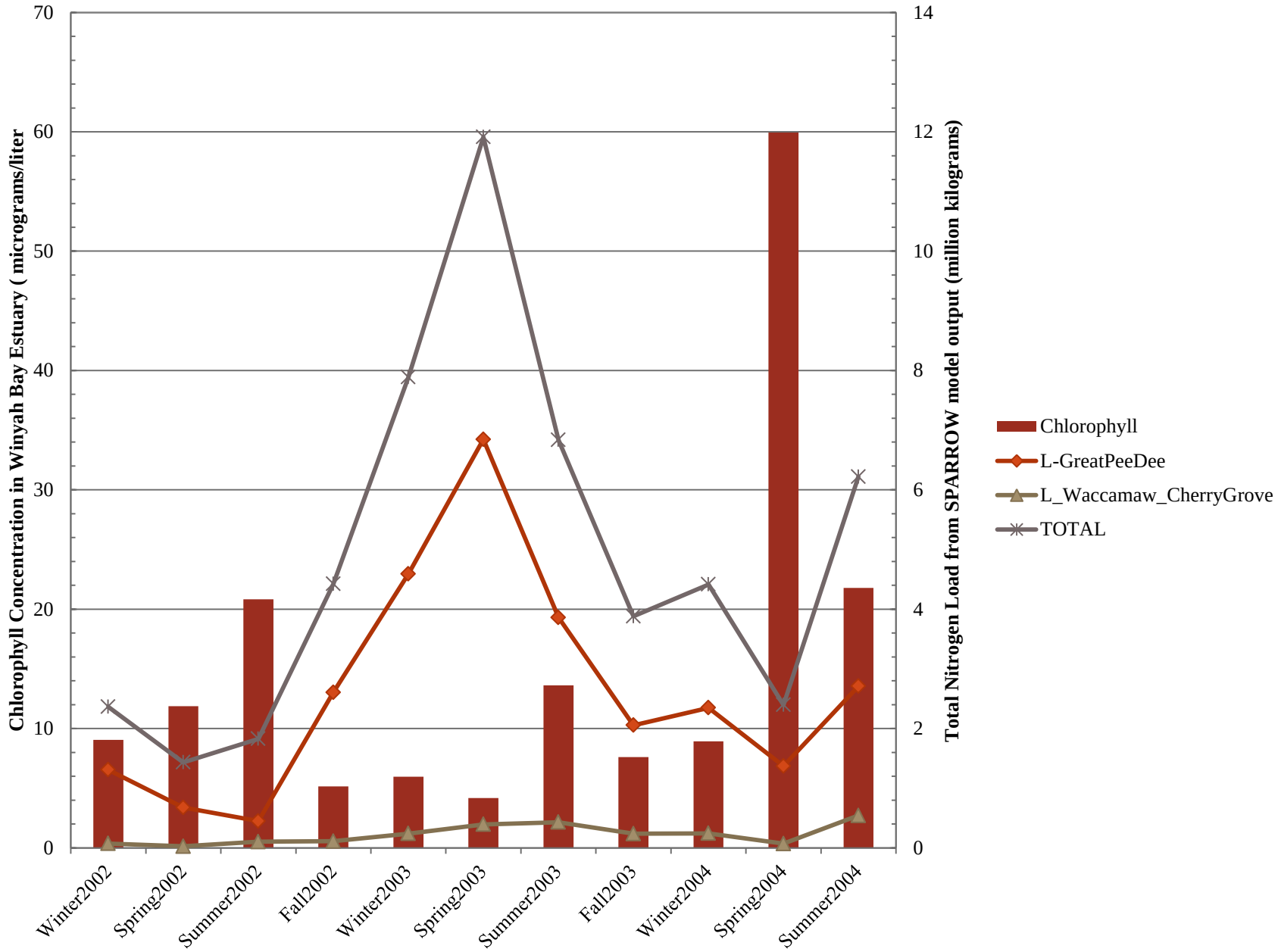

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Southeastern (MRB2 – South Atlantic-Gulf and TN) SPARROW Models

- **Total Nitrogen Model**

- Anne Hoos and Gerard McMahon
- http://water.usgs.gov/nawqa/pubs/nitrogen_loads/
  - Spatial Analysis of Instream Nitrogen Loads and Factors Controlling Delivery to Streams in the Southeastern United States using Spatially Referenced Regression on Watershed Attributes (SPARROW) and Regional Classification Frameworks
  - Input data and model predictions available for download

- **Total Phosphorus Model**

- Ana Maria Garcia, Anne Hoos, and Silvia Terziotti
- http://water.usgs.gov/nawqa/pubs/phosphorus_streams/
  - A Regional Modeling Framework of Phosphorus Sources and Transport in Streams of the Southeastern United States
  - Input data and model predication available for download
  - Bedrock contribution to TP load at http://pubs.usgs.gov/sim/3102

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SPARROW Decision Support System

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South Carolina

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Phosphorus

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Total Phosphorus Model for the South Atlantic-Gulf and Tennessee Region - 2002

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- SPARROW Applications & Documentation
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Select a video... Watch now >>

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Explore this model in the Decision Support System >>

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Pearl River Watershed Go >>

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Source Changes in Neuse River Basin	Example scenario showing changes in the total load of phosphorus due to a 25 percent reduction of manure sources in the Neuse River Basin.

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Limitations of SPARROW DSS

- Static Model
  - Statistically calibrated
  - Describes the average relationship between sources and stream conditions
  - Based on long-term water-quality monitoring data and spatially referenced explanatory information (watershed characteristics)
  - Annual loads for 2002 only
  - Does not provide seasonal and between-year changes in contaminant sources
- Dynamic model
- "Land-to-water" transport term related to loss in storage will be modified to include 1st order rate coefficients expressed as a function of temperature and the Enhanced Vegetation Index (index of vegetative growth)
  - EVI from Terra Satelllite-born MODIS sensor (NASA)

Dynamic SPARROW Model for South Carolina

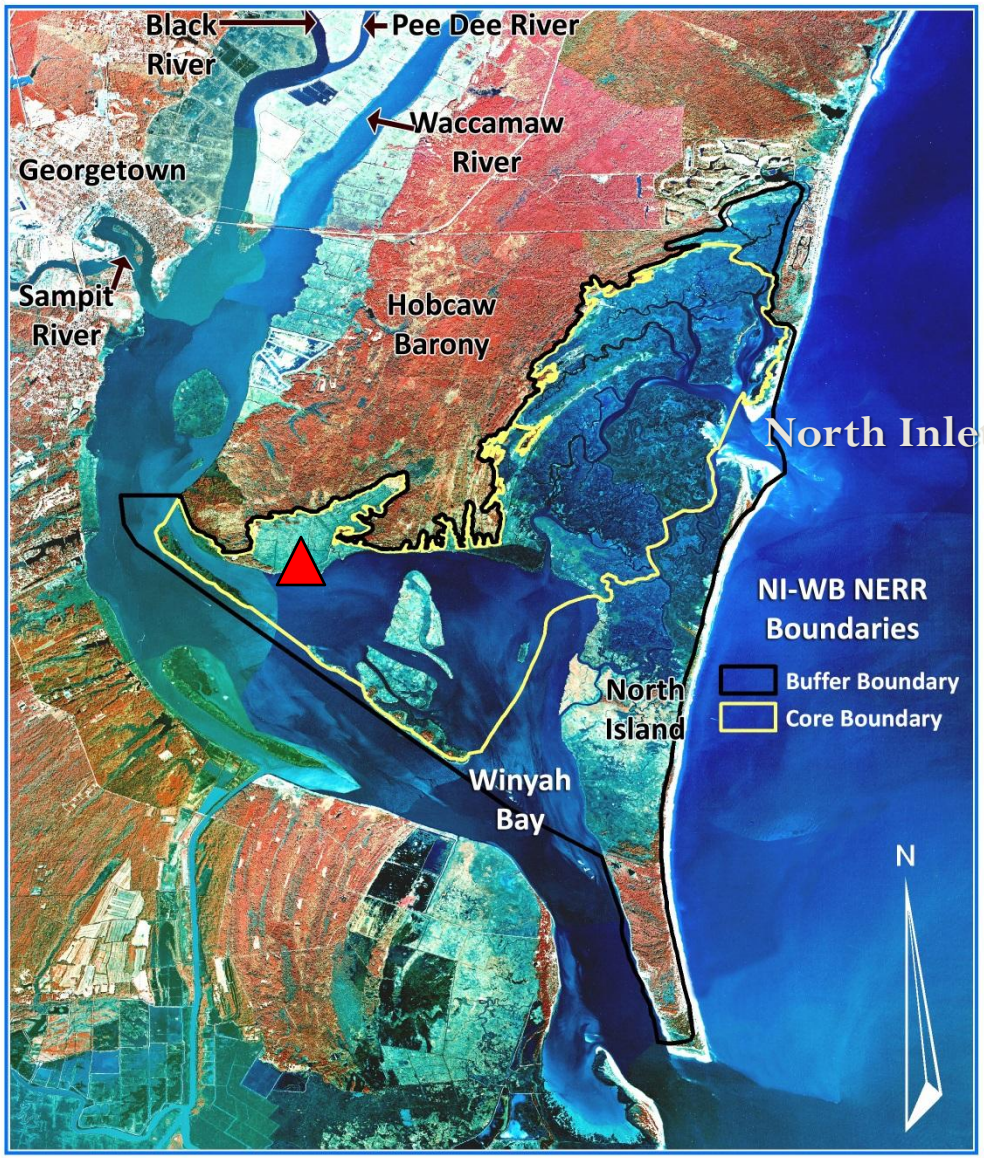
- Enhanced Vegetation Index
  - EVI from Terra Satelllite-born MODIS sensor (NASA)

- NHDPlus (1:100,000 scale)
  - National Hydrography Dataset (NHD)
  - National Elevation Dataset (NED)
  - National Land Cover Dataset (NLCD)
  - Watershed Boundary Dataset (WBD)

Results from Potomac River Basin

- Potomac River Basin Dynamic Nitrogen Model
  - Seasonal EVI was strongly significant in nitrogen delivery to stream (coefficient in nonlinear regression).
  - Half of the TN yield in a watershed comes from nitrogen stored for longer than one season.
  - Yields varied greatly as a function of seasonal runoff, with high values in winter and spring.
  - Large drop in summer yields due to low runoff and temporary retention in vegetation.
  - Year to year variation can be large.

Geographic Context of the North Inlet - Winyah Bay National Estuarine Research Reserve



Thousand Acre Station WQ sampling

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