Chesapeake Bay SPARROW models Background and updates

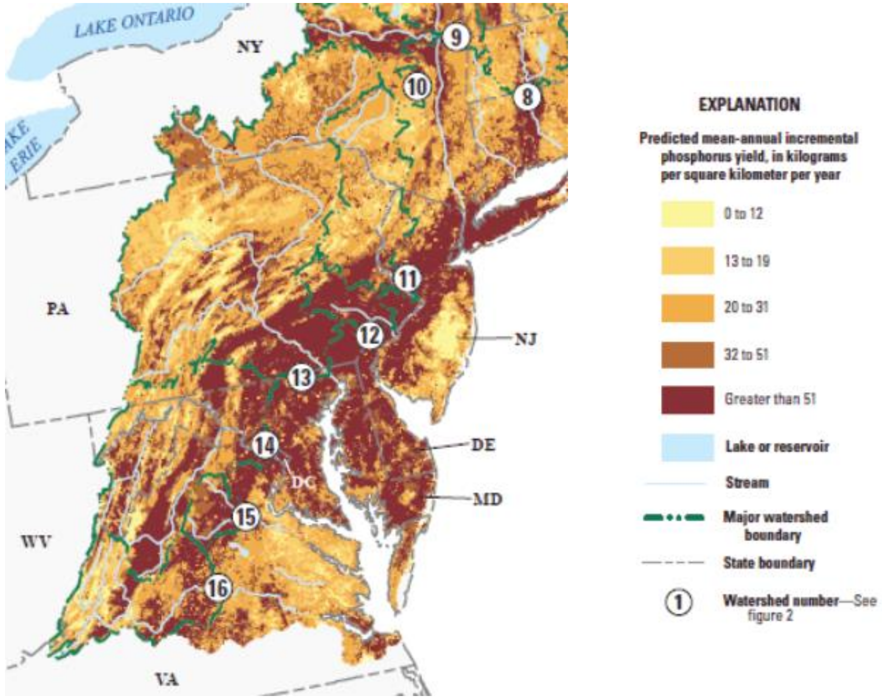
April 22nd 2024

Andrew Sekellick

Alex Soroka

Kyle Hurley

Scott Ator

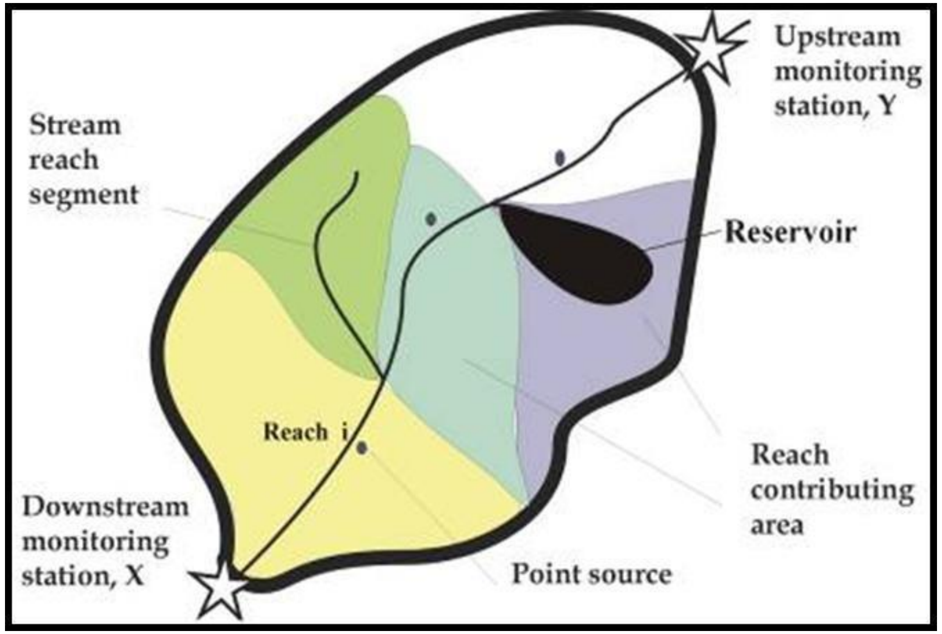


U.S. Geological Survey, Maryland-Delaware-D.C. Water Science Center

What is SPARROW?

SPAtially **R**eferenced **R**egression **O**n **W**atershed attributes

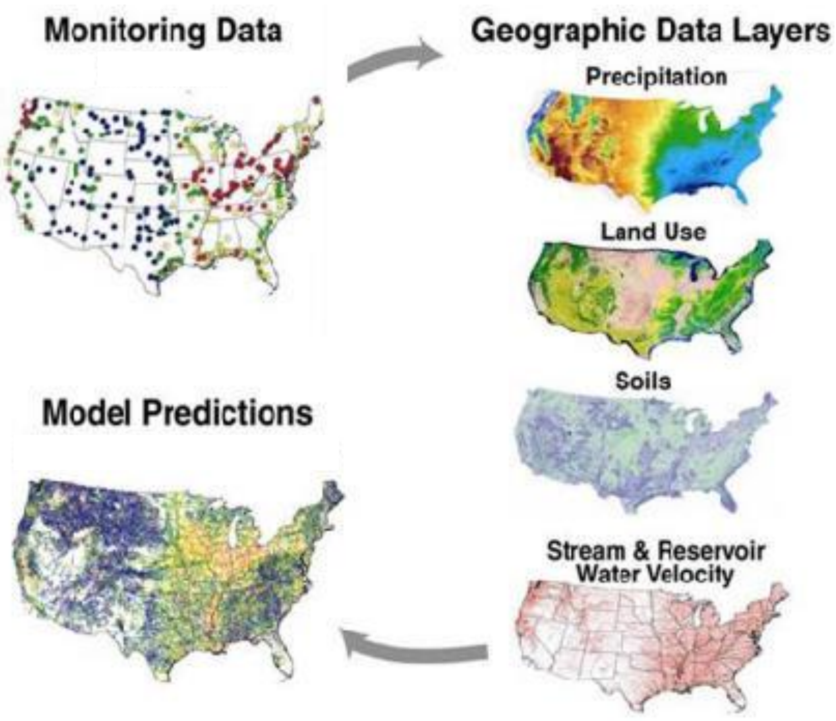
Relates water-quality measurements in a monitoring network to landscape characteristics, contaminant sources, and environmental factors to estimate loads in unmonitored streams.



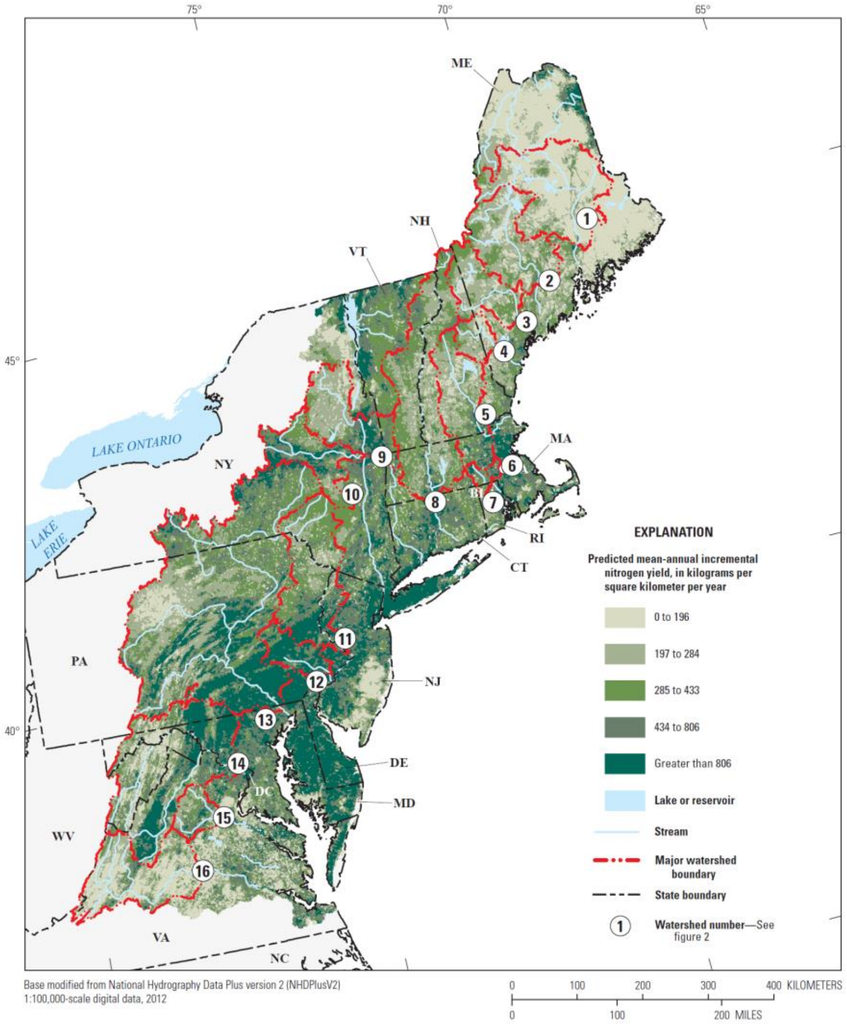
What is SPARROW?

Input data layers include:

- Monitoring (calibration) data
- Sources (point and non-point)
- Land-to-water delivery factors
- Decay factors



What is SPARROW?

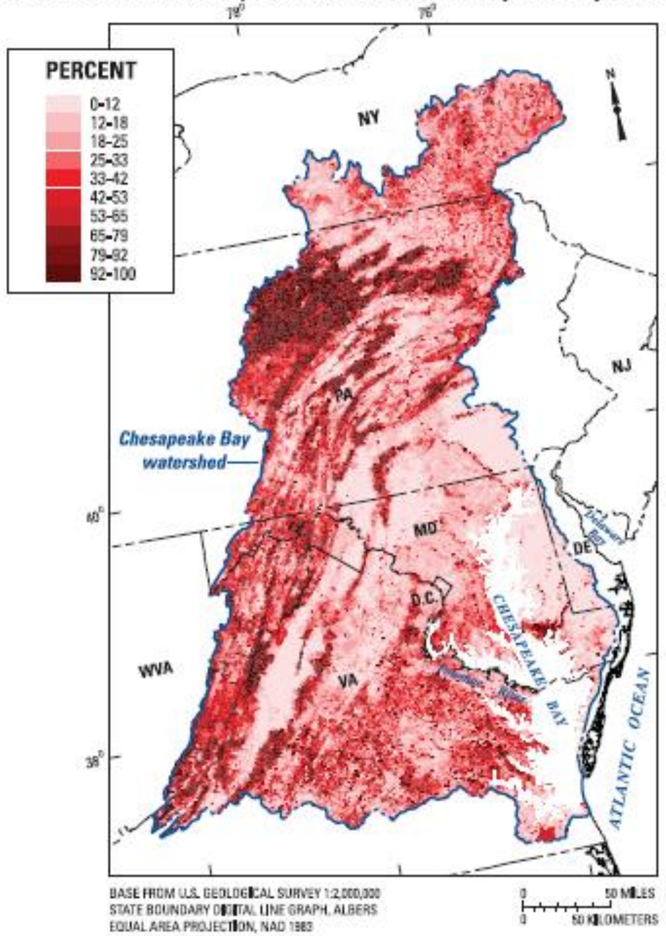


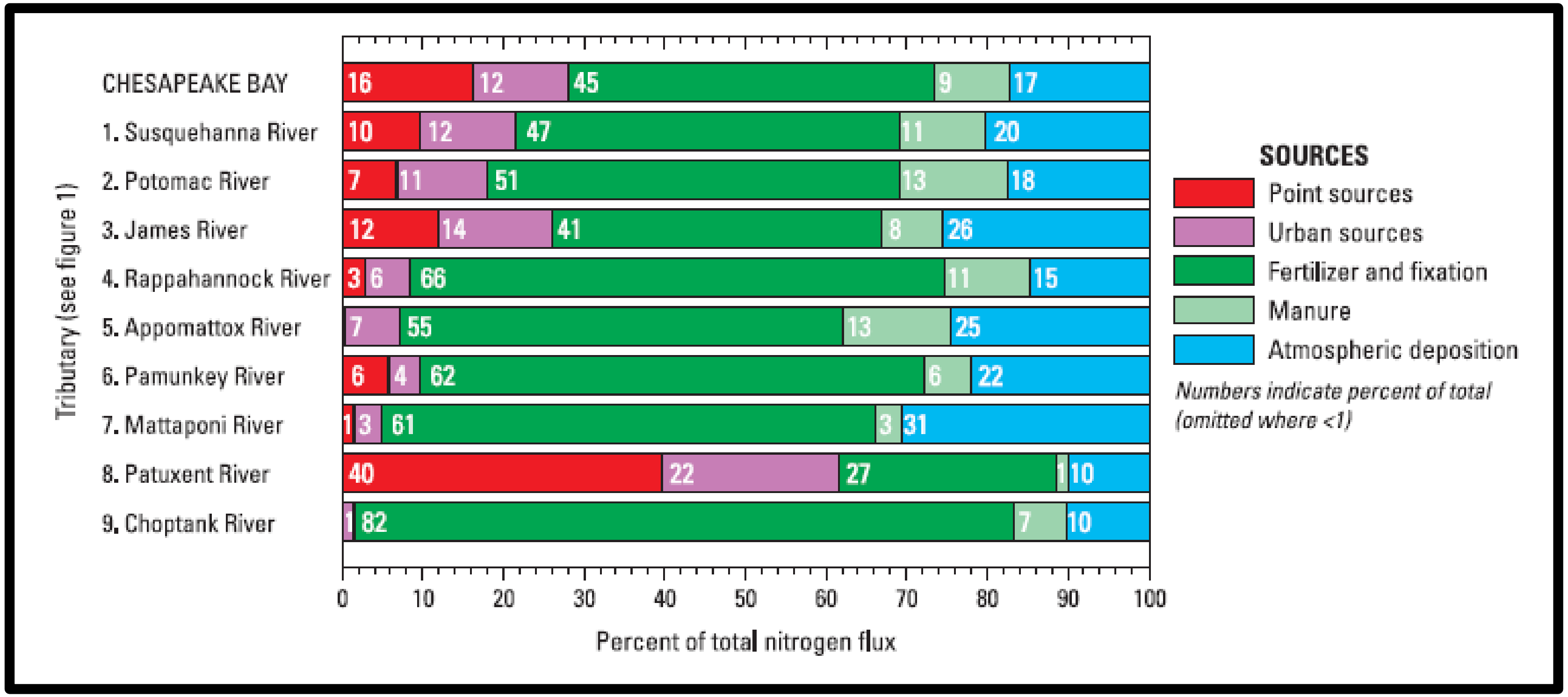
Variable	Variable unit	Coefficient unit	Model coefficient value	90-percent confidence interval for the model coefficient: Low	90-percent confidence interval for the model coefficient: High	Standard error of the model coefficient	*p*-value[a]	*t*-value	Variance inflation factor
Source									
Wastewater point sources	kg yr⁻¹	Fraction, dimensionless	0.589	0.411	0.766	0.108	<0.0001	5.5	1.2
Septic system effluent	kg yr⁻¹	Fraction, dimensionless	0.509	0.316	0.702	0.117	<0.0001	4.4	3.9
Fertilizer applications	kg yr⁻¹	Fraction, dimensionless	0.105	0.0454	0.164	0.0360	0.0019	2.9	10.0
Crops that fix nitrogen	km⁻²	kg km⁻² yr⁻¹	2,730	154	5,310	1,560	0.0407	1.7	9.9
Manure applications	kg yr⁻¹	Fraction, dimensionless	0.0940	0.0307	0.157	0.0384	0.0074	2.4	7.2
Atmospheric deposition	kg yr⁻¹	Fraction, dimensionless	0.244	0.191	0.297	0.0320	<0.0001	7.6	6.3
Urban area	km⁻²	kg km⁻² yr⁻¹	549	286	812	159	0.0003	3.4	7.5
Land-to-water delivery									
Ln(Carbonate rock)	Percent	Dimensionless	0.0472	0.00791	0.0864	0.0238	0.0483	2.0	2.0
Ln(Forest or wetland)	Percent	Dimensionless	–0.276	–0.371	–0.180	0.0581	<0.0001	–4.7	4.2
Ln(Mean-annual air temperature, 2000–14)	°C	°C⁻¹	–0.868	–1.18	–0.553	0.191	<0.0001	–4.6	4.5
Ln(Cover crops)	Percent of agriculture	Dimensionless	–0.167	–0.329	–0.00467	0.0984	0.0906	–1.7	37.8
Ln(Mean soil depth)	Inches	Inches⁻¹	–0.205	–0.398	–0.0110	0.117	0.0822	–1.7	2.5
Ln(Conservation tillage or no-till)	Percent of agriculture	Dimensionless	0.210	0.000411	0.420	0.127	0.0993	1.7	81.1
Ln(Mean-annual runoff)	mm	mm⁻¹	0.336	0.0656	0.606	0.164	0.0412	2.0	2.5
Aquatic loss									
Travel time in streams with mean-annual discharge LE 5 ft³/s	Days	Days⁻¹	1.31	–0.258	2.88	0.952	0.0845	1.4	5.0
Travel time in streams with mean-annual	Days	Days⁻¹	0.154	–0.246	0.555	0.243	0.2627	0.6	5.5
Reservoir inverse hydraulic load	yr m⁻¹	m yr⁻¹	6.60	3.82	9.38	1.69	<0.0001	3.9	1.5

This information is preliminary and is subject to revision. Not for Citation or Distribution.

What is SPARROW?

B. Shares of total local yields attributable to atmospheric deposition





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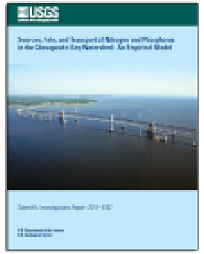
SPARROW examples in the watershed



Sources, Fate, and Transport of Nitrogen and Phosphorus in the Chesapeake Bay Watershed: An Empirical Model

Scientific Investigations Report 2011-5167

By: Scott W. Ator, John W. Brakebill, and Joel D. Blomquist

https://doi.org/10.3133/sir20115167

Spatially Referenced Models of Streamflow and Nitrogen, Phosphorus, and Suspended-Sediment Loads in Streams of the Northeastern United States

Scientific Investigations Report 2019-5118

National Water Quality Program

By: Scott W. Ator

https://doi.org/10.3133/sir20195118

Predicting Near-Term Effects of Climate Change on Nitrogen Transport to Chesapeake Bay

Scott Ator, Gregory E. Schwarz, Andrew J. Sekellick, Gopal Bhatt

First published: 12 June 2022

https://doi.org/10.1111/1752-1688.13017

Estimated reduction of nitrogen in streams of the Chesapeake Bay in areas with agricultural conservation practices

Andrew J. Sekellick, Scott W. Ator, Olivia H. Devereux, Jeni L. Keisman

Published: May 5, 2023 • https://doi.org/10.1371/journal.pwat.0000108

Toward Explaining Nitrogen and Phosphorus Trends in Chesapeake Bay Tributaries, 1992–2012

Scott W. Ator, Ana Maria García, Gregory E. Schwarz, Joel D. Blomquist, Andrew J. Sekellick

First published: 24 May 2019

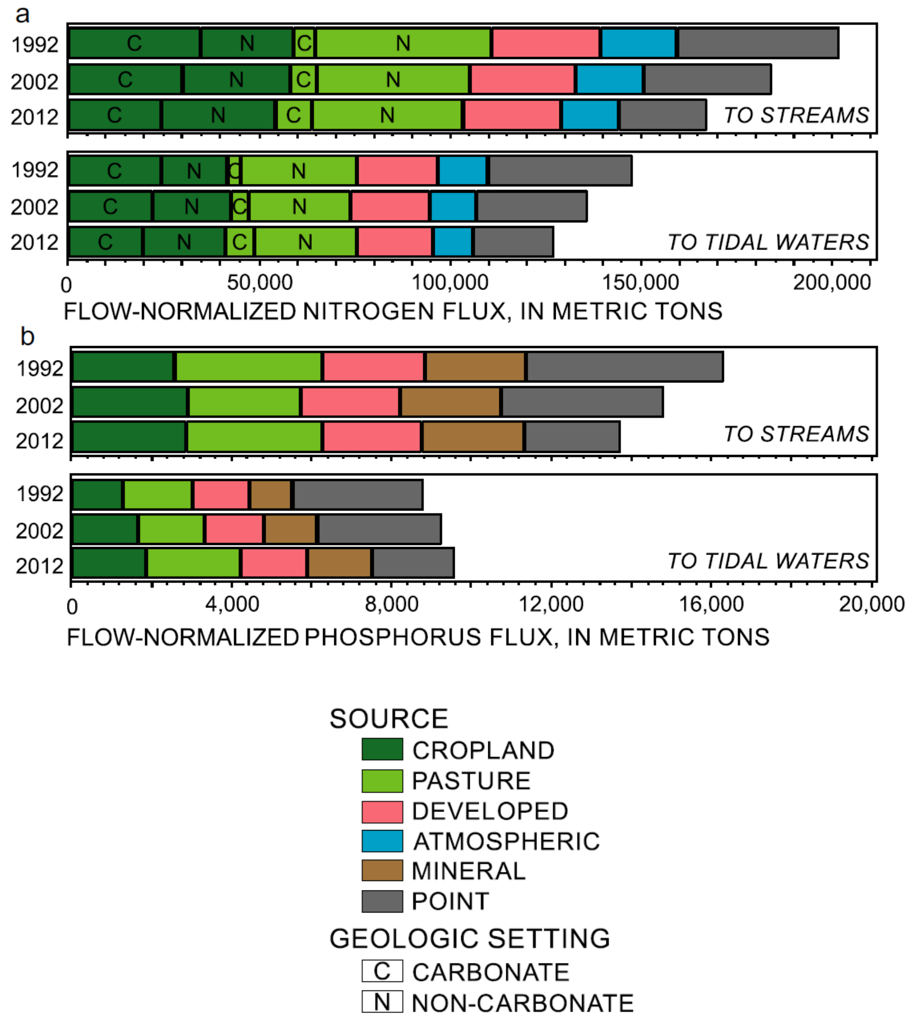
https://doi.org/10.1111/1752-1688.12756

What are we doing now?

- New model being developed for model year 2021

- Additional “decadel” time step model (2011 and 2021) for a temporal analysis

- Models built with the goal of consistent updates in mind



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USGS

What are we doing now?

- A new workflow - efficiency, repeatability, accessibility
- Entirely an R pipeline…no SAS, no ArcGIS, etc.
- Thinking creatively and asking for input

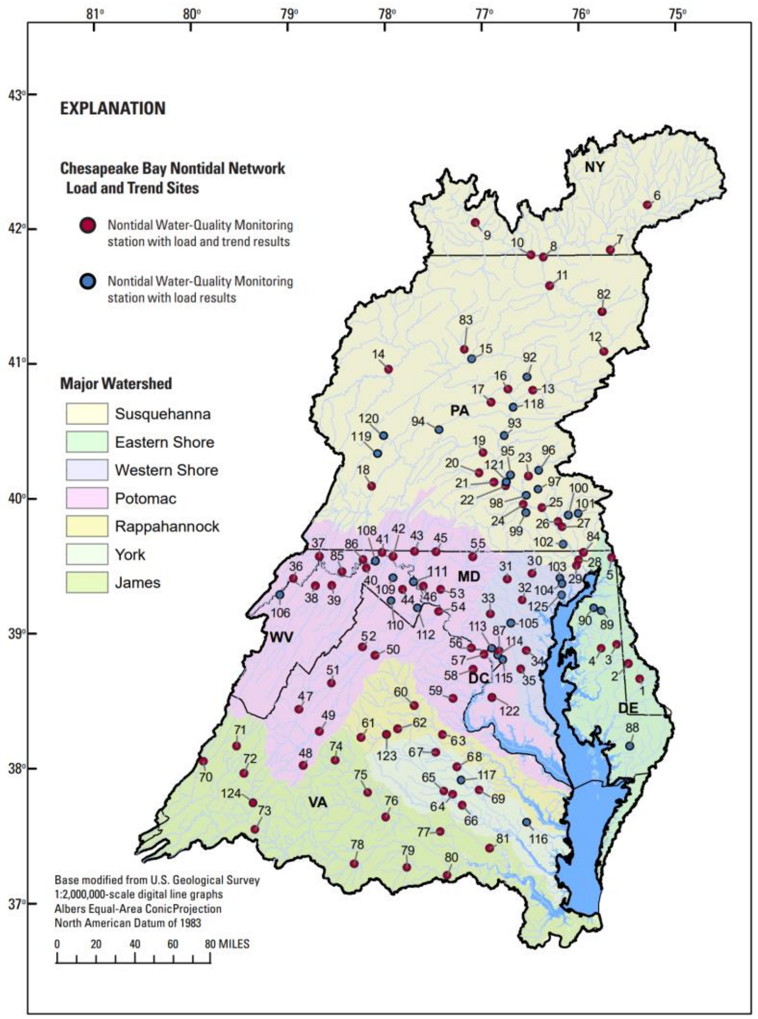
RSPARROW (Version 2.0)

RSPARROW is a system of R scripts and functions for executing and evaluating SPARROW models that generates graphical, map, and tabular output. Users operate the system within RStudio from a single control script that accesses the supporting input files and functions. Only minimal knowledge of R is required to use the system.

SPARROW (SPAtially Referenced Regressions on Watershed attributes) is a spatially explicit, hybrid (statistical and mechanistic) water-quality model developed by the USGS. The model has been used to quantify the sources and transport of contaminants in watersheds of widely varying sizes, from catchment to continental scales. SPARROW includes three major process components that explain spatial variability in stream water quality: (1) contaminant source generation, (2) land-to-water delivery, and (3) stream and reservoir transport and decay. The non-linear and mechanistic structure of the model includes mass balance constraints and non-conservative transport components. This includes factors that control the attenuation and delivery of contaminants to streams via surficial and subsurface pathways and the removal of contaminants in streams and reservoirs, according to first-order decay kinetics. SPARROW is structured as a network of one-dimensional stream segments and their contributing drainage areas.

What data are we looking into?

- CAST data – biosolids, septic, point sources, etc.
- Rainfall seasonality
- FACET (floodplains + channels)
- Land cover *change*
- Hydrologic connectivity
- Open to suggestions!



Current status

- 2021 NTN data release is a vital component of this project (calibration data)
- Assembling more explanatory data and refining workflow
- Summer - calibrating a 2019 test model