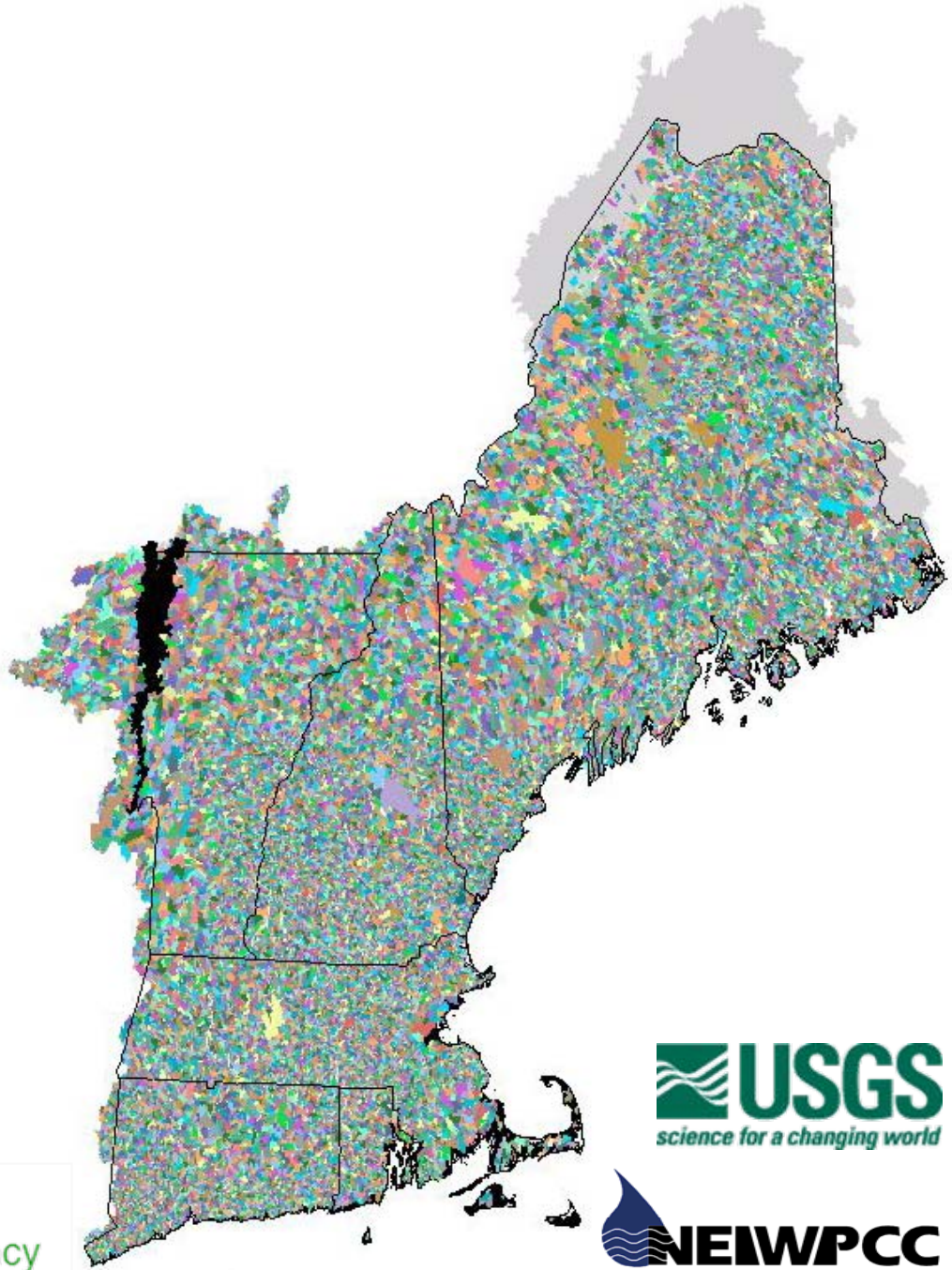
New England SPARROW MODEL

Example Applications of Model Results

by

Richard Moore
Laura Blake



USGS science for a changing world

EPA United States Environmental Protection Agency

NEIWPCC

Presentation Outline

- Purpose and design of the New England SPARROW models
- Results & applications

Purpose of the New England SPARROW is to support major water-quality management activities

- Nutrient criteria development - Ranges in nutrient concentrations in rivers and streams
- TMDL program - Identification of factors (sources and watershed characteristics) affecting nutrient loads
- Coastal Water Assessments - Transport of nutrients by rivers (especially interstate) to coastal waters

Design of the New England SPARROW

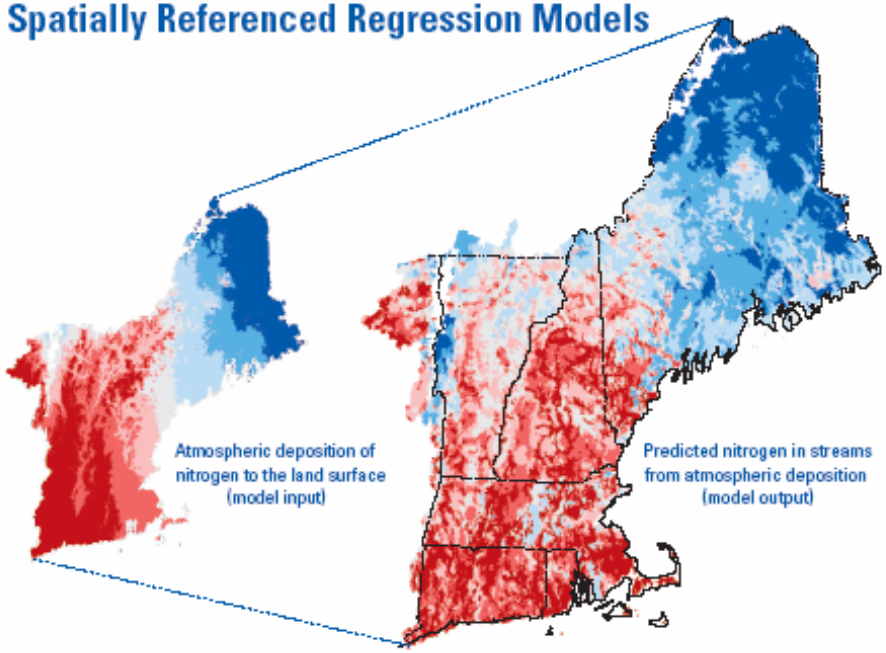
- Focus on Total Nitrogen and Phosphorus loads
- Model for the mid-1990s time period

http://nh.water.usgs.gov

USGS
science for a changing world

In cooperation with the
New England Interstate Water Pollution Control Commission and
U.S. Environmental Protection Agency

Estimation of Total Nitrogen and Phosphorus in New England Streams Using Spatially Referenced Regression Models

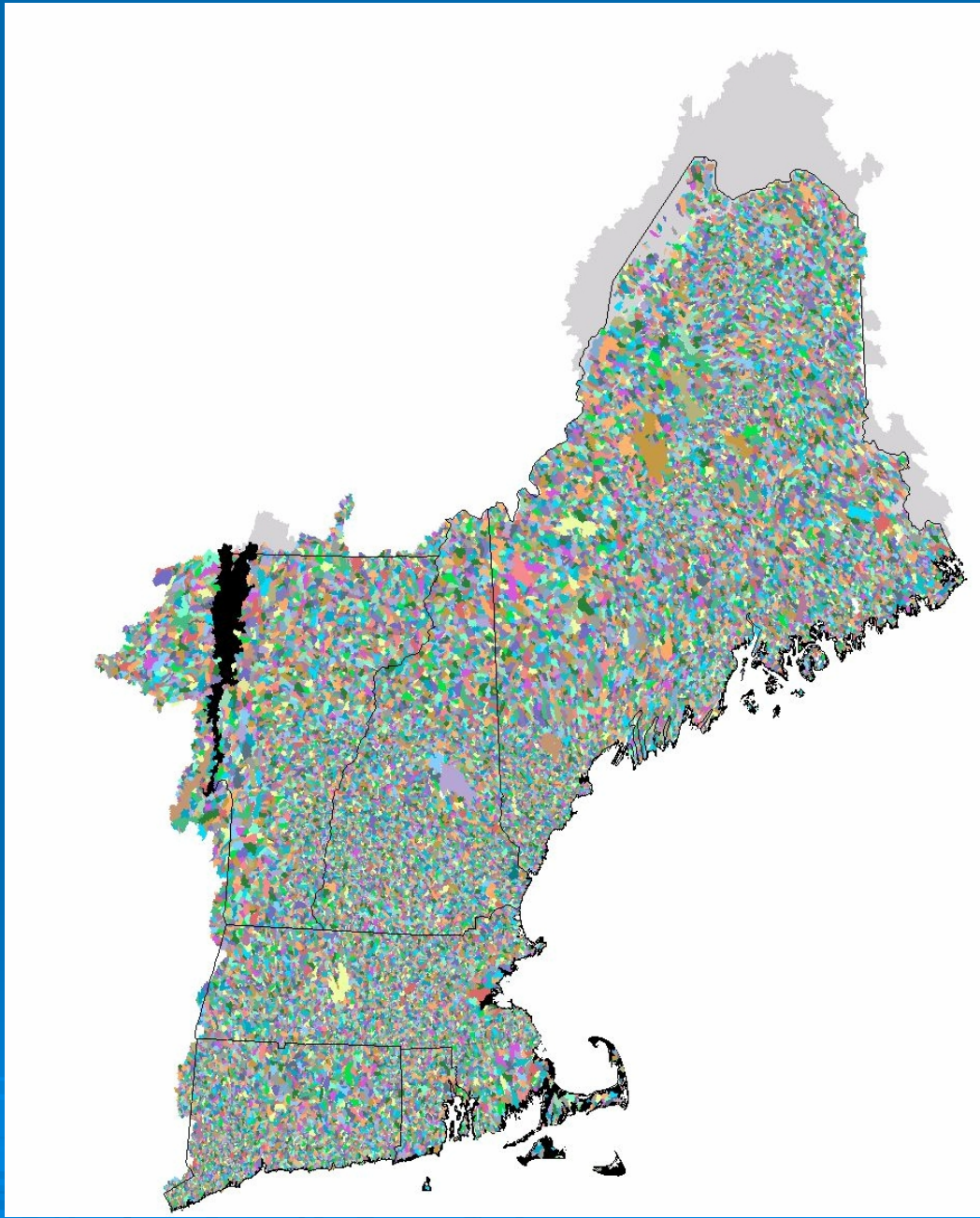


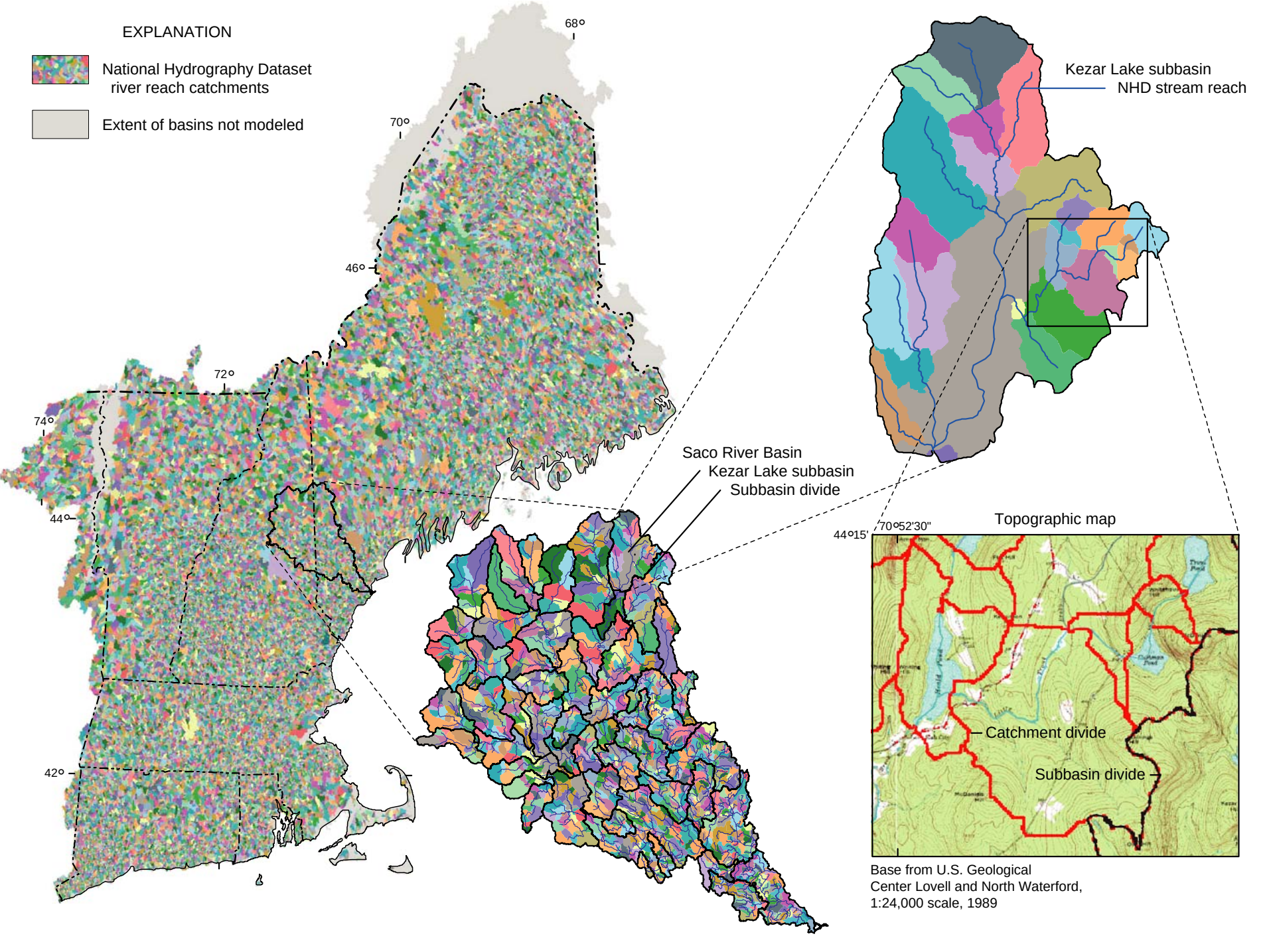
Scientific Investigations Report 2004-5012

U.S. Department of the Interior
U.S. Geological Survey

New England Model Framework of Catchments and Streams Reaches

- Based on the National Hydrography Data Set (NHD)
- Approx 42,000 in model
- Average 1.7 mi^2 in size
- Corrected to NRCS 12-digit watershed boundary dataset




EXPLANATION
National Hydrography Dataset river reach catchments
Extent of basins not modeled
68°
70°
46°
72°
74°
44°
42°
Saco River Basin
Kezar Lake subbasin
Subbasin divide
Kezar Lake subbasin
NHD stream reach
Topographic map
44°15'
70°52'30"
Catchment divide
Subbasin divide
Base from U.S. Geological Center Lovell and North Waterford, 1:24,000 scale, 1989

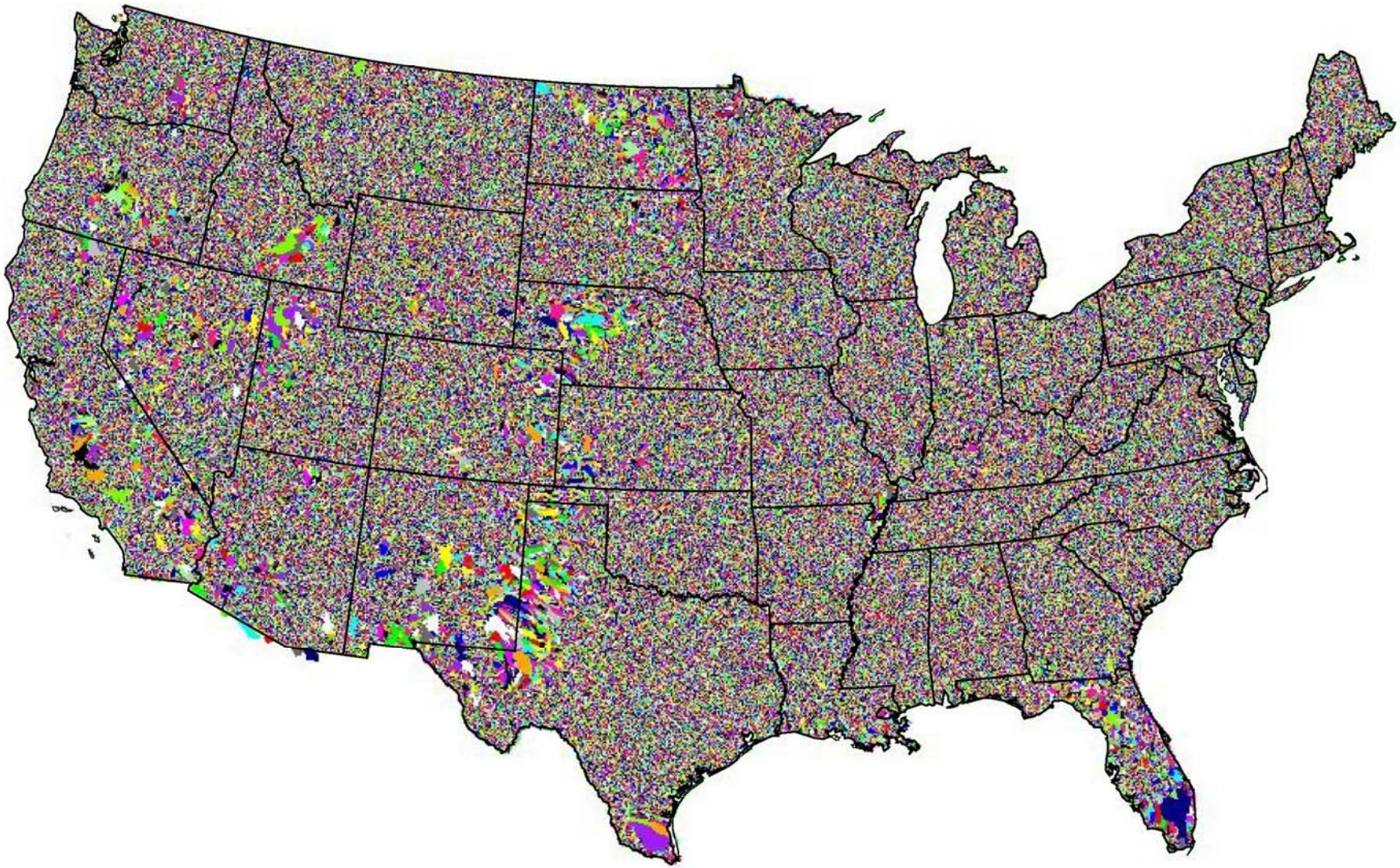
National Pilot Study for NHD catchment delineation

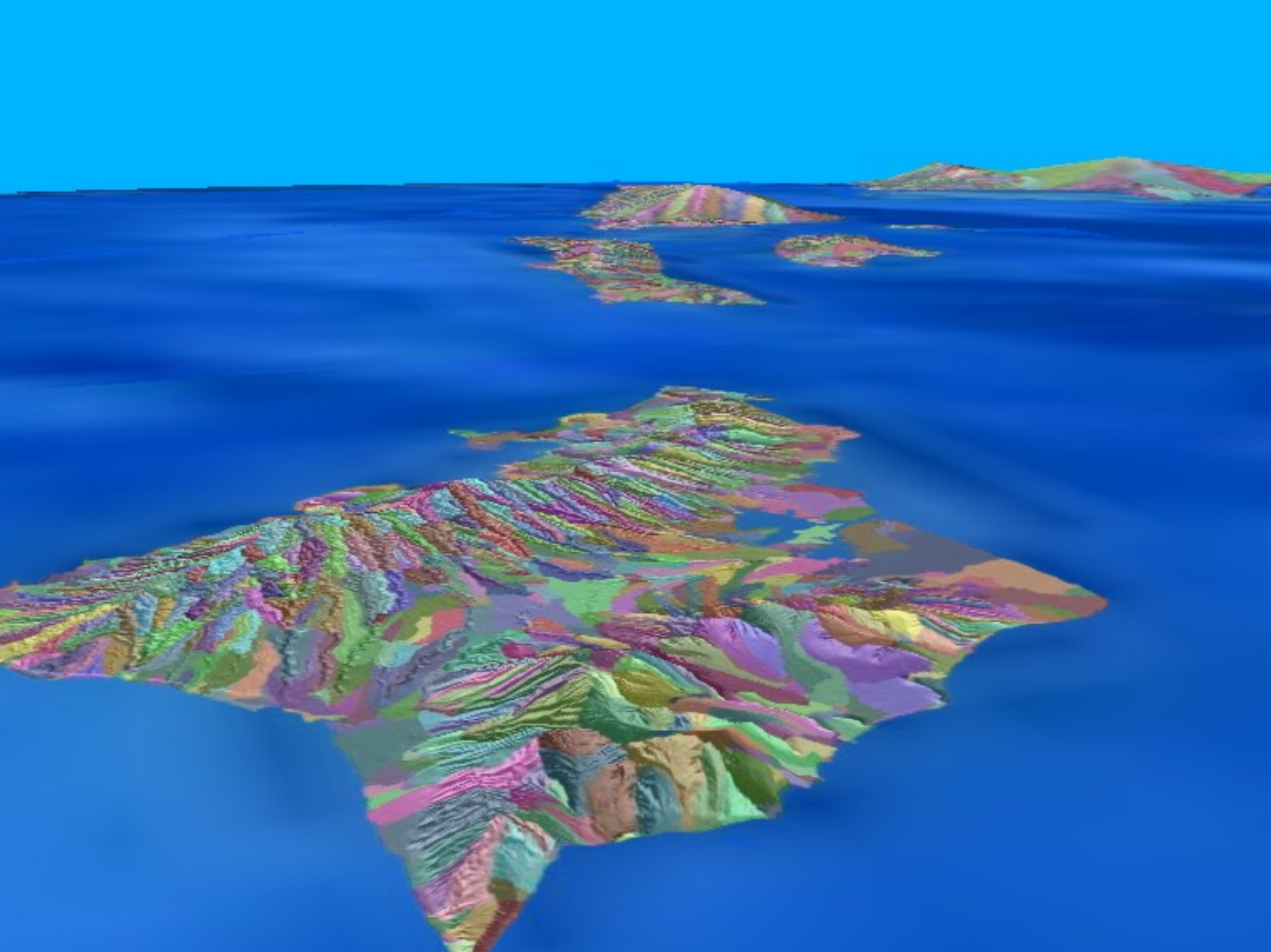
- New England method typically gives the most accurate results
- Is being applied nationally as part of NHDPlus!

A National Seamless Database of Topographically Derived Catchments

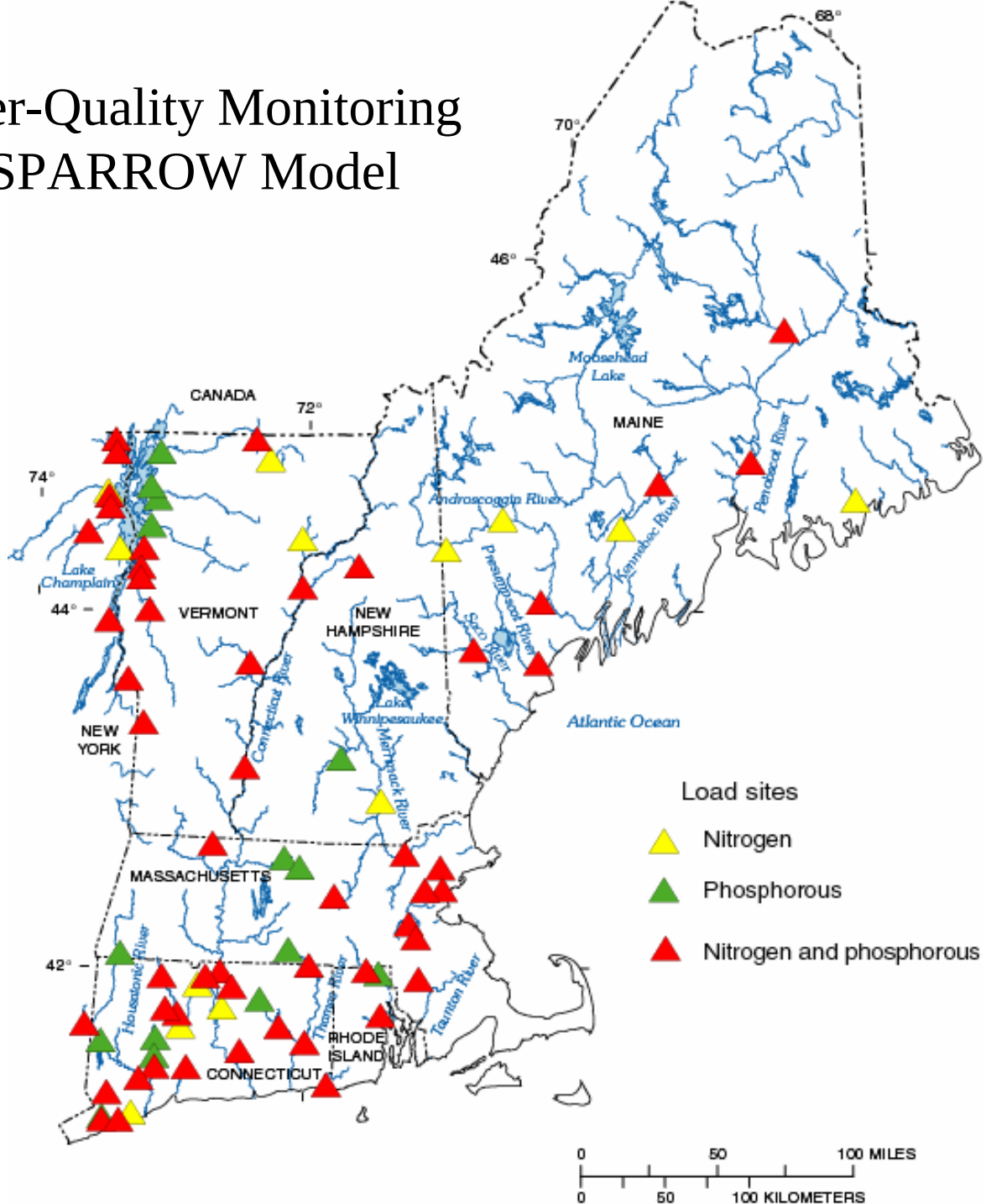
part of the 1:100,000-scale NHDPlus

2,613,709 catchments

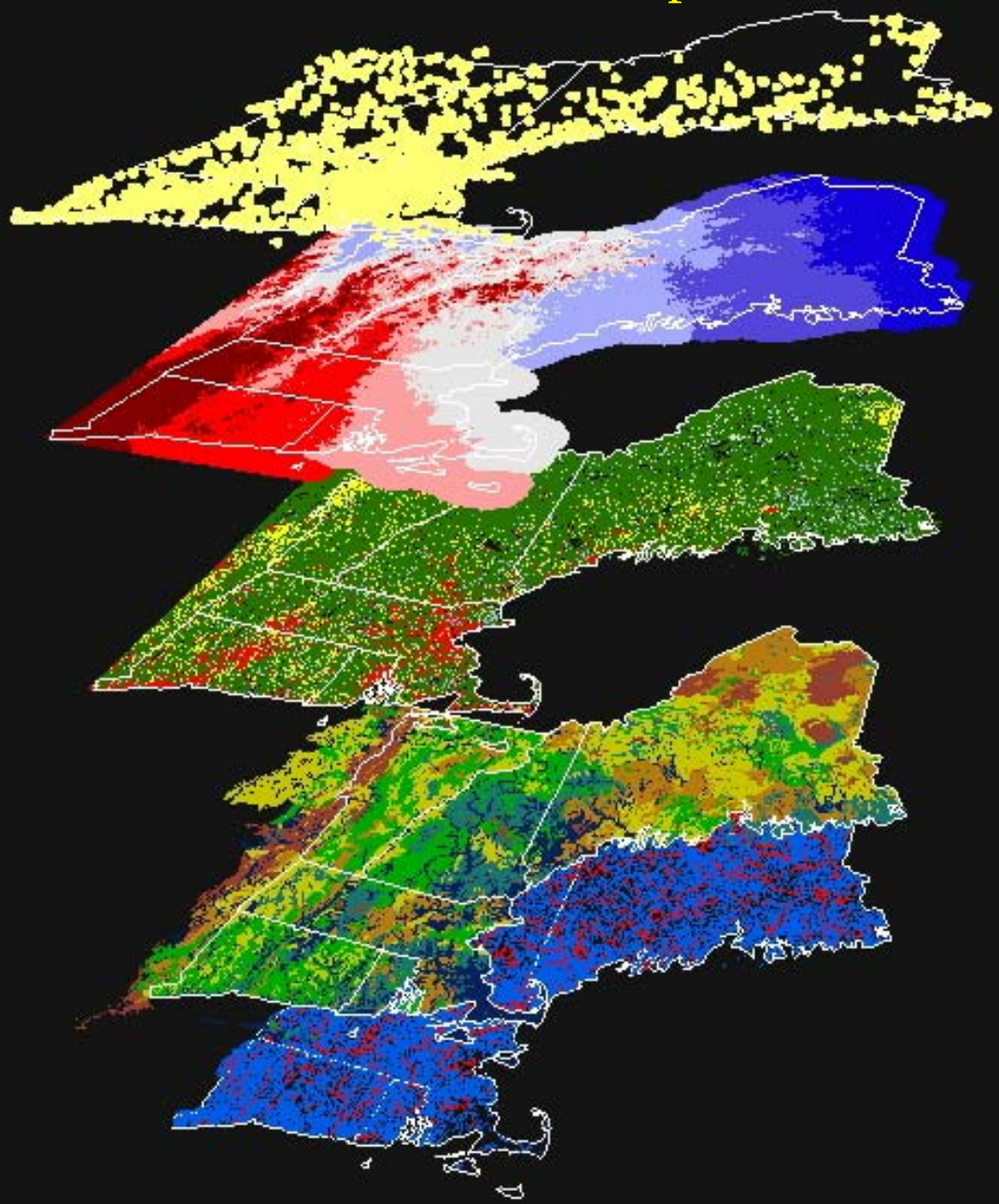




Nutrient Water-Quality Monitoring Sites used in SPARROW Model



NE SPARROW Model Input



Nutrient Sources

Point Source

Atmospheric deposition of nitrogen (Ollinger 1992)

National Land Cover Dataset 1992

- Agriculture
- Developed
- Forest

Processes

Land to water delivery

Soil permeability – STATSGO

In-stream loss

Stream travel time
Reservoir detention

Model Calibration Results for the New England SPARROW Nitrogen Model

R-squared = .95, MSE = 0.16

Variable SOURCES	Bootstrap model coefficient	Standard error of coefficient	p-value
Municipal wastewater-treatment facilities	1.13	0.36	<.005
Atmospheric deposition	.36	.07	<.005
Agricultural land ($kg/km^2/y$)	910	362	.005
Developed land ($kg/km^2/y$)	988	385	.010

Model Calibration Results for the New England SPARROW Nitrogen Model (cont.)

R-squared = .95, MSE = 0.16

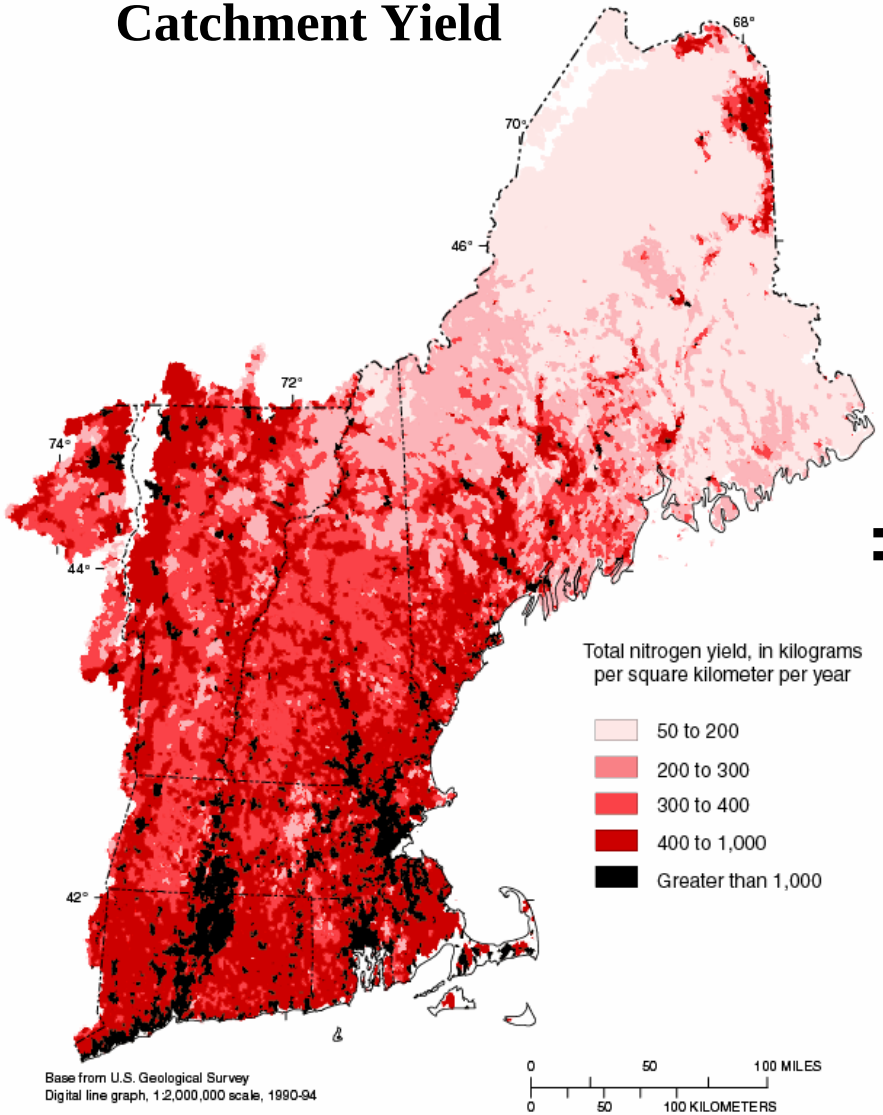
Variable	Bootstrap model coefficient	Standard error of coefficient	p-value
Delivery variable:			
Natural Log of Soil Permeability	**0.36**	**0.14**	**<.005**
Decay Variable:			
Stream decay for streams <= 100 cfs (per day)	**.71**	**.52**	**.065**

Application of SPARROW Results

SPARROW nutrient load predictions are made for 42,000 reaches throughout New England

SPARROW Model Results:

Predicted Total Nitrogen Catchment Yield



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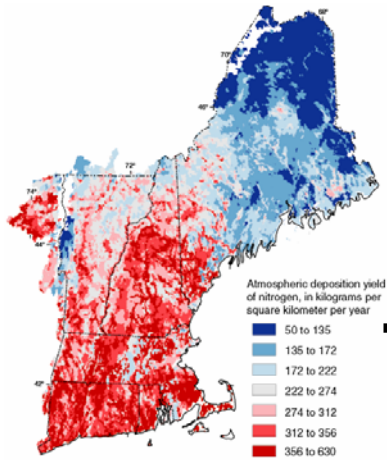
Contributions to Total Nitrogen from each source



Atmospheric

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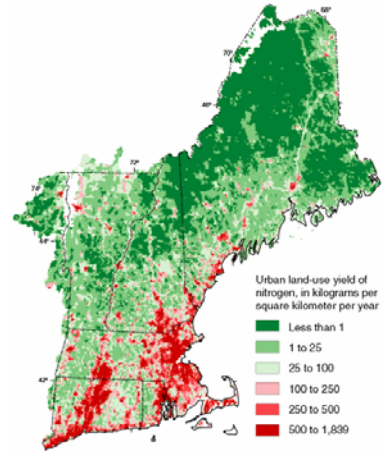

Developed

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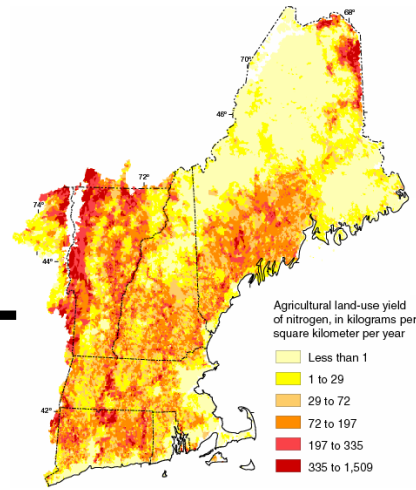

Agriculture

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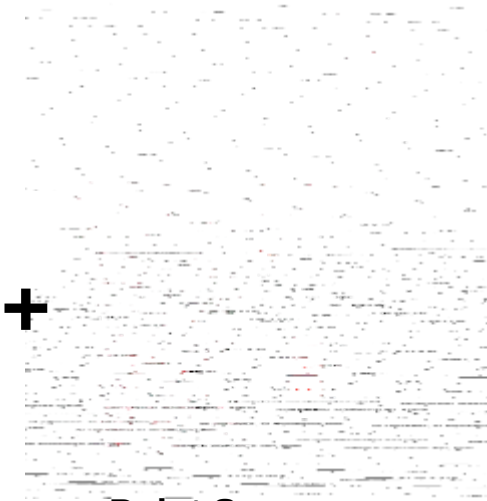
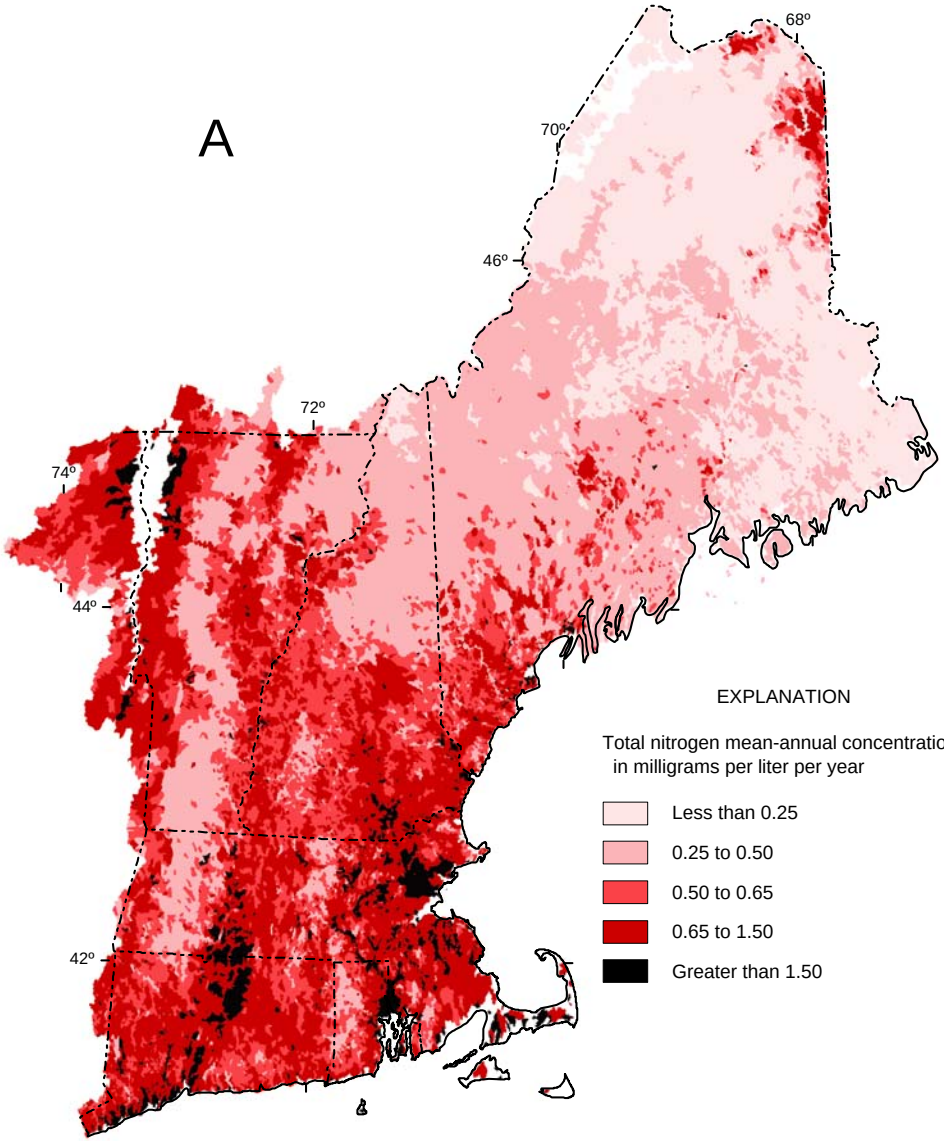
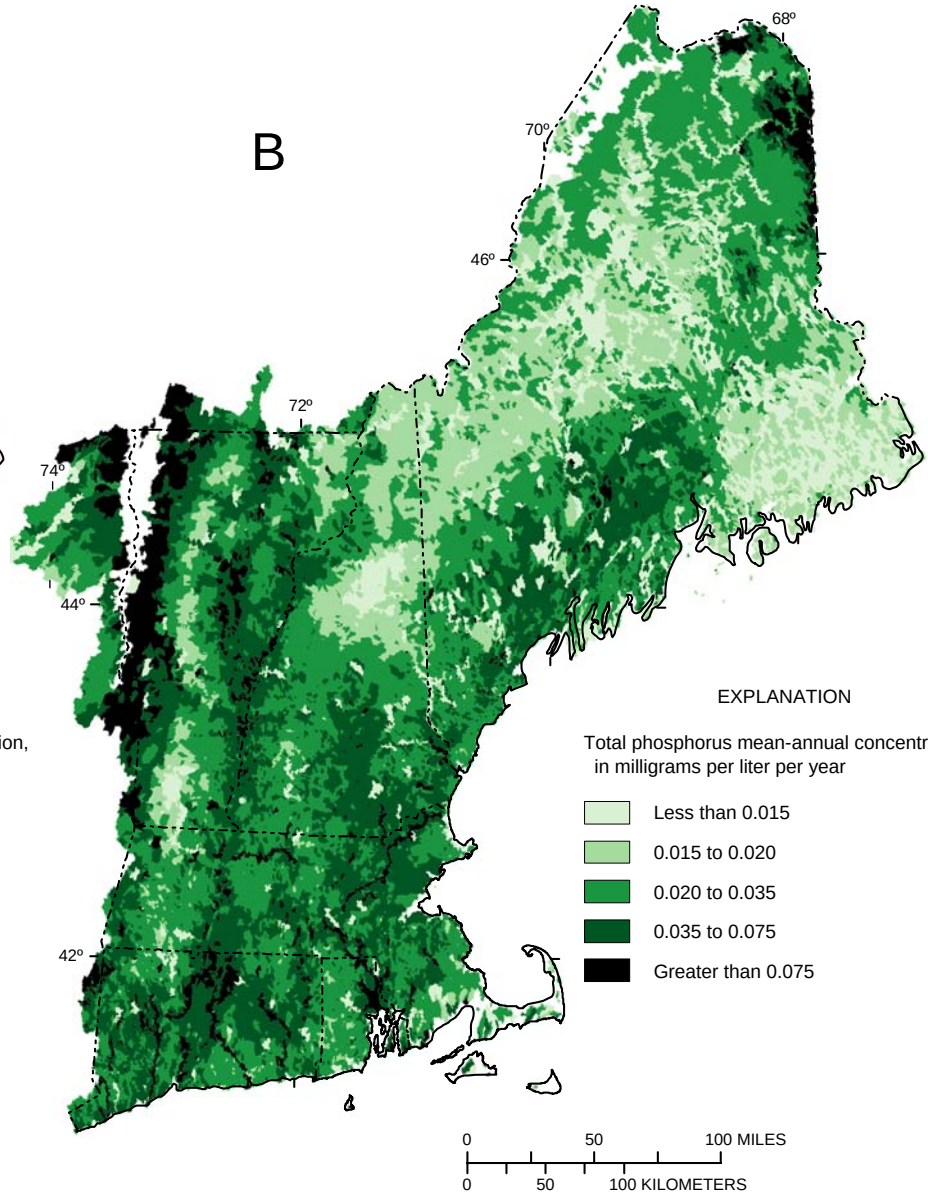


Point Source

Applications

- SPARROW results can be expressed in terms of concentration (mean-annual flow-weighted)





Base from U.S. Geological Survey
Digital line graph, 1:2,000,000 scale, 1990-94

NE SPARROW applications by other investigators

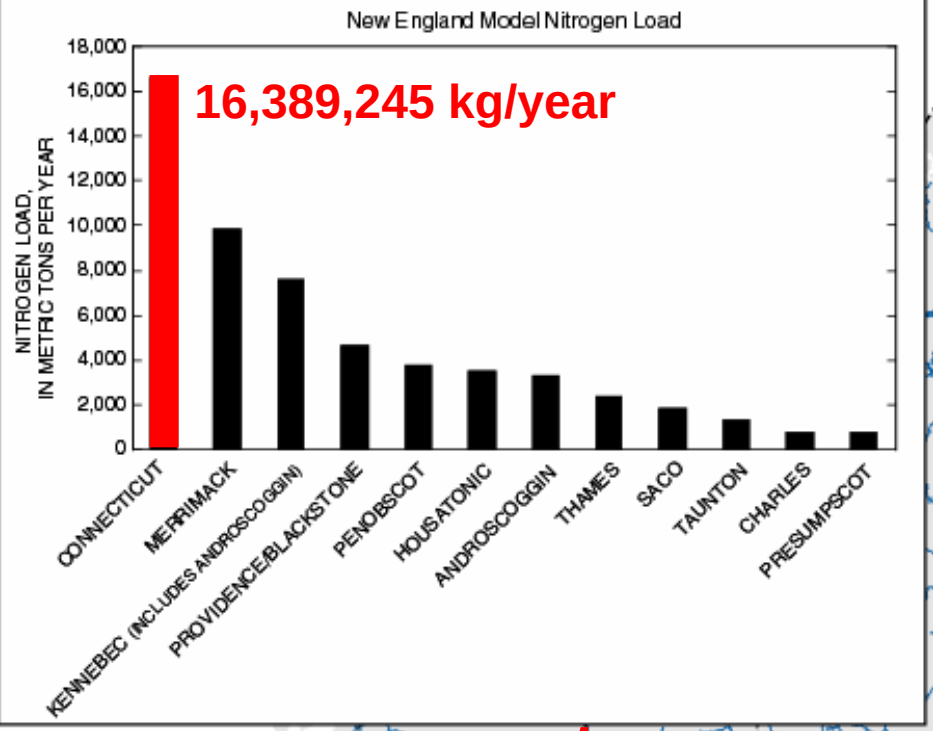
- In Vermont - Nutrient Criteria work relating NE Sparrow results and VT Nutrient Criteria Dataset for phosphorus in lakes and streams.

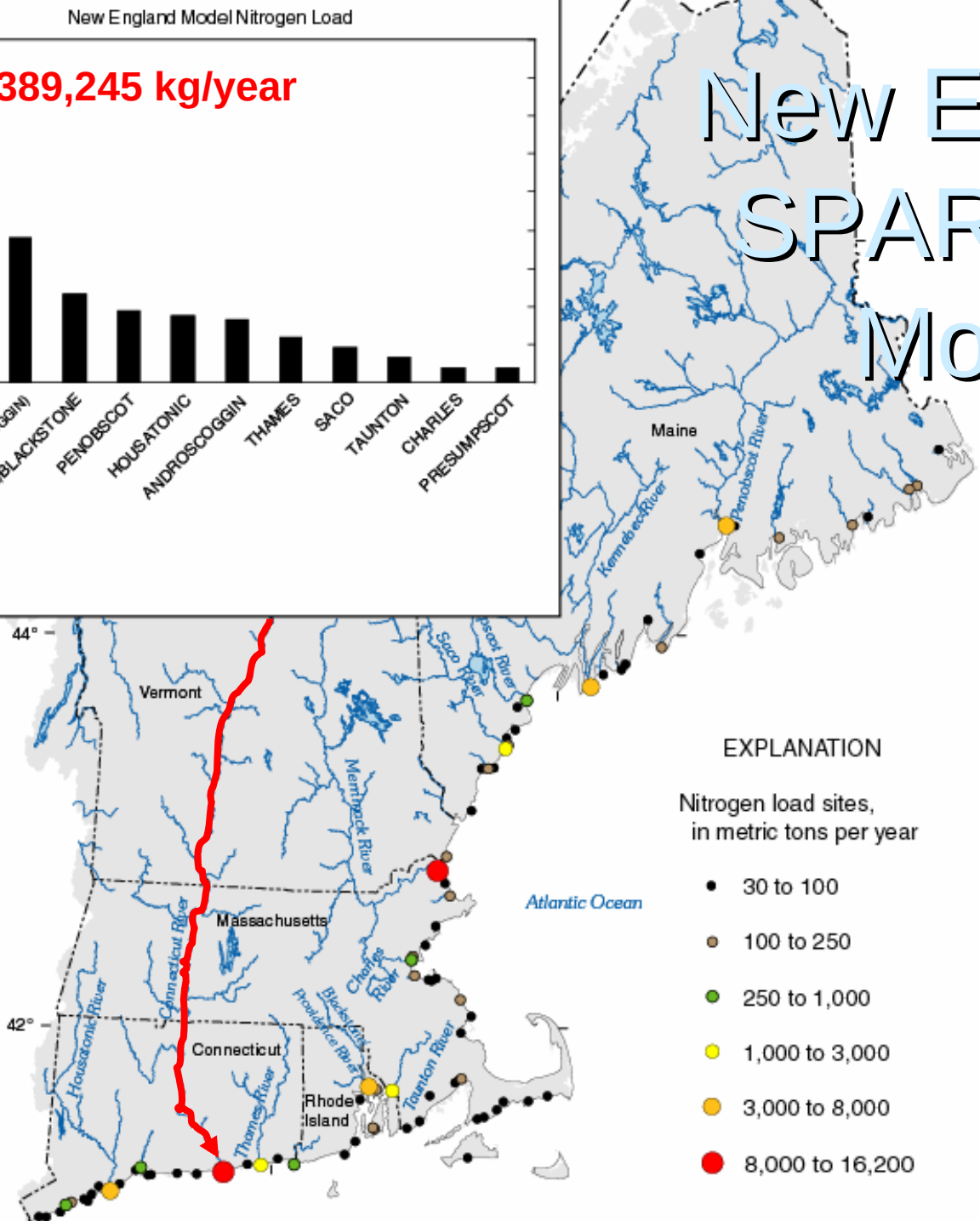
- In New Hampshire - study by conservation organizations to identify "pristine" watersheds with higher priority for protection.

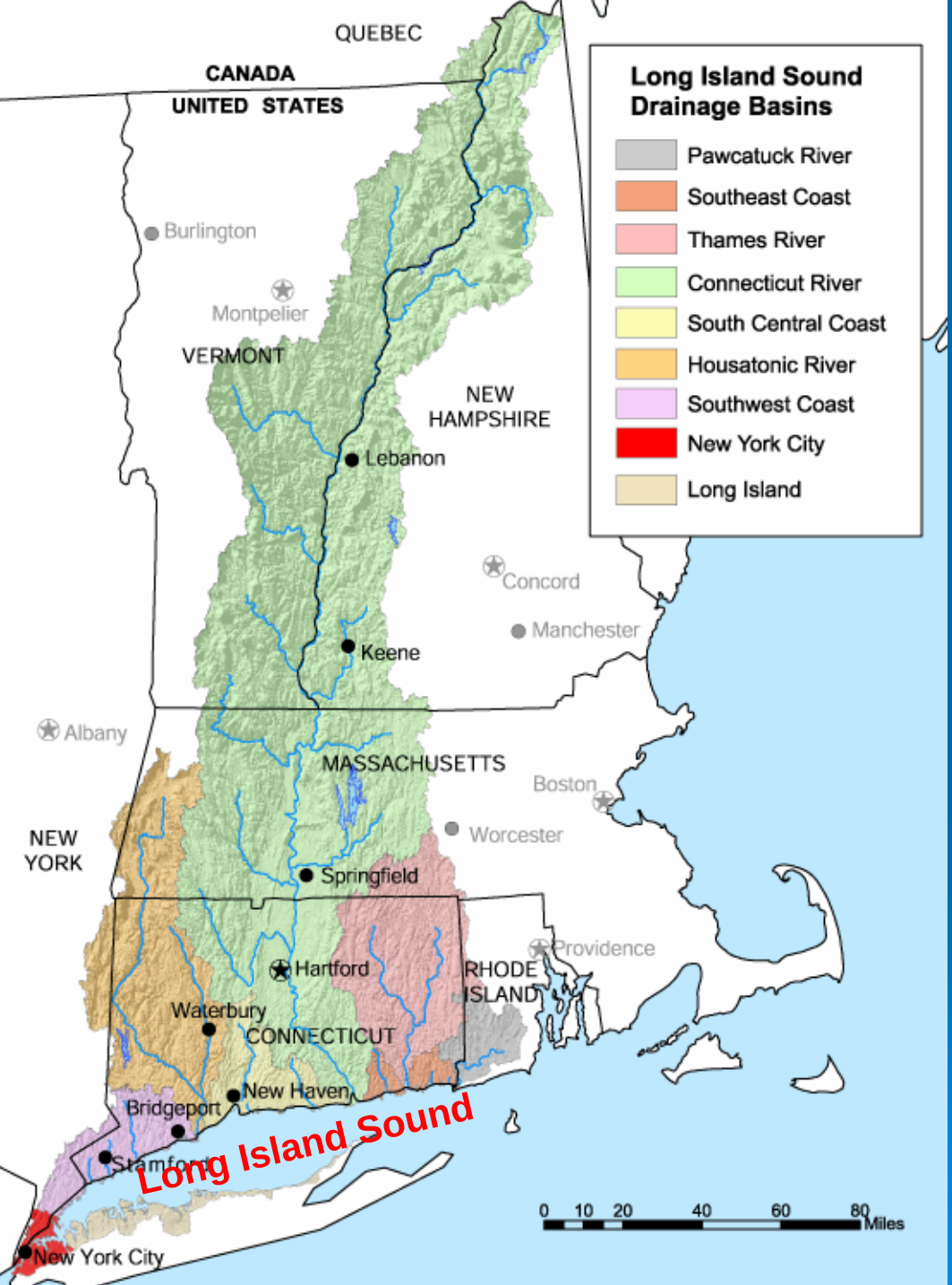
Applications (cont.)

- SPARROW results are useful in evaluating load assessments to receiving waters

New England SPARROW Model

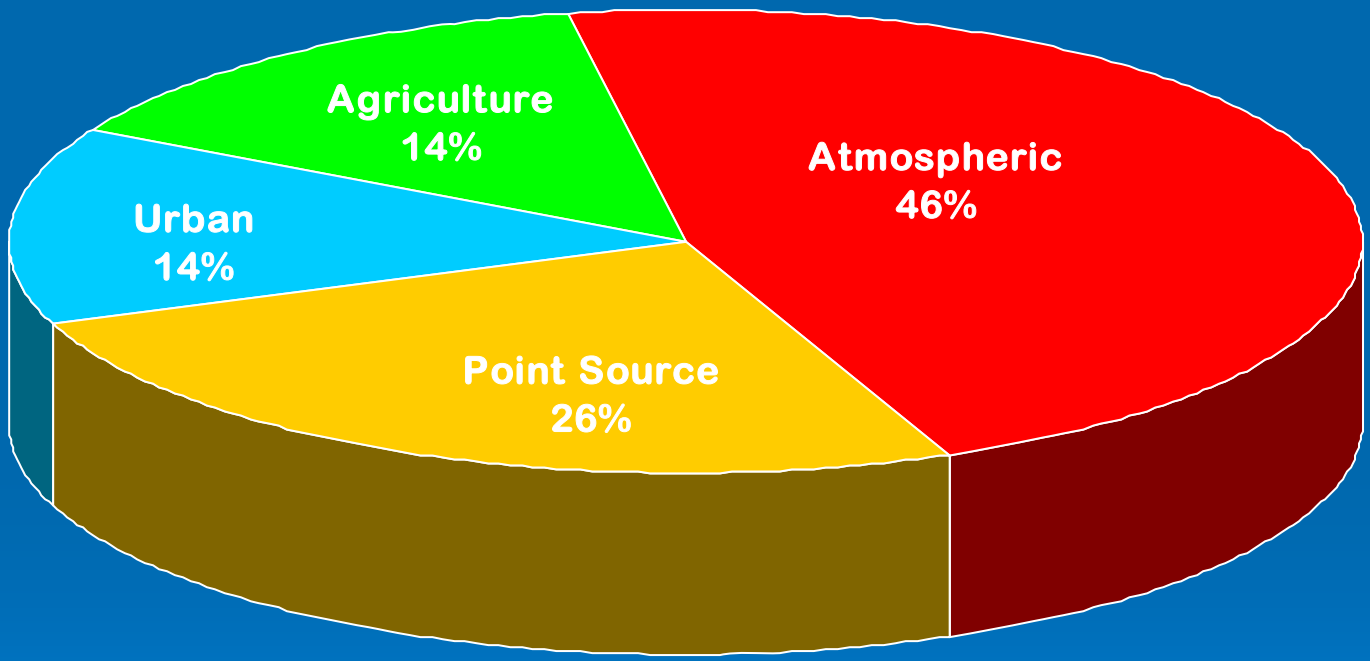






Connecticut River Nitrogen Loading Assessment

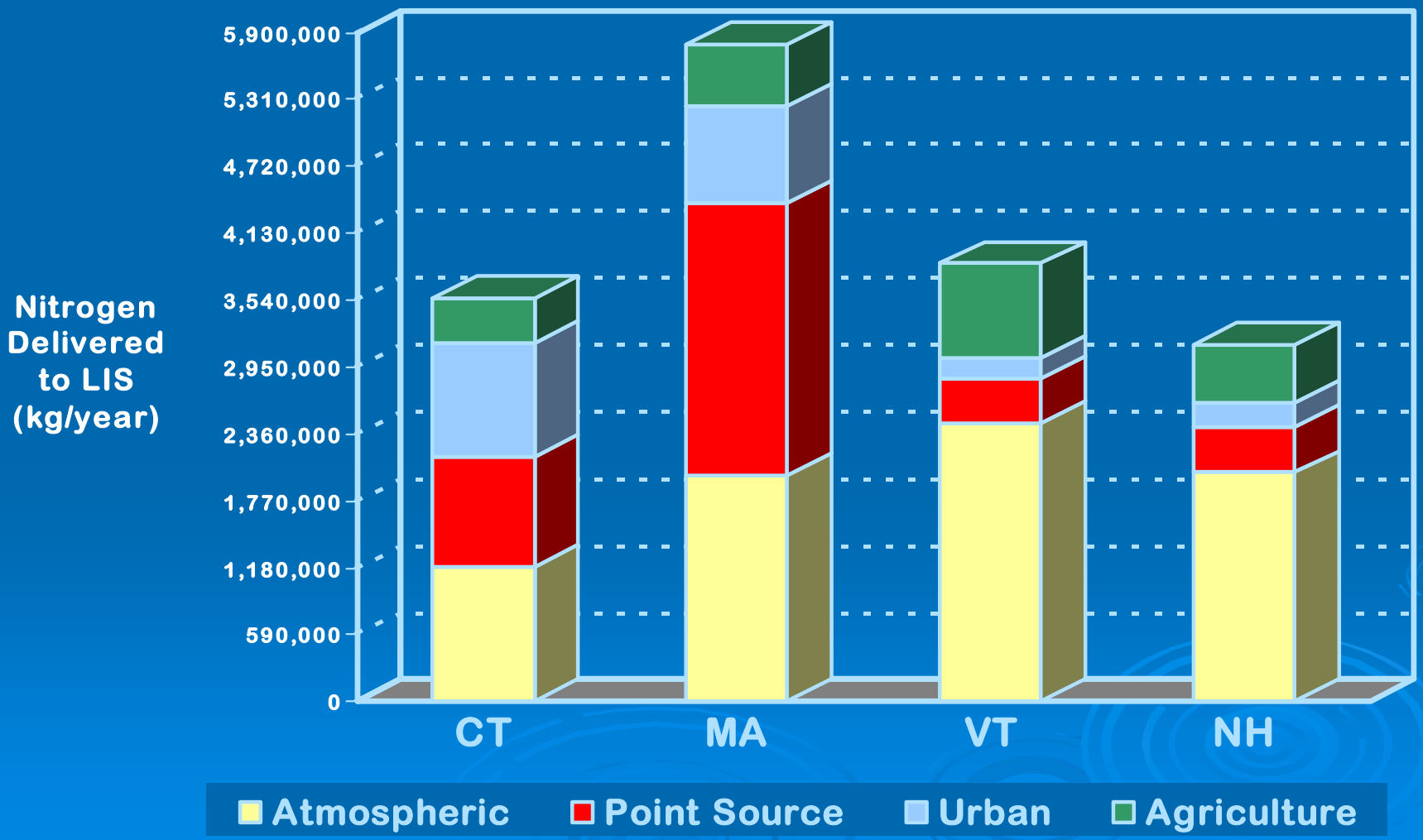
Predicted Sources of Nitrogen Loading in Connecticut River Watershed to LIS



NE SPARROW applications by other investigators

- Long Island Sound TMDL program
- two related USGS / NEIWPCC projects
  - nutrient loads in the upper CT basin
  - rate of nitrogen loss in selected reaches

Predicted Nitrogen Load Delivered to LIS from Connecticut River Watershed States



NE SPARROW applications by other investigators

- SPARROW *input* data is being used to help identify relations between observed mercury concentrations in water and sediment throughout New England.

NE SPARROW applications by other investigators

- Studies by Atlantic Ecology Division of the U.S. EPA Office of Research and Development
  - Linking SPARROW results to EPA's Coastal Waters Assessment for the New England region
  - proposed work to combine regional information from SPARROW models with EPAs probability surveys

NE SPARROW applications by other investigators

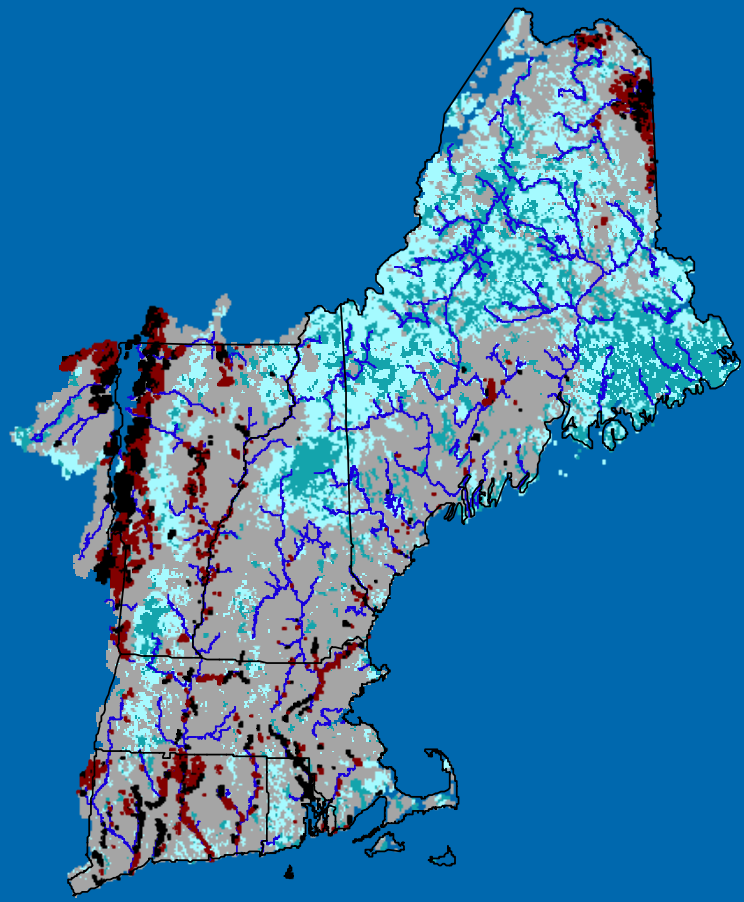
- New England SPARROW model is being used to assess contributions from headwater reaches on flows and nutrient loads in the major rivers (of importance to on-going discussions of Federal Clean Water Act)

Applications (cont.)

- SPARROW quantified estimates of uncertainty
- Results can be expressed in terms of probability of exceeding a specific mean-annual concentration

SPARROW

Probability of exceeding a specific mean-annual concentration



Probability of exceeding 0.05 mg/l Phosphorus

- less than 10 %
- 10 to 25 %
- 25 to 75 %
- 75 to 90 %
- Greater than 90 %

Conclusion

The detail and functionality of the NHD (NHDPlus) combined with SPARROW modeling capabilities produces an excellent water-quality modeling tool with numerous applications