New England Regional SPARROW Water-Quality Model
Purpose of the New England Model is to support major water-quality management activities

- **Nutrient Criteria Development**
  - expected ranges in concentrations
  - variation by ecoregion
  - relate concentrations to designated use attainment

- **Total Maximum Daily Load Allocations**
  - magnitude and sources of loads
  - load transport (especially interstate)
Design of the New England SPARROW Model

• 2 models: Total Nitrogen and Total Phosphorous

• Calibrating model for the early-mid 1990s time period

• Improve on national model by improved spatial detail and by additional local data sets

• Work began in 1999; now completing report summarizing results
New England Model
Network of River
Reaches and Reach
Catchments

- Based on the 1:100,000 scale National Hydrography Data Set (NHD)
- 42,000 reaches in model
- Average size is 1.7 mi²
- Corrected to NRCS 12-digit watersheds
- Hydrologically connected
Reach Watersheds/catchments

National Model
(2,462 watersheds
mean size 29.2 sq. mi.)

New England Model
(42,000 watersheds
mean size 1.7 sq. mi.)
Spatial Detail of the SPARROW Network

Saco River Cataloging Unit Example
Enhanced Predictor Variables being tested in the Model – Physical Watershed Features

• Mean annual flow estimations
  based on Randall (1996) – regional runoff map
• Time of travel/impoundment detention estimations
  - time of travel based on Jobson (1996); function of drainage area size, streamflow and slope
  - settling factor for lakes/impoundments (surface area / flow)
• Wetlands from National Land Cover Data
• Climatic data (temperature and precipitation) from Oregon State PRISM program
Nutrient Sources

• Land use
  National Land Cover Dataset (11 classes)

• Point Sources
  1993 TN and TP discharge estimates provided by EPA;
  ~2600 in New England

• Agricultural fertilizer and manure applications
  USDA Natural Resource Inventory by county applied to
  ag land use areas

• Atmospheric Deposition of Total Nitrogen
  based on Ollinger and others (1993)
Nitrogen fertilizer use for Androscoggin County Maine

Green is crop land
Atmospheric Deposition of Nitrogen

Range 3.2 to 12.0 kg/ha/yr
(Ollinger and others, 1992)
Nutrient Data (Dependent Variable) Used in the Model

- Collected data from USGS, STORET, States, research studies
- Calculated streamflow/nutrient relation to predict nutrient loads during all conditions of a hydrograph using the USGS Estimator Program.
- Loads are average over a period of record for streamflow data
Sites where Nutrient Loads Calculated

- 72 Nitrogen Sites
  - 65 sites used in the model
- 95 Phosphorus Sites
  - 67 sites used in the model
Model Results

- Nitrogen and Phosphorous Models have been calibrated and bootstrap models have been run
- Writing report
Model Calibration Runs for the New England SPARROW Nitrogen Model

Significant Predictors:
Point Sources (municipal STPs), Atmospheric Deposition, agricultural land, and urban land
R-squared = .94, MSE = 0.18

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Observed Natural Log of the Nitrogen Load in kilograms / year (Kg/y)

Predicted

Natural Log of the Nitrogen Load in kilograms / year (Kg/y)
SPARROW Predicted Nitrogen Yield

Catchment Yield (kg / sq km)

- 100
- 200
- 250
- 300
- 400
- 500
- 600
- 800
- 1,000
- 1,500
- 2,300
- 2,700 - 4,800
- 4,800 - 10,000
- 10,000 - 32,000
- > 32,000
SPARROW Predicted Nitrogen Yield URBAN Sources

Catchment Yield (kg / sq km)

- 0
- 2 - 15
- 15 - 35
- 35 - 67
- 67 - 114
- 114 - 183
- 183 - 277
- 277 - 400
- 400 - 552
- 552 - 776
- 776 - 1271
Coefficient Error of Total Load

error in percent
(model error of about 34% is in addition to these percentages)

- 0 - 6.5
- 6.5 - 7.3
- 7.3 - 8.3
- 8.3 - 9.5
- 9.5 - 10.8
- 10.8 - 11.7
- 11.7 - 11.9
- 11.9 - 13.1
- 13.1 - 21.7
- 21.7 - 41.7
Model Calibration Runs for the New England SPARROW Phosphorous Model

Significant Predictors:
Point sources (municipal STPs and paper), Forest land, agricultural land, urban land, Attenuation in lakes with surface areas $\leq 10$ km$^2$

R-squared = .91, MSE = .36

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Observed $\ln(\text{load kg})$
Using the New England SPARROW Model to Assist in the Upper Connecticut River TMDL Process

- Compare SPARROW results to other load estimates, modeling studies and professional judgment
- Use New England SPARROW model to determine loads, sources of loads, and errors
- Determine if additional/refined SPARROW modeling is needed
  - Nested model to assess attenuation
- Use SPARROW model to assist in design of monitoring network to better define loads
- Revised SPARROW model after additional data collection
Utility of **New England SPARROW** Model

Results for TMDL Applications –
An Example from the Connecticut River Basin

- **Point source**
- **Agriculture**
- **Atmospheric**
- **Urban**

**Sources in NH-VT**

- Point source: 5%
- Agriculture: 13%
- Atmospheric: 9%
- Urban: 73%

**TN Loads to Long Is Sound**

- Loads NH-VT: 36%
Mercury SPARROW Model

• Multivariate regression model (not true SPARROW)
  - dependent variable: Hg in tissue by species
  - independent variables: SPARROW-generated watershed characteristics, Hg deposition, other Hg sources, water chemistry, other variables shown to influence Hg in fish

• Data collection initiated

• Model development in 2003/04?

• EPA/NEIWPCC/NESCAUM/USGS cooperative study
Summary of Results

• 1:100,000 NHD needed work

• Quality point source data difficult to obtain

• New England TN and TP models are improvements over the national SPARROW model

• Packaged and documented SPARROW programs needed

• Significant interest and value in SPARROW products from EPA, NEIWPCC, and state agencies
Residual (percent) Sparrow Nitrogen

Percent Error

- Overestimated + under-estimated

R1
States ne
71 - 373
31 - 71
12 - 31
2 - 12
-10 - 2
-16 - 10
-23 - 16
-35 - 23
-57 - 35

States ne
71 - 373
31 - 71
12 - 31
2 - 12
-10 - 2
-16 - 10
-23 - 16
-35 - 23
-57 - 35