New Regional Water-Quality Monitoring in New England by the US Geological Survey

Keith Robinson
USGS, NH-VT Water Science Center

NEAEB Meeting, March 2010

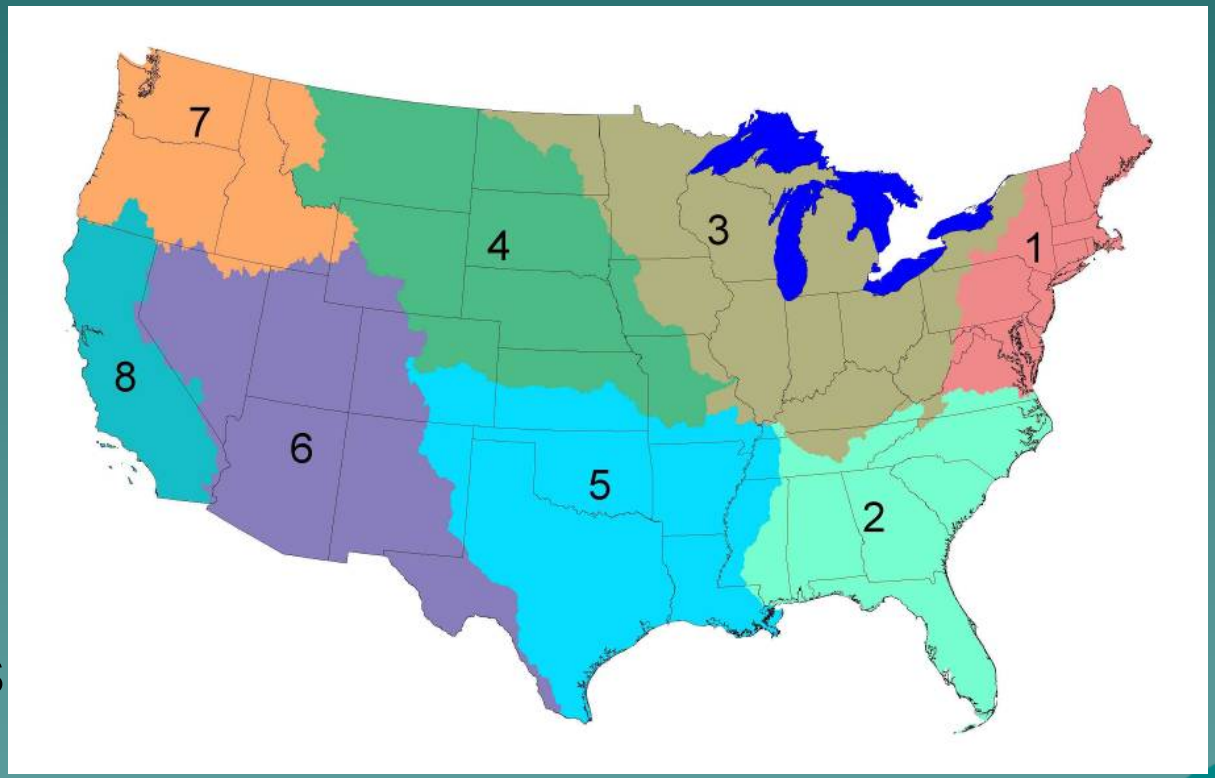
USGS
science for a changing world

Northeast US SPARROW Nutrient Models

MERGANSER Fish Tissue Model for New England

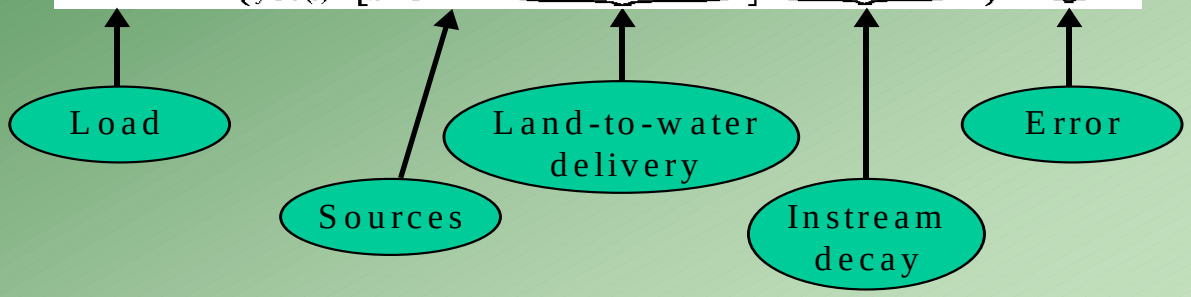
Northeast SPARROW Models (Spatially Referenced Regressions on Watershed Attributes)

- Developed by the USGS NAWQA Program
- Most of Nation being completed now
- Northeast Authors – R. Moore, C. Johnston, R. Smith, B. Milstead



SPARROW Estimated Equation

$$\text{Load}_i = \left\{ \sum_{j \in J(i)} \left[\sum_{n=1}^{N} S_{n,j} \beta_n \exp(-\boldsymbol{\alpha}' \boldsymbol{Z}_j) \right] \exp(-\boldsymbol{\delta}' \boldsymbol{T}_{i,j}) \right\} \exp(\epsilon_i)$$

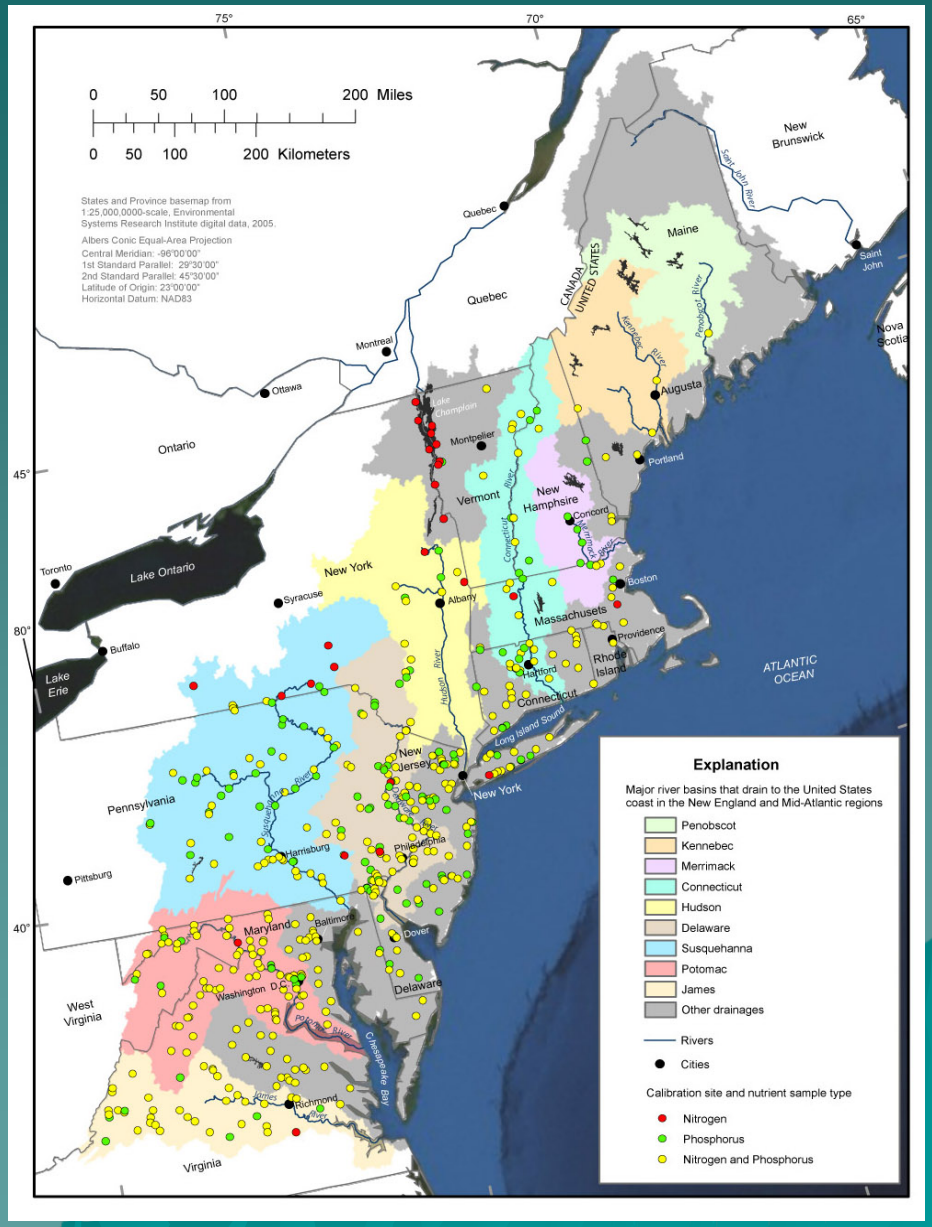


- Multivariate regression model predicts mean annual loads & concentrations of total N and P

- Based on NHD 1:100,000 hydrography (about 195,000 reaches/catchments in the model area)

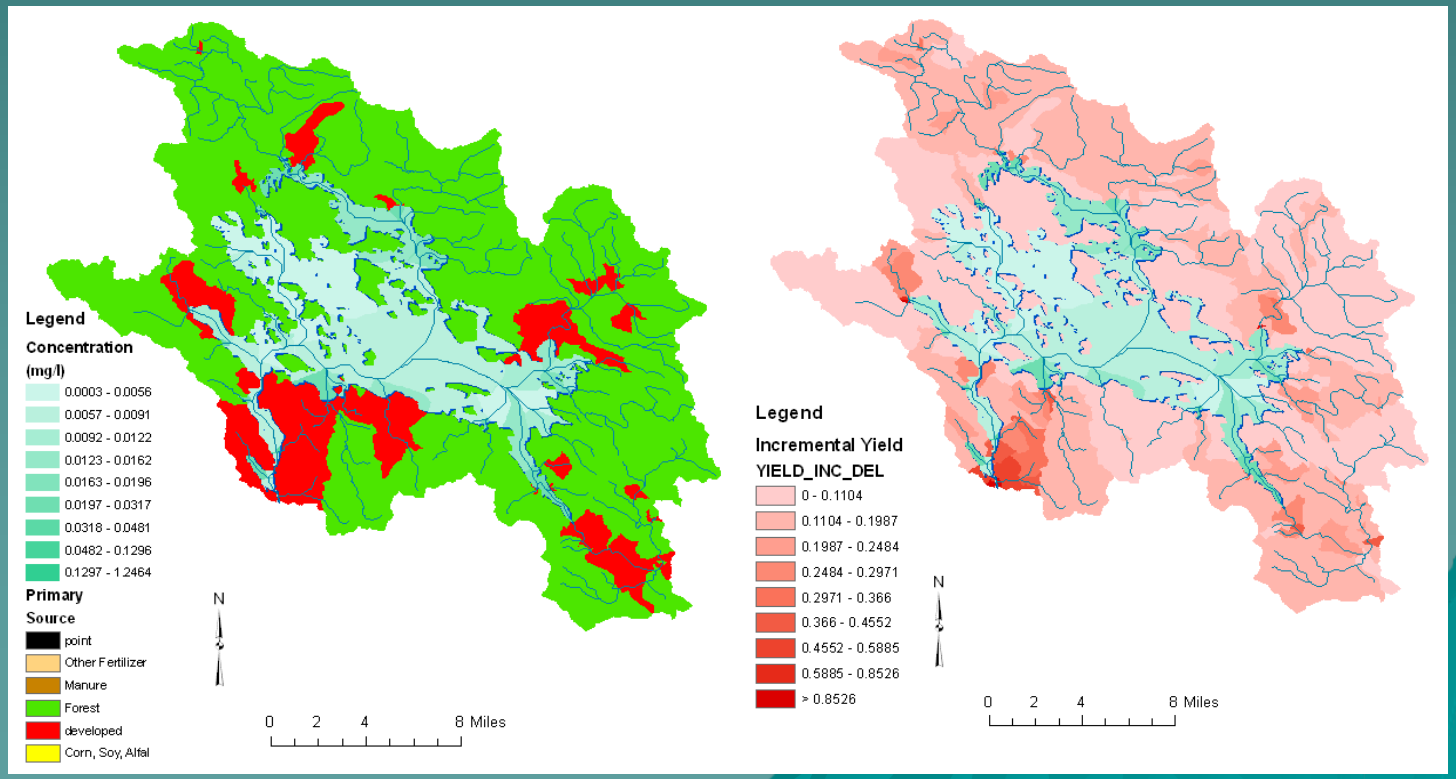
Data Used in the Models

- Dependent variables
  - -loads of N and P
  - -state, regional and federal monitoring programs
  - -multiple years of data
  - -located at/near gage
- Independent variables
  - -physical watershed features
  - -lakes/reservoirs
  - -land uses/population
  - -point sources
  - -atmospheric deposition



Northeast SPARROW Phosphorus Model

- Model used to describe P input/output for 13 regionally important lakes/reservoirs
- Results compared to USEPA probabilistic survey data



Northeast SPARROW Models

- Results to be published in JAWRA in 2011
- Results to be made available for each reach/ catchment
- Models will be linked to a new USGS SPARROW web-based decision support tool that will allow application of models to hypothetical tests

MERGANSER - MERcury Geo-spatial AssessmeNtS for the New England Region

Merganser Builds on Existing Research

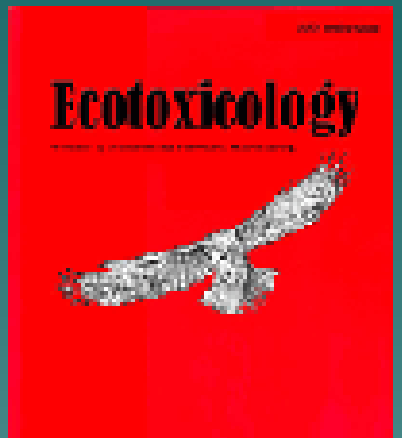
USEPA regional supported studies

- -emissions inventories
- -atmospheric deposition and transport models
- -fish tissue assessments

USDA Northeastern Ecosystem Research Cooperative – NE Mercury Research Group

Numerous other studies

SPARROW type approach



Ecotoxicology Papers

The content for this report was distilled, in large part, from: Biogeographical patterns of environmental mercury in northeastern North America. 2005. *Ecotoxicology* Volume 14, numbers 1 and 2. Guest Editors: David C. Evers and Thomas A. Clair. Editor: Lee R. Shugart.

1. Mercury in northeastern North America: a synthesis of existing databases. D.C. Evers and T.A. Clair.
2. Approaches to reducing mercury in North America. J. Weiss.
3. Mercury policy and science in northeastern North America: The Mercury Action Plan of the New England Governors and Eastern Canadian Premiers. C.M. Smith and L.J. Trip.
4. Patterns of mercury deposition and concentration in northeastern North America (1996-2002). A. VanArsdale, J. Weiss, G.J. Keeler, E.K. Miller, G. Boulet, R. Brulotte and L. Poissant.
5. Estimation and mapping of wet and dry mercury deposition across northeastern North America. E.K. Miller, A. VanArsdale, G.J. Keeler, A. Chalmers, L. Poissant, N.C. Kamman and R. Brulotte.
6. Long-term atmospheric mercury deposition at Underhill, Vermont. G.J. Keeler, L.E. Gratt and K. Al-Wali.
7. Deconstruction of historic mercury accumulation in lake sediments, northeastern United States. E. Perry, S.A. Norton, N.C. Kamman, P.M. Lorey and C.T. Driscoll.
8. Factors influencing mercury in freshwater surface sediments of northeastern North America. N.C. Kamman, A. Chalmers, T.A. Clair, A. Major, R.B. Moore, S.A. Norton and J.B. Shanley.
9. Distribution patterns of mercury in lakes and rivers of northeastern North America. I.F. Dennis, T.A. Clair, C.T. Driscoll, N.C. Kamman, A. Chalmers, J.B. Shanley, S.A. Norton and S. Kahl.
10. Physical controls on total and methylmercury concentrations in streams and lakes of the northeastern U.S. J.B. Shanley, N.C. Kamman, T.A. Clair and A. Chalmers.
11. Patterns of mercury bioaccumulation and transfer in aquatic food webs across multi-lake studies in the northeast U.S. C.Y. Chen, R.S. Stemberger, N.C. Kamman, B. Mayes and C. Folt.
12. Mercury in the northern crayfish, *Orconectes virilis* (Hagen), in New England, USA. C.M. Pinnizo, O.P. Lane, D.C. Evers, R.J. Taylor and J. Loukmas.
13. Mercury in freshwater fish of northeast North America – a geographic perspective based on fish tissue monitoring databases. N.C. Kamman, N.M. Burgess, C.T. Driscoll, H.A. Simonin, W.M. Goodale, J. Linehan, R. Estabrook, M. Hutcheson, A. Major and A.M. Scheuhammer.
14. Mercury bioaccumulation in two-lined salamanders from streams in the northeastern U.S. M.S. Bank, C.S. Loftin and R.E. Jung.
15. Patterns and interpretation of mercury exposure in freshwater avian communities in northeastern North America. D.C. Evers, N.M. Burgess, L. Champoux, B. Hoskins, A. Major, W.M. Goodale, R.J. Taylor, R. Poppenga and T. Daigle.
16. Mercury levels in Bicknell's thrush and other insectivorous passerine birds in montane forests of the northeastern United States and Canada. C.C. Rimmer, K.P. McFarland, D.C. Evers, E.K. Miller, Y. Aubry, D. Busby and R.J. Taylor.
17. Mercury and other contaminants in common loons breeding in Atlantic Canada. N.M. Burgess, D.C. Evers and J.D. Kaplan.
18. Relating cover characteristics and common loon mercury levels using geographical information systems. D. Kramar, W.M. Goodale, L. Kennedy, B. Carstensen and T. Kaur.
19. Mercury levels in mink and river otter in northeastern North America. D. Yates, D. Mayack, K. Munney, D.C. Evers, R.J. Taylor, T. Kaur and A. Major.
20. Developing a cyber infrastructure for integrated assessments of environmental contaminants. T. Kaur, J. Singh, W.M. Goodale, D. Kramar and P. Nelson.
21. An approach to predict risks to wildlife populations from mercury and other stressors. D. Nacci, M. Pelletier, J. Lake, R. Bennett, J. Nichols, R. Haebler, J. Grear, A. Kuhn, J. Copeland, M. Nicholson, S. Walters and W.R. Munns Jr.

What is the MERGANSER Model

- A geo-spatial statistical model designed to explain the variation in fish tissue mercury concentrations in lakes and reservoirs throughout New England.
- Identify significant predictors of Hg in fish tissue from a host of environmental variables and mercury sources
- Links fish tissue mercury predictions to population response models for piscivorous birds
- Applied to lakes/reservoirs greater than 20 acres (~4400)

MERGANSER estimated equation (linear model)

multiple linear-regression equation:

$M_i = b_0 + b_1 P_{i,1} + b_2 P_{i,2}$ ……etc. + e_i

Where M_i = Hg content, $P_{i,1}$ = predictor variable (e.g. sources, methylation factors, fish species), b_1 = regression coeff

Log linear form:

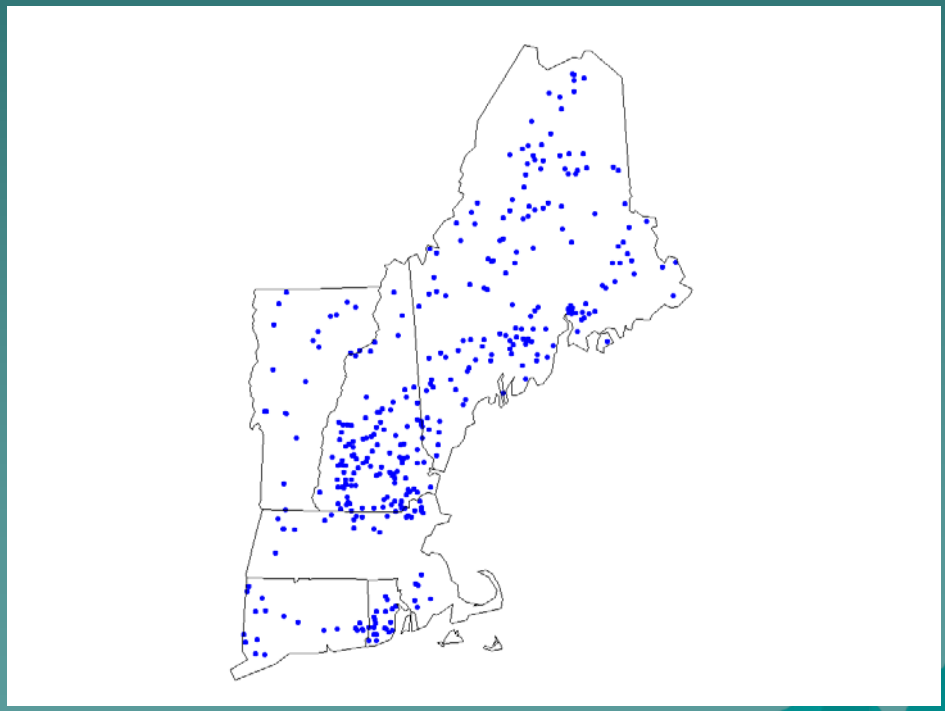
$\ln M_i = b_0 + b_1 \log P_{i,1} + b_2 \log P_{i,2}$+…etc. + e_i

Fish and Loon Data Used in the Model

Dependent variables

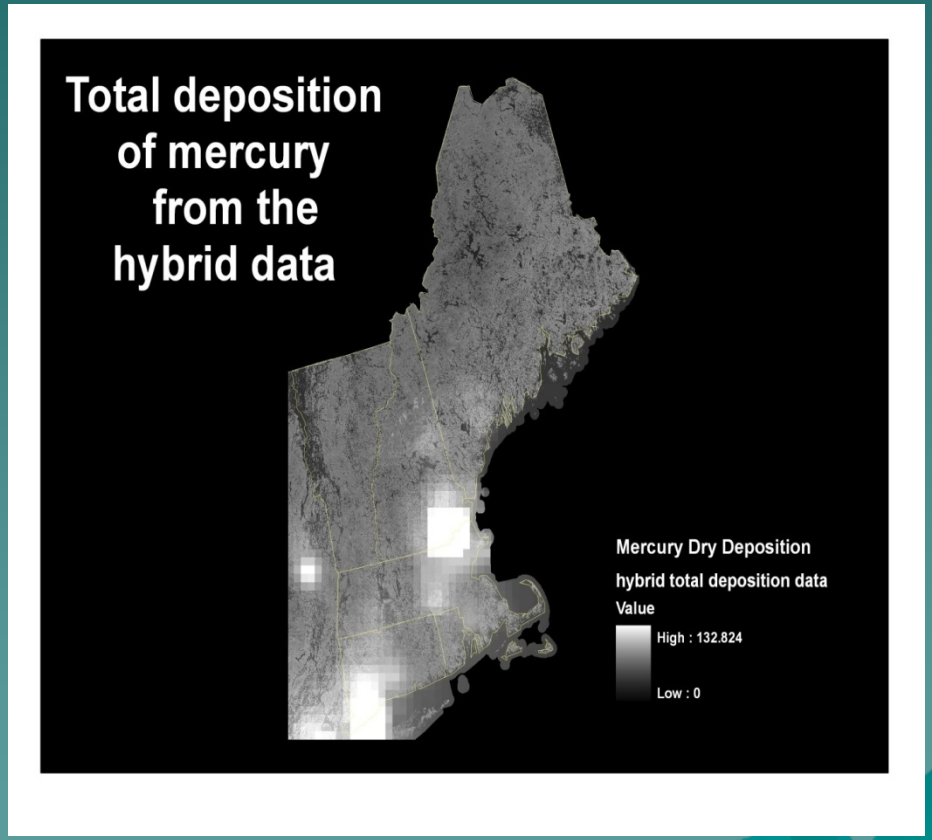
-fish tissue Hg conc, 358 lakes in 6 New England States; sampled by states and USEPA (1996 to 2006), represents variety of species

-loon blood Hg conc; ~500 lakes



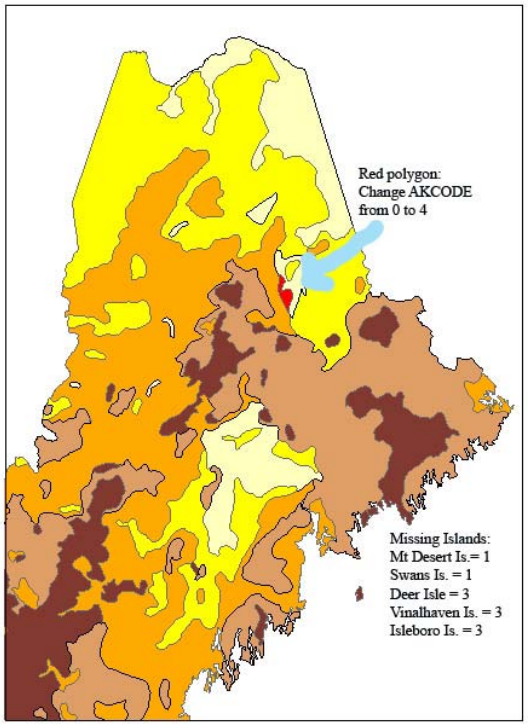
Explanatory Variables Evaluated

- Watershed features from NHDPlus and climatic conditions
- Land cover from NLCD
- Wetland types – NWI
- Modeled Hg deposition from land cover, elevation, and deposition data (Eric Miller-Ecosystems Research Group)



Explanatory Variables Evaluated

- pH (proxy) – Eric Miller
- Sulfur deposition – Eric Miller
- Stream alkalinity- EPA Ecoregions team
- SPARROW phosphorus predictions
- Percent watershed as upgradient lake and other lake watershed features



Next Steps

- Complete fish tissue model development and apply to all lakes (next month)
- Complete loon blood Hg model and apply (next month)
- Prepare journal papers summarizing study (by early summer)
- Prepare summary report and hold workshops on results of study (later in year)

For More Information…

- Northeast SPARROW Model:
  Richard Moore, USGS
  rmoore@usgs.gov

- MERGANSER Model:
  Alison Simcox, USEPA
  simcox.alison@epa.gov

  Jamie Shanley, USGS
  jshanley@usgs.gov

Thank you!