

Biogeographical patterns of environmental mercury in northeastern North America

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Environment
Canada

Environnement
Canada



Northeast States for Coordinated
Air Use Management



Northeastern Ecosystem Research Cooperative Northeast Mercury Research Group

Version 2.0 November 2002



BIODIVERSITY
RESEARCH INSTITUTE

Structure and Timeline

- USDA funding source – Northeastern Ecosystem Research Cooperative. Initiated in 2002
- Hg project was one of several competitively awarded grants in 2002
 - Tom Clair, Environment Canada and myself were the co-P.I.s
 - Basic premise initially to summarize available Hg databases into a web accessible format
 - Data from a designated area of the NE and from freshwater only
 - Provide summarized data on CDs to researchers and policy interests

Workshops

- First workshop in 2002, ~50 participants presented
 - Built committees based on compartment type
- Second workshop in 2003, return of nearly everyone with additional interests
 - Committees presented and reported progress on data summaries
 - First generation of database complete and made into a CD
 - Announced the ability to have a special issue in a peer-reviewed journal
 - Papers were organized and followed data compartments with some inter-compartment analysis
- Third workshop in 2004
 - Senior authors presented their papers
 - Discussed timeline for special issue

71 scientists:
American and
Canadian
4 years
21 papers

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. Gratz 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. Pennuto, 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. Hitchenson, 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.

MERCURY CONNECTIONS

*The extent and effects of
mercury pollution in
northeastern North America*



Post-workshop efforts

- Oct-Dec. 2004
 - Peer review from 2-3 outside reviewers
- February 2005
 - Submit final manuscripts
- Mid-March 2005
 - Preprints of Ecotoxicology papers provided (courtesy of Kluwer)
 - Mercury Connections Rept.
 - Congressional briefings
 - Environ. Public Works
 - Senate briefings
- Early April, 2005
 - Ecotoxicology 14(1-2) special issue on Hg

Key Messages

- Comprehensive analysis of air, sediment, water, fish and wildlife show that Hg levels are pervasive and higher than once thought in the Northeast
- Many wildlife species, even forest songbirds, have elevated Hg body burdens
- Nine biological hotspots that pose ecological risk are identified in the Northeast
- Environmental monitoring programs must be expanded to fully document the extent and impact of Hg pollution changes in North America

>30,000 datapoints

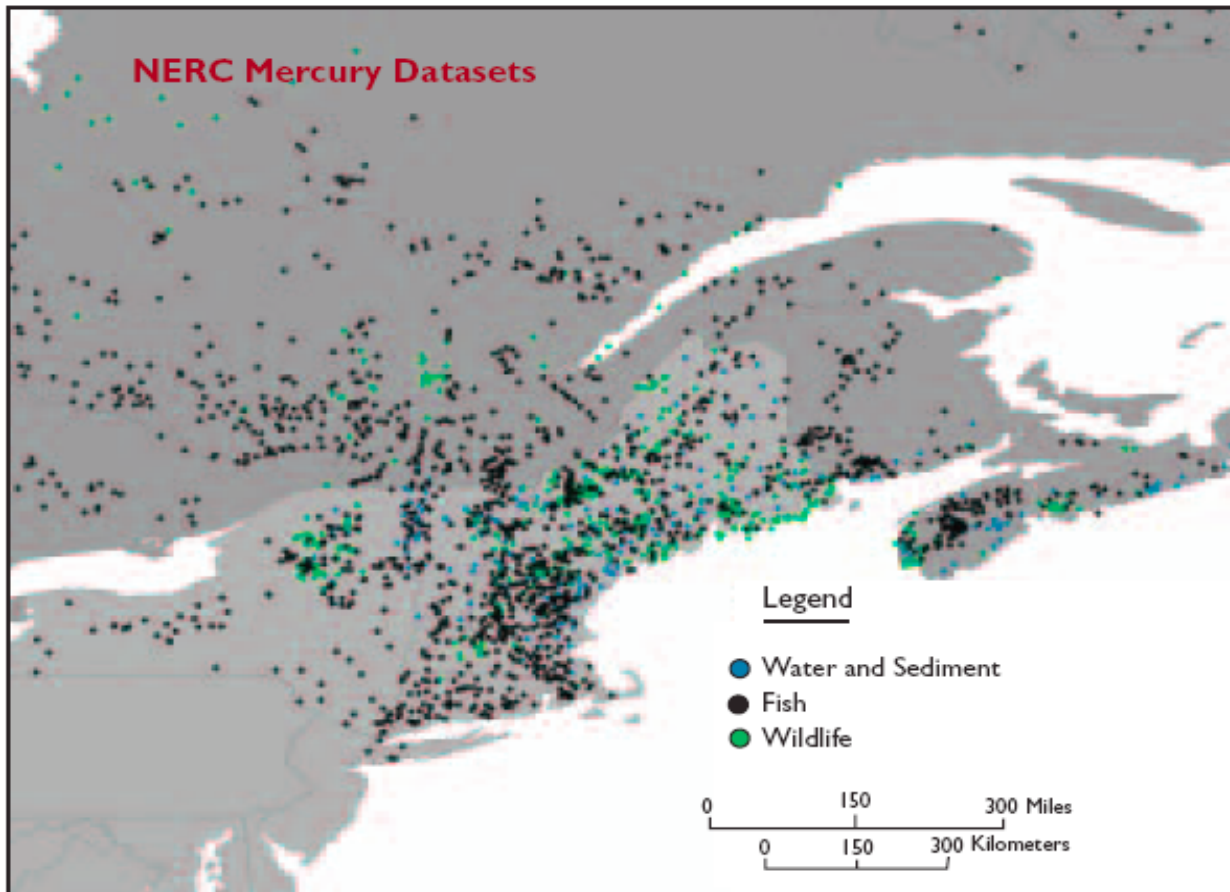
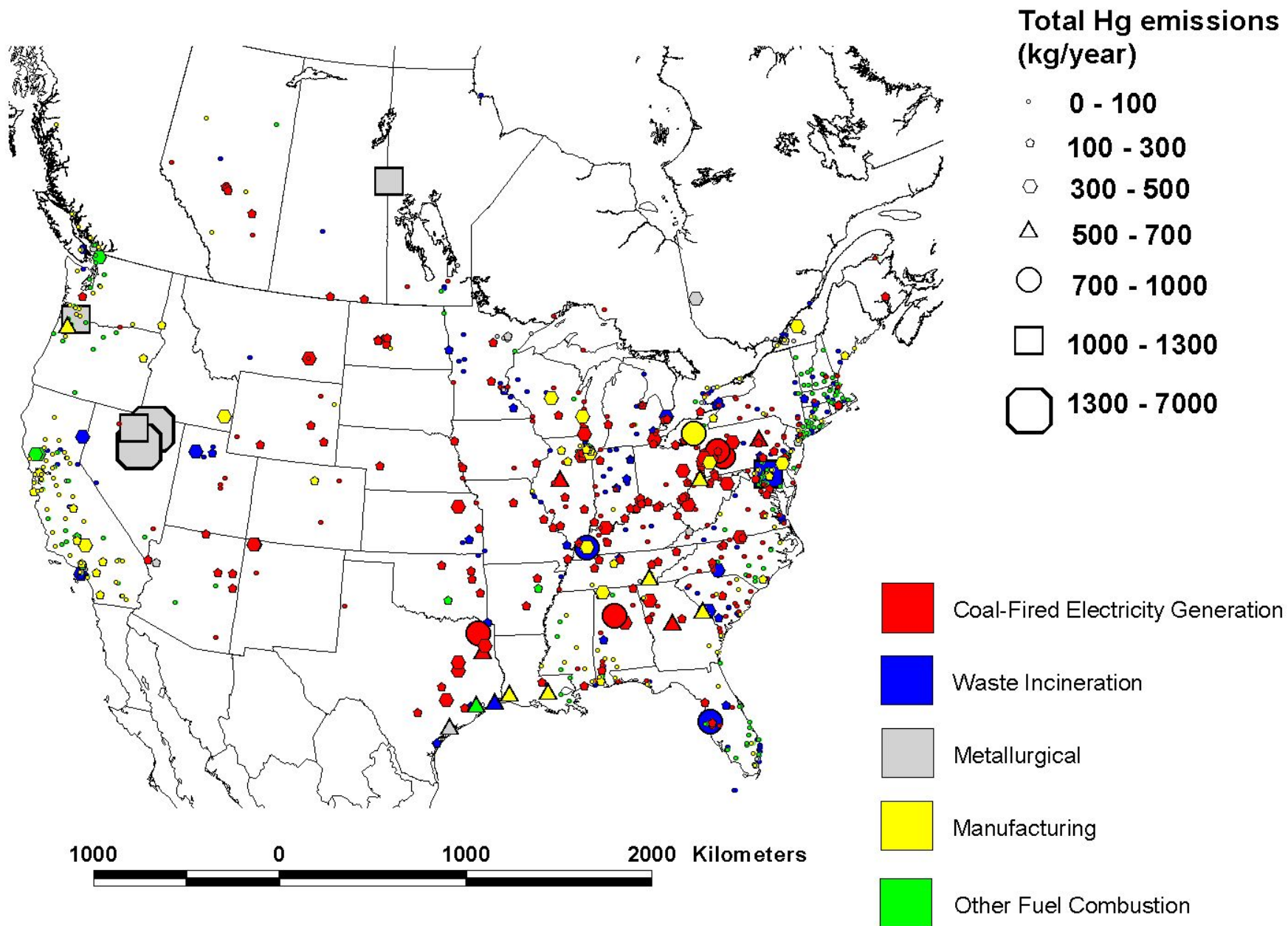
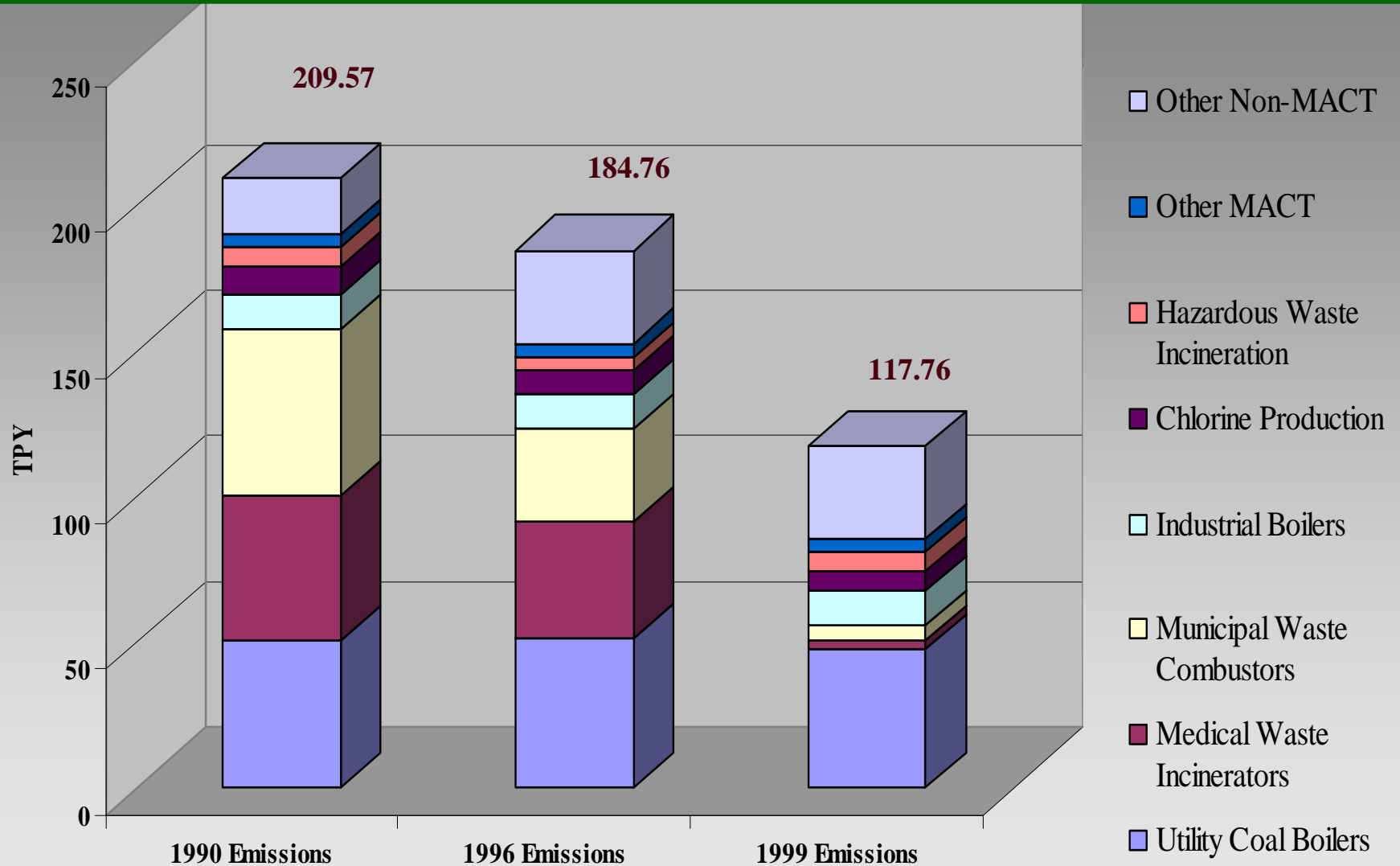
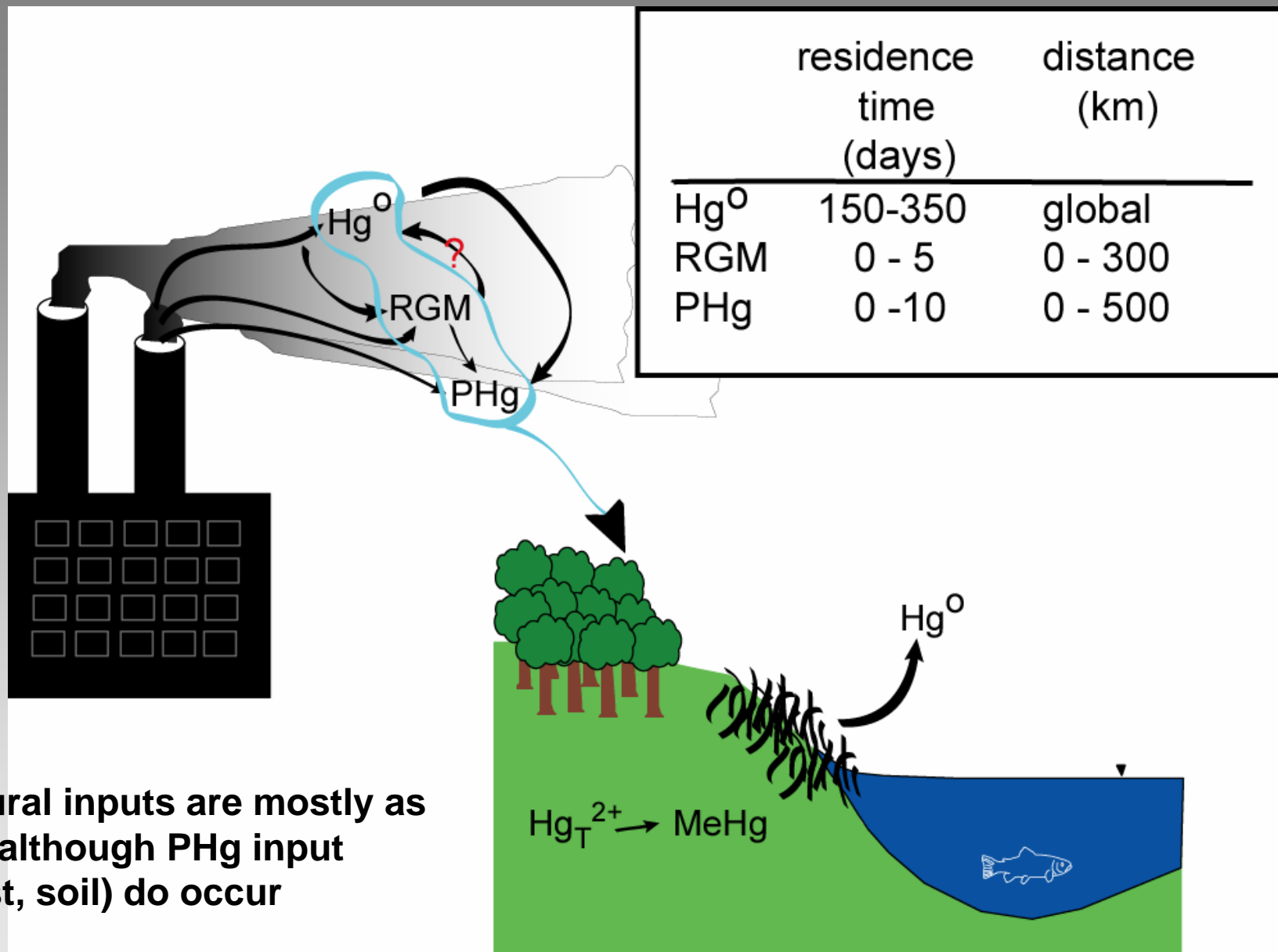


Figure 1: Map of the study area and mercury data compiled by the mercury working group of the Northeastern Ecosystem Research Cooperative. Areas north to Newfoundland, Labrador and central Quebec were in the study area but are not shown here.



U.S. Atmospheric Mercury Emissions





Estimation and mapping of wet and dry deposition across northeastern North America

- Model includes wet AND dry deposition
- Greatest total Hg deposition in:
 - High elevation areas
 - Southern parts of the NE
- Mercury emission sources for the NE are now of concern in PA, WV, OH, and MD.

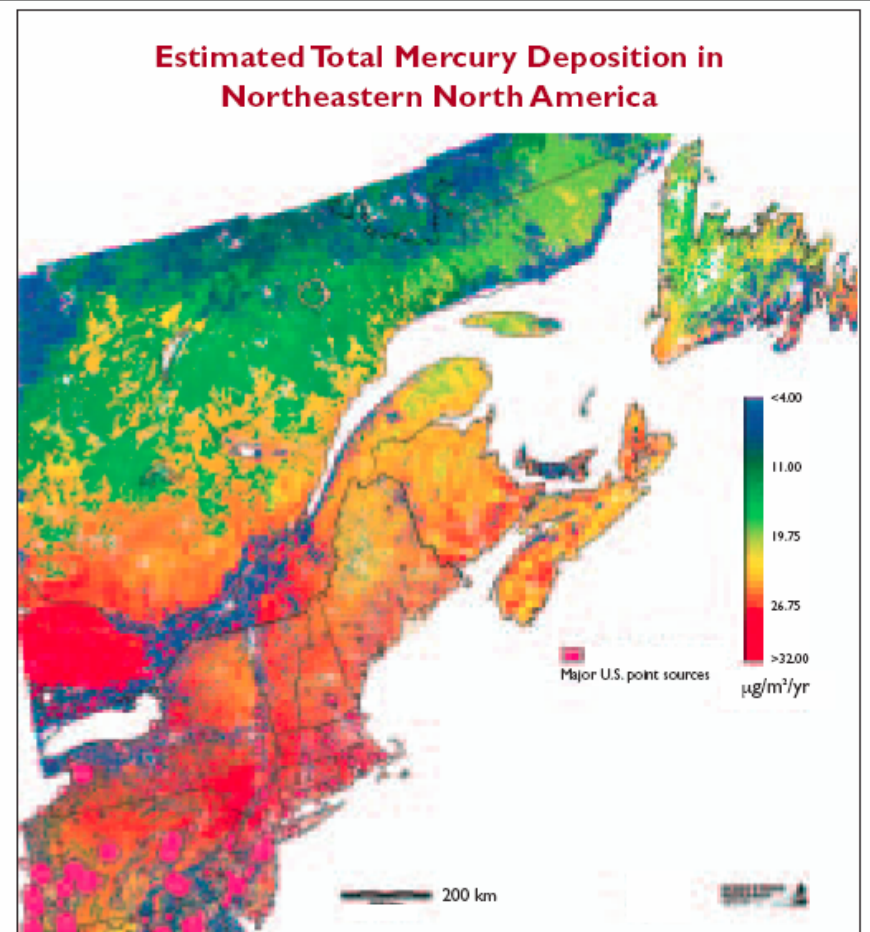
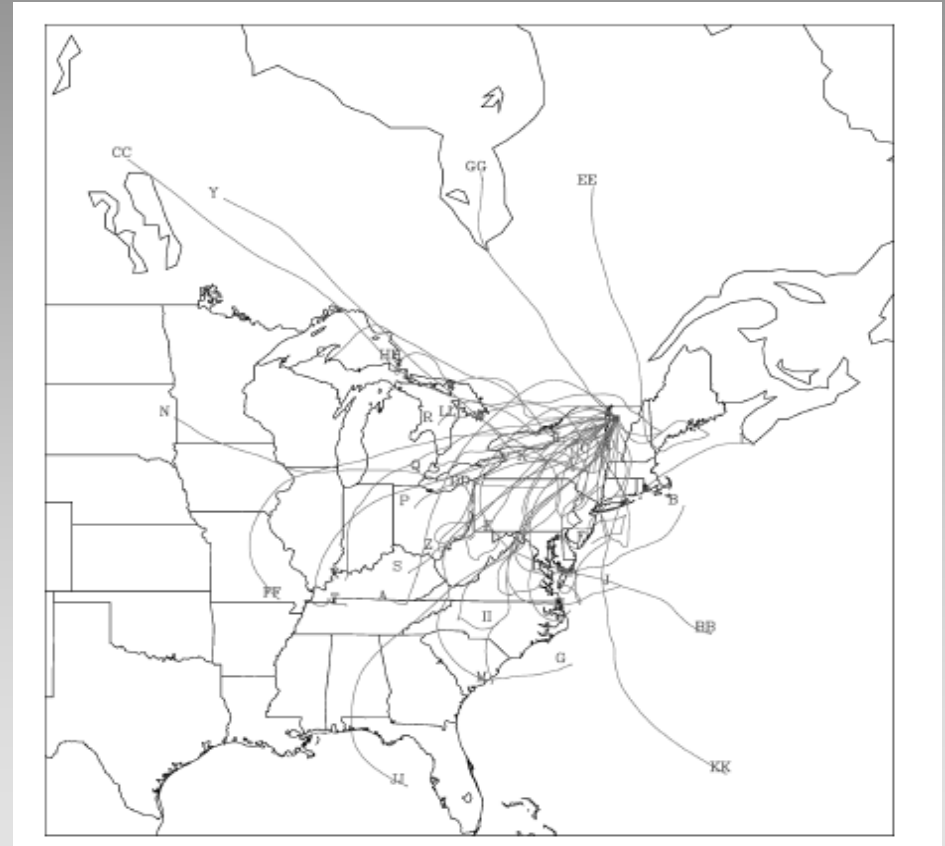


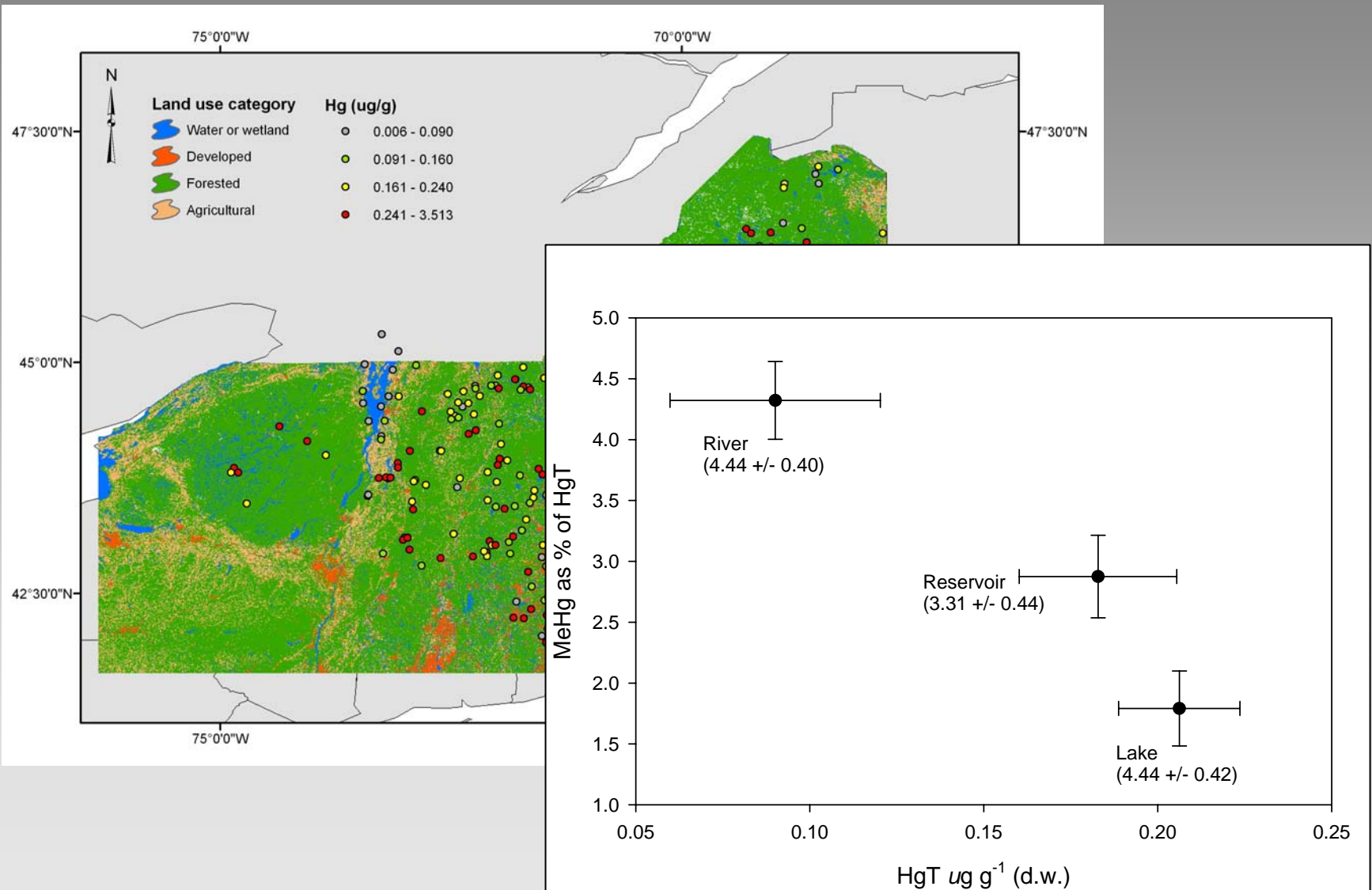
Figure 4: Total mercury deposition based on a new model intended to better depict dry deposition. The model does not fully incorporate the effects of large point sources in the region and those areas are masked in pink.

Long-term atmospheric mercury deposition at Underhill, Vermont

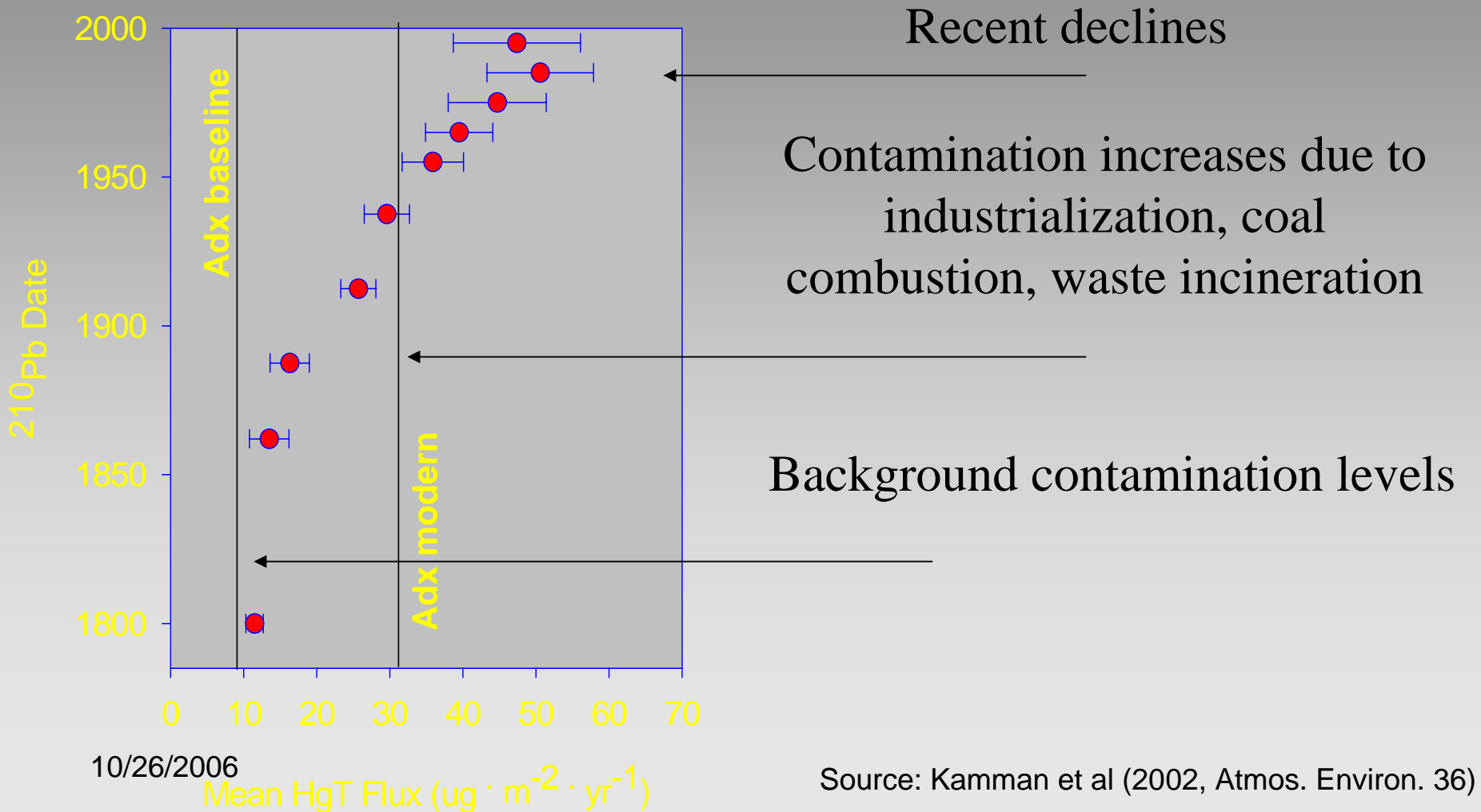
- Continuous record since 1992
- Annual mean wet deposition ranged from 7.8 to 10.5 ppt
- Has highlighted seasonality of Hg deposition (higher in spring, summer).
- No clear trend in annual averages, but...
- Significant decreases in the maximum concentrations, '92-'03.



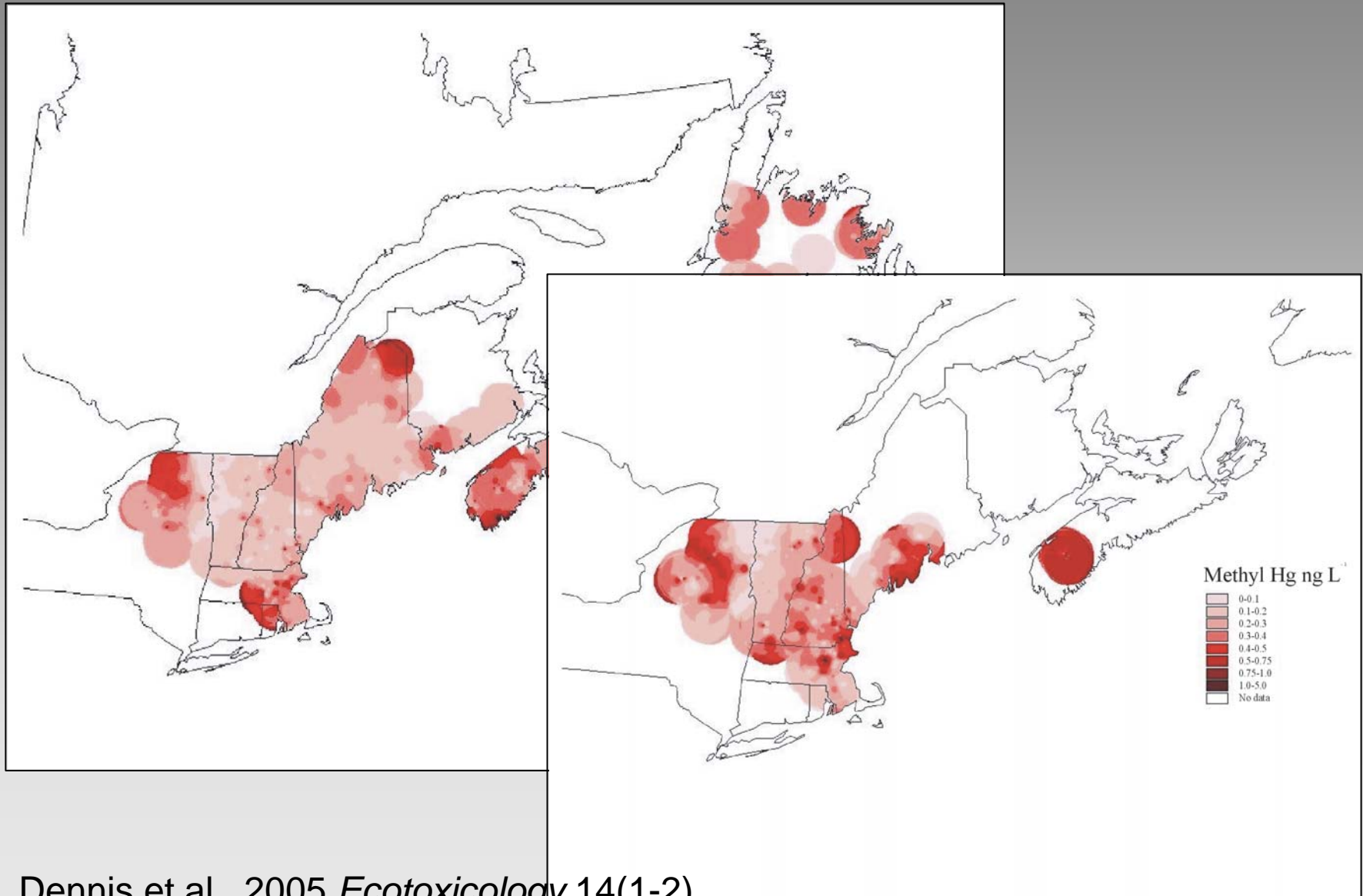
Factors influencing mercury in freshwater surface sediments of northeastern North America



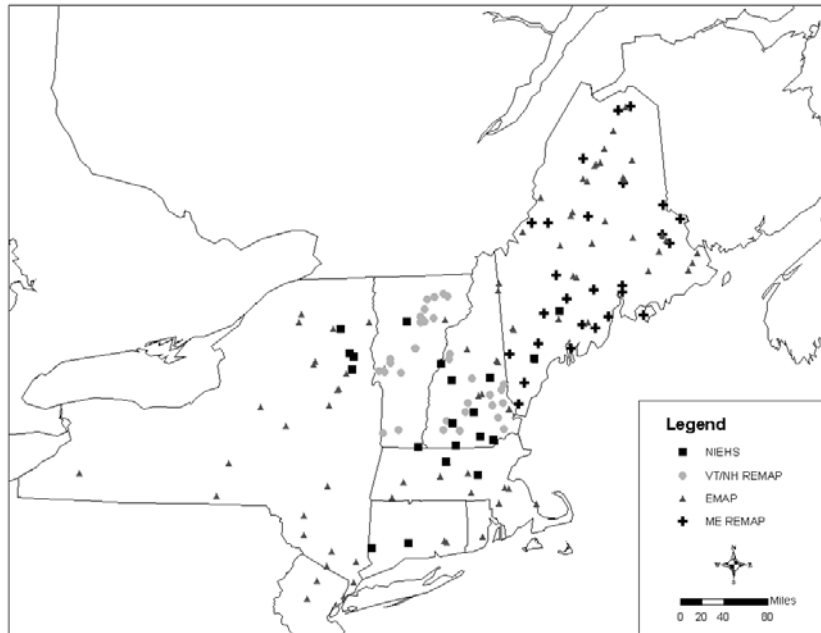
REMAP Project - History of mercury contamination in the Northeast shows recent decline in mercury deposition



Distribution patterns of mercury in lakes and rivers of northeastern North America



Patterns of mercury bioaccumulation and transfer in aquatic food webs across multi-lake studies in the northeast U.S.



- Watershed disturbance was negatively correlated with fish and zooplankton Hg concentrations
- Hg in plankton and fish declined with increases in chlorophyll and zooplankton abundance
- Lake types associated with the greatest amount of Hg bioaccumulation are poorly buffered, low pH, low primary productivity lakes having forested watersheds and minimal human land use

Mercury in the northern crayfish, *Orconectes virilis* in New England, USA.

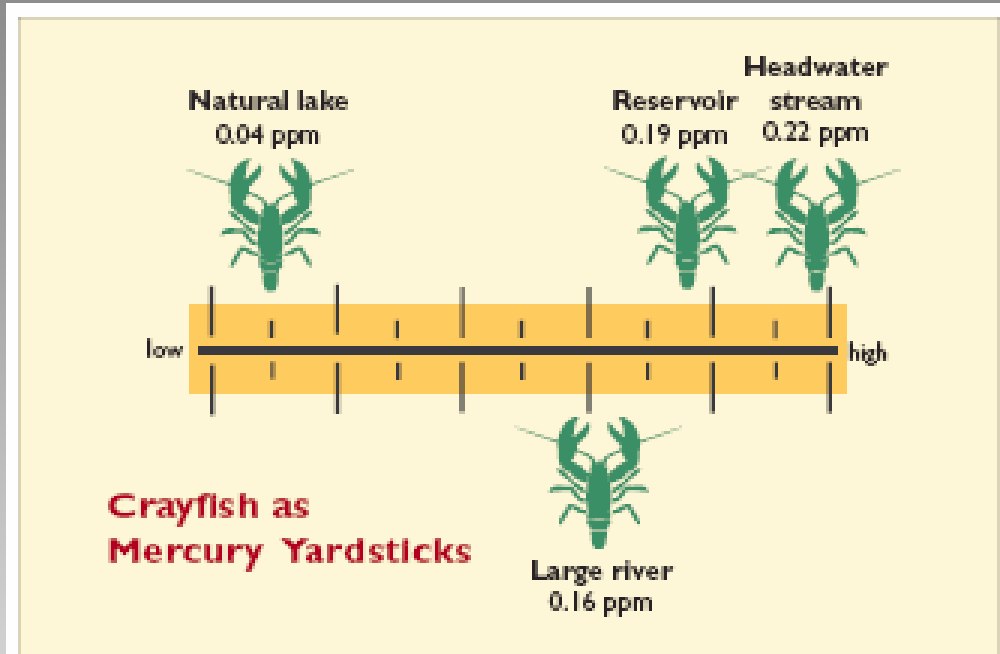
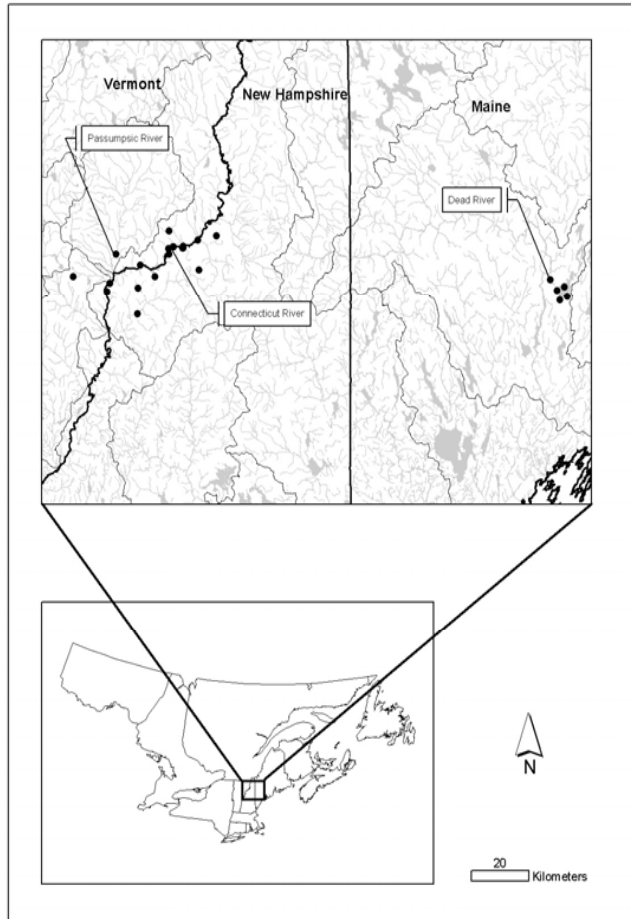


Figure 8: Crayfish depict changes in mercury concentrations in different habitats of the upper Connecticut River watershed.

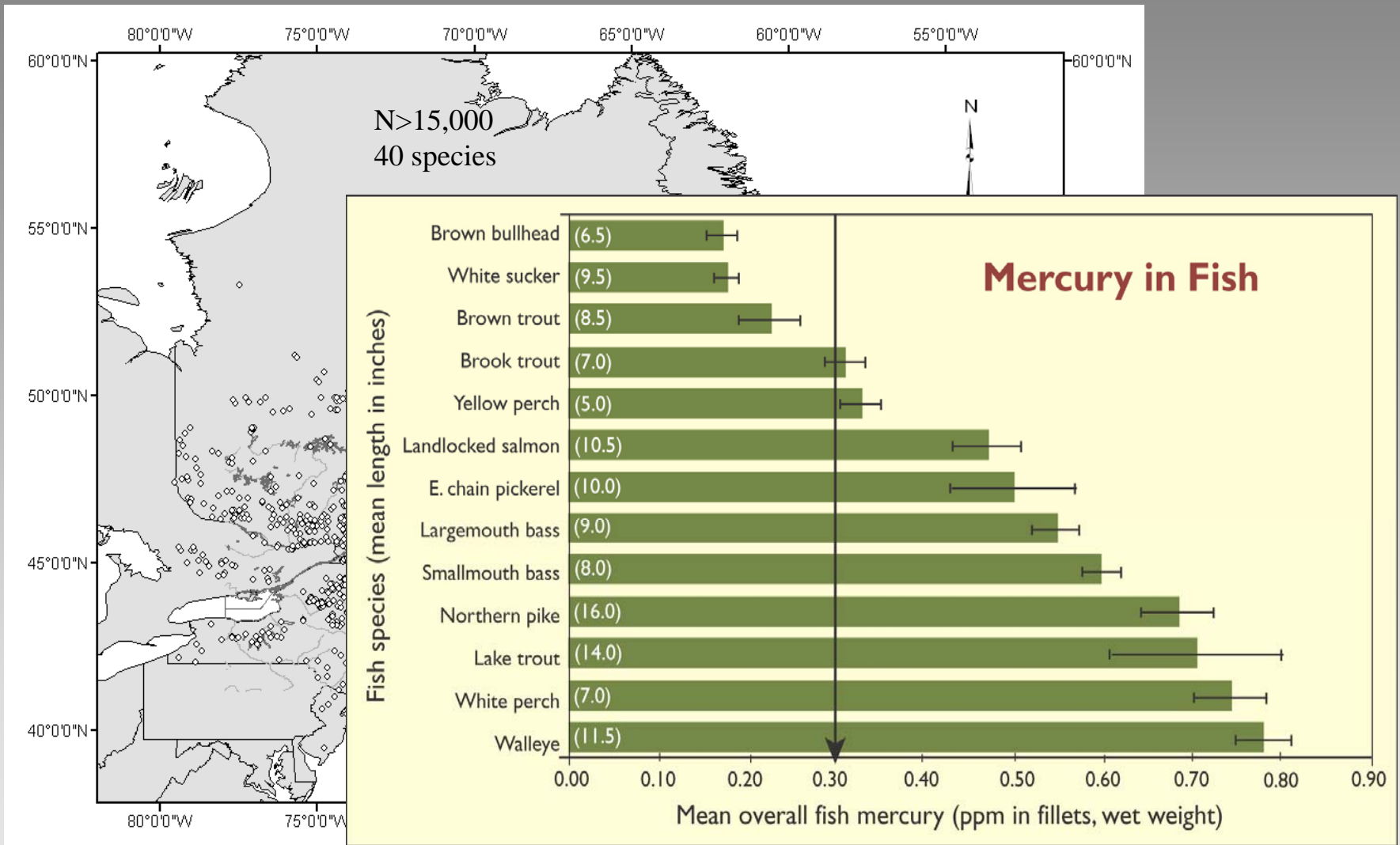
- Crayfish Hg levels were a function of individual size, habitat type, and location

Mercury bioaccumulation in two-lined salamanders from streams in the northeastern United States



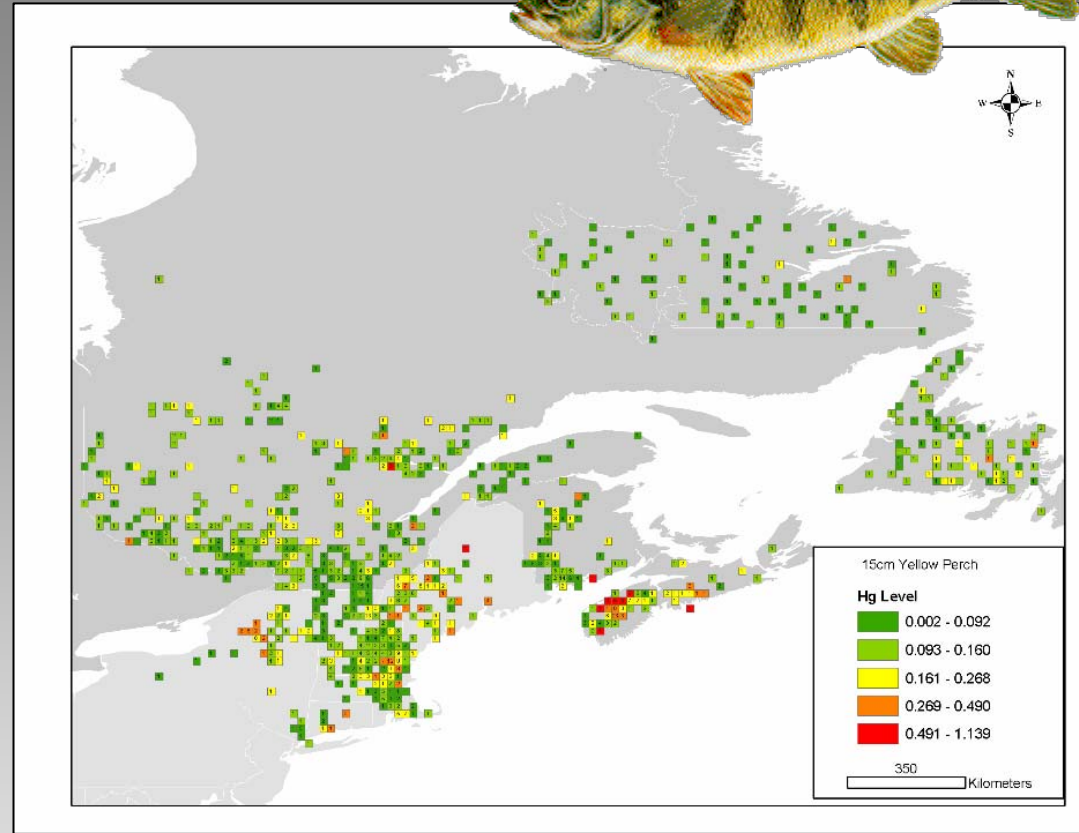
- Total Hg levels were significantly higher in salamander larvae collected at Acadia in contrast with Shenandoah N.P.
- Watershed-scale attributes including fire history, wetland extent, and forest cover type influence mercury bioaccumulation in salamanders inhabiting lotic environments.
- Disconnect in biotic Hg levels between lakes and their upper catchments

Mercury in freshwater fish of northeast North America: a geographic perspective based on fish tissue



Mercury in freshwater fish

- Four species with the highest mean Hg concentrations were muskellunge, walleye, white perch, and northern pike.
- Several species had greater Hg concentrations in reservoirs, relative to lakes and rivers.
- Waterbodies exceeding EPA criterion for fish Hg (0.3 ppm) ranged from 14% for standard-length brook trout fillets to 42% for standard-length yellow perch fillets.



Normalized deviations from mean tissue levels for yellow perch and brook trout were mapped

Patterns and interpretation of mercury exposure in freshwater avian communities in northeastern North America

Habitat

Trophic level

Age

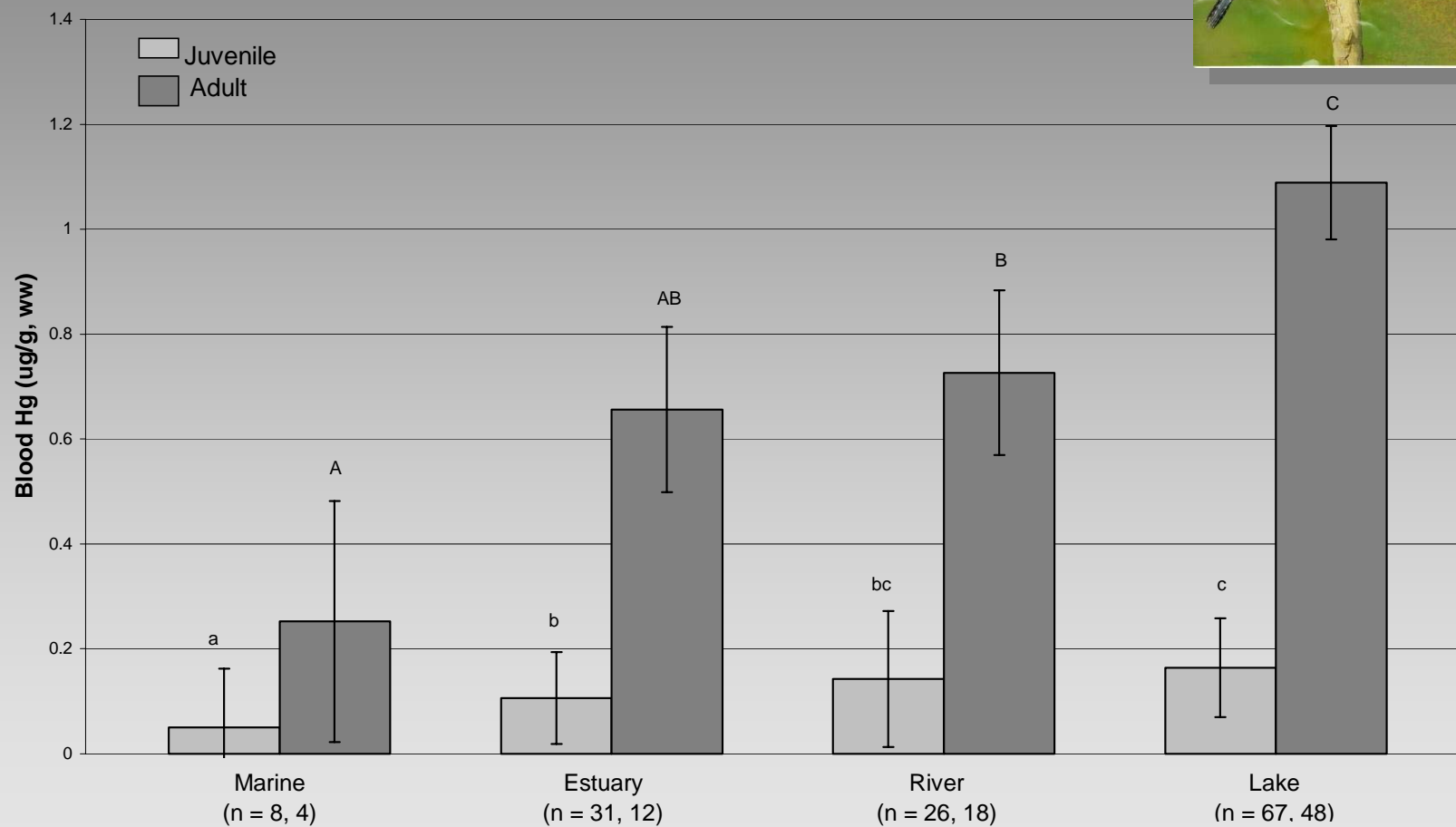
Gender

Body mass

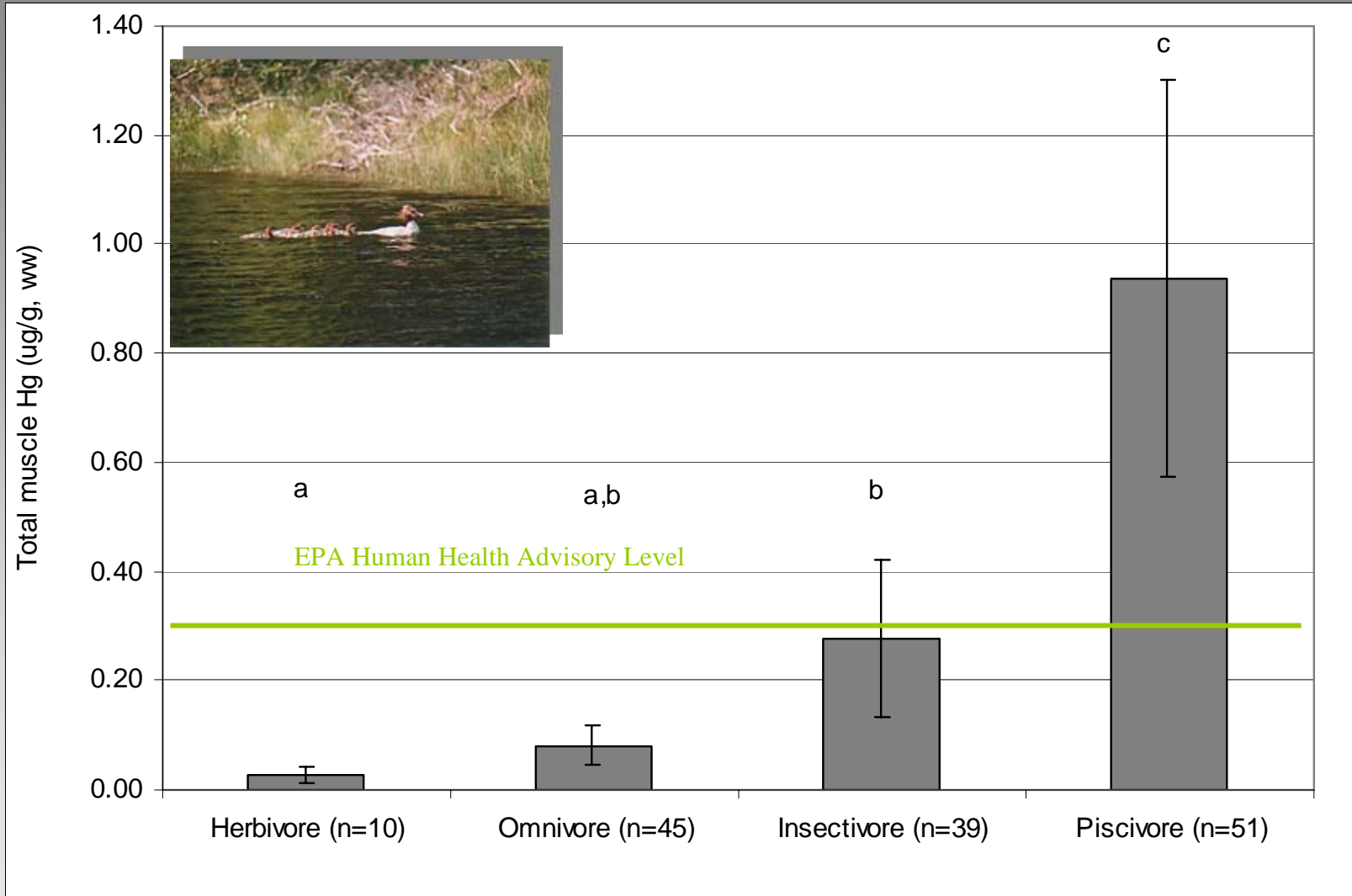
Geography



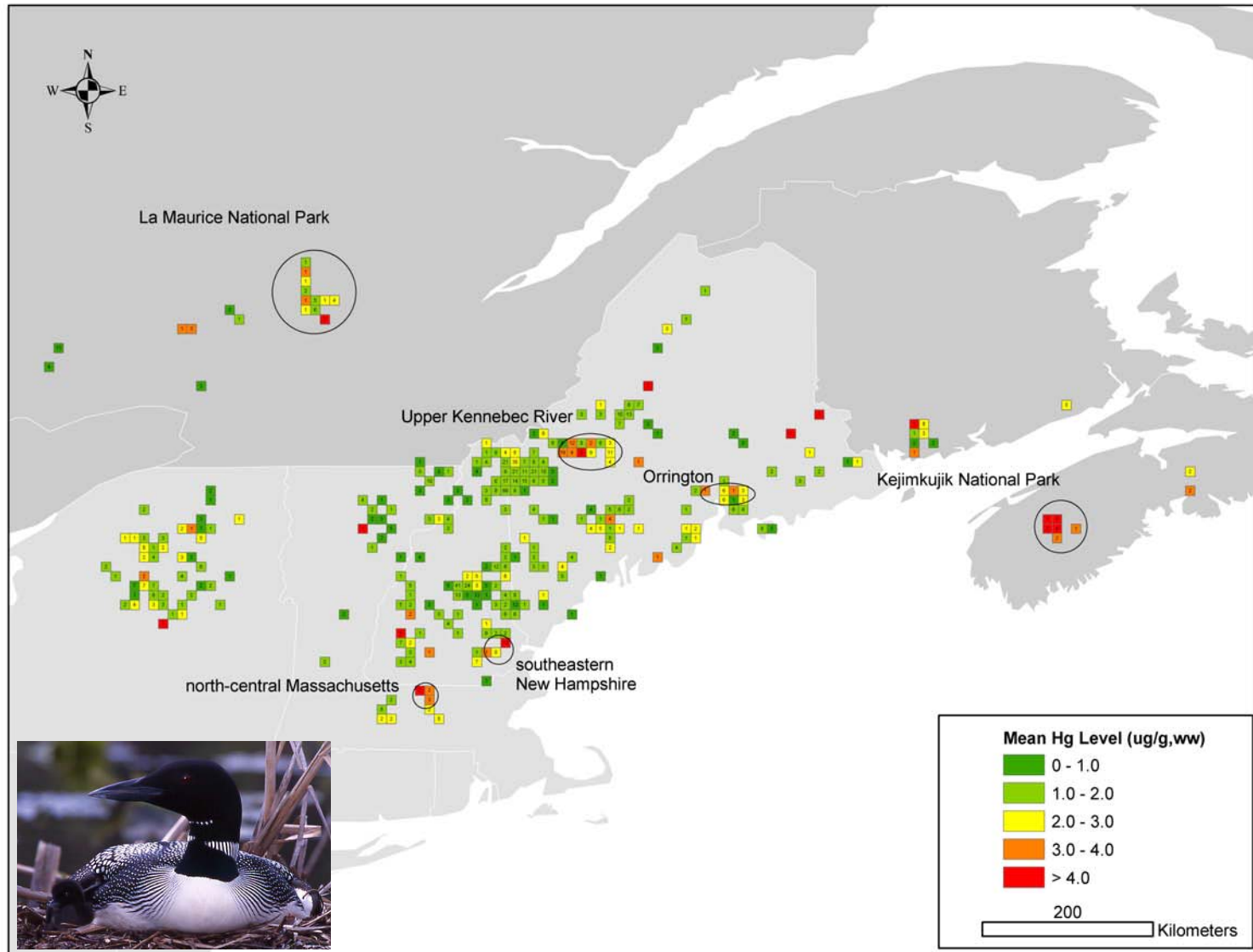
Major aquatic habitat



Trophic level influence: duck muscle



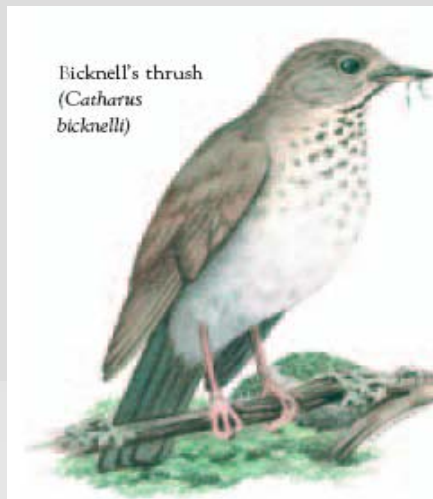
Geographical influence



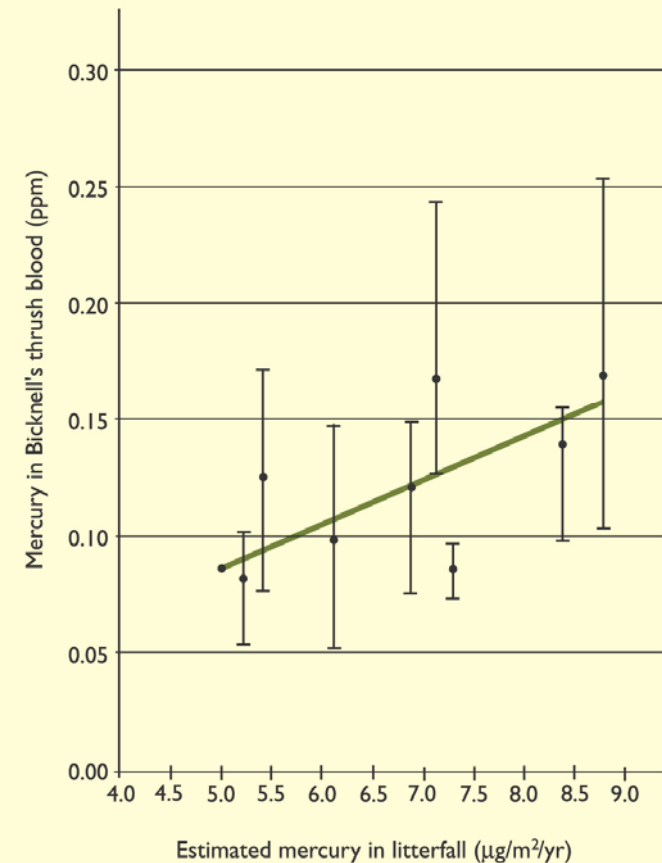
Mercury levels in Bicknell's Thrush and other insectivorous passerine birds in montane forests of the northeastern United States and Canada

Very important ramifications:

1. Terrestrial systems on mountaintops contain available methylmercury for insect-eating birds
2. Important indicator species for high elevation landscapes
3. One of the few demonstrated relationships between atmospheric Hg deposition and biotic Hg levels

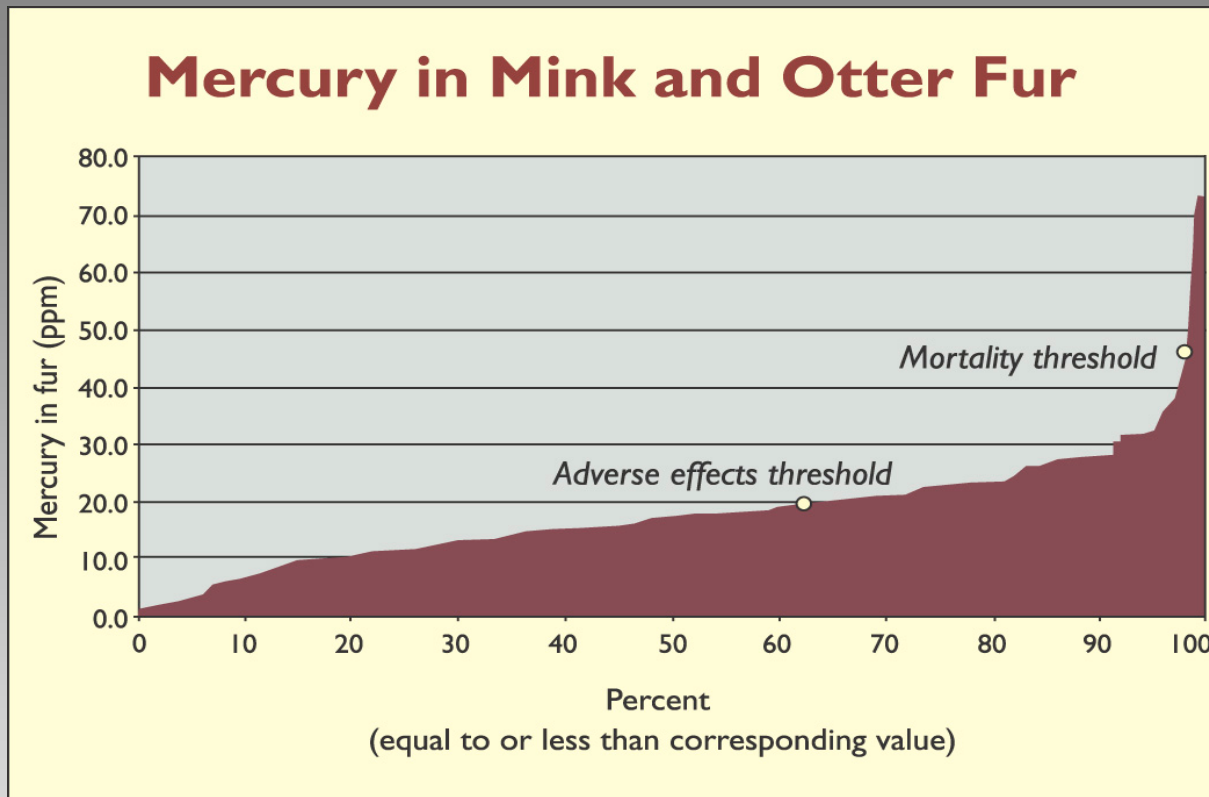


Mercury in Bicknell's Thrush and Litterfall



Rimmer et al. 2005. *Ecotoxicology*.

Mercury levels in mink and river otter in northeastern North America



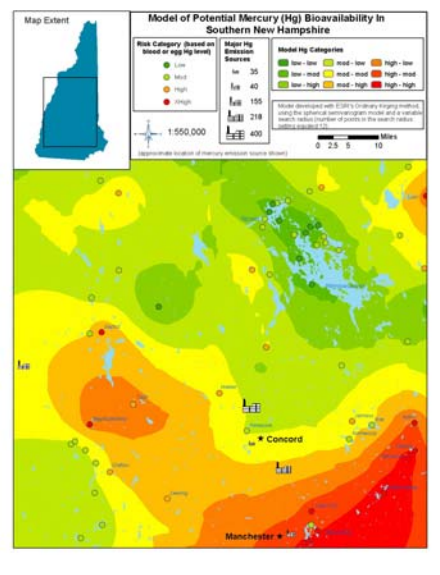
Mink and otter data show that 36% of the animals sampled exceed the threshold for adverse effects and 1% exceed the threshold for acute toxicity leading to death.

Post-project happenings

- Research
 - Emerging issue of concern for organisms feeding in terrestrial habitats and on the insect-foodweb
 - Further identification of hotspots with emphasis on connecting with major Hg emission sources
- Publications
 - Paper in Bioscience on biological Hg hotspots
- Policy
 - Presentations at state legislative levels for state-sponsored Hg bills
 - Joint effort with a national Hg monitoring plan

New Hampshire “biological hotspot”

1. Detected by USEPA atmospheric deposition models;
2. Likely related to high Hg emissions from local municipal and hospital waste incinerators and coal-burning plants;
3. Loon tissue Hg (n=266; 47 lakes);
4. Recent assessments show a decline in the biotic Hg signal.



Biological Hotspots in Northeastern North America

A preliminary map of biological hotspots in aquatic systems shows nine areas of concern where mercury levels in biota exceed levels at which adverse impacts occur.



Legislative Bill for national Hg monitoring

To provide for the establishment of a national mercury monitoring program.

IN THE HOUSE OF REPRESENTATIVES

Mr. ALLEN introduced the following bill; which was referred to the Committee
on _____

A BILL

To provide for the establishment of a national mercury
monitoring program.

*Be it enacted by the Senate and House of Representatives of the United
States of America in Congress assembled*

SECTION 1. SHORT TITLE

This Act may be cited as the “Comprehensive National Mercury Monitoring
Program Establishment Act”

Acknowledgements

- Tom Clair, Environment Canada
- 71 scientists that co-authored papers
- Northeastern Ecosystem Research Cooperative
- Jessie Cox Foundation
- Foundation for a Sustainable Future

For more information

- Mercury connections report – www.briloon.org/mercury
- Ecotoxicology special issue –
<http://springerlink.metapress.com>