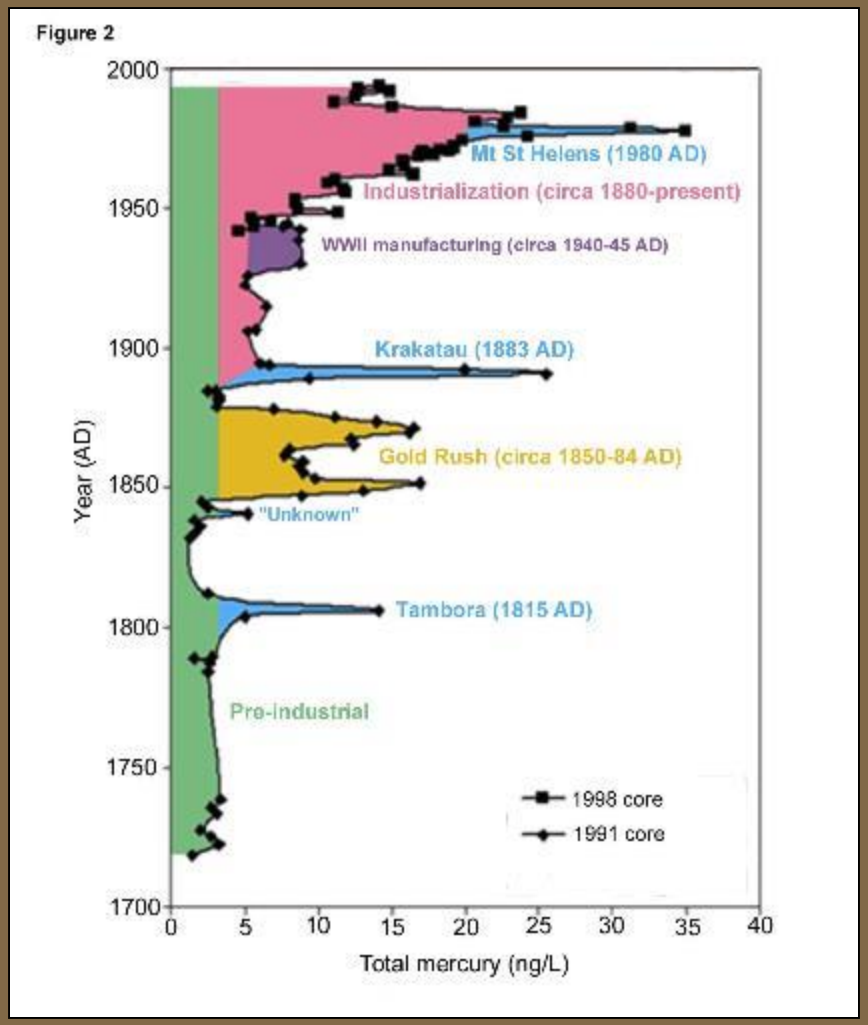
Mercury in Vermont
Problems, Processes, and Prospects



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Montpelier, VT

Acknowledgements
Tim Scherbatskoy
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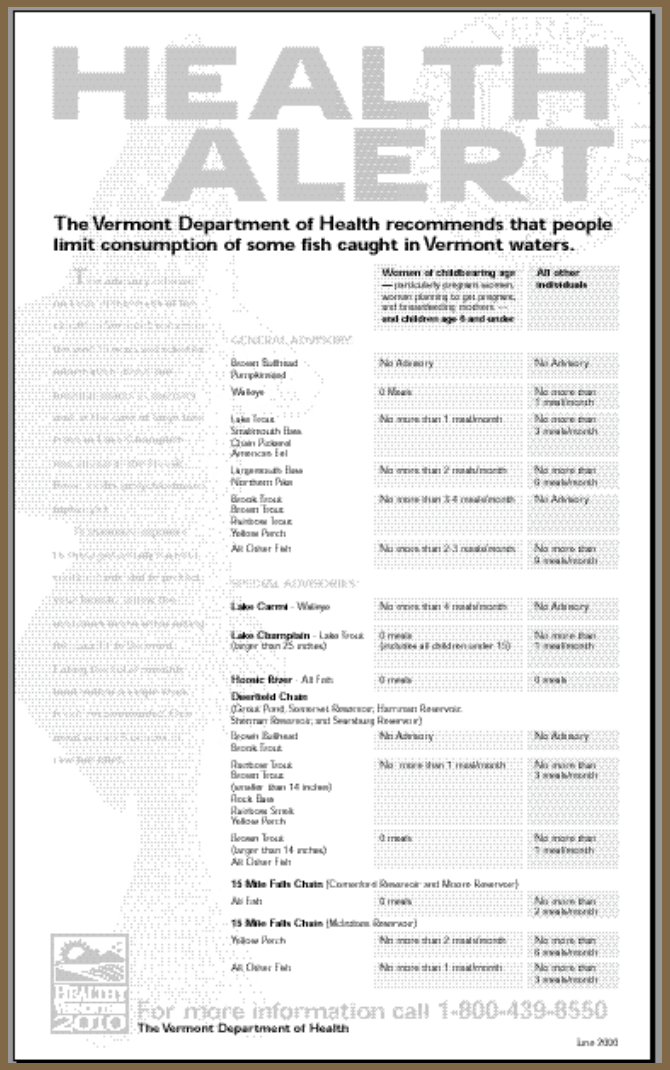
Neil Kamman
Don Ross

The mercury problem



HEALTH ALERT

The Vermont Department of Health recommends that people limit consumption of some fish caught in Vermont waters.

	Women of childbearing age — particularly pregnant women, women planning to get pregnant, and breastfeeding mothers — and children age 6 and under	All other individuals
GENERAL ADVISORY		
Brown Bullhead Pumpkinseed	No Advisory	No Advisory
Walleye	0 Meals	No more than 1 meal/month
Lake Trout Smallmouth Bass Chain Pickerel American Eel	No more than 1 meal/month	No more than 3 meals/month
Largemouth Bass Northern Pike	No more than 2 meals/month	No more than 6 meals/month
Brook Trout Brown Trout Rainbow Trout Yellow Perch	No more than 3-4 meals/month	No Advisory
All Other Fish	No more than 2-3 meals/month	No more than 6 meals/month
SPECIFIC ADVISORIES		
Lake Carmi - Walleye	No more than 4 meals/month	No Advisory
Lake Champlain - Lake Trout (longer than 25 inches)	0 meals (includes all children under 15)	No more than 1 meal/month
Hazen Brook - All Fish	0 meals	0 meals
Deerfield Chain (Zetrouf Pond, Somerset Reservoir, Harriman Reservoir, Sherman Reservoir, and Searsburg Reservoir)		
Brown Bullhead Brook Trout	No Advisory	No Advisory
Rainbow Trout Brown Trout (smaller than 14 inches) Rock Bass Rainbow Smelt Yellow Perch	No more than 1 meal/month	No more than 3 meals/month
Brown Trout (larger than 14 inches) All Other Fish	0 meals	No more than 1 meal/month
15 Mile Falls Chain (Comerford Reservoir and Moore Reservoir)		
All Fish	0 meals	No more than 2 meals/month
15 Mile Falls Chain (Millers Run Reservoir)		
Yellow Perch	No more than 2 meals/month	No more than 6 meals/month
All Other Fish	No more than 1 meal/month	No more than 3 meals/month

For more information call 1-800-439-8550

The Vermont Department of Health

June 2008

Fish consumption
No walleye for children

The mercury problem

Artisanal gold mining

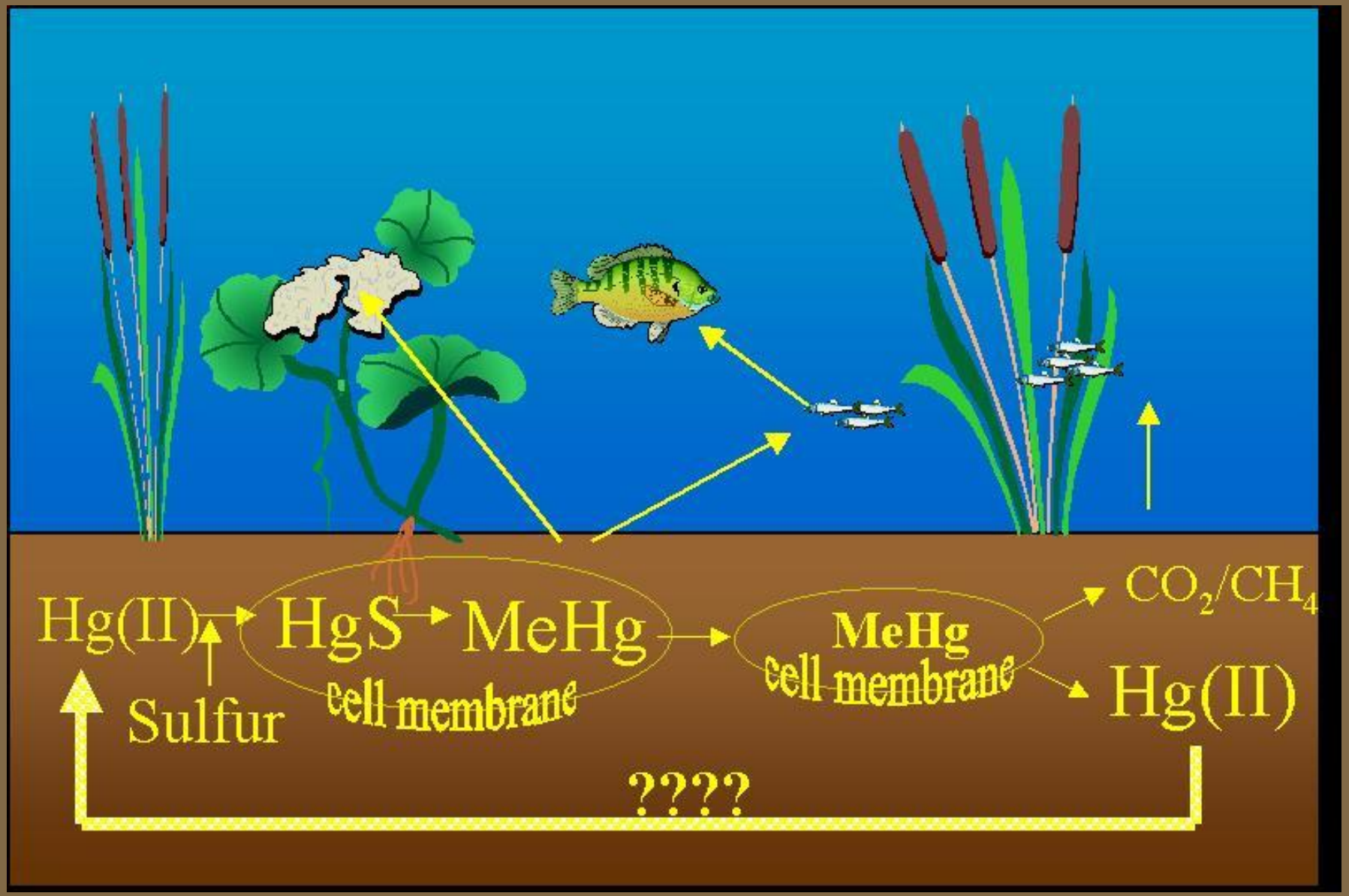
Inhalation of elemental Hg

The mercury problem

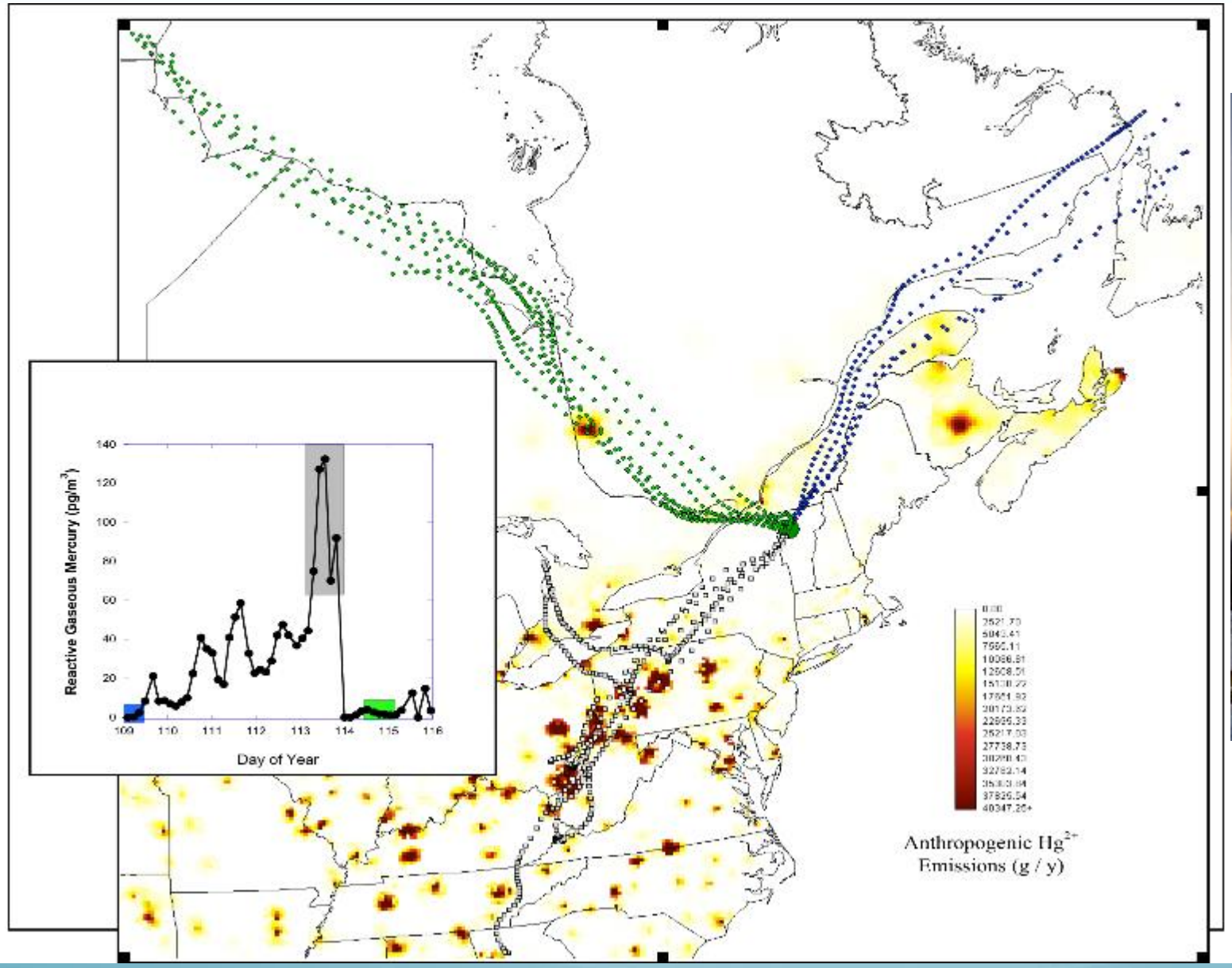
Wildlife

Vermont Center for Ecostudies

Mercury Methylation

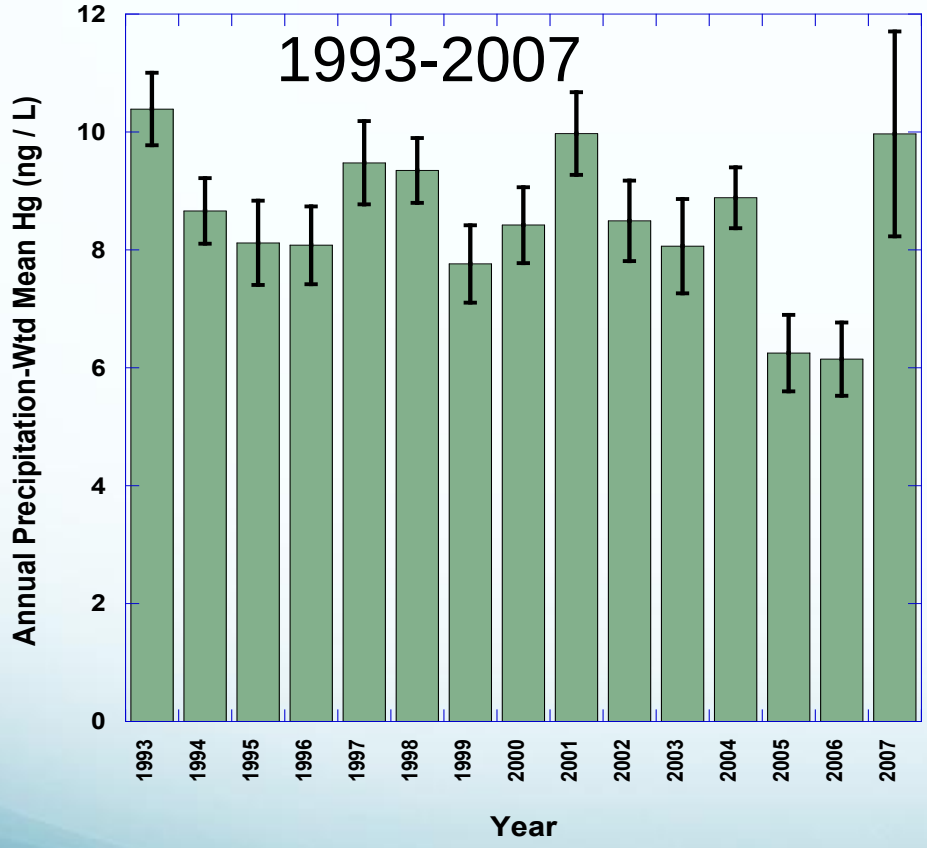


Atmospheric mercury sources

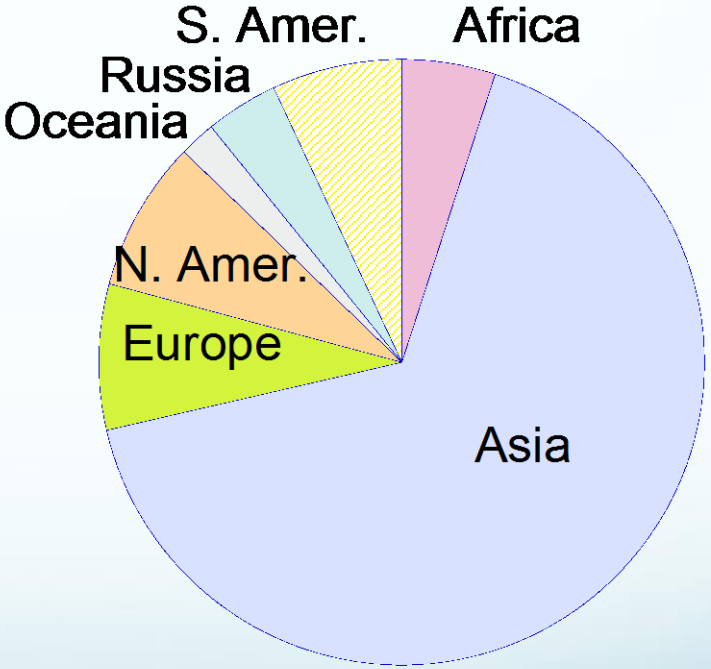


Emissions data:
Mark Cohen, NOAA

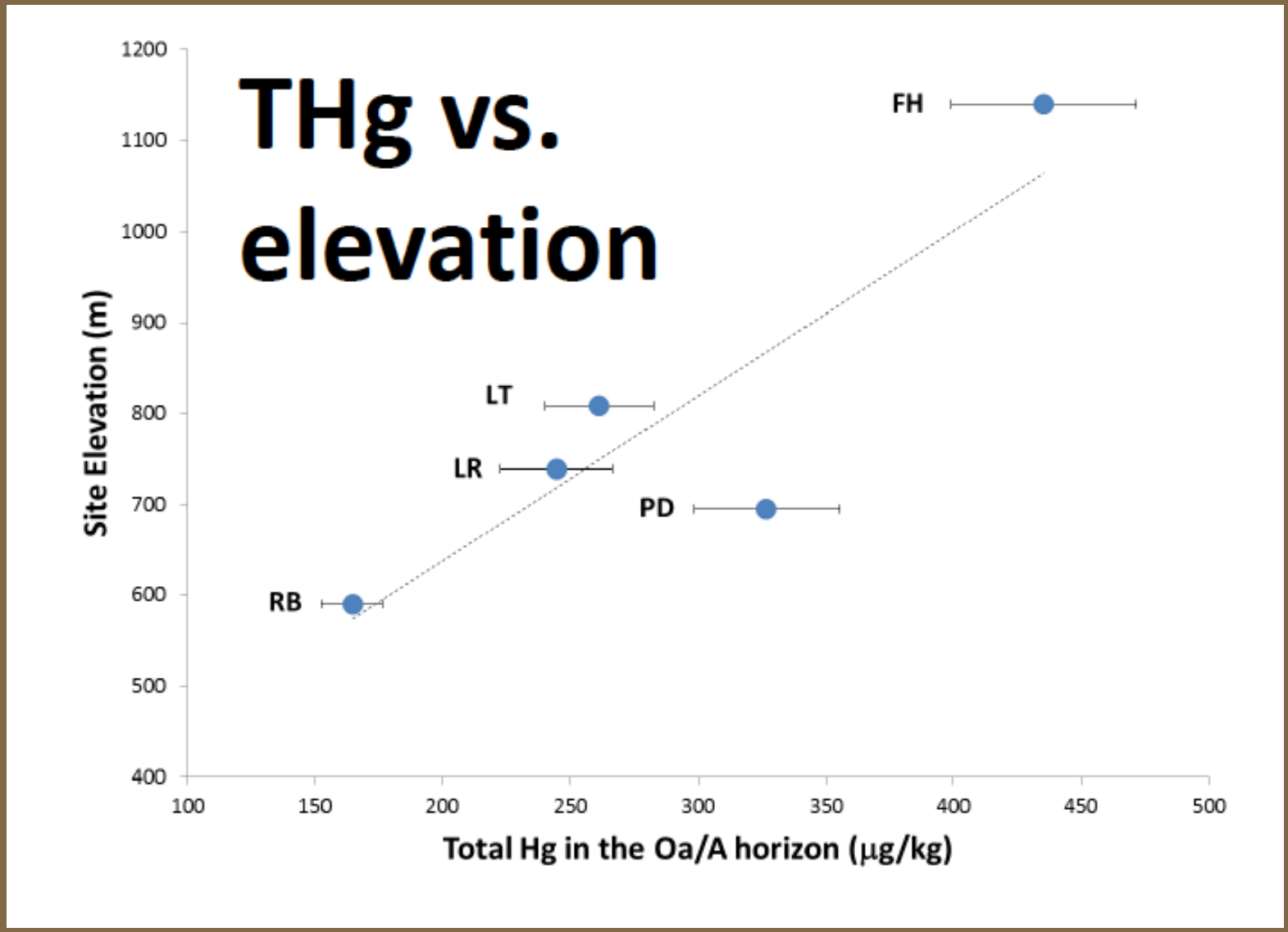
Hg Deposition at Underhill (VT99)



Global Hg emissions



VMC 200-yr soil study



Don's poster

Long-Term Monitoring of Forest Soil Mercury by the Vermont Monitoring Cooperative

Donald Ross[1], James Shanley [2], Scott Bailey [3], Thomas Villars[4], Sandy Wilmot[5], Nancy Burt[3] and Neil Kamman[6]

[1] Univ. Vermont, [2] US Geological Survey, [3] USDA Forest Service, [4] USDA Natural Resources Conservation Service, [5] VT Dept. of Forests, Parks and Recreation; [6] VT Dept. Environmental Conservation

Introduction

- Ongoing monitoring of total mercury (THg) concentration in soils is essential for detecting, predicting and addressing environmental change.
- We have established a long-term soil monitoring study on forested sites in the northeastern USA where annual wet deposition of Hg has been in the range of 10 ∝g/m^2.
- Five 50 x 50 m plots were located in protected areas, three on Mt. Mansfield and two in the Lye Brook Wilderness Area.
- In addition to Hg, we have been monitoring carbon, nitrogen, pH and exchangeable cations.

Methods

- Each plot contains 100 5 x 5 m subplots with sampling dates assigned randomly (10 subplots sampled on each date). See plot plan below.
- Small pits were dug in the center of each subplot and the soils were described and sampled by horizon.
- Separate samples for THg were taken from a fresh pit face as pictured below. The uppermost sampleable humified soil horizon was taken, either an Oa (H) or A horizon.

Results

- Plots were sampled in 2002, 2007 and 2012 (analysis still in progress for the latter).
- Mean Oa or A horizon THg concentration at each site ranged from 162 to 444 ∝g/kg (Fig. 1) with no consistent trend between years.
- There was a trend towards greater THg concentration at higher elevation, consistent with greater deposition (Fig. 2)
- Carbon concentration in the Oa/A horizon also had a wide range among sites (Fig. 3) and there was an increasing trend in THg with greater C concentration.

Jamie Shanley and Stew Clark of the USGS sampling for THg

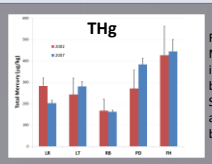
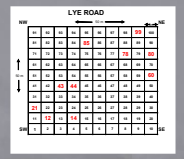


Figure 1. Mean total Hg conc. in the Oa/A horizon by plot and year). See Table 1 for site abbreviations. Error bars are SE (n = 10).

Abbrev	Name	Elevation (m)	Soil Classification (US system)	Dominant Trees
LR	Lye Road (Kelley Stand)	739	coarse-loamy, mixed, frigid, Aquic Haplorthods	*Fagus grandifolia, Acer saccharum, Betula alleghaniensis*
LT	Lye Trail (Branch Pond)	800	coarse-loamy, mixed, frigid, Aquic Haplorthods	*Acer rubrum, Betula papyrifera*
RB	Ranch Brook (Mansfield)	590	coarse-loamy, mixed, frigid, Aquic Dystrudepts	*Acer saccharum, Fagus grandifolia*
PD	Polka Dot (Mansfield)	695	coarse-loamy, mixed, frigid, Aquic Haplorthod	*Betula alleghaniensis, Abies balsamea*
FH	The Forehead (Mansfield)	1140	coarse-loamy Lithic Cryorthent	*Abies balsamea, Picea rubens*

Table 1. Site characteristics



Typical plot plan (subplots in red were sampled in 2002)

Podzol soil horizon sequence from the Lye Road site. THg was measured in the Oa horizon.

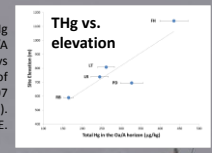
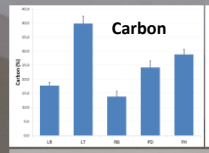


Figure 2. Total Hg conc. in the Oa/A horizon by plot vs elevation. Mean of 2002 and 2007 results (n = 20). Error bars are SE.



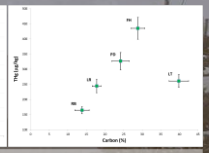


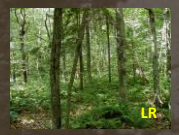
Figure 3. Mean carbon at each plot. Figure 4. THg vs C at each plot. Both figures show the means of 2002 and 2007 results (n = 20).

Discussion

- The differences among the sites are likely due to an interaction between elevation (increased THg deposition) and soil carbon concentration (increased THg retention).
- Recent work at 15 lower elevation sites (mean 424 m) in Vermont found 283 and 131 ∝g/kg THg in Oa and A horizons respectively (Juillerat *et al.* 2012 DOI: 10.1002/etc.1896). THg pools in the forest floor were strongly related to carbon pools.
- Monitoring will continue on a regular basis to provide a time-series of data capable of detecting change.

Lye Brook Sites

Lye Road



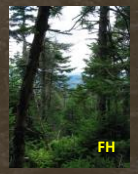
Lye Trail

Ranch Brook

Mt. Mansfield Sites

Polka Dot

Forehead



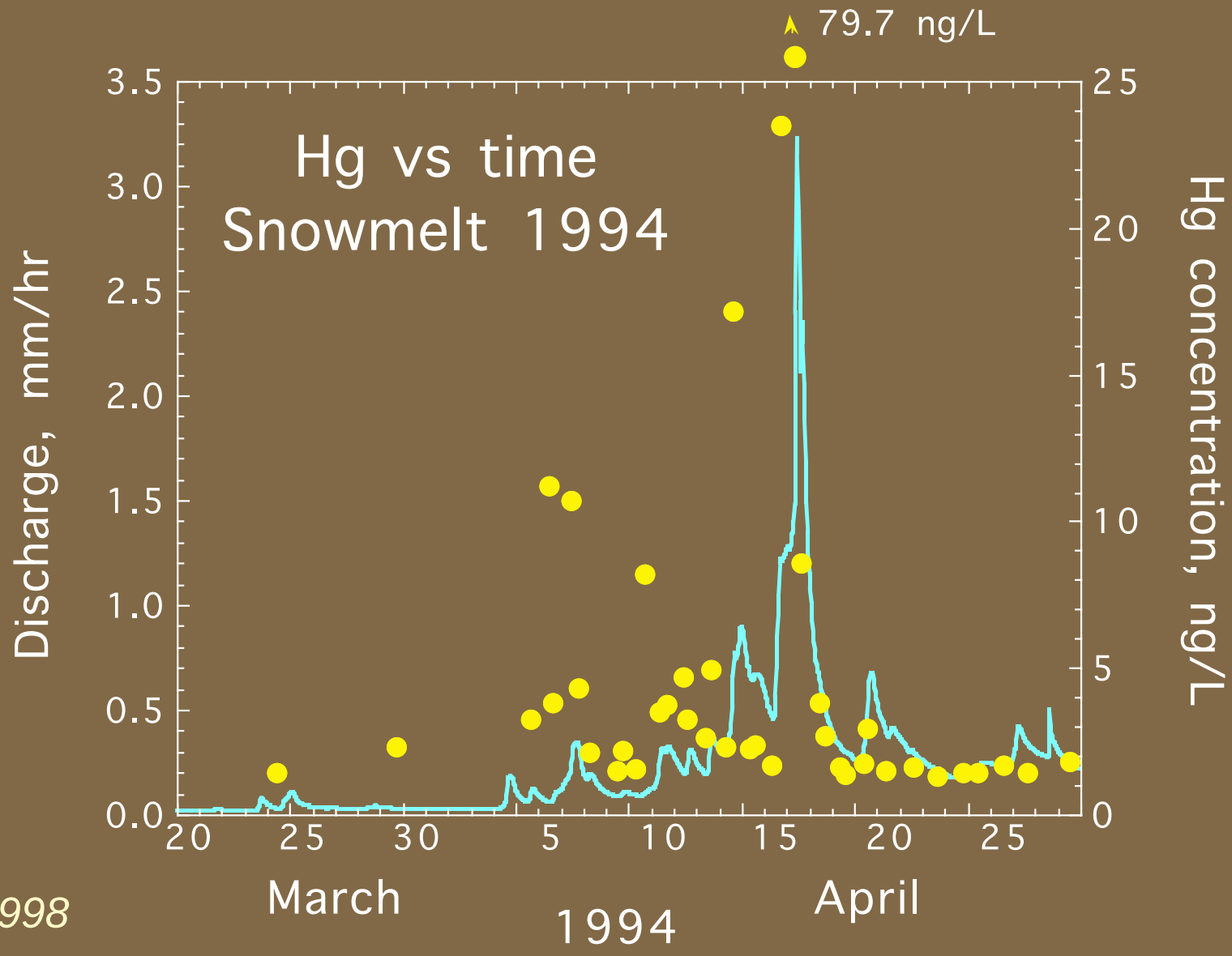
Views of the forest and representative soil profiles at each plot. The two profiles from PD show different degrees of podzol expression. The FH soils were at high elevation (for Vermont) and usually shallow to bedrock. Samples for THg were taken from the dark near-surface horizon (just above the grey E horizon).

Each area has a **Soil Climate Analysis Network** (SCAN) site (located at LT and PD). The SCAN objectives are to collect long-term data on weather, soil moisture and soil temperature to complement measurements of physical, chemical, and biological parameters at the long-term soil monitoring sites that have been established nearby. For more information, see: http://www.wcc.nrcs.usda.gov/scan/

Acknowledgements. Partners include all of the authors' organizations (see above). Financial and logistical support has been provided by the Vermont Monitoring Cooperative (Carl Waite) and the Green Mountain and Finger Lakes National Forest (Nancy Burt). Many thanks to the Vermont Youth Conservation Corp (above on left) for help in the field. Also thanks to numerous students for both field and lab work. Mercury analysis was generously provided by the VT DEC.

The **Vermont Monitoring Cooperative** (VMC) was established in 1990 to track changes occurring in Vermont's forests. Only limited information about the health and baseline conditions of forested ecosystems was available at that time. Vermont lacked the ability to perceive subtle changes in ecosystem condition over time and thus to be able to identify forces affecting forest ecosystem health and productivity. VMC was envisioned and created to collect, assemble, and distribute high-quality, documented data and information to better understand environmental changes and their impacts on forested ecosystems.

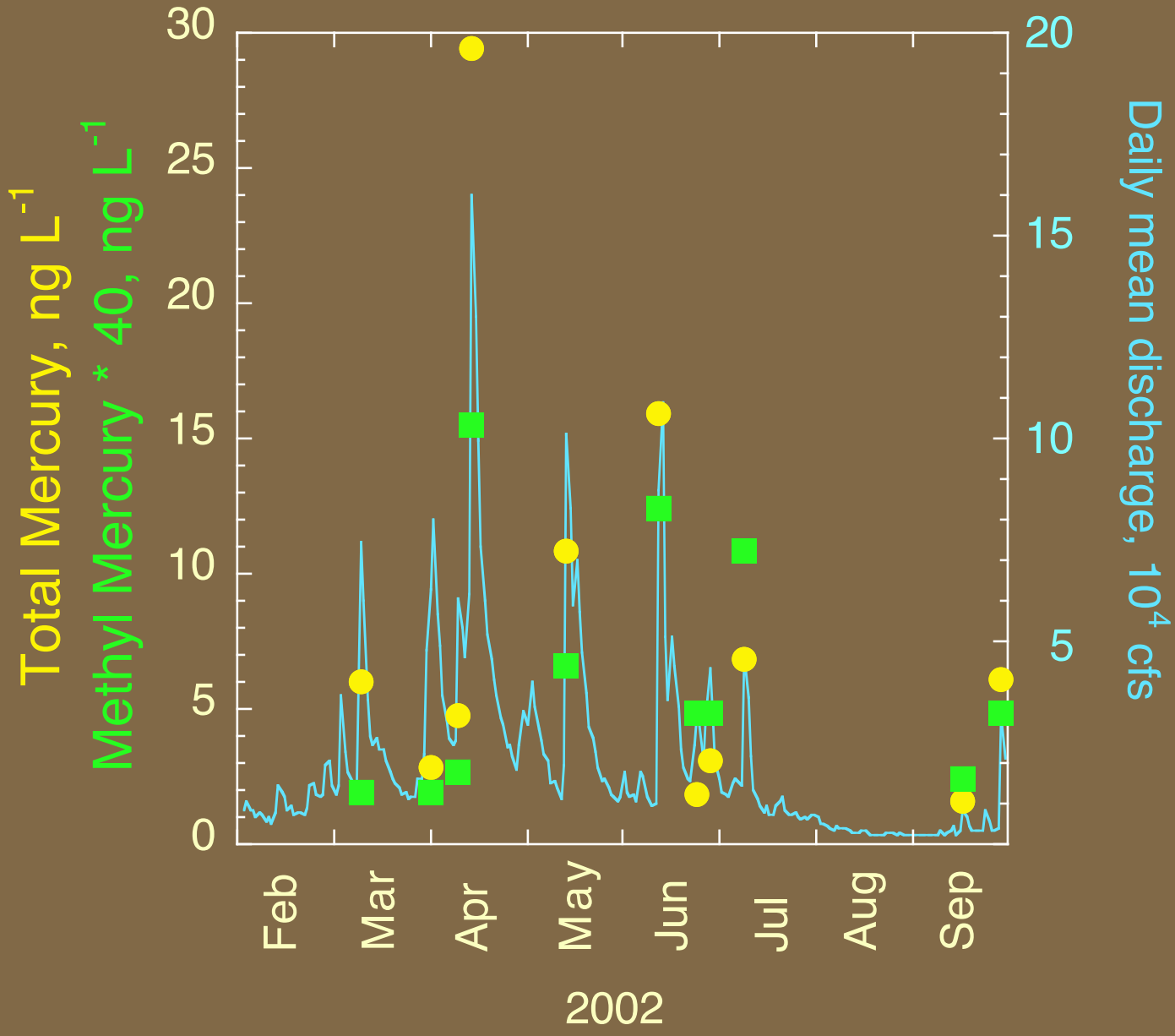
Mercury at Nettle Brook, Underhill



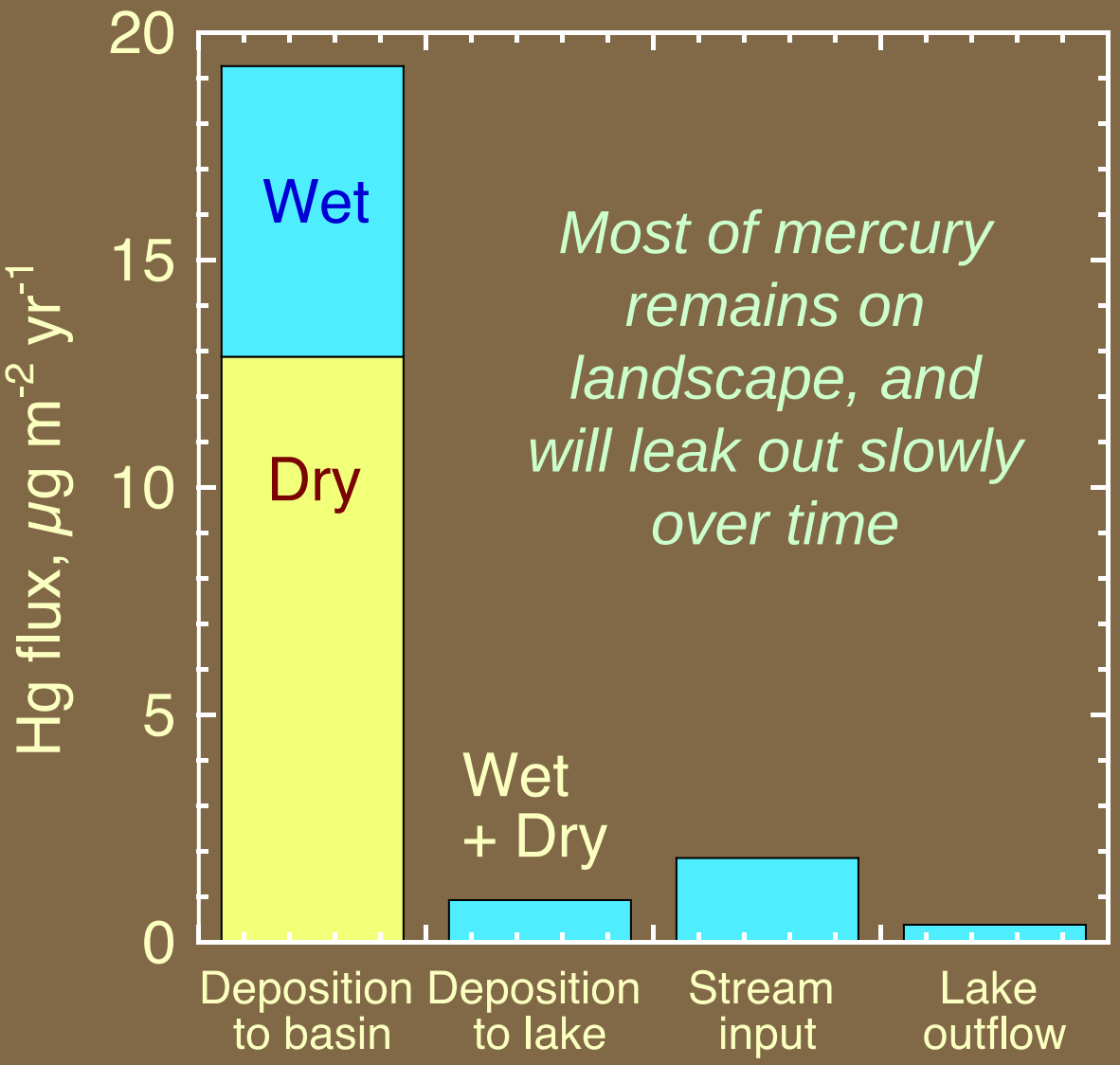
Scherbatskoy et al., 1998

Lake Champlain

Winooski River Hg in 2002



Lake Champlain mass balance

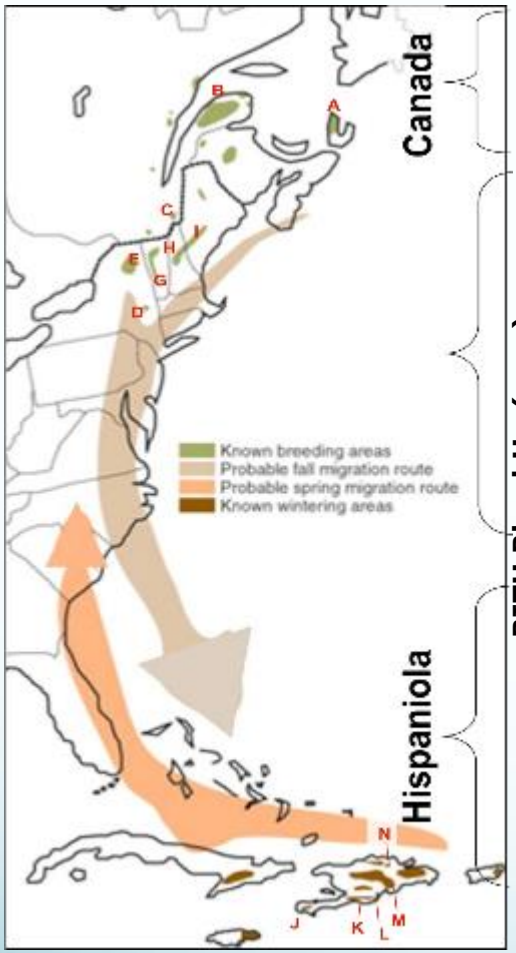


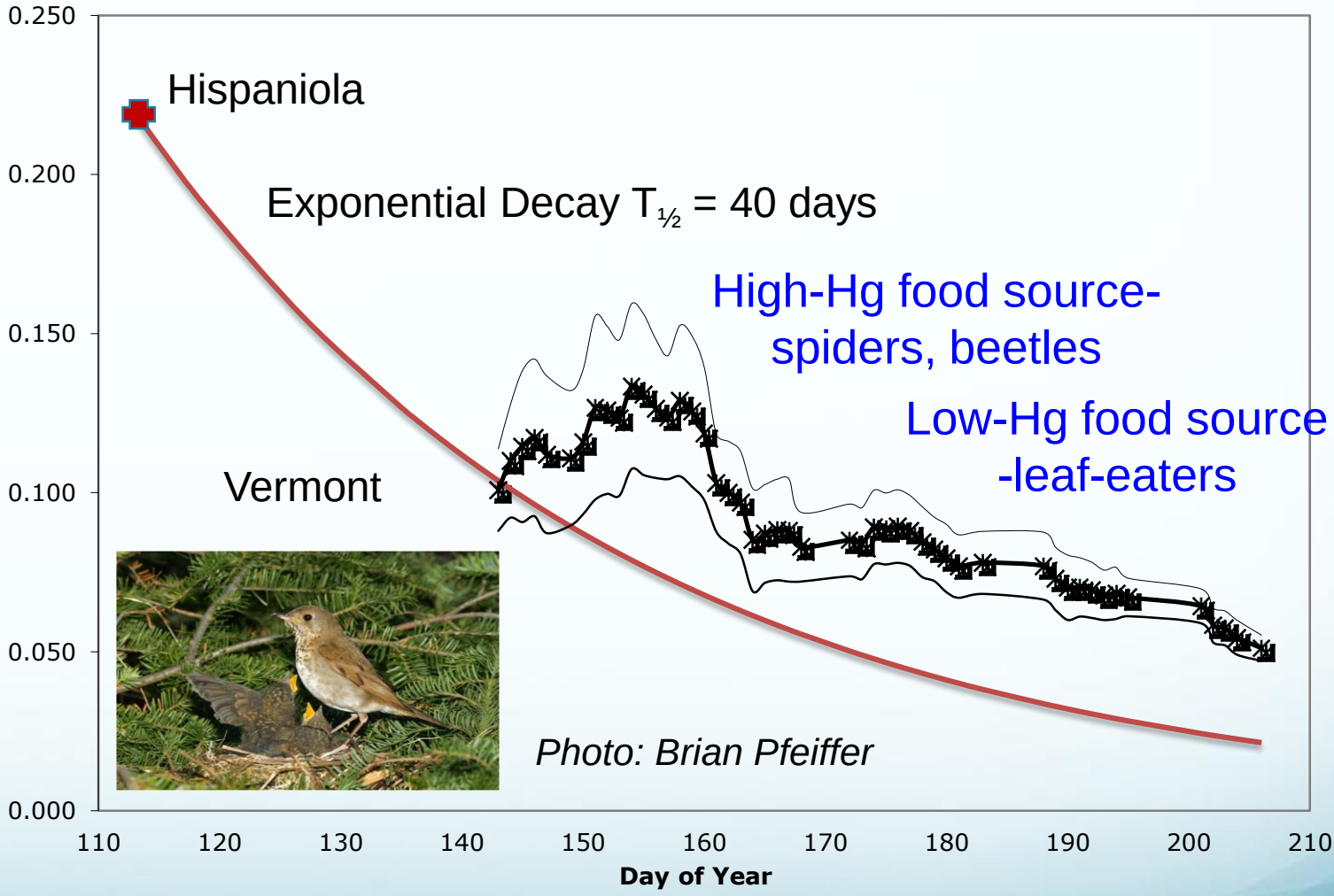
Mercury and Phosphorus

- Very different sources

- Very similar behavior
  - mobilized at high flows
  - primarily associated with particulates
  - legacy storage in soil and sediment

Mercury in Bicknell's Thrush





Rimmer et al. (2009)

Take homes

- Mercury source – some regional / midwest, but much is global
- Mercury taken up by soil and released slowly (decades)
- Small fraction of mercury is methylated (organic form)
- Methylmercury enters terrestrial and aquatic food webs
- Like phosphorus, legacy mercury will persist