Long-Term Monitoring of Forest Soil Mercury by the VMC

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Mercury emissions/deposition

- Emissions
  - elemental Hg
  - particulate Hg
  - reactive gaseous Hg
- Deposition
  - Precipitation
  - Cloud water
  - Throughfall
  - Litterfall
  - Dry deposition

Mercury accumulation in biota

Ecotoxicology, 14, 223–240, 2005

Mercury Concentrations in Bicknell's Thrush and Other Insectivorous Passerines in Montane Forests of Northeastern North America

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- Methylation of deposited Hg must occur before it is taken up by biota.
- Methylation rates in high elevation soils are unknown.

Blood Hg in 4 Catharus thrush species along an elevational gradient in the Catskills

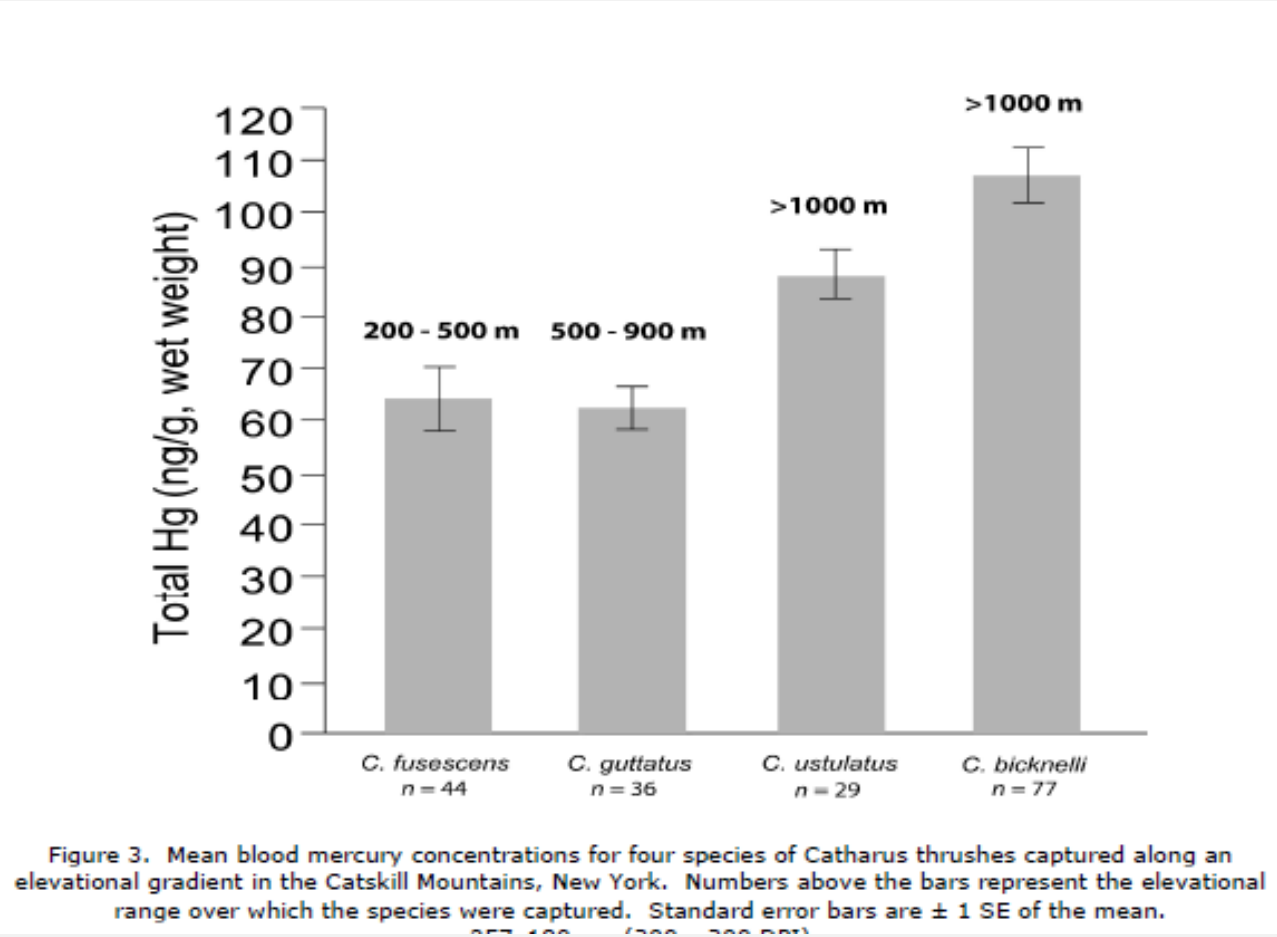


Figure 3. Mean blood mercury concentrations for four species of Catharus thrushes captured along an elevational gradient in the Catskill Mountains, New York. Numbers above the bars represent the elevational range over which the species were captured. Standard error bars are ± 1 SE of the mean.

Avian, salamander, and forest floor mercury concentrations increase with elevation in a terrestrial ecosystem Jason M. Townsend ,Charles T. Driscoll, Christopher C. Rimmer, Kent P. McFarland. ETC 2013:in press

Long term soil monitoring:

- Air pollution and climate change may be affecting forest soils.
  - Calcium depletion
  - Mercury accumulation
- There is a high degree of spatial variability in forest soil properties and detecting change is difficult.
- Having a long-term monitoring study will greatly aid efforts to detect change.

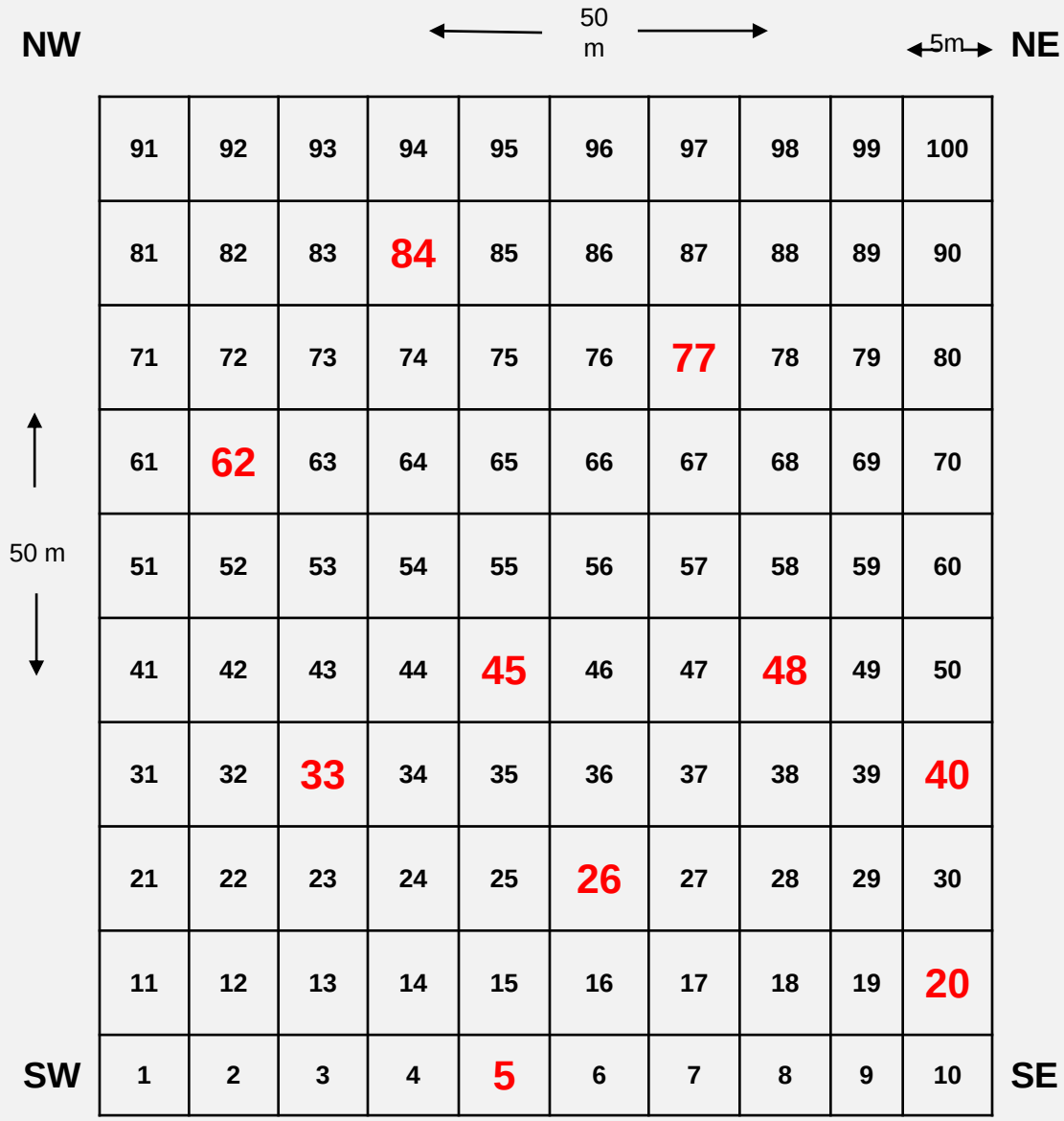
VMC 200-yr soil monitoring:

1. Five 50 x 50 m plots (100 subplots) in sites associated with the VMC.
2. Sample 10 subplots at **0, 5, 10**, …, 20, 50, 100, 150 and 200 years. **Year 0 = 2002**
3. Archive samples for later comparisons.
4. Protect the plots for future monitoring.

Sites

- Mt. Mansfield Ranch Brook
  - northern hardwood
  - 590 m (1936’)
- Mt. Mansfield Forehead
  - high elevation spruce/fir
  - 1140 m (3740’)
- Mt. Mansfield Underhill State Forest
  - Transitional (SCAN site)
  - 695 m (2280’)
- Lye Brook “Road”
  - northern hardwood (SCAN)
  - 739 m (2425’)
- Lye Brook “Trail”
  - Transitional
  - 808 m (2651’)

Mansfield Forehead



91	92	93	94	95	96	97	98	99	100
81	82	83	**84**	85	86	87	88	89	90
71	72	73	74	75	76	**77**	78	79	80
61	**62**	63	64	65	66	67	68	69	70
51	52	53	54	55	56	57	58	59	60
41	42	43	44	**45**	46	47	**48**	49	50
31	32	**33**	34	35	36	37	38	39	**40**
21	22	23	24	25	**26**	27	28	29	30
11	12	13	14	15	16	17	18	19	**20**
1	2	3	4	**5**	6	7	8	9	10

A typical plot plan.

Plots with red numbers were sampled in 2002 (Year 0).

Lye Road
2425’


Lye Road


DIG
HERE
-37
Lye Road

Lye Trail

2650’

Lye Trail


Ranch Brook 1940’

Ranch Brook
2007, plot 30


Forehead 3740’


Forehead


Die Here
36
Forehead

Underhill State Park or ‘Polka-Dot’, 2280’

Polka-dot
PD

Polka-dot PD

Stu Clark, USGS, sampling for mercury, Forehead 2002

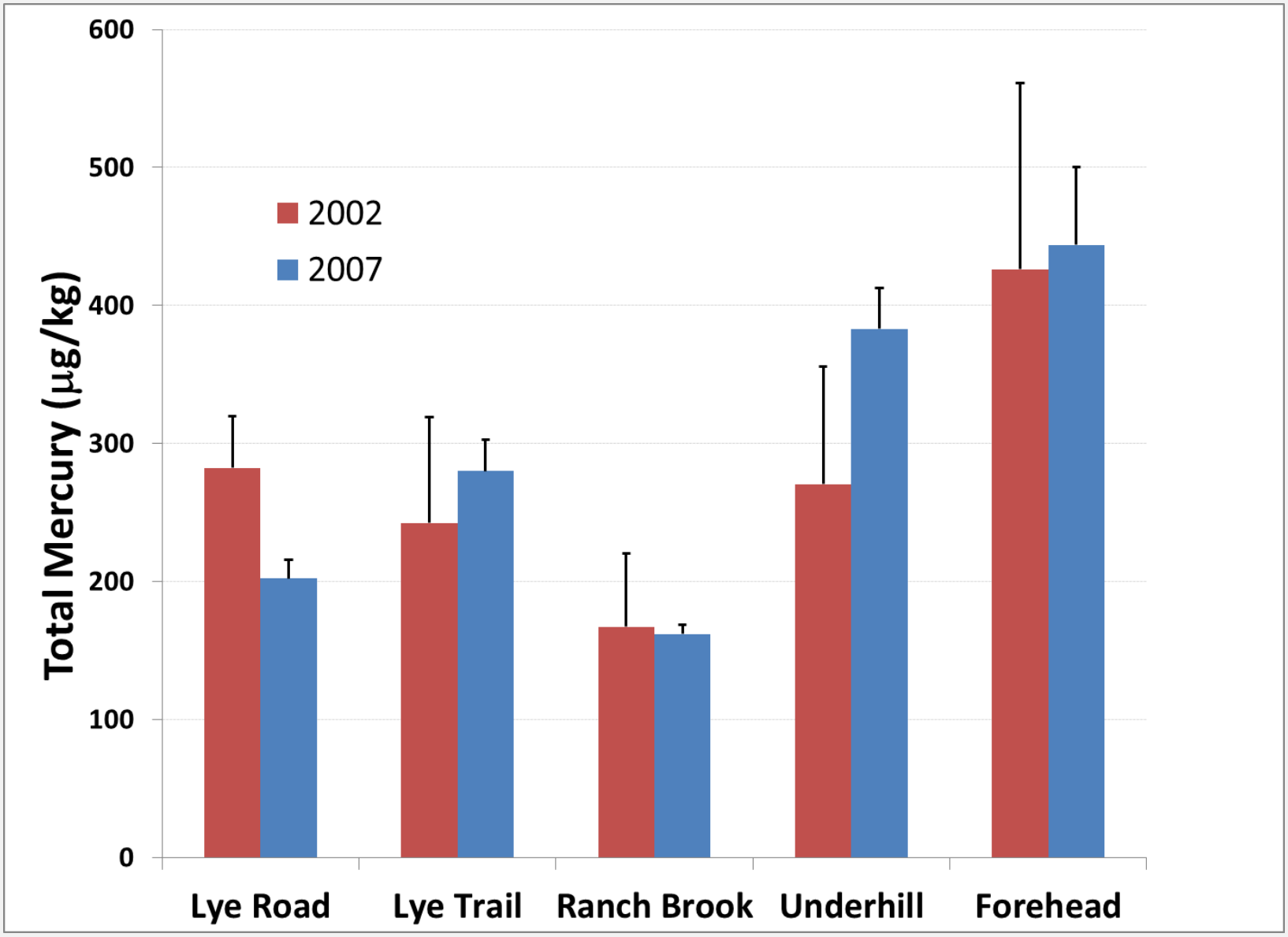
Stu sampling at Ranch Brook with Juliette Juillerat in 2007

Jamie Shanley sampling for mercury at Ranch Brook in 2007

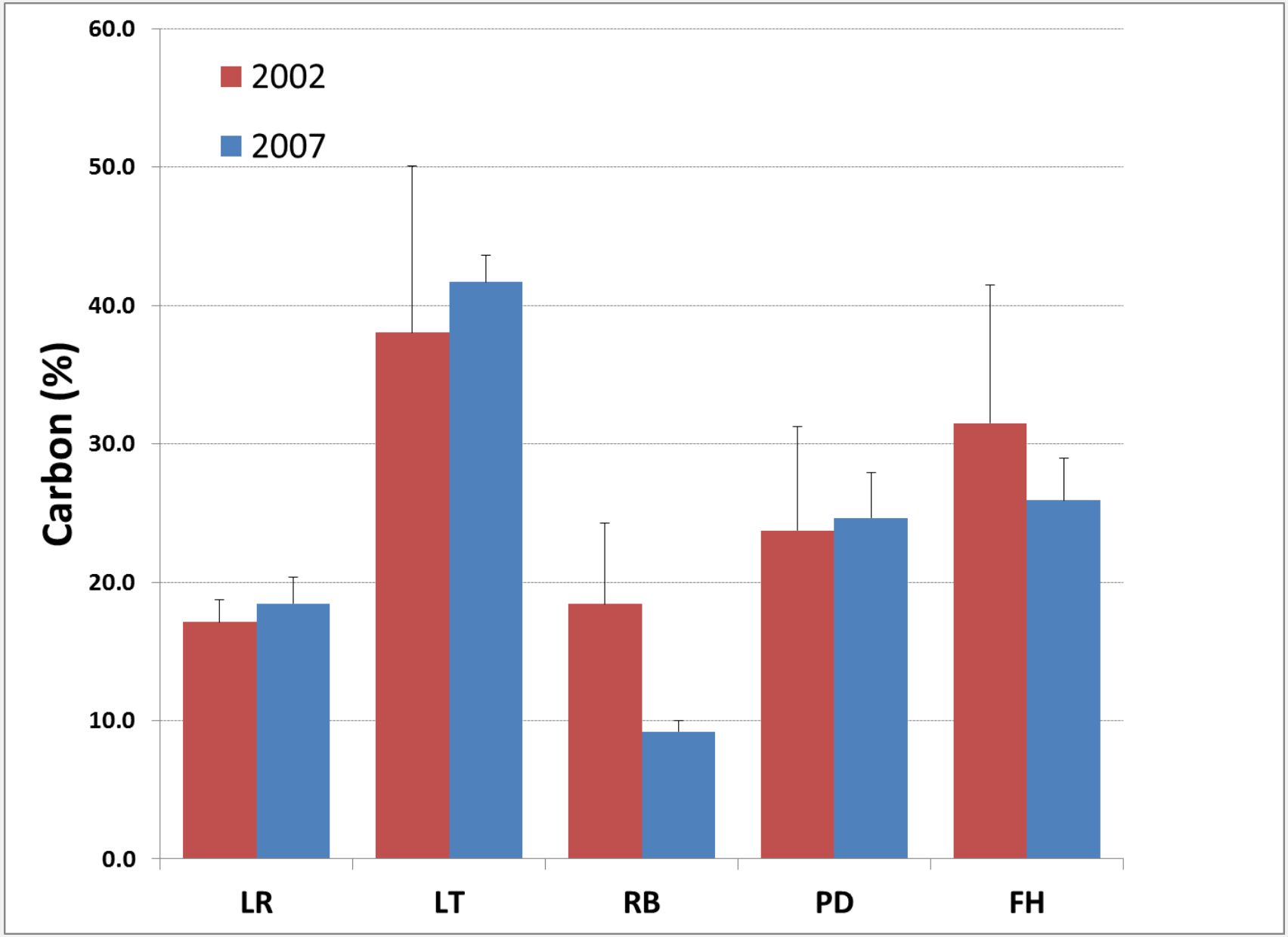
Jamie Shanley sampling for mercury at Ranch Brook in 2007

Oa/A Horizon Mercury 2002 and 2007

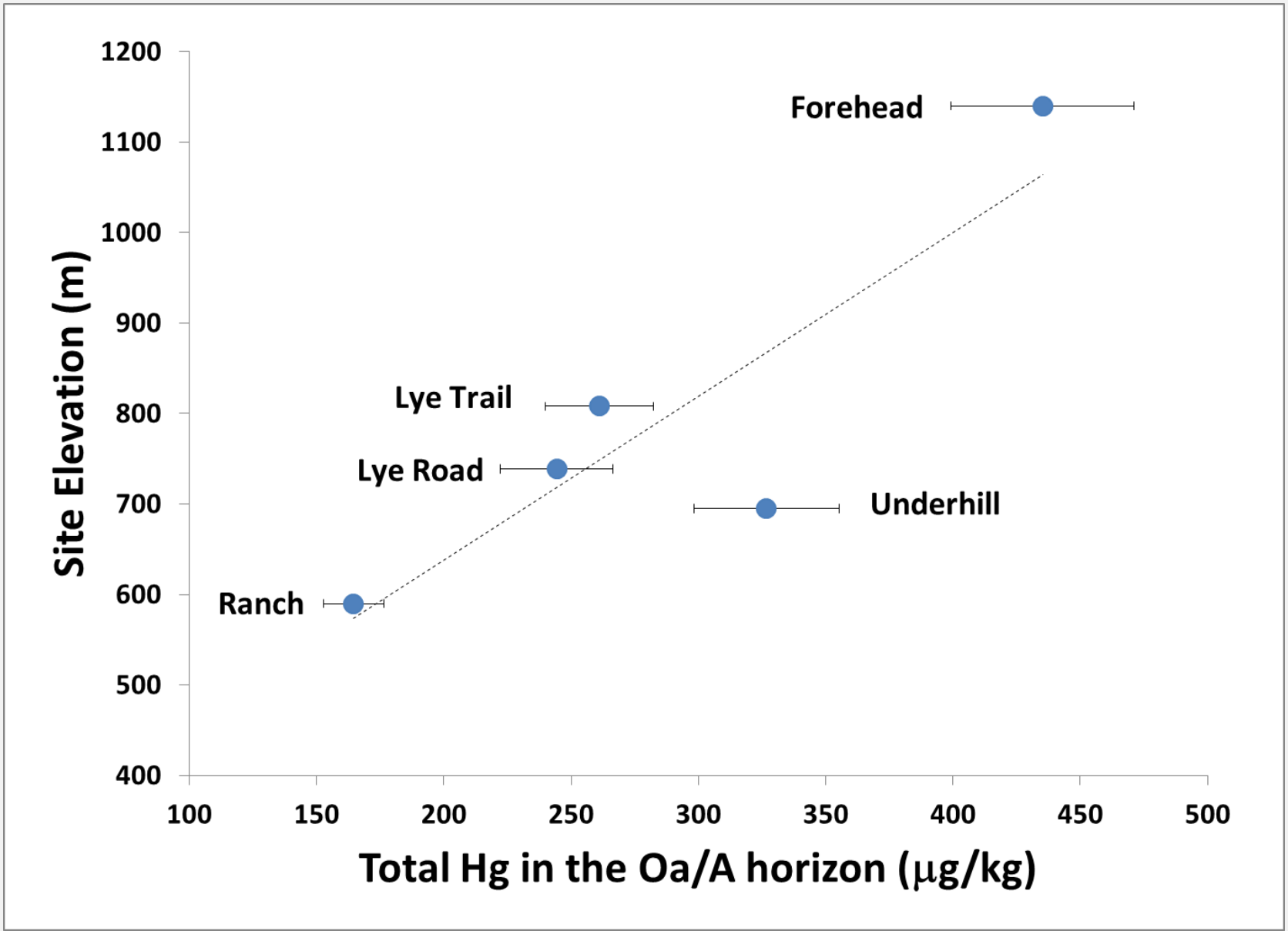
(courtesy of VT DEC lab and Neil Kamman)



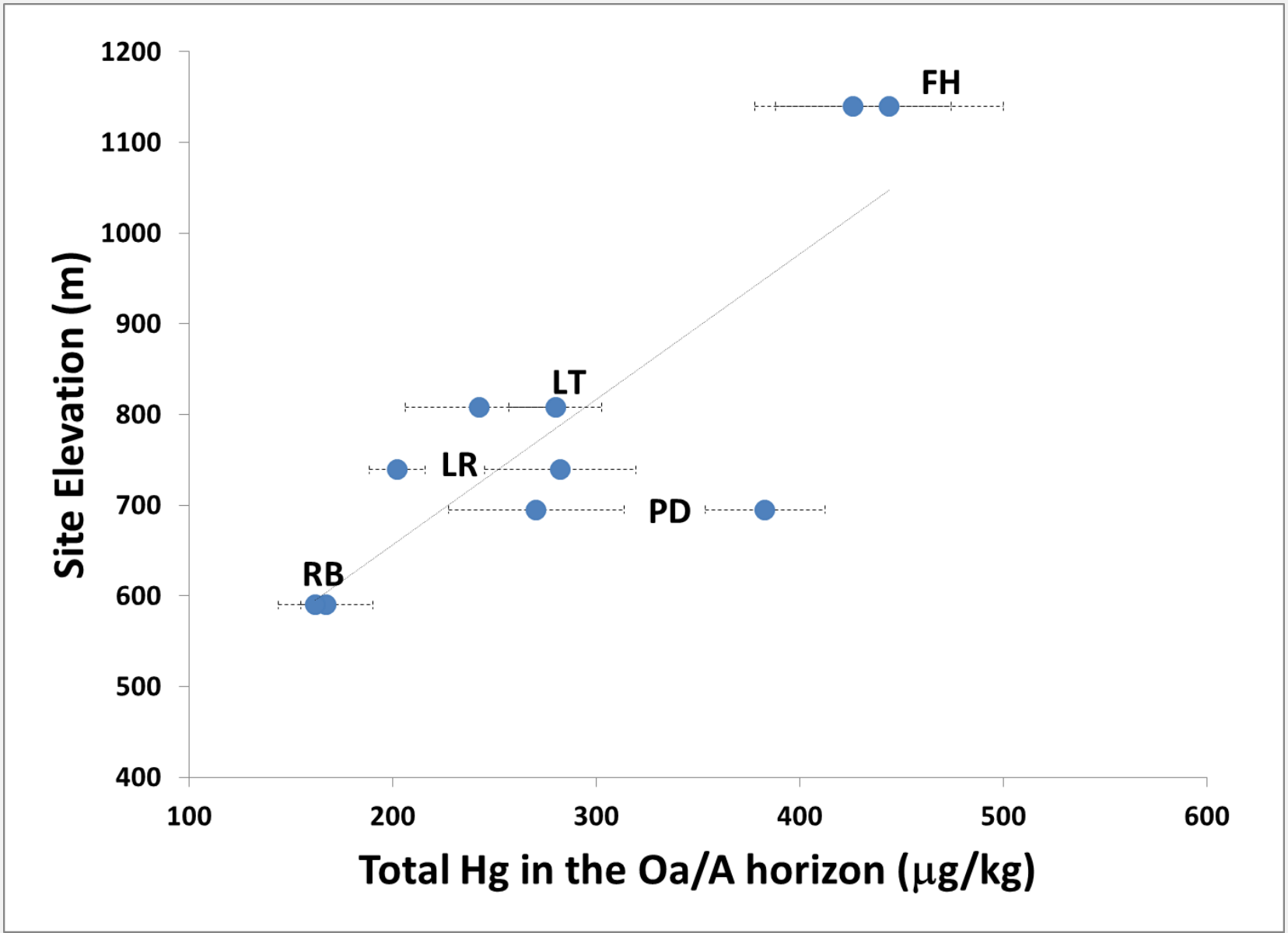
Oa/A Horizon Carbon 2002 and 2007



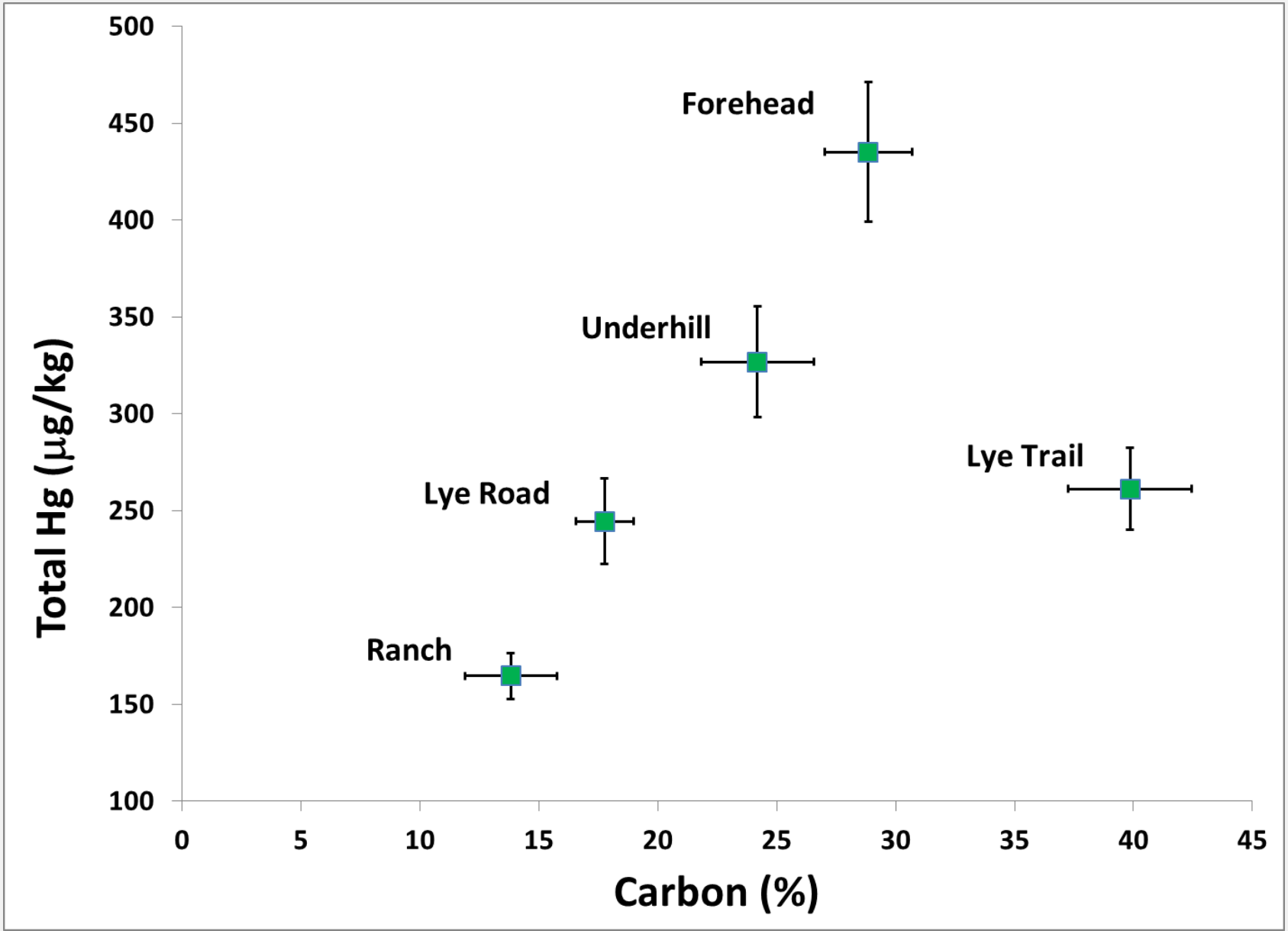
Elevation vs. Mercury



Elevation vs. Mercury, 2002 and 2007



Mercury vs. Carbon

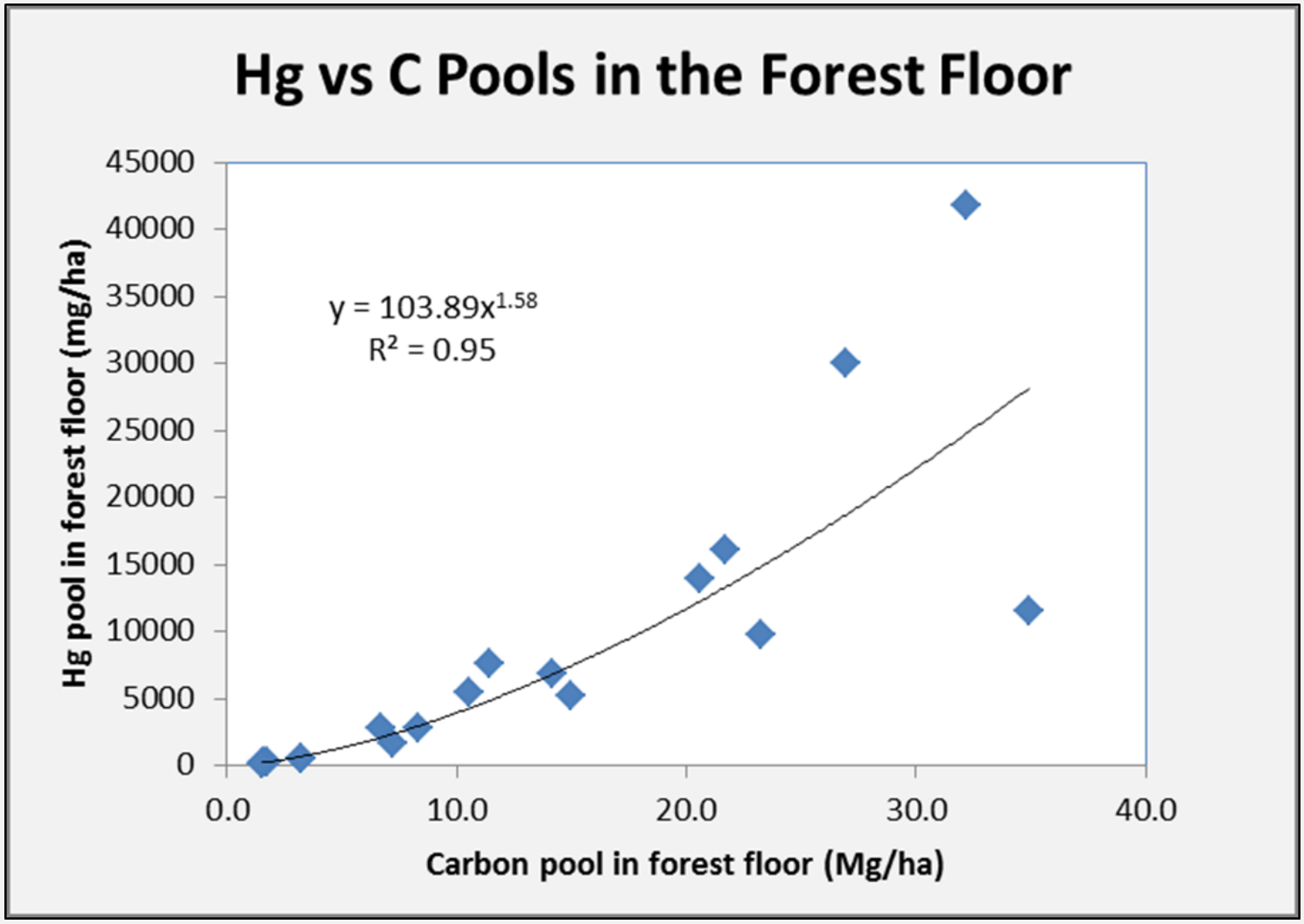


Results from other studies

- Juliette Juillerat's M.S. research at 18 managed forest sites in Vermont
- Elevation range 150-650 m (no trend w Hg)

Horizon	THg (ng/g)	stnd dev
Oi (L)	72.2	16.4
Oe (F)	228.0	75.6
Oa (H)	240.0	107.1
A	142.1	67.1

- Our study THg 162-444 ng/g, elevation 590-1140 m.



Juillerat, J.I., Ross, D.S., Bank, M.S., 2012. Mercury in litterfall and upper soil horizons in forested ecosystems in Vermont, USA. *Environmental Toxicology and Chemistry* 31, 1720-1729.

Other studies

- Richardson et al. 2013.Environmental Pollution 182
- 17 forested sites across the northeast.
  - Forest floor Hg = 274 ± 13 μg kg^{-1}

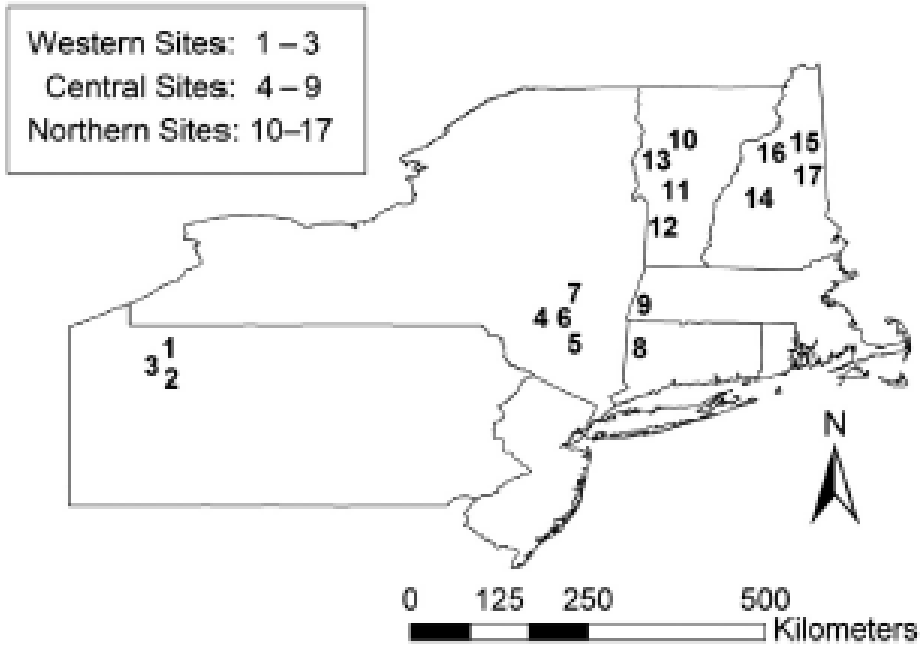
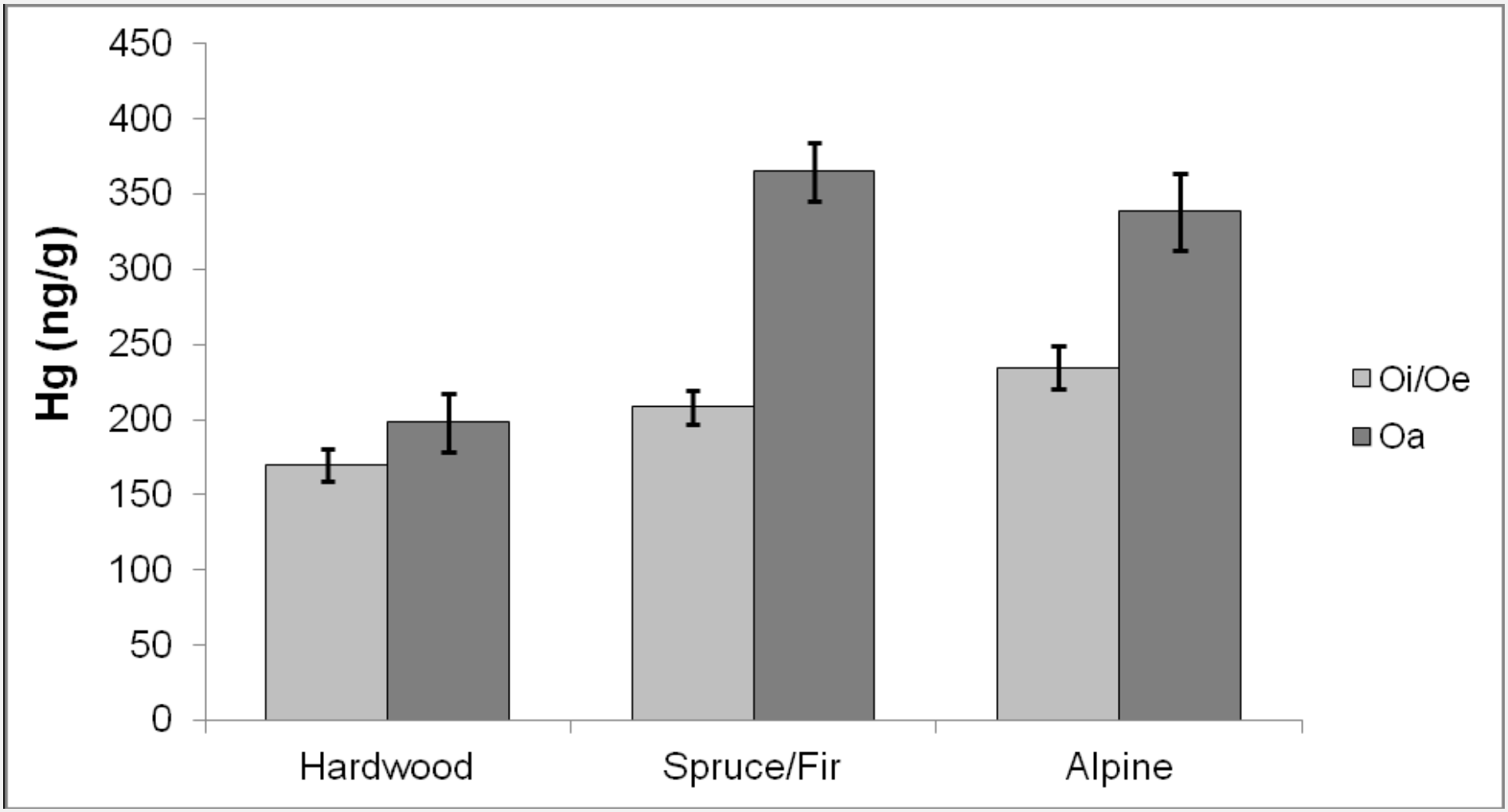


Fig. 1. Location of the upland forest, long term research sites and their sub-region across the northeastern United States.

Elevation trend on Whiteface Mtn, New York

Bradley D. Blackwell and Charles T. Driscoll (submitted)



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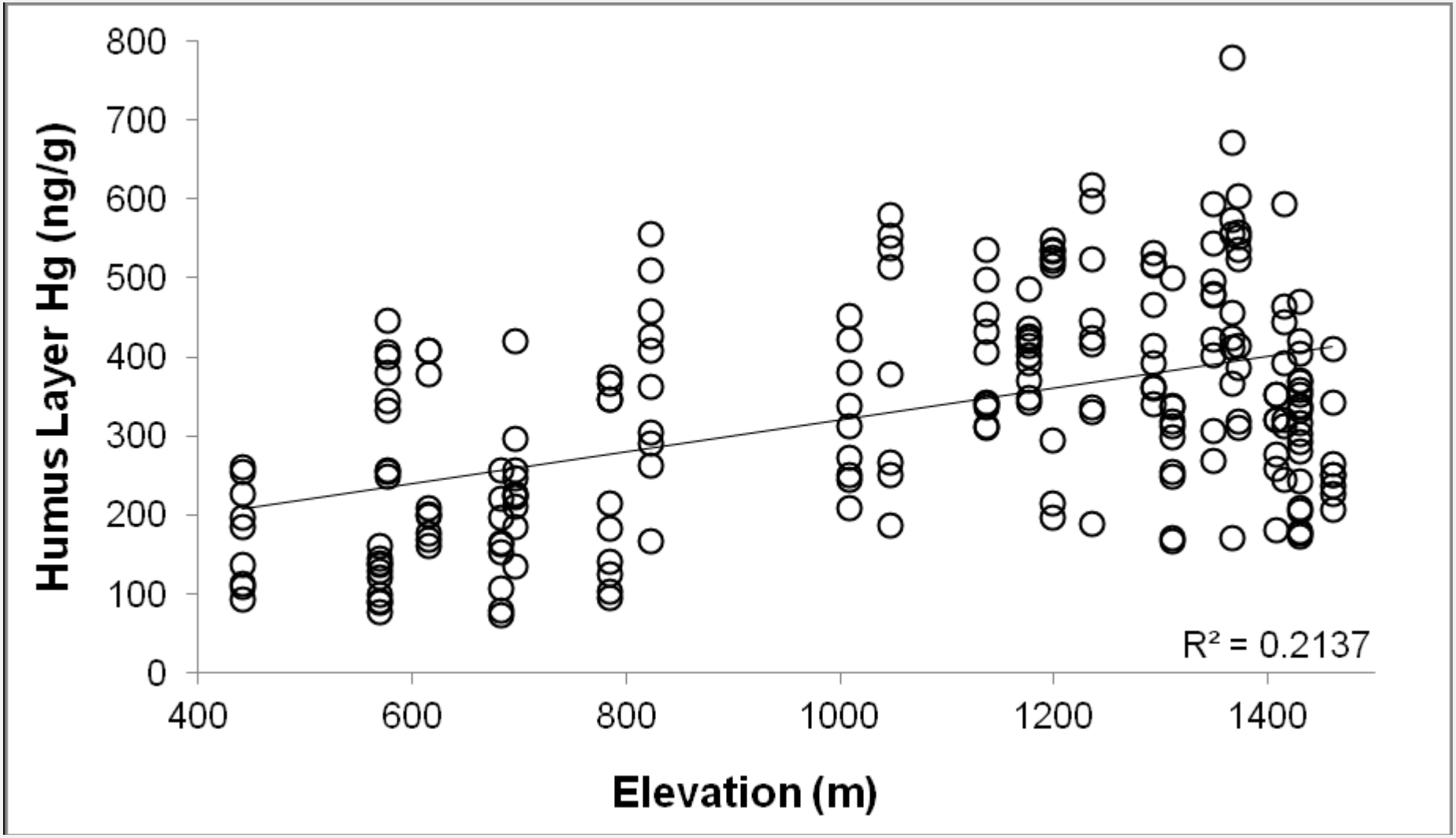


Elevation trend in the Catskill Mountains

Townsend et al. 2013 Environmental Toxicology and Chemistry: in press

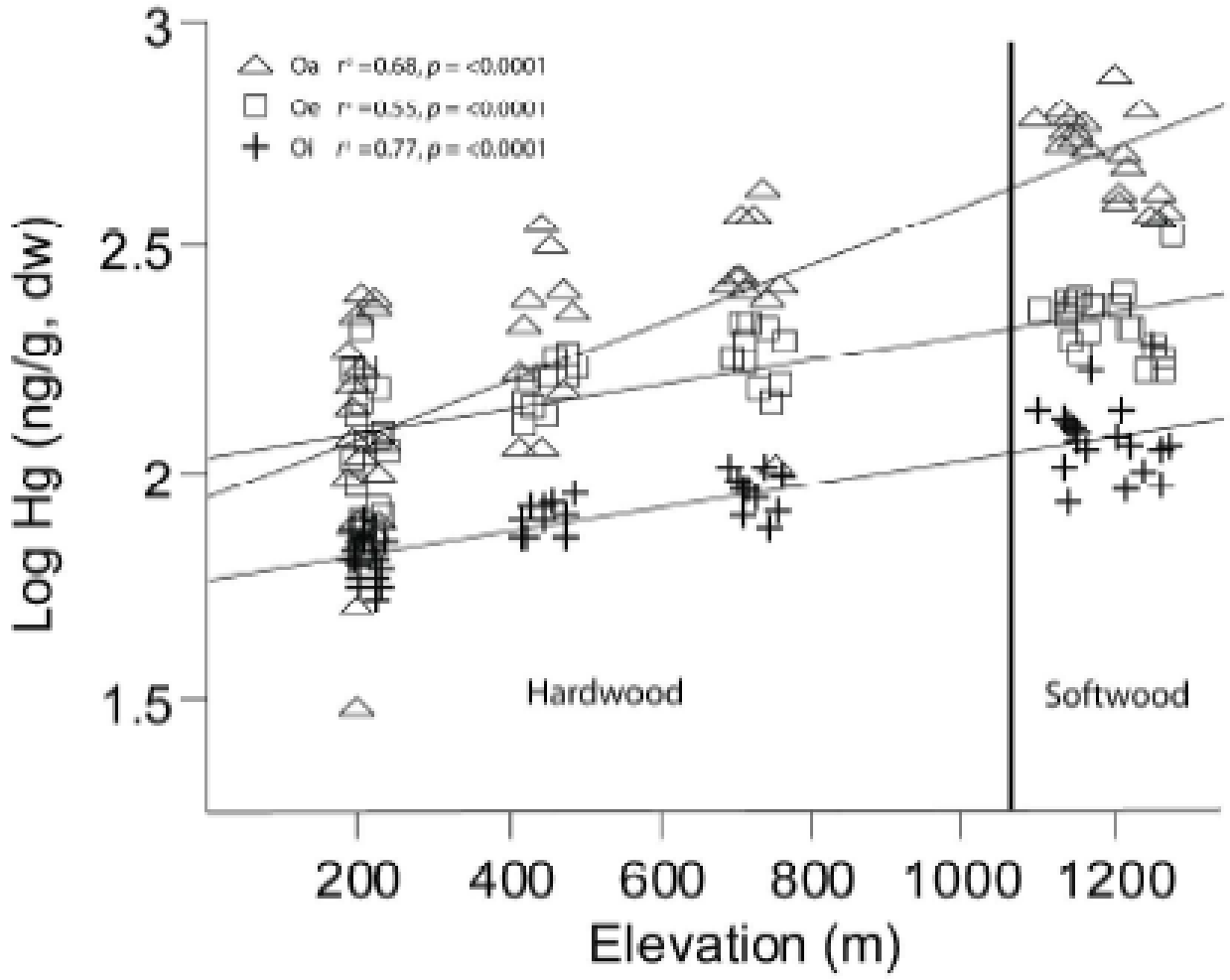
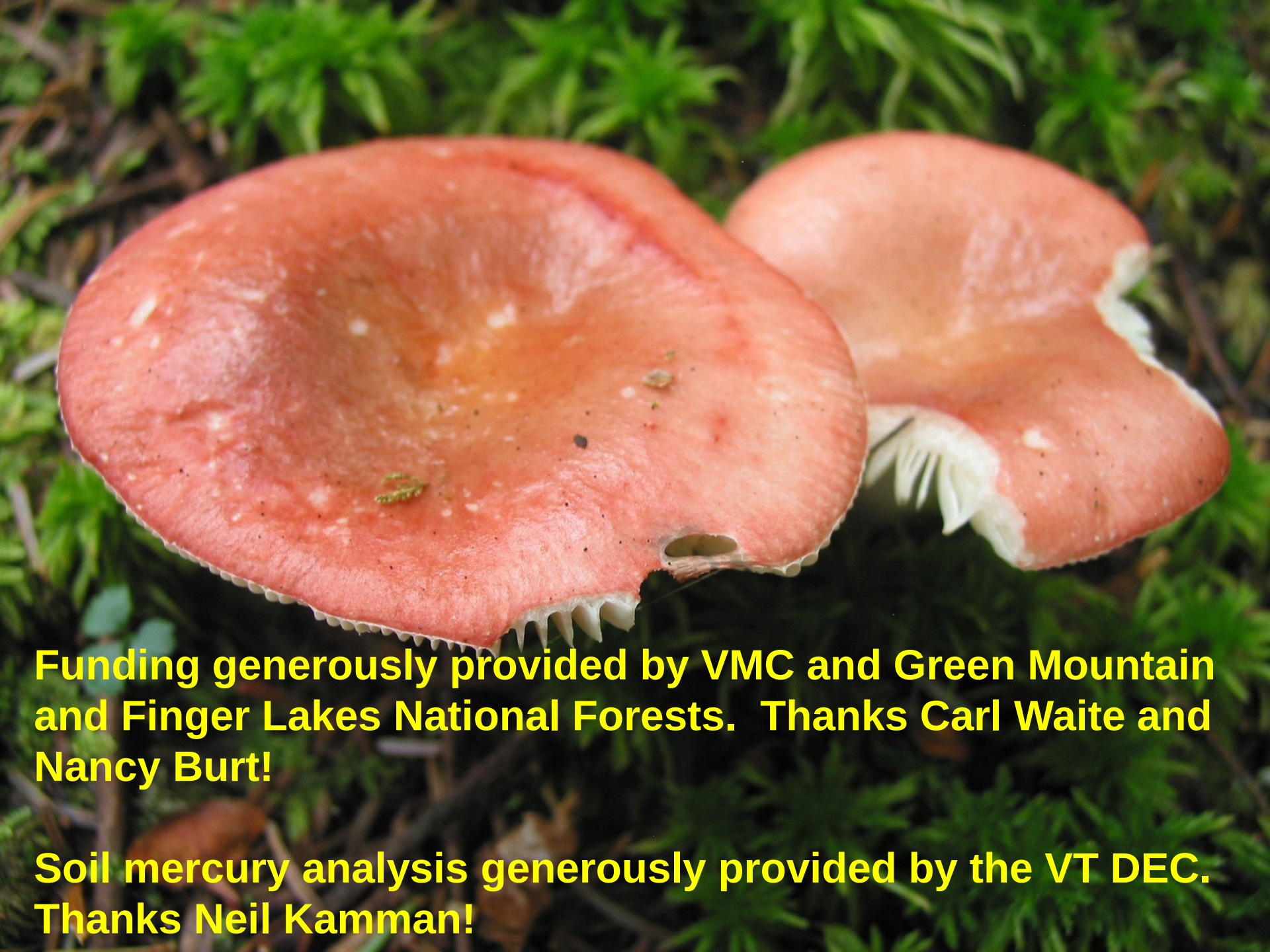


Figure 1. Mean mercury concentrations for forest floor horizons (Oa, Oe, Oi) sampled at 60 plots arrayed along an elevational gradient in the Catskill Mountains, New York. Hardwood tree species predominated at elevations below 1050 m and softwood species were dominant above 1050 m.

Conclusions

- VMC elevation trend consistent with
  - Other studies in New York
  - Blood Hg levels in thrush species
- How will changes in Hg deposition be reflected in soil Hg concentrations?
  - What is the source (form) of the accumulated Hg?
  - How important are re-emissions?
- How will climate change affect methylation rates?
  - Current rates not (at all) well understood



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Soil mercury analysis generously provided by the VT DEC. Thanks Neil Kamman!

Young volunteers needed!