Mountain Studies Institute

Mercury Transport and Fate in the Atmosphere and Hydrosphere

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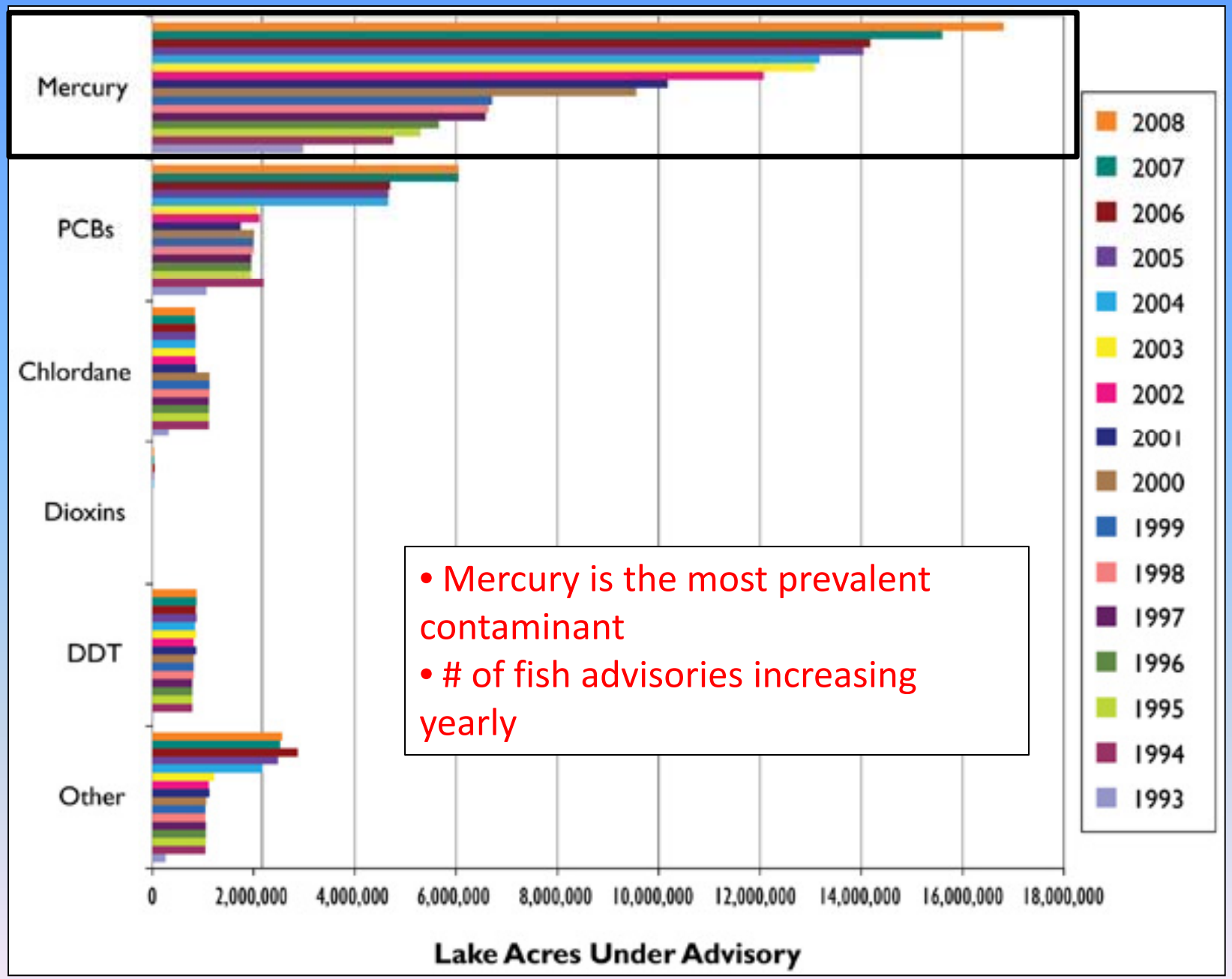
www.mountainstudies.org

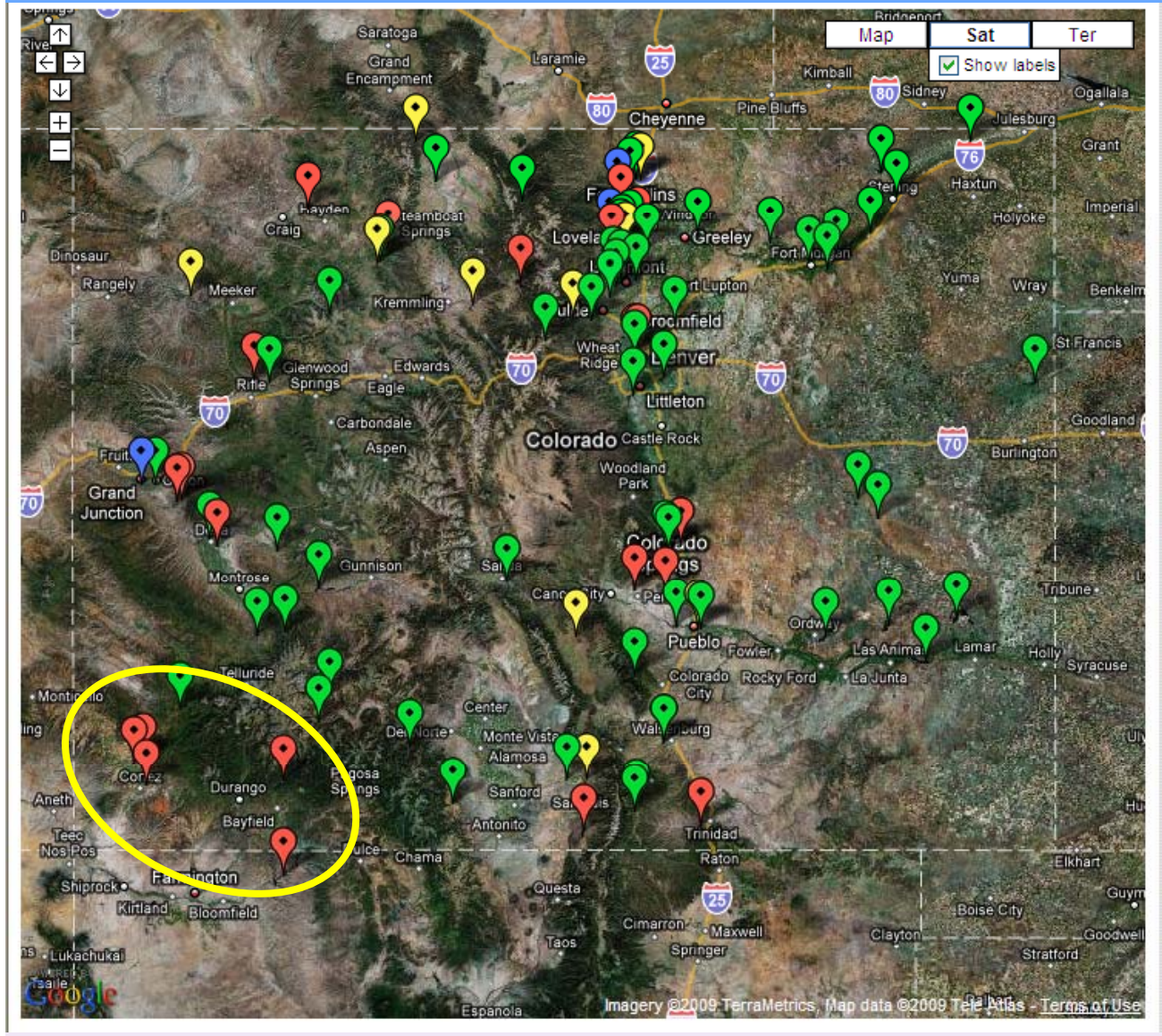
Mountain Studies Institute
SAN JUAN MOUNTAINS, COLORADO

All states now have fish consumption advisories for mercury



- Mercury is the most prevalent contaminant
- # of fish advisories increasing yearly

Mercury Advisories in Colorado & New Mexico



Colorado:
http://www.cdphe.state.co.us/wq/fishcon/index.html

McPhee, Narraguinepp, Totten, Vallecito, & Navajo Reservoirs in SW Colorado.

New Mexico:
http://www.nmenv.state.nm.us/swqb/advisories/

Abiquiu, Blue Water, Cochiti, & El Vado Reservoirs; Eagles Nest Lake, Heron Lake, Lake Farmington/Beeline Lake, and Navajo, San Juan River (below Hammond) in NW New Mexico.

Colorado Department of Public Health and Environment

VALLECITO RESERVOIR

2006

ATTENTION ANGLERS

Colorado Department of Public Health and Environment

Routine sampling has shown that some fish from this water exceed the mercury action level of 0.5 parts per million set by the Colorado Department of Public Health and Environment. Eating fish that exceed this level may cause health problems, especially for the unborn fetus and small children.

The Colorado Department of Public Health and Environment has categorized the fish according to mercury levels. To find out the recommended amounts of fish that may be consumed, find the fish and size you caught and follow the recommendations described below, in terms of the number of meals per month for each group of people.

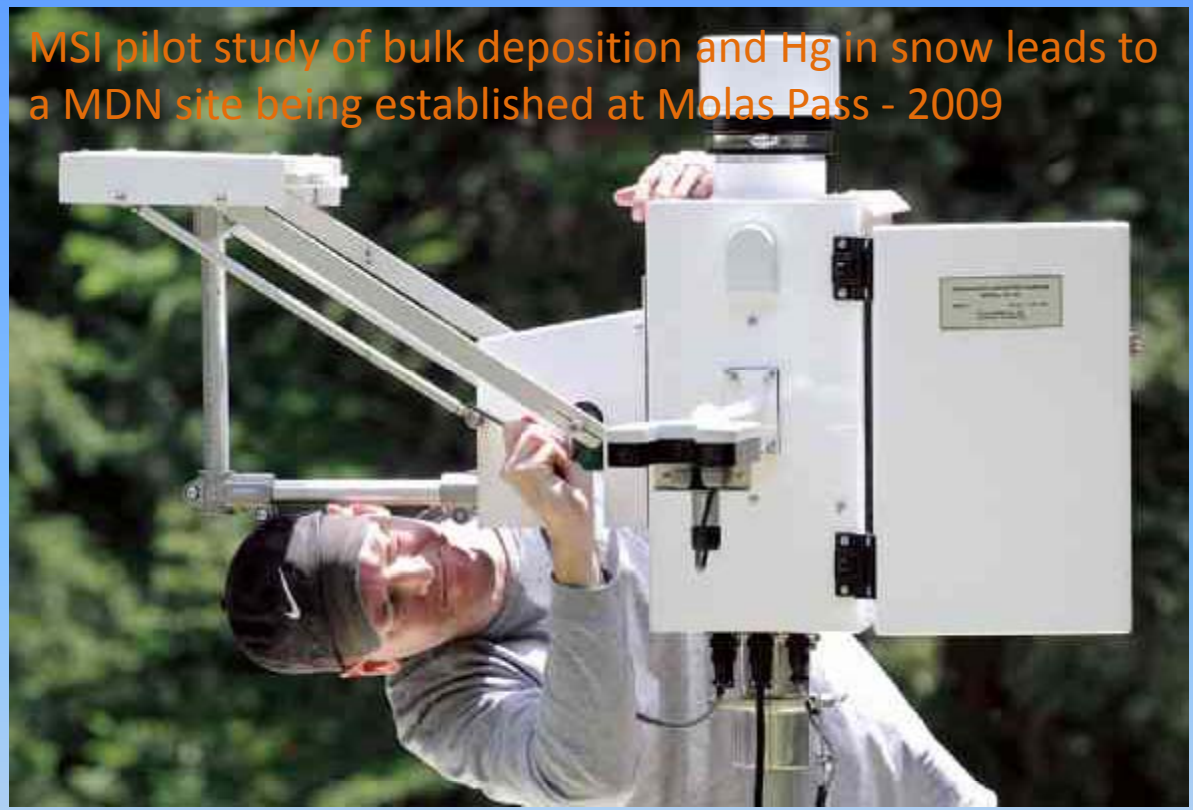
FISH	SIZE	PREGNANT WOMEN, NURSING WOMEN AND WOMEN WHO PLAN ON BEING PREGNANT	CHILDREN 6 YEARS OR YOUNGER	GENERAL POPULATION
Northern Pike	Larger than 27 inches	1 Meal per Month	Do Not Consume	1 Meal per Month
Walleye	Larger than 18 inches	Do Not Consume	Do Not Consume	1 Meal per Month
Walleye	Smaller than 18 inches	1 Meal per Month	1 Meal per Month	2 Meals per Month

Rainbow trout and kokanee salmon can also be caught at Vallecito Reservoir and although they haven't been tested, they have been found, consistently throughout the state, not to contain elevated levels of mercury in their tissue.

Meal size for adults weighing 150 pounds = 8 ounces
Meal size for children = 4 ounces.

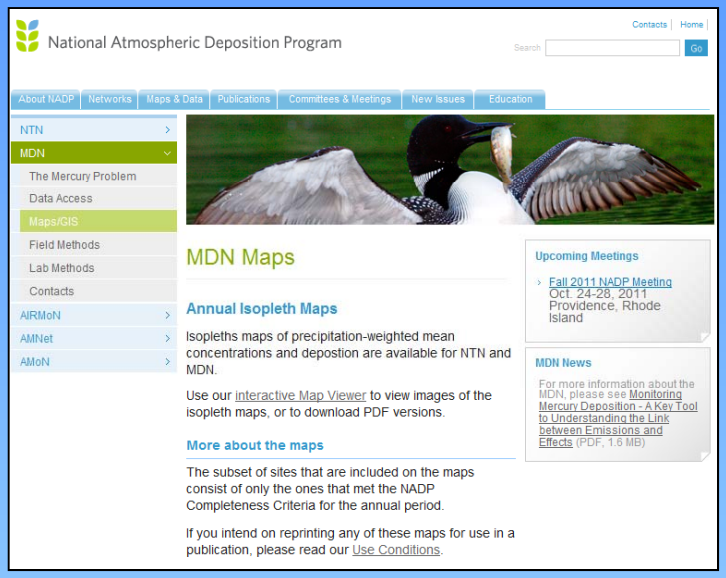
If the fish and size you caught are not listed above, either the Department hasn't tested them or they were found to be safe to eat. The report "Mercury Concentrations in Fish from Vallecito Reservoir" can be found at http://www.cdphe.state.co.us/wq/monitoring/monitoring.html. For questions regarding mercury in fish call the Water Quality Control Division (303 692-3500). For general information about fish and nutrition, consult: http://www.epa.gov/waterscience/fish/. For questions about human health and mercury call the Disease Control and Environmental Epidemiology Division (303 692-2700).

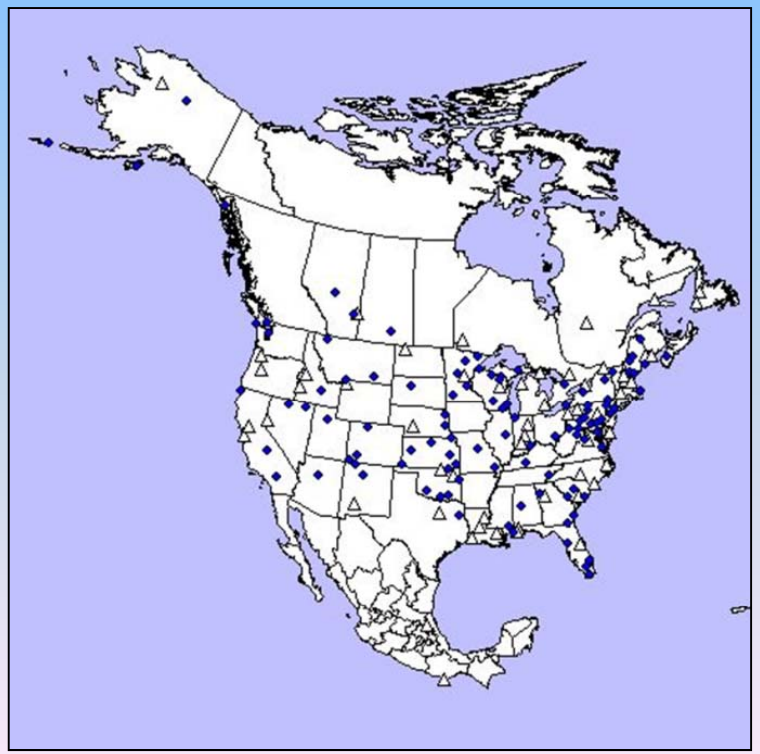
- Do we have elevated levels of atmospheric mercury deposition?
  - Where does it come from? Has mercury input changed over time?
- Do we have landscapes that are sensitive to transport and methylation of mercury?
  - Where is mercury bio-accumulating in ecosystems and species?

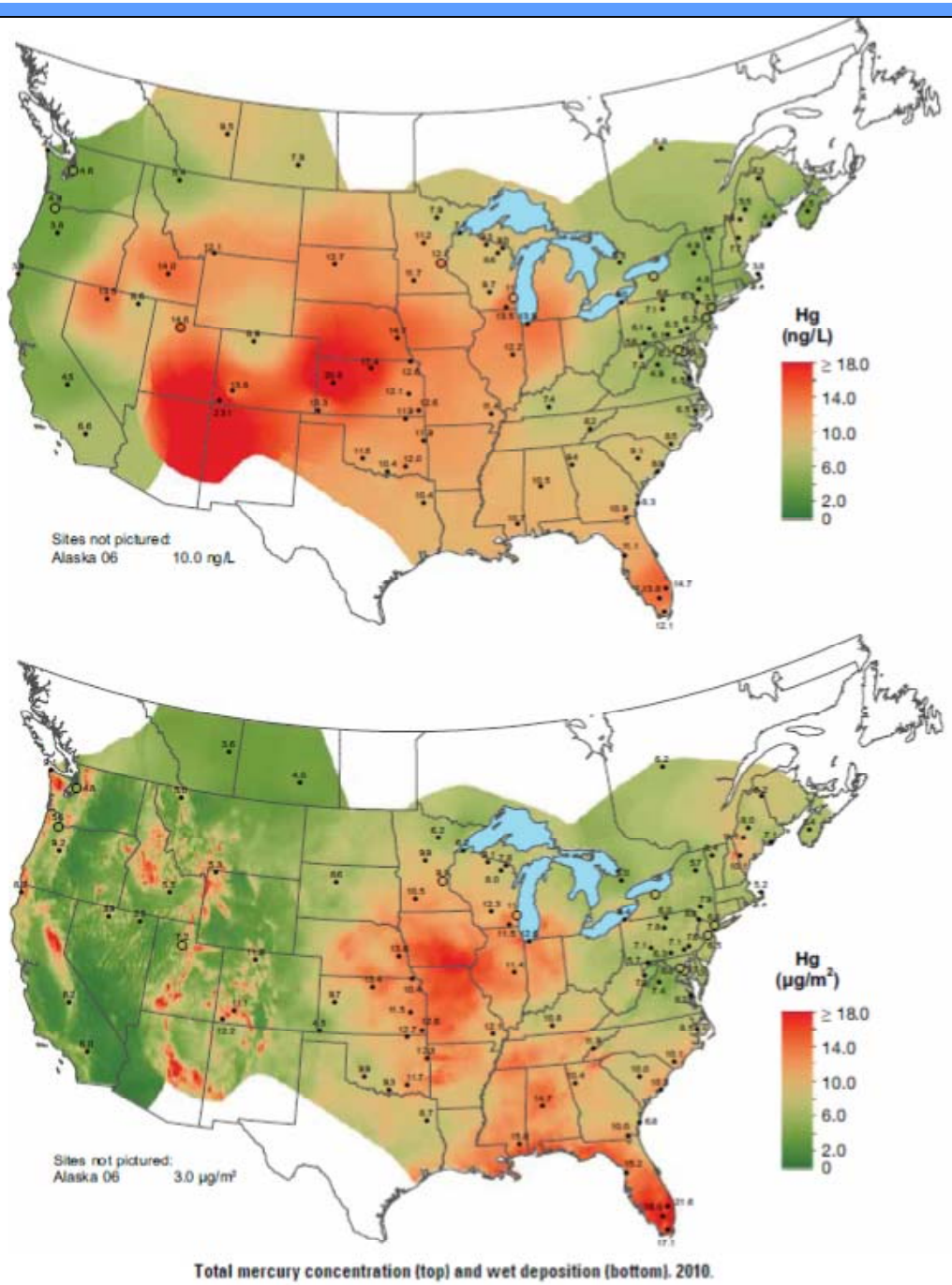


	2007			2008		
	Precip (mm)	Hg Conc (ng/L)	Hg Dep (ug/m2)	Precip (mm)	Hg Conc (ng/L)	Hg Dep (ug/m2)
Molas Pass	442.5	12.7	5.6	291.3	18.2	5.3
Mesa Verde	254.1	23.2	5.6	164.7	28.5	4.4

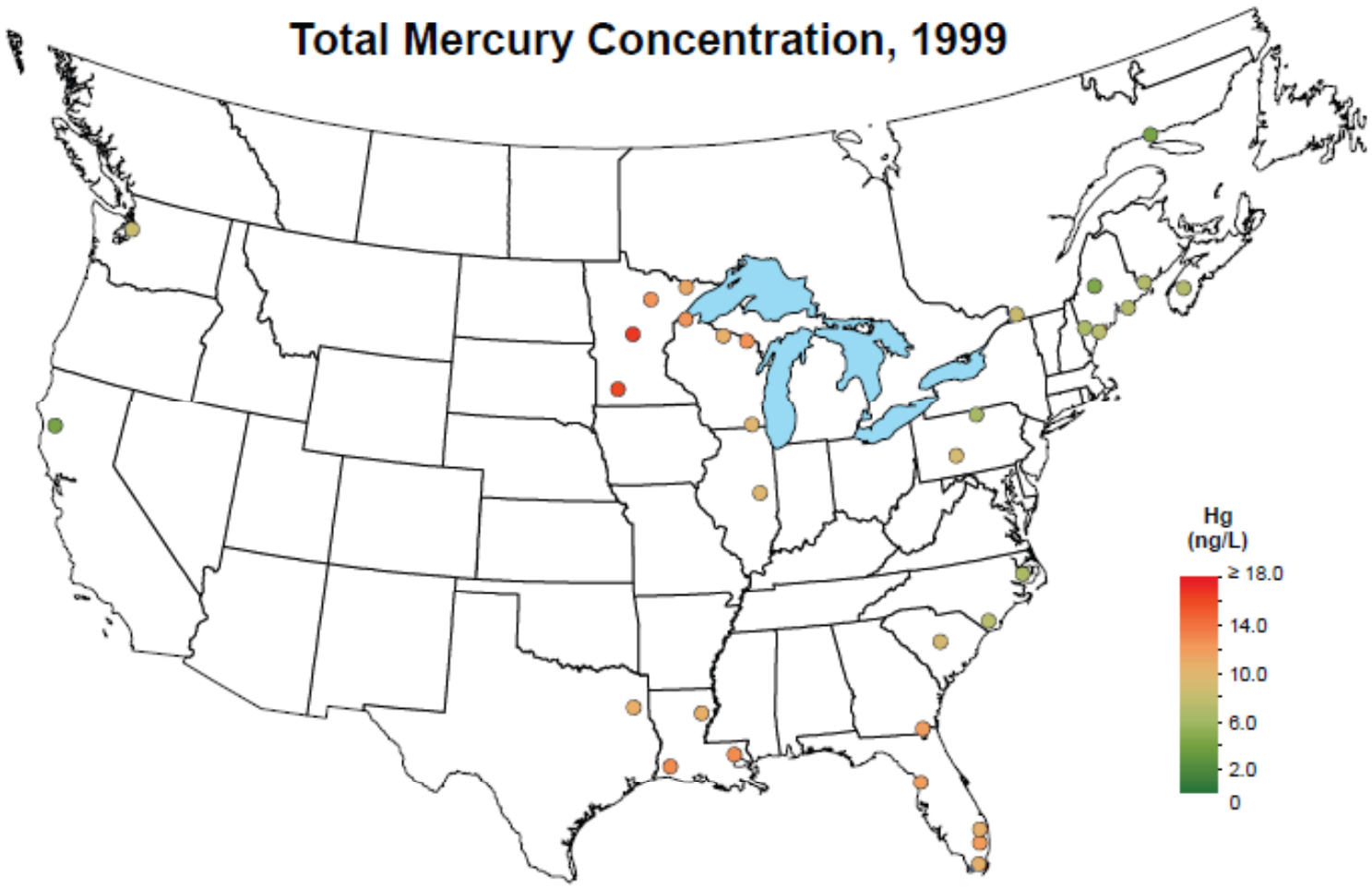
Table 1. Total precipitation amount, volume-weighted mercury concentration (Hg Conc), and mercury deposition (Hg Dep) recorded in bulk deposition at Molas Pass and wet deposition at Mesa Verde National Park during collection periods in 2007 and 2008.



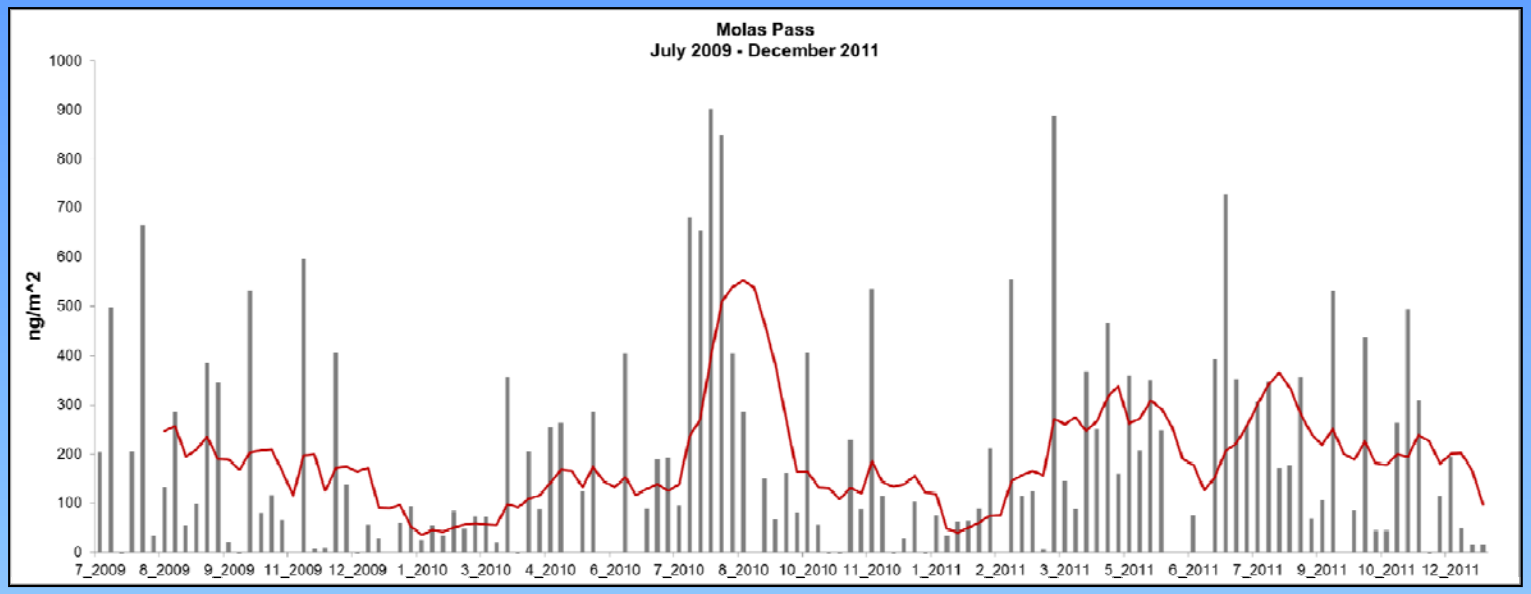




Total mercury concentration (top) and wet deposition (bottom). 2010.



National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu


Molas Pass
July 2009 - December 2011
ng/m^2
1000
900
800
700
600
500
400
300
200
100
0
7_2009
8_2009
9_2009
11_2009
12_2009
1_2010
3_2010
4_2010
6_2010
7_2010
8_2010
10_2010
11_2010
1_2011
2_2011
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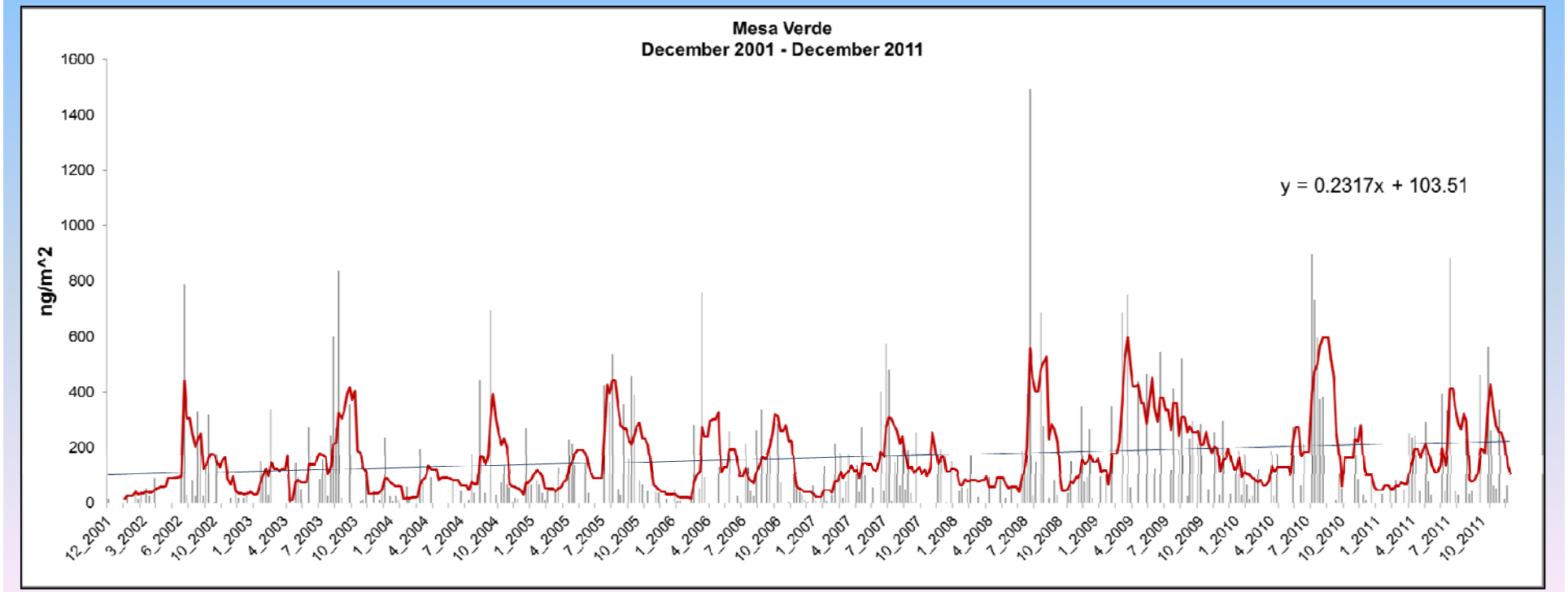
6_2011
7_2011
9_2011
10_2011
12_2011


Mesa Verde
December 2001 - December 2011
ng/m^2
1600
1400
1200
1000
800
600
400
200
0
y = 0.2317x + 103.51
12_2001
3_2002
6_2002
10_2002
1_2003
4_2003
7_2003
10_2003
1_2004
4_2004
7_2004
10_2004
1_2005
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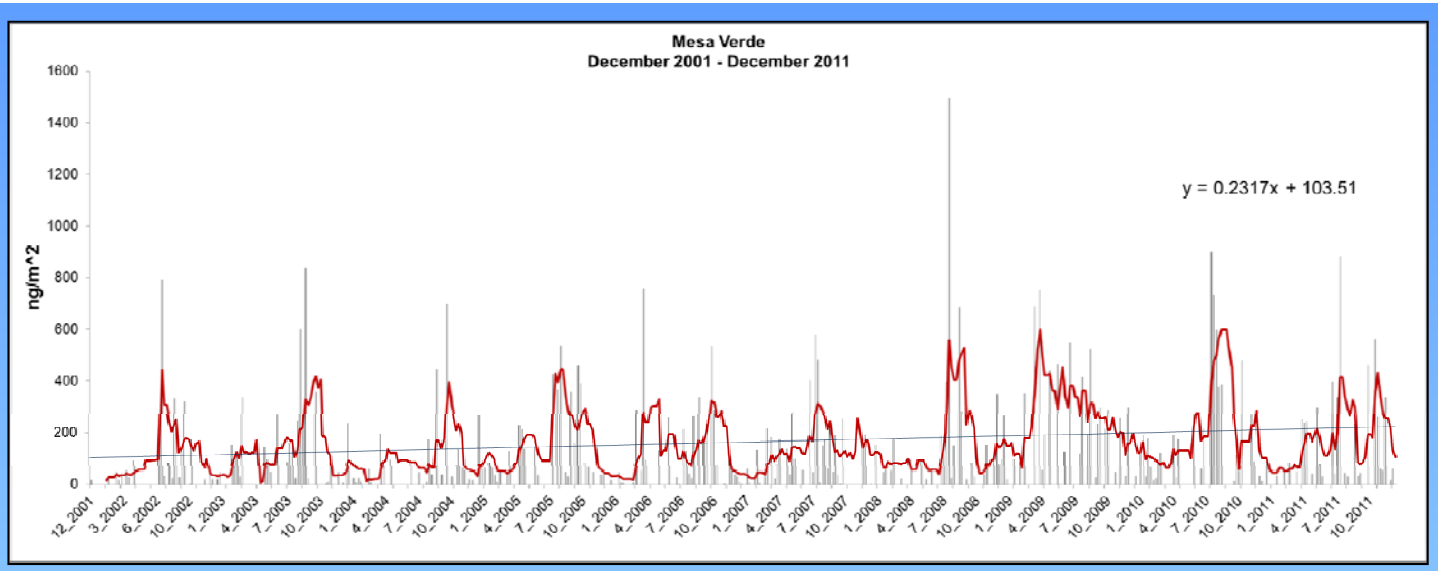
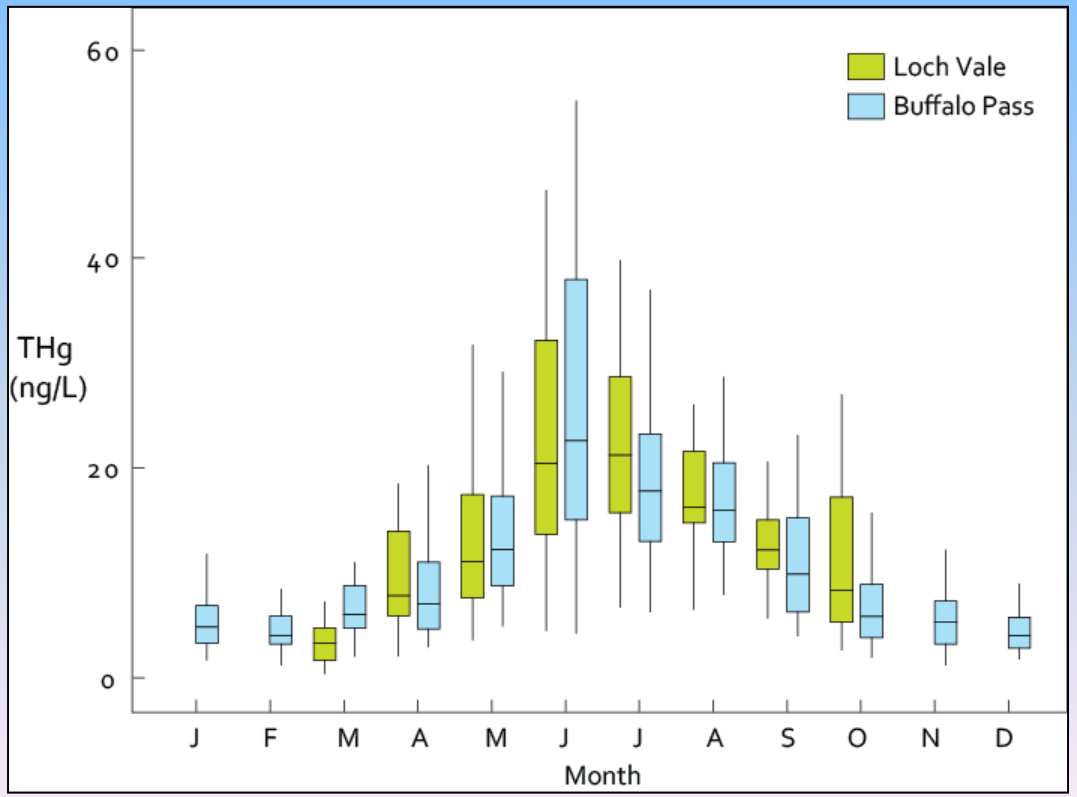




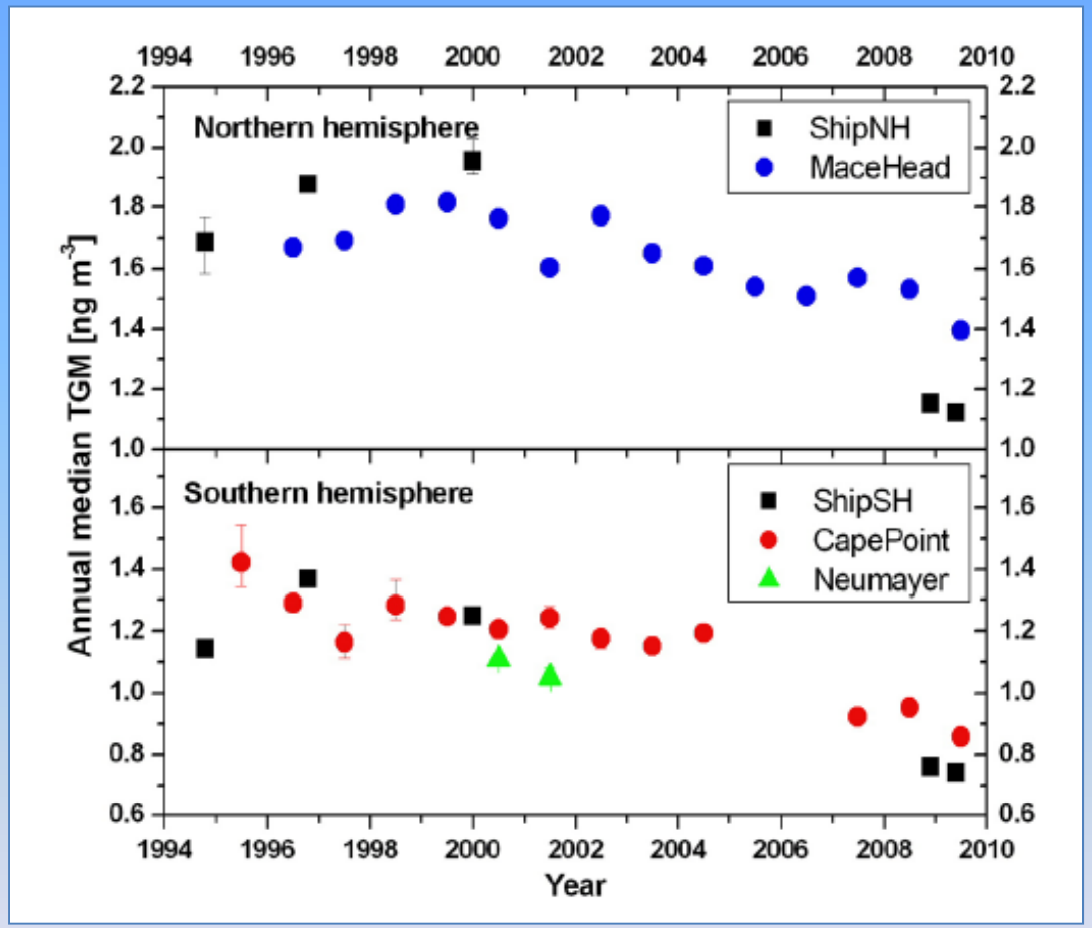
Response of lake chemistry to changes in atmospheric deposition and climate in three high-elevation wilderness areas of Colorado

M. Alisa Mast · John T. Turk · David W. Clow · Donald H. Campbell

Worldwide trend of atmospheric mercury since 1995

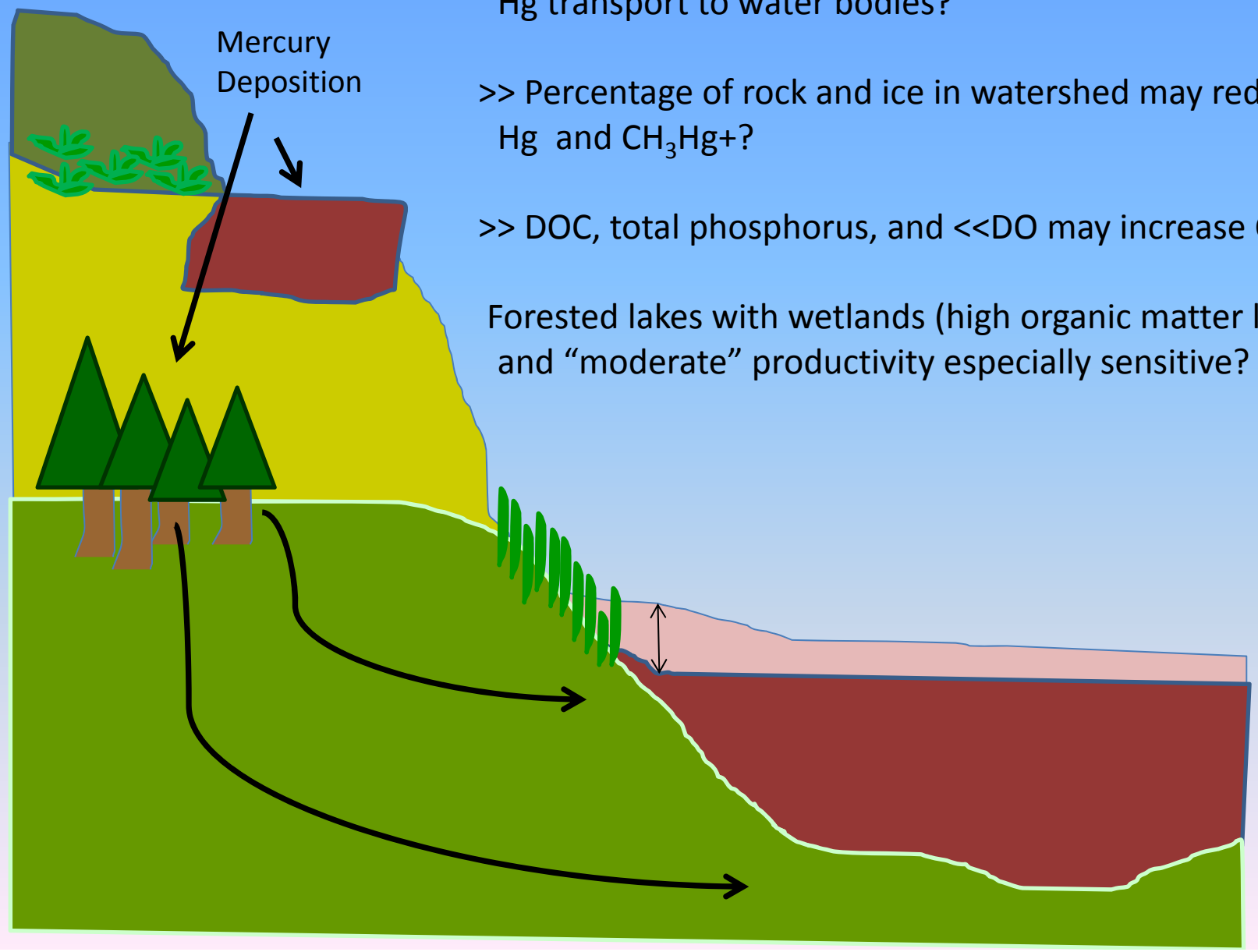
F. Slemr[1], E.-G. Brunke[2], R. Ebinghaus[3], and J. Kuss[4]

[1]Max-Planck-Institut für Chemie, P.O. Box 3060, 55020 Mainz, Germany
[2]South African Weather Service c/o CSIR, P.O. Box 320, Stellenbosch 7599, South Africa
[3]GKSS Forschungszentrum Geesthacht GmbH, Max-Planck-Strasse, 21502 Geesthacht, Germany
[4]Leibniz Institute for Baltic Sea Research, Seestrasse 15, 18119 Rostock-Warnemünde, Germany



"…worldwide atmospheric mercury concentrations have decreased by about 20 to 38% since 1996 as indicated by long-term monitoring at stations in the Southern and Northern Hemispheres combined with intermittent measurements of latitudinal distribution over the Atlantic Ocean."

Are high-elevation lakes sensitive to accumulating methyl mercury?

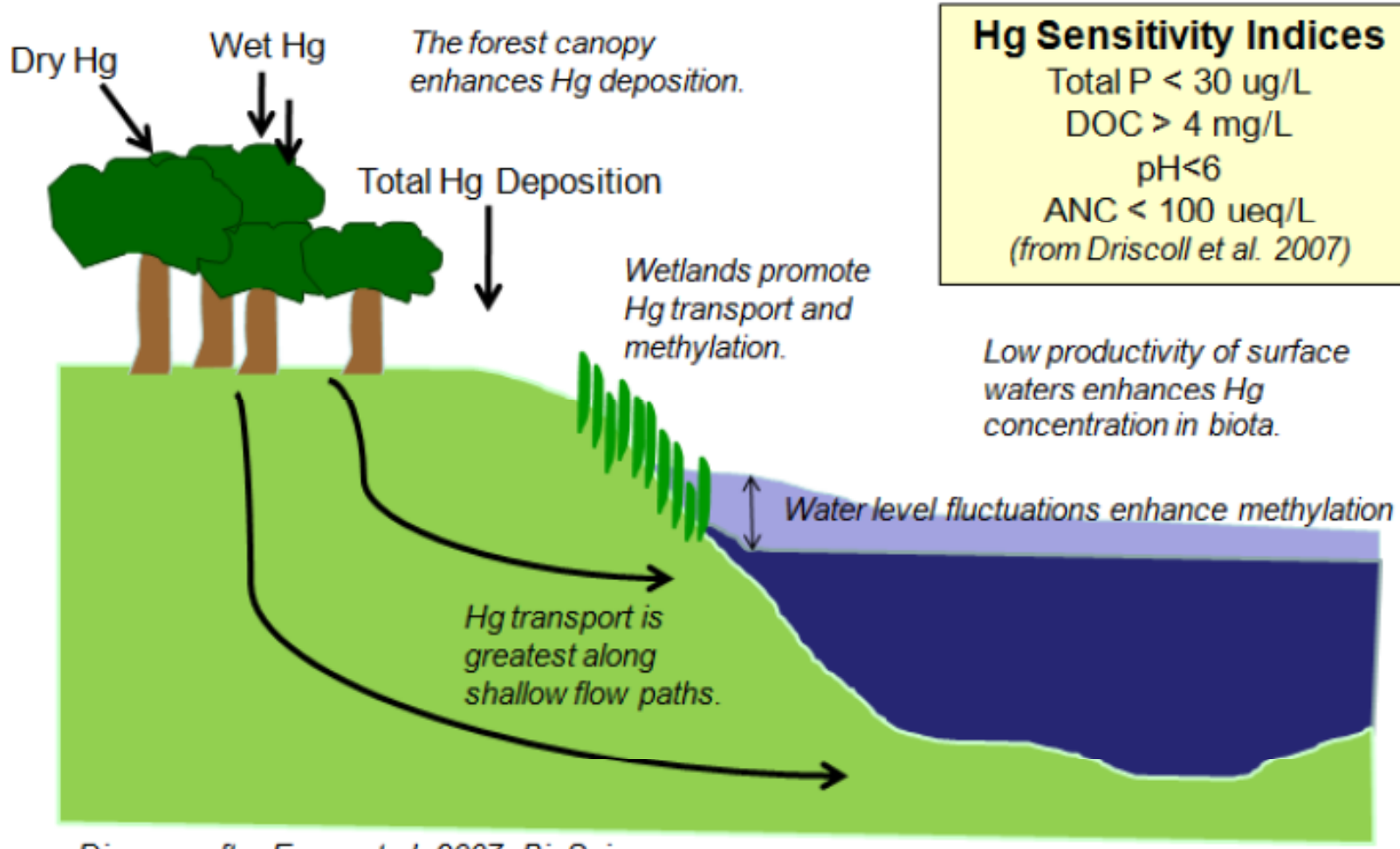


>>Percentage of forest cover in the watershed may enhance Hg transport to water bodies?

>> Percentage of rock and ice in watershed may reduce total Hg and CH_3Hg+?

>> DOC, total phosphorus, and <<DO may increase CH_3Hg+?

Forested lakes with wetlands (high organic matter leaching) and "moderate" productivity especially sensitive?



Hg Sensitivity Indices

Total P < 30 ug/L
DOC > 4 mg/L
pH<6
ANC < 100 ueq/L
(from Driscoll et al. 2007)

Diagram after Evers et al. 2007. BioScience

Mercury in Lake Zooplankton

- How do Hg concentrations compare to other studies?
- What are the sensitivity indices for this set of lakes?

Measurements:

- Water chemistry
- Lake productivity indices
- Watershed Land Cover
- Zooplankton:
  - 2 size fractions of zooplankton:
    - 80-300 µm (small) – 17 lakes
    - > 300 µm (big) – 22 lakes
  - Total & methyl mercury in zooplankton

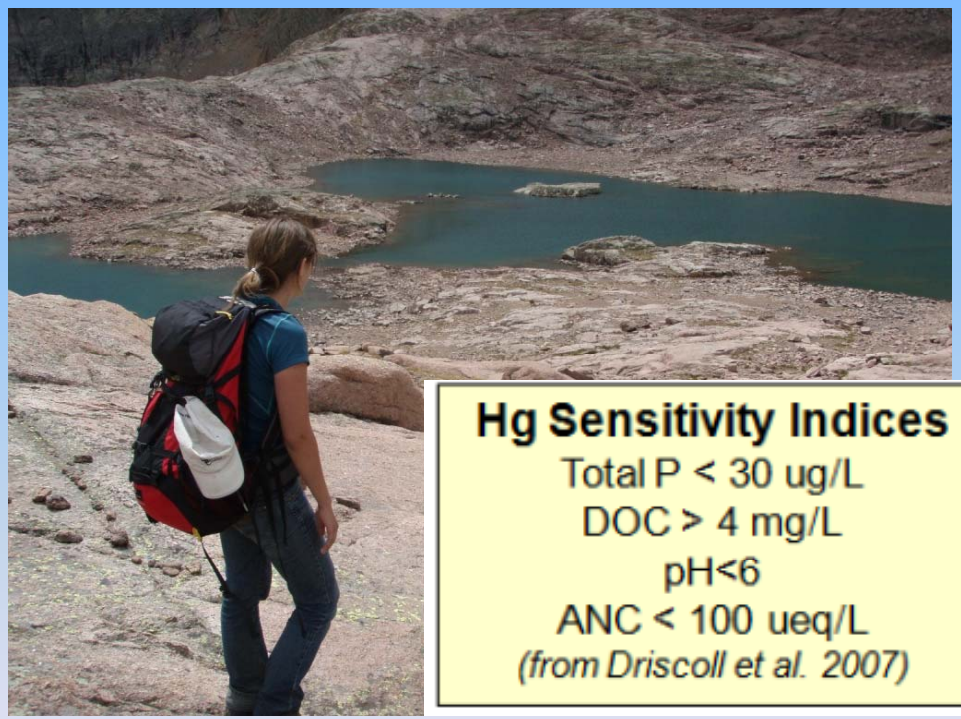
Why Zooplankton?

- Key link in aquatic food web
- Hg in zoopl. often correlated to Hg in fish
- Easy to sample
- Exist in (almost) all lakes
- Use as an index

Bosmina cladoceran - Daphinia

An Overview of the Lakes

	Mean	Min	Max
Elevation (ft)	11,117	6,683	13,100
ANC (ueq/L)	80	12	258
pH	7.2	5.6	8.4
Total P (ug/L)	6	1	15
Chl *a* (Epi)	2	0.3	6
DOC (mg/L)	2.7	1.5	6.8
NO3-N (ug/L)	73	0	306
% Rock & ice	40%	0%	89%
% Forest	47%	0%	91%



Hg Sensitivity Indices

Total P < 30 ug/L

DOC > 4 mg/L

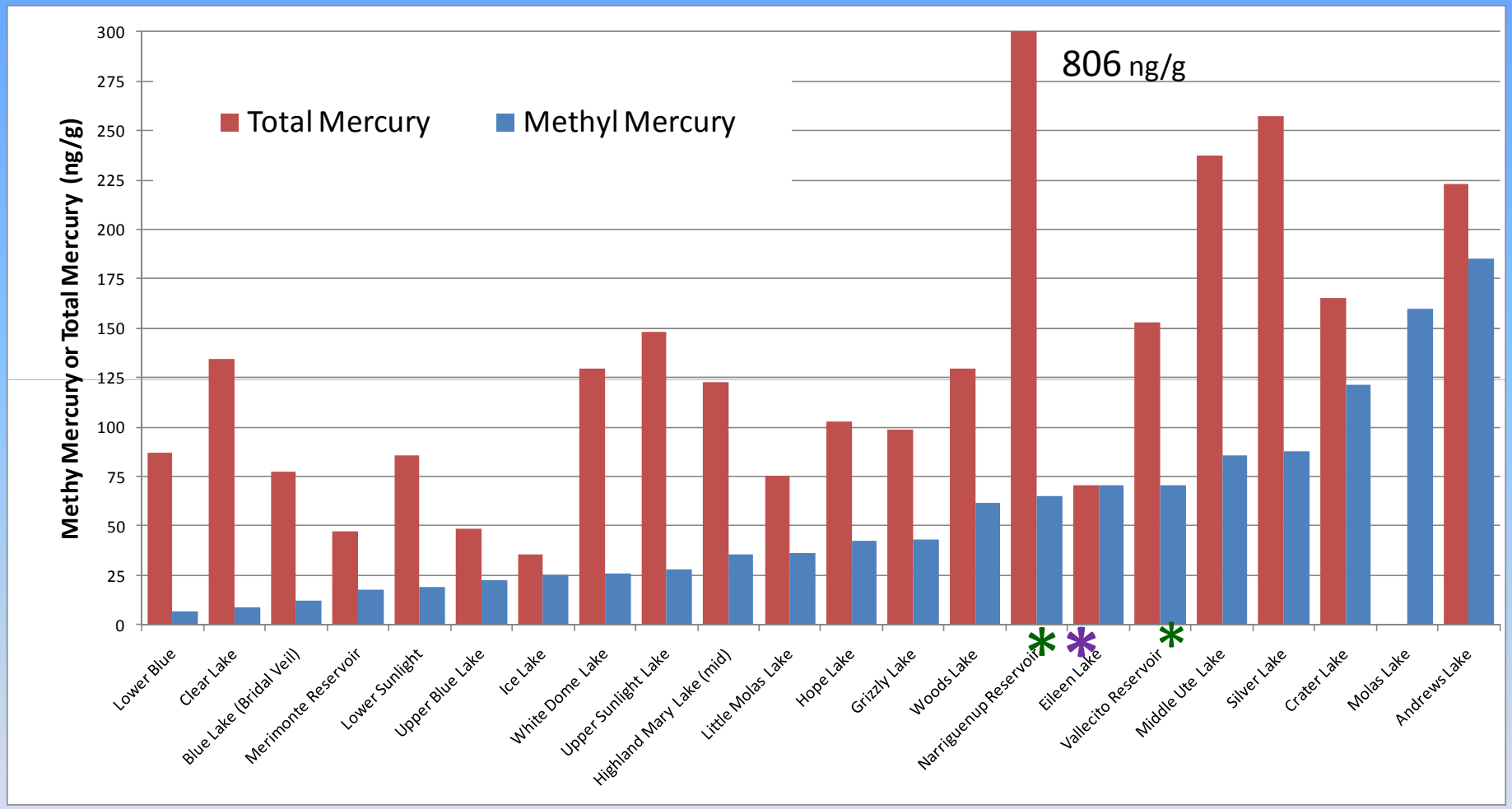
pH<6

ANC < 100 ueq/L

(from Driscoll et al. 2007)

- Includes 2 reservoirs with Hg advisories, for comparison.
- 1 of these has geologic/mining source of Hg, in addition to atmospheric deposition.
- No known geologic/mining sources for other lakes.

Mercury in Zooplankton (>300 um)

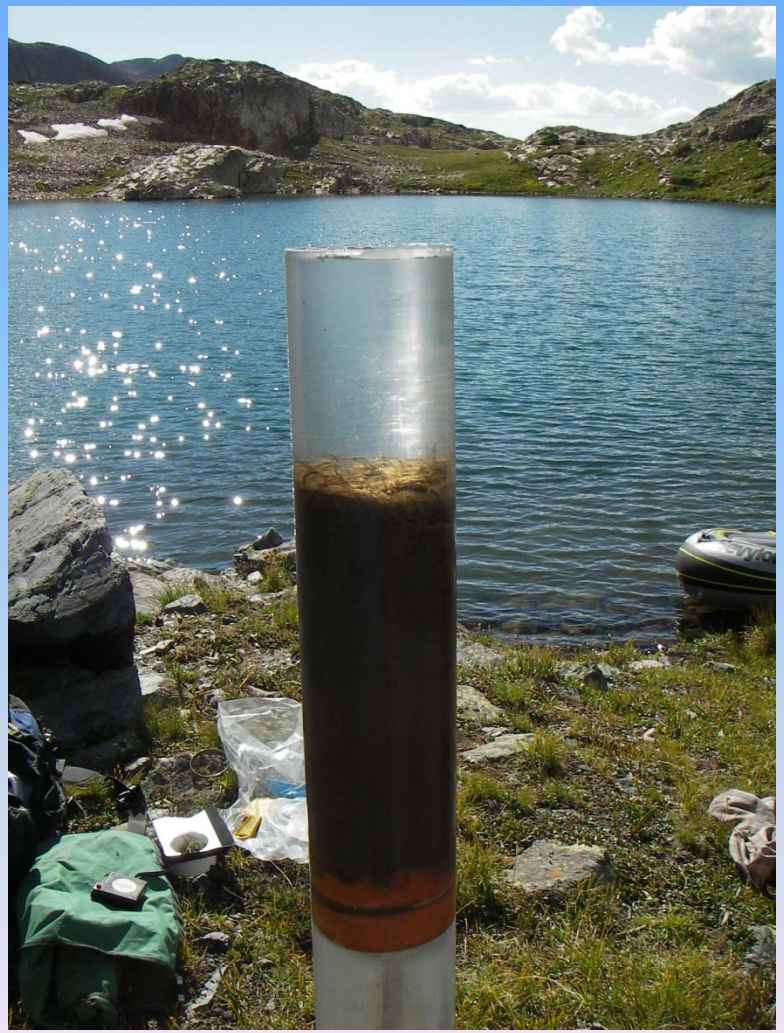


* Reservoirs that have a fish consumption advisory for mercury

* Known source of geologic & mining Hg

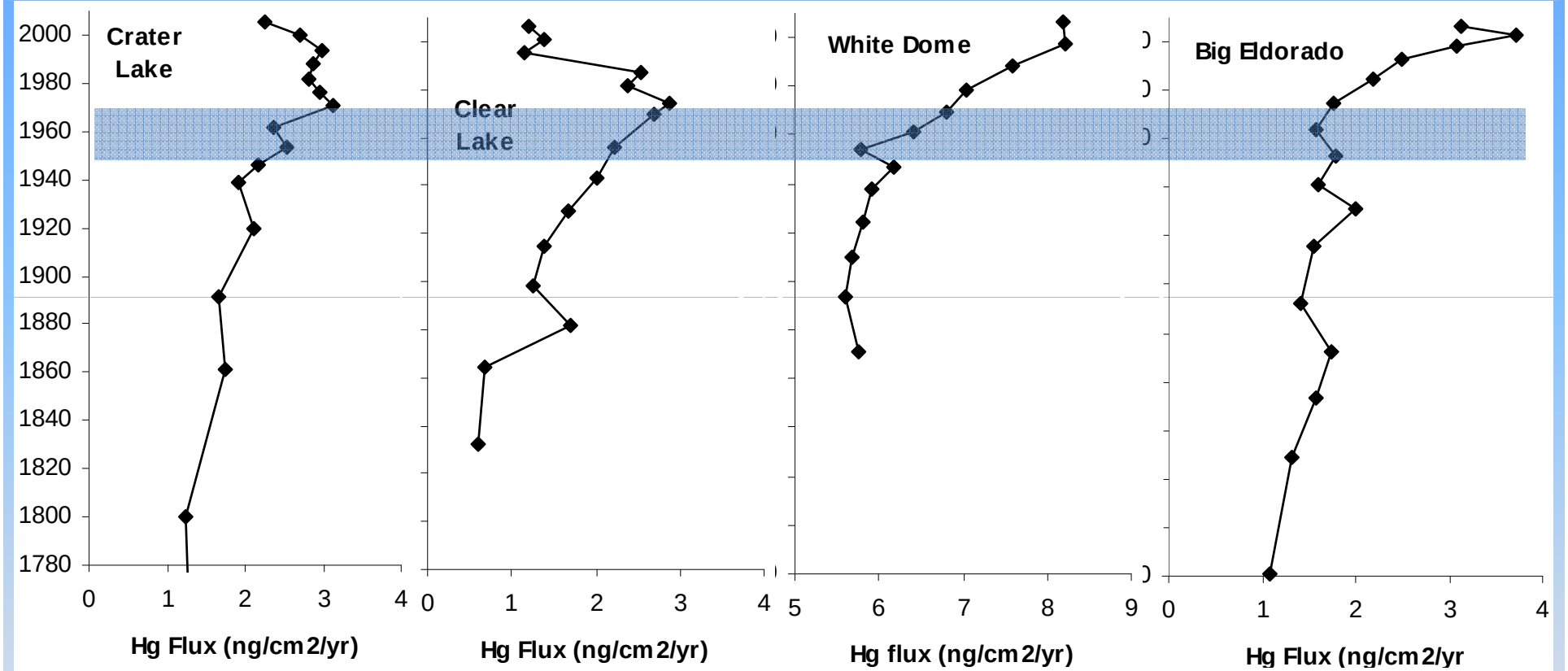
How has input of mercury changed over time?

Mercury in Lake Sediment Cores



How has input of mercury changed over time?

Mercury in Lake Sediment Cores

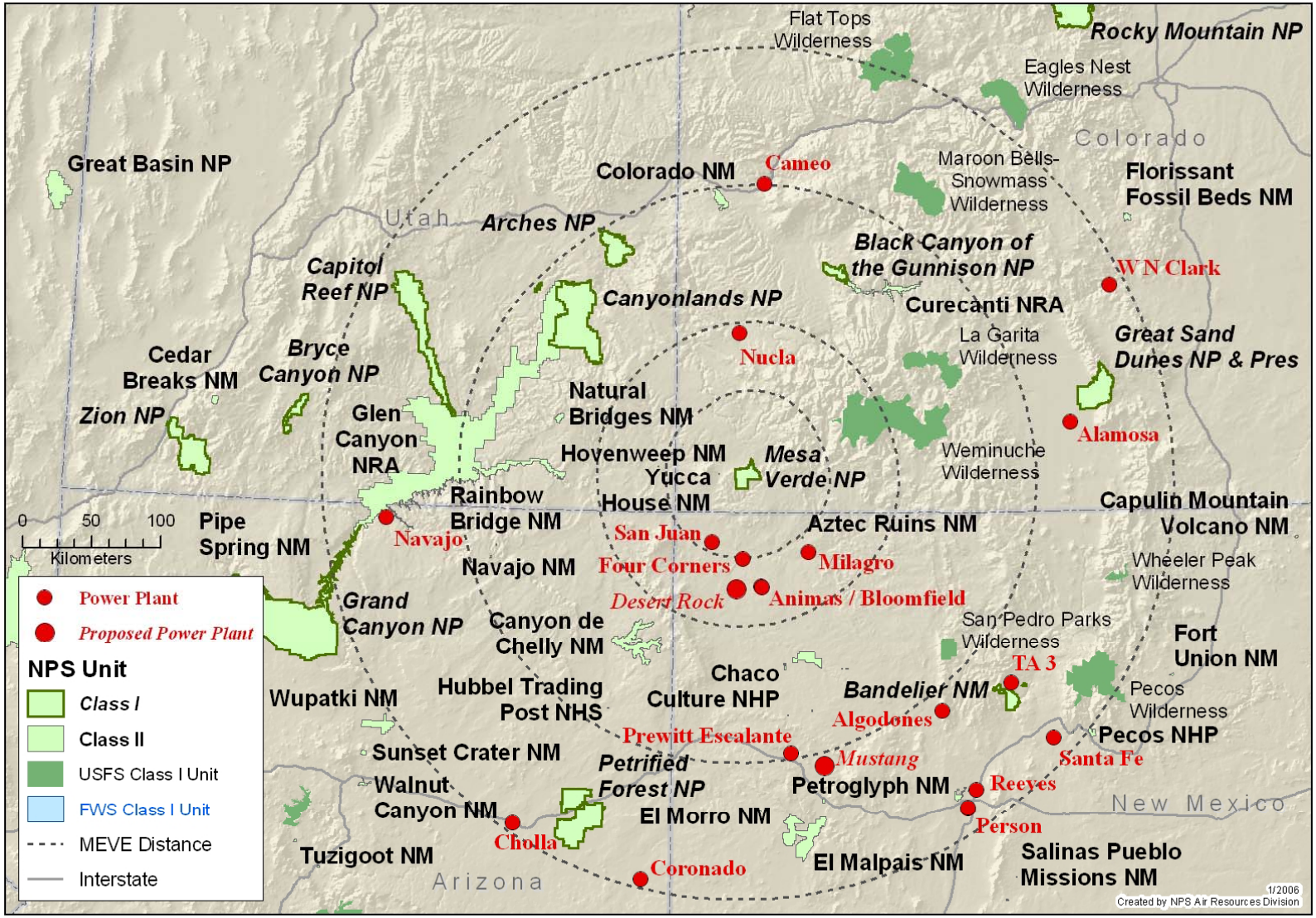


Similar results for 4 cores in Narraguinepp Reservoir (Gray et al. 2005) and small ponds in Pine River Watershed (Win Wright).

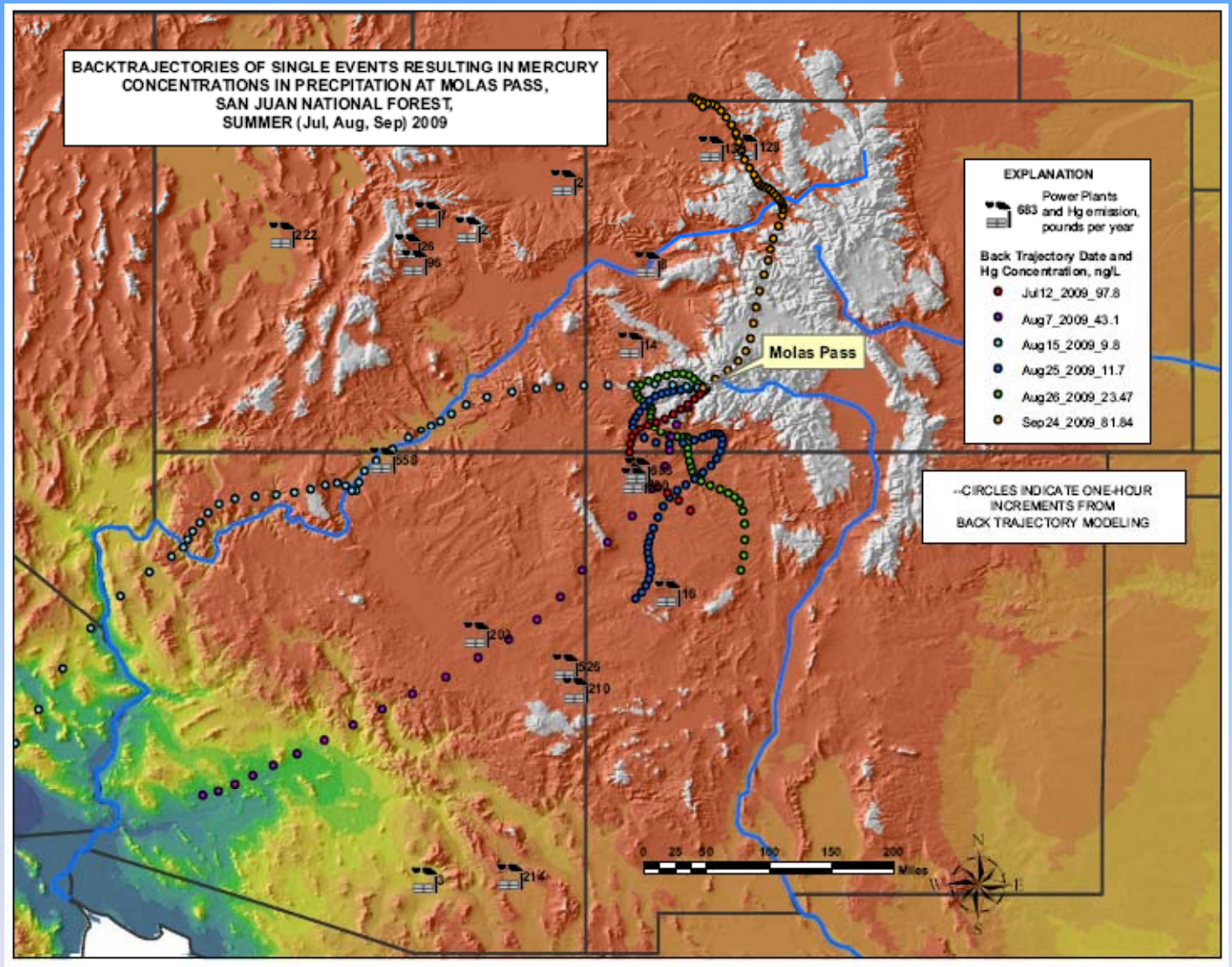
A signature of power plants built in the 1960s and 1970s and subsequent emission reductions?

Nydick, 2010

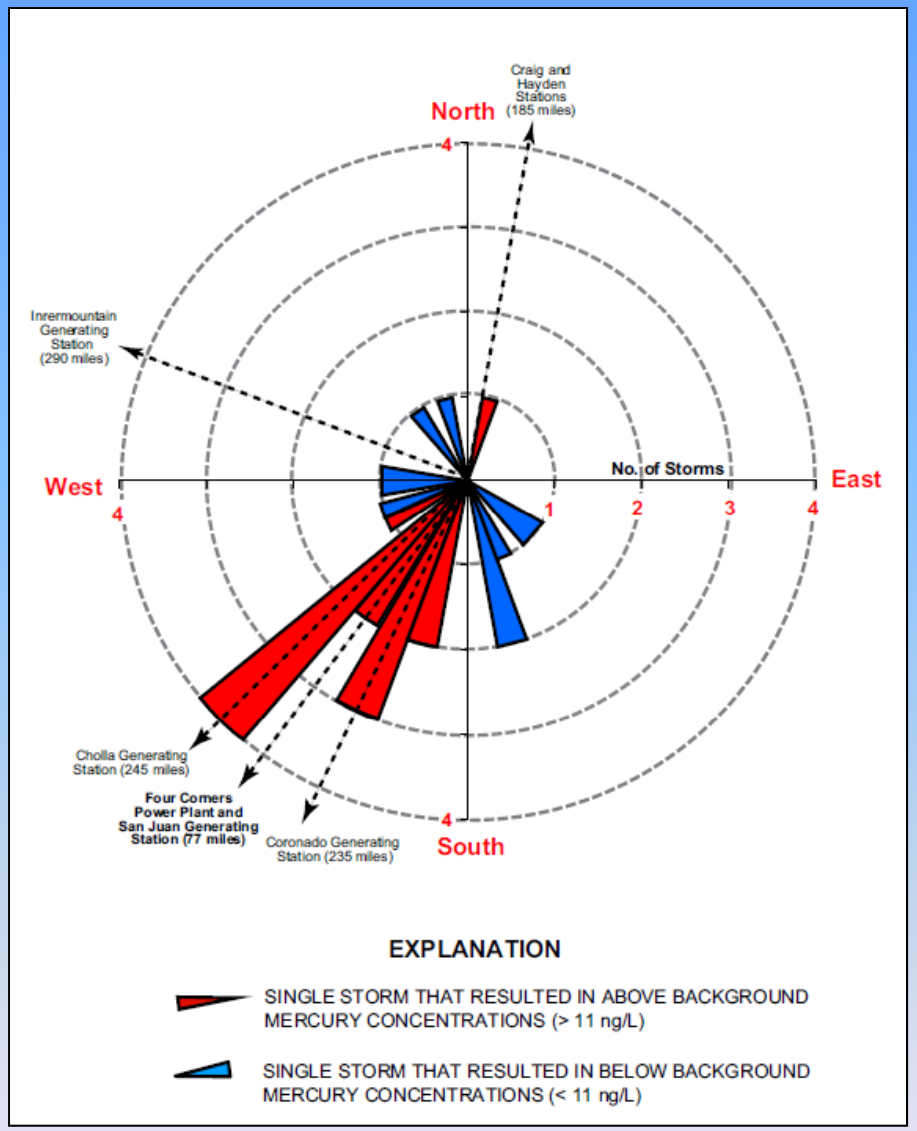
Under what conditions does Hg get transported to alpine lakes?

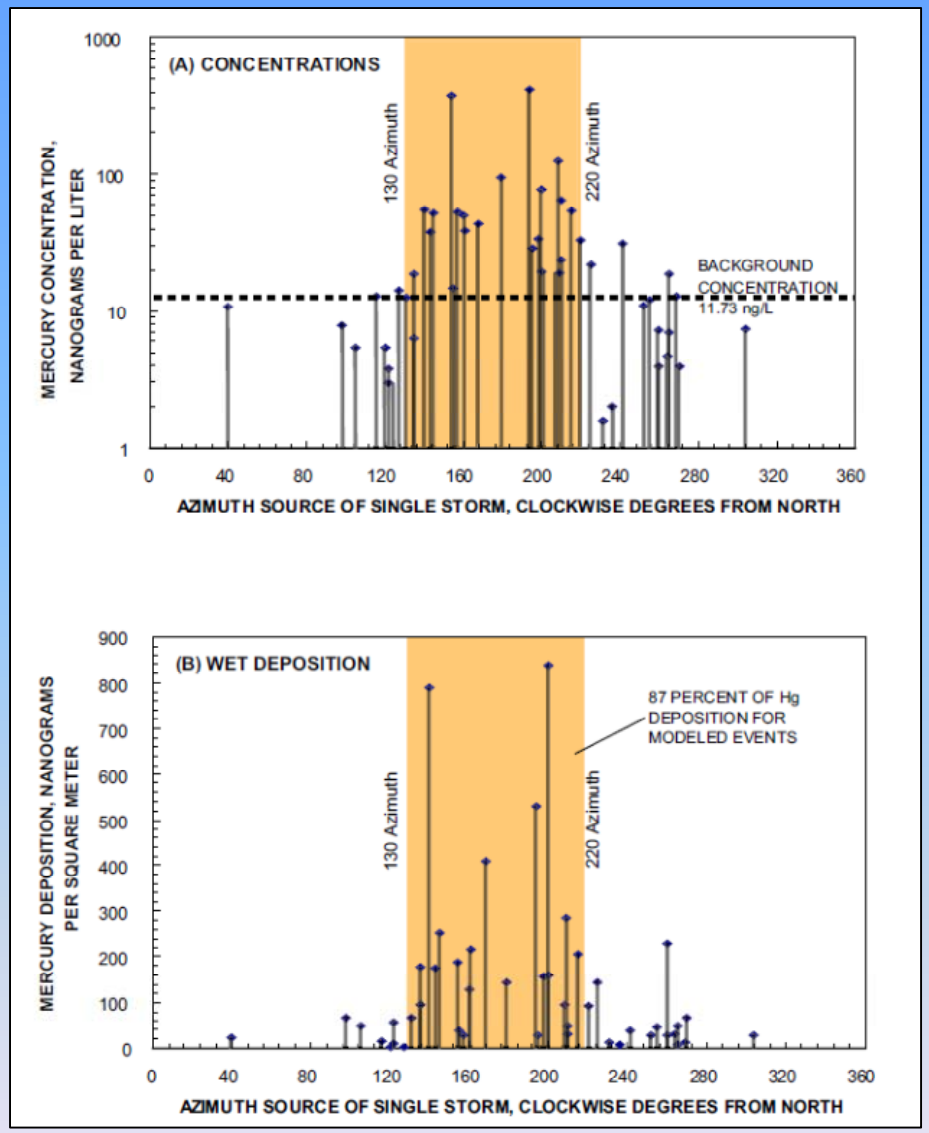


Sources of Atmospheric Mercury Concentrations and Wet Deposition at Molas Pass, Southwestern Colorado (Wright, 2011)

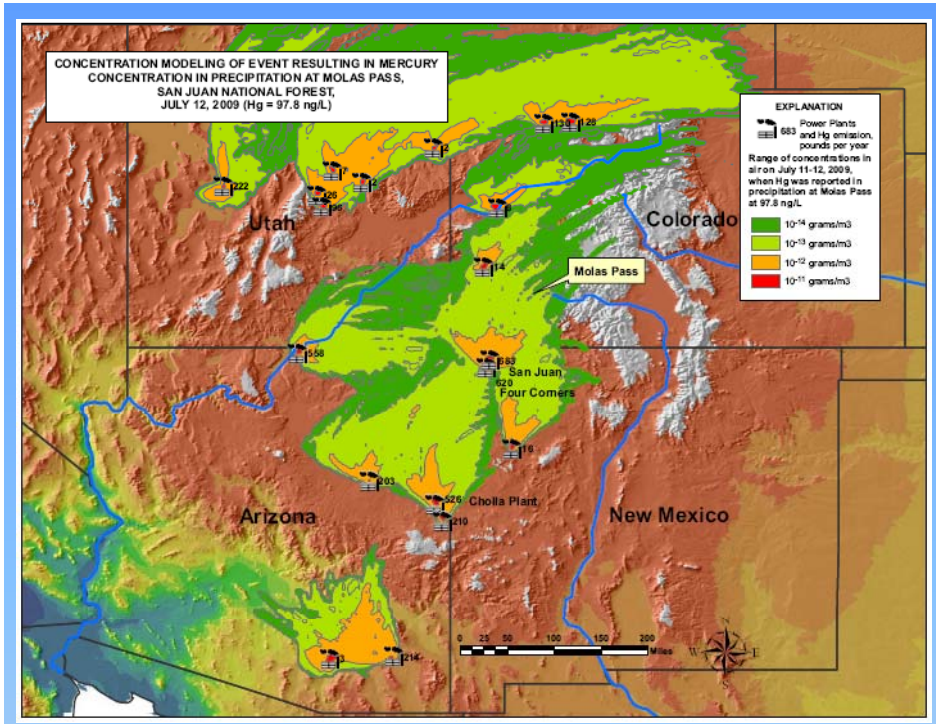


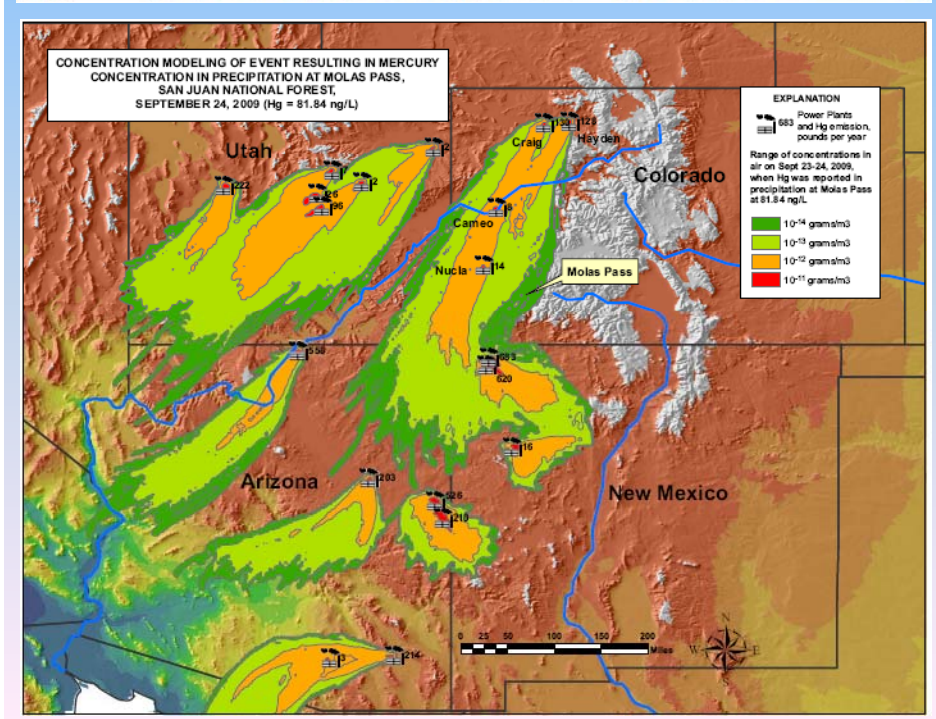
HYSPLIT Model (HYbrid Single-Particle Lagrangian Integrated Trajectory)
http://www.arl.noaa.gov/HYSPLIT_info.php

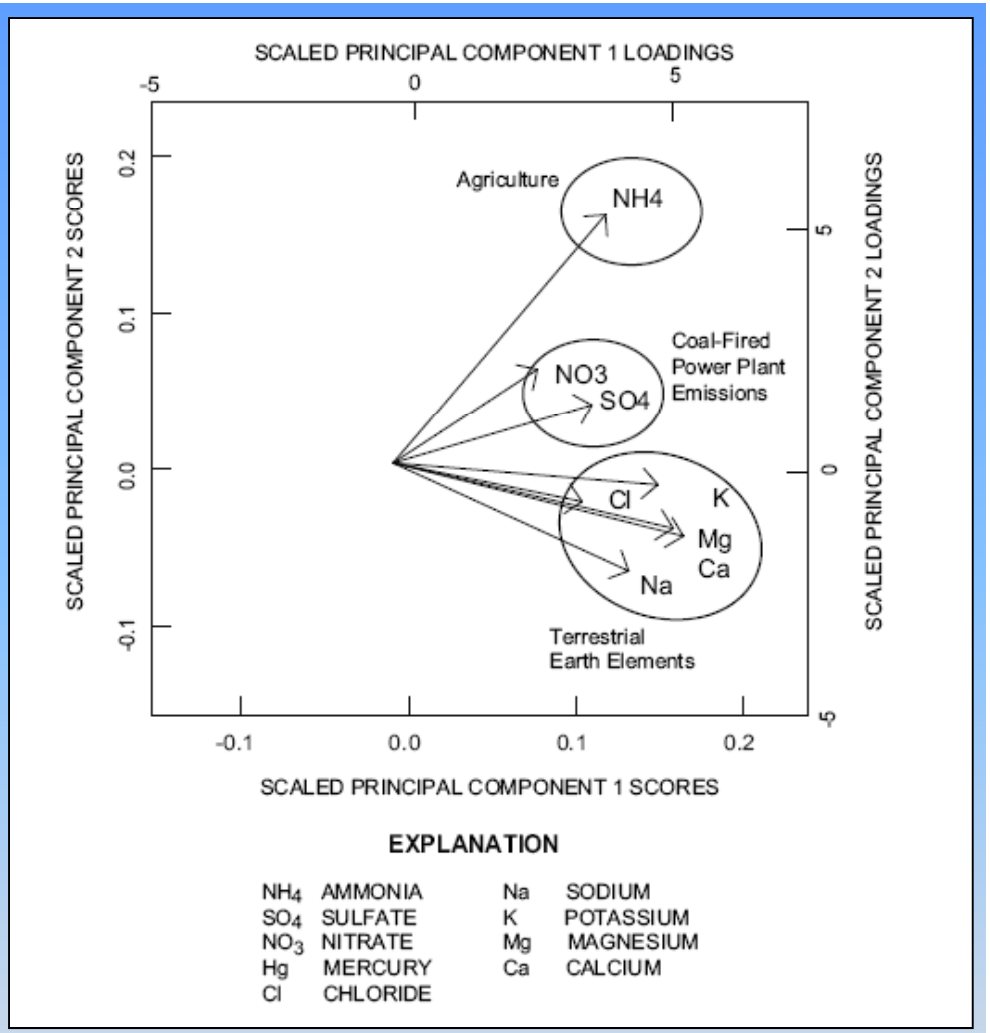

North
Craig and Hayden Stations (185 miles)
Innermountain Generating Station (290 miles)
West
East
No. of Storms
1
2
3
4
Cholla Generating Station (245 miles)
Four Corners Power Plant and San Juan Generating Station (77 miles)
Coronado Generating Station (235 miles)
South
EXPLANATION
SINGLE STORM THAT RESULTED IN ABOVE BACKGROUND MERCURY CONCENTRATIONS (> 11 ng/L)
SINGLE STORM THAT RESULTED IN BELOW BACKGROUND MERCURY CONCENTRATIONS (< 11 ng/L)


(A) CONCENTRATIONS
MERCURY CONCENTRATION, NANOGRAMS PER LITER
130 Azimuth
220 Azimuth
BACKGROUND CONCENTRATION
11.73 ng/L
AZIMUTH SOURCE OF SINGLE STORM, CLOCKWISE DEGREES FROM NORTH
(B) WET DEPOSITION
MERCURY DEPOSITION, NANOGRAMS PER SQUARE METER
87 PERCENT OF Hg DEPOSITION FOR MODELED EVENTS
130 Azimuth
220 Azimuth
AZIMUTH SOURCE OF SINGLE STORM, CLOCKWISE DEGREES FROM NORTH

(Wright, 2011)







Mercury deposition events coincide with specific storm tracks,

Deposition events associated with deposition of NO_3 and SO_4

How will changing climatic conditions affect the fate and transport of mercury?

Effects of Fire and Subsequent Sediment Burial on Sulfur and Mercury Binding in Organic Matter of Forest Soils

Joseph N. Ryan (CU Bolder), George R. Aiken (USGS), Kathryn L. Nagy (University of Illinois), Christopher Peltz (MSI)

Graduate Students:

Jackson P. Webster (CU)

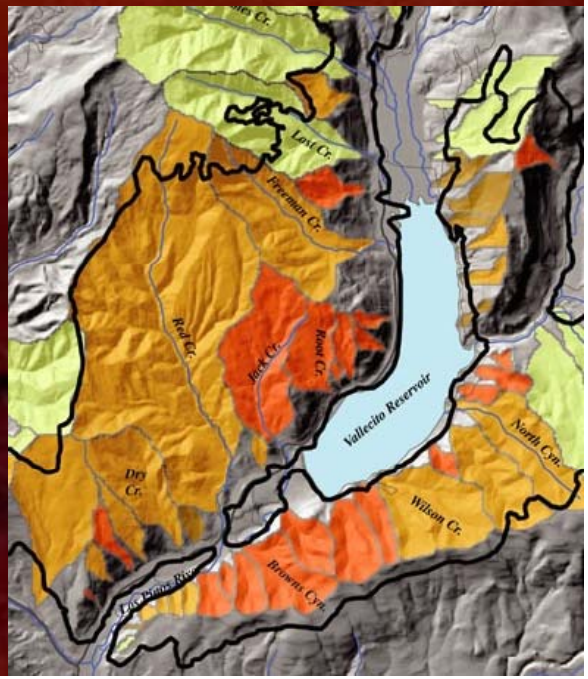
Undergraduate Students:

Crystal Kelly (Fort Lewis College)

Eric Falk (Fort Lewis College)

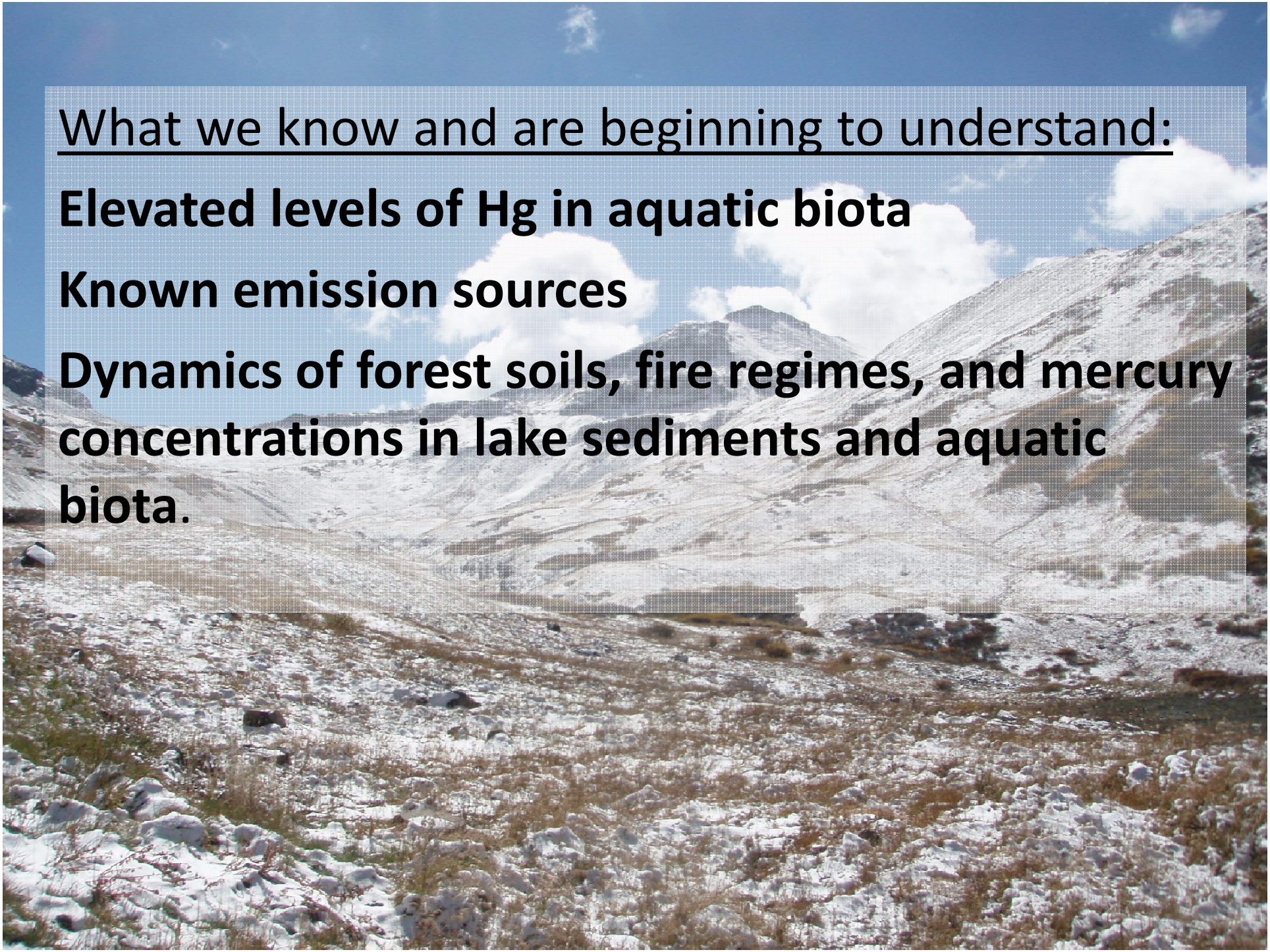
Doug Winter (CU Bolder)

Chelsea Ottenfeld (Virginia Tech)



Lake sediment from Vallecito Reservoir June, 2011

Burned organic layer from recent Rx fires



What we know and are beginning to understand:

Elevated levels of Hg in aquatic biota

Known emission sources

Dynamics of forest soils, fire regimes, and mercury concentrations in lake sediments and aquatic biota.

Mountain Studies Institute
SAN JUAN MOUNTAINS, COLORADO

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Home

Air Quality in the San Juan Mountains

Overview

MSI is addressing regional air quality issues and concerns by doing research, long-term monitoring, outreach, and collaborating with regional partners.

The San Juan Mountains are perceived as having crystal clean air because of their remoteness from large cities. However, these mountains are in close proximity to an industrialized area. The Four Corners is a center for coal-fired energy and methane (natural gas) production. For example, San Juan County, in northwestern New Mexico, is one of the largest emitters of power plant mercury among all counties in the nation.

An additional coal-fired power plant and about 12,000 more natural gas wells are proposed for the Four Corners. Concerns about mercury, ground-level ozone, nitrogen and other pollutants and their effects on human health, visibility, and ecosystems are growing. Mercury concentrations in precipitation are alarmingly high and several water bodies in the region have fish consumption advisories due to mercury. Ozone levels are approaching the limit for public health considerations. Nitrogen concentrations in gaseous NOx and in precipitation are increasing.

Click on the links below to find out about different projects within MSI's Air Quality Program.

Mercury Deposition & its Effects in the San Juans

In 2007, MSI began studying mercury in rain and snow, lakes, and forest soils. Mercury is an emerging environmental health concern in the Four Corners.

Ozone Bio-Monitoring Project: Assessment of Vegetation for Signs of Injury due to Ozone

This 2009 baseline survey looked for signs of vegetation injury due to ozone. A type of unknown injury was found in one of the study species, but it was concluded, after much literature review and expert opinion, not be be caused by ozone.

San Juan Air Quality Forum

Get Involved

Donate