Measurement of Mercury Mobilization and Accumulation in Fish in Response to Wildland Fire in a Boreal Forest Ecosystem

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Wind-Fire Symposium
Cloquet Forestry Center
February 18, 2009

Collaborators

- Randy Kolka, PI - Northern Research Station, Grand Rapids
- Laurel Woodruff, Bill Cannon – USGS
- Ed Nater – U of M
- Jason Butcher, Ken Gebhardt and the Superior NF fish crew

Outline

Background on Mercury

- **Hydrologic Cycling of Total Mercury**

Research

- **Study Background**
- **Mercury in Soils**
- **Forest Canopy Effects on Hg Deposition**
- **Fire Effects on Mercury Cycling**
- **Watershed Affects**
- **Summary**

A Little About Mercury

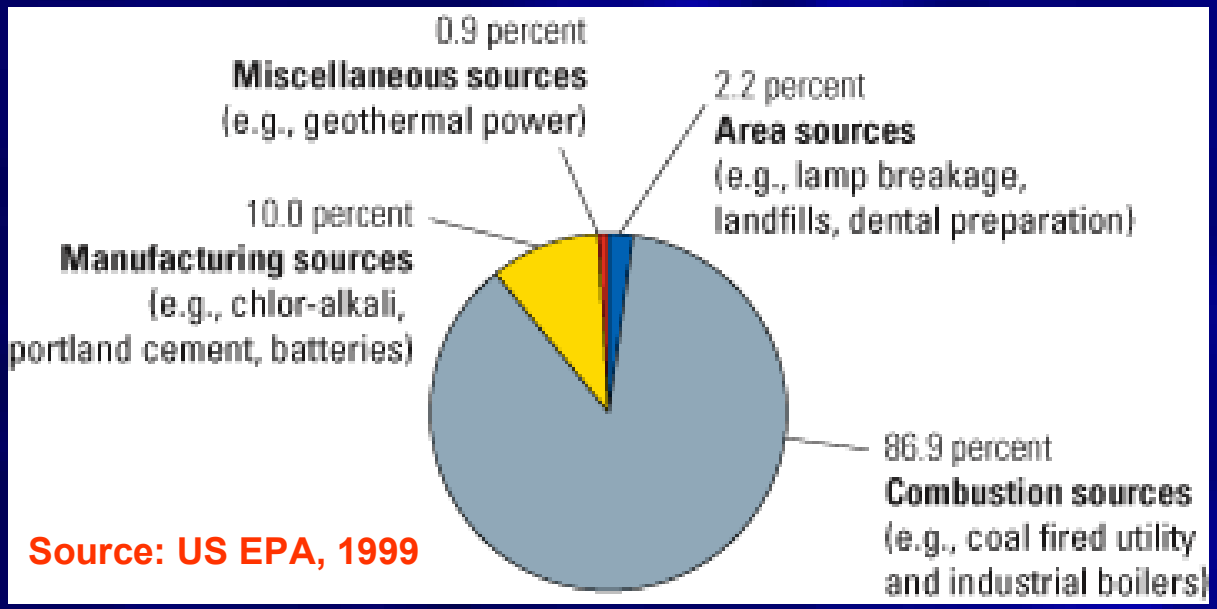
- Background
  - Sources and Forms
  - Landscape Influences
  - Health Risks

Background – Sources of Hg

- Natural Sources of Hg
  - Not Many
  - Geologic Materials
    - Cinnebar
    - Volcanic
    - Carbon Deposits

Background – Sources of Hg

- **Anthropogenic Sources of Hg**
  - **Power Plants**
  - **Other Fossil Fuel Combustion**
  - **Manufacturing**



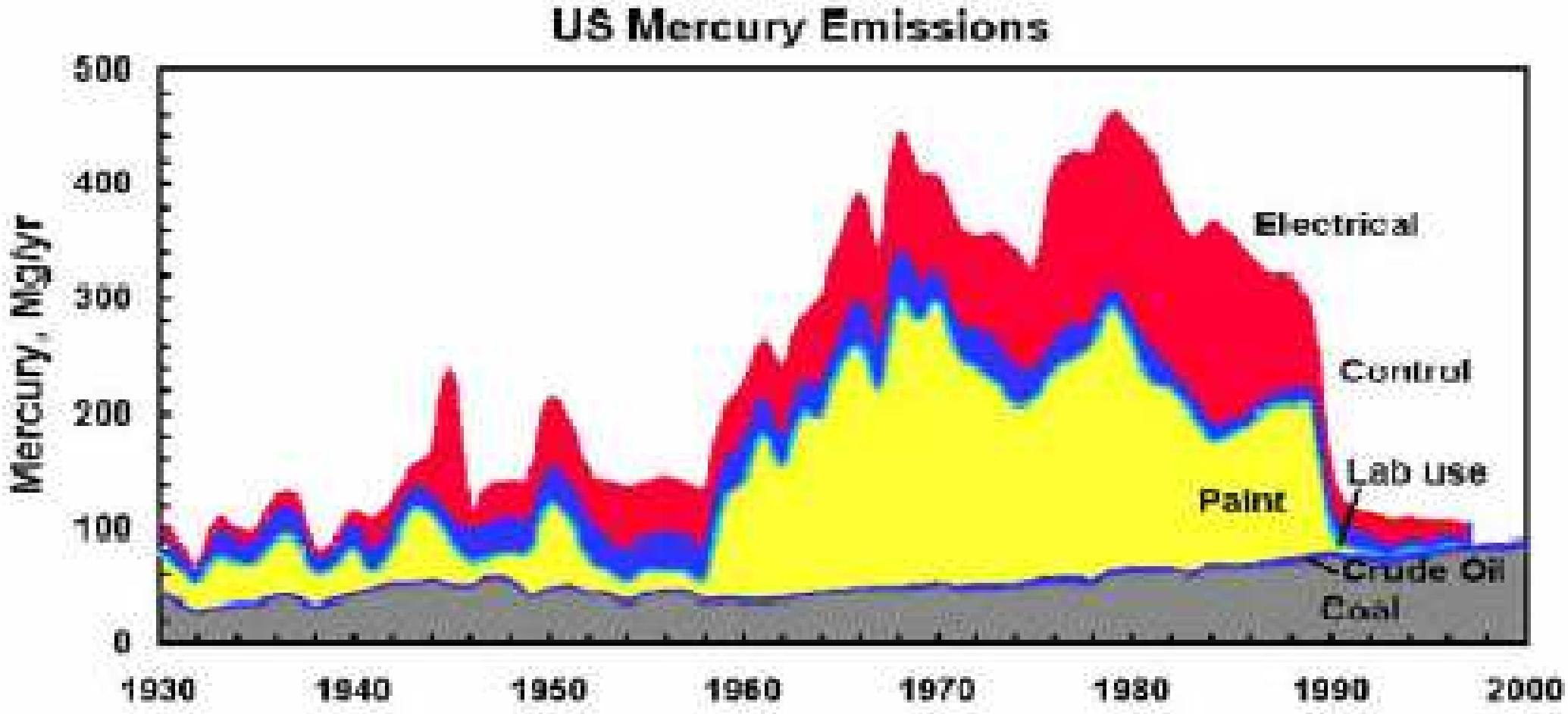
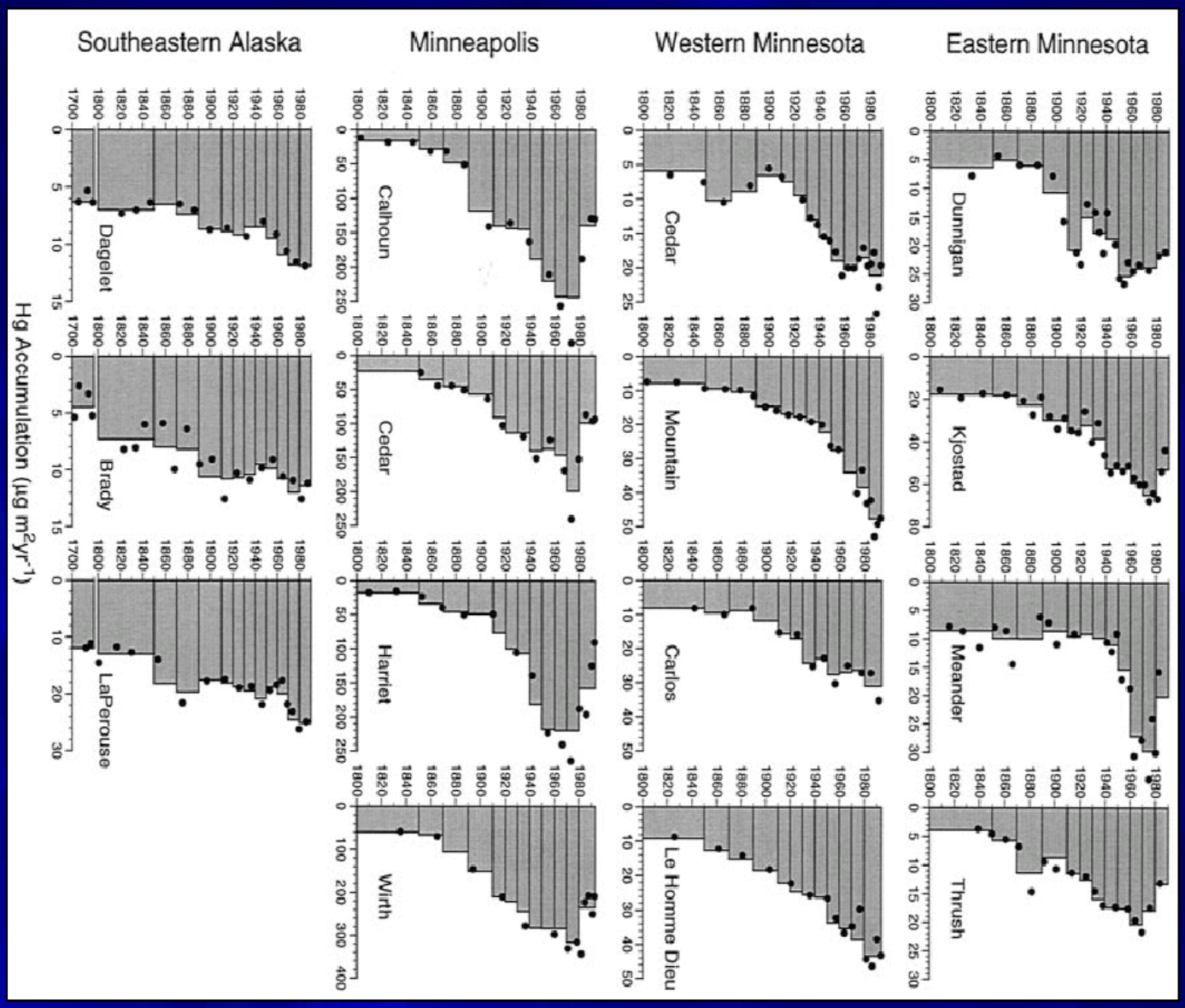


Figure 12 United States Mercury Emissions by Category

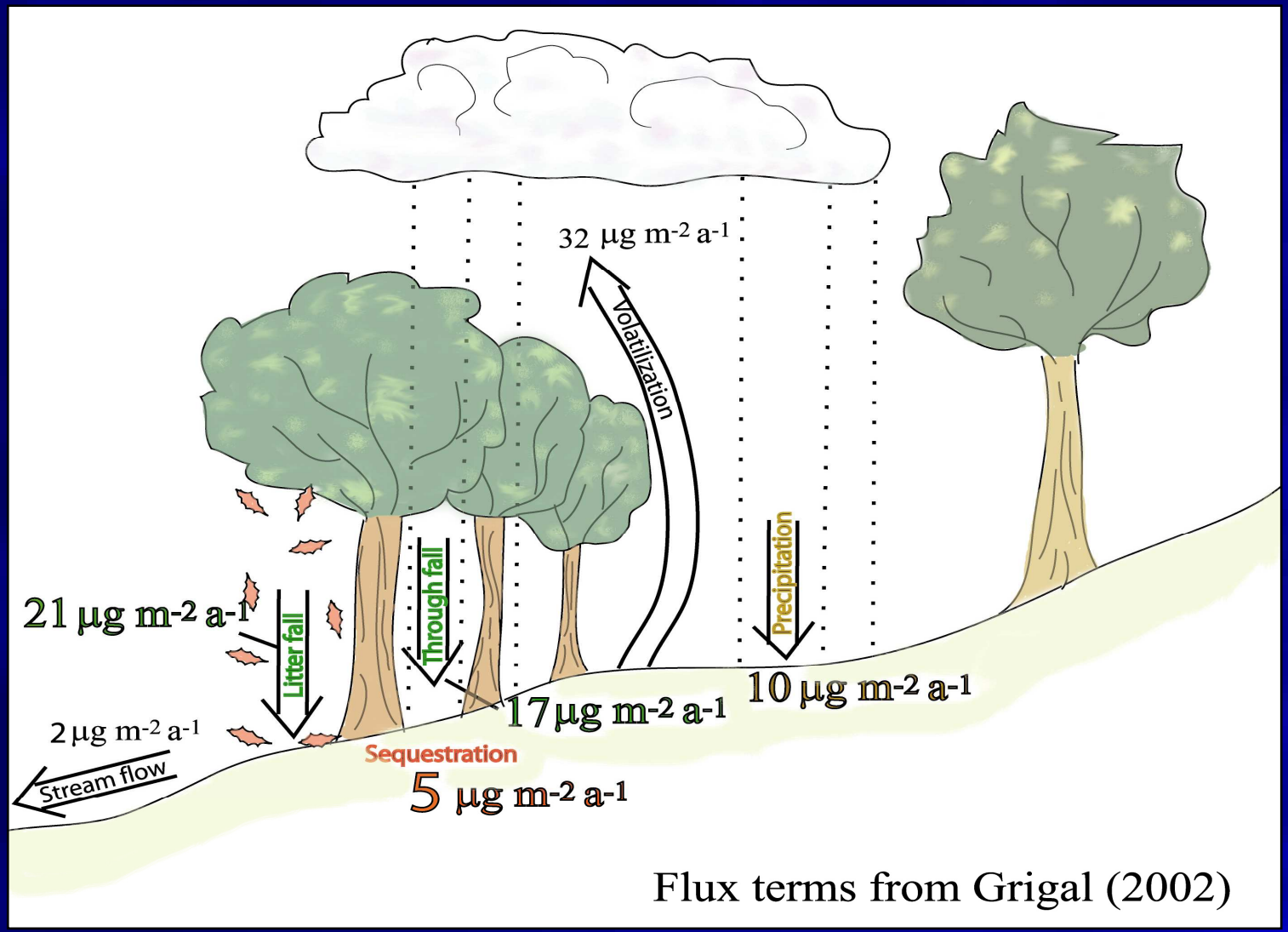
Ref. - Minnesota's Total Maximum Daily Load Study Of Mercury Draft* May 24, 2005, Prepared By Minnesota Pollution Control Agency

Lake Sediment Cores



Engstrom and Swain, 1997

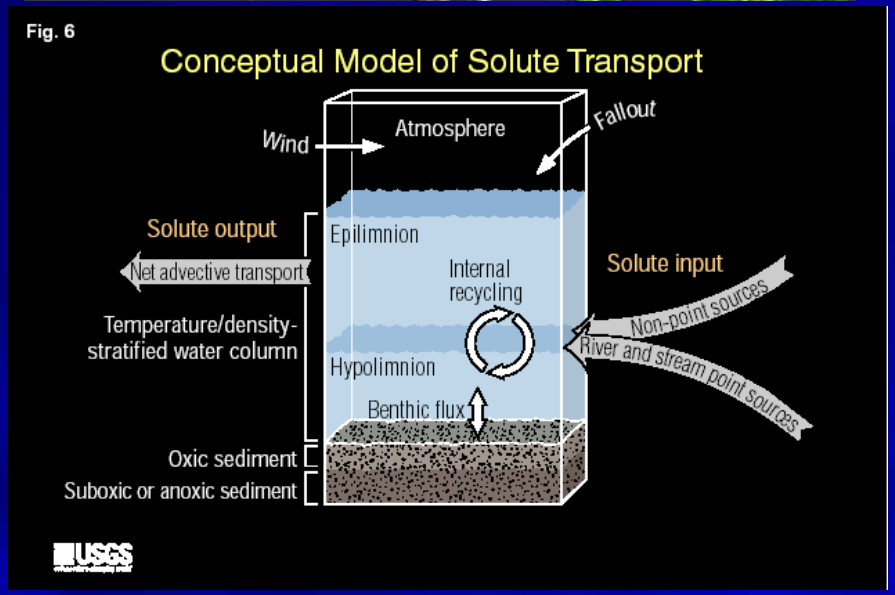
Forest Mercury Cycle



Flux terms from Grigal (2002)

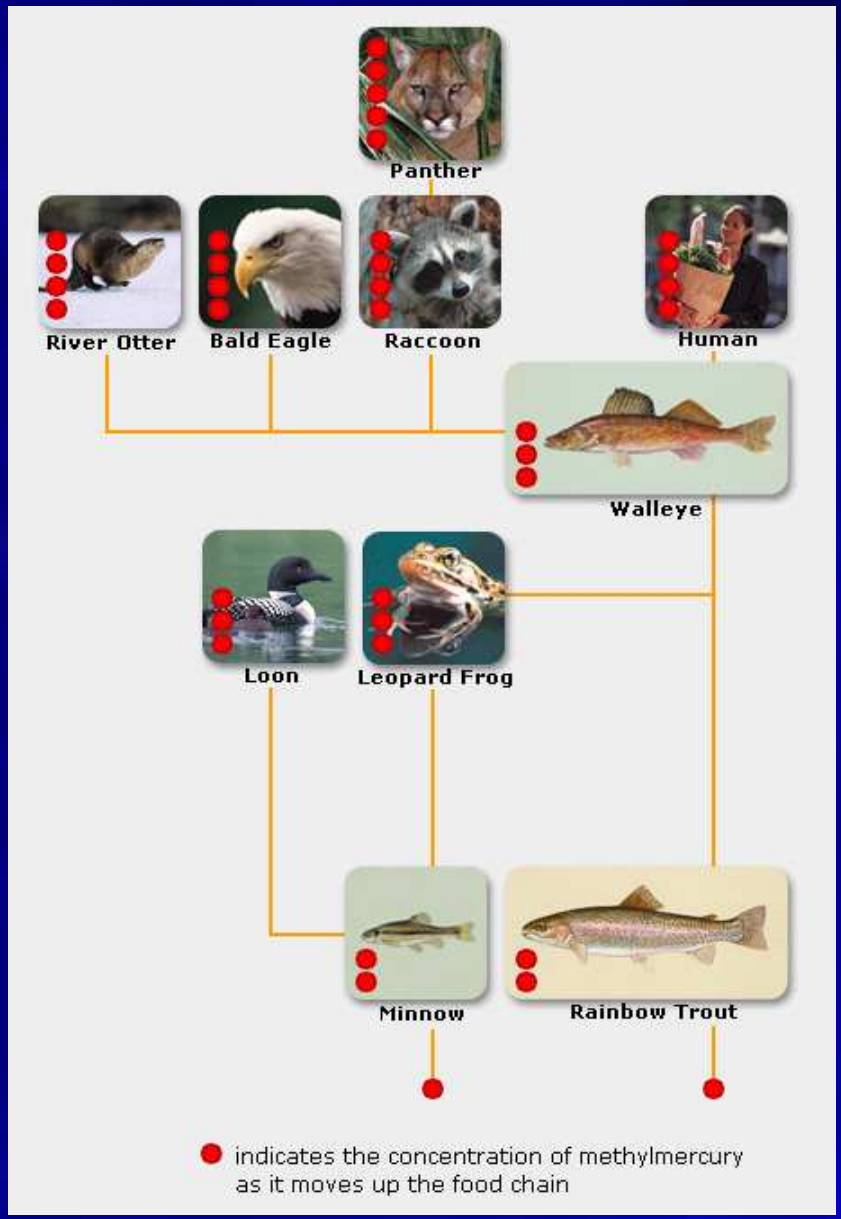
Background – Landscape Influences

- Production of Methyl-Hg
  - Low Oxygen
  - Food (Carbon)
- WETLANDS
- LAKE/STREAM BOTTOM



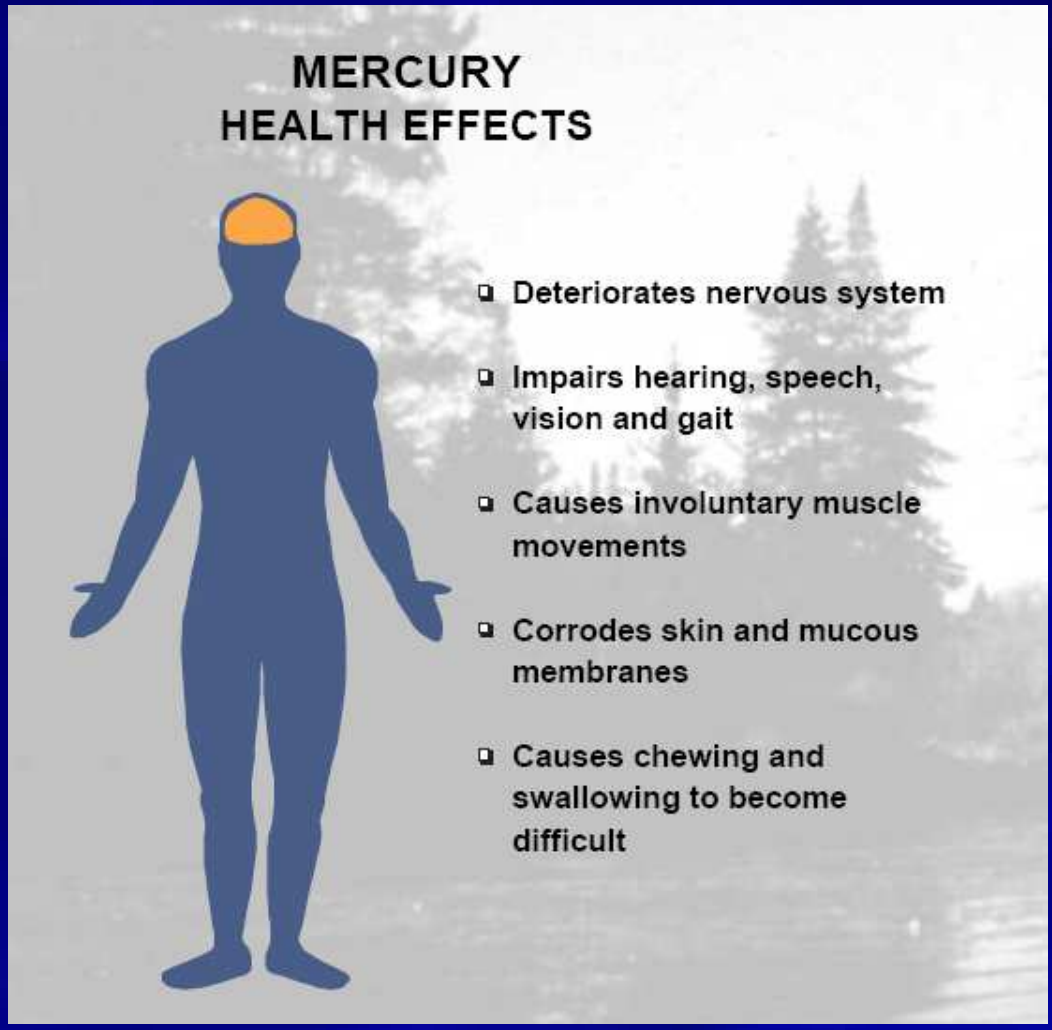
Background – Health Risks

- **Bioaccumulation in the Aquatic Food Chain**
  - **Bioaccumulation factor ~ 1 million from concentration of mercury in water versus humans**



Background – Health Risks

- Health Consequences
  - Attacks Nervous System
  - Reproductive System
  - Mercury Poisoning
    - Mad Hatters Disease
    - Iraq Poisoning
    - Minamata Disease

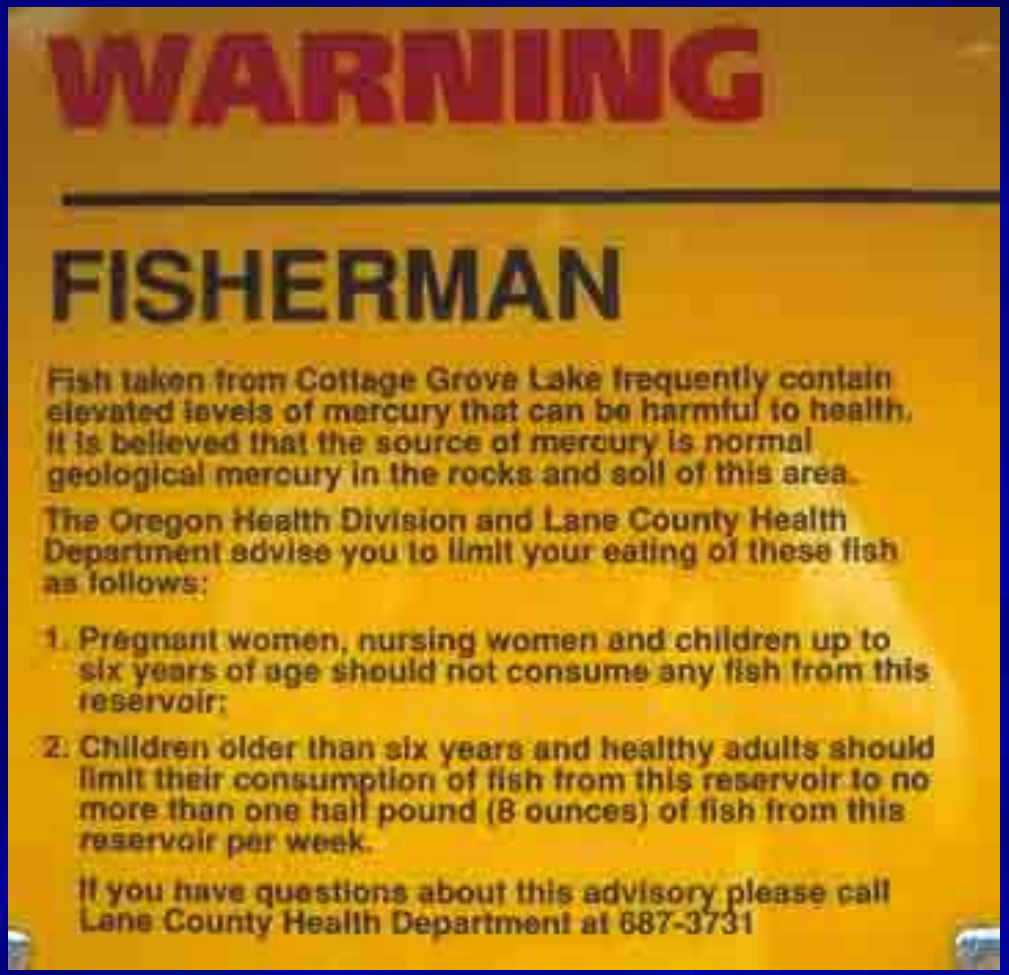


Background – Health Risks

- **Susceptible Groups**
  - **Fetuses and Young Children**
  - **Women of Childbearing Age**
  - **Native Americans, Asians and Pacific Islanders**

Background – Health Risks

- **Fish Consumption Advisories**
  - **Now in Every US state, Canadian Province and Across Europe**
  - **In MN All Surface Waters Have Warnings**



Background – Health Risks

Guidelines for pregnant women, women planning to become pregnant and children under age 15

Kind of fish you eat	How often can you eat it?*
Fish caught in Minnesota:	
Sunfish, crappie, yellow perch, bullheads	→ 1 meal a week
Walleyes shorter than 20 inches, northern pike shorter than 30 inches, smallmouth bass, largemouth bass, channel catfish, flathead catfish, white sucker, drum, burbot, sauger, carp, lake trout, white bass, rock bass, whitefish, other species	→ 1 meal a month
Walleyes longer than 20 inches, northern pike longer than 30 inches, muskellunge	→ **Do not eat.**
Commercial fish:	
• Shark, swordfish, tile fish, king mackerel	→ **Do not eat.**
• Other commercial species, including canned tuna	→ See MDH's brochure, *"An Expectant Mother's Guide to Eating Minnesota Fish."*

* These guidelines apply even if eating fish just during a vacation or for just one season.

What it's All About !

Mercury Research

- Study Background
- Mercury in Soils
- Forest Canopy Effects on Hg Deposition
- Fire Effects on Mercury Cycling
- Watershed Affects
- Summary

An Idea Conceived

The Joint Fire Science Program was established by Congress in 1998 to provide scientific information and support for wildland fuel and fire management programs. The program is a partnership of six federal agencies;

in the Department of Agriculture:

- Forest Service

in the Department of the Interior:

- Bureau of Indian Affairs
- Bureau of Land Management
- National Park Service
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

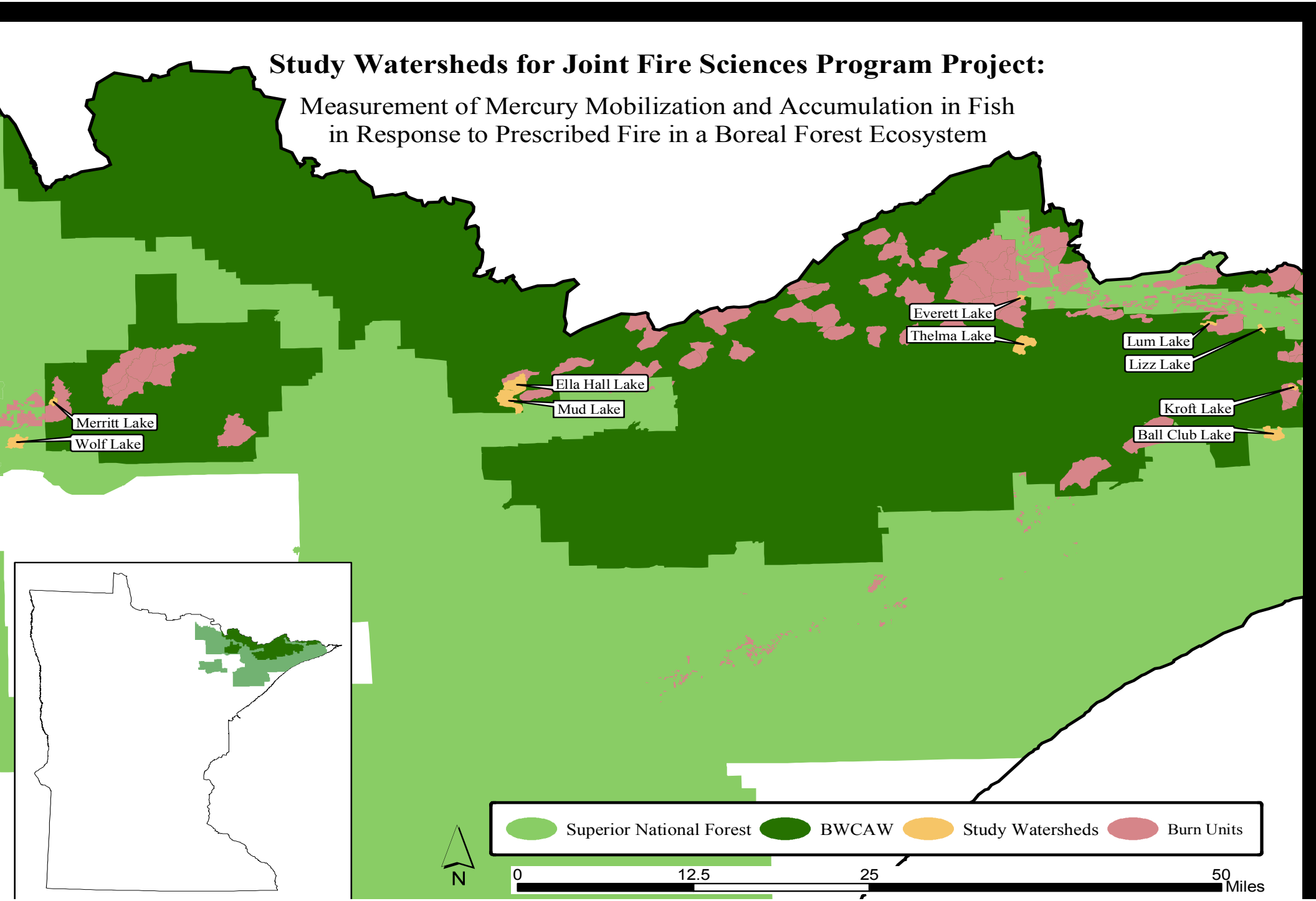
USGS
science for a changing world

Questions to be Addressed

- Will burning activities cause the mercury content of fish to change?
- Will the mercury content of the fish return to pre-burn levels?
- What is the time scale for these changes?

Additional Ancillary Questions

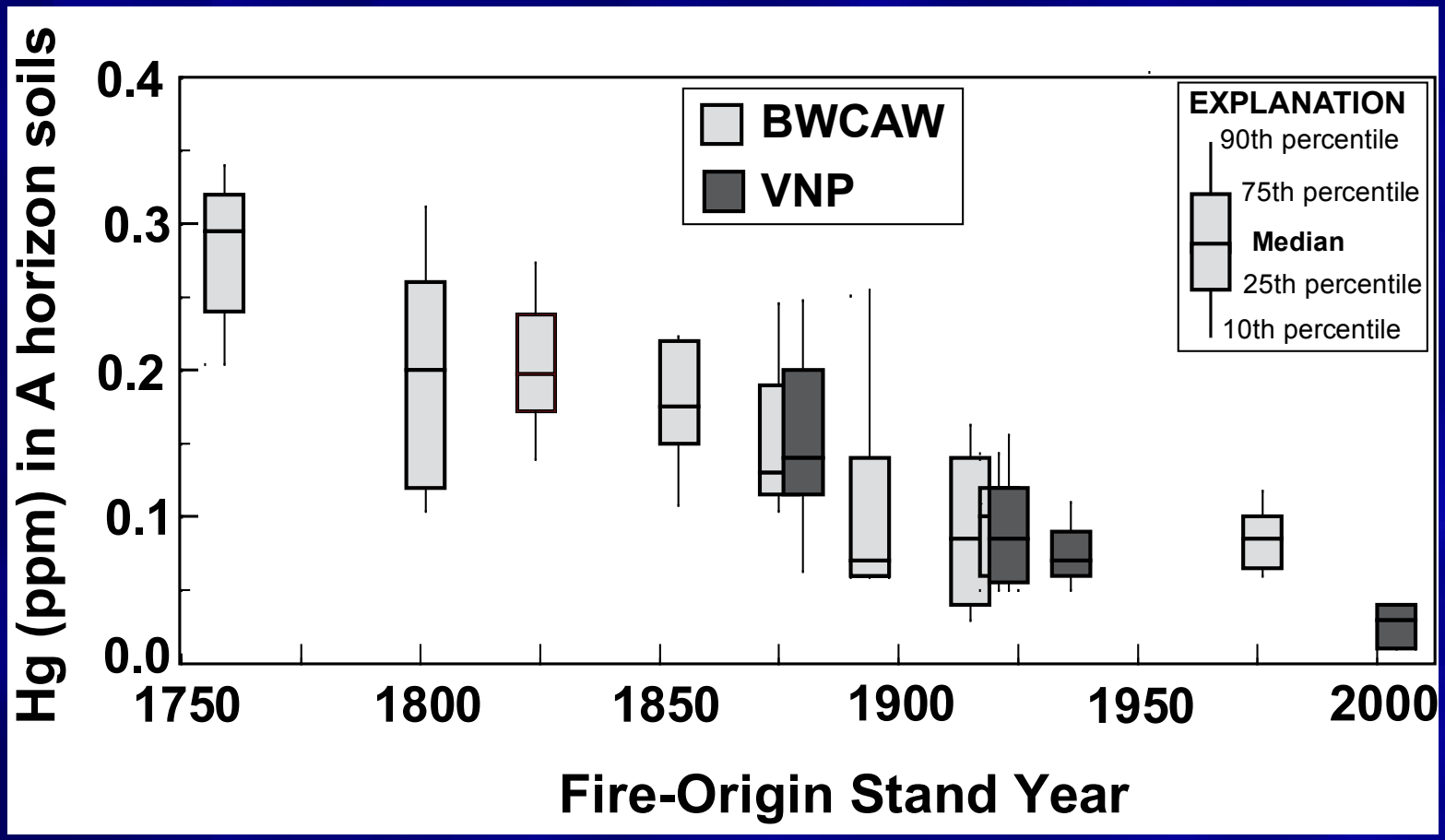
- Gain a better understanding of the mechanisms underlying the changes in fish mercury observed
- Determine if fire intensity affects the magnitude of the change in fish mercury
- Suggest mitigation measures based on our overall understanding of how mercury cycles in the ecosystem.


Study Watersheds for Joint Fire Sciences Program Project:
Measurement of Mercury Mobilization and Accumulation in Fish
in Response to Prescribed Fire in a Boreal Forest Ecosystem
Everett Lake
Thelma Lake
Lum Lake
Lizz Lake
Ella Hall Lake
Mud Lake
Kroft Lake
Ball Club Lake
Merritt Lake
Wolf Lake
Superior National Forest
BWCAW
Study Watersheds
Burn Units
N
0
12.5
25
50
Miles

Study Workplan

- Paired Watershed study
  - 5 pairs of lakes across the forest
    - One in a burned watershed
    - One nearby in an unburned watershed
- Parameters measured, pre and post burn
  - Water Quality, epilimnion and hypolimnion
    - General chemistry and total and methyl mercury
  - Fish Mercury (perch)
  - Soils
  - Deposition

Mercury in Soils

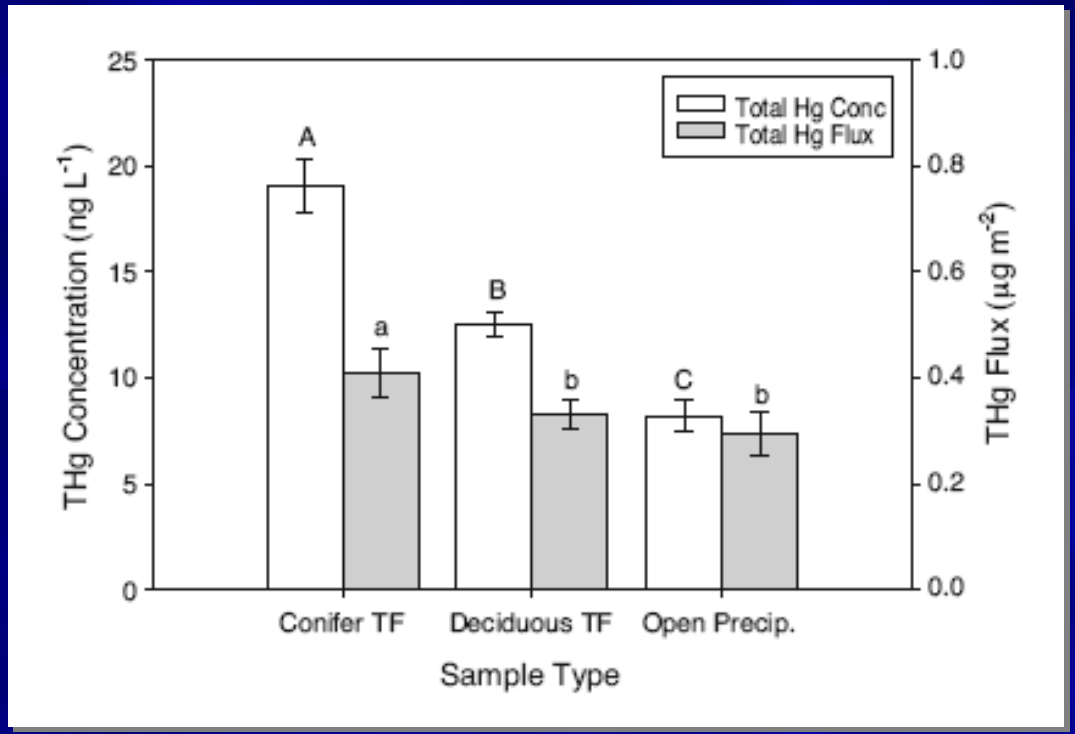


Woodruff and Cannon

Mercury in forest soils is strongly influenced by forest disturbance, especially forest fires

Forest Canopy Effects on Hg Deposition

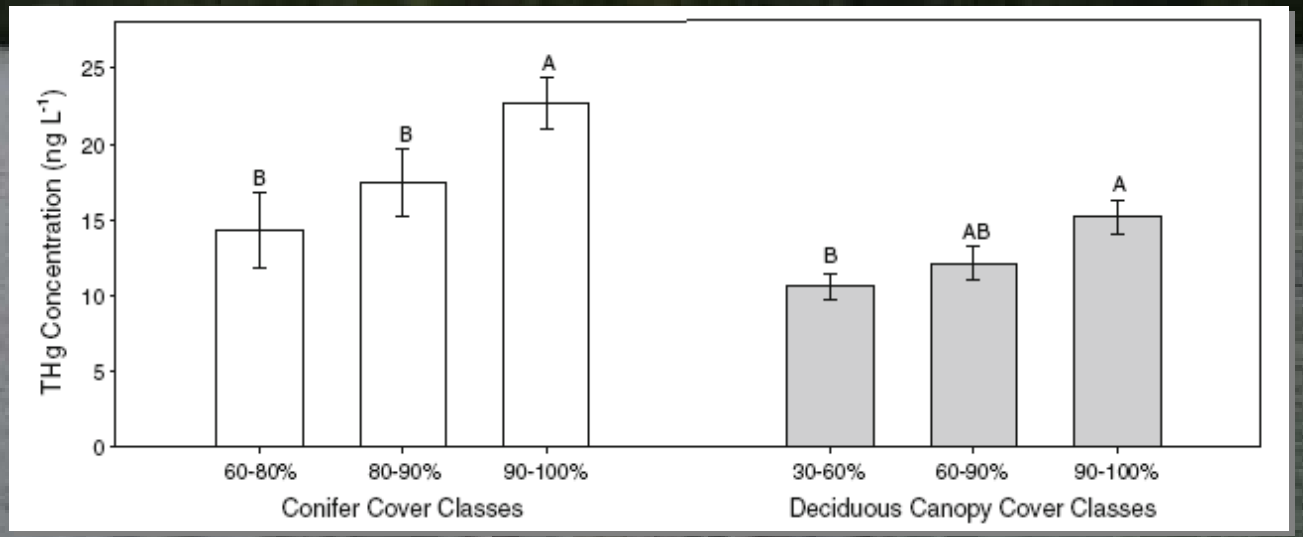
- Sampled throughfall under conifer, deciduous and open canopies in the BWCAW
- Found higher concentrations of Total Mercury under conifer canopies
- Deposition of Total Mercury was also highest under conifer canopies



Witt et al., 2008a

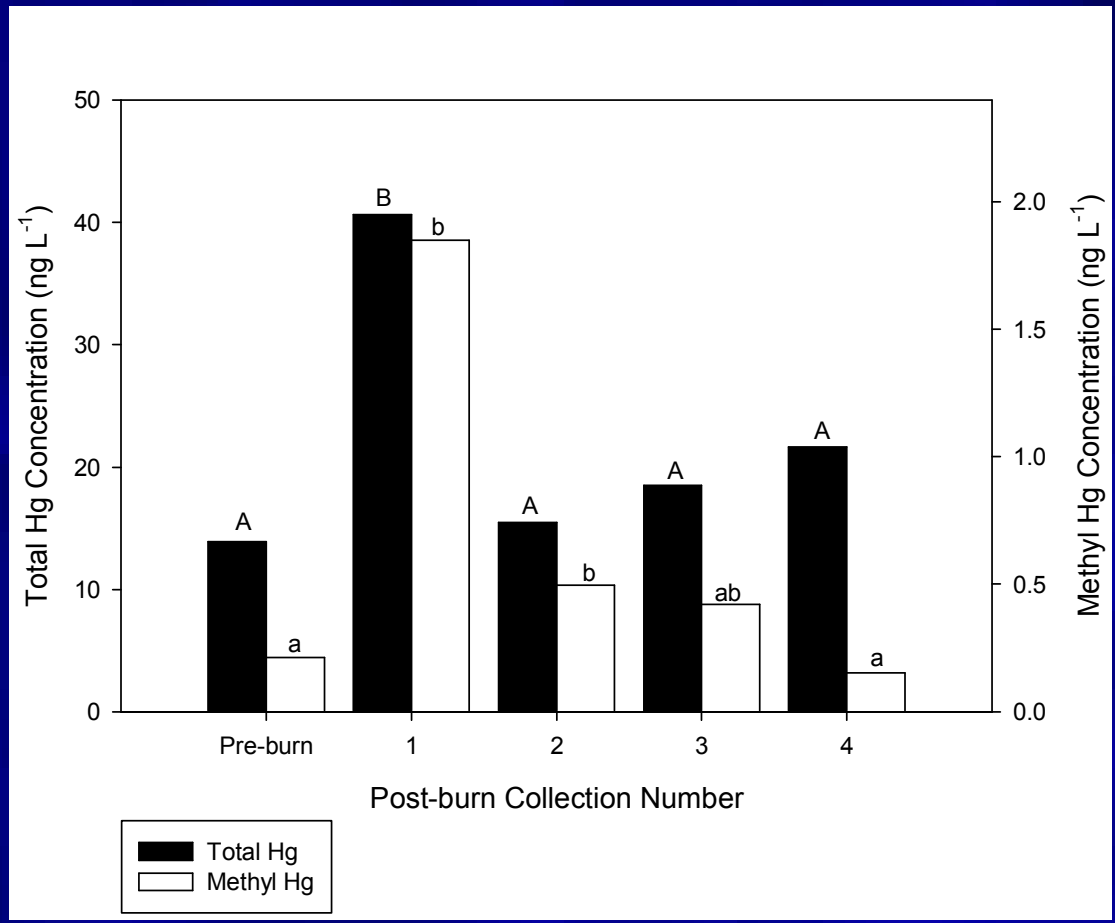
Forest Canopy Effects on Hg Deposition

- Increasing canopy density increased concentrations of total mercury in throughfall for both conifer and deciduous canopies



Fire Effects on Hg Cycling

- Fire leads to a short-term pulse of deposition of mercury downwind, especially in conifer systems
- Increase is about 30-40% of annual deposition
- Will this one-time pulse of deposition cause a measureable change in the fish?
- Still working on it, Stay Tuned!

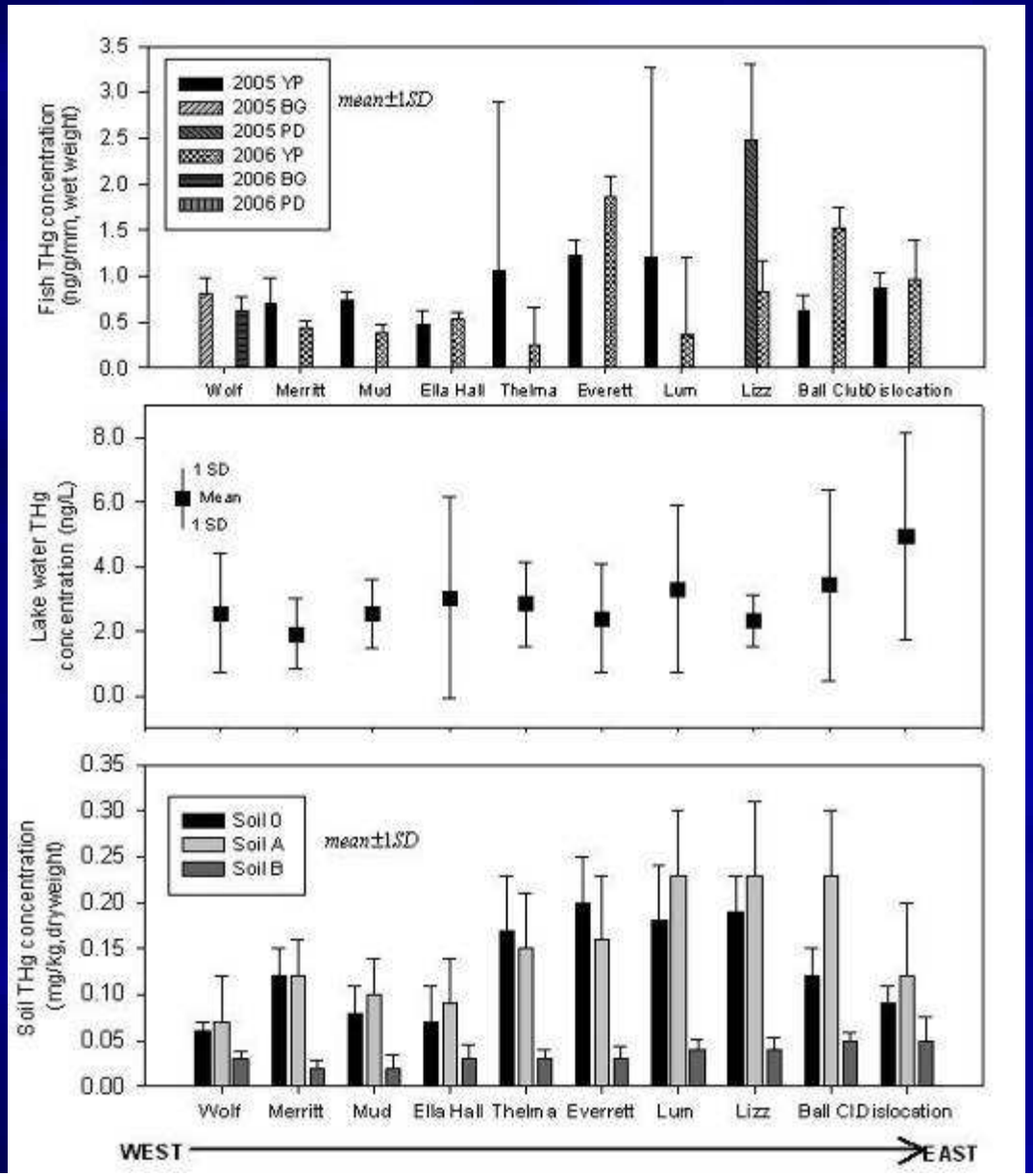


Witt et al., 2008

Watershed Affects

- Relationships between yellow perch mercury tissue concentration and a total of 45 watershed and water chemistry parameters were evaluated for two separate years: 2005 and 2006.
- The main factor controlling and/or predicting fish mercury levels was soil mercury concentrations
- Secondary factors included: watershed area, lake water pH, and nutrient levels
- Waiting for burns to look at changes in these factors due to fires

Watershed Affects



Summary

- Forest canopy is a source of mercury
- Forested mercury deposition is 2X that in an opening
- Watershed soils are sinks for mercury
- Over the long term the level of mercury in fish is related to the level in the soils of the fish's watershed, which is itself related to its fire history
- Due to a lack of burns we have little info on short term (1-5 years) changes in these factors due to fires
- Until the world reduces emissions of mercury, mercury contamination of fish will continue to be a problem
- We are looking for resources to continue our work…


Thank You!