

Effects of Forest Type and Fire on Mercury Deposition in Boreal Ecosystems

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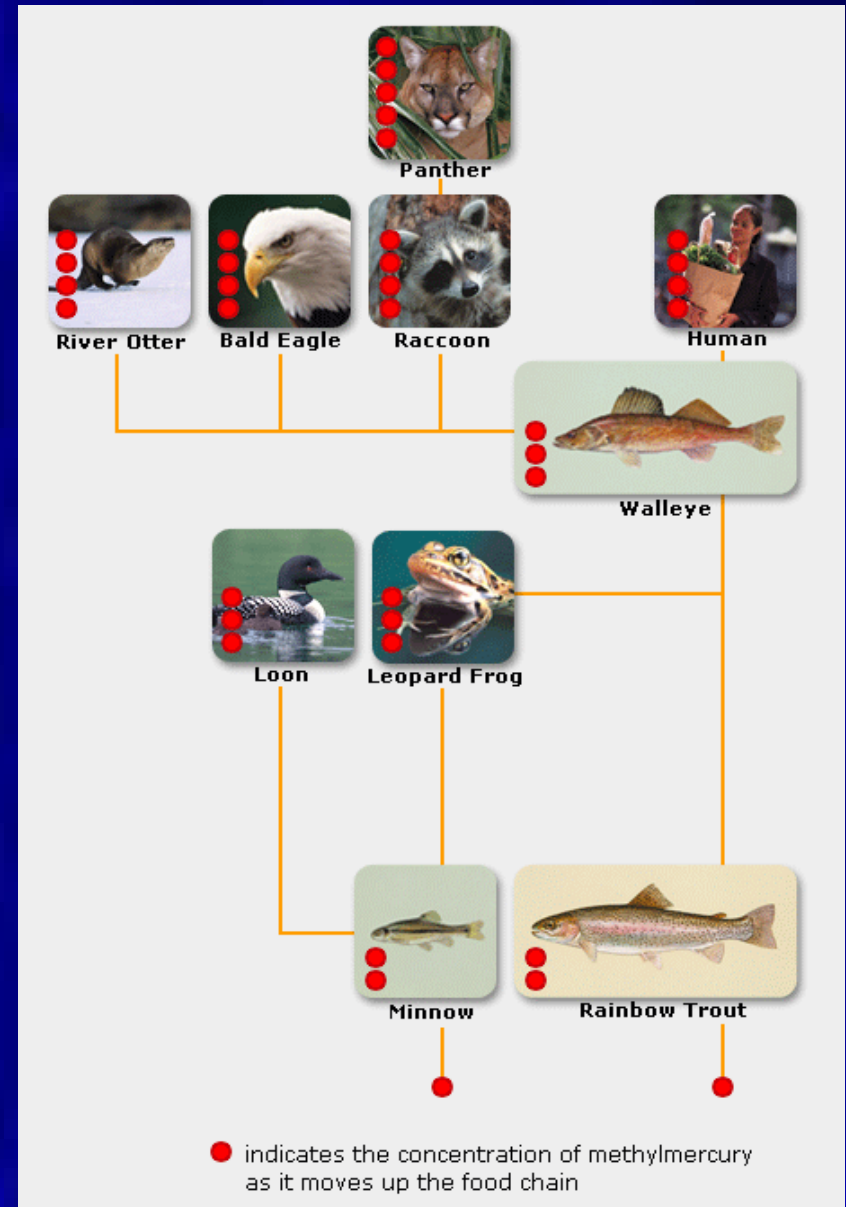


Outline

- **Introduction to Hg**
- **Introduction to the BWCWA/Blowdown Event**
- **Methods**
- **Canopy Type Study Results**
- **Fire Influence Study Results**
- **Summary/Publications**

Background – Health Risks

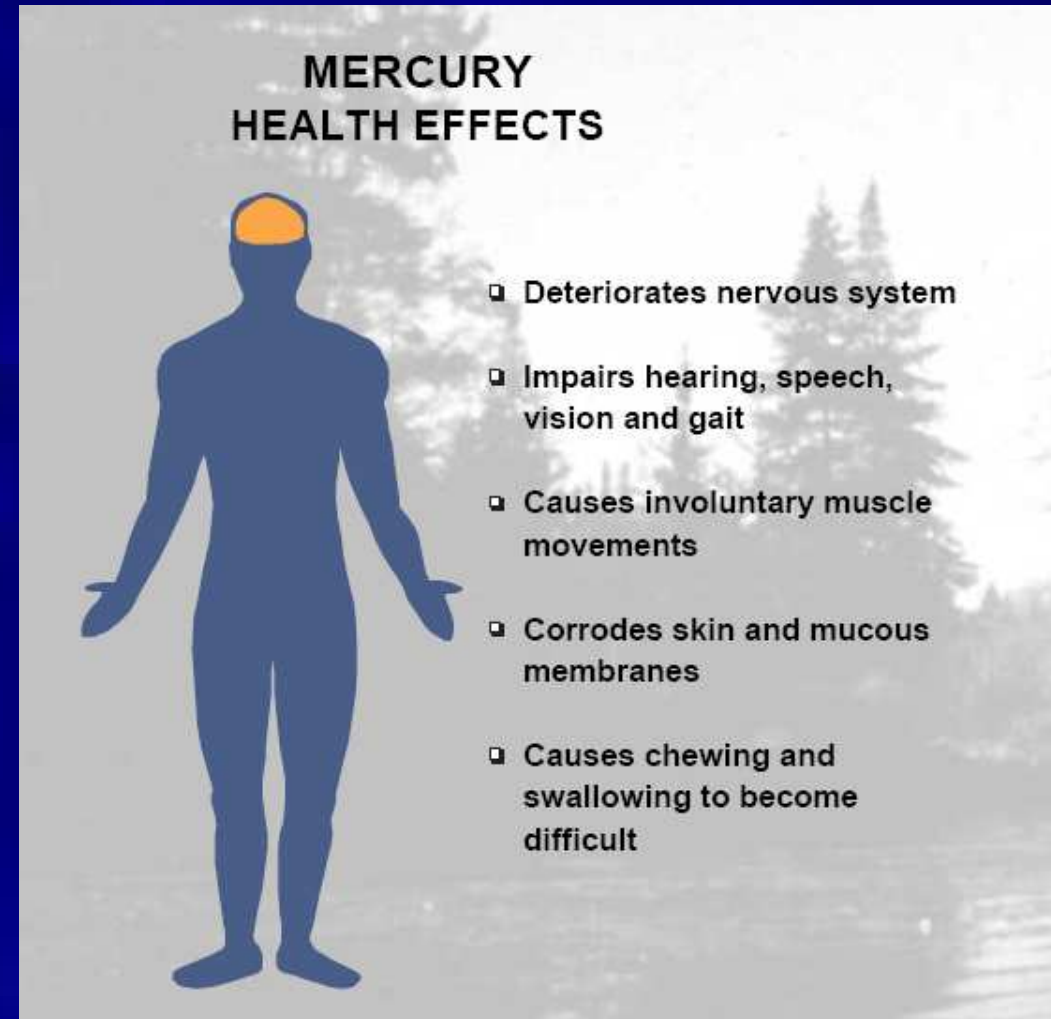
- Bioaccumulation in the Aquatic Food Chain
 - BAFs of ~ 1 million in Humans



Background – Health Risks

- **Health Consequences**
 - **Attacks Neural Network and Nervous System**
 - **Reproductive System**
 - **Mercury Poisoning**
 - **Mad Hatters Disease**
 - **Minamata Disease**

Not until the mid-1950's did people begin to notice a "strange disease". Victims were diagnosed as having a degeneration of their nervous systems. Numbness occurred in their limbs and lips. Their speech became slurred, and their vision constricted. Some people had serious brain damage, while others lapsed into unconsciousness or suffered from involuntary movements. Furthermore, some victims were thought to be crazy when they began to uncontrollably shout. People thought the cats were going insane when they witnessed "suicides" by the cats. Finally, birds were strangely dropping from the sky.



Background – Health Risks

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

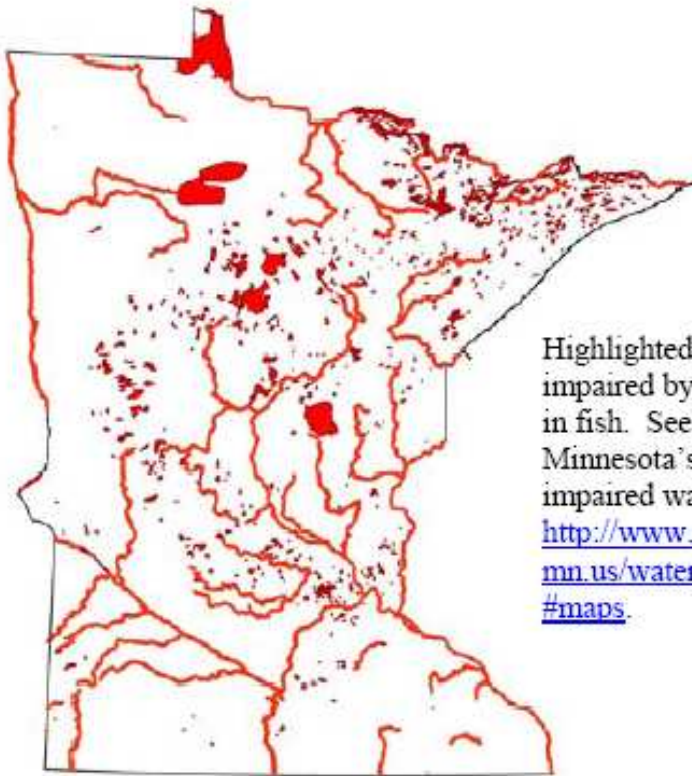


Background – Health Risks

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



Background – Health Risks



Highlighted waters are impaired by mercury in fish. See maps of Minnesota's mercury-impaired waters at <http://www.pca.state.mn.us/water/tmdl.html#maps>.



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.

Background – Health Risks

Guidelines for men, and for women not planning to become pregnant

Kind of fish you eat	How often can you eat it?*
Fish caught in Minnesota:	
Sunfish, crappie, yellow perch, bullheads	→ unlimited amount
Walleyes, northern pike, 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 week
Commercial fish:	
Limit the following species: shark, swordfish, tile fish, king mackerel	→ 1 meal a month

* In general, adults who eat fish just during vacation or one season can eat fish twice as often as recommended in these guidelines.

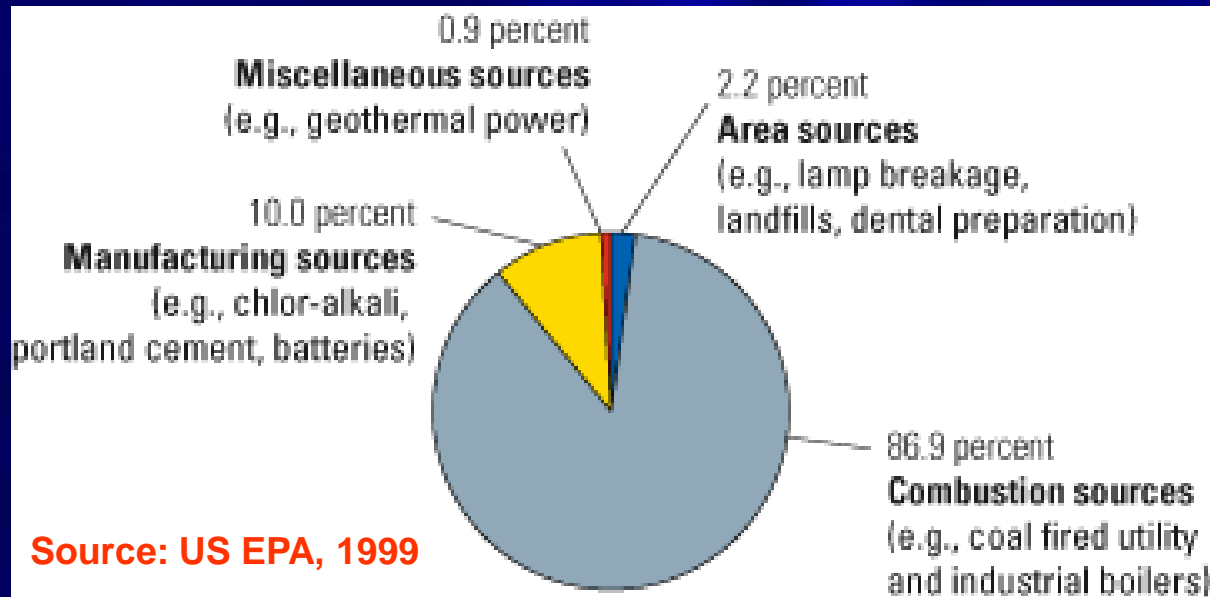
Background – Sources of Hg

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

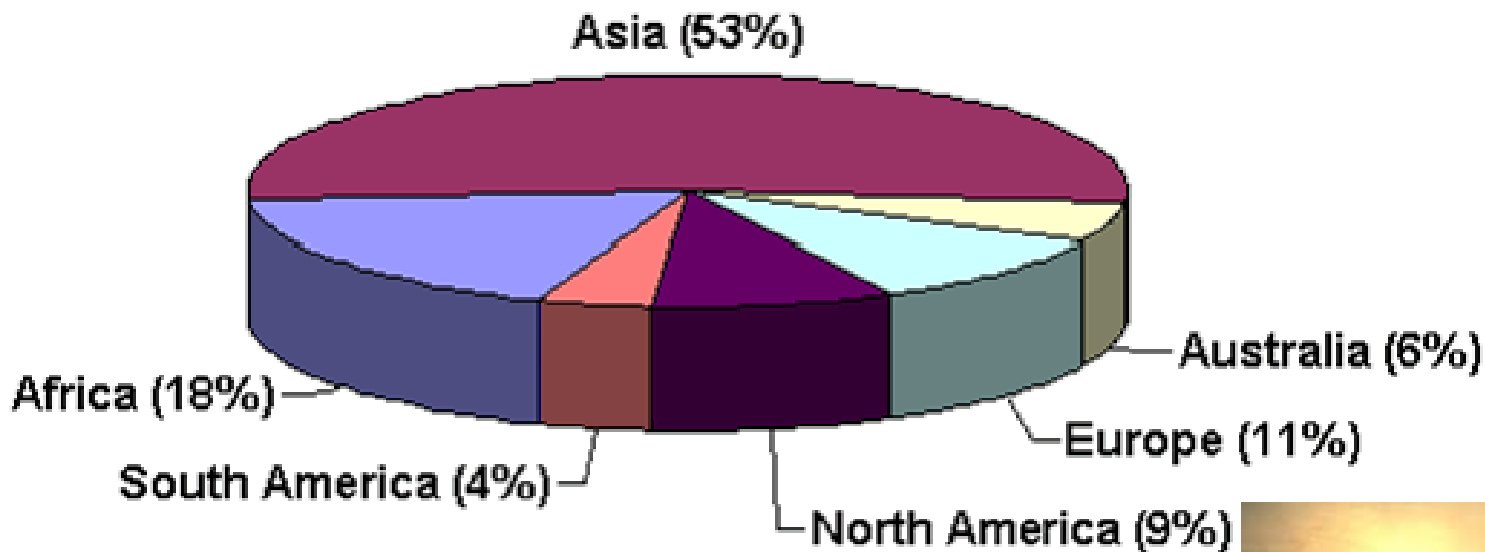


Background – Sources of Hg

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



Background – Global Geographic Sources of Hg



Pacyna and Munthe, 2004



Beijing, 2006

Background – Sources & Forms of Hg

- **Atmospherically Derived**

- **Precipitation + Dry Deposition**
- **Local to Global Sources**

- **Important Forms**

- **Gaseous (Elemental)**
- **Ionic**
- **Organic - Methyl Hg**
- **Total Hg**

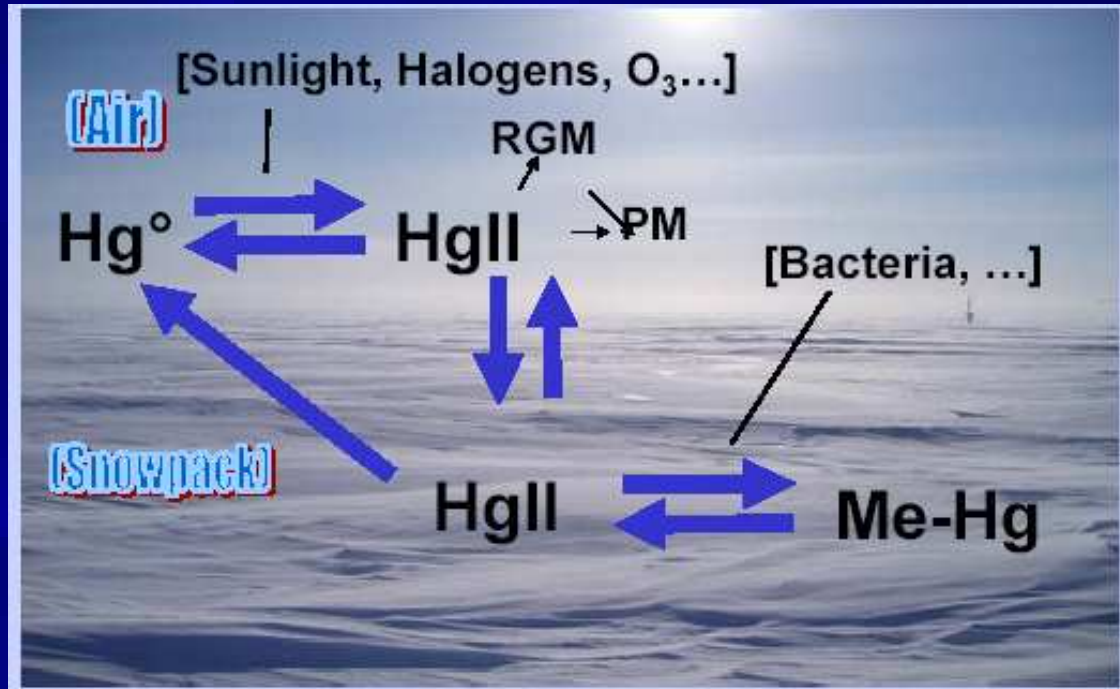
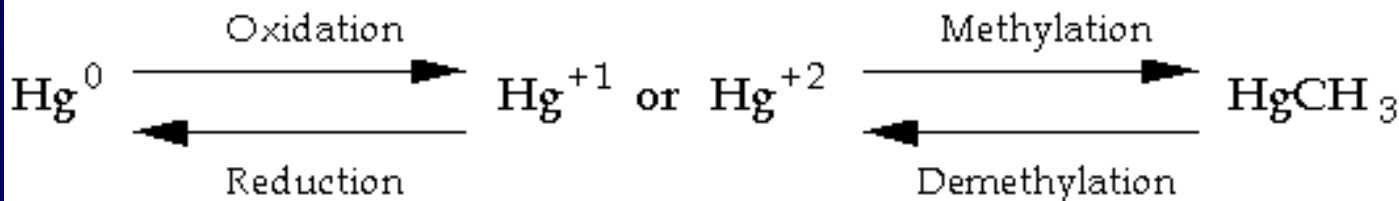


Figure 2-1
Common Mercury Transformations



Boundary Waters Canoe Wilderness Area (BWCWA)

- Located in the Superior National Forest (SNF) in NE Minnesota
- Southern Extent of the Boreal Forest
- Common Canopy Species:
 - White, Red, Jack Pine
 - Aspen, Birch, Balsam Fir
 - Black Spruce, Eastern Larch, White Cedar



BWCWA

- Experienced a 190,000 ha Blowdown Event on July 4, 1999
- Installation of an Active Prescribed Fire Program
- Management Concerns about the Effect of Fire on Hg Cycling – Sensitive Area
 - Wetlands/Lakes/DOC
 - Shallow Upland Soils
- If No Effect Here – NO PROBLEM



Study Objectives

- Assess How Canopy Type and Density Influences THg and MeHg Concentrations and Fluxes
- Assess How Canopy Type Influences THg and MeHg Concentration and Fluxes Following Fire
- How Important is Fire Added Deposition to Annual Deposition



Methods

- Throughfall Collectors in 5 Strategic Locations Across the SNF
- Collector Interior all Teflon or Glass
- Collections Made About Every 2 Weeks: May-Oct. 2005 & 2006
- Dirty Hands/Clean Hands Technique
- THg and MeHg Analyzed with CVAFS

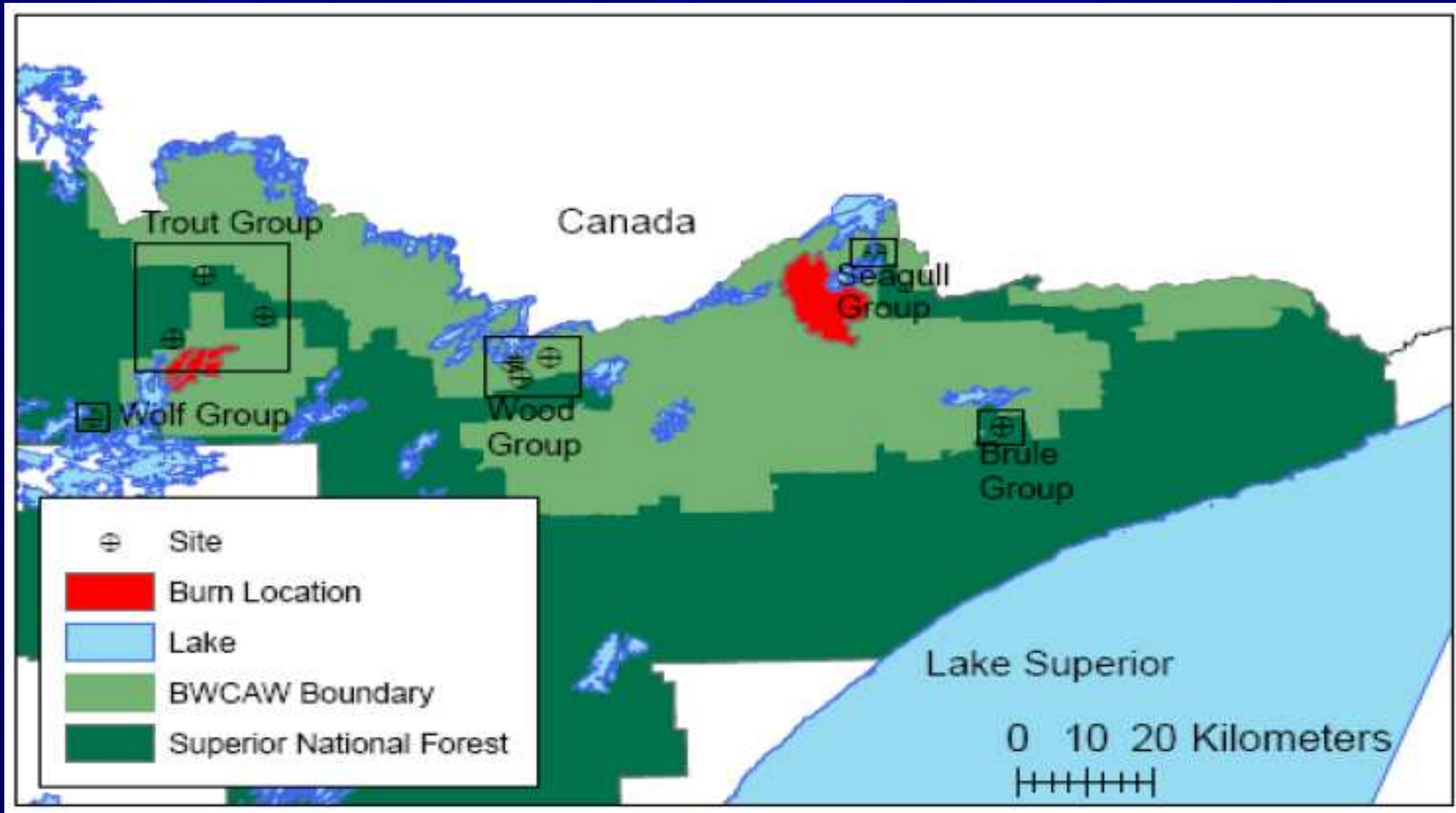


Methods

- Placed Collectors Where We Expected Prescribed Burns
- Only 1 Prescribed Burn During the Duration of the Study
 - Trout Lake Burn (2005)
- Two Wildfires
 - Alpine Lake (2005)
 - Cavity Lake (2006)



Site Locations



Site Information

Group	Smoke Impacted	Number of Sites	Total Number of Collectors	Conifer Collectors	Deciduous Collectors	Bulk Collectors
Wolf Group	No	1	9 (1 duplicate)	4	4	0
Trout Group	Yes	3	9	3	3	3
Wood Group	No	4	9 (1 duplicate)	4	4	0
Brule Group	Yes	1	3	1	1	1
Seagull Group	Yes	1	5 (1 duplicate)	2	1	1
Total		10	35	14	13	5

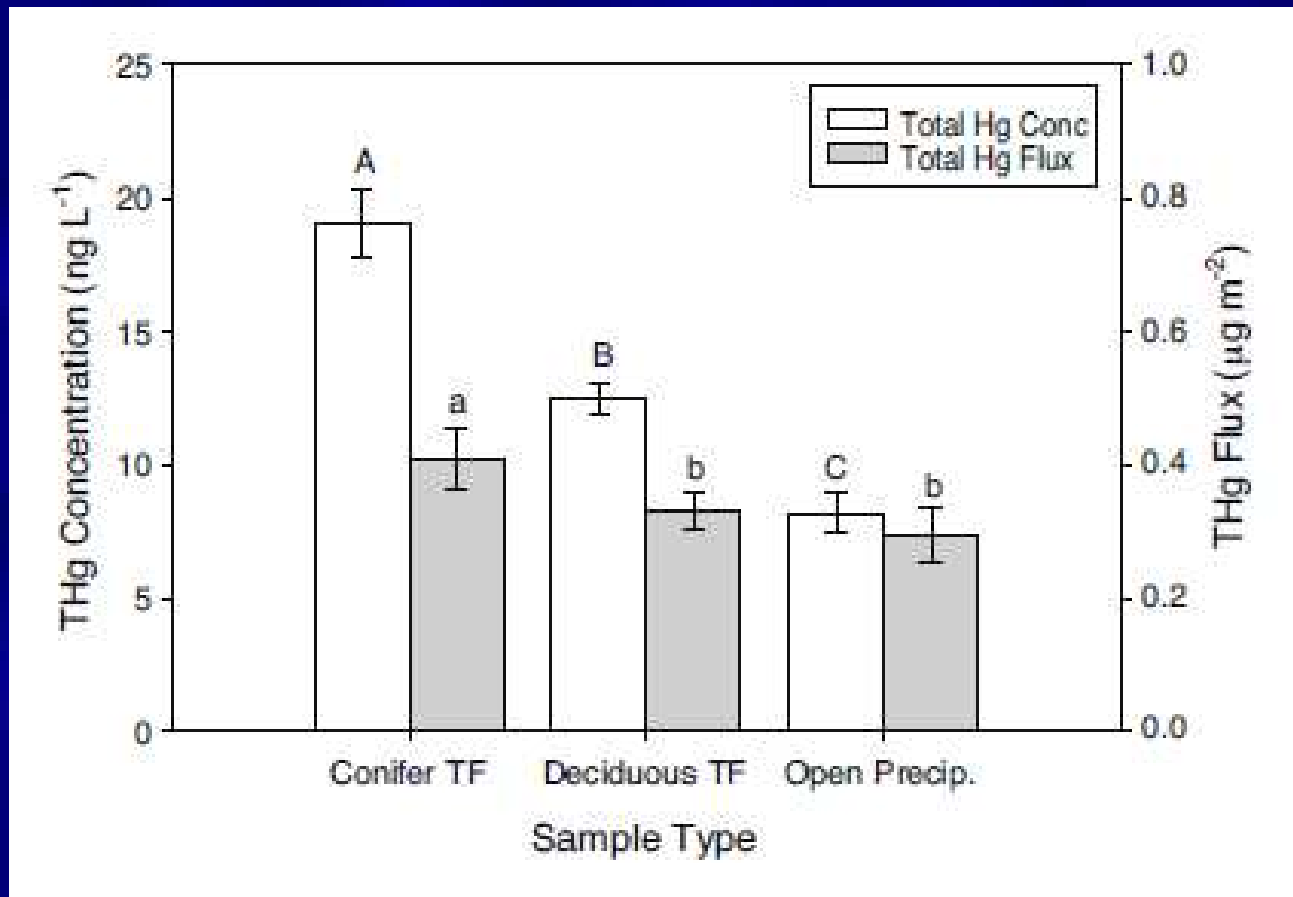
- To Determine When a Site was Impacted by Fire

- Tracked Fire Plumes
- Tracked Precipitation Events
- Analyzed Data By the Number of Collection After Beginning of Fire



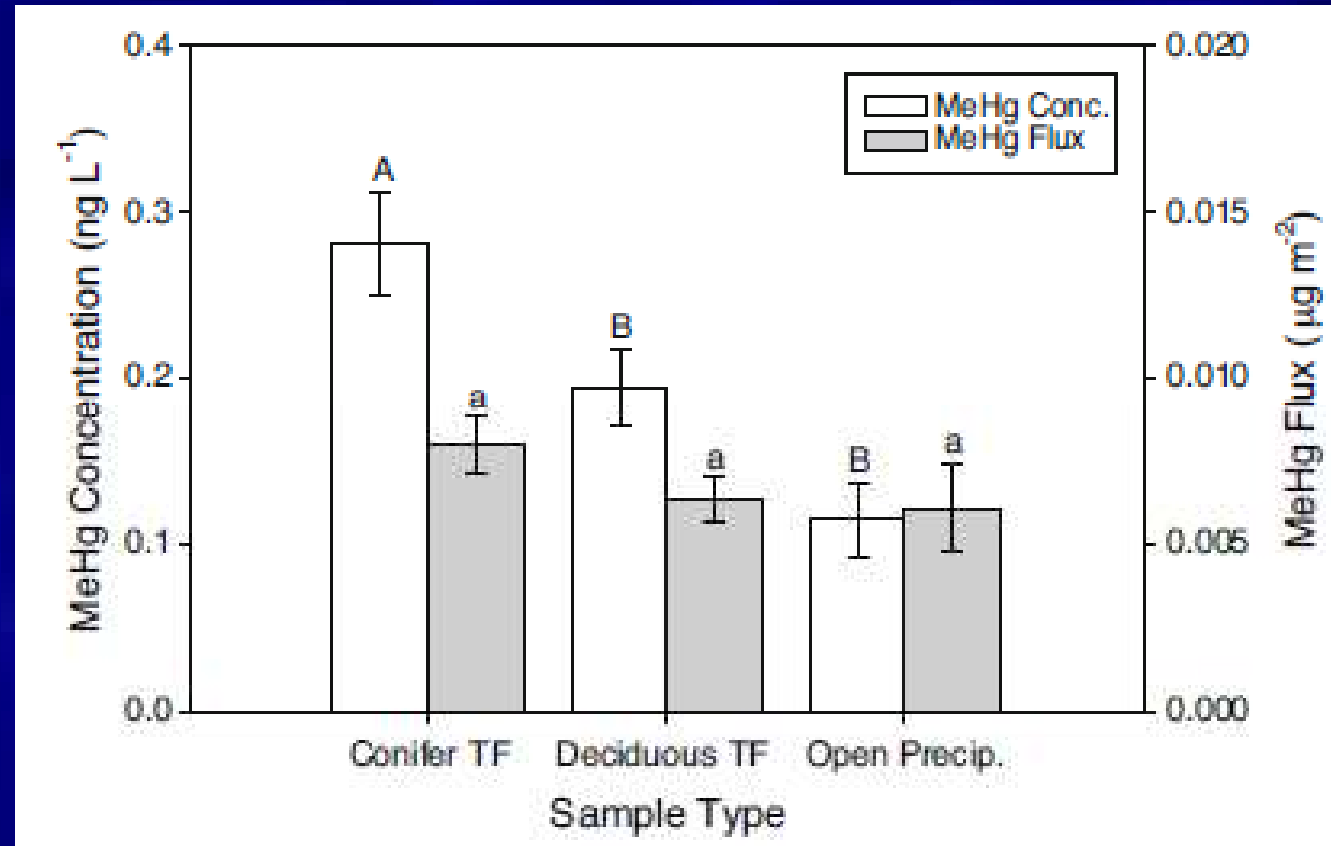
THg Canopy Results – Preburn

- Concentrations
 - Conifer > Deciduous > Open
- Deposition (Fluxes)
 - Conifer > Deciduous = Open

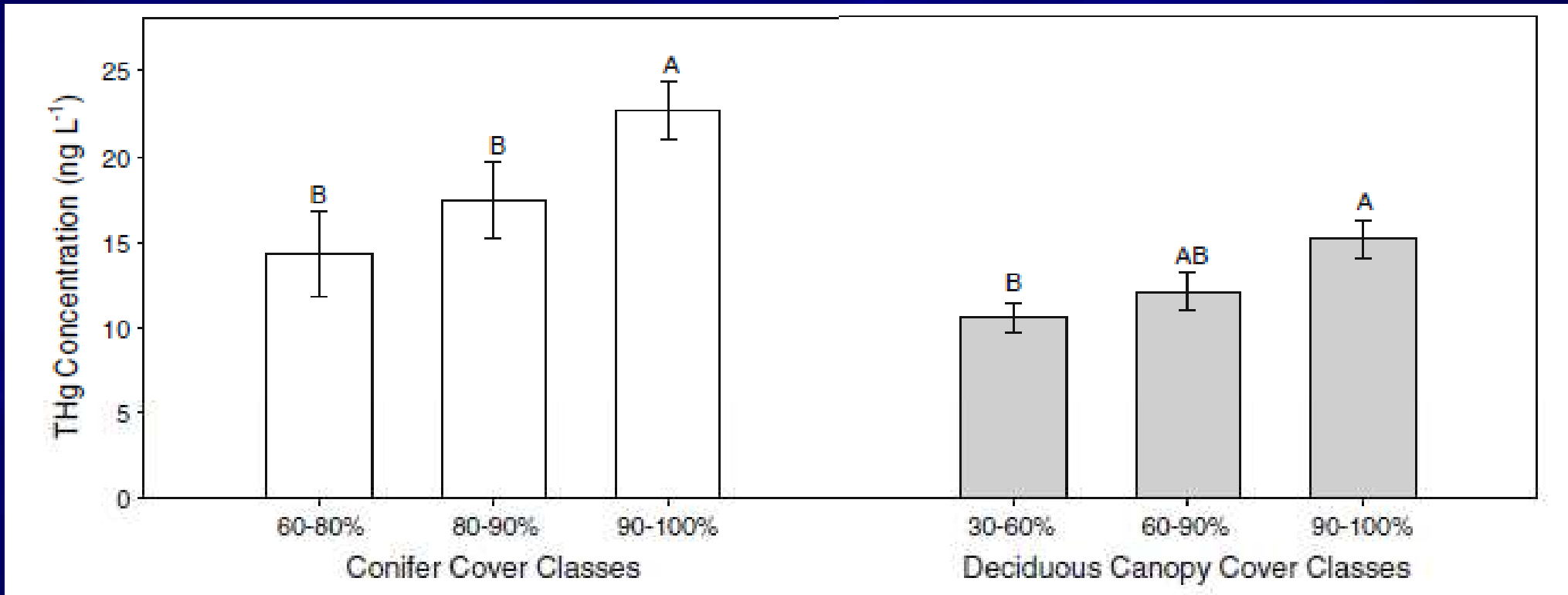


MeHg Canopy Results - Preburn

- Concentrations
 - Conifer > Deciduous = Open
- Deposition (Fluxes)
 - No Differences

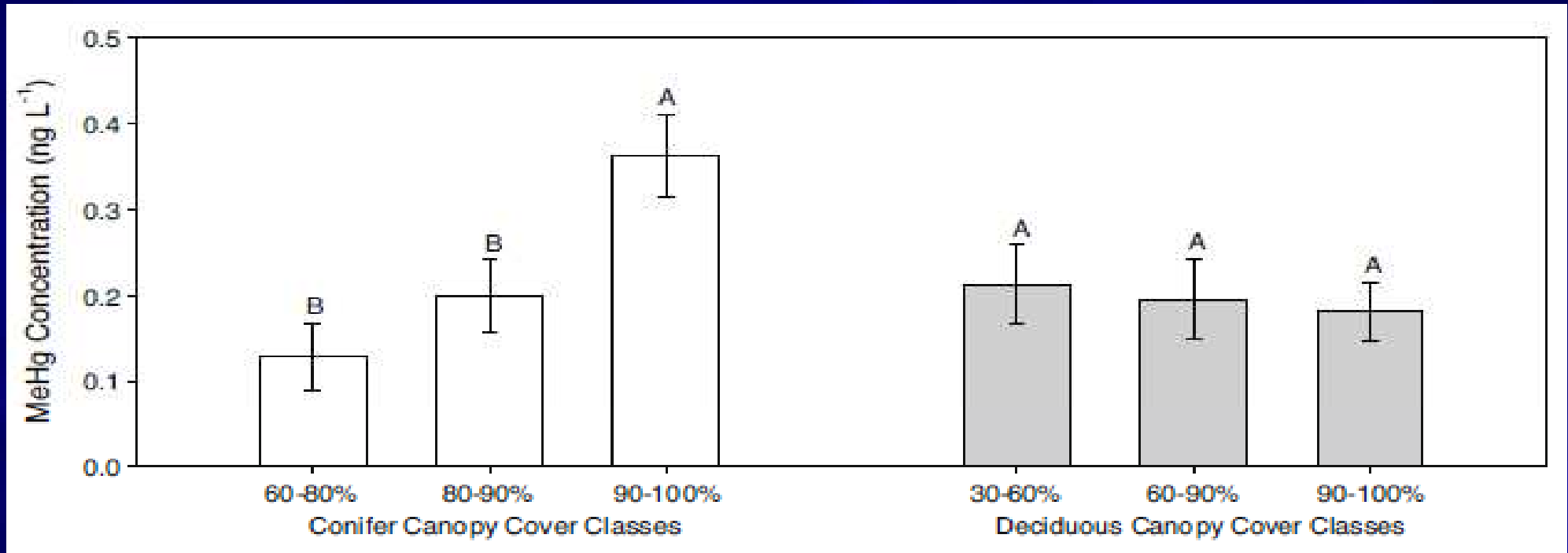


THg Canopy Density Results - Preburn



- Concentrations
 - Conifer & Deciduous Differences at Highest Density Classes
- Deposition (Fluxes)
 - No Differences

MeHg Canopy Density Results - Preburn

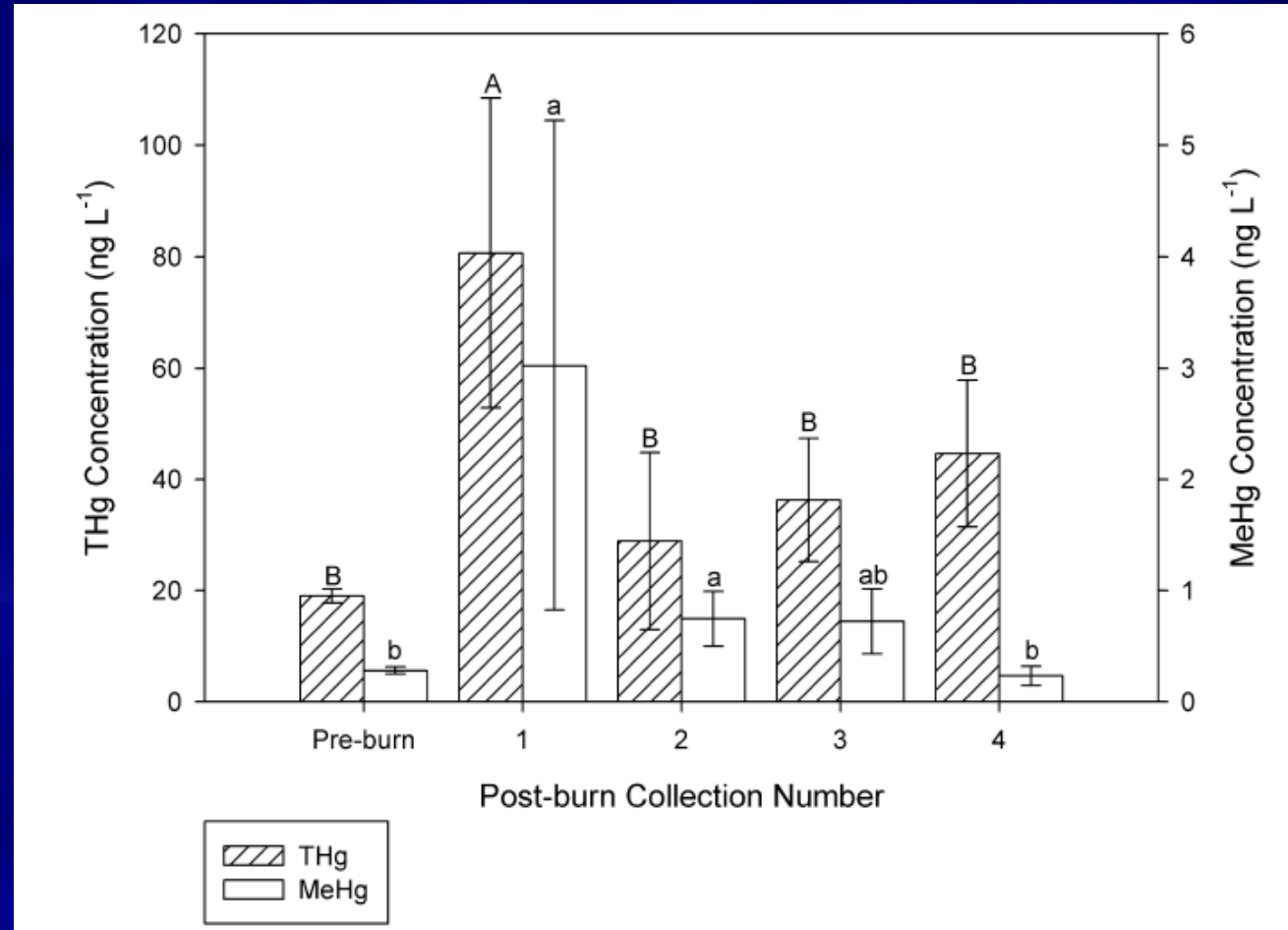


- Concentrations
 - Conifer Greatest at Highest Density Class
 - Deciduous No Differences
- Deposition (Fluxes)
 - No Differences

Results – Fire Effects on Hg Deposition

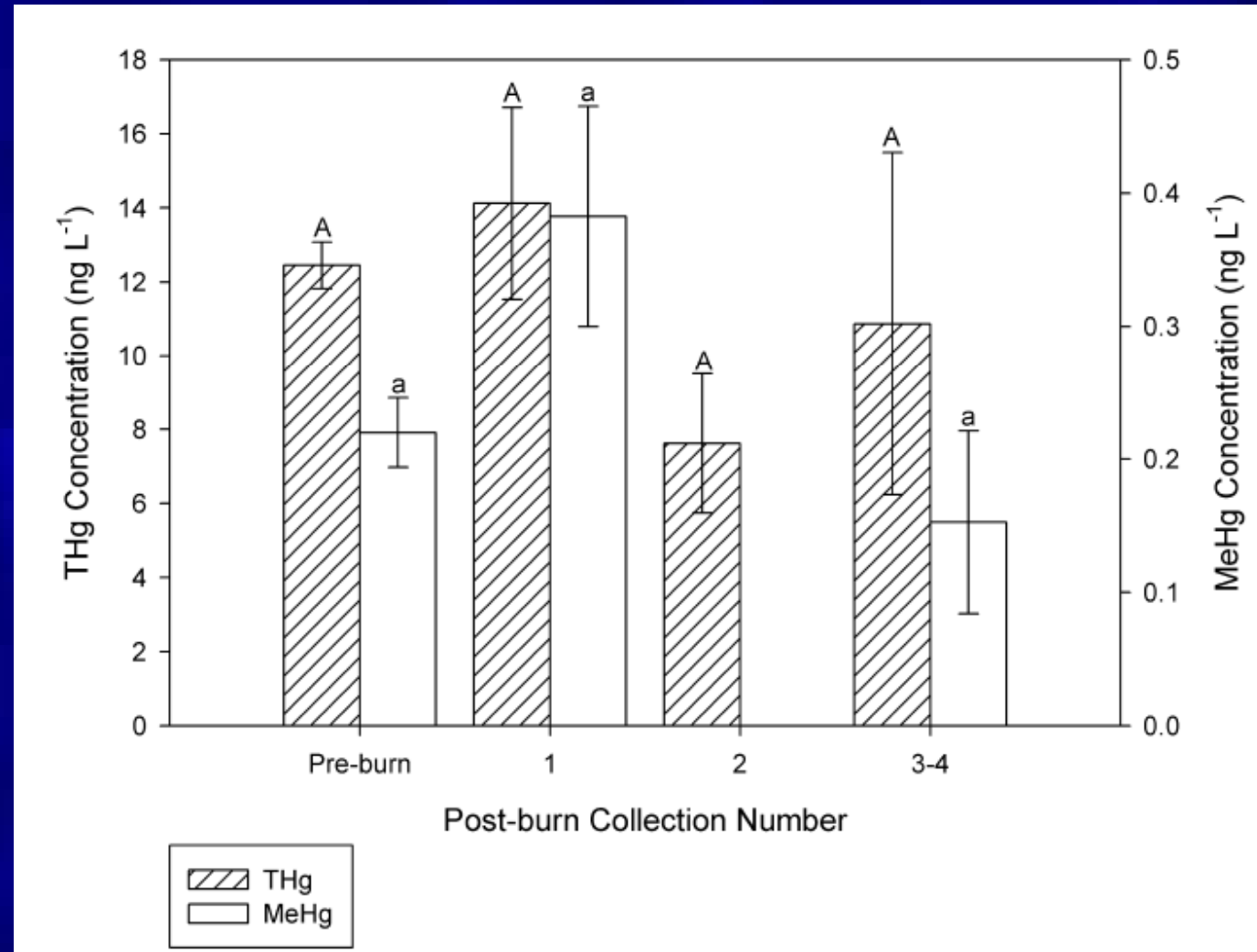
• Conifers Important

- **THg Concentrations Higher After First Sampling**
- **MeHg Concentrations Higher for the First 2 Samplings**
- **Deposition Also Greater Following Fire**



Results – Fire Effects on Hg Deposition

- Deciduous and Open
 - No Important Differences in Concentration or Deposition.
- All About Conifers!



Summary – Canopy Effects on Hg

- **Largest Influence on THg and MeHg Concentrations and Fluxes is Canopy Type**
- **Because of Leaf Area Differences Conifers are Better Able to Scavenge Dry Deposition**
- **Higher Conifer Canopy Density Led to Greater THg and MeHg Concentrations and Higher THg Fluxes (No Differences in MeHg Flux)**
- **Higher Deciduous Canopy Density Led to Greater THg Concentrations but not MeHg Concentrations (No Differences in Flux)**
- **Conifer-dominated Ecosystems at Higher Risk for Hg Related Water Quality Issues**
- **Climate Change Predictions: Conifers Moving North (<Hg)**

Summary – Fire Effects on Hg

- **Fire Leads to Higher Short-term Concentrations and Increased Deposition of Hg (both THg and MeHg) in Conifer Systems**
- **Concentrations Generally Returned to Preburn Levels in the Second or Third Sampling Event, an Average of 14 to 39 days After Fire**
- **Appears There is a Local Effect on Particulate Deposition During Fire**
- **Increase is About 40% of Annual Deposition**
- **Can We Pick Up That Pulse of Hg in the Food Chain? Still Working on it, Stay Tuned!**
- **If We Do, Important Management Implications**

Publications

Witt, E.L., R.K. Kolka, E.A. Nater, and T.R. Wickman. 2009. Influence of the forest canopy on total and methyl mercury deposition in the boreal forest. *Water, Air, and Soil Pollution*, 199: 3-11.

Witt, E.L., R.K. Kolka, E.A. Nater, and T.R. Wickman. 2009. Forest fire effects on mercury deposition in the boreal forest. *Environmental Science and Technology*, 43(6): 1776-1782.

Thank You!



Questions?