Mercury transport and transformation in a forest/wetland system

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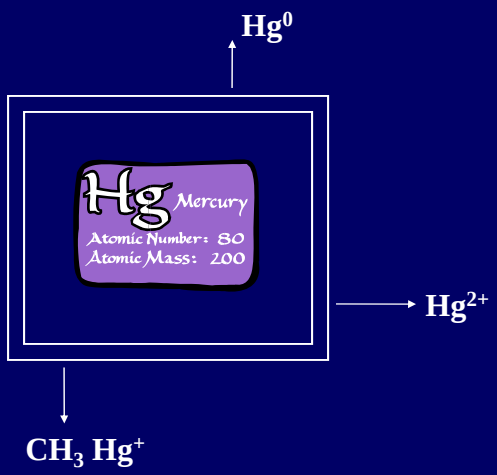
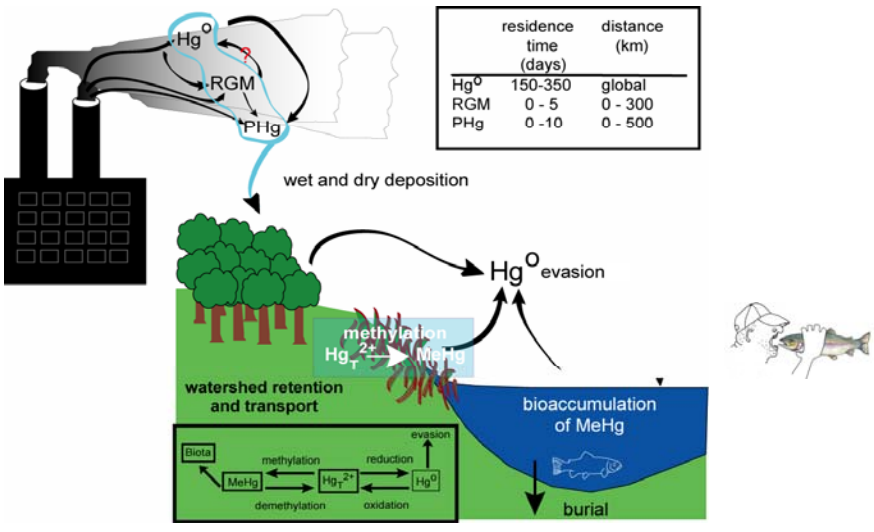
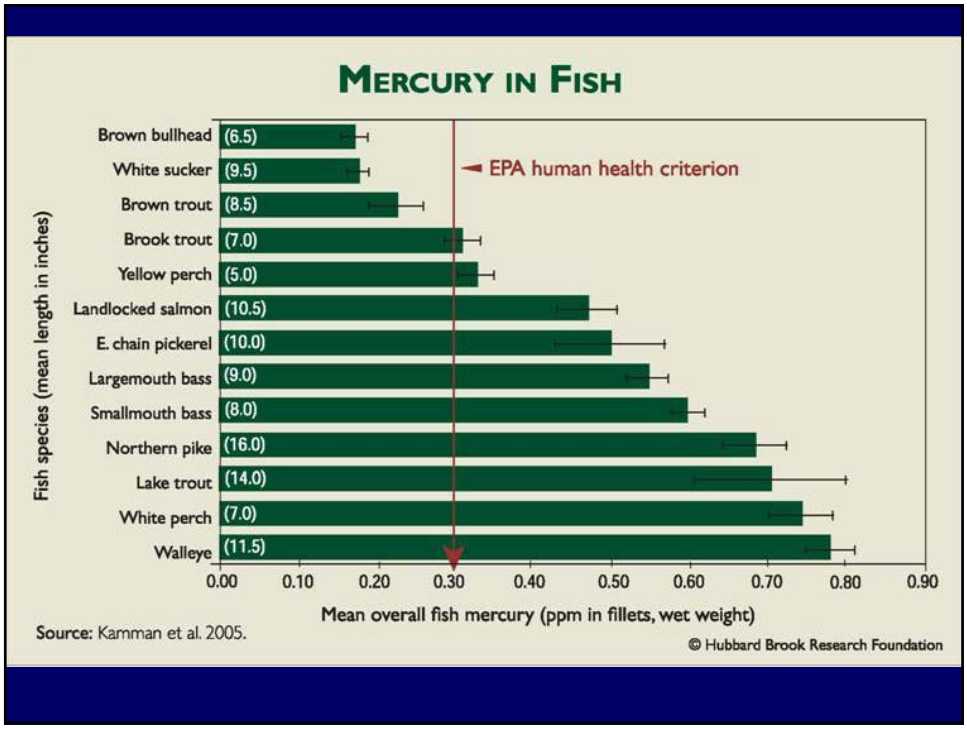
Outline

- Background
- Research project
  - Approach and Methods
  - Results
  - Conclusions
- Questions

Mercury in the Environment






MERCURY IN FISH
Brown bullhead (6.5)
White sucker (9.5)
Brown trout (8.5)
Brook trout (7.0)
Yellow perch (5.0)
Landlocked salmon (10.5)
E. chain pickerel (10.0)
Largemouth bass (9.0)
Smallmouth bass (8.0)
Northern pike (16.0)
Lake trout (14.0)
White perch (7.0)
Walleye (11.5)
EPA human health criterion
Fish species (mean length in inches)
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90
Mean overall fish mercury (ppm in fillets, wet weight)
Source: Kamman et al. 2005.
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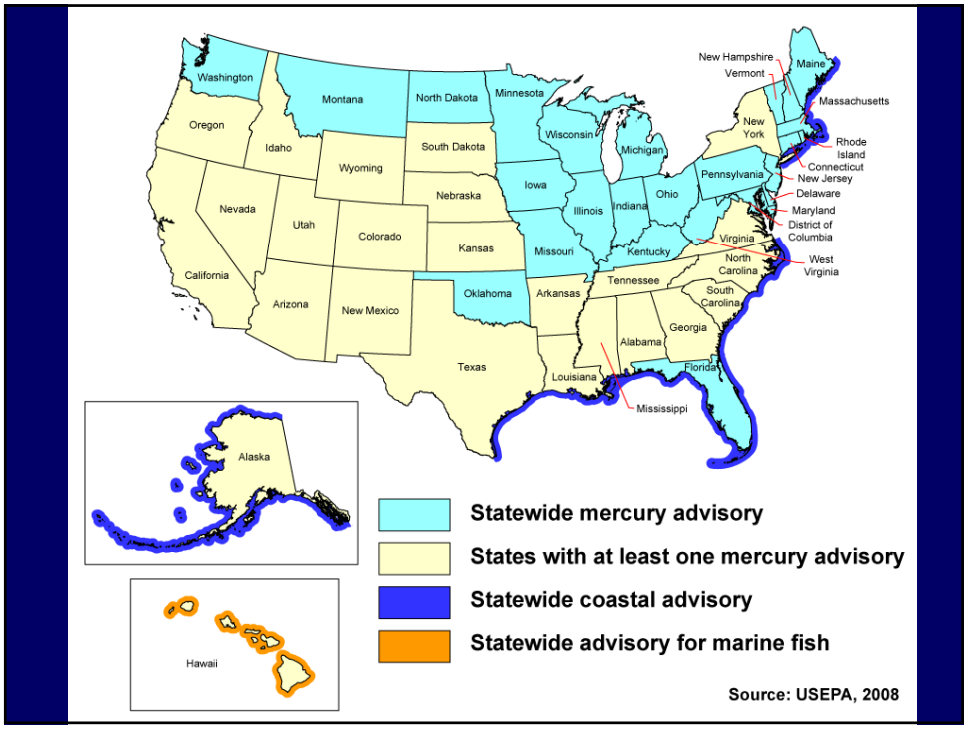
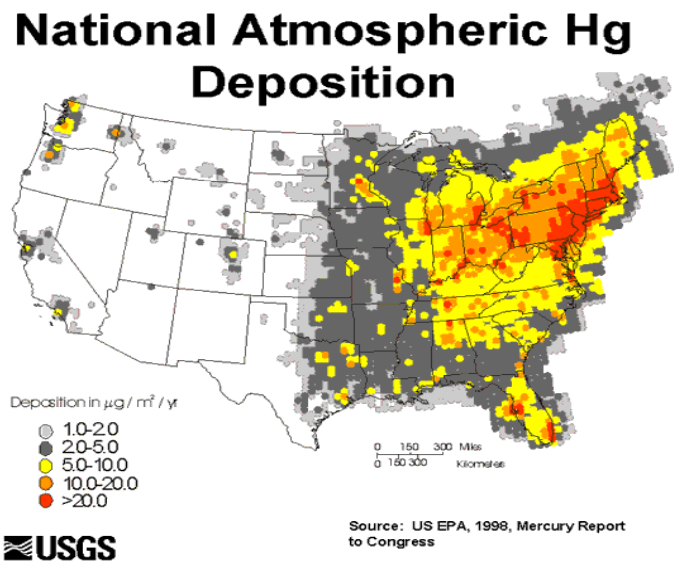
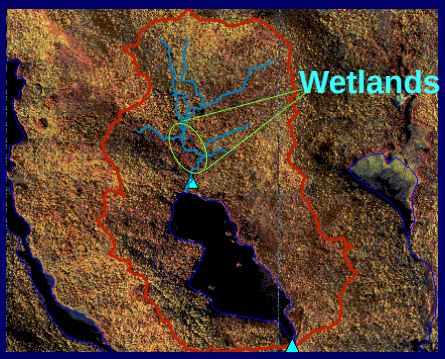

Washington
Oregon
California
Idaho
Nevada
Montana
Wyoming
Utah
Arizona
Colorado
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minnesota
Iowa
Missouri
Arkansas
Louisiana
Wisconsin
Illinois
Michigan
Indiana
Ohio
Kentucky
Tennessee
Mississippi
Alabama
Georgia
Florida
South Carolina
North Carolina
Virginia
West Virginia
Pennsylvania
New York
New Hampshire
Vermont
Maine
Massachusetts
Rhode Island
Connecticut
New Jersey
Delaware
Maryland
District of Columbia
Alaska
Hawaii
Statewide mercury advisory
States with at least one mercury advisory
Statewide coastal advisory
Statewide advisory for marine fish
Source: USEPA, 2008



Fate and Transport of Mercury in Wetlands

- Objective: To evaluate the sources, transformation, retention and transport of mercury in wetlands

Arbutus Lake Watershed-352 ha



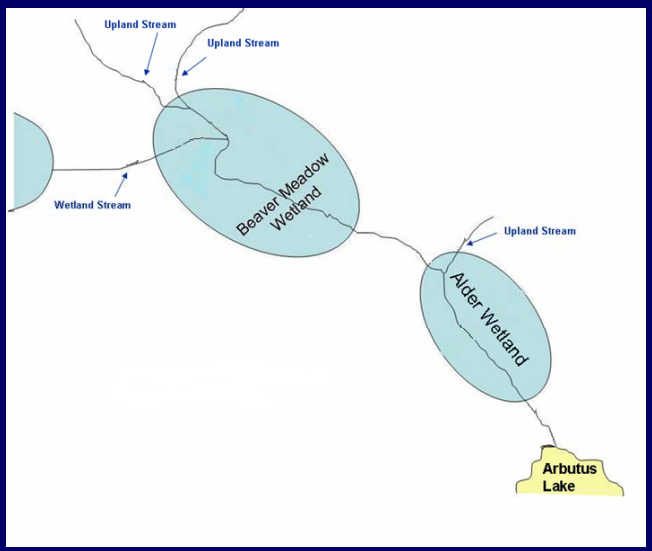
Methods

- Monitoring interval
  - monthly (Aug 2004 – July 2006)
- Stream and pore water
- Hydrology
  - flow monitored at watershed outlet
  - flow prorated at upstream locations
- Chemical analysis
  - THg & MeHg
  - ancillary (DOC, SO_4^{2-}, NO_3^- pH, base cations)

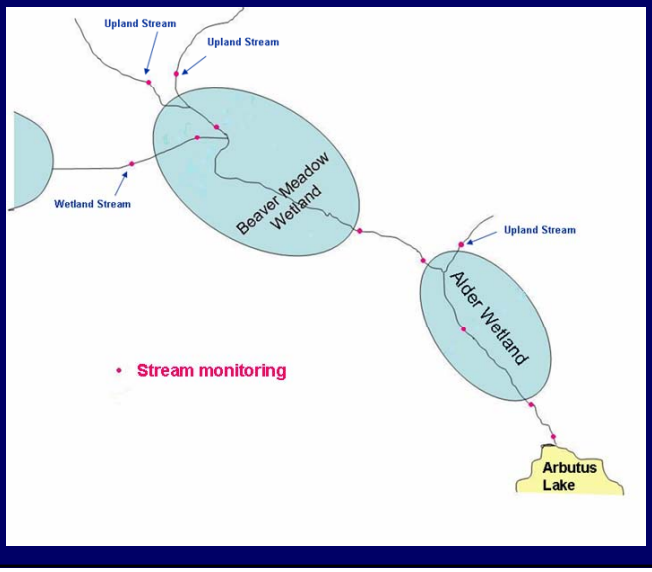
Monitoring Approach

- Phase I (monthly)
  - Surface water monitoring
  - Ground water monitoring
  - Hydrology monitoring
  - Atmospheric deposition monitoring
- Phase II (diurnal/seasonal/annual)
  - Ambient air monitoring
  - Soil vapor monitoring
  - Vapor extraction from liquid phase
  - Soil sampling
  - Vegetation sampling

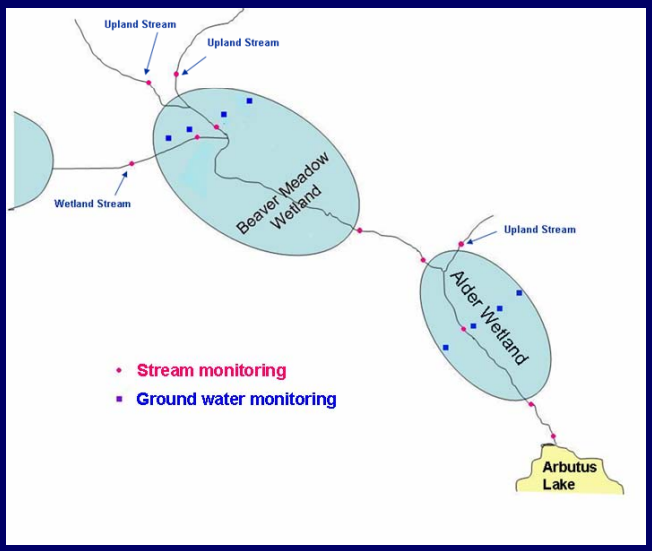
Monitoring Approach



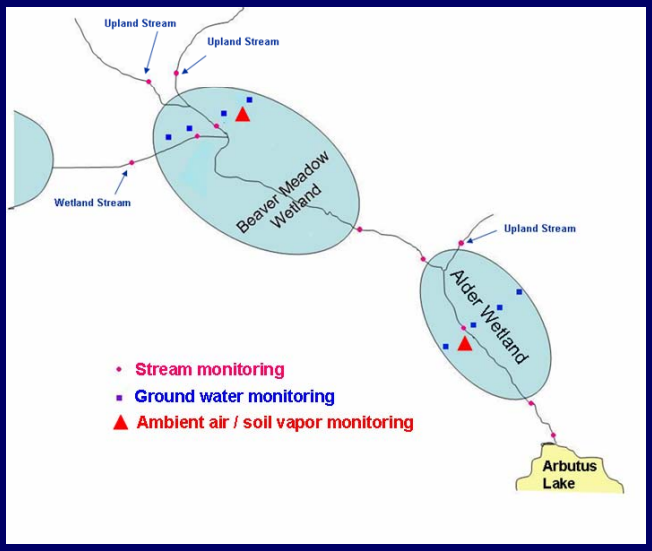
Monitoring Approach



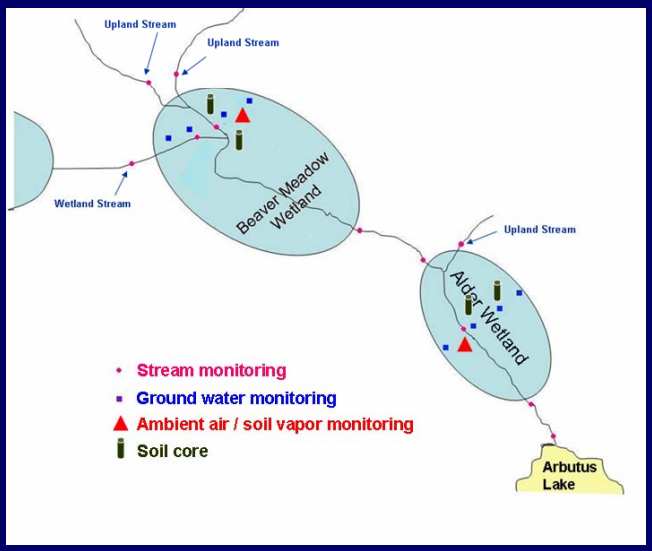
Monitoring Approach



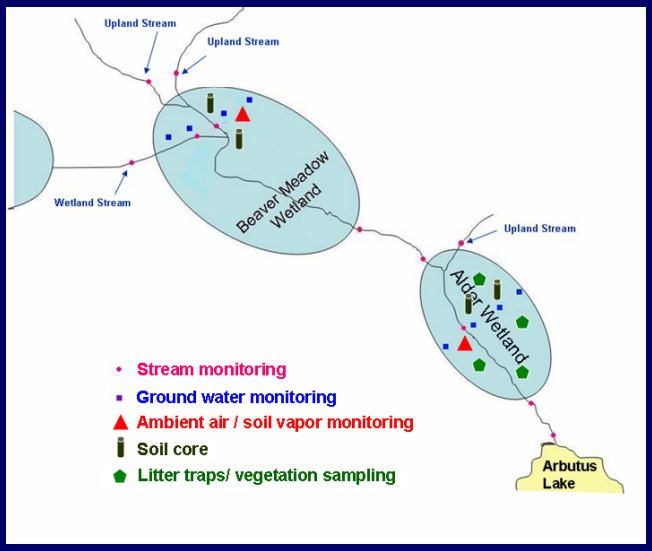
Monitoring Approach



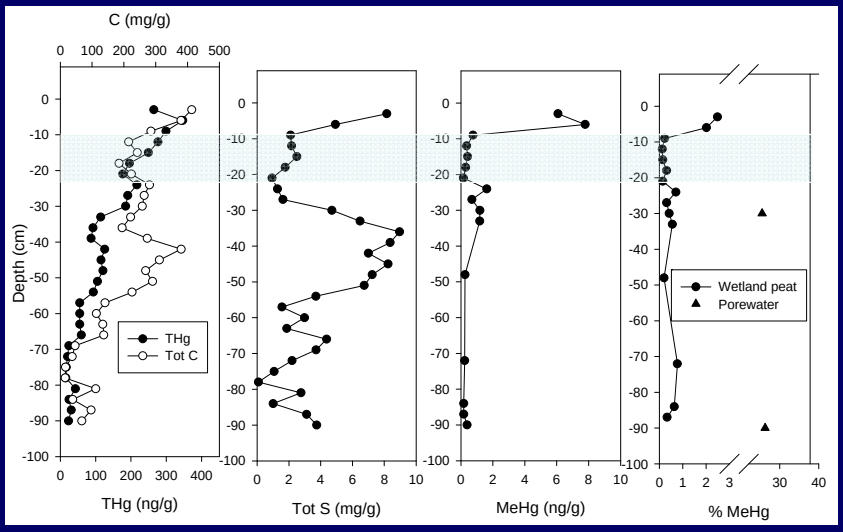
Monitoring Approach



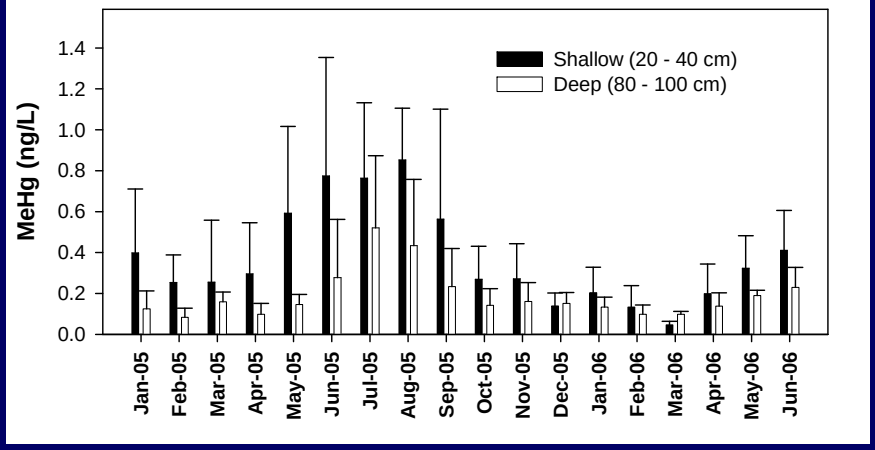
Monitoring Approach

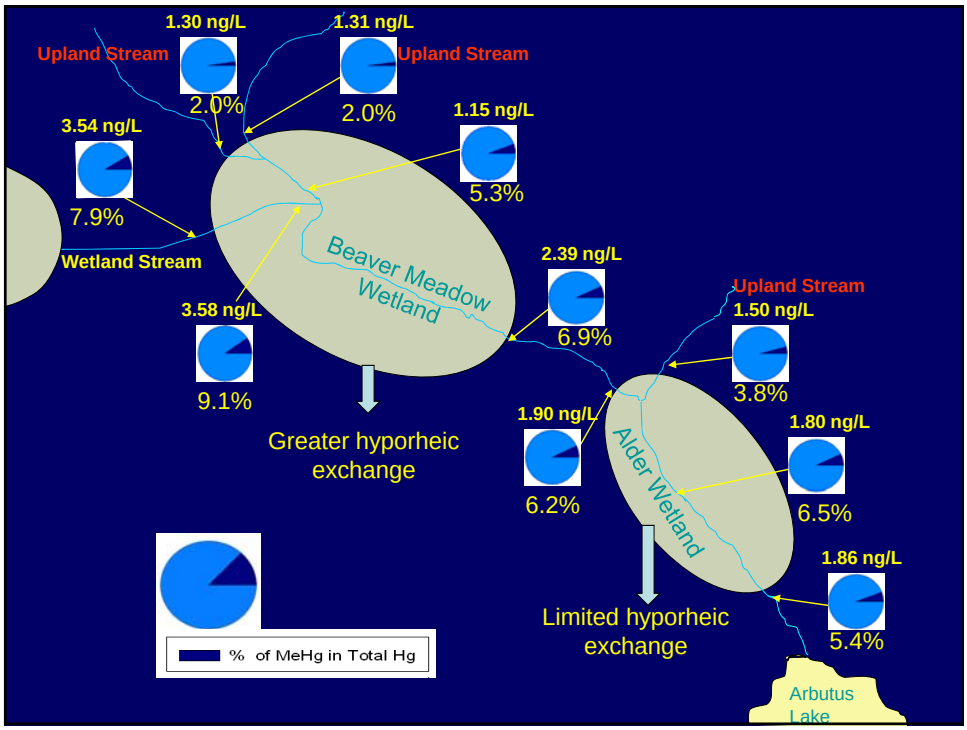


Wetland Peat Profile

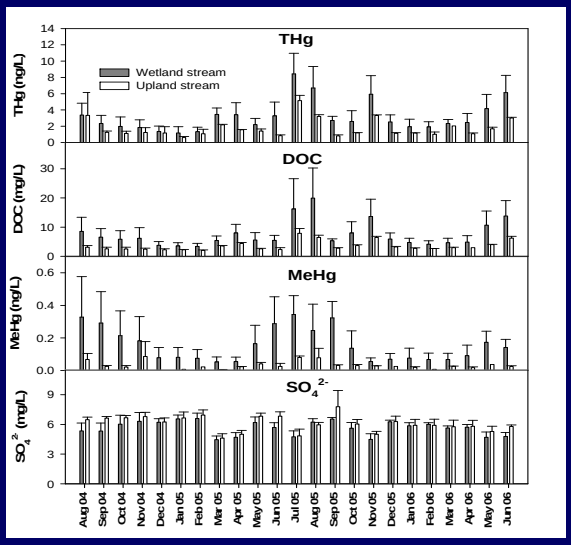


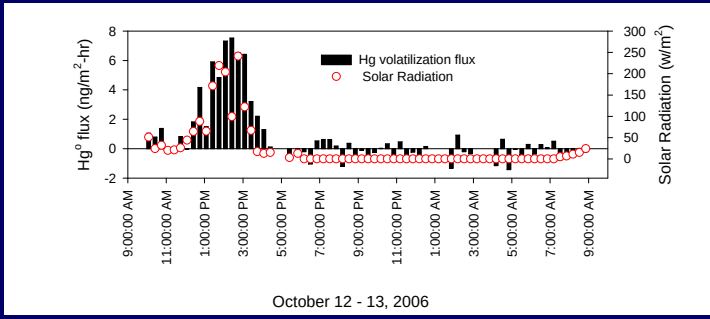
Wetland Pore Water



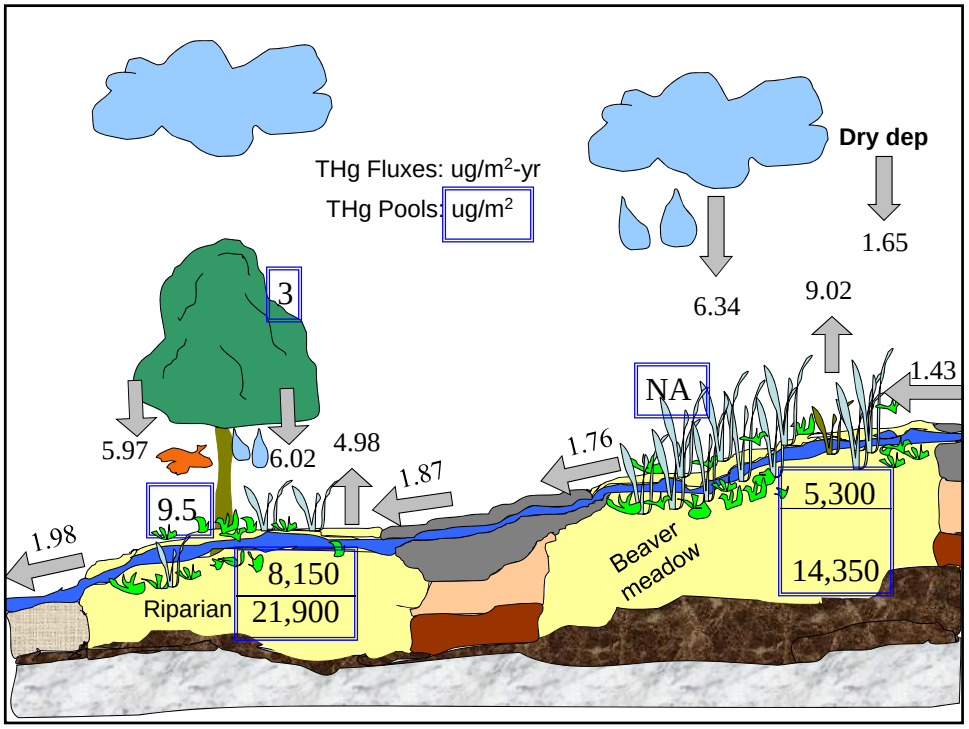


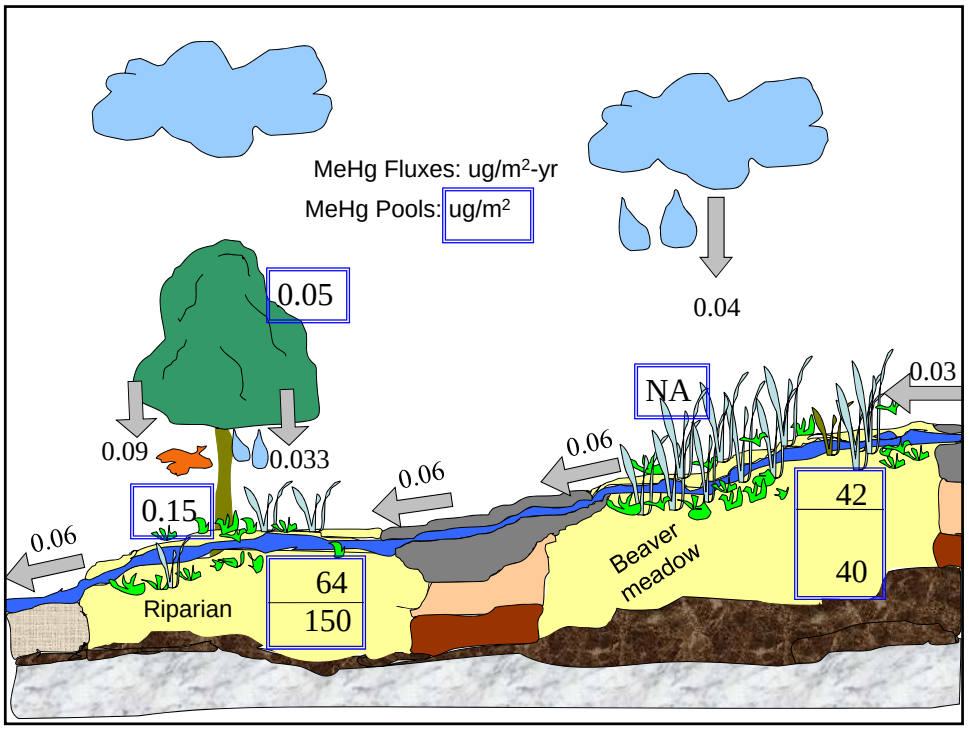
Temporal Patterns





- Photo reduction: $Hg^{2+} \xrightarrow{\text{Sunlight}} Hg^0$
- Controlling variables: Sunlight, ambient temperature, % relative humidity

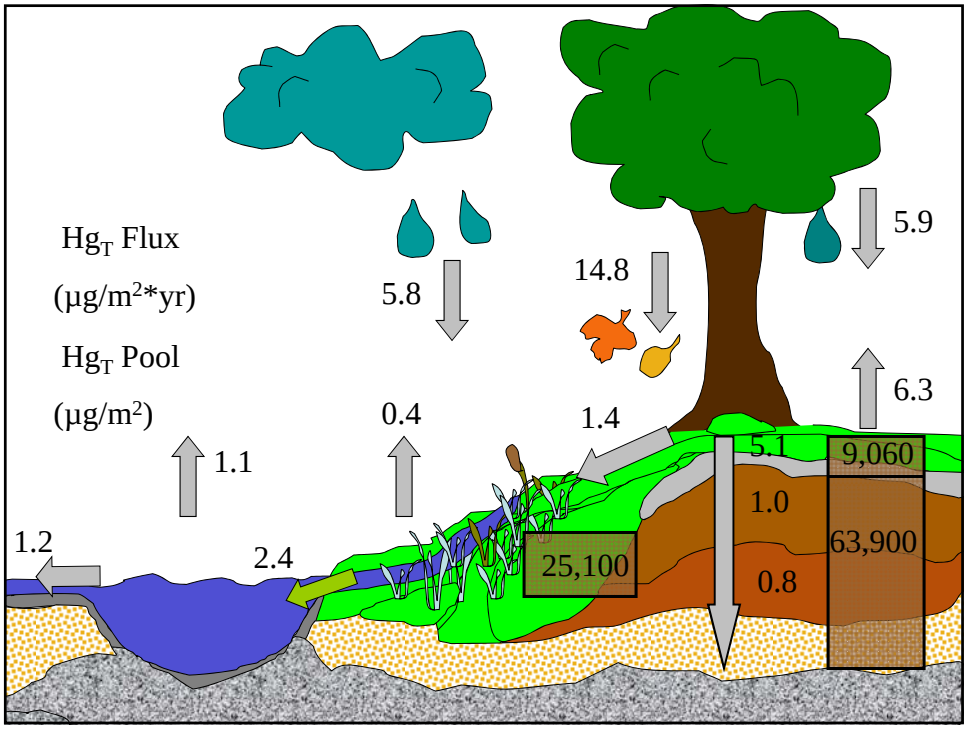

THg Fluxes: ug/m²-yr
THg Pools: ug/m²
Dry dep
1.65
6.34
9.02
1.43
3
NA
5.97
6.02
4.98
1.87
1.76
9.5
5,300
1.98
8,150
21,900
14,350
Riparian
Beaver meadow


MeHg Fluxes: ug/m²-yr
MeHg Pools: ug/m²
0.04
0.05
NA
0.03
0.09
0.033
0.06
0.06
0.06
0.15
42
64
150
40
Riparian
Beaver meadow

Conclusions

- Presence of small valley bottom wetlands in forested landscapes is ecologically significant due to the net increase in THg and MeHg and DOC transport to downstream aquatic ecosystems
- Distinctively high MeHg concentrations in surface waters draining wetlands were evident during warm summer months when biological activity, SO_4^{2-} reduction and hydrologic residence time were greatest.
- Subsurface production of MeHg within the wetlands was evident from the high levels of MeHg and % MeHg detected in wetland pore water
- Hydrologic connectivity is an important controller of Hg export in wetlands
- The storage of THg and MeHg in wetland soil is a large pool; wetland soil pool is a source of Hg species to stream water through DOC binding.
- Wetlands could potentially behave as a long-term source of THg, regardless of industrial Hg emission reductions, due to large storage of THg in wetland soil.
- Volatilization is an important component of Hg mass balance in wetlands

Questions?


Hg$_T$ Flux
(µg/m^2*yr)
Hg$_T$ Pool
(µg/m^2)
5.8
14.8
5.9
6.3
0.4
1.4
1.1
5.1
9,060
1.0
63,900
1.2
2.4
25,100
0.8