MERCURY IN BURIED LOGS FROM THE GREAT DISMAL SWAMP NATIONAL WILDLIFE REFUGE

Atlantic White Cedar Alliance Symposium, June 2012

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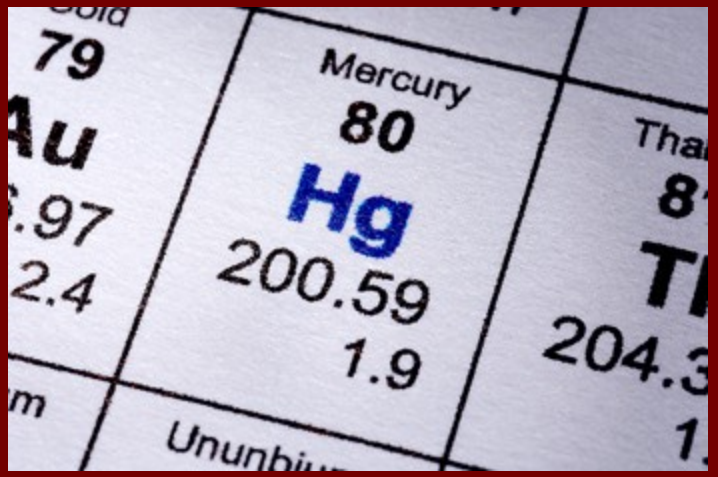
Mercury

Elemental	Inorganic	Methyl-mercury
Hg_0 In air for 2 years	Hg II 2 week lifespan	Ch_3Hg or MeHg Bio-accumulates

- Natural Element
- Anthropogenic Disturbance
  - Coal burning
- Organic transfer via food chain



Mercury toxicity

Neurological disorders

- Numbness in arms and legs
- Blurring, loss of vision, loss of hearing
- Muscle coordination
- Alzheimer's & Parkinson's

Polyvinyl Chloride Industrial Plant Effluent
-(1932-1968)-

Methyl-Mercury

Thousands of people affected, hundreds died

Fetal blood barrier

- Lowered mental development of children

Mercury in the environment

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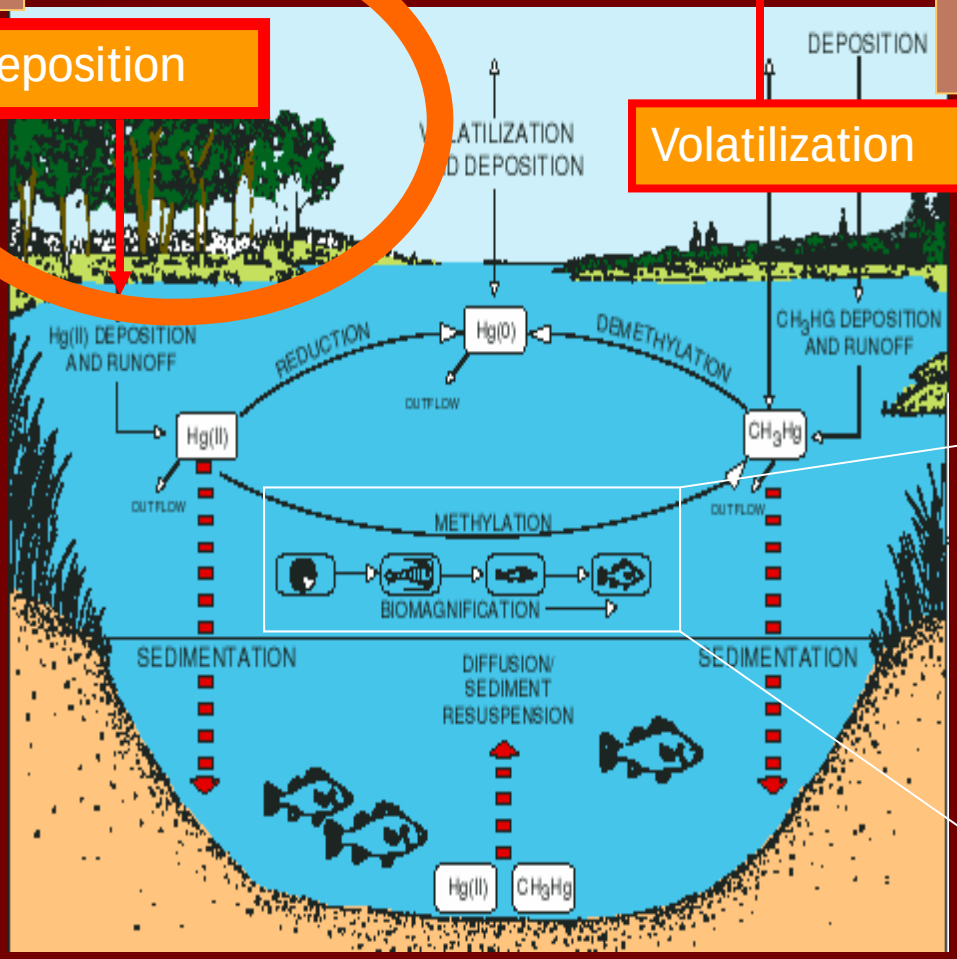
Deposition



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Volatilization

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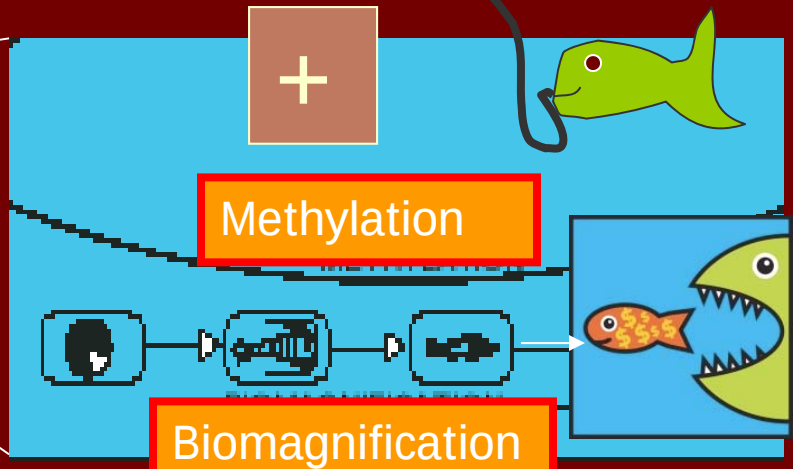
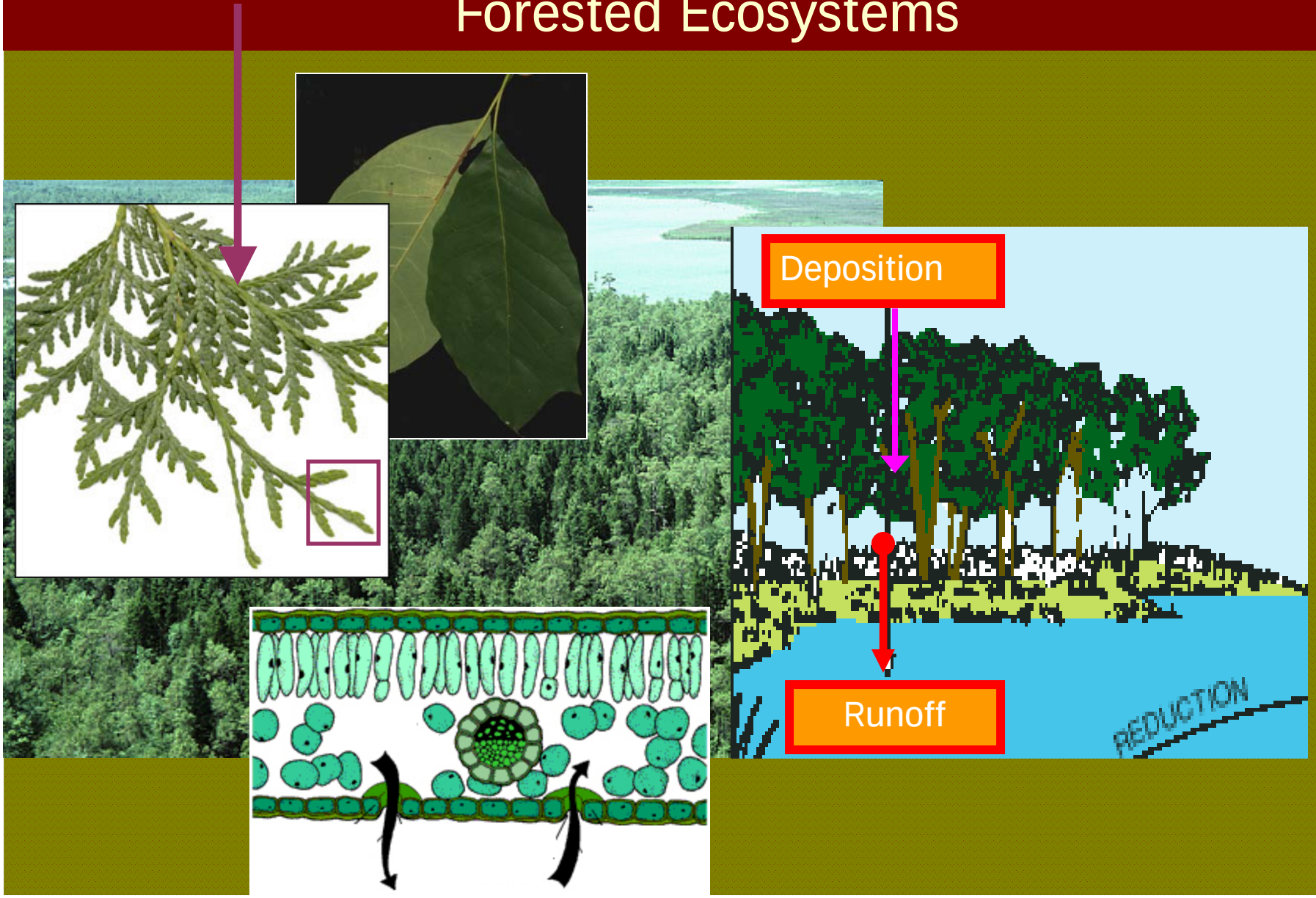
Methylation



Biomagnification

Mercury in
Forested Ecosystems



Mercury in peatlands

- Peat accumulation – hotspot for mercury
- Wildlife in the peatland
- Remobilization:
  - Drainage with Hg runoff into aquatic systems
  - Fire re-emission

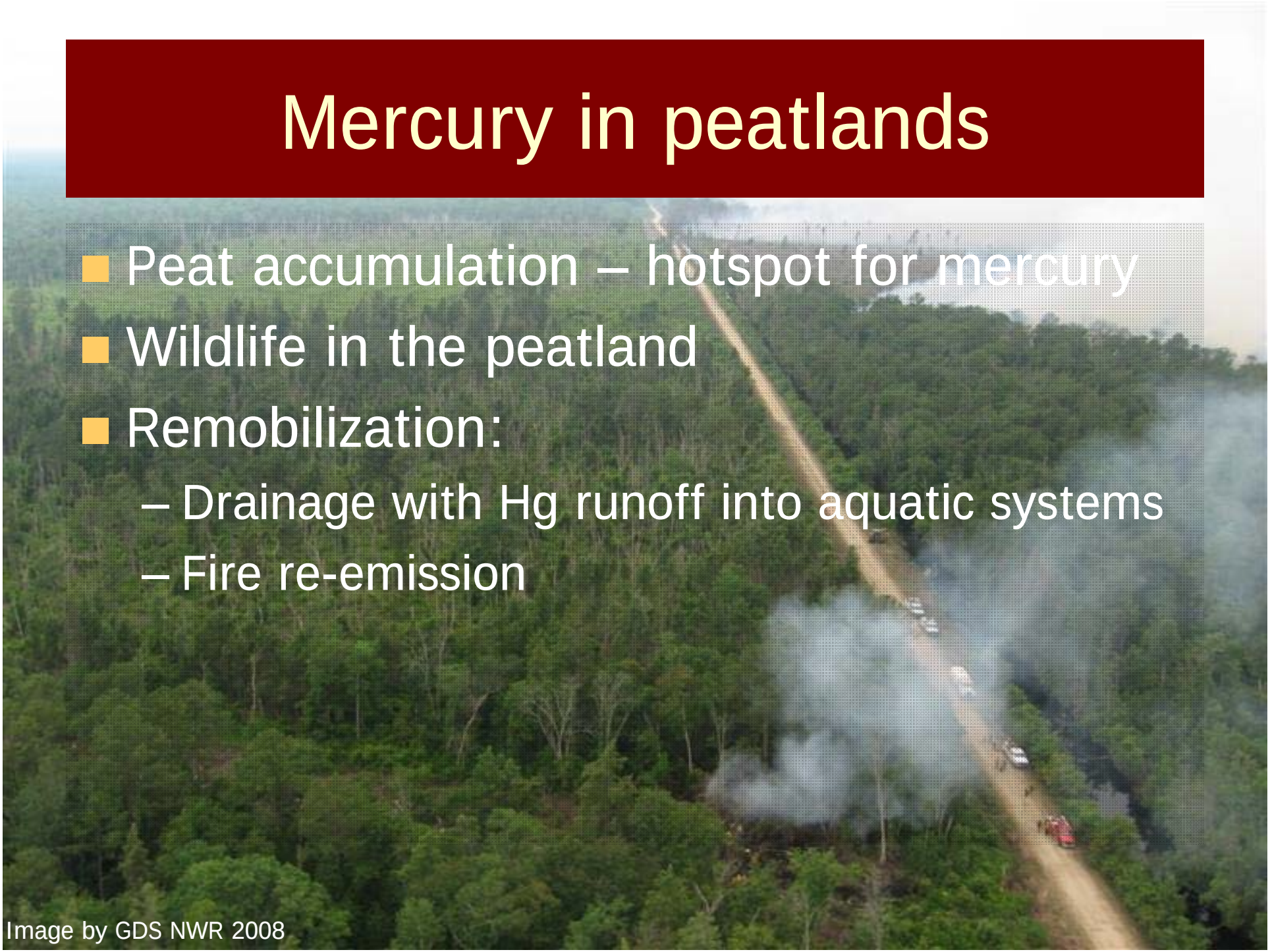


Image by GDS NWR 2008

Biogeochemical cycle: Sinks, sources, pools, and you!

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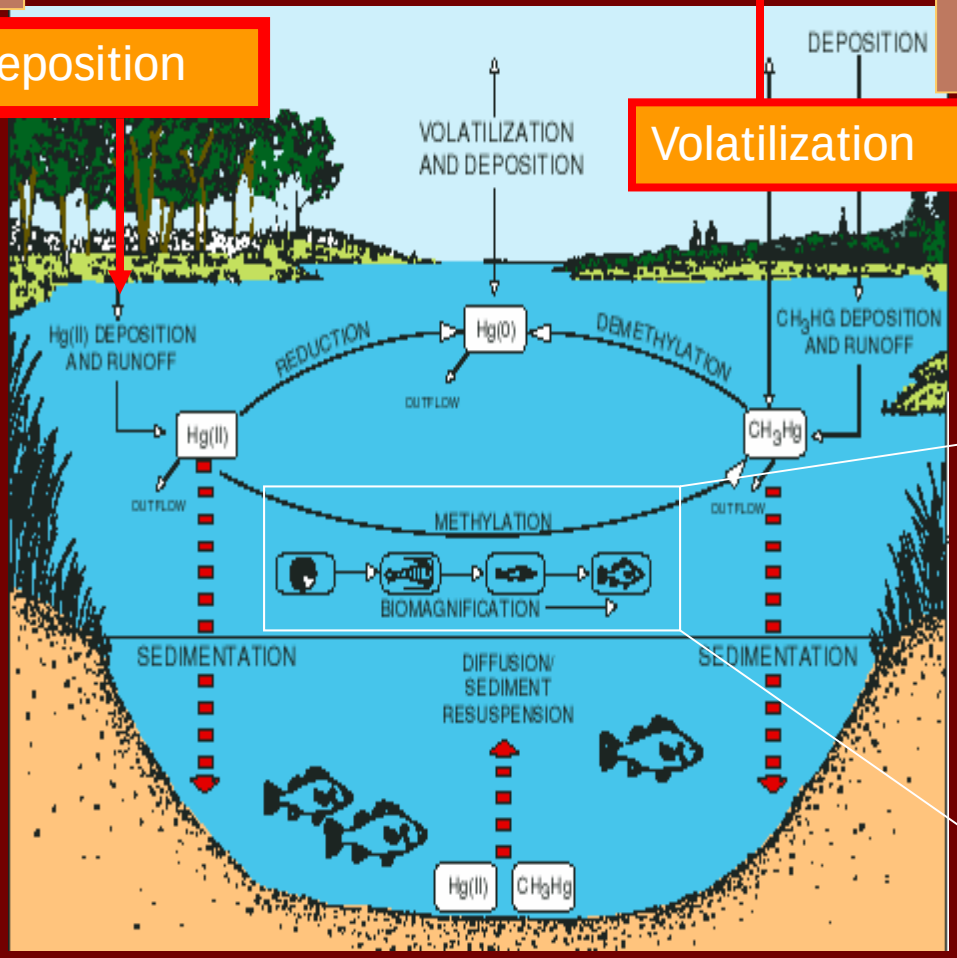
Deposition



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Volatilization

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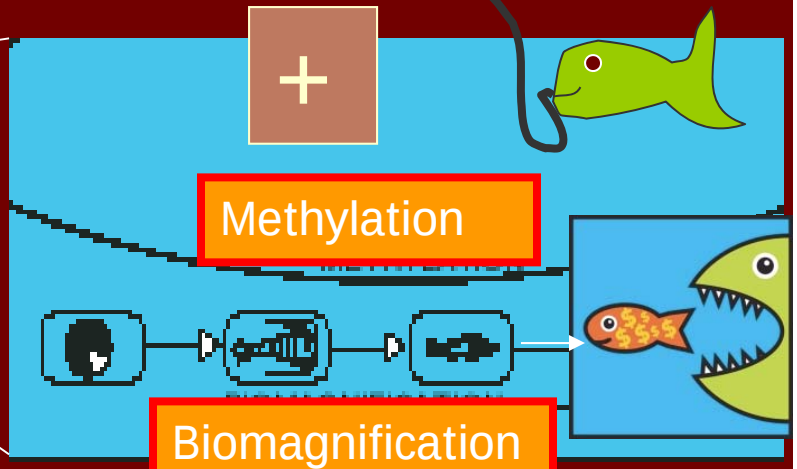
Methylation



Biomagnification

What's missing in the mercury cycle?

- Tree biomass:
  - Dead standing and dead felled (Grigal 2003)

Images provided by GDS NWR

Buried logs as an un-quantified pool for mercury in peat soil

- Dense log layer as a part of the peat (Davis 1907)
- Ecosystem characteristics cause log layer
  - Peat low pH, low decomposition (Thompson et al. 2000)
  - Atlantic White Cedar (AWC)
    - Rot resistant (Akerman 1923)
    - Susceptible to blow-down events

- In an AWC forest, trees make up >99% of biomass (DeBerry et al. 2000).

Purpose

Given the extensive presence of buried logs in peatlands, and the scarcity of studies on mercury in buried logs,

the purpose of this study was to quantify mercury in buried logs,

which will improve terrestrial biogeochemical cycling models and enhance our understanding of mercury remobilization risks.

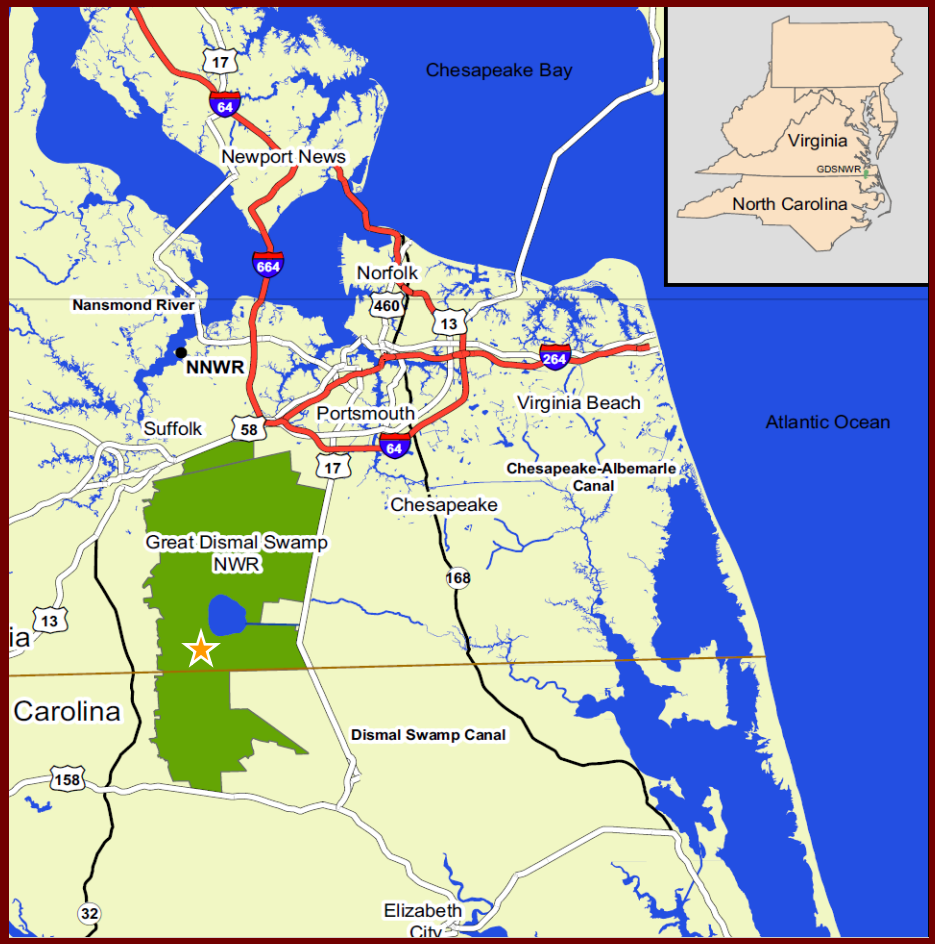
Study Aims:

1. Is there mercury, and how much?
2. How did it get there?

- "Sentient recorders" similar to ice cores? (Abreu et al. 2008)
- Other mechanisms?

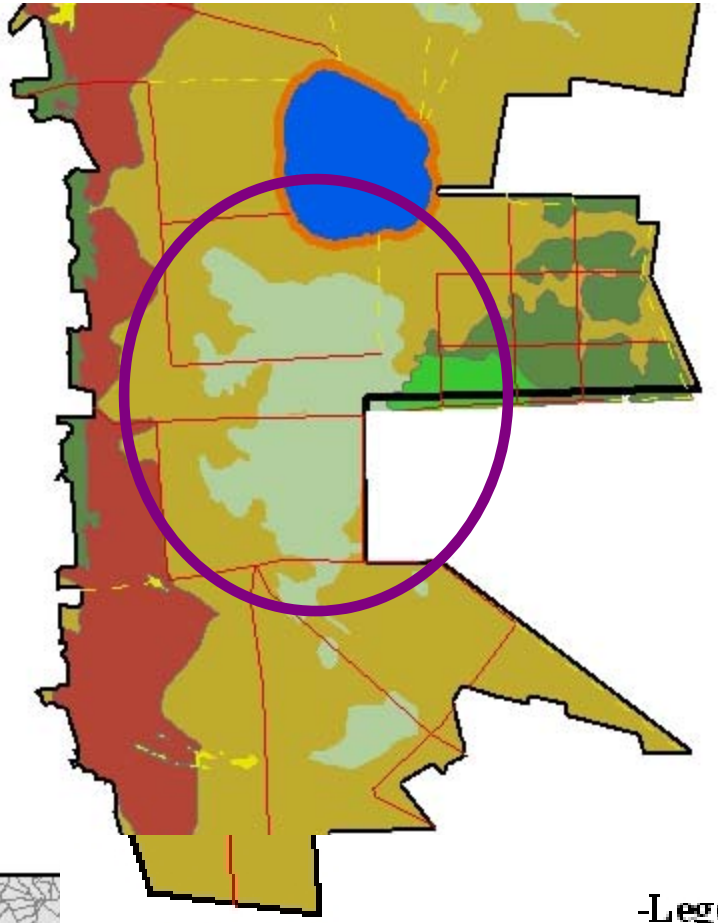
Site Description:

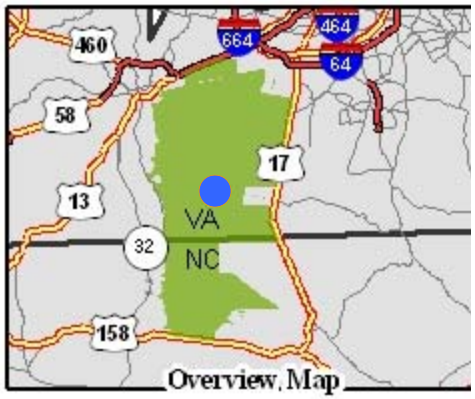
Great Dismal Swamp National Wildlife Refuge (GDS NWR)



Great Dismal Swamp
National Wildlife Refuge

Forest Cover Communities





-Legend-

- Maple-Gum Forests
- Mesic Mixed Hardwood Forests
- Non-Riverine Pine Hardwood Forests
- Cypress-Gum Forests
- Natural Lake Drawn-Down Shores
- Peatland Atlantic White Cedar Forests
- Pond Pine Woodlands and Pocosins
- Maintained
- Unmaintained

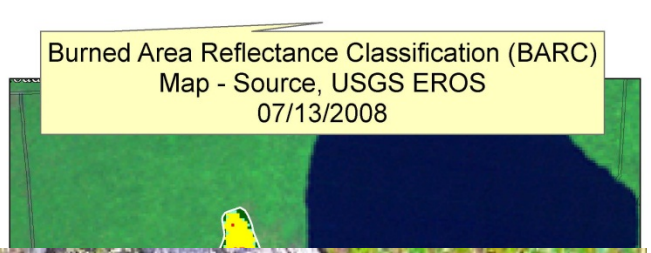
0 1 2 4 6 8 Miles

Image provided by GDS NWR

South-One Fire 2008

- Burned through peat, exposing previously buried logs

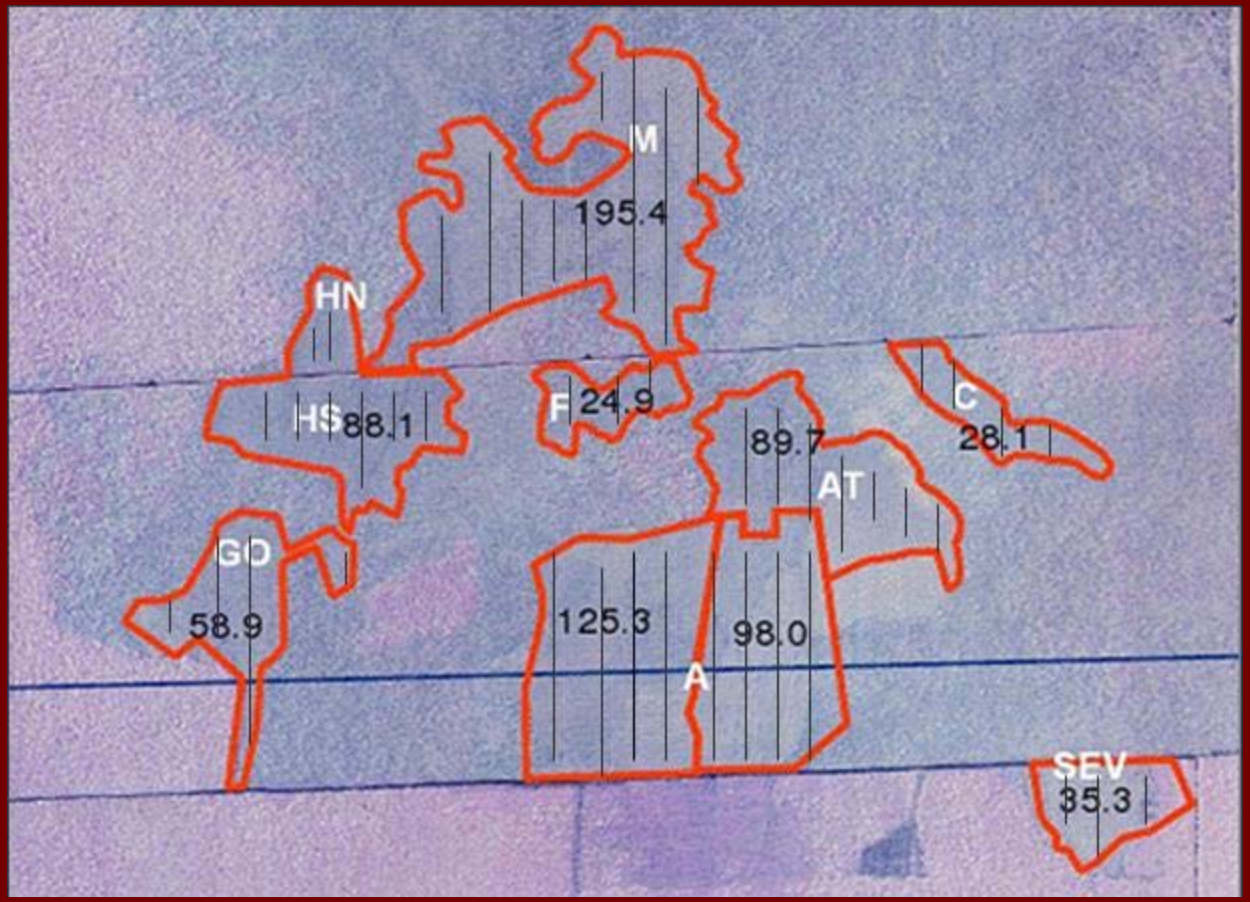

Image provided by GDS NWR



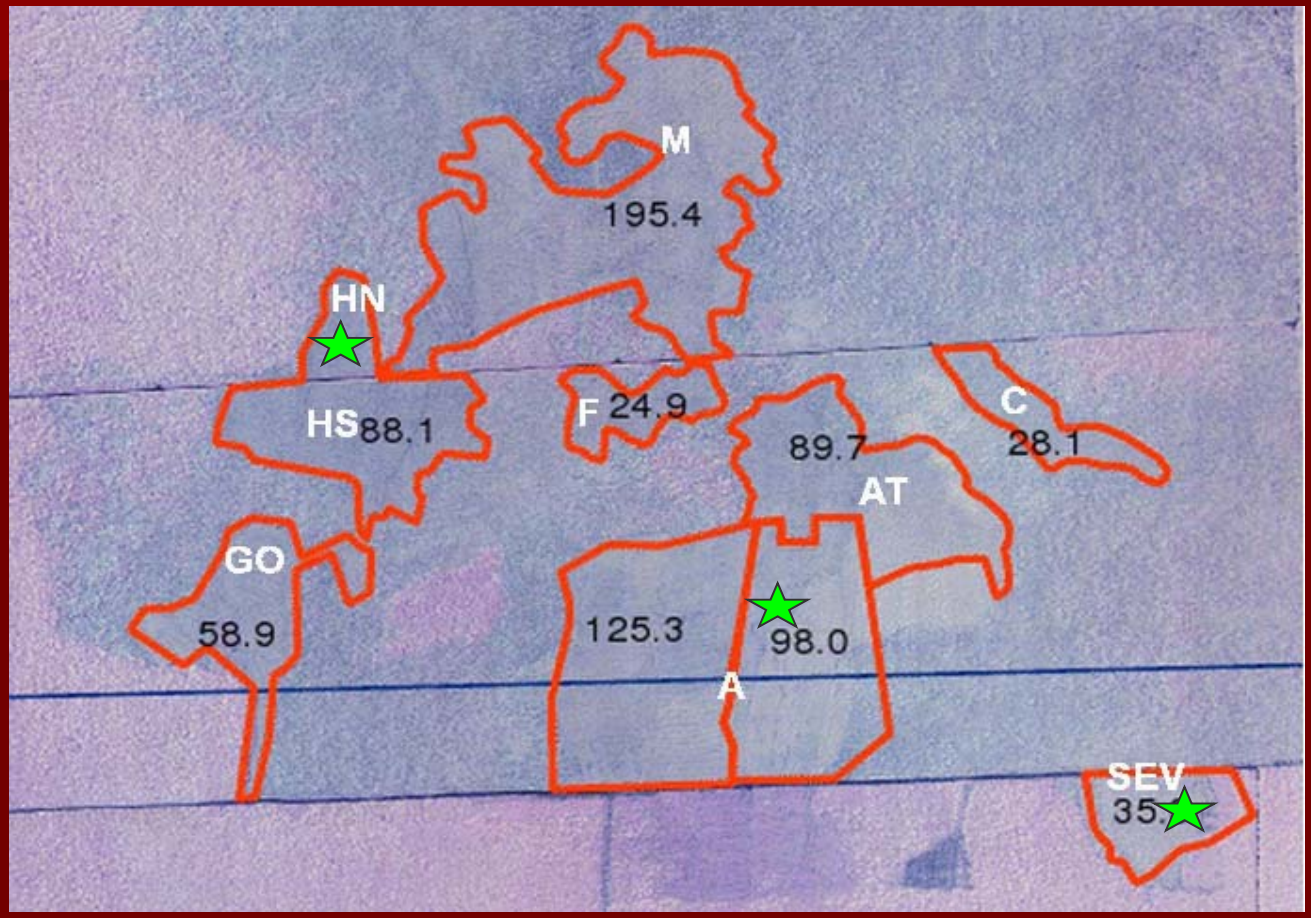

Photograph by Dallas Peck

2009 Survey

- 122 buried logs identified and locations recorded during regeneration study



Three regions selected for analysis



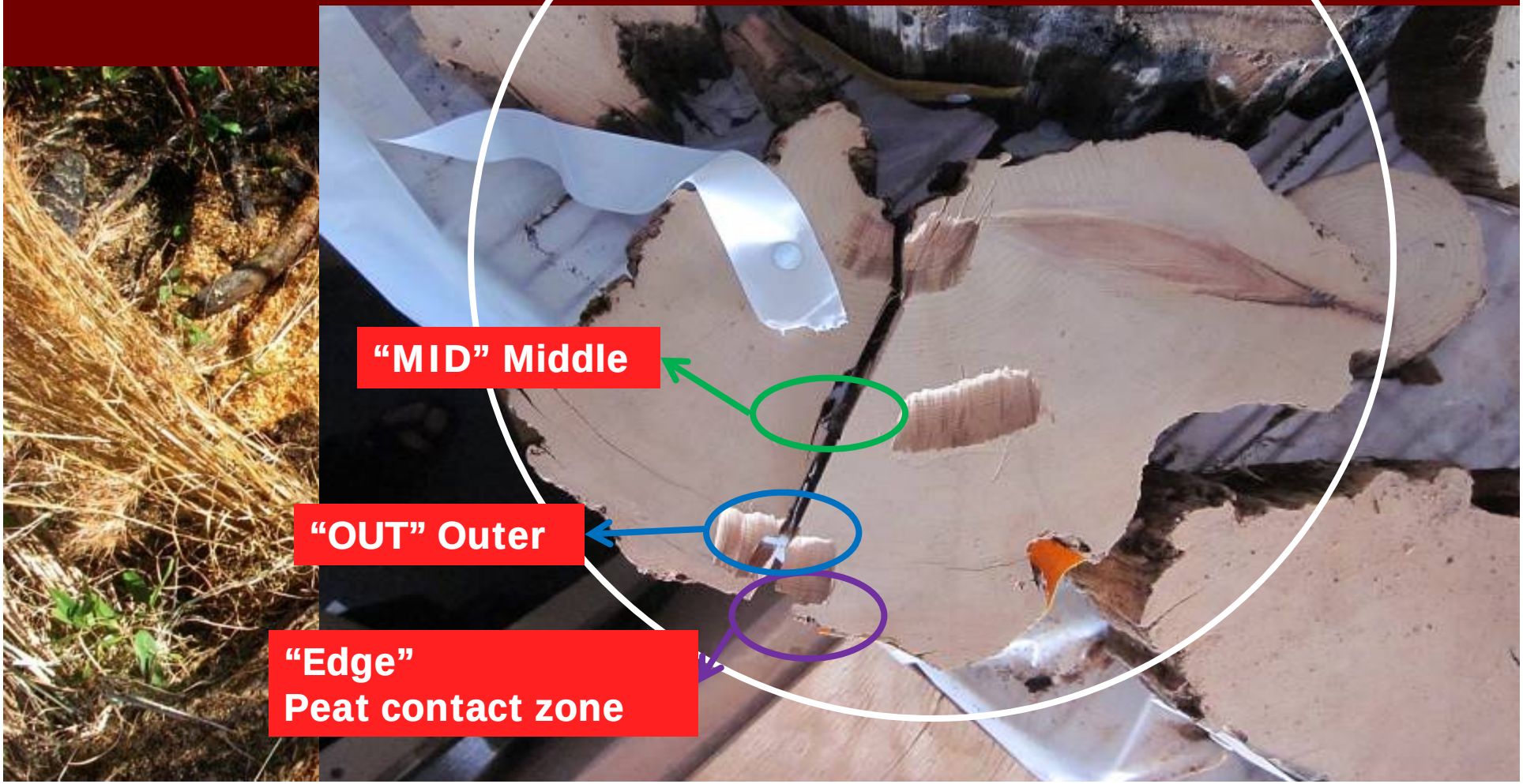
Sample Collection

- 32 log samples collected
- Subset of nine were analyzed

Photographs by Dallas Peck

Wood sample retrieval

-Decomposition and burning
-The “Edge” is different than the chronological ring that would be most recent.

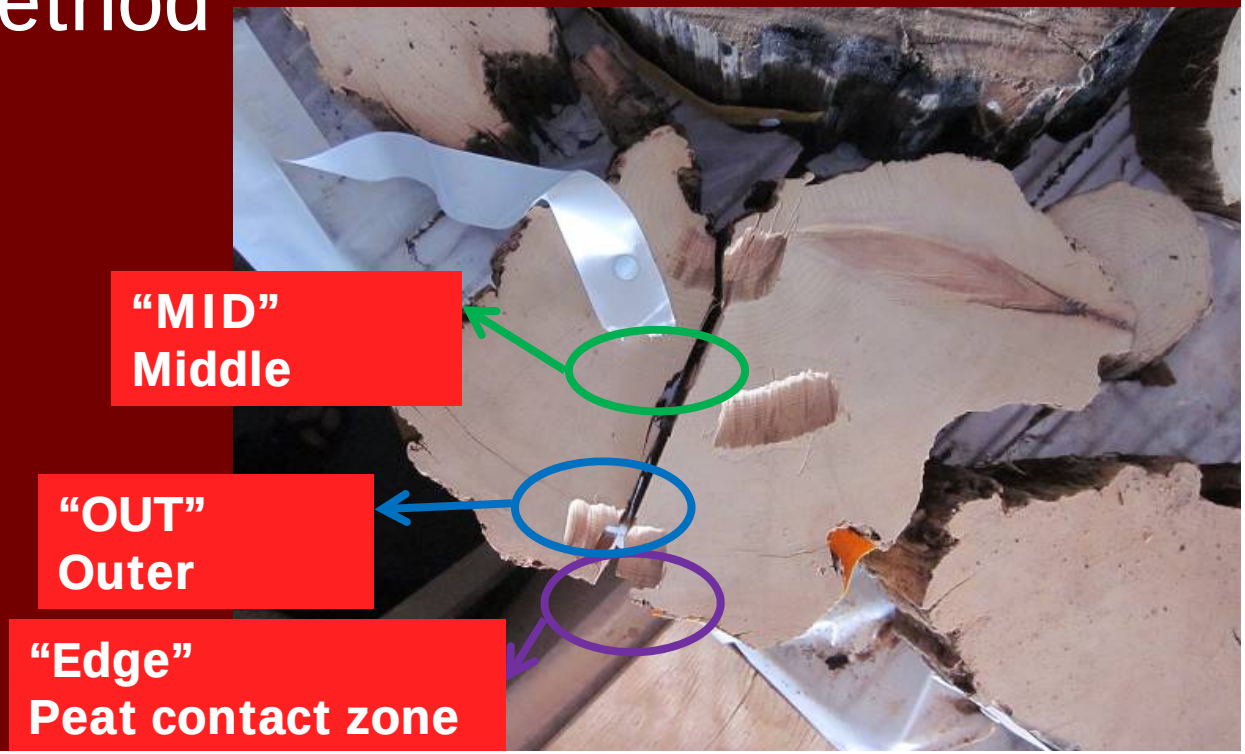


Anaysis-
Atomic Absoprtion Spectroscopy

- Freeze dried samples
- $\frac{\text{Total mercury (mg)}}{\text{dry mass (kg)}}$

Study Design

- 3 replicates from 3 regions (9 “cookies”),
- 3 positions: Middle, Outer, and Edge
- Samples run in triplicate
- Modified EPA Method



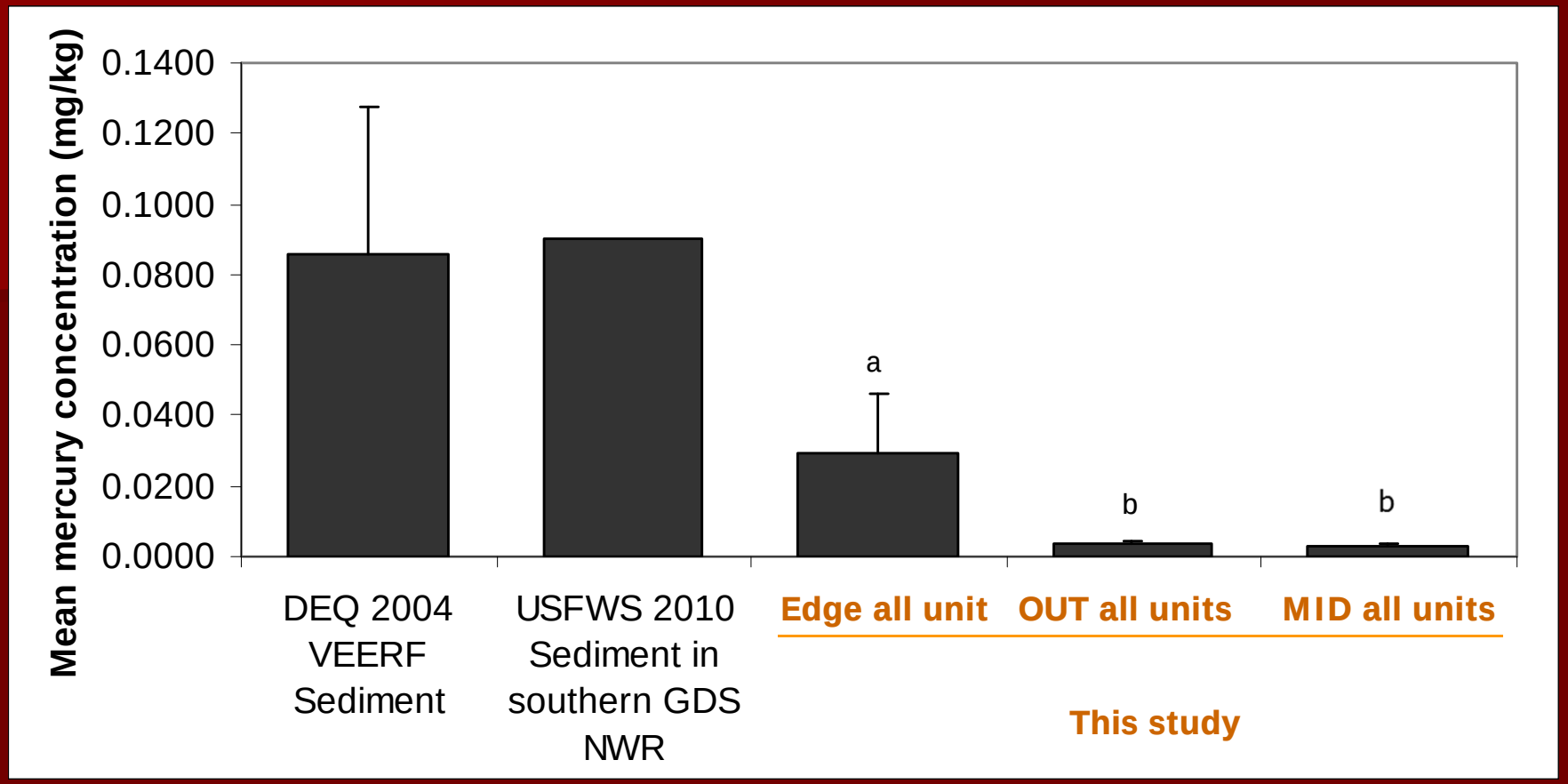


Figure 1. Mean mercury concentration for the Outer, Middle, and Edge positions of buried logs from three salvage units in the GDS NWR

(n = 23, unavailable, 9, 9, and 9; error = +1 SD, SD unavailable for USFWS 2010 data; p = 0.05, 2004 DEQ and USFWS 2010 data not included in significance testing).

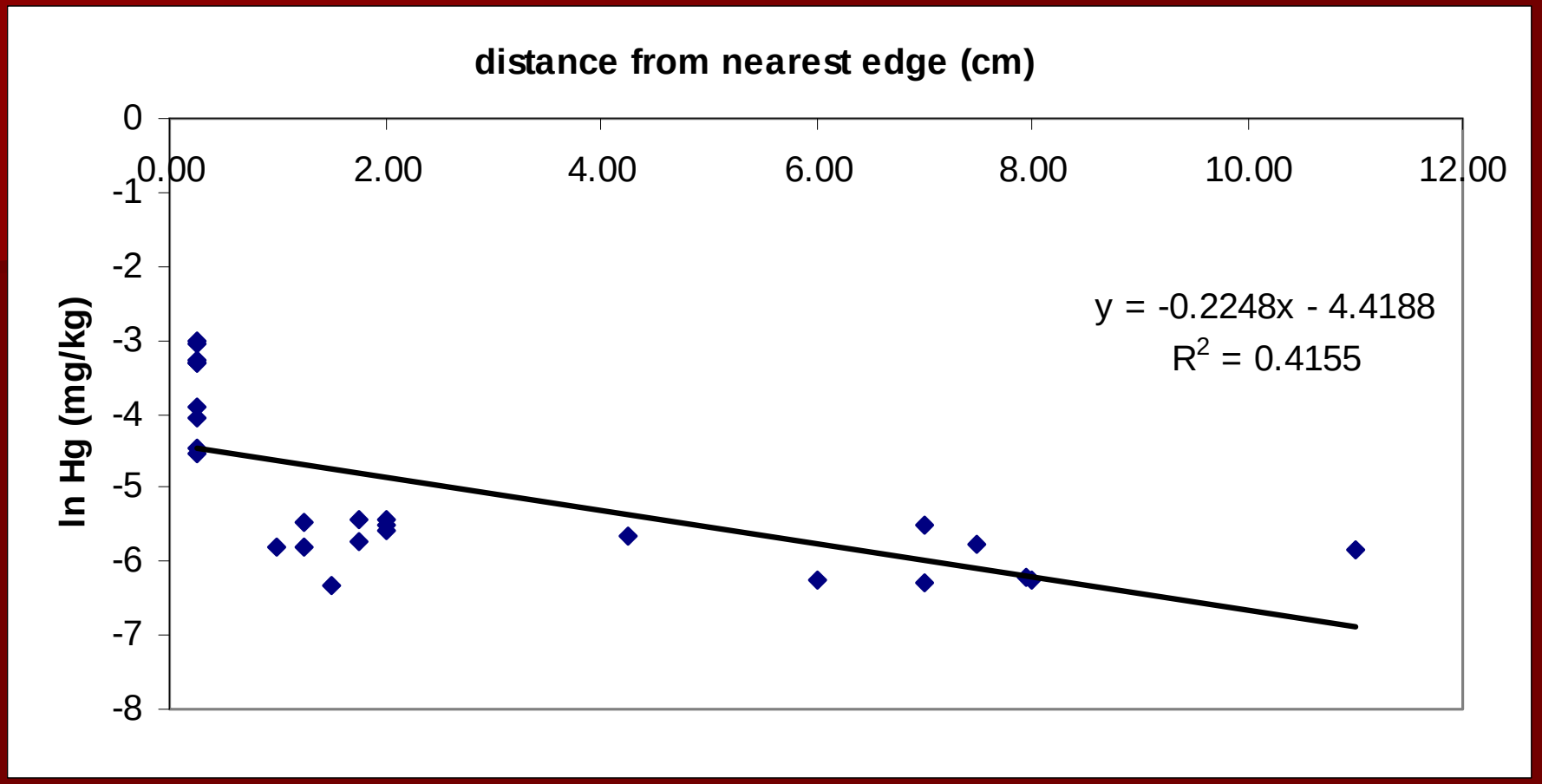


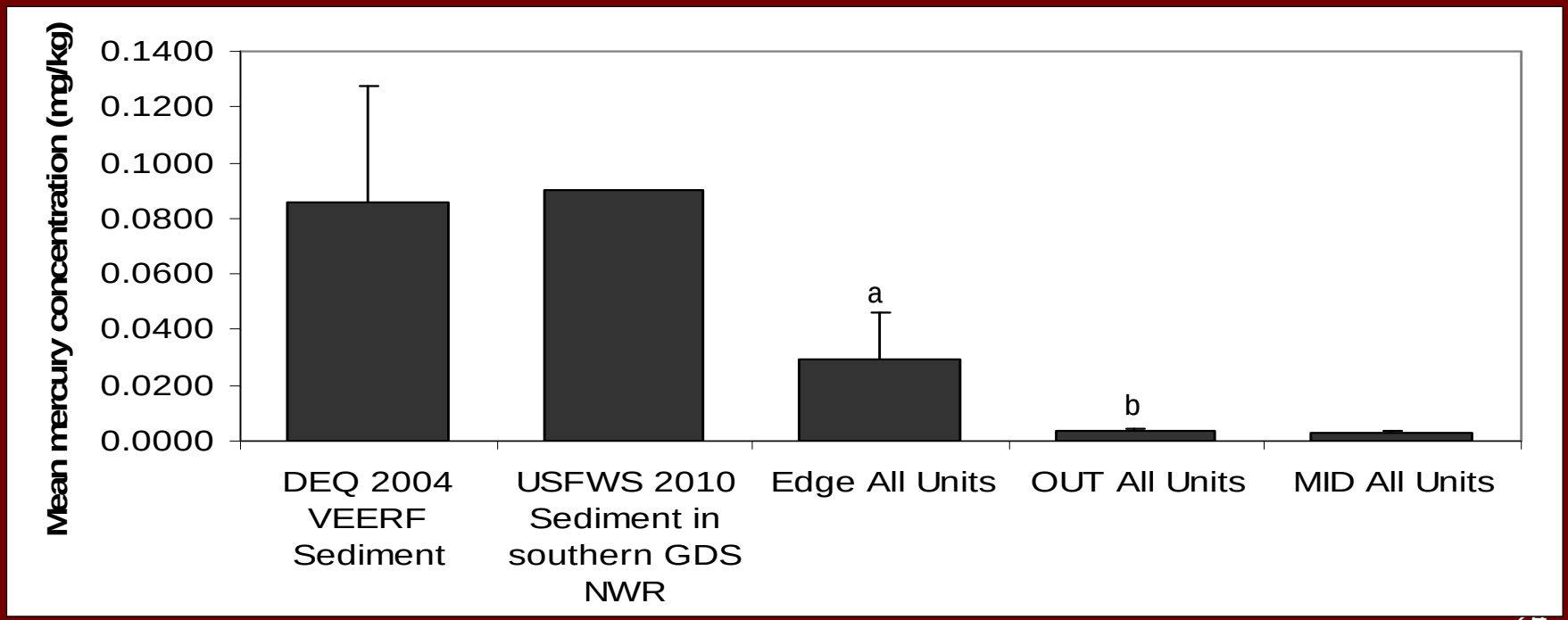
Figure 2. Natural logarithm of mercury concentration and distance to nearest edge of the buried logs found in the GDS NWR (n = 26, r^2 = 0.416, $p<0.01$)

Results summary

- Varies with distance from edge, where there was contact with peat.
  - As the distance from the contact zone increases towards the center of the wood, the Hg concentration drops logarithmically
- No difference among collection regions

1. How much mercury is in buried logs?

- It depends on what position is sampled
- Edge 10x > Inner samples
  (0.0295 and 0.003 ppm respectively)



Discussion

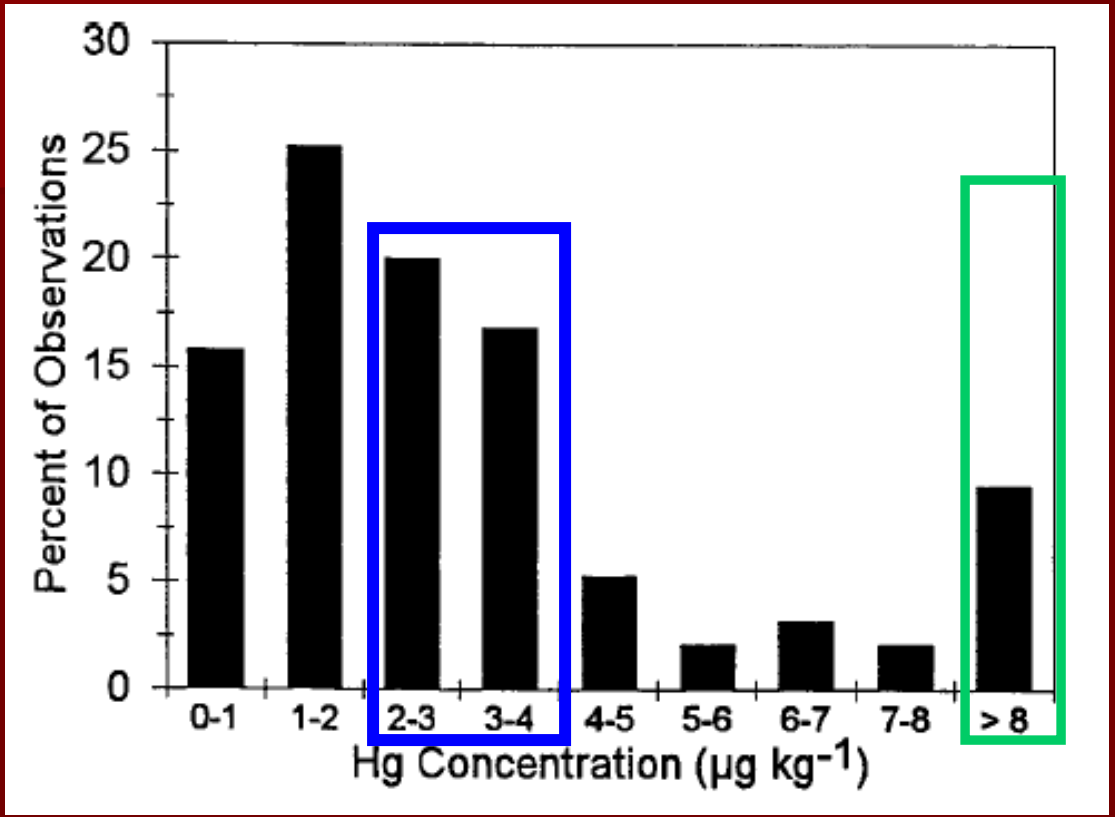


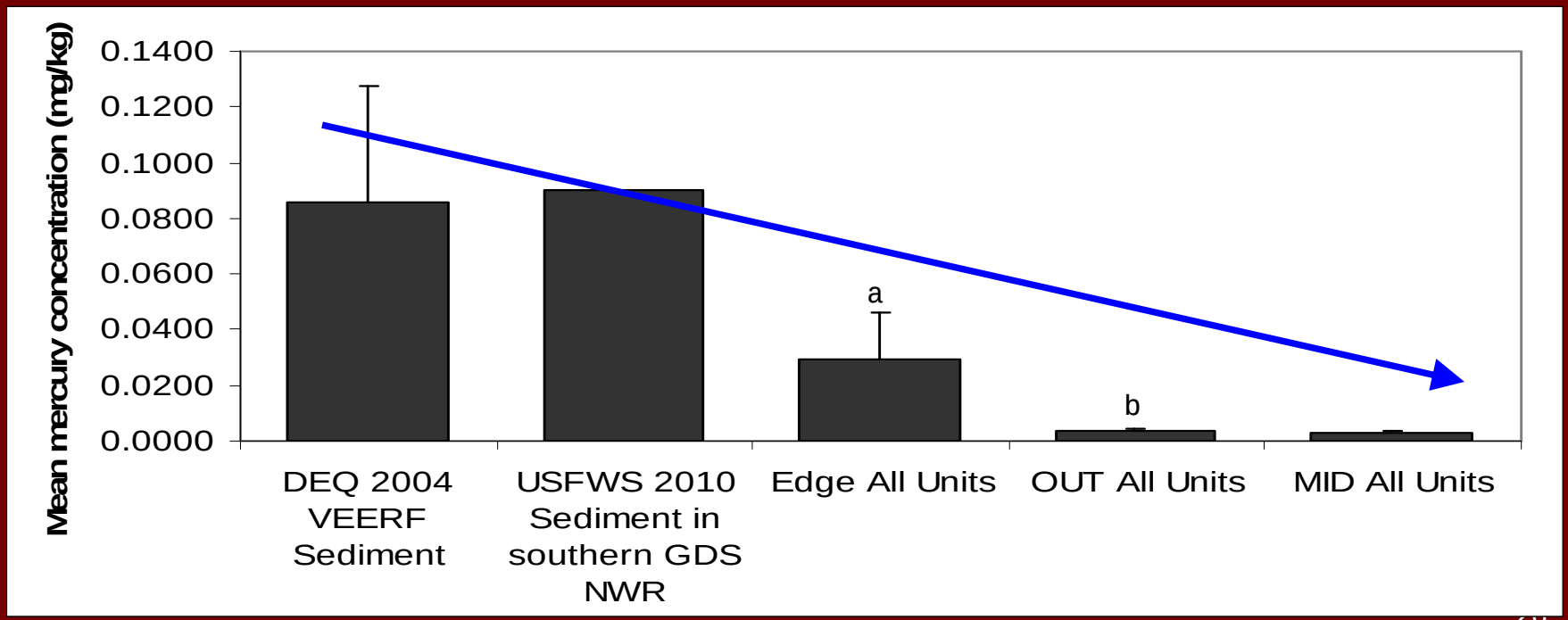
Figure 3. Frequency distribution of Hg concentration in wood and associated bark from a variety of predominantly deciduous tree species (n=95)

- ug/kg = ppb. 1 ppb = 1000 ppm.
- 0.003 ppm = 3 ppb; 0.0295 ppm = 30 ppb

Nader in Grigal 2003

2. Are buried logs similar to ice cores?

- Sediment 2x > Edge 10x > Inner samples
- Inconsistent edge
- Diffusion as the likely mechanism
  - NOT passive recorders



Edge contact zone as a position in peat

Methyl-mercury?

- Only total mercury in buried logs was analyzed in this study.
- Live trees have very low % methyl-mercury
- The inner part to the log, similar in Hg concentration to live trees (Grigal 2003)
  - Likely very low in methyl mercury, high in inorganic
- Biogeochemical transformations
- Animals, such as fish, are inversely proportional, they are likely > 99% methyl mercury

If it's not methyl mercury where's the risk?

- Biogeochemical cycling
  - Avoid entering biological cycles through sequestration
- Peatland management of water table
- Re-emission and leaching to downstream waterways.
- Methylation after redeposition and then incorporation into food web.

Mercury cycle implications

- Hg in dead woody biomass
  - research is limited
- By quantifying the mercury concentration in buried logs, better assessment of peat mercury can
  - Improved mercury risk modeling
    - Re-emission
    - Waterways
    - Wildlife
    - Human health
- Synergistic effect of management

Acknowledgements

CNU Center for Wetland Conservation

- Dr. Robert Atkinson, Director
- Jackie Roquemore, Assistant Director

Great Dismal Swamp National Wildlife Refuge

- Bryan Poovey
- Chris Lowey

Virginia Institute of Marine Science

- Dr. Michael Newman
- Erica Holloman
- Xiayu Xu
- Jincheng Wang

Colonial Williamsburg

- Jim Wesson, Master Craftsman

Williamsburg Environmental Group

Field Crew!

- Shawn Wurst
- M. Emily Foster
- J. Bayley Cook
- Lauren Achtemeier
- Sam Burks
- And many volunteers!

Laboratory Crew

- Justin Weisser
- Crystal Levenson

Photography

- Dallas Peck
- M. Emily Foster

Thank you!

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Table 2-1. Mean mercury concentration (mg/kg) in three sections of buried logs from the GDS NWR (n = 9, error = +1 SD).

	Edge		Outer		Middle	
Salvage Unit	Mean	SD	Mean	SD	Mean	SD
A	0.0215	0.0133	0.0029	0.0011	0.0023	0.0007
H	0.0317	0.0180	0.0039	0.0006	0.0023	0.0006
SEV	0.0355	0.0143	0.0037	0.0007	0.0035	0.0006

How much Hg in one log?

Mean biomass of tree x mean mercury concentration

Two regions with different concentrations

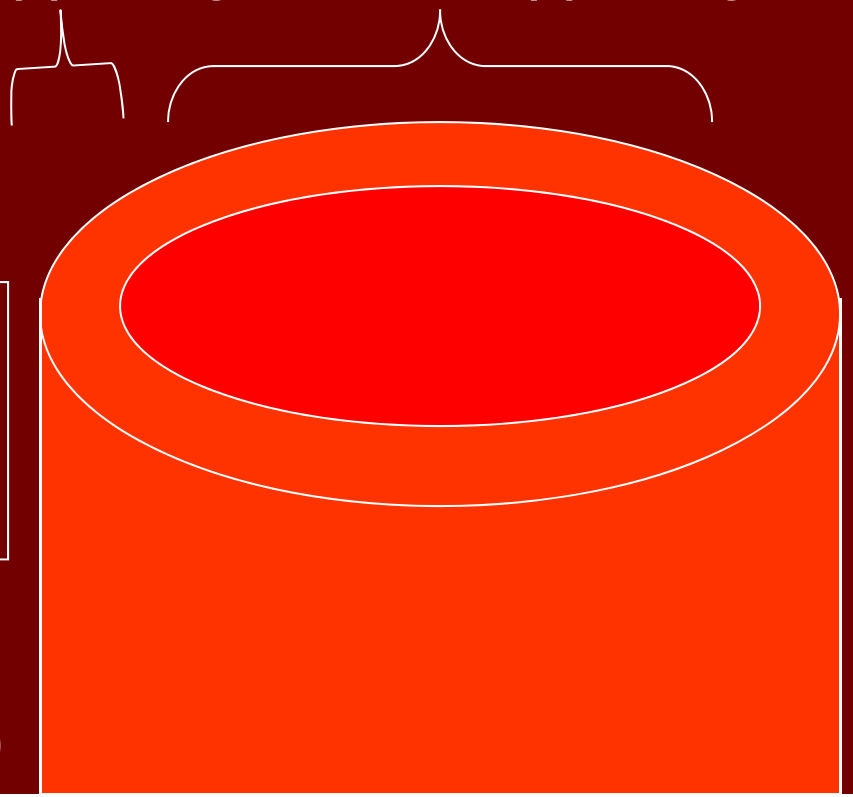
0.4 to 0.6 mg Hg per buried log

(35-75 kg/stem)

Mass of the outer cylinder x [Hg] Edge

+

Mass of the inner cylinder x [Hg] inner



Biomass estimates from DeBerry et al. (2000)

How much Hg is in GDS NWR wildlife?

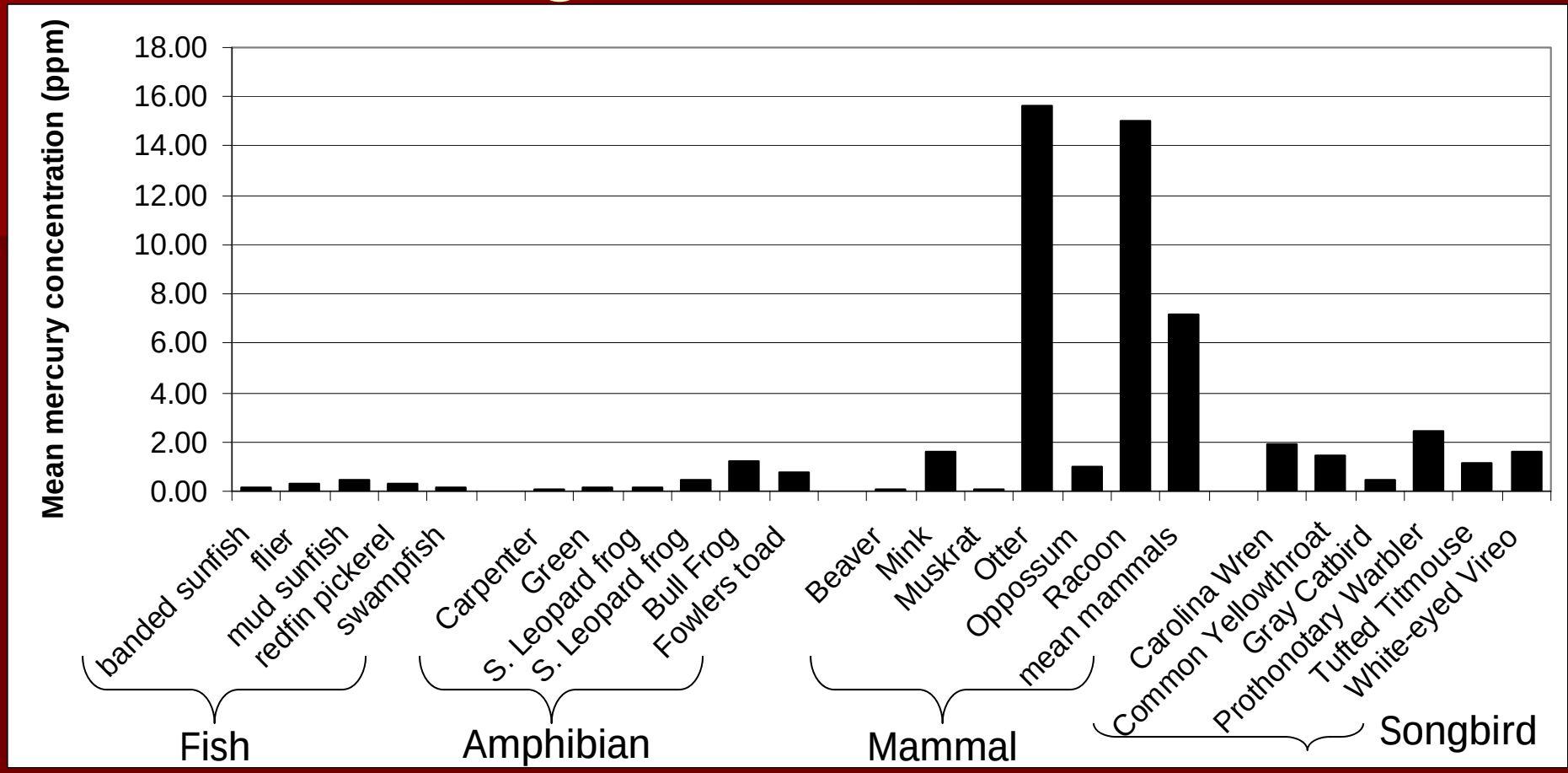


Figure 4. Select mean mercury concentrations in Great Dismal Swamp National Wildlife Refuge fauna adapted from USFWS (Lingenfelser, 2010).

Fish Values for birds and mean mammal concentrations are a subset including only captures in the southern part of the GDS NWR. Data for fish concentrations tissue type: wet weight whole body for species with > 1% of sample over advisory threshold of 0.4 ppm, amphibian tissue type: unavailable, mammal concentrations tissue type: fur, and bird concentrations tissue type: feathers (n = 7,11,2,4,31 for fish respectively, n unavailable for amphibians, n = 2,3,3,8,3,7 for mammals, n unavailable for mean mammals, n =7,4,8,6,2,3 for birds respectively).

Gradient of change in mercury over the positions of the logs.

- Gradient 1 =
  (mean [Hg] Edge – mean [Hg] Outer) /
  (mean dist. to Edge – mean dist. to Outer)

- Gradient 2 =
  (mean [Hg] Outer – mean [Hg] Middle) /
  (mean dist. to Outer – mean cm to Middle)

Mercury gradient within log

- Edge to Outer (-0.0196 (mg/kg Hg) / cm)
- Outer to Middle (-0.0001(mg/kg Hg) / cm)