# Mercury in Atlantic white cedar (*Chamaecyparis thyoides*) tree rings from Great Dismal Swamp National Wildlife Refuge: Analysis of concentrations over time

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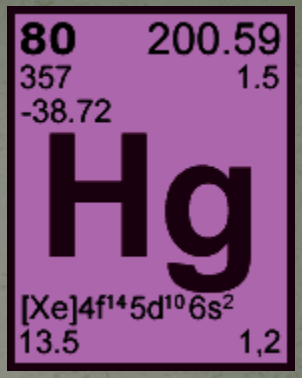
# Outline

- Mercury
- Dendrochemistry
- Peatlands and Atlantic White Cedar
- Site description
- Sampling and analysis
- Results and implications for peatland management

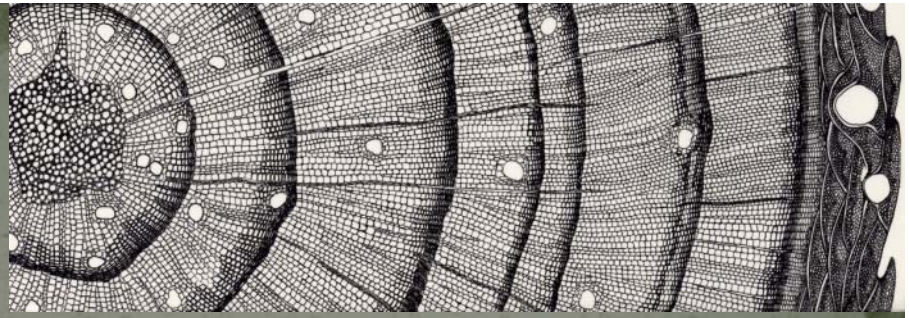
# Mercury




- Naturally occurs:
  - Coal, cinnabar/mercury sulfide
  - Anthropogenic release
- A "heavy metal"
  - Toxic
  - Arsenic, Lead, Beryllium, Cadmium and Chromium

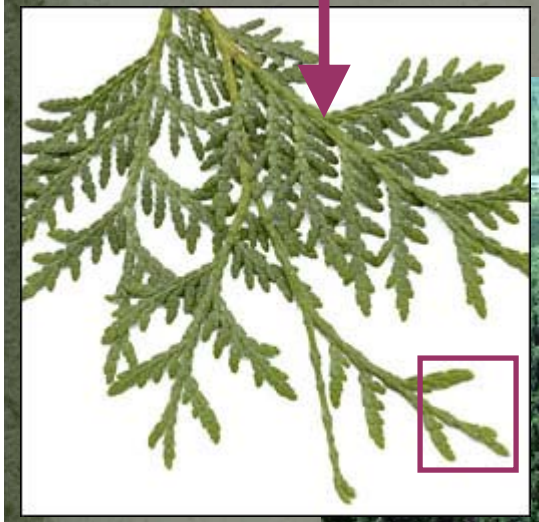
- Methyl Mercury
  - Species of concern
    - Lipophilic
    - Low dissolved $O_2$ → anaerobic respiration → sulfur reducing bacteria → Methylation of Hg
      - Conditions in Atlantic white cedar swamps (Thompson et al. 2000)

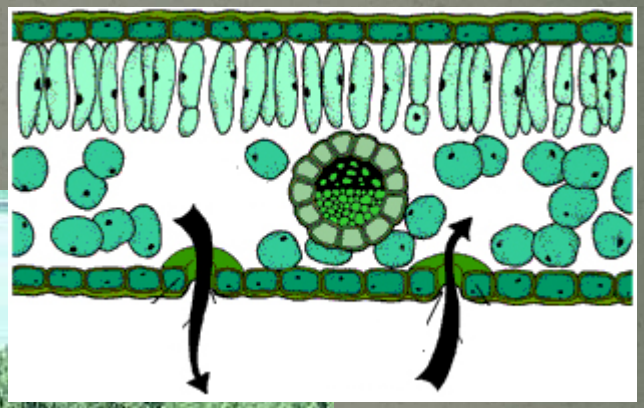
# Dendrochemistry



- *The science, related to dendrochronology, that uses the analysis of trace minerals in tree rings to study pollution in past times.*
- Almaden mining district of Spain
  - Moderate to high levels of Hg in both the roots and aerial parts of several plant species.
  - Bolewood concentrations much lower
    - Not translocating from roots to bolewood (Molina et al. 2006)
- Quebec Black Spruce (*Picea mariana*)
  - Sun and temperature effected mercury uptake
  - Indicates Hg observed in tree rings deposited from the atmosphere onto the tree surface and taken in by stomata (Zhang et al. 1995)
- Tree rings a potential "data logger" of mercury in aquatic systems (Abreu et al. 2008).

# Peatland mercury





# Atlantic white cedar as an un-quantified pool for mercury in peatland ecosystems

- Atlantic White Cedar (AWC) forest in the Great Dismal Swamp National Wildlife Refuge(GDSNWR):
  - Trees made up >99% of live above ground biomass (DeBerry et al. 2003).
- Susceptible to blow-down events

# Purpose

Logs represent a significant uncertainty in wetland biogeochemical cycling models; and an unknown risk of mercury remobilization.

**The purpose of this study is to quantify mercury in Atlantic white cedar tree rings and characterize trends over time.**

# Site description:
## Great Dismal Swamp National Wildlife Refuge (GDS NWR)

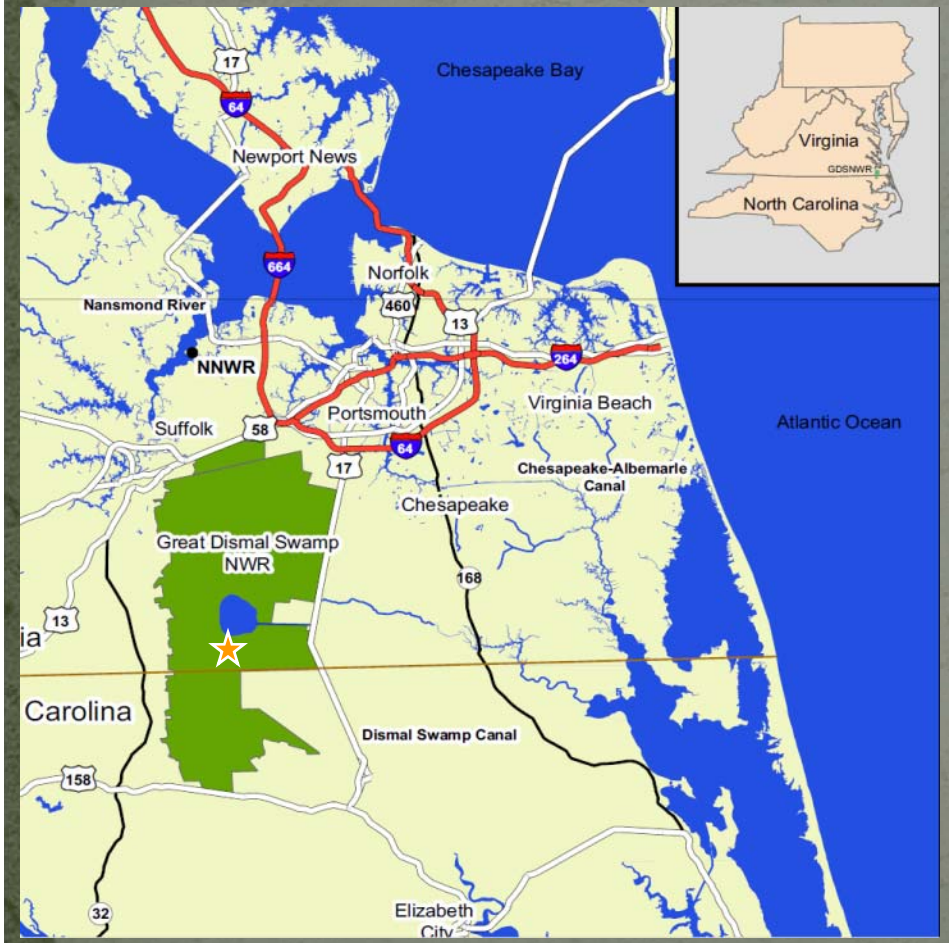



Image provided by GDSNWR

- Dismal Swamp Act of 1974 to U.S. Fish and Wildlife Service:

  "Manage the area for the primary purpose of protecting and preserving a unique and outstanding ecosystem..."

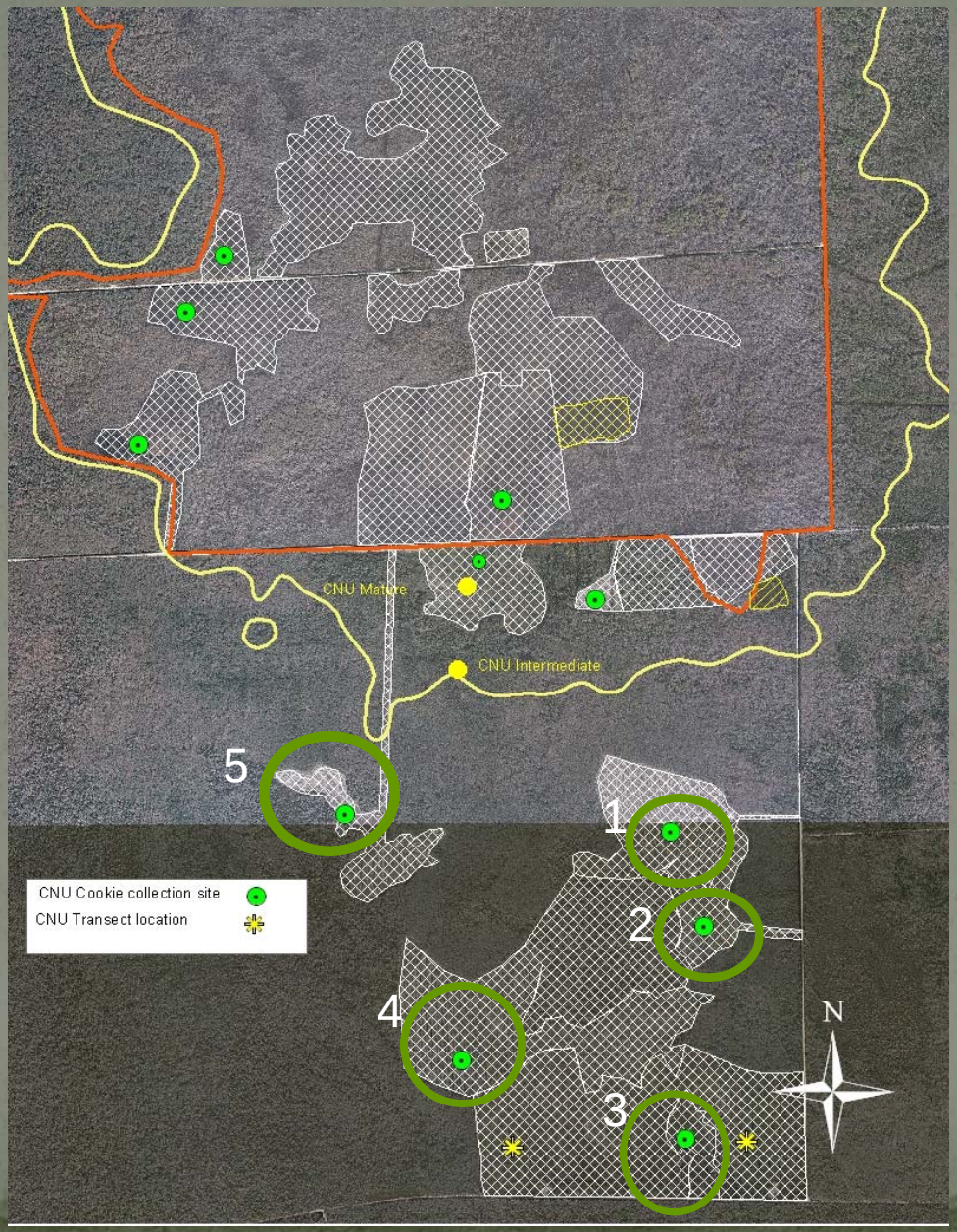
- Including protection and restoration of AWC.

- 45,000 ha across SE Virginia and NE North Carolina.

# Hurricane Isabel, 2003

Images provided by GDS NWR

# Salvage logging units selected for analysis



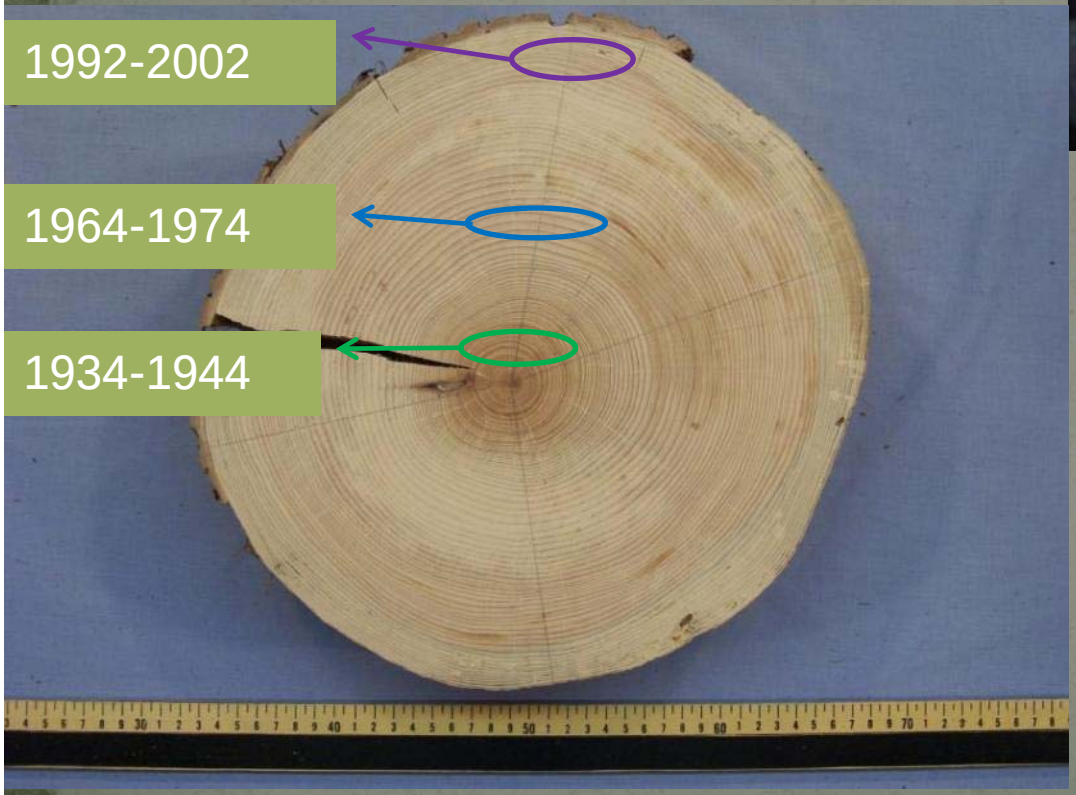
# Sample collection

Cross-sectional log segments or “Cookies”

Craig Patterson

80 year old tree stands

# Sampling design



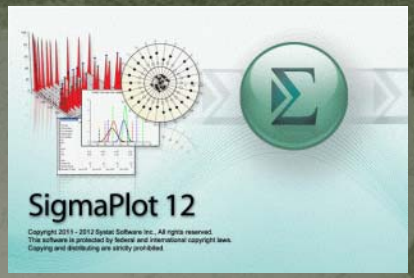

- Preparation for dendrochemical analysis.

# Sample analysis

- Freeze-dried and cut into the shape of the sample loading trays (boats) for analysis
- Modified EPA method for quality control measures.

- Atomic Absorption Spectroscopy (DMA-80) at Virginia Institute of Marine Science.

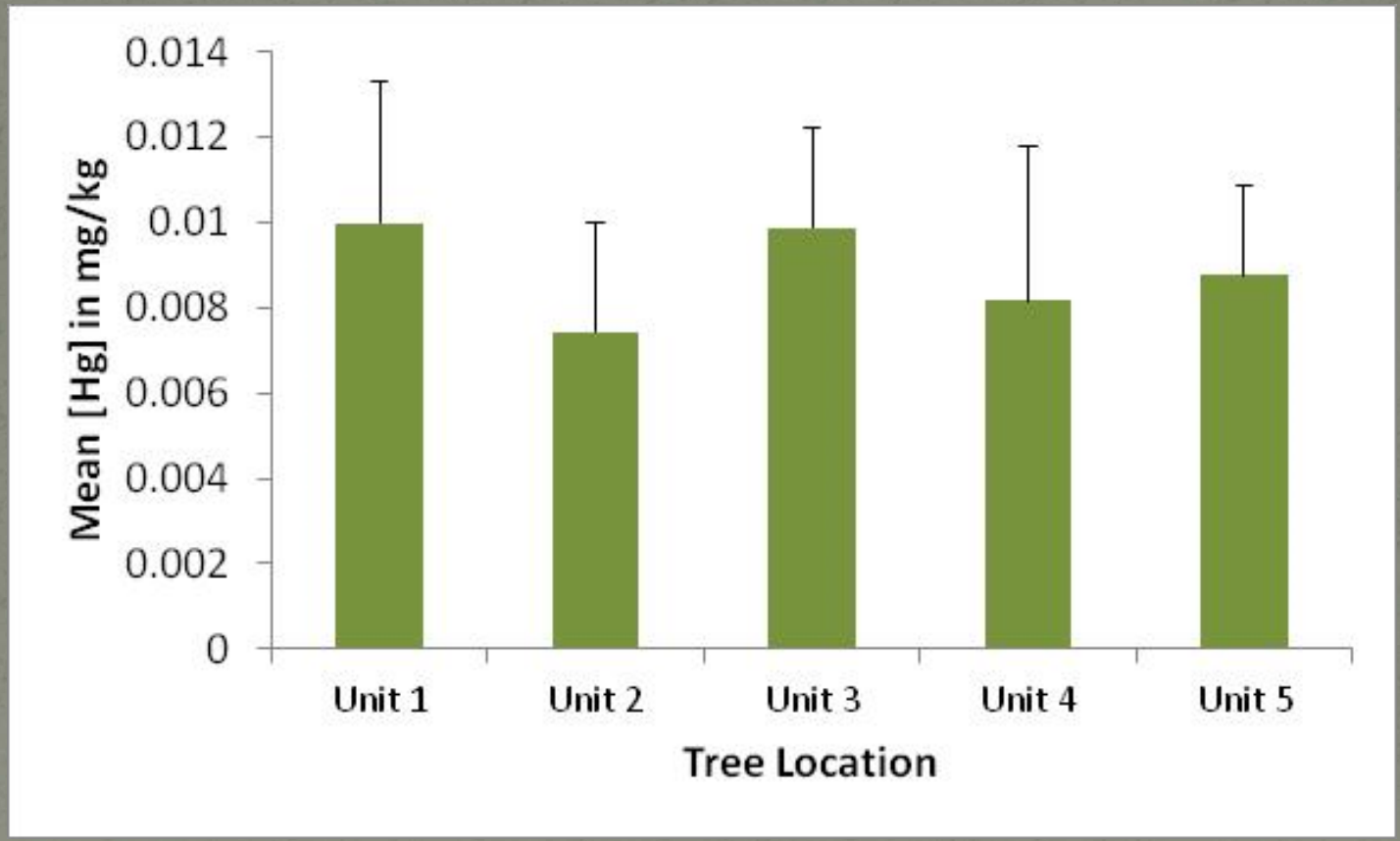
# Data Analysis




- 19 tree "cookies"
- 4 cookies from each of the units 1-4, 3 from unit 5.
- 3 sample locations per tree → year classes
  - Three subsamples per location per tree

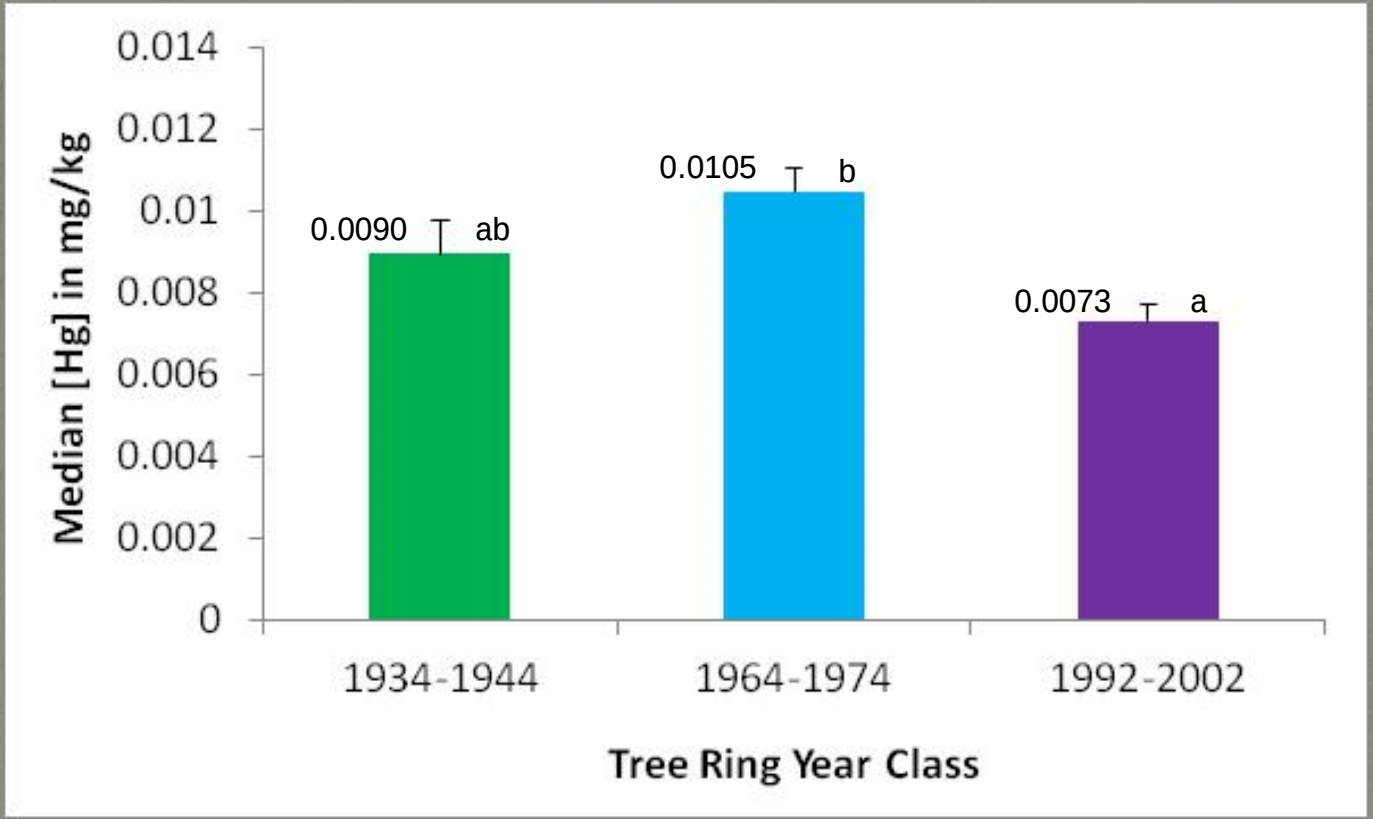
- Concentrations of mercury among salvage logging units was compared via one way ANOVA of means with sigma plot 12.3
- Concentrations of mercury among year classes was compared using one way ANOVA on ranks of medians using sigma plot 12.3

# Mercury per salvage logging unit




*no significant difference among unit locations, p= 0.154, Error=+1 SD, n=12

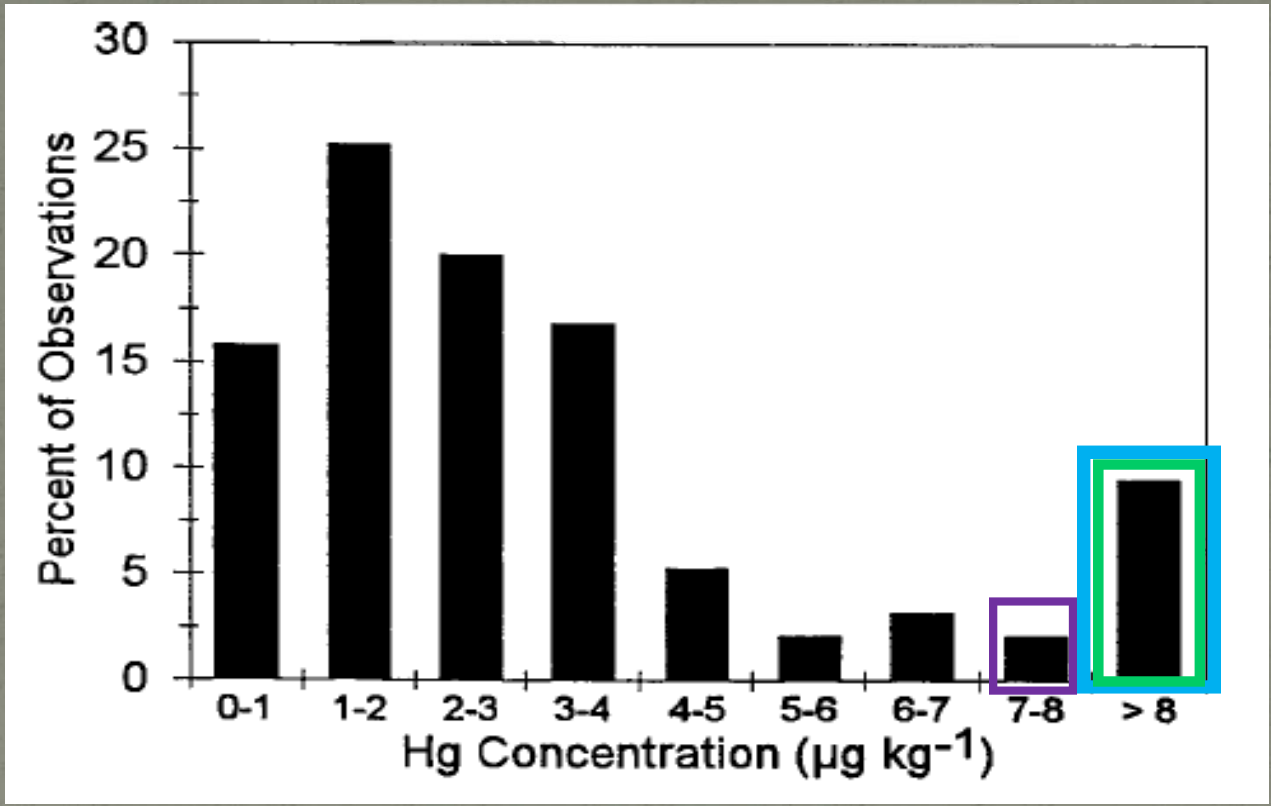
# Mercury in Tree Rings




Medians with the same letter were not significantly different, p<0.05, Error=+1 SE, n= 19

# Discussion

Nader in Grigal 2003




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

- Boxed= [Hg] per year:
  - 1934-1944, 1967-1974, 1992-2002

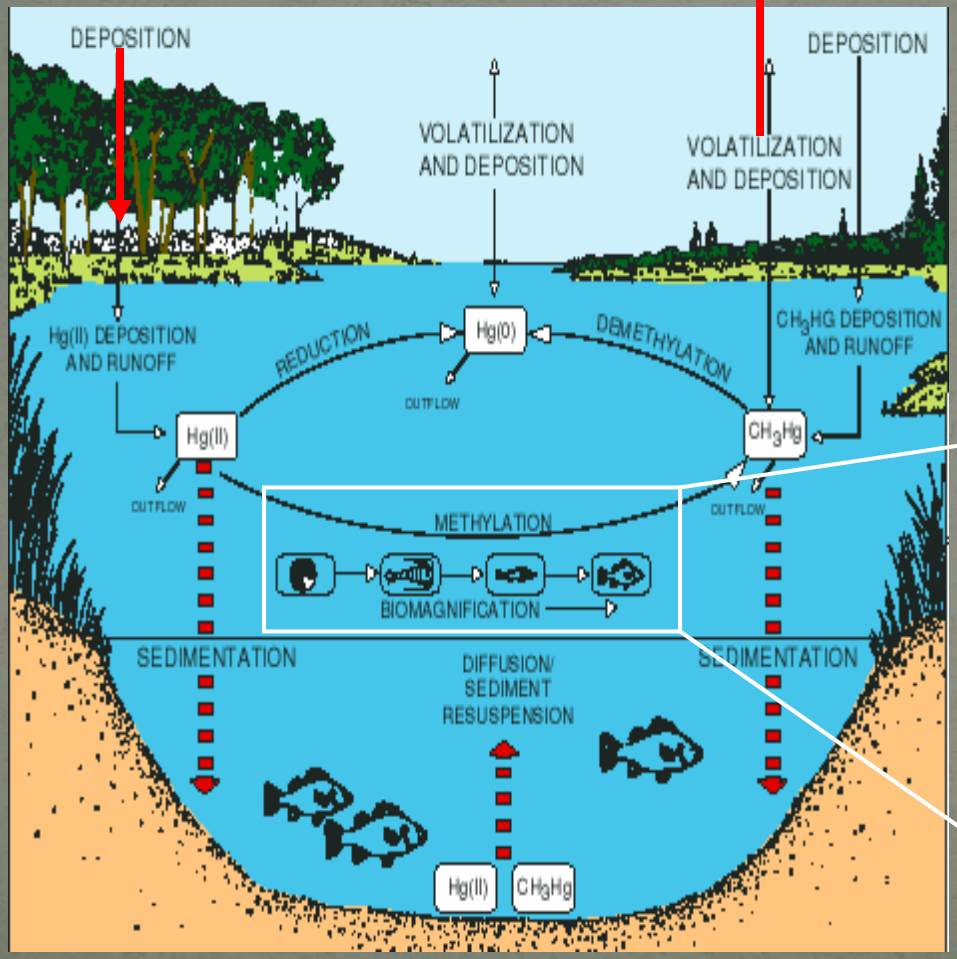
# How much mercury the trees?

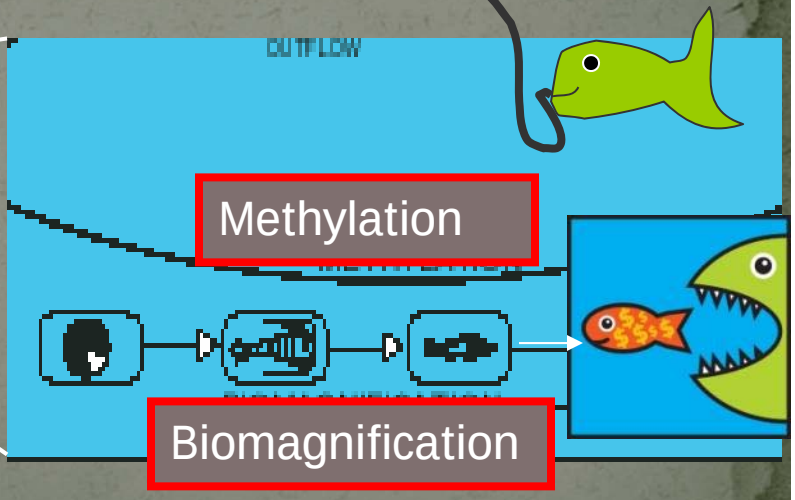
- Single standing tree estimate = 1.42– 42.60 mg Hg
  - 15-21 m tall, 0.22-0.28 m diameter , 310 mg/kg density (Schroeder and Taras, 1985)
    - **0.00733** - **0.1050** mg Hg/kg
- 1.42 – 42.6 g Hg/ha of mature AWC forest
  - derived from DeBerry et al. 2003
- Fallen logs store mercury that can be volatilized by fire.
  - Water table management can limit fire effects.
  - High water tables reduce peat oxidation from both fire and decomposition.

# Implications

- Significant decrease in mercury found in AWC was after Clean Air Act (1970).
  - More stringent air quality standards further decrease mercury input to GDSNWR and amount seen in AWC growth rings.
    - 1990's section 112 amendments- "maximum achievable control technology" standards.
- Refuge established in 1974 and raised water level to support their mission.
  - Limits peat oxidation and release of mercury
- Future studies should speciate mercury to distinguish atmospheric from peat sources
  - Inorganic vs organic

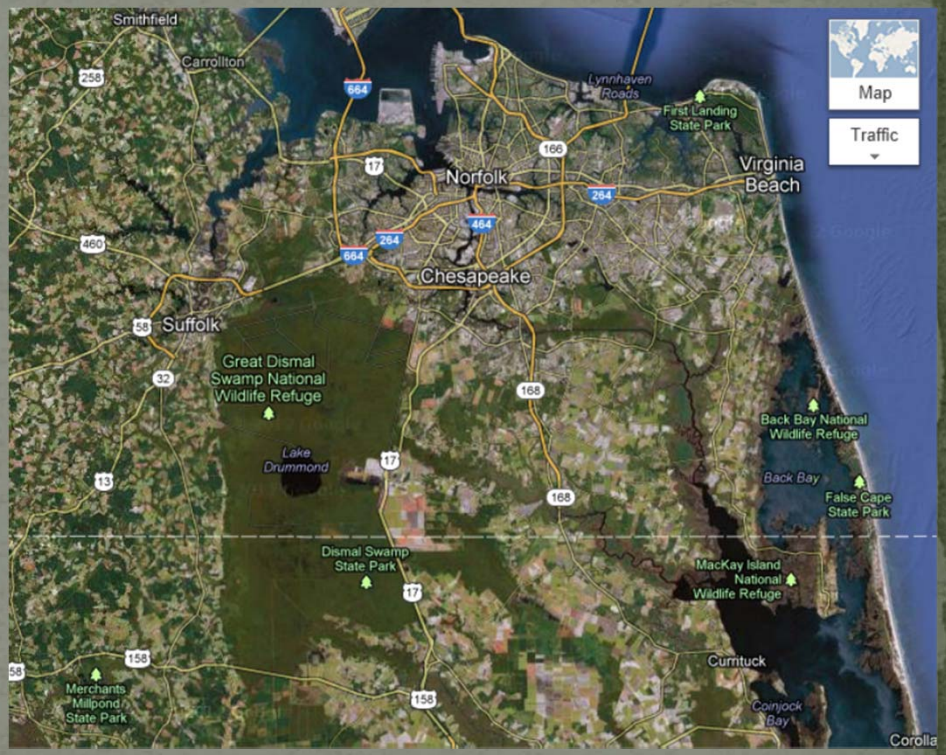
# Mercury in the environment



# Methyl mercury poses public health and ecosystem risks.

- Emmission or leaching downstream
- Methylation after deposited/leached
  - incorporated into food web
    - Bioaccumulation and subsequent magnification up food chains



# Acknowledgements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  - (and family roped in)

# Thank You!

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# Mercury toxicity

Neurological disorders

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

Fetal blood barrier

- Lowered mental development of children


QUICK-CHEK
15.346
ZERO