Mercury Bioaccumulation within Terrestrial Foodwebs in the Northeastern United States

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Appalachian Mountain Mercury Network

Partnering agencies and organizations to gain a better understanding of atmospheric deposition and impacts of pollution on forested ecosystems using thrushes and other songbirds as indicators.

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Detrimental impacts have been documented in studies relating to amphibian and songbird communities in the Northeastern United States.
Effects of Mercury on Songbirds

Lowered Reproductive Success
- Fewer eggs produced
- Compromised embryonic development
- Lower chick survival

Behavior
- Less time spent hunting, flying, walking
- Increased time preening
- Offspring less responsive to parent

Neurological
- Tremors
- Difficulty walking, flying, standing
- Inability to coordinate muscle function

Physiological
- Increased feather assymmetry
- Disrupted hormone levels
- Brain lesions
- Spinal cord degeneration

In Maine and New York, studies have identified mercury concentrations in songbird blood that exceed threshold levels where adverse physiological effects become evident.
Seasonally, songbirds are able to reduce the concentrations of mercury in their bodies through feather growth and egg deposition.

With continued ingestion of prey species high in mercury content, individuals may accumulate mercury faster than they can rid their bodies of it through natural processes.
Insectivores are widespread across the landscape—necessary to understand the role that these species may represent in regards to the health of the surrounding environment.
Band the bird
Individual Characteristics

Age, Sex & Weight

Bill, Wing, Tail Measurements
Sample Collection

Feather extraction ~
Long-term mercury exposure
Sample Collection

Blood Extraction ~
Short–term mercury exposure
Invertebrate Sample Collection

**Carnivore**

**Herbivore**

**Detrivore**
**Invertebrate Hg and MeHg, 2005-2006:** Spider and centipede Hg levels were generally higher than other invertebrates. Calcium-rich prey items such as isopods and millipedes had moderate Hg levels. Most invertebrate Hg levels were 50-80% MeHg; slug, caterpillar, and cricket Hg levels contained only <30% MeHg.

Source: BioDiversity Research Institute, 2006
STUDY SITES INCLUDE ~

- Acadia National Park, Maine
- Hubbard Brook Experimental Forest & White Mountain National Forest, NH
- Green Mountains, VT
- Harvard Forest and the Berkshire Mountains, MA
- Tug Hill, Catskill and Adirondack Mountains, NY
- Powdermill Nature Preserve, PA
- Shenandoah National Park, VA
- Fernow Experimental Station, WV.

Study Area
Our current study includes nearly 60 sites across the Northeast and south to Great Smoky Mountain National Park

1999-2010
1878 individuals
79 species
Indicator Species for Terrestrial Ecosystems

- Regional efforts conducted by BioDiversity Research Institute to assess the impacts of Hg on songbird species across 5 terrestrial ecosystems.

- Each system has an indicator species that best represents the mercury risk in that particular habitat ~ identify at-risk species and sensitive habitats.

Source: Hidden Risks, BRI 2011
Indicator Species for Terrestrial Ecosystems

Risk categories associated with reductions in nesting success

Source: Hidden Risks, BRI 2011
~ Bald Eagles~

Mercury Exposure in New York State

Mercury concentrations vary by region in New York State

- Hg concentrations higher in eagles in Delaware/Catskills region
- No NY territories exceeded 0.7 ppm outside the Delaware/Catskill region
- Only territory considered highly elevated (>1.0 ppm) was in Catskill Park - Neversink Reservoir
~ Bald Eagles ~

Mercury Exposure in New York State

Territories with Elevated mercury values

- 10% - New York State
- 25% - Delaware-Catskill Region
- 43% - Catskill Park

Proportion of New York bald eagle territories in which mean eaglet blood Hg concentrations fell within 4 ranges of Hg concentration

[Bar chart showing proportions]
Methylmercury Bioaccumulation within Montane, High-Elevation Foodwebs

Do mercury concentrations in songbirds change with elevation and seasonal variation in high-elevation, terrestrial foodwebs?

- Mercury deposition 2-5x higher in high-elevation, boreal forests as compared to surrounding low-elevation, hardwood forests
  ~Miller et al. 2005
Esopus Creek Watershed

- Slide Mountain
  Highest peak in the Catskills

- Densely forested

- Continuous tracts of forest from 200 m to >1200 m
1. Spring (mid-May)
2. Early Summer (mid-June)
3. Mid Summer (mid-July)
4. Late Summer (late-August)
5. Fall (October)

**HIGH: 1200 m**
Balsam fir/Red Spruce

**LOW & MID: 400-700 m**
Beech/Birch/Maple

**LOW HARDWOOD: 200 m**
Oak/Beech/Maple

**BIOTIC**
- Thrushes
- Salamanders
- Spiders
- Millipedes
- Beetles

**FLORA/ABIOTIC**
- Living Foliage
- Leaf Litter (Oi)
- Decomposing (Oe)
- Organic Soil (Oa)
F = 7.22, DF = 2, P = 0.0013

Blood Total Hg (ppm wet wt.)

Veery 200 m
N = 44

Hermit 700 m
N = 35

Bicknell’s 1200 m
N = 77
Blood Hg Increases with Elevation

\[ r^2 = 0.2, \ p < 0.001 \]

\[ N = 176 \]
Red-backed Salamander Hg

\[ r^2 = 0.45, \ p = 0.001 \]

\[ N = 30 \]

Body Total Hg (ppm dry wt.) vs. Elevation (m)
Sharp-shinned Hawk Mercury

2 captured: 1.03 and 1.04 ppm w.w.
High Elevation Terrestrial Biomagnification

- Salamander: 0.2 ppm d.w.
- Thrush: 0.4 ppm d.w.
- Hawk: 4.2 ppm d.w.

Total Hg (ppm d.w.)

- Salamander: 2 x increase
- Thrush: 10 x increase
- Hawk: 4.0 ppm d.w.

- Hg total 2 x
- Hg total 10 x

Salamander

Thrush Haw

Hawk
For all thrush species: Blood mercury DECLINED with breeding season date

Veery

$r^2 = 0.51$
$p < 0.0001$
Hermit Thrush

$r^2 = 0.43$
$p = 0.013$
Using Science to Inform Policy

1. Identify the species, habitats, and regions at risk to mercury exposure

2. Set air pollution thresholds for ecosystems

~ Establish MercNet ~
- Improve mercury monitoring in both aquatic and terrestrial ecosystems across the United States
- Develop science-based policy recommendations for setting air pollution thresholds to protect ecosystems and species
3. Minimize wildlife mercury exposure by reducing mercury emissions

~Use best available technology ~
~ Prevent biological mercury hotspots ~

Using Science to Inform Policy
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