Songbirds as Indicators of Environmental Mercury Loads in New York

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Abstract

It is established that avian piscivores in aquatic ecosystems accumulate high levels of mercury that affect reproduction and behavior. Breeding avian invertivore populations in a terrestrial ecosystem may be suffering the negative effects of multiple stressors such as habitat fragmentation, acidic and mercury (Hg) deposition, as well as other human-caused environmental changes. The effects of air pollutants, available calcium and sensitive habitats in breeding avian invertivores, such as Red-eyed Vireo, Palm Warbler and Wood Thrush, in northeastern forests are examined. In 2005-2007, we collected soil, litterfall, invertebrates and bird tissues (blood and feather) to test for mercury. We show results for avian invertivores in New York and throughout the northeastern US. We further demonstrate links among Hg deposition and soil and songbird levels, habitats and geographical areas at greatest risk, and other factors that contribute to mercury contamination in songbirds.

Wood Thrush

Red-eyed Vireo

Background: Mercury and Acid Rain are a bad mix

The atmospheric deposition of sulfuric acid (S), nitric acid and Hg has the potential to have negative landscape-level impacts on bird populations. Sulfuric acid deposition or acid rain has negatively impacted parts of northeastern North America for many decades. Hg methylation by sulfate-reducing anaerobic bacteria that convert non-toxic inorganic mercury (Hg) into toxic organic methylmercury (MeHg) is enhanced in acidic environments. Acidic environments are also typically poor in calcium (Ca), and Ca-rich prey are needed by many birds to successfully reproduce. Further, both the uptake and the effects of Hg are increased by ingesting many Ca-rich prey items. Insectivorous birds in acidified areas of mountains and bog habitats are thus particularly susceptible to the combined impacts of air pollutants because they occur at high trophic levels (e.g., susceptible to biomagnification of Hg), are dependent on Ca-rich prey items for breeding, are potentially more lethargic because of elevated Hg levels during a time when they require more energy to find specific Ca-rich prey items, which when combined has the potential synergistic impact of reducing overall productivity and survival. This and other such ecotoxicological relationships in New York ecosystems needs further study.

Palm Warbler

Alder Flycatcher

Objectives

(1) Describe a previously undocumented terrestrial pathway linking atmospheric deposition of Hg with the bioaccumulation of converted MeHg into the blood of birds foraging within the insectivorous pathway;

(2) Assess potential risk of elevated Hg and deficient Ca availability to birds;

(3) Determine habitats and areas that are highly sensitive to potential impacts;

(4) Identify avian invertivores at greatest risk;

(5) Develop a spatial gradient for linking major Hg emission sources in the Ohio River Valley with rates of MeHg availability in New York;

(6) Develop and implement a monitoring program, the Appalachian Mountain Mercury Network (AMMN), to quantify Hg inputs to sensitive forested habitats that receive high S and Hg loading;

(7) Integrate AMMN with nationwide Hg measurements in abiotic and biotic ecosystems to monitor changes in Hg levels over time;

(8) Network with other avian monitoring projects such as the Cornell Lab of Ornithology's (CLO) Birds in Forested Landscapes (BFL), Vermont Center for Ecostudies' Mountain BirdWatch (MBW), and Partners in Flight (PIF) to determine the effects of elevated Hg and lowered Ca availability on productivity, presence and density of birds;

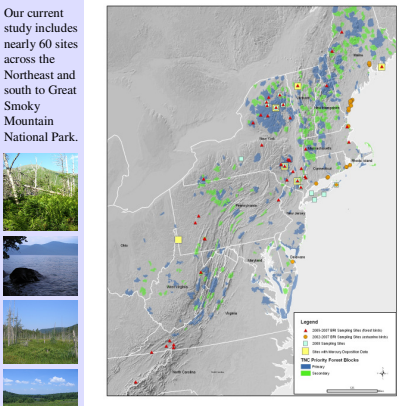
(9) Provide products of our research that will be communicated to the lay public and legislators via printed material and websites.

Cerulean Warbler

Lincoln's Sparrow

Study Area

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



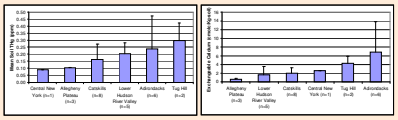
Methods

Sampling efforts include high and low elevation sites across the study region. Sites are not randomly chosen and instead are based on known information on thrush presence, logistical considerations, and site-based partnerships. Thrushes and other insectivorous birds are sampled from mid June to early August using mist nets in conjunction with playback tapes and thrush decoys. Each bird is banded, sampled for blood and feathers, and then measured. Soil and invertebrate samples are collected from each site. All Hg analysis follows standard and established lab procedures.

Results and Conclusions

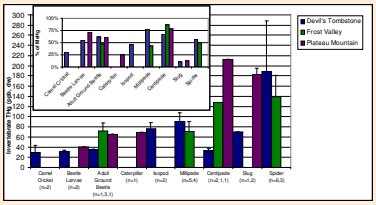
Soils

1. Mean soil Hg and soil exchangeable calcium sampled in different regions of New York, 2005-2006. Soil Hg and exchangeable calcium are higher in the Adirondack region than in the Catskill region of New York.



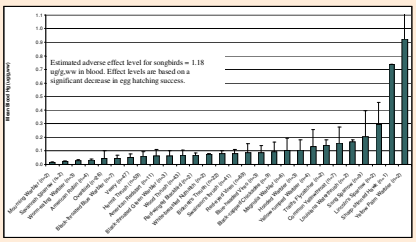
Invertebrates

2. Invertebrate Hg and MeHg for three sites, 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.



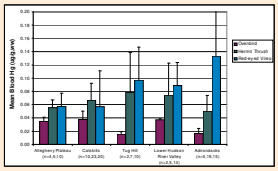
Songbirds

3. Breeding NY Songbirds, 2000, 2005-2006. Palm Warblers tend to have higher Hg levels than other species of songbirds. There is a tendency for bog,wetland and riparian species to have higher Hg levels than upland species.



Results and Conclusions, continued

Songbirds continued



4. Mean blood Hg for common breeding songbirds for multiple regions in New York, 2005-2006. Red-eyed Vireos in the Adirondacks have higher Hg levels than their counterparts in the Catskills. However, Hermit Thrushes in the Catskills have higher Hg levels than the Adirondacks. Certain species of songbirds may be at a higher risk for Hg contamination in certain New York regions.

5. Change in mean songbird blood Hg levels, 2005-2006. The Hermit Thrush experienced an increase in mean blood Hg levels at multiple sites across New York. Species sampled in western New York also experienced an increase in mean blood Hg levels.

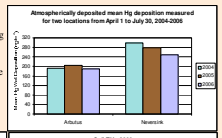
Hermit Thrush

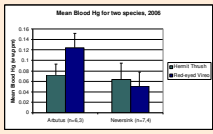
Song Sparrow

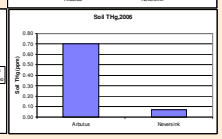
	Allegany State Park	Black Rock Forest	Devil's Tombstone	Tug Hill	Plateau Mtn.	Slam's Pond
American Redstart						
Bicknell's Thrush					0-3	
Common Yellowthroat						
Hermit Thrush						
Myrtle Warbler						0-3
Ovenbird						
Red-eyed Vireo						
Swainson's Thrush					0-3	
Veery						
Wood Thrush						
High Elevation						

Comparisons

6. Mercury Deposition Network (MDN) stations for two sites compared to mean blood and soil Hg values. Summertime wet Hg deposition varied over a three year period for each station. Soil Hg tended not to correlate with Hg deposition. Some songbird blood Hg levels significantly correlated with soil Hg levels.

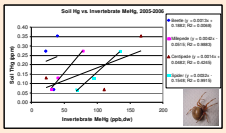


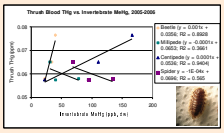




7. Soil Hg and Invertebrate MeHg tended to correlate best for millipedes and centipedes.

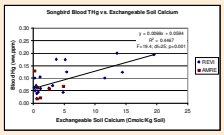
8. Invertebrate and songbird relationships were similar for Hg and MeHg. Based on small sample sizes for three stations, centipede MeHg levels were most predictive for thrush blood Hg levels.

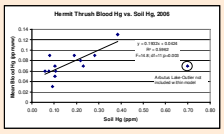




9. Mean blood Hg from upper canopy foragers found in deciduous forests. Some songbird blood Hg significantly increased as exchangeable soil calcium increased.

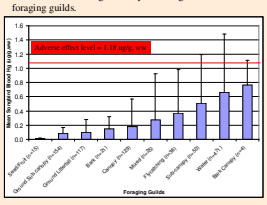
10. Hermit thrush blood Hg significantly increased as soil Hg increased

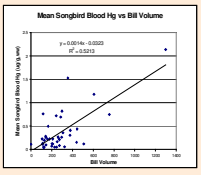




11. Mean songbird blood Hg levels from sites across the Northeast and south to Tennessee. Songbirds foraging on seed and fruit have significantly lower Hg levels than other foraging guilds.

12. Bill Volume (length*width*depth) for songbird invertivores from sites across the Northeast and south to Tennessee. Songbird blood Hg levels increase as bill volume increases.

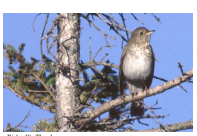




Recommendations for 2008

1. Better understand the mechanisms of MeHg cycling in terrestrial biota through further sampling of soil, litterfall, invertebrates, and songbirds with an emphasis on acidic and wetland habitats;
2. Sample more areas within New York to determine which regions are at greatest risk for Hg contamination and have formed biological Hg hotspots;
3. Establish long-term Hg monitoring efforts for sites within the Mercury Deposition Network to determine the relationship between atmospheric Hg deposition and Hg found in New York's abiotic and biotic compartments;
4. Further develop lowest observed adverse effect levels using behavioral, physiological, reproductive and survival endpoints for songbirds breeding in New York.

Louisiana Waterthrush



Bicknell's Thrush

Saltmarsh Sharp-tailed Sparrow

Acknowledgements:

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