VERMONT CENTER FOR ECOSTUDIES
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Research Notes
Number 2

Pictured from top to bottom: Northern Saw-whet Owl (juvenile), Bicknell's Thrush, Red-backed Salamander, geometrid caterpillar (© Ron Kelley), Balsam Fir. All other photos © Vermont Center for Ecostudies or Bryan Pfeiffer/Wings Photography.

Mercury in the Mountains

VCE Biologists Track a Toxin's Movement through the Food Web

Offering novel insights into mercury's threat to wildlife, the Vermont Center for Ecostudies (VCE) has for the first time revealed how this insidious toxin moves and concentrates across the food chain in forest ecosystems. In newly published research, VCE biologists tracked mercury up the food web – from tree needles and leaves to insects and spiders to salamanders and songbirds, and in due course to top predators such as hawks and owls. VCE's work, published in the journal *Ecotoxicology*[1], is significant because it documents patterns of mercury's migration through a forest ecosystem. The research could help inform the development of strategies to ease mercury's dangerous effects on ecosystems and their wildlife inhabitants.

Background: Bioaccumulation and Biomagnification

Scientists have long recognized mercury as an environmental toxin threatening humans and wildlife. It impairs reproductive performance, growth and development, behavior, motor skills, and survivorship in aquatic birds and other wildlife. Mercury can also concentrate progressively over time in a given organism, presenting risks even if environmental levels of the toxin are low — a process known as bioaccumulation. Similarly, mercury levels can increase as the chemical moves up the food chain, going, for example, from flies to flycatcher. This amplification of a toxin at successive positions along the food web (each called a "trophic level") is known as biomagnification.

For many years freshwater ecosystems dominated the attention of scientists because water bodies offer conditions favorable to a particularly toxic form of mercury, methylmercury. But that view changed in 2005 when VCE, in pioneering research, documented that mercury can be transported in the atmosphere beyond fresh water and then converted to its methylated form in forested ecosystems. Suddenly, mercury was recognized as a threat to wildlife far beyond lakes and ponds. Yet relatively little was known about how the toxin actually behaved in these terrestrial ecosystems. VCE's latest research offers some answers.

VCE biologists Chris Rimmer, Kent McFarland and Steve Faccio, working as mercury detectives on Vermont's Stratton Mountain, tracked the toxin at discrete levels in the mountain's food web: leaf litter, foliage, foliage-eating insects, omnivorous arthropods (insects and snails, for example), a terrestrial salamander (Red-backed Salamander), an insectivorous songbird (Bicknell's Thrush) and two raptors (Sharp-shinned Hawk and Northern Saw-whet Owl). Their goal was to examine mercury concentrations and variability in organisms at different trophic levels during summer.

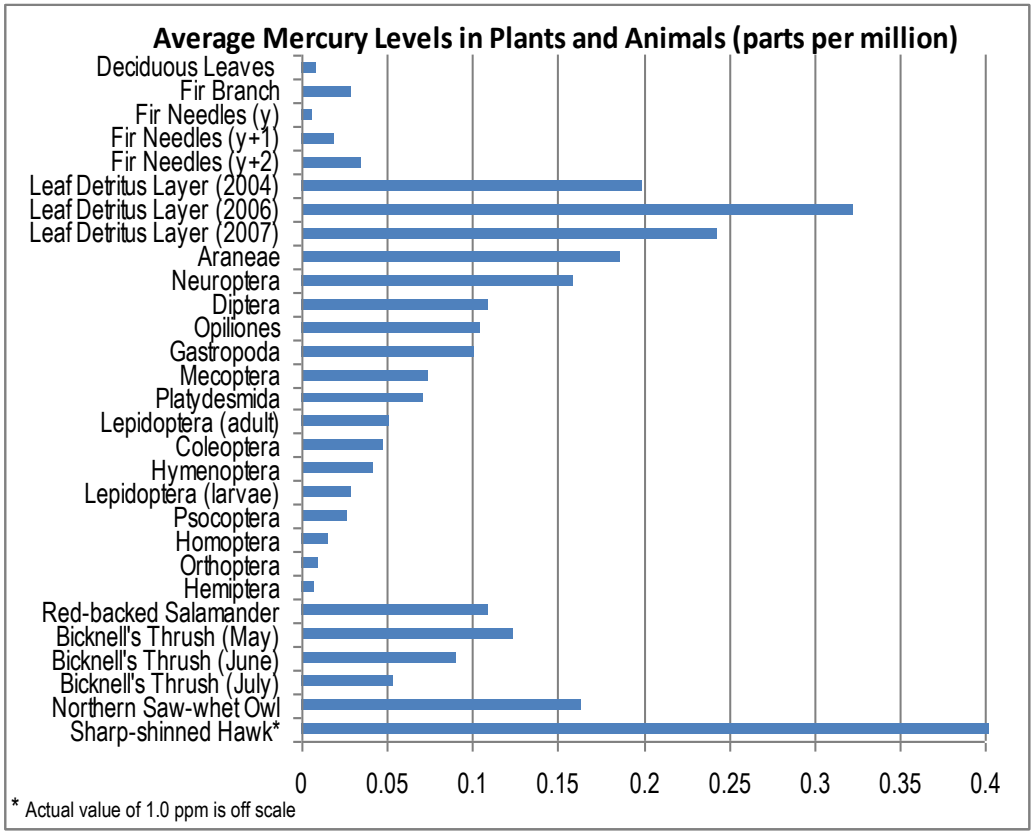
Results and Conclusions

VCE's work documented generally rising mercury concentrations up the food web — from plants to plant-eaters to carnivores. As might be expected, Sharp-shinned Hawk and Northern Saw-whet Owl, at the top of the montane forest food web, showed the highest mercury levels in their blood. Although leaf litter might be considered the base of the food web, this zone showed relatively high levels of mercury as well, higher than any other biotic compartment except Sharp-shinned Hawk. One explanation for this is that mercury can accumulate and persist over time in the leaf litter, leaching out of the fallen foliage during decomposition.

[1] Rimmer, C.C., E.K. Miller, K.P. McFarland, R.J. Taylor, and S.D. Faccio. 2009. Mercury bioaccumulation and trophic transfer in the terrestrial food web of a montane forest. Ecotoxicology. DOI 10.1007/s10646-009-0443-x.

To read the full paper, visit **http://www.vtecostudies.org/PDF/Rimmeretal2009ecotoxicology.pdf**

In live plant foliage, balsam fir needles showed greater concentrations of mercury than the three deciduous tree species VCE sampled: paper birch, mountain ash and pin cherry. Fir needles grow and remain on a tree for up to three years, accumulating mercury each year, compared to only one-year's growth in deciduous species. Even so, the three deciduous species showed increasing mercury levels throughout the season, at a rate higher than that observed in balsam fir needles



Moving up the food web to insects and other arthropods, mercury concentrations ranged widely but were lowest in herbivorous insects (such as grasshoppers, leaf hoppers and moth caterpillars), and higher in the predatory insects (such as scorpionflies and lacewings). Finally, among all arthropods sampled, carnivorous spiders and harvestmen showed the highest mercury concentrations, an expected result among these longer-lived predators of other insects.

Red-backed Salamanders showed relatively high concentrations of mercury, suggesting that they feed at higher trophic levels within the invertebrate community or that they prefer prey species that themselves accumulate relatively high amounts of mercury. As it turns out, Red-backed Salamanders live and forage in moist soils, often near stream edges, where methylmercury concentrations may be relatively high.

Perhaps the study's most compelling discovery involved Bicknell's Thrush. Mercury levels in this signature montane songbird spiked early in the season and decreased over the course of the summer. A likely explanation is that when Bicknell's Thrush returns to breeding sites in May, spiders, harvestmen, predatory beetles and other prey species relatively high in mercury are more numerous and probably constitute a significant portion of the songbird's diet. Snails, also relatively high in mercury, may be consumed by female thrushes to mobilize additional calcium for egg production. But as new coniferous and deciduous foliage emerges during June, Bicknell's Thrush almost certainly shifts its diet to newly abundant populations of leaf-eating insects with lower mercury levels. This seasonal dietary shift likely explains the decline in thrush blood mercury concentrations between early and late summer.

Results of VCE's investigation provide critical evidence that mercury bioaccumulates and biomagnifies in the montane forest biotic community. Bicknell's Thrush, already receiving ample attention from VCE, may serve as a valuable bioindicator for the continued monitoring of mercury contamination in terrestrial food webs. VCE's previous work has already demonstrated that high-elevation coniferous forests are particularly vulnerable to climatic warming. The cumulative impacts of climate change, mercury toxicity and other stressors on these geographically restricted montane habitats could profoundly threaten their unique assemblage of flora and fauna, as well as aesthetic and recreational opportunities for millions of people in the northeastern United States.

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The Vermont Center for Ecostudies (VCE) is an independent group with a mission to advance wildlife conservation through research, monitoring and citizen engagement. VCE brings more than 20 years of experience to its goal of promoting conservation practices that benefit biodiversity. With a reach extending from northern New England through the Caribbean to South America, VCE's work unites people and science for conservation.