The Call to ~~Action~~ Collect Dragonflies

Citizen scientists study mercury contamination in national parks

By Colleen Flanagan Pritz, Sarah Nelson, and Collin Eagles-Smith

IT'S A CRISP AUGUST MORNING at Lily Lake, Rocky Mountain National Park. Twelve Arizona high school students arrive at the parking lot, beaming with excitement about their journey to Colorado and the adventures that await them, all dressed in the same green-colored T-shirts: "BioBlitz." The year is 2012. They grab nets and waders, magnifying glasses, and field guides; some wear GoPros to video-record the experience. They head for the lakeshore in search of little bugs that live in the water. But not just any little bugs . . . dragonfly larvae.

The students—citizen scientists—seek out little faces with two big, beady eyes and a sinister "smile" made of extending (prehensile) mouthparts, an apparatus with jagged, grasping edges used to snatch prey and devour it whole. This underwater creature is the dragonfly in its larval stage, before it morphs into the colorfully aerial, adult dragonfly we all know.

Dragonfly larvae are widespread across the United States and are an important food source for fish, amphibians, and birds. They live underwater for up to five years before undergoing incomplete metamorphosis. At this time they crawl out of the water onto emergent vegetation, the shore, a dock, a rock, or any dry place, then shed their exoskeleton, dry their wings, and fly off. Robert DuBois, naturalist and author of the field guide *Dragonflies and Damselflies of the Rocky Mountains*, describes the transformation: "After months or years of clambering about underwater, the nymph is freed from the shackles of this ignoble existence in one grand moment of emancipation. Almost instantly it becomes one of the most graceful, elegant, and masterful flying creatures under the sun."

A student steps out from the cattails and asks, "Is this one?" She hands over a shallow plastic spoon holding a bug, about 10 millimeters (0.4 in) in length, eyes very large in proportion to its head, wriggling in a thin veil of water.

"How many legs does it have?"
"Six," she replies.

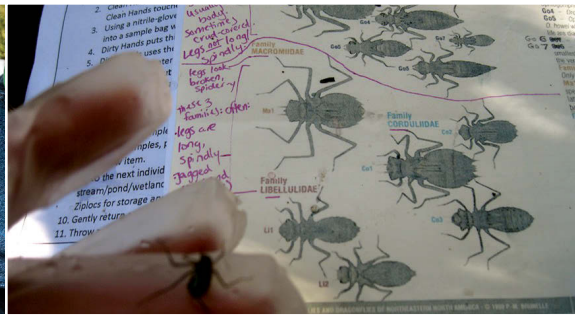
"Would you call the abdomen slender or bulky?"
"It's skinny and long," she says with certainty.

"What are those three feathery things extending from the tip of the abdomen?"
"Hmm." She pages through the field guide. "Gills?"

"Yes." She pauses. "Is it a dragonfly nymph?" She looks back at the book.
"Aw, man! It's a *damsel*-fly. . ."

"Keep looking. You were close!"

Thanks to the foundation laid by the Acadia Learning Project, an opportunity arose to engage citizen scientists in a project that both educates participants about park science and provides parks with valuable environmental information.



(Facing page) A student from Sabino High School in Arizona searches for dragonfly larvae at Lily Lake, Rocky Mountain National Park, Colorado. (Above) A classmate of hers searches a net for larvae.

A student measures the length of a larva. The students traveled to the park in August 2012 and sampled dragonfly larvae as part of the National Park Service–National Geographic Society "BioBlitz."

A student refers to a field guide to identify dragonfly larvae at Great Smoky Mountains National Park, Tennessee. Dragonfly larvae are being tested for use as an indicator of mercury contamination in the national parks.

Mercury rising

Both dragonflies and damselflies belong to the order Odonata, "toothed ones," which includes some of the most ancient and beautiful insects that ever roamed Earth, as well as some of the largest flying invertebrates ever to have lived. Dragonflies belong to the subgroup *Anisoptera*, and damselflies to the group *Zygoptera*. Among other differences, the abdomen of the larval dragonfly is shorter and bulkier than that of the damselfly. Odonates are set apart from other aquatic macroinvertebrates by their relatively large size, particularly large eyes, and prehensile mouthparts.

Like their adult counterparts, dragonfly larvae are predatory insects. These voracious eaters maintain a higher position on the food chain than other aquatic insects like mosquito larvae and caddisflies, sometimes even eating small fishes. Organisms near the top of the food chain, such as dragonfly larvae, are more sensitive to environmental pollutants like mercury that both build up (bioaccumulate) and increase in concentration higher on the food chain (biomagnify).

Contaminant exposure can be dangerous for humans and wildlife because of the potential for negative health effects. Mercury, a toxic heavy metal, is a contaminant of particular concern, given its ubiquitous nature and ability to induce neurological and reproductive impairment. Mercury threatens the natural resources and values the National Park Service is charged with protecting.

Although there are natural sources of mercury such as volcanoes, much of the mercury that affects national parks is the result of air pollution, and more specifically coal-burning power plants. Waste incinerators and mining operations are other human-caused sources of mercury. Human activities have increased levels of atmospheric mercury at least threefold over the past 150 years. Mercury has an especially long residence time in the atmosphere, and may arrive in parks from distant places such as Asia. Atmospherically deposited mercury can harm the ecological integrity of aquatic and terrestrial communities in national parks and the wildlife that depend on them.

Biosentinels

Concentrations of mercury in dragonfly larvae could indicate the potential risk for the ecosystem. Similar to the "canary in the coal mine," dragonfly larvae are *sentinel species*, or biosentinels. As surrogates for ecosystem health, they can be used to detect the potential risk to humans and wildlife by providing advance warning of a danger.

Levels of mercury in dragonfly larvae can serve as proxies for mercury in fish from the same water body. This has potential implications for organisms higher on the food chain, including fish-eating birds and humans. More than 16 million lake acres (6 million ha) and 1 million river miles (1.6 million km) in the United States are under fish-consumption advisories because of mercury, and 81 percent of all fish-consumption advisories issued by the U.S. Environmental Protection Agency are due to mercury contamination. Fish-consumption advisories for mercury are in effect in all 50 states.

While fish are perhaps the most commonly used indicator for mercury contamination because they occur across a wide geography and provide strong links to human and wildlife health, dragonfly larvae are far easier to collect, and they represent the risk from mercury in fishless ecosystems like shallow ponds, ephemeral pools, and marshes—some of the most productive and ecologically important aquatic habitats. They remain in the pond or stream where they hatched from eggs, giving researchers and managers a clearer picture of mercury risk within the watershed where they are caught.

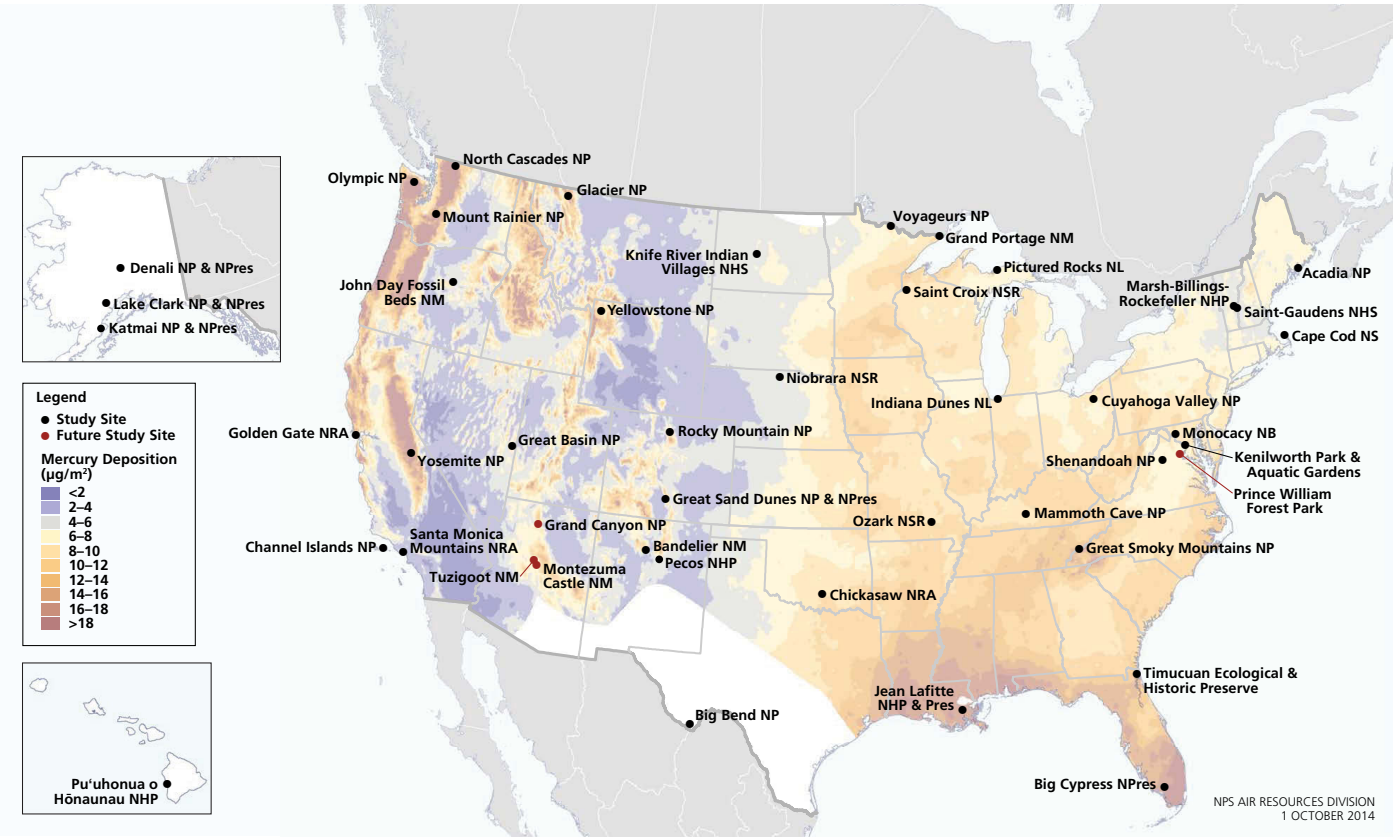


Figure 1. Parks participating in the dragonfly mercury study, 2014. The map background shows measured and interpolated mercury deposition data from 2012, courtesy of the National Atmospheric Deposition Program/Mercury Deposition Network.

Dragonfly larvae present an ideal vehicle for researchers and park managers to engage citizen scientists in connecting with the natural world. In addition to connecting people to parks and advancing the educational mission, the scientist-citizen partnership makes dragonfly larvae cost-effective tools for monitoring mercury dynamics across many locations.

Results

Forty-two of 46 participating parks have engaged in sampling to date (fig. 1), from Denali National Park and Preserve (Alaska) and Big Cypress National Preserve (Florida) to Acadia National Park (Maine) and Golden Gate National Recreation Area (California), collecting more than 800 dragonfly larvae at 60-plus sites. Close to 300 citizen scientists, including students, Youth Conservation Corps, volunteers (VIPs), bug camp attendees, and bioblitz participants, have thus far contributed approximately 1,800 hours of volunteer time.

Citizen scientists, such as the high school students from Arizona, are collecting dragonfly larvae in at least 50 park units across the nation over five years (2011–2015) for analysis of mercury. The species are being tested as biosentinels, shedding light on the risk of mercury contamination throughout the National Park System. Results indicate that no single water chemistry parameter, landscape variable, or dragonfly characteristic adequately describes the pattern of mercury in dragonfly larvae. However, analyses found that dissolved organic carbon, total mercury in water, and pH are important variables, with some influence exerted by east-west position, topography (e.g., wetlands), and habitat guild. Furthermore, site differences within parks reveal that dragonfly larvae can describe fine-scale differences in mercury risk, which supports the utility of these species as biosentinels.

Other research reveals that mercury in dragonfly larvae was correlated with both mercury in water and mercury in fish in the same water bodies (see the article by Roger Haro on page 70). Resource managers and the public appreciate an understanding of mercury levels in the ecosystem because people (and wildlife) rely on the services a healthy ecosystem provides, such as clean water, fish, and enjoyment of the landscape. Bird lovers visit parks to observe birds, not a lack thereof.

The project Web page (http://www.nature.nps.gov/air/Studies/air_toxics/dragonfly/index.cfm) includes the data, available for use by citizen scientists and parks. Final results will be published in the peer-

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Dragonfly larva of the family Gomphidae, collected at Hodgdon Pond, Acadia National Park, Maine, 2012.

reviewed literature and incorporated into larger-scale mercury research synthesis efforts.

The student returns with another specimen:

"Is THIS it?!" The bug is big and has huge eyes.

"What's different about this one?"
"It doesn't have feathery gills," she says.

"And the abdomen?"
"Short and bulky," she continues, "and it ends with three short spines."

"Congratulations!"

From field to lab

She excitedly hands the dragonfly larva to her clean-handed, latex-gloved partner, who carefully places it into a labeled, resealable zipper storage bag, double-bagged to further prevent contamination. They proceed to identify the sample to family, a determination that is validated in the lab by an odonatologist. Each family maintains a slightly different ecological niche, a variable that can contribute to differences in mercury concentrations.

The samples are preserved on dry ice in the field, then shipped overnight to labs at the University of Maine, Dartmouth College, or the U.S. Geological Survey, where field notes are validated and the samples are analyzed for mercury. Water and sediment samples are collected at the same sampling sites to inform scientists about the influence of environmental characteristics, including pH, dissolved organic carbon, and wetland coverage.

While searching for odonates, citizen scientists also learn about the great diversity of ponds, pools, and other slow-moving (lentic) aquatic systems. Water skimmers, midges, mosquito larvae, and water boatmen are only a handful of other aquatic macroinvertebrates that appear in the sampling nets. Fish, slugs, tadpoles, and baby snapping turtles have also been found, enlightening youth and the public about biodiversity and the influence humans have upon natural systems.

The year is 2011. The NPS director issues a Call to Action in an effort to foster stewardship and engagement in the national parks leading up to the centennial celebration of the National Park Service in 2016. Great Smoky Mountains National Park (North Carolina/Tennessee) agrees to be one of two pilot parks for the citizen scientist study of mercury in dragonfly larvae. A Cherokee High School student yells, "I think I found one!"

About the authors

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