

The Dragonfly Mercury Project: A National Scale Assessment of Mercury Bioaccumulation and Risk in US National Parks Through a Citizen Science Framework

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Abstract

The Dragonfly Mercury Project (DMP) is a dynamic national scale program coupling scientific efforts to understand mercury pollution risks to protected areas with citizen engagement and education. We conducted a national-scale assessment of mercury (Hg) bioaccumulation in aquatic ecosystems using dragonfly larvae as biosentinels and implemented a carefully designed sampling methodology for citizen scientists to facilitate biological sampling. We assessed variation in dragonfly Hg concentrations across >450 sites spanning 100 US national parks and other protected places and examined intrinsic and extrinsic factors associated with variation in Hg concentrations. Mercury concentrations ranged between 10.4-1,411 ng/g across sites and varied among habitat types. Dragonfly Hg concentrations were up to 1.8-fold higher in lotic habitats than in lentic habitats, and 37% higher in waterbodies with abundant wetlands along their margins than those without wetlands. Mercury concentrations in dragonflies differed among families, but were correlated with each other, enabling adjustment to a consistent family to facilitate spatial comparisons among sampling units. Dragonfly THg concentrations were positively correlated with THg in both fish and amphibians from the same locations, indicating that dragonfly larvae are effective indicators of Hg bioavailability in aquatic food webs. Using the relationships between dragonfly and fish Hg concentrations we developed a series of integrated impairment indices that inform potential risk of Hg exposure to fish, wildlife, and human health. Most sample sites were in the moderate to low risk category, but 12% of sites were at high or severe risk for mercury, potentially causing harm to fish, wildlife, and people who eat those fish and wildlife. The scope and depth of this work stand it up as a potential landmark study on mercury in NPS lands and across the landscape, particularly in light of the citizen science framework under which it was implemented. More information on the Dragonfly Mercury Project can be found at <https://wim.usgs.gov/geonarrative/dmp/> and <https://www.nps.gov/articles/dragonfly-mercury-project.htm>.

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Overview

The Dragonfly Mercury Project (DMP) is a dynamic national-scale program that engages citizen scientists and community volunteers in the collection of dragonfly larvae for mercury analysis across six eastern national parks. By conducting robust public participation with additional laboratory and data analysis, the DMP improves total mercury exposure while providing important insights into mercury and health risk across the nation.

Empowering Communities

As a program that engages public participants, the DMP provides people and community members with authentic opportunities and resources to improve parks, to better inform public and private decisions, and to provide important information for learning about a critical environmental issue for natural resources and human health.

Linking Hg in dragonfly larvae to health risks for wildlife and humans

Dragonfly larvae are the ideal mercury bioindicator because they are ubiquitous across ecosystems, easy to collect and identify in the field, and provide high-quality data that reflect mercury exposure in fish and other wildlife. Findings from this study indicate that dragonfly larvae mercury can serve as a surrogate for fish mercury concentrations, and represent the risk of mercury to aquatic ecosystems (Eagles-Smith et al., 2020).

Hg in dragonfly larvae varies widely

The results of this study reveal that total mercury concentrations (THg) in dragonfly larvae vary widely both among parks and within parks among sites within parks. Dragonfly THg varied by as much as 13.5-fold among parks and 34-fold within parks. Why mercury varies among sites that are very close to one another, highlighting the importance of site characteristics in determining dragonfly larvae mercury exposure and accumulation.

Engaging Youth

The multi-agency and multi-institutional DMP Training Committee works to train up a citizen-science program that provides continuous educational opportunities for policy and management decision-making, meets the needs of stakeholders from all participating parks and agencies, and is regularly and flexibly sustainable over the long term. Efforts to be under-sampling and partnerships will not only improve our understanding and our understanding of the risks to ecosystems, but also provide more mercury pollution data and other multiple opportunities to connect people to the environment.

Next Steps

The multi-agency and multi-institutional DMP Training Committee works to train up a citizen-science program that provides continuous educational opportunities for policy and management decision-making, meets the needs of stakeholders from all participating parks and agencies, and is regularly and flexibly sustainable over the long term. Efforts to be under-sampling and partnerships will not only improve our understanding and our understanding of the risks to ecosystems, but also provide more mercury pollution data and other multiple opportunities to connect people to the environment.

ABSTRACT REFERENCES CONTACT AUTHOR PRINT GET POSTER

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PRESENTED AT:



OVERVIEW

The Dragonfly Mercury Project (DMP) is a dynamic national-scale program that engages citizen scientists and community volunteers in the collection of dragonfly larvae for mercury analysis across our nation's national parks. By combining robust public participation with advanced laboratory and data analyses, the DMP inspires next-generation stewards while providing resource managers with information and tools to better understand and mitigate mercury risk across varied ecosystems.



Mercury (Hg) is among the most ubiquitous environmental contaminants, with a global distribution due to its release into the atmosphere via coal combustion, gold mining, and other sources; its ability to transport vast distances in the atmosphere; and subsequent deposition to watersheds and aquatic ecosystems. Once deposited, naturally occurring bacteria convert the atmospheric Hg into a more toxic form called methylmercury, which bioaccumulates and biomagnifies up the food chain and can have toxic effects at high concentrations. Given its persistent, bioaccumulative, and toxic effects, Hg is found at elevated levels in even the most remote and pristine ecosystems, such as those managed by the National Park Service (NPS).

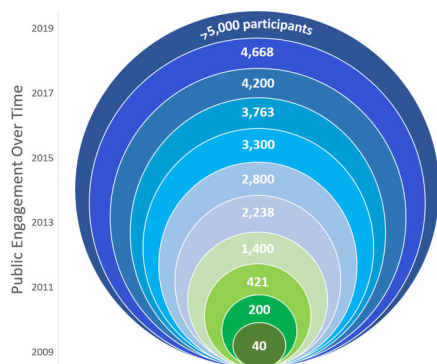
The Dragonfly Mercury Project (<https://www.nps.gov/articles/dragonfly-mercury-project.htm>) is built upon the power of public participation and citizen science. Without help from hundreds of participants each year, the scope and geographic coverage of the DMP would not be possible.

EMPOWERING COMMUNITIES

As a program that engages public participants, this project connects youth and community members with authentic research and education experiences in national parks, in some of most pristine and remote settings our nation offers, providing experiential opportunities for learning about a critical conservation threat to natural resources and human health.

A strong majority (96%) of DMP parks to date have participated in project multiple years, commonly citing “getting kids outdoors” as a highlight. Post-sampling feedback includes testimonials such as:

- “...the enthusiasm and curiosity of the students while participating. During the nymph capturing, students were actively engaged with the process and asking many questions about the water body itself as well as how their work would be used for science.”
- When the data was released back to a biology class, “a huge light came on... students were beaming with pride.”
- “It’s not just a learning experience; it empowers.”

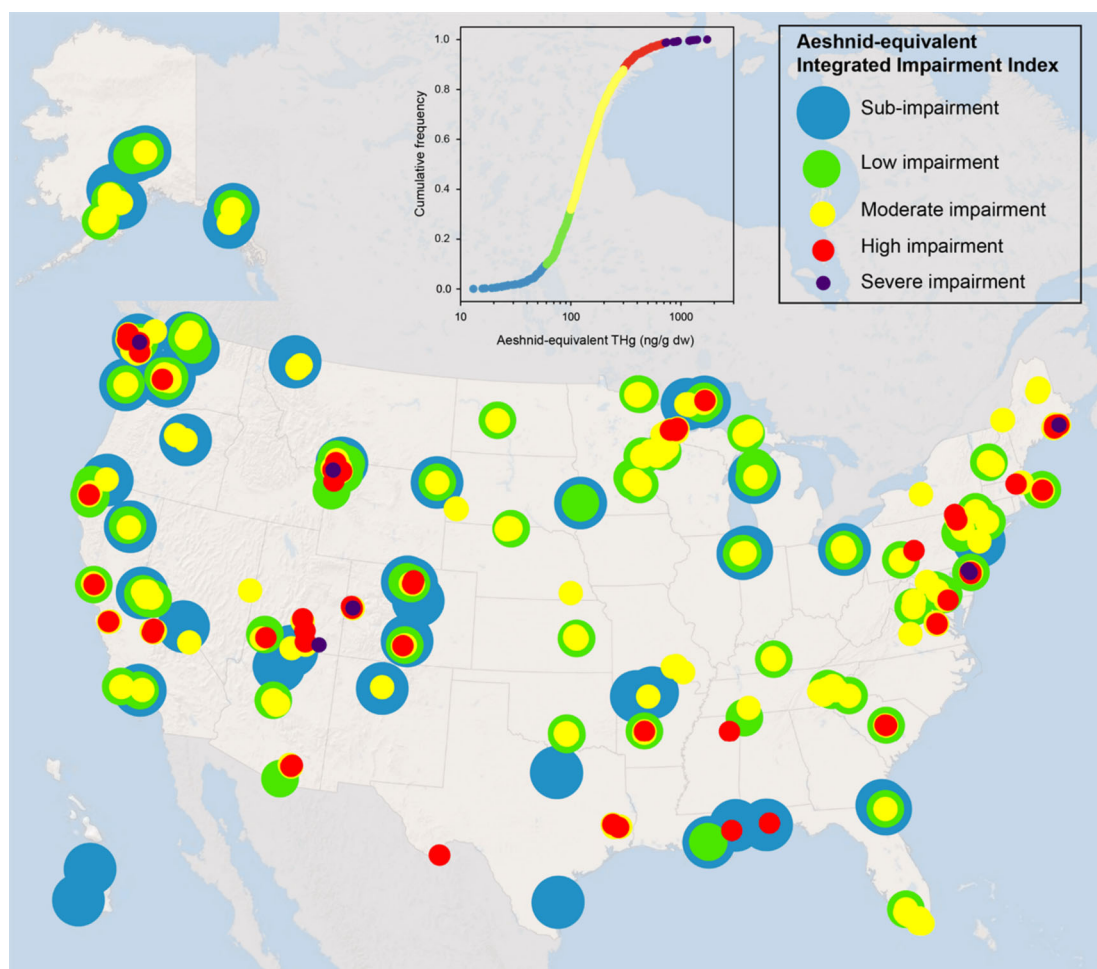


To date, over 5,000 citizen scientists and community volunteers have contributed greater than 20,000 hours of service to the DMP. As the project continues to grow, more and more youth and diverse participants are engaged in a program that empowers local communities while also contributing to the most comprehensive assessment of mercury contamination and environmental risk in the nation’s protected lands.

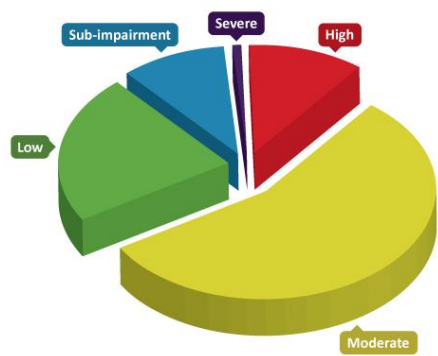
LINKING HG IN DRAGONFLY LARVAE TO HEALTH RISKS FOR WILDLIFE AND HUMANS

Dragonfly larvae are the ideal mercury biosentinel because they are ubiquitous across ecosystem types, easy and cost-effective to monitor, and provide high-quality data that reflect mercury exposure in fish and other wildlife. Findings from this study indicate that dragonfly larvae mercury can serve as a surrogate for fish mercury concentrations and represent the risk of mercury to aquatic ecosystems (Eagles-Smith et al. 2020).

This study quantified risk according to a series of Integrated Impairment Indices based on dragonfly mercury concentrations. These index categories are centered on both the number of taxa exceeding various benchmarks, as well as the severity of the benchmarks themselves. Impairment benchmarks for mercury are the concentrations above which an organism's health may be harmed.

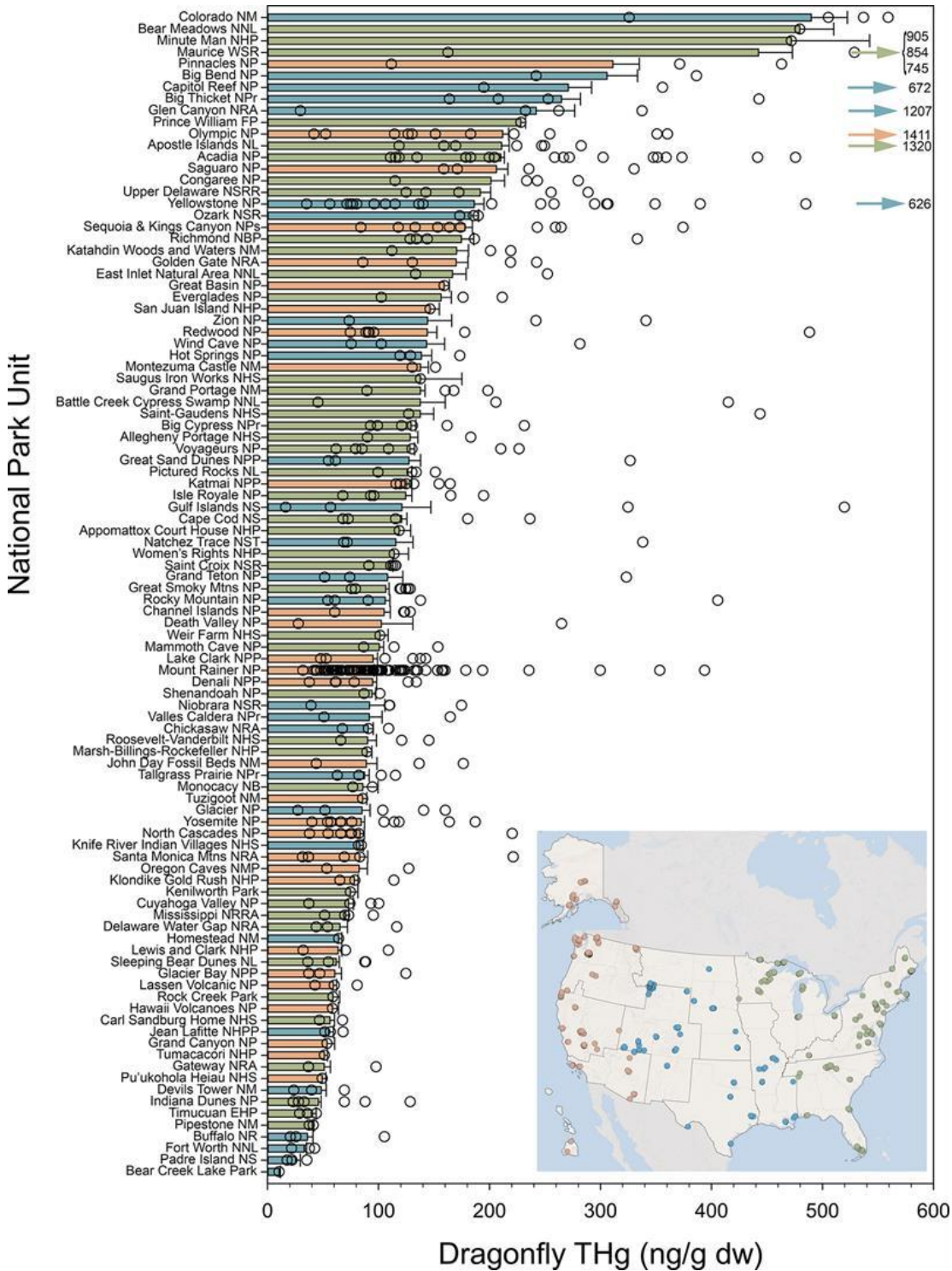


While 10 percent of the sites sampled were safer (below known impairment benchmarks), 12 percent of sites, distributed across all regions of the U.S., posed high or severe risk of impairment to fish, wildlife, and humans. These sites with elevated risk for mercury toxicity in protected areas show the widespread nature of mercury contamination.



HG IN DRAGONFLY LARVAE VARIES WIDELY

The results of this study reveal that total mercury concentrations (THg) in dragonfly larvae vary widely both among park units as well as among sites within parks. Dragonfly THg varied by as much as 135-fold among parks and 34-fold within parks. THg even varied among sites that are very close to one another, highlighting the importance of site characteristics in determining dragonfly larvae mercury exposure and accumulation.



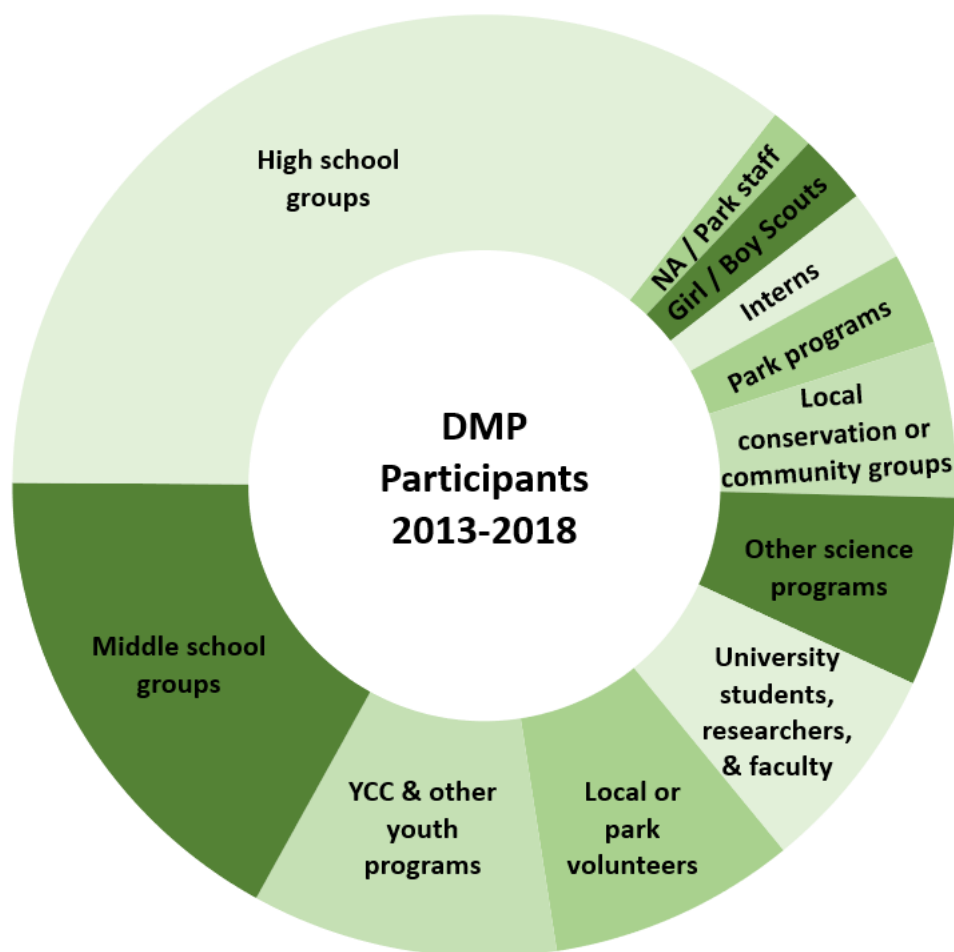
Furthermore, findings indicate that Hg risk differed among habitats, with rivers being higher than lakes, and that the presence of wetlands further increased risk in nearby water bodies. This work also found evidence that local ecosystem factors confound the direct linkage between atmospheric Hg deposition and patterns of Hg risk to fish and wildlife.

ENGAGING YOUTH

DMP sampling operates under a train-the-trainer method, whereby participating park staff and partners receive project training used to coordinate, teach, and lead citizen scientists and community volunteers. Participants follow standardized protocols to collect dragonfly larvae using dip nets, identify each larva to family, place them in zipper-seal bags, and take field notes. The lead park staff or partner then oversees the shipment of samples on dry ice to a centralized laboratory at the US Geological Survey where the specimens are analyzed for mercury.



Post-sampling interview results indicate that nearly two-thirds of the participants in the Dragonfly Mercury Project are youth. Those youth are comprised mainly of high school groups (35%), middle school groups (17%), and the Youth Conservation Corps (YCC) and other youth programs (11%).









NEXT STEPS

Efforts to broaden sampling and partnerships will not only improve risk forecasting and our understanding of how best to mitigate risks associated with mercury pollution, but will also multiply opportunities to connect people to parks, advance the NPS educational mission, utilize parks as outdoor classrooms, and create next generation stewards.

The multi-agency and multi-institutional DMP Steering Committee works to stand up a robust program that provides continually relevant and applicable information for policy and management decision-making, meets the needs of stakeholders from all participating groups and agencies, and is logistically and financially sustainable over the long-term.



The DMP is poised to help protect natural resources – and the people who enjoy and depend on them – from mercury exposure. We welcome you to help us achieve that goal!

Visit our storymap (<https://wim.usgs.gov/geonarrative/dmp/>) to learn more!

ABSTRACT

The Dragonfly Mercury Project (DMP) is a dynamic national scale program coupling scientific efforts to understand mercury pollution risks to protected areas with citizen engagement and education. We conducted a national-scale assessment of mercury (Hg) bioaccumulation in aquatic ecosystems using dragonfly larvae as biosentinels and implemented a carefully designed sampling methodology for citizen scientists to facilitate biological sampling. We assessed variation in dragonfly Hg concentrations across >450 sites spanning 100 US national parks and other protected places and examined intrinsic and extrinsic factors associated with variation in Hg concentrations. Mercury concentrations ranged between 10.4-1,411 ng/g across sites and varied among habitat types. Dragonfly Hg concentrations were up to 1.8-fold higher in lotic habitats than in lentic habitats, and 37% higher in waterbodies with abundant wetlands along their margins than those without wetlands. Mercury concentrations in dragonflies differed among families, but were correlated with each other, enabling adjustment to a consistent family to facilitate spatial comparisons among sampling units. Dragonfly THg concentrations were positively correlated with THg in both fish and amphibians from the same locations, indicating that dragonfly larvae are effective indicators of Hg bioavailability in aquatic food webs. Using the relationships between dragonfly and fish Hg concentrations we developed a series of integrated impairment indices that inform potential risk of Hg exposure to fish, wildlife, and human health. Most sample sites were in the moderate to low risk category, but 12% of sites were at high or severe risk for mercury, potentially causing harm to fish, wildlife, and people who eat those fish and wildlife. The scope and depth of this work stand it up as a potential landmark study on mercury in NPS lands and across the landscape, particularly in light of the citizen science framework under which it was implemented. More information on the Dragonfly Mercury Project can be found at <https://wim.usgs.gov/geonarrative/dmp/> (<https://wim.usgs.gov/geonarrative/dmp/>) and <https://www.nps.gov/articles/dragonfly-mercury-project.htm> (<https://www.nps.gov/articles/dragonfly-mercury-project.htm>).



(https://agu.confex.com/data/abstract/agu/fm20/9/6/Paper_755669_abstract_724378_0.jpg)

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Growing the Impact and Value of the Dragonfly Mercury Project



Public participants in the Dragonfly Mercury Project at Saguaro National Park (AZ), Indiana Dunes National Park (IN), and Cuyahoga Valley National Park (OH), left to right.

Overview

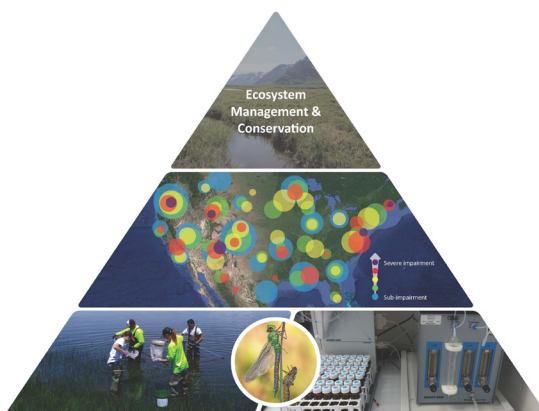
The Dragonfly Mercury Project assesses ecosystem health in U.S. national parks. This unique program is a monitoring, research, and education initiative that engages community volunteers nationwide in sampling an ideal biosentinel, dragonfly larvae, to estimate the risks that mercury contamination pose to resources managed by the National Park Service, and to human health. The existing infrastructure combines public participation, advanced laboratory and computational analyses, and robust data management, positioning this program to provide information and tools for resource managers to better understand and work toward mitigating mercury risks across varied ecosystems.

Engaging the public in science to inform resource management and protect public health

To date, the Dragonfly Mercury Project (DMP) has engaged more than 5,000 citizen scientists to quantify mercury impairment using dragonfly larvae from over 500 waterbodies across greater than 100 U.S. national parks and other federal, state, and local protected areas. The DMP's multi-tiered approach benefits diverse partners by providing authentic research experiences for youth and other volunteers, delivering information that can be used to quantify mercury risk and inform resource management actions. Further development of this program, building on the successful framework already in place, will expand its utility for park management.

Specifically, developing geospatial models to predict potential risks in unsampled waters requires additional geographic coverage across ecosystems and environmental gradients. The outcome of this expansion would provide direct information on the extent of contamination in participating regions, quantify the most important ecosystem drivers that regulate mercury risk in different ecosystem types, and establish baseline data on mercury to track changes through time. Collectively, these outcomes can be used to communicate potential risks, monitor sensitive populations, and inform management actions that may facilitate risk reduction.

Linking mercury concentrations in dragonfly larvae to health risks for wildlife and humans



The Dragonfly Mercury Project is a landscape-scale surveillance study that links scientific efforts to understand the risks of mercury pollution with public engagement and management actions.

Mercury is among the most globally pervasive environmental contaminants, harming the health of people and wildlife across the U.S. and abroad. Because it is transported through the air, mercury contamination can impact even remote and protected lands. Dragonfly larvae are the ideal mercury biosentinel because they are ubiquitous across ecosystem types, easy and cost-effective to monitor, and provide high-quality data that reflect mercury exposure in fish and other wildlife. As a result, a major contribution from the DMP to date, is the development of linkages between mercury concentrations in dragonfly larvae to exposure and potential health risks in fish, wildlife, and humans.

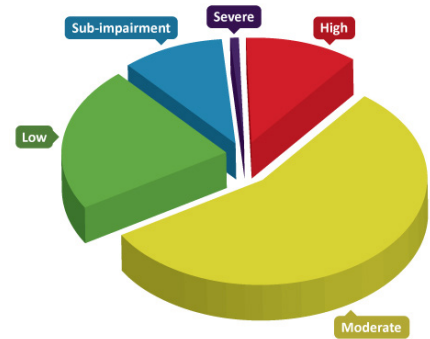
Demonstrated value for risk assessment and public engagement

This study is the most comprehensive assessment of mercury contamination and environmental risk in the nation's protected lands. This foundational work (Eagles-Smith et al. 2020):

- Developed an index that informs wildlife and human health risk to mercury based on dragonfly concentrations.
- Determined that mercury risk differed among habitats, with rivers being higher than lakes, and that the presence of wetlands further increased risk in nearby waterbodies.
- Found evidence that local ecosystem factors confound the direct linkage between atmospheric mercury deposition and patterns of mercury risk to fish and wildlife.
- Engaged citizenry in meaningful research and experiential learning opportunities that provide community learning and important

scientific contributions, and an exceptional cost savings to the public in comparison to more common approaches.

- Found 10 percent of sites were safer (below known impairment benchmarks); whereas, 12 percent of sites posed high or severe risk of impairment to fish, wildlife, and humans.



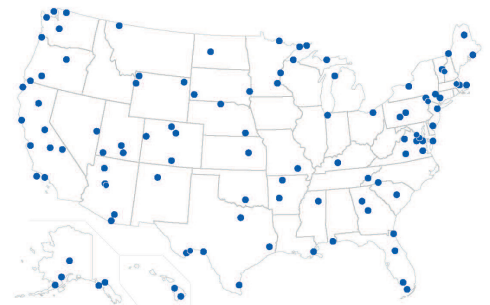
Percentage of sample sites with dragonfly mercury concentrations that correspond with defined risk categories of ecosystem health.

Growing the Dragonfly Mercury Project will increase its ability to address critical needs for managers and the public

The data delivery and interpretation tools developed by the DMP serve resource managers and public health officials in decision making and management actions. However, the utility of these tools is still limited. Opportunities to grow the program for achieving goals central to the missions of resource management and environmental protection agencies, include:

1. Developing risk forecasting models to identify safer water bodies for fishing and those that pose health risks to people and wildlife;
2. Informing management techniques and tools that could reduce mercury risk;
3. Assessing the effectiveness of domestic and international efforts to reduce mercury in the environment;
4. Engaging and enhancing learning of citizen scientists and the public; and
5. Communicating the importance and understanding of mercury issues for a variety of audiences.

Achieving these objectives requires broadening the baseline operations to incorporate new habitats and ecoregions, reach more public audiences, and strengthen partnerships with additional agencies and organizations; and implementing targeted activities associated with each specific goal, e.g., filling spatial data gaps.



Dragonfly Mercury Project sampling locations across 107 national parks and other protected places, 2009-2019.

The DMP is poised to help protect natural resources – and the people who enjoy and depend on them – from mercury exposure. We invite you to help us achieve that goal.

For More Information

Project Webpage:
<http://go.nps.gov/dragonflymercury>

Interactive Story Map:
<https://wim.usgs.gov/geonarrative/dmp/>

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