

A publication of the North American Lake Management Society

# LAKELINE

Volume 45, No. 4 • Winter 2025

**National Lakes Assessment**





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## UPCOMING IN LAKELINE

### **Spring 2026: Volunteer Monitoring**

There are many volunteer monitoring programs out there focusing on collecting chemical, physical and biological data from our surface waters. The focus of this issue will be to feature the work of some of those programs, including any novel methods as well as data collected as part of these monitoring efforts. Values and uses of these data, engaging volunteers, and leveraging support for these programs are all topics of interest.

***Drafts for spring issue are due by March 30, for publication in April.***

### **Summer 2026: DNA Barcoding in Lake Studies**

More and more we are hearing about the use of DNA barcoding, eDNA, and metabarcoding to monitor our surface waters. What is it, how is it used, what is it used for, and who's using it? These are all topics that are being sought for articles to round out this issue. Are you working with DNA barcoding in your lake(s)? Please consider submitting an article about your work!

***Draft articles are due by June 30, for publication in July.***

### **Fall 2026: Fisheries**

Topics related to fisheries ecology, biology, food webs, and management, along with toxins in fish tissue, fish habitat, and other fisheries related topics are welcome.

***Draft articles are due by September 30, for publication in October.***

### **Winter 2026: Agriculture in Watersheds**

A range of topics related to agriculture in watersheds is welcome, including farm pond management, nutrient runoff, erosion, agriculture BMPs for lake protection, and more.

***Draft articles are due by December 30, for publication in January.***

If you are interested in submitting an article on these or another topic, reach out to the LakeLine Editor at [LakeLine@nalms.org](mailto:LakeLine@nalms.org).

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**NALMS 2026**

KELOWNA, BC 🍁

# 46th International Symposium for the North American Lake Management Society

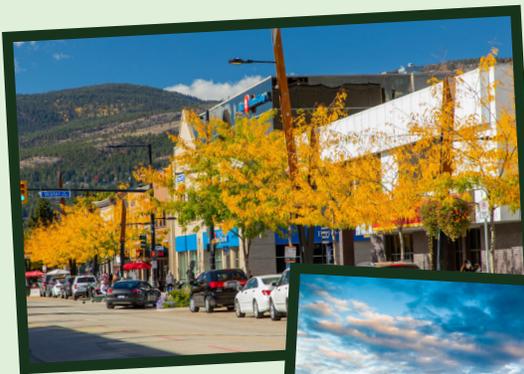
Swimming Upstream: Tackling Environmental Challenges through Partnership, Innovation, & Science

November 2-6, 2026 -- Kelowna, British Columbia, Canada



Kelowna appears to have abundant water, but this city is in the most water-scarce region of Canada. The water resources in this semi-arid setting are under increasing pressure, compounded by watershed-scale disturbance and a warming climate. Warmer, drier conditions in the growing season means agricultural needs, urban use, and environmental flow needs frequently exceed the available water resources.

To discuss these, and other, issues, NALMS is pleased to return to Canada (after ten years) for NALMS 2026! The program will feature the below topics (and more), workshops, field trips, presentations, networking events, and vendor displays.



### Potential topics include:

Aquatic Invasive Species    Climate Change  
Paleolimnology    Harmful Algal Blooms  
Community-Based Science  
Emerging Technologies & Methods  
Eutrophication & Nutrient Management  
Indigenous-Led Monitoring & Stewardship  
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Mining & Resource Extraction Impacts  
Science & Management of Salmon Lakes  
Urban Lakes & Stormwater Ponds

For sponsorship or general information, visit [www/nalms.org/nalms2026](http://www.nalms.org/nalms2026) or contact [nalms2026@nalms.org](mailto:nalms2026@nalms.org). For other details, contact Conference Coordinator, Sara Peel ([speel@arionconsultants.com](mailto:speel@arionconsultants.com)) or Conference Chairs, Hamish Kassa ([hamishkassa@gmail.com](mailto:hamishkassa@gmail.com)) and Lucie Thomson ([lucie.thomson@gov.bc.ca](mailto:lucie.thomson@gov.bc.ca)).

# LAKELINE

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IBC Lakespert

### On the cover:

“Standing on bubbles, frozen in time at Pigeon Lake, Alberta.” Photo by: Kirsten Letendre. This entry to the NALMS 2025 Photo Contest earned Popular Vote.

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*Editor:* Amy P. Smagula

*Advertising Manager:* Alyssa Anderson

*Production:* Parchment Farm Productions

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P.O. Box 14 • Caledonia, MN 55921

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Address all editorial inquiries to:

Amy P. Smagula

29 Hazen Drive

Concord, NH 03301

Tel: 603/419-9325

LakeLine@nalms.org

Address all advertising inquiries to:

Alyssa Anderson

North American Lake Management Society

PO Box 14 • Caledonia, MN 55921

aanderson@nalms.org

Payments:

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# From Amy P. Smagula **the Editor**

The winter issue of *LakeLine* highlights the exceptional work of both staff at the Environmental Protection Agency (EPA) and the many biologists who conduct the field work associated with the National Aquatic Resource Surveys (NARS) each year. While there are national condition assessments for coastal, wetland, lakes, and rivers and streams, because this is *LakeLine*, the focus of the articles contained within is of course on the National Lakes Assessment (NLA) efforts. Each of the six articles included in this issue is provided by an EPA staff person directly tied into the National Lakes Assessment efforts.

**Lareina Guenzel** provides an introductory article, including an overview of NARS, and the various assessments categories and habitats within the scope of the national surveys.

**Meredith Brehob, Robert Sabo, and Michael Pennino** discuss the very large data sets they had at hand as a result of the NLA, to predict nutrient and chlorophyll-*a* concentrations in waterbodies that do not have rigorous data sets, which is the premise of the probabilistic monitoring framework of NARS. The authors used machine learning models to incorporate nutrient and chlorophyll-*a* data, coupled with other datasets, to predict the risk of harmful algal blooms across the United States.

**Jana Compton, Michael Dumelle, Marc Weber, and Amalia Handler** utilize data from the NLA to define mountain lakes by their unique characteristics and distribution, tallying

over 12,000 mountain lakes within the contiguous United States, most of which are in better condition than other lake types across the country, based on indicators that were monitored as part of NLA. Despite their overall good water quality, it is a category of lakes at risk from shoreline development and other pressures.

**Richard Mitchell and Alan Herlihy** review the multi-metric index adapted from stream assessments for use in the NLA, which used both zooplankton and benthic macroinvertebrates in the assessment. Based on the index, EPA was able to categorize benthic macroinvertebrate populations in five assessment regions across the United States.

**Mari Nord and Amina Pollard** provide an overview of the 2017 sediment contaminant mass sampling component. The deep spot sediments that were collected at NLA lakes that year were analyzed for 127 different parameters, to gauge condition relative to bottom dwelling organisms in lakes. This

was the first large scale assessment of contaminants across a range of lakes in the United States, and it provided useful insights into the health of our nation's lakes.

**Lester L. Yuan** shares an article on aquatic macrophyte communities in shallow lakes across the United States and discusses alternate stable states (clear versus turbid water) in relation to plant communities and other parameters (like turbidity, chlorophyll-*a*, and nutrients).

Also in this issue, we hear from our new (and first repeat) NALMS President, **Julie Chambers** with a President's Message; the NALMS Executive Director, **Philip Forsberg**, with a NALMS 2025 Symposium wrap-up; and **Alyssa Anderson**, NALMS Director of Development and Marketing on a rundown of the NALMS annual awards and recognitions. **Steve Lundt**, NALMS Lakespert, goes back to the future of lake assessment.

We hope you enjoy this issue of *LakeLine*!



## Get **BUSY** at **NALMS**

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# From Julie Chambers the President

Writing this article seems a bit surreal as it's been a decade since I've had the honor of



serving as President of NALMS. The past few weeks have been a whirlwind, from attending the annual conference in Myrtle Beach, South Carolina, to jumping right into

the holidays. Now, once again, I have the pleasure of writing my first "From the President" article.

The topic for this issue of *LakeLine* National Lake Assessment (NLA), is a personal favorite of mine, as it speaks to the unified effort to monitor and assess lake health across the country. The NLA survey is a collaborative effort among state, federal, and tribal partners, that most lake managers across the United States are familiar with it, as the U.S. EPA has completed five iterations of the survey since 2007. Beyond the data collected, NLA surveys offer additional benefits, including technology transfer and increased knowledge and capacity to participating programs. In fact, Oklahoma, my home state has incorporated several components from the NLA into its current program, including biological sampling and habitat assessment efforts, and continues to use NLA protocols beyond the survey year.

The NLA is one of the EPA's National Aquatic Resource Surveys (NARS), which are designed to assess the quality and condition of the nation's waters. Surveys are conducted every five years on a rotating basis. By using a statistical or probabilistic survey design, NARS provides a robust scientifically

based approach to water quality monitoring that allows resource managers to draw reliable conclusions about a large population of lakes and reservoirs based on unbiased samples from a smaller subset of lakes. A key strength of statistical surveys is the power to characterize the overall waterbody population with documented statistical confidence (NWQMC 2017). Using an unbiased sample, statistical surveys can estimate waterbody condition on a broader scale, such as statewide, ecoregional, or national level, allowing lake managers to draw conclusions about lakes and reservoirs across the country.

The NLA is designed to answer specific questions about the condition of lakes, reservoirs, and ponds across the contiguous United States. Specifically, statistical based survey designs assist lake managers in several ways:

- Estimate the extent of impacted waters within a state
- Support analysis of impacted waterbodies and their attributes for priority management. Conduct statistically valid assessments of the condition of lakes and reservoirs within a state program
- Assist resource managers in long- and short-term program planning and resource allocation
- Evaluate relationships between stressors such as nitrogen and phosphorus, and indicators of condition, including chlorophyll-*a*

The next NLA is scheduled for the summer of 2027, so the timing for this issue of *LakeLine* is perfect as planning is well underway.

**Julie Chambers** leads the Oklahoma Water Resources Board's Beneficial Use Monitoring Program (BUMP) Lake Monitoring section. She has 25 years of experience in statewide water quality management, from program design through data collection, management, reporting, and dissemination of information. Over the last 22 years her program has thrived and is responsible for conducting water quality studies, assessments, and bathymetric surveys on reservoirs across Oklahoma, as well as managing lake and wetland projects funded through federal grants and other contracts. Julie serves on the water quality steering committee for the EPA's National Lake Assessment as well as on several state technical workgroups focused on the assessment of lakes and field protocol development. Julie has been an active member of The North American Lake Management Society (NALMS) for 20 years serving on various committees and representing as past president since 2016. ☀

## And while you're at it . . .

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Send any corrections to [membershipservices@nalms.org](mailto:membershipservices@nalms.org)



# NALMS Symposium Wrap-Up

by Philip Forsberg, NALMS Executive Director

Conference Photos: Todd Tietjen



**November 4–7, 2025**

45th NALMS International Symposium

Myrtle Beach Convention Center • Myrtle Beach, South Carolina

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## Navigating Change Together: Enhancing Lake, Reservoir, and Watershed Resilience

**NALMS WELCOMED MORE THAN 440 ATTENDEES FROM THROUGHOUT THE US, CANADA, AND NINE OTHER COUNTRIES TO MYRTLE BEACH, SOUTH CAROLINA, FOR NALMS' 45TH INTERNATIONAL SYMPOSIUM.**

The week started with a full slate of pre-conference workshops on a wide variety of topics including algae identification, lake mapping, sediment phosphorus inactivation, R, and others. The day also included field trips to Waties Island and the Anne Tilghman Boyce Coastal Reserve; a coastal marsh seine netting experience; and a tour of Brookgreen Gardens, where attendees learned about the local Gullah culture.

The three-day conference program started with an opening plenary session with talks by Dr. Jeffery Allen, Emeritus Director of the South Carolina Water Resources Center at Clemson University, and JoAnn Burkholder, a William Neal Reynolds Distinguished Professor of Aquatic Ecology in the Department of Applied Ecology at North Carolina State University (Photos 1 and 2).

Technical sessions over the three days of the conference included approximately 155 oral presentations spread over 43 sessions covering topics such as reservoir management, nutrient management, invasive species management, HAB management, Carolina Bay lakes, climate, and oxygenation, among other topics.

Breakout meetings during the week included meetings for student members of NALMS, the professional certification program, Women of Aquatics, and the *Lake and Reservoir Management* journal associate editors.

The annual awards presentation was held as a plenary session on Thursday morning of the conference. The presentation recognized the accomplishments and contributions of NALMS members and other worthy recipients. The Secchi Disk Award, the Society's most prestigious award, given to a member who has made extraordinary contributions to the goals and objectives of the Society was bestowed upon Amy Smagula. A full list of 2025 award recipients can be found in this issue of *LakeLine*.

Thursday's extracurricular schedule included the Clean Lakes Classic 5K (Photo 3), which took participants on a route on the Myrtle Beach Boardwalk. Some participants added a quick dip in the Atlantic Ocean to their run. Thursday evening's activities included the inaugural "Unofficial" NALMS Mini-Golf Outing, organized by Chris Doyle (Photo 4). Seventeen teams of four players competed, with The Golf Goddesses winning the 1st place trophy, and Team Canada and Beginner's Luck tying for 2nd place. Thursday night also saw the return of the NALMS hospitality trivia contest hosted by Todd Tietjen (Photos 5 and 6). Not to be outdone by the mini-golfers, Secchi disk medals were awarded to the top three teams.

Thank you to all who attended this year's symposium! We look forward to seeing you next November in Kelowna, British Columbia, for NALMS 2026!



Photo 1



Photo 2



Photo 3

Photo 4



Photo 6



Photo 5



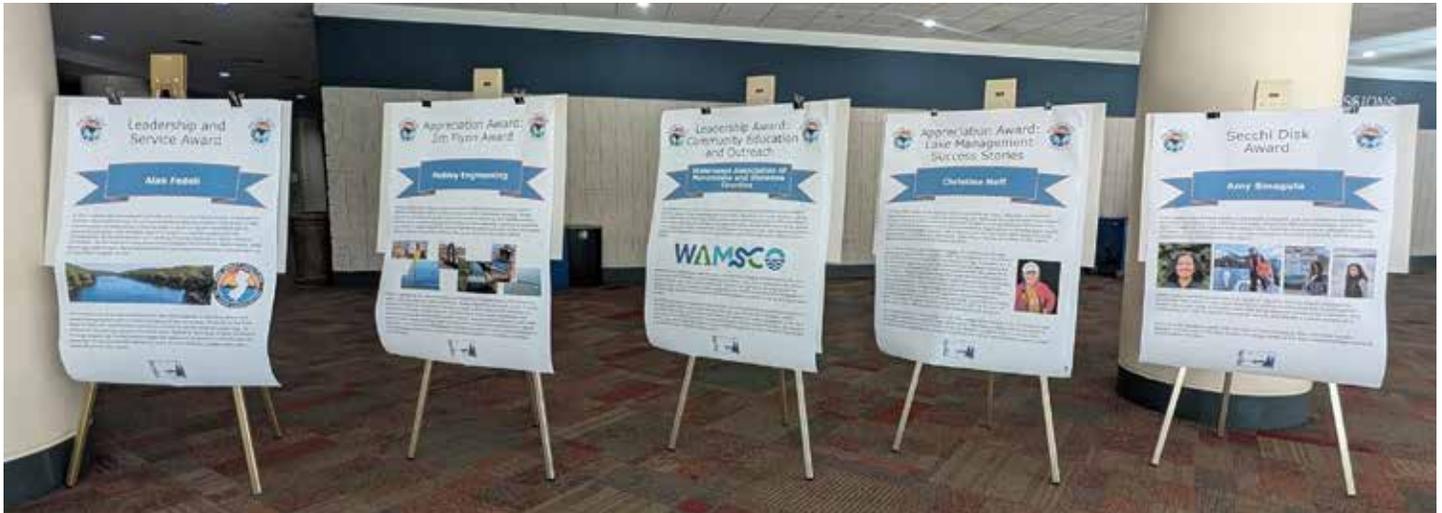
# Additional Conference Event Summaries – NALMS Awards

## North American Lake Management Society Honors Members & Partners with 2025 Achievement Awards

Alyssa Anderson

SHINING A SPOTLIGHT ON DESERVING INDIVIDUALS AND ORGANIZATIONS WHO HAVE MADE VALUABLE CONTRIBUTIONS TO THE GOALS OF THE NORTH AMERICAN LAKE MANAGEMENT SOCIETY (NALMS), OR HAVE MADE SIGNIFICANT STRIDES IN LAKE MANAGEMENT, NALMS Annual Achievement Award winners represent the very best amongst its members and partners.

NALMS Achievement Awards are presented annually at the Society's International Symposium, which was recently held November 4-7, 2025, in iconic Myrtle Beach, SC. This year, NALMS was pleased to honor and recognize a variety of individuals and groups, who were nominated by their peers .



NALMS Leadership & Service Awards, formerly known as the Technical Merit Awards, are given annually to recognize and honor individuals or groups for **Successful Projects, Volunteer Actions, Research Efforts, and Public Education/Outreach**. The 2025 Leadership and Service Award recipients are as follows:

- *Waterways Association of Menominee and Shawano Counties (WAMSCO)*  
Community Education and Outreach
- Alan Fedeli  
Volunteer

The Lake Management Success Stories Award is awarded to an individual or team who has demonstrated improvement in lake/reservoir condition or watershed management in a cost-effective manner. The **Advancements in Lake Management Technologies Award** is awarded to an individual or team who have completed research projects that contribute to the science of lake management. The 2025 Appreciation Award winners are as follows:

- Christine Neff (left), Friends of the Eau Claire Lakes Area  
*Lake Management Success Stories Award*



The **Jim LaBounty Best Paper Award**, established in 2003, is given annually to recognize and honor the best paper published in the Lake and Reservoir Management journal. This year's honor went to:

- R. Gorney, E. Nystrom, M. Stouder, A. St. Amand, C. Sauve, D. Clark, E. Stelzer, C. Givens & J. Graham  
"An evaluation of cyanobacterial occurrence and bloom development in Adirondack lakes"

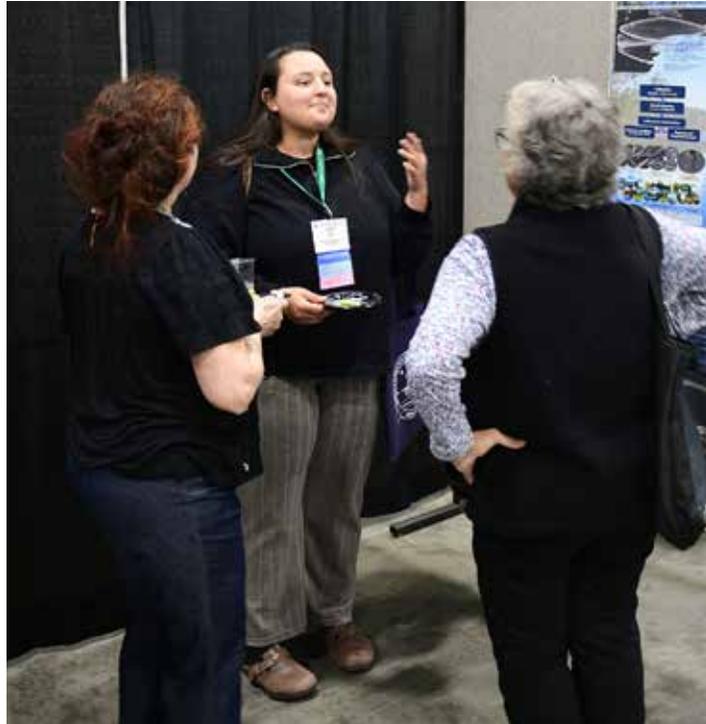
Special awards also included the **Secchi Disk Award**, the **Jim Flynn Outstanding Corporation Award**, and the **Friends of NALMS Award**, given annually, respectively, to the individual and the corporation who has made the most significant contributions to the goals and objectives of the Society. The 2025 special award winners are as follows:

- Amy Smagula  
*Secchi Disk Award (photo at right)*
- Mobley Engineering  
*Jim Flynn Outstanding Corporation Award*

### NALMS Student Paper Awards

Each year the North American Lake Management Society (NALMS) presents student awards to the best student presentation and best student poster (photo at left, below) at the annual NALMS symposium. The 2025 student awards were sponsored by the New England Chapter of NALMS.

The NALMS Board of Directors renamed the student award as the Jody Connor Student Award in memory of Jody Connor, a long-time friend of NALMS who was active on the Education Committee and participated in the reviews of student presentations and posters. The first-place winners receive a check for \$250 and a plaque, while the honorable mention or second place winners receive a plaque. The awards are based on scientific merit, research design, visual aids, clarity, and presentation.



We are delighted to share that the 2025 *first-place oral presentation winner* is **Julie Critchfield, University of California Davis, Davis, CA**, for her talk entitled "Quantifying Differential Cooling in Deep Oligotrophic Lakes." The 2025 *first-place poster presentation winner* is **Lillian Doll, Clemson University, Clemson, SC**, for her poster entitled "Validating the Pond Shoreline Assessment Tool (PSAT) Using Grand Strand Stormwater Wet Ponds to Implement as a Future Inspection Technique." Congratulations to Julie and Lillian for your excellent work!

We are also happy to share the 2025 Honorable Mention awards, for both oral and poster presentations! The 2025 *honorable mention oral presentation winner* is **Catherine Schlenker**, for her talk entitled "Examining the Impact of Emerging Contaminants on Phytoplankton Communities in a Managed Reservoir: Lake Murray, SC." The 2025 *honorable mention poster presentation winner* is **Summer Weidman**, for her poster entitled "Using Satellite Imagery to Detect Northern Hydrilla: Time[1] Series Analysis of Northern Hydrilla in the Connecticut River From 1994–2024." Congratulations to Catherine and Summer!

*We thank the New England Chapter of NALMS for sponsoring the student awards and for all of the students who presented and/or attended the NALMS symposium in Myrtle Beach! We look forward to excellent student participation at the NALMS 2026 symposium in Kelowna, British Columbia, Canada!*

# NALMS Photo Contest Results

THIS YEAR NALMS RECEIVED 35 ENTRIES IN THE NALMS PHOTO CONTEST,  
COVERING A RANGE OF SUBJECTS AND LAKES ACROSS THE GLOBE.

TWO WINNERS WERE SELECTED:

**Popular Vote** (voted on by NALMS conference attendees):

*Standing on bubbles, frozen in time at Pigeon Lake, Alberta*

Photo by: Kirsten Letendre

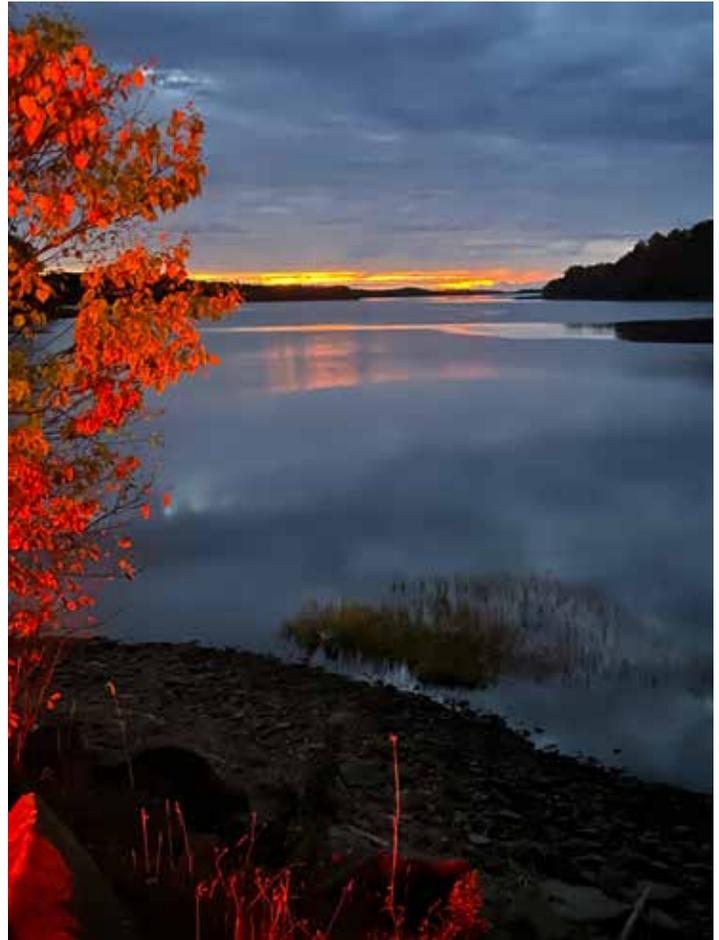


**Editor's Choice** (voted on by the *LakeLine* Editor and

*LakeLine* Production Editor):

*Mabou Harbor, Cape Breton Island, Nova Scotia*

Photo by: David Pronchick



Founded in 1980, the North American Lake Management Society (NALMS) is a member-driven nonprofit organization focused on the management and protection of lakes and reservoirs. Welcoming anyone with an interest in lakes, NALMS strives to forge partnerships among citizens, scientists, and professionals to achieve this mission.



# Determining the condition of the nation's lakes...and more: It's the National Lakes Assessment

Lareina Guenzel

Every summer, teams across the country head into the field to collect data at over a thousand waterbodies as part of a collaborative effort to comprehensively assess water quality of the nation's waters (Figure 1). The United States Environmental Protection Agency (EPA) works with state, Tribal and federal partners to design and implement the National Aquatic Resource Surveys (NARS) using cost-effective and nationally consistent approaches. The NARS include four individual surveys that are implemented on a rotating basis:

- National Coastal Condition Assessment (NCCA 2010, 2015, 2020, and 2025);
- National Wetland Condition Assessment (NWCA 2011, 2016, and 2021);
- National Lakes Assessment (NLA 2007, 2012, 2017 and 2022); and
- National Rivers and Streams Assessment (NRSA 2008-09, 2013-14, 2018-19 and 2023-24).

Each survey uses a probabilistic design to assess the status of and changes in the quality of the nation's coastal waters, lakes and reservoirs, rivers and streams, and wetlands. The field crews sample the sites that are selected at random, which allows EPA to extrapolate the results from the sampled lakes to the full survey target population and provide a snapshot of the overall condition of the nation's water. Because the surveys use standardized field and lab methods, survey partners can compare results from different parts of the country and between survey years. For more information, see the NARS history page and Nahlik et al. 2025.

For the NLA, EPA, states, tribes, and other partners survey a wide array of lakes, from small ponds and alpine lakes to large lakes and reservoirs, on federal, tribal, state and private lands. To be included in the survey the waterbody must be within the 48 contiguous United States, greater than 1 hectare (ha) in surface area, a permanent

waterbody, at least 1 meter deep, and have a minimum 0.1 ha of open water. Samples are collected from an index site, which is the deepest location in a natural lake or the mid-point in a reservoir, and from ten littoral locations evenly distributed around the lake perimeter. The four survey cycles have generated large spatial datasets of chemical (in water, sediments, and fish tissue); physical habitat (shallow water and shoreline); and biological (phytoplankton, zooplankton, and benthic macroinvertebrate) parameters. Check the Map of NARS Sampling Locations for where we have sampled.

In 2022, over 80 field crews sampled 981 lakes from June through September. NLA 2022 results continued to show widespread nutrient pollution, with 50 percent of lakes in poor condition for phosphorus and 47 percent in poor condition for nitrogen. Additionally, high levels of algae and cyanobacteria growth were observed, with 30 percent of lakes classified



Figure 1. NLA 2022 crews practicing field protocols at Sheridan Lake, SD during the regional training attended by the states of North Dakota, Nevada, South Dakota, Utah, and Wyoming and Standing Rock Sioux Tribe.

as hypereutrophic. The algal toxin microcystin was detected in 50 percent of the nation's lakes (Figure 2). Of the 268,020 lakes in the target population, approximately 31 percent were natural lakes (83,560 lakes), and 69 percent were reservoirs (184,460 lakes).

The 2022 field crews also collected fish fillet samples that were analyzed for contaminants of human health concern including mercury, polychlorinated biphenyls (PCBs) and per- and polyfluoroalkyl substances (PFAS). It had been 20 years since EPA conducted a lake fish survey of this magnitude and this was the first NLA survey to include PFAS samples. Contaminants were detected in all composite fish tissue samples, with the mercury concentrations of fish tissue samples exceeding the EPA's 300-ppb water quality criterion in about half of the lakes and PCB concentrations of fish tissue samples exceeding the EPA's 12-ppb cancer screening level in 6 percent of lakes (Figure 3).

For more information on the 2022 survey and results, visit the NLA 2022 Web-Report. To explore all survey results including regional results and results from past surveys, visit the NLA Data Dashboard.

The NLA reports and data dashboard serve as essential communication tools for EPA. However, what truly resonates with our survey partners is our commitment to enhancing water quality monitoring programs nationwide. By fostering collaboration on new methods, developing new water quality indicators, and advancing research, we elevate the NLA beyond the core reporting requirements. In this issue of *LakeLine*, we are thrilled to showcase the NLA research initiatives born from field collaboration and the subsequent analysis and application of survey data. Our field crews have eagerly collected samples that extend beyond typical lake monitoring, such as benthic macroinvertebrates, while EPA scientists have utilized NLA data to tackle national water quality challenges and create tools to inform future policy and lake management decisions. Enjoy the lake condition insights and data discoveries shared within!

## Reference

Nahlik, A.M., S.G. Paulsen, M. Dumelle, S. Holdsworth, S. Lehmann, N.S. Tulve, S.J. Paul, and H.C. Frey. 2025.

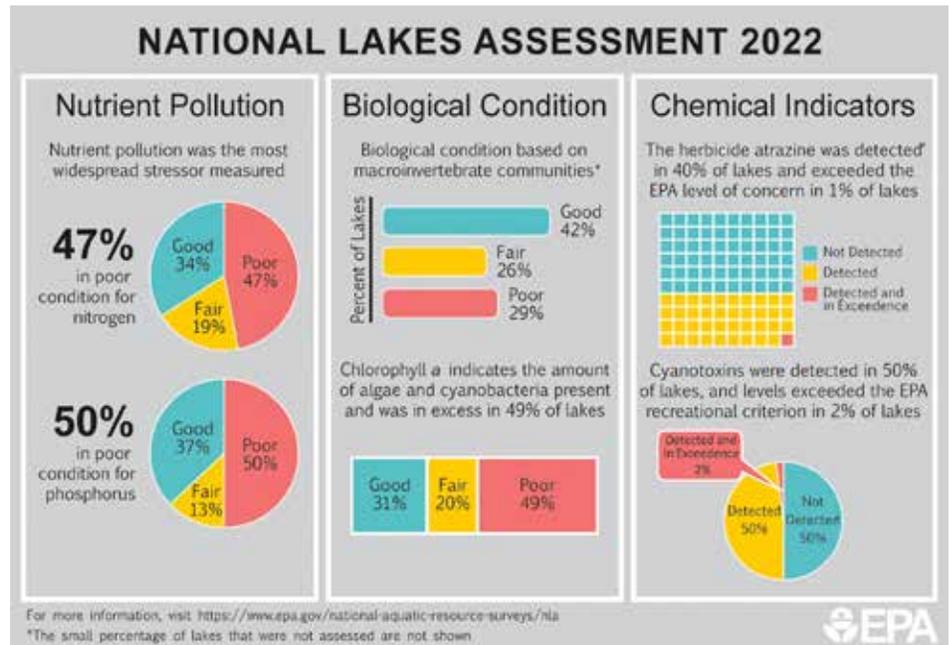


Figure 2. Key chemical and biological findings from NLA 2022.

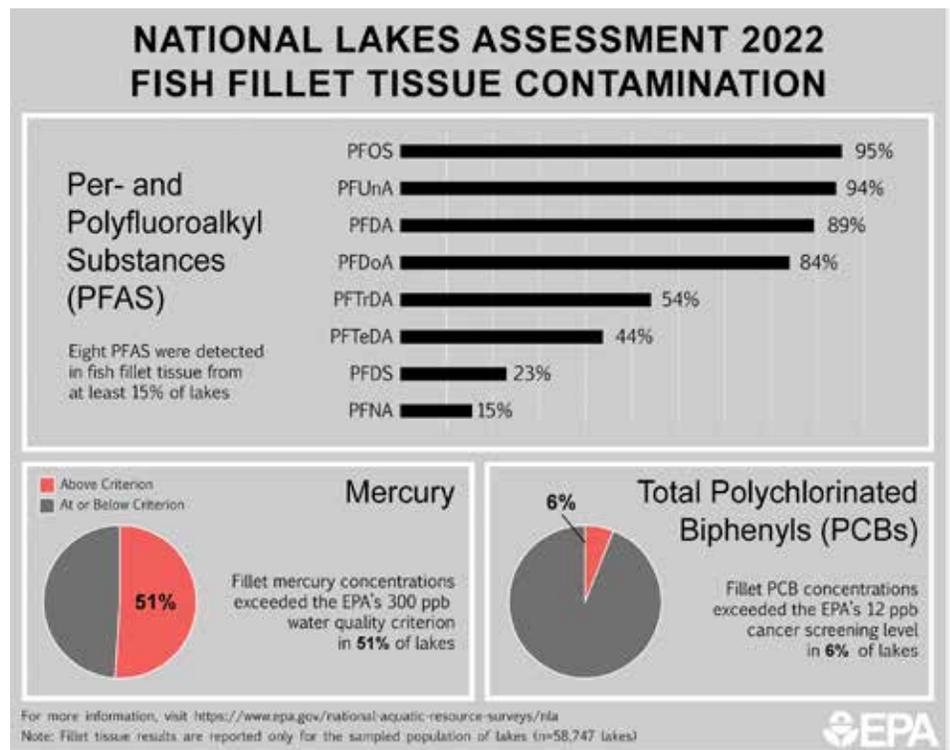


Figure 3. Fish fillet tissue contamination results from NLA 2022.

National Aquatic Resource Surveys (NARS): the foundation for long-term aquatic monitoring data across the United States. *Environ Monit Assess* 197, 1291(2025). <https://doi.org/10.1007/s10661-025-14629-8>

Lareina Guenzel is a biologist in the EPA's Office of Water in Washington, D.C. She has worked at the EPA for 18 years and has served as the National

Lakes Assessment survey lead for the past five years. In her role, she oversees all aspect of the NLA including survey design, field crew training, data analysis and reporting. You can contact Lareina at [guenzel.lareina@epa.gov](mailto:guenzel.lareina@epa.gov).



# National modeling of lake nutrient & chlorophyll-*a* concentrations **to characterize HAB risk**

Meredith Brehob, Robert Sabo, & Michael Pennino

**H**armful algal blooms (HABs) occur when excessive algal growth leads to negative outcomes such as unsightly and odorous waters, oxygen depletion, and toxin production. Through these mechanisms, HABs detract from the freshwater ecological services that humans rely on (e.g., recreation, fisheries, and safe drinking water). It is broadly understood that nutrient pollution leads to eutrophication of waterbodies and growth of HABs. However, because HABs occur sporadically and are difficult to monitor, it is often not possible to match observed HAB events with corresponding nutrient measurements. This mismatch makes it difficult to identify waterbodies susceptible to HABs and the anthropogenic and environmental drivers responsible.

To advance HABs research efforts, we leveraged large environmental datasets to predict nutrient conditions and chlorophyll-*a* concentrations (an indicator of HABs) in lakes that do not have robust water quality datasets. Total nitrogen, total phosphorus, and chlorophyll-*a* data from the 2007 and 2012 NLA surveys were paired with watershed-scale weather (PRISM Group), terrestrial net primary productivity (NASA Earth Observations), annual nutrient input (e.g., farm fertilizer and atmospheric deposition; EPA's National Nutrient Inventory), and landscape (e.g., soil properties and land cover; LakeCat Data) datasets. We then used this data in machine learning models to investigate watershed drivers of nutrient and chlorophyll-*a* concentrations and to characterize the risk of HABs in lakes across the United States (US) (Brehob et al. 2024).

To broaden and enhance the accuracy of chlorophyll-*a* predictions, we developed a modelling structure which used predicted lake nitrogen and phosphorus concentrations as indicators of chlorophyll-*a*. This

approach was applied to a national dataset of watershed nutrient input data, weather parameters, and landscape factors to make nutrient and chlorophyll-*a* predictions for 112,023 lakes. In addition to watershed-specific lake predictions, we estimated lake nutrient and chlorophyll-*a* concentrations across the entire landscape. These broader landscape predictions are powerful because they provide insights into eutrophication trends across the U.S., including the smaller headwater lakes that typically lack watershed data coverage.

The models demonstrated strong predictive power, explaining 65 percent of the variation in total nitrogen, 62 percent in total phosphorus, and 68 percent in chlorophyll-*a* across the 112,023 lakes. As expected, based on our common understanding of lake eutrophication dynamics, lake chlorophyll-*a* concentrations were primarily driven by total nitrogen and total phosphorus concentrations. Interestingly, lake depth also plays an important role. As lake depth increased, nutrient and chlorophyll-*a* concentrations tended to decrease. While there are many ways lake depth influences nutrient and chlorophyll-*a* concentrations, the most important is likely tied to a longer water residence time. Deeper lakes tend to hold water longer, allowing more time for natural nutrient cycling, sedimentation, and processing to occur, leading to lower nutrient levels and, subsequently, lower chlorophyll-*a* concentrations.

After accounting for lake depth in the nutrient models, agricultural inputs largely drove lake nutrient concentrations, with higher predicted nutrient concentrations for lakes in major US agricultural regions (bottom panel of Figure 1). Generally, agricultural variables such as fertilizer inputs and soil agricultural erodibility factors tend to increase lake nutrient and

chlorophyll-*a* concentrations, while variables such as lake depth and watershed runoff attenuate nutrient loads and lower lake chlorophyll-*a* concentrations.

This predictive modeling work leverages some of the most advanced publicly available estimates of weather conditions, terrestrial net primary production, anthropogenic nutrient inputs, soil factors, and in-lake characteristics to predict nutrient and chlorophyll-*a* concentrations in more than 100,000 lakes across the contiguous US. These results (1) provide insight into the drivers of eutrophication and HABs in lakes at a national scale and (2) identify lakes and headwater areas that are at risk for HABs. The predicted nutrient and chlorophyll-*a* estimates are publicly available and may be used by managers tasked with protecting American waterways to identify areas of concern from HABs and assist in addressing nutrient pollution challenges.

In addition to its management relevance, this work represents a broader, rapidly growing trend in environmental science: harnessing big data and machine learning to predict, forecast, and interpret major challenges at continental scales. These efforts rely on high-quality national datasets like the US EPA's National Aquatic Resource Surveys, providing dependable data from probabilistic surveys of the nation's coasts, lakes, rivers, and wetlands; the National Nutrient Inventory, delivering detailed estimates of anthropogenic nitrogen and phosphorus inputs and outputs; and the StreamCat and LakeCat datasets, providing reach- and watershed-scale landscape metrics for every lake and stream in the contiguous US. As HABs continue to compromise our water resources, scalable tools built on these foundational EPA resources and other national datasets are essential. This study and the associated

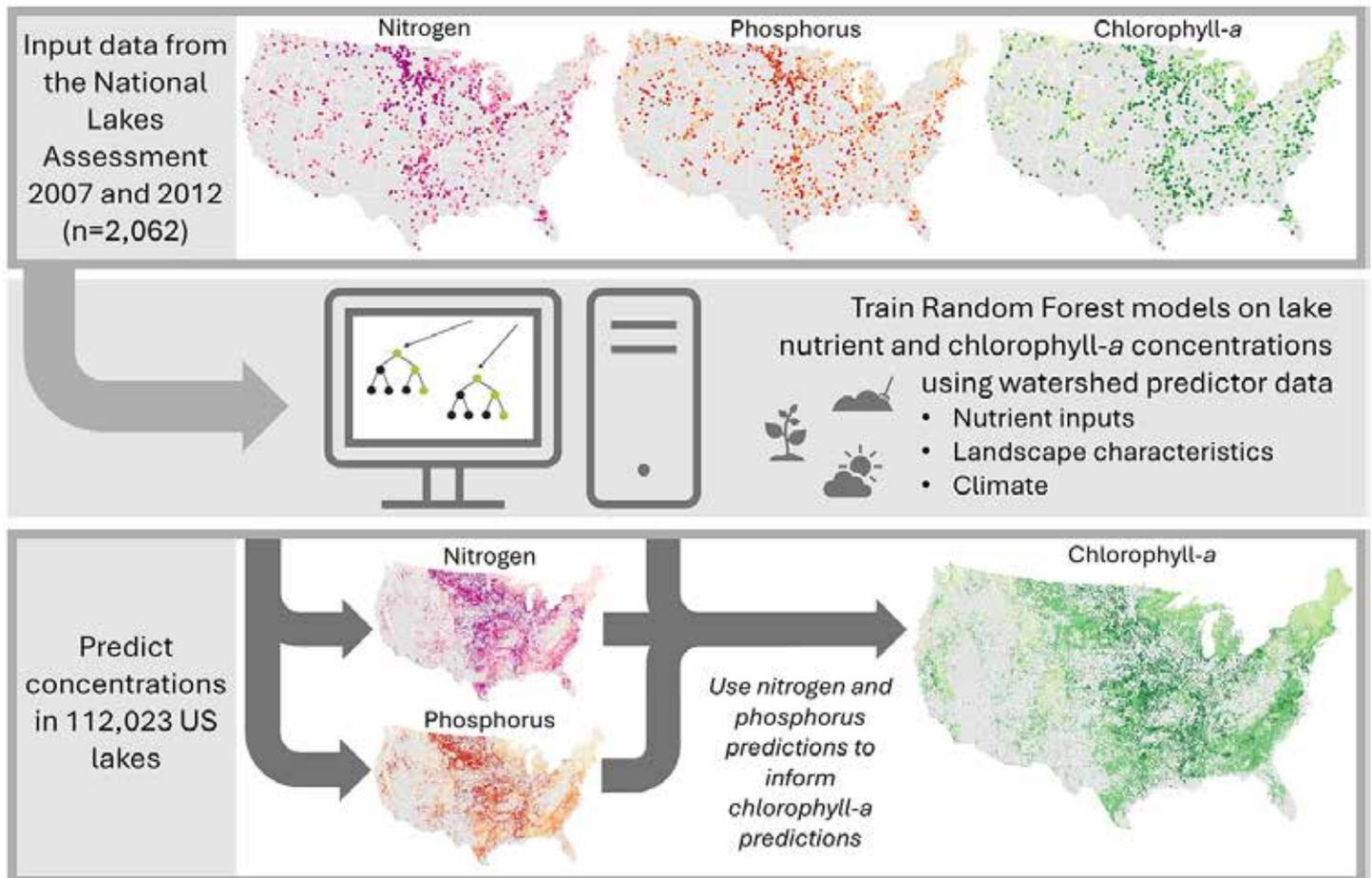


Figure 1. Diagram showing the workflow that led to predictions of total nitrogen, total phosphorus, and chlorophyll-a concentrations for 112,023 US lakes.

databases serve as one practical step forward for lake management and an example of what can be achieved when powerful open data and modern analytics come together.

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**Meredith Brehob** is an aquatic ecologist with an ORISE fellowship at the U.S. EPA's Office of Research and Development. In this role, she works on applying national data to assess nutrient impacts on freshwater ecosystems and drinking water



systems. Meredith has a Master of Science degree in Natural Resources and Environmental Science from the University of Nevada, Reno. To reach out, email [Brehob.Meredith@epa.gov](mailto:Brehob.Meredith@epa.gov).

**Robert Daniel Sabo** is a scientist at the EPA's Office of Water. He began his career as an ORISE fellow with ORD in 2015 and joined the agency as a federal researcher in December 2019. Robert is the research lead for EPA's National Nutrient Inventory Research Portfolio, a multi-agency effort developing novel tools, models, and datasets designed to track the evolution of point and nonpoint sources of nutrient pollution to waterways across the U.S. and how changing environmental conditions impact waterbodies. Beyond research, Robert enjoys escaping to the mountain and Piedmont forests of Virginia for hiking and flyfishing with his wife and five daughters.



**Michael Pennino** is an ecologist with EPA's Office of Applied Sciences and Environmental Solutions in Washington, DC. He focuses his research on understanding spatial and temporal trends for indicators of environmental quality and human health, at regional and national scales. Michael uses machine learning models and other data science techniques to help answer questions about our Nation's important water resources. Currently, Michael is leading projects that assess impacts of harmful algal blooms, urban best management practices, and other factors that influence contaminants in surface waters and drinking water. He holds a B.A. from Oberlin College (2005) and a Ph.D. from the University of Maryland, Baltimore County (2014). 🌱



# Mountain lakes: Ecological gems facing unique challenges

Jana Compton, Michael Dumelle, Marc Weber, & Amalia Handler

Mountain lakes are cherished for their beauty, recreation, and vital role in providing fresh water. But what truly defines a “mountain lake?” And how healthy are they? A new study from Handler et al. (2025) offers the first comprehensive look at the condition of mountain lakes across the contiguous United States, revealing both their health and potential vulnerabilities. Historically, defining a “mountain lake” has been difficult and has often focused only on very high elevation “alpine” lakes, excluding many highly valued lakes in lower mountain ranges or in lower portions of mountain ranges. To address this, we applied a topography-based approach to define mountain lakes in the National Lake Assessment dataset (NLA; Figure 1). Mountain lakes were classified based on the extent of mountainous landforms within a given area around each lake, using the USGS Landforms dataset. The result includes a wider range of mountain lakes from the Northern Highlands in the East to the Rockies and Cascades in the West. According to this new definition, we estimate that there are over 12,000 mountain lakes across the contiguous U.S., accounting for about 6.7 percent of all lakes.

## Generally healthier, but not without concerns

The good news is that for most health indicators such as water clarity, nutrient levels, and aquatic life, mountain lakes are in significantly better condition than other U.S. lakes (Figure 2). This is largely because many are still remote and less impacted by widespread human development. However, this study also uncovered important issues. Around 25 percent of mountain lakes show signs of excessive nutrients like phosphorus, which can lead to unwanted algae growth. Also, mountain lakes generally have a lower ability to neutralize acid, making them more

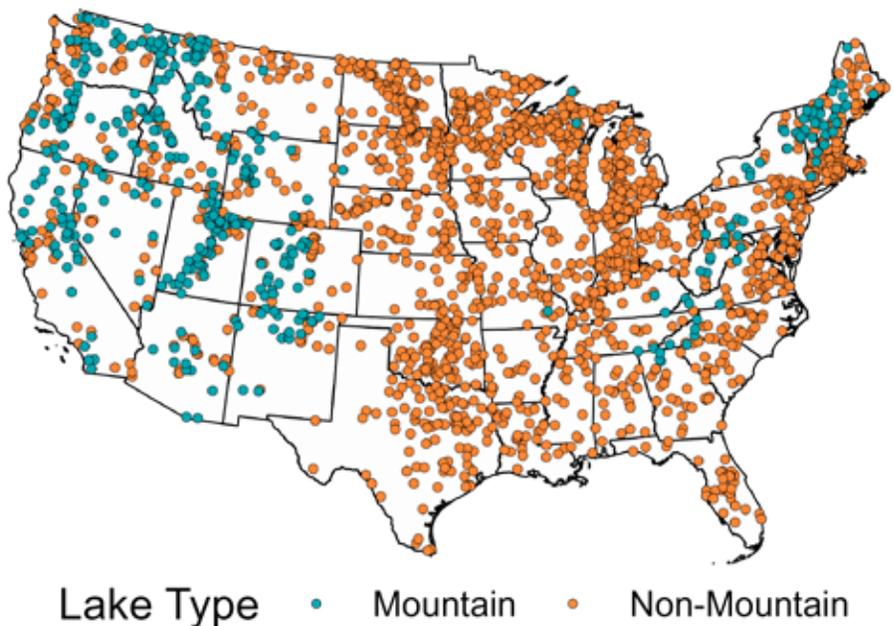


Figure 1. Mountain or non-mountain lakes sampled in the National Lakes Assessment.

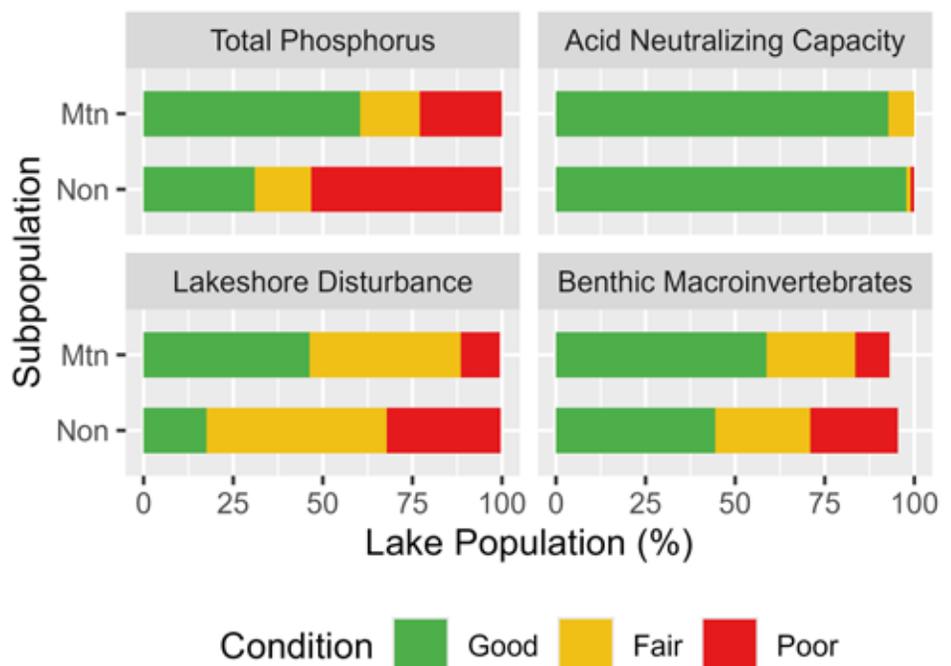


Figure 2. Proportion of the U.S. mountain (Mtn) and non-mountain (Non) lake population that are in good, fair, and poor condition, with respect to ecological indicators.

vulnerable to acid rain, though conditions have improved in many areas since the enactment of the Clean Air Act. More surprisingly, nearly half of mountain lakes show fair or poor conditions for lakeshore disturbance, potentially indicating that some direct human activity along the shoreline may be taking a toll. Lastly, about a third of mountain lakes have poor condition communities of benthic macroinvertebrates, often due to lingering acidification effects or the introduction of non-native fish that prey on these insects.

### Unique vulnerabilities to development

While mountain lakes have less overall development than other lakes, the study found a critical difference: development around mountain lakes is often concentrated right along the lakeshore. This is an important concern because mountain lake characteristics can make them especially susceptible to pollution. Their steeper slopes and high runoff mean pollutants from developed areas or air pollution can quickly wash directly into the lake. Additionally, thin soils and shallow bedrock provide less natural filtering of pollutants before they reach the water, making these lakes less resilient. Even a small amount of development close to a mountain lake can have a disproportionately large negative impact.

### Protecting our “water towers”

With billions of people worldwide relying on water from mountainous regions, protection of mountain lakes as “water towers of the planet” merit research and management. This study underscores the potential for targeted conservation on mountain lake shorelines and improved management strategies that account for their unique vulnerabilities. Understanding what makes mountain lakes unique and where their vulnerabilities lie is key to safeguarding these invaluable natural resources.

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**Jana Compton** is an ecologist with the Environmental Protection Agency in Corvallis, OR. Her research focus is on the biogeochemical connections between landscape characteristics and water quality. Her research interests include the sources, effects and management of nutrients related to water quality of streams, lakes and drinking water. You can contact Jana at [compton.jana@epa.gov](mailto:compton.jana@epa.gov).



**Michael Dumelle** is a statistician with the Environmental Protection Agency in Corvallis, OR. He is the lead statistician for EPA's National Aquatic Resource Surveys (NARS) program. His research focuses primarily on creating and maintaining freely available software that applies statistical and machine learning techniques to spatial data. You can contact Michael at [dumelle.michael@epa.gov](mailto:dumelle.michael@epa.gov).



**Marc Weber** is a geospatial scientist with the Environmental Protection Agency Office of Water in Corvallis, OR. He provides geospatial support for the EPA's National Aquatic Resource Surveys (NARS) program, he co-developed the EPA StreamCat database and application, and he provides GIS and programming expertise in spatial analysis and water research at the EPA. You can contact Marc at [weber.marc@epa.gov](mailto:weber.marc@epa.gov).



**Amalia Handler** is an ecologist and affiliate faculty at Oregon State University in Corvallis, OR. Her research focus is on the ecology of watersheds and consequences for water quality. Her research interests include the patterns and effects of nutrients and harmful algal blooms in lakes, rivers, and streams. You can contact Amalia at [handlera@oregonstate.edu](mailto:handlera@oregonstate.edu). \*





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# Development of a nationally consistent benthic macroinvertebrate indicator of **lake biological condition**

Richard Mitchell & Alan Herlihy

The assessment of lake condition has traditionally focused on chemical parameters and less so on the biological assessment of lake communities. As part of the National Aquatic Resource Surveys (NARS), the National Lakes Assessment (NLA) provides a comprehensive assessment of the physical, chemical and biological condition of lakes within the contiguous United States (US EPA 2024). To assess the biological condition of the nation's lakes, NLA developed both a zooplankton and benthic macroinvertebrate multi-metric index (MMI) of biotic integrity (Mitchell et al. 2025). MMIs have been widely used for assessing biological condition in stream for well over 40 years, with stream benthic macroinvertebrates being the assemblage used for most MMIs. The use of benthic macroinvertebrates for MMIs in lentic systems, however, has been much more limited.

Benthic macroinvertebrates used in the development of the NLA MMI were collected by kick/sweep netting from ten littoral zone plots spaced around the lake and composited into a single lake sample. Data from the 2007 and 2012 NLA surveys were used to develop the MMI. A standardized exact count of 300 organisms was used to calculate community metrics for all analyses. Organisms were typically identified to genus; however, some taxa were keyed to higher taxonomic levels (e.g., Family, Order). A total of 126 metrics based on taxa richness, percent of individuals, and percent of taxa, were developed using taxonomic composition measures and autecology information. Autecology based metrics included information on habitat use, feeding behavior and pollution tolerance. Defining a gradient of human disturbance condition is essential to develop and evaluate the usefulness of an MMI.

Identification of NLA least-disturbed reference and most disturbed sites was accomplished by screening NLA data using five chemical factors (total phosphorus, total nitrogen, chloride, sulfate, turbidity), three physical habitat indices based on riparian habitat disturbance, and three indices derived from a field stressor checklist (Mitchell et al. 2025). Screening thresholds and the MMI scoring were set separately for each of five aggregate NLA ecoregions (Figure 1).

When developing the NLA MMI, one best performing metric was selected from each of the six following metric categories: composition, diversity, richness, feeding group, habit, and tolerance. Metrics were standardized to a 0-10 scale, summed together, and multiplied by 100/60 so that the final MMI ranged from 0-100. MMIs were developed separately for five aggregate NLA ecoregions (Figure 1). Metric and MMI performance were evaluated using signal:noise ratios, a range

test, and responsiveness to the human disturbance gradient. An all-subsets procedure was used to evaluate all possible combination of metrics to find the optimal combination of the six metrics that were included in the MMI (Table 1).

In addition to being used for evaluating metric and MMI responsiveness, reference sites were used for setting condition category (good/fair/poor) benchmarks. MMI benchmarks were set at the 5<sup>th</sup> and 25<sup>th</sup> percentile of the reference site distribution for each of the five assessment regions (Table 2).

Results from the 2022 NLA survey showed that at the national level 44 percent of the lake target population was in good condition for littoral benthic macroinvertebrates, with 26 percent in fair and 27 percent in poor condition. Three percent of the target lake population was not assessed due to missing benthic macroinvertebrate data for a subset of sampled lakes. Within the five assessment

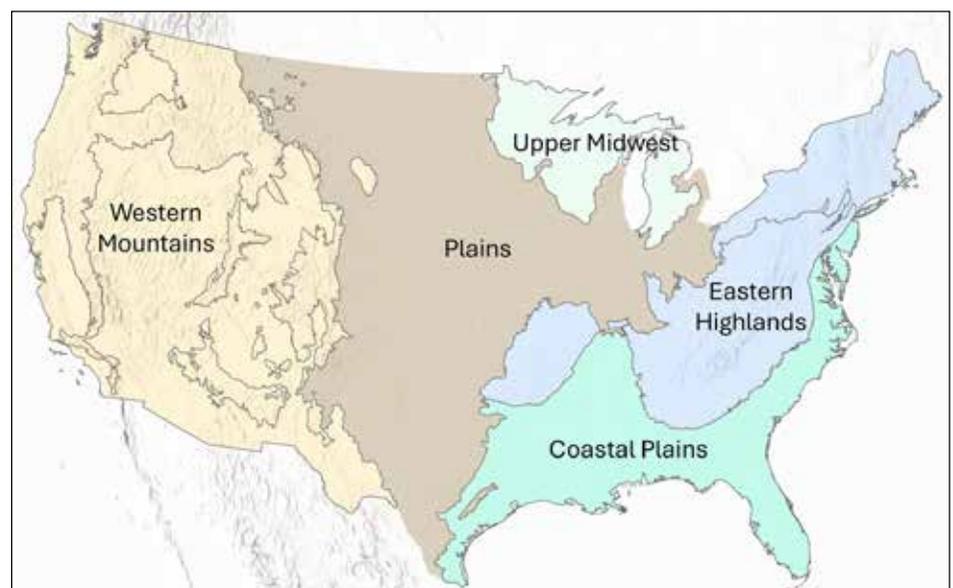


Figure 1. Five aggregate ecoregions used for multi-metric index development.

**Table 1.** Benthic macroinvertebrate metrics used in each of the five NLA biological ecoregions MMIs.

Ecoregion	Composition	Diversity	Feeding Group	Habit	Richness	Tolerance
<b>Coastal Plains</b>	percent Non-Insect Taxa (-)	percent Individuals in Top 3 Chironomid Taxa (-)	Predator Richness (+)	Sprawler Richness (+)	EPT <sup>a</sup> Taxa Richness (+)	percent Individuals with PTV <sup>b</sup> < 6 (+)
<b>Eastern Highlands</b>	percent Non-Insect Taxa (-)	percent Individuals in Top 3 Chironomid Taxa (-)	Collector-Gatherer Richness (+)	Clinger Richness (+)	EPOT <sup>c</sup> Richness (+)	Taxa Richness with PTV <sup>b</sup> ≥2.0 and <4.0 (+)
<b>Plains</b>	percent Diptera Taxa (-)	Shannon Diversity Index (+)	Predator Richness (+)	percent Climber Taxa (+)	EPOT Richness (+)	percent Individuals with PTV <sup>b</sup> ≥2.0 and <4.0 (+)
<b>Upper Midwest</b>	percent Non-Insect Individuals (-)	percent Individuals in Top 3 Chironomid Taxa (-)	percent Shredder Individuals (-)	Clinger Richness (+)	Crustacean Richness (-)	percent Taxa with PTV <sup>b</sup> ≥2.0 and <4.0 (+)
<b>Western Mountains</b>	percent Odonata Individuals (-)	percent Individuals in Top 5 Chironomid Taxa (+)	Scraper Richness (-)	Clinger Richness (+)	Trichoptera Richness (+)	percent Taxa with PTV <sup>b</sup> ≥2.0 and <4.0 (+)

<sup>a</sup>Ephemeroptera, Plecoptera, Trichoptera; <sup>b</sup>Pollutant Tolerance Value; <sup>c</sup>Ephemeroptera, Plecoptera, Odonata, Trichoptera; (+/-) Positive or Negative relationship to disturbance

**Table 2.** Macroinvertebrate MMI condition class benchmarks calculated as the 25<sup>th</sup> percentile (good) or 5<sup>th</sup> percentile (poor) from the reference lake distribution in NLA 2007-2017 lakes.

Ecoregion	# of Ref Lakes	MMI Good Condition Benchmark (25 <sup>th</sup> of reference lakes)	MMI Poor Condition Benchmark (5 <sup>th</sup> of reference lakes)
<b>Coastal Plains</b>	29	≥ 51.8	< 40.4
<b>Eastern Highlands</b>	105	≥ 44.5	< 31.4
<b>Plains</b>	84	≥ 39.5	< 26.6
<b>Upper Midwest</b>	76	≥ 51.4	< 37.2
<b>Western Mountains</b>	122	≥ 47.6	< 32.6

regions (Figure 2), the percentage of lakes in good condition ranges from a high of 56.5 percent in the Plains to a low of 25.5 percent in the Eastern Highlands. When developing multiple metric indices at a large geographic scale (national/continental) it is important to consider both the natural variation and human disturbance gradients across the landscape. The process by which multiple general stressor gradients were identified across various regions of the United States has allowed the NLA program to develop regionally relevant benthic

macroinvertebrate MMIs for assessing the biological condition of the nation's lakes. The responsiveness to disturbance and good repeatability of these MMIs across the first four NLA surveys (2007 through 2022) will allow the NLA program to provide consistent biological condition estimates for future surveys and capture changes due to human influence over time.

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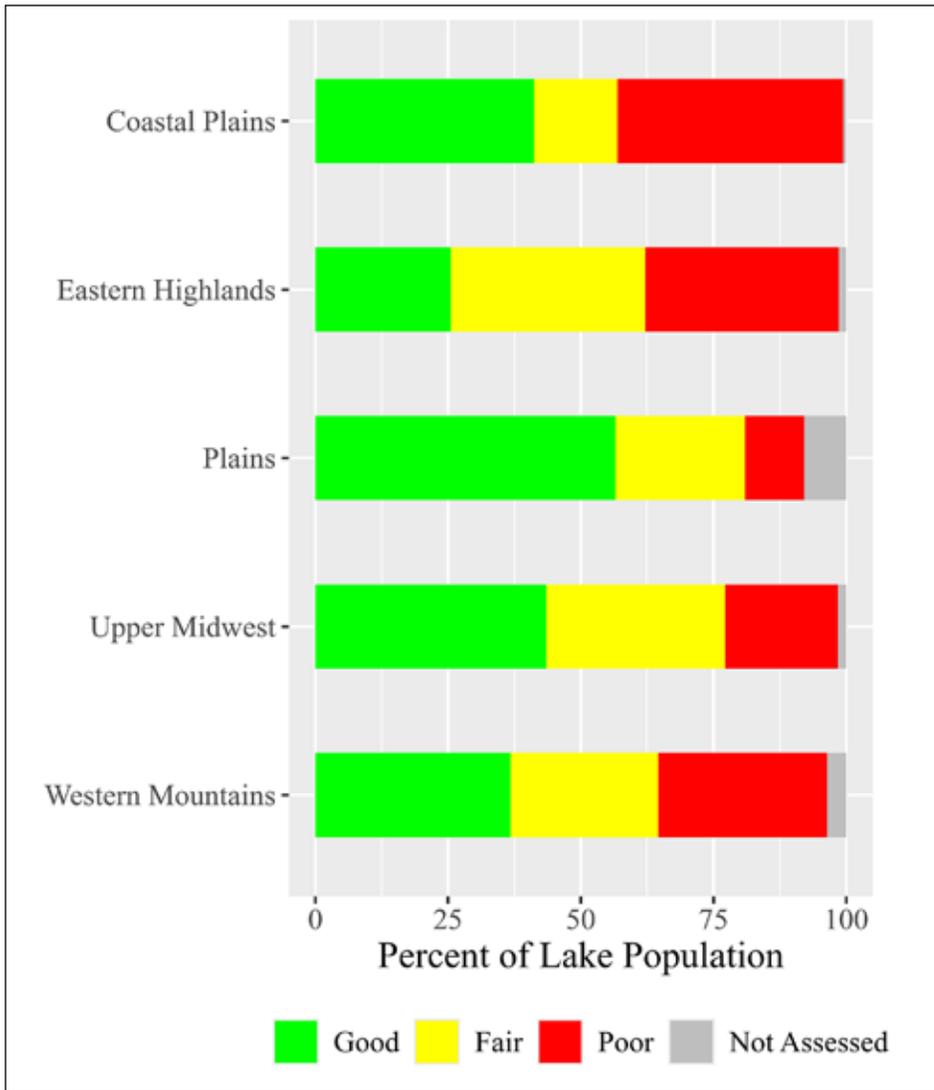


Figure 2. Proportion of U.S. lakes in good, fair, and poor benthic macroinvertebrate condition with respect to assessment ecoregions.

**Richard Mitchell** is a biologist with EPA's Office of Wetland Oceans and Watersheds. He is a team member of the National Aquatic Resource Surveys (NARS) and is the lead of the National Rivers and Stream Assessment (NRSA). In addition to leading NRSA, he has been involved in various efforts to develop biological indicators for use in NARS, and more general for the bioassessment community.



**Alan Herlihy** was a long-time member of the research faculty and is currently a Courtesy Professor at Oregon State University in the Department of Fisheries, Wildlife, and Conservation Sciences. His research projects focus on developing survey methodology, assessment approaches, and ecological indicators for assessing surface water ecological condition at large spatial scales. He recently completed a Senior NRC research fellowship at the Corvallis EPA laboratory analyzing data from EPA's National Aquatic Resource Surveys.



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# Sediment quality assessment of lakes in the conterminous U.S.

Mari Nord & Amina Pollard

Lakebed deposits, or sediments, are an incredible archive and can provide insight into historic, ongoing, and potential stress to ecosystems and human health. One aspect of understanding the potential for ecosystem stress is to examine contaminants within sediment, which are chemicals including metals, metalloids, and organic compounds. There are multiple ways these chemicals can be transported to lakes such as through point sources, atmospheric deposition, and surface runoff from surrounding watersheds. Some may be natural processes such as bank erosion, mineral weathering, forest fires and some are due to human activity such as industrial, urban and agricultural runoff; oil and chemical spills; hazardous waste incineration and coal burning. These contaminants can then accumulate in sediment over time and pose a risk to aquatic life directly through toxicity as well through bioaccumulation and biomagnification in the food chain, potentially affecting wildlife and humans that consume them.

Typically, sediment contaminant measures are focused on lakes with known concerns. In contrast, this study samples a broad range of lakes where the contaminant status was initially unknown. In 2017, the USEPA in partnership with states and tribes conducted the first national scale survey of sediment quality of inland lakes as part of the National Lakes Assessment under the National Aquatic Resource Survey program.

## What did we do?

Sediment samples were collected from 969 lakes and reservoirs from across the United States. In each sample, the top 5 cm of surficial sediment was collected from a single spot near the deepest location of each lake using a corer as shown in Figure

1. These samples were analyzed at a single laboratory for 127 unique parameters including 16 metal(loids), 25 polycyclic aromatic hydrocarbons (PAHs), 53 polychlorinated biphenyl (PCBs) congeners, 27 legacy pesticides and metabolites, total organic carbon and grain size. Once the samples were analyzed, the results were interpreted using an effects-based approach that represents the likelihood of sediment toxicity to bottom-dwelling organisms. More specifically, we used consensus-based sediment quality guidelines and an integrative chemical index of mean probable effect concentration quotients. To align the sediment results with other NLA indicator categories, sediment quality was

categorized into three condition categories based on mean probable effect concentration quotients. The “good” condition corresponds to a low incidence of toxicity to benthic dwellers, the “fair” condition is associated with less known incidence of toxicity and a “poor” condition with a high incidence of sediment toxicity.

A subset of the data was further analyzed to calculate ambient background values that include natural and or diffuse anthropogenic sources. By utilizing USEPA software, proUCL an upper tolerance limit UTL95-95 was calculated for Minnesota and several ecoregions. This helps explore the possibility of developing another approach for environmental



Figure 1. NLA field team measuring to ensure collection of the top 5 cm from the sediment core.

practitioners to explore when evaluating sediment data and clean up goals. Results were also compared against lake, watershed and land use parameters.

### What we learned

Sediment quality in U.S. lakes was mostly in good or fair condition. Our analysis suggests that approximately 26 percent of lakes were in good condition, 69 percent were in fair condition, and 2 percent of lakes were in poor condition (Figure 2). Deeper lakes tended to have higher concentrations of metals and PAHs than shallow lakes. While the pattern is clear, this study could not determine whether these higher contaminant levels were the result of natural enrichment or human activity around lakes. On a landscape scale, lower elevation lakes were also associated with more contamination than higher elevation lakes. We also found that there was greater contamination associated with watersheds that had a higher percentage of areas that were developed such as urban, residential neighborhoods and recreational parks.

Even with discontinued use, some legacy contaminants and their degradants were still observed in lakes across the U.S. For instance, DDT has been banned in the U.S. since 1972, however metabolites such as 4,4'-DDD was detected at 16.4 percent, and 4,4'-DDE was detected 33 percent of lakes. These lakes with legacy contaminants are spread across the U.S.

There was a wide range of lake and reservoir sizes and types included in the

survey which can be analyzed to further inform how other indicators may be influenced by physical, chemical, and other lake characteristics.

Typically, lake sediment monitoring is targeted to known contaminated sites whereas this was a robust first assessment and step toward exploring sediment as an indicator to help better understand the health of our water bodies and in managing them. For example, a companion study examined a subset of these samples to better understand background levels of contaminants in sediment among lakes. Inclusion of sediment quality monitoring in a wide range of lakes can help determine if pollution prevention efforts, environmental laws and policies, and improvement in land use practices are making a difference.

### Acknowledgements

We thank the states, Tribal partners, EPA regions, and contractor field crews who collected sediment samples for the NLA 2017 study, as well as the analytical staff at Physis Environmental Laboratories, Inc. for analyzing the samples. Our partners in analyzing and interpreting the data Judy Crane (Minnesota Pollution Control Agency MPCA, retired), Alex Bijak (Virginia Institute of Marine Sciences), Michelle Maier (U.S. EPA). The input and support of the NLA sediment workgroup helped to make this study a success. This workgroup included David Krabbenhoft (U.S. Geological Survey [USGS], emeritus) Peter Van Metre (USGS, deceased 2021), Jim Lazorchak (U.S. EPA), David Mount

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**Mari Nord** is a scientist with EPA's Water Division in the Great Lakes region. She coordinates and manages water quality and biological monitoring and serves as the regional coordinator for the National Aquatic Resource Surveys. With over 24 years of experience on Clean Water Act projects and research, she is a technical contact for states and tribes on water quality monitoring. Whenever she can, she spends time on the water verifying recreational-use status ([nord.mari@epa.gov](mailto:nord.mari@epa.gov)).



**Amina Pollard** is an environmental scientist with a focus on water quality and aquatic ecosystems. With over two decades of experience, Amina has shaped sustainable water management practices and influenced decisions through her research. As an educator and mentor, she is committed to training the next generation of scientists while advocating for innovative solutions to global water challenges. Whether it's through her published works or speaking engagements, Amina is driving change to ensure clean and safe water for all ([Pollard.Amina@epa.gov](mailto:Pollard.Amina@epa.gov)).

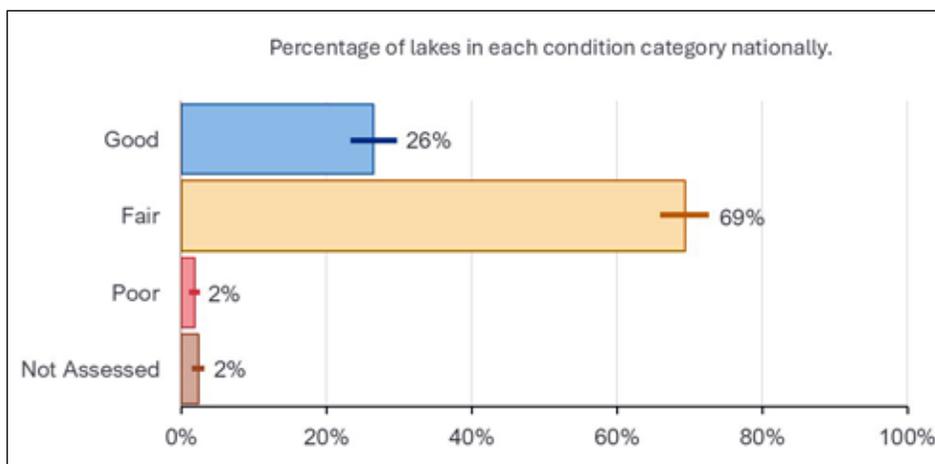


Figure 2. Percent of condition category for sediment quality. Good condition has a confidence interval of 20-33 percent, Fair condition has a CI of 63-76 percent, and poor has a CI of 0.3-3 percent. Each bar represents the percentage of the population of lakes in each condition category, where the numeric percent is shown and 95 percent confidence intervals are identified as bars around the percentage.

# Understanding the effects of aquatic plants on water clarity in shallow lakes using National Lake Assessment data

Lester Yuan

Shallow lakes, defined as those less than about three meters deep, are vital aquatic resources that support biodiversity and recreation. They offer habitats for a variety of plants, fish, and wildlife both in the water and surrounding areas, and provide crucial stopovers for migratory birds. Recreational activities like boating, fishing, and birdwatching are popular in these lakes.

Shallow lakes typically exist in one of two stable states: clear or turbid. Clear lakes are characterized by abundant aquatic plants (macrophytes) and support a wide diversity of biota, while turbid lakes often lack aquatic plants, experience frequent algal blooms, and support less biodiversity. These states are stable and resilient, meaning lakes maintain their biological and water quality characteristics and are resistant to change; however, large or persistent disturbances over time can cause them to shift. For instance, excessive nutrient inputs of nitrogen or phosphorus, can turn a clear lake turbid. Then, reversing this shift is challenging, often requiring substantial nutrient reduction to restore a clear water state.

Aquatic plants are closely linked to clear water conditions, as they help improve clarity through several mechanisms (Figure 1). Their roots stabilize lake sediments, reducing suspended particles. They also absorb nutrients, limiting those available for phytoplankton growth. Additionally, they provide habitat for zooplankton that consume phytoplankton and reduce turbidity. Some plants (e.g., common waterweed) may release chemicals that inhibit algae growth. Understanding these mechanisms can aid environmental managers in enhancing water clarity in different lakes.

Most of the research on shallow lakes has examined the conditions in single lakes,

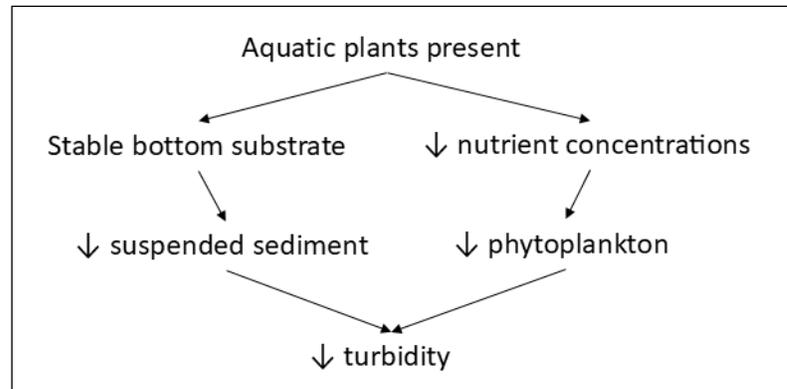


Figure 1. Conceptual model showing two ways that aquatic plants can affect water clarity in shallow lakes.

but the National Lakes Assessment (NLA) provided an opportunity to consider whether patterns in shallow lakes across the U.S. followed trends predicted by previous work conducted in smaller regions (Yuan, 2021). That is, does the presence of aquatic plants predict whether lakes across the U.S. were in a clear water or turbid state? Furthermore, if aquatic plants do improve water clarity, can we determine whether they alter the amount of phytoplankton in the water column or the amount of suspended sediment?

Data available from the NLA is extensive, and for this analysis only a small fraction of this data was used. During each NLA field visit, a water sample was collected which was analyzed for turbidity and chlorophyll-*a* concentration. The chlorophyll-*a* concentration provided a measure of phytoplankton biomass in the water column, while turbidity provided a measure of the combined effect of phytoplankton and suspended sediment on water clarity. At each lake, sampling crews also documented whether they observed aquatic plants at evenly spaced locations around the edge of the lake.

Statistical models were used to

estimate relationships between inorganic suspended sediment, chlorophyll *a*, and turbidity in lakes with and without aquatic plants. Findings confirmed that shallow lakes with aquatic plants had lower turbidity. Aquatic plants reduced both chlorophyll-*a* and inorganic suspended sediment, but the magnitude of their effects on suspended sediment was substantially greater than on chlorophyll-*a*.

Management information for shallow lakes can also be derived from the analysis. Based on statistical models, national relationships between chlorophyll *a* and turbidity could be estimated for shallow lakes when aquatic plants were absent and when plants were present (Figure 2). These relationships can inform management decisions to maintain clear water states in shallow lakes or restore turbid lakes to clear water conditions. Importantly, chlorophyll-*a* thresholds and associated nutrient loading targets for maintenance versus restoration will be different. For example, when aquatic plants are present, targeted chlorophyll-*a* concentrations can be as high as 20  $\mu\text{g/L}$  to maintain a turbidity of 6 NTU. Conversely, to restore a lake without aquatic plants to a clear water

state, targeted chlorophyll *a* concentrations of 14 µg/L are needed to achieve the same level of turbidity. Hence, nutrient loads to maintain clear water conditions when aquatic plants are present may be greater than nutrient loads needed to restore clear water conditions. Overall, NLA data enhance our understanding of shallow lake stable states to help manage the condition of shallow lakes in the U.S.

**References**

Yuan, L.L. 2021. Continental-scale effects of phytoplankton and non-phytoplankton turbidity on macrophyte occurrence in shallow lakes. *Aquatic Sciences* 83, 14.

**Lester Yuan** has worked at the U.S. EPA for 20 years and in the most recent 10 years has focused on nutrient issues in the Office of Water. He received a doctorate in mechanical engineering from Stanford University studying the physics of fluid flow. \*

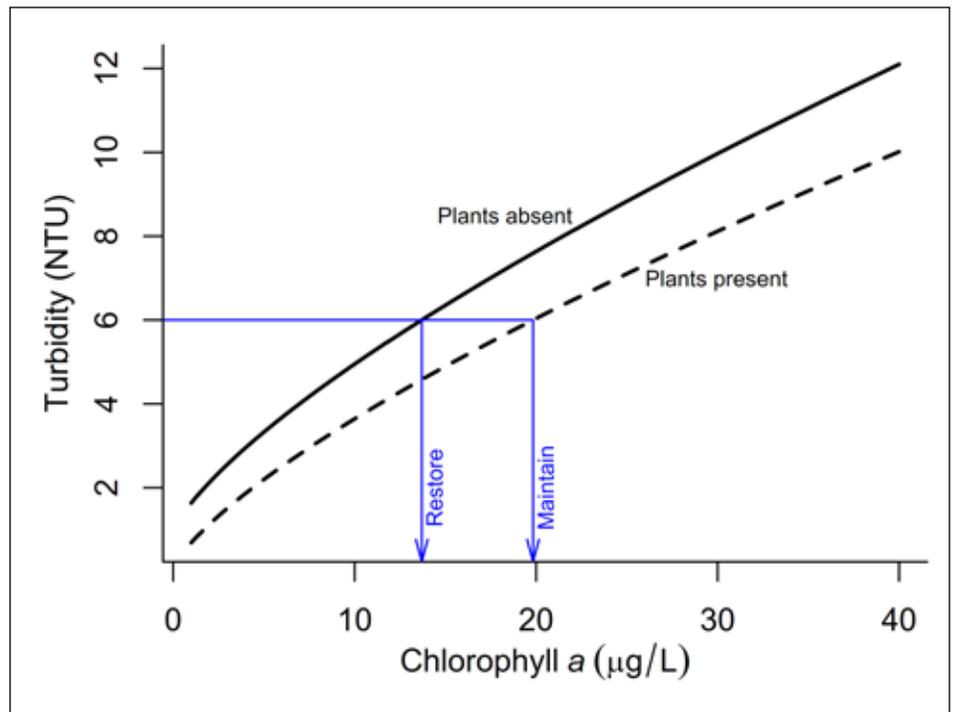


Figure 2. Estimated relationships between chlorophyll-a and turbidity when aquatic plants are present (dashed line) or absent (solid line). Blue line segments and arrows show threshold values for chlorophyll-a concentrations associated with maintaining clear water conditions at turbidity = 6 NTU or restoring clear water conditions.



# PhycoTech, Inc.

620 Broad Street, Suite 100  
 Saint Joseph, Michigan 49085  
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[Info@phycotech.com](mailto:Info@phycotech.com)  
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# “Lakespert” – Old School Edition – 1975 NES Data

Steve Lundt, CLM #00-05M

I love it when people call me “old school” and this is nothing new. I just gave up my flip phone last year, I still go to the bank, and I use all-weather paper to record my lake profile data. For 2026, get ready for “old school” edition *Lakespert*.

U.S. EPA has been conducting nationwide surveys of our lakes and reservoirs going back to the 1970s. With 2030 quickly approaching, the '70s seem *soooper* old.

Here is why I cherish 1975. Thanks to U.S. EPA efforts, that is the summer where I have historical water quality data for the two reservoirs I look after (Figure 1). The 1975 National Eutrophication Survey or NES included the use of Army Huey helicopters, retro-fitted with a pontoon landing system, landing directly on the water to collect samples. Talk about old school. Can you imagine sampling a lake from a war-era helicopter three times a summer? They did have some hi-tech, remote monitoring equipment on board to help with the surveys. Dial up on America Online (AOL) and take a look for yourself.

Thanks to U.S. EPA, I have total phosphorus and soluble reactive phosphorus data from 1975 that I can compare to my data spanning 2002 – 2025. I am pleased to say that all trends are going in the right direction when it comes to nutrients (water clarity and chlorophyll-*a* is a different story). The '75 survey revealed how all that laundry soap, used to clean bell bottoms and polyester shirts, really contributed to the high phosphorus levels in lakes. There was almost a milligram per liter of soluble reactive phosphorus in my reservoir in 1975. Today, phosphorus is still elevated but continues to decline

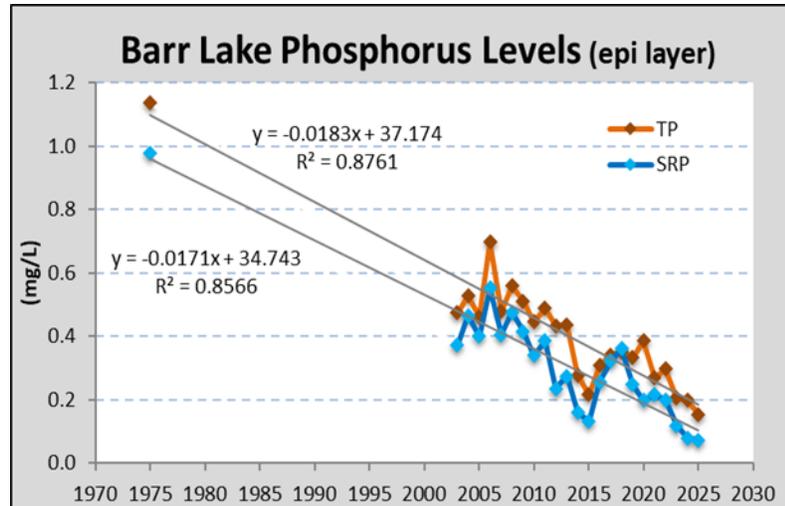


Figure 1. Graph showing trends in Barr Lake (Colorado) phosphorus over time, with original 1975 data from USEPA.

thanks to better policies, wastewater and storm water treatment technology, and overall public awareness.

The more recent U.S. EPA's surveys are key to mapping our lakes health and changes over time. There is overlap between all the surveys going back to 1970s which can help track longer-term changes for many of our lakes and reservoirs. These national surveys provide great data and information for our lakes.

Even though I am old school, what I am excited about is the future in lake monitoring. What will it be like 50 years from now? What national efforts will be going on to monitor our lakes? How will the data be collected? My guess is that we will again sample from the air. This time using drones, robots, and satellites. What I hope is that my 20+ year dataset will be an important part of showing how water quality has improved over the decades and that it helps future generations of *Lakeperts*.

**Steve Lundt**, Certified Lake Manager, has monitored and worked to improve water quality at Barr Lake (Denver, Colorado) for over 20 years. Steve is active with the Colorado Lake & Reservoir Management Association and is a past Region 8 director for NALMS and an active member since 1998. 🌟



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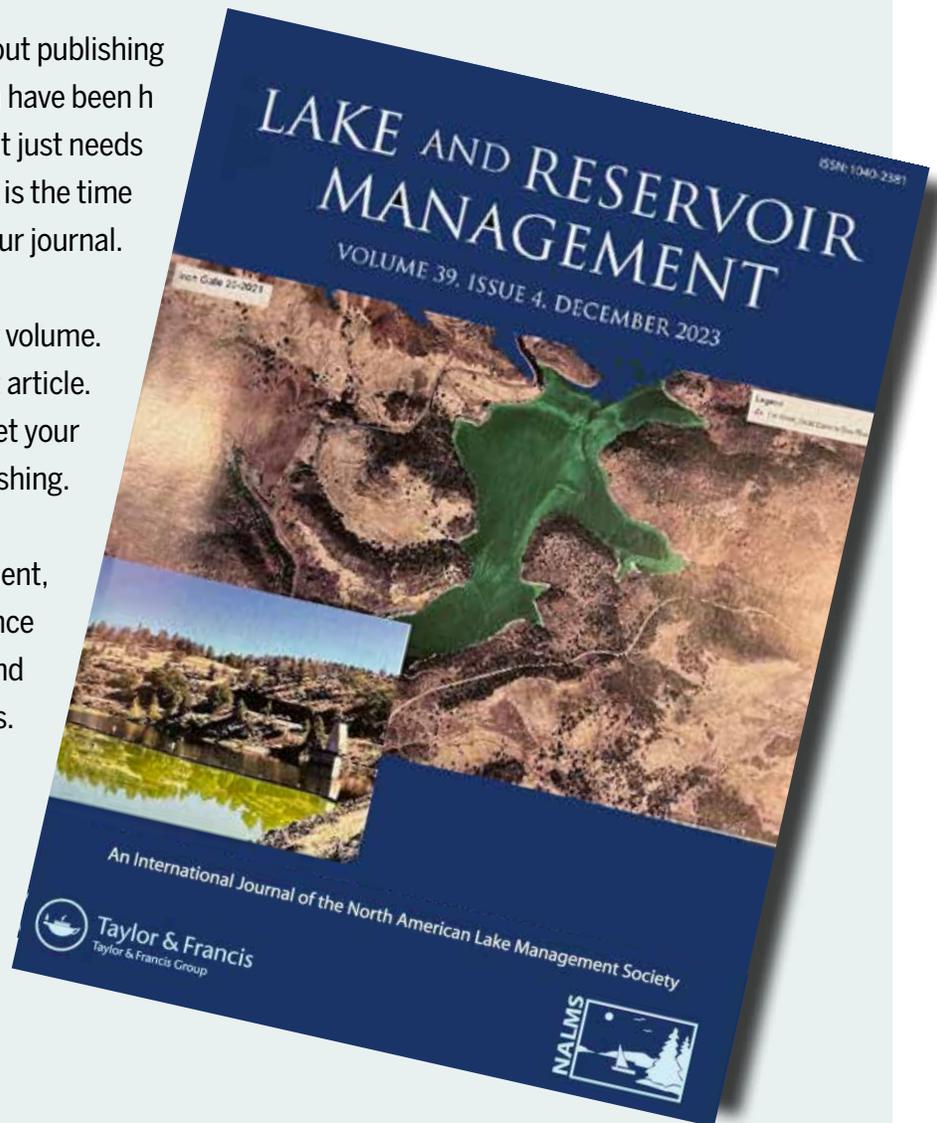
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