IAGLR
LAKES Letter

This issue explores the ecosystem approach to understanding and managing large lakes

CONTENTS

Back to the future with the ecosystem approach

by Catherine Febria, Brad Cardinale, Doug Haffner, and John Hartig

WE ARE NOW TWO YEARS into struggling through COVID-19, and a surprising outcome of the global pandemic has been been our growing reliance on nature to maintain mental and physical health and renewed relationships with nature during isolating times. Never before has the connection between natural ecosystems and society been more inextricably linked, particularly in the Laurentian Great Lakes, where human health, vitality, and well-being directly relate to the health and management of entire watersheds and the multitude of ecosystems that comprise them.

The ecosystem approach has long served as a collaborative framework for governing, researching, and stewarding the health of large watersheds like the Great Lakes (Hartig and Zarull 1992; Munawar and Hartig 2020). Operationalized through programs such as the Great Lakes Areas of Concern and the Coordinated Surveillance and Research Initiative, the ecosystem management framework has resulted in multiscale solutions and partnerships that continue to evolve and grow toward improved relationships, research, and management into the future (Alsip et al. 2021).

Although there are examples of ecosystem-based approaches to research and management of the Great Lakes and other large collections of ecosystems (e.g., Australia's Great Barrier Reef, the African Great Lakes), climate change has become a threat multiplier, and the interaction of multiple stressors has led to greater uncertainty about how these systems will respond to management actions. Now, more than ever, we need to progress toward more holistic and strategic approaches to managing natural ecosystems to protect their biodiversity and the ecosystem services upon which we depend.

How can ecosystem-based efforts be accelerated into action more effectively, strategically, and with greater certainty of success? Over the past few years, a Great Lakes-based collaborative has been underway, focusing on a shared vision to make progress on the ecosystem approach as a key framework that will integrate knowledge systems and expertise from around the world specifically to help inform and guide science and management of this critical region. To elevate this effort, and no longer willing to wait for COVID uncertainties to dissipate, we are thrilled to announce the forthcoming *Ecosystem Approach in the 21st Century* as a hybrid conference and workshop summit.

Save the date August 22–24, 2022, for the event, hosted at the University of Windsor situated in the Traditional Territory of the Three Fires Confederacy and the heart of the Great Lakes basin. Convened in celebration of the 50th anniversary of the Canada-U.S. Great Lakes Water Quality Agreement, the event is sponsored by The Nature Conservancy, University of Windsor, Fisheries and Oceans Canada, Great Lakes Fishery Commission, International Joint Commission, U.S. Geological Survey, Aquatic Ecosystem Health & Management Society, University of Michigan's School of Environment and Sustainability, and IAGLR. Its hybrid model will combine a one-day online international conference featuring plenaries, posters, and presentations to help connect the global community engaged in dimensions of an ecosystem-based approach to science, research, and management. This will set the tone for the in-person summit, a writing-intensive gathering of multiple working groups focused on unpacking key dimensions of the ecosystem approach. While the workshop is planned to be in person, we are monitoring the pandemic globally and simultaneously planning for the possibility of a virtual format. Intentionally embedded with diverse knowledge systems and expertise and inclusive modes of engagement and participation, the event will have multiple outputs that include and extend beyond a special issue of *Aquatic Ecosystem Health and Management*, book(s), and a traveling discussion series that will contribute to the Great Lakes Public Forum being planned by the Canadian and U.S. federal governments for September.

This issue of *Lakes Letter* features a number of examples of the ecosystem approach in research and management to get the conversation going and ideas flowing. We look forward to engaging with you more in 2022 as part of this collaborative effort.

Catherine Febria, Doug Haffner, and John Hartig, University of Windsor, Great Lakes Institute for Environmental Research; and Brad Cardinale, Pennsylvania State University, Department of Ecosystem Science and Management.

IAGLR NEWS SHORTS

WE'RE HIRING!

The IAGLR Board of Directors is pleased to announce that it **seeks an executive director** responsible for the strategic leadership and efficient operation of IAGLR. We are accepting applications until the position is filled. The position will soon be posted on several online job portals, where candidates are asked to submit their application. In the meantime, please view the job description for details and share within your networks. Direct any questions to Trevor Pitcher, chair of the IAGLR Executive Director Search Committee and member of the IAGLR Board of Directors, at tpitcher@uwindsor.ca.

AWARDS NOMINATIONS

We're seeking nominees for the 2022 IAGLR Lifetime Achievement Award and the John R. (Jack) Vallentyne Award. Nomination packets are due **March 31**.

JOIN THE BOARD

Interested in serving on the IAGLR Board of Directors? View the Call for Nominations and submit your nomination package online by **March 25**. We're looking to fill three positions: a Canadian regular member, a U.S. regular member, and a U.S. student member.

STATE OF LAKE ERIE 2022

Cleveland, Ohio | Online, March 16–17

Join us for the 2022 State of Lake Erie Conference, March 16–17, online and in Cleveland, Ohio. Check out the program to see all the great science in store. IAGLR members enjoy discounted registration rates.

IAGLR | JASM 2022

Grand Rapids, Mich. | Hybrid, May 14–20

- Registration is open; early-bird rates through April 1. Discounted rates for IAGLR members. **Make sure to check off IAGLR as your membership affiliation when you register!** Virtual registration for developing countries has been reduced to $25.
- Meeting rooms are available for science-based alumni and networking events. Request a meeting room for your group.
- Abstract submission will open again in early March for student in-person posters and developing country virtual presentations. Deadline March 25.

ANNUAL BUSINESS MEETING & AWARDS CEREMONY

Save the date! The IAGLR Annual Business Meeting will be held online **June 15**. All IAGLR members are welcome to learn about the business of the association, share any issues or concerns, welcome new board members, and celebrate the 2022 award and scholarship recipients.

2021 Donors & Sponsors

Thank you to the following individuals and organizations who joined with us last year to advance understanding of the world's large lake ecosystems. IAGLR is a unique group that brings together people from multiple disciplines and knowledge systems for the good of the lakes. The support of the following contributors makes this work possible, and we are grateful for their support.

INDIVIDUALS

Carmen Aguilar
Justin Chaffin
Jason Fischer
Wendy Foster
Tara Gallagher
Mary Ginnebaugh
Robert Hecky
John Kennedy
Loren King
Margaret Lansing
Barry Lesht
Sally MacIntyre
Christine Manninen
Paula McIntyre
Francine McCarthy
Neil Rooney
Michael Twiss
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NOAA Great Lakes Environmental Research Laboratory
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University of Windsor, Great Lakes Institute for Environmental Research

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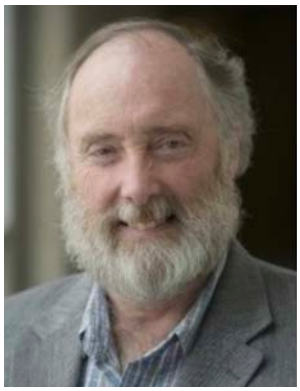
In memoriam: William D. Taylor (1950–2022)



We have lost a leader of Great Lakes science and a great friend in Bill Taylor, who died January 24 of cancer. Taylor was a biology professor at the University of Waterloo for more than 32 years and a recipient of the IAGLR Lifetime Achievement Award in 2018. Several of his papers are considered limnological classics, and his research has greatly increased our understanding of phosphorus cycling in lakes and the importance of microzooplankton in nutrient cycling and food webs of lakes.

"His research has been remarkably eclectic, extending from nutrient loading to fish and from small lakes to the largest lakes in the world, while always bringing a novel perspective to the issues confronting aquatic systems from eutrophication to contaminant cycling," noted Robert Hecky, editor of the *Journal of Great Lakes Research*, in his letter supporting Taylor's nomination for the award.

Taylor served as a member of the IAGLR Board of Directors and the Awards and Publications committees, as an associate editor to the *Journal of Great Lakes Research*, and as a session chair at annual conferences. He received IAGLR's Chandler-Misener Award for the best paper in the journal in 1992. He also served numerous government agencies and organizations in Canada and abroad. His research activities have also been recognized by others. He received the Frank Rigler Memorial Award from the Canadian Society of Limnologists and a Career Achievement Award from the Canadian Council of University Biology Chairs, and held a Tier 1 Canada Research Chair position.

While Taylor's research contributions are impressive, when news of his passing broke on social media, the overwhelming memory shared of him was of his kindness, of the time he took for people, and the encouragement he gave. "Bill was a light during my early Ph.D. days," tweeted Oana Birceanu, now an assistant professor at Western University. "He was so generous with his lab space, advice and support. We lost a good one."

Calling him a "generous mentor," Rebecca Rooney wrote, "When I came to U Waterloo as a nervous new prof, Bill was so welcoming and always made time to talk. He was emotionally and materially supportive to so many of us!"

That support has made a lasting impact on those who continue in the field. "He has contributed to what many of us are today, with good science, humour and encouragements," tweeted Jérôme Marty, University of Ottawa. "Limnologists from many countries will miss him."

Ralph Smith, biology professor emeritus at University of Waterloo, captured that sentiment in his nomination letter for Taylor's IAGLR award. "All who know Bill know his generosity of spirit, unfailing respect for others, and refreshing sense of humour."

A celebration of Taylor's life is planned for this spring. Condolences to the family and memorial donations can be arranged by contacting the funeral home.

KUDOS

Congratulations to the following IAGLR members!

BOPI BIDDANDA (Annis Water Resources Institute, Grand Valley State University) for receiving the University's Distinguished Contribution in a Discipline Award.

CATHERINE FEBRIA and members of the Healthy Headwaters Lab (University of Windsor, Great Lakes Institute for Environmental Research) as recipients of the 2021 Essex Region Conservation Award in Education in recognition of their work with stakeholders and decision makers "to restore freshwater ecosystems to full health and vitality."

DANIEL HEATH (GLIER-UWindsor) as recipient of an Excellence in Leadership award from the University of Windsor.

DOUG KANE (Heidelberg University) for receiving the Ohio Lake Management Society's Innovation in Lake Management award for "devotion to his students, always helping to foster the next generation of lake stewardship in Ohio."

ELLEN MARSDEN (University of Vermont Rubenstein School of Environment and Natural Resources) for being named a 2021 Fellow by the American Fisheries Society.

RENÉ SHAHMOHAMADLOO (University of Guelph and Washington State University) for being selected as a Liber Ero Postdoctoral Fellow to research harmful algal blooms in the Great Lakes.

ED VERHAMME (LimnoTech) on the launch of a new company, Freeboard Technology, that will focus on cool new tech for the Great Lakes.

Welcome to the following members, who joined IAGLR between November 2021–January 2022.

Zach Amidon
Zia Ul Hassan
William Henry
Gabby Izma
Shay Keretz
Tyler Kunze
Jennifer Powell
Thornton Ritz
Alicia Sendrowski
Ian Stone
Alana Tedeschi
John Walakira
Colleen Yancey
Fasong Yuana

NEW MEMBER SPOTLIGHT

Bill Henry

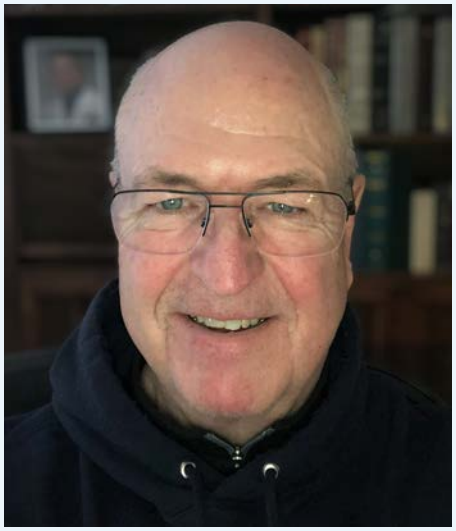
Consultant, Amensal Systems, LLC

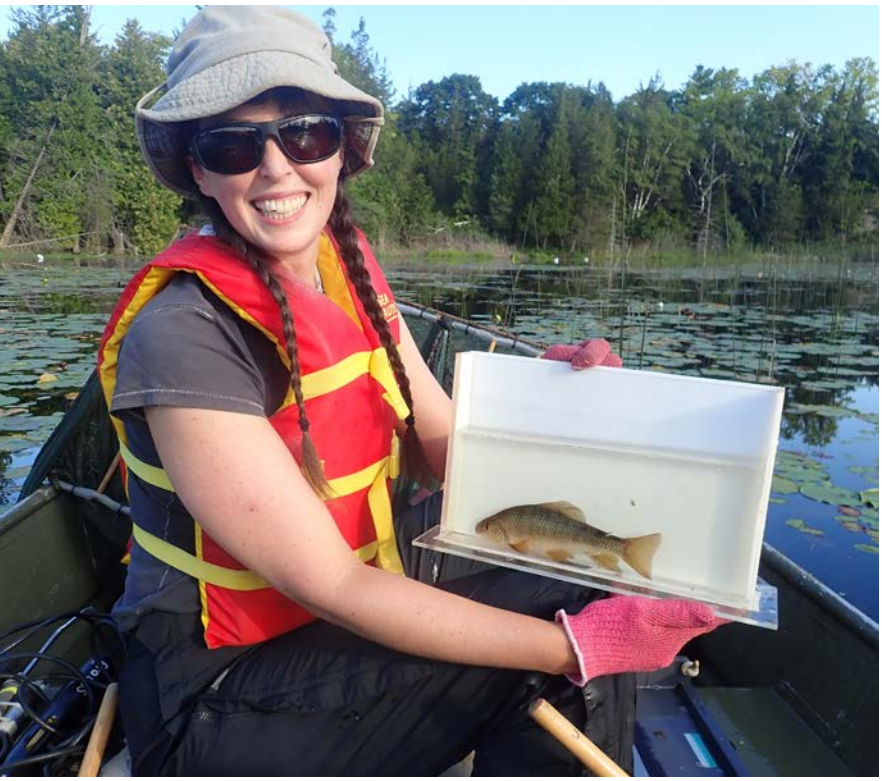
ABOUT MY WORK

My day job is in food processing, automation engineering, and food safety systems. I specialize in bioprotection—the use of probiotic cultures to block the growth of pathogenic organisms on ready-to-eat and minimally processed foods, most commonly fresh produce. Successful systems require equal parts microbiology, fluids flow, and phytomorphology. For fun I work with the Alliance for the Great Lakes, where I am a board member currently serving as secretary. I am a life-long advocate for, and beneficiary of, Lake Michigan in particular and the Great Lakes in toto.

WHY IAGLR?

I joined IAGLR to learn more about the science underlying the Great Lakes, its ecosystems, and the natural and anthropogenic threats they face. I hope to explore a possible use of microorganisms in the field to diminish the need for phosphorous fertilizers, to fixate excess nitrogen in the soil, or to otherwise reduce the damaging effects of agricultural runoff.





Jennifer Powell

Ph.D. Student, University of Toronto Scarborough

ABOUT MY WORK

I returned to academia after almost a decade as a fisheries biologist working in environmental consulting on the Great Lakes and five years as the scientific coordinator of a nature reserve in Costa Rica. I am currently pursuing a Ph.D. in the department of physical and environmental sciences at the University of Toronto Scarborough, in the Mandrak lab. My research focuses on the effect of multiple stressors (hypoxia and temperature) on Lake Chubsucker *(Erimyzon sucetta)* physiology and habitat usage in the hopes of developing a habitat model for the species and assessing its ability to successfully adapt to climate change.

WHY IAGLR?

As a member of IAGLR, I am looking forward to opportunities to network and share knowledge with other freshwater aquatic scientists working on this unique ecosystem, in particular at the IAGLR conference in May.

NEW MEMBER SPOTLIGHT

Alicia Sendrowski

Research Associate, Michigan State University

ABOUT MY WORK

I am a research associate in civil and environmental engineering at Michigan State University, with a focus on water resources. I study coastal and riverine systems, with projects in the Great Lakes, the Arctic, and coastal Louisiana. Using field work, statistical analysis, and remote sensing, I aim to understand how hydrological and biogeochemical processes interact in the landscape to create resilient systems. I am specifically interested in the dynamics of hydrological connectivity in coastal wetlands, the role of large wood in storing carbon in the landscape, and the impact of climate change on the Great Lakes.

WHY IAGLR?

I joined IAGLR to make connections with the Great Lakes community. I look forward to participating in conferences and learning from other scientists, managers, and stakeholders. I hope to also share my science and establish meaningful collaborations that enhance Great Lakes resiliency.

Alana Tedeschi

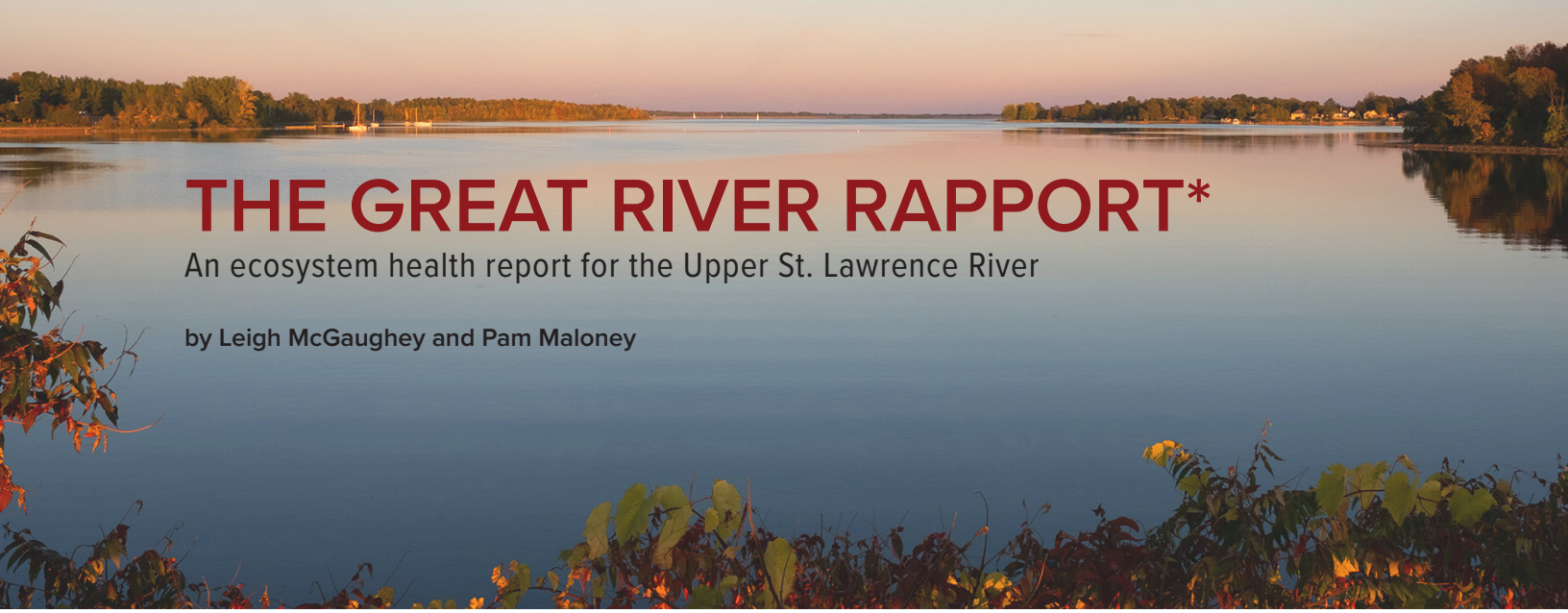
Ph.D. Candidate, McMaster University

ABOUT MY WORK

My research focuses on water quality in stream networks that contribute nutrients to Lake Erie. My work integrates science and communication through exploring spatiotemporal changes in phosphorus runoff in the Eastern Lake Erie Watershed and designing ways to effectively communicate the science of eutrophication to encourage public engagement in remediation strategies. I am currently investigating the influence of climate change and land-use activities on seasonal phosphorus export from the Grand River, a main tributary of the Eastern Basin, and I am particularly interested in stream water quality during the rapidly changing winter season. My work also develops educational resources and stream-monitoring methods for volunteers to learn about water-quality issues and collect data from streams throughout the Lake Erie Watershed.

WHY IAGLR?

I hope to gain a broader understanding of Great Lakes ecosystems, especially as the impacts of climate change continue to unfold. Keeping up with emerging research and interacting with like-minded members of the community greatly interests me.



THE GREAT RIVER RAPPORT*

An ecosystem health report for the Upper St. Lawrence River

by Leigh McGaughey and Pam Maloney

Sunset over Lake St. Lawrence seen from the Long Sault Parkway. All photos by Stephany Hildebrand.

The Great River Rapport was inspired by the most commonly asked question in the community: *What is the health of the St. Lawrence River?* With no simple answer, we wanted to explore ways to describe the complexities of the ecosystem with a wide public audience.

Ecosystem health reports have become commonplace across the globe, and many provide comparative results based on the same ecological health parameters. Although some national and global health reports have described the Upper St. Lawrence River region as data deficient, the St. Lawrence River Institute of Environmental Sciences (River Institute) believed that an ecosystem health report could be developed using a unique set of ecological indicators that best characterize the river. The Great River Rapport was developed to carefully disseminate the data that exist, identify the gaps and needs for future research, and provide answers for the public in a language that is accessible for community members.

Young of the year Muskellunge and northern pike in a fish viewer surveyed as part of the Fish Identification Nearshore Survey (FINS) project.

The Upper St. Lawrence River region represents a complex jurisdiction that encompasses the international Canada/USA border, the Ontario/Quebec border, and the traditional territory of the Kanien'kehá:ka (Mohawk), part of the Haudenosaunee Confederacy. As collaborators on the Great River Rapport, our colleagues at the Mohawk Council of Akwesasne provided the inspiration to frame the project in the Haudenosaunee Thanksgiving Address (Ohenton Karihwatehkwen), "Words That Come Before All Else." These traditional words are spoken at the start of important gatherings to bring minds together and to honour all elements of nature (including people) and their interconnectivity in the natural world. Through our partnership with Akwesasne, we embrace the two-row wampum approach to honour and engage the biocultural context of the Haudenosaunee. The result includes both Indigenous Knowledge and scientific findings in formats that encourage ongoing conversation, insight, and friendships through this co-creation.

* Great River–Term used by Indigenous People to describe the St Lawrence River; Rapport –"A close and harmonious relationship in which the people or groups concerned understand each other's feelings or ideas and communicate well."

As part of the project, we wrote community stories about project participants published through Perch Magazine: Under the direction of Henry Lickers (left), the project has been wrapped around a framework of Ohenton Karihwetehkwen, the Haudenosaunee Thanksgiving Address. Ian Macintosh (middle) describes his observations on the river to Dr. Leigh McGaughey. At right, Jessica Shenandoah leads a team of community members to transplant and reintroduce wild ginger to Akwesasne where it was once abundant.

To help anchor the Great River Rapport project in the Haudenosaunee Thanksgiving Address, artist Victoria Ransom created illustrations to depict different parts of the address. The illustration above represents **Otsi'nonwa'shn:'a (Insects).**

We thank the insects for continuously keeping our environment clean and balancing the natural equilibrium. So, we turn now to the Insects and send our greetings and thanks. Now our minds are one.

Artist's description: Chosen for this element are the dragonfly and shad fly, based on their significance to the river. The dragonfly is centered in the middle, as well as at the bottom surrounded by water lilies. Skydomes and pottery designs circle the center dragonfly, and the shad fly is depicted in the outer circle.

Illustration by Victoria Ransom, depicting part of the Haudenosaunee Thanksgiving Address.

With this unique approach, it was important from the outset to develop a "rapport" with the people who live and interact with the environment. To answer the original question, *What is the health of the St. Lawrence River?*, we started with the people who live in the communities along the river. Surveys and workshops gathered feedback that defined their priorities and concerns. With this feedback, scientists, partners, and Akwesasronon (Akwesasne Community Members) were recruited to nominate and select ecological indicators that characterize the issues and concerns raised by the community. A grading and prioritizing process narrowed the list to 35 indicators, and the team started gathering all of the available data from academia, NGOs, government agencies, and citizen scientists. Ongoing data collection, compilation, and peer review follows a scientific approach for each indicator, with the detailed results expressed through a series of technical reports.

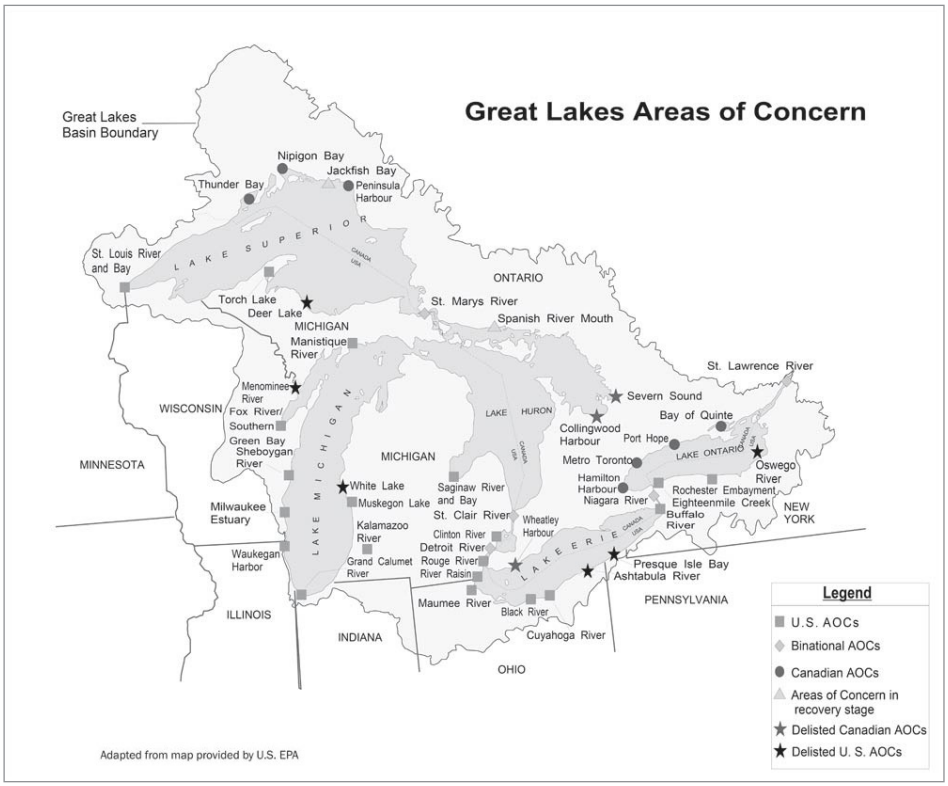
To maintain the goal of translating the science into accessible formats for the general public, we hired a photographer, an Indigenous artist, and a technology expert to incorporate art, photos, video, and stories. These elements give the project life, and invite people from all backgrounds to engage as we move along.

Since it began, the Great River Rapport has evolved into an ongoing quest for knowledge that promises to share current and future discoveries about the changing ecosystem. We appreciate the diverse lenses through which people view and enjoy the river, and we continue to find ways for people to access and connect with the environment.

The Great River Rapport reflects the diverse group of people who inspire and contribute to its growth. We are grateful to the artists, story tellers, knowledge keepers, scientists, community members, nonprofit groups, academics, government representatives, environmental groups, passionate individuals, community organisers, writers, editors, digital media experts, and designers who leave their signature on this unique project.

Leigh McGaughey is a research scientist and Pam Maloney is the fund development officer at the River Institute.

Evolving institutional arrangements for use of an ecosystem approach in restoring Great Lakes Areas of Concern



by John Hartig and Peter Alsip

GREAT LAKES AREAS OF CONCERN (AOCs) serve as microcosms of use of an ecosystem approach in resource management. Our recently published study in the journal *Sustainability* sheds light on how and why institutional arrangements have changed over time to apply an ecosystem approach in restoring AOCs and to address emerging challenges in each local area.

Following the 1985 recommendation of the International Joint Commission's Great Lakes Water Quality Board, the federal, state, and provincial governments committed to working with local stakeholders to develop remedial action plans (RAPs) to clean up each AOC within their political boundaries and restore impaired beneficial uses using an ecosystem approach. RAPs were then added to the 1987 Protocol to the Great Lakes Water Quality Agreement, giving international legitimacy to the program and providing laser-like focus for all stakeholders to work together to eliminate any of 14 "beneficial use impairments."

Our study found that institutional arrangements in 35 of the 43 AOCs evolved over time into structures with broader stakeholder representation and more active participation. Broader stakeholder representation and more active participation leads to accessing local knowledge and enhancing creative problem solving. In 32 of the 43 AOCs, a partnership was established with a nonprofit organization or a Conservation Authority in Canada that has nonprofit status. The establishment and growth of these nonprofit organizations helped build local capacity and ownership, broadened the timeline to think about life after being removed from the AOC list, enabled a watershed focus, and often strengthened the connections among science, policy, and management.

This study also found that 30 of the 43 AOCs now recognize "life after delisting" as an AOC or "sustainability" as part of their focus. For example, the Environmental Network of Collingwood, an organization that emerged from the RAP process, remains active in promoting sustainability 26 years after delisting Collingwood Harbour as an AOC. Cleanup of Great Lakes AOCs has been found to be a springboard for local communities to convert areas that were once a detriment to economic growth into valuable waterfront economic assets. For example, cleanup of the Detroit River has led to the development of the Detroit RiverWalk that has reaped over $1 billion of economic benefits in its first 10 years. Finally, use of an ecosystem approach, by nature, is adaptive, where assessments are made, priorities established, and actions taken in an iterative fashion for continuous learning and improvement.

Use of an ecosystem approach in RAPs has required cooperative learning that involves stakeholders working in teams to accomplish a common goal and individual and group accountability. The next important step in furthering use of an ecosystem approach is to better promote this as a primary philosophy guiding science and management in the Great Lakes and the rest of the world. We believe that continued improvement in the implementation of an ecosystem approach can be facilitated through the sharing of experiences between the AOC program and other restoration programs using this approach elsewhere in the world. Indeed, that is one of the primary purposes of convening the conference titled *The Ecosystem Approach in the 21st Century: Guiding Science and Management* in August 2022 at the University of Windsor in celebration of the 50th anniversary of the Canada-U.S. Great Lakes Water Quality Agreement (see page 1).

John H. Hartig, University of Windsor, Great Lakes Institute for Environmental Research, and Peter Alsip, University of Michigan, Cooperative Institute for Great Lakes Research.

Systems thinking and the ecosystem approach

by Peter Stoett and Paula McIntyre

Large lakes are complex, open systems that face myriad threats. They cannot be managed over the long term without respecting the interactions between their component parts, including coasts, water, biodiversity, drainage points, economic sectors such as fisheries and tourism, and pollution, to name a few. Further, the human dimensions cannot be ignored nor minimized. The demands of adaptive governance of large lakes can only be met if policy makers and stakeholders alike take a systems approach to thinking about problems and solutions.

In our discipline-driven work, we can lose sight of the broader system in which we are engaged. Most environmental management efforts were initially focused on an equilibrium view—the pursuit of static as opposed to dynamic stability—and on the control of variables ("command-and-control" management). What does it mean to take a systems thinking approach to complex problems? In the words of Donella Meadows, a system is "an interconnected set of elements that is coherently organized in a way that achieves something" (Meadows 2008). Examining a system by observing only the component parts is generally referred to as a reductionist approach; a systems thinking approach, in contrast, implies that we need to consider how those parts interact (Waltner-Toews et al. 2008). As David Peter Stroh writes, "optimizing the system requires improving the relationships among its parts, not optimizing the individual parts as is often assumed and rewarded" (Stroh 2015).

> **"Optimizing the system requires improving the relationships among its parts, not optimizing the individual parts"**
>
> David Peter Stroh

One approach that has gained legitimacy at the regional and global levels is the ecosystem approach, which has been endorsed by the Parties to the United Nations Convention on Biological Diversity (CBD). According to Article 2 of the CBD, an ecosystem is "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit." Ecosystems are not stable, pristine entities from which we can inexhaustibly draw beneficial resources. They are characterized by thresholds, regime shifts, resilience, leverage points, and feedbacks.

The ecosystem approach demands flexible thinking, adaptive management, and the ability to respond to feedbacks. This may entail interagency cooperation among governing authorities, or even deep organizational change, and the participation by many stakeholders in consensus-based decision making, rather than command-and-control by a few. Great Lakes management has proven a leader in this effort, and researchers focusing on various parts of these ecosystems have much to contribute and coordinate as they pursue the common goals of promoting sustainability and resilience.

In this pursuit, it's important to recognize that systems work is happening under different terminology, frameworks, and worldviews, and it can be helpful to learn from these existing approaches. For example, some researchers consider lakes as part of *socioecological systems*, a view highlighting that real people with rights and obligations live within the ecosystems being studied. Indeed, it is increasingly common to refer to *biocultural systems,* a framing stemming partially from a much older conceptualization of interconnected life originating in Indigenous worldviews (e.g., the Haudenosaunee Thanksgiving Address, see p. 6). Biocultural community protocols can represent these systems according to local understandings and governance arrangements, and be shared with national governments as well as researchers working in the area. Regardless of whether such protocols exist, simple research ethics demands the free, prior, informed consent of local communities before research is conducted, and the open sharing of results. It is foolhardy to ignore the accumulated wisdom of the caretakers of land and water, many of whom have been engaged in a form of systems thinking all along.

Systems thinking is a method that has emerged to guide people toward transformative change. It calls for relinquishing the idea of controlling a system or completely understanding it. Instead, Meadows writes, "We can listen to what the system tells us, and discover how its properties and our values can work together to bring forth something much better than could ever be produced by our will alone." On the following page, we share some ways to get started.

Peter Stoett is Dean of the Faculty of Social Science & Humanities at Ontario Tech University and co-chair of the IPBES Assessment on Invasive Alien Species. Paula McIntyre is communication director of the International Association for Great Lakes Research.

Stepping into systems thinking

Plan to adapt

Because lake ecosystems are open systems constantly influenced by external forces, we need to accept uncertainty as the norm and plan accordingly. Rather than making a fixed, long-term plan, know what you're aiming for, design an initial step with other stakeholders, and test it out. Monitor and evaluate what happens, learn from the experience, and adjust. Repeat with your next best shot.

Know the conditions

Understanding the conditions that affect a system helps us to prioritize our efforts. While there are different models (e.g., the iceberg model, the six conditions of systems change), in general, responding to the explicit conditions that demand our attention, such as news and events, will rarely leverage long-lasting change. Systems thinking requires us to go deeper, looking not only at policies, practices, and resource flows, but relationships, power dynamics, and underneath it all, our mental models that hold the system in place. Addressing these implicit conditions holds the power for us to transform a system (Kania et al. 2018).

Broaden your timelines

Systems thinking asks us to extend our timeline when considering our ecosystem work. We need to take a cumulative view that looks at impacts over time and focuses on sustainability (resilience promoted through adaptive management and governance). "It is easy to ignore larger systems if your time horizon spans only months and quarters," writes Peter Senge. "Your perspective shifts when you think about consequences of your decisions over decades." (Senge et al. 2010)

Set your boundaries

An ecosystem approach considers the whole array of ecosystem components (e.g., human activities, habitats, species, and physical processes) and interactions, as well as the services they provide. Yet analyzing every single component and linkage within an ecosystem would be physically and intellectually impossible. Instead, we should concentrate on what we feel are key elements and the interactions between them and set a suitable boundary around them. Meadows urges us to "invent boundaries for clarity and sanity," while also cautioning us that "boundaries can produce problems when we forget that we've artificially created them" (Meadows 2008).

Map your system

Mapping a system involves creating a visual representation of the relationships between parts, feedback loops that help drive the system, and forces affecting the system. It is a complex, subjective exercise that can help identify possible leverage points where concerted action can affect the whole. While it may seem that a map is the intended benefit of this exercise, the real benefit of systems mapping is that it provides a way for all stakeholders to engage in the process. It helps them to see how they contribute to the performance of the system as a whole, whether good or bad. (Stroh 2015).

Discover your story

How you tell the story of your system can have a profound impact on the success of your efforts. "Stories make, prop up, and bring down systems," writes Ella Saltmarshe. "Stories shape how we understand the world, our place in it, and our ability to change it." The creation of the Detroit River International Wildlife Refuge illustrates the power of story. One of the few urban refuges, and the only international one in North America, a story helped unite people with different perspectives around a shared vision. This binational story told of how cooperative conservation is re-creating gathering places for people and wildlife in the refuge. This story "had to be carried in the hearts and minds of all, and had to result in shared meaning" (Hartig 2015).

See yourself in the system

Becoming well-versed in systems is an important capacity to develop. Through systems thinking, we come to see that the greatest leverage we have to change a system begins with changing ourselves (Stroh 2015). Systems thinking helps us understand that developing collaborative skills, sharing information, building relationships, and adopting a learning mindset are not just niceties; they are vital for transformative change. Taking the responsibility to be the best version of our "systems self" and understanding our own position and role will help us to collectively design and sustain the healthy large lake ecosystems we envision.

By Paula McIntyre and Peter Stoett

Evolution of a conservation organization

by Scott Sowa

Aerial view of Saginaw Bay shoreline in Lake Huron at the outlet of Mud Creek showing a complex landscape that is emblematic of TNC's evolution as an organization and diverse areas of work such as coastal resilience, protection of migratory bird stopover habitat, regenerative agriculture and reduction of nutrient runoff, and siting of renewable energy. We take an ecosystem approach to conservation where we seek to understand the complex, interconnected challenges we face in order to devise durable solutions that will lead to a world where both people and nature can thrive. Photo credit: Fauna Creative.

The Nature Conservancy is a global environmental nonprofit working to create a world where people and nature can thrive. The Conservancy's roots date to 1915 with the formation of the Ecological Society of America. In 1946, famed ecologist Victor Shelford and 14 colleagues left the ESA to form The Ecologist Union, resolving to take "direct action" to protect threatened natural areas. In 1950, the Ecologist Union changed its name to The Nature Conservancy and we incorporated as a nonprofit organization in 1951.

The Conservancy completed its first land acquisition in 1955, purchasing a 60-acre parcel of old growth hemlock forest at Mianus Gorge in New York. Since that time, we have worked with countless partners across the world to protect hundreds of millions of acres of lands and waters. We have over 4,000 staff members—including 400 scientists—working in every U.S. state and 76 countries. Protection will always be a core priority for the Conservancy, but today our strategies go well beyond land acquisition. Over the years, we have grown from a small land trust working to protect separate parcels of land to a global organization that takes a comprehensive systems approach to solving the two greatest conservation challenges we face today: climate change and biodiversity loss.

This evolution has been driven by science, which continues to drive all our work. For our first 20 years we worked with various partners to assemble the data and expert input needed to identify and prioritize places most in need of protection. In 1970, the Conservancy created a new biological inventory of the United States. That inventory led to the creation of the Natural Heritage Network, which is now known as the NatureServe Network. These data brought more scientific rigor to protection efforts and were instrumental to the next big evolution in our approach to conservation.

The 1970s through the 1990s was a period of rapid technological and theoretical advancement across the world of conservation. Remote sensing and geospatial technologies advanced rapidly while new fields of conservation biology and landscape ecology sought to respond to increasing threats to our natural world. The Nature Conservancy embraced these new technologies and concepts in multiple ways, from developing the rigorous conservation assessment and planning process of Conservation by Design in 1995 to creating international and whole system programs like the Great Lakes

Program, which launched in 1996. These assessments offered a more comprehensive view of threats facing complex ecosystems, while the new programs fostered the collaboration needed across TNC and with peer organizations to address those issues at a scale that leads to tangible and lasting impact.

As the Conservancy invested more heavily in climate change strategies, we piloted successful collaborations working with global supply chains, innovative financing, and market-based solutions. In 2015, a global situation analysis by TNC spelled out the top threats to nature and human communities. This assessment led to four global priorities for the Conservancy: increasing land and water protection, bringing greater sustainability to food systems and water resources, addressing climate change through both mitigation and adaptation, and addressing the global human migration to cities and the interrelated impacts on natural resources and human health.

The Nature Conservancy's efforts to explicitly consider people and communities in our strategies led to recent revisions to Conservation by Design to consider social outcomes in all we do and to work even more intensively with all sectors of society, including Indigenous Peoples, to develop practical conservation solutions. Acting with a more comprehensive view and approach to managing ecosystems, we focus on global goals with specific metrics for land, oceans, carbon, freshwater, and people. We also recognize that at the heart of any ecosystem approach is a shared understanding and vision of a healthy ecosystem. The Nature Conservancy strives to promote and support partnerships and governance structures that foster shared understanding and visions that lead to policies and programs providing durable solutions to achieve them.

"At the heart of any ecosystem approach is a shared understanding and vision of a healthy ecosystem."

This year marks the 50th anniversary of the Clean Water Act and Great Lakes Water Quality Agreement, both grounded in an ecosystem approach. Many events will celebrate these landmark pieces of legislation and offer an opportunity to reflect on what is and isn't working when it comes to real-world application of the ecosystem approach. I'm hopeful this period of deep reflection will lead to another leap forward in the application of the ecosystem approach to conservation. These times demand nothing less.

Scott Sowa is the Juli Plant Grainger, Great Lakes Director of The Nature Conservancy.

Protection of places like the Shivering Sands Preserve (left) will always be a core priority for The Nature Conservancy to combat habitat loss and fragmentation and create a resilient and connected network of healthy habitats for nature that also provide critical ecosystem services to people. However, we know we must do more, which is why we have expanded the work we do and where we work as is reflected by the photo at right showing Peter Limbu (right), our Lake Tanganyika Fisheries Director, working with two volunteer data collectors who are helping monitor the fish being harvested from the lake to ensure populations remain healthy for future generations. Photo credits: Gerald H. Emmerich, Jr. (left) and Ami Vitale (right).

The dilemma of the ecosystem approach

ON LAKE VICTORIA

by Martin Van der Knaap

When we established the Lake Victoria Fisheries Organization (LVFO) in 1994, we believed we would apply the ecosystem approach to managing the fishery of this African Great Lake. But the voluntary introductions of the Nile perch and Nile tilapia caused havoc among the lake's original biodiversity at the expense of many cichlid fish species. They caused changes in the entire food web as we used to know it. In addition, our efforts to achieve long-term ecosystem health bump into the more immediate needs of local people who rely on the lake as a source of food, employment, and income generation.

Consider the case of the Nile perch, which was introduced to Lake Victoria in the 1950s as a potential game fish species. In the '90s, the unbridled expansion of fish processing plants for Nile perch export and the resulting demand for the fish put great pressure on the species. Around 2000, the fishery was considered sustainable, but only for a short while as the lake continued to attract additional fishers. During the heyday of the Nile perch, a trader could fill a fish truck in just three days; nowadays it takes a full week to fill half a truck. Did the ecosystem approach fail? Alternatively, was it a failure to control access to the lake? Perhaps the ecosystem approach and "open access" cannot go together?

As the Nile perch became scarce, small pelagic cyprinid species flourished. Target species of the fishery changed also. In certain bays, mainly in the Kenyan portion of the lake, hardly any fish remained. As a result, through the input of some foreigners, fishers were encouraged to rear young Nile tilapia in floating cages in the lake. This effort appeared successful, and many people followed the example, until large commercial farms were established. Their production increased over the years to several thousands of tonnes of tilapia per year. In theory, the convention of the LVFO called for an ecosystem approach to aquaculture. But nobody foresaw the magnitude that the cage industry could achieve. Today, without the right policies in place, the commercial expansion threatens to get out of hand. There is an immediate need to determine the carrying capacity of the lake and to provide a formula for spatial planning. High fish densities in the cages may attract diseases and parasites. Will fish farmers be tempted to apply antibiotics and other chemicals to reduce the impact of diseases? What will be the effect of the locally high concentrations of fish excrements?

A fish truck with Nile perch on ice. Photo courtesy of Martin Van der Knaap.

With the biodiversity of the lake severely impacted, can we sustainably make further changes, for instance by fish (re)stocking programs? Can these manipulations of fish species be part of the ecosystem approach to fisheries and aquaculture? To what extent may we intervene in the ecosystem? Each intervention, whether fishing, fish rearing, or stock enhancing, will impact the ecosystem, often in unintended ways. The ecosystem approach is an excellent principle for management of natural resources in the Great Lakes, but can it be successful when the tendency to overexploit these resources exists? Time will tell. Lake Victoria went through many disasters; likely, it will overcome this one as well.

Martin Van der Knaap, Fishery and Aquaculture Officer, FAO Sub-regional Office for Eastern Africa, Addis Ababa, Ethiopia

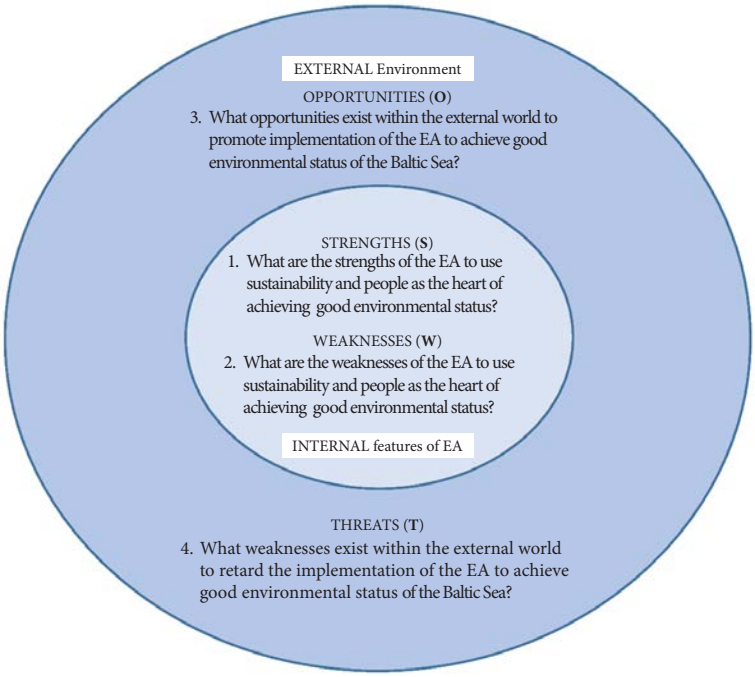
A SWOT analysis of the ecosystem approach in the Baltic Sea region

Given the central role the ecosystem approach plays in key policy documents such as the Convention on the Protection of the Marine Environment of the Baltic Sea area, our research aims to investigate factors that lead to its better implementation.

In a recently published article, we examined the implementation of the ecosystem approach in the Baltic Sea region, one of the largest water catchments in the world and a part of the European Union. This study was unique, as it used the strengths, weaknesses, opportunities, and threats (SWOT) framework from business theory in the analysis of key documents to identify themes relevant to the approach in the Baltic Sea region.

The study found that Baltic Sea experts cherish the simplicity of the approach in communicating the importance of environmental stewardship. However, the downside is that there are many interpretations of the approach, as the language can be complex and unclear. This study showed that with a streamlined allocation of resources, more stakeholder engagement through capacity building, and political leadership, the ecosystem approach could facilitate interdisciplinary knowledge pooling to achieve a good ecological status of the Baltic Sea and other regions of the world. This work continues with our doctoral student Varvara Lahtinen, who will further investigate the implementation of the ecosystem approach in the Nordic Region.

By Savitri Jetoo, Ph.D. Adjunct Professor, Åbo Akademi University, Turku, Finland.

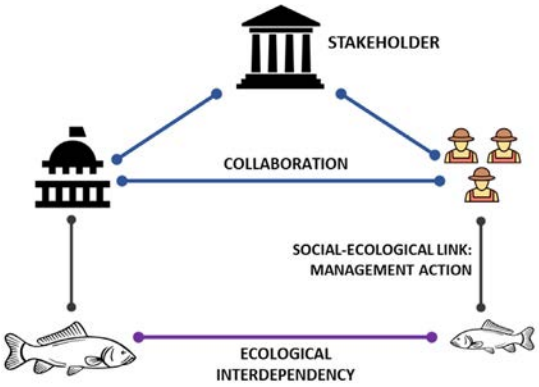


Strengths and weaknesses can be seen as internal attributes of the ecosystem approach, while opportunities and threats are external features. Each has associated research questions related to the Baltic Sea Action Plan.

How an ecosystem approach can accelerate socio-ecological systems mapping and management of aquatic invasive species in the Great Lakes

Successful invasive species management depends on far more than the biological conditions of a given system. It also depends on human interactions with the ecosystem, and coordination and cooperation among interdependent stakeholders (Lubell et al. 2017, Bodin 2017). To fully understand the complexity of aquatic invasive species (AIS) management, we must consider all the interconnected elements, both ecological and social. This is where the idea of social-ecological systems (SES) comes into play and exemplifies an ecosystem approach. The SES framework attempts to address the complex interdependent relationships between humans and the natural environment, supporting a systems perspective in which the relationships between multiple social and ecological components are at the center (Sternlieb et al. 2013).

In AIS governance, management actions taken by myriad actors (governments, NGOs, researchers, corporations, etc.) create mutual interdependence, where actions and outcomes in one component of the SES can lead to outcomes in another (either intentionally or unintentionally) (Bodin et al. 2019). Our project focuses on AIS governance in the Great Lakes, understood as an SES. We seek to understand the patterns of social interdependencies between actors, and how well they reflect the existing interdependencies in the ecosystem. For example, if two actors are managing two interconnected elements of the ecosystem (such as one species that preys on another), we would expect that these actors collaborate in some form to "internalize" or reflect the existing ecological interdependence (see illustration).



To "reconstruct" the social and ecological subsystems, we rely on existing food web models to understand the ecological components, and on stakeholder surveys to understand the social system. We are currently analyzing survey data and will present our initial results at the 2022 ICAIS Conference in April. This project has the potential to shape our understanding of complex freshwater governance systems as well as meaningful implications for the development of a cohesive management approach for AIS in the Great Lakes.

By Federico Holm, University of Michigan, Ramiro Berardo, The Ohio State University, and Steven Alexander, University of Waterloo.

Participatory, holistic management of great lakes: Experiences from Lake Vättern, Sweden

Participatory, holistic management of ecosystems and water resources has been practiced in traditional cultures for millennia. The need to balance exploitation with nature's resilience and biodiversity is often more imminent in such cultures, since livelihoods are closely connected to nature there.

New inventions during the Industrial Revolution made life easier in many other societies. More efficient production could feed more people and provide more jobs. Concurrently, industrialization, urbanization, and changes in land use put increasing anthropogenic pressure on ecosystems, often leading to undesired ecological states. Environmental management gradually became more centralized, with the aim to focus protective action first where it is best needed.

During the past few decades, however, there has been an increasing scientific, management and policy interest in what is called the *ecosystem approach*, or, when applied to fisheries, *ecosystem-based fisheries management*. In a nutshell, it's about managing ecosystems and resources in a more participatory and holistic manner while using new, low-impact techniques.

Studying Arctic char migration in Lake Vättern. Photo courtesy of the County Administrative Board Jönköping.

In 2019–2021, our research team investigated the way the management of Lake Vättern, Sweden, works in relation to ecosystem-based fisheries management. Management tends to work with the whole lake ecosystem in focus and involves stakeholders quite extensively. Some notable progress has been made; eutrophication has been reversed and the iconic fish species Arctic char has been brought to a more sustainable population level. However, there are many remaining challenges to management, such as climate change, pollution, and invasive species. Participatory structures have been in place for many decades, which we saw as instrumental for this type of management. If other great lakes are to be managed in similar participatory, holistic ways, Lake Vättern is definitely an example worth learning from.

By Andreas C. Bryhn, associate professor at the Swedish University of Agricultural Science.

Reducing our agricultural footprint to preserve, protect, and restore the ecological health of the Great Lakes

By 2050, humanity will need to produce 10 times more food each year than all the food ever produced throughout the history of humankind. However, current "best-practices" are wholly unsustainable. Agricultural run-off is leading to toxic algal blooms in our Great Lakes, and the prophylactic application of pesticides on agricultural landscapes has been linked with biodiversity loss, including declines in birds and pollinators. Around the world, arable land is being gobbled up by development, while new, pristine land and forests are converted to monoculture cultivation. Small-scale farmers experience difficulty entering the market and are often forced to consolidate with large-scale operations just to break even. The pandemic has exposed the fragility of global food economies that were designed for maximizing profits and feeding the masses but at a high environmental cost. We need a vision to reimagine sustainable food production because continuing with business as usual is no longer an option.

Our paper argues the 2020s can be a transformative decade for human interaction with the environment. We present an agrosystem approach that is inspired by the United Nations' 17 Sustainable Development Goals. The agrosystem model we propose is defined to promote regenerative agriculture, an integrative approach that provides greater resilience to a changing climate, reverses biodiversity loss, and improves soil health; honors Indigenous ways of knowing and a holistic approach to living off and learning from the land; and supports the establishment of emerging circular economies and community well-being.

To truly develop a regenerative and nourishing food system in the Great Lakes that will feed humanity by 2050, we need to go beyond individualistic approaches and adopt community-centric approaches that create a sustainable path for the future. Creating unity of vision requires unity in action.

By René S. Shahmohamadloo, Liber Ero Postdoctoral Fellow at Washington State University and the University of Guelph.

Adopting an agrosystem approach inspired by the United Nations' Sustainable Development Goals can result in a regenerative and nourishing food system in the Great Lakes that is community-centric and sustainable. Photo courtesy of the Ontario Agricultural College, University of Guelph.

Exploring pluralism in ecosystem governance

While pluralism is not a new idea in environmental governance, recent calls for broadening participation in ecological and sustainability solution-building—such as for climate change-related extreme weather events and the COVID-19 pandemic—have prompted renewed urgency in understanding how diverse institutions and people can effectively govern ecosystems to promote ecological sustainability and human well-being. By pluralism, we refer to the diversity of aspects of human culture and/or the natural environment.

The field known as translational ecology (TE) emphasizes linking ecological science to evidence-based decision making, taking its verbiage from translational medicine. TE uses cross-disciplinary research, together with broader participation, to address the social, ecological, and political contexts of environmental problems, with an aim to improve decision making for environmental management and conservation. This approach, along with other, similar approaches, requires deliberate engagement with a range of actors, as well as an understanding of the social and cultural contexts in which research is conducted. One challenge of this approach lies in integrating different types of knowledge, like scientific evidence, practical know-how, and Indigenous and traditional knowledge. TE and other fields of participatory environmental research also recognize that much of what we know does not get "used" because of implementation challenges.

Related to our work on the scientific project ResNet, which promotes sustainable and resilient ecosystems in Canada, our upcoming special issue of the *Advances in Ecological Research* book series titled "Pluralism in Ecosystem Governance" aims to deepen understanding of pluralism in a translational ecology context. This issue will present a diverse selection of in-depth synthesis articles that explore a range of ideas, from human-animal relations to conservation conflicts. These studies represent a range of disciplines, geographies, methods and case studies.

Academic collaborators and students get the lay of the land at Windsor causeway foreshore salt marsh, Bay of Fundy NS, August 2018. Photo by Kate Sherren.

By Jen Holzer, Environmental Sustainability Research Centre, Brock University.

New aquatic research facility at University of Waterloo seeks collaborators

In January the University of Waterloo officially launched the Waterloo Aquatic Threats and Environmental Research facility. The multi-million dollar WATER facility is one of the largest aquatic research facilities in Ontario and provides the capacity to study a wide variety of aquatic species, including temperate and tropical fish species, amphibians, and aquatic reptiles found in Canada. Most exciting, the WATER facility is equipped with cutting-edge technology, including a pathogen challenge area, that will allow researchers to study the impact of disease agents and contaminants of concern on aquaculture, expose populations to controlled climate-related stressors like water temperature and oxygen saturation levels, and measure the effects of human-centric pollution, such as wastewater, on aquatic ecosystems.

"A major challenge in extrapolating from lab studies to the real world is that the constraints of lab facilities limit our ability to look at cumulative and combined effects of multiple stressors," says Rebecca Rooney, associate professor in Waterloo's biology department. "In the Great Lakes, for example, fish are exposed to a contaminant at the same time as they are experiencing disease and temperature or oxygen stress, and these insults can combine in unexpected ways." The WATER facility allows researchers to control multiple stressors independently to look at their effects in isolation and combination.

A $1.5 million 2020 Canadian Foundation for Innovation Infrastructure Grant helped support development of the WATER facility. According to Paul Craig, grant co-lead and associate biology professor, "Our new facility will allow researchers to bridge the gap between lab and fieldwork by studying the impact of climate-related stressors in a controlled environment, which can then be translated towards field-based studies to make better predictions about the impacts that humans have on our aquatic species." The facility is designed to support field and lab studies to rapidly advance ecotoxicology research in the face of multiple stressors.

Paul Craig beside one of the new pathogen challenge recirculating systems capable of holding both cold and temperate aquatic species. Photo by Elizabeth Kleisath.

"With the opening of the WATER facility, we are looking to expand our research areas and expertise," Craig says. "We invite researchers across Canada in areas of water research and aquatic conservation to collaborate with us to carry out new and innovative research." Interested researchers can learn more about the facility by contacting Craig.

Save the date for the upcoming *Ecosystem Approach in the 21st Century: Guiding Science and Management* hybrid event scheduled for August 22–24, 2022. The first day will feature an international virtual conference followed by a two-day in-person synthesis workshop hosted by the University of Windsor, in Windsor, Ontario, Canada. The conference and workshop will explore the following themes:

1. Origin of the ecosystem approach
2. Development of an integrative framework
3. Science-policy solutions
4. Education, outreach, knowledge mobilization
5. Human dimensions (health, relationships, non-monetary)
6. Blue economy
7. Dealing with uncertainty
8. Technological advances

Sign up for updates on abstract submission, registration, and the opportunity to join organizational and early career fellow teams. The website will launch in March 2022.

Tentative Schedule

August 22
Virtual conference showcasing plenaries, plus posters and talks on applications of the ecosystem approach from around the world.

August 23-24
A writing-intensive, in-person workshop with six to eight working groups that will synthesize findings and recommendations for each of the conference themes. The results of their efforts will be published in a special issue of the AEHMS journal and a monograph and further refined through feedback from stakeholder meetings.

Lakes Letter is published quarterly by the International Association for Great Lakes Research, a scientific organization made up of researchers studying the Laurentian Great Lakes, other large lakes of the world, and their watersheds, as well as those with an interest in such research.

It is edited by IAGLR Communication Director Paula McIntyre with assistance from Alex Duncan and Jessica Ives, members of the *Lakes Letter* editorial team.

International Association for
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2022 IAGLR membership drive

Thank you for supporting IAGLR with your annual membership! Our members hail from many countries and disciplines, and they come together to create a vibrant community to learn about and advance large lake science. This diversity is our strength and each of you contribute to that strength. We value your participation in the IAGLR community. We invited you to **renew your membership and celebrate all the reasons you benefit from being an IAGLR member**: the confererences, the *Journal of Great Lakes Research*, the opportunity to grow professionally, and the connections to others in this unique large lake research community. To help strengthen these connections, we're hard at work to bring you a new member directory this spring. We can't wait to share it with you! Why wait? **Renew today**!

iaglr.org/membership/

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