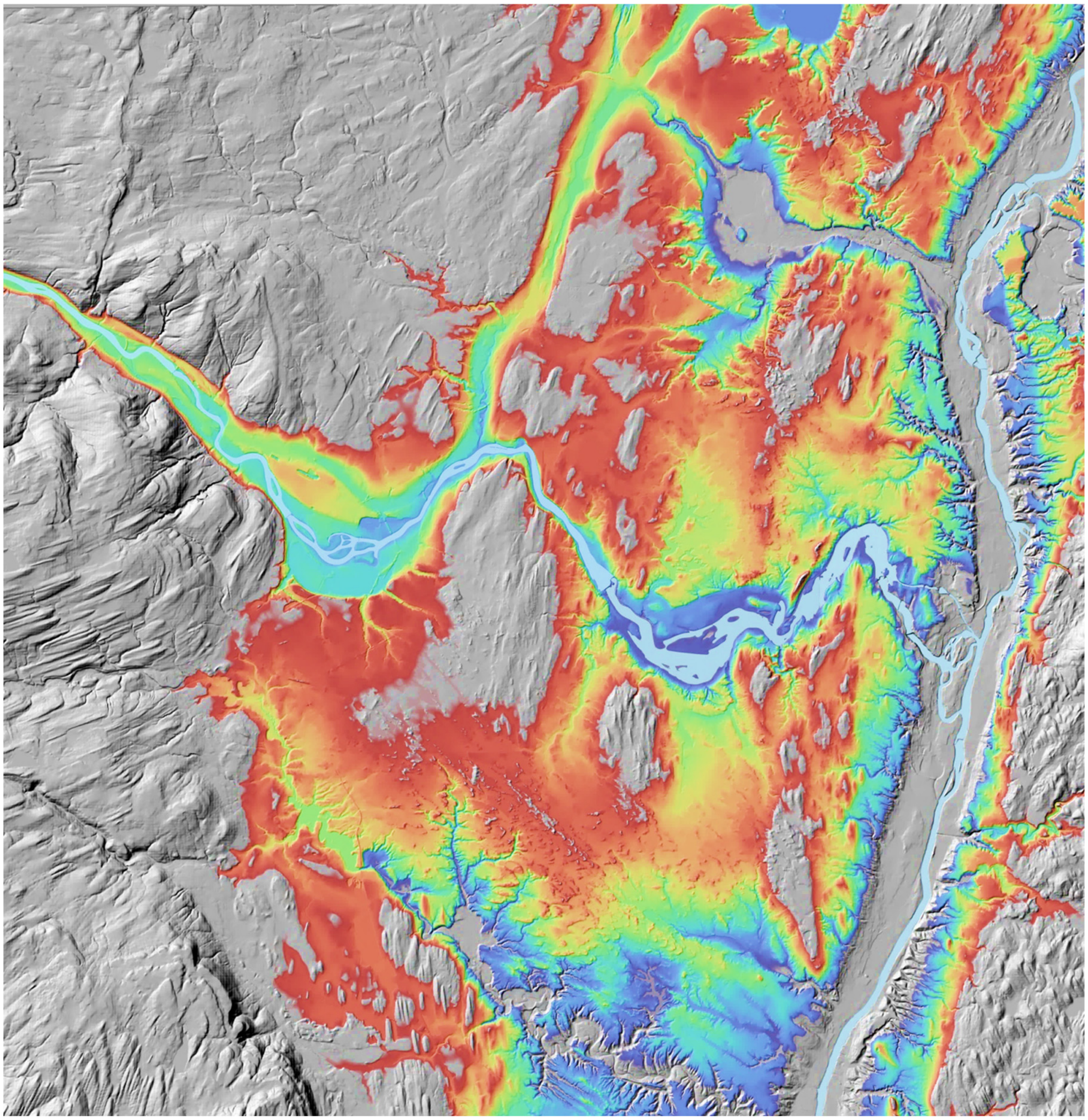
Mohawk Watershed Symposium 2025



Abstracts and Program

College Park Hall, Union College

Schenectady NY

21 March 2025

Mohawk Watershed Symposium 2025
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Schenectady, NY
21 March 2025

Edited by

Carolyn M. Rodak, John I. Garver, and Jacqueline A. Smith

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On the Cover

A digital elevation model of the confluence of the Mohawk and Hudson rivers. This image is based on 10 m lidar from the NYS GIS database, and it includes a hillshade and a color ramp to represent elevation changes in the critical interval between 107 and 55 m. The higher elevations that are above modification by the Mohawk and its predecessor are not colored. In the color ramp, the highest color (burnt orange) is 107 m (354 ft), and the lowest color of the ramp (dark blue) is 55 m (~180 ft - below that is uncolored). This color ramp highlights the complicated late glacial history of this confluence where part or all of the river flowed north through the Ballston Channel and that drainage included Round Lake. Incision and downcutting in the Normanskill can be seen in the drainage to the south. The dunes of the Pine Bush and Central Park are thought to have been derived from sediment of the Schenectady delta. The sharp topography to the south is the Helderberg escarpment, and this includes Thacher Park. (Image: JI Garver)

Table of Contents

Abstracts

Preface to the 2025 Mohawk Watershed Symposium

The 15th Mohawk Watershed Symposium offers an exciting and diverse set of presentations on water quality, fisheries and habitats, flooding and resilience, and recreation and stewardship. The 2021-2026 Mohawk River Basin Action Agenda, our critical guiding document, focuses on conserving, preserving, and restoring the Mohawk River Watershed while helping to manage the ecosystem services for a sustainable future.

Much of the defining discussion by stakeholders occurs at the annual Mohawk Watershed Symposium, and given this watershed blueprint, ongoing environmental change, and political headwinds, we see that the challenge ahead is enormous.

Educational institutions and federal agencies - and many of our key stakeholders - are under threat. We need to ensure that science, engineering, and sound policy decisions guide our path forward. Now more than ever we need to redouble our efforts to advocate for clean water, fight the spread of invasive species, implement resilient flood mitigation projects, and understand how climate change has affected and will continue to affect almost everything in the watershed.

The support of the DEC in this effort, and the partnership between the DEC and the Symposium, has made an enormous difference in fostering a sense of community and providing direction for watershed investigations. Additional support from Riverkeeper and the Mohawk-Hudson Land Conservancy is greatly appreciated, along with your attendance at this year's Mohawk Watershed Symposium.

The 2025 Mohawk Watershed Symposium features 38 technical presentations that cover a wide range of topics. We are delighted to see so many familiar names and welcome those new to the Symposium.

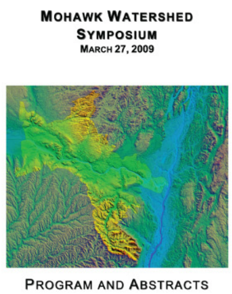
Enjoy the day.

Carolyn M. Rodak, Civil and Environmental Engineering, Union College

John I. Garver, Geosciences Department, Union College

Jacqueline A. Smith, Geosciences Department, Union College

MWS 2025 Co-chairs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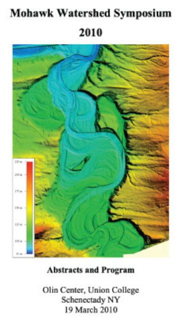
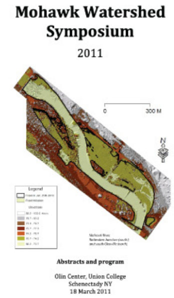
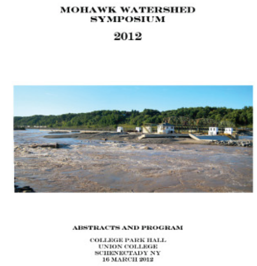
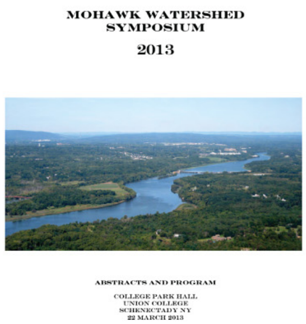
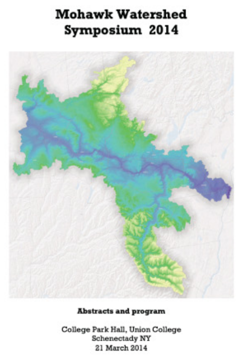
MARCH 27, 2009
PROGRAM AND ABSTRACTS

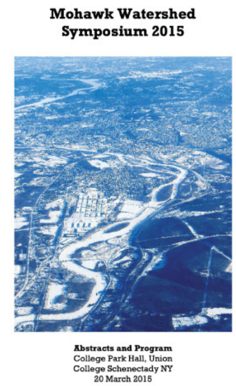

Mohawk Watershed Symposium
2010
Abstracts and Program
Olin Center, Union College
Schenectady NY
19 March 2010


Mohawk Watershed Symposium
2011
Abstracts and program
Olin Center, Union College
Schenectady NY
18 March 2011


MOHAWK WATERSHED SYMPOSIUM
2012
ABSTRACTS AND PROGRAM
COLLEGE PARK HALL
UNION COLLEGE
SCHENECTADY NY
16 MARCH 2012


MOHAWK WATERSHED SYMPOSIUM
2013
ABSTRACTS AND PROGRAM
COLLEGE PARK HALL
UNION COLLEGE
SCHENECTADY NY
22 MARCH 2013


Mohawk Watershed Symposium 2014
Abstracts and program
College Park Hall, Union College
Schenectady NY
21 March 2014


Mohawk Watershed Symposium 2015
Abstracts and Program
College Park Hall, Union College Schenectady NY
20 March 2015

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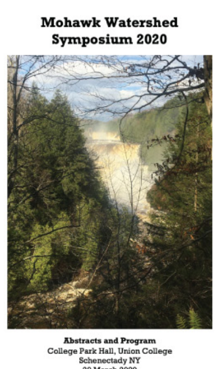
Mohawk Watershed Symposium 2016
Abstracts and Program
College Park Hall, Union College
Schenectady NY
18 March 2016

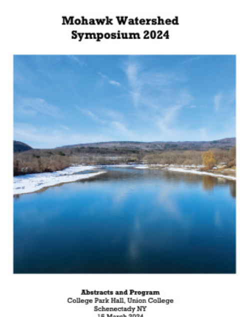

Mohawk Watershed Symposium 2017
Abstracts and Program
College Park Hall, Union College
Schenectady NY
17 March 2017


Mohawk Watershed Symposium 2018
Abstracts and Program
College Park Hall, Union College
Schenectady NY
23 March 2018


Mohawk Watershed Symposium 2019
Abstracts and Program
College Park Hall, Union College
Schenectady NY
22 March 2019


Mohawk Watershed Symposium 2020
Abstracts and Program
College Park Hall, Union College
Schenectady NY
20 March 2020


Mohawk Watershed Symposium 2023
Abstracts and Program
College Park Hall, Union College
Schenectady NY
17 March 2023


Mohawk Watershed Symposium 2024
Abstracts and Program
College Park Hall, Union College
Schenectady NY
15 March 2024

Major Financial Support for MWS 2025

Major Financial support for MWS 2025 was provided by the **New York State Department of Environmental Conservation though the Mohawk River Basin Program**.

The Mohawk River Basin Program (MRBP) is a multi-disciplinary environmental management program focused on conserving, preserving and restoring the environmental, economic, and cultural elements of the Mohawk River Watershed. Through facilitation of partnerships among local, state and federal governments, the MRBP works to achieve the goals outlined in the Mohawk River Basin Action Agenda (2012-2016). The MRBP sees the continuation of the Union College Mohawk Watershed Symposium as an ideal platform for communication among stakeholders at all levels.

The **Mohawk Hudson Land Conservancy**'s mission is to conserve and steward the lands and waters of the Mohawk and Hudson River Valleys for the benefit of people and the environment. Our conservation work protects natural resources to ensure clean water, clean air, and working landscapes for farming and forestry for a healthier Capital Region for current residents and for future generations. Visit mohawkhudson.org to learn more.

Riverkeeper's mission is to protect the environmental, recreational and commercial integrity of the Hudson River and its tributaries. Visit the webpage to learn more: Riverkeeper.org.

2025 Mohawk Watershed Symposium - Exhibitors

Barbara Heinzen, PhD	**Barbara Heinzen Consulting** Barbara Heinzen is a consultant who specializes in long range scenario planning. Barbara employs work with scenarios that identify pressures that are forcing societies to confront the possibility of profound systemic change. She also offers services in learning how to survive systemic change including how to shape its direction and master its skills. *http://www.barbaraheinzen.com/index.php*
	Capital-Region Partnership for Regional Invasive Species Management (PRISM) Covering the counties of Albany, Columbia, Montgomery, Rensselaer, Schenectady and portions of Fulton, Greene, Herkimer, Saratoga, Warren, and Washington, the Mission of the Capital Mohawk PRISM is to: *"Detect, prevent, and control invasive species through direct action and education to protect biodiversity, the natural environment, economy and quality of life." www.capitalregionprism.org*
	Cornell University – The NYS Water Resources Institute (WRI) Through the Federal Water Resources Research Act of 1984, WRI was established under state law in 1987 to address water resource quality and management through research, outreach and education, grant and funding opportunities, and building relationships with state agencies, professional organizations and citizen stakeholder groups. *https://cals.cornell.edu/water-resources-institute*
	Drinking Water Source Protection Program (DWSP2) *DWSP2* is a locally led, state-supported program that empowers municipalities to take action to improve and protect their public water sources and surrounding environment. Communities work with technical assistance providers to develop and initiate implementation of Drinking Water Source Protection Programs to protect their drinking water sources now and into the future. *https://dec.ny.gov/environmental-protection/water/water-quality/dwsp2*
	Hudson River Watershed Alliance The Hudson River Watershed Alliance's mission is to unite and empower communities to protect our shared waters. The Alliance works across the Hudson River watershed to support watershed groups, help communities work together on water issues, and communicate as a collective voice, empowering effective stewardship to ensure the availability of clean, abundant water today and into the future. *https://hudsonwatershed.org/*
	iMapInvasives – New York Natural Heritage Program (NYNHP) NYNHP administers i*MapInvasives* as the official centralized invasive species database for New York State. Conservation partners across the state use *iMap* to document surveys, track management efforts, and gather information to inform management decisions. NYNHP is a program of the State University of New York College Environmental Science and Forestry (SUNY-ESF) funded primarily by the NYS Department of Environmental Conservation (NYSDEC). *www.imapinvasives.org*
	Mohawk Hudson Land Conservancy The Mohawk Hudson Land Conservancy's mission is to conserve and steward lands and waters of the Mohawk and Hudson River Valleys for the benefit of people and the environment. Our conservation work protects natural resources to ensure clean water, clean air, and working landscapes for farming and forestry for a healthier Capital Region for current residents and for future generations. *https://www.mohawkhudson.org/*
	Mohawk River Basin Program DEC's Mohawk River Basin Program (MRBP) works to promote the integrated and coordinated management of the many environmental resources of the Mohawk River and its unique watershed. As a partnership-based initiative, the MRBP fosters collaborative decision-making based on an understanding of the entire ecosystem, recognizing that the complex issues within the region cannot be fully resolved by managing certain sectors, species, or pollutants on an individual basis. *https://dec.ny.gov/nature/waterbodies/lakes-rivers/mohawk-river-watershed*

2025 Mohawk Watershed Symposium - Exhibitors

Mohawk Towpath Scenic Byway
The Mohawk Towpath Scenic Byway parallels the Mohawk River, Erie Canal, and the New York Barge Canal from the Village of Waterford to the City of Schenectady. The Byway is designed to celebrate the rich history of the region while highlighting the rural and scenic beauty of the Mohawk. *https://www.mohawktowpath.org/*

New York State Canal Corporation
The New York State Canal Corporation operates and maintains the 524-mile New York State Canal System, a network of waterways and trails, available for public use. The Canal Corporation is committed to environmental stewardship and regularly collaborates with many organizations on aquatic invasive species risks throughout the canal corridor. *canals.ny.gov/community/environmental/Invasive_Species.html*

New York State Region 4 & 6 Fisheries Units
The New York State Regions 4 and 6 Fisheries Units manage the Mohawk River watershed. They have recently been collaborating on several studies to update understanding of sportfish of the Mohawk River including boat electrofishing surveys of the lower impounded sections, creel surveys, and online angler surveys. *https://dec.ny.gov/places/mohawk-river-barge-canal*

New York State Resilient Watersheds Grant Program
The New York State Resilient Watershed Grant Program is a new grant program that provides funding to implement flood mitigation projects that would otherwise not be possible using local funds. The goals of this grant are to protect public health and safety and protect community infrastructure. *https://dec.ny.gov/environmental-protection/water/water-quantity/resilient-ny*

Rebecca Martin Consulting
Rebecca Martin has expertise in creating impactful campaigns and initiatives through coalition-building, collaborative strategies, and targeted communications. Rebecca is project manager of the report, "The Threat of Landfill Leachate to Drinking Water in Hudson and Mohawk Rivers", a project of the Hudson and Mohawk Rivers Leachate Collaborative. *https://rebeccamartinconsulting.com/*

Riverkeeper
A member of the Mohawk River Basin Program's steering committee, Riverkeeper is a non-profit organization formed in 1966 and devoted to protecting the Hudson River and its tributaries. Riverkeeper's work in the Mohawk River watershed began in 2014, when Capt. John Lipscomb extended his Hudson River patrols into the Mohawk and continues with water quality monitoring in partnership with several local universities. *www.riverkeeper.org*

Schoharie River Center – Environmental Study Teams
Established in 1999, the Schoharie River Center (SRC) is a not-for-profit organization dedicated to educational and cultural programming about Schoharie Creek and surrounding communities. SRC operates and sponsors Environmental Study Team (EST) programs designed to engage middle and high school youth to study, monitor and improve water quality of local streams, rivers, and lakes. While learning about their environment, EST members go hiking, swimming, biking, cross-country skiing, snowshoeing, canoeing, kayaking, and sailing, and in the spring can learn how to make maple syrup in the Center's maple syrup sugar shack. *www.schoharierivercenter.org*

United States Geological Survey (USGS)
As the Nation's largest water, earth, and biological science and civilian mapping agency, USGS collects, monitors, analyzes, and provides science about natural resource conditions, issues, and problems. USGS' diverse expertise enables them to carry out large-scale, multidisciplinary investigations and provide impartial scientific information to resource managers, planners, and others. In partnership with the Mohawk River Basin Program, USGS has taken the lead on projects such as Ice Jam Monitoring, Sediment Monitoring, Fish Assemblages of the Mohawk, and assisting with outreach and education efforts. *www.usgs.gov*

Mohawk Watershed Symposium - 2025

21 March 2025, College Park Hall, Union College, Schenectady NY

Oral session (College Park) - Registration and badges required. No photography

7:30 AM	8:15 AM	***Registration, Coffee - College Park***
8:15 AM	8:20 AM	**Introductory Remarks**
		John Garver, MWS Co-chair, Geosciences Department, Union College, Schenectady, NY
8:20 AM	8:35 AM	**Potential safety concerns of earth dams within the Mohawk River Watershed**
		Ashraf Ghaly, Civil and Environmental Engineering, Union College, Schenectady, NY
8:35 AM	8:50 AM	**Big Creek restoration strategy**
		Jo-Anne Humphreys, Northeast Coldwater Habitat Program, Trout Unlimited, Arlington, VA
8:50 AM	9:05 AM	**Salinity tolerance of Round Goby: informing invasion potential in the Hudson River Estuary and adjacent coastal waters**
		Kelsey Alvarez del Castillo, Dept. of Natural Resources and the Environment, Cornell University, Ithaca, NY
9:05 AM	9:30 AM	**Angler survey results for the Mohawk River (2024)**
		Stephen Manning, Scott Wells, NYS DEC, Region 4 Fisheries suboffice, Stamford, NY
9:30 AM	9:45 AM	**Leave it to beavers: the expanding role of Nature's engineers in the Mohawk Watershed**
		John Garver, MWS Co-chair, Geosciences Department, Union College, Schenectady, NY
9:45 AM	10:45 AM	***COFFEE and POSTERS (see next page for listing)***
10:45 AM	11:00 AM	**What goes up must come down: assessing the fate of Blueback Herring spawning in the Mohawk River**
		Wes Eakin, Department of Natural Resources and the Environment, Cornell University, Ithaca, NY
11:00 AM	11:15 AM	**Biogeochemical BBH: what we've learned about the remarkable life histories of the Blueback Herring, Alosa aestivalis, from biogeochemical tracers**
		Karin Limburg, Dept. of Environmental Biology, SUNY College of Environmental Science & Forestry, Syracuse, NY
11:15 AM	11:30 AM	**Home is where we made it: mussel research leads to mudpuppy habitat**
		Adam Haines, NYS DEC Department of Fish and Wildlife, Bureau of Ecosystem Health, Albany, NY
11:30 AM	11:45 AM	**Protecting public drinking water in the Mohawk Watershed with the Drinking Water Source Protection Program (DWSP2)**
		Tyler Bobko, NEIWPCC, NYS DEC, Albany, NY
11:45 AM	12:10 PM	**Some critical water resource issues in the Mohawk watershed and beyond**
		Brian Rahm, New York State Water Resources Institute at Cornell University, Ithaca, NY
12:10 PM	1:30 PM	***LUNCH and POSTERS - Lunch at College Park Hall***
1:30 PM	1:40 PM	**NYS DEC Remarks**
		Carol Lamb-Lafay, NYS DEC, Albany, NY
1:40 PM	1:55 PM	**Deepening sense of place and water literacy of the Mohawk River Watershed through art, science, and indigenous knowledge**
		Anna Davidson, Department of Natural Resources and the Environment, Cornell University, Ithaca, NY
1:55 PM	2:20 PM	**A Day in the Life of the Mohawk River: 2024 program overview**
		Doug Reed, Watershed Community Organizer
2:20 PM	2:35 PM	**Longitudinal snapshots of nutrients in the Mohawk River show clear and distinct effects of agriculture and sewage effluent**
		Julian Damashek, Department of Biology, Hamilton College, Clinton, NY
2:35 PM	2:50 PM	**Trends and observations from 10 years of fecal indicator bacteria (enterococci and Escherichia coli) monitoring partnership in the Mohawk River Watershed: toward a more swimmable Mohawk**
		Neil Law, SUNY Cobleskill, Cobleskill, NY 12043
2:50 PM	3:40 PM	***COFFEE and POSTERS (see next page for listing)***
3:40 PM	4:05 PM	**Climate impacts to drinking water**
		Dan Shapley, Riverkeeper, Ossining, NY
4:05 PM	4:30 PM	**The threat of landfill leachate to drinking water in the Hudson and Mohawk Rivers**
		Rebecca Martin, John Lipscomb, Hudson and Mohawk Rivers Leachate Collaborative
4:30 PM	4:55 PM	**Federal funding and advocacy for the Mohawk River**
		Jeremy Cherson, Riverkeeper, Ossining, NY
4:55 PM	5:00 PM	**Concluding Remarks**
		Carolyn Rodak, MWS Co-chair, Civil and Environmental Engineering, Union College, Schenectady, NY

*The lead or presenting author(s) is(are) listed here; for complete author listings and affiliations please refer to the abstract.

5:00 PM	7:00 PM	***Symposium Reception in College Park Hall Lobby, 5:00 - 7:00 PM***

Poster session (all day)

P1 **Schoharie River Center's Community Ecology Internship: using stewardship of the Mohawk Watershed to promote job skill development and community advancement**

Annemarie Dooley, Schoharie River Center Inc., Burtonville, NY

P2 **The Schenectady Environmental Education Center: connecting communities, parks and schools through environmental literacy education and neighborhood-based stewardship activities: a progress report, March 2025**

John McKeeby, Schoharie River Center, Inc., Burtonville, NY

P3 **Bringing A Day in the Life to the Mohawk River**

Doug Reed, Community Watershed Organizer

P4 **Using citizen science data to inform avian surveys in the Mohawk and Hudson River watersheds**

Zoe Gliosco, NYS DEC Bureau of Ecosystem Health, Albany, NY

P5 **Mohawk Watershed Enterococcus and E. coli sampling sites time series have different geographic distributions: results of clustering by dynamic time warping**

Juliana Hanle, Riverkeeper, Ossining, NY

P6 **Observations from a decade of monitoring fecal indicator bacteria (enterococci and Escherichia coli) in the Mohawk River Watershed**

Neil Law, SUNY Cobleskill, Cobleskill, NY

P7 **Prevalence of PFAS contaminants in surface water in the Capital Region**

Michael McKenna, Geosciences Department, Union College, Schenectady, NY

P8 **Evaluating NY State's wastewater infrastructure for a healthier future**

Emmett Parkerson, Environmental Science, Policy, and Engineering Program, Union College, Schenectady, NY

P9 **Survey study of presence of cyanotoxins in wadeable stream sites in New York State, US (2017-2021)**

Keleigh Reynolds, NYS DEC, Division of Water, Bureau of Water Assessment and Monitoring, Albany, NY

P10 **Sustaining a Brook Trout stronghold: initiatives in the West Kill**

Steven Swenson, NYS DEC, Bureau of Ecosystem Health, Stamford, NY

P11 **The effect of road salt on benthic macroinvertebrate community health: a comparison of Vermont and New York streams**

Noah Fahey, Environmental Science, Policy, and Engineering Program, Union College, Schenectady, NY

P12 **Sodium and chloride in the lower Mohawk River: implications of imperviousness and urbanization on drinking water sources**

John Garver, MWS Co-chair, Geosciences Department, Union College, Schenectady, NY

P13 **Assessing Neogobius melanostomus (Round Goby) abundance in the Mohawk River and Hudson River using eDNA**

Vivian Tidd, Geosciences Department, Union College, Schenectady, NY

P14 **Diet shifts and spatial growth variation of Round Goby in Schoharie Creek, NY**

Thomas Sadekoski, Department of Fisheries, Wildlife, & Environmental Science, SUNY Cobleskill, Cobleskill, NY

P15 **Investigating antibiotic-resistant genes in Hudson River water samples: implications for environmental health**

Shalini Varma, BCP Department, Hudson Valley Community College. Troy, NY

P16 **Molecular detection of invasive species in the Hudson River using DNA barcoding**

Shalini Varma, BCP Department, Hudson Valley Community College. Troy, NY

P17 **Large scale solar proliferation in the Mohawk River Watershed**

Stephen Helmin, President & Co-Chair, GlenFARMLand, Inc; President, Stop Energy Sprawl

P18 **A smallholder's perspective on a very big issue: managing invasives on the Hudson River shoreline 2010-2023, who pays?**

Barbara J. Heinzen, Landowner, New Baltimore/Coeymans, NY

P19 **X-Snow: A regional citizen-science project for snow**

Margaret Turrin, Lamont-Doherty Earth Observatory, Columbia Climate School, Palisades, NY

P20 **A forensic investigation examining the failure of Edenville and Sanford dams**

Ashraf Ghaly, Civil and Environmental Engineering, Union College, Schenectady, NY

P21 **Some local and global analysis related to CO2 and climate change**

Frank Wicks, Professor Emeritus, Union College, Schenectady, NY

*The lead or presenting author(s) is(are) listed here; for complete author listings and affiliations please refer to the abstract.

Symposium Reception in College Park Hall Lobby, 5:00 - 7:00 PM

Congressman Paul Tonko

NY 20th Congressional District

Congressman Paul D. Tonko is a nine-term member of the U.S. House of Representatives, representing New York's 20th Congressional District in the Capital Region, including most of the lower part of the Mohawk Watershed. Congressman Tonko serves on the Energy and Commerce Committee, the oldest standing committee in the House. He is the Ranking Member of the Energy and Commerce Subcommittee on Environment, Manufacturing, & Critical Materials, and he is a member of the Committee on Science, Space, and Technology.

Late in 2024 Congressman Tonko was instrumental in securing the allocation of $100m to support water and wastewater infrastructure for the Mohawk River and tributaries under the Water Resources Development Act (WRDA). This federal investment for the Mohawk Watershed includes funding for stormwater management, surface water resource protection, environmental restoration, and related infrastructure. This funding is transformative for the Watershed and will allow forward progress for a number of water quality projects.

In 2021, Congressman Tonko introduced the NY-NJ Watershed Protection Act. Early versions of the bill were first introduced as the Hudson-Mohawk River Basin Act of 2012, and that bill was modified and reintroduced to the US House as the Hudson-Mohawk River Basin Act in December 2016 and then in December 2018. The NY-NJ Watershed Protection Act, which was reintroduced in April 2023, grew from these earlier efforts on the Mohawk River.

Congressman Tonko has long been a champion for clean energy and water infrastructure. A priority has been advocating for addressing our aging and broken infrastructure both above and below ground. In December 2024 he marked 50 years of the Safe Drinking Water Act by introducing the AQUA act, legislation that fixes America's drinking water systems. He noted: "*This bill tackles devastating PFAS contamination in our drinking water and helps local communities get their water systems onto more sustainable footing. As we celebrate 50 years of drinking water investments and improvement, let's continue working to rebuild America's infrastructure, removing dangerous contaminants, and creating a strong, healthy, resilient economy for all.*"

We welcome Congressman Tonko back to the Mohawk Watershed Symposium.

UPDATE: Congressman Tonko has had to cancel his scheduled appearance at this year's Symposium.

Salinity tolerance of Round Goby: informing invasion potential in the Hudson River Estuary and adjacent coastal waters

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[3]*Department of Natural Resources and the Environment, Cornell University, Ithaca, NY, in cooperation with the New York State Dept. of Environmental Conservation, Division of Marine Resources, New Paltz, NY 12561*
[4]*Cornell University, Dept. of Animal Science, Cornell University, Ithaca, NY 14850*
[5]*Brooklyn College, Dept. of Earth and Environmental Sciences, Brooklyn, NY 11210*

Background

Round Goby (*Neogobius melanostomus*) is one of the fastest spreading non-native fish species in North America. Since their introduction in the Great Lakes in the 1990s, Round Goby has spread eastward across New York via the Erie Canal and Mohawk River and were first documented in the Hudson River estuary in the summer of 2021. Round Gobies are a small benthic fish that can cause major impacts to ecosystems they invade by outcompeting native species, consuming fish eggs, and are a vector for multiple diseases. Conversely, Round Gobies serve as a food source for many fish species and consume invasive dreissenid mussels. Questions arise as to how far throughout the estuary and connected marine environments Round Goby can spread given the lack of information regarding salinity tolerance of populations in North American coastal watersheds. Here we assessed salinity tolerance of Round Goby through two, temperature dependent, lab-based trial and used the survival results of these trials to develop seasonal invasion risk maps, predicting Round Goby survival throughout the Hudson River Estuary, New York Harbor, and Long Island Sound to inform managers about continued expansion and future invasion risk.

Methods

Salinity tolerance trials. For the first trial, Round Gobies were taken from two distinct locations on the eastward expansion front: Oneida Lake and the Mohawk-Hudson River confluence. Study specimens were held at an energetically optimal temperature of 20°C and subjected to regular salinity increases of 3 ppt per week, concluding at 33 ppt. Round Gobies from only Oneida Lake were used in the second trial due to no significant ($p<0.05$) difference in mortality rate between Mohawk River and Oneida Lake Round Gobies in the first trial. The second trial consisted of tanks held at a 26°C and 5°C, representing temperature extremities expected in the Hudson River watershed to determine whether temperature impacts Round Goby salinity tolerance.

Invasion risk map. The salinity tolerance survival results were applied directly to the watershed under study by incorporating them into a model that predicts survival rate of Round Goby for one-week at any given temperature and salinity combination. To provide a more realistic timeframe for Round Goby to transit through an area or increase the likelihood of long-term survival, we extrapolated the one-week predicted survival to one-month survival. Using historic datasets of benthic temperature and salinity layers in GIS, we mapped seasonal predicted one-month Round Goby survival throughout the Hudson River Estuary, New York-New Jersey Harbor Estuary, and Long Island Sound.

Results and Conclusions

When held at 20°C there was 0% mortality up to 24 ppt salinity, which increased to 17.5% at 27 ppt, 78.5% at 30 ppt, and 100% by 33 ppt (Figure 1). Mortality in the warm water treatment (26°C) occurred earlier than at 20°C with 1% mortality at 21 ppt, and increased to 12% at 24 ppt, 62% at 27 ppt, 93% at 30 ppt, and 100% by 33 ppt. Earlier mortality in the warm water was anticipated as warmer water increases metabolism and osmoregulation rates. We believe experimental fish in the warm water could not meet the energy requirements needed to keep up with the increased physiological demands associated with temperature and salinity stress. In contrast, at 5°C water only 14% mortality occurred throughout the trial, while the remaining Round Gobies persisted at the endpoint salinity of 33 ppt until the experiment concluded. These results indicate that Round Goby may be able to overwinter in high salinity waters, at least temporarily. No control fish died in either the 20°C or 26°C treatment, however there was background mortality in the control tanks at 5°C, resulting in no significant difference between experimental and control tanks in the cold-water treatment.

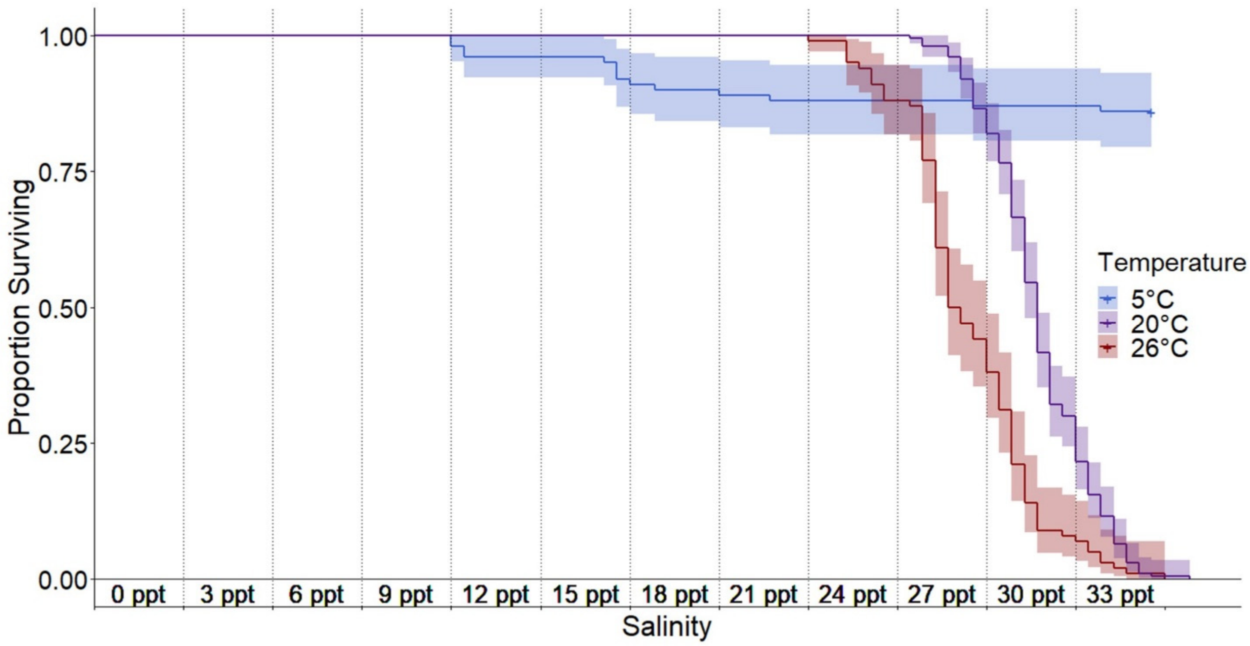

Figure 1: Survival rate of experimental Round Gobies during three temperature-modulated salinity trials.

Seasonal invasion risk maps demonstrate the significance of the interaction between salinity and temperature on Round Goby survival throughout the Hudson River Estuary and connected waters (Figure 2). We predict high survivorship throughout the entire Hudson River Estuary, New York-New Jersey Harbor Estuary, and Long Island Sound in winter and spring when water temperatures are low. With higher water temperatures in summer and fall, predicted survival is lower throughout the study region, with suitable habitats predominately restricted to the Hudson River Estuary, New Jersey waters, and western bays of Long Island Sound; however, summer and fall predicted Round Goby survival is not 0%. In conclusion, we predict Round Goby will be able to survive throughout the entire Hudson River Estuary year-round and if they can transit through the slightly higher saline waters of upper New York Bay then New Jersey waters are also at high risk of invasion year-round. Round Goby may be able to transit higher saline waters throughout Long Island Sound in cooler water temperatures to reach tributaries that will provide reprieve from salt stress as water temperatures increase.

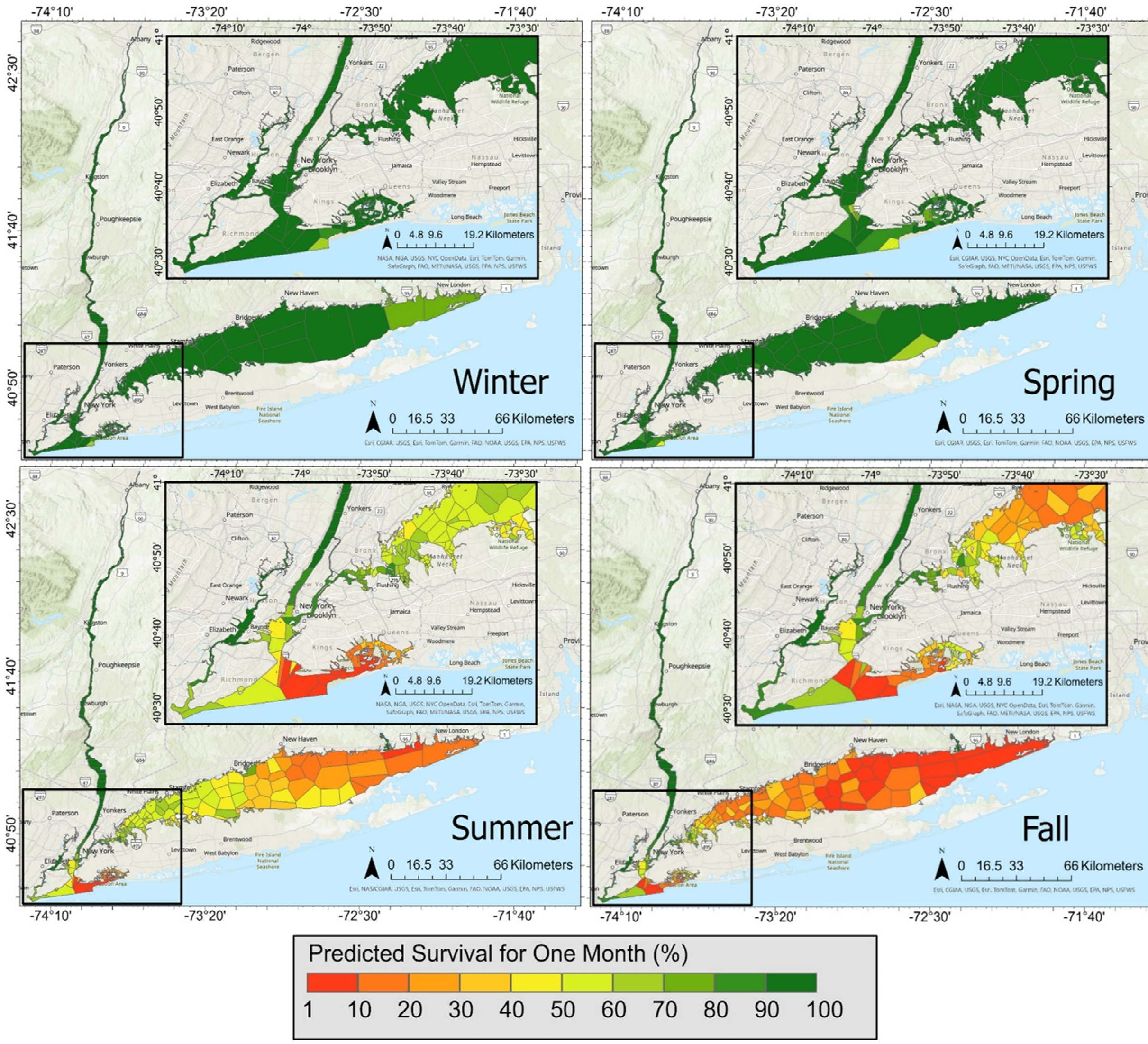

Figure 2. Round Goby *(Neogobius melanostomus*) seasonal invasion risk maps that show the predicted one-month survival rate (%) for adult Round Goby given temperature and salinity conditions in the Hudson River Estuary and adjacent coastal waters

Range expansion and establishment of Round Goby throughout North American coastal watersheds is not only dependent on adult survival. Future experiments are needed to examine the ability of Round Goby, sourced from this invasion front, to successfully reproduce at varying salinity levels, and examine the viability of early life stages in these waters. This information would fill a crucial knowledge gap to inform establishment potential of Round Goby in brackish and marine waters in North America.

Protecting public drinking water in the Mohawk Watershed with the Drinking Water Source Protection Program (DWSP2)

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Introduction

DWSP2 is a locally led, state-supported program that empowers municipalities to take action to improve and protect their public water sources and surrounding environment. Participating communities work with technical assistance (TA) providers to develop and initiate implementation of their unique Drinking Water Source Protection Program, leading to actionable steps each municipality can take to protect their drinking water sources now and into the future. Implementation is a key element of the DWSP2 program, and Mohawk Watershed communities undertaking actions to protect their sources of drinking water will be highlighted.

Background

Since 2019, DWSP2 has worked to help NYS municipalities improve and protect water quality. The program is rooted in several foundational principles that allow participants and program staff to capitalize on their investment in addressing water quality concerns.

Proactive vs. Reactive

- DWSP2's proactive approach helps communities to identify potential contaminant sources that can impact source waters and proactively implement ways to address those threats.

Community Driven

- DWSP2 is a program built for its participants, requiring a municipality or water system owner be the driver of the program. This makes it more likely that the plan will be fully implemented and successful. In addition, every DWSP2 community first forms a stakeholder group during plan development that is reflective of the community and then a program management team (PMT) during the implementation phase to ensure the program remains viable through leadership changes.

Agency Collaboration

- The New York State Department of Environmental Conservation (NYSDEC) and the New York State Department of Health (NYSDOH) each have a role in protecting public drinking water sources and are equal partners in DWSP2, with support from the state's Department of Agriculture and Markets (AGM) and Department of State (DOS). The agencies compliment and leverage off each other's expertise and knowledge, making the program holistic which benefits participating municipalities.

Free Technical Assistance

- One aspect of DWSP2 that we take pride in is offering completely free technical assistance through plan development and initial implementation. At no out-of-pocket cost to the community, DWSP2 participants are paired with at least one of 15 statewide TA providers upon acceptance into the program.

Action-Oriented Implementation

- DWSP2 ensures that the planning effort is put into action by having the technical assistance providers continuing to work with communities after plan completion for 6 –12 months. To launch implementation, municipalities can select up to three priority issues from the DWSP2 plan to implement immediately (e.g., community education and outreach, grant writing and application assistance, or a local law gap analysis). See an example of an implementation activity in the Mohawk Watershed below.

Data Storage and Analysis

- In an effort to continually improve the program, the DWSP2 team is modernizing data collection from participating communities. When launched, this pilot platform that will collect plan data and track implementation progress to build upon the strengths and best understand communities' needs.

Mohawk River Watershed Implementation Spotlight (Ravena)

The Village of Ravena is located in Albany County, NY. The Village participated in the DWSP2 with the intention of protecting their main drinking water source through methods like monitoring, reporting and public education and outreach. Upon state acceptance in 2022, Ravena desired to use their DWSP2 Plan to carry out various implementation activities.

One particular implementation activity Ravena focused on was an Intermunicipal Agreement (IMA). An IMA is a collaboration between two or more municipalities with a shared interest to develop solutions of mutual concern. Instead of drafting a full IMA, Ravena first decided to develop an Intermunicipal Planning Toolbox to outline the benefits of an IMA through a collection of fact sheets, guidelines, and templates. The Toolkit will be used by potential IMA collaborators like water operators, planning boards, and neighboring municipalities to further understand the benefits of entering into an IMA. As the Village prepares to participate in a full IMA, they can expect to enjoy the following benefits:

- Access additional funding sources by forming partnerships across watersheds.
- Build a collaborative atmosphere with partners to benefit water quality improvements.
- Combine municipal resources for cost-effective planning.

DWSP2 in Numbers

DWSP2 is working with 102 municipalities, serves more than 2.5 million water consumers, and evaluated 134 source waters. These metrics will continue to grow as more communities join the program.

Figure 1. Status of DWSP2 in numbers.

Conclusion

DWSP2 will continue making a positive impact on the quality of public drinking water across New York State. The program is committed to increasing awareness and protection of source water throughout the state. By collaborating with program partners and gathering feedback from DWSP2 participants and TA providers through interviews, meetings, and data analysis, DWSP2 strives to adapt to best suit the needs of all parties. The voluntary nature of the program provides municipalities the opportunity to be proactive in the methods used to protect source waters.

Federal funding and advocacy for the Mohawk River

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As New York communities face an urgent need to upgrade aging water and sewer infrastructure—amid an estimated $80 billion investment gap over the next 20 years—securing critical federal funding is essential. Riverkeeper played a pivotal role in the successful passage of the Water Resources Development Act (WRDA) of 2024, an omnibus legislative package authorization over $300 million in the Hudson River Watershed. Through collaboration with a bipartisan group of congressional representatives, Riverkeeper helped establish new authorizations via the Army Corps Environmental Infrastructure Program, including a historic $100 million allocation for the Mohawk River watershed. It is important to understand that an **authorization** is a legislative measure that permits agencies to undertake specific projects or programs, while an **appropriation** is the subsequent process by which Congress actually allocates the money. Even with an authorization in place, the actual funds appropriated may be less than the authorized amount.

Now that WRDA 2024 is law, there is a critical need for citizens to contact their members of Congress to urge them to fully appropriate the $100 million infrastructure and habitat restoration funding for the Mohawk. Equally vital is the ongoing education of congressional members on the unique challenges and needs of the Mohawk River, ensuring that lawmakers remain well-informed. Mohawk River advocates must also work to build robust political support, not only to secure current funding but also to prepare for the next opportunity in WRDA 2026. Collaborative and sustained advocacy will be key to replacing aging sewer pipes, securing drinking water supplies, addressing invasive species, and mitigating flood risks—driving lasting improvements in water quality and resilience across watersheds.

Longitudinal snapshots of nutrients in the Mohawk River show clear and distinct effects of agriculture and sewage effluent

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Understanding controls on Mohawk River water quality is essential for maintaining its use for recreation, sanitation, and drinking water. Although there is consensus that nutrient dynamics are a critical gap in our understanding of the ecology of the Mohawk, there is relatively little data on dissolved nutrients in the river and tributary creeks. Knowledge of nitrogen sources and cycling is particularly sparse. While phosphorus is generally considered the limiting nutrient in freshwater ecosystems, both phosphorus and nitrogen are brought to rivers as a result of human development: treated and untreated sewage are rich in both, as are both urban and agricultural runoff. Furthermore, there is mounting evidence that freshwater nitrogen limitation (or phosphorus-nitrogen co-limitation) occurs more frequently than previously thought, as well as recent research indicating that nitrogen is often an important control on the growth and toxicity of freshwater harmful algal blooms (HABs). Finally, the HAB literature also suggests the type of nitrogen in freshwater is important, with many HAB-forming species preferentially assimilating reduced nitrogen such as ammonium and urea, such that systems where reduced nitrogen is a relatively high fraction of the nutrient load are often more susceptible to toxic blooms.

The relatively high nutrient load of the Mohawk may make this system "primed" for algal blooms if favorable growth conditions materialize, even temporarily. This is a concern for the entire river, but particularly relevant where the river is used as a drinking water source or heavily used for recreation. A greater understanding of nutrient ratios and the cycling of specific nitrogen compounds is a necessary step toward determining potential ecological risks of high nutrient loads in the Mohawk River.

Here, we present data on a wide variety of nitrogen and phosphorus compounds in the Mohawk River system, primarily the western reaches of the river and Oriskany Creek. From May through November 2024, monthly samples were collected in collaboration with the volunteer network organized by Riverkeeper, SUNY Cobleskill, and Union College, providing detailed longitudinal snapshots of nutrient concentrations over time. Our primary objective was to document a suite of dissolved nutrients: nitrate, nitrate, ammonium, urea, phosphate, and total dissolved phosphorus. We also measured concentrations of numerous other dissolved ions, which help determine water sources due to regional geology (reflected by calcium, magnesium, and sulfate) and urbanization (chloride).

Overall, our data indicate the system is nitrate-rich, likely due to the watershed as a whole primarily draining agricultural and forested land. However, there was a clear nutrient signal from the Oneida County Water Pollution Control Plant in Utica, which consistently led to an increase in nitrate that persisted through Herkimer but dissipated before Little Falls. Nitrite, commonly an indicator of nitrification, was elevated in the same region. Additionally, sewage outfalls in both Utica and Herkimer were often sites of elevated ammonium and urea, though these effects were highly localized. Surprisingly, nutrients other than nitrate were typically rather high at the river head (just downstream of the Delta Lake dam), then decreased by the time the upper river mixed with the barge canal in Rome. Across our dataset, reduced nitrogen was typically ~10% of the total nitrogen load, with sporadic spikes to ~30-40%. Despite high nitrate concentrations in this system overall, the ratio of nitrogen to phosphorus was usually quite low, often below the Redfield ratio, a canonical benchmark of phytoplankton nutrient demand (though we note that the cellular nitrogen to phosphorus ratio of algae and cyanobacteria in the Mohawk River is unknown).

These data suggest nitrogen, despite its high availability compared to phosphorus, may be an important driver of overall production in the river. Both agricultural and urban inputs are sustaining elevated concentrations of numerous nitrogen compounds in the Mohawk River, with the potential to stimulate productivity and potentially harmful algae if favorable growth conditions develop.

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Deepening sense of place and water literacy of the Mohawk River Watershed through art, science, and indigenous knowledge

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Overview

Undergraduate field courses foster experiential learning by immersing students in hands-on activities, observations, and discussions within a field setting. The transformative impacts of these field experiences on students' sense of identity and connection to local environments, or sense of place, mirror the effects of an art-making practice. The Mohawk River Valley was selected as the study site for a Cornell Eco-Arts course titled, *The Art and Science of the Mohawk River Valley*, to harness the power of art to bring attention to environmental and cultural concerns in the Valley. This course was designed as a place-based field experience, with three field trips to locations including: the Schoharie River Center, New York Mills Middle School, and Cohoes Falls. At these sites, students are taught to interpret the geographical, environmental, and people's history of the watershed and channel their knowledge and emotions into artwork. The region is further highlighted and critiqued by guest lecturers, including Indigenous storytellers and historians. Final artwork serves to critically engage students with the Mohawk River and further the goals of the Mohawk River Action Agenda, especially through public exhibition. To study the student outcomes following this experience, a pre-post survey was designed and is being administered for a second semester. Thus far, significant increases in sense of place and identity as an artist and scientist were observed, supporting the need for place-based courses in environmental science curricula. By immersing students in regionally specific lectures, readings, and site visits, they grew as environmental stewards and deepened their appreciation for a long-neglected river's history, people, and ecosystem.

Course Background: *The Art and Science of the Mohawk River*

The Art and Science of the Mohawk River was designed as a community-engaged, place-based, interdisciplinary field course in ecology, art and culture. It was taught for the first time in 2024 to ~ 20 junior and senior Cornell undergraduates in the Environment and Sustainability major, fulfilling their "capstone" requirement and desires to incorporate art into their major. The class engages at least 100+ middle school students from the Mohawk Valley, eight eco-artists using rivers as an artistic medium, seven scientists, three Haudenosaunee people, the New York folklorist, two politicians, and twelve organizations involved in the Mohawk River Watershed.

The goals and learning outcomes of the course and artwork were inspired by NY Water Resource Institute's "Action Agenda Goals" to improve the lives and water quality of Mohawk River Watershed Basin including:

- Improve the understanding of social barriers to aquatic restoration; develop tools to inform decision-making processes in communities; and improve outreach and communication practices utilized by resource managers.
- Explore the benefits of and ways of knowing about riparian systems from multiple perspectives, including Traditional Ecological Knowledge, and develop approaches to better communicate those systems.
- Identify how equity concerns intersect with flooding and adaptation.
- Engage with students, communities, and statewide stakeholders to increase water literacy in NY.
- Understand how field experiences improve classroom learning and change student attitudes and behavior towards the environment.

The first quarter of the class is dedicated to interpreting and critiquing examples of ecological art and exploring the history of this unique arts practice. Artists working with rivers as their medium engage with students to jumpstart the artistic inspiration process. During the second quarter of the class, students hear from a range of water scientists from a variety of organizations from American Rivers to the Department of Environmental Conservation. Once the students have a foundation in art and science, they travel to the Mohawk Valley for the field component of the course, to engage with river-based communities.

For example, partnering with the Onondaga Environmental Institute, we engage with the New York Mills Middle School seventh grade science classes who spend time studying the Sauquoit creek, a dominant tributary of the Mohawk. Creekside, Cornell students sat with groups of ~5-7 middle school students who had prepared presentations using paper slides containing information and drawings about their watershed. Following student presentations, we sampled the creek for macroinvertebrates and water quality before contributing messages and drawings to a community art project: a 15ft canoe that would be paddled down the Mohawk River and displayed for lawmakers. This experience was mutually rewarding for Cornell and NY Mills students, having both made meaningful contributions to stream monitoring and environmental advocacy.

Another field trip was to the Mohawk Valley Youth Climate Summit at the Oneida-Herkimer-Madison BOCES. This was a free event for 7-12th graders organized by the Onondaga Environmental Institute. Once again, Cornell students solicited "messages for the Mohawk” to promote place-based environmental awareness.

Art and Science of the Mohawk River students also engaged with several Indigenous people from the Mohawk Valley. Tom Porter, a spiritual leader who founded the Kanatsiohareke Mohawk community in Fonda, NY, shared his wisdom with the class. Kay Olan, a Mohawk storyteller, met the students at the Amsterdam Castle to pass on Haudenosaunee tales about the river. Finally, students joined Hickory Edwards on a canoe trip down the river, while Hickory used canoeing as a form of teaching about his ancestral waterways.

Finally, students attended the Mohawk Watershed Symposium, where we set up an artmaking station, drawing curious eyes and sparking conversation with scientists and politicians, many of whom contributed messages to the canoe project. For many of the students it was their first scientific conference, and they began recognizing the significance of the course in the context of upstate New York politics and cutting-edge science.

The final portion of the class was dedicated to the conception, production and exhibition of artwork that was inspired by each of these experiences. The resulting art projects were displayed in three exhibitions around the state. The first exhibition, “Connected Waterways” took place at the Schoharie River Center in Esperance, NY, in the Watershed that inspired the projects. Several visitors who viewed the students’ artwork at the Schoharie River Center said the exhibition “was a gift,” it sent a “powerful message” and was “extremely informative.”

The second exhibition was in the Concourse of the State Capitol in Albany. Over three days, Davidson paddled the Canoe down the Mohawk and Hudson Rivers to deliver community-sourced messages to the lawmakers as a performance art piece. The final exhibition took place on Cornell’s campus, at Mann Library, to make the artwork and messages accessible for students.

a. b. c.

Figure 1a-c. a) Mohawk storyteller Kay Olan telling the tale of the great peacemaker uniting the Haudenosaunee confederacy. b) Cornell class uses art to engage with high school students at the Mohawk Valley Youth Climate Summit. c) Class Art exhibition at the Schoharie River Center.

Research Background & Methods

Cornell University students from two "eco-arts" classes, or environmental field classes with a major art focus (*Art and Science of the Mohawk River* and *Earth Projects*), were asked to participate in Likert-type pre-class and post-class surveys on the value and impact of integrating the arts into environmental field courses. *Earth Projects* (ENVS 3200) is an interdisciplinary community-engaged place-based field course focused on four fieldtrips (two of them weekend-long) to various locations including Lake Oneida, Arnot Forest, Cascadilla Solar Facility, and a rural organic sheep farm outside Spencer, NY. *The Art and Science of the Mohawk River* (ENVS 4700) focuses on the Mohawk River Valley specifically and includes overnight fieldtrips. Both are community engaged learning classes, and both conclude in public art exhibitions. A traditional field biology (*Field Biology*) course containing no art was included as a comparison group. Upon completion of the class, semi-structured interviews were conducted from a sample of students from each class.

Preliminary analysis

Our preliminary analysis revealed that incorporating methods in the arts into environmental field courses significantly increases students' identity as both artists *and* scientists in addition to significantly increasing their sense of belonging to each discipline (Figure 2). Additionally, 100% of ecoarts students feel that adding art to an environmental field experience has enriched their education, 100% feel a deeper connection to their peers as a result of this class format, and 90% feel this course had a positive effect on their mental health.

These findings prompted the question, how does integrating art into a place-based field course affect a student's sense of place? Sense of place is defined as the living ecological relationship between a person and a place including physical, biological, social, cultural and other factors (Kincheloe et al., 2006). Sense of Place is made up of two components, *place attachment*, the bond between people and places, or the degree to which a place is important to people (Jorgensen and Stedman 2001; Low and Altman 1992; Stedman 2003b) and *place meaning*, symbolic meanings that people ascribe to settings. Empirical research has demonstrated significant correlations between place attachment and pro-environmental behavior (Vaske and Korbin, 2010). How do we encourage emotional connections to natural settings? How do we tap into the deep emotional components of place meaning? We argue that the arts can be harnessed to enhance environmental field courses in ways that help undergraduates develop a lasting sense of place.

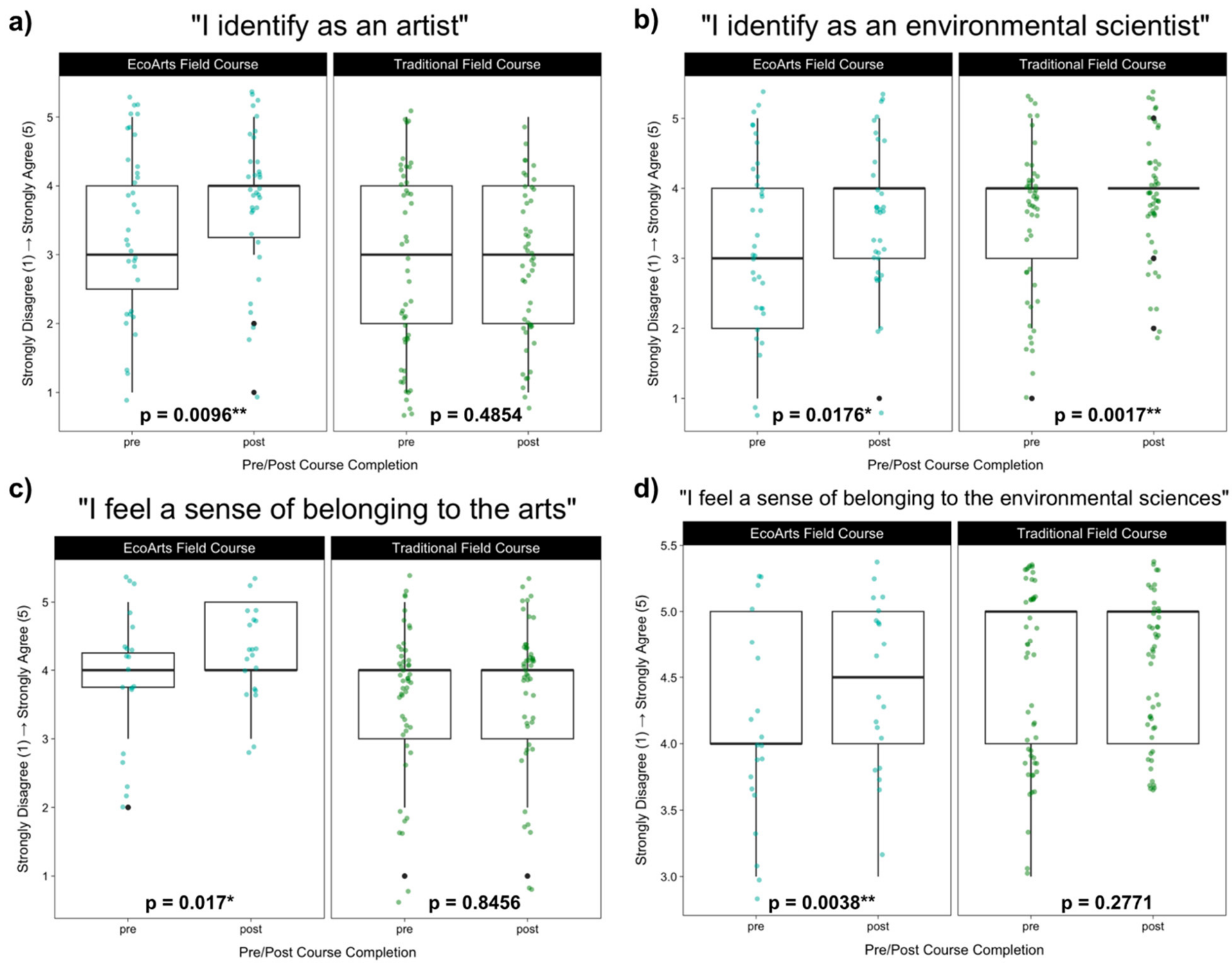

Figure 2a-d. Comparison of response distributions for individual survey items pre-course and post-course between an Eco-Arts Field Course (*Earth Projects*) and a Traditional Field Course (*Field Biology*).

Creative community-engaged exercises in the ecological arts when blended with traditional environmental field lessons, can add texture to a local environment that once seemed flat and void of meaning. In only half a semester, students report a significant increase in sense of art and science identity, belonging, and place attachment (Figure 2), challenging the traditionally held belief that a sense of place only develops after many years (Tuan, 1974). This current study focuses on how these interdisciplinary methods can strengthen a sense of place and pro-environmental behaviors when incorporated into environmental field courses. It will lay the groundwork for future research exploring how these courses can lead to lasting environmental stewardship, mental health benefits, and a renewed passion for students' academic pursuits.

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Schoharie River Center's Community Ecology Internship: using stewardship of the Mohawk Watershed to promote job skill development and community advancement

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Starting in July 2024, the Schoharie River Center (SRC) partnered with Schenectady Job Training Agency (SJTA) to develop a 6-week long summer internship program for Schenectady High School students centered around career development, academic enrichment, and job skills training through experiential learning outdoors. Six students, aged 14-18, participated in the program based out of Central Park, Schenectady, where they explored the fields of Community Ecology, Urban Ecology/Aquatic Biology, and Community/Cultural Documentation. Summer youth employees investigated these topics through place-based learning within their local watershed, learning the connectivity of water within their city as it relates to their drinking water. They received formal training from environmental scientists, counselors, and educators, learning the skills to investigate and develop awareness of the Mohawk Watershed, as outlined in the targeted actions recommended in NYS DEC Mohawk River Basin Action Agenda for 2021-2026 to promote community-based environmental education.

The program extended into Schenectady parks such as Vale, Woodlawn/Schenectady Pine Barrens, Great Flats Aquifer, and Lock 8 on the Mohawk River, where they tested and documented local water quality conditions, performed ecological assessments of plants and wildlife, completed plastic surveys, and learned media skills to further document their research. Interns developed field study skills while generating baseline assessments of water quality at each of the sites. Interns also learned to utilize public spaces such as local parks to share their research within their community and involve community members in the study local water quality of ponds and streams within the parks. Alongside hands-on research and data collection, students received counseling in generic vocational and career skills, such as the importance of prompt and on-time attendance at work, proper attitude display, and the use of appropriate language and communication skills with co-workers, supervisors and the public.

The internship extended into the calendar school year, with interns participating in Environmental Study Team (EST) meetings with the SRC, connecting students from across the greater Mohawk River region. EST is an organization of high school students, meeting every other Sunday, who explore ways to improve the local environment, enjoy the outdoors through seasonal recreation, and instill a sense of environmental awareness in the community. Through this participation, interns continued expanding their community ecology skills development within the greater Mohawk Watershed, expanding their knowledge and research beyond urban community settings.

Interns continued to develop their environmental education and outreach skills, by working with environmental educators in the SRC's after-school environmental literacy program. They learned how to engage students ranging from elementary, middle, and high school within Schenectady City School District. Interns participated in the first "Day in the Life of a Mohawk River". Interns are also actively involved in a collaboration with Lamont-Doherty researchers at Columbia University and NASA, called X-Snow. The Community Ecology Internship program will continue into the upcoming summer, fostering the development of greater student and public awareness of the Mohawk River watershed utilizing Schenectady City parks as outdoor classrooms and settings for community outreach.

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What goes up must come down: assessing the fate of Blueback Herring spawning in the Mohawk River

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Introduction

The management of anadromous fishes is inherently complicated as this suite of species exhibit complex life histories in multiple habitats and are subject to varying natural and anthropogenic influences during discrete ontogenetic periods. Fishery scientists and managers have utilized acoustic telemetry studies to help understand spatial distributions and residence time during spawning events, as well as to assess the impacts of barriers to migration such as dams and other anthropogenic impediments. In this study, we utilized acoustic telemetry to better understand the survival and distribution of Blueback Herring spawning in the Hudson River Estuary Complex including the Mohawk River.

Our goals were to 1) estimate differences in survival rates of Blueback Herring that spawn in the novel habitat of the Mohawk River relative to those that spawn in Hudson River and 2) determine the proportion of Hudson River Blueback Herring that select this novel habitat for spawning. Simulation models developed in Stich et al. (2024) reported that with a minimum 80% upstream and downstream survival of adult and juvenile Blueback Herring and at least a 25% of the population using the Mohawk River for spawning, access to the historically unavailable habitat in the Mohawk River could increase population abundance. The empirical data collected in this study will allow us to refine the simulation models and evaluate the likelihood that access to this novel spawning habitat confers increased population abundance.

Methods

We tagged a total of 134 fish with Innovsea V7-4x coded transmitters at four general locations: Haverstraw Bay (RKM 57; n=50), Federal Dam in Troy (RKM 244; n=16), Waterford, NY (RKM 249; n=24) and the Mohawk River at Locks 10, 14 and 15 (RKM 56; n=30, RKM 98; n=11, and RKM 103; n=3, respectively). Fish were captured using drift gillnets, boat electrofishing and hook and line. Transmitters were either inserted gastrically via insertion down the throat into the stomach cavity or surgically into the peritoneal cavity through a 5-mm incision directly anterior to the vent. Acoustically tagged fish were detected on an extensive array consisting of 68 acoustic receivers in the Hudson River proper spanning from the New York Harbor to below Lock C1 in the upper Hudson River. An additional 25 receivers were deployed in the Mohawk River from the confluence with the upper Hudson River to above Lock 15 near Fort Plain, NY. Receivers were deployed from early April to mid-September 2024 and collected nearly 417,000 total detections within the Hudson and Mohawk rivers. We received an additional 1000 detections from other coastal arrays along the Atlantic coast spanning from the Gulf of Maine to the mouth of the Chesapeake Bay.

Results and Conclusions

After removing individuals that were lost during the study due to presumed tagging mortality, tag expulsion or immediate emigration following tagging events, we found differences in survival between Hudson and Mohawk tagged individuals representing survival rates of 84% and 8%, respectively

(Figure 1). Only 3 out of 37 individuals tagged in the Mohawk River successfully emigrated back to the Hudson River (Figure 2). Of those three, only one individual successfully returned to marine waters. Preliminary results indicate that Blueback Herring that utilize the Mohawk River to spawn are experiencing significantly lower survival rates than fish spawning in the main-stem Hudson River ($Z = -4.882$, p-value = 1.05e-06).

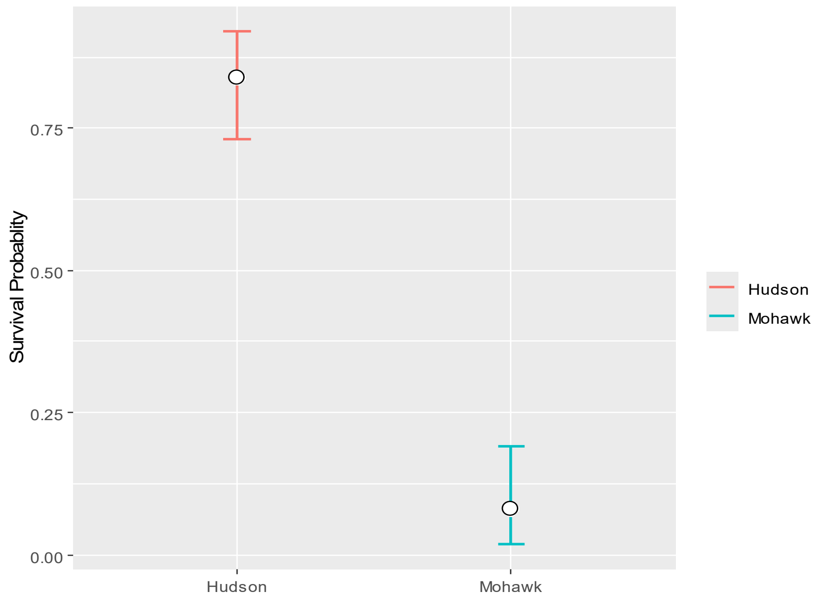

Figure 1. Estimated survival probabilities of Blueback Herring acoustically tagged in the Hudson and Mohawk Rivers. Error bars are 95% confidence intervals.

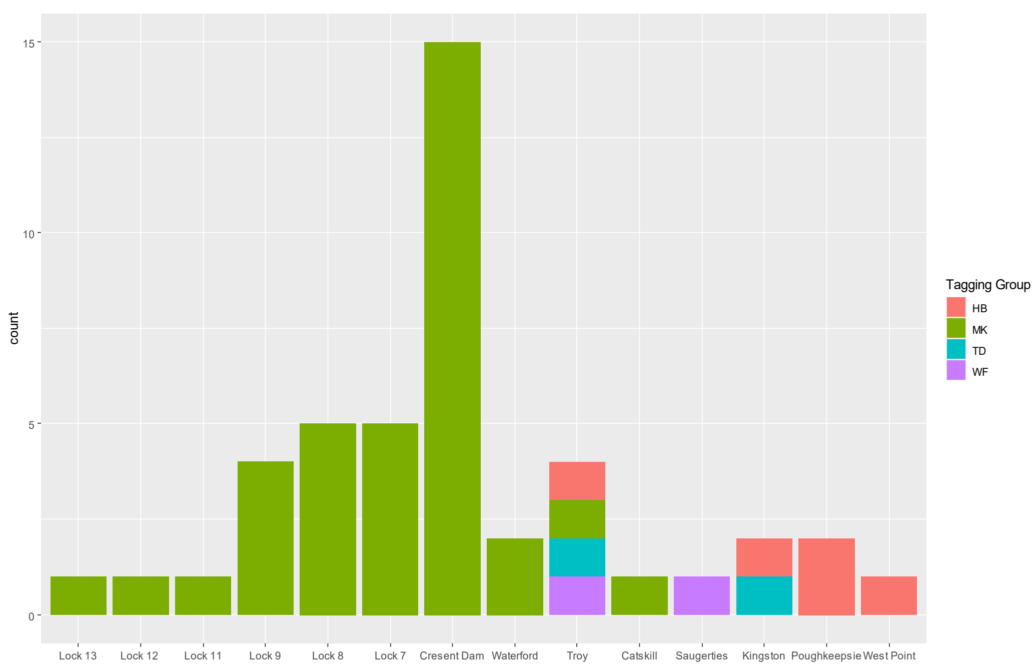

Figure 2. Last detection locations and presumed mortality locations of acoustically tagged Blueback Herring. Tagging Group indicates tagging location. HB=Haverstraw Bay, MK= Mohawk River, TD=Troy Dam, WF=Waterford.

Of 23 fish tagged in Haverstraw Bay, only one entered the Mohawk River. This suggests that only 4.3% of Blueback Herring entering the Hudson River Estuary Complex are using the Mohawk River to spawn. However, further studies are needed to corroborate the validity of these observed proportions.

Further analysis is currently underway to better characterize the observed differences in survival between Blueback Herring spawning in the Hudson and Mohawk rivers. However, we hypothesize the low survival of Mohawk tagged individuals can be largely attributed to the many dams and locks associated with the complex canal infrastructure which is largely absent in the lower Hudson River. Lastly, preliminary results should prompt fishery managers to re-evaluate current management strategies regarding Blueback Herring access to the Mohawk River.

The effect of road salt on benthic macroinvertebrate community health: a comparison of Vermont and New York streams

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Introduction

In 2023 the State of New York applied more than 600,000 tons of dry sodium chloride (NaCl) road salt, the highest amount in the United States (Annual Survey, 2025). In the inland Northeastern United States this road salt washes away from impervious surfaces and enters streams and rivers (Cary institute, 2024). There is an extensive body of existing scientific work showing the negative effects of chloride pollution on drinking water quality, human infrastructure, and on fish and amphibian health. Nonetheless, there has been little investigation into the extent in which New York's abnormally high use of road salt is affecting the health of the base of the freshwater food web. Benthic macroinvertebrates, aquatic insects who feed on the bottom of stream beds, are key biological indicators for overall stream health. Benthic macroinvertebrates serve two key ecological functions. First, many invertebrates feed on and break down plant matter which enters streams. This function is a key component of nitrogen, phosphorus, and carbon cycles and maintains high water quality (Cao et al, 2018). Invertebrates are also a primary food source for many fish, amphibians, and birds (King County, 2024).

A large threat these invertebrates face, particularly the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT), is their low tolerance to dissolved chloride. Exposure to high amounts of chloride can cause invertebrates physiological stress, death, or to shift their ecological niche (Timpano et al, 2018). For these reasons benthic macroinvertebrate community metrics are commonly used as indicators for overall stream health. Preserving the health of these small organisms is crucial. A decrease in their abundance and diversity could lead to an ecosystem collapse in which fish and birds are starved and our streams no longer provide key ecosystem services. Road salt usage in New York is likely affecting the diversity and abundance of benthic macroinvertebrates, with important implications for ecosystem health. Documenting the impact of road salt on benthic invertebrate communities is key for watershed conversation, including setting data-informed recommendations for standards and limits on pollution concentrations in freshwater ecosystems.

Methods

To assess the extent in which extensive road salt use in New York State is affecting stream health we compared the health of 12 streams in two states, 6 in Vermont and 6 in New York. Vermont was chosen as a reference state because there is some road salt use in the winter however, because it is much more rural, they use much less than New York. Over the past 5 years New York has led the country using on average 936,916 tons of dry salt a year whereas Vermont has used an average of 138,397 tons of dry salt a year (Annual Survey, 2025). We selected our streams based on how urbanized the proximal land was and attempted to create a gradient of road salt use and chloride concentrations.

We collected three types of data: benthic macroinvertebrate data, stream attribute data, and ion concentration data. All data were collected in the summer between 6/1/2024 and 8/12/2024 to account for seasonality. To collect benthic macroinvertebrates we used the D-net kick sampling method (a standard method) to gather 3 invertebrate samples in riffles at each site, for a total of 48 samples, 24 from each state. Samples were stored in 70% ethanol and kept refrigerated. Benthic invertebrates within each sample

Rodak, C.M., Garver, J.I., Smith, J.A. 2025. Proceedings of the 2025 Mohawk Watershed Symposium, Union College, Schenectady, NY, March 21, 2025, Volume 15, 89 pages.

were then identified to the lowest taxonomic unit and counted under microscope. Invertebrate sample processing is ongoing.

Filtered water samples were also collected at the same 12 streams and were stored in the fridge over the summer to prevent degradation. Water samples were then run using an ion chromatograph to determine the concentration of various ions in each stream. Stream attribute data including stream width, depth, velocity, water temperature, elevation, dissolved oxygen content, population of nearest city or town, and tree cover were also collected at each site as well.

Results

We succeeded in creating a gradient of streams with increasing chloride concentrations that features Vermont on the low end and New York on the high end with a slight overlap (Figure 1). Additionally, two of the sites in New York had chloride values above the level which Environment and Climate Change Canada (ECCC) has determined chronic exposure to chloride is harmful to invertebrates (Figure 1). There is a strong positive relationship between the population of the nearest city and town and chloride concentrations (Figure 3). Preliminary analysis of the invertebrate data demonstrates a negative relationship between chloride concentrations and both Shannon's diversity index and species richness (Figures 4 & 5). Preliminary invertebrate data also shows that EPT abundance generally has a negative relationship with chloride concentration (Figure 6).

Discussion

We confirm that higher road salt use in New York compared to Vermont resulted in notably higher chloride concentrations in New York streams in summer 2024, a particularly dry summer. Additionally, chloride concentration is strongly correlated with higher populations in the nearest town or city, which implies that an increase in dissolved chloride is a direct result of human activity including increased infrastructure and road salt use.

Our preliminary data and other scientific work indicate that chloride has a negative effect on invertebrate community health, reducing the species diversity and lowering the abundance of taxa such as Ephemeroptera, Plecoptera, and Trichoptera. There could be many implications for overall freshwater ecosystem health if invertebrate community dynamics shift with the increasing amounts of road salt. The invertebrates are a low point in the food chain, which support fish, birds, and many other organisms. The invertebrates are also the first line for detritus breakdown, so a shift decreasing the number of detritus consuming invertebrates could increase the amount of allochthonous matter in freshwater streams which could disturb nutrient cycling and water quality. Overall, the loss of invertebrate diversity and abundance could cause an ecosystem collapse. With more data processing we hope to establish a data informed chloride limit which could be implemented in stream conservation in New York to reduce the impact of road salt on our aquatic ecosystems.

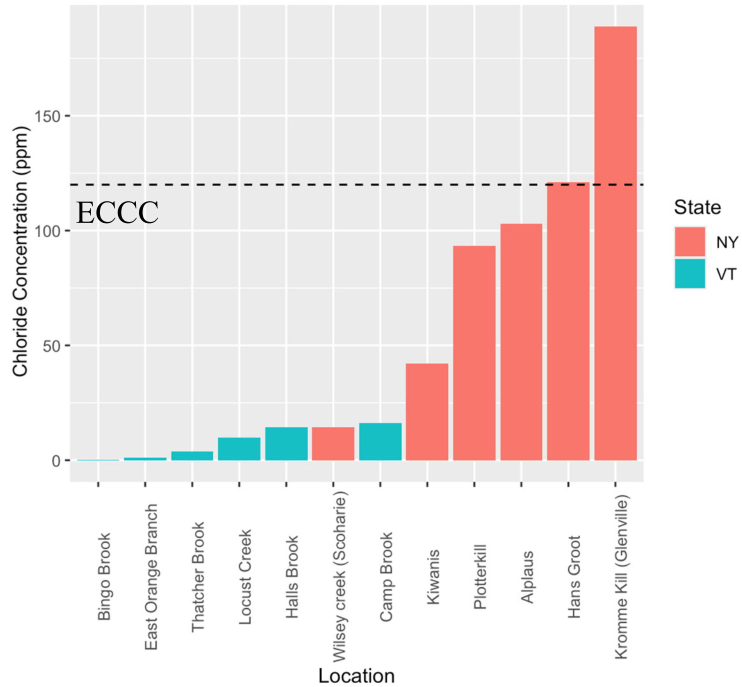

Figure 1: Bar plot of the **chloride** concentrations recorded at each site sampled (n=12). Colors indicate whether the sample was taken in Vermont (blue) or New York (red). The concentration of chloride designated by the ECCC (Environment and Climate Change Canada) at which chronic exposure to chloride is harmful to invertebrates is marked by the dashed black line. All data were collected in the summer of 2024.

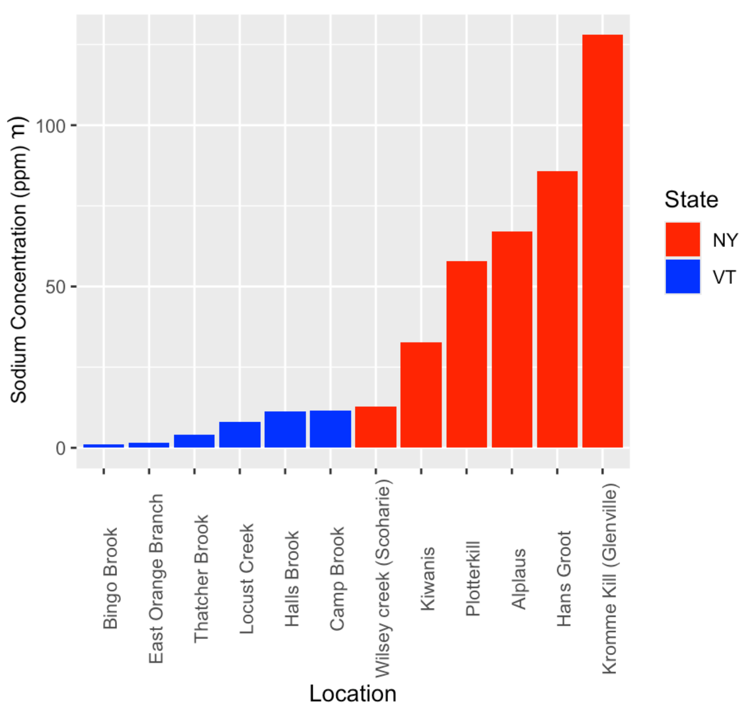

Figure 2: Bar plot of the **sodium** concentrations recorded at each site sampled (n=12). Colors indicate whether the sample was taken in Vermont (blue) or New York (red). All data were collected in the summer of 2024.

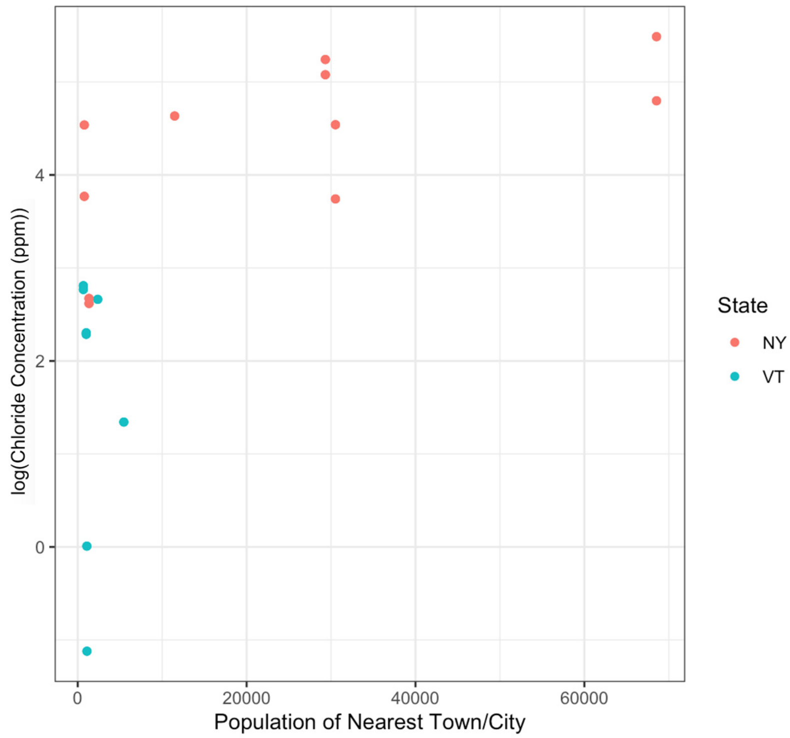

Figure 3: Scatter plot of the log transformed chloride concentration at each site and their respective nearest town or city's population (n=12). Colors indicate whether the sample was taken in Vermont (blue) or New York (red). All data were collected in the summer of 2024.

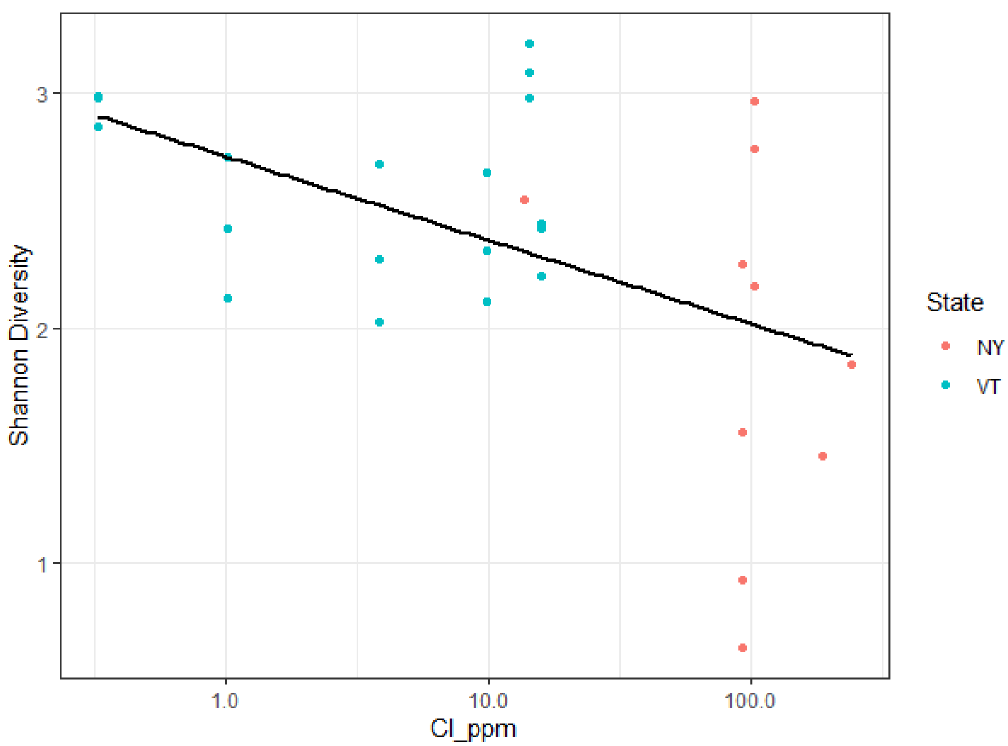

Figure 4: Scatter plot of the chloride concentration and Shannon's diversity index of each sample (n=27 samples across 12 streams). Colors indicate whether the sample was taken in Vermont (blue) or New York (red). All data were collected in the summer of 2024.

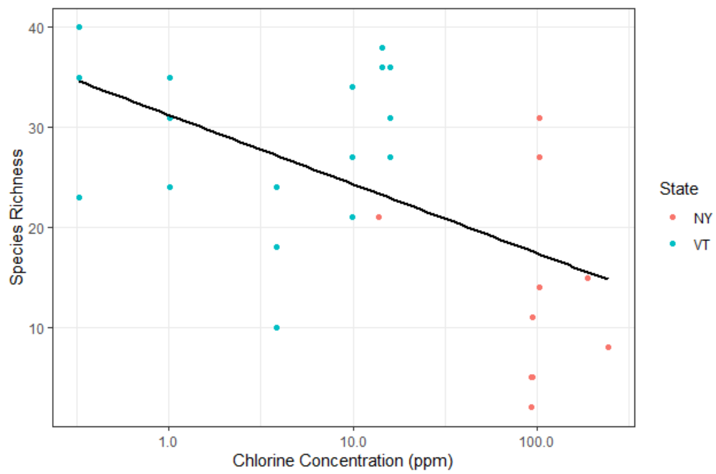

Figure 5: Scatter plot of the chloride concentration and species richness of each sample (n=27 samples across 12 streams). Colors indicate whether the sample was taken in Vermont (blue) or New York (red). All data were collected in the summer of 2024.

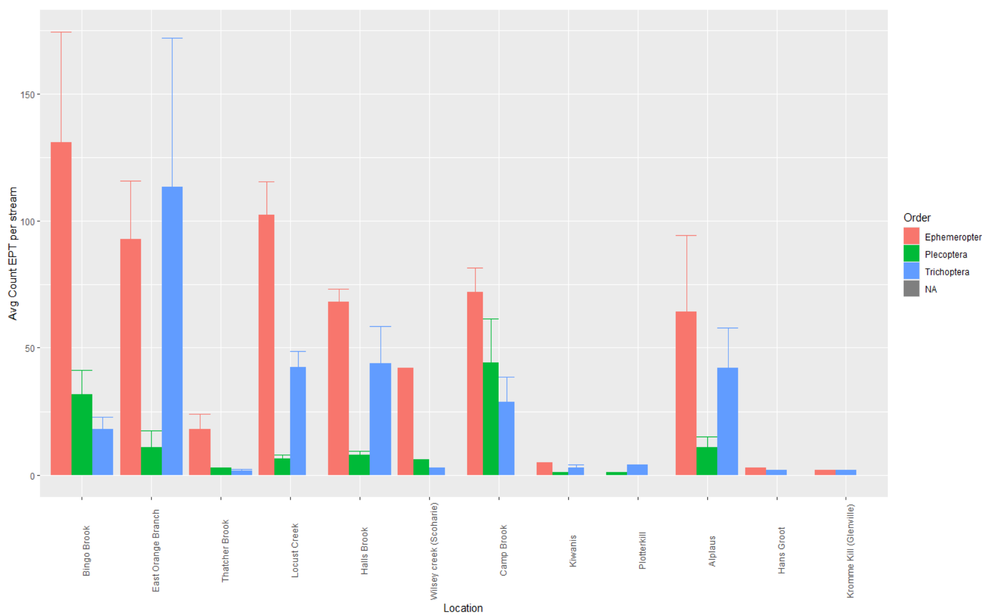

Figure 6: Bar plot of the average abundance of the orders Ephemeroptera (red), Plecoptera (green), and Trichoptera (blue) at each site. Error bars represent standard error across the three invertebrate samples per stream. Sites increase by chloride concentration across the x-axis. All data were collected in the summer of 2024.

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Leave it to beavers: the expanding role of Nature's engineers in the Mohawk Watershed

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Could beavers play a central role in flood mitigation and climate resilience in the Mohawk Watershed? Historically, we have had a complex relationship with beavers, but perhaps we need to recognize their potential as "eco-engineers" that can mitigate the effects of climate change in watershed hydrology [1]. Beavers build dams and wetlands that slow water flow and capture sediment, and thousands of these dam complexes across the Watershed can reduce the impact of flooding and improve water quality. In fact, they may already have a major impact. Given the good they can do, these furry rodents may soon be key players in watershed management in the Mohawk and other watersheds in the Northeast.

Should we be including beavers and the wetlands they construct in climate adaptation plans in NY and the Northeast? If we modify our current strategy, we can partner with beavers to trap sediment, sequester carbon, reduce peak flooding, and provide wetlands that support biodiversity. Industrious beavers and the dams they build may be central to climate action plans focused on maintaining freshwater ecosystems [2]. However, in the recently released Scoping Plan by the NYS Climate Action Council, beavers and bio-engineered wetlands receive no mention [3].

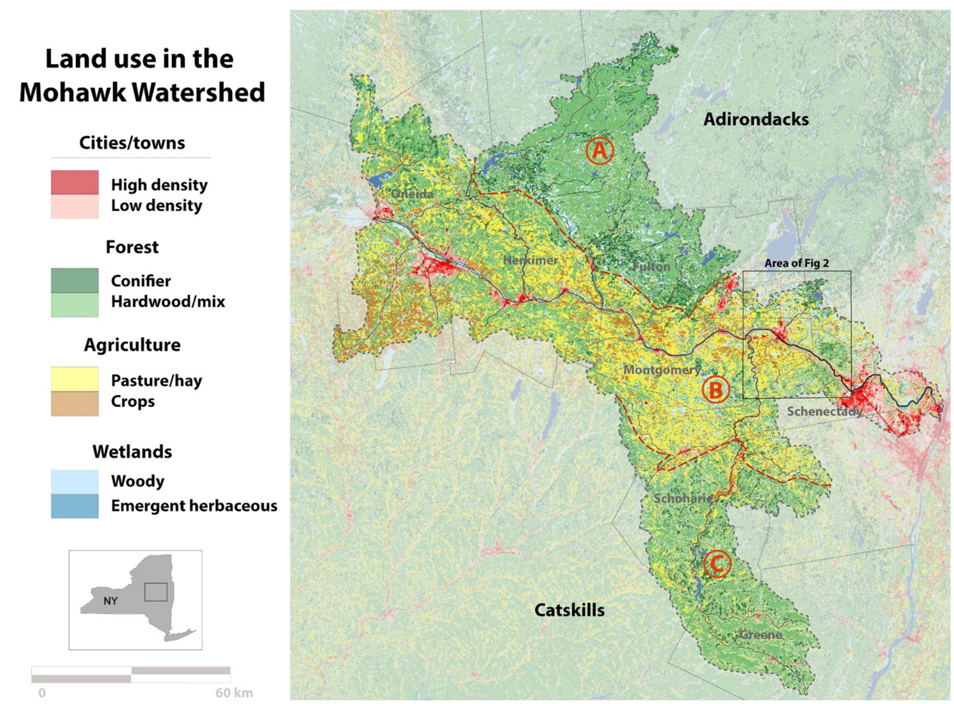

Figure 1. Land use in the Mohawk watershed simplified from the National Land Use Database (see [4]). For practical purposes we can divide the watershed into three primary ecozones: A - Adirondacks, B - Mohawk Lowlands, and C - Catskills. Recent land use changes in the Mohawk Lowlands can be assessed using the National Land Cover Database (NLCD) from the MRLC Consortium. The most significant changes have occurred in the Mohawk Lowlands (B in figure), which is ~2/3 of the watershed. Comparing land-use data from 2001 to 2019, developed land increased by 18%. In rural areas, fallow farmland has reverted to forests and wetlands. Shrub/grassland decreased by 77%, offset by an 8% increase in forest cover and a 34% increase in wetlands. Wetlands expanded from ~332 to ~444 square miles, and this increase is linked to beaver activity [4].

Encouraging beavers to build more wetlands could offer sustainable solutions in response to extreme precipitation and drought - the weather whiplash we have seen over the past few years. While complex, this approach is gaining traction in other watersheds [1,2,6]. These industrious animals and their dam complexes could become central to climate action strategies aimed at preserving freshwater ecosystems and managing the effects of climate change [3].

The last century has been relatively good for beavers in New York State, largely due to careful management by the State [5]. However, this may be changing. Since the early twentieth century, legal protection was established, beavers were reintroduced and actively managed, and populations have made a remarkable comeback. The success of NY beavers and the collapse of the global fur market starting in ~1990 effectively put beavers on a new trajectory: numbers continue to grow and human-beaver conflict has increased. NYS formerly tracked the fur harvest through sealed pelts, but this stopped in 2010, and wildlife management units have been reduced to two [5]. This is happening in a time of extraordinary change in the Watershed, so perhaps we need a broader view of the role that beavers may play in climate adaptation.

Given this background, it seems like a good time to evaluate nature-based solutions to watershed management and the role that beavers may play in climate adaptation [6]. However, we have limited data on the number of beavers, beaver dams, and total area of wetlands supported by beaver efforts. This paper is an attempt to determine beaver dam density in part of the Mohawk Watershed as a first step in trying to understand the impact that their dams have on watershed hydrology. Dams were counted using images from ~1996 and ~2022, thus these data show the change in dam-building over the last ~25 years.

TABLE 1: Beaver dams in sub-watersheds

	Area			Woody wetlands		Beaver Dams				
HUC 12 unit	km^2	mi^2	Acres	km^2	%	2022[a]	BVD/Mi^2	1996[b]	BVD/Mi^2	Change
Up Alplaus	59.1	22.8	14,609	12.9	21.8	92	4.0	52	2.3	77%
N Chuctanunda	112.1	43.3	27,708	24.5	21.8	155	3.6	52	1.2	198%
Kayaderosseras	84.9	32.8	20,979	7.9	9.3	85	2.6	12	0.4	608%
Eva's Kill	109.2	42.2	26,994	10.2	9.4	62	1.5	18	0.4	244%
S Chuctanunda	84.0	32.4	20,754	4.6	5.5	20	0.6	10	0.3	100%
Sandsea Kill	82.9	32.0	20,492	2.5	3.1	15	0.5	6	0.2	150%
	532.3	205.5	131,537	63		429	2.1	150	0.7	186%

Note: Area of Woody wetlands from USGS NLDC database (2019); a) counted on satellite images ± 2 yr; b) counted on USGS air photos ± 1 yr.

Methods

Beaver dams were counted in six HUC12 units in the lower part of the Mohawk Watershed (Table 1). Beaver dams were first identified using satellite images taken within two years of 2022; the most useful were those taken in the spring, when deciduous trees are bare. All visibly active dams were counted, regardless of quality or disrepair, thus this count included some dams that were recently breached (several breached in 2020). Beaver dams were then counted on 1995-96 USGS air photos, which are of high quality but lack the clarity of the high-resolution satellite images. The sub-watersheds are in Schenectady, Montgomery, Fulton, and Saratoga counties. Land use is based on the USGS National Land Cover (NLC) database (2019). Using the NLC database, the fraction of Woody Wetlands (WW) was calculated for each subbasin. Trapping mortality in the Watershed was modelled using county-based numbers from the NYS DEC and the NY Fur Trappers association through 2010 and extrapolated to today based on DEC trapper surveys.

Results

In the six sub-basins, 429 beaver dams were counted in an area of ~206 square miles. In that same area only 150 beaver dams were counted in the air photos from 1995-97. The upper Alplaus Kill and North Chuctanunda Creek have both the largest area of Woody Wetlands (according to the NLC database) and the highest beaver dam density. Beaver dam density is lower in basins that are steep (here, steep means slopes >4°) and in farmed areas, especially those with high-quality land underlain by the Utica Shale.

There are two important findings from these data. First is that the number of beaver dams (BVD) has nearly tripled since 1995. The largest apparent change is in the Kayaderosseras (+600%) and the smallest apparent change is in the upper Alplaus Kill (+77%), which is also the sub-basin that has the highest density of beaver dams (here 4.0 BVD/mi^2) among those evaluated. The average change in all the sub-watersheds was +186%. Second, the area of Woody Wetlands in the NLC database is the best predictor of beaver dam density, which is important because it allows for a method of regional extrapolation for dam numbers.

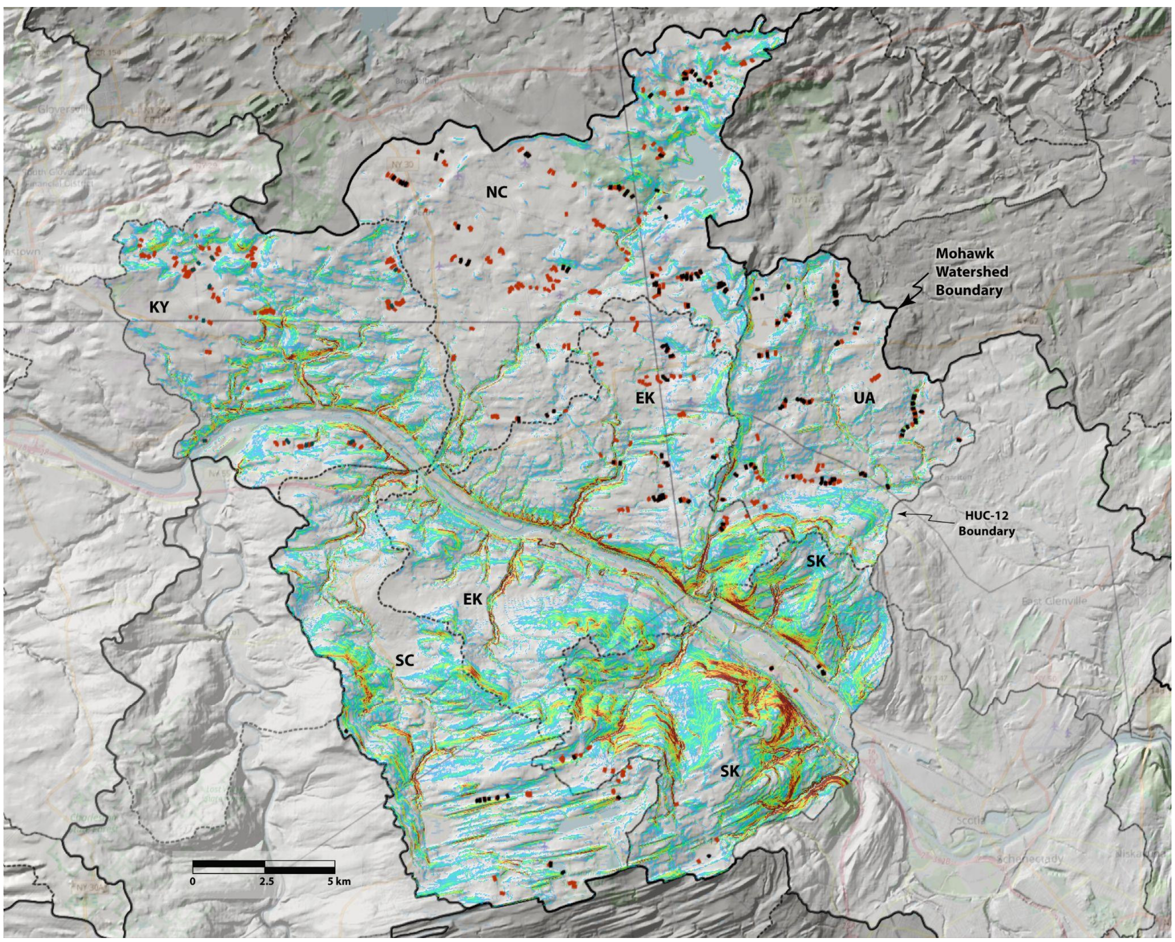

Figure 2. Beaver dams shown on a map indicating slope (in blue-red >4°) and HUC-12 boundaries. Beaver dams in black appear on USGS air photos from 1995-1997, and those in red are active or near active dams counted on 2022-23 satellite images). Virtually all dams in 1995-7 were also occupied in 2022-23, so in this image, areas with red dams but without black dams represent expansion. Beavers prefer gentle slopes and streams with low gradients and the lack of beaver dams in the steep Glenville Hills (SK) is clear. Slope on this map shows terrain greater than 4°, and slope is shown only in sub-basins where beaver dams were counted. Dashed lines are HUC12 basin boundaries delineated from Modelmywatershed.org. Watersheds included: KY- Kayaderosseras, NC- North Chuctanunda, UA- upper Alplaus Kill; SC- South Chuctanunda; EK- Eva's Kill, and SK-Sandsea Kill. Map topography based on NYS 10 m DTM from NYS GIS and the Open Street map from OpenStreetmap.org.

Discussion

Several land use factors influence beaver habitat and its stability. One of the most significant is the presence of suitable topography and low-relief areas, many of which were likely inhabited by beavers before the Beaver Era (c. 1600-1800 AD). Another key factor is the conflict with active farming, where dairy farms, abandoned farmland, and reforestation intersect.

The strong correlation between Woody Wetlands (WW) and beaver dam density (~7 BVD/km² of WW) allows for an extrapolation across the entire Watershed, however imperfect. Based on this approach, the Mohawk Watershed may currently have ~3,620 beaver dams. For comparison, the NYS DEC dam database lists 401 human-built dams in the Watershed [7]. Further research is needed to determine differences in beaver dam density within the Watershed's three primary biozones: the Adirondacks, Mohawk Valley, and Catskills (Fig. 1).

New York is in new territory with respect to beaver management, and we have a major opportunity to capitalize on their industriousness. Four key factors have converged: 1) The number of beavers is increasing; 2) trapping has declined significantly; 3) land use changes favor new beaver habitat; and 4) we need to build resilience into our Watershed. The current management of beavers in NYS *"focuses solely on reducing beaver-human conflict*" and thus New York "*now joins many other states with a similar hands-off management strategy*" [4].

The Mohawk Watershed is experiencing significant hydrological shifts due to climate change. These shifts include more frequent extreme precipitation events, particularly in summer, reduced snow and ice, increased upland erosion, and greater sediment deposition in lowland areas. Given their profound ecological impact, beavers are increasingly being incorporated into climate action plans elsewhere. It may be time to reassess how beavers can be managed, and even encouraged, to enhance resilience in the Watershed. Right now we have a golden opportunity to integrate beavers into climate adaptation strategies and watershed management plans.

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Sodium and chloride in the lower Mohawk River: implications of imperviousness and urbanization on drinking water sources

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New York State leads the nation in road salt use, and its watersheds and drinking water supplies are suffering the consequences. Since the 1950s, chloride levels in the Mohawk River have risen by over 300%, persisting in surface waters year-round, not just in winter (Garver and others, 2023). Heavy road salt application for snow and ice removal has contaminated drinking water sources, and the damage appears to be particularly severe in groundwater. Municipal water supplies serving nearly 250,000 people in Colonie, Cohoes, Glenville, Rotterdam, Schenectady, and Scotia show increasing salt contamination, exceeding public health recommendations for sodium in tap water. In some municipalities that draw water from wells in the Great Flats Aquifer (in the Schenectady area), high chloride levels may be corroding pipes and plumbing, potentially contributing to elevated lead levels (Garver and others, 2023). An overlooked issue is the contribution of road salt runoff from urban areas to the Mohawk River, particularly in the heavily urbanized Capital District, where significant areas may store part of the winter salt load, thus potentially having a year-round effect on municipal water sources.

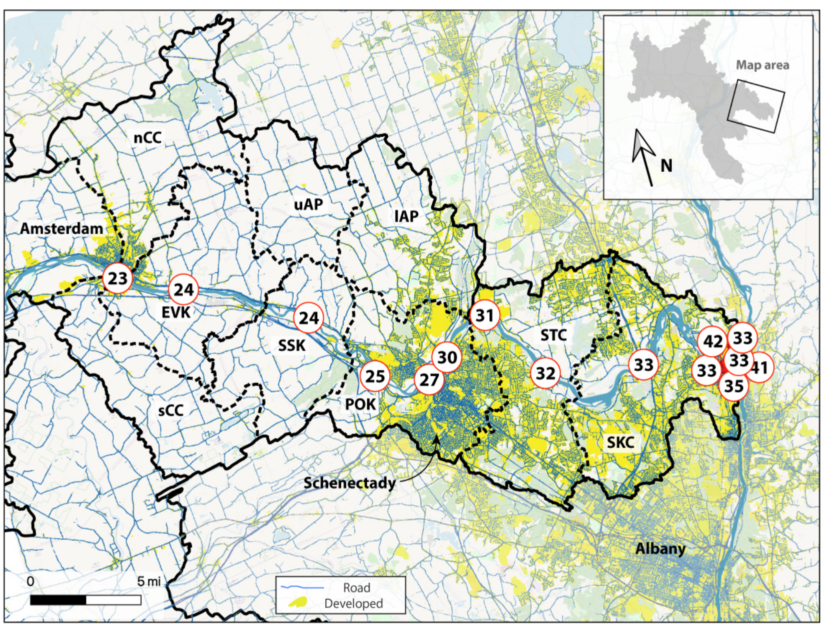

Figure 1: Map with sample locations on the Mohawk River and the boundaries of its watershed. Light blue areas represent road networks and road density, while yellow indicates urbanized regions. The land use data are derived from the National Land Cover Database (NLCD) and they represent an "Impervious Surface" descriptor. This descriptor illustrates the extent of non-permeable surfaces including roads, buildings, and other structures that prevent water infiltration. Also shown are the HUC12 watershed boundaries, which delineate localized drainage areas that contribute runoff to the Mohawk River as it flows through the highly urbanized Capital District region.

Experimental overview. In early October 2024, we conducted a study to assess sodium and chloride concentrations in the lower Mohawk River. Samples were collected nearly simultaneously from 15 locations along the river, from the confluence with the Hudson River to Amsterdam, New York. The goal was to examine the impacts of urban runoff and possible groundwater contributions on water quality in the lower Mohawk, partly to understand the impact on municipal drinking water sources. We collected samples in October, as this is the latest time in the year with minimal influence from winter road salt, allowing the levels of sodium chloride to reflect the baseline contamination in the river. This timing was especially advantageous because the year was dry, minimizing the dilution effect of rainwater. On 6 October the discharge at Cohoes (the USGS stream gage on the lower Mohawk) was ~1000 to 1500 cfs, which is less than half the long-term (100 yr) median discharge (p50) for this site (3260 cfs) (data: USGS Waterwatch). Precipitation recorded in Albany was anomalously low for September and October.

This portion of the river transitions from a largely rural landscape to a predominantly urban environment, where impervious surfaces, including roads and parking lots, are abundant. During the winter, these surfaces receive heavy applications of road salt, which studies show has led to a substantial increase in salt concentrations in the Mohawk over time. We are interested in exploring the effect that this urban transition has on water quality in the Mohawk.

Sodium and chloride in surface waters originate from various anthropogenic sources, including municipal water systems, sewage treatment plants, certain agricultural activities, and road salt used for winter de-icing. Recent studies in New York State and the Northeast have identified road salt as the dominant contributor to sodium and chloride in surface waters in this region (Kaushal and others, 2005). Sodium and chloride behave differently in the environment. Chloride is particularly concerning because it is stable and non-reactive in typical surface water conditions, allowing it to persist and accumulate over time. In contrast, sodium can undergo exchange processes with other anions in groundwater, rivers, and streams, making its environmental behavior more variable. Given the persistence and insidious nature of chloride, our focus is primarily on its concentrations and long-term effects, particularly as it poses significant challenges for drinking water quality and treatment.

Both the Town of Colonie and the City of Cohoes obtain their municipal water from the Mohawk, and elevated chloride levels can be detrimental to drinking water quality for two reasons. First, high levels of sodium and chloride can pose health risks and they are difficult to remove with standard drinking water treatments. While there is no maximum contaminant level (MCL) for chloride, the recommended limit for sodium is 20 mg per liter. High chloride can lead to elevated lead from corrosion of household pipes. Second, elevated chloride levels can interfere with the water treatment process, potentially increasing disinfectant by-products. For these reasons, communities should prioritize raw water sources that have lower sodium and chloride levels, but for most municipalities the levels of Na, and Cl are not under their direct control.

Methods. To assess sodium and chloride in the lower Mohawk River, we conducted a study on 6 October 2024. We collected samples from 15 sites from its confluence with the Hudson River to Amsterdam, a distance of about 38 miles. Samples were filtered and aliquots were run with check standards for major anions and cations using a Dionex Ion Chromatograph at the Geology Department at Union College. To assess the extent of urbanization and the proportion of impervious surfaces, primarily roads, we analyzed land use data using the MRLC dataset within the Model My Watershed platform. These data illustrate the amount of developed land in the HUC-12 subwatersheds of the lower Mohawk River (Table 2).

Results and discussion. Sodium and chloride concentrations in the lower Mohawk River show a marked downstream increase. Upstream of the Stockade area in Schenectady, chloride levels range between 23 and 25 ppm. However, once the river flows past the Stockade and other sites in Schenectady, concentrations rise significantly, reaching 30 ppm and higher. This trend appears to continue past the

Alplaus, which is only lightly developed (~15%), which flows into the Mohawk just upriver from the Rexford sample locality.

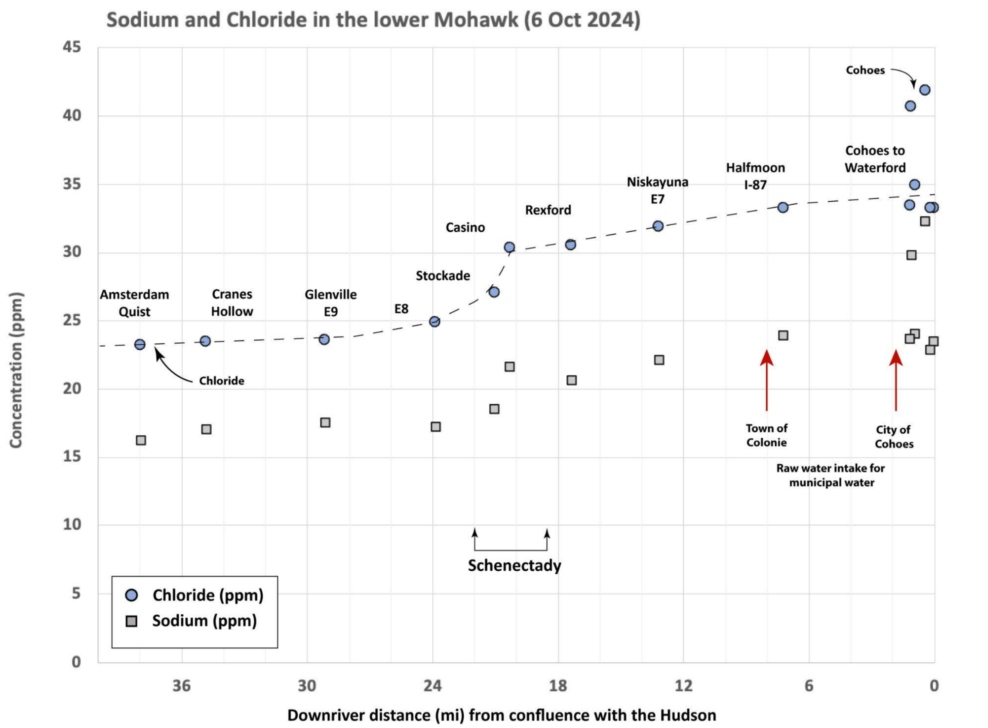

Figure 2: Plot of sodium and chloride concentrations in the lower Mohawk River from October 6, 2024.

This upward trend in chloride concentration continues to the confluence with the Hudson River in Waterford. In the Cohoes area, two samples show chloride levels between 40 and 43 ppm, likely indicating a local source rather than uniformly elevated levels across the river. Specific conductance values of the Mohawk River at Rexford were measured simultaneously at Rexford (HRECOS) and at Cohoes Falls (USGS).

Table 1: Anion and Cation data for samples taken 6 October 2024

			Anions							Cations						
Sample number	River Mile	Location	F^- ppm	Cl^- ppm	NO_2^- ppm	Br^- ppm	NO_3^{2-} ppm	SO_4^{2-} ppm	PO_4^{3-} ppm	Li^+ ppm	Na^+ ppm	NH_4^+ ppm	K^+ ppm	Mg^{2+} ppm	Ca^{2+} ppm	Sr^{2+} ppm
1	0	Waterford Harbor	0.074	33.3	0.086	0.008	2.66	20.5	0.152	0.003	23.4	0.083	1.51	6.93	38.9	0.28
2	0.2	Cohoes- Van Schaick Island	0.076	33.3	0.077	0.014	2.94	23.3	0.062	0.003	22.8	0.043	1.52	7.11	38.3	0.26
3	0.4	Cohoes- Van Schaick Island	0.076	41.8	0.079	0.029	2.77	21.1	1.217	0.003	32.2		1.50	7.42	39.5	0.32
4	0.9	Green Island- Silhouette Boathouse	0.083	34.9	0.078	0.006	2.93	23.0		0.003	24.0	0.106	1.54	7.40	39.6	0.32
5	1.1	Waterford- Tail Race fishing area	0.074	40.7		0.017		22.3	0.329	0.003	29.7		1.53	7.44	39.3	0.33
6	1.13	Cohoes- Launch at New Courtland St	0.077	33.4	0.093	0.010	2.91	22.5	0.085	0.003	23.6	0.084	1.54	7.41	39.9	0.32
7	7.21	Halfmoon- I-87 crossing	0.083	33.3	0.120	0.007	3.02	22.0	0.293	0.003	23.9	0.074	1.54	7.15	40.2	0.31
8	13.14	Niskayuna- Lock 7 boat launch	0.083	31.9	0.177	0.012	2.95	22.0	0.039	0.003	22.1	0.253	1.52	6.82	38.7	0.30
9	17.33	Niskayuna- Aqueduct Park docks	0.076	30.5	0.074	0.018	3.07	21.3	0.082	0.003	20.6	0.032	1.31	6.37	36.2	0.29
10	20.3	Schenectady- Rivers Casino	0.073	30.3	0.025	0.010	2.80	21.0	0.031	0.003	21.6	0.015	1.32	6.84	37.2	0.30
11	21	Schenectady- Union College docks	0.076	27.0	0.008	0.017	2.95	21.2	0.068	0.003	18.5	0.032	1.21	6.19	35.6	0.30
12	23.83	Rotterdam- Lock 8	0.074	24.8	0.027	0.012	2.77	21.2	0.067	0.003	17.2	0.050	1.18	6.13	35.0	0.30
13	29.12	Glenville- Lock 9 boat launch	0.072	23.5	0.048	0.004	2.56	19.3		0.003	17.5	0.309	1.20	6.15	35.8	0.29
14	34.83	Florida- Lock 10 boat launch	0.069	23.5	0.025	0.009	2.77	18.6	0.017	0.003	17.0	0.339	1.17	5.99	34.5	0.27
15	37.95	Amsterdam- Riverlink Park	0.078	23.2	0.020	0.009	3.01	19.4	0.070	0.002	16.2	0.055	1.30	5.85	34.7	0.27

Excluding these outliers from Cohoes, chloride concentration increases from around 24 ppm upstream of Schenectady to ~33 ppm downstream, a ~40% increase. These data, collected during a period of low river flow and limited recent rainfall, suggest a long-term salinization effect linked to urban areas, including groundwater that contributes to the River discharge. Figure 2 also indicates the drinking water intake points for the Town of Colonie and the City of Cohoes, marked by red arrows. These results indicate that, during this period, raw water for both municipalities exceeded 20 ppm sodium, a DOH threshold for individuals on severely restricted sodium diets.

The two outliers from the Cohoes/Waterford area (0.4 mi, and 1.1 mi) are higher than all other samples, and this result may indicate that these sample sites are affected by local runoff and outlet contamination rather than affected by the main flow of the river. The fact that we see this result is an advantage of taking these samples during low flow conditions. Riverkeeper and partners reported fecal indicator bacteria (FIB, here *Enterococcus*) for a subset of these same samples (exact same samples, taken at the same time), and the sample with the highest chloride (~42 ppm at Van Schaick Island at Heartt Ave), had the poorest water quality of all samples reported for that date (2420 mpn/100 ml - Riverkeeper, 2024). The water from this site is also notable because it has elevated bromide and phosphate, which are both associated with sewage (i.e. Garver et al., 2024). This result may indicate that this water is affected by local outfalls, and that the high chloride may be used as a forensic tool during low flow on the Mohawk to locate sources of sewage contamination.

“Developed land” (i.e., urban areas) dominates most small sub-watersheds in the lower Mohawk River (HUC-12). In the land-use classification, “developed land” is categorized as open space, low-density, medium-density, and high-density developed areas. The use of road salt for winter de-icing is strongly correlated with urban density, particularly in low-, medium-, and high-density developed areas (Kaushal et al., 2005). Our analysis shows that once the River passes the Schenectady area, approximately 50% of the land area is classified as developed, a contrast to the significantly lower levels of development upstream (most <10%). This almost certainly reflects the relationship between increasing urbanization, impervious surfaces, and road salt use, which has profound implications for chloride concentrations in surface waters.

Groundwater around the river is contaminated with road salt, and during dry periods it almost certainly contributes to sodium and chloride loading in the Mohawk (Allen and Waller, 1981). Measurements of municipal groundwater water drawn from fluvial sands and gravel adjacent to the River gives us a clue of the severity of salt contamination. Sodium and chloride values reported from groundwater in 2023 annual water quality reports from municipal sources that have a direct connection to the River include: Niskayuna (Cl- 219 ppm, Na+ 80 ppm), Rotterdam (Cl- 128 ppm, Na+ 77 ppm), Scotia (Cl- 120 ppm, Na+ 64 ppm), Glenville (Cl- ~78 ppm, Na+ 46 ppm). These chloride values are 250 to 550% higher than that of adjacent river samples, and thus a reasonable hypothesis is that salinization of the Mohawk at low flow conditions is partly from river-adjacent contaminated glacio-fluvial sands and gravels [1].

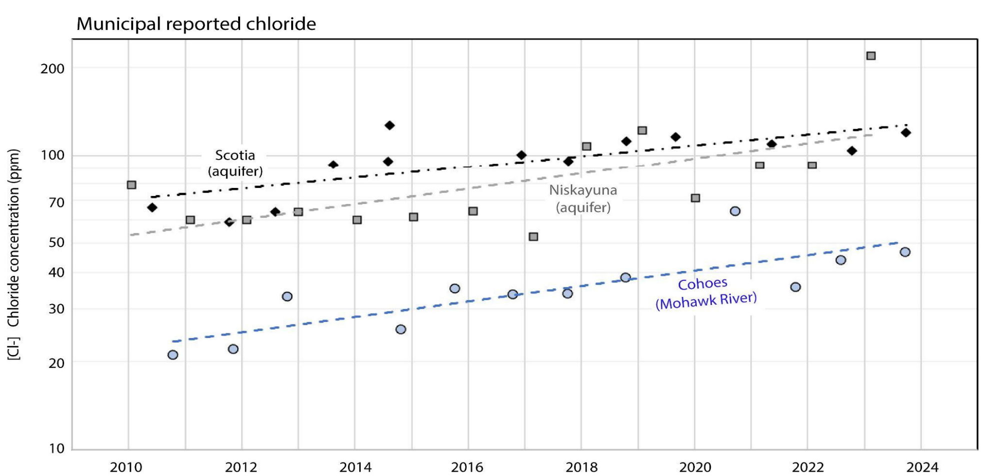

Figure 3: Reported chloride concentrations in municipal water from three municipalities that have available annual water quality reports. Concentrations (y-axis) are plotted on log scale.

Finally, we know that those municipal water sources have reported chloride values that are increasing over time (Garver et al., 2023). Of the river-proximal municipalities in the lower Mohawk, only Cohoes (Mohawk River source), Niskayuna (aquifer), and Scotia (aquifer - record only to 2010) have an accessible regular and long-term record of annual water quality reports and every site shows significant salinization over time. The data from Cohoes is late season (mostly October), and those data show an increase in chloride by ~46% in the last 20 years (since 2004). In that same twenty-year interval the reported winter chloride concentrations (Jan and Feb) in groundwater in sands and gravels of the Niskayuna aquifer have increased ~84%. The last decade has been even more remarkable: since 2010, Niskayuna and Cohoes have reported change greater than 120%, and Scotia nearly 80% [shown above - 2]. Published records show chloride in Scotia averaged 13.5 ppm between 1971 and 1974 (Peters and Turk, 1981), and thus in the following 50 years has appeared to have increased nearly 800%.

Table 2: Developed land and impervious serfaces in subwatersheds to the lower Mohawk River

		A to D (%)	C-D (%)	(A) OPEN space		(B) LOW density		(C) MEDIUM density		(D) HIGH density	
	Watershed (HUC 12)	Total	Low-High	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
SKC	Shakers Creek	54.1	38.0	**20.4**	16.1	**22.6**	17.8	**17.4**	13.8	**8.1**	6.4
STC	Stony Creek	47.3	26.4	**24.8**	20.9	**19.2**	16.2	**8.8**	7.4	**3.4**	2.8
POK	Poentic Kill	58.2	43.2	**15.3**	15.0	**18.1**	17.7	**17.7**	17.5	**8.2**	8.0
ALP	Alplaus Kill*	15.2	6.6	**12.4**	8.6	**7.3**	5.1	**1.7**	1.2	**0.4**	0.3
SSK	Sandsea Kill	7.5	3.5	**3.3**	4.0	**1.7**	2.0	**2.0**	1.2	**0.2**	0.3
EVK	Eva's Kill	11.5	6.8	**5.1**	4.7	**3.6**	3.3	**3.3**	2.7	**0.9**	0.8
SCC	South Chuctanunda Ck	8.8	4.2	**3.9**	4.6	**2.2**	2.6	**2.6**	1.3	**0.3**	0.3
NCC	North Chuctanunda Ck	12.7	6.9	**6.5**	5.8	**4.4**	4.0	**4.0**	2.1	**0.8**	0.8

Data from HUC 12 boundaries in Model My Watershed, based on MRLC data. *Alplaus is two HUC 12 units combined.

Conclusions. These data demonstrate that chloride concentrations in the Mohawk River increase as the river flows through the Capital District during low flow. This finding is significant because it underscores the impact of urbanized areas with a high proportion of impervious surfaces on water quality. It has long been recognized that extensive use of road salt for winter de-icing has negatively affected surface water in New York, and the Mohawk watershed (Peters and Turk, 1981; Godwin and others, 2003). What is remarkable is that such dramatic changes occur in the early fall, about six months after the last salt was spread on roads from the 2023-24 winter. A hypothesis is that the river is gaining from base flow from contaminated glacio-fluvial deposits and other near-surface sources. This study provides further evidence of how chloride and sodium have become insidious in the environment and thus they have affected the drinking water sources for a large portion of the region's population. It is encouraging that the NY Road Salt Reduction Task Force has initiated discussions on strategies to reduce road salt usage. Such efforts are crucial for protecting both surface water quality and drinking water sources in the area.

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[1] These data are from Annual Water Quality reports for Niskayuna, Rotterdam (wells 3,4), Scotia, and Glenville. Schenectady does not reliably report chloride.

[2] Data from Niskayuna, Scotia, and Cohoes annual water quality reports available from those respective water departments. Plotted here are only 2010 to 2023 data, which are the common years for all reports. These are fitted with an exponential and then endpoints calculated (2010 to 2023) for percent change. Most reported samples from Scotia were analyzed in the summer, Niskayuna in the winter, and the Cohoes data are mainly from the fall.

Potential safety concerns of earth dams within the Mohawk River watershed

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Earth dams have been used all over the world for thousands of years. The appeal of earth dams stems from the fact that they are built of soil materials that are abundant almost everywhere where humans needed to dam waterways. This type of dams could be entirely made of earth or partially made of earth together with other materials such as rock fill, masonry, or concrete. Because of the non-homogenous nature of earth, extreme care must be exercised in the construction of dams that are made fully or partially of earth. The State of New York has 159 dams where earth is fully or partially used as a construction material. The Mohawk River watershed has 16 dams with some earth components. Eleven of these 16 dams are built entirely with earth material. Six of the 16 dams are over a century old and the average age of the other 10 dams is over 60 years. The dams that are over a century old were built at a time when the understanding of modern geotechnical engineering was limited and knowledge of soil as a construction material was primitive. Building earth dams relied significantly on experience due to the absence of the science needed to appreciate and, if possible, predict the future behavior of earth structures. Also, the lack of modern construction equipment and testing devices of the soil properties constituted a serious handicap in ensuring the quality of built dams.

Modern dam construction follows stringent rules and procedures that can help such dams stand the test of time and other adverse natural conditions. For instance, earth dams in the past were built by piling up soil until the required height was reached. The lack of heavy compaction machinery and the absence of checking the quality of piled soil allowed for the possibility of the formation of pockets of weakness within the body of the dam. Soils in modern dams are placed in lifts, which get compacted with a known amount of energy to achieve a certain density that can be verified using standard testing procedures. Other aspects universally used in modern dams that were not used in building old dams include the use of milder slopes in both the upstream and downstream faces of the dams because this adds to the stability of soils that are less stable at steep slopes. Furthermore, modern dams are provided with an impervious core to assure a total cutoff of possible seepage that may percolate from the upstream side to the downstream side of the dam, which could compromise the dam’s structural integrity over time. Additional accessories used in modern dams include the use of a riprap protective layer on the upstream side of the dam and a drainage system on the downstream side of the dam to collect any seepage water that could have penetrated and traversed the body of the dam. These features are essential to improve the stability of dams and to considerably decrease the possibility that dams could experience a localized internal liquefaction that could lead to a catastrophic failure. For the 16 dams fully or partially built of earth materials in the Mohawk River watershed, the potential hazard to the downstream area resulting from failure or mis-operation of the dam is this: 14 dams are rated as a high hazard and 2 as a significant hazard, which is the most elevated level of hazard. This is a serious concern and should be taken with due consideration. In light of recent failures of century-old earth dams elsewhere in the United States, it is prudent to subject earth dams, especially old ones, to a comprehensive inspection to evaluate their structural health, integrity, and safety, and to upgrade their stability provisions, or replace or remove them. The do-nothing approach is unwise as it leaves people downstream vulnerable to potential disasters.

A forensic investigation examining the failure of Edenville and Sanford dams

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Edenville dam was constructed at the confluence of the Tittawabassee River with the Tobacco River in Michigan. The Sanford dam was located on Tittawabassee River a short distance downstream from the Edenville dam. They were constructed in the 1920s to generate electricity when most electric power generation was mainly local in absence of an extensive power grid. The Edenville dam was an earth fill embankment dam with two spillways and a powerhouse. Wixom Lake was formed upstream with the water impounded by the dam. Sanford dam consisted of an earthen embankment, gated spillway, emergency spillway, and a powerhouse. On May 18, 2020, heavy rain raised the level of water in the Wixom Lake to just three feet below the top of the dam. Dam operators opened all flood gates to release flood water as fast as possible. On May 19, a depression was noticed in a section of the earth embankment. That section showed signs of distress and erosion control measures were introduced to prevent the formation of severe erosion. The water level in Wixom Lake reached its highest level in its history and was only one foot below the top of the dam but never topped the dam. A section of the dam's earth embankment experienced what a forensic analysis determined to be a localized static liquefaction, which occurs when a weak spot results in the creation of a structurally compromised pocket of fluidized soil that fails to resist the elevated hydraulic pressure and ultimately yield collapsing that section of the dam. Within two hours, the water of the reservoir formed by Wixom Lake rushed unhindered downstream through the breached section of the dam. This roaring water eroded and washed away the unsuspecting Sanford dam causing a catastrophic failure. The waters of Wixom and Sanford Lakes continued their torrent journey downstream inundating entire communities and causing widespread loss and damage. Although Edenville's dam was in service for almost a century, it has never experienced conditions similar to those that occurred on the day it failed.

The forensic investigation into the dam failure used triaxial tests on a core of uniform fine sand samples from Edenville dam. Tests results revealed that the pattern of brittle collapse behavior exhibited by the soil was consistent with the phenomenon known as static liquefaction. Further investigation revealed that the procedures used in Edenville dam construction lacked significant safety provisions used in modern dam construction. The following are some of the features used in the construction of dams today but were not commonplace at the time of Edenville dam construction: earth embankments rise in lifts and each is compacted with heavy machinery to densify it; an impervious core is used to prevent seepage water from traveling from the upstream to the downstream face of the dam which could weaken the structure considerably; upstream and downstream faces of modern dams use gentle slopes to add to the stability of the dam as soil is naturally unstable on steep slopes; rock riprap is used on the upstream face to prevent waves from eroding the body of the dam; and drains are used on the downstream side of the dam to prevent the buildup of pressure, filter the seepage water, and prevent the washing away of fine soil particles. The lesson learned from this study was that some invisible factors that may not be possible to observe from outside of the dam could result in unanticipated disasters. This makes it imperative to subject old dams to rigorous inspection to determine whether they constitute a failure hazard and to mitigate any potential problems before they materialize.

Using citizen science data to inform avian surveys in the Mohawk and Hudson River watersheds

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Bank Swallows are a riparian species of migratory bird found worldwide and are in global decline[1]. These swallows form nesting colonies of 10-2,000 nests in vertical cliffs or banks along waterbodies, but due to habitat loss, these birds have adapted to nesting in ephemeral human-made sites such as sand and gravel quarries, road cuts, and construction sites.

NYSDEC has conducted a pilot study to assess Bank Swallow breeding colonies along the eastern stretch of the Mohawk and upper Hudson River and their tributaries to identify potential areas for habitat restoration and/or land preservation. The Cornell Lab of Ornithology's eBird project is a citizen science initiative to document bird distribution, abundance, habitat use, and trends through user-submitted checklists. The eBird database was used to determine survey locations along these waterbodies where foraging Bank Swallows are likely to be present and, by extension, be within 2 km of Bank Swallow nest colonies[2]. This poster explores the process and efficacy of using citizen science data to inform survey locations for the purpose of potential land preservation and/or habitat restoration projects.

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Home is where we made it: mussel research leads to mudpuppy habitat

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Mudpuppies (*Necturus maculosus*) are large aquatic salamanders and cryptic by nature. Unlike most herpetofauna, mudpuppies are more active in months with colder water and inhabit hard to reach habitats, making them an understudied and underreported species. In collaboration with the New York State Museum, we assisted in the experimental use of native freshwater mussel propagation cages within the Upper Hudson River.

Mussel propagation cages (0.6m x 0.9m x 0.3 m) placed in Thompson Island Pool (Saratoga/Washington County, NY) were retrieved after 15 months via SCUBA diving. Three mudpuppies were observed under three of the ten recovered cages. Post-cage removal, an additional three adults and one juvenile mudpuppy were discovered during a site survey of six partially buried logs. All three mudpuppies found under holding cages appeared to have spine deformations and had difficulty swimming. We cannot say whether these observed deformities are related to contaminants or some other cause.

While SCUBA has been a suggested survey method for mudpuppies in several papers, it has yet to be documented as a successful survey technique. These field observations show that mudpuppies will occupy anchored coverboards in the wild and SCUBA is a successful way to survey for this species. These findings could help promote the conservation of mudpuppy populations throughout their range and help us understand potential impacts of environmental stressors on mudpuppies in the Hudson River ecosystem.

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Mohawk Watershed *Enterococcus* and *E. coli* sampling sites time series have different geographic distributions: results of clustering by dynamic time warping

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Riverkeeper and its many academic partners and citizen science volunteers have collected over 2000 water samples from the Mohawk River, its major tributaries, and the NYS Barge Canal as it parallels the river since 2015. This effort began as a means of locating potential regions of impairment and exploring potential trends by looking at concentrations of fecal indicator bacteria (FIB) at 40-plus fixed sites near the river's headwaters of Delta Lake in Rome, NY to its confluence with the Hudson River in Waterford, NY. Samples are typically collected within a 14-24 h period (9 h shortest; 48 h longest). Samples are processed within 6 hours for both *Enterococcus* and *E. coli* using IDEXX's Enterolert method (EPA Standard Method 9230D) and Colilert system (EPA Standard Method 9223B) respectively. Bacteria levels are reported and compared to the Beach Action Value (BAV) set forth by the US Environmental Protection Agency's (US EPA) in its 2012 publication: Recreational Water Quality Criteria.

We tested a method to detect change in time and relationships with potential sources and drivers of *Enterococcus* and *E. coli* concentrations by clustering sampling sites by similarity in concentration of each parameter over time. Sources of *Enterococcus* and *E. coli* include fecal contaminants from sewage, confined and wild animal waste, and septic wastewater. Counts vary with season and rainfall. Given this highly variable and robust dataset, we tested whether certain sites had similar patterns of change in fecal indicator bacteria concentration through time and could therefore be analyzed for the effects of infrastructure, land cover, and site characteristics by group or cluster. By clustering sites by time series profile, we aimed to test whether time series profile would support further analysis to identify the most significant impacts. While cluster analysis of landscape features has been commonly used for site characterization to optimize water sampling location and design, clustering by dynamic time warping is increasingly used for water quality analysis across sampling locations. It is commonly used for land use change assessment in remote sensing.

To that end, we ran cluster analysis by dynamic time warping on data from all sites along the Mohawk River with at least 40 samples. This comprised 35 sites across the Mohawk Watershed. Samples were taken from July 2015 to October 2024 and measured for *Enterococcus* and *E. coli*. We used mean within cluster distance to determine the appropriate numbers of clusters. Once the clusters were formed, we examined similarity between *Enterococcus* and *E. coli* cluster distributions, within-cluster similarity and patterns, relationships of individual groups with landscape and site characteristics (land cover, presence of Combined Sewage Overflow (CSO) or wastewater treatment plants, CAFOs, and river characteristics).

We observed that sites with similar patterns of *Enterococcus* and *E. coli* abundance through time did not align, indicating poor consistent correlation between the presence and temporal trends of these two indicators. While across the full dataset there is a weak linear relationship between the two, and at certain sites a very strong linear relationship, their time series patterns were not grouped similarly, indicating that different factors contribute to the presence of each and how they change over time. While group members of the *Enterococcus* clusters are distributed across the larger Mohawk Watershed, group members of *E. coli* clusters are closer to each other. The influence of land cover, wastewater effluent, and agricultural operations on cluster groups was also assessed in order to understand whether certain types of sites responded similarly to source of pollution or river characteristics within a watershed and whether site-types could be developed with expected characteristics.

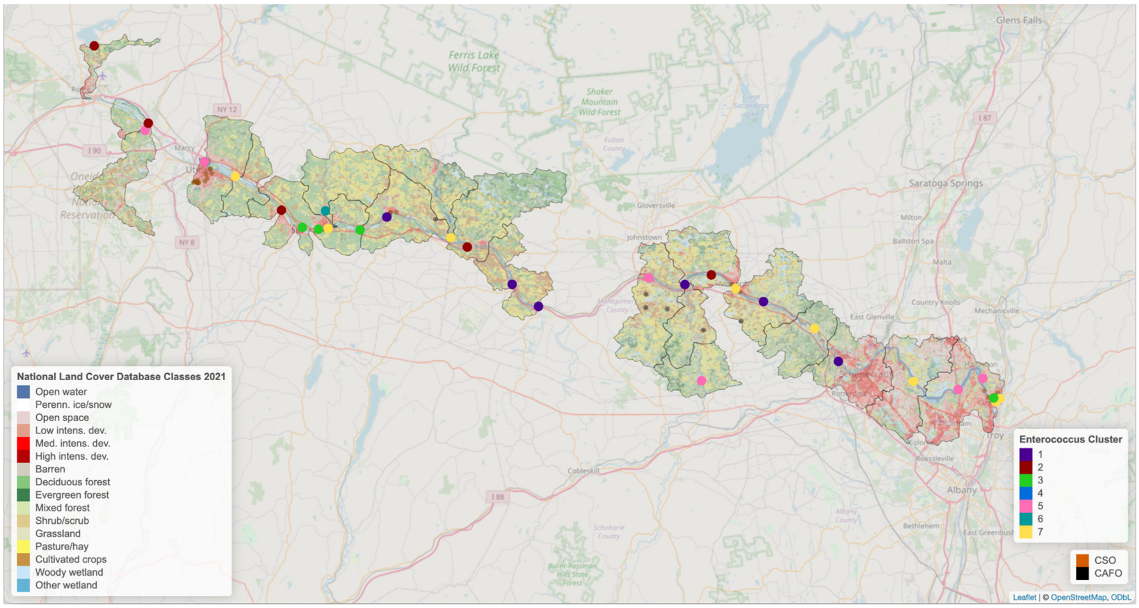

Figure 1. Mohawk Watershed water quality sampling site by ***Enterococcus*** cluster. 2021 National Land Cover shown in HUC 12 watersheds that intersect with a sampling location. CSO and CAFO locations in brown and black.

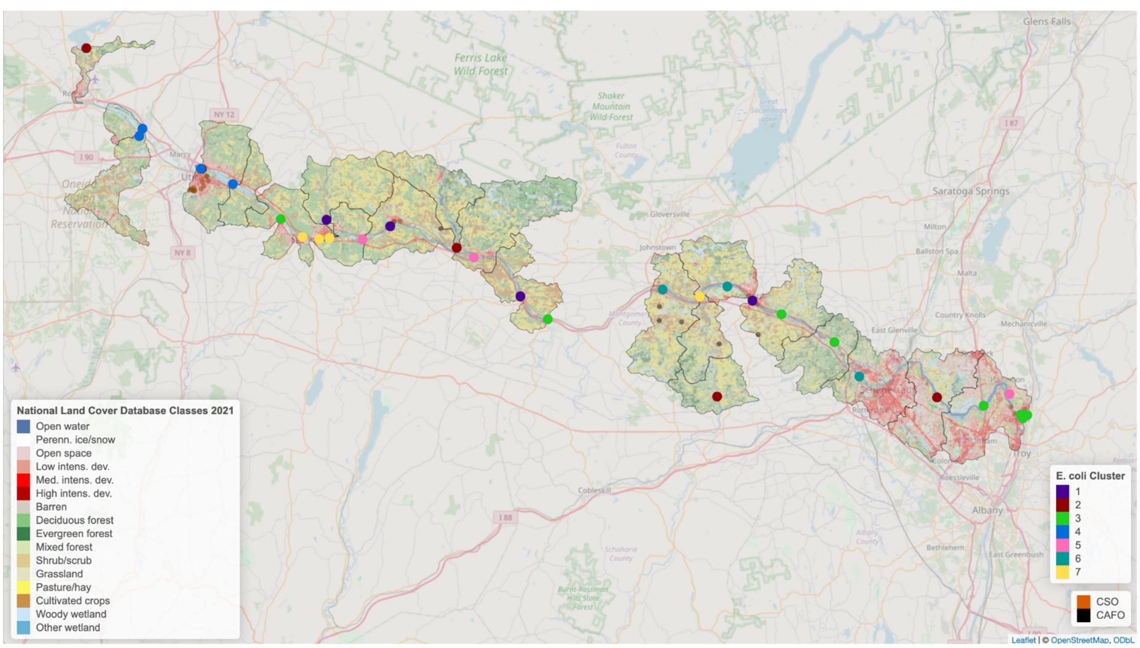

Figure 2. Mohawk Watershed water quality sampling site by ***E. coli*** cluster. 2021 National Land Cover shown in HUC 12 watersheds that intersect with a sampling location. CSO and CAFO locations in brown and black.

A smallholder's perspective on a very big issue: managing invasives on the Hudson River shoreline 2010-2023, who pays?

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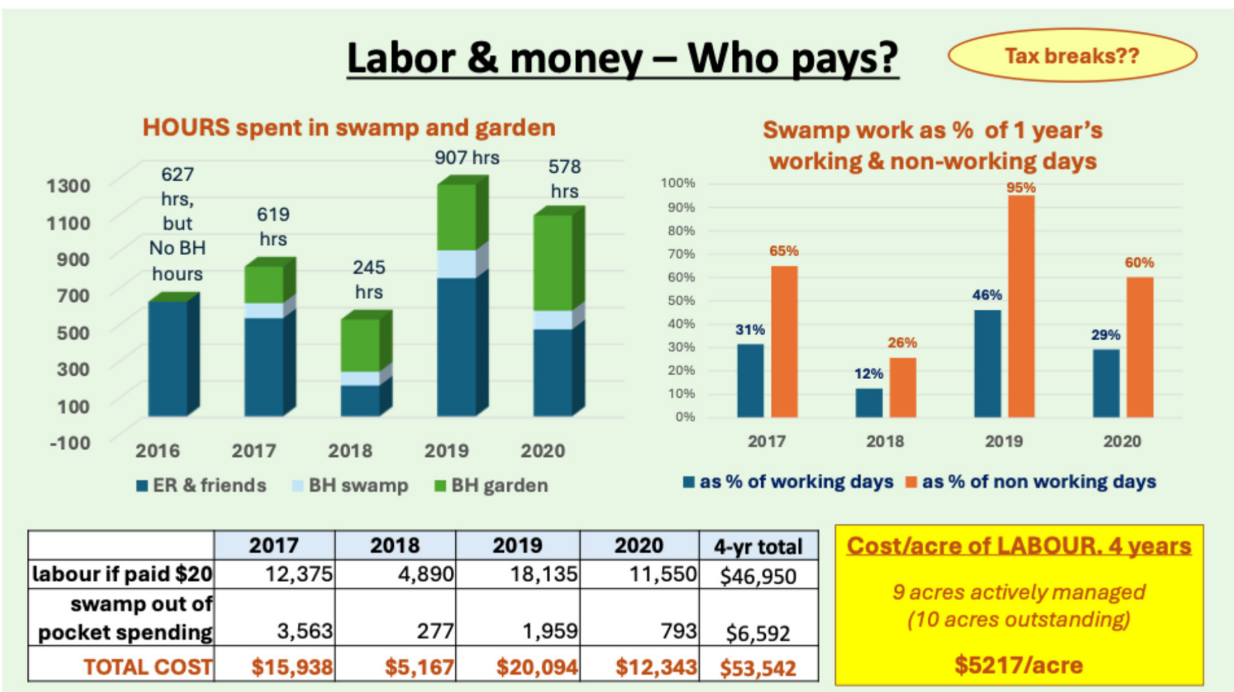
A large proportion of the land in the Mohawk/Hudson Rivers watershed is owned by individuals, many of whom own less than 20 acres of land. As land managers, these owners face numerous challenges. This poster will present the costs in time and money to manage a few acres at the mouth of the Hannacroix Creek on the Hudson River.

This poster will present 12 slides illustrating the challenge and rewards of clearing invasive plant species from a small portion of a 19+ acre floodplain along the Hudson River. It will also show the costs in labor and time required to do the bare minimum to improve the biodiversity of these few acres. These slides were prepared for a presentation in 2023 to the New York State Invasive Species Expo, Saratoga, NY. Based on the experience of managing the land, the poster asks how smallholders in the watershed might be rewarded for good environmental stewardship.



	2017	2018	2019	2020	4-yr total
labour if paid $20	12,375	4,890	18,135	11,550	$46,950
swamp out of pocket spending	3,563	277	1,959	793	$6,592
TOTAL COST	$15,938	$5,167	$20,094	$12,343	$53,542

Figure 2. Numbers are based on the logs kept by the authors of the work they did between 2016 and 2020.

Large-scale solar proliferation in the Mohawk River Watershed

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President & Co-Chair, GlenFARMLand, Inc; President, Stop Energy Sprawl;
and in conjunction with the Residents for the Preservation of the Mohawk Valley

Introduction

Municipalities throughout the Mohawk Valley have found themselves increasingly approached by developers seeking to site large-scale solar- and wind-energy generation facilities, encompassing thousands of acres apiece. The companies are attracted to New York because of the financial incentives available – lucrative State contracts, government support, tax breaks, and favorable financing. They have been flocking to the Mohawk River Valley, in particular, for three reasons: relatively inexpensive land, available supporting infrastructure, and the lack of sophisticated government systems in place at the local level to assure an equitable treatment for the region's citizenry.

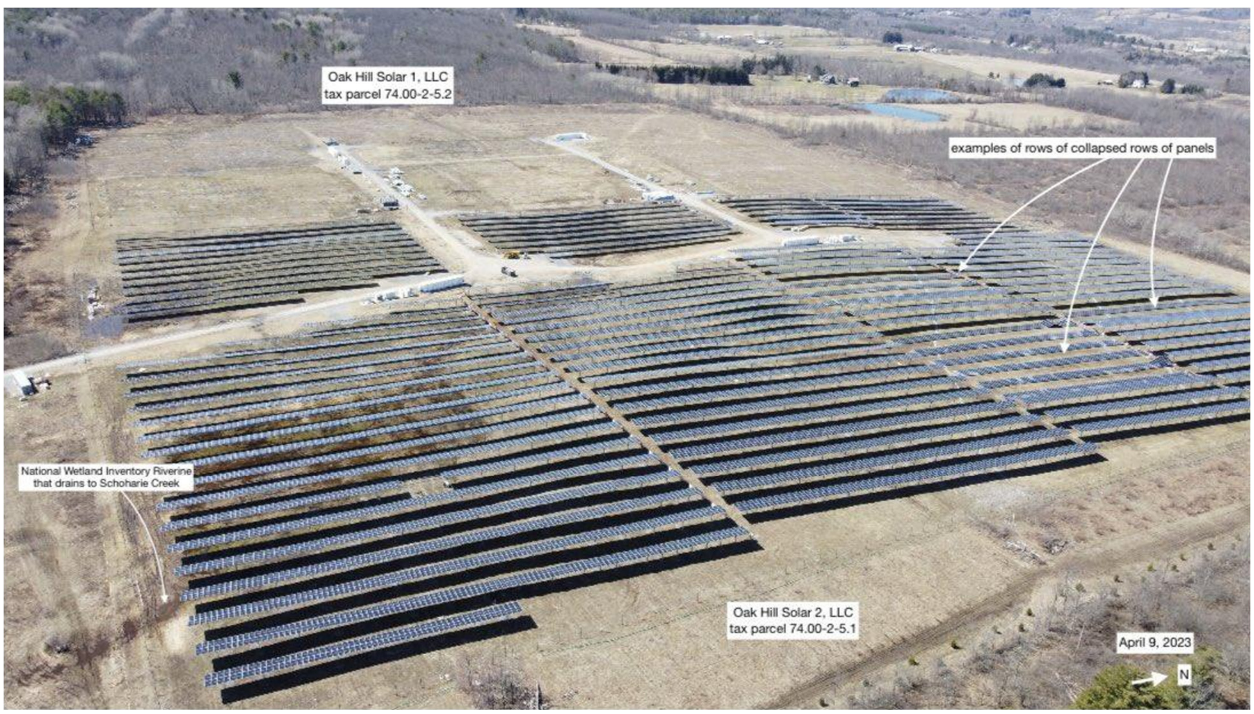

Figure 1. Oak Hill Solar 1, 7.5MW facility in Duanesburg, NY, four months after partial array collapse.

Focus on Montgomery County

Montgomery County is the only county in the State of New York that is completely contained by the Mohawk River Watershed. It is also one of the State's smallest counties with a population of approximately 50,000 and an area of 408 square miles. Yet, Montgomery County communities are among the most targeted for proliferation of solar generating facilities (Figure 1).

Solar facilities developers, primarily from out-of-state, and State agencies alike have proposed some 1.25 GW of nameplate solar facilities be built in Montgomery County, far exceeding the electrical power needs of the County. The facilities are to be built primarily on farmland, with an aggregate footprint of more than 10,000 acres (Figure 2). Significant forested areas will be clear-cut in support of these projects

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leading to a loss of carbon sequestration and natural cleansing of the air on this busy portion of the NYS Thruway.

The impacts to the watershed itself are largely unknown. The replacement of forest and farmland with impervious glass & steel photovoltaic panels and concrete slabs for associated equipment also has worrisome potential impacts for stormwater management. The proposed large-scale facilities unsurprisingly abut or transect significant tributaries to the Mohawk River, such as the Auries Creek, the Canajoharie Creek, Flat Creek, Ravine Creek and others. In addition, solar facility installation has been shown to impact negatively tiling and similar controls. The impacts to these streams and the watershed, in general, from the cumulative impacts of these facilities requires additional study.

Further, the loss of active farmland and the displacement of farm workers in exchange for a smattering of maintenance jobs for these facilities has real impacts for an agriculturally based economy, such as that found in Montgomery County. Less farmland means fewer needs for seed, farm equipment and farming supplies.

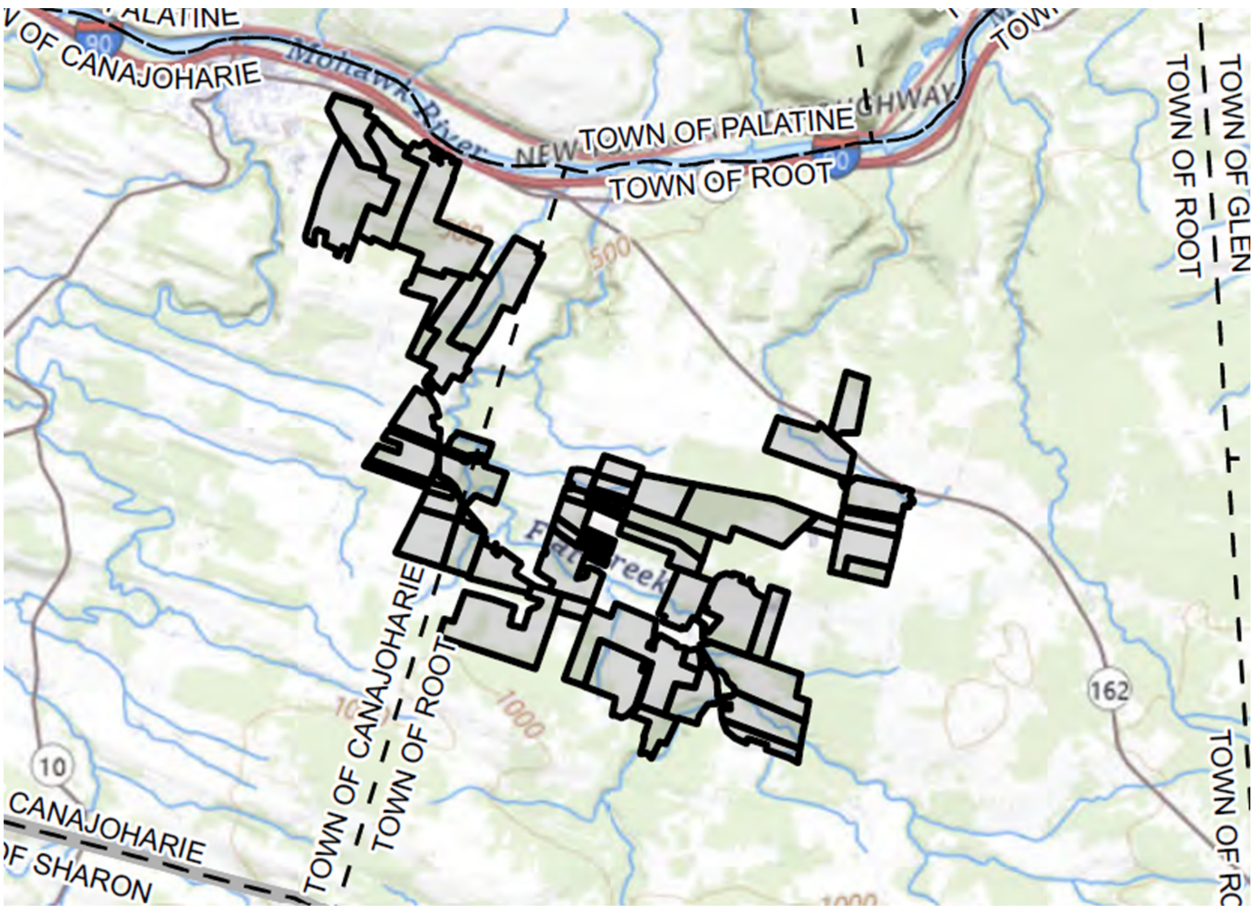

Figure 2. Site map of sprawling 300 MW solar facility proposed for the Towns of Root and Canajoharie (from company application in ORES case 23-02992)

The economic concerns, of course, do not end there. Montgomery County's historic and agriculturally-based tourism are also threatened. The County is home to the third largest county archives in New York state, significant Amish populations, several museums, and pick-your-own apple orchards and garden shops, in addition to being bisected by the Mohawk River and the New York State Barge Canal. Historic sites and artifacts associated with the Barge Canal and its predecessor, the Erie Canal abound, including the spectacular Schoharie Crossing at the mouth of the Schoharie Creek.

The visual, cultural, and economic impacts are indisputable and require additional analysis. The impacts to the residents, our families, our homes, and the character of our communities has already been felt. Schisms between family members and neighbors and outmigration have already begun. For each facility built, nearby property owners will see a decrease in their property's values.

Enabled by State Legislation

New York State subsidizes utility-scale solar (facilities > 1 MW) in three important ways: capping property taxes at artificially low levels, providing direct funding to so-called "community solar" projects (generally less than 20MW), and providing lucrative contracts for utility-scale solar projects through the NYSERDA Tier 1 Awards program. These key competitive advantages and incentives for solar developers are major factors in the targeting of rural areas of the State like the Mohawk Valley. From Real Property Tax Law (RPTL) §487 which made all solar facilities property tax exempt unless municipalities took specific actions to stand-alone acts like the Accelerated Renewable Energy Growth and Community Benefit Act and the Climate Leadership and Community Protection Act (CLCPA) to RPTL 575 (b) which set artificially low valuation (robbing municipalities of millions of dollars in tax receipts), the cumulative impact has been to turn rural upstate communities into energy colonies for other portions of the state.

Conclusion

The impacts from well-meaning, but fatally flawed legislation and the ensuing gold rush by solar developers into upstate New York will have lasting negative consequences for the watershed, its residents and their financial and community health. Further study regarding the cumulative impacts of these projects is sorely needed. Awareness of these issues and the lopsided targeting of these communities is the first step into changing the regulatory landscape to enable these New Yorkers a stronger voice in what happens in their own towns.

Big Creek restoration strategy

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The Big Creek Restoration Strategy is an example of how collaborative and progressive restoration methods can benefit a degraded watershed for long-term community benefits. Big Creek is an important tributary to the Oriskany Creek and is also a native and wild trout fishery with C(TS) water quality classification. Historical channelization and damming as well as a series of severe storm events have exacerbated long-term instability throughout the main stem.

In 2013, New York State identified 13 watersheds, including Big Creek, for [1] "Emergency Transportation Infrastructure Recovery and Water Basin Assessment" reports. The assessments were conducted by Milone and MacBroom (MMI) on behalf of the New York State. MMI's Big Creek report identified multiple high-risk areas and provided recommendations to mitigate stream instability and flooding. Progress was made when undersized spans were upgraded and several small-scale stream stabilization projects were implemented.

However, on October 31, 2019, southern Oneida County received approximately five inches of rainfall in 12 hours, triggering catastrophic damage within the Big Creek corridor. The event activated landslides, further degraded incised reaches and added tons of sediment into the channelized system. Where the valley becomes unconfined, the stream's path shifted up to 200 feet overnight. Residents awoke to undermined foundations and evacuations. The Village of Waterville's Department of Public Works Superintendent immediately established a collaborative team of partners including Trout Unlimited, the United States Fish and Wildlife Service, New York State Department of Conservation and the Oneida County Soil and Water Conservation District to develop a comprehensive action plan to address widespread instability on Big Creek.

Five years into the Big Creek Restoration strategy, the partners have many accomplishments. To date, the team has completed a detailed geomorphic survey of over two miles of stream, developed a prioritized list of potential project sites and implemented the top three priority projects. The completed projects have resulted in the restoration and stabilization of over 1,500 linear feet. Proposed work in 2025 will include an 800-foot-long restoration project on the main stem on Village land. Trout Unlimited staff will present an overview of the historic conditions in Big Creek as well as the current restoration strategies.

Restoration strategies to be discussed are floodplain reconnection, bank restoration and removal of impoundment remnants that can simultaneously protect the entire riparian community. Staff will also present how watershed scale planning and diverse partnership can leverage state funding for widescale watershed improvements.

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Observations from a decade of monitoring fecal indicator bacteria (enterococci and *Escherichia coli)* in the Mohawk River Watershed

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Providing drinking water sources, recreational opportunities, and habitat for wildlife, among others, the Mohawk River Watershed surface water quality is of interest to all people who live within its boundaries. Over a decade from 2015 to 2024, the surface water quality of the Mohawk River Watershed has been monitored by this collaborative effort.

Water quality trends are observed by sampling for fecal indicator bacteria, FIB (enterococci and *E. coli*) along the Mohawk River (along with its tributaries and some sites in the parallel or co-located Barge Canal) from Delta Lake to its confluence with the Hudson River. Samples are collected usually six times per year, monthly, between May and October, which corresponds with the season during which people are most likely to interact with the water, for example by swimming or boating. Samples are typically collected within a 14-24 h period (9 h shortest; 48 h longest).

Samples are analyzed for enterococci, by using IDEXX's Enterolert method (EPA Standard Method 9230D); *E. coli* are measured using the IDEXX Colilert system (EPA Standard Method 9223B). Bacteria levels are reported and compared to the Beach Action Value (BAV) set forth by the US Environmental Protection Agency (US EPA) in its 2012 publication: Recreational Water Quality Criteria. This work uses the BAVs of 60 CFU/100mL for enterococci and 190 CFU/100mL) for *E. coli* (CFU/100mL is colony forming units per 100 mL of sample, which is proportional to the number of bacteria per 100 mL of sample). Thus, this work provides a view of water quality through two widely accepted FIB methods.

Although enterococci may typically not be harmful, in part due to their existence in the guts of warm-blooded animals, their presence in water samples indicates the likely presence of more harmful pathogens associated with fecal contamination. Contributing bacteria may enter a waterway through combined sewer overflows, sewer system failures, septic system failures, urban surface water run-off (including domestic and wildlife sources), or agricultural run-off. Contamination typically continues to be highest after precipitation events in both tributaries and on the main stem.

This presentation extends the data over ten years from 2015-2024. The value of such long-term data as those reported on here is the ability to address trends that might not be evident from a single year sampling campaign. For example, the data continue to show that the surface water is more impacted in wet weather (defined as >0.25 inches of rain, cumulatively, on the day of and in the three days preceding

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sampling). In addition, more than 50% of the sites exceed the BAV for enterococci, while the opposite has been observed for *E. coli*. Annually, the geometric means for the aggregated data from a set of reference sites show that the bacteria count levels vary, but that the long-term trend suggests enterococci concentrations in the Mohawk River Watershed have increased over the decade as samples have been collected. Additional analysis of the data, now that a ten-year data set has been achieved, is in progress, and emerging results may be presented.

Trends and observations from 10 years of fecal indicator bacteria (enterococci and *Escherichia coli*) monitoring partnership in the Mohawk River Watershed: toward a more swimmable Mohawk

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Introduction

The water quality of the Mohawk River Watershed should be of concern to all who live within its boundaries, because it serves as a drinking water source to 280,000 people in multiple municipalities[2], provides for a variety of recreational opportunities, and provides habitat for wildlife.

Since 2015, we have monitored and observed water quality trends in the Mohawk River Watershed by sampling for two fecal indicator bacteria, FIB (enterococci and *E. coli*). It must be noted, that measured FIB are not necessarily harmful; however, their presence in water samples may be used to predict the likely presence of other potentially harmful pathogens.[1,3-8] Wherever higher concentrations of FIB are present, then other pollutants that may be associated with the same source of those FIB may also be present. These other pollutants may include nutrients and wastewater-associated micropollutants such as pharmaceuticals or microplastics. Among the potential FIB sources are combined sewer overflows (CSOs), wastewater discharges without disinfection, sewer or septic system failures, wildlife and pet wastes, contaminated sediments, and surface water or agricultural run-off.[1,3-8]

The samples for FIB analysis were collected at sites on the main stem, major tributaries, and within the co-located or parallel New York State Barge Canal. At least forty sites spanning more than 120 miles of the waterway were sampled between Delta Lake near the Mohawk River headwaters and the confluence with the Hudson River. Sampling has been conducted monthly, typically within a single day, from May to October. The May-October period also represents the season when recreation and interaction with the waterway would be expected to be at its height. The samples are analyzed for enterococci, using IDEXX's Enterolert method (EPA Standard Method 9230D). *E. coli* are measured using the IDEXX Colilert system (EPA Standard Method 9223B). The most probable number (MPN) reported as colony forming units (CFU) per 100 mL of sample water (CFU/100 mL) are determined and compared to the US Environmental Protection Agency's (EPA) Beach Action Values (BAV) reported in the 2012 publication titled "Recreational Water Quality Criteria".[1] This document recommends three criteria for water quality based on these two widely accepted FIB methods: the Geometric Mean (GM), Statistical Threshold Value (STV) and Beach Action Value (BAV). As indicated in our 2023 contribution[2], the US EPA used epidemiological data to set threshold levels for each of those criteria so that no more than an estimated 32 or 36 illnesses would occur per 1,000 bathers using that waterbody. In this work, the FIB levels are

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compared to the more stringent BAV level of 32 illnesses per 1,000 persons/bathers. The pass/fail BAV level for *E. coli* equals 190 CFU/100 mL; for enterococci, the BAV equals 60 CFU/100 mL.

Results and Discussion

The 2024 sampling campaign represented the 10th year of water quality monitoring data collection by this partnership in the Mohawk River Watershed. Over those ten years, general trends have emerged and continue to be consistent. Among the trends and patterns that have been observed, and that are relevant to the public using the watershed and to management of the river and its watershed, are:

1) Most sampled sites fail to meet EPA-recommended safe-swimming criteria (Figure 1)
2) Despite the observation in Point 1, water quality does vary significant along the length of the Mohawk River and in its tributaries.
3) Rainfall does affect whether or not sites are safe for recreation (Figure 2); nearly every site sampled shows higher concentrations of FIB measured in weather defined as "wet".[12]
4) Water quality varies significantly on an interannual basis (Figure 3):
   - Enterococci concentrations: varied, with a generally increasing trend from 2015-2024,
   - *E. coli* concentrations varied, but without any apparent overall trend from 2016-2024.

Figure 1 shows the percentage of single samples that were below, or exceeded the more protective of the US EPA's BAVs for enterococci and *E. coli*. The trends in percent of single samples passing versus failing hold. For enterococci, over 8 years, 57% exceeded the BAV; over 10 years, 61% of all of the single samples exceeded the BAV. For *E. coli*, over 8 years, 26% of the *E. coli* samples versus 23% over 10 years of *E. coli* samples exceeded the BAV. The individual sampling sites show a range from 91% of samples meeting the BAV at one site to only 5% meeting the BAV at another. For 30 out of 40 sites, half or more of the single samples recorded from 2015-2024 exceeded the BAV (up from 28 in 2023[2]). For *E. coli*, the sampling sites range from only 26% of samples meeting the BAV at one site to 98% meeting the BAV at another. In contrast to the enterococci data, for *E. coli* only 2 out of the 40 sites had half or more of the single samples recorded fail to meet the US EPA BAV, from 2016-2024. The fact that the percentages differ is consistent with reported differences in survival in surface water between the two, which might also include factors such as the source concentrations of FIB, sunlight, and water temperature.[6-8]

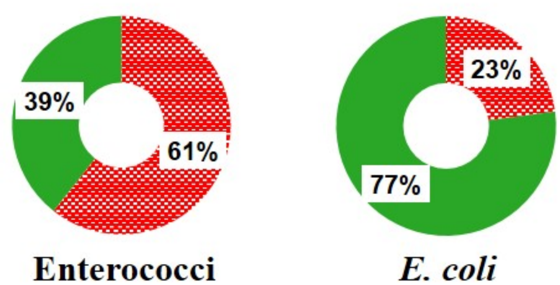

Figure 1. On these two circle charts, the green portions (on the left side of each circle chart) represent the percentages of single samples that were collected from all sampling sites that would meet the US EPA BAV from 2015-2024. The red portions (right side of each circle chart) represent those single samples recorded from all of the sampling sites that would exceed the US EPA BAV from 2016-2024.

Figure 2 shows the wet versus dry aspect of the data. Over the decade, whenever samples have been drawn on sampling dates deemed "wet"[12], these samples have show higher FIB counts than those samples that were drawn on sampling dates that were deemed "dry". These observations are consistent with the primary literature, for example higher bacterial counts when precipitation increased runoff were reported in a 2020 USGS report on the Chattahoochee River in Georgia.[9] Within the Mohawk River Watershed, a

2022 publication by Lininger, et al., analyzing three years of data near Rome and Utica, NY, reported correlations between FIB counts and precipitation. The observed correlations were deemed to be stronger in more urban areas where there is greater potential for surface run-off, resuspension of sediment, and prevalence of CSOs.[5]

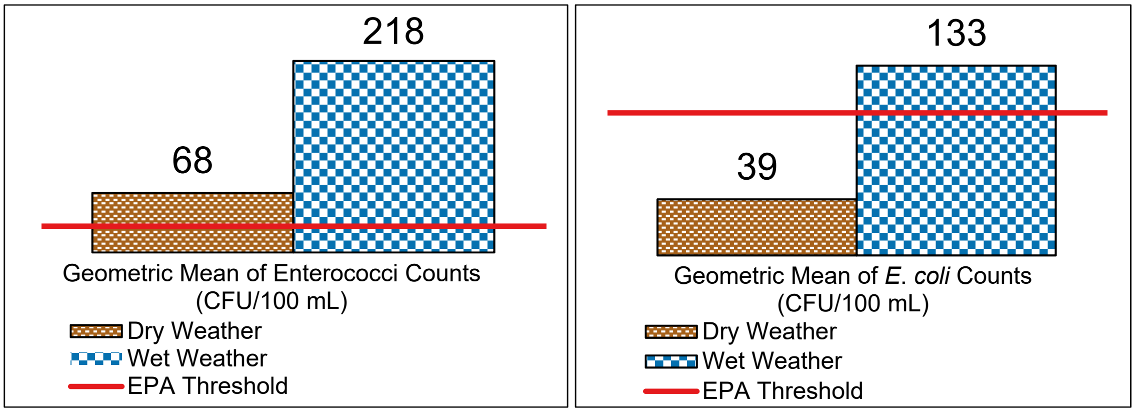

Figure 2. Dry weather versus wet weather geometric means for enterococci and *E. coli* samples. The dry samples, brown (left hand column) and wet samples, blue (right hand column). Samples collected in wet weather show increased bacterial counts. The US EPA BAV geometric means threshold values are 30 CFU/100 mL for enterococci and 100 CFU/100 mL for *E. coli.* For comparison, the enterococci data were 66/193 (dry/wet); the *E. coli* were 41/151 in the 2023 report.[2] Wet weather samples are defined as >0.25 inches of rain, cumulatively, on the day of and in the three days preceding sampling.

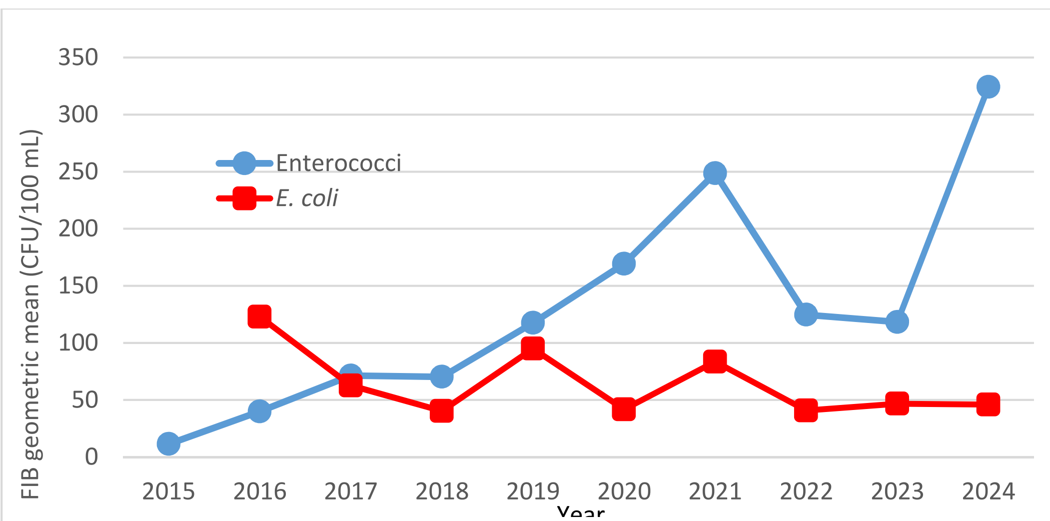

Figure 3. Interannual trends for enterococci (blue line/dots; 2015-2024) and *E. coli* (red line/squares; 2016-2024). The enterococci data indicate an increasing trend versus the *E. coli* data.

The longitudinal nature of this work allows year-to-year comparisons, Figure 3, which shows an overall enterococci geomean collected at several consistently sampled reference sites. Year-to-year from 2015-2024 the trend is toward greater concentrations of enterococci; however, in contrast while *E. coli* demonstrates year-to-year variability, the same overall increasing pattern is not observed. Additional statistical analyses are in progress with this data set, and additional results from that work may be presented. Among questions under consideration are whether or not there are inputs due to infrastructure or land use pattern changes/wet versus dry conditions. In that same vein, whether or not reported climate change related rainfall trends[10] and recently reported research noting that extreme rainfall events have been increasing across the northeastern United States[11] might show an affect on the collected data set.

In conclusion, the collected data support on-going water-quality monitoring. The decade-long, established data set provides value with respect to long-term monitoring that tracks changes over time with respect to climate change and its impacts on precipitation intensity and patterns, and ongoing wastewater infrastructure investments. In addition, as we indicated in our 2023 contribution[2] to the Mohawk Watershed Symposium, a continued commitment to investing in the in the watershed's infrastructure, is critical for the future water quality of the Mohawk River Watershed.

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Acknowledgments

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Biogeochemical BBH: what we've learned about the remarkable life histories of the Blueback Herring, *Alosa aestivalis*, from biogeochemical tracers

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Blueback Herring (*Alosa aestivalis*) is a signature anadromous fish in the Hudson-Mohawk watershed. It is known to have used the Mohawk River since at least the 1930s. This species has demonstrated a great deal of plasticity in its use of the watershed, having been documented to have wandered westward into lakes Oneida and Ontario from time to time. Here we document movement ecology and, with the help of biogeochemical biomarkers in muscle tissues, otoliths, and most recently eye lenses, insights on habitat use both inside the Hudson-Mohawk watershed and out at sea. We have found markers that give us improved understanding of provenance, as well as complex habitat use and migration histories.

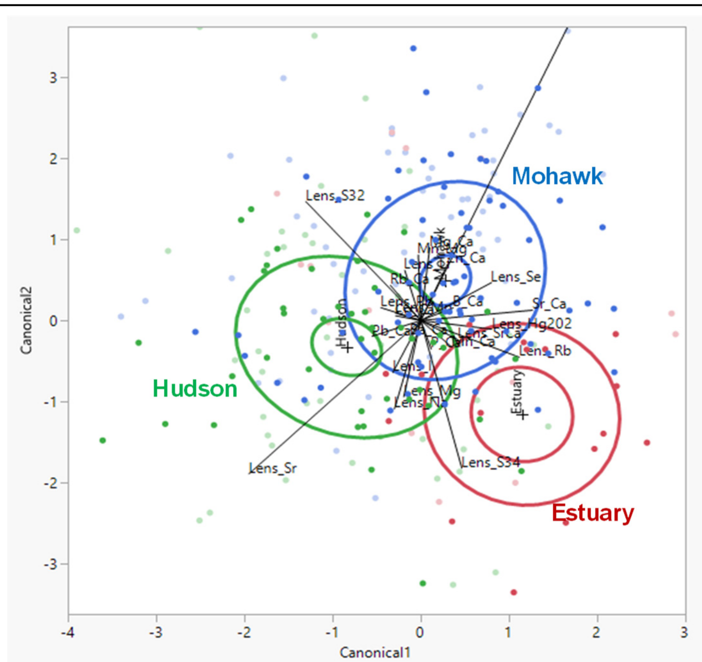

Figure 1. Quadratic Discriminant Function Analysis used to distinguish provenance of Blueback Herring. The QDFA performed best when combining eye lens and otolith chemical markers for the first two years of life.

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Angler survey results for the Mohawk River (2024)

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The NYSDEC Bureau of Fisheries completed a six-month open water angler (creel) survey on the Mohawk River extending from Rome to Waterford, NY between May-October, 2024. Staff conducted just over 2,000 interviews from more than 3,500 anglers at 42 fishing access sites totaling 208 trips to collect information on the current state of this diverse fishery ahead of a new management plan. Nearly 90% of interviews came from shore-based anglers largely due to a bus route methodology. Around three-quarters of all anglers interviewed live within 10 miles of the river-canal in the study area. Though nearly 60% of anglers interviewed were fishing for any species, others were mostly targeting Smallmouth Bass, followed by Walleye, Common Carp, Northern Pike, Channel Catfish, and Freshwater Drum, respectively. A summary of total percentage of the reported catch revealed slightly different numbers (Fig. 1). The use of bait and lure was about evenly split and nearly a quarter of all shore and boat anglers were using both methods. Worms were a favorite bait, followed by (homemade) pack baits and corn, minnows, and lastly chunk (fish) bait. Anglers were most interested in improving the sportfishery for Walleye, Black Bass, and Northern Pike, followed by Carp, (stocked) Tiger Muskie and Brown Trout, in that order. Most anglers claimed they were satisfied on the daily fishing trip to their spot on the river-canal. Over 1,100 catch cards were issued to anglers (still fishing) with a return rate of nearly 28%, specifically to gather more post-interview fishing data. A full summary report should be available by summer 2025.

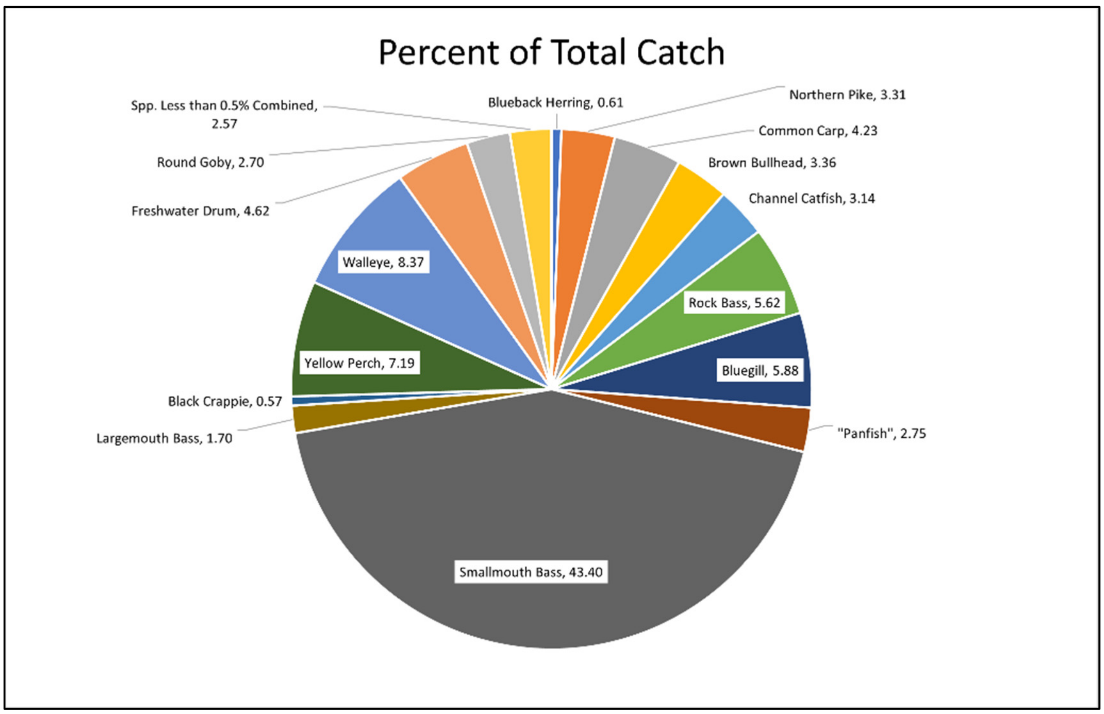

Figure 1: Summary of fishes captured during the 2024 Mohawk River angler survey showing Smallmouth Bass comprising nearly one-half the total reported catch (>43%).

The threat of landfill leachate to drinking water in the Hudson and Mohawk Rivers

Rebecca Martin
Jennifer Epstein
John Lipscomb

Hudson and Mohawk Rivers Leachate Collaborative

Introduction

Modern landfills must take extensive measures to contain liquid waste, or leachate, in order to protect surrounding groundwater and streams from contamination. Yet once this leachate is collected, it is typically sent to sewer treatment plants (STPs) that are not designed or equipped to remove the hazardous chemicals commonly found in leachate, even where STPs discharge into waters that are drinking water supplies. Instead, contaminants such as per-and polyfluoroalkyl substances (PFAS), 1,4-dioxane, and other emerging contaminants pass through STPs and into rivers. The communities that drink water from the Hudson and Mohawk Rivers must assume the cost of treatment to make the water safe for consumption. In some cases, operators of drinking water plants are unaware that STPs are accepting and discharging leachate nearby. We call this problem the "Leachate Loophole."

Over the past decade, studies have linked perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) in drinking water to the presence of STPs in a watershed (Hu et al., 2016) and confirmed that landfill leachate is a source of PFAS to STPs (Masoner et al., 2020). In fact, PFAS concentrations may be larger in STP effluent compared to influent as these compounds are transformed when passing through the sewage treatment process (Helmer et al., 2022; Eriksson et al., 2017). EPA recently set maximum concentration limits for six PFAS in drinking water. Ruyle et al. (2025) modeled PFAS concentrations in surface water and concluded that STP effluent could cause EPA's new drinking water standards to be exceeded for up to 23 million people in the U.S.

Members of the public need information about the handling of leachate – from landfills to sewage treatment plants to rivers and drinking water sources – in order to identify the risks and call for alternatives and solutions. Only a well-informed public can close the Leachate Loophole, which persists because of inadequate environmental laws covering solid waste, surface water and drinking water. By mapping available data, and detailing how regulations are failing to protect rivers and drinking water sources from leachate pollution, we hope to assist communities in achieving solutions.

Methods

We collected information on leachate disposal practices in the portions of the Hudson and Mohawk Rivers that are used as drinking water supplies, either as surface water or as groundwater under the influence of surface water, as well as areas connecting or immediately upstream of NYS-designated drinking water reaches. We submitted Freedom of Information Law (FOIL) requests to municipalities within this area that operate STPs discharging into the Hudson River Estuary or Mohawk River, asking for information about landfill leachate sources and volumes for the years 2019-2023. We used the FOIL responses along with publicly available landfill compliance reports to calculate annual average leachate volumes by STP, landfill, landfill status (active vs. inactive), and watershed. In addition, we worked with the Pace Environmental Law Clinic to review the history of regulations covering landfills, STPs, surface water quality, and drinking water quality. We also reviewed State Pollutant Discharge Elimination

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System (SPDES) operating permits for STPs in the project area that accept leachate.

The Historical Context

The practice of disposing of solid waste in landfills became common in the U.S. after World War II. As rainfall percolates through a landfill, it picks up substances from the waste material and becomes a toxic liquid called leachate. But knowledge about the toxicity of leachate was limited at the time that landfilling became popular, even as increasing numbers of petroleum-based chemicals were being introduced into commercial goods that were marketed as safe and disposable, and waste generation increased (Tarr, 1996; Copley, 2024).

By the 1960s, it had become clear that leachate was seeping out of unlined landfills and polluting nearby groundwater and surface water. In 1976, Congress passed the Resource Recovery and Conservation Act (RCRA), to address the nation's growing volume of municipal and industrial waste. Subsequent regulations required landfills to control leachate by installing impermeable liners and collection pipes. Once leachate collection was under control, the question of what to do with it needed to be addressed. Historical documents show that the answer was taken for granted from the beginning: send it to municipal STPs, which had been a common way for industries to dispose of waste for more than a half a century (EPA, 1975; Melosi, 2008). This was the start of a reciprocal relationship between landfills and STPs. To this day, STP operators see it as part of their public duty to accept leachate. In turn, landfills accept sludge – the solids that remain at the end of the sewage treatment process – from STPs.

How the Leachate Loophole Works

In New York State (NYS), facilities that discharge waste into surface or groundwater are regulated under the SPDES permit program, part of the Clean Water Act (CWA). The purpose of SPDES permits is to limit the amount of polluting substances that facilities discharge. The CWA sets minimum baseline requirements according to the facility type (a state may apply more stringent standards), and requires SPDES permits to be renewed every five years. Originally, Congress intended this renewal process to provide an opportunity for state agencies to require new water pollution control technology in SPDES permits as it developed. In turn, pollution discharges would be eliminated as technological capacity increased (Coplan, 2005).

SPDES permits for STPs focus on indicators of human waste, not the synthetic chemicals contained in leachate (DEC 1997). NYS requires landfill operators to protect nearby water quality by regularly monitoring groundwater and leachate for 47 synthetic chemicals that are potentially present in industrial and municipal solid waste (Westlaw, 2022). Only two of these 47 compounds appear in any of the STP SPDES permits for facilities that accept leachate in the project area.

Two of the assumptions underpinning U.S. pollution regulations is that polluting substances break down in the environment fairly rapidly and that human health and ecological impacts can be controlled by managing contaminants one at a time. These assumptions are rooted in water pollution science that dates back to the 1930s, before synthetic chemical production boomed (Tarr, 1996). EPA lists 86,000 unique chemicals that are used in manufacturing or processing in the U.S., not including chemicals used in foods, drugs and cosmetics, with more added almost every day (EPA, 2024a). This includes many emerging contaminants – substances that are potentially harmful to people or ecosystems, but are poorly studied and therefore unregulated.

Because emerging contaminants such as PFAS break down extremely slowly, they persist in the water much longer than the conventional pollutants that our environmental regulations are designed to handle. What's more, these substances can affect living beings in barely detectable concentrations, so dilution does not eliminate their harmful effects. Emerging contaminants have changed how we should look at water pollution, but our regulatory system has not kept pace.

Impacts in the Mohawk River Watershed

Within the Mohawk River Watershed, eight public drinking water intakes draw water from the Mohawk Rivers and Great Flats Aquifer, serving more than 266,000 people in 12 municipalities, including groups that disproportionately experience environmental harms (EPA, 2024b; EPA, 2024c) (Table 1).

Table 1. Drinking water intakes and municipalities served in the project area: Mohawk River Watershed.

Intake Name	Public Water Supply Name	Municipality Name	Municipality Type	Number of People Served Within the Municipality
Mohawk River				
City of Cohoes	Cohoes City	Cohoes	city	16,883
	Waterford Water Works	Waterford	town	9,800
Latham Water District	Latham Water District	Colonie	town & village	85,590
Great Flats Aquifer				
Town of Glenville	Charlton Water District	Charlton	town	2,000
	Burnt Hills-Ballston Lake Water District	Ballston	town	10,000
	Glenville Water District #11	Glenville	town	15,000
Niskayuna Consolidated Water District	Niskayuna Consolidated Wd #11	Niskayuna	town	22,287
Town of Rotterdam (Main Street)	Rotterdam Water District #3	Rotterdam	town	1,900
Town of Rotterdam (Rice Road)	Rotterdam Water District #5	Rotterdam	town	28,000
City of Schenectady	Schenectady City Water Works	Schenectady	city	61,821
Village of Scotia	Scotia Village Water Works	Scotia	village	12,800

Over the years 2019-2023, six STPs in the Mohawk River Watershed portion of the project area accepted a total of nearly 33 million gallons of landfill leachate per year (Table 2). Of this, approximately 27 million gallons per year were discharged from active landfills, and about 6 million gallons were from inactive landfills (Table 2).

The Seneca Meadows landfill is one case study that provides an example of how leachate disposal works in NYS. Seneca Meadows is the largest active landfill in NYS. Managed by the Texas-based company Waste Connections, it processes more than 6,000 tons of waste each day, generated throughout NYS

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(Cornerstone Engineering, 2023). The City of Amsterdam STP began accepting leachate from Seneca Meadows late in 2023. In one month, the City of Amsterdam STP discharged 414,000 gallons of Seneca Meadows leachate into the Mohawk River upstream of the Great Flats Aquifer and surface water intakes. Seneca Meadows' leachate was tested for 21 PFAS compounds in 2018 (Test America, 2018). Fourteen compounds were detected, at a total concentration of 12,847.3 ppt (Test America, 2018).

Table 2. Landfill leachate flows in the project area: Mohawk River Watershed.

Landfill Name	Landfill Status	WWTP Name	Gallons Per Year, Average (Includes 2019-2023 unless noted)	Payment Per Gallon, Average (Includes 2019-2023 unless noted)	Payment Per Year, Average (Includes 2019-2023 unless noted)
Mohawk River					
Fulton County	Active	Gloversville- Johnstown	14,667,000	$0.01	$147,000
Town of Colonie	Active	Mohawk View (Town of Colonie)	10,320,000	$0.01	$103,000
Central Service (Montgomery County)	Inactive	Village of Canajoharie	2,944,000	$0.03	$88,000
Bourne	Active	City of Amsterdam	1,667,000	$0.04	$67,000
Town of Rotterdam	Inactive	Town of Rotterdam Sewer District #2	1,009,000	No data	No data
Eastern Service (Montgomery County)	Inactive	City of Amsterdam	983,000	$0.04	$39,000
Modern Waste (Browning Ferris)	Inactive	City of Amsterdam	978,000	$0.04	$39,000
Seneca Meadows	Active	City of Amsterdam	414,000	$0.04	$17,000
Town of Glenville	Inactive	City of Schenectady	16,000	No data	No data

NYS Rulemaking on Leachate Disposal

Despite current efforts to regulate a few emerging contaminants, contaminants present in solid waste landfills will be present in landfill leachate for the foreseeable future. If current leachate disposal practices continue, yesterday's trash will be an ongoing source of persistent contaminants to drinking water sources. As regulations for emerging contaminants such as PFAS and 1,4-Dioxane are developed and implemented, one of the first sensible actions is to assess how regulations will affect municipalities, communities, and budgets by testing for their presence and concentration in landfill leachate and STP influent and effluent.

However, in the case of landfill leachate, our existing regulatory approach has failed to protect drinking water sources and people's health. New regulations that limit concentrations of individual chemical contaminants will improve the situation, but they are not a complete solution to the problem. Because of the large number of potential contaminants in leachate, and the lack of epidemiological studies about emerging contaminants, it is not possible to design a testing regime that can ensure protection of the environment, aquatic life, and people who drink water from areas where STPs are accepting landfill leachate. Protections need to be in line with the known threats, and this means that landfill leachate management will require a new approach. For now, leachate should remain onsite at the landfill.

In 2023, NYS DEC announced that it was considering new regulations to require leachate treatment and disposal onsite at landfills (NYS DEC, Undated). We are urging NYS DEC to open the formal rulemaking process, with a 90-day comment period. For more information, visit www.leachateloophole.org.

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The Schenectady Environmental Education Center: connecting communities, parks and schools through environmental literacy education and neighborhood-based stewardship activities: a progress report, March 2025

John McKeeby, Executive Director

Schoharie River Center, Inc., Burtonville, NY

In 2023 the City of Schenectady, in partnership with the Schoharie River Center, Inc. (SRC), and its partners: the Environmental Clearing House of Schenectady (ECOS), Community Fathers, Inc.(CFI) and the Upper Union Neighborhood Association (UUNA), pledged to work to transform the abandoned "Casino Building" located in the City's Central Park, into a modern environmental education center that will serve as learning hub for advancing environmental literacy in the City, through school and community neighborhood parks-based environmental education, environmental stewardship activities, citizen science research, digital media education, and youth workforce development programing. This project was announced in 2024 at last year's Mohawk Watershed Symposium.

The project is the latest example of the SRC's ongoing commitment to create and promote community based environmental education programs designed to foster greater public awareness of the ecosystem of the Mohawk River watershed through experiential learning and science-based education. [1] When completed (November 2025), the Schenectady Environmental Education Center (SEEC) will be and excellent venue from which to engage the public, (especially urban youth) in environmental education programs, stewardship and community based water quality and pollution monitoring throughout the City of Schenectady, focusing on the historical impact Schenectady has on the Mohawk River and it's watershed.

Building Renovations / Construction Plan

Working with the City and our community partners, we have secured the services of a locally-based design team consisting of Keith Cramer Architects, Simmons Design and Development, L&S Energy Services and Quantum Engineering Co. P.C. Working with Keith et al., the City and community partners, a series of building plans have been developed and schematic drawings have been completed and approved (Figure 1). Construction drawings can go out to bid immediately after all necessary funding has been procured. Bidding will follow the city's established bid process, under the supervision of the city engineer. Bidders will have 30 days to respond; after bid opening and review, a recommendation will be made to award bids subject to city council approval.

Funding for Building Renovation and Construction

Together, we envision a modern facility that will be a community resource where area youth and others will have the opportunity to enjoy and learn about their local natural environment, and what can be done to protect it. Our goal is to renovate and repurpose the building so it will be a modern sustainable, carbon net zero facility that will produce all the energy needed to operate the Environmental Education Center. We believe our approach can serve as a model for other communities along the Mohawk Basin, and elsewhere. The projected cost to complete the needed renovations is $1.4 million dollars. Fund raising for the project has been a high priority for the City and the partners and thus far we have secured funding totaling about $1 million through State, City and local foundation support. We hope to have the remaining

[1] Mohawk River Basin Action Agenda, 2021-2026, New York State Department of Environmental Conservation

$450 K raised by late spring, including funding from NYS DEC's Community Environmental Education Center grant program (EJCEEC-R1).

Table 1. Schenectady Environmental Education Center Construction – Source of Funds Detail

Source	Amount	% of total
Schenectady Foundation Mini Grant	$6,000.00	0.43%
CREST NYS Dormitory Authority	$500,000	35.49%
City of Schenectady	$250,000	17.75%
Carlillian Foundation	$25,000	1.77%
BCCC – NYSERDA	$118,000	8.44%
Investment Tax Credit	$33,900	2.41%
NYS DEC CEEC grant	$475,000	33.72%
Total	1,408,800	100.00%

Figure 1. Architectural rendering of the future Schenectady Environmental Education Center (SEEC). Source: Krammer and Associates.

The Environmental Education Center will be open daily, year round and become a hub for a range of community based programming provided by the SRC, our partners, interested in promoting a more healthy, sustainable and equitable City of Schenectady and Mohawk River Basin.

Prevalence of PFAS contaminants in surface water in the Capital Region

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Introduction

Per- and polyfluoroalkyl substances (PFAS) comprise a set of close to 5,000 man-made chemicals that have widespread application in the manufacturing of consumer items and other materials. In the production of non-stick materials, PFAS chemicals are notable for their fluoropolymer coatings, which are resistant to water, heat, and oil. This is the result of the strong carbon-fluorine bond of which PFAS chemicals are composed. However, because of this bond, they do not easily degrade, instead persisting in the environment and within organisms when it is emitted as a byproduct of manufacturing. When released, PFAS chemicals can contaminate aquatic environments and groundwater in particular. (European Environment Agency, 2023) This is significant, because both are a direct path to human exposure via drinking water. If consumed PFAS can build up in the body, leading to a variety of health issues, including forms of cancer, and developmental problems during pregnancy.

In the Capital Region, PFAS is of particular interest as there are several sites denoted as PFAS-contaminated by the Environmental Working Group. Along the Mohawk River, the Environmental Working Group's PFAS contamination map indicates at least three sites of drinking water above the maximum contaminant level (Environmental Working Group, 2024). Previous sampling in 2017 by the towns of Waterford and Colonie found PFAS concentrations of 1-3 parts per trillion (ppt) in the Mohawk River, after concerns were raised regarding the Colonie Landfill as a potential source of contamination (Riverkeeper, 2018). Previously, the town of Hoosick Falls in Rensselaer County has been subject to extremely high levels of PFAS in groundwater as a result of industrial fumes and wastewater (Gonzales et. al, 2021).

Methods

Six sites with surface water access along the Mohawk and Hudson rivers were selected for a 6-week sampling campaign starting on the 18th of June 2024. Along the Hudson River, samples were collected at Hudson Shores Park in Watervliet, Halfmoon Lighthouse Park in Halfmoon, and the Mechanicville City Docks in Mechanicville. The Mohawk River sites sampled for the weekly sequence included the Flightlock Boat Launch in Waterford, Lock 7 Boat Launch in Niskayuna and the docks on Aqueduct Road in Niskayuna. On the final day of weekly testing, four individual surface water access sites were sampled in addition to the main six. These additional samples were collected at Henry Hudson Park in Bethlehem, the Albany Rowing Center docks in Albany, the boat launch on River Bend Rd. in Waterford, and the Hans Groot Kill in Schenectady (Figure 1).

To test for the PFAS contaminants, Water Test Kits for PFAS, a product manufactured by Cyclopure was employed. The Water Test Kit for PFAS test kit consists of a small cup-like device, and has the user fill 250 milliliters of the desired water sample (Figure 2). Once filled, the water sample then drains through the bottom of the cup, through a proprietary filter extraction disc that removes PFAS contaminants from the sample. This filter utilizes the company's patented technology, DEXSORB, which utilizes molecular selectivity to target fifty-five common PFAS chemicals with rapid, high-capacity adsorption. Once all 250 mL of water has passed through the DEXSORB filtration disc, the test is sealed at the top, and an informational card with the test's date and location were filled. Once complete, the test kit was mailed to

Cyclopure where the disc underwent standard solid-phase extraction (SPE), to recover the absorbed PFAS. After a roughly ten-day wait period, results were returned via email. Measured PFAS concentrations were reported in parts per trillion (ppt).

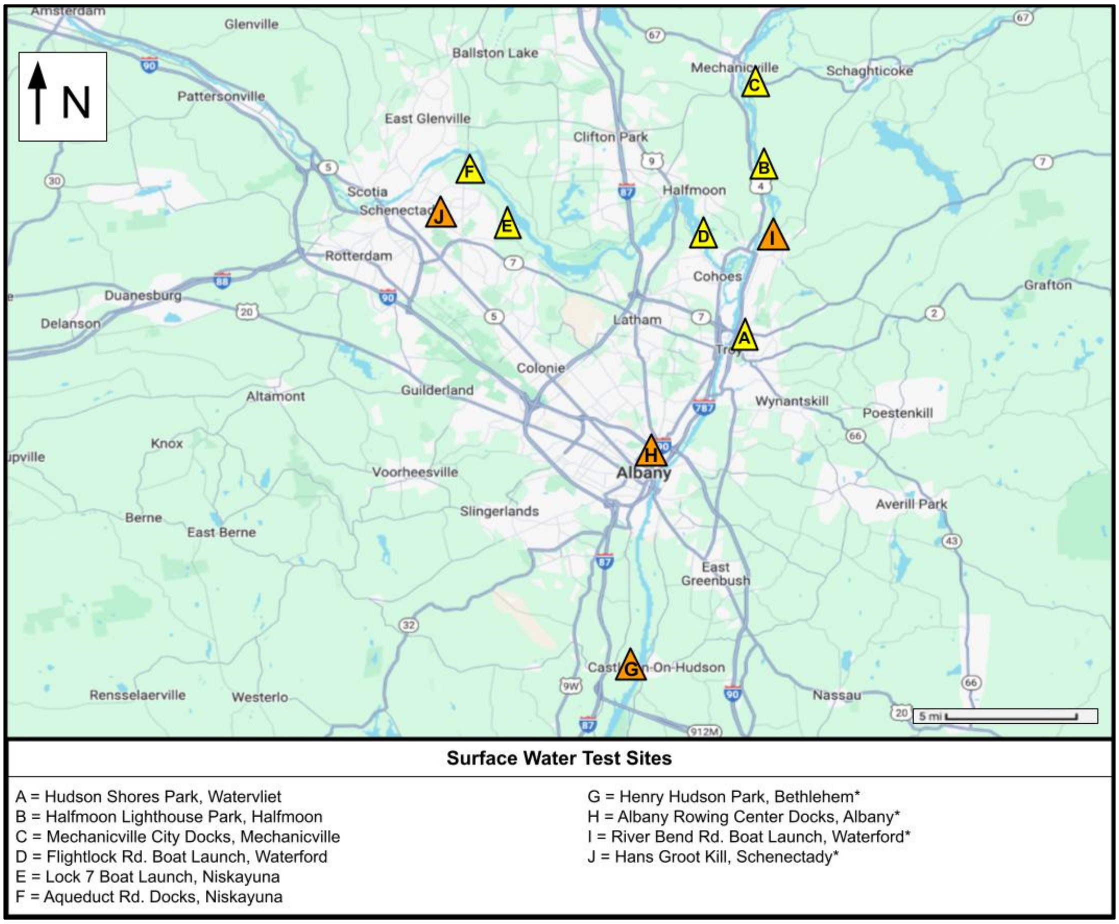

Figure 1. Map of surface water sampling sites in the Capital Region. Triangles indicate surface water access points. Yellow indicates that the site is part of the weekly sequence. Orange indicates that the site was part of the additional water tests. Map image from Google Maps. * Site was tested only once as part of additional water tests on the final sampling day.

Figure 2. Cyclopure Water Test Kit in use.

Results and Discussion

Among the weekly surface water tests, the total average PFAS concentrations ranged from 1.4 to 4.5 parts per trillion (ppt). Each site contained at least one PFAS chemical average equal to or greater than 1 ppt. (Table 1).

Table 1. Average PFAS chemical concentrations (ppt) at weekly sequence sites, 6/24/24-7/31/24.

Individual PFAS chemicals	Hudson Shores Park	Halfmoon Lighthouse Park	Mechanicville City Docks	Flightlock Rd. Boat Launch	Lock 7 Boat Launch	Aqueduct Rd. Docks
PFBA	0	0	0	0	0	0.2
PFPeA	0	0	0	0.2	0	0.2
PFHxA	0	0	0	0.6	0.6	0.4
PFHpA	0	0	0	0	0	0
PFOA	1.4	1.6	1.4	0.2	0.2	0
PFNA	0	0	0	0	0	0
PFDA	0	0	0	0	0	0
GenX	0	0	0	0	0	0
PFBS	0	0	0	0	0	0
PFHxS	0	0	0	0	0	0
PFOS	1.1	0	0	2.2	1	2
10:2 FTS	0	0.2	0	1.3	0	0.2
Total PFAS (All Detected)	**2.5**	**1.8**	**1.4**	**4.5**	**1.8**	**3**

The greatest totals of the averaged weekly measurements were seen at Hudson Shores Park, the Aqueduct Rd. docks in Niskayuna, and the Flightlock Rd. boat launch in Waterford, with readings of 2.5 ppt, 3, and 4.5 respectively. The other three weekly sites had average totals of 1.8 ppt or lower (Figure 3). The most prevalent PFAS chemical among the weekly trials was PFOA, at five of the sites, while the chemical that appeared in the greatest concentrations was PFOS, which appeared at four of the sites at 1 ppt or greater. Other chemicals that were detected at <1 ppt include PFHxS, PFHxA, PFPeA, and PFBA.

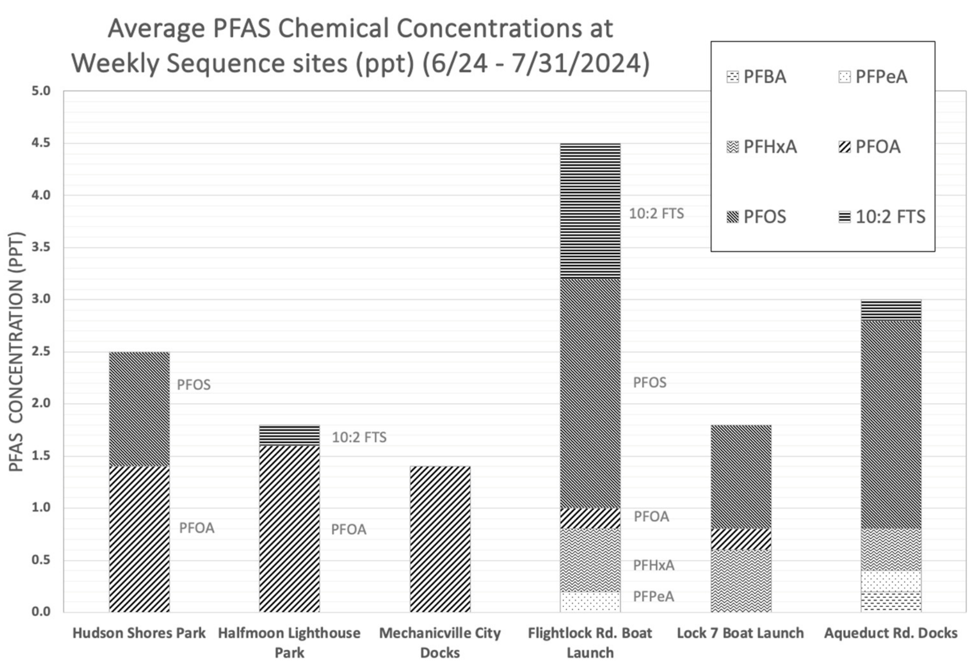

Figure 3. Average PFAS chemical concentrations (ppt) at weekly sequence sites, 6/24/24 - 7/31/24.

In the single-day tests, the total PFAS concentration ranged from 1.8 ppt to 6.3 among the main six sites. The greatest measurements were at the Aqueduct Rd. Docks, Flightlock Rd. Boat Launch, and Lock 7 Boat Launch, with readings of 6.3 ppt, 4.5 ppt, and 3.8 ppt respectively. Hudson Shores Park reported 2.4 ppt, and the remaining sites were below 2 ppt. Including the additional four locations, the range of total PFAS concentration is increased, as Henry Hudson Park measured 6.9 ppt PFAS. Also notable are the Albany Rowing Center docks and Hans Groot Kill, each measuring over 5 ppt PFAS. (Table 2). Prevalence of individual PFAS chemicals is the same as in the main six sites with PFOA being detected at five sites, and PFOS occurring in the greatest quantity (Figure 4). However, including the four additional tests, NEtFOSE and PFBS are seen, exclusive to Henry Hudson Park and the Hans Groot Kill, respectively. Out of the ten sites sampled, the Hans Groot Kill is unique in that it was the only small tributary sampled.

Table 2. PFAS chemical concentrations (ppt) at all sites, 7/31/24.

Individual PFAS chemicals	Hudson Shores Park	Halfmoon Lighthouse Park	Mechanicville City Docks	Flightlock Rd. Boat Launch	Lock 7 Boat Launch	Aqueduct Rd. Docks
PFBA	0	0	0	0	0	1.1
PFPeA	0	0	0	0	0	1.3
PFHxA	0	0	0	0	1.2	1.5
PFHpA	0	0	0	0	0	0
PFOA	1.4	1.8	1.6	1.1	1	0
PFNA	0	0	0	0	0	0
PFDA	0	0	0	0	0	0
GenX	0	0	0	0	0	0
PFBS	0	0	0	0	0	0
PFHxS	0	0	0	0	0	0
PFOS	1.2	0	0	3.4	1.6	2.4
10:2 FTS	0	0	0	0	0	0
NEtFOSE	0	0	0	0	0	0
Total PFAS (All Detected)	**2.4**	**1.8**	**1.6**	**4.5**	**3.8**	**6.3**

Individual PFAS chemicals	Henry Hudson Park	Albany Rowing Center Docks	River Bend Rd. Boat Launch	Hans Groot Kill		
PFBA	1	1.2	1	0		
PFPeA	1.1	1	0	0		
PFHxA	0	0	0	0		
PFHpA	0	0	0	0		
PFOA	2.1	1.4	1.6	0		
PFNA	0	0	0	0		
PFDA	0	0	0	0		
GenX	0	0	0	0		
PFBS	0	0	0	1.5		
PFHxS	0	0	0			
PFOS	1.3	1.2	0	3.8		
10:2 FTS	0	0	0	0		
NEtFOSE	1.4	0	0	0		
Total PFAS (All Detected)	**6.9**	**4.8**	**2.6**	**5.3**		

Moving downstream on the Hudson River there is a trend of increasing PFAS concentrations when both the weekly averages and the single tests are included. Starting with the northernmost Hudson site, the Mechanicville kayak launch exhibited a total weekly average of 1.8 ppt, with only one test exceeding 2 ppt. The greatest single test results at each of the subsequent sites south of Mechanicville increase, with the greatest of 6.9 ppt at Henry Hudson Park, the southernmost site. This suggests PFAS contaminants could be accumulating downstream as point sources further contribute chemicals.

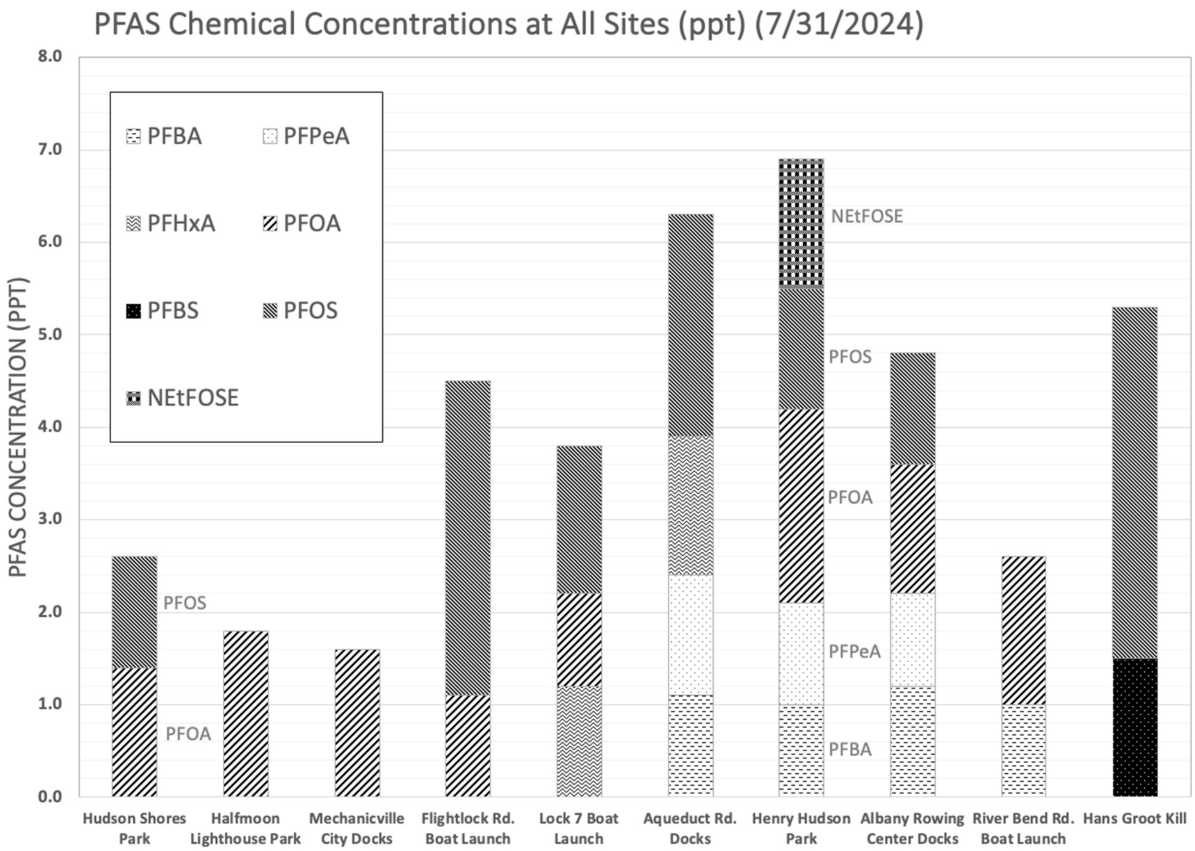

Figure 4. PFAS chemical concentrations (ppt) at all sites, 7/31/24.

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Evaluating NY State's wastewater infrastructure for a healthier future

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Introduction

Wastewater systems make up a crucial part of our infrastructure. If facilities are not properly designed or maintained, an increased risk of unintended sewage discharge presents itself. This not only compromises the health of local water bodies, but also the health of humans who interact with those water bodies. Wastewater is one of New York's lowest-rated infrastructure sectors, tied with roads and transit. Around 40% of the state's operational sewers have been in use for over 60 years (Report Card for America's Infrastructure). Large sums of money must be invested to renew and repair aging pipes and treatment facilities. To achieve this, an increased awareness of this as an issue must surface. New York State must be held to a higher standard regarding their sewer systems, and the first step to accomplishing this is informing the public.

Thanks to the Sewage Pollution Right to Know (SPRTK) Act, which was passed in NY state in 2013, municipalities are required to notify the Department of Environmental Conservation (DEC) of all wastewater release events within 2 hours of discovery and must notify the public along with other nearby municipalities within 4 hours. The passing of this law has represented a significant step forward for NY's wastewater infrastructure. However, this does not fix the problem itself. The publicly available data is overwhelming and difficult to interpret. This serves little use to the public in terms of referring to past events. With more organized and uniform release event data, the state of New York can enhance their ability to improve this infrastructural sector while also keeping the public informed.

Methods

The SPRTK data on wastewater release event records was compiled into one cumulative Excel spreadsheet. Only records from after July of 2017 were used in the evaluation, as those before then were too incomplete to be considered useful. The data was cleaned and organized, which entailed unit conversions, simplification, removal of duplicate entries, and more. These records were aggregated and analyzed by county, by region, by year, and by month.

Three metrics were used to assess wastewater infrastructure performance with respect to each aggregation: reliability, resilience, and vulnerability (RRV). Reliability was represented by the occurrence of release events and was calculated by dividing the number of days in which a release event occurred by the number of days the data spanned. Resilience was represented by the duration of events and was calculated by dividing the number of records lasting less than 24 hours by the total number of records. Lastly, vulnerability was with respect to the average quantity of discharged water and was calculated by dividing the sum of all discharge volumes by the total number of records.

The capabilities of Rstudio were used to determine the coordinates of the records that did not already have entered coordinates by using their associated addresses. Each record was then imported into ArcMap as individual points, along with RRV data.

Rodak, C.M., Garver, J.I., Smith, J.A. 2025. Proceedings of the 2025 Mohawk Watershed Symposium, Union College, Schenectady, NY, March 21, 2025, Volume 15, 89 pages.

Results and Discussion

Over 18,000 wastewater release events occurred over the span of 2,131 day (Table 1). Only 100 of those days were free of wastewater releases in the state of New York, as there was an average of 8.5 releases per day.

Table 1. Overall analysis of wastewater release data

Analysis Summary (Aug 2017 to Apr 2024)	
Total # of releases	18,110
Months of data coverage	69
Days of data coverage	2,131
# of unique days with releases	2,031
% of days in which a release occurred	95.3
Average release frequency	~2 hours and 50 mins
Average releases per day	8.5

Monthly trends were partially consistent with a previous study on water quality and fecal indicator bacteria (FIB) in the Mohawk River (Rodak, 2022). The 24-hr resiliencies were lower in the colder winter months compared to the warm summer months. This indicates that on average, release events persist for longer periods of time in colder weather. Additionally, both studies showed December to be the most vulnerable month. There are various possible explanations for this finding. This could be attributed to freezing temperatures causing blockages, or even to increased domestic water use or improper disposal of fat and other food waste from the holidays, which would in turn clog water-transport piping systems.

Regional findings show much variation of RRV. It was found that Erie County experienced the highest number of release events by an alarmingly significant margin (Figure 1). Almost 7,000 wastewater release events occurred in Erie during the timespan of the study, meaning approximately 38% of these events took place in that county alone. Niagara County was behind Erie with just over 1,000 releases, while the Onondaga, Rensselaer, Orange, and Albany counties were close behind. Erie County is also the only county with a reliability below 50%. However, Erie is not nearly as obvious of an outlier in this category. This could be attributed to a combination of factors:

1) A high population density: Erie includes Buffalo, which is one of the largest cities in NY State. It has one of the largest population densities that is not part of New York City. Because of this, it also has more wastewater treatment plants (WWTPs) and a higher number of sewage lines compared to most other counties.
2) Older wastewater infrastructure: Buffalo and its surrounding small cities and suburbs are old industrial areas with aging infrastructure (Vedachalam et al.) Erie contains many combined sewer overflows (CSOs). These result from the presence of combined sewer systems (CSSs), which are when wastewater and stormwater are transported through the same pipe. These severely increase the risk of unwanted discharge, and although CSSs are no longer constructed in the US for this reason, many old ones in Erie County still have not been replaced and thus continue to operate.

3) Strong lake effect precipitation: The Great Lakes are notorious for having extreme lake effect precipitation. The movement of cold air from Lake Ontario causes increased instances and magnitudes of rainfall, which is the main cause of release events.

Figure 1. RRV and # of release events by county

Erie, however, did not top the charts with respect to resilience and vulnerability. Rather, Ulster County was least resilient out of the counties with a significant number of release events, with a 24-hr resilience of only 10.5%. It should be noted, however, that a large portion of Ulster County's records have identical durations and volumes, which has led to skepticism over the accuracy of reported information particularly within this county. Putnam County and Sullivan County also have poor 24-hr resiliencies, though these counties were not found to have particularly questionable data like that of Ulster. Regarding vulnerability, Broome County was a clear outlier with a reported average of 13.6 million gallons (MG) per release event. Clinton, Saratoga and Nassau counties did particularly well, each with under 20,000 gallons per release event.

Conclusions

The ability to consistently identify and address areas of the state that struggle with high instances of wastewater release events will remain paramount moving forward. Pinpointing weak areas of our infrastructure with respect to both seasonality and spatiality can narrow down areas and aspects that need to be invested in and prioritized with the interest of maintaining both environmental and human health. Improving our sewer systems and treatment plants starts with identifying the source of the problem.

With four spreadsheets organized by county, region, month, and year, this sewage discharge data can now be efficiently utilized and directed toward the real challenge: repairing and enhancing New York's wastewater infrastructure. The improved availability of readable and interpretable data should raise the bar for discharge reports in the future. It should not only encourage municipalities to report information with maximum accuracy but also serve as a milestone for public awareness and bring to light the need for significant investments in this sector of New York's infrastructure.

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Some critical water resource issues in the Mohawk watershed and beyond

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Overview

At the New York State Water Resources Institute at Cornell University (NYSWRI), we work to identify and address critical water resource issues across the state and the nation. Generally, we support robust science and dialogue between researchers, managers, policymakers, and the general public to improve water management through original research and outreach.

Working in the Mohawk

With support from the NYS Environmental Protection Fund, and in partnership with the NYSDEC Hudson River Estuary Program, the Mohawk River Basin Program, and Great Lakes Program, NYSWRI has been able to conduct and support research and outreach in and around the Mohawk basin on a variety of important topics.

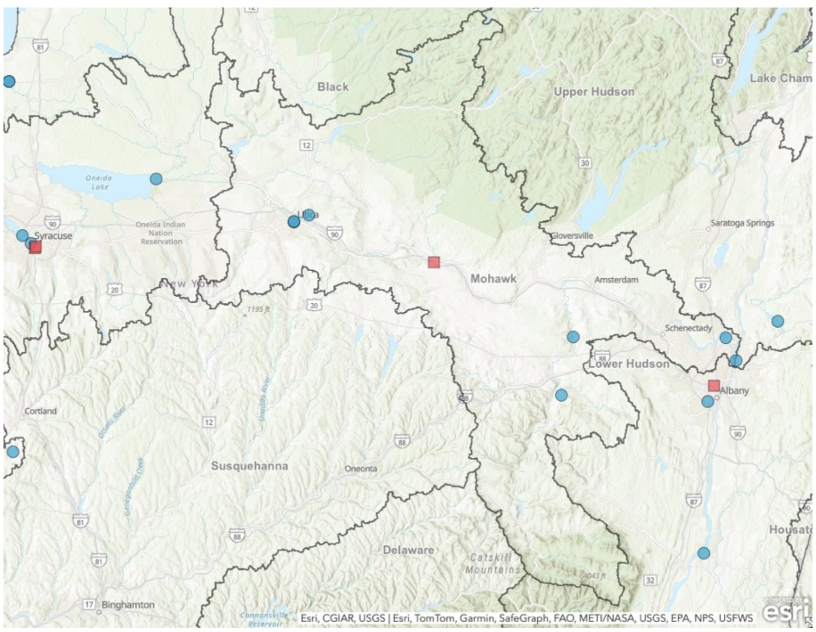

Figure 1. The Mohawk watershed; each dot on the map represents a NYSWRI funded project from the last three years.

Critical themes in watershed health

Direct measurements of watershed health, including physical, chemical, and biological characterizations of surface and ground water, are critical to collect, understand, and improve. That said, watershed health encompasses so much more. Appropriately designed and well-maintained infrastructure, resilient and diverse habitats, resilient and equitable social networks, and a water literate populace are all critical elements of health in the Mohawk. NYSWRI works across a broad range of these watershed elements in pursuit of the Mohawk River Basin Action Agenda. In this talk, I will highlight some of our efforts to address water resources holistically in the Mohawk Basin.

Rodak, C.M., Garver, J.I., Smith, J.A. 2025. Proceedings of the 2025 Mohawk Watershed Symposium, Union College, Schenectady, NY, March 21, 2025, Volume 15, 89 pages.

Bringing A Day in the Life to the Mohawk River

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A Day in the Life of the Mohawk River is an annual field-based student-focused event. It's kids thinking like a watershed. Education partners collaborate with schools to capture a snapshot of the river's ecology on one day. Trainings, workshops, classroom programs, equipment and resources are provided by NYS DEC in partnership with the National Estuarine Research Reserve, Lamont-Doherty Earth Observatory, NEIWPCC (New England Interstate Pollution Control Commission,) SUNY-ESF, Mohawk River Basin Program, Onondaga Environmental Institute, SUNY-Cobleskill, Schoharie River Center, and Friends of the North Chuctanunda. Students practice critical thinking, environmental observation, data reporting, and interpretation skills in the classrooms, in the stream, and in the lab.

Each fall all along the Hudson River from the Adirondacks to the Atlantic Ocean, and Mohawk River, teachers and education partners team up to bring school groups to the water's edge to collect samples and learn from the river. This unique event is designed to both celebrate the Hudson River and its watershed, and educate participants on the uniqueness of this valuable local resource. Our poster will showcase the sites that participated in 2024 along the Mohawk River watershed.

Nine school groups spent a Day in the Life of the Mohawk River from Rome to the Hudson River observing and documenting the physical, biological and chemical characteristics of their chosen river site. Key environmental and water quality indicators include: current velocity; air and water temperature; weather; benthic macroinvertebrates; fish; dissolved oxygen; pH; nutrients; sediment and turbidity. Students learn water safety, how to use basic water quality testing kits and equipment, how to identify benthic macroinvertebrates and fish, and how to record and interpret data. Students take home a new sense and appreciation for their home watershed.

A Day in the Life of the Mohawk River is an enormous expression of good will and action. Miracles happen with commitment. We're committed. We'll continue building and serving the people of Mohawk River Basin through classroom, laboratory and outdoor watershed education. A group of high-level educators, high school students, and NYS DEC are creating an annual Day in the Life of the Mohawk River. We're forming a steering committee, developing relevant Mohawk Watershed data sheets and central data management for all participants. This is a powerful unique project for the next generation of watershed stewards. We invite your participation. Please sign up at our exhibit table. We appreciate your support.

A Day in the Life of the Mohawk River: 2024 program overview

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The first *'Snapshot Day* - *A Day in the Life of the Hudson River*' in October 2003 brought 300 teachers and students to nine different sites along the Hudson River Estuary. The project has expanded above and beyond all expectations. After decades of progress in the Hudson, we focused on expanding the program last year throughout the Mohawk and Adirondack watersheds. On Thursday October 10th, 2024, 5,000 partners, teachers and students went to over 100 river and tributary sites from New York Harbor to Rome and Newcomb.

In an effort to expand service throughout the Hudson River Basin, NYS DEC and a dedicated group of watershed organizers teamed up in the fall of 2023. We reached across the divide of geographic and social networks the old-fashioned in-person way. Through one by one personal reference, email and phone call, mile by mile of travel up and down 140 miles of the Mohawk Valley, we met new partners, teachers and students. We organized nine groups for A Day in the Life of the Mohawk River.

From Rome to the Hudson River, each group spent a Day in the Life of the Mohawk River observing and documenting the physical, biological and chemical characteristics of each river site. Key environmental and water quality indicators include: current velocity; air and water temperature; weather; benthic macroinvertebrates; fish; dissolved oxygen; pH; nutrients; sediment and turbidity. Students learn how to use basic water quality testing kits and equipment, how to identify benthic macroinvertebrates and fish, and how to record and interpret data. Students take home a whole new sense of place and appreciation for their home watershed.

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Survey study of presence of cyanotoxins in wadeable stream sites in New York State, US (2017-2021)

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Cyanobacteria are naturally occurring in the environment, but when conditions become favorable for proliferation, can pose a threat to the ecological integrity and human uses of freshwaters. These water column or planktonic accumulations - Harmful Algal Blooms (HABS) - pose potential health risks to waterbody users. Benthic (attached) cyanobacteria are far less studied than their planktonic counterparts, yet they also produce cyanotoxins, including microcystin, anatoxin, and nodularin.

This study was a first step in understanding prevalence of benthic mats and cyanobacteria in flowing waters. This analysis investigated the spatial prevalence of cyanotoxins and toxigenic strains of benthic cyanobacteria present in the water column and periphyton of over 1000 wadeable stream sites across New York, representing a gradient of trophic and habitat conditions.

Sample collection and analysis was conducted over a five-year period (2017-2021). Detections of cyanotoxins were rare (<10%) and occurred mainly in benthic scrape samples. Anatoxin was the most common cyanotoxin detected throughout the study, often associated with the presence of *Oscillatoria spp*. No sites had the co-occurrence of any cyanotoxins (anatoxin, microcystins, or paralytic shellfish poison), and only two sites had detections in both the mats and the water column at the same time. Additionally, there was no clear spatial pattern in toxin presence across the state.

This study found differences in chemical and physical characteristics of sites with cyanotoxin detections: those with lower total nitrogen, lower total phosphorus, and lower specific conductance as well as lower canopy cover and high natural land cover were more likely to have benthic cyanotoxin detections. Results indicate a low rate of occurrence of cyanobacteria and associated toxins in flowing waters, suggesting low potential for recreational contact.

Diet shifts and spatial growth variation of Round Goby in Schoharie Creek, NY

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Round Goby (*Neogobius melanostomus*), an invasive benthic fish species, has adversely affected aquatic ecosystems in North America since its introduction in the 1990s. Introduced through ballast water, Round Goby initially established populations in the Great Lakes before spreading to other watersheds, including the Mohawk River watershed in New York, where it was first recorded in 2014.

This study investigates diet composition and spatial differences in the age of Round Goby in Schoharie Creek, the largest tributary to the Mohawk River. Gut content analysis reveals a dietary shift between sites, with downstream individuals primarily consuming Dreissenid mussels, while upstream individuals rely on non-shelled invertebrates like Chironomids. Growth models suggest that Round Goby grow faster at upstream locations dominated by Chironomid diets compared to those near the Mohawk River confluence, where Dreissenid mussels are more prevalent.

The ability of Round Goby to exploit varied food resources demonstrates their adaptability and potential to thrive in diverse habitats. The expansion of Round Goby into Schoharie Creek raises significant ecological concerns, particularly regarding resource competition and the potential displacement of native species. Understanding habitat preferences and dietary patterns is critical for developing effective management strategies to mitigate the effect of Round Goby on native ecosystems.

Climate impacts to drinking water

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Shannon Roback

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As New York State communities develop drinking water source protection plans and climate adaptation plans, they need guidance to understand how climate change will impact drinking water quality. Riverkeeper produced a report, based on the New York State Climate Impacts Assessment, peer-reviewed literature and expert interviews, in order to provide information that can prompt greater attention to this issue and provide water suppliers with information on likely changes to water quality that will need to be contented with in the future. The Climate Impacts to Drinking Water report also includes an exploration of how climate will impact infrastructure and treatment plants and describe feedback loops and impact chains that may affect drinking water quality in the region. This Project has been funded in part by a grant from the New York State Environmental Protection Fund through the Hudson River Estuary Program of the New York State Department of Environmental Conservation.

A range of climate impacts will affect drinking water quality, including warming air and water temperatures; shifting seasons; increased precipitation; flooding, drought and other extreme weather events; wildfires and sea-level rise. In many cases, multivariable events and co-occurring events have compounding or cascading effects. The degree to which these impacts will affect water quality in drinking water supplies is determined by the severity and simultaneity of these impacts, and how they interact with the watersheds associated with drinking water supplies. Some watershed-specific factors that will influence the severity of impacts include underlying pollution burdens, particularly from nutrients (nitrogen and phosphorus) and road salt, hydrology and bathymetry, and land use

Some of the climate impacts anticipated to affect surface water supplies, such as lakes, reservoirs and rivers, include increased risks from harmful algal blooms, disinfection byproducts and trace contaminants. In the case of the Hudson River Estuary, increasing salinity driven by sea-level rise is also a concern. A separate Riverkeeper analysis of publicly available water quality data from public drinking water supplies in the Hudson River Watershed show that these contaminants are already emerging as concerns.

The report will be available at riverkeeper.org

Sustaining a Brook Trout stronghold: initiatives in the West Kill

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The New York State Department of Environmental Conservation has partnered with Trout Unlimited to focus efforts and funding on Brook Trout waters. The West Kill, a high-quality Brook Trout stream in the Upper Schoharie Creek drainage, is characterized by consistent cold-water upwelling, low-intensity land use, and genetically unique heritage Brook Trout. These attributes make the West Kill a priority for both attention and protection.

Since 2019, three aquatic habitat improvement projects have been completed, along with riparian plantings and a DNA analysis of Brook Trout in Hunter Brook, a primary tributary of the West Kill. By the end of 2025, additional efforts will include another aquatic habitat improvement project, a large wood "Chop and Drop" initiative, suppression of invasive plant species, additional riparian plantings, and a DNA analysis of Brook Trout in the Upper West Kill.

These efforts are critical to preserving Brook Trout populations in the face of a warming climate and increasing Brown Trout populations. This concentrated watershed-based approach is intended to reap maximum benefit from efforts and have additive advantages, compared to spot treatments spread out across different watersheds.

Assessing *Neogobius melanostomus* (Round Goby) abundance in the Mohawk River and Hudson River using eDNA

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Introduction

The Round Goby (*Neogobius melanostomus*) is a benthic invasive species from the Black and Caspian Seas of Eurasia. This species has outcompeted native fish by consuming fish eggs and small aquatic species, and hosting diseases like hemorrhagic septicemia (George et al., 2021). This population of invasive fish has spread at exceedingly rapid rates in the Great Lakes watershed, with its first appearance in 1990 in the St. Clair River (Nevers et al., 2018). Since this invasion of US waterways, they have traveled eastward through New York's canal systems and have populated regions of the Mohawk River and Hudson River, damaging local aquatic ecosystems. The abundances of Gobies in these rivers are sparse, so traditional capturing methods like electrofishing or trawling can miss the presence of Gobies. Therefore, researchers use highly sensitive eDNA techniques as indicators of the presence of Round Goby.

For our study we captured water samples from the Hudson River and Mohawk River containing fragments of eDNA from aquatic organisms known to be present in these waterways, and potentially Goby as well. This eDNA was extracted from the water samples and analyzed using qPCR technology. Using eDNA to track Round Goby dynamics and their adverse effects on local ecosystems allows for early mitigation strategies to limit these populations.

Methods

The eDNA samples were taken in sterilized 1 liter Nalgene bottles from surface water in nine sites along the Hudson River and Mohawk River in Upstate New York once a week for 6 weeks (Fig.1). Each site was also tested in situ for general water-quality parameters to see if there is any correlation with eDNA presence. The YSI Pro Digital Multimeter was used to test temperature (°C), specific conductivity (µS/cm), pH, %DO, DO (mg/L), barometry (kPa), and turbidity (FNU).

The eDNA samples were transported on ice back to Union College where they were filtered through 2 µm, 47 mm glass fiber filters to capture the eDNA, then stored in the -80°C freezer. The entire process from collection to freezer occurred within six hours to ensure minimal DNA decomposition. Samples were extracted in preparation for qPCR analysis using the Qiagen Blood and Tissue Kit protocol (without Bead-beating) at SUNY ESF. The qPCR analysis was performed using the QuantStudio3 Applied Biosystems thermocycler. Samples were considered positive when one or more out of the three replicate reactions were amplified with a cycle threshold value of less than 40.

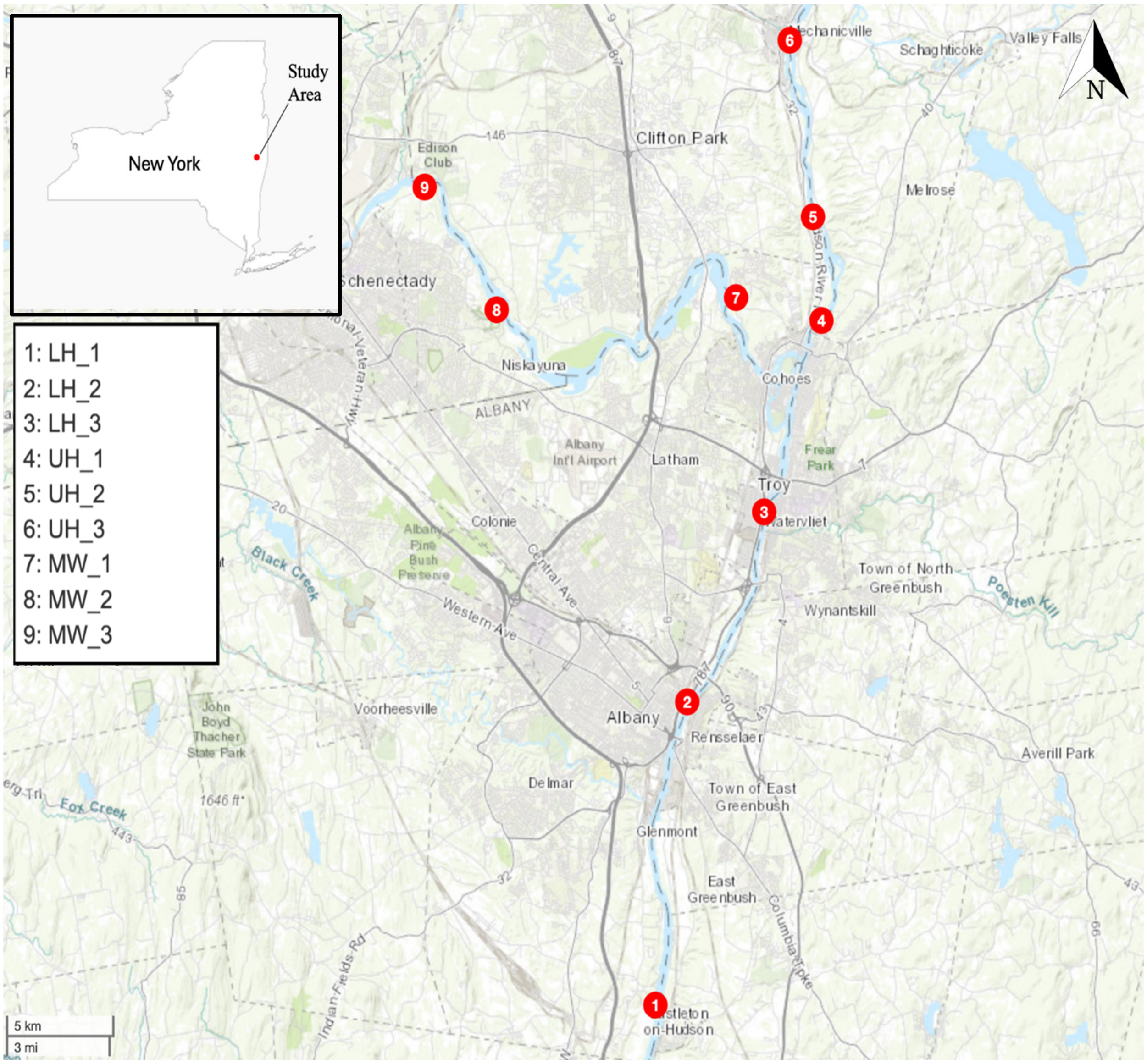

Figure 1. Map of sampling sites for eDNA and water quality. Sample IDs were created based on location grouping in the Mohawk and Hudson River; With LH= Lower Hudson, UH=Upper Hudson, MW=Mohawk River. Sample sites were determined by accessibility and previous records of Round Goby sightings from the USGS NAS. Basemap layer sourced from Environmental Systems Research Institute (Esri) Topographic.

Results

Most samples did not yield sufficiently large quantities of eDNA for reliable quantification but can be used to indicate presence of Round Goby. For this analysis, samples from every site and collection day were put into a rank system of 0-4 with 0 being no detection, 1 being detected in one of three replicate reactions, 2 being detected in two of three replicate reactions, 3 being detected in all three replicate reactions, and 4 having quantifiable data. Each sampling day was then averaged to provide an average rank for each site (Table 1, Figure 2).

Table 1. Average rank of each site's eDNA samples collected over six weeks.

Site	Ave. rank
LH-1	1.8
LH-2	1.7
LH-3	2.5
MW-1	3.2
MW-2	2.0
MW-3	1.8
UH-1	2.2
UH-2	0.0
UH-3	0.0

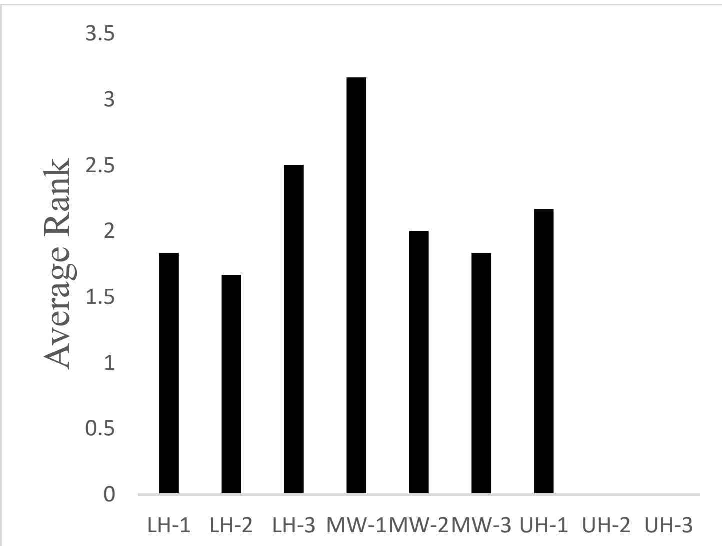

Figure 2: Average rank of each site's eDNA samples collected over six weeks. Rankings of 0-4 are dependent on detection across replicate reactions when samples were analyzed using qPCR.

MW-1 samples displayed the highest average ranking with detection of Round Goby eDNA in every sample collected over the summer. Of the sites where Round Goby was detected, LH-2 had the lowest average ranking. No Round Goby eDNA was detected in UH-2 and UH-3. The lack of Round Goby detection in UH-2 and UH-3 reflects the efficiency of the "double draining" procedure of lock C1 which is located directly below these two sites. The "double draining" procedure is the process in which locks are emptied completely two times during locking operations, one drainage before vessels enter the lock, and one during the time vessels are present in the lock (NYS Canal Corporation, 2023). This procedure is used for the purpose of avoiding the introduction of invasive species to upper Hudson waters from passing vessels.

Sites LW-3, MW-1, UH-1 yielded the highest results and were in similar localities along the confluence between the Mohawk River and Hudson River. The likely explanation for this result is that these three sites are located near lock segments with permanent impoundments compared to other sites located within seasonal impoundments. Seasonal impoundments along the Mohawk River are reduced during winter months to prevent flooding in the spring (George and Baldigo, 2016). As a result of this drawdown, winter habitats for aquatic species that provide refuge from harsh winter conditions are eliminated, causing population decrease and winter kill. Nonnative species have been found to be more vulnerable in these circumstances, as they are less adaptive to these riverine conditions as native fish populations are (George and Baldigo, 2016).

Conclusions

Using eDNA to observe minute populations of Round Goby in the Hudson River and Mohawk River is beneficial, as early detection can help create mitigation strategies before native species begin to be impacted by these populations. Protecting our local waterways from invasive species interactions helps sustain biodiversity among native species and maintain water quality long term.

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X-Snow: A regional citizen-science project for snow

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Introduction

Snow is an integral part of the climate system that has undergone unprecedented changes within the past decades (Rantanen et al., 2022). Despite its importance, accurately measuring and projecting future snowpacks presents significant challenges. Snow is a complex phenomenon influenced by temperature, wind, humidity, and topography (Hall et al., 2017; Tedesco, 2014). These factors combine to create an uneven distribution of snow on the ground, making it difficult to get a true picture of the snowpack properties. Estimating snow properties in mountain regions is prohibitive from a remote sensing perspective from both the intrinsic limitations of remote sensing tools (e.g., obscuration by vegetation or clouds) and extrinsic limits (e.g., topography, slope, deep snow). Models are used to provide estimates of snowpack structure and predictions about how the pack will evolve over time, however, models suffer from limitations related to the granular nature of the processes characterizing the spatio-temporal variability of snow processes in mountain regions, which require ground measurements for evaluation and improvement.

Citizen/Community Science Project

Over the past years, citizen or community science has emerged as a powerful tool in many scientific applications (Fraisl et al., 2022), such as validation of model outputs and remote sensing products as well as early warning systems (See, 2019). The absence of in-situ observations can be complemented by data collected by citizens equipped with proper tools and properly educated on standardized measurement techniques and processes. Engaging community members in sampling expands project capacity through increased spatial 'reach' and temporal ability to gather regular in situ snow measurements. This is especially important when considering that the places where we need the most accurate information for water resources management, seasonal tourism and other societal applications (e.g., mountains) are also the places where models and remote sensing tools fail, providing the worst performances (Tedesco, 2014; Tedesco et al., 2015).

We have launched X-Snow, a citizen science NASA partner project, focusing on the Catskill, Mohawk and Adirondacks regions as a launching point. The program offers a unique opportunity to enhance our understanding of snow properties and improve remote sensing estimates and modeling outputs, while connecting community members with their environment. By equipping citizens with tools provided by scientists, such as snow depth probes, snow density kits, and smartphone applications, individuals directly measure various snow parameters in their local environments. These datasets will increase our ability to capture spatial and temporal variability in mountainous regions where complex terrain and microclimates lead to significant variations in snow properties over short distances and timeframes.

Our ability to estimate water storage and changes is limited by the number of local measurements of snow cover and snow properties. Additionally, winter tourism in the Mohawk Valley is an important economic resource for the area. Using satellites, selected properties of snow cover, such as the amount of snow, the extent of snow, and the percentage of sunlight the snow reflects can be estimated. Models can provide additional estimates of snowpack structure and predictions about how the snowpack will evolve over time. However, both models and satellite-derived estimates require ground measurements for evaluation and improvement and are strongly limited in mountain areas by limitations arising from spatial resolution, influence of vegetation, and cloud masking, for example. Additionally, most of the data collected to support models is from the West Coast where the snow is less dense. We need more East Coast in situ data collection to support the accuracy of our regional models. Ultimately, the X-Snow project empowers individuals and communities to contribute to scientific research, fostering a deeper connection to their local environment while advancing our knowledge of crucial snow-related phenomena.

The fieldwork activities are designed to produce a set of measurements that are necessary for validating the accuracy of satellite measurements and models of the snowpack. Building on the power of citizen science, having numerous simple measurements spread over a wide area may be more valuable than a small set of measurements taken over a small area with sophisticated equipment because these measurements will allow for the evaluation of satellite measurements and model results across a wide area under a variety of conditions. We will supplement these with images taken from an unmanned aerial vehicle (UAV) or drone to construct a digital elevation map of the general field area and repeat these measurements to assess the evolution of snow depth over time.

Sampling Protocol

Working with both Community Organizations like the Schoharie River Center, the Catskill Center, and the Adirondack Wild Center, and local teachers in these regions, we have been hosting trainings and supporting three different tiers of data collection from the very simple temperature, snow depth, and photo collection, up to a more intense snowpit density collection. Sampling can include:

- Snow depth measurements: Simple measurements of snow depth made with a snow probe allow variations in snow depth to be measured over a wide area.
- Meteorological measurements: Local measurements of air temperature, wind speed, humidity, and pressure provide an understanding of factors that can influence the snow. Models require estimates of these parameters to simulate the snowpack.
- Surface albedo measurements: The reflectivity or albedo of the snow surface is an important factor in determining how much sunlight is absorbed by the snow, which can affect the rate of snowmelt. Local measurements of albedo help evaluate satellite estimates on a large scale.
- Snow grain measurements with a microscope: Measurements of snow grain, size, and shape can be done by eye, but using a microscope increases the accuracy of such measurements. The measurements are useful for understanding the optical properties of snow as well as the physical structure of the snowpack.
- Traditional Snowpit Measurements: These involve digging a pit in the snow, exposing a vertical cross-section of the snowpack, along which a profile of various parameters is measured, including snow depth, density, temperature, and snow grain size, shape, and hardness and the thickness of different distinct layers in the snow. These measurements are valuable for providing a detailed evaluation of the modeled vertical structure of the snowpack.

Along with the science that is being collected, we want to enhance the participants' understanding of the climate system through our collaborations. Regular meetings and communications are designed to refine protocols, address participant questions and challenges and to share results.

Future plans

We are in the first year of this NASA partner project and plan to expand as we find additional groups who are interested in participating in this project.

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Investigating antibiotic-resistant genes in Hudson River water samples: implications for environmental health

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Research on antibiotic-resistant genes (ARGs) in the Hudson River is an important and growing area of environmental study. The Hudson River, like many water bodies near urban and agricultural areas, is susceptible to contamination from both point-source pollution (such as sewage treatment plants) and non-point-source pollution (such as agricultural runoff). This makes it an ideal location to study the spread and impact of ARGs in a freshwater ecosystem. Urban centers along the Hudson River have wastewater treatment plants that may release treated but still contaminated water containing antibiotic-resistant bacteria and ARGs. The agricultural areas along the Hudson River watershed can contribute to ARGs in the water through runoff containing antibiotics used in livestock. Manure or biosolid application to farmland can carry these genes into nearby rivers and streams, which eventually flow into the Hudson River.

Agricultural runoff often contains residues from antibiotics used in livestock. When these antibiotics are present in the environment, bacteria in the water may adapt and become resistant, leading to the spread of antibiotic-resistant pathogens. Sewage facilities, especially those with inadequate treatment processes, may also release antibiotic-resistant bacteria and ARGs into nearby water sources. In addition to this wildlife in the river can both be affected by and contribute to the spread of ARGs. Animals can carry antibiotic-resistant bacteria from contaminated environments, and resistance can spread through aquatic food webs. The presence of these bacteria can have long-term implications as wildlife populations may be reservoirs for resistance genes.

These ARGs can then spread to humans, animals, and the environment, posing a challenge to public health and ecological balance. The spread of ARGs in the Hudson River is a potential risk for human health, especially in terms of drinking water, recreational activities, and seafood consumption. For example, people who come into contact with contaminated water while swimming or fishing may be exposed to antibiotic-resistant pathogens. Additionally, fish and shellfish in the river could serve as vectors for transmitting resistant bacteria to humans.

It is important to monitor sites along the Hudson for ARGs and to develop effective management strategies to reduce the spread of resistance, such as improved wastewater treatment technologies and responsible agricultural practices.

This study aims to assess the prevalence and diversity of ARGs in the Hudson River using real-time PCR (qPCR) to detect and quantify resistance genes in water, and sediment from various locations along the river. Samples will be collected from multiple sites, including areas impacted by urban wastewater

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discharges and agricultural runoff. The presence or absence of ARGs will be determined with genes conferring resistance to commonly used antibiotics such as tetracycline, sulfonamides, and beta-lactams along with 16S rRNA gene as a molecular marker to identify the bacterial species present in the samples. Since it is highly conserved across many bacterial species, it is a powerful tool for detecting and studying bacterial diversity in environmental samples, including water.

Molecular detection of invasive species in the Hudson River using DNA barcoding

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Invasive species in rivers pose a significant threat to both the ecological balance and the human activities that rely on healthy aquatic ecosystems. The Hudson River is particularly vulnerable to invasive species due to its connection to various other water systems, including the Atlantic Ocean, which can introduce new species via shipping traffic. The Hudson River faces an escalating threat[1] from specific invasive species like the Round Goby and water chestnut that threaten not only the biodiversity of the river but also the economic and recreational activities that depend on a healthy river ecosystem. By incorporating DNA barcoding into monitoring efforts, scientists can gain a more detailed and efficient understanding of where and how these species are spreading.

The Round Goby (*Neogobius melanostomus*) and water chestnut (*Trapa natans*) are two prime examples of invasive species that pose significant threats to river ecosystems, including in places like the Hudson River. The Round Goby competes with native fish species for food and habitat, disrupts the food chain by feeding on eggs of other species, and can spread disease by acting as vectors for parasites. DNA Barcoding can help with early detection and monitoring, tracking distribution and assessing genetic variation, that can help in targeted removal. Water chestnuts grow in dense mats that diminish the quality of the habitat for other aquatic plants and animals. They also reduce biodiversity and interfere with water use. DNA Barcoding can help with monitoring and early detection, mapping infestations and tracking genetic differences.

Research

As a pilot study, the researchers obtained water samples from 12 different locations along the Hudson River and isolated DNA from each sample. These samples were then subjected to PCR using the COI primers to detect Round Goby and RbcL primers to detect water chestnut samples.

The application of eDNA will provide an efficient and non-intrusive method of invasive species detection in addition to providing valuable insights into the diversity and dynamics of the Hudson River ecosystem. This study explores the application of DNA Barcoding as a molecular tool for the precise identification of invasive species within the Hudson River. Utilizing DNA sequences from specific genetic markers, such as mitochondrial cytochrome C oxidase I (COI) gene, we aim to develop a comprehensive reference database specific to the Hudson River ecosystem. This database will facilitate the identification of invasive species based on their unique genetic signatures.

We aim to develop a robust monitoring system that aids in the early detection, management, and mitigation of the impact of invasive species. This will contribute to the preservation and sustainability of

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the Hudson River ecosystem by facilitating proactive measures. DNA barcoding could also complement other monitoring techniques, helping managers make data-driven decisions about conservation and invasive species control.

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Some local and global analysis related to CO_2 and climate change

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Climate change is an evolving reality with different impacts felt globally and locally. The global effect has been unlivable conditions in the more impoverished and hotter regions, leading to desperate refugees that are not all welcome in the more affluent and less impacted countries.
In contrast, climate change has been bettering some conditions in the New York capital region and the Mohawk River watershed. Growing seasons are getting longer. Vineyards are being created. Less snow means less shoveling and less probability of spring flooding of the Mohawk River in the Schenectady Stockade.

Thus, the capital region is ripe for near future growth, with the immigrants ranging from affluent to impoverished and hard working. The increased cost of property damage and fire and flood insurance other regions will also push new construction and populations toward the less vulnerable greater New York Capital district. It will also create costly new demands on municipal water and sewage systems, beyond the existing capacity.

CO_2 Rising

The increase of CO_2 in the atmosphere has become is an indisputable fact. It was about 280 ppm before the fossil fuel mining for CO_2 emitting fires that powered the Industrial Revolution. It had risen to 312 ppm in 1958 when Charles Keeling initiated daily measurements at the Mauna Loa Observatory in Hawaii. The latest measurements are about 425 ppm.

The rate of increase is also rising. It was about .1 ppm per year from 1759 to 1959. It increased to .5 ppm per year in the 1960s. It rose to 2.5 ppm per year in the last decade and 3.5 ppm per year from 2024 to 2025.

If the rate of 3.5 ppm per year is held constant, it will increase by another 140 ppm resulting in 565 ppm by 2065. This corresponds to when most current college students are still in the work force.

The problem is that fossil fuels are relatively good, cheap and convenient. The alternatives are limited or feeble. Wind and solar along with energy storage also require sites. They can disrupt nature and agriculture. Local zoning is effectively delaying or stopping many ambitious initiatives.

Thus, the massive burning of fossil fuels will continue for the foreseeable future and CO_2 emissions and atmospheric accumulation will continue to result in uneven and increasing unpredictable costs and social upheavals. Meanwhile, recoverable fossil fuel is limited. Production rate will probably peak in the next generation. Drilling sites that are now been banned because of environmental concerns will be allowed. Depletion of oil and gas may result in returning to more polluting and CO_2 producing coal.

Important Conversion Factor and Calculations

The mass of the earth's atmosphere can be obtained from surface pressure times area. The value is 5.15×10^{18} kg. The ratio of molecular weight of air and CO_2 is .658. This results in the following important conversion between metric tons of CO_2 and ppm of CO_2.

7.82 billion metric tons of CO_2 = 1 ppm CO_2 in atmosphere

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This conversion provides the basis for a "Black Box" or "Flow Diagram" analysis of emission, atmospheric storage and surface absorption of CO_2.

Rate In = Rate of Storage + Rate Out (ppm CO_2 per year)

"Rate In" is mostly the yearly CO_2 from burning fossil fuels. This is well known. Agencies tabulate coal and oil and gas use and emissions data.
"Rate of Storage" in the atmosphere is known from estimates during the early years of the Industrial Revolution, and more precisely since 1958 as the result of daily measurements.
"Rate Out" is the rate that CO_2 is absorbed on the surface land and oceans. It is local and distributed. There is no realistic method to directly measure it. Thus, the unknown "Rate Out" or rate at which land and oceans are absorbing is best calculated from the better data for "Rate In" and "Rate of Storage"

Rate Out = Rate In – Rate Storage (ppm CO_2 per year)

Last year about 36 billion metric tons of CO_2 were emitted by burning fossil fuels and plus an estimated 4 billion tons from concrete and land use. Thus about 40 billion tons of CO_2 were emitted to the atmosphere corresponding to 5.11 ppm. The measured increase in the atmosphere was about 3.5 ppm. This means 2.66 ppm was absorbed from the atmosphere by surface land and oceans. This can also be in percentages. Rate in is defined as 100 %. Thus, 68 % stays in the atmosphere and 32 % is absorbed by land and oceans.

Annual vegetation is carbon neutral by absorbing CO_2 by photosynthesis while growing and releasing CO_2 as it decays. Trees are also carbon neutral but on about a hundred-year cycle. Oceans are getting warmer and more acidic and thus less effective in absorbing CO_2. Warming can also release CO_2 along with methane that has been stored in the permafrost.

The same calculation but starting with the Industrial Revolution

About 1800 billion tons of CO_2 has been emitted to the atmosphere since the start of the industrial revolution. This corresponds to 1800/7.82 or 230 ppm. Meanwhile atmospheric CO_2 has increased from 280 ppm to 425 ppm in 2025. This is an increase of 145 ppm. Thus, 145/230 or 63% of the CO_2 emitted has remained in the atmosphere while 37 % has been absorbed by the surface land and water. The results rely upon the best available data. These calculations are a recommended exercise for teachers and students and all concerned. They are encouraged to verify and update with possibly better input data.

Geological Time Scale Temperature vs CO2 Measurements and Cycle Analysis

Skeptics have dismissed human created climate change by noting climate has always been changing. An appropriate answer is that climate has always been changing in natural cycles and geological time scales. In contrast, CO_2 and global temperature have been increasing and accelerating in recent generations corresponding to human activities. Louis Agassiz in the 1830s claimed that there had been Ice Age with glaciers covering much of the northern hemisphere. Geologists have confirmed and dated cycles by studying ice cores, ocean sediments and fossils.

In the 1920s and 1930s Serbian engineer, mathematician, climatologist and science popularizer, Milutin Milankovic, correlated the Ice Age cycles with small variations of the earth's position and axis caused by gravitational forces from other planets. He noted that his work was inspired by another native Serbian, Nikola Tesla.

The notable environmentalist and activist Bill McKibben wrote a story in 2021 entitled "Glasgow: Where Climate Wreckage Began." He was referring to the invention of coal-fueled engines by Thomas

Newcomen and James Watt. Steam engines also motivated Scottish scientist Joseph Black to pioneer the science of thermodynamics and combustion. He defined latent heat related to boiling phase change and sensible heat to change in temperature. He also isolated CO_2 as a product of combustion. He called it "fixed air." It put out a fire and was slightly heavier than air.

The "Greenhouse Effect" of the atmosphere was suggested in 1824 by French scientist and mathematician Joseph Fourier. It keeps the earth warm because the atmosphere obstructs the radiation emitted from the surface.

American Eunice Newton Foote studied, worked and lived in Troy and Albany. She is known as a pioneer in women's rights. She was also an experimental scientist. In the 1850s she placed glass jars of air and of CO_2 in the sun. The CO_2 filled jar had the highest temperature rise. The premier American scientist Joseph Henry presented the research of Foote to the fledging American Association for the Advancement of Science that can be traced back to Benjamin Franklin. Joseph Henry was also born in Albany and connected to Union College, via his wife and astronomer brother-in-law and cousin, Stephen Alexander. Joseph Henry also showed that magnetism can produce electricity. It is the basis for all electric motors and generators along with transformers.

Irish scientist Joseph Tyndall in 1859 developed an instrument to directly measure the absorption of short-wave radiation from the sun and the long-wave infrared radiation from the earth. Planck's law and graph shows wavelength varies inversely with the absolute temperature of the emitter. The surface of the sun is twenty times hotter than the surface of the earth. Thus, the wavelength of radiation from earth is twenty times longer than the solar radiation.

The "Greenhouse Effect" was quantified by Swedish chemist Svante Arrhenius in 1896. He calculated how much hotter the earth would be if CO_2 in the atmosphere doubled and how much colder no CO_2. The conclusion is the existing level of CO_2 is the most desirable for life as we know it. Conversely, life has evolved to adjust to this temperature.

British engineer Guy Callendar is best known for teaming with his father, Hugh Callendar, in measuring and tabulating the properties of steam and water. His father also developed instruments to measure temperatures at remote locations. Guy Callendar observed the melting of glaciers. He proceeded to correlate worldwide temperature trends. In 1938, he reported a slow but steady rate of global warming.

The daily measurements of temperature at the Mauna Loa Observatory in Hawaii started as part of the American scientist Charles Keeling. The resulting Keeling curve of global CO_2 versus time has been described as the world's most important graph. While working at Scripps Institution Keeling developed a portable instrument for measuring CO_2 to five significant numbers. His first measurements were on the streets of San Diego as a function of the traffic. He then took hourly measurements while camping in a forest and observed the daily variations. CO_2 decreased during the day because of photosynthesis and increased at night. Keeling then arranged to take samples from an airplane at different latitudes and altitudes. It established that a global average could be measured at a single location.

Early confirmations surprises and explanations with Keeling CO_2 measurements

The first measurement was on March 29 of 1958. It initially increased daily as was expected but started to decline in May. It increased again in October. Thus, he was measuring the annual CO_2 breathing cycle of vegetation. The northern hemisphere dominates because it contains 68 % of the global land mass.

International, local and individual initiatives to limit climate change

A yearly International Conference on Climate Change (ICCC) was initiated in 2008. It led to member countries pledging reductions in CO_2 emissions. It has resulted in installing much new wind and solar generation, but not nearly enough to reverse the upward trend of CO_2 emissions.
The 2024 Conference was sponsored by oil producers in the city of Baku in the major oil-producing country Azerbaijan. Some pledges to reduce CO_2 emissions have been replaced with pledges to capture and underground storage of CO_2. While there exist some ideas and small-scale demonstrations for capturing CO_2, it is unrealistic to expect doubtful that any significant portion can be captured and stored.

Federal legislation calls for mostly electric vehicles. New York and other states have pledged net zero CO_2 emissions. It includes mandates to replace oil and gas space heating and cooking with electric. It also mandates all electric school buses by 1935.

Mandates are well intentioned but unrealistic. Climate change is now a problem with no realistic solution. A carbon neutral New York state will require installing much more wind and solar and battery storage. It is not doable because of public resistance.

Individual voluntary initiatives include consuming less meat and no unnecessary air travel along with electric cars that will require more wind and solar powered electricity. There would be more and multiple benefits by mandating smaller vehicles and lower speed limits. The public accepted gasoline rationing during wartime and lower speed limits during the long lines at the gas pumps in the 1970s. Today's public will reject lower speed limits and want oversized and wasteful vehicles.

Much of the public expect some new technology to solve the climate change problem, rather than recognizing that the only way it can be slowed is by draconian conservation. The major carbon free electric power sources are hydro and nuclear. Most of the viable hydro has been harnessed. Environmentalists celebrate when power dams are removed. More nuclear is meeting much resistance. Hydrogen is promoted but does not make sense. Nuclear fusion can be used for explosions but not harnessed for steady state.

Author's Conclusion

Public policy should focus on what is doable and not waste resources on the undoable and know the difference. Climate change and related pollution can be slowed but not reversed. Thus, the challenge for future generations will be how to adjust. All varieties of pollution on the local and global levels are the related problem. Most solutions rely upon using water without causing more damage. Solid waste has been dumped in oceans and exported to other locations for fees that are increasingly difficult to negotiate and expensive. Transportation of solid waste is energy dependent and thus further compounding the problem of climate change.

Note: A poster presentation will include the following figures

- Figure 1 Picture of Charles Keeling
- Figure 2 Keeling Yearly CO_2 graph since 1958
- Figure 3 Keeling seasonal CO_2 graph showing vegetation breathing CO_2
- Figure 4 Table of CO_2 emissions (about a constant 40 billion metric tons per year)
- Figure 5 Converting metric tons of CO_2 to ppm CO_2 in atmosphere
- Figure 6 Show the 7.82 billion metric tons of CO_2 = 1 part per million (ppm) calculation
- Figure 7 Black box or flow diagram of CO_2 emitted, stored and absorbed in percent.
- Figure 8 Project 40 years at 2.5 ppm per year = 425+ 40 x 2.5 = 525 ppm
- Figure 9 Show how CO_2 increase compares with measurements of temperature rise

Note: Author Frank Wicks PhD, PE is an emeritus professor at Union College.