United States Geological Survey

Massachusetts Cooperative Fish and Wildlife Research Unit

Biennial Report 2022-2023

Amherst, MA
December 2023

EXECUTIVE SUMMARY

The Cooperative Research Units Program

The Cooperative Research Unit (CRU) program is a nationwide program within the U.S. Geological Survey, with cooperators from the U.S. Fish and Wildlife Service, the Wildlife Management Institute, state conservation agencies, and a host university where the Unit is housed.

The CRU Mission is to provide:
- Graduate education to develop the workforce
- Actionable research to meet cooperator science needs
- Technical assistance to cooperators

The Massachusetts Cooperative Fish and Wildlife Research Unit

The Massachusetts CRU began in 1948, with cooperators from the University of Massachusetts Amherst (UMass), the Massachusetts Division of Fisheries and Wildlife, the Massachusetts Division of Marine Fisheries, the U.S. Fish and Wildlife Service, and the Wildlife Management Institute.

The Massachusetts Unit is currently comprised of a Unit Leader, Dr. Allison Roy, who specializes in fisheries and aquatic ecology, and two Assistant Unit Leaders, Dr. Graziella DiRenzo and Dr. Tammy Wilson, who are quantitative wildlife ecologists. The Unit's Administrative Assistant is Ms. Deb Wright, who is a University employee; we are also assisted by several other administrative specialists in the Department of Environmental Conservation at UMass, administrative and supervisory staff at the CRU headquarters, and our cooperating agencies.

Research in the MA Coop Unit

We conduct research in terrestrial and aquatic ecosystems on a variety of topics. Some quick facts about our research funding, collaborations, and productivity:

- Typical operating budget of $1.5–2.5 million annually (over half is research grants)
- Grant funding includes a variety of federal (e.g., USGS, USFWS, USDA, NSF, NPS), state (e.g., MassWildlife, MDMF, MDER), and nonprofit (e.g., TNC, Woods Hole Sea Grant) sources
- 29 scientific papers and reports were published in 2022 and 2023, with an additional 20 papers listed as in review, in revision, or in press over that time period
- 6 data releases and 9 software releases in the last 2 years
- 82 presentations at conferences and public meetings in the last 2 years
- Collaborators include scientists and managers from over 39 state, federal, and private conservation agencies, institutions, and groups

Mentorship and Graduate Education in the MA Coop Unit

In the last 2 years, we:

- Advised or co-advised 10 postdoctoral researchers, 9 PhD students, 13 MS students, and 5 BS Honor's students, including students currently in the program and completed students
- Provided 2 working professionals with graduate school opportunities
- Provided field and laboratory research experiences to numerous undergraduate student technicians, independent study students, practicum students, and volunteers
- Mentored 6 students in the Doris Duke Conservation Scholars Program
- Taught 10 graduate courses on topics related to research design, data analysis and modeling, data management, and aquatic ecology
- Served on 18 graduate student committees
- Had 7 students in the USFWS Pathways Program

Common Shiner in spawning colors (Ayla Skorupa)

CONTENTS

Abbreviations

CHC = Commonwealth Honors College
CRU = Cooperative Research Unit
CRUP = Cooperative Research Units Program
CWD = Chronic Wasting Disease
DDCSP = Doris Duke Conservation Scholars Program
DEIJ = diversity, equity, inclusion, and justice
DOC = dissolved organic carbon
ECO = Department of Environmental Conservation
MassWildlife = Massachusetts Division of Fisheries & Wildlife
MDER = Massachusetts Division of Environmental Resources
MDMF = Massachusetts Division of Marine Fisheries
NABat = North American Bat Monitoring Program
NE CASC = Northeast Climate Adaption Science Center
NEWMN = Northeast Wildlife Monitoring Network
NGO = Non-governmental organization
NHESP = Natural Heritage & Endangered Species Program
NMDS = Nonmetric multidimensional scaling
NSF = National Science Foundation
OEB = Organismic and Evolutionary Biology
PN = Penobscot Nation
SDM = Structured Decision Making
SSP = Science Support Partnership
SUNY = State University of New York
TNC = The Nature Conservancy
UMass = University of Massachusetts Amherst
USDA = US Department of Agriculture
USFWS = US Fish and Wildlife Service
USGS = US Geological Survey
WD = Winter drawdowns
WHOI = Woods Hole Oceanographic Institute

Cover Photos

Left: Sunset view from Mt. Tom, MA (Elsa Cousins)
Top: A bee among the flowers (Ayla Skorupa), Alewife migrating up Town Brook in Plymouth, MA (James Garner)
Bottom: Tributary to the Millers River, MA (Ayla Skorupa), A uniquely colored Spring Peeper (Ayla Skorupa)
Back Cover: Wahconah Falls in Dalton, MA (Ayla Skorupa)

Photo Credits Provided in Parentheses
Report Compiled By: Elsa Cousins

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Massachusetts Cooperative Fish and Wildlife Research Unit

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RR 1, Box 587, Spur Road
North Stratford, NH 03590

Todd Richards, Rick Bennett, Paige Warren, and Mike Armstrong lead a panel discussion at the May 2023 Cooperator's Meeting (Allison Roy).

COLLABORATING FACULTY AND COOPERATORS

Amherst College
Thea Kristensen

Biodrawversity, Inc.
Ethan Nedeau

Cole Ecological, Inc.
Mike Cole

Connecticut Department of Energy and Environmental Protection
Chris Bellucci, Jacque Benway, Justin Davis, Laura Saucier

Connecticut River Conservancy
Andy Fisk

Cornell Lab of Ornithology
Gemma Clucas

Charles River Watershed Association
Lisa Kumpf, Marielena Lima

Dartmouth College
Frank Magilligan

Florida International University
John Kominoski, Liz Ortiz Muñoz. Christopher Rizzie

Maine Department of Inland Fisheries and Wildlife
Lee Kantar, Beth Swartz

Massachusetts Department of Conservation and Recreation
Jamie Carr, Jillian Whitney

Massachusetts Department of Environmental Protection
Robert Smith, Allyson Yarra

Massachusetts Division of Ecological Restoration
Kate Bentsen, Joseph Gould, Chris Hirsch,, Beth Lambert

Massachusetts Division of Marine Fisheries
Mike Armstrong, Brad Chase, Ben Gahagan, Gary Nelson, John Sheppard

Massachusetts Division of Fisheries and Wildlife
Jason Carmignani, Martin Feehan, Mike Huguenin, Mike Jones, Steven Mattocks, Carolyn Mostello, Rebecca Quiñones, Todd Richards, Jason Stolarski, Dave Wattles

Massachusetts Military Reserve
Jacob McCumber, Annie Curtis

Michigan State University
Elise Zipkin, Neil Gilbert

Monmouth University
Sean Sterrett

Mount Holyoke College
Renae Brodie

Mystic River Watershed Association
Andy Hrycyna

National Park Service
Krista Bartz, Heather Coletti, Kyle Cutting, Troy Hamon, Mike Hanam, Buck Mangipane, Benjamin Pister, Joel Reynolds, Dylan Schertz, Joshua Schmidt, Carlene Schultz, William Thompson, Dan Young

Neponset River Watershed Association
Sean McCanty

New Hampshire Department of Fish and Game
Catherine Callahan, Henry Jones, Jillian Killborn

Penobscot Nation
Ben Simpson

Pennsylvania State University
David Miller, Ephraim Hanks

Portland State University
Jennifer Morse, Jacob Rudolph

The Nature Conservancy
Alison Bowden, Katie Kennedy, Angela Sirois-Pitel

Smithsonian Environmental Research Center
Rebecca Hale

SUNY- ESF
Paul Jensen

SUNY-Cobleskill
Andrew Gascho-Landis

Tetra Tech, Inc.
Jen Stamp

Trout Unlimited
Erin Rodgers

University of Georgia
Krista Capps, Shuo Chen, Peter Hazelton, Seth Wenger

University of Massachusetts Amherst
Jeremy Anderson, Konstantinos Andreadis, Caitlyn Butler, Brian Cheng, John Finn, John Gibbons, Lian Guo, Xinchen He, Scott Jackson, Adrian Jordaan, Jason Kamilar, Kelly Klingler, William Pfadenhauer

University of New Hampshire
Kyle Dunfey-Ball

University of Vermont
Laurence Clarfeld, Brittany Mosher, Elias Rosenblatt, Alexej Sirén, Cheryl Sullivan

USDA Forest Service
Robert Abrams, Suzanne Gifford, Dave King, Keith Nislow, Leighlan Prout, Sue Staats, Scott Wixom

U.S. Fish and Wildlife Service
Rachel Cliché, Sandra Doran, Donovan Drummey, Christine Dumoulin, Zachary Ladin, Christine McCue, David Perkins, Ken Sprankle, Anthony Tur, Timothy Warren, Linda Welch, Nathan Whelan, Thomas Wittig

U.S. Geological Survey
Cooperative Research Units Program
Therese Donovon, Christina Murphy, John Organ

Eastern Ecological Science Center
Jonathan Cook, Christine Dumoulin, Jenn Fair, Mary Freeman, Evan H. C. Grant, Ben Letcher, Steve McCormick, Michael Runge, David Smith

Forest and Rangeland Ecosystem Science Center
Collin Eagles-Smith

National Wildlife Health Center
Robin Russell, Dan Walsh

New England Water Science Center
Dave Armstrong

Northeast Climate Adaptation Science Center
Toni Lyn Morelli, Michelle Staudinger

South Atlantic Water Science Center
Kristina Hopkins

Upper Midwest Water Science Center
David Krabbenhoft, Jacob Ogorek,

Western Ecological Research Center
Liz Bowen

Vermont Department of Fish and Game
Chris Bernnier, Nick Fortin, Katrina Gieder, Tony Smith

Woods Hole Oceanographic Institute
Joel Llopiz

The Cooperative Research Units Program (CRUP) was established in the 1930s to enhance graduate education in fisheries and wildlife sciences and to facilitate research between natural resource agencies and universities on topics of mutual concern. The catalyst for the idea of a cooperative program was the conservationist and political cartoonist, J.N. "Ding" Darling. Darling's innovative thinking and push for conservation reforms in Iowa led to the first Unit, which was established between Iowa State College and the Iowa Fish and Game Commission in 1932. Paul Errington, a student of Aldo Leopold and a notable wildlife biologist, became the Iowa Unit's first leader.

In 1935, Darling and others successfully established a national program for Cooperative Research Units, which involved a federal agency (the Bureau of Biological Survey, a precursor to today's U. S. Fish and Wildlife Service) as well as a land-grant university and a state agency. Nine Units were formed: Oregon, Utah, Texas, Iowa, Maine, Connecticut, Virginia, Alabama, and Ohio. The Connecticut Unit was only in operation from 1935-1937, and the Ohio Unit was closed in 1991.

The Massachusetts Unit was established in 1948 and was one of a second wave of new Units, which included Missouri, Pennsylvania, Colorado, Idaho, Oklahoma, Alaska, Arizona, and Montana. Originally, Cooperative Wildlife Research Units preceded Cooperative Fishery Research Units, and the two types of Units were separate entities. In 1963, the Massachusetts Fishery Unit was formed. In 1990, most Wildlife Units and Fishery Units were combined, and the two Units at the University of Massachusetts became the combined Massachusetts Cooperative Fish and Wildlife Research Unit.

The CRUP was part of the U. S. Fish and Wildlife Service until the 1990s, when CRUP joined the U. S. Geological Survey. Today, there are 43 Cooperative Research Units in 41 states. Each Unit consists of 2-5 federal scientists and 1-2 administrative specialists, and each is a partnership among the U.S. Geological Survey, state natural resource agencies, a host university, the Wildlife Management Institute, and in many cases the U. S. Fish and Wildlife Service. A formal Cooperative Agreement specifies the responsibilities of each cooperator, and a Coordinating Committee meets annually and serves to advise and guide the Unit. Staffed by federal personnel, Cooperative Research Units conduct research on applied conservation questions, participate in the education of graduate students, provide technical assistance and consultation on natural resource issues, and provide continuing education for natural resource professionals.

Throughout its history, the primary three-fold mission of the CRUP has remained the same: (1) Graduate Education, (2) Research, and (3) Technical Assistance in matters related to fish and wildlife populations and their habitats.

Sand dunes on Cape Cod, MA (Elsa Cousins)

Allison H. Roy
Leader - Fisheries
Research Associate Professor

My research broadly revolves around characterizing anthropogenic impacts on aquatic ecosystems and identifying conservation strategies for effectively protecting and restoring watersheds. Understanding the mechanisms by which human threats (e.g., urbanization, dams, water withdrawals, climate change) and their associated stressors result in degraded biotic assemblages is an overarching challenge of my research program. I examine effects of alterations on fishes, mussels, and macroinvertebrates; population ecology and conservation of rare and endangered species; and potential for management to restore freshwater ecosystems.

Graziella V. DiRenzo
Assistant Leader - Wildlife
Research Assistant Professor

I am a quantitative ecologist interested in examining community and population ecology, disease dynamics, and developing biologically realistic quantitative tools. To mimic natural hierarchical systems, I develop hierarchical Bayesian models, and I use data collected over space and time to separate ecological and observational processes to answer ecological questions. My research program focuses on unifying ecological and evolutionary theory to address fundamental questions in ecology using field, experimental, and quantitative approaches.

Tammy L. Wilson
Assistant Leader - Wildlife
Research Assistant Professor

I am an applied wildlife ecologist interested in evaluating the responses of wildlife to anthropogenic change. I specialize in the application of statistical models to understand complex drivers of species distribution, abundance, and habitat selection. I apply this work to support science-based decision-making in wildlife management and conservation.

Deb Wright
Administrative Assistant

I have been with the MA Cooperative Research Unit since 2014 and still find the work as meaningful as when I first started. Whether it's a grant proposal, ordering supplies, or juggling vehicle maintenance there's never a dull moment with this bustling Unit! In my free time, I thoroughly enjoy being outdoors whether it's on a run, hike, or just hanging out in the garden. I feel very fortunate to be a part of such an energetic, invaluable program that connects and benefits so many.

COOPERATOR SERVICE

University

- ECO Quantitative Science Group (DiRenzo, Wilson)
- ECO Tenure-track Wildlife Ecologist Search Committee (DiRenzo)
- ECO & OEB Graduate Committee member (DiRenzo, Roy, Wilson)
- ECO & OEB R Hacky Hour (DiRenzo)
- OEB Admissions Committee Chair (Roy)
- OEB Graduate Faculty & Steering Committee (DiRenzo, Roy, Wilson)
- UNVEIL Program Advisory Committee (DiRenzo & Roy)

Other

- Brook Floater Working Group (Roy)
- Yellow Lampmussel Working Group (Roy)
- Survey design co-creation and consultation for Penobscot Nation, MDIFW, NPS, USFS, USFWS (Wilson)

USGS SERVICE

- DEI Committee (DiRenzo)
- 2023 All Hands Meeting Planning Committee (Roy)

PROFESSIONAL SERVICE

- Past Vice President, Long Range Planning Committee, and Headwaters Leadership Academy; Society for Freshwater Science (Roy)
- Associate Editor, Ecosphere (DiRenzo)
- Data Paper Editor, Ecology (DiRenzo)
- Chair, Advisory Board, Symposium on Urbanization and Stream Ecology (Roy)

AWARDS AND RECOGNITION

- Ecological Society of America Early Career Fellow 2022 (DiRenzo)
- UMass ECo Diversity, Equity, Inclusion, & Justice Faculty Award 2022 (DiRenzo)
- UMass Graduate School Distinguished Mentor Award 2023 (Roy)

GRADUATE COURSES TAUGHT

Spring 2022

- *Species Distribution and Habitat Modeling (ECO 693D: Wilson)*

Fall 2022

- *Research Concepts (ECO 601: DiRenzo)*
- *Aquatic Ecology (NRC 560: Roy)*
- *N-Mixture Modeling Practicum (ECO 696: Wilson)*

Spring 2023

- *Resource Selection Practicum (ECO 696: Wilson)*

Fall 2023

- *Data Wrangling (ECO 697STC: DiRenzo)*
- *Data Visualization (ECO 697STB: DiRenzo)*
- *Data Simulation (ECO 697STA: DiRenzo)*
- *Analysis of Environmental Data (ECO 602: Wilson)*
- *Research Concepts (ECO 601: Roy)*

The Connecticut River below Turners Falls dam, MA (Elsa Cousins)

We welcome the following people in their new roles associated with the Massachusetts Coop Unit:

Dr. Everose Schlüter

Deputy Director
MA Division of Fisheries & Wildlife

Eve received her B.S. in biology and literature from Claremont McKenna College and her Ph.D. in biology from Tufts University. She joined MassWildlife in 2007, where she served first as a Senior Endangered Review Biologist and then as the Chief of Regulatory Review, overseeing the implementation of the Massachusetts Endangered Species Act. In 2017, she briefly left MassWildlife to be the Assistant Director of the Massachusetts Environmental Policy Act Office (MEPA) at the Massachusetts Executive Office of Energy and Environmental Affairs. In 2019, Eve returned to MassWildlife to become the Assistant Director at MassWildlife for the Natural Heritage and Endangered Species Program (NHESP) and oversaw all aspects of the program including conservation research, habitat management, rare species restoration, data management, and regulatory reviews of proposed projects under the Massachusetts Endangered Species Act. In Fall of 2023, Eve was promoted to Deputy Director at MassWildlife.

Jesse Leddick

Assistant Director
Natural Heritage & Endangered Species Program
MA Division of Fisheries & Wildlife

Jesse received his B.S. in Ecology from the University of California and conducted ecological research at the Scripps Institution of Oceanography and the Smithsonian. He subsequently received Masters of Environmental Management and another in Forestry from Duke University, and worked for several years as a land protection and stewardship specialist for a regional land trust in California before joining The Massachusetts Division of Fisheries & Wildlife's (MassWildlife) Natural Heritage & Endangered Species Program (NHESP) in 2012. Between 2012 and 2022 – first as an Endangered Species Review Biologist and then as Chief of Regulatory Review – he worked in environmental review and permitting to protect state-listed rare species and their habitats. He briefly served as MassWildlife's Landscape Conservation Program Manager before becoming Assistant Director of NHESP in late 2023.

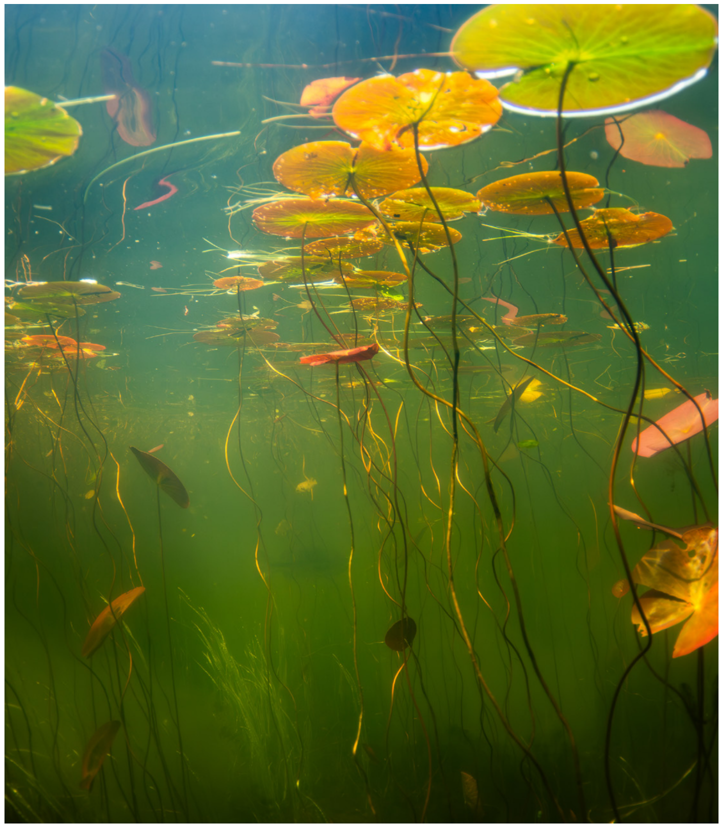
William Ardren

Assistant Regional Director
Science Applications
North Atlantic-Appalachian Region
U.S. Fish and Wildlife Service

Bill is passionate about supporting science-based decisions in collaborative conservation partnerships. He joined the Northeast Region as Assistant Regional Director of the USFWS Science Applications Program in May of 2023, after serving as the Director of the Service's Midwest Fisheries Center in Wisconsin. He brings 25 years of experience providing science leadership to enhance recovery and restoration of native species at the local, regional, and national levels. His previous positions include Regional Geneticist at the Abernathy Fish Technology Center in Washington State and Senior Fish Biologist at the Lake Champlain Fish and Wildlife Conservation Office in Vermont. Bill grew up in Duluth, MN, and received a B.A. in biology from St. John's University; Ph.D. in fisheries science from University of Minnesota; and he is currently a visiting scholar at Dartmouth College. He has authored over 50 scientific papers and is a two-time recipient of the Service's Rachel Carson Award for Exemplary Scientific Accomplishment.

CURRENT GRADUATE STUDENTS AND POSTDOCS

Molly Bletz, Post-doc (DiRenzo)
Meg McEachran Post-doc (DiRenzo)
Alexej Siren, Post-doc (Wilson)
Anna Baynes, Ph.D. (Roy)
Matt Devine, Ph.D. (Roy and Jordaan)
Stefanie Farrington, Ph.D. (Roy)
Alexa Hershberger, Ph.D. (Roy)
Ayodelé O'Uhuru, Ph.D. (DiRenzo)
Leslie Skora, Ph. D. (Wilson)
Julian Burgoff, M.S. (Roy and Jordaan)
Adrienne Dunk, M.S. (Roy)
Connor Morrow, M.S. (Wilson)
Jackie Stephens, M.S. (Roy and Jordaan)
Ednita Tavarez-Jimenez, M.S. (DiRenzo)
Joy Trahan-Liptak, M.S. (Roy)
Isabella Ceresia, B.S. Honors (Roy)
Malvika Someshwar, B.S. Independent Study (Roy)



UNDERWATER PERSPECTIVE (AYLA SKORUPA)

COMPLETED GRADUATE STUDENTS AND POSTDOCS 2022-2023

Fer Arce, Post-doc (DiRenzo) – A review of the role of white-tailed deer (*Odocoileus virginianus*) in SARS-CoV-2 outbreaks (September 2023)

Brian Hoven, Post-doc (DiRenzo) – Chronic wasting disease (CWD) knowledge, risk perception, and management acceptance are influenced by media engagement and trust among deer hunters in Massachusetts (September 2023)

Abhishek Kumar, Post-doc (Roy) – Rethinking lake management for invasive plants under future climate: Sensitivity of lake ecosystems to winter water level drawdowns (December 2023)

Riley Mummah, Post-doc (DiRenzo) – Inferring pathogen presence when sample misclassification and partial observation occur (June 2023)

Annika Quick, Post-doc (Roy) – Scales and dirivers of variability in dissolved organic carbon across diverse urban watersheds (August 2022)

Jenny Rogers, Post-doc (DiRenzo and Roy) – Framework for protecting aquatic biodiversity in the Northeast under changing climates (January 2024)

Ayla Skorupa, Post-doc (Roy) – Landscape drivers of freshwater mussel assemblages and imperiled species status: implications for optimal allocation of conservation effort within the Delaware River Basin (May 2023)

Katherine Abbott, P.hD. (Roy) – River restoration through dam removal: Examining ecological responses to small dam removals across Massachusetts (September 2023)

Meghna Marjadi, P.hD. (Roy) – Timing is everything: Climate change implications for phenological events and reproductive success in river herring (May 2023)

Ayla Skorupa, P.hD. (Roy) – Developing a restoration strategy for brook floater (*Alasmidonta varicosa*) in Massachusetts (February 2023)

Juliana Berube, M.S. (Wilson) – Effects of habitat, density, and climate on moose and winter tick ecology in the Northeast US (February 2024)

Jessica Bonin, M.S. (Wilson) - Resource selection of human-associated resources by massachusetts black bears across seasons and reproductive status (February 2024)

Andrew Gordon, M.S. (DiRenzo) - Pine barrens wildlife management: exploring the impact of a stressor and active management on two taxa at camp edwards (September 2023)

Desireé Smith, M.S. (DiRenzo) - A review and analysis of the linked decisions in the confiscation of illegally traded turtles (Sep 2023)

Julia Vineyard, M.S. (Roy) - Bog turtle (*Glyptemys muhlenbergii*) population dynamics and response to habitat management in Massachusetts (September 2023)

Emily Chalfin, B.S. Honor's (Roy) - Evaluating freshwater macroinvertebrate taxa temperature tolerances in the Northeastern U.S. (May 2022)

Abigail Farrell, B.S. Honor's (Roy) - Assessing food avaiability and growth rates as emigration cues for juvenile river herring (May 2023)

Callista Macpherson, B.S. Honor's (Roy) - Fish assemblage responses to dam removals (May 2023)

Jack Soucie, B.S. Honor's (Roy) - Spatial and temporal variability in urban stream conductivity in Boston, MA (December 2023)

The Doris Duke Conservation Scholars Program (DDCSP) Collaborative is a two-year experiential conservation training program for undergraduates who are interested in careers in conservation and in promoting diversity, equity, and inclusion in the field. The program is a consortium of universities united to empower a diverse new generation of conservation leaders. UMass Amherst joined the consortium in 2020. The other members of the consortium are the University of Florida, University of Arizona, University of Idaho, and North Carolina State University. Scholars conduct applied field research projects in their first summer and participate in professional internships in their second summer. Scholars learn a variety of research techniques and present their research at a national scientific conference. The students meet regularly with graduate student mentors to discuss research and leadership skills, graduate school, conservation careers, and other topics. Both Andrew Gordon (DDSCP mentor Spring 2022 - Summer 2023) and Ayodele O'Uhuru (DDCSP mentor Fall 2023 – present), CRU graduate students, served as graduate student mentors. Through this program, students develop strong professional networks and are prepared to help increase diversity, equity, and inclusion in the field of conservation through coursework in communication, creative problem solving, leadership, and diversity, equity, and inclusion. Over the past two years, DDCSP scholars have participated in three research projects under the direct supervision of CRU graduate student mentors.

Owen (left) and Anjali (right) observe an eastern box turtle (Andrew Gordon)

Eastern Box Turtle (Summer 2022)

The scholars, **Owen Blacker** (Environmental Science) and **Anjali Shukla** (Biology), participated in a research project involving the Eastern Box Turtle (*Terrapene carolina carolina*) at Camp Edwards at Joint Base Cape Cod (Bourne, MA), under the supervision of MS student Andrew Gordon. The overall project objectives included quantifying impacts of a parasitic fly (*Cistudinomyia cistudinis*) on movement and shell temperature. They conducted turtle surveys, tracked radio-tagged turtles, recorded turtle body size, and collected habitat data. Owen and Anjali presented a poster at the Ecological Society of America Conference in Portland, Oregon in August 2023. Their results found that both groups moved similar distances and had minimal difference in shell temperature, but further research is necessary to explore this host-parasite relationship.

River Herring (Summer 2023)

The scholars, **Adamaris Agosto** (Natural Resources Conservation, Wildlife Ecology) and **Grace Davis** (Natural Resources Conservation, Fisheries), participated in field data collection under the supervision of MS student Julian Burgoff, including: purse seining for river herring in lakes at night, seining in estuaries, zooplankton sampling, and water quality sampling. In the lab, DDCSP students extracted fish otoliths. The scholars learned about river herring biology, threats, and conservation needs. Ada and Grace will be presenting a combined poster at the Society for Freshwater Science annual meeting in Philadelphia, PA in June 2024. Ada's project aims to investigate the effect of water quality on the growth of River Herring focusing on the interannual comparison of age and growth in response to water quality variables from 2021 to 2022. Grace's work addresses the effects of population density on juvenile river herring growth at a high density and low density site.

Grace (front) and Ada (back) on the research vessel (Grace Davis)

Julia (left) and Estela (right) helping with fieldwork at a dam removal site (Alexa Hershberberger)

Freshwater Mussels (Summer 2023)

The scholars, **Estela Garcia** (Environmental Sciences, North Carolina State University) and **Julia Hatzis** (Natural Resources Conservation), participated in a variety of field and lab work under the supervision of PhD students Stefanie Farrington and Alexa Hershberger while stationed at the USFWS Cronin Aquatic Resource Lab in Sunderland, MA. Field work included: 1) sidescan sonar habitat mapping on the Connecticut River, 2) mussel snorkel surveys on the Connecticut River, 3) sediment trap deployment and water quality sampling in the Ware River, and 4) snorkel surveys for mussels and habitat in several streams in Connecticut and Massachusetts. In the lab, the scholars worked in GIS to map habitat characteristics to relate to Yellow Lampmussel and assisted with a host fish trial for Yellow Lampmussel using largemouth bass and striped bass. Julia will be presenting a poster on effects of a dam on water quality and mussels and Estela will be presenting a poster on Yellow Lampmussel and Alewife Floater distribution and habitat in the Connecticut River at the Society for Freshwater Science Annual Meeting in Philadelphia, PA in June 2024.

U.S. FISH & WILDLIFE SERVICE PATHWAYS PROGRAM

The U.S. Fish and Wildlife Service (Service) Northeast Regional Office in Hadley, MA has supported many CRU students in recent years through the Pathways Internship Program. These internships provide students with the opportunity to explore career paths or interests related to their academic fields of study in the conservation field. The internships also provide direct hiring authority with the Service following graduation, and a few of our recent graduates have been hired by the Service. The Service is very focused on diversifying their workforce to include groups that are currently underrepresented in their agency, so they have focused recent efforts toward recruiting diverse candidates for these internship opportunities.

PAST PATHWAYS PROGRAM INTERNS

Dulani Sandanayaka
Pathways Intern
Wildlife and Sport Fish Restoration Program
Hadley Regional Office
2021 – 2022

Position description: I managed a database that kept track of all the work being done through federal grants to help threatened and endangered species in the Northeast region. I used this database to create species status assessments detailing the funding that was going towards that species and what work was being done with it.

Grants Management Assistant
Wildlife and Sport Fish Restoration Program
Hadley Regional Office
2022 – Present

Position description: Since becoming a permanent employee in WSFR, I have gotten more involved with the grants process by reviewing applications, reports, and conducting site visits.

Desireé Smith
Pathways Intern
Wildlife and Sport Fish Restoration Program
Hadley Regional Office
2021 – 2023

Position description: I helped review land grants applications, went on site visits to view the land and talk to state partners, and created communication material such as powerpoints, story maps, and articles to bring awareness to the program.

Wildlife Inspector
Office of Law Enforcement (Atlanta, GA)
2023 – Present

Position description: I am currently in training to enforce the laws, treaties and policies set in place by both national and international governments to ensure that wildlife shipments, packages and baggage are imported with proper permits and documentation. The goal is to make sure that wildlife, wildlife byproducts and plants are traded in a sustainable manner in order to prevent extinction and ensure the survival of the species.

CURRENT PATHWAYS PROGRAM INTERNS

Juliana Berube
Wildlife and Sportfish Restoration Program
Region 5 Office
2022 – Present

Position description: I support the administration of grants that fund fish and wildlife conservation and outdoor recreation programs. I complete site visits of grant funded projects, write federal reports of environmental findings, and partner with state and tribal agencies to facilitate conservation.

Stefanie Farrington
Fish and Aquatic Conservation Program
Richard Cronin Aquatic Resource Center
2021 – Present

Position description: I conduct research on Yellow Lampmussel that will guide management for this At-Risk freshwater mussel species. Projects include using sidescan sonar to map habitat features for species distribution modeling in the Connecticut River, and assessing Striped Bass as host fishes.

Ayodelé O'Uhuru
Ecological Services Division
Region 5 Office
2022 – Present

Position description: I help coordinate implementation of bat monitoring activities in the Northeast Region, focusing on USFWS-managed and adjacent lands. I work with state, federal, and other partners to plan and help conduct bat monitoring in accordance with the protocols established by the North American Bat Monitoring Program (NABat).

Jacqueline Stephens
Fish and Aquatic Conservation Program
Richard Cronin Aquatic Resource Center
Connecticut River Fish & Wildlife Conservation Office
2022 – Present

Position description: I work with the lead biologists and seasonal technicians conducting the USFWS Annual River Herring Stock Assessment. This past year, additional information on the parasitic larvae of freshwater mussels present on the river herring was collected and will be used to inform future management considerations for both the fish and mussels.

Ednita Tavarez-Jimenez
Regional Directorates
Region 5 Office
2022 – Present

Position description: As the Combined Federal Campaign (CFC) Manager, I oversee and coordinate CFC activities, ensuring compliance with campaign regulations and promoting employee engagement. I handle incoming correspondence, reports, and work requests, ensuring their routing to the appropriate staff members.

Current distribution of mussel biodiversity across the Northeast

Mussels are critical to the health of freshwater systems for the stabilization, water purification, and nutrient cycling services they provide, yet they are suffering from dramatic population declines to the extent that they are currently considered among the most imperiled group of aquatic organisms. Restoration of mussel populations is challenging because of their long generation times, specific habitat requirements, and sedentary nature as well as their dependence on a fish host to complete their reproductive cycle. In this project, we describe freshwater mussel diversity across the Northeast and identify predictors of mussel biodiversity. Through this, we hope to support the development of effective freshwater mussel management plans in the Northeast by compiling population-level survey data of freshwater mussels collected by state agencies with current geographic, climate, and land cover conditions alongside host fish distributions. To enhance the accessibility of our findings to regional managers, our report will be coupled with the production of a website outlining our findings and describing recommended management actions throughout the region.

POST DOC	Rebecca O'Brien	
ADVISOR	Allison Roy Graziella DiRenzo	
FUNDING	MassWildlife NE CASC	
COLLABORATORS	Jason Carmignani Melissa Doperalski Michelle Graziosi Todd Richards Corey Pelletier	Rebecca Quiñones Jennifer B. Rogers Laura Saucier Beth Swartz

A group of Eastern Pearlshell (Ayla Skorupa)

Population dynamics and restoration ecology of anadromous river herring

Anadromous river herring (collectively alewife and blueback herring) populations declined sharply over a half century ago, and conservation measures have not resulted in population recovery. Factors limiting recovery remain unclear and lack of information about growth and mortality in freshwater and estuarine environments limits the ability of population models to determine important factors. Additionally, variation among years in river herring densities presents challenges to understanding the effects of restoration on fish productivity. This project is investigating: 1) juvenile river herring densities and growth in coves along the Connecticut River. 2) inter-annual variation in juvenile river herring densities and growth in relation to lake specific and regional environmental conditions, and 3) the timing and magnitude of recovery of juvenile river herring productivity and dynamics following dam removal.

STUDENT	Matt Devine (PhD)	
ADVISORS	Allison Roy Adrian Jordaan	
FUNDING	TNC MDMF USGS/USFWS SSP	Woods Hole Sea Grant USGS CRU
COLLABORATORS	Alison Bowden Mike Armstrong Ben Gahagan	Gary Nelson Jacque Benway Justin Davis

Juvenile river herring being released after capture in a purse seine (Matt Devine)

Changing flow and temperature effects on stream fish assemblages

Climate change and anthropogenic disturbances alter stream temperature and flow, with consequences for fish assemblages. Stream temperatures are increasing under climate change making coldwater refugia, a network of coldwater patches, important habitat for coldwater fishes. Stream flow is altered by both climate change and direct human activities, such as water supply reservoirs storing water and diverting it for human consumption. However, there is a lack of information about how these changes in temperature and flow impact the streams and fish assemblages. Our objectives are to 1) quantify flow alteration and the predictability of flow downstream of water supply reservoirs, 2) determine how flow alteration resulting from water supply reservoirs impacts fish assemblages, 3) predict coldwater patch locations within streams and 4) identify fish species-specific use of coldwater patches. Results will help guide water allocation management and coldwater conservation of stream habitat and fishes.

STUDENT Anna Baynes (PhD)

ADVISOR Allison Roy

FUNDING MassWildlife
UMass OEB Program

COLLABORATORS Jenn Fair, Ben Letcher, Todd Richards, Rebecca Quiñones

Surveying a river (Anna Baynes)

Examining host fish, habitats, and range-wide status of the Yellow Lampmussel

The freshwater mussel Yellow Lampmussel (*Lampsilis cariosa*) is declining throughout its range, and the species has a special conservation status in nearly all of the states and provinces where it occurs. There are several key information gaps for this species that are crucial to its conservation and management, including assessments of the species' host fishes and habitat use. This project aims to address these information gaps through 1) a comprehensive literature review on the species, 2) evaluation of Striped Bass as a host fish using laboratory trials, 3) assessment of range-wide host fish use using wild-caught fish and molecular methods, and 4) predicting species distribution and microhabitat use in the Connecticut River. The results of this project will be used by practitioners across the species' range in the creation and evaluation of management and restoration plans for Yellow Lampmussel.

STUDENT Stefanie Farrington (PhD)

ADVISOR Allison Roy

FUNDING USFWS Pathways Program
USGS/USFWS SSP
UMass OEB Program

COLLABORATORS David Perkins, Timothy Warren, Jason Carmignani, Laura Saucier, Christina Murphy, John Gibbons

Stefanie and Tim collect Yellow Lampmussel glochidia for host fish trials (Estela Garcia)

Advancing freshwater mussel conservation in wadeable streams

Freshwater mussels are critical to the ecological integrity of freshwater systems as they have the capability to improve water quality and stream composition. While the United States is a global biodiversity hotspot for freshwater mussels with over 300+ species, roughly 20 species are extinct and over 200 of the remaining are considered endangered, threatened, or vulnerable. This project aims to assess the impact of habitat stressors on freshwater mussel species found in wadeable streams. The primary objectives of this study are to 1) investigate the short-term impact of a phased dam removal on two rare freshwater mussel species in Massachusetts, 2) identify habitat drivers of freshwater mussel multi-species occupancy and abundance along the eastern USA, and 3) develop a pre-stocking and post-stocking freshwater mussel protocol. Results from this study will provide information to partners and stakeholders regarding the conservation efforts needed during a dam removal, identify restoration tools when investigating stocking sites and habitat restoration, and produce a protocol that will reduce uncertainty in restoration decisions and track productivity of restored populations.

STUDENT Alexa Hershberger (PhD)

ADVISOR Allison Roy

FUNDING USFWS Competitive State Wildlife Grant
UMass OEB Program

COLLABORATORS

Jason Carmignani
Laura Saucier
David Perkins
Tim Warren
Pete Hazelton

Alexa records mussel shell measurements during a snorkel survey in CT (Jackie Stephens)

River herring as hosts for freshwater mussels within the Connecticut River watershed

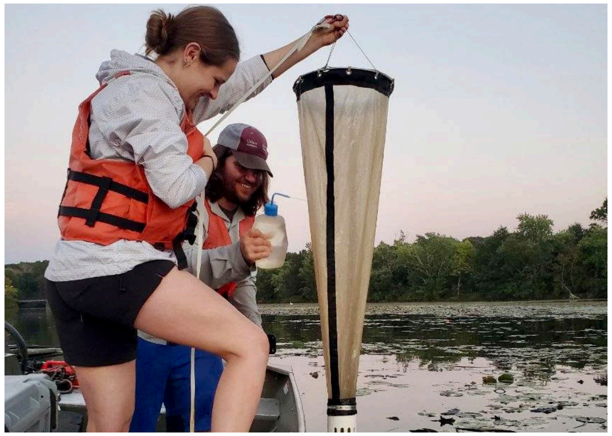
The anadromous lifecycle of river herring (blueback herring *Alosa aestivalis* and alewife *A. pseudoharengus*) allows them to provide many ecological services to both marine and freshwater environments. During their annual spring migration into coastal watersheds for spawning, river herring can act as hosts for the transformation and transportation of the parasitic larvae of freshwater mussels. For At-Risk mussels, using river herring as hosts may become an additional vulnerability as their populations have been experiencing declines and phenological shifts to their spawning migration. This project aims to 1) assess long term changes in the spawning composition of returning river herring, 2) investigate the temporal patterns of mussel larvae densities during river herring migration, and 3) evaluate associations between fish characteristics and mussel larvae densities. The results of this research will provide insight on the current population status of river herring and their use as hosts by freshwater mussels within the Connecticut River watershed, and inform management actions for species conservation.

STUDENT Jackie Stephens (MS)

ADVISORS Allison Roy
Adrian Jordaan

FUNDING USFWS Pathways Program

COLLABORATORS David Perkins
Kenneth Sprankle
Tim Warren



Jackie helps collect zooplankton with Julian Burgoff (James Garner)

Linking juvenile river herring growth, diets and habitat use in coastal Massachusetts

River herring (alewife *Alosa pseudoharengus* and blueback herring *A. aestivalis*) populations have declined drastically over the last century due to overfishing, habitat degradation and impediments to migration. There are significant data gaps associated with the habitat use, growth rates, and survival of juvenile river herring as they migrate from freshwater to estuarine habitats. The first objective is to quantify differences in age and growth of juvenile river herring between freshwater lakes and estuary habitats in three watersheds in coastal Massachusetts. This information will inform the characteristics that make successful juvenile emigrants and will help to identify the importance of access to estuary habitats for the growth and survival of juvenile river herring. The second objective is to quantify the contributions of littoral habitats in freshwater lakes to juvenile river herring diets and growth prior to emigration. This research has the potential to reveal novel diet information and provide insight into the factors that allow for increased growth in nursery habitats. Ultimately, the findings from this research will be used to inform population models that will guide decision making regarding river herring management in coastal New England.

STUDENT	Julian Burgoff (MS)	
ADVISORS	Allison Roy Adrian Jordaan	
FUNDING	MDMF TNC	USGS CRUP Woods Hole Sea Grant
COLLABORATORS	Ben Gahagan Michelle Staudinger Jason Stolarski	

Conducting a purse seine haul in Upper Mystic Lake (Julian Burgoff)

Quantifying wetland change following small dam removals in Massachusetts

The rate of dam removal pales in comparison to the number of aging dams across Massachusetts. Because dam removals alter open water and contiguous wetlands, they must be authorized through multiple regulatory paradigms. These regulations ask specific questions about resource area impacts; however, little standardized data exists to satisfactorily answer these questions. To address this uncertainty, this research is focused on measuring wetland area changes over the first 10 years following removal using imaging and geospatial information systems (GIS). We will evaluate the effect of landscape characteristics and dam removal design on wetland change. These results will help describe wetland change following dam removals, as well as identify practices to minimize wetland conversion.

STUDENT	Adrienne Dunk (MS)
ADVISOR	Allison Roy
FUNDING	Society of Wetland Science – New England Chapter
COLLABORATORS	Paul Davis Scott Jackson

Ox Pasture Brook before dam removal (left, 2008) and ten years after dam removal (right, 2019). Aerial imagery is provided by Massachusetts Bureau of Geographic Information Systems (MassGIS)

Evaluating factors contributing to loon egg hatching success in the Quabbin Reservoir

The common loon (*Gavia immer*) is an aquatic bird species recognized as an indicator species for environmental health. They are water-dependent and only come to the shore to breed and nest. In Massachusetts, they come from late May to early July to breed, and one prime location is the Quabbin Reservoir. While their populations are stable globally, they are currently considered a species of special concern in Massachusetts, so understanding their population health is vital. In the past few years, there has been a decrease in hatching success in the Quabbin Reservoir. This project aims to assess the impact of environmental factors (e.g., sun exposure, predation, flooding, low water levels) on loon hatching success in the Quabbin Reservoir (2009—2022). The primary objectives of this study are to (1) evaluate the differences in hatching success among different loon nest types (scrape, bowl, and raft), (2) understand whether egg failure types (predation, intruding loons, flooding, nest abandonment) differs among nest type, (3) evaluate how interannual differences in temperature and water levels during nesting affect hatching success, and (4) identify if there is a relationship between loon nest failure and territory in the Quabbin Reservoir. Results from this study will inform management practices (e.g., water level management, raft deployment) to protect the loon population.

STUDENT	Isabella Ceresia (BS Honor's)
ADVISORS	Allison Roy
FUNDING	UMass CHC
COLLABORATORS	Jillian Whitney Alexa Hershberger

Loon sighting in the Quabbin Reservoir (Isabella Ceresia)

Comparing zooplankton communities and juvenile river herring diets in littoral and pelagic habitats

Juvenile river herring are size selective predators that consume large-bodied zooplankton during their seasonal residence in freshwater lakes. Previous studies suggest that some juvenile river herring shift towards foraging in littoral lake habitats in response to the depletion of large-bodied prey available to them in open water pelagic habitat. The objective of this study is to compare zooplankton communities (density and taxonomic composition) and juvenile river herring diets between littoral and pelagic habitats over time. We conducted zooplankton tows and collected juvenile river herring from pelagic and littoral habitat in Upper Mystic Lake, Arlington, MA. This information will be used to estimate prey selectivity by juvenile river herring and to quantify the importance of littoral lake habitat as a source of prey for juvenile river herring late in the season. Results from this study will aid in modeling juvenile river herring growth during freshwater residence and will be used to inform lake management strategies that protect zooplankton assemblages in freshwater lakes.

STUDENT	Malvika Someshwar (BS)
ADVISOR	Allison Roy
FUNDING	MDMF TNC
COLLABORATORS	Julian Burgoff Adrian Jordaan

Microscope set-up for zooplankton identification (Malvika Someshwar)

Freshwater biodiversity in the Northeastern United States, climate change, and the role of management

Freshwater habitats support disproportionately high biodiversity compared to other habitats, despite their small footprint. Due to a history of habitat degradation, species invasion, overexploitation, and intensifying climate change, many species that rely on freshwater ecosystems—such as fishes and mussels—are imperiled. For conservation or restoration opportunities to successfully offset climate change impacts, a clear targeted biodiversity endpoint is important to identify.

The goal of this research was to 1) calculate and describe freshwater fish and mussel biodiversity using novel methods for lotic systems across six Northeastern states, 2) estimate the impacts of climate change on these biodiversity endpoints, and 3) assess which management interventions can ameliorate any negative climate change impacts. Fish and mussel species occurrence data was collated and standardized from eight state fish and wildlife agencies. Models were developed to predict the proportional abundance of freshwater fishesand mussels using a series of land use, streamflow, stream temperature, water quality, and geographic variables.

POST DOC Jennifer B. Rogers

ADVISORS Graziella DiRenzo
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FUNDING NE CASC

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Todd Richards
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Matthew Carpenter
Jason Stolarski
Courtney Buckley
James Deshler
Merry Gallagher
Jerrod Parker
Alan Libby
Chris Bellucci
Jason Carmignani
Michelle Graziosi
Melissa Winters
Beth Swartz
Cory Pelletier
Laura Saucier
Jeff Walker

Models were applied to baseline conditions and climate change conditions to project the distributions of each fish and mussel species within HUC12 watershed bounds. Fish and mussel species were then grouped by commonly used traits (e.g. temperature guilds, life history strategy, etc.) or by empirical clustering using habitat conditions associated with species occurrence.

We analyzed the major drivers of these groups' distributions and the changing distributions under a climate change scenario. We found that some species are not well described by an associated guild and thus their conservation may be overlooked by managers focusing efforts on watersheds identified using predefined guilds distribution. For example, only one of two freshwater fish clusters composed of species that are found in cold water were highly correlated with the distribution of the cold water guild and shared similar drivers (Figure 1). When we combined baseline projections of freshwater fish and mussel biodiversity we found that the watersheds of conservation interest varied if the focus was on maximizing native species (lower Connecticut River watershed and eastern Maine) or if the focus was on maximizing species most vulnerable to climate change (high elevation watersheds from western Massachusetts to northern Maine) (Figure 2).

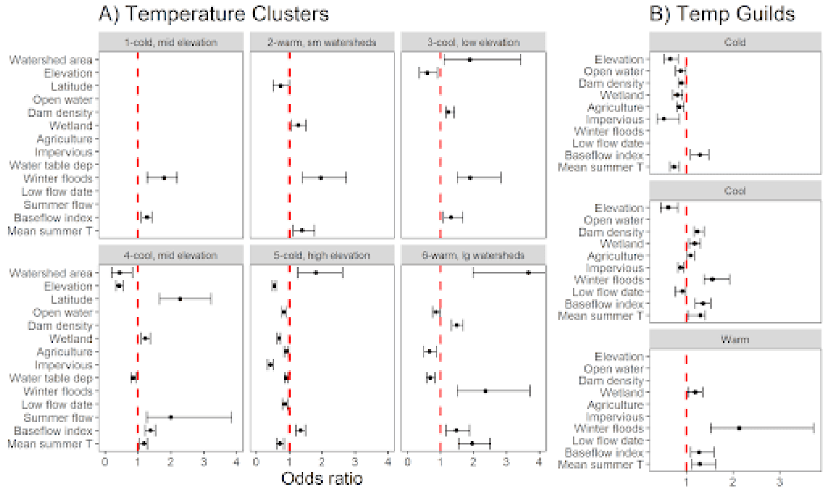

Figure 1. The average of the odds ratio (OR) and upper and lower bound for temperature clusters (A) and the temperature guilds (B) showing the 95% confidence intervals (only showing the odds ratios that are significant at $P < 0.05$). Red dotted vertical line is at x = 1. Odds ratios greater than 1 signify a positive relationship and odds ratios less than 1 signify a negative relationship. For cluster 6, the OR upper bound is 6.7.

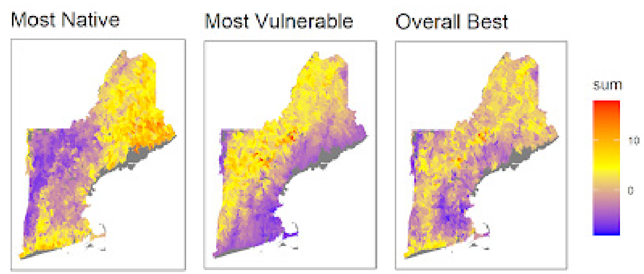

Figure 2. Baseline biodiversity maps combined for fish and mussels. Most native combines the fish origin ration and the mussel spp richness. Most vulnerable combines fish temp, fish habitat, mussel size, and mussel life history strategy.

Climate change is most likely to harm native species in the most eastern portion of Maine, whereas it is most likely to harm species designated as vulnerable to climate change in the high elevation regions of Vermont and New Hampshire.

Spatial and temporal variation in quantity and bioavailability of dissolved organic carbon in urban streams in the Greater Boston area

The magnitude, bioavailability, and timing of fluxes of dissolved organic carbon (DOC) in riverine systems are key factors in stream ecosystem functions, including nutrient cycling. Urban riverine systems are complicated by variability in impervious cover, wastewater and stormwater infrastructure, riparian cover, and channelization, which affect sources and transport of carbon.

We sampled stream water from 100 sites in the greater Boston area reflecting a range of land cover, riparian vegetation, stream size, housing and infrastructure age, and socio-demographic characteristics (Figure 1). Water samples were collected from tributary and mainstem sites in the Mystic, Charles, and Neponset River watersheds during four seasons and analyzed for DOC concentration and fluorescence (fDOC, indicative of type and source of DOC). Parallel Factor Analysis (PARAFAC) was conducted to classify the dissolved organic carbon as microbial, terrestrial, or protein-like.

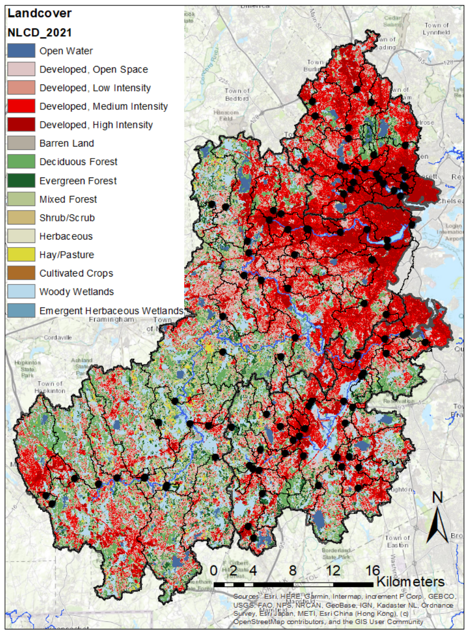

Figure 1. Watersheds for 100 sampling sites in the greater Boston area (black circles). The colors indicate land cover, based on the National Land Cover Database.

Seasonally, DOC concentrations were highest during the July sampling, possibly due to low precipitation and streamflow. Spatially, we observed strong correlations between impervious cover and DOC characteristics. Increasing carbon bioavailability with urbanization has implications for stream ecosystem function and water quality. For example, potential impacts may include increased rates of in-stream respiration, oxygen depletion, nitrogen cycling, and resulting cascading effects. Interestingly, sampling sites downstream of combined sewer outfalls showed distinctly higher concentrations of protein-like dissolved organic matter, suggesting the influence of current or legacy sewage overflow, with implications for water quality management in cities with older infrastructure, such as Boston.

To further analyze temporal changes, sensors were installed at three of the sampling sites to measure CDOM (colored dissolved organic matter) and standard water quality parameters every 15 minutes over one year. These sites drained watersheds of similar size but with a range of urban development (14%, 64%, and 83%). Combined with weekly measurements of fDOC from grab samples (Figure 2), we observed seasonal changes occurring in each watershed and that DOC from the highly developed watershed was more microbial and autochthonous and less humic than the least developed watershed.

Overall, our data show the impacts of urbanization on the characteristics and bioavailability of DOC in streams, potentially increasing rates of ecosystem metabolism, although these impacts vary seasonally.

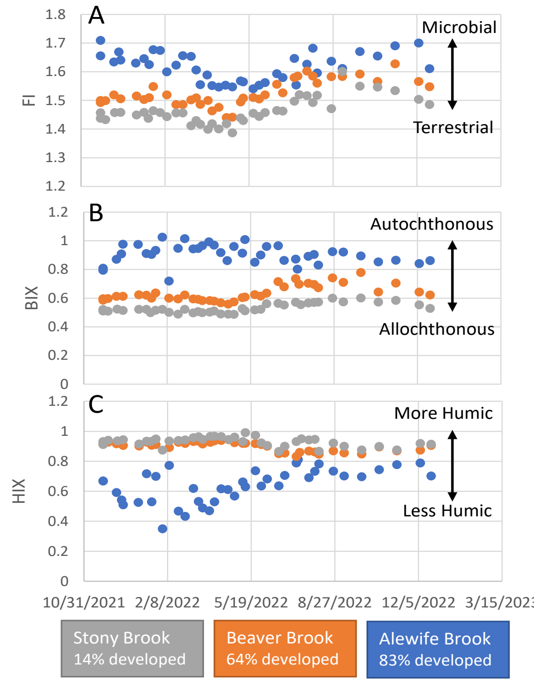

Figure 2. Fluorescent dissolved organic carbon (fDOC) indices for stream water samples measured at three locations (Stony Brook, gray symbols, 14% developed; Beaver Brook, orange symbols, 64% developed, and Alewife Brook, blue symbols, 83% developed over one year (November 2021 to December 2022). The Fluorescence Index or FI (A) increases with microbial DOC sources. Biological Index or BIX (B) increases with more autochthonous DOC sources. Humification Index or HIX (C) increases with the humic character of DOC.

POST DOC Annika Quick
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FUNDING NSF
COLLABORATORS
Rebecca Hale, Jennifer Morse
Krista Capps, Shuo Chen
Kristina Hopkins, Christopher Rizzie
John Kominoski, Liz Ortiz Muñoz

Rethinking lake management for invasive plants under future climate: sensitivity of lake ecosystems to winter water level drawdowns

Using remote sensing data, validated with on-the-ground water level data, we developed a cloud-computing framework to process time-series synthetic aperture radar (Sentinel 1-SAR) and optical sensor (Landsat-8, Sentinel-2) data to characterize winter drawdown (WD) lakes across Northeast and Midwest United States from 2016-2021.

Comparison with in-situ logger data showed Sentinel-1 derived surface water area captured relative water level fluctuations indicative of WD. A machine learning approach classified lakes as WD versus non-WD based on seasonal water level fluctuations derived from Sentinel 1-SAR data.

POST DOC	Abhishek Kumar
ADVISOR	Allison Roy
FUNDING	NE CASC
COLLABORATORS	Konstantinos Andreadis Caitlyn Butler Xinchen He

Within MA, results showed WDs occurred in over 75% of lakes during the study period, with high interannual variability in the number of lakes conducting WD (Figure 1A). WD start date was later and duration was longer in wet years, indicating climate mediation of WD implementation driven by management decisions (Figure 1B).

This study demonstrated a scalable approach using open access Sentinel 1-SAR data and cloud computing tools that could be applied across large regions to map and monitor water level fluctuations in lakes. The data and analysis framework developed under this study can serve as a template for assessing drawdown practices in other parts of the world, which is not feasible with in-situ monitoring alone.

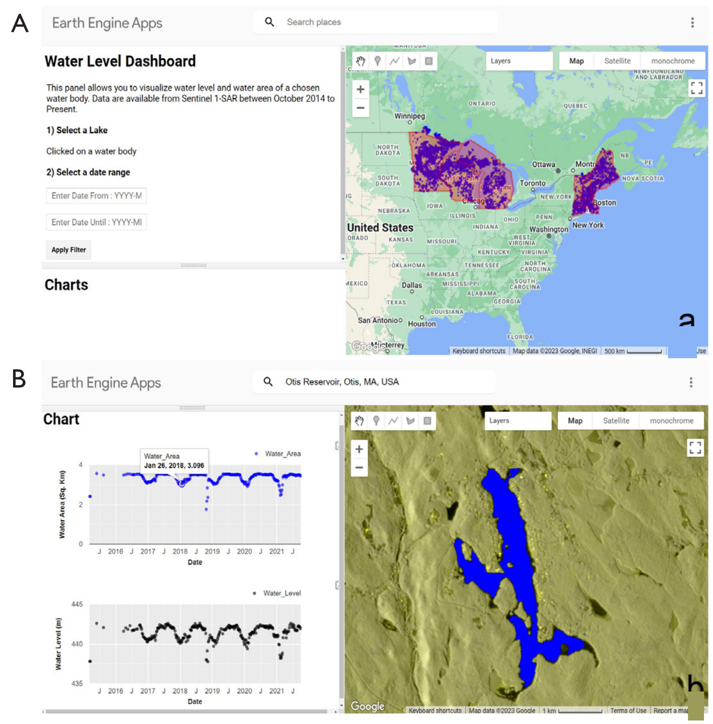

Figure 2. A) Google Earth Engine-based water level monitoring web application for deriving water area and level time-series data (October 2014 to present), B) an example of time-series data for Otis Reservoir in MA.

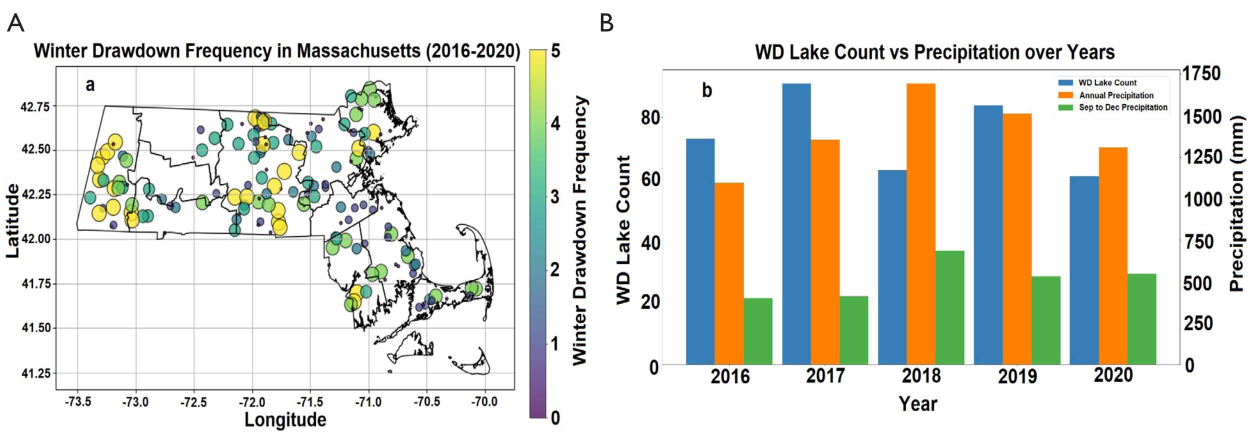

Figure 1. A) Winter drawdown frequency for 166 lakes across MA for five years; bubble size and color indicate frequency. B) Total number of WD lakes (blue) total annual precipitation (orange), and total precipitation between September to December (green) for contiguous MA.

The information on drawdown frequency and metrics can aid water managers and policy makers in setting guidelines for balancing the intended benefits of drawdowns for nuisance plant control and infrastructure protection versus the potential ecological impacts of these artificial water level manipulations. The interactive web-interface developed through this project provides state agencies and other stakeholders with a user-friendly tool to visualize drawdown frequency and characteristics (Figure 2).

River restoration through dam removal: examining ecological responses to small dam removals across MA

Due to negative ecological impacts, high costs of repair and maintenance, and safety risks, small dams (<15 m) are being removed from streams (e.g., Fig. 1). Despite the increase in removal projects within MA and beyond, we lack information describing how different stream ecological parameters respond to dam removals across a range of site and watershed characteristics, limiting the ability of practitioners to prioritize projects, set appropriate restoration targets, and communicate transparently with the public. Therefore, the goal of our research was to investigate a suite of ecological parameters before and after dam removal to better understand how streams respond to this restoration action.

We characterized responses of water quality, benthic macroinvertebrates, and fish assemblages to small dam removals across MA. At 11 dam removal sites, we monitored continuous stream temperature year-round before and up to 5 years after removal. At 10 sites, we monitored dissolved oxygen (DO) during summer months before and 1 year after removal.

Across sites, we observed reduced spring and summer temperatures in former impoundments and downstream reaches after dam removal (Fig. 2), with thermal recovery modulated by dam height and forest cover. Streams in smaller, steeper, and more forested watersheds generally experienced greater thermal benefits than those in lower elevation, warmer systems. Within one year following dam removal, DO in most impoundments (80%) increased to meet upstream reference conditions, with the magnitude of recovery corresponding with the magnitude of pre-removal impacts. Although dam removal led to reduced temperatures in some systems, we did not consistently observe an increase in coldwater macroinvertebrates or fish taxa. However, benthic macroinvertebrate sampling revealed increases in the percent of sensitive macroinvertebrate taxa, such as mayflies and stoneflies, within all former impoundments. Generally, macroinvertebrate communities across upstream, downstream, and formerly impounded reaches became more similar after dam removal (Fig. 3). We observed similar responses in fish assemblages, and increasing taxonomic similarity between upstream and downstream fish assemblages suggest dam removal led to a restoration of stream connectivity at these sites.

This research broadly documents the timescale and extent to which dam removal improves ecological integrity across varying parameters. These results point to the importance of setting appropriate restoration targets based on the context of the system. Small dams vary in their impact across the landscape; thus, not all dam removals will result in the same magnitude of ecological recovery.

Day of dam removal Oct 2021, Pepperell, MA | **1 year after removal Oct 2022**

Figure 1. View of the former impoundment of Sucker Brook (Pepperell, MA) after dam removal.

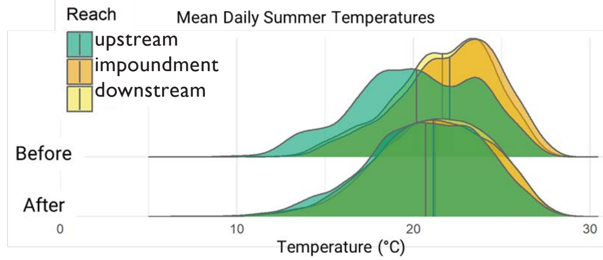

Figure 2. Density estimates of the mean summer (July–September) temperature distributions before and after dam removal across all sites included in this study. Vertical lines indicate median temperature of a given distribution.

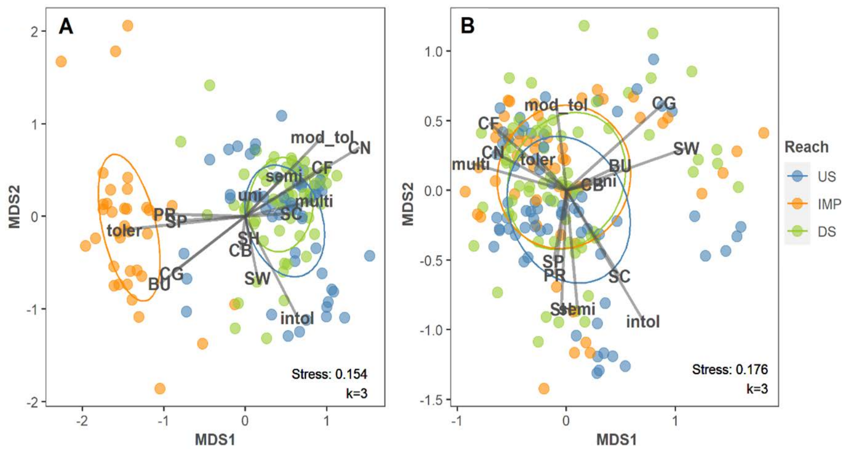

Figure 3. Non-metric multidimensional scaling (NMDS) of log-transformed relative abundance data of macroinvertebrates. Plots show macroinvertebrate assemblages A) before and B) after dam removal across all sites and years.

STUDENT Kate Abbott (PhD)

ADVISOR Allison Roy

FUNDING MA DER
MassWildlife
MET and their sale of license plates
NE CASC
Trout Unlimited

COLLABORATORS

Kris Houle
Frank Magilligan
Steven Mattocks
Keith Nislow
Rebecca Quiñones
Todd Richards
Erin Rodgers

Timing is everything: climate change implications for phenological events and reproductive success in river herring

Each spring, anadromous river herring (alewife, *Alosa pseudoharengus*, and blueback herring, *Alosa aestivalis*) migrate from the ocean to freshwater to spawn. Juveniles then reside in freshwater before emigrating to the ocean. The timing of life cycle events for river herring in fresh water are poorly understood and climate change may alter environmental cues that prompt both adult migration and juvenile emigration.Clarifying how environmental changes influence these life-history events will allow for better informed predictions of how they might be influenced by changes in climate. This research considered considered how changes in climate could influence the life cycle of anadromous river herring, at each of these stages: 1) duration of adult spawning, 2) timing of adult migration, 3) triggers of juvenile emigration.

To investigate duration of adult spawning, we used otolith-inferred juvenile ages and genetic pedigrees to estimate how long adult alewives spawned in freshwater and to match adults to their offspring to assess relationships between spawning duration and reproductive success. We stocke adult alewife in Pentucket Pond (MA) and connected adult and juvenile data over multiple years (2014-2015). Based on our results, adult alewife spawned in freshwater for longer (mean = 26 days) and over a larger range (3–64 days) than previously thought. Longer stays in freshwater were associated with higher reproductive success, which may reflect opportunities to spawn multiple clutches across a range of nursery conditions (Figure 1).

STUDENT Meghna Marjadi (PhD)

ADVISOR Allison Roy

FUNDING USGS/USFWS SSP
UMass OEB Program
MDMF
WHOI

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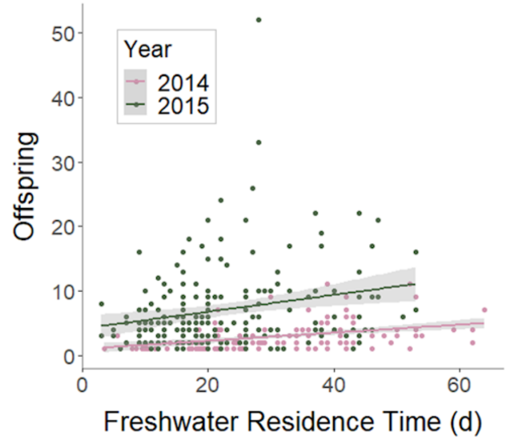

Figure 1. Relationships between offspring assignment and freshwater residence time in days (d)

We used multi-decadal datasets to evaluate trends in adult blueback herring spawning migration and juvenile counts in relation to environmental and climatic variables in the Connecticut River. We found that adult blueback herring migrations started 0.20 days/year earlier and became 0.30 days/year shorter over time. Additionally, shorter winters and higher winter precipitation were among predictors of earlier migrations. Climate-related changes in adult phenology and environmental conditions influenced juvenile counts in this system; longer adult migrations, more variation in summer temperatures, and higher winter precipitation predicted higher juvenile counts. The Connecticut River dataset is one of the longest available of its kind to include data on both adults and juveniles.

Results from this study make connections between adult phenology, environmental data, and juvenile counts over multiple decades, which allows understanding of interannual variation and temporal trends in these metrics.

We placed a video camera to collect continuous footage during proposed juvenile emigration periods and developed a neural-network based AI mode to process collected video. Over 3,000 volunteers helped us evaluate model performance by categorizing images on zooniverse.org, a public science participation platform. Our code is available for use on GitHub. Our video and processing model counted emigrating juveniles (9.4% error) over two study years (2017, 2018) at Great Herring Pond.

Juveniles emigrated continuously through the study period (June – December) in both study years, with high passage pulses in July and October (Figure 2). In both study years, juveniles were more likely to emigrate during low-light moon phases (crescent, new moon), but other cues for large passage events differed interannually. Our results highlight the value of continuous data to evaluate river herring emigration and explore interannual variation in emigration triggers.

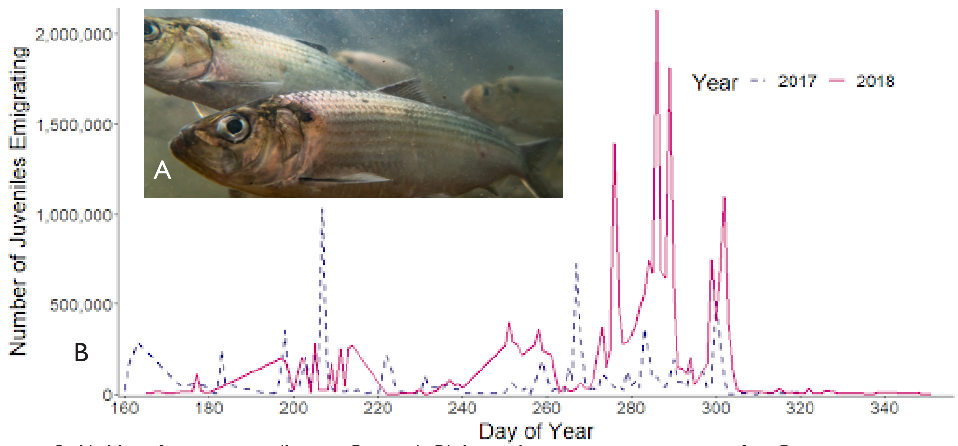

Figure 2. A) Alewife migrating (James Garner), B) Juvenile emigration patterns for Great Herring Pond in 2017 and 2018 based on processed continuous video data.

FISH & AQUATIC ECOLOGY
COMPLETED PROJECTS

Developing a restoration strategy for the Brook Floater (*Alasmidonta varicosa*) in Massachusetts

The brook floater (*Alasmidonta varicosa*) is a freshwater mussel (Order: Unionida) native to Atlantic Slope drainages from Canada (Nova Scotia and New Brunswick) to Georgia, U.S. (Figure 1). The precipitous loss of brook floater populations and extant low densities in many regions evokes an urgency to establish conservation initiatives for the species. A targeted approach to population restoration is critical in Massachusetts where brook floater remain in low abundances in only 4 of the 11 originally occupied watersheds (Hydrologic unit code-12). A succinct strategy to restore a rare freshwater mussel species is unavailable yet critical to aid restoration.

Figure 1. Brook floater propagated at the U.S. Fish and Wildlife Service Cronin Aquatic Resource Center during host fish experimets. (Ayla Skorupa)

STUDENT Ayla Skorupa (PhD)

ADVISOR Allison Roy

FUNDING MET and their sale of license plates
USFWS State Wildlife Grant
USFWS Directorate Fellows Program

COLLABORATORS

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David Perkins
Andrew Fisk
Timothy Warren
Sean Sterrett
Jason Carmignani
Brian Cheng

We focusd on key aspects of population restoration that include propagation, habitat, and juvenile growth and survival. To propagate brook floater, we evaluated host fishes that maximized juvenile production in a laboratory. Brook floater glochidia metamorphosed on all fish species tested (ten in six families); however, relative metamorphosis success was variable among species and may depend on fish collection location.

To understand riverine habitat of brook floater and co-occurring mussel species (i.e., triangle floater, eastern pearlshell, creeper, eastern elliptio), we sampled 25 sites in 9 watersheds across MA. Brook floater abundances were similar across mesohabitat types evaluated (i.e., dammed pool, run, riffle, scour pool). Of the species sampled brook floater exhibted a unique unimodal relationship with heterogeneous substrate (Figure 2). Flow transitions, like depositional areas that create heterogeneous substrates, may provide habitats for the species.

We assessed how growth rates relate to water quality within the four rivers with extant populations in MA by deploying propagated Age 1 and Age 2 brook floater in contained systems for one growing season (June to October). Mussels had a higher growth rate at chlorophyll a values ≥2.82 mg/L over the temperature range measured (biweekly mean 16-26°C). Sodium limited the growth rate of mussels (Figure 3) and other cations (magnesium, potassium, and calcium)—potentially linked to road deicers—also negatively impacted growth rate in all four rivers.

Research objectives were co-produced with decision makers; therefore results from this research are integral to aid conservation and restoration of brook floater in MA. This work provides a blueprint for population restoration steps to consider for any rare mussel species.

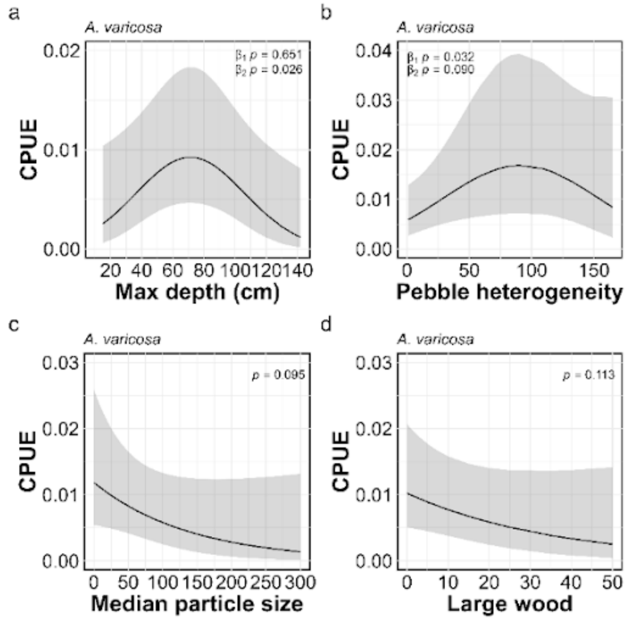

Figure 2. Models of habitat features on the response scale predicting brook floater (*A. varicosa*) abundance. Each fixed effect is conditioned on the mean of all additive variables for one minute of search time and variability across random effects is not shown. Black lines are model predictions and shaded gray areas are 95% confidence bands. CPUE = catch per unit effort in mussels per minute.

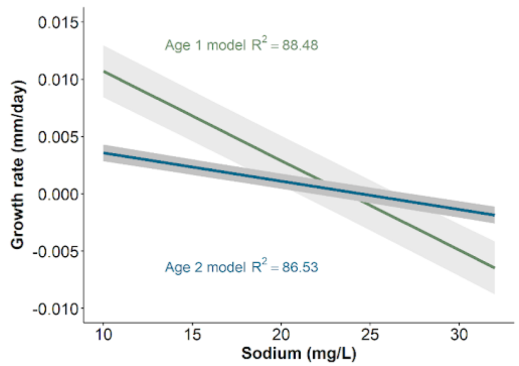

Figure 3. The negative relationship between modeled growth rate and sodium for Age 1 and Age 2 brook floater (*A. varicosa*) in Massachusetts; one model for each age. Black lines are model predictions and shaded gray areas are 95% confidence bands.

Evaluating freshwater macroinvertebrate taxa temperature tolerances in the Northeastern U.S.

Rising air temperatures and altered precipitation due to climate change is impacting stream temperature and hydrology. These changes will shift abundance and distribution of biota such as macroinvertebrates, particularly those that are thermally sensitive. We evaluated freshwater macroinvertebrate taxa tolerances to water temperature in the Northeast region of the United States.

Occurrence (presence/absence) and relative abundance data were used to assign taxa to thermal preference categories and calculate thermal metrics. Macroinvertebrate data were compiled from each state (Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont) and the Environmental Protection Agency's (USEPA) National Rivers and Streams Assessment into a database and then we paired samples (n = 7,114) with modeled stream temperature.

STUDENT	Emily Chalfin (BS Honor's)
ADVISOR	Allison Roy
FUNDING	U.S. Environmental Protection Agency
COLLABORATORS	Jennifer Stamp

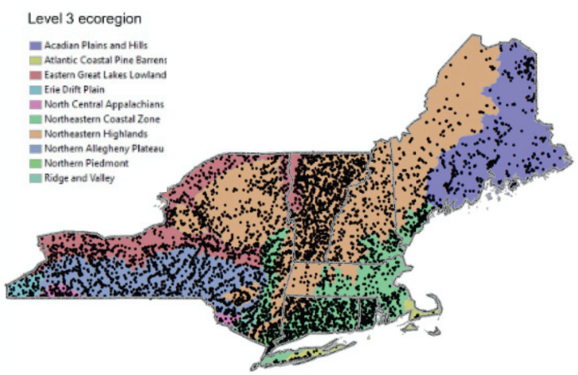

Figure 1. Study area within the Northeastern U.S. Points indicate sample sites (n = 8,648) and colors represent Level 3 Ecoregion.

For each of the 740 taxa with ≥ 30 sampled sites, generalized additive models were developed showing the probability of each taxon's occurrence along a temperature gradient, and weighted average optima were determined based on relative taxa abundance to estimate the central tendency of the macroinvertebrate taxa along a thermal gradient (Figure 2).The results of these analyses were used to assign taxa to one of six thermal preference categories: coldest, cold, cool, transition cool to warm, warm, and eurythermal.

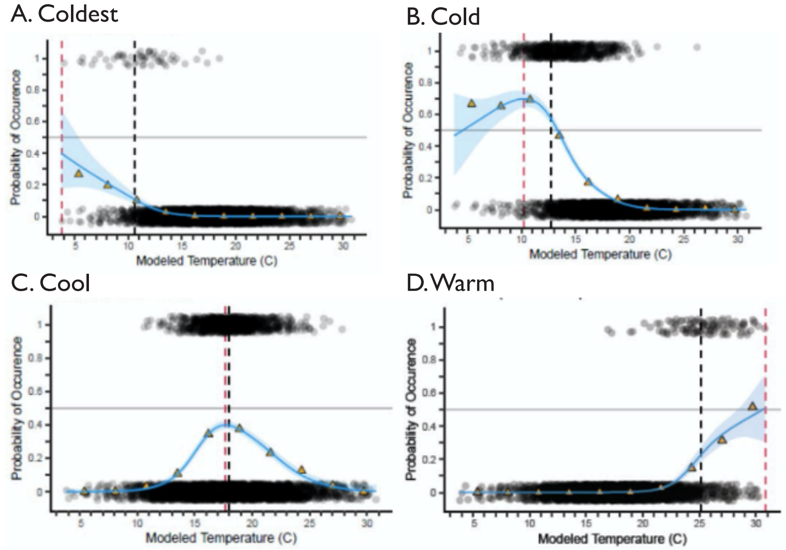

Figure 2. Example GAM plot patterns for A) coldest, B) cold, C) cool, and D) warm thermal categories.

Cool (31% of taxa), cold (27% of taxa), and transition cool to warm (25% of taxa) thermal categories had the most taxa. The orders Diptera, Ephemeroptera, Plecoptera, and Trichoptera had the highest proportion of coldest and cold taxa, perhaps due to the large number of taxa in these orders (Figure 3).There may have been fewer warm taxa due to the Northeast's cold climate, and that nonwadeable streams tend to be warmer and are not well represented in our dataset.

When comparing thermal tolerance metrics to common biotic metrics, we found a strong positive correlation between thermally sensitive taxa and pollution sensitive taxa suggesting that taxa that are sensitive to temperature are also sensitive to pollution. When finalized, the thermal indicator taxa list will help practitioners to better understand macroinvertebrate responsiveness to temperature and inform future decisions for stream protection and adaptation strategies for climate change.

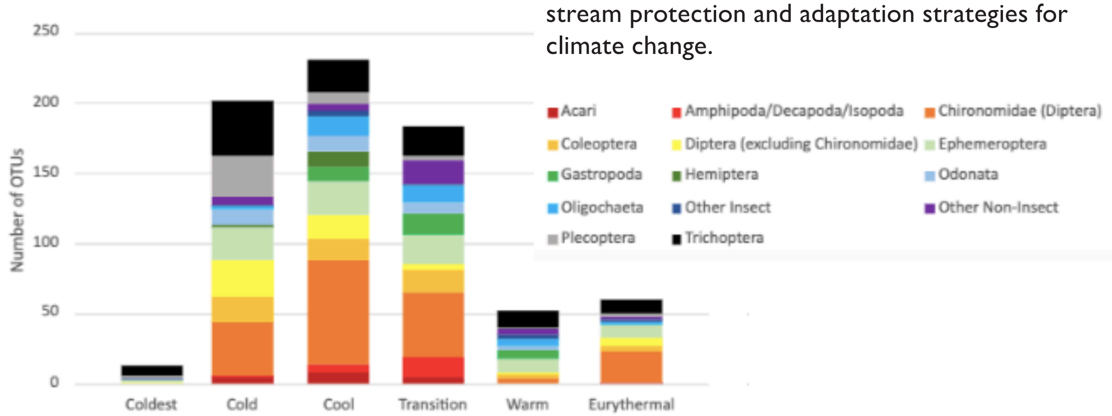

Figure 3. Number of Operational Taxonomic Units (OTUs) within major macroinvertebrate taxonomic groups for each thermal category.

Assessing food availability and growth rates as emigration cues for juvenile river herring

River herring (alewife, *Alosa pseudoharengus*, and blueback herring, *Alosa aestivalis*) move into coastal freshwater lakes seasonally for spawning purposes, affecting the dynamics of their zooplankton prey. Decreases in these food sources may trigger emigration of juvenile river herring as they seek more resources. Food availability also affects fish growth rates and size, which may be a biological cue for emigration. Understanding these lake dynamics is important because they help explain freshwater portions of the life cycle for river herring.

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ADVISOR Allison Roy

FUNDING MDMF
UMass CHC
USGS/USFWS SSP

COLLABORATORS

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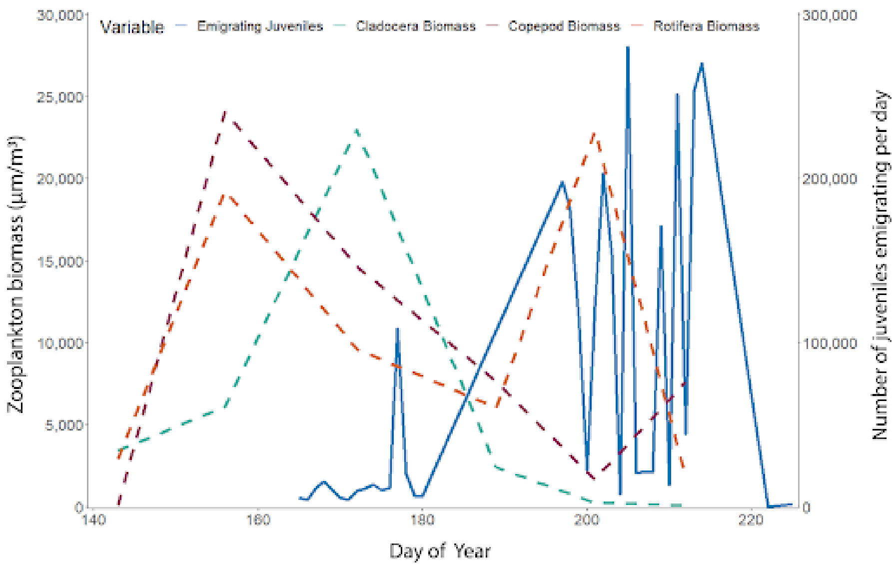


Figure 1. Emigrating river herring counts per day and biweekly zooplankton biomass.

We assessed food availability and individual growth as emigration triggers for river herring from Great Herring Pond, a lake in Plymouth Massachusetts. Zooplankton were collected biweekly from May 23rd to October 1st in 2018. Non-emigrating juvenile river herring were sampled using a purse seine, while emigrating juvenile river herring were sampled using dip nets in Monument River at the outlet of the lake. We extracted otoliths to assess age and growth rates for emigrating and non-emigrating fish. We deployed a video camera in the Monument River to count emigrating river herring using a computational model (YOLOv5). Zooplankton density and biomass decreased throughout the summer, with rotifers making up the majority of the density, while cladocerans and copepods comprised more of the biomass (Figure 1).

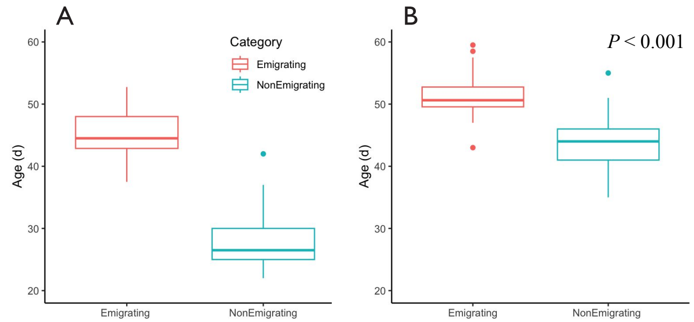


Figure 2. A comparison of emigrating and non-emigrating juvenile river herring ages sampled on (A) 7/9/18 and (B) 7/30/18.

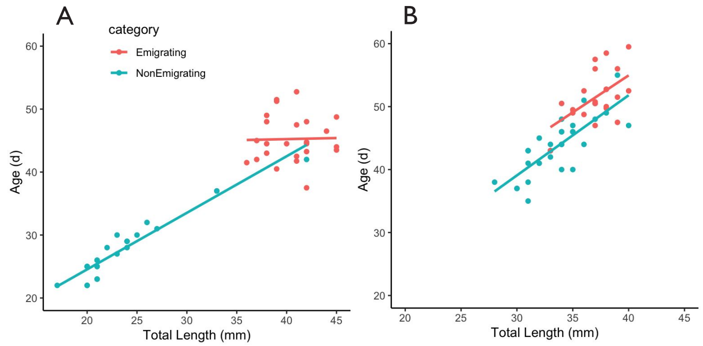


Figure 3. Length versus age relationships for emigrating and non-emigrating juvenile river herring from (A) 7/9/18 and (B) 7/30/18.

River herring emigration counts increased around July 19th, after cladoceran and copepod biomass decreased. Emigrating fish were larger, older, and had faster growth rates than non-emigrating river herring in early July (Figure 2A and Figure 3A). In contrast, non-emigrating juveniles had faster growth rates than emigrating juveniles in late July (Figure 3B). This suggests that decreases in food resources or reaching a certain size at age (40 ± 2.654 mm in early July; 37.1 ± 1.816 mm in late July) may cue river herring emigration. However, growth may also depend on spawning time which could explain the differences in growth from early to late July. This study contributes to the understanding of emigration cues for river herring which could help expand management practices to this stage of the river herring life cycle in the future.

Examining fish assemblage responses to dam removals

Massachusetts has over 3,000 dams, 91% of which are unmanaged or no longer serve their original purpose, rendering them obsolete. Small dams (<15 m) alter streams physically, chemically, and biologically, directly and indirectly impacting fish assemblages. Due to rising ecological and safety concerns, dam removals are becoming more prevalent, but the impacts of dam removals on fish assemblages are not well known.

The objectives of our research were to examine how fish assemblages changed upstream and downstream of former impoundments following dam removal. Using backpack electrofishing data collected by MassWildlife from 1999–2002, we selected 26 sites in 8 of the 13 ecoregions of Massachusetts including highly developed, agricultural, forested, and wetland areas (Figure 1). Sites were selected based on data availability before and after removal within 3 km of the former dam at either or both the upstream or downstream reach and the absence of additional barriers and tributaries 100 m downstream of the former dam.

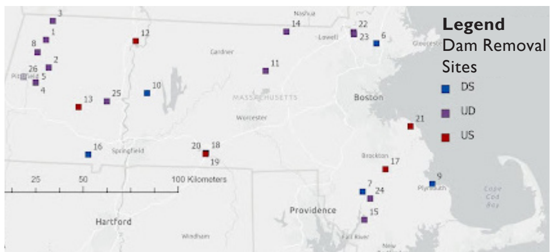


Figure 1. Location of dam removal sites with upstream fish data (red), downstream fish data (blue), and data corresponding with both the upstream and downstream reach (purple).

Fishes were categorized into functional trait groups (habitat use, thermal class, and tolerance class). Watershed boundaries were delineated using the U.S. Geological Survey's StreamStats at the location of the former dam. Drainage area, developed land cover, forest cover, road crossings, road length, and wetland area within the former watershed were extracted from StreamStats using R 4.2.

Our results suggest that changes in fish assemblages after dam removals are largely site specific, with few ubiquitous trends occurring across all 26 sites (Figure 2). However, fourteen sites had new species detected upstream following dam removal with representatives from each of the thermal and tolerance classes, likely due to the increase in habitat connectivity from removing a physical barrier to movement. The average species richness across all sites decreased in the downstream reach following dam removal (Figure 3), possibly due to the disturbance caused by dam removals or conditions being made less favorable to generalists. While watershed-scale variables did significantly impact fish assemblages, they were not statistically significant in fish assemblage response to dam removal. This suggests that in watersheds impaired due to threats other than dams (e.g., urbanization), dam removal may not result in improvements to fish assemblages.

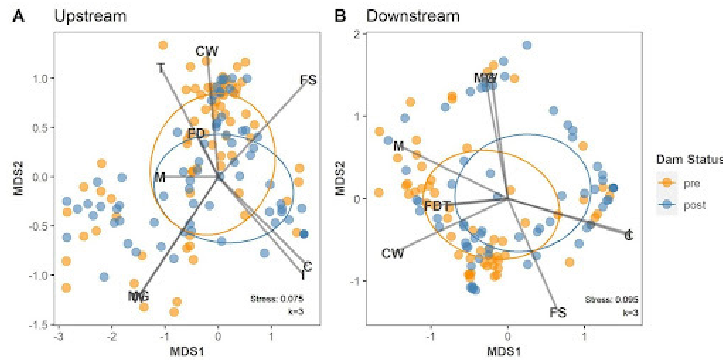


Figure 2. A non-metric multidimensional scaling (NMDS) ordination of A) upstream fish communities (based on log-transformed relative abundances) and B) downstream fish communities before and after dam removal. Abbreviations for functional trait classes are as follows: I (intolerant), M (moderately tolerant), T (tolerant), FD (fluvial dependent), FS (Fluvial Specialist), MG (macrohabitat generalist), C (coldwater), CW (coolwater), and W (warmwater).

Changes in fish assemblages in the upstream and downstream reaches over time were also found to be variable across study sites, supporting the idea that other environmental variables contribute to fish assemblage response to dam removal, beyond the dam removal itself.

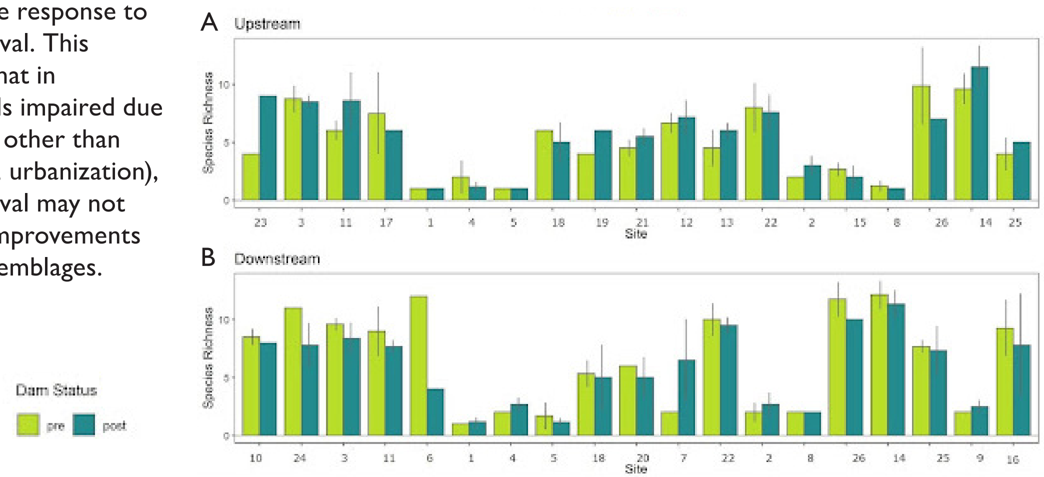


Figure 3. Average species richness at study sites with pre and post dam removal data before (light green) and after (dark green) dam removal at the A) upstream and B)downstream reaches. Standard error bars were used, where no error bar is present, only one sampling event was conducted for that site and time period.

STUDENT Callista Macpherson (BS Honor's)
ADVISOR Allison Roy
FUNDING MA DER
MassWildlife
UMass CHC
COLLABORATORS Kate Abbott
Scott Jackson

Informing management decisions for novel emerging amphibian diseases

Hypervirulent emerging infectious diseases cause species extinctions, population declines, and reduce the functioning of human and natural systems. The high-profile emerging amphibian pathogen, *Batrachochytrium salamandrivorans* (Bsal), has not yet been detected in North America, a hotspot of global salamander diversity. Thus, North America has a unique opportunity to proactively manage susceptible amphibian communities for the imminent invasion of Bsal. However, identifying an optimal management is challenging, in part because of the deep uncertainty that exists in the early stages of pathogen invasion, but also because managers must balance multiple objectives and management actions. Consequently, it is fairly common for decision-makers to take a reactive approach to disease management. We are working with management decision makers to evaluate proactive and reactive management actions to inform what actions minimize the impacts of Bsal on amphibian populations, while balancing trade-offs with other objectives. To evaluate the efficacy of management actions for maintaining salamander populations, we developed a quantitative model, to forecast host and pathogen occupancy following the emergence of the pathogen under both proactive and reactive management scenarios. We are integrating estimates from these models into a full multi-criteria decision analysis that incorporates other objectives, including cost, non-target ecosystem effects and stakeholder values. This work will help inform optimal strategies for promoting persistence of disease-threatened salamander populations.

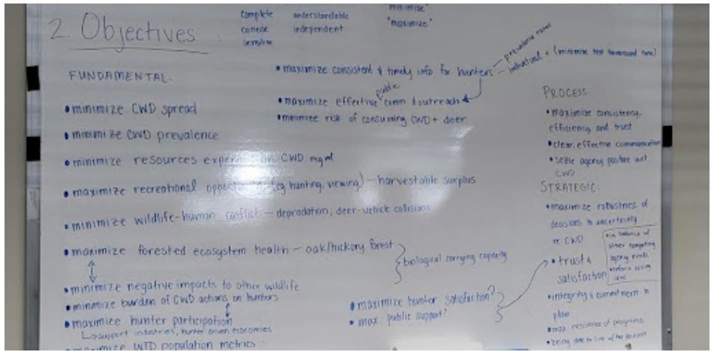
POST DOC	Molly Bletz
ADVISOR	Graziella DiRenzo
FUNDING	USGS
COLLABORATORS	Evan Grant

Eastern newt (Molly Bletz)

Supporting decision-making for chronic wasting disease management by state, federal, and tribal wildlife agencies

Chronic wasting disease (CWD) is a progressive, neurodegenerative prion disease that is fatal to the cervid species it infects, including white-tailed deer, mule deer, and Rocky Mountain elk. Because CWD is incurable and infectious prions can last for years in the environment, agencies across the country are faced with limited options for managing its negative impacts once the disease is introduced to free-ranging populations. Many affected species are culturally and ecologically important to the communities that rely on them, so agencies are motivated to find balanced strategies for CWD management that meet the needs of hunters, community members, and other important stakeholders. To help agencies navigate these difficult decisions, our project applies structured decision making (SDM). We are applying SDM for agencies in several disease and governance contexts, including for a tribal agency in Oregon where CWD is not yet found, for the US Fish and Wildlife Service managing elk in the Greater Yellowstone Ecosystem where CWD was recently discovered, and for Ohio's deer program where CWD has been steadily increasing for a few years. We provide quantitative support to make predictions about the effectiveness of proposed management actions and guide decision makers through the structured process of identifying the best alternatives to meet their agency goals and needs.

POST DOC	Meg McEachran
ADVISOR	Graziella DiRenzo
FUNDING	USGS
COLLABORATORS	Collaborators from the US Geological Survey, US Fish and Wildlife Service, and wildlife management agencies in 4 different states



An example of a list of fundamental objectives for one of the agencies we are working with, created as part of a structured decision making workshop (Meg McEachran)

Effects of habitat, density, and climate on moose and winter tick ecology in the Northeastern U.S.

Moose (*Alces alces*) populations have declined by at least 30% in the Northeastern U.S. over the past couple decades. Concern has risen among natural resource agencies charged with maintaining viable moose populations, spurring research initiatives throughout the Northeast. Previous research confirms that high winter tick (*Dermacentor albipictus*) infestations are a major driver of moose population trends, with some animals hosting over 60,000 ticks, negatively affecting both survival and reproduction. MA CRU, Vermont CRU, Maine Department of Inland Fisheries and Wildlife, Penobscot Nation (PN), and several other state and federal agencies formed a collaborative effort in 2021 to develop cost-effective and robust approaches for monitoring moose and winter ticks across the Northeastern U.S. and to identify the extent to which climate, habitat, and density-dependence influences moose-tick dynamics. This effort has resulted in a large camera network (Northeast Wildlife Monitoring Network; NEWMN) that includes 12 collaborators from 5 states and an efficient database management approach for ferrying, storing, and analyzing large amounts of camera data. Additionally, MA CRU developed a new camera design with the intention of improving multi-species monitoring and worked with PN to integrate their novel method of estimating off-host tick abundance into NEWMN.

POST DOC Alexej Sirén
ADVISOR Tammy Wilson
FUNDING USGS
COLLABORATORS

Lee Kantar	Rachel Cliché	Suzanne Gifford
Benjamin Simpson	Nick Fortin	David Wattles
Henry Jones	Katherina Geider	Paul Jensen
Riley Patry	Chris Bernier	Jacqueline Frair
Leighlan Prout	Jillian Kilborn	Vanessa Rojas

Alexej Sirén in the field (Marketa Zimova)

Echos of conservation: bridging gaps in bat monitoring through communication, technology, and collaborative strategies in North America

Over the last decade, the North American Bat Monitoring program (NABat) has increasingly been documenting bat presence/absences for nine species across North America. NABat was co-created by the U.S. Fish and Wildlife and U.S. Geological Survey as a response to drastic bat declines caused white nose syndrome since the early 2000s. However, data contributors and partners to NABat have a diversity of objectives and operate at a variety of scales (e.g., national, regional, local). This work evaluates NABat's communication strategies, aiming to decipher the motivations behind individuals engaging in conservation efforts. We are also applying translational ecology and coproduction approaches, collaborating with federal, state, and NGO partners to sample priority and priority-adjacent grid cells for bat population monitoring. We are also investigating remote sensing methods to discern habitat characteristics of bat populations. The objective is to explore the potential use of hyperspectral satellite imagery to identify suitable habitats, guided by ground truth surveys and airborne multispectral satellite imagery. Through improved communication, technological innovation, and strengthened partnerships, our aim is to provide practical insights for sustainable bat conservation in the Northeast.

STUDENT Ayodelé O'Uhuru (PhD)
ADVISOR Graziella DiRenzo
FUNDING GEM Fellowship
USFWS Pathways
COLLABORATORS

Jonathan Reichard	Christina Kocer
Jeremy Coleman	David Hughes

A Northern Long-eared Bat (Ayodelé O'Uhuru)

Estimating brown bear abundance using aerial surveys in Katmai National Park, Alaska

Katmai National Park in Southwest Alaska is home to one of the world's largest brown bear populations, supported by the largest sockeye salmon run in the world. Katmai's remote location coupled with harsh weather and limits to staff and funding make it difficult to estimate and monitor brown bear population dynamics using traditional mark-recapture techniques. Yet the park's mission to protect high concentrations of brown bears, increasing public interest, and concerns over how the bear population might be changing drives the need to understand this unique bear population. Recent advances in quantitative techniques may offer a way to use Katmai's long-term (1970–present) aerial survey data to estimate trends in the bear population. Our goals are to combine counts of bears congregating along salmon spawning streams with demographic data from Brooks River to estimate trends in brown bear use of salmon spawning streams, trends in brown bear population abundance, and to examine environmental factors influencing these trends.

STUDENT Leslie Skora (PhD)

ADVISOR Tammy Wilson

FUNDING Katmai National Park
The Katmai Conservancy
Southwest Alaska Network

COLLABORATORS Amy Miller
Troy Hamon

Conducting aerial surveys along the Funnel Creek in Katmai National Park, AK. Researchers count bears congregating on salmon spawning streams (Leslie Skora)

Road ecology of black bears and moose in Western Massachusetts

Utilizing an array of 60 wildlife cameras as part of a larger camera monitoring network (Northeast Ecological Monitoring Network) and state-wide radio collar data on black bears and moose, we are working to improve our understanding of the road ecology of black bears and moose across western Massachusetts. The aim of this research is to provide data that can help reduce vehicle collisions, reduce the number of injured animals, and potentially inform decisions on where to invest in building wildlife crossings across the state. This will involve statistical population modeling, considering population distribution and relative density, evaluating and predicting movement patterns and dispersal, incorporating vehicle collision data, as well as considering current and projected human population data. The results and accompanying recommendations could influence decisions on wildlife crossing location and design, road design, road route development, as well as other future infrastructure development across the state.

STUDENT Connor Morrow (MS)

ADVISOR Tammy Wilson

FUNDING MassWildlife

COLLABORATORS Dave Wattles

Moose and Black bear captured on Trail Cameras (NEWMN)

Understanding the impact of introducing confiscated turtles that carry disease and deleterious alleles into wild turtle populations

Global turtle biodiversity is threatened by illegal wildlife trade due to long generation times and low recruitment rates. In some cases, illegally trafficked turtles are intercepted and confiscated by law enforcement, wildlife biologists, or others, providing the opportunity to reintroduce them back into the wild. However, the introduction of confiscated turtles back into the wild comes with many risks and uncertainties, such as introducing novel disease that may have been picked up during transit or introducing an individual with deleterious alleles into a wild population. Therefore, the objectives of this research are to (1) quantify the impact of introducing a confiscated turtle that carries disease into a wild population and (2) quantify the impact of introducing a confiscated turtle that carries deleterious alleles into a wild population. We will use the wood turtle (*Glyptemys insculpta*) as a case study because they are highly sought after in the illegal wildlife trade for food, medicinal properties, and pets. To achieve our objectives, we will use a population viability analysis, sensitivity analysis, and population projections. These results will help improve plans of action for confiscated animals made by researchers, state, federal, and NGO's by employing quantitative methods that showcase the effects of introducing confiscated animals back into the wild.

STUDENT Ednita Tavarez-Jimenez (MS)

ADVISOR Graziella DiRenzo

FUNDING USFWS
USGS

COLLABORATORS Evan H. Grant
Jillian E. Fleming
Molly C. Bletz

A wood turtle (Jill Fleming)

Resource selection of human-associated resources by Massachusetts black bears across seasons and reproductive status.

Black bears (*Ursus americanus*) in Western MA live in an urbanizing landscape rich in human-derived food sources such as bird feeders, garbage bins, and agricultural crops. Managers are interested in learning how bears use resources in urbanizing environments to mitigate human bear conflicts. Our objectives were to quantify resource selection of human-associated resources by black bears, including how season and reproductive status may affect selection. Bears with cubs did not normally change selection behavior. Bears selected forest in proportion to availability, and wetland sites at higher probability than available, particularly in Spring. In most cases, bears selected sites farther from built structures and selected human dominated land cover classes less than predicted by their availability. The exception to this was in the fall when bears selected agricultural crops, predominately corn, when crops were ripe and near harvest. Reproductive condition did not appear to affect bear habitat selection.

STUDENT Jessica Bonin (MS)

ADVISORS Tammy Wilson

FUNDING MassWildlife

COLLABORATORS Dave Wattles

Jessica Bonin holds an American black bear cub in Massachusetts.

Chronic wasting disease (CWD) knowledge, risk perception, and management acceptance are influenced by media engagement and trust among deer hunters in Massachusetts

Human behaviors, including translocation of live animals or animal parts, can play an integral role in wildlife disease emergence and spread into new areas, prompting wildlife managers to employ education and outreach efforts to change risky behaviors. Therefore, public education campaigns can be an effective tool in shaping the determinants of important disease mitigation behaviors. One noteworthy wildlife disease is chronic wasting disease (CWD), which is spreading across the United States but has not been detected in Massachusetts. MassWildlife is interested in designing education and outreach strategies utilizing media sources and channels most likely to reach core stakeholder groups prior to CWD detection in the state (Massachusetts deer hunters).

We conducted a survey of deer hunters (n=6334) in Massachusetts to detect patterns in channel usage and source trustworthiness, as well as across socio-demographic variables (age, sex, education, club membership). We also conducted a path analysis to assess the relationship among CWD knowledge, risk perception, management acceptability, and state wildlife agency trust.

We found that both channel usage and source trustworthiness varied by all socio-demographic factors tested (age, sex, education, and club membership). We also found that engagement with popular channels and trust in accurate sources were positively correlated with CWD knowledge.

POST DOC Brian Hoven
ADVISORS Graziella DiRenzo
FUNDING USDA
COLLABORATORS Martin Feehan
Margaret McEachran

CWD risk perception mediated the relationship between knowledge and management acceptability. We also found that state wildlife agency trust and risk perception were positively correlated with management acceptance.

In Massachusetts, where CWD has not been detected to date, CWD knowledge is low, and CWD risk perception is high among deer hunters. Our research indicates capitalizing on initially high-risk perceptions as well as considerable trust in MassWildlife could be an effective approach. An education campaign employing accurate sources, such as MassWildlife, and utilizing a mixed-media approach could be an effective means of improving deer hunter knowledge of CWD. Improving their knowledge prior to detection of CWD can help develop an appropriate risk perception and improve acceptance of management proposals to limit the spread of CWD.

Future directions:
This study provides a baseline understanding of CWD knowledge, state wildlife agency trust, CWD risk perception, and CWD management acceptance of deer hunters in Massachusetts, a state where CWD has not been detected. For further insight, this population should be re-evaluated in the future to assess temporal trends before/after potential CWD introduction. A follow-up survey to our multi-media education approach would be beneficial to determine if the MassWildlife CWD education program was successful at (1) improving basic knowledge of CWD, (2) increasing CWD risk perception, (3) improving trust in MassWildlife, and (4) increasing acceptability of management approaches to minimizing CWD spread.

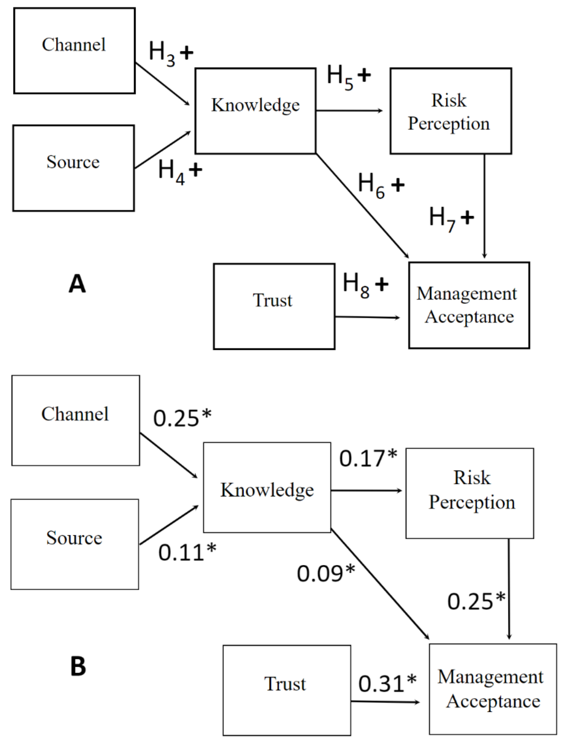


Figure 1. Model diagram illustrating hypothesized (A) and modeled (B) relationships between Channel (engagement), Source (trustworthiness), Knowledge (CWD), Risk Perception (CWD), Management Acceptability (CWD management actions), and Trust (in MassWildlife). Hypotheses in panel A: H3: Engagement with popular channels, will be positively associated with higher CWD knowledge scores; H4: Reported trust in broadly preferred sources, will be positively associated with higher CWD knowledge scores (Figure 1A); CWD knowledge scores will be associated with higher risk perception scores (H5); and higher management acceptance scores (H6); H7: Risk perception scores will be positively associated with management acceptance scores; and H8: Trust in the state wildlife agency will be positively associated with management acceptance scores. Only structural paths and path coefficients are displayed, variances and covariances have been omitted for clarity purposes. An * denotes significance at alpha=0.05.

Inferring pathogen presence when sample misclassification and partial observation occur

Detection of emerging pathogens often relies on surveillance programs and molecular diagnostic methods to make inference about pathogen presence. However, molecular detection methods are imperfect and can result in misclassification (i.e., false positives and false negatives) or partial detection errors (i.e., detections with 'ambiguous', 'uncertain', or 'equivocal' results). Then, when these data are to be analyzed, partial observations are either discarded or censored, but this disregards information that could be used to inform inference on the true state of the system. More direction and guidance related to how many samples are enough to declare a unit of interest 'pathogen-free' are needed for prompt and responsive decision-making.

We developed a Bayesian hierarchical framework which accommodates misclassification and partial detection errors (i.e., false negative, false positive, and uncertain detections) to improve inference related to pathogen occupancy at a site (Figure 1).

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ADVISORS	Graziella DiRenzo
FUNDING	USGS Biological Threats & Invasive Species Program
COLLABORATORS	Evan H.C. Grant Brittany Mosher Jonah Evans

We explored dimensions of pathogen occupancy, pathogen prevalence, diagnostic rates, and misclassification to provide guidance on sample sizes required to be 95% certain a target organism is absent from a site in the presence of partial detections. As a case study, we applied our modeling framework to the fungal pathogen *Pseudogymnoascus destructans* (Pd) identified in bats at the invasion front of white-nose syndrome in Texas.

We found that increased variability in the resulting posterior probability distributions of pathogen occurrence when partial detections were present. Our estimates of required sample size (to be 95% certain a target organism was absent from a site) were very sensitive to prior information about pathogen occupancy, pathogen prevalence, and diagnostic test specificity (Figure 2). In the Pd case study, we estimated that the posterior probability of pathogen occupancy was very low as late as 2018 but approached 1 by 2020, reflecting increasing prior probabilities of pathogen occupancy and pathogen prevalence elicited from the site manager.

Our modeling framework results in a posterior probability distribution of pathogen occurrence, which can be subjectively interpreted by a decision-maker. To facilitate the use of our methods, make them more accessible to the scientific community, and improve future surveillance programs, we developed an interactive RShiny app that generates estimates of occupancy and sample size. Our modeling framework and sample size guide can improve the use of molecular surveillance data and be applied in other systems where misclassifications and partial detections occur. We have extended this framework into an inferential model and are using simulated and empirical Pd data to explore the impacts of sample size, pathogen occupancy and prevalence, censorship of partial detections, and model formulations on model performance.

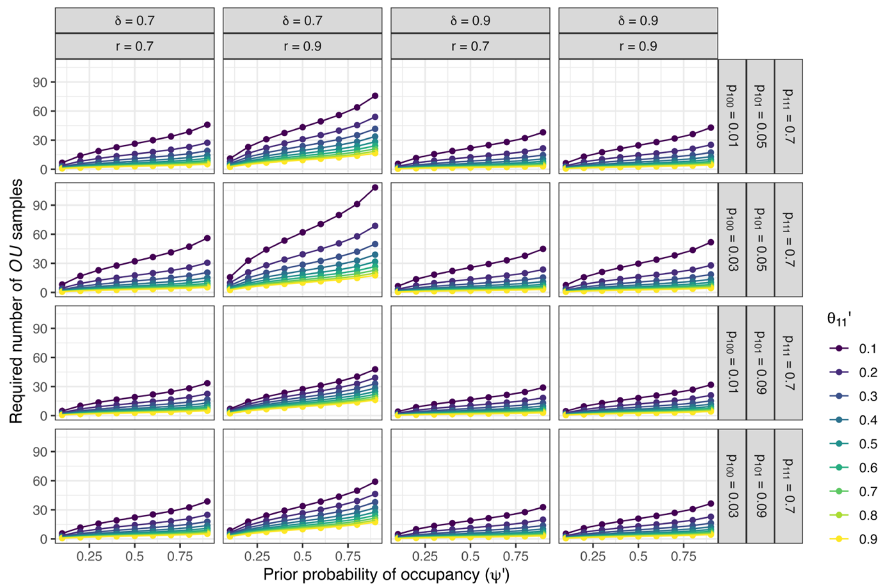

Figure 2. Sample size estimates reflecting the number of 0U infection histories across a range of parameter combinations. Each figure panel shows the minimum 0U sample size necessary to be 95% confident that the pathogen is absent from a site given an increasing prior probability of occupancy (ψ').

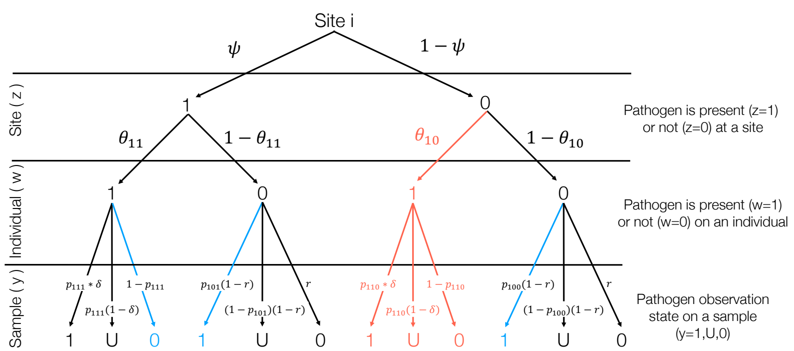

Figure 1. Decision tree diagram. Symbols and definitions are not provided as a part of this summary. The decision tree is read from top to bottom.

Effects of habitat, density, and climate on moose and winter tick ecology in the Northeast US

Over the past several decades, moose (*Alces alces*) populations in New England have been in decline due to winter tick (*Dermacentor albipictus*) parasitism. Winter ticks have been known to infest moose, with over 90,000 ticks being recorded on a moose. These infestations cause epizootics, in which 50% of calf mortalities are due to ticks, adult calving is reduced by 60%, and twinning rates are reduced by 5%. Given this, it is increasingly important to effectively monitor moose and winter ticks to address consistent population decline of moose due to winter tick epizootics. Objectives of this work were to measure off-host winter tick abundance and associated environmental variables and compare off-host tick abundance in relation to moose abundance.

Figure 1. Juliana collecting vegetation measurements during a winter tick survey (Juliana Berube)

STUDENT Juliana Berube (MS)

ADVISOR Tammy Wilson

FUNDING USGS

COLLABORATORS Laurence Clarfeld, Therese Donovan, Alexej Sirén, Ben Simpson, Cheryl Sullivan

To address this, we used a combination of camera traps and winter tick sampling to assess moose and winter tick density (Figure 1). We established an array of 60 cameras across central-western Massachusetts, contributing to the New England Regional Monitoring Network. We used a plot-based strategy that is effective for heterogenous habitat types developed by the Penobscot Nation to sample winter ticks at sites in western and central Massachusetts and the White Mountain National Forest and Umbagog National Wildlife Refuge in New Hampshire. The Penobscot Nation contributed winter tick data from sovereign trust lands. We used occupancy and n-mixture models to generate estimates of tick abundance for the three study areas, and to assess moose abundance in Massachusetts in relation to winter tick abundances.

In total, 719 winter tick samples were collected from 40 sites in Maine, 11 in New Hampshire, and 20 in Massachusetts. From these samples, 3,530 ticks were recorded, and ticks were found in all states. We found that detection probability of winter ticks peaked during mid-October (Figure 2) and that both tick occupancy and abundance were greatest at sites with intermediate vegetation height.

Out of the 60 cameras set to detect moose, 23 of them have detected moose to date. The probability of moose occupancy in Massachusetts was 33%, and the overall probability of detection was 9%. We found that winter tick abundance increased as moose abundance increased (Figure 3).

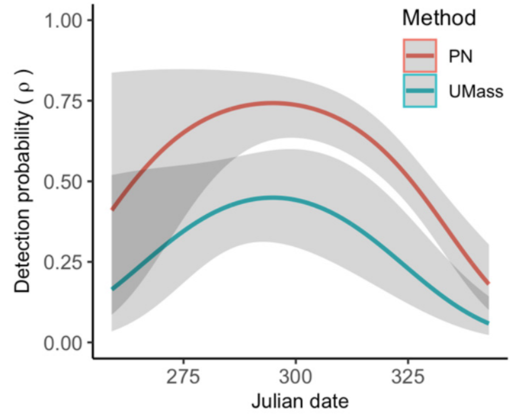

Figure 2. Model predictions for detection probability of winter ticks according to day of year indicating detection probability peaks mid-October during the questing season (~ Sept-Dec) of ticks.

Results from this study can inform monitoring strategies for ticks, predict epizootic severity, and develop tools to mitigate threats to moose. This is important for managers looking to prevent further declines in moose populations due to winter ticks and tribes seeking to maintain populations for sustenance.

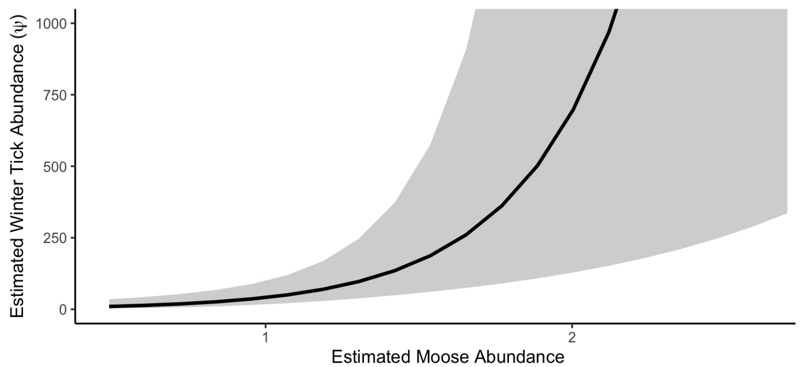

Figure 3. Modeling prediction for winter tick abundance in relation to moose abundance via camera trap and winter tick sampling during 2022. Because winter tick abundance increases as moose abundance increases, this relationship may be density-dependent.

Pine barrens wildlife management: exploring the impact of a stressor and active management on two taxa at Camp Edwards

Mandated by the Sikes Act of 1960, natural resource managers work to manage the habitats and wildlife that are found on military installations in the United States and Territories. At Camp Edwards Military Training Reservation (Camp Edwards) in Bourne, MA, such wildlife includes the state-protected eastern box turtle (*Terrapene carolina carolina*) and the declining prairie warbler (*Setophaga discolor*), which both occupy pine barrens. In 2020, natural resource managers at Camp Edwards noticed that eastern box turtles were being infected by myiasis, which occurs when flesh flies deposit larvae into the living tissue of a vertebrate host (Figure 1).

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Figure 1. Picture of eastern box turtle with myiasis infection (Andrew B. Gordon).

In the literature, it has been documented that several ectothermic hosts respond to disease or parasite infection through a phenomenon referred to as 'behavioral fever' by moving to warmer locations to raise their internal temperature. Behavioral fever may clear the infection faster because higher body temperatures can induce parasite mortality or prevent secondary infections. However, it is unclear if myiasis induces behavioral fever in eastern box turtles or impacts other aspects of their behavior, such as habitat use.

In the first part of the project, we compare behavior and habitat characteristics of myiasis infected and noninfected eastern box turtles at Camp Edwards. We radio-tracked 48 turtles weekly from May to August 2022. Upon capture, we recorded their infection status, shell surface temperature, and capture location habitat characteristics: understory vegetation, basal area, and canopy closure. We used generalized linear models and linear models to compare body condition indexes, shell temperatures, habitat use, and movement distances between infection statuses, sexes, and age classes. We found that myiasis infection had no significant effect on any variable other than shell surface temperature, which suggests infected turtles may be exhibiting behavioral fever.

A second species of great concern at Camp Edwards are prairie warblers. Prairie warblers occupy early successional forests, which means that habitat management could have a direct impact on the distribution and abundance of this species. Despite declining populations regionally, prairie warbler populations at Camp Edwards have increased in the last few years. In the second part of this project, we analyze the effect of management projects (i.e., prescribed fire and mechanical projects) on prairie warbler colonization, extinction, and detection probabilities at Camp Edwards. We used a point count dataset collected across the military base from 2013-2022 (Figure 2). We found that colonization was significantly predicted by the number of years since management and the proportion of the following vegetation cover types at a site: grassland, disturbed land, pitch pine – oak forest, and pitch pine – scrub oak community. We also found that extinction was significantly predicted by the proportion of pitch pine – scrub oak community at a site.

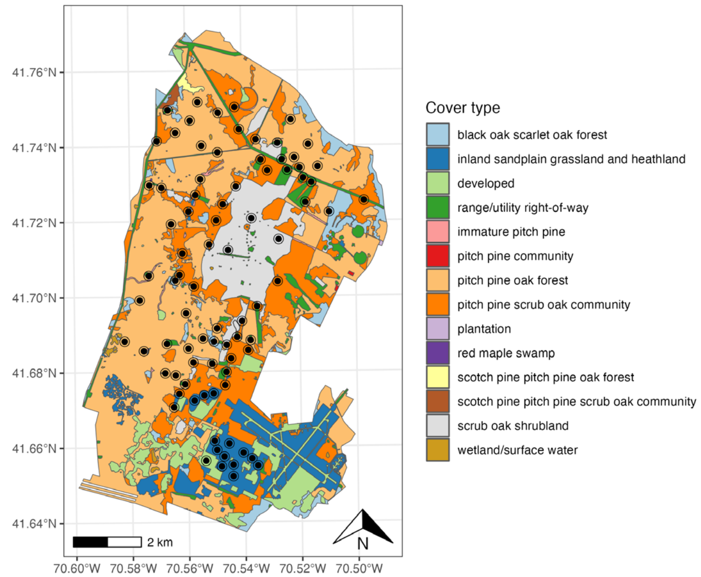

Figure 2. Vegetation cover type map of Camp Edwards with the 84 point count sites overlayed (black points) with 100 m buffers around the points (gray dotted borders around points).

Lastly, we found that detection probability was significantly predicted by the year of observation and the proportion of the following vegetation cover types: grassland, pitch pine – oak forest, and pitch pine – scrub oak community. These results can help managers predict how prairie warbler populations respond to management projects at Camp Edwards.

An analysis of the linked decisions in the confiscation of illegally traded turtles

Illegal wildlife trade is a growing problem both nationally and internationally; it is estimated as a multi-billion-dollar industry in the US, and internationally, wildlife trafficking is the fourth largest illegitimate business. There has been a steady increase in the demand for turtles in the illegal wildlife trade due to their popularity in the pet trade and uses for consumption and traditional medicine.

In the Northeastern U.S., freshwater turtles are routinely confiscated from trade routes after being illegally harvested from their natural habitats. Often, there is little information about a turtle's disease status, genetics or origin, which makes returning individuals to their original population, or repatriating them to a new population, a difficult decision. There are three discrete types of risk that span the individual- and population-levels that need to be considered when deciding whether to repatriate a confiscated turtle: (1) risk of population decline, (2) genetic outbreeding risk, and (3) disease risk.

The decision related to 'what happens to a confiscated turtle' is further complicated because it is a 'linked decision,' where the choices available to one decision maker depends on the choices made by another decision maker. The choices made by each decision maker is linked to the person that came before them and influences the ones that come after. Using models to visualize the linked decisions that take place when dealing with a confiscated turtle could improve the efficiency and decision-making process.

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ADVISORS	Graziella DiRenzo
FUNDING	USGS USFWS
COLLABORATORS	Evan Grant Jill Fleming Meg McEachran

We applied decision analysis tools to a wood turtle (*Glyptemys insculpta*) case study, a species of conservation concern in part due to illegal wildlife trade. We interviewed decision makers (e.g., managers from state and federal agencies, wildlife biologists, environmental law enforcement, and zoological parks staff) in order to: (1) identify points of intervention in the turtle trade and decision-making authority using conceptual models, (2) outline the linked decisions for confiscation and repatriation using decision trees, and (3) evaluate the decision tree to identify optimal decisions for a range of example scenarios. Collectively, our approach offers a new perspective to an age-old problem, and it affords the user greater flexibility in decision making.

Interviews revealed that decisions regarding the disposition of confiscated turtles are complicated by uncertainty in disease status and potential differences in origin and confiscation locations (Figure 1). Decision makers that handle confiscated turtles also recognize that their decisions are linked, where linkages rely on personal contacts.

In evaluating our decision trees, we found that the optimal decisions were typically to either release the confiscated turtles to the wild or conduct captive breeding programs if resources were available, even after accounting for different amounts and kinds of uncertainties.
There is a strong need for a more robust and formalized governance structure among decision-maker groups to build and strengthen relationships. In part, a centralized database of roles and responsibilities for decision makers could make it easier for people to connect. Programs like the Collaborative to Combat the Illegal Trade in Turtles (CCITT) and Saving Animals from Extinction (SAFE) are good examples of programs that seek to conserve native U.S. freshwater turtle populations by improving the coordination among decision makers. Such a database could be hosted by these programs to facilitate networking among decision maker groups. This group could then use the linked decision trees presented here to evaluate the complete decision, and evaluate and compare multiple options for placement of confiscated turtles.

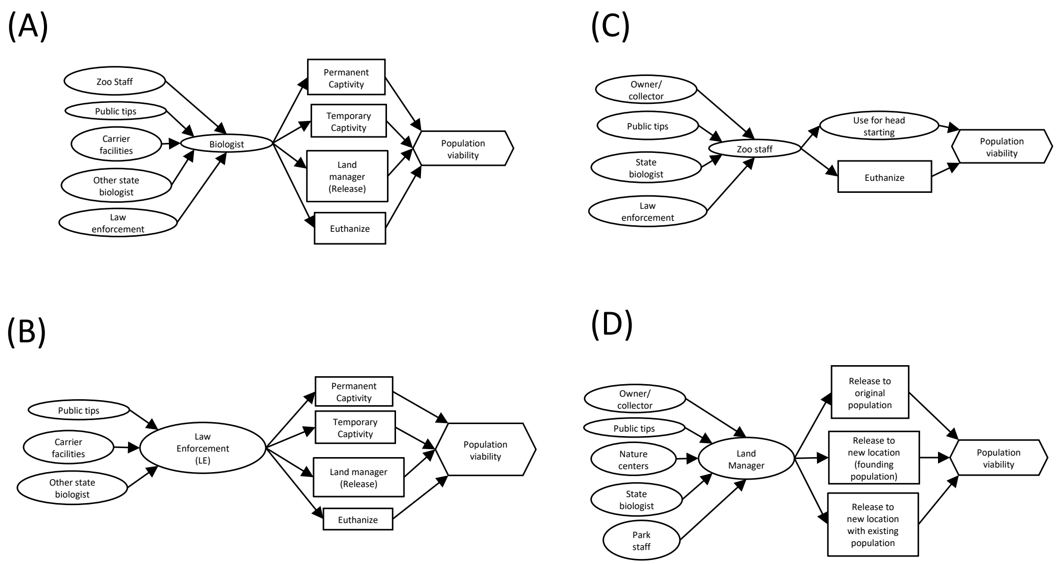

Figure 1. Four general conceptual models created for (A) biologist, (B) law enforcement, (C) zoo staff, and (D) land managers related the stochastic events (circles) and decisions (squares) made when dealing with confiscated turtles.

Bog Turtle (*Glyptemys muhlenbergii*) population dynamics and response to habitat management in Massachusetts

The Bog Turtle (*Glyptemys muhlenbergii*) has been listed as a federally threatened species since 1997 primarily due to habitat loss, fragmentation, and degradation (Figure 1). There are two known, extant Bog Turtle populations in Massachusetts, both of which are located on protected and managed land. Habitat management at these sites has focused on creating and maintaining high quality habitat since the late 1990s. Bog Turtles are habitat specialists that depend upon the unique water and soil chemistry, vegetation composition, and communities of wildlife present in seepage fens. Throughout the active season Bog Turtles use a variety of different habitat types (Figure 2). Maintaining and increasing areas of open canopy fen, controlling invasive vascular plant species, and mitigating the threats to hydrology posed by beaver populations has allowed the populations of Bog Turtle to persist at these two sites.

We assessed the population demographics and spatial distribution of Bog Turtles at these two sites on two different temporal scales. We collected and compiled data from 2019–2022.

Figure 1. Julia Vineyard holding a Bog Turtle (Billy Janus)

STUDENT Julia Vineyard (MS)

ADVISOR Allison Roy

FUNDING USFWS, MassWildlife, TNC

COLLABORATORS Mike Jones, Angela Sirois-Pitel, Tammy Wilson

This current dataset (Period 3) was compared to data collected one decade (Period 2: 2005–2009) and two decades (Period 3: 1994–1997) ago to assess the long-term (multi-decadal) population trends and responses to ongoing habitat management.

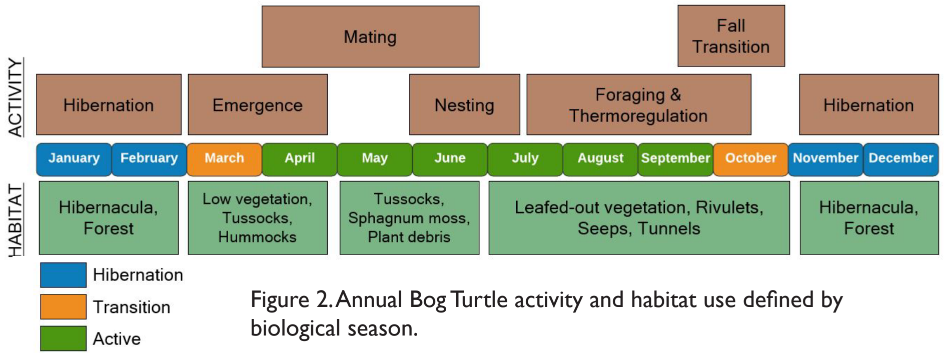

Figure 2. Annual Bog Turtle activity and habitat use defined by biological season.

During the current study period, 143 adult turtles were observed across both sites. More adult turtles were found at Site 1 (n=90) than at Site 2 (n=53). Most adult turtles were seen multiple times across the 4 years of the study (Site 1 n=57, Site 2 n=41) while only 24 turtles were seen once at Site 1, and 12 turtles were seen once at Site 2. The male:female sex ratio did not vary significantly by year when analyzing the sites independently (ANOVA: Site 1 $F=0.0065$, $p=0.823$; Site 2 $F=0.652$, $p=0.504$).

Estimates of adult population abundance across the three decades revealed an increase from the first study period (Site 1 $\bar{X} = 37.3 \pm 10.4$, Site 2 $\bar{X} = 36.2 \pm 3.2$) to the last study period (Site 1 $\bar{X} = 65.1 \pm 17.9$, Site 2 $\bar{X} = 42.5 \pm 10.9$) across both sites (Figure 3). Estimates of annual survival across all study periods remained above 90% at Site 1 and were 100% for two years at Site 2. We constructed 95% minimum convex polygon (MCP) and 95% kernel density estimation (KDE) home ranges for 71 turtles. At Site 1 there was no significant influence of the study period on home range estimates. The increase in abundance estimates, high survival, and stable home range sizes at Site 1 suggest that ongoing management has maintained quality habitat.

At Site 2, the average home range size decreased by approximately half after Period 1 in response to flooding but increased in Period 3. Fluctuations in population abundance, and home range size at Site 2 throughout the study periods reflect the cycles of habitat degradation and habitat management.

These results indicate that habitat management efforts implemented since the late 1990s have provided quality habitat for the two Bog Turtle populations in Massachusetts while also mitigating long-term negative impacts on the populations. These results further support the importance of long-term analysis of Bog Turtle populations, especially at sites where active habitat management is occurring.

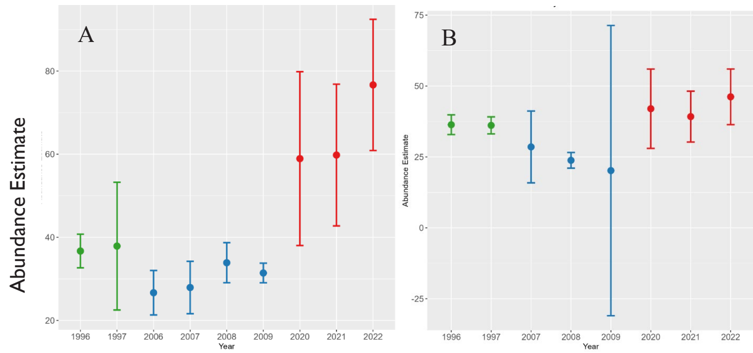

Figure 3. Population estimates (mean ± standard error) of Bog Turtles at Site 1 (A) and Site 2 (B) in Period 1 (green), Period 2 (blue), and Period 3 (red).

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Bear tracks in the snow (Juliana Berube)

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Moose calf on a trail camera (Juliana Berube)

Berube, J., A.P.K. Sirén, C.F. Sullivan, L. Clarfeld, B. Simpson, and T.L. Wilson. A big little problem. Assessing winter tick epizootics and moose populations in the Northeastern US. Northeast Regional Native American Fish and Wildlife Society. 6-9 November 2023.

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Bletz, M.C., G.V. DiRenzo, and E.H.C. Grant. Proactive disease management outperforms reactive action, regardless of action chosen. Ecological Society of America Conference, 2023, Portland, OR.

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Sea Lamprey showing off, caught in the Jones River MA (James Garner)

Chen, S., K. Capps, K. Hopkins, R.L. Hale, J. Kominiski, A.H. Roy, J.L Morse, A.M. Quick, L. Ortiz Munoz, and C. Rizzie. Urbanization alters the quantity and quality of dissolved organic matter in subtropical river networks in metropolitan Atlanta, Georgia, USA. Freshwater Sciences 2023, 3-7 June 2023, Brisbane, Australia.

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Farrington, S.J., C. Murphy, D. Perkins, and A.H. Roy. Range-wide ecology, conservation, and research needs for Yellow Lampmussel. Northeast Aquatic Biologists Meeting, 15-17 February 2023, Plymouth, MA.

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Gordon, A.B., D. Drummey, A. Tur, A.E. Curtis, J.C. McCumber, M.T. Jones, and G. V. DiRenzo. Comparison of shell temperature and habitat characteristics of myiasis infected and uninfected Eastern Box Turtles (*Terrapene carolina carolina*) at Camp Edwards. Ecological Society of America Conference, 2023, Portland, OR.

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He, X., K. Andreadis, A.H. Roy, and A. Kumar. A hydrological modeling framework for assessing winter drawdown lakes management. American Geophysical Union Fall Meeting, 12-16 December 2022, Chicago, IL.

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Hershberger, A.M. and A.H. Roy. Assessing the conservation of freshwater mussels in the eastern United States. Northeast Aquatic Biologists Meeting, 15-17 February 2023, Plymouth, MA. (Poster)

Hershberger, A.M., A.H. Roy, J.R. Carmignani, and P.D. Hazelton. Drivers of brook floater (*Alasmidonta varicosa*) occupancy and abundance: A watershed analysis across their historic range. Freshwater Mollusk Conservation Society Symposium, 10-14 April 2023, Portland, OR. (Poster)

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Hoven, B.M., M.C. Mceachran, M.J.R. Feehan, and G.V. DiRenzo. Knowledge and risk perception of Chronic wasting disease (CWD) among hunters in Massachusetts, a state where CWD has not been detected. U.S. Northeast Association of Fish and Wildlife Agencies Conference, 30 April – 2 May 2023, Hershey, PA.

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Kumar, A., A.H. Roy, K. Andreadis, and X. He. An integrated multi-sensor cloud-based framework to characterized winter water level drawdown of lakes and reservoirs. American Geophysical Union Chapman Conference, 12-16 September 2022, Golden, CO.

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Kumar, A., A.H. Roy, K. Andreadis, X. He, and C. Butler. A multi-sensor cloud-based tool for monitoring cyanobacterical harmful algal blooms in small waterbodies. 13th National Monitoring Conference, 24-28 April 2023, Virginia Beach, VA.

Macpherson, C.B., K.M. Abbott, and A.H. Roy. Examining fish assemblage response to dam removal. Joint meeting of the Northeast Division and Southern New England Chapter of the American Fisheries Society, 8-10 January 2023, Boston, MA. (Poster)

Macpherson, C.B., K.M. Abbott, and A.H. Roy. Examining fish assemblage response to dam removal. Northeast Aquatic Biologists Meeting, 15-17 February 2023, Plymouth, MA. (Poster)

Leaping deer on a trail cam (Juliana Berube)

Marjadi, M.N., A.H. Roy, M.T. Devine, B.I Gahagan, A. Jordaan, J. Rosset, and A.R. Whiteley. Alewife that stay longer mate longer: An investigation of adult freshwater residence time. Southern New England Chapter of the American Fisheries Society Winter Meeting, 21 January 2022, Amherst, MA.

Marjadi, M.N., A.H. Roy, M.T. Devine, B.I Gahagan, A. Jordaan, J. Rosset, and A.R. Whiteley. Longer adult freshwater residence time related to higher reproductive output in an anadromous clupeid. Ecological Society of America Meeting, 14-19 August 2022, Montreal, Quebec, Canada.

Marjadi, M.N., J.K. Llopiz, M.G. Slocombe, J.J. Sheppard, S. Batchelder, R. Govostes, and A.H. Roy. Using video monitoring to assess emigration patters for juvenile alewife. Joint meeting of the Northeast Division and Southern New England Chapter of the American Fisheries Society, 8-10 January 2023, Boston, MA.

McEachran, M., J.D. Cook, R.E.W. Berl, G. DiRenzo, E.H. Campbell Grant, and M.C. Runge. Integrating social science to make better decisions for cervid carcass management. International CWD Symposium, 2022.

McEachran, M., J.D. Cook, R.E.W. Berl, G. DiRenzo, E.H. Campbell Grant, and M.C. Runge. People and prions: human dimensions of CWD decision making. The Wildlife Society, 2023, Louiseville, KY.

O'Uhuru, A.C., J.T.H. Coleman, J.D. Reichard, C.J. Kocer, G.V. DiRenzo, and L.M. Eaton. Let's Talk About It: Expanding North American Bat Monitoring (NABAT) Data Contributions On And Around Federal Lands In The Northeast Region. The Northeast Bat Working Group Conference. 2023. Burlington, VT. (Poster)

Ortiz Munoz, L.D., J.S. Kominoski, K. Capps, S. Chen, R. Hale, K. Hopkins, A. Quick, J.L. Morse, C. Rizzie, and A.H. Roy. Stormwater infrastructure and seasonal hydrology transform dissolved organic carbon and nutrients in urban coastal waters. Freshwater Sciences 2023, 3-7 June 2023, Brisbane, Australia.

Quick, A., A. Roy, R. Hale, K. Capps, K. Hopkins, J. Kominoski, and J. Morse. Variability in dissolved organic carbon across urban streams in Boston, Massachusetts. Northeast Aquatic Biologists Conference, 2-4 March 2022, Portland, ME.

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Quick, A., A. Roy, R. Hale, K. Capps, K. Hopkins, J. Kominoski, J. Morse, S. Chen, C. Rizzie, and L. Ortiz. Characterizing seasonal trends in dissolved organic carbon among urban streams in Boston, USA. 13th National Monitoring Conference, 24-28 April 2023, Virginia Beach, VA.

Quick, A., A. Roy, R. Hale, K. Capps, K. Hopkins, J. Kominoski, J.L. Morse, S. Chen, C. Rizzie, and L. Ortiz Muñoz. Spatial and temporal variation in quantity and bioavailability of dissolved organic carbon within a metropolitan area. 6th Symposium on Urbanization and Stream Ecology, 29 May - 1 June 2023, Brisbane, Australia.

Quick, A., A. Roy, R. Hale, K. Capps, K. Hopkins, J. Kominoski, J.L. Morse, S. Chen, C. Rizzie, and L. Ortiz Muñoz. Spatial and temporal variation in quantity and bioavailability of dissolved organic carbon within a metropolitan area. Freshwater Sciences 2023, 3-7 June 2023, Brisbane, Australia.

Rogers, J.B., G. DiRenzo, R.M. Quinones, T. Richards, A. Roy, C. Bellucci, C. Buckley, M. Carpenter, A. Chapman, J. Deshler, M. Gallagher, A. Libby, and J. Stolarski. Modeling aquatic biodiversity in New England streams to support management decisions that consider climate change. Joint meeting of the Northeast Division and Southern New England Chapter of the American Fisheries Society, 8-10 January 2023, Boston, MA.

American Shad with unwanted sea lamprey passenger swimming up the Connecticut river (James Garner)

Rogers, J.B., G. DiRenzo, R.M. Quinones, T. Richards, A. Roy, C. Bellucci, C. Buckley, M. Carpenter, A. Chapman, J. Deshler, M. Gallagher, A. Libby, and J. Stolarski. Modeling aquatic biodiversity in New England streams to support management decisions that consider climate change. Joint meeting of the Northeast Division and Southern New England Chapter of the American Fisheries Society, 8-10 January 2023, Boston, MA.

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Rogers, J.B., G. DiRenzo, R.M. Quinones, T. Richards, and A. Roy. Modeling freshwater mussel biodiversity in New England streams to support management decisions that consider climate change. Northeast Association of Fish and Wildlife Agencies Conference, 30 April - 2 May 2023, Hershey, PA.

Roy, A. and M. Devine. Limits to juvenile river herring densities and restoration potential. Massachusetts River Herring Network, 25 October 2023, Pembroke, MA.

Roy, A.H. and K. Andreadis. Lake water level management under changing climates. Northeast Climate Adaptation Science Center Webinar Series, 8 March 2023, Amherst, MA.

Roy, A.H. X. He, A. Kumar, K. Andreadis, and C. Butler. Winter lake drawdowns: prevalence, hydrologic characteristics, and ability to meet management guidelines. Northeast Aquatic Biologists Meeting, 15-17 February 2023, Plymouth, MA.

Roy, A.H., J. Soucie, A. Quick, and R. Hale. Salted urban streams: understanding spatial and temporal variability in conductivity to guide management. 6th Symposium on Urbanization and Stream Ecology, 29 May - 1 June 2023, Brisbane, Australia.

Roy, A.H., J.R. Carmignani, P.D. Hazelton, A.J. Skorupa, S.C. Sterrett, N. Whelan, and the Brook Floater Working Group. Using regional working groups for mussel species conservation. Freshwater Mollusk Conservation Society Symposium, 10-14 April 2023, Portland, OR.

Roy, A.H., J.R. Carmignani, P.D. Hazelton, A.J. Skorupa, S.C. Sterrett, N. Whelan, and the Brook Floater Working Group. Using regional working groups for mussel species conservation. Freshwater Sciences 2023, 3-7 June 2023, Brisbane, Australia.

Roy, A.H., S.M. Clinton, J. Hartman, and K.H. Macneale. Stream macroinvertebrate reintroductions: A cautionary approach for restored urban streams. Northeast Aquatic Biologists Conference, 2-4 March 2022, Portland, ME.

Sirén, A., L. Clarfeld, C. Balantic, K. Gieder, P. Jensen, T. Wilson, and T. Donovan. Northeast Wildlife Monitoring Network (NEWMN): A Unifying Framework for Regional Collaboration Using Autonomous Monitoring Units. Northeast Natural History Conference, 21-23 April 2023, Burlington, VT.

Sirén A.P.K., T.L. Wilson, K. Dunfey-Ball, K.D. Gieder, C.A. Bernier, N.L. Fortin, T. Smith, J.R. Kilborn, C.B. Callahan, R.M. Cliché, L. S. Prout, S. Wixsom, S. Staats, R. Abrams, S. Gifford, R.K. Patry, L.E. Kantar, and T.L. Morelli. Broad scale climate and habitat drivers mediate occupancy-dependent parasitism along trailing range edges. Workshop on moose research needs in the Northeast. 13 December 2023. Sherbrooke, QC, Canada.

Skora, L., T.L. Wilson. Estimating brown bear abundance along salmon spawning streams in Katmai National Park, Alaska. EURING Analytical Meeting & Workshop, 17 – 21 April 2023, Montpellier, France.

Skorupa, A., A.H. Roy, P.D. Hazelton, D. Perkins, and T. Warren. Assessing propagated brook floater growth and survival across four rivers. Northeast Aquatic Biologists Conference, 2-4 March 2022, Portland, ME.

Skorupa, A., A.H. Roy, P.D. Hazelton, D. Perkins, and T. Warren. Growth and survival of propagated brook floater in four rivers: implications for population restoration. Northeast Association of Fish and Wildlife Agencies Conference, 30 April - 2 May 2023, Hershey, PA.

Entrance to a Protected Bat Cave (Ayodele O'Uhuru)

Skorupa, A.J., S. Doran, C.E. Dumoulin, A.H. Roy, and D.R. Smith. Evaluating habitat and conservation actions for mussel assemblages in the Delaware River basin, U.S. Northeast Association of Fish and Wildlife Agencies Conference, 30 April - 2 May 2023, Hershey, PA.

Skorupa, A.J., S. Doran, C.E. Dumoulin, A.H. Roy, and D.R. Smith. Predicting the effect of restoration actions on mussel assemblage habitat: A decision tool to aid practitioners. Freshwater Mollusk Conservation Society Symposium, 10-14 April 2023, Portland, OR.

Stephens, J., A.H. Roy, A. Jordaan, D. Perkins, and K. Sprankle. Investigating the role of river herring as hosts for freshwater mussels in the Connecticut River watershed. Freshwater Mollusk Conservation Society Symposium, 10-14 April 2023, Portland, OR. (Poster)

Vineyard, J.A., M.T. Jones, A.H. Roy, and A. Sirois-Pitel. Bog Turtle (*Glyptemys muhlenbergii*) population dynamics and response to habitat management in Massachusetts. Northeast Association of Fish and Wildlife Agencies Conference, 30 April - 2 May 2023, Hershey, PA.

Wilson, T.L. Data Doctor, University of Massachusetts, 7 October 2022. Amherst, MA.

Wilson, T.L. Distance Sampling of Wildlife, University of Massachusetts, 4 February 2022. Amherst, MA.

Wilson, T.L., J.A. Berube, and A.P.K. Sirén, Perfecting the Imperfect Detection of Ticks: Winter Tick Epizootics and Moose Populations in the Northeastern U.S. Moose research in the Northeast U.S. and eastern provinces of Canada: 2022 project updates. 6 July, 2022 (Virtual)

Wilson, T.L., A.P.K. Sirén, J. Berube, L. Clarfeld, and T.M. Donovan. Designing camera trap arrays for multi-species monitoring of mammals at large spatial extents. Annual Meeting, International Association for Landscape Ecology- North America, 19-23 March 2023, Riverside, California

Wilson, T.L., A.P.K. Sirén, J. Berube, and B. Simpson. Effects of imperfect detection on inference from tick-borne disease surveillance data. Joint Workshop on Transboundary Wildlife Diseases. October 10-11 2023, Jeju, Republic of Korea.

Wilson, T.L., A.P.K. Sirén, J. Berube, B. Simpson, K. Klingler. A novel method for monitoring off-host winter ticks in habitat where detection and abundance are expected to be low. Workshop on moose research needs in the Northeast. 13 December 2023. Sherbrooke, QC, Canada.

Wittig, T.W., T.L. Wilson, K. Zolfonoon, and Z.S. Ladin. Using nest cameras and machine learning to explore nesting and provisioning of Bald Eagles (*Haliaeetus leucocephalus*). Annual Meeting of the Raptor Research Foundation and the Florida Ornithological Society. 4-9 October 2022, Fort Lauderdale, FL. (Poster)

National and Regional Awards

Kate Abbott: Fellowship in Ecological Restoration, The Garden Club of America 2022
Adrienne Dunk: Study Research Award, Society of Wetland Science - New England Chapter 2023
Andrew Gordon: USFWS Directorate Fellows Program Award 2022
Ayodelé O'Uhuru: The National GEM Consortium Fellowship 2023

UMass ECO Awards

Alexa Hershberger: Richard Cronin Fisheries Research Fund Award 2023
Ednita J Tavarez-Jimenez: Silvio Conte Scholarship, UMass and USFWS 2023
Desireé Smith: ECO Graduate Fellowship 2022

UMass Awards

Isabella Ceresia: CHC Research Grant 2023
Abigail Farrell: CHC Research Grant 2022
Alexa Hershberger: Public Writing Fellowship, Graduate School Office of Professional Dvelopment 2023
Callista Macpherson: CHC Research Grant 2022
Ayodelé O'Uhuru: CNS summer award 2023
Mickala Stratton: CHC Research Assistant Fellowship 2023

Conference Awards

Kate Abbott: Best Oral Student Presentation, Northeast Aquatic Biologists Conference 2023
Abigail Farrell: Best Student Poster, Northeast Division and Southern New England Chapter of the American Fisheries Society Meeting 2023
Stefanie Farrington: Best Student Poster Northeast Aquatic Biologists Conference 2022
Stefanie Farrington: Runner up for Best Oral Student Presentation, Northeast Aquatic Biologists Conference 2023
Alexa Hershberger: Runner-up for Best Student Poster, Northeast Aquatic Biologists Conference 2023
Callista Macpherson: Best Student Poster, Northeast Aquatic Biologists Conference 2023

Travel Awards

Kate Abbott: SUSE6 Advancing Collaboration Grant, Symposium on Urbanization and Stream Ecology 2023
Kate Abbott: Student Endowment Award, Society for Freshwater Science 2023
Stefanie Farrington: Student Travel Award, Freshwater Mollusk Conservation Society 2023

View from Goat Peak at Mt Tom State Reservation, Easthampton, MA (Elsa Cousins)

USGS Massachusetts Cooperative Fish and Wildlife Research Unit
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