# Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife, Fisheries, and Conservation Biology University of Maine

## 2024 Report to Cooperators

## *UNIT COOPERATORS*

*University of Maine*

*Maine Department of Inland Fisheries and Wildlife*

*United States Geological Survey*

*United States Fish and Wildlife Service*

*Wildlife Management Institute*

Compiled and Edited by:
Rena A. Carey and Joseph Zydlewski

Special thanks to Mark McCullough for allowing us to use his original pen and ink drawings throughout the report.



To download a digital copy of this report, please visit:
https://www1.usgs.gov/coopunits/unitDocuments/Maine/docs *or*
https://umaine.edu/mainecoopunit/research/

*Cover Photo*: Maine Cooperative Fish and Wildlife Research Unit

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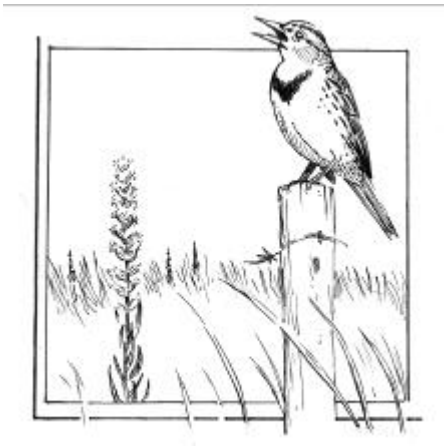
# UNIT Mission

The Maine Cooperative Fish and Wildlife Research Unit (CFWRU) is uniquely suited to pursue research relevant to fish and wildlife conservation in northern ecosystems. Maine is the most heavily forested state in the Nation and is covered by numerous ponds, lakes, wetlands, streams, and rivers. Maine has an extensive coast line with a rich variety of habitats adjacent to one of the most productive marine areas of the world, the Gulf of Maine. Tourism and forest product industries are extremely important to Maine's economy and culture. These industries generate management challenges for fish and wildlife that require solutions based on sound science. The Maine CFWRU applies expertise in both terrestrial and aquatic ecology to State and Federal natural resource management priorities.

The primary objectives of the CFWRU are to: (1) facilitate and strengthen professional education and training of fisheries and wildlife scientists; (2) carry out research programs of aquatic, mammalian, and avian organisms and their habitats; and (3) disseminate research results through the appropriate media, especially peer-reviewed scientific articles. The educational and training objective is achieved through advisement of graduate students and their research projects, formal classroom instruction, and supervision of technicians and research associates conducting collaborative research with University staff. In addition, Unit personnel are involved with extension and technical assistance to cooperating agencies and to the general public.

The research program of the Maine CFWRU broadly reflects the needs of the cooperators. Funding in recent years reflects a diversity of studies. Priority research areas are: (1) ecological studies on species of State and Federal interest (e.g., amphibians, Atlantic salmon, brook trout, native pollinators, black bears); (2) management and habitat-related studies with special reference to the effects of land and water-use practices (e.g., forest harvest, dams) on fish and wildlife; and (3) issues related to the effects of land management and forestry on aquatic and wetland systems, and fisheries management in Maine and northern New England.



# STATE of the Unit and Department

Dear Friends:

The Maine Cooperative Fish and Wildlife Research Unit (Unit) and the University of Maine's Department of Wildlife, Fisheries, and Conservation Biology (WFCB) have a tradition of summarizing our joint research accomplishments and activities in this annual report. It is an opportunity to look at the projects initiated, assess the progress made and celebrate the completion of students' work. Without a doubt, the success of the Unit and the Department is linked to the hard work, persistence and abilities of our graduate students and post-doctoral associates. This document bears this out as we leave 2024 in the rear-view mirror.

It is notable that the beginning of 2025 marks 90 years for the Maine Unit – and 101 years for the graduate program at the University of Maine. The Cooperative Fish and Wildlife Research Units program was established to produce management-relevant research, to provide technical assistance to cooperators, and to train future natural resource professionals. This unique national program places federal researchers in strategic university settings to facilitate research and academic collaborations among our Cooperators and partners. The five Maine Unit Cooperators are the *Maine Department of Inland Fisheries and Wildlife*, the *University of Maine*, the *U.S. Fish and Wildlife Service*, the *U.S. Geological Survey*, and the *Wildlife Management Institute*.

Our 90-year legacy of success at the University of Maine began with the hiring of the first Unit Leader, Dr. Clarance Aldouse, in 1935. His onboarding established Maine as one of the first nine Units placed at land grant universities across the nation. In the following years, it was clear that this combination was both effective and responsive in meeting conservation management needs. The program grew. As of 2025, there are 43 Units in 41 states. The commitment and vision for applied and actionable research through graduate education continues.

The Maine Unit and the WFCB Department share a mission of mentorship and education, a central focus of the national program. Our research is predominantly conducted as part of Department's graduate degree program or post-graduation positions. The blurred line between the Unit and the University underscores the collaborative nature of the undertaking here in Maine. Unit researchers serve as full faculty at the University but wear multiple "hats." We are federal employees with all the benefits – and uncertainties – that come with being USGS employees.

The Unit and Department's national footprint is significant. Our recent graduates are the next generation of leaders in the fields of fisheries, wildlife, and conservation biology. We pride ourselves on a legacy of past students who serve as faculty, federal, state, and tribal agency scientists as well as non-governmental organization professionals. We are fortunate that those that have left our program often remain collaborators, colleagues, and allies.

# STATE of the Unit and Department *Cont.*

As I write this today, after 90 years of success, it is time to celebrate the collaboration of our five cooperators and nod to Ding Darling's vision. But 2025 is a time of uncertainty for federal programs, and the Unit program is not different. Over the last weeks I have been asked countless times "*what is going to happen to the Unit?*", and the answer is "*I don't know*." Every day brings a snippet of news; trying to read these like tea leaves is a fools' errand.

Let us recall that the Coop Units have come a long way on a winding road. The Unit program was born during the Great Depression, a time realizing the consequences of highly exploitative resource management strategies. The Units persisted through World War II and the rise of white nationalism. The Units persisted through the cold war, the formation of NATO, the Korean War, Vietnam, and 9/11. All the while, the Units did what they could, where they were, with what they had, to serve our country through research to advance science in wildlife and fisheries.

The Units continue to strive to bring in the brightest and best young scientists, and to promote full participation for those for whom the professional pathways of fisheries and wildlife were socially discouraged or directly prevented. Our students, past and present, ably represent our academic and research programs locally, regionally, and internationally.

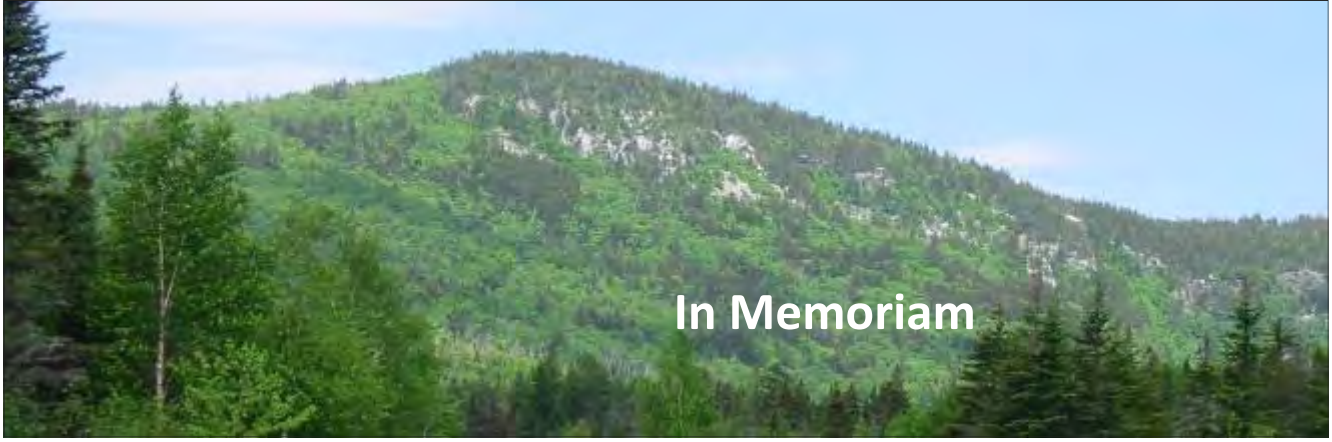
Our active graduate program continues to attract exceptional students. During the past year, Maine Unit and Department faculty mentored an impressive 45 graduate students and postdoctoral scholars. We worked with scientists from State, Federal and Tribal agencies, universities, and non-governmental organizations on 39 research projects. In these pages, you will see that the hallmark of our efficacy is our continued and demonstrated ability to advance science in wildlife and fisheries.

Sincerely,

Joseph Zydlewski
Unit Leader and Professor of Fisheries Science
Josephz@maine.edu

Eric Blomberg
Professor and Chair, WFCB

P.S. You can reach the investigators of the projects summarized in this report via contact information listed on the Unit (www1.usgs.gov/coopunits/Maine) or Department (www.umaine.edu/wle/) websites.



# In Memoriam

In 2024, Matt Altenritter left his family and the fisheries community too soon, at the young age of 37. His journey ended after struggling with stomach cancer. He received his PhD from the University of Maine through the School of Biology and Ecology in 2015 working with the Maine Coop Unit on sturgeon in Maine. He went on to be a post-doc at Texas A&M University-Corpus Christi and the University of Illinois before settling into a role as an Assistant Professor of Fisheries Science at the State University of New York at Brockport in the Department of Environmental Science and Ecology. He is remembered for his outstanding mentorship in the fisheries field, his quiet humor and his love of all things fish.

Marcos Rodriguez, a graduate student, colleague and friend to us all died at the age of 26 in 2024. After his graduation from Brown in 2020 he looked for opportunities to meld teaching with his love for the sciences. He eventually settled at the University of Maine where he pursued his Master of Science in Ecology and Environmental Sciences. He had an unsatiable curiosity, an impressive intellect, and a thoughtful, engaging, demeanor. His passion about nature and ecology was equaled only by his kindness and consideration for others.

## *COOPERATING PERSONNEL*

### UNIVERSITY OF MAINE

Dr. Kody Varahramyan, Vice President for Research and Dean of the Graduate School
Dr. Diane Rowland, Dean, College of Earth, Life, and Health Sciences
Dr. Erik J. Blomberg, Chair, Department of Wildlife, Fisheries, and Conservation Biology

### MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE

Mr. Nathan Webb, Director, Wildlife Division

### U.S. FISH AND WILDLIFE SERVICE

Ms. Amanda Cross, Supervisor, Maine Field Office

### U.S. GEOLOGICAL SURVEY

Jonathan R. Mawdsley, Chief, Cooperative Research Units Program

### WILDLIFE MANAGEMENT INSTITUTE

Mr. Tony Wasley, President

## *UNIT PERSONNEL*

### SCIENTISTS

Christina A. Murphy, Assistant Unit Leader for Fisheries, and Assistant Professor of Wildlife Ecology
Tristan Nuñez, Assistant Unit Leader for Wildlife, and Assistant Professor of Wildlife Ecology
Joseph D. Zydlewski, Unit Leader, and Professor of Fisheries Science

### SUPPORT STAFF

Rena A. Carey, Administrative Support Supervisor
Katherine Goodine, Administrative Specialist
Molly Langlais-Parker, Administrative Specialist

## UNIVERSITY OF MAINE COLLABORATORS

### Department of Wildlife, Fisheries, and Conservation Biology

Erik J. Blomberg, *Chair and Associate Professor*
Aram J.K. Calhoun, *Professor Emerita*
Noah D. Charney, *Assistant Professor*
Stephen M. Coghlan, Jr., *Associate Professor*
Malcolm L. Hunter, Jr., *Professor Emeritus*
Jessica J. Jansujwicz, *Assistant Research Professor*
Cynthia S. Loftin, *Associate Professor*
Sabrina Morano, *Assistant Professor*
Alessio Mortelliti, *Assistant Research Professor*
Sydne Record, *Associate Professor*
Amber M. Roth, *Associate Professor*
Lindsay C.N. Seward, *Instructor*
Carly C. Sponarski, *Graduate Faculty*

### Department of Art

Susan L. Smith, *Associate Research Professor*

### School of Biology and Ecology

Allison Gardner, *Associate Professor*
Jacquelyn L. Gill, *Professor*
Erin K. Grey, *Assistant Professor*
Hamish S. Greig, *Professor*
Michael T. Kinnison, *Professor*
Amanda J. Klemmer, *Associate Professor*
Danielle L. Levesque, *Associate Professor*
Brian J. McGill, *Professor*
José E. Meireles, *Assistant Professor*
Brian J. Olsen, *Professor*
Jasmine E. Saros, *Professor*

### School of Food and Agriculture

Pauline L. Kamath, *Associate Professor*

### School of Forest Resources

Adam J. Daigneault, *Associate Professor*
Shawn R. Fraver, *Associate Professor*
Daniel J. Hayes, *Associate Professor*
Parinaz Rahimzadeh-Bajgiran, *Associate Professor*
Nicole S. Rogers, *Assistant Professor*
Erin Simons-Legaard, *Associate Research Professor*
Aaron R. Weiskittel, *Professor*

### School of Marine Sciences

Kristina M. Cammen, *Associate* Professor

### Senator George J. Mitchell Center for Sustainability Solutions

Samuel G. Roy, *Research Associate*
Linda Silka, *Senior Fellow*
Tora Johnson, *Director, Sustainable Prosperity Initiative*

## EXTERNAL COLLABORATORS

Bayu Wisnu Broto, *Forest Research and Development Institute, Makassar*

James M. Cook, *Associate Professor; University of Maine, Augusta*

David Courtemanch, *Freshwater Science and Policy Specialist, The Nature Conservancy*

Susan L. Eggert, *Research Aquatic Ecologist, U.S. Forest Service, Northern Research Station*

Danielle M. Frechette, *Fisheries Biologist, Maine Department of Inland Fisheries and Wildlife*

Angela K. Fuller, *Professor and Unit Leader, NY Cooperative Fish and Wildlife Research Unit*

David C. Fulton, *Professor and Assistant unit Leader, Wildlife; MN Cooperative Fish and Wildlife Research Unit*

Nathan B. Furey, *Associate Professor, University of New Hampshire*

Allyson K. Jackson, *Associate Professor, Purchase College*

Laura S. Kenefic, *Research Forester and Principal Silviculturist, U.S. Forest Service, Northern Research Station*

John F. Kocik, *Supervisory Research Fishery Biologist, NOAA Fisheries Service, Maine Field Station*

Zachary G. Loman, *University of Maine Graduate Faculty*

Susan J. Mazer, *Professor, University of California, Santa Barbara*

Ernst B. Peebles, *Associate Professor, University of South Florida*

David L. Perkins, *Director, Richard Cronin Aquatic Resource Center, U.S. Fish and Wildlife Service*

Allison H. Roy, *Assistant Unit Leader – Fisheries, Massachusetts Cooperative Fish and Wildlife Research Unit*

Benjamin Simpson, *Wildlife Manager, Penobscot Nation Department of Natural Resource*

Daniel S. Stich, *Associate Professor, State University of New York College at Oneonta*

Kelsey Sullivan, *Wildlife Biologist, Maine Department of Inland Fisheries and Wildlife*

David P.L. Toews, *Assistant Professor, Pennsylvania State University*

Junior A. Tremblay, *Research Scientist, Environment and Climate Change Canada*

Linda J. Welch, *Wildlife Biologist, US Fish and Wildlife Service*

James White, *Hydrologist, U.S. Geological Survey, Oregon Water Science Center*

John A. Young, *Research Biologist, U.S. Geological Survey, Eastern Ecological Science Center*

## COLLABORATING AGENCIES AND ORGANIZATIONS

Alliance for Tompotika Conservation, Indonesia
American Forest Management, Inc.
Appalachian Mountain Club
Appalachian Mountain Joint Venture
Army Corps of Engineers
Atlantic Canada Conservation Data Center
Atlantic States Marine Fisheries Commission
Audubon North Carolina
Audubon Vermont
Bangor Beautiful
Bangor Water District
Barbara Wheatland Geospatial and Remote Sensing Analysis Laboratory
Baskahegan Company
Bigelow Laboratory
Brunswick Topsham Land Trust
Canaan Valley National Wildlife Refuge
Cape Breton University
Cerulean Warbler Technical Group
Clayton Woodland Holdings, LLC
Collaborative Management Structure (CMS)
Connecticut Department of Energy and Environmental Protection's Wildlife Division
Cooke Aquaculture
Cornell University – Cornell Wildlife Health Lab
Delaware Department of Natural Resources and Environmental Control
Delaware Division of Fish and Wildlife
Environment and Climate Change Canada
Fisheries and Oceans Canada
Fort Drum Natural Resources Branch
Garden Club of America, The
Georgia Department of Natural Resources
Golden-winged Warbler Working Group
Indiana University of Pennsylvania
International Joint Commission on the St. Croix Waterway
International Union for Conservation of Nature – Save Our Species
J.D. Irving, Ltd.
Katahdin Forest Management, LLC
Kentucky Department of Fish and Wildlife Resources
Kepulauan Togean National Park Agency, Indonesia
Knobloch Family Foundation
Lake Stewards of Maine
Louisiana Department of Wildlife and Fisheries
Maine Audubon
Maine Department of Environmental Protection
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
Maine Outdoor Heritage Fund
Manulife Investment Management
Maryland Department of Natural Resources
Maryland Wildlife and Heritage Service
Massachusetts Division of Fisheries and Wildlife
Massachusetts Division of Fisheries and Wildlife – Natural Heritage and Endangered Species Program
Missouri Department of Conservation
Mohamed bin Zayed Species Conservation Fund, The
Morris Animal Foundation
National Oceanic and Atmospheric Administration
National Park Service
National Science Foundation
National Science Foundation – Experimental Program to Stimulate Competitive Research
Nature Conservancy, The
Nature Conservancy, The in Vermont
New Brunswick Museum
New Hampshire Department of Environmental Services
New Hampshire Natural Heritage Bureau
New Jersey Department of Environmental Protection
New Jersey Division of Fish and Wildlife
New Jersey Endangered and Nongame Species Program
New York Department of Environmental Conservation
New York Natural Heritage Program
New York State Museum
North Carolina Wildlife Resources Commission
Northeastern States Research Cooperative (NSRC)
Northern New York Audubon Society
Orono Land Trust
Orono, Town of

## *COLLABORATING AGENCIES AND ORGANIZATIONS—CONT.*

Partners in Flight Eastern Working Group
Partnership for the Delaware Estuary
Passamaquoddy Tribe
Pelletier Brothers, Inc.
Pennsylvania Fish and Boat Commission
Pennsylvania Natural Heritage Program
Penobscot Indian Nation
Penobscot River Restoration Trust
Penobscot Valley Chapter of Maine Audubon Society
Rhode Island Department of Environmental Management
Road to Recovery
Rufford Foundation
Saint Lawrence University – Department of Biology
Schoodic Institute
SELVA
Seven Islands Land Company
Silvio O. Conte National Fish and Wildlife Refuge
South Carolina Department of Natural Resources
Sportsman's Alliance of Maine
State University of New York – Cobleskill
State University of New York – Oneonta
Timberdoodle Habitat Society
Topsham, Town of
U.S. Army, Fort Drum
U.S. Fish and Wildlife Service
U.S. Fish and Wildlife Service – Craig Brook National Fish Hatchery
U.S. Fish and Wildlife Service – Webless Migratory Game Bird Program
U.S. Forest Service
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Florida – College of Marine Science
University of Maine
University of Maine – Advanced Computing Group
University of Maine – Climate Change Institute
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Ecology and Environmental Sciences Program
University of Maine – Maine Adaptative Silviculture Network
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Maine Cooperative Forestry Research Unit
University of Maine – NRT Conservation Science
University of Maine – School of Biology and Ecology
University of Maine – School of Food and Agriculture
University of Maine – School of Forest Resources
University of Maine – Senator George J. Mitchell Center
University of Massachusetts Amherst
University of Minnesota – Duluth Natural Resources Research Institute
University of New Brunswick
University of New Hampshire – Department of Biological Sciences
University of Tennessee
University of Vermont
Upper Mississippi/Great Lakes Joint Venture
Vermont Department of Environmental Conservation
Vermont Fish and Wildlife Department
Virginia Commonwealth University
Virginia Department of Wildlife Resources
Wagner Forest Management, Ltd.
West Virginia Division of Natural Resources
Weyerhaeuser Company
Yellow Lampmussel Working Group
Zoological Society for the Conservation of Species and Populations


## GRADUATE COMMITTEE LEADERSHIP

Unit scientists served as major advisors or co-advisors for these students during the reporting period.

| | |
|---|---|
| Murphy | Stevie Benson, MS (June 2022 – Present)<br>Jillian Fedarick, PhD (January 2023 – Present)<br>Guillermo Figueroa, PhD (January 2023 – Present)<br>Edwin Njuguna, PhD (June 2022 – Present)<br>Glenn Schumacher, PhD (January 2023 – Present)<br>Aurooba Shafquat, MS (September 2024 – Present)<br>Daison Weedop, MS (September 2021 – May 2024) |
| Zydlewski | Cody Dillingham, MS (September 2021 – Present)<br>Guillermo Figueroa, PhD (January 2023 – Present)<br>Melissa Flye, PhD (January 2020 – Present)<br>Emilie Hickox, MS (June 2020 – Present)<br>Lara Katz, PhD (September 2023 – Present)<br>Matthew Mensinger, PhD (January 2021 – August 2024)<br>Carolyn Merriam, MS (June 2022 – Present)<br>Rylee Smith, PhD (January 2021 – Present)<br>Sarah Vogel, PhD (September 2020 – Present) |

## RECENT GRADUATES AND CURRENT PURSUITS

*Student, Degree, Curriculum* — *Graduate Date*
*Current Pursuits* — *Advisor(s)*

**Liam Berigan**, PhD, Wildlife Ecology — May 2024
*Postdoctoral Researcher, Kansas State University* — Erik J. Blomberg/Amber M. Roth

**Emily Filiberti**, MS, Wildlife Ecology — May 2024
*Environmental Licensing Specialist, State of Maine* — Amber M. Roth

**Gabriela Franzoi Dri**, PhD, Wildlife Ecology — August 2024
*Biometrician, State of Maine* — Malcolm L. Hunter, Jr./Alessio Mortelliti

**Brigit Humphreys**, MS, Ecology and Environmental Sciences — August 2024
*PhD Student, University of Maine* — Alessio Mortelliti

**Agus Jati**, PhD, Wildlife Ecology — August 2024
Alessio Mortelliti

**Megan Lamb,** MS, Wildlife Ecology — May 2024
*Senior Planner, Maine Land Use Commission* — Aram J.K. Calhoun/Jessica J. Jansujwicz

**Carolina Luciani**, Master of Wildlife Conservation — May 2024
*Environmental Educator, Blue Ridge Outdoor Education Center* — Amber M. Roth

**Matthew Mensinger**, PhD, Ecology and Environmental Sciences — August 2024
*Postdoctoral Researcher, UC Santa Cruz* — Alessio Mortelliti/Joseph D. Zydlewski

**Annie Oviedo Stupik**, MS, Wildlife Ecology — August 2024
*Biologist, State of New York* — Sabrina Morano/Pauline L. Kamath

**Daison Weedop**, MS, Wildlife Ecology — May 2024
*Fulbright Fellow, Holar University* — Christina A. Murphy

## *CURRENT STUDENTS & POSTDOCS*

| *Student, Degree, Curriculum* | *Advisor(s)* |
|---|---|
| **Deborah Alademehin**, PhD, Wildlife Ecology | Stephen M. Coghlan, Jr. |
| **Lizbeth Amador**, PhD, Ecology and Environmental Sciences | Sydne Record |
| **Kate Behrens,** PhD, Ecology and Environmental Sciences | Jessica J. Jansujwicz/Tora Johnson |
| **Stevie Benson**, MS, Ecology and Environmental Sciences | Christina A. Murphy |
| **Ryan Brodie**, MS, Ecology and Environmental Sciences | Amber M. Roth |
| **Kylie Brunette**, MS, Wildlife Ecology | Erik J. Blomberg/Amber M. Roth |
| **Christy Carovillano**, MS, Ecology and Environmental Sciences | Sabrina Morano/Adam J. Daigneault |
| **Rachel Darling**, PhD, Wildlife Ecology | Erik J. Blomberg/Amber M. Roth |
| **Cody Dillingham**, MS, Wildlife Ecology | Joseph D. Zydlewski |
| **Alyson East**, PhD, Ecology and Environmental Sciences | Sydne Record |
| **Adam Eichenwald**, Postdoctoral Research Associate | Sydne Record |
| **Kirstin Fagan**, PhD, Wildlife Ecology | Erin Simons-Legaard |
| **Jillian Fedarick**, PhD, Ecology and Environmental Sciences | Christina A. Murphy/Sydne Record |
| **Guillermo Figueroa**, PhD, Wildlife Ecology | Christina A. Murphy/Joseph D. Zydlewski |
| **Melissa Flye**, PhD, Ecology and Environmental Sciences | Joseph D. Zydlewski |
| **Harrison Goldspiel**, PhD, Wildlife Ecology | Noah D. Charney |
| **John Grady,** Postdoctoral Research Associate | Sydne Record |
| **Rory Hannon**, MS, Wildlife Ecology | Joseph D. Zydlewski |
| **Emilie Hickox**, MS, Wildlife Ecology | Joseph D. Zydlewski |
| **Nina Kappel**, MS, Wildlife Ecology | Sabrina Morano |
| **Lara Katz**, PhD, Wildlife Ecology | Erik J. Blomberg/Joseph D. Zydlewski |
| **Ruhammah LaGarry**, Master of Wildlife Conservation | Erik J. Blomberg |
| **James Longo**, MS, Ecology and Environmental Sciences | Amber M. Roth |
| **Carolyn Merriam**, MS, Wildlife Ecology | Joseph D. Zydlewski |
| **Margaret Merz**, PhD, Ecology and Environmental Sciences | Alessio Mortelliti |
| **Marisa Monroe**, MS, Ecology and Environmental Sciences | Noah D. Charney |
| **Edwin Njuguna**, PhD, Wildlife Ecology | Cynthia S. Loftin/Christina A. Murphy |
| **Kurt Ongman**, PhD, Ecology and Environmental Sciences | Amber M. Roth |
| **Glenn Schumacher**, PhD, Wildlife Ecology | Christina A. Murphy |
| **Aurooba Shafquat**, MS, Wildlife Ecology | Christina A. Murphy |
| **Rylee Smith**, PhD, Wildlife Ecology | Joseph D. Zydlewski |

## *CURRENT STUDENTS & POSTDOCS CONT.*

| *Student, Degree, Curriculum* | *Advisor(s)* |
|---|---|
| **Shawn Snyder**, Postdoctoral Associate | Joseph D. Zydlewski |
| **Percival Ulsamer**, MS, Wildlife Ecology | Amber M. Roth |
| **Sarah Vogel**, PhD, Ecology and Environmental Sciences | Cynthia S. Loftin/Joseph D. Zydlewski |
| **Ivy Yen**, PhD, Ecology and Environmental Sciences | Alessio Mortelliti |

# FISHERIES and aquatic

# FISHERIES and aquatic Cont.

## Does predation limit Atlantic salmon recovery?

1. Infer patterns of predation mortalities of smolts in the Penobscot River using existing telemetry data
2. Assess predation mortality of migrating smolts in the Penobscot River by using an acoustic "predator tag"
3. Measure predation of smolts through direct event recording

ABSTRACT: Salmon populations across the globe have incurred substantial declines over the last 50 years with many on the verge of extinction. Among these, the Gulf of Maine Distinct Population Segment of Atlantic salmon (*Salmo salar*) has declined by > 95%, and was subsequently listed under the Endangered Species Act in 2000. Once inhabiting rivers throughout New England, Maine is the last place in the United States where sea-run adults return to spawn each spring. The majority of these fish return to the Penobscot River, which has been the focus of intense restoration and research efforts over the last two decades.

The smolt stage of the salmon life cycle, when salmon migrate from freshwater to the marine environment, is a period of low survival. During migration, smolts incur high mortality as they negotiate impoundments, salinity differences, and novel predators in route to marine entry. Since 2005, researchers from the National Oceanic and Atmospheric Administration, University of Maine, and U.S. Geological Survey have tagged over 5,000 smolts to better characterize the risks incurred by smolts that move through the Penobscot River. These studies have revealed areas of elevated mortality and movement patterns that may be indicative of predation. High levels of predation, especially if beyond natural levels, can be a limiting factor in population recovery. However, beyond anecdotal accounts and evidence from other systems, there remains a critical knowledge gap in the understanding of smolt predation risk in this system.

In this study, we used novel methods to quantify predation rates, identify smolt predators, and describe relationships between predation risk and environmental, seasonal, and individual influences during smolt migration in the Penobscot River. We tagged smolts with acid-sensitive acoustic predation transmitters with temperature sensors (n=270) from 2021–2023 to quantify predation rates and identify predator taxa. Tagging studies were paired with the use of Predation Event Recorders to capture predation on tethered smolts (n=660) in effort to link acute environmental conditions with predator activity. Results from these studies were then used to inform retrospective assessments of smolt survival through the lower Penoboscot River from 2005–2023. First, we used known fates from predated and surviving smolts to develop a machine learning model to characterize annual variation in bird and mammal predation in the Penobscot River Estuary. Then we used detection data from over 3,600 acoustic-tagged smolts to describe survival through the Penobscot River Estuary, Penobscot Bay, and the greater Gulf of Maine.

Our results indicate that smolts incur predation throughout migration. Through smolt tagging and tethering studies, we observed 290 predation events from 2021–2023. In the main-stem Penobscot River, we estimated that at least 46% of all smolts were predated before entering Penobscot Bay which contributed to at least 55% of all smolt mortality. Relative predation risk was greatest through the impoundments of hydropower dams and the lower estuary, where on average, predation rates were 5- and 9-fold greater than free-flowing reaches, respectively. In freshwater, predation on tethered smolts was dominated by smallmouth bass (Micropterus dolomieu, accounting for 71% of predated smolts), but we also documented chain pickerel (*Esox niger,* 27%) and brown bullhead (*Ameiurus nebulosus*, 2%) as potential smolt predators. We found that predator

*(Continued on page 20)*

activity in these areas was primarily influenced by water temperature and river bathymetry. Temperature sensor -equipped acoustic transmitters indicated that species-specific risk shifted to marine mammals once smolts entered tidal waters, while avian predation was documented throughout the watershed.

Time series assessments indicated that predation risk from marine mammals varies annually, and that bird predation in the estuary has decreased since 2008. Overall, smolt survival through the estuary was relatively high (91%), where we attributed among-individual variation in survival to differences in migration history, arrival time, and body condition. Once smolts leave the estuary, we identified the primary migration route and estimated survival (71%) through Penobscot Bay. From there, at least 34% of smolts reached the Scotian Shelf off of Halifax, Nova Scotia, Canada as they traveled to foraging grounds off West Greenland.

This body of research represents as significant advancement in our understanding of smolt mortality risk for this and other salmonid populations. We demonstrate that multiple predator species have the potential to consume smolts in the Penobscot River. Collectively, these studies suggest that anthropogenic actions may increase predation risk for smolts and other migratory species by impounding waterways, warming rivers via climate change, and introducing non-native predators (e.g., smallmouth bass). However, our results indicate potential opportunities to mitigate smolt losses by facilitating safe movement through dams, managing predator populations, and adjusting stocking locations. We anticipate these findings will be used by salmon mangers at local, regional, and global levels in effort to conserve and restore endangered populations.



Investigator: Matt Mensinger (PhD)

Advisors: Joseph D. Zydlewski (Co-Advisor)
Alessio Mortelliti (Co-Advisor)
John F. Kocik
Erik J. Blomberg

Duration: January 2021—May 2025

Cooperators:

Maine Department of Marine Resources
National Oceanic and Atmospheric Administration
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

## Investigating relationships between fish assemblages and food web structures

1. Investigate the food webs of varying fish community compositions.

ABSTRACT: Fish are affected through a variety of mechanisms, including community composition shifts and changes in temperature and river flow. We used case studies in two different locations: Acadia National Park (Maine, USA) and the Willamette Valley (Oregon, USA) to investigate fish responses in a variety of conditions.

The diverse fish stocking history of the Acadia National Park (ACAD) lakes provided us the opportunity to study food webs with varying fish community compositions in a small geographic area. We used carbon and nitrogen stable isotopes to understand trophic relationships in ACAD lakes, focusing efforts on the fish community, their prey, and basal resources. We then used this data to create biplots to map out food webs and mixing models using SIMMR to estimate the proportion of each fish predator species' diet. We also quantified the niche opportunity each fish species was utilizing, and competition in the form of standard ellipses areas corrected for small sample sizes ($SEA_c$). Through our sampling and analyses we documented that fish compositions may have changed between 1998-2022 and that certain species may be unable to coexist without competition at our study sites. We then used our mixing model estimates to present evidence that fish at our study sites consumed a greater proportion of resources within an aquatic system than outside. Finally, $SEA_c$ overlap demonstrated isotopic niche crowding amongst invertivorous fish and less so between common piscivores. In aggregate, we add to the knowledge of trophic ecology in Maine.

We furthered our understanding of fish communities, species interactions, and how environment influences a species by analyzing a long-term passage dataset. Climate change is expected to stress freshwater systems, potentially altering fish movement and survival. Water temperature increases influence fish physiology and more frequent extreme weather events result in changes to the hydrologic regimes. Contemporary fish movements may provide insight into environmental drivers and could highlight species of particular concern. We examined 15 years of water temperature, river flow, and fish passage data to assess their relative influence on fish moving upstream in the McKenzie River, Oregon USA and patterns over time. Comparisons of realized timing and conditions while each species passed upstream through the Leaburg Dam fish ladders revealed that some species were more consistent seasonally, experiencing a more restricted range of conditions compared to others. For both groups, calendar date appeared to be a primary driver of movement timing, even considering environmental factors of temperature and flow. This suggests that fish may continue to move during consistent time periods, even under shifting thermal regimes, potentially increasing their exposure risk to sub-optimal environmental conditions. We also note surprising declines of Mountain Whitefish [*Prosopium williamsoni*] and Largescale Sucker [*Catostomus macrocheilus*] during years of extreme weather events. Our results demonstrate the utility of long-term passage data in detecting patterns in timing, co-occurring environmental conditions in fish movement, and the potential sensitivity of fishes to future change.

Investigator: Daison Weedop (MS)

Advisors: Christina A. Murphy (Advisor)
Michael T. Kinnison
Amanda J. Klemmer
Allyson K. Jackson

Duration: September 2021—May 2024

Cooperators:

Maine Department of Inland Fisheries and Wildlife
National Park Service
Schoodic Institute

## Timber harvesting effects on the aquatic ecology of northern white-cedar lowlands

1. Expand our understanding of northern white-cedar aquatic habitat and processes.
2. Determine how rates of aquatic leaf litter processing and decomposition rates vary between pit and mound microclimates.
3. Compare invertebrate biodiversity, assemblages, and biomass between harvested and control lowland sites.

Northern white-cedar lowlands in Maine are aquatic forest habitats that are managed as conventional timberlands. Although forests may appear dry during harvest periods, recent data has shown they can remain wetted in localized pits throughout the year and at times much of the forest may be flooded. Even from a terrestrial perspective, impacts of forestry operations on these ecosystems remain poorly understood. There remains a gap in the literature as to what types of aquatic biodiversity and processes these forests support and how those are impacted by forest management practices. Our research encompasses harvested and control stands in three working cedar forestlands in Maine. The goal of this research is to expand our understanding of the intermittent aquatic habitat and processes of northern white-cedar, with specific objectives to: 1) compare aquatic invertebrate biodiversity, assemblages, and biomass between harvested and control lowland sites; 2) determine how rates of aquatic leaf litter processing vary between hollow and hummock microclimates. Answering these questions will help to inform managers of the hidden biodiversity and processes that drive habitat functioning and will provide a basis for further research on aquatic ecosystem processes in these habitats.

Field work for the project began in fall 2022 with the deployment of leaf litter bags in wetted and dry areas along the forest floor in harvested and control stands at each site. These were deployed to measure both short and long-term decomposition rates. A subset of bags in each stand was collected at one week, followed by one month post-deployment to capture the most immediate weight loss. Another subset of bags was collected approximately six months post-deployment. This year the final one year and eighteen months post-deployment bags were collected and analyzed. Invertebrate collections occurred throughout 2023 and sample identification and quantification were finalized in 2024. Stevie Benson defends in December.

**Investigator:** Stevie Benson (MS)

**Advisors:** Christina A. Murphy (Co-Advisor)
Noah D. Charney (Co-Advisor)
Shawn R. Fraver
Laura S. Kenefic
Susan L. Eggert

**Duration:** August 2022—December 2024

**Cooperators:**

Baskahegan Company
Northeastern States Research Cooperative (NSRC)
U.S. Forest Service
Wagner Forest Management, Ltd.

## Characterizing the movement of two anadromous species through impounded habitats

1. Characterize the movement and distribution of adult sea lamprey in the Penobscot River watershed using telemetry and eDNA
2. Build upon existing knowledge of passage efficacy for sea lamprey at each mainstem dam on the Penobscot River

Anthropogenic influences have dramatically altered the habitats used by diadromous fishes and have led to steep declines in global abundance. In contrast with their historical populations, native populations of sea lamprey currently exist in low abundance and have experienced widespread range contraction. The factors that have driven the declines of diadromous fishes include global climate change, overexploitation, and reduced river connectivity. Reduced connectivity, may be a natural result of the system's chemistry, temperature, velocity, and/or depth. However, the primary source of fragmentation is the widespread impoundment of rivers and streams by dams, culverts, and road-stream crossings

There are more than 40 rivers and streams in the Penobscot River basin that are thought to have historically been inhabited by sea lamprey. Radio telemetry provides invaluable information on the movement patterns of individual fish and the ability of these fish to pass anthropogenic structures. However, telemetry is often inadequate to provide comprehensive distribution information due to the significant costs associated with the intensive tagging and tracking. Telemetry is also unable to describe the occurrence of untagged individuals, precluding the detection of larvae that may be present in the system.

An alternative approach is an environmental (e)DNA survey, which can capture and detect trace amounts of DNA shed by a target species in water samples, even when the species occurs at low abundances. These surveys are widely used and have previously been used to detect sea lamprey adults and larvae in other systems. Sea lamprey die after spawning and their larvae persist in the river for many years, so there is consistently eDNA present from their larvae and a large seasonal pulse post-spawn from carcasses and gametes.

We used a combination of telemetry and eDNA to assess the restoration pattern of this specie in the Penobscot River.

We are effectively using these two complementary methods to assess the movements and distribution of sea lamprey in the Penobscot River basin. We used radio telemetry to monitor the patterns of sea lamprey movements and their passage through dams, and to derive a minimum estimate of their distribution within the basin. The ability for sea lamprey to pass dams varied among years and sites. Sea lamprey passed the dams at Milford, Howland, and West Enfield in higher proportions than the average among Petromyzontiformes at fishways across the United States.

The success rates at Howland and West Enfield are likely due to the design of the bypasses at those dams (nature-like and vertical slot, respectively). Sea lamprey benefit greatly from bypass designs that allow fish to volitionally pass through fast-moving water with frequent resting pools and continuous access to the bottom of the channel (e.g., the vertical slot fishway at West Enfield Dam). Conversely, fishways with vertical steps and sharp corners are known to delay or prevent passage in other lamprey species. These attributes may contribute to the low passage rate we observed at Mattaceunk Dam's denil fishway. All data has been collected and the project is in the final stages of analysis and write up.

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|---|---|
| **Investigator:** | Cody Dillingham (MS) |
| **Advisors:** | Joseph D. Zydlewski (Advisor)<br>Erik J. Blomberg<br>Danielle M. Frechette |
| **Duration:** | September 2021—December 2024 |

**Cooperators:**

Maine Department of Marine Resources
National Oceanic and Atmospheric Administration
Penobscot River Restoration Trust
Nature Conservancy, The
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit

## The Yellow Lampmussel conservation project

1. Determine how to best use freshwater mussel museum records and if they can be used to clarify temporal and spatial range dynamics of Yellow Lampmussel.
2. Determine local (Penobscot River, Maine) suitable habitat for Yellow Lampmussel and changes from dam removal.
3. Assess range wide habitat suitability of Yellow Lampmussel and determine regional patterns of habitat and host preferences.
4. Create a freshwater mussel themed art mural to engage the local community about their value and explore the benefits and challenges of science art dynamics.

The Yellow Lampmussel is a federal at-risk freshwater mussel species with status ranging from apparently secure to presumed extirpated across its occupied range, Georgia to Nova Scotia. Because of the high variation of host and habitat preferences for this animal and its at-risk status, a range-wide review of its distribution, and drivers thereof, is needed to best inform conservation practices. I want to ask (and answer) the questions, "*Where did the Yellow Lampmussel used to be*?" "*Where are they now?"* and, "*How do we get people to care?"* These broad questions have informed the objectives of my project, in which I will delve into the Yellow Lampmussel's historical range, examine where they are now using side scan sonar and range wide modeling techniques, and then paint a mural depicting these animals hard at work keeping our rivers clean to invoke the support of the local community.

As of September 2024, I have drafted results from my first chapter into a manuscript that is close to submission. I have created a draft species distribution model workflow and output for Yellow Lampmussel. I've received funding for a mural project (~$5,000) from the Maine Department of Inland Fisheries and Wildlife that I will be headlining in the Spring. I have also collected sonar data from across the Penobscot River which will help inform a local species distribution model here in Maine.

https://sites.google.com/view/ylmwg/members/leadership-team

**Investigator:** Jillian Fedarick (PhD)

**Advisors:** Christina A. Murphy (Co-Advisor)
Sydne Record (Co-Advisor)
Allison H. Roy
David L. Perkins
Susan L. Smith

**Duration:** June 2023—May 2027

**Cooperators:**

Atlantic Canada Conservation Data Center
Bangor Beautiful
Cape Breton University
Connecticut Department of Energy and Environmental Protection's Wildlife Division
Delaware Department of Natural Resources and Environmental Control
Delaware Division of Fish and Wildlife
Fisheries and Oceans Canada
Georgia Department of Natural Resources
Maine Department of Inland Fisheries and Wildlife
Maryland Department of Natural Resources
Maryland Wildlife and Heritage Service
Massachusetts Division of Fisheries and Wildlife
New Brunswick Museum
New Hampshire Department of Environmental Services
New Hampshire Natural Heritage Bureau
New Jersey Department of Environmental Protection
New Jersey Division of Fish and Wildlife
New Jersey Endangered and Nongame Species Program
New York Department of Environmental Conservation
New York Natural Heritage Program
New York State Museum
North Carolina Wildlife Resources Commission
Partnership for the Delaware Estuary
Pennsylvania Fish and Boat Commission
Pennsylvania Natural Heritage Program
Rhode Island Department of Environmental Management
South Carolina Department of Natural Resources
U.S. Fish and Wildlife Service
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Massachusetts Amherst
University of New Brunswick
Vermont Department of Environmental Conservation
Vermont Fish and Wildlife Department
Virginia Department of Wildlife Resources
West Virginia Division of Natural Resources
Yellow Lampmussel Working Group

## PFAS variability in fishes

1. Understand how variability in age, sex, size, metabolic rate, and other characteristics, even intra - and interspecific across species, impacts PFAs assimilation and sample results in Maine fishes, especially as these samples are typically composites.

In 2024, a meta-analysis compelling information on PFAS content in fish filets at a global scale was conducted, looking at the influence of fish origin, filet type and filet lipid content on PFAS variability. In 2025 we expect conduct a whole-lake manipulation experiment to assess experimentally the effect of sex, fish biometrics and seasonality on PFAS variation in fish.

Guillermo compiled a large database of PFAS data of fish from literature and state databases in order to examine variability and patterns in PFAS contamination with tissue, in particular skin-on vs. skin -off filets. This work has been prepared for publication and he is now working with the observed PFAS data to generate model simulations for how individual variability and compositing interact to influence observations of PFOS. Guillermo is also working to develop a field study to understand seasonal and growth responses to observed PFAS levels in fish.

**Investigator:** Guillermo Figueroa-Munoz (PhD)

**Advisors:** Christina A. Murphy (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)

**Duration:** June 2022—December 2026

**Cooperators:**

Bigelow Laboratory
Maine Department of Environmental Protection
Maine Department of Inland Fisheries and Wildlife

## Beyond Recovery: A social-ecological approach to protected species conservation

1. Evaluate and compare the communication structure, experiences, and perceptions between the Atlantic Salmon Recovery Framework and the Collaborative Management Strategy. Identify areas of concern to contribute to finalizing the Atlantic salmon governance structure in Maine.
2. Characterize attitudes, perceptions, beliefs, and knowledge about Atlantic salmon, aquaculture, and the use of aquaculture for conservation.
3. Use expert elicitation to characterize national and regional conflict typologies for human-marine mammal interactions under NOAA jurisdiction.
5. Identify opportunities and barriers to proactive human-marine mammal conflict mitigation in NOAA's conservation planning process.

This interdisciplinary work explores several aspects of social-ecological systems through three separate case studies. In each case study we focus on a different component of coupled human-natural systems (governance, public and social systems, and human-wildlife interactions) involving protected species (Gulf of Maine Distinct Population Segment of Atlantic salmon; DPS and NOAA managed marine mammals). Following up on previous work, our team has partnered with Tribal, State, and Federal managers to evaluate the efficacy of the Collaborative Management Structure (CMS), the new collaborative governance structure for Atlantic salmon in Maine using communication network analysis and parallel research design. Upon restructuring the managing entities for the DPS decided to pursue a novel conservation approach utilizing conservation aquaculture. Since commercial aquaculture has been a controversial topic in Maine and across the globe, we will use a public questionnaire to explore public attitudes, perceptions, knowledge, and trust in order to better understand community level support and opposition toward conservation aquaculture. We will explore human-wildlife interactions involving NOAA managed marine mammal species using expert elicitation. Through this exploratory approach we will identify regional and national conflict typologies which will serve as a reference tool for NOAA managers to prioritize mitigation efforts and share relevant resources.

One manuscript focused on understanding public perceptions of conservation aquaculture practices has been accepted and published in Marine Policy. The CMS case study manuscript is under review (submitting to Environmental Science and Policy). Survey data collection for the human-wildlife interactions case study and regional workshops have been completed. One chapter on programmatic resource allocation is drafted and analysis on another, focused on conflict typologies, is underway.

**Investigator:** Melissa Flye (PhD)

**Advisors:** Joseph D. Zydlewski (Co-Advisor)
Carly C. Sponarski (Co-Advisor)
Danielle M. Frechette
Kristina M. Cammen
Adam J. Daigneault

**Duration:** January 2020—May 2025

**Cooperators:**

Collaborative Management Structure (CMS)
Cooke Aquaculture
Maine Department of Marine Resources
National Oceanic and Atmospheric Administration
Penobscot Indian Nation
U.S. Fish and Wildlife Service
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit

## Assessment of upstream migration, dam passage, and habitat use for Atlantic Salmon in the Piscataquis River

1. Track adult Atlantic salmon migration throughout the Piscataquis River using radio and acoustic telemetry.
2. Evaluate effectiveness of engineered " nature like" fishway at Howland Dam.
3. Evaluate passage at Brownsmill dam, and possible delay imposed from "pike jump" control barrier.
4. Compare migration and dam passage rates of Piscataquis stocked salmon with those stocked in the lower Penobscot river.
5. Assess system wide attraction, and use of cool water refugia throughout the Piscataquis River.

The Piscataquis River represents a substantial portion of spawning habitat available to Atlantic salmon in the Penobscot watershed, with the potential to produce a large number of smolts annually. There have been recent attempts to improve access to this habitat, through the Penobscot River Restoration Project, with the removal of two dams on the lower Penobscot River, and the construction of a nature like fishway at Howland Dam. We seek to evaluate the effectiveness of the Howland fishway, by quantifying approach, delay and passage of Atlantic salmon as they migrate into the Piscataquis River.

Further upstream, at Brownsmill dam, there is an effort to control invasive Northern Pike from migration, through the use of a "pike jump" barrier installed in the fishway. Assessment is needed to determine if this barrier is causing delay to Atlantic salmon attempting to reach spawning habitat.

A program implemented in 2022 to begin stocking smolts in the upper Piscataquis provides the opportunity to assess upstream migration and passage of both tributary stocked, and lower river stocked salmon, with the added benefit of informing future smolt stocking practices.

Atlantic salmon were tagged at Milford fishway in 2024 (n=33), with gastrically implanted radio and acoustic transmitter tags. 15 stationary radio receivers, and high gain antennas were positioned along migratory route to track upstream movement from tagging site, into the Piscataquis River, as well as Howland and Brownsmill dams and associated fishways. Existing Penobscot acoustic array was supplemented with additional receivers placed in areas of interest throughout the Piscataquis. Data collection from tagged fish is ongoing, with weekly download of stationary receiver data, as well as mobile tracking of tagged fish. Environmental conditions including water temperature and flow are also collected to determine effect on migration behavior.

**Investigator:** Rory Hanon (MS)

**Advisors:** Joseph D. Zydlewski (Advisor)

**Duration:** May 2024—December 2026

**Cooperators:**

National Oceanic and Atmospheric Administration
Nature Conservancy, The
Penobscot River Restoration Trust
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

## Alewife approach and passage of Grand Falls and Woodland Dams on the St. Croix River

1. Track adult alewife as they migrate upstream and downstream of Grand Falls and Woodland Pulp dams.
2. Asses approach & estimate passage rates of adult alewife at each dam.
3. Inform decision on new passage designs for both dams to improve fish passage.

This study assessed adult alewife approach and passage at Woodland Pulp (WP) and Grand Falls (GF) dams on the St. Croix River using radio telemetry. In spring 2022, we installed six radio arrays and tagged 230 upstream migrating alewife (115 at each dam). Based on Year 1 results, we expanded monitoring coverage in 2023 by adding five receivers to the original array configuration. In Year 2, we tagged 350 alewife across four groups: 150 released downstream of WP, 50 transported above WP, 100 released below GF and 50 transported above GF. We conducted twice weekly data downloads throughout the migration season. Data analysis focuses on quantifying upstream and downstream approach and passage rates at each dam, with particular attention to channel preference between routes with and without passage using an Index of Relative Location (IRL) analysis. These findings will inform upcoming fishway improvements at both facilities. Manuscript completion is targeted for spring 2025.

Both field seasons (2022 & 2023) have been completed with the successful tagging of 230 alewife for Year 1 and 350 for Year 2. All receivers recorded detections and all data has been uploaded. Data filtering has been completed to address noise interference near dam infrastructure. Data processing and quality control checks have been performed on detection files. Analysis on passage, approach, and channel preference calculations using the Index of Relative Location (IRL) have been completed for both dams. Final analysis and manuscript has been drafted and is undergoing revision for anticipated completion in spring 2025.

**Investigator:** Emilie Hickox (MS)

**Advisors:** Joseph D. Zydlewski (Co-Advisor)
Danielle M. Frechette (Co-Advisor)
Christina A. Murphy

**Duration:** May 2022—May 2025

**Cooperators:**

International Joint Commission on the St. Croix Waterway
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
Passamaquoddy Tribe
Nature Conservancy, The
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

## Atlantic Salmon movements and mortality in the State of Maine

1. Characterize seaward movement and patterns throughout the Penobscot and Machias rivers.
2. Quantify apparent mortality rates and identify areas of overwintering and mortality in the rivers.
3. Assessing survival to the ocean in the dammed (Penobscot) and undammed river (Machias) in Maine.
4. Characterize passage at high priority dams on the Penobscot River mainstem and a primary tributary, the Stillwater River.

The Atlantic salmon (*Salmo salar*) is an ecologically, economically, and culturally important species. Currently, the species is federally listed as Endangered and the heavily dammed Penobscot River is home to the largest run of Atlantic Salmon in the United States. Because the Penobscot run persists only with extensive hatchery support, conservation efforts have focused on first time returns rather than repeat spawning. As a result, post-spawn survival and behavior of downstream migrating Salmon are poorly characterized. In this study, we intend to assess downstream migration rates, overwintering habitat, site fidelity, and dam passage survival post-spawn Atlantic salmon.

Beginning in the fall of 2022, we are using acoustic telemetry to monitor two groups: 1) captive-reared adult fish from the Salmon for Maine's Rivers project and 2) post-spawn sea-run adults used for hatchery brood stock on the Penobscot River. Both groups will be released into the East Branch of the Penobscot River and their downstream progress and survival will be assessed.

In 2022, we successfully tagged and released 59 captive -reared fish from the Salmon for Maine's Rivers project into the Penobscot and Machias Rivers. In addition, we tagged 50 post-spawn sea-run fish and released them in the Penobscot river. Movement data from our acoustic receivers will be collected after retrieval in the late spring.

In 2023 we acoustically tagged and released smolt-to-adult supplemented fish into the Penobscot and Machias rivers during the summer and fall. We also released sea-run Atlantic salmon from Craig Brook National Fish Hatchery into the Penobscot river in the fall.

In 2024 we completed the field work for the project by deploying and collecting data from our acoustic receivers in the Penobscot and Machias rivers. Analyses of the data was completed in the fall of 2024 and the thesis is scheduled to be defended in November 2024.

**Investigator:** Carolyn Merriam (MS)

**Advisors:** Joseph D. Zydlewski (Co-Advisor)
Danielle M. Frechette (Co-Advisor)
Allison Gardner

**Duration:** June 2022—November 2024

**Cooperators:**

Maine Department of Marine Resources
National Oceanic and Atmospheric Administration
U.S. Fish and Wildlife Service
U.S. Fish and Wildlife Service – Craig Brook National Fish Hatchery
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

## Investigating impact of flow dynamics on freshwater benthic invertebrates in Willamette Basin, Oregon

1. Utilize passive acoustic monitoring to quantify flow magnitudes that mobilize bed substrate to assess the relationship between flow and substrate movement.
2. Investigate how existing flow conditions influence aquatic invertebrate community structure and biomass.
3. Create a mechanistic model to identify optimal flow magnitudes that support healthy aquatic invertebrate communities. Use model insights to propose novel flow recommendations, if needed, to mitigate the negative impacts of flow regulation.

This research work supports recent and ongoing efforts of the U.S. Geological Survey (USGS) in evaluation of a U.S. Army Corps of Engineers (USACE) effort known as the Sustainable Rivers Program (SRP) with a focus on performing the science and monitoring needed to quantify ecosystem responses to effects of USACE reservoir operations. In a natural riverine ecosystem variation of flows, especially the extreme highs and lows, structure and drive the rich ecosystem of these biomes. The natural flow regime supports ecological processes and ecosystem services. These flow regimes can be significantly altered by large-scale anthropogenic developments, such as hydropower dams. Hydropower dams regulate the waters so that they can be utilized for human needs, e.g., irrigation, energy generation, flood control and more. Alteration of river flows comes at a major cost for biota inhabiting freshwater and riparian ecosystems threatening the ecosystem services they provide. This project aims to understand the relationship between benthic invertebrate communities, substrate type, and substrate movement driven by river flows. Additionally, we will evaluate how the existing flow regime influences invertebrate communities and whether a designed flow regime would produce different outcomes. To achieve this, we will be using a mechanistic multi-species modeling approach. This technique has been widely applied in various studies because it allows us to assess the impact of a designed flow regime before its physical implementation, enabling more informed decision-making.

We're on the first stage of understanding and analyzing the data collected through the years.



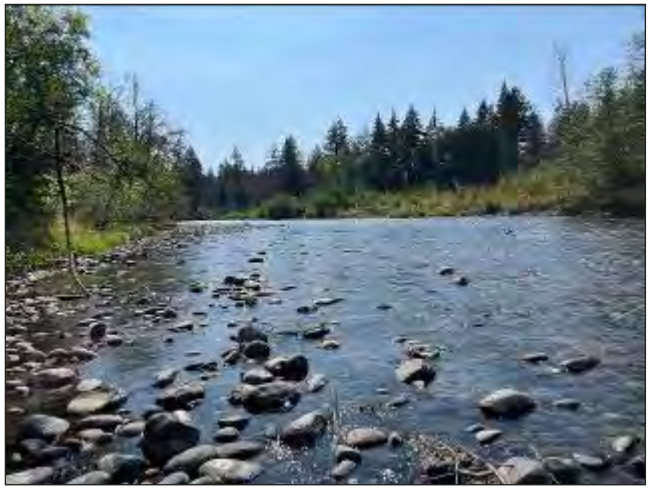

**Investigator:** Aurooba Shafquat (MS)

**Advisors:** Christina A. Murphy (Advisor)
James White
Hamish S. Greig


**Duration:** September 2024—December 2026

**Cooperators:**

U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology



## Arctic Charr trophic variation: insights into the climate resilience of southern edge populations

1. Characterize resource variability in Floods Pond, and oligotrophic Arctic Charr lake.
2. Characterize trophic variability exhibited by southern landlocked Arctic Charr in Maine lakes.
3. Clarify the direction and timing of ontogenetic dietary shifts in Maine Arctic Charr.
4. Develop a theoretical model describing relationships between habitat and community structure , and the trophic niches occupied by Arctic Charr.

Understanding a species capacity to adapt to change is helpful in identifying disturbance resilient or threatened species. A species ecosystem role is influenced by habitat characteristics and co-occurring species, therefore, estimating species response to climate change requires an understanding of its environmental role in a community context. Arctic Charr (*Salvelinus alpinus*) are a cold-water salmonid exhibiting several distinct trophic morphs (e.g., pelagic piscivorous, pelagic planktivorous, littoral generalist) although the species has limited warm water tolerance and is a poor direct interspecific competitor. The southernmost populations of Arctic Charr occur in Maine lakes, where disturbance is more likely to alter resource and community structure (e.g., lake productivity may shift from pelagic to littoral habitat and species diversity patterns may change). We are investigating community structure, limnological characteristics, and food web structure (using stable isotope analysis) in several Maine Arctic Charr lakes to understand Arctic Charr trophic roles in ecosystem context. Additionally, we are using eye lens stable isotope analysis to investigate variable ontogeny across Arctic charr population, and collaborating with researchers investigating Arctic Charr from perspectives of genetics, movement, habitat use, and morphology, and will synthesize our insights to estimate long term viability of southern range Arctic Charr.

We sampled Arctic Charr and co-occuring organisms in four Maine lakes: Floods Pond, Wadleigh Pond, Long Pond, and Gardner Pond. Two years of monthly sampling was conducted in Floods Pond to characterize resource patterns (i.e., primary production, invertebrates, and forage fishes) and abiotic habitat (i.e., water quality and water nutrients). We conducted carbon and nitrogen stable isotope analysis on twelve species of fishes as well as invertebrates and basal resources in Floods Pond. Preliminary results suggest that Floods Pond Arctic Charr are top piscivore predators in the system, compete most directly with Brook Trout (Salvelinus fontinalis), and may be more dependent pelagic resources than most other Floods Pond fishes. We are continuing to process community, limnilogical, and stable isotope samples. Eye lens stable isotope analysis is being used to reconstruct life time trophic histories of charr in each lake, and early results suggest considerably different trophic trajectories across populations.

**Investigator:** Glenn T. Schumacher (PhD)

**Advisors:** Christina A. Murphy (Advisor)
Nathan B. Furey
Michael T. Kinnison
Jasmine E. Saros
Ernst B. Peebles

**Duration:** January 2023—December 2026

**Cooperators:**

Bangor Water District
Maine Department of Inland Fisheries and Wildlife
National Science Foundation – Experimental Program to Stimulate Competitive Research
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Florida – College of Marine Science
University of Maine – Climate Change Institute
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – School of Biology and Ecology
University of New Hampshire – Department of Biological Sciences

## Predatory and competitive interactions of juvenile Atlantic salmon and two predatory species in Maine Rivers

1. Estimate the population, growth and age structure of smallmouth bass and chain pickerel in the Weldon Headpond, an area of high migratory risk of the Penobscot River.
2. Estimate predator consumption rates to determine the predation risk in relation to variations in water temperature.
3. Create habitat suitability models for Atlantic salmon, smallmouth bass and chain pickerel in Maine river systems.
4. Create species distribution models of Atlantic salmon, smallmouth bass, and chain pickerel habitat in Maine rivers to estimate the probability of a species' occurrence.
5. Characterize the influence of climate change on Atlantic salmon, smallmouth bass and chain pickerel under climate change scenarios

A mark recapture study will be performed in in the Weldon Headpond to estimate population size of smallmouth bass and chain pickerel. After the mark recapture study, otoliths will be extracted and analyzed to estimate age and growth structure of smallmouth bass and chain pickerel. Habitat suitability models and species distribution models will be created using literature (depth, substrate, and habitat type) and modeled temperature to identify niche habitat characteristics, predict the likelihood of species occurrence and predict the theoretical distribution of species. Historic electrofishing data will be used in conjunction to assess the spatial and temporal overlap of species. Bioenergetic models will be used to estimate predator consumption rates in relation to variation in water temperature to estimate the risk of predation of juvenile salmon by smallmouth bass and chain pickerel at various locations. Climate change models will be conducted and modeled temperature will be used to predict the influence of climate change scenarios on predation risk, habitat suitability and species distribution.

The mark-recapture study in the Weldon Headpond to estimate smallmouth bass and chain pickerel populations was concluded, and focus has shifted to otolith extraction with the current samples. Otolith extraction was completed in 2024, and growth rates of smallmouth bass were estimated using the von Bertalanffy growth curve. This data has been incorporated into the bioenergetic consumption model, which simulates predator consumption rates with varying smolt migration numbers. Preliminary results show that higher smolt numbers result in fewer smolts being consumed.

Currently, we are developing a water temperature model for Maine, which will be used as a habitat variable in the species distribution and habitat suitability models. Preliminary HSI and SDM models have been created without temperature data. The integration of the temperature model will allow for improved predictions of species distribution, habitat suitability, and the impact of climate change on predation risk and species occurrence. Analysis of historic electrofishing data is ongoing to assess species overlap.

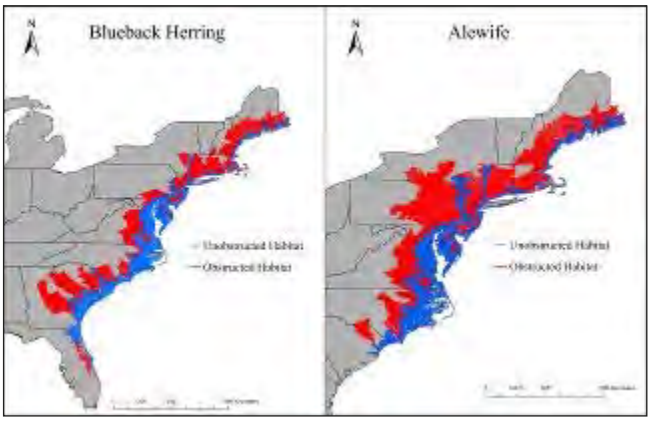
**Investigator:** Rylee Smith (PhD)

**Advisors:** Joseph D. Zydlewski (Advisor)
Christina A. Murphy
Erik J. Blomberg
Sydne Record
Hamish S. Greig

**Duration:** January 2021—July 2025

**Cooperators:**

Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
National Oceanic and Atmospheric Administration
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology




## Impacts of dams on coast-wide and regional abundances of River Herring and American Eels

1. Estimate the current and historical extent of accessible freshwater habitat for Alewife, Blueback Herring and American Eel
2. Develop and parameterize Alewife, Blueback Herring and American Eel river-specific population models across their entire ranges

We will develop and parameterize Alewife, Blueback Herring and American Eel river-specific population models across their entire ranges. These models will be populated with estimates of region-specific life-history parameters, estimates of habitat (e.g., acres) and the dam landscape. Once developed, these models will be freely available to hydro practitioners for the use in planning for species conservation and recovery relative to hydropower at both local and regional scales. The challenges for developing the habitat and population model components vary greatly among these three species.

River-specific population models have been developed for Alewife and Blueback Herring. We have updated the Anadrofish R programming package to include habitat data generated for these two species. Results from our river-specific population models have contributed to the Atlantic States Marine Fisheries Commissions stock assessment for River Herring. Habitat and presence data has been acquired for the American eel in the Chesapeake Bay Watershed and life-history parameters are being identified and parameterized.

**Investigators:** Shawn Snyder (Postdoc)
Joseph D. Zydlewski
Daniel S. Stich
John A. Young
Samual G. Roy

**Duration:** August 2023—December 2024

**Cooperators:**

Atlantic States Marine Fisheries Commission
State University of New York – Oneonta
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit

# WILDLIFE and habitats

# WILDLIFE and habitats continued

## Full annual cycle analysis of American Woodcock (*Scolopax minor*) distribution, habitat use, and migration ecology

1. Evaluate American woodcock habitat ecology throughout their full annual cycle, including variability in breeding, stopover, and wintering habitat relationships and how these relationships change with geography and vary among age/sex classes.
2. Assess migration ecology of woodcock breeding along a latitudinal gradient to evaluate differences in migration strategies and sources of variation in migratory behavior.
3. Evaluate mortality risk during woodcock migration, compare with risks experienced during non-migratory periods, and identify potentially important risk factors.
4. Use a combination of genomic, isotopic, and GPS tracking methods to assess woodcock population and migratory connectivity throughout their range to inform management and better understand the species' ecology.
5. Conduct a comprehensive study of woodcock spatial ecology in West Virginia, covering all 4 ecoregions

ABSTRACT: The widespread availability of satellite tracking devices has made it possible to track individual migratory birds throughout the full annual cycle, examining how distribution and habitat use change between seasons and regions while also describing the characteristics of migratory movements. We used these devices to examine the full annual cycle ecology of American Woodcock (*Scolopax minor*; hereinafter woodcock), an early successional habitat specialist whose populations are declining throughout their range in eastern North America. We used these data to develop a multi-season distribution model for woodcock management in Pennsylvania, demonstrating the importance of considering habitat use across multiple seasons for migratory bird conservation. We also used woodcock migratory movements to demonstrate improved methods for classifying animal locations into migratory states, allowing inferences into migratory behavior despite sparse and incomplete data. We examined changes in woodcock habitat selection among seasons, finding that woodcock likely undergo a functional response in their habitat selection to changes in habitat availability throughout the full annual cycle. Finally, we described woodcock flight altitudes and their corresponding vulnerability to various airspace obstacles, finding that low altitude flights are likely a contributing factor to woodcocks' disproportionate collisions with buildings. Stabilizing woodcock populations will likely require better understanding of woodcock ecology throughout the full annual cycle, as well as the threats they face at each stage. We hope that our comprehensive analysis of woodcock distribution, habitat use, and migration ecology throughout the full annual cycle will improve conservation of this iconic upland bird species.

Our project would not be possible without the involvement of state and federal agencies, universities, and non-governmental organizations throughout eastern North America. For more information on the project, to read our annual report, or to follow woodcock during migration, visit woodcockmigration.org

Investigators: Liam Berigan (PhD)

Advisors: Erik J. Blomberg (Co-Advisor)
Amber M. Roth (Co-Advisor)
Joseph D. Zydlewski

Duration: October 2017—May 2026

Cooperators:

Audubon Vermont
Canaan Valley National Wildlife Refuge
Environment and Climate Change Canada
Louisiana Department of Wildlife and Fisheries
Nature Conservancy, The in Vermont
New Jersey Department of Environmental Protection
New York Department of Environmental Conservation
Penobscot Valley Chapter of Maine Audubon Society
Silvio O. Conte National Fish and Wildlife Refuge
South Carolina Department of Natural Resources
State University of New York – Cobleskill
Timberdoodle Habitat Society
U.S. Fish and Wildlife Service
U.S. Fish and Wildlife Service – Webless Migratory Game Bird Program
University of Maine
Vermont Fish and Wildlife Department
West Virginia Division of Natural Resources

## Estimating Golden-winged Warbler annual survival for integration with range -wide demographic modeling

1. Estimate male-focused Golden-winged Warbler annual survival across their full breeding range through temporal encounter history datasets.
2. Use new telemetry technology to estimate female Golden-winged Warbler annual survival in relation to male survival.

ABSTRACT: The Golden-winged Warbler (*Vermivora chrysoptera*) is a Nearctic-Neotropical migratory songbird that has experienced over 70% population loss since the 1960s. While primary drivers of decline are unclear, habitat loss and hybridization with the genetically similar Blue-winged Warbler (*Vermivora cyanoptera*) are likely causes. This species breeds in two geographically allopatric regions, the Great Lakes and the Appalachian Mountains. These two populations are experiencing different rates of decline, with the Appalachian Mountain population facing steeper decline than the Great Lakes. Due to pronounced range-wide population decline, Golden-winged Warbler is currently under review for protection under the Endangered Species Act, however information pertaining to adult annual survival and variations that may occur temporally, geographically, or demographically is currently lacking. Specifically, survival information for female Golden-winged Warblers is uncommon given that females are elusive in nature and thus are largely absent in historical capture-mark-recapture datasets. To better understand sex-, site-, and region-specific variations in apparent annual survival, we conducted a range-wide, hierarchical multi-population Cormack-Jolly-Seber analysis that encompassed 23 sites across Golden-winged Warbler breeding and wintering grounds. Each site represented a capture-mark-recapture dataset collected between 1980-2022 by a large network of researchers studying various aspects of Golden-winged Warbler demographics. We found a tendency for apparent annual survival to be higher in the Appalachians region but overlapping credible intervals did not support a substantial difference. More standardized data collection across datasets and an increase in the number of years represented in individual capture histories would have increased our certainty in the presence or absence of regional variation. Male apparent annual survival tended to be higher than females but was not substantially different. However, this was a male-biased analysis with only 20% female representation across the compiled dataset. To increase female representation in survival analyses, we used VHF-telemetry to increase annual female detectability and ran additional apparent annual survival and return rate analyses to better understand differences in sex-specific variations. This analysis encompassed data collected across 13 sites in their breeding range from 2021-2023. With different methods used to detect females, along with a concentrated effort to mark females, we were able to achieve 45% female representation in our apparent annual survival analysis and 37% female representation in our annual return rate analysis. Results showed that females had substantially lower apparent annual survival and return rate probabilities than males, which suggests that females are experiencing either increased mortality at some point during their full annual cycle, or they have a higher dispersal rate than males. These findings provide crucial insights into how sex influences the survival and return rate of Golden-winged Warblers and underscore the need for more female-focused survival studies.

Investigator: Emily Filiberti (MS)

Advisors: Amber M. Roth (Advisor)
Joseph D. Zydlewski
Erik J. Blomberg

Duration: October 2020—May 2024

Cooperators: Audubon North Carolina

Golden-winged Warbler Working Group
Indiana University of Pennsylvania
Kentucky Department of Fish and Wildlife Resources
Knobloch Family Foundation
Missouri Department of Conservation
North Carolina Wildlife Resources Commission
Road to Recovery
U.S. Army, Fort Drum
U.S. Fish and Wildlife Service
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station
University of Minnesota – Duluth Natural Resources Research Institute
University of Tennessee
Virginia Commonwealth University

## Drivers of spatio-temporal dynamics in long-term studies of mammal and bird populations in Maine

1. To understand the long-term capacity of animals to track and exploit the wave of pulsed resources
2. To examine the causes and consequences of temporal increase in abundance and body weight of white-footed mouse (*Peromyscus leucopus*)
3. To investigate how two species of mouse (*Peromyscus* spp.) differ in their foraging behavior and its implications for tree species distributions under climate change
4. To identify how Canada lynx occupancy is influenced by forest composition and disturbance over space and time
5. To assess the functional diversity of mammal and bird communities and how they relate to different forest management practices

ABSTRACT: Investigating the dynamics of animal populations across large spatial and long temporal scales is fundamental to fully comprehend complex ecosystem processes since animals are responsible for many vital ecological functions including seed dispersal and vegetation regeneration. Spatial and temporal trends are particularly important in a changing world, where land-use and climate change can dramatically affect species distributions and interactions. Therefore, understanding how global change modifies populations' structure in space and time is crucial for developing efficient conservation actions.

The goal of my dissertation is to examine the drivers of spatio-temporal distribution patterns and demographic parameters of mammal and bird populations in the context of global change. My research advances our knowledge on this topic through five case-studies encompassing multiple taxa and ecological scales in the temperate forests of Maine.

Chapter 1 investigates the long-term capability of small mammals (white-footed mice [*Peromyscus leucopus*], southern red-backed voles [*Myodes gapperi*], eastern chipmunks [T*amias striatus*], and American red squirrels [*Tamiasciurus hudsonicus*]) to track and exploit pulsed resources, characterized by food resources that dramatically change in availability over space and time (e.g. mast-seeding) and its cascading effect on habitat selection and survival by using a 39-year capture-mark-recapture dataset. Chapter 2 examines the causes and consequences of the temporal increase in abundance and body weight of white-footed mice by using the same dataset as Chapter 1. Chapter 3 reports a laboratory experiment that investigates how white-footed mice and deer mice (*Peromyscus maniculatus*) differ in their acorn foraging behavior and its implications for oak distributions under climate change. Chapter 4 identifies how Canada lynx (*Lynx canadensis*) occupancy is influenced by forest composition and disturbance over 16 years throughout Maine. Finally, Chapter 5 describes how the functional diversity of mammal and bird communities is related to different forestry practices by using a 4-year dataset from Vermont, New Hampshire, and Maine.

This dissertation elucidates some key mechanisms behind the spatial-temporal dynamics of multiple animal species, by combining large-scale, long-term empirical data across taxa with advanced modeling methods, and thus are of broad applicability to ecology and conservation.

Investigator: Gabriela Franzoi Dri (PhD)

Advisors: Alessio Mortelliti (Co-Advisor)
Malcolm L. Hunter, Jr. (Co-Advisor)
Aaron R. Weiskittel
Brian J. McGill
Cynthia S. Loftin

Duration: January 2020—August 2024

Cooperators:

Maine Department of Inland Fisheries and Wildlife

## Effects of personality on cache pilferage and activity patterns in Maine's forest-dwelling small mammals

1. Determine how intraspecific traits in small mammals, including personality and body condition, affect the ability of individuals to pilfer other individuals' seed caches.
2. Determine how forest management impacts personality distributions of the American red squirrel (*Tamiasciurus hudsonicus*) and how personality traits affect activity in the wild, with ecological implications for seed fate.

ABSTRACT: Personality, or the tendency for individuals to behave consistently, has been observed throughout the animal kingdom and is known to have key ecological and evolutionary consequences. Because different personalities play distinct roles in a community, it is critical to understand which personalities are more likely to complete vital ecosystem functions, and how anthropogenic land-use change may influence personality compositions of a population. The purpose of my research is to contribute to filling these knowledge gaps, using forest -dwelling small mammals as a model system. Small mammals such as mice and voles play a fundamental role in the ecosystem service of seed dispersal by caching seeds in small hoards that germinate under beneficial conditions, facilitating forest regeneration. Personality has been found to influence decision-making during foraging, resulting in different seed dispersal outcomes. Within the context of an 8-year capture-mark-recapture study, we trapped and tested the personality of small mammals using standardized behavioral tests in the Penobscot Experimental Forest in Maine.

Chapter 1 focuses on pilferage, a key step in the seed dispersal process in which animals steal seeds from other individuals' caches. Pilferers often recache stolen seeds, which are often pilfered by new individuals, who may recache again, and so on, potentially leading to compounded increased dispersal distance. Within the context of the long-term study, we conducted a pilferage experiment, in which we created artificial caches using eastern white pine (*Pinus strobus*) seeds monitored with trail cameras and buried antennas for individual identification. Of the 436 caches created, 83.5% were pilfered by 10 species, including deer mice (*Peromyscus maniculatus*) and southern red-backed voles (*Myodes gapperi*). We show how individuals differ in their ability to pilfer seeds and that these differences are driven by personality, body condition, and sex. More exploratory deer mice and those with lower body condition were more likely to locate a cache, and female southern red-backed voles were more likely than males to locate caches.

Chapter 2 investigates the effects of land-use type on personality compositions and its potential implications on activity patterns. Managed forests make up over half of forests globally, with the majority used for timber harvest. To ensure efficient forest regeneration, it is vital that we understand how different management regimes affect the behaviors of seed-dispersing and seed-predating animals. We used personality data from 325 individual American red squirrels (*Tamiasciurus hudsonicus*) over 8 years across different silvicultural treatments. During 2 years of the study, we deployed collar-mounted light-level geolocators on 14 individual squirrels to measure daily activity patterns. Our analysis reveals that personality distributions differ between unmanaged and managed forests, and that personality influences activity patterns. Specifically, uniform and irregular shelterwood forests had lower proportions of aggressive individuals than unmanaged forests, and more exploratory individuals spent more time active per day on average. My research adds to a growing body of knowledge showing that the unique personalities of individual small mammals play a critical role in forest regeneration by impacting seed dispersal, and that anthropogenic alterations to landscapes can shift personality compositions, with ecological implications.

**Investigators:** Brigit Humphreys (MS)

**Advisors:** Alessio Mortelliti (Advisor)
Sydne Record
Danielle L. Levesque

**Duration:** January 2022—July 2024

**Cooperators:**

University of Maine
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology


## Developing an optimal monitoring program for the Endangered Togean Islands babirusa through the support of citizen scientists

1. Identify key habitat features and map the distribution of the Togean babirusa.
2. Develop a cost effective monitoring protocol for the species.
3. Train national park wardens and local citizen scientists to conduct the monitoring.

ABSTRACT: For centuries, the Archipelago of Indonesia has attracted numerous naturalists worldwide, including Alfred Russel Wallace (1823-1913), who described this region as "the land of orangutan and the birds of paradise." This description alone implies the uniqueness of the archipelago's fauna communities because those two animals represent two different biogeographical realms: Asiatic and Australian. Until about 6,000 years ago, the western part of Indonesia was connected to the Asian mainland and the eastern part was part of Australia, which explains how these biogeographical realms were formed (Lohman et al., 2011). Fauna communities in the Asiatic realm show similar characteristics with Asian wildlife, while animals in the Australian realm share similar traits with Australian wildlife. The area in between, known as the Wallacea, harbor animal communities that resemble both Asian and Australian wildlife. Because of this biogeography, Indonesia is extremely rich in biodiversity and was ranked as the second most biodiverse country in the world (Mittermeier, 1997; Myers et al., 2000). Despite its unique biodiversity, this country has among the highest number of threatened species globally (Baillie et al., 2004; Pereira et al., 2012), with habitat loss from severe deforestation as the primary threat (Giam, 2017; Margono et al., 2014). Moreover, research development in Indonesia is suboptimal, with many poorly understood species and regions. For example, researchers often focus on a few charismatic megafaunas, limiting studies on other less recognized threatened species in the country, such as the babirusas (*Babyrousa spp.*). Consequently, we lack knowledge on how habitat loss may affect these unpopular species, undermining potential actions to safeguard the country's biodiversity. My dissertation, structured into four chapters, explores research gaps in biodiversity issues in Indonesia, focusing on poorly studied taxa. Chapter 1 reports the status of research on Artiodactyla, an underrepresented mammalian order in Indonesia, throughout the archipelago. Following up, Chapter 2, 3, and 4 specifically examine an endangered Artiodactyla species endemic to the Togean Archipelago, the Togean Islands babirusa (*Babyrousa togeanensis*), and discuss potential strategies to conserve the species. This babirusa is one of the most poorly studied wild pigs in the world, with no prior field-based ecological study conducted before my research endeavors. In Chapter 1, I reviewed research articles covering Artiodactyla species throughout Indonesia and, as a comparison, Malaysian Borneo, aiming to identify biases in Artiodactyla research in the region. I found three sources of bias: 1) geographical bias, with most studies being conducted in the western part of the country and Malaysian Borneo, i.e., Asiatic realm; 2) taxonomic bias, with the number of papers covering the three most studied species equivalent to the number of papers covering the rest of the species combined; and 3) bias in research approaches, whereby few studies measured habitat selection and quality. To address these biases, I provide suggestions for future research priorities to develop knowledge on Artiodactyla-habitat relationships in Indonesia. One of the Artiodactyla species that requires more study is the Togean Islands babirusa which I will explore more in the following three chapters. Chapter 2 focuses on habitat selection of the Togean Islands babirusa. I deployed camera traps throughout the entire distribution range of the species to collect babirusa data and estimated habitat characteristics through remote sensing, GIS, and field measurements. I fitted single-season occupancy models to identify how habitat features affected the occupancy probabilities of the species. I found that the proportion of forests and mangroves positively affected babirusa occupancy, emphasizing the importance of protecting the remaining natural vegetation in the Togean Archipelago. However, we found that about 50% of the archipelago's remaining forests are not protected, while about 30% of the protected areas (i.e., Togean Islands National Park) are non-forests. This indicates that the conservation strategies currently in place may not be effective to safeguard the babirusa. Moreover, there was not a standard protocol to evaluate whether

*(Continued on page 41)*

our efforts to maintain the babirusa's population were effective. Therefore, in Chapter 3, I developed a monitoring protocol to detect occupancy changes of the species over time. First, I divided the study area, based on the occupancy probability estimated in Chapter 2, into three categories: high, medium, and low occupancy areas. Then, I employed power analysis to estimate the required sampling efforts (i.e., number of camera trap stations) to detect 10-50% declines in babirusa occupancy. Realistically, the smallest occupancy declines this protocol can detect are 20% in high occupancy area and 40% in medium occupancy area. The low occupancy area is a low-quality habitat, and it requires unrealistically high sampling efforts to monitor, and can therefore be excluded. I also provided budgeting scenarios relevant to developing countries as guidelines to plan and perform species monitoring programs. Finally, Chapter 4 provides updates and new insights into the demography and behavior of the Togean Islands babirusa. Through N-mixture modeling, I estimated the population size of the babirusa as 341.49 – 580.48 individuals, with a sex ratio of 1:2.3. Males were mostly solitary, but females were usually part of groups of up to 11 individuals. I also performed multistate occupancy modeling and found that the probability of a reproductive babirusa being present in an occupied site was 0.741 and was positively affected by distance to human settlement. Despite high human pressure in the archipelago, the Togean Islands babirusa maintained its activity pattern during the day, with two peaks in early morning and late afternoon. My studies suggest that the Togean Islands babirusa should remain Endangered under the IUCN Red List Category and Criteria. To improve the conservation of the species, I recommend the following actions: 1) Revise the national park boundary to protect a larger forested area in the Togean Archipelago; 2) Regularly monitor the babirusa to detect occupancy changes overtime; 3) Integrate human-wildlife coexistence in management strategies and spatial development plan; and 4) Involve local communities in research and efforts to conserve the species.

**Investigators:** Agus Sudibyo Jati (PhD)
Bayu Wisnu Broto

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Noah D. Charney
Malcolm L. Hunter, Jr.
Shawn R. Fraver
Daniel J. Hayes

**Duration:** February 2021—December 2025

**Cooperators:**

Alliance for Tompotika Conservation, Indonesia
International Union for Conservation of Nature – Save Our Species
Kepulauan Togean National Park Agency, Indonesia
Mohamed bin Zayed Species Conservation Fund, The Rufford Foundation
Zoological Society for the Conservation of Species and Populations


## Engaging stakeholders in community driven wetland conservation

1. Investigate program sustainability of the Maine Vernal Pool Special Area Management Plan (VPSAMP) through qualitative program evaluation in the first wave of towns that have recently adopted the VPSAMP (Topsham, Orono); add additional towns to the database of social and institutional factors as research and SAMP progresses. Additionally, test whether existing sustainability frameworks for health research apply to the VPSAMP.
2. Use the database and data collected from observations and stakeholder interviews to to examine what characteristics (including governance structures, and community capacities (i.e., technical assistance, administrative staffing, funding, structure of town governance, social networks and level of support of relevant town boards and committees) may influence acceptance and implementation of the Maine Vernal Pool SAMP in different community contexts.
3. Develop a spatial analysis tool for land trusts and municipalities to aid with Vernal Pool SAMP implementation.

ABSTRACT: Maine's Vernal Pool Special Area Management Plan (VP SAMP) is an innovative conservation tool that balances local economic development with the conservation of vernal pools, small ephemeral wetlands that occur predominantly on private lands. The VP SAMP, collaboratively developed by researchers and practitioners, is a locally based tool that uses an in-lieu fee mechanism to conserve vernal pools in rural areas while directing development to designated growth areas. Although the VP SAMP has been adopted by two Maine municipalities, full implementation has yet to be completed, highlighting the need to look beyond the creation of the VP SAMP tool to consider how it is applied in practice. Our research examines the process of VP SAMP implementation to better understand and improve use of the tool in current and future contexts. In Chapter 1, we use a qualitative research approach consisting of document analysis, participant observations, and interviews to conduct a formative evaluation of the VP SAMP and identify facilitators and barriers to implementation in two Maine towns. In Chapter 2, we test a multi-criteria spatial prioritization model created to identify conservation opportunities and support implementation decisions in four Maine towns. Our research identified direct facilitators of the first full VP SAMP implementation (defined as: Direct facilitators include: program champions, or individuals that devote resources to implementation; communication that continuously engages partners; education and information sharing for capacity building; evaluation of specific implementation steps; and program adaptation based on the findings of evaluations. Direct barriers to the first full implementation include lack of organizational capacity to carry out evaluation and communication; aspects of the VP SAMP framework not working when implemented; factors outside of town control, such as the COVID-19 pandemic and low development pressure, that have prolonged use; a shortage of properties that afford, or have the characteristics that allow for VP SAMP use; pushback from community members that oppose development; and misinterpretation of VP SAMP partner responsibilities resulting in less support for the program. Facilitators of sustained implementation include positive perceptions of VP SAMP development; integration of the VP SAMP into town policy; strategic planning that is highly participatory; a program framework that utilizes familiar tools such as ordinances and conservation easements and relies on familiar partnerships; capacity building materials such as model ordinances that support the adoption of the VP SAMP in new towns; and policy that supports and aligns with the goals and structure of the VP SAMP such as town comprehensive plans. Barriers to sustained

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implementation include a lack of program access in new communities due to resource intense prerequisites for adoption; leadership turnover resulting in a lack of support for VP SAMP goals; a lack of official program evaluation planning; gaps in communication strategies; and slow or unfinished VP SAMP program implementation. Our decision support tool successfully identifies parcels that are suitable for conservation through the VP SAMP and serves as an evaluation tool for VP SAMP conservation criteria and goals. Resulting maps depict conservation opportunities in the town providing necessary information for implementation decision making. Our findings offer adaptation strategies for more effective implementation and sustained use of the VP SAMP in current and future contexts.

**Investigator:** Megan Leach (MS)

**Advisors:** Aram J.K. Calhoun (Co-Advisor)
Jessica J. Jansujwicz (Co-Advisor)
Tora Johnson

**Duration:** September 2021—August 2024

**Cooperators:**

Brunswick Topsham Land Trust
Orono Land Trust
Orono, Town of
Topsham, Town of

## Evaluating management methods to conserve a nesting Tern colony on Petit Manan Island, ME


**Investigator:** Carolina Alexa Luciani (MWC)

**Advisors:** Amber M. Roth (Advisor)
Cynthia S. Loftin
Linda J. Welch


**Duration:** August 2022—May 2024

**Cooperators:**

U.S. Fish and Wildlife Service

1. Explore the effect of vegetation management actions, such as mowing and burning of vegetation, as well as lethal management, such as egg control, on reducing laughing gull nest density and increasing the tern population on the island

Many islands in the Gulf of Maine provide nesting refugia for a variety of breeding seabird populations. Many colonial seabirds are in decline due to threats such as food depletion from overfishing, competition for nesting space, habitat loss, and adverse weather conditions due to climate change. Increasing native predator populations, particularly gulls, pose a significant threat to smaller seabird species and conservation efforts. Our goal was to evaluate control measures to reduce the impact of laughing gulls on Common and Arctic tern populations on Petit Manan Island as part of a conservation program implemented by the U.S. Fish and Wildlife Service. Vegetative management, including mowing and burning, and lethal methods, such as egg destruction, were studied to assess their efficacy in reducing gull nesting and restoring tern colonies. Years with more mowed area corresponded to increased gull and tern nest counts, though this was confounded by a large tern emigration event in the same years. Nevertheless, mowing is likely important for creating and maintaining tern nesting habitat. Egg control had a potential positive but inconclusive impact on gull nest counts, warranting further investigation. Management efforts should continue to maintain nesting habitat for tern populations and should be considered to mitigate the impacts of gull predation across seabird islands in the GoM and beyond.

## Drivers of space use and winter tick loads of moose in Maine

1. Determine the demographic and environmental characteristics that drive variation in seasonal home and core range area in moose, pertaining to the winter tick drop-off and questing periods.
2. Quantify seasonal home range overlap of moose.
3. Explore drivers of variation in seasonal home range overlap in moose.
4. Evaluate effects of habitat use, seasonal overlap, and climate conditions on winter tick loads of moose.

ABSTRACT: The moose (*Alces alces)* population in the northeastern United States has experienced regional declines in recent years, primarily due to parasitism by winter ticks (*Dermacentor albipictus*). Three factors drive winter tick epizootics: climate change, moose density, and overlap in moose seasonal space use. Previous research has shown that moose density increases with the proportion of optimal habitat (regenerating forest stands) available on the landscape, and average individual tick load is positively correlated with moose density. We used data from GPS-collared moose from 2014–2022 in Maine to explore relationships between moose space use, seasonal overlap, climate, and tick loads on moose.

For Chapter 1, we identified drivers of seasonal moose space use and overlap moose corresponding to the drop-off (spring) and questing (fall) periods of winter ticks. We modeled seasonal home and core range area and seasonal home range overlap, using generalized linear models, and modeled habitat selection of overlap areas using resource selection functions. Fall area increased with precipitation and decreased with later first frost dates. Juveniles had larger fall areas than adults. Spring area decreased with the availability of optimal habitat (forest aged 4-20 years) and snow depth, and it increased with the availability of older forest (aged 21-37 years). Seasonal overlap was positively correlated with the availability of older forest and negatively correlated with snow depth and percent hardwood. Moose selected for optimal habitat within overlap areas compared to the surrounding landscape. Our findings indicate that moose concentrate space use in optimal habitat. Additionally, moose appeared to overlap less in areas with more hardwood, likely due to habitat preferences during the leaf-off season. These results provide insight into demographic and environmental drivers of moose seasonal space use, which play a role in the winter tick system.

In Chapter 2, we modeled tick loads on moose as a function of fall space use, spring-fall home range overlap, and weather variables. To examine the effects of space use and overlap, we made inferences about moose behavior in the period prior to capture based on data from collared individuals after capture. We used generalized linear mixed models to analyze these relationships. Fall precipitation was negatively correlated with tick loads on moose, while late summer drought and snow depth in early spring had positive effects on tick loads. Tick loads were lower on individuals that generally had higher percentages of hardwood in their fall home ranges. Moose with higher seasonal overlap on average had higher tick loads. Our results support the hypothesis that the degree to which moose overlap space use between drop-off and questing seasons may expose individuals to higher tick loads due to re-infection. Additionally, the observed relationship between percent hardwood and tick loads suggests that forest type may affect tick distribution and moose exposure. We recommend that future research focus on winter tick distribution and survival on the landscape at different life stages. Overall, results from this study build upon previous research in the moose-winter-tick system, highlighting the potential importance of space use in parasite transmission.

**Investigator:** Annie Stupik (MS)

**Advisors:** Sabrina Morano (Co-Advisor)
Pauline L. Kamath (Co-Advisor)
Erin Simons-Legaard

**Duration:** September 2021—August 2024

**Cooperators:**

Maine Department of Inland Fisheries and Wildlife
Morris Animal Foundation
National Science Foundation
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – NRT Conservation Science
University of Maine – School of Food and Agriculture
University of Maine – Senator George J. Mitchell Center

## Scales of influence: Predicting plant phenological responses through multiple open-sourced data across the U.S.

1. Identify the challenges and potential of overcoming phenological data silos through data harmonization.
2. Map the probability of phenological events under different climatic, geologic, and urbanization conditions.
3. Map the probability of phenological events under different climatic, geologic and urbanization conditions for future time periods.
4. Quantify the range and phenologic relationships under geographic location and origin constraints.

Plant phenology is an important life history cycle with recurring budding, leafing, flowering and fruiting traits. Angiosperms provide important ecosystem functions and services that have both human and wildlife implications (e.g., agro-commercial dependencies, nutrient cycling). In the United States, the timing of flowering has found to be changing with a large portion of the country experiencing earlier onsets of spring. Shifts in these responses are not well understood at varying spatial and temporal scales, especially with a move towards continental scale studies. There are many different data types used to monitor plant phenology (e.g., herbarium, ecological networks, community science initiatives, remote sensing); however, rarely are these data harmonized limiting model predictions. Improving these predictions are vital towards understanding changes in ecosystem processes (e.g., carbon flux) and species interactions (e.g., pollinator synchrony) with rapid global change. The goal of this project is to better understand the scales of influence on phenological responses to changing predictors across the United States, using open- and multi- sourced data. Data types of focus include herbarium specimens, long-term ecological networks, and community science initiatives. This project will build our knowledge of phenology responses at continental spatial extents and support continuing efforts to progress data harmonization.

A framework for harmonized phenology models has been drafted for submission to scientific journal (i.e., first objective). This will guide further data harmonization throughout the remainder of the objectives, outlining limitations and strengths. Thousands of flowering records from digitized herbarium, the USA National Phenology Network, and the National Ecological Observatory Network have been acquired. The next course of action is to build species distribution models that focus on the phenophase status, to create maps of flowering.

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| Investigator: | Lizbeth Amador (PhD) |
| Advisors: | Sydne Record (Advisor)<br>Jacquelyn L. Gill<br>Susan J. Mazer<br>José E. Meireles<br>Brian J. McGill |
| Duration: | January 2023—August 2026 |
| Cooperators: | |



## A framework to model current and future nonbreeding distributions for four declining Nearctic-Neotropical migratory forest birds to inform conservation planning

1. Map current (2012-2021) wintering ground distributions using selected environmental variables from historical climate conditions (1970-2000 averages) and a multi-source species occurrence dataset.
2. Map future (2050) wintering ground distributions under two climate scenarios (SSP2-RCP4.5 and SSP5-RCP8.5) and three global coupled climate models (CMCC-ESM2, FIO-ESM-2-0, MIROC-ES2L).
3. Map autumn and spring migratory corridors as a representation of airspace habitat.
4. Map migratory stopover within migratory corridors to determine medium- and high-use stopover landscapes.
5. Overlap migratory stopovers to determine stopover hotspots that are shared among all focal species and between migratory seasons.

Many Nearctic-Neotropical migratory forest bird populations are under steep decline due to environmental stressors. In the Neotropics, land use and climate research suggest that major contributors of population decline are rapid deforestation and declines in food availability due to climate change. Recent projections of future breeding ground distributions highlight the need to understand the effects of climate and land use on migratory forest bird species and to expand projection modeling to the Neotropics. The goal of this research is to increase populations of declining Nearctic-Neotropical migratory bird species by using projections of current and future distributions to inform near-term conservation planning. The four focal species in this research are Canada Warbler, Cerulean Warbler, Golden-winged Warbler, and Wood Thrush. Selected environmental variables and multi-source occurrence datasets will be used in a Biomod2 modeling framework to map current (2012-2021) and future (2050) wintering ground distributions. Current wintering ground distributions will be projected based on historical climate conditions (1970-2000 averages), while future distributions will be projected under two climate scenarios (SSP 245 and SSP 585) and three global coupled climate models. This research will provide a framework that can be used to model wintering ground distributions of other Nearctic-Neotropical migrant species.

Project is complete and thesis has been finalized. Waiting for final thesis to be uploaded to UMaine Library and degree to be conferred in December/January.

**Investigator:** Ryan Brodie (MS)

**Advisors:** Amber M. Roth (Advisor)
Sydne Record
Erin Simons-Legaard

**Duration:** September 2022—December 2024

**Cooperators:**

Appalachian Mountain Joint Venture
Cerulean Warbler Technical Group
Environment and Climate Change Canada
Golden-winged Warbler Working Group
Partners in Flight Eastern Working Group
SELVA
U.S. Fish and Wildlife Service
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station
Upper Mississippi/Great Lakes Joint Venture

## American woodcock (*Scolopax minor*) migration ecology in eastern North America

1. Evaluate American woodcock habitat ecology throughout their full annual cycle, including variability in breeding, stopover, and wintering habitat relationships and how these relationships change with geography and vary among age/sex classes.
2. Assess migration ecology of woodcock breeding along a latitudinal gradient to evaluate differences in migration strategies and sources of variation in migratory behavior.
3. Evaluate mortality risk during woodcock migration, compare with risks experienced during non-migratory periods, and identify potentially important risk factors.
4. Use a combination of genomic, isotopic, and GPS tracking methods to assess woodcock population and migratory connectivity throughout their range to inform management and better understand the species' ecology.
5. Conduct a comprehensive study of woodcock spatial ecology in West Virginia, covering all 4 ecoregions

Migratory animals face numerous challenges as they traverse seasonally suitable habitats throughout the full annual cycle. Migratory animals often must traverse foreign landscapes and face many novel threats to which they are naïve. Migratory birds in particular face numerous challenges in human-dominated landscapes, including both direct (e.g., cell towers, wind farms, buildings) and indirect (e.g., changing landscape, light pollution, feral cats) dangers.

The American Woodcock (*Scolopax minor*) is a migratory gamebird that has and continues to experience prolonged declines throughout eastern North America. Woodcock breed from the southeastern United States to southern Canada (March -October) and overwinter primarily in the mid-Atlantic and southeastern United States (November-February). We created the Eastern Woodcock Migration Research Cooperative (EWMRC) to capture and mark woodcock with GPS satellite transmitters throughout the breeding and wintering range.

We have deployed more than 700 GPS transmitters to track woodcock on their breeding and wintering grounds, and during their migrations, and future deployments are planned over the coming years. Ultimately, we will investigate migratory phenology, routes, and connectivity, quantify survival, and evaluate how habitat quality, anthropogenic disturbance, and breeding and overwintering latitude influence these metrics.

As of October 1, 2024, we deployed 737 GPS transmitters on woodcock in 15 states and 3 Canadian provinces. We received location data from 714 of these transmitters, providing data on 547 migration attempts and 433 full migratory paths. We collected feather or blood samples from most marked woodcock to assess woodcock population structure via genomic and isotopic methods. So far, the project has resulted in 2 completed PhD Dissertations, 1 Undergraduate Honors Thesis, and 3 scientific publications in 2024. Additional work is in progress by 1 PhD student and 1 MS student at UMaine, and the project contributed to recently completed theses of collaborators at the University of Rhode Island (1 PhD student) and SUNY-Brockport (1 MS student).

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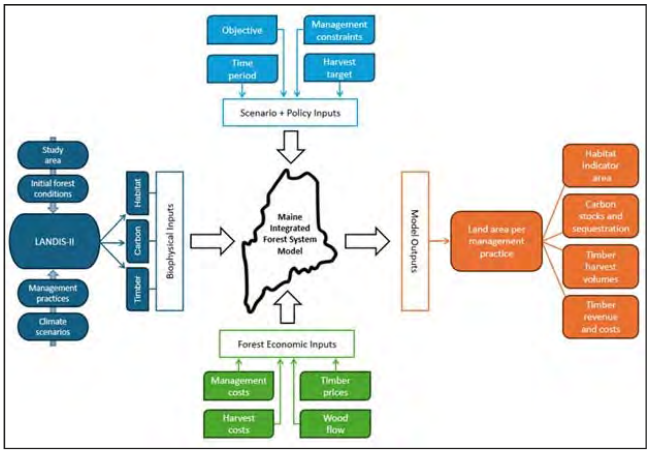
| Investigators | Kylie Brunette (MS)<br>Rachel Darling (PhD) |
| Advisors: | Erik J. Blomberg (Co-Advisor)<br>Amber M. Roth (Co-Advisor) |
| Duration: | October 2017—May 2026 |

Cooperators:

Canaan Valley National Wildlife Refuge
Environment and Climate Change Canada
Louisiana Department of Wildlife and Fisheries
Maine Outdoor Heritage Fund
New York Department of Environmental Conservation
Penobscot Valley Chapter of Maine Audubon Society
South Carolina Department of Natural Resources
State University of New York – Cobleskill
Timberdoodle Habitat Society
U.S. Fish and Wildlife Service
U.S. Fish and Wildlife Service – Webless Migratory Game Gird Program
University of Maine
West Virginia Division of Natural Resources




## Prioritizing wildlife habitat in Maine's commercial forest landscapes: a bio-economic modeling analysis of ecosystem service provision under future management pathways

1. Establish a baseline relationship model between forest structure and composition and species habitat use.
2. Assess the impact of forest management practices and climate scenarios on key components of wildlife habitat.
3. Explore ecosystem service trade-offs and synergies when prioritizing wildlife habitat under alternative management scenarios.

The future of Maine's forests and the ecosystem services they provide, such as wildlife habitat, carbon sequestration and storage, and timber, is uncertain in the face of many climatic, social, economic, and political influencing factors. Changes in Maine's forest management objectives are expected in the upcoming decades and can alter the forested landscape, impacting the quality and suitability of wildlife habitat. This project aims to examine Maine's socio-economic and political drivers of forest management decisions in the context of changing climates to understand how they may impact the bottom line for wildlife, carbon, and timber. The project plan is to extend recent modeling frameworks and forest sector analyses from focuses on timber production and carbon sequestration to explicitly consider the habitat implications of potential forest industry changes for big game species (e.g., moose, white-tailed deer, and black bear), another important component of Maine's forest economy. Integrated model outputs, including spatial land cover and habitat condition projections, will allow us to quantify the trade-offs of potential management pathways on our key ecosystem services over time, contributing to a more informed discussion on how to manage Maine's forests to optimize or balance their multiple functions.

The project is currently in the final stages of thesis drafting after completion of the analysis for chapters 1 and 2. Chapter 1 focused on modelling the spatiotemporal effects of seven management practices on eleven habitat indicators spanning 100 years and under three different climate scenarios (none/moderate/high). Outputs from Chapter 1's analysis served as the biophysical inputs for Chapter 2's analysis which used optimization modelling to determine an optimal distribution of management practices that will enable meeting multiple ecosystem service objectives and how key ecosystem services are anticipated to change over time under the modeled pathway.

**Investigator:** Christy Carovillano (MS)

**Advisors:** Sabrina Morano (Co-Advisor)
Adam J. Daigneault (Co-Advisor)
Erin Simons-Legaard

**Duration:** September 2022—May 2025

**Cooperators:**

National Science Foundation
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – NRT Conservation Science
University of Maine – School of Forest Resources

## Landscape-scale responses of marten populations to 30 years of habitat change in commercially managed landscapes of northern Maine

1. Replicate previous trapping protocols conducted during spring and summer 1989–19987 to survey spatial occurrence of resident, non-juvenile (≥1 year) martens on commercially managed timberlands bordering the western boundary of Baxter State Park. Radio-collar captured marten and track using VHF triangulation throughout the leaf-on season to estimate boundaries of sex-specific territories.
2. Utilize a time series of satellite imagery, aerial photography, and ground measurements to create a detailed landcover map documenting forest characteristics and harvest histories as they relate to habitat currencies for marten in Maine.
3. Develop landscape-scale models to evaluate how patterns of occurrence, habitat selection, density, and demographics of martens have changed in association with the cumulative effects of landscape change resulting primarily from timber harvesting.
4. Provide reliable models for predicting forest harvesting effects on martens in contemporary landscapes.

Since the enactment of the Maine Forest Practices Act, it is unclear to what degree forest-dependent wildlife have responded to the resulting patterns of landscape composition and connectivity. The goal of this project is to better understand the effects of cumulative landscape changes resulting from timber harvesting in the past 30 years on habitat quality for American marten in northcentral Maine. Analyses will utilize empirical data collected during historical (1989–1998) and contemporary (2018–2019) field studies of marten, which surveyed an industrial forest (T4R11/T5R11 WELS) and a forest reserve (portion of Baxter State Park). We will use these data in conjunction with a time series of forest characteristics derived from aerial photography and satellite imagery to assess potential changes in second-order habitat selection, home range characteristics, and survival in non-juvenile, resident marten, as well as consequences for patterns of spatial occurrence, population densities, and demographics. Providing reliable models characterizing the behavioral and demographic responses of marten to varying intensities of timber harvest over time would enhance the ability of managers to both assess the current status of marten populations in contemporary landscapes and predict future outcomes of alternative forest management scenarios on marten.

Efforts during 2021 focused on conducting a multi-method analysis comparing estimates of marten detection and proportion of area occupied between camera traps and live trapping.

All data has been collected and the project is in the final stages of analysis and write up.

**Investigator:** Kirsten Fagan (PhD)

**Advisors:** Erin Simons-Legaard (Advisor)
Erik J. Blomberg
Zachary G. Loman
Angela K. Fuller

**Duration:** January 2018—May 2025

**Cooperators:**

Katahdin Forest Management, LLC
Pelletier Brothers, Inc.
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Maine Cooperative Forestry Research Unit

## Environmental DNA (eDNA) sampling in vernal pools

1. Develop vernal pool eDNA assays for detecting target wildlife species.
2. Develop and test field protocols for vernal pool eDNA sampling.
3. Cooperate with participating landowners, community science programs, and school groups to perform vernal pool eDNA sampling across Maine.

Vernal pools support habitat for numerous sensitive species that can be difficult to detect with traditional methods. Modern techniques for analyzing environmental DNA (eDNA) offers the potential to detect such species by simply collecting a small amount of water from the pools. As a relatively new field, there is little guidance on how to apply eDNA approaches to vernal pools. This project aims to develop laboratory assays and optimize field protocols for eDNA sampling of vernal pools, looking at both selected rare species as well as broader analyses of the ecological communities. In the first year, we are analyzing repeated sampling conducted at a handful of vernal pools to understand how eDNA varies over space within a pool and over time throughout the vernal pool active season. With these samples, we are developing laboratory protocols for extracting and cleaning DNA, developing PCR primers for blue-spotted salamander, Jefferson salamanders and unisexual salamander complex, and conducting meta-barcoding of the species in these samples. In future years we will expand our suite of target species and collect from more sites, working with landowners, community members and researchers to advance management and conservation objectives.

As of August 2024, we have performed several studies and worked in the lab to optimize eDNA protocols in vernal pools and better understand cryptic biodiversity patterns in Maine's forested wetlands. In 2021, we performed a pilot study in 12 wetlands in the northeastern US and used eDNA metabarcoding to evaluate spatial and temporal variation in vernal pool communities. In 2023, we conducted a validation study in 15 wetlands comparing eDNA to traditional monitoring methods for amphibians and other wildlife using vernal pools. This validation study was part of a larger eDNA study in central Maine that surveyed over 30 sites to estimate blue-spotted salamander and unisexual Ambystoma breeding habitat requirements. In the lab, we have designed and tested eDNA assays for species-level and community-level ecological applications and are currently working to optimize methods for studying rare salamanders in the northeast.


**Investigators:** Harrison Goldspiel (PhD)

**Advisors:** Noah D. Charney (Advisor)
Erin K. Grey
Aram J.K. Calhoun
Brian J. McGill
Joseph D. Zydlewski

**Duration:** February 2021—December 2025

**Cooperators:**

Cornell University – Cornell Wildlife Health Lab
Massachusetts Division of Fisheries and Wildlife – Natural Heritage and Endangered Species Program
Saint Lawrence University – Department of Biology


## Evaluating moose-winter tick dynamics utilizing remote cameras on Penobscot Nation Lands

1. Determine how Winter Tick related hair loss influences Moose space-use on tribal lands.
2. Quantify patterns of hair loss caused by winter tick infestation.
3. Estimate moose abundance on tribal lands using remote cameras.

Moose have significant ecological, economic and cultural importance both to the Penobscot and the people of Maine. A growing concern for moose on tribal lands is the spread of winter tick, a parasite that feeds on moose to undergo their life cycle. Moderate to severe winter tick infestation can have significant negative consequences for moose health, reproduction, and survival, posing a serious threat to moose populations. Because of the unique relationship between winter tick and moose, tick distributions and abundance are believed to be directly related to moose distributions and density during the tick questing period in the fall and drop-off in early spring. Thus understanding the factors influencing Moose distribution on Penobscot lands is critical for identifying potential environmental reservoirs contributing to the increase in winter tick infestations of Moose. Using data from 75 cameras across 7 tribal properties we will employ multi-state occupancy models to understand moose space use and the influence of winter tick infestation on moose distributions.

Over 75 thousand images from our remote cameras have been annotated by 24 undergraduate students and 39 volunteers. Over 30 different taxa have been observed on our remote cameras, including roughly 70 thousand detections of moose (*Alces alces*), 10 thousand detections of white-tailed deer (*Odocoileus virginianus*), and 2 thousand detections of black bear (*Ursus americanus*). We have begun assessing infestation severity of individual moose using a quardrant scoring system and plan to use this preliminary data to develop our multi-state occupancy models.

**Investigator:** Nina Kappel (MS)

**Advisors:** Sabrina Morano (Co-Advisor)
Benjamin Simpson
Alexje Siren
Pauline L. Kamath

**Duration:** July 2023—December 2025

**Cooperators:**

Penobscot Indian Nation
University of Vermont

## A structured decision making framework to guide wild turkey population and harvest management in Maine

1. Quantify uncertainty in turkey abundance estimates originating from data collection using a simulation approach and identify the most efficient sampling framework moving forward for robust population inference. This will include an evaluation of uncertainty related to various hunter reporting met.
2. Evaluate candidate harvest management regulations by simulating region-specific turkey abundance over time to predict likely future population outcomes.
3. Provide MDIFW with a web-based tool that allows managers to evaluate potential population outcomes under varying harvest scenarios.

We will develop a simulated population model that uses previously-developed population estimates, historic (2017-2023) reporting data, and additional data collection (e.g., contemporary reward banding) to project future turkey population size. This simulated data will be used to assess future data collection needs to maintain the integrated population model estimates in order to track future population dynamics and support subsequent management decision making. We will use the completed simulation model from objective 1 to predict turkey population responses to a portfolio of management options that may be considered by MDIFW. We will project turkey populations forward in time under the candidate management options to provide expected outcomes and associated uncertainty for each decision. Using the R package 'shiny', we will create a web-based user interface for evaluating turkey response to particular management decisions.

We have designed 12 variations to the original turkey population data simulation to determine how changes to the model inputs affect estimates of abundance, harvest rate, survival rate, and recruitment rate. These simulations include 1) age ratio at capture (Adult:Juvenile), 2) a low number of capture sites, 3) a medium number of capture sites, 4) a high number of capture sites, 6) harvest rate estimates from only banding data, 7) juvenile recruitment as a spatial variable, 8) the use of reward bands, 9) a spatial trend in harvest rate, 10) a temporal trend in harvest rate, 11) a spatial and temporal trend in harvest rate, and 12) variations in the number of turkeys banded per year. We are now testing different modifications of the original integrated population model to determine if banding should occur every year and which version of the model should be used for the web-based tool.

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| Investigator: | Lara Katz (PhD) |
| Advisors: | Joseph D. Zydlewski (Co-Advisor)<br>Erik J. Blomberg (Co-Advisor)<br>Kelsey Sullivan |
| Duration: | September 2023—December 2027 |

Cooperators:

Maine Department of Inland Fisheries and Wildlife
University of Maine – Advanced Computing Group
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Ecology and Environmental Sciences Program
University of Maine – Maine Agricultural and Forest Experiment Station

## Birds, trees, and satellites: Modeling high-elevation spruce-fir forest patch dynamics to inform forestry practices and Bicknell's Thrush breeding habitat models

1, Model spatial characteristics of Bicknell's Thrush breeding habitat in the Northeast US and Southeast Canada.
2. Translate findings into silvicultural recommendations that aid managers of working forests.

This research focuses on Bicknell's Thrush and their breeding habitat selection in the Northeast US and Southeast Canada. Bicknell's Thrush is a declining migratory songbird that breeds in both naturally disturbed high-elevation spruce-fir forests and working forests regenerating after harvest. These forests are typically at lower elevations and resemble their natural breeding habitat, although the effects on breeding behavior are largely unknown.

The primary objective of my research is to model the spatial characteristics of Bicknell's Thrush breeding habitat using field data and remote sensing technologies. Analyses will rely on citizen science data to estimate Bicknell's Thrush spatial abundance and satellite and LiDAR datasets to map forest composition and structure. By analyzing patterns and trends in habitat selection, I aim to identify factors affecting the availability and quality of breeding sites.

The ultimate goal of this research is to translate these findings into practical silvicultural recommendations that aid forest managers. By providing insights into how disturbances impact habitat suitability, my work will help develop management practices that support the long-term viability of Bicknell's Thrush populations. This research will serve as a framework for predicting habitat suitability for Bicknell's Thrush and similar species, contributing to effective conservation planning and management.

For our first chapter, we examined Bicknell's thrush nesting habitat as a mosaic of vegetation stages and structures within a forested landscape. We modeled how the size, number, and arrangement of patches affect thrush abundance during the nesting season. Our models predict higher abundances of Bicknell's Thrush where there are large patches of dense, short spruce-fir forest that are minimally fragmented. Proximity to tall, sparse forests can negate this preference, possibly due to increased nest predation from squirrels and competition with other bird species. Currently we are investigating how habitat stability (i.e. the size, frequency, and magnitude of forest disturbances) affects Bicknell's thrush occupancy over time. Together, these results will inform ecological forestry approaches to Bicknell's thrush breeding habitat management.

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**Investigator:** James Longo (MS)

**Advisors:** Amber M. Roth (Advisor)
Erin Simons-Legaard
Nicole S. Rogers
Junior A. Tremblay

**Duration:** January 2023—August 2025

**Cooperators:**

Environment and Climate Change Canada
University of Maine – Maine Agricultural and Forest Experiment Station

## Resource selection in a landscape of fear: effects of risk perception and personality on small mammal microhabitat use and seed choice

1. Assess how predator presence alters associations between small mammal microhabitat selection and personality.
2. Determine the consequences of gray squirrel personality on novel seed dispersal .
3. Assess how predation risk and personality influence seed foraging decisions by southern red-backed voles.
4. Investigate how the personality of small mammals influences their effectiveness at finding seeds.
5. Determine how the proportion of personalities in a small mammal population affects forest regeneration .

I am working on an ongoing capture-mark-recapture small mammal study in the Penobscot Experimental Forest and will use capture and personality data from all 8 years of this study. I will conduct predator monitoring, use microhabitat data from our study area, and map home ranges of individuals to link personality to microhabitat selection under variable predation risk. I will trap squirrels throughout New England, run personality tests, and offer seeds, including seeds native throughout New England and seeds native only in southern New England, to assess how squirrel personality affects dispersal variables and whether these relationships are mediated by seed novelty. For objective #3, I will use data collected about the decisions of voles at risky versus safe foraging sites to determine the role of personality and predation risk in foraging decisions. I will also conduct a field experiment offering scattered seeds to small mammals and recording how long they search for seeds, the area they search over, and how many seeds they find to determine individual effectiveness. Lastly, I will incorporate our data with forest growth simulators to determine how changing proportions of personalities in a population influence the number of seeds that are recruited in the next generation.

The field work portion of this project has been fully completed. Objectives 1-3 are done, a manuscript detailing objective 3 has been published, and manuscripts explaining the results of objectives 1 and 2 have been submitted for publication. I am finalizing results and writing the manuscript for objective 4 now. The next step is to submit my manuscript for objective 4 and start working on objective 5.

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| Investigator: | Margaret Merz (MS) |
| Advisors: | Alessio Mortelliti (Co-Advisor)<br>Sydne Record (Co-Advisor)<br>Sabrina Morano<br>Aaron R. Weiskittel<br>Brian J. McGill |
| Duration: | July 2021—May 2025 |
| Cooperators: | |

## Using citizen science to map and predict amphibian road crossings in Acadia National Park

Many taxa of wildlife are affected by habitat fragmentation by roads and the associated mortality risks. Amphibians may migrate across roads to reach breeding areas, while foraging in terrestrial habitat, and when out-migrating from natal habitat as a juvenile. Knowledge of when and where amphibians migrate across roads is almost non-existent in Acadia National Park, which in the mid-coast region of Maine, and knowledge of how the movements of different life stages of amphibians differ (adults v. juveniles) is rare. Park managers have asked researchers to initiate a citizen science project to investigate amphibian road movements. Knowledge from this research will be used to develop spatial and temporal predictive models of amphibian road crossing hotspots. Models will be used by managers to implement mitigation techniques within the park.

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| Investigator: | Marisa Monroe (MS) |
| Advisors: | Noah D. Charney (Advisor) |
| Duration: | September 2023—December 2025 |
| Cooperators: | |

National Park Service
Schoodic Institute

BCG Model Upper Tana Watershed

1. Conduct a comprehensive literature review on biotic indices to ascertain the potential use of community science collected bird data in bioassessmenta and use of birds as bioindicators to assess watershed health.
2. Evaluate the impacts of disturbance/stressors on the bird community composition in the Upper Tana Watershed, identifying key bird species that serve as reliable indicators for different levels of watershed disturbance.
3. Combined with results of objective 1,2, available literature, and Kenyan Ornithologists, develop a bird-based biotic index for riparian watersheds using assemblages derived from community science observations for the UTW.

Watersheds are complex hydrological systems supporting biodiversity. Measuring ecosystem integrity at a watershed scale may be important to understanding and prioritizing conservation. Most watershed integrity indices have relied on aquatic macroinvertebrates, fish, and algae. Despite relatively wide adoption, indices developed from these taxonomic groups may be expensive and time consuming. The popularity of birding and the recent increases in community science projects associated with birds suggest that they may provide a promising alternative. However, it remains relatively unknown to what extent community science generated data on birds can be used to inform watershed bio-assessments. I seek to develop an avian biotic index to assess the status of the Upper Tana Watershed in Kenya as a case study using community science bird data from the Kenya Bird Map project and the habitat characteristics generated from spatial and temporal land cover analysis to examine relationships between landscape composition features and avian diversity. The pilot working draft bird-based Biological Condition Gradient (BCG) matrix includes 6 tiers based primarily on forest bird species. I seek to further explore the variables and tiers that best describe bird community relationships with ecosystem condition and hope that this can be used as a model elsewhere to help inform best watershed management practices.

Student passed comprehensive exams and advanced to PhD candidacy and has continued to make progress analyzing bird community responses to disturbance in the Upper Tana Watershed. A major accomplishment was developing and validating a composite disturbance gradient incorporating land use and road density data. Although an NMDS analyses did not reveal distinct bird assemblages across disturbance levels, functional trait analysis showed patterns in feeding guilds and habitat preferences across the gradient. The student has initiated development of a 3-tier Biotic index and re-assessing his model's performance. Next steps include refining the disturbance gradient and to assess how this relates to the bird species compositions, trait-based analyses, completing expert validation of the BCG framework, and developing final biotic index criteria. The project remains on schedule, with analytical approaches refinement based on committee recommendations ongoing. The research continues to advance toward its goal of developing a bird-based biotic index for watershed assessment using community science data.

**Investigator:** Edwin Njuguna (PhD)

**Advisors:** Christina A. Murphy (Co-Advisor)
Cynthia S. Loftin (Co-Advisor)
Malcolm L. Hunter, Jr. (Co-Advisor)
David Courtemanch
Brian J. McGill

**Duration:** May 2022—December 2025

**Cooperators:**

Nature Conservancy, The

## Breeding Ecology of Hybridizing Golden-winged Warbler and Blue-winged Warbler at Fort Drum, New York

1. Breeding Ecology of Hybridizing Golden-winged Warbler and Blue-winged Warbler at Fort Drum, New York
2. Assess spring arrival timing and nest initiation relative to green-up phenology to account for variation in nest survival
3. Estimate species fecundity by analyzing genotypic composition of nesting broods
4. Evaluate whether shrub community composition at nest sites influences nestling diets

Golden-winged Warblers have experienced an average annual decline of 1.4% since 1966, sparking significant conservation interest in these Neotropical-Nearctic migratory songbirds. In addition to habitat loss and climate change, hybridization with the closely related Blue-winged Warbler is considered a major factor contributing to their decline. This project is investigating the mechanisms behind Golden-winged Warbler declines in hybrid zones.

By evaluating how habitat preferences, migration timing, and genetic swamping may result in fitness advantages for Blue-winged Warblers over Golden-winged Warblers, this project aims to uncover key drivers of the Golden-winged Warbler decline within a major hybrid zone located at Fort Drum, New York. This research involves nest monitoring, population modeling, habitat characterization using aerial LiDAR and satellite imagery, and genetic analysis of adults and juveniles at Fort Drum, New York. By integrating these factors, the project hopes to inform conservation strategies aimed at maintaining viable Golden-winged Warbler populations and mitigating the impacts of hybridization.

As of Fall 2024, two field seasons are now completed on Fort Drum, with a reduced field season slated for Spring 2025. Our crews were successful in finding 106 nests and monitoring them every 3 days until nest fates were determined. We tracked 79 fledglings 1,072 times with radio telemetry. We also sampled vegetation at 1,578 plots and documented locations with a high-accuracy GNSS receiver for precise habitat modeling. The project is currently in the data analysis and manuscript preparation stage.

**Investigator:** Kurt M. Ongman (PhD)

**Advisors:** Amber M. Roth (Advisor)
Erik J. Blomberg
Brian J. Olsen
Parinaz Rahimzadeh-Bajgiran
David P.L. Toews

**Duration:** August 2022—August 2026

**Cooperators:**

Army Corps of Engineers
Fort Drum Natural Resources Branch
Garden Club of America, The
Golden-winged Warbler Working Group
Northern New York Audubon Society
U.S. Fish and Wildlife Service
Barbara Wheatland Geospatial and Remote Sensing Analysis Laboratory

## Birds as indicators of forest management sustainability in Maine: An evaluation of past surveys and future assessment approaches

1. Analyze bird line-transect survey data collected from 2017-2024 to assess bird diversity, individual species density, and community composition in response to silvicultural treatments through time.
2. Develop a cost-effective, long term survey plan to evaluate bird response to silvicultural treatments using Automated Recording Units (ARUs).
3. Develop a consortium of long-term, regional bird studies from the Acadian Forest region with the goal of differentiating local forest management effects from regional phenomenon.

Sustainable forest management benefits from the use of ecological indicators, such as birds. However, the impact of silvicultural treatments on Acadian Forest birds over time is debated and calls for more regional long-term surveys to better understand its effects.

The Maine Adaptive Silviculture Network (MASN) is a statewide network of forest landowners which demonstrates a range of silvicultural treatment options across a range of forest conditions. Bird transect surveys have been conducted on these sites since 2017. Using this data, we can explore differences in bird community and species responses to different silvicultural treatments across Maine over time.

Continued long-term studies at these sites will be difficult due to the remote and spread out locations. A solution comes in the form of Automated Recording Units (ARUs). ARUs automatically take audio recordings of its surroundings based on a determined schedule. Thus, with multiple ARUs, multiple sites can be surveyed at the same time, every day, over a span of weeks. However, we need to understand the accuracy and limits of ARU surveying specifically in Maine forests before a new survey plan is developed.

The most recent transect data was collected in the summer of 2024. 16 ARUs were deployed across 5 different MASN sites and retrieved thanks to our cooperators. Transect and ARU surveys was done simultaneously at these sites to explore the potential differences in results. ARU experiments to test detection distances of different bird songs and frequency in different forest conditions were conducted this late summer/early fall. The current course of action is to begin data analysis of both transect and ARU data. Results will be used to prepare for survey methodology development with the ARU technical team in the spring.

https://ambermroth.weebly.com/

**Investigator:** Percival Ulsamer (MS)

**Advisors:** Amber M. Roth (Co-Advisor)
Erin Simons-Legaard (Co-Advisor)

**Duration:** May 2024—May 2026

**Cooperators:**

American Forest Management, Inc.
Appalachian Mountain Club
Baskahegan Company
Clayton Woodland Holdings, LLC
J.D. Irving, Ltd.
Maine Audubon
Manulife Investment Management
Seven Islands Land Company
University of Maine – Maine Cooperative Forestry Research Unit
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Adaptative Silviculture Network
University of Maine – School of Forest Resources
Wagner Forest Management, Ltd.
Weyerhaeuser Company

## Ecological consequences of small mammal personality and land-use change on stress response, novel seed dispersal, vector-pathogen disease dynamics, and interspecific competition

1. Assess whether land-use change differentially affects behavioral types in deer mice, if effects are mediated by glucocorticoids, and if there are associated fitness consequences.
2. Examine how personality-driven seed predation/dispersal decisions affect the expansion of climate-change-induced range shifts in plant species.
   2a. Does personality predict selection, predation, and dispersal of novel seeds?
   2b. Do silvicultural practice modify relationships between personality and seed interaction parameters?
3. Explore personality traits as determinants of Lyme disease infection status, if this relationship is mediated by microhabitat use, and if land-use change can alter existing relationships.
4. Determine how individual survival depends on the behavioral composition of neighboring heterospecifics and whether land-use change affects these relationships.

The project plan is to explore how land-use change affects individual behavioral variation which in turn may affect dynamics on the community and ecological scale. I will be continuing a capture-mark-recapture study on 5 species of small mammals in the Penobscot Experimental Forest (Bradley, ME) alongside two other graduate students. This CMR study began in the summer of 2016, incorporates 3 different behavioral tests, and continued until the end of the field season in 2023 for a total data set spanning 8 years. The current plan is to submit the manuscript for objective 4 in March 2025 and prepare logistics for working in the lab to collect data for objective 1. I plan to defend August of 2025.

To date, there are 8 complete seasons of demography and personality data. Since June 2020, I have finished collecting data and samples for objectives #2, 3, and 4. Further data collection is needed for objective 1 and I am in contact with Heather Hamlin to work in her lab. Objective 3 has been published in the Journal of Mammalogy and the manuscript for objective 2 has been accepted in Ecosphere.

**Investigator:** Ivy Yen (PhD)

**Advisors:** Alessio Mortelliti (Advisor)
Noah D. Charney
Shawn R. Fraver
Allison Gardner
Michael T. Kinnison

**Duration:** June 2020—August 2025

**Cooperators:**

National Science Foundation – Experimental Program to Stimulate Competitive Research
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – School of Biology and Ecology

# INTEGRATED ecology

## Can freshwater fisheries provide sustenance in an age of scarcity, simplification and strife? A biophysical economic analysis of ice-angling for panfish in central Maine

1. Use otoliths from ice fished panfish to infer survival, growth, longevity , age -size structure and biomass production of panfish
2. Investigating lake productivity using trophic transfer efficiency mode
3. Angler attitude and behavior to ice-fishing amidst economic and climate crises
4. Biophysical economic analysis of freshwater fisheries sustenance

Recent decades of fossil-fuel-driven economic and population growth have pushed humanity beyond Earth's carrying capacity, contributing to climate change, biodiversity loss, resource depletion, and social unrest. In response, rural communities in Maine may increasingly depend on local ecosystems for sustenance via activities such as fishing, hunting, and foraging. Our project aims to assess the potential of ice-angling for panfish to provide food security for Mainers in a future marked by scarcity and economic instability. We will analyze otoliths from panfish collected over the past 10+ years to derive key individual and population-level characteristics, and integrate these data with trophic transfer models to evaluate the species' capacity to sustain local anglers, in essence, estimate lake productivity. Additionally, we will survey and interview Maine anglers to understand how climate and economic shocks influence fishing practices and harvest pressure. Eventually, compare the demand for panfish with the productive capacity of local ponds using a biophysical-economic model that incorporates human behavior, we aim to reveal feedback loops between fish populations, lake productivity, and angler behavior.

For our first objective, which focuses on the age, growth, and size structure of panfish, data collection from Hermon Pondand analysis have been completed, and we are currently drafting a manuscript detailing our findings. For our second objective—assessing human perceptions and behavioral responses to climate and economic crises—we are actively collecting data. To facilitate this, we published an advertisement for responses in the Winter 2025 edition of the Sportman's Alliance of Maine Newsletter. Finally, concerning the lake productivity piece, we are in the planning phase, working on logistics and preliminary arrangements to ensure successful data acquisition of both physical and chemical parameters in Hermon Pond, Fields pond and Hicks Pond.

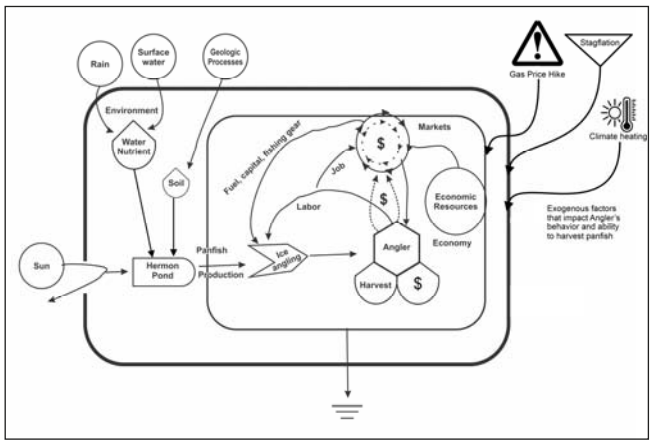
**Investigator:** Deborah Alademehin (PhD)

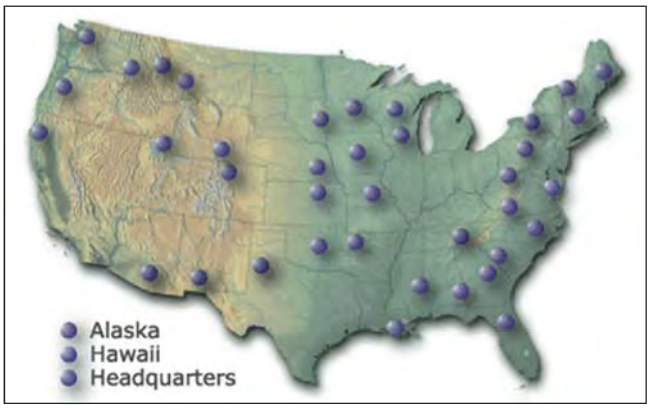
**Advisors:** Stephen M. Coghlan, Jr. (Advisor)
Christina A. Murphy
Cynthia S. Loftin
Jessica J. Jansujwicz
Michael T. Kinnison

**Duration:** August 2022—August 2026

**Cooperators:**

Lake Stewards of Maine
Maine Outdoor Heritage Fund
Sportsman's Alliance of Maine
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station






## A collaborative organizational network analysis of the cooperative research units program

1. Examine the variation among Unit and Cooperator characteristics as linked to success in meeting mission goals.
2. Determine how spatial characteristics play a role in meeting unit goals.
3. Characterize cooperator engagement and communication and identify barriers to effective collaboration.
4. Assess the success of the Units in terms of demographic inclusivity at all levels.
5. Describe the degree to which changes in natural resource management have influenced the CRU Program's mission goals.

The USGS Cooperative Fish and Wildlife Research Units (CRU) program originated in 1935 to fill a need for qualified wildlife and fisheries professionals and provide evidence-based research to inform resource management. Currently, the program supports 42 individual units in 40 states and formalizes relationships between a state natural resources management agency, a host university, the USGS, the USFWS, and the Wildlife Management Institute. The CRU has contributed to a legacy of success by conducting decades worth of research projects while mentoring graduate students and providing technical assistance to address the breadth of cooperator information needs. Though its contributions to research and management are well regarded, questions have been raised about the program's long-term success in meeting mission goals given the changing natural resources landscape.

The Units and Cooperating are diverse and serve a community with equally varied economic and conservation priorities. Cooperating partners employ different management styles, strategies, and resources to meet programmatic goals. These differences likely influence how individual units operate. Using surveys, interviews, and historical accounts, we will conduct social network analyses to examine the structure, communication, and socio-technical connectivity of the program. The data we collect will allow us to characterize the current state of the CRU, identify variability across the Units, and link specific attributes to success in meeting mission goals. In particular, we will investigate how relationships among cooperators (internal and external) shape program outcomes, the effect of regional variability, and diversity across the Units and Cooperators.

In the 2022-23 fiscal year, the social network analysis of CRU Cooperators continued, refining our understanding of collaboration patterns and influencing factors. The OMB-approved Cooperator perception survey was successfully administered, capturing diverse viewpoints on program effectiveness from various leadership levels and organizations. We completed an analysis of 20 years of CRU publications, revealing trends in co-authorship, organizational representation, and evolving research topics. This bibliographic study provided valuable insights into changing priorities among cooperators. Our ongoing examination of historical website data of signatory cooperators, dating back to 1996, is tracking shifts in organizational culture, priorities, and public communication strategies. This multi-faceted approach is enhancing our understanding of the CRU program's evolution, its impact, and how cooperators have adapted to address emerging conservation challenges over time.

**Investigator:** Sarah Vogel (PhD)

**Advisors:** Cynthia S. Loftin (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)
James M. Cook
David C. Fulton
Linda Silka

**Duration:** September 2020—May 2025

**Cooperators:**

University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit

# PUBLICATIONS and presentations

## PUBLICATIONS


Allen, D.C., Larson, J., Murphy, C.A., Garcia, E.A., Anderson, K.E., Busch, M.H. et al. (2024) Global patterns of allochthony in stream–riparian meta-ecosystems. *Ecology Letters*, 27, e14401.

Clements, S. J. et al. Satellite tracking of American Woodcock reveals a gradient of migration strategies. *Ornithology* 141, 1–14 (2024).

Eberhardt, E., Murphy, C.A., Gerth, W., Konstantinidis, P., and Arismendi, I. Documenting historical anchorworm parasitism of introduced warmwater fishes in the Willamette River Basin, Oregon. *Northwest Science* 97:2.

Fish, A. C. et al. American woodcock migration phenology in eastern North America: implications for hunting season timing. 1–24 (2024) *Journal of Wildlife Management* e22565. doi:10.1002/jwmg.22565.

Flye, M., Sponarski, C., McGreavy, B., and Zydlewski, J. (2023) Leading the charge: A qualitative case-study of leadership conditions in collaborative environmental governance structures. *Journal of Environmental Management*, 348, 119203. DOI: 10.1016/j.jenvman.2023.119203

Katz, L.S., Coghlan, S.M., Blomberg, E.J., Kinnison, M.T., York, G. and Zydlewski, J.D. (2024). An integrative approach to assessing bridle shiner (*Notropis bifrenatus*) distribution using environmental DNA and traditional techniques. *Canadian Journal of Fisheries and Aquatic Sciences*, 81(9), pp.1217–1237. doi: https://doi.org/10.1139/cjfas-2023-0234.

Larson, M.S., A. Choudhury, E.N. Gardner, P. Konstantinidis, C.A. Murphy, M.L. Kent, J.T. Peterson, and C.E. Couch. 2024. Diet and Philonema oncorhynchi infections in reservoir -rearing juvenile Chinook salmon (Oncorhynchus tshawytscha). *Transactions of the American Fisheries Society* 153(3): 312-325.

Mensinger, M., Hawkes, J., Goulette, G., Mortelliti, A., Blomberg, E., and Zydlewski, J. (2024) Dams facilitate predation during Atlantic salmon smolt migration. *Canadian Journal of Fisheries and Aquatic Sciences* 81 (1): 38-51. DOI: 10.1139/cjfas-2023-0175.

Murphy, C.A., Gerth, W.G., Neal, T., Antonelli, K., Sanders, J.L., Williams T., Roennfeldt, R-L., Crowhurst, R., Arismendi, I. Evidence for infection influencing survival of the freshwater copepod Salmincola californiensis, a parasite of Pacific salmon and trout. *Journal of Aquatic Animal Health*, Volume 35, Issue 4, December 2023, Pages 280–285. https://doi.org/10.1002/aah.10206.

Murphy, C.A., Pollock, A.M.M., Arismendi, I. and Johnson, S.L. (2023). HABs and HAB nots: Dynamics of phytoplankton blooms across similar oligotrophic reservoirs. *Limnologica*, [online] p.126110. doi:https://doi.org/10.1016/j.limno.2023.126110.

Pope, A.C., Kock, T.J., Perry, R.W., Cogliati, K.M., O'Malley, K.G., Murphy, C.A., Hance,

D.J., Fielding, S.D. Using parentage-based tagging to estimate survival of Chinook salmon fry in a large storage reservoir. *Environmental Biology of Fishes.*

Poulet, C., Lassalle, G., Jordaan, A., Limburg, K., Nack, C., Nye, J., O'Malley, A., O'Malley-Barber, B., Stich,D., Waldman, J., Zydlewski, J. and Lambert, P. (2023) Effect of dispersal capacities and reproductive strategies/tactics on the structure of American shad populations across the species native range: an exploration based on a mechanistic species distribution model. *Ecosphere* 14(12): 1-21.

Slezak, C. R. et al. Unconventional life history in a migratory shorebird: desegregating reproduction and migration. *Proc. R. Soc. B Biol. Sci.* 291, (2024).

Smith, R. Niches and species distribution models. *Teaching Issues and Experiments in Ecology*, Vol. 20: Practice #4.

Zydlewski, J., Coghlan. Jr., S., Dillingham, C., Figueroa-Muñoz, G., Merriam, C., Smith, S., Smith, R., Stich, D., Vogel, S., Wilson, K., and Zydlewski, G. (2023) Seven dam challenges for migratory fish: insights from the Penobscot River. *Frontiers in Ecology and Evolution*. 11, 1253657. DOI: 10.3389/fevo.2023.1253657.

## TECHNICAL PUBLICATIONS

Brunette, K., R. Darling, A. Roth, E. Blomberg. 2023. Migration and nesting ecology of American Woodcock in West Virginia. Year 1 Progress Report.

Carey, R. and J. Zydlewski. 2024. The Maine Cooperative Fish and Wildlife Research Unit and University of Maine Department of Wildlife Ecology 2023 Annual Report to Cooperators. 70 pp.

Carey, R. and J. Zydlewski. 2024. The Maine Cooperative Fish and Wildlife Research Unit and University of Maine Department of Wildlife Ecology 2022 Report to Cooperators. 80 pp.

Darling, R., Berigan, L.A., Fish, A., S. Clements, K. Brunette, C. Slezak, K. Filkins, A. Roth, S. McWilliams, J. Straub, and E. Blomberg. 2023. American woodcock (*Scolopax minor*) migration ecology in the eastern management unit. Year 6 Progress Report. Available Online

## THESES AND DISSERTATIONS

Berigan, L. A. 2024. Full annual cycle analysis of American Woodcock (*Scolopax minor*) distribution, habitat use, and migration ecology. PhD Dissertation, University of Maine. Digital Commons.

Berigan, Liam A., "Full Annual Cycle Analysis of American Woodcock (*Scolopax minor*) Distribution, Habitat Use, and Migration Ecology" (2024). *Electronic Theses and Dissertations*. 3941.

Filiberti, Emily, "Spatial and Demographic Variations in Apparent Annual Survival of Golden-Winged Warblers: a Range-Wide Investigation" (2024). Electronic Theses and Dissertations. 3998.

Franzoi Dri, Gabriela, "Drivers of Spatio-temporal Dynamics in Long-term Studies of Mammal and Bird Populations in Maine" (2024). Electronic Theses and Dissertations. 4020.

Humphreys, Brigit R., "Effects of Personality on Cache Pilferage and Activity Patterns in Maine's Forest-Dwelling Small Mammals" (2024). *Electronic Theses and Dissertations*. 4041.

Jati, Agus, "Conserving Underrepresented Taxa in Indonesia: Lessons From the First Ecological Studies of the Endangered Togean Islands Babirusa" (2024). Electronic Theses and Dissertations. 4067.

Leach, Megan E., "Implementing Innovative Conservation Tools: Lessons Learned From Maine's Vernal Pool Special Area Management Plan" (2024). *Electronic Theses and Dissertations*. 3924.

Mensinger, Matthew, "Characterizing predation risk during Atlantic salmon smolt

migration" (2024). *Electronic Theses and Dissertations*. 4046.

Stupik, Annie, "Drivers of Space Use and Winter Ticks Loads of Moose in Maine" (2024). Electronic Theses and Dissertations. 4050.

Weedop, Daison H., "Investigating Relationships Between Fish Assemblages, Disturbance, and Food Web Structures" (2024). *Electronic Theses and Dissertations*. 3957.

## POSTER PRESENTATIONS

Alademehin, D. F. and Coghlan S. M. Can Freshwater Fisheries Provide Sustenance in an Age of Scarcity, Simplification, and Strife? A Biophysical Economic Analysis of Ice-Angling for Panfish in Central Maine. 2024 Maine Sustainability & Water Conference. Augusta, Maine, March 28, 2024 [poster]

Amador, L.G., T. Ramirez-Parada, I. Park, S. Mazer, S. Peng, C. Davis, A. Ellison, S. Record. Advancing understanding of plant macrophenology through data integration. Poster presentation at the National Science Foundation Macrosystem Biology Virtual Meeting. February 7, 2024.

Monroe, M. Using citizen science to map and predict amphibian road crossings in Acadia National Park. Northeast Association of Fish & Wildlife Agencies. April 22, 2025, Hyannis, MA.

Monroe, M. Using citizen science to map and predict amphibian road crossings in Acadia National Park. Northeast Partners in Amphibian & Reptile Conservation. July 29, 2024. Winter Harbor, ME.

Njuguna, Edwin, Christina A. Murphy, Peter Njoroge, David Courtemanch, Cynthia Loftin, Malcolm Hunter, Brian McGill. Bridging community science and standardized bird-based biotic. Presented at the 2024 Society for Freshwater Science Meeting held in Philadelphia, June 6.

## PROFESSIONAL PRESENTATIONS

Alademehin, D. F. and Coghlan S. M. Can Freshwater Fisheries Provide Sustenance in an Age of Scarcity, Simplification, and Strife? A Biophysical Economic Analysis of Ice-Angling for Panfish in Central Maine. 47th Annual Meeting of the Atlantic International Chapter of the American Fisheries Society Annual Meeting. Saint John, New Brunswick, Canada, October 15, 2023 [oral].

Amador, L.G. Nitrogen Deposition Predictions from Hyperspectral Data of Pitcher Plants in Bogs. Stipend award presentation at the Maine Associations of Wetland Scientists Annual Meeting, Agusta, Maine. March 21, 2024.

Amador, L.G. To flower or not to flower: Scales of influence on plant phenological responses across the U.S. Wildlife, Fisheries, Conservation Biology Seminar series: Dissertation proposal seminar, Orono, Maine. April 1, 2024.

Atkinson, E. and Zydlewski, J. (2024) Identifying Optimal Egg Planting Scenarios for Atlantic Salmon (*Salmo salar*) in Eastern Maine, USA. The Atlantic Salmon Ecosystems Forum, University of Maine, Orono, Maine. January 9.

Benson, S., Murphy, C.A., Charney, N., Eggert, S., Fraver, S., Kenefic, L. 2024. Maine's Secret Clam Flats: The Aquatic Diversity of Northern White-Cedar Forests. Presentation to the Society for Freshwater Science Annual Meeting, Philadelphia, PA. June 6.

Berigan, L. A. Examining individual variation in American Woodcock habitat selection throughout the full annual cycle. Western Hemisphere Shorebird Group Annual Meeting, Sackville, New Brunswick. August 2024.

Blomberg, E. The American Woodcock Singing Ground Survey largely conforms to the phenology of male woodcock migration. Western Hemisphere Shorebird Group Annual Meeting, Sackville, New Brunswick. August 2024.

Blomberg, E. The American Woodcock singing ground survey largely conforms to the phenology of male woodcock migration. Maine State Chapter of the Wildlife Society Fall Meeting, Orono, Maine. December 2023.

Bredeweg, E., Arismendi, I., Murphy, C.A., Henkel, S. The dark underside of floating solar panels: Iterative runs of CE-QUAL-W2 models as an assessment tool for understanding the effects of floating photovoltaic arrays on reservoir limnology. Presentation to the Oregon Lakes Association Meeting. November 15, 2023. Corvallis, OR.

Brunette, K. Habitat associations of American Woodcock on reclaimed surface mines in West Virginia. Western Hemisphere Shorebird Group Annual Meeting, Sackville, New Brunswick. August 2024.

Clements, S. Satellite tracking of American Woodcock reveals a gradient of migration strategies. Western Hemisphere Shorebird Group Annual Meeting, Sackville, New Brunswick. August 2024.

Darling, R. Troubled waters: assessing American woodcock over-water migration in relation to offshore wind energy development. Western Hemisphere Shorebird Group Annual Meeting, Sackville, New Brunswick. August 2024.

Dillingham, C., Katz, L., York, G., and Zydlewski, J. (2024) Using multiple methods to assess the response of Sea Lamprey distribution to a major river restoration project in Maine. 154th Annual Meeting of American Fisheries Society, Honolulu, Hawai'i. September 15.

Fedarick, J., Murphy, C.A., Record, S., Roy, A., Perkins, D. 2024. Using museum collections to improve range wide modeling and conservation planning for at-risk mussel species. Presentation to the Society for Freshwater Science Annual Meeting, Philadelphia, PA. June 6.

Fedarick, J., Murphy, C.A., Record, S., Roy, A., Perkins, D. One Shell of a Home: Habitat Suitability for Yellow Lampmussel. Presentation to Northeast Association of Fish & Wildlife Agencies. April 21-24 2024, Cape Cod, MA.

Fedarick, J.R. "One Shell of a Home: Habitat Suitability for Yellow Lampmussel." Presentation at the Northeast Association of Fish and Wildlife Agencies Conference, Cape Cod, Massachusetts. April 23, 2024.

Fedarick, J.R. "Using Museum Collections to Improve Range-wide Modeling and Conservation Planning for at-risk Mussel Species". Presentation at the Society for Freshwater Sciences Conference, Philadelphia, Pennsylvania. June 6, 2024.

Figueroa, G., Murphy, C.A., Zydlewski, J. 2024. Understanding PFAS variability in fishes. Society for Freshwater Science Annual Meeting. Philadelphia, PA. June 6.

Figueroa, G., Murphy, C.A., Zydlewski, J. 2024. Understanding PFAS variability in fishes. Society for Freshwater Science Annual Meeting. Philadelphia, PA. June 6.

Flye, M., Sponarski, C., and Zydlewski, J. (2024) Beyond Recovery: Assessing human-marine mammal interactions and agency response across the United States. International Association for Society and Natural Resources (IASNR), Cairns, Australia, June 26.

Flye, M., Sponarski, C., and Zydlewski, J. (2024). Alaska regional trends in human-marine mammal interactions. Beyond Recovery Regional Workshop. Juneau, Alaska. May 10.

Flye, M., Sponarski, C., and Zydlewski, J. (2024). Alaska regional trends in human-marine mammal interactions. Beyond Recovery Regional Workshop. Anchorage, Alaska. May 14.

Flye, M., Sponarski, C., and Zydlewski, J. (2024). Northeast regional trends in human-marine mammal interactions. Beyond Recovery Regional Workshop. Marlborough, Massachusetts. July 31.

Flye, M., Sponarski, C., and Zydlewski, J. (2024). Pacific Islands regional trends in human-marine mammal interactions. Beyond

Recovery Regional Workshop. Honolulu, Hawaii. April 4.

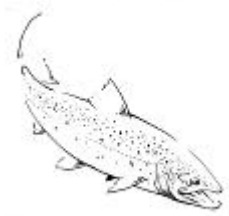
Flye, M., Sponarski, C., and Zydlewski, J. (2024). Southeast regional trends in human-marine mammal interactions. Beyond Recovery Regional Workshop. Miami, Florida. February 12.

Flye, M., Sponarski, C., and Zydlewski, J. (2024). West coast regional trends in human-marine mammal interactions. Beyond Recovery Regional Workshop. Seattle, Washington. January 26.

Flye, M., Sponarski, C., Zlatich, A., and Zydlewski, J. (2024). Did changing the governance structure of Atlantic salmon in Maine improve collaborative efficacy? Wells Conference Center, Orono, Maine. February 9.

Hickox, E., Frechette, D., and Zydlewski, J. (2024) Approach and passage of adult alewife at two dams on the St. Croix River. 154th Annual Meeting of American Fisheries Society, Honolulu, Hawai'i. September 15.

Kronisch, G.R., Furey, N.B., Kinnison, M.T., Murphy, C.A., Schumacher, G.T., Banister, T. (2024) Fine-scale Habitat Use by Landlocked Arctic Charr (*Salvelinus alpinus*) in a Maine, USA Lake. Presentation for OTN Symposium. September 23-26. Halifax, Nova Scotia.



Mensinger, M., Hawkes, J., Goulette, G., Mortelliti, A., and Zydlewski, J. (2024) Changes in Atlantic salmon smolt survival following large-scale river restoration in the Penobscot River, Maine. 154th Annual Meeting of American Fisheries Society, Honolulu, Hawai'i. September 15.

Merriam, C., Frechette, D., and Zydlewski, J. (2024) Navigating Barriers: The Continuing Impact of Dams on Atlantic Salmon in Maine. 154th Annual Meeting of American Fisheries Society, Honolulu, Hawai'i. September 15.

Merriam, C., Frechette, D., and Zydlewski, J. 2024, (September 15–19). Navigating Barriers: The Continuing Impact of Dams on Atlantic Salmon in Maine [Conference presentation]. AFS 2024 Annual Conference, Honolulu, Hawaii, United States.

Murphy, C.A. Phytoplankton to fish: An ecological exploration of reservoirs. Presentation to the Oregon Lakes Association Meeting. November 15, 2023. Corvallis, OR

Murphy, C.A. Understanding PFAS variability in fishes. Maine Sustainability & Water Conference. March 28, 2024. Augusta, ME.

Murphy, C.A., Gerth, W., Wallick, J.R., White, J. 2024. Invertebrate Indicators of Environmental Flows in the Willamette Basin, Oregon. Presentation to the Society for Freshwater Sciences Annual Meeting, Philadelphia, PA. June 6.

Njuguna, E. Murphy, C.A., Loftin, C., Hunter, M., McGill, B., Courtemanch, D., Njoroge, P. 2024. Bridging community science and standardized bird-based biotic indices to advance watershed monitoring. Presentation to Society for Freshwater Science Annual Meeting. Philadelphia, PA. June 6.

Pham, K., Murphy, C.A., Romer, J.D., Stertz, K.A. 2024. Freshwater CSI: Chinook Salmon life-history influences how diagnostic structures relate to fish length. Presentation to the Society for Freshwater Science Annual Meeting, Philadelphia, PA. June 6.

Schumacher, G.T., Murphy, C.A., Furey, N.B., Kinnison, M.T., Can trophic flexibility mitigate shifting habitat and community structure for a climate-sensitive fish? Presentation to Society for Freshwater Science Annual Meeting. Philadelphia, PA. June 6.

Schumacher, G.T., Murphy, C.A., Furey, N.B., Kinnison, M.T., Kronisch, G.R., Erdman, B., Peebles, E.B. 2024. Trophic ontogeny of an elusive fish through eye lens stable isotope analysis. Presentation for the American Fisheries Society Annual Meeting. Honolulu, Hawai'i. September 15-19, 2024.

Smith, R., C. Murphy and J. Zydlewski. 2024. Predation or Survival? Atlantic Salmon Smolt Encounters with Smallmouth Bass in the Weldon Headpond. 2024 Atlantic Salmon Ecosystem Forum, Orono, ME, USA. January 9. [oral]

Smith, R., C. Murphy and J. Zydlewski. 2024. Quantifying Smallmouth Bass Predation on Atlantic Salmon Smolts: A Bioenergetic Model

Approach. American Fisheries Society 154rd Annual Meeting, Honolulu, HI, USA. September 2024. [oral]

Smith, R., Murphy, C., and Zydlewski, J. (2024) Survival of the smallest. Predation on Atlantic Salmon smolts by Smallmouth Bass in the Weldon Headpond. 154th Annual Meeting of American Fisheries Society, Honolulu, Hawai'i. September 15.

Snyder, S., D. Stich, J. Zydlewski. 2024. Impacts of dams on river herring populations through their native range: what's left?. Atlantic Salmon Ecosystems Forum, 9 January- 10 January, Orono, Maine.

Snyder, S., Stich, D., and Zydlewski, J. (2024) Impacts of dams on river herring populations through their native range: what's left? 154th Annual Meeting of American Fisheries Society, Honolulu, Hawai'i. September 15.

Vogel, S., Loftin, C., and Zydlewski, J. (2024) Charting collaborative waters: Network dynamics of the USGS CRU program. Charting collaborative waters: Network dynamics of the USGS CRU program. 154th Annual Meeting of American Fisheries Society, Honolulu, Hawai'i. September 15.

Zydlewski, J., Carr, T., Flye, M., Frechette, D., Kircheis, D., Loring, Jr., C., McCaw, D., Merriam, C., Sponarski, C. Restoring migratory fish and their cultural connection in the Penobscot River. 154th Annual Meeting of American Fisheries Society, Honolulu, Hawai'i. September 15.

## PUBLIC PRESENTATIONS

Blomberg, E. EWMRC research at the Maine Audubon Fields Pond nature center. April 2024.

Blomberg, E. Talk at Central Maine Chapter of the Ruffed Grouse Society. Brewer, ME, November 2023.

Darling, R.L. "Fall migration over the Gulf of Maine and the American woodcock". Maine Audubon Fields Pond Nature Center. Orland, ME, June 2024.

Darling, R.L. "Migration, Habitat, and Populations: studying woodcock with the Eastern Woodcock Migration Research Cooperative". South Carolina Chapter of the Ruffed Grouse Society (via Zoom), August 2024.

Monroe, M. Amphibian road crossings in Acadia National Park. Public talk at the Jessup Library, Bar Harbor, ME. April 11, 2024.

Monroe, M. Amphibian road crossings in Acadia National Park. Public talk at the Somesville Parish House, Somesville, ME. February 24, 2024.

Monroe, M. Amphibian road crossings in Acadia National Park. Public talk at the Gilley Museum, Southwest Harbor, ME. March 22, 2024.

Monroe, M. Protecting amphibian pathways: Using citizen science to map and predict amphibian road crossing hotspots. Acadia National Park: Lunch and Learn. December 12, 2023.

## WORKSHOPS

Fedarick, J. Attended the Freshwater Mussel Recovery Implementation Workshop in Moncton, New Brunswick. November 9, 2023.

## AWARDS, HONORS, AND APPOINTMENTS

Alademehin, D. F. and Coghlan S. M. 2023. Can Freshwater Fisheries Provide Sustenance in an Age of Scarcity, Simplification, and Strife? A Biophysical Economic Analysis of Ice-Angling for Panfish in Central Maine. 47th Annual Meeting of the Atlantic International Chapter of the American Fisheries Society Annual Meeting. Saint John, New Brunswick, Canada, October 15, 2023. Deborah received the NED -AFS Soggy Boot award for most engaging presentation.

Alademehin, D.F. Graduate Thurgood Marshall Scholarship for the 2024-2025 academic year, March 5, 2024.

Amador, L. 2023 Maine Association of Wetland Scientists (MAWS) Education Stipend award ($2,000)

Amador, L. 2024 NSF Environmental Science Inclusion and Innovation Lab (ESIIL) working group funding to study Macrophenology (L. Amador and S. Record).

Merriam, C. AFS Skinner Award 2024.

Monroe, M. Acadia Science Fellow 2024-2025. Schoodic Institute, Winter Harbor, ME.

Njuguna, E. The Howard L. Mendall '31, 34 Memorial Scholarship. April 2024.

Zydlewski, J. American Fisheries Society Fellow, American Fisheries Society, Society recognition of outstanding contributions in leadership, research, teaching and mentoring, resource management and/or conservation, and public outreach and engagement. (2024-09-15).

## TELEVISION, RADIO, AND NEWSPAPER INTERVIEWS AND ARTICLES

Fedarick, J. Was quoted in an article and video on WABI 5 entitled "Young minds showcased at Maine Invention Convention" by Grace Bradley. March 23, 2024. https://www.wabi.tv/2024/03/23/young-minds-showcased-maine-invention-convention/

Monroe M. 2024. Interviewed for the podcast Sea to Trees, Season 3, episode 3: "Past, present, and future: Ferrying frogs and measuring mice". https://www.nps.gov/podcasts/sea-to-trees.htm

Monroe, M. 2024. Interviewed for the article "Midcoast residents gather in the darkness to protect amphibians" by Laura Sitterly. June 13, 2024. https://www.pressherald.com/2024/06/13/midcoast-residents-gather-in-the-darkness-to-protect-amphibians/

Roth, A. & Blomberg, E. 2024. Notes from the Field: American Woodcock Migration. USGS Bird Banding Lab. Available Online.