2020

Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife, Fisheries, and Conservation Biology 2020 Report to Cooperators

Maine Cooperative Fish and Wildlife Research Unit

Cynthia S. Loftin

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

2020 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:
Cynthia S. Loftin and Rena A. Carey

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: Leanord's Mills in Bradley, Maine; photo by Allison Brehm

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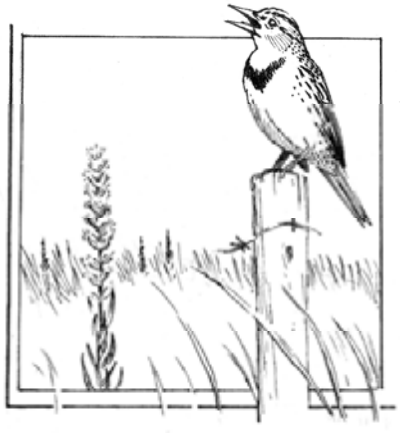
UNIT Mission

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 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

The Maine Cooperative Fish and Wildlife Research Unit and the University of Maine Department of Wildlife, Fisheries, and Conservation Biology are pleased to summarize the past year's research accomplishments and activities in this annual report. Together, we have collaborated with scientists from State and Federal agencies, universities, and non-governmental organizations on 37 research projects presented in the pages that follow. These collaborative relationships enable us to pose a variety of research questions in interdisciplinary studies to address the resource management information needs of our research sponsors and to advance science in wildlife and fisheries ecology, management, and conservation. We value these opportunities to work together and look forward to continuing these relationships as well as developing new collaborations in the year ahead.

Our research occurs primarily in Maine and New England; however, our science is applicable beyond this geographical area. We broadly group our diverse array of projects into three categories: Fisheries and Aquatic; Wildlife and Habitats; Integrated Ecology. This report includes summaries of research ranging from defining species-habitat relationships, to modeling species responses to habitat change, and to developing tools to integrate public input into natural resource management decisions and understand the human dimensions affecting conservation actions. The majority of our research is conducted as part of graduate degree programs; during the past year, Unit and Department faculty mentored 39 graduate students and postdoctoral scholars, 7 graduate students completed requirements for M.S. or Ph.D. degrees, and 1 graduate student completed requirements for the Master of Wildlife Conservation degree. Our recent graduates are working for universities, federal and state agencies, and non-governmental organizations, as well as pursuing additional graduate degrees.

This has been a productive year for the Unit and its cooperators. The Unit is fortunate to have the opportunity to fill a vacant Assistant Unit Leader (AUL) position, and together with our Collaborators we identified fisheries science and quantitative ecology as areas for research program growth. We anticipate that the selected AUL-Fisheries will join the Unit by the end of 2020. COVID-19 has presented unprecedented challenges for all of us. Our students and research partners have made great efforts this year towards accomplishing our research, technical assistance, and graduate education goals while working within safe practices guidelines. We look forward to the time when we can again be working side-by-side with each other! We are excited about the many new staff at the University, the Maine Department of Inland Fisheries and Wildlife and the U.S. Fish and Wildlife Service-Maine Field Office. We look forward to continuing to work with them to address their resource management information needs.

The past year also has been a productive research year for the Department and Unit, with external research funding continuing to support our growing program. Our graduate program continues to be active and attract outstanding students who ably represent our academic and research programs locally and at professional meetings across the country. Other changes are on the horizon for the department, as we address growing enrollments, while also meeting expanding research opportunities, and faculty transitions.

The Unit and Department look forward to another year of continuing our current and developing new collaborations with our colleagues. 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. We welcome your comments.

COOPERATING PERSONNEL

UNIVERSITY OF MAINE

Dr. Kody Varahramyan, Vice President for Research and Dean of the Graduate School
Dr. Mario Teisl, Interim Dean, College of Natural Science, Forestry and Agriculture
Dr. Brian J. Olsen, Chair, Department of Wildlife, Fisheries, and Conservation Biology

MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE

Mr. James Connolly, Director, Bureau of Resource Management

U.S. FISH AND WILDLIFE SERVICE

Ms. Anna Harris, Supervisor, Maine Field Office

U.S. GEOLOGICAL SURVEY

Dr. John Thompson, Chief, Cooperative Research Units Program

WILDLIFE MANAGEMENT INSTITUTE

Mr. Steve Williams, President

UNIT PERSONNEL

SCIENTISTS

Cynthia S. Loftin, Unit Leader, and Associate Professor of Wildlife Ecology
Joseph D. Zydlewski, Assistant Unit Leader for Fisheries, and Professor of Wildlife Ecology

SUPPORT STAFF

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

COLLABORATING AGENCIES AND ORGANIZATIONS

Alabama Department of Conservation and Natural Resources
American Recovery and Reinvestment Act (ARRA)
Baxter State Park
Brookfield Renewable Power
Cooke Aquaculture
Downeast Lakes Land Trust
Environment and Climate Change Canada
Florida Fish and Wildlife Conservation Commission
Georgia Department of Natural Resources
Giraffe Conservation Foundation
J.D. Irving, Ltd.
Katahdin Forest Management, LLC
Kruger Energy
Maine CFRU Landowner access and assistance
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
Maine Department of Transportation
Maine Outdoor Heritage Fund
Maine Research Reinvestment Fund
Maryland Department of Natural Resources
Muckleshoot Indian Tribe
National Audubon Society
National Fish and Wildlife Foundation
National Oceanic and Atmospheric Administration
National Park Service
National Science Foundation – Experimental Program to Stimulate Competitive Research
National Wild Turkey Federation
New Hampshire Audubon
New Jersey Department of Environmental Protection
New York Department of Environmental Conservation
North Carolina Wildlife Resources Commission
Northern Rangelands Trust
Pelletier Brothers, Inc.
Pennsylvania Game Commission
Penobscot Indian Nation
Penobscot River Restoration Trust
Rhode Island Department of Environmental Management
San Diego Zoo Global
Seven Islands Land Company
South Carolina Department of Natural Resources
State University of New York – Cobleskill
The American Woodcock Society
The Nature Conservancy
The North Maine Woods
The Ruffed Grouse Society
U.S. Fish and Wildlife Service
U.S. Fish and Wildlife Service – Craig Brook National Fish Hatchery
U.S. Fish and Wildlife Service – Division of Migratory Birds
U.S. Forest Service
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Geological Survey – Patuxent Wildlife Research Center
U.S. Navy
U.S.D.A. National Cold Water Marine Aquaculture Center
University of Maine
University of Maine – Center for Undergraduate Research
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Maine Cooperative Forestry Research Unit
University of Maine – School of Biology and Ecology
University of Maine – School of Computing and Information Science
University of Maine – School of Marine Sciences
University of Maine – Senator George J. Mitchell Center for Sustainability Solutions
University of Maine at Fort Kent
University of Maine at Presque Isle
University of Rhode Island
Vermont Fish and Wildlife Department
Virginia Department of Game and Inland Fisheries
Wagner Forest Management
Weyerhaeuser Company
WILD-ONE
Wildlife Management Institute
William P. Wharton Trust

UNIVERSITY OF MAINE COLLABORATORS

Department of Wildlife, Fisheries, and Conservation Biology

Brian J. Olsen, *Chair and Professor*
Erik J. Blomberg, *Associate Professor*
Aram J.K. Calhoun, *Professor*
Stephen M. Coghlan, Jr., *Associate Professor*
Daniel J. Harrison, *Professor*
Malcolm L. Hunter, Jr., *Professor*
Jessica J. Jansujwicz, *Assistant Research Professor*
Zachary G. Loman, *Research Scientist*
Sabrina Morano, Assistant *Research Professor*
Alessio Mortelliti, *Assistant Professor*
Amber M. Roth, *Assistant Professor*
Lindsay C.N. Seward, *Instructor*
Carly C. Sponarski, *Assistant Professor*

Department of Anthropology

Samuel P. Hanes, *Associate Professor*

School of Biology and Ecology

Allison Dibble, *Assistant Research Professor*
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Brian J. McGill, *Professor*
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Department of Communication and Journalism

Bridie McGreavy, *Associate Professor*
Laura N. Rickard, *Associate Professor*

School of Computing and Information Science

Kate Beard-Tisdale, *Professor*
Roy M. Turner, *Associate Professor*

School of Earth and Climate Sciences

Andrew S. Reeve, *Professor*

School of Economics

Caroline L. Noblet, *Associate Professor*

School of Food and Agriculture

Pauline L. Kamath, *Associate Professor*
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School of Forest Resources

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Shawn R. Fraver, *Associate Professor*
Anthony P. Guay, *Remote Sensing Technical Specialist*
Daniel J. Hayes, *Associate Professor*
Jessica E. Leahy, *Professor*
Kasey R. Legaard, *Assistant Research Professor*
David Sandilands, *Arial Survey Pilot and Remote Sensing Technician*
Erin Simons-Legaard, *Assistant Research Professor*
Aaron R. Weiskittel, *Professor*

School of Marine Sciences

Nishad Jayasundara, *Assistant Professor*
Gayle B. Zydlewski, *Professor*

EXTERNAL COLLABORATORS

Shannon Beliew, *Data Management Specialist, USGS Patuxent Wildlife Research Center, Laurel, MD*

John-Pascal Berrill, *Professor, Humboldt State University*

Ruth Boettcher, *Wildlife Biologist, Virginia Department of Game and Inland Fisheries*

Martin A. Briggs, *Research Hydrologist, USGS – Hydrogeophysics Branch*

Phillip deMaynadier, *Wildlife Biologist, Maine Department of Inland Fisheries and Wildlife*

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

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

Jenny A. Glikman, *Former Associate Director of Community Engagement, San Diego Zoo*

Walker Golder, *Director of Atlantic Flyway Coast Strategy, National Audubon Society*

Walter Jakubas, *Mammal Group Leader, Maine Department of Inland Fisheries and Wildlife*

Tora Johnson, *Professor, University of Maine, Machias*

Ian Kiraly, *Fisheries Biologist, Gomez and Sullivan Engineers*

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

Adrienne J. Leppold, *Songbird Specialist, Maine Department of Inland Fisheries and Wildlife*

James E. Lyons, *Research Ecologist, USGS Patuxent Wildlife Research Center*

Courtney Marneweck, *Post-doctoral Research Fellow, Clemson University*

David G. Marneweck, *Postdoctoral Fellow, Nelson Mandela University*

Alyson E. McKnight, Associate *Professor, Unity College*

Glen Mittelhauser, *Executive Director, Maine Natural History Observatory*

Michael C. Runge, *Research Ecologist, USGS Patuxent Wildlife Research Center*

Caleb S. Spiegel, *Marine Bird Biologist, U.S. Fish and Wildlife Service*

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Joan G. Trial, *Retired, Maine Department of Marine Resources*

Jonathan Watson, *Marine Habitat Resource Specialist, NOAA, Maryland*

Shevenell Webb, *Furbearer and Small Mammal Biologist, Maine Department of Inland Fisheries and Wildlife*

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

Mark Wimer, *Wildlife Program Manager, USGS Patuxent Wildlife Research Center*

GRADUATE COMMITTEE LEADERSHIP

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

Loftin	Brandon Boxler, MS (September 2017 – Present) Logan Kline, MS (September 2019 – Present) Meredith Lewis, MS (September 2019 – Present) Shawn Snyder, PhD (June 2019 – Present Sarah Vogel, PhD (September 2020—Present)
Zydlewski	Ernest Atkinson, MS (September 2018 – Present) Kevin Job, MS (January 2016 – January 2020) Matthew Mensinger, MS (September 2018 – Present) Alejandro Molina-Moctezuma, PhD (May 2015 – August 2020) Erin Peterson, PhD (September 2017 – Present) Sarah Rubenstein, MS (January 2018 – Present) Sarah Vogel, MS (January 2017 – January 2020) Sarah Vogel, PhD (September 2020 – Present) Kory Whittum, MS (June 2019 – Present)

RECENT GRADUATES AND CURRENT PURSUITS

Student, Degree, Curriculum
Current Pursuits

Graduate Date
Advisor(s)

Sara Boone, MS, Wildlife Ecology

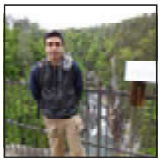
August 2020
Alessio Mortelliti

Melissa Flye, MS, Ecology and Environmental Sciences
PhD student, University of Maine

January 2020
Carly C. Sponarski

Kevin Job, MWC, Wildlife Ecology
Fisheries Biology, Connecticut Department of Energy and Environmental Protection

January 2020
Joseph D. Zydlewski



Alejandro Molina-Moctezuma, PhD, Wildlife Ecology
Postdoctoral Associate, Lake Superior State University

August 2020
Joseph D. Zydlewski

Nicole Ramberg-Pihl, PhD, Ecology and Environmental Sciences

August 2020
Stephen M. Coghlan, Jr.; Hamish Greig

Kirstie Ruppert, PhD, Ecology and Environmental Sciences
Researcher, San Diego Zoo Global Wildlife Conservancy

June 2020
Carly C. Sponarskii

Sarah Vogel, MS, Wildlife Ecology
PhD Student, University of Maine

January 2020
Jessica J. Jansujwicz, Joseph D. Zydlewski

Kaitlyn Wilson, MS, Wildlife Ecology
Coordinator, Cloquet Forestry Center, MN

August 2020
Amber M. Roth

CURRENT STUDENTS & POSTDOCS

Student, Degree, Curriculum	Advisor(s)
Jean-Marc Andre, MS, Wildlife Ecology	Daniel J. Harrison
Ernest Atkinson, MS, Wildlife Ecology	Joseph D. Zydlewski
Liam Berigan, PhD, Wildlife Ecology	Erik J. Blomberg, Amber M. Roth
Amay Bolinjkar, Master of Wildlife Conservation	Alessio Mortelliti
Brandon Boxler, MS, Ecology and Environmental Sciences	Cynthia S. Loftin
Allison Brehm, PhD, Wildlife Ecology	Alessio Mortelliti
Brianne Du Clos, Postdoctoral Associate	Cynthia S. Loftin
Michelle Duffy, Master of Wildlife Conservation	Amber M. Roth
Margaux Duparcq, PhD, Ecology and Environmental Sciences	Alessio Mortelliti
Bryn Evans, PhD, Wildlife Ecology	Alessio Mortelliti
Kirstin Fagan, PhD, Wildlife Ecology	Daniel J. Harrison
Alexander Fish, PhD, Wildlife Ecology	Erik J. Blomberg, Amber M. Roth
Gabriela Franzoi Dri, PhD, Wildlife Ecology	Malcolm L. Hunter, Jr.; Alessio Mortelliti
Melissa Flye, PhD, Ecology and Environmental Sciences	Carly C. Sponarski
Matthew Gonnerman, PhD, Wildlife Ecology	Erik J. Blomberg
Margaret Hallerud, MS Ecology and Environmental Sciences	Alessio Mortelliti
Christopher Heilakka, MS, Ecology and Environmental Sciences	Erik J. Blomberg
Agus Jati, PhD, Wildlife Ecology	Alessio Mortelliti
Logan Kline, MS, Ecology and Environmental Sciences	Cynthia S. Loftin, Daniel J. Hayes
Meredith Lewis, MS, Ecology and Environmental Sciences	Cynthia S. Loftin, Daniel J. Hayes
Matthew Mensinger, MS, Wildlife Ecology	Erik J. Blomberg, Joseph D. Zydlewski
Dakota Perry, Master of Wildlife Conservation	Alessio Mortelliti
Katie Perry, MS, Ecology and Environmental Sciences	Carly C. Sponarski, Jessica E. Leahy
Erin Peterson, PhD, Wildlife Ecology	Joseph D. Zydlewski
Jeffrey Rodriguez, PhD, Ecology and Environmental Sciences	Aram J.K. Calhoun, Jessica J. Jansujwicz
Sarah Rubenstein, MS, Wildlife Ecology	Joseph D. Zydlewski
Shawn Snyder, PhD Ecology and Environmental Sciences	Cynthia S. Loftin, Andrew S. Reeve
Joel Tebbenkamp, PhD, Wildlife Ecology	Erik J. Blomberg, Daniel J. Harrison
Sarah Vogel, PhD, Ecology and Environmental Sciences	Cynthia S. Loftin, Joseph D. Zydlewski

Continued

CURRENT STUDENTS & POSTDOCS CONT.

Student, Degree, Curriculum	Advisor(s)
Kory Whittum, MS, Wildlife Ecology	Stephen M. Coghlan, Jr.; Joseph D. Zydlewski
Tyler Woollard, MS, Wildlife Ecology	Daniel J. Harrison
Ivy Yen, PhD, Ecology and Environmental Sciences	Alessio Mortelliti

UNIT SUPPORTED RESEARCH

Name, Affiliation	Unit Advisor(s)
Catlin Ames, PhD, Marine Biology	Joseph D. Zydlewski

OTHER RESEARCH

Name, Affiliation	Other Advisor(s)
Luke Douglas, MS, Forest Resources	Amber M. Roth

FISHERIES and aquatic

Passage of Atlantic salmon smolts migrating seaward from the Penobscot River

1. Model the survival of hatchery-origin Atlantic salmon smolts through the Penobscot River and Estuary.
2. Assess movement and behavioral patterns of migrating Atlantic salmon smolts through the Penobscot River.
3. Characterize passage and survival of Atlantic salmon smolts at Howland Dam in the Piscataquis River.

Abstract: The Penobscot River system hosts the largest population of endangered Atlantic salmon *Salmo salar* in the United States. However, total adult returns in this river remain low. Historically low numbers led to listing of the distinct population segment (DPS) in 2000, and the Penobscot River population was included in the DPS in 2009. Reducing mortality in all life stages is crucial for the recovery of Atlantic salmon populations. One of the life stages associated to high mortality is the juvenile stage (smolts), in which individuals migrate downstream towards the estuary. During this migration smolts face a series of new conditions such as novel predators, the physiological challenge of increased salinity, and dams. Dams are a primary cause for low abundance of this species in the Penobscot River, and dams remain a considerable source of mortality for smolts. Acoustic and radio telemetry was used to explore the survival, and movement of downstream migrating smolts. First, the historical survival and movement of smolts in the Piscataquis River, a major tributary of the Penobscot River, was investigated, with particular emphasis on the effects of dams on delays. System-wide survival from 2015-2019 was obtained and compared to survival in previous years in the Penobscot River. A decision making tool for evaluating survival of smolts was developed, and an experiment for analyzing the phenology and energetic effects on individual physiological responses.

Movement, delays, and survival of Atlantic salmon *Salmo salar* smolts were evaluated through the Piscataquis River, Maine, USA. We explored the effects of the four dams from 2005 to 2019. During this period, the downstream-most dam (Howland Dam) transitioned from full hydropower generation to be decommissioned with the construction of a nature-like fish bypass. We estimated survival through open river reaches, and at each dam using acoustic telemetry (n = 1,611). Dams decreased survival, with per rkm apparent survival averages of 0.972, 0.951, and 0.990 for the three upstream dams, compared to 0.999 for open river reaches. Turbine shutdowns increased survival at Howland Dam (~0.95), as did the nature-like fish bypass (~0.99). We used radio-telemetry in 2019 (n = 75) and approximately 1/3 of the fish used the bypass. Smolts passing multiple dams had lower survival through Howland Dam than smolts that passed no dams prior to Howland Dam. One of the upstream dams, caused extended delays, (median delay > 48h). Overall, delays and mortality represent an impediment to the use of the high quality spawning habitat.

System-wide survival of hatchery-reared smolts was evaluated for four years (2016-2019) in the Penobscot River and compared to previous survival estimates in a changing system. We estimated survival through the main-stem and its main tributary river, the Piscataquis River. This system been recently transformed through two dam removals and construction of new nature-like bypass passage structure. The influences of these structural changes and environmental conditions were assessed. We estimated survival using acoustic telemetry, and multi-state mark-recapture methods (n=1,482). Six different release sites, as well as two release dates were included in the study design, in order to assess system-wide survival. High flow conditions positively influenced smolt survival. Survival from 2017-2019 was considerably higher than survival in previous years, with total cumulative survival between 0.55, and 0.90 depending on the year, and release site. We found an effect of delays on survival, with higher delays causing lower survival. Despite the overall high survival, one dam had survival comparable to that found in previous year. Overall, survival increased in all reaches except for one dam.

Quantifying the downstream survival of migrating fish past dams is critical for conservation efforts. Regulators require assessments of survival as a condition of operation. Failure to meet an established survival standard may result in required operational or costly structural changes at a facility. Establishing the

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survival standard, as well as the rules of assessment, is a point of contention between regulators and operators. Management goals are based on biological criteria, but there are inherent statistical and probabilistic trade-offs when choosing a standard value and the method for assessment. We make a distinction between a "biological" goal (the conservation goal) and a "statistical" standard (a function of the biological goal, sample size, assessment method, and years of consecutive evaluation). An effective statistical standard maximizes true positives (passing the standard when the biological goal is being met) and true negatives (failing the standard when the goal is not being met), while minimizing false negatives and false positives. We explored the effects of sample size, true survival, and assessment methods on the probability of passing different statistical standards by simulating survival studies (simulating mark-recapture experiments). We observed a strong influence of assessment methods on the probability of making the right decision (true positive or true negative), especially when sample size, and recapture probability was low. As a support tool, we developed an interactive user interface to explore specific scenarios, and to aid communication among decision makers.

Investigator: Alejandro Molina-Moctezuma (PhD)

Advisors: Joseph D. Zydlewski (Advisor)
Nishad Jayasundara
John F. Kocik
Michael T. Kinnison
Erik J. Blomberg

Duration: January 2016—March 2020

Cooperators:

American Recovery and Reinvestment Act (ARRA)
Maine Department of Marine Resources
National Fish and Wildlife Foundation
National Oceanic and Atmospheric Administration
Penobscot River Restoration Trust
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

Investigating fish passage decision-making in the FERC regulated hydropower relicensing process

1. Characterize the suite of social and technical factors that influence the implementation of fish passage prescriptions including the regulatory and non-regulatory tools afforded by the existing legal/ regulatory framework.
2. Assess basin-wide decision-making and the degree to which regulatory decisions at dams are independent of the characteristics and regulation in other nearby dams.
3. Evaluate the construction and use of ecological information, environmental studies, and the valuation of "best available science" as it pertains to unique stakeholder groups
4. Communicate results to resource agencies to inform future relicensing decisions

Abstract: Hydropower dams represent a significant challenge for the successful migration of sea-run fish, many species of which are in decline. Most hydropower dams in the United States are regulated by the Federal Energy Regulatory Commission (FERC), an independent federal agency responsible for granting 30 to 50-year licenses to projects for their continued operation. Licenses typically include conditions for the conservation of sea-run fish such as fish passage construction, operational changes, monitoring of effectiveness, and other mitigative conditions. While FERC remains the primary authority in licensing, the current regulatory framework stipulates input from other federal and state resource and regulatory agencies, many working from differing timeframes, varying levels of authority, and within the bounds of a complex legal system.

Outside of the relicensing process, modifications and improvements are not required unless prescribed in the original license or prompted by legal action (e.g., the listing of new species under the ESA). In effect, the relicensing process presents the most effective opportunity for agencies to influence dam operations. Due to accelerated construction of hydropower dams in the 1980s, many of the projects in Maine will require relicensing within the next decade requiring input from an array of federal and state agencies. W hen negotiating hydropower operations, agencies must make timely decisions and examine tradeoffs based on their respective and often competing authorities, values, and objectives. Using the Kennebec and Penobscot Rivers in Maine as a model system, the overall goal of this research is to examine the hydropower relicensing process to: 1) identify and describe the role and authority of resource agencies during dam relicensing, 2) determine the factors that may affect the design and implementation of fish passage measures, and 3) highlight management and policy implications that may be used to inform fish passage decisions and future relicensing efforts. This research provides the historical context for fish passage in the study area and describes hydropower regulation.

The first chapter uses content analysis of relicensing documents readily available on the Federal Energy Regulatory Commission (FERC) eLibrary to identify the main factors that influence fish passage decision-making and describe patterns in agency engagement during relicensing. Our results indicate an overall increase in concern for fish passage over time with mitigation measures focused almost exclusively on Atlantic salmon and American eel. Agency engagement and the use of regulatory authority increased after the 1900s, especially with regards to the use of Water Quality Certification conditions as a tool for addressing fish passage. Overall, hydropower projects were found to differ along a spatial gradient with coastal projects correlated strongly to fish passage language and input from the Maine Department of Marine Resources (MDMR), United States Fish and Wildlife Service (USFWS), and National Oceanic and Atmospheric Administration (NOAA) and inland projects to input from the Maine Department of Inland Fisheries and Wildlife (MDIFW). Despite stated interest in basin-scale planning, policies in support of it, and continued improvement, implementation has been slow at best. Our results suggest there remain significant opportunities to spatially integrate the FERC process.

The second chapter investigates the concept of "best available science" (BAS) as it applies to the relicensing decision process. Agency regulators are tasked with using the BAS to make informed decisions about hydropower operations and management. Although embraced as the standard, best available science is not well-defined and is inconsistently applied. Citation

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analysis and an online survey of regulatory and resource agency staff were used to identify the informational sources used in relicensing and assess agency perceptions of BAS. Analysis of relicensing documents (n=62) demonstrates that FERC and licensee documents (i.e., documents produced by the individual or organization that was granted the license) are highly similar in citation composition. NOAA reports typically cite more sources and are three times more likely to cite peer-reviewed literature than FERC and licensee documents. Survey data reveals that federal and state agency respondents (n=49) rate peer-reviewed literature highly in terms of BAS, followed by university (e.g., theses), agency (e.g., agency grey literature), and expert sources (e.g., guidance from experts), while industry (e.g., consultant reports) and community (e.g., comments and personal interactions) sources rate poorly. Overall, there is low agreement among respondents with regards to BAS rankings of informational sources. The reported differences in information use may be linked to disparities in access to certain sources, particularly peer-reviewed literature. A common concern expressed by agency staff is the lack of applied technical information for all aspects of dam operations.

One such disparity relates to the difficulty in assessing downstream passage for out-migrating juvenile fish. The final chapter addresses this knowledge gap by describing the development of a novel buoyancy conversion (BC) tag that may be used to facilitate fish recapture for passage assessments. The BC tag uses low-cost materials, does not significantly hinder fish movement, and has a delayed deployment. This chapter provides a detailed description of the BC tag and describes the process used to optimize the tag for a range of fish sizes, specifically for juvenile river herring. This work is intended for the public domain and is meant to be highly adaptable for use with many fish species and life stages.

Investigator: Sarah Vogel (MS)

Advisors: Joseph D. Zydlewski (Co-Advisor)
Jessica J. Jansujwicz (Co-Advisor)
Carly C. Sponarski

Duration: June 2017—December 2019

Cooperators:

National Science Foundation – Experimental Program to Stimulate Competitive Research
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Senator George J. Mitchell Center for Sustainability Solutions

Painting the big picture: Addressing critical research objectives for sturgeon conservation in the Gulf of Maine

1. Determine if Atlantic Sturgeon are forming winter aggregations in Penobscot Bay, describe the physical features coinciding with these areas, and assess abundance of the aggregation.
2. Define critical foraging habitat for both species by determining key prey items, identifying the habitats that contain those prey, and determining environmental predictors of prey occurrence.
3. Develop an age at length relationship for both species to ascertain rates of mortality and growth for better management, and to evaluate use of alternative aging structures.
4. Estimate the population size of both species in the Penobscot River and assess the impact, if any, of management actions in the past decade.

Currently, marine habitat use of Atlantic Sturgeon in the GOM, particularly Penobscot Bay, is limited and does not include habitat features. To expand the range of detection and collect concurrent physical data we will use an autonomous underwater vehicle affixed with a Vemco acoustic receiver. Locations where sturgeon are detected will be surveyed using Side Scan Sonar to determine the presence of sturgeon, approximate abundance, substrate type, and benthic structure. The uncertainty of habitat use of these species in the Kennebec and Penobscot rivers, and need for clarity on critical habitat extent related to foraging, warrants further investigation into the diets and prey availability for sturgeon in the GOM. To accomplish this, we will identify key species of sturgeon diets, habitats that contain those prey, and environmental predictors of prey occurrence. Fisheries management requires variables including age, growth and lengths to determine stock trends. Age, size and weight will be determined from sturgeon captured in the Merrimack, Saco, and Penobscot rivers in Maine. As Atlantic Sturgeon seasonally use Canadian waters, collections from Minas Passage and New Brunswick will also be provided by collaborators. To estimate the population sizes of Shortnose and Atlantic sturgeon we will combine mark/recapture techniques with telemetry to determine population models for the Penobscot River residents.

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

Investigator: Catlin Ames (PhD)

Advisors: Gayle B. Zydlewski (Co-Advisor)
Michael T. Kinnison (Co-Advisor)
Joseph D. Zydlewski
Erik J. Blomberg
Michael J.W. Stokesbury

Duration: May 2016—December 2020

Cooperators:

Maine Outdoor Heritage Fund
National Audubon Society
Penobscot River Restoration Trust
The Nature Conservancy
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine
University of Maine – School of Biology and Ecology
University of Maine – School of Marine Sciences

Examining dispersal of point stocked Atlantic salmon fry relative to habitat qualities

1. Characterize the dispersal pattern of egg planted Atlantic salmon as a function of habitat characteristics.
2. Construct a GIS based tool to optimize stocking of egg planted Atlantic salmon by incorporating biotic and abiotic habitat characteristics in conjunction with dispersal patterns.

The Gulf of Maine Distinct Population Segment of Atlantic salmon has suffered from habitat loss and exploitation over the last century. Hatchery supplementation has unquestionably prevented the extirpation of the species over the last decades, but risks domestication effects. Egg planting and fry stocking replicate the natural spawning process in streams and provide a natural experience which can be important maintaining wild traits. However, survival and dispersal behavior of salmon fry immediately after emergence from eggs planted in artificial nests is poorly characterized with respect to spatial distribution and the influence of habitat quality. To address these uncertainties, dispersal of salmon fry planted as eyed eggs will be assessed during the winters of 2019 and 2020 during the first year of growth across nine, two-kilometer reaches. These reaches represent "high", "medium" and "low" quality rearing habitat.

Reaches have been selected for study for the duration of this project, distributed across the Machias, Pleasant and Narraguagus Rivers. Within each drainage there are three reaches the represent High, medium, and low -quality habitat. From these, sites were selected for egg planting beginning in the in the winter of 2019. A total of 212 thousand eggs were planted into the nine reaches. Electrofishing surveys for this first year were completed in the fall of 2019. This work was repeated in 2020 and fall electrofishing surveys were carried out.

Work has begun to construct a GIS based tool to optimize stocking of egg planted Atlantic salmon by incorporating biotic and abiotic habitat characteristics in conjunction with dispersal patterns collected from 2019 and 2020. Data are organized and analysis of the effect of habitat on abundance and dispersal in ongoing.

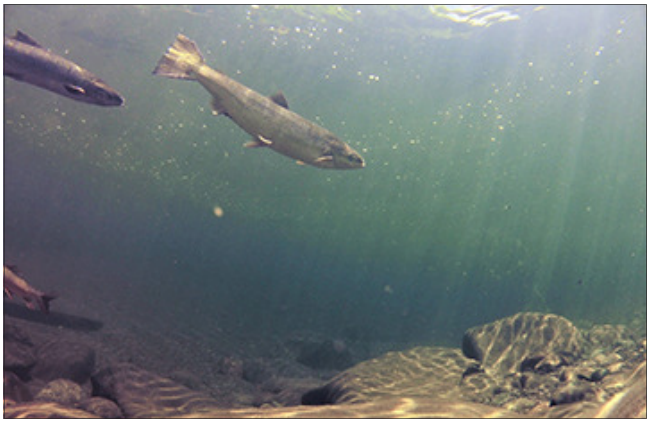
Investigator: Ernie Atkinson

Advisors: Joseph D. Zydlewski (Advisor)
Stephen M. Coghlan, Jr.
Joan G. Trial

Duration: January 2019—June 2021

Cooperators:

Maine Department of Marine Resources
U.S. Fish and Wildlife Service – Craig Brook National Fish Hatchery
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit



Homeward bound: Returning Atlantic salmon to Maine rivers using aquaculture

1. Characterize attitudes, perceptions, beliefs, and knowledge about Atlantic salmon, aquaculture, and the use of aquaculture for conservation.
2. Characterize public trust in natural resource management agencies.
3. Identify barriers or potential conflicts arising from the use of aquaculture for conservation.
4. Aid in the development of public outreach and education aimed at addressing knowledge gaps and building trust between natural resource agencies and the public.
5. Monitor growth and development of native Atlantic salmon smolts reared to maturity in net pens.
6. Monitor in-river movements of adult salmon and characterize habitat use.

This work uses biological monitoring and social science approaches to assess the efficacy of the "Salmon for Maine Rivers" program and contribute to public outreach and education surrounding this novel net pen rearing effort led by the Maine Department of Marine Resources (DMR). There are two complementary efforts. First, we will use measures of growth, condition, and in-river movement behavior of Atlantic salmon reared in ocean net pens to help evaluate the biological potential of this novel rearing approach for restoration of this critically endangered fish. The project timing provides the opportunity to study native Atlantic salmon spawning and habitat use at an important time for the program. Additionally, we will collaborate with DMR in the development of education and outreach programs by studying the beliefs, attitudes, perceptions, and knowledge gaps in the public's views of Maine's Atlantic salmon management program and aquaculture. To do so, we will use social science approaches (interviews, surveys, focus groups) to engage stakeholders in the region.

The project has been initiated and efforts have been focused on scoping conversations with collaborators and stakeholders. Survey content is being developed for subsequent regional distribution.

Investigator: Melissa Flye (PhD)

Advisors: Carly C. Sponarski (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)
Danielle M. Frechette

Duration: January 2020—December 2023

Cooperators:

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

Migration of American eels past hydroelectric dams in the Penobscot River, Maine

1. Collect data to inform development of forecasting model to predict downstream migration of American eels based on environmental factors (e.g., weather, lunar phase).
2. Use acoustic tags to track silver eels during emigration from the Penobscot River, and quantify mortality incurred at Milford and West Enfield Dams.

The proposed work will use field data to inform a predictive Bayesian forecasting modeling framework as to both timing of migration and behavior and survival at dams. Such a model could serve as a useful tool to managers to inform management and conservation decisions with regard to hydropower facility operation. Results from telemetry will be used to inform our developing model in conjunction with historical data from American eel fishermen in the Penobscot River. Such efforts could allow sensitivity analyses of turbine shut downs in order to balance conservation and financial objectives.

The tagging of collected American eels and release into the upper Penobscot River will make use of an established acoustic telemetry infrastructure to describe passage, path choice, and survival of through hydropower dams. The developing technology of acoustic telemetry allows us to tag and identify individual fish and detect them throughout the river during downstream migration with more than 100 autonomous, stationary listening devices. This array has been deployed in project years and has provided an opportunity to describe path choice and dam related mortality.

To understand the consequences of dam passage in the Penobscot River, Maine, we captured and implanted acoustic transmitters into more than 300 adult eels from 2016–2019. Tagged eels were released upstream of West Enfield and Milford Dams and tracked with an extensive acoustic array (60 fixed receivers). We used a Cormack-Jolly-Seber mark-recapture model to estimate survival as eels continued downstream migration. Survival through dams varied among years, but was lower than free-flowing river sections. We found evidence of a compounding effect of dam passage - passing a dam lowered the chance of surviving the next dam. Eels moved slower in impounded reaches when compared to free flowing river sections.

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

Investigator: Matthew Mensinger (MS)

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

Duration: September 2015—December 2020

Cooperators:

Maine Department of Marine Resources
Muckleshoot Indian Tribe
National Oceanic and Atmospheric Administration
National Science Foundation – Experimental Program to Stimulate Competitive Research
The Nature Conservancy
U.S. Fish and Wildlife Service
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit

Continued monitoring of Penobscot River migratory fishes to assess the long-term impacts of dam removals

1. Assess the migratory behavior of Atlantic salmon in the lower Penobscot River.
2. Assess the spawning migration patterns and demography of the American shad since the removal of Veazie Dam, and track their movements upstream of Milford Dam.
3. Determine river herring (alewife and blueback herring) run timing and demography throughout the spawning runs.
4. Assess river herring fidelity to spawning reaches across years.

The above objectives are part of a long-term monitoring project of adult anadromous fishes that has included several previous graduate students. The overarching goal of this project is to assess the impacts on migratory fishes of dam removal and restoration activities undertaken as part of the Penobscot River Restoration Project. Each year, Atlantic salmon, American shad, and river herring are tagged and released both above and below Milford Dam, currently the lowest dam on the mainstem Penobscot, and their movements are tracked. Data collected from these efforts are used to determine how regaining access to historical habitat has changed the demography and movements of these fishes, and also to evaluate the effectiveness of the fish passage facility at Milford Dam. Fishes are tracked using stationary radio antennas located on shore, weekly mobile radio tracking, acoustic receiver arrays located throughout the river, and PIT antennas installed in the fishways of existing dams.

During 2018 -20 a total of 189 Atlantic salmon were gastrically tagged with radio transmitters at Milford Dam and transported downstream to be released. These fish were tracked to provide an assessment of their movements up to, and through dams in the river. We will use this data to create maps of salmon movements that will show where salmon are located while they are delayed. During the same period, more than 300 American Shad were radio or acoustic tagged in the river, including upstream of Milford Dam. The tracks of the shad released above Milford represent some of the first data about the movements of this species into habitat that has been inaccessible for more than a century.

We also handled and tagged thousands of river herring with PIT tags and released them above Milford. Hundreds of detections of river herring occurred at upstream dams, a significant increase over previous years. These data will allow us to assess speed, path choice and site fidelity among years. A number of fish detected were tagged in previous years, affording a rare opportunity to inform this question.

Investigator: Erin Peterson (PhD)

Advisors: Joseph D. Zydlewski (Advisor)
Joan G. Trial
Stephen M. Coghlan, Jr.
Hamish S. Greig
Erik J. Blomberg

Duration: September 2017—May 2022

Cooperators:

Brookfield Renewable Power
Kruger Energy
Maine Department of Marine Resources
National Oceanic and Atmospheric Administration
Penobscot Indian Nation
Penobscot River Restoration Trust
The Nature Conservancy
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine

Energetic impacts of passage delays in migrating adult Atlantic salmon

1. Understand and quantify the bioenergetic cost of delays that adult migrating salmon experience at dams
2. Characterize the influence of energy expenditure on female Atlantic Salmon reproductive quality
3. Quantify the bioenergetic effects of thermal experiences on prespawning Atlantic Salmon

The purpose of this study is to understand the energetic impact of dam facilitated delays on migrating adult Atlantic Salmon. Delays below dams expose salmon to increased water temperatures, and this project will explore the connections between thermal experience, energetic expenditure, and reproductive quality. There are three overarching portions of this project. The first is a field-based study to tag and track salmon movement up to and through fish passage at Milford and Lockwood Dams on the Penobscot and Kennebec rivers, respectively, as well as to characterize the energy loss and thermal regimes of those tagged salmon below the dams. From there, a bioenergetic mathematical model will be developed to quantify metabolic loss of delayed salmon. The second part of the study will take place during fall spawning at Craig Brook Fish Hatchery. Female reproductive quality will be investigated through egg count, size distribution, and eye up and hatching dates. The energy reserves of the females (which are Penobscot river run fish) will be connected to the reproductive quality.

Tagging and tracking of 40 Penobscot and 26 Kennebec salmon has occurred in the 2018 and 2019 field season. This work has included the collection of empirical fat data on first capture, upon recapture, and for a subset of fish, post spawn. These data will be used to estimate the energetic costs of migrating salmon delayed below the dams. Preliminary data analysis has is consistent with the hypothesis that delays in warm waters below dam can result in greater loss of energy stores. Spawning of adult Atlantic salmon at the USFWS at Craig Brook National Fish Hatchery provided another opportunity to assess energy stores of salmon post spawn in both years. Egg number and quality will be assessed through the winter and spring to test the hypothesis that adult condition is associated with the size and survivability of young. This project is in the final stages of analysis and write up.

Investigator: Sarah Rubenstein (MS)

Advisors: Joseph D. Zydlewski (Advisor)
Nishad Jayasundara
Stephen M. Coghlan, Jr.

Duration: January 2018—May 2021

Cooperators:

Brookfield Renewable Power
Maine Department of Marine Resources
National Oceanic and Atmospheric Administration
U.S. Fish and Wildlife Service – Craig Brook National Fish Hatchery
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S.D.A. National Cold Water Marine Aquaculture Center
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

Dam removal and fish passage improvement influence fish assemblages in the Penobscot River, Maine

1. Describe changes to fish assemblages associated with the removal of two main-stem dams on the Penobscot River.
2. Describe species specific shifts associated with dam removal, habitat change, and fish passage modification.
3. Describe white catfish (*Ameiurus catus*) distribution and growth throughout the main-stem of the Penobscot River.
4. Describe white catfish life histories using micro chemical analysis of trace elemental concentrations correlated to changes in salinites.

Dams fundamentally alter the morphology and ecological characteristics of rivers. Populations of diadromous fishes have been drastically impacted by the construction of dams because they severely limit access to critical spawning habitat. Dam removal has been proposed as a method to rehabilitate the integrity of riverine systems as it has become an increasingly popular management solution.

The Penobscot River Restoration Project (PRRP) was one of the largest river restoration efforts in the United States. It aimed to increase the connectivity of the watershed through both dam removal and enhanced fish passage. Prior to restoration efforts, we conducted baseline fish assemblage surveys to allow for appraisal of this restoration. We found distinct assemblages associated with the lentic habitat in former impoundments and evidence of low habitat connectivity. We will ultimately describe any changes to Penobscot River fish assemblages by comparing pre post-dam removal surveys.

In addition, we are completing a study examining white catfish growth rates in the Penobscot River watershed to determine baseline parameters for this newly established invasive species. We also will examine potential variations in white catfish life histories using laser ablation as a method to detect changes in trace elemental concertation associated with changes in experienced salinity.

We are monitoring fish assemblages in the Penobscot River using shoreline electrofishing and a stratified random design. Sampling was conducted twice a year in both early summer (May-June) and fall (September-October) from the spring of 2010 until the summer of 2012. Sampling was resumed in the spring of 2014 and concluded in the spring of 2016. The second round of post dam removal surveys resumed in the spring 2019 and will continue through spring 2021. Dams of interest were removed during the interim (2012-2013) of sampling periods.

Initial results suggested anadromous fishes are now able to access all areas of the main-stem river and that lacustrine fishes have largely disappeared from former impoundments. In addition, a newly established invasive species (white catfish) was detected in the spring of 2019. We are hoping to establishing baseline growth and life history parameters for this invasive species outside of its native range.

Investigators: Kory Whittum (MS), Jonathan Watson, Ian Kiraly

Advisors: Stephen M. Coghlan, Jr. (Co-Advisor), Joseph D. Zydlewski (Co-Advisor), Daniel J. Hayes

Duration: May 2019—May 2021

Cooperators:

American Recovery and Reinvestment Act (ARRA)
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
Maine Outdoor Heritage Fund
National Oceanic and Atmospheric Administration
Penobscot River Restoration Trust
The Nature Conservancy
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S.D.A. National Cold Water Marine Aquaculture Center
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology

Finding the over wintering area for Atlantic sturgeon in the Gulf of Maine

Investigators: Joseph D. Zydlewski
Gayle B. Zydlewski

Duration: 2020—2022

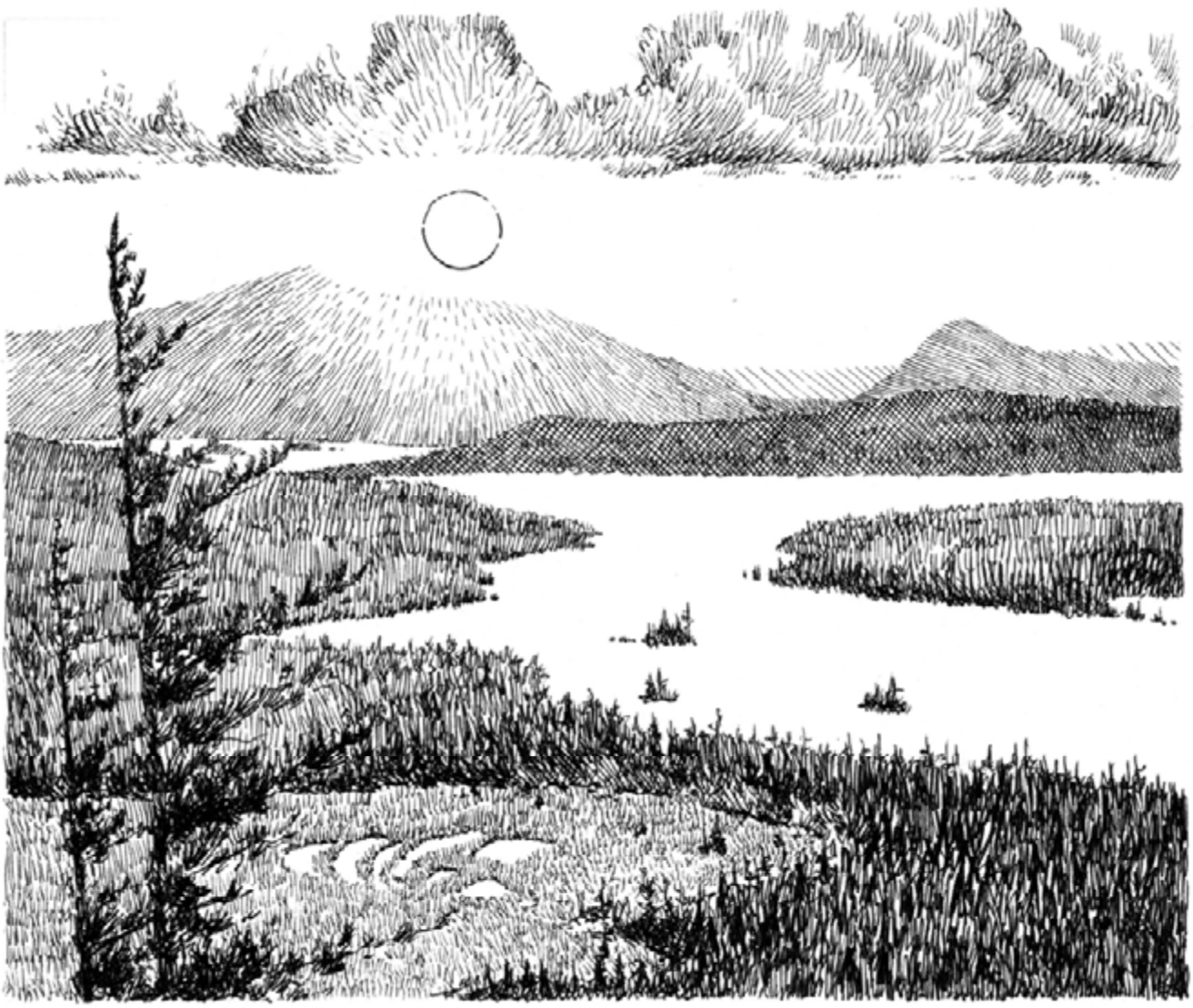
Cooperators:

University of Maine
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit

1. Describe the over winter habitat use by sub-adult and adult Atlantic sturgeon in the Gulf of Maine.

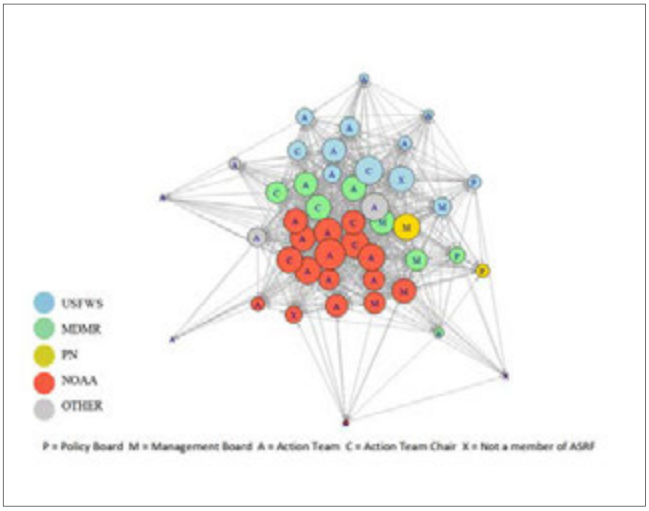
We are continuing a long-term project on federally (ESA) listed Atlantic sturgeon in the Gulf of Maine. Over the last decade we have systematically gill netted, tagged and tracked hundreds of fish using acoustic telemetry. This has increased the understanding of how these fish move seasonally within and among coastal river systems, including the Penobscot and Kennebec Rivers. Atlantic sturgeon enter these Gulf of Maine rivers in the summer months, leaving by fall to overwinter in the coastal environment. Our intent is to advance this program by using satellite tags to understand movement patterns through winter months (a priority of NOAA Fisheries). We intend to gill net and satellite tag sub-adult Atlantic sturgeon in the Kennebec and Penobscot Rivers in the summer. Tags are anticipated to pop off during the winter to provide this critical location information to reveal patterns of marine habitat use.

Atlantic sturgeon from the Penobscot and Kennebec Rivers have been captured in the summer of 2020 and released. Satellite tags are projected to detach from January to April 2021 and transmit movement data.



WILDLIFE and habitats

WILDLIFE and habitats continued



Getting over the dam: Overcoming institutional barriers to the recovery of Atlantic salmon by navigating the social-science/policy interface

1. Investigate how individuals in Atlantic salmon management entities communicate the history of and changes to the management structure over time
2. Evaluate the patterns of communication within and between management entities
3. Investigate member perceptions of management roles and responsibilities
4. Identify opportunities for and barriers to collaboration within and between management entities

Abstract: The term governance has undergone somewhat of an evolution since its inception, originally describing the act of governing, it has come to represent a more collaborative form of governing which is distinct from hierarchical control models (Marin and Mayntz, 1991). Collaborative governance refers to the systems associated with public policy decision making and resource management which span the jurisdictional boundaries of public agencies, levels of government, and/or public and private spheres in order to pursue a public policy goal or outcome (Emerson et al., 2012). Environmental management is often considered an inherently collaborative effort, as ecological systems and species rarely fall neatly within political or other human constructed boundaries (Bodin, 2017a).

Collaborative environmental governance systems can be a response to joint-jurisdictional management, where multiple managing organizations have legal jurisdiction over a species or system. This is often the case with species listed under the United States Endangered Species Act (ESA). Collaborations can also aid in dealing with the challenges of operating in a resource limited world. By forming collaborative governance structures, organizations aim to leverage resources, expand knowledge of the system, and avoid working at cross-purposes (Emerson and Nabatchi, 2015; Ulibarri and Scott, 2017). Whatever the original motivator, there are practical challenges associated with implementing a collaborative governance structure, and the success with which these structures operate varies greatly (Emerson et al., 2012).

Using the Atlantic Salmon Recovery Framework (ASRF) as a mixed-methods case study, we aim to further our understanding of communication, collaboration, institutional capacity for change, and barriers and opportunities for collaboration through Communication Network Analysis (CNA) and semi-structured interviews with members of the ASRF. The Gulf of Maine (GOM) Distinct Population Segment of Atlantic salmon (DPS) is managed by the National Oceanic and Atmospheric Administration (NOAA) the United States Fish and Wildlife Service (USFWS), the Maine Department of Marine Resources (MDMR), and the Penobscot Nation (PN). Individuals from these four organizations make up the ASRF, the current governance structure for Atlantic salmon management and recovery in the state of Maine.

In chapter 2, we describe the theoretical frameworks, methods, results, and significant implications of the CNA we conducted. 95% (N=41) of the individuals identified as members of the ASRF (N=43) participated in an online sociometric survey. The sociometric survey asked participants about their position within their organization and the ASRF, how long they have worked in Atlantic salmon management and/or recovery, the frequency with which they communicate with other members of the ASRF, and the productivity of those communications, using open and close-ended questions. In chapter 3, we describe

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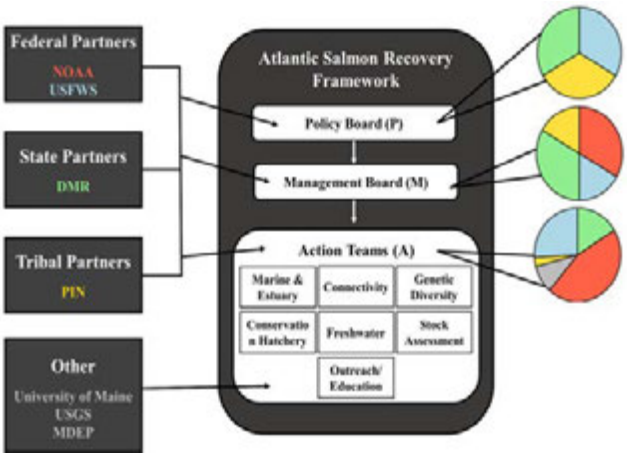

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the theoretical frameworks, methods, results, and significant implication of the semi-structured interviews we conducted. 68% (N=28) of individuals who were invited (N=41), participated in a semi-structured interview. The semi-structured interviews focused on member perceptions of ASRF operations, procedures, strengths, weaknesses, and power dynamics.

The CNA reveled that there is relatively high network density for individual communication (56%), but that connections are decentralized, a characteristic that can be incompatible with some organizational structures. Challenges reported by members fit into three general categories; 1. slow and ineffective decision-making, 2. confusion surrounding leadership and accountability, and 3. low adaptive capacity. The semi -structured interviews suggest that the lack of integration across organizations could be due in part to members reporting issues associated with leadership, operational transparency, lack of trust, and perceived differences in management styles and objectives. The lack of leadership was evident in both the CNA and interview data. As the managing organizations work to restructure the ASRF, the results and recommendations provided in this thesis have served as a valuable tool in identifying strengths, weaknesses, institutional barriers, and capacity of change.

Investigator:	Melissa Flye (MS)
Advisors:	Carly C. Sponarski (Advisor) Joseph D. Zydlewski Bridie McGreavy
Duration:	August 2017—December 2019
Cooperators:	

Human dimensions of giraffe conservation in northern Kenya

1. Establish baseline measurements of community knowledge, attitudes, and beliefs around human-giraffe interactions.
2. Quantify local levels and identify areas of giraffe part and product usage in and two conservancies.
3. Investigate how estimates of poaching behavior differ between three questioning techniques.
4. Integrate human dimensions data with giraffe movement patterns to inform conservancy management.

Abstract: Giraffe (*Giraffe* spp.) are iconic wildlife species to Africa, yet relatively little conservation funding and research have been directed at protection of giraffe in the wild. A growing number of national governments and conservation organizations are implementing management strategies to address the threats that giraffe face. To inform these plans, there is a need for social science that examines the human pressures associated with decline of giraffe populations, including poaching and the use of giraffe parts. As the large majority of reticulated giraffe (*Giraffa reticulata*) range occurs outside formally protected areas, conservation plans must be made with pastoralist communities and other actors in northern Kenya where the land is shared between people, their livestock, and wildlife. The research presented in this dissertation was conducted as part of a community-based program focused on reticulated giraffe, called the Twiga Walinzi Initiative ("Giraffe Guards" in Swahili), and represents the first quantitative study on the human dimensions of giraffe conservation.

Goals of the research project were to examine key cognitions to human-giraffe interactions (i.e. attitudes, beliefs, perceptions), assess relationships between certain cognitions within areas that adopt a community -based conservation approach, and understand the extent and drivers of giraffe meat and part usage. Face-to-face interviews were conducted at two study sites over survey periods in 2016/17 (n=579) and 2019 (n=680).

Results from these studies provide insights to how pastoralist communities view and act toward local giraffe. Factors that significantly influenced support for giraffe conservation differed between study sites, suggesting that local context is important to shaping human-giraffe interactions (Chapter 2). For instance, perceived benefits had stronger influence on normative belief in communities more recently connected with wildlife-based tourism. The linkages between perceived benefits, attitudes, and behaviors were further explored by assessing the relationships between these concepts within a community-based conservation setting (Chapter 3). Findings suggest a positive association between perceived benefits and attitudes toward giraffe, but there was less evidence that perceptions of wildlife-related benefits influenced use of giraffe meat/parts. As human behavior is of central interest to conservation, we also assessed levels of giraffe meat consumption (Chapter 4) and determinants of intention to consume giraffe meat (Chapter 5). Specialized questioning techniques were utilized to estimate prevalence of giraffe meat consumption preceding the two surveys. Estimated prevalence of giraffe meat consumption declined after establishment of the Twiga Walinzi. Perceived behavioral control had stronger relative influence than attitudes and subjective norms on future intention to consume giraffe meat. Collectively, these research findings are relevant for applied giraffe conservation efforts and provide a framework for understanding human-giraffe interactions and associated threats in diverse global settings.

Investigators: Kirstie Ruppert (PhD)

Advisors: Carly C. Sponarski (Co-Advisor)
Jenny A. Glikman (Co-Advisor)
Sandra M. De Urioste-Stone
Laura N. Rickard
Caroline L. Noblet

Duration: January 2017—May 2020

Cooperators:

Giraffe Conservation Foundation
Northern Rangelands Trust
San Diego Zoo Global
The Nature Conservancy

Bicknell's Thrush habitat use on commercial forestlands in Maine

1. Identify forest structure characteristics associated with breeding habitat selection by Bicknell's Thrush on commercial forestlands in Maine at multiple scales, both above and below the traditional elevation threshold for the species.
2. Identify novel, LiDAR-derived forest structure estimates that explain Bicknell's Thrush habitat selection.
3. Obtain or recreate forest management records to describe the management history that has resulted in the occupied breeding habitat.

Abstract: Forest reliant species may be significantly impacted by forest management practices. Understanding these impacts, and whether they are positive or negative, requires a species- specific understanding of habitat use. Bicknell's thrush (*Catharus bicknelli*) is a range-restricted habitat specialist occurring in balsam fir (*Abies balsamea*) dominated montane forests that have been recently disturbed and are undergoing successional growth. While research investigating this species' habitat use has been conducted throughout much of its breeding range, knowledge of Bicknell's thrush habitat use in Maine is lacking. Greater understanding of habitat use in Maine would improve the ability of forest managers to promote conservation of habitat for this species of concern. We documented the use of a method for tracking small songbirds in a landscape disadvantageous to using very-high-frequency (VHF) telemetry. Given that the habitat Bicknell's thrushes occupy is often characterized by rugged terrain and dense forest conditions, efforts to effectively track this species to estimate home-ranges and evaluate habitat use may be confounded. To ameliorate this, we explored the use of a combination tag with a global positioning system (GPS) and VHF component. All things considered, GPS+VHF telemetry was less expensive than VHF telemetry. However, VHF telemetry via triangulation was more accurate than GPS telemetry by 15.09 m. GPS+VHF tags provided greater spatial coverage by collecting data in areas we were otherwise unable to use VHF telemetry effectively. We conclude that GPS+VHF tags offer a feasible alternative to VHF telemetry in densely forested, rugged field conditions. We discuss the potential advantages and disadvantages to VHF- and GPS- based telemetry and make recommendations to researchers interested in employing these methods on small songbirds. We suggest that researchers consider the use of a GPS+VHF tag attached with a weak link leg-loop harness. We also recommend that while researchers should rely on the GPS component of the tag for the majority of their data, we also encourage researchers to continue to track individuals using the VHF tag component when study objectives deem it necessary.

We also captured and tracked 24 Bicknell's thrushes during 2018-2019 in a harvested and non-harvested study area in Maine, USA, and evaluated the influence of forest structure and composition on habitat selection. At the landscape level, Bicknell's thrushes demonstrated avoidance of tall canopy heights and a large proportion of hardwood tree. At the home-range level within the harvested area, Bicknell's thrushes selected increasing numbers of small trees (2.54 to 10 cm dbh) and demonstrated a quadratic relationship for selection of canopy height. Similarly, at the home-range level within the non-harvested area, Bicknell's thrush demonstrated a quadratic relationship for selection of the number of small trees and canopy height. We concluded that Bicknell's thrushes use lower elevation forest stands in harvested landscapes in Maine. We recommend quantifying forest structure using LiDAR to identify and prioritize stands for use by Bicknell's thrush.

Investigator: Kaitlyn Wilson (MS)

Advisors: Amber M. Roth (Advisor)
Erik J. Blomberg
Daniel J. Hayes
Adrienne J. Leppold

Duration: August 2017—May 2020

Cooperators:

The Nature Conservancy
U.S. Navy
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Maine Cooperative Forestry Research Unit
Weyerhaeuser Company

Demography, resource selection and conservation of a previously unstudied population of African wild dogs (*Lycaon pictus*) in central Mozambique

1. To use photo recognition of identifiable individuals acquired during direct sightings over 10 years, coupled with indirect observations (e.g., scats and tracks) to estimate the minimum number and mean size and age composition of African wild dog packs inhabiting the study region so that plausible population size and age structure can be inferred.
2. Analyze the clustering of pack locations within the denning period to estimate position of their core breeding areas across the study region and to interpret possible overlap and evidence of interpack aggression.
3. Develop a logistic regression model using a complete dataset of 210 pack locations to test the effects of vegetation type, availability of potential prey, presence of other large carnivores, and distance to human activities, on spatial occurrence.
4. Compare diet composition from standard scat analysis to availability of potential preys from extensive sampling of spoor along strip transects.

The African wild dog (*Lycaon pictus*) is the most threatened carnivore in sub-Saharan Africa and is listed as "Endangered" by the IUCN. Previous fieldwork conducted by the investigator documented evidence of a peculiar subpopulation inhabiting a heavily forested portion of the Marromeu Complex in the Northern Sofala province of central Mozambique; this subpopulation was previously undocumented. This subpopulation is small, with unknown connectivity and confined to an area much smaller than is typical for the species that we hypothesize it to be associated with primary use of a dense population of meso-mammals and affected by relationships with other large carnivores. The only genotype obtained so far has not been previously described for adjacent populations and has distant origins in northern Kenya, suggesting a past colonization event followed by genetic isolation. Being located at the southeastern edge of the species distribution, this population is interesting and important given its potential for connecting geographically disparate subpopulations in various directions, thus its persistence is a conservation priority. Our results are expected to position field managers to make science-based decisions for mitigation of both anthropogenic and natural threats to this unique and important subpopulation.

Exploratory analysis was undertaken on data from 569 ungulate spoor strip transects that was tested for significant difference between seasons.. Three potential predictor variables (Abundance, Biomass and Species Richness) were identified to describe availability for 5 different prey size groupings (15 variables in total); paired correlation coefficients were used to reduce redundancies. Resultantly, three variables describing prey abundance and diversity were selected to be incorporated into logistic regression modeling to describe predictors of African Wild Dog across the surveyed area. The influence of additional predictor variables including distance from human activities, habitat composition, and presence of other large carnivores on African Wild Dog occurrences will also be evaluated.

Identification of prey from standard scat analysis has now started and should be ongoing in early 2021 The target date for project completion is May 2021.

Investigator: Jean-Marc André (MS)

Advisors: Daniel J. Harrison (Advisor)
Brian J. McGill
David G. Marneweck
Courtney Marneweck

Duration: January 2019—May 2021

Cooperators:

Effects of silviculture and other human activities on the occupancy and reproductive success of American black bears in Maine

1. Using motion-triggered trail cameras to estimate the effects of land use change on the occupancy of American Black bears in Maine.
2. Using data collected over three summers to estimate the proportion of bears in a reproductive state (sow with cubs).
3. Comparing number of reproductive and single bears to anthropogenic features such as logging activity, so as to look for potential relationships between the state of the forest and reproductive success of black bears.
4. The use of multi-state occupancy models to understand how landscape features, land use change and harvest pressure may impact bear population and reproductive rates at broad spatial scales.

Black bears (*Ursus americanus*) have always been integrated with the identity of Maine. These carnivores hold significant economic, cultural, sentimental and recreational value to the people of Maine. Additionally, they are ecological significant as both apex predators and vegetation foragers throughout the region. Motion-triggered remote cameras have been placed in forests all over northern and central Maine, for the primary purpose of collecting occupancy data and developing an optimal monitoring protocol for mesocarnivores. These forests exist under varying levels of human influence. In the north, many areas are heavily logged, and thus of young and middle-aged forest stands. As we move closer to the central Maine counties, the proximity to human habitation increases. While these areas are comparatively less heavily logged and are older forests, they may experience other anthropogenic influences. Multi-state occupancy models will be used to observe the effects of land-use change, hunting, silviculture and other anthropogenic factors that affect the population, presence and reproductive success of black bears. This data can then be used to devise an appropriate conservation strategy as well as assist agencies in estimating a recommended number of hunting licenses to issue in certain areas.

The project is in the Final stage. The analysis has been conducted and will be run again. The results are being consolidated and the writing is taking place.

Investigator: Amay Bolinjkar (MWC)

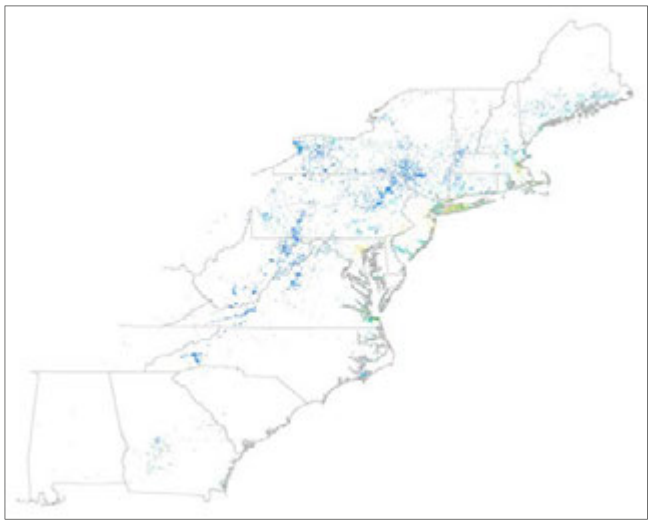
Advisors: Alessio Mortelliti (Advisor)

Collaborators: Bryn Evans
Griffin Archambault

Duration: September 2019—December 2021

Cooperators:

Baxter State Park
Downeast Lakes Land Trust
Maine CFRU Landowner access and assistance
Maine Department of Inland Fisheries and Wildlife
The North Maine Woods
University of Maine
University of Maine – Maine Cooperative Forestry Research Unit



Monarch Butterfly (*Danaus plexippus*) roosts-site selection and viability east of the Appalachian Mountains

1. Characterize the habitat criteria that monarch butterflies in the Atlantic flyway population use in selecting fall stop-over locations.
2. Identify and map sites meeting these habitat criteria, including previously known sites as well as locations where monarchs are not known to occur.
3. Evaluate current and future vulnerability of these sites as defined by adaptive capacity, sensitivity, and exposure.

The monarch butterfly is a flagstone species and pollinator whose populations are declining. The largest population overwinters in Mexico, then disperses north across the United States and Canada to breed in spring and summer. They migrate back south in fall, splitting into two flyways: one in the central U.S., one along the Atlantic coast. They fly during the day, and at night roost in groups. The roost-site criteria that monarchs select for are currently unknown. We are developing an ecological niche model for the Atlantic flyway roost sites using Maximum Entropy and Genetic Algorithm for Ruleset Prediction. We are using citizen scientist reported occurrences and environmental variables that are known to affect monarchs in alternate life stages, including weather, topography, vegetation, and human impacts. We are partnering with land managers to validate model predictions, and developing a phone app to collect data for model validation. The models will be used in a vulnerability analysis of roost habitat with respect to land use and climate change using variables describing exposure, sensitivity, and adaptive capacity. Final products will include models of current monarch roost habitat suitability, and assessment of stopover areas in the Atlantic flyway that are at risk of future change.

The models have been completed and a draft of the write-up is complete. It is currently undergoing review by the committee members in preparation for submittal and defense.

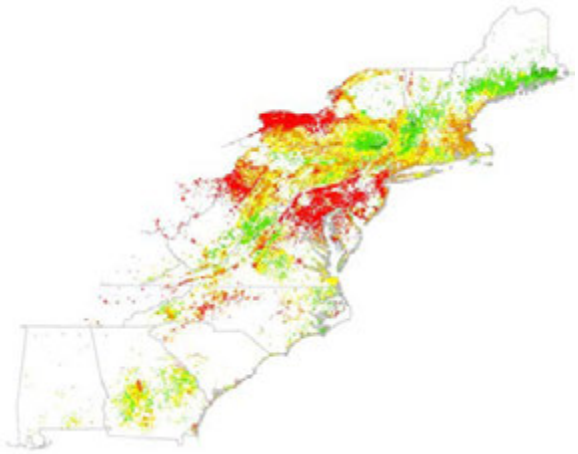
Investigator: Brandon Boxler (MS)

Advisors: Cynthia S. Loftin (Co-Advisor)
William B. Sutton (Co-Advisor)
Francis A. Drummond
Joseph D. Zydlewski
Phillip deMaynadier

Duration: August 2017—December 2020

Cooperators:

Maine Department of Inland Fisheries and Wildlife
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Veterans Administration
University of Maine



Consequences of small mammal personalities on habitat use, seed dispersal effectiveness, and demography

1. Examine the validity of personality measurements obtained from wild, trapped animals by testing whether or not the time confined to a live-trap influences behavior in standardized tests.
2. Test whether land-use change alters patterns of individual niche specialization in the small mammal community.
3. Assess whether a scatter-hoarder's personality influences its position along a predator/mutualist continuum by affecting its seed dispersal effectiveness.
4. Assess whether silvicultural practices impact survival rates of small mammals and test the specific hypothesis that personality traits mediate the response of individuals to land-use change.

Individual variation is at the root of all evolution via natural selection. Despite this fact, until recent years, individual behavioral variation has been largely considered as noise and ignored in the literature. Now, a growing body of research suggests that individual differences should be embraced as possible drivers of community and ecosystem processes, rather than as statistical noise. Within this project, I explore the interplay between individual behavioral variation, land-use change, and community/ecological consequences using small mammals in the Penobscot Experimental Forest (Bradley, ME) as model species.

Background to current experiments - Objective #3: Small mammals perform an important function in a forest ecosystem because they aid seedling germination by dispersing and caching seeds. Although we have been aware of scatter hoarding behavior for hundreds of years, we still don't understand it totally since the mutualism between dispersers and seeds is conditional (i.e., whether they actually help or hurt the trees depends on several factors - some still unknown). The objective of this experiment will be to look at whether or not individual small mammals differ in their contributions to this complex system. Is the population uniform in terms of contributions, or are some individuals more or less important for this important ecosystem process?

June - October 2020 marks the final field season of my PhD and wraps up the work I have done in the Penobscot Experimental Forest since June 2016! In addition to ongoing mark-recapture experiments (tagging and measure personality in 5 primary target species) I have been undertaking a large-scale field experiment to further our understanding of small mammal seed dispersal and caching behavior. These experiments, performed in September and October 2020, will allow me to meet Objective #3.

Primarily, these experiments involve presenting individually tagged seeds to wild small mammals in the field and using fluorescent UV tracking powder to relocate cached seeds. High-definition trail cameras allow me to identify the owner of each cached seed, so that I can assess individual seed disperser effectiveness by monitoring caches over time.

Objective #2 has been completed and the publication resulting from this work is currently under revision at Ecological Applications.

Investigator: Allison Brehm (PhD)

Advisors: Alessio Mortelliti (Advisor)
Erik J. Blomberg
Shawn R. Fraver
Brian J. McGill
Malcolm L. Hunter, Jr.

Duration: January 2019—August 2021

Cooperators:

University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station

Rusty Blackbird use of commercial forests of northern New England

1. Describe Rusty Blackbird nest and fledgling site selection at both stand and within-stand scales in commercially managed forests in New Hampshire and Maine.
2. Describe habitat and vegetation characteristics associated with Rusty Blackbird nest and fledgling survival at multiple spatial scales.
3. Propose recommendations to forest landowners to manage their lands to promote Rusty Blackbird breeding habitat.

The Rusty Blackbird (*Euphagus carolinus*) has experienced a steep population decline since the 1970s, with qualitative accounts suggesting that the species' numbers have been falling prior to the 1950s. The species is a habitat specialist that relies on spruce-fir stands located near wetlands for breeding in the boreal and Acadian forests of North America. Historically the natural disturbance regime in this region included agents such as beaver and spruce-budworm outbreaks, though over the last century anthropogenic change due to commercial logging has become more commonplace. Rusty Blackbirds response to intensive commercial forestry practices within their breeding range has yet to be assessed. We are examining Rusty Blackbird nesting and fledgling habitat selection and survival in intensively managed forests in Maine and New Hampshire that contain practices such as precommercial thinning, regenerating clearcuts, and planted stands. Fledglings are affixed with VHF-radio transmitters and tracked via radio telemetry. Nest and fledgling GPS points are paired with random points to compare habitat/harvest metrics and determine which characteristics are preferentially selected. General linear mixed models are used to compare used vs. available sites and survival under different conditions.

During the 2019 field season, Rusty Blackbirds were confirmed nesting in naturally regenerating stands, stands that underwent precommercial thinning, and undisturbed wetlands. A second field season was planned for summer 2020, but was postponed to 2021 due to COVID-19. Analysis of the first field season's data suggests that nest site selection was primarily driven by canopy height and wetland cover at the stand scale, and by canopy cover and basal area of small softwoods at the within-stand scale. Our findings suggest that nest survival at the stand-scale was driven by the percent cover of young softwood stands and canopy cover, and by canopy cover at the within-stand scale. Fledgling habitat selection and survival analysis is still ongoing, though early results suggest that low-slope soils and the relative number of small trees influence site selection. Current tasks include finishing preliminary fledgling analysis and planning for the 2021 field season.

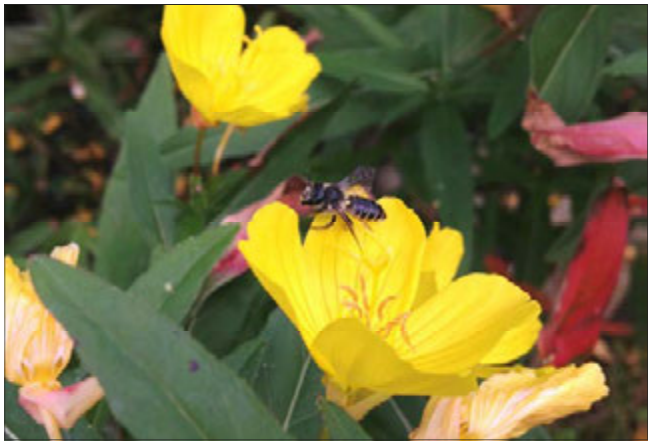
Investigator: Luke Douglas (MS-FOR)

Advisors: Amber M. Roth (Advisor)
Cynthia S. Loftin
Aaron R. Weiskittel

Duration: August 2018—May 2021

Cooperators:

Maine Department of Inland Fisheries and Wildlife
Maine Research Reinvestment Fund
New Hampshire Audubon
University of Maine – Center for Undergraduate Research
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Maine Cooperative Forestry Research Unit
Wagner Forest Management
Weyerhaeuser Company
William P. Wharton Trust
J.D. Irving, Ltd.
Maine Outdoor Heritage Fund
University of Maine at Fort Kent
University of Maine at Presque Isle
Seven Islands Land Company



Literature review and meta-analysis of rights-of-way management for wild insect pollinators with focus on application in Maine and the northeastern U.S.

1. Are there specific ROW (e.g., roadsides and powerlines) management practices that successfully enhance pollinator abundance and diversity?
2. Which insect pollinator taxa respond most significantly to common ROW management enhancement practices?
3. Are there elements of landscape context that serve to enhance (e.g., adjacent fields or wetlands) or threaten (e.g., traffic volume, road class) the success of ROW management for pollinator conservation?
4. How do answers to the questions above inform recommended best management practices for roadside and ROW habitat enhancement for pollinators?
5. Is there a relationship between pollinator abundance and diversity at site surveyed by F. Drummond at ten managed Priority 1 roads in Maine and landscape context?

We propose to complete a systematic review and meta-analysis of published literature on pollinator habitat management within and in similar habitats to roadside rights-of-way (ROW). ROW are typically maintained as herbaceous plant-dominated habitat, similar to pasture, prairie, or early-successional forest. These habitat types provide forage and nesting resources for wild pollinating insects, including bees, butterflies, and hoverflies. As pollinator habitat is lost owing to reforestation, urbanization, or agricultural intensification, relying on remnant habitat such as that found within ROW may conserve and promote wild insect pollinator populations. This is an emerging field of study in pollination ecology, and much new research has been published on the topic since the literature was last reviewed by Wojcik and Buchmann (2012). We will assess ROW habitat conditions and management practices globally and then summarize and synthesize existing data to create guidelines for pollinator habitat management in Maine and the northeastern U.S. Our assessment will include academic and non-academic sources to obtain the greatest breadth of available information and create products that are relevant to and readily applicable by managers. We will employ qualitative and quantitative methods to provide detailed descriptions and rigorous statistical analysis of trends and outcomes in ROW management for pollinators.

We conducted a literature search on Web of Science and Google Scholar for academic and grey literature on pollinator habitat management in rights-of-way and similar habitats. Search results provided more than 500 pieces of information, which we have catalogued in a detailed database. Following a priori protocol we developed for this project, we are currently reviewing our gathered information in detail to determine trends and identify knowledge gaps in management strategies, habitat characteristics, and landscape context that influence pollinator communities in ROW. We are also extracting quantitative data from this literature through the review process to analyze using meta-analytical techniques. Our output from this project will include a technical report summarizing our findings from the literature and a manuscript detailing quantitative relationships between ROW habitat and pollinators. Early findings suggest that reduced mowing and seeding of native plants are effective strategies to promote pollinator abundance and diversity in ROW and similar fallow habitat. This research has expanded substantially in scope in the last 10 years; our review will provide a critical update for practitioners and academics. This project will be completed in May 2021.

Investigator: Brianne Du Clos (Postdoc)

Investigators: Cynthia S. Loftin (Advisor)
Francis A. Drummond
Phillip deMaynadier

Duration: September 2019—May 2021

Cooperators:

Maine Department of Inland Fisheries and Wildlife
Maine Department of Transportation
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine

The potential of wildlife rehabilitation datasets in avian conservation science

1. Calculate admission number and release rates of varying causes of wild bird admission to rehabilitation centers.
2. Compare the admission number and release rate of anthropogenic causes of admission to natural causes of admission.
3. Determine how number of admissions, release rates, and anthropogenic caused admissions change over the 1-year study period.
4. Compare the number of birds admitted into rehabilitation centers sourced from rural vs. urban population centers.

The number of admissions to wildlife rehabilitation centers are increasing, yet little is known about admission trends throughout the United States because the body of research on causes of admission often focuses on a single species or single rehabilitation center. The purpose of this study is to combine avian data from multiple rehabilitation centers to determine the role of these centers in avian conservation. To accomplish the proposed study, data will be voluntarily submitted by wildlife rehabilitation centers and used to calculate release rates, the proportion of anthropogenic caused admissions to naturally caused admissions, and admission numbers in urban and rural environments. Data will be compared across avian taxa, by cause of admission, and wildlife rehabilitation center. A minimum of five centers from an urban area and five centers from a rural area will be used. The submitted data will be reclassified and organized for uniformity among centers. Once organized, statistics will be performed using Studio R. A better understanding of admission causes and release rates by cause will help focus mitigation efforts to reduce human impacts on wildlife and understand the role of rehabilitation centers in bird conservation.

For data collection, 24 rehabilitation centers were contacted as well as the Wild-ONe database. Data have been submitted from 5 of the 24 centers contacted plus 20 centers from the Wild-ONe database for a total of 6 datasets. Five of these centers are located in urban areas. Across all centers, we received data for 49,272 individual bird admissions. The datasets are being reclassified for uniformity with the help of an undergraduate student. Four datasets have been completed, and two are in progress. Analysis of the submitted data included creating code in R to analyze admissions by species and cause in relation to the rehabilitation outcomes.

Investigator: Michelle Duffy (MWC)

Advisors: Amber M. Roth (Advisor)
Cynthia S. Loftin
Anne B. Lichtenwalner

Duration: January 2019—December 2020

Cooperators:

University of Maine – Maine Agricultural and Forest Experiment Station
WILD-ONE

How climate change and land use change affect scatter-hoarding rodents and their ecosystem service

1. Investigate the extent to which scatter-hoarding rodents displaying different behavioral traits participate in the development of forest vegetation in distinct sylvicultural treatments.
2. Estimate the impact of climate change (early-onset spring) on seed availability in different sylvicultural treatments and the influence on decision making (cache vs consumption) in scatter-hoarding rodents.
3. Investigate the relationship between land-use change/seed abundance and the emotional response triggered by the discovery of a pilfered cache in scatter-hoarding rodents.
4. Explore the interest of small mammals in novel seeds, predicted to move Northward as a result of climate change, focusing on pilfering behavior.

In recent years, a growing body of evidence demonstrates the existence of consistent individual differences in behavior across time and context, referred to as personality traits, in diverse animal species. Progressively, the ecological implications of personality traits started to be investigated (e.g. evolution, population dynamics and spatial distribution), but their effects on ecosystem services provided by animals still need to be explored. This project aims to understand how land-use change influences the distribution of personality traits and cognitive abilities in scatter-hoarding rodents, to subsequently investigate the impact on the development of forest vegetation.

Objective 1 will be fulfilled through the realization of a forest vegetation development model to show the importance of preserving the diversity of personality traits for the maintenance of the ecosystem. However, climate change is expecting to disrupt ecosystems functioning, for example by modifying the phenology of seed production or favoring the propagation of novel seed species. Therefore, Objectives #2 and #4 have been designed to respectively predict foraging decisions of small mammals during years of early seed abundance and test their interest in novel seeds. Finally, an innovative experiment investigating the effect of land-use change on scatter-hoarders emotions will be attempted (Objective #3) to understand how pilferage affect the internal state of the cache owner in different forest treatment.

Data collection for my PhD started with the field season in June 2020. As part of a long term project initiated in 2016, five main species of small mammals: deer mouse, Southern red-backed vole, Northern short -tailed shrew, American red squirrel and Eastern chipmunk have been trapped on a regular basis in the Penobscot Experimental Forest (Bradley, Maine). For each individual, morphological measurements (body weight, body length, tail length) and standard behavioral tests assessing for personality traits (open-field, emergence and handling bag tests) have repeatedly been performed using the capture-mark-recapture method. Although October 2020 marks the end of the field season, it also marks the beginning of the analysis of the behavioral videos collected, the realization of the pilot studies for the objective #3 and the writing of my PhD proposal.

Investigator:	Margaux Duparcq (PhD)
Advisors:	Alessio Mortelliti
Duration:	September 2020—August 2025
Cooperators:	

Development of optimal monitoring protocol for mesocarnivores in Maine

1. Assess optimal arrangement for motion-triggered trail cameras used to detect diverse mesocarnivore species in Maine
2. Conduct trail camera surveys across a gradient of timber harvest intensities throughout Maine forests to understand current occupancy patterns for mesocarnivore species of conservation and management interest (marten, fisher, coyote, lynx, and black bear as high priority species)
3. Investigate interspecific dynamics between marten and fisher, conspecific species that exhibit antagonistic to indifferent interaction in various parts of their range
4. Provide user-friendly guidelines on optimal monitoring approaches for key species to MDIFW, including the costs and benefits of surveys in winter versus summer, length of deployments, landscape features, and desired level of precision.
5. Assess efficacy of trail cameras for long-term, multi-species monitor at large spatial scales and best method practices.

Our research is aimed at understanding the efficacy of using arrays of motion-triggered trail cameras, an increasingly popular and robust tool for wildlife research, to collect biologically relevant information on occupancy and detection patterns for mesocarnivores in Maine. Carnivore populations are important at global, regional and local scales due to their ecological role, their aesthetic and economic value, and the numerous threats to their conservation. American martens (*Martes americana*) and fisher (*Pekania pennanti*) are medium-sized carnivores (*mesocarnivores*) native to North America, and methods to track changes in population independent of harvest reports will be valuable to the Maine Department of Inland Fisheries and Wildlife. These species are also likely to respond to habitat changes that occur as a result of timber extraction, thus we are conducting surveys across landscape features to create a natural experiment and enable comparison between different forest types, harvest histories, and degrees of fragmentation. Additionally, our methods will allow us to investigate the relationship of numerous other species (for example weasels (*Mustela sps.*), lynx (*Lynx canadensis*), and coyote (*Canis latrans*) which are of interest due to lack of current knowledge in Maine, changing status and conservation concerns, or potential conflict with other species of management priority.

We are in our fourth and final year of full scale surveys planned for data collection. During winter 2020 we set and retrieved the sites of our third year of winter surveys, which included new areas selected to collect data across a range of recreational trapper harvest (furbearing species of interest are marten, fisher, and coyote). Over summer 2020 we revisited "permanent" survey locations as Covid travel restrictions permitted, to collect multi-year data on carnivore species. PhD student Bryn Evans completed the comprehensive exam process, and in January a second publication related to the project, led by undergraduate honors student Mike Buyaskas, was published in Mammalian Biology.

Investigator: Bryn E. Evans (PhD)

Advisors: Alessio Mortelliti (Advisor)
Cynthia S. Loftin
Walter Jakubas
Daniel J. Hayes
John-Pascal Berrill

Duration: January 2017—December 2021

Cooperators:

Baxter State Park
Downeast Lakes Land Trust
Maine CFRU Landowner access and assistance
Maine Department of Inland Fisheries and Wildlife
The North Maine Woods
University of Maine
University of Maine – Maine Cooperative Forestry Research Unit
American Forest Management
The Nature Conservancy

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.

We have completed all field work to resurvey commercially managed timberlands bordering the western boundary of Baxter State Park for American marten. Despite consistent spatial and temporal trapping effort, we documented lower resident capture rates and more strongly male-biased sex ratios in the contemporary era compared with historical data. Multi-method occupancy models developed with live-capture and camera-trapping data collected in 2019 supported the efficacy of the established capture-based methods used in our study area to assess marten occurrence. Both cameras and live-traps yielded similarly high cumulative probabilities of marten detection, but spatial use and demographic information from the traditional combination of live-trapping and telemetry was superior in reducing both Type I and Type II error in estimates of resident marten occupancy. Efforts during 2021 will focus on developing models of cause-specific mortality among resident martens, and predictive models of marten occurrence.

Investigator: Kirsten Fagan (PhD)

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

Duration: January 2018—December 2021

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

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

1. Assess patterns (rate and migratory path) of migration from breeding areas in the fall, and from wintering grounds to breeding areas in the spring.
2. Compare migration ecology for woodcock breeding along a latitudinal gradient to evaluate differences in migration strategies based on breeding latitude.
3. Identify stopover areas and analyze landscape patterns affecting migratory stopover during both spring and fall migration.
4. Evaluate survival of woodcock during migration and relate observed patterns in mortality with processes identified in objectives 1-3.

Migratory animals in general face numerous challenges as they traverse seasonally suitable habitats throughout the full annual cycle. Often times, migratory animals must traverse a foreign landscape and face many novel threats to which they are naïve. Migratory bird in particular face numerous challenges in human dominated landscapes facing 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 experienced prolonged declines through eastern North America. Woodcock breed from the south-eastern United State to southern Canada (March-October) and overwinter primarily in the southeastern United States and mid-Atlantic 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 350 GPS transmitters to track woodcock individually as they travel between breeding and wintering regions, and have future deployments planned over the coming years. Ultimately we will investigate migratory phenology, routes, quantify survival, and evaluate how breeding/over-wintering latitude influences these metrics

As of November 2020, we have deployed 351 GPS transmitters on pre-migratory woodcock; 7 Alabama, 12 Georgia, 19 Maine, 19 Maryland, 30 New Jersey, 39 New York, 21 North Carolina, 7 Nova Scotia, 5 Ontario, 37 Pennsylvania, 22 Quebec, 47 Rhode Island, 17 South Carolina, 69 Virginia, 18 Vermont, and 5 West Virginia. In the past year we added three states; Alabama, Georgia, and Vermont. The COVID-19 global pandemic has limited travel and deployments in some states/provinces, but we are hoping to continue capture efforts in spring 2021.

We have commitments to continue transmitter deployment through the fall and winters 2021/2022, but plan to continue the project as long as interest remains among cooperators. Our project would not be possible without the involvement of state and federal agencies, universities, and non-governmental organizations throughout eastern North America.

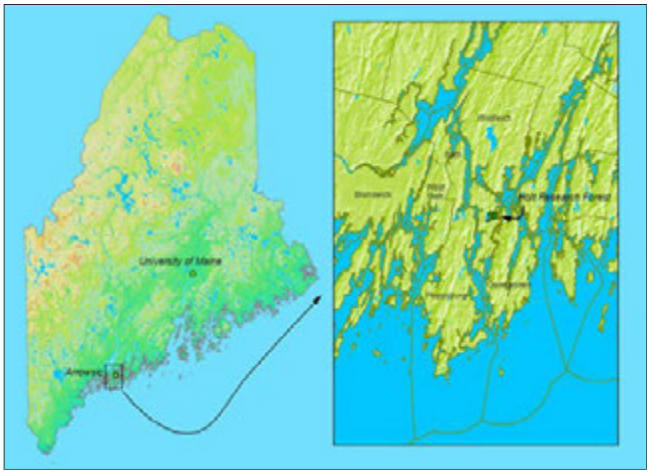
Investigators: Alexander Fish (PhD)
Liam Berigan (PhD)

Advisors: Erik J. Blomberg (Co-Advisor)
Amber M. Roth (Co-Advisor)
Joseph D. Zydlewski
Erin Simons-Legaard
Brian J. Olsen

Duration: October 2017—May 2022

Cooperators:

Alabama Department of Conservation and Natural Resources
Environment and Climate Change Canada
Florida Fish and Wildlife Conservation Commission
Georgia Department of Natural Resources
Maine Department of Inland Fisheries and Wildlife
Maryland Department of Natural Resources
New Jersey Department of Environmental Protection
New York Department of Environmental Conservation
North Carolina Wildlife Resources Commission
Pennsylvania Game Commission
Rhode Island Department of Environmental Management
South Carolina Department of Natural Resources
State University of New York – Cobleskill
The American Woodcock Society
The Nature Conservancy
The Ruffed Grouse Society
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Geological Survey – Patuxent Wildlife Research Center
University of Rhode Island
Vermont Fish and Wildlife Department
Virginia Department of Game and Inland Fisheries
Wildlife Management Institute



Pulsed resources in a changing world: responses of small mammal and bird populations over a 40 year period

1. To understand the long-term capacity of animals to track and exploit the wave of pulsed resources.
2. To investigate the spatial-temporal cascading effects of pulsed resources on animal habitat selection.
3. To assess how two seed predator species differ in their ability to exploit resources and the implications of different foraging strategies for species distribution shifts.

Many environments have spatiotemporal variability in resources that may constitute pulsed resources – changes in resource abundance in space and time. Mast-seeding – an intermittent production of large seed crops by tree populations – is a pulsed resource which regulates the population of many seed predator species. Despite the large literature addressing the importance of mast-seeding events for animal population density, the extent to which small mammal and bird populations can follow pulsed resources in space and time and how this influences individual fitness and coexistence remain still poorly understood.

Additionally, the implications of pulsed resources for forest dynamics go beyond local scales; indeed, the association between small mammals and seeds could ultimately modify landscapes at continental scales. Some small mammal and tree species are exhibiting northward shifts in their distribution range due to climate change and their strong interactions could play a major role because the caching behavior of small mammals shapes seed dispersal and forest regeneration. Hence, understanding how the biotic association of small mammals and seed species can influence species range shifts is fundamental to predicting ecosystem functioning under climate change.

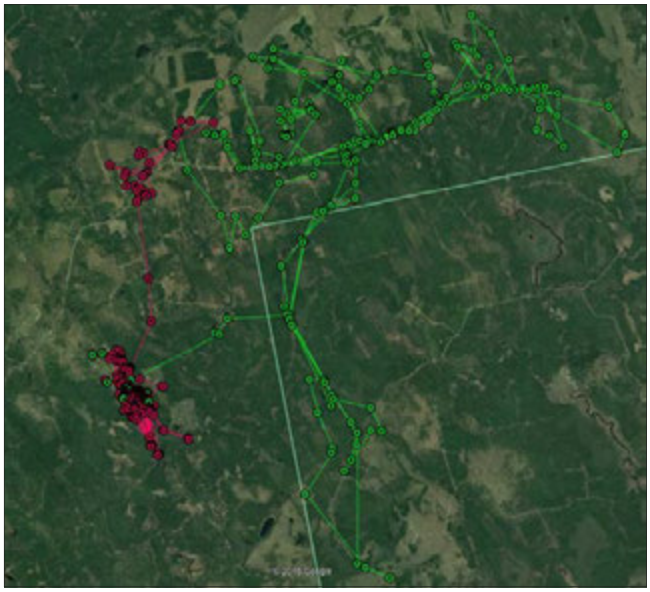
Here I take advantage of the time series provided by the Holt Research Forest (HRF) dataset. The HRF is a 120-ha forest located in Arrowsic, Maine in which 37 years of data (1983 – 2020) have been collected on small mammal and bird populations, vegetation structure, and tree seed abundance, within a 40-ha grid. During 2020, I'm working on building yearly seed maps based on data collected on seed traps. To investigate how small mammals respond to the changes in seeds abundance over time, I'm analyzing yearly small mammal population and individual parameters – density, home range size, fitness, and coexistence/competition.

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—December 2023

Cooperators:



Wild turkey population ecology across land use gradients in Maine

1. Develop a model to estimate wild turkey abundance specific to wildlife management districts in Maine using a band recovery model and harvest information.
2. Develop a multi-scale predictive model for wild turkey nesting habitat based on nest site selection relationships at multiple scales as well as nest success.
3. Use dynamic Brownian Bridge Movement Models to evaluate space use and movement of wild turkeys during different seasons of the year.
4. Create models of nest daily survival rate that accounts for the individual variation that may be caused by differences in hen movement behavior prior to nesting.

This project is focused on trapping and tracking of wild turkeys in Maine to understand the dynamics of their population ecology across a landscape resource gradient. Trapped individuals will be banded for harvest reporting, which will be combined with total harvest information provided by the Maine Department of Inland Fisheries and Wildlife in a Lincoln estimator to estimate population size. We will use VHF and GPS transmitters to monitor hen movements during the prenesting season and to identify nesting behavior. Using this data, we will produce a predictive model of nesting habitat quality that incorporates information on the multiple scales of nest site selection and the probability of nest success. We will use location information from GPS-marked hens in a dynamic Brownian bridge movement model to assess land cover correlates with use a movement behavior during different seasons of the year. This location information will also be used to quantify different aspects of hen pre-nesting movement behaviors. We will assess whether variation in these movement behaviors affect nest success.

We have completed 3 years of data collection. Over that time, we captured 892 unique wild turkeys, each of which we banded. We fitted 151 females with VHF transmitters and 59 with GPS transmitters. In addition, we fitted 57 males with VHF transmitters and 2 with GPS transmitters. To estimate nest survival, we located and monitored 118 nests from marked females. We are currently finalizing a model to estimate turkey abundance within each wildlife management district. Following completion of this objective, we will be shifting focus to assessing resource selection of wild turkeys across Maine's resource gradient and how it differs according to time of the year. We will also be working to assess wild turkey habitat quality by quantifying nest success and selection at multiple scales.

Investigator: Matthew Gonnerman (PhD)
Stephanie Shea (PhD)

Advisors: Erik J. Blomberg (Advisor)
Kelsey Sullivan
Pauline L. Kamath

Duration: January 2018—August 2022

Cooperators:

Maine Department of Inland Fisheries and Wildlife
National Wild Turkey Federation

Interactions between gray squirrel personality, movement patterns, and seed dispersal behavior in an anthropogenic landscape

1. Test whether and how gray squirrel personality affects seed fate and seed dispersal of novel seeds, with an emphasis on seed dispersal across anthropogenic barriers (e.g. roads, parking lots, and sidewalks).
2. Test whether and how personality impacts spatiotemporal movement and activity patterns of gray squirrels.
3. Model seed shadows of tree species in anthropogenic landscapes as a function of gray squirrel movement patterns and seed dispersal behavior.

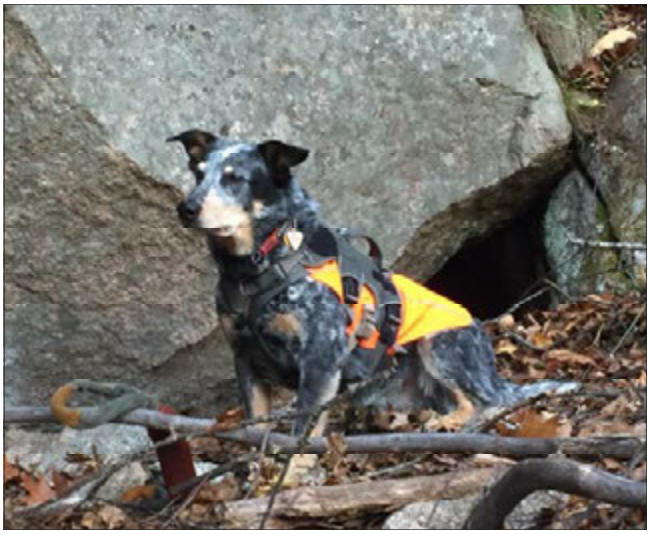
The overarching goal of this project is to build a simulation model connecting personality to seed shadows based on the interactions between personality, movement patterns, and disperser behavior. To base this model in reality, we first need to collect enough field data to understand the mechanisms behind squirrel foraging and caching behavior. On a small-scale, we expect squirrels to interact differently with seeds based on intrinsic characteristics of the seed (i.e., tree species, seed mass) and intrinsic characteristics of the squirrel (i.e., personality, sex, age, reproductive status). On a large scale, landscape configuration impacts squirrel density and movements patterns, both of which likely impact squirrel-seed interactions.

In order to understand how all of these factors ultimately interact with seed fate and caching behavior, we must present many known individual squirrels with many different seeds in many different contexts, and then quantify the outcome of these individual squirrel-seed interactions. This will be accomplished by first marking and collecting personality data from the majority of the campus gray squirrel population, GPS collaring a subset of the population to collect movement data, and by running seed dispersal experiments recording individual squirrel-seed interactions and long-term cache tracking to determine the final seed shadow.

August 2020 marked the beginning of this project and the start of my first field season on the University of Maine-Orono campus. Ongoing fieldwork has included capturing, marking, and collecting behavioral data on more than 70 individual animals, primarily eastern gray squirrels but also including American red squirrels and eastern chipmunks. In addition to personality data, a subset of gray squirrels have been fitted with rechargeable GPS collars to collect home range, movement, and activity data.

In October 2020 we will also start our first set of seed dispersal experiments, focusing on seed dispersal behavior on campus. Stations consists of a trail camera aimed at a set of marked seeds which allows me to identify how individual marked squirrels interact with individual seeds. Seeds are marked with reflective tape so that I can find them and record seed fate as well as follow caches long-term, even when seeds are moved.

Investigator:	Margaret Hallerud (MS)
Advisors:	Alessio Mortelliti
Duration:	September 2020—December ?
Cooperators:	



Investigation of the importance of talus slopes and rock faces to Myotis bats during an important life history phase (hibernation) in Maine

1. Identify the spatial distribution of talus used by hibernating Myotis Bats in Maine and evaluate characteristics of occupied talus sites.
2. Evaluate environmental factors (e.g. weather) that affect activity levels during winter.
3. Identify local-scale features within talus slopes that are used by hibernating Myotis Bats and evaluate methods for monitoring local use of talus.

Bat populations, particularly those associated with the genus Myotis, have experienced catastrophic declines due to mortality associated with a fungal pathogen known commonly as White Nose Syndrome (WNS). Typically WNS affects bats during hibernation, making this life phase critical to understand for bat conservation. Knowledge of hibernacula in Maine is limited, and this project seeks to assess winter use of talus slopes by Myotis bats. In the first component we will assess the large scale patterns of winter occupancy of talus slopes by bats in Maine through the use of passive ultrasonic acoustic receivers during the core winter period (December - February). After successfully documenting winter bat activity on talus slopes, during the second component we will use multiple methods (an ultrasonic acoustic array, scent detection dogs, visual surveys and emergence counts) to assess what local scale features within Maine talus slopes are used by hibernating Myotis Bats.

We have wrapped up the field portion of the first component by sampling of 44 talus slopes, and documented use by Myotis bats at 16 of these sites. We are currently analyzing the data using single season occupancy models to determine how occupancy and detection probability differs among talus sites.

Preliminary results suggest a detection-corrected occupancy probability of 0.43 (=/- 0.07 SE) for Myotis bats in general. Based on an assessment of a number of covariates, we have found that the nightly detection probability (a surrogate for activity rates) is clearly affected by minimum daily temperature, with bats generally inactive when temperatures drop below 0 degrees Celsius. Site with larger total area and lower density of trees were most likely to be occupied, while smaller sites with more trees were less likely. During fall and winter 2019/2020, we conducted surveys at 5 focal slopes using a scent detection dog team and an acoustic sampling grid to document local site use at occupied slopes

Investigator: Christopher Heilakka (MS)

Advisors: Erik J. Blomberg (Advisor)
Walter Jakubas
Danielle L. Levesque
Shevenell Webb

Duration: September 2018—June 2021

Cooperators:

Maine Department of Marine Resources
National Park Service

Using unoccupied aerial vehicles and automated detection to monitor colonial birds in Maine

1. Compare the accuracy and efficiency of manually deriving seabird and wading bird abundance, species, and behaviors from both historical and recent plane-based imagery, Unoccupied Aerial Vehicle (UAV) imagery, and ground surveys, and identify sources of error in these estimates.
2. Develop automated processes using AI to derive seabird and wading bird abundance, species counts, and behaviors from historical and recent plane- and UAV-based imagery, and identify sources of error in these processes.
3. Investigate the feasibility of large-scale UAV use in seabird and wading bird monitoring surveys by quantifying the labor costs of automated processing versus manual processing and ground surveys.

Coastal ecosystems face constant pressure from anthropogenic threats. Birds function as indicators of coastal ecosystem health; however, traditional avian survey methods have limitations in observer errors and visibility bias. Recently, Unoccupied Aerial Vehicles (UAVs) have been used in monitoring wildlife populations. Lightweight, programmable for automated flight, and able to accommodate photographic instruments, UAVs offer a solution to limitations of traditional surveys. These advantages also have costs, such as the labor required to interpret imagery. The development of automated processing tools for object detection and classification with artificial intelligence offers promise, however issues persist in the application of this technology on a broad scale. Additionally, a user-friendly tool is needed for biologists and citizen scientists to apply automated analyses. The goal of our research is to develop accurate and efficient automated processes for estimating colonial nesting bird abundance from plane- and UAV-based imagery as well as ground-based counts of bird populations within the Gulf of Maine region. High-resolution plane- and UAV-based imagery will be supplemented with ground surveys to validate the automated interpretation of multiple bird species and behaviors. Our goal is to understand sources and amounts of errors in population estimates developed from these survey platforms, leading to improved accuracy.

This project is entering its second year of data collection. Imagery collected via plane survey in 2019 has been manually interpreted by three observers and automated processing algorithms are being developed and tested on this imagery. Forty-two UAV flights were conducted over colonies of herring gulls (*Larus argentatus*), great black-backed gulls (*Larus marinus*), double-crested cormorants (*Phalacrocorax auritus*), great blue herons (*Ardea herodias*), and common eiders (*Somateria mollissima*) in 2020. This imagery is being manually processed and classifications of birds will be compared to GPS ground survey classifications of nesting birds.

Investigator: Logan Kline (MS)
Meredith Lewis (MS)
Alexander Revello (MS)

Advisors: Cynthia S. Loftin (Co-Advisor)
Daniel J. Hayes (Co-Advisor)
Roy M. Turner
Kasey R. Legaard
Alyson E. McKnight
Linda J. Welch

Duration: September 2019—December 2022

Cooperators:

Maine Department of Inland Fisheries and Wildlife
U.S. Fish and Wildlife Service
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – School of Computing and Information Science

Laying the groundwork for science-based management of colonial waterbirds

1. Evaluate contents of USGS-managed Colonial Waterbird Database (CWBD) and update with data for the eastern US since the database became inactive (~2013), including archived data made available by partners.
2. Provide guidance on coordinated surveys in the eastern US in 2018 for selected species and regions based on consultation with stakeholders and preliminary assessment.
3. Evaluate and revise CWBD user access, data security and quality, meta-data content and quality, and data entry and viewing formats, and facilitate data export for stakeholder use, and work with partners to compile information to inform development of a geospatial user interface for viewing, summarizing, manipulating, and analyzing CWBD contents.
4. Update revised CWBD with completed 2018 survey data provided by partners.
5. Provide guidance for future surveys by standardizing methodologies.
6. Display species trends for select focal species (e.g., Black Skimmer, Laughing Gull) graphically within the CWBD user interface, and evaluate trends and conservation goals.

The original CWB database that we began working with was incomplete, and quality and format of previously contributed data varied. Therefore, we evaluated CWBD data protocols and data condition, and worked with the Atlantic Marine Bird Cooperative's SCAW-WG, associated subgroups, and state and federal biologists charged with conducting waterbird surveys to facilitate standardizing survey data to enhance accuracy and efficiency for inclusion in the revised CWBD. We have worked with USGS-Patuxent CWBD developers to improve format and accessibility of the database, and we have developed a web portal with instructions for data uploading to accept new data into the database. This tool has simple display and sorting functions for quick visual assessment of the data. We recently began working with the Avian Knowledge Network to develop long-term archiving for the database, so that the data are accessible following the end of this project. We will evaluate the dataset for completeness and compare data among years to assess trends for selected species of interest.

We received the CWBD and associated files from Patuxent, and thoroughly reviewed the contents. We solicited data from the various state agencies on the east coast and added considerable data from previous Atlantic flyway waterbird surveys during 1976-1996. We incorporated additional MANEM (mid-Atlantic New England and Maritime regional step down plan surveys) data from states, and existing databases within the region including the North Carolina PAWS database, maritime Canadian provinces and the Maine Seabird Colony Database. The CWBD had no functioning access to data, no updated contact information and no way to view, visualize, contribute to, summarize, download or analyze its contents. We created and deployed the beta version of a web-based tool using Shiny Apps in R (https://visualizebirds.shinyapps.io/shinyApp/) to address these needs, incorporating feedback to best address stakeholder needs. We developed and distributed a standardized data recording format and distributed standardized methods developed by Biodiversity Research Institute (BRI) specifically for waterbird surveys. This and other relevant waterbird information were made available through a newly created colonial waterbird website we created to provide updated information about the CWBD. We have begun trend analyses for focal species (double-crested cormorant, laughing gull, black skimmer, common tern, least tern), prepared a manuscript describing this analysis, and have transferred the database, containing roughly 100,000 records from >12,000 unique survey locations, to the Avian Knowledge Network for long-term archiving.

Investigators:
Zachary G. Loman
Cynthia S. Loftin
Shannon Beliew
Ruth Boettcher
James E. Lyons
Walker Golder
Michael C. Runge
Caleb S. Spiegel
Mark Wimer

Duration: July 2018—December 2021

Cooperators:

National Audubon Society
U.S. Fish and Wildlife Service – Division of Migratory Birds
U.S. Geological Survey – Patuxent Wildlife Research Center
Virginia Department of Game and Inland Fisheries

Modeling the occupancy of coyotes in Maine

1. Assess presence/absence of coyotes throughout Maine's forested lands
2. Model occupancy of coyotes through use of covariates
3. Determine factors affecting first and second order selection of habitat for coyotes in the state of Maine

The study takes place in the northern two thirds of the state in Maine's forested habitat and encompassing a range of environmental conditions from latitude to forest composition to high-low disturbance forests. While not originally native to the area, sightings and interactions with coyotes has been increasing and is a topic of great public concern. Through the use of camera traps, this study aims to determine what habitat conditions are being sought out by this normally desert and grassland dwelling species. Detection histories from camera arrays left out for 2-4 weeks were run through Program Presence in an attempt to model their occupancy and allow us to make predictions of where in Maine could be desirable for coyotes. Our basic parameters include latitude, percent hardwood composition, contiguousness of forest (as a result of timber harvest). Additionally, snow depth in the winter will provide insights to if coyotes make use of different habitats between seasons.

Research from the 2017-2018 year was collected by PhD student Bryn Evans. The data is currently being modeled and interpreted with sections of the resultant paper already under construction/completed. The project is set to be fully completed and submitted on December 11, 2020

Investigator: Dakota Perry (MWC)

Advisors: Alessio Mortelliti (Advisor)
Carly C. Sponarski
Cynthia S. Loftin

Duration: January 2019—December 2020

Cooperators:

Acting out of Lyme: Investigating the sociocognitive determinants of Lyme disease preventative behavior

1. Explore and compare the attitudes and behaviors of recreationists and private woodland owners regarding Lyme disease prevention and management at both the individual and community level.
2. Evaluate the application of two popular health behavior models (health belief model and sociocognitive theory) in the context of Lyme disease prevention.
3. Provide a sociocognitive lens for understanding Lyme disease preventative action to inform intervention and outreach efforts in the future.
4. Develop an improved understanding of private woodland owners perceptions of Lyme disease prevention as it relates to land management.
5. Identify opportunities for and barriers to private woodland owners adoption of adaptive land management strategies for disease mitigation.

Over the last three decades, tick-borne diseases have spiked in both prevalence and severity across the United States. Today, diseases transmitted by hard-bodied ticks are considered to be the infectious diseases of highest public health concern in the United States. Lyme disease (LD), a tick-borne disease transmitted by the black-legged tick, poses a particularly unique risk. Due to the poorly understood and difficult-to-manage nature of the disease at the environmental and medical level, it is widely acknowledged that changing human behavior is the most viable option for disease management. Previous research has evaluated individuals' attitudes and behaviors regarding LD, however a clear understanding of what drives individuals' preventative behaviors is still lacking. This research aims to explore the sociocognitive factors that influence LD preventative behavior in recreationists and private woodland owners, two populations with heightened chance of disease exposure. The first component of this study focuses on common preventative behaviors such as tick checks, and protective apparel among both populations. The second component of this study makes a more specific assessment of how private woodlot owners currently incorporate LD prevention into their woodlot management decisions. These research objectives will be addressed through survey methods designed for the populations of interest.

Primary recreationist data collection, involving a questionnaire administered at Bradbury Mountain State Park using an intercept survey method, was completed in the summer of 2019. Private woodland owner data collection, using a combination of drop-off pick-up and mailing survey methods, is ongoing and will be completed by the end of 2019. Quantitative data analysis will be completed by May 2021.

Investigator: Katie Perry (MS)

Advisors: Carly C. Sponarski (Co-Advisor)
Jessica E. Leahy (Co-Advisor)
Allison Gardner

Duration: January 2019—May 2021

Cooperators:

Implementation of a Special Area Management Plan (SAMP) for vernal pool conservation: an examination of social and institutional factors

Objectives for Phase I (2020-2021)

1. Systematically examine comprehensive plans and institutional arrangements (formal and informal) in the first wave of towns that have recently adopted the Vernal Pool SAMP (Topsham, Orono); add additional towns to the database of social and institutional factors as research and SAMP progresses
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 town typology to inform future SAMP implementation.

This phase of the project will provide an analysis of social and institutional factors that impact the use of the Special Area Management Plan (SAMP) for vernal pool conservation. The primary goal of this research is to examine factors that influence adoption and implementation of the SAMP for vernal pool conservation in diverse community contexts around Maine, and to identify tools and strategies that enhance community capacities and reduce roadblocks. The project will use a combination of qualitative and quantitative research methods for a mixed-methods approach to provide a broad understanding of the social factors. Document analysis and interviews will be used for qualitative analysis and spatial analysis tools and survey research will be used for quantitative analysis. The research team will seek to publish academic manuscripts and a dissertation from this research as well as provide the community a broad understanding of this project.

The project is in the proposal development stage. Jeff Rodriguez is currently working on a proposal to advance this research and to provide an overview of this literature around these ideas, their broader significance, the project goals, methods, deliverables, and a timeline of this project.

Investigator: Jeffrey Rodriguez (PhD)

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

Duration: September 2020—December 2023

Cooperators:

Effects of 30 years of forest change on American marten patch-scale habitat selection

1. Replicate marten trapping protocols established during two previous studies (1989-1990, 1994-1997) to systematically resurvey American marten occupying two commercially managed townships in north-central Maine. Track radio-collared resident, non-juvenile martens through the end of the leaf-on season via VHF triangulation to estimate resident marten home ranges and patch-scale habitat use.
2. Assess potential functional responses in patch-scale habitat selection by marten to changes in forest type availability over 30 years of extensive timber harvesting by modeling marten habitat selection as a function of year, habitat availability, and harvest history using data from three studies (1989-1990, 1994-1997, 2018-2019) conducted on the same commercially managed study area in north-central Maine.
3. Evaluate the effects of patch isolation, patch area, and patch edge density on marten patch use and patch-scale selection and determine if these effects have shifted in response to temporal changes in within home range patch configuration.

The goal of this research is to evaluate the effects of changes in forest patch structure, composition, and configuration on the patch-scale habitat selection patterns of American marten occupying the commercially managed forests of Maine. We have replicated marten trapping and tracking protocols established from 1989-1997 during 2018 and 2019. Year-specific (1989-1990, 1994-1997, 2018-2019) forest type maps based on harvest history, species composition, canopy over and tree height have been developed and will be used to quantify patch-scale habitat availability, use and selection for all years of study. We will model marten patch-scale habitat selection as a function of study year, habitat availability, and harvest history to evaluate any shifts or potential functional responses in marten patch-scale habitat selection. We will then model marten patch use intensity as a function of patch area, patch isolation, and patch edge density to determine the effects of within home range patch configuration on marten habitat use and selection. We anticipate that our findings will help inform future marten conservation and land management by providing a longitudinal evaluation of the patch-scale responses of an area-sensitive, forest associated umbrella species to cumulative changes in habitat structure, composition, and configuration associated with timber harvesting.

We systematically replicated historical trapping and tracking protocols in 2018 and 2019, capturing and tracking 7 resident female and 18 resident male martens. We collected 903 telemetry locations with accuracy suitable for the determination of patch-scale habitat use which will be used as part of a composite dataset comprised of 5685 telemetry locations of 143 resident martens. We are in the process of finalizing year-specific habitat classification maps and will focus on patch-scale selection analyses during spring 2020. Analyses related to objective 3 will comprise our primary activities during summer 2020. The anticipated date for project completion is December 2020.

Investigator: Tyler Woollard (MS)

Advisors: Daniel J. Harrison (Advisor)
Erin Simons-Legaard
Cynthia S. Loftin

Duration: January 2018—December 2020

Cooperators:

University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Maine Cooperative Forestry Research Unit

The significance of small mammal personality on demograpy, disease, and seed selection in human-disturbed landscapes

1. Examine the relationship between animal personality and stress response and how the association may contribute to fluctuating populations through maternal effects, particularly in human-disturbed landscapes.
2. Measure how differing personality types interact with novel seeds to further postulate how populations of varying personality compositions may interact with range-shifting plant species drive by climate change..
3. Determine if disease prevalence differs in different silvicultural landscapes and if the distribution of personality types can predict the variation.

The plan of this project 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 another PhD student. This CMR study began in the summer of 2016, incorporates 3 different behavioral tests, and will continue until the end of the field season in 2023 for a total data set spanning 8 years. Starting in June 2021, I will collect additional data and execute additional experiments to fulfill objectives #1-3. For objective #1, I will begin to collect samples to measure stress reactivity in individuals and will also need to develop a protocol to determine parent-offspring pairs and necropsy our kill population. For objective #2, I will develop an experiment testing how individuals learn to use a novel resource in a social context. For objective #3, I will first need to target a disease with moderate prevalence before surveying the rest of the population and exploring the epidemiological mechanism.

Field season 2020 has been completed and we are currently working on analyzing the library of behavioral videos. To date there are 5 complete seasons of demography and personality data. The next steps in the project are to write up the project proposal to present on April 12, 2021. Alongside drafting the proposal I will execute pilot studies to identify the feasibility of current objectives and to troubleshoot choke-points.

Investigator: Ivy Yen (PhD)

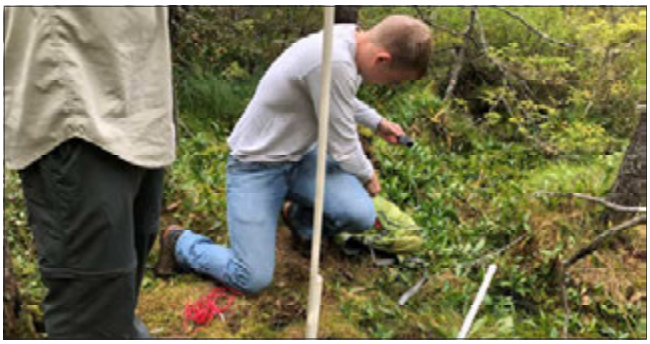
Advisors: Alessio Mortelliti (Advisor)

Duration: June 2020—May 2025

Cooperators:

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

INTEGRATED ecology



Identification, characterization, and threat assessment of groundwater influenced ecosystems (GIE) in the northeastern United States

1. Create a habitat suitability model that predicts GIE presence based on spatial data describing hydrogeologic conditions.
2. Determine vulnerability of GIEs across the region to environmental and anthropogenic factors.
3. Characterize the hydrology of selected GIEs across the region and survey for groundwater-dependent biota.

Globally, groundwater influenced ecosystems (GIEs) are increasingly vulnerable to water extraction and land use practices. Groundwater supports these ecosystems by providing inflow, which can maintain water levels, water temperature, and chemistry necessary to sustain the biodiversity that they support. Many aquatic systems receive groundwater as a portion of baseflow, and in some systems (e.g., springs, seepages, subterranean streams, fens) the connection with groundwater is significant and important to the system's integrity and persistence. Groundwater management decisions for human use often do not consider ecological effects of those actions on GIEs, which rely on groundwater to maintain ecological function. Despite the importance of these resources to both human and wildlife populations, GIEs in the northeastern United States are largely unmapped and poorly studied. The objectives of our research are to identify, characterize, and conduct a threat assessment of GIEs across the northeastern United States. We will be applying geographically referenced information about known GIEs in the region to produce a logistic-scale distribution map of GIEs across the northeastern states. We will further characterize and determine associated threats to GIEs in the region with field-collected data, while also sampling for groundwater influenced biota.

Hydrological monitoring wells have been installed at GIEs in three Wildlife Refuges in Maine (Sunkhaze Meadows, Moosehorn, Rachel Carson). Our preliminary distribution models for GIEs in the northeast have been created and we spent Summer 2020 validating these models by conducting on-site rapid assessments at ~200 locations in Maine. We are evaluating model accuracy and sources of commission and omission errors in areas of wetlands and streams where our model predicts high suitability for GIE presence. We will also be taking thermal images from a UAV this winter to map groundwater discharge zones in river, streams, and wetland GIEs to further validate our distribution model.

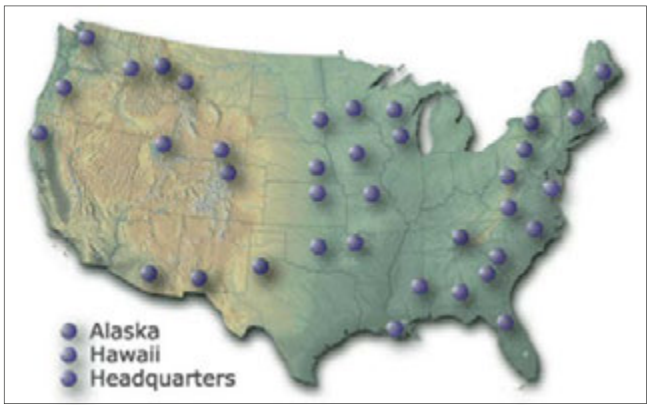
Investigator: Shawn Snyder (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Andrew S. Reeve (Co-Advisor)
Daniel J. Hayes
Aram J.K. Calhoun
Martin Briggs

Duration: June 2019—May 2023

Cooperators:

U.S. Fish and Wildlife Service
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine



A collaborative organizational network analysis of the cooperative research units program

1. Develop an Organizational Network Analysis of the Units to describe the structure and composition of relationships (represented by types and abundance of connections) within the CRU.
2. Develop an ONA of the Cooperators as a layer in the CRU analysis (Obj 1) to evaluate the structure and composition of the CRU relationships with our partnering organizations.
3. Develop a Dynamic Network Analysis that simulates realized and potential changes in the CRU-Cooperator networks, informed by the statistical analysis in Objectives 1 and 2, to examine evolutions and adaptations of CRU-Cooperator relationships over time. This analysis will seek to identify the strengths and vulnerabilities of the program overall and within individual Unit networks.
4. Summarize the analysis in a computer-based Organizational Analysis Tool with a user interface that provides data visualizations, as well as in summary reports for meeting participants and participating Cooperative Research Units, and in peer-reviewed manuscripts.

The Cooperative Fish and Wildlife Research Units (CRU) program formalizes a relationship among the state natural resources management agency, the host University, the USGS, the USFWS, and the Wildlife Management Institute. The purpose of the program is to facilitate collaboration among these groups to develop and execute research to address the cooperators' information needs. Originating in 1935, the program now has 40 CRUs in 38 states at Universities with graduate fish and wildlife academic degree programs. The success of the program is well-recognized. Since the program's inception, Units have conducted decades of research projects while mentoring graduate students and providing technical assistance to address the breadth of cooperator information needs. Thousands of graduates of the program have been employed as conservation professionals in public agencies and NGOs and as faculty and professional staff at universities throughout the country. While the program's mission to provide education and technical assistance through graduate research has remained largely unchanged through its tenure, the issues challenging fish and wildlife conservation have transformed. The landscape is more fragmented by people less attracted to outdoor traditions. These same traditional uses of fish and wildlife were foundational to the Unit program's establishment. This raises the question of the program's support and sustainability. Is the program's original model well suited to serve the cooperators' research and information needs of today? Alternately, are there different models that better fit the present geographic, social, and ecological context for natural resources conservation? We propose to conduct an Organizational Network Analysis (ONA) of the Cooperative Research Units program to examine the structure, communication, and socio-technical connectivity within the organization. This analysis will reveal how the networks have evolved over time.

This project has just been initiated.

Investigator: Sarah Vogel (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)

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
U.S. Fish and Wildlife Service

PUBLICATIONS and presentations

SCIENTIFIC PUBLICATIONS

Allen, B.B., D.G. McAuley, and E.J. Blomberg. (2020). Multi-scale resource selection by American woodcock (*Scolopax minor*) during fall migration at Cape May, New Jersey. The *Condor: Ornithological Applications.*

Blomberg, E.J., and C. Hagen. (2020). How many leks does it take? Minimum sample sizes for measuring local-scale conservation outcomes in Greater Sage-grouse. *Avian Conservation and Ecology.*

Blomberg, E., Watson, V., Conway, M., Corell, M., Elphick, C., Hodgman, T., . . . Blomberg, E. (2020). Horizon angle and edge avoidance predict saltmarsh sparrow abundance better than habitat area. *Condor: Ornithological Applications.*

Brehm A., Tironi S., Mortelliti A. 2020. Time since capture does not affect personality measurements in a guild of forest small mammals. *Plos one DOI 10.1371/journal.pone.0221136.*

Bujaskas, M., Evans, B., and Mortelliti, A. (2019). Assessing the effectiveness of trail cameras with attractants to detect northeastern mammals. *Mammalian Biology, 100, 91-100.*

Du Clos, B., Drummond, F., and Loftin, C. (2019). Landscape context across a single crop system affects wild bee communities. *Environmental Entomology, 1-14.*

Eakin, C., A.J.K. Calhoun, and M. Hunter, Jr. 2019. Effects of suburbanizing landscapes on vernal pool-breeding amphibian reproductive effort. *Herpetological Conservation and Biology 14:515–532.*

Eakin, C., A.J.K. Calhoun, and M. Hunter, Jr. 2019. Indicators of wood frog condition in a suburbanizing landscape. *Ecosphere 10. 10.1002/ecs2.2789.*

Homola, J., Loftin, C., and Kinnison, M. (2019). Landscape genetics reveals unique and shared effects of urbanization for two sympatric pool-breeding amphibians. *Ecology and Evolution, 9, 11799-11823.*

Homola, J., Loftin, C., Cammen, K., Helbing, C., Birol, I., Schultz, T., and Kinnison, M. (2019). Replicated landscape genomics identifies evidence of local adaptation to urbanization in wood frogs. *Journal of Heredity, 110(6), 707-719.*

Lima, K., Gallo, S., Hodgman, T., Potter, D., Call, E., and Blomberg, E. (2020). Influence of environmental conditions and call-broadcast on detection of eastern forest owls during standardized surveys. *Condor: Ornithological Applications.*

Mangelinckx, J., Brown, S., Sullivan, K., Allan, B., and Blomberg, E. (2019). Effects of forest characteristics on ruffed grouse nesting ecology in central Maine, USA. *Wildlife Biology DOI: 10.2981/wlb.00598.*

Marshall, H., E.J. Blomberg, V. Watson, M. Conway, J.B. Cohen, M.D. Correll, C.S. Elphick, T.P. Hodgman, A.R. Kocek, A.I. Kovach, W.G. Shriver, W.A. Wiest, and B.J. Olsen. (2020). Horizon angle and edge avoidance predict saltmarsh sparrow abundance better than habitat area. *Condor: Ornithological Applications*.

McKnight, A., Irons, D., Loftin, C., McKinney, S., and Olsen, B. (2020). Combined influence of intrinsic and environmental factors in shaping seabird productivity in a small pelagic gull, the Black-legged Kittiwake Rissa tridactyla. *Marine Ecology Progress Series, 633*, 207-223.

Molina-Moctezuma, A., and Zydlewski, J. (2020). A decision making tool for evaluating biological and statistical thresholds for survival analysis. *River Research and Applications, 2020, 1-9*.

Mortelliti, A., and Boone, S. (2019). Small mammal tree seed selection in mixed forests of the Eastern United States. *Forest Ecology and Management, 449*.

Mortelliti, A., Grentzmann, I., Fraver, S., Brehm, A., Calkins, S., and Fisichelli, N. (2019). Small mammal controls on the climate-driven range shift of woody plant species. *Oikos, 128, 1726-1738*.

Roy, S., Daignault, A, Zydlewski, J., Truhlar, A., Smith, S., Jain, S., and Hart, D. (2020). Coordinated river infrastructure decisions enhance social-ecological resilience. *Environmental Research Letters. On Line Aug 7. — IPDS: IP-117688*.

Song, C, O'Malley, A., Zydlewski, J., and Mo, W. (2020). Balancing fish-energy-cost tradeoffs through strategic basin-wide dam management. *Resources, Conservation & Recycling 161:1-12. DOI: 10.1016/j.resconrec.2020.104990*.

Vogel, S., Jansujwicz, J., Sponarski, C., and Zydlewski, J. (2020). Science in action or science inaction? Evaluating the implementation of "best available science" in hydropower relicensing. *Energy Policy, 143, 1-10*.

Wood, C., McKinney, S., Loftin, C., and Loman, Z. (2020). Testing prediction accuracy in a short-term ecological study. *Basic and Applied Ecology, 43, 77-85*.

TECHNICAL AND SEMI-TECHNICAL PUBLICATIONS

Blomberg, E.J., J. Tebbenkamp, S.W. Dunham, and D.J. Harrison. 2020. Population dynamics of spruce grouse in the managed forest landscapes of northern Maine. Final Project Report to the Maine Cooperative Wildlife Research Unit, University of Maine, Orono. 60 pp.

Harrison, D. and E. Simons-Legaard. 2020. Responses of marten populations to 30 years of habitat change in commercially managed landscapes of northern Maine. Pages 68-75 *in* S. Anderson and M. Ferguson, editors, Cooperative Forestry Research Unit: 2019 Annual Report, University of Maine, Orono.

Harrison, D.J. and Z.G. Loman. 2020. Temporal dynamics and forest treatment-scale responses of snowshoe hare populations in Maine 2001-2015. Final report to U.S. Fish and Wildlife Service for Cooperative Agreement Number F14AC01237. The University of Maine, Orono. 43 pp.

THESES AND DISSERTATIONS

Flye, Melissa. 2019. "Getting over the dam: Overcoming institutional barriers to the recovery of Atlantic salmon by navigating the social-science/policy interface. M.Sc. *University of Maine, Electronic Theses and Dissertations. 3155*.

Molina Moctezuma, Alejandro. "Movement and Survival of Atlantic Salmon Smolts in the Penobscot River, Maine". (2020). *University of Maine, Electronic Theses and Dissertations. 3223*.

Ramberg-Pihl, Nicole C. "Responses of Juvenile Atlantic Salmon to Competition and Environmental Change: Implications for Performance in Maine Streams". (2020). *University of Maine Electronic Theses and Dissertations. 3258*.

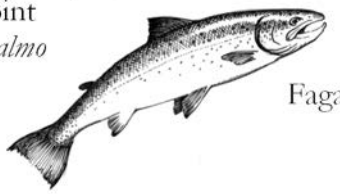
Vogel, Sarah. "Fish Passage and Hydropower: Investigating Resource Agency Decision-making During the FERC Hydropower Relicensing Process". (2019*). University of Maine Electronic Theses and Dissertations. 3135*.

Wilson, Kaitlyn. 2020. "Bicknell's Thrush Habitat Use on Commercial Forests in Maine, USA. MS Wildlife Ecology. University of Maine, 78pp.

PRESENTATIONS

Ames, C., Zydlewski, G., Kinnison,M., and Zydlewski, J. (2020). "Age structure of non-reproductive, partial migratory populations of sturgeon species in the Penobscot River, Maine." 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Atkinson, E., and Zydlewski, J. (2020). "Examining dispersal of point stocked Atlantic salmon (*Salmo salar*) fry relative to habitat qualities in streams in eastern Maine, USA." 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.



Blomberg, E. 2020. "Eastern Woodcock Migration Research Cooperative Update." Atlantic Flyway Technical Council. February.

Calhoun, A. 2020. "Maine' Special Area Management Plan: locally driven conservation of wetlands on private lands." Michigan State University Vernal Pool Work Group. February 4.

Calhoun, A. 2020. "Vernal pool project for Maine middle schools as part of the Gulf of Maine Research Institute learning programs." GMRI middle school project. 29 April.

Coghlan Jr., S.M. 2019. "Preparing for Economic and Ecological Collapse: Can Homesteading Provide Sustenance and Surplus in an Age of Scarcity?" Terrell House Permaculture Living and Learning Center's Seminar Series: November 21.

Coghlan Jr., S.M. 2019. " Economics as if Your Future Matters: Energy, Climate, Money, and Planetary Bankruptcy." Presented at Socialist and Marxist Seminar Series, University of Maine, October 10.

Coghlan Jr., S.M. 2020. "Ecology of Sea-Run Alewife in Maine Lakes." Presented at Eskutassis Lake Fishway Steering Committee meeting, Bangor, ME, February 3 (invited).

Coghlan Jr., S.M. 2020. "Preparing for Economic and Ecological Collapse: Can Homesteading Provide Sustenance and Surplus in an Age of Scarcity? Guest lecture presented at ECO 381: February 12.

Dillingham, C., Zydlewski, J., Peterson, E., and Lasley-Rasher, R. (2020). "Distribution and abundance of zooplankton in the Penobscot River estuary." 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Fagan, K.E., D.J. Harrison, E.M. Simons-Legaard, and T.F. Woollard. 2020. "Challenging the assumed superiority of camera- versus capture-based surveys for assessing occupancy: A case study with a cryptic forest mustelid." Presentation at The Wildlife Society Annual Meeting, (virtual in 2020), September 29, 2020.

Flye, M., Sponarski, C., Zydlewski, J., and McGreavy, B. (2020). "Does leadership have a role in collaborative environmental governance?" 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Jansujwicz, J. 2019. "Engaging rural landowners in the conservation of vernal pools." Presentation for WLE 423 Wetland Ecology. November 20.

Lewis, M., L. Kline, A. Revello, L. Maher, C. Loftin, K. Beard, D. Hayes, R. Turner, A. Guay, and D. Sandilands. 2020. "An interdisciplinary approach to building data literacy in wildlife survey technologies." University of Maine System Board of Trustees, Buchanan Alumni House, University of Maine, Orono, February 9.

Lewis, M., L. Kline, C.S. Loftin, and D.H Hayes. 2020. "UMaine-Orono Gull and Cormorant census data and unmanned aerial vehicle (UAV) project." Gulf of Maine Seabird Working Group Annual Meeting. March 25.

Loftin, C. 2019. "Applications of spatial science in wetland ecology." Presentation to WLE 423 Wetland Ecology and Conservation, University of Maine, Orono, ME. November 22.

Loftin, C.S. 2019. "Responsible conduct in research: Animal welfare." Presentation to SFR 521 Research Methods, University of Maine, Orono, ME. 14 November.

Loman, Z. and C.S. Loftin. 2019. "Waterbird Project Presentation and Proposal Development." Coastal Big Data Hub Meeting, Philadelphia, PA. 11-12 December.

Mensinger, Blomberg, E. and Zydlewski, J. (2020). "Understanding the influence of dams on migrating eels in the Penobscot River." Penobscot County Conservation Association. Brewer, ME. January 9.

Mensinger, M., Blomberg, E., and Zydlewski, J. (2020). "Dams, death, and delay in the Penobscot River - the complex and cumulative influence of hydropower dams on migrating American eels." 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Molina-Moctezuma, A., Peterson, E., and Zydlewski, J. (2020). "Movement and survival of Atlantic salmon, *Salmo salar*, in the Piscataquis River." 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Mortelliti, A. 2019. "Small mammal foodies: Food preferences and the impacts on forest regeneration." The Wildlife Society Annual Conference, Reno, NV. November.

Mortelliti, A. 2020. "Food for thought: effects of personality on seed dispersal in modified landscapes." Frugivory and Seed Dispersal Conference (India): March 2020.

Peterson, E., Rubenstein, S., and Zydlewski, J. (2020). "Movements of radio-tagged Atlantic salmon (*Salmo salar*) in the Penobscot River, Maine." 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Peterson, E., Zydlewski, J. (2020). "Movement behavior of American Shad five years after dam removal in the Penobscot River, Maine." Penobscot County Conservation Association. Brewer, ME. January 9.

Rubenstein, S., Peterson, E., and Zydlewski, J. (2020). "The impact of dams on Migrating adult Atlantic Salmon." Penobscot County Conservation Association. Brewer, ME. January 9.

Rubenstein, S., Zydlewski, J., Peterson, E., Jayasundara, N., and Christman, P. (2020). "Energetic impacts of passage delays in migrating adult Atlantic salmon." 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Song, C., Mo, W., Zydlewski, J., O'Malley, A. (2020). "Balancing fish-energy-cost tradeoffs through strategic basin-wide dam management." International Symposium on Sustainable Systems and Technology (ISSST). Pittsburgh, PA. June 8.

Sponarski, C. 2020. "Do different methods of communication impact undergraduate student's attitudes, knowledge, and beliefs toward white-nose syndrome in Little Brown bats." Southeast Environment and Recreation Research Conference: 03/2020.

Vogel, S., Jansujwicz, J., and Zydlewski, J. (2020). "Fish passage decision-making during hydropower relicensing in the Kennebec and Penobscot Rivers, Maine." 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Weaver, D., Sigourney, D., Delucia, M., and Zydlewski, J. (2020). Forecasting the downstream migration of adult silver phase American eels. 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Whittum, K., Coghlan Jr., S., Zydlewski, J., and Hayes, D. (2020). "Fish community assessment six years following dam removal in the Penobscot River, Maine." 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Woollard, T.F., D. J. Harrison, E. M. Simons-Legaard, and K. E. Fagan. 2020. "A longitudinal study of shifting habitat selection by American martens in response to 30 years of intensive forest harvesting." Presentation at The Wildlife Society Annual Meeting, (virtual in 2020), September 30.

Zenga, A., Peterson, E., and Zydlewski, J. (2020). "Alewife Energetics and its Possible Implications on Fitness." 2019 Atlantic Salmon Ecosystems Forum. January 14. University of Maine, Orono, Maine.

Zydlewski, J. (2020). "Science for comfort or conservation- how do we inform and avoid action on fish passage?" 2019 Atlantic Salmon Ecosystems Forum. University of Maine, Orono, Maine. January 14.

Zydlewski, J. (2020). "The lovable lamprey." Penobscot County Conservation Association. Brewer, ME. January 9.

Zydlewski, J. (2020). "The state of passage for Atlantic salmon in the Penobscot River." Penobscot River Salmon Habitat Recovery Unit Meeting. Mitchell Center, University of Maine. Orono, ME. March 12.

AWARDS

Calhoun, A. 2020. *Conservation Leadership Award.* Natural Resources Council of Maine, 5 October.

Seward, L. 2019. *Award of Meritorious Service.* The Wildlife Society, Maine Chapter.