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

2019 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/Maine/Documents/ *or*
http://umaine.edu/mainecoopunit/

Cover Photo: Bobcat taking notice of a trail camera during summer 2017 surveys. Bryn Evans. Research Image

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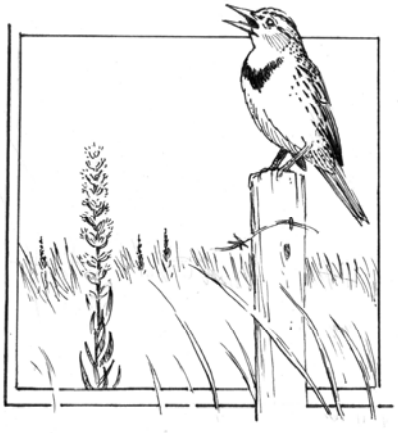
UNIT Mission

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 38 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 41 graduate students and postdoctoral scholars, 6 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 and Department of Wildlife, Fisheries, and Conservation Biology, with leadership from Dr. Brian Olsen, collaborated in evaluating the undergraduate and graduate programs to develop and enhance training opportunities and partnerships with future employers of our graduates. The graduate and undergraduate programs continue to grow, presenting us with challenges as well as opportunities. The Maine Department of Inland Fisheries and Wildlife and the U.S. Fish and Wildlife Service-Maine Field Office welcomed new staff to their programs during the past year. 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. Frederick A. Servello, 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, Acting 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

COLLABORATING AGENCIES AND ORGANIZATIONS

American Recovery and Reinvestment Act (ARRA)
Association of Field Ornithologists
Audubon Vermont
Baxter State Park
Brookfield Renewable Power
Cornell Lab of Ornithology
Downeast Lakes Land Trust
Environment Canada
Giraffe Conservation Foundation
Indiana University of Pennsylvania
Inland Bird Banding Association
International Joint Commission on the St. Croix Waterway
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
Michigan Technological University
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
Natural Resources Foundation of Wisconsin
New Brunswick Department of Energy and Resource Development
New Brunswick Wildlife Trust Fund
New Hampshire Audubon
New Jersey Department of Environmental Protection
New York Department of Environmental Conservation
North Carolina Wildlife Resources Commission
Northeast Deer Research Partnership
Northern Rangelands Trust
Oazaukee-Washington Land Trust
Pelletier Brothers, Inc.
Pennsylvania Game Commission
Penobscot Indian Nation
Penobscot River Restoration Trust
Quality Deer Management: Canada
Rhode Island Department of Environmental Management
San Diego Zoo Global
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. Department of Agriculture
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. 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
U.S.D.A. SARE Grants
University of Maine System
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 Marine Sciences
University of Maine – Senator George J. Mitchell Center for Sustainability Solutions
University of Maine – Sustainable Solutions Initiative
University of Moncton at Edmundston
University of New Brunswick
University of Rhode Island
Virginia Department of Game and Inland Fisheries
Virginia Game Commission

COLLABORATING AGENCIES AND ORGANIZATIONS CONT.

Wagner Forest Management
Weyerhaeuser
WILD-ONE
William P. Wharton Trust
Wisconsin Audubon Council, Inc. and eight associated Audubon chapters around Wisconsin
Wisconsin Department of Natural Resources
Wisconsin SFI Implementation Committee
Wisconsin Young Forest Partnership

UNIVERSITY OF MAINE COLLABORATORS

Department of Wildlife, Fisheries, and Conservation Biology

Brian J. Olsen, *Chair*
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*
Molly-Jean Langlais-Parker, *Administrative Specialist*
Zachary G. Loman, *Research Scientist*
Sabrina Morano, Assistant *Research Professor*
Alessio Mortelliti, *Assistant Professor*
Amber M. Roth, *Assistant Professor*
Frederick A. Servello, *Professor of Wildlife Ecology*
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*
Francis A. Drummond, *Professor*
Allison Gardner, *Assistant Professor*
Hamish S. Greig, *Associate Professor*
Rebecca L. Holberton, *Professor*
Michael T. Kinnison, *Professor*
Danielle L. Levesque, *Assistant Professor*
Brian J. McGill, *Professor*
Brian J. Olsen, *Associate Professor*

Department of Communication and Journalism

Bridie McGreavy, *Assistant 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 Kamath, *Assistant Professor*
Anne B. Lichtenwalner, *Associate Professor*

School of Forest Resources

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

School of Marine Sciences

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

EXTERNAL COLLABORATORS

Dana M. Bauer, *Assistant Director and Research Scientist, Clark University*

Shannon Beliew, *Biologist, USGS Patuxent Wildlife Research Center*

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

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

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

Daniel Gautreau, *Liaison Office of the School of Forestry, Université de Moncton-Edmundston*

Jenny A. Glikman, *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, *Associate Professor, University of Maine, Machias*

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*

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

Glen Mittelhauser, *Director, Maine Natural History Observatory*

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

Jason Jeremy Schaffler, *Senior Quantitative Scientist, Muckleshoot Indian Tribe*

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

Michael J.W. Stokesbury, *Canada Research Chair, Acadia University*

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

William B. Sutton, *Assistant Professor, Tennessee State University*

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

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, *Deputy Center Director, USGS Patuxent Wildlife Research Center*

Petra B. Wood, *Assistant Unit Leader-Wildlife, WV Cooperative Fish and Wildlife Research Unit*

Fred Wurster, *Hydrologist, US Fish and Wildlife Service*

Jerry J. Vaske, *Professor, Colorado State University*

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) Brianne Du Clos, PhD (September 2012 – May 2019) Logan Kline, MS (September 2019 – Present Meredith Lewis, MS (September 2019 – Present) Brian Rolek, PhD (September 2012 – December 2018) Shawn Snyder, PhD (June 2019 – Present
Zydlewski	Ernest Atkinson, MS (September 2018 – Present) Kevin Job, MS (January 2016 – Present) George Maynard, PhD (May 2013 – May 2019) Matthew Mensinger, MS (September 2018 – Present) Alejandro Molina-Moctezuma, PhD (May 2015 – Present) Erin Peterson, PhD (September 2017 – Present) Sarah Rubenstein, MS (January 2018 – Present) Sarah Vogel, MS (January 2017 – Present) Kory Whittum, MS (June 2019 – Present)

RECENT GRADUATES AND CURRENT PURSUITS

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

Allison Brehm, MS, Wildlife Ecology — December 2018
PhD student, University of Maine — Alessio Mortelliti

Anna Buckardt, MS, Wildlife Ecology — May 2019
Avian Ecologist, Iowa Department of Natural Resources — Amber M. Roth

Brianne Du Clos, PhD, Ecology and Environmental Sciences — May 2019
Postdoctoral Research Associate, University of Maine — Cynthia S. Loftin

Francesca Gundrum, MS, Wildlife Ecology — August 2019
Research Assistant, University of Maine — Carly C. Sponarski

Scott Lindemann, Master of Wildlife Conservation — December 2018
Wildlife Biologist, Jacobs Engineering — Aram J.K Calhoun, Malcolm L. Hunter, Jr.

George Maynard, PhD, Wildlife Ecology — December 2018
Research Coordinator, Cape Code Fishermen's Alliance — Joseph D. Zydlewski

Brian Rolek, PhD, Wildlife Ecology — December 2018
Quantitative Ecologist, The Peregrine Fund — Cynthia S. Loftin, Daniel J. Harrison

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
Amay Bolinjkar, Master of Wildlife Conservation	Alessio Mortelliti
Sara Boone, MS, Wildlife Ecology	Alessio Mortelliti
Kathleen Borderwieck, PhD, Ecology and Environmental Sciences	Aram J.K. Calhoun, Jessica J. Jansujwicz
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
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
Melissa Flye, MS, Ecology and Environmental Sciences	Carly C. Sponarski
Matthew Gonnerman, PhD, Wildlife Ecology	Erik J. Blomberg
Christopher Heilakka, MS, Ecology and Environmental Sciences	Erik J. Blomberg
Kevin Job, MS, Wildlife Ecology	Joseph D. Zydlewski
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
Alejandro Molina-Moctezuma, PhD, Wildlife Ecology	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
Nicole Ramberg-Pihl, PhD, Ecology and Environmental Sciences	Stephen Coghlan, Hamish Greig
Sarah Rubenstein, MS, Wildlife Ecology	Joseph D. Zydlewski
Kirstie Ruppert, PhD, Ecology and Environmental Sciences	Carly C. Sponarski
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, MS, Wildlife Ecology	Jessica J. Jansujwicz, Joseph D. Zydlewski
Daniel Weaver, Postdoctoral Associate	Joseph D. Zydlewski
Kory Whittum, MS, Wildlife Ecology	Stephen M. Coghlan, Jr., Joseph D. Zydlewski
Kaitlyn Wilson, MS, Wildlife Ecology	Amber M. Roth
Tyler Woollard, MS, Wildlife Ecology	Daniel J. Harrison

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

Monitoring of upstream migrating fish in the Penobscot River, Maine

1. Determine the rate, timing and efficiency of upstream passage of Atlantic salmon, American shad and alewife through major dams in Penobscot River.
2. Provide near real time information to cooperating agencies as to the effects of fishway operation on migratory success.
3. Provide a quantitative assessment of the effect of dam removal on the migratory success of migratory fish in the Penobscot River.

Abstract: The construction of industrial dams across major rivers in New England began in the early 1800s with textile mills in Massachusetts. Because of its legacy of mill dams and log driving dams, New England has the highest density of dams anywhere in North America, averaging one dam for every 44 km^2 of drainage area. By the early 1900s, these dams drastically limited migrations by diadromous fishes, resulting in declines in populations of migratory fishes, including Atlantic salmon *Salmo salar* and American shad *Alosa sapidissima*. Since that time, different fishway designs and river management plans have been tried around the region in an attempt to balance hydropower generation, water storage, flood control, and fish passage.

The Penobscot River, in Maine, USA, is the second largest river in New England, with a drainage area of 22,000 km^2, and presents an ideal opportunity for understanding fish passage and migratory movements in a heavily-modified river system. Historically, the river contained runs of eleven species of diadromous fishes including alewife *Alosa pseudoharengus*, American shad, blueback herring *A. aestivalis*, Atlantic salmon, sea lamprey *Petromyzon marinus*, American eel *Anguilla rostrata*, rainbow smelt *Osmerus mordax*, Atlantic tomcod *Microgadus tomcod*, striped bass *Morone saxatilis*, brook trout *Salvelinus fontinalis*, Atlantic sturgeon *Acipenser oxyrinchus*, and Shortnose Sturgeon *A. brevirostrum*, many of which supported subsistence and commercial fisheries prior to dam construction. The Penobscot River Restoration project (initiated in 2004), decommissioned three hydroelectric dams, upgraded fish passage at four dams, and increased generation capacity at three dams, theoretically opening much of the watershed to migratory fishes. We used a combination of telemetry methods, historic data, and modeling to assess the potential for fishways to select for certain traits with enough power to cause evolutionary change in migratory fish populations and evaluate the ability of migratory fish to use newly available habitat in the Penobscot River watershed.

The primary fishway design used in New England for many years was the Denil fishway, which uses angled baffles to reduce water velocity while maintaining high volume and thus, high attraction flow. In order to reach their spawning grounds in the headwaters of the Penobscot River watershed, in-migrating Atlantic salmon have had to navigate between five and seven (mostly Denil) fishways at different dams. Six years of PIT telemetry data were used to evaluate passage success at fishways on the second, third, and fourth dams in the system (Great Works Dam, Milford Dam, and either Howland Dam or West Enfield Dam, depending on path choice) as a function of water temperature, flow, migratory timing, and fish length. At the lower two fishways (Great Works and Milford Dams), fish length was a significant predictor of passage success, with a 91-cm salmon 21%–27% and 12%–16% less likely to pass than a 45-cm salmon, at Great Works and Milford Dams, respectively. Additionally, we analyzed thirty-four years of escapement data and found that the slow maturing and iteroparous individuals that represented the largest salmon size classes were essentially lost from the population during that time, and that Penobscot River fish have shorter fork lengths at maturity (45 – 91 cm) than Atlantic salmon in undammed systems (45 – 110 cm). Both of these results indicate that selective pressure towards smaller sizes at maturity (exerted by fishways) may be driving evolutionary responses in Atlantic salmon in the Penobscot River.

Size at maturity and age at maturity are heritable in salmonids and have ramifications for population stability over time, as body size is an important predictor of an individual salmon's egg quality and quantity. To test whether the selection against large-bodied fish exerted by fishways was substantial enough to elicit an evolutionary response from a population of Atlantic salmon over many years, we developed a computer simulation of an Atlantic salmon population, which was primarily informed by research done in the Penobscot River as well as other rivers in Maine and rivers in Atlantic Canada. Using an individual based model, we allowed a population of Atlantic salmon to

evolve over a 100-year period of exposure to between zero and five dams, using different narrow-sense heritability values for age at maturity and size at maturity. This necessitated 150 different combinations of heritability values and dams, each of which was simulated 1000 times. Populations without dams present never went extinct, but 7.2% of populations exposed to one dam, 63.2% of populations exposed to two dams, and > 85% of populations exposed to three or more dams went extinct more than 30 years before the end of the simulation. Coefficient of Variation of size at maturity decreased over time when dams were present, indicating that dams may be a source of stabilizing or directional selection.

Little is known about the survival of hatchery-spawned kelts that are released into the natural environment. As the Penobscot River population of Atlantic salmon is primarily captured and spawned out in captivity, managers are faced with a decision of whether to release the post-spawn adults (kelts) in the estuary (downstream of the dams) or upstream of the dams in freshwater habitat. We released radio-tagged kelts at two sites (upstream of Milford Dam and in the Penobscot River estuary) in the late fall to evaluate overwinter survival and successful outmigration from each release location. Unexpectedly, 71% of tagged kelts made upstream movements after release, but were blocked by dams with fishways that had been shuttered for the season. Overwinter survival was low (23.6%) and neither survival nor behavior differed between release locations. Low overwinter survival may have contributed to the precipitous decline in iteroparous spawners in this population over the past four decades.

Another potentially iteroparous species in the Penobscot River assemblage is the American shad. Thought to have been extirpated from the system until fairly recently, a spawning population was recently documented near the head of tide. However, with the removal of the first two dams in the system and passage improvements at upstream dams, American shad should have access to up to 93% of its historic spawning habitat. To assess habitat use by these fish, we gastrically tagged 265 American shad at the head of tide between 2015-2017 and monitored their movements from the time of tagging until the end of summer (mid-September) each year. Additionally, we collected scales and used them to estimate the age and spawning history of each tagged fish. Few tagged fish moved upstream beyond the previously documented spawning grounds. Those that did were all virgin spawners, indicating that repeat spawners may be less likely to overshoot known spawning areas. Additionally, none of the tagged fish that approached the dam successfully used the new fishway there. However, several thousand untagged fish used the fishway each year during our study.

Investigator: George Maynard (PhD)

Advisors: Joseph D. Zydlewski (Advisor)
Erik J. Blomberg
Michael T. Kinnison
Joan G. Trial
Gayle B. Zydlewski

Duration: September 2009—December 2018

Cooperators:

American Recovery and Reinvestment Act (ARRA)
Brookfield Renewable Power
Maine Department of Marine Resources
National Oceanic and Atmospheric Administration
Penobscot River Restoration Trust
U.S. Fish and Wildlife Service – Craig Brook National Fish Hatchery
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit

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.

A trial mission of a drone mission was carried out in April 2018, and a tracking mission is scheduled for January 2019. The glider was able to navigate complex bathymetry and travelled across Penobscot Bay over two weeks. Diet from both species and prey samples have been obtained from the Kennebec and Penobscot rivers. The rivers differed in prey species, abundance, and in diet suggesting that the interchange between the rivers may be related to specific forage items or competition release. Aging structures have been obtained from both species in the Penobscot River, and data of genetically identified GOM fish from Canada will be incorporated into stock analysis. Size and weight data are and have been collected on both species for 10+ years in the Penobscot. Population sizes of sturgeon from 2007 - 2018 in the Penobscot vary seasonally and annually for both Shortnose (250 - 2924 individuals) and Atlantic sturgeon (500 - 708).

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—August 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 will be repeated in 2020.

Investigator: Ernie Atkinson

Advisors: Joseph D. Zydlewski (Advisor)

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

A tool for understanding likely fish passage and harvest management outcomes for alewife on the St. Croix River

1. Develop a user-friendly interface for assessing scenarios associated with the recovery of alewife populations.
2. Engage with stakeholders to develop and address fundamental questions associated with alewife management, resulting in a document with scenario-specific population information.

An interactive web tool that can be used to compare possible management approaches related to passage improvements, commercial fishery placement within the watershed, and stocking, among other potential scenarios. This will involve converting an existing alewife population model from one form to a code format that can be used on a web platform. This will result in a user-friendly online tool that can be made publicly available as a web application. To identified management scenarios that would be of management value, the work will undergo a scientific peer review to ensure that the best available science is used and that all interested parties in both the US and Canada are included in its development. When complete, we will create a video tutorial that describes how to use the web-based modelling application. "Hands on" workshops for the tool will also be held.

This work has been completed. We have been primarily focused on developing the interactive web tool and an existing alewife population model we developed has been converted into a usable form for a web interface. We have constructed a user interface for the project and tested it with our stakeholders. The beta version of this model is available for use (https://umainezlab.shinyapps.io/alewifepopmodel/).

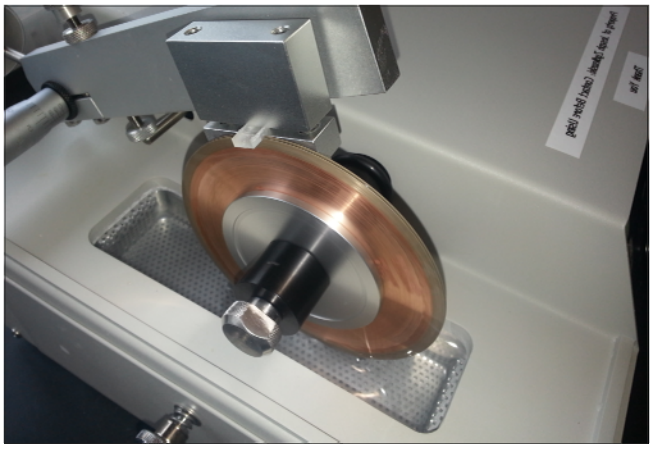
Investigators: Betsy Barber (Postdoc)
Alejandro Molina-Moctezuma (PhD)

Advisor: Joseph D. Zydlewski (Advisor)

Duration: June 2018—December 2019

Cooperators:

International Joint Commission on the St. Croix Waterway
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit



Using otolith microchemistry to infer early life histories of American shad and American eel habitat use in the Penobscot River, Maine

1. Using otolith microchemistry, we plan to infer early life histories of American shad and American eel habitat use (spatial and temporal patterns) in the Lower Penobscot River.
2. We plan to utilize microchemical data to provide a baseline for American shad and American eel early life histories in the Penobscot River prior to Veazie dam removal.

Removals of Veazie (2013) and Great Works (2012) Dams were completed in conjunction with three upstream fish passage modification projects on the Penobscot River in Maine as part of the Penobscot River Restoration Project. Prior to these fish passage modifications, upstream passage of American shad was negligible through the historic Veazie Dam and many believed American shad were largely absent from the river. Similarly, upstream passage of juvenile American eels is believed to have been repressed by these Dams. Understanding the degree to which these fish species persisted in the estuary prior to the removal of Veazie and Great Works Dams is important for their management and restoration.

In an attempt to provide a baseline for American shad and American eel early life histories in the Penobscot River prior to dam removal, we plan to analyze otolith (ear bones) microchemical structures (elemental ratios of Barium:Calcium, Strontium:Calcium, etc.), utilizing laser ablation inductively coupled plasma mass spectrometry. Resulting elemental ratios will afford us the opportunity to reconstruct early life histories of American shad and American eels through comparative analysis with surrounding water microchemistries.

We have removed, mounted, and have prepared more than 800 individual otoliths from American shad and more than 120 American eels. All samples for American shad from Penobscot River (2011 to 2017) and American eels (2013 to 2017) have been processed and prepared for microchemical analysis. The microchemistry of these samples has been analyzed using laser ablation inductively coupled plasma mass spectrometry (ICPMS) at the Woods Hole Oceanic Institute. Strontium and barium levels indicate varied time spent in seawater for both species and demonstrate the likely role the lowermost dams have had on disrupting movement patterns. This project is complete and is in the process of being written up for publication.

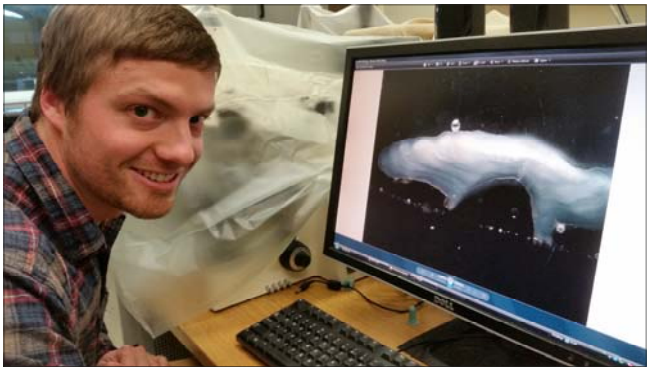
Investigator: Kevin Job (MS)

Advisors: Joseph D. Zydlewski (Advisor)
Erik J. Blomberg
Jason Jeremy Schaffler

Duration: January 2016—October 2019

Cooperators:

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



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.

To improve predictions of timing and magnitude of eel migrations, we used a 30-year data set consisting of daily eel catch and environmental variables (discharge, temperature, moon phase, ordinal date) among several Northeastern US rivers. We constructed generalized additive models and generalized linear mixed models with a Bayesian hierarchical framework to describe the relationships between variables and the migration of silver eels. A Bayesian hierarchical approach effectively estimated parameters and error structure across multiple systems. This work represents a step towards the development of a forecasting model to predict silver eel movement using environmental covariates.

Investigator:	Matthew Mensinger (MS) Daniel Weaver (Postdoc)
Advisors:	Erik J. Blomberg (Co-Advisor) Joseph D. Zydlewski (Co-Advisor)
Duration:	September 2015—June 2021

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

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.

This project will draw upon a growing body of telemetry data reaching back to work begun in 2005 and continued through to present. Targeted releases of Atlantic salmon smolts implanted with acoustic "pingers" are tracked through the entire Penobscot River system using an extensive deployment of stationary receivers. These acoustic receivers are deployed as part of ongoing cooperative work between NOAA-Fisheries, USGS Maine Cooperative Fish and Wildlife Research Unit and the University of Maine. The observed series of detections of an individual fish are used to construct a model of survival through the River system. Such a model allows the assessment of areas of high mortality, such as dams. We continued tagging hatchery-origin Atlantic salmon smolts from the Penobscot River through 2019. Beginning with the 2016, this project focused on survival and passage through Howland Dam in the Piscataquis River. A new downstream fish passage at Howland Dam has the potential to greatly increase smolt survival through this reach. Therefore, it is important to characterize current survival at this dam in comparison to previous work.

Acoustic telemetry data have been collected from hundreds of downstream migrating Atlantic salmon smolts released in 2016-2019 to assess movement and survival through the Penobscot River and Estuary. These data have been used to estimate survival of Atlantic salmon smolts throughout the system and are routinely used by agencies associated with the management of this federally endangered species. In aggregate, these data allow a post-restoration assessment of Atlantic salmon survival in the Penobscot River. These data have provided a comprehensive analysis of smolt passage in the Piscataquis River indicating greatly improved survival through the Howland Dam after the construction of the nature like fishway.

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

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 and 2019 a total of 99 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 200 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 a total of 6,000 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. The final portion of the study will be a collaboration with the National Cold Water Marine Aquaculture Center for a controlled study of bioenergetic effects on prespawning adult salmon experiencing different thermal regimes. Two study groups of fish will be held at different temperatures from spring until fall spawning, allowing the characterization of thermally mediated metabolic acceleration on whole body use and the influence of increased metabolic rate on gametic development and larval metabolism.

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.

Investigator: Sarah Rubenstein (PhD)

Advisors: Joseph D. Zydlewski (Advisor)
Nishad Jayasundara

Duration: January 2018—August 2020

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

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

Decision-making regarding dams in New England stands at a crossroad. Many dams in Maine, New Hampshire, and Rhode Island will require FERC relicensing in the next decade, many are approaching their design life, and preferences for dams and ecosystem services are changing. However, despite increased momentum for change and renewed calls to consider a broader range of options including removal, dams remain a symbol of cultural identity, economic prosperity, and technological innovation; they represent a source for clean energy and an opportunity for recreation. Placed squarely at the center of the contentious debate are numerous federal and state resource and regulatory agencies charged with the difficult task of balancing ecological, economic, and social tradeoffs related to dam relicensing decisions.

Numerous federal and state agencies assert jurisdiction over dam projects, and a confusing array of laws and policies inform dam relicensing, removal, retrofit, and on-going operations. Through interagency coordination and engagement with stakeholders including private landowners, non-governmental organizations, municipal governments, and industry, agencies have the capacity to mobilize action at the basin-wide scale using a range of regulatory and non-regulatory tools. The use of science-based information is key to making well-informed decisions and conceptual "blueprints" for basin-scale hydropower development have been introduced.

To date, these decision frameworks have proven difficult to implement in practice. Instead, agency actions tend to be case-specific and reactive to individual projects and events rather than proactive, considering alternative actions and consequences before issues reach a boiling point. This research attempts to characterize agency actions and perspectives including knowledge gaps and challenges faced in the relicensing process.

Work began in 2017 and has focused on content analysis of document sources for 47 projects in the Kennebec and Penobscot River watersheds. A database of fish passage related correspondences, comments, and official documents relating to hydropower energy projects was constructed from the FERC eLibrary. From these sources, technical and social correlates are being quantified in relation to regulatory outcomes. A targeted content analysis of these sources is being used utilizing machine learning techniques to characterize the roles of agencies and tribal entities, entity participation, and agency decision-making behaviors. The use of science in decision-making has been identified as an important component of the relicensing process. Citation analysis is being used to identify major sources of knowledge used in the process, where it originates from, and how it is used. Knowledge of these patterns may inform future relicensing efforts. This project is near completion and the write up is in progress.

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

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.

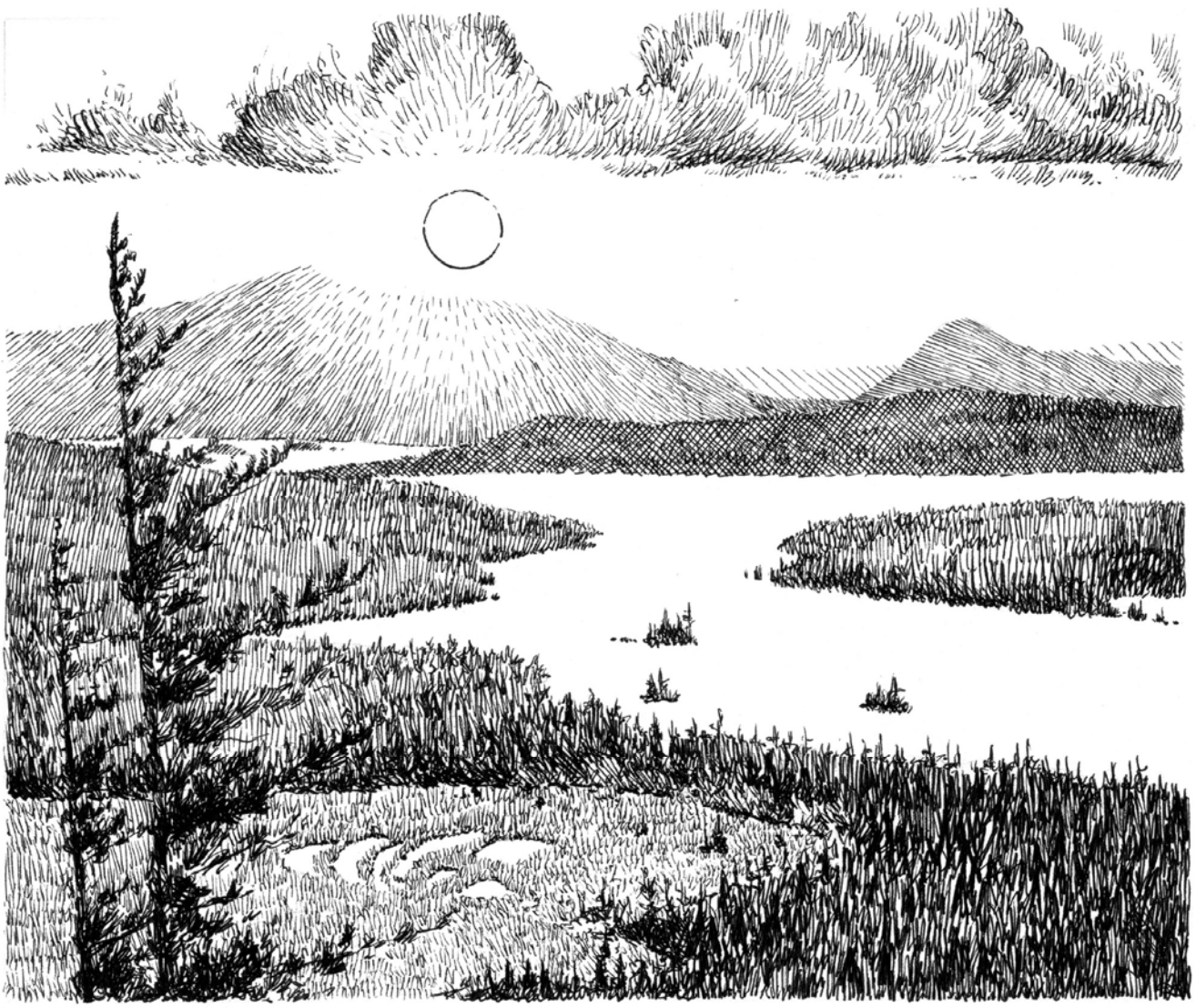
Investigators: Kory Whittum (MS)
Jonathan Watson
Ian Kiraly

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



WILDLIFE and habitats

WILDLIFE and habitats continued

Investigating the effects of silvicultural practices on individual and population-parameters in small mammals: from personality to seed predation

1. Determine whether or not individuals with different personality types have differential fitness across forest management areas.
2. Explore whether or not personality affects the key processes of seed predation and dispersal.

Abstract: To Individual animals exhibit consistent behavioral tendencies over time and across contexts that have been termed *personalities*. Personality encapsulates an individual's unique way of behaving and responding to life's challenges, and since individuals vary in both personality type and their ability to exhibit behavioural plasticity, there are important links between an individual's personality and its response to a changing environment; resulting in the study of animal personalities becoming increasingly popular in recent years. Previous research suggests that personality traits measured through standardized behavioural tests predict trappability (i.e. 'trap happiness' versus 'trap shyness'). This relationship has been explored only within single species and never across environments, but it is essential to understand this link, because if personality drives trap response this suggests that samples obtained through active trapping methods are behaviorally-biased (perhaps weighing more heavily on the bold individuals) – violating any assumption of a random sample. Further, if personality traits predict trappability, it would be possible to extract personality data from long-standing mark-recapture datasets by using trappability as a proxy for personality. My thesis contributes to this growing field by clarifying the relationship between trappability and personality in Chapter 1, and by demonstrating a critical relationship between personality and an essential ecosystem process: *seed dispersal* in Chapter 2. To meet these goals, we designed a large-scale field experiment to measure personality and trappability in five small mammal species and across varying forest types. Using standardized tests, we quantified behaviour in deer mice (*Peromyscus maniculatus*), Southern red-backed voles (*Myodes gapperi*), American red squirrels (*Tamiasciurus hudsonicus*), woodland jumping mice (*Napaeozapus insignis*), and Northern short-tailed shrews (*Blarina brevicauda*). Using this same experimental design, we performed a detailed seed predation experiment to observe interactions with seeds by known-individuals across different forest treatments. Chapter 1 shows that, although we identified personality in all five of target species, personality traits did not predict different aspects of trappability, suggesting that our work examined a random-subset of the population (i.e. not behaviorally-biased) and that trappability cannot be used as a proxy for personality. In Chapter 2, we remotely observed interactions with seeds and assessed whether personality traits influenced key decisions in a natural environment and at vital stages of the dispersal process. Ultimately, this research provides the first evidence that personalities influence four critical stages of seed predation and dispersal by scatter-hoarding small mammal, and that conserving behavioral diversity could maintain a diversity of ecological functions by conserving individuals with certain personality traits.

Investigator: Allison Brehm (MS)

Advisors: Alessio Mortelliti (Advisor)
Erik J. Blomberg
Shawn R. Fraver

Duration: June 2016—December 2018

Cooperators:

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

Evaluating young forest management as an avian conservation strategy

1. To assess the effectiveness of using young forest management on private non-industrial forest lands to create quality habitat for breeding birds.
2. To determine how and in what capacity landowners are willing and able to participate in wildlife monitoring of their young forest management areas.
3. Investigate broad-scale Golden-winged Warbler habitat use and annual movements to determine migration routes and timing and wintering areas.

Abstract: Early successional forest and shrubland habitats are collectively called young forest. Changes in disturbance regimes and land use conversion resulted in declines of young forest and associated wildlife across eastern North America. Conservation of declining young forest birds relies on the maintenance and creation of young forest habitats used for breeding. American Woodcock (AMWO; Scolopax minor) and Golden-winged Warbler (GWWA; Vermivora chrysoptera) are two declining young forest species. Conservation plans for both species use an adaptive management framework, which is an iterative process of planning, management actions, and monitoring and evaluation, in the context of species conservation goals. Adaptive management programs often fail to meet their conservation goals when monitoring and evaluation is missing or ineffective. To address this short coming, my research focuses on the monitoring and knowledge gathering aspects of the iterative process.

First, I investigated the role of landowners in monitoring the response of AMWO to habitat management on private properties. I interviewed Wisconsin landowners to determine their monitoring preferences and then developed a pilot monitoring protocol where landowner citizen scientists documented the response of male AMWO to habitat management on their properties. I conducted sideby-side AMWO monitoring with landowners followed by an interview to gauge landowner understanding, ability, and satisfaction with the monitoring protocol. Although landowners were willing and excited to participate in AMWO monitoring, their hearing often limited their ability to collect quality data. In order to create a successful AMWO monitoring program that suits the needs of landowners and managers, I recommend in-person training, periodic hearing assessments, and flexible data submittal options.

Second, I quantified the response of male GWWA to woody vegetation shearing, a best management practice intended to create quality breeding habitat. GWWA point counts and associated patch-level vegetation surveys were conducted in three habitat management types throughout Minnesota and Wisconsin (mature alder shrubland, sheared alder shrubland, and sheared aspen sapling). Using integrated likelihood models in a distance sampling framework, I investigated the impact of 1) habitat management, and 2) patch-level vegetation characteristics, on the relative abundance of male GWWA. Habitat-management type and habitat age were included in my top supported management model, and occurrence of graminoids, no woody regeneration, and 1-2m tall woody regeneration were supported habitat factors affecting male GWWA abundance. I recommend the continuation of the shearing management practice, particularly when habitat elements are missing.

Finally, I tracked the migratory connectivity patterns of GWWA and Blue-winged Warbler (BWWA; Vermivora cyanoptera) in four previously unstudied populations. I used light-level geolocators deployed on male Vermivora to determine individual wintering ranges. Previous research has shown weak migratory connectivity structure in BWWA and strong migratory connectivity structure in GWWA, with GWWA breeding in the Great Lakes region wintering in Central America and those breeding in the Appalachians wintering in South America. I discovered previously unknown intricacies of GWWA migratory connectivity structure with birds from one site in the Great Lakes region wintering in Central America (n=2)

and South America (n=3). I propose incorporating migratory connectivity as a criterion for population segment and conservation region designation.

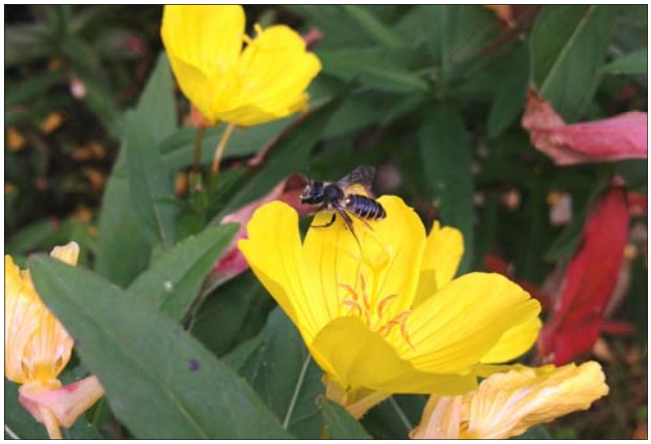
Investigator: Anna Buckardt (MS)

Advisors: Amber M. Roth (Advisor)
Erik J. Blomberg
Jessica E. Leahy

Duration: June 2016—May 2019

Cooperators:

Association of Field Ornithologists
Audubon Vermont
Cornell Lab of Ornithology
Indiana University of Pennsylvania
Inland Bird Banding Association
Michigan Technological University
Natural Resources Foundation of Wisconsin
Oazaukee-Washington Land Trust
U.S. Fish and Wildlife Service
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
Wisconsin Audubon Council, Inc. and eight associated Audubon chapters around Wisconsin
Wisconsin Department of Natural Resources
Wisconsin SFI Implementation Committee
Wisconsin Young Forest Partnership



Landscape pattern and native bee communities in the northeastern United States

1. Determine if a relationship exists between pesticide residues in pollen loads and landscape configuration.
2. Examine power line rights-of-way as semi-natural habitat for native bees.
3. Compare the performance of a spatially explicit ecosystem service simulation model in landscapes with different complexities.
4. Develop a tool for blueberry growers to assess native bee habitat in the landscape surrounding their crop fields.

Abstract: Commercial production of lowbush blueberry (*Vaccinium angustifolium* Aiton) in Maine relies primarily on managed honeybee hives; however, naturally occurring wild bees are more efficient pollinators of the crop. Wild bees have short foraging distances and must nest near crop fields to provide pollination services. After crop bloom, the surrounding landscape must provide sufficient forage to maintain wild bee populations for the remainder of the growing season. Lowbush blueberries in Maine are produced in a mixed-use landscape with two distinct landscape contexts. Here, we document bee communities and habitat resources (nesting and floral) in power line rights-of-way and eight land cover types including and surrounding lowbush blueberry fields. We assess landscape pattern surrounding crop fields in the two contrasting contexts and determine any effect of arrangement of habitat patches on wild bee abundance or diversity. Additionally, we use our field data to inform and validate predictions of wild bee abundance from a spatial model applied to the lowbush blueberry production landscape and assess any influence of landscape pattern on prediction accuracy. Finally, we describe a collaboration with lowbush blueberry growers to develop an interactive web mapping tool that provides maps of habitat resources and predicted wild bee abundance. We documented 168 wild bee species across 72 study sites; three bee species had not been previously recorded in Maine. Power line rights-of-way had diverse and abundant bee communities owing to high habitat quality, especially within resource-poor landscapes near lowbush blueberry fields. We observed abundant floral resources in lowbush blueberry fields, forest edges, and small towns and found ample nesting resources in lowbush blueberry fields and shrubby wetlands. Bees were less abundant and diverse in a homogeneous landscape context; however, that homogeneity led to more accurate model predictions of bee abundance in crop fields. We improved prediction accuracy in a mixed-use landscape and produced accurate predictions in non-crop land cover types in a heterogeneous landscape context; however, we found that predictions of wild bee abundance in crop fields are influenced by landscape heterogeneity. The maps we share through the web tool aid growers and other stakeholders in developing pollination management and conservation plans.

Investigator: Brianne Du Clos (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Francis A. Drummond (Co-Advisor)
Dana M. Bauer
Samuel P. Hanes
Allison Dibble

Duration: January 2012—May 2019

Cooperators:

U.S. Department of Agriculture
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S.D.A. SARE Grants
University of Maine
University of Maine – Sustainable Solutions Initiative

Battle over black bears: Investigating perceptions of the black bear hunting referendums in Maine

1. Analyze news media surrounding the 2004 and 2014 black bear hunting referendums.
2. Investigate representation of themes in of the debate in public discourse.
3. Investigate varying attitudes, beliefs, and norms shared by those on either side of the debate.
4. Explore black bear hunting as a phenomenon to help characterize its contentious nature in Maine.
5. Characterize institutional barriers and factors that will impact future black bear hunting policy in Maine.

ABSTRACT: Human dimensions of wildlife is an emerging discipline that seeks to understand the complex relationships between people, wildlife, and their conflicts and/or interactions (Decker, Riley, & Siemer, 2012). Human dimensions research utilizes several tested theoretical frameworks to investigate these complexities, such as cognitive hierarchy theory and wildlife value orientations (WVOs). Both of these theoretical frameworks were examined in this study, which investigated the content of news media during controversial American black bear (*Ursus americanus*) hunting referenda in Maine, and stakeholder perceptions of black bear management. Maine is the only state that allows hunters to take a black bear over bait, with hounds, and with traps (Gore, 2003; Morell, 2014). Due to perceptions that some or all of these harvest methods are cruel and unfair, Maine has endured two state-wide referendums that called on citizens to consider eliminating the three practices entirely (Gore, 2003; Morell, 2014). In 2004 and 2014, both referendums narrowly failed, thus stabilizing the legitimacy of current bear hunting practices (Maine Secretary of State, 2004; Maine Secretary of State, 2014). This complex debate has permeated and divided the state politically, ethically, and socially for decades. This study explored the nature of the debate via quantitative and qualitative research and delivered several valuable findings that could help to mitigate future conflict amongst key stakeholders.

A quantitative content analysis (QCA) of news media surrounding Maine's controversial bear hunting referendums was used to explore the presence of differing cognitions toward current bear management. Various stakeholder groups vocalized their opinions in news media before, during, and after both referendums. It is clear that media played an integral role in informing the public of this issue in Maine. The initial part of this study investigated the representation of different debate themes in public discourse. A total of 247 newspaper articles from Maine's five major newspapers by distribution were analyzed surrounding the referendums. Cognitive hierarchy theory guided our analysis of attitudes, beliefs, and norms toward baiting, hounding, and trapping that were present in news media. Our results illustrated that those in favor of the referendums frequently expressed negative attitudes toward baiting, hounding, and trapping, while conversely those against the referendums argued that they believe Maine needs these methods to control the population and that these methods benefit humans. These findings guided our characterization of the debate and our conclusions regarding the future of black bear hunting policy. Through the exploration of the debate's substance in news media, our research is an important step toward developing effective communication strategies amongst key stakeholders.

The second portion of this thesis used a phenomenological approach to explore how cognitions, wildlife value orientations, and differing perceptions about bear hunting practices in Maine ultimately characterize the issue and provide clarity when determining ways to mitigate future conflict amongst stakeholders. This study used combined online questionnaire and semi-structured interviews with key stakeholders within the debate to explore varying perceptions regarding bear management. Key stakeholders were identified from the QCA of news media and then asked to participate in an online questionnaire and semi-structured interview. These two methods allowed us to investigate cognitions toward bear management and WVOs, as well as stakeholders' motivations for being involved in shaping bear hunting policy, thoughts on the contentious nature of the debate, effects that the referenda processes had on their mental health and feelings of personal safety, and insights regarding strategies for developing bear hunting policy that is representative of all interest

groups and in line with the best available science. Our results revealed the need for an extension of legitimacy and respect for collaboration amongst diverse stakeholders and possible practical changes to the black bear management plan in Maine. Ultimately, it is clear that a future bear hunting referendum would be detrimental to the integrity of the stakeholder community and would only divide stakeholder groups further.

This research contributes to human dimensions of black bear and game management literature. In this study, we supplied several potential approaches to developing a stakeholder community that is respectful, communicative, and capable of pursuing logical compromises in a future black bear management plan.

Investigator:	Francesca Gundrum
Advisors:	Carly C. Sponarski (Advisor) Laura N. Rickard Sandra M. De Urioste-Stone
Duration:	September 2017—August 2019

Cooperators:

Maine Department of Inland Fisheries and Wildlife

Effects of forest management practices in the Acadian northern forest region on forest bird communities, with emphasis on species of regional conservation priority and concern

1. Quantify and define the composition and forest associations of coniferous bird communities in several silvicultural treatments including: regenerating, mature, overstory removal, precommercially thinned, selection, and shelterwood harvest.
2. Model the influences of silvicultural practices and vegetative attributes on coniferous forest bird communities.
3. Model factors influencing the abundance, occupancy, and distribution of focal species. This analysis will take a multi-scale approach and use both USGS Breeding Bird Surveys along with surveys that will be conducted 2013-2015.

Abstract: Habitat loss is the primary cause of species loss and declines of global biodiversity. Several birds associated with the spruce-fir forest type (hereafter spruce-fir birds) have declining populations across the continent in the Atlantic Northern Forest, and the extent of coniferous forest has declined in some areas. This region is extensively and intensively managed for timber products.

To investigate the influence from harvest treatments on the spruce-fir bird assemblage during the breeding and post-breeding period in lowland conifer and mixed -wood forests, we used avian point count detection data to test for associations between avian assemblages and seven common harvest treatments. Spruce-fir avian assemblages had greatest abundance in regenerating clearcuts combined with postharvest treatments (i.e., herbicide and precommercial thinning), and within stands having ≥60% spruce-fir tree composition. Richness of spruce-fir avian assemblages were greatest in stands with immature trees and greater spruce-fir tree composition, and clearcuts combined with postharvest treatments had greater spruce-fir tree composition compared to other treatments.

Next, we tested for effects from management, years-since-harvest, and vegetation on abundance of 19 conifer associated avian focal species while accounting for the effects from detection probability. Abundance of six species differed significantly among harvest treatments, and one species was associated with years-since-harvest, indicating that management treatments provided important information. In addition, fourteen species had significant associations between abundance and vegetation variables, suggesting that managers could target specific vegetative outcomes when managing for focal species.

We tested for differences in avian abundance and richness at stand interior ≥80 m from edges, low-contrast edges at the junction of two regenerating stands, and high-contrast road edges with managed buffers using a novel multi-species abundance model. Spruce-fir birds had greater richness at stand interior compared to high-contrast edge, and stand interior had greater spruce-fir tree composition compared to high-contrast edge, while low-contrast edge was intermediate. Road edges reduced habitat for spruce-fir birds. Combined our results suggest that management could promote habitat for spruce-fir birds through: 1) application of postharvest treatments such as herbicide and precommercial thinning; 2) using management that targets focal species by using outcome-based silviculture; 3) minimizing access road edges and roadside buffers.

Investigator: Brian Rolek (PhD)

Advisors: Daniel J. Harrison (Co-Advisor)
Cynthia S. Loftin (Co-Advisor)
Petra B. Wood
Brian J. McGill
Brian J. Olsen

Duration: August 2012—December 2018

Cooperators:

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

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 of packs over 10 years, coupled with indirect observations (e.g., scats and tracks) to estimate the minimum number and mean size of packs inhabiting the study region.
2. Analyze the clustering of pack locations within the denning period to estimate position of core breeding areas for packs across the study region.
3. Develop a general linear model of habitat selection using 210 pack locations of African wild dogs to measure effects and interactions of vegetation type, ungulate densities, presence of other large carnivores, and distance to human activities on habitat selection.
4. Compare diet composition from standard scat analysis to availability of potential preys from a vast cover of ungulate spoor intersects to document prey selection.

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, isolated and confined to an area much smaller than is typical for the species and we hypothesize this is associated with primary use of a dense population of meso-mammals and similarly uncommon 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 and 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.

Transects totaling 1,869 km of transects were surveyed on foot and expanded from 37 km in 2008 to 624 km in 2016. Each transect was surveyed on an average of 3 occasions.. Spoors (including tracks and feces) of African wild dogs, other carnivores, and ungulate species were recorded; scats deposited by African wild dogs were collected for prey identification in the lab. To date, data from direct sightings and indirect observations were analyzed and have resulted in important new insights regarding numbers of packs, minimum pack sizes, and distribution and size of core denning areas in our study region. Currently, data on ungulate spoor intercepts collected over 583 sampling occasions is being entered and spatial mapping of carnivore observations and spoor will occur during summer 2020. Prey analysis of 55 feces from African wild dogs will occur in 2020. Modeling of habitat selection by African wild dogs will be the primary activity during fall 2020 with a target date of project completion of December 2020.

Investigator:	Jean-Marc André (MS)
Advisors:	Daniel J. Harrison (Advisor) Brian J. McGill
Duration:	January 2019—December 2020
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 first semester, and data mining and cleaning work is underway. Next steps include preliminary analyses, occupancy modeling design, and the generation of specific research questions.

Investigator: Amay Bolinjkar (MWC)

Advisors: Alessio Mortelliti (Advisor)

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

Small mammals personality and seed choice in a landscape of fear.

1. To study how individual and population responses interact and affect seed predation by investigating seed preference and choice, and behavior and personality and risk in response to varying ecological factors.
2. To study the response of individuals and populations to land-use change processes. The response variables of interest include individual-scale parameters such as health status, personality, and individual survival; and population-scale parameters such as population density, population growth rates, and population structure.

Seed predation/dispersal. This experiment's aim is to identify which seeds are preferred by different small mammal species, and how personality influences the choices of each individual. Our experiments are conducted using PIT tags and high-resolution infrared game cameras, which allow us to estimate the predation rate of different species and the amount dispersed/predated by each individual. It also allows us to assess the behavioral responses by different individual personality types when exposed to various ecological factors such as seed size, hardness, and nutritional value; vegetative cover; predation risk; and other habitat variables. These data are important for providing information about seed predation that can be used in forest regeneration models.

Small mammals and land-use change. We are using a large-scale capture-mark recapture study across two different forest management treatments, as well as unharvested control sites, to allow us to measure individual- and population-level parameters. These data will help us determine if personality and behavior are associated with different silvicultural practices, and what implications forest management will have on the make-up of small mammal communities and their affect on forest composition and regeneration.

We trapped from June through October of 2017, 2018 and 2019 in six trapping grids located in the Penobscot Experimental Forest near Bradley, ME. Three grids, each with a replicate (6 total), were set in two different silvicultural treatment sites and one mature forest site. Grids contained 100 Longworth and 50 Tomakawk traps. Captures were processed twice daily, and individuals were uniquely marked with PIT tags and metal ear tags. Weight, sex, reproductive status, and body measurements were recorded. Three field tests were performed to measure personality.

Field and laboratory seed preference experiments were conducted in two rounds during July and August 2017. Over 3,000 videos recorded six small mammal species selecting seeds from seven available tree species. Additionally, field experiments were conducted in July, August, and September 2018 to assess how different individual personalities respond to risk when presented with two seed choices. Over 10,000 videos were collected and are currently being processed.

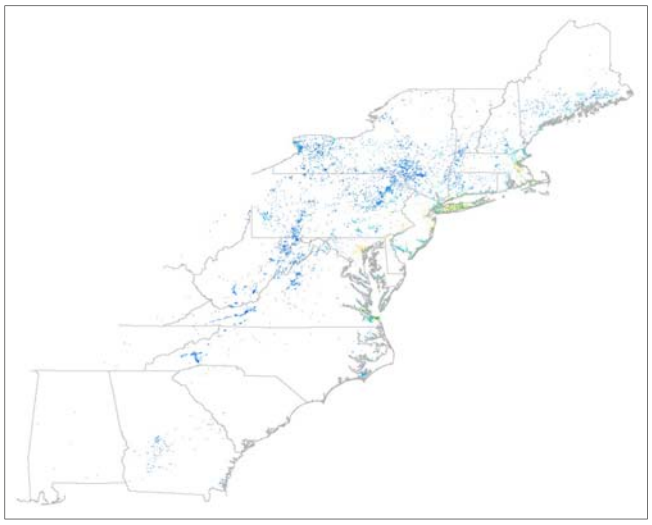
Investigator: Sara Boone (MS)

Advisors: Alessio Mortelliti (Advisor)
Malcolm L. Hunter, Jr.
Rebecca L. Holberton

Duration: June 2017—May 2020

Cooperators:

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



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 suitability and vulnerability models for the Atlantic Coast have been completed. The smartphone application has been launched and we are gathering responses from it. We are supplementing the low response rate from the app with ground-truthers reviewing Google Earth images. Next steps are to analyze the results of the groundtruthing, and modify the models as needed. Concurrently to that, we are researching assessment metrics and statistical analyses to use which will provide maximum usefulness to any land managers attempting to action off our model. Time permitting, we will expand our area of coverage to include the central flyway, and assess similarities and differences in the roost criteria between the two flight paths.

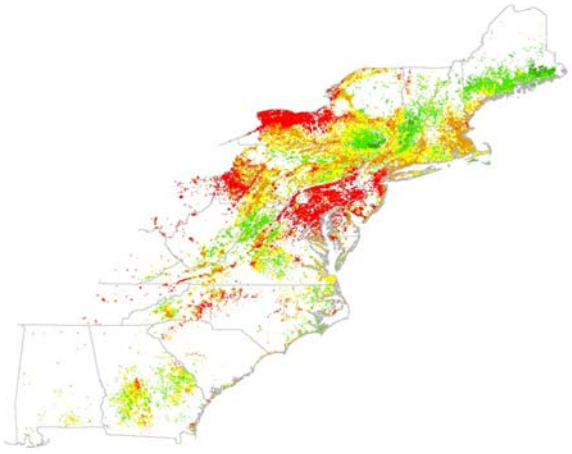
Investigator: Brandon Boxler (MS)

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

Duration: August 2017—May 2020

Cooperators:

Maine Department of Inland Fisheries and Wildlife
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
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 will 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. Specifically, I will investigate the role of animal personalities on microhabitat selection, seed dispersal effectiveness, and demography. I will assess whether forest management alters these patterns and relationships.

June - October 2019 marked the first field season of my PhD, but I will also be using data I have collected in the Penobscot Experimental since June of 2016 to meet my objectives! During the 2019 field season, I utilized a large-scale mark-recapture experiment and trapped small mammals from 5 primary target species (deer mice, southern red-backed voles, northern short-tailed shrews, woodland jumping mice, and American red squirrels) plus several others such as eastern chipmunks, masked shrews, and long-tailed shrews. Fieldwork involved marking individuals, taking morphometric measures, and assessing behavior in standardized tests. Additionally, in September and October I will run a pilot study to inform experiments I will perform in Autumn of 2020 to meet my third objective. I completed objective #1, and the publication resulting from this work is currently under revision at PLOS ONE. I am currently working on objective #2, and plan to have a publication resulting from this work completed by December 2019.

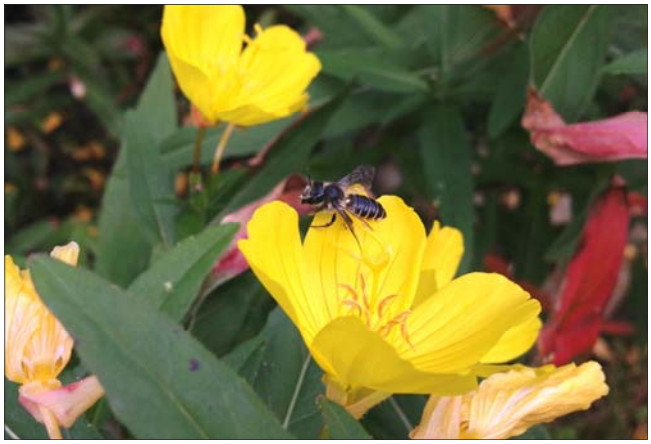
Investigator: Allison Brehm (PhD)

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



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. This research has expanded substantially in scope in the last 5 years; our review will provide a critical update for practitioners and academics.

Investigator: Brianne Du Clos (Postdoc)

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

Duration: September 2019—August 2020

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

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. How Rusty Blackbirds react to intensive commercial forestry practices within their breeding range have yet to be assessed. I propose to examine 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 will be affixed with VHF-radio transmitters and tracked via radio telemetry. Nest and fledgling GPS points will be paired with random points to compare habitat/harvest metrics and determine which characteristics are preferentially selected. General linear mixed models will be used to compare used vs. available sites and survival under different conditions.

During the 2019 field season, a total of 23 nests were found in New Hampshire (NH) and 9 in Maine (ME). Rusty Blackbirds were confirmed nesting in naturally regenerating clearcut stands, stands that underwent precommercial thinning, and undisturbed wetlands. Radio transmitters were deployed on 10 nestlings from 6 nests in ME and 10 nestlings and 6 nests in NH. Fledglings and adults received USGS aluminum bands and color bands for individual/group identification. We located 107 fledgling use points at the Maine site. At least two tagged fledglings from Maine were still alive based on condition at last location at the end of the field season. Vegetation characteristics were recorded at nest plots and paired random plots for all nests. Current tasks include preliminary data analysis and planning for the second 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
William P. Wharton Trust

A retrospective study on avian wildlife rehabilitation admissions

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—May 2020

Cooperators:

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

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 distinct landscape types, in both summer and winter, to simultaneously assess occupancy patterns and detection probabilities for marten, fisher, coyote, and other high priority species
3. Provide user-friendly guidelines on optimal monitoring approaches for key species to MDIFW
4. Investigate interspecies dynamics among native mesocarnivores and the potential impact on detection and occupancy
5. Assess species response to landuse dynamics and the pros and cons of trail camera surveys as the tool relates to large-scale, multi-species management, research and conservation

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 third year of full scale surveys, out of four years planned for data collection. During summer 2019 we revisited "permanent" survey locations (n = 59) and set new sites to expand our sampling effort under varying degrees of fur harvest pressure for marten, fisher and coyote (n = 38). This completed our natural experimental design across spatial, seasonal, forest management and landscape configuration variables. These sites will be set in winter 2020 to complete year 3 data collection, and the permanent surveyed again in the fourth year of the study.

In June 2019, our first peer-reviewed chapter was published in PlosONE (DOI: e0217543).

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

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 compared with previous studies of marten in our study area, we documented the lowest annual resident capture rate of any year of study and sex ratios skewed towards males. Ground telemetry locations gathered in 2018/2019 (n = 964) contributed to an overall historical/contemporary dataset of 7,009 telemetry locations on 153 resident marten. Efforts during 2020 will focus on a) completing a companion study to assess the efficacy of systematic live-trapping for resident marten using data from motion-triggered trail cameras placed at trap sites, and b) developing predictive models of marten occurrence based on field data collected during historical and contemporary field studies of marten in the industrial forest study area and adjacent forest reserve.

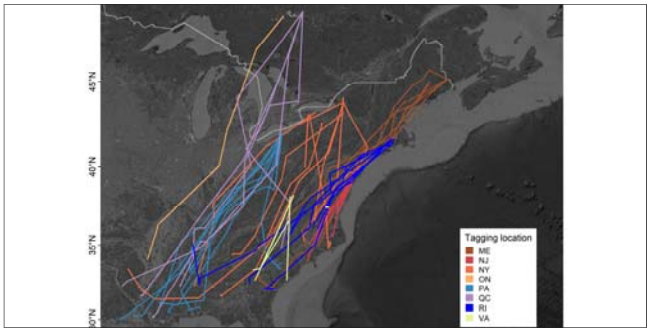
Investigator: Kirsten Fagan (PhD)

Advisors: Daniel J. Harrison (Co-Advisor)
Erin Simons-Legaard (Co-Advisor)
Erik J. Blomberg
Zachary Loman
Angela 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*) migratory 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.
5. Combine survival data with other existing datasets (band recovery, singing ground survey, parts collection) to develop an integrated, full life cycle population model for American woodcock.

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 plan to deploy more than 300 transmitters to track woodcock individually as they travel between breeding and wintering regions. Ultimately we will investigate migratory phenology, routes, quantify survival, and evaluate how breeding/over-wintering latitude influences these metrics.

As of November 2019, we have deployed 214 GPS transmitters on pre-migratory woodcock; 13 Maine, 10 Maryland, 15 New Jersey, 39 New York, 6 North Carolina, 7 Nova Scotia, 5 Ontario, 24 Pennsylvania, 15 Quebec, 30 Rhode Island, 9 South Carolina, 37 Virginia, and 4 West Virginia. We tracked 121 transmitters October 2017 through August 2019, and will track 93 woodcock during fall 2019. We anticipate deploying another 107 GPS transmitters on wintering woodcock (December 2019-February 2020); 6 Alabama, 5 Florida, 12 Georgia 12 Maryland, 15 New Jersey, 15 North Carolina, 10 South Carolina, and 32 Virginia. We will track winter deployed transmitters throughout spring migration and anticipate a sub-sample of fall deployed transmitters continuing to transmit locations for spring migration.

We have commitments to continue transmitter deployment through the fall and winters 2020/2021, but plan to continue the project as long as interest remains among cooperators.

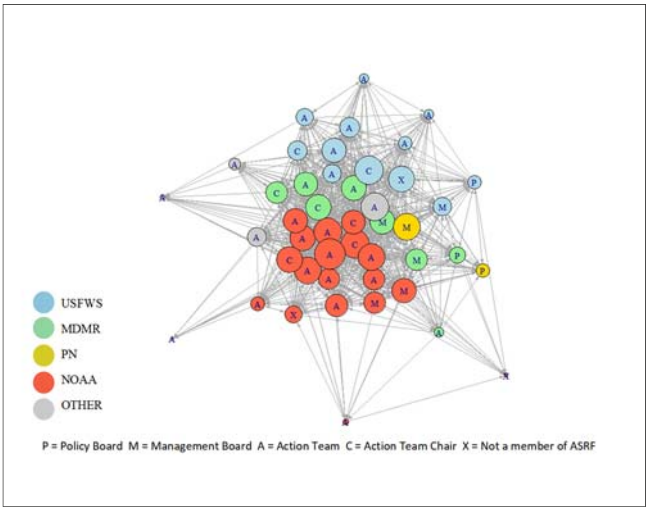
Investigator: Alexander Fish (PhD)

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

Duration: October 2017—May 2021

Cooperators:

Environment Canada
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 Ruffed Grouse Society
U.S. Geological Survey – Patuxent Wildlife Research Center
University of Rhode Island
Virginia Game Commission



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

Atlantic salmon populations in Maine remain critically low despite hatchery supplementation and habitat improvement efforts over the past four decades. In 2000 the Gulf of Maine Distinct Population Segment was listed as federally endangered with joint listing authority shared by the National Oceanic and Atmospheric Administration and the United States Fish and Wildlife Service. Because, regulators and managers from Federal, State, and Penobscot Nation context operate with independent authorities, recovery decisions depend upon effective communication and coordination. From 1980-2005 management and regulatory bodies, non-profit organizations, and citizens met as a single group, the Maine Technical Advisory Committee (TAC). The dissolution of TAC resulted in reduced coordination across authorities until 2011 when the Atlantic Salmon Recovery Framework (ASRF) was formed. The ASRF is both a management framework and a governance structure which emphasizes coordination and collaboration. We intend to assess the social factors of this governance system using a mixed-methods case study approach involving communication network analysis, semi-structured interviews, and document analysis. We contend that an evaluation of the interactions among entities may inform the processes by which recovery policies and actions are implemented. Specifically, we intend to characterize institutional barriers and factors that impact Atlantic salmon recovery decision making.

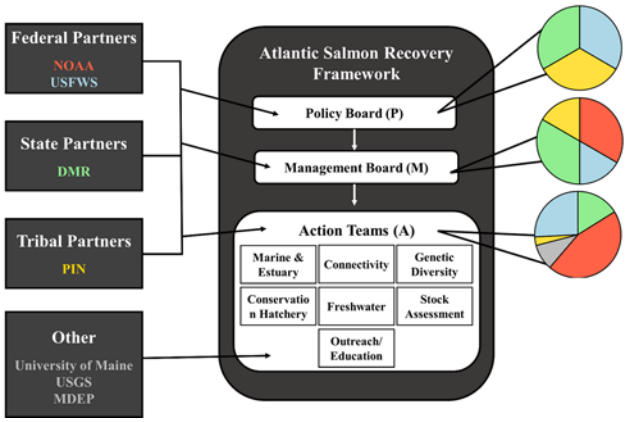
Data collection and analysis complete, quantitative Communication Network Analysis manuscript, *Understanding collaborative governance from a communication network perspective: A case study of the Atlantic Salmon Recovery Framework* has been submitted to *Fisheries Magazine* and is under review. Second manuscript is currently being written.

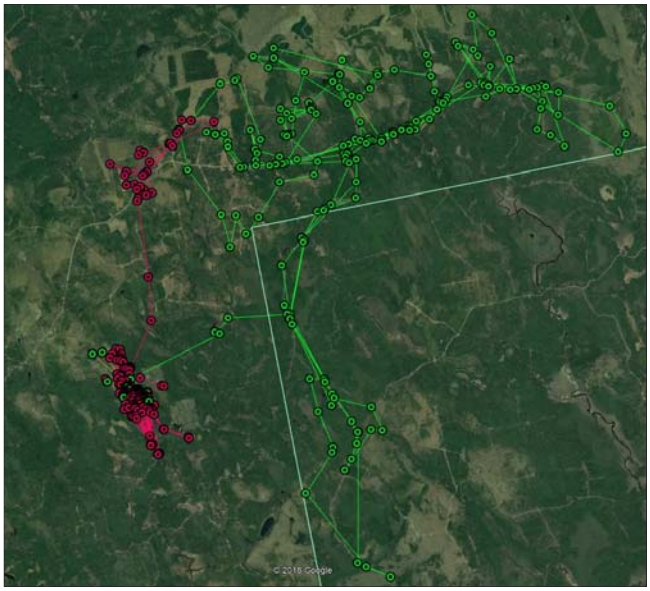
Investigator: Melissa Flye (MS)

Advisors: Carly C. Sponarski (Advisor)
Joseph D. Zydlewski
Bridie McGreavy

Duration: August 2017—December 2019

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 currently completed 2 years of data collection. During 2018, we captured 124 unique wild turkeys and in 2019 we captured 395 unique wild turkeys, all of which were banded. We fitted 116 females with VHF transmitters and 39 with GPS transmitters. In addition, we fitted 33 males with VHF transmitters and 1 with a GPS transmitter. To estimate nest survival, we located and monitored 28 nests in 2018 and 41 in 2019 from marked hens. We are currently preparing for the final trapping season in 2020 in which we will continue to capture and monitor birds across the state. Following success in our expanded trapping efforts in 2019, we will be continuing to trap in additional regions of Maine for banding and estimation of population size.

Investigator:	Matthew Gonnerman (PhD) Stephanie Shea (PhD)
Advisors:	Erik J. Blomberg (Advisor) Kelsey Sullivan Pauline Kamath
Duration:	January 2018—August 2022

Cooperators:

Maine Department of Inland Fisheries and Wildlife
National Wild Turkey Federation

Examining the interacting roles of social influences and risk perceptions of white-tailed deer feeding and management in Maine and New Brunswick

1. Develop an improved understanding of the individual motivations and cognitions toward deer feeding behavior in both New Brunswick and Maine.
2. Understand how public and stakeholder motivations and cognitions toward deer feeding may be linked to current deer and forestry management practices.
3. Develop a better understanding of stakeholder attitudes and how this contributes to conflict management.

The catalyst for this study stems from a collaborative effort to better understand abiotic and biotic factors impacting the white-tailed deer population across Maine and New Brunswick, known as the Northeast Deer Research Partnership. As a part of this effort, researchers from the University of New Brunswick have initiated satellite tracking studies on deer populations; this study has demonstrated the significant impact that feeding is having on deer migration patterns. Biologists from the New Brunswick Department of Energy and Resource Development (NBERD), Maine Department of Inland Fisheries and Wildlife (MDIFW), and researchers from Quality Deer Management Association (QDMA) have expressed concerns with the broader impacts that winter feeding may have on both the deer population and on public health and safety. A social science examination of this phenomenon is necessary in order to better understand the complexities of this coupled human-natural system. The project will involve semi-structured interviews with key stakeholders in New Brunswick, a survey via drop-off/pick-up method of motivations and cognitions toward deer feeding of known deer feeders in New Brunswick, a large-scale survey of residents via mail questionnaire in New Brunswick, and a large-scale survey of residents via mail questionnaire in Maine.

New Brunswick: Semi-structured interviews with individuals known to participate in winter deer feeding practices was completed in summer of 2018. Analysis of interview data has started and will be completed by May 2020. Data collection for the survey via drop-off/pick-up method of known deer feeders was completed in November 2019. Analysis of the deer feeder survey will be completed by January 2020. The survey via mail questionnaire was mailed out in November 2019; analysis of the mail questionnaire will be completed by February 2020.

Maine: The survey via mail questionnaire was mailed out in November 2019; analysis of the mail questionnaire will be completed by January 2020.

Investigators: Francesca Gundrum, Carly C. Sponarski, Daniel Gautreau, Jerry J. Vaske

Duration: September 2017—August 2021

Cooperators:

Irving, Ltd.
Maine Department of Inland Fisheries and Wildlife
New Brunswick Department of Energy and Resource Development
New Brunswick Wildlife Trust Fund
Northeast Deer Research Partnership
Quality Deer Management: Canada
University of Moncton at Edmundston
University of New Brunswick

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 0.54 (=/- 0.09 SE). We selected 5 talus slopes with documented winter activity for use during the second project component. We have set up 5 acoustic arrays and completed the scent detection work on these 5 slopes. The dog team obtained a total of 76 potential locations where bat scent was present. We will monitor these locations and our acoustic array throughout the winter 2019/20 to confirm hibernation activity and evaluate further fine-scale use of slopes by bats during winter.

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

Can Unmanned Aerial Systems be used to estimate abundance and productivity of colonial birds?

1. Estimate the population size of colonial seabirds in the Gulf of Maine using aerial imagery, Unmanned Aerial Systems (UAS), and ground surveys.
2. Compare estimates between survey specifications and account for errors in bird detection across survey specifications.
3. Assess how UAS flights in breeding colonies impact bird behavior and levels of disturbance within the colony.
4. Develop a framework and a toolkit for using UASs to survey colonial birds accessible to a range of agencies and citizen scientists.

Colonial seabirds and long-legged waders are often designated of species of interest and concern, as they are indicators of ecosystem health in coastal and marine ecosystems. Gathering accurate estimates of species presence, abundance, and productivity is central to understanding the influences of changing environmental conditions on these species. Tracking populations trends of colonial waterbirds is logistically challenging, expensive, and subject to errors in detection. This project aims to evaluate the efficacy of using Unmanned Aerial Systems to gather estimates of waterbird abundance and productivity. Plane-based imagery will be collected over 200 islands in the Gulf of Maine. This imagery will be surveyed for nesting seabirds. During the summer of 2020, 5-10 of these islands will be surveyed using a combination of Unmanned Aerial Systems and ground counts. Multiple site visits to these islands will be done in 2020. Using this data, n-mixture models will be used to estimate seasonal abundance of nesting birds and productivity of nesting birds. Additionally, additional flight will be conducted on islands to see how different flight parameters impact behavior and levels of disturbance in colonial seabirds.

In May and June 2019, plane-based imagery was collected of over 200 islands in the Gulf of Maine.

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

Advisors: Cynthia S. Loftin (C0-Advisor)
Daniel J. Hayes (Co-Advisor)
Erik J. Blomberg
Glen Mittelhauser
Roy M. Turner
Kasey R. Legaard
Alyson E. McKnight
Linda J. Welch

Collaborators: Anthony P. Guay
Kate Beard-Tisdale
David Sandilands
Tora Johnson

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

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 CWB database is incomplete, and quality and format of previously contributed data varied. Therefore, we will evaluate current CWBD data protocols and data condition, and work 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 will work with USGS-Patuxent CWBD developers to improve format and accessibility of the database. The web portal will provide a species data summary and retrieval, and trend analysis. Additionally, we will summarize interviews regarding spatial data display needs to inform development of a geospatial user interface for CWBD contents. We will incorporate 2018 data provided by partners into the CWBD, evaluate and summarize 2018 data, and develop a comprehensive trend analysis of the complete record for each species with adequate data.

We will evaluate data quality and develop summaries of archived data for a subset of CWBD species. We will display trends and compare data among years to provide guidance for improving reliability of trend assessments with additional data. We will assess threats to breeding success and management currently employed to address those threats within the region.

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 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).

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

Duration: July 2018—May 2020

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

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 2020.

Investigator:	Katie Perry (MS)
Advisors:	Carly C. Sponarski (Co-Advisor) Jessica E. Leahy (Co-Advisor) Allison Gardner
Duration:	January 2019—December 2020
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.

Giraffe are icons of Africa, but given their high profile, knowledge about giraffe is surprisingly limited. Population estimates across the continent suggest that giraffe numbers have fallen by about 40% in the last few decades, prompting a reassessment in 2016 by the IUCN that moved their status from "Least Concern" to "Vulnerable." This rapid decline is mainly thought to be due to habitat loss and fragmentation, land degradation, and poaching. There is yet to be any published literature on the social aspects of giraffe conservation and associated threats, which points to the urgent need for human dimensions (HD) research to inform the many growing conservation efforts.

Despite the prevalence of poaching and connection to decreasing giraffe populations, the factors that influence hunting activity are not well understood. This research will estimate levels of giraffe part and product usage among two pastoralist communities in northern Kenya and assess the relationships between key cognitions, like attitudes, norms, and beliefs, with poaching-related behaviors.

My PhD research is part of a larger conservation program, based at the research arm of the San Diego Zoo. The giraffe research program began in May 2016, and I have been leading the training and coordination of our field team. Preliminary data has been collected, and additional data will be gathered in 2019.

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.

Bicknell's Thrush (*Catharus bicknelli;* BITH) is a rare, range-restricted habitat specialist occurring in balsam fir-dominated montane forests that have been recently disturbed and are undergoing successional growth. The species traditionally occurs at elevations above 800 meters in the U.S., but if suitable habitat is available BITH can occur at elevations below this threshold. The potential for suitable habitat at lower elevations exists in Maine because of the state's unique distribution of tree communities, and due to changes in forest structure and composition brought about by forestry practices. The extent to which BITH use regenerating fir stands at lower elevations in Maine, however, remains unknown. Further, while best management practices (BMPs) have been developed for Canada and the U.S., they have not been applied and evaluated in Maine. By means of telemetry, resource selection functions and LiDAR, this research aims to understand the use and availability of breeding habitat for BITH in commercial forestlands in Maine. The research will produce a detailed description of BITH use of commercially managed fir-spruce forests in Maine. Furthermore, the research will contribute to the eventual development of Maine-specific forest BMPs to provide high quality breeding habitat for BITH while meeting commercial forest landowner objectives.

During the 2019 breeding season, we captured 22 Bicknell's Thrush. Thirteen of these individuals were fitted with VHF-radio transmitters in a harvested landscape at Kibby Mountain, and 9 with PinPoint archival GPS tags in a non-harvested landscape at Mt. Redington. We successfully tracked 9 of the 13 VHF tagged birds, and 7 of the PinPoint tagged birds to obtain a total of 16 home ranges (all male birds). With the addition of 11 total home ranges from 2018, our study total is 27 home ranges. Home ranges averaged 14.1 hectares at Kibby Mountain, and 29.4 hectares at Mt. Redington. This was our first attempt at using PinPoint archival GPS tags and this technology allowed us to acquire locations in places where we could not track individuals wearing VHF tags alone. Additionally, we were able to collect many more points per individual using the archival GPS tags. Scale optimization of LiDAR-derived habitat forest structure estimates is underway, and we will begin habitat selection analysis soon.

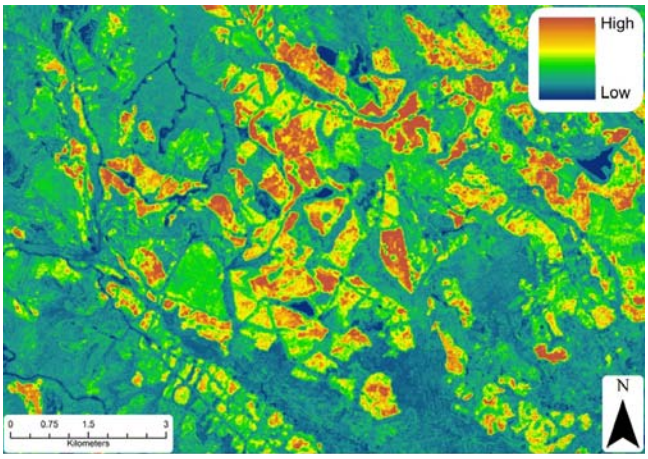
Investigator: Kaitlyn Wilson (MS)

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



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

INTEGRATED ecology

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

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

Globally, groundwater dependent ecosystems (GDEs) 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 GDEs, which rely on groundwater to maintain ecological function. Despite the importance of these resources to both human and wildlife populations, GDEs 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 GDEs across the northeastern United States. We will be applying geographically referenced information about known GDEs in the region to produce a logistic -scale distribution map of GDEs across the northeastern states. We will further characterize and determine associated threats to GDEs in the region with field-collected data, while also sampling for groundwater dependent biota.

Hydrological monitoring wells have been installed at GDEs in three Wildlife Refuges in Maine (Sunkhaze Meadows, Moosehorn, Rachel Carson). Spatial datasets that will be used in our predictive model have been accumulated and we have been working with other state and federal agencies to compile all known locations of GDEs across the region. Preliminary analysis of locations compiled thus far have suggested that there is an abundance of known locations of GDEs in the New England states and along the Atlantic coast. Creation of our predictive model will be completed in Spring 2020, with model-validation efforts taking place in Summer 2020-2022.

Investigator: Shawn Snyder (PhD)

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

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

PUBLICATIONS and presentations

SCIENTIFIC PUBLICATIONS

Begley, M., Coghlan, Jr., and Zydlewski, J. 2018. Sensitivity of white sucker (*Catostomus commersonii*) age-structure to commercial harvest. *Journal of Freshwater Ecology* 33:1, 413-428, DOI: 10.1080/02705060.2018.1496951

Boone S., Mortelliti A. 2019. Seed selection by small mammals in eastern mixed forests. *Forest Ecology and Management* 449, 117487.

Evans B, Mosby C., Mortelliti A. 2019. Assessing linear arrays with multiple trail cameras to detect North American mammals. *Plos One*, 14(6), e0217543.

Smith A., Kujala H., Lahoz-Monfort J., Guja L.K., Burns E.L., Nathan R., Alacs E., Barton P., Bau S., Driscoll D.A., Lentini P.A., Mortelliti A., Rowe R., Buckley Y.M. 2019. Managing uncertainty in movement knowledge for environmental decisions. *Conservation Letters*, e12620.

Brehm, A., Mortelliti, A., Maynard, G., and Zydlewski, J. 2019. Land-use change and the ecological consequences of personality in small mammals. *Ecology Letters* 22:1387-1395.

Clare, J., S.T. McKinney, C.S. Loftin, E.M. Simons -Legaard, and J.E. DePue. 2019. Satellite-detected forest disturbance forecasts American marten population decline: the case for supportive space-based monitoring. *Biological Conservation* 233:336-345. https://doi.org/10.1016/j.biocon.2019.02.020.

Eakin, C., Hunter, M., and Calhoun, A. (2019, February) The influence of land cover and within -pool characteristics on larval, froglet, and adult wood frogs along a rural to suburban gradient. *Urban Ecosystems* 22:493-505Available: DOI: 10.1007/s11252-019-0830-x.

Gibson, D., E. J. Blomberg, M. T. Atamian, S. P. Espinosa, and J. S. Sedinger. 2018. Effects of transmission lines on demography and population dynamics of greater sage-grouse. *Wildlife Monographs* No 200.

Gilbert, C., and E.J. Blomberg. 2019. Changing occupancy of spruce grouse on Mount Desert Island, Maine, over a 25-year period. *Northeastern Naturalist* 26:275-286.

Hoffmann, K., Hunter, M., Calhoun, A., and Bogart, J. 2018. Post-breeding migration and habitat of unisexual salamanders in Maine, USA. *Journal of Herpetology 52*(3), 273-281.

Johnston, C., Zydlewski, G., Smith, S., Zydlewski, J., and Kinnison, M. 2018. River reach restored by dam removal offers suitable spawning habitat for endangered shortnose sturgeon. *Transactions of the American Fisheries Society* DOI:10.1002/tafs.10126.

Levesque, V., Calhoun, A., and Bell, K. 2019. Actions speak louder than words: Designing transdisciplinary approaches to enact solutions. *Journal of Environmental Studies and Sciences 9*(2), 159-169.

Levesque, V., Calhoun, A., and Hertz, E. 2019. Vernal pool conservation: Innovative approaches to using and enhancing existing policy tools. *Case Studies in the Environment* article id: cse-2018-001636.

Lopez-Calderon, C., Van Wilgenburg, S., Roth, A., Flaspohler, D., and Hobson, K. 2019. An evaluation of isotopic (δ2H) methods to provide estimates of avian breeding and natal dispersal. *Ecosphere 10*(4).

Mangelinckx, J., S. Davis, R. B. Allen, S. Sullivan, and E. J. Blomberg. 2018. Reproductive status affects summertime resource selection and survival of Ruffed Grouse in Maine, USA. *The Auk: Ornithological Advances* 135:933 -948.

Maynard, G., Izzo, L., and Zydlewski, J. 2018. The fate of hatchery-spawned Atlantic salmon kelts released into the Penobscot River, Maine. *Fishery Bulletin* 116:281-290. DOI: 10.7755/FB.116.3-4.6

McKnight, A., E.J. Blomberg, D.B. Irons, C.S. Loftin, and S.T. McKinney. 2019. Survival and recruitment dynamics of black-legged kittiwakes (*Rissa tridactyla*) at an Alaskan colony. *Marine Ornithology* 47: 209-222.

Mortelliti, A., and Broto, B. 2019. The status of research on the mammals of Sulawesi, Indonesia. *Mammal Review 49*(1), 2019th ser., 78-93.

Rolek, B. W., D.J. Harrison, C.S. Loftin, and P.B. Wood. 2018. Regenerating clearcuts combined with postharvest forestry treatments promote habitat for breeding and post-breeding spruce-fir avian assemblages in the Atlantic Northern Forest. *Forest Ecology and Management* 427: 392-413. Data DOI: 10.1111/jav.01779; https://doi.org/10.1016/j.foreco.2018.05.068.

Roy, S., Uchida, E., Souza, S., Blachly, B., Fox, E., Gardner, K., Gold, A., Jansujwicz, J., Klein, S., McGreavy, B., Mo, W., Smith, S., Vogler, E., Wilson, K., Zydlewski, J., and Hart, D. 2018. Damming decisions: a multi-scale approach to balance trade-offs among dam infrastructure, river restoration, and cost. *Proceedings of the National Academy of Sciences of the United States of America* 115(47):12069-12074. DOI: 10.1073/pnas.1807437115.

Simons, E., Harrison, D., and Legaard, K. 2018. Ineffectiveness of local zoning to reduce regional loss and fragmentation of wintering habitat for white-tailed deer. *Forest Ecology and Management 427*, 78-85.

Smith A., Kujala H., Lahoz-Monfort J., Guja L.K., Burns E.L., Nathan R., Alacs E., Barton P., Bau S., Driscoll D.A., Lentini P.A., Mortelliti A., Rowe R., Buckley Y.M. 2019. Managing uncertainty in movement knowledge for environmental decisions. *Conservation Letters* e12620.

Song, C., O'Malley, A., Roy, S., Zydlewski, J., Barber, B., and Mo, W. 2019. Managing dams for energy and fish tradeoffs: What does a win-win solution take? *Science of the Total Environment* 669:833-843. DOI: 10.1016/j.scitotenv.2019.03.042.

Sponarski, C.C., Loeffler, T.A., Vaske, J.J. and Bath A. J. 2019. Retaining change in attitudes and emotions toward coyotes using experiential education. *Wildlife Research* 46(2): 97-103. DOI: https://doi.org/10.1071/WR18035.

Sponarski, C.C., Miller, C., and Vaske, J.J. 2018. Perceived risks and coyote management in an urban setting. *Journal of Urban Ecology* 4(1): juy025. DOI: https://doi.org/10.1093/jue/juy025.

Stich, D., Sheehan, T., and Zydlewski, J. 2018. A dam passage performance standard model for American Shad. *Canadian Journal of Fisheries and Aquatic Sciences* DOI:10.1139/cjfas-2018-0008.

Watson, J., Coghlan, S., Zydlewski, J., Hayes, D., and Stich, D. 2019. Role of recovering River Herring *Alosa spp.* population on Smallmouth Bass diet and growth. *American Fisheries Society Symposium* 87:1-17.

Weaver, D., Brown, M., and Zydlewski, J. 2019. Observations of American Shad approaching and using a vertical slot fishway at the brunswick head-of-tide dam on the Androscoggin River, Maine. *North American Journal of Fisheries Management* DOI: /10.1002/nafm.10330.

Weaver, D., Ratten, S., Coghlan, Jr., S., and Sherwood, G., and Zydlewski, J. 2018. Age and growth of a native, lightly exploited, population of Lake Whitefish *Coregonus clupeaformis* in a small natural lake in Maine, USA. *Northeastern Naturalist* 25(4):599-610. DOI: 10.1656/045.025.0406.

TECHNICAL AND SEMI-TECHNICAL PUBLICATIONS

Blomberg, E., Tebbenkamp, J., Dunham, S., and Harrison, D. 2018. Demography and population status of spruce grouse in northern Maine forests. (pp. 1-53, Tech.). Orono, ME.

Harrison, D., and Loman, Z. 2019. Spatial and temporal dynamics and forest treatment-scale responses of snowshoe hare populations in Maine 2001-2015 (pp. 1-40, Tech.). Orono, ME.

Harrison, D., E. Simons-Legaard, K. Fagan, and T. Woollard. 2019. Responses of marten populations to 30 years of habitat change in commercially managed landscapes of northern Maine. Pages 62-68 *in* Roth, B.E., editor, Cooperative Forestry Research Unit: 2018 Annual Report, University of Maine, Orono.

Loftin, C.S, and R. Carey. 2019. The Maine Cooperative Fish and Wildlife Research Unit and University of Maine Department of Wildlife Ecology 2018 Annual Report to Cooperators. 64 pp.

Rolek, B. W., D. Harrison, C. Loftin, P.B. Wood. 2018. Influence of harvest treatments, vegetation, and edges on abundance of breeding spruce-fir avian species in regenerating forested stands. USGS annual report. Maine Cooperative Fish and Wildlife Research Unit.

Rolek, B. W., D. Harrison, C. Loftin, P.B. Wood. 2018. Influence of harvest treatments, vegetation, and edges on abundance of breeding spruce-fir avian species in regenerating forested stands. USGS annual report. West Virginia Cooperative Fish and Wildlife Research Unit.

Simons-Legaard, E., Harrison, D., and Legaard, K. 2018. Evaluating deer wintering habitat zoning through remote sensing (Tech.). Orono, ME.

THESES AND DISSERTATIONS

Brehm A. 2018. "Ecological consequences of personality in a guild of terrestrial small mammals: from trappability to seed dispersal". M.S. Thesis, Wildlife Ecology, University of Maine, Orono.

Buckardt, A. 2019. "Improving conservation of declining young forest birds through adaptive management". M.S. Thesis, Wildlife Ecology, University of Maine, Orono.

DuClos, B. 2019. "Landscape pattern and wild bee communities in Maine". Ph.D. Dissertation, Ecology and Environmental Sciences, University of Maine, Orono.

Gundrum, F. 2019. "Battle over black bears: investigating perceptions of the black bear hunting referendums in Maine". M.S. Thesis, Wildlife Ecology, University of Maine, Orono.

Maynard, G. 2018. "Assessing migrations and habitat connectivity for two anadromous species following a major restoration effort in the Penobscot River, Maine". Ph.D. Dissertation, Wildlife Ecology, University of Maine, Orono.

Rolek, B. 2018. "Associations between avian spruce-fir species, harvest treatments, vegetation, and edges." Ph.D. Dissertation, Wildlife Ecology, University of Maine, Orono.

PRESENTATIONS

Ames, C., Kinnison, M., Zydlewski, J., and Zydlewski, G. 2019. "Foraging ecology and prey availability of Atlantic and shortnose sturgeon populations in Maine." 149th Annual Meeting of the American Fisheries Society. Reno Nevada. September 29. (Author Only, Invited).

Ames, C., Kinnison, M., Zydlewski, J., and Zydlewski, G. 2019. "Recovery of shortnose and Atlantic sturgeon in the Penobscot River, Maine." 2019 Maine Sustainability and Water Conference, Augusta, Maine. March 28. (Author Only, Invited).

Atkinson, E., and Zydlewski, J. 2019. "Examining dispersal of point stocked Atlantic salmon fry relative to habitat qualities in streams in eastern Maine, USA." 149th Annual Meeting of the American Fisheries Society. Reno Nevada. September 29. (Author Only, Invited).

Barber, B., Gibson, J., Molina Moctezuma, A., and Zydlewski, J. 2019. "A tool for understanding likely fish passage and harvest management outcomes for alewife on the St. Croix River, Maine." IJC St. Croix Board & Partners Meeting. St. Stephen, New Brunswick, Canada. June 4. (Author Only, Invited).

Barber, B., Gibson, J., O'Malley, A., and Zydlewski, J. 2019. "Exploring how a range of management objectives could affect alewife population recovery." 2019 Maine Sustainability and Water Conference, Augusta, Maine. March 28. (Author Only, Invited).

Blomberg E., J. Tebbenkamp, S. Dunham, and D. Harrison. 2019. "Effects of forest management on population dynamics of spruce grouse on commercially managed forest in northern Maine." Spring 2019 Meeting of the Maine Cooperative Forestry Research Unit, Orono, Maine: April 11.

Blomberg, E. 2019. "American woodcock migration ecology in the eastern region: a collaborative approach." Atlantic Flyway Council Winter Meeting. Kittyhawk, NC, Atlantic Flyway Council Winter Meeting: January 2019.

Blomberg, E.J., J. Tebbenkamp, S Dunham, and D.J. Harrison. 2019. "Population ecology of spruce grouse in commercially-managed forests." Presentation at American Ornithological Society Annual Conference, Anchorage, Alaska. 24-28 June.

Blomberg, E.J., J. Tebbenkamp, S Dunham, and D.J. Harrison. 2019. "The role of forest disturbance inhabitat relationships and population ecology of spruce grouse." Midwest Fire Science Consortium Webinar Series. January 2019.

Boxler, B., C.S. Loftin, and W.B. Sutton. 2019. "Monarch Butterfly (*Danaus plexippus*) migration roost site selection and viability: App demonstration and hands-on activity." Dexter High School, Dexter Maine. 2 May. (Author Only, Invited).

Boxler, B., C.S. Loftin, and W.B. Sutton. 2019. "Monarch Butterfly (*Danaus plexippus*) migration roost site selection and viability." Presentation at the Northeast Association of Fish and Wildlife Agencies annual meeting, 14-16 April, Groton, CT. (Author Only, Contributed).

Buckardt Thomas, A., A. Roth, D.J. McNeil, K. Johnson, A. Rodewald, and J. Larkin. 2019. "Are we sure about shearing? Evaluating the impact of a widely used but poorly assessed habitat management practice." Contributed

oral presentation at the American Ornithological Society annual meeting, Anchorage, AK. June 26.

Buyaskas M, Evans B, Mortelliti A. 2019. "Assessing the effectiveness of trail cameras with attractants to detect northeastern mammals." 2019 University of Maine Student Symposium. April 2019.

Calhoun, A.J.K. 2019. "The Maine special area management plan". Fields pond Nature Center, Orrington, ME: 15 May.

Coghlan Jr, S.M. 2019. "Energy, economics, and climate change". Presented at Honors College Earth Day Panel Discussion, April 25.

Coghlan Jr., S.M. 2018. "Can homesteading provide sustenance and surplus in an age of scarcity?" Presented at Senator George J. Mitchell Center for Sustainability Solutions Seminar Series, Orono, ME, December 3.

Coghlan Jr., S.M. 2018. "Ramblings of a fish squeezer: How I became and aquatic ecologist and various tangential tales." Guest lecture to WLE 100 (Instructors: L. Seward S. Morano), November 29.

Coghlan Jr., S.M. 2019. "Biophysical economics primer." Guest lecture/facilitated discussion in WLE 100 (Instructor - L. Seward), April 18.

Coghlan Jr., S.M. 2019. "Can homesteading provide sustenance and surplus in an age of scarcity?" Guest lecture presented at ECO 416 (Instructor - T. Waring), February 25.

Coghlan Jr., S.M. 2019. "Economics as if your future mattered: Helping Earthlings understand limits to growth on a finite planet". Presented at University of Maine Earth Day Celebration, April 25.

Coghlan Jr., S.M. 2019. "Economics as if your future mattered: Helping Earthlings understand limits to growth on a finite planet". Presented at The Wildlife Society Annual Student Conclave, April 13.

Coghlan Jr., S.M. 2019. "Externalize the Internalities! An old idea gives new insight on the value of wetlands". Presented at the Maine Association of Wetland Scientists Annual Meeting, April 14.

Coghlan Jr., S.M. 2019. "Limits to growth of a finite planet: peak energy, climate, and debt". Guest lecture to WLE 230 (Instructor - D.J. Harrison).

Flye, M., Sponarski, C., Zydlewski, J., and McGreavy, B. 2019. "Communication and collaboration within the Atlantic salmon governance structure of Maine." 149th Annual Meeting of the American Fisheries Society. Reno Nevada. September 29. (Author Only, Invited).

Flye, M., Sponarski, C., Zydlewski, J., and McGreavy, B. 2019. "Communication and collaboration within the Atlantic salmon governance structure of Maine." 2019 Maine Sustainability and Water Conference, Augusta, Maine. March 28. (Author Only, Invited).

Flye, M., Sponarski, C.C., Zydlewski, J., and McGreavy, B. 2019. "Communication and collaboration within the Atlantic salmon governance structure of Maine." Maine sustainability water conference. Augusta Civic Center, Augusta, Maine. March 28. (Oral and Poster)

Gundrum, F.A. and Sponarski, C.C. 2018. "Battle over black bears: Investigating perceptions of black bear hunting referendums." Annual AP Environmental Science Speaker Series. John Bapst Memorial High School, Bangor, ME, USA. November 29.

Gundrum, F.A. and Sponarski, C.C. 2018. "Cognitions toward black bear hunting in Maine: A quantitative content analysis of the

print news media surrounding major hunting referendums in 2004 and 2014". Maine Department of Inland Fisheries and Wildlife Collaborator Meeting, Augusta, ME. December 18.

Gundrum, F.A. and Sponarski, C.C. 2019. "A quantitative content analysis of print news media surrounding black bear hunting referendums in Maine". Pathways: Human Dimensions of Wildlife Conference. YMCA, Estes Park, CO. September 23.

Gundrum, F.A., Sponarski, C.C., and Flye, M. 2019. "Organizational collaboration within Maine's Atlantic salmon governance structure." Pathways: Human Dimensions of Wildlife Conference. YMCA, Estes Park, CO. September 26.

Homola, J.J., T.M. Waring, C.S. Loftin, and M.T. Kinnison. 2019. "Effects of landscape spatial and temporal autocorrelation on likelihood of population recovery following environmental change." Presentation at the 2019 Evolution meeting, 21-25 June, Providence, RI.

Hunter, M. 2019. "Old-growth forest ecology and conservation: the fundamentals." Forests at Risk, Warsaw Poland: 12-14 Feb 2019.

Kundel, H., K. DeGoosh, C, Loftin, and E. Schilling. 2019. "Are Chaoborus mandibles in lake sediments a reliable indicator of historical fish absence in post-glaciated regions of Maine and Minnesota?" Annual Meeting of the Society of Freshwater Science, 19-23 May, Salt Lake City, UT. (Author Only, Contributed).

Loman, Z. and C.S. Loftin. 2019. 'Presentation of the USGS colonial waterbird database (CWDB) and web tool." Avian Conservation Database Management Workshop. Raleigh, NC. 4 April 2019. (Author Only, Invited).

Loman, Z. and C.S. Loftin. 2019. "Colonial waterbird database (CWDB) web tool demonstration." Atlantic Flyway Committee Technical Section Waterbird Committee. Kitty Hawk, NC. 26 February 2019 (Author Only, Invited).

Loman, Z. and C.S. Loftin. 2019. "Colonial Waterbird Database (CWDB) and web tool presentation." Atlantic Flyway Council Waterbird Committee. Plymouth, MA. 27 September. (Invited Oral)

Loman, Z. and C.S. Loftin. 2019. "The colonial waterbird database tool." Presentation at the Association of Fish and Wildlife Agencies Partners in Flight/Shorebird/Waterbird Working Group at the 84th North American Wildlife and Natural resources Conference, Denver, CO. 2 March 2019. (Author Only, Invited).

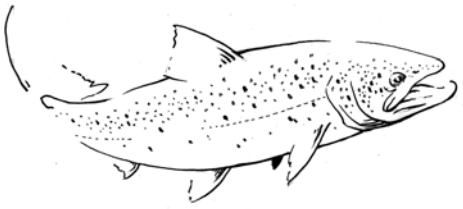
Loman, Z. and C.S. Loftin. 2019. "Using shinyR for web-based and interagency sharing of wildlife survey data." Presentation at the Joint Conference of the American Fisheries Society and The Wildlife Society, Reno, NV, 29 September-3 October. (Author Only, Invited).

Mensinger, M., Zydlewski, J., and Blomberg, E. 2019. "American eels incur mortality and delay at hydroelectric dams during seaward migration in the Penobscot River, Maine." 149th Annual Meeting of the American Fisheries Society. Reno Nevada. September 29. (Author Only, Invited).

Mensinger, M., Zydlewski, J., and Blomberg, E. 2019. "American eels incur high mortality at dams during seaward migration in the Penobscot River." 2019 Maine Sustainability and Water Conference, Augusta, Maine. March 28. (Author Only, Invited).

Molina-Moctezuma, A., and Zydlewski, J. 2019. "A decision-making tool for evaluating biological and statistical thresholds for survival analysis of migrating fishes." 149th Annual Meeting of the American Fisheries Society. Reno Nevada. September 29. (Author Only, Invited).

Molina-Moctezuma, A., and Zydlewski, J. 2019. "Historical movement and survival of Atlantic salmon smolts in the Piscataquis River from 2009-2018." 2019 Maine Sustainability and Water Conference, Augusta, Maine. March 28. (Author Only, Invited).



Olechnowicz, C., Leahy, J., Sponarski, C.C., and Gardner, A. 2019. "Developing a community risk perception and social vulnerability profile for tick-borne disease in Maine". International Symposium on Society and Resource Management 2019 Conference. Oshkosh, WI, USA, June 2 – June 6.

Peterson, E. and Zydlewski, J. 2019. "Movement behavior of American shad five years after dam removal in the Penobscot River, Maine." 149th Annual Meeting of the American Fisheries Society. Reno Nevada. September 29. (Author Only, Invited).

Peterson, E., and Zydlewski, J. 2019. "American shad demography and motivation: A re-evaluation of Penobscot River American shad post dam removal." 2019 Maine Sustainability and Water Conference, Augusta, Maine. March 28. (Author Only, Invited).

Ramberg-Pihl, N., Coghlan, C., and Zydlewski, J. 2019. "Unraveling the impacts of competition and warming on juvenile Atlantic salmon (*Salmo salar*) performance in Maine streams." The 2019 Annual Meeting of the Society for Freshwater Science, Salt Lake City, Utah, May 19. (Author Only, Contributed).

Rolek, B. W., D. J. Harrison, C. S. Loftin, and P. B. Wood. 2018. "Effects of forest management practices in the Acadian northern hardwood/conifer forests of Maine on forest bird communities, with emphasis on species of regional conservation priority and concern." Fall 2018 Meeting of the Maine Cooperative Forestry Research Unit, Orono, Maine: October 24.

Roth, A. 2018. "Characterizing deer wintering area habitat quality using LiDAR". Northeast Deer Research Partnership: 29 November.

Roth, A. 2018. "Golden-winged warblers: past, present, and future". Unified Science Team (of bird partnerships): 14 December.

Roth, A. 2019. "Golden-winged Warbler demographic shifts due to natal dispersal". Invited oral presentation to the Appalachian Mountain Joint Venture Technical Committee, Frostburg, MD. August 7.

Roth, A. 2019. "Golden-winged Warbler Working Group". Invited oral presentation to the Partners in Flight Eastern Working Group. Nashville, TN. April 24.

Roth, A. 2019. "Midwest Migration Network". Invited oral presentation to the Partners in Flight Eastern Working Group, Nashville, TN. April 24.

Roth, A. 2019. "Stand- to landscape-level tools for improved deer wintering area management". University of Maine Cooperative Forestry Research Unit Winter Meeting: 31 January.

Roth, A. 2019. "Sustainability of collaboration". Senator George J. Mitchell Center for Sustainability Solutions Sustainability Talks: 22 April.

Roth, A. 2019. "Wildlife implications on the loss of beech". New England Regional Council on Forest Engineering: 18 March.

Roth, A. and A. Buckardt Thomas. 2019. "Conservation in the context of migratory connectivity: A Golden-winged Warbler case study." Contributed oral presentation at the American Ornithological Society annual meeting, Anchorage, AK. June 26.

Rubenstein, S., Jayasundara, N., Christman, P., Peterson, E., and Zydlewski, J. 2019. "Energetic impacts of passage delays in migrating adult Atlantic salmon." 149th Annual Meeting of the American Fisheries Society. Reno Nevada. September 29. (Author Only, Invited).

Rubenstein, S., Zydlewski, J., Jayasundara, N., and Christman, P. 2019. "Energetic impacts of passage delays in migrating adult Atlantic salmon." 2019 Maine Sustainability and Water Conference, Augusta, Maine. March 28. (Author Only, Invited).

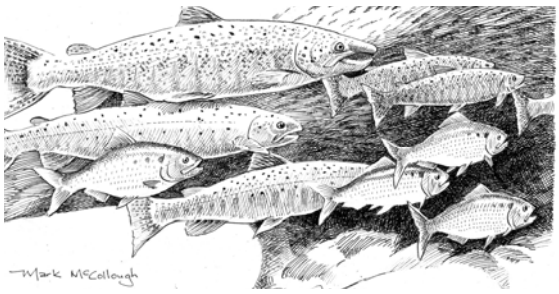
Song, C., Mo, W., O'Malley, A., Roy, S., Zydlewski, J., and Barber, B. 2019. "Managing dams for energy and fish biodiversity tradeoffs: What does a win-win solution take?" AEESP Research and Education Conference. University of Arizona, Tucson, Arizona, May 14. (Author Only, Contributed).

Turso, M., K. Wilson, and A. Roth. 2019. "Acoustic monitoring of Bicknell's Thrush in Maine." Invited oral presentation to the International Bicknell's Thrush Conservation Group, Quebec City, Quebec. August 27.

Vogel, S., Jansujwicz, J., and Zydlewski, J. 2019. 'Science in action or science inaction: the use of best available science in the FERC hydropower relicensing process." 149th Annual Meeting of the American Fisheries Society. Reno Nevada. September 29. (Author Only, Invited).

Vogel, S., Jansujwicz, J., and Zydlewski, J. 2019. "What does 'best available science' mean in the FERC hydropower relicensing process?" 2019 Maine Sustainability and Water Conference, Augusta, Maine. March 28. (Author Only, Invited).

Weaver, D., Brown, M., and Zydlewski, J. 2019. "Where there's a will, but not a way: behavior of American shad approaching the Brunswick dam fishway on the Androscoggin River, Maine." 2019 Maine Sustainability and Water Conference, Augusta, Maine. March 28. (Author Only, Invited).



Weaver, D., Sigourney, D., Delucia, M., and Zydlewski, J. 2019. 'Forecasting the downstream migration of adult silver phase American eels." 149th Annual Meeting of the American Fisheries Society. Reno Nevada. September 29. (Author Only, Invited).

Wilson, K. and A. Roth. 2019. "Bicknell's Thrush Habitat Use on Commercial Forests in Maine", Invited oral presentation at the Society of Canadian Ornithologists, Quebec City, Quebec. August 28.

Zydlewski, J., Mensinger, M., Molina-Moctezuma, A., Murphy, J., Payne Wynne, M., Peterson, E., Rubenstein, S., and Vogel, S. 2019. "Fish passage in a changing system - how bioengineering and policy are shaping the ecology of the Penobscot River." 149th Annual Meeting of the American Fisheries Society. Reno Nevada. September 29. (Presenter & Author, Invited).

POSTER PRESENTIONS

Ames, C., Kinnison, M., Zydlewski, J., and Zydlewski, G. 2019. "Recovery of shortnose and Atlantic sturgeon in the Penobscot River, Maine." 2019 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit. Orono, ME. March 26. (Poster) (Author Only).

Archambault G, Evans B, Mortelliti A. 2019. "Developing a novel approach to estimate reproductive success of black bears in Maine." 2019 University of Maine Student Symposium. April 2019. [Poster]

Atkinson, E. and Zydlewski, J. 2019. "Optimizing strategies to hydraulically plant Atlantic salmon eggs based on fry dispersal patterns". 2019 Maine Sustainability and Water Conference, Augusta, Maine. Poster. March 28. (Author Only).

Atkinson, E. and Zydlewski, J. 2019. "Optimizing strategies to hydraulically plant Atlantic salmon eggs based on fry dispersal patterns." 2019 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife

Research Unit. Orono, ME. March 26. (Poster) (Author Only).

Barber, B., Gibson, J., O'Malley, A., and Zydlewski, J. 2019. "Exploring how a range of management objectives could affect alewife population recovery." 2019 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit. Orono, ME. March 26. (Poster) (Author Only).

Boone, S., A. Mortelliti. 2019. "Small mammal foodies: Food preferences and the impacts on forest regeneration." The Wildlife Society Annual Conference, Reno, NV. September 2019. [Poster]

Boone, S.R., A. Mortelliti. 2019. "Small Mammal Foodies: Impacts on Forest Regeneration." Maine Cooperative Fish and Wildlife Research Unit Annual Meeting. University of Maine, Orono, Maine. March 2019. [Poster]

Boxler, B., C.S. Loftin, and W.B. Sutton. 2018. "Monarch Butterfly (*Danaus plexippus*) roost site selection and viability during fall migration east of the Appalachian Mountains." Poster presentation, 2018 Student Conference on Conservation Science -New York, The Center for Biodiversity and Conservation, 24-26 October. New York, New York. (Author Only).

Brehm, A.M., Mortelliti, A., Maynard G.A., and Zydlewski, J. 2019. "Land-use change and the ecological consequences of personality in small mammals." 2019 Maine Cooperative Fish and Wildlife Research Unit Annual Meeting, University of Maine, Orono, Maine. March 2019. [Poster]

Brittingham R., Brehm A., Mortelliti A. 2019. "Staying out of my stash: deer mice and red-backed vole seed management." 2019 University of Maine Student Symposium. April 2019. [Poster]

Davan, K., and C.C. Sponarski. 2019. "Do different methods of communication impact undergraduate student's attitudes, knowledge, and beliefs toward white-nose syndrome in Little Brown bats." University of Maine Student Symposium, Bangor, ME, USA, April 15. (Poster)

Douglas, L. and A. Roth. 2019. "Rusty Blackbird (*Euphagus carolinus*) use of commercial spruce-fir forests of northern New England." Poster for the USGS Maine Cooperative Fish and Wildlife Research Unit Annual meeting, Orono, ME. March 26.

Fish, A., A.M. Roth, and E.J. Blomberg. 2019. "Low migratory connectivity of American woodcock (*Scolopax minor*) in eastern north America." Poster at the joint annual conference of the American Fisheries Society and The Wildlife Society, Reno, NV. September 30.

Fish, A., E. Blomberg, and A. Roth. 2019. "Migratory ecology of American Woodcock (*Scolopax minor*) in Eastern North America." Poster for the USGS Maine Cooperative Fish and Wildlife Research Unit Annual meeting, Orono, ME. March 26.

Fish, A., E. Blomberg, and A. Roth. 2019. "Migratory ecology of American Woodcock (*Scolopax minor*) in eastern North America". Poster at the American Ornithological Society annual meeting, Anchorage, AK. June 26.

Flye, M., Sponarski, C., Zydlewski, J., and McGreavy, B. 2019. "Communication and collaboration within the Atlantic salmon governance structure of Maine." 2019 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit. Orono, ME. March 26. (Poster) (Author Only).

Homola, J. J., T.M. Waring, C.S. Loftin, and M.T. Kinnison. 2019. "Effects of landscape spatial and temporal autocorrelation on likelihood of population recovery following environmental change." Poster Presentation at the 2019 Evolution meeting, 21-25 June, Providence, RI. (Author Only).

Mensinger, M., Zydlewski, J., and Blomberg, E. 2019. "American eels incur high mortality at dams during seaward migration in the Penobscot River." 2019 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit. Orono, ME. March 26. (Poster) (Author Only).

Mensinger, M., Zydlewski, J., and Blomberg, E. 2019. "Does American eel personality explain variation in juvenile dispersal?" 149th Annual Meeting of the American Fisheries Society. Poster. Reno Nevada. September 29. (Author Only)

Molina-Moctezuma, A., and Zydlewski, J. 2019. "Historical movement and survival of Atlantic salmon smolts in the Piscataquis River from 2009-2018." 2019 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit. Orono, ME. March 26. (Poster) (Author Only).

Molina-Moctezuma, A., and Zydlewski, J. 2019. "Phenology and energetic effects on Individual physiological response to salinity in *Salmo salar* juveniles." 149th Annual Meeting of the American Fisheries Society. Poster. Reno Nevada. September 29. (Author Only)

Mueller, W., A. Roth, T. Will, B. Lenz, and S. Bielke. 2018. "Research tracks of the Midwest Migration Network." Poster for the 2nd Annual Southeastern Wisconsin Conservation Summit, Port Washington, WI. November 2-3.

Peterson, E., and Zydlewski, J. 2019. "American Shad demography and motivation: a re-evaluation of Penobscot River American Shad post dam removal." 2019 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit. Orono, ME. March 26. (Poster) (Author Only).

Rubenstein, S., Zydlewski, J., Jayasundara, N., and Christman, P. 2019. "Energetic impacts of passage delays in migrating adult Atlantic salmon." 2019 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit. Orono, ME. March 26. (Poster) (Author Only).

Vogel, S., Jansujwicz, J., and Zydlewski, J. 2019. "What does 'best available science' mean in the FERC hydropower relicensing process?" 2019 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit. Orono, ME. March 26. (Poster) (Author Only).

Weaver, D., Brown, M., and Zydlewski, J. 2019. "Where there's a will, but not a way: Behavior of American shad approaching the Brunswick dam fishway on the Androscoggin River, Maine." 2019 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit. Orono, ME. March 26. (Poster) (Author Only).

Wilson, K. and A. Roth. 2019. "Bicknell's Thrush (*Catharus bicknelli bicknelli*) habitat selection on commercial forestlands in Maine." Poster for the USGS Maine Cooperative Fish and Wildlife Research Unit Annual meeting, Orono, ME. March 26.

Zydlewski, J., Bailey, M. Roy, S., Sheehan, T., Sprankle, K., and Stich, D. 2019. "What have we lost? American shad's impounded history." 149th Annual Meeting of the American Fisheries Society. Poster. Reno Nevada. September 29. (Presenter & Author).

WORKSHOPS, NEWSPAPER, RADIO, TELEVISION INTERVIEWS/ARTICLES, AND OUTREACH

Loftin, C.S. 2019. Maine student campus newspaper article about Monarch Model Validator app. September 9.

Loftin, C.S. 2019. UMaine News article about the Monarch Model Validator App; article written by Elyse Catalina, Division of Marketing and Communications, University of Maine. USA Today, The Washington Times, News Center Maine, NECN, Portland Press Herald, The Times Record,

Maine Public and The Eagle carried the AP report. The Maine Edge and Environmental News Network published an UMaine news release about the app. August 19.

Loftin, C.S. 2019. WMI Outdoor News Bulletin article about the Monarch Model Validator App. September.