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

2017 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.

This report details the research objectives, procedures, and findings of numerous investigators. Since data contained may be preliminary and inconclusive, permission to reproduce or publish any of the contents of this report in any way is withheld pending specific authorization from the Leader, Maine Cooperative Fish and Wildlife Research Unit; and Chair, Department of Wildlife, Fisheries, and Conservation Biology.

To download a digital copy of this report, please visit:
http://www.coopunits.org/Maine/Documents/ *or*
http://umaine.edu/wle/maine-cooperative-fish-and-wildlife-research-unit/

Cover Photo: Stanley Brook, Acadia National Park (Maine Coop Unit file photo).

TABLE of contents

MISSION STATEMENT 4

COOPERATORS AND PERSONNEL 6

GRADUATE EDUCATION 9

RESEARCH

FISHERIES & AQUATIC 12

WILDLIFE & HABITATS 28

INTEGRATED ECOLOGY..... 50

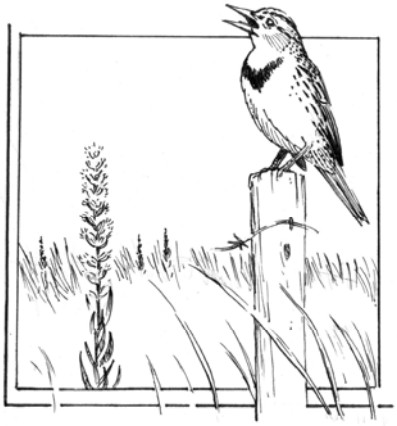
PUBLICATIONS & PRESENTATIONS 54

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 31 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. Many of these projects have been recent, some are long-term, and some have been completed during the past year. 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, 10 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 Department of Wildlife, Fisheries, and Conservation Biology continues to excel under the leadership of Dr. Malcolm Hunter as interim Department Chair and Dr. Stephen Coghlan as interim Assistant Chair. Lindsay Seward will replace Dr. Coghlan as interim Associate Chair in late 2017. We look forward to filling the Chair position with a permanent appointment in 2018. 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 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 (www.coopunits.org/Maine/) or Department (www.umaine.edu/wle/) websites. We welcome your comments.

COOPERATING PERSONNEL

UNIVERSITY OF MAINE

Dr. Kody Varahramyan, Vice President for Research
Dr. Frederick Servello, Dean, College of Natural Science, Forestry and Agriculture
Dr. Malcolm L. Hunter, Jr., Interim 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 Organ, 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 Carey, Administrative Support Supervisor
Katherine Goodine, Administrative Specialist

COLLABORATING AGENCIES AND ORGANIZATIONS

American Forest Management
American Recovery and Reinvestment Act (ARRA)
Atlantic Salmon Federation
Audubon Vermont
Baxter State Park
Brookfield Renewable Power
Canadian-American Centre; Downeast Salmon Federation
Central Maine Power
Cornell Lab of Ornithology
Downeast Lakes Land Trust
Gerald Pelletier, Inc.
Giraffe Conservation Foundation
Indiana University of Pennsylvania
International Joint Commission on the St. Croix Waterway
Katahdin Forest Management
Maine Association of Wetland Scientists
Maine Audubon Society
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
Maine Outdoor Heritage Fund
Maine Sea Grant
Michigan Technological University
Muckleshoot Indian Tribe
National Fish and Wildlife Foundation
National Oceanic and Atmospheric Administration
National Park Service
National Science Foundation – Dynamics of Coupled Natural and Human Systems (CNH)
National Science Foundation – Experimental Program to Stimulate Competitive Research
Natural Resources Foundation of Wisconsin
Northern Rangelands Trust
NSF Adaptation to Abrupt Climate Change IGERT
Oazaukee-Washington Land Trust
Orono Land Trust
Passamaquoddy Tribe
Penobscot River Restoration Trust
Penobscot Valley Audubon Chapter
Ruffed Grouse Society
San Diego Zoo Global
School of Agricultural, Forest, and Environmental Sciences at Clemson University
St. Croix International Waterway Commission
The Nature Conservancy
The North Maine Woods
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 – Biological Resources Discipline
U.S. Geological Survey – Eastern Regional Cooperative Fish and Wildlife Research
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Geological Survey – Patuxent Wildlife Research Center
U.S. Geological Survey – Science Support Program
University of Guelph
University of Maine
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 – Sustainable Solutions Initiative
USDA SARE Grants
Wildlife Management Institute
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

Malcolm L. Hunter, Jr., *Interim Chair, Professor*
Lindsay C.N. Seward, *Interim Associate Chair, Instructor*
Erik J. Blomberg, *Assistant Professor*
Aram J.K. Calhoun, *Professor*
Stephen M. Coghlan, Jr., *Associate Professor*
Cory Gardner, *Scientific Research Assistant*
Daniel J. Harrison, *Professor*
Thomas Hastings, *Scientific Research Specialist*
Jessica J. Jansujwicz, *Research Assistant Professor*
Molly-Jean Langlais-Parker, *Administrative Specialist*
Sabrina Morano, *Research Assistant Professor*
Alessio Mortelliti, *Assistant Professor*
Amber M. Roth, *Assistant Professor*
Frederick A. Servello, *Professor of Wildlife Ecology*
Carly C. Sponarski, *Assistant Professor*

Department of Anthropology

Samuel P. Hanes, *Assistant Professor*

School of Biology and Ecology

Allison Dibble, *Assistant Research Professor*
Francis A. Drummond, *Professor*
Hamish S. Greig, *Assistant Professor*
Rebecca L. Holberton, *Professor*
Michael T. Kinnison, *Professor*
Brian J. McGill, *Associate Professor*
Brian J. Olsen, *Associate Professor*

Department of Civil and Environmental Engineering

Aria Amirbahman, *Professor*

Department of Communication and Journalism

Laura N. Rickard, Assistant Professor

School of Earth and Climate Sciences

Stephen A. Norton, *Emeritus Professor*

School of Economics

Caroline L. Noblet, *Assistant Professor*
Timothy M. Waring, *Associate Professor*

School of Forest Resources

Shawn Fraver, *Assistant Professor*
Daniel J. Hayes, *Assistant Professor*
Jessica E. Leahy, *Professor*

School of Marine Sciences

Jeffrey A. Runge, *Research Professor*
Gayle B. Zydlewski, *Associate Professor*

EXTERNAL COLLABORATORS

Brad Allen, *Wildlife Biologist, Maine Department of Inland Fisheries and Wildlife*
Kyle Barrett, *Assistant Professor, Clemson University*
Dana M. Bauer, *Assistant Director and Research Scientist, Clark University*
James P. Bogart, *Professor Emeritus, University of Guelph*
Phillip deMaynadier, *Wildlife Biologist, Maine Department of Inland Fisheries and Wildlife*
Jenny A. Glikman, *Associate Director of Community Engagement, San Diego Zoo*
David Irons, *Alaska Seabird Coordinator, U.S. Fish and Wildlife Service*
Walter Jakubas, *Mammal Group Leader, Maine Department of Inland Fisheries and Wildlife*
Ian Kiraly, *Fisheries Biologist, Gomez and Sullivan Engineers*
Daniel G. McAuley, *Station Leader, USGS Patuxent Wildlife Research Center*
Shawn T. McKinney, *former Assistant Unit Leader, ME Cooperative Fish and Wildlife Research Unit*
Jerry V. Mead, *Assistant Scientist and Section Leader, Drexel University*
Allison Moody, *Post-doctoral Research Associate, University of Wisconsin, Madison*
Priya Nanjappa, *Project Coordinator, Association of Fish and Wildlife Agencies*
Jason Jeremy Schaffler, *Senior Quantitative Scientist, Muckleshoot Indian Tribe*
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 Trial, *Retired, Maine Department of Marine Resources*
Andrew R. Whiteley, *Assistant Professor, University of Massachusetts Amherst*
Petra B. Wood, *Assistant Unit Leader-Wildlife, WV Cooperative Fish and Wildlife Research Unit*

GRADUATE COMMITTEE LEADERSHIP

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

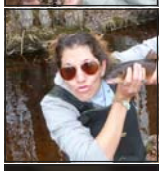
Loftin

Brandon Boxler, MS (September 2017 – Present)
Brianne Du Clos, PhD (September 2012 – Present)
Luke Groff, PhD (January 2011 – December 2016)
Jared Homola, PhD (September 2013 – Present)
Alyson McKnight, PhD (September 2013 – May 2017)
Brian Rolek, PhD (September 2012 – Present)
Nikko Shaidani, MS (September 2012 – May 2017)

Zydlewski

Betsy Barber, PhD (May 2013 – Present)
Megan Begley, MS (May 2014 – December 2016)
Melissa Flye, MS (September 2017 – Present)
Berlynna Heres, MS (May 2016 – Present)
Kevin Job, MS (January 2016 – Present)
George Maynard, PhD (May 2013 – Present)
Alejandro Molina-Moctezuma, PhD (May 2015 – Present)
Erin Peterson, PhD (September 2017 – Present)
Sarah Vogel, MS (January 2017 – Present)
Daniel Weaver, PhD (May 2013 – May 2017)

RECENT GRADUATES AND CURRENT PURSUITS

Student, Degree, Curriculum Current Pursuits	Graduate Date Advisor(s)
Brian Allen, MS, Wildlife Ecology	August 2017 Erik J. Blomberg
 **Megan Begley**, MS, Wildlife Ecology Teacher, Orono School System	December 2016 Stephen M. Coghlan, Jr., Joseph D. Zydlewski
Samantha Davis, MS, Wildlife Ecology Temporary Scientist, University of Maine	August 2017 Erik J. Blomberg
Luke Groff, PhD, **Ecology** and Environmental Sciences Nongame Wildlife Specialist, Minnesota Department of Natural Resources	December 2016 Aram J.K. Calhoun, Cynthia S. Loftin
Kristine Hoffmann, PhD, Wildlife Ecology Post-doctoral Associate, University of Maine	May 2017 Aram J.K. Calhoun, Malcolm L. Hunter, Jr.
Ellie Mangelinckx, MS, Wildlife Ecology Temporary Scientist, University of Maine	August 2017 Erik J. Blomberg
Alyson McKnight, PhD, Ecology and Environmental Sciences Lecturer, Unity College	May 2017 Cynthia S. Loftin, Shawn T. McKinney
Brock Sandrock, Master of Wildlife Conservation	May 2017 Daniel J. Harrison
Nikko-Ideen Shaidani, MS, Zoology Research Technician, Woods Hole Oceanographic Institution	May 2017 Cynthia S. Loftin, Michael T. Kinnison
Jonathan Watson, MS, Wildlife Ecology Natural Resource Biologist, Maryland Department of Natural Resources	May 2017 Stephen M. Coghlan, Jr.
Daniel Weaver, PhD, Wildlife Ecology Assistant Professor, State University of New York	August 2017 Stephen M. Coghlan, Jr., Joseph D. Zydlewski

CURRENT STUDENTS & POSTDOCS

Student, Degree, Curriculum	Advisor(s)
Betsy Barber, PhD, Wildlife Ecology	Joseph D. Zydlewski
Sara Boone, MS, Wildlife Ecology	Alessio Mortelliti
Brandon Boxler, MS, Ecology and Environmental Sciences	Cynthia S. Loftin
Allison Brehm, MS, Wildlife Ecology	Alessio Mortelliti
Bayu Broto, Master of Wildlife Conservation	Alessio Mortelliti
Anna Buckardt, MS, Wildlife Ecology	Amber M. Roth
Elyse DeFranco, MS, Ecology and Environmental Sciences	Carly C. Sponarski
Brianne Du Clos, PhD, Ecology and Environmental Sciences	Cynthia S. Loftin, Francis A. Drummond
Carly Eakin, PhD, Wildlife Ecology	Aram J.K. Calhoun, Malcolm L. Hunter, Jr.
Bryn Evans, PhD, Wildlife Ecology	Alessio Mortelliti
Alexander Fish, PhD, Wildlife Ecology	Erik J. Blomberg, Amber M. Roth
Melissa Flye, MS, Ecology and Environmental Sciences	Carly C. Sponarski, Joseph D. Zydlewski
Francesca Gundrum, Master of Wildlife Conservation	Carly C. Sponarski
Berlynna Heres, PhD, Wildlife Ecology	Erik J. Blomberg, Joseph D. Zydlewski
Kristine Hoffmann, Postdoctoral Associate	Aram J.K. Calhoun, Malcolm L. Hunter, Jr.
Jared Homola, PhD, Ecology and Environmental Sciences	Cynthia S. Loftin, Michael T. Kinnison
Kevin Job, PhD, Wildlife Ecology	Joseph D. Zydlewski
Scott Lindemann, Master of Wildlife Conservation	Aram J.K. Calhoun, Malcolm L. Hunter, Jr.
Lydia Kifner, MS, Ecology and Environmental Sciences	Aram J.K. Calhoun, Aria Amirbahman
Zachary Loman, Postdoctoral Associate	Cynthia S. Loftin, Daniel J. Harrison
George Maynard, PhD, Wildlife Ecology	Joseph D. Zydlewski
Alejandro Molina-Moctezuma, PhD, Wildlife Ecology	Joseph D. Zydlewski
Erin Peterson, PhD, Wildlife Ecology	Joseph D. Zydlewski
Nicole Ramberg-Pihl, PhD, Ecology and Environmental Sciences	Stephen Coghlan, Hamish Greig
Brian Rolek, PhD, Wildlife Ecology	Cynthia S. Loftin, Daniel J. Harrison
Kirstie Ruppert, PhD, Ecology and Environmental Sciences	Carly C. Sponarski
Joel Tebbenkamp, PhD, Wildlife Ecology	Erik J. Blomberg, Daniel J. Harrison
Sarah Vogel, MS, Wildlife Ecology	Jessica J. Jansujwicz, Joseph D. Zydlewski
Kaitlyn Wilson, MS, Wildlife Ecology	Amber Roth

UNIT SUPPORTED RESEARCH

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

FISHERIES and aquatic

Understanding the impact of commercial harvest on white sucker (*Catostomus commersonii*) in Maine 14

Dam removal and fish passage improvement influence fish assemblages and predator-prey interactions in the Penobscot River, Maine 16

Anadromous sea lamprey (*Petromyzon marinus*) as vectors of marine-derived nutrients in Atlantic coastal streams 18

Response of sturgeon to the Veazie and Great Works Dam removals 20

Marine-derived nutrient cycling in the St. Croix River, Maine 21

Life history and migration of American eels in the Penobscot River, Maine 22

Using otolith microchemistry to infer early life histories of American shad and American eel habitat use in the Penobscot River, Maine 23

Monitoring of upstream migrating fish in the Penobscot River, Maine 24

Passage of anadromous fish at mainstem dams on the Penobscot River, Maine 25

Life history and migration of American eels in the Penobscot River, Maine 26

Understanding the impact of commercial harvest on white sucker (*Catostomus commersonii*) in Maine

1. Compare the demographics of spawning suckers from fished and unfished lakes.
2. Use demographic data to assess sensitivity of suckers to fishing pressure.

Abstract: The State of Maine issues an unlimited number of commercial permits for the harvest of White Suckers *Catostomus commersonii* in Maine's inland waters. The fishery provides a necessary source of fresh lobster *Homarus americanus* bait to coastal communities at a time when other bait sources are scarce. The impacts of the increasing number of permits and subsequent numbers of fishermen on the white sucker population is unknown. The Maine Department on Inland Fisheries and Wildlife (MDIFW) has closed a number of waters due to concerns that overfishing and incidental catch of other fish species may occur.

In Chapter 1, we investigated demographic differences of White Suckers from lakes open to and closed to harvest. Each harvested lake was paired to a lake closed to harvest (reference lake) of similar size. Fish were captured from each lake and biological information was collected for each individual (i.e. sex, mass, gonadosomatic index, fecundity, and age). Distributions of each demographic were compared in a series of paired lake by sex analysis. Fish from harvested lakes were younger, smaller, and had lower fecundity than fish from reference lakes. Estimated mortality rates for harvested lakes were also two fold higher than reference lakes. There were some detectable differences in growth parameters from the von Bertalanffy growth function (and K) between lake pairs as might occur under selective pressure. White Suckers are long-lived and the few differences found in growth may also reflect the infancy of the fishery (established in 1991). These data do suggest that current levels of exploitation are resulting in age truncation of white sucker populations.

In Chapter 2, we built a deterministic population model of White Suckers using parameters from literature and field studies to investigate the theoretical effects of harvest mortality on age-structure and fecundity. We compared the age-structure of White Suckers from our reference lakes to a baseline model and observed and simulated distributions were similar. When harvesting mortality increased in the model there was an expected truncation in age-classes. The average mortality from harvested lakes was used to run the harvest model and the age structure was compared to the aggregate of harvested lakes. A similar age truncation pattern occurred, however distributions were different. This could be due to the variation in the additive mortality estimated for each harvested lake. The results of harvest pressure were evaluated under the assumptions of–both a Beverton-Holt and Ricker recruitment curves.

In Chapter 3, we determined the spatial scale of harvesting effort in Maine using commercial sucker permits issued from 2006 to 2016. Of the seven-biological regions managed by MDIFW, Region B had the highest number of permitted waters and Region G had the lowest. A list was also compiled for each biological region for waterbodies with eight permits (issued in the last five years) to provide managers an idea of where to focus efforts for monitoring in future harvest seasons. Possible areas for improvement to aid in management might include the use of a central database for harvesting information, as well as requiring more harvest information from commercial harvesters. It would be advantageous for managers if future commercial sucker report logs were site-specific to inform managers of areas that harvesters repeatedly target.

In aggregate, this study provided an important first-look at harvest impacts on white sucker populations in Maine. We now have a better understanding of how White Suckers respond to additive mortality through both field work and deterministic models. The permit analysis also provides managers with specific locations where monitoring efforts could be focused for the next harvest season. Additional data on the number of traps used, where traps are set, effort, and catch total per harvester will be important for future fishery management. Monitoring the age structure of harvested lakes could help assess the viability, productivity, and resilience of white sucker populations. An important next step in the commercial sucker fishery is identifying critical levels of white sucker mortality that cause declines in resilience and productivity, ultimately leading to population collapse.

Investigator: Megan Begley (MS)

Advisors: Stephen M. Coghlan, Jr. (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)
Michael T. Kinnison

Duration: January 2012—December 2016

Cooperators:

Maine Department of Inland Fisheries and Wildlife

Dam removal and fish passage improvement influence fish assemblages and predator-prey interactions 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 smallmouth bass (*Micropterus dolomieu*) growth and diet in sections of the Penobscot River watershed with varying abundances of river herrings.
4. Use bioenergetic modelling to project future changes to smallmouth bass growth associated with the observed population increases of river herrings in this watershed associated with restoration actions.

Abstract: Dams and their impoundments disrupt river habitat connectivity to the detriment of migratory fishes. Removal of dams improves riverine connectivity and lotic habitat which benefits these fishes along with resident fluvial specialist species. Restoration efforts on the Penobscot River (Maine, USA) are among the largest recently completed in the United States, and include the removal of the two lower-most dams and improvements to fish passage at several remaining barriers. Here we describe initial and potential future changes to fish communities in the Penobscot River associated with these restoration efforts.

We assessed fish assemblages in the mainstem river and several major tributaries before (2010-2012) and after dam removal (2014-2016) using boat electrofishing surveys and a stratified-random sampling design. In total, we sampled 303 km of shoreline and captured 107,335 individual fish from 39 species. Similarity indices suggest that the most pronounced changes in fish assemblage composition occurred in reaches that underwent both habitat and connectivity changes (i.e. directly above removed dams). The newly connected reaches became more compositionally similar, as demonstrated by an average increase of 31% in similarity scores. The similarity score changes in these reaches were driven by increasing access for anadromous fish and decreasing abundances of slow-water specialist species. For example, we observed a marked reduction in lacustrine species in former impoundments. We also found all anadromous species in greatest abundance below lower-most dam during each respective sampling period. River herrings *Alosa spp.* passed through the new fish elevator at the new lower-most dam and spawned in newly available habitat upstream, as evidenced by presence of juveniles in our samples. Our results demonstrate the potential for large dam removal projects to restore both fluvial and anadromous fish assemblages.

We also examined the current and future impacts of rebounding river herring populations on Smallmouth Bass. Here we describe the diet and growth of Smallmouth Bass collected from different areas of the Penobscot River watershed and project changes to annual growth associated with increasing access to juvenile river herring prey using bioenergetics modeling. We collected 765 Smallmouth Bass throughout 2015, examined the stomach contents of 573 individuals, and found notable differences in diet between river reaches with common seasonal trends. Juvenile river herring composed an average of 19% (SE = ±6%) of stomach contents by mass from

Smallmouth Bass collected in the freshwater tidal area but were observed only rarely in the diets upstream. We used von Bertalanffy growth models to examine potential difference in growth among reaches and found overlapping 95% credible intervals for all estimated growth parameters in each area, with the exception of the freshwater tidal reach where the average asymptotic length was the largest (425 mm TL). Results from bioenergetics models suggest that increasing consumption of juvenile river herring will likely lead to increases in seasonal growth throughout the watershed as river herring populations continue to rebound. Our results provide new insight to both the predator-prey dynamic of these fish in a large river and the implications of anadromous river herring population recovery in systems where Smallmouth Bass has been introduced.

Investigator: Jonathan Watson (MS)

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

Duration: May 2014—April 2017

Cooperators:

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

Anadromous sea lamprey (*Petromyzon marinus*) as vectors of marine-derived nutrients in Atlantic coastal streams

1. Quantify the spatial and temporal effects of marine-derived nutrient subsidies from adult sea lamprey.
2. Compare autotrophic and heterotrophic nutrient response pathways from nutrient subsidies.
3. Characterize the spatial heterogeneity of juveniles (ammocoets) within the Penobscot Watershed.
4. Develop a model that predict nutrient responses in freshwater systems.

Abstract: Anadromous sea lamprey *Petromyzon marinus* are native to Atlantic coastal systems and serve as a functional link between marine and freshwater ecosystems. Sea lamprey spend one–two years in the ocean parasitizing marine vertebrates before migrating into freshwaters during the spring to spawn. There they construct nests, spawn, then die shortly afterwards. Larvae hatch, bury into fine sediments and reside in streams for generally 6–8 years, but up to 14. Larvae then undergo metamorphosis, a non-feeding period characterized by a series of physical and physiological changes. The juveniles (macropthalmia) then migrate to the ocean to begin the parasitic juvenile phase.

Historically, marine and freshwater ecosystems were linked by migrating anadromous fish, including sea lamprey. However, barriers such as dams have reduced or eliminated these migrations and therefore the delivery of nutrients via metabolic waste, eggs, and carcasses to recipient freshwater systems. This thesis generally focused on characterizing the dynamics and delivery of nutrients from sea lamprey, the pathways by which these nutrients may be assimilated in stream food webs, and factors that may alter or influence these effects.

A first step to understanding the role of sea lamprey in freshwater food webs is to characterize the composition of adult tissue and subsequent dynamics of decomposition and nutrient liberation. First, the timing of decomposition and subsequent nutrient liberation of sea lamprey carcasses was characterized with a field and laboratory experiment. Elemental composition revealed lamprey carcass nitrogen:phosphorus ratios of 20.2:1 (± 1.18 SE). The experiments demonstrated that carcasses exponentially decompose over a three to four week period in the stream leaving 27% (± 3.0% SE) of the initial biomass remaining and liberating the majority of phosphorus and nitrogen. These experiments characterize the dynamics of nutrients delivered to freshwater systems and suggest that these subsidies may serve to enrich stream food webs and alleviate nutrient limitations.

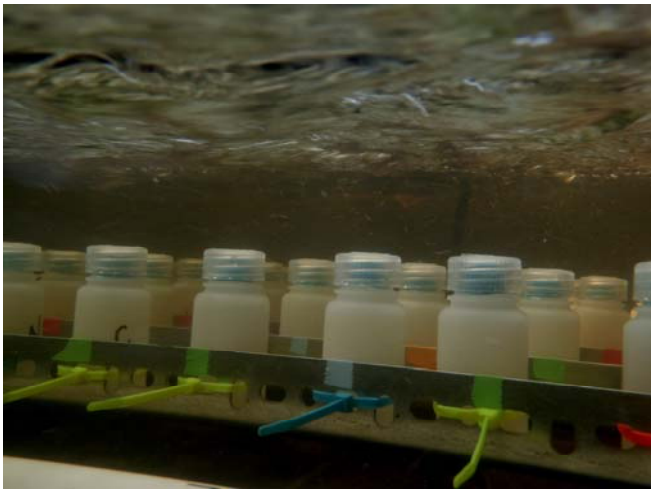
The spatial and temporal dynamics of sea lamprey carcass nutrients were examined. Carcass addition experiments were conducted to examine changes in stream nutrients, primary productivity, and nutrient assimilation among consumers. Field experiments revealed 57–71% increases in algal biomass in areas with experimentally added sea lamprey carcasses compared to an upstream reference. However, broader spatial changes from multiple-site carcass addition may have been influenced by canopy cover from adjacent riparian vegetation that limit incoming sunlight to the stream. Several macroinvertebrate families including Heptageniidae, Hydropsychidae, and Perlidae assimilated carcass nutrients, as determined with stable isotopes analysis. Results from these experiments suggest that carcass nutrients may evoke localized effects on food webs, and the pathways of assimilation by organisms may be coupled to adjacent terrestrial systems.

Resource flows from sea lamprey across ecosystem boundaries may subsidize recipient communities and influence bottom-up and top-down processes in food webs. However, dams and barriers to fish passage may limit returns of spawning adult sea lamprey to freshwater streams. Carcass addition experiments tested the effects of a gradient of increasing carcass nutrients on primary producers and decomposers in stream reaches flowing through open and closed riparian forest canopies. These experiments revealed that manipulating the quantity of nutrient resources affected producers and decomposers differently and that trends were further influenced by adjacent terrestrial systems. A carcass addition experiment also revealed that larval lamprey assimilate a portion of carcass nutrients. Therefore, collectively these experiments demonstrate that sea lamprey carcasses may stimulate bottom-up trophic dynamics by

alleviating nutrient limitations, and additionally these nutrients may be captured by higher trophic levels. This suggests that cross-ecosystem linkages may be mediated by subsidy quantity from donor systems and environmental characteristics from recipient systems.

Sea lamprey function as an ecosystem engineer through nest building and spawning activities and as a vector of nutrients to freshwater systems. Macroinvertebrates, an important intermediate pathway in the cycling of nutrients and transfer of energy, may be influenced by these physical and chemical perturbations.

We examined the colonization of macroinvertebrate assemblages on cleaned coarse substrate designed to mimic substrate modified by sea lamprey spawning and subsequent nutrient enrichment from post-spawned sea lamprey carcasses. We found that abundance and biomass in sites receiving carcass nutrients were structured largely by Simuliidae, compared to control sites that were structured by Hydropsychidae, Philopotamidae, and Chironomidae. Environmental factors such as stream flow may further shape assemblages by physically constraining the foraging capabilities of certain macroinvertebrate families. Larval sea lamprey reside in streams for 6–8 years to upwards of 14 years and function as a filter feeding detritivore and utilize nutrients from adult carcasses. As a result, larvae may exhibit higher growth rates during the post-spawn period of increasing temperatures and nutrient limitation.



The sensitivity of life history parameters and influence of sea lamprey carcass nutrients on the age and growth of larval conspecifics was examined with a deterministic stock recruitment model. Larval populations receiving carcass nutrients demonstrated increases in larval growth and lower age-at-metamorphosis that, over time, resulted in a three fold increase in the numbers of returning adults to freshwaters. This model exemplifies two potential alternative ecosystem states, one in which fish populations are uninhibited during migration, and another in which fish passage is constrained by migratory barriers. migration and spawning.

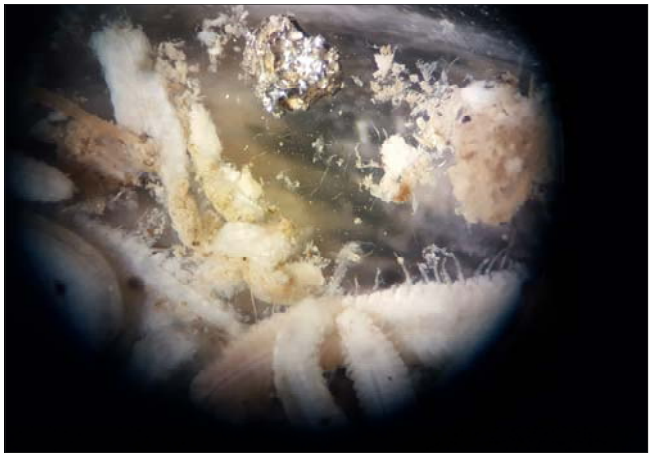
Investigator: Daniel Weaver (PhD)

Advisors: Stephen M. Coghlan, Jr. (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)
Hamish S. Greig
Michael T. Kinnison
Jerry V. Mead

Duration: May 2013—May 2017

Cooperators:

Maine Sea Grant
Atlantic Salmon Federation
Maine Audubon Society
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
Penobscot Valley Audubon Chapter
National Oceanic and Atmospheric Administration
The Nature Conservancy



Response of sturgeon to the Veazie and Great Works Dam removals

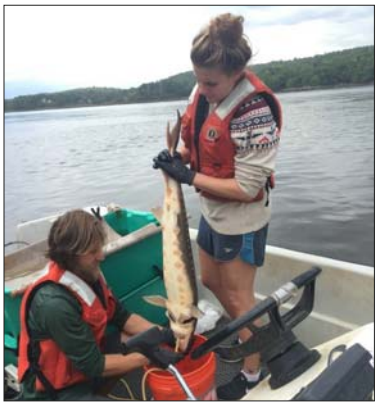
1. Characterize the distributions of adult Shortnose and Atlantic sturgeon in the Penobscot River, particularly in the context of dam removal and habitats upstream to Milford Dam. This will entail determining seasonal sturgeon presence in different river habitats, with a focus on spawning, feeding, and wintering as well as fish condition for those travelling furthest upstream each season.
2. Assess presence of early life stage sturgeon in the Penobscot River, particularly just downstream of the Milford dam site.
3. Model trends in abundance and condition of adults using the Penobscot River during summer, fall, and winter relative to baseline assessments of 2007-2010.

Our research on the Penobscot River aims to document sturgeon use of the river and responses to the recent dam removals. We monitor movement patterns of sturgeon in the Penobscot River using acoustic telemetry. We also sample for early life stage sturgeon, collect data for a robust mark-recapture estimation, and concurrently sample for diet and prey availability. Acoustic telemetry will continue to be used to assess seasonal movements, presence and aggregations. This will include upkeep and data collection from the acoustic receiver array to monitor spatial and temporal distribution of sturgeon from Milford dam to Verona Island from April to November and a smaller receiver array from November to April.

A robust mark-recapture estimate of adult Shortnose Sturgeon using the Penobscot River prior to dam removal exists, and capture efforts will continue for estimates post dam removal for comparison. In conjunction with gill netting, we will use trotlines to ensure capture of all fish size classes. Foraging behavior and habitat will be assessed by capturing sturgeon and observing feeding status (by taking stomach samples) and diet selectivity (by taking prey availability samples of the benthos) to inform presence and distribution of the species as it is related to critical habitat.

Intensive early life stage sampling was carried out in 2016-2017 from May through June at known sturgeon aggregation sites. Despite this effort, no sturgeon eggs or larvae were collected. Gill netting for adult Shortnose and Atlantic Sturgeon was conducted from July-November, resulting in the capture of more than 300 Shortnose Sturgeon and 50 Atlantic Sturgeon. Gastric lavage was performed on a subset of both Shortnose and Atlantic Sturgeon. PONAR sampling of the river bottom was conducted in tandem with netting to compare available prey with lavaged stomach contents. In addition to PONAR sampling, invertebrate samplers were assembled and deployed in the fall to better characterize prey availability.

The acoustic receiver array in the Penobscot River was deployed March of 2017 and retrieved in December. Telemetry data have been downloaded from receivers to be uploaded to a central database and analysis is pending. Invertebrate and stomach samples are being processed and categorized.



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:

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

Marine-derived nutrient cycling in the St. Croix River, Maine

1. Characterize the food web in the St. Croix prior to alewife return.
2. Characterize the temporal influx of marine nutrients due to alewife migration.
3. Explore how changes in passage efficiency at three main stem dams might change the flow and distribution of nutrients in a complex river system.

The purpose of this study is to determine how the presence of alewife affects the St. Croix watershed, both in terms of nutrient input and food web interactions. This will be done by developing a model of the existing food web using stable isotope data procured through sampling river and lake sites. Isotopes will include carbon and nitrogen, which typically show distinct signatures when moving from marine to freshwater environments. Samples will be collected three times annually at seven sites in the St. Croix concurrent with the alewife run. Nutrient limitation will also be determined at each site. Two sites on the East Machias River will be sampled as a reference.

The data from this study will be incorporated into a model to determine how alewives affect the input and output of nutrients within streams and lakes in the St. Croix watershed. The presence of alewives has the potential to directly affect other species in the system, including species of interest such as small mouth bass. As alewives are reintroduced into the St. Croix watershed in large numbers this study will be able to track their effect on nutrient cycling, as well as determine their role in the food web.

Sampling has been carried out for 2013-2015 at seven sites in the St. Croix and 2014-2015 at two sites in the East Machias. Fish muscle, aquatic invertebrate, and plankton samples were collected at each site in May, June, and July. The majority of these samples have been prepared and sent to a lab for stable isotope analysis, but food web modelling still needs to be performed on the data. All data analyzed so far has revealed expected trophic associations between fish and invertebrate taxa in the region. A marine "signal" was also clear from migrating alewife in the St. Croix system. All sites on the St. Croix are oligotrophic based on nutrient limitation data. Analysis of stable isotope data is nearly complete and nutrient information is being incorporated into an alewife population model to explore nutrient dynamics in the St. Croix River.

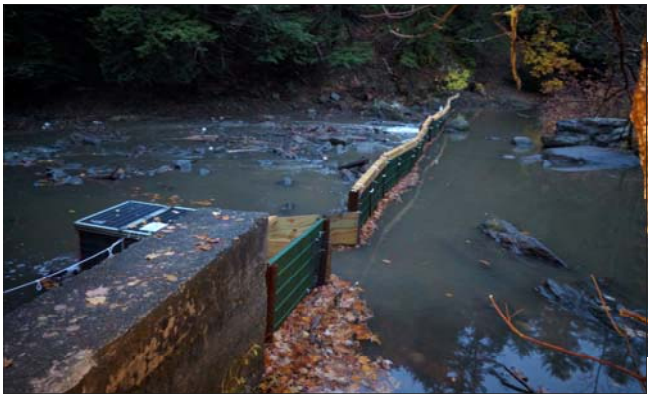
Investigator: Betsy Barber (PhD)

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

Duration: May 2012—December 2017

Cooperators:

Atlantic Salmon Federation
International Joint Commission on the St. Croix Waterway
U.S. Fish and Wildlife Service
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
Passamaquoddy Tribe
Canadian-American Centre; Downeast Salmon Federation
St. Croix International Waterway Commission



Life history and migration of American eels in the Penobscot River, Maine

1. Develop a model to forecast the downstream migration timing 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.
3. Examine the effect of marine derived nutrients on American eel populations in the Penobscot River by determining growth rate through otolith microchemistry and stable isotopes.

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 as to hydropower facility operation. Results from telemetry will be used to inform our developing model. Efforts would allow sensitivity analysis of turbine shut down to conservation and financial objectives appear absent.

Examining marine derived nutrients (MDNs) on American eels will help determine the overall effect of returning anadromous fish to previously dammed streams. We will collect yellow eels and sample for MDNs spatially and temporally. We will also collect otoliths from eels in streams with know dates of anadromous fish repopulations. We will analyze the growth rate of eels before and after anadromous fish repopulation.

Work in the fall of 2017 included the improved design and installation of a weir and a steal and fiberglass grate trap on a tributary of the Penobscot River. Analysis of the previous years data. And currently, one hundred silver eels were captured and surgically tagged and released above West Enfield Dam. The passive tracking of these fish is currently underway.

Preliminary research into objective three is underway. Site selection and permits were completed and samples were collected and processed, ready for stable isotope analysis.

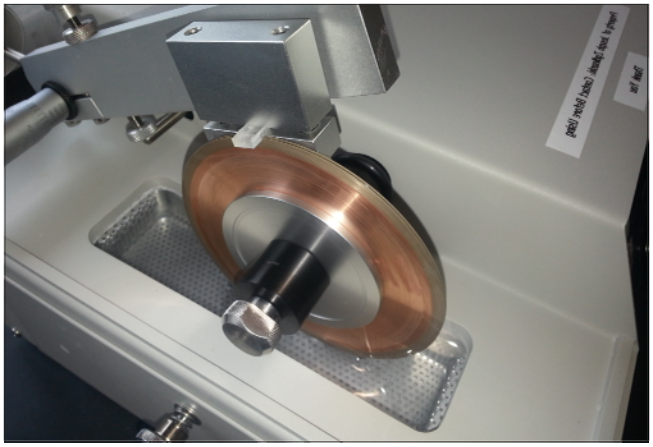
Investigator: Berlynna Heres (PhD)

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

Duration: September 2015—June 2020

Cooperators:

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



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 are working to prepares more than 800 individual otoliths from American shad and more than 120 American eels. Currently, we have processed American shad otoliths from Penobscot River shad between the years of 2011 and 2017 and Penobscot River eels between the years of 2013 and 2017. Additionally we have processed American eels from the Union River in Maine, and American shad from the Sheepscot river in Maine. The majority of samples were prepared for microchemical analysis and analyzed using laser ablation inductively coupled plasma mass spectrometry at the Woods Hole Oceanic Institute in 2017. The remaining samples will be run in early 2018.

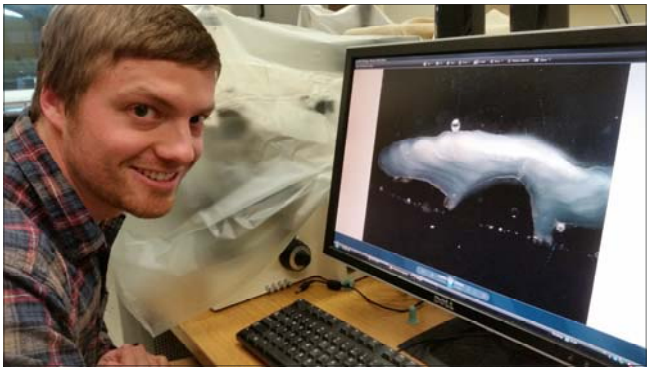
Investigator: Kevin Job (MS)

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

Duration: January 2016—October 2018

Cooperators:

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



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.

The Penobscot River watershed is Maine's largest and hosts a number of anadromous species including the largest remaining run of Atlantic salmon in the USA. For many species, however, the majority of high quality spawning and rearing habitats are located upstream of lower river dams. By the fall of 2013, the two most downstream dams were removed as part of the Penobscot River Restoration Project (PRRP). Ultimately, benefits of dam removal for Atlantic salmon and other species will depend on the degree and fashion by which remaining dams facilitate fish passage success.

In order to assess migratory success, we are using passive integrated transponders (PIT tags) to remotely track fish through nine major dams in the lower Penobscot River. Beginning in 2013, PIT tagging of fish occurred at the lower most dam (Milford) requiring an antenna installation at the new fishway in coordination with Maine Department of Marine Resources. This work will incorporate and build on recent research that demonstrated migratory behavior and passage efficiency of Atlantic salmon in the Penobscot River. The long term scope of this project is to monitor the effects of the PRRP with respect to Atlantic salmon in accordance with the State Operational Plan for the Restoration of Anadromous Fishes to the Penobscot River. This study requires coordination with USGS, NOAA, DMR, the Penobscot River Restoration Trust (PRRT), the Penobscot Indian Nation, USFWS, and the various dam operators.

The project was initiated September 2009 and has included an M.S. student, a Ph.D student and a post-doctoral associate over the years. By spring of 2010, PIT arrays were installed at all targeted lower mainstem dams and preliminary passage data were collected from more than 1,000 tagged fish. By spring of 2011 eight sites were fully functional and were maintained through the 2011 adult salmon season. Coordination with Department of Marine Resources allowed the successful tagging and tracking of 2,429 adult Atlantic salmon in 2011. Efforts were continued in 2012 and priorities will shift to data analysis and "near real time" coordination with management agencies for the optimization of fish passage. A Ph.D. student began this work in spring of 2013 and low Atlantic salmon returns have necessitated a shift in focus to other species. In addition to a limited number of Atlantic salmon in 2014, hundreds of alewife, sea lamprey and American shad have been tagged and tracked. Additional efforts to radio tag and track adult American shad in 2014-17 have provided an improved picture of habitat use post-dam removal. The presence of iteroparous river herring in the Penobscot River was documented for the first time in recent history as individuals that were PIT tagged in 2014 were tracked upstream in 2015 -16. Radio telemetry of Atlantic salmon was made possible in 2016 by a donation of tags from Brookfield Renewable Power. This work will conclude in the spring of 2018.

Investigator: George Maynard (PhD)

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

Duration: September 2009—March 2018

Cooperators:

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

Passage of anadromous fish at mainstem dams on the Penobscot River, Maine

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, 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 2015. For the upcoming years, this project will focus on survival and passage through Howland Dam in the Piscataquis River. Beginning with the 2016 downstream migration, new downstream fish passage will be present in Howland Dam that has the potential to increase smolt survival. Therefore, it is important to characterize survival in this dam and compare it to survival in previous years.

Acoustic telemetry data have been collected from downstream migrating Atlantic salmon smolts 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.

Investigator: Alejandro Molina-Moctezuma (PhD)

Advisors: Joseph D. Zydlewski (Advisor)

Duration: January 2006—January 2020

Cooperators:

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

Life history and migration of American eels in the Penobscot River, Maine

1. Characterize the suite of regulatory and non-regulatory tools afforded by existing legal/ regulatory framework (i.e., FERC, CWA) and public-private landscape scale synthesis efforts.
2. Characterize the degree to which regulatory decisions at dams are independent of the characteristics and regulation in other nearby dams.
3. Assess perceived range of regulatory actions, specific authorities, knowledge of available tools, information gaps, use of ecological information in decision-making, and history of stakeholder driven actions in the local region.
4. Communicate results to resource agencies to inform future relicensing decisions

Decision-making regarding dams in New England stands at a crossroad. Over 52 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. As key stakeholders in the process, however, agencies have the unique opportunity to serve as "agents of change." 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. 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 will characterize agency actions and perspectives including knowledge gaps and challenges faced in the relicensing process.

Work began in 2017 and has focused on document analysis of document sources for projects in the Kennebec and Penobscot River watersheds. Data from the FERC eLibrary Database provide detailed correspondences, comments, and official documents relating to hydropower energy projects. From these sources, abiotic, biotic and social correlates are being quantified about regulatory outcomes. A targeted content analysis of these sources is being used to characterize the roles of agencies and tribal entities, entity participation, and agency decision-making behaviors. Knowledge of these patterns may inform future relicensing efforts.

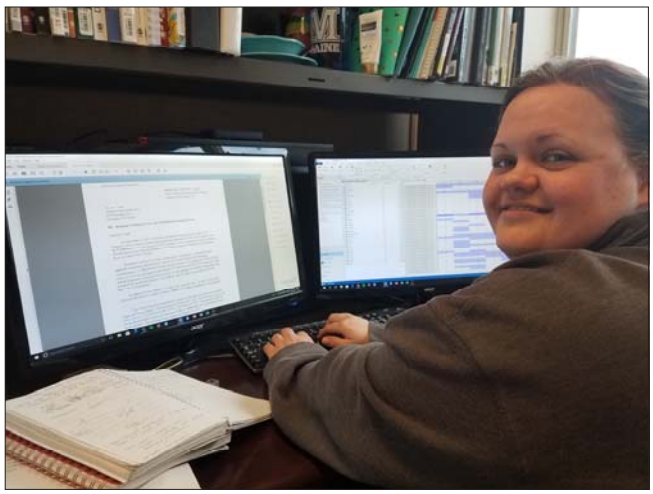
Investigator: Sarah Vogel (MS)

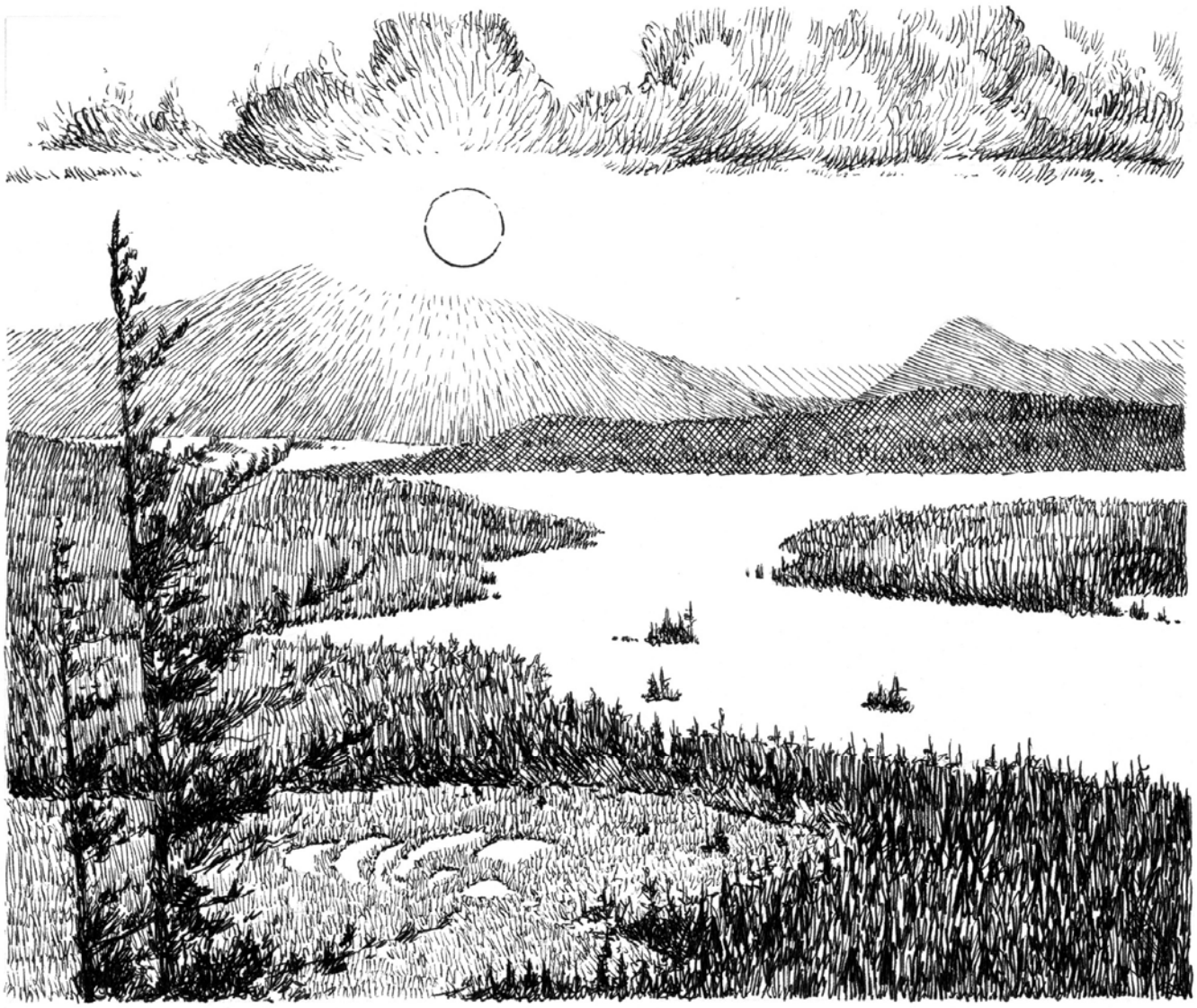
Advisors: Joseph D. Zydlewski (Co-Advisor)
Jessica J. Jansujwicz (Co-Advisor)
Carly C. Sponarski

Duration: June 2017—June 2020

Cooperators:

National Science Foundation – Experimental Program to Stimulate Competitive Research
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit





WILDLIFE and habitats

American woodcock migration ecology on the Mid-Atlantic coast 30

Harvest, seasonal survival, and drumming ecology of ruffed grouse in Maine 31

The habitat ecology of pool-breeding amphibians during all annual life history periods in the Mountains of the Dawn 32

Breeding ecology and habitat selection of the blue-spotted salamander (*Ambystoma laterale*) and its unisexual kleptogen 34

Ruffed grouse nest-site selection, nest success, and summer habitat use in central Maine 35

Individual, colony, and metapopulation-scale drivers of seabird colony dynamics 36

Biogeography and conservation of Maine's island amphibians, with focus on redback salamanders (*Plethodon cinereus*) 37

Small mammals and seed predation: how their behavior and personality affects forest composition and regeneration 38

Investigating the effects of silvicultural practices on individual and population-parameters in small mammals: from personality to seed predation 39

Evaluating young forest management as an avian conservation strategy 40

Landscape pattern and native bee communities in the northeastern United States 41

Wildlife use of vernal pool in an urbanizing landscape with a focus on vernal pool-breeding amphibian population vitality 42

WILDLIFE and habitats continued

Development of optimal monitoring protocol for mesocarnivores in Maine 43

Land-use effects on movement between and around breeding sites by wood frogs 44

Water chemistry dynamics in four vernal pools in Maine, USA 45

Evaluation of representative bird species' Landscape Capability models developed by the Designing Sustainable Landscapes project in the 13-state, northeastern region of the United States 46

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 47

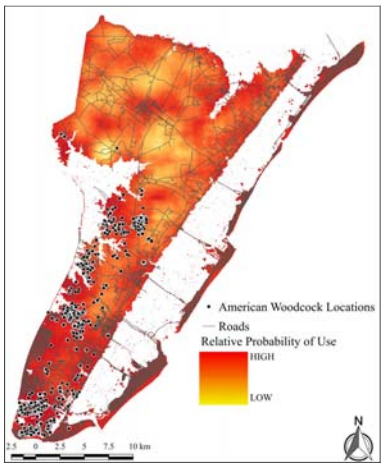
Human dimensions of giraffe conservation in northern Kenya 48

Population dynamics of spruce grouse in the managed forest landscapes of northern Maine 49

American woodcock migration ecology on the Mid-Atlantic coast

1. To investigate en route second order habitat selection of migratory woodcock during stopover.
2. To evaluate drivers affecting migratory decision making of woodcock during stopover.
3. To determine age- and sex-specific departure rates.
4. To determine if habitat use influences minimum stopover duration: a proxy for habitat quality.

Abstract: Migration poses risks and energetic demands to individuals that may be greater than those experienced during non-migratory periods. Most migratory birds require stopover sites to rest and recuperate energy spent during migratory flights, and stopover locations can alleviate risks and provide supplemental energy en route to the animal's end destination. An individual's stopover duration is contingent first on energy acquisition that is constrained by resource availability, and secondarily on environmental conditions such as weather that may facilitate or constrain continued migration. From 2010 to 2013 I conducted a radio-telemetry study of a short-distance migrant, the American Woodcock (*Scolopax minor*), on the Cape May Peninsula, New Jersey, an important stopover site for American Woodcock during fall migration (October – January). My research objectives were to (Chapter 1) describe diurnal land-cover type characteristics used by American Woodcock and to evaluate second-order resource selection during the fall migration period, and (Chapter 2) to evaluate the influence of individual (age, sex, mass) and environmental (weather, moon illumination) variables on stopover departure rates and test whether resource selection affected the timing of departure. In this latter case, I specifically asked whether the decision to depart based on weather conditions changed depending on individual resource selection. I radio-marked 271 individuals and collected 1,949 locations, and used GIS and generalized linear mixed models to compare land cover types and other landscape characteristics between used and available locations. I found that American Woodcock selected portions of the Cape May Peninsula with greater proportions of deciduous wetland forest, old fields, and shrub-covered wetlands, and avoided deciduous forest, coniferous forests and sites further away from potential roosting fields. I used these results to develop a predictive model of habitat distribution at Cape May as both continuous and discrete surfaces, which predicted 17.5% of the Cape May Peninsula as potential woodcock habitat with 90% classification accuracy based on a withheld validation dataset. To evaluate stopover departure, I used Cormack-Jolly-Seber survival analysis to estimate daily woodcock detection and residency probabilities, where the probability of departure from Cape May was defined as 1 – residency. Woodcock detection probabilities varied among and within years, ranging from 0.79 (+/-0.52 SE) to 0.98 (+/- 0.004 SE). I found woodcock departed more frequently when individuals had higher average resource selection, an evening tailwind and higher temperatures. However there was also an interaction between resource selection and wind direction; individuals with lower resource selection values did not depart as regularly with a tail wind. This suggests that individuals were better-able to take advantage of favorable weather conditions when they used higher quality habitat. The results in my thesis not only help fill a knowledge gap in the annual cycle of American woodcock, but further contribute to greater understanding of avian migratory stopover ecology.



Investigator: Brian B. Allen (MS)

Advisors: Erik J. Blomberg (Advisor), Daniel G. McAuley, Joseph D. Zydlewski, Brian J. Olsen

Duration: October 2010—May 2017

Cooperators:

U.S. Fish and Wildlife Service – Division of Migratory Birds

U.S. Geological Survey – Patuxent Wildlife Research Center

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

Harvest, seasonal survival, and drumming ecology of ruffed grouse in Maine

1. Evaluate seasonal survival and harvest rates in relation to environmental variables to build and improve future management and harvest practices.
2. Understand relationships among individuals, and groups of individuals such as, age and sex, that contribute to mortality risk throughout the year.
3. Evaluate selected habitat characteristics at display stages of male ruffed grouse during the breeding season by comparing vegetation at used and unused locations.
4. Record drumming rates at each stage to determine if structural differences among drumming stages affect male breeding behavior and performance.

Abstract: Understanding population dynamics and how species interact with their environment are important components for conservation and management. Ruffed grouse (*Bonasa umbellus*) are a widely distributed and common game bird in North America and are a considered an important economic and cultural icon in Maine. Although they are a well-studied species, there has been little research focused on ruffed grouse population dynamics and habitat relationships in Maine. My thesis aims to improve this knowledge gap by focusing on research related to survival and harvest of ruffed grouse, as well as male ruffed grouse resource selection at breeding display sites. Ruffed grouse are generally considered abundant in Maine, but there is a lack of state-specific knowledge of their survival and harvest rates to inform harvest management. To address this component we estimated seasonal and annual survival rates, harvest rates, and documented cause-specific mortality of 248 radio-marked ruffed grouse at two study areas in central Maine from 2014 –2016. We used nest survival models implemented in Program MARK to evaluate sources of spatial, temporal, and individual variation that may affect survival and harvest. Our results showed survival was lowest during the month of October and during winter, and adult ruffed grouse had a higher survival probability than juveniles throughout the year (β-0.49 ± 0.15 SE). Harvest rates were greater in a state owned Wildlife Management Area, and were lower at our study area comprised of commercially-managed private forest (β=0.72 ± 0.38 SE). Pooled across all years and study areas, the ruffed grouse harvest rate was 0.16 (95% CI = 0.14-0.18). Our results are comparable to other range-wide studies, and suggest that ruffed grouse hunting regulations in Maine produce rates of harvest that are consistent with sustainable population management.

Resource selection reflects behavioral choices that species make at different levels within their environment, but the fitness consequence of these choices are not always well understood. We evaluated habitat selection at breeding display sites, and the effects on breeding behavior, of male ruffed grouse in central Maine during April and May 2015–2016. We used resource selection functions (RSFs) that took the form of generalized linear models to compare habitat characteristics at used display locations (n=72) with those at available locations (n=144), and we further assessed how selected habitat features from the RSFs were associated with three drumming display characteristics; drumming rate, wing beat rate, and total wing beats. We used Akaike's Information Criterion to assess model support and selection. We found that male ruffed grouse selected drumming locations with high total stem density (β=0.54, 95% CI= 0.23-0.86), as well as high conifer stem density within 5m from the display stage (β= 0.57, 95% CI= 0.24-0.90). However we did not find that these same variables were associated with drumming behaviors, suggesting no effect of habitat selection on breeding display behavior. Understanding habitat selection and the possible fitness consequences of those selection choices will allow managers to identify areas of critical habitat needed to further benefit the species.

Investigator: Samantha Davis (MS)

Advisors: Erik J. Blomberg (Advisor)
Kelsey Sullivan
Brad Allen
Brian J. Olsen
Alessio Mortelliti

Duration: May 2014—May 2017

Cooperators:

Maine Department of Inland Fisheries and Wildlife
American Forest Management
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
The Nature Conservancy

The habitat ecology of pool-breeding amphibians during all annual life history periods in the Mountains of the Dawn

1. Identify the habitat features selected by wood frogs (*Lithobates sylvaticus*) during spring migration and the post-breeding period, and determine if these periods are ecologically distinct. Describe the spatial and temporal arrangement of habitats used during the breeding, spring and fall migration, post-breeding, and hibernal periods.
2. Identify the habitat features selected by wood frogs prior to hibernation and investigate the thermal ecology of overwintering frogs.
3. Evaluate the influence of local and landscape scale variables on wood frog and spotted salamander (*Ambystoma maculatum*) breeding site occupancy in Maine's Upper Montane/Alpine Zone ecoregion.

Abstract: Montane amphibians face many challenges. For example, amphibians are among the most climate change vulnerable taxa; high elevation populations are thought to be less resilient than lowland populations; and forested wetlands, a primary breeding habitat for many montane species, have sustained the greatest loss in area of all wetland types. Broadly, the aim of my dissertation was to evaluate the habitat ecology of pool -breeding amphibians during all annual life history periods (i.e., breeding, post-breeding, hibernal) in the Mountains of the Dawn. This research was conducted during 2011–2014 in Maine's Upper Montane/Alpine Zone and Quebec/New England Boundary Mountains ecoregions.

Breeding period. I evaluated the relative importance of breeding and landscape scale features to spotted salamander (*Ambystoma maculatum*) and wood frog (*Lithobates sylvaticus*) wetland occupancy. Occupancy by both species was influenced solely by breeding scale habitat features. Spotted salamander occupancy probabilities increased with beaver (*Castor canadensis*) presence, and wood frog probabilities increased with site area and percent shallows. These results suggest pool-breeding amphibian conservation in montane Maine include measures to maintain beaver populations and large wetlands with proportionally large areas of shallows ≤ 1 m deep.

Post-breeding period. I evaluated wood frog habitat selection and movement patterns during spring migration and the post-breeding period and described the spatio-temporal variability of used habitats. Telemetered frogs spent the greatest percentage of each field season in hibernacula, followed by post-breeding, migration, then breeding habitats. During spring migration, frogs exhibited different movement patterns (e.g., turn angles), selected different habitat features, and selected habitat features less consistently than during the post-breeding period. These results indicate the migration and post-breeding periods are ecologically distinct. Failing to discriminate among annual life history periods may obscure true ecological relationships.

Hibernal period. I evaluated wood frog thermal ecology within hibernacula and hibernal habitat selection. Hibernaculum temperature and relative humidity was significantly different and less variable than leaf litter, ambient air, and random location microclimate. Frogs selected for decreased canopy cover and increased leaf litter depth and microhabitat structure (i.e., logs, stumps). These habitat features likely insulate hibernating frogs from extreme and variable air temperatures and, therefore, may be critical to the species' acclimatization to altered winter conditions (e.g., reduced snowpack).

Cumulatively, my results indicate pool-breeding amphibians are place-based species with flexible ecologies that vary spatially. Therefore, the efficacy of amphibian conservation may be improved by considering how context (i.e., environment characteristics) shapes and defines these species' ecologies.

Investigator: Luke Groff (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Aram J.K. Calhoun (Co-Advisor)
Daniel J. Harrison
Brian J. McGill
Francis A. Drummond

Duration: January 2010—December 2016

Cooperators:

Maine Department of Inland Fisheries and Wildlife
U.S. Geological Survey – Eastern Regional Cooperative Fish and Wildlife Research
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Sustainable Solutions Initiative
School of Agricultural, Forest, and Environmental Sciences at Clemson University

Breeding ecology and habitat selection of the blue-spotted salamander (*Ambystoma laterale*) and its unisexual kleptogen

1. Compare the breeding site selection of blue-spotted salamanders to that of unisexual salamanders.
2. Explore terrestrial habitat use by unisexual salamanders.
3. Examine the breeding success, abundance, sex ratio, and orientation of each lineage at 4 vernal pools.
4. Investigate statistical methods used to assess directionality at amphibian drift fence arrays using both field data and simulations.

Abstract: Unsexual Salamanders within the Blue-Spotted Salamander Complex carry combinations of ambystomatid genomes (those of Blue-Spotted Salamanders, *Ambystoma laterale*, and Jefferson Salamanders, *A. jeffersonianum* in Maine). They are nearly all female, breed in wetlands, and use sperm of related species to reproduce. Little is known about their ecology to guide the conservation of this unique lineage. I examined breeding site occupancy, demographics, orientation, and terrestrial habitat selection of Unisexual Salamanders in comparison to Blue-Spotted Salamanders and other amphibians. I compared statistical tests of orientation to determine which was most appropriate for pitfall data.

Unisexual Salamander occupancy at breeding sites was positively related to counts of captured Blue-Spotted Salamanders, hydric soil, and vegetation characteristics. Blue-Spotted Salamander occupancy was related to the same vegetation characteristics, but Spotted Salamander occupancy was related to other characteristics.

I examined demographics and orientation of Unisexual Salamanders, Blue-Spotted Salamanders, Spotted Salamanders, and Wood Frogs (*Lithobates sylvaticus*) at four vernal pools. The ratio of juveniles per female was not significantly different among taxa, though only 1% of my Blue-Spotted Complex Salamander populations were males. I used simulated and field data to examine the effects of common scenarios on statistical tests, and found the Rayleigh test to be most suitable as a test of uniformity and the Kruskal-Wallace test the most suitable test of homogeneity. Orientation of Blue-Spotted Complex Salamanders was generally like that of other taxa.

Telemetered Unisexual Salamanders migrated distances similar to those of parent species, and used sites with high numbers of burrows, lower temperatures, and low cover by forest floor vegetation. Ninety percent of Unisexual Salamanders stayed within the forest matrix, but some migrated to disturbed areas such as backyards.

These findings relate Unisexual and Blue-Spotted Salamanders to their community and habitat. These two salamanders are similar in their use of both breeding sites and non-breeding habitat, but the former may range beyond the reach of this sperm-host. Additionally, managers who conserve terrestrial habitat near the pool for other species may also be aiding in the movements of sympatric Blue-Spotted Complex Salamanders, and pools with few males may still support viable populations of the complex.

Investigator: Kristine Hoffmann (PhD)

Advisors: Aram J.K. Calhoun (Co-Advisor)
Malcolm L. Hunter, Jr. (Co-Advisor)
Daniel J. Harrison
Michael T. Kinnison
James P. Bogart

Duration: January 2012—January 2017

Cooperators:

National Science Foundation – Experimental Program to Stimulate Competitive Research
University of Guelph
Orono Land Trust
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Sustainable Solutions Initiative

Ruffed grouse nest-site selection, nest success, and summer habitat use in central Maine

1. Identify vegetative and microclimatic variables that are associated with successful ruffed grouse nests, calculate a cumulative nest success rate for ruffed grouse nests in Maine, and compare this rate to that observed in other portions of the ruffed grouse range.
2. Identify vegetative variables that are selected by non-reproductive and brood rearing ruffed grouse at the home range and study area scales, which could guide future management for high-quality ruffed grouse habitat in Maine.
3. Contribute to the broader understanding of forest management effects on wildlife populations by examining variation in ruffed grouse demographic rates as a function of forest structure, composition, landscape characteristics, and forest management practices.

Abstract: Species-habitat relationships are often complex, therefore effective management for forest wildlife requires a broad understanding of how forest structure and composition influence habitat use and vital rates during all aspects of annual life-cycles. The ruffed grouse (*Bonasa umbellus*) is a popular game bird that has long been a focal species for forest management, however, greater information on the links between forest characteristics and components of ruffed grouse reproduction would further enhance the ability of managers to promote the species. We monitored 45 ruffed grouse nests during 2015–2017 at two study areas in central Maine, USA, and evaluated the influence of forest characteristics on nest-site selection, nest survival, and female survival while nesting. Ruffed grouse females selected nest sites with greater horizontal visual obstruction ($\beta = 0.163 \pm 0.059$ 85% CI) and greater conifer stem density ($\beta = 0.075 \pm 0.054$ 85% CI) than found at other sites that were locally available to them, however, neither of these characteristics appeared to improve nest survival. Nest survival was reduced by the presence of coarse woody debris (CWD) at nest sites ($\beta = -0.410 \pm 0.332$ 85% CI), but we found no evidence that other habitat characteristics or characteristics of nests themselves were related to nest survival. However, reduced female survival while nesting was associated with the presence of CWD ($\beta = -1.057 \pm 0.778$ 85% CI), greater basal area ($\beta = -0.632 \pm 0.472$ 85% CI), and greater conifer stem density ($\beta = -0.333 \pm 0.224$ 85% CI) at nest sites. We provided management goals to promote attractive ruffed grouse nesting habitat while potentially mitigating multiple sources of nesting failure.

We also investigated multi-level resource selection and summer survival of non-reproductive and brood-rearing ruffed grouse in central Maine, USA, to understand the relationship between life-stage-specific resource selection and the cost of brood-rearing to ruffed grouse. At the landscape-level, non-reproductive ruffed grouse selected areas with greater stem densities ($\beta = 0.26$, 85% CI = 0.04 - 0.48), while brood-rearing females avoided these areas ($\beta = -0.38$, 85% CI = -0.65 - -0.12). Non-reproductive individuals further selected areas with greater stem densities at the local-level ($\beta = 0.38$, 85% CI = 0.04 - 0.72), while brood-rearing females again avoided areas with greater stem densities ($\beta = -0.66$, 85% CI = -1.12 - -0.21) and selected locally-available areas with greater ground cover by Rubus at this scale ($\beta = 0.38$, 85% CI = 0.13 - 0.63). Weekly survival rates were reduced for brood-rearing females ($S = 0.9551 \pm 0.0220$ SE) compared with non-reproductive individuals ($S=0.9973 \pm 0.0027$ SE), which resulted in a 76% chance that a female would survive raising a brood to 6 weeks. In contrast, non-reproductive individuals had a 98% chance of survival over the same 6-week period. Our results suggest that non-reproductive ruffed grouse selected resources that reduced their mortality risk, thereby investing in survival and their future reproduction, while brood-rearing females selected resources to benefit current reproduction and also incurred a cost to their own survival.

Investigator: Joelle "Ellie" Mangelinckx (MS)

Advisors: Erik J. Blomberg (Advisor)
Kelsey Sullivan
Brad Allen

Duration: August 2014—August 2017

Cooperators:

Maine Department of Inland Fisheries and Wildlife
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
Ruffed Grouse Society

Individual, colony, and metapopulation-level drivers of seabird colony dynamics

1. Investigate long-term costs of reproduction in a long-lived seabird.
2. Investigate differences in life-history strategy between two allopatric seabird populations with differing survival rates.
3. Investigate factors driving seabird productivity.
4. Investigate seabirds' ability to buffer productivity against fluctuations in food availability.
5. Investigate factors driving seabird colony initiation and extinction.
6. Investigate factors affecting seabird nesting patch selection.
7. Use results from 1-6 to develop an agent-based model of seabird dynamics to allow population-level prediction in novel situations.

Abstract: Seabirds have great potential to serve as marine indicators. However, before we can interpret seabird trends with confidence, we need a better understanding of the role of intrinsic processes, mediating influences, and lifetime experience in modulating relationships between prey availability and seabird population dynamics.

Intrinsic processes, mediating influences, and seabird productivity. I assessed productivity (chicks per breeding attempt) at Black-legged Kittiwake *(Rissa tridactyla)* colonies in Prince William Sound, AK and managed Common Tern *(Sterna hirundo)* colonies in the Gulf of Maine. Both systems showed evidence of intrinsic control; factors mediating access to prey were also important.

Mediating influences, individual heterogeneity, and seabird productivity. Productivity integrates events over successive reproductive stages, so events at one stage can modulate the effects of events at other stages. I investigated the effects of individual age and multiple stressors on kittiwake reproduction in Alaska. I found older birds enjoyed greater success across the board, but different external influences drove success at different stages. These results highlight the need to account for both individual heterogeneity and potential interactions among extrinsic processes in interpreting seabird productivity.

Individual heterogeneity and reproductive costs. Reproduction can incur short-term costs in the form of reduced parental survival or breeding activity in the following season. I found evidence of long-term costs in kittiwakes that underwent 0-4 forced nest failures in the early 1990s. Individuals that were forced to fail more were less likely to skip breeding over the following decade, presumably due to associated cost savings. The lack of an observed survival effect suggests that survival is well-buffered in long-lived species, with costs instead borne by parameters less important to lifetime reproductive success.

Intrinsic processes, individual heterogeneity, and seabird survival and recruitment. I investigated the role of colony size in survival, recruitment, and post-recruitment survival of kittiwakes from an Alaskan colony. I found declines in apparent survival associated with increased colony size, likely resulting from increased dispersal of individuals as the colony grew. Recruitment was age-dependent. These results highlight the need to consider intrinsic processes when relating marine bird population dynamics to prey availability and changes in marine ecosystems.

Investigator: Alyson McKnight (PhD)

Advisors: Shawn T. McKinney (Co-Advisor)
Cynthia S. Loftin (Co-Advisor)
Erik J. Blomberg
Brian J. Olsen
Jeffrey A. Runge
David Irons

Duration: September 2013—May 2017

Cooperators:

U.S. Fish and Wildlife Service

Biogeography and conservation of Maine's island amphibians, with focus on redback salamanders (*Plethodon cinereus*)

1. Survey Maine islands and near coastal areas for redback salamanders (*Plethodon cinereus*).
2. Conduct microsatellite DNA and trait-based assessments of genetic diversity, local adaptations, and colonization history of island redback salamanders and relate these data to spatial analyses of island features and historic sea levels.
3. Share information on islands likely to support genetically unique populations with stakeholders, and collaborate on outreach concerning the importance of islands for the natural history and conservation of Maine's amphibians.

Abstract: Island populations of terrestrial species have an increased potential, compared to mainland populations, to adapt and diverge, as these populations often are isolated with respect to gene flow from other populations and may be subjected to novel pressures. Indeed, extended isolation of individuals can elicit dramatic changes within populations and is recognized as a common driver of speciation. It is for these reasons that island populations are often a priority for conservation. Plethodontid salamanders are among the most terrestrial of Maine's amphibians and are not tolerant of prolonged exposure to seawater, and yet, they are found on a number of Maine's coastal islands. Here I present findings of the first study of the population genetic structure of Maine's island red-backed salamanders to elucidate their probable origins. I collected samples from 12 coastal island and 10 mainland sites. Using 9 microsatellite loci, I found that 199 of 210 pairwise comparisons showed significant multilocus differentiation. Island populations had fewer alleles and lower heterozygosity than most mainland populations. Islands farthest from shore displayed particularly strong divergence from all other sites, a finding consistent with ancient colonization. Phylogenetic and Bayesian structure analyses supported weak regional affiliation, which may be the result of extended isolation and divergence of distant island populations. Salamanders from island sites displayed no overall pattern of isolation by distance, whereas, those from mainland sites showed a weakly positive trend, implying a greater dispersal limitation among island populations.

Isotopic analyses revealed that Maine's coastal islands vary from one another and from mainland systems in productivity baselines and trophic structure, indicating potential differences in sources of primary productivity and food web structure. Alternative ecological dynamics such as these have the potential to instigate adaptive divergence of island salamanders from their mainland counterparts. Consistent with this idea, red-backed salamanders on Maine's coastal islands appear to feed at a higher mean trophic level than mainland salamanders, with smaller, seabird nesting islands featuring the highest estimated trophic position. Salamander populations varied widely in body size and morphological trait allometry suggesting potentially widespread trait divergence that may be linked to local adaptations. Within this general population variation, island populations featured larger head proportions (snout-gular length) for their body size, a pattern that may be adaptive given the higher mean trophic position of these populations. These findings suggest some island populations of *P. cinereus* likely represent isolated and potentially unique components of post-glacially derived variation within this widespread species and support the operation of mechanisms generating at least limited phenotype-environment associations in Maine's red-back salamanders. Indeed, Maine's island red-backed salamanders encourage a closer look at other widespread species on these coastal islands for the possibility that they similarly represent cryptic components of Maine's biodiversity.

Investigator: Nikko-Ideen Shaidani (MS)

Advisors: Cynthia S. Loftin (Co-Advisor)
Michael T. Kinnison (Co-Advisor)
Rebecca L. Holberton

Duration: September 2012—January 2017

Cooperators:

Maine Outdoor Heritage Fund
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service
University of Maine
National Park Service

Small mammals and seed predation: how their behavior and personality affects forest composition and regeneration.

1. To study how individual and population responses interact and affect seed predation. This includes investigating seed preference and choice, and behavior and personality 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. Our experiment is conducted using techniques such as PIT tags and high-resolution infrared game cameras, which allows us to estimate the predation rate of several 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 realistic estimates to be used in 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 in six trapping grids located in the Penobscot Experimental Forest (PEF) in Bradley, ME. Two grids, each with a replicate, were set in two different silvicultural treatment sites, and one grid (with a replicate) was set in a reference grid. Each grid contained 100 Longworth and 50 Tomahawk traps. Captures were processed twice daily, and individuals were marked with PIT tags and numbered metal ear tags. Weight, sex, reproductive status, and body measurements were also recorded. Additionally, three field tests were performed to measure personality.

Cafeteria-style experiments were performed to begin investigating seed choice and dispersal in both the field and the lab. Field seed choice experiments were conducted in two rounds during July and August 2017, and lab experiments are ongoing. Over 3,000 field videos recorded six small mammal species selecting seeds from seven available tree species. Lab experiments will collect videos from individuals of two species, captured in the PEF, housed in the lab, and released thereafter.

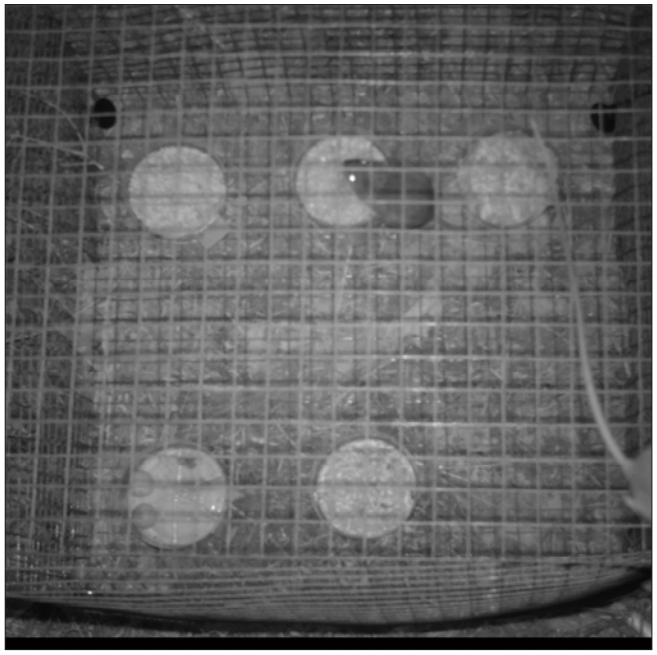
Investigator: Sara Boone (MS)

Advisors: Alessio Mortelliti (Advisor)

Duration: June 2017—December 2019

Cooperators:

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



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.

To investigate the effects of silvicultural practices on both individual and population-level parameters in small mammal communities, we are implementing a large-scale capture-mark recapture study. We will measure individual-level parameters such as body condition, survival, and personality. Population-level parameters that we will measure include density and population growth rates. The data that we collect will allow us to investigate whether or not forest management and forest disturbance give advantage to certain individuals based on personality type by using personality as a predictor of survival in capture-mark recapture models.

Small, scatter-hoarding mammals play a critical role in forest ecosystems through the key processes of seed predation and dispersal. There is extensive evidence that small mammal communities play a significant role in shaping forest composition by selecting the seeds of certain species over others. The decision to predate or disperse a seed is affected by multiple parameters such as vegetation cover, predation risk, seed abundance, and population density. These parameters are likely to be affected by silvicultural practices. Thus far, no previous studies have investigated the role that individual personality may play in the seed decision making process. We will address this key question through a series of seed predation experiments.

June-October of 2017 was the second and primary field season for this project. We continued our large-scale capture-mark recapture study in the Penobscot Experimental Forest in Bradley, ME. We processed over 2,000 captures and marked over 1,000 individuals with PIT tags and small mammal ear tags. We measured body condition (weight, body length, tail length, and reproductive status) and personality (using three different standardized tests) for each individual.

Along with trapping, we performed a seed experiment which will allow us to investigate the response of individual small mammals to seeds of different sizes. We presented seeds of varied size in the field. PIT reading technology identified individual animals and trail cameras recorded decisions made. We recovered dispersed seeds and measured dispersal distance, direction, seed fate, and location of cache. We will extract behavioral data from these videos and investigate these data for effects of personality on preference and dispersal behavior.

Investigator: Allison Brehm (MS)

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

Duration: June 2016—December 2018

Cooperators:

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

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.

American Woodcock (AMWO; *Scolopax minor*) and Golden-winged Warbler (GWWA; *Vermivora chrysoptera*), which require young forest habitat (YFH) for breeding, are experiencing population declines due to YFH loss in the United States. Conservation plans stress the importance of YFH management on public and private lands to increase AMWO and GWWA populations. I conducted avian point counts, GWWA playback surveys, and AMWO singing ground surveys to investigate bird use of four forest types in northcentral Wisconsin: mature aspen, mature alder, harvested aspen (<20 years) and sheared alder (<20 years). All harvested and sheared sites were on private family forest lands and mature sites were predominantly on public land. I will use ordination to compare the bird communities using each of the forest types. To understand the potential role of landowners in monitoring young forests on their properties, I conducted interviews asking questions about barriers and preferences for participating in citizen-science-based monitoring. In 2017, a protocol for landowner AMWO monitoring was piloted by landowners and their thoughts on the protocol and monitoring experience were captured through follow-up interviews. Archival light-level geolocators were deployed on male GWWA to gather information on migratory routes, timing, and duration, and stopover and wintering locations.

I completed two field seasons of AMWO singing ground surveys, GWWA playback surveys, and avian point counts in April-June 2016 and 2017 and conducted vegetation sampling in July 2016/2017. In 2016 GWWA were located and target-netted to deploy 28 light-level geoloctators and 21 control bird were banded. In 2017 we relocated 5/21 control birds and relocated and recovered 7/28 geolocators. Each of those seven birds received a new geolocator and an additional four male GWWA received geolocators. I will return for a short field season in June 2018 to search for these 11 GWWA geolocators. In 2017 I completed my pilot season on Wisconsin Woodcock Watch, a citizen science program for landowners to monitor woodcock in their management areas. Thirteen landowners participated in a total of 29 woodcock surveys and follow-up interviews. I am currently working on interview and geolocator analysis and will start eon bird community analysis this spring.

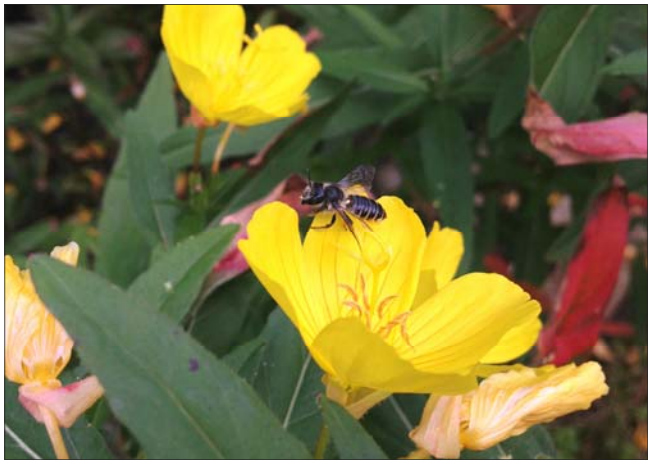
Investigator: Anna Buckardt (MS)

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

Duration: June 2016—December 2018

Cooperators:

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



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.

Native bees provide a critical ecosystem service to human and wildlife populations by pollinating fruit-bearing cultivated crops and wildlife forage. Historically, commercially managed bees have been an important pollinator of agricultural crops, however, Colony Collapse Disorder has decreased hive availability, increasing reliance on native bees to provide this service. Enhancing habitat around crop fields to promote native bee populations will benefit fruit production for both agricultural interests and wildlife populations. In Maine, wild blueberry growers invest heavily in honey bees for pollination; concern about pollination deficit due to fewer honey bees and growing costs has lead to increased interest in management to promote native bee pollination. This study is examining factors that potentially affect native bee abundance in wild and cultivated fruits from a spatial ecology perspective. Our spatial assessment includes evaluation of relationships between landscape pattern and composition and exposure of native bees to pesticides applied to crop fields; evaluates habitat quality of power line rights-of-way as semi-natural habitat for native bees; compares performance of a spatially explicit ecosystem service simulation model (InVEST) in landscape with different pattern complexities; and, develops a tool for blueberry growers to use to assess native bee habitat in the landscape surrounding their crop fields.

Parameters of the InVEST Crop Pollination model have been updated to reflect on the ground conditions, leading to improvement in model predictions. These predictions were incorporated into BeeMapper, an online decision support system, that displays estimated wild bee abundance throughout Maine's wild blueberry landscape. BeeMapper was launched in July 2017. Surveys of non-crop land cover and assessment of landscape pattern indicate that in Maine, wild bees are more diverse and abundant in urban areas and wild blueberry fields. In the heavily forested Downeast region, wild bees rely heavily on the resources provided by blueberry fields in the early summer and urban areas throughout the summer to survive and provision nests. Analysis of bee communities in power lines will be completed in Spring 2018. Project completion will be in May 2018.

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 2018

Cooperators:

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

Wildlife use of vernal pools in an urbanizing landscape with a focus on vernal pool-breeding amphibian population vitality

1. Characterize wood frog and breeding pools along a gradient of human disturbance via documentation of biotic factors (faunal assemblages, vegetation), abiotic factors (temperature, water chemistry, hydroperiod), and land cover types and configuration at various scales in the surrounding landscape;
2. Examine the effects of breeding pool characteristics on wood frog (*Lithobates sylvaticus*) survival, morphology, and disease susceptibility; and
3. Examine population dynamics (e.g., occupancy, breeding effort and success, and connectivity) relevant to wood frog and mole salamander (*Ambystoma spp.*) population persistence.

Pool-breeding amphibians in Maine are threatened by urbanization and the resultant habitat loss, fragmentation, and degradation. These amphibians require aquatic and terrestrial habitats to complete their life cycles and are, thus, sensitive to disturbances in both environments. Landscape conditions may not immediately affect population demographics, but there may be a time-lag between impaired individual condition and population reductions. It is currently unknown how pool-breeding amphibian health and survival are affected by various intensities of urbanization. Understanding how pool-breeding amphibians respond to urbanization will provide crucial information for land managers and policy makers to direct urban development that best conserves pool-breeding amphibians.

Our project addresses how urbanization affects pool-breeding amphibian health and survival. In 2018 we will analyze data and write and submit manuscripts to peer-reviewed journals addressing, specifically: (1) Pool-breeding amphibian larval morphology and survival along an urbanization gradient (written, will submit); (2) Response of terrestrial-stage phenotypes to site characteristics experienced during larval development (written, will submit); (3) Relationships between site characteristics and vernal pool-breeding amphibian reproductive effort along an urbanization gradient (will write and submit); and (4) Compile all manuscripts and datasets resulting from this project into a dissertation; PhD defense scheduled for April 26, 2018.

We completed three field seasons focusing on characterizing vernal pools and the health and survival of larval wood frog and mole salamander populations along a development gradient. We estimated reproductive effort and survival through metamorphosis using egg and late-stage larvae counts (manuscript in preparation). We conducted weekly tadpole development surveys and quantified site characteristics that likely affect larval health and survival (manuscript in preparation). We camera-trapped birds and mammals and submitted a manuscript, "Bird and mammal use of vernal pools along an urban development gradient" to Landscape and Urban Planning (in review). We conducted lab experiments examining how larval site characteristics affect terrestrial stage responses (manuscript in preparation) and how road salt, food availability, ranavirus infection, and insect predators affect wood frog tadpole growth, development, and survival.

Investigator: Carly Eakin (PhD)

Advisors: Malcolm L. Hunter, Jr. (Co-Advisor)
Aram J.K. Calhoun (Co-Advisor)
Hamish S. Greig
Rebecca L. Holberton
Michael T. Kinnison

Duration: August 2013—May 2018

Cooperators:

National Science Foundation – Experimental Program to Stimulate Competitive Research
University of Maine – Department of Wildlife, Fisheries, and Conservation Biology
University of Maine – Maine Agricultural and Forest Experiment Station

Development of optimal monitoring protocol for mesocarnivores in Maine

1. Assess optimal array (number and transect spacing) for motion-triggered trail cameras used to detect diverse mesocarnivore species in Maine.
2. Use trail cameras to survey 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 land use dynamics and the pros and cons of trail camera surveys as the tool relates to large-scale, multi-species management, research and conservation.

This research will assess 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. Understanding trends in the abundance and distribution of carnivores is 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, and 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.

During January to March 2017 we completed a pilot season of field work, setting up 32 stations of 5-camera arrays in three study areas. During April to May 2017, we analyzed the pilot season data and prepared for our summer fieldwork season. During June-September, we deployed 121 stations of 3-camera arrays in 15 study areas. Currently, we are analyzing data from this first year and planning our January to March 2018 fieldwork. Thereafter summer and winter field seasons will continue, including expanding our study areas, as well as ongoing analyses and report writing.

Investigator: Bryn E. Evans (PhD)

Advisors: Alessio Mortelliti (Advisor)
Cynthia S. Loftin
Walter Jakubas

Duration: January 2017—December 2021

Cooperators:

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

Land-use effects on movement between and around breeding sites by wood frogs

Investigator: Thomas Hastings

Supervisors: Malcolm L. Hunter, Jr.
Aram J.K. Calhoun

Participant: Kristine Hoffmann

Duration: September 2015—April 2018

Cooperators:

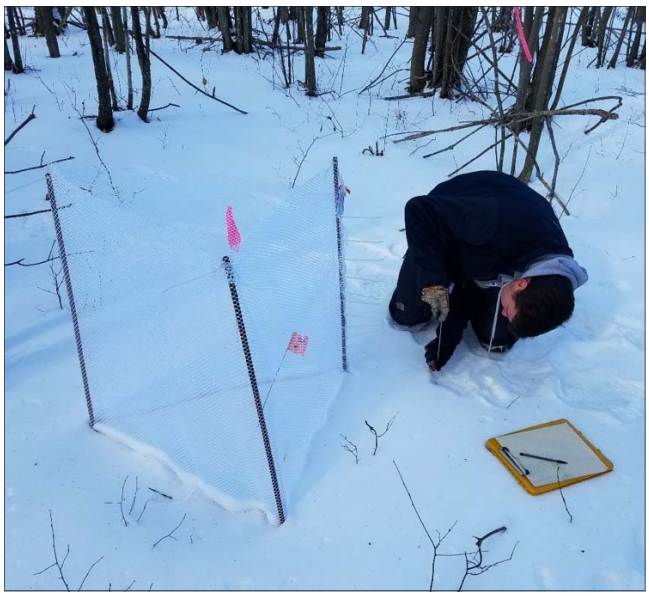
National Science Foundation – Dynamics of Coupled Natural and Human Systems (CNH)

1. We seek to understand the persistence of Wood Frogs in urban areas by studying their movements and habitat selection.
2. Quantify habitat selection and movements of frogs in urban areas at a course scale
3. Quantify the paths used by frogs to emigrate through an urban landscape at a fine scale
4. Compare the characteristics of urban hibernacula to random locations and to previous data on hibernacula in more natural forests.

Adult wood frogs were tracked in a forested wetland patch surrounded by suburban terrain such as neighborhoods, buildings, and roads. We captured frogs in traps at the breeding pool and by hand in terrestrial habitat.

Frogs in objective one were located daily from spring to hibernation, though most frogs were not online during the entire study. Frogs in objective two were located every hour from dusk to dawn on nights when movement occurred (rainy nights) and from dusk to midnight on nights when frogs did not move. For our hibernation objective, we built enclosures around each frog once in hibernacula to study winter survival and hibernacula selection. We placed climate data loggers in the hibernacula, as well as in random locations.

We have completed all field work for this project, and are currently modeling the results.



Water chemistry dynamics in four vernal pools in Maine, USA

1. Measure the aqueous concentrations of the greenhouse gasses CH_4 and CO_2 in four vernal pools in Maine. Estimate diffusive flux from these concentrations and other data collected.
2. Create a carbon mass balance for four vernal pools in Maine, using the evaporative flux and groundwater inflows and outflows. Compare carbon inputs to carbon outputs of vernal pools. Scale up the CH_4 and CO_2 emissions using the vernal pool density in Maine.
3. Identify environmental covariates of CH_4 and CO_2 in four vernal pools in Maine.
4. Characterize temporal water chemistry trends for four vernal pools in Maine. This information can be used to guide future studies of vernal pool biogeochemistry.

Vernal pools are small seasonal wetlands that are a common wetland landscape feature that contribute to biodiversity in northeastern North American forests. However, even basic information about their biogeochemical functions, such as carbon cycling, is limited. Dissolved gas concentrations (CH_4, CO_2) were monitored weekly at the bottom and surface of four vernal pools in central and eastern Maine. Fluxes of CH_4 and CO_2 into the atmosphere ranged from 0.2 to 73 mmol m-2 d-1, and 30 to 5.9×102 mmol m-2 d-1, respectively. This is a carbon export of up to 2.4×102 kgC, which is less than the estimated carbon leaf litter input. The production rates of CH_4 and CO_2 ranged from -2.4×10-2 to 6.6×10-1 and 4.0×10-1 to 4.6 gC m-2 d-1, respectively, and increased significantly over the season. Concentrations of CH_4 and CO_2 covaried with alkalinity, temperature, and dissolved oxygen. Our study pools were characterized by large concentrations and effluxes of CH_4 and CO_2 with respect to other permanently inundated wetlands, indicating vernal pools may be important contributors to the global carbon budget and are metabolically active sites.

In addition to dissolved gas concentrations, temporal trends of other water chemistry parameters were characterized in order to inform future studies on vernal pool biogeochemistry.

We have completed two field seasons: one where surface water samples were collected weekly at four vernal pools in Maine, and one where soil samples were collected at the same four pools. We analyzed the water samples for pH, dissolved oxygen, strong acid anions, strong base cations, gasses (CO_2, CH_4, and N_2O), P, N, Fe, Mn, Al, Si, DOC, and chlorophyll a between April and August 2016. Data sets for this project are completed. Data have been analyzed for CH_4 and CO_2 diffusive fluxes, mass balance, and environmental covariates. Water chemistry data has been analyzed for temporal trends. Master's thesis will be defended on November 16, 2017. A manuscript titled "Methane and carbon dioxide flux within four vernal pools in Maine, USA" will be submitted to Biogeochemistry by January 1, 2018.

Investigator: Lydia Kifner

Advisors: Aram J.K. Calhoun (Co-Advisor)
Aria Amirbahman (Co-Advisor)
Stephen A. Norton

Duration: August 2015—December 2017

Cooperators:

National Science Foundation – Dynamics of Coupled Natural and Human Systems (CNH)

Evaluation of representative bird species' Landscape Capability models developed by the Designing Sustainable Landscapes project in the 13-state, northeastern region of the United States

1. Evaluate relationships between abundance of selected representative species and DSL Landscape Capability products with breeding bird points count survey data collected within the northern region of the Connecticut River watershed and then across the NA-LCC region.
2. Evaluate Landscape Capability models under development for additional species (e.g., Cerulean Warbler) for which we have point count data and after upon completion of the models by the DSL project (scheduled for completion by 2015).
3. Evaluate relationships between predictions of representative species Landscape Capability models evaluated in Objectives 1-2 and the species they represent within ME, NH, PA, VA, and WV to evaluate the models from watershed to regional extents.
4. Provide information to managers regarding relationships of priority, forest-associated avian species populations and forest structure and landscape conditions to inform conservation and land management planning

The University of Massachusetts Designing Sustainable Landscapes (DSL) project has developed Landscape Capability models (LC) for representative species, integrating climate niche, habitat capability, and prevalence models to assess sustainability of the representative species in the 13 northeastern states under future landscape conditions. Several representative species for which Landscape Capability models have been completed are USFWS priority species of high conservation concern in coniferous, hardwood-dominated or mixed coniferous-deciduous forest in the northeastern region, and models for some representative species are expected to serve as surrogate models for other species with USFWS Northeast Region conservation priority designation. Although the LC models for most bird species have been evaluated with recent eBird data, they have not been evaluated with data collected in independent, systematic, repeated surveys, nor has the transferability of the representative species models been evaluated for the species they are assumed to represent. Additionally, the application of DSL models to meet regional population objectives remains uncertain, because these models have not been tested for associations between abundance while accounting for detectability. Our analysis will incorporate detectability in evaluating the utility and predictive ability of DSL LC models and will facilitate transferability of these models into concrete conservation objectives and actions.

Activity on the project began in early September 2015 with appointment of the Post-Doctoral Research Associate, Dr. Zachary Loman, to the project. We have completed evaluation of DSL LC models for Ruffed Grouse, American Woodcock, and representative species and published these analyses in manuscripts. Our evaluation of the represented species models is is summarized in a manuscript currently in review. We currently are assessing the value of additional site-based data for improving DSL model performance. Those analyses will be summarized in a manuscript to be submitted for review in early 2018. The project will be completed during 2018.

Investigator: Zachary Loman (Postdoc)

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

Duration: September 2015—May 2018

Cooperators:

U.S. Geological Survey – Biological Resources Discipline
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service
U.S. Geological Survey – Science Support Program

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.

To test for effects from forestry on bird densities, we conducted multi-species point count surveys in 2013 through 2015 during the breeding season of most passerine species (June through August) in the silvicultural treatments listed above. Our surveys recorded the number of birds present for each species along with variables that may influence their probabilities of detection. We measured vegetation at each survey location in 2014. Stand attributes will be used to assess habitat selection on focal species and communities. Additionally, we surveyed Bay-breasted Warbler reproductive success and spruce budworm adult moths (prey) in 2015. These data will be supplemented with USGS Breeding Bird Survey data to address large-scale questions, temporal trends, and the influence of budworm outbreaks. We will model habitat selection by birds to make inference about their responses to silvicultural management. We thank the U.S.F.W.S. Migratory Bird Division; U.S.F.W.S. National Wildlife Refuge System; UMaine Cooperative Forestry Research Unit; UMaine Department of Wildlife, Fisheries, and Conservation Biology; Maine Cooperative Fish and Wildlife Research Unit; and Baxter State Park for access to sites, project support, and funding.

We established sampling protocols for birds and vegetation and collected multi-species bird data at five areas throughout the Acadian forest region: Nulhegan NWR (VT), Umbagog NWR (NH), North Maine Woods (ME), Baxter State Park (ME), Aroostook NWR (ME), and Moosehorn NWR (ME) using standardized point count surveys. A total of 6,163 bird surveys were conducted during the summer of 2013, 2014, and 2015, and 65,760 detections of birds were collected during surveys at 657 point count locations within 117 forest stands. Vegetation surveys were completed at all sites during 2014. Reproductive success and eastern spruce budworm data were collected in 2015. All field data collection was completed in 2015. Statistical analysis and reporting of results are underway, with project completion anticipated in mid 2018.

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—May 2018

Cooperators:

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

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 2018.

Investigators: Kirstie Ruppert (PhD)

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

Duration: January 2017—December 2019

Cooperators:

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

Population dynamics of spruce grouse in the managed forest landscapes of northern Maine

1. Estimate demographic rates of spruce grouse, including adult survival, nest success, chick survival, and recruitment using radio-telemetry and capture-mark-recapture methods.
2. Evaluate habitat characteristics at multiple spatial scales to determine how spruce grouse select resources and how these choices affect demographic rates during important life history phases such as nesting, brood rearing, and dispersal.
3. Relate objectives one and two to population performance using predictive stage-structured population models. Then, use these results to evaluate the overall trajectory of spruce grouse populations, and classify populations as stable, increasing, or declining.
4. Provide guidance in the form of a status evaluation and recommendations for future conservation of spruce grouse populations. Specifically, with regards to how forest management activities may promote habitat structure and composition that is consistent with healthy spruce grouse populations.

Spruce grouse are native forest birds that inhabit conifer forests throughout the northern U.S. and Canada. The mixed Acadian forests of the northeastern U.S. represents the southeastern periphery of the spruce grouse's range. In other northeastern states spruce grouse are state-listed as threatened or endangered, but the current status of spruce grouse in Maine is unclear. We are using radio telemetry and mark-recapture methods to collect data on survival and reproductive success of marked individuals. Survival is being evaluated year-round, as well as during distinct biological season's (e.g. breeding vs. overwinter). Reproductive success is being monitored during the spring and summer breeding season (May - August). We are monitoring birds in areas of varying forest composition and silvicultural activities, and have sampled vegetation characteristics at the micro-site scale as well as to characterize habitat at a larger scale that would likely be used on a daily or seasonal basis. Using these data we will evaluate the current status of spruce grouse populations to determine the populations trajectory based on observed demographic rates. Ultimately, we will link population characteristics to components of spruce grouse habitat for the purpose of informing forest management and state-level management decisions.

During the 2017 field season we monitored 41 radio-marked spruce grouse, including 19 that were previously radio-marked and 22 captured during the 2017 field season. We located and monitored six nests, and obtained weekly location and survival data for nine females between mid-June and 1 August. We conducted vegetation sampling at nest sites and three dependent random locations near nests. We also measured vegetation at weekly locations of females and at one dependent random location for each. All radio-marked birds, including those captured during fall, were located twice per week from 1 August through 31 October. We will continue monitoring survival of radio-marked grouse once per month over the winter. With the bulk of fieldwork now complete, we will be focusing on data analysis and manuscript preparation during 2018.

Investigator: Joel Tebbenkamp (PhD)

Advisors: Erik J. Blomberg (Co-Advisor)
Daniel J. Harrison (Co-Advisor)
Rebecca L. Holberton
Alessio Mortelliti
Shawn Fraver
Brad Allen
Kelsey Sullivan

Duration: September 2014—May 2018

Cooperators:

Maine Department of Inland Fisheries and Wildlife
Maine Outdoor Heritage Fund
University of Maine – Maine Cooperative Forestry Research Unit
University of Maine – Maine Agricultural and Forest Experiment Station
Katahdin Forest Management
Gerald Pelletier, Inc.

INTEGRATED ecology

Eco-evolutionary implications of environmental change across developing landscape.....51

Assessing Priority Amphibian and Reptile Conservation Areas (PARCAs) and vulnerability to climate change in the North Atlantic Landscape Conservation Cooperative 53

Eco-evolutionary implications of environmental change across developing landscape

1. Empirically evaluate the consequences of ongoing urbanization on the structure and connectivity of Maine's wood frog and spotted salamander populations.
2. Develop eco-evolutionary agent-based models to examine consequences of varying rates and forms of environmental perturbation across a complex landscape.
3. Examine evidence of genetic selection associated with urbanization in wood frogs.
4. Quantify the gene expression profiles of ESD infected and uninfected lobsters to evaluate correlations between environmental stress and disease presence.

The influence of natural and anthropogenic barriers to gene flow among wood frog and spotted salamander populations will be assessed using a landscape genetics approach, whereby observable inter-population genetic structure is evaluated for correlations with various landscape features. Genome scan approaches will be used to identify signals of genetic selection through comparisons of allele frequencies for several rural and urban wood frog populations. The patterns documented using those analyses will be incorporated into agent-based simulation models (ABMs), which will be used to assess the ecological and evolutionary responses of species to environmental perturbation. Because ABMs allow simulated individuals with unique characteristics to interact with each other, they provide an excellent tool for capturing emergent phenomena in naturally complex eco-evolutionary systems. Finally, as part of an interdisciplinary research effort designed to improve understanding of the causes of epizootic shell disease (ESD), I will be quantifying differences in gene expression profiles of infected and uninfected lobster from presumably high stress and low stress environments. These analyses will be competed using the RNA-Seq technique, which has recently been developed to utilize advances in next generation sequencing technologies to quantify gene expression profiles in non-model organisms.

Sampling for wood frog and spotted salamander larvae for use in landscape genetic analyses was conducted throughout Maine in the springs of 2014, 2015, and 2016. In total, 2,935 wood frogs and 2,862 spotted salamanders from over 100 sites were collected and genotyped. Analyses indicate strongest population structuring and reduced connectivity coincide with areas of greatest urban development. Genomic data collection has been completed to examine signs of selection associated with urbanization for wood frogs and analyses identified several genomic regions that may be experiencing divergent selection. The agent-based model simulation framework is currently under development with hypotheses being established and the details of the models being finalized. I have completed analyses to evaluate signals of differential expression associated with epizootic shell disease in American lobster and have identified several genes that are likely associated with the disease such as those related to apoptosis and the production of chitin.

Investigator: Jared J. Homola (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Michael T. Kinnison (Co-Advisor)
Malcolm L. Hunter, Jr.
Timothy M. Waring
Andrew R. Whiteley

Duration: September 2013—August 2018

Cooperators:

Maine Department of Inland Fisheries and Wildlife
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
Maine Association of Wetland Scientists
NSF Adaptation to Abrupt Climate Change IGERT
Central Maine Power
National Science Foundation – Dynamics of Coupled Natural and Human Systems (CNH)

Assessing Priority Amphibian and Reptile Conservation Areas (PARCAs) and vulnerability to climate change in the North Atlantic Landscape Conservation Cooperative

1. Compile reptile and amphibian species record data from states in the NE-LCC region into a data base.
2. Develop species distribution models of priority amphibians and reptiles in the NA-LCC region. Combine these models with richness data to identify conservation areas for priority reptile and amphibian species (PARCAs).
3. Combine modeled PARCAs with climate vulnerability models to identify areas within the NA-LCC where losses of vulnerable species are anticipated, where potential climatic refugia for priority species occur, and identify species for which gaps in current known distributional data prohibit these projections.
4. Identify conservation lands that fall within the priority amphibian and reptile areas identified in Objective 2, and identify areas with highest priority for supporting reptiles and amphibians in the Northeast that are not currently protected.
5. Incorporate climate vulnerability projections into final PARCA analysis, including a ranking of high priority current and future conservation areas.
6. Communicate results to key state, federal, and NGO partners via publications and regional workshops.

Amphibians and reptiles are experiencing severe habitat loss throughout North America; however, this threat to biodiversity may be mitigated by identifying and conserving areas that serve a disproportionate role in sustaining herpetofauna. Identification of such areas must take into consideration the dynamic nature of habitat suitability. Areas currently deemed climate-suitable may no longer be so in the future. We are collaborating with scientists from Clemson University, Tennessee State University, Maine Department of Inland Fisheries and Wildlife, and the Association of Fish and Wildlife Agencies to generate spatially-explicit models to (1) identify Priority Amphibian and Reptile Conservation Areas (PARCAs) – those discrete areas most vital to maintaining reptile and amphibian diversity, (2) project regions of current and future climatic suitability for a number of priority reptiles and amphibians in the North Atlantic Landscape Conservation Cooperative, and (3) identify gaps in distributional data for these species that may prevent or inhibit the identification of species-level climatic suitability.

We received species occurrence data from 13 NA-LCC states and Washington, DC and converted datasets into a spatial format. We combined occurrence data with expert-selected environmental variables to develop species distribution models with the Maximum Entropy modeling approach, combined these models with species richness information, and spatially applied guidelines (Sutherland and deMaynadier 2012) for identifying priority reptile and amphibian habitat to model draft PARCAs. We evaluated draft models developed with richness data from state and web-available sources, scaled to state and ecoregions within state, and with alternative estimates of landscape viability, incorporating feedback from state reptile and amphibian experts into the revised PARCA maps. We combined the proposed PARCAs with species climate niche models to evaluate predicted distributions of climate suitable habitat with climate change. Project files have been uploaded to DataBasin, and review with states to confirm release of their PARCA maps is nearly completed. We are compiling the project summary report, which includes a detailed methods summary, assessment of the representativeness of priority species habitat in the draft PARCAs, and provides guidelines for spatially implementing the criteria (Sutherland and deMaynadier 2012) in other regions. The project summary report will be completed during early 2018.

Investigators: Cynthia S. Loftin, Phillip deMaynadier, Kyle Barrett, William B. Sutton, Priya Nanjappa, Allison Moody

Duration: August 2012—December 2017

Cooperators:

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

PUBLICATIONS and presentations

SCIENTIFIC PUBLICATIONS

Bartolommei P., Sozio G., Bencini C., Cinque C., Cozzolino R., Gasperini S., Manzo E., Prete S., Solano E., and Mortelliti A. 2016. Field identification of *Apodemus flavicollis* and *Apodemus sylvaticus*: development of an empirical model for practical purposes. *Mammalia* 80:541-547.

Begley, M., S. Coghlan, Jr., and J. Zydlewski. 2017. A comparison of age, size, and fecundity of harvested and intact White Sucker (*Catostomus commersoni*) populations in Maine. *North American Journal of Fisheries Management* 37:510–523. DOI:10.1080/02755947.2017.1290719.

Blomberg, E.J., D. Gibson, J.S. Sedinger, and M.T. Atamian. 2017. Variable drivers of primary versus secondary nesting; density-dependence and drought effects on greater sage-grouse. *Journal of Avian Biology* 48:827-836.

Calhoun, A.J.K., D. Mushet, L.C. Alexandr, E.S. Dekeyser, L. Fowler, C.R. Lane, M.W. Lang, M.C. Rains, S.C. Richter, and S.C. Walls. 2017. The significant surface-water connectivity of "Geographically Isolated Wetlands". *Wetlands* DOI:10.1007/s13157-017-0887-3.

Clare, J., S.T. McKinney, C.S. Loftin, and J.E. DePue. 2017. Multiple methods improve inferences and evaluate method-specific biases, with extensions for observation dependence. *Ecological Applications* DOI:10.1002/eap.1587.

Cline, B.B. and M.L. Hunter, Jr. 2016. Initial movements of a dispersing amphibian in response to partial harvesting in the Acadian forest of Maine, USA. *Forest Science* 62:333-342.

Cline, B.B. and M.L. Hunter, Jr. 2016. Movement in the matrix: Substrates and distance to forest edge affect the post-metamorphic movements of a forest amphibian. *Ecosphere* 7(2):e01202.10.1002/ecs2.1202.

Coates, P.S., M.A. Ricca, B.G. Prochazka, M.L. Brooks, E.J. Blomberg, K.E. Doherty, C.A. Hagen, and M.L. Casazza. 2017. Fire, climate, and invasive grass impact and indicator species by reshaping sagebrush ecosystems. *Proceedings of the National Academy of Sciences* 113:12745-12750.

Coates, P.S., M.L. Casazza, M.A. Ricca, B.E. Brussee, E.J. Blomberg, K.B. Gustafson, C.T. Overton, D.M. Davis, L.E. Neil, S.P. Esinosa, S.C. Gardner, and D.J. Delehanty. 2016. Integrating spatially explicit indices of abundance and habitat quality: an applied example for greater sage-grouse management. *Journal of Applied Ecology* 53:83-95.

Cohen, M.J., I.F. Creed, L. Alexander, N.B. Basu, A.J.K. Calhoun, et al. 2016. Do geographically isolated wetlands influence landscape functions? *Proceedings of the National Academy of Sciences* 113:1978-1986.

Dibello F.J., A.J.K. Calhoun, D.E. Morgan, and A.F. Shearin. 2016. Efficiency and detection accuracy using print and digital stereo aerial photography for remotely mapping vernal pools in New England Landscapes. *Wetlands* 36:505-514.

Fremgen, M., D. Gibson, R. Ehrlich, A. Krakauer, J. Forbey, E. Blomberg, J. Sedinger, G. Patricelli. 2017. Necklace-style radio-transmitters are associated with changes in display vocalizations of male Greater Sage-grouse. *Wildlife Biology* DOI:10.2981/wlb.00236. http://www.bioone.org/doi/pdf/10.2981/wlb.00236.

Gibson, D., E.J. Blomberg, M.T. Atamian, and J.S. Sedinger. 2016. Nesting habitat selection

influences reproductive success beyond survival of the nest in a ground-nesting bird with nidifugous offspring. *Condor: Ornithological Applications* 118:689-702.

Gibson, D., E.J. Blomberg, M.T. Atamian, and J.S. Sedinger. 2017. Weather, habitat composition, and female behavior interact to modify offspring survival in greater sage-grouse. *Ecological Applications* 27:168-181.

Groff, L., C.S. Loftin, and A.J.K. Calhoun. 2017. Predictors of breeding site occupancy by pool-breeding amphibians in Maine's wetland-limited, montane landscapes. *Journal of Wildlife Management* 81:269–278. DOI:10.1002/jwmg.21184.

Groff, L.A., A.J.K. Calhoun, and C. Loftin. 2016. Hibernal ecology and habitat selection of wood frogs (*Lithobates sylvaticus*) in a northern New England montane landscape. *Journal of Herpetology* 50:559-569. http://dx.doi.org/10.1670/15-131R1.

Groff, L.A., A.J.K. Calhoun, C.S. Loftin. 2017. Amphibian terrestrial habitat selection and movement patterns vary with annual life history period. *Canadian Journal of Zoology* 10.1139/cjz-2016-0148.

Groff, S.C., C.S. Loftin, F.A. Drummond, S. Bushmann, and B. McGill. 2016. Parameterization of the InVEST Crop Pollination Model to spatially predict abundance of wild blueberry (*Vaccinium angustifolium Aiton*) native bee pollinators in Maine, USA. *Environmental Modeling and Software* 79:1-9.

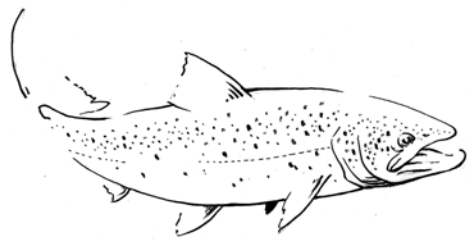
Hager, S.B., B.J. Cosentino, M.A. Aguilar-Gómez, M.L. Anderson, M. Bakermans, T.J. Boves, D. Brandes, M.W. Butler, E.M. Butler, N.L. Cagle, R. Calderón-Parra, A.P. Capparella, A. Chen, K. Cipollini, A.A.T. Conkey, T.A. Contreras, R.I. Cooper, C.E. Corbin, R.L. Curry, J.J. Dosch, M.G. Drewq, K. Dyson, C. Foster, C.D. Francis, E. Fraser, R. Furbush, N. Hagemeyer, K.N. Hopfensperger, D. Klem, Jr., A. Lahey, K. Lamp, G. Lewis, S.R. Loss, C.S. Machtans, J. Madosky, T.J. Maness, K.J. McKay, S.B. Menke, K.E. Muma, N. Ocampo-Peñuela, T.J. O'Connell, R. Ortega-Álvarezk, A.L. Pitt, A.L. Puga-Caballero, J.E. Quinncc, C.W. Varian-Ramosmm, C.S. Ridingdd, A.M. Roth, P.G. Saenger, R.T. Schmitz, J. Schnurr, M. Simmons, A.D. Smith, D.R. Sokoloski, J. Vigliotti, E.L. Walters, L.A. Walters, J. Weir, K. Winnett-Murray, J.C. Withey, I. Zuria. 2017. Continent-wide analysis of how urbanization affects bird-window collision mortality in North America. *Biological Conservation* 212:209-215.

Hoffmann, K., A. Calhoun, and M. Hunter. 2016. A Deep-Water Funnel Trap for Salamanders. *Herpetological Review* 47:205-206.

Hunter, M.L., D. Lindenmayer, and A.J.K. Calhoun. 2016. Saving the earth as a career: Advice on becoming a conservation professional. 2nd edition. Wiley-Blackwell, Oxford, United Kingdom.

Hunter, M.L., P. Barton, A.J.K. Calhoun, et al. 2016. Two roles for ecological surrogacy: Indicator surrogates and management surrogates. *Ecological Indicators* 63:121-125.

Izzo, L., Maynard, G.A., and Zydlewski, J. 2016. Upstream movements of Atlantic salmon in the lower Penobscot River, Maine following two dam removals and fish passage modifications. *Marine and Coastal Fisheries* 8(1):448-461. DOI:10.1080/19425120.2016.1185063.



Kane, K., J. Sedinger, D. Gibson, E.J. Blomberg, and M. Atamian. 2017. Fitness landscapes and life table response experiments predict the importance of local areas to population dynamics. *Ecosphere* DOI:10.1002/ecs2.1869.

Kay, G., Driscoll D.A., Lindenmayer D., Pulsford S.A., and Mortelliti A. 2016. Pasture height and crop direction influence reptile movement in an agricultural matrix. *Agriculture, Ecosystems and Environment* 235:164–171.

Kay, G.M.., Mortelliti A., Tulloch A., Barton P., Wood J., and Lindenmayer D. 2017. Effects of past and present livestock grazing on herpetofauna in a landscape-scale experiment. *Conservation Biology* 31:446–45.

Larkin, J.L., D. Raybuck, A.M. Roth, L. Chavarria-Duriaux, G. Duriaux, M. Siles, H. Streby, and C. Smalling. 2017. Light-level geolocation technology confirms alignment of Golden-winged Warbler wintering and breeding grounds conservation efforts and reveals areas used as prolonged stopover sites. *Journal of Field Ornithology* 88:288-298.

Levesque, V., A.J.K. Calhoun, and K.P. Bell. 2016. Turning contention into collaboration: Engaging power, trust, and learning in collaborative networks. *Society and Natural Resources* 1-16.

Levesque, V., K.P. Bell, and A.J.K. Calhoun. 2016. Planning for sustainability in small municipalities: The influence of interest groups, growth patterns, and institutional characteristics. *Journal of Planning, Education, and Research* p.0739456X16655601.

Lindenmayer D., Mortelliti A., Ikin K., Pierson J., Crane M., Michael D., Okada S. 2017. The vacant planting: limited influence of habitat restoration on colonization and extinction patterns by arboreal marsupials in south-eastern Australia. *Animal Conservation* 20:294–304.

Loman, Z.G., E.J. Blomberg, W.V. Deluca, D.J. Harrison, C.S. Loftin, and P.B. Wood. 2017. Landscape capability predicts upland game bird abundance and occurrence. *Journal of Wildlife Management* DOI:10.1002/jwmg.21265.

Maynard, G.A., Kinnison, M.T., and Zydlewski, J. 2017. Size selection from fishways and potential evolutionary responses in a threatened Atlantic salmon population. *River Research and Applications* 2017:1–12. DOI:10.1002/rra.3155.

McGreavy, B., A.J.K. Calhoun, V. Levesque, and J.S. Jansujwicz. 2016. Citizen science and natural resource governance: Applying a resilience framework to vernal pool policy innovation. *Ecology and Society* 21:48. http://dx.doi.org/10.5751/ES-08437-210248.

Midway, S., Wagner, T., Zydlewski, J., Irwin, B., and Paukert, C. 2016. Transboundry fisheries science: Meeting the challenge of inland fisheries in the 21st century. *Fisheries*, 41(9):536-546. DOI:10.1080/03632415.2016.1208090.

O'Malley, A., Enterline, C., and Zydlewski, J. 2017. Comparison of size, growth and age structure among anadromous and landlocked populations of rainbow smelt (*Osmerus mordax*). *North American Journal of Fisheries Management* 37:2, 326-336. DOI:10.1080/02755947.2016.1264508.

Sponarski, C.C., Loeffler, T.A., Vaske, J.J. and Bath A.J. 2016. Changing attitudes and emotions toward coyotes with experiential education. *Journal of Environmental Education* 47(4):296-306. DOI:http://dx.doi.org/10.1080 /00958964.2016.1158142.

Sponarski, C.C., Spacapan, M., Miller, C.A., and Vaske, J.J. 2016. Modelling perceived risk from coyotes among Chicago residents. *Human Dimensions of Wildlife* 21(6):491-505. DOI:10.1080/10871209.2016.1190989.

Tulloch, A., Mortelliti, A., Kay, G.F., Laurance, D., Lindenmayer, D.B. 2016. Using empirical models of species colonization under multiple threatening processes to identify complementary threat mitigation strategies. *Conservation Biology* 30:867–882.

Vaske, J.J., Beaman, J., and Sponarski, C.C. 2016. Rethinking the internal consistency of Cronbach's alpha. *Journal of Leisure Sciences* DOI:http://dx.doi.org/10.1080/01490400.2015.1127189.

Villaseñor, N.R., D.A. Driscoll, P. Gibbons, A.J.K. Calhoun, and D.B. Lindenmayer. 2016. Contrasting responses of common and rare frogs to aquatic and terrestrial variables in a forest-urban gradient and their implications for amphibian conservation. *Landscape and Urban Planning* 157:26-37.

Weaver, D., Coghlan, S., and Zydlewski, J. 2016. Sea lamprey carcasses exert local and variable food web effects in a nutrient-limited Atlantic coastal stream. *Canadian Journal of Fisheries and Aquatic Sciences* (online) DOI:10.1139/cjfas-2015-0506.

Weaver, D.M., S.M. Coghlan Jr., and J. Zydlewski. 2017. Sea lamprey carcasses exert local and variable food web effects in a nutrient-limited Atlantic coastal stream. *Canadian Journal of Fisheries and Aquatic Science* 73:1-10.

Wood, C.M., J.W. Witham, and M.L. Hunter Jr. 2016. Climate-driven range shifts are stochastic processes at a local level: two flying squirrel species in Maine. *Ecosphere* 7(2):e01240.10.1002/ecs2.1240

Wood, C.M., S.T. McKinney, and C.S. Loftin. 2016. Intraspecific functional diversity of common species enhances community stability. *Ecology and Evolution* DOI:10.1002/ece3.2721.

Zydlewski J., Stich, D.S., and Sigourney, D. 2016. Hard choices in assessing survival past dams; a comparison of single and paired release strategies. *Canadian Journal of Fisheries and Aquatic Sciences* (999) 1-13. DOI:10.1139/cjfas-2015-0480.

TECHNICAL AND SEMI-TECHNICAL PUBLICATIONS

Dunham, S. and D. Harrison. 2017. Spruce grouse habitat in the Acadian forests of Maine: Results

and recommendations for forest managers. CFRU Research Note No. 17-01, Maine Cooperative Forestry Research Unit. University of Maine. Orono, ME.

Harrison, D., S. Morano, and S. Olson. 2016. Relationships among forest harvesting, snowshoe hares, and Canada lynx in Maine. Pages 52-56 *in* Roth, B.E. (Ed.) Cooperative Forestry Research Unit: 2015 Annual Report. University of Maine. Orono, ME.

Loftin, C.S, R. Carey, and K. Goodine. 2017. The Maine Cooperative Fish and Wildlife Research Unit and University of Maine Department of Wildlife Ecology 2016 Annual Report to Cooperators. 50 pp.

Loman, Z., D. Harrison, C.S. Loftin, P.B. Wood. 2016. Evaluation of representative bird species' landscape capability models developed by the designing sustainable landscapes project in the 13-state, northeastern region of the United States. Annual report of project activity to the USFWS. 7 pp.

Rolek, B., D. Harrison, C. Loftin, and P. Wood. Report 2016. Bird communities of coniferous forests in the Acadian region: habitat associations and responses to forest management. Pages 57-61 *in* Roth, B.E. (Ed.) Cooperative Forestry Research Unit: 2015 Annual Report. University of Maine. Orono, ME.

Tebbenkamp, J., E. Blomberg, D. Harrison, and S. Dunham. 2016. Population dynamics of spruce grouse in the managed forest landscapes of northern Maine. Pages 57-61 *in* Roth, B.E. (Ed.) Cooperative Forestry Research Unit: 2015 Annual Report. University of Maine. Orono, ME.

THESES AND DISSERTATIONS

Allen, B. 2017. "American woodcock migration ecology at an important stopover, Cape May, New Jersey". M.S. Thesis, Wildlife Ecology, University of Maine, Orono: 73 pp.

Begley, M. 2016. "Understanding the impact of commercial harvest on white suckers (*Catostomus commersonii*) in Maine". M.S. Thesis, Wildlife Ecology, University of Maine, Orono: 105 pp.

Davis, S. 2017. "Survival, harvest, and drumming ecology of ruffed grouse in central Maine, USA". M.S. Thesis, Wildlife Ecology, University of Maine, Orono: 61 pp.

Groff, L. 2016. "The habitat ecology of pool-breeding amphibians during all annual life history periods in the mountains of the dawn". Ph.D. dissertation, Wildlife Ecology, University of Maine, Orono: 164 pp.

Hoffmann, K.E. 2017. "Breeding ecology and habitat use of unisexual salamanders and their sperm-hosts, Blue-Spotted Salamanders (*Ambystoma laterale*)". Ph.D. Dissertation, Wildlife Ecology, University of Maine, Orono: 112 pp.

Mangelinckx, J. 2017. "Nesting ecology and summertime resource selection of ruffed grouse in central Maine, USA". M.S. Thesis, Wildlife Ecology, University of Maine, Orono: 76 pp.

McKnight, A. 2017. "Population ecology of colonially breeding seabirds: How intrinsic processes, mediating influences, and individual heterogeneity affect population vital rates". Ph.D. Dissertation, Ecology and Environmental Sciences, University of Maine, Orono: 199 pp.

Shaidani, N. 2017. "The biogeographic origins and trophic ecology of Maine's island red-backed salamanders (*Plethodon cinereus*)". M.S. Thesis, Zoology, University of Maine, Orono: 87 pp.

Watson, J. 2017. "Effects of dam removal on assemblage composition and the interactions of fishes in the Penobscot River, Maine". M.S. Thesis, Wildlife Ecology, University of Maine, Orono: 79 pp.

Weaver, D. 2017. "Sea lamprey (*Petromyzon marinus*) as a functional link between marine and freshwater ecosystems". Ph.D. dissertation, Wildlife Ecology, University of Maine, Orono: 147 pp.

PROFESSIONAL TALKS PRESENTED

Allen, B.B., D.G. McAuley, E.J. Blomberg, R. Brown, and C. Dwyer. 2016. "Habitat selection by American Woodcock during fall stopover on Cape May Peninsula, New Jersey". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster

Blomberg, E.J. 2016. "Integrating new technologies in forest grouse research and management". The Wildlife Society Annual Conference, Raleigh, NC. October 2016.

Bollert, L., C. Eakin, A. J. K. Calhoun, and M. L. Hunter. 2016. "Prevalence of Ranavirus and Icthyophonus symptoms in wood frog (*Lithobates sylvaticus*) tadpoles". Poster presented at the annual meeting of the Northeast Partners in Amphibian

and Reptile Conservation, Poultney, VT. August 10.

Bothwell, K. and A.M. Roth. 2017. "Economic impacts of wildlife regulations on forest management: the opportunity cost of managing deer wintering areas". The Wildlife Society Maine Chapter, New England Society of American Foresters, and Northeastern Forest Pest Council Annual Meeting, Bangor, ME. March 8.

Buckardt, A., and A.M. Roth. 2017. "Barriers to citizen science: investigating pre-participant family forest landowners in a wildlife monitoring case study". International Symposium on Society and Resource Management, Umeå, Sweden. June 19-22.

Buckardt, A. and A. Roth. 2017. "Evaluating conservation approaches that aim to reverse the decline of young-forest-dependent bird species". 2017 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish, and Wildlife Research Unit, Orono, ME. March 22. Poster.

Calhoun, A.J.K. 2017. Keynote presentation: "Conserving pools and watersheds: spanning and matching of scales". Maine Sustainability and Water Conference, Augusta, ME. March 30.

Calhoun, A.J.K. and E. Hertz. 2017. Symposium coordinators. "New approaches to integrating wetland conservation into land-use planning". Sustainability and Water Conference, Augusta, ME. March 30.

Coghlan Jr., S.M. 2017. "Back to the future: An old idea gives new insight into conflicts between fish and dams". Atlantic Salmon Research Forum, Machias, ME. February 2017.

Davis, S., E.J Blomberg, J. Mangelinckx, B. Allen, and K. Sullivan. 2016. "Seasonal survival and harvest rates of ruffed grouse in central Maine, USA". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster.

Davis, S., E.J Blomberg, J. Mangelinckx, B. Allen, and K. Sullivan. 2016. "Habitat selection and the effects on male ruffed grouse display behavior and performance in central Maine, USA". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster.

Du Clos, B., Loftin, C.S., and Drummond, F.A. 2017. "Wild bee communities in non-crop land cover in the Maine wild blueberry landscape". Oral presentation. One Hundred and second Annual Meeting of the Ecological Society of America, Portland, OR. 6-11 August.

Eakin, C.E., A.J.K. Calhoun, and M.L. Hunter. 2017. "Wood frog (*Lithobates sylvaticus*) larval condition, development, and survival along an urbanization gradient". Society of Wetland Scientists Annual Meeting, San Juan, Puerto Rico. June 5.

Harrison, D. J., B. W. Rolek, C.S. Loftin, P.B. Wood. 2017. "Effects of forest management practices in Acadian conifer forests on spruce-fir bird communities". Presentation to Irving Corporation Wildlife Biologists and Foresters and to the New Brunswick Forest Research Advisory Committee Advisory, Sainte Anne de Madawaska, New Brunswick, Canada. May 30.

Hastings, T., M. Jones, M.L. Hunter, and A.J.K. Calhoun. 2016. "Wood frog (Lithob*ates sylvaticus*) movement through a suburban landscape". Poster presented at the annual meeting of the Northeast Partners in Amphibian and Reptile Conservation, Poultney, VT. August 10.

Hastings, T.P., A.J.K. Calhoun, and M.L. Hunter. 2017. "Wood frog (*Lithobates sylvaticus*) habitat selection and movement in a suburban landscape". Society of Wetland Scientists Annual Meeting, San Juan, Puerto Rico. June 5.

Hertz, E. and A.J.K. Calhoun. 2017. "Maine vernal pool special management plan". New England Chapter of the Society of Wetland Scientists, Biddeford, ME. May 6.

Hoffmann, K., A. Calhoun, and M. Hunter. 2016. "Pitfalls of analyzing pitfall data on amphibian orientation". Talk to the annual meeting of the Northeast Partners in Amphibian and Reptile Conservation, Poultney, VT. August 11.

Hoffmann, K., A.J.K. Calhoun, and M.L. Hunter. 2017. "Environmental factors affecting wetland use by cryptic salamanders". Society of Wetland Scientists Annual Meeting, San Juan, Puerto Rico. June 5.

Homola, J.J., M.T. Kinnison, and C.S. Loftin. 2017. "Comparative landscape genetics of two vernal pool amphibians in an urbanizing landscape". Presentation at the Annual Meeting of the Society

of Wetland Scientists, San Juan, Puerto Rico. 5-8 June.

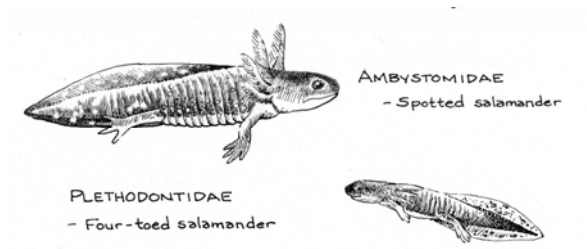
Homola, J.J., M.T. Kinnison, and C.S. Loftin. 2017. "Comparative population structure of two pool breeding amphibian species in an urbanizing landscape". Presentation at the Annual Meeting of Evolution, Portland, OR. 23-27 June.

Homola, J.J., S.L. Belknap, K.R. Tanaka, C.S. Loftin, and M.T. Kinnison. 2017. "Differential gene expression associated with epizootic shell disease infection in wild-caught American lobster". Presentation at the Annual Meeting of the American Fisheries Society, Tampa, FL. 20-24 August.

Kifner, L., A. Amirbahman, A.J.K. Calhoun, and S. Norton. 2017. "Greenhouse gas fluxes from four vernal pools in Maine, USA". Society of Wetland Scientists Annual Meeting. San Juan, Puerto Rico. June 5.

Loftin, C., W. Sutton, P. deMaynadier, K. Barrett, P. Nanjappa, and A. Moody. 2016. "Modeling priority amphibian and reptile conservation areas (PARCAs) in the northeastern United States". Annual meeting of The Wildlife Society, Raleigh, NC. 15-21 October.

Loftin, C.S., W. Sutton, K. Barrett, P. deMaynadier, P. Nanjappa, and A. Moody. 2017. "Priority amphibian and reptile conservation areas: Navigating quantitative approaches and expert opinion to identify conservation areas and evaluate vulnerability". 73rd Annual Meeting of the Northeast Association of Fish and Wildlife Agencies, Norfolk, VA. 9-11 April.



Loftin, C.S., W. Sutton, K. Barrett, P. deMaynadier, P. Nanjappa, and A. Moody. 2017. "Priority Amphibian and Reptile Conservation Areas: Navigating quantitative approaches and expert opinion to identify conservation areas and evaluate vulnerability". Annual Meeting of the Maine Chapter of The Wildlife Society, Bangor, ME. 9 March.

Loman, Z., E.J. Blomberg, W.V. Deluca, D. Harrison, C.S. Loftin, B.W. Rolek, and P.B. Wood. 2016. "Landscape capability as a predictor of upland game bird space use in the northeastern United States". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster

Loman, Z.G., E.J. Blomberg, W.V. Deluca, D.J. Harrison, C.S. Loftin, and P.B. Wood. 2016. "Validating landscape capability as a predictor of upland game bird abundance and occurrence". Poster presentation at the Annual meeting of The Wildlife Society, Raleigh, NC. 15-21 October.

Loman, Z., D. Harrison, C. Loftin, and P.B. Wood. 2017. "Validation of designing sustainable landscapes models using forest game birds, passerine birds, and a representative species approach". Workshop on representative species model analyses. US Fish and Wildlife Service, Hadley, MA. January 12.

Loman, Z.G., .W.V. Deluca, D.J. Harrison, C.S. Loftin, and P.B. Wood. 2017. "Do representative forest songbirds effectively predict occurrences of ecologically similar species?" 73rd Annual Northeast Fish and Wildlife Conference, Norfolk, VA. April 11.

Mangelinckx, J., E.J. Blomberg, S. Davis, B. Allen, and K. Sullivan. 2016. "Summer habitat selection by non-reproductive ruffed grouse in Maine". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster.

Mangelinckx, J., E.J. Blomberg, S.B. Davis, B. Allen, and K. Sullivan. 2016. "Nest-site selection and nesting success of ruffed grouse in Maine". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster.

McKnight, A., C.S. Loftin, and S.T. McKinney. 2017. "Universal drivers of seabird productivity: Patterns across two systems". Gulf of Maine Seabird Working Group Winter Meeting, Bangor, ME. 29 March.

McKnight, A., E. Blomberg, D. Irons, C. Loftin, and S. McKinney. 2017. "Colony size influences fidelity in a colonial nesting seabird". Presentation at the 44th Annual Meeting of the Pacific Seabird Working Group, Greater Tacoma Convention and Trade Center, Tacoma, WA. 22-25 February.

Morano, S., E.J. Blomberg, and C. Mosby. 2016. "Monitoring bat populations in Maine: new strategies for citizen science data collection". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster

Mushet, D. and A.J.K. Calhoun. 2017. "Biotic connectivity: breaking down the geographically isolated wetlands wall". AWRA spring specialty conference, Reston, VA. April 25.

Parkhill, N.S., J.M. Tebbenkamp, S.W. Dunham, D.J. Harrison, and E.J. Blomberg. 2016. "Effect of

forest structure on nest site selection by spruce grouse across two spatial scales". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster

Rolek, B.W., D. Harrison, C.S. Loftin, and P.B. Wood. 2017. "Workshop on spruce-fir birds, management, and habitat associations". U.S. Fish and Wildlife Service Migratory Bird Division. Hadley, MA. 12 January.

Rolek, B.W., D.J. Harrison, C.S. Loftin, and P.B. Wood. 2017. "Regenerating clearcuts and post-harvest treatments increase spruce-fir avian assemblages and richness in managed stands". Presentation at the 24th Annual Meeting of The Wildlife Society, Albuquerque, NM. 23-27 September.

Roth, A.M. 2016. "Midwest landbird migration monitoring network – process and progress 2011-2016". State of Stopover Symposium, Milwaukee, WI. October 5-7. Poster.

Roth, A., W. Mueller, B. Lenz, and K. Koch. 2016. "Midwest landbird migration monitoring network – process and progress 2011-2016." Annual meeting of the Inland Bird Banding Association, Connersville, IN. November 11-13. Poster.

Roth, A., M. Shieldcastle, W. Mueller, B. Lenz, K. Koch. 2017. "Midwest Migration Network: Coordinated regional research for migrating landbirds." Joint Meeting of American Ornithological Society and the Society of Canadian Ornithologists, East Lansing, MI. August 2.

Roth, A.M. 2017. "Wanted: Researchers and banders to participate in the Midwest Migration Network." Annual meeting of the Inland Bird Banding Association, Kalamazoo, MI. September 30.

Ruppert, K., D. O'Connor, C.C. Sponarski, and J. Glikman. 2017. "Taking towers: Uncovering drivers of giraffe hunting behavior in northern Kenya". 2017 Maine Sustainability and Water Conference, Augusta, ME. March. Poster.

Shute, K., E.J. Blomberg, and C. Wood. 2016. "Statistical analysis of trapping biases related to small mammals in western Maine and New Hampshire". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster.

Sponarski, C.C., J.J. Vaske, and A.J. Bath. 2017. "Discriminant and convergent validity: Comparing relationship between wildlife value orientations and normative beliefs". Pathways to Success Conference, Estes Park, CO. September.

Sponarski, C.C., J.J. Vaske, TA. Loeffler, and A.J. Bath. 2017. "Can experiential education have long term effects on attitudes and risk perceptions toward coyotes?" International Symposium on Society and Resource Management 2017 Conference, Umeä, Sweden. June.

Sponarski, C.C., J.J. Vaske, TA. Loeffler, and A.J. Bath. 2017. "Can experiential education change attitudes and emotions toward coyotes over the long term?" Northeastern Recreation Research Symposium (NERR) 2017 Conference, Annapolis, MA. April.

Sullivan, K., E.J. Blomberg, M. Martin, and A. Demusz. 2016. "Spatial and temporal trends in density and site-occupancy of ruffed grouse in Maine". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster.

Sutton, W.B., K. Barrett, C. Loftin, P. deMaynadier, P. Nanjappa, A. Moody. 2016. "Determining vulnerability of priority amphibian and reptile conservation areas to climate change in the Northeastern United States". Presentation at the Annual Meeting of The Wildlife Society, Raleigh, NC. 15-21 October.

Tebbenkamp, J., E. Blomberg, D. Harrison, and R. Holberton. 2016. "Is autumnal display associated with territorial defense or mate prospecting? A case study with spruce grouse". The Wildlife Society Annual Conference, Raleigh, NC. October 15-19.

Tebbenkamp, J.T., E.J. Blomberg, D.J. Harrison, and R.L. Holberton. 2016. "Is autumnal display associated with territorial defense or mate prospecting? A case study with spruce grouse". The Wildlife Society Annual Conference, Raleigh, NC. October 2016. Poster.

Zydlewski, J. 2016. "Fish and Dams". St. John River Watershed International Cross-Boundary Riverside Resort and Conference Centre, Fredericton, New Brunswick, Canada (via webinar). November 1.

Zydlewski, J. 2017. "Fish and Dams". Maine Association of Wetland Scientists (MAWS) Annual Winter Conference, Bowdoin College, Brunswick, ME. March 23.

Zydlewski, J. 2017. "Fish and Dams". Ontario Ministry of Natural Resources and Forestry, Great Lakes Management Unit Conference, Geneva Park Ramara, Ontario, Canada. April 5.

PUBLIC TALKS PRESENTED

Ames, C., Zydlewski, G., Kinnison, M., and Zydlewski, J. 2017. "Road to Success: Determining the status and responses of Gulf of Maine sturgeon to management". Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 22.

Barber, B., Gibson, J., and Zydlewski, J. 2017. "Marine-derived nutrient cycling in the St. Croix River, Maine". Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 22.

Calhoun, A.J.K. 2017. EPA interagency training on conserving wetlands at a landscape scale, webinar. August 17.

Calhoun, A.J.K. and E. Hertz. 2017. "The Maine vernal pool special area management Plan". Scarborough town officials, Scarborough, ME. May 18.

Calhoun, A.J.K. and E. Hertz. 2016. "An innovative, local vernal pool conservation tool". GrowSmart Maine annual meeting. Thomas College, Waterville, ME. Oct.

Calhoun, A.J.K. and E. Hertz. 2017. "Maine vernal pool special area management plan". Annual meeting of the Maine Land Trust Network, Topsham, ME. April 21.

Calhoun, A.J.K. and E. Hertz. 2017. Invited presentation to Board of Environmental Protection on Delegated authority for Topsham, Maine to implement the Vernal Pool Special Area Management Program, Augusta, ME. May 4.

Du Clos, B., C.S. Loftin, and F. Drummond. 2017. "Landscape pattern and native bee communities in the northeastern U.S." Poster Presentation at the Annual Meeting of the Maine Cooperative Fish and Wildlife Research Unit's Coordinating Committee Meeting, Orono, ME. 22 March.

Du Clos, B., C.S. Loftin, and F. Drummond. 2017. "Landscape pattern and native bee communities in the northeastern U.S." Presentation at the Annual Meeting of the Maine Cooperative Fish and Wildlife Research Unit's Coordinating Committee Meeting, Orono, ME. 22 March.

Harrison, D. 2017. Field tour of Black Brook management unit in northern New Brunswick with foresters from Irving Corporation. May 31.

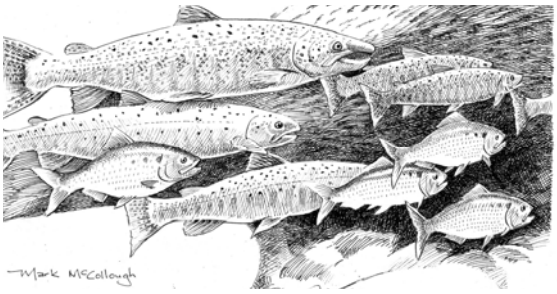
Harrison, D.J., B.W. Rolek, C.S. Loftin, P.B. Wood. 2017. "Effects of forest management practices in Acadian conifer forests on forest bird communities, with emphasis on species of conservation priority". Presentation to Advisory Committee of Maine Cooperative Forestry Research Unit, Orono, ME. April 12.

Heres, B., E. Blomberg, and J. Zydlewski. 2017. "Forecasting downstream migration of American eel". Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 22.

Homola, J.J., M.T. Kinnison, and C.S. Loftin. 2017. "Comparative population structure of vernal pool amphibians across a changing landscape". Presentation at the Maine Cooperative Fish and Wildlife Research Unit's Annual Coordinating Committee Meeting, Orono, ME. 22 March.

Homola, J.J., M.T. Kinnison, and C.S. Loftin. 2017. "Comparative population structure of vernal pool amphibians across a changing landscape". Poster. Maine Cooperative Fish and Wildlife Research Unit's Annual Coordinating Committee Meeting, Orono, ME. 22 March.

Job, K., Schaffler, J., and Zydlewski, J. 2017. "Using otolith microchemistry to infer habitat use of American shad and American eel prior to dam removal in the Penobscot River, Maine". Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 22.



Loftin, C.S. 2016. "Responsible conduct in research: Animal welfare". Presentation to SFR 521 Research Methods, University of Maine, Orono, ME. 2 November.

Loftin, C.S., W. Sutton, K. Barrett, P. deMaynadier, P. Nanjappa, and A. Moody. 2016. "Priority amphibian and reptile conservation areas: Navigating quantitative approaches and expert opinion to identify conservation areas and evaluate vulnerability". Seminar Series, National

Center for Geographic Information and Analysis, University of Maine, Orono, ME. 19 November.

Loftin, C.S., W. Sutton, K. Barrett, P. deMaynadier, P. Nanjappa, and A. Moody. 2017. "Combining quantitative approaches and expert opinion to identify priority amphibian and reptile conservation areas (PARCAs) and evaluate vulnerability". Seminar Series, Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME. 13 February.

Loman, Z.G., D. Harrison, C.S. Loftin, and P.B. Wood. 2017. "Evaluation of a fine-grained landscape conservation planning tool for songbird conservation in the Northeastern United States". Annual Meeting of the Maine Cooperative Fish and Wildlife Research Unit's Coordinating Committee Meeting, Orono, ME. 22 March.

Maynard, G., Kinnison, M., and Zydlewski, J. 2017. "Assessing anadromous fish migrations and habitat connectivity following a major restoration effort in the Penobscot River, Maine". Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 22.

McKnight, A., C.S. Loftin, and S.T. McKinney. 2017. "Universal drivers of seabird productivity: Patterns across two systems". Maine Cooperative Fish and Wildlife Research Unit Annual Coordinating Committee Meeting, Orono ME. 22 March.

Molina-Moctezuma, A., and Zydlewski, J. 2017. "Assessing Atlantic salmon downstream migration in a changing system (Penobscot River, Maine)". Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 22.

Rolek, B.W., D. Harrison, C.S. Loftin, and P.B. Wood. 2017. "Softwood forest birds and forestry in New England". Maine Cooperative Fish and Wildlife Research Unit Annual Coordinating Committee Meeting, Orono ME. 22 March.

Ruppert, K., D. O'Connor, C.C. Sponarski, and J. Glikman. 2017. "Taking towers: Poaching as a threat to giraffe in northern Kenya". Maine Cooperative Fish and Wildlife Research Unit 2017 Coordinating Committee Meeting, University of Maine, Orono, ME. March 22. Poster.

Sutton, W., C.S Loftin, K. Barrett, P. deMaynadier, P. Nanjappa, and A. Moody. 2016. "Priority Amphibian and Reptile Conservation Areas: Navigating quantitative approaches and expert opinion to identify conservation areas and evaluate vulnerability". Seminar Series, University of Georgia, School of Forestry and Natural Resources, Athens, GA. 10 October.

Vogel, S., Jansujwicz, J., and Zydlewski, J. 2017. "How regulatory agencies weigh energy and environmental tradeoffs in dam relicensing". Annual meeting of the Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. March 22.

Watson, J., Coghlan, Jr., S.M., Zydlewski, J., Hayes, D. and Kiraly, I. 2017. "Dam removal and fish passage improvement influence fish assemblages in the Penobscot River, Maine". Maine Cooperative Fish and Wildlife Research Unit Annual Meeting, University of Maine, Orono. March 22.

Weaver, D.M., S.M. Coghlan Jr., L.B. Perkins, and J. Zydlewski. 2017. "Sea Lamprey carcasses influence nutrient recycling in an Atlantic coastal stream". Maine Cooperative Fish and Wildlife Research Unit Annual Meeting, University of Maine, Orono, ME. March 22.

Zydlewski, J. 2016. "Fish and Dams". UNH American Fisheries Society Seminar Series. University of New Hampshire, Durham, NH. November 28.

Zydlewski, J. 2017. "Fish and Dams- Understanding our impounded legacy". Senator George J. Mitchell Center for Sustainability Solutions Lecture Series, University of Maine, Orono, ME. April 3.

Zydlewski, J. 2017. "Fish and Dams". Bristol Mills Town Meeting, Maine. May 9.

Zydlewski, J. 2017. "Track-2 NEST and Dams: Overview of the New England Sustainability Consortium (NEST) and its safe beaches and shellfish project and the new future of dams project". 2017 Maine EPSCoR State Conference, University of Maine, Orono, ME. May 23.

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

Blomberg, E. 2016. Ruffed grouse research in the Northwoods Sporting Journal, December 2016.

Blomberg, E. 2017. "If you like grouse, you'll like this information." George's Outdoor News, a Bangor Daily News Blog Post. January 25.

Blomberg, E. 2017. "Maine bats fighting for survival". Lewiston Sun Journal. April 23.

Blomberg, E. 2017. Ruffed grouse research in the Northwoods Sporting Journal, March 2017.

DuClos, B. 2017. "Brianne Du Clos has created a tool to help wild blueberry farmers". Portland Press Herald. July 23.

DuClos, B. 2017. "Scientists to unveil new tool to map bees around farms". AP News. July 19.

DuClos, B. 2017. "UMaine researchers to unveil wild bee habitat assessment tool July 19". UMaine News. July 17.

Zydlewski, J. 2016. "Taking down dams and letting the fish flow". Interview with Clay Groves of Fish Nerds Podcast (http://www.fishnerds.com/fishing-podcast/?s=128). November 17.

Zydlewski, J. 2016. "Taking down dams and letting the fish flow". New York Times. October 24.

Zydlewski, J. 2016. "American Shad in changing river in Maine". Wildlife Management Institute Outdoor News Bulletin. December 2016 edition.

AWARDS

Calhoun, A.J.K. 2017. Rising Tide Career Award.

Du Clos, B. 2016. Graduate Student Research Presentation Award, International Congress of Entomology.

Du Clos, B. 2017. Edith M. Patch and Frank H. Lathrop Prize in Entomology, University of Maine, School of Biology and Ecology.

Du Clos, B. 2017. Norris Charles Clements Graduate Student Award, University of Maine, College of Natural Sciences, Forestry, and Agriculture.

Du Clos, B. 2017. The Edith M. Patch Award for Graduate Excellence, The Friends of Dr. Edith Marion Patch

Homola, J. 2017. University of Maine, Graduate School, Janet Waldron Doctoral Research Fellowship.

Homola, J. 2017. University of Maine, School of Biology and Ecology, Graduate Prize in Animal Biology.

Zydlewski, J. 2017. Graduate Student Government Mentor Award for Graduate Faculty for the College of Natural Sciences, Forestry, and Agriculture.

The University of Maine does not discriminate on the grounds of race, color, religion, sex, sexual orientation, including transgender status and gender expression, national origin, citizenship status, age, disability, genetic information or veteran status in employment, education, and all other programs and activities. The following person has been designated to handle inquiries regarding nondiscrimination policies: Director, Office of Equal Opportunity, 101 North Stevens Hall, 207.581.1226, equal.opportunity@maine.edu.