Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife Ecology, University of Maine

2012 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, Rena A. Carey, and Katherine Goodine

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

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/

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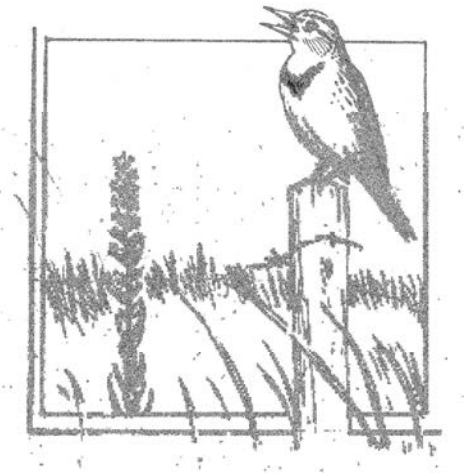
MISSION statement

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 coordinated 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., four-toed salamanders, freshwater mussels, Atlantic salmon, brook trout, Canada lynx, and marsh birds); (2) management and habitat-related studies with special reference to the effects of land and water-use practices (e.g., logging, 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 Ecology are pleased to summarize the past year's accomplishments and activities in this annual report. Together, we have collaborated with scientists from State and Federal agencies, universities, and non-governmental organizations on 34 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. 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 projects into three categories (Fisheries and Aquatic, Wildlife and Habitats, Integrated Ecology) to capture our program variety. This report includes summaries of research ranging from defining species-habitat relationships to modeling species responses to habitat change or management actions to developing tools to integrate public input into natural resource management decisions. Many of these projects are recently begun, some are long-term studies, and several 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 31 graduate students, and 7 graduate students completed requirements for M.S. or Ph.D. degrees. Our new graduates are working for universities and state and federal agencies, as well as pursuing additional graduate degrees.

The year brought several changes to the Unit and its cooperators. Dr. James Gilbert retired from the University of Maine after 36 years as a faculty member where he served as Wildlife Ecology Department Chair for 14 years. Dr. Judith Rhymer assumed the Chair position in January 2012. The Unit's Assistant Unit Leader-Wildlife position was filled in February with the addition of Dr. Shawn McKinney. Dr. McKinney is a forest community ecologist and worked with the National Park Service in the western United States before joining the Unit. We welcomed Katherine Goodine to the Department and Unit in early Fall; Katherine and Rena Carey provide administrative support to our program. The Wildlife Ecology Department continues to be the home for the Ecology and Environmental Sciences undergraduate and graduate degree programs, directed by Dr. Aram Calhoun. The Wildlife Ecology Department's Master of Wildlife Conservation non-thesis program began its second year with five graduate students. Other changes are on the horizon for the department, as current department Chair, Dr. Judith Rhymer, prepares for retirement in mid-2013 and plans are developed for future faculty hires. The Maine Department of Inland Fisheries and Wildlife (MDIFW) also welcomed new staff to their programs. During the past year we have had opportunities to build relationships with MDIFW, and we look forward to continuing to work with them to address their resource management information needs.

The Unit and Department look forward to another year of continuing and new relationships 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 AGENCIES

UNIVERSITY OF MAINE

Dr. Michael Eckardt, Vice President for Research

Dr. Judith M. Rhymer, Chair: Department of Wildlife Ecology

MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE

Mr. John Boland, Director, Bureau of Resource Management

U.S. FISH AND WILDLIFE SERVICE

Ms. Laury Zicari, Supervisor, Maine Field Office

U.S. GEOLOGICAL SURVEY

Dr. B. Ken Williams, 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

Shawn T. McKinney, Assistant Unit Leader for Wildlife and Assistant Professor of Wildlife Ecology

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

SUPPORT STAFF

Rena Carey, Administrative Support Supervisor

Katherine Goodine, Administrative Specialist

COLLABORATING AGENCIES AND ORGANIZATIONS

American Philosophical Society
American Recovery and Reinvestment Act (ARRA)
Androscoggin River Watershed Council
Army Corps of Engineers
Atlantic Salmon Federation
Biodiversity Research Institute
Biology Department, Acadia University, Nova Scotia, Canada
Biology Department, SUNY Potsdam, NY
Connecticut Department of Energy and Environmental Protection
Cooperative Fish and Wildlife Research Unit, University of Massachusetts
Eastern Maine Conservation Initiative
Holt Woodlands Research Foundation
Lowe's Home Centers, Inc.
Maine Association of Wetland Scientists
Maine Audubon Society
Maine Bureau of Parks and Lands
Maine Department of Environmental Protection
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
Maine Outdoor Heritage Fund
Maine River Bird Volunteer Network
Maine Sea Grant
Maine State Planning Office
Maine Water Resources Research Institute
Massachusetts Division of Fisheries and Wildlife
Massachusetts Institute of Technology (MIT) Lincoln Laboratory
National Fish and Wildlife Foundation
National Oceanic and Atmospheric Administration
National Park Service
National Science Foundation
National Science Foundation – Experimental Program to Stimulate Competitive Research
New Hampshire Fish and Game Department
New York State Department of Environmental Conservation
Newry, Town of
Orono Land Trust
Orono, Town of
Pennsylvania Fish & Boat Commission's Natural Diversity Section
Penobscot Indian Nation
Penobscot River Restoration Trust
Penobscot Valley Audubon Chapter
Project SHARE (Salmon Habitat and River Enhancement)
Swampwalkers Wetland Ecosystem Specialists, Parker River Association, MA
The Nature Conservancy
Topsham, Town of
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 – Eastern Brook Trout Joint Venture
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
University of Guelph
University of Maine
University of Maine – Department of Wildlife Ecology
University of Maine – Electrical and Computer Engineering Department (ECE)
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 – Senator George J. Mitchell Center for Environmental and Watershed Research
University of Maine – Sustainable Solutions Initiative

UNIVERSITY OF MAINE COLLABORATORS

Department of Wildlife Ecology

Judith M. Rhymer, *Chair, Associate Professor*
Aram J.K. Calhoun, *Professor*
Krista Capps, *Postdoctoral Associate*
Stephen M. Coghlan, Jr., *Assistant Professor*
James R. Gilbert, *Professor Emeritus*
Margaret Guyette, *Postdoctoral Associate*
Daniel J. Harrison, *Professor*
Malcolm L. Hunter, Jr., *Professor*
Linda Ilse, *Research Assistant* Professor
William B. Krohn, *Professor Emeritus*
Allison Moody, *Postdoctoral Associate*
Dawn E. Morgan, *Research Associate*
Frederick A. Servello, *Professor*
Lindsay C.N. Seward, *Instructor*
Douglas Sigourney, *Postdoctoral Associate*
Jack W. Witham, *Assistant Scientist*

School of Biology & Ecology

Francis A. Drummond, *Professor*
William E. Glanz, *Associate Professor of Zoology and Cooperating Professor of Wildlife*
Michael T. Kinnison, *Associate Professor*
Joyce .E. Longcore, *Research Associate Professor*
Brian J. McGill, *Assistant Professor of Biological Sciences*
Brian J. Olsen, *Assistant Professor of Biology & Ecology*
Jasmine E. Saros, *Associate Professor*
Kevin S. Simon, *Associate Professor*
Seth Tyler, *Professor of Zoology and Cooperating Professor of Marine Sciences*

School of Earth and Climate Sciences

Andrew S. Reeve, *Professor*

School of Economics

Kathleen P. Bell, *Associate Professor*
Mario Teisl, *Professor*

School of Forest Resources

Alan J. Kimball, Associate *Professor*
Steven A. Sader, *Professor*
Robert S. Seymour, *Curtis Hutchins Professor of Forest Resources*
Alan S. White, *Professor*

School of Marine Sciences

Teresa R. Johnson, *Assistant Professor Marine Policy*
Gayle B. Zydlewski, *Assistant Professor*

Department of Mathematics & Statistics

William Halteman, *Professor and Co-Chair*
David Hiebeler, *Associate Professor*

EXTERNAL COLLABORATORS

Michael M. Bailey, *Fish Biologist, U.S. Fish and Wildlife Service*
James P. Bogart, *Professor Emeritus, University of Guelph*
Angela Fuller, *Assistant Professor and Assistant Unit Leader, NY Cooperative Fish and Wildlife Research Unit*
Daniel B. Hayes, *Professor, Michigan State University, Department of Fisheries and Wildlife*
Joseph E. Hightower, Assistant Unit Leader, *NC Cooperative Fish and Wildlife Research Unit*
Michael W. Klemens Ph.D., *Michael W. Klemens, LLC.*
John Kocik, *Maine Task Chief, NOAA - NMFS Maine Field Station*
Daniel G. McAuley, *Station Leader, USGS Patuxent Wildlife Research Center*
Mark McCollough, *Endangered Species Specialist, U.S. Fish and Wildlife Service*
Dave Owen, *Associate Professor, University of Maine School of Law*
Brad Timm, *Department of Environmental Conservation, University of Massachusetts*
Joan G. Trial, *Senior Biologist, Maine Department of Marine Resources*
Jennifer H. Vashon, *Wildlife Biologist, Maine Department of Inland Fish and Wildlife*
Karen Wilson, *Assistant Research Professor, Department of Environmental Science and Aquatic Systems Group, University of Southern Maine*
Petra B. Wood, *Assistant Unit Leader-Wildlife, WV Cooperative Fish and Wildlife Research Unit*

GRADUATE COMMITTEE PARTICIPATION

Unit scientists served as major advisors or committee members for these students during the reporting period.

Loftin..... Erynn M. Call, PhD (April 2009 – Present)
Shannon Chapin , MS (January 2012 – Present)
Sarah Drahovzal, MS (September 2008 – Present)
Luke Groff, PhD (January 2011 – Present)
Margaret Guyette, PhD (January 2008 – September 2012)
Brianne Looze, PhD (September 2012 – Present)
Ian McCullough, MS (September 2010 – June 2012)
Brian Rolek, PhD (September 2012 – Present)
Amanda Shearin, PhD (June 2006 – May 2012)

McKinney.....Stephen Dunham, MS (January 2012 – Present)

Zydlewski.....Wesley Ashe, MS (September 2009 – September 2012)
Erynn M. Call, PhD (April 2009 – Present)
Britt Cline, PhD (January 2010 – Present)
Paul Damkot, MS (May 2010 – Present)
Ann Grote, MS (January 2010 – Present)
Margaret Guyette, PhD (January 2008 – September 2012)
Robert Hogg, MS (October 2009 – Present)
Edward Hughes, MS (October 2009 – May 2012)
Ian Kiraly, MS (January 2010 – August 2012)
Silas Ratten, MS (January 2011 – Present)
Kevin Ryan, PhD (January 2008 – Present)
Daniel Stich, PhD (March 2011 – Present)

RECENT GRADUATES AND CURRENT PURSUITS

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

Wesley Ashe MS, Wildlife Ecology — September 2012
Assistant Regional Fisheries Biologist, Maine Department of Inland Fisheries & Wildlife — Stephen M. Coghlan, Jr.

Sasha Greenspan, MS, Ecology and Environmental Sciences — December 2011
Field Ecologist, Joseph W. Jones Ecological Research Center, GA, — Aram J.K. Calhoun

Margaret Guyette, PhD, Wildlife Ecology — September 2012
Post-Doc, University of Maine, Orono — Cynthia S. Loftin, Joseph D. Zydlewski

Edward Hughes, MS (non-thesis), Ecology and Environmental Sciences — May 2012
Oregon Department of Fish and Wildlife — Joseph D. Zydlewski

Ian Kiraly, MS, Wildlife Ecology — August 2012
Environmental Scientist, Gomez & Sullivan Engineers, P.C. — Stephen M. Coghlan, Jr.

Ian McCullough, MS, Wildlife Ecology — June 2012
PhD Student, University of California, Santa Barbara — Cynthia S. Loftin, Steven A. Sader

Amanda Shearin, PhD, Ecology and Environmental Sciences — May 2012
Biologist, Maine Department of Transportation — Aram J.K. Calhoun, Cynthia S. Loftin

CURRENT STUDENTS

Student, Degree, Curriculum	*Advisor(s)*
Erynn Call, PhD, Wildlife Ecology	Malcolm L. Hunter, Jr.
Shannon Chapin, MS, Ecology and Environmental Sciences	Cynthia S. Loftin, Francis A. Drummond
Chen-An Chen, Master of Wildlife Conservation	Malcolm L. Hunter, Jr.
Brittany Cline, PhD, Wildlife Ecology	Malcolm L. Hunter, Jr.
Paul Damkot, MS, Wildlife Ecology	Stephen M. Coghlan Jr.
Adam Derkacz, Master of Wildlife Conservation	Malcolm L. Hunter, Jr.
Sarah Drahovzal, MS, Ecology and Environmental Sciences	Cynthia S. Loftin, Judith M. Rhymer
Rachel Dunham, Master of Wildlife Conservation	Malcolm L. Hunter, Jr.
Stephen Dunham, MS, Wildlife Ecology	Daniel J. Harrison
Luke Groff, PhD, Ecology and Environmental Sciences	Aram J.K. Calhoun, Cynthia S. Loftin
Ann Grote, MS, Wildlife Ecology	Joseph D. Zydlewski
Kristine Hoffman, PhD, Wildlife Ecology	Aram J.K. Calhoun, Malcolm L. Hunter, Jr.
Robert Hogg, MS, Wildlife Ecology	Stephen M. Coghlan Jr., Joseph D. Zydlewski
Vanessa Levesque, PhD, Ecology and Environmental Sciences	Aram J.K. Calhoun
Brianne Looze, PhD, Ecology and Environmental Sciences	Cynthia S. Loftin, Francis A. Drummond
David Mallett, MS, Wildlife Ecology	Daniel J. Harrison
Sheryn Olson, MS, Wildlife Ecology	Daniel J. Harrison
Andrew O'Malley, MS, Wildlife Ecology	Joseph D. Zydlewski
Margaret Owens, Master of Wildlife Conservation	Malcolm L. Hunter, Jr.
Jennifer Raber, Master of Wildlife Conservation	Malcolm L. Hunter, Jr.
Silas Ratten, MS, Wildlife Ecology	Joseph D. Zydlewski
Brian Rolek, PhD, Wildlife Ecology	Cynthia S. Loftin, Daniel J. Harrison
Kevin Ryan, PhD, Wildlife Ecology	Aram J.K. Calhoun
Daniel Stich, PhD, Wildlife Ecology	Joseph D. Zydlewski

FISHERIES and aquatic

First-summer survival and growth of juvenile Atlantic salmon in headwater streams: Implications for restoring connectivity at road culverts

1. Quantify growth and survival of juvenile ATS in headwater streams, spanning multiple environmental gradients.
2. Determine the relative importance of measured habitat features to juvenile ATS growth and survival.
3. Compare the production potential of headwater streams to the mainstream and other already stocked tributaries.

Abstract: The Machias River, located in downeast Maine, harbors one of the few remaining wild populations of Atlantic salmon *Salmon salar* in the U.S. and provides a model system for investigating the productive capacity of headwater streams currently inaccessible to wild salmon because of impassable culverts. Historically, headwater streams provided high -quality nursery habitat to juvenile salmon as they encompass > 70% of the total stream area in a watershed, and have more favorable and consistent temperature regimes, more available food, and fewer predators than larger rivers. In spring 2010 and 2011, we stocked salmon fry in twenty study reaches and quantified survival and growth across multiple environmental gradients. Fry migration was quantified at representative sites with directional traps, where movement was invariably in a downstream direction, negligible in distance, away from suboptimal habitat, and predominantly within days of stocking. Despite near drought conditions in 2010, late summer electrofishing resulted in fry abundance, apparent survival, growth, biomass, density, and PBI (potential biomass index) estimates that were comparable to 2011 values. Due to the low water event in 2010, the physical habitat variables prevailed, as warmer early season water temperatures, greater water depths, more abundant large wood, reduced detritus substrate, faster late season velocity, and larger drainage areas contributed most to fry metrics. In 2011, a more benign environment persisted, and biotic habitat variables were also important, as brook trout *Salvelinus fontinalis*, early season abundance and mass of drifting invertebrates, and late season drifting Diptera, Ephemeroptera, Plecopetera, Trichoptera (EPT), and terrestrial inputs contributed most to fry metrics. Our results indicate that headwater streams, although variable in their productive capacity, are essential rearing habitat for juvenile Atlantic salmon. We suggest that based on a select suite of habitat variables, problematic culverts can be targeted for removal, thus reconnecting the highest-quality streams for restoration purposes.

Investigator: Wesley Ashe (MS)

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

Duration: September 2009—September 2012

Cooperators:

University of Maine – Department of Wildlife Ecology
University of Maine
Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
Maine Water Resources Research Institute
American Recovery and Reinvestment Act (ARRA)
National Oceanic and Atmospheric Administration
Project SHARE (Salmon Habitat and River Enhancement)
U.S. Fish and Wildlife Service – Craig Brook National Fish Hatchery

The role of marine derived nutrients delivered by anadromous fish in restoration of freshwater ecosystems in the Penobscot River watershed, Maine

Objective: Experimentally supplement marine derived nutrients into Atlantic salmon nursery streams to examine effects of increased nutrients on stream productivity (algae, macroinvertebrates) and young Atlantic salmon growth and condition.

Abstract: This research examined responses of Atlantic salmon (Salmo salar) stream communities to experimental simulation of marine-derived nutrient input. Prior to construction of dams beginning in the early 1800s, Atlantic salmon and other anadromous species migrated from the ocean to spawn in Maine's extensive rivers and streams. Spawning fish transported marine-derived nutrients to these systems as carcasses, eggs, and waste products. These contributions may have influenced productivity in otherwise nutrient limited systems, bolstering growth and survival of young Atlantic salmon and other anadromous species and influencing other components of the stream communities.

This study involved a reach-scale experiment to explore assimilation of marine-derived nutrients supplied to small streams in Maine. Four headwater streams were stocked with Atlantic salmon fry in May 2009 and 2010, and marine-derived nutrient input was simulated with a carcass analog placed in treatment reaches to match timing of sea lamprey (*Petromyzon marinus*; July) and Atlantic salmon (October) spawning. Total dissolved nitrogen and phosphorus concentrations were greater in treatment reaches two days following carcass analog additions and returned to background concentrations approximately one month later. Periphyton biomass did not differ between control and treatment reaches for eight weeks following additions. Macroinvertebrate community assemblages differed between control and treatment reaches two and four weeks following additions. Macroinvertebrates and Atlantic salmon assimilated nitrogen (12-57% of total N) and carbon (21-65% of total C) from carcass analogs, and the magnitude and duration of enrichment varied temporally and by functional feeding group. Mass was 33-48% greater and length was 9-15% greater in young-of-the-year Atlantic salmon in treatment reaches for four months following nutrient additions. Percent total lipids in Atlantic salmon were twice as great in treatment reaches one month following carcass analog additions, and lipid levels remained elevated for two more months. Absolute growth rates, based on otolith microstructure analysis, correlated with water temperature fluctuations in all reaches and were elevated in treatment reaches for one month following carcass analog additions. Simulated sea lamprey spawning increased stream water nutrient concentrations, shifted macroinvertebrate community structure, and increased growth potential of juvenile Atlantic salmon, which may contribute to population persistence and ecosystem productivity.

Investigator: Margaret Guyette (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)
Kevin S. Simon
William Halteman
Jasmine E. Saros

Duration: September 2007—September 2012

Cooperators:

National Oceanic and Atmospheric Administration
U.S. Geological Survey – Eastern Region Cooperative Fish and Wildlife Research Units
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife Ecology
University of Maine – Maine Cooperative Forestry Research Unit

Quantifying the effects of dam removal on the structure of fish assemblages in the Penobscot River

1. Establish the level of natural variability within fish assemblages in the Penobscot River before dam removal occurs.
2. Improve the precision of fish assemblage monitoring.
3. Reduce sampling bias within fish assemblage monitoring.
4. Determine the most efficient and/or effective sampling method for quantifying fish assemblages in the Penobscot River.

Abstract: The Penobscot River drains the largest watershed in Maine, and once provided spawning and rearing habitats to at least 11 species of diadromous fish.

The construction of dams blocked migrations of these fish and likely changed the structure and function of fish assemblages throughout the river. Further alteration to fish assemblage structure likely occurred as a result of habitat fragmentation and alteration. The proposed removal of two main-stem dams, improved upstream fish passage at a third dam, and construction of a fish bypass on dam obstructing a major tributary is anticipated to increase passage of diadromous and resident fishes. To sample fish assemblages within the lower 70 kilometers of the Penobscot River prior to dam removal, we used standardized boat electrofishing methods during both summer and fall in 2010 and 2011 while implementing two sampling designs. Fixed -station sampling on the Penobscot River was conducted at eleven pre-established 1000-meter transects. Stratified-random sampling was conducted among nine strata, at multiple randomly selected 500-meter transects within each stratum. Major tributaries were also sampled along eight fixed-station transects.

In total, we captured 61,837 fish of 35 species while sampling 114 kilometers of river and tributary shoreline. Our sampling designs were equivalent in precision and efficiency for encountering species and estimating total species richness; we found no significant differences between sampling designs for the proportional abundance of all species, although the stratified-random design was slightly more efficient for characterizing proportional abundance. We combined data from both sampling designs for further analyses and identified longitudinal patterns of fish assemblage structure within the study area. Distinct fish assemblages were present among river sections bounded by dams, indicating that dams were a major driver of fish assemblage patterns within the river. Alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) were captured frequently within the tidal river section, but at no locations upriver. Fundulus species were also abundant within the tidal river section. Smallmouth bass (*Micropertus dolomieu*) and pumpkinseed (*Lepomis gibbosus*) were most prevalent within Veazie Dam impoundment, along with the free flowing river section immediately upriver.

Further upriver, warm-water species such as chain pickerel (*Esox niger*), brown bullhead (*Ameiurus nebulosus*), and yellow perch (*Perca flavescens*), along with cyprinid species such as common shiner (*Luxilus cornutus*) and fallfish (*Semotilus corporalis*) were more prevalent than within any other river section.

Patterns of fish assemblage structure did not change considerably during our sampling; we identified relatively few species which contributed to seasonal and annual variability within the main-stem river, including smallmouth bass, white sucker (*Catostomus commersoni*), pumpkinseed, and golden shiner (Notemigonus crysoleucas). We predict that many anadromous fish will migrate further upriver after dam removal, potentially causing broad shifts in fish assemblage structure. Improved connectivity among habitats for many fish species could also change the longitudinal pattern of fish assemblage structure within the river.

While it is difficult to predict specific changes to fish assemblages in this large river, such predictions can be tested by future studies to evaluate river rehabilitation success and the recovery of historically important fish species

Investigator: Ian Kiraly (MS)

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

Duration: January 2010—August 2012

Cooperators:

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

Effects of large woody debris addition on wild brook trout and in stream habitat in Western Maine

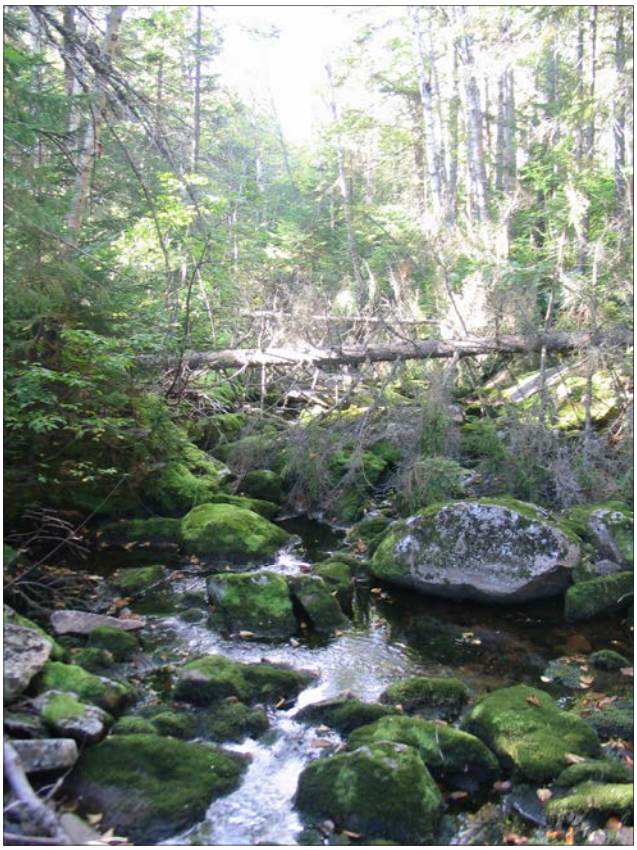
1. Quantify the effects of CWD addition on brook trout, aquatic insects, and streamside salamanders in brook trout stream.
2. Quantify the effects of brook trout relocation and/or CWD addition on aquatic insects and salamanders in fishless streams.

Maine is the last stronghold for native populations of eastern brook trout Salvelinus fontinalis in the US, but after decades of high-impact timber harvesting, many streams show evidence of habitat degradation such as lack of in-stream structure and local extirpation of trout.

We designed a before-after / control-impact study to test for the effects of habitat improvement and translocating wild trout into vacant habitat in headwater streams of the Mahoosuc Range of the White Mountains in western Maine. In 2007 and 2008, we added coarse woody debris (CWD) by felling riparian trees into and across the channels of six streams that contained trout and four streams that contained no trout; six other trout streams and four other trout-free streams served as reference sites. In 2010, we translocated wild trout into vacant habitat in four of those trout-free streams, two of which had received CWD addition and two that did not.

We assessed size and/or abundance metrics of brook trout, streamside salamander, and benthic macroinvertebrate populations for at least one year prior to CWD treatment (with the exception of one stream) and at least three years post-treatment, and monitored in-stream habitat features for up to two years after treatment. One year of post-translocation data is available for streams that received trout additions. Prior to treatment, there was a paucity of naturally-occurring CWD in study streams, with most streams containing no CWD. Post-treatment, mean CWD abundance in treated sites was double that in reference sites, although 75% of added wood did not reach the wetted stream channel. There was no

significant increase in pool abundance after CWD addition. Brook trout abundance and size structure were highly variable within and among streams over the course of the study, and there was no apparent effect of CWD addition on brook trout density, biomass, or mean weight. Translocation was generally not successful, with retention rates of < 10% one year after stocking, although translocated trout did spawn successfully in one site. In most sites, salamander abundance was highly variable from year to year and did not seem to be related to CWD addition, but the extreme high-elevation streams with chronically low pH usually contained few or no salamanders. Invertebrate abundance was also extremely variable, both within sites and among sites and also among seasons, and as of this report, about half the samples still need to be analyzed; thus we cannot draw conclusions yet. The influence of CWD addition on physical habitat and biota may take longer to become apparent than the post-treatment monitoring period of this study. Alternately, these streams may not respond to CWD addition because of geomorphological constraints or seasonally inhospitable water chemistry, as other studies have suggested. Either way, at least over the short-term, neither CWD addition nor translocation appear to be effective conservation or restoration tactics in high-elevation headwater streams in western Maine, but we should resample our sites after more time has elapsed before drawing this conclusion.



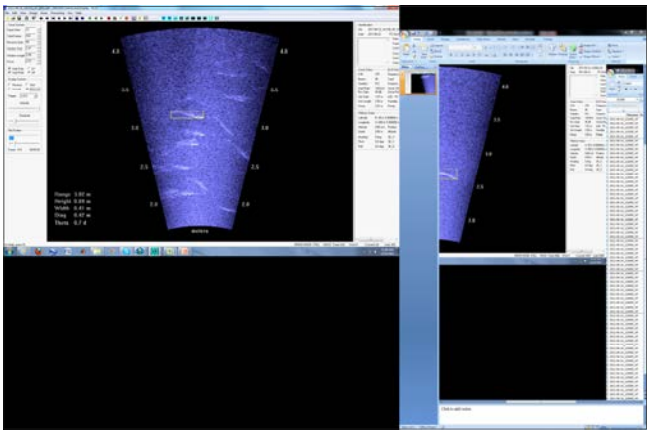
Investigator: Paul Damkot (MS)

Advisors: Stephen M. Coghlan, Jr. (Advisor)
Joseph D. Zydlewski
Kevin S. Simon

Duration: July 2007—January 2012

Cooperators:

University of Maine – Department of Wildlife Ecology
Maine Department of Inland Fisheries and Wildlife
Maine Bureau of Parks and Lands
Androscoggin River Watershed Council
Maine Department of Environmental Protection
Maine Outdoor Heritage Fund
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service – Eastern Brook Trout Joint Venture
National Fish and Wildlife Foundation
Newry, Town of



Establishing baselines for American shad in the Penobscot River

1. Develop age and length distributions of adult American shad in Penobscot River via electrofishing.
2. Characterize spawning migratory behavior and habitat use with radio and acoustic telemetry.
3. Generate a length frequency distribution of fish approaching Veazie Dam using high definition imaging sonar (DIDSON technology).
4. Generate a population estimate for American shad in the Penobscot River using a novel application of radio telemetry and DIDSON technology.

American shad populations are declining throughout their native range and conservation programs have been implemented in rivers from Maine to North Carolina. The proposed habitat restoration plan to remove the Veazie and Great Works Dams on the Penobscot River (as part of the Penobscot River Restoration Project) is anticipated to reestablish access to spawning and rearing habitat for numerous diadromous fish species, including American shad. Recent modeling efforts indicate that the time to recovery for American Shad in the Penobscot River may be highly sensitive to small changes in starting population size. Additionally, in this model, sensitivity to stocking (the ability of stocking to increase run size) decreases with increasing population size. Because of the timeline of restoration activity and the importance of the current population level, specific demographic information on American shad in the Penobscot River would be invaluable. The work underway is using a combination of radio telemetry and DIDSON hydro acoustic assessment to study American shad to collect baseline data prior to dam removals and implementation of proposed stocking programs. Work will be conducted over three years (2010-2012), and will address two main data gaps: characterization of adult shad migratory behavior and characterizing the existing Penobscot River run.

In 2010 and 2011, a total of ninety three American shad were captured via boat electrofishing. Age and length data were collected for these fish and 85 fish were tagged for telemetry work (70 radio and 15 acoustic). Tagged fish were tracked using fixed radio antenna and acoustic receiver arrays along with active tracking. Directional antennas were mounted at Veazie Dam, to describe dam approach behavior. Additional stationary radio antennas were installed at intervals between Orrington and Veazie Dam. Acoustic receivers were located from at intervals from Penobscot Bay to Veazie Dam.

In 2009 - 2011 a DIDSON hydro acoustic camera was deployed to conduct imaging surveys at the base of the Veazie Dam fishway. Analysis of the 2011 DIDSON data indicate that large numbers of American shad, Atlantic Salmon, and river herring approached the fishway. The DIDSON approach has been an effective tool for making species determinations, measuring the size of fish, and developing size distributions in order to meet the full objectives of this project. Analysis has focused on sampling these data to provide a size distribution of observed fish. A Bayesian mixture model was developed to demonstrate that American shad dominated observation frequencies.

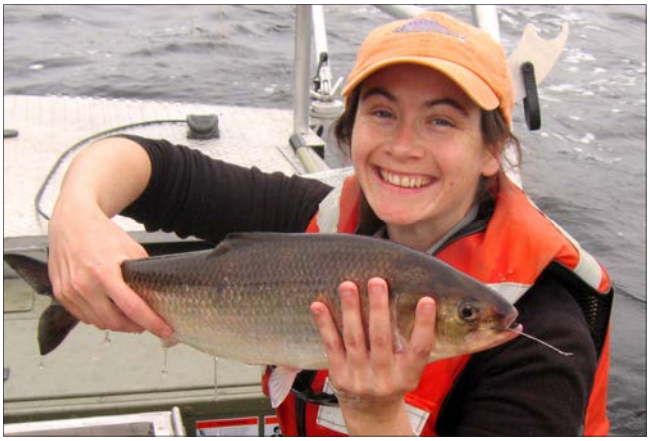
Investigator: Ann Grote (MS)

Advisors: Joseph D. Zydlewski (Co-Advisor)
Michael M. Bailey (Co-Advisor)
Joseph E. Hightower
Daniel J. Harrison

Duration: January 2006—January 2013

Cooperators:

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



Barrier removal in Sedgeunkedunk Stream: Sea lamprey recolonization and implications for Atlantic salmon habitat restoration

1. Characterize fish community changes (species, size, abundance, distribution, etc) in response to barrier removals.
2. Evaluate abundance, size-structure, habitat use, and nest fidelity of spawning sea lamprey.
3. Characterize fine scale changes to stream-bed in response to sea lamprey nest construction.
4. Characterize changes to aquatic invertebrate community in response to sea lamprey spawning activities

Sedgeunkedunk Stream, a third-order tributary to the Penobscot River, historically supported several anadromous fish species including sea lamprey and Atlantic salmon. However, two small dams constructed in the 1800s reduced or eliminated spawning runs entirely. In 2009, efforts to restore marine–freshwater connectivity culminated with removal of the lowermost dam returning five-km of lotic habitat accessible to anadromous fish. To evaluate the efficacy of dam removal as a restoration tool, we sought to compare pre- and post-dam removal conditions, as part of an ongoing before-after-control-impact (BACI) study. Electrofishing survey protocols were used to test the hypothesis that dam removal would lead to increased diversity, abundance, and biomass of fish assemblages upstream. Additionally, we tagged and tracked migrating sea lamprey during their annual spring spawning runs to test the hypothesis that dam removal would facilitate recolonization of a sentinel anadromous species. Furthermore, we collected macroinvertebrate drift samples downstream of active lamprey nests to test the hypothesis that spawning activities release benthic invertebrates thereby increasing prey for drift-feeding fishes. Finally, we sampled the stream-bed topography of lamprey nests to test the hypothesis that lamprey "condition" microhabitat to the benefit of Atlantic salmon via alteration of substrate.

Field work was completed in mid-October 2011 and completion of associated lab work is anticipated mid-February 2012. Preliminary analyses revealed that diversity, density, and biomass of the resident fish community increased at all sites upstream of the 2009 dam removal with few changes detected at unimpacted reference sites. The most current surveys revealed a consistent homogeneous distribution of the resident fish along the headwaters-to-mouth gradient with evidence of successful recolonization by anadromous river herring. Additionally, age 0+, 1+, and 2+ Atlantic salmon parr were observed where they were previously absent prior to dam removal. Mark-recapture histories indicated a four-fold increase in the abundance of spawning sea lamprey, and analysis of lamprey nesting sites suggests that spawning activities may have conditioned microhabitats favorably for Atlantic salmon. Additional data analysis and writing are in progress for a Master of Science thesis, expected for completion in December 2012.

Investigator: Robert Hogg (MS)

Advisors: Stephen M. Coghlan, Jr. (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)
Kevin S. Simon

Duration: January 2010—August 2012

Cooperators:

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

Investigating lake whitefish and Arctic charr reintroductions

1. Characterize lake whitefish movements as they relate to thermal stratification and potential spawning locations.
2. Examine the seasonal movements of reintroduced Arctic charr.
3. Assess lake whitefish growth (annual and seasonal) and spawning within Clear and St. Froid Lakes.
4. Model physical habitat data to identify potential spawning areas for lake whitefish in St. Froid Lake.

Lake whitefish (*Coregonus clupeaformis*) and Arctic charr (*Salvelinus alpinus*) are native species of substantial historical and recreational importance in Maine. A combination of creel census and annual inventory data collected by Maine Department of Inland Fisheries and Wildlife (MDIFW) indicate lake whitefish and Arctic charr are both experiencing population declines. These findings prompted extensive restoration efforts, including hatchery programs and subsequent reintroductions of these species. This research will provide critical information regarding these lake whitefish and Arctic charr populations.

Acoustic telemetry will be used to characterize lake whitefish and Arctic charr movements. In concert with these efforts, temperature logger arrays will be deployed to provide a better characterize the thermal dynamics of the study lakes. Growth of lake whitefish in St. Froid and Clear Lakes will be assessed through otolith and scales collection. The efficacy of acoustic sonar (DIDSON) to document spawning will be evaluated in Clear Lake. Lastly, an autonomous underwater vehicle (AUV) will be utilized to collect physical habitat data to be incorporated into a habitat model in order to identify potential spawning habitat for lake whitefish in St. Froid Lake.

Lake whitefish otolith and scale samples were collected in 2010, 2011, and 2012 for age and growth analysis. Acoustic receivers were deployed in St. Froid Lake(15) and Clear Lake(5) to passively track movements of tagged lake whitefish. Seven lake whitefish have been tracked since 2009 in Clear Lake and additional fish are anticipated to be tagged in the winter of 2012-2013. Thirteen lake whitefish were tagged in St. Froid Lake. In the winter of 2012 an additional seven lake whitefish will be tagged in St. Froid Lake. In an analogous manner, acoustic receivers were deployed in Big Reed Pond to passively track the movements of Arctic charr. In the fall of 2011, ten sub-adult Arctic charr were tagged and released. Vertical temperature and light data logger arrays were deployed within each lake system to monitor thermal dynamics and relative light levels (to indicate ice cover). Retrieval of receivers from all of these sites in spring of 2013 will provide the data necessary for final analysis.

Investigator: Silas Ratten (MS)

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

Duration: January 2006—December 2013

Cooperators:

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

PIT tag monitoring of adult Atlantic salmon in the Penobscot River, Maine

1. Determine the rate, timing and efficiency of upstream passage of Atlantic salmon 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 Atlantic salmon in the Penobscot River.

The Penobscot River watershed is Maine's largest and hosts the largest remaining run of Atlantic salmon in the USA, however the majority of high quality spawning and rearing habitats are located upstream of at least four dams. Plans are currently underway to remove the two most downstream dams as part of the Penobscot River Restoration Project (PRRP). Great Works Dam has already been removed. Ultimately, benefits of dam removal for Atlantic salmon restoration will depend in large part on the degree and fashion by which remaining dams facilitate fish passage success. In order to assess migratory success of adult Atlantic salmon, we are using passive integrated transponders (PIT tags) to remotely track fish through nine major dams in the lower Penobscot River. Currently, PIT tagging of fish occurs at the lower most dam (Veazie Dam-which is scheduled for removal in 2013) 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 Andromous Fishes to the Penobscot River. This study will require 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. By spring of 2010, PIT arrays were installed at all targeted lower mainstem dams and preliminary passage data were collected from more than 1000 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 2429 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 has been recruited to continue this work in the future.

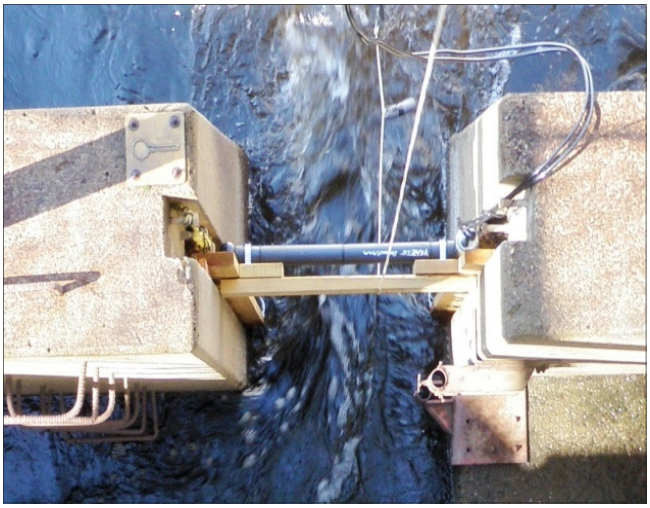
Investigator: Douglas Sigourney (Post-doc)

Advisors: Joseph D. Zydlewski (Supervisor)

Duration: January 2006—May 2012

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



Passage of Anadromous Fish at Mainstem Dams on the Penobscot River, Maine

1. Model the survival of wild- and hatchery-origin Atlantic salmon smolts through the Penobscot River and Estuary.
2. Assess movement patterns and rates of migration for Atlantic salmon smolts through the Penobscot River.
3. Characterize patch choice and survival of Atlantic salmon smolts at Milford Dam on the Penobscot River.
4. Characterize the development of seawater tolerance and behavioral preference for seawater of Atlantic salmon smolts.

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. Beginning in 2010, greater emphasis has been placed on movements near Milford Dam, a known site of high mortality, using radio telemetry. We will continue tagging wild and hatchery-origin Atlantic salmon smolts from the Penobscot River through this periods of study. Beginning 2012, a series of laboratory experiments will be conducted using direct seawater transfer (to assess seawater tolerance) and seawater preference (using a novel selection apparatus). Data from these experiments will be used to inform the interpretation of movement patterns of Atlantic salmon smolt migration through the Penobscot River estuary.

Acoustic telemetry data have been collected since 2005 for hatchery-origin and 2006 for wild origin 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. The use of radio telemetry was successfully initiated in 2010 and will be continued in 2012 to refine estimates of survival and path choice in smolts past Milford Dam in the Penobscot River. These data have been used to model smolt survival in this segment of the River. Physiological experiment are being initiated in 2013.

Investigator: Daniel Stich (PhD)

Advisors: Joseph D. Zydlewski (Advisor)
Michael M. Bailey
Michael T. Kinnison
John Kocik
Gayle B. Zydlewski

Duration: January 2006—January 2014

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 Ecology
National Fish and Wildlife Foundation
Penobscot River Restoration Trust
U.S. Fish and Wildlife Service
Penobscot Indian Nation

Effects of aluminum on Atlantic smolt migration and physiology

1. Determine the impact of current fresh water acid-Al conditions on seawater tolerance of hatchery and wild Atlantic salmon smolts.

2. Use gill Al and Na+,K+-ATPase as biomarkers to connect current acid-Al conditions to impacts on salmon parr and smolts, and as a monitoring tool for assessing the potential beneficial effects of liming.

To examine the impacts of acid-Al on naturally reared (wild) migrating Atlantic salmon smolts, we will sample smolts as they migrate downstream in spring and subject them to a seawater challenge test. Once per year at each of six sites, 12 fish will be sampled non-lethally in freshwater for measurement of gill Al and gill Na+,K+/ATPase activity. An additional 12 fish will be transferred into 35 ppt seawater using water-jacketed tanks and river water to maintain appropriate temperature. After 24 hours in seawater animals will be bled for measurement of plasma chloride, allowed to recover for several hours in fresh water and released. Water chemistry data (field pH, aluminum (total, organic and inorganic), dissolved organic carbon (DOC) and Acid Neutralizing Capacity (ANC)) will be collected at each site at the time of fish collection. These studies will be conducted in spring 2011, 2012 and 2013.

In order to directly determine the impact of current water chemistry conditions on Atlantic salmon, we will hold hatchery smolts in cages at targeted field sites and subject them to a seawater challenge test after six days of exposure. Eight sites in Maine with known water chemistry representing a range of water chemistry were chosen. In late April, Penobscot River origin hatchery smolts will transferred to cages and then sampled after 5 d. Such data will allow us to determine if acid-Al conditions may be excluding salmon populations from these streams.

This work was initiated in 2012 and sampling was carried out using both naturally migrating Atlantic salmon smolts and "caged" smolts. Laboratory analysis of these samples is underway and preliminary data have been analyzed. Data from 2012 will inform selection of sampling sites for 2013.

Investigator: Andrew Weinstock (PhD)

Advisors: Stephen McCormick (Co-Advisor)
Joseph D. Zydlewski (Co-Advisor)

Duration: January 2011—October 2015

Cooperators:

Maine Department of Inland Fisheries and Wildlife
Maine Department of Marine Resources
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service
U.S. Geological Survey – Biological Resources Discipline

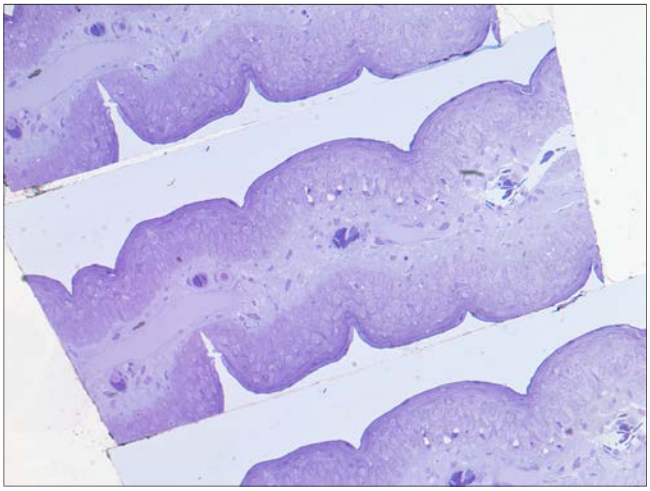
WILDLIFE and habitats

WILDLIFE and habitats continued

Establishment of *Batrachochytrium dendrobatidis* in anuran epidermis and experimental transmission from bullfrogs to wood frogs

1. To determine how the amphibian skin pathogen *Batrachochytrium dendrobatidis* (Bd) invades host cells
2. To determine if skin structure differs in Bd-resistant bullfrogs and Bd-susceptible wood frogs
3. To determine if the bullfrog acts as a vector of Bd

Abstract: Chytridiomycosis, a skin disease caused by the fungus *Batrachochytrium dendrobatidis* (Bd), threatens anuran populations worldwide. Mild infections in the bullfrog are well-documented. In contrast, wood frogs can die from chytridiomycosis. We tested whether skin structure and host invasion by Bd differed in bullfrogs and wood frogs. Bullfrog skin was thicker than wood frog skin. Bd invades host cells with germination tubes; the invasion process did not differ in the model hosts. We encourage further research on skin structure as a potential determinant of susceptibility to Bd. We also conducted an ex-situ experiment to determine whether Bd-infected bullfrogs can act as disease vectors. Bullfrogs transmitted Bd to wood frog tadpoles, causing mortality in wood frogs after metamorphosis. We highlight bullfrog disease screening as a management challenge because their low infection loads can be difficult to detect.



Investigator: Sasha E. Greenspan (MS)

Advisors: Aram J.K. Calhoun (Co-Advisor)
Joyce E. Longcore (Co-Advisor)
Seth Tyler

Duration: September 2009—December 2011

Cooperators:

University of Maine – Department of Wildlife Ecology
University of Maine – School of Biology and Ecology

Amphibian communities in vernal pools, fishless lakes, and fish-containing lakes in Downeast Maine, and effects of predation of spotted salamanders (*Ambystoma maculatum)*

1. Characterize amphibian communities of fishless and fish-containing lakes in Maine.
2. Determine if egg mass morphology and oviposition affect *Ambystoma maculatum* resistance to predation.
3. Determine morphological plasticity of larvae and fitness of adult *Ambystoma maculatum* breeding in vernal pools, fishless lakes, and fish-containing lakes.

Abstract: *Ambystoma maculatum* (spotted salamander) breeds in seasonal wetlands (vernal pools) as well as in wetlands with permanent hydroperiods. Ability to successfully recruit young in these latter breeding habitats may be particularly important in landscapes with low vernal pool density but may require alternative breeding strategies. We examined relationships among breeding habitat and landscape characteristics and *A. maculatum* occurrence, ovipositioning behavior, egg mass morphology, and embryo survival, and occurrences of other amphibian species during 2006-2010 in ten vernal pools and permanent waterbodies (seven fishless lakes and five stocked but naturally fishless lakes) in Maine, USA, and in laboratory experiments. We also used automated audio recording devices to evaluate the effectiveness of generalized listener-based audio surveys for detecting relatively rare or audibly cryptic anurans in Maine.

Landscape-scale characteristics (number and area of ephemeral to semi-permanent wetlands within 500 m) were most important for predicting breeding occurrence by vernal pool amphibians (*A. maculatum, Lithobates sylvaticus* [wood frog]) in lakes, whereas lake-scale characteristics (e.g., vegetative cover, fish presence) were better predictors for species (e.g., *L. septentrionalis* [mink frog], *L. pipiens* [northern leopard frog]) associated with permanent waterbodies. Ambystoma maculatum breeding effort was greatest in lakes where more typical breeding habitats (e.g., vernal pools, beaver flowages) within 500 and 4000 m were less abundant. Egg masses and hatching larvae were approximately 13 and 33%, respectively, larger in vernal pools than in lakes. Survival of *A. maculatum* embryos to hatching while exposed to in situ predation was approximately 180% higher in vernal pools than both lake types. When compared with full-night surveys, generalized listener surveys may result in omissions and misclassifications of chorus sizes for certain species in Maine (e.g., *L. septentrionalis, L. palustris* [pickerel frogs]).

Vernal pool-centric conservation measures may fail to account for connectivity among pools and alternative permanent breeding habitats in maintaining population persistence in long lived species such as *A. maculatum*. Lakes potentially provide alternative breeding habitat for *A. maculatum* in landscapes with few or poor quality vernal pools or in drought years; however, vernal pools are the optimal breeding habitat for this species in our study landscape.

Investigator: Amanda Shearin (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Aram J.K. Calhoun (Co-Advisor)
Kevin S. Simon
William Halteman
William E. Glanz

Duration: January 2006—May 2012

Cooperators:

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

River restoration in the northeast: Implications for avian assemblages

1. Develop a monitoring framework that will assess the response of River Bird Assemblage (RBA) to dam removal.
2. Characterize RBA prior to and potentially during dam removal (pending dam removal timeline).
3. Examine pre-dam removal Osprey distribution, abundance, and productivity as a baseline for measuring response to fish restoration.
4. Investigate the relationship between habitat and RBA.
5. Evaluate the relative importance of marine and freshwater prey to Bald Eagle, Osprey, Belted Kingfisher, and Tree Swallow using analysis of marine derived nutrients.

Understanding the feeding and habitat relationships of various species is a key to unraveling ecosystem function and thus is critically important in discerning responses to human impacts. Most research within river systems identifies fish as the top predators and focuses at this or lower levels in the food web. However, many bird species also rely on the river system and can be linked to the river food web as omnivores, insectivores, and piscivores. Their importance in riverine ecosystems is often overlooked. This study examines community dynamics of riverine birds and their interactions with dams and river habitat variation.

The ultimate goal of the study is to quantify how river associated bird assemblages respond to various habitat conditions that are likely to be impacted by dam removal and the subsequent restoration of spawning diadramous fishes. It is reasonable to assume that dam removal will alter some of these river variables and thus affect bird assemblages in both the short and long -term.

The river bird monitoring framework was established in the fall of 2008 and became fully operational the following spring with a network of 45 volunteers set up along the Penobscot and other Maine rivers. The first 4 years (5/09 – 5/13) of monitoring encompass the time prior and during the Great Works dam removal (Veazie 2013) and provide context for the next 4 years of river bird monitoring, post-dam removal. Funding was awarded by the Maine Outdoor Heritage Fund (MOHF) to examine Osprey distribution, abundance, and productivity. Measures were acquired during the 2011 and 2012 breeding seasons. Collection of habitat variables at each survey site was finalized at low, medium, and high water levels. MOHF also facilitated the the collection and processing of bird and prey samples and data were received in 2012. Analysis and summary of all project objectives will be completed in 2013.

Investigator: Erynn M. Call (PhD)

Advisors: Malcolm L. Hunter, Jr. (Advisor)
Cynthia S. Loftin
Brian J. Olsen
Karen Wilson
Joseph D. Zydlewski

Duration: April 2009—May 2013

Cooperators:

Eastern Maine Conservation Initiative
Maine Department of Inland Fisheries and Wildlife
Biodiversity Research Institute
Maine Audubon Society
Maine River Bird Volunteer Network
Maine Outdoor Heritage Fund
The Nature Conservancy
Penobscot River Restoration Trust
University of Maine – Sustainable Solutions Initiative
University of Maine – Department of Wildlife Ecology
National Oceanic and Atmospheric Administration

Effects of landscape composition and pattern on native bee assemblages in selected wild and cultivated fruit crops in the Northeast.

1. Assess the suitability of the InVEST pollinator model for studying relationships between landscape composition and pattern on Maine's wild blueberry pollinators.
2. Assess the suitability of the InVEST pollinator model for studying relationships between landscape composition and pattern on pollinators or apples, squash, pumpkins, and cranberries in Maine and other northeastern states.
3. Examine how diversity and abundance of pollinators is affected by landscape composition and pattern.

Pollinator-dependent crops require a readily available source of pollinators. Although honey bees provide this service for a variety of crops, a diverse pollinator community is needed to ensure sustainability in in this service. Native bee pollinators potentially contribute to this sustainability, however, knowledge about factors that affect their abundance and distributions is lacking. Our team from the University of Maine is collaborating with teams from the University of Massachusetts, University of Connecticut, University of Tennessee, and Cornell University to examine a variety of factors, ranging from individual pollinators to the landscapes they inhabit, that potentially affect pollinators of fruit and vegetable crops in the northeastern US. The research focus in Maine is wild blueberries, while apples, cranberries, squash and pumpkins are the focal crops in the other participating states. Our role on the Maine team is to examine relationships between the pollinator community composition and abundance and arrangement and composition of the landscape where the focal crops occur. We are combining the team's field-based studies of pollinator communities with the National Capital Project's InVEST models and netrual landscape models in our spatial assessment of pollinator communities. Our research coordinates with the agricultural community through demonstration projects and collaborative interactions to improve distribution and implementation of research results by growers and the native pollinator conservation community.

We have begun analysis of the Invest pollination model for its suitability to Maine's wild blueberry crop. We concluded from our assessment of the available land cover data for the wild blueberry crop that a new land cover classification targeting blueberries was needed, and we have purchased SPOT satellite imagery for this purpose. We also have begun assessment of available spatial data layers for linear landscape elements to include in our analysis of land cover and pattern relationships with the pollinator community. We will expand our focus to cranberries, squash, pumpkins, and apples in Maine and the partner states during 2013, beginning with an assessment of land cover data quality. Eventually, we will apply the InVest model to these crops and landscapes to examine relationships of landscape composition and pattern with the pollinator community.

Investigators: Shannon Chapin (MS)
Brianne Looze (PhD)

Advisors: Cynthia S. Loftin (Co-Advisor)
Frank A. Drummond (Co-Advisor)
Brian J. McGill

Duration: January 2012—December 2016

Cooperators:

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

Amphibian movement in complex landscapes: Effects of forestry and urbanization on juvenile dispersal of vernal pool-breeding amphibians

1. Quantify differences in habitat permeability of open-canopy habitats (forest clear-cuts, lawns, hayfields, row crops) to juvenile wood frogs during post-metamorphic dispersal period.
2. Develop a miniaturized harmonic direction finding (HDF) system for direct tracking of individual amphibians, with applications for other small-bodied organisms or commercialization of the technology.
3. Assess effects of heavy partial harvest systems on dispersing and overwintering juveniles.
4. Assess effects of landscape composition on dispersing and overwintering juveniles – using a combination of direct-tracking and field/laboratory trials to quantify movement, microhabitat selection and terrestrial settling patterns (aspects of amphibian terrestrial ecology heretofore limited by transmitter lifespan).
5. Quantify individual amphibian movement parameters for building and validating an individual-based behavioral model of dispersal (*Lithobates sylvaticus*; *Ambystoma maculatum)*

For many amphibian species, the juvenile life stage represents the primary driver of gene flow and population connectivity. However, there is a paucity of data on juvenile movement/emigration because direct tracking is hampered by: (a) the small size of metamorphs; (b) the biphasic (terrestrial-aquatic) life history and cryptic behavior associated with this life stage; and (c) prior limitations in longevity/size of tracking technologies. Thus, our research focuses on juveniles, with a principal intent to describe breeding dispersal – or the process of emigration from natal pool to eventual breeding pool. Development of a miniaturized technology (harmonic radar transponder tags) will allow us to follow the fate and behavior of individually-marked amphibians across multiple life stages. Our ultimate objective is to assess the effects of different land-use and forestry practices on amphibian dispersal, to understand how these movement processes affect population persistence.

This project is part of the Land-use Effects on Amphibian Populations (LEAP) project. We also pursue interdisciplinary research in coupled social-ecological systems (SESs) through the Sustainability Solutions Initiative (SSI), as part of the subproject "Protecting Natural Resources at the Community Scale: Using Population Persistence of Vernal Pool Fauna as a Model System to Study Urbanization, Climate Change and Forest Management."

Our research in 2012 focused on the influence of different land-cover types on juvenile movements. Specifically, we: (1) developed proof-of-concept for a miniaturized harmonic direction finding system (HDF/radar), as technological means for tracking cryptic and small-bodied life stages; and (2) performed field tests to build on our understanding of habitat connectivity in landscapes that span gradients of forest cover and urbanization.

Partnering with electrical and computer engineers, we developed an optimally-sensitive transponder tag and limited-range radar for tracking juvenile *L. sylvaticus*. We performed systematic evaluations of the effects of our lightweight, passive tag on short-term behavior of individual wood frogs and surrogate species (*Rana pipiens p.*). We conducted pilot HDF assessments in situ, experimentally releasing HDF-tagged juveniles in contiguous forest to examine post-metamorphic behavior. Specifically, we released 20 individuals (10 tagged, 10 untagged) along 400-m transects, and tracked individual movement paths using a combination of radar and fluorescent-powder monitoring techniques.

Investigator: Britt B. Cline (PhD)

Advisors: Malcolm L. Hunter, Jr. (Advisor)
Aram J.K. Calhoun
David Hiebeler
Robert S. Seymour
Joseph D. Zydlewski

Duration: January 2010—January 2014

Cooperators:

National Science Foundation
University of Maine – Department of Wildlife Ecology
University of Maine – Sustainable Solutions Initiative
Maine Association of Wetland Scientists
Massachusetts Institute of Technology (MIT) Lincoln Laboratory
University of Maine – Electrical and Computer Engineering Department (ECE)

Environmental assessment of circumneutral fens with shrubby cinquefoil (*Dasiphora fruticosa*): Host plant of the endangered Clayton's copper butterfly (*Lycaena dorcas claytoni*)

1. Compare hydroperiod, pore water chemistry, peat chemistry/morphology, and plant species associated with shrubby cinquefoil among wetlands sites and between wetland sites inhabited and uninhabited by Clayton's copper butterfly.
2. Compare age structure, phenology, and size of stand among shrubby cinquefoil populations and between populations inhabited and uninhabited by Clayton's copper.
3. Compare morphology/robustness, quality of flowers and leaves, and location of shrubby cinquefoil plants within wetlands inhabited and uninhabited by Clayton's copper.

Clayton's copper butterfly (*Lycaena dorcas claytoni*) is a Maine state endangered species that relies exclusively on shrubby cinquefoil (*Dasiphora fruticosa*) as its host plant. This shrub typically is found on the edges of wetlands rich in calcium carbonate or limestone. Calcareous wetland habitats that support large, persistent stands of *D. fruticosa* are rare in Maine. Currently only 21 sites in Maine are known to support large stands of *D. fruticosa*, and *L. d. claytoni* populations have been observed at only ten of these.

Conservation and recovery of *L. d. claytoni* depends in part on the ecological integrity of its habitat. It is unknown if there are other factors in addition to the presence of the host plant that contribute to the suitability of a site for Clayton's copper. To make effective conservation recommendations, we need more information about environmental site characteristics of Clayton's copper habitat. By comparing the quality of the habitat used by *L. d. claytoni* for nectaring and egg-laying to unoccupied habitat, this research aims to address the following questions: Is there an association between butterfly occurrence and the hydrological environment, pore water chemistry, peat chemistry and morphology, and plant assemblages of a wetland site? Is there an association between butterfly occurrences and the age structure, phenology, and size of the shrubby cinquefoil stands within a wetland site? Is there an association between butterfly occurrence and cinquefoil morphology or "robustness," quality and quantity of flowers, quality and quantity of leaves, and location of individual shrubby cinquefoil plants in the wetland?

We installed monitoring wells equipped with continuous water level recorders (Solinst Leveloader Gold) at nine sites inhabited by Clayton's copper butterfly and three uninhabited sites to determine vertical flow and water table fluctuations in each wetland during May-October 2009 and 2010. We collected pore water samples within the root zone of *D. fruticosa* plants as well as from the monitoring wells to compare nutrients and chemical conditions between occupied and unoccupied sites. Peat samples were collected within the root zone of *D. fruticosa* plants to compare nutrients and morphological conditions of the peat. We are comparing chemical composition and water content as well as physical characteristics of leaves collected from several plants at occupied and unoccupied sites. Nectar samples were collected at several locations to evaluate collection and analysis techniques. We also collected whole shrubby cinquefoil plants from occupied and unoccupied wetlands to determine age structure of shrubby cinquefoil populations in these wetlands; we sectioned, measured and counted growth rings in collected shrubs and determined whole shrub above ground biomass to compare with growth rates, shrub age, growth form, and location within the wetland. Finally, we characterized the shrub and tree communities on transects placed within shrubby cinquefoil patches where other chemical, physical, and cinquefoil sample collections occurred, and where Clayton's copper population surveys were completed in previous studies. Data analysis currently is underway, and the M.S. thesis will be completed by May 2013.

Investigator: Sarah A. Drahovzal (MS)

Advisors: Cynthia S. Loftin (Co-Advisor)
Judith M. Rhymer (Co-Advisor)
Frank A. Drummond
Andrew S. Reeve

Duration: September 2008—May 2013

Cooperators:

Maine Outdoor Heritage Fund
Maine Department of Inland Fisheries and Wildlife
The Nature Conservancy
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Maine Agricultural and Forest Experiment Station
University of Maine – Department of Wildlife Ecology

Relative densities, patch occupancy, and population performance of spruce grouse in managed and unmanaged forests in northern Maine

1. Survey and compare mating season densities and patch occupancies of spruce grouse among A) regenerating clearcuts; B) two age classes of stands that have been clearcut, herbicided, and precommercially thinned; and C) residual stands of mid- and late-successional coniferous lowland forest.
2. Evaluate and compare home range area, survival, and recruitment of spruce grouse among our three vegetation types to evaluate relative population performance.
3. Model vegetation, stand, and landscape attributes associated with patterns of occurrence and home range placement of spruce grouse to evaluate characteristics that might be retained in harvested areas to maintain use by spruce grouse after harvesting.

Spruce grouse (*Falcipennis canadensis*) are a species of forest grouse dependent on conifer dominated forests. The southeastern extent of the geographic range of spruce grouse coincides with southeastern distribution of red and black spruce within the Acadian forests of Maine, northern New Hampshire, northernmost Vermont, the Adirondacks region of New York State, as well as the eastern maritime provinces of Canada. Although there is no hunting season on the species in Maine, little else is known about their current status.

Although industrial forest management has been shown to reduce the survival and reproductive success of spruce grouse, populations in unharvested portions of the Adirondack Forest Preserve also have exhibited substantial declines. Additionally, spruce grouse have been documented to occur in plantations and PCT stands. The effects of extensive forest management in commercially managed landscapes on habitat viability for spruce grouse is unknown. Thus, this study will evaluate of the effects of commercial forest management in northern Maine on patterns of habitat occupancy, habitat use, and reproductive success of spruce grouse using breeding season occupancy surveys and radio telemetry of females during the brood rearing season.

During the summer and fall of 2011 we established survey transectes in 19 forested stands in the Telos region of Piscatiquis County, Maine. In May of 2012 we conducted breeding season occupancy surveys in those stands and captured and banded 17 males. Later, in June , we again surveyed the stands using a chick distress call to facilitate capturing, banding, and radio-collaring of females with broods. We captured and collared 15 females. Except for one female who slipped her necklace, we located all females at least 25 times between July and September.

Vegetation measurements, additional occupancy surveys, and capture and radio telemetry of additional females will be conducted during May-December 2013. The expected date of project completion is August 2014.

Investigator: Stephen Dunham (MS)

Advisors: Daniel J. Harrison (Advisor)
Brian J. Olsen
Shawn T. McKinney
Daniel G. McAuley (ex-officio)

Duration: July 2011—May 2016

Cooperators:

University of Maine – Maine Cooperative Forestry Research Unit

Harbor seal abundance survey

1. Develop a statistically robust harbor seal aerial abundance survey design based on bay units that were delineated in a 2001 survey (Gilbert et al. 2005).
2. Conduct harbor seal live capture and tagging (VHF, satellite, sonic) in Chatham Harbor, Cape Cod Bay, and western Penobscot Bay.
3. Conduct aerial photographic surveys and VHF radio tracking along the Maine coast during peak pupping period.
4. Write a report suitable for publication in a peer review journal.

Twenty nine harbor seals were captured and radio-tagged during the spring of 2012, 17 in Chatham Harbor and 12 in Penobscot Bay. Aerial surveys were conducted in a sample of 13 of the bay units using a Twin Otter aircraft and digital imagery. To obtain a correction factor for those seals not available to be counted, a second aircraft was used to determine if radio-tagged seals were out or in the water. For this purpose we attempted to locate each of 18 radio-tagged seals (9 from each capture area) that were in the area during the survey.

Digital images were still be counted by NMFS contractors at the termination of this project. We anticipate the project to be complete by mid-March.

Investigator: James R. Gilbert

Duration: May 2011—December 2012

Cooperators:

National Oceanic and Atmospheric Administration
University of Maine – Maine Agricultural and Forest Experiment Station

Habitat use by pool breeding amphibians In Maine's montane region

1. Determine micro- and macro-habitats selected for by Wood Frogs (*Lithobates sylvaticus*) during the post-breeding period.
2. Determine hibernaculum characteristics selected for by wood frogs prior to the overwintering period.
3. Examine how Wood Frog and Spotted Salamander (*Ambystoma maculatum*) breeding site occupancy is influenced by local and landscape scale variables across an elevational gradient.

Maine is ecologically diverse with a varied landscape. Although pool-breeding amphibians generally are distributed across the state, the vernal pools they typically use for breeding are more limited geographically. Current legislation to protect vernal pools is based on research conducted in southern, central, and downeast Maine where vernal pools are relatively abundant; it is not clear how these species use alternative breeding habitat where vernal pools are scarce. For example, Maine's montane region is rugged and relatively wetland-limited, with one of the coldest climates in New England. Very little is known about pool-breeding amphibian dispersal, migration, hibernation, and habitat selection in this pool-limited region of Maine. Hibernaculum selection may be critical to individual fitness; six-months of hibernation ends with a short, explosive breeding period in nearby wetlands that are not necessarily typical vernal pool habitat used elsewhere in the state. Our research examines habitats used by pool-breeding amphibians throughout the annual life cycle in Maine's western and interior mountains.

We have completed two field seasons, with the primary foci being the assessment of Wood Frog post-breeding and overwintering habitat selection. We used radio telemetry to track the post-breeding movements of individuals in the landscapes surrounding two study lakes. We continued to track a reduced number of individuals throughout the fall until they were poised for hibernation. Enclosures were then erected around each individual so that they could again be tracked post-hibernation; this allowed us to link overwintering and breeding habitats. We also conducted amphibian surveys at 5-7 sites during these field seasons.

Specifically, we surveyed all water bodies within a 1km radius of our study lakes. This information obtained from these surveys will help inform field research related to occupancy modeling (i.e., Objective 3) that will begin in the spring of 2013.

Investigator: Luke Groff (PhD)

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

Duration: January 2010—December 2014

Cooperators:

Maine Department of Inland Fisheries and Wildlife
U.S. Geological Survey – Eastern Region Cooperative Fish and Wildlife Research Units
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife Ecology
University of Maine – Sustainable Solutions Initiative

Assessment of vegetation succession and spatial dynamics in Okefenokee Swamp, Georgia

1. Establish a current vegetation map of the Okefenokee Swamp documenting post-2011 fire vegetation regrowth.
2. Use the new and previously created vegetation (1977, 1990, 2001, 2008) and fire perimeter and severity (1974-2011) maps to conduct an assessment of vegetation change with fire.
3. Use a Bayesian Belief Network approach to develop a spatially explicit forecast of vegetation succession with various swamp fire management scenarios. This approach will spatially relate environmental factors (fire and hydrology) with vegetation community composition in a Geographic Information System to develop spatial projections of vegetation change with swamp fire management.

Fires that burned in Okefenokee Swamp in 2011 appear to have changed the vegetation structure of the swamp more drastically than the past recent fires, creating an increasingly homogenous landscape with fewer barriers to shift fire behavior. In combination with knowledge about hydrological conditions and vegetation-hydrology relationships, fire behavior may be anticipated based on recent post-burn vegetation maps. Vegetation maps developed from photography and imagery captured in 1977, 1990, 2001, and 2008, fire severity maps developed in 2001, 2007, and 2011, and species-hydrology relationships quantified from data collected during 1991-1995 provide a rich database to inform a spatially explicit forecast of vegetation succession with various swamp fire management scenarios. Our approach will relate ecological factors (e.g., fire and hydrology) with vegetation community composition in a spatially explicit Bayesian Belief Network.

We purchased a SPOT5 multispectral satellite image in October 2012 and have conducted an unsupervised

classification, which we are evaluating for classification accuracy. We have developed a bayesian belief network and are beginning analysis and refinement of the network, which will continue into early 2013.

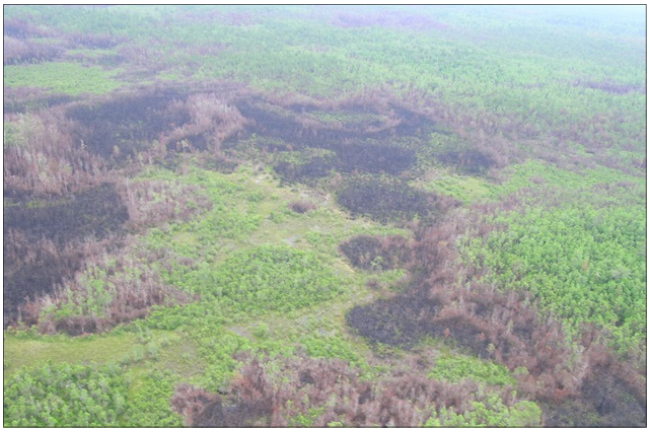
Investigator: Margaret Guyette (Post-doc)

Advisors: Cynthia S. Loftin (Advisor)

Duration: August 2012—September 2013

Cooperators:

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



Urban ecology of the blue-spotted salamander complex

1. Create and test a predictive model that will identify vernal pools that are likely breeding sites of blue-spotted salamanders. This model will be used by urban planners and citizen scientists to determine which pools are likely to require additional effort to find their cryptic egg masses.
2. Explore variation in egg masses, so that urban planners and citizen scientist may be able to differentiate pools with and without unisexuals based solely on egg masses.
3. Compare habitat use within the complex by genotype and urbanization..

The blue-spotted salamander complex in Maine consists of the blue-spotted salamander (*Ambystoma laterale*) and a unisexual lineage containing both the DNA of the blue-spotted and Jefferson salamander (*A. jeffseronianum*). The unisexuals are almost entirely polyploid females, and parasitize sperm from the blue-spotted salamanders to reproduce. We will examine the urban ecology, breeding site selection, reproductive variation, and upland habitat use of this complex.

We are currently developing our research proposal, and these methods may be modified.

Breeding model: We will conduct egg mass surveys and collect environmental data at a large sample of vernal pools. Using occupancy modeling, we will create a predictive model to determine what characteristics increase the likelihood a pond is used for reproduction. The following year we will test this model on an independent sample of pools, and simplify our recommendations.

Egg mass variation: We will capture migrating salamanders on their way to breeding ponds, and place pairs in breeding chambers within the wetland. We will collect tissue for genotyping and release the pairs

after mating/egg deposition, then compare the egg masses and spermatophores.

Habitat use: Using drift fences at six vernal pools, we will mark adult and juvenile salamanders with PIT tags and collect tissue samples for genotyping. We will use a series of transects and a back pack scanner to search for the salamanders as they disperse from the pond, and compare the habitat selection by ploidy and extent of urbanization.

We have completed a preliminary field season to refine our research questions, and are now in the process of writing the research proposal.

Investigator: Kristine Hoffmann (PhD)

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

Duration: January 2012—May 2017

Cooperators:

National Science Foundation – Experimental Program to Stimulate Competitive Research
University of Guelph
Orono Land Trust
University of Maine – Department of Wildlife Ecology
University of Maine – Sustainable Solutions Initiative

Black Bear Population Modeling

1. Estimate demographic parameters and population change rates from long-term black bear data in Maine.
2. Predict population trajectories.
3. Evaluate the effectiveness of the Maine Department of Inland Fisheries and Wildlife's current bear monitoring program and population estimates.
4. Determine whether alternative research and monitoring methods are appropriate.

For more than 30 years, the Maine Department of Inland Fisheries and Wildlife has used information acquired from intensive field work and data collection on black bears (*Ursus americanus*) in Maine, including trapping and marking bears, radio telemetry of female bears, and visiting winter dens, to estimate and monitor Maine's black bear population. While this long-term project has produced a unique data set and tremendous insight into black bear biology, current fiscal constraints and emerging wildlife issues have necessitated an evaluation of the program with an aim of increasing efficiency while maintaining a high-quality management program.

The black bear population modeling project will use this extensive and unique data set and explore new modeling approaches to quantify black bear population trends and investigate whether efficiencies can be gained in the program. One approach to explore will be the use of integrated population models which allow for the joint estimation of population parameters by exploiting the overlap in information across multiple surveys providing data on demographic rates. This approach has numerous benefits including proper accounting of uncertainty and increased precision of parameter estimates; it can also help identify which surveys are vital for adequately monitoring population trends.

Investigator: Shawn T. McKinney

Duration: April 2012—April 2015

Cooperators:

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

Spatial responses of Canada lynx to changing hare densities

1. To understand the effects of vegetation type, topography, and season on accuracy and success of GPS fixes of radio- collared lynx.
2. To evaluate how changing hare densities affect spatial requirements and extent of spatial overlap among adjacent resident lynx.
3. To determine whether landscape-and stand-scale habitat choices by resident lynx change from periods of high vs. low hare densities.

Canada lynx (*Lynx canadensis*) have been listed as federally threatened under the Endangered Species Act since 2000. Lynx are a specialist predator of snowshoe hares and their populations closely lag the snowshoe hare population cycle. During periods of lower hare abundance, lynx may be forced to alter aspects of their spatial ecology to survive. For example, habitat selection, home range area, recruitment, and territorial overlap may change as lynx adjust to declining numbers of prey. Some of these relationships have been studied in the northern portion of their range, but the existence of hare cycles, and the expected responses of lynx to changing hare densities are unknown within the Acadian Forest region where the dominant factor influencing the quality and supply of high quality lynx and hare habitat is commercial-scale forest harvesting.

The largest population of lynx in the contiguous U.S. occurs in Maine where large clearcuts were a common form of timber harvest prior to the enactment of the Maine Forest Practices Act in 1989. Since 1992, partial harvests have become the dominant form of timber harvest, thus reducing the extent, of regenerating conifer-dominated clearcut stands. Those changes densities of regenerating conifer stems, which are positively associated with hare density and patterns of lynx occupancy. Additionally, broad-scale factors that might contribute to regional changes in hare populations could exacerbate effects of anthropogenic processes on future habitat quality for hares and lynx.

This study is evaluating relationships among temporally changing hare densities, spatial ecology of lynx, and multi-scalar patterns of habitat selection by lynx within northern Maine. Additionally, we are evaluating effects of vegetation, topography and season on our success and accuracy at locating lynx using GPS collars to account for methodological biases that might occur using GPS technology.

Our study to evaluate relative fix success and location accuracy within 7 stand types previously documented as important habitat currencies for lynx has been completed across 2 seasons and 66 test sites. Results have been drafted into the first chapter of a 3 chapter thesis. Ongoing studies of spatio-temporal dynamics in hare populations have identified 2 periods of high and low hare density, and we have collaborated with Maine Department of Inland Fisheries and Wildlife to collect information for estimating home range, inra- and inter-sexual spatial overlap, and stand-scale and landscape-scale habitat selection for 13 male and 11 female Canada lynx during the high hare density period and for 10 male and 6 female lynx during the low hare density period. Lynx maintained territories during both the high and low hare density periods and exhibited similar patterns of spatial overlap and home range sizes between periods of high and low hare density. Further, patterns of second-order habitat use and 3rd-order habitat selection were similar between the 2 hare density periods, suggesting that hare densities do not reach the extreme low levels that might be associated with social disruption and large shifts in spatial use and habitat selection.

All analyses are complete and the expected date of project completion is May 2013.

Investigator: David Mallett (MS)

Advisors: Daniel J. Harrison (Co-Advisor)
Angela K. Fuller (Co-Advisor)
Richard S. Seymour
Jennifer H. Vashon (ex-officio)

Duration: May 2008—May 2013

Cooperators:

University of Maine – Department of Wildlife Ecology
University of Maine – Maine Agricultural and Forest Experiment Station
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service
Maine Department of Inland Fisheries and Wildlife
University of Maine – Maine Cooperative Forestry Research Unit

Seasonal variation of snowshoe hare density and implications for Canada lynx in managed forests of northern Maine

1. To document the influence of different forest stand types and seasonality on stand-level snowshoe hares densities.
2. To determine the relationship between seasonal changes in vegetation structure among different forest stand types and seasonal snowshoe hare densities.
3. To document seasonal food habits of Canada Lynx in northern Maine.

The federally threatened Canada lynx (*Lynx canadensis*) are specialist predators of snowshoe hare (*Lepus americanus*) which comprise up to 97% of lynx diet. Lynx movement, survival, and recruitment are closely associated with snowshoe hare availability. Harvest activities alter the composition and structure of forests, affecting the quality and availability of snowshoe hare and lynx habitat. Refugia from predators provided by vegetative cover changes seasonally and by forest stand type, which may affect relative densities of hares and their vulnerability to predation by lynx.

Our study is evaluating how relative hare densities change seasonally across forest types and management regimes within the Acadan forest region and we have quantified seasonal changes in vegetation structure and visual obstruction of hares associated with phenological change to understand the mechanisms associated with seasonal changes in habitat selection by hares and lynx.

Lynx can shift to alternative prey at their southern extents of their distribution, during low hare density periods and during snow-free periods. Thus, the third component of this project will document seasonal food habits of lynx to determine if there are dietary shifts associated with seasonal changes in lynx habitat selection.

Hare fecal pellet counts were conducted biannually in 28 stands composed of four forest and management

types in 2010, 2011, and 2012. These data continue a time series collected since 2001. We are evaluating how relative hare densities change across these types across seasons and years.

Vegetation and structural data were collected from 20 plots in each of the 28 stands during summer 2011 and winter 2012. Metrics used were lateral cover, canopy cover, and vegetation composition at four heights within a 10 m squared plot. From January-March 2011, those stands were re-measured for the same lateral and canopy cover variables, as well as snow depth. Additionally, we took photographs of a snowshoe hare silhouette from 2 random directions and are using software to quantify seasonal changes in visual obstruction across our stand types.

To assess lynx diet, winter samples collected by MDIFW and previously by personnel in our lab have been compiled. Additionally, summer scats were collected using a scat detection dog team in July, 2011. Genetic analyses have verified > 200 lynx scats and we have contracted with a lab to evaluate the gender of the lynx. Dietary analyses of all lynx scats will be conducted during winter 2013. The expected date of project completion is May 2013.

Investigator: Sheryn J. Olson (MS)

Advisors: Daniel J. Harrison (Advisor)
William B. Krohn
Richard S. Seymour
Jennifer H. Vashon (ex-officio)
Mark McCollough (ex-officio)

Duration: January 2010—May 2013

Cooperators:

University of Maine – Department of Wildlife Ecology
University of Maine – Maine Agricultural and Forest Experiment Station
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service
Maine Department of Inland Fisheries and Wildlife
University of Maine – Maine Cooperative Forestry Research Unit

Effects of forest management practices in the Acadian Northern Hardwood/Conifer Forests of Maine on forest bird communities, with emphasis on species of regional conservation priority and concern

1. Relate avian diversity and abundance to stand quality (indicated by stand vegetation structure and composition) in forests that have been harvested with a range of intensities along a temporal gradient in northern Maine.
2. Quantify relationship between avian community composition and forest harvest pattern in the landscape.
3. Examine trends in regional and national surveys of USFWS conifer-associated priority species and relationships observed between avian species and forest condition documented during this study.

The goal of this study is to examine effects of Maine's forest harvest practices used in the northern deciduous/coniferous forest on diversity and abundance of the forest bird community, with a focus on species of conservation interest (e.g., Bay-breasted Warbler, Blackburnian Warbler, Cape May Warbler). We will document bird communities in manipulated stands compared to reference stands and within the larger landscape context. Time since harvest will range from > 60 years (i.e., mature residual stands) to 17-40 years in regenerating clearcuts, and 14-18 years since initial harvest entry in stands harvested at various intensities. We will take a hierarchical approach to extensively and intensively survey forest stands in northern Maine during mid-May to mid-July, the breeding season for forest birds in this region. The forest stands will serve as intensive study sites to quantify the avian community via point count surveys, and vegetation data already available from these stands will be related to avian metrics. Additional stands in the vicinity of these intensive study stands will be

selected to provide a broader representation of the range of forest conditions resulting from partial harvesting. We will be collaborating with US Fish and Wildlife Service staff at Lake Umbagog, Nulhegan, and Moosehorn National Wildlife Refuges to use the same survey protocols used in northern Maine to conduct avian and vegetation surveys on their refuge lands to expand the geographical extent of our study to the northern forest beyond Maine's borders. The results of this study will inform our understanding of responses by these and other bird species to stand age and structure as they relate to habitat quality and in the context of changing land use practices in the northern forest landscape.

We are working with refuge staff and staff at Baxter State Park to select study stands and develop survey protocols. Field work will begin in May 2013.

Investigator: Brian Rolek (PhD)

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

Duration: August 2012—December 2016

Cooperators:

University of Maine
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

Genetic analysis of Blanding's turtle populations

1. Assess the population genetic structure of Blanding's turtle populations in the Northeast and incorporate findings into conservation planning and priority area management in Maine, Massachusetts, New Hampshire, New York, and Pennsylvania.
2. Examine isolated/outlier Blanding's turtle populations in Pennsylvania and New York to determine origin (naturally occurring or introduced).
3. Compare the genetic structure of Blanding's turtle populations within the Northeast region to those in the Midwest region and Canada to provide a spatially explicit assessment of the discrete population groups across the species' range.

The geographic range of Blanding's turtle (*Emydoidea blandingii*) occurs in the mid-continent of North America, with the majority of populations occurring in the Great Lakes region and southern Ontario. In the Northeast United States, there is a small contiguous population in Massachusetts, New Hampshire and Maine, two disjunct populations in eastern New York, and one population in Pennsylvania of unknown status. Blanding's turtle populations are declining throughout their range, and are state-listed as threatened in New York and Massachusetts, as endangered in Maine and New Hampshire, and as a Species in Greatest Need of Conservation (SGCN) in all Northeast states where it occurs. In Canada, the Great Lakes/St. Lawrence population in Ontario and Quebec is listed as threatened and the disjunct population in Nova Scotia is listed as endangered (Committee on the Status of Endangered Wildlife in Canada, COSEWIC). A status assessment has been completed for the species in the Northeast and the next high priority action to implement is the development of a regional conservation plan including an assessment of genetic variation throughout the region, and development and implementation of a

monitoring protocol. Although some research has been done on the genetic structure of Blanding's turtle populations among regions across their range, adequate information is not available to determine the degree and boundaries of discreteness of northeastern populations. This research will compare the genetic structure of populations in the Northeast with those across the species range in the United States and Canada using DNA sequencing and genotyping. Results will be used to determine the distinctiveness of the Northeast populations compared to the Midwest/ Great Plains region, which could affect the approach to managing the species in the Northeast. These data are essential for informed management and conservation planning for Blanding's turtles in the Northeast.

Investigator: Judith M. Rhymer

Duration: June 2011—May 2014

Cooperators:

Maine Department of Inland Fisheries and Wildlife
University of Maine – Department of Wildlife Ecology
University of Maine – Maine Agricultural and Forest Experiment Station
U.S. Fish and Wildlife Service
Cooperative Fish and Wildlife Research Unit, University of Massachusetts
Massachusetts Division of Fisheries and Wildlife
New York State Department of Environmental Conservation
Biology Department, Acadia University, Nova Scotia, Canada
Swampwalkers Wetland Ecosystem Specialists, Parker River Association, MA
Biology Department, SUNY Potsdam, NY
New Hampshire Fish and Game Department
Pennsylvania Fish & Boat Commission's Natural Diversity Section

Genetic structure of Clayton's copper butterfly (*Lycaena dorcas claytoni*) metapopulation

Analyze genetic structure of Clayton's copper butterfly metapopulation in Maine with nuclear DNA loci [microsatellites and Amplified Fragment Length Polymorphisms (AFLPs)].

The focus of this research is to analyze the genetic structure of Clayton's copper butterfly populations in the state of Maine. Clayton's copper is a state endangered species and is currently found at only nine sites in Maine, however nothing is known about the metapopulation structure of this subspecies. This research will estimate levels of gene flow among sites, which will help us to understand the metapopulation dynamics of Clayton's copper butterfly by estimating levels of dispersal and isolation that contribute to population stability.

Preliminary results indicate that there are three distinct clusters of subpopulations in Maine: northern Maine near Caribou, northwestern Maine in the Allagash region and central Maine near Lincoln. Genetic structure of subpopulations within regions will be analyzed with AFLP data. Results will contribute to efforts to estimate the diversity and size of the Clayton's copper population in the state, and will aid in developing a management strategy for the species in Maine.

Investigator: Judith M. Rhymer

Duration: September 2008—December 2012

Cooperators:

University of Maine – Department of Wildlife Ecology
University of Maine – Maine Agricultural and Forest Experiment Station
U.S. Fish and Wildlife Service
Maine Department of Inland Fisheries and Wildlife
Maine Outdoor Heritage Fund
The Nature Conservancy
American Philosophical Society

Breeding ecology and terrestrial habitat requirements of the eastern spadefoot (*Scaphiopus holbrookii*) and pure-diploid blue-spotted salamander (*Ambystoma laterale*) in eastern Connecticut

The objectives of the study are to collect information on:

1. breeding population size
2. breeding philopatry
3. movement patterns of adults/juveniles to and from breeding wetlands (immigration and emigration orientation)
4. juvenile recruitment
5. juvenile and adult dispersal rates
6. non-breeding habitat use and home range size
7. burrowing ecology (eastern spadefoot)
8. larval interactions (blue-spotted salamander and spotted salamanders [*A. maculatum*])

The research provides valuable information on two Massachusetts, New York and Connecticut State-listed species, the eastern spadefoot (*Scaphiopus holbrookii*) and the pure-diploid blue-spotted salamander (*Ambystoma laterale*). Both species merit scientific investigation as information on the terrestrial ecology of both animals is sparse. Our results will help to determine best management practices for mitigation of developments affecting habitat for these and other pool-breeding species that depend on adjacent terrestrial habitats for the majority of their lives.

Information is collected on study animals through the use of: (1) pitfall trapping (mark-recapture), (2) radio-telemetry, (3) PIT tag scanning: a technique entailing systematically scanning for animals with implanted PIT tags using a PITpack (an electronic tag reading device reminiscent of a metal detector), and (4) toad-totes (a stationary tag-reading device used to monitor eastern spadefoot toad burrow emergence). The larval experiment was conducted using a series of mescosms.

As of the fall of 2011 fieldwork for this project has been completed. Data analyses and subsequent production of dissertation chapters/journal articles are ongoing. A manuscript entitled "Monitoring Eastern Spadefoot (*Scaphiopus holbrookii*) response to weather using a passive integrated transponder (PIT) system" has been submitted to the Journal of Herpetology and is currently under review. A second chapter "Using passive integrated transponder (PIT) systems for terrestrial detection of blue-spotted salamanders in situ" is in in progress and is planned for submission to Herpetological Review within the next several months. Two additional chapters focusing on terrestrial habitat requirements of eastern spadefoots and blue-spotted salamanders are scheduled to be completed by the summer of 2013.

Investigator: Kevin J. Ryan (PhD)

Advisors: Aram J.K. Calhoun (Advisor)
Michael W. Klemens
Joseph D. Zydlewski
Brad Timm
Malcolm L. Hunter, Jr

Duration: January 2008—August 2013

Cooperators:

University of Maine – Department of Wildlife Ecology
University of Maine – Sustainable Solutions Initiative
Connecticut Department of Energy and Environmental Protection
Lowe's Home Centers, Inc.

A long-term forest ecosystem study

1. Describe the structure of the plant and animal communities in an oak-pine forest ecosystem.
2. Investigate the effect of woodlot management on populations and community structure.
3. Document phenological, inter annual, and long-term changes in population and community structure.

This continuing study is being conducted on a 120 ha, red oak-white pine woodlot in Arrowsic, Maine, called the Holt Forest. A 40 ha study area is gridded into forty 1-ha blocks with 20 ha serving as a control area and 20 ha as an experimental area.

Over the years we have collected data sets that include a 100% inventory of trees (>10cm DBH), intensive inventories of tree saplings and seedlings, tree mapping on 20ha, a complete record of the vascular plant vegetation using the relevé technique, an inventory of all breeding bird territories, annual small mammal trapping, salamander cover object counts, estimates of seed and fruit production, frass counts of canopy insect defoliators, and vascular plant densities in 1m2 plots.

A 1987/1988 timber harvest with three objectives: (1) increase wood production; (2) increase wildlife diversity and abundance; and (3) maintain the forest's aesthetic value has provided a basis of comparison to better understand the impacts of harvesting. By continuing to monitor populations and processes, we have better insights into plant and wildlife populations. Over the course of nearly 30 years, we have begun to better understand seasonal and annual changes in populations and the ecosystem structure.

In 2012, our 30th field season, all yearly monitoring projects were completed, updating tree location information was the major initiative for the field season but a limited field crew could not accomplish the task. In 2013, our goal is to continue work on improving our tree map data and numbering methods. This will give us better control over tree number loss and improve the efficiency of future inventory work. All yearly monitoring will be conducted except for fruit counts which were discontinued due to the much reduced fruit production in recent years.

High acorn mast in 2010 and good conditions in the spring of 2011 resulted in the highest density of oak seedlings ever recorded at HRF. Where they were prolific, oak seedlings were the dominant vegetation of the forest floor. A selection of 1m2 plots will continue to be monitored to follow the success of this cohort of oak seedlings in 2013 and future years.

Investigators: Malcolm L. Hunter, Jr.
Alan J. Kimball
Alan S. White
Jack W. Witham

Duration: January ongoing—January 2014

Cooperators:

Holt Woodlands Research Foundation
University of Maine – Sustainable Solutions Initiative

INTEGRATED ecology

Remote monitoring of water clarity of Maine lakes using Landsat Thematic Mapper

1. Determine if Landsat data can reliably duplicate late water clarity assessment with Secchi Depth and chlorophyll a data collected at selected lakes.
2. Determine temporal frequency (when, how often) and spatial limitations (resolution, location) of image collection for lake water clarity monitoring to complement field data collection programs.
3. Retrospective analysis of Maine's lake water clarity based on archived remote sensing data.

Abstract: Water clarity is an ideal metric of regional water quality because clarity can be accurately and efficiently estimated remotely on a landscape scale. Remote sensing of water quality is useful in regions containing numerous lakes that are prohibitively expensive to monitor regularly using traditional field methods. Field-assessed lakes generally are easily accessible and may represent a spatially irregular, non-random sample. Remote sensing provides a more complete spatial perspective of regional water quality than existing, interest-based sampling; however, field sampling accomplished under existing monitoring programs can be used to calibrate accurate remote water clarity estimation models. We developed a remote monitoring procedure for clarity of Maine lakes using Landsat Thematic Mapper (TM) and Moderate-Resolution Imaging Spectroradiometer (MODIS) satellite imagery. Similar Landsat-based procedures have been implemented for Minnesota and Wisconsin lakes, however, we modified existing methods by incorporating physical lake variables and landscape characteristics that affect water clarity on a landscape scale. No published studies exist using MODIS data for remote lake monitoring owing to the coarse spatial resolution (500 m) (Landsat=30 m), however, daily image capture is an important advantage over Landsat (16 days). We estimated secchi disk depth during 1990 -2010 using Landsat imagery (1,511 lakes) and during 2001-2010 using MODIS imagery (83 lakes) using multivariate linear regression (Landsat: R^2=0.69-0.89; 9 models; MODIS: R^2=0.72-0.94; 14 models). Landsat is useful for long-term monitoring of lakes > 8 ha, and MODIS is applicable to annual and within-year monitoring of large lakes (> 400 ha).

An important application of remote lake monitoring is the detection of spatial and temporal patterns in regional water quality and potential downward shifts in trophic status. We applied the Landsat-based methods to examine trends in Maine water clarity during 1995-2010. Remote change detection of water clarity should be based on August and early September (late summer) imagery only owing to seasonally poor clarity conditions and stratification dynamics, so our analysis was restricted to years in which late summer imagery were available. We focused on the overlap region between Landsat TM paths 11-12 to increase late summer image availability. We divided Maine intro three lake regions (northeastern, south-central and western) to examine spatial patterns in lake clarity. The overlap region contains 570 lakes > 8 ha and covers the entire north-south gradient of Maine. We found an overall decrease in average statewide lake water clarity of 4.94-4.38 m during 1995-2010. Water clarity ranged 4-6 m during 1995-2010, but consistently decreased during 2005-2010. Clarity in both the northeastern and western regions has experienced declines from 5.22 m in 1995 to 4.36 and 4.21 m respectively in 2010, whereas clarity in the south-central region remained unchanged since 1995 (4.50 m).

Investigator: Ian McCullough (MS)

Advisors: Cynthia S. Loftin (Co-Advisor)
Steven A. Sader (Co-Advisor)
William Halteman
Aram J.K. Calhoun

Duration: June 2010—July 2012

Cooperators:

Maine Department of Environmental Protection
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife Ecology

An examination of the drivers, institutions and economics of sustainability planning in Maine

1. Characterize sustainability policies in Maine municipalities and identify the drivers that lead to the adoption of such policies.
2. Study efforts of two Maine towns that are developing vernal pool regulatory policy, as an example of a sustainable policy.
3. Conduct economic policy analysis to inform local vernal pool policy development.

The project plan is as follows: 1) Develop specific measures of sustainability patterns in Maine towns and examine patterns of adoption using spatial analysis and statistical classification (January through June 2013). 2) Participant observation of all relevant stakeholder meetings (throughout 2013). Draft semi-structured interview protocol (summer 2013). Conduct interviews (summer 2013). Collect documents (throughout 2013).
3) Conduct economic analysis for towns (as needed 2013). Finalize research plan (January—April 2013).

Passed written and oral comprehensive exams. Attended approximately 15 stakeholder meeting in 2012. Conducted economic analysis in cooperation with Robb Freeman, EMCC to determine vernal pool impact fee. Collected data to measure municipal policies that contribute to sustainability and the drivers that lead to such policies. Presented poster at Maine Water Conference in March 2012 titled, "Sustainability in Maine Municipalities". Presented poster at Society for Conservation Biology (CA, July 2012) titled, "Municipal vernal pool policy development: Sustainability Science in Action". Presented poster at Maine EPSCoR Conference in September 2012 titled, "Municipal vernal pool policy development: Sustainability Science in Action". Participated in panel about innovative municipal planning at the Northern New England Chapter of the American Planning Association meeting in October 2012.

Presented paper at the Association of Collegiate Schools of Planning (OH, November 2012) titled, "Some do and some don't: Factors that enable smaller communities to contribute to sustainability".

Investigator: Vanessa Levesque (PhD)

Advisors: Aram J.K. Calhoun (Co-Advisor)
Kathleen P. Bell (Co-Advisor)
Mario Teisl
Teresa R. Johnson
Dave Owen

Duration: January 2010—June 2014

Cooperators:

Maine Department of Environmental Protection
Maine Department of Inland Fisheries and Wildlife
University of Maine – Sustainable Solutions Initiative
Maine State Planning Office
Army Corps of Engineers
Topsham, Town of
Orono, Town of

Assessing vulnerability of treeline ecosystems in the Sierra Nevada

1. Produce species distribution models for high-elevation white pine species–whitebark pine (*Pinus albicaulis*) and foxtail pine (*P. balfouriana*)–under current conditions and under projected climate change scenarios within Sierra Nevada Network national parks. Exploit the latitudinal gradient of environmental conditions and variety of management contexts among park units to discern relationships and provide a regional view.
2. Produce distribution models for the invasive pathogen, white pine blister rust under current conditions and under projected climate change scenarios within the parks.
3. Use these two sets of models to evaluate the potential effects of the two interacting stressors (climate change, pathogen) on the future distribution of high-elevation white pine species.

The high-elevation occurrence of whitebark pine and foxtail pine render these two species and the communities they define particularly vulnerable to continued trends in atmospheric warming. The non-native disease, white pine blister rust (WPBR) and its associated impacts on community dynamics pose the most severe near-term threat. Increased atmospheric warming and its secondary effects (e.g., large-scale mountain pine beetle outbreaks) present a potentially bleak long-term outlook for these species.

Projecting shifts in the climate envelopes of white pines and WPBR will inform long-term monitoring of high-elevation white pines. It will also help evaluate the long-term threat posed by WPBR to subalpine communities by determining the amount of potential future overlap between the ranges of the tree species and the pathogen. We expect that monitoring targets of species composition and demography, stand structure, and the incidence of WPBR will respond directly to alterations in temperature and moisture. Our products will assist in moving beyond determining status and trend by addressing causes of change in subalpine ecosystems, and will help park managers anticipate short- and long-term changes in high-elevation ecosystems. Modeling results will assist with characterizing the vulnerability of subalpine forest communities in Sierra Nevada national parks for use in adaptive management planning.

1. Data compilation and summarization describing abundance by species for each of 10 ecological and survey plot data sets. 2. Preparation of current climate surfaces for precipitation (PPT), monthly maximum temperature (Tmax), monthly minimum temperature (Tmin), and monthly mean temperature (Tmean). 3. Preparation of climate surfaces for 2050 and 2090 for the same climatic variables. 4. Construction of current distribution models for whitebark pine and foxtail pine based on climatic and topographic variables. 5. Comparison and ranking of competing current distribution models to inform variable selection for 2050 and 2090 distribution models.

Investigators: Shawn T. McKinney, Peggy Moore, Qinghua Guo, Matthew Brooks

Duration: October 2010—September 2013

Cooperators:

National Park Service
U.S. Geological Survey – Biological Resources Discipline
U.S. Geological Survey – Maine Cooperative Fish and Wildlife Research Unit

Assessing Priority Amphibian and Reptile Conservation Areas (PARCAs) and vulnerability to climate change in the north Atlantic landscape conservation cooperative

1. Gather reptile and amphibian species record data from states in the NE-LCC region to compile in a central data base.
2. Develop maps of current distributions of priority amphibians and reptiles in the NA-LCC region. Combine these maps with maps of climate change-projected habitat suitability maps.
3. Rank species vulnerability to climate change based projected losses in the species' ranges, and identify areas within the NA-LCC where losses of vulnerable species are anticipated, where there is potential for climatic refugia for priority species, 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 3, 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 a Northeast regional workshop.

Amphibians and reptiles are experiencing severe habitat loss throughout North America; however, this threat to biodiversity can 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. As climate rapidly changes it is possible that areas currently deemed suitable may no longer be so in the future. To address these needs, we are collaborating with scientists from Clemson University and the Association of Fish and Wildlife Agencies to generate spatially-explicit data that will (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 have received species record data from nearly all of the states in the NA-LCC and are reviewing and converting datasets into a spatial format. We are exploring use of species distribution predictions from the National Gap Analysis, as well as other tools for generating these maps to combine with the occurrence data. We are developing methodology for PARCA identification with Maine's data and will repeat the analysis with other states' data.

Investigator: Allison Moody (Post-doc)

Advisor: Cynthia S. Loftin

Collaborator: Phillip deMaynadier

Duration: August 2012—December 2014

Cooperators:

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

PUBLICATIONS and presentations

SCIENTIFIC PUBLICATIONS

Barringer, L.E., D.F. Tomback, M.B. Wunder, and S.T. McKinney. 2012. Relative health of whitebark pine and cone production as predictors of visitation by Clark's Nutcracker. PLoS ONE 7(5): e37663

Calhoun, A.J.K., M.K. Gahl, and R.F. Baldwin. 2012. Northeastern seasonal woodland pools. Pages 135 -148 *In* D. Batzer and A. Baldwin, eds. Wetland habitats of North America: Ecology and conservation concerns. University of California Press, Berkeley, CA.

Campbell, S.P., J.W. Witham, and M.L. Hunter Jr. 2012. Long-term changes in spatial distribution of birds responding to a group-selection timber harvest. *Wildlife Society Bulletin* 36:313-327.

Danielson, T.J., C.S. Loftin, L. Tsomides, J.L. DiFranco, and B. Connors. 2011. Algal bioassessment metrics for wadeable streams and rivers of Maine, USA. *J. North American Benthological Society* 30:1033-1048.

Danielson, T.J., C.S. Loftin, L. Tsomides, J.L. DiFranco, B. Connors, D.L. Courtemanch, F. Drummond, and S.P. Davies. 2012. An algal model for predicting attainment of tiered biological criteria of Maine's streams and rivers. *Freshwater Science* 31:318-340.

Freeman, R.C., K.P. Bell, A.J.K. Calhoun, and C.S. Loftin. 2012. Incorporating economic models into vernal pool conservation planning: using local land use regulations to enhance state regulations. *Wetlands* 32: 509-520.

Gardner, C., S.M. Coghlan Jr., and J. Zydlewski. 2012. Distribution and abundance of Anadromous sea lamprey spawners in a fragmented stream: Current status and potential range expansion following barrier removal. *Northeastern Naturalist* 19(1):99-110.

Gorsky, D., J. Zydlewski, and D. Basely. 2012. Characterizing seasonal and diel vertical movement and habitat use of lake whitefish (*Coregonus clupeaformis*) in Clear Lake, Maine. *Transactions of the American Fisheries Society* 141 (3):761-771.

Greenspan S.E., J.E. Longcore, and A.J.K. Calhoun. 2012. Host invasion by Batrachochytrium dendrobatidis: Fine structure of the amphibian chytrid in model anurans. *Diseases of Aquatic Organisms* 100:201–210.

Greenspan, S.E., A.J.K. Calhoun, J.E .Longcore, and M.G. Levy. 2012. Transmissions of Batrachochytrium Dendrobatidis to wood frogs (*Lithobates sylvaticus*) via a Bullfrog (*L. catesbeianus*) vector. *Journal of Wildlife Diseases* 48:575–582.

Kazyak, D. and J. Zydlewski. 2012. High-Density Polyethylene Pipe: A New Material for Pass-By Passive Integrated Transponder Antennas. *North American Journal of Fisheries Management* 32:49-52.

McCullough, I.M., C.S. Loftin, and S.A. Sader. 2012. Combining lake and watershed characteristics with Landsat TM data for remote estimation of regional lake clarity. *Remote Sensing of Environment* 123:109-115.

McCullough, I.M., C.S. Loftin, and S.A. Sader. 2012. High-frequency remote monitoring of large lakes with MODIS 500 m imagery. *Remote Sensing of Environment* 124:234-241.

McGreavy, B., T. Webler, and A.J.K. Calhoun. 2012. Local decision maker attitudes to vernal pool conservation in Maine. *Journal of Environmental Management* 95:1-8.

Popescu, D., M.L. Hunter, D. Patrick, and A.J.K. Calhoun. 2012. Predicting the response of amphibian communities to disturbance across multiple temporal and spatial scales. *Forest Ecology and Management* 270:163-174.

Popescu, V., B.S. Brodie, M. Hunter, and J. Zydlewski. 2012. Use of olfactory cues by newly metamorphosed wood frogs (*L. sylvaticus*) during emigration. *Copeia* 2012:424–431.

Shearin, A., A.J.K. Calhoun, and C.S. Loftin. 2012. Evaluation of listener-based amphibian surveys with automated recording devices. *Wetlands* 32:737 -751.

Wathen, R.A., S.M. Coghlan Jr., J. Zydlewski, and J.G. Trial. 2012. Effects of smallmouth bass on Atlantic salmon habitat use and diel movements in an artificial stream. *Transactions of the American Fisheries Society* 141:174-184.

Zydlewski, G., M. Kinnison, P. Dionne, J. Zydlewski, and G. Wippelhauser. 2011 Understanding habitat connectivity for shortnose sturgeon: The importance of small coastal rivers. *Journal of Applied Ichthyology* 27(s2):41-44.

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Keane, R.E., D.F. Tomback, C.A. Aubry, A.D. Bower, E.M. Campbell, C.L. Cripps, M.B. Jenkins, M.F. Mahalovich, M. Manning, S.T. McKinney, M.P. Murray, D.L. Perkins, D.P. Reinhart, C. Ryan, A.W. Schoettle, and C.M. Smith. 2012. A range-wide restoration strategy for whitebark pine (*Pinus albicaulis*). Gen. Tech. Rep. RMRS-GTR-279. Fort Collins, CO. U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station. 108 pp.

McKinney, S.T., T. Rodhouse, L. Chow, G. Dicus, L. Garrett, K. Irvine, D. Sarr, and L.A. H. Starcevich. 2012. Monitoring white pine (*Pinus albicaulis, P. balfouriana, P. flexilis*) community dynamics in the Pacific West Region: Klamath, Sierra Nevada, and Upper Columbia Basin Networks. Natural Resource Report NPS/PWR/NRR—2012/532. National Park Service, Fort Collins, CO.

Silka, L., B. McGreavy, B. Cline, and L. Lindenfeld. 2012. Introduction to Sustainability: Special Issue from the Margaret Chase Smith Policy Center. *Maine Policy Review* 21:10-13.

THESES AND DISSERTATIONS

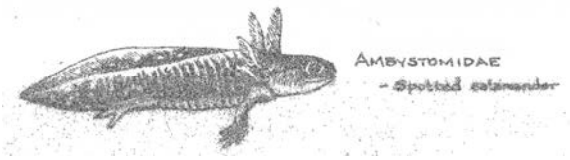
Ashe, Wes. A. 2012. First-summer survival and growth of juvenile Atlantic Salmon in headwater streams: Implications for restoring connectivity at road culverts. M.S. Thesis, University of Maine, Orono. 47 pages.

Guyette, Margaret Q. 2012. Responses of Atlantic salmon stream communities to marine-derived nutrients. Ph.D. Dissertation, University of Maine, Orono. 195 pp.

Kiraly, Ian A. 2012. Characterizing fish assemblage structure in the Penobscot River prior to dam removal. M.S. Thesis, University of Maine, Orono. 83 pp.

McCullough, Ian M. 2012. Remote estimation of regional lake clarity with Landsat TM and MODIS satellite imagery. M.S. Thesis, University of Maine, Orono. 90 pp.

Shearin, Amanda F. 2012. Influence of landscape arrangement and wetland condition on breeding dynamics of *Ambystoma maculatum* (Spotted Salamander) in Maine, USA. Ph.D. dissertation, University of Maine, Orono. 236 pp.



PROFESSIONAL TALKS PRESENTED

Altenritter, M., G. Zydlewski, M. Kinnison and J. Zydlewski. 2012. "Coastal river connectivity and shortnose sturgeon: A metapopulation perspective." 2012 Forum, Atlantic Salmon and their Ecosystems, January 10-11, Bangor ME.

Ashe, W., and S.M. Coghlan Jr. 2012. "Atlantic salmon growth and survival as an indicator of habitat quality in small tributaries of the Machias River watershed." The Annual Maine Water Conference, March 14, Augusta, ME.

Ashe, W.A., S.M. Coghlan Jr., J.G. Trial, and J. Zydlewski. 2012. "The growth and survival of stocked juvenile Atlantic salmon in small tributaries of the Machias River watershed." The Atlantic Salmon and their Ecosystem Research Forum, January10, Orono, ME, USA.

Aumann, H., E. Kus, B. Cline, and N.W. Emanetoglu. 2012. "A 5.8 GHz RF Tag for Tracking Amphibians." IEEE International Conference on Wireless Information Technology and Systems, July 29 - August 2, Honolulu, HI.

Calhoun, A.J.K. 2011. "Advice on becoming a conservation professional." The International Congress of the Society for Conservation Biology, December 6, Auckland, NZ.

Calhoun, A.J.K. 2011. "Vernal pools: Can amphibians and humans find common water?" The International Congress of the Society for Conservation Biology, December 6, Auckland, NZ.

Cline, B.B. 2012. "Juvenile amphibian movement in complex landscapes: Insights about dispersers from terrestrial experiments." Maine Association of Wetland Scientists, Annual Meeting. March 29. Hallowell, ME.

Cline, B.B., D.V. Popescu, and M.L. Hunter. 2012. "Amphibians in complex landscapes: Effects of forestry and urbanization on juvenile movements." World Congress of Herpetology (WCH.7) Symposia 25. The Implications of Habitat Fragmentation on Herpetofauna: A Global Problem with Local Solutions. August 8-14, Vancouver, BC, CA.

Coghlan Jr., S.M. 2012. "Restoring the Penobscot River: Dam removal and recovery of native fishes." The Marine Environmental Research Institute's Rachel Carson Seminar Series, January 26, Blue Hill, ME.

Coghlan Jr., S.M., and P.D. Damkot. 2012. "Effects of large woody debris addition on wild brook trout and in-stream habitat in western Maine." The Northeastern Natural History Conference, April 18, Syracuse, NY.

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Coghlan Jr., S.M., I. Kiraly, J. Zydlewski, and D.B. Hayes. 2012. "Quantifying the structure of fish assemblages in the Penobscot River in anticipation of dam removal." The annual Northeastern Natural History Conference, April 16-18, Syracuse, NY.

Coghlan Jr., S.M., J. Zydlewski, P. Damkot, R. Hogg, R. Saunders, and K. Simon. 2012. "Conservation and restoration of Atlantic salmon, brook trout, and their habitats." The 17th Annual Androscoggin River Watershed Conference, May 23, Auburn, ME.

Coghlan, Jr., S.M., J. Zydlewski, R. Hogg, C. Gardner, K. Simon and R. Saunders. 2012. "Effects of dam removal on anadromous fishes, resident fishes, and physical habitat in a coastal Maine stream." The 2012 Northeastern Natural History Conference, April 16, Syracuse, NY.

Damkot, P.D., and S.M. Coghlan Jr. 2012. "The influence of riparian forest characteristics on terrestrial invertebrate input and brook trout diet in headwater streams." The Annual Maine Water Conference, March 14, Augusta, ME.

Drahovzal, S.A., Loftin, C.S., Rhymer, J.M. 2012. "Assessment of circumneutral wetlands with shrubby cinquefoil (*Dasiphora fruticosa*): Hhost plant of the endangered Clayton's Copper butterfly (*Lycaena dorcas claytoni*)." Society of Freshwater Science Annual Meeting, May 21, Louisville, KY,.

Fuller, A. and D. Harrison. 2011. "Trade-offs among forest management objectives, focal wildlife species, and ecological reserves: Implications for future biodiversity and timber harvests." Poster, the Society of Annual Foresterâ Annual Conference, November 4, Honolulu, HI.

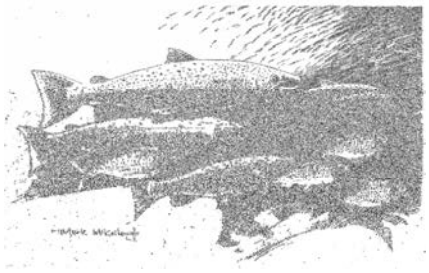
Fuller, A., D. Harrison, and W. Krohn. 2011. "The role of ecological reserves to maintain American marten and Canada lynx in a working forest landscape." Poster, The Wildlife Society, 18th Annual Conference, November 9, Waikoloa, HI.

Greenspan S.E. 2011. "Break on through: Host invasion by *Batrachochytrium dendrobatidis*." The Annual Meeting of Integrated Research Challenges in Environmental Biology (Emerging Wildlife Diseases: Threats to Amphibian Biodiversity), October, Tempe, AZ

Groff, L.A., A.J.K. Calhoun and C.S. Loftin. 2012. "Habitat Use by Pool-breeding Amphibians in Maine's Montane Region." Northeast Partners in Amphibian and Reptile Conservation; 25 July, Crawford Notch, NH, USA. (poster)

Grote, A., J. Zydlewski and M. Bailey. 2012. "Exploring the movements of migratory fish in the Penobscot River using DIDSON Technology." 2012 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, March 20, Orono, ME.

Grote, A., J. Zydlewski and M. Bailey. 2012. "River American shad: Establishing baselines prior to restoration." 2012 Forum, Atlantic Salmon and their Ecosystems, January 10-11, Bangor, ME.



Grote, A., J. Zydlewski, M. Bailey. 2012 "DIDSON Assessment of Fish Approaching a Hydroelectric Dam." Oral presentation at the 142nd Annual Meeting of the American Fisheries Society, August 19, Minneapolis-St. Paul, MN.

Guyette, M., C. Loftin, J. Zydlewski. 2011. "The role of marine derived nutrients delivered by anadromous fish in Penobscot River watershed nursery streams." University of New Brunswick, December 9, Fredericton, NB.

Guyette, M., C. Loftin, J. Zydlewski. 2012. "Marine-derived nutrient uptake in macroinvertebrate communities in Atlantic salmon nursery streams." Society for Freshwater Science Annual Meeting, May 20-24, Louisville, KY.

Guyette, M., Loftin, C., Zydlewski, J. 2012. "Evidence of marine-derived nutrient uptake in Atlantic salmon nursery stream communities." The 2012 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit. Orono, 20 March, ME, USA.

Hogg, R., S.M. Coghlan Jr., J. Zydlewski and C. Gardner. 2012. "Barrier removal in Sedgeunkedunk Stream: Sea lamprey recolonization and implications for Atlantic salmon habitat restoration." 2012 Forum, Atlantic Salmon and their Ecosystems, January 10, Bangor, ME.

Hogg, R., S.M. Coghlan Jr., J. Zydlewski, and C. Gardner. 2012. "Sea lamprey recolonization and implications for Atlantic salmon habitat restoration." The Atlantic Salmon and Their Ecosystems research forum, January 10-11, Bangor, ME.

Hunter, M.L. 2011. "Looking backwards to see forward." The International Congress for Conservation Biology, December 9, Auckland NZ.

Hunter, M.L. 2011. "Maintaining biodiversity in highly dynamic forests." The International Congress for Conservation Biology, December 7, Auckland NZ.

Hunter, M.L. 2012. "Careers in conservation." the David Smith Postdoctoral Fellows in Conservation Science, May 30, Acadia National Park, ME.

Hunter, M.L. and A.J.K. Calhoun. 2011. "Advice for newcomers workshop." The International Congress for Conservation Biology, December 6, Auckland NZ.

Kiraly, I., S.M. Coghlan Jr., J. Zydlewski, and D.B. Hayes. 2012. "Quantifying fish assemblage structure in the Penobscot river in anticipation of dam removal." The Maine Water Conference, March 14, Augusta, ME.

Kocik, J. F., J. P. Hawkes, D. Stich, J. Zydlewski, M. Dever, C. Byron and A. Lamont. 2012. "Blue Highways: The migration ecology of Atlantic salmon from Maine estuaries to the Scotian Shelf." The 142nd Annual Meeting of the American Fisheries Society, August 19, Minneapolis-St. Paul, MN.

Levesque, V., A.J.K. Calhoun, K. Bell. 2012. "Municipal Vernal Pool Policy: Sustainability Science in Action." Poster. Society for Conservation Biology, July 15-20 Oakland, CA.

Levesque, V., K. Bell, and A.J.K. Calhoun. 2012. "Some do and some don't: Factors that enable smaller communities to contribute to sustainability." Association of Collegiate Schools of Planning, October 31 – November 4, Cincinnati, OH.

McCullough, I. M., C. S. Loftin and S. A. Sader. 2012. "Remote monitoring of regional lake water clarity with satellite imagery." Maine Water Conference, March 14, Augusta, ME,.

McCullough, I. M., C. S. Loftin and S. A. Sader. 2012. "Remote estimation of regional lake clarity with Landsat TM and MODIS satellite imagery." Earth Systems Research Center, University of New Hampshire, March 1, Durham, NH.

McCullough, I. M., C. S. Loftin and S. A. Sader. 2012. "Remote monitoring of regional lake water clarity with satellite imagery: a case study of Maine lakes." Society for Freshwater Science Annual Meeting, May 24, Louisville, KY, USA.

McKinney, S.T. 2011. "Trophic cascades and functional losses: Using models of species interactions to restore an imperiled ecosystem." Yosemite National Park, Croaking Toad Lecture Series, October 27, El Portal, CA..

Norris, K., K.S. Simon, M. Mineau, S.M. Coghlan Jr., and J. Saros. 2012. "Do anadromous alewife influence nutrient limitation in lakes and streams?" Poster, The Annual Maine Water Conference, March 14, Augusta, ME.

O'Malley, A., J. Zydlewski, O. Cox, P. Ruksznis, J. Trial. 2012. "The fate of lower mode Atlantic salmon, (*Salmo salar)* stocked into the Penobscot River, Maine." 2012 Forum, Atlantic Salmon and their Ecosystems, January 10-11, Bangor, ME.

Ratten, S. and J. Zydlewski. 2012. "Evaluating lake whitefish reintroduction in St. Froid Lake, Winterville, Maine." The 142nd Annual Meeting of the American Fisheries Society, August 19, Minneapolis-St. Paul, MN.

Ryan, K., A.J.K. Calhoun, J. Zydlewski. 2012 "Monitoring eastern spadefoot (*Scaphiopus holbrookii*) burrow emergence with passive integrated transponders." SCB North America Congress for Conservation Biology, July 15, Oakland, CA.

Sigourney, D., E. Hughes, J. Zydlewski and O. Cox. 2012. "Monitoring adult Atlantic salmon in the Penobscot River using PIT telemetry." 2012 Forum, Atlantic Salmon and their Ecosystems, January 10-11, Bangor ME.

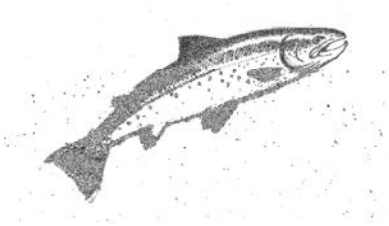
Sigourney, D., E. Hughes, O. Cox, A. O'Malley, and J. Zydlewski. 2012. Assessment of live transport of adult Atlantic salmon in the Penobscot River, USA. The 142nd Annual Meeting of the American Fisheries Society, August 19, Minneapolis-St. Paul, MN.

Simons-Legaard, E. and D. Harrison. 2012. "Trends in habitat conditions in LURC-zoned deer wintering areas." Annual Program and executive board Meeting of The Maine Chapter of The Wildlife Society, May 10, Brewer, ME.

Snook, E., A. Danylchuk, B. Letcher, J. Zydlewski, A. Whiteley, T. Dubreuil, and S. Hurley. 2012. "Movement patterns of anadromous Brook Trout in a restored coastal stream system in southern Massachusetts." The 142nd Annual Meeting of the American Fisheries Society, August 19, Minneapolis-St. Paul, MN.

Stich, D. and J. Zydlewski. 2011. "Atlantic salmon smolt behavior and survival 2010 and 2011." Penobscot River Restoration Trust, November 15, University of Maine, Orono, ME.

Stich, D. S., M. Bailey, C. M. Holbrook, M. Kinnison, J. Kocik, G. Zydlewski, and J. Zydlewski. 2012 "Atlantic salmon smolt migration and survival prior to dam removal." The 142nd Annual Meeting of the American Fisheries Society, August 19, Minneapolis-St. Paul, MN.



Stich, D., M. Bailey, C. Holbrook, M. Kinnison, G. Zydlewski, J. Zydlewski. 2012. "Atlantic salmon smolt movements and survival in the Penobscot River." 2012 Forum, Atlantic Salmon and their Ecosystems, January 10-11, Bangor, ME.

Tomback, D.F., L.E. Barringer, M.B. Wunder, and S.T. McKinney. 2012. "Whitebark pine stand condition, tree abundance, and cone production as predictors of visitation by Clark's nutcracker." Whitebark Pine Ecosystem Foundation Science Seminar, September 14, Kimberley, BC, CA.

Zydlewski, J., D. Stich, and D. Sigourney. 2012. "Understanding impacts of dams on up and downstream passage- lessons from Atlantic salmon in the Penobscot River." The 142nd Annual Meeting of the American Fisheries Society, August 19, Minneapolis-St. Paul, MN.

PUBLIC TALKS PRESENTED

Calhoun, A.J.K. 2011. "Vernal pools and collaborative natural resources management." The Acadia National Park Science Symposium, October 26, Schoodic Education and Research Center, Winter Harbor, ME.

Calhoun, A.J.K. 2012. "Citizen scientists and vernal pool conservation." The Virginia Commonwealth University citizen science group, January 22, Richmond, VA.

Calhoun, A.J.K. 2012. "Collaborative approaches to vernal pool conservation: A Maine case study." The Virginia Commonwealth University, January 23, Richmond, VA.

Calhoun, A.J.K. 2012. "Informal discussion leader on careers in conservation biology for the 2012 Smith Fellows." The Smith Fellows, May 30, Schoodic Education and Research Center, Winter Harbor, ME.

Calhoun, A.J.K. 2012. "Maine Vernal Pool Mapping Project field presentation to recruit new towns." Conservation commissions and town officials from Lincolnville and Camden., April 20, Lincolnville, ME.

Calhoun, A.J.K. 2012. "Role for land trusts, nature centers, and communities in vernal pool education and conservation." The Hidden Valley Nature Center and Maine Master Naturalist Program, April 20, Jefferson, ME.

Calhoun, A.J.K. 2012. "Stakeholder based research and conservation." The Acadian Internship Program, Schoodic Education and Research Center, July 20, Winter Harbor, ME.

Calhoun, A.J.K. 2012. "Vernal pool conservation using innovative, local approaches." The Blue Hill Land Trust, April 18, Blue Hill, ME.

Calhoun, A.J.K. 2012. "Vernal pool mitigation: A last resort." The General Electric employees, CT state agencies, 12 September, Pittsfield, MA.

Calhoun, A.J.K. 2012. "Vernal pool team update." The EpSCor Conference, May 15, Orono, ME.

Calhoun, A.J.K. 2012. Field trip leader, Acadia National Park: "Wetlands of the Park." Presented to BIOGEOMON Annual Conference, July 18, Belfast, ME.

Call, E.M. 2012. "A bird's eye view: How our birds tell the story of Maine's rivers". Sunkhaze Meadows NWR Café Series, August 18, Old Town, ME, USA.

Call, E.M. 2012. "River coastal connections: Birds as beacons of change". Maine Studies MES 201, September 25, University of Maine, Orono, ME, USA.

Chapin, S., C. Loftin, and F. Drummond. 2012. "GIS and Blueberry Pollination." University of Maine's Cooperative Extension - Wild Blueberry Field Day, July 18, Jonesboro, Maine, USA.

Chapin, S., C.Loftin, and F. Drummond. 2012. "Landscape Ecology of Native Bees of the Northeast." Poster, the Annual Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, March 20, Orono, Maine, USA.

Cline, B.B. 2012. "Amphibians in complex landscapes: Effects of forestry and urbanization on juvenile movements." Friends of Sunkhaze National Wildlife Refuge. September 15. Sunkaze Café, Old Town, ME.

Cline, B.B. 2012. "Amphibians in complex landscapes: Effects of forestry and urbanization on juvenile movements." Sustainability Solutions Initiative (SSI) All-Team Meeting. September 17, Senator George J. Mitchell Center, University of Maine, Orono, ME.

Coghlan Jr., S.M. 2012. "Ecology and conservation of Maine's Freshwater Fishes." The Kezar Lake Watershed Association's monthly meeting, August 22, Lovell, ME, USA.

Coghlan Jr., S.M. 2012. "Impacts of spawning sea lamprey on foraging behaviors and growth potential of stream fishes." The Atlantic Salmon and Their Ecosystems Research Forum, January 10, Orono, ME.

Coghlan Jr., S.M. 2012. "Impacts of spawning sea lamprey on foraging behaviors and growth potential of stream fishes." The Northeastern Natural History Conference, April 17, Syracuse, NY.

Coghlan Jr., S.M. 2012. "Restoring the Penobscot River: Dam removal and recovery of native fishes. The Carrabec High School's Diversity Day, April 23, North Anson, ME, USA.

Drahovzal, S.A., Loftin, C.S., Rhymer, J.M. 2012. "Environmental assessment of circumneutral fens with shrubby cinquefoil (*Dasiphora fruticosa*): Host plant of the endangered Clayton's Copper butterfly (*Lycaena dorcas claytoni*)." The 2012 Annual Coordinating Committee Meeting of the USGS, Maine Cooperative Fish and Wildlife Research Unit, March 20, Orono, ME, USA.

Drahovzal, S.A., Loftin, C.S., Rhymer, J.M. 2012. "Maine's circumneutral fens with shrubby cinquefoil (*Dasiphora fruticosa*): Host plant of the endangered Clayton's Copper butterfly (*Lycaena dorcas claytoni*)." The Maine Chapter of the Wildlife Society Annual Program, May 10, Brewer, ME, USA.

Erbland, P., G. Zydlewski, J. Zydlewski, and J. Hightower. 2012. "Estimating Penobscot River Fish Passage using Fixed Location SONAR." 2012 Forum, Atlantic Salmon and their Ecosystems, January 10-11, Bangor, ME.

Groff, L.A., A.J.K. Calhoun and C.S. Loftin. 2012. "Habitat Use by Pool-breeding Amphibians in Maine's Montane Region." Maine EPSCoR Sustainability Solutions Initiative Workshop, September 23, Orono, ME.

Groff, L.A., A.J.K. Calhoun and C.S. Loftin. 2012. "Habitat Use by Pool-Breeding Amphibians in Maine's Western Highlands." Annual Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, March 20, Orono, ME.

Guyette, M. 2012. "Effects of marine-derived nutrients on juvenile Atlantic salmon (*Salmo salar*) growth and body condition." College of Natural Sciences, Forestry, & Agriculture Graduate Student Research Awards Competition, University of Maine, February 22, Orono, ME, USA.

Guyette, M., C. Loftin and J. Zydlewski. 2012. "Effects of marine-derived nutrients on juvenile Atlantic salmon (*Salmo salar*) growth and body condition." 2012 Forum, Atlantic Salmon and their Ecosystems, January 10-11, Bangor, ME, USA.

Guyette, M., C. Loftin and J. Zydlewski. 2012. "Evidence of marine-derived nutrient uptake in Atlantic Salmon nursery stream communities." 2012 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, March 20, Orono, ME.

Harrison, D. 2012. "Effects of forest management on Maine's forest bird communities." Meeting of the Maine Cooperative Forestry Research Unit, January 25, Orono, ME.

Harrison, D., and E. Simons-Legaard. 2012. "Trends in biodiversity in Maine's northern forest." Annual Program and executive board Meeting of The Maine Chapter of The Wildlife Society, May 10, Brewer, ME.

Hogg, R., S.M. Coghlan Jr., and J. Zydlewski. 2012. "Barrier removal in Sedgeunkedunk Stream: Sea lamprey recolonization and implications for Atlantic salmon habitat restoration." 2012 Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, March 20, Orono, ME.

Kiraly, I.A., S.M. Coghlan Jr., J. Zydlewski and D. Hayes. 2011. "Annual update: Quantifying the effects of dam removal on the structure and function of fish assemblages in the Penobscot River." Penobscot River Restoration Trust Annual Meeting, November 16, Orono, ME.

Kiraly, I.A., S.M. Coghlan Jr., J. Zydlewski, and D. Hayes. 2012. "The structure of fish assemblages in the Penobscot River prior to dam removal." Veazie Salmon Club Meeting: The State of the River, January 18, Veazie, ME.

Kiraly, I.A., S.M. Coghlan Jr., J. Zydlewski, and D.B. Hayes. 2012. "Quantifying fish assemblage structure in the Penobscot River prior to dam removal." The Northeastern Natural History Conference, April 18, Syracuse, NY, USA.

Kiraly, I.A., S.M. Coghlan Jr., J. Zydlewski, and D.B. Hayes. 2012 "Quantifying fish assemblage structure in the Penobscot River prior to dam removal." The State of the Penobscot River Panel Discussion, April 5, Veazie, ME, USA.

Kus, E., H. Aumann, N. Emanetoglu, B. Cline, and M. Hunter. 2012. "Tracking juvenile amphibians with harmonic radar." Maine EPSCoR State Conference: Building Partnerships for Sustainability Solutions. Wells Conference Center, University of Maine, 24 September, Orono, ME. POSTER.

Levesque, V., A.J.K. Calhoun, K. Bell. 2012. "Municipal Vernal Pool Policy: Sustainability Science in Action." Poster. Maine EPSCoR Conference, September 24, Orono, ME.

Levesque, V., K. Bell, A.J. K. Calhoun. 2012 "Sustainability in Maine Municipalities." Maine Water Conference, March 14, Augusta, ME.

McCullough, I. M. C.S. Loftin and S. A. Sader. 2011. "Remote monitoring of lake water clarity with satellite imagery and physical lake parameters." Student Conference on Conservation Science. American Museum of Natural History, October 11 -14, New York, NY, USA.

McCullough, I. M., C. S. Loftin and S. A. Sader. 2012. "Implementing satellite-based remote lake monitoring in Maine." Maine Department of Environmental Protection, June 8, Augusta, ME, USA.

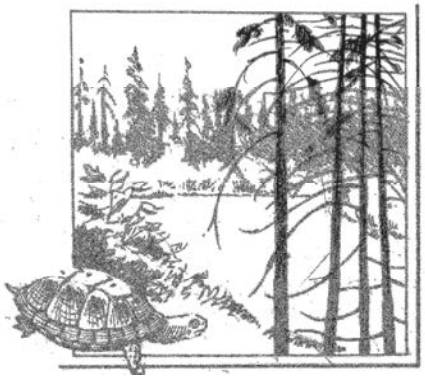
McCullough, I. M., C. S. Loftin and S. A. Sader. 2012. "Integrating citizen science and satellite-based remote sensing for monitoring of Maine's lakes." Maine Volunteer Lake Monitoring Program

Annual Conference, July 21, Turner, ME, USA.

McCullough, I. M., C. S. Loftin and S. A. Sader. 2012. "Predicting water quality in Maine's lakes by relating field-collected secchi disk transparency depth data with satellite imagery." Maine Cooperative Fish and Wildlife Research Unit Annual Meeting, University of Maine, March 20, Orono, ME, USA.

McKinney, S.T. 2012. "Trophic cascades and functional losses: Using models of species interactions to restore an imperiled ecosystem." Maine Department of Inland Fisheries and Wildlife, March 22, Bangor, ME.

Morgan, D.E. and A.J.K. Calhoun. 2011. "Research-extension partnerships in sustainability science: Bridging research-based knowledge with client-based needs." SSI-UMaine Cooperative Extension Workshop and World Sustainability Teach-in Day, Senator George J. Mitchell Center, University of Maine, December 3, Orono, ME.



Witham, J.W. 2011. Welcome and introductory remarks. Symposium "Many Rivers One Estuary: Collaborations, Connections and Challenges. Translating Knowledge into Action: A symposium connecting stakeholders and researchers within the Androscoggin and Kennebec watersheds." Bowdoin College, November 17, Brunswick, ME. ORGANIZER, MODERATOR

Witham, J.W. 2012. "Forest Research at Holt Forest." Tour and discussion with U.S. Forest Service, September 4, Arrowsic, ME.

Witham, J.W. 2012. "Introduction to Holt Research Foundation." Maine Tree Foundation Board of Directors, September 19, Arrowsic, ME.

Witham, J.W. 2012. "Local Forests in Perspective." Kennebec Estuary Land Trust Lecture Series. Working Landscapes: Forests, October 25, Bath, ME.

Zydlewski, J. 2012. "Migratory fish in the Penobscot River." Veazie Salmon Club, April 5, Veazie, ME.
Zydlewski, J., A. Firmenich, P. Santavy, C. Lipsky, J. Hawkes, J. Kocik. 2012. "Assessing the direct stocking of imprinted smolts into the Penobscot River Estuary." 2012 Forum, Atlantic Salmon and their Ecosystems, January 10-11, Bangor ME.

Zydlewski, J., A. Firmenich, P. Santavy, C. Lipsky, J. Hawkes, J. Kocik. 2012. "Assessing the direct stocking of imprinted smolts into the Penobscot River Estuary." 2012 Forum, Atlantic Salmon and their Ecosystems, January 10-11, Bangor, ME.

Zydlewski, J., and G. Zydlewski. 2012. "Understanding the migratory fish species of Maine-visions of recovery." Penobscot Fly Fishing Club, February 1, Bangor, ME.

WORKSHOPS

Coghlan Jr., S.M. 2012. "Collection, identification, and natural history of Maine's freshwater fishes." Trout Unlimited Youth Trout Camp, June 26, North Anson, ME.

Coghlan Jr., S.M. 2012. "Fly fishing in Central New York: A stream for all seasons." Kennebec Valley Trout Unlimited / Maine Sportsmen's Show, March 31, Augusta, ME.

Coghlan Jr., S.M. and R. Saunders. 2012. "Dam removal and recovery of Maine's native fishes." Hirundo Wildlife Refuge's Summer "Activities Series, August 18, Alton, ME.

Coghlan Jr., S.M. and K. Norris. 2012. "Aquatic life through the ice: winter ecology of fish and invertebrates." Maine Audubon Fields Pond Nature Center Winter Activity Series, February 3, Holden, ME.

Coghlan Jr., S.M. and J. Zydlewski. 2012. "Sea lamprey, dam removal, and habitat restoration." Maine Sea Grant, May 25, www.youtube.com/watch?v=9VZX8HU-BRA.

Coghlan Jr., S.M. and J. Zydlewski. 2012. "River Reviver." UMaine /Today Magazine, December 31: http://umainetoday.maine.edu/past-issues/winter-2012/river-reviver/

Coghlan Jr., S.M. 2012. "The Penobscot undammed: restoring the river." MPBN Speaking in Maine, February 10: http://www.mpbn.net/OnDemand/AudioOnDemand/SpeakingInMaine/tabid/294/ctl/ViewItem/

mid/3480/ItemID/20207/
Default.aspx .TzhO9y15TcI.facebook.

Coghlan Jr., S.M. 2012. "Acadia National Park BioBlitz: Aquatic Insects." Acadia National Park / Schoodic Education and Research Center Institute, July 13, Winter Harbor, ME.


Mark McCollough