

**DEPARTMENT OF WILDLIFE ECOLOGY AND
MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT**

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University of Maine

Maine Department of Inland Fisheries and Wildlife

U.S. Geological Survey- Biological Resources Discipline

Wildlife Management Institute



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

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Rita Seger	Ph.D.	MDIFW, EES
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Dissertations and Theses Completed this Period

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Personnel Notes

CASEY JACKSON received her M.S. in Wildlife Ecology in May 2009 and currently is working as a Fisheries Biologist at the US Fish and Wildlife Service Spring Creek National Fish Hatchery, Washington.

RITA SEGER, M.D. received her Ph.D. in Ecology and Environmental Science in December 2008. She currently practices internal medicine and works as a Research Assistant Professor in the Department of Animal and Veterinary Sciences at the University of Maine.

ERIN SIMONS received her Ph.D. in Wildlife Ecology in May 2009 and currently is working as a Post-doctoral Research Assistant Scientist for the University of Maine, Department of Wildlife Ecology and Center for Research on Sustainable Forests.

RANDY SPENCER received his M.S. in School of Biology and Ecology and continues to work as a Fisheries Biologist at the Maine Department of Marine Resources.

Collaborating Agencies and Organizations

American Philosophical Society	APS
American Society of Ichthyologists and Herpetologists	ASIH
Androscoggin River Watershed Council	ARWC
Centro de Ecologia Aplicada and CONAMA (National Environment Commission)	CEACONAMA
Environmental Solutions Initiative, Senator George J. Mitchell Center	ESI
Fulbright and State Organization of the Americas	FSOA
Houlton Band of Maliseet Indians	HBMI
Huber Resources Corporation	HRC
Lowe's Home Center, Inc.	LHC
Maine Agricultural and Forest Experiment Station	MAFES
Maine Aquaculture Innovation Center	MAIC
Maine Atlantic Salmon Commission	MASC
Maine Audubon Society	MAS
Maine Bureau of Parks and Lands	MBPL
Maine Department of Environmental Protection	MDEP
Maine Department of Inland Fisheries and Wildlife	MDIFW
Maine Department of Marine Resources	DMR
Maine Department of Transportation	MDOT
Maine Forest Service, Policy and Management Division	MFS
Maine Outdoor Heritage Fund	MOHF
Manomet Center for Conservation Sciences	MCCS
National Audubon Society	NAS
National Council on Air and Stream Improvement	NCASI
National Fish and Wildlife Foundation	NFWF
National Oceanic and Atmospheric Administration - National Marine Fisheries Service	NOAA - NMFS
National Park Service	NPS
National Science Foundation	NSF
National Science Foundation - Research Fellowship	NSFRF
New Hampshire Department of Environmental Services	NHDES
Norcross Wildlife Foundation	NWF
Stantec, Inc.	STAN
The Nature Conservancy	TNC
The Nature Conservancy - Maine Chapter	TNCME
Town of Newry	NEWRY
Trout Unlimited	TU
U.S. Environmental Protection Agency	EPA
United Nations Educational, Scientific, and Cultural Organization	UNESCO
University of Georgia - Savannah River Ecological Laboratory	SREL
University of Maine	UM
University of Maine - Alumni Association	UMAA
University of Maine - Association of Graduate Students	AGS

University of Maine - Department of Wildlife Ecology	WLE
University of Maine - Ecology and Environmental Sciences Program	EES
University of Maine - Maine Cooperative Forestry Research Unit	CFRU
University of Maine - McIntire-Stennis	MCS
University of Maine – Senator George J. Mitchell Center for Environmental and Watershed Research	CEWR
University of Maine – School of Biology and Ecology	REP
University of Maine – School of Forest Resources	SBE
University of Maine – School of Resource Economics & Policy	MCS
University of Missouri	UMS
U.S. Fish and Wildlife Service	FWS
U.S. Fish and Wildlife Service – Eastern Brook Trout Joint Venture	FWS-EBTJV
USGS - Maine Cooperative Fish and Wildlife Research Unit	MCFWRU
USGS - Biological Resources Discipline	BRD
Wagner Forest, Sunday River Inn, Caribou Springs	WF
Wildlife Conservation Society	WCS
WWF--World Wide Fund For Nature	WWF

ENDANGERED AND THREATENED SPECIES

Influences of Past and Future Forest Management on the Spatiotemporal Dynamics of Habitat Supply for Canada Lynx and American Martens in Northern Maine

Investigator: Erin Simons

Advisors: D. J. Harrison, Co-chair
W. B. Krohn, Co-chair
M. McCollough
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*Cooperators/
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit
U.S. Fish and Wildlife Service
Maine Department of Inland Fisheries and Wildlife
Maine Cooperative Forestry Research Unit
Maine Agricultural and Forest Experiment Station
National Council on Air and Stream Improvement
University of Maine - Department of Wildlife Ecology
University of Maine - Center for Research on Sustainable Forests
The Nature Conservancy - Maine Chapter
Huber Resources Corporation

Objective:

- 1) Develop a retrospective time series (1970-2007) of predicted occurrence for Canada lynx and American martens in northern Maine.
- 2) Evaluate and compare spatial and temporal variability in the broad-scale pattern of predicted occurrence of Canada lynx and American martens in northern Maine, and correlate spatiotemporal variation to landscape change due to past forest management.

SCOPE

In the Acadian Forest of Maine, timber harvesting is currently the dominant driver of landscape change, and over the last 40 years timber harvesting rates and patterns have been strongly influenced by natural disturbance events and changes in forest policy and forestland ownership. Forest management affects both stand- and landscape-scale forest structure, the combined effects of which will have short- and long-term consequences for forest dependent wildlife, such as the federally threatened Canada lynx and American martens. Methods are needed that can provide insight into how landscape change affects the spatiotemporal variability in habitats and species occurrence patterns for these wide ranging forest carnivores in order to predict and mitigate the effects of land-use activities. Further, lynx and martens have shown great potential as umbrella species for conservation planning in the Acadian forest and because they have different habitat association, early- and mid-to-late successional forests respectively, understanding how their habitat has changed will also provide a better understanding of how broad-scale habitat conditions have changed on commercial forestlands in northern Maine for a wide variety of species with similar habitat requirements.

PROJECT STATUS

All requirements for a Ph.D. were met in May 2009. The abstract of the dissertation follows:

I evaluated the effects of past and future forest management on habitat supply and probability of occurrence for Canada lynx (*Lynx canadensis*) and American martens (*Martes americana*). I used timber harvest and forest composition information derived from Landsat satellite imagery to develop spatially-explicit time series of habitat for lynx and martens (1970-2007) across 1.62 million hectares of commercial forestland in Maine. Timber harvesting was widespread with 55% of the forestlands receiving a harvest 1970-2007, which ultimately resulted in the broad-scale loss of marten habitat (>435,000 ha) and the increase of lynx foraging habitat (~189,000 ha). Rapid declines in habitat supply and probability of occurrence for martens occurred 1975-1991, as large blocks of spruce-fir forest were salvage logged in response to the 1973-1985 spruce budworm (*Choristoneura fumiferana*) outbreak. As regenerating forest created during this period began to reach 16 years post-harvest there was a rapid increase in lynx foraging habitat and the mean density of snowshoe hares (*Lepus americanus*) within potential lynx home ranges, 1985-2007. Probability of occurrence for lynx increased during this period in areas of increased hare density. Marten habitat continued to decline in the 1990s and 2000s, which coincided with shifts in timber harvesting patterns that resulted from new forest policies implemented in 1991.

To provide a better understanding of how past forest management legacy (1970-2007) will influence outcomes of future forest management, I developed alternative forest management scenarios to model the effects on habitat supply and population density for lynx and martens, 2007-2032, across 14 townships with diverse legacies. The worst scenario for future lynx and marten habitat was a continuation of recent (2001-2007) trends in harvest rates, including an aspatial limit (~4% of total acreage harvested) on clearcut harvesting to mimic the effects of current forest policies in Maine. Removing the limit on clearcut harvesting provided some limited benefit to both species; under all harvest scenarios, however, habitat supply and densities for both species are expected to decline from current levels as a result of past forest management legacies. Future conservation planning for these species will need to incorporate anticipated declines in habitat supply.

Taxonomic and Population Status of the Clayton's Copper Butterfly (*Lycaena dorcas claytoni*)

Investigator: E.S. Knurek

Advisors: J.M. Rhymer, Co-chair
F.A. Drummond, Co-chair
C.S. Loftin

*Cooperators/
Project Support:* Maine Outdoor Heritage Fund
Maine Department of Inland Fisheries and Wildlife
U.S. Fish and Wildlife Service
The Nature Conservancy
American Philosophical Society

Objective:

- 1) Determine taxonomic status of Clayton's copper butterfly as a distinct subspecies from the nominate Dorcas copper, through morphological and genetic analyses and comparison with nominate species and other closely related Lycaenids.
- 2) Estimate size of Clayton's copper subpopulations in Maine, and establish a baseline for future population monitoring.

SCOPE

Clayton's copper butterfly (*Lycaena dorcas claytoni* Brower) was first discovered in Maine and described as a distinct subspecies in 1940, morphologically different and geographically isolated from the nominate subspecies, Dorcas copper (*Lycaena dorcas dorcas* Kirby) and other closely related Lycaenids. In 1997, Clayton's copper was listed as endangered in Maine because it is known from few sites statewide, is found in abundance at only 1-2 sites, occurs only in an uncommon habitat type, and its entire global range is nearly confined to Maine.

Basic information about Clayton's copper taxonomy and population status is necessary to effectively manage this endangered species. The subspecific status of Clayton's copper is in question, especially since the taxonomic distinction between Clayton's copper and Dorcas copper has never been quantified. This taxonomic uncertainty must be resolved to delineate appropriate management units for conservation. Additionally, except for at Maine's largest site, censuses to estimate population size have never been done. Without development of a baseline population estimate, species status cannot be accurately assessed, trends cannot be monitored, and recovery goals cannot be developed.

This study will conduct detailed morphological and genetic analyses to determine if Clayton's copper is taxonomically distinct from Dorcas copper and develop population estimates, establishing a baseline for future population monitoring. These data will aid in determining the national and global conservation status of Clayton's copper and informing conservation planning and recovery efforts.

PROJECT STATUS

Morphological and molecular genetic analyses to compare Clayton's copper, Dorcas copper, Florus copper (*Lycaena dorcas florus*), Maritime copper (*Lycaena dospassosi*), Purplish copper (*Lycaena helloides*), and Bog copper (*Lycaena epixanthe*) specimens were completed. Molecular genetic analysis indicates little difference between Clayton's and Dorcas copper, based on sequence from a portion of the mitochondrial gene cytochrome oxidase subunit 1 (COI) as well as from a portion of the nuclear gene elongation factor 1-alpha (EF1 α). Clayton's and Dorcas coppers can be distinguished by multivariate analysis of traditional morphometric characters based on the original subspecies description. There is a high degree of correlation between morphological traits and climatic variables, indicating that morphological differentiation may be a result of environmental variation. Analysis of transect counts to derive population estimates for 2008 has also been completed.

FUTURE PLANS

Write thesis and defend by December 2009.

Landscape Planning Initiative for Northern Maine Using Area Sensitive Umbrella Species: A Wildlife Habitat-Based Approach to Forestland Planning Across Large Ownerships in Northern Maine

Investigators: A. K. Fuller
D. J. Harrison
W. B. Krohn

*Cooperators/
Project Support* The Nature Conservancy
USDA Natural Resources Conservation Service

Objectives:

- 1) Quantify and map current and past habitat conditions for marten and lynx across TNC ownerships.
- 2) Apply spatial optimization tools to harvesting plans to identify tradeoffs among lynx and marten habitat, forest management objectives, and special habitat features.
- 3) Quantify the net conservation benefit for lynx and marten relative to the baseline forest conditions (2009), a no-harvest option, and draft forest harvest plan developed by TNC foresters.

SCOPE:

The Maine Chapter of The Nature Conservancy (TNC) is enrolled in the Healthy Forest Reserve Program of the USDA Natural Resources Conservation Service. Under this program, TNC proposes to manage their extensive forestlands in northwestern Maine consistent with providing adequate habitat for Canada lynx, a species of early forests, and the American marten, a species associated with mid-successional and older forests. Research at the University of Maine has shown that landscape-scale habitat conservation directed at these 2 species would disproportionately benefit 86% (n = 111) of vertebrate species co-occurring in the forests of northern Maine. The issue of providing habitats in managed forestlands consistent with providing both vertebrate biodiversity and forest products is an issue that extends throughout Maine and the Acadian forests of eastern North America where commercial forestry is a major economic activity. How exactly to provide a temporally and spatially dynamic matrix of habitats for both sustainable habitats and wood products is complex; thus, an operational method has not been developed. Ongoing research at the University of Maine has developed predictive models of occurrence for both lynx and marten based on landscape and stand-scale conditions. These tools provide the rough framework on which an interactive, habitat-based, moving matrix approach to forestlands planning could be developed. The goals of this project are to develop, implement, and evaluate a landscape-scale habitat-management system useful in sustainable management of the forestlands owned and managed by TNC and other interested participants of the Healthy Forest Reserve Program.

PROJECT STATUS:

We developed a forest cover map of the TNC ownership based on 2004 Landsat Thematic Mapper (TM) satellite imagery. We used change detection work using the TM data (1988-2004) and Multispectral Scanner data (1973-1988) to evaluate biomass decreases that represented forest harvesting. Previous research at the University of Maine identified heavy and light harvest intensity classes using the magnitude of the normalized difference moisture index (NDMI) across 1-3 year intervals. The NDMI is an equation using near-infrared and middle-infrared bands from the satellite imagery. We cross-walked the forest cover map to habitat currencies relevant to Canada lynx and American marten and compared the satellite-derived maps with the landowner forest cover maps to determine which map to use for all future modeling. This decision was based on three field visits in which we sampled 99 stands measuring variables important for marten and lynx (e.g., tree height, canopy closure, basal area). We contracted with James W. Sewall Company to provide photo interpretation of a sub-sample of areas that appeared to be problematic based on our field visits. We used a combined approach by interfacing data from the time series (harvest information) with landowner forest cover maps (typing information) to develop a final vegetation map relevant to the habitat currencies important for martens and lynx. We evaluated retrospective trends in habitat supply for lynx and marten using the time series data and adjusted the values based on our 2004 baseline. We applied probability of occupancy models to the 2007 time series data set and evaluated occupancy of marten and lynx across the landscape. We are currently using the Remsoft Spatial Planning System to translate forest harvest planning goals and alternatives into spatially-explicit management scenarios developed around lynx

and marten habitat requirements. We are evaluating management scenarios that optimize for fiber objectives, marten or lynx habitat objectives, and combined fiber and habitat objectives. The spatial optimization tools will identify tradeoffs among lynx and marten habitat and forest management objectives, and will guide long-term forest management. We have provided five project updates to sponsors to date (September 2007, December 2007, May 2008, November 2008, May 2009).

Future Plans:

The final contract report will include a 10-year management plan for TNC incorporating the habitat requirements of lynx and marten and fiber objectives. This project is scheduled for completion by 31 January 2010.

Spatio-temporal Variation In Snowshoe Hare Densities and Effects of Hare Populations on Predicted Lynx Occurrences in Northern Maine.

Investigator: S.A. Scott

Advisors: D.J. Harrison, Co-chair
W.B. Krohn, Co-chair
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*Cooperators/
Project Support:* University of Maine – McIntire Stennis
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U.S. Fish and Wildlife Service
USGS - Maine Cooperative Fish and Wildlife Research Unit
University of Maine – Department of Wildlife Ecology
Maine Department of Inland Fisheries and Wildlife
National Council for Air and Stream Improvement
Maine Agricultural and Forest Experiment Station

Objective:

- 1) Understand the relationship between forest management, natural succession, and other exogenous population process on hare densities in the Acadian forest.
- 2) Investigate the consequences of empirical changes in hare populations on the probability of lynx occurrences.

SCOPE

Snowshoe hare (*Lepus americanus*) is the primary prey of Canada lynx (*Lynx Canadensis*) and is an important prey species for a number of other forest predators. Lynx population dynamics, survival, and recruitment are closely tied to snowshoe hare availability. Lynx and snowshoe hare populations in the boreal forest cycle with 8 to 11 year periodicity, 5 to 25 fold changes in amplitude, and geographic synchrony over large areas. The nature of lynx and snowshoe hare population dynamics in the contiguous U.S.A. is unclear, and whether or not hares and lynx cycle in the Acadian forest has not been studied. The Federally threatened species status of the lynx mandates that conservation efforts be developed to lead to recovery of the species. The importance of snowshoe hare in the diet of lynx necessitates that ecological relationships between snowshoe hare, lynx, and their habitats be considered in lynx conservation activities.

The largest population of lynx in the contiguous U.S.A. occurs in Maine. Timber harvesting is the predominant land use practice affecting lynx and snowshoe hare habitat. Harvest activities alter the composition and structure of forests, thereby affecting the quality and availability of snowshoe hare and lynx habitat. Forest practices have changed significantly since passage of the Maine Forest Practices Act in 1989, with recent harvests relying predominantly on partial harvest methods. Regenerating conifer forests generated from earlier clearcut practices have repeatedly been shown to contain the highest snowshoe hare densities. Future quality hare habitat may be limited due to low creation of regenerating conifer clearcuts and succession-induced changes to existing stands. The reduction in quality hare habitat will most likely result in lower snowshoe hare abundance, with possible negative consequences for lynx populations.

This research contributes to long-term investigations in to the effects of forest management on snowshoe hare density and aspects of Canada lynx ecology in the industrial forests of Maine. Previous studies have quantified stand-level snowshoe hare densities for specific forest types. This study will provide additional and up to date hare density estimates across four major forest types, provide a comprehensive analysis of the temporal and spatial patterns of hare density fluctuations, and quantify succession-induced changes in vegetation structure and the effects on hare density. Maine

Department of Inland Fisheries and Wildlife (MDIFW) has been conducting a lynx research project which began in 1999 to document movements, survival, habitat use, and reproduction of lynx. Another study by MDIFW began in 2003 to document lynx occurrence across northern Maine. Results show a possible increase in adult mortality and a decline in lynx productivity since 2003. Lynx demographic changes, in combination with a recent observed decline in snowshoe hare densities, suggest that hare densities may have dropped below a critical threshold required for lynx reproduction and survival. Studies in other areas have documented an increase in lynx home range size during periods of decreased hare abundance. This study will evaluate spatiotemporal changes in hare populations during the period 2001-2009 and will use hare density data and previous lynx occurrence models developed in our lab to evaluate the consequences of fluctuating hare abundance on the density of hares on the predicted distribution and occurrence of Canada lynx throughout a 1.6 million ha area of northwestern Maine.

PROJECT STATUS

Hare density estimates were determined using biannual fecal pellet counts for four of the major forest types present on the landscape: 1) established regenerating conifer clearcuts; 2) partially harvested stands (including shelterwood and selection cut methods); 3) mature mixed deciduous-coniferous stands; 4) and mature deciduous stands. Surveys during May-June provide winter hare estimates and surveys during September-October provide summer estimates. I have completed hare fecal pellet counts for the winters of 2006-07 and 2007-2008, 2008-2009 and for the summers of 2006, 2007, 2008 and 2009. Counts were completed on 36 previously established survey grids in partial harvest (n = 21) and regenerating conifer (n = 15) stands in the Telos and Clayton study areas, and on newly established survey grids on second-growth mature coniferous (n = 7) and second-growth mature mixed deciduous-coniferous (n = 5) stands in the Telos study area.

I measured vegetation structure characteristics in all stands types and developed a photo catalog of all stands during the summers of 2008 and 2009. Data collection and analyses have been completed, and a draft of my thesis is currently being reviewed by my major advisors, and will soon go to Committee for their review.

FUTURE PLANS

I plan to defend the thesis and complete the project by December 2009.

Comparative Ultrastructural Morphology of *Batrachochytrium dendrobatidis* in Amphibian Tissue

Investigator: Sasha E. Greenspan

Advisors: A.J.K. Calhoun, Co-chair
J.E. Longcore, Co-chair
S. Tyler
M. Gahl

Project Support: University of Maine – Department of Wildlife Ecology
University of Maine – School of Biology and Ecology

Objectives:

- 1) Determine the morphological features of *Batrachochytrium dendrobatidis* during infection of amphibian epidermal cells.
- 2) Explain the mechanisms associated with these morphological features.
- 3) Compare these mechanisms in the epidermis of American bullfrogs (*Lithobates catesbeianus*) and wood frogs (*Lithobates sylvaticus*).
- 4) Identify the life stages at which these species co-occur in New England vernal pools and if transmission of *B. dendrobatidis* occurs during these life stages.

SCOPE

Rapid population declines have occurred in over 400 amphibian species on six continents since 1980, a far faster rate of decline than would be expected from the Earth's natural fluctuations. Nearly half of these declines have occurred in pristine habitats or where obvious causes of decline, such as habitat loss and overexploitation, do not exist. Recent experimental studies have shown strong evidence that the emerging infectious disease chytridiomycosis is the cause of many of these

enigmatic declines. Chytridiomycosis, an infection of the epidermis of amphibians, is caused by the chytrid fungus *Batrachochytrium dendrobatidis*.

Amphibian populations exhibit variable responses to *B. dendrobatidis*. Some amphibian populations undergo devastating declines due to chytridiomycosis; others appear to be resistant to lethal infections. The reasons for these variable responses are largely unknown. Previous studies have described the morphology of *B. dendrobatidis* thalli and zoospores, the life cycle stages of *B. dendrobatidis*, and the effects of *B. dendrobatidis* on amphibian skin cells. One aim of this study is to describe the morphological processes by which *B. dendrobatidis* initiates infections in amphibian epidermal cells and how these processes may differ in American bullfrogs (*Lithobates catesbeianus*), a species resistant to lethal infection by *B. dendrobatidis*, and wood frogs (*Lithobates sylvaticus*), a species capable of acquiring lethal infection by *B. dendrobatidis*. Increased understanding of the morphology of *B. dendrobatidis* and the pathogenesis of chytridiomycosis could provide insights into past and future patterns of amphibian decline.

Another component of this project will involve a field study of American bullfrogs and wood frogs in New England vernal pools. Chytridiomycosis has not been implicated in declines of amphibian populations in northeastern North America but *B. dendrobatidis* is common in soils and freshwater systems in parts of New England. American bullfrogs, a widespread species considered invasive in many parts of the world, are known carriers of *B. dendrobatidis* and use vernal pools as non-breeding habitat. Wood frogs are a vernal pool-breeding species of conservation concern in many parts of their range. Our objectives for this component of the project are to determine the life stages at which these species co-occur in vernal pools and if transmission of *B. dendrobatidis* occurs during these life stages. This information is not only of local conservation interest given the potential role of American bullfrogs as disease vectors but may also be particularly applicable to other amphibian communities in which bullfrogs are invasive and co-occurring species are susceptible to chytridiomycosis.

PROJECT STATUS

This project was initiated in September, 2009. Continued review of the literature and project planning are currently underway.

FUTURE PLANS

The laboratory-based component of this project, which will involve a comparison of infected bullfrog and wood frog tissue using transmission electron microscopy, will be conducted in winter 2009 and spring 2010. The field-based component of this project will begin in spring 2010

FISHERIES RESOURCES

The Critical Conflict between Brook Trout (*Salvelinus fontinalis*) and Smallmouth Bass (*Micropterus dolomieu*) in the Rapid River

Investigator: C. A. L. Jackson

Advisors: J. Zydlewski, Chair
G. Zydlewski
C. Loftin

*Cooperators/
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit
Maine Department of Inland Fisheries and Wildlife
Maine Outdoor Heritage Fund
Trout Unlimited

Objectives:

- 1) Describe the movements of juvenile brook trout, smallmouth bass, and Atlantic landlocked salmon in the Rapid River system.
- 2) Construct an artificial stream to observe and describe interactions between brook trout and smallmouth bass.
- 3) Develop a model to examine affects of hooking mortality on brook trout population sustainability.

SCOPE

The Rapid River in western Maine has supported one of the most prominent brook trout (*Salvelinus fontinalis*) fisheries in Maine. Illegally introduced *Micropterus dolomieu* have quickly become a dominant ecological force in the Rapid River system and are believed to compete with the native brook trout. The nature and extent of the competition is poorly characterized, but thermal refuges may be a limiting resource for the Rapid River fish. This interaction is further complicated by the presence of landlocked Atlantic salmon (*Salmo solar*). A general overlap in habitat use by these three species may allow for complex inter-specific species competition. To identify regions of use by each of these three species, an intensive telemetry study was initiated in late spring 2005. Tracking and relocation of tagged individuals was accomplished on a weekly basis from initial tagging through the life of the tag. In order to assess the effects of intensive fishing in this system, the effects of catch and release on native brook trout are also being evaluated. In coordination with the State, angler survey data are being used to model potential impacts of intense fishing pressures on age/class structure and survival risk.

PROJECT STATUS

All requirements for a Master's degree were met in August 2009. The abstract of the thesis follows:

Summer movement patterns and spatial overlap of native sub-adult brook trout, non-native landlocked Atlantic salmon (*Salmo solar*), and non-native smallmouth bass in the Rapid River were investigated with radio telemetry in 2005 to assess the potential of competitive interactions between these three species. Fish were captured by angling, surgically implanted with a radio transmitter, and tracked actively from June through September. Most brook trout (96%) and landlocked salmon (72%) displayed long distance movements (>1 km) to open water bodies (28 June to 4 July), followed by periods of time spent in presumed thermal refugia (5 July to 16 September). Summer water temperatures rose above 25 °C, near the reported lethal limits for these cold water species. In contrast, the majority of smallmouth bass (68%), a warm water species, did not make long distance movements (< 1km) from areas of initial capture, remaining in main stem sections of the river (28 June to 16 September). Spatial overlap of smallmouth bass and brook trout in the summer is unlikely because brook trout move to thermal refugia during this time. However, some level of interspecific competition between brook trout and landlocked salmon may occur since they selected similar habitats in this study.

As fish populations decline across their native ranges across the United States, angling regulations such as fly-fishing-only and catch and release are being used by management agencies to conserve fish while maintaining angling opportunities. Post-release mortality, however, may significantly impact age and size structure of protected populations. A deterministic model was used to assess the possible effects of catch and release fishing on brook trout population structure. Data from several sources were used to create a brook trout population in which 5 age classes occurred. Changes in population characteristics at varying levels of angler effort (0-240 rod hours ha⁻¹ yr⁻¹) and post-release mortality rates (0-14%) were examined. A "trophy" brook trout fishery was sustainable only at low levels of angling intensity (<120 rod hours ha⁻¹ yr⁻¹). As angling effort increased, the proportion of older aged fish (3, 4, and 5 years old) declined significantly. At higher levels of angling effort, 4, and 5 year old fish were no longer part of the population. Increases in post-release mortality rates resulted in similar declines of older age classes. The results of this simulation indicate that heavy angling pressure and post-release mortality, as might be common in catch and release fisheries, significantly shifts the age structure of a population, reducing trophy-angling potential

Evaluation of Dennys and Penobscot River Smolt (*Salmo solar*) Performance: Does Brood Stock Rearing Technique Affect Behavior and Physiology?

Investigator: R. Spencer

Advisors: J. Zydlewski, Chair
G. Zydlewski
J. Trial
J. McCleave

*Cooperators/
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit
Maine Atlantic Salmon Commission
U.S. Fish and Wildlife Service

Objectives:

- 1) Compare the physiological and development of smolts reared from Penobscot River brood stock (from seawater origin) and Dennys River brood stock (from domesticated parr).
- 2) Compare the development of migratory behavior in smolts reared from Penobscot River

brood stock and Dennys River brood stock.

SCOPE

In the Dennys River, efforts to boost adult recruitment through smolt (*Salmo salar*) stocking have had poor results. The question is why. Smolt to adult returns are clearly influenced by many variables that can, for hatchery fish, be categorized as being related to successful emigration or ocean survival. In a general sense, time at sea can be argued to be a commonality between systems within a region. Therefore, potential differences in the smolt experience need to be understood to promote survival.

Do these survival differences represent smolt-specific rearing practices or river-specific environmental conditions? Or could the rearing practices used to produce Dennys smolts simply produce poorly performing smolts? Smolts produced for the Dennys are unique in their production by necessity. Because of the minimal returns, brood stock are captured as parr and reared to adulthood in captivity (whereas in the Penobscot brood stock relies on adult returns). The influence of artificial husbandry techniques on the next generation remains poorly characterized. Smolt quality has been assessed in previous broods of Dennys fish using physiological indicators of smolt performance (McCormick, unpublished data) but migratory performance is difficult to quantify. Physiological parameters associated with smolting are clearly indirect indicators of performance potential. Simultaneous use of physiological and behavioral assessment could generate a clearer picture of smolting.

It is the goal of this study to directly compare the physiological and behavioral development of smolts reared from Penobscot River brood stock (from seawater origin) and Dennys River brood stock (from domesticated parr). This project is consistent with the priorities to evaluate stocking programs and fish quality repeatedly identified by the NRC and in the Draft Atlantic Salmon Recovery Plan. The work would be conducted at Green Lake National Fish Hatchery and still have direct implications for management practices. Specifically, the results of this study will help either identify smolt production as a potential concern or further focus attention on the environment of the Dennys system.

PROJECT STATUS

All requirements for a Master's degree were met in August 2009. The abstract of the thesis follows:

Hatchery reared Atlantic salmon *Salmo salar* smolts produced from captive-reared Dennys River and sea-run Penobscot River broodstock are released into their source rivers in Maine. The adult return rate of Dennys smolts is comparatively low. This may be a function of ecological factors unique to the Dennys River and bay, or reflect poor quality of Dennys River hatchery smolts. The Dennys River environment compares favorably to the Penobscot, but the potential impact of ecological factors in Dennys Bay (numerous Atlantic salmon aquaculture sites and complex bay geography and hydrology) on smolt survival are unknown. Broodstock genetic composition and rearing environment differ between watersheds and may affect smolt quality. Penobscot smolts are produced from Penobscot genetic-stock that experience a normal anadromous life history, although most originate as stocked hatchery smolts. Dennys smolts are produced from Dennys genetic-stock that experience an artificial hatchery environment during most of their life cycle. Captive-rearing of Dennys broodstock may magnify negative domestication effects relative to anadromous broodstock and reduce smolt quality.

To assess smolt quality and performance indices for these stocks, behavioral trials were conducted using smolts placed in naturalized annular tanks with circular flow. "Migratory urge" (downstream movement) was remotely monitored via PIT tags and Na^+ , K^+ -ATPase activity was measured cyclically as an index of smolt development. Migratory urge of both stocks was low in early April, increased 20-fold through late May, and subsided by the end of June. Migratory urge of Penobscot smolts increased with greater magnitude (up to 35%) than Dennys smolts early in the migration, but cumulative (seasonal) distribution of downstream movement was independent of stock.

Gill Na^+ , K^+ -ATPase activity of Dennys smolts was higher than Penobscot smolts in April, but otherwise similar. Gill Na^+ , K^+ -ATPase activity of both groups increased in advance of migratory urge, declining while migratory urge was increasing. There was no clear relationship between migratory urge and enzyme activity at the individual or stock level. Maximum diel movement was observed from 2 h after sunset through 1 h after sunrise, but varied seasonally. Dennys smolts were slightly more nocturnal than Penobscot smolts. Penobscot and Dennys smolts were generally similar in the characteristics measured, and it is unclear if the observed modest differences could be responsible for the large differences observed in adult return rates.

Investigating the Decline of Whitefish (*Coregonus clupeaformis*) in Maine

Investigators: D. Gorsky

Advisor: J. Zydlewski

J.E. Marsden
 Y. Chen
 L. Kling
 M. Kinnison

Cooperators/ USGS - Maine Cooperative Fish and Wildlife Research Unit
Project Support: Maine Department of Inland Fisheries and Wildlife
 University of Maine

Objectives:

- 1) Understand the basic movement patterns of whitefish in key systems.
- 2) Compile historic data of whitefish presence and smelt introductions in Maine waters.
- 3) Assess the likelihood that smelt and whitefish are directly competing.

SCOPE

Lake whitefish (*Coregonus clupeaformis*) is a salmonid species with considerable fisheries importance in Maine. Many Maine lakes once had strong whitefish populations, however, over the past few decades creel survey and inventory data indicate a marked decline. During this same period of time, smelt have been introduced into many of these waters. The correlation between these events has spurred concerns that smelt introductions are causal to the whitefish declines. The few systems with relatively robust populations (e.g., Clear Lake) are currently being tapped as a source of hatchery supplementation. Approaches to address these three core objectives are in progress and are in close coordination and collaboration with MDIFW biologists.

PROJECT STATUS

Vemco VR2 acoustic receivers were deployed on Clear Lake for year round passive detection of tagged individuals. Thirty-two lake whitefish were tagged at Clear Lake (11 in 2004, 4 in 2005, and 17 in 2006). Results indicate a consistent seasonal pattern of movement. During winter months, fish maintain a deep position in the water column restricted to a small deep hole in Clear Lake located off the northeast shore. This appears to be where the tagged fish consistently positioned themselves during periods of ice coverage through the winter months. At the commencement of ice-out, fish begin to migrate vertically into shallower depths of the water column. The timing of ice-out, light penetration and surface water temperature change appear to be highly correlated and are likewise correlated with vertical migration of tagged fish. Following this spring vertical migration, the lake waters stratify and a thermocline develops between 9 and 10 meters. Vertical migration is hypothesized to be temperature driven, but also is synchronous with the beginning of spawning. In Clear Lake, whitefish spawn on a shallow shoal (3-5m). Following spawning events and as ice formation completes, fish descend and reach the deeper habitats commonly occupied during winter months, completing the cycle.

Baseline data on larval growth has been measured for lake whitefish in 2006 and 2007. Eggs were transported and hatched in lab space located in the Aquaculture Research Center (ARC) on the University of Maine campus in Orono. Larvae were immediately fed abundant live rotifers and one day old *Artemia nauplii*. After the yolk sac was absorbed in most of the fish, they were separated into treatment groups, which were three levels of feeding and four levels of fish density. Growth was monitored under these conditions. Preliminary analysis shows what one would expect based on food resource availability. Generally, as fish density increases and food availability decreases, growth is slowed. In 2008, we were successful in rearing smelt and conducted a series of detailed competition experiments. Preliminary results indicate that smelt were not effective competitors with lake whitefish, contrary to the initial hypothesis. Rather, due to their small size relative to whitefish, smelt were out-competed and eventually became preyed upon by whitefish when reared together. These data indicated that other interactions may be causal to lake whitefish declines.

A second level of interaction between lake whitefish and smelt may occur in early spring when larval whitefish are emerging and adult smelt are returning from spawning runs. Literature has indicated that post-spawned adult smelt are voracious feeders and, if there is overlap in spawning and larval habitat use between smelt and whitefish, predation by smelt on larval whitefish could effect larval recruitment. In 2009, we conducted detailed predation experiments at the University of Maine. These data indicate that the window of predation (based on attack success) may be only 8-10 weeks, after which juvenile size may preclude smelt predation. This work will be repeated and concluded in 2010.

FUTURE PLANS

A Ph. D. dissertation is expected to be completed in 2010.

- Investigators:* R. Wathen
- Advisor* S. Coghlan, Co-chair
J. Zydlewski, Co-chair
J. Trial
- Cooperators/
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit
Maine Department of Inland Fisheries and Wildlife
University of Maine
- Objectives:*
- 1) Construct an artificial stream to study interactions of smallmouth bass and salmon in a controlled setting.
 - 2) Conduct field surveys to assess the impact of small mouthbass on habitat selection of juvenile Atlantic salmon.

SCOPE

Today, wild Atlantic (*Salmo salar*) populations have declined precipitously and persist in only a handful of Maine rivers. Part of the remaining population (~2000 spawning adults annually) is now federally protected by the Endangered Species Act (2000), however, the species still faces extirpation. Declines in range and numbers primarily are due to anthropogenic disturbances, including pollution, loss of habitat, disruption of river hydrology, and over-fishing. Although *Salmo salar* have received much conservation attention, little research has addressed ecological effects of invasive species, and no data exist on interactions with smallmouth bass (*Micropterus dolomieu*). Predation and direct competition by invasive small mouth bass are thought to affect the population dynamics of Atlantic salmon in many Maine rivers. This study addresses threats posed to Atlantic salmon by competition from *Micropterus dolomieu* in the last remaining habitats of wild Atlantic salmon. Understanding the important ecological factors that may compromise survival, growth, and habitat use in nursery streams is critical to the conservation of the endangered *Salmo salar*.

PROJECT STATUS

To better understand this issue and conduct basic research, we have constructed an artificial stream comprised of a mixture of pool and riffle micro-habitats at the Aquaculture Resource Center at the University of Maine. Juvenile salmon and smallmouth bass have been placed in this artificial stream where their movement, position choice, and feeding behavior has been observed (by video and through PIT tag identification) under different flow conditions. Preliminary results indicate that age 0+ smallmouth bass cause habitat use shifts in age 0+ Atlantic salmon.

In corroborate and augment studies in the laboratory, we have conducted a field assessment of habitat choice by Atlantic salmon with snorkeling survey techniques. Open systems containing both species in sympatry and allopatry have been assessed; habitat choice information has been analyzed with respect to the density of smallmouth bass in the system. Furthermore, a controlled invasion experiment was conducted in the summer of 2008 and fall of 2009. This experiment examined the changes in habitat use of Atlantic salmon parr after juvenile smallmouth bass were introduced into the system.

Results indicate that age 0+ smallmouth bass overlap substantially in habitat use with age 0+ Atlantic salmon during mid summer months, and the presence of smallmouth bass may cause Atlantic salmon to alter their habitat use in natural systems.

This study was initiated in 2007. The artificial stream is completed and tests have been on-going since summer 2008. Field methods have been tested in 2007, and two field seasons have been completed (summer-fall 2008, 2009).

FUTURE PLANS

A Master of Science thesis is expected to be completed in 2010.

Monitoring Changes in Resident Fish Communities and Anadromous Sea Lamprey in Sedgeunkedunk Stream (Penobscot Co., Maine) After Low-head Dam Removal.

- Investigators:* C. Gardner
- Advisors:* S. Coghlan, Co-chair
J. Zydlewski, Co-chair
- Cooperators/* USGS - Maine Cooperative Fish and Wildlife Research Unit

Project Support: National Oceanic and Atmospheric Administration
University of Maine

Objectives:

- 1) Quantify population abundance, biomass, and size structure of resident fish species in representative habitats/reaches in treatment sites (presumably affected by barrier removal) and control sites (presumably unaffected by barrier removal) both before and after dam removal takes place.
- 2) Test for differences in fish community structure, total fish biomass, and secondary production attributable to barrier removal.
- 3) Conduct size-spectra analysis as an indicator for changing patterns of energy flow attributable to barrier removal.
- 4) Characterize the population metrics and habitat use of sea lamprey - the only prominent anadromous species in the system

SCOPE

The manipulation or disturbance of an ecosystem can have numerous effects on both the biotic and abiotic constituents found within that ecosystem. Monitoring how the biotic and abiotic components respond to a manipulation or disturbance within their habitat is a critical component necessary for our understanding of ecosystem response to such changes. This work began monitoring the effects of a restoration project on the fish community in the Sedgeunkedunk watershed, a tributary to the lower Penobscot River. This system had two dams removed in 2008 and 2009; if ecosystem response can be understood, then ultimately we may be able to increase our ability to manage Maine's native fish communities adaptively in such situations.

PROJECT STATUS

This study was initiated in 2007. Sampling was conducted biannually at both the Sedgeunkedunk Stream watershed and a reference system in 2007, 2008, and 2009. The last sampling of 2009 was completed after the completion of the last dam removal. Sampling included electrofishing selected stream reaches and trap-netting selected pond locations. Fish captured were identified and measured to characterize the community structure and population metrics. Sea lamprey, the only prominent anadromous fish in the system, were captured and tagged to estimate abundance and distribution of spawning activities. Daily surveys were conducted to record patterns of movement and behavior. Preliminary data have been taken to study the potential effects of sea lamprey on stream habitat and productivity.

Preliminary data show that species richness, total fish abundance, and species-specific abundance were greatest directly below the lowermost dam, and least at the site directly above the lowest dam in the system. Richness and abundance increased at sites further upstream of the dam, but never recovered to the high levels found below the dam. Sampling immediately following the removal of the lowest dam in the system showed a change in this pattern. Species richness and abundance declined drastically at the site below the dam after the removal, probably because the dam removal process caused a disturbance in the waterflow and a large amount of sediment to enter the stream. While species richness above the dam site did not increase, fish abundance suggests that the response of species common at all sites to the disturbance was to move upstream past the location of the former dam.

The 2008 sea lamprey run consisted of 51 spawning adults, and nest abundance increased from the mouth of Sedgeunkedunk Stream upstream to the base of the lowermost dam. There was no run in 2009, most likely due to extremely high discharge resulting from prolonged heavy rainfall and dam removal activities. Now that the lower dam has been removed, we expect sea lamprey to colonize the remainder of Sedgeunkedunk Stream in 2010.

FUTURE PLANS

Data analysis and writing are in progress for a Master of Science thesis, expected to be completed in May 2010.

Impacts of Riparian Characteristics on Terrestrial Invertebrate Input and Brook Trout Bioenergetics

AND

Influence of Coarse Woody Debris Addition and Brook Trout Relocation on Stream Communities

Investigators: P. Damkot

Advisor: S. Coghlan, Chair

J. Zydlewski
K. Simon

For: Impacts of Riparian Characteristics on Terrestrial Invertebrate Input and Brook Trout Bioenergetics:

Cooperators/ University of Maine – Department of Wildlife Ecology
Project Support: USGS - Maine Cooperative Fish and Wildlife Research Unit

- Objectives:*
- 1) Evaluate the influence of riparian characteristics on terrestrial invertebrate input and quantify the resultant energetic input available for brook trout consumption.
 - 2) Quantify the availability of aquatic invertebrates in stream benthos and drift and the resultant energetic input available for brook trout consumption.
 - 3) Assess foraging selectivity in brook trout and quantify the relative amounts of energy provided by aquatic and terrestrial invertebrates.
 - 4) Integrate data with an existing bioenergetics model and simulate the effects of riparian forest structure on brook trout energetics.

SCOPE

Maine contains the largest intact, wild populations of *Salvelinus fontinalis* in the United States. The fate of these fish is linked inextricably to the surrounding watershed, as riparian forests maintain suitable stream temperatures and physical habitat, facilitate aquatic prey production, and provide terrestrial prey subsidies critical for trout survival, growth, and reproduction. Because most brook trout streams in Maine flow through privately-owned land managed for commercial timber harvest, however, disturbances to the structural integrity of the riparian forest are common but their resultant effects on brook trout often are not known or considered. Without adequate knowledge of the effects of forest harvesting and regeneration patterns on brook trout in these streams, resource managers lack a critical piece of the puzzle when projecting outcomes of various management scenarios. We developed a project to investigate the role that riparian forest structure plays in determining growth and production of brook trout in sensitive habitats – that is, headwater streams in the White Mountains region of western Maine surrounded by economically-valuable forests. Specifically, we will quantify the effects of various riparian forest characteristics (e.g., along gradients of canopy cover, basal area, stem density, and coniferous/deciduous dominance) on stream temperature, aquatic prey abundance, and terrestrial prey input, and ultimately link these factors to brook trout growth and production.

PROJECT STATUS

During the summer of 2008, we chose sites on eight headwater streams in western Maine and northeastern New Hampshire along a gradient of deciduous and coniferous riparian stand dominance, presumably reflective of logging history; sites ranged from 99% deciduous and 1% coniferous to 80% coniferous and 20% deciduous. We sampled each stream three times throughout the summers of 2008 and 2009 with 24-hour sampling cycles. During each sampling interval, we collected benthic macroinvertebrates in four Surber samples, drifting aquatic invertebrates every six hours with four ½-hour drift net sets, and terrestrial invertebrates with six pan traps deployed for the entire 24-hour period. In addition, we collected 10-22 brook trout stomach samples for diet analysis by gastric lavage. Laboratory work to enumerate and identify invertebrates and quantify energy availability and consumption began during the winter of 2008/2009. Preliminary results from a subsample of 2008 samples have not shown a significant effect of stand dominance on terrestrial invertebrate availability, although there were significantly larger proportions of terrestrial invertebrates in diet samples from one stream. Laboratory work will be completed during the winter of 2009/2010. These data will then be integrated with an existing bioenergetics model to predict how brook trout growth would be affected by riparian forest alterations and climate change.

FUTURE PLANS

A Master of Science thesis is expected to be completed in 2010.

For: Influence of Coarse Woody Debris Addition and Brook Trout Relocation on Stream Communities:

Cooperators/ University of Maine – Department of Wildlife Ecology
Project Support: USGS - Maine Cooperative Fish and Wildlife Research Unit
Maine Department of Inland Fisheries and Wildlife
Maine Bureau of Parks and Lands
U.S. Fish and Wildlife Service – Eastern Brook Trout Joint Venture
Androscoggin River Watershed Council
National Fish and Wildlife Foundation
Town of Newry
Maine Department of Environmental Protection

Wagner Forest, Sunday River Inn, Caribou Springs

- Objectives:*
- 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.

SCOPE

Headwater streams in Maine are very sensitive to human disturbance but are vital for *Salvelinus fontinalis* persistence. Historically, disturbance included intense logging in the riparian zone and loss of in-stream habitat from subsequent log drives. As a consequence, many of these streams are now devoid of large trees (coarse woody debris or CWD) that create pools, trap organic matter, retain spawning gravel, and temper hydrologic variability, all of which should yield high quality habitat for brook trout. Furthermore, disturbance in many high-elevation streams has eliminated brook trout, and steep gradients have prevented natural re-colonization, so former brook trout habitat remains vacant. We have initiated a project to restore CWD to headwater streams to improve brook trout habitat as well as reduce downstream flooding and erosion, and are stocking trout in vacant habitat with and without CWD addition, to determine the relative efficacy of each conservation measure. We also are monitoring the responses of non-target taxa (aquatic invertebrates and streamside salamanders) to identify any incidental effects of our conservation actions.

PROJECT STATUS

We have chosen 20 study sites on headwater streams in the Mahoosuc Range (Oxford and Franklin Counties) to study the interactive effects of CWD addition and trout relocation. Twelve sites contain wild populations of brook trout, six of which will receive CWD addition and six of which will serve as reference sites. The remaining eight sites are currently devoid of fish, although most likely once contained brook trout; two will receive CWD, two will receive brook trout, two will receive both CWD and brook trout, and the remaining two will serve as reference sites. Variables of interest include 1) abundance, density, biomass, and size-structure of brook trout; 2) abundance and community structure of aquatic insects; 3) abundance of streamside salamanders; and 4) physical habitat characteristics. Sampling occurs seasonally, both prior to treatments and for several years after treatments. Using this before-after / control-impact design, we will be able to quantify the effects of both restoration actions on aquatic fauna. We added CWD to 5 sites in 2007 and 4 sites in 2008, and sampling has occurred twice yearly for brook trout, seasonally for aquatic insects, once yearly for salamanders, and once yearly for physical habitat. Brook trout relocation to vacant sites will occur in summer 2010. Currently we are identifying aquatic insects and analyzing fish, salamander, and habitat data. Habitat data show a significantly greater abundance of in-stream wood in treated sites, but no differences in substrate composition and pool characteristics. Rather, marked annual variation in stream flow (i.e., drought in 2007, late summer flooding in 2008, early summer flooding in 2009) probably masked changes in habitat due to CWD addition. Fish data show no overall patterns that can be attributable to CWD addition, however, the two study sites that contained the least pre-treatment trout abundance and biomass in 2007 have improved markedly in trout productivity through 2009. We caution that the short time elapsed since the CWD addition may not have allowed for detectable changes to have taken place in many sites, and because our study streams varied greatly in terms of pre-treatment abundance and biomass of trout, sites varied in their potential to translate improved habitat into increased brook trout production. Furthermore, individual pieces of CWD appear to have moved substantially during floods, which may have caused disturbance to the stream habitat and biota. However, as CWD settles into semi-permanent jams, we expect to observe improvements in habitat quality and brook trout should respond positively.

FUTURE PLANS

A Master of Science thesis is expected to be completed in 2010, and we expect to continue monitoring brook trout populations at least through 2012.

Understanding the Ecology of Sea-Run Brook Trout in Acadia National Park

Investigators: D. Kazyak

Advisor: J. Zydlewski, Chair
B. Letcher
S. Coghlan

*Cooperators/
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit
USGS -Biological Resources Discipline
National Park Service
University of Maine
Maine Department of Inland Fish and Wildlife

Objectives:

- 1) Describe the seasonal movements and habitat use of brook charr using radio telemetry.
- 2) Examine growth variability of brook charr with PIT technology.
- 3) Explore the influence of age and size on survival.
- 4) Examine the effects of movement on growth.

SCOPE

The iconic *Salvelinus fontinalis* has suffered from the effects of habitat degradation, competition with non-native species and population fragmentation throughout its range during recent decades. These effects have been characterized succinctly in the Trout Unlimited-produced status report for the “Eastern Brook Trout Joint Venture” (comprised of fish and wildlife agencies from 17 states, U.S. Geological Service, U.S. Forest Service, U.S. Fish and Wildlife, the National Park Service, the Office of Surface Mining and many conservation organizations and academic institutions). Maine was identified as the last stronghold for this valuable sport fish in the United States. Among Maine management agencies and the public, there is emerging interest in understanding and protecting the ecological integrity and diversity of this species, particularly with regard to life history variation.

Historically, coastal streams have supported anadromous runs of brook trout, but this life history form is presumed to have declined precipitously from their once historic distribution range. However, the status of anadromous populations is largely unknown for most Maine waters. Likewise, survival rates, recruitment and movement characteristics within and among neighboring stream systems represent significant data gaps impeding successful fisheries management. This project is aimed at collecting such basic information in communication and cooperation with regional stakeholders.

PROJECT STATUS

This research focuses on the movement patterns of brook charr and the implications of those patterns for growth in two systems, Cove and Stanley Brooks. Growth in salmonids is important as it is strongly correlated with survival and reproductive success. Temperature and habitat attributes have been measured in an attempt to quantify these environmental gradients. A stationary PIT antenna has been installed and maintained at the downstream terminus of Stanley Brook (2006) and Cove Brook (2008) to assess downstream migration. Available habitat has been quantified in summer 2009 during low-flow conditions in Cove Brook. Preliminary analysis of mark-recapture data indicates substantial spatial heterogeneity in growth during the months of October through April. Growth rates of brook charr will be compared across several environmental gradients across the study area. Growth data were gathered using biannual mark-recapture sampling of PIT tagged fish.

An adequate understanding of habitat use is also important for restoration and mitigation activities. Radio telemetry has been used to locate 15 brook charr in Cove Brook over the course of approximately one year (beginning spring of 2009) with weekly surveys. Seasonal changes in the movement patterns and habitat use of brook charr will be examined with a particular focus on temperature during the summer months and habitat during the spawning season. Movement rates of brook charr will be compared across seasons and between individuals. Mark-recapture data from ongoing PIT tagging studies will be used in conjunction with detections from stationary antennae arrays and PIT-packing to assess the effects of size and age on survival. The program MARK will be used to calculate survival estimates for different age and size classes.

Ultimately, the results of this study may provide useful background information when examining the effects of a regulatory changes being instituted on Stanley Brook effective 2010 and may prove insightful for managers attempting to maintain and restore coastal brook charr populations.

FUTURE PLANS

A Master of Science thesis is expected to be completed in 2011

HABITAT RESOURCES

Characteristics of the Presettlement Forest of Northern Maine

Investigators: L. J. Mitchner

Advisors: W. B. Krohn, Co-chair
 A. S. White, Co-chair
 C. V. Cogbill
 R. S. Seymour
 J. S. Wilson
 J. A. Hepinstall (unofficial)

*Cooperators/
 Project Support:* The Nature Conservancy
 University of Maine - Department of Wildlife Ecology
 University of Maine – Ecology and Environmental Sciences Program
 USGS - Maine Cooperative Fish and Wildlife Research Unit

Objectives:

- 1) Determine the frequency, distribution and composition of the presettlement vegetation along survey lines in northern Maine.
- 2) Develop and test new methods for predicting estimated relative abundance of dominant species from abiotic factors.
- 3) Document the type, frequency, and severity of disturbance events along the township lines, prior to significant European settlement.
- 4) Test the likelihood of specific disturbances across the landscape.
- 5) Develop and test a new method for detecting sample bias in the MLO records.

SCOPE

Understanding the pattern and process of presettlement vegetation is important to scientists and land managers alike. This understanding is especially important in regions, such as northern Maine, where extensive logging, or other anthropogenic disturbance, has removed much of the original forest cover leaving little basis for relating the mature post-settlement vegetation to the original presettlement vegetation. Given the lack of original forest cover, the influence of disturbance on the presettlement forest is not easily discernible. The General Land Office (GLO) surveys conducted prior to and during early settlement serve as a means to reconstruct the forest composition associated disturbance regimes. The GLO surveys in Maine cover much of northern Maine at township-level resolution. These surveys, once entered into a Geographic Information System (GIS) can be combined with present-day environmental data from the Maine Office of GIS (Maine OGIS) to analyze the presettlement species-environment relationship. Statistical modeling of the species-environment relationship will result in a landscape scale model of presettlement forest conditions. Spatially explicit knowledge of the vegetation composition and the disturbance agents of the presettlement forest can, therefore, serve as a baseline for both ecological and silvicultural programs.

PROJECT STATUS

The first chapter documents who surveyed which townships, and when, along with the methods used. Witness tree selection in the Northwest Maine is the focus of the second chapter. Chapter three examines the methodology break in the survey that masks a biogeographic shift in forest composition in northern Maine. The utility of survey notes in reconstructing Maine's disturbance history are the focus of chapter four. Random forest was used to model the forest at the species and cover type analysis in chapter five.

FUTURE PLANS

Completion of the dissertation is scheduled for the winter of 2010.

A Long-Term Forest Ecosystem Study

Investigators: M. L. Hunter, Jr.
 A. J. Kimball
 A. S. White
 J. W. Witham

*Cooperators/
 Project Support:* Holt Woodlands Research Foundation
 University of Maine - McIntire-Stennis

Objectives: 1) Describe the structure of the plant and animal communities in an oak-pine forest ecosystem.

- 2) Investigate the effect of woodlot management on community structure.
- 3) Document phenological, inter annual, and long-term changes in community structure.

SCOPE

Thousands of people own woodlots, and they control a resource that is not currently being adequately managed despite a growing demand for forest products. For many landowners, perhaps most, economic return from timber extraction is secondary to considerations such as recreation, aesthetics, and wildlife. In the absence of management advice, these people often choose not to manage their land at all. Thus, there is a great need for information on how to manage small woodlots, particularly in ways that maintain or enhance wildlife and similar values.

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

Our primary objective is to describe the structure of the plant and animal community. We have undertaken (1) a 100% inventory of trees (>10 cm DBH) and intensive inventories of tree regeneration, (all trees are being individually numbered and on 12 tracts, mapped); (2) a complete description of the vascular plant vegetation using the relevé technique; (3) an inventory of all breeding bird territories; (4) small mammal trapping; (5) salamander cover object counts; (6) estimates of seed and fruit production; (7) general surveys of canopy insect abundance. These data, largely population estimates, are integrated by area units (usually 0.25 ha blocks) and analyzed to portray the forests' community structure. After five years of gathering baseline data, in 1987 we began managing the experimental area with three objectives: (1) increase wood production; (2) increase wildlife diversity and abundance; and (3) maintain the forest's aesthetic value. Regular timber inventories have enabled us to closely monitor tree growth and determine how well the wood production objective was met. By continuing to monitor populations and processes, we can attain the second objective. Over the course of 25 years, we have begun to understand how the community changes seasonally and from year to year; this is the essence of the third objective.

PROJECT STATUS

In 2009, our twenty-sixth field season, tasks 3, 4, 5, 6, 7, above were completed, tree regeneration was measured in 1, 4, and 200m² plots, timber inventory corrections were made.

FUTURE PLANS

The 2010 field season will cover all the parameters measures annually. In addition, we will update our vascular plant vegetation data.

Using Algae to Evaluate the Condition of Maine's Streams and Rivers

Investigators: T. J. Danielson

Advisors: C. S. Loftin, Chair
D. Courtemanch
S. Brawley
F. Drummond
J. Stevenson

*Cooperators/
Project Support* University of Maine - Department of Wildlife Ecology
Maine Department of Environmental Protection
U S Environmental Protection Agency
Houlton Band of Maliseet Indians
Manomet Center for Conservation Sciences
USGS - Maine Cooperative Fish and Wildlife Research Unit

Objectives:

- 1) Develop analytical tools to evaluate the condition of stream algal communities across a gradient of conditions ranging from minimally disturbed streams to those that have been highly degraded.
- 2) Build a model to predict stream classification attainment based on algal community attributes.

SCOPE

The state of Maine Department of Environmental Protection currently evaluates the conditions of Maine's streams and rivers by sampling communities of aquatic macroinvertebrates at specific locations. This information is used with supporting chemical, physical, and landscape data to determine if streams and rivers are achieving aquatic life goals assigned to them under the State's Water Classification System (e.g., Class A, Class B, Class C). In this project, we will develop bio-assessment methods that examine stream algal communities and their relationships with water quality conditions. We will also develop a model to predict if streams attain assigned classes (e.g., Class A) based on characteristics of their algal communities.

PROJECT STATUS

Data analysis is complete and manuscript and dissertation preparation is underway.

FUTURE PLANS

Dissertation completion is expected early 2010.

Changes in Vegetative Composition, Structure and Function Following Silvicultural Management in Softwood Forested Wetlands with Respect to the Attitudes of Foresters and Loggers

Investigators: Gordon Moore

Advisors: A.J.K. Calhoun, Chair
M.L. Hunter, Jr.
J. Leahy
A. Kimball
K. Lausten, ex-officio

*Cooperators/
Project Support:* Maine Forest Service, Policy and Management Division
University of Maine – Department of Wildlife Ecology

Objectives:

- 1) Provide baseline data on vegetative and hydro-geologic changes in evergreen forested wetlands in northern Maine following timber harvesting.
- 2) Create a rapid assessment procedure for forested wetlands and vernal pool wetlands and habitat management guidelines (HMG) containing options for foresters, loggers and landowners with respect to the management of forested wetland resources.
- 3) Survey attitudes and beliefs of foresters to create workable best management practices and to understand the motivations in this population with respect to forested wetlands.
- 4) Create and test rapid monitoring protocols to monitor the outcome of forestry operations in forested wetlands and isolated forested wetlands (vernal pools), and incorporate the product onto the Maine Forest Service's existing monitoring protocol for timber harvest operations.

SCOPE

The importance of appropriate forested wetland management increases as the demand for timber resources and pressure for development continue to escalate. Forested wetlands are important sites for the retention of flood water, wildlife habitat, organic filters which produce clean water and for the production of timber. Forested wetland losses continue to be problematic, and additional information as to their function and perceptions of their value are necessary to arrest further ecosystem degradation. The boundaries of forested wetlands often are poorly delineated on National Wildlife Inventory maps, and as these maps are the standard for many regulatory mapping schemes. These wetlands are overlooked by regulatory agencies in Maine and other states. Current protection for these sites is limited and silvicultural Best Management Practices, while well intended, do not adequately protect the function of forested wetlands. This project evaluates the effects of timber harvesting management on the functions of evergreen forested wetlands dominated by Black Spruce (*Picea mariana*) and Red Spruce (*Picea rubens*), and isolated forested wetlands (vernal pools) in Maine. In this study, we evaluate (1) the attitudes and knowledge of foresters and loggers and (2) the on-the-ground effects of these on the functions of the resource. To address objective (1) foresters will be interviewed regarding their attitudes and beliefs about wetlands and forested wetlands. The interviews will be followed up with a mailed survey questionnaire on the same topic. Secondly, I will investigate the vegetation and hydrology of 3 evergreen softwood palustrine forested wetlands in north

western Maine from pre-harvest through several temporal stages post harvest with a primary goal of discerning the changes to the complexity and structure of these vegetative communities. I anticipate two products from this work: a rapid monitoring protocol for forested wetlands and isolated forested wetlands (vernal pool) which will be created as an addition to the existing protocol for monitoring forestry Best Management Practices (BMPs) currently being used by Maine Forest Service and several northeastern states; and creation of Habitat Management Guidelines for timber harvesting in palustrine forested wetlands, which will be viewed as an update and augmentation to the existing BMPs for timber harvest operations in forested wetlands .

PROJECT STATUS

Currently, we are conducting a review of scholarly and applied literature 1) focused on psychological tendencies, attitudes and beliefs with respect to natural resources issues as understood through the theory of planned behavior and 2) examining the effects on palustrine forested softwood wetlands, which have been altered by timber harvesting. We are conducting a pilot interview process with selected forestry practitioners with a pending evaluation and interpretation of the interview data and testing the theory of planned behavior. A rapid assessment procedure for vernal pools following timber harvest management on the adjacent areas has been created and tested through one field season. Collected data currently are being evaluated and analyzed. Sites and have been identified and initial monitoring of vegetation and hydrologic changes through inventory and shallow well (piezometers) have been initiated. Data are currently incomplete and will require at least one more field season.

FUTURE PLANS

Thesis seminar is anticipated in the winter 2009/2010. Other key tasks are as follows:

Continue to review the literature on qualitative inquiry and research design and vegetative and hydrologic research design and analysis; finish the interview/survey instrument; complete the interview process with foresters and loggers anticipated in the fall of 2009; complete the installations of piezometers and monitoring through the fall of 2010; vegetative analysis will be completed during the summer field season 2009; create report on the first field season and analysis of vernal pool monitoring data winter 2008/2009; complete and edit rapid assessment procedure for vernal pools following timber harvesting and analyze the data set in the fall of 2009; create rapid assessment procedure for palustrine forested wetland spring 2009 and conduct monitoring in the field during the summer 2009; and begin development of habitat management guidelines with respect to palustrine forested wetlands fall 2009.

Are There Any Negative Effects on the Ecology of Maine's Aquatic Ecosystems From the Invader *Myriophyllum heterophyllum*?

Investigator: Jacolyn E. Bailey

Advisors: Aram J.K. Calhoun, Chair
Ann Dieffenbacher-Krall
Cyndy Loftin
Kevin Simon
Dan Buckley

Project Support: Maine Department of Environmental Protection / Maine Volunteer Lake Monitoring Program
University of Maine - Department of Wildlife Ecology

Objectives:

- 1) Document fish, amphibian, and invertebrate communities in native macrophyte beds and managed and unmanaged non-native milfoil beds.
- 2) Measure the relative abundance and presence/absence for each of three taxa: fish, amphibians, and invertebrates.
- 3) Measure plant community composition and structure in native macrophyte beds and managed and unmanaged non-native macrophyte communities
- 4) Determine if there are differences in communities in native macrophyte beds and managed and unmanaged invasive macrophyte beds
- 5) Determine potential differences in plant and animal community dynamics in these communities.

SCOPE

Invasive aquatic species are one of the primary causes of freshwater species extinctions. These invaders grow and spread rapidly with destructive effects on aquatic ecosystems including loss of native plant and animal communities, habitat disruption, and damaged fisheries. Invasive macrophytes have been shown to affect biologically important variables such as dissolved oxygen concentrations and substrate characteristics which can reduce the availability of suitable habitat quality for fishes and macroinvertebrates .

In addition to ecological effects, invasive aquatic species reduce property values, hinder recreational experiences and lead to enormous management costs. In Maine, our economy is tightly linked to our lakes and ponds. Annually, visitors to Maine's lakes generate \$3.5 billion in total economic activity which supports over 50,000 jobs. Maine currently has 28 waterbodies infested with invasive aquatic plants and we are considered lucky as many other states have infestations in most, if not all, of their waterbodies. If Maine waterbodies reach the levels of infestation that other states are experiencing, it could be devastating to Maine's tourism industry and economy in general.

We propose to evaluate the affect of invasive milfoil beds on fish, amphibian, and invertebrate communities in lakes. Our research could raise the profile of ecosystem-scale effects of invasive aquatics. Our results can be used by lake managers to better focus their control efforts and more effectively use the limited resources available to them.

In short, many of Maine's lake associations with infested waterbodies are struggling to manage their lakes with a variety of costly control methods. There is a continuing need for additional funding to manage these infestations as well as future infestations. This research is the crucial step needed to determine the degree of environmental disruption posed by invasive aquatic plants. This information can then be used by resource managers to leverage additional funding by providing necessary data to support their requests to federal resources and private foundations. This study also help lake managers determine whether management for these invasive aquatic plants requires intense wide-scale management of a lake or can be focused on areas of human activity thereby more efficiently allocating limited resources.

PROJECT STATUS

During the 2009 summer season, research sites were selected, surveyed, and baseline data collection began. Additionally, sampling methods were tested and assessed.

FUTURE PLANS

Field studies are planned for 2010 and 2011, with project completion in 2012.

Managing Natural Resources on Private Lands: Theory and Practice of Collaborative Approaches Using Vernal Pool Conservation Planning in Maine

Investigators: Jessica S. Jansujwicz

Advisors: A.J.K. Calhoun, Co-chair
R. Lilieholm, Co-chair
J. Acheson
R. Judd
L. Lindenfeld

Cooperators/ University of Maine - Senator George J. Mitchell Center for Environmental and Watershed Research

Project Support: University of Maine - School of Forest Resources

Objectives:

- 1) Discuss the theoretical underpinnings of collaboration, addressing the hypothetical benefits, expected outcomes, and critical concerns.
- 2) Consider the limitations of past and current approaches used to evaluate collaboration in practice.
- 3) Develop an integrated performance evaluation framework to measure success and failure of collaborative initiatives.
- 4) Offer a practical example to examine the social and environmental outcomes of collaborative vernal pool conservation planning in Maine.
- 5) Evaluate the role of collaboration in shaping the character of local-level planning efforts.
- 6) Provide insight on the barriers and opportunities for using collaboration as a management tool for protecting natural resources on private lands.

SCOPE

Managing natural resources for the common good is a complex issue, particularly when achieving conservation goals requires management of private lands. While private lands are important for managing biological diversity, tensions between a landowner's perceived property rights and conservation interests make landscape-scale conservation a challenge. Landowners often are reluctant to cooperate in resource management strategies that may incur a personal cost, lower the value of their land, or impose restrictions on land use. Many also resent the layers of regulation affecting their property, questioning the use of state controls to produce a public good on private land.

To reconcile these diverse interests in land, there has been a growing trend toward more inclusive, participatory efforts to involve multiple stakeholders in local land use planning decisions. At the heart of this movement is the theory that collaborative natural resource planning can temper the confrontational politics of conventional regulatory approaches and overcome the limitations of traditional planning tools, thereby offering an alternative strategy to achieve government-mandated environmental objectives.

A collaborative, "bottom-up" approach, however, is not without critics, and debate over the merits of collaboration has prompted calls for a more formal evaluation of the effectiveness of collaborative processes in decision-making for land management. Responding to this call for better empirical analysis, a growing number of studies offer criteria against which collaborative efforts can be evaluated in practice. While recent studies have led to a better understanding of the process of collaboration, few empirical studies focus on both the social and environmental outcomes of collaborative natural resource planning.

The objective of this study is to generate empirical data to link the process and outputs of collaboration as a planning tool to manage natural resources on private lands with social and environmental outcomes. This study will document the extent to which multi-stakeholder engagement in natural resource planning processes influences conservation planning decisions at the local level by examining the creation and evolution of two collaborative mechanisms for vernal pool conservation planning in Maine: (1) the Vernal Pool Working Group (VPWG), a government-initiated, multi-stakeholder decision-making process; and (2) the municipal vernal pool mapping and assessment project, a community-based education and outreach effort jointly initiated by Maine Audubon Society and the University of Maine.

PROJECT STATUS

The first phase of this study gathered data with two qualitative research methods: (1) ethnographic tools of participant observation at public meetings, planning workshops, and citizen scientist vernal pool training sessions; and (2) semi-structured interviews with private landowners, citizen-elected local officials (e.g., Town Council), paid professionals (e.g., government agency personnel, town planners, GIS coordinators, consultants, developers, tax assessors, and local realtors) in several Maine towns. This stage of our research has been on-going since the Spring of 2008.

FUTURE PLANS

The second phase of this study will be developed beginning in late Fall 2009 and will involve landowner focus groups and a mail-back questionnaire administered in a subset of the towns involved in the vernal pool mapping and assessment project. The goal of this part of the study is to better understand landowner and general public attitudes toward vernal pools and vernal pool conservation planning in Maine.

Conserving Vernal Pools through Community Based Conservation

Investigators: Dawn Morgan

Advisor: A.J.K. Calhoun, Chair

Committee: K. Bell
L. Morin
L. Hertz

*Cooperators/
Project Support:* University of Maine - Environmental Solutions Initiative, Senator George J. Mitchell Center
University of Maine - Department of Wildlife Ecology (Teaching Assistantship)
National Audubon Society
Maine Audubon Society
Stantec Inc.

Objective: To coordinate proactive mapping of vernal pools and encourage conservation of natural resources

at the town level in Maine.

SCOPE

Vernal pools are small seasonal wetlands that fill with spring rains and generally dry down by the summer's end. They are critical breeding habitat for species adapted to life in temporary waters, including fairy shrimp, spotted and blue spotted salamanders, and wood frogs, and provide food to upland wildlife as well. Because of their small size and ephemeral nature, vernal pools often are overlooked by regulatory agencies and are filled for development. As a result, vernal pools are among the most threatened wetland types in the northeastern US. While a number of northeastern states have been proactive in their attempt to maintain the functional value of vernal pools, the Maine legislature was the first to recognize a subset of vernal pools (Significant Vernal Pools) as Significant Wildlife Habitat, a status that allows both the pool and a portion of the adjacent upland habitat. As of September 2007, pools that meet certain biological criteria (based on egg mass abundance of key species and presence of listed species) are deemed to provide Significant Wildlife Habitat and as such are regulated under the Maine Natural Resource Protection Act. The state is unable to pre-map these resources, so it is incumbent upon private landowners to determine if they harbor Significant Vernal Pools prior to developing their land. The most efficient and cost-effective way to ensure the long-term viability of vernal pool resources is through local planning initiatives that move management from a reactive crisis mode to a proactive planning mode. The original intention of this project was to work with citizenry and town officials in Orono, Maine, to inventory and assess vernal pool resources with trained citizen scientists, and to encourage the Town to incorporate vernal pools into a natural resource database for conservation planning purposes. Since we started the project, many additional towns have contacted us for help in proactively mapping their vernal pools. Given our limited resources, it became clear that our project should expand its purpose to include development of a Maine Municipal Guide to Mapping and Conserving Vernal Pools designed to provide pertinent information on vernal pool ecology and the process of using citizen scientists to map and assess pools. The Guide will also outline options for using a vernal pool data layer in conjunction with other spatial data layers to initiate conversations about natural resource planning. Feedback from project stakeholders has provided us with guidance in developing this document.

PROJECT STATUS

Mapping initiatives are underway in the towns of Orono, Brunswick, Topsham, Yarmouth, Freeport, Cumberland, Windham, Bar Harbor, and Scarborough and additional towns and land trusts have expressed interest in our materials and assistance. The Community Based Conservation: Maine Vernal Pools website was launched in March 2009 for the purpose of disseminating materials related to the proactive municipal mapping initiative, vernal pool ecology, and conservation of natural resources. Creation of the Maine Municipal Guide to Mapping and Conserving Vernal Pools and associated training materials will be completed in the fall of 2009 with plans to print and distribute to interested towns early in 2010.

FUTURE PLANS

Project completion is planned for December 2009.

Spatial Relationships between Burn Patterns, Pre-Burn Vegetation Composition and Distribution, and Short-Term Vegetation Recovery in Okefenokee National Wildlife Refuge, Georgia

Investigators: C. S. Loftin
P. Wetzel

Project Support U.S. Fish and Wildlife Service-Okefenokee National Wildlife Refuge
University of Maine - Department of Wildlife Ecology
USGS - Maine Cooperative Fish and Wildlife Research Unit

Objectives:

- 1) Describe fire severity and fire spatial patterns resulting from the 2007 wildfires in ONWR.
- 2) Compare the burn pattern descriptive analysis with vegetation classifications based on archived and newly acquired satellite imagery and aerial photography.
- 3) Compare pre- and post-burn vegetation classifications with archived spatial data of land cover, hydrology, and fire to identify relationships of vegetation recovery and site condition history.

SCOPE

Fire perimeter maps developed from thermal imagery captured while the swamp was burning during summer 2007 provide a time series of fire movement across the swamp. These maps present the impression of a uniform burn, yet a

differenced normalized burn ratio fire-severity map produced after the fire indicates a diverse burn intensity pattern and rapid post-fire vegetation regrowth. Comparison of these fire perimeter and burn severity maps with vegetation maps developed from aerial photography, merged SPOT multispectral and panchromatic satellite imagery collected during 1990, 2001 and 2.5 m SPOT imagery collected during June 2007, and newly acquired imagery during 2008 will improve our understanding of vegetation burn and recovery patterns in the swamp. This analysis also will provide a foundation data layer describing the pre- and post burn swamp landscape for other researchers' reference in their studies.

PROJECT STATUS

Digital aerial photography and SPOT satellite imagery were collected during summer 2008. Classification and accuracy assessment are complete and comparisons of the classified vegetation map and burn severity and progression maps to describe vegetation community composition and pattern changes over time are underway.

FUTURE PLANS

Completion of the project is expected in early 2010

Effects of Habitat Fragmentation on the Dispersal Success of Vernal Pool-breeding Amphibians

Investigator: D. V. Popescu

Advisors: M. L. Hunter, Jr., Chair
A. J. K. Calhoun
J. Zydlewski
J. P. Gibbs
R. Seymour

*Cooperators/
Project Support:* National Science Foundation
University of Maine – Department of Wildlife Ecology
University of Missouri
University of Georgia - Savannah River Ecological Laboratory
Maine Association of Wetland Scientists

Objectives:

- 1) Evaluate the effects of forest regeneration on a Maine amphibian community up to six year post-harvesting.
- 2) Quantify the permeability to juvenile amphibian movements of different-aged woodland habitats resulted from clearcutting.
- 3) Identify orientation mechanisms used by juvenile amphibians during dispersal and migration.
- 4) Understand the potential effects of microclimate on habitat use by juvenile amphibians.

SCOPE

This project is part of the Land-use Effects on Amphibian Populations (LEAP) project currently underway at the University of Maine, Orono. Land-use practices, such as forest harvesting, that reduce the quality of terrestrial habitat surrounding a pond may threaten the persistence of a local amphibian population and may disrupt dispersal between local populations within the metapopulation. LEAP involves 4 replicates of 4 forest harvesting treatments (clearcut with coarse woody debris [CWD] removed, and clearcut with CWD retained, 50% canopy cover partial cut, and uncut forest) centered on amphibian breeding ponds. In pond-breeding amphibian metapopulations, most individuals in a local population are philopatric to their natal breeding site and use the terrestrial habitat surrounding the breeding pond for foraging and overwintering. The treatments extend 164 m from the pond's center to capture 95% of several species of amphibians in that local population.

Specifically, the two overarching foci of this research are: (1) to assess what is the time frame in which clearcuts will revert to a suitable habitat to woodland amphibians; and 2) to understand connectivity of amphibian populations in a managed forest context by studying the movements of juveniles, which are the dispersing stage in several amphibian species.

PROJECT STATUS

The majority of the data required to meet the proposed objectives were collected during the 2007 – 2009 field seasons, and statistical analyses currently are underway.

We used a combination of drift fences and pitfall traps to capture all amphibians that migrate to and from the experimental pools for breeding wood frogs (*Lithobates sylvaticum*), spotted salamanders (*Ambystoma maculatum*), and blue-spotted salamanders (*Ambystoma laterale*), newly metamorphosed animals leaving experimental pools, as well as any other individuals that use the four treatments for foraging or transit movements. The drift fences were positioned in concentric arrays at 16.6 m (1 fence per treatment per site), 50 m (3 fences), 100 m (6 fences), and 150 m (9 fences) from the breeding pool. Pitfall traps were checked daily for amphibians during April (breeding season) and between June and September (emergence season of newly metamorphosed amphibians). I also documented forest regeneration at 4 – 6 years post harvesting (2007 – 09) by gathering habitat and microclimate data. These activities represent the continuation of a study conducted between 2004 and 2006 at the same experimental sites. Thus, we will be able to document any changes in the amphibian community and relate them forest regeneration for a period of six year post harvest. To characterize the microclimate of 5 – 6 year-old clearcuts and the effect of the coarse woody debris we deployed temperature and relative humidity data loggers at ground surface and under CWD at random locations at the four experimental sites.

We used field experiments to assess the permeability of three different-aged habitats resulted from clearcutting (2-3, 11, and 20 year-old regenerations) compared to a mature forest. Three 50 x 2.5 m silt fence enclosures were built in the four experimental treatments and batches of newly metamorphosed wood frogs (*Lithobates sylvaticum*) were released during July-August 2008 and 2009. We quantified habitat permeability by comparing the number of animals reaching various distances from the release point, the proportion of individuals showing avoidance behavior, and movement rates. This experiment will help us understand the consequences of clearcutting for connectivity of amphibian populations, and will also provide a fast-forward time-series approach answering the question ‘what is the time frame for alleviating the effects of clearcutting for juvenile amphibians’.

FUTURE PLANS

A small pilot experiment in 2009 showed an active avoidance of wetland cues by juvenile wood frogs, which is in contradiction to other studies in the current literature. In 2010 we will perform a dichotomous choice experiment aimed at understanding the use of olfactory and hygrostatic cues during emigration movements. Also, we will finish analyzing the data from the other experiments and produce four manuscripts to be submitted for publication.

Does Fish Introduction Influence Amphibian Community Composition and Reproductive Effort?

Investigators: David M. Ellis

Advisors: A.J.K. Calhoun, Co-advisor
Cynthia Loftin, Co-advisor
William Glanz
William Halteman

Collaborators and Project Support: University of Maine – Department of Wildlife Ecology
Maine Department of Inland Fisheries and Wildlife
USGS - Maine Cooperative Fish and Wildlife Research Unit
USGS - Eastern Region Cooperative Fish and Wildlife Research

Objectives:

- 1) Determine if fish presence has an influence on amphibian community composition and reproductive effort.
- 2) Develop a habitat selection model for wood frog (*Rana sylvatica*) in western Maine compare findings for northern and western mountain region’s to eastern lowlands.

SCOPE

Amphibian populations face a multitude of complex threats. Habitat loss or modification is contributing to amphibian declines globally. Fish introduction to previously fishless alpine lakes in the western United States has led to declines in endangered frogs and salamanders found in those systems, however, effects of fish introductions on the amphibian communities breeding in previously fishless lakes in western Maine is not well-documented. Our research documents amphibian communities and reproductive effort in 14 mid-elevation lakes in western and northern Maine, and wetlands within a 1km buffer surrounding the lakes. The study lakes are of three types: naturally fishless since deglaciation, historically fishless but stocked with brook trout during the past century, and historically stocked and now fishless.

We are documenting amphibian presence and abundance with a variety of methods, including visual encounter surveys, passive auditory surveys (i.e., remote audio recorders), and trapping. We are particularly interested in vernal pool breeding species' (*Ambystoma maculatum*, *Ambystoma laterale*, *Rana sylvatica*) use of these aquatic habitats and linkage with wetlands and the surrounding terrestrial environment used during non-breeding, to understand potential effects of modifying the non-breeding habitat on persistence of these species in this western and northern Maine landscape.

We are tracking post-breeding wood frogs with radio transmitters to determine their hibernacula selection, and will resume tracking in late winter to determine wetlands used for breeding habitat. The habitat use information gained from our telemetry studies will be combined with data from the wetland and lake amphibian presence and reproductive effort surveys to improve our understanding of how this landscape is used throughout the year. This information will provide guidance for conservation of these western Maine lakes and surrounding uplands to ensure longterm persistence of these species in this wetland limited landscape.

PROJECT STATUS

Two field seasons to document amphibian presence, reproductive effort, breeding habitat use, and post-breeding and hibernacula selection are planned. We have completed one field season, focusing on surveying the lakes and the area within 1 km of the lakes for breeding habitat use and availability and wetlands and uplands used during the non-breeding season. We began our telemetry studies at 2 lakes, and will continue this and the wetland lake surveys next spring-summer.

FUTURE PLANS

A second field season is planned for 2010, with thesis completion in May 2011.

Environmental Assessment of Circumneutral Fens with Shrubby Cinquefoil (*Dasiphora fruticosa*): Host Plant of the Endangered Clayton's Copper Butterfly (*Lycaena dorcas claytoni*)

Investigator: S.A. Drahovzal

Advisors: J.M. Rhymer, Co-chair
C. S. Loftin, Co-chair
F.A. Drummond
A.S. Reeve

*Cooperators/
Project Support:* University of Maine- Maine Agricultural and Forest Research Station
University of Maine – Department of Wildlife Ecology
Maine Department of Inland Fisheries and Wildlife
Maine Outdoor Heritage Fund
U.S. Fish and Wildlife Service
USGS – Maine Cooperative Fish and Wildlife Service

Objectives:

- 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 and between used and randomly selected plants in wetlands inhabited by Clayton's copper.

SCOPE

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 nine 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 and plants selected by *L. d. claytoni* for nectaring and egg-laying to randomly selected plants, 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?

PROJECT STATUS

Monitoring wells equipped with continuous water level recorders (Solinst Leveloader Gold) were installed at six sites inhabited by Clayton's copper butterfly and two uninhabited sites to determine vertical flow and water table fluctuations in each wetland during May-October 2009. Pore water samples were collected 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. Leaves from several plants at occupied and unoccupied sites were collected to compare chemical and water content as well as average leaf area. Nectar samples have been collected at one site to evaluate collection and analysis techniques. Leaf, peat, and nectar samples are currently being analyzed.

FUTURE PLANS

Preliminary data analysis is currently underway and future field based data collection and analyses will be guided by the results.

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

Investigators: M. Bailey
J. Zydlewski

*Cooperators/
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit
National Oceanic and Atmospheric Administration
University of Maine – Department of Wildlife Ecology

Objectives:

- 1) Assess the survival of hatchery origin Atlantic salmon smolts through the mainstem of the Penobscot River.
- 2) Describe the approach of Atlantic salmon smolts to Milford Dam.
- 3) Assess seawater willing performance of hatchery smolts stocked into the Penobscot River.
- 4) Develop Habitat Sustainability Index model for Alosines in the Penobscot River.

SCOPE

The proposed plan to remove the Veazie and Great Works dams on the Penobscot River (as part of the Penobscot River Restoration Project; PRRP) offers an unusual opportunity to examine the ecological and environmental changes surrounding a major river restoration in New England. Fish passage at the remaining dams, both upstream and downstream, is necessary for the completion of the life histories of many fishes. This proposed work is aimed at characterizing current passage conditions of Atlantic salmon and Alosine fishes.

PROJECT STATUS

The work proposed for this objective will replicate the approach used in a previous 2005-2006 study, collecting up to three additional years of smolt survival data. Greater emphasis will be placed on movements near Milford Dam. Acoustic receivers will be deployed through the Penobscot River as part of ongoing cooperative work with NOAA-Fisheries, Maine Cooperative Fish and Wildlife Research Unit and the University of Maine. In 2009, 2010, and 2011; hatchery smolts from the Green Lake National Fish Hatchery will be implanted with acoustic tags and released into the Penobscot River. Retrieval of receivers has allowed for estimation of survival and passage success in 2009.

Beginning in 2010, downstream movement of hatchery salmon will be monitored with active and passive radio telemetry, to characterize details of path choice and downstream passage success at the Milford dam site. Radio receivers will be installed at Milford Dam and up to one 100 hatchery smolts will be released into the Penobscot River upstream of the dam.

Osmoregulatory ability will be assessed after a forced swimming seawater challenge and the results compared with static seawater challenge data. All smolts being studied in objectives 1 and 2 also will be assessed for physiological status using gill sodium, potassium ATPase as an indirect indicator of performance. Work for 2009 has been completed and will be repeated in 2010.

We propose to assess the current status of data and models available to first determine the feasibility of HSI application in the Penobscot River. Contingent upon the successful outcome, HSI models will be applied to the Penobscot River to model the range of population outcomes for dam removal on Alosines

FUTURE PLANS

Completion of the project is anticipated in 2012.

The Role of Marine Derived Nutrients Delivered by Anadromous Fish in Eestoration of Freshwater Ecosystems in the Penobscot River Watershed, Maine

Investigators: M. Guyette

Advisors: C. Loftin, Co-chair

J. Zydlewski, Co-chair

William Haltemann

Jasmine Saros

Kevin Simon

Cooperators/ University of Maine

Project Support: USGS - Maine Cooperative Fish and Wildlife Research Unit
National Oceanic and Atmospheric Administration

Objectives:

- 1) Experimentally supplement marine derived nutrients to examine effects of increased nutrients on stream productivity and young Atlantic salmon growth and condition.
- 2) Characterizing historic contributions of marine derived nutrients with sediment cores.

SCOPE

The ecological role of prominent migratory fish species is a poorly characterized natural history in the Penobscot River. Manipulation of this river through habitat modification and impoundments has resulted in a greatly reduced exchange of nutrients between inland and marine waters. Considerable runs of anadromous fish (e.g., American shad, alewife, sea lamprey and Atlantic salmon) occurred in the Penobscot River prior to the construction of main-stem dams in the early 1800s. Fish populations declined precipitously after dams were installed. With the planned removal of two main-stem dams on the Penobscot River, there is great optimism that reestablishment of passage will lead to restoration of the ecosystem. In order to restore, however, it is necessary to understand how historical connectivity affected fish populations. The role of marine derived nutrients (MDN) is of interest as restoration of anadromous fish runs may depend, in part, on a continuous cycle of nutrient import from the ocean. The proposed study will probe the role of MDN in the Penobscot River watershed by studying exchange of nutrients in streams with implanted salmon fry, documenting how increased nutrients affect the productivity and quality of Atlantic salmon, and characterizing historic MDN incorporation in stream ecosystems.

PROJECT STATUS

Four streams that had historic salmon runs in the Penobscot watershed have been selected and characterized (stream invertebrates, water chemistry, algal biomass and composition, aquatic macrophytes, fish) in preparation for two years of manipulation beginning in 2009. Following initial characterization stream reaches were supplemented with marine derived nutrients delivered as anadromous fish analogs. Pre-treatment stable isotope signatures were collected from all trophic levels at all sites (i.e., algae, aquatic macroinvertebrates, fish). Ecological responses (e.g., changes in species richness, abundance, species composition) to nutrient enhancement will be tracked as well as changes in stable isotope ratios in the biota and environment. All streams have been stocked with Atlantic salmon fry (equal numbers into control and treatment sites) to assess juvenile salmon response (measured in growth/productivity as well as changes in tissue stable isotope ratios)

to presence and absence of nutrient enhancement. Individual applications of MDN will be enriched with stable isotope so that assimilation time for specific applications can be followed within and among seasons, and response (productivity measures, species composition and diversity) will be measured during and after the season MDN are delivered.

The ratios of naturally-occurring levels of carbon (^{13}C and ^{12}C) and nitrogen (^{15}N and ^{14}N) isotopes in biota are influenced by a number of factors including trophic level and environment. Marine systems generally have greater proportions of heavier isotopes. These “signatures” also are observed in anadromous fish that migrate between marine and freshwater environments. The relative movement of these nutrients can be assessed with stable isotopes by examining their uptake through the environment and trophic levels of aquatic ecosystems. These signatures should also be found in the accumulation of sediments. Sediment cores collected from selected lakes and ponds in the Penobscot River drainage afford a potential opportunity to assess the historic MDN contribution to sediment layers. These cores also provide opportunity to “ground truth” the approach. Before dams were installed during the past 200 years, many headwater streams in the Penobscot River drainage were reached by migrating fish, and small ponds connected to low-order streams were the migration terminus for some (e.g., alewives). Delivery of MDN to these systems during the past two centuries also has been impeded by dams. In recent decades some of these dams have been removed, and migrating alewives have been documented where previous runs had ceased. Such changes should be discernible in the core layers.

Concentrations of nitrogen and carbon stable isotopes will be measured in sediments accumulated prior to dam construction, during the period dams were in place, following dam removal, and recently to determine change over time. Zooplankton and algal remains will be extracted from the sediment cores, and used to both qualitatively and quantitatively characterize historic productivity of the systems. Twenty lakes have been identified using the criteria of 1) no historic or current fish 2) current and historic non anadromous fish only 3) current anadromous fish and 4) historical but not current anadromous fish. Coring was completed in April 2009.

FUTURE PLANS

Field work will continue through 2010. A Ph.D. dissertation is expected to be completed in 2012.

PIT Tag Monitoring of Adult Atlantic Salmon in the Penobscot River, Maine.

Investigator: E. Hughes

Advisors: J. Zydlewski, Chair

Cooperators/ NOAA – NMFS

Project Support: Penobscot River Restoration Trust

USGS - Maine Cooperative Fish and Wildlife Research Unit

Maine Department of Marine Resources

Objectives:

- 1) Determine the rate, timing and efficiency of upstream passage of Atlantic salmon through 9 major dams in the lower Penobscot River basin
- 2) Monitor the effects of the Penobscot River Restoration Project with respect to Atlantic salmon in accordance with the Operational Plan for the Restoration of Anadromous Fishes to the Penobscot River.

SCOPE

Dams have been identified as one of the most acute impediments to restoration of Atlantic salmon (*Salmo salar*) in the USA. While the Penobscot River watershed is Maine’s largest and hosts the largest remaining run of Atlantic salmon in the USA, all high quality spawning and rearing habitats are located upstream of at least four hydroelectric dams. Plans are currently underway to remove the two most downstream dams (Veazie and Great Works) as part of the Penobscot River Restoration Project. Ultimately, benefits of dam removal for Atlantic salmon restoration will depend in large part on the degree and fashion by which these dams currently affect salmon passage success and behavior. The objective of this project is to determine the rate, timing and efficiency of upstream passage of Atlantic salmon through 9 major dams in the lower Penobscot River basin including Veazie, Great Works, Milford, Howland, West Enfield, Mattaceunk, Brown’s Mill, Dover-Foxcroft, and Guilford. PIT tag antennas employing Destron Fearing full duplex PIT tag technology will be installed at the entrance and exit of the fish ways of these dams. PIT tagging of fish passed at the Veazie Dam will be a coordinated effort with Department of Marine Resources, (DMR). This work will incorporate and build on recent research that demonstrated migratory behavior and passage efficiency of Atlantic salmon in the Penobscot. The long term scope of this project will monitor the effects of the Penobscot River Restoration Project with respect to Atlantic salmon in accordance with the State

Operational Plan for the Restoration of Anadromous 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.

PROJECT STATUS

The project was initiated September 2009. Initial efforts have been aimed at 1) purchasing equipment for PIT array installation 2) coordination with facility owners and agency managers.

FUTURE PLANS

Installation of arrays will be completed by spring of 2010.

WILDLIFE RESOURCES

Population Trends of Marsh Birds of Management Concern in Maine

Investigator: J. Hayden

Advisors: F. A. Servello, Co-chair
C. S. Loftin, Co-chair
T. P. Hodgman
W. E. Glanz

*Cooperators/
Project Support:* University of Maine - Department of Wildlife Ecology
USGS - Maine Cooperative Fish and Wildlife Research Unit
Maine Department of Inland Fisheries and Wildlife
Maine Outdoor Heritage Fund

Objectives:

- 1) Determine long and short-term change in proportions of wetlands occupied by five species of breeding marsh birds in Maine.
- 2) Determine detection rates of least bitterns during call- response surveys.
- 3) Determine rates for major reproductive parameters of least bitterns in Maine including clutch size, hatchability, nest success, and chick survival to day 15.
- 4) Determine home range size of least bitterns in Maine.

SCOPE

Wetland marsh birds, such as rails and bitterns, generally are recognized as being among the least studied and understood avian groups because of their secretive nature. Over the last several decades, several species have been in apparent decline, but information on population trends is limited. Previous surveys for marsh birds performed in 73 wetlands during 1989-1990 and 125 wetlands during 1998-2001 provide an excellent opportunity to measure short and long-term changes in wetland occupancy for these species. In the present study I will be re-surveying previous sites to document temporal changes in wetland use by the Least Bittern (*Ixobrychus exilis*), Sora (*Porzana carolina*), Virginia Rail (*Rallus limicola*), American Bittern (*Botaurus lentiginosus*), and Pied-billed Grebe (*Podilymbus podiceps*) in Maine. The Least Bittern is of particular concern in Maine, because its numbers have declined in Maine recently.

PROJECT STATUS

Field work for the project was completed in late July of 2005 with a total of 75 sites being surveyed across southern, central and eastern Maine. Of these 75 sites, 37 had originally been surveyed in 1989-1990 and 38 sites had originally been surveyed in 1998-2000. Virginia Rail was the most frequently encountered species. Overall, wetland occupancy was greater for Virginia Rails and American Bitterns, and less for Least Bitterns than in earlier surveys. Wetland occupancy for Soras and Pied-Billed Grebes was similar between periods. Only seven individual Least Bitterns were detected in 2005-2006. These individuals were found in five separate wetlands and breeding pairs were observed at only one site. Detection probabilities were relatively high for each of the species.

Rainfall and temperature patterns did not differ substantially among survey periods, and these factors likely did not influence the occupancy trends that we observed. Habitat conditions had not changed substantially in sites previously occupied by Least Bitterns.

Preliminary analysis of data on habitat use suggests that Least Bittern presence was strongly associated with wetlands that had large areas of emergent vegetation along with some open water, whereas wetlands dominated by shrub vegetation were avoided. Least bitterns were not sensitive to wetland size. Pied-billed Grebes were strongly associated with large

wetlands dominated by open water with some emergent vegetation. The likelihood of a wetland supporting Pied-billed grebes increased greatly when total wetland area was >400 hectares and there was at least 20% open water. Soras and Virginia Rails were strongly associated with the availability of emergent vegetation, but Soras also nested in wetlands containing a large component of shrub vegetation, whereas Virginia Rails selected against wetlands dominated by shrub vegetation or open water. The presence of American Bitterns was strongly related to the area of shrub vegetation in wetlands.

Final analyses will focus on quantifying habitat thresholds values or other probability of occurrence relationships that will provide valuable information for assessing effects of environmental perturbations on these marsh birds.

FUTURE PLANS

Thesis preparation is nearly completed, and the project is expected to be finished early in 2010.

Monitoring Seabird Behavior on a Coastal Maine Island: Developing Methods to Better Understand Potential Effects of Marine Finfish Aquaculture on Seabird Breeding Colonies.

Investigator: M. Parsons

Advisors: F. A. Servello, Co-chair
C. S. Loftin, Co-chair
J. Sowles
J. Gilbert
W. Halteman

*Cooperators/
Project Support:* Maine Department of Marine Resources
USGS - Maine Cooperative Fish and Wildlife Research Unit
Maine Agricultural and Forest Experiment Station
University of Maine – Department of Wildlife Ecology
USFWS – Maine Coastal Islands National Wildlife Refuge
Maine Aquaculture Innovation Center

Objectives:

- 1) Document activity patterns and behavior during nesting and brood-rearing for selected seabird species to inform future studies about aquaculture-seabird interactions in Maine
- 2) Develop methods and techniques for monitoring selected seabird species to identify and document effects of aquaculture-related disturbance.

SCOPE:

There are no published studies of effects of aquaculture operations on seabird nesting islands in Maine or elsewhere. There is a relatively large body of literature on effects of human activities, specifically research and monitoring, on seabird behavior, however, these results are not directly applicable to aquaculture issues. Information on the “natural” patterns of variability in seabird behaviors are needed to develop study designs for determining effects of aquaculture operations in future studies. Traditional approaches using observers to study seabird behavior are not a good option because of logistical and funding constraints and need to minimize the confounding of effects of investigator and aquaculture disturbance. Remote monitoring tools (e.g., cameras, temperature sensors, movement monitoring) potentially provide a means to increase sample replicates while minimizing human-caused disturbance. Our study combines active observer and passive recording to document seabird activity on selected coastal islands during the nesting and brood-rearing periods.

We studied behaviors of four species of seabirds, Black Guillemots (*Cepphus grylle*), Common Eiders (*Somateria mollissima*), Herring Gulls (*Larus argentatus*) and Great Black-backed Gulls (*Larus marinus*) nesting on Jordan’s Delight Island, Washington Co., Maine. We used a combination of temperature loggers, time-lapse cameras, and motion activated cameras to measure nest attendance of gulls and eiders and colony attendance of guillemots and gulls. We also conducted over 200 hours of observations to evaluate the utility of the remote monitoring equipment for detecting disturbance events and documenting typical disturbance regimens for this island. We will quantify the behavioral responses to different types of disturbances to help predict how birds will react to aquaculture activity and make recommendations on effective monitoring methods for assessing effects of an aquaculture facility placed near a breeding island. We also are developing methods to automate counts of flying gulls captured on digital photographs to improve efficiency of camera based monitoring.

STATUS:

We have completed two field seasons of monitoring selected seabird species on Jordan's Delight Island. Data analysis is ongoing and will be completed by mid 2010.

FUTURE PLANS

A Master of Science thesis is expected to be completed in 2010.

Priority Sites for Chilean Wetlands Conservation

Investigator: P. A. Palacios

Advisors: M. L. Hunter Jr., Co-chair
A. J. K. Calhoun, Co-chair
C. Loftin
W. Krohn
J. Swenson

*Cooperators/
Project Support:* Fulbright
Centro de Ecología Aplicada and CONAMA (National Environment Commission)

Objectives:

- 1) Assess the vulnerability, condition and irreplaceability of Chilean wetlands remotely based on biological and physical information, and human demography.
- 2) Combine information about condition and vulnerability to identify those wetlands that should be targeted for conservation in three political regions that are representative of the major geographical areas of the country.
- 3) Compare the above results, by political region, to the more subjective process conducted by CONAMA.

SCOPE

The goal of my doctoral research is to identify priority areas for wetland conservation in Chile, using a Geographical Information System (GIS) as a tool to analyze threats and condition of these areas. Previously, priority areas for wetland conservation in Chile have been selected based solely on expert opinion. I will use GIS to combine layers of digital information about Chilean wetland types distribution with information about vulnerability and condition, to find areas that should be prioritized for wetland conservation in three political regions of Chile (one northern, one central and one southern). These maps will be systematically compared to the conservation priority area maps developed by the Chilean National Environment Commission, using expert opinion methodology.

PROJECT STATUS

Analyses are underway. The results of the classification for Chilean wetlands are published at the National System of Environmental Information website: http://www.sinia.cl/1292/articles-41115_recurso_1.pdf

FUTURE PLANS

Identify priority areas for wetland conservation.

An Investigation of the Maintenance of Eucalcemia in the Setting of Disuse and Anuria in Hibernating Black Bears

Investigators: Rita Seger, M.D.

Advisors: F. Servello, Co-chair
R. Causey, Co-chair
W. Halteman
W. Glanz
A. Bushway
C. Rosen
W. Jakubas

*Cooperators/
Project Support:* University of Maine - Ecology and Environmental Sciences Program
Maine Department of Inland Fisheries and Wildlife

- Objectives:*
- 1) Compare radiographs of bears obtained late in active season to those obtained during hibernation, to determine whether bears experience immobility-induced bone loss during hibernation.
 - 2) Compare serum markers of bone resorption and formation in black bears during hibernation and active season to determine the degree of bone turnover in hibernating bears.
 - 3) Evaluate effects of age, sex, body condition, lactation, parity, and genetics on bone turnover and bone mass in black bears.
 - 4) Measure hormones involved in calcium homeostasis and bone metabolism (vitamin D, PTH, calcitonin, IGF-I and leptin) in active and hibernating bears to elucidate patterns related to season, age, sex, and adiposity.
 - 5) Evaluate hypothetical mechanisms by which hibernating bears maintain normal serum calcium in the setting of immobility with absence of urination.
 - 6) Compare the above findings to human and laboratory animal models to elucidate unique features of calcium homeostasis and bone metabolism in black bears.

SCOPE

The ability to respond to mechanical strain is a fundamental property of bone, and maintenance of bone mass requires mechanical strain. Skeletal unloading results in prompt, extensive bone loss, with release of calcium into the bloodstream. Excess calcium must be eliminated in urine to avoid high serum calcium, with resultant physiological havoc. Hibernating black bears remain nearly immobile and go without urinating for several months, yet their serum calcium remains in the normal range. Therefore it appears that bears either possess the unique ability to avoid immobility-induced bone loss, or else they have a mechanism for reapplying bone mineral to the skeleton to prevent hypercalcemia. Relatively little is known about ursine bone metabolism.

This project will use radiographic and biochemical analyses to provide a picture of bone metabolism and calcium homeostasis in free-ranging black bears (*Ursus americanus*). The bears are trapped in the springtime and radiocollared by the Maine Department of Inland Fisheries and Wildlife, then subsequently handled in their winter dens. Radiographs also will be obtained from hunter-killed bears in autumn. The following list of analyses is initially planned on approximately 100 bears to construct a coherent picture of bone metabolism in this species: serum total calcium, phosphate, albumin, creatinine, osteocalcin, bone-specific alkaline phosphatase (BSAP), degradation products of C-terminal telopeptides of Type-I collagen (CTX), PTH, calcitonin, 25(OH) D, and calcitriol, IGF-I, and leptin. Radiographs of the forepaws will be obtained on approximately 140 bears. With this information it will be possible to evaluate five alternative hypothetical mechanisms that might explain the maintenance of normal serum calcium in hibernating bears. Elucidating the ursine mechanism of maintaining normal serum calcium the setting of immobility with absence of urination has potential to inform medical research into normal bone metabolism and to shed light on a variety of skeletal pathologies.

PROJECT STATUS

The project was completed December 2008. The abstract for the dissertation is as follows:

Mechanical strain is an essential anabolic stimulus for bone. Skeletal unloading causes rapid, marked bone loss. Hibernating bears uniquely avoid net bone loss, and maintain eucalcemia, during approximately six months of immobility and anuria. This study's first goal was to elucidate the mechanism by which the hibernating black bear (*Ursus americanus*) maintains eucalcemia, by developing a biochemical and radiographic picture of bone metabolism in active and hibernating, free-ranging, female black bears. Four alternative hypotheses were evaluated: High Turnover, Resorption Balance, Bone Metabolic Suppression, and Mechanostat Suppression. The second goal was to compare lactating and non-lactating, hibernating bears to understand how skeletal demands of milk production, effects of unloading, and the need to maintain eucalcemia, are balanced.

Bears were sampled from three areas in Maine, during spring and autumn active seasons and winter hibernation, 2005 through 2007. During spring and winter, serum markers of bone turnover and bone metabolic hormones were measured (16 to 50 bears per season), including: calcium corrected for albumin, phosphate, creatinine, the bone formation marker bone specific alkaline phosphatase (BSAP), bone resorption markers C-terminal telopeptide of type I collagen (CTX) and tartrate-resistant acid phosphatase (TRAcP), parathyroid hormone (PTH), insulin-like growth factor-I (IGF-I), leptin, 25-hydroxy vitamin D [25(OH)D], and calcitriol. Metacarpal cortical thickness, measured by digital x-ray radiogrammetry, was compared between autumn (60 bears) and winter (79 bears).

During hibernation, bone turnover was persistent, but suppressed. Cortical thickness was greater in autumn than winter in younger bears, but older bears showed no difference between seasons. The weight of evidence supports Mechanostat Suppression: the hibernating ursine skeleton may perceive that it is loaded, when it is unloaded. Leptin positively correlated with BSAP in non-lactating bears and with CTX in lactating bears. Sympathetic nervous system suppression associated with hibernation may prevent unloading-induced bone loss by counteracting leptin's catabolic effect in non-lactating bears. In lactating bears, bone resorption was greater, and PTH suppressed, compared to non-lactating bears. Calcitriol was produced despite anuria. Leptin and calcitriol may facilitate milk production. Correlations of 25(OH)D and calcitriol with bone turnover markers suggest that vitamin D may suppress bone resorption during hibernation.

Assessing the Diet of the American Black Bear (*Ursus Americanus*) In Maine Using Stable Isotope Analysis

Investigators: Rita Seger
F. Servello
W. Jakubas

*Cooperators/
Project Support:* University of Maine - Ecology and Environmental Sciences Program
Maine Department of Inland Fisheries and Wildlife

Objectives:

- 1) Measure stable isotopes of nitrogen, sulfur and carbon in plants (including specific black bear foods), herbivores, and black bears, to determine signatures for each trophic level.
- 2) Use the signature(s) of nitrogen \pm sulfur and/or carbon to assess the contribution of carnivory to the assimilated protein of Maine black bears.
- 3) Assess determinants of carnivory by comparing isotope signatures between age and sex classes, and between bears from three study areas in Maine that differ by types of available foods.
- 4) Compare nitrogen signatures across the course of hibernation to assess whether protein turnover during hibernation may change the nitrogen signature of red blood cells.

SCOPE

Black bears (*Ursus americanus*) are highly omnivorous. The historical range of the American black bear includes forested biomes across North America, encompassing a wide variety of food resources. The diet of black bears in Maine has not been thoroughly investigated, but is known to include greens, buds and catkins, hard and soft mast, invertebrates, neonatal ungulates, winter- and road-killed carcasses, human crops and garbage, and hunters' baits. In other parts of their range, black bear predation is an important source of mortality to neonatal ungulates. The significance of black bear predation on moose calves and deer fawns in Maine is unknown.

This project will use stable isotopes analysis to assess the contribution of carnivory to the assimilated protein of free-ranging black bears in Maine. The analysis will use blood clot that is available, collected in vacuum tubes with no additive, from bears radiocollared by the Maine Department of Inland Fisheries and Wildlife, and sampled by phlebotomy for a separate project in which the serum was used. Samples were collected during spring trapping season (mid-May through late June), and during winter denning (mid-January through late March), 2005-2007.

Findings will be compared between three study areas that differ in their moose and deer populations and in other available foods. Age and sex classes of bears will be compared, to evaluate the hypothesis that adult males are the most carnivorous black bears in Maine. The impact of hibernation on the 15-nitrogen signature will be assessed to determine whether analyses will require adjustment for hibernation.

PROJECT STATUS

We have determined the nitrogen stable isotope signature ($\delta^{15}\text{N}$) for a total of 126 blood clot samples from 96 individual black bears, with 31 of these bears sampled on more than one date. Data analyzed so far have indicated that Maine black bears have diets ranging from complete herbivory to substantial carnivory. Between our three study areas, bears differ in their degrees of carnivory. In one study area, we have analyzed enough samples to document positive correlations between body weight and carnivory among male bears in spring, and between age and carnivory among hibernating females.

FUTURE PLANS

We have recently received the latest batch of data, which we are still analyzing, including $\delta^{15}\text{N}$ values for samples obtained during winter 2009. These reflect the effect on bear diets of the harsh winter of 2008, during which Maine's deer population is believed to have been reduced.

Amphibian Communities Associated with Fishless Lake Environments in Maine

Investigators: A. Shearin

Advisors: C.S. Loftin, Co-chair
A. J. K. Calhoun, Co-chair
W. Glanz
W. Halteman
K. Simon

Project Support Maine Department of Inland Fisheries and Wildlife
University of Maine - Department of Wildlife Ecology
USGS - Maine Cooperative Fish and Wildlife Research Unit

Objectives:

- 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 effects of fishless lake, fish-containing lake, and vernal pool predators on survival of *Ambystoma maculatum* eggs and larvae.
- 4) Determine fitness of adult *Ambystoma maculatum* adults breeding in vernal pools, fishless lakes, and fish-containing lakes.

SCOPE

Lakes in Maine with natural and stocked fish populations support invertebrate communities that differ from those naturally without fish. The introduction of fish to historically fishless lakes also may affect the amphibian species that reside, breed, or feed in these water bodies. Introduced fish may affect amphibian species abundance and composition by changing food resources, eating the amphibians, eating aquatic insects that prey on amphibians, and by altering amphibian breeding and refuge sites. Amphibian species that are palatable to fish, for example, may be consumed by fish or may avoid fish by altering their movements in the landscape to locate alternative fishless sites. Lakes stocked with fish may become biological sinks for amphibian populations that continue to use the water bodies for egg-laying in spite of the presence of fish, resulting in their offspring, or the adults themselves, being consumed by fish. It is not clear whether there are mechanisms in naturally fishless lakes stocked with fish that allow amphibians to persist in these modified environments. Habitat characteristics such as structural complexity and egg laying sites as well as characteristics of eggs masses may affect breeding success in these permanent water bodies. Through this study, we hope to identify characteristics of *Ambystoma maculatum* (spotted salamander) egg masses occurring in fishless and fish-containing lakes and adjacent vernal pools and features of these habitats that make them suitable or unsuitable habitat for this species. Furthermore, we will determine if amphibian community composition differs among fishless and fish-containing lakes.

PROJECT STATUS

Fishless and fish-containing lake pairs in Downeast Maine were surveyed for amphibian occurrence with audio, visual, and trapping surveys in 2007 and 2008. Associated vernal pools were surveyed in 2008 and 2009. Adult *A. maculatum* fitness characteristics were measured in spring 2009. Field and lab experiments examining the effects of fish and invertebrate predators on *A. maculatum* egg masses and larvae were completed in summer 2009. Vegetation and substrate surveys for all lakes and vernal pools were completed in summer 2009.

FUTURE PLANS

Data analysis and synthesis is currently underway with the dissertation expected to be completed in December 2011.

Considering Water Quality and Mercury Effects on Amphibians In Vernal Pools: A Pilot Study In Acadia National Park, Maine

Investigators: C.S. Loftin
A.K. Calhoun
S.J. Nelson

K. Simon
A. Elskus

Project Support Maine Department of Inland Fisheries and Wildlife
University of Maine - Department of Wildlife Ecology
USGS - Maine Cooperative Fish and Wildlife Research Unit

Objectives:

- 1) Describe the water chemistry of short-hydroperiod amphibian breeding pools.
- 2) Characterize relationships among vernal pool chemical and physical environments (e.g., pool substrate, forest cover type, size, hydroperiod).
- 3) Document the presence and bioaccumulation of Hg in vernal pool food webs.
- 4) Identify relationships between the vernal pool chemical environment and amphibian developmental condition.

SCOPE:

Vernal pools are a unique wetland type at tremendous risk due to habitat degradation and loss, a situation that has triggered recent legislation in Maine aimed at vernal pool conservation. Vernal pools host a diversity of biota (e.g., wood frogs [*Rana sylvatica*], ambystomatid salamanders [*Ambystoma spp.*], fairy shrimp [*Eubranchipus spp.*]) adapted to larval development in temporary waters, but these wetlands are endangered by a subtle threat to their function: non-point source pollution. Our study examines one such potential “invisible” risk in Acadia National Park (ANP), Maine: the role of mercury (Hg) in the broader context of vernal pool water chemistry and its effects on amphibian larval development. Our overarching goal is to understand the vernal pool chemical environment, the transport of Hg through vernal pool biota, the linkages between food web structure and Hg concentration in biota, and the potential toxicity of Hg to amphibians in vernal pools of the northeastern U.S. where atmospheric deposition of Hg is a well-documented phenomenon. We will characterize the chemical environment (including Hg) of short-hydroperiod vernal pools in ANP, including potentially large Hg contributions from snow and seasonal snow melt. Changes in Hg concentrations in the water, leaf litter, biofilm, sediment, and developing embryos and larvae will be determined over time. Developmental abnormalities in amphibian embryos and larvae and time-to-metamorphosis will be related to vernal pool chemistry. This exploratory research project will contribute to our knowledge about relationships between chemistry and biology in pool environments and will lead to refined hypotheses for future studies about potential synergistic interactions of the vernal pool chemical environment. This information could be applied to regions outside the Park to aid in conservation of pools with risks of chemical pollution due to physical setting or pool chemistry.

STATUS:

Water, sediment, litter, and biota were sampled from snow melt to dry-up in four vernal pools at Acadia National Park during spring-early summer 2008. Sample and data analysis are complete. Manuscript preparation is underway.

FUTURE PLANS:

This study provides baseline and preliminary data for a more comprehensive study for a future proposal.

Breeding and Terrestrial Habitat Requirements of the Eastern Spadefoot (*Scaphiopus Holbrookii*) and Pure-Diploid Blue-Spotted Salamander (*Ambystoma Laterale*) in Eastern Connecticut

Investigators: Kevin J. Ryan

Advisor: A.J.K. Calhoun

Committee: M.W. Klemens
J. Zydlewski
B. Timm

Project Support: Lowe’s Home Centers, Inc.

Objectives:

- 1) Document terrestrial habitat movements of adult eastern spadefoot toads and blue-spotted salamanders to and from breeding wetlands.
- 2) Document breeding philopatry.
- 3) Identify movement patterns of adults/juveniles to and from breeding wetlands (immigration and emigration orientation).

- 4) Quantify juvenile recruitment.
- 5) Document non-breeding habitat use and home-range size of both juveniles and adults.
- 6) Estimate breeding population size.
- 7) Describe eastern spadefoot burrowing ecology.

SCOPE

The research will provide valuable information on two New York and Connecticut State-listed species, the eastern spadefoot (*Scaphiopus holbrookii*) (Special Concern and Endangered, respectively) and the pure-diploid blue-spotted salamander (*Ambystoma laterale*) (Special Concern and Threatened, respectively). 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.

A review of the literature on spadefoots yielded numerous publications on the species dating back to the late-1800s. Most early accounts document their characteristic explosive breeding events which are now known not to occur on a rhythmic, annual basis. These early accounts also characterized the curious fossorial nature of these animals as well as the amazingly rapid development of their tadpoles. A small number of papers in the 1940s and 50s began to take a closer look at spadefoots the most comprehensive being written by Pearson (1955). Since Pearson, numerous papers have been published regarding various aspects of spadefoot life history, however the majority of studies on the eastern spadefoot (the only spadefoot species east of the Mississippi River) have been based in the South, where the animals are much more commonly encountered than in more northern latitudes; few, if any, studies have focused on northern populations. In New England, eastern spadefoot populations are particularly localized, usually being found at scattered sites in river valleys at elevations below 200 feet. These types of habitats also are preferred sites for human habitation, and many of these already localized populations have been extirpated due to urban/suburban development.

Data on eastern spadefoot ecology are sparse, and considerably less exist on the blue-spotted salamander, especially the rarer pure-diploid populations. The vast majority of published material pertains to the hybridization of the blue-spotted salamander with its close relative, the Jefferson salamander (*Ambystoma jeffersonianum*), which produces populations consisting of a wide array of genetic combinations (up to genetic pentaploids). These populations consist almost entirely of females, which are capable of reproducing gynogenetically (sperm fertilizes an ovum, but does not contribute genetic material). In southern New England, hybrid populations are far more abundant than populations of genetically-pure parental species. Previous studies working with either “bluespots” or “Jeffersons” recognize that hybrids exist, however make no attempt to describe their ecology based on the actual genetic makeup of the populations. Karyotyping previously conducted by Klemens indicate that the populations of blue-spotted salamanders at our project sites in eastern CT are genetically-pure. We know of no published information on the ecology and terrestrial habitat needs of blue spotted-salamanders, an important vernal pool species throughout New England and Atlantic Canada. Data on its non-breeding habitat are directly applicable to management of vernal pool habitats to ensure long-term viability of pool-breeding species.

PROJECT STATUS

For this project there are two study sites (“Lowe’s” and “Shinkiewicz”). During spring, summer and fall of 2008 we installed 410 pit-fall traps (connected by just over two kilometers of silt fence) at the Shinkiewicz site in a fashion that compartmentalizes the different habitat types present, allowing us to inventory amphibian species present, their breeding population sizes, and their movement patterns. Pit-fall traps were repaired, modified, and reinstalled at the Lowe’s site. Trap installation began after the onset of amphibian migration, therefore the first field season served as a pilot investigation to collect preliminary pit-fall trapping data and test data collection methods to be used during the following field season (2009).

2009 served as the first full season of data collection. The 410 individual pitfall traps at the Shinkiewicz site have been in operation since late February; the 127 traps at the Lowe’s site have been in operation since mid-May. Pitfall traps are scheduled to be closed just after hibernation in November. All breeding blue-spotted salamanders captured exiting breeding wetlands at the Shinkiewicz site (n=239) were implanted with Passive Integrated Transponders (PIT tags). Ten of these salamanders were implanted with radio-transmitters and subsequently tracked. A total of six eastern spadefoots at the Shinkiewicz site and ten at the Lowe’s site were implanted with radio-transmitters and subsequently tracked. Pit-fall trapping at both sites was supplemented by nocturnal searches during rain events on the roads surrounding and on the grounds of the field sites.

FUTURE PLANS

Additional data collection will continue in the spring, fall of 2010. The project is scheduled to be completed in 2012.

Wild Turkey Crop Depredation on Wild Blueberry Fields in Maine

- Investigators:* J. A. Huebner
- Advisor:* F. A. Servello, Co-chair
D. E. Yarborough, Co-chair
F. A. Drummond
- Cooperators/ Project Support:* University of Maine – Department of Plant, Soil, and Environmental Sciences. Wild Blueberry Commission of Maine
Maine Department of Inland Fisheries and Wildlife
- Objectives:*
- 1) Determine the attitudes and beliefs of Maine's commercial wild blueberry growers concerning wild turkey and wildlife use and damage levels on blueberry farms.
 - 2) Determine the diet of wild turkeys while feeding on blueberry farms.
 - 3) Determine wild turkey behaviors and use of blueberry farms.
 - 4) Estimate rates of blueberry crop loss from wildlife and species responsible for blueberry damage.

SCOPE:

A highly successful reintroduction program has restored wild turkeys (*Melagris gallopavo*) to Maine in large numbers and the population continues to increase and expand into northern and eastern regions of the state. While Maine state government and hunters support an increasing population, agricultural producers have expressed concerns about crop damage. Wild blueberry (*Vaccinium angustifolium*) growers in particular complain that wild turkeys are commonly on their farms and cause significant crop damage. Growers report that wild turkeys eat berries, knock berries off stems as they walk through fields, and damage plants when they scratch in search of food. The wild turkey's conspicuous and gregarious diurnal behavior makes them highly visible, which often results in farmers attributing crop damage from other wildlife species to wild turkeys. Studies of wild turkey damage to corn, oats, and soybeans have found minimal to no damage and in general problems are often less severe than. Impacts of wild turkeys on wild blueberry agriculture have not been studied. Studies of bird damage on wild blueberry farms in Maine and New Hampshire pre-dated wild turkey reintroductions. Additionally, recent interest in wild turkey introductions into neighboring Atlantic Canada provinces have raised similar concerns by the wild blueberry industry in that region. Wild blueberries are a unique agrosystem and commercially important to Maine and Atlantic Canadian providences. With over 66,600 ha in wild blueberry management, Maine and Canada produced over 246 million pounds of blueberries in 2008. Under conventional practices, blueberry farms are managed in a 2-year cycle of pruning that yields berries in alternate years. Many farms contain acres in both management cycles, and field types have similar vegetative structure with the prune field lacking the obvious berry food source. Growers indicate wild turkeys utilize both field types and during seasons in which berries are not ripe. Blueberry farm management methods and topography characteristics create few visual obstructions providing excellent opportunities for viewing wild turkeys. The goal of this study was to understand the effect wild turkey foraging and activity on wild blueberry farms.

PROJECT STATUS:

Seven wild blueberry farms in Knox County, Maine, were studied from mid-May through July in 2008 and 2009. Measures of wild turkey activity included documenting wild blueberry field type and season use, and studying behavior with an activity budget. Wild turkey diet was assessed with observational methods and fecal sample analysis. Estimates of total crop loss were determined with an enclosure study. Other wildlife activity on blueberry farms was monitored during surveys and with remote trail cameras. Wild turkeys used wild blueberry farms more in the season prior to blueberry ripening and used field types in similar proportions. Wild turkeys spent approximately 10 – 30% of their time in feeding behaviors on wild blueberry farms, with differences detected between seasons, field type, site, and year. Other important behaviors included searching for food and comfort. In the season prior to blueberries ripening, the wild turkey diet consisted mostly of weedy vegetation. When blueberries were ripe, the diet consisted of blueberries and weedy vegetation. Results of the enclosure experiment indicated that blueberry loss was similar on treatment plots that allowed and prevented access by wildlife. Deer and wild turkeys were most commonly observed on wild blueberry farms. Results of this study will be used to estimate total wild blueberry crop loss from wild turkeys.

FUTURE PLANS:

A Master of Science thesis is expected to be completed in December 2009.

Genetic Structure of Clayton's Copper Butterfly (*Lycaena dorcas claytoni*) Metapopulation and Analysis of Butterfly-Host Plant Attraction

Investigator: C.L. Michaud

Advisors: J.M. Rhymer, Chair
F.A. Drummond
C.S. Loftin
W. Halteman
M.T. Kinnison

*Cooperators/
Project Support:* Maine Outdoor Heritage Fund
Maine Department of Inland Fisheries and Wildlife
U.S. Fish and Wildlife Service
The Nature Conservancy
American Philosophical Society

Objectives:

- 1) Analyze genetic structure of Clayton's copper butterfly populations with nuclear DNA loci [microsatellites and single nucleotide polymorphisms (SNPs)].
- 2) Compare frequencies of genotypes among individuals in Clayton's copper populations for a locus [phosphoglucose isomerase (PGI)] linked to dispersal probability.
- 3) Combine genetic data with GIS analysis to study landscape ecology and metapopulation structure of Clayton's copper butterfly.
- 4) Gather basic behavioral and developmental data to better understand general life history and developmental requirements of Clayton's copper.
- 5) Identify volatile organic compounds present in cinquefoil leaves from habited and uninhabited sites, and analyze data for potential links between specific compounds and Clayton's copper presence and larval activity.

SCOPE

Clayton's copper butterfly (*Lycaena dorcas claytoni* Brower) was identified and described as a subspecies of Dorcas copper (*L. d. dorcas*) at 11 sites in Maine in 1940. It was listed as endangered in Maine in 1997, based on its restricted range, current presence at only 8 sites statewide, abundance at only 1-2 sites, and its occurrence in an uncommon habitat type (circumneutral fens with its host plant shrubby cinquefoil, *Dasiphora fruticosa*). Although additional apparently suitable habitat is available, Clayton's copper's distribution is restricted to certain cinquefoil patches. In order to manage populations of this rare invertebrate, more information must be gathered concerning population structure, dispersal patterns among sites, and habitat requirements.

Microsatellite and single nucleotide polymorphism DNA analyses will be used to measure genetic diversity within the metapopulation, and estimates of relatedness and dispersal among subpopulations will be calculated. An understanding of what constitutes optimum host plant conditions also will be gained by attempting to correlate larval and adult behavior with host plant characteristics and chemistry.

By combining population and landscape genetics and host plant chemistry, results of this study will elucidate patterns of diversity and dispersal among Clayton's copper populations in Maine, as well as identify potential chemical components of suitable Clayton's copper habitat. Information on diversity and dispersal behavior will aid managers in determining which populations are most robust, which populations are greatly related, and which populations are most unique. Insight into what constitutes suitable host plant conditions will aid in habitat management. Such information is paramount to maintaining current sites and ensuring longevity of this native butterfly population in Maine.

PROJECT STATUS

Using a library of 158 Clayton's copper DNA samples collected in 2007 and 2008, 12 microsatellite loci currently are being selected and optimized to assay diversity of the metapopulation. In addition, an assay for SNPs in the PGI gene is being developed to assess allelic genetic variation and potential links to dispersal behavior. In summer of 2009, 162 additional *L. d. claytoni* samples were collected across six sites to increase sample sizes and allow for analyses of spatial and temporal genetic trends in Clayton's copper populations. Larval and adult behaviors were observed in the field, and shrubs with feeding or ovipositioning activity were flagged for future studies. Temperature loggers were placed on shrubs

where larvae were observed, to measure ground and air temperatures throughout larval feeding, pupation, and the adult flight season. Twenty-three larvae were collected from Dwinal Wildlife Management Area (WMA) for laboratory rearing, observation of development, and collection of eggs for establishment of a lab colony.

FUTURE PLANS

Genetic and metapopulation structure analyses of Clayton's copper butterflies among sites will continue. Landscape genetics will be used to correlate genetic trends with geographic features and dispersal patterns. A laboratory colony of Clayton's copper butterflies will be established from eggs collected in 2009 to observe developmental rates, and for feeding and oviposition preference experiments. These data will be compared to field data on the population at Dwinal WMA.

Spatial Responses of Canada Lynx to Changing Hare Densities

Investigator: David Mallett

Advisors: A.K. Fuller Co-chair
D.J. Harrison Co-chair
R.S. Seymour
J.H. Vashon

*Cooperators/
Project Support:* University of Maine – McIntire-Stennis
Maine Cooperative Forestry Research Unit
University of Maine – Department of Wildlife Ecology
Maine Department of Inland Fisheries and Wildlife

Objective:

- 1) To evaluate if habitat choices by lynx are different at low vs. high hare densities.
- 2) To evaluate how changing hare densities affect spatial requirements and extent of spatial overlap among adjacent lynx.
- 3) To understand how variability and distribution of conifer stem density within a stand influences snowshoe hare density at the stand-scale and the distribution of hare pellets within stands.

SCOPE

Canada lynx (*Lynx canadensis*) have been listed as federally threatened under the Endangered Species Act since 2000. In response to this listing there has been increased interest in conducting research on lynx and their primary prey species, the snowshoe hare (*Lepus americanus*). Lynx and hares are linked in their population dynamics, survival, and habitat requirements. Lynx are a specialist predator of the snowshoe hare and their population cycle closely lags the snowshoe hare population cycle. Changes or fluctuations in the hare cycle will influence lynx behavior and ecology. 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 within boreal forests where hares exhibit much more widely fluctuating dynamics than have been documented within the Acadian forest region.

The largest population of lynx in the contiguous U.S. occurs in Maine. One of the largest factors influencing the type and amount of habitat available for both hares and lynx is timber harvesting. Prior to the Maine Forest Practices Act in 1989, clearcuts were the dominant form of timber harvest. These clearcuts produced regenerating conifer forests that have been shown to support the greatest densities of hares in Maine. However, partial harvests have become the dominant form of timber harvesting in recent years, thus reducing the number of regenerating conifer forests that provide high quality hare habitat. This reduction in the amount of high quality hare habitat could either cause or contribute to lower hare density, which could negatively influence the future population of lynx in Maine.

This project is contributing to long term investigations conducted by the University of Maine and the Maine Department of Inland Fisheries and Wildlife (MDIFW) focusing on lynx spatial ecology and lynx and hare habitat relationships. Previous research has focused on lynx spatial ecology during a period of high hare density, as well as the influence of timber harvesting and other changes in vegetation structure on snowshoe hare habitat. This study will focus on how a declining hare density will influence lynx spatial ecology by comparing habitat selection, home range composition, overlap of home ranges, and recruitment between and high and declining hare density. Additionally, it will focus on snowshoe hare habitat at the stand and within stand level by relating how conifer stem density influences snowshoe hare density.

PROJECT STATUS

To continue to monitor hare density, biannual fecal pellets counts have been conducted in stands representing two types of timber harvests, including regenerating conifer clearcuts (since 2001) and in partially harvested stands (since 2005), as well as in two types of mature softwood-dominated and deciduous-dominated forest habitat (since 2008). In an effort to study lynx in Maine the MDIFW has been trapping lynx since 1999 as part of a long term monitoring project. Trapping efforts are conducted during both late summer/early fall and again in the winter to either capture new lynx to deploy radiocollars or to recapture lynx to deploy new collars. Both VHF and GPS radiocollars have been deployed on lynx to obtain location points which will be used to construct home ranges and to determine habitat selection. Another aspect of the MDIFW effort involves locating dens of females with kittens in June, as well as backtracking females in the winter to determine the presence and number of kittens.

FUTURE PLANS

I will continue to count hare fecal pellets during the spring and fall of 2010. Field work was started during the summer and fall of 2009 to determine error associated with the GPS collars that are deployed on lynx. Location error and fix success are two factors being tested during a leaf on season (summer and fall 2009) and a leaf off season (late fall and winter 2009/2010) for these collars. I will also assist with the winter lynx trapping efforts, as well as backtracking of females to determine presence of kittens during the winter of 2010. The winter of 2010 will be the last trapping effort of the MDIFW and collars will be collected from lynx by trapping or picking them up after automatic drop off in March 2010. Data analysis and writing for the thesis will be conducted during summer and fall of 2010.

PUBLICATIONS, THESES AND DISSERTATIONS, PROFESSIONAL AND PUBLIC PRESENTATIONS, AND AWARDS

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- Jackson, C.A. L, 2009. Fishing, water regulation and competition; the past, present and future of brook trout in the Rapid River, Maine, M.S. Thesis, University of Maine, Orono. 88 pp.
- Seger, R.L, M.D., 2008. Elucidating the mechanism for maintaining eucalcemia despite immobility and anuria in the hibernating black bear (*Ursus americanus*). Ph.D. Dissertation, University of Maine, Orono. 95pp.
- Simons, E.M. 2009. Influence of past and future forest management on the spatiotemporal dynamics of habitat supply for Canada lynx and American martens in northern Maine. Ph.D. Dissertation, University of Maine, Orono. 229 pp.
- Spencer, R. C 2009. Migratory urge and gill Na⁺, K⁺ -ATPase activity of hatchery reared Atlantic salmon smolts from Dennys and Penobscot River stocks, Maine, and review of enhancement programs. M.S. Thesis, University of Maine, Orono. 85pp.

Professional Talks Presented

- Beaudry, F., P. DeMaynadier, and M. Hunter. Using Temporally Explicit Population Viability Simulations to Identify Hot Moments in Road Mortality Risk for Blanding's Turtles. Presented at the Northeast Transportation and Wildlife Conference, Meredith, NH. September 25, 2008.
- Blomquist, S.M.. Forest management alters multi-scale habitat selection and breeding success of *Rana sylvatica*. Joint Meeting of the American Society of Ichthyologists and Herpetologists, American Elasmobranch Society, the Herpetologists' League, and the Society for the Study of Amphibians and Reptiles. Montreal, Quebec, Canada. Received the American Society of Ichthyologists and Herpetologists Frederick H. Stoye Award for the best paper on a conservation theme.
- Drahovzal, S. Environmental assessment of circumneutral fens with shrubby cinquefoil: host plant of the endangered Clayton's copper butterfly. Department of Wildlife Ecology MS research proposal seminar. Orono, Maine. May 2009.
- Fuller, and E. M. Simons. Variation in snowshoe hare densities as related to Canada lynx and forest management in eastern north america. Eastern Canada/U.S.A. Forest Science Conference, University of Maine, Orono. (Published on the web site of the Maine Cooperative Forestry Research Unit, University of Maine). October 17, 2008.
- Fuller, A. K., D. J. Harrison, B. K. Hearn, and J. A. Hepinstall. Spatial responses to habitat loss in 2 populations of forest martens. Paper presented at The Wildlife Society 15th Annual Conference, Miami, Florida. November 11, 2008.
- Fuller, A. K., D. J. Harrison, and W. B. Krohn. Applications of lynx and marten models to operational forest management. Invited presentation at Lynx on the landscape: workshop and fall field tour, Cooperative Forestry Research Unit, Greenville, Maine. October 8, 2008.
- Fuller, A. K., D. J. Harrison, and W. B. Krohn. Landscape planning on The Nature Conservancy lands in northern Maine. Invited presentation to executive director and regional staff of The Nature Conservancy, Brunswick, Maine. February 24, 2009.
- Fuller, A. K. Responses of forest mammals to landscape composition and configuration. Invited seminar presented to the Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, Vermont. June 4, 2009.
- Fuller, A. K. Multi-scale responses of forest mammals to human-induced landscape changes. Invited seminar presented to the Department of Natural Resources, Cornell University, Ithaca, New York. June 17, 2009.
- Gilbert, J. Regional Harbor Seals in the Gulf of Maine. Gulf of Maine Seals - populations, problems, and, priorities. Woodshole, MA. May 28, 2009.

- Gilbert, J., S. Wood, T. Frasier, B. McLeod, B. White, D. Bowen, M. Hammill, G. Waring, and S. Brault. Regional U.S. Gray Seal Recolonization: Status and Stock Structure Gulf of Maine Seals - populations, problems and priorities. Woodhole, MA. May 28, 2009
- Gilbert, J., M., Nelson. Regional Interactions between harbor seals and Atlantic salmon Aquaculture in Maine. Gulf of Maine Seals - populations, problems, and priorities. Woodhole, MA. May 28, 2009
- Guyette, M., C. Loftin, J. Zydlewski. The role of marine derived nutrients delivered by anadromous fish in freshwater ecosystems within the Penobscot River watershed, Maine. Presented by M. Guyette at the Bureau of Sea-run Fisheries and Habitat Monthly Meeting, Bangor, Maine. February 9, 2009.
- Guyette, M., C. Loftin, J. Zydlewski. The role of marine derived nutrients delivered by anadromous fish in freshwater ecosystems within the Penobscot River watershed. Presented by M. Guyette, Maine Chapter of The Wildlife Society, Spring Meeting, Brewer, Maine. April 22, 2009.
- Guyette, M., C. Loftin, J. Zydlewski, and J. Saros. Historical records of anadromous fish runs from sediment cores in Penobscot River watershed lakes, Maine. American Fisheries Society Annual Meeting, Nashville, TN. Poster. Guyette presented. August 31, 2009.
- Harrison, D. J., A. K. Fuller, J. A. Hepinstall, and E. Simons. Forests, forest carnivores, and fragmentation: Wildlife-habitat relationships in the Acadian forests of Maine, USA. Invited seminar, Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences, As, Norway. September 19, 2008.
- Harrison, D. J., A. K. Fuller, J. A. Hepinstall, E. Simons, B. J. Hearn, and D. Payer. Forests, forestry, and forest martens: a landscape perspective. Invited presentation at conference titled: Pour une sylviculture adaptee a al feret irreguliere et sa faune, Faculty of Forestry, University of Laval, Baie Comeau, Quebec. October 8, 2008.
- Harrison, D. J. Forestry and Forest Wildlife, Chaired session at New England Society of American Foresters 89th Winter Meeting, Portland, Maine. March 19, 2009.
- Harrison, D. J., W. Patterson and A. K. Fuller. Field tour of the Nature Conservancy St. John ownership: silvicultural prescriptions for maintaining marten and lynx habitat requirements for Nature Conservancy staff, US Fish and Wildlife Service, Huber Resources Group. May 4-6, 2009.
- Harrison, D. J., W. B. Krohn, and E. M. Simons. Past and future trends in habitat supply for forest carnivores in northern Maine: implications for forest policy. Invited presentation to leadership of Maine Forest Service, Maine Department of Inland Fisheries and Wildlife and Maine Natural Areas Program, Augusta, Maine. June 30, 2009.
- Harrison, D. J., A. K. Fuller, J. A. Hepinstall, and E. Simons. Forests carnivores as a tool for landscape conservation: Case studies focusing on American martens and Canada lynx. Seminar presented at Grimso Wildlife Research Station, Lindesberg, Sweden. September 19, 2009.
- Huebner, J. A. Wild turkey behavior and crop depredation in wild blueberry agrosystems in Maine. University of Maine Cooperative Extension. Waldoboro, Ellsworth, and Machias, Maine. March 18 – 21, 2009.
- Huebner, J. A. Wild turkey behavior and crop depredation in wild blueberry agrosystems in Maine. Maine Chapter of the Wildlife Society. Brewer, Maine. April 22, 2009.
- Hunter, M.L. Should we actively assist species to shift their geographic ranges in response to climate change. The Wildlife Society, Augusta, Maine. January 15, 2009.
- Hunter, M.L. Climate change and maintaining biodiversity: a six-step plan. The Wildlife Society, Augusta, Maine. January 15, 2009.
- Hunter, M.L. Of toadstools and trees: principles of managing forest biodiversity. Kennebec Land Trust Lycaeam. April 2, 2009.
- Hunter, M.L., Jr., and A.J.K. Calhoun. 2009. Symposium. Advice on attending a professional meeting. *Society for Conservation Biology Annual Meeting*, Beijing, China. July 12, 2009.
- Krohn W. B., D. J. Harrison, S. A. Scott, L. L. Robinson, C. L. Hoving, A. K. Fuller, and E. M. Simons. Variation in snowshoe hare densities as related to Canada lynx and forest management in eastern North America. Presentation at Eastern CANUSA Forest Science Conference, Orono, Maine. October 1, 2008.
- Krohn, W. B. Distributional dynamics of Martes in eastern North America: spatiotemporal analyses of historical patterns, 1699-2001. Invited presentation (and abstract) at the 5th International Martes Symposium, University of Washington, Seattle, Washington. September 9, 2009.

- Michaud, C. Genetic structure of Clayton's copper butterfly metapopulation and chemical analysis of butterfly-host plant attraction. Department of Wildlife Ecology PhD research proposal seminar. Orono, Maine. May 2009.
- Nelson, S.J., C.S. Loftin, A. Calhoun, A. Elskus, K. Simon, P. Vaux. Growing up in the wrong neighborhood? Mercury in vernal pool amphibians at Acadia National Park. Northeast Regional Air Quality Committee Meeting (NERAQC), Winter Harbor, ME, Sept. 24, 2008.
- Parsons, M., C.S. Loftin, F. Servello. Monitoring Seabird Behavior on a Coastal Maine Island: Developing methods to better understand potential effects of marine finfish aquaculture on seabird breeding colonies. Presentation to the State Chapter of The Wildlife Society, Brewer, ME. 22 April 2009.
- Parsons, M., C.S. Loftin, and F. Servello. Assessment of disturbance responses by nesting seabirds on a coastal island in Maine, Gulf of Maine Seabird Working Group, Biddeford, ME. Parsons presented. August 12, 2009.
- Politi, N., M. Hunter, Jr. L. Rivera, Dinámica de los árboles con huecos: implicancias de manejo para la conservación de aves que nidifican en huecos. XIII Reunión Argentina de Ornitología. Tafi del Valle, Argentina. June 11, 2009.
- Popescu, D. V., D. A. Patrick. Multi-scale habitat-resistance models for predicting road mortality "hotspots for reptiles and amphibians. International Conference on Ecology and Transportation. Duluth, Minnesota, September 13-17, 2009.
- Schilling, E.G., C.S. Loftin, and A.D. Huryn. Effects of introduced fish on macroinvertebrate communities in historically fishless headwater and kettle lakes. Maine Inland Fisheries and Wildlife, Wildlife Division Meeting, Bangor ME. 20 November 2008. Invited. Schilling presented.
- Scott, S. A, D.J. Harrison, and W. B. Krohn. The relative effects of forest practices and natural population processes on the temporal dynamics of hare populations in northern Maine. New England Society of American Foresters 89th Winter Meeting. Bio: Mass, Fuel, Products, Diversity - Resource Management in a Changing World. Portland, Maine. March 19, 2009.
- Scott, S. A., D. J. Harrison, and W. B. Krohn. The relative effects of forest practices and natural population processes on the temporal dynamics of snowshoe hare populations in northern Maine. Invited presentation at special wildlife/forestry session of Bio: Mass, Fuel, Products, Diversity: Resource Management in a Changing World, a joint conference of the Northeast Section of the Society of American Foresters and the Maine Chapter of The Wildlife Society. Portland, Maine. March 19, 2009.
- Scott, S.A., D.J. Harrison, and W.B. Krohn. Spatio-temporal dynamics of snowshoe hares in northern Maine. Presentation to Maine Cooperative Forestry Research Unit, Orono, Maine. April 15, 2009.
- Scott, S. A., D. J. Harrison, and W. B. Krohn. Spatio-temporal dynamics of snowshoe hares in northern Maine. Paper presented at Northeast Fish and Wildlife Conference, Lancaster, Pennsylvania. April 15, 2009.
- Seger, R.L. A black bear model of skeletal unloading. Invited presentation at the 14th Annual Maine State Symposium on Osteoporosis, Sugarloaf USA, Maine. February 1, 2009.
- Seger, R.L., R.A. Cross, C.J. Rosen, R.C. Causey, C.M. Gundberg, T.O. Carpenter, T.C. Chen, W.A. Halteman, K. Henriksen, M.F. Holick, W.J. Jakubas, D.H. Keisler, R.M. Seger, and F.A. Servello. 2008. Maintaining eucalcemia despite prolonged immobility and anuria in the hibernating black bear (*Ursus americanus*). Poster presentation (and published abstract, listed above) at the 38th Meeting of the International Sun Valley Workshop on Skeletal Tissue Biology, Sun Valley, Idaho. August 3-6, 2008.
- Seger, R.L., R.A. Cross, C.J. Rosen, D.H. Keisler, R.C. Causey, C.M. Gundberg, W.J. Jakubas, R.M. Seger, and F.A. Servello. Leptin may be important in the unique skeletal metabolism of ursine hibernation. Poster presentation at the American Society of Bone and Mineral Research conference, New Frontiers in Skeletal Research: Bone, Fat and Brain Connections, Bethesda, Maryland. April 27-28, 2009.
- Seger, R.L., R.A. Cross, F.A. Servello, T.O. Carpenter, M.F. Holick, T.C. Chen, C.J. Rosen, C.M. Gundberg, W.J. Jakubas, R.C. Causey. Calcitriol is produced during ursine hibernation despite prolonged anuria. Poster presentation at the 58th Annual Meeting of the Wildlife Disease Association, Blaine, Washington. August 2-7, 2009.
- Seger, R.L., R.A. Cross, F.A. Servello, R.M. Seger, W.A. Halteman, W.J. Jakubas, and R.C. Causey. Measuring metacarpal cortical bone mass in free-ranging black bears (*Ursus americanus*) using portable radiography. Invited presentation at the 58th Annual Meeting of the Wildlife Disease Association, Blaine, Washington. August 7, 2009.
- Simons, E. M., D. J. Harrison, W. B. Krohn, K. R. Legaard and S. A. Sader. Ecological factors associated with landscape-scale occurrences of Canada lynx in northern Maine. Invited presentation at Lynx on the Landscape: What You

- Need to Know Workshop and Field Tour, Maine Cooperative Forestry Research Unit, Greenville, Maine. October 29, 2008
- Simons, E. M., D. J. Harrison, W. B. Krohn, K. R. Legaard, and S. A. Sader. Retrospective changes in habitat supply for Canada lynx and snowshoe hares resulting from timber harvesting: Implications for lynx recovery? Presented at The Wildlife Society 15th Annual Conference, Miami, Florida. November 9, 2008.
- Simons, E. M., K. R. Legaard, D. J. Harrison, W. B. Krohn, and S. Sader. Evaluating broad-scale changes in timber harvesting patterns, forest landscape structure, and wildlife habitat supply for umbrella species in northern Maine. Invited presentation at Friends of ForCAST, Center for Research on Sustainable Forests, Orono Simon and Legaard co-presentors. November 20, 2008.
- Simons, E. M., D. J. Harrison, W. B. Krohn, K. R. Legaard, J. S. Wilson, and S. A. Sader. Past and future trends in habitat supply for martens and lynx across the landscapes of northern Maine, 1973-2032. Invited presentation to executive director and regional staff of The Nature Conservancy, Brunswick, Maine. February 24, 2009.
- Simons, E. M., D. J. Harrison, W. B. Krohn, K. R. Legaard, J. S. Wilson, and S. A. Sader. Past and future trends in habitat supply for martens and lynx across the landscapes of northern Maine, 1973-2032. Invited Paper at New England Society of American Foresters 89th Winter Meeting, Portland, Maine. March 19, 2009.
- Simons, E. M. Influences of past and future forest management on the spatiotemporal dynamics of habitat supply for Canada lynx and American martens in northern Maine. Ph.D. defense seminar, The University of Maine, Orono. March 25, 2009.
- Simons, E. M., J. S. Wilson, D. J. Harrison, W. B. Krohn, Future trends in habitat supply for martens and lynx across the landscapes of northern Maine under alternative forest management scenarios, 2007-2032. Presentation to Maine Cooperative Forestry Research Unit, Orono, Maine. April 15, 2009.
- Simons, E. M., D. J. Harrison, and W. B. Krohn. Influences of past and future forest management on the spatiotemporal dynamics of habitat supply for Canada lynx and American martens in northern Maine. Invited presentation to the Director and Division supervisors of the Maine Forest Service, Augusta, ME. Krohn & Harrison presenters. June 30, 2009.
- Wathen, R., S. Coghlan, and J. Zydlewski, Competition between Atlantic salmon smolts and smallmouth bass; experiments in an artificial stream 138th Annual Meeting of the American Fisheries Society. Ottawa, Canada. August 17-21, 2009.
- Witham, J. Introduction to Holt Research Forest. Maine Mycological Association for a Mushroom Foray. October 4, 2008.
- Patterson, W. and A. K. Fuller. Field tour of the Nature Conservancy St. John ownership: silvicultural prescriptions for maintaining marten and lynx habitat requirements for Nature Conservancy staff, US Fish and Wildlife Service, Huber Resources Group. May 4-6, 2009.
- Webster, K.E., D.Anderson, E.G. Schilling, and C.S. Loftin. The influence of landscape setting and fish status on the body size of cladocerans in Maine (USA) lakes. Poster presented at the American Society of Limnology and Oceanography-Aquatic Sciences, Centre de Congres Acropolis, Nice, France. January 25, 2009.
- Zydlewski, J., J.Kocik, S. Fernandes, and J. Hawkes, Patterns of movement in striped bass, *Morone axatilis* in the Penobscot River, Maine. 138th Annual Meeting of the American Fisheries Society. Ottawa, Canada. August 17-21, 2009.
- Zydlewski, G. and J. Zydlewski. 2008 Long-term Seawater performance of Atlantic salmon smolts. 138th Annual Meeting of the American Fisheries Society. Ottawa, Canada. August 17-21, 2009.
- Zydlewski, G., M. Kinnison, J. Zydlewski, S. Fernandes, P. Dionne, C. Lipsky, J. Kocik, and G. Wippelhauser. (2008) Assessment of endangered shortnose sturgeon in Maine Rivers ICES Annual Meeting, Halifax, Nova Scotia. September 24, 2009.

Public Talks Presented

- Calhoun, A.J.K. New England Aquarium. Vernal pool conservation issues Boston, Massachusetts. October 27, 2009.
- Calhoun, A.J.K. University of Southern Maine. Vernal pool conservation. Who Benefits? Portland, Maine. February 13, 2009.

- Calhoun, A.J.K. Towns of Topsham, Cumberland, Yarmouth, Freeport. Training workshops vernal pool conservation. Freeport, Maine. February 23, 2009.
- Calhoun, A.J.K. Training workshops vernal pool conservation. Scarborough, Maine. March 17, 2009.
- Calhoun, A.J.K. Training workshops vernal pool conservation. Brunswick, Maine. March 24, 2009.
- Calhoun, A.J.K. Training workshops vernal pool conservation. Training workshops vernal pool conservation. Windham, Maine. March 30, 2009.
- Calhoun, A.J.K. Training workshops vernal pool conservation. Orono, Maine. March 31, 2009.
- Calhoun, A.J.K. Field training for vernal pool mapping project. Windham, Maine. April 17, 2009.
- Calhoun, A.J.K. Towns of Brunswick, Topsham, and Freeport. Field training for vernal pool mapping project. Brunswick, Maine. April 18, 2009.
- Calhoun, A.J.K. Towns of Cumberland, Yarmouth, Harpswell Field training for vernal pool mapping project. Yarmouth, Maine. April 19, 2009.
- Calhoun, A.J.K. Field training for vernal pool mapping project. Scarborough, Maine. April 20, 2009.
- Calhoun, A.J.K. Field training for vernal pool mapping project. Orono, Maine. April 21, 2009.
- Calhoun, A.J.K. Great Pond Land Trust. Mapping and assessing vernal pools for land trusts. Orland, Maine. May 8, 2009.
- Calhoun, A.J.K. Maine Association of Assessing Officers. Vernal pool conservation and land values. Hallowell, Maine. May 15, 2009.
- Calhoun, A.J.K. Bangor Comprehensive Planning Committee. Town conservation of vernal pools and natural resources. Bangor, Maine. June 9, 2009.
- Coghlan, Jr., S.M. A fish-eye's view of stream habitat: the bioenergetic implications of stream restoration. Presented at the Project SHARE annual research meeting, Orono, Maine. March 9, 2009.
- Coghlan, Jr., S.M., R.A. Wathen, and J. Zydlewski. Interactive ecology of Atlantic salmon and smallmouth bass in Maine rivers. Presented at Maine Sportsmen's Show / Trout Unlimited, Augusta, Maine. April 4, 2009.
- Dionne, P.E., M.T. Kinnison, G.S. Wippelhauser, J.D. Zydlewski, G.B. Zydlewski. Outside the box: coastal movements of shortnose sturgeon and implications for management. School of Marine Science Graduate Symposium, Damariscotta, Maine. May 1, 2009.
- Fuller, A. K., D. J. Harrison, and W. B. Krohn. Applications of lynx and marten models to operational forest management. Invited presentation at Lynx on the Landscape: Workshop and Fall Field Tour, Cooperative Forestry Research Unit, Greenville, Maine. October 28, 2008.
- Fuller, A. K., D. J. Harrison, B. K. Hearn, and J. A. Hepinstall. Spatial responses to habitat loss in populations of forest martens. Presented at The Wildlife Society 15th Annual Conference, Miami, Florida. November 11, 2008.
- Gardner, C., J. S., Coghlan, and J. Zydlewski. Monitoring changes in resident and anadromous fish communities in Sedgeunkedunk Stream (Penobscot Co., ME) after low head dam removal. 138th Annual Meeting of the American Fisheries Society. Ottawa, Canada. August 17-21, 2009.
- Gorsky, D., J. Zydlewski, and D. Basley. Characterizing basic movements and habitat use of lake whitefish (*Coregonus clupeaformis*) in Clear Lake, Maine. 138th Annual Meeting of the American Fisheries Society. Ottawa, Canada. August 17-21, 2009.
- Gorsky, D., J. Zydlewski, and L. Kling. Intraspecific competition in lake whitefish; the interactive effect of food availability and fish density on growth rates in a laboratory setting. 138th Annual Meeting of the American Fisheries Society. Ottawa, Canada. August 17-21, 2009.
- Harrison, D. J., A. K. Fuller, J. A. Hepinstall, E. Simons, B. J. Hearn, and D. Payer. Forests, forestry, and forest martens: a landscape perspective. Invited presentation at conference titled: Pour une sylviculture adaptee a al feret irreguliere et sa faune, Faculty of Forestry, University of Laval, Baie Comeau, Quebec. October 8, 2008.
- Hunter, M.L. Biodiversity: Buzzword or fundamental concept? Colby College, Waterville Maine. November 11, 2008.
- Hunter, M.L. Saving the earth as a career. Colby College, Waterville Maine. November 11, 2008.

- Hunter, M.L. Using nature's template as a model for natural resource management. Carlton Owen Distinguished Lecture, College of Forest Resources, Mississippi State University. April 2009.
- Knurek, E.S., Drummond, F.A., and J.M. Rhymer. Resolving the taxonomic status of a state endangered butterfly. Ecological Society of America Annual Meeting. Albuquerque, NM. August 4, 2009.
- Krohn, W. B. Manly Hardy (1832-1910): early Maine naturalists and wildlife writer. Penobscot Fly-Fisher's Club, Brewer, Maine. October 1, 2008.
- Krohn, W. B. Joshua Gross Rich (1820-1897): western Maine pioneer and wildlife writer. Department of Wildlife Ecology's Noontime Seminar Series, University of Maine, Orono. November 17, 2008.
- Krohn, W. B. Return of the Canada Lynx to Maine: Why? Invited presentation to the Sportsman's Show of the Penobscot County Conservation Association, University of Maine, Orono. March 14, 2009.
- Krohn, W. B. Manly Hardy (1832-1910): early Maine naturalists and wildlife writer. Invited presentation to the Bangor Nature Club, First Congregational Church, Brewer, Maine. April 8, 2009.
- Krohn, W. B. Come back of the snowshoe cat: the story of Canada lynx in Maine. Invited presentation to Rangeley Region Guides and Sportsmen's Association. Oquossoc, Maine. May 21, 2009.
- Popescu, V. D., M. Hunter. Effects of forestry practices on the dispersal success of vernal pool-breeding amphibians. Invited presentation at the Maine Association of Wetland Scientists Annual Meeting. Hallowell, Maine, March 27, 2009.
- Popescu, V. D., M. Hunter. Effects of forestry practices on the dispersal success of vernal pool-breeding amphibians. Presentation to the State Chapter of The Wildlife Society, Brewer, Maine. April 22, 2009.
- Rhymer, J. Taxonomic and population status of Clayton's copper butterfly and future research directions. Presentation to Wildlife Management group at Maine Department of Inland Fisheries & Wildlife. Bangor, Maine. April 2009.
- Shearin, A.F. The ecology and conservation of vernal pools. Belfast Bay Watershed Coalition, March 5, 2009.
- Shearin, A.F. Vernal pools: hands-on tour. Belfast Bay Watershed Coalition, Belfast, Maine. April 24, 2009.
- Witham, J. Wildlife of Merry Meeting Bay, Friends of Merry Meeting Bay. Bowdoinham, Maine. September 8, 2008.
- Witham, J. Featured speaker for Arbor Week Celebration by Bath Forestry Committee presented Holt Research Forest – 25 Years of Change. May 21, 2009.
- Zydwski, J. Migration studies in the Penobscot River. Veazie Salmon Club. Veazie, Maine. January 22, 2009.

Workshops

- Harrison, D. J. The growing need to fund additional scientists working on forest-wildlife interactions in Maine: a proposal. Presentation to Maine Cooperative Forestry Research Unit, Orono, Maine. February 26, 2009.
- Harrison, D. J., and A. K. Fuller. Relative densities, patcho, and population performance of spruce grouse in regenerating conifer, precommercially thinned, mature conifer, and conifer wetlands stands: a proposal. Presentation to Maine Cooperative Forestry Research Unit, Orono, Maine. April 15, 2009.
- Harrison, D. J., E. M. Simons, and W. B. Krohn. Habitat changes for wildlife umbrella species: implications for landscape conservation strategies in northern Maine. Invited presentation to northern Appalachians landscape conservation committee, The Nature Conservancy, Brunswick, Maine. May 21, 2009.
- Hunter, M. and A. Calhoun. Advice for newcomers workshop. Society for Conservation Biology Conference, Chattanooga Tennessee. April 14, 2009.
- Scott, S., D.J. Harrison, and W. B. Krohn. Partial harvests: contributing to foraging habitat?. Presentation at Lynx on the Landscape Workshop, Maine Cooperative Forestry Research Unit, Workshop. Greenville, Maine. October 28, 2008.

Awards, Honors, and Appointments

- Rhymer, J. Taxonomic and population status of clayton's copper butterfly. Presentation to awards committee for University of Maine NSFA graduate student awards.

Seger R.L., R.A. Cross, C.J. Rosen, D.H. Keisler, R.C. Causey, C.M. Gundberg, W.J. Jakubas, R.M. Seger, and F.A. Servello. Leptin may be important in the unique skeletal metabolism of ursine hibernation. Poster presentation at the American Society of Bone and Mineral Research conference, New Frontiers in Skeletal Research: Bone, Fat and Brain Connections, Bethesda, Maryland. April 27-28, 2009. R.L. Seger received the American Society of Bone and Mineral Research Young Investigator Award.

The Maine Cooperative Fish and Wildlife Research Unit (i.e., Krohn, Loftin, and Zydlewski) selected by the US Geological Survey's (USGS) Cooperative Units Research Program for the 2008 Unit Scientific Excellence Award. This award is given to one USGS Cooperative Fish and Wildlife Research Unit nationally each year. It is based on scientific productivity, and the effect that the Unit's scientific information is having at state, regional, and national levels.

Television, Radio, and Newspaper Interviews and Articles

W. B. Krohn, and E. Simons were quoted in an article in *The Boston Globe* entitled "Lynx and logging share interests: natural habitat is at risk as clear-cutting fades," by Murray Carpenter. Page 5 of the Business Section. April 27, 2009.

C.S. Loftin, was interviewed for an article about fishless ponds and research in Maine. *New York Times* science page. April 28, 2009.

M. Hunter, Featured in "As a leading conservation biologist, Malcolm Hunter acts globally and locally Mac's World," *UMaine Today*. Fall 2009.