

**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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## PERSONNEL AND COOPERATORS

### Coordinating Committee

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*Wildlife Management Institute*

Scot J. Williamson, Vice President and Northeastern Representative

### Unit Personnel

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Kenneth D. Elowe, Director, Bureau of Resource Management  
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John J. Boland, Director, Fisheries Operations  
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## Graduate Students

<i>Name</i>	<i>Degree Candidacy</i>	<i>Support</i>
Frederick Beaudry	Ph.D.	MDOT, UM, MDIFW, MOHF, EPA, TNC, NWF, FW
Sean M. Blomquist	Ph.D.	NSF, MCS, UMS, SREL, ASIH, UM
Steven P. Campbell	Ph.D.	HWRF, UM, NSF
Thomas J. Danielson	Ph.D.	UM, USGS, MDEP, EPA, HBMI, MCCC
Katie E. DeGoosh	M.S.	MOHF, MDIFW, UM, MCFWRU
Stephen Fernandes	M.S.	MCFWRU, NOAA
Sharon L. Fleming	M.S.	MASC, NMFS, MCFWRU
Dimitry Gorsky	Ph.D.	MCFWRU, MDIFW, UM
Jeremiah Hayden	M.S.	UM, MCFWRU, MDIFW, MOHF
Brian J. Hearn	Ph.D.	UM, NRC-CFS, NDFRA-WD, WNMF, CPP, AC
Christopher M. Holbrook	M.S.	MCFWRU, NMFS, PIN, FWS, MASC
Casey A. L. Jackson	M.S.	MCFWRU, MDIFW, MOHF, TU
Jennifer Kurth	M.S.	MDIFW, MOHF, USGS, MCFWRU, UM, MAFES
Lori Jean Mitchner	Ph.D.	TNC, UM, MCFWRU
Pilar A. Palacios	Ph.D.	USDS, UM
David A. Patrick	Ph.D.	NSF, UMS, SREL
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Shonene Scott	Ph.D.	USDAFS, CFRU, MCFWRU, NCASI, UM, MDIFW
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Erin Simons	Ph.D.	MCFWRU, FWS, MDIFW, CFRU, MAFES, NCASI, UM, TNC, HRC
Randall Spencer	M.S.	MCFWRU, MASC, FWS

## Dissertations and Theses Completed This Period

<i>Student</i>	<i>Degree Candidacy</i>	<i>Support</i>
Angela K. Fuller	Ph.D.	CFRU, MDIFW, MAFES, FWS, TNC
Stephen Kneeland	M.S.	MDIFW, MOHF, USGS, MAFES, UM
Jon T. McCloskey	Ph.D.	USGS-BRD, FWS, MCFWRU, UM, ONWR
Laura L. Robinson	M.S.	MCFWRU, MDIFW, CFRU, FWS, UM, TNC, CLW, HRC, IL, NCASI
John P. Skinner	M.S.	NMFS, MAFES, UM

## Personnel Notes

**ANGELA FULLER** received her Ph.D. degree in Wildlife Ecology and is continuing to work with the Department of Wildlife Ecology. **STEPHEN KNEELAND** received his M.S. degree in Ecology and Environmental Sciences and continues to work with the Department of Wildlife Ecology. **JON MCCLOSKEY** received his Ph.D. degree in Ecology and Environmental Sciences and is seeking employment while working with the Department of Wildlife Ecology. **LAURA ROBINSON** received her M.S. degree in Wildlife Ecology and is currently working with lynx and wolverine in Glacier National Park, Montana. **JOHN SKINNER** received his M.S. degree in Wildlife Ecology and now works with sea lions in Alaska.

## Collaborating Agencies and Organizations

Abitibi Consolidated	AC
American Society of Ichthyologists and Herpetologists	ASIH
Clayton Lake Woodlands	CLW
Corner Brook Pulp & Paper	CPP
Florida Power Light Energy	FPLE
Fulbright & State Organization of the Americas	FSOA

Holt Woodlands Research Foundation	HWRF
Houlton Band of Maliseet Indians	HBMI
Huber Resources Corporation	HRC
Irving LLC	IL
Maine Agricultural and Forest Experiment Station	MAFES
Maine Agricultural and Forest Experiment Station - Hatch	MAFES-HATCH
Maine Atlantic Salmon Commission	MASC
Maine Department of Environmental Protection	MDEP
Maine Department of Inland Fisheries and Wildlife	MDIFW
Maine Department of Transportation	MDOT
Maine Outdoor Heritage Fund	MOHF
Manomet Center for Conservation Sciences	MCCS
National Council on Air and Stream Improvement	NCASI
National Marine Fisheries Service	NMFS
National Oceanic & Atmospheric Administration	NOAA
National Science Foundation	NSF
National Science Foundation - Research Fellowship	NSFRF
National Science Foundation - GK 12 Teaching Fellowship	GK-12TF
Natural Resources Canada	NRC
Natural Resources Canada - Canadian Forest Service	CFS
Newfoundland and Labrador Wildlife Division	
Newfoundland Forest Service	NFS
Newfoundland Inland Fish and Wildlife Division	NIFWD
Norcross Wildlife Foundation	NWF
Penobscot Indian Nation	PIN
The Nature Conservancy	TNC
The Nature Conservancy - Maine Chapter	
Trout Unlimited	TU
U.S. Department of State - Fulbright Program	
U.S. Environmental Protection Agency	EPA
U.S. Fish and Wildlife Service	FWS
U.S. Fish and Wildlife Service - Endangered Species Program	
U.S. Fish and Wildlife Service - Okefenokee National Wildlife Refuge	ONWR
U.S. Fish and Wildlife Service - Partnerships for Wildlife Program	
United Nations Educational, Scientific, & Cultural Organization	UNESCO
University of Georgia	UG
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 Biological Sciences	DBS
University of Maine - Department of Wildlife Ecology	DWE
University of Maine - Ecology and Environmental Sciences Program	EES
University of Maine - Graduate Research Assistantship	GRA
University of Maine - Maine Cooperative Forestry Research Unit	CFRU
University of Maine - McIntire-Stennis	MCS
University of Missouri	UMS
USGS -Biological Resources Discipline	BRD
USGS - CRU Eastern Region Funds	
USGS - Eastern Region State Partnership Program	ERSPP
USGS - Florida Integrated Science Center	FISC
USGS - Maine Cooperative Fish and Wildlife Research Unit	MCFWRU
USGS - S. O. Conte Anadromous Fish Research Laboratory, Leetown Science Center	
USGS - State Partnerships Program	SPP
Western Newfoundland Model Forest	WNMF
Wildlife Conservation Society	WCS

## ENDANGERED AND THREATENED SPECIES

### Winter Habitat Selection and Movement Paths by Canada Lynx (*Lynx canadensis*) in Maine

*Investigator:* A. K. Fuller

*Advisors:* D. J. Harrison, Chair  
W. E. Glanz  
W. B. Halteman  
W. B. Krohn  
J. S. Wilson

*Cooperators/  
Project Support:* Maine Cooperative Forestry Research Unit  
Maine Department of Inland Fisheries and Wildlife  
Maine Agricultural and Forest Experiment Station  
U. S. Fish and Wildlife Service  
The Nature Conservancy

*Objectives:*

- 1) Evaluate stand-scale habitat selection by lynx using snow tracking.
- 2) Develop a model to determine which habitat variables best predict sub-stand scale habitat selection by lynx across a range of forest types.
- 3) Describe sub-stand scale features of rest sites used by lynx and lynx activities.
- 4) Describe spatial-use and movement patterns of lynx.

#### SCOPE

Determining the appropriate scale to study a particular ecological problem has been recognized as increasingly important, and pattern and scale have been a central problem in ecology. To understand how and why species select particular habitat types or features within habitat types, we must first understand at what spatial scales the species views or perceives their habitat. However, species may respond strongly and simultaneously to habitat at different scales, and responses may be contradictory across scales. This research examined responses of Canada lynx (*Lynx canadensis*) and American martens (*Martes americana*) to habitat features at several spatial scales. The overall goal was to understand how process and structure influence habitat choice at multiple spatial scales using the two carnivore species as case studies.

#### PROJECT STATUS

All requirements for a Ph.D. degree in Wildlife Ecology were met in May 2006. The abstract of the dissertation is as follows:

I examined responses of Canada lynx (*Lynx canadensis*) and American martens (*Martes americana*) to habitat features at multiple spatial scales. At the stand-scale, lynx (n = 6) selected tall regenerating clearcuts (4.4-7.3 m, 11-26 years post-harvest) and established partially harvested stands (11-21 years post-harvest) and they selected against short regenerating clearcuts (3.4-4.3 m, 11-26 years), recent partially harvested stands (1-10 years), and mature stands (>40 years). The highest fractal dimension of foraging paths was in tall regenerating clearcuts and established partially harvested stands, which were stands that provided intermediate to high snowshoe hare (*Lepus americanus*) density, intermediate cover for hares, and intermediate levels of canopy closure and live-tree basal area. Movement paths of lynx had increasing fractal dimension at smaller scales and were straighter than they were at broader spatial scales, suggesting that lynx were trying to avoid switching from highly preferred to lesser preferred stands. Lynx maximized time in areas with high-intermediate hare densities to facilitate increased capture success of snowshoe hares, supporting the hypothesis that lynx select for prey access of prey density.

I developed models incorporating landscape composition and configuration to predict occurrence of home ranges (n = 62 for American martens in Newfoundland) and to evaluate the relative influences of habitat loss versus fragmentation on this endangered subspecies. Habitat loss was the primary determinant of occupancy of landscapes by martens. The probability of occupancy declined precipitously as the percent of suitable habitat fell below 60% of home-range sized landscapes; therefore, efforts to recover marten populations should focus on maintaining suitable habitat above 60%. I also compared threshold responses in occupancy of martens to the amount of suitable habitat in the landscape between two geographically isolated subspecies (*Martes americana americana* in Maine and *Martes americana atrata* in Newfoundland) that differed greatly in the amount of landscape-scale fragmentation and amount of suitable habitat. Drastic declines in occupancy occurred much sooner in Maine (70-80% suitable habitat) than in Newfoundland (30-40% suitable habitat),

indicating that martens in Maine are more sensitive to landscape change, and the Newfoundland subspecies has evolved to be less responsive in its more inherently fragmented environment.

## **Effects of Snowshoe Hare (*Lepus americanus*) Density and Landscape Characteristics on Habitat Use by Canada Lynx (*Lynx canadensis*) in Maine**

*Investigator:* L. L. Robinson

*Advisors:* D. J. Harrison, Co-chair  
W. B. Krohn, Co-chair  
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*Cooperators/  
Project Support:* Maine Cooperative Fish and Wildlife Research Unit  
Maine Department of Inland Fisheries and Wildlife  
Maine Cooperative Forestry Research Unit  
U.S. Fish and Wildlife Service  
University of Maine - Department of Wildlife Ecology  
University of Maine - McIntire-Stennis  
University of Maine - Graduate Research Assistantship  
The Nature Conservancy  
Clayton Lake Woodlands  
Huber Resources Corporation  
Irving LLC  
National Council on Air and Stream Improvement

*Objectives:*

- 1) Document hare densities in partial harvest stands (including selective, shelterwood, and uneven-aged harvests) and evaluate changes in hare densities in these stands as understories develop.
- 2) Evaluate spatial differences in hare density between areas in the core of the lynx range (Clayton Lake region) and areas on the southern edge of the lynx range (Telos region) for regenerating conifer clear cuts and ten-year-old mixed selection harvests.
- 3) Evaluate the effects of vegetative characteristics on hare densities across stand types and within stands.
- 4) Develop and test models for discriminating habitat characteristics (e.g., hare densities, stand-scale habitat characteristics, and landscape metrics) between simulated lynx home ranges where lynx were and were not detected during systematic winter track surveys.

### **SCOPE**

The Federally threatened Canada lynx (*Lynx canadensis*) is a wide-ranging felid occupying most of Canada and some northern parts of the U.S.A., with Maine supporting the only verified U.S. population of lynx east of Minnesota. Lynx are considered specialist predators of snowshoe hares (*Lepus americanus*), and hare density acts as a regulating factor for lynx populations. Hare densities in the Northeast are strongly associated with dense, conifer understory, which provides hares with thermal cover in the winter and escape cover from predators. Dense, conifer understory is associated with mid-successional forest, can be produced artificially through forest management practices, and is found in regenerating conifer clear cuts approximately 15 to 30 years after cutting and herbicide application. Relatively young regenerating stands as large as 5,000 hectares are common throughout Maine today resulting from past clear cutting in response to the widespread eastern spruce budworm (*Choristoneura fumiferana*) outbreak of the late 1970s and early 1980s. However, the Maine Forest Practices Act of 1989 placed large disincentives on clear cuts larger than 35 acres. This contributed to a shift in forest management in Maine away from clear cuts in favor of various forms of partial harvesting, which now constitute 96% of the forest management in Maine. Soon after cutting, some partial harvest stands maintain only about 5-10% of the hare density that can be supported by regenerating conifer clear cuts. Thus, the shift to partial harvesting in Maine could have potential implications for lynx conservation in the Northeast, although a wider range of partial harvests need to be studied over a larger time interval after cutting.

This project will study hare densities in different forest cover types and will evaluate changes in hare densities as those forest stands mature. These data will then be combined with data from previous studies of hare density so that estimates of hare density will be known for each major forest type in northern Maine. We will use data from ecoregional snow tracking

surveys conducted by the Maine Department of Inland Fisheries and Wildlife to simulate lynx home ranges where lynx have and have not been detected. We will apply hare density estimates to these simulated home ranges to evaluate the influence of hare density on habitat use by lynx in northern Maine.

Because lynx are wide-ranging animals capable of dispersing greater than 900 km, other landscape characteristics such as edge, distance from core population, and snowfall may be important in the selection of habitat for home ranges by lynx in addition to hare densities. In addition to considering ecoregional occurrence of potential competitors (e.g., bobcats) of lynx, this study will compare these landscape characteristics for areas where lynx were and were not detected to determine which habitat variables are important to lynx.

#### *PROJECT STATUS*

All requirements for a Master of Science degree were met in August 2006. The abstract of the thesis follows:

Understanding the ecological factors affecting habitat use by the Canada lynx (*Lynx canadensis*) and its primary prey, the snowshoe hare (*Lepus americanus*), could help formulate conservation strategies for this carnivore, which is federally listed as threatened and occurs in only four regions of the U.S.A. I measured vegetation characteristics and snowshoe hare densities in 15 regenerating conifer clearcuts and 21 partially harvested stands in northern Maine during the leaf-off seasons, 2005 and 2006; and the leaf-on season, 2005. Regenerating clearcut stands had been harvested between 1974 and 1985 and were subsequently treated with an aerial application of herbicide between 1982 and 1997. Partially harvested stands were last harvested between 1985 and 2004 and included selection harvests shelterwood harvests, and overstory removal harvests.

Vegetation characteristics varied widely across partially harvested stands. This variance can be described by two principal components associated with the conifer composition and understory density within these stands. Snowshoe hare densities also varied widely in partially harvested stands: 0.26-1.65 hares/ha for the combined 2005-2006 leaf-off seasons. All 21 partially harvested stands had lower hare densities than the mean hare density for regenerating conifer clearcuts (2.10 hares/ha, SE=0.22) during these two years.

I modeled the relationship of individual vegetation variables to hare densities across the 36 stands surveyed using an information theoretic approach. Hare density during the leaf-off season was positively associated with conifer stem density and basal area removed and was negatively related to the density of logs in the stand. These three variables explained 67% of the variance in observed hare densities; however, conifer stem density was the single variable that was most strongly related to hare densities.

I used GIS modeling to evaluate the relationships between lynx occurrence/non-detection and hare density, bobcat occurrence, fisher harvest density, maximum snow depth, and elevation at the geographic range and home range scales in Maine. At the geographic-scale, lynx occurrence was associated with: 1) areas of higher hare density, and 2) absence of bobcats. Within the geographic range of lynx, simulated home ranges centered on lynx occurrences were associated with: 1) higher hare densities, 2) absence of bobcats, and 3) an interaction between hare density and bobcat occurrence, compared to surveyed areas without lynx detections. Only two surveys detected both bobcats and lynx, but these data suggest geographic- and home range-scale allopatry between these two species.

At the geographic-scale, the area of land in regenerating clearcuts was positively associated with lynx occurrence, likely as a result of the high hare densities supported by regenerating clearcuts. Annual clearcutting in Maine has been decreasing since the early 1990s and this trend may result in less regenerating forest on the landscape in the future, which might have long-term negative consequences if the objective is to maintain or increase current population levels of Canada lynx in Maine.

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### **Genetic Identification of Fish Hosts for the Yellow Lampmussel (*Lampsilis cariosa*) and Tidewater Mucket (*Leptodea ochracea*)**

*Investigator:* S. C. Kneeland

*Advisors:* J. M. Rhymer, Chair  
C. S. Loftin  
M. Kinnison  
J. Zydlewski

*Cooperators/* Maine Department of Inland Fisheries and Wildlife  
*Project Support:* Maine Outdoor Heritage Fund  
USGS - State Partnerships Program

MAFES - Hatch  
University of Maine - Department of Wildlife Ecology

- Objectives:*
- 1) Develop a genetic identification key for *Lampsilis cariosa* and *Leptodea ochracea* and other freshwater mussel species in Maine with overlapping distributions.
  - 2) Compare known distributions of *Lampsilis cariosa* and *Leptodea ochracea* and life history characteristics of these species with fish in Maine to predict likely hosts in the wild.
  - 3) Sample naturally parasitized fish in localities where *Lampsilis cariosa* and *Leptodea ochracea* occur to confirm and/or designate fish as suitable hosts.

#### SCOPE

North America has nearly 300 species of freshwater mussels, yet nearly 72% are of special concern, threatened, endangered, or possibly extirpated. Reasons for decline are largely anthropogenic, as mussels have been subjected to habitat loss or alteration due to channelization, siltation, eutrophication, and river impoundment. In Maine, the yellow lampmussel (*Lampsilis cariosa*) and tidewater mucket (*Leptodea ochracea*) are found in only three watersheds and are state listed as threatened.

Yellow perch (*Perca flavescens*) and white perch (*Morone americana*) are probable hosts for the yellow lampmussel, and white perch is a probable host for the tidewater mucket. However, it is possible that other host species not yet tested exist for both mussel species. This study will involve creating a genetic identification key that will be used to identify glochidia attached to naturally parasitized fish in the wild. The genetic identification key will be developed by collecting tissue samples from known adult mussel species. Glochidia will be removed from naturally parasitized fish and identified with the key to confirm or designate fish as suitable hosts for the yellow lampmussel and tidewater mucket.

The conservation of some freshwater mussels is limited by inadequate knowledge of host species. The spread of exotic species, illegal stocking, and dam removal has caused some fish communities to change in many areas. Therefore, knowledge of host species in changing or stable fish communities is essential for mussel conservation.

#### PROJECT STATUS

All requirements for a Master's degree were met in August 2006. The abstract of the thesis follows:

The yellow lampmussel (*Lampsilis cariosa*) and tidewater mucket (*Leptodea ochracea*) are two species of freshwater mussels of conservation concern throughout their range. They are listed as Threatened in Maine, where their distribution is restricted to the Penobscot, St. George, and Kennebec River drainages, and are listed as Endangered, Threatened, or of Special Concern in several states throughout their range from Nova Scotia to Georgia. Like most freshwater mussels, they have an unusual life cycle during which their larvae (glochidia) are obligate parasites of specific fish species, and knowledge of host fish species is critical to freshwater mussel conservation. Previous laboratory studies have indicated that white perch (*Morone americana*) and yellow perch (*Perca flavescens*) are potential hosts for *L. cariosa* and white perch for *L. ochracea*. However, it is possible that other host fish species exist, and that some species are more effective hosts than others in the wild.

The goal of this research was to determine if previously identified hosts act as host fish in natural populations and also to assess additional species as possible hosts by sampling naturally parasitized fish in the wild. Due to the small size of glochidia, morphological identification of the species of glochidia attached to fish can be very difficult or impossible. To identify glochidia attached to wild-caught fish, a species-specific molecular identification key utilizing restriction fragment length polymorphism (RFLP) patterns of the mitochondrial ND1 gene was developed and tested for accuracy prior to sampling naturally parasitized fish.

Naturally parasitized fish were captured at thirteen localities in the Penobscot, St. George, and Kennebec River drainages and inspected for glochidia infestations. The fish hosts identified under laboratory conditions for both mussel species were confirmed from naturally parasitized fish. Five additional fish species were also found to be potential hosts for *L. cariosa*, three of which are native species (banded killifish [*Fundulus diaphanous*], chain pickerel [*Esox niger*], and white sucker [*Catostomus commersoni*]) and two are introduced species (smallmouth bass [*Micropterus dolomieu*] and largemouth bass [*Micropterus salmoides*]). One species, the banded killifish, was a potential host for *L. ochracea*. For both mussel species, white perch was the most commonly and abundantly infested host fish, and several fish in multiple localities were found with heavy infestations of *L. cariosa* and/or *L. ochracea* glochidia. In contrast, only one individual of each of the other species of fish, including yellow perch, was found with *L. cariosa* or *L. ochracea* glochidia. This highlights the importance of identifying the important fish hosts for mussel populations in natural ecosystems, because yellow perch was previously identified as an effective host under laboratory conditions. Confirmed and potential host fish exhibited some degree of spatial and temporal variation within and among localities in Maine. The results of this study are crucial for understanding the complex ecological interactions between mussels and their hosts and for conservation planning.

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## Landscape Thresholds and Response to Fragmentation by Endangered Newfoundland Marten (*Martes americana atrata*)

*Post-doctoral  
Scientist:* A. K. Fuller

*Collaborators:* D. J. Harrison  
B. J. Hearn

*Cooperators/  
Project Support:* Natural Resources Canada - Canadian Forest Service  
Newfoundland Inland Fish and Wildlife Division  
Corner Brook Pulp & Paper  
Abitibi Consolidated  
Newfoundland Forest Service  
Western Newfoundland Model Forest  
Maine Agricultural and Forest Experiment Station

*Objectives:*

- 1) Evaluate and define landscape-scale currencies that are associated with habitat occupancy by martens in Newfoundland, and determine how patterns of occupancy change with amount of suitable habitat and degree of fragmentation in home range-sized landscapes.
- 2) Evaluate how patterns of habitat occupancy by martens are affected by the amount of suitable habitat, landscape pattern, and fragmentation.
- 3) Develop a series of landscape thresholds for predicting landscape-scale occupancy of habitat by martens and to compare to thresholds in Maine. Use the thresholds to develop a tool for use in predicting population responses of marten to proposed forest-harvesting scenarios.
- 4) Evaluate whether marten are responding to habitat loss or habitat fragmentation. Determine whether spatial-use strategies and responses to fragmentation exhibited by martens in Newfoundland differ from processes exhibited by American martens at less extensive (e.g. Maine) spatial scales.

### SCOPE

Newfoundland marten (*Martes americana atrata*) are an endangered subspecies of mustelid that are endemic to the island of Newfoundland. Marten have large area requirements per unit body weight, are sensitive to fragmentation, and have been documented to respond to landscape pattern at scales larger than individual home ranges. However, because marten are intrasexually territorial, they may not be able to expand their ranges into new areas following landscape fragmentation. These characteristics make marten a good coarse-filter species to use in evaluating the effects of fragmentation and how species respond to pattern and process on the landscape.

I developed models incorporating landscape composition and configuration to predict occurrence of home ranges ( $n = 63$ ) for adult marten. Simulated unoccupied home ranges ( $n = 29$ ) were generated in areas that were unoccupied by resident marten, incorporating the size, shape, and range overlap observed in occupied ranges. I used an information-theoretic approach to evaluate the relative support for potential relationships between home range occupancy and measures of habitat composition and configuration. I ranked 9 logistic regression models, including 3 variables representing landscape composition (percent of the home range composed of suitable habitat, largest patch index, radius of gyration) and 5 variables representing landscape configuration (mean patch size, patch size coefficient of variation, mean nearest neighbor, nearest neighbor coefficient of variation, clumpy).

I defined a biologically relevant categorization of habitat availability that most directly influences the spatial decisions by an animal at a particular scale (habitat currency) as the percent of the home range in suitable habitat (coniferous stands  $\geq 6.6$  m tall, canopy closure  $>50\%$ ; coniferous stands  $\geq 12.6$  m tall,  $\leq 50\%$  canopy closure; insect killed conifer stands,  $<25\%$  canopy closure; and pre-commercially thinned conifer stands, 20-30 years old,  $>50\%$  canopy closure). This model correctly predicted (based on a cutoff of 0.5) 72% of the verification data and 77% of the validation data ( $n = 21$  occupied and 10 unoccupied ranges). The model sensitivity was 94% for the verification data and 95% for the validation data, indicating that the model did an excellent job of correctly predicting home range occupancy. Of our 84 occupied home ranges, 82% had  $\geq 35\%$  suitable habitat in their home range and 15% had  $\geq 60\%$  suitable habitat and of the 39 unoccupied home ranges, 49% had  $\geq 35\%$  suitable habitat in their home range and only 5% had  $\geq 60\%$  suitable habitat. The percent of the home range in suitable habitat was the best model, suggesting that landscape configuration was not as important as landscape composition for marten in Newfoundland. Indirect evidence from recently published field studies in Utah, Maine, and

Quebec suggests that marten may seldom occupy landscapes with greater than 30-40% of the forest in openings or early seral stages. In contrast, all marten in Newfoundland had at least 22% unsuitable habitat within their home ranges and 97% of all marten had >30%. Marten in Newfoundland have large body sizes, large home range sizes, and evolved in a landscape that is highly naturally fragmented and has a low diversity of prey species. These factors likely influenced their tolerance for increased levels of unsuitable habitat within their home range relative to marten with smaller body sizes, home ranges, and landscapes with a diversity of prey species and little natural fragmentation. The model that I developed will be used to predict how changes in the currency affect probability of occupancy of landscapes by marten in Newfoundland, and will provide a tool for evaluating the influences of proposed forest harvesting scenarios on landscape-level habitat occupancy by marten.

### PROJECT STATUS

The project is complete and a summary of the final contract report follows:

The relative influences of habitat loss and fragmentation on population processes is a contentious issue in conservation biology. Newfoundland marten (*Martes americana atrata*) are a genetically distinct, endangered subspecies of mustelid that are endemic to the island of Newfoundland. Members of the genus *Martes* have large area requirements per unit body weight, have been documented to be sensitive to fragmentation, and to respond to landscape pattern at scales larger than individual home ranges. I developed models incorporating landscape composition and configuration to predict occurrence of home ranges ( $n = 63$ , representing 54 individuals) for adult martens and to evaluate the relative influences of habitat loss versus fragmentation on this habitat-limited subspecies. Simulated home ranges ( $n = 29$ ) were generated in areas that were surveyed, but were unoccupied by resident martens, incorporating the size, shape, and range overlap observed in occupied ranges. I used an information-theoretic approach to rank 9 logistic regression models, including 3 variables representing landscape composition (percent of the home range in suitable habitat, largest patch index, radius of gyration) and 5 variables representing landscape configuration (mean patch size, patch size coefficient of variation, mean nearest neighbor, mean nearest neighbor coefficient of variation, CLUMPY). I defined a statistically based and biologically relevant categorization of suitable versus unsuitable habitat (suitable = coniferous stands  $\geq 6.6$  m tall, canopy closure >50%; coniferous stands  $\geq 12.6$  m tall,  $\leq 50\%$  canopy closure; insect killed conifer stands, <25% canopy closure; and precommercially thinned conifer stands, 20-30 years old, >50% canopy closure) to create a binary landscape. The top-ranked model included a single variable describing the extent of habitat loss (PHR: percent of the home range in suitable habitat) and correctly predicted 72% of the verification data and 77% of the validation data ( $n = 21$  occupied and 10 unoccupied ranges). Model sensitivity was 94% for the verification data and 95% for the validation data, indicating that the model was reliable for predicting home range occupancy. Models that incorporated landscape fragmentation did not perform better than the PHR-only model, suggesting that landscape composition is the primary determinant of occupancy of landscapes by martens in Newfoundland. Of the 84 occupied home ranges, 82% had  $\geq 35\%$  suitable habitat in their home range, 50% had  $\geq 45\%$  suitable habitat, and 15% had  $\geq 60\%$  suitable habitat. In contrast, of the 39 unoccupied home ranges, 49% had  $\geq 35\%$  suitable habitat, 31% had  $\geq 45\%$  suitable habitat, and only 5% had  $\geq 60\%$  suitable habitat. The probability of occupancy by martens began to decline faster as the percent of suitable habitat fell below 60% of home-range sized landscapes, thus, efforts to recover marten populations should focus on maintaining suitable habitat above 60% of landscapes. This model can be used to predict how changes in habitat currency affect the probability of occupancy of landscapes by this endangered subspecies of marten, and to provide insights into the non-linear effects of habitat loss on wide-ranging, area sensitive species in landscapes with limited suitable habitat resulting from natural and anthropogenic processes.

I also examined the response to habitat loss for two subspecies of American marten (*Martes americana*) in Maine (*M. a. americana*) and Newfoundland (*M. a. atrata*) that evolved in landscapes with differing composition and configuration of suitable habitat to evaluate threshold responses in second-order habitat occupancy. I identified threshold zones as areas with non-linear and drastic declines in occupancy, calculated as the difference between the slopes of occupied and unoccupied cumulative distribution functions of the amount of suitable habitat within home-range-sized landscapes. I compared my empirical data on threshold responses of martens to theory and to responses hypothesized for martens in the literature. I evaluated whether the shape of the occupancy curves best represented a) linear declines, b) exponential declines, or c) curvilinear declines and compared my observed threshold values to those reported in the literature. Martens in Maine and Newfoundland exhibited responses to habitat loss, but the shape of the decline curves and actual threshold zones differed between subspecies and did not approximate the responses predicted by threshold theory or by hypothesized responses for martens. The greatest declines in occupancy occurred much sooner in Maine (70-80% suitable habitat) than in Newfoundland (30-40% suitable habitat), indicating that *M. a. americana* were more sensitive to landscape change than *M. a. atrata*. The occupancy curve for *M. a. americana* was best represented by an exponential decline and *M. a. atrata* was best represented by a curvilinear decline. I suggest that the differences in responses to changes in amount of suitable habitat between the two subspecies of marten can be explained by differences in landscape composition and configuration, community structure, and ecological traits. I hypothesize that Newfoundland martens were not as sensitive to landscape

change because that subspecies evolved in a naturally fragmented landscape where their larger body size and home ranges relative to martens in Maine allowed them to include more unsuitable habitat. Lower diversity and density of potential prey species in Newfoundland necessitated traversing a wider range of habitat conditions relative to martens in Maine. Further, the lack of fishers (*Martes pennanti*) in Newfoundland allowed increased use of open areas by martens without the need for vertical cover to escape predation from the larger con-generic competitor (i.e., ecological release). The different responses that I observed by the same species in different geographic areas suggest that threshold responses are not an inherent species-specific trait. This exemplifies the need to understand the specific responses in second-order habitat occupancy of populations that have evolved in different types of landscapes with different competitors and cautions against the assumption that a particular response curve is an inherent trait of a species. Finally, these results indicate the insufficiency of assuming that animals exhibit theoretical or hypothetical responses to landscape change and that wildlife community and landscape processes interact to determine the different responses of isolated populations to local conditions.

## **Population Ecology of Black Terns (*Chlidonias niger*) in Maine**

*Investigator:* F. A. Servello

*Cooperators/  
Project Support:* University of Maine – Department of Wildlife Ecology  
Maine Department of Inland Fisheries and Wildlife  
U.S. Fish and Wildlife Service, Partnerships for Wildlife Program  
Maine Outdoor Heritage Fund  
Florida Power Light Energy

*Objectives:*

- 1) Determine the annual local survival of breeding adult black terns (*Chlidonias niger*) in Maine, site fidelity to individual wetlands, and movement rates among wetlands.
- 2) Determine breeding success at black tern colonies and factors influencing rates of nest and chick losses.
- 3) Determine the relative effects of demographic parameters on population rates of change for black terns using demographic models, and use stochastic modeling to evaluate extinction risk and management strategies.

### *SCOPE*

The black tern (*Chlidonias niger*) was formally state-listed as an endangered species in Maine in 1997, a legal status it also has in a number of states in the northern U.S. In Maine and the northeastern U.S., black tern populations are disjunct from the core breeding range in North America and are relatively small. The Maine population has approximately 80 breeding pairs distributed among 6-9 colony sites. With a few exceptions studies of black tern ecology in North America have focused on nest success, nesting habitat, and breeding behavior, apparently, because the low and variable reproductive success may be a contributing factor in the slow recovery of this species and the low densities in peripheral regions such as the northeastern U.S. Information on recruitment, survival, and site fidelity needed to examine population dynamics issues is insufficient. Other than annual census data, little is known about the basic population characteristics or limiting factors of black terns in Maine.

### *PROJECT STATUS*

Banding data for adult black terns were collected over a 6-year period at six breeding colonies in Maine. This data set is being analyzed to determine adult survival overall and movement rates among colonies.

Analyses of breeding success results are in progress. Modeling of extinction risk and management strategies is awaiting final data for breeding parameters.

### *FUTURE PLANS*

Complete survival, movement, and breeding success analyses.

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## **Factors Affecting Habitat Selection and Population Performance of American Marten (*Martes americana atrata*) in Newfoundland**

*Investigator:* B. J. Hearn

*Advisors:* D. J. Harrison, Chair  
M. L. Hunter, Jr.  
W. B. Krohn  
A. S. White

*Cooperators/  
Project Support:* University of Maine - Department of Wildlife Ecology  
Natural Resources Canada - Canadian Forest Service  
Newfoundland and Labrador Wildlife Division  
Western Newfoundland Model Forest  
Corner Brook Pulp & Paper  
Abitibi Consolidated

*Objectives:*

- 1) Document the population characteristics of Newfoundland marten in areas open and closed to trapping and snaring.
- 2) Determine scale-specific (i.e., stand- and landscape-level) habitat selection of marten across the range of habitat conditions present on the study area.
- 3) Examine home-range area and habitat composition in relation to the paradigm that Newfoundland marten are restricted in distribution areas dominated by old-growth forests.

### SCOPE

The Newfoundland marten (*Martes americana atrata*) is an endangered subspecies of the American marten (*M. a. americana*) and 1 of only 14 terrestrial mammals endemic to the island of Newfoundland. Since the early 1900s, the Newfoundland marten has declined both in numbers and distribution; excessive trapping, in combination with habitat loss due to logging and fire, are suggested as the major factors contributing to the decline. Commercial trapping for marten was closed on the island in 1934; however, despite this protection, marten populations continued to decline. Trapping for marten remains closed, but some numbers of marten are killed each year in traps and snares set for other furbearers and snowshoe hares (*Lepus americanus*). In 1973, the Pine Marten Study Area (PMSA) was established in southwestern Newfoundland for the protection of the marten and this wildlife reserve is generally considered to contain the largest concentration of marten remaining on the Island; the PMSA is closed to all land-based trapping and snaring. In 1996, the Newfoundland marten was nationally listed as an endangered species.

Earlier work on Newfoundland marten was conducted within the PMSA and focused on the effects of timber harvesting on "old growth" habitat and the underlying association of Newfoundland marten with old growth (81+ years) balsam fir (*Abies balsamea*) forests. In general, these studies concluded that loss of old growth habitat through clear cut logging was limiting the distribution and recovery of marten in Newfoundland. Subsequent work in the mid 1990s, examined forest structure and prey densities in forest of various ages, and suggested that marten in Newfoundland are more specialized in the habitat associations than mainland populations and restricted to mature and overmature balsam fir due to the lack of prey in younger stands. An alternative hypothesis explaining the association of Newfoundland marten with areas of mature and overmature timber is that marten in Newfoundland are restricted due to habitat security (i.e., marten occupying second-growth stands in previously-harvested area have road access thus marten experience increased incidental from hare snaring and trapping.)

In 1995, a 5-year cooperative project to determine the basic population characteristics of Newfoundland marten, particularly in relation to old-growth habitat was initiated. The overarching goal of the project was to evaluate competing explanations for the historical decline and current restricted distribution of Newfoundland marten. Field work began in June 1995 and in 1996 a second study site outside the PMSA and centered near Red Indian Lake in south-central Newfoundland was added. This second study site had what was believed to be a newly-established (<10 years) marten population. It was also assumed that because of past forest harvesting, the RIL study area had a recently established, low-density marten population occurring in sink habitat.

### PROJECT STATUS

Between 1995-2000, 157 martens were radiocollared within the core of their remaining distribution in southwestern and southcentral Newfoundland, and home-range characteristics, habitat use, survival rates, and cause-specific mortality factors were documented.

Annual home-range areas (95% minimum convex polygon) of adult resident martens in Newfoundland (males = 30.8 km<sup>2</sup>, n = 43; females = 12.8 km<sup>2</sup>, n = 49) were disproportionately larger than those reported for a marten population inhabiting a mainland setting in northcentral Maine (males = 3.8 km<sup>2</sup>, n = 135; females = 2.5 km<sup>2</sup>, n = 91). Allometric analyses revealed that home-range area (HR) of martens from Maine scaled approximately linearly (slope = 0.914) with body weight (BW) as  $HR = 0.73BW^{0.914}$  ( $r^2 = 0.148$ ) whereas the relationship in Newfoundland was strikingly nonlinear (slope = 1.545;  $HR = 0.04BW^{1.545}$ ).

Habitat selection by Newfoundland martens across landscapes comprised of a range of habitat types was based on 2,861 locations for 58 adult ( $\geq 1$  yr) resident martens from which 92 year-specific home ranges were calculated. At both the landscape- and stand-scales, martens utilized a broad range of habitat types within their home ranges, including, recent cuts, regenerating forest <6.5 m, precommercially thinned stands, and medium height (6.6-12.5 m) softwood stands, as well as mature (61- 80-years old) and overmature forest. Martens occupied home ranges that were not dominated by mature and overmature forest conditions; median availability of mature and overmature forest within the individual home range was only 30.03% (range 10.7-75.6%). Selection for tall closed softwood stands, which based on previous research was considered “preferred” marten habitat, was intermediate in relative preference to other vegetation classes at the landscape scale, and comprised only 12.5% of home ranges of adult resident martens. Age distributions were not different among martens with high, intermediate, and low amounts of mature and overmature forest in their home range. Further, martens occupying home ranges dominated by mature and overmature forests did not exhibit higher survival rates. Past studies of habitat selection by Newfoundland martens which concluded that Newfoundland martens were more dependent on old-growth coniferous forests than populations inhabiting mainland North America were not supported.

#### *FUTURE PLANS*

Two of the three chapters of the dissertation are completed: Chapter 1 documents home-range and spatial characteristics of marten in Newfoundland marten, and Chapter 2 reports the results of the multi-scale habitat selection analyses. The final chapter of the dissertation is in preparation and is using program MARK to analyses covariates associated with mortality and survival of marten in Newfoundland. The dissertation is scheduled for completion in May 2007.

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### **Fish Hosts and Population Structure of the Yellow Lampmussel (*Lampsilis cariosa*) and Tidewater Mucket (*Leptodea ochracea*) in Maine**

*Investigator:* J. M. Rhymer  
A. Huryn  
M. Kelly  
P. Wick  
S. Kneeland

*Cooperators/  
Project Support* Maine Department of Inland Fisheries and Wildlife  
Maine Outdoor Heritage Fund  
USGS-BRD Eastern Region State Partnership Program  
FWS - Endangered Species Program  
Maine Cooperative Fish and Wildlife Research Unit  
University of Maine - Department of Wildlife Ecology  
MAFES - Hatch

*Objectives:*

- 1) Increase our understanding of the demography and genetic structure of populations of yellow lampmussel and tidewater mucket in Maine.
- 2) Identify host fish species for these mussel species and relate host fish and mussel distributions.
- 3) Spatially relate the genetic and demographic composition of existing populations of tidewater mucket and yellow lampmussel to landscape factors.

We are collaborating with Dr. Cynthia Loftin (MCFWRU) to identify landscape scale factors that indicate suitable mussel and host fish habitat (Landscape Control of the Distribution of Two Rare Atlantic Slope Freshwater Mussels in Maine); results of that study are presented in a separate report.

#### *SCOPE*

Maine’s rarest mussels, the tidewater mucket, *Lampsilis ochracea* and yellow lampmussel, *Lampsilis cariosa*, are listed as threatened in the state and as endangered, threatened or of special concern by states elsewhere in their northeastern range. They occur as fragmented populations in three watersheds in central Maine - the Kennebec, Penobscot, and St. George. By virtue of the high quality of its water resources and the absence of zebra mussels, Maine has some of the last significant populations of these mussels. These watersheds could well serve as important refugia for *Lampsilis ochracea* and *Lampsilis cariosa* if populations along the Atlantic slope are extirpated. Although the current distributions of the tidewater mucket and yellow lampmussel have been well documented in Maine, conservation efforts are hampered by lack of knowledge of:

1) fish host(s) and factors affecting their distribution, 2) population age (viability) and genetic structure (degree of isolation), and 3) effects of disconnected or deteriorating habitat quality on mussel distribution. Isolation of mussel populations could affect their age structure, reproductive potential, and population viability, and also promote genetic divergence among populations. Understanding patterns of genetic differentiation among populations will provide a rationale for determining whether their metapopulation should be managed as one or several distinct conservable units, and may provide a more logical basis for understanding factors responsible for the present-day distribution of these mussels in Maine.

#### *PROJECT STATUS*

Laboratory experiments revealed that white perch (*Morone americana*) is a probable host for both yellow lampmussel and tidewater mucket and yellow perch (*Perca flavescens*) may also be a host for yellow lampmussel. Population age structure has been analyzed for several populations of each mussel species and genetic analyses are complete.

#### *FUTURE PLANS*

DNA analysis was done to determine if fish species other than those identified in the lab are used in nature by tidewater mucket and yellow lampmussel. MS theses on fish hosts and population structure were completed in May 2006 and August 2006.

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### **Landscape Control of the Distribution of Two Rare Atlantic Slope Freshwater Mussels in Maine, the Yellow Lampmussel (*Lampsilis cariosa*) and the Tidewater Mucket (*Leptodea ochracea*)**

*Investigators:* C.S. Loftin

*Cooperators/  
Project Support:* USGS-BRD Eastern Region State Partnership Program  
University of Maine - Department of Wildlife Ecology  
University of Maine - Department of Biological Sciences  
Maine Cooperative Fish and Wildlife Research Unit

*Objectives:* Identify landscape-scale factors indicating suitable habitat for yellow lampmussels and tidewater muckets in Maine.

(This study is part of larger study developed under the USGS State Partnership Program with Drs. Judith Rhymer and Alex Huryn at the University of Maine. The final project report combined the results of Dr. Rhymer's and Dr. Huryn's study with the study discussed herein.)

#### *SCOPE*

The declining condition of the world's aquatic environments is resulting in a loss of aquatic biodiversity. Freshwater bivalves are experiencing drastic declines in distribution and number due to a variety of disturbances. North America contains the greatest diversity of freshwater bivalves in the world, yet more than half of the remaining species are threatened with extinction. Although in many cases mussel decline can be attributed to manipulations of the local environment, forces at a larger scale may contribute to the occurrence and structure of mussel communities. Cumulative effects of upstream and stream-side land uses and hydrological modifications may affect mussel occurrence in a watershed, potentially deteriorating quality of occupied sites or leading to population isolation due to unsuitable hydrological conditions between occupied sites. These modifications may lead not only to a change in mussel community composition, but also to a change in ecosystem structure and function resulting from modification of the density and composition of the bivalve community. However, mussel distributions may also be somewhat independent of habitat conditions and more tightly regulated by abundance and diversity of host fish. Efforts to conserve North America's remaining mussel populations must recognize the complexity of relationships among potential determinants of mussel community composition, distribution, and demography and the multiple scales at which those relationships occur (Vaughn 1997).

Distributions of Maine's mussel species have been documented by Maine's Department of Inland Fisheries and Wildlife (MDIFW). The tidewater mucket (*Leptodea ochracea*) and the yellow lampmussel (*Lampsilis cariosa*) are state-listed as threatened species due to their scattered, declining populations. The relationships of these mussel distributions to watershed conditions such as stream connectivity, dam locations, riparian land use, and hydrological condition have not been examined. Identification of landscape- and local-scale conditions of stream reaches, river segments, and ponds and lakes occupied by these mussels is critical to conservation of these mussel species. Given that Maine contains some of the last, significant populations of the tidewater mucket and yellow lampmussel in eastern North America, and its watersheds are relatively undeveloped, conservation of these species may hinge on protection of the populations that remain in Maine.

**PROJECT STATUS**

The study is complete.

**FUTURE PLANS**

A brief synopsis of the study results follows:

Watershed analysis based on available GIS data layers and mussel survey data indicated that tidewater muckets and yellow lampmussels occupy streams with similar characteristics. Both species were found in streams with forested riparian zones as the dominant cover type. There was a greater proportion of wetland area in the reach and contributing watersheds where these species were found than was present statewide, and wetland comprised a greater proportion of the buffer of reaches occupied by tidewater muckets than in reaches where yellow lampmussels were found. In the region where these species occur, streams that did not contain these species had more forest cover and less wetland streamside in the reach catchments than in reaches where the species was present. Yellow lampmussels and tidewater muckets occupy reaches that are longer, have larger contributing areas, more upstream connecting first order streams, and lower gradients than reaches that are not occupied by these species. These reach characteristics indicate conditions that create hydrological stability, a feature suggested in other mussel studies to be a useful predictor of yellow lampmussel occurrence and mussel community composition. Tidewater muckets were found more often in reaches connected upstream to shorelines of large streams or rivers and downstream in reaches connected to shorelines of large streams and lakes; downstream connections were less often to small streams. The number of dams did not differ between reaches with and without tidewater muckets, but the total dam height per stream mile in the contributing area of sites without muckets exceeded the cumulative height per stream mile for sites with muckets. Percent calcareous bedrock in the cumulative upstream drainage area was greater in reaches containing tidewater muckets than where they were not found, reflecting the near-coastal distribution of the species in Maine. Yellow lampmussels were found at sites most often connected to streams and shorelines of large rivers and less often to lakes, and stream order was greater and cumulative watersheds larger where this species was found. Number of upstream dams was not different between reaches with and without yellow lampmussels, although cumulative dam height per stream mile in the contributing area was less where the species occurred than where it was not found. In contrast to watersheds occupied by tidewater muckets, those where yellow lampmussels were found contained less calcareous bedrock in the cumulative upstream drainage area. Attempts to develop logistic regression models describing features of watersheds occupied by tidewater muckets and yellow lampmussels were unsuccessful; the low numbers of sites containing mussels distributed across a broad range of conditions resulted in unreliable models.

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## **Road Mortality Risk for Spotted (*Clemmys gattata*) and Blanding's (*Emys blandingii*) Turtle Populations**

*Investigator:* F. Beaudry

*Advisors:* M. L. Hunter, Co-chair  
P. G. deMaynadier, Co-chair  
J. M. Rhymer  
D. J. Harrison  
D. Hiebeler

*Cooperators/  
Project Support:* Maine Department of Transportation  
University of Maine - Department of Wildlife Ecology  
Maine Department of Inland Fisheries and Wildlife  
Maine Outdoor Heritage Fund  
U. S. Fish and Wildlife Service  
U. S. Environmental Protection Agency  
The Nature Conservancy  
Norcross Wildlife Foundation

*Objectives:*

- 1) Evaluate habitat selection and seasonal movement patterns of spotted and Blanding's turtles in Maine.
- 2) Develop a GIS-based model to identify turtle-road hotspots, which will allow targeting current mitigation needs and modeling avoidance planning during future projects.

- 3) Develop a predictive model of spotted and Blanding's turtle persistence and road mortality rates linked to a spatially-explicit population viability analysis.
- 4) Complete a comprehensive review of road conservation mitigation options suitable for endangered turtles in southern Maine.

#### *SCOPE*

Recent population analyses of several freshwater turtle species indicate that as little as 2-3% additive annual mortality of adults is unsustainable, leading ultimately to local population extinction. As such, road-kill may prove to be the single most important factor threatening the extinction of the Spotted (*Clemmys gattata*) and Blanding's (*Emys blandingii*) turtle in Maine. There is increasing emphasis on the part of federal and state transportation authorities to minimize and mitigate impacts to wildlife populations from road construction and improvement projects. To this end, the project objectives outlined above are designed to help identify the extent and significance of road impacts to endangered turtles in Maine as a precursor towards a) designing strategic mitigation measures for problem road sections, and b) identifying remaining roadless remnants of the landscape where long term turtle population viability remains highest.

#### *PROJECT STATUS*

From 2004 through 2006, 41 spotted turtles and 50 Blanding's turtles have been tracked by radio-telemetry. Movement data has been collected at two scales, and habitat variables have been collected at 228 wetlands.

#### *FUTURE PLANS*

Analyses, modeling, and writing will be ongoing through the spring 2007.

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### **Methods for the Translocation of the Yellow Lampmussel (*Lampsilis cariosa*) and the Tidewater Mucket (*Leptodea ochracea*) in the Fort Halifax Dam Impoundment of the Sebasticook River, Maine.**

*Investigator:* J. Kurth

*Advisors:* J. M. Rhymer, Co-chair  
C. S. Loftin, Co-chair  
J. Zydlewski  
M. Kinnison

*Cooperators/  
Project Support:* Maine Department of Inland Fisheries and Wildlife  
USGS – State Partnerships Program  
Maine Cooperative Fish and Wildlife Research Unit  
University of Maine - Department of Wildlife Ecology

- Objectives:*
- 1) Perform qualitative and quantitative surveys of the Fort Halifax dam impoundment to determine locations, densities, and population age/size structures of yellow lampmussel and tidewater mucket.
  - 2) Translocate mussels within the Sebasticook River and to Unity Pond and Sandy Stream to determine survival rates.
  - 3) Assess PIT tags as a monitoring tool for relocating mussels.

#### *SCOPE*

Potential removal of the Fort Halifax dam on the Sebasticook River is currently under review. Its removal would strand populations of yellow lampmussel and tidewater mucket during dewatering, and as such, would present a unique situation in North America. Dam removals have not affected listed mussel species in other cases. Even if the Fort Halifax dam is not removed, petitions to remove dams in Maine are expected to increase in the future. Our data will provide insight into the current and potential distribution of these species, as well as provide information on the potential success of using mussel translocation as a tool to minimize effects of dam removals. This information will assist agencies in conservation planning for and recovery of protected mussel species.

#### *PROJECT STATUS*

Qualitative and quantitative mussel surveys have been done of the Sebasticook impoundment and experimental translocations have been completed both within the impoundment and at two other localities within the same drainage.

Experimental use of PIT tags for freshwater mussel relocations has been explored. All mussels in the translocation studies were tagged with PIT tags attached externally to the shell. Mussels translocated in 2004 were recaptured in 2005 using visual searches only or with a backpack PIT tag reader with visual confirmation. Recapture rates using PIT tags exceed those of visual searches alone in 2005. All translocated mussels were recaptured in 2006 using only the backpack PIT tag reader with visual confirmation. Internal PIT tag retention was studied in tanks at the Aquaculture Research Center, University of Maine, in 2004, and in enclosures in Unity Pond in 2005. Tissue samples from mussels tagged in 2005 and placed in enclosures were collected for at time of tagging and again in August 2006 for glycogen analysis as a measure of condition. Glycogen analyses of tissue samples were completed in Fall 2006. Final recapture of translocated PIT tagged mussels was completed during Summer 2006, and a manuscript detailed this research will be published in the Journal of the North American Benthological Society in 2007.

#### *FUTURE PLANS*

The M.S. thesis will be completed in spring 2007.

## **Spatial and Temporal Dynamics of Habitat Supply for Canada Lynx (*Lynx canadensis*) and American Martens (*Martes americana*) on Commercial Forestlands in Maine**

*Investigator:* Erin Simons

*Advisors:* D. J. Harrison, Co-chair  
W. B. Krohn, Co-chair  
M. K. Beard-Tisdale

S. A. Sader  
J. S. Wilson

*Cooperators/  
Project Support:* 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 – School of Forest Resources  
The Nature Conservancy - Maine Chapter  
Huber Resources Corporation

*Objective:*

- 1) Develop a retrospective time series (1988-2004) 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 spatio-temporal variation to landscape change due to past forest management.
- 3) Develop a set of future (25+ years) time series based on alternative future forest management scenarios exploring tradeoffs between fiber and wildlife habitat objectives.
- 4) Determine how future (25+ years) forest management may affect the township-scale pattern and spatial variability of Canada lynx and American martens habitat supply and predicted occurrence in Maine.

#### *SCOPE*

This project will use predictive species occurrence models to evaluate the effects of forest management on the spatio-temporal dynamics of habitat quantity and distribution for the Canada lynx (*Lynx canadensis*) and the American marten (*Martes americana*) in northern Maine. 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 lynx and martens. Because both species are area sensitive and are known to respond to landscape change at large spatial scales, it is important to evaluate habitat change at a large-scale. Managing for a species' habitat should incorporate enough area to

allow for a relatively constant supply of habitat, even though it may move around on the landscape as a result of landscape change. Also, one can expect that patterns of lynx and marten occupancy will be affected differentially by landscape change because of dissimilarities in their habitat requirements.

Maine in particular provides an interesting setting for studying the effects of forest management on landscape change and on lynx and marten habitat supply because Maine is greater than 90% forested, and the vast majority (97%) of Maine's forestlands are privately owned. Consequently, changes to regulations governing timber-harvesting practices can affect the entire area occupied by lynx and martens in Maine. Following the 1989 Maine Forest Practices Act (MFPA), trends in commercial timber harvesting have shifted towards increasing reliance on partial harvesting in Maine's Acadian Forest. Partial harvests now account for approximately 96% of the annual harvest. Lynx, along with its primary prey the snowshoe hare (*Lepus americanus*), are associated with early-successional forest, the availability of which has likely decreased since the implementation of the MFPA and the reduction in the total area being clear-cut annually. Martens in Maine have been shown to use a variety of mid- to late-successional forest types, but there is a threshold, defined by 30% canopy closure and 18 m<sup>2</sup>/ha basal area, below which martens are considerably less likely to use a forest stand. Partial harvests may result in the loss of the within-stand vertical and horizontal structure martens require.

This project will use both satellite imagery and stand-scale forest simulation to determine how forest management affects the habitat supply of lynx and martens in Maine, and to provide a tool for forest managers to use in managing for lynx and marten habitat in the future. In collaboration with two laboratories in the School of Forest Resources, we will develop two time series datasets that will be used as the basis for applying logistic regression models for predicting probability of occurrence by lynx and martens. We will develop a retrospective time series (1988-2004) of species occurrence maps based on Landsat Thematic Mapper (TM) satellite imagery classified according to the Maine GAP land cover map and modified using NDVI-based change detection techniques to identify harvests. We will also develop a prospective time series of species occurrence maps based on the projections of stand maps for select townships 25-50 years into the future given a range of future management scenarios. With these time series, we can determine the short- and long-term effects of forest management on the pattern and spatial variability of predicted occurrence of lynx and martens. By evaluating specific alternative forest management strategies, this analysis will allow us to make recommendations to forest managers concerning the maintenance or creation of lynx and marten habitat. In evaluating the spatio-temporal dynamics of lynx and marten habitat supply in Maine, this project will provide a better understanding of the relationships between forest management, landscape change, and occurrence patterns of wide ranging forest carnivores.

#### *PROJECT STATUS*

The Landsat TM-based time series identifying areas harvested 1988-2004 has been completed and we are currently creating updated forest cover maps (1988-2004) and preparing this time series for application of the lynx and marten predictive occurrence models. We have also begun development of the alternative forests management scenarios and preparation of forest stand maps for simulation.

#### *FUTURE PLANS*

Using the retrospective time series of forest cover maps, we will document the cumulative effects of evolving management practices, including changes in landscape pattern, forest age class distributions, forest composition, and consequent changes in lynx and marten habitat supply. Once alternative forest management scenarios are fully developed, we will evaluate the effects of forest management on future lynx and marten habitat supply. The expected completion date of this project is May 2008.

## **FISHERIES RESOURCES**

### **Alternative Methods for Enumerating Juvenile Atlantic Salmon (*Salmo salar*) and Studying Their Distribution in Maine Rivers**

*Investigator:* S. L. Fleming

*Advisors:* K. E. Webster, Co-chair  
J. R. Trial, Co-chair  
J. F. Kocik  
J. Zydlewski  
J. Moring, Chair –deceased

*Cooperators/  
Project Support:* Maine Atlantic Salmon Commission  
National Marine Fisheries Service  
Maine Cooperative Fish and Wildlife Research Unit

*Objectives:*

- 1) Test three alternative techniques for estimating juvenile Atlantic salmon populations in Maine rivers as possible replacements for electrofishing.
- 2) Develop density distributions of juvenile Atlantic salmon as related to physical parameters of sites.

#### *SCOPE*

Atlantic salmon populations in eight Maine rivers have been placed on the Endangered Species List. The common method of assessing stream populations of juvenile salmon is backpack electrofishing – a potentially harmful technique. This project observes juvenile Atlantic salmon in various river conditions using the less invasive techniques of snorkeling, streamside viewing, and overhead observation. In addition, while conducting the snorkeling technique, locations of fishes were flagged and density distributions for the site were analyzed.

#### *PROJECT STATUS*

All fieldwork has been completed and data are being analyzed.

#### *FUTURE PLANS*

A manual detailing method for conducting juvenile Atlantic salmon surveys using the snorkeling technique will be prepared for the Maine Atlantic Salmon Commission. A Master of Science thesis is expected to be completed in 2007.

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

*Investigator:* C. A. L. Jackson

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

*Cooperators/  
Project Support:* 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 smallmouth bass 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 a 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 impacts of catch and release on native brook trout is 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*

Juvenile brook trout, smallmouth bass (*Micropterus dolominei*), and landlocked Atlantic salmon movement data were collected and are being analyzed.

#### *FUTURE PLANS*

A Master of Science thesis is expected to be completed in December 2007.

## **Movements and Survival of Adult and Juvenile Atlantic Salmon (*Salmo salar*) in the Penobscot River**

*Investigator:* C. M. Holbrook

*Advisors:* J. Zydlewski, Co-chair  
M. T. Kinnison, Co-chair  
J. F. Kocik

*Cooperators/  
Project Support:* Maine Cooperative Fish and Wildlife Research Unit  
National Marine Fisheries Service  
Penobscot Indian Nation  
U.S. Fish and Wildlife Service  
Maine Atlantic Salmon Commission

*Objectives:*

- 1) Use acoustic telemetry to assess mortality, passage, and behavior of emigrating Atlantic salmon smolts in the Penobscot River.
- 2) Assess migratory patterns of adult Atlantic salmon through the Penobscot Bay and River.

#### *SCOPE*

The Penobscot River supports the largest run of Atlantic salmon (*Salmo salar*) in the United States. Despite extensive hatchery supplementation, salmon numbers in this system have recently declined and remain low. In an effort to mitigate losses, two main stem dams are scheduled for removal within the next ten years, with increased fish passage and hydroelectric upgrades scheduled at others. In this study, movement of both hatchery- and naturally-reared smolts will be described in order to quantify 1) path choice 2) transit times and 3) loss to the system (mortality).

An array of acoustic telemetry receivers was deployed, and juvenile salmon were implanted with coded acoustic pingers in order to track movements. Additionally, adult Atlantic salmon were implanted with acoustic pingers in order to assess the feasibility of using acoustic telemetry to describe migratory patterns. These data will provide a baseline for assessing effects of dams on survival, for determining the relative success of stocking practices, and for predicting potential benefits associated with management activities in the Penobscot River.

#### *PROJECT STATUS*

Data collection for smolt and adult movements is complete. Analysis is in progress.

#### *FUTURE PLANS*

A Master of Science thesis is expected to be completed in May 2007.

## **Does Descaling Impair Osmoregulation in Seawater Challenged Atlantic Salmon Smolts (*Salmo salar*)**

*Investigators:* J. Zydlewski  
G. Zydlewski

*Cooperators/  
Project Support:* Maine Cooperative Fish and Wildlife Research Unit  
U.S. Fish and Wildlife Service  
University of Maine

*Objectives:*

- 1) Evaluate the ability of smolts to successfully osmoregulate in seawater after receiving a descaling injury.
- 2) Evaluate variation in this response over the period of smolt migration.
- 3) Characterize the time course of recovery to full osmoregulatory performance subsequent to this injury.

#### *SCOPE*

The Penobscot River supports the largest run of Atlantic salmon (*Salmo salar*) in the United States. Nonetheless, populations in this and neighboring systems have experienced precipitous declines, culminating in Endangered Species Act listing of nearby runs. Efforts to mitigate losses in the Penobscot have included extensive supplementation efforts dating back to the late 1800s. The continuing decline of wild stocks and the failure of hatcheries to stem declines have been attributed to many factors including poor downstream passage.

Mortality of both wild- and hatchery-reared smolts can be significant. Survival of hatchery reared Atlantic salmon from stocking locations to saltwater entry may be as low as 50%. Dams are known to be a site of impact through delays in migration, increased predation risk, and direct injury. Descaling is a commonly observed injury in many migrating smolts, particularly towards the end of the migratory season. The significance of this injury and the long-term prognosis for these fish are uncertain.

Though descaling is used as an index of physical damage, few studies have examined the physiological responses of salmonids to scale loss or subsequent performance and survival. It is the goal of this study to evaluate 1) the ability of smolts to successfully osmoregulate in seawater after receiving a descaling injury, 2) variation in this response over the period of smolt migration, and 3) the time course of recovery to full osmoregulatory performance subsequent to this injury. The information and criteria developed from this study are of highest priority as outlined in the Draft Atlantic Salmon Recovery Plan, which urge the examination of early mortality as smolts transition from fresh water to the ocean.

#### *PROJECT STATUS*

The study has been completed. Final analysis and reporting is complete.

#### *FUTURE PLANS*

A manuscript is being prepared for publication.

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### **Evaluation of Dennys and Penobscot River Smolt (*Salmo salar*) 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:* Maine Cooperative Fish and Wildlife Research Unit  
Maine Atlantic Salmon Commission  
U.S. Fish and Wildlife Service

*Objectives:*

- 1) Compare the physiologic 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

This study was carried out and completed in 2005.

#### FUTURE PLANS

A Master of Science thesis is expected to be completed in spring 2007.

## Long Term Seawater Performance of Atlantic Salmon (*Salmo salar*) with Different Freshwater Experiences

*Investigators:* J. Zydlewski  
G. Zydlewski

*Cooperators/  
Project Support:* Maine Cooperative Fish and Wildlife Research Unit  
U.S. Fish and Wildlife Service  
University of Maine

*Objectives:* Assess gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity as an evaluation tool to predict long term performance of Atlantic salmon smolts in seawater.

#### SCOPE

Gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity is highly variable during smolting and can vary with environmental conditions, yet is used by natural resource agencies as a predictor of seawater performance. We want to determine whether it is a true predictor of long-term seawater performance. In 2006, two groups of Atlantic salmon (*Salmo salar*) will be used to determine the predictability of long-term seawater performance using gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity: hatchery fish and streamside-reared fish. Fish (with known levels of gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity) will be moved to a seawater facility (Center for Cooperative Aquaculture Research - CCAR) where they will be monitored daily. All fish will be non-lethally sampled every 2 weeks through August for performance. Measurements that will be taken for all individuals include: fork length, weight, scales (a minimal number with forceps), and picture for landscape analysis (quantification of body shape). Specific growth rates for all individuals from the hatchery will be calculated and correlated to freshwater gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity. For streamside reared fish (with known water quality history) specific growth in seawater will be correlated with freshwater gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity and compared among sites with varying water quality. On several occasions (24 and 72 h; 2, 4, 8, and 16 weeks after seawater transfer), 20 fish will be lethally sampled to determine a potential period of osmoregulatory difficulty. Blood will be drawn to determine plasma ion concentration and osmolality to examine osmoregulatory performance. Gill samples will be taken to determine final gill  $\text{Na}^+$ ,  $\text{K}^+$ -ATPase activity. Tissue will be sampled for RNA/DNA ratios at the 72 h and 2 week lethal time points. Sex and degree of maturity/gonadal development will be

determined and scale samples will be taken for examining the timing of ring deposition. Freshwater gill  $\text{Na}^+, \text{K}^+$ -ATPase activity will be correlated with individual specific growth rates, final gill  $\text{Na}^+, \text{K}^+$ -ATPase activity, and final degree of maturity.

*PROJECT STATUS*

This study has been completed.

*FUTURE PLANS*

A report and publication is expected in spring 2007.

**Using Dendrochronology and Stable Isotopes to Document the Presence of Marine Derived Nutrients Deposited Historically in the Penobscot River Basin, Maine**

*Investigators:* C. Loftin  
J. Zydlewski  
G. Zydlewski

*Cooperators/  
Project Support:* Maine Cooperative Fish and Wildlife Research Unit  
National Oceanic & Atmospheric Administration  
University of Maine  
USGS – Cooperative Research Units Eastern Region Funds

*Objectives:*

- 1) Obtain dendrochronological cores from old, riparian trees in areas that have been exposed to marine derived nutrient contribution and control sites in Maine.
- 2) Measure ratios of marine to freshwater-derived carbon and nitrogen isotopes in annual growth rings.
- 3) Identify areas in the Penobscot drainage with old growth trees that may have been exposed to marine derived nutrients prior to main-stem dam construction (early 1800s) for future study.

*SCOPE*

Characterizing the role of marine derived nutrients in the Penobscot River has important implications for management of the watershed. This topic is central to discussions concerning the planned removal of two main-stem dams. The ecological role of historically prominent migratory species is controversial in both scientific and political arenas because of the paucity of historical data.

The ratios of naturally occurring levels of carbon ( $^{13}\text{C}$  and  $^{12}\text{C}$ ) and nitrogen ( $^{15}\text{N}$  and  $^{14}\text{N}$ ) 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” are also observed in anadromous fish that migrate between marine and fresh water environments. Anadromous fish runs can deliver considerable marine-derived biomass to the food webs of fresh water systems, leaving detectable “marine signatures” in the ecosystem, including the plant community. Importantly, trees can chronicle fluctuations in this signature by the growth of annual rings.

Long-lived trees offer tremendous opportunity to chronicle marine derived nutrient contributions to fresh water ecosystem in the Penobscot River watershed. Those few large trees whose growth has spanned periods before and subsequent to dam construction may carry quantifiable signatures of marine derived nutrients through a historic time series. These data may also help interpret the spatial extent of this contribution throughout the Penobscot River drainage.

*PROJECT STATUS*

Initial samples have been collected and are being processed.

*FUTURE PLANS*

A report is anticipated in 2007.

## **Investigation into the Distribution and Abundance of Atlantic Sturgeon (*Acipenser oxyrinchus*) and Other Diadromous Species in the Penobscot River, Maine**

*Investigators:* S. Fernandes

*Advisors:* G. Zydlewski, Co-chair  
M. Kinnison, Co-chair  
J. Zydlewski

*Cooperators/  
Project Support:* Maine Cooperative Fish and Wildlife Research Unit  
National Oceanic and Atmospheric Administration

*Objectives:* Obtain information on the presence and seasonal distribution of Atlantic sturgeon in the Penobscot River.

### **SCOPE**

Information as to the presence and seasonal distribution of Atlantic sturgeon (*Acipenser oxyrinchus*) in the Penobscot River will be collected. This information is important to the ongoing status review on this species and will provide information that can be used to determine the effects of dam removal on the redistribution of diadromous species in the river.

This study will be concentrated on the Penobscot River from the mouth of the river to immediately below the Veazie Dam. The sturgeon research protocols developed by the National Marine Fisheries Service for studying Atlantic and short nose sturgeon will be followed. Gillnets and possibly trammel nets will be set in areas in which Atlantic sturgeon are believed to be present (either from anecdotal reports or in areas of suitable habitat). The study will be initiated in the fall of 2005 with initial assessments of likely habitat, planning of survey activities and possible test net developments. Full net surveys will commence in spring and summer 2006 and continue through fall during periods when water conditions permit safe capture and handling of sub adult and adult Atlantic sturgeon. Healthy sub adult and adult Atlantic sturgeon will be tagged with internal ultrasonic "acoustic" transmitters and will be tracked to determine seasonal distribution within the river.

### **PROJECT STATUS**

Project has been initiated.

### **FUTURE PLANS**

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

## **Movement of Lake Whitefish (*Coregonus clupeaformis*) in Clear Lake, Northern Maine**

*Investigators:* J. Zydlewski

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

*Objectives:* Characterize movements of adult whitefish in Clear Lake using acoustic telemetry.

### **SCOPE**

Lake whitefish (*Coregonus clupeaformis*) is a salmonid species with considerable fisheries importance in Maine. Many Maine lakes once had strong whitefish populations but over the past few decades, creel survey and inventory data indicate a marked decline. The few systems with relatively robust populations (e.g., Clear Lake) are currently being tapped as a source for hatchery supplementation. In the interest of effectively managing current populations and of mitigating regional losses, the Maine Department of Inland Fisheries and Wildlife has identified several key objectives including understanding the basic movement patterns of whitefish in key systems.

Acoustic telemetry offers a cost effective method for monitoring fish movement, with many advantages in lake systems. Acoustic telemetry functions by having a tag or "pinger" implanted into the fish of interest. The pinger gives off a unique series of energy pulses that can be recognized by listening receivers in their vicinity. Receivers for these tags are relatively

inexpensive and can be deployed individually throughout the area of interest in an “acoustic array”. An array in Clear Lake is being used to study movements (both vertical and throughout the systems) to identify key habitats.

#### *PROJECT STATUS*

Tagging of fish was initiated in 2004 and tracking will continue into 2007.

#### *FUTURE PLANS*

This project has attracted MDIFW support for a Ph.D. student project and this effort will be continued as part of the student’s dissertation.

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

*Investigators:* D. Gorsky

*Advisor* J. Zydlewski

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

*Objectives:*

- 1) Understanding the basic movement patterns of whitefish in key systems.
- 2) Compile historic data of whitefish presence and smelt introductions in Maine waters.
- 3) Conducting studies to 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 but over the past few decades creel survey and inventory data indicate a marked decline (Basely, personal communications). 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. In the interest of effectively managing current populations, and of mitigating regional losses, the Maine Department of Inland Fisheries and Wildlife (MDIFW) has identified several key objectives including: (1) Understanding the basic movement patterns of whitefish in key systems, (2) Compiling historic data of whitefish presence and smelt introductions in Maine waters, and (3) Conducting studies to assess the likelihood that smelt and whitefish are directly competing.

Approaches to address these three core objectives are in progress and are in close coordination and collaboration with MDIFW biologists.

#### *PROJECT STATUS*

This study has been initiated.

#### *FUTURE PLANS*

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

### **HABITAT RESOURCES**

#### **Simulating Wetland-Landscape Fire Disturbance and Succession to Demonstrate Potential for Changes in Amphibian Presence/Absence**

*Investigator:* J. McCloskey

*Advisors:* C. S. Loftin, Chair  
L. Smith

S. A. Sader  
W. B. Halteman  
J. Wilson

*Cooperators/  
Project Support:* USGS - BRD Florida Integrated Science Center  
U.S. Fish and Wildlife Service  
Okefenokee National Wildlife Refuge  
Maine Cooperative Fish and Wildlife Research Unit  
University of Maine - Department of Wildlife Ecology

*Objectives:*

- 1) Use satellite data to create a land cover map showing dominant vegetation associations within the Okefenokee Swamp.
- 2) Develop vegetation change detection maps by comparing current and past vegetation maps.
- 3) Develop model to simulate spatial and temporal effects of water levels and fire on vegetation composition and structure.
- 4) Develop models to show habitat association of specific amphibians species within the swamp vegetation types.

### *SCOPE*

The Okefenokee National Wildlife Refuge (ONWR) is a mosaic of several wetland communities covering approximately 1700 km<sup>2</sup>. Many amphibian species found within ONWR are obligatorily linked to water. Human activity (particularly fire suppression, logging, dredging, peat mining, and water impoundment) within ONWR may cause changes in the swamps natural hydrologic and fire regime. Such changes may be permanently altering the vegetation composition and structure of the swamp, thereby adversely affecting amphibian populations. This study will determine how changing fire and water levels effect the vegetation spatial distributions, composition, and structure of vegetation within ONWR. Subsequently, we will determine associations between existing vegetation and presence/absence of amphibians.

### *PROJECT STATUS*

All requirements for a Ph.D. degree were met in May 2006. The abstract of the dissertation follows:

Initially my goal was to examine relationships between vegetation composition and structure and amphibian abundance within Okefenokee National Wildlife Refuge (ONWR). Unfortunately, the data were unsuitable for extrapolating species-habitat relationships beyond the sampled areas (Appendix A). Therefore, I examined ways of restoring natural processes (i.e., fire) responsible for creating vegetative diversity and patchiness within which amphibians have evolved.

I used satellite data to provide managers with an accurate and efficient way to extract and monitor land cover changes due to fire. Results suggest ONWR is changing to a hardwood, fire intolerant system under a policy that disrupts the natural fire regime. I also tested two assumptions of fire policy: 1) wildfire activity has increased, and 2) increases are due to fuel accumulation following decades of fire suppression. Both assumptions are invalid for ONWR and burning is more dependent on fire weather than on age or spatial patterns of fuels. Therefore, I explored relationships among the El Niño Southern Oscillation (ENSO) cycle, local weather patterns, and fire frequency and extent. The La Niña phase of ENSO was associated with lower dry season rainfall and lower water levels. These two variables are correlated with increases in the number of fires and area burned. Thus, large fires within ONWR are inevitable events, and current policy should be revised to consider global controls on fire.

I developed a spatial model to investigate effects of different fire management scenarios on the composition and distribution of vegetation in ONWR. Results suggest current policies may be causing the ONWR system to shift into a different ecological state, resulting in a loss of vegetative diversity, patchiness, and resilience. Policy allowing a more natural fire cycle may prevent such a shift and could be accomplished through prescribed burns in specific communities or by allowing natural fires to burn.

Finally, I gain perspective into the cultural attributes of research and management communities that combine to inhibit institutional change and critique institutional arrangements that determine fire policy. I propose a model to facilitate exchange of information between researchers and managers in hopes of implementing an adaptive management program at ONWR.

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## **Characteristics of the Presettlement Forest of Northern Maine**

*Investigators:* L. J. Mitchener

*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 – Department of Ecosystem Science  
 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 chapters, which document who surveyed which townships, and when, along with the methods used, has been completed. A second chapter, comparing methods used and documenting major characteristics of the presettlement forest in northern Maine, is drafted and now in revision. Data analysis for the last two chapters, which will predict distributions of forest cover types and major tree species in northern Maine, is underway.

#### *FUTURE PLANS*

Completion of the dissertation is scheduled for the summer of 2007.

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## **A Long-Term Forest Ecosystem Study**

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

*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. Too 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 are undertaking (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; (8) meteorological observations. 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. By continuing to monitor populations and processes, we can attain the second objective. Over the course of 24 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 2006, tasks 3, 4, 5, 6, 7, 8, and as outlined above were completed.

### *FUTURE PLANS*

The 2007 field season will cover all the parameters measures annually.

## **Environmental Factors Associated with Unique Lake Communities in Maine**

*Investigators:* E. Schilling (Ph.D. student)  
K. DeGoosh (M.S. student)  
D. Anderson (Research Associate)

*Advisors:* For Emily Schilling (Ph. D. student):  
C. S. Loftin, Chair  
A. Huryn  
K. Webster  
P. Vaux  
J. Trial

For Katie DeGoosh (M. S. student):  
C. S. Loftin, Co-chair  
K. Webster, Co-chair  
D. Anderson  
A. Dieffenbacher-Krall  
M. Kinnison

*Cooperators:* Maine Outdoor Heritage Fund  
*Project Support* Maine Department of Inland Fisheries and Wildlife  
University of Maine - Department of Wildlife Ecology  
University of Maine - Department of Biological Sciences

National Science Foundation Research Fellowship  
Maine Cooperative Fish and Wildlife Research Unit

- Objectives:*
- 1) Determine the effects of the introduction of fish on macroinvertebrate communities of fishless lakes in Maine.
  - 2) Identify attributes of macroinvertebrate communities that indicate fishlessness.
  - 3) Identify geomorphic and geographical factors controlling the distribution and abundance of fishless lakes in Maine.
  - 4) Build GIS-based models predicting the probability that a given lake is fishless.
  - 5) Assess the accuracy of the models using macroinvertebrate indicator species.

*SCOPE*

Throughout much of the 20<sup>th</sup> century, the introduction of game fish to inland waters of the United States and Canada was conducted at a furious pace. The goal of these introductions was generally to enhance game-fishing opportunities. In some cases, lakes and streams with native fish species, such as members of the Cyprinidae, were stocked with other species considered more desirable as game fish. In other cases, lakes and streams that were truly “fishless” were stocked. Until recently, fishless lakes were viewed as having little or no value to society, as indicated by the term “barren” that was widely used to describe them. Over the past several decades, however, there has grown a considerable body of knowledge supporting views of such “barren” water bodies as habitats for uniquely structured animal communities, as excellent trophic habitats for waterfowl, and as landscape-level source habitats for amphibians and other biota.

Over the past several decades, financial support for the documentation and management of the biodiversity and ecological integrity of public lands has increased. This has resulted in considerable effort toward the enumeration, conservation, and restoration of fishless lakes. However, accurate estimates of the number and distribution of these habitats, prior to the widespread stocking efforts of the mid- to late 20<sup>th</sup> century, are few. Estimates for six of Canada’s western mountain parks indicate that over 20% of their lakes have been altered through introductions of non-native fish. The situation in the United States is more extreme. Fewer than 45% of the 16,000 high lakes in the western mountains remain un-stocked, although 95% were naturally fishless. The rehabilitation of stocked lakes is now a priority for national park management in North America.

Maine Department of Inland Fisheries and Wildlife (MDIFW) has documented at least 30 fishless ponds in Maine; many ponds currently with fish are known to have been fishless prior to stocking. Documented fishless ponds and stocked but previously fishless ponds (and perhaps previously fishless ponds that were stocked and are now populated with naturalized stock) occur throughout the state, many in watershed headwaters. This wide distribution suggests that other fishless ponds likely exist. The ability to predict the likelihood that a particular pond is currently or historically fishless based on its landscape setting and geomorphic features would assist the MDIFW in balancing recreational management objectives with the responsibility to protect unique wildlife habitats. We will sample invertebrates in ponds in selected regions of Maine that are currently “fishfull” and compare those with ponds that have various degrees of fishlessness (naturally and those with a history of stocking). These data will be combined with geomorphic and geographic information to develop GIS-based models predicting locations of ponds that are most likely, naturally fishless. Macrovertebrate indicator species will be used to assess the accuracy of model predictions during subsequent field sampling. We will also develop and apply methodologies to document the historic presence or absence of fish in lakes predicted to be fishless but found to contain fish, to confirm model predictions.

*PROJECT STATUS*

Invertebrate and fish surveys of fishless-fishfull lake pairs: During the summers of 2002 and 2003, thirty-seven ponds (18 currently fishless, 6 historically fishless, 12 fishfull) were sampled around the state using various techniques to quantify differences in invertebrate communities between fishless and fishfull lakes. The study lakes represent two types of fishless lakes. In central and western Maine the lakes are at high elevations and are located high in the watershed, some on the watershed boundary. Lakes located high in the watershed likely have steep outlet streams, which create barriers to fish migration. This is the probable cause for fishlessness of this set of lakes. In Downeast Maine, we sampled a set of kettle lakes that have no outlet or inlet and have a low pH (less than 5.0). The pH of these lakes makes them inhabitable by fish unless they are limed (a practice that has been conducted by MDIFW to make acidic waters habitable by stocked fish). GIS analyses were conducted to describe landscape characteristics for study lakes. The data were used to build a model to predict the probability of a given lake being fishless. During the summer of 2004, we surveyed 20 new ponds (10 of each type) that were predicted to be fishless for fish and invertebrates. The fish survey data combined with data gathered from sediment cores (described below) will provide an indication of the accuracy of our predictive model. Invertebrate samples from all study lakes are currently being sorted and identified, with the aim of finding species that can be used as indicators of the fishless condition.

Paleolimnological study of fishless-fishfull lake pairs: Published research has shown the presence of certain species of the aquatic larvae of *Chaoborus* spp. (Diptera), indicates fishless conditions in lakes. This paleolimnological indicator, *Chaoborus americanus*, may be identified in sediments by their mandibles, which can remain in sediments of hundreds of years. During the summer of 2004, sediment cores were collected at 40 ponds (n=18 fishless ponds, 22 fishfull ponds) using a Huung-ve gravity corer. The top sediments in these cores will be examined for the presence of *Chaoborus americanus*, to determine if *Chaoborus* remains in the sediment do indeed indicate fishless ponds in Maine. Further, the cores from those ponds predicted to be fishless by the model described above will be analyzed to determine historical fish presence in the pond.

#### *FUTURE PLANS*

Invertebrate and fish surveys of fishless-fishfull lake pairs: Invertebrate samples collected during the 2001-2004 field seasons have been sorted and taxonomic identification is complete. Data analysis is underway.

Paleolimnological study of fishless-fishfull lake pairs: The calibration data set has been completed, and the GIS model has been evaluated. The thesis will be completed in early 2007.

## **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  
USGS Biological Resources Discipline  
Maine Department of Environmental Protection  
U. S. Environmental Protection Agency  
Houlton Band of Maliseet Indians  
Manomet Center for Conservation Sciences

*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*

Sample analysis, including algal species identification, is currently underway.

#### *FUTURE PLANS*

Data analysis will continue during 2007; dissertation completion is expected during 2008.

## WILDLIFE RESOURCES - MIGRATORY BIRDS

### The Long-Term Effects of a Selective Timber Harvest on the Bird Community of an Oak-Pine Forest in Maine

*Investigator:* S. P. Campbell

*Advisors:* M. L. Hunter, Chair  
W. B. Halteman  
D. J. Harrison  
J. M. Rhymer  
A. S. White

*Cooperators/  
Project Support:* Holt Woodlands Research Foundation  
University of Maine - Department of Wildlife Ecology  
NSF GK-12 Teaching Fellowship

*Objectives:*

- 1) Examine changes in bird abundance in response to harvest-created gaps.
- 2) Examine shifts in habitat use in response to harvest-created gaps.
- 3) Compare local trends in bird abundance to regional trends.
- 4) Investigate temporal and spatial stochasticity of habitat use.

#### SCOPE

Population declines in many species of Neotropical migrant birds have largely been attributed to the destruction and degradation of forest on their tropical wintering grounds as well as on their temperate breeding grounds. These findings have in turn drawn considerable attention to forest management in both tropical and temperate regions. Much of this attention has been given to the effects of even-aged forest management practices such as clear-cutting; however, few studies have examined the effects of uneven-aged forest management practices such as group selection, which creates small openings or gaps in a forest.

One such study that is examining the effects of a group-selection harvest on the forest bird community is being conducted at the Holt Research Forest in Arrowsic, Maine. The Holt Research Forest is the location of a long-term (24 years to date) oak-pine forest ecosystem study that was established with the broad goals of monitoring long-term changes in the forest's plant and animal communities and documenting the effects of forest management practices on these communities. The research forest was established in 1983 and after five years of baseline data collection on the entire 40-ha study area, the managed half of the area was harvested such that 10 1-ha blocks were partially cut with a group-selection timber harvest. The control half of the forest remained unharvested. Since the timber harvest in 1987-1988, data collection has continued. This effort has resulted in long-term databases reflecting the effects of harvest-created gaps on the forest and its associated communities. In particular, the resident scientist (J. Witham) has compiled an extensive database on the bird community by territory mapping all species encountered in 16 visits to the study area during each breeding season.

Using the first 20 years of this long-term data set, I plan to examine various aspects of the effects of harvest-created gaps on the bird community. Specifically, I will be examining changes in abundance and spatial distribution in response to the creation of the gaps. In addition, I will compare the long-term population trends of birds at the Holt Forest to those trends occurring on a regional scale to assess the possibility that the local population dynamics were simply a reflection of regional population dynamics. Finally, I plan to investigate the degree of temporal and spatial stochasticity of habitat use, i.e., I will analyze the pre-harvest bird distributions to see if the same areas of the forest are repeatedly preferred or if territory placement is random.

#### PROJECT STATUS

I have completed manuscripts that address the changes in abundance and spatial distribution following the harvest (Objectives 1 and 3) and will submit them for publication in peer-reviewed scientific journals. I have also completed the analysis that compares local trends to regional trends (Objective 2); the results will be included in the dissertation. I am currently investigating the degree of year-to-year stochasticity in habitat use (Objective 4). Brief qualitative summaries of the results corresponding to the first three objectives are below.

The first cutting cycle of a group-selection harvest did not result in overwhelmingly positive or negative effects on bird abundance at the Holt Research Forest. There was a slight increase in the number of species in the study area, but no change in the combined abundance of 28 bird species. Among the 22 individual species abundant enough for analysis, the responses were quite varied, but in general the group selection harvest retained the mature forest bird community while

temporarily benefiting a few early successional bird species. Most notably, the Eastern Wood-Pewee, Winter Wren, Pine Warbler, and White-throated Sparrow increased in abundance in the managed half of the study area following the harvest while the Veery decreased in the same area. The Black-and-white Warbler, Nashville Warbler, and Common Yellowthroat showed a positive response as indicated by decreases in abundance in the control half and more protracted declines or stable abundances in the managed half. Comparisons of the trends in abundances from the Holt Research Forest to statewide BBS trends showed little agreement, which suggests that birds were primarily responding to local habitat conditions.

Although there were few strong responses in terms of abundance, the spatial shifts in habitat use were more notable. Eight species (Eastern Wood-Pewee, Winter Wren, Hermit Thrush, Nashville Warbler, Black-and White Warbler, Pine Warbler, Common Yellowthroat, and White-throated Sparrow) responded positively to the disturbance as indicated by an increase in their use of the harvested areas and decrease in their average distance from these areas. Three species (Ovenbird, Black-throated Green Warbler, and Veery) responded negatively and thus showed the opposite trend in use and distance to the harvested areas. These results in combination with those on the numerical responses underscore the importance of considering the spatial distribution of organisms in response to a disturbance. This was especially true for birds that prefer mature forest habitat; these species showed almost negligible changes in the abundance suggesting little to no effect of the disturbance yet they showed a strong avoidance of the harvest-created gaps.

#### *FUTURE PLANS*

Data analysis is on going. Dissertation will be completed in May 2007.

## **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  
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, are generally 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 and having 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 impacts of environmental perturbation on these marsh birds.

#### *FUTURE PLANS*

Thesis writing is nearing completion and the project is expected to be finished early in 2007.

## **WILDLIFE RESOURCES - OTHER THAN MIGRATORY BIRDS**

### **Physical and Behavioral Development of Nursing Harbor Seal (*Phoca vitulina*) Pups in Maine**

*Investigator:* J. P. Skinner

*Advisors:* J. R. Gilbert, Chair  
D. J. Harrison  
W. E. Glanz  
J. Schreer (SUNY – Potsdam)

*Cooperators/  
Project Support:* National Marine Fisheries Service  
Maine Agricultural and Forest Experiment Station  
University of Maine – Department of Wildlife Ecology

*Objectives:*

- 1) Document morphological and life history characteristics of neonate harbor seals along the coast of Maine.
- 2) Examine changes in diving behavior, home range size and site fidelity.

#### *SCOPE*

Maine lies at the southern end of the breeding range of the Western Atlantic Harbor Seal (*Phoca vitulina concolor*), which is found from the arctic waters of Canada east to the shores of Greenland to as far south as the coast of Virginia in the United States. This subspecies has been largely studied in Canada but to a lesser extent in the United States. In North America, harbor seals were heavily hunted in the early 20<sup>th</sup> century. After the establishment of the Marine Mammals Protection Act (1972) the U.S. population has grown markedly, however, the Canadian population has continued to decline in recent years. Differences in habitat and the population status at the northern and southern ends of the harbor seal range offer us an opportunity to study behavioral and phenotypic plasticity of this species. This study will document early life history characteristics and morphometrics of neonate harbor seals in Maine. Additionally, we will examine changes in movement and haul-out behavior of harbor seal pups from nursing to independent foraging. These characteristics will allow us to make comparisons with the results from studies conducted in other parts of the Western Atlantic Harbor Seal range.

#### *PROJECT STATUS*

All requirements for a M.S. degree in Wildlife Ecology were met in May 2006. The abstract of the thesis follows:

Compared to other phocid seals, the maternal investment strategy of the small bodied female harbor seal (*Phoca vitulina*) is complex. Females are unable to fast for the entire duration of pup rearing and are therefore reliant on resources

in the vicinity of the pupping aggregation to continue provisioning their pup by mid-lactation. At the same time, harbor seal pups are highly active during lactation which increases energetic costs to the female but also offers an opportunity for females to influence the behavioral development of her pup. To understand how females maximize their pup's survival it is important to examine both the physical and behavioral development of harbor seal pups. The goal of my research was to describe the morphological development and ontogeny of diving behavioral for harbor seal pups in Maine in respect to the potential factors influencing these two measures of maternal investment. I conducted my research at pupping sites in the vicinity of Stonington, Maine. During two seasons, 156 pups were captured, weighed and measured, and equipped with identification tags. Birth dates were estimated for all individuals and a subset of animals received VHF radio transmitters and time-depth recorders (TDRs) in order to monitor movements, activity, and diving behavior. Pups were monitored using telemetry and were recaptured opportunistically to recover TDRs and measure growth. There was no difference in the timing of births between years and the mean pupping date was found to be May 23 estimated for all individuals and a subset of animals received VHF radio transmitters and time-depth recorders (TDRs) in order to monitor movements, activity, and diving behavior. Pups were monitored using telemetry and were recaptured opportunistically to recover TDRs and measure growth. There was no difference in the timing of births between years and the mean pupping date was found to be May 23 (SE = 0.5). Mean birth mass was 11.1 kg (SE = 0.23) and mass gain rate averaged 0.45 kg/d (SE= 0.03). Pup mass gains were found to differ between years and decline late in the pupping season. Additionally, pup mass gain rates were found to be positively associated with increased 'in water' activity after controlling for temporal. Data from TDRs revealed that pups spent a large portion of time in water (61%) during lactation and dove up to 100 m near weaning. Activity and diving behavior was found to be influenced by pup birth mass, mass gain rate, age as well as the depth available and tide heights experienced by pups during TDR deployment. Maximal dive duration and dive depths were highly associated with bathymetry and this factor was most important in limiting pup diving depths early in lactation. The positive association between pup mass gain rate and activity is likely explained by the intermediary effects of female size and condition on both female attendance and pup growth. Although the lower mean mass gain rates in Maine compared to Canadian populations may be explained by differences in population status, this did not explain the lower range of values observed in this study. Resource limitations in the vicinity of pupping sites may provide an explanation for lower pup development and the significant decline in mass gain rates late in the pupping period in this study.

## **Functions of Chilean Wetlands: Threats and Watershed Based Conservation**

*Investigator:* P. A. Palacios

*Advisors:* M. L. Hunter Jr., Chair  
A. J. K. Calhoun, co-chair  
M. Contreras  
F. A. Servello  
R. Holberton  
I. Fernandez

*Cooperators/* Fulbright grant - U. S. Department of State  
*Project Support:* Centro de Ecologia Aplicada & CONAMA (National Environment Commission)

*Objectives:*

- 1) Classify Chilean wetlands.
- 2) Determine watershed-based conservation priorities for wetlands.
- 3) Creation of general management plans for each wetland ecotype.

### **SCOPE**

Wetlands have diverse functions such as nutrient cycling, sediment retention, flood control, and providing wildlife habitat. Anthropogenic activities that threaten these functions include, for example, water use for mining activities, spillage of pollutants, and draining for agriculture. We were asked by the Chilean government to classify Chilean wetlands and prioritize their conservation. For this, we are using a geographical information system to classify wetlands into different ecotypes based on their physical features such as temperature, precipitation, soil permeability, and slope. To determine watershed-based conservation priorities for wetlands, each ecotype will be associated with functions and threats. This information will be combined with data on proximity to populated areas and water extraction to identify a hierarchy of sites to conserve based on landscape-scale characteristics of the wetland. We will also evaluate the ecotype classification model by studying a particular function in different wetlands classified as the same ecotype, and we will create management plans for each ecotype.

*PROJECT STATUS*

We are in the process of validating the ecotype classification model on the field.

*FUTURE PLANS*

Associate functions and threats to each ecotype, and creation of general management plans for each ecotype.

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## **Relative Fitness and Behavioral Compensation of Amphibians in a Managed Forest**

*Investigator:* S. M. Blomquist

*Advisors:* M. L. Hunter, Jr., Chair  
A. J. K. Calhoun  
D. J. Harrison  
C. S. Loftin  
A. S. White

*Cooperators/  
Project Support:* National Science Foundation  
University of Maine - McIntire-Stennis  
University of Missouri  
University of Georgia - Savannah River Ecological Laboratory  
University of Maine - Association of Graduate Students  
University of Maine - Alumni Association  
American Society of Ichthyologists and Herpetologists

*Objectives:* Determine potential ultimate and proximate mechanisms behind loss of local amphibian populations in forested wetland ecosystems altered by forest harvesting by asking 2 questions:  
1) What are the effects of terrestrial habitat alteration on the relative fitness of wood frogs (*Rana sylvatica*)?  
2) Do adult amphibians change their movement patterns and habitat selection in response to alteration of the terrestrial habitat?

*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 amphibians in that local population.

I will use a linear series of experiments on the eggs, larvae, metamorphs, juveniles, and adults of wood frogs and conduct breeding experiments with adult wood frogs to calculate components of relative fitness: survival and reproductive success, for each treatment. Wood frog larvae reared in aquatic mesocosms in each treatment will be transferred to terrestrial pens in the same treatment and allowed to mature. Because wood frogs live only 3-5 years, I will be able to assess the relative fitness for these frogs.

Habitat selection will be assessed for frogs at the subpatch (4th order), patch (3rd order), and home range (2nd order) based on locations of radio-tracked, wild wood frogs and northern leopard frogs (*Rana pipiens*) and fluorescent powder tracking or string trailing. The habitat choices and movements of wild wood frogs and northern leopard frogs within the LEAP array will allow me to assess ways in which animals with different habitat preferences could behaviorally compensate for a potentially stressful environment. These choices will be directly related to body condition and survival of the tracked frogs. Based on habitat choice at the home range scale, the condition and survival of that individual can be compared to the survival and condition of animals penned in that treatment. The strength of this design is that it allows assessment of fitness and habitat choice in amphibians. This link has not been made previously for amphibians.

*PROJECT STATUS*

In 2006, I reared northern leopard frogs from egg through metamorphosis in aquatic mesocosms in each treatment. The growth and survival of these animals was assessed in response to canopy, light, temperature, and food availability in each treatment. The northern leopard frogs from this experiment were marked individually and released to the terrestrial pens to assess survival and growth. I continued to assess the growth and survival of the wood frogs and spotted salamanders (*Ambystoma maculatum*) in the terrestrial pens. To assess ways in which other frogs respond to the potentially stressful environment created by forest harvesting, habitat selection was assessed at the subpatch (4th order), patch (3rd order), and home range (2nd order) scales based on locations of 40 radio-tracked, wild northern leopard frogs during May-June 2006. To assess seasonal difference in habitat selection, I radio-tracked 40 wild wood frogs during September-November 2006.

#### *FUTURE PLANS*

In 2007, I plan to assess the breeding success of individuals captured entering the LEAP ponds from each treatment.

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### **The Loss of Mature Neotropical Montane Forests and Its Effect on Cavity-Nesting Avifauna**

*Investigator:* N. Politi

*Advisors:* M. L. Hunter, Chair  
F. A. Servello  
W. B. Krohn  
R. Holberton  
A. S. White

*Cooperators/  
Project Support:* Fulbright & State Organization of the Americas  
United Nations Educational, Scientific & Cultural Organization  
Wildlife Conservation Society

*Objectives:*

- 4) Determine the density and characteristics of trees and stands with cavities and assess which features are important in nest site selection (tree level and stand level).
- 5) Determine the effects of forestry practices on: a) structure of the cavity-nesting guild, b) cavity density and selection, and c) interactions among cavity-nesters.

#### *SCOPE*

Only a small percentage of the total forested land can be set aside as reserves to conserve biodiversity and management of forests outside reserves will determine the fate of much biodiversity. A balance must therefore be reached between biological diversity and forest uses. In order to meet this challenge, there is a need for sound scientific knowledge specifying the characteristics necessary to maintain functioning forest ecosystems and how to manage for them. The overall goal is to study the composition and function of the avian cavity-nesting community and the dynamics of cavity formation as a basis for developing a forest management system that will sustain biodiversity in national parks and surrounding areas in the Yungas montane forests of Argentina.

#### *PROJECT STATUS*

The project is underway. We have carried out five field surveys: December 2003, from June to August 2004, December 2004, from June until September 2005, and throughout 2006. The first three surveys have helped us adjust methodologies and determine the sites where we are currently conducting our project. We have selected six control sites (three in the piedmont and three in montane forest). Until now, we have completed the surveys in the piedmont sites. Unlike the previous data where we considered that primary cavity excavators (mainly woodpeckers) do not seem to be a keystone species in this forested ecosystem, it seems from our recent data that they are playing an important role in providing nesting sites for cavity nesters in the piedmont forests. We have also been able to identify tree species and characteristics that seem to favor cavity formation. These surveys have also made us realize that in order to maintain mature forests managements guidelines should be urgently implemented since forests are being lost at an alarming rate. Furthermore, most forests are managed through regulations by the Argentine governments that address the timber resource but with no consideration for wildlife.

#### *FUTURE PLANS*

We are conducting fieldwork until February 2007, and then analysis and writing will begin.

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## The Effects of Habitat Alteration on Juvenile Amphibian Dispersal

*Investigator:* D. A. Patrick

*Advisors:* M. L. Hunter, Jr., Co-Chair  
A. J. K. Calhoun, Co-Chair  
D. Hiebeler  
W. B. Krohn  
J. Gibbs

*Cooperators/  
Project Support:* National Science Foundation  
University of Missouri, Columbia  
University of Georgia - Savannah River Ecological Laboratory

*Objective:* Determine the effects of terrestrial habitat alteration on dispersal of 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 regional population. LEAP involves 4 replicates of 4 forest harvesting treatments (control, partial cut of 50% canopy removal, clearcut with coarse woody debris [CWD] removed, and clearcut with CWD retained) surrounding a central breeding pool. The treatments extend 164 m from the pond's center to capture 95% of amphibians in the local populations.

I used terrestrial drift fences to capture marked juvenile amphibians of two species, the wood frog, *Rana sylvatica*, and the spotted salamander, *Ambystoma maculatum*, at 16, 50, 100, and 150 m from the pond's edge. This information was compared with abiotic and biotic surveys detailing the composition of the different forestry treatments. I also conducted habitat manipulations at three smaller scales to look at the effects of ecological scale on habitat selection. The empirical experiments were combined with spatially explicit models using a cellular automata approach. These models examined the effects of including detailed ecological information on habitat heterogeneity and movement behaviour on the spatial distribution of emigrating amphibians. The models also allow predictions of the likely effects of further habitat change.

### PROJECT STATUS

I have now completed my dissertation research with three years of data from 2004 to 2006. In total I marked 10,690 wood frogs with 1,635 recaptures. A total of 1,038 juvenile spotted salamanders were marked with 81 recaptures. In addition to these marked animals I also captured a total of 19,852 unmarked amphibians, representing 14 species. Combining these data with the results from the three additional habitat manipulations showed that juvenile wood frogs responded to habitat heterogeneity at multiple spatial and temporal scales. Theoretical models demonstrated that inclusion of habitat heterogeneity and explicit behavior including habitat selection provided the best predictions of the spatial distribution of amphibians following emigration.

### FUTURE PLANS

The dissertation is scheduled to be defended in the winter 2007.

## Examination of Mercury Contamination in Northern Two-Lined Salamanders (*Eurycea bislineata*) and Slimey Sculpin (*Cottus cognatus*) Inhabiting Watersheds in Coastal Maine

*Investigators:* C. S. Loftin  
J. Zydlewski  
A. Elskus

*Cooperators/  
Project Support:* Maine Outdoor Heritage Fund  
USGS-Maine Cooperative Fish and Wildlife Research Unit  
USGS - S. O. Conte Anadromous Fish Research Laboratory, Leetown Science Center  
University of Maine – Department of Wildlife Ecology

*Objectives:* Document total mercury and methylmercury concentration levels in northern two-lined salamanders (*Eurycea bislineata*) and slimey sculpin (*Cottus cognatus*) found in selected watersheds in the downeast region of Maine.

#### SCOPE

Concentrations of mercury in larval northern two-lined salamanders (*Eurycea bislineata*) in eastern Maine were documented by Bank (2005), and this work suggested that the species might be a useful indicator of mercury contamination in streams. The utility of an indicator species, however, is limited by range and density. In areas where two-lined salamanders are absent or few in numbers, other species must be assayed. The slimey sculpin is a species that might be used as a complementary indicator. Sculpin inhabit the stream benthos and, like the two-lined salamander, do not range far during their life history. This species has a 1-2 year juvenile period, feeds on benthic invertebrates and small fish, and provides food for trout, salmon, and other larger fish. Similarities between sculpin and two-lined salamander food habits and use of stream habitat suggest that mercury bioaccumulation levels may also be similar. Both species are prey for other stream biota (e.g., fish, waterbirds, and otter) and thus transfer methyl mercury accumulated in their tissues to higher trophic levels. The synergistic utility of these two animals as complimentary indicator species depends on establishing a relationship between the mercury bioaccumulation in areas where both species exist. Such information will allow greater comparison of contamination patterns throughout Maine and also provide valuable insights as to the degree of mercury contamination in the selected streams.

We will collect northern two-lined salamander larvae and juvenile sculpin to determine the degree and extent of mercury contamination in selected coastal watersheds in Waldo, Hancock, Washington, and Penobscot Counties in Maine. Specific objectives of this investigation are to:

- (1) Quantify mercury contamination levels in two species (northern two-lined salamander larvae and slimey sculpin) found in similar trophic positions,
- (2) Characterize and compare the ratio of methylmercury (toxic form) and total mercury in these two species from different watersheds, and
- (3) Determine if a direct relationship exists between the bioaccumulation of total mercury and methylmercury in northern two-lined salamander and slimey sculpin.

#### PROJECT STATUS

Appropriate permits have been secured and collections will be coordinated with other researchers sampling the area's stream-dwelling fish. Sampling occurred during summer 2006 and sample analysis is underway.

#### FUTURE PLANS

The study will be completed by July 2007.

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

*Investigators:* Rita Seger

*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  
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 in order 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. 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 will also be obtained using hunter-killed bears in autumn. In order to construct a coherent picture of bone metabolism in this species, the following list of analyses is initially planned on approximately 100 bears: 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 in 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*

A pilot study was completed in 2005, followed by the first year of the full study in 2006. To date, radiographs of approximately 80 bears have been obtained. Methods have been established for measuring the biochemistries listed above using black bear serum (with the exception of calcitonin). Data analysis is in progress.

### *FUTURE PLANS*

During 2007, radiographic sampling will continue. A second phase of the project is being planned, to include serum studies and maybe additional radiographs that will focus on another region of bone (trabecular bone). Data collected in the first phase of this project will be supplemented with longitudinal studies on a few individual bears, by sampling them near the beginning and again near the end of winter den season.

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

### **Scientific Publications**

- BANK, M.S., C.S. LOFTIN, and R.E. JUNG. 2005. Effects of watershed heterogeneity on mercury bioaccumulation in two-lined salamanders from the northeastern United States. *Ecotoxicology* 14:181-191.
- CHALMERS, R.J. and C.S. LOFTIN. 2006. *Hemidactylium scutatum* (four-toed salamander). Morphology/phenology. *Herpetological Review* 37 (1): 69-71.
- ELIAS, S.P., J.W. WITHAM, and M.L. HUNTER, JR. 2006. A cyclic red-backed vole (*Clethrionomys gapperi*) population and seedfall over 22 years in Maine. *Journal of Mammalogy* 87:440-445.
- GILBERT, J.R. 2006. Book Review: A Field Guide to North Atlantic Wildlife: Marine Mammals, Seabirds, Fish and Other Sea Life by Noble S. Proctor and Patrick J. Lunch. *Wildlife Society Bulletin* 34:898-899.
- GILBERT, J.R., G.T. WARING, K.M. WYNNE, and N. GULDAGER. 2005. Change in abundance of harbor seals in Maine, 1981 – 2001. *Marine Mammal Science* 21(3):519-535.
- GILBERT, T.A., and F.A. SERVELLO. 2005. Insectivory versus piscivory in Black Terns: Implications for food provisioning and growth of chicks. *Waterbirds* 28:436-444.
- GILBERT, T.A., and F.A. SERVELLO. 2005. Water level dynamics in wetlands and nest success of Black Terns in Maine. *Waterbirds* 28:181-187.
- HILL, M., G. ZYDLEWSKI, J. ZYDLEWSKI, and J. GASVODA. 2006. Development and evaluation of portable PIT tag detection units: PITpacks. *Fisheries Research* 77:102-109.
- HOMYACK, J.A., D.J. HARRISON, J.A. LIVAITIS, and W.B. KROHN. 2006. Quantifying densities of snowshoe hares in Maine using pellet plots. *Wildlife Society Bulletin* 34 (1):74-80.
- HUNTER, M.L. Jr. 2005. A mesofilter complement to coarse and fine filters. *Conservation Biology* 19:1025-1029.
- KELLY, M.W. and J.M. RHYMER. 2005. Population genetic structure of a rare unionid (*Lampsilis cariosa*) in a recently glaciated landscape. *Conservation Genetics* 6:789-802.
- KROHN, W.B. 2005. A fall fur-hunt from Maine to New Brunswick, Canada – the 1858 journal of Manly Hardy. *Northeastern Naturalist* 12 (4):509-541.
- NELSON, M.L., J.R. GILBERT, and K.J. BOYLE. 2006. The influence of sighting and deterrence methods on seal predation at Atlantic salmon (*Salmo salar*) farms in Maine, 2001-2003. *Canadian Journal of Fisheries and Aquatic Sciences* 63:1710-1721.
- PATRICK, D.A., M.L. HUNTER Jr., and A.J.K. CALHOUN. 2006. Effects of experimental forestry treatments on a Maine amphibian community. *Forest Ecology and Management* 234:323-332.
- PERKINS, D.W. and M.L. HUNTER, Jr. 2006. Effects of riparian timber management on amphibian communities in Maine. *Journal of Wildlife Management* 70:657-670.
- REHFISH, M., J. ALLEN, B. HUGHES, J. RHYMER, P. ROBERTSON, K. SHW, AND M. WILLIAMS. 2006. Competition and hybridization from introduced Waterbirds: a rising political issue. *Acta Zoologica Sinica* 59 (Supplement): 570-571.
- RHYMER, J.M. 2006. Extinction by hybridization and introgression in Anatinae ducks. *Acta Zoologica Sinica* 52 (Supplement): 583-585.
- RHYMER, J.M., D.G. MCAULEY, and H.L. ZIEL. 2005. Phylogeography of the American Woodcock (*Scolopax minor*): are management units based on band recovery data reflected in genetically based management units? *The Auk* 122:1149-1160.
- SCHULTE, LISA A., R.J. MITCHELL, M.L. HUNTER, Jr., J.F. FRANKLIN, R.K. McIntyre, and B.J. PALIK. 2006. Evaluating the conceptual tools for forest biodiversity conservation and their implementation in the United States. *Forest Ecology and Management* 232:1-11.
- WARING, G.T., J.R. GILBERT, J. LOFTIN, and N. CABANA. 2006. Short-term movements of radio-tagged harbor seals in New England. *Northeastern Naturalist* 13(1):1-14.

### **Technical and Semi-Technical Publications**

- BLOMQUIST, S.M. 2005. *Bufo retiformis*, Sonoran Green Toad. Pp. 847-852. In: M.J. Lannoo, editor. *Declining Amphibians: A United States' Response to the Global Problem*. University of California Press, Berkeley.
- DOW, W.E., J.R. GILBERT, G.T. WARING, and A.J. REED. 2006. Atlas of harbor seal haul-out sites in Maine, 1981 – 2001. Presented on-line through the Ocean Biogeographic Information System-Sea Map (OBIS). <http://seamap.env.duke.edu/>.
- FULLER, A.K., D.J. HARRISON, B.J. HEARN, and J.A. HEPINSTALI. 2006. Landscape thresholds, occupancy models, and responses to habitat loss and fragmentation by martens in Newfoundland and Maine. Final Contract Report to Canadian Forest Service and the Western Newfoundland Model Forest. 92 pp.
- FULLER, A.K. and D.J. HARRISON. 2006. Ecology of red foxes and niche relationships with coyotes on Mount Desert Island, Maine. Final contract report to U. S. National Park Service, Boston, Massachusetts. 41 pp.
- FULLER, A.K. and D.J. HARRISON. 2005. Influence of forest practices on stand and sub-stand scale selection and movements of Canada lynx. Pages 56-60 in Maine Cooperative Forestry Research Unit Annual Report, Maine Agricultural and Forest Experiment Station Miscellaneous Report 435, Orono, Maine.
- HARRISON, D.J. and J.A. HEPINSTALL. 2005. Evaluating the umbrella species approach for biodiversity conservation on commercial forestlands in Maine. Pages 64-67 in Maine Cooperative Forestry Research Unit Annual Report, Maine Agricultural and Forest Experiment Station Miscellaneous Report 435, Orono, Maine.
- HARRISON, D., S. SADER, J. WILSON, and W. KROHN. 2006. Predicting responses of forest landscape change on wildlife umbrella species. Pages 53-59 in Maine Cooperative Forestry Research Unit Annual Report, Maine Agricultural and Forest Experiment Station Miscellaneous Report 438, Orono, Maine.
- HOMYACK, J., D. HARRISON, and W. KROHN. 2005. Temporal changes in abundance of snowshoe hares in Maine: 1995-2002. Pages 61-63 in Maine Cooperative Forestry Research Unit Annual Report, Maine Agricultural and Forest Experiment Station Miscellaneous Report 435, Orono, Maine.
- KITTREDGE, D.B., D.J. HARRISON, R. SMARDON, and L. BLUM. 2006. Final Program Evaluation of the External Review Team: Department of Natural Resources, University of New Hampshire. 31 pp.
- KROHN, W.B., and C.S. LOFTIN (compilers and editors). 2005. Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife Ecology – 2005 Report to Cooperators. Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME. 54 pp.
- LOFTIN, C.S. 2005. Landscape control of the distribution of two rare Atlantic slope freshwater mussels in Maine, the yellow lampmussel (*Lampsilis cariosa*) and the tidewater mucket (*Leptodea ochracea*). Final report to USGS-State Partnership Program, Research Work Order 47, 50 pp.
- MCCLOSKEY, J.T., and C.S. LOFTIN. 2006. Final report for Research Work Order 44, Southeastern Amphibian Research and Monitoring Initiative: Modeling vegetation succession and species-habitat relationships in the Okefenokee Swamp. Prepared as Ph.D. dissertation (J.T. McCloskey, Evaluating effects of fire management policy on vegetation communities in the Okefenokee Swamp, Georgia, 232 pp.)
- RHYMER, J.M. and A. HURYN. 2005. Fish hosts and population structure of yellow lampmussels and tidewater muckets. Final report to Maine Outdoor Heritage Foundation.
- RHYMER, J.M., C. LOFTIN, and A. HURYN. 2005. Fish hosts, population structure, and landscape control of the distribution of two rare Atlantic slope freshwater mussels in Maine, the yellow lampmussel and tidewater mucket. USGS State Partnership final report.
- ROBINSON, L., D. HARRISON, W. KROHN, and A. FULLER. 2006. Responses of snowshoe hares and lynx to alternative forest harvesting practices. Pages 60-68 in Maine Cooperative Forestry Research Unit Annual Report, Maine Agricultural and Forest Experiment Station Miscellaneous Report 438, Orono, Maine.

### **Theses and Dissertations**

- FULLER, A.K. 2006. Multi-scalar responses of forest carnivores to habitat and spatial pattern: case studies with Canada lynx and American martens. Ph.D. Dissertation, University of Maine, Orono. 223 pp.
- KNEELAND, S. 2006. Identification of fish hosts for wild populations of rare freshwater mussels (*Lampsilis cariosa* and *Leptodea ochracea*) using a molecular identification key. M.S. Thesis, University of Maine, Orono.
- MCCLOSKEY, J.T. 2006. Evaluating effects of fire management policy on vegetation communities in the Okefenokee Swamp, Georgia. Ph.D. Dissertation, University of Maine, Orono. 232 pp.
- ROBINSON, L. 2006. Ecological relationships among partial harvesting, vegetation, snowshoe hares, and Canada lynx in Maine. M.S. Thesis, University of Maine, Orono. 184 pp.
- SKINNER, J.P. 2006. Physical and behavioral development of nursing harbor seal (*Phoca vitulina*) pups in Maine." M.S. Thesis, University of Maine, Orono. 129 pp.

### **Professional Talks Presented**

- BEAUDRY, F., M.L. HUNTER, and P. DEMAYNADIER. "Habitat selection for spotted and Blanding's turtles in southern Maine." Invited presentation to the Maine Association for Wetland Scientists meeting, Augusta, ME. March 24, 2006.
- BEAUDRY, F., M.L. HUNTER, and P. DEMAYNADIER. "Modeling Road Mortality Risk for Spotted and Blanding's Turtle Populations." Presented at the Northeastern Transportation and Wildlife Conference, Bethel, ME. September 12, 2006.
- BEAUDRY, F., M.L. HUNTER, and P. DEMAYNADIER. "Road Mortality and Conservation of Spotted and Blanding's Turtles in Southern Maine." Presented at the Lunchtime lecture series, Maine Office of The Nature Conservancy, Brunswick, ME. October 18, 2006.
- BEAUDRY, F., M.L. HUNTER, and P. DEMAYNADIER. "Road Mortality Risk for Spotted and Blanding's Turtles in Maine: Progress Report." Presented at the Northeast Natural History Conference, Albany, NY. April 21, 2006.
- BLOMQUIST, S.M. and M.L. HUNTER, JR. 2006. Relative Fitness of Wood Frogs in a Managed Forest. 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. New Orleans, Louisiana. July 16, 2006.
- BLOMQUIST, S.M. and M.L. HUNTER, JR. "Relative fitness and behavioral compensation of amphibians in a managed forest." Presented at the Cooperative Forest Research Unit Penobscot Experimental Forest Meeting. October 20, 2005.
- DEGOOSH, K.E., SCHILLING, E.G., C.S. LOFTIN, and K.E. WEBSTER. "There's something fishy about fly larvae: Chaoborus assemblages as an indicator of fishless ponds." Invited to 30th Annual Meeting of the New England Association of Environmental Biologists, Bethel, ME. March 29-31, 2006.
- DEGOOSH, K.E., E.G. SCHILLING, C.S. LOFTIN, and K.E. WEBSTER. "Identifying historically fishless lakes as a target for conservation." Twelfth Annual Maine Water Conference, Augusta, ME. March 22, 2006.
- DOW, W.E., J. GILBERT, and A.J. REED. "Comparison of harbor seal, *Phoca vitulina*, distribution and haul-out site use during pupping and molting seasons in Maine." Poster & Abstract accepted for the 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA. December 12-17, 2005.
- FULLER, A.K. "Research Perspectives From My Point of View as an Ecologist". Invited lecture in Wildlife Ecology and Management class, Unity College, Unity, Maine. April 20, 2006.
- FULLER, A.K. 2006. "Landscape thresholds and responses to habitat loss and fragmentation by martens in Maine and Newfoundland". PhD dissertation defense seminar, University of Maine, Orono, Maine. April 10, 2006.
- FULLER, A.K. "Relationships among forest management practices, forest structure, prey density, and habitat selection by Canada lynx during winter." University of Maine, Department of Forest Ecosystem Science Seminar Series. March 3, 2006
- FULLER, A.K., and D.J. HARRISON. "Stand-scale habitat relationships of lynx in northern Maine." Final contract report presentation to Maine Cooperative Forestry Research Unit, Orono, Maine. January 25, 2006.

- FULLER, A.K., D.J. HARRISON, and B.J. HEARN. "Effects of habitat loss and fragmentation on the endangered Newfoundland marten." Presented to the model forest workshop. Corner Brook, Newfoundland. November 1, 2005.
- FULLER, A.K., D.J. HARRISON, and B.J. HEARN. "Applying the probability of occupancy model for Newfoundland marten to endangered species recovery." Presented to the Newfoundland Marten Recovery Team, Corner Brook, Newfoundland. November 2, 2005.
- FULLER, A.K., D.J. HARRISON, and J.A. HEPINSTALL. "Occupancy models, landscape thresholds, and responses to habitat loss and fragmentation by martens in Maine and Newfoundland." Presented to Maine Department of Inland Fisheries and Wildlife, Bangor, Maine. May 18, 2006.
- GILBERT, J. "Harbor Seal - Finfish Aquaculture Interactions." Presented at the Non-Lethal Deterrents for Pinnipeds Workshop, San Diego, CA. December 9, 2005.
- GILBERT, J.R. "Marine Mammals." Presented at the UM Marine Science Club Meeting. February 8, 2006.
- GILBERT, J. Guest lecture for WLE 100, University of Maine, Orono. October 21, 2005.
- GORSKY, D., J. ZYDLEWSKI, and D. BASLEY. "Movements of Whitefish in Clear Lake." Allagash working Group Meeting, Augusta, ME. November 2, 2005.
- HARRISON, D.J. "Managing forest stands and landscapes to maintain wildlife biodiversity." Invited presentation at Research, Results and the Resource Workshop, sponsored by Maine Cooperative Forestry Research Unit, Orono, Maine. May 25, 2006.
- HARRISON, D.J. "Research results and applications for management: stand and landscape management for marten and lynx on commercial forestlands in Maine." Invited presentations and field tour to Annual meeting of Foresters, Wagner Land Management Corp., Bethel, Maine. May 3, 2006.
- HARRISON, D.J. "Quantifying biodiversity values across managed landscapes in northern and western Maine." Presentation to Maine Cooperative Forestry Research Unit, Orono, Maine. April 26, 2006.
- HARRISON, D.J. "Wildlife, forest succession, vegetation management, and biodiversity". Invited lecture in FES 435/535: Managing Forest Succession, University of Maine, Orono. April 13, 2006.
- HARRISON, D.J., W.B. KROHN, and J.A. HEPINSTALL. "A landscape planning framework for northern Maine: an overview of recent research results for marten, lynx and other forest vertebrates." Presentation to Maine Department of Inland Fisheries and Wildlife, Augusta. December 21, 2005.
- HARRISON, D.J., W.K. KROHN, L. ROBINSON, J.A. HOMOYACK, and A.K. FULLER. "Temporal and spatial variation in hare densities within the geographic range of lynx in Maine". Invited paper presented at Symposium on Lynx Conservation in the lower 48 states, The Wildlife Society Annual Conference, Anchorage, Alaska. September 27, 2006.
- HAYDEN, J., F.A. SERVELLO, C.S. LOFTIN, and T.P. HODGMAN. "Population trends of marsh birds of conservation concern in Maine." Presented at the 29th Annual Meeting of the Waterbird Society, Jekyll Island, Georgia. October 14, 2005.
- HAYDEN, J., F.A. SERVELLO, C.S. LOFTIN, and T.P. HODGMAN. "Temporal changes in marsh bird occupancy of Maine wetlands." Poster presented at the 62nd Annual Northeast Fish and Wildlife Conference, Burlington, Vermont. April 26, 2006.
- HAYDEN, J., F.A. SERVELLO, and C.S. LOFTIN. "Temporal Changes in Marsh Bird Occupancy in Maine Wetlands." Waterbird Society Annual Meeting, Jekyll Island, GA. October 12-16, 2005.
- HEARN, B.J., A.K. FULLER, and D.J. HARRISON. "An update of results from marten habitat studies and occurrence modeling of marten in western Newfoundland." Presentation to Recovery Team for the Endangered Newfoundland marten, Corner Brook, Newfoundland. June 6, 2006.
- HIERL, L., C. LOFTIN, J. LONGCORE, and D. URBAN. "A multivariate assessment of changes in wetland habitat for waterbirds at Moosehorn National Wildlife Refuge, Maine, USA." Twenty-first Annual Symposium of the United States regional Chapter of the International Association of Landscape Ecologists, San Diego, CA. March 28 -April 1, 2006.

- HIERL, L., C.S. LOFTIN, J.R. LONGCORE, D.G. MCAULEY, and D. URBAN. "A Multivariate Assessment of Changes in Wetland Habitat Conditions for Waterbirds at Moosehorn National Wildlife Refuge, Maine, USA." Invited to the New England Chapter of the Wildlife Society, Annual Workshop, Hadley, MA. October 28, 2005.
- HOLBROOK, C.M., J. ZYDLEWSKI, and M.T. KINNISON. "Migration of Penobscot River salmon smolts and adults." Senator George J. Mitchell Center for Environmental and Watershed Research. Orono, Maine. January 26, 2006.
- HOLBROOK, C.M., J. ZYDLEWSKI, and M.T. KINNISON. "Penobscot River salmon smolts: movements, survival and path choice." Maine Atlantic Salmon Technical Advisory Committee Meeting. Augusta, Maine. May 18, 2006.
- HOLBROOK, C.M., J. ZYDLEWSKI, and M.T. KINNISON. "Penobscot River salmon smolts: movements, survival and path choice during a flood year." Third Maine Atlantic Salmon Technical Advisory Committee Research Forum. University of Maine, Orono, Maine. January 10, 2006.
- HUDSON, M., J. JOHNSON, J. HOGLE, J. BRUNZELL, and J. ZYDLEWSKI. "Adult Coastal Cutthroat Trout Movement and Habitat Use in the Lower Columbia River." Presented at the Coastal Cutthroat Trout Symposium: Biology, Status, Management, and Conservation 2005. Fort Worden State Park, Washington.
- HUNTER, M.L. "Using natural disturbance regimes to inform landscape management." Presented at the Landscape Management in Australia Conference, Bowral, NSW, Australia. March 2006.
- HUNTER, M.L. and D. LINDENMAYER. "Ecological thresholds and the design of environmental regulations." Presented to the Society for Conservation Biology, San Jose, CA. June 2006.
- JACKSON, C. and J. ZYDLEWSKI. "The critical conflict between brook trout and smallmouth bass in the Rapid River." Maine Department of Inland Fisheries and Wildlife Strategic Meeting. January 23, 2006.
- JACKSON, C.A.L. and J. ZYDLEWSKI. "Brook trout and smallmouth bass in the Rapid River." Annual Fly Fishing in Maine Conclave. June 2006.
- KIERNAN, J.R., J. SCHREER, and J. GILBERT. "Comparison of diving capabilities of neonate and weaned harbor seal pups in Maine." Poster & Abstract accepted for the 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA. December 12-17, 2005.
- KNEELAND, S. and J.M. RHYMER. "Determination of fish host use in wild populations of threatened freshwater mussels using a molecular genetic identification key." Presented at the Society for Conservation Biology annual meeting. UC Santa Cruz, CA. June 26, 2006.
- KROHN, W.B. "Harvest-induced changes in forest age, composition, structure, and composition: effects of recent forestry changes on wildlife habitats in Maine." Presented to the New England Chapter of the Society of American Foresters, University of Maine, Orono, ME. October 11, 2005.
- KROHN, W.B. "Manly Hardy (1832-1910): Maine's first wildlifer?" Presented at the Department of Wildlife Ecology's Noontime Seminar, University of Maine, Orono, ME. April 24, 2006.
- KURTH, J.E., C.S. LOFTIN, J. ZYDLEWSKI, and J. RHYMER. Methods for relocation of freshwater mussels threatened by habitat alteration (dam removal) on the Sebasticook River. 12th Annual Maine Water Conference, Augusta, ME. March 22, 2006.
- NELSON, S.J., K.B. JOHNSON, D.P. KRABBENHOFT, C.S. LOFTIN, and K.C. WEATHERS. "Deposition, re-emission, and evasion: snow sampling provides estimates of mass fluxes in winter at Acadia National Park, Maine, USA." Presented at the Eighth International Conference on Mercury as a Global Pollutant, Madison, WI. August 6-11, 2006.
- PATRICK, D.A., M.L. HUNTER, and A. CALHOUN. "The effects of forest harvesting on juvenile wood frog dispersal." Presented to the Society for Conservation Biology, San Jose, CA. June 2006.
- PATRICK, D.A., M.L. HUNTER, and A. CALHOUN. "The effects of forest harvesting on juvenile wood frog dispersal." Presented at the Midwest Ecology and Evolution Conference, St. Louis University, MO. March 2006.
- PERKINS, J.C., and F.A. SERVELLO. "Nocturnal nest attentiveness and nest depredation in Least Terns." Poster presented at the Atlantic Coast Piping Plover and Least Tern Workshop, Sheperdstown, West Virginia. January 2006.
- PERKINS, J.C., and F.A. SERVELLO. "Nocturnal nest attentiveness and nest depredation in Least Terns." Poster presented at the 29th Annual Meeting of the Waterbird Society, Jekyll Island, Georgia. October 12-15, 2005.

- ROBINSON, L., D.J. HARRISON, and W.B. KROHN. "Ecological relationships between partial harvesting, snowshoe hares, and lynx in Maine". Presentation and discussion for Forestry and Wildlife Professionals. University of Maine, Orono. August 24, 2006.
- RHYMER, J. 2006. How to infer population structure from molecular data. Invited. Keynote address in Symposium: Dispersal and gene flow in populations: linking molecular methods to direct observations. International Ornithological Congress, Hamburg, Germany. August 13-19, 2006.
- RHYMER, J., C.S. LOFTIN, S. KNEELAND, J. KURTH, and P. WICK. "An overview of the University of Maine freshwater mussel research program." Invited to Maine Department of Inland Fisheries and Wildlife, Wildlife Division Monthly Meeting, Bangor, ME. January 19, 2006.
- SCHILLING, E.G., C.S. LOFTIN, A.D. HURYN, and K.E. DEGOOSH. "A habitat on the brink? An assessment of the status of fishless lakes in Maine." Annual meeting of the North American Benthological Society, Anchorage, AK. June 4-9, 2006.
- SCHILLING, E.G., C.S. LOFTIN, and K.E. DEGOOSH. "Using GIS as a tool to predict the distribution of naturally fishless lakes in Maine, USA." Presented at Annual Meeting of the Society for Conservation Biology, San Jose, CA. June 24-29, 2006.
- SCHILLING, E.G., C.S. LOFTIN, and A.D. HURYN. "Landscape Attributes and Invertebrate Communities of Fishless Lakes in Maine." Presentation to BIO 468 Limnology, University of Maine, Orono, ME. November 6, 2005.
- SCHILLING, E.G., K.E. DEGOOSH, C.S. LOFTIN, A. HURYN, R. BUTLER, and P. DEMAYNADIER. "Assessing the geographic distribution and invertebrate biodiversity of naturally fishless lakes in Maine." Thirtieth Annual Meeting of the New England Association of Environmental Biologists, Bethel, ME. March 29-31, 2006.
- SCHILLING, E.G., K.E. DEGOOSH, C.S. LOFTIN, A. HURYN, R. BUTLER, and P. DEMAYNADIER. "Assessing the geographic distribution and invertebrate biodiversity of naturally fishless lakes in Maine." 12th Annual Maine Water Conference, Augusta, ME. March 22, 2006.
- SERVELLO, F.A., and J.C. PERKINS. "Evaluation of methods for estimating Least Tern fledging success." Presented at the Atlantic Coast Piping Plover and Least Tern Workshop, Shepardstown, West Virginia (Invited). January 19, 2006.
- SERVELLO, F.A., and S.R. HEATH. "Factors affecting predation of nests and chicks of Black Terns." Presented at the 29th Annual Meeting of the Waterbird Society, Jekyll Island, Georgia. October 14, 2005.
- SEWARD, L.C.N. "Importance of extended field programs at the University of Maine to undergraduate education: benefits and limitations." Presented to The Wildlife Society, Madison, Wisconsin. September 27, 2005.
- SKINNER, J., J. GILBERT, and J. SCHREER. "Behavior and life history characteristics of neonate harbor seals in Maine." Poster & Abstract accepted for the 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA. December 12-17, 2005.
- SKINNER, J., J. SCHREER, and J. R. GILBERT. "The ecology of neonate harbor seals in the Gulf of Maine." Presented at the Mystic Aquarium Seminar Series, Mystic, CT. November 28, 2005.
- SPENCER, R., J. ZYDLEWSKI, and G. ZYDLEWSKI. "Comparing the migratory behavior and physiology of Atlantic salmon smolts from Dennys and Penobscot River stocks." Presented at the 29th Annual Meeting of the Atlantic International Chapter of the American Fisheries Society, Rangeley, Maine. 2005.
- WITHAM, J.W. "Overview of Hold Research Forest – Long-term Data". Presented to the Maine Tree Foundation - Forest Inventory and Growth Training for Teachers, Nobleboro, ME. June 26, 2006.
- WOOD, S., J. GILBERT, and S. BRAULT. "Historical changes in grey seal populations in New England." Poster & Abstract accepted for the 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA. December 12-17, 2005.
- ZIEL, H.L., D.G. MCAULEY, and J.M. RHYMER. 2006. Inferences about the mating system of American Woodcock (*Scolopax minor*) based on paternity analysis. Tenth American Woodcock Symposium, Lansing, MI. October 6-9, 2006.

- ZYDLEWSKI, G., J. ZYDLEWSKI, and R. DANNER. "Descaling impairs the osmoregulatory ability of Atlantic salmon smolts." Senator George J. Mitchell Center for Environmental and Watershed Research. Orono, Maine. April 4, 2006.
- ZYDLEWSKI, G., J. ZYDLEWSKI, and R. DANNER. "Descaling impairs the osmoregulatory ability of Atlantic salmon smolts." Maine Atlantic Salmon Technical Advisory Committee Research Forum. University of Maine, Orono, Maine. January 10, 2006.
- ZYDLEWSKI, G, J. ZYDLEWSKI, and R. DANNER. "Does descaling impair osmoregulation in seawater challenged Atlantic salmon smolts?" Presented at the 29th Annual Meeting of the Atlantic International Chapter of the American Fisheries Society, Rangeley, Maine. 2005.
- ZYDLEWSKI, J, J. JOHNSON, G. ZYDLEWSKI. "Cutthroat trout (*Oncorhynchus clarki*) in the Lower Columbia River: migration and residency." Presented at the Coastal Cutthroat Trout Symposium: Biology, Status, Management, and Conservation 2005. Fort Worden State Park, Washington.
- ZYDLEWSKI, J, J. JOHNSON, J. HOGLE, J. BRUNZELL, S. CLEMENTS, M. KARNOWSKI, and C. SCHRECK. "Cutthroat trout (*Oncorhynchus clarki*) in the Lower Columbia River." Invited presentation at the University of New Brunswick Seminar Series. January 26, 2006.
- ZYDLEWSKI, J, J. JOHNSON, J. HOGLE, J. BRUNZELL, S. CLEMENTS, M. KARNOWSKI, and C. SCHRECK. "Seaward migration of coastal cutthroat trout (*Oncorhynchus clarki*) from four tributaries of the Columbia River." Presented at the Coastal Cutthroat Trout Symposium: Biology, Status, Management, and Conservation 2005. Fort Worden State Park, Washington.
- ZYDLEWSKI, J. and D. BASLEY. "Movements of Lake Whitefish in Clear Lake, Maine." Presented at the 29th Annual Meeting of the Atlantic International Chapter of the American Fisheries Society, Rangeley, Maine. 2005.
- ZYDLEWSKI, J., C.M. HOLBROOK, and M.T. KINNISON. "Adult 3rd Maine Atlantic Salmon Technical Advisory Committee Research Forum". University of Maine, Orono, Maine. January 10, 2006.

### **Public Talks Presented**

- BEAUDRY, F. "The southern Maine rare turtle research project." Fund raising event, The Mount Agamenticus to the Sea Conservation Initiative, York, ME. October 21, 2005.
- BEAUDRY, F. "Road Mortality, Population Dynamics and Conservation of Spotted and Blanding's Turtles in Maine." Invited presentation to an Environmental Science class, Marshwood High School, South Berwick, ME. April 4, 2006.
- BEAUDRY, F. "Roads and turtles in York County: a deadly mix." Mount Agamenticus Conservation Coalition, York, ME. May 26, 2006.
- BEAUDRY, F. "Our woodland turtles." Lecture and field walk for day campers, White Pine Programs, York, ME. June 6, 2006.
- BLOMQUIST, S.M. "Forestry and wildlife from a graduate student perspective." WLE 100: Introduction to Wildlife Resources. University of Maine, Orono. September 15, 2006.
- BLOMQUIST, S.M. "Wildlife ecologist for high school students interested in shadowing." Bangor High School. August 7-10, 2006.
- HARRISON, D.J. Organized and led field trip to commercial forestlands to discuss forest wildlife management for WLE 100, Introduction to Wildlife Resources, October 28, 2005.
- KROHN, W.B. "An overview of Maine's largest terrestrial predators - historical patterns, habitat relationships, and current management issues." Presented at Senior College, University of Maine, Orono, ME. March 12 and 24, 2006.
- KROHN, W.B. "Manly Hardy: The life and writing of a 19th century Maine businessman and naturalists." Invited slide presentation at the Author's Series, Bangor Public Library, Bangor, ME. October 22, 2005.
- KROHN, W.B. "Manly Hardy: Early sportsman and naturalist from Brewer, Maine." Presented to the Penobscot County Conservation Association, Brewer, ME. October 6, 2005.
- SEWARD, L.C.N. "Wildlife Radiotelemetry Workshop." Presented at Craig Brook National Fish Hatchery for "Biology Day" for John Bapst Memorial High School, Bangor, Maine. May 2006.

SEWARD, L.C.N. Participated in NSF-GK-12 program conducting small mammal trapping for Milford Elementary School. June 2006.

WITHAM, J.W. "Overview of Holt Research Forest." Presented to Gray-New Gloucester High School Ecology Class, Gray, ME. October 7, 2005.

WITHAM, J.W. "Wildlife of Merrymeeting Bay." Presented at Bay Day, Bowdoinham, ME. May 24, 2006.

### **Workshops**

CAMPBELL, S.P. Participated as a panel member in "Preparing for academic careers today: a workshop for graduate students and people who care about them" for the Center for Teaching Excellence. November 11, 2005.

HUNTER, JR., M.L. Participated in a panel discussion on the "Human footprint in the Northern Appalachians" for the Ecology and Environmental Sciences Seminar Series. December 6, 2005.

WITHAM, J.W. Organized "Networking Across Borders" semi-annual meeting at Houlton Higher Education Center, Houlton, ME. May 4-5, 2006.

### **Awards, Honors, and Appointments**

BLOMQUIST, S.M. Awarded American Society of Ichthyologists and Herpetologists Travel Grant. May 5, 2006.

BLOMQUIST, S.M. Awarded University of Maine Graduate Student Government Grant. March 27, 2006.

BLOMQUIST, S.M. Inducted into Phi Kappa Phi honor society. April 26, 2006.

FULLER, A.K. Outstanding Wildlife Ecology Graduate Student Award, University of Maine, Orono, Maine. April 2006.

HARRISON, D.J. Recipient of the G. Peirce and Florence Pitts-Webber Award to the Outstanding Researcher in Forest Resources, University of Maine. 2006

HUNTER, JR., M.L. Co-recipient of the First President Abram W. Harris Award from the University of Maine Foundation for special contributions to the University of Maine. Other recipients include George Jacobson, Steve Norton, David Smith, and George Markowsky. 2006.

KNEELAND, S. Griffiee graduate student award for outstanding M.S. research. December 2005.

KROHN, W.B. Recipient of the 2006 Distinguished Wildlife Alumnus Award, University of Maine. This recognition is given annually by the University's wildlife alumni and faculty for long-term and significant contributions to the wildlife profession. April 26, 2006.

LOFTIN, C.S. USGS Cooperative Research Units National Service Excellence Award. 2006.

SCHILLING, E.G. Awarded 2006-2007 University Graduate Research Assistantship for EES. August 2006.

SERVELLO, F.A. College of Natural Sciences, Forestry and Agriculture 2005-06 Outstanding Teaching Award.

### **Television, Radio, and Newspaper Interviews & Articles**

BEAUDRY, F. *Portsmouth Herald* – Jen Keefe – Article on road signs installed to reduce turtle road mortality. June 14, 2006.

BEAUDRY, F. WGME Channel 13 – Emily Apel – Television interview on turtles, road mortality, and road signs. June 16, 2006.

BEAUDRY, F. *York Weekly* – authored press release – Road signs aid endangered turtles. June 16, 2006.

BEAUDRY, F. *York Weekly* – Chris Outcalt – Interview about vandalism on road signs installed to reduce turtle mortality. June 21, 2006.

GILBERT, J.R. *Cape Cod Times* – Gray Seal numbers. September 24, 2006.

GILBERT, J.R. *Palm Beach Post* (Fla.) – Hooded Seals. September 15, 2006.

GILBERT, J.R. *Cape Cod Times* – Seals and Sharks. July 17, 2006.

- GILBERT, J.R. MPBN Radio - Interview on seals. February 23, 2006.
- HARRISON, D.J. *Adirondack Explorer* - Phil Brown - Wolf genetics and restoration. April 2, 2006.
- HARRISON, D.J. *Bangor Daily News* - Kevin Miller - Conservation of deer yards. February 21, 2006.
- HARRISON, D.J. Vermont's Statewide Newspaper -- Michael Caduto - Interview on coyote ecology. October 27, 2005.
- KROHN, W.B. A review of Krohn's book about Manly Hardy entitled "Hardy book a delight – biography documents change in nature, attitudes." George Smith, executive director of Sportsman's Alliance of Maine, wrote this review an opinion piece for the *Morning Sentinel* (Waterville, ME), February 22, 2006, p. A7.
- KROHN, W.B. A review of Krohn's Hardy book published in the *Bangor Daily News*, September 25, 2006, p. C7. The review was authored by Murray Carpenter, a long-time environmental writer.
- LOFTIN, C.S. *UMaine Today* "Conserving Mussels" article (November/December 2005) mentions collaborative research with Judith Rhymer.
- RHYMER, J. *UMaine Today*, "Conserving Mussels" November/December 2005 issue.
- RHYMER, J. *Portland Magazine*, The Home Team: Maine's endemic species. September 2006.
- ZYDLEWSKI, J. Interview with Beth Daley, *Boston Globe* staff "Effort to save Maine Salmon is losing ground." January 31, 2006.
- ZYDLEWSKI, J. Interview with Bri O'Reilly of "Our Ocean World" radio show. 2006.
- ZYDLEWSKI, J. "Joining the Branches", a publication of the Penobscot Indian Nation *Pretty in Hot Pink* Issue 3. 2005.
- ZYDLEWSKI, J. *The Maine Campus*, Article on the survival of the Atlantic Salmon in the Penobscot River graduate project of Christopher Holbrook. January 30, 2006.