

**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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Eleanor Groden, Chairperson, Department of Biological Sciences, College of Natural Sciences Forestry, and Agriculture

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## Maine Department of Inland Fisheries and Wildlife:

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 Paul F. Jacques, Deputy Commissioner  
 Kenneth D. Elowe, Director, Bureau of Resource Management  
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 Eugene A. Dumont, Supervisor, Regional Wildlife Management Section  
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Name	Degree Candidacy	Support
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Steven P. Campbell	Ph.D.	HWRF, UM, NSF
Thomas J. Danielson	Ph.D.	UM, USGS, MDEP, EPA, HBMI, MCFWRU, MCCS
Katie E. DeGoosh	M.S.	MOHF, MDIFW, UM, MCFWRU
S. Fernandes	M.S.	MCFWRU, NOAA
Sharon L. Fleming	M.S.	MASC, NMFS, MCFWRU
Angela K. Fuller	Ph.D.	CFRU, MDIFW, MAFES, FWS, TNC
Merry Gallagher	Ph.D.	MCFWRU, MDMR, MDIFW, UM
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Brian J. Hearn	Ph.D.	UM, NRC-CFS, NDFRA-WD, WNMF, CPP, AC
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Student	Degree Candidacy	Support
Volker Bahn	Ph.D.	USGS-BRD, MCFWRU, UM
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Jordan C. Perkins	M.S.	UM, MOHF, MDIFW, RCNWR, MAS
Steven C. Renner	M.S.	MAFES, COA, UM

## PERSONNEL NOTES

**VOLKER BAHN** received his Ph.D. degree in Wildlife Ecology and is a post-doctoral candidate at McGill University in Montreal, Quebec, Canada. There he will be continuing to research various aspects of species distribution modeling. **MICHAEL S. BANK** received his Ph.D. degree in Ecology and Environmental Science and is a post-doctoral candidate at the Harvard School of Public Health in Boston, MA. **JORDAN C. PERKINS** received her M.S. degree in Wildlife Ecology and is employed at the Maine Department of Inland Fisheries. **STEVEN C. RENNER** received his M.S. degree in Wildlife Ecology and is exploring employment options.

## COLLABORATING AGENCIES AND ORGANIZATIONS

Abitibi Consolidated - AC  
 Aquaculture Research Center - ARC  
 Clayton Lake Woodlands - CLW  
 College of the Atlantic – COA  
     Allied Whale - AW  
 Corner Brook Pulp & Paper - CPP  
 Declining Amphibian Population Task Force - DAPTF  
 Eastern National Park Research Fund - ENPRF  
 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 Atlantic Salmon Commission - MASC  
 Maine Audubon Society - MAS  
 Maine Department of Environmental Protection - MDEP  
 Maine Department of Inland Fisheries and Wildlife - MDIFW  
 Maine Department of Marine Resources - MDMR  
 Maine Department of Transportation - MDOT  
 Maine Outdoor Heritage Fund - MOHF  
 Manomet Center for Conservation Sciences - MCCA  
 National Council of the Paper Industry for Air and Stream Quality Improvement - NCASI  
 National Marine Fisheries Service - NMFS  
 National Oceanic & Atmospheric Administration - NOAA  
 National Science Foundation - NSF  
     GK-12 Teaching Fellowship –GK-12TF  
     Research Fellowship - RF  
 Natural Resources Canada - NRC  
     Canadian Forest Service -CFS  
 Newfoundland Department of Forest Resources and Agrifoods Wildlife Division - NDFRA  
 Newfoundland Forest Service - NFS  
 Newfoundland Inland Fish and Wildlife Division – NIFWD  
 Norcross Wildlife Foundation - NWF  
 Penobscot Indian Nation - PIN  
 Rachel Carson National Wildlife Refuge - RCNWR

The Nature Conservancy - TNC  
Trout Unlimited - TU  
United Nations Educational, Scientific & Cultural Organization - UNESCO  
University of Maine - UM  
    Association of Graduate Students - AGS  
    Maine Cooperative Forestry Research Unit - CFRU  
    Department of Biological Sciences - DBS  
    Department of Civil and Environmental Engineering - CEE  
    Department of Forest Ecosystem Science - FES  
    Department of Wildlife Ecology – DWE  
    Graduate School – GS  
    Graduate Research Assistantship - GRA  
    McIntire-Stennis – MCS  
    School of Marine Sciences - SMS  
    Maine Agricultural and Forest Experiment Station - MAFES  
University of Missouri – UMS  
University of Georgia - UG  
    Savannah River Ecological Laboratory - SREL  
U.S. Fish and Wildlife Service – FWS  
    Moosehorn National Wildlife Refuge - MNWR  
    Okefenokee National Wildlife Refuge - ONWR  
USGS Biological Resources Discipline - BRD  
    Eastern Region State Partnership Program - ERSPP  
    Florida Integrated Science Center - FISC  
    Maine Cooperative Fish and Wildlife Research Unit – MCFWRU  
    Maine Water Research Institute – MWRI  
National Park Service - NPS  
    Acadia National Park – ANP  
    Patuxent Wildlife Research Center - PWRC  
    State Partnerships Program - SPP  
U. S. Environmental Protection Agency - EPA  
Western Newfoundland Model Forest – WNMF  
Wildlife Conservation Society - WCS

## ENDANGERED AND THREATENED SPECIES:

### FACTORS AFFECTING LEAST TERN (*Sterna antillarum*) PRODUCTIVITY IN MAINE

- Investigator:* J. C. Perkins
- Advisors:* F. A. Servello, Chair  
J. M. Rhymer  
J. Kelley  
M. A. McCollough
- Cooperators/  
Project  
Support:* University of Maine  
Maine Outdoor Heritage Fund  
Maine Department of Inland Fisheries and Wildlife  
Rachel Carson National Wildlife Refuge  
Maine Audubon Society
- Objectives:*
- 1) Determine rates for major reproductive parameters of the least tern population in Maine including clutch size, hatchability, nest success, chick survival, and fledgling success.
  - 2) Evaluate management alternatives for increasing least tern productivity.
  - 3) Determine rates of nest losses to predators, storm tides, and other factors, and identify predator species if possible.
  - 4) Determine temporal patterns and intensity of predator and non-predator disturbances at the largest Maine colony (Crescent Surf Beach) during the incubation period, with an emphasis on predator activity.
  - 5) Document spatial patterns of nest losses within colonies due to predation, storms, and other factors.
  - 6) Examine temporal patterns in vegetation, shape, and other characteristics of beaches used by least terns for nesting, and determine relationships with colony occurrence.

**SCOPE:** The least tern is a state-listed endangered species in Maine. Historically, there may have been as many as 20 potential nesting sites within Maine. In the last 25 years, there have been only 12 sites on which least terns have produced successful nests, and only seven sites have produced successful nests in the last five years. The goals of this project are to understand the factors influencing population growth and occurrence in Maine and to provide information on nesting ecology, predation, and disturbance for making recommendations on future management.

**PROJECT STATUS:** All requirements for a M. S. degree in Wildlife Ecology were met in December 2004. The abstract follows:

Least Terns (*Sterna antillarum*) are state-listed as endangered in Maine, and the limited existing information indicates that breeding success is low and variable. Loss of nests and chicks to predators is believed to be a major cause of low productivity, and agencies are considering predator deterrence options. The objectives of this study were to document reproductive success of Least Terns in Maine and use these data to evaluate the effectiveness of management strategies. I also documented nocturnal nest attentiveness and examined relationships with nest depredation. Least tern colonies in Maine were monitored to document clutch size, hatchability, nest success, chick survival and fledgling residency in 2002-2003. I used these data, excluding fledgling residency, to estimate increases in fledgling production for three levels of effectiveness at reducing nest and chick losses (30, 60, and 90%). Effectiveness levels were evaluated for five temporal management periods (intense nesting period, early season nesting, peak season nesting, late season nesting, and total season nesting). Nocturnal nest attentiveness was measured at three colonies during the nocturnal period (21:00-04:30) in 2002 and 2003. Hatchability was high (0.89-1.00) and clutch size (1.67-2.33) and nest success (0.00-0.82) varied widely among colonies. Chick survival

ranged from 0.15-0.74 among three breeding sites and mean  $\pm$  SE fledgling residency for all sites and years pooled was  $13.3 \pm 0.7$  days. The greatest increase in reproductive success occurred when management was applied for the entire nesting season (29 May-27 August), but early (29 May-16 July) and peak (12 June-30 July) nesting periods had similar and only slightly lower effectiveness. Management effectiveness  $\geq 30\%$  produced an increase in fledgling production above 1.0 for the total, early, and peak season periods. We monitored 119 nests for a total of 723 nocturnal periods and 5424 hr for nest attentiveness. The proportion of nest-nights with  $\geq 1$  absence ranged widely (0.07-0.63) and differed among colonies ( $P < 0.001$ ). The number of absences per nest-night for nests with absences differed among colonies and ranged from 1.0-1.4 ( $P < 0.001$ ). Overall, mean ( $\pm$ SE) absence length was 113 min ( $\pm 8.86$ ) but exhibited two distinct patterns. Incubation resumed either at dawn or within 1.5 hr after departure, regardless of departure time. Concurrent departures by  $\geq 2$  terns occurred commonly (generally more than 10% of nights monitored), but there was not evidence of simultaneous absences of all terns monitored in a colony being common. Mean absence length and proportion of nights with an absence did not differ ( $P > 0.05$ ) among the first, second, and third weeks of incubation. In conclusion, this reproductive success model showed that decreasing Least Tern nest and chick losses early or throughout the entire breeding season in Maine was adequate to sustain or increase Least Tern reproductive success to the putative level for population maintenance. In addition, nocturnal absences by Least Terns in Maine are common and often of long duration, but nest attentiveness did not exhibit relationships with nest depredation in colonies. Additional research is needed on the cause and consequences of poor nest attentiveness of Least Terns in Maine.

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## POPULATION ECOLOGY OF BLACK TERNS (*Chlidonias niger*) IN MAINE

*Investigator:* F. A. Servello

*Cooperators/* University of Maine -  
*Project* Department of Wildlife Ecology  
*Support:* 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. A

parallel study is being conducted in Wisconsin by a biologist at Loras College, and results will be examined concurrently to look for common patterns in survival and movements along the southern edge of the black tern's range.

Breeding success results for the period 1997-2002 are complete except for the nest success data. Recently developed nest success estimators are being evaluated before application to these data. Modeling of extinction risk and management strategies is awaiting final data for breeding parameters.

*FUTURE PLANS:* Continue survival and viability analyses.

## 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  
United States 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 substand-scale features of rest sites used by lynx and lynx activities.
- 4) Describe spatial-use and movement patterns of lynx.

### *SCOPE:*

I studied winter habitat selection and compared frequency of successful snowshoe hare (*Lepus americanus*) kills and tortuosity of foraging paths among 5 forest stand-types to evaluate whether Canada lynx (*Lynx canadensis*) selected stands based on highest snowshoe hare densities (i.e., prey density hypothesis), based on intermediate hare densities where access to hares is enhanced by lower understory cover (i.e., prey access hypothesis), or based on areas with highest thermal and escape cover for lynx (i.e., thermal and escape cover hypothesis). I also estimated relative hare densities based on track intersections, measured sub-stand scale structural characteristics in 5 stand-types, and used an information theoretic modeling approach to infer which characteristics in stands were associated with highest densities of hares.

I snowtracked radiocollared adult lynx (3 F, 3 M) for 65.50 km during January - March, 2002 and 2003. At the stand-scale, lynx selected tall mid-successional clearcuts (4.4-7.3m, 11-26 years post-harvest) and established partially harvested stands (11-21 years post-harvest), and they selected against short mid-successional clearcuts (3.4-4.3m 11-26 years), recent partially harvested stands (1-10 years), and mature second-growth stands (>40 years, coniferous, deciduous, and mixed coniferous-deciduous). Density of snowshoe hares was positively associated with live stem cover units (SCU = 3 x coniferous saplings + deciduous saplings) and negatively associated with overstory canopy closure. Mid-successional clearcuts (short and tall) supported the greatest relative density of hares based on having the greatest SCU and the greatest number of track intersections. Despite similar hare densities in tall and short mid-successional regenerating clearcuts, taller clearcuts were in the self-thinning stage (i.e., 2.7X more dead saplings) and had 24% fewer conifer saplings and lower SCU, which likely enhanced the visibility and vulnerability

of hares to lynx (i.e., support for prey access hypothesis). There were disproportionately greater numbers of kills in short and tall mid-successional stands, despite the highest SCU in the shorter stands. This suggests a strong interaction between prey access and prey density in determining the foraging success of lynx. This interaction is apparent by the positive selection by lynx for established partial harvests, which had intermediate SCU and canopy closure, and intermediate hare densities; selection against recent partial cuts, which had the lowest hare densities and SCU; selection against mature stands, which had the highest canopy closure (negatively associated with hares) and low hare densities, and selection against short mid-successional stands, which had high hare densities but the highest numbers of coniferous saplings and SCU for hares to avoid. Correspondingly, the highest fractal dimension of foraging paths was in tall mid-successional clearcuts and established partially harvested stands, suggesting that lynx were actively foraging in stands that provided intermediate to high hare density, intermediate cover for hares, and intermediate levels of canopy closure and live-tree basal area, but avoided areas with high densities of hares where coniferous saplings exceed 11,000 stems/ha and SCU exceed 50,000 stems/ha. Lynx also avoided habitats where prey density was low, with low densities of conifer saplings (<5,000 stems/ha) and SCU (<35,000 stems/ha), or where canopy closure exceeded 60%. In managed landscapes, optimal foraging habitat for lynx is provided by regenerating areas with few overstory trees dominated by a mixture of conifer and deciduous saplings that are in the stage of stem exclusion. In the Acadian forests of Maine, these stand conditions typically occur 15-30 years following partial or complete overstory removal.

*PROJECT STATUS:* A final report is scheduled for completion by December 2005.

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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 and Paper  
Abitibi Consolidated

*Objectives:*

- 1) Document the population characteristics of Newfoundland marten on two study areas, one area open to trapping and snaring and the other closed, representing a range of forest management and natural habitat conditions.
- 2) Determine scale-specific (i.e., seasonal and annual stand- and landscape-level) habitat selection of marten across the range of habitat conditions present within the two study areas.
- 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 one 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 early decline. In 1934, commercial trapping for marten was closed on the island. Despite

this protection, marten populations continued to decline. Today, trapping for marten remains closed, but some number 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 and is generally considered to contain the largest concentration marten remaining on the Island. The PMSA is closed to all land-based trapping and snaring. In 1986, the status was uplisted to Endangered.

Earlier work on Newfoundland marten was conducted within the PMSA and focused on the effects of timber harvesting on “old growth” habitat and addressed the underlying association of Newfoundland marten with old growth (81+ year-old balsam fir (*Abies balsamea*) forests. In general, these studies concluded that loss of old growth habitat through clearcut logging was limiting the distribution and recovery of marten in Newfoundland. Subsequent work in the mid 1990’s, examined forest structure and prey densities in forest of various ages, and suggested that marten in Newfoundland are restricted to mature and overmature balsam fir due to the lack of prey in younger stands. An alternative hypothesis is that marten in Newfoundland are restricted in distribution due to habitat security, that is, marten occupying second-growth stands have increased mortality due to incidental 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 goal of the project is to evaluate these 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 area was added. This second area was outside the PMSA and was centred near Red Indian Lake in south-central Newfoundland. This area had what was believed to be a newly-established (< 10 years) marten population. It was assumed, that due to past forest harvesting, the RIL study area had a recently established, low-density marten population occurring in sink habitat. Following the analysis of factors influencing habitat selection and restriction, we hope to develop forest and wildlife management recommendations for the conservation and management of Newfoundland marten.

*PROJECT STATUS:* Between January and March 2005, a landscape-scale habitat analysis was completed as a companion analysis to the stand-scale habitat selection conducted in 2004. The landscape-scale analysis was a cooperative research effort with A. Fuller (PhD Candidate – Department of Wildlife Ecology – University of Maine) and complementary to her efforts to develop a predictive habitat model for Newfoundland marten. Results of the landscape-scale analysis were combined with the previous stand-scale habitat analysis in a final contract report entitled: *Scale-dependent habitat Selection by Newfoundland Marten 2005: B. J. Hearn, D. J. Harrison, C. Lundrigan, W. J. Curran, and A. K. Fuller*. This report was submitted to project co-operators in May 2005. The report was also presented to the national COSEWIC (Committee on the Status of Endangered Wildlife in Canada) Newfoundland Marten Recovery Team, as well as provincial natural resource managers, and forest industry partners.

In June 2005, the habitat definitions, guidelines and management recommendations outlined in the report were adopted by the Newfoundland Wildlife Service and the Marten Habitat Assessment Working Group as the new provincial standards.

Additionally, we completed a meta analysis of marten diet in Newfoundland as a companion study to our habitat selection work to further investigate the potential mechanisms underlying local habitat associations. The research paper summarizing the work is in press in *Canadian Field Naturalist*.

*FUTURE PLANS:* Future work will focus on the preparation of 2 journal manuscripts (dissertation chapters) from the results presented within the final contract report prepared in 2005. The first paper will focus on spatial characteristics of Newfoundland marten while the second paper will summarize the analysis concerning habitat selection patterns of Newfoundland marten. A third and final journal manuscript (dissertation chapter) will be developed during winter 2006 concentrating on survival, cause-specific mortality, and population demography of marten in Newfoundland. The three chapters will comprise the Ph.D. dissertation, which is scheduled for completion in 2006.

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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/ *Maine Department of Inland Fisheries and Wildlife*  
*Project Support:* Maine Outdoor Heritage Fund  
 USGS-BRD Eastern Region State Partnership Program  
 USFWS Endangered Species Program  
 Maine Cooperative Fish and Wildlife 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 entry (page 7).

*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 is underway 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 will be completed.

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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:* USGS-BRD Eastern Region State Partnership Program  
University of Maine  
Department of Wildlife Ecology  
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 with the results of Dr. Rhymer's and Dr. Huryn's study (reported in the previous project summary).

**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.

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 spatial database of mussel population distribution and watershed characteristics was developed, data analysis was completed, and a final report was prepared. Watershed analysis indicated that tidewater muckets and yellow lampmussels occupy aquatic sites 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 mucketts 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 mucketts, but the total dam height per stream mile in the contributing area of sites without mucketts exceeded the cumulative height per stream mile for sites with mucketts. Percent calcareous bedrock in the cumulative upstream drainage area was greater in reaches containing tidewater mucketts 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 mucketts, those where yellow lampmussels were found contained less calcareous bedrock in the cumulative upstream drainage area. Attempts to develop logistic regression models of watershed features where tidewater mucketts and yellow lampmussels were found were unsuccessful; the low numbers of sites containing mussels distributed across a broad range of conditions resulted in unreliable models.

*FUTURE PLANS:* The final project report will be completed in December 2005.

**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  
J. S. Wilson  
M. A. McCollough  
W. J. Jakubus

*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  
McIntire-Stennis  
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 clearcuts 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 and use these models to predict lynx occurrence at the landscape (i.e., home range) scale.

**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 clearcuts 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 clearcutting 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 clearcuts larger than 35 acres. This contributed to a shift in forest management in Maine away from clearcuts 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 clearcuts. 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 variables are important in habitat selection by lynx.

This study will supply important information on the relationship between lynx occurrence and the abundance of its primary prey, in addition to other landscape characteristics that can be used to more accurately evaluate the potential for lynx occurrence within the landscapes of northern and western Maine.

**PROJECT STATUS:** Ecoregional surveys were completed by MDIFW in 61 townships and will be the basis for occurrence modeling in 2005-2006. Pellet plots to estimate hare density in 37 forest stands were counted in the spring of 2005. Preliminary estimated hare densities for the leaf-off season from fall 2004 to spring 2005 ranged from 0.26-1.64 hares/ha within partial harvest stands and 1.09-4.17 hares/ha within regenerating conifer stands.

**FUTURE PLANS:** Study stands will be recounted in fall of 2005 and model development and data analysis will begin in the late fall of 2005. The expected date of project completion is August 2006.

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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  
United States 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:* Over two field seasons 30 spotted turtles and 37 Blanding's turtles have been tracked by radio-telemetry. Movement data have been collected at two scales, and habitat variables have been collected.

*FUTURE PLANS:* Field data will be compiled and analyses will be started during the 2005-2006 winter, followed by a third field season in spring and summer 2006.

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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/  
Project  
Support:

Maine Department of Inland Fisheries and Wildlife  
Maine Outdoor Heritage Fund  
USGS State Partnerships Program  
Maine Agricultural and Forestry Experiment Station - 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:** A total of 256 tissue samples have been obtained representing eight mussel species that coexist with the yellow lampmussel and the tidewater mucket. Samples were obtained from multiple populations throughout the Kennebec, St. George, and Penobscot River drainages. Laboratory work is underway to develop a genetic identification key.

A pilot study to evaluate methods of catching fish, rates of parasitism, and species parasitized was performed. Fish capture continued in the following field season throughout the Kennebec, St. George, and Penobscot River drainages. A total of 396 fish gill or fin specimens with glochidia attached were kept for identification of glochidia using the genetic identification key. Laboratory work to identify glochidia is currently underway.

**FUTURE PLANS:** Complete laboratory work to identify glochidia on naturally parasitized fish, write and defend thesis.

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**HABITAT SELECTION, RELOCATIONS, AND FISH HOSTS OF THE YELLOW LAMPMUSSEL  
(*Lampsilis cariosa*) AND TIDEWATER MUCKET  
(*Leptodea ochracea*) IN MAINE**

Investigator: J. Kurth

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

*Cooperators/* *Maine Department of Inland Fisheries and Wildlife*  
*Project Support:* Maine Outdoor Heritage Fund  
USGS – State Partnerships Program  
Maine Cooperative Fish and Wildlife Research Unit  
University of Maine  
Department of Wildlife Ecology  
MAFES (Hatch)

*Objectives:*

- 1) Analyze habitat selection of yellow lampmussel and tidewater mucket in Maine to determine potential suitable locations for these species in the Kennebec drainage and elsewhere in Maine.
- 2) Measure survival, growth and movements of resident and translocated populations of these species to determine efficacy of experimental relocations in the Sebasticook River drainage.

*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, in that 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 in the future. Our data will provide insight into the current and potential distribution of these species and their fish hosts, as well as provide information on the potential success of using mussel relocation 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 mussel surveys of the Sebasticook impoundment and experimental translocations were completed within the impoundment and at two other localities within the same drainage. Experimental use of PIT tags for freshwater mussel relocations was explored. Quantitative mussel surveys in the Sebasticook River impoundment were completed, and translocation experiments will continue for another year.

*FUTURE PLANS:* Mussels in the three study areas will be resurveyed in early summer 2006 to determine survival and recapture success. Summary of PIT tagging experiments are underway. Project completion is anticipated in December 2006.

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## LANDSCAPE THRESHOLDS AND RESPONSE TO FRAGMENTATION BY ENDANGERED NEWFOUNDLAND MARTEN (*Martes americana atrata*)

*Investigator:* A. K. Fuller

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

*Cooperators/* Canadian Forest Service

*Project Support:* Newfoundland Inland Fish and Wildlife Division  
 Corner Brook Pulp and Paper  
 Abitibi Consolidated  
 Newfoundland Forest Service  
 Western Newfoundland Model Forest  
 Maine Agricultural and Forest Experiment Station

- Objectives:*
- 1) Evaluate and define landscape-scale currencies (defined below) that are associated with habitat occupancy by marten in Newfoundland, and determine how patterns of occupancy change with amount of suitable habitat and degree of fragmentation in home range-sized landscapes. Evaluate how patterns of habitat occupancy by marten are affected by the amount of suitable habitat, landscape pattern, and fragmentation.
  - 2) Develop a series of landscape thresholds for predicting landscape-scale occupancy of habitat by marten and to compare to thresholds currently being developed in Maine. Use the thresholds to develop a tool for use in predicting population responses of marten to proposed forest-harvesting scenarios.
  - 3) Evaluate whether marten are responding to habitat loss or habitat fragmentation. Determine whether spatial-use strategies and responses to fragmentation exhibited by marten in Newfoundland differ from processes exhibited by American marten 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 precommercially 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:* Objectives 1 and 2 are complete.

*FUTURE PLANS:* Data analysis will continue with final project completion scheduled for December 2005.

## 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 Inlands Fisheries and Wildlife  
Cooperative Forestry Research Unit  
Maine Agricultural and Forest Experiment Station  
National Council on Air and Stream Improvement  
University of Maine  
Department of Wildlife Ecology  
Department of Forest Management  
The Nature Conservancy, Maine Chapter  
Huber Resources Corporation

*Objective:*

- 1) Develop a retrospective time series (1988-2005) of predicted occurrence for lynx and martens in north-central Maine.
- 2) Evaluate and compare spatial and temporal variability in the broad-scale pattern of predicted occurrence by lynx and martens, and correlate spatio-temporal variation to landscape change due to past forest management.
- 3) Develop a set of future scenarios representing alternative forest management scenarios, and develop a future time series (25+ years) of predicted occurrence for lynx and martens for select townships based on each scenario.
- 4) Determine how future (25+ years) forest management may affect the township-scale pattern and spatial variability of predicted occurrence by lynx and martens 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 Canada lynx (*Lynx canadensis*) and American marten (*Martes americana*) in Maine. Forest management affects both stand-scale 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 have large spatial requirements and are known to respond to landscape change at large spatial scales, it is important to evaluate habitat change at a large-scale (e.g., lynx and marten ranges within Maine). 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 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 away from clearcutting and towards partial harvesting in the spruce-fir forest of Maine. 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 area clearcut. 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 marten are considerably less likely to use a forest stand. Partial harvests may result in the loss of the within-stand vertical and horizontal structure marten require.

This project will use both remote sensing technology and forest simulation to determine how forest management affects the habitats of lynx and marten in Maine, and to provide a tool for forest managers to use in managing for lynx and marten habitat. In collaboration with two laboratories in the Department of Forest Management, 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 marten. We will develop a retrospective time series (1988-2005) 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 by lynx and marten. 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 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-based time series is currently being developed, as is the process for applying the marten occurrence model to the time series. Stand maps for forest projections are being acquired and alternative management scenarios are being considered.

*FUTURE PLANS:* Fieldwork to evaluate the transferability of the marten habitat model, which was developed based on townships in Baxter State Park and adjacent townships of industrial forest, to northern Maine is planned for Spring 2006.

## **FISHERIES RESOURCES:**

### INVENTORY OF INTERTIDAL AND ESTUARINE FISHES OF ACADIA NATIONAL PARK

*Investigators:*  
P. Bryer

**A. Jordaan**

*Supervisor:* L. J. Kling

*Cooperators/  
Project Support:* National Park Service - Acadia National Park  
University of Maine - School of Marine Sciences  
Maine Cooperative Fish and Wildlife Research Unit

*Objectives:* ..... 1)  
..... Inventory fish species found in tidepools at locations adjacent to Park  
..... lands on Mount Desert Island and Schoodic Peninsula, and  
2) Conduct detailed assessments of estuarine fishes at Northeast  
Creek, Frazer Creek, Bass Harbor Marsh,  
Mosquito Cove, and Somes Sound over different seasons and estuarine locations.

*SCOPE:* Acadia National Park (ANP) is part of the National Park Service's Northeast Temperate Network, and inventory and monitoring activities are becoming increasingly important to the long-term management goals of ANP. Summaries of past studies of freshwater fish resources of ANP have been issued (Bowes et al. 1999) and more detailed inventories (with relative abundance assessments) have been published (Moring et al. 2001). However, detailed inventories of fishes of estuaries and intertidal areas adjacent to ANP lands are limited.

Fishes inhabiting these mixing areas between the land and ocean are extremely important components of ecosystems (Edwards et al. 1982). Estuaries are typically the most productive regions of coastal waters, and tidepools serve important nursery and refuge functions for many commercially-important species of marine fishes in Maine waters, such as juvenile pollock (*Pollachius virens*), Atlantic herring (*Clupea harengus*), winter flounder (*Pleuronectes americanus*), and lumpfish (*Cyclopterus lumpus*). As a consequence, future Park management may rely heavily on baseline inventories of species presence and their relative abundance.

In this project fishes were inventoried during three field seasons: 2001, 2002 and 2003. The objective was to sample as many diverse habitats as possible in the intertidal and estuarine zones to maximize the resultant species lists rather than to focus on quantitative sampling procedures that would have allowed for repetitive comparisons in future years.

*PROJECT STATUS:* Major Findings: There are essentially two primary findings, the first involves the tidepool study and the second involves the estuarine study. The tidepool study strongly suggests a pattern of fish species dividing along a wave energy gradient. That is, tidepools in quiet areas, where mudflats and salt marshes dominate, contained one group of species, whereas another group of species dominated along highly exposed coastline. The estuarine study demonstrated that the primary determinant of the distribution of species in the freshwater-marine setting was the presence/absence and placement of bridges and causeways that change the flow regime within the estuary. The final report will discuss these findings, in conjunction with the consequences of climate and land-use changes and the potential damage caused from oil spills along the coast of Mount Desert Island. The fieldwork component of the project has been completed. Data have been compiled into Microsoft Access and Excel databases and are now undergoing a quality check. A draft of the tidepool section of the report has been completed, and the estuarine section is being drafted.

*FUTURE PLANS:* A final report will be issued in 2005.

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*INVESTIGATIONS INTO THE CULTURE OF RAINBOW SMELTS (Osmerus mordax)*

*Investigator:* M. A. Hachey

*Supervisor:* L. J. Kling, Chair  
M. Gallagher  
M. Kinnison

*Cooperators/  
Project Support:* University of Maine - School of Marine Sciences  
Aquaculture Research Center

Maine Department of Inland Fisheries and Wildlife  
 Maine Cooperative Fish and Wildlife Research Unit  
 Maine Outdoor Heritage Fund

*Objectives:* To demonstrate a cost-effective and environmentally friendly method for rearing rainbow smelts in intensive re-circulating aquaculture systems that will allow individuals to hatch and grow disease free smelts as an additional source for the retail baitfish market.

*SCOPE:* Rainbow smelt (*Osmerus mordax*) is an anadromous species with a historic distribution encompassing the Atlantic coastal drainage from New Jersey to Labrador with a few native landlocked populations occurring within this range (Scott and Crossman 1973). In Maine, native and transplanted landlocked rainbow smelt populations support important commercial bait and recreational fisheries as well as a forage base for the state's salmonid fisheries. Commercial smelters provide smelt for sportfish anglers to use as live bait, while recreational anglers catch them for food.

Most smelt are captured with dipnets during the spawning runs at night as they ascend natal streams in the Spring of the year. This practice has contributed to dramatic population fluctuations and closures of certain inland waters. In this project we demonstrated intensive culture production techniques to produce rainbow smelt.

*PROJECT STATUS:* During the project period we developed methods for spawning in captivity, egg incubation, disinfection and fungicidal treatment of eggs. Larval fish were reared in greenwater using enriched rotifers and then enriched *Artemia spp.* Survival through metamorphosis was 7-10%. Fish were weaned successfully onto a commercial salmon starter diet. Growth and survival during the weaning trials are in the process of statistical evaluation. A temperature rearing trial is being conducted on the juveniles to predict temperature unit growth rates and to develop optimal feeding procedures.

*FUTURE PLANS:* A final report will be produced by March 2006.

## MOVEMENTS OF AMERICAN EELS IN FRESHWATER LAKES

*Investigator:* M. Gallagher

*Advisors:* W. E. Glanz, Co-chair  
 J. G. Trial, Co-chair  
 A. D. Huryn  
 J. D. McCleave  
 F. W. Kircheis

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

*Objectives:* To document seasonal and daily movement patterns of American eels and relate these movements to habitat and environmental conditions.

*SCOPE:* Little is known about the commercially important American eels in their freshwater residence, especially their habitat selection and patterns of movement. This project captured eels and tracked their movements using surgically implanted radio transmitters. In Year 1, all fieldwork was conducted in Hermon Pond. In Year 2, the studies were expanded to include several other ponds, along with habitat mapping of ponds.

*PROJECT STATUS:* All fieldwork has been completed. Data analysis is nearly completed and writing of the dissertation has started.

*FUTURE PLANS:* A Ph.D. dissertation will be completed in May 2005.

### 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

*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 methods 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 2006.

### THE CRITICAL CONFLICT BETWEEN BROOK TROUT (*Salvelinus fontinalis*) AND SMALLMOUTH BASS (*Micropterus dolomieu*) IN THE RAPID RIVER

*Investigator:* C. A. L. Jackson

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

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

- Objectives:*
- 1) Use radio telemetry to describe movement 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

*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 interactions at a finer scale, an artificial stream comprised of pool and riffle micro-habitats with controllable water flow will be constructed at the Aquaculture Resource Center at the University of Maine. Juvenile trout and smallmouth bass will be placed in this artificial stream where their movement, position choice, and feeding behavior will be observed (by video and through PIT tag identification) under different flow conditions. These data are necessary to determine potential effects of flow mitigation efforts in areas such as the Rapid River. This work is the logical progression of recently completed radio telemetry work done in the Rapid River.

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

*FUTURE PLANS:* In the summer of 2006, juvenile trout and smallmouth bass will be placed in an artificial stream where their movement, position choice, and feeding behavior will be observed (by video and through PIT tag identification) under different flow conditions. A Master of Science thesis is expected to be completed in May 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 the feasibility of using acoustic telemetry tags to describe 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, ten 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:* Smolt movement data were collected and are being analyzed for the 2005 field season.

*FUTURE PLANS:* Adult movement data will be collected in late October 2005. The smolt component of the project will be repeated in 2006. A Master of Science thesis is expected to be completed in May 2007.

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## 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 and
- 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 NRC report and 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 was initiated and completed in 2005.

*FUTURE PLANS:* Final analysis and reporting will be completed in 2006.

**EVALUATION OF DENNY'S 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 (Maine Fisheries Complex) and have direct implications for management practices. Specifically, the results of this study will either help 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 2006.

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## 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:* 1) Assess gill Na<sup>+</sup>,K<sup>+</sup>-ATPase activity as an evaluation tool to predict long term performance of Atlantic salmon smolts in seawater

*SCOPE:* Gill Na<sup>+</sup>,K<sup>+</sup>-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 Na<sup>+</sup>,K<sup>+</sup>-ATPase activity: hatchery fish and streamside-reared fish. Fish (with known levels of gill Na<sup>+</sup>,K<sup>+</sup>-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 Na<sup>+</sup>,K<sup>+</sup>-ATPase activity. For streamside reared fish (with known water quality history) specific growth in seawater will be correlated with freshwater gill Na<sup>+</sup>,K<sup>+</sup>-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 time 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 Na<sup>+</sup>,K<sup>+</sup>-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 Na<sup>+</sup>,K<sup>+</sup>-ATPase activity will be correlated with individual specific growth rates, final gill Na<sup>+</sup>,K<sup>+</sup>-ATPase activity, and final degree of maturity.

*PROJECT STATUS:* This study will be initiated in Spring 2006.

*FUTURE PLANS:* A report is expected in Spring 2007.

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## 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  
NOAA  
University of Maine  
USGS – CRU 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 (Craig 1953; Peters et al. 1978; Owens 1987). 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 previous to 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 2006.

## 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  
NOAA Fisheries

*Objectives:*

- 1) 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 also 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 NMFS for studying Atlantic and shortnose 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 subadult and adult Atlantic sturgeon. Healthy subadult 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:* 1) 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 2006.

*FUTURE PLANS:* A report will be completed in 2006.

### **HABITAT RESOURCES:**

## THE ROLE OF DISPERSAL IN TERRESTRIAL VERTEBRATE DISTRIBUTIONS

*Investigator:* V. Bahn

*Advisors:* W. B. Krohn, Co-chair  
R. J. O'Connor, Co-chair  
M. K. Beard-Tisdale  
W. B. Halteman  
G. L. Jacobson

*Cooperators/  
Project  
Support* Biological Resources Division, USGS  
Maine Cooperative Fish and Wildlife Research Unit  
University of Maine  
Department of Wildlife Ecology

*Objectives:*

- 1) Review current concepts and techniques for modeling terrestrial vertebrate occurrences and identify most critical field for improvement.
- 2) Compare traditional and spatially-explicit distribution models with advanced model selection techniques to determine their relative effectiveness.
- 3) Investigate causes of spatial autocorrelation in species' distribution patterns.

*SCOPE:* This project reviews current modeling concepts and techniques for terrestrial vertebrate occurrences with the goal of improving current approaches. Specifically, the influence of dispersal on distribution patterns and its consequences to distribution modeling was identified as the problem with the highest negative effect and the best chance for improvement. Within this topic, the first part was to improve spatial modeling techniques and model selection. The second part was to investigate the causal link between dispersal and spatial autocorrelation in distribution patterns.

*PROJECT STATUS:* All requirements for a Ph.D. degree in Wildlife Ecology were met in August 2005. The abstract follows:

Modeling the geographical distributions of wildlife species is important for ecology and conservation biology. Spatial autocorrelation in species distributions poses a problem for distribution modeling because it invalidates the assumption of independence among sample locations. I explored the prevalence and causes of spatial autocorrelation in data from the Breeding Bird Survey, covering the conterminous United States, using Regression Trees, Conditional Autoregressive Regressions (CAR), and the partitioning of variance. I also constructed a simulation model to investigate dispersal as a process contributing to spatial autocorrelation, and attempted to verify the connection between dispersal and spatial autocorrelation in species' distributions in empirical data, using three indirect indices of dispersal.

All 108 bird species modeled showed strong spatial autocorrelation, which was significantly better modeled with CAR models than with traditional regression-based distribution models. Not all autocorrelation could be explained by spatial autocorrelation in the underlying environmental factors suggesting another process at work, which I hypothesized to be dispersal. In the simulation model, dispersal produced additional autocorrelation in the distribution of population abundances. The effect of dispersal on autocorrelation was modulated by the potential population growth rate, with low growth rates leading to a stronger effect. The effect of dispersal on population sizes was different between populations at the periphery and core of a range. Due to their relative isolation, peripheral populations received fewer immigrants than populations at the core, causing lower population sizes. Dispersal could therefore be an explanation for range structures independent of environmental conditions. The verification of dispersal as a partial cause of autocorrelation failed. The most plausible cause was the indirectness of the indices used to represent dispersal.

Distribution modelers should generally include space explicitly in their models, especially for species with

low potential population growth rates. Dispersal has a strong potential to shape species distributions and requires more explicit consideration in distribution models and conservation plans. To reach this goal, direct research on dispersal distances and strength is urgently needed. Disruptions in natural dispersal patterns through removal of habitat isolates populations and thus may harm species beyond the effects of only direct habitat removal.

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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  
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, interannual, 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. To 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 for 20 years 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 20 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 2004, tasks 1, 3, 4, 5, 6, 7, 8, and as outlined above were completed; 100% tree inventory was postponed.

*FUTURE PLANS:* The 2006 field season will cover all the parameters measures annually.

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## 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 Intergrated 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:* Amphibian data collected by the Florida Integrated Science Center were used to develop statistical models to examine habitat associations of certain amphibian species. Programming of the spatial landscape model and sensitivity analysis are complete, and model experiments are underway. Experimentation includes an analysis of effects of various fire management policies on vegetation composition and structure (measured using patch, isolation, and compositional metrics) within ONWR. For example, we used 48 years of output from Loftin's (1998) hydrology model that predicted continuous water level depths in every 500 m cell over the entire ONWR and this information was re-classified into thematic maps showing four water depth categories for each of two seasons. The maps were further categorized into hydroperiod coverage (i.e., the number of times in a season that a cell spent in a particular water depth category). We then use the hydroperiod coverage as a time series to develop rules for fire ignition and spread as well as for vegetation succession. We assume that the empirical water level, precipitation, and Southern Oscillation Index (SOI) data capture the frequency and autocorrelation of wet and dry years. Thus, we can constrain the model by choosing to start the time series at different years (i.e., wet or dry) or allowing it to randomly choose water level condition. Contrasting these two approaches may show the effect of autocorrelation of wet and dry years on the fire regime and vegetation dynamics. A time series model was developed to forecast severe wildfire years using the SOI and historical wildfire, water level, and rainfall data as parameters.

### *FUTURE PLANS:*

Dissertation and manuscript preparation are underway. We will be communicating the results of this research to the refuge staff during early 2006.

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## 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 Program  
*Project* Maine Department of Inland Fisheries and Wildlife  
*Support* University of Maine -  
Department of Wildlife Ecology  
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 unstocked, 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. Macroinvertebrate 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 Huang-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 will be sorted and taxonomic identification is underway. Data analysis will begin.

Paleolimnological study of fishless-fishfull lake pairs: The calibration data set has been completed, and we are now processing samples collected to validate the GIS model (see above). Sample analysis will be completed by January 2006 and data analysis and the thesis will be completed by June 2006.

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## 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/*

**University of Maine, Department of Wildlife**

**Ecology**

*Project Support* U.S. Geological Survey, 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 bioassessment 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:* Stream algae and water chemistry were completed during summer 2005. Sample analysis, including algal species identification, is currently underway.

*FUTURE PLANS:* Data analysis will continue during 2006.

## THE PRESETTLEMENT FOREST OF NORTHERN MAINE

*Investigator:* L. J. Mitchener

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A. S. White, Co-chair  
C. V. Cogbill  
R. S. Seymour  
J. S. Wilson

*Cooperators/* The Nature Conservancy

*Project Support:* University of Maine  
 Department of Forest Ecosystem Science  
 Department of Wildlife Ecology  
 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 two chapters of the dissertation have been drafted, and data analysis and writing is on-going with the third. Data analysis is also on-going with the last chapter, but writing has begun.

*FUTURE PLANS:* Completion of the dissertation is scheduled for the spring of 2006.

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## **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  
 R. J. O'Connor  
 J. M. Rhymer  
 A. S. White  
 W. B. Halteman

*Cooperators/  
 Project  
 Support:* Holt Woodland 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 current forest management practices in both tropical and temperate regions. Much of this attention has been given to the effects of clear-cutting and fragmentation; however, few studies have examined the effects of small harvest-created openings or gaps in a forest.

One such study that is examining the effects of small harvest-created gaps 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 (23 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, one half of the area was harvested such that 10 1-ha blocks were partially cut with a group-selection timber harvest. The other half of the forest was left as an unharvested control. 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 habitat use 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 long-term data on habitat use to see if the same areas of the forest are repeatedly preferred or if territory placement is random.

*PROJECT STATUS:* Manuscripts addressing the first three objectives have been completed and will be submitted for publication in peer-reviewed scientific journals. Brief qualitative summaries of the results therein are below. I am currently investigating the degree of year-to-year stochasticity in habitat use (Objective 4).

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. Comparisons of the trends in abundances from the Holt Research Forest to statewide trends from Breeding Bird Survey 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. Six species (Eastern Wood-Pewee, Winter Wren, 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 a 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 August 2006.

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## 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:* Webless marsh birds, such as rails and bitterns, are generally recognized as being among the least studied and understood avian groups. Their secretive nature and use of inaccessible habitat has resulted in an overall poor understanding of their life histories and habitat requirements. Consequently, there are significant gaps in our knowledge of marsh bird population trends particularly in the northeastern United States. Over the last several decades these species have been in apparent decline, and information about the current population status and trends of these birds is both necessary and lacking.

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 variation in marsh bird presence. In the present study I will be re-surveying previous sites to document temporal and spatial 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 results will provide evidence of whether or not declines in populations seen further south in New England are also occurring in Maine. The Least Bittern is of particular concern in Maine, because its numbers have declined in Maine recently, and more estimates of population size are needed. Maine represents the northern geographic edge of the Least Bittern range and they are extremely rare here, having only been verified as breeding at 28 sites.

*PROJECT STATUS:* The first field season was completed in late July of 2005 with a total of 38 sites being surveyed across southern and eastern Maine. Virginia Rail was the most frequently encountered target species. Based on preliminary data collected to date, more Virginia Rails and American Bitterns, and fewer Least Bitterns were observed than during previous surveys. Soras and Pied-Billed Grebes appear to have remained stable. Only three individual Least Bitterns were detected in 2005. These individuals were found in three separate wetlands. Additional analysis data is currently underway.

*FUTURE PLANS:* We will survey 37 additional sites in 2006 bringing the total to 75 unique wetlands resurveyed. In addition, we will resurvey all sites from 2005 with historic records of Least Bittern. This will add 10 sites for a total of 47 wetlands to be surveyed in 2006. We will be catching any Least Bitterns that are detected locally to accomplish the radio telemetry goals we have set. We will prepare a report detailing the status and trends of Least Bitterns throughout the northeast by contacting individuals from neighboring states and provinces. This will be

presented together with state and regional population estimates. Color digital photos will be used to quantify habitat conditions at sites where Least Bitterns have been found to no longer occupy to investigate habitat changes that may have occurred since original surveys were completed. Lastly, climate data will be analyzed to determine if the 2005 season was abnormal and if it differed from years when past surveys were conducted.

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

### **AN ANALYSIS OF HARBOR SEAL (*Phoca vitulina*) AND GRAY SEAL (*Halichoerus grypus*) HAUL-OUT PATTERNS, BEHAVIOR BUDGETS, AND AGGRESSIVE INTERACTIONS ON MOUNT DESERT ROCK, MAINE**

*Investigator:* S. C. Renner

*Advisors:* J. R. Gilbert, Chair  
W. E. Glanz  
F. A. Servello  
S. K. Todd

*Cooperators/  
Project  
Support:* University of Maine Agricultural and Forest Experiment Station  
College of the Atlantic  
Allied Whale  
University of Maine  
Department of Wildlife Ecology

*Objectives:*

- 1) Compare behavior patterns of harbor seals and gray seals on Mount Desert Rock, including aggressive encounters, resting, and non-resting behaviors as a function of tide cycle, species composition on the haul-out ledge, and animal density.
- 2) Determine environmental factors (tide, time of day, sea-state, or cloud cover) that influence haul-out patterns for both species of seals.
- 3) Evaluate differences in haul-out site characteristics between ledges used primarily by gray seals and those used by harbor seals.

*SCOPE:* The number of gray seals (*Halichoerus grypus*) in the Gulf of Maine has been increasing for more than 20 years. Substantial data exist that quantify overlap of food resources for gray seals and harbor seals (*Phoca vitulina*), but few researchers have observed both species on common haul-out sites. Hauling-out serves several important functions for most phocids including rest between foraging forays (thus fat storage), predator avoidance, and molting. This project will address inter- and intra-specific interactions that may affect haul-out duration, location, and function.

*PROJECT STATUS:* All requirements for a M.S. degree in Wildlife Ecology were met in May 2005. The abstract follows:

As gray seal (*Halichoerus grypus*) populations continue to grow in the Gulf of Maine, it is necessary to quantify changes to the regional ecology for both management and conservation purposes. This study compares haul-out patterns, presents summer activity budgets, and contrasts intra- and interspecific aggressive interactions among the harbor seal (*Phoca vitulina*) and gray seal population on Mount Desert Rock, Maine. These data were collected using Altman's scan method and focal animal sampling.

Time to low tide and day of year influenced both harbor seal and gray seal haul-out patterns on Mount Desert Rock. For both species, more seals hauled-out closer to low tide. Day of year was correlated positively with numbers of harbor seals and negatively with numbers of gray seals.

Overall activity budgets are presented for both species; the harbor seal budget agrees well with previously published data, and the gray seal budget is the first documented for this species during summer months, but is generally similar to breeding budgets. Intrinsic and environmental factors influenced harbor seal behavior patterns. Gray seals had little, if any, effect on harbor seal behavior patterns and were only important in one of three models describing harbor seal sleep budgets. Harbor seal behavior budgets and rates were most broadly affected by number of adjacent seals. At moderate densities of 4-6 adjacent seals, focal harbor seals slept more in longer, fewer bouts, while reducing overall time scanning via fewer bouts. Sleep budgets were also positively correlated with total number of seals on a haul-out ledge, day of year, wind speed, and cloud cover and negatively correlated with absolute time to low tide and air temperature. Sleep bouts occurred more frequently during higher tides and during calm wind conditions. Scanning budgets were positively correlated with higher tide states and the absence of fog and negatively correlated with number of seals on a ledge, wind speed, day of year, and cloud cover.

Harbor seal sleep and scan behaviors varied over the course of a day. The activity cycle was independent of tide state and was characterized by alternating peaks of sleep and scan behavior. Sleep peaked near midday in both years, and this may explain why maximum haul-out numbers occur near midday in numerous other studies.

Although gray seals did not affect harbor seal behavior patterns, male gray seals clearly were dominant to harbor seals during aggressive interactions. Intra- and interspecific interactions involving only two individuals were similar in duration. Harbor seals responded aggressively less frequently when a gray seal changed body position than when another harbor seal performed the same behavior. Harbor seals may recognize and avoid confrontations with significantly larger opponents.

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DOI AMPHIBIAN RESEARCH AND MONITORING INITIATIVE (ARMI):  
EFFECTS OF LANDSCAPE HETEROGENEITY AND ENVIRONMENTAL  
STRESSORS ON PALUSTRINE AND LOTIC AMPHIBIAN POPULATIONS  
IN ACADIA NATIONAL PARK

*Investigators:* M. Bank (Ph. D. student)  
R. Chalmers (M.S. student)

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J. Longcore  
R. E. Jung

For M. Bank (Ph.D. student):  
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J. Jellison, Co-chair  
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W. Glanz  
R. E. Jung

*Cooperators/  
Project Support:* U. S. Geological Survey  
Patuxent Wildlife Research Center  
University of Maine  
Department of Wildlife Ecology  
Department of Biological Sciences  
National Park Service  
Acadia National Park  
Maine Cooperative Fish and Wildlife Research Unit  
Eastern National Park Research Fund  
Declining Amphibian Task Force

- Objectives:*
- 1) Develop species-habitat models of selected amphibian species in Acadia National Park at various spatial scales.
  - 2) Identify environmental correlates related to selected amphibian species occurrence and population status in ANP palustrine and riparian wetlands.
  - 3) Determine the relationship between counts of stream-dwelling salamanders and estimates of population sizes.
  - 4) Evaluate the relationship between mercury contamination and population performance in northern two-lined salamanders (*Eurycea bislineata bislineata*) along a spatial and temporal gradient.

*SCOPE:* Worldwide amphibian declines and increased reports of amphibian malformations have prompted the United States Department of Interior (DOI) to initiate an Amphibian Research and Monitoring Initiative (ARMI). Regional ARMI programs are planned throughout the United States. Acadia National Park (ANP) is serving as a long-term intensive amphibian monitoring index site. This research includes defining relationships of stream-dwelling salamanders and cross-scale habitat composition (within-stream to watershed-scale), with the intent of using northern two-lined (*Eurycea bislineata bislineata*) salamander population counts and trends as indicators of park stream conditions. Although mercury contamination in lotic ecosystems in the Park is well-documented and is a result of non-point atmospheric deposition, levels in streamside salamanders are unknown. This study will provide insights into mercury bioaccumulation levels in stream-side salamanders, how they contribute to mercury cycling and transfer in both lotic and terrestrial food webs, and the potential for a decline of stream-dwelling biota with increasing mercury contamination. Another aspect of this research includes a survey of four-toed (*Hemidactylium scutatum*) salamanders, a species of concern in Maine, Massachusetts, and Vermont. The distribution of four-toed salamander has decreased throughout its range due to wetland loss associated with land clearing and development. This species may require mature hardwood or conifer forests and fishless wetland breeding sites, making it vulnerable to habitat disturbance. Our objective is to document the distribution and habitat associations of this species within ANP, and develop predictive models of their potential occurrence in the Park based on the documented local- and landscape-scale habitat associations.

*PROJECT STATUS:*

Wetland and nest scale habitat use by the four-toed salamander (*Hemidactylium scutatum*) in Maine, and a comparison of survey methods

The M.S. thesis was completed and defended. The thesis abstract follows:

Conserving amphibian populations requires knowledge of a species and its habitat relationships. The four-toed salamander (*Hemidactylium scutatum*) is listed as Endangered in Indiana, Threatened in Illinois, and Rare or of Special Concern in Maine, Massachusetts, Vermont, Ohio, Wisconsin, Missouri, and Minnesota. Little is known of *H. scutatum* ecology despite the species' extensive range. Infrequent sightings of *H. scutatum* throughout its range may indicate either low numbers or that the species' behavior make detection difficult. Records for *H. scutatum* in Maine existed from only 32 sites before my study, and the total number of occurrences of this species in Maine is unknown (P. deMaynadier, Maine Department of Inland Fisheries and Wildlife, personal communication). I found 238 four-toed salamander nests in 36 wetlands, which were new sites. The survey protocol, natural history descriptions, and definitions of wetland and shoreline habitat presented will increase detections of this species and thus improve the monitoring and management of *H. scutatum* and the wetland habitat that this species occupies. In the first chapter, I compare monitoring techniques for the species, document new points in which I found the species, and present natural history information. I conducted surveys of adults on roads during rainy spring nights, surveys of nests, and surveys of larvae with dipnetting in wetlands, and I present incidental visual encounters and pitfall captures for comparison. Greatest numbers of salamanders were found with the nest surveys, which were conducted in palustrine wetlands by walking in the water and parting the shoreline vegetation to search for eggs and attendant females. I found *H. scutatum* nests in 35 of 92 wetlands searched. In the second chapter, I investigate species-habitat relationships that predict *H. scutatum* presence at two scales: the wetland (and surrounding landscape) and the available shoreline points in which nests could occur. I collected data at wetlands with and without nests, and I collected data along the shoreline at points with and without nests. With these data, I created models that predicted

wetlands with nests, and I created and evaluated models that predicted nest point selection within a wetland and available point characteristics between wetlands with and without nests. Wetlands with nests were best predicted by higher pH and were negatively associated with shrub scrub and unconsolidated bottom NWI classes. Wetlands with nests were also predicted by the availability of shoreline points that provided *Sphagnum* spp. for egg attachment, wood substrate, water flow, the presence of blue-joint reed grass (*Calamagrostis canadensis*), meadowsweet (*Spiraea alba*), steeplebush (*Spiraea tomentosa*), and sensitive fern (*Onoclea sensibilis*), and the absence of sheep laurel (*Kalmia angustifolia*) and deciduous forest NWI class. Within wetlands with nests, shoreline points with nests were best distinguished from shoreline points without nests by steeper shores, greater near-shore and basin water depth, deeper nesting vegetation, presence of moss and winterberry (*Ilex verticillata*), and a negative association with *Spiraea alba*, leatherleaf (*Chamaedaphne calyculata*), and *Kalmia angustifolia* within 1m of the shoreline point.

Effects of trophic and watershed complexity on mercury contamination in two-lined salamanders:

Ph.D. dissertation was completed and defended. The dissertation abstract follows:

The objective of this investigation was to study mercury bioaccumulation and habitat use in lotic and lentic amphibians at Acadia National Park (ANP). I report concentrations of methyl Hg (MeHg – at ANP only) and total mercury (Hg) in larval northern two-lined salamanders (*Eurycea bislineata bislineata*) collected from streams in Acadia National Park (ANP), Maine, Bear Brook Watershed, Maine (BBWM; a paired, gauged watershed treated with bimonthly applications {25 kg/ha/yr} of ammonium sulfate [(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>] since 1989), and Shenandoah National Park (SNP), Virginia. MeHg comprised 73-97% of total Hg in the larval salamander composite samples from ANP.

At BBWM I detected significantly higher Hg levels in larvae from the (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> treatment watershed. At ANP Hg concentrations in salamander larvae were significantly higher from streams in unburned watersheds in contrast with samples collected from streams located in watersheds burned by the 1947 Bar Harbor fire. Hg levels were higher in salamander larvae collected at ANP in contrast with SNP salamanders and ANP lentic amphibians (bullfrog – *Rana catesbeiana* and green frog – *Rana clamitans* tadpoles ~1 year of age). At ANP, 44% of the ponds ( $n=9$ ) had methylation efficiency rates greater than 10%, suggesting that some wetlands in ANP are likely susceptible to high levels of Hg bioaccumulation. Microhabitat data indicate that salamander larvae were generally found  $\leq 50$  cm from stream edge and at water depths  $\leq 9$ cm. Larval salamander density was greater in streams draining watersheds burned by the 1947 fire (hardwood dominated) in comparison to streams from unburned, conifer dominated watersheds. Among streams, the best approximating model for both occurrence and abundance of salamander larvae included pH (+), % embeddedness (-), and fish abundance (-). Among watersheds, percent conifer forest (+) in the watershed was the best approximating model for total Hg bioconcentration factors in salamander larvae. Overall, this investigation suggests that stream heterogeneity influences patterns of distribution, abundance, and biomass of larval two-lined salamanders at multiple spatial scales. Risk assessment model should include a watershed perspective since headwater streams and their associated receiving wetlands and ponds may have substantial differences in rates of mercury bioaccumulation and biomagnification.

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## BEHAVIOR AND LIFE HISTORY CHARACTERISTICS OF NEONATE HARBOR SEALS (*Phoca vitulina*) IN MAINE

*Investigator:* J. P. Skinner

*Advisors:* J. R. Gilbert, Chair  
D. J. Harrison  
W. E. Glanz

*Cooperators/* National Marine Fisheries Service  
*Project* Maine Forest and Agriculture Experiment Station  
*Support:* 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 as harbor seal pups are weaned from their mothers and become independent foragers.
  - 3) Compare the frequency of pup hauling out behavior with pup age, location, weather conditions, time of day and tide cycle.

*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:* Our study area included parts of eastern Penobscot Bay (Stonington) and western Blue Hill Bay (Jerico Bay). These areas contain many intertidal and protected ledges suitable for harbor seal pupping. Two seasons of field work were completed in July 2005. We captured 66 pups and 2 adult seals in 2004 and 89 pups in 2005. Measurements were taken during all captures and movement and diving behavior was recorded for a subset of individuals using VHF telemetry and time-depth recording devices. The data is currently being analyzed and results should be ready in the spring 2006.

*FUTURE PLANS:* The project is scheduled for completion by May 2006. Some results will be displayed as a poster entitled, "Using Reproductive Parameters to Examine Population Performance in the Western Atlantic Harbor Seal (*Phoca vitulina concolor*)" at the 16<sup>th</sup> biennial conference of The Society for Marine Mammalogy Dec. 11<sup>th</sup> - 16<sup>th</sup>, 2005. These and other results will also be published in suitable refereed journals.

## THE RESPONSE OF MAULINO FOREST AMPHIBIANS TO EXOTIC PINE PLANTATIONS

*Investigator:* P. A. Palacios

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

*Cooperators/  
Project  
Support:* Fulbright grant - U. S. Department of State  
University of Maine Graduate Student Association

- Objectives:*
- 1) Determine if there is a difference in amphibian species richness and abundance among continuous forest, forest fragments, and pine plantations.

- 2) Determine if body condition of amphibians is diminished by pine plantations and fragmentation.
- 3) Identify if amphibian dispersal occurs between continuous forest, forest fragments, and pine plantations.

*SCOPE:* Deforestation and forest fragmentation have increased worldwide, becoming a significant threat to biodiversity. Maulino forest is a scarce type of Chilean temperate forest which has been reduced to small fragments as a result of deforestation. The main cause of the decrease of maulino forest has been cutting to use the land for agriculture and its replacement by plantations of exotic species, such as *Pinus radiata*.

Amphibian populations are declining globally. In maulino forest, 7 species of amphibians are potentially present, all of them endemic to Chile and threatened on a national level. The overall goal of this research is to study the effect of maulino forest fragmentation and its replacement by exotic pine plantations on the endemic amphibian community. This will be undertaken by systematic sampling of amphibians with pitfall traps and drift fences in a landscape with forest fragments, pine plantations, and a 145 ha national reserve considered as a continuous forest.

*PROJECT STATUS:* Trap building and amphibian survey are in progress.

*FUTURE PLANS:* Amphibian monitoring will continue until December 2007. After determining the effect of plantations and fragmentation on amphibians, we will undertake experiments to try to understand their responses.

## 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  
McIntire-Stennis  
University of Missouri  
University of Georgia, Savannah River Ecological Laboratory  
University of Maine Association of Graduate Students

*Objectives:*

- 1) Determine the effects of terrestrial habitat alteration on the fitness of wood frogs (*Rana sylvatica*).
- 2) Determine whether or not 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 2005, I completed construction of terrestrial pens. I reared wood 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 wood frogs from this experiment were marked individually and released to the terrestrial pens to assess survival and growth. I captured metamorphosing spotted salamanders (*Ambystoma maculatum*) from vernal pools, marked them individually, and released them to the terrestrial pens to assess survival and growth. To assess ways in which wood frogs can behaviorally compensate for a potentially stressful environment, habitat selection was assessed at the subpatch, patch, and home range scales based on locations of 40 radio-tracked, wild wood frogs during May-June 2005. I also compared movement behavior of wood frogs and northern leopard frogs using string trailing in August 2005.

*FUTURE PLANS:* In 2005-2007, I plan to continue assessing the growth and survival of the wood frogs and spotted salamanders in the terrestrial pens. In 2006, I will repeat the aquatic mesocosm experiment using northern leopard frogs and add these animals to the terrestrial enclosures. In 2006, I will assess habitat selection and fine-scale movement study of northern leopard frogs. In 2007, I will also perform breeding experiments with wood frogs reared in cattle tanks and pens to determine the breeding success of individuals 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 and State Organization of the Americas  
United Nations Educational, Scientific and Cultural Organization  
Wildlife Conservation Society

*Objectives:*

- 1) 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).
- 2) 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 four field surveys: December 2003, from June to August 2004, December 2004, and from June until September 2005. 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 a year-long field survey until the end of 2006.

## THE EFFECTS OF HABITAT ALTERATION ON JUVENILE AMPHIBIAN DISPERSAL

*Investigator:* D. A. Patrick

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

*Cooperators/  
Project  
Support:* National Science Foundation  
University of Missouri  
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 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. The treatments extend 164 m from the pond's center to capture 95% of amphibians in that local population.

I am using terrestrial drift fences to capture individually marked juvenile animals of two species, wood frog, *Rana sylvatica*, and spotted salamander *Ambystoma maculatum*, at 50, 100, and 150 m from the ponds edge. This information will be compared with detailed biotic and abiotic surveys in the different forestry treatments, in order to

parameterize a predictive model of population redistribution. Separate choice experiments at two spatial scales (fine scale at a 1 m range, and mesocosm within 10 m diameter enclosures) will also be used in the parameterization process. This model will then be used to make predictions as to how land-use changes are likely to affect dispersal and long term viability of amphibian populations and metapopulations.

*PROJECT STATUS:* In 2005, I marked 6088 wood frog juveniles and 600 spotted salamanders. I also captured approximately 6000 unmarked amphibians at the terrestrial drift fences. In addition to this, I conducted several habitat choice experiments involving fluorescent powdering of juvenile frogs. Theoretical dispersal models incorporating habitat heterogeneity were also developed.

*FUTURE PLANS:* In the winter of 2005 I intend to continue with model development, with a final field season planned for summer of 2006.

## EXAMINATION OF MERCURY CONTAMINATION IN NORTHERN TWO-LINED SALAMANDERS (*Eurycea bislineata bislineata*) AND SLIMEY SCULPIN (*Cottus cognatus*) INHABITING WATERSHEDS IN COASTAL MAINE

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

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

*Objectives:* The objective of this project is to document total mercury and methylmercury concentration levels in northern two-lined salamanders (*Eurycea bislineata 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 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:

- Quantify mercury contamination levels in two species (northern two-lined salamander larvae and slimey sculpin) found in similar trophic positions.
- Characterize and compare the ratio of methylmercury (toxic form) and total mercury in these two species from different watersheds.

- 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 will occur during summer 2006.

**PUBLICATIONS, THESES AND DISSERTATIONS  
PROFESSIONAL AND PUBLIC TALKS GIVEN, AND AWARDS**

SCIENTIFIC PUBLICATIONS

- BANK, M. S., C. S. LOFTIN, and R. E. JUNG. 2005. Mercury bioaccumulation in two-lined salamanders from streams in the northeastern United States. *Ecotoxicology* 14:181-191.
- CAMPBELL, S. P., A. K. FULLER and D. A. G. PATRICK. 2005. Looking beyond research in doctoral education. *Frontiers in Ecology and the Environmen* 3:153-160.
- ELIAS, S. P., J. W. WITHAM, and M. L. HUNTER, JR. 2004. Maine *Peromyscus leucopus* abundance and acorn mast: population fluctuation patterns over 20 years. *Journal of Mammology* 85:743-747.
- FROST, H. C., W. B. KROHN, E. A. BEZEMBLUK, R. LOTT, and C. R. WALLACE. 2005. Prenatal development in fishers (*Martes pennanti*). *Theriogenology* 63(5):1440-1453.
- FULLER, A. K. 2004. Canada lynx predation on white-tailed deer. *Northeastern Naturalist* 11:394-398.
- FULLER, A. K. and D. J. HARRISON. 2005. Influence of partial timber harvesting on American martens in north-central Maine. *Journal of Wildlife Management* 69:710-722.
- GILBERT, A. T. and F. A. SERVELLO. 2005. Water level dynamics in wetland sand nesting success of black terns in Maine. *Waterbirds* 28:180-186.
- 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.
- HOMYACK, J. A., D. J. HARRISON, and W. B. KROHN. 2005. Long-term effects of precommercial thinning on small mammals in northern Maine. *Forest Ecology and Management* 205:43-57.
- HOVING, C. L., D. J. HARRISON, W. B. KROHN, W. J. JAKUBUS, and M. A. MCCOLLOUGH. 2004. Canada lynx *Lynx canadensis* habitat and forest succession in northern Maine, USA. *Wildlife Biology* 10(4): 285-294.
- HOVING, C. L., D. J. HARRISON, W. B. KROHN, R. A. JOSEPH, AND M. O'BRIEN. 2005. Broad-scale predictors of Canada lynx occurrence in eastern North America. *Journal of Wildlife Management* 69(2): 739-751.
- HUNTER, JR., M. L. 2005. A mesofilter complement to coarse and fine filters. *Conservation Biology* 19:1025-1029.
- HUNTER, JR., M. L., A. CALHOUN, and D. S. WILCOVE. Goliath Heron fishing with an artificial bait? *Waterbirds* 27:312-313.
- MATTHEWS, S. N., R. J. O'CONNOR, L. R. IVERSON, and A. M. PRASAD. 2004. Atlas of climate change effects in 150 bird species of the eastern United States. USDA Forest Service, Newtown Square, PA. 340 pp.
- SERVELLO, F. A., E. C. HELLGREN, AND S. R. MCWILLIAMS. 2005. Techniques for Wildlife Nutritional Ecology. Pages 554-590 in C. Braun (ed.) *Techniques for wildlife investigations and management*. Sixth

Edition, Bethesda, Maryland.

#### TECHNICAL AND SEMI-TECHNICAL PUBLICATIONS

- FULLER, A. K. and D. J. HARRISON. 2005. Influence of forest practices on stand-scale habitat selection by lynx in northern Maine: preliminary results. In L. S. Kenefic, M. J. Twery, eds. Changing Forests – Challenging times: Proceedings of the New England Society of American Foresters 85<sup>th</sup> Winter Meeting Gen. Tech. Rep. NE-325, Newton Square, PA: U. S. Department of Agriculture, Forest Service, Northeastern Research Station: 13. March 16-18, 2005.
- HEARN, B. J., D. J. HARRISON, C. LUNDRIGAN, W. J. CURAN, and A. K. FULLER. 2005. Scale-dependent habitat selection by Newfoundland marten. Final contract report to Western Newfoundland Model Forest, Newfoundland-Labrador Wildlife Division, Canadian Forest Service, Corner Brook Pulp and Paper and Abitibi Consolidated. 86 pp.
- KROHN, W. B. (compiler and editor). 2005. Manly Hardy (1832-1910): the life and writing of a Maine fur-buyer, hunter, and naturalist. Northeast Folklore Vol. 38, University of Maine, Orono, ME. 343 pp.
- KROHN, W. B. and C. S. LOFTIN (compilers and editors). 2005. Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife Ecology – 2004 Report to Cooperators. Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME. 54 pp.
- KROHN, W. B. and D. J. HARRISON. Canada lynx in the North Maine Woods. Pages 8-9 in North Maine Woods 2005. Annual publication of North Maine Woods, Ashland, ME.
- LOFTIN, C. S. Final Report, Research Work Order 45, Northeast Amphibian Research and Monitoring Initiative: effects of landscape heterogeneity and environmental stressor on palustrine and lotic amphibian populations in Acadia National Park. Prepared as Ph.D. dissertation (Michael Bank, Mercury Bioaccumulation and habitat relations of lotic and lentic amphibians from Acadia National Park, Maine, USA) and M. S. thesis (Rebecca Chalmers, Wetland and nest scale habitat use by the four-toed salamander (*Hemidactylum scutatum*) in Maine, and a comparison of survey methods). December 31, 2004.

#### THESES AND DISSERTATIONS

- BAHN, V. 2005. Implication of spatial autocorrelation and dispersal to the modeling of species distributions. Ph.D. Dissertation, University of Maine, Orono, ME. 103 pages.
- BANK, M. 2005. Mercury bioaccumulation and habitat relations of lotic and lentic amphibians from Acadia National Park, Maine. Ph.D. Dissertation, University of Maine, Orono, ME. 155 pages.
- CHALMERS, R. J. 2004. Wetland and nest scale habitat use by the four-toed salamander (*Hemidactylum scutatus*) in Maine, and a comparison of survey methods. M. S. Thesis, University of Maine, Orono, ME. 109 pages.
- PERKINS, J. C. 2004. Reproductive success and evaluation of management strategies for least terns in Maine. M. S. Thesis, University of Maine, Orono, ME. 94 pages.
- RENNER, S. 2005. An analysis of harbor seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*) haul-out patterns, behavior budgets, and aggressive interactions on Mount Desert Rock, Maine. M.S. Thesis, University of Maine, Orono, ME. 80 pages.

## PROFESSIONAL TALKS PRESENTED

BANK, M. S., C. S. LOFTIN, J. CROCKER, R. MACDONALD, A. AMIRBAHMAN. "Mercury, stream salamanders and watershed heterogeneity: coping with a risky environment." Presented at the Maine Water Conference Annual Meeting, Augusta, ME. March 22, 2005.

DANIELSON, T. J. "Using algae to evaluate the condition of Maine's streams and rivers." Presented at the 44<sup>th</sup> Annual meeting of the Northeast Algal Society, Rockport, ME. April 15-17, 2005.

DEGOOSH, K. E., E. G. SCHILLING, C. S. LOFTIN, and K. E. WEBSTER. "Message in the mud: what the presence of *Chaoborus americanus* can tell us about fish distributions throughout the Maine landscape." Presented at the American Society of Limnology and Oceanography, Aquatic Sciences Meeting, Salt Lake City, UT. February 20-25, 2005.

DEGOOSH, K. E., E. G. SCHILLING, S. C. LOFTIN, and K. E. WEBSTER. "Message in the mud: does *Chaoborus americanus* indicate fish absence in Maine ponds?" Presented at the 11<sup>th</sup> Annual Maine Water Conference, Augusta, ME. March 22, 2005.

DEGOOSH, K. E., E. G. SCHILLING, S. C. LOFTIN, and K. E. WEBSTER. "Message in the mud: does *Chaoborus americanus* indicate fish absence in Maine ponds?" Presented at University of Maine Graduate Student Expo, Orono, ME. April 12, 2005.

DEGOOSH, K. E., E. G. SCHILLING, S. C. LOFTIN, and K. E. WEBSTER. "Message in the mud: does *Chaoborus americanus* indicate fish absence in Maine ponds?" Presented at the Annual meeting of the New England Chapter of the North American Lake Management Society, Plymouth, NH. June 4, 2005.

ELIAS, S. P., J. W. WITHAM, and M. L. HUNTER, JR. "Mice, mast, and a group-selection harvest: 20 years on the Holt Research Forest." Presented at The 85<sup>th</sup> Annual Winter Meeting of the New England Society of American Foresters, South Portland, ME. March 15-18, 2005.

FULLER, A. K. and D. J. HARRISON. "Influence of forest practices on stand-scale habitat selection of lynx in northern Maine." Presented at Eastern CANUSA Forest Science Conference, Fredericton, New Brunswick. October 16, 2004.

FULLER, A. K. and D. J. HARRISON. "Stand-scale habitat selection by lynx in northern Maine: preliminary results." Presented at the Fourth Northeastern Mesocarnivore Workshop: lynx and marten in the northern Appalachians, Portland, ME. December 9, 2004.

FULLER, A. K., D. J. HARRISON, and J. VASHON. "Stand-scale habitat selection by lynx on commercial forestlands in northern Maine." Presented to the New England Chapter of Society of American Foresters Conference, Portland, ME. March 17, 2005.

FULLER, A. K., D. J. HARRISON, and J. H. VASHON. "Effects of forest practices on habitat selection by Canada lynx during winter." Presented at the Lynx Research Working Group Meeting, Orono, ME. April 14, 2005.

GILBERT, J. R. "Marine Mammals." Presented at the Penobscot River Forum.

GILBERT, J. R. "Interactions between seals and Atlantic salmon aquaculture in Maine, 2001-2003." Poster presentation to Fish Health Workshop.

GRYGO, A., K. WEBSTER, C. S. LOFTIN, K. TONNESSEN, and S. KAHL. "A GIS landscape model examining DOC variability among watersheds in National Parks." Presented at the Maine Water Conference Annual Meeting, Augusta, ME. March 22, 2005.

GRYGO, A., K. WEBSTER, C. S. LOFTIN, K. TONNESSEN, and S. KAHL. "A GIS landscape model examining DOC variability among watersheds in National Parks." Presented at the University of Maine Graduate Student Research Expo, Orono, ME. April 12, 2005.

GRYGO, A., P. VAUX, S. NELSON, K. TONNESSEN, and D. MANSKI. "Sharing the wealth: information exchange among research watersheds." Presented at The George Wright Society Biennial Conference Parks, Protected Areas, and Cultural Sites, Philadelphia, PA. March 14-18, 2005.

HARRISON, D. J., W. B. KROHN, L. ROBINSON, and A. K. FULLER. "Lynx and hare research sponsored by the Maine Cooperative Forestry Research Unit." Field tour at sites in northern Maine for forest industry representatives. October 28, 2004.

HARRISON, D. J. and J. A. HEPINSTALL. "Predicting marten and lynx occurrences across the landscape: evaluating the utility of Forest carnivores as umbrella species to promote biodiversity conservation." Presented at the Wildlife Ecology Seminar Series, Orono, ME. December 6, 2004.

HARRISON, D. J. and J. A. HEPINSTALL. "Broad-scale viability habitat modeling, habitat supply trends, and umbrella species applications for marten and lynx in Maine." Presented at the Fourth Northeastern Mesocarnivore Workshop: Lynx and marten in the northern Appalachians, Wildlife Conservation Society, Portland, ME. December 9, 2004.

HARRISON, D. J., A. K. FULLER, and B. HEARN. "Updates of results on habitat selection and fragmentation studies on Newfoundland marten." Presented to Newfoundland Marten Recovery Team, Corner Brook, Newfoundland. December 15, 2004.

HARRISON, D. J. and J. A. HEPINSTALL. "Evaluating the utility of forest carnivores as umbrella species to promote biodiversity conservation." Presented to Maine Cooperative Forestry Research Unit, University of Maine, Orono, ME. January 26, 2005.

HARRISON, D. J. "An overview of the research program in the Department of Wildlife Ecology." Presented to the Office of the Vice President for Research, University of Maine, Orono, ME. February 1, 2005.

HARRISON, D. J. "Overview of research conducted by The University of Maine during 1980-1994 regarding the population status and relationships of deer and vegetation in Acadia National Park." Presentation to Acadian National Park Resource Management Staff, Bar Harbor, ME. July 26, 2005.

HARRISON, D. J., and W. B. KROHN. "Relationships among partial harvesting, snowshoe hares, Canada lynx and forest harvesting: a survey of research activities at the University of Maine and Maine Cooperative Fish and Wildlife Research Unit." National Lynx Biology Team Meeting, Minneapolis, MN. August 17, 2005.

HARRISON, D. J., and W. B. KROHN. "Predicting responses of snowshoe hares and Canada lynx to alternative forest harvesting scenarios: a progress report." National Council for Air and Stream Improvement, Kingfield, ME. August 24, 2005.

HARRISON, D. J. and W. B. KROHN. "A summary of preliminary research findings from studies of snowshoe hares and lynx conducted by the University of Maine and the Maine Cooperative Fish and Wildlife Research Unit." Presentation to Eastern Science Team, National Council for Air and Stream Improvement, Sugarloaf, U. S. A. August 24, 2005.

HARRISON, D. J. and W. B. KROHN. "An overview of published and unpublished results from lynx-snowshoe hare studies conducted by The University of Maine and the Maine Cooperative Fish and Wildlife Research Unit." Presentation to national lynx Biology Team, Minneapolis, MN. August 17, 2005.

HEARN, B. J., D. J. HARRISON, and A. K. FULLER. "The latest research results from habitat studies of the endangered Newfoundland marten." Presented to Newfoundland Marten Recovery Team, Corner Brook, Newfoundland. May 17, 2005.

HEARN, B. J., D. J. HARRISON, and A.K. FULLER. "Landscape-scale habitat selection by Newfoundland marten & an update on efforts to model habitat for Newfoundland marten." Presented to the Newfoundland Marten Recovery Team, Corner Brook, NL. May 17, 2005.

HEARN, B. J. "Habitat ecology of Newfoundland marten: implications for local forest managers." Presented to the National Board of Directors, Wildlife Habitat Canada, Corner Brook, NL. June 22, 2005.

- HEARN, B. J. "Of Moose, Mice and Men: Wildlife Interactions, Habitat Associations & The Newfoundland Marten." Presented to the North American Association of Fish and Wildlife Technology Instructors, Corner Brook, NL. June 24, 2005.
- HEARN, B. J. "Feedback from the field: Recovering the Newfoundland Marten (*Martes americana atrata*). Invited Presentation." Presented to the National Federal – Provincial Working Group for Species at Risk. Corner Brook, NL. September 22, 2005.
- HEPINSTALL, J. A. and D. J. HARRISON. "Utility of forest carnivores (American marten and Canada lynx) as umbrella species for biodiversity conservation. Carnivores 2004 Conference, Santa Fe, New Mexico. November 15, 2004.
- HOMYACK, J.A., D. J. HARRISON, W. B. KROHN, A. K. FULLER, and C. L. HOVING. "Comparing conservation issues affecting Canada lynx within the northeastern and western USA." Presentation and abstract to the Wyoming Chapter of The Wildlife Society, Dubois, WY. December 2, 2004.
- HOMYACK, J. A., D. J. HARRISON, and W. B. KROHN. "Effects of precommercial thinning on snowshoe hares, small mammals, and forest structure in northern Maine." Presented to Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Frostburg, VA. April 26, 2005.
- HUDSON, M., J. JOHNSON, J. HOGLE, J. BRUNSELL, 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, WA.
- HUNTER, JR., M. L. "Using nature's template to maintain forest biodiversity." Invited lecture for the Aldo Leopold Memorial Lecture series, University of Wisconsin, Madison, WI. April 21, 2005.
- HUNTER, JR., M. L. "Defining late successional and old growth forests." Presented at the Late Successional and old-growth forest workshop, National Commission on Science and Sustainable Forestry, Portland, ME. April 28, 2005.
- HUNTER, JR. M. L., L. SCHLTE, R. MITCHELL, J. FRANKLIN, B. PALIK, and K. MCINTYRE. 2005. "Evaluating the conceptual tools for forest biodiversity conservation." Presented at the Society for conservation Biology Conference, Brasilia, Brazil. July 17, 2005.
- HUNTER, JR., M. L., S. BLOMQUIST, D. PATRICK and D. VEVERKA reported on current research for the Maine Cooperative Forest Research Unit's tour of the Penobscot Experimental Forest. October 21, 2005.
- JOHNSON, J., J. ZYDLEWSKI, J. HOGLE, J. BRUNSELL, and M. HUDSON. "Coastal cutthroat trout life history strategies in Abernathy Creek and Chinook River, Washington, two tributaries of the Columbia River." Presented at the Oregon Chapter of the American Fisheries Society Annual Meeting, Corvallis, OR. February 16-18, 2005.
- KELLY, M. W. and J. M. RHYMER. "Range-wide taxonomic analysis of two rare freshwater mussel species (*Bivalvia: Unionoida*) raises questions about hybridization and congeneric species boundaries." Presented at the Freshwater Mollusk Conservation Symposium, St. Paul, MN. May 16-18, 2005.
- KNEELAND, S. and J. M. RHYMER. "Genetic identification of fish hosts for the yellow lampmussel (*Lampsilis cariosa*) and tidewater mucket (*Leptodea ochracea*) using a molecular identification key." Presented at the Freshwater Mollusk Conservation Symposium, St. Paul, MN. May 16-18, 2005.
- KROHN, W. B., and C. S. TODD. "Cormorants and eagles: indicators of ecological change and integrity in a large riverine ecosystem." Invited presentation (and printed abstract) at the Penobscot River Science Forum, University of Maine, Orono, ME. October 19, 2004.
- KROHN, W. B. "Changing forest practices and the habitat ecology of snowshoe hare and Canada lynx in Maine: new projects at the University of Maine." Presented at the Wildlife Conservation Society's workshop on lynx and marten conservation in the northeastern USA and eastern Canada, Portland, ME. December 9, 2004.

KROHN, W. B. "Changing wildlife populations: the interactions of multiple factors at multiple scales." Lecture and discussion in Wildlife-habitat Relationships (WLE 450). University of Maine, Orono, ME. April 21, 2005.

KURTH, J.E., C. S. LOFTIN, J. D. ZYDLEWSKI, and J. M. RHYMER. "Use of PIT tags to track freshwater mussels in Maine." Presented at the Freshwater Mollusk Conservation Symposium, St. Paul, MN. May 16-18, 2005.

LOFTIN, C. S. "Using modeling and GIS in studies of aquatic systems." Guest lecture for BIO 546 (Aquatic Ecology: Landscape Approach), University of Maine. April 14, 2005.

MARKS, C., B. J. HEARN, G. STRICKLAND, T. MOULTON, D. FRAMPTON, S. TAYLOR, J. BRAZIL, I. SCHMELZER, C. DOUCET, and K. MORGAN. "Newfoundland Marten Habitat Assessment Model." Presented to the Newfoundland Marten Recovery Team, Corner Brook, NL. May 16, 2005.

MCCLOSKEY, J., C. S. LOFTIN, and B. BECKEGE. "The influence of fuel accumulation and climatic condition on the fire regime of the Okefenokee Swamp." Presented at the 26<sup>th</sup> Annual International Meeting of the Society of Wetland Scientists, Charleston, SC. June 5-10, 2005.

MITCHELL, R., J. FRANKLIN, B. PAKIK, K. KIRKMAN, L. SMITH, R. ENGSTRON, and M. L. HUNTER, JR. "Natural disturbance-based silviculture for the restoration and maintenance of biodiversity." Presented at the Ecological Society of America Conference, Portland, OR. August 2004.

NELSON, D., S. WOODS, and M. HUNTER. "An evaluation of the role of standing dead trees (snags) as a substrate for epiphytes and invertebrates." Presented to the Acadian Entomological Society, Frederickton, NB, Canada. June 20, 2005.

NELSON, S.J., K.C. WEATHERS, C.S. LOFTIN, K.B. JOHNSON, and J.S. KAHL. "Pick your season: under-estimation (summer) and over-estimation (winter) of total mercury deposition by MDN collection methods at Acadia National Park, Maine." Presented at the National Atmospheric Deposition Program 2005 Scientific Symposium and Annual Technical Committee Meeting, Jackson, Wyoming. September 27-30, 2005.

NELSON, S.J., K.C. WEATHERS, C.S. LOFTIN, K.B. JOHNSON, and J.S. KAHL. "Pick your season: under-estimation (summer) and over-estimation (winter) of total mercury deposition by MDN collection methods at Acadia National Park, Maine." Presented at the North East Regional Air Quality Committee Annual Meeting, Roosevelt Campobello International Park, Campobello Island, Canada. September 7-9, 2005.

PALACIOS, P. and M. L. HUNTER, JR. "Chilean amphibians and exotic pine plantations: a bad mix?" Presented at the Graduate Research Exposition, University of Maine, Orono, ME. April 11-12, 2005.

PALACIOS, P. A. and J. A. SIMONETTI. "Litterfall dynamics in Maulino forest fragments, Chile." Presented at the 19<sup>th</sup> annual meeting of the Society for Conservation Biology, Universidade de Brasilia, Brazil. July 15-19, 2005.

PATRICK, D. and E. B. HARPER. "Predicting amphibian declines in an African biodiversity hotspot." Presented at the Society for the Study of Amphibian & Reptiles 2005 Meeting, Tampa, FL. July 11, 2005.

PATRICK, D., A. J. K. CALHOUN, and M. L. HUNTER, JR. "An experimental assessment of the orientation of juvenile wood frogs, *Rana sylvatica*. Presented at the Society for the Study of Amphibian & Reptiles 2005 Meeting, Tampa, FL. July 9, 2005.

PERKINS, J. C., and F. A. SERVELLO. "Nocturnal nest attentiveness of least terns in Maine." Presented at the Annual Meeting of the American Ornithological Society, August 2005.

POLITI, N. "Fire and grazing in the arid Chaco of Argentina: effects on bird diversity." Presented at the Wildlife Ecology Seminar Series, Orono, ME. November 22, 2004.

POLITI, N., L. RIVERA, and M. L. HUNTER, JR. "The effect of timber practices on usable cavities for birds in the Piedmont of Argentina." Presented at the 19<sup>th</sup> Annual meeting of the Society of Conservation Biology, Brasilia, Brazil. July 15-19, 2005.

RHYMER, J. and M. REYNOLDS. "Genetic variation in Laysan Ducks." Presented at the 124<sup>th</sup> Annual Meeting of the American Ornithologists' Union, University of California, Santa Barbara, CA. August 26, 2005

SCHILLING, E. G., K. E. DEGOOSH, C. S. LOFTIN, A. D. HUYRN, R. G. BUTLER, and P. G. DEMAYNADIER. "Assessing the geographic distribution and invertebrate biodiversity of naturally fishless lakes in Maine, USA." Presented at the Tenth annual Spring symposium of the Center for Biodiversity and Conservation: new currents in conserving freshwater systems, American Museum of Natural History, New York, NY. April 2005.

SCHILLING, E. G., K. E. DEGOOSH, C. S. LOFTIN, and A. HURYRN. "Assessing the geographic distribution and invertebrate biodiversity of naturally fishless lakes in Maine, USA." Presented at the annual meeting of the Ecological Society of America, Montreal, Quebec. August 2005.

SCHILLING, E. G. "Fishless lakes in Maine." Presented at the annual meeting of the Maine Volunteer Lake Monitoring Program, Central Maine Community College, Auburn, ME. July 30, 2005.

SCHULTE, L., B. MITCHELL, M. L. HUNTER, JR., J. FRANKLIN, K. MCINTYRE, B. PALIK. "Theories, Tests, Applications: How do we get from here to there?" Symposium for Ecological Society of America Conference, Montreal, Quebec. August 2005.

SERVELLO, F. A. and J. C. PERKINS. "Least tern ecology and management in Maine." Presented at the Meeting of Least Tern Stakeholders in Maine. Rachel Carson NWR, Wells, ME. June 7, 2005.

SIMONS, E. "Predicting suitable habitat for the pygmy rabbit using a Geographic Information System." Presented at the Wildlife Ecology Seminar Series, Orono, ME. January 31, 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 29<sup>th</sup> Annual Meeting of the Atlantic International Chapter of the American Fisheries Society, Rangeley, ME. 2005.

STRICKLAND, G., B. J. HEARN, J. LUTHER, and J. GOSSE. "Mapping Newfoundland Marten Habitat Using Forest Inventory and Remote Sensing, Greater Terra Nova National Park." Presented to the Newfoundland Marten Recovery Team, Corner Brook, NL. May 16, 2005.

STROJNY, C. A. and M. L. HUNTER, JR. "A comparison of amphibian abundance in harvest gaps and natural canopy gaps in a northeastern forest." Presented at the Eastern CANUSA Forest Science Conference, Fredericton, NB. October 15-16, 2004.

WITHAM, J. W., M. L. HUNTER, A. J. KIMBALL, A. S. WHITE, S. P. ELIAS, and L. S. KENEFIC. "Long-term study of a pine oak forest ecosystem: Holt Research Forest. Presented at The 85<sup>th</sup> Annual Winter Meeting of the New England Society of American Foresters, South Portland, ME. March 15-18, 2005.

WITHAM, J. W., A. J. KIMBALL, S. P. ELIAS, and L. S. KENEFIC. "Tree regeneration at Holt Research Forest: impacts of Red maple removal and White-tailed deer browsing." Presented at The 85<sup>th</sup> Annual Winter Meeting of the New England Society of American Foresters, South Portland, ME. March 15-18, 2005.

WITHAM, J. W. On response panel for session: Long-term studies in managed and unmanaged stands: harvesting results for management and for science. Presented "Learning for non-timber values." Presented at The 85<sup>th</sup> Annual Winter Meeting of the New England Society of American Foresters, South Portland, ME. March 15-18, 2005.

WITHAM, J. W., M. L. HUNTER, JR., A. J. KIMBALL, A. S. WHITE, S. P. ELIAS, AND L. S. KENEFIC. "Mice, mast, and a group-selection harvest: 20 years on the Holt Research Forest." Presented at the meeting of the New England Society of American Foresters, Portland, ME.

WITHAM, J. "Wildlife of Merrymeeting Bay." Presented at Bay Day, Bowdoinham, ME. September 27, 2005.

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, ME. 2005.

ZYDLEWSKI, J., J. JOHNSON, S. CLEMENTS, M. KARNOWSKI, C. SCHRECK, and G. ZYDLEWSKI. "Movements of coastal cutthroat trout (*Oncorhynchus clarki*) in the Lower Columbia River." Presented at the Atlantic International Chapter of the American Fisheries Society Annual Meeting, Fairlee, VT. September 1-21, 2004.

ZYDLEWSKI, J. "Populations troubles? (where to start?)" Invited speaker Rangeley Region Guides' and Sportsman's Association, Rangeley, ME. 2004.

ZYDLEWSKI, J., J. JOHNSON, J. HOGLE, J. BRUNSELL, S. CLEMENTS, M. KARNOWSKI, and C. SCHRECK. "Seaward migration of coastal cutthroat trout (*Oncorhynchus clarki*) from four tributaries to the Columbia River." Presented at the Coastal Cutthroat Trout Symposium: Biology, Status, Management, and Conservation 2005, Fort Worden State Park, WA.

ZYDLEWSKI, J., J. JOHNSON, and 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, WA.

ZYDLEWSKI, J. and D. BASLEY. "Movements of Lake Whitefish in Clear Lake, Maine." Presented at the 29<sup>th</sup> Annual Meeting of the Atlantic International Chapter of the American Fisheries Society, Rangeley, ME. 2005.

ZYDLEWSKI, J., S. MCCORMICK, J. KUNKEL, and M. SHRIMPTON. "Osmoregulation and migration in juvenile American shad: when to go and how they know." Presented at the Wildlife Ecology Seminar Series, Orono, ME. January 24, 2005.

#### PUBLIC TALKS PRESENTED

GILBERT, J. R. "Maine's Wildlife." Presented to the Winterport Historical Society.

HARRISON, D. J. "Predators, prey, and forestry in northern and eastern Maine: a historical perspective. Presented to University of Maine at Machias Science Club and Downeast Salmon Federation, Machias, ME. March 2, 2005.

HARRISON, D. J. Led field trip to Bangor Bog for High School Biology Class. June 2005.

KROHN, W. B. "Maine's changing wildlife populations: a historical perspective." Invited presentation to University of Maine at Machias Science Club and Downeast Salmon Federation, Machias, ME. March 24, 2005.

KROHN, W. B. "An overview of Maine's largest terrestrial predators." Invited presentation to Senior College, University of Maine, Orono, ME. April 1, 2005.

SERVELLO, F. A. "Black tern ecology in Maine." Presented at the Maine Audubon, Field Pond Audubon Center. April 1, 2005.

SERVELLO, F. A. Introduction of Wildlife Ecology Program and Wildlife Ecology scholarship students at a meeting of the Penobscot County Conservation Association meeting, Bangor, ME. April 7, 2005.

## WORKSHOPS

HUNTER JR., M. L. Chaired a discussion session on science issues surrounding late successional old growth conservation at the Northeast Late Successional Old growth dialogue, Portland, ME. April 28, 2005.

HUNTER JR., M. L. Chaired the Student Award Symposium for the Society for Conservation Biology Conference in Brasilia, Brazil. July 16, 2005.

## AWARDS, HONORS, AND APPOINTMENTS

DEGOOSH, K. E., E. G. SCHILLING, C. S. LOFTIN, AND K. E. WEBSTER. "Message in the mud: what the presence of *Chaoborus americanus* can tell us about fish distributions throughout the Maine landscape." Outstanding student poster award for poster presented at the American Society of Limnology and Oceanography, Aquatic Sciences Meeting. Salt Lake City, UT. February 20-25, 2005.

WITHAM, J. W., M. L. HUNTER, A. J. KIMBALL, A. S. WHITE, S. P. ELIAS, and L. S. KENEFIC. Winner of Outstanding Poster Award. "Long-term study of a pine oak forest ecosystem: Holt Research Forest. Presented at The 85<sup>th</sup> Annual Winter Meeting of the New England Society of American Foresters, South Portland, ME. March 15-18, 2005.

## TELEVISION, RADIO, AND NEWSPAPER INTERVIEWS

KROHN, W. B. Interviewed about the Manly Hardy book on the radio program "Maine Outdoors" (103.9 FM). Topics discussed included the reasons for writing the book, content and organization of the book, and relevancy of information in the Hardy book to on-going wildlife conservation issues. August 21, 2005.