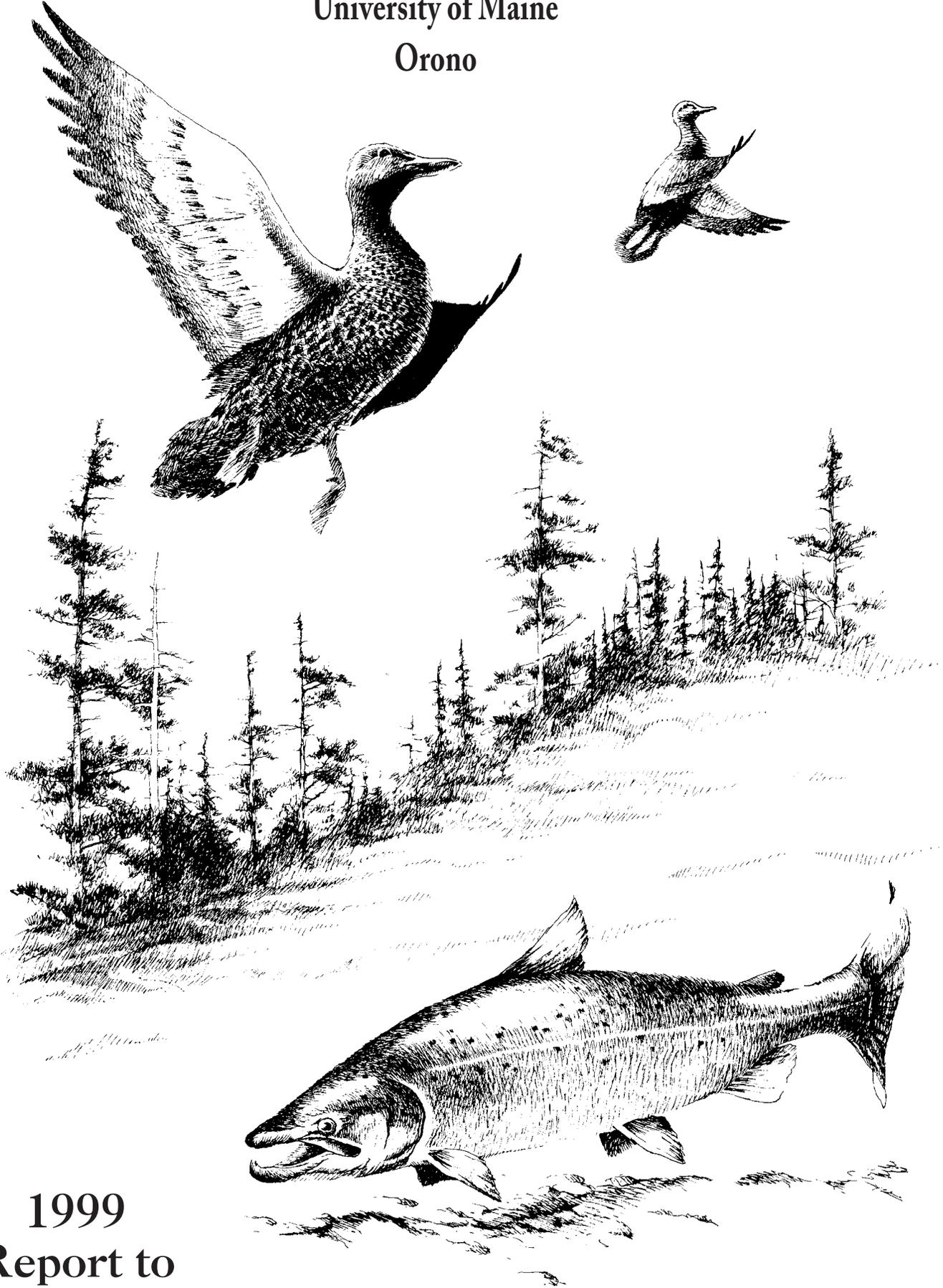


# MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

University of Maine

Orono



1999  
Report to  
Cooperators

—Mark McCollough '86

# **MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT**

5755 Nutting Hall, Room 210\*  
University of Maine  
Orono, Maine 04469-5755

## **COOPERATORS**

UNIVERSITY OF MAINE

MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE

BIOLOGICAL RESOURCES DIVISION, U.S. GEOLOGICAL SURVEY

WILDLIFE MANAGEMENT INSTITUTE

October 1998 - September 1999

Compiled and Edited by  
William B. Krohn and John R. Moring

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 Unit Leader.

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\*The Unit's Fisheries Program is located in 313 Murray Hall and is within the Department of Biological Sciences, College of Natural Sciences, Forestry, and Agriculture; the Unit's Wildlife Program is located in 210 Nutting Hall and is within the Department of Wildlife Ecology, College of Natural Sciences, Forestry, and Agriculture.



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## PERSONNEL AND COOPERATORS

### COORDINATING COMMITTEE

Maine Department of Inland Fisheries and Wildlife  
Lee Perry, Commissioner

#### University of Maine

James R. Gilbert, Chairperson, Department of Wildlife Ecology, College of Natural Sciences,  
Forestry, and Agriculture

J. Malcolm Shick, Chairperson, Department of Biological Sciences, College of Natural Sciences  
Forestry, and Agriculture

#### USGS Biological Resources Division

Michael W. Tome, Supervisor, Cooperative Research Units

#### Wildlife Management Institute

Scot J. Williamson, Northeastern Representative

### UNIT PERSONNEL

#### Unit Staff:

William B. Krohn, Unit Leader, Professor of Wildlife Ecology and Cooperating Professor of Zoology

John R. Moring, Assistant Unit Leader for Fisheries, Professor of Zoology

Cynthia F. Loftin, Assistant Unit Leader for Wildlife and Assistant Professor of Wildlife Ecology

Susan Anderson, Unit and USGS-LSC Administrative Assistant - Fisheries

Nora Ackley, Unit Administrative Assistant - Wildlife Ecology

Shirley Moulton, Secretary - Wildlife Ecology

**Associated Faculty and Staff, Departments of Wildlife Ecology and Biological Sciences:**

James R. Gilbert, Chairperson, Department of Wildlife Ecology, College of Natural Sciences, Forestry, and Agriculture, and Professor of Wildlife Ecology  
 J. Malcolm Shick, Chairperson, Department of Biological Sciences, College of Natural Sciences, and Professor of Zoology  
 William E. Glanz, Associate Professor of Zoology and Cooperating Associate Professor of Wildlife Ecology  
 Kevin J. Boyle, Associate Professor, Department of Agriculture and Resource Economics, and Cooperating Associate Professor of Wildlife Ecology  
 Michael S. Bank, Instructor, Department of Wildlife Ecology  
 Susan Gerken, Research Associate, Wildlife Ecology  
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 Jeff Hepinstall, Research Associate, Wildlife Ecology  
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 Allan O'Connell, Faculty Associate and Leader, Cooperative National Park Unit, USGS  
 Raymond J. O'Connor, Professor of Wildlife Ecology  
 Frederick A. Servello, Associate Professor of Wildlife Ecology  
 Judith Rhymer, Assistant Professor of Wildlife Ecology  
 Jerry R. Longcore, Faculty Associate, Wildlife, and Research Wildlife Biologist, USGS  
 Terry A. Haines, Professor of Zoology and Fishery Research Biologist, USGS  
 Jack Witham, Assistant Scientist, Wildlife Ecology  
 Phillip G. deMaynadier, Research Associate, Wildlife Ecology

**Maine Department of Inland Fisheries and Wildlife:**

Lee E. Perry, Commissioner  
 Frederick B. Hurley, Jr., Deputy Commissioner  
 Kenneth D. Elowe, Director, Bureau of Resource Management  
 G. Mark Stadler, Director, Wildlife Division  
 Peter M. Bourque, Director, Fisheries and Hatcheries Division  
 George J. Matula, Jr., Supervisor, Wildlife Resource Assessment Group  
 Eugene A. Dumont, Supervisor, Regional Wildlife Management Section  
 Kendall Warner, Supervisor, Fisheries Research and Management Section

**GRADUATE STUDENTS**

<b>Name</b>	<b>Degree Candidacy</b>	<b>Support</b>
John G. Bartlett	Ph.D.	NBS
Sarah C. Billig	M.S.	MCCS, McIntire-Stennis, PCTC
John R. Burgess	M.S.	NBS
Steven P. Campbell	Ph.D.	McIntire-Stennis
Bradley W. Compton	M.S.	U of M, MDIFW, McIntire-Stennis, USFWS
Lia R. Daniels	M.S.	MDMR
Danielle DiMauro	M.S.	McIntire-Stennis
Mustapha El Hamzaoui	Ph.D.	USAID/USDA
Carol R. Foss	Ph.D.	USFS, USFWS, SEFP
Angela K. Fuller	M.S.	MDC
Merry Gallagher	Ph.D.	MDMR, MDIFW
Andrew T. Gilbert	M.S.	MDIFW, USFWS, McIntire-Stennis

Anne D. Guerry	M.S.	U of M
Nikolina Guldager	M.S.	NMFS
Mitschka J. Hartley	Ph.D.	McIntire-Stennis
Brian J. Hearn	Ph.D.	Canadian Forest Service
Thomas A. Hoffman	M.S.	MDIFW
Christopher L. Hoving	M.S.	NCASI, USFWS, MDIFW, WCS
Jon B. Lê	M.S.	NPS
Nathan G. Leaman	M.S.	MDMR
Jennifer M. Lowry	M.S.	
Marcy Lucas	M.S.	MDMR
Dawn L. Nelson	Ph.D.	HWRF
Stephanie L. Painton	M.S.	MOHF, MCFWRU
David C. Payer	Ph.D.	MDIFW, CFRU, U of M, NCASI
Anne M. Perillo	M.S.	USFWS, USFS, MDIFW
Dustin Perkins	Ph.D.	MS
Regina M. Purtell	M.W.C.	Personal Funding
Teresa M. Sauer	M.S.	U of M
Sandra M. Schaefer	M.S.	BRD/GAP, MCFWRU
Ashley M. Smith	M.S.	NBS
Shelley Spohr	M.S.	NWTF, WF, UM, CDEP
James Stahlnecker	M.S.	MDMR
Jennifer A. Stone	M.S.	NPS
Marcia L. B. Summers	M.S.	U of M
Amy S. Williams	M.S.	NMFS, NBS
Heather L. Ziel	M.S.	U of M

**DISSERTATIONS AND THESES COMPLETED THIS PERIOD**

<b>Student</b>	<b>Degree Candidacy</b>	<b>Support</b>
Lia R. Daniels	M.S.	MDMR
Danielle DiMauro	M.S.	McIntire Stennis
Jon B. Lê	M.S.	NPS
David C. Payer	Ph.D.	MDIFW, CFRU, U of M, NCASI

**PERSONNEL NOTES**

After receiving her M.S. in Wildlife Ecology, **DANIELLE DI MAURO** was employed by Exponent Environmental Group, where she is currently working in Denver, Colorado as a wildlife biologist. **DAVID PAYER** has received his Ph.D. degree in Wildlife Ecology and is in Fairbanks, Alaska, serving as a data analyst for Dr. Daniel Harrison.

**PHILLIP DE MAYNADIER**, former graduate student and research associate, assumed a full time position as an endangered species biologist with the Maine Department of Inland Fisheries and Wildlife, Bangor, Maine. In June, **CYNTHIA S. LOFTIN** started work as the Assistant Leader for Wildlife, Maine Cooperative Fish and Wildlife Research Unit. Cyndy obtained her Ph.D. at the University of Florida where she worked in the Florida Unit on the hydrology of the Okefenokee Swamp.

**LIA DANIELS** received her M.S. in Zoology and is employed by the Maine Department of Inland Fisheries

and Wildlife in Bangor. JON LÉ received his M.S. degree in Zoology and is completing a cooperative education agreement prior to taking a biologist position with the U.S. Fish and Wildlife Service in the West.

## COLLABORATING AGENCIES AND ORGANIZATIONS

American Wildlife Research Foundation - AWRF  
 Audubon Society of New Hampshire - ASNH  
 Baldwin Foundation - BF  
 Baxter State Park - BSP  
 Boise Cascade - BC  
 Bowater-Great Northern Paper, Inc. - BGNP  
 Central Maine Power - CMP  
 Connecticut Department of Environmental Protection -  
     Wildlife Division - CDW  
 Cooper Ornithological Society - COS  
 Holt Woodlands Research Foundation - HWRF  
 Fort James Corporation - FJC  
 Maine Association of Wetland Scientists - MAWS  
 Maine Bureau of Public Lands - MBPL  
 Maine Department of Conservation - MDC  
 Maine Department of Environmental Protection - MDEP  
 Maine Department of Inland Fisheries and Wildlife - MDIFW  
 Maine Department of Marine Resources - MDMR  
 Maine Forest Service - MFS  
 Maine Geological Survey - MGS  
 Maine Office of Geographic Information Systems - MOGIS  
 Maine Outdoor Heritage Fund - MOHF  
 Manomet Center for Conservation Sciences - MCCS  
 National Council of the Paper Industry for Air and Stream Quality Improvement - NCASI  
 National Science Foundation - NSF  
 National Wild Turkey Federation -  
     Connecticut Chapter - CCNWTF  
 New Hampshire Fish & Game Department - NHFG  
 New Hampshire Department of Resources and Economic Development -  
     Division of Forests and Lands - NHDFL  
 Penobscot Valley Conservation Association - PVCA  
 Plum Creek Timber Company - PCTC  
 Seven Islands Land Company - SILC  
 Switzer Environmental Fellowship Program - SEFP  
 University of Maine - U of M  
     Association of Graduate Students - AGS  
     College of Natural Sciences, Forestry, and Agriculture  
     Cooperative Forestry Research Unit - CFRU  
     Department of Forest Management - DFM  
     Department of Wildlife Ecology - DWE  
     Forest Ecosystem Science - FES  
     Maine Image Analysis Lab - MIAL  
     McIntire-Stennis - MS  
     Maine Agricultural and Forest Experiment Station - MAFES  
 U.S. Department of Agriculture - USDA  
     Forest Service - USFS

**U.S. Department of Commerce****National Marine Fisheries Service - NMFS****U.S. Environmental Protection Agency - EPA****U.S. Department of the Interior - USDI****U.S. Fish and Wildlife Service - FWS****Gulf of Maine Project - GMP****Neotropical Migratory Bird Program - NMBP****Northern Maine National Wildlife Refuge Complex - NMNWRRC****Partnerships for Wildlife - PW****Petit Manan National Wildlife Refuge - PMNWR****National Biological Service - NBS****USGS Biological Resources Division - BRD****Cooperative Park Studies Unit - CPSU****Gap Analysis Program - GAP****Leetown Science Center - LSC****Maine Cooperative Fish and Wildlife Research Unit - MCFWRU****National Park Service - NPS****Acadia National Park - ANP****Wagner Forest Management, Ltd. - WFM****Wildlife Forever - WF**



## ENDANGERED AND THREATENED SPECIES:

### WINTER ECOLOGY OF HARLEQUIN DUCKS IN MAINE

*Investigator:* G. H. Mittelhauser

*Advisors:* W. E. Glanz, Chairperson  
W. B. Krohn  
J. R. Longcore

*Cooperators/  
Project  
Support:* Maine Outdoor Heritage Fund  
National Park Service -  
Acadia National Park  
Maine Department of Inland Fisheries and Wildlife  
U.S. Fish and Wildlife Service -  
Petit Manan National Wildlife Refuge  
Gulf of Maine Project  
University of Maine

*Objectives:*

- 1) Compile and analyze current and historic population data for harlequin ducks in Maine to determine population size, distribution, and trends.
- 2) Identify significant wintering areas and determine essential characteristics of wintering habitat in Maine; compare habitat use to time of year, flock size and composition, and environmental conditions.
- 3) Determine activity budgets for harlequins at Isle au Haut relative to day length, time of day, tide cycle, environmental conditions, and habitat.

**SCOPE:** The number of harlequin ducks (*Histrionicus histrionicus*) in eastern North America is estimated at 1,500 individuals and counts show population declines have occurred, and may be ongoing. More than 50% of this eastern North American population is concentrated at a small number of traditional wintering areas on the coast of Maine. Little is known about the winter ecology and population of harlequin ducks in Maine at these concentration areas. This project will address harlequin duck population size, distribution, trends, and movements in Maine, assess habitat at concentration areas, and determine activity budgets.

**PROJECT STATUS:** Two years of field work have been completed. A thesis outline has been approved and data analysis writing has been initiated. Preliminary results were presented at the October 1999 Harlequin Duck Recovery Team meeting.

**FUTURE PLANS:** A Master of Science thesis is expected by May 2000.

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## FISHERIES RESOURCES:

### FOOD HABITS OF AMERICAN EELS IN FRESH WATER

- Investigator:* L. R. Daniels
- Advisors:* J. R. Moring, Chairperson  
J. D. McCleave  
A.D. Huryn  
F.W. Kircheis
- Cooperators/  
Project  
Support:* Maine Department of Marine Resources
- Objective:* Investigate aspects of the life history of the American eel, especially aspects of feeding in yellow eels.

**SCOPE:** Maine supports abundant populations of American eel, but there has been a rapid increase in harvest of the elver stage in recent years. Elvers ascend local rivers, taking up residence for many years in lakes and rivers, before migrating back to the sea as silver eels in fall months. There always has been a pot fishery on yellow eels and a fall fishery on silver eels, but this accelerated fishery on the elver stage means that the populations are being harvested at three stages during the life cycle. As a result, this project examines one component of the freshwater stage--the summer feeding by eels--with additional information collected on the fall migration of adult silver eels and the abiotic and biotic factors triggering such migration.

**PROJECT STATUS:** The project was completed in August 1999 and the abstract of the thesis follows:

Recent increases in fishing pressure on American eels (*Anguilla rostrata*) in Maine combined with possibly declining American eel stocks have led to concern over local eel populations. While considerable research has been conducted on American eels, little is known about the food habits of American eels in lakes. This study examined the food habits of American eels in freshwater lakes in Maine. To determine when American eels were likely to be feeding, a preliminary study of the activity patterns of American eels was conducted from 27 May through 6 June 1997. American eels were captured using 0.28 cm<sup>2</sup> mesh trap nets. The 24-hour day was divided into four six-hour intervals. Trap nets were set for one six-hour interval per day for four days. Nets were checked every two hours during each six-hour interval. American eels were active primarily between the hours of 2200 and 0200 EST. These results were confirmed when the activity study was repeated in 1998. American eels probably consumed some fish while captured in the trap nets. A laboratory study of the digestion rates of American eels was conducted. Individual American eels were placed in glass aquaria, fasted, and fed prey fish. Results showed a slow digestion rate (0.27 g h<sup>-1</sup>), indicating it was possible that prey fish found in the eel stomachs were consumed prior to eels entering the trap nets.

American eels were captured between 6 June and 25 August 1997 for the food habitats study, nets were set by 1900 hours and collected between 0200 and 0600 hours EST. Analysis of diet composition indicated fish and insects comprised the majority of the diet of American eels by dry weight and by number. Larger American eels (>40 cm) ate more fish than did smaller eels (≤40 cm). Diet composition shifted for all American eel sizes from more insects in June to more fish in July and August. This corresponds with emergence times for several species of fish. The most common fish species found in the diet of eels in Maine were: alewives (*Alosa pseudoharengus*); white perch (*Morone americana*); yellow perch (*Perca flavescens*); and sunfish (primarily *Lepomis* spp.). Odonata, Ephemeroptera, Trichoptera and Diptera were the most common orders of insects consumed by American eels. Small sample sizes prevented comparisons of diets of eels among individual lakes. Analysis of eel diet by county showed no significant differences in proportions of

diet items by dry weight or by number.

Results were consistent with previous studies which indicated that American eels can be significant predators of fishes, particularly young-of-the-year. White perch was the only heavily targeted sport fish commonly consumed by American eels in Maine. It is possible that American eels affect popular sport fishes primarily through competition for food. The wide number and types of prey consumed by American eels indicate that they probably feed opportunistically. Management efforts for American eels should consider the importance of young-of-the-year fishes as prey, but special efforts to manage area lakes for eel diet items is probably not necessary.

## FISHERIES RESOURCES OF ACADIA NATIONAL PARK

*Investigators:* J. B. Lê  
J. A. Stone

*Advisors:* J. R. Moring, Chairperson  
J. G. Trial  
D. P. Chivers  
A. D. Huryn

*Cooperators/  
Project  
Support:* National Park Service -  
Acadia National Park

*Objective:* To inventory fish species and their associated habitat in lakes and brooks of Acadia National Park, especially concentrating on life history aspects of brook trout.

*SCOPE:* There are no comprehensive inventories of fish species found in Acadia National Park. This project attempts to describe the species, location, relative abundance, native or non-native status, habitat associations, and associated abiotic parameters. For the students' theses, several life history parameters will be studied for the native brook trout. This project will include investigations by two separate investigators over two field seasons, 1998 and 1999, studying different life history characteristics.

*PROJECT STATUS:* Field inventories of the Park's waters have been completed. Work on the first brook trout study--instream movements--was completed in fall 1998. Brook trout spawning locations were observed in fall 1998 and field work for the second project with brook trout is near completion.

*FUTURE PLANS:* One Master of Science thesis will be completed in December 1999, and another is expected in August 2000. A final report on fish inventories is expected in August 2000, and a final technical report of previous data on fishes was completed in June 1999. The abstract of the first M.S. thesis follows; thesis writing is underway for the second thesis.

Movements of brook trout, *Salvelinus fontinalis*, were examined at Hunter's Brook, Acadia National Park, Maine, using mark-recapture. Five fin-clip combinations were used to identify fish caught in five separate marking sections. Recapture periods consisted of sampling all marking sections and randomly chosen sections by backpack electrofishing. Water temperature, species diversity, habitat, and productivity were measured to further examine factors that may influence movements. Except for habitat, parameters measured were relatively homogenous throughout the study reach. Recaptures of marked fish outside their sections of original capture were low. Although proportions of unmarked to marked fish in the marking sections were high (35-60%) in the first recapture period, summer recapture periods had lower proportions of unmarked to marked fish (<30%) in marking sections. However, there was an increase in unmarked fish during the last

recapture period. These proportions of unmarked fish are most likely the result of immigration. Seasonality and spawning movements may explain increases in immigration percentage in the first and last recaptures, respectively. Overall, brook trout movement was observed and detected by both recaptures of marked, mobile fish and immigration of unmarked fish into marking sections. An interesting observation was that large proportions of immigrants were 1 and 2-year-old fish. This is contrary with previous literature on the size of mobile salmonids.

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## POPULATION STUDIES OF MAINE INTERTIDAL FISHES

*Investigator:* J. R. Moring

*Cooperators/  
Project  
Support:* University of Maine

*Objectives:*

- 1) Identify environmental conditions associated with arrival and departure of fishes in the intertidal zone.
- 2) Identify and quantify algal and food associations of intertidal fishes.
- 3) Study movement patterns of Maine tidepool fishes.

*SCOPE:* Intertidal fishes are unique members of the intertidal ecosystem. Tidepools serve a nursery function, and young of economically important offshore fishes utilize tidepools as refuges and nurseries. Because of specific algal and habitat associations, these fishes can be susceptible to environmental contaminants in coastal waters, both of a direct and indirect nature.

Surveys since 1979 have identified 23 species of tidepool fishes in Maine. The movements of the rock gunnel have been examined in marking studies, and algal associations and food habits of lumpfish and Atlantic seasnails have been quantified. Three study pools on Schoodic Peninsula have been studied since 1979, and work has also involved the first description of rock gunnels as the first intermediate host of the digenean fluke, *Cryptocotyle lingua* and seasonal habitat changes of tidepool fishes and sand shrimp.

*PROJECT STATUS:* Experiments with movements of juvenile grubbies and shorthorn sculpins are ongoing.

*FUTURE PLANS:* Work dealing with intertidal movements of sculpins will continue in 2000, along with ecological studies of fishes and sand shrimp. Additional manuscripts are being prepared on community dynamics and intertidal movement patterns.

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## POPULATION DYNAMICS OF SEA-RUN ALEWIVES

*Investigator:* J. F. Stahlnecker, III

*Advisors:* J. R. Moring, Chairperson  
J. D. McCleave  
J. G. Trial

*Cooperators/  
Project  
Support:* Maine Department of Marine Resources  
Maine Department of Inland Fisheries and Wildlife

*Objective:* To understand the interactions and between stocking rates and the resultant numbers of juvenile and adult alewives in Maine ponds.

*SCOPE:* The Maine State Legislature has instructed the Department of Marine Resources to restore sea-run alewives to their original range in Maine. To do this requires information on stocking rates appropriate for producing adequate numbers of adult alewives. Some data from a restricted number of ponds are available, but a wider range of stocking rates is necessary to identify the appropriate stocking rates for the future.

*PROJECT STATUS:* Field work has been completed, with data analysis underway.

*FUTURE PLANS:* The investigator is enrolled on a part-time status, but is conducting the additional work in cooperation with the Department of Marine Resources. A Master of Science thesis is expected by May 2000.

### LENGTH/WEIGHT VARIATIONS AND MERCURY LEVELS IN AMERICAN EELS IN FRESH WATER

*Investigator:* N. G. Leaman

*Advisors:* J. R. Moring, Co-advisor  
T. A. Haines, Co-advisor  
J. D. McCleave

*Cooperators/  
Project  
Support:* Maine Department of Marine Resources

*Objective:* To conduct research on aspects of the freshwater residence of American eels in Maine. Mercury content of eels will be measured in conjunction with other collections with life history objectives.

*PROJECT STATUS:* Eel samples have been collected from three rivers in Maine that differ in watershed characteristics. All samples have been digested and mercury analysis of digestates is in progress. Selected eels have been processed for stable nitrogen isotope analysis to assess food chain position, and isotope analysis has been completed.

*FUTURE PLANS:* Mercury analysis of eel digestates has been completed and a Master of Science thesis has been tentatively approved. The defense is scheduled for Fall 1999, and the degree is expected in December 1999.

### COMPETITION BETWEEN SPLAKE AND LANDLOCKED SALMON

*Investigator:* T. A. Hoffman

*Advisors:* J. R. Moring, Chairperson  
J. G. Trial  
D. P. Chivers  
L. Kling  
F. W. Kircheis

*Cooperators/* Maine Department of Inland Fisheries and Wildlife  
*Project* University of Maine  
*Support:* Baxter State Park

*Objective:* To determine if competition for food exists between landlocked salmon and stocked splake (brook trout x lake trout).

*SCOPE:* Splake--a hatchery-produced hybrid--are being used with wider frequency in Maine waters. These fishes grow rapidly and tolerate marginal water conditions. However, there is concern that such introductions may adversely affect populations of landlocked salmon--especially if splake and salmon compete for the same foods. This project examines food habits of splake and salmon in three Maine lakes in different seasons.

*PROJECT STATUS:* All field work has been completed and a thesis is being completed.

*FUTURE PLANS:* A Master of Science thesis is expected in December 1999.

## MOVEMENTS OF AMERICAN EELS IN FRESHWATER LAKES

*Investigator:* M. Gallagher

*Advisors:* J. R. Moring, Chairperson  
 J. G. Trial  
 D. P. Chivers  
 A. D. Huryn  
 J. D. McCleave  
 F. W. Kircheis

*Cooperators/* Maine Department of Marine Resources  
*Project* Maine Department of Inland Fisheries and Wildlife  
*Support:*

*Objective:* 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 captures eels and tracks their movements using surgically-implanted radio transmitters. In Year 1, all field work 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:* Field work for Year 2 is nearly completed and data processing, degree requirements, and thesis writing will occur in late December 1999 and into 2000.

*FUTURE PLANS:* Analysis of data will occur well into 2000. A Ph.D. dissertation is expected in August 2000.

**HABITAT RESOURCES:****REPRODUCTION OF AMPHIBIANS IN NATURAL AND ANTHROPOGENIC TEMPORARY POOLS IN MANAGED FORESTS**

*Investigator:* D. DiMauro

*Advisors:* M. L. Hunter, Jr., Chairperson  
W. E. Glanz  
M. A. McCollough  
A. J. K. Calhoun

*Cooperators/  
Project  
Support* University of Maine -  
Department of Wildlife Ecology  
McIntire-Stennis  
Penobscot Valley Conservation Association  
Maine Association of Wetlands Scientists  
James River Timber Corporation

*Objectives:*

- 1) Evaluate the reproductive success of amphibians breeding in natural and anthropogenic temporary pools in industrial forests.
- 2) Evaluate the landscape-scale use of temporary pools by breeding amphibians in industrial forests.
- 3) Characterize the features of temporary pools which best predict amphibian reproductive effort and success.

**SCOPE:** Temporary pools are unique habitats filled by meltwater, rain, or runoff, and characterized by annual drying and the lack of permanent inlets or outlets. Because of their ephemeral nature, temporary pools are unsuitable habitats for fish, and thus are particularly hospitable for amphibian species with vulnerable larvae incapable of withstanding intense predation pressure. In the Northeast, species such as the wood frog (*Rana sylvatica*), spotted salamander (*Ambystoma maculatum*), and blue-spotted salamander (*A. laterale*), rely heavily on productive, fishless water bodies for reproduction.

Several amphibian species deposit eggs in pools which form in roadside ditches and machinery ruts in industrial forests, but no studies have quantified the reproductive success of animals breeding in anthropogenic pools of this type. The availability of such pools may or may not benefit amphibian populations. Successful reproduction in additional pools could mitigate the loss of breeding habitats damaged in the course of harvesting operations or road construction, but unsuccessful reproduction might suggest that anthropogenic pools function as ecological traps. To better understand these interactions, I am studying populations of amphibians breeding in temporary pools located in industrial forests. This study focuses on the relationships between amphibian reproduction and a set of environmental factors which may differ between anthropogenic and natural pools.

**PROJECT STATUS:** All requirements for the degree of Master of Science (in Wildlife Ecology) were completed in December 1998. An abstract of the thesis follows:

Vernal-pool breeding amphibians often oviposit in anthropogenic pools formed during industrial forest-management activities. I quantified amphibian reproductive effort, larval growth, and metamorph emergence: pool hydroperiods and habitat features; and natural and anthropogenic pool density across the landscape to compare the reproductive effort and success of amphibians breeding in natural and anthropogenic pools in managed forest.

Numbers of egg masses in anthropogenic and natural pools did not differ for either wood frogs

(median number masses/pool = 15 and 13.5, respectively) or spotted salamanders (13 and 12.5 masses/pool), but anthropogenic pools outnumbered natural pools on survey transects by a factor of 3.7. Pool area, depth, temperature, solar exposure, and coverage of closed-canopy forest within 100 m influenced amphibian reproductive effort in temporary pools.

In 1997, a year with typical rainfall during the breeding season, anthropogenic pools had shorter hydroperiods than natural pools (median drying dates: 17 June and 30 July, respectively), and extensive larval mortality occurred upon pool drying. The two pool types had similar hydroperiods in 1996 (median drying dates: 17 and 28 August), during an unusually wet breeding season. Small area, high levels of solar exposure, and high water temperatures contributed to the abbreviated hydroperiods of anthropogenic pools relative to natural pools. The diversion of breeding adults to anthropogenic pools is probably detrimental to local populations of wood frogs in some years, but has an uncertain effect on spotted salamander populations.

The results of this study indicate that the majority of anthropogenic pools function as ecological traps for breeding wood frogs in most years, and that creation of new pools should usually be avoided. However, when creation of pools is desirable or unavoidable, managers should endeavor to locate pools near existing forested stands and create pools with sufficient shading, depth, and area to promote adequate hydroperiods for emergence of larval amphibians.

## THREATS TO BIODIVERSITY

*Investigator:* J. G. Bartlett

*Advisors:* R. J. O'Connor, Chairperson  
D. M. Mageean  
M. K. Beard-Tisdale  
M. L. Hunter, Jr.  
G. L. Jacobson

*Cooperators/  
Project  
Support:* U.S. Environmental Protection Agency

*Objectives:*

- 1) Compile selected databases of information about anthropogenic stressors of biodiversity.
- 2) Develop methods of quantifying the impacts of stressors on biodiversity.

*SCOPE:* The influence of anthropogenic stressors on biodiversity is well-known but their effects at large spatial scales have rarely being quantified. This project extends the use of classification and regression free methods (CART) to the analysis of data sets derived from environmental and demographic sources for the conterminous United States. The environmental data include remotely sensed land cover class information and metrics computed to reflect concepts used in landscape ecology. Additionally, data on climate, elevation, and land ownership have been combined with nine variables extracted from the files of the Bureau of the Census; these variables been chosen to characterize the spectrum of general population impacts on the natural environment. These data have been used to generate 5 environmental models: 1) a model of the distribution of the human population in relation to climate and land cover; 2) a model allowing recognition of when a change in scale is necessary to accommodate processes influencing the distribution of population; 3) a model distinguishing two distinct patterns of population settlement across the conterminous United States and showing that one particular pattern, termed beta settlement, selectively impacts particularly fragile ecosystems on barrier islands, coastal dunes, and desert edges; 4) a model of bird species richness in terms of land cover classes and in terms of agricultural activity, in both cases with additional information from climate and

elevation data; and 5) a model characterizing the joint occurrence of environmental constraints on ecosystem process, biodiversity, and anthropogenic impacts.

**PROJECT STATUS:** Several papers have been submitted to appropriate outlets. A doctoral thesis is currently scheduled for completion in December 1999. An abstract of the dissertation follows:

I demonstrate here that spatially extensive analysis can reveal considerable detail as to human-environment interactions of regional concern. In Chapter 1, I used regression-trees to model human population density and relative change in population density in relation to environmental variables across the United States.

In Chapter 2, I considered the utility of regression-tree analysis in identifying relevant spatial scales when relating the distribution of human populations to the biophysical environment. Our results imply that no single scale is optimal for social-demographic analysis over a continental extent. Instead, initial global models need to be locally refined in a recursive but geographically specific manner using hierarchical models.

In Chapter 3, I compared the efficiency of agricultural census versus remotely sensed data in explaining continental-scale patterns of bird species richness. The implications of using each database for predicting avian species richness are discussed.

In Chapter 4, I described an approach to modelling the spatial distribution of human-environment interactions using principal component analysis (PCA) on a set of demographic variables. I modelled the environmental determinants of these axes using regression-tree analysis.

In Chapter 5, I further developed the Chapter 4 methodology but concentrated on the second principal component axis ( $\beta$ -settlement) which described relative population growth correlated with recent construction in non-agricultural areas.  $\beta$ -settlement was greatest in coastal and desert areas, and coincided with national concentrations of threatened and endangered species.

In Chapter 6, I used regression-trees to separately model: 1) breeding bird species richness, 2) actual evapotranspiration, and 3) population density in relation to environmental variables. Our three models used the environmental variables as predictors to identify areas of interaction, as end nodes for each regression-tree. All locations in a given end node shared a unique combination of environmental constraints on the dependent variable and were concentrated regionally. These end nodes were numbered uniquely within trees and then overlaid in a GIS to identify areas of spatial overlap. These overlap areas thus defined the co-occurrence of individual patterns of the respective interactions of biodiversity, ecosystem function, and human activity with the biophysical environment, simplifying and defining the domain of process models of global change.

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## DEVELOPMENT AND TESTING A HABITAT MAP FOR MAINE

*Investigator:* J. A. Hepinstall

*Advisors:* S. A. Sader  
W. B. Krohn

*Cooperators/  
Project  
Support:* USGS Biological Resources Division  
Maine Cooperative Fish and Wildlife Research Unit  
University of Maine -  
Department of Forest Management  
Maine Image Analysis Laboratory  
Department of Wildlife Ecology

*Objectives:* 1) Classify satellite images and create a vegetation and land cover map of Maine at a 1:100,000 scale.

- 2) Evaluate map classification accuracy with a minimum of 80% correct for major habitat types.
- 3) Prepare final report and publications.

*SCOPE:* As biodiversity is decreasing and many wildlife species and their habitats are becoming threatened, we need more comprehensive information for conservation efforts. A major requirement for conservation is a reliable statewide habitat map to provide a base for predicting distribution of wildlife species. Ground investigation is time consuming, expensive, and inefficient for large area surveys. Satellite images have advantages for statewide habitat mapping. This research uses aerial videography and satellite imagery to map habitat types for Maine.

*PROJECT STATUS:* Landsat-Thematic Mapper (TM) imagery for the state was used, along with ancillary geographic information system (GIS) data such as U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) maps to delineate 37 different vegetation and land cover types in Maine for use in the Maine Gap Analysis Project (ME-GAP). ME-GAP, conducted between 1991-1998, used satellite image processing for vegetation and land cover map development initiated during the summer of 1995. Training samples for the supervised portions of our image classification were derived from statewide aerial videography transects flown in June and October 1994. From this data set, 5,629 polygons were identified on the TM data and labeled according to cover type for use in training TM data and testing the accuracy of the final map.

Statewide classification proceeded on a TM scene-by-scene basis, thereby limiting the effects associated with radiometric scene differences from different acquisition dates. A total of 8 full TM scenes and one partial scene was required to obtain statewide coverage. Two years (1991 and 1993) of statewide imagery were obtained with cooperation from the Maine Department of Conservation (1991 imagery) and the Multi-Resolution Land Characteristics program (1993 imagery).

The final vegetation and land cover map was tested using polygons interpreted from videography. Eighty percent accuracy was required for all major vegetation types. Results from the final accuracy assessment indicate an overall accuracy of the map for 5 superclasses (Agricultural Lands, Forestlands, Wetlands, Developed Lands, and Other) was 88%. Overall accuracy of forest versus non-forest classes was well over 90%. Within regrouped forest types (regeneration, hardwood, softwood, and mixed) the agreement with interpreted videography ranged from 60 to 80% except for mixed forest, which had only 45% agreement. The low agreement of mixed forest is expected given the ambiguous nature of defining a cut-off between deciduous, mixed, or coniferous forest. Our final vegetation and land cover map is most applicable at the 1:40,000 scale (or smaller) and contains a minimum area or polygon size of 0.81 ha (2 ac), while retaining the original 0.09 ha (0.22 ac) pixel size in a raster format.

Results of our statewide mapping effort are summarized by environment variables (biophysical region, elevation, slope-aspect), political boundaries (counties, towns), and ownerships (industrial and non-industrial forestland ownerships). We also provide a comparison of our results with the forest area estimates from the 1995 USDA Forest Service statewide inventory and the results of a Maine Forest Service study.

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## MAINE GAP ANALYSIS

*Investigators:*

W. B. Krohn
R. B. Boone
S. A. Sader
J. A. Hepinstall
S. M. Schaefer
S. L. Painton

*Cooperators/  
Project  
Support:* USGS Biological Resources Division  
University of Maine -  
Department of Wildlife Ecology  
Maine Image Analysis Laboratory  
Maine Department of Inland Fisheries and Wildlife  
Maine Department of Conservation  
Maine Office of Geographic Information Systems

- Objectives:*
- 1) Develop detailed range maps for terrestrial (i.e., non-fish) vertebrate species in Maine, using literature and expert review.
  - 2) Create matrices depicting habitat relationships for the terrestrial vertebrate species breeding in Maine.
  - 3) Develop spatially-explicit, statewide predictions of how likely species are to occur in habitats.
  - 4) Develop species richness predictions by vertebrate classes and all terrestrial vertebrates, and compare these distributions to the locations of conservation lands in Maine.
  - 5) Prepare the final report for Maine Gap Analysis and provide results to cooperators.

**SCOPE:** Recovering endangered vertebrate populations can be expensive, disruptive to the species and to society, and may not succeed. The recognition that ensuring that the more common species remain common is an efficient conservation strategy that spawned Gap Analysis. In Gap Analysis, the distributions of species are predicted, then compared to the patterns of conservation lands in a region. To conduct Gap Analysis for Maine, we require predicted distributions of the non-fish vertebrate species that breed in inland Maine.

**PROJECT STATUS:** The Maine Gap Analysis Project (ME-GAP) was initiated in 1992 as a cooperative effort between the Biological Resources Division of the U.S. Geological Survey (USGS) and state, federal, and private natural resources groups in Maine. The objectives of ME-GAP were to: (1) produce databases for use in Geographic Information Systems (GIS) at a scale of 1:100,000 to describe current land cover, distributions of native species of terrestrial (i.e., non-fish, non-marine) vertebrate species, ownership of conservation and public lands, and land management status; (2) identify land cover types and vertebrate species that currently are not represented or are under-represented in areas managed for long-term maintenance of biodiversity (i.e., identify conservation gaps); and (3) facilitate cooperative development and use of information so that institutions, agencies, and private land owners may be more effective stewards of Maine's biological resources. ME-GAP is a preliminary step toward the more detailed studies and efforts needed for the long-term conservation of biodiversity in Maine.

The system used to classify the land cover consisted of 37 types (19 upland types, 16 wetlands, 2 water). This classification was a compromise between the habitats needed to predict vertebrate distributions and those classes that could be discerned from satellite imagery and ancillary GIS databases. Landsat Thematic Mapper (TM) imagery from 1991 and 1993, in conjunction with aerial videography, was used to identify and map the water and upland types. Wetland polygons came primarily from the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI). NWI maps of Maine were done at 1:24,000 and based on aerial photographs mostly from the mid- and late-1980s. To facilitate the predicting of vertebrate species' distributions, NWI wetland types, defined largely in terms of physiographic locations on the landscape, were re-labeled so types related to the occurrences of vertebrates in terms of vegetative and structural characteristics. A comparison of vegetation and land cover types mapped from TM data to serial videography had an overall accuracy of 88.1% at the level of superclasses. For groups of forestland classes, accuracy levels from 45% to 80%; accuracy by types also varied geographically across the state as different TM scenes were used in various parts of the state.

A GIS database of private and public conservation lands was assembled in cooperation with the Maine

State Planning Office. Conservation lands comprise less than 6% of Maine, with public lands consisting of approximately 5.3%. Conservation lands are well distributed throughout the state except for the northwestern portion, which is largely without public conservation lands. In southern Maine, conservation lands are highly scattered and generally smaller than in the rest of the state. Private commercial forestlands (i.e., large blocks in corporate ownership) and Native American lands managed for forestry encompass approximately 50% of Maine. Lands were denoted as to the degree to which they are managed for maintenance of biodiversity and long-term ecological processes. The Gap Analysis Program requires use of a 1 through 4 scale to denote high to low management for biodiversity maintenance based on legal and management status. While not all lands could be unequivocally classified as to management category, less than 3% of the state occurs in management categories 1 and 2, with almost no Category 1 lands in southern Maine (lands owned by the Maine Chapter of The Nature Conservancy are the exception). Category 3 lands made up almost 53% of the state and consist primarily of privately owned or public multiple-use forestlands. Category 4 lands occur mostly in southern Maine, along the coast, and in the northeastern corner of the state. The land ownership map should not be interpreted as a legal document, but as a representation of general ownership patterns.

The number of species (i.e., richness) of native terrestrial vertebrates that regularly breed in Maine ( $n = 270$ ) is the highest in coastal and southern Maine. This pattern is similar to the richness patterns of terrestrial threatened and endangered species and woody plants. In the long term, human occupation of the natural landscape is the driving force underlying habitat loss. The density of Maine's human populations in 1990 was highest in the coastal and southern portions of the state. The distribution of Maine's human population is changing (like elsewhere in the nation) with people moving out of population centers into adjacent rural areas; the distribution of people into rural areas is most extensive in southern Maine. When looking at the distribution of conservation lands by management categories, note few Category 1 areas occur statewide. Southern Maine is clearly the area of highest richness of terrestrial vertebrates, threatened and endangered species, and woody plants, but contains only small and scattered Category 2 and 3 conservation lands. In addition to coastal and southern Maine, the northwestern part of Maine also merits special consideration in conservation planning because this region contains few reserves and provides habitat for northern species at the southern limits of their distributions.

To demonstrate the flexibility of ME-GAP data, two sets of species-specific conservation analysis of terrestrial vertebrates are presented. In set one, data related to the management of a rare forest bird (i.e., Bicknell's Thrush) and a common aquatic mammal (American Beaver) were analyzed using predicted distributions from ME-GAP. In set two, analyses were done on actual habitat data collected by Maine's Department of Inland Fisheries and Wildlife (MDIFW) for an uncommon wetland species (Bald Eagle) versus a widespread upland mammal (White-tailed Deer). The range of issues covered by these examples clearly shows that this report has barely touched the potential of the data assembled herein to address conservation and management, as well as research, questions.

With the completion of ME-GAP, the long-term maintenance, revision, and application of the GIS databases is a concern. In addition to these data becoming part of the National Biological Information Infrastructure of the USGS Biological Resources Division, these databases will be housed and used by various state agencies. The MDIFW will continue to use the vertebrate data (i.e., range limits and habitat associations) and the vegetation and land cover map; the Maine Image Analysis Laboratory, University of Maine, will store and use the TM and aerial videography data; and the Maine Office of GIS will maintain and distribute the conservation and public lands database created by the SPO and ME-GAP. In the end, the relative success of this project should be judged on how long these databases are revised and reused in the decision-making processes affecting Maine's biological resource.

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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. E. Gerken  
H. Tedford

*Cooperators/  
Project  
Support:* Holt Woodlands Research Foundation  
McIntire-Stennis  
Maine Outdoor Heritage Funds  
Baldwin Foundation

*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 2 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) transect surveys of nonbreeding birds; (5) small mammal trapping; (6) salamander quadrat counts; (7) observations of reproductive efforts (flowering and fruiting) for 13 herb and shrub species; (8) estimates of seed and fruit production; (9) general surveys of canopy insect abundance; and (10) 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 will begin to understand how the community changes seasonally and from year to year; this is the essence of the third objective.

*PROJECT STATUS:* In 1999, tasks 2, 3, 4, 5, 6, 8, 9, and 10 as outlined above, were completed.

*FUTURE PLANS:* The 2000 field season will replicate the 1999 field season with additional work on plants, birds, and soil moisture.

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## WILDLIFE COMMUNITIES OF VERNAL POOLS IN SOUTHERN MAINE

- Investigator:* A. M. Perillo
- Advisors:* M. L. Hunter, Jr.  
M. A. McCollough  
K. E. Gibbs  
S. C. Gawler
- Cooperators/  
Project  
Support:* Maine Department of Inland Fisheries and Wildlife  
University of Maine -  
Department of Wildlife Ecology  
U.S. Fish and Wildlife Service  
U.S. Forest Service  
U.S. Environmental Protection Agency
- Objectives:*
- 1) Describe the biotic community of vernal pools in southern Maine, including reptile, amphibian, macroinvertebrate, and plant species;
  - 2) Characterize the physical, chemical, and biological parameters that contribute to the value of these pools for wildlife.
  - 3) Develop guidelines for predicting wildlife values of vernal pools in southern Maine.

**SCOPE:** Wetlands are well-recognized as highly productive communities, and in Maine are used by a disproportionate number of state-listed rare, threatened and endangered species. Currently, Maine laws generally protect only wetlands greater than 10 acres. Small wetlands in southern Maine are in immediate peril, due primarily to residential development causing habitat degradation and loss. Recent studies have demonstrated that several populations of the state-threatened spotted and Blanding's turtles are centered in wetland complexes in southern Maine dominated by vernal pools. Vernal pools are also extremely important breeding habitat for many amphibian species, serving as centers for mating, egg deposit, embryonic development, larval development, and metamorphosis. Many amphibian species return to their natal pools to breed. Therefore, local populations of state-threatened turtles and many amphibian species could be severely limited or extirpated by loss of vernal pools. The information collected in this study will provide a basis for consideration of additional protection initiatives for small wetlands in Maine.

**PROJECT STATUS:** Forty-five vernal pools were selected for study in York County, Maine. Field work was completed during April-September 1994 and 1995. Data collection included counting amphibian egg masses, trapping larval amphibians and aquatic invertebrates, surveying to determine the presence and abundance of reptiles, amphibians and other vertebrate species using the pools, and conducting aural surveys of breeding frogs and toads using the pools. Other data collected included water temperature, depth, pH, and conductivity, pool shrinkage and hydroperiod, pool flora, vegetation type, structure and percent cover for all vegetation growing within or overhanging pools, and average tree height and forest type of area surrounding pools. Invertebrate samples were sorted, identified, and counted during 1995 and 1996. Additional fieldwork was conducted during the winter of 1997 to gather data on solar input for all pools. Analysis was conducted in Spring 1997, and a preliminary report of research results was prepared.

**FUTURE PLANS:** A final thesis is in preparation.

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## BARK INVERTEBRATES OF WHITE PINE AND RED OAK SNAGS IN A SOUTHERN MAINE FOREST

*Investigator:* D. L. Nelson

*Advisors:* M. L. Hunter, Jr.  
R. J. O'Connor  
A. S. White  
S. A. Woods  
C. S. Stubbs

*Cooperators/  
Project  
Support:* Holt Woodlands Research Foundation  
University of Maine -  
Department of Wildlife Ecology

*Objectives:*

- 1) Document the invertebrates on and within the bark of standing dead pines and oaks in the Holt Research Forest.
- 2) Relate variability in abundance and taxa composition of these invertebrates to characteristics of the snags and their local environment.
- 3) Document the characteristics and availability of snags within the Holt Research Forest from 1984 to 1996.

**SCOPE:** Dead wood is an important component of many forest ecosystems. Trees in various stages of decay contribute structural diversity to forests, serve as long-term nutrient sources and sinks, reduce erosion, contribute to soil development and enrichment, influence seedling establishment, provide habitat for mammals, birds, amphibians, reptiles, invertebrates, plants, and fungi, and retain moisture through times of drought. Of all organisms that use decaying wood, invertebrates compose possibly the largest and most diverse group. Invertebrates also play essential roles in the process of wood decomposition. Even so, comparatively little is known about the ecology of most wood-loving invertebrates.

Current forest management practices often discriminate against dead trees, which are reduced through thinnings and short rotations, eliminated as both fire and safety hazards, and destroyed to prevent the spread of timber pests and diseases. These practices may alter the size, species composition, and recruitment rate of dead trees, affect patterns of decay and nutrient cycling, and cause ecosystem simplification. The implications of such practices on forest ecosystems are just beginning to be investigated.

This study is designed to address issues relating to invertebrate and dead tree conservation. I wish to quantitatively explore the links between snag condition and the community attributes of bark invertebrates. I also wish to explore the dynamics of snag production and decay. This knowledge could be important for the wise management of forest resources.

**PROJECT STATUS:** Invertebrate samples were collected from logs, snags, and live oaks and pines throughout the summer of 1997 and identified to varying degrees, depending upon the availability of published keys and help from expert taxonomists.

**FUTURE PLANS:** A final thesis is in preparation. In addition, the timber inventories conducted in 1984, 1988, and 1996 will be used to examine the numbers and kinds of snags available in the forest, and the rate of snag production and fall.

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## INVESTIGATIONS OF THE ACCURACY TESTS OF PREDICTED VERTEBRATE OCCURRENCES FROM GAP ANALYSIS

- Investigator:* S. M. Schaefer
- Advisors:* W. B. Krohn, Chairperson  
D. J. Harrison  
S. A. Sader  
R. B. Boone (*ad hoc* member)
- Cooperators/  
Project  
Support:* Gap Analysis Program -  
USGS Biological Resources Division  
Maine Cooperative Fish and Wildlife Research Unit  
University of Maine -  
Department of Wildlife Ecology
- Objectives:*
- 1) Determine if there is a relationship between the percent of errors reported and the type of test data available (long-term versus short-term field inventory), the size of test site, and definition of what constitutes a breeding species.
  - 2) Determine if the commission errors reported for avians from ME-GAP relate to *a priori* measures of ease of inventory termed Likelihood Of Occurrence Ranks.
  - 3) Partition out the potential sources of error (i.e., range limits, habitat map, habitat model) in the predicted avian occurrences using the Breeding Bird Survey as the standard of comparison.

**SCOPE:** Predicted vertebrate occurrences from Gap Analysis, a national program of the USGS Biological Resources Division, are currently tested by comparison with existing species lists for a selected conservation area. The reporting of omission error (percentage of species that occur on the area but are not predicted by GAP) and commission error (percentage of species not reported on an area that are predicted by GAP) for a state project gives an indication of how well the models and data layers used correctly predicted species occurrences. Limitations associated with the current method of accuracy assessment range from variability in the size of test sites used, to the difficulty that comes with trying to qualitatively interpret the omission and commission error. Another question that arises in assessing the accuracy of the vertebrate predictions is, what data layer used in making the prediction is causing the error. The purpose of my research is to explore these limitations and questions so that future tests of predicted vertebrate occurrences can be strengthened.

**PROJECT STATUS:** The literature review has been completed and a research proposal has been drafted.

**FUTURE PLANS:** Once the proposal is reviewed and approved by committee members, creation of the data layers and analysis will begin.

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## REPRESENTATIONAL ANALYSES OF CONSERVATION AREAS IN MAINE

*Investigator:* S. L. Painton

*Advisors:* W. B. Krohn, Chairperson  
M. L. Hunter  
M. K. Beard-Tisdale

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

*Objectives:*

- 1) Measure how similar the abiotic and biotic variables are on conservation areas versus non-conservation areas of Maine.
- 2) Aggregate the variables and spatially analyze the highly under-represented areas from the represented areas on the major biophysical regions of Maine.
- 3) Conduct a representational analysis on the most under-represented biophysical region of the state with similar abiotic and biotic variables.
- 4) Assess the degree to which terrestrial vertebrates and major environment variables are represented on state and Federal wildlife management lands in Maine.

*SCOPE:* While the State of Maine continues to purchase conservation areas, no scientific analysis has been done to determine the role of existing conservation areas in conserving the state's natural heritage. A set of conservation areas that is as representative as possible of Maine's natural diversity has the greatest chance of conserving the biodiversity, and uncoordinated and unplanned decisions may seriously compromise progress toward that goal. Thus, the purpose of this study is to assess how well the conservation areas in Maine are representing the natural diversity of the state.

*PROJECT STATUS:* The conservation areas in Maine are incorporated into a digital database (scale = 1:100,000), which will be analyzed to determine whether or not the current conservation areas are representative of Maine's natural variability. This analysis will be separated into three chapters. In the first chapter, twelve variables (10 abiotic and 2 biotic) will be analyzed on conservation areas versus non-conservation areas using a Geographic Information System (GIS) at a 1.86 x 1.86 km resolution. Maine was divided into biophysical regions using GIS and cluster analyses and for this analysis were modified into five roughly equal-sized regions. The representativeness of the variables will be compared for the five regions in the state. In the second chapter, a similar analysis will be conducted on the most under-represented region at a 94.6 x 94.6 m resolution. Similar variables will be analyzed (5 abiotic and 2 biotic) along with a threat and opportunity variable, road density. The areas identified as under-represented by this analysis will represent important areas for conservation acquisition, assuming the State of Maine's goal is to have a sample of conservation areas that fully represents the natural diversity in the state. The third chapter will assess the contribution of State Wildlife Management Areas (WMAs) and Federal National Wildlife Refuges (NWRs) to conservation in Maine. In addition to determining the extent to which Maine's terrestrial vertebrates are represented on these lands, representative analyses of major environmental variables such as elevation, slope, mean temperature, and snowfall will also be done.

**FUTURE PLANS:** The statewide analysis has been completed and the initial draft is under review. The regional analysis is being completed and the WMA/NWR analysis will be done next. All analyses will be done by December 1999.

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## EFFECTS OF LANDSCAPE PATTERN ON AMPHIBIAN SPECIES ASSEMBLAGES IN AN AGRICULTURALLY-FRAGMENTED LANDSCAPE

**Investigator:** A. D. Guerry

**Advisors:** M. L. Hunter, Chairperson  
R. J. O'Connor  
D. J. Harrison  
A. J. K. Calhoun

**Cooperators/  
Project  
Support:** McIntire-Stennis  
National Science Foundation  
Maine Association of Wetlands Scientists

**Objectives:**

- 1) Document the distribution (and in some cases relative abundance) of breeding amphibians in ponds in a variety of landscapes that represent predominantly agricultural landscapes, predominantly forested landscapes, and patchy combinations of the two. Determine whether or not the context in which a pond lies affects the species assemblage that breeds there.
- 2) Determine whether or not connectivity of habitat-patches mitigates the effects of habitat loss by looking at a number of different "landscapes" (1 km circles centered on breeding ponds) with the same areas of natural habitat but different spatial arrangements of habitat-patches with respect to the ponds.
- 3) Locate potential thresholds at which the amount of open-land surrounding a pond prohibits particular species from using breeding pools or reduces the probability of a species occurrence.

**SCOPE:** One of the themes of landscape ecology is that the landscape mosaic surrounding a patch is often more important to patch function than are characteristics within the patch. This study tests this paradigm in a particular case. The landscape pattern in eastern Aroostook County provides a valuable opportunity to test theoretical models of habitat fragmentation. In this fragmented landscape, an inhospitable agricultural matrix separates many ponds from the surrounding uplands. For many amphibians, agricultural practices can limit the use of preferred breeding habitat because migration from woodland hibernacula to breeding ponds in Spring must be across a matrix with very little protection from the drying effects of wind and sunlight. Juvenile dispersal, immigration, and re-colonization can also be limited in a fragmented landscape such as eastern Aroostook County.

**PROJECT STATUS:** One hundred seventeen ponds were chosen for study using National Wetland Inventory (NWI) maps, land-cover maps created by the Maine GAP project, and field checks. All ponds were classified by the NWI as palustrine unconsolidated bottom or palustrine emergent vegetation, are large enough to appear on the NWI map (approximately 0.1 hectares), and smaller than 0.5 hectare. They were chosen to fill 3 classes (0-33%, 34-66%, 67-100%) indicating the amount of open-land in the 1 km landscape surrounding the pond, quantified within a Geographic Information System (GIS). Seventy-four ponds were surveyed in 1998, 43 new ponds were added in 1999, and 18 ponds were surveyed in both years.

Surveys were conducted throughout the 1998 and 1999 breeding-seasons to look for adults, egg masses, and larvae. Anurans were also detected using night surveys to detect the presence of calling males; protocols from the North American Amphibian Monitoring Program (NAAMP) were used. Local-scale habitat components such as water chemistry, pond vegetation, and the presence or absence of fish were recorded for each pond. Small-scale landscape variables such as active or abandoned agricultural fields, and proximity to forest were also documented both in the field and from aerial photographs. Large-scale landscape variables such as wetland density and arrangement of forest patches were retrieved from the GIS.

Preliminary analysis of the data shows that the likelihood of occurrence of 7/9 species studied is affected by the amount of open-land within a 1 km radius of the breeding pond. The less vagile caudates (salamanders and newts) in particular display a pattern of occupancy that strongly reflects the amount of forest surrounding the breeding pond. Spotted salamanders also seem to be affected by the spatial arrangement of forest patches with respect to the ponds; they are more likely to be present in ponds surrounded by less open land and that are connected to the forest. Models built with both landscape variables and pond variables may help to explain occurrences for some species.

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## INVESTIGATIONS OF THE ACCURACY TESTS OF PREDICTED VERTEBRATE OCCURRENCES FROM GAP ANALYSIS

*Investigator:* S. M. Schaefer

*Advisors:* W. B. Krohn, Chairperson  
D. J. Harrison  
S. A. Sader  
R. B. Boone (*ad hoc* member)

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

*Objectives:*

- 1) Determine if there is a relationship between the percent of errors reported and the type of test data available (long-term verses short-term field inventory), the size of test site, and definition of what constitutes a breeding species.
- 2) Determine if the commission errors reported for avian's from ME-GAP relate to *a priori* measures of ease of inventory termed Likelihood Of Occurrence Ranks.
- 3) Partition out the potential sources of error (i.e., range limits, habitat map, habitat model) in the predicted avian occurrences using the Breeding Bird Survey as the standard of comparison.

**SCOPE:** Predicted vertebrate occurrences from gap analysis, a national program of the USGS Biological Resources Division, are currently tested by comparison with existing species lists for a selected conservation area. The reporting of omission error (percentage of species that occur on the area but are not predicted) and commission error (percentage of species not reported on an area that are predicted) for a state project gives an indication of how well the models and data layers used correctly predicted species occurrences. Limitations associated with the current method of accuracy assessment range from variability in the size of test sites used, to the difficulty that comes with trying to qualitatively interpret the omission and commission error. Another question that arises in assessing the accuracy of the vertebrate predictions is, what data layer used in making

the prediction is causing the error. The purpose of my research is to explore these limitations and questions so that future tests of predicted vertebrate occurrences can be strengthened.

**PROJECT STATUS:** Investigation into the first two objectives has been completed and a draft report dealing with the second objective is being reviewed.

**FUTURE PLANS:** Complete the digitizing of habitat types along Breeding Birds Survey routes which will be a major factor in analyzing the third and final objective. Thesis completion is scheduled for December 1999.

## A MULTI-SCALE STUDY OF LYNX (*Lynx canadensis*) HABITAT IN EASTERN NORTH AMERICA

**Investigator:** C. L. Hoving

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

**Cooperators/  
Project  
Support:** University of Maine –  
Department of Wildlife Ecology  
Maine Cooperative Fish and Wildlife Research Unit  
Maine Department of Inland Fisheries and Wildlife  
National Council of the Paper Industry for Air and Stream  
Improvement, Inc.  
U.S. Fish and Wildlife Service

**Objectives:**

- 1) Develop and test a spatially explicit predictive habitat model for Canada lynx in eastern North America.
- 2) Develop and test spatially explicit predictive habitat models for snowshoe hares (*Lepus americanus*) and lynx in Maine.
- 3) Develop and test a spatially explicit predictive habitat model for lynx in the northwestern part of Maine.
- 4) Determine if the range of lynx has contracted significantly over the past several hundred years, and document changes in habitat, climate, and predator-prey communities over that time in eastern North America.

**SCOPE:** The U.S. Fish and Wildlife Service (USFWS) proposed in 1998 to list the Canada lynx as threatened under the Endangered Species Act. The state of Maine is one of the few states in which lynx occur; however, the ecology of lynx in eastern North America is limited. The ecological processes that determine lynx habitat occur at many scales. Therefore a multi-scale approach to lynx habitat modeling is necessary.

**PROJECT STATUS:** Land-cover/land-use data from Advanced Very High Resolution Radar (AVHRR) imagery and digital line graph (DLG) transportation data at a 1:100000 scale and Digital Elevation Model (DEM) at 1:250000 have been obtained from the United States Geologic Service (USGS). Similar data have been obtained from Geomatics Canada. Snowfall and temperature data have been acquired from the National Oceanic and Atmospheric Administration (NOAA) and the Atmospheric, Climate, and Water Systems Branch of Environment Canada. A digital map of rivers streams and lakes has been provided by Champion, Inc. Locations of lynx harvested south of the St. Lawrence Seaway have been provided by the Quebec Ministry of

the Environment and Wildlife. Locations of incidental harvest in New Brunswick have been provided by the New Brunswick Department of Natural Resources and Energy. Locations of lynx in Maine have been gathered from a variety of sources. Track data from snowmobile transects run by the Maine Department of Inland Fisheries and Wildlife (MDIFW) for lynx between 1994–1999 have been digitized, and locations of lynx tracks will soon be added. Transects run with the same protocol for bobcat (*Lynx rufus*), fisher (*Martes pennanti*), American marten (*Martes americana*) and snowshoe hare have also been digitized. With the exception of the climate data, track data and Canadian roads, all data sources have been incorporated into ARC-INFO (Environmental Systems Research Institute, Redlands, CA).

A research protocol was drafted and is being reviewed by my graduate committee and project funding sources.

**FUTURE PLANS:** I will write the final research proposal, incorporate review comments, and finish incorporating data into ARC-INFO. I will use this data to model lynx habitat at three spatial scales. Historical research will provide insight at further temporal scales.

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## HABITAT ASSESSMENT SUPPORT TO THE MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE

*Investigators:* J. A. Hepinstall  
W. B. Krohn

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

*Objectives:*

- 1) Develop digital data resources for use in GIS analyses.
- 2) Support MDIFW personnel in preparing habitat portion of species assessment.
- 3) Develop a Southern Maine Habitat Analysis system to aid towns with land use and conservation planning.

**SCOPE:** The purpose of this study is to determine the feasibility of doing habitat assessment for selected species of high priority to the MDIFW. The ultimate objective is to incorporate statewide habitat data in MDIFW's planning and species assessment processes, thus bringing the levels of habitat analyses up to the levels of detail for the population analyses.

**PROJECT STATUS:** Digital data development included 1) obtaining and incorporating missing National Wetlands Inventory (NWI) digital data into a statewide NWI coverage and integrating the new data into ME-GAP vegetation and land cover map; 2) mosaicing 1:24,000 scale data (included rivers, streams, lakes and ponds, transportation) into statewide coverages; and 3 ) organizing all available MDIFW GIS data relating to species habitat management. GIS analyses for beaver, river otter, muskrat, and mink were conducted to support development of habitat assessment plans. A Southern Maine Habitat Analysis system was developed to aid towns with land use and conservation planning. Model development went through several iterations. Initial model included ranking habitats. Subsequent models dropped ranking habitats in favor of estimating the potential habitats "conserved" through existing shoreland zoning regulations. The current model compares species predicted to be present in a township according to ME-GAP predictions with species predicted to be present in shoreland zones, and with combined shoreland zones and Important Habitat (defined as MDIFW special habitats and habitats of regulatory concern).

**FUTURE PLANS:** Support for species assessments is ongoing. Modeling American Woodcock habitat and a representational analysis of the Woodcock Singing-Ground Survey routes are beginning. Southern Maine Habitat Analysis System refinement is ongoing, but final products are expected to include an information system, individual or regional information systems to support town planning, and a publication in a peer reviewed journal.

## EXPLORING GRASSROOTS EFFORTS TO MONITOR WILDLIFE

**Investigator:** R. Purtell

**Advisors:** M. L. Hunter, Jr.  
R. J. O'Connor  
D. M. Mageean

**Cooperators/  
Project  
Support:** Eastern Maine Conservation Initiative  
Penobscot County Conservation Association  
University of Maine -  
Department of Wildlife Ecology

**Objectives:**

- 1) Determine the mission, monitoring proficiency, expert input, and infrastructure of grassroots wildlife monitoring groups in Maine.
- 2) Describe dominant trends, variables, and implications of these four facets of grassroots monitoring efforts.
- 3) Synthesize a description of the current and potential value that grassroots monitoring programs have to wildlife conservation.
- 4) Present a profile of grassroots wildlife-monitoring groups, and an inventory of such groups in Maine.

**SCOPE:** Conservation biologists extol the virtues of community-based conservation strategies that incorporate local people, leaders, and institutions. Research into the roles that local people play in conservation has focused on projects initiated by government agencies, environmental organizations, and industry. Little attention has been given to truly grassroots approaches: those that begin with citizens in a community, evolve in response to local interests, and carry potential for effective and lasting biological conservation. This project examines grassroots groups that monitor wildlife to explore current and potential values such groups might have for wildlife conservation.

Using written questionnaires and in-depth interviews of approximately 25 coordinators, I will explore the 1) mission, 2) monitoring proficiency, 3) expert input, and 4) infrastructure of grassroots groups. Following analysis, I will describe dominant trends, variables, and implications of these four facets of grassroots monitoring efforts. Given the relative paucity of research into citizen-based conservation activities, my research should help address the current gap in knowledge, create an awareness of grassroots resources available to biologists, generate hypotheses for subsequent investigation, and hopefully inspire others to pursue research on the human dimension of wildlife conservation.

**PROJECT STATUS:** Through a snowball sampling process of over one hundred telephone conversations, 25 grassroots groups have been identified. Coordinators have received and are gradually returning written questionnaires with background information. In-person or telephone interviews are currently being scheduled for the month of November. Audio-taping and transcribing equipment is being tested. The text information database program, *askSam*, has been procured and will be installed shortly.

*FUTURE PLANS:* Interviews and transcriptions will be completed by the beginning of December, 1999. Analysis of interview texts will continue through the month of December with project completion scheduled for the end of January, 2000.

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

### **SITE FIDELITY OF SONGBIRDS IN SELECTIVELY HARVESTED AND UNHARVESTED MIXED WOODS**

*Investigator:* M. J. Hartley

*Advisors:* M. L. Hunter  
R. J. O'Connor  
A. S. White  
W. B. Halteman  
W. A. Glanz

*Cooperators/  
Project  
Support:* University of Maine -  
Forest Ecosystem Research Program  
Department of Wildlife Ecology  
Maine Department of Inland Fisheries and Wildlife  
USDA Forest Service  
Cooper Ornithological Society  
American Wildlife Research Foundation

*Objectives:*

- 1) Describe changes in breeding bird communities on sites that are experimentally harvested (with selection silviculture) and unharvested.
- 2) Determine if selective timber harvesting affects site fidelity of Ovenbirds and Hermit Thrushes, as estimated by:
  - a) annual return rates,
  - b) distance between territories of successive years.

*SCOPE:* Forests are dynamic ecosystems that may only be understood through long-term research projects that focus on many different aspects of structure, function, and biota within and between stands. The Forest Ecosystem Research Program (FERP) was formed to address such long-term research issues. The FERP has established nine long-term research sites at the Penobscot Experimental Forest (PEF). These 10 ha stands are grouped into three replicates of "triplets" (three plots) that are treated with light selection cutting (1% annual harvest, with many retention trees), moderate selection cutting (2% annual harvest, with some retention trees), or no cutting (i.e., control). These three replicates are all within one 1400 ha mixed-wood forest. My role in the FERP is to study how these treatments affect one aspect of biodiversity in the forest: breeding bird communities. If selective timber harvesting causes migratory songbirds to be displaced from their territories of previous years, then harvesting would negatively affect breeding productivity.

*PROJECT STATUS:* The first FERP triplet was harvested in the winter of 1995, so the summer of 1996 (the first year of return data) resulted in returns to 2 treated and 7 untreated sites. The second triplet was harvested the following winter (1996/97), so 1997 yielded return data for 4 harvested sites and 5 controls, including two sites that were harvested two years earlier. By the final field season (summer 1998) all 6 (of 9) sites were harvested, and data collection was finished. Using over 100 nets and averaging 4,000 mist-net hours per summer, I captured and banded approximately 300 birds each summer from 1995-1998, and individually

colormarked nearly half the birds. Return rates varied during the three sampling periods, being much higher in some years for both species. Preliminary return rates for Ovenbirds ( $n = 111$ ) have consistently averaged 60% per year, whereas Hermit Thrushes ( $n = 143$ ) average 70%. These estimates are higher than those reported in the literature, probably because many investigators fail to include recapture probability in survival estimates. Territory mapping data have shown very few changes in songbird communities due to harvest activities. Year-to-year variations in bird densities, e.g., due to changes in predator abundance, are much stronger than differences among treatments and controls.

*FUTURE PLANS:* Statistical analyses began during fall 1998 and should be finished during spring 2000.

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## DEVELOPMENT AND APPLICATION OF OBSERVATION-BASED TECHNIQUES FOR ASSESSING FOREST SONGBIRD NESTING SUCCESS

- Investigator:* C. R. Foss
- Advisors:* M. L. Hunter, Jr., Chairperson  
W. A. Halteman  
W. B. Krohn  
R. J. O'Connor  
R. S. Seymour
- Cooperators/  
Project  
Support:* University of Maine  
Switzer Environmental Fellowship Program  
McIntire-Stennis  
U.S. Fish and Wildlife Service -  
Lake Umbagog National Wildlife Refuge  
Neotropical Migratory Bird Program  
USDA Forest Service  
N.H. Fish and Game Department  
Maine Department of Inland Fisheries and Wildlife  
N.H. Department of Resources and Economic Development  
Division of Forests and Lands  
Boise Cascade  
Mead Corporation  
James River Corporation  
Crown Vantage, Inc.  
Maine Bureau of Public Lands  
Seven Islands Land Company  
Wagner Forest Management, Ltd.  
Audubon Society of New Hampshire
- Objectives:*
- 1) Assess the effectiveness of reproductive index ranking of territories and fledgling surveys as indices of nesting success in forests.
  - 2) Identify any behavioral biases that may skew reproductive index ranks for particular species.
  - 3) Determine the relative effectiveness of sampling points and transects in fledgling surveys.
  - 4) Determine effective sampling radii for fledglings.
  - 5) Determine appropriate seasonal and diurnal periods for fledgling surveys.

- 6) Assess effects of partial cutting in spruce-fir forests on species composition, abundance, and nesting success of breeding bird communities using behavior mapping and reproductive index ranking.

**SCOPE:** Recent concerns about the relationships between forest fragmentation, harvesting practices, and biological diversity have increased the need for data on avian distribution, abundance, and productivity in forested landscapes. Recent population declines of some songbird species, notably some neotropical migrants, have underscored the need to understand patterns of reproductive success for forest songbirds. Selection management has been championed by some conservation groups as an alternative to clearcutting, which provides for both timber and wildlife habitat needs while minimizing ecosystem disturbance. Research has yet to address many important questions about impacts of selection harvests on native wildlife.

This study explores the potential for observation-based survey techniques to provide relatively cost-effective indices to avian nesting success in forested habitats, and uses a combination of established and newly developed field survey techniques to study relationships between cutting intensity in spruce-fir stands and species composition, abundance, and nesting success of forest birds.

**PROJECT STATUS:** Pilot field work during May-August 1994 involved surveys on 12 20-ha plots in northern New Hampshire, 4 each in managed hardwoods, spruce-fir forest, and regenerating clearcuts. Surveys included a modified spot-mapping method, which focused on observations of breeding behaviors, and point and transect surveys, which focused on detection and identification of fledged young. Results led to the evolution of two techniques, behavior mapping for intensive surveys of rectangular study plots, and fledgling surveys for use in combination with point counts on linear transects.

The study of effects of partial cutting in spruce-fir forests began in 1995 on 11 20-ha plots in managed spruce-fir forests of the Androscoggin headwaters area of northern New Hampshire and western Maine. Treatments ranged from no cutting in the past 60 years through commercial thinning to progressively heavier partial cuts, conducted during the past 5-7 years. Field work conducted during May-August 1995 and 1996 involved behavior mapping of all birds encountered on the 11 plots. Vegetation surveys, including prism point sampling and collection of relevé data in each of 80 50x50 m-cells on each of the 11 plots, were completed during September-November 1996. Behavior mapping continued in 1997 on 6 of the 11 plots that spanned the range of silvicultural treatments. Comparisons of behavior mapping with nest-searching and monitoring were conducted on 10-ha subsets of 3 of the 11 plots in 1996, and of behavior mapping with constant-effort mist netting were conducted by a collaborator on a plot elsewhere in Maine in 1995 and 1996. This work was presented at a symposium, "Contemporary Research on the Effects of Forest Management on Bird Populations," during the Annual Conference of The Wildlife Society in Snowmass Village, Colorado, in September 1997, and have been submitted for publication with the symposium proceedings in the Wildlife Society Bulletin in early 1998.

**FUTURE PLANS:** Preparation of papers is the priority for the 1999-2000 academic year.

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## PHYLOGEOGRAPHY AND MATING SYSTEM OF AMERICAN WOODCOCK (*Scolopax minor*)

**Investigator:** H. L. Ziel

**Advisors:** J. M. Rhymer, Chairperson  
D. G. McAuley  
C. R. Maher

*Cooperators/  
Project  
Support:* U.S. Geological Survey -  
Patuxent Wildlife Research Center  
University of Maine -  
Department of Wildlife Ecology

*Objectives:*

- 1) Study phylogeography of American woodcock using DNA sequencing.
- 2) Study mating system of American woodcock using DNA fingerprinting and behavior observations.

**SCOPE:** The continental population of American woodcock (*Scolopax minor*) has declined over the last 30 years. As a result, there has been renewed interest in studying aspects of woodcock biology. Recent advances in genetic techniques have made new methods available for studies in ecology and population biology. Molecular techniques will be used to examine two aspects of woodcock biology. Banding data used to trace migration routes of birds from different regions have determined that there is a split between birds from the eastern and western portions of the species' range. I will study phylogeographic patterns of woodcock using mitochondrial DNA (mtDNA) to determine if genetic variation exists among populations. The mating system of woodcock is complex and unusual, and controversy still exists over what type of mating system they have. I will use DNA fingerprinting techniques to study paternity and the mating system of woodcock.

**PROJECT STATUS:** To determine phylogeographic structure of American Woodcock, I examined sequences from the ND6 gene and the control region of mtDNA and compared them among birds from different geographic regions. The U.S. Fish and Wildlife Service and the Canadian Wildlife Service provided woodcock wings from each state and province where woodcock are hunted. I extracted DNA from either feathers or wing tissue. I initially used primers developed for the Ruddy Turnstone (*Arenaria interpres*) control region and later designed primers to amplify and sequence the ND6 gene and 5' end of the control region in woodcock. Sequences are being analyzed using the Clustal method in Sequence Navigator (ABI).

Two field seasons for the study of the mating system have been completed. In spring 1999, we caught most of the males on the study site, and collected blood samples from all males. After the females nested and chicks hatched, trained bird dogs located females and broods in areas where we caught males. We caught the females and chicks with hand nets and took small blood samples. I extracted DNA from the blood samples, and I am using microsatellite loci, developed for Ruffs (*Philomachus pugnax*), to determine paternity.

**FUTURE PLANS:** Analysis of population structure and paternity is continuing. A thesis is being written.

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## DIRECT EFFECTS OF GROUP SELECTION HARVEST GAPS ON THE BIRD COMMUNITY OF AN OAK-PINE FOREST

*Investigator:* S. P. Campbell

*Advisors:* M. L. Hunter, Chairperson  
R. J. O'Connor  
J. M. Rhymer  
S. White  
W. B. Halteman

*Cooperators/  
Project* Holt Woodland Foundation  
University of Maine -

*Support:* Department of Wildlife Ecology

- Objectives:*
- 1) Characterize the movement of breeding birds in the harvested and unharvested areas of the forest by examining:
    - a) forest canopy gap usage and avoidance
    - b) frequency and distance of territorial excursions.
  - 2) Determine if territory sizes change in response to harvesting.
  - 3) Investigate possible changes in bird behavior (e.g., changes in location of foraging, singing, nesting or resting).

**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 clearcutting 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 (16 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 community and documenting the effects of forest management practices on these communities. It 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 ten 1-ha blocks were partially cut with a group-selection timber harvest. The other half of the forest was left as an unharvested control. Data collection after the harvest has continued and results to date indicate that, in terms of abundance, some bird species (e.g., Black-throated Green Warbler, Ovenbird) have responded negatively to the gaps, some (e.g., Eastern Wood-Pewee, Common Yellowthroat, White-throated Sparrow) have responded positively, but the majority of the species have shown little to no effect.

My research will provide a closer examination of the effects of group selection created gaps on the bird community. In other words, I will look for effects beyond simple changes in abundance, which can be a misleading indicator of habitat quality, and focus on the more direct effects of the gaps. Specifically, I will be looking for alterations in movement patterns within and outside the territories of the birds, changes in territory size, and shifts in behaviors or locations of behaviors.

**PROJECT STATUS:** I have completed my first field season during which I banded 83 birds, 66 of which I also color banded. The three species comprising most of the captures were Black-Throated Green Warbler (24%) followed by Hermit Thrush (20%) and Ovenbird (13%).

I recorded 336 behavioral observations, each of which consists of the following information: location, species, sex, time, tree species, tree height, bird height, location within crown, crown radius, distance of bird from bole of tree, and behavior (forage [glean, hawk, hover, probe and drill], feeding, inactive, sing, call, flush and preen).

I also conducted preliminary tests on the use of radio telemetry to monitor bird movements and will be examining the results to refine my methodology for an expanded telemetry study in subsequent years.

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## PHILOPATRY AND DISPERSAL OF BLACK LEGGED KITTIWAKES (*Rissa tridactyla*) IN PRINCE WILLIAM SOUND, ALASKA

*Investigator:* T. M. Sauer

*Advisors:* J. R. Gilbert, Chairperson

W. E. Glanz  
F. A. Servello

*Cooperators/  
Project  
Support:* U.S. Fish and Wildlife Service -  
Migratory Bird Management  
University of Maine -  
Department of Wildlife Ecology

*Objectives:*

- 1) Determine philopatry and dispersal by cohort.
- 2) Determine differences within and between cohorts of philopatric fledglings and evaluate movement patterns.
- 3) Estimate demographic parameters including juvenile and adult local survival rates, age of first breeding and resighting probabilities.
- 4) Evaluate the factors of colony size, colony growth, productivity, distance from, and direction to natal colony in explaining the observed pattern of dispersal.
- 5) Quantify the error associated with local survival rate calculations.

*SCOPE:* Most information on Black legged Kittiwakes is based on data obtained from colonies in the Atlantic which may not be applicable to birds breeding in the Pacific Ocean. Preliminary data suggest that life history strategies are geographically different. Prince William Sound, Alaska, contains twenty-seven Black Legged Kittiwake colonies. Data have been collected annually by the U.S. Fish and Wildlife Service on the number of nests and chicks at all colonies. Additionally, an intensive banding of chicks and resighting effort of adults has been done at the Shoup Bay colony since 1988 and 1991. Resighting efforts at all other colonies will allow natal dispersal of birds from the Shoup Bay colony to be estimated.

*PROJECT STATUS:* The data base of resighting information, banding information, nest locations, and plot information will be completed by December 1999. Field seasons to collect dispersal information were completed in 1997 and 1998 (additional information was collected in 1999). All requirements for the M.S. degree in Wildlife Ecology will be completed by Spring 2000.

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

### **INFLUENCES OF TIMBER HARVESTING AND TRAPPING ON HABITAT SELECTION AND DEMOGRAPHIC CHARACTERISTICS OF MARTEN**

*Investigator:* D. C. Payer

*Advisors:* D. J. Harrison, Chairperson  
K. D. Elowe  
J. R. Gilbert  
W. B. Krohn  
R. J. Seymour

*Cooperators/  
Project* Maine Department of Inland Fisheries and Wildlife  
Federal Aid in Wildlife Restoration Project W-82-R-II-368

**Support:** University of Maine -  
 Cooperative Forestry Research Unit  
 Department of Wildlife Ecology  
 National Council of the Paper Industry for Air and Stream Improvement  
 Maine Forest Service  
 McIntire-Stennis  
 Baxter State Park  
 Great Northern Paper Company, Bowater, Inc.

- Objectives:**
- 1) Document and compare seasonal habitat selection and population characteristics (i.e. home range size, inter- and intra-sexual home range overlap, home-range fidelity across seasons and years, density, age and sex structure, survival and percent females lactating) by martens in an untrapped forest reserve, an untrapped industrial forest, and a trapped industrial forest.
  - 2) Compare microsite characteristics between areas receiving high, low or no use-intensity by resident, non-juvenile martens in an industrial forest with trapping closure and a forest reserve.

**SCOPE:** Much recent research with implications for management of the American marten (*Martes americana*) in the U.S. and Canada has focused on habitat alteration associated with timber harvesting. Although habitat loss through timber harvest has contributed to declines of some marten populations, the relative contribution of increased marten harvest following the construction of forest roads has not been fully elucidated. This is a significant oversight in light of the species' vulnerability to overharvest associated with ease of capture, low reproductive rates and relatively high pelt value. In fact, overtrapping has been implicated in large-scale declines of marten populations during the early 1900's, and has also contributed to declines in some modern populations.

The effects of timber harvesting and trapping on marten population viability must be isolated to effectively manage for sustained marten populations while providing reasonable opportunities for exploitation of forest products (i.e., timber and fur). We will attempt to isolate these effects by concurrently studying marten habitat associations in three contiguous sites in northcentral Maine at three spatial scales, i.e., position of the home range on the landscape (landscape-level selection), selection for overstory characteristics within the home range (stand-level selection), and use of microhabitat features within selected occupied areas. We are also studying population characteristics of marten on these sites. The three study sites differ in regard to habitat alteration and trapping pressure as follows: 1) timber harvest and trapping, 2) timber harvest and no trapping, and 3) neither timber harvest nor trapping.

**PROJECT STATUS:** All requirements for the Ph.D. degree (in Wildlife Ecology) were completed in August 1999. The abstract follows:

American marten (*Martes americana*) have large spatial requirements and specific habitat needs. Presumed habitat requirements of marten form the basis for some forest-management regulations, although few studies have evaluated the effects of timber harvesting on demographic performance. Trapping may confound studies of demography and habitat associations by reducing marten density. Therefore, I investigated habitat selection and demographic characteristics of 163 (87 M, 76 F) radiocollared, nonjuvenile ( $\geq 1$  yr) marten in an untrapped reserve, a trapped industrial forest, and an untrapped industrial forest in Maine. I also compared structural characteristics of mature, insect-defoliated, and clearcut stands receiving different intensities of marten use.

Areas receiving use by marten had greater tree height, basal area, and snag volume than unused areas. Volume of woody debris and understory foliage density was similar in regenerating and mature stands. Insect-defoliated stands with < 50% overstory canopy closure were intensively used, suggesting that vertical structure provided by large snags can substitute for live trees, and that marten do not require a closed

overstory canopy. In managed stands, I recommend maintenance of  $> 18 \text{ m}^2/\text{ha}$  basal area in live trees and snags, protection of advance regeneration, and retention of woody debris.

Clearcutting reduced marten density because marten avoided regenerating clearcuts when selecting territories. In the trapped area, trapping mortality was additive for males and further reduced marten density. In both industrial-forest treatments, incidence of lactation in adult females and natural-mortality rates were comparable to the reserve because marten selected high-quality territories with proportionally more mature forest and less young forest than was available in the landscapes. Few marten maintained ranges with  $> 40\%$  early successional forest. Within home ranges, marten also avoided young stands. Marten did not select among mature deciduous, coniferous, or mixed forests, suggesting that overstory type should not be considered a criterion of habitat quality *per se*. Marten in the industrial-forest treatments maintained larger territories than marten in the reserve, and home-range area was inversely related to the proportion of mature forest within the range. Density of lactating females was 3x greater in the reserve than in either industrial-forest treatment, suggesting that timber harvesting decreased population-level productivity by reducing suitable habitat; marten generally did not maintain ranges that compromised individual performance.

### PREY SELECTION BY HARBOR SEALS IN THE GULF OF MAINE SINK GILLNET FISHERY

*Investigator:* A. S. Williams

*Advisors:* J. R. Gilbert, Chairperson  
F. A. Servello  
R. S. Steneck

*Cooperators/  
Project* National Marine Fisheries Service,  
BRD, USGS

*Support:* University of Maine -  
Department of Wildlife Ecology

*Objectives:*

- 1) Evaluate the diets of harbor seals caught in fishing nets.
- 2) Determine seasonal and spatial prey abundance and availability.
- 3) Estimate prey selection by harbor seals on commercial fish species.

*SCOPE:* The harbor seal (*Phoca vitulina*) is often accused of having negative effects on fishery yields in the northwestern Atlantic Ocean by preying on fish, damaging fish quality and tearing nets. Populations of seals in the Gulf of Maine have increased over the past twenty years. Potential loss of commercial fish to seals is a growing concern in the multispecies groundfish sink gillnet fishery. There is insufficient knowledge of the foraging ecology of seals to evaluate the effects of seal predation on the abundance of commercial fish stocks.

I will quantify the diets of harbor seals that were accidentally killed in gillnets. I will compare the food habits data, spatially and temporally, with quantities of available prey species and prey size.

*PROJECT STATUS:* Sample collection of whole animals and stomachs from seals killed in the commercial sink gillnet fishery has been completed through August 1997. Eighty-six stomachs have been analyzed. The ages of the seals have been estimated by counting the growth layer groups in the cementum of thin, stained sections of canine teeth. A Northeast Seal Working Group has been created to coordinate seal research projects requiring biological samples. Data on abiotic and biotic factors such as water temperature, depth, and prey abundance from the seal collection sites have been obtained and archived in Oracle tables.

**FUTURE PLANS:** Field work, lab analysis, and data archiving have been completed. Thesis completion is anticipated by December 1999.

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## FACTORS AFFECTING NESTING SUCCESS OF THE EASTERN WILD TURKEY IN CONNECTICUT: NEST ATTENTIVENESS, VEGETATIVE COVER, AND LANDSCAPE CHARACTERISTICS

**Investigator:** S. M. Spohr

**Advisors:** F. A. Servello, Co-Chairperson  
D. J. Harrison, Co-Chairperson  
J. R. Longcore  
J. M. Ringo

**Cooperators/  
Project  
Support:** National Wild Turkey Federation -  
Connecticut Chapter  
Wildlife Forever  
University of Maine -  
Department of Wildlife Ecology  
Connecticut Department of Environmental Protection -  
Wildlife Division

**Objectives:**

- 1) Determine if nest success is influenced by attentiveness of hen turkeys.
- 2) Examine the effects of landscape characteristics on success and rates of predation on nests of wild turkeys in eastern Connecticut.
- 3) Determine the relationship between vegetative cover and the fate of turkey nests in eastern Connecticut.

**SCOPE:** In northern and midwestern regions of the U.S., winter mortality has been reported as one of the most important variables affecting eastern wild turkey (*Meleagris gallopavo silvestris*) populations. However, previous studies have concluded that winter mortality may not influence turkey populations in southern New England. Instead, annual population fluctuations of turkeys in New England are thought to result from variable reproductive success. Thus, nest success appears to be the most important demographic variable influencing annual population change of turkeys in this region. High annual variation in nest success is common, but the relative importance of environmental and behavioral factors that may affect nest success is not known. Our objectives are to determine the relative effects of nest attentiveness, cover, weather, and landscape characteristics on nest success of wild turkeys in Connecticut.

**PROJECT STATUS:** Fifty-nine wild turkey hens were captured and equipped with radio transmitters in the winters of 1996 and 1997. Hens were monitored daily during the reproductive season to determine timing of incubation and to quantify and identify sources of mortality. A Rustrak recorder was set up near 16 nests to monitor hen activity and attentiveness to her nest. After hatching or abandonment, 48 nests were examined to determine clutch size and hatching success. Vegetative cover was measured in a 10-meter radius around each nest to determine habitat differences between successful and unsuccessful nests. Landscape characteristics (e.g., edge, developed land, agricultural land, patch density) were quantified at several scales using vector-based geographic information systems (ArcInfo and MapInfo) to determine differences between successful and predated nests.

**FUTURE PLANS:** Field work has been completed and data analysis is proceeding. Thesis completion is anticipated in 2000.

## INFLUENCE OF SELECTION HARVESTING ON AMERICAN MARTEN AND THEIR PRIMARY PREY IN NORTHCENTRAL MAINE

**Investigator:** A. K. Fuller

**Advisors:** D. J. Harrison, Chairperson  
W. J. Jakubas  
J. M. Rhymer  
R. S. Seymour

**Cooperators/  
Project Support:** Maine Cooperative Forestry Research Unit  
Maine Department of Inland Fisheries and Wildlife  
Maine Agricultural and Forest Experiment Station

**Objectives:**

- 1) Document stand-scale patterns of habitat selection by marten whose home ranges have been influenced by selection harvesting and compare to patterns of habitat selection of marten in areas without selection harvesting.
- 2) Estimate small mammal and snowshoe hare densities in selectively harvested stands and compare with mature and regenerating forest stands.
- 3) Document and compare overstory, understory, and coarse woody debris characteristics between selectively harvested stands and mature forest stands.

**SCOPE:** Silvicultural practices in northern forests are shifting from a reliance on clearcutting (residual basal area < 6.9 m<sup>2</sup>/ha) to an emphasis on partial harvesting (residual basal area > 6.9 m<sup>2</sup>/ha). For example, partial overstory removal (residual basal area > 6.9 m<sup>2</sup>/ha) composed 94% of the total acreage harvested in Maine during 1997, an increase of 17% since 1990. The influence of selection harvesting on marten (*Martes americana*) habitat selection at the stand scale has been studied little, and the influence of selection harvesting on marten in a landscape matrix where extensive areas of regenerating clearcuts occur is speculative. Thus, we investigated the responses of marten at the sub-stand, stand-, and landscape-scales to predict the influences of large-scale selection harvesting on marten habitat quality, and evaluated current forest management objectives for marten.

Choice of forest stands by marten is also associated with food abundance and availability. We compared small mammal and snowshoe hare (*Lepus americanus*) densities in selectively harvested stands to mature and regenerating forest stands, and related to habitat use by marten.

**PROJECT STATUS:** We had 21 marten (13 M, 8 F) whose home ranges comprised > 10% selectively harvested stands. We collected 2,070 independent telemetry locations, obtained year-round from both ground and aircraft. Small mammals were live-trapped in 1997 and 1998 on 20 trap grids in 5 forest types (n = 7 partial harvest, 7 mature mixedwood, 2 mature hardwood, 2 mature softwood, and 2 regenerating clearcut). Small mammal trapping resulted in 1,326 captures of 601 individuals (63% red-backed voles (*Clethrionomys gapperi*), 24% deer mice (*Peromyscus maniculatus*), 13% shrews (*Sorex cinereus* and *Blarina brevicauda*)) during 7,595 trap-nights in 1997 and 758 captures of 400 individuals (49% red-backed voles, 32% shrews, 15% deer mice, and 4% jumping mice (*Napaeozapus insignis*)) during 7,589 trap-nights in 1998. Snowshoe hare pellets were counted in Spring of 1998 on 5 m x 30 cm transects on the innermost 12 trapping stations within each grid used to census small mammals. Within-stand habitat features were measured at the trapping

grids and were used to build a predictive model for snowshoe hare abundance. During a companion study in 1995, microhabitat features were measured on the trap grids for small mammals located in mature ( $n = 11$ ) and regenerating ( $n = 2$ ) forest stands, and during 1997 the microsite characteristics were sampled at 112 locations distributed across 7 selectively harvested grids.

**FUTURE PLANS:** Project completion is scheduled for December 1999.

## POPULATION ECOLOGY OF BLACK TERNS IN MAINE

**Investigator:** F. A. Servello

**Cooperators/  
Project  
Support:** University of Maine -  
Department of Wildlife Ecology  
Maine Department of Inland Fisheries and Wildlife  
U.S. Fish and Wildlife Service -  
Northern Maine National Wildlife Refuge Complex  
Maine Outdoor Heritage Fund

**Objectives:**

- 1) Determine the annual local survival of breeding adult black terns (*Chlidonias niger*) in Maine and site fidelity to individual 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 ultimately conduct a population viability analysis of the Maine population to evaluate extinction risk.

**SCOPE:** The black tern 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 75-100 breeding pairs distributed among 6-8 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. This project will provide information needed to assess the vulnerability of the existing population to extinction and its potential for future population growth.

**PROJECT STATUS:** The third year of field work has been completed. We have banded a total of 105 adults terns with USFWS metal bands and color bands for resighting individuals and have banded 101 nestlings with USFWS bands in the 6 major colonies. Nest success has been measured in 6 colonies and fledging success has been measured in 2-3 colonies each year. Development of a black tern population model for sensitivity analyses of population parameters is in progress.

**FUTURE PLANS:** Field work on these objectives is planned for years 2000-2003.

## THE EFFECTS OF FOOD LIMITATION AND ENVIRONMENTAL FACTORS ON BLACK TERN PRODUCTIVITY

*Investigator:* A. T. Gilbert

*Advisors:* F. A. Servello, Chairperson  
J. M. Rhymer  
A. J. K. Calhoun  
M. A. McCollough

*Cooperators/  
Project  
Support:* University of Maine -  
Department of Wildlife Ecology  
Maine Department of Inland Fisheries and Wildlife  
Maine Outdoor Heritage Fund  
U.S. Fish and Wildlife Service -  
Northern Maine Natural Wildlife Refuge Complex

*Objectives:*

- 1) Determine effects of long-term weather patterns on Black Tern nest loss and insect abundance in tern colonies in Maine.
- 2) Determine relationships between Black Tern chick growth and food provisioning.
  - a) determine if Black Tern productivity is food limited in Maine.
  - b) develop a less invasive method for monitoring Black Tern chick growth and survival.
- 3) Identify wetlands suitable for Black Tern nesting in Maine.

**SCOPE:** Black Terns, a state-listed endangered species in Maine, breed at 7-9 inland emergent wetlands. Limited or poor quality habitat in Maine may contribute to reduced productivity and survival, ultimately leading to its rare status in the state. Reproductive success in Black Terns may be limited by adverse weather, food-limited growth of chicks, the lack of suitable breeding habitat, and predation. I am addressing the first three as part of a long-term population study of Black Terns in Maine. This information will be used to develop conservation measures to enhance productivity of Black Terns in Maine.

**PROJECT STATUS:** The first year of fieldwork has been completed. Seven nests were enclosed at a single colony, and weight and structural growth of chicks were measured daily for a period of one week. Food provisioning observations of enclosed broods were made concurrently from tower blinds. Videography was used to determine the accuracy of food habits observations. Food habits data also was collected from observation towers in two additional colonies. Daily air and water temperature and water level data were measured at these colonies. Water levels were measured at two other colonies and local rainfall was measured from a central location. Precipitation and water level data will be used for analysis of nest loss due to flooding at these 4 colonies. Insect abundance was monitored at one colony using aerial sticky traps. Analysis of first year data has begun. A GIS-based habitat assessment of the availability of tern habitat in Maine using National Wetlands Inventory maps of Maine is in progress.

**FUTURE PLANS:** Preliminary data analysis and habitat identification will be completed. Analyses of long-term rainfall and temperature patterns in Maine will be conducted using existing databases to evaluate effects on tern productivity and food abundance. A second year of fieldwork will be conducted in 2000.

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## SPATIAL AND TEMPORAL PATTERNS OF HAUL-OUT USE BY BREEDING HARBOR SEALS

- Investigator:* N. Guldager
- Advisors:* J. R. Gilbert, Chairperson  
W. B. Krohn  
J. T. Kelley
- Cooperators/  
Project  
Support:* National Marine Fisheries Service  
Maine Forest and Agriculture Experiment Station  
University of Maine-  
Department of Wildlife Ecology
- Objectives:*
- 1) Evaluate spatial and temporal patterns of haul-out use by breeding harbor seals.
  - 2) Examine the effects of time of year, tidal phase, time of day, and weather conditions on haul-out use by breeding harbor seals.

**SCOPE:** The harbor seal (*Phoca vitulina*) is the most common Pinniped that is found off the Maine coast. In late May and early June, harbor seals come inshore to have their pups on the many islands and intertidal ledges that scatter the coastline. Easily accessible, undisturbed rocky ledges of gentle slope and vegetative covering are often used. Researchers have found in various different geographic regions that annual timing of pupping, tidal phase, time of day and weather conditions have an effect on the proportion of seals hauled out. It is important to understand the effect of these covariables on haul-out numbers in Maine in order to obtain a precise population estimate from aerial surveys.

Aerial surveys have been conducted for the Maine coast during the pupping period in 1981, 1982, 1986, 1993, and 1997, during which all hauled-out seals and pups were counted within two hours on either side of low tide. These counts represent a minimum population estimate. The average annual rate of increase in the counts since 1981 has been 4.2 percent. Minimum number of seals observed in June 1981 was 10,543 and 30,990 in June of 1997. Estimated pup production has increased from 676 individuals in June 1981 to 5,359 individuals in June of 1997.

I will examine spatial and temporal patterns of haul-out use by mother/pup pairs during the pupping period and potential environmental factors affecting use in Penobscot and Blue Hill Bays, Maine. I will also document breeding phenology and investigate the effects of tide, time of day and weather conditions on haul-out numbers in a smaller area of Penobscot Bay (Muscle Ridges) during the pupping period.

**PROJECT STATUS:** Aerial surveys were completed in June 1997. The five years of census data have been geo-referenced using a Geographic Information System (GIS). Environmental variables were calculated by use of a GIS as of October 1998. Field data on haul-out numbers, tidal phase, time of day and weather conditions were collected in the Muscle Ridges in May and June of 1998. Data were analyzed during 1999.

**FUTURE PLANS:** A thesis is being written. Project completion is scheduled for December 1999.

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## ECOLOGY AND CONSERVATION OF THE WOOD TURTLE (*Clemmys insculpta*) IN MAINE

- Investigator:* B. W. Compton
- Advisors:* J. M. Rhymer, Chairperson  
M. A. McCollough  
D. J. Harrison  
A. D. Huryn
- Cooperators/  
Project  
Support:* Maine Department of Inland Fisheries and Wildlife  
Central Maine Power  
U.S. Fish & Wildlife Service -  
Partnerships for Wildlife  
Maine Outdoor Heritage Fund  
McIntire-Stennis  
University of Maine -  
Department of Wildlife Ecology
- Objectives:*
- 1) Build and test a thermal model of nesting success (thermal regime is a hypothesized major limiting factor on nest survival in western Maine and a possible determinant of northern range limit). Predict northern range limit from thermal nesting success, and compare this with known distribution.
  - 2) Model habitat selection at watershed and microhabitat scales.
  - 3) Determine whether water releases from a dam upriver from the study site are reducing nesting success.
  - 4) Test effectiveness of state wetland protection regulations at protecting wood turtle habitat.
  - 5) Build a demographic model to estimate the effects of anthropogenic adult mortality on populations.

**SCOPE:** Wood turtle populations appear to be declining throughout their range. The wood turtle is listed in 13 of the 17 states in its range and is protected in the four Canadian provinces where it occurs. Wood turtle populations are threatened by habitat destruction and fragmentation, high populations of nest predators such as raccoons and skunks, road kills, and collection of adults for the pet trade. The wood turtle shares with most turtle species a life history strategy of low nest and juvenile survival, late maturity, and high adult survival that leaves it vulnerable to increases in adult mortality. The slow growth potential of turtle populations (population doubling times have been estimated in the thousands of years for some species) suggests that a strategy for conserving turtles must be especially proactive.

Wood turtle habitat use and population dynamics have not been well-studied, especially in New England. Preliminary work has shown that western Maine wood turtles use habitat differently than do other populations that have been studied, and that constraints on nesting success differ. Wood turtles in the study population tend to move much greater distances and to use areas such as bogs and fens where they are not found elsewhere in their range. Nesting success appears to be limited by the short, cool summers of western Maine, rather than by nest predators.

This project continues a radio-telemetry study of a population of wood turtles in western Maine initiated by Central Maine Power in 1994. Our goal is to obtain information that will be useful for conservation of wood turtles in Maine. We modeled egg development based upon nest temperatures, and tested this model with data collected from nests in the field as well in the laboratory. Habitat use was modeled at two spatial scales, based upon habitat sampling at turtle locations and random locations.

**PROJECT STATUS:** We tracked 36 radio-tagged wood turtles from June through August, 1997, and 37 from May through September, 1998. In 1997, we found and monitored 11 nests; none of these hatched, apparently because of low temperatures. Of the 15 nests found in 1998, 4 nests produced 23 hatchlings in the field, and 7 nests produced 41 hatchlings in incubators in the laboratory. We collected both field and laboratory temperature data for all nests. A model of nesting success across the range supports the hypothesis that the effect of short, cool summers on incubation limits the northern range of wood turtles.

We located 36 animals 1-2 times per week in 1997 (for a total of 962 locations), and 37 animals 1-3 times weekly in 1998 (1,298 locations). We sampled habitat at each location in 1997. In 1998, more detailed habitat data were sampled at each turtle location, as well as at random locations. Transmitters were removed from animals in May, 1999. Habitat modeling suggests that wood turtles select activity areas close to streams and rivers with moderate forest cover and little open water. Within activity areas, they select nonforested locations close to open water with low canopy cover.

Water releases from an upstream dam destroy about 25% of nests annually. Current land use ordinances do not adequately protect riparian habitat used by wood turtles. Demographic modeling suggests that removal of only a few adults annually from a stable population could lead to extirpation in a few decades. These analyses suggest that wood turtles are particularly vulnerable near their northern range limits. Efforts to protect riparian habitat, minimize flooding and other disturbances at nest sites, and to protect adults from collection as pets will be necessary to conserve wood turtles in Maine.

A thesis has been completed and submitted to the advisory committee.

**FUTURE PLANS:** A thesis will be defended in November, 1999. Three manuscripts will be submitted to peer-reviewed journals.

## BAT AND SMALL MAMMAL HABITAT RELATIONSHIPS IN THE INDUSTRIAL FORESTS OF NORTHERN MAINE

*Investigator:* S. C. Billig

*Advisors:* F. A. Servello, Chairperson  
D. J. Harrison  
W. E. Glanz  
J. M. Hagan

*Cooperators/  
Project  
Support:* Manomet Center for Conservation Sciences  
College of Natural Sciences, Forestry, and Agriculture -  
Department of Wildlife Ecology  
Plum Creek Timber Company

*Objectives:*

- 1) Determine effects of forest microhabitat characteristics on small mammal abundance and occurrence.
- 2) Determine if separation zones between clearcuts retain pre-harvest species assemblages of small mammals.
- 3) Determine effects of forest stand age on bat flight and feeding activity.
- 4) Identify bat species occurring in the western Maine study area.
- 5) Determine the effects of landscape-level features on bat flight and feeding activity.

**SCOPE:** A difficulty in designing forested landscapes that maintain existing biological diversity in northern Maine is our poor understanding of how many species relate to managed forest habitats. The goal of this project

is to better understand the relationships of small mammals, including bats, to habitat features in industrial forestlands of northern Maine. It has been hypothesized that small mammal abundance is related to coarse woody debris, but there is a lack of research demonstrating this hypothesis. There is also little research on the value of separation zones for retaining small mammal species in harvested landscapes. I will examine microhabitat factors in relation to small mammal abundance and occurrence, with special emphasis on the importance of coarse woody debris and determine if separation zones, clearcuts, and continuous forest habitats maintain different small mammal species assemblages.

Overall, little is known about bats in northern New England except from research in New Hampshire which indicates that bats need mature forests and corridors, such as roads, for travel pathways. I will identify bat species occurring in the study site in western Maine, examine bat activity in relation to stand age, and determine effects of landscape-level features on bat activity using GIS.

This project is being conducted in conjunction with the Shifting Mosaic Project, a forest research and management project of the Manomet Center for Conservation Sciences.

*PROJECT STATUS:* First year fieldwork was completed in Summer 1999. Small mammals were trapped on 30 sites, 15 in young mixed-wood stands and 15 in mid-aged mixed-wood sites. I will use microhabitat and forest structure data collected on these sites by Shifting Mosaic personnel. Small mammals were trapped in separation zones (n = 10), clearcuts (n = 10), and continuous forest (n = 10), to evaluate species assemblages. Bat activity was surveyed using broadband ultrasonic bat detectors. Bat activity data were collected from 35 sites: clearcuts (n = 6), regeneration stands (n = 6), young stands (n = 6), mid-age stands (n = 6), and mature stands (n = 6), all stands were of the mixed-wood cover type.

*FUTURE PLANS:* A second year of fieldwork will be conducted in summer 1999. Preliminary data analyses are in progress.

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

**SCIENTIFIC PUBLICATIONS**

- ALLEN, A.P., T.R. WHITTIER, P.R. KAUFMANN, D.P. LARSEN, R.J. O'CONNOR, R.M. HUGHES, R.S. STEMBERGER, S.S., DIXIT, R.O. BRINKHURST, A.T. HERLIHY, and S.G. PAULSEN. 1999. Concordance of taxonomic richness patterns across multiple assemblages in lakes of the northeastern United States. Canadian Journal of Fisheries and Aquatic Sciences 56:739-767.
- BANK, M.S., and W.L. FRANKLIN. 1998. Puma (*Puma concolor patagonica*) feeding observations and attacks on guanacos (*Lama guanicoe*). Mammalia 62(4):599-605.
- BANK, M.S., R.K. LAURENCE, W.L. FRANKLIN, and I.M. ORTEGA. 1999. Importance of wetland habitats to people and wildlife in the grazing agroecosystem of southern Chile. Vida Silvestre Neotropical 7(1):43-45 (special wetlands edition).
- BOONE, R.B., and W.B. KROHN. 1999. Modeling the occurrence of bird species: are the errors predictable? Ecological Applications 9(3):835-848.
- CHAPIN, T.G., D.J. HARRISON, and D.D. KATNIK. 1998. Influence of landscape pattern on habitat use by American marten in an industrial forest. Conservation Biology 12:1327-1337.
- deMAYNADIER, P.G., and M.L. HUNTER, JR. 1999. Forest canopy closure and juvenile emigration by pool-breeding amphibians in Maine. Journal of Wildlife Management 63:441-450.
- DIBBLE, A.C., M.L. HUNTER, JR., and J.C. BRISSETTE. 1999. Putting community data to work: understory plants indicate red spruce regeneration habitat. Forest Ecology and Management 114(2-3): 275-291.
- ENGSTROM, R.T., S. GILBERT, M.L. HUNTER, JR., D. MERRIWETHER, G.J. NOWACKI, and P. SPENCER. 1999. Practical applications of disturbance ecology to natural resources management. Pages 313-329 in Johnson, N.C., A.J. Malk, W.T. Sexton, and R. Szaro (eds.). *Ecological Stewardship: A Common Reference for Ecosystem Management*. Elsevier Science Ltd., Oxford.
- FROST, H.C., E.C. YORK, W.B. KROHN, K.D. ELowe, T.A. DECKER, S.M. POWELL, and T.K. FULLER. 1999. An evaluation of two parturition indices in fishers. Wildlife Society Bulletin 27(1):221-230.
- FULLER, A.K., H. J. LACHOWSKI, and D. J. HARRISON. 1999. Responses of mammals at two trophic levels to stand-scale forest harvesting in Maine. Page 100 in Program and Abstracts, North American Forest Ecology Workshop, University of Maine, Orono.
- GILBERT, J.R. 1999. Review of previous Pacific walrus surveys to develop improved survey designs. Pages 75-84 in G.W. Garner, S.C. Amstrup, J.L. Laake, B.F.J. Manley, L.L. McDonald, and D.G. Robertson. *Marine Mammal Survey and Assessment Methods*, Balkema, Rotterdam, Holland. 287pp.
- HARRISON, D.J., and T.G. CHAPIN. 1998. Extent and connectivity of habitat for wolves in eastern North America. Wildlife Society Bulletin 26(4):767-775.

- HARRISON, D. J. 1999. Responses of wide ranging carnivores to forest characteristics at multiple spatial scales. Page 117 in Program and Abstracts, North American Forest Ecology Workshop, University of Maine, Orono.
- HERKE, S.W., and J.R. MORING. 1999. "Soft" harness for external attachment of large radio transmitters to northern pike (*Esox lucius*). Fisheries Research 39:305-312.
- HUNTER, M.L., JR. 1999. Maintaining biodiversity in forest ecosystems. Cambridge University Press, Cambridge, England. 698pp.
- HUNTER, M.L., JR. 1999. Biological diversity. Pages 3-21 in Hunter, M.L. (ed.) Maintaining biodiversity in forest ecosystems. Cambridge University Press, Cambridge, England. 698pp.
- HUNTER, M.L., JR., A. CALHOUN, and M. McCOLLOUGH (eds.). 1999. Maine amphibians and reptiles. University of Maine Press, Orono, ME. 252pp.
- JONES, M.T., J.G. BARTLETT, and D.M. MAGEEAN. 1999. Visualizing the hierarchical organization of a spatially explicit socioeconomic system. International Journal of Systems Research and Informational Systems 8:137-149.
- KROHN, W.B., R.B. BOONE, and S.L. PAINTON. 1999. Quantitative delineation and characterization of hierarchical biophysical regions of Maine. Northeastern Naturalist 6(2):139-164.
- LONG, R.A., A.F. O'CONNELL, and D.J. HARRISON. 1998. Mortality and survival of white-tailed deer *Odocoileus virginianus* fawns on a North Atlantic coastal island. Wildlife Biology 4:237-247.
- LONGCORE, J., D. MCAULEY, G. HEPP, and J. RHYMER. 1999. American Black Duck. In The Birds of North America (A. Poole, ed.). Philadelphia: The Academy of Natural Sciences, Washington, DC; The American Ornithologists' Union. 97pp.
- O'CONNOR, R.J. 1999. Review of: W.J.M. Hagermeijer, and M.J. Blair (eds.). European Atlas of Breeding Birds. London: Academic Press (T & A D Poyser). Wilson Bulletin 111:154-156.
- O'CONNOR, R.J. 1999. Review of: R.E. Ricklefs, and J.M. Starck (eds.). Avian Growth and Development. New York: Oxford University Press. Condor 101:722-726.
- PERKINS, D.W., T.P. HODGMAN, R.B. OWEN, JR., and J.B. DIMOND. 1998. Long-term persistence of DDT in shrews, Soricidae, from Maine. Canadian Field-Naturalist 112(3):393-399.
- REMLEY, M.O., and J.M. RHYMER. 1999. Wood Turtle (*Clemmys insculpta*). Pages 138-143 in M.L. Hunter, Jr., A.J.K. Calhoun and M. McCollough (eds.). Maine Amphibians and Reptiles. University of Maine Press, Orono, ME. 252pp.
- SEYMOUR, R., and M.L. HUNTER, JR. 1999. Principles of ecological forestry. Pages 22-61 in M.L. Hunter (ed.). Maintaining biodiversity in forest ecosystems. Cambridge University Press, Cambridge, England. 698pp.
- VICKERY, P.D., M.L. HUNTER, JR., and J.V. WELLS. 1999. Effects of fire and herbicide treatment on habitat selection in grassland birds in southern Maine. Studies in Avian Biology 19:149-159.

VREELAND, J.K., F.A. SERVELLO, and B. GRIFFITH. 1998. Effects of conifer release with glyphosate on summer forage abundance for deer in Maine. Canadian Journal of Forest Research 28:1574-1578.

YOUNG, H.G. and J.M. RHYMER. 1998. Meller's duck: a threatened species receives recognition at last. Biodiversity and Conservation 7:1313-1323.

#### TECHNICAL AND SEMI-TECHNICAL PUBLICATIONS

BANK, M.S. 1998. What do the national science education standards of the National Research Council tell us about teaching science as inquiry? *In Teaching Science as Inquiry: national standards inform us.* Herman G. Weller (ed.) Science Teaching Resource Center Workshop Report, University of Maine, Orono. 31pp.

BOONE, R.B., and W.B. KROHN. 1998a. Maine gap analysis vertebrate data - Part I: distribution, habitat relations, and status of amphibians, reptiles, and mammals in Maine. Part of final contract report to USGS Biological Resources Division, Gap Analysis Program, Moscow, ID. 175pp. plus appendices.

BOONE, R.B., and W.B. KROHN. 1998b. Maine gap analysis vertebrate data - Part II: distribution, habitat relations, and status of breeding birds in Maine. Part of final contract report to USGS Biological Resources Division, Gap Analysis Program, Moscow, ID. 367pp. plus appendices.

BOONE, R.B., and W.B. KROHN. 1999. A technique for representing diminishing habitat occupation: feathering predicted species distributions near range limits in Maine. Pages 41-43 *in* E. S. Brackney and M. D. Jennings (eds.). Gap Analysis - Bulletin No. 7, Gap Analysis Program, U.S. Geological Survey - Biological Resources Division, Moscow, Idaho. 74pp.

BOWES, K., J. LÊ, and J.R. MORING. 1999. Fishes and other aquatic resources of Acadia National Park: a synopsis of published and unpublished information. National Park Service, Technical Report NPS/B50-RNR/NRTR/00-6. 120pp.

CHILELLI, M.E., J.R. GILBERT, B. GRIFFITH, and A.F. O'CONNELL. 1998. Analysis of factors affecting population viability and reintroduction attempts of native mammals in Acadia National Park. Tech. Report NPS/NESO-RNR/NPTR/98-06. 95pp.

deMAYNADIER, P., and M. McCOLLOUGH. 1998. Keeping track of winged jewels: the Maine Damselfly and Dragonfly Survey. Maine Entomological Newsletter No. 4, Winter. 2pp.

deMAYNADIER, P., and T. HODGMAN. 1998. A survey of rare, threatened, and endangered fauna in Maine: central interior, midcoast, and Penobscot Bay regions. Report submitted to the Maine Department of Inland Fisheries and Wildlife. 47pp + appendices.

GILBERT, J.R., and N. GULDAGER. 1998. Status of harbor and gray seal populations in northern New England. Report to National Marine Fisheries Service, NEFSC, Woods Hole, Mass. Contract 14-16-009-1557. 13pp.

HARRISON, D.J. and D.C. PAYER. 1999. Effects of timber harvesting and trapping on population characteristics, habitat selection, and area occupancy by American martens. Pages 28-32 *in* 1998 Annual Report and Research Summary of the Cooperative Forestry Research Unit, CFRU Information Report #43 and Maine Agricultural and Forest Experiment Station Miscellaneous Report #411, Orono, Maine.

- HARRISON, D.J. and A.K. FULLER. 1999. Influence of partial harvesting on American marten and their primary prey. Page 27 in 1998 Annual Report and Research Summary of the Cooperative Forestry Research Unit, CFRU Information Report #43 and Maine Agricultural and Forest Experiment Station Miscellaneous Report #411, Orono, Maine.
- HARRISON, D.J. and D.C. PAYER. 1998. Managing harvested areas to maintain habitat use by marten. Maine Cooperative Forestry Research Unit Newsletter, November, Orono, Maine.
- HIGGINS, J., A.F. O'CONNELL, JR., and F.A. SERVELLO. 1998. Survey of flying squirrels and their associations with vegetative communities on Mount Desert Island (Acadia National Park), Maine. Final report to the National Park Service. 18pp.
- HUNTER, M.L. 1999. Should a land trust cut its forest? Land Trust News 4(1):3-4.
- JOHNSON, C.M., and W.B. KROHN. 1998. Coastal Maine: island habitats and fauna. Pages 207-208, 218 in M.J. Mac, P.A. Opler, C.E. Puckett Haecker, and P.D. Doran (eds.). Status and trends of the nation's biological resources. Vol. 1. USDI U.S. Geological Survey, Reston, Virginia. 436pp.
- KROHN, W.B., R.B. BOONE, S.A. SADER, J.A. HEPINSTALL, S.M. SCHAEFER, and S.L. PAINTON. 1998. Maine Gap Analysis - a geographic analysis of biodiversity. Final contract report to USGS Biological Resources Division, Gap Analysis Program, Moscow, ID. 123pp. plus appendices.
- LAPLANT, S., and J.M. RHYMER. 1999. Field survey methods and results for Wood Turtles (*Clemmys insculpta*) in Maine, 1998-1999. Report to Maine Department of Inland Fisheries and Wildlife, Endangered Species Group. 8pp.
- O'CONNOR, R.J. 1999. Stellar biodiversity. Trends in Ecology and Evolution 14(3):124.
- PAYER, D.C., and D.J. HARRISON. 1999. Effects of forest structure on spatial distribution of American marten. NCASI Technical Bulletin No. 787, National Council of the Paper Industry for Air and Stream Improvement, Research Triangle Park, North Carolina. 48pp.

#### THESES AND DISSERTATIONS

- DANIELS, L.R. 1999. Diet of American eels (*Anguilla rostrata* LeSueur) in five freshwater lakes, Maine, U.S.A. M.S. Thesis, University of Maine, Orono. 60pp.
- DiMAURO, D. 1999. Reproduction of amphibians in natural and anthropogenic temporary pools in managed forests. M.S. Thesis, University of Maine, Orono. 76pp.
- PAYER, D. 1999. Influences of timber harvesting and trapping on habitat selection and demographic characteristics of marten. Ph.D. Dissertation, University of Maine, Orono. 297pp.

#### PROFESSIONAL TALKS PRESENTED

- ALLEN, A.P., and R.J. O'CONNOR. "Interacting effects of land use and other factors on regional bird distributions." International Association of Landscape Ecology Congress, Snowmass, CO, August 2, 1999.

- BANK, M.S., and W.L. FRANKLIN. "Home range characteristics of guanaco male groups in southern Chile: conservation implications." Poster presented at the 79<sup>th</sup> annual meeting of the American Society of Mammalogists, University of Washington, Seattle, WA, June 19-24, 1999.
- BARTLETT, J.G., R.J. O'CONNOR, D.M. MAGEEAN, and S.G. McNULTY. "Potential impacts of climate change and residential expansion on water resources." Ecological Society of America, Spokane, WA, August 8, 1999.
- CALHOUN, A. M.L. HUNTER, and M. McCOLLOUGH. "Developing partnerships for amphibian and reptile conservation in Maine." Society for Conservation Biology, College Park, MD, June 19, 1999.
- COMPTON, B.W., J.M. RHYMER, and M. McCOLLOUGH. "Thermal limits on nesting success of the wood turtle (*Clemmys insculpta*) in western Maine." Presentation to Northeast Wildlife Graduate Student Conference, Orono, ME, February 20, 1999.
- COMPTON, B.W., J.M. RHYMER, and M. McCOLLOUGH. "Thermal limits on nesting success of the wood turtle (*Clemmys insculpta*)." Invited speaker, Clemmys Symposium, Society for the Study of Amphibians and Reptiles, 42nd Annual Meeting, State College, PA, June 30, 1999.
- DANIELS, L.R. "Food and feeding by American eels in freshwater." Paper presented at the American Eel Workshop, Bangor, ME, April 5, 1999.
- FULLER, A.K., and D.J. HARRISON. "Use of partially harvested stands by American marten: a preliminary analysis." Poster presentation at Northeast Graduate Wildlife Student Conference, University of Maine, Orono, ME, February 21, 1999.
- FULLER, A.K., and D.J. HARRISON. "Use of partially harvested stands by American marten: a preliminary analysis." Poster presentation at Graduate Student Research Exposition, University of Maine, Orono, ME, March 19, 1999.
- FULLER, A.K., H.J. LACHOWSKI, and D.J. HARRISON. "Responses of mammals at two trophic levels to stand-scale forest harvesting in Maine." North American Forest Ecology Workshop, University of Maine, Orono, June 28, 1999.
- FULLER, A.K., and D.J. HARRISON. "Influence of partial harvests on American marten habitat selection in Maine." The Wildlife Society 6<sup>th</sup> Annual Conference, Austin, TX, September 10, 1999.
- GALLAGHER, M. "An alternative anesthetic for American eels." Paper presented at the American Eel Workshop, Bangor, ME, April 5, 1999.
- GALLAGHER, M., and J.R. MORING. "An experimental test of Eugenol as an alternative anesthetic for American eel (*Anguilla rostrata*)." Paper presented at the Northeast Fish and Wildlife Conference, Manchester, NH, April 13, 1999.
- HARRISON, D.J. "Influence of dispersal on social ecology of coyotes: comparison of a mainland and island population." The Wildlife Society 6<sup>th</sup> Annual Conference, Austin, TX, September 11, 1999.
- HARRISON, D.J. "Responses of wide ranging carnivores to forest characteristics at multiple spatial scales." North American Forest Ecology Workshop, University of Maine, Orono, ME, June 28, 1999.

- HARRISON, D.J. Session summary: "Stand- and landscape-scale responses of wildlife to forest practices." North American Forest Ecology Workshop, University of Maine, Orono, ME, June 30, 1999.
- HARRISON, D.J. "Habitat associations of marten in Maine: responses to forestry and trapping." Invited presentation at Pine Marten Symposium, Corner Brook, Newfoundland, January 27, 1999.
- HARRISON, D.J. "Using carnivores as a model for landscape-scale forest planning." Invited paper at Maine Forest Biodiversity Conference, Orono, ME, November 19, 1998.
- HARRISON, D.J. 1998. "A summary from 10 years of marten research with a look to the future." Invited seminar presented to Resource Assessment Staff, Maine Department of Inland Fisheries and Wildlife, Bangor, November 19, 1998.
- HARTLEY, M. "Effects of selective silviculture on avian community composition: an experimental approach." Wilson Ornithological Society annual meeting, Colby College, Waterville, ME, June 12, 1999.
- HARTLEY, M. "Effects of ecological forestry on avian community composition: an experimental approach." Society for Conservation Biology annual meeting, College Park, MD, June 18, 1999.
- HARTLEY, M. "Rationale and strategies for conserving biodiversity in plantation forests." Second annual North American Forest Ecology Workshop, University of Maine, Orono, ME, June 27, 1999.
- HARTLEY, M. "Effects of habitat disturbances on site-fidelity of the Ovenbird and Hermit Thrush." American Ornithologists Union Annual Meeting, Ithaca, NY, August 1999.
- HARTLEY, M. "Effects of partial cutting on songbird communities: an experimental approach." The Wildlife Society Annual Meeting, Austin, TX, September 1999.
- HAYES, L., and R.J. O'CONNOR. "The continental distribution of habitat-sensitivity in birds." Annual meeting of the Society for Conservation Biology, University of Maryland, College Park, MD, June 18, 1999.
- HEPINSTALL, J.A. "Development and testing of a vegetation and land cover map of Maine." Invited slide presentation and hands-on remote sensing documentation to Maine GIS User Group meeting, Bangor, ME, May 19, 1999.
- HOFFMAN, T., and J.R. MORING. "Food habits of splake in the presence and absence of landlocked salmon: assessment of potential competition." Paper presented at the Northeast Fish and Wildlife Conference, Manchester, NH, April 13, 1999.
- HUNTER, M.L., JR. Chaired the session entitled Basic Concepts of Biodiversity Conservation at the Biodiversity in Maine Conference, University of Maine, Orono, ME, November 20, 1998.
- HUNTER, M.L., JR. "What is biodiversity and why is it important?" Paper presented at the Biodiversity in Maine Conference, University of Maine, ME, Orono, November 20, 1998.
- HUNTER, M.L., JR. "Natural ecosystem processes as models for managing natural resources." University of Missouri-St. Louis, MO, May 4, 1999.
- HUNTER, M.L., JR. "Rocks, water, energy and the diversity of life." Plenary speaker at the National Gap Conference, Duluth, MN, August 3, 1999.

- HUNTER, M.L., JR. "Wildlife conservation in the northern forest." U.S. Fish and Wildlife Service Ecosystem Team, Orrington, ME, September 17, 1999.
- KROHN, W.B. "An overview of terrestrial vertebrate biodiversity in Maine." Invited slide presentation to the Maine Forest Biodiversity Conference, Orono, ME, November 20, 1998.
- KROHN, W.B., and J.A. HEPINSTALL. "An introduction to remote sensing and GIS for wildlife biologists." Invited slide presentation to the Maine Chapter of The Wildlife Society, Brewer, ME, April 16, 1999.
- KROHN, W.B., R.B. BOONE, and J.A. HEPINSTALL. "An evaluation of conservation thresholds used to define protected and unprotected vertebrates in Gap Analyses." Slide presentation at the 9<sup>th</sup> Annual National GAP Meeting, Duluth, MN, August 4, 1999.
- LE, J., and J.R. MORING. "Movements of brook trout (*Salvelinus fontinalis*) on Hunter's Brook, Acadia National Park, Maine." Paper presented at the Northeast Fish and Wildlife Conference, Manchester, NH, April 13, 1999.
- LEAMAN, N. "Mercury concentrations in Maine eels." Paper presented at the American Eel Workshop, Bangor, ME, April 5, 1999.
- MAGEEAN, D.M., J.G. BARTLETT, and R.J. O'CONNOR. "Residential expansion as a continental threat to U.S. coastal ecosystems." Population Association of America annual meeting, New York, NY, March 23-25, 1999.
- MAGEEAN, D.M., J.G. BARTLETT, and R.J. O'CONNOR. "Operationalizing the human dimensions of the environment: a continental case history." Paper presented at the Population and the Environment Session of the annual meeting of the American Sociological Association, Chicago, IL, August 7, 1999.
- MITCHELL, R., B. PALIK, and M.L. HUNTER, JR. Chaired a session at the North America Forest Ecology Workshop, Orono, ME entitled "Natural disturbance regimes as models for silviculture," June 28, 1999.
- MORING, J.R. "Advances in the culture of smelt (*Osmeridae*)." Paper presented at the Northeast Fish and Wildlife Conference, Manchester, NH, April 14, 1999.
- MORING, J.R. "Restoration and rehabilitation of Atlantic salmon in Maine." Paper presented at the Atlantic Salmon Workshop, Syracuse, NY, October 30, 1998.
- O'CONNOR, R.J., J.G. BARTLETT, and D.M. MAGEEAN. "Ecoregions as confluence of ecosystem process, biodiversity, and environmental stressors." British Ecological Society Winter Meeting, University of Leicester, England, January 1999.
- O'CONNOR, R.J., J.G. BARTLETT, and D.M. MAGEEAN. "Congruence of continental productivity, biodiversity and anthropogenic stressors under climate and landscape constraints." The International Association for Landscape Ecology Congress, Snowmass, CO, August 1, 1999.
- O'CONNOR, R.J. Participated in the analysis of data from the Analysis of Species Recovery Plans Project, Santa Barbara, CA, September 17-19, 1999.
- PAINTON, S.L., and W.B. KROHN. "Major conservation lands and the Maine landscape: What should be conserved and where?" Poster presentation at the annual meeting of the Society for Conservation Biology, University of Maryland, College Park, MD, June 17-21, 1999.

- RHYMER, J.M., M.G. FAIN and C. KRAJEWSKI. "Conservation genetics of Sandhill Cranes: subspecies or clinal variation?" Society for the Study of Evolution, University of Wisconsin, Madison, WI, June 1999.
- RHYMER, J.M. 1999. "Genetic markers and ecology." Department of Biology, York University, Toronto, Canada, September 2, 1999.
- SCHAEFER, S.M. "Factors affecting commission error rates of predicted vertebrate occurrences from Gap Analysis." Poster presentation at 1999 Northeast Wildlife Graduate Student Conferences, University of Maine, Orono, ME, February 20-21, 1999.
- SCHAEFER, S.M., and W.B. KROHN. "Accuracy assessment of predicted vertebrate occurrences: are detailed national standards technically feasible?" Slide presentation at the 9<sup>th</sup> Annual National Gap Meeting, Duluth, MN, August 3, 1999.
- WHITE, A., and M.L. HUNTER, JR. "Ecological thresholds and the definition of old growth forest." Eastern Old Growth Conference, Harvard Forest, MA, November 6, 1998.
- WITHAM, J. "Wildlife corridors." Conference on Wildlife Habitat in a Developing Landscape, Auburn, ME, October 24, 1998.
- ZIEL, H., J.M. RHYMER, and D. McAULEY. "Phylogeography and mating system of American Woodcock (*Scolopax minor*)." Northeastern Wildlife Graduate Student Conference, Orono, ME, February 1999.

#### PUBLIC TALKS PRESENTED

- BANK, M.S. "Conservation biology and ecology of the Patagonia puma (*Puma concolor patagonica*)." Presented at the 1998 Wildlife Society Student Chapter Seminar Series, University of Maine, Orono, ME, November 4, 1998.
- COMPTON, B.W. "Turtles: why are they cool; why are they in trouble?" Guest lecture to Wildlife Ecology 200, University of Maine, Orono, ME, December 7, 1998.
- COMPTON, B.W. "Nesting ecology of wood turtles in Maine." Presentation to Maine Audubon Society, March 27, 1999.
- COMPTON, B.W. "Wood turtle research in western Maine." Guest lecture to Biology 591, University of Massachusetts, Amherst, MA, April 1, 1999.
- COMPTON, B.W. "Wood turtle research in western Maine." Presentation to Maine Herpetological Society, Newport, ME, May 15, 1999.
- deMAYNADIER, P. "The ecological mystery of amphibian declines." Maine Audubon Society Fields Pond Nature Center, March 28, 1999.
- deMAYNADIER, P. "The Maine Damselfly and Dragonfly Survey." Stanton Bird Club, Lewiston-Auburn, ME, April 5, 1999.
- FULLER, A.K. "GIS applications in wildlife research." Invited lecture in Wildlife Habitat-Relationships (WLE 450), University of Maine, Orono, April 1999.

- GILBERT, J.R. Presentation on Wildlife to FFA Convention. University of Maine, Orono, ME, May 10, 1999.
- HARRISON, D.J. "Wolves, science, and the future of Maine's forests." Invited lecture to Forum for Undergraduate Science Majors, University of Maine, Orono, ME, December 10, 1998.
- HARTLEY, M. "Ecological forestry: can logging be for the birds?" Maine Spring Bird Festival, Maine Audubon Society, Falmouth, ME, May 21, 1999.
- HEPINSTALL, J.A. "Methods used to develop a statewide vegetation and land cover map." Presented to a group of high school teachers participating in the GAIA Crossroads Project, Brunswick, ME, August 5, 1999.
- HOFFMAN, T. "Preliminary assessment of food habit competition between splake and salmon in Maine." Graduate Colloquium Series, Department of Biological Sciences, University of Maine, Orono, ME, April 8, 1999.
- HUNTER, M.L., JR. "Benchmarks for managing ecosystems. What is natural?" Wildlife Ecology Department, University of Maine, Orono, ME, March 22, 1999.
- HUNTER, M.L., JR. "The conservation role of land trusts." Maine Association of Land Trusts, Orono, ME, April 30, 1999.
- HUNTER, M.L., JR. "Natural ecosystem processes as models for managing natural resources." Talk given at Columbia University, Columbia, MO, May 6, 1999.
- HUNTER, M.L., JR. "Maintaining forest biodiversity." Acadian Institute for Journalism and Natural Resources, Bangor, ME, September 30, 1999.
- KROHN, W.B. "Patterns of biodiversity in Maine: implications for land conservation." Invited slide presentation to Coastal Mountains Land Trust, Rockport, ME, August 11, 1999.
- LÊ, J.B.C. "Movements of brook trout (*Salvelinus fontinalis*) at Hunter's Brook in Acadia National Park." Graduate Colloquium Series, Department of Biological Sciences, University of Maine, Orono, ME, April 8, 1999.
- MORING, J.R. "Fishes of Walker Pond." Talk presented at the annual meeting of the Friends of Walker Pond, Sedgwick, ME, August 26, 1999.
- SERVELO, F.A. "Physiological and anatomical adaptations for feeding in vertebrate wildlife." Invited lecture in WLE 450, Wildlife Habitat Relationships, University of Maine, Orono, ME, January 28, 1999.
- SERVELO, F.A. "Effects of herbicides use in forest management on wildlife habitat." Invited lecture in WLE 450, Wildlife Habitat Relationships, University of Maine, Orono, ME, March 15, 1999.
- STONE, J. "Movement patterns of brook char, *Salvelinus fontinalis*, in lakes of Acadia National Park, Maine." Graduate Colloquium Series, Department of Biological Sciences, University of Maine, Orono, ME, April 9, 1999.

**AWARDS, HONORS, AND APPOINTMENTS**

- FULLER, A.K.** Received Outstanding Graduate Student Award, Department of Wildlife Ecology, University of Maine, Orono, ME, April 1999.
- GILBERT, J.R.** Chaired Atlantic Scientific Review Group meeting for Marine Mammals of National Marine Fisheries Service and US Fish and Wildlife Service, Portland ME, November 13-14, 1998.
- GILBERT, J.R.** Invited participant Marine Mammal Fishery Interactions, Jan 11-14, NMFS, Washington DC, January 11-14, 1999.
- GILBERT, J.R.** Invited Participant, NOAA Strategic Planning Workshop, Washington DC, February 17-18, 1999.
- GILBERT, J.R.** Invited Participant (as NE NAFWUP Representative) Sustainable Forestry on Private Lands (CREES) Washington DC, February 22-23, 1999.
- HARTLEY, M.** Received Howard Mendall Award, Department of Wildlife Ecology, University of Maine, Orono, ME, 1999.
- HARTLEY, M.** Elected President, Maine Chapter of The Wildlife Society, 1999.
- HUNTER, M.L., JR.** Elected President-elect of the Society for Conservation Biology, June 15, 1999.
- LOFTIN, C.S.** Presented a National Wetlands Conservation Award by the U.S. Fish and Wildlife Service for her research on Okefenokee Swamp, Georgia.

