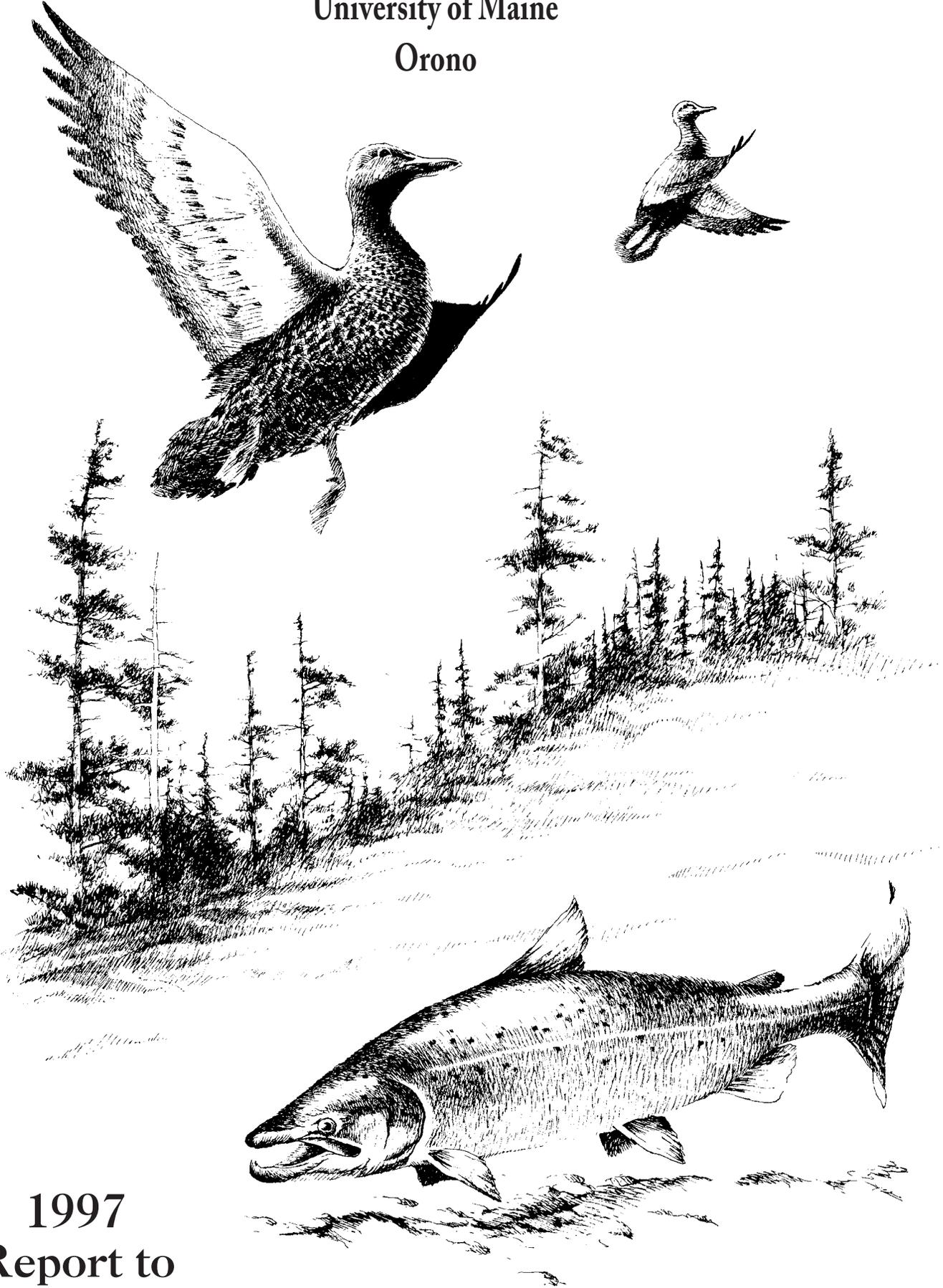


# MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

University of Maine

Orono



1997  
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 1996 - September 1997

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 206 Nutting Hall and is within the Department of Wildlife Ecology, College of Natural Sciences, Forestry, and Agriculture.



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## PERSONNEL AND COOPERATORS

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University of Maine

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Forestry, and Agriculture

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

Christopher Campbell, Acting Chair, Department of Biological Sciences, College of Natural  
Sciences, Forestry, and Agriculture

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Michael W. Tome, Supervisor, Cooperative Research Units

Wildlife Management Institute

Scot J. Williamson, Northeastern Representative

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

Nora Ackley - Unit Administrative Assistant - Wildlife Ecology

Shirley L. Moulton, Secretary - Wildlife Ecology

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 T. 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  
 Daniel J. Harrison, Associate Professor of Wildlife Ecology  
 Malcolm L. Hunter, Jr., Professor of Wildlife Ecology  
 Allan O'Connell, Faculty Associate and Leader, Cooperative National Park Unit, USGS  
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 Jack Witham, Assistant Scientist, Wildlife Ecology  
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 Phillip G. deMaynadier, Research Associate, Wildlife Ecology  
 Randall B. Boone, Research Associate, Wildlife Ecology

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 Matthew Scott, Deputy Commissioner  
 Frederick B. Hurley, Jr., Director, Bureau of Resource Management  
 Kenneth D. Elowe, Director, Wildlife Division  
 Peter M. Bourque, Director, Fisheries and Hatcheries Division  
 George J. Matula, Jr., Supervisor, Wildlife Resource Assessment Group  
 Kendall Warner, Supervisor, Fisheries Research and Management Section

**GRADUATE STUDENTS**

<b>Name</b>	<b>Degree Candidacy</b>	<b>Support</b>
Andrew Allen	M.S.	USEPA
John G. Bartlett	Ph.D.	NBS
Lewis R. Boobar	Ph.D.	USFWS
Randall B. Boone	Ph.D.	MCFWRU, USGS BRD
John R. Burgess	M.S.	NBS
Merrie A. Cartwright	Ph.D.	U of M, MDIFW
Bradley Compton	M.S.	U of M, MDIFW
Lia R. Daniels	M.S.	MDMR
Danielle DiMauro	M.S.	McIntire-Stennis
Sarah E. Dooling	M.S.	McIntire-Stennis
Mustapha El Hamzaoui	Ph.D.	USAID/USDA
Richard T. Finlayson	M.S.	NBS, USFWS, EPA
Carol R. Foss	Ph.D.	USFS, USFWS, SEFP
Angela Fuller	M.S.	MDC
Merry Gallagher	M.S.	U of M, MDIFW
Anne D. Guerry	M.S.	U of M

Nikolina Guldager	M.S.	NBS
Mitschka J. Hartley	Ph.D.	McIntire-Stennis
Catherine M. Johnson	Ph.D.	USGS BRD, U of M
Malcolm T. Jones	Ph.D.	CPM
Lisa A. Joyal	M.S.	U of M
Henry J. Lachowski	M.S.	U of M, McIntire-Stennis
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Karen E. McCracken	Ph.D.	U of M
Craig R. McLaughlin	Ph.D.	Personal Funding
Laura M. Monti	M.S.	HWRF
Dawn L. Nelson	Ph.D.	HWRF
Stephanie L. Painton	M.S.	MCFWRU
David C. Payer	Ph.D.	MDIFW, CFRU, U of M
Anne M. Perillo	M.S.	USFWS, USFS, MDIFW
John G. Poulsen	Ph.D.	Consortium of pesticide manufacturers
Michael W. Powell	M.S.	U of M
Regina M. Purtell	M.W.C.	Personal Funding
Teresa M. Sauer	Ph.D.	U of M
James W. Schneider	Ph.D.	McIntire-Stennis
Sandra M. Schaefer	M.S.	USGS/BRD
Ashley M. Smith	M.S.	NBS
Shelley Spohr	M.S.	NWTF, WF, UM, CDEP
James Stahlnecker	M.S.	MDMR
Marcia L. B. Summers	M.S.	U of M
Tracey E. Walls	M.S.	USDI/NBS
Hannah M. Webber	M.S.	NPS
Heather L. Ziel	M.S.	U of M

### DISSERTATIONS AND THESES COMPLETED THIS PERIOD

<b>Student</b>	<b>Degree Candidacy</b>	<b>Support</b>
Andrew Allen	M.S.	USEPA
Lewis R. Boobar	Ph.D.	USFWS
Randall B. Boone	Ph.D.	MCFWRU, USGS BRD
Merrie A. Cartwright	Ph.D.	U of M, MDIFW
Malcolm T. Jones	Ph.D.	CPM
Lisa A. Joyal	M.S.	U of M
Henry J. Lachowski	M.S.	U of M, McIntire Stennis
Karen E. McCracken	Ph.D.	U of M
John G. Poulsen	Ph.D.	Consortium of pesticide manufacturers
Michael W. Powell	M.S.	U of M

## PERSONNEL NOTES

After completing a Ph.D. in Wildlife Ecology at the University of Maine, **RANDY BOONE** accepted a position as a Research Associate with the Maine Cooperative Fish and Wildlife Research Unit. Dr. Boone is leading the vertebrate analyses for Maine Gap Analysis, scheduled for completion in early spring 1998. **LEWIS BOOBAR** is serving as an aquatic ecologist for the National Park Service. He is stationed in Page, Arizona and is responsible for studies on Lake Powell. **KAREN McCracken** is a Professor of Biology at Defiance College, Defiance, Ohio. **LISA JOYAL** has been employed by the Migratory Birds Division of the U.S. Fish and Wildlife Service as a biologist in Alaska. **DREW ALLEN** is currently employed by Dynamac, Inc., in-site contractors to the Environmental Protection Agency in Corvallis, Oregon. Since completing his M.S. in Wildlife Ecology, **JOE LACHOWSKI** has worked as a back-country ski ranger in Utah and as a seasonal fire ranger in Sequoia National Park.

**MICHAEL POWELL** received his M.S. in Zoology and currently is teaching biology courses at Husson College. **MERRIE CARTWRIGHT** received her Ph.D. in Zoology and is currently job hunting.

## COLLABORATING AGENCIES AND ORGANIZATIONS

Audubon Society of New Hampshire  
 Baxter State Park - BSP  
 Boise Cascade - BC  
 Bowater-Great Northern Paper, Inc. - BGNP  
 Champion International Corporation - CI  
 Connecticut Department of Environmental Protection -  
     Wildlife Division - CDW  
 Davis Conservation Association - DCA  
 Hirundo Wildlife Refuge - HWR  
 Holt Woodlands Research Foundation - HWRF  
 James River Corporation - JRC  
 Maine Association of Wetland Scientists  
 Maine Atlantic Salmon Authority - MASA  
 Maine Audubon Society - MAS  
 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 Geologic Survey - MGS  
 Maine Image Analysis Lab - MIAL  
 Maine Office of Geographic Information Systems - MOGIS  
 National Biological Service - NBS  
 National Council of the Paper Industry for Air and Stream Quality Improvement - NCASI  
 National Wild Turkey Federation -  
     Connecticut Chapter - CC NWTF  
 New Brunswick Fish and Wildlife Branch - NBFW  
 New Hampshire Fish & Game Department - NHFG  
 New Hampshire Department of Resources and Economic Development -  
     Division of Forests and Lands - NHDFL  
 Oak Ridge National Laboratory  
     Environmental Sciences Division - ORNL

Penobscot Valley Conservation Association - PVCA  
Seven Islands Land Company - SILC  
Switzer Environmental Fellowship Program - SEFP  
University of Maine - U of M  
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    Cooperative Forestry Research Unit - CFRU  
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    Department of Wildlife Ecology - DWE  
    Forest Ecosystem Research Program - FERP  
    McIntire-Stennis - MS  
    Maine Agricultural and Forest Experiment Station - MAFES  
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    National Marine Fisheries Service - NMFS  
U.S. Environmental Protection Agency - EPA  
    Environmental Laboratory, Corvallis, OR  
U.S. Department of Agriculture  
    Agricultural Research Service - ARS  
    Economic Research Service - ERS  
    Forest Service - USFS  
    Forestry Sciences Laboratory, Corvallis, OR  
    Pacific Northwest Region, Portland, OR  
U.S. Department of the Interior  
    U.S. Fish and Wildlife Service - FWS  
    Lake Umbagog National Wildlife Refuge - LUNWR  
    Neotropical Migratory Bird Program - NMBP  
    National Biological Service - NBS  
    USGS Biological Resources Division - BRD  
    Leetown Science Center - LSC  
    Cooperative Park Studies Unit - CPSU  
    Patuxent Wildlife Research Center - PWRC  
National Park Service - NPS  
    Acadia National Park - ANP  
Wagner Forest Management, Ltd. - WFM  
Wildlife Forever - WF



**ECOLOGY OF BLANDING'S AND SPOTTED TURTLES  
IN SOUTHERN MAINE: POPULATION STRUCTURE, HABITAT USE,  
MOVEMENTS, AND REPRODUCTIVE BIOLOGY**

*Investigator:* L. A. Joyal

*Advisors:* M. L. Hunter, Jr., Chairperson  
M. A. McCollough  
D. J. Harrison  
K. E. Gibbs

*Cooperators/  
Project  
Support:* Davis Conservation Association  
Maine Department of Inland Fisheries and Wildlife  
Maine Audubon Society  
University of Maine

*Objectives:*

- 1) Estimate population size; density; and sex, size, and age structure.
- 2) Characterize home ranges and terrestrial movements, and determine if they are affected by wetland isolation.
- 3) Document hatching dates, hatching success, hatchling movements, and habitat use by hatchling turtles.
- 4) Characterize wetlands and upland areas used by each species and determine if certain habitats are used at different times of the year or for different activities.

**SCOPE:** Both the Blanding's and the spotted turtle are believed to be declining throughout their geographic range. Although both species are listed as threatened in Maine, the past and present population status of each species is poorly known. Nevertheless, known populations of Blanding's and spotted turtles occur primarily in York County, where the human population is rapidly growing. Increased development associated with human growth has resulted in the filling of many wetlands and possibly the pollution of others. Development may also fragment habitat and cause turtle populations to become isolated and face a greater risk of local extinction. Wetlands less than ten acres, commonly used by both species, are not protected through existing state legislation. Habitat information is needed in order to implement habitat protection measures through the Maine Endangered Species Act and Natural Resources Protection Act.

**PROJECT STATUS:** All requirements for the M.S. degree (in Wildlife Ecology) were completed in December 1996. The abstract follows:

The spotted turtle and the Blanding's turtle are listed as Threatened in the state of Maine, where they are at the northern periphery of their ranges. To provide baseline data for conservation, I investigated the population structure, reproductive biology, seasonal movements, and habitat use of both species using mark-recapture methods, radio-telemetry, and wetland surveys. Sixty-nine spotted turtles and 16 Blanding's turtles were captured on a 9 km<sup>2</sup> area from 1991-1993. Individual turtles of both species (16 spotted, 9 Blanding's) were radio-tagged for 1-3 seasons. The sex ratio for each species was not significantly different than 1:1. Juveniles were rarely seen, but this can probably be attributed to sampling bias.

Fourteen spotted turtle nests and six Blanding's turtle nests were located and monitored from oviposition to hatchling emergence. Turtles nested during June and clutch size ranged from 3-7 ( $\bar{x} = 5.27$ ) and from 5-11 ( $\bar{x} = 8.50$ ) in spotted turtles and Blanding's turtles, respectively. Twenty-six percent of spotted turtle eggs and 47% of Blanding's turtle eggs were successful. Egg failure was due to infertility or arrested development, or invertebrate predation.

Both species used upland areas for nesting, estivating, and traveling between wetlands. Most spotted

turtles followed a seasonal pattern of emergence from hibernation, travel overland to an activity pool, nesting excursion and return to pool (for females), overland travel to estivation site, and overland travel to hibernation site. Seasonal trends among Blanding's turtle movements were not apparent. Total distance traveled throughout a season by radio-tagged spotted turtles ranged from 513-2001 m ( $\bar{x}$  = 1120). Total distance travelled overland by radio-tagged Blanding's turtles ranged from 0-6.76 km ( $\bar{x}$  = 2.90).

Habitat use was significantly different between 1992 and 1993, with both species spending more time upland during 1993. Warmer and drier weather during 1993 caused seasonal wetlands to dry up during 1993. Warmer and drier weather during 1993 caused seasonal wetlands to dry up earlier in the year. Pools occupied by spotted turtles were larger, remained wet longer, received more sun-hours, and were less isolated than unoccupied pools. Pools occupied by Blanding's turtles were larger, deeper, received more sun-hours, and were less isolated than unoccupied pools. Both species estivated in forested or scrub-shrub swamps, or upland. Upland estivation sites were 12-80 m (spotted) and 30-110 m (Blanding's) from the nearest wetland boundary. Both species hibernated in forested or scrub-shrub swamps, or pools. Spotted turtles also hibernated in streams. Four of 16 radio-tagged spotted turtles hibernated communally. This study suggests the importance of maintaining buffers around wetlands for estivation, and the importance of conserving wetlands in groups.

## CONTAMINANT BURDENS AND ECOLOGY OF BALD EAGLES NEAR ACADIA NATIONAL PARK

- Investigator:* A. C. Matz
- Advisors:* J. R. Gilbert, Co-Chairperson  
A. F. O'Connell, Co-Chairperson  
K. E. Carr  
W. E. Glanz  
D. J. Harrison  
W. B. Krohn  
R. B. Owen, Jr.  
C. A. Todd
- Cooperators/  
Project  
Support:* University of Maine -  
Department of Wildlife Ecology  
National Park Service -  
Cooperative Park Studies Unit  
Acadia National Park  
Maine Department of Inland Fisheries and Wildlife  
Maine Department of Environmental Protection  
U.S. Fish and Wildlife Service
- Objectives:*
- 1) Measure contaminant levels in eggs, chicks, adults, prey items, and sediments or sessile marine animals within nesting territories of bald eagles on Maine's central coast.
  - 2) Describe disturbance stress, winter stress, home range and foraging areas for selected nesting pairs.
  - 3) Relate all factors to eagle productivity using a multivariate analysis.

**SCOPE:** The reproductive rate of Maine's eagles is 10-40% below rates of other recovering populations. This 4-year, Ph.D. level study will identify factors responsible for low productivity in coastal eagles.

Contaminants are a main focus, as this study follows a 2-year U.S. Fish and Wildlife Service/University of Maine study which found extremely high levels of persistent compounds (PCBs and organochlorine insecticides) in coastal eagle nestlings.

**PROJECT STATUS:** In 1996, blue mussels (*Mytilus edulis*) and American eels (*Anguilla rostrata*) were collected from throughout the study area. All archived samples, including bald eagle nestling blood, are scheduled to be analyzed for contaminants over the winter of 1996-97. A report on disturbance at selected nests near Acadia is in the National Park Service peer review process; major findings were that fledglings may be more sensitive to disturbance than nesting adults, and that human activity close to the nest resulted in higher levels of disturbance. Management recommendations include a 500 m buffer zone around nests, maintained through August.

**FUTURE PLANS:** Data analysis is underway and reports are being prepared.

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## **FISHERIES RESOURCES:**

### **ECOLOGICAL INTERACTIONS BETWEEN FISHES AND INVERTEBRATES IN AN ESTUARY IN SOUTHERN MAINE**

**Investigator:** M. A. Cartwright

**Advisors:** J. R. Moring, Chairperson  
J. G. Trial  
J. H. Dearborn  
M. Dionne  
R. S. Steneck  
W.B. Krohn

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

**Objective:** Analyze benthic and planktonic prey items available to fishes utilizing the Little River estuary and relate availability to selection in a dynamic system.

**SCOPE:** Estuaries are commonly assumed to be important nursery grounds for juvenile marine fishes. In recent years, the stocking of brown trout (*Salmo trutta*) in the lower rivers of several coastal estuaries has shown rapid growth when fish move into estuaries. This project examines this ecosystem for benthic prey availability. Collections of juvenile fishes in the estuary are related to salinity and tidal differences and shifting availability of prey items over time, season and tidal cycles, as well as seasonal changes in benthic prey.

**PROJECT STATUS:** All requirements for the Ph.D. degree (in Zoology) were completed in May 1997. The abstract follows:

Several mensurative experiments were performed during the summers of 1994 and 1995 on the benthic and fish communities in the Little River (the unvegetated creek channel of a small, undisturbed salt marsh in southern Maine) to determine the spatial and temporal factors affecting daytime community structure and trophic patterns. Intra-annual abiotic factors, such as seasonal temperature change and spatial variation in salinity, significantly influenced benthic community structure. Overall abundance of benthic organisms

increased throughout the summer, showing some evidence of a seasonal successional pattern. Dominance patterns varied between upper and lower locations.

Fish community analyses revealed both spatial and temporal patterns in abundance and diversity. Species richness and evenness were highest in the lower estuary, due to the presence of marine species. This system was proportionally more important as a conduit for anadromous species (vs. a "nursery area" for marine-spawned species) than most southern estuaries, although there were "estuarine spawners" whose young remained in the Little River throughout the summer.

Fish diets generally conformed to the expected pattern of trophic generalism derived from studies in other areas. This was true for both benthic and water-column prey. Selectivity analyses were performed for the benthic component of diet, and most species exhibited some selectivity for one or two preferred prey types. Selectivity sometimes varied with prey abundance ("switching"), which itself varied temporally and spatially. Predator size did not significantly influence the sizes of major prey types taken by each fish species individually; however, there were some interspecific trends in prey size that most likely resulted from a combination of size constraints and other factors.

Feeding patterns--and their relation to ecological theory--differed among species. Fourspined sticklebacks (*Apeltes quadracus*) broadened their diet when abundance of benthic food increased, possibly supporting the "threshold" hypothesis of feeding behavior. In contrast, ninespined sticklebacks (*Pungitius pungitius*) and striped bass (*Morone saxatilis*) broadened their diets when and where benthic food was less plentiful, in concurrence with classical optimal foraging theory. Dominant prey items and patterns of niche overlap differed markedly between this system and a previously studied marsh in mid-coast Maine.

## 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 1981, 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. One paper on intertidal fishes was published in 1996 and a new funded project is underway.

**FUTURE PLANS:** Work dealing with intertidal movements of sculpins will continue in 1998, along with experiments on Atlantic seasnail feeding and innovative fish marking techniques. Additional manuscripts are

being prepared on community dynamics.

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### DISTRIBUTION AND STATUS OF REDFIN PICKEREL (*Esox americanus americanus*) IN CENTRAL AND SOUTHERN MAINE

*Investigator:* M. Gallagher

*Advisors:* J. R. Moring, Chairperson  
L. J. Kling  
J. G. Trial

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

*Objective:* Determine the status of grass and/or redbfin pickerel in the state and to establish a biological data base for chain pickerel.

*SCOPE:* Three unusual pickerel, identified as a grass pickerel (*Esox americanus vermiculatus*) or redbfin pickerel (*E. a. americanus*), were collected in streams near Bath, Maine in 1977. Since that time there have been unconfirmed reports of other non-chain pickerel (*E. niger*) esocids observed near that location and in other parts of the state. If grass pickerel or the closely-related subspecies, redbfin pickerel still exist in Maine, they may be candidates for special protection under Maine's laws. Despite the wide distribution and popularity of chain pickerel, little biological data on age structure, length/weight, age specific length, spawning characteristics, and distribution are available. This project will address both questions during field work in 1996.

*PROJECT STATUS:* All field and laboratory work has been completed and a thesis is nearly completed. Thesis defense is scheduled for early 1998.

*FUTURE PLANS:* A Master of Science thesis is expected by May 1998.

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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

*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 is nearing completion, with additional data from 1998 to be added.

**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 December 1998.

### FOOD HABITS OF AMERICAN EELS IN FRESH WATER

**Investigator:** L. R. Daniels

**Advisors:** J. R. Moring, Chairperson  
J. D. McCleave  
A. Huryn

**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 has always 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--the abiotic and biotic factors triggering such migration.

**PROJECT STATUS:** Field work has been completed and laboratory analyses of stomach contents is continuing.

**FUTURE PLANS:** A thesis will be written over winter, 1997-1998. A Master of Science thesis is expected in summer 1998.

### FISHERIES RESOURCES OF ACADIA NATIONAL PARK

**Investigator:** J. B. Lê

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

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

*Support:*

*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 student's thesis, 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:* The project is newly funded and just underway. Planning will occur over winter, 1997-1998, with field work beginning in 1998.

*FUTURE PLANS:* A Master of Science thesis is expected by May 1999.

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

*Investigator:* N. Leaman

*Advisors:* J. R. Moring, Co-Chairperson  
T. A. Haines, Co-Chairperson  
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.

*SCOPE:* Little is known of the freshwater residence of yellow-stage eels in Maine lakes and rivers. New aspects of the life history of this species will be examined, with the specimens collected used for measuring mercury levels in eels.

*PROJECT STATUS:* The project is just beginning. Field work will commence in 1998.

*FUTURE PLANS:* A Master of Science thesis is expected by May 1999.

### HABITAT RESOURCES:

#### SEED PREDATION BY SMALL MAMMALS ON THREE TREE SPECIES IN SOUTHERN MAINE

*Investigator:* K. E. McCracken

*Advisors:* M. L. Hunter, Jr., Chairperson  
 W. E. Glanz  
 D. J. Harrison  
 R. J. O'Connor  
 A. S. White

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

*Objectives:*

- 1) Determine whether intensity of seed predation varies among habitats (continuous forest and four types of forest gap).
- 2) Determine which animals are relatively more effective at removing three species of tree seeds (i.e., "small" rodents [mice and voles], "large" ents [squirrels], or other potential avian and mammalian seed predators).
- 3) Investigate other possible correlates of seed predation (i.e., seed size, seed preference, time of day, lunar cycle).
- 4) Investigate the response of small mammals (population levels, animal condition) to temporal and spatial variation in seed fall.

*SCOPE:* Many species of small mammals in temperate forests depend on tree seeds for a substantial portion of their diet. Thus, temporal and spatial variation in seed fall may profoundly affect animal condition, reproduction, and survival, resulting in dramatic intra- and inter-annual fluctuations in population levels. This study examines how temporal and spatial variation in seed fall of three species of trees [red maple (*Acer rubrum*), northern red oak (*Quercus rubra*), and white pine (*Pinus strobus*)], affect small mammal populations in the Holt Forest, an oak-pine ecosystem in southern Maine.

*PROJECT STATUS:* All requirements for the Ph.D. degree (in Wildlife Ecology) were completed in December 1996. The dissertation abstract follows:

I examined spatial and temporal patterns of seed predation by small mammals on three tree species in an oak-pine forest in southern Maine. Predation rates varied with tree species, and exposure to three suites of seed predators (all seed predators, medium-sized rodents, and small rodents). *Acer rubrum* seeds were removed more slowly than seeds of either *Quercus rubra* or *Pinus strobus*. Levels of cumulative removal varied with year, but not with microhabitat (four types of forest gap and intact forest). Field data and feeding trials with captive *Peromyscus leucopus* and *Clethrionomys gapperi* suggest that *Pinus* seeds are more likely to be eaten when detected, whereas *Quercus* acorns are more likely to be cached.

I also analyzed ten years of data (1983-1992) to investigate relationships between seed fall and population characteristics of *Peromyscus* and *Clethrionomys*. Spring populations of *Peromyscus* were positively associated with magnitude of previous years' *Quercus* and *Pinus* crops, whereas summer populations were correlated with *Quercus* crop only. Adult male and female *Peromyscus* were heavier in springs following years of high versus low *Quercus* production. This difference was greater for females, perhaps because more individuals were pregnant these years.

Spatially, *Peromyscus* captures were positively associated with the number of live *Quercus* trees > 10 cm DBH per quadrat following two years of high acorn production. Group selection logging was associated with increased captures of *Peromyscus* per quadrat for two out of four years, probably due to increases in both herbaceous cover and fruit production of shrubs. In summary, seed production of *Quercus* was associated with several population characteristics of *Peromyscus*, but not *Clethrionomys*. Seed production of *Pinus* and *Acer* had little or no effect on population characteristics of either species.

The influence of lunar period, month, habitat, and microhabitat on patterns of nocturnal seed predation was also examined. Predation rates varied with all of these variables. However, results were not consistent among years, suggesting that (i) small mammals may vary their foraging activity relative to the risk

of predation at both large and small scales, and (ii) to determine which scales are relatively more important, longer-term studies may be needed.

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## AN ASSESSMENT OF TERRESTRIAL VERTEBRATE DIVERSITY IN MAINE

*Investigator:* R. B. Boone

*Advisors:* W. B. Krohn, Chairperson  
M. K. Beard-Tisdale  
M. L. Hunter, Jr.  
G. L. Jacobson, Jr.  
M. A. McCollough  
R. J. O'Connor

*Cooperators/  
Project  
Support:* USGS Biological Resources Division  
University of Maine  
Maine Department of Inland Fisheries and Wildlife  
Maine Department of Conservation  
Maine Office of Geographic Information Systems  
Champion International Corporation  
Bowater-Great Northern Paper, Inc.  
New Brunswick Fish and Wildlife Branch

*Objectives:*

- 1) Develop detailed range maps of non-fish vertebrate species in Maine, using literature on species-habitat relations, and expert review.
- 2) Create species richness maps for various groups of species (e.g., neotropical migrant birds), and compare them to areas managed for natural vegetation, to identify gaps in biodiversity protection.
- 3) Correlate species richness distributions with woody plant distribution, climatic variables, and geomorphology, to characterize factors determining the distribution of Maine terrestrial vertebrates.
- 4) Determine the usefulness of selected ecological factors to measure the likelihood of a species' occurrence being correctly predicted by Gap Analysis.

**SCOPE:** Developing and implementing recovery plans for species that are threatened or endangered is expensive, disruptive, and may be unsuccessful. Conservation plans are best implemented when species are common and with broad ranges, when more options are available for managers. Gap Analysis is a tool that identifies, on a regional scale, areas of high species richness and relates these locations to areas already managed for natural vegetation. Managers can use the results of the Maine Gap Analysis in regional land management decisions, specifically to provide adequate habitat to maintain species populations.

In additional research, I wish to determine why groups of species in Maine are distributed unevenly. I will compare species richness maps with woody plant species richness, climatic variables, and geomorphology, to prioritize the importance of variables in determining vertebrate species richness. I will relate my findings to: 1) the utility of plant diversity in predicting vertebrate diversity; 2) theoretical predictions of the relationship of amphibians, reptiles, birds, and mammals to landscape variables; and 3) potential effects of global climate change on vegetation in conservation lands.

**PROJECT STATUS:** All requirements for the Ph.D. degree (in Wildlife Ecology) were completed in December 1996. The dissertation abstract follows:

The ranges of terrestrial vertebrates breeding in inland Maine were defined based upon observations, literature, and expert review. For those avian species with range limits in Maine (n=80), ranges were compared to smoothed Breeding Bird Survey (BBS) data (n=47 species with adequate BBS data). For species well-represented in BBS, ranges compared reasonably well ( $\bar{x} = 8\%$  area of Maine in spatial disagreement for 18 species with good smoothed BBS maps; 4% error by absolute area for 37 species with a semivariogram  $r^2 > 0.7$ ). In analyses of tessellations (grids of cells) used to map ranges, maximum errors introduced depended upon cell-size and shape (e.g., townships - 2% by area of Maine, 640 km<sup>2</sup> hexagons - 4%, and counties - 20%). When ranges for terrestrial vertebrates (n=275) were compared with environmental variables, amphibian and reptile ranges were related positively to temperature and productivity and negatively to snowfall. Seven mammal ranges were related positively to temperature, and productivity, and six were positively associated with snowfall and elevation. Many bird ranges (n=47) were positively associated with temperature and productivity and negatively with snowfall, but some (n=29) were related oppositely. Birds that were classed as forest specialists, and those classified as early successional, were spatially coincident with the north-south and east-west plant transition zones, respectively. Forest generalists and birds classified as using barren/urban or wetland/water habitats were not associated with either transition zone. In models describing variation in total species richness, climatic variation was the best descriptor ( $r^2 = 92\%$  in tree regression), followed by woody plant distributions (87%) and geomorphology (87%). Reptiles were highly correlated with environmental variables (93%), followed by amphibians (85%), birds (82%), and mammals (81%). Avian species were ranked as to how likely their presence would be correctly modeled in species-habitat modeling (i.e., Likelihood Of Occurrence Ranks, or LOORs were assigned). Logistic regression was used to model the spatial incidence of species within Breeding Bird Atlas (1978-1983) data, based upon species' ecological attributes (e.g., niche width), then incidences were updated using BBS to 1984-1993, and ranked to become LOORs. When LOORs were tested against analyses of six study areas, the numbers of species correctly modeled were correlated with ranks ( $\rho$  from 0.68 to 0.93,  $P < 0.032$ ). The accuracy of analyses increased in larger (e.g., > 1,000 ha) sites, and for sites sampled for longer periods (e.g., > 10 years). LOORs were low for bird species that are spatially aggregated, rare, difficult to observe, inhabit inaccessible areas, have narrow niches, and large body size.

## EFFECTS OF HEAVY METALS ON FISHES AND EAGLES OF THE NORTHEASTERN UNITED STATES

**Investigators:** T. A. Haines  
R. W. Perry  
M. W. Powell

**Advisors:** T. A. Haines, Chairperson  
I. J. Fernandez  
S. A. Norton  
J. R. Moring

**Cooperators/  
Project  
Support:** USGS Biological Resources Division -  
Leetown Science Center

**Objective:** Analyze aspects of heavy metals in waters of northern New England and the potential influence on fishes and bald eagles.

**SCOPE:** High concentrations of mercury have been found in fish and wildlife in locations remote from industrial discharges or mercury-bearing rock. Such conditions have been documented for fish and bald eagles

in Maine. Atmospheric deposition of mercury emitted to the atmosphere from fossil fuel combustion, refuse incineration, or industrial processes and deposited with rain and snow is believed to be the major source of mercury to these areas. The problem occurs primarily in areas where waters are low in acid neutralizing capacity. Other factors such as acidification, construction of impoundments, and increased temperature may increase bioavailability of mercury. Conversely, treatment of waters with lime may reduce bioavailability. In order to manage this threat, information is needed on the source of mercury, the factors that control bioavailability, and possible remedial techniques.

**PROJECT STATUS:** Project has ended. An M.S. thesis from M. Powell was completed in August 1997. An abstract follows:

The role of watershed acidification on the speciation and bioaccumulation of mercury in brook trout (*Salvelinus fontinalis*) at the Bear Brook watersheds was investigated. East Bear Brook served as a control watershed and West Bear Brook was acidified by application of granular ammonium sulfate to the soil. Mercury concentrations were determined in precipitation, stream water, sediment, invertebrates, and brook trout. Total mercury concentration (HgT) in precipitation collected in the summer was significantly higher than in the precipitation collected in all other seasons. Stream water collected in the summer had HgT concentrations that were significantly higher than during other seasons in both East Bear and West Bear Brooks. Total mercury concentration in stream water was significantly higher in East Bear than in West Bear, however, methylmercury fractions were over twice as high in West Bear than in East Bear. Total mercury was inversely associated with stream discharge for both watersheds. Sediment and invertebrate samples showed no significant difference in mercury concentrations between East and West Bear Brooks. Total mercury concentrations in brook trout from West Bear were significantly greater than those from East Bear. Although total mercury concentrations were higher in East Bear stream water, chronic acidification of West Bear has resulted in higher methylmercury fractions, and results in higher mercury concentrations in brook trout in West Bear.

A computer model was developed that simulates the transport of bioavailable mercury species across the cell membrane in phytoplankton, and biomagnification in higher trophic levels. The membrane transport sub-model includes passive diffusion and diffusion limitation. The fish uptake sub-model uses equations of fish bioenergetics coupled with pollutant biokinetics and considers uptake both from the diet and directly from water across the gill. The bioaccumulation model was coupled with the geochemical thermodynamic equilibrium speciation model MINEQL+ to determine the equilibrium concentrations of bioavailable mercury species from measured total mercury concentrations. The results of the model indicate that the diet is the major route of mercury accumulation. The model predicts methylmercury bioconcentration factors of approximately  $10^{6.5}$  for brook trout in the Bear Brook watersheds.

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## SPATIAL AND ANTHROPOGENIC GRADIENTS IN THE STRUCTURE OF AVIAN ASSEMBLAGES ON LAKES

**Investigator:** A. P. Allen

**Advisors:** R. J. O'Connor, Chairperson

**Cooperators/  
Project** U.S. Environmental Protection Agency  
University of Maine -

**Support:** Department of Wildlife Ecology

**Objectives:**

- 1) Refine and evaluate candidate avian indicators of the environmental quality of northeastern lakes.
- 2) Determine the role of spatial patterning of land use as a stressor of lake

quality.

*SCOPE:* Earlier research developed preliminary indicators of lake quality in the northeastern U.S. based on the proportional representation of different guilds of bird species within the lake bird community. These indicators were shown to be correlated with lake chemistry and with road density in the surrounding watershed.

*PROJECT STATUS:* All requirements for the M.S. degree (in Wildlife Ecology) were completed in December 1996. The abstract follows:

The work described in this thesis was conducted using lake shore avian assemblage data collected between 1992 and 1994 as part of an EMAP pilot study initiated in 1991 to investigate the potential of several taxa, including birds, to serve as indicators of lake condition in the northeastern United States (New England, New York, and New Jersey). A total of 158 lakes were analyzed, with the bird data for each lake collected during a single survey less than four hours in length conducted along a transect 10 m from and parallel to the lake shore. These lakes were a random sample from the population of lakes present in the region and thus accurately reflected the environmental conditions present therein.

The objectives of this investigation were to document the spatial patterns of lake shore avian assemblages across the region and to identify significant environmental correlates of these patterns. I focused on three aspects of lake shore avian assemblage structure: proportional allocations of individuals among life history groups, species composition, and species richness. Assemblages were characterized as to patterns of life history using compositional analysis techniques, a new application of this statistical approach. Assemblage-level patterns of species composition were determined using the two-way indicator species analysis (TWINSPAN) algorithm. A randomization approach was used to estimate species richness for fixed samples of individuals to control for differential sampling effort among lakes. For all assemblage measures, classification and regression tree (CART) modeling was used to generate hierarchically structured models, with explanatory variables chosen from a suite of candidates characterizing the region, landscape, lake shore, and lake basin.

Local and regional patterns of human development were most important in predicting assemblage-level patterns of life history with regard to foraging technique, dietary preference, migratory status, and tolerance to human development. In contrast, landscape coniferous forest was found to be the most important predictor of species composition. Taken together, these two findings suggest that humans imposed the most significant constraint on life history groups with regard to individual abundance, while non-anthropogenic factors were of greater importance in determining species identity. The thirty individual estimates of species richness peaked at sites with moderate levels of human development, a pattern consistent with the notion that moderate human disturbance served to enhance local bird diversity by increasing habitat heterogeneity. Species richness remained relatively constant across a wide range of environmental conditions and was only significantly depressed in the most pristine and heavily urbanized settings, implying that richness was relatively insensitive to environmental conditions as compared to the other aspects of assemblage structure considered. The importance of anthropogenic variables in predicting all three aspects of avian assemblage structure suggested that human-induced habitat features were as important, if not more important, than non-anthropogenic habitat features in structuring lake shore avian assemblages across this region.

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## A LONG-TERM FOREST ECOSYSTEM STUDY

*Investigators:*

- M. L. Hunter, Jr.
- A. J. Kimball
- A. S. White
- J. W. Witham
- E. H. Moore

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

*Objectives:*

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

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

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

Our primary objective is to describe the structure of the plant and animal community. We are undertaking (1) a 100% inventory of trees (> 10 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 1997, tasks 3, 4, 5, 6, 8, 9, and 10 as outlined above, were completed. Short-term work on vegetation in gaps dominated the 1997 field season.

*FUTURE PLANS:* The 1998 field season will replicate the 1995 field season with additional work on snags and forest gap dynamics and their effects on forest understory plants.

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## FACTORS AFFECTING FOOD CHAIN TRANSFER OF MERCURY IN THE VICINITY OF THE NYANZA SITE, SUDBURY RIVER, MASSACHUSETTS

*Investigators:* T. A. Haines  
R. W. Perry  
M. W. Powell  
R. T. Finlayson

*Advisors:* T. A. Haines Chairperson

L. E. Katz  
 J. R. Moring  
 S. A. Norton

*Cooperators/  
 Project* U.S. Fish and Wildlife Service, Region 5  
 U.S. Environmental Protection Agency, Region 1  
*Support:* USGS Biological Resources Division -  
 Leetown Science Center

*Objective:* Determine total and methyl mercury concentrations in water, sediment, invertebrates, and fish in reference and contaminated sites in the Sudbury River in order to determine the importance of sediment reservoirs of mercury in the continuing contamination of fish and wildlife resources in the river.

*SCOPE:* The Nyanza site on the Sudbury River was used by several companies involved in the manufacturing of textile dyes and dye intermediates during the period from 1917 to 1978. As a result, large quantities of chemical wastes were disposed of on-site, or discharged into surface waters draining into the Sudbury River. The contaminants of concern include mercury plus other metals. Previous studies have documented extensive mercury contamination of sediments and biota in the Sudbury River downstream of the site, but sufficient information is not available to make a risk-based cleanup decision for the contaminated river reaches. This study addressed some of the data needs required for the cleanup decisions.

*PROJECT STATUS:* All field samples have been collected. All samples for total mercury have been digested and analyzed. Approximately 75% of the samples for methyl mercury have been digested and analyzed. All samples are anticipated to be completely analyzed by January 1998. A computer model has been developed and tested, and is now being polished by addition of user-friendly features to enable use by non-technical personnel.

*FUTURE PLANS:* The final report was submitted in June 1997. One M.S. thesis was completed in August 1997 (see M. W. Powell). A second M.S. thesis is anticipated in May 1998.

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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* Maine Department of Inland Fisheries and Wildlife  
 University of Maine -  
*Support:* 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; and
- 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:* Currently invertebrate samples are being sorted for identification to family or general levels. After completion of invertebrate identification, all data will be analyzed and final thesis prepared. Data analysis continues. A final thesis is in preparation.

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## REPRODUCTION OF AMPHIBIANS IN ANTHROPOGENIC AND NATURAL TEMPORARY POOLS IN INDUSTRIAL FORESTS

<i>Investigator:</i>	D. DiMauro
<i>Advisors:</i>	M. L. Hunter, Jr., Chairperson W. E. Glanz M. A. McCullough A. J. K. Calhoun
<i>Cooperators/ Project Support</i>	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:* In the 1996 and 1997 field seasons, I identified 53 temporary pools containing amphibian egg-masses. I counted and measured the wood frog and spotted salamander egg-masses in each pool, monitored pool depth, periodically measured tadpoles, and recorded dates on which pools dried. In addition, I trapped, counted, and weighed recently-metamorphosed wood frogs and spotted salamanders at pools which persisted until juvenile emergence. I also conducted survey transects to determine the distribution of pools across the landscape, and evaluated the surrounding cover types and microhabitat conditions of study pools. Preliminary data analysis occurred in winter/spring 1997.

*FUTURE PLANS:* I will conduct final data analysis and prepare my thesis during fall and winter 1997-98.

## SOURCES, FATE, AND EFFECTS OF MERCURY IN AQUATIC SYSTEMS AT ACADIA NATIONAL PARK, MAINE, AND CAPE COD NATIONAL SEASHORE, MASSACHUSETTS

- Investigators:* J. R. Burgess  
H. M. Webber
- Advisors:* T. A. Haines, Chairperson  
J. H. Dearborn  
J. R. Moring  
W. E. Glanz  
R. J. Van Beneden
- Cooperators/  
Project  
Support:* USGS Biological Resources Division -  
Leetown Science Center  
National Park Service

- Objectives:*
- 1) Characterize the extent of mercury contamination in fish and piscivorous wildlife species in Acadia National Park (ANP) and Cape Cod National Seashore (CCNS), and assess the environmental factors controlling mercury bioavailability to aquatic organisms.
  - 2) Demonstrate food chain transfer of mercury, and determine geochemical and biological factors that regulate bioavailability of mercury in order to predict fish and species at risk from mercury contamination.
  - 3) Determine historical trends in mercury deposition to aquatic environments at ANP and CCNS.
  - 4) Develop a precipitation chemistry monitoring program at ANP to assess long-term changes in mercury deposition.

*SCOPE:* High concentrations of mercury have been found in fish and wildlife in areas that are remote from industrial pollution. Thousands of lakes have health advisories against human consumption of fish because of the threat of mercury poisoning, and these levels are an even greater threat to wildlife. Previous research identified high levels of mercury in fish from northern Maine lakes. Bald eagle nestlings in the same area contain very high levels of mercury in feathers, up to 33 ppm. Analysis of the distribution of lakes in Maine containing fish with high levels of mercury indicates that geological or industrial point sources are not the likely sources of mercury contamination. Deposition from the atmosphere has been implicated as a major source of mercury in lakes. There is considerable evidence that pre-industrial atmospheric deposition of mercury was substantially lower (by a factor of three or more) than present deposition. Coal-fired electric power plants and municipal solid waste incinerators are reported to be the two most important anthropogenic sources for airborne mercury. The Clean Air Act Amendments of 1990 Title III classified mercury as a hazardous air pollutant, and provides for the regulation of industrial mercury emissions if damage to natural resources from atmospheric emissions can be demonstrated. The mercury content of rain and snow in Maine ranges 5-16 ng/L, which is similar to that in other regions where fish are contaminated with mercury. Although the environmental factors that control bioavailability of mercury to fish are poorly understood at present, fish mercury content seems to be highest in lakes that are softwater (low in dissolved ions and in acid-neutralizing capacity) and slightly acidic (pH < 7) - conditions that are common in ANP and CCNS lakes.

*PROJECT STATUS:* Fish were collected from 5 lakes in CCNS and 10 in ANP and analyzed for mercury in whole-body and edible tissue. Two lakes in ANP were selected for intensive study and samples of fish, fish prey, sediment, and water were collected and analyzed for mercury. Sediment cores from two lakes and one ombrotrophic bog at ANP were dated and analyzed for historical trends in mercury deposition. A precipitation chemistry station affiliated with the Mercury Deposition Network was installed in ANP and has been operating since October 1995.

*FUTURE PLANS:* Analysis of samples collected during the field season will continue. Analysis is completed. One M.S. thesis has been written and a degree was received in December 1997.

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## 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 been quantified. O'Connor and his students have developed methods of using remotely-sensed land use and pattern data in conjunction with climate data to quantify their effects on avian species diversity within the coterminous U.S. The present project is a collaboration with fellow Biodiversity Research Consortium researchers at the University of California at Santa Barbara to compile anthropogenic stressor data for use with an extensive compilation of Breeding Bird Survey data.

A review of potential sources of data has been completed. Nine variables extracted from the Bureau of the Census provided information on population density, population change, income, building, and information as to farming and urban status. Harvest and yield data for various agricultural crops and indices of agricultural diversity were extracted and/or derived from the National Agricultural Statistics Service database and incorporated into the stressor database. These datasets provide much information on the distribution of humans, their migration and consumption patterns and their agricultural activities across the United States and thus provide a source of information as to the intensity of anthropogenic factors. The relationship between the census variables and a suite of satellite-derived climate, land use, and land cover characteristics for the coterminous United States has been investigated using classification and regression tree (CART) methods. This analysis has shown that expansive population growth is highest in fragile ecosystems such as barrier islands, coastal sand dunes and desert edges. Additionally, a hyperdimensional index of human-environment interactions has been devised for investigating multiple pathways of environmental influence on demographic phenomenon.

**PROJECT STATUS:** Several papers have been submitted to appropriate outlets. Completion is scheduled for December 1997.

## 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 habitat 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 acquired in summer 1991 and fall 1993 were obtained from a variety of government agencies and private sources. Portions of eight TM scenes at each date were required to cover the entire State of Maine (16 scenes total). All scenes have been geometrically corrected and co-registered. Clouds, shadows, water, and urban areas were stratified out from these scenes to be processed separately. Aerial videography transects covering 7,100 km were collected in summer and fall 1994. Systematic samples at one minute intervals along each flight line were interpreted to provide training sites for supervised classification and locations for accuracy assessment of the final habitat map. Classification of all scenes, both supervised and unsupervised, has been completed. Residential and urban areas were delineated through a combination of GIS rules using the transportation network from Digital Line Graphs and unsupervised classifications. National Wetland Inventory (NWI) wetland polygons are being used to delineate wetlands. For the several areas of the state without digital NWI maps available, supervised classification is being used to delineate wetlands. Scene matching, necessary because of the different dates of scene acquisition for different parts of the state, is proceeding.

**FUTURE PLANS:** A preliminary habitat map is expected by mid-November. Selected areas will be plotted at 1:40,000 and sent to various state conservation organizations and forest companies for verification. Comments from these groups as well as in-house comparisons with aerial video polygons and aerial photographs will be used to update the classifications. Final map production and error checking will be completed by the end of 1997. Documentation and map production will be completed by February 1998.

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## MULTI-TAXON INDICATORS OF LAKE QUALITY

**Investigators:**

R. J. O'Connor  
T. E. Walls (through March 1997)

**Cooperators/**

USGS Biological Resources Division

**Project**

U.S. Environmental Protection Agency -

**Support:**

Environmental Laboratory, Corvallis, OR

**Objective:**

- 1) Assess the extent to which a variety of taxonomic groups respond similarly or differentially to environmental stress.
- 2) Evaluate the utility of fuzzy logic as a technique for assessing environmental indicator information.

**SCOPE:** The Environmental Monitoring and Assessment Program (EMAP) of the U.S. Environmental Protection Agency seeks to develop a variety of indicators for different types of resources in the country. Much of the research to date has been focused on determining the effectiveness of methodology with specific indicators, whose taxonomic identity varies from resource to resource. Little research has been devoted to the problem of integrating the information from a spectrum of indicators for a particular resource. In the case of EMAP Surface Waters, indicator information has been collected on the same lakes in the eight northeastern

states for birds, fish, zooplankton, diatoms, and benthos. The present project seeks to better develop means of integrating the information in these indicators.

The information contained in a suite of indicators could be totally redundant, with all indicators providing the same information, or could be completely independent with different indicators responding to different facets of the environmental stress present on the lakes. The present project examines the possibility of distinguishing the extent to which these two extremes are present in the data, both identifying the extent to which a common signal is present in the suite of indicators and help determine the extent to which differential information is being provided by particular groups. This will help determine the extent to which information is redundant, thus reducing the cost of collecting information on these indicators, and the extent to which particular indicators provide unique insights into environmental stress.

*PROJECT STATUS:* The initial methods used consisted of multivariate analysis of the data. An initial set of 19 pilot lakes gathered outside the standard EMAP sample grid were used to resolve methodological issues and to clarify concepts. These results suggest that about one-third of the variation indicators is in common, with substantial additional information coming from different combinations of the remaining taxa. Thus, birds and benthos, for example, seem to serve as generalized indicators of stress, while certain fish metrics convey information about specific types of stress. This initial pilot investigation has been completed and a paper prepared for a journal.

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## MAINE GAP ANALYSIS

*Investigators:* W. B. Krohn  
R. B. Boone

*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 more common species remain common is most efficient 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:** We have identified 287 terrestrial vertebrates that regularly breed in inland Maine. For each of these species, we have defined ranges based upon literature, expert review, personal communications, and personal experiences. For birds (n=187), these ranges were assessed by comparing them to patterns from smoothed U.S. Fish and Wildlife Service Breeding Bird Survey data, and judged to depict reasonably well the distribution of species. The ranges of amphibians and reptiles (n=34) have been further refined using atlas information from the region, and will be used in a book describing the herpetofauna of Maine. The ranges of all vertebrates were also provided to colleagues producing a volume describing the animals of New England.

To quantify species-habitat associations, a matrix containing 48 habitats was constructed for each species. In each matrix, breeding and feeding habitat was assigned a score from 0 to 4, representing how frequently the habitats are used by species. Draft matrices are in-place for each species, and the matrices are under review. The amphibian and reptile matrices are essentially finalized, as are the mammal matrices (n=56). About 50 of the bird species-habitat matrices require careful review. The many changes to matrices during their review must be entered into databases, then predicting species occurrences may proceed.

Several data layers are used during species occurrence modeling and Gap Analysis overlays. These include layers describing habitats, conservation lands (including ownership and management status), hydrography (including stream order), wetlands, elevation, watershed boundaries, road networks, and political boundaries. With the exception of habitats, which is nearing completion, these layers are in place.

**FUTURE PLANS:** Over the coming months, Maine Gap Analysis will be completed. After species-habitat matrices are finalized and a habitat map is available, Arc/Info programs that predict species occurrence will be written and run. Predicted species-occurrences will be reviewed, then the models finalized. Predicted occurrences will then be stacked to form richness maps and compared to conservation lands (by ownership as well as management categories). A final report will be prepared and data provided to our cooperators.

## 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. Invertebrates are currently being identified to varying degrees, depending upon the availability of published keys and help from expert taxonomists.

*FUTURE PLANS:* All invertebrates will be taken to the level of class, many to family, and some to species. In addition, the time 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.

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

### **SPATIO-TEMPORAL DYNAMICS AND THE CORE SATELLITE MODEL**

*Investigator:* M. T. Jones

*Advisors:* R. J. O'Connor, Chairperson  
J. R. Gilbert  
M. L. Hunter  
K. Tinsdale-Beard  
J. A. Wilson

*Cooperators/  
Project  
Support:* Consortium of Agricultural Manufacturers  
U. S. Environmental Protection Agency

*Objective:*

- 1) Empirically evaluate the predictions of Hanski's core-satellite model using BBS data.
- 2) Evaluate simpler alternatives such as the Taylor Power Law to explain observed patterns.

*SCOPE:* Analysis and interpretation of the population effects of pesticide use on wildlife requires understanding the underlying dynamics over space and time. This project focuses on the core-satellite model developed by J. Hanski. The model posits certain assumptions about how populations change and derives predictions about the frequency distributions of abundance classes and frequency of occurrence of species. This project empirically evaluates the validity of these assumptions and predictions, using Breeding Bird

Survey data for New England as the test dataset.

**PROJECT STATUS:** All requirements for a Ph.D. (in Wildlife Ecology) were completed in December 1996. The abstract of the dissertation follows:

I examined avian abundance and distribution patterns for New England using data from the USGS Biological Resources Division's Breeding Bird Survey (BBS). I identified three distinct avifaunal regions within New England, which formed the sample units for all further analyses. For each of these regions I tested the predictions of Hanski's core-satellite hypothesis, Brown's ecological specialization hypothesis and Wright's sampling hypothesis to determine which best explained the observed patterns.

Mean abundance (birds/route) was correlated with spatial incidence (i.e., proportion of sites occupied) for all 26 years examined in each region. The frequency distribution of spatial incidence was extremely bimodal for all but three years in any region, as predicted by the core-satellite species hypothesis (i.e., most species occurred on either a few or most sites). Also, this is the first known study to document the occurrence of core-satellite switching, with three species switching from satellite to core species and two species switching from core to satellite species by the end of the study.

No evidence was found to support Brown's ecological specialization hypothesis, which predicts that ecological generalists should have higher densities than specialists. Rather, I found that specialists had higher local densities than generalists. I suggest that the failure of other studies to show a similar relationship is the result of a failure to control for the confounding effect of spatial incidence. In all regions, Wright's sampling model explained 56 - 62% of the variation in spatial incidence.

I also examined species' spatial and temporal dynamics using Taylor's Power Law (TPL). Approximately 50% of the species had statistically significant temporal or spatial exponents. Classification and regression tree analyses indicated no correlation between the spatial exponents and natural history correlates; only 15 - 25% of the mean deviance of the temporal exponents was explained by life history correlates. I showed that this index was probably extremely biased, especially with species that had an overall mean abundance less than two.

## MACROINVERTEBRATES IN BROOD-REARING WETLANDS OF WATERFOWL (ANATIDS) IN FORESTED AND AGRICULTURAL LANDSCAPES IN MAINE

*Investigator:* L. J. Boobar

*Advisors:* K. E. Gibbs (Advisor)  
J. R. Longcore (Field Advisor)  
R. B. Davis  
W. A. Halteman  
R. B. Owen, Jr.

*Cooperators/  
Project  
Support:* U.S. Fish and Wildlife Service (now USGS/BRD)  
University of Maine

*Objectives:*

- 1) Determine if macroinvertebrate diversity is different among waterfowl brood-rearing wetlands in two landscapes (forested and agricultural) in northern Maine.
- 2) Relate invertebrate diversity and productivity to wetland water chemistry, periphyton production, vegetation structure, and wetland morphology.
- 3) Evaluate the suitability of incorporating these data in a Geographic

## Information System.

**SCOPE:** During the field seasons of 1993-1996 selected wetlands in each landscape were sampled for macroinvertebrates using several techniques (cylinder sampler, activity traps, sweep nets). Data on invertebrates were related to wetland features, including water chemistry and chlorophyll-a. Hypotheses of differences in variables between forested and agricultural landscapes were tested.

**PROJECT STATUS:** All requirements for the Ph.D. degree (in Wildlife Ecology) were completed in August 1997. The abstract follows:

Research comparing three aquatic sampling methods, a comparison of macroinvertebrate biomass and diversity in ponds between agricultural and forested areas in Aroostook County, and a review of the species of predaceous diving beetles in Maine were performed from 1993 through 1995.

I compared abundance, biomass, caloric content and non-species diversity of macroinvertebrates among 1.2 L. horizontally-oriented activity trap, 1 m long drag D-frame aquatic net and 0.2 m<sup>2</sup> area cylinder samples. The mean numbers of insects/trap for 50 matched samples were greater ( $P \leq 0.05$ ) for a cylinder sampler and D-frame aquatic net than in an activity trap. Number of taxa and size of taxa in samples from a cylinder sampler were more similar to sweep net samples than those from an activity trap. The cylinder sampler captured 75 genera from 7 orders of insects, the sweep net 60 genera from 6 orders, and the activity trap 35 genera from 5 orders. Activity traps captured a greater ( $P \leq 0.004$ ) percent of adult Coleoptera, Acariformes, and Arhynchobdellida than sweep nets that captured more Diptera, Ephemeroptera, Hemiptera, Trichoptera, Amphipoda, Gastropoda, and Bivalvia. A greater percentage of beetles than other insects were captured in activity traps as the length of time the trap was deployed increased beyond 24 hr. Ranks of fourteen ponds based on activity trap and sweep net samples were not correlated for insect abundance ( $\rho = -0.14$ , biomass ( $\rho = -0.09$ ), or calories ( $\rho = -0.17$ ). Activity trap and sweep net samples provide different information about the aquatic macroinvertebrate assemblages inhabiting wetlands.

I compared macroinvertebrate, amphibian, and fish abundance in ponds between an area with  $> 42\%$  agricultural land-use (AGR) and an area with  $\leq 42\%$  (FOR). Seven orders, 46 families, and 99 genera of macroinvertebrates were captured; 9 families and 20 genera were unique to the FOR area, and 6 families and 17 genera were unique to the AGR area. An assemblage of snails, Planorbidae; mayflies, Caenidae; and beetles, Haliplidae identified by Detrended Correspondence Analysis was characteristic of ponds from the AGR area. The mean abundance ( $\bar{x}$ ) of insects was greater ( $P \leq 0.05$ ) in the FOR area than in the AGR area; however, the number of calories of insects and Shannon-wiener non-species diversity indices was not different between areas. Pathway analyses showed that nutrients explained different amounts of the variation in periphyton biomass and macrophyte cover within the AGR and FOR areas, and at the regional scale.

Locations, habitat descriptions, and collection dates are listed for new records of 4 genera and 12 species of predaceous diving beetles (Coleoptera: Dytiscidae) in Maine. Previously, 17 genera and 53 species of the aquatic beetle family Dytiscidae were reported from Maine.

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**EFFECTS OF LAND USE AND LANDSCAPE PATTERN ON  
BIRD DISTRIBUTION PATTERNS IN NEBRASKA FARMLAND:  
A STUDY AT MULTIPLE SPATIAL SCALES**

*Investigator:* J. G. Poulsen

*Advisors:* R. J. O'Connor, Chairperson  
M. L. Hunter  
J. R. Gilbert  
F. A. Drummond  
K. J. Boyle

W. A. Halteman

*Cooperators/  
Project  
Support:* United States Department of Agriculture -  
Agricultural Research Service

*Objectives:*

- 1) Test an extant model predicting bird species richness of windbreaks.
- 2) Examine the effect of habitat class aggregation in predictions of bird community components.
- 3) Determine the spatial scale at which variance in bird community compositions is best explained.

**SCOPE:** The effect of land use and landscape pattern upon patterns of breeding bird communities in Nebraska farmland is explored.

The decline of many wild flora and fauna species has been severe in agroecosystems around the world. In Europe and North America, changes in abundance of species and communities of the fauna and flora during the past two or three decades have been associated with the intensification of farming practices, and similar patterns have been suggested for Asia and Australia. Since about 50% of the earth's terrestrial ecosystems is managed for agriculture, including open range and highly managed pastures, biodiversity also needs to be maintained and enhanced in agroecosystems.

Bird distribution patterns are affected directly by the methods of management of non-crop areas (e.g., hedgerows and adjacent natural habitat), and at a larger scale by the agricultural landscape structure. Landscape structure and management of non-crop areas are in turn affected by agricultural practices. Only a few studies have however looked at landscape level patterns of agricultural practices, and distribution of crop versus non-crop land on bird species communities.

Nebraska has been chosen to be a case study to test a Bird Species Richness Index (BSRI) model in the Great Plains. The model predicts wildlife species richness in shelterbelts on the basis of specific habitat variables: foliage height diversity, number of snags/ha, average height of the tallest shelterbelt row, and shelterbelt size.

It has also been asserted that the BSRI model for windbreaks could potentially be used to explain bird species richness at the larger farm or landscape level. A larger area (65 ha), in which the windbreak was located, was therefore also surveyed. This allows an investigation of how bird community patterns in the windbreak was related to that in the larger area. The implications of this upon the wider applicability of the BSRI model is investigated.

A separate study was also conducted, designed experimentally to compare bird community patterns in heterogeneous and homogeneous farmland in several areas of Nebraska. This study was conducted at several spatial scales.

**PROJECT STATUS:** All requirements for the Ph.D. degree (in Wildlife Ecology) were completed in May 1997. The abstract follows:

The effect of land use and landscape pattern upon birds in Nebraska farmland is explored. Chapter 1 summarizes the literature on the impact of agricultural activities upon birds. In Chapter 2, I examine the relationship between breeding birds and spatial and vegetative characteristics of windbreaks. A habitat suitability index model was found to fail in predicting species richness in windbreaks. I also compared the patterns of the bird community in the windbreaks and the 65-ha areas to examine 1) the relationship between the number of breeding bird species recorded within the windbreaks and the land use and other landscape metrics of the quarter-section (65 ha) in which the windbreak was located, and 2) whether the habitat suitability index model could be used as a predictor of the birds in the 65-ha areas. Observed and predicted species richness in the windbreaks were not related to the land use and landscape variables of the 65-ha areas, indicating that the environmental quality of the windbreaks was independent of its landscape context. Bird species richness of the 65-ha areas was not related to that of the windbreak, particularly so in most wooded

areas. This masked guild-specific responses: most wooded areas lacked most forest-edge and forest-interior species in the windbreak, and there were fewer grassland-edge species at windbreaks in most wooded sites.

Chapter 3 examines the extent to which patterns of the breeding bird community within 65-ha units of farmland were determined by land use and landscape heterogeneity. There were more species in areas with more woodland-cover and patchy landscape structure, but there were fewer grassland-field species in such areas.

Chapter 4 evaluates the impact of landscape heterogeneity upon bird community patterns. The total number of bird species and the rate of species accumulation with increasing spatial extent were both higher in heterogeneous areas than elsewhere. Grassland-edge (including rare, area-sensitive) species benefitted substantially from higher edge density in heterogenous areas, while grassland-field species occurred mostly in homogeneous areas.

### HABITAT RELATIONS OF SELECTED SEABIRDS: BREEDING PATTERNS IN SPACE AND TIME

*Investigator:* C. M. Johnson

*Advisors:* W. B. Krohn, Chairperson  
R. L. Dressler  
J. R. Gilbert  
W. E. Glanz  
A. E. Hutchinson  
J. R. Moring

*Cooperators/  
Project  
Support:* USGS Biological Resources Division  
U.S. Fish & Wildlife Service  
University of Maine -  
Department of Wildlife Ecology  
Maine Department of Inland Fisheries and Wildlife  
Maine Office of Geographic Information Systems  
Maine Department of Marine Resources  
Maine Geological Survey

*Objectives:*

- 1) Develop a database detailing historical surveys of Maine's seabird nesting islands, and measure current use of selected islands by three species of breeding seabirds.
- 2) Compare current use and nest density data for seabirds with historical patterns of island use to assess the temporal stability of breeding sites.
- 3) Evaluate environmental, interspecific, and anthropogenic factors affecting the distribution of breeding seabirds in Maine and develop habitat models.
- 4) Examine temporal and spatial patterns in island use by several seabird species and identify important habitats, or mosaics of habitat types, for long-term conservation of selected seabirds.

**SCOPE:** The Maine coastline encompasses several thousand islands and ledges; however, only a small percentage of these are used by nesting seabirds. While several studies have looked at nest site habitat selection along the Maine coast on individual islands, there is a paucity of information regarding landscape-level habitat selection. We are developing a spatial database of landscape-level environmental factors and potential anthropogenic stressors associated with individual islands in mid-coastal Maine. These data will be

used, in conjunction with historic seabird surveys, to examine the temporal and spatial patterns of seabird colonies and their use of insular and aquatic habitats in coastal Maine.

As part of this study, we will assess annual (1993-97) variability and long term temporal patterns of island use for selected seabird species, using survey data collected periodically over the past 80 years. Habitat models will be developed in order to determine the importance of various environmental, social and anthropogenic factors in determining site use. Finally, patterns of occupancy will be examined at both local and regional scales to assess the overall value of particular islands, island groupings, and surrounding habitats to Maine's colonial seabirds.

*PROJECT STATUS:* Habitat models have been created for six of Maine's more common seabirds: the Black Guillemot, Common Eider, Double-crested Cormorant, Greater Black-backed Gull and Herring Gull. I have also developed temporal habitat models for the Double-crested Cormorant to look at potential changes in habitat use over a 50-year period. Nest count data for the last four years are currently being analyzed to determine peak nesting times for cormorants and gulls and to assess what surveying procedures might efficiently be used to determine long-term population trends for these birds.

*FUTURE PLANS:* Over the coming months, I will be finalizing data analyses regarding the temporal patterns of habitat use in coastal Maine. A draft of my thesis will be completed in early 1998.

## 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  
U.S. Forest Service  
Cooper Ornithological Society  
American Wildlife Research Foundation

*Objectives:*

- 1) To describe changes in breeding bird communities on sites that are experimentally harvested (with selection silviculture) and unharvested.
- 2) To 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 that is managed for long-term ecosystem research. 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:* I have captured and banded approximately 300 birds each summer from 1995-1997, over 150 of which were individually colormarked. 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 of 9 sites, including two sites that were harvested two years earlier. Next summer (1998) will be my final data collection period. By then all harvesting will be finished, so I will estimate returns on 6 treated sites and 3 controls. Preliminary return rates for Ovenbirds ( $n=90$ ) have consistently been just below 30% per year, whereas Hermit Thrushes ( $n=100$ ) are more variable, with return rates ranging from 25-50%. Spot-mapping data have shown very subtle changes in songbird communities on harvested sites, including small decreases in densities of some forest-interior species.

*FUTURE PLANS:* During the winter of 1997/98, the third and last triplet will be harvested. Next summer (1998) will be the last season of intensive spot-mapping and color-banding on all nine research areas. Statistical analyses will begin in fall of 1998, including return rates to harvested versus unharvested areas, distances between territories of successive years, and return rate decay functions one, two and three years after harvest. These data will yield valuable information on post-disturbance breeding dispersal of adult Ovenbirds, Hermit Thrushes, and possibly other Neotropical migrant songbirds.

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

<i>Investigator:</i>	C. R. Foss
<i>Advisors:</i>	M. L. Hunter, Jr., Chairperson W. A. Halteman W. B. Krohn R. J. O'Connor R. S. Seymour
<i>Cooperators/ Project Support:</i>	University of Maine Switzer Environmental Fellowship Program McIntire-Stennis U.S. Fish & Wildlife Service - Lake Umbagog National Wildlife Refuge Neotropical Migratory Bird Program USDA Forest Service N.H. Fish & 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 50x50m-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 addressing the pilot year findings, use of fledgling surveys in combination with point counts, and comparison of behavior mapping and point count results, and addressing analysis methods and analyst variability for behavior map interpretation will be priorities for the 1997-98 academic year. Plans for the 1998 field season are pending evaluation of 1995-97 behavior-mapping data.

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## WILDLIFE RESOURCES - OTHER THAN MIGRATORY BIRDS:

### RELATIONSHIPS BETWEEN MARTEN PREY ABUNDANCES AND MICROHABITAT CHARACTERISTICS IN NORTHERN MAINE

**Investigator:** H. J. Lachowski

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

**Cooperators/  
Project  
Support:** University of Maine -  
Department of Wildlife Ecology  
McIntire-Stennis

**Objectives:**

- 1) Document seasonal food habits of marten on our study site in northern Maine.
- 2) Estimate small mammal densities in different forest types classified based on overstory type, tree height, canopy closure, and stocking den (mature mixedwood, mature hardwood, mature softwood, regenerating forest, and stands with severe spruce-budworm damage), and test for differences in densities of preferred prey species across types.
- 3) Evaluate which microhabitat characteristics are the best predictors of small mammal densities across those habitats.

**SCOPE:** Recent research on habitat selection by American marten (*Martes americana*) in Maine indicates disproportionately high use of stands affected by spruce-budworm. This may result from large volumes of coarse woody debris, an important habitat feature for marten, in these stands. Small mammal populations have been shown to be positively correlated with coarse woody debris. Thus, the reason that marten select microhabitats with large volumes of coarse woody debris might be related to prey abundance and availability.

We investigated the relationship between microhabitat characteristics and densities of prey species that comprise the majority of the marten diet. Marten scats collected over the past 6 years were analyzed for percent occurrence of food items. Small mammals were live-trapped in 5 habitat types (mature mixedwood, mature hardwood, mature softwood, regenerating forest, and stands with severe spruce-budworm damage). Microhabitat characteristics were measured on the trapping grids and then analyzed to determine if small mammals demonstrate habitat selection at the stand level (based on overstory type) or the microhabitat level.

**PROJECT STATUS:** All requirements for the M.S. degree (in Wildlife Ecology) were completed in May 1996. The abstract follows:

American marten (*Martes americana*) are thought to be associated with forest and woodland landscapes that include mature, conifer-dominated forests. However, in a forest preserve in northern Maine, marten extensively use mature mixed coniferous-deciduous and deciduous dominated stands, as well as

regenerating stands defoliated by spruce budworm (*Choristoneura fumiferana*). Small mammal populations have been shown by previous researchers to be positively correlated with volume of coarse woody debris and preference by marten for mature conifer stands has been linked to higher prey densities and higher amounts of coarse woody debris. Thus, marten may select microhabitats with large volumes of coarse woody debris because of prey abundance and availability. I examined marten food habits, overstory habitat selection by small mammals, and microhabitat characteristics associated with small mammals captures.

Percent occurrence of food items was quantified for 219 individual marten scats. Red-backed voles occurred in 45.5% of scats and deer mice in 32.3%. Snowshoe hare and red squirrel were more frequently consumed in winter and occurred in 35.3% of winter scats. Berries were the principle component of the marten diet (> 71% occurrence in scats) during summer and fall. Marten seemed to select mice and voles in proportion to their relative abundance. Proportionately, red-backed voles and deer mice, respectively, accounted for 62.7% and 37.3% of mice and vole occurrences in scats and comprised 66.8% and 32.1% of mice and vole captures.

Small mammal populations experienced a 67% decline between 1995 and 1996. During both years, deciduous and mixed coniferous-deciduous stands had greater small mammal abundance than coniferous and regenerating stands. Abundance in budworm-killed stands declined only 27%, whereas regenerating habitat seems to be a poor habitat for mice and voles (88% decline). Snowshoe hare density was greater in regenerating and budworm-killed stands than either deciduous or mixed stands. Red squirrels were ubiquitous in distribution across the five forest cover types. Budworm-killed stands may be important to marten because of their prey base and abundance of potential resting sites (i.e., snags for summer thermoregulation and ground structure for winter subnivean access).

Small mammal abundance was higher in mature stands than in regenerating or budworm-killed stands and was correlated with several variables that reflected stand maturity (canopy cover, average dbh, volume of stumps). In this study, small mammals did not seem to select habitat based on structure or volume of coarse woody debris, perhaps because in northern Maine sufficient structure was available in all mature stands to satisfy small mammal habitat requirements.

Studies in northern Maine suggest that marten may select complex horizontal and vertical structure found in mature and insect defoliated stands. Marten also use mixed and deciduous stands, possibly because of higher prey abundances compared to regenerating stands. Small mammals may also be associated with structure associated with mature forest stands. Further research needs to address thresholds of structure required by small mammals. Increasing structural diversity in regenerating stands may increase small mammal abundances, which in turn may encourage greater marten use.

## POPULATION ECOLOGY OF FEMALE BLACK BEARS IN MAINE

*Investigator:* C. R. McLaughlin

*Advisors:* R. J. O'Connor, Co-chairperson  
G. J. Matula, Jr., Co-chairperson  
W. A. Halteman  
D. J. Harrison  
W. B. Krohn

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

*Objectives:* 1) Describe the survival, fecundity, and population densities of female black bears living in MDIFW study areas from 1982-1990.

- 2) Assemble the above parameter estimates into a predictive population model.

*SCOPE:* Survival and reproductive data from 1982-1996 have been analyzed, and a predictive computer model has been constructed, with most sensitivity testing completed. The model is individual-based, and of expanded Leslie-matrix design. It contains 25 year classes and 6 reproductive categories. Within a simulation year, each bear is assigned to a reproductive category according to age, prior reproductive history, and probabilities of cub production and litter survival. Density-dependent reduction in survival and environmental stochasticity can be accommodated. A strong nutritional relationship with reproductive success, and reduction of subadult survival following food stress are included, allowing study of the influence of fluctuating food planes on population dynamics. The model's annual cycle includes three periods: denning, spring-summer, and fall. Annual survival is the product of survival during each period; cub production is generated at the start of the denning period. Hunting survival can be specified as year class specific survival probabilities, or as year class specific harvests.

Female bear densities have been estimated from plots of telemetry locations for each of 3 study areas at 3 points in time: 1985, 1989, and 1995. These estimates are being used to validate model performance.

*PROJECT STATUS:* A doctoral dissertation is anticipated in early 1998.

*FUTURE PLANS:* Once the thesis has been completed, the results derived from the Bradford study area in central Maine will be assessed as to the need for further modifications of the model. Data from the Stacyville study area in northcentral Maine have been reserved as an independent dataset to permit further refinement and testing of the model should this prove necessary.

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## EFFECTS OF TIMBER HARVESTING AND TRAPPING ON HABITAT SELECTION AND POPULATION CHARACTERISTICS OF AMERICAN MARTEN IN NORTHERN MAINE

*Investigator:* D. C. Payer

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

*Cooperators/  
Project  
Support:* Maine Department of Inland Fisheries and Wildlife  
Federal Aid in Wildlife Restoration Project W-82-R-II-368  
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  
Bowater-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, 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 undoubtedly 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 sustainable opportunities for exploitation of forest products (i.e., timber and fur). We will attempt to isolate these effects by concurrently studying habitat associations and population characteristics in three contiguous sites in northcentral Maine. The sites differ in regards 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. Habitat choice by martens will be evaluated at three spatial scales (position of the home range on the landscape, selection for overstory characteristics within the home range, and use of microhabitat features within selected occupied areas) on each of the three study sites.

**PROJECT STATUS:** We radiocollared 48 (21 F, 27 M), 55 (22 F, 33 M), 76 (28 F, 48 M) and 51 (18 F, 33 M) martens on the three study sites in 1994, 1995, 1996 and 1997, respectively. Approximately 11,000 relocations have been obtained via ground and aerial telemetry through 30 September 1997. In 1995 we sampled microhabitat features in 360 randomly placed plots in areas receiving high, low or no marten use-intensity within the industrial forest. The protocol was repeated in 1996 on 288 plots in areas receiving high and low use within the forest reserve.

Preliminary results from multivariate analysis suggest that, within the industrial forest, areas used by marten were distinguished from unused areas primarily by characteristics related to stand maturity, i.e., used areas had greater snag volume and tree height. In contrast, unused areas had a more open overstory canopy and denser growth in the shrub layer. Relatively high hardwood basal areas and deep litter characterized areas that received high marten use. These relationships were consistent with habitat associations of preferred small mammal prey species, as described in a companion study. Thus, marten appeared to be selecting habitat to maximize access to prey. We further conclude that forestry practices that preserve characteristics of stand maturity in harvested stands (e.g., partial harvesting and snag retention) will likely benefit marten and urge additional research into the effects of partial harvesting of forests on habitat quality for marten.

In contrast to the industrial forest, we detected few differences between areas receiving high vs. low use by marten in the forest reserve. Factors other than the habitat characteristics we studied (e.g., intraspecific competition, access to mates, prey abundance) may influence choice of microsites by marten in areas where nearly all of the forested stands include mature trees, and where human harvesting has little influence on marten demographics. We are currently analyzing data comparing habitat choice and population characteristics of marten among the three treatment areas.

**FUTURE PLANS:** Radiocollars were removed from martens in the forest reserve in October 1997. Radiocollared marten within the industrial forest will be monitored weekly through April 1998. Scheduled project completion date is December 1998.

## PREY SELECTION BY HARBOR AND GRAY SEALS ON COMMERCIAL FISH SPECIES

*Investigator:* A. S. Williams

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

*Cooperators/  
Project  
Support:* National Marine Fisheries Service  
National Biological Service  
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:* Completion is scheduled for May 1998.

## FACTORS AFFECTING NESTING SUCCESS OF THE EASTERN WILD TURKEY IN CONNECTICUT: NEST ATTENTIVENESS, NESTING HABITAT, CLIMATIC CONDITIONS, 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/* National Wild Turkey Federation -

*Project Support:* 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.
- 4) Evaluate the influences of weather on nest attentiveness by hen turkeys.

*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 size) will be quantified to determine differences between successful and unsuccessful nests using aerial photographs of the nesting areas. Daily weather data such as precipitation and temperature were obtained from NOAA weather stations near the study sites and we will evaluate associations between weather variables and patterns of nest attentiveness.

*FUTURE PLANS:* Field work has been completed and data analysis is proceeding. Thesis completion is anticipated by December 1997.

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### REDBACK SALAMANDER (*PLETHODON CINEREUS*) HABITAT PREFERENCES IN A MAINE OAK-PINE FOREST

*Investigator:* L. M. Monti

*Advisors:* M. L. Hunter, Jr.  
I. J. Fernandez  
R. J. O'Connor

*Cooperators/  
Project* Holt Woodlands Research Foundation  
University of Maine -

*Support:* Department of Wildlife Ecology

- Objectives:*
- 1) Evaluate the use of artificial refugia as a valuable method for the assessment of redback salamander populations.
  - 2) Assess how microhabitat variables affect the distribution and abundance of the redback salamander in an oak-pine forest, with special emphasis placed on coarse woody debris.

**SCOPE:** The redback salamander (*Plethodon cinereus*) is a very common species of terrestrial amphibian. Monitoring its population density and establishing its habitat preferences are important for at least two reasons. First, this species may play a key role in ecosystem function, in part through its sheer abundance. Second, the sensitivity of amphibians to their environments might render them useful indicators of overall ecosystem health. In order to monitor the population density of redback salamanders, accurate censusing methods must be available. Current methods are not well suited to this species or to repetitive measurements. A relatively new technique, involving coverboards placed on the forest floor and monitored at regular intervals, has been utilized for the past eight years at the Holt Forest. However, its efficacy has not yet been closely examined, nor have the data been used to establish habitat preferences of this species. This study attempted to evaluate the coverboard method and use the data obtained with this technique to determine the habitat preferences of that species and answer specific questions about certain habitat components.

**PROJECT STATUS:** The first field season involved the establishment of 60 new "salamander stations" modelled after the 60 already in use at the Holt Forest. All 120 were monitored throughout the summer. In order to determine which portion of the salamander population was using the stations, individuals found at the new stations were toe-clipped to allow for recognition of individuals. To determine habitat preferences, the vegetation and the soil at each of the 60 older stations were characterized. This data set and the data resulting from six years of salamander counts at these stations were used to look for correlations between salamander abundance and habitat variables.

For the second and final field season, specific habitat and methodological variables were investigated more closely. Experiments to determine the pH preference of redbacks, the effects of soil moisture on salamander use of the stations, and the impact of coarse woody debris on apparent population density were performed. An experiment designed to assess whether aging the cover items used at the stations was necessary to ensure use by salamanders was also performed.

After analyzing the data, a model correlating salamander abundance and habitat variables was produced. The model was unfortunately weak. The more specific experiments produced interesting results, revealing seasonal abundance patterns that apparently were not due to soil moisture changes. A lack of sensitivity to low pH exhibited in the field was not borne out in the lab. The effects of coarse woody debris on apparent abundance was ambiguous. Finally, the age of the cover objects was not important, but newly established stations experienced little use. The cover board method was found to be non-destructive, efficient, and safe. However, it is still not ideal for some uses such as assessing habitat preferences.

**FUTURE PLANS:** Analysis and evaluation are complete. A final paper is expected by January 1997.

## NUTRITIONAL AND PHYSIOLOGICAL EFFECTS OF PLANT SECONDARY METABOLITES CONSUMED BY WHITE-TAILED DEER DURING WINTER

*Investigator:* J. W. Schneider

*Advisors:* F. A. Servello, Chairperson  
W. B. Krohn

J. M. Rhymer  
 B. J. W. Cole  
 M. R. Stokes

*Cooperators/  
 Project  
 Support:* McIntire-Stennis

*Objectives:*

- 1) Determine the effects of plant secondary metabolites in forages of white-tailed deer on foraging energetics and detoxification costs.
- 2) Evaluate the effectiveness of urine indices for predicting diet quality and nutritional status for white-tailed deer consuming natural forage diets.
- 3) Determine the interspecific variation of plant secondary metabolite levels in common forages consumed by white-tailed deer during winter.
- 4) Determine the metabolic and energetic responses of deer to increasing concentrations of selected phenolic and terpenes compounds.

*SCOPE:* Research on foraging ecology of vertebrate herbivores has recently focused on the influence of plant secondary metabolites because of effect these compounds have on forage selection and nutritional value. It has been suggested that forage selection by ruminants may be determined in part by the rate of detoxification or elimination of plant defensive chemicals, but there is little data on energetic costs of detoxification in deer. During winter in northern region, white-tailed deer are exposed to diets which vary in types and concentrations of plant secondary metabolites. The primary goal of this study is to understand the metabolic and energetic costs of ingested phenolic and terpene compounds in winter diets of white-tailed deer in Maine. Experiments will be conducted using captive white-tailed deer fed natural forage diets and commercial pelleted diets formulated with specific secondary metabolites. Secondary goals of this study are to evaluate the use of detoxification metabolites as indices of diet quality and to evaluate several existing urinalysis methods for evaluating the nutritional status of deer during winter.

*PROJECT STATUS:* A series of digestion trials with captive deer fed diets of natural winter forages were completed in February-March 1996 to 1) test the use of glucuronic acid in urine as an index of diet quality, 2) evaluate detoxification costs, and 3) evaluate urea nitrogen and potassium (as ratios to creatinine) in urine as indexes of nutritional status. Glucuronic acid excretion was elevated on conifer diets and greatest on a balsam fir diet suggesting that this metabolite has potential as an indicator of diet composition and quality. Urea nitrogen:creatinine ratio was not affected by the potential biases of diet composition and food intake level. Potassium:creatinine ratio was a poor indicator of food intake.

*FUTURE PLANS:* Analysis of energetic costs of detoxification are in progress. Additional experimental work on this project has been terminated with the resignation of JWS to take a position at Pennsylvania State University.

## INFLUENCE OF PARTIAL HARVESTING ON AMERICAN MARTEN AND THEIR PRIMARY PREY

*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) Compare changes in use of the landscape by marten before and after partial harvesting.
  - 2) Document stand-scale patterns of habitat selection by marten whose home ranges have been influenced by partial harvesting and compare to patterns of habitat selection of marten in areas without partial harvesting.
  - 3) Estimate small mammal and snowshoe hare densities in partially harvested stands and compare with other forest types.
  - 4) Document and compare overstory, understory, and coarse woody debris characteristics among partially harvested stands and uncut, mature forest stands.

**SCOPE:** Habitat loss has been cited as a major cause of extinction of American marten (*Martes americana*) from its original range. Research conducted on the effects of forest harvesting on populations of American marten have focused largely on clearcutting. Forest practices in Maine are currently shifting from a reliance on clearcutting to partial harvesting (97% of all Maine timber harvesting in 1996 was partial harvesting); however, few studies have determined use of partially harvested areas by marten. Thus, we will investigate the effects of partial harvesting on patterns of selection by marten at the landscape and stand scales.

Choice of forest stands by marten is also associated with food abundance, and it has been suggested that marten populations are proximally food regulated. We will compare small mammal densities in partially harvested stands to other forest types and relate densities to microhabitat features, including coarse woody debris. Small mammals will be live-trapped on 20 trapping grids in 6 forest types (n=3 mixed partial harvest, 4 deciduous partial harvest, 7 uncut mature-mixed, 2 uncut mature-hardwood, 2 uncut mature-softwood, and 2 regenerating clearcut). Microhabitat features will be measured at the trapping grids and will be used to evaluate the influence of stand and microsite variables on the abundance of small mammals. 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.

**PROJECT STATUS:** We currently have 11 (3 F, 8 M) radiocollared marten whose home ranges comprise >20% partially harvested stands. Approximately 575 telemetry locations have been obtained from ground and aircraft. Small mammal trapping was conducted in partially harvested and mature stands and 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 7,680 trap-nights. Microsite characteristics were sampled at 112 locations distributed across 7 grids used to census small mammals. Grids were located in forest stands that were partially harvested during 1991-1995.

**FUTURE PLANS:** We will attempt to capture and radiocollar all resident martens with home ranges that comprise partially harvested stands on our 165 km<sup>2</sup> study site during spring 1998. Radiolocations on radiocollared animals will be obtained during winter 1998, summer 1998, and winter 1999. Small mammal trapping will be repeated during summer 1998. At the end of the leaf-off season (spring 1998), counts of snowshoe hare pellets will be conducted on 5 m x 30 cm transects on the innermost 12 trapping stations within each grid used to census small mammals. Project completion is scheduled for May 1999.

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PROFESSIONAL AND PUBLIC TALKS GIVEN, AND AWARDS**

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- O'CONNOR, R.J., M.T. JONES, D. WHITE, C. HUNSAKER, T. LOVELAND, B. JONES, and E. PRESTON. 1996. Spatial partitioning of environmental correlates of avian biodiversity in the conterminous United States. Biodiversity Letters 3:97-110.
- O'CONNOR, R.J., and M.T. JONES. 1997. Using hierarchical models to index the ecological health of the nation. Transactions 62<sup>nd</sup> North American Wildlife and Natural Research Conference: 501-508.
- RAYMOND, K.S., and F.A. SERVELLO. 1997. Nutritional quality of glyphosate-injured browse for moose in Maine. Alces 33:181-185.
- RAYMOND, K.S., F.A. SERVELLO, D. GRIFFITH, and W.E. ESCHHOLZ. 1996. Winter foraging ecology of moose on glyphosate-treated clearcuts in Maine. Journal of Wildlife Management 60(4):753-763.
- RHYMER, J.M., and D. SIMBERLOFF. 1996. Extinction by hybridization and introgression. Annual Review Ecology & Systematics 27:83-109.
- SPOHR, S.M., H.J. KILPATRICK, and G.G. CHASKO. 1997. Coyote depredation of a mute swan nest. Canadian Field-Naturalist 111(4):258-259.
- STUTCHBURY, B., W. PIPER, D. NEUDORF, S. TAROF, J. RHYMER, G. FULLER, and R. FLEISCHER. 1997. Correlates of extra-pair fertilization success in hooded warblers. Behavioural Ecology and Sociobiology 40:119-126.
- WHITCOMB, S.D., F.A. SERVELLO, and A.F. O'CONNELL. JR. 1996. Patch occupancy and dispersal of spruce grouse along the edge of its range in Maine. Canadian Journal of Zoology 74:1951-1955.

#### TECHNICAL AND SEMI-TECHNICAL PUBLICATIONS

- BLACKWELL, B.F., and W.B. KROHN. 1996. The Double-crested Cormorant in Maine - Part II. Is the cormorant a major predator of commercial fishes? Maine Fish and Wildlife Magazine 38(3):8-11.
- BOONE, R.B., and W.B. KROHN. 1997. Species occurrence: what, why, and where? Gap Analysis Bulletin No. 6.
- CARTWRIGHT, M., M. COLE, and J.R. MORING. 1997. Where'd they go, anyway?: tracing black bass movements. Maine Fish and Wildlife Magazine 39(1):12-15.

- CHAPIN, T.G., D.J. HARRISON, D.D. KATNIK, D.M. PHILLIPS, and E.C. YORK. 1996. Influence of landscape pattern, forest type, and forest structure on use of habitat by marten in Maine. NCASI Technical Bulletin No. 728, Research Triangle Park, North Carolina. 78pp.
- GALLAGHER, M., and J.R. MORING. 1997. The status of redbfin pickerel *Esox americanus americanus* and possible hybridization with native chain pickerel *E. niger* in Maine waters: a progress report. Thirteen unnumbered pages in R. Soderberg (editor), 1996 Warmwater Workshop Proceedings: Esocid Management and Culture. American Fisheries Society and Pennsylvania Fish and Boat Commission.
- HAGAN, J.M, and R.B. BOONE 1997. Harvest rate, harvest configuration, and forest fragmentation: a simulation of the 1989 Maine Forest Practices Act. Manomet Center for Conservation Sciences, Division of Conservation Forestry. Report No. MCDCE-97001.
- HARRISON, D.J. 1996. Effects of timber harvesting and trapping on population characteristics, habitat selection, and area occupancy by American martens in northern Maine: the Baxter Park study. Pages 37-41 in W. Ostrofsky (editor). 1996 Annual Report and Research Summary of the Cooperative Forestry Research Unit. Misc. Rep. 401, Maine Agric. Forest Exp. Station, University of Maine, Orono.
- HARRISON, D.J., and T.G. CHAPIN. 1997. An assessment of potential habitat for eastern timber wolves in the northeastern United States and connectivity with occupied habitat in southeastern Canada. Wildlife Conservation Society Working Paper No. 7, Bronx, New York. 12pp.
- HARRISON, D.J., and T.B. WIGLEY. 1997. Study of American marten in Maine exploring management options. National Council of Paper Industry for Air and Stream Improvement, Clemson, SC. 2pp.
- KROHN, W.B., and B.F. BLACKWELL. 1996. The Double-crested Cormorant in Maine - Part I: Concerning a study to determine whether or not this controversial Maine nester is a major predator of Atlantic salmon smolts in the Penobscot River. Maine Fish and Wildlife Magazine 38(2):8-12.
- KROHN, W.B., and R.D. KELLY, JR. 1997. A conservation and public lands database for Maine: project history and database documentation. Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono. 16pp.
- LONG, R.A., D.J. HARRISON, and A.F. O'CONNELL, JR. 1997. Annual survival and cause-specific mortality of white-tailed deer fawns on Mount Desert Island, Maine. U.S. National Park Service Technical Report NPS/NESO-RNR/NRTR /97-04. 56pp.
- MADDEN, A., and J.R. MORING. 1996. The good, the bad, and the ugly: black crappies in Maine. Maine Fish and Wildlife Magazine 38(4):19-22.
- MORING, J.R. 1997. The legacy of Julia and Emelie Melville to theater of the American West. Journal of the West 35(2):24-31 (a refereed history journal).
- O'CONNOR, R. J. 1996. Re-thinking the role of peer reviewers: Letter. Chronicle of Higher Education, December 6, 1996, p. B3.
- O'CONNOR, R.J. 1997. Review of: R.J. Fuller (1995) Bird life of woodland and forest. Cambridge University Press. Wilson Bulletin 109:185-186.

SAYEN, J. and D.J. HARRISON. 1997. Study evaluates potential wolf habitat and travel corridors in northeastern U.S. Northern Forest Forum 5(4):14.

#### THESES AND DISSERTATIONS

ALLEN, A.P. 1996. Spatial and anthropogenic gradients in the structure of avian assemblages on lakes. M.S. thesis, University of Maine, Orono, ME. 117pp.

BOOBAR, L.R. 1997. Effects of landscape on macroinvertebrate assemblages in beaver-mediated wetlands, Aroostook County, Maine. Ph.D. dissertation, University of Maine, Orono, ME. 454pp.

BOONE, R.B. 1996. An assessment of terrestrial vertebrate diversity in Maine. Ph.D. dissertation, University of Maine, Orono, ME. 222pp.

CARTWRIGHT, M.A. 1997. Dietary habits of benthic-feeding fishes in a southern Maine salt marsh: evaluation of prey availability and feeding selectivity. Ph.D. dissertation, University of Maine, Orono, ME. 135pp.

JONES, M.T. 1996. Avian spatio-temporal dynamics and the core-satellite species hypothesis. Ph.D. dissertation, University of Maine, Orono, ME. 237pp.

JOYAL, L.A. 1996. Ecology of Blanding's and spotted turtles in southern Maine: Population structure, habitat use, movements, and reproductive biology. M.S. thesis, University of Maine, Orono, ME. 145pp.

LACHOWSKI, H.J. 1996. Relationships between marten prey abundances and microhabitat characteristics in northern Maine. M.S. thesis, University of Maine, Orono, ME. 73pp.

McCRACKEN, K.E. 1996. Seed predation by small mammals on three species of trees in an oak-pine forest ecosystem. Ph.D. dissertation, University of Maine, Orono, ME. 103pp.

POULSEN, J.P. 1997. Effects of land use and landscape pattern on bird distribution patterns in Nebraska farmland: a study at multiple spatial scales. Ph.D. dissertation, University of Maine, Orono, ME. 176pp.

POWELL, M.W. 1997. Modeling the effects of watershed acidification on the speciation and bioaccumulation of mercury in brook trout (*Salvelinus fontinalis*) at the Bear Brook watersheds, Maine, USA. M.S. thesis, University of Maine, Orono, ME. 84pp.

REMLEY, M.O. 1997. Nesting ecology and habitat use of wood turtles in western Maine. Honor's thesis, University of Maine, Orono, ME. 29pp.

#### PROFESSIONAL TALKS PRESENTED

BARTLETT, R.I., J.A. HEPINSTALL, and W.B. KROHN. "Maine wildlife habitats identified from spring versus fall aerial videography." Joint meeting of New England Society of American Foresters, Maine Chapter of The Wildlife Society, and Northeastern Forest Pest Council, Portland, ME, March 12-14, 1997.

- BARTLETT, J.G., and D. MAGEEAN. "Using population and environmental data to address the problem of human dimensions of environmental change." *Geospatial Information Age 1997*. Combined Conference of the American Congress for Surveying and Mapping, American Society for Photogrammetry and Remote Sensing, Resource Technology Institute, and Auto-Carto 13. Washington State Convention Center, Seattle, WA, April 7-9, 1997.
- BOONE, R.B., and W.B. KROHN. "Forest birds and woody plants: Broad-scale habitat relations in the North Maine Woods." Poster presentation at the joint meeting of New England Society of American Foresters, Maine Chapter of The Wildlife Society, and Northeastern Forest Pest Council, Portland, ME, March 12-14, 1997.
- BOONE, R.B., and W.B. KROHN. "Forest birds and woody plants: GIS analysis of broad-scale biogeographic relations." *Second Annual Meeting of the Society of Canadian Ornithologists*, August 7-9, 1997.
- BOONE, R.B., and W.B. KROHN. "Forest birds and woody plants: Broad-scale habitat relations in the north Maine woods." *Seventh Annual Gap Analysis Principal Investigators Meeting*, Reston, VA, August 4-8, 1997.
- BOONE, R.B., and W.B. KROHN. "Broad-scale correlates of vertebrate richness as a biogeographic foundation for Maine Gap Analysis." *Seventh Annual Gap Analysis Principal Investigators Meeting*, Reston, VA, August 4-8, 1997.
- BOONE, R.B., and W.B. KROHN. "Predictability of avian species occurrences and assessing predicted vertebrate distributions from Gap Analysis." *Seventh Annual Gap Analysis Principal Investigators Meeting*, Reston, VA, August 4-8, 1997.
- CRONN, D., J.R. MORING, F. AMAR, and J.M. SHICK. "The Isis Project at the University of Maine." Poster paper presented at the Project Kaleidoscope Conference, Waterville, ME, October 25, 1996.
- DEMAYNADIER, P., and M.L. HUNTER, JR. "Even-aged forest management and amphibians in the Northeast." *Joint meeting of New England Society of American Foresters, Maine Chapter of The Wildlife Society, and Northeastern Forest Pest Council*, Portland, ME, March 12-14, 1997.
- DEMAYNADIER, P., and M.L. HUNTER, JR. "Eastern amphibians and forest age: Lessons for managed forest landscapes." *Fourth Eastern Ancient Forest Conference*, Clarion, PA, June 5-7, 1997.
- DIMAURO, D. "Reproduction of amphibians in temporary pools in industrial forests: A project update." *Maine Association of Wetlands Scientists*, Augusta, February 26, 1997.
- DIMAURO, D. "Natural versus anthropogenic pools: A research update." *Workshop on Locating and Describing Vernal Pools*, University of Maine, Orono, May 21, 1997.
- FOSS, C.R. "Breeding bird communities in mature spruce fir forest: insights from behavior mapping." *First NH-VT Partners in Flight Bird Conservation Conference*, Fairlee, VT, April 12, 1997.
- FOSS, C.R., B.R. STURTEVANT, T.P. SKALING, and M.L. HUNTER, JR. "Breeding bird community composition and nesting success in managed spruce-fir forests of northern New England: Insights from behavior mapping, nest searching, and constant-effort mist netting." *The Wildlife Society National Conference*, Snowmass, CO, September 24-27, 1997.

- GALLAGHER, M., and J.R. MORING. "The status of redbfin pickerel *Esox americanus americanus* and possible hybridization with native chain pickerel *E. niger* in Maine waters: a progress report." The 1996 Warmwater Workshop: Escocid Management and Culture, Mayville, NY, September 25, 1996.
- GALLAGHER, M., and J.R. MORING. "The status of redbfin pickerel *Esox americanus americanus* and possible hybridization with native chain pickerel *E. niger* in Maine waters. The Northeast Fish and Wildlife Conference, Framingham, MA, April 30, 1997.
- GILBERT, J. R. "The role of take-reduction teams in marine mammal management." University of Southern Maine Law School Seminar Series, Portland, October 24, 1996.
- GILBERT, J.R. "Role of the University of Maine's Wildlife Ecology Department." Sportsman's-Landowner's Alliance Meeting, Brewer, July 17, 1997.
- HAGAN, J., and F.A. SERVELLO. "Shifting Mosaic Model: A project to manage industrial forest land in Maine for biodiversity and wood supply." Presented at the Joint Meeting of the New England Society of American Foresters, Maine Chapter of The Wildlife Society, and Northeastern Forest Pest Council. Portland, ME, March 13, 1997.
- HARRISON, D.J. "Habitat selection by American marten at multiple spatial scales." Invited seminar presented to Wildlife Division, Department of Natural Resources, St. Johns, Newfoundland, Canada, March 3, 1997.
- HARRISON, D.J. "Influence of forest harvesting and trapping on populations of American marten." Invited seminar presented to forest industry personnel, Corner Brook, Newfoundland, Canada, March 4, 1997.
- HARRISON, D.J. "Influence of forest harvesting and fur trapping on populations of American marten." Marten Biology and Habitat Guidelines Workshop, Sault Ste. Marie, Ontario, Canada, May 28, 1997.
- HARRISON, D.J. "Influence of landscape composition and configuration on habitat occupancy by American marten." Marten Biology and Habitat Guidelines Workshop, Sault Ste. Marie, Ontario, Canada, May 28, 1997.
- HARRISON, D.J. "Integrating marten and forest management: the Maine experience." Marten Biology and Habitat Guidelines Workshop, Sault Ste. Marie, Ontario, Canada, May 28, 1997.
- HARRISON, D.J. "Microhabitat-, stand-, and landscape-scale habitat selection by marten in Maine." Workshop on Lynx and Marten Management in Eastern Boreal Forests, White Mountain National Forest, Gilead, ME, August 25-27, 1997.
- HARRISON, D.J., and W.B. KROHN. "What do, and don't, we know about lynx and marten in Maine?" Workshop on Lynx and Marten Management in Eastern Boreal Forests, White Mountain National Forest, Gilead, ME, August 25-27, 1997.
- HARTLEB, C.F., and J.R. MORING. "A bioenergetics model for brook trout living in sub-optimal conditions." Annual Meeting of the American Fisheries Society, Monterey, CA, August 28, 1997.
- HARTLEY, M.J. "A meta-analysis of forest cover, edge effects, and artificial nest predation rates." Department of Conservation Biology, Swedish University of Agricultural Sciences, Uppsala, Sweden, September 17, 1997.

- HARTLEY, M.J. "A meta-analysis of forest cover, edge effects, and artificial nest predation rates." Grimsö Wildlife Research Station, Swedish University of Agricultural Sciences, Riddarhyttan, Sweden, September 18, 1997.
- HEPINSTALL, J.A., and S.A. SADER. "Preliminary results from Maine's habitat mapping effort." Seventh Annual Gap Analysis Principal Investigators Meeting, Reston, VA, August 4-8, 1997.
- HUNTER, M.L., JR. "A triad approach to landuse allocation." Harvard University School of Design, Cambridge, MA, October 4, 1996.
- HUNTER, M.L., JR. "Ecosystem structure versus ecosystem function: a foundation for conservation." Department of Wildlife Ecology, University of Maine, Orono, January 27, 1997.
- HUNTER, M.L., JR. "Lessons from paleoecology for conservation biology." Université Laval, Quebec, PQ, Canada, February 14, 1997.
- HUNTER, M.L., JR. "Perspectives on overexploitation of biological diversity." College of Environmental Sciences and Forestry, State University of New York, Syracuse, February 27, 1997.
- HUNTER, M.L., JR. Presented the Dence Memorial Lecture, "The biological dynamics of landscapes," at the College of Environmental Sciences and Forestry, State University of New York, Syracuse, February 27, 1997.
- HUNTER, M.L., JR. "Forest ecosystem management at large scales." Keynote speech at the Forest Ecosystem Management Workshop, Terrace, British Columbia, Canada, May 28, 1997.
- HUNTER, M.L., JR. Organized a round table discussion, "What is natural?" at a Society for Conservation Biology meeting, Victoria, British Columbia, Canada, June 7, 1997.
- HUNTER, M.L., JR. "A biologist's perspective on diversity." Diversity Forum, Rockland, ME, August 6, 1997.
- JONES, M.T. "Avian spatio-temporal dynamics and the core-satellite species hypothesis." Department of Biological Sciences, East Tennessee State University, Johnson City, February 6, 1997.
- JONES, M.T. "Avian metapopulation dynamics." Spring meeting Maine Chapter of The Wildlife Society, Brewer, ME, April 27, 1997.
- KROHN, W.B., and R.B. BOONE. "Biodiversity and the North Maine Woods - what's all the fuss?" Joint meeting of the New England Society of American Foresters, Maine Chapter of The Wildlife Society, and Northeastern Forest Pest Council, Portland, ME, March 12-14, 1997.
- MORING, J.R. "A century of smelt culture (Osmeridae)." Annual Meeting of the American Fisheries Society, Monterrey, CA, August 26, 1997.
- MORING, J.R. "The creation of the Nation's first salmon hatchery at Craig's Brook, Maine." Northeast Fish and Wildlife Conference, Framingham, MA, April 30, 1997.
- MORING, J.R. "Cruises of the U.S. Fish Commission Steamer Albatross off San Diego and other parts of southern California, 1887-1917." Annual meeting of the American Society of Ichthyologists and Herpetologists, Seattle, WA, July 1, 1997.

- MORING, J.R., P. PETRIK, F. AMAR, and C. SLAVIN. "Using the Lewis and Clark Expedition and other case studies for teaching interdisciplinary courses." Inclusive and Interdisciplinary Conference: Building the New Curriculum, Portland, ME, September 11, 1997.
- O'CONNOR, R.J. "Strategies for adaptive environmental monitoring: making sense of bird population responses to pesticide use." Canadian Wildlife Service, Pacific Wildlife Research Centre, Vancouver, BC, November 5, 1996.
- O'CONNOR, R.J. "A risk assessment approach to biodiversity and land use." H. R. MacMillan Lecture in Conservation Biology. Department of Forest Sciences, University of British Columbia, Vancouver, BC, November 7, 1996.
- O'CONNOR, R.J., and M.T. JONES. "Using hierarchical models to index the ecological health of the nation." Paper presented at the Ecosystem Health in Contemporary Landscapes Session, 62nd North American Wildlife and Natural Resources Conference, Washington, DC, March 18, 1997.
- O'CONNOR, R.J. "Developing the tools to meet the nation's monitoring needs." Paper presented at the Third EMAP Research Symposium, Albany, NY, April 8-11, 1997.
- O'CONNOR, R.J. "A prototype national risk assessment for the U.S." IBC Workshop on Ecological risk assessment strategies for an emerging discipline, Boston, MA, July 17, 1997.
- O'CONNOR, R.J. "Review of some computer modeling packages." USEPA Working Group on probabilistic risk assessments for terrestrial ecosystems, Crystal City, VA, August 8, 1997.
- O'CONNOR, R.J. D.M. MAGEEAN, J. BARTLETT, C.T. HUNSAKER, M.T. JONES, and D. WHITE. "Population, land use and climate constraints on continental biodiversity: an integrated assessment model." Population Dimensions of Regional Environmental Change in the U.S., a session of the 1997 Open Meeting of the Human Dimensions of Global Environmental Change Research Community, Laxenburg, Austria, June 12, 1997.
- O'CONNOR, R.J. "An attempt at population risk assessment for birds and pesticides." Birds and Pesticide Effects Workshop, National Audubon Society, New York, NY, June 19, 1997.
- PAYER, D.C., and D.J. HARRISON. "Influence of site-level habitat characteristics on spatial patterns of habitat use by American marten in an industrial forest and a forest preserve in Maine." The Wildlife Society National Conference, Snowmass, CO, September 25, 1997.
- PERILLO, A. "Predictive models for assessing amphibian use of vernal pools in southern Maine: A report on preliminary analyses." Study for the Society of Amphibians and Reptiles Conference, Seattle, WA, June 26, 1997.
- RHYMER, J.M. "Application of molecular markers to ecology and conservation biology." Department of Botany and Plant Pathology, University of Maine, Orono, April 16, 1997.
- RHYMER, J.M. "Evolution and conservation of Hawaiian anatids." In Symposium on The status, ecology and conservation of the Hawaiian avifauna. Cooper Ornithological Society Annual Meeting, Hilo, Hawaii, May 3, 1997.
- RHYMER, J.M. "Application of molecular techniques to wildlife ecology and conservation." Delta Waterfowl & Wetlands Research Station, Delta, Manitoba, Canada, July 7, 1997.

WITHAM, J.W., M.L. HUNTER, and A.J. KIMBALL. "Patterns of avian nest predation near edges in forested landscapes in Maine." Where Do We Stand on Edges Symposium?, The Wildlife Society National Conference, Snowmass, CO, September 24-27, 1997.

#### PUBLIC TALKS PRESENTED

BOONE, R.B., and W.B. KROHN. "Patterns and correlates of vertebrate richness in Maine, with emphasis on breeding birds." Slide presentation to the Maine Chapter of The Nature Conservancy, Brunswick, ME, January 15, 1997.

BOONE, R.B., and W.B. KROHN. "Patterns and correlates of vertebrate richness in Maine, with emphasis on breeding birds." Maine Department of Inland Fisheries and Wildlife Habitat Group, Bangor, February 20, 1997.

BOONE, R.B. "Patterns and correlates of bird richness in Maine." Maine Chapter of The Wildlife Society, Brewer, ME, April 25, 1997.

DANIELS, L. "New studies with American eels." Swan Lake Association, Searsport, ME, September 9, 1997.

DEMAYNADIER, P. Portland Press Herald - interview for an article on current efforts to inventory and conserve rare dragonflies in Maine, August 17, 1997.

GILBERT, J.R. "Seals of Maine." Penobscot County Conservation Association, Brewer, ME, December 5, 1996.

HARRISON, D.J. "Influence of clearcutting on wildlife populations." Panel presenter at public meeting on forestry referendum, Harmony, ME, October 22, 1997.

HARRISON, D.J. "A conservation model for habitat of American martens in Maine." Executive Council, Maine Audubon Society, Ellsworth, ME, November 11, 1996.

HARRISON, D.J. "Forest practices alternatives: implications for wildlife." Guest lecture in NRC 324, University of Maine, Orono, November 25, 1996.

HARRISON, D.J. "Wolf ecology and restoration." Guest lecture in WLE 200, University of Maine, Orono, December 12, 1996.

HARRISON, D.J. "Results from ongoing studies of American marten on industrial forestland in Maine." Seminar presented to Advisory Committee, Maine Cooperative Forestry Research Unit, Orono, ME, January 21, 1997.

HARRISON, D.J. "Predator ecology, research and management." Guest lecture in WLE 100, University of Maine, Orono, January 29, 1997.

HARRISON, D.J. "Ecology and habitat relationships of American martens in Maine." Penobscot Valley Chapter, Maine Audubon Society, February 7, 1997.

HARRISON, D.J. Canadian Broadcasting Corporation (Newfoundland) - live interview on forest practices and marten, March 4, 1997.

- HARRISON, D.J. Bangor Daily News - interview for article on wolves in Maine, March 5, 1997.
- HARRISON, D.J. Portland Press Herald - interview on wolves in Maine, March 20, 1997.
- HARRISON, D.J. Associated Press - interview for article on wolf habitat in Maine, March 21, 1997.
- HARRISON, D.J. National Public Radio - live radio interview on status of lynx in Maine, March 31, 1997.
- HARRISON, D.J. Associated Press - interview for 2nd article on wolf restoration in northeast U.S., April 1, 1997.
- HARRISON, D.J. Maine Times Magazine - interview on wolves in Maine, April 5, 1997.
- HARRISON, D.J. "Results from coyote-deer studies in Acadia National Park: insights into predator social ecology and prey demography." Seminar presented to Department of Wildlife Ecology, University of Maine, Orono, April 7, 1997.
- HARRISON, D.J. Northern Forest Forum - interview on wolf habitat in Maine, April 9, 1997.
- HARRISON, D.J. Canadian Broadcasting Corporation Television (New Brunswick) - forest practices and marten, April 15, 1997.
- HARRISON, D.J. Journal Enquirer, Connecticut - interview for article on coyotes, July 22, 1997.
- HARRISON, D.J. Press Republican, Plattsburg, NY - interview for article on wolf habitat in New York, July 24, 1997.
- HARRISON, D.J. Times Union, Albany, NY - interview for article on wolf habitat in New York, July 25, 1997.
- HARRISON, D.J. "Life table analysis." Guest lecture in WLE 410, University of Maine, Orono, September 17, 1997.
- HARRISON, D.J. "Estimating survival rates." Guest lecture in WLE 410, University of Maine, Orono, September 19, 1997.
- HUNTER, M.L., JR. "The amphibians and reptiles of Maine." Humboldt Field Station, Steuben, ME, June 17, 1997.
- JOHNSON, C. "Wildlife and wetlands" and "Introduction to wetland birds and mammals." Lectures given to Wetland Biology class, University of Maine, Orono, September 9, 1996.
- JOHNSON, C. "Destruction and conservation of wetlands." Lecture given to Wetland Biology class, University of Maine, Orono, December 2, 1996.
- JOHNSON, C. "Maine's seabirds and the threats of oil pollution." Expanding Your Horizons Conference, University of Maine, Orono, March 4, 1997.
- KROHN, W.B. "A preliminary Gap Analysis of Maine: Implications for conservation land acquisition." Invited slide presentation to the Governor's Land Acquisition Priorities Committee, Augusta, ME, April 10, 1997.

- KROHN, W.B., and R.B. BOONE. "A preliminary Gap Analysis of Maine: conservation and policy implications." Slide presentation to the Maine Audubon Society, Falmouth, ME, January 14, 1997.
- KROHN, W.B., and R.B. BOONE. Presented a poster and computer demonstrations entitled "Use of GIS to analyze statewide patterns in biodiversity." Mainewatch Institute Conference on Forest Sustainability, Augusta, ME, April 16, 1997.
- PAYER, D.C. "Physiological and anatomical indices for condition in ruminants (lecture) and necropsy techniques for the white-tailed deer" (demonstration). WLE 450 class, University of Maine, Orono, November 12, 1996.
- PAYER, D.C. "Diagnosis and management of diseases in wildlife, and necropsy techniques for wildlife species" (lecture and demonstration). WLE 410 class, University of Maine, Orono, March 31, 1997 and April 2, 1997.
- PAYER, D.C. "Marten research in Maine: results of recent work, and future directions." Slide presentation and discussion presented to the Central Maine Chapter of the Maine Trappers Association, Palmyra, ME, April 3, 1997.
- PAYER, D.C. "Mainly marten: marten ecology and research in Baxter State Park." Lecture and discussion presented to the public at Kidney Pond, Baxter State Park, ME, August 6, 1997.
- SERVELLO, F.A. Review of the effects of herbicides on wildlife in Maine. Pesticide Recertification Meeting. Bangor, ME, April 15, 1997.
- WITHAM, J. Three presentations at the Center for Teaching and Learning, a private elementary school in Edgecomb, ME, describing his position as a wildlife researcher, January 15-16, 1997.
- WITHAM, J. "Wetlands conservation in the Lower Kennebec Estuary: a working partnership." Noontime seminar, Department of Wildlife Ecology, University of Maine, Orono, January 20, 1997.

#### AWARDS, HONORS, AND APPOINTMENTS

- HARTLEY, M.J. Received a scholarship award "Dedicated to encouraging excellence and professionalism in communicating outdoor sports and natural resources" from the New England Outdoor Writers Association.
- HARTLEY, M.J. Awarded the 1997 Arthur Sullivan Scholarship by the New England Outdoor Writers Association at their annual meeting, Worcester, MA. February 1997.
- HARTLEY, M.J. Received the Swedish-American Bicentennial Exchange Grant Award to facilitate study of wildlife and forestry issues in Sweden for 3-6 weeks, September 1997.
- KROHN, W.B. Received a performance award by the USGS Biological Resources Division for sustained research productivity and effectively working with Unit cooperators. September 1997.
- MATZ, A.C. Awarded the Howard L. Mendall Memorial Scholarship, Department of Wildlife Ecology, University of Maine. April 1997.

**MORING, J.R.** Awarded the D. A. Webster Award of Merit from the Northeastern Division of the American Fisheries Society for outstanding service to the fisheries profession. April 1997.

**MORING, J.R.** Received a performance award from the USGS Biological Resources Division for outstanding research productivity and peer recognition for his fisheries research and teaching accomplishments. August 1997.

**MORING, J.R.** President of the Fisheries History Section of the American Fisheries Society, and co-editor of the Section's Newsletter.

**MORING, J.R.** Member of the Governing Board, American Fisheries Society, and appointed Chair and/or member of three standing committees in the Society.

**O'CONNOR, R.J.** Member Peer Review Panel for USEPA's Research Grants Program on Endocrine Disruptors.

**O'CONNOR, R.J.** Member USEPA's Working Group on Probabilistic Risk Assessment for Pesticides.

**PAYER, D.C.** Named outstanding graduate student in Department of Wildlife Ecology, University of Maine. May 1997.

**WITHAM, J.W.** Promoted to Associate Scientist, Department of Wildlife Ecology, University of Maine.

