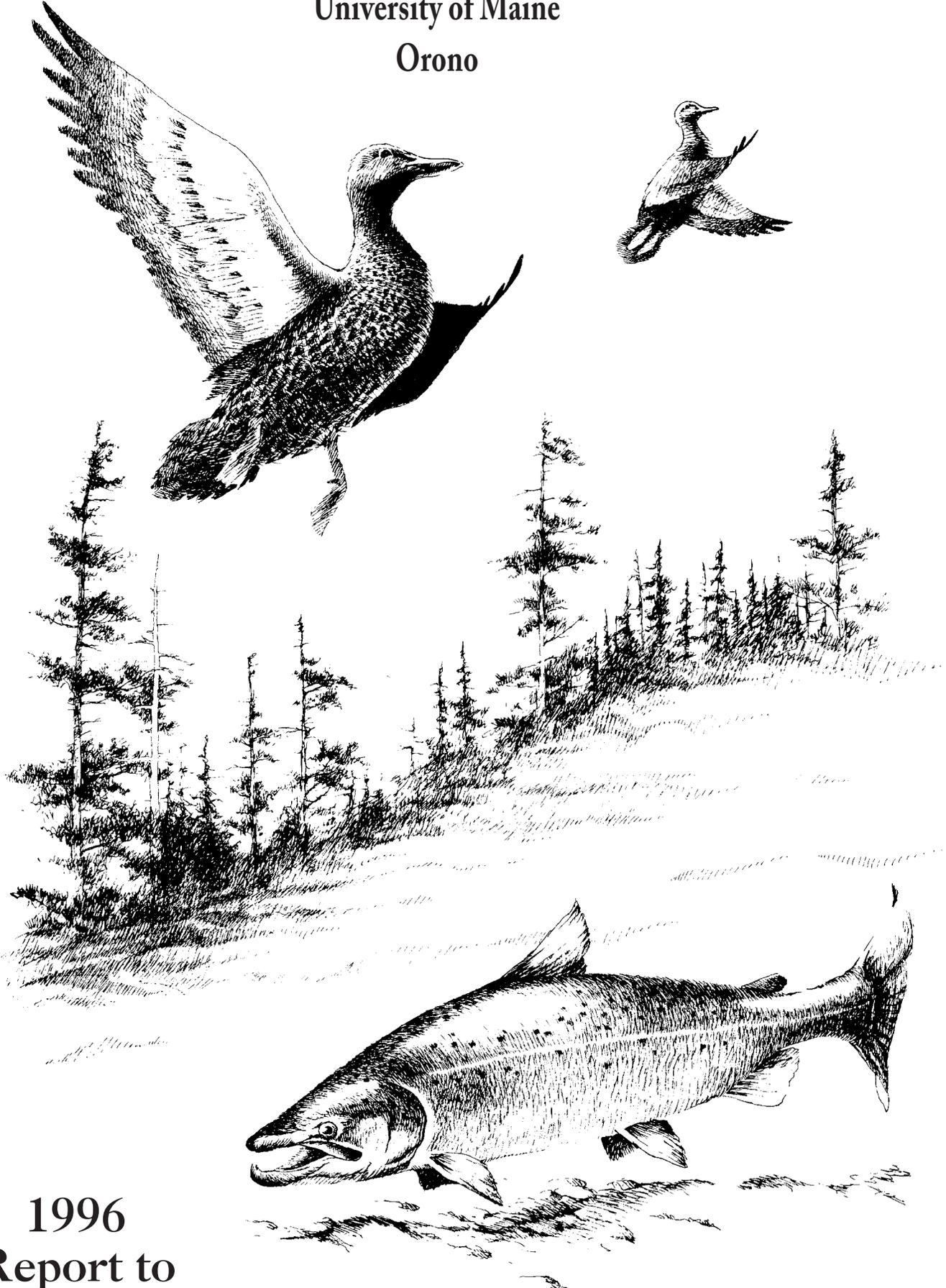


MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

University of Maine

Orono



1996
Report to
Cooperators

—Mark McCollough '86

MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

5755 Nutting Hall, Room 206*
University of Maine
Orono, Maine 04469-5755

COOPERATORS

UNIVERSITY OF MAINE

MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE

NATIONAL BIOLOGICAL SERVICE, U.S. DEPARTMENT OF THE INTERIOR

WILDLIFE MANAGEMENT INSTITUTE

October 1995 - September 1996

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.

*The Unit's Fisheries Program is located in 313 Murray Hall and is within the Department of Zoology, College of Sciences; the Unit's Wildlife Program is located in 206 Nutting Hall and is within the Department of Wildlife Ecology, College of Natural Resources, Forestry, and Agriculture.

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PERSONNEL AND COOPERATORS

COORDINATING COMMITTEE

Maine Department of Inland Fisheries and Wildlife
Ray B. Owen, Jr., Commissioner

University of Maine
James R. Gilbert, Chairperson, Department of Wildlife Ecology, College of Natural Resources,
Forestry, and Agriculture
J. Malcolm Shick, Chairperson, Department of Zoology, College of Sciences

National Biological Service
W. Reid Goforth, Director, Division of Cooperative Research

Wildlife Management Institute
Rollin D. Sparrowe, President

UNIT PERSONNEL

Unit Staff:

William B. Krohn, Unit Leader, Professor of Wildlife Ecology and Cooperating Professor of Zoology
 John R. Moring, Assistant Unit Leader for Fisheries, Professor of Zoology
 Susan Anderson, Unit and USFWS-LSC Administrative Assistant - Fisheries
 Nancy Knight - Unit Administrative Assistant - Wildlife Ecology
 Nora Ackley - Unit Administrative Assistant - Wildlife Ecology
 Shirley L. Moulton, Secretary - Wildlife Ecology

Associated Faculty and Staff, Departments of Wildlife Ecology and Zoology:

James R. Gilbert, Chairperson, Department of Wildlife Ecology, College of Natural Resources, Forestry, and Agriculture, and Professor of Wildlife Ecology
 T. Malcolm Shick, Chairperson, Department of Zoology, College of 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, NBS
 Raymond J. O'Connor, Professor of Wildlife Ecology
 Frederick A. Servello, Associate Professor of Wildlife Ecology
 Judith Rhymer, Assistant Professor of Wildlife Ecology
 Jerry R. Longcore, Faculty Associate, Wildlife, and Research Wildlife Biologist, NBS
 James A. Sherburne, Director, International Programs and Professor of Wildlife Ecology
 Terry A. Haines, Professor of Zoology and Fishery Research Biologist, NBS
 Ruth W. Perry, Research Assistant, Zoology
 Elizabeth Moore, Research Assistant, Wildlife Ecology
 Jack Witham, Assistant Scientist, Wildlife Ecology
 Thomas P. Hodgman, Research Associate, Wildlife Ecology
 Malcolm T. Jones, Research Associate, Wildlife Ecology

Maine Department of Inland Fisheries and Wildlife:

Ray B. Owen, Jr. Commissioner
 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

Name	Degree Candidacy	Support
Andrew P. Allen	M.S.	USEPA
John Bartlett	Ph.D.	USDI/NBS
Randall B. Boone	Ph.D.	MCFWRU, NBS
John R. Burgess	M.S.	NBS
Merrie A. Cartwright	Ph.D.	U of M, MDIFW
Theodore D. Chapin	M.S.	McIntire-Stennis
Lia R. Daniels	M.S.	MDMR
Phillip G. de Maynadier	Ph.D.	McIntire-Stennis
Danielle DiMauro	M.S.	McIntire-Stennis
Diana M. Eignor	Ph.D.	U of M
Mustapha El Hamzaoui	Ph.D.	USAID/USDA
Richard T. Finlayson	M.S.	NBS, USFWS, EPA
Carol R. Foss	Ph.D.	USFS, USFWS, SEFP
Merry Gallagher	M.S.	U of M, MDIFW
Stephen L. Glass	Ph.D.	ANP
Christopher F. Hartleb	Ph.D.	MDIFW
Mitschka J. Hartley	Ph.D.	McIntire-Stennis
Catherine M. Johnson	Ph.D.	NBS, 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
Paula MacKay	M.S.	Hatch
Andrew P. Madden	M.S.	MDIFW, U of M
Angela C. Matz	Ph.D.	ANP
Karen E. McCracken	Ph.D.	U of M
Craig R. McLaughlin	Ph.D.	Personal Funding
Laura M. Monti	M.S.	HWRP
Dawn L. Nelson	M.S.	HWRP
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
James W. Schneider	Ph.D.	McIntire-Stennis
Ashley M. Smith	M.S.	NBS
Shelley M. Spohr	M.S.	CCNWIF, CDW, U OF M, WF
James Stahlnecker	M.S.	MDMR
Marcia L. B. Summers	M.S.	Personal Funding (Grad. School Assistantship)
Tracey E. Walls	M.S.	USDI/NBS
Hannah M. Webber	M.S.	NPS
Amy S. Williams	M.S.	NMFS, NBS, U of M

DISSERTATIONS AND THESES COMPLETED THIS PERIOD

Student	Degree Candidacy	Support
Bradley F. Blackwell	Ph.D.	MCFWRU, USFWS
Phillip G. de Maynadier	Ph.D.	McIntire-Stennis
Christopher F. Hartleb	Ph.D.	MDIFW
Andrew P. Madden	M.S.	MDIFW, U of M

PERSONNEL NOTES

The following people received graduate degrees in Wildlife Ecology, or Wildlife Conservation, in December, May or August:

BRAD BLACKWELL is a research associate continuing to work on fisheries/cormorant issues at the University of Massachusetts, Amherst. **PHILLIP deMAYNADIER** was appointed to a Research Associate position in the Department of Wildlife Ecology and will be working in collaboration with Malcolm Hunter and Robert Seymour on a book entitled "Ecological Forestry on Private Lands."

The following people received graduate degrees in Zoology in August:

CHRISTOPHER HARTLEB joined the faculty of the University of Wisconsin-Stevens Point as Assistant Professor. **ANDREW MADDEN** accepted a biologist position with the Chesapeake Bay Biological Laboratory in Solomons, Maryland.

COLLABORATING AGENCIES AND ORGANIZATIONS

Audubon Society of New Hampshire-ASNH
 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
 Cooper Ornithological Society
 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
 Association of Graduate Students - AGS
 College of Natural Resources, Forestry, and Agriculture
 Cooperative Forestry Research Unit - CFRU
 Department of Forest Management - DFM
 Department of Wildlife Ecology - DWE
 Forest Ecosystem Research Program - FERP
 McIntire-Stennis - MS
 Maine Agricultural and Forest Experiment Station - MAFES
U.S. Department of Commerce
 National Maine Fisheries Service - NMFS
U.S. Environmental Protection Agency - EPA
 Environmental Laboratory, Corvallis, OR
U.S. Fish and Wildlife Service - FWS
 Lake Umbagog National Wildlife Refuge - LUNWR
USDA Agricultural Research Service
USDA Economic Research Service - ARS
USDA Forest Service - USFS
 Forestry Sciences Laboratory, Corvallis, OR
 Pacific Northwest Region, Portland, OR
USDI National Biological Service - NBS
 Leetown Science Center - LSC
 Cooperative Park Studies Unit - CPSU
 Patuxent Wildlife Research Center - PWRC
USDI National Park Service
 Acadia National Park - ANP
Wagner Forest Management, Ltd. - WFM
Wildlife Forever - WF

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: Final funds have been received and will allow analysis of archived samples. Weather and food supply data are being analyzed to determine effects on eagle productivity. Project completion is expected in 1997.

**POPULATION STATUS AND HABITAT USE OF
BLANDING'S AND SPOTTED TURTLES IN SOUTHWESTERN MAINE**

- 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: Data analysis is in progress.

FUTURE PLANS: Revise thesis.

FISHERIES RESOURCES:

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*.

PROJECT STATUS: Experiments with movements of juvenile grubbies and shorthorn sculpins are ongoing. One paper on intertidal fishes was published in 1996 and several talks were presented.

FUTURE PLANS: Work dealing with intertidal movements of sculpins will continue in 1997, along with experiments on Atlantic seasnail feeding and innovative fish marking techniques. Additional manuscripts are being prepared.

GROWTH, SURVIVAL, AND PERFORMANCE OF STOCKED BROOK TROUT IN LAKES WITH HEAVY COMPETITION

Investigator: C. F. Hartleb

Advisors: J. R. Moring, Chairperson
J. H. Dearborn
K. E. Gibbs
W. H. Howell
I. L. Kornfield

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

Objective: Compare growth and survival of stocked spring yearling brook trout in waters with heavy competition and waters with limited competition.

SCOPE: The state of Maine currently stocks yearling brook trout in bodies of water where angling demand is high, but where competition from other species (smallmouth bass, yellow perch, white perch, suckers, chain pickerel) may make such use cost-ineffective. There are no data on survival or performance of such stocked fish in these marginal waters, but this policy is relatively common in southern and central Maine. The study involves a sampling program in two lakes to analyze growth of brook trout and food habits of trout and competing species over two seasons. Growth rates and survival will be compared and used in a model to predict potential success of stocking in Maine lakes.

PROJECT STATUS: All requirements for the Ph.D. degree (in Zoology) were completed in August 1996. The abstract follows:

Performance by stocked brook trout (*Salvelinus fontinalis*) differs with respect to the native species

present in the community into which the trout are placed. Understanding the dietary and habitat requirements of the native species, and how the brook trout alter the ecosystem, can lead to better trout management.

I investigated diet composition and prey abundance and location in order to determine the foraging habitat and dietary overlap of non-salmonid species in two Maine ponds that received hatchery-reared brook trout. Golden shiners (*Notemigonus crysoleucus*) and chain pickerel (*Esox niger*) had specialized diets, feeding on plants/algae and other fish, respectively. Yellow perch (*Perca flavescens*) and pumpkinseeds (*Lepomis gibbosus*) had broad diets, but coexisted because of abundant prey and habitat partitioning.

Stocked brook trout growth and survival were poor in one pond because of unsuitable temperature and oxygen conditions. Brook trout were restricted to foraging in epipelagic water, which altered the foraging patterns of yellow perch.

The diet of brook trout stocked in the other pond did not overlap with any other species and brook trout occupied foraging habitat that was underutilized by the fish community. Introduced brook trout did not seem to affect the interactions of the native species, and the brook trout appeared to fill a niche where suitable temperature, oxygen and prey allowed continued survival.

In the final section of this study, I developed a bioenergetics model based on a synthesis of studies on the energetics of brook trout and other salmonids. Temperatures that exceeded optimal conditions for brook trout decreased growth and survival. Lowest maintenance rations were required by brook trout at 13°C and by smaller-sized trout. Food limitations and interspecific competition affected larger brook trout less than smaller-sized fry. No differences were observed in the survival and growth of fall-fingerling and spring-yearling brook trout and either size could be stocked when conditions are sub-optimal.

COMPETITION BETWEEN WHITE PERCH AND ILLEGALLY-INTRODUCED BLACK CRAPPIE

- Investigator:* A. P. Madden
- Advisors:* J. R. Moring, Chairperson
J. G. Trial
W. E. Glanz
- Cooperators/
Project
Support:* Maine Department of Inland Fisheries and Wildlife
University of Maine
- Objective:* Document the impacts of illegally-introduced black crappie on growth and population structure of white perch.

SCOPE: Black crappie have been illegally introduced into several waters of Maine. In recent years, the species has been introduced into Herman Pond, long the home of a popular white perch fishery, as well as fisheries for smallmouth bass and chain pickerel. Black crappies have successfully reproduced and the population numbers have increased substantially, possibly to the detriment of white perch. This project examines the impact of this introduced centrachid on the native white perch.

PROJECT STATUS: All requirements for the M.S. degree (in Zoology) were completed in August 1996. The abstract follows:

The invasion of black crappie (*Pomoxis nigromaculatus*) in Hermon Pond continued an expansion of the species range into central Maine. Black crappie are rapid colonizers, a characteristic which could have potentially detrimental effects on resident fish populations. Coinciding with crappie invasion was a reported decrease in quality of the historically important recreational white perch (*Morone americana*) fishery in Hermon Pond. I compared individual growth rates of white perch before and after the appearance of black

crappie to detect effects of black crappie invasion. I further conducted diet comparisons to determine the role of feeding in white perch-black crappie interactions. White perch growth in each of the prime growing years greatly decreased when crappie densities were presumably highest. White perch and black crappie diets were similar, but evidence of interspecific competition for food resources was inconclusive.

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

*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 from both the predator and prey aspects. Collections of juvenile fishes in the estuary will be related to salinity and tidal differences and shifting availability of prey items over time, season and tidal cycles.

PROJECT STATUS: Two field seasons have been completed at the Wells National Estuarine Research Reserve and data are being analyzed to prepare three chapters of the dissertation in Fall 1996. A Ph.D. dissertation is expected in early 1997.

DISTRIBUTION AND STATUS OF PICKEREL (*Esox* spp.) 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 and the Pemaquid River, in 1972. 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: Field work began in 1996 and viable populations of either redbfin or grass pickerel have been discovered in two watersheds of central coastal Maine. Genetic analyses will be conducted in Fall 1996 to determine whether these esocids are true redbfin or grass pickerel or are some form of hybrid with chain pickerel.

FUTURE PLANS: Genetic studies are scheduled for Fall 1996, followed by thesis writing. A Master of Science thesis is expected by August 1997.

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: The new work will begin in 1997. Site identification and planning will continue in 1996-1997.

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 in December 1999.

AUTUMN MIGRATION OF AMERICAN EELS

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 factors influencing the fall migration of the silver eel stage.

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 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 (including the yellow eel stage). As a result, this project examines one component of the freshwater stage--the summer feeding by eels and the fall migration of adult silver eels--and the abiotic and biotic factors triggering such migration.

PROJECT STATUS: The project has just been funded and preliminary field work will commence in Fall 1996.

FUTURE PLANS: Project planning will occur during 1996-1997, with field work in summer-fall 1997. A Master of Science thesis is expected in May 1998.

HABITAT RESOURCES:

PATTERNS OF MOVEMENT AND HABITAT USE BY AMPHIBIANS IN MAINE'S MANAGED FORESTS

Investigator: P. de Maynadier

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

*Cooperators/
Project
Support:* Maine Agricultural and Forest Experiment Station
McIntire-Stennis
Hirundo Wildlife Refuge
University of Maine -
Association of Graduate Students
National Council of the Paper Industry for Air & Stream Quality Improvement

Objectives:

- 1) Document the amphibian community of clearcut and mature forest stands and identify microhabitat variables of potential importance.
- 2) Investigate the effects of forest-clearcut edges of various contrast on the habitat use of resident and dispersing amphibian populations.
- 3) Determine the effects of logging roads on patterns of abundance and

- movement by adjacent forest amphibian populations.
- 4) Conduct a comprehensive review of forestry-amphibian relationships and generate management guidelines for amphibian conservation in managed forest landscapes.

SCOPE: Forest fragmentation may threaten some native wildlife populations by eliminating blocks of once continuous habitat or by degrading the quality of remaining habitat for those species sensitive to an increase in the amount of forest edge. While the process of fragmentation in forested landscapes may generate only temporary impacts at the stand scale, cumulative impacts to sensitive wildlife populations may be significant at the landscape scale. Formerly continuous populations that become reduced in size and isolated from other populations can become increasingly susceptible to stochastic extinction processes. Species characterized by relatively limited dispersal capabilities and an association with forest interior conditions are likely to be most affected by the disturbance of formerly continuous forest.

Amphibians are the most abundant vertebrate class in many temperate forest-types and their populations may play a critical role in forest ecosystem dynamics. However, the effects of forest fragmentation, and of edge effects in particular, remain largely unstudied for this taxon. Specific aspects of the natural history of amphibians, including their often small home ranges, relatively poor dispersal capability, highly permeable skin, and sensitivity to chemical, temperature, and moisture gradients, suggest that this taxon may be especially responsive to the change in microhabitat and climate that occurs following canopy removal. This study is designed to increase our knowledge of the effects of clearcutting and forest road construction on patterns of movement and habitat use by Maine's amphibian community.

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

Forested landscapes dominated by logging are often characterized by an extensive network of logging roads and harvest-created canopy openings. This thesis explores the effects of forest roads, clearcuts, and their associated forest edge habitats on the local abundance and movements of northern temperate forest amphibians in order to better understand the effects of silvicultural canopy removal. In the first chapter, I examined the effects of a wide, heavily used logging road and a narrow, less used forest track on the roadside abundance and crossing rates of eight species of amphibians in Maine. Salamanders avoided roadside habitat and crossings to a greater extent than anurans with the wide logging road filtering movements more than the narrow road. The barrier effect of the wide road also varied depending upon the specific type of life history movement made (i.e., home-range, dispersal, and migration).

In Chapter Two I contrasted the forest amphibian community (14 species) sampled from clearcut stands and paired control stands to examine the short-term effects of even-aged management. Concentrating the sampling effort along transects bisecting forest edges permitted analyses of species-specific responses to the spatial and temporal habitat gradient that occurs along stand boundaries of different age and management intensity. Salamanders were generally more sensitive to canopy removal than anurans, but closed-canopy habitat generalists and specialists were identified within both groups. Degree of edge contrast between treatment and control stands affected the magnitude of edge effects for a subset of management-sensitive species (*Plethodon cinereus*, *Amystoma* spp., and *Rana sylvatica*) for whom detectable edge effects penetrated approximately 25-35 meters into forest stands abutting recent clearcuts (< 12 years old). Structural microhabitat variables identified as potentially limiting to amphibians near forest edges included canopy cover, litter cover, and a measure of stumps, snags and their root channels.

The third chapter examined the effect of canopy removal on dispersal movements of recently metamorphosed pool-breeding amphibians. Artificial breeding pools were installed along the abrupt forest edge of a powerline right-of-way and surrounded by a 20 meter diameter continuous drift-fence. Juvenile wood frogs selected closed-canopy habitat immediately upon metamorphosis, and responded positively to understory vegetation density. Natural populations of dispersing juvenile wood frogs and spotted salamanders sampled along clearcut edges abutting mature forest stands showed similarly distinct selection for closed-canopy forest habitat.

Chapter four provides a synthesis of the North American literature on forestry-amphibian relationships. Clearcut harvesting generally has negative short-term impacts on local amphibian populations, especially among salamanders in the family Plethodontidae. An analysis of the results of 18 studies which examined the effects of clearcutting on amphibians yielded a 3.5 fold median difference in abundance of amphibians on controls over clearcuts. However, research on the influence of forest age suggests that the long-term effects of forest harvesting on amphibians are variable, and for many species these effects can be mitigated if regeneration practices leave adequate microhabitat structure intact. Other forest practices reviewed for their effect on amphibians include plantations, prescribed fire, logging roads, and streamside harvesting. Management recommendations relevant to conserving upland and riparian zone amphibian habitat during forest harvesting are offered.

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: 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.

FUTURE PLANS: Graduation is anticipated in December 1996.

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 1996, tasks 1, 3, 4, 5, 6, 7, 8, 9, and 10 as outlined above, were completed, and three graduate student projects (red oak regeneration, salamander abundance and distribution, and insects associated with the bark of dead trees) continued their work.

FUTURE PLANS: The 1997 field season will replicate the 1995 field season with additional work on salamander distribution and abundance, snags, and forest gap dynamics and their effects on forest understory plants.

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

Investigators: T. A. Haines
R. W. Perry

Advisors: T. A. Haines, Chairperson (for Eignor, Powell)
I. J. Fernandez
S. A. Norton
J. R. Moring

*Cooperators/
Project
Support:* USDI National Biological Service -
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 is anticipated by May 1997.

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:* USDI National Biological Service
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: Draft species synopses have been completed for all inland terrestrial vertebrates. We met with experts in the region, and reviewed portions of the synopses. Comments regarding the synopses were favorable. We have provided copies of the synopses to interested commercial forestland owners, and have assisted them in applying Gap Analysis methods to their lands. Ultimately, the species synopsis volumes will be published, perhaps accompanied by a computer compact-disk containing species-habitat relations and distribution maps.

Development of a 1:100,000 scale conservation land ownership GIS database is nearing completion. In cooperation with Richard Kelly of the State Planning Office, and with the support of several interested parties (e.g., Maine Department of Inland Fisheries and Wildlife, U.S. Fish and Wildlife Service), the Unit is digitizing maps of lands owned by federal, state, and non-profit organizations.

I have completed analyses that tested the avian ranges I had defined in the synopses, using the Breeding Bird Survey for comparison. Species that I had judged *a priori* to be represented well in the survey had a median disagreement of 8%. I also quantified the error introduced into ranges by mapping using different tessellations. For example, mapping ranges with townships introduced 1.5% error and using Maine counties introduced an error of 20%.

Bird species that breed within the state ($n \approx 182$) have been ranked as to how likely they are to be observed in future surveys. These rankings were tested using Gap Analyses from areas with habitat maps or habitat descriptions. Rankings tested well, with species with high ranks more likely to be correctly predicted. Researchers may use ranks derived for their region to provide more informative reports of the accuracy of their modeling efforts.

For richness maps for amphibians, reptiles, birds, mammals, and all vertebrates, I partitioned the variation they contained into four components: environmental, spatial, an environmental-spatial interaction, and unexplained. I used multiple regression and regression trees to correlate geomorphologic, climatic, and floral characteristics to richness. Reptiles were most closely correlated with environmental variables, followed by mammals, amphibians, and then birds. In general, 79% of the variation in total species richness was explained by environmental variables with multiple regression, 91% using regression trees.

FUTURE PLANS: In the upcoming year we anticipate that Maine Gap Analysis will be completed. A draft of my thesis will be complete in late October, with graduation in December 1996 anticipated. Throughout this and the following year, Dr. Krohn, working with a research associate and other cooperators, will: 1) complete the habitat map, 2) incorporate new species-habitat information into models and predict the occurrence of each terrestrial vertebrate species in the state, 3) complete the ownership map, and 4) prepare a final report on Maine Gap Analysis.

DEVELOPMENT AND TESTING A VEGETATION COVER MAP FOR MAINE

Investigator: Z. Yin

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

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

- Objectives:*
- 1) Use aerial videography as ground truth in classification and testing.
 - 2) Classify satellite images and create a vegetation cover map of Maine at a 100,000 scale.
 - 3) Evaluate the map accuracy and make it at least 80% accuracy for major cover type.
 - 4) 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 vegetation cover 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 land cover mapping. This research utilizes aerial videography and satellite image processing to map land cover types for Maine.

PROJECT STATUS: Landsat-Thematic Mapper (TM) imagery recorded in summer 1991 and fall 1993 were acquired 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 from these scenes to be processed separately. Land cover classification methods were tested on a selected study area to determine appropriate methods to be conducted on the statewide basis. Aerial videography transects covering 7100 km were collected in summer and fall 1994. Systematic samples at one minute intervals along each flight line are being "photo" interpreted to identify land cover types. The samples will be stratified for computer classification training and testing. Classification of the first scene in northern Maine has been initiated.

FUTURE PLANS: The research associate position has been vacant since mid-summer 1996, slowing progress on the work. Recruiting for the RA position will be conducted in fall 1996. Classifications will be performed on each scene starting from north to south. Cloud, cloud shadows, and water are being stratified and processed separately from the non-cloud affected terrestrial data. The strata will be merged after classification. Rule-based strategies using existing GIS coverages (urban area boundary, wetland, ownership, topography) will be developed to mitigate some of the spectral confusion that causes misclassification between two or more land cover types. Classification accuracies will be tested using random samples of video interpreted land cover types.

AN ANALYSIS OF BIODIVERSITY ALONG THE MAINE COAST: INSULAR HABITATS AND VERTEBRATE DIVERSITY

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* USDI National Biological Service
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 Geologic 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 habitat and social factors affecting the distribution of breeding seabirds in Maine and develop habitat models.
 - 4) Create species richness maps for vertebrates breeding and wintering along the mid-Maine coast, and compare their location to conservation lands to identify gaps in biodiversity protection.

SCOPE: A Gap Analysis is currently underway for the State of Maine, identifying areas of high vertebrate species richness and gaps in the protection of such areas. However, the vast majority of islands along the Maine coast fall well below the minimum mapping unit size used for this terrestrial statewide analysis. As part of this study, I will be assessing vertebrate species richness along the mid-Maine coast; base mapping for this larger-scale coastal analysis will include both aquatic and terrestrial habitat types. This spatial database will be used in combination with other biotic and abiotic variables, to formulate coastal species-habitat models. These models will be used to predict seasonal (breeding and wintering) distributions of vertebrate species along the Maine coast.

Beyond determining patterns of species richness, I will be examining the temporal stability of insular habitat use in this dynamic environment. I will assess annual (1993-97) variability in island use by cormorants and gulls in the Penobscot Bay area. Long-term temporal patterns of habitat use also will be examined for selected seabird species, using survey data collected periodically over the past 80 years. Spatial patterns of seabird island use will be examined in relation to a variety of physical and biological habitat factors.

PROJECT STATUS: Data collection for the coastal Gap Analysis portion of this study is complete, with the exception of a finalized habitat map. A preliminary vegetation/substrate map has been developed for the Penobscot Bay area and is currently being tested for accuracy; a finalized map for this area is expected in the near future.

Aerial photos of more than 100 islands in Penobscot Bay known to have supported breeding populations of cormorants, black-backed gulls or herring gulls were taken periodically during the breeding seasons of 1994-96. I have finished photo nest counts for these islands and have begun analysis of annual peak counts. This data is being used, in conjunction with the historical seabird database, to assess long term temporal patterns of habitat use, and to develop habitat models for selected species.

FUTURE PLANS: Over the coming months, I will be completing analyses of the seabird data I have gathered, creating habitat models, and assessing the long-term value of particular islands, or groups of islands for breeding seabirds. I also will be writing my thesis over the next year.

TOXICOLOGICAL AND ECOLOGICAL EFFECTS OF MOSQUITO CONTROL
METHODS AT BOMBAY HOOK NATIONAL WILDLIFE REFUGE, DELAWARE

Investigators: D. M. Eignor
T. A. Haines

Advisors: T. A. Haines, Chairperson (for Eignor)
R. J. Van Beneden

J. H. Dearborn
J. R. Moring

*Cooperators/
Project
Support* U.S. Fish and Wildlife Service
USDI National Biological Service -
Patuxent Environmental Science Center
Leetown Science Center

Objective: Determine the effects of pesticides used for mosquito control on non-target organisms in salt marsh habitat at Bombay Hook National Wildlife Refuge.

SCOPE: For many years, Bombay Hook National Wildlife Refuge has been sprayed with a variety of pesticides to reduce mosquito breeding. Aerial spraying is initiated on short notice, based on field counts in breeding areas. The primary larvicide is the organophosphate temephos (Abate). The bacterial toxin, *Bacillus thuringiensis*, and the growth hormone methoprene (Altoside), have been used to a much lesser extent. The primary adulticides are the organophosphate naled (Dibrom), and Scourge (the synthetic pyrethroid resmethrin plus piperonyl butoxide). With the exception of several caged fish and shrimp trials performed about 20 miles south of Bombay Hook, no recent field tests have been conducted to examine possible non-target impacts of mosquito control spraying at the Refuge.

PROJECT STATUS: Project has been terminated and sediment samples have been returned to U.S. Fish and Wildlife Service for analysis by their personnel.

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 (for Powell)
L. E. Katz
J. R. Moring
S. A. Norton

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

Objectives: 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 1997. 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: One M.S. thesis is anticipated in May 1997 and a second in August 1997.

WILDLIFE COMMUNITIES OF VERNAL POOLS IN SOUTHERN MAINE

Investigator: A. M. Perillo

Advisors: M. L. Hunter, Jr.
M. A. McCollough
K. E. Gibbs
S. C. Gawler

*Cooperators/
Project
Support:* Maine Department of Inland Fisheries and Wildlife
University of Maine -
Department of Wildlife Ecology
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Environmental Protection Agency

Objectives:

- 1) Describe the biotic community of vernal pools in southern Maine, including reptile, amphibian, macroinvertebrate, and plant species;
- 2) Characterize the physical, chemical, and biological parameters that contribute to the value of these pools for wildlife; 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.

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.

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

Investigator: D. DiMauro

Advisors: M. L. Hunter, Jr., Chairperson
W. E. Glanz
M. A. McCullough

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

Objectives:

- 1) Evaluate the reproductive success of amphibians breeding in natural and anthropogenic temporary pools in industrial forest.
- 2) Evaluate the landscape-scale use of temporary pools by breeding amphibians in industrial forest.
- 3) Characterize the features of temporary pools which best predict use by breeding 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 field season I identified 40 temporary pools containing amphibian egg-masses. I counted the wood frog and spotted salamander egg-masses in each pool, and measured the dimensions of egg masses in several pools. I also monitored pool depth, periodically measured tadpoles, and recorded dates on which pools dried. I trapped, counted, and weighed emerging, recently-metamorphosed wood frogs and spotted salamanders at several pools.

FUTURE PLANS: Although I have already identified several natural (control) pools for study, this fall I am attempting to locate additional natural pools to improve my sample size. I will begin preliminary data analysis this winter. Next year I plan to closely monitor the dates of egg deposition and numbers of egg masses in each pool, and will again measure tadpole growth, patterns of juvenile emergence, and pool depth. I will also survey transects to determine the density of pools in the landscape, and will collect microhabitat data for study pools. I will conduct final data analysis after the 1997 field season.

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
J. H. Dearborn
J. R. Moring
W. E. Glanz
R. J. Van Beneden

Cooperators/ USDI National Biological Services -
Leetown Science Center
Project National Park Service

Support:

- 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 ($\text{pH} < 7$) - 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. An M.S. thesis is anticipated in May 1997 and a second in August 1997.

THE EFFECTS OF AGRICULTURE ON WILDLIFE: A STUDY OF NON-USE VALUES

Investigators: K. Boyle
R. J. O'Connor
R. Bishop
M. Welsh

*Cooperators/
Project
Support:* USDA Economic Research Service

Objectives:

- 1) Estimate the values of selected wildlife closely associated with agriculture. Emphasis will be on non-use, rather than use, values, with the Farm Conservation Receive Program receiving special attention because of its immediate policy implications.
- 2) Eliminate biases in the valuation process.

SCOPE: The Farm Conservation Reserve Program (CRP) is a long-term (ten years, and probably to be renewed) Federal program to retire highly erodible farmland from cultivation. The program costs are known, as are some of the consequences, largely beneficial, for wildlife. This project seeks to develop methods of assigning valuation to these wildlife benefits, so as to properly value the full costs and benefits to society of this program.

Initial analysis of the Birds and Agriculture database in the Department was used to document the areas of and trends in bird species changes with respect to the CRP. This information was used to design a set of survey questions describing scenarios of CRP change and their wildlife consequences and asking respondents to describe how they value these changes. Following testing in a series of focal groups, the survey was administered to natural and regional demographically-controlled samples totalling ca. 3,000 people.

PROJECT STATUS: Project completion is scheduled for December 1997.

THREATS TO BIODIVERSITY

- Investigator:* J. G. Bartlett
- Advisors:* R. J. O'Connor, Chairman
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: Many anthropogenic factors impact biodiversity, but their effects have rarely been quantified. Recent work by O'Connor and his students has 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 researchers at the University of California at Santa Barbara to compile anthropogenic stressor data for use with these methods.

A review of potential sources of data as to stressor effects has been completed and the data available classified into three groups, namely those that definitely deserve incorporation into the analysis, those that might possibly be cost-effective to use, and those that either because of data quality or because of cost cannot be so incorporated. The datasets to be analyzed are ultimately needed in terms of the spatial units provided by USEPA's Environmental Monitoring and Assessment Program (EMAP), namely a grid of 12,500 hexagons spread across the 48 states, with each hexagon approximately 640² kilometers in area. Methods for translating data from other spatial units to this grid have been developed. Several of the databases already available in the Department from other projects have been converted to this grid. Substantial effort has been invested, in collaboration with Professor Deirdre Mageean of the Margaret Chase Smith Center for Public Policy at the University, in incorporating data from the Bureau of the Census into the analysis. These datasets provide much information on the distribution of humans and their activities across the United States and thus provide a source of information as to the intensity of anthropogenic factors. Eight datasets available in the Bureau of the Census were extracted to provide information on population density, population change, income, building, and information as to farming and urban status. These data have been extensively investigated using classification and regression tree (CART) methods. These analyses were primarily conducted to study the extent to which the different datasets were cross-correlated, but much useful information has been obtained and has been presented in a series of seminars and conference papers. The most striking outcome was the development of a method of segregating the incidence of population growth associated with new construction of housing and other buildings from the background/pattern of change associated with existing human settlement. Analysis of these results in relation to the climatic and land use data available from the satellite imagery showed that this expansive population growth is selectively located in fragile ecosystems, such as the barrier islands, coastal sand dunes and desert edges. This pattern has not been previously reported.

In addition to this work several new analytical approaches have been devised for handling the complexity of data involved in this project. The applicability of these methods is currently being investigated.

PROJECT STATUS: Completion is scheduled for December 1997.

SPATIAL PATTERNING OF WATERSHEDS AND THE DEVELOPMENT OF AVIAN BIOINDICATORS OF LAKE QUALITY

- Investigator:* A. P. Allen
- Advisors:* R. J. O'Connor, Chairman
- Cooperators/
Project
Support:* U.S. Environmental Protection Agency
University of Maine -
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.

A variety of statistical analyses have been conducted to investigate the determinants of these ecological indicators. Several models of individual components of indicators (such as the proportion of the bird community comprised by particular guilds) have been developed, with considerable success. The predictive error of these models ranges from 1 to 22 percent. In addition to this high predictive power, these models allow incorporation of known anthropogenic factors: for example, if a town is already present on a lake shore, or if the lake is already being managed as a fishery, then one would not expect the lake to have the same indicator values as a pristine lake, but this departure from pristine conditions should not be regarded as a measure of environmental pollution. Instead, it constitutes the outcome of a decision as to the management of that lake, and the effects of this management need to be recognizable as due to that management decision and not to unanticipated pollution. The new models, hierarchical in structure as a result of analysis by classification and regression tree methods, permit one to recognize and quantify such influences. Residuals about the predictions of these models then constitute indicators of environmental pollution.

Substantial effort has been devoted to recognizing the effects of regional factors and of local factors in understanding the indicator values for lakes. Given the large biogeographic variation that prevails across the northeastern states, one needs to allow for these effects: the bird community of the Maine north woods is quite different from that of New Jersey, and this needs to be taken into account. Trend surface models based on the use of Breeding Bird Survey data and of the data gathered in our own surveys of these lakes have been compared and shown to yield similar results. Deviations about these trend surfaces can then be used to distinguish local factors at these lakes from the more regional effects. The problem of recognizing interactions between regional and local effects needs further study.

PROJECT STATUS: Completion is scheduled for December 1996.

MULTI-TAXON INDICATORS OF LAKE QUALITY

Investigators: R. J. O'Connor

T. E. Walls

*Cooperators/
Project
Support:* U.S. National Biological Service/
U.S. Environmental Protection Agency -
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 being used consist of multivariate analysis of the data. An initial set of 19 pilot lakes gathered outside the standard EMAP sample grid have been 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. The next phase will consist in exploring the complete EMAP Surface Waters dataset for the northeastern lakes, developing this work in conjunction with the principal investigators who have headed up the various projects focused on particular taxonomic groups. This large-scale investigation will then show the extent to which the methods developed in the pilot are effective and will document the extent to which the different types of stressors are actually manifest in the Northeast.

One of the standard problems with ecological indicators is that while the measurements taken, e.g., counts of fish, are often exact, their relationship to the underlying concept of interest, e.g., the presence of a particular stressor, is often less well defined. There is thus a high measurement error as to the relevant stressor. One way of analyzing this is to use the emerging techniques of fuzzy logic, a set of techniques from artificial intelligence that is designed to allow systematic analysis from ill-defined information. In parallel with the full multivariate analysis, this project is exploring the utility of the fuzzy logic approach.

FUTURE PLANS: This work is being conducted as an M.S. thesis project and is scheduled to be completed by September 1997.

WILDLIFE RESOURCES - MIGRATORY BIRDS:

ECOLOGY OF THE DOUBLE-CRESTED CORMORANT IN THE LOWER PENOBSCOT RIVER: EMPHASIS ON SMOLT PREDATION

- Investigator:* B. F. Blackwell
- Advisors:* W. B. Krohn, Chairperson
J. R. Gilbert
J. R. Moring
W. E. Glanz
F. A. Servello
- Cooperators/
Project
Support:* U.S. Fish and Wildlife Service - WO, Federal Aid
USDI National Biological Service
Maine Department of Inland Fisheries and Wildlife
Maine Atlantic Salmon Authority
- Objectives:*
- 1) Monitor cormorants at roosting and foraging areas, determine time of roost departure and return, and locate foraging locations relative to smolt migration.
 - 2) Quantify seasonal variation in cormorant food habits during spring and summer.
 - 3) Estimate the number of cormorant days of predation during the spring migration of Atlantic salmon smolts through the Penobscot River.
 - 4) Estimate the number of Atlantic salmon smolts eaten by cormorants in the Penobscot River ecosystem.

SCOPE: Populations of double-crested cormorants (*Phalacrocorax auritus*) increased in size and distribution during the past 30 years across the United States and southern Canada, most likely responding to protection afforded by amendments to the Migratory Bird Treaty Act and reduction in DDT contamination. With this increase has come the perception of cormorants competing with humans for fish. Potential loss of commercial and sport fisheries to cormorants is a growing concern in Maine, particularly given the multi-million dollar efforts by federal, state, and private organizations to restore the Atlantic salmon (*Salmo salar*).

Measures to control double-crested cormorants have been implemented in Maine. However, control programs can prove to be counterproductive by increasing the proportion of young birds attaining breeding status, and possible shifting of breeders to other areas. Further, control programs implemented without accurate prediction or quantification of the effects of predation on individual prey species cannot be justified.

The most accurate means of estimating the biomass of prey removed from a system by cormorants is direct sampling of food habits via collection of stomach samples. By comparison of food habits data relative to time and feeding location with estimates of cormorant days of predation, quantities of prey species consumed can be estimated.

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

During 1992-94, I examined temporal and spatial variation in habitat and prey use by double-crested cormorants (*Phalacrocorax auritus*) over 288 km of the Penobscot River, Maine. In 1993, I also examined foods of nestling double-crested cormorants on 10 island colonies located in Penobscot Bay, Maine, a 35 x 60 km estuarine/marine ecosystem. My objectives relative to the Penobscot River were to examine variation in habitat use, quantify seasonal and spatial variation in cormorant foods during spring, estimate the number of

cormorant days-of-predation, and estimate the number of smolts eaten by cormorants. With regard to nestling cormorants my objectives were to compare, temporally and spatially, the diet of nestling cormorants in Penobscot Bay, determine the extent to which Atlantic salmon smolts contribute to the nestling diet, and compare my findings to historic data. To obtain diet information from birds using the Penobscot River, 190 cormorants were collected and stomach contents analyzed, I used aerial and ground surveys to estimate foraging distribution and cormorant numbers. Nestling foods were recovered from 743 regurgitant samples.

In all years ground and aerial surveys of the Penobscot River were significantly (Pearson correlation coefficient, $P < 0.01$) correlated, suggesting that the same birds were counted on both surveys. Cormorants were first seen on the Penobscot River between 15 and 20 April, 1992-94. Total roost counts peaked on 4 May 1992 (969 birds), 10 May 1993 (532 birds), and 3 May 1994 (792 birds). Birds with immature plumate characteristics were not observed until the first week of May 1992-94.

Cormorants consistently selected (Bonferroni family confidence coefficients, $P < 0.05$) against use of two large tributaries and the extreme northern sections of the mainstem of the Penobscot River. From late April through early June of all years, birds selected ($P < 0.05$) for use of mainstem dams and the estuarine portion of the river. Cormorant use of dams remained at or above expected levels until the second week in June in all years.

Cormorants foraging above the head of tide consumed 11 species (including freshwater, anadromous, and catadromous types), whereas birds foraging below the head of tide consumed 27 freshwater species and seasonally available estuarine, marine benthic, marine invertebrate, and pelagic taxa. Salmon smolts were not recovered from stomachs collected in April, rare during the first week of June, and absent thereafter. In contrast, smolts were among the five highest ranking prey taxa across all three river sections throughout May. Assuming that all smolts recovered from cormorants were hatchery-reared, cormorants consumed on average $7.3 \pm 1.2\%$ (range = $6.4 \pm 1.2\%$ to $8.6 \pm 1.0\%$) of the total number of smolts stocked per year.

In nestling diets, five benthic taxa, sculpins (Cottidae), sand shrimp (*Crangon septemspinosa*), wrymouth (*Cryptochanthes maculatus*), rock gunnel (*Pholis gunnellus*), and cunner (*Tautoglabrus adspersus*) were consistently among the highest ranking prey taxa in temporal and spatial comparisons. Only one Atlantic salmon smolt was recovered from 743 regurgitant samples. Further, in contrast to historic data, groundfish species were negligible components of the nestling diet. The weak contribution of groundfish species to the current nestling diet is supportive of concerns regarding declines in groundfish populations in the Gulf of Maine and shifts in community structure towards small, noncommercial, benthic species.

MACROINVERTEBRATES IN BROOD-REARING WETLANDS OF WATERFOWL (ANATIDS) IN FORESTED AND AGRICULTURAL LANDSCAPES IN NORTHERN 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
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 will be sampled for macroinvertebrates using several techniques (cylinder sampler, activity traps, sweep nets). Data on invertebrates will be related to wetland features, including water chemistry and chlorophyll-a. Hypotheses of differences in variables between forested and agricultural landscapes will be tested.

PROJECT STATUS: (Activities for the period October 1, 1995 to September 30, 1996). We completed entering taxa and environmental data into a dBase file for the 1,472 samples collected during 1993-1995. Data verification was completed and data analysis is underway. Voucher specimens were placed in the local NBS macroinvertebrate reference collection maintained for research purposes and in the University of Maine Insect Collection, which was upgraded somewhat. Three publications associated with the dissertation have been prepared. One of the three manuscripts "New records of predaceous diving beetles (Coleoptera; Dytiscidae) in Maine" has been accepted for publication in Entomological News (November, 1996). A second paper entitled "Reliability of data from activity traps in ranking aquatic communities" was presented at the annual meeting in June, 1996 of the North American Benthological Society, and has been submitted for publication in Wetlands. The remaining paper is in peer review. After the methodology paper was finished further analyses were started on relating macroinvertebrate distribution to wetland chemistry and to landscape variables.

FUTURE PLANS: Exploratory data analyses will continue using standard ecological and spatial techniques on relating environmental variables to macroinvertebrate distribution and abundance. Mean differences will be tested and results integrated with the literature and the thesis will be prepared and defended by the Graduate Assistant in late 1996 or early 1997. Additional appropriate sections of the dissertation will be submitted to peer-reviewed journals for publication.

NATIONAL PATTERNS OF BIRD ABUNDANCE AND DIVERSITY

Investigators: R. J. O'Connor
M. T. Jones

**Cooperators/
Project** U.S. Environment Protection Agency -
Environmental Laboratory, Corvallis, OR

Support: U.S. Forest Service -
Forestry Sciences Laboratory, Corvallis, OR
Pacific Northwest Region, Portland, OR
Oak Ridge National Laboratory, Oak Ridge, TN -
Environmental Sciences Division

Objectives:

- 1) Develop a database of avian species distribution compatible with the EMAP hexagon grid from 1990 Breeding Bird Survey data and develop maps of avian species richness.
- 2) Evaluate the effects of scale on the correlations between bird and AVHRR land classification distributions.

SCOPE: Patterns of species richness are poorly understood. This study will evaluate the correlations of avian distribution and richness with land cover characteristics derived from 1 kilometer resolution Advanced Very

High Resolution Radometer (AVHRR) satellite imagery. AVHRR data, when combined with existing species distribution data (e.g., Breeding Bird Survey), may prove to be a cost-effective method of evaluating changes in species richness over time. Additionally, by varying the number of land cover classes we will study the effects of scale on the correlations between species distributions and land cover classes.

PROJECT STATUS: Breeding Birds Survey (BBS) data were used to obtain the species richness data for each location with a route. In addition, the incidence of each species at each route (the proportion of surveys between 1981 and 1990 on which the species of interest was detected at the route) was calculated for each species. The diversity data and the individual species incidence data were each related to satellite imagery data using Classification and Regression Tree (CART) techniques. The satellite data was complemented with climate data from the Hierarchical Climate Network (HCN) and with some other data (road densities, waterways densities, land ownership).

When the land use data were consolidated to yield an Anderson Level II classification (14 land cover classes), the CART analysis yielded a statistical model discriminating eleven types of regions. Within each region species richness was determined (insofar as this may be inferred from the essentially correlative analysis conducted here) by unique combinations of climate and land use. The dominant predictors of species richness were average July temperature, average precipitation, and geographical location. Land use variables with predictive power included the proportion of mixed deciduous/coniferous forest and the extent of mixed grass/rangeland and the presence of large water bodies in the area. Since the independent variables were known for all 12,500 spatial units in the 48 states, it is possible to map the results of these models to the whole country, thus effectively creating ecoregions based on the discrimination by birds of the environmental correlates of these regions.

FUTURE PLANS: This project is now complete under its present auspices and manuscripts are being prepared for publication.

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

Objectives:

- 1) To describe changes in breeding bird communities on sites that are experimentally harvested (with selection silviculture) and unharvested.
- 2) To estimate site fidelity (i.e., annual return rates) of breeding migratory songbirds on experimental sites, and determine if timber harvesting affects site fidelity.
- 3) To compare productivity indices of breeding songbirds among harvested

and unharvested sites.

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 recently formed to address such long-term research issues. The FERP has established nine long-term research sites at the Penobscot Experimental Forest. 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 set aside 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: My first field season took place during the summer of 1995. No FERP areas had been harvested, so this season served as a pre-treatment benchmark for comparisons to future years. All territorial birds were spot-mapped on the nine research areas. Over 300 migratory songbirds were individually color-marked on FERP research areas. During 1996 the first return data were obtained, yielding return estimates of 50% for Hermit Thrushes, and ca. 30% for Ovenbirds. Captures of these two focal species average over 40 individuals per species, per summer.

FUTURE PLANS: During the winter of 1996/97 the second of three triplets will be harvested. Next summer (1997) I will continue to spot-map and intensively color-band birds on all nine research areas. By fall of 1997 I will analyze return rates on four harvested areas compared to five unharvested areas. By summer of 1998 (my projected final season) I will have return rates for six harvested stands, including stands that are one and two years post-harvest. These data will yield valuable information on post-disturbance breeding dispersal of adult Ovenbirds, Hermit Thrushes, and possibly other Neotropical migrant songbirds.

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 - Neotropical Migratory Bird Program USDA Forest Service Lake Umbagog National Wildlife Refuge N.H. Fish & Game Department N.H. Department of Resources and Economic Development Division of Forests and Lands Wagner Forest Management, Ltd.

Boise Cascade
 James River Corporation
 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.

STATUS: Pilot field work was conducted during May-August 1994, involving surveys on 12 20-ha plots, 4 each in managed hardwoods, spruce-fir forest, and regenerating clearcuts in northern New Hampshire. 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 indicated that transect surveys were more effective than point surveys in detecting fledglings, and that morning surveys were more productive than those conducted in late afternoon. The combination of survey techniques in the pilot year documented 60 bird species which appeared to be maintaining territories on the 12 study areas, and 403 encounters with fledglings or family groups of 50 species.

The study of effects of partial cutting in spruce-fir forests began in 1995. Field work conducted during May-August 1995 and 1996 involved behavior mapping of all birds encountered on 11 20-ha plots in managed spruce-fir forests. Treatments on the 11 plots ranged from no cutting in the past 60 years through commercial thinning to progressively heavier partial cuts, conducted during the past 4-6 years. Nest-searching and monitoring were conducted on 10-ha subsets of 3 plots during the 1996 field season to enable a comparison of results from this technique with those from behavior mapping. A collaborator has conducted both behavior mapping and constant-effort mist netting on a plot elsewhere in Maine, enabling comparison of those techniques as well. Vegetation surveys of the 11 plots are underway during September-October 1996.

FUTURE PLANS: Preparation of a techniques paper addressing fledgling surveys, behavior mapping, and comparisons of behavior mapping with nest searching/monitoring and constant-effort mist netting will be the priority for the 1996-97 academic year. Plans for the 1997 field season are pending evaluation of 1995 and

1996 behavior-mapping data.

EFFECTS OF LANDSCAPE PATTERN ON BIRD COMMUNITIES IN AGROECOSYSTEMS, AT MULTIPLE SPATIAL SCALES AND LEVELS OF HABITAT RESOLUTION

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 need 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: The field studies were completed in 1995. The breeding birds in windbreaks and surrounding area in each of 23 study areas in Nebraska were surveyed, and habitat, landuse, and additional landscape variables were collected, the latter to provide context for farms. Analyses have been completed, and reports are being delivered to the sponsoring agencies.

FUTURE PLANS: Target date for project completion is December 1996.

WILDLIFE RESOURCES - OTHER THAN MIGRATORY BIRDS:

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: The black bear has evolved into an important trophy big-game species in Maine, with considerable public interest in the welfare of the resource. Since 1985 Maine Department of Inland Fisheries and Wildlife's (MDIFW) bear management goal has been to maintain 1985 levels of bear distribution and abundance (21,000 bears).

Increasing harvest pressure and changing habitat conditions necessitate careful monitoring of the state's bear population to meet management objectives. Greater knowledge of population dynamics is needed to reliably assess impacts of management actions and habitat alterations on the bear resource.

This research is designed to document age-specific survival and fecundity of female bears in Maine, and describe their population dynamics. Of particular interest are the impacts fluctuating fall food supplies and hunting harvests have on the growth rate of female bear populations.

These relationships have been investigated using a computer model based upon parameter estimates from field data. Observed changes in population status of bears living within MDIFW study areas have provided a basis for evaluating harvest-related monitoring techniques. The model will eventually be used to further test the sensitivity of new monitoring techniques over a wide range of population conditions.

PROJECT STATUS: Analysis is now largely complete and a doctoral thesis is being prepared on the basis of the work done to date.

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.

**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
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

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 preserve, an untrapped industrial forest, and a trapped industrial forest.
- 2) Compare microhabitat characteristics among areas receiving high, low or no use-intensity by resident, non-juvenile martens in an industrial forest with trapping closure and a forest preserve.

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 reasonable opportunities for exploitation of forest products (i.e., timber and fur). We will attempt to isolate these effects by concurrently studying marten habitat associations 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) 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.

PROJECT STATUS: We radiocollared 48 (21 F, 27 M), 55 (22 F, 33 M) and 76 (48 M, 28 F) martens on the

three study sites in 1994, 1995, and 1996, respectively. Approximately 9,000 relocations have been obtained via telemetry and captures through 15 September 1996. 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. This protocol was repeated on 288 plots in the forest preserve. Data is currently being analyzed.

FUTURE PLANS: Martens will be trapped and radiocollared annually through June 1997. Relocations of radiocollared animals will be obtained through April 1998. Scheduled project completion date is December 1998.

RELATIONSHIPS BETWEEN MARTEN PREY DENSITIES AND MICROHABITAT CHARACTERISTICS IN NORTHERN MAINE

Investigator: H. J. Lachowski

Advisors: D. J. Harrison, Chair
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 density (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 will investigate 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 will be analyzed for percent occurrence of food items. Small mammals will be live-trapped in 5 habitat types (mature mixedwood, mature hardwood, mature softwood, regenerating forest, and stands with severe spruce-budworm damage). Microhabitat characteristics will be 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: We experienced a 67% decline in small mammal captures from 1995 (865 individuals in 1995, 287 individuals in 1996). In 15,552 trap nights, we totaled 2,549 captures of 1,152 individuals (49% red-backed voles (*Clethrionomys gapperi*), 23% deer mice (*Peromyscus maniculatus*), 22% shrews (*Sorex cinereus*, *Blarina brevicauda*)). Percent occurrence of marten food items in 219 scats, weighted equally among four seasons, was 45% red-backed voles, 32% deer mice, 13% shrews, 23% red squirrel (*Tamiasciurus hudsonicus*), 13% snowshoe hare (*Lepus americanus*), and 42% berries. Microhabitat

characteristics were sampled at 320 locations across 20 trapping grids partitioned among the 5 habitat types. Snowshoe hare pellet counts were conducted at the end of the leaf-off season on transects (n=240). Small mammal abundance and overstory habitat relations are being examined with repeated measures ANOVA. Small mammal microhabitat relations on the stand level scale are being modeled with interactive stepwise linear regression. Small mammal microhabitat relations at the microhabitat level are being modeled with logistic regression.

FUTURE PLANS: The completion of the final thesis is anticipated by December 1996.

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* National Marine Fisheries Service
National Biological Service
Support: University of Maine -
Department of Wildlife Ecology

Objectives:

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

SCOPE: The harbor seal (*Phoca vitulina*) and the gray seal (*Halichoerus grypus*) are often accused of having negative effects on fishery yields in the northwestern Atlantic Ocean. The predatory activities of pinnipeds near commercial fishing grounds have long provoked heated arguments. 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 and gray 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 will be collected through August 1997. Fifty-seven stomachs have been analyzed, with an additional 15 samples awaiting processing. 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.

FUTURE PLANS: Completion may be scheduled for December 1997.

**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/
Project
Support:* National Wild Turkey Federation -
Connecticut Chapter
Wildlife Forever
University of Maine -
Department of Wildlife Ecology
Connecticut Department of Environmental Protection -
Wildlife Division
- Objectives:*
- 1) Determine if nest or hatching success are affected by attentiveness of the female to her nest.
 - 2) Determine the effects of weather on nest attentiveness and reproductive parameters.
 - 3) Determine the effects of vegetative cover on nest success.
 - 4) Examine the effects of landscape characteristics on nest success and nest depredation.

SCOPE: In many states winter severity is thought to be one of the most important physical factors influencing eastern wild turkey (*Meleagris gallopavo silvestris*) populations. Winter mortality is thought to be the ultimate result of severe winters in northern and midwestern states. However, winter mortality may not be a limiting factor in southern New England. Instead, annual population fluctuations are most likely the result of variable reproductive success. Nest success appears to be the most important demographic variable influencing annual population change. High annual variation in nest success is common, but factors that directly cause this variation are not known. My objectives are to determine the relative effects of nest attentiveness, cover, weather, and landscape characteristics on nest success of turkeys in Connecticut.

PROJECT STATUS: During the winter of 1996 I trapped 22 hens and equipped them with back-pack transmitters. These hens were monitored throughout the winter, spring, and summer. I monitored nest attentiveness of 4 hens with Rustrak recorders positioned near nests. Daily weather data such as precipitation, wind speed, and temperature were obtained by placing weather stations near nests. After nesting was complete, I quantified vegetation around each nest site. Using aerial photographs, I will estimate the amount of edge (defined as an opening in the forest canopy with a diameter ≥ 3 times the height of the adjacent trees) near each nest, as well as distance to nearest edge, distance to roads, and distance to urban areas.

In the second year of this study I will trap and mark approximately 40 additional hens. The above data will be collected on these hens as well as on the hens remaining from the initial study population. Completion is anticipated by December 1997.

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

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 thinning 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: Pilot work in the summer of 1995 and the beginning of summer 1996 established an appropriate methodology for sampling snag invertebrates. The remainder of the 1996 field season was spent recording a broad spectrum of data for three size and three condition categories of oaks and pines, and collecting four different sample types. 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. Based upon analysis of these data, the strategy of sampling in future years may remain the same or become more focused. Future work may address the impact of forest harvests on the invertebrate community of snag bark.

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 Support:* Holt Woodlands Research Foundation
University of Maine -
Department of Wildlife Ecology
- Objectives:*
- 1) Evaluate the use of artificial refugia as a valuable method for the assessment of redback salamander populations.
 - 2) Estimate the density of the redback salamander population in an eastern oak-pine forest.
 - 3) 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 seven 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 will attempt to evaluate the coverboard method and use data obtained with this technique to estimate the redback salamander population at the Holt Forest, 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 60 new sites 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 salamanders 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.

FUTURE PLANS: Data will be collected through October. Analysis and evaluation will then begin. 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 that potentially high concentrations of plant secondary metabolites in forages of white-tailed deer have on deer 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 the foraging ecology of vertebrate herbivores has recently focused on the influence of plant secondary metabolites, because of the effect these compounds have on forage selection and quality. Plant secondary metabolites are a large (33,000 - 38,000) diverse group of organic compounds, which may be bitter-tasting, poisonous, offensively odorous, or have anti-nutritional properties. Phenolics and terpenes are the most prevalent classes of plant secondary metabolites and have the greatest overall influence on herbivore ecology. Herbivores have developed mechanisms to modify, degrade, or inhibit ingested compounds before absorption, or to detoxify and excrete absorbed compounds. The effects of plant secondary metabolites on herbivores varies depending on both the type of compound ingested and the herbivore ingesting it. It has been suggested that forage selection by ruminants is most likely a function of defense chemicals as determined by the rate of detoxification and elimination, but there is no available data on the detoxification abilities or energetic costs associated with detoxifying plant secondary metabolites by deer.

During winter, white-tailed deer are exposed to diets which vary in types and concentrations of plant secondary metabolites. The primary goal of my study is to understand the metabolic and energetic costs of ingested phenolic and terpene compounds in winter diets of white-tailed deer. Two experiments will be conducted using captive white-tailed deer fed both mixed natural forage diets and commercial pelleted diets formulated with specific secondary metabolites. These two experiments should provide an adequate means for comparing diet quality, detoxification metabolite output, energetic costs, and nutritional status of deer fed plant secondary metabolites.

Secondary goals of this study are to evaluate the use of detoxification metabolites as indices of diet quality. Several techniques have been proposed for evaluating the nutritional status of deer during winter using urine samples collected from snow. Although these techniques have received considerable attention, they have not been tested with deer fed natural winter diets, nor have they evaluated the potential confounding effects of plant secondary metabolites. Urine samples collected during the two plant secondary metabolite experiments will be analyzed and evaluated as indices of the nutritional status and diet quality of white-tailed deer.

PROJECT STATUS: Experiment 1 was conducted during February and March 1996. Chemical analyses of feed, feces, and urine samples are currently being conducted.

FUTURE PLANS: Experiment 2 will be initiated following chemical analyses from experiment 1 and evaluation of secondary metabolite concentrations to be used in formulated experimental diets.

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

SCIENTIFIC PUBLICATIONS

- BLACKWELL, B.F., W.B. KROHN, and R.B. ALLEN. 1995. Foods of nestling double-crested cormorants in Penobscot Bay, Maine, USA: temporal and spatial comparisons. Colonial Waterbirds 18(2):199-208.
- BOONE, R.B., and M.L. HUNTER, JR. 1996. Using diffusion models to simulate the effects of land use on grizzly bear dispersal in the Rocky Mountains. Landscape Ecology 11:51-64.
- CHILELLI, M., B. GRIFFITH, and D.J. HARRISON. 1996. Interstate comparisons of river otter harvest data. Wildlife Society Bulletin 24(2):238-246.
- COOPER, A., J. RHYMER, H. JAMES, S. OLSEN, C. McINTOSH, M. SORENSON, and R. FLEISCHER. 1996. Ancient DNA and island endemics. Nature 381:484.
- deMAYNADIER, P., and M.L. HUNTER, JR. 1995. The relationship between forest management and amphibian ecology: A review of the North American literature. Environmental Reviews 3:230-261.
- HAI, D.J., LIEN, J., NELSON, D., and CURREN, K. 1996. A contribution to the biology of the white-beaked dolphin *Lagenorhynchus albirostris* in waters off Newfoundland. Canadian Field-Naturalist 110(2):278-287.
- HARRISON, D.J. 1995. Effect of timber harvesting and trapping on American martens in northern Maine. Pages 27-32 in 1995 Annual Report and Research Summary of the Cooperative Forestry Research Unit. Miscellaneous Report No. 397, Maine Agricultural and Forest Experiment Station. University of Maine, Orono.
- HARTLEB, C.F., and J.R. MORING. 1995. An improved gastric lavage device for removing stomach contents from live fish. Fisheries Research 24(3):261-266.
- HARTLEY, R.A., and J.R. MORING. 1995. Differences in mortality between largemouth and smallmouth bass caught in tournaments. North American Journal of Fisheries Management 15:666-670.
- HUNTER, M.L., JR. 1996. Fundamentals of Conservation Biology. Blackwell Scientific Press, Cambridge, MA. 488pp.
- HUNTER, M.L., JR. 1996. Benchmarks for managing ecosystems: Are human activities natural? Conservation Biology 10(3):695-697.
- HUNTER, M.L., JR., and A. CALHOUN. 1996. A triad approach to land-use allocation. Pages 477-491 in Biodiversity in managed landscapes, R. Szaro and D. Johnston (eds.). Oxford University Press, New York. 778pp.
- KROHN, W.B., R.B. ALLEN, J.R. MORING, and A.E. HUTCHINSON. 1995. Double-crested cormorants in New England: population and management histories. Pages 99-109 in The double-crested cormorant: biology, conservation, and management, D. N. Nettleship and D. C. Duffy (eds.). Colonial Waterbirds 18 (Special Publication 1).

- MOORE, E.H., and J.W. WITHAM. 1996. From forest to farm and back again: Land use history as a dimension of ecological research in coastal Maine. Environmental History 1(3):50-69.
- MORING, J.R. 1996. Fish discoveries by the Lewis and Clark and Red River expeditions. Fisheries 21(7):6-12.
- MORING, J.R., J. MARANCIK, and F. GRIFFITHS. 1995. Changes in stocking strategies for Atlantic salmon restoration and rehabilitation in Maine, 1871-1993. American Fisheries Society Symposium 15:38-46.
- MUGANGU, T.E., M.L. HUNTER, JR., and J.R. GILBERT. 1995. Food, water, and predation: A study of habitat selection by buffalo in Virunga National Park, Zaïre. Mammalia 59(3):349-362.
- O'CONNOR, R.J. 1996. Toward the incorporation of spatiotemporal dynamics into ecotoxicology. Pages 281-317 In O.E. Rhodes, R.K. Chesser, and M.H. Smith (editors), Population dynamics in ecological space and time. Chicago University Press, Chicago, IL.
- PARAGI, T.F., W.B. KROHN, and S.M. ARTHUR. 1994. Using estimates of fisher recruitment and survival to estimate population trend. Northeast Wildlife 51:1-11.
- PARAGI, T.F., S.M. ARTHUR, and W.B. KROHN. 1996. Importance of tree cavities as natal dens for fishers. Northern Journal of Applied Forestry 13(2):79-83.
- POULSEN, J.G. 1996. Behaviour and parental care of skylark (*Alauda arvensis*) chicks. Ibis 138:525-531.
- POULSEN, J.G., and N.J. AEBISCHER. 1995. Quantitative comparison of two methods of assessing diet of nestling skylarks (*Alauda arvensis*). Auk 112:1070-1073.
- RHYMER, J.M., and D.S. SIMBERLOFF. 1996. Genetic extinction through hybridization and introgression. Annual Review of Ecology and Systematics 27:83-109.
- RODENHOUSE, N.L., L.B. BEST, R.J. O'CONNOR, and E.K. BOLLINGER. 1995. Effects of agricultural practices and farmland structure. Pages 269-293 In T.E. Martin and D.M. Finch (editors), Status and management of neotropical migratory birds. Oxford University Press, New York.
- SPICER, A.V., J.R. MORING, and J.G. TRIAL. 1995. Downstream migratory behavior of hatchery-reared, radio-tagged Atlantic salmon (*Salmo salar*) smolts in the Penobscot River, Maine, USA. Fisheries Research 23(3/4):255-266.
- THOMPSON, M.E., J.R. GILBERT, G.J. MATULA, JR., and K.I. MORRIS. 1995. Seasonal habitat use by moose on managed forest lands in northern Maine. Alces 31:233-245.
- WHITCOMB, S.D., A.F. O'CONNELL, JR., and F.A. SERVELLO. 1996. Productivity of the spruce grouse at the southeastern limit of its range. Journal of Field Ornithology 67(3):422-427.
- WITHAM, J.W., and A.J. KIMBALL. 1996. Use of a geographic information system to facilitate analysis of spot-mapping data. Journal of Field Ornithology 67(3):367-375.

TECHNICAL AND SEMI-TECHNICAL PUBLICATIONS

- CHAPIN, T.G., D.J. HARRISON, D.D. KATNIK, D.M. PHILLIPS, and E.C. YORK. 1995. Influence of

- landscape pattern, forest type, and forest structure on use of habitat marten in Maine. Final contract report submitted to National Council of the Paper Industry for Air and Stream Improvement. 87pp.
- deMAYNADIER, P. 1996. Research on amphibians and forestry practices reported in The Forestry Source, a publication of the Society of American Foresters, April 1996, Vol. 1, No. 3.
- HUNTER, M.L., JR. 1996. A desktop reference for conservationists. Book review of Conservation and Environmentalism (by J. Pahlke). Conservation Biology 10:1477-1478.
- LONG, R.A., D.J. HARRISON, and A.F. O'Connell, Jr. 1996. Annual survival and cause-specific mortality of white-tailed deer fawns on Mount Desert Island, Maine. Final Report No. CA-1900-1-9016, Amendment #S:5.19, North Atlantic Region, National Park Service, Boston, Mass. 51pp.
- MORING, J.R. 1995. Book review of The Rockpool Fishes of New Zealand (C. Paulin and C. Roberts, 1994, Museum of New Zealand). Fisheries Review 40(3):574.
- MORING, J.R. 1996. Book review of The Frontiersman: The Real Life and the Many Legends of Davy Crockett (by M. Derr, 1993, William Morrow and Company, New York, 304p.) Journal of the West 35(3):109.
- MORING, J.R., and K. FINLAYSON. 1996. Effects of land-use activities on Atlantic salmon (*Salmo salar*): a literature review. Final Report to the National Council of the Paper Industry for Air and Stream Improvement. 86pp.
- PAYER, D., and S.R. CRAVEN. 1995. Wild turkeys: A problem for Wisconsin. University of Wisconsin Cooperative Extension, Publication No. 63623. 19pp.
- PAYER, D., B.J. HOLMES, and R.E. SPRINGMAN. 1995. Pollution control guide for milking center wastewater management. North Central Regional Extension Publication NCR 549. 45pp.

THESES AND DISSERTATIONS

- BLACKWELL, B.F. 1996. Ecology of double-crested cormorants using the Penobscot River and Bay, Maine. Ph.D. Dissertation, University of Maine, Orono, ME. 141pp.
- deMAYNADIER, P. 1996. Patterns of movement and habitat use by amphibians in Maine's managed forests. Ph.D. Dissertation, University of Maine, Orono. 222pp.
- HARTLEB, C.F. 1996. Ecology and performance of stocked brook trout (*Salvelinus fontinalis*) in two Maine ponds. Ph.D. Dissertation, University of Maine, Orono. 210pp.
- MADDEN, A.P. 1996. The effects of invading black crappie on the resident white perch population in a lake of central Maine. M.S. Thesis, University of Maine, Orono. 64pp.

PROFESSIONAL TALKS PRESENTED

- BARTLETT, J., and D. MAGEEAN. "Integrating social science data with the landscape ecology of the coterminous United States." International Open Science Meeting on Land-use and Land-cover Change,

Amsterdam, The Netherlands, January 1996.

- MAGEEAN, D., and J. BARTLETT. "Integrating census data with the landscape ecology of the coterminous United States." Sixth International Symposium on Society and Resource Management, Pennsylvania State University, May 1996.
- MAGEEAN, D., and J. BARTLETT. "Putting people on the map: Integrating social science data with environmental data." Pecora 13 International Symposium on Human Interactions with the Environment: Perspectives from Space, Sioux Falls, SD, August 1996.
- BOONE, R.B., W.B. KROHN, S.A. SADER, Z. YIN, R.I. BARTLETT, and A.P. GUAY. "Use of aerial videography to create a habitat map for Maine." National Conference of the Society of American Foresters, Portland, ME, October 28-29, 1995.
- CHAPIN, T.G., and D.J. HARRISON. "Influence of landscape pattern on spatial use of habitat by marten in an industrial forest." National Conference of the Society of American Foresters, Portland, ME, November 1, 1995.
- CHAPIN, T.G., and D.J. HARRISON. "Seasonal selection of habitats by resting marten in Maine." 52nd Northeast Fish and Wildlife Conference, Farmington, CT, April 2, 1996.
- CHAPIN, T.G., and D.J. HARRISON. "Seasonal habitat selection by marten in an untrapped forest preserve." Ecological Society of America 1996 Annual Combined Meeting, Providence, RI, August 14, 1996.
- deMAYNADIER, P., and M.L. HUNTER, JR. "Forest management and amphibians: Insights from the North American literature." NCASI Northeast Regional Meeting, Portland, ME, October 18, 1995.
- deMAYNADIER, P. "Amphibian conservation in the working forest." Biodiversity in the Working Forest Workshop, University of Maine, Orono, December 12, 1995.
- deMAYNADIER, P. "Forest management and amphibian conservation in the Northeast." Maine Forest Biodiversity Project, Ellsworth, ME, March 12, 1996.
- deMAYNADIER, P. "Are vernal pool-breeding amphibians closed-canopy specialists?" Maine Audubon Society's Vernal Pool Workshop, Maine Audubon's Gilsland Farm Center, March 22, 1996.
- deMAYNADIER, P. "Best management practices for the uplands surrounding amphibian breeding pools." James River Corporation, Old Town, ME, April 18, 1996.
- HARRISON, D.J. "Influence of forest harvesting on marten populations in northern Maine." Society of American Forester's National Convention, Portland, ME. November 1, 1995.
- HARRISON, D.J. "Ecology and life history of the northeastern coyote. Seminar presented to Illinois Natural History Museum, University of Illinois, Urbana. November 14, 1995.
- HARRISON, D.J. "Social ecology and prey relationships of the eastern coyote: the influence of prey size on pack formation. Seminar presented to Dept. Of Ecology, Ethology, and Evolution, University of Illinois, Urbana. November 15, 1995.
- HARRISON, D.J. "Habitat requirements of American marten: reassessing paradigms." Department of Wildlife Ecology, University of Maine, November 28, 1995.

- HARRISON, D.J. Habitat requirements of American marten in northeastern forests. Seminar presented to Fraser Paper, Inc. and J. D. Irving Corporation's foresters. Edmundston, New Brunswick. February 27, 1996.
- HARRISON, D.J. "Marten, forests, and biodiversity: a model for conservation." Maine Forest Biodiversity Conference, Ellsworth, ME, March 12, 1996.
- HARRISON, D.J. "Funding, infrastructure, and partnerships for wildlife conservation in the U.S." Seminar presented to Department of Ecosystem Planning, Tokyo Noko University, Japan, March 20, 1996.
- HARRISON, D.J. "Habitat relationships of American marten: specialist or generalist." Seminar presented to U.S. Forest Service Redwood Sciences Laboratory and College of Natural Resources, Humboldt University, Arcata, CA, March 28, 1996.
- HARRISON, D.J. "Influence of spatial and body scaling on habitat selection by mammalian carnivores." Seminar presented to Utah Cooperative Fish and Wildlife Research Unit and Department of Fisheries and Wildlife, Utah State University, Logan, April 5, 1996.
- HARRISON, D.J. "Influence of spatial and body scaling on habitat selection by mammalian carnivores." Seminar presented to Department of Zoology and Physiology, University of Wyoming, Laramie, April 11, 1996.
- HARRISON, D.J., and S. L. Glass. Comparative social ecology of coyotes: does large prey cause pack formation? Paper presented at Ecological Society of America 1996 Annual Combined Meeting, Providence, RI. August 13, 1996.
- HARTLEB, C.F., and J.R. MORING. "A comparison of a bioenergetics model and field surveys on the survival of stocked brook trout." American Fisheries Society, Atlantic International Chapter, Annual Meeting, Gorham, NH, September 25, 1995.
- HARTLEY, M.J., and M.L. HUNTER, JR. "Effects of forest cover on nest predation rates and edge effects: A synthesis." Northeast Wildlife Graduate Student Conference, Acadia University, Wolfville, NS, Canada, March 2-3, 1996.
- HARTLEY, M.J., and M.L. HUNTER, JR. "Songbird site-fidelity in managed forests: An experimental study." Maine Bird Conference, Bates College, Lewiston, ME, April 26-27, 1996.
- HARTLEY, M.J. "Songbird site-fidelity and forest management. Part of "Acadia without birdsong?" Workshop/seminar Resource Acadia Seminar Series, Acadia National Park, May 11, 1996.
- HARTLEY, M.J., and M.L. HUNTER, JR. "Forest cover, artificial nest predation rates and edge effects: A meta-analysis." Joint meeting of the Ecological Society of America/Society for Conservation Biology, Providence, RI, August 10-14, 1996.
- HUNTER, M.L., JR. "Wildlife management across multiple ownerships." Society of American Foresters' National Convention, Portland, ME, November 1, 1995.
- HUNTER, M.L., JR. "Ecological thresholds and the definition of old growth trees." Forestry Seminar Series, University of Maine, Orono, November 10, 1995.
- HUNTER, M.L., JR. "Biodiversity: buzzword or fundamental concept." University of Montana, Missoula,

MT, December 1, 1995.

- HUNTER, M.L., JR. "Ecological reserves." New York chapters of the Wildlife Society, Society of American Foresters, and American Fisheries Society, Syracuse, NY, February 2, 1996.
- HUNTER, M.L., JR. "Lessons from paleoecology for conservation biology." University of Massachusetts-Boston, Biology Department, April 5, 1996.
- HUNTER, M.L., JR. Organized a symposium entitled "Northern forests: Diverse perspectives on bioregional planning," at the Ecological Society of America/Society for Conservation Biology Conference, Providence, RI, August 11, 1996.
- KROHN, W.B. "Use of aerial videography to create a habitat map of Maine from satellite imagery." A laboratory demonstration that was part of a professional development course on Remote Sensing and Forest Management, University of Maine, Orono, March 4, 1996.
- KROHN, W.B. "Management and status of American eider ducks." Slide presentation to a Wildlife Ecology class, University of Maine, Orono, March 20, 1996.
- KROHN, W.B. "Cormorants and Atlantic salmon restoration in the Penobscot River." Slide presentation to the Maine Atlantic Salmon Technical Advisory Committee, Bangor, ME, May 8, 1996.
- KROHN, W.B., and R.B. BOONE. "Gap Analysis in Maine - concepts and preliminary results." Poster and slide presentation at the Maine Forest Biodiversity Project meeting, Kingfield, ME, May 21, 1996.
- KROHN, W.B. and R.B. BOONE. "A preliminary Gap Analysis of Maine." Poster presentation at the 6th National Gap Analysis Meeting, Key Largo, FL, July 15-19, 1996.
- KROHN, W.B. and R.B. BOONE. "The status of Maine Gap Analysis." Slide presentation at a conference on Science-based Efforts to Design Ecological Reserves in Northern New England, Pinkham Notch, NH, September 24, 1996.
- LONG, R.A., D.J. HARRISON, and A.F. O'CONNELL, JR. Survival and cause-specific mortality of white-tailed deer fawns on Mount Desert Island, Maine. Paper presented at Ecological Society of America 1996 Annual Combined Meeting, Providence, RI. August 14, 1996.
- MADDEN, A.P., and J.R. MORING. "Effects of invading black crappie on the resident white perch populations in a lake of central Maine." Northeast Fish and Wildlife Conference, Farmington, CT, April 3, 1996.
- MAGEEAN, D.M., and J. BARTLETT. "Integrating social science data with the landscape ecology of the coterminous United States." Open Science Meeting on Land-use and Land-cover Change, Royal Netherlands Academy of Sciences, Amsterdam, Netherlands, January 1996.
- MAGEEAN, D.M., and J. BARTLETT. "Integrating social science data with the landscape ecology of the coterminous United States." Sixth International Conference on Society and Natural Resources, Pennsylvania State University, College Park, PA, May 1996.
- MAGEEAN, D.M., and J. BARTLETT. "Putting people on the map: Integrating population and environmental data." PECORA 13 Conference on Human Interactions with the Environment: Perspectives from Space, Sioux Falls, SD, August 1996.

- MOORE, E.H., and J.W. WITHAM. "From forest to farm and back again: Land use history as a dimension of ecological research in coastal Maine." National Society of American Foresters Convention, October 28-31, 1995.
- MORING, J.R. "The early culture of Atlantic salmon in Maine, 1871-1899." Poster presentation at the American Fisheries Society Annual Meeting, Tampa, FL, August 30, 1995.
- MORING, J.R. "Trends in anadromous fishes." Workshop on the Decline of Fisheries Resources in New England, Boston, MA, March 26, 1996.
- MORING, J.R. "The early culture of Atlantic salmon in Maine, 1871-1899." Poster presentation at the Northeast Fish and Wildlife Conference, Farmington, CT, April 1, 1996.
- O'CONNELL, A.F., and F.A. SERVELLO. "Spruce grouse ecology on Mount Desert Island, Maine." Ornithology Department Seminar, American Museum of Natural History, New York, NY, July 9, 1996.
- O'CONNOR, R.J. "Habitat correlates of grassland birds in North America." International Conference on Conservation and Ecology of Grassland Birds, Tulsa, OK, October 26-28, 1995.
- O'CONNOR, R.J., and M.T. JONES. "The environmental determinants of the avifauna of the coterminous United States." Winter meeting of the British Ecological Society, Sheffield, England, December 19, 1995.
- O'CONNOR, R.J. "A prototype biodiversity assessment for the coterminous United States. Seminar, Center for Population Biology, Imperial College, Silwood Park, Ascot, England, January 5, 1996.
- O'CONNOR, R.J. "Using the North American Breeding Bird Survey to measure ecosystem changes." Second National Science Meeting, Ecological Monitoring and Assessment Network, Halifax, NS, January 17-20, 1996.
- O'CONNOR, R.J. "Ecological theory as a path to adaptive conservation monitoring." Society for Conservation Biology Annual Meeting, Providence, RI, August 12, 1996.
- O'CONNOR, R.J. "The interface of theoretical ecology and conservation biology." Society for Conservation Biology Annual Meeting, Providence, RI, August 12, 1996.
- O'CONNOR, R.J. "Using hierarchical models of neotropical migrant birds for environmental assessment." Society of Canadian Ornithologists, Fredericton, NB, August 27-29, 1996.
- PAYER, D. "Ecology and management of bighorn sheep in Oregon." Student Chapter of The Wildlife Society, University of Maine, Orono, November 6, 1995.
- PAYER, D. "Diagnosis and management of wildlife diseases and necropsy techniques for wildlife." Lecture and demonstration given to WLE 410 class, University of Maine, Orono, March 25 and 27, 1996.
- PAYER, D. "Marten research in Maine: Implications of silvicultural practices for marten." NCASI Eastern Wildlife Task Group field trip to northern Maine, August 22, 1996.
- PAYER, D. "Marten research in Maine: Implications of silvicultural practices for marten." WLE 450 field trip to northern Maine, September 20, 1996.

- RHYMER, J.M. "The application of genetic methods to Conservation Biology." Maine Department of Inland Fisheries and Wildlife, Bangor, ME, August 27, 1996.
- SADER, S.A., Z. YIN, and W.B. KROHN. "An examination of land cover classification methods to create a habitat map of Maine." Poster presentation at the National Gap Analysis meeting, Key Largo, FL, July 15-19, 1996.
- SERVELLO, F.A. "Soil-plant-caribou dynamics in the Arctic Refuge: An avenue for assessing sustainability." Wildlife Department Seminar Series, University of Maine, April 2, 1996.
- YOUNG, H.B., and J.M. RHYMER. "A threatened species receives recognition at last?" Ecology Society of America, Providence, RI, August 14, 1996.

PUBLIC TALKS PRESENTED

- BOONE, R.B. Participated in an EPA High Performance Computing and Communication Technical Review Panel, Washington, DC, July 23-25, 1996.
- GILBERT, J.R. "Role of mammals and seabirds in the Gulf of Maine, patterns in space and time." Darling Marine Center Summer Scientific Lecture Series, July 18, 1996.
- HARRISON, D.J. "Marten as a barometer of forest health in Maine." Annual Meeting, Maine Chapter of The Wildlife Society, Brewer, ME, April 25, 1996.
- HARRISON, D.J., D. PAYER, and H.J. LACHOWSKI. "Influence of forest harvesting and forest structure on habitat selection by American marten." Presentation and field tour to NCASI and other forest industry representatives, Millinocket, ME, August 22, 1996.
- HARRISON, D.J. Adaptions of birds and mammals to their environment. Presentation to 2nd grade classes, McGraw School, Hampden, Maine. October 18, 1995.
- HARRISON, D.J. Animal's adaptions to winter. Presentation to Bangor Montessori School, Bangor, Maine. October 19, 1995.
- HARTLEB, C.F. "Evaluation of stocked brook trout." Presentation to the Fisheries Division, Maine Department of Inland Fisheries and Wildlife, Orono, ME, December 4, 1995.
- HUNTER, M.L., JR. "Biodiversity: What is it - Why do we care about it?" Support for Science Students Program, University of Maine, Orono, January 31, 1996.
- HUNTER, M.L., JR. "Exploration." University of Maine Commencement, Orono; May 11, 1996.
- HUNTER, M.L., JR. "A primer on biodiversity." University of Maine Alumni Reunion, Orono, June 2, 1996.
- HUNTER, M.L., JR. "Spatial and temporal patterns of forest diversity." USDA Forest Service, Clemson University, SC, September 20, 1996.
- KROHN, W.B. "Cormorants and smolts - what's happening in the Penobscot River?" Slide presentation to the Penobscot County Conservation Association, Brewer, ME, February 1, 1996.

- KROHN, W.B. "Cormorants and Atlantic salmon restoration in the Penobscot River." Slide presentation to the East Eddington Salmon Club, Eddington, ME, April 3, 1996.
- LACHOWSKI, J. "Mainely marten - Marten ecology and research techniques in Baxter State Park." Talk given to staff and public, Kidney Pond, Baxter State Park, July 17, 1996.
- LACHOWSKI, J. "Mainely marten - Marten ecology and research techniques in Baxter State Park." Talk given to public, Nesoadnahunk Field, Baxter State Park, July 25, 1996.
- LACHOWSKI, J. "Marten research in Maine - Implications for silvicultural practices for marten." Talk given to WLE 450 students on field trip to northern Maine, September 20, 1996.
- MADDEN, A.P. "Effects of invading black crappie on the resident white perch population in a lake of central Maine." Presentation to the Fisheries Division, Maine Department of Inland Fisheries and Wildlife, Bangor, ME, April 30, 1996.
- MORING, J.R. "Fish discoveries by the Lewis and Clark and Red River expeditions." Wildlife Department Seminar Series, University of Maine, October 2, 1995.
- MORING, J.R. "Animals." Old Town-Orono YMCA, Old Town, ME, March 11, 1996.
- PAYER, D. "Marten research in Maine: 1988 to present." Kennebec Valley Chapter of the Maine Trappers Association, North Anson, October 8, 1995.
- PAYER, G. "Mainely marten - Marten ecology and research techniques in Baxter State Park." Talk presented to the general public, Baxter State Park, July 17, 1996.
- WITHAM, J. "Overview of the Holt Research Forest." Brown-bag Series, School of Renewable Natural Resources, University of Arizona, Tucson, March 1, 1996.
- WITHAM, J. "Population trends of neotropical migrant birds in northeastern U.S." Conservation Biology Seminar, Dept. of Ecology and Evol. Biology, University of Arizona, Tucson, April 4, 1996.

AWARDS, HONORS, AND APPOINTMENTS

- BOONE, R.B. Received the 1996 Outstanding Graduate Student Award, Department of Wildlife Ecology, University of Maine.
- FOSS, C.R. Received the New Hampshire Fish and Game Department and University of New Hampshire Cooperative Extension 1995 Wildlife Stewardship Award.
- FOSS, C.R. Received the General Federation of Women's Clubs-New Hampshire 1995 Centennial Conservation Award.
- GILBERT, J.R. Appointed to National Marine Fisheries Service Gulf of Maine Aquaculture Pinniped Interaction Task Force, 1995-96.
- GILBERT, J.R. Appointed to National Marine Fisheries Service Harbor Porpoise Reduction Task Force, 1996.
- GILBERT, J.R. Appointed to National Marine Fisheries Service Atlantic Scientific Review Group for Marine

Mammals, 1995.

HUNTER, M.L., JR. Appointed to the Board of Editors of Ecological Applications, November 6, 1995.

HUNTER, M.L., JR. Appointed to the Scientific Advisory Committee of the Joseph Jones Ecological Research Center in Newton, Georgia, March 20, 1996.

HUNTER, M.L., JR. Named 1996 Distinguished Maine Professor.

KROHN, W.B. Requested by Champion International to serve as a member of an interdisciplinary team to review Champion's Forest Stewardship and Sustainability Initiative.

MORING, J.R. Elected President, Fisheries History Section, American Fisheries Society.

MORING, J.R. Served as Chair, the University of Maine Institutional Animal Care and Use Committee.

MORING, J.R. Newsletter Co-Editor, Fisheries History Section, American Fisheries Society.

MORING, J.R. Appointed to on the Forestry Working Group for the Governor's Atlantic Salmon Task Force.

RHYMER, J.M. Appointed to NSF Dissertation Improvement Grants panel, January 1996.

RHYMER, J.M. Appointed to Wilson Ornithological Society Student Research Grants Committee, February 1996.

SERVELLO, F.A. Member of a design team developing management plans for two wildlife/forest management demonstration areas in Maine in conjunction with Manomet Observatory, Great Northern Paper, and S. D. Warren.

