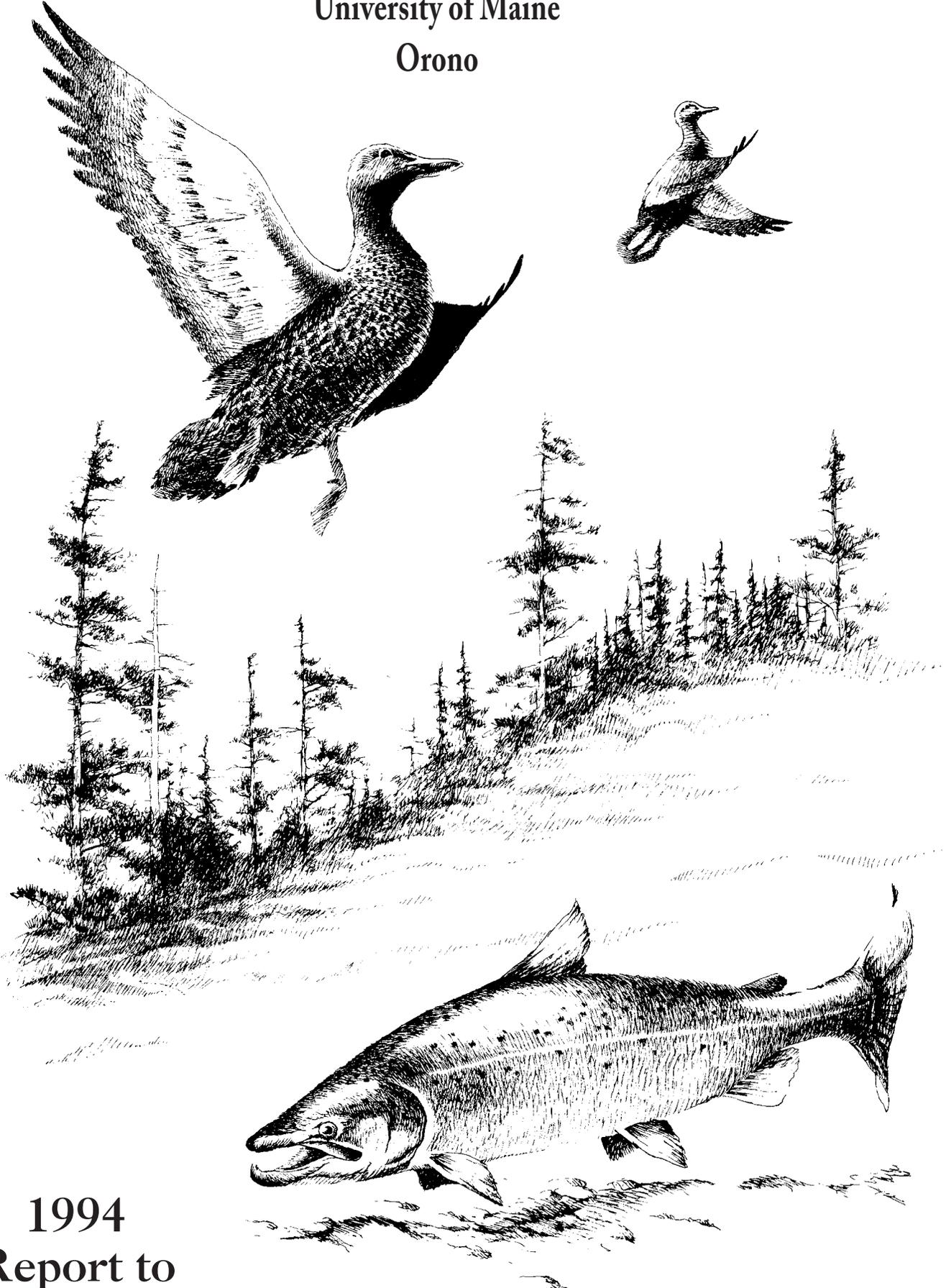


MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

University of Maine

Orono



1994
Report to
Cooperators

—Mark McCollough '86

MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

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COOPERATORS

UNIVERSITY OF MAINE

MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE

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

WILDLIFE MANAGEMENT INSTITUTE

October 1993 - September 1994

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 Survey

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 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

Maxine L. Horne, Unit Administrative Assistant - Wildlife

Shirley L. Moulton, Secretary - Wildlife

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

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

Kevin J. Boyle, Associate Professor, Department of Agriculture and Resource Economics, and Cooperating Associate Professor of Wildlife

Daniel J. Harrison, Associate Professor of Wildlife

Malcolm L. Hunter, Jr., Professor of Wildlife

Allan O'Connell, Faculty Associate and Leader, Cooperative National Park Unit, NBS

Raymond J. O'Connor, Professor of Wildlife

Frederick A. Servello, Assistant Professor of Wildlife

Jerry R. Longcore, Faculty Associate, Wildlife, and Research Wildlife Biologist, NBS

James A. Sherburne, Director, International Programs and Professor of Wildlife

Terry A. Haines, Professor of Zoology and Fishery Research Biologist, NBS

Ruth W. Perry, Technician, Zoology

Elizabeth Moore, Research Assistant, Wildlife

Jack Witham, Assistant Scientist, Wildlife

Thomas Hodgman, Research Associate, Wildlife

Malcolm T. Jones, Research Associate, Wildlife

Maine Department of Inland Fisheries and Wildlife:

Ray B. Owen, Jr. Commissioner

Norman E. Trask, Deputy Commissioner

Frederick B. Hurley, Jr., Director, Bureau of Resource Management

Gary G. Donovan, 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
Cathryn C. Abbott	M.S.	USFWS
Andrew P. Allen	M.S.	USEPA
Bradley F. Blackwell	Ph.D.	MCFWRU, USFWS
Randall B. Boone	Ph.D.	MCFWRU, USFWS
Theodore D. Chapin	M.S.	McIntire-Stennis
Michael B. Cole	M.S.	MDIFW
Phillip G. de Maynadier	Ph.D.	McIntire-Stennis
Stephen S. Ditchkoff	M.S.	McIntire-Stennis
Diana M. Eignor	Ph.D.	USFWS and USACOE
Mustapha El Hamzaoui	Ph.D.	USAID/USDA
William E. Eschholz	M.S.	CFRU, MCFWRU
Carol R. Foss	Ph.D.	USFS, USFWS, Switzer Env. Fellowship
Herbert C. Frost	Ph.D.	MDIFW, MCFWRU
Stephen L. Glass	Ph.D.	ANP
P. Brian Gray	M.S.	McIntire-Stennis
Christopher F. Hartleb	Ph.D.	MDIFW
Mitschka J. Hartley	Ph.D.	McIntire-Stennis
Karen S. Hockett	M.S.	USFWS
Catherine M. Johnson	Ph.D.	USFWS
Malcolm T. Jones	Ph.D.	CPM
Lisa A. Joyal	M.S.	U of M
Siti C. Kaniawati	M.W.C.	Indonesia
Mary Kay Kenney	M.S.	U.S. Natl. Marine Fisheries and DEP
Charles G. Kitchens	M.S.	USFWS
Daniel H. Kusnierz	M.S.	DWRS, NBDNRE
Henry J. Lachowski	M.S.	U of M, McIntire-Stennis
Laurance Lisle	M.W.C.	Personal Funding
Robert A. Long	M.S.	Acadia - NPS
Paula MacKay	M.S.	Hatch
Andrew P. Madden	M.S.	MDIFW, U of M
Angela C. Matz	Ph.D.	Acadia - NPS
Thomas C. McCall	M.S.	Hatch, McIntire-Stennis
Karen E. McCracken	Ph.D.	U of M
Craig R. McLaughlin	Ph.D.	Personal Funding
Laura M. Monti	M.S.	Holt Woodlands Research Foundation
Deborah A. Moreau	M.S.	USFWS-CAFL
Dawn L. Nelson	M.S.	Holt Woodlands Research Foundation
Sara J. Oyler	M.S.	EPA
David C. Payer	Ph.D.	MDIFW, CFRU, U of M
Ann M. Perillo	M.S.	USFWS, USFS, MDIFW
David M. Phillips	M.S.	U of M
John G. Poulsen	Ph.D.	Consortium of pesticide manufacturers
Michael W. Powell	M.S.	U of M
Kevin S. Raymond	M.S.	CFRU, MCFWRU
Steven L. Shepard	M.S.	BHE
Craig P. Stafford	M.S.	U of M
Sarah S. Stockwell	Ph.D.	Personal Funding

Marcia L. B. Summers	M.S.	Personal Funding (Grad. School Assistantship)
Emy E. Suwarni	M.W.C.	USAID/Indonesia
Linda J. Welch	M.S.	USFWS
Scott Whitcomb	M.S.	NPS

DISSERTATIONS AND THESES COMPLETED THIS PERIOD

Student	Degree Candidacy	Support
Cathryn C. Abbott	M.S.	USFWS
Michael B. Cole	M.S.	MDIFW
William E. Eschholz	M.S.	CFRU, MCFWRU
Herbert C. Frost	Ph.D.	MDIFW, MCFWRU
P. Brian Gray	M.S.	McIntire-Stennis
Karen S. Hockett	M.S.	USFWS
Charles G. Kitchens	M.S.	USFWS
Thomas C. McCall	M.S.	Hatch, McIntire-Stennis
Sara J. Oyler	M.S.	EPA
David Phillips	M.S.	U of M
Kevin S. Raymond	M.S.	CFRU, MCFWRU
Sarah S. Stockwell	Ph.D.	Personal Funding
Linda J. Welch	M.S.	USFWS
Scott D. Whitcomb	M.S.	NPS

PERSONNEL NOTES

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

BERT FROST received a Ph.D. and has accepted a position teaching Biology at the University of Maine in Farmington. **BRIAN GRAY** completed the M.S. program and is working as a wildlife biologist at the Kentucky Department of Fish and Wildlife Resources. **CHUCK KITCHENS** obtained his M.S. degree and returned to work as a Wildlife Biologist for the Moosehorn National Wildlife Refuge in Calais, Maine. **TOM McCALL** received an M.S. and is now working for the Washington Wildlife Department. **SARA OYLER** completed the M.S. program and has been accepted as a Ph.D. student at Colorado State University in Fort Collins. **WILLIAM ESCHHOLZ** completed his M.S. program and is a wildlife biologist with PlumCreek Timber Company in Washington. After working and rearing a family, **SARAH STOCKWELL** returned to finish her Ph.D. degree and resume her position with the Maine Audubon Society. **LINDA WELCH** was a Cooperative Education student with the U.S. Fish and Wildlife Service and holds a position with them at their Old Town, Maine field headquarters. **SCOTT WHITCOMB** received an M.S. degree and now holds a position with the Clinch Mountain Wildlife Management Area in West Virginia.

MICHAEL COLE received his M.S. in Zoology in August 1994 and took a position with a consulting company in Florida. **KAREN HOCKETT** completed her M.S. in May and is in the Ph.D. program at Virginia Tech. **CATHRYN ABBOTT** received her M.S. degree at the University of Maine and is continuing on for her Ph.D. in Zoology at Maine. **DEBORAH MOREAU** did not complete her M.S. thesis and has entered the Mother of God Monastery in Springfield, Massachusetts.

RAY OWEN continued on sabbatical, serving as Commissioner of the Maine Department of Inland

Fisheries and Wildlife. **RAYMOND O'CONNOR** returned to his University position after completing his sabbatical with the U.S. Environmental Protection Agency in Corvallis, Oregon. **MAXINE HORNE** retired in August 1994 from her position as the Administrative Assistant for the Cooperative Fish and Wildlife Research Unit and the Department of Wildlife Ecology after 47 years of dedicated service.

COLLABORATING AGENCIES AND ORGANIZATIONS

Atlantic Salmon Federation - ASF
 Bangor Hydro-Electric - BHE
 Baxter State Park - BSP
 Bowater-Great Northern Paper, Inc. - BGNP
 Champion International Corporation - CI
 Davis Conservation Association - DCA
 Hirundo Wildlife Refuge - HWR
 Holt Woodlands Research Foundation - HWRF
 Maine Atlantic Sea Run Salmon Commission - MASRC
 Maine Audubon Society - MAS
 Maine Department of Conservation - MDC
 Maine Department of Environmental Protection - MDEP
 Maine Department of Inland Fisheries and Wildlife - MDIFW
 Maine Image Analysis Lab - MIAL
 Maine Land Use Regulation Commission - MLURC
 Maine Office of Geographic Information Systems - MOGIS
 Maine Trappers Association - MTA
 National Fisheries Research Center - Leetown
 National Marine Fisheries Service - NMFS
 National Rifle Association - NRA
 Nature Conservancy - NC
 Maine Chapter - NC-MC
 New England Salmon Association - NESAs
 Oak Ridge National Laboratory
 Environmental Sciences Division
 Penobscot County Conservation Association - PCCA
 Signal Fuels, Inc. - SF
 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
 Hatch Act Funds - HAF
 McIntire-Stennis - MS
 Department of Zoology - DZ
 Maine Agricultural and Forest Experiment Station - MAFES
 U.S. Environmental Protection Agency - EPA
 Environmental Laboratory, Corvallis, OR
 U.S. Fish and Wildlife Service - FWS
 Ecological Services
 Federal Aid and Fisheries
 Refuges

USDA Forest Service - USFS
Forestry Sciences Laboratory, Corvallis, OR
Pacific Northwest Region, Portland, OR

USDI National Biological Survey - NBS
Leetown Science Center - LSC
Midwest Science Center - MSC
Patuxent Wildlife Research Center - PWRC

U.S. National Park Service - NPS
Acadia National Park

PROJECT REPORTS

ENDANGERED AND THREATENED SPECIES:

CONTAMINANT BURDENS AND REPRODUCTIVE RATES OF BALD EAGLES BREEDING IN MAINE

Investigator: L. J. Welch

Advisors: W. B. Krohn, Co-chairperson
R. B. Owen, Jr. Co-chairperson
J. R. Moring
K. C. Carr, Ex-officio
C. S. Todd, Ex-officio

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

Objectives:

- 1) Determine the production level of all known pairs of bald eagles breeding in Maine.
- 2) Evaluate relationships of contaminant residues in blood samples from nesting bald eagles with regional variations in eagle productivity, variable trophic status of the adults, and contaminant residues in prey from that area.
- 3) Determine correlations between mercury residues in feathers and prey items to blood levels of mercury in nestlings. Levels will be compared to individual nest site and regional productivity.
- 4) Identify the occurrence and residue levels of environmental contaminants in unhatched bald eagle eggs.
- 5) Determine the current deviation of eggshell thickness from the "precontaminant" era standard.
- 6) Determine correlations among contaminant residue levels in tissue samples obtained from eagle carcasses to time of exposure (age of the bird) and regional variations in productivity.

SCOPE: In 1978, the bald eagle was classified as an endangered species in Maine and 42 of the other contiguous states, and threatened in the remaining 5 states. At that time, environmental contaminants were shown to be adversely affecting many of the eagle populations. Currently, Maine bald eagles have reproductive rates 15-40% lower than all other North American populations, and it is believed that contaminants may still be responsible. Past studies of Maine's eagle population have found uniquely high levels of contaminants in unhatched eggs.

PROJECT STATUS: All requirements for the degree of Master of Science (in Wildlife Management) were completed in May 1994. An abstract of the thesis follows:

Contaminant investigations conducted on bald eagle (*Haliaeetus leucocephalus*) eggs collected in Maine in the 1970's and 1980's reported significant levels of environmental contaminants. Many of these contaminants have been correlated with reduced reproductive rates in bald eagle populations. Within Maine, eagles have never reached the production level of 1.00 young / occupied nest, associated with healthy populations. The Maine bald eagle population continues to exhibit reproductive rates consistently below

levels achieved by all other major populations of eagles.

To determine current contaminant exposure in the Maine bald eagle population, eggs and nestling blood and feather samples were collected during 1991 and 1992. Samples were analyzed for organochlorine pesticides, PCBs, TCDD-EQ and mercury. Brain and liver samples were collected from eagles recovered within Maine.

Contaminant residues and production rates varied significantly between habitat types. PCB and DDE concentrations were significantly higher in nestlings sampled along the coast of Maine. In contrast, mercury concentrations in both blood and feather samples were significantly higher in eagle samples from inland nest sites. Eagles nesting along the coast experienced significantly higher rates of production than eagles nesting in interior regions of Maine.

Prey remains collected at nest sites indicated differences in diet composition between coastal and inland nesting eagles. Piscivorous avian species, particularly gulls and cormorants, were frequently recovered (77%) from coastal sites. Prey remains identified from interior nest sites indicated a diet of predominately fish (26%). DDE levels in addled eggs collected in Maine have decreased significantly during the last 20 years. However, mercury concentrations in eggs have increased during this time period. Elevated levels of contaminants were also recorded in brain and liver samples of known-age eagle carcasses recovered in Maine.

Significantly elevated concentrations of mercury, PCBs, DDE, and TCDD-EQ were observed in the Maine bald eagle population. Contaminant concentrations observed in this study exceed levels associated with reduced reproductive rates in bald eagles. Results indicate that environmental contaminants are limiting the reproductive capabilities of the Maine eagle population.

CONTAMINANT BURDENS AND ECOLOGY OF BALD EAGLES NEAR ACADIA NATIONAL PARK

- Investigator:* A. C. Matz
- Advisors:* R. B. Owen, Co-Chairperson
A. F. O'Connell, Co-Chairperson
D. J. Harrison
W. E. Glanz
W. B. Krohn
C. A. Todd, Ex-officio
- Cooperators/
Project
Support:* University of Maine -
Department of Wildlife Ecology
National Park Service -
Cooperative Park Studies Unit
Maine Department of Inland Fisheries and Wildlife
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 attempt to 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: The 1994 (May through August) field season was used to collect blood samples from nesting eagles and relocate previously radio-tagged adults. Feather samples, age and sex measurements were collected from each bird handled. Prey remains were collected from each nest site, and several specimens of seal blubber were collected for future contaminants analysis. Observations on 3 nests yielded data about disturbance factors and provided a foundation for further study.

FUTURE PLANS: Samples collected for contaminants analysis will be analyzed by USFWS Patuxent Analytical Control Facility. Three more full field seasons are anticipated, with project completion occurring in December 1996.

FISHERIES RESOURCES:

THE EFFECTS OF COVER AND A MODEL KINGFISHER ON THE ANTI-AVIAN PREDATOR RESPONSE OF JUVENILE ATLANTIC SALMON (*SALMO SALAR*)

Investigator: K. S. Hockett

Advisors: J. R. Moring, Chairperson
W. B. Dowse
W. E. Glanz

**Cooperators/
Project
Support:** U.S. Fish and Wildlife Service -
WO, Federal Aid

Objectives:

- 1) Document the response availability of salmon smolts to potential avian predation.
- 2) Test the retention of the learned response by hatchery-cultivated Atlantic salmon.

SCOPE: Double-crested cormorants are known predators of Atlantic salmon smolts. Survival of Atlantic salmon from smolts to returning adults averages 0.6%, or less, in the Penobscot River, and part of this mortality may be due to predation by aquatic birds during the downstream migration. This project documents the susceptibility of smolts to in-river predation by cormorants and other bird predators and whether the avoidance response is lost in the continued absence of cover by using a series of laboratory experiments and challenges.

PROJECT STATUS: All requirements for the degree of Master of Science (in Zoology) were completed in May 1994. An abstract of the thesis follows:

The behavioral effects of rearing Atlantic salmon (*Salmo salar*) parr under varying conditions of environmental complexity (black substrate and PVC pipes) and different activity levels (none, human disturbance, bird model) were assessed with a 3 x 2 design. Observations were made on sixty parr reared in each of the six treatments for 47 days. Success of the training, measured by the shelter seeking tendency, was evaluated by simulating a stocking event into a stream tank. Fifteen individuals and six groups of seven

fish were tested for each treatment. After 20 minutes in the stream tank, a bird model was "flown" over in order to observe the fright reaction of the fish. The behavior of the fish reared under different conditions was compared to document the effects on the anti-predator response.

Fish in the human disturbance treatments habituated to overhead disturbance. Shelter use by fish in the human activity-cover treatment peaked within the first ten days and then steadily declined. Model-cover treatment fish increased their shelter use more slowly, but maintained a high level of use throughout the training period. The no-activity fish used shelter less ($P < 0.001$) than did fish in the human and model treatments. After disturbance, fish in the human and model treatments used significantly greater cover ($P < 0.001$). Fish in the model treatment used cover more ($P < 0.001$) after disturbance than did the human treatment fish.

Fish in the cover treatments spent a greater time settled on the substrate than did the no-cover fish, after transfer to the stream tank ($P < 0.001$). Cover treatment fish also used shelter (PVC pipes) and black more than did the no-cover fish ($P < 0.001$). Fish in all treatments increased their time settled following model presentation ($P < 0.05$).

Fish in the model-cover treatment response to the model most similarly to the observed fright reactions of wild parr. These salmon remained stationary if they were already settled and sank to the bottom, without darting, if they had been swimming. Fish in the other treatments darted much more before settling, and some did not respond to the model.

Fish in groups were much more active than were individual fish ($P < 0.0001$). Individuals also spent a greater time in shelter than did the group fish ($P < 0.01$).

The maintenance of high shelter use by the cover treatment fish after transfer suggests that survival may be increased on providing some form of cover in rearing tanks. The high level of activity by the no-cover treatments and fish in groups would decrease survival by increasing visibility of salmon to predators.

SUMMER MOVEMENTS AND HABITAT USE BY THREE SIZE CLASSES OF SMALLMOUTH BASS (*MICROPTERUS DOLOMIEU*) IN GREEN LAKE, MAINE

Investigator: M. B. Cole

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

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

Objectives: 1) Follow daily and seasonal movements of smallmouth bass in several lakes.
2) Examine the role of larger bass found in deep waters.

SCOPE: It is believed that a segment of the smallmouth bass population in lakes may be included in population surveys or may be utilizing habitat managed for other species. The project involves radio tracking smallmouth bass in Green Lake to examine daily and seasonal patterns at the time of spawning, during summer, and in the fall. Fish were tagged during the spawning time in late spring, and tracked into fall 1993.

PROJECT STATUS: All requirements for the degree of Master of Science (in Zoology) were completed in August 1994. An abstract of the thesis follows:

Fisheries managers utilize SCUBA to count smallmouth bass (*Micropterus dolomieu*) in lakes during the summer months in Maine, separating the observed bass into three size classes. These data are used to

estimate size compositions of smallmouth bass populations. Such estimates may be biased if the size composition of the bass encountered by SCUBA divers is not representative of the entire population. Knowledge of how summer movements and habitat use are related to fish size is important in determining whether a bias occurs. This study radio-tracked 44 adult smallmouth bass of three different size classes to investigate the effect of fish size on summer movements and habitat use. Radio-tagged bass were tracked through the summer of 1993 on Green Lake, Hancock County, Maine.

Size class affected depth use during the late summer (July 15 - September 1) tracking period. Large (>406 mm) smallmouth bass used deep water (>8 m) more often than did small (248 mm - 279 mm) bass ($p = 0.009$) or medium-sized (305 mm - 356 mm) bass ($p = 0.0130$) during the late summer. Large bass also used mid-depths (4-8 m) significantly ($p = 0.037$) more often than did small bass during the late summer.

Cover use was also related to bass size class. Small bass used cover more frequently ($p < 0.001$) than did large bass during the early summer tracking period (June 10 - July 13). Both small and medium-sized bass used cover more frequently than did large bass during the late summer tracking period ($p < 0.001$, $p = 0.007$ respectively).

Movement distances varied among smallmouth bass size classes. Small bass had significantly smaller total ranges than did large bass ($p = 0.004$). All three size classes showed significantly different mean active displacements ($p_{\text{small-medium}} = 0.045$, $p_{\text{medium-large}} = 0.032$, $p_{\text{small-large}} < 0.001$). Large smallmouth bass were located within residence areas less often than were small ($p < 0.001$) or medium-sized ($p < 0.001$) smallmouth bass.

Large radio-tagged smallmouth bass were less visible to SCUBA divers than were radio-tagged small bass during the early summer tracking period ($p = 0.036$), and were less visible than were both smaller size classes during the late summer tracking period ($p_{\text{large-small}} = 0.004$, $p_{\text{large-medium}} = 0.007$). Proportional stock density (PSD) estimates generated by SCUBA counts changed little when adjusted by early summer or late summer visibility scores. Relative stock density (RSD) was more than doubled when it was adjusted by late summer visibility scores, indicating that a significant RSD bias may occur if SCUBA counts of smallmouth bass populations are made after adults have completed spawning and nest guarding. SCUBA counts of smallmouth bass populations should be made early in the summer, when water temperatures are rising from 15 to 20°C, and smallmouth bass are spawning and nest guarding.

POPULATION STUDIES OF MAINE INTERTIDAL FISHES

Investigator: J. R. Moring

Cooperators/ University of Maine

Project

Support:

- 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) Develop a species checklist 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, *Cryptocotile lingua*.

PROJECT STATUS: Experiments with movements of juvenile grubbies, shorthorn sculpins, and lumpfish are ongoing. One paper on the subject was published in 1994 and a seminar was presented. In addition, an invited paper was presented at a special Intertidal Fishes symposium held in conjunction with the Annual Meeting of the American Society of Ichthyologists and Herpetologists.

FUTURE PLANS: Work dealing with intertidal movements of sculpins will continue in 1995, along with experiments on Atlantic seasnail feeding and innovative fish marking techniques. Additional manuscripts are being prepared.

UPSTREAM MIGRATION OF ATLANTIC SALMON IN THE PENOBSCOT RIVER

Investigator: S. L. Shepard

Advisors: J. R. Moring, Chairperson
I. L. Kornfield
J. D. McCleave

**Cooperators/
Project
Support:** Bangor Hydro-Electric Company

Objective: Document and correlate environmental factors influencing upstream movements of Atlantic salmon.

SCOPE: Even with adequate fish passage facilities, upstream-migrating adult Atlantic salmon are delayed by each dam. However, it has not been documented whether part of these delays may be due to environmental factors such as streamflow. Using radio telemetry, this project correlates the movement patterns of salmon with measurements of environmental parameters.

PROJECT STATUS: Salmon were tagged and monitored in 1990, 1991, and 1992. Analysis of data is underway.

FUTURE PLANS: An M.S. thesis is expected in May 1995.

REFINEMENT AND TESTING OF THE HABITAT SUITABILITY INDEX MODEL FOR ATLANTIC SALMON

Investigator: D. A. Moreau

Advisors: J. R. Moring, Chairperson
D. L. Parrish
J. G. Trial
H. B. Dowse

Cooperators/ U.S. Fish and Wildlife Service - CAFRL

Project Penobscot County Conservation Association
Support: New England Salmon Association

Objectives:

- 1) Incorporate low-flow data into the existing Atlantic salmon Habitat Suitability Index (HSI) model.
- 2) Measure habitat parameters for adult cover, and test a model.

SCOPE: Habitat Suitability Index models are commonly used for evaluating habitat capacity to support various species of animals and to use in conjunction with mitigation projects and environmental assessments. The current model for Atlantic salmon is non-functional because several aspects of habitat need to be included and tested. This project incorporates existing low-flow habitat information and measures and tests habitat data for adult holding areas.

PROJECT STATUS: Data on adult holding areas were collected from observations of Atlantic salmon on the Dennys River, near Dennysville, Maine during summer 1990. Because of the relatively low numbers of salmon entering the smaller rivers in Maine, additional measurements of salmon were made in streams in New Brunswick in August 1990, and during May-October 1991. All field work has been completed and the model has been developed.

FUTURE PLANS: The thesis was not completed, but a final report was issued in January 1993. Habitat data for HSI model development were collected in 1991 in Dungarvon and Big Salmon rivers, New Brunswick. The model is based on temperature in the pools, maximum pool depth, percent instream cover, and the proximity of spawning habitat. Due to physiological constraints, temperature is a limiting factor. Except when temperatures exceed 28°C, the Habitat Suitability Index of a pool is the arithmetic mean of the suitability indices of maximum pool depth, percent instream cover, and proximity of spawning habitat.

GROWTH, SURVIVAL, AND PERFORMANCE OF STOCKED AND WILD 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, survival, and angler return of stocked spring yearling brook trout and wild 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 several lakes to analyze growth of brook trout and food habits of

trout and competing species over two seasons. Identified competitors will be excluded from one lake where spring yearling brook trout will be stocked. Growth rates and survival will be compared.

PROJECT STATUS: The second field season has been completed and analyses of extensive samples will continue over the winter.

FUTURE PLANS: A third field season will commence in late spring 1995 to examine biomanipulation and the role of competition. A Ph.D. dissertation is expected in May 1996.

COMPETITION BETWEEN WHITE PERCH AND ILLEGALLY-INTRODUCED BLACK CRAPPIE

Investigator: A. P. Madden

Advisor: 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 smallmouth bass and chain pickerel. Black crappies have successfully reproduced and the population numbers have increased substantially, apparently to the detriment of white perch. This project examines the impact of this introduced centrarchid on the native white perch.

PROJECT STATUS: The project has just begun, with field work scheduled for 1995. A Master of Science degree is anticipated for May 1996.

HABITAT RESOURCES:

EFFECTS OF DIGESTIBLE ENERGY CONTENT OF WINTER FORAGES ON WHITE-TAILED DEER NUTRITIONAL ECOLOGY: IMPLICATIONS FOR MEASURING FORAGE AVAILABILITY IN DEER WINTERING AREAS

Investigator: P. B. Gray

Advisors: F. A. Servello, Chairperson
M. R. Stokes
R. L. Dressler

*Cooperators/
Project* McIntire-Stennis

Support:

- Objectives:**
- 1) Determine relationships between dietary digestible energy content and digestible energy and nitrogen intake for white-tailed deer fed winter diets.
 - 2) Determine interspecific and intraspecific variation in the nutritional quality of winter forages.

SCOPE: Mature spruce-fir forest stands are critical winter habitat for white-tailed deer (*Odocoileus virginianus*) in Maine. The high value of timber on these sites provides an opportunity to integrate the management of timber resources and deer wintering habitat. However, the relative value of timber harvesting methods for improving shelter and foraging habitat for deer in wintering areas is poorly understood. Assessing the value of timber harvest relative to deer nutrition requires an understanding of forage quantity and quality variation in wintering areas and its relationship to deer nutritional limitations. The purpose of this project is to assess diet quality in wintering areas and to determine limitations of deer for using poor quality winter diets.

PROJECT STATUS: All requirements for the degree of Master of Science (in Wildlife Management) were completed in December 1993. An abstract of the thesis follows:

Winter is a critical period for white-tailed deer (*Odocoileus virginianus*) in Maine because they are confined to winter habitats where food availability is low. I studied relationships between the digestible energy (DE) content of winter diets and the intake of food, DE, and nitrogen by white-tailed deer. Eight diets that were composed of winter forages and that varied in DE content were fed to 9 captive deer in 4 sets of *in vivo* digestion trials. Digestible energy content of the forage diets ranged from 1.95 - 2.39 kcal/gram. Dry matter and DE intake were positively and linearly related to dietary DE content ($P \leq 0.01$). Digestible energy intake on the browse diets was 36-88% of maintenance requirements (158 kcal/kg^{0.75}/day), and I estimated that deer consuming these diets would lose 7.8-42.8% of their initial fall weight over a 90-day winter period. Food availability in winter habitats should be measured relative to dietary DE content because of effects on food intake.

Thirteen common winter deer forages in Maine were studied for interspecific and intraspecific variation in forage quality (DE, protein, tannin phenolics). Digestible energy content of the forages ranged from 1.18-2.86 kcal/gram. Crude protein ranged from 4.0-7.6% and tannin phenolics from 0.0 - 7.0%. Shade, past browsing, and plant size had little effect on the nutritional quality of winter forages. Twig diameter was negatively related ($P < 0.01$) to digestible energy (kcal/g), crude protein (%), and tannin phenolics (%) but positively related ($P < 0.01$) to neutral detergent fiber for 3 hardwood browses tested. When evaluating food and energy availability in winter habitats of deer, variation in forage quality due to species and twig diameter should be considered to determine the availability of forages from a nutritional perspective.

MOOSE ACTIVITY IN CLEARCUTS AFTER CONIFER RELEASE WITH GLYPHOSATE

- Investigator:** W. E. Eschholz
- Advisors:** F. A. Servello, Co-Chairperson
W. B. Krohn, Co-Chairperson
J. R. Gilbert
R. D. Briggs
M. L. McCormack, Jr.

Cooperators/ Maine Cooperative Forestry Research Unit
Project Maine Cooperative Fish and Wildlife Research Unit
Support: University of Maine

- Objectives:*
- 1) Determine if moose activity differs between glyphosate treated clearcuts and untreated clearcuts 1-2 years post-treatment and 7-10 years post-treatment.
 - 2) Determine the effects of landscape scale habitat characteristics on moose habitat use in glyphosate treated and untreated clearcuts.
 - 3) Determine the effects of stand development characteristics on moose use of glyphosate treated clearcuts and untreated stands.

SCOPE: Early seral forest communities created by clearcutting provide large quantities of hardwood browse for moose. Herbicides are applied to clearcuts in Maine to suppress hardwood vegetation and hasten growth of coniferous trees. Use of herbicides in forest management is a subject of public concern because of uncertain effects on moose habitat. Glyphosate, trade name Roundup, is the most commonly used herbicide for conifer release in Maine.

PROJECT STATUS: All requirements for the degree of Master of Science (in Wildlife Management) were completed in December 1993. An abstract of the thesis follows:

Forestland in northern Maine is typically treated with the herbicide glyphosate several years after harvest. This treatment reduces hardwood regeneration, the primary winter food of moose (*Alces alces*), and therefore may negatively affect moose populations in the state. There is a possibility that glyphosate may eventually improve browse and cover conditions for moose as the stand develops (compared to untreated clearcuts). I tested this hypothesis by studying the effects of glyphosate application on moose activity and winter cover characteristics at 2 stages of stand development: 1 and 2 years post-treatment and 7-10 years post-treatment. Tracks of foraging moose and bed counts were 340% and 488% greater ($p < 0.10$), respectively, on untreated clearcuts ($n = 6$) than treated clearcuts ($n = 6$) at 1 and 2 years post-treatment, but there were no differences in winter cover. Tracks of foraging moose and bed counts were 219% and 209% greater, respectively, on the treated ($n = 6$) clearcuts than the untreated clearcuts ($n = 5$) at 7-10 years post-treatment. Conifer stems $> 2m$, which provide winter cover, were denser on the treated clearcuts at 7-10 years post-treatment and may explain the greater activity on the treated clearcuts. In general, moose activity was greater on older clearcuts than the younger clearcuts, likely because of greater protective cover (conifer stems $> 2m$) on the older sites. These results suggest that glyphosate treatment reduces the suitability of recently treated stands for foraging and bedding activity, but that glyphosate treatment improves foraging and bedding habitat later in stand development (7-10 years post-treatment).

EFFECTS OF THE HERBICIDE GLYPHOSATE ON THE WINTER NUTRITIONAL ECOLOGY OF MOOSE IN MAINE

Investigator: K. S. Raymond

Advisors: F. A. Servello, Chairperson
W. B. Krohn
J. R. Gilbert
R. D. Briggs
M. L. McCormack

Cooperators/ Maine Cooperative Forestry Research Unit
 Project Maine Cooperative Fish and Wildlife Research Unit
 Support: University of Maine

- Objectives:
- 1) Determine effects of glyphosate on winter browse and digestible energy availability for moose at 1-2 and 7-10 years post-treatment.
 - 2) Determine effects of glyphosate on winter browse utilization and diet quality for moose at 1-2 and 7-10 years post-treatment.

SCOPE: The herbicide glyphosate is used extensively in forest management after clearcutting to control hardwoods and promote softwood regeneration. Moose feed primarily on hardwoods in winter and must maintain a high food intake to compensate for low energy content of browse and increased energy requirements during this time. Consequently, glyphosate may significantly affect food intake and diet quality for moose. However, the effects of glyphosate on moose nutrition may vary as the stand regenerates from treatment.

PROJECT STATUS: All requirements for the degree of Master of Science (in Wildlife Management) were completed in May 1994. An abstract of the thesis follows:

The herbicide glyphosate is sprayed on tens of thousands of acres each year in northern Maine to suppress hardwood regeneration and promote conifer growth after clearcutting and may affect the availability, utilization, and quality of winter browse for moose (*Alces alces*). By sampling 24-40 plots on each of 31 sites, I studied the effects of glyphosate (Roundup™) treatment of naturally regenerating clearcuts on winter browse availability and utilization at 2 stages of stand development: 1&2 and 7-10 years post-spray. I also studied the effects of glyphosate on browse quality in the second winter post-spray. Available biomass of deciduous browse decreased ($P < 0.001$) 70% on sprayed clearcuts relative to unsprayed clearcuts from pre-spray to 2 years post-spray. At 7-10 years post-treatment, available biomass of deciduous browse did not differ ($P = 0.289$) between sprayed and unsprayed clearcuts of similar age. Availability of deciduous browse did not differ on sprayed clearcuts 2 and 7-10 years after treatment, but on similarly-aged unsprayed clearcuts it was 66% less later in stand development ($P = 0.004$). Patterns of deciduous browse availability relative to forage quality were similar to that of total deciduous browse. Moose consumed $\leq 21\%$ of the available deciduous browse. Percent use of deciduous browse did not differ ($P = 0.236$) between sprayed and unsprayed clearcuts from pre-spray to 2 years post-spray. However, at 7-10 years post-treatment, percent use of deciduous browse was 5x greater ($P = 0.036$) on sprayed clearcuts than on unsprayed clearcuts of similar age. Percent use of deciduous browse was similar ($P = 0.202$) 2 and 7-10 years after treatment for both sprayed and unsprayed clearcuts. Preference for deciduous browse species generally did not change ($P > 0.10$) after spraying. Moose did not show any detectable difference ($P = 0.10$) in preference among deciduous browse species either and use was generally in proportion to availability. Digestible energy and tannin levels of sprayed paper birch (*Betula papyrifera*) twigs were slightly lower ($P < 0.10$) than those of unsprayed twigs despite similar size. Protein levels did not differ ($P > 0.10$) between sprayed and unsprayed paper birch twigs. Diet quality levels of moose did not change ($P > 0.10$) after treatment and were below maintenance requirements. The effects of glyphosate on availability of deciduous browse are dynamic and the ultimate result on moose nutrition depends on the interspersed of clearcuts of different age classes and treatment types across the landscape at any given time.

A LONG-TERM FOREST ECOSYSTEM STUDY

Investigators: M. L. Hunter, Jr.
A. J. Kimball
A. S. White
J. W. Witham
E. 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 1994, tasks 3, 4, 5, 6, 7, 8, 9, and 10 as outlined above, were completed, and a study investigating the vegetation of tree fall gaps, ledge openings, and patchcuts and how they influence predation on bird nests was continued.

FUTURE PLANS: The 1995 field season will replicate the 1994 field season with additional work on salamander distribution and abundance, snags, red oak regeneration, 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:* C. C. Abbott
D. M. Eignor
T. A. Haines
R. W. Perry
M. W. Powell
C. P. Stafford
- Advisors:* T. A. Haines, Chairperson (for Abbott, Eignor, Powell, Stafford)
I. J. Fernandez
S. A. Norton
J. R. Moring
- Cooperators/
Project
Support:* USDI National Biological Survey
National Fisheries Contaminant Research Center -
Columbia, MO
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. One M.S. thesis was completed in May 1994, abstract follows. A second thesis is anticipated in December 1994, and a third in May 1995. All requirements for the degree of Master of Science (in Zoology) were completed by C. C. Abbott in May 1994. An abstract of the thesis follows:

The effects of whole watershed acidification on mercury concentrations in soil, soil water, stream water, and brook trout were studied at the Bear Brook paired watersheds in Maine. West Bear was experimentally acidified via aerial application of ammonium sulfate (391 kg/ha), and East Bear was a reference. Research focused on the interaction of mercury with organic matter by measuring the concentration of organic matter in soil, soil water, and stream water. Mercury in wet precipitation averaged 7.88 ng/liter, resulting in a deposition rate of 7.0×10^{-6} g/m²/year. Mercury concentrations were significantly higher in soil and soil water in the O (organic) horizon than in the B (mineral) horizon. Mercury concentrations were significantly higher in O horizon soil water under softwood canopies than under hardwood canopies. In West Bear, mercury concentrations in O horizon soils were significantly higher under softwoods than under hardwoods. In B horizon soils, mercury concentration was significantly positively correlated with elevation and higher concentrations of mercury were found in West Bear relative to East Bear. Mercury concentrations were highly correlated with dissolved organic carbon (DOC) in stream water, suggesting that mercury may be transported to the stream by organic matter. Although more mercury was deposited on East Bear, more mercury was retained in the soils of West Bear. Mercury and DOC

concentrations were significantly higher in East Bear Brook. Concentrations of mercury in brook trout were negatively correlated with condition factor, and were significantly higher in fish harvested in the fall than in the spring. Fish harvested in the fall from East Bear were significantly higher in mercury than those from West Bear. Treatment may be decreasing the export of organic matter (and thereby mercury) from West Bear, reducing the amount of mercury available in stream water for methylation and uptake by fish.

QUANTIFYING THE RELATIONSHIP OF FOREST MANAGEMENT TO MAINE'S MARTEN HARVEST WITH A GEOGRAPHIC INFORMATION SYSTEM

Investigator: T. P. Hodgman

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

Objective: Examine the relationship between Maine's marten harvest and trapper access and habitat types using spatial analyses.

SCOPE: The remote habitat occupied by pine martens (*Martes americana*) has offered some protection from overexploitation. However, continued construction of logging roads has provided marten trappers with access to previously inaccessible areas. Past studies on the effects of trapper access on Maine's marten harvest did not account for misreporting the location of capture nor the spatial arrangement of habitat types and forest roads. To overcome these limitations, towns will be grouped by geographic region; marten harvest, trapper access, and habitat data will be summarized by these township clusters. Also, a supervised classification of a 1986 Landsat TM image ("leaf on") will be used to identify habitat types. This classification will be part of a GIS, which also includes roads and township borders for approximately 75 townships in northern Maine. After removing the area occupied by unsuitable marten habitat (i.e., water, clearcut, etc.) in each township cluster, comparisons will be made between the harvest of marten and the amount and spatial arrangement of forest roads and habitat types.

PROJECT STATUS: Processing of satellite imagery is complete. A database of primary and secondary roads for the entire study area is complete. The road database has been broken into regions and hard copies generated for each. Maps and/or photos to be used for editing the database have been acquired for all towns. Editing the road database is underway, approximately 12 townships have been completed.

FUTURE PLANS: Editing should be completed by late 1994. Analysis of harvest, access, and habitat data will be performed in late 1994 and early 1995.

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" rodents [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: Three field seasons have been completed. For two years, removal rates of red maple, red oak, and white pine seeds were monitored during their respective periods of seed fall, in five habitat types (ledge, dead tree, and small harvest gaps, matched by size; large harvest gaps, and forest), and in four treatment regimes (seeds on the open ground, or in a wire cage, with one section that excludes all mammalian and avian seed predators, one that allows access to mice and voles only, and one that allows access to mice, voles, and larger mammalian seed predators, primarily chipmunks and squirrels). This was again replicated with red maple seeds in June 1993, and was replicated at a subset of sites with red oak and white pine seeds in October. In 1992, rates of seeds removed nocturnally versus diurnally were monitored for three days to substantiate the observed patterns. In late August, small mammal abundance at experimental sites was quantified by four nights of trapping during all three years.

Removal rates of red maple seeds have been monitored all three years in large harvest gaps and continuous forest, during full and new-moon periods, to test whether small mammals shift their foraging microhabitat to sites with more cover (under a bush versus three meters away) as ambient light increases.

In 1992, red oak acorns and white pine seeds were placed together in trays and covered with 3 cm of sand to determine which species was preferred.

Other aspects of seed predation investigated include effects of: 1) acorn size, and 2) preference of seed predators for oak or pine seeds, on rates of seed removal.

Ten years of data from the Holt Forest are currently being analyzed to assess the density response and animal weights (as an index of condition) of small mammals to temporal and spatial variation in seed fall.

An additional set of experiments was designed for October 1993 based on preliminary results from analysis of both field observations and the long-term data sets, and included seed preference trials with captive *Peromyscus leucopus* and *Clethrionomys gapperi* to investigate effects of seed size and tannin level of red oak and white pine seeds on palatability.

FUTURE PLANS: One chapter draft of the dissertation has been completed. Data analysis continues, with two chapter drafts in progress, and dissertation defense is targeted for Spring 1995.

AN INVESTIGATION OF FORESTRY-AMPHIBIAN RELATIONSHIPS IN MAINE

Investigator: P. de Maynadier

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

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

Objectives:

- 1) Investigate the influence of forest-clearcut edges on the habitat use of resident and dispersing amphibians.
- 2) Determine the importance of logging roads as a potential barrier to amphibian movements.
- 3) Document the amphibian community in managed and unmanaged northern hardwood stands and identify habitat variables of potential importance.
- 4) Conduct a comprehensive review of previous research on forestry-amphibian relationships and recommend management guidelines.

SCOPE: Forest fragmentation has potentially profound effects on the isolation of wildlife populations and is presently a major threat to biological diversity worldwide. Forest landscapes are increasingly bisected by human development, including 1) linear features such as roads, power and gas right of ways, and rail lines, and 2) block features such as agriculture and clear-cuts. It is important to understand the permeability of these barriers to the movements of various wildlife taxa. Formerly continuous populations which become isolated may exhibit metapopulation dynamics and may be more prone to extinction through demographic, genetic, or environmental stochasticity. In order to better understand the importance of barriers as isolating mechanisms, this study will quantify amphibian response to Maine's forest roads and clearcut edges.

In addition, there is increasing public pressure on Maine's industrial forest managers to provide for multiple uses on their ownerships including non-game wildlife habitat. Despite their relative inconspicuousness amphibians are the most abundant vertebrate group in the northeast and may serve an important role in forest ecosystem dynamics. In an effort to better understand the response of this relatively unstudied taxa to common silvicultural practices this study will compare the amphibian community between managed and unmanaged northern hardwood stands.

PROJECT STATUS: Upland forest-clearcut edges chosen from a gradient of high to low contrast were sampled using drift-fences built perpendicular to the forest edge. Captures of snakes, amphibians and small mammals were monitored continuously from June to September, 1992-1993. The trapping technique is especially effective at capturing a large abundance and richness (15 spp.) of aquatic dispersing and upland resident amphibians. Preliminary analysis reveals a general decline in richness and abundance across the gradient from forest to clearcut habitat. Species-specific responses included generalists (American toad) and forest specialists (wood frog and redback salamander); however, no species was found to specialize on clearcut or nonforested habitat.

In order to better understand the effect of forest edge habitat on amphibian movements a semi-natural experimental approach was used in the 1993 field season. Cultured wood frog larvae were released adjacent to discrete forest/powerline edges and their movements monitored using an enclosed drift-fence

design. It appears that even dispersing, juvenile wood frogs avoid non-forested cover when given the choice.

In the spring of 1992 paired drift-fences were placed adjacent to a logging road edge and in the forest interior serving as treatment and controls, respectively. This design allowed for tests of potential barrier effects the road might have on amphibian and small mammal movements. As a group, salamanders made significantly more movements through the forest than equivalent movements across the road (a narrow, gated forest track). However, for those animals that approached the road's edge there was no filtering of movements for any species. A wider (15 m), heavily used logging road was studied in 1993 (the Stud Mill road) and its effects on movements were compared to those of the narrower (5 m) forest track. Generally, anuran movements were unaffected by even the larger road barrier, but salamander captures in roadside traps were only 20% of those in forested controls suggesting that the larger road significantly inhibited movements by this group between bisected populations of the forest. It appears that forest roads can act as both a quantitative and qualitative filter to amphibian movements, but that their influence is unlikely to affect population dynamics.

Finally, drift-fence arrays were established in a replicated (6), block design of uncut, selectively cut and clearcut northern hardwood stands in north-central Maine to evaluate the impact of partial and complete canopy removal on local amphibian populations. Habitat data collected surrounding each of the eighteen arrays included % canopy, shrub and ground cover, litter depth and type, density of coarse woody debris and stand basal area. Trap monitoring began in June and is continuing until October 1994 at which time analysis of the data will begin.

FUTURE PLANS: Trap monitoring and habitat data collection is continuing until late October/November of 1994 for the northern hardwood forest management drift-fence arrays. Analyses for these data and those of all previous field work is scheduled to be completed by spring of 1995. In addition, a comprehensive review paper is being prepared on North American forestry-amphibian relationships for a recently awarded grant proposal by the National Council for Air and Stream Improvement (NCASI). Work on the review paper is scheduled for completion in February 1995.

AN ANALYSIS OF BIODIVERSITY IN NEW ENGLAND: GIS 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:* U.S. Fish and Wildlife 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: The initial Gap Analysis of Maine (i.e., Phase I) is nearing completion. Personnel at the University of Massachusetts are developing the vegetation map for Maine based on satellite data. They experienced problems identifying vegetation types using the existing cover maps we provided, so aerial videography techniques were used to identify vegetative types. Aerial video images were acquired for transects spaced every 24 km across Maine, in June and October 1994. The Maine Unit funded workshops to train New England personnel in the use of aerial videography, and we are currently interpreting Maine videography from June for use by the University of Massachusetts, to produce the Phase I vegetation map. We have received from Massachusetts a portion of the existing vegetation map for Maine that is now being evaluated. Assuming funds become available next fiscal year, a Phase II map will be produced using the October as well as June videography, and additional satellite data.

To augment and improve the vegetation map we use in Maine Gap Analysis, we began projects to identify special habitats in Maine. A student was hired to visit and map almost 800 blueberry barrens and grasslands within southcentral and eastern Maine. These fields are being entered into a geographic information system for mapping and storage. Also, a second student is identifying wetland types for about 5,500 wetlands shown in a USGS land cover map, using National Wetland Inventory maps. In cooperation with personnel in the Department of Botany, we will verify this information using ground-truthed data for about 150 peatlands. Grasslands, a rare habitat type, and wetlands, a habitat that drives species richness in Maine, will be incorporated into the final Phase I map, which will be done by the end of December, 1994.

We have developed and sent-out to reviewers species synopses for the amphibians and reptiles, and for mammals that breed in Maine. Experts' reviews of the amphibian and reptile information have been returned, and I am finalizing the synopses for these groups. Drafts of synopses for birds are partially completed, and will be finished in the coming months.

As part of my dissertation, I began a research effort that will potentially identify species that are less likely to be correctly predicted using Gap Analyses. In Gap Analysis, occurrences of rare species are mapped directly, so that group of species should be predicted well. My research indicated that the occurrence of abundant species also are predicted well using Gap Analysis. Those species that are

intermediate are less likely to be correctly predicted. Using a series of life-history and population attributes, I am ranking the predictability of species that breed in Maine. I will test the validity of these rankings by comparing the results of a Gap Analysis of the Holt Research Forest, and long-term survey data for that site. Similar comparisons will be made using statewide data from the Breeding Bird Survey.

The Maine Gap Analysis project worked with the Maine Department of Inland Fisheries and Wildlife and a contractor to digitize the deer wintering areas (DWAs) within a large section of southcentral Maine, which is complete. In Maine, DWAs (i.e., mostly mature conifer stands) are important habitats for several wildlife species, and DWAs are legislatively protected, although regulations for organized towns have not yet been developed.

FUTURE PLANS: Through the following months, we will be completing the synopses for the birds that breed in Maine, finalizing the synopses for all groups, and completing the species richness maps in Maine Gap Analysis. I will then complete ancillary research using the Gap Analysis results, and prepare a dissertation.

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 Survey
U.S. Fish & Wildlife Service
University of Maine -
Department of Wildlife Ecology
Maine Department of Inland Fisheries and Wildlife
Maine Offices of Geographic Information Systems
Maine Geologic Survey

Objectives:

- 1) Create species richness maps for vertebrates breeding and wintering along the Maine coast, and compare their location to conservation lands to identify gaps in biodiversity protection.
- 2) Develop a database detailing historical surveys of Maine's seabird nesting islands, and measure current use of selected islands by 3 species of breeding seabirds.
- 3) Compare current use and nest density data for selected seabird islands with historical patterns of island use to assess the temporal stability.
- 4) Evaluate habitat and social factors affecting the distribution of breeding seabirds in Maine.

SCOPE: A Gap Analysis is currently underway for the State of Maine, identifying areas of high vertebrate species richness during the breeding season. However, the vast majority of the islands along the Maine coast fall well below the minimum mapping unit size used for this statewide analysis. Further, the traditional approach to Gap Analysis focuses on terrestrial ecosystems, with vegetation mapping providing

the foundation for predicting distributions of most species. For this coastal analysis, base mapping will include aquatic variables as well as terrestrial vegetation mapping. This spatial database will be used in combination with other biotic and abiotic variables (e.g., island size and human disturbance levels), 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 habitat use in this dynamic environment. On a relatively short term time scale, I will assess seasonal variability in species richness patterns by comparing results for the breeding and wintering seasons. Long term temporal patterns of habitat use will be assessed for selected seabird species, using survey data collected over the past 80 years. Spatial patterns of seabird island use also will be examined in relation to a variety of physical and biological habitat factors.

PROJECT STATUS: Over the past year, I have collected digital databases (e.g., 24K USGS coverage and bathymetry) for use in creating a comprehensive base map for coastal Gap analysis. We have completed aerial videography for the Maine coast and plan to use this data in conjunction with LANDSAT imagery to create the coastal vegetation map.

I have been working on creating several other coastal databases from available information regarding land use and species distributions. These include databases for coastal conservation lands, based on the Maine State Planning Office's Conservation Lands; distributions of selected fish species, based on the NOAA publication, Distribution and Abundance of Fishes and Invertebrates in North Atlantic Estuaries; and distributions of nesting seabirds, based on a literature review of historical survey information and a recently compiled MDIFW seabird survey database. The seabird database will include historical accounts of breeding populations dating back to approximately 1910. I have developed templates for species synopses, including habitat matrices and other ecological information for all coastal species breeding in Maine and bird species wintering throughout the state.

Islands in Penobscot Bay known to support breeding populations of cormorants, black-backed gulls or herring gulls were surveyed in early summer 1994; nest counts were made from the air at an altitude of approximately 150-200 feet. These islands will be surveyed again in 1995 and 1996 at approximately 10 day intervals throughout the breeding season to determine peak species nest counts for each island.

FUTURE PLANS: In the coming year I plan to produce the vegetation map for coastal Maine and complete the species synopses for review by experts. I will continue to collect survey data for seabird nesting islands and begin developing the detailed seabird habitat models.

APPLICATION OF SATELLITE DATA TO MONITOR NEOTROPICAL MIGRANT BIRD HABITAT IN CENTRAL AMERICA

Investigators: J. A. Hepinstall
J. P. Spruce
S. A. Sader

**Cooperators/
Project
Support:** USDI National Biological Survey -
Patuxent Wildlife Research Center
University of Maine -
Department of Forest Management

Objectives:

- 1) Apply computer-aided processing of satellite data to map and monitor neotropical habitat availability for avian migrants wintering in Central American study sites.
- 2) Use developed habitat classifications for selected areas of Belize and

- natural vegetation maps of the country to develop human disturbance maps.
- 3) Combine disturbance maps and bird species survey data to model potential density and distribution for selected species of avian migrants in Belize.

SCOPE: In order to estimate habitat change and habitat availability, natural vegetation maps for Belize have been combined with satellite imagery to produce human-disturbance maps. These maps will be analyzed with wintering migratory and resident bird species data gathered from several field visits over the past five years into summary maps showing species richness, distribution, and relative abundance. Total winter population estimates for all areas with adequate field data will be calculated.

PROJECT STATUS: An international conference, co-organized by the USNBS, University of Maine, and the National Autonomous University of Mexico, was held in Veracruz, Mexico, November 5-7, 1993. The conference was well attended by US and Mexican professionals and also included several participants from other Central American countries and Canada. Peer review is near completion and final arrangements are being made with a book company to publish the papers in 1995.

Land cover maps derived from classified satellite images of Belize have been combined with digitized natural vegetation maps to identify human versus natural classes of savanna, shrub savanna, and broadleaf shrub. Visual interpretation of these maps in digital and paper format will be completed in fall 1994. Bird species data has been digitized and awaits completion of disturbance maps. A meeting of University of Maine personnel and USNBS scientists is planned for November 1994 to discuss methods and publication procedures for this project. Final completion of the Belize project is expected in December 1994.

FUTURE PLANS: The work order is being phased out and expected to end in March 1995. Further work is planned to assess and improve habitat availability maps for current field sites in Guatemala.

HABITAT SELECTION BY WINTERING WATERFOWL IN COASTAL FRESHWATER WETLANDS OF MOROCCO; THE CASE OF MEHDIYA WETLAND

Investigator: M. El Hamzaoui

Advisors: J. A. Sherburne, Chairperson
W. B. Glanz
D. J. Harrison
F. L. Newby
D. G. McAuley

**Cooperators/
Project
Support:** USAID/USDA

- Objectives:**
- 1) Examine the distribution and abundance of wintering avifauna in Lake Mehdiya, Morocco, and associated marshlands.
 - 2) Determine temporal and seasonal (fall and winter) differences in habitat use by wintering waterfowl.
 - 3) Determine the relation between habitat variables (e.g., vegetation cover and density, water depth) and waterfowl use of the site.
 - 4) Assess the impacts of grazing and recreation activities on wintering

- waterfowl populations.
- 5) Develop a comprehensive conservation plan for freshwater wetlands of Morocco.

SCOPE: Coastal freshwater wetlands of Morocco are important in contributing to biodiversity. They are, however, extremely vulnerable natural habitats. The few remaining freshwater wetlands are used extensively by the human populations surrounding them, as well as by the migratory waterfowl which use these sites as wintering areas.

Virtually nothing is known about the use of freshwater wetlands by wintering waterfowl as well as the extent of various human activities. The proposed study will determine seasonal habitat use of freshwater wetlands by wintering waterfowl. Physical, chemical, and biological variables of selected habitats will be identified. The impact of diverse human activities on wetland resources and functions will be evaluated. The above information is important to developing an overall comprehensive conservation strategy that would ensure sustainable and multiple use of freshwater wetlands resources of Morocco.

PROJECT STATUS: Field research is currently being conducted in Morocco.

COMPARISON OF THE RELATIVE OBSTACLES TO MEETING MANAGEMENT OBJECTIVES OF THREE DIFFERENT CONSERVATION SYSTEMS IN INDONESIA: NATURE RESERVES, GAME RESERVES, AND NATIONAL PARKS

Investigator: E. E. Suwarni

Advisors: J. A. Sherburne, Chairperson
D. J. Harrison
J. F. Tynon

**Cooperators/
Project
Support:** USAID/Indonesia

- Objectives:**
- 1) Examine and compare management structures, approaches, and objectives in selected and representative Nature Reserve, Game Reserve, and national park located in one province.
 - 2) Understand management infrastructure and approach for each area.
 - 3) Assess the obstacles to effective management of programs in each area.
 - 4) Assess and evaluate the relative effect these obstacles have on effective management of each area.

SCOPE: Indonesia has several conservation areas. Some of these, nature reserves and game reserves, have long histories on the islands. In recent years, another and more encompassing system of managing natural resources has been established - the national park. Each of these three major systems has different objectives and is operated under a different management approach and infrastructure. Yet all three are designed for the same overall purpose, i.e., to conserve and manage Indonesia's valuable natural resources. As the interaction of these three primary systems evolves, it will be necessary to assess and evaluate the effectiveness of the different conservation areas, as well as the overlapping management approaches. This research will address the first important step in that process by exploring and assessing policy and management factors, structure, approaches, facilities and programs applied in each system.

PROJECT STATUS: Field work and data collection in Indonesia were carried out over the summer.

**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, Region 5
U.S. National Biological Survey -
Midwest 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: This study will collect information on the impacts of chemical spraying for mosquito control on non-target organisms at Bombay Hook National Wildlife Refuge. These data will be used as part of a Service-wide effort to evaluate the ecological risks of various mosquito control methods in use or proposed for use on Service lands.

FUTURE PLANS: This project has just started and no results are yet available. A thesis is anticipated in December 1996.

**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

Advisors: T. A. Haines Chairperson (for Powell)
L. E. Katz
J. R. Moring
S. A. Norton

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

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

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

PROJECT STATUS: This study will collect information on total and methyl mercury concentrations in water, sediment, invertebrates, and fish in reference and contaminated sites in the Sudbury River, in order to assist in the determination of the importance of sediment reservoirs of mercury in the continuing contamination of fish and wildlife resources in the river.

FUTURE PLANS: This project has just started. An additional graduate student is being sought for the project. One thesis is expected in August 1995 and another in August 1996.

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

Objectives:

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

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

PROJECT STATUS: Forty-five vernal pools have been selected for study in York County, Maine. The first field season took place during April-September 1994. Data collection included counting amphibian egg masses, sampling pools monthly to determine the presence and abundance of larval amphibians and aquatic invertebrates, and surveying each pool approximately every 10 days to determine the presence or absence of turtles, frogs, toads, and other vertebrate species using the pool. Immediately after each survey, air temperature, and water temperature, depth, pH, and conductivity were measured. In mid-June, pool shrinkage was measured and data were collected on the type and percent cover of herbaceous vegetation in the pool. During August and September, data were collected on the flora, vegetation type, structure and percent cover for all vegetation (woody and herbaceous) growing within or hanging over the pools.

FUTURE PLANS: Prior to the beginning of next field season, all invertebrates collected during monthly sampling will be identified to family or genera levels. During the second field season, data collection will continue using the same methods used in the first season. Additional data collection will include the percent of sunlight reaching each pool unobscured by vegetation, general surrounding vegetative community structure, pool elevation, and the number and area of surrounding wetlands.

WILDLIFE RESOURCES - MIGRATORY BIRDS:

HABITAT SELECTION AND COMMUNITY ORGANIZATION OF BIRDS IN EIGHT PEATLANDS OF MAINE

Investigator: S. S. Stockwell

Advisors: M. L. Hunter, Jr., Chairperson
R. B. Davis
W. E. Glanz
J. R. Longcore

**Cooperators/
Project
Support:** Maine Department of Inland Fisheries and Wildlife
Signal Fuels, Inc.
Maine Chapter of The Nature Conservancy
Maine Land Use Regulation Commission
Maine Department of Environmental Protection

Objectives:

- 1) Identify those species of birds that inhabit Maine's peatlands.
- 2) Quantify the abundances of each species relative to peatland vegetation and hydrology.
- 3) Determine whether large, commercially valuable peatlands differ in their

- 4) "value" to wildlife from smaller, non-commercially valuable peatlands. Determine which of five environmental factors (foliage height diversity, area of peatland, peatland-foliage height diversity, type of peatland, and peatland vegetation diversity) are important in influencing bird species composition, bird species richness, and bird density in peatlands.

SCOPE: Peatlands are one of the last remaining undisturbed ecosystems in the Northeast. Thus, the state of Maine has an unusual opportunity to develop a comprehensive plan for conserving Maine's peatlands. However, before this project was initiated, no surveys of the wildlife in Maine's peatlands had been conducted. Before issuing mining permits or establishing peatland preserves, the state needs to know what bird species depend on peatlands for their continued survival, if any, and whether certain species are restricted to particular types or sizes of peatlands.

This study relates the abundances and distributions of birds in eight Maine peatlands to peatland vegetation, size, and geomorphology.

PROJECT STATUS: All requirements for the Ph.D. degree (in Wildlife) were completed in May 1994. The abstract follows:

This study relates the abundance and distribution of birds in eight Maine peatlands to peatland vegetation, size, and geomorphology, and uses data on peatland birds to test predictions of the density assessment hypothesis of habitat selection. I censused birds in eight Maine peatlands of varying types and sizes during May and June of 1983 and 1984. Eight distinct vegetation types occurred in the peatlands. I used a variable-width transect method for censusing birds and estimated bird densities from a modified Emlen method and the Fourier Series Estimator in computer program TRANSECT.

Bird species richness (BSR, number of species censused) of the peatlands I sampled (48-81 per site, 101 in total) was greater than that reported for other habitats in Maine. Among the eight vegetation types, bird species richness was not correlated with foliage height diversity (vertical heterogeneity of vegetation), but density of birds (BD, number of birds per 40 ha) and bird species diversity (BSD, Shannon Diversity Index) were correlated with foliage height diversity.

Among the eight peatlands, BSR and BD were highly correlated with horizontal heterogeneity of vegetation (PVD, peatland vegetation diversity). Density of birds was lower in peatlands dominated by open vegetation than in peatlands dominated by wooded vegetation. BSD was not correlated with peatland type, peatland area, peatland-foliage height diversity, peatland vegetation diversity, or with any combination of these variables. Bird species composition (species distribution and abundance) was most dissimilar between peatlands with >50% of their area covered by wooded vegetation and peatlands with <12% of their area covered by wooded vegetation, and between wooded and open groups of vegetation types.

I conclude that horizontal heterogeneity of vegetation is more important than vertical structure of vegetation in influencing bird species richness and bird density in these peatlands.

I tested three predictions of the density assessment hypothesis of Fretwell and Lucas on habitat selection in birds. First, linear regression revealed that those species with higher population densities used a wider variety of habitats than those species with lower population densities, both on intraspecific and interspecific levels. Second, most species whose population level changed showed increases or decreases in density simultaneously across several habitats. Third, most species showed changes in dominance consistent with those predicted by the density assessment hypothesis, especially if modified to account for philopatry. These findings generally support the density assessment hypothesis of density-dependent habitat selection.

AVIAN BIOINDICATOR DYNAMICS

Investigator: S. J. Oyler

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

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

- Objectives:*
- 1) Evaluate the applicability of the Taylor Power Law concept to the North American avifauna.
 - 2) Map bird diversity and develop indices of biodiversity and community structure to land use patterns on the basis of Major Land Resource Area (MLRA) classification.
 - 3) Examine the effects of short-term change in land use on bioindicators.
 - 4) Determine the relative effects of yearly variation in weather conditions and agricultural changes on bioindicators.

SCOPE: EPA's Environmental Monitoring and Assessment Program (EMAP) assumes changes in the abundance of bioindicators correspond directly to changes in environmental condition such as landscape pattern, habitat structure, or land use practices. Thus, any fluctuation in biodiversity or other environmental indicator is assumed by EPA to be caused by some change in environmental condition. Because intrinsic dynamical variability in biodiversity and ecological indicator values may not be small compared to the changes brought about by alterations in the environment, this investigation examines how bird diversity and ecological indicators are affected by underlying pattern of dynamics in bird abundance. These patterns are being determined both from empirical data from national bird and land use databases already collated in the Wildlife Department and from theoretical models of population processes. These underlying patterns of variation in bird abundance will be related to land-use patterns within the coterminous United States to aid the future interpretation of EMAP results.

PROJECT STATUS: All requirements for the degree of Master of Science (in Wildlife Management) were completed in December 1993. An abstract of the thesis follows:

Because most ecological problems involve large-scale processes, ecologists have begun to study large-scale population dynamics. This analysis investigates the population dynamics of birds in the United States by testing the applicability of the Taylor Power Law for a different avifauna on a much larger scale than Taylor's original analyses. Of 497 species analyzed, 457 conformed to the Taylor Power Law (TPL) both spatially and temporally. I compared the TPL parameters calculated in this analysis to the parameters from Taylor's analysis and found differences. Because Taylor's analysis was conducted on a much smaller scale than my continental analysis, I repeated the analysis on a regional scale for birds in the United States. The regional distribution of TPL parameters for the United States was more similar to Taylor's original analysis. Comparison of the regional and continental analyses in the U.S. showed that the difference in spatial distributions was one of scale.

I also determined the spatio-temporal patterns of the 457 species that conformed to TPL. Two hundred and six species had spatio-temporal patterns previously defined by McArdle et al. (1990). Seventy-three species were classified as refugia species, 126 as fixed and mobile hot spot species, one as a capacity limited species, and six as outbreak species. I considered the implications of these classifications for monitoring and found that those species classified as fixed and mobile hot spot species would make the most sensitive bioindicators.

VARIABLES AFFECTING HABITAT USE AND MOVEMENTS
OF AMERICAN BLACK DUCKS AND MALLARDS
ON THE MISSISQUOI NATIONAL WILDLIFE REFUGE

Investigator: C. G. Kitchens

Advisors: R. B. Owen, Jr., Chairperson
J. R. Longcore
W. E. Glanz

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

Objective: Evaluate the use/importance of managed wetlands by radio-marked black ducks at Missisquoi National Wildlife Refuge during hunting and non-hunting periods.

SCOPE: During the fall staging periods of 1990 and 1991, a sample of hatching-year female (n = 35) and male (n = 35) black ducks and hatching-year female (n = 40) mallards were equipped with radio-transmitters to determine the importance of the refuge impoundments and associated wetlands to these waterfowl during non-hunting and hunting periods.

PROJECT STATUS: All requirements for the degree of Master of Science (in Wildlife Management) were completed in May 1994. An abstract of the thesis follows:

The decline of American black ducks over the past 30 years has raised many questions. The causes are uncertain but researchers believe that either habitat loss, overhunting, or hybridization with mallards is leading to this decline. Contrary to population declines in black ducks, mallard populations have risen dramatically in the Atlantic Flyway in the past 30 years. Eighty juvenile female mallards, 74 juvenile female black ducks, and 75 juvenile male black ducks were radio-marked and tracked from September - December of 1990 and 1991 to determine habitat use and movements on the Missisquoi National Wildlife Refuge (MNWR), a staging area in northwestern Vermont, with emphasis on hunting disturbance.

Use of wetland types by radio-marked ducks was compared to their availability before, during, and after hunting seasons. Wetland use was variable between years and appeared to be heavily influenced by water levels on Lake Champlain that fluctuated as much as 3 feet between 1990 and 1991. However, palustrine emergent wetlands were used extensively during both years, especially 1991, when nearly 90% of all locations on MNWR were located in these wetlands. Palustrine scrub-shrub wetlands were used heavily in 1990 but rarely in 1991. Lacustrine emergent wetlands and riverine wetlands were not used until late in the season when, presumably, food availability in the palustrine emergent and scrub-shrub wetlands declined. The effect of hunting disturbance on wetland use was confounded by the extreme variability in water levels for Lake Champlain.

Movements of black ducks and mallards seemed to be affected by hunting disturbance. Movements differed from 1990 to 1991 but the overall pattern was the same. Home range size, length, width, and index of linearity was calculated only for 1991 when the sample size was sufficient for comparisons. Home range size decreased for black duck males and females from the pre-hunting to the hunting interval and increased from the hunting to the post-hunting interval. Mallard home range size remained the same from the pre-hunting to the hunting interval but decreased during the post-hunting interval. Home range lengths and widths followed the same pattern as the home range size. Indices of linearity indicated very narrow home ranges before, during, and after hunting for all ducks. Distances between consecutive locations differed from 1990 to 1991 with longer distances moved in 1990 when water levels were high. However, the pattern

of movement remained the same with distances between consecutive locations shorter during the hunting interval than either the pre-hunting or post-hunting intervals. Directional flights were variable between years. Radio-marked ducks flew predominantly north in 1990 with little movement south, east, or west. Directional movements during 1991 were strongly north but southerly movements were more pronounced than in 1990. Movement east and west was low.

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 Survey
Maine Department of Inland Fisheries and Wildlife
Maine Atlantic Sea Run Salmon Commission

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: Field work for the project was completed in August 1994. In addition to censusing cormorants at feeding and roosting sites, which began in 1992, cormorants were monitored at dams this past

summer to determine numbers, how these areas are used, and by how many birds. Counts of cormorants were made every 10 days from the air (to determine feeding locations) and at night roosts (to estimate total numbers) from early April through late June. Peak numbers on the Penobscot River in 1994 occurred in late May and early June, later than in 1992, but about the same time as in 1993. Weather conditions and river flow rate from April through June will be examined as possible factors affecting cormorant arrival and distribution along the Penobscot. In 1994, adult cormorants again arrived before subadults and contributed to the in-river predation on Atlantic salmon smolts. Cormorant use of dams during 1994 was, as in the previous two years, disproportionately high relative to use of free flowing habitat.

FUTURE PLANS: Prey items regurgitated by nestling cormorants were collected from 10 breeding colonies in Penobscot Bay during July, 1993. These data were analyzed and presented at the 1994 meeting of the Colonial Waterbird Society. Data for the entire project will be tabulated and analyzed this winter; a final report will be done by the summer of 1995.

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, 1993 to September 30, 1994.) In this second field season of sampling 280 samples (140 samples one each June 16 and July 7) were obtained with activity traps from 10 waterfowl brood-rearing wetlands (5 in the agricultural and 5 in the forested landscape). From 25 July to 3 August 100 samples were collected by sweep net from these 10 ponds. In addition, a study to determine the effect of length of time the trap was activated on total captures was completed between June 20 and June 22 in Hammond Flowage. A sample of traps ($n = 17$) was collected at 12-hour intervals from

a set of 68 traps. Preliminary review depicts distinct diurnal and nocturnal patterns of activities for certain taxa. Sorting and identification of samples has progressed well. Dr. Antti Jansson, Finnish Museum of Natural History, has either verified or identified to species 300 specimens of Corixidae. Sixteen different species occurred in 12 ponds. A reference collection is being established to facilitate further identifications. Distribution of certain species seems aligned with the type of landscape, some species favoring the agricultural landscape. Further collaboration for species identification is being arranged with Dr. Paul J. Spangler, Smithsonian Institution, who is an expert on aquatic beetles (Coleoptera). Water depths in about 50 wetlands were recorded for June, July, and August, and in early July water was collected from all wetlands sampled for invertebrates and from the wetlands sampled for waterfowl broods. Water has been submitted to the Sawyer Analytical Laboratory where an array of water chemistry variables, including Chlorophyll-a, will be measured. Wetlands were all mapped during late July through early September to determine vegetative structure. Rainfall and temperature records for the previous ten years and for study years were obtained from the official weather station in Presque Isle, Maine.

FUTURE PLANS: Sorting and identification of specimens will continue through the academic year. Wetland maps will be completed and planimeted to obtain area of wetlands and of life forms. Weather data, wetland data, and specimen data will be entered in D-Base files for later summary by the SAS. The graduate student will pursue his academic program during the semester and write his comprehensive exam.

NATIONAL PATTERNS OF BIRD ABUNDANCE AND DIVERSITY

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

**Cooperators/
Project
Support:** U.S. Environment Protection Agency -
Environmental Laboratory, Corvallis, OR
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 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). These analyses provided a series of wildlife-habitat relationships at the 1 km resolution of the AVHRR imagery. The analyses were conducted at multiple scales of habitat aggregation and image filtering. Comparison of the results suggested that there was little gain in using aggregation and/or filtering, and further analysis was conducted on the basis of the unaggregated and unfiltered landcover characteristics classification. These data were used to develop a prototype risk assessment map for the coterminous United States.

FUTURE PLANS: This project is being completed under its present auspices and manuscripts are being prepared for publication. Additional work to incorporate information on stressor data as modifiers of avian distribution will be pursued under alternate funding.

WILDLIFE RESOURCES - OTHER THAN MIGRATORY BIRDS:

POPULATION CHARACTERISTICS, PATCH OCCUPANCY, AND FALL DISPERSAL OF SPRUCE GROUSE ON MOUNT DESERT ISLAND, MAINE

Investigator: S. D. Whitcomb

Advisors: F. A. Servello
D. J. Harrison
A. F. O'Connell
W. E. Glanz

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

Objectives:

- 1) Identify potential habitat patches occupied by breeding spruce grouse in Acadia National Park and on Mount Desert Island.
- 2) Determine the minimum breeding population of spruce grouse in Acadia National Park and on Mount Desert Island.
- 3) Determine habitat types selected by dispersing juvenile spruce grouse, and describe dispersal movements.

SCOPE: Spruce grouse were believed to be extirpated on Mount Desert Island in the late 1800s but a breeding population currently exists. However, little is known about the population or its long term viability. Spruce grouse breeding habitat is predominantly lowland conifer cover. This cover type has a highly fragmented distribution on the island and occupies only 3% of the island's area. Therefore, the potential breeding habitat for spruce grouse is limited, and dispersal of juveniles between widely separated patches of breeding habitat may be important for maintaining a viable population on Mount Desert Island.

PROJECT STATUS: All requirements for the degree of Master of Science (in Wildlife Management) were completed in December 1993. An abstract of the thesis follows:

I studied patch occupancy, fall dispersal and the population characteristics of spruce grouse (*Dendragapus canadensis*) in fragmented habitat on the southeastern edge of their range. I identified 36 insular patches of potential habitat that varied in size and were widely distributed on Mount Desert Island (MDI), Maine. I systematically surveyed each habitat patch during April-May 1992-1993 to determine patch occupancy and estimate population sizes. Female spruce grouse ($n = 18$) and juveniles ($n = 9$) were

equipped with radio transmitters and monitored from nesting through fall dispersal.

Spruce grouse occupied 31% ($n = 11$) of patches searched, and occupancy was related to patch size, interpatch distance, and patch shape. Six of 9 large habitat patches (>20 ha) were occupied in 1992 and 1993, compared with 2 of 6 medium-sized patches (10-20 ha), and 3 of 21 small patches (4-10 ha). Occupied patches were closer to other occupied patches and had a smaller perimeter to area ratio than unoccupied patches. All juvenile spruce grouse dispersed from summer brood range and net dispersal distances ranged to 7.2 km, and radius of dispersal to 7.8 km. Upland conifer, lowland conifer and mixed conifer-deciduous habitat types were used by dispersing juveniles during dispersal, indicating that these cover types did not constitute a barrier to spruce grouse. Eighty-one percent of spruce grouse observed during surveys on MDI were captured and marked (M = 39, F = 18). Population estimates for MDI were 72 grouse in 1992 and 56 in 1993. The number of individuals in habitat patches ranged from 1-10 and the mean breeding density in patches >20 ha was 13.7 grouse/100 ha.

Spruce grouse on MDI are confined to a few small patches of lowland conifer habitat which are at risk of local extinction. Successful dispersal among habitat patches is therefore important to the long term persistence of the island's population. Although dispersers moved great enough distances to reach habitat patches, only 2 of 9 moved to a different patch. Additionally, production on MDI was lower than previously reported. Several factors including productivity, patch occupancy, and dispersal probably combine to regulate the spruce grouse population on MDI.

REPRODUCTIVE BIOLOGY OF CAPTIVE FISHERS

Investigator: H. C. Frost

Advisors: W. B. Krohn, Chairperson
D. J. Harrison
C. R. Wallace
H. C. Gibbs
K. D. Elowe

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

Objectives:

- 1) Evaluate placental scars and mammae size for estimating the percentage of breeding-age females raising young.
- 2) Document male and female reproductive cycles by: a) monitoring levels of reproductive hormones; b) documenting the estrous cycle and implantation dates of females; and c) monitoring testes size, sperm viability, and baculum development in males.
- 3) Document growth and development of embryos and kits in captivity.

SCOPE: Common reproductive indices used for fisher management are counts of corpora lutea, blastocysts, and placental scars. Recently, the Maine Cooperative Fish and Wildlife Research Unit documented the reproductive biology of fishers using radio-telemetry. These studies indicate that counts of corpora lutea and blastocysts overestimate the number of young born. However, the proportion of adult females with placental scars was similar to the proportion of females denning and raising young in the wild. The use of placental scars has been questioned because of the reliability of observing them on the uterus and determining how long they remain visible. The validity of using placental scars and mammae size as estimates for determining how many females give birth will be investigated. In addition, the male and female reproductive cycles will be documented along with the growth and development of embryos and young.

PROJECT STATUS: All requirements for the Ph.D. (in Wildlife Ecology) were completed in August 1994. The abstract of the dissertation is as follows:

I studied the reproductive biology, growth, and development of 82 fishers (*Martes pennanti*) between 1990-1993. Males (>6 months of age) were nonreproductive from June through January based on regressed testes. Testosterone levels and testes size increased in January and reached a maximum in March, whereas sperm production was at its maximum from March through May. Testosterone levels decreased, testes were regressed, and sperm production ceased by June. Adult females (>2 years old) were anestrus from June through March and vaginal cornification remained high for 3 to 5 weeks after the birth of kits (\bar{X} birth date = 23 March, n = 14).

Laparotomies were performed on adult females which gave birth to evaluate placental scar visibility, and nipple size was measured on all females throughout the year. One placental scar was found in 1 of 14 females which gave birth. Nipple size for nonbreeders remained small throughout the year but increased slightly during the breeding season in former breeders. Nipple size for current breeders was larger than all other classes. No overlap occurred in 95% confidence intervals between current breeders and nonbreeders. Placental scars appear unreliable as an estimator of parturition, whereas nipple enlargement is a useful measure of parturition.

The gestation period of fishers was >10 months, but active embryo development was <45 days (n = 21). The appearance and development of embryos were monitored with ultrasound. Biparietal and body diameters of fetuses were accurate predictors of parturition dates as early as 23 days prepartum.

Maternal body mass and litter size were positively correlated ($r^2 = 0.59$, $P = 0.009$). Fishers were born altricial and remained so until their eyes and ears opened at approximately 48 days of age. After their eyes opened and they began to eat solid food, body size increased rapidly as did other morphological and behavioral traits. Body mass was similar for males (n = 22) and females (n = 16) at birth, but by 90 days of age the mean daily gain of males was twice that of females. Kits were weaned as early as 68 days of age, corresponding to the time wild kits leave natal dens.

RELATIONSHIP OF BEAVER MANAGEMENT AND WATERFOWL PRODUCTION IN SOUTHCENTRAL MAINE

Investigator: T. C. McCall

Advisors: R. B. Owen, Jr., Chairperson
D. J. Harrison
W. B. Krohn
W. A. Halteman
J. R. Longcore
P. O. Corr, Ex-Officio
K. D. Elowe, Ex-Officio

**Cooperators/
Project
Support:** McIntire-Stennis
Hirundo Wildlife Trust
Maine Cooperative Fish and Wildlife Research Unit
Maine Department of Inland Fisheries and Wildlife
Maine Trappers Association
National Rifle Association
Penobscot County Conservation Association

Objectives:

- 1) Determine the yearly response of the density of beaver on an area open to recreational beaver trapping and an area recently closed to trapping.
- 2) Compare the number of wetlands and surface area of water on both areas.

- 3) Compare the area of lifeforms of habitat for waterfowl on both areas.
- 4) Compare the annual response in the density of breeding pairs of selected waterfowl species on both areas.

SCOPE: Beaver are one of the primary agents influencing wetland creation and dynamics in North America. Furthermore, beaver flowages have been recognized for years as high quality habitat for waterfowl and many other wildlife species. However, it is unclear how beaver trapping influences beaver densities, wetland dynamics, and waterfowl densities. This study is designed to provide data for better management of beaver to (1) ensure maximum waterfowl and other wildlife habitat, (2) ensure a sustainable beaver harvest, (3) minimize impact of beaver damage, and (4) maximize aesthetic enjoyment of wildlife for the public.

One 111 km² area in south-central Maine was closed to beaver trapping for 4 years beginning in 1989, whereas a similar area remained open to trapping. Each October from 1988-92, the density of active beaver colonies was determined on both areas from fixed-wing aircraft. On the trapped area, trappers were interviewed annually to determine the harvest of beaver. Each May the number and sizes of wetlands and the lifeforms of habitat associated with each of the 270 wetlands was determined using aerial photos. From July-September 1989-92 each wetland was visited to verify the accuracy of the data obtained from the photos. Each wetland was visited in the spring and summer to record the condition of the beaver dam and the water level. From April-May 1989-92, ground counts of breeding pairs of selected waterfowl species were compared on each area.

PROJECT STATUS: All requirements for the degree of Master of Science (in Wildlife Management) were completed in May 1994. An abstract of the thesis follows:

Beaver (*Castor canadensis*) flowages are a habitat used by breeding waterfowl and many other species of wildlife. During 1988-92 in south-central Maine, I determined the density of beaver colonies and beaver harvest, wetland characteristics, and density of breeding pairs of waterfowl on a 111 km² area that was recently closed to beaver trapping and a similar area open to trapping.

Density of beaver colonies increased from 0.15 to 0.32/km² (113%) on the untrapped area during 1988-92 but changed little (0.19-0.20/km², +5%) on the trapped area. Annual harvest of beaver was highly correlated with mean pelt price of beaver ($r = 0.97$). There was a strong correlation between the number of beaver dams maintained by beaver and the density of beaver colonies on the untrapped area ($r = 0.99$) but little relationship on the trapped area ($r = -0.18$).

Number of wetlands on the untrapped area increased from 120 to 134 (12%) and was highly correlated ($r = 0.92$) with the density of beaver colonies. On the untrapped area wetlands increased (103-110, 7%) during 1989-92 but was poorly correlated ($r = -0.13$) with the density of beaver colonies. Total surface area of water on the untrapped area increased from 115.4 to 157.5 ha (36%) with concomitant increases in flooded lifeforms of vegetation (open water, 12%; emergent herbaceous, 28%; ericaceous, 111%; alder/willow, 153%; timber, 81%). On the trapped area, surface area of water remained stable with minor changes in flooded vegetation. Surface water was correlated with the density of beaver colonies on both the untrapped ($r = 0.67$) and trapped areas ($r = 0.89$).

The density of pairs of black ducks (*Anas rubripes*) remained relatively stable on both the untrapped (27.0 ± 1.7 - $31.5 \pm 0.8/100\text{km}^2$, + 2 pairs) and trapped areas (27.9 ± 3.1 - $20.7 \pm 1.7/100\text{km}^2$, -2.4 pairs) during 1989-92. Other species of waterfowl increasing slightly to moderately on the untrapped area included Canada geese (*Branta canadensis*) (3.6 - $9.0 \pm 0.5/100\text{km}^2$, 4.9 pairs), hooded mergansers (*Lophodytes cucullatus*) (23.0 ± 0.5 - $28.8 \pm 1.8/100\text{km}^2$, 3.5 pairs), and mallards (*Anas platyrhynchos*) (6.8 ± 0.5 - $12.2 \pm 1.4/100\text{km}^2$, 3.5 pairs). Also, numbers of wetlands used by pairs of each species of waterfowl increased on the untrapped area.

A ≥ 1 -year closure of beaver trapping is sufficient to increase the density of beaver colonies, while 1 2-3 year closure is necessary to increase wetland habitat, whereas ≥ 3 -4 years is required to begin influencing waterfowl. Although increased wetland habitat created by beaver on the untrapped area had a slight to moderate influence on the density of waterfowl, it probably benefitted many other species of wildlife as well.

SPATIAL CHARACTERISTICS AND DISPERSAL OF AN UNEXPLOITED POPULATION OF MARTENS IN A FOREST PRESERVE

- Investigator:* D. M. Phillips
- Advisors:* D. J. Harrison, Chairperson
W. B. Krohn
K. D. Elowe
W. A. Halteman
- Cooperators/
Project
Support:* McIntire-Stennis
Maine Department of Inland Fisheries and Wildlife
Baxter State Park
Hirundo Wildlife Trust
Penobscot County Conservation Association
- Objectives:*
- 1) Compare spatial characteristics of an unexploited marten population with a recently studied population in an area characterized by extensive timber harvesting and intensive trapping.
 - 2) Document the extent of home range fidelity for martens across seasons and years.
 - 3) Document characteristics of dispersal in an unexploited population of martens.

SCOPE: Martens (*Martes americana*) are commonly considered habitat specialists and indicator species of mature coniferous forest. The species is also vulnerable to overexploitation by trappers. Since 1986, population indices have shown a declining trend in the number of martens in Maine, which suggests that the species' numbers may have been affected by recent extensive clearcutting and liberal trapping regulations. Most studies of martens have involved exploited populations and/or study areas under intensive forest management. A comparison of spatial characteristics of two populations of martens in areas characterized by different disturbance regimes may reveal differences in the quality of habitat for the species.

As a result, our goal is to document spatial characteristics (e.g., home range size and indices to home range size, seasonal and annual home range shift, spatial overlap of home ranges) of martens in a 60 km² area of Baxter State Park, and compare them with the results of a recently completed study in an area characterized by extensive timber harvesting and intensive trapping. Within the Baxter population, we will test for differences across seasons and across years in home range size and indices to home range size. We will also test for differences across seasons and across years in the positions of home ranges on the landscape, and in the degree of spatial overlap of home ranges. We will then compare the two populations of martens by testing for differences between summer home range sizes, and between indices to home range size. The extent of territoriality will be compared by testing for differences in overlap of home ranges between the two populations.

Recent timber harvesting has caused habitat fragmentation, and has increased the network of roads that provide access to martens by trappers. The effect of these unnatural obstacles on the ability of martens to disperse long distances is unclear. Baxter State Park may be serving as a refugia, supplying a sustained annual harvest of martens in the adjacent commercial forestland. Our goal is to document characteristics of dispersal (e.g., timing, distance, directionality) for an unexploited population of martens in a forested preserve, and to identify natural and human generated barriers to dispersal. We will test for differences in the proportion of martens moving outside the park with the proportion remaining inside the park. We will also test for differences in directionality of dispersal movements from protected and unprotected areas. We

hypothesize that poorer quality habitat with decreased social pressure outside the park will result in non-random patterns of dispersal.

PROJECT STATUS: All requirements for the degree of Master of Science (in Wildlife Ecology) were completed in August 1994. An abstract of the thesis follows:

Results from previous research suggest that American marten (*Martes americana*) require mature forest habitat; however, the relationship of trapping and timber harvesting to performance of marten populations is not well documented. I compared sex-specific indices of performance (i.e., density, age structure, sex ratio, percent of females lactating, home-range area, percent of occupied area, and intrasexual overlap of home ranges) for 61 non-juvenile (≥ 1 year) marten (27 M, 34 F) that were radio-monitored in a forest preserve (Baxter State Park), with measures of performance for 28 non-juvenile marten (14 M, 14 F) monitored in an industrial forest (Telos). The preserve was closed to trapping and timber harvesting for > 35 years, and the industrial forest was characterized by intensive trapping and extensive timber harvesting.

Density of non-juvenile resident marten during summer in the forest preserve was 4.86 times the density in the industrial forest. Mean sex-ratios of non-juvenile marten were similar to 1:1 in Baxter (1.1:1) and Telos (0.85:1). Male marten were older ($P < 0.001$) in the forest preserve; fewer yearlings (1-2 years) and more adults (≥ 2 years) were livetrapped in the preserve. Alternatively, no difference in age structure of females ($P = 0.181$) or in the proportion of non-juvenile (≥ 1 year old) females lactating ($P = 0.460$) occurred between sites. The proportion of adult (≥ 2 years) females that lactated in early summer was not different ($P = 0.949$) between sites.

Lower density in the industrial forest was associated with increased range size ($P = 0.002$) and reduced spatial overlap for non-juvenile males; however, I observed no difference in range size ($P = 0.257$) between lactating females in the forest preserve and the industrial forest. Male ranges were larger ($P = 0.023$) than ranges of lactating females in the industrial forest; however, range areas did not differ ($P = 0.590$) between sexes in the forest preserve. A lower percent of the industrial forest was occupied by marten, and males occupied a greater percent of the available area than females on both sites. I observed greater intrasexual overlap among male ranges in the high density than in the low density population; however, female marten shared $< 2\%$ of their range area with conspecifics on both sites. My data suggest that males in the low density population increased range area to increase access to mates, and that social pressure was greater for males in the high density population. Overall measures of population performance did not differ between marten inhabiting the forest preserve or the industrial forest. Females may occupy ranges of comparable habitat quality in logged and unlogged areas via habitat selection at the landscape scale. Recently harvested forest stands are disproportionately excluded from marten ranges; thus effects of logging appeared to result from reduced density in harvested landscapes.

The influence of season on population density, and size and location of marten ranges has not been documented. Knowledge of seasonal variation in population characteristics would improve interpretations of the seasonal importance of specific habitats. I examined seasonal and annual variation in population density and range area, and documented the extent of range fidelity for marten of each sex in the forest preserve.

Density of non-juvenile marten in the Baxter preserve varied by only 0.09 marten/km² across 3 winters (1 Nov-31 Mar) and by 0.16 marten/km² across 3 summers (15 May-31 Oct). Mean density did not differ between summer (0.68 marten/km²) and winter (0.67 marten/km²); however, density of males during winter was consistently higher than females. Indices to sex-specific range area did not differ between early- (1 Nov-31 Dec) and late- (1 Jan-31 Mar) winter for males ($P = 0.266$) and females ($P = 0.782$), or between winter and summer for males ($P = 0.637$) and females ($P = 0.248$). All of 19 males and 5 of 13 females monitored > 1 season exhibited a high degree of range fidelity; however, 4 females abandoned previously established ranges and began wandering over large areas, and 4 additional females were wandering when livetrapped. Male ranges may have shifted in late-winter in response to wandering females that established resident ranges; however, males maintained access to areas used during the previous summer. My data suggest that females abandoned their range in response to increased social pressure associated with high population density, whereas males shifted or shared area with conspecifics in the high density population.

Knowledge of dispersal characteristics of juvenile marten could assist managers in developing strategies to maintain viable populations in commercial forest landscapes; however, specifics of dispersal and survival probabilities of newly independent juvenile marten have not been documented. I documented timing, distance, rate of travel, and directionality during dispersal, and documented survival probabilities for 28 juvenile (≤ 1 year) marten (14 M, 14 F) that were radiocollared in the Baxter Park preserve.

Dispersal of juvenile marten began prior to August 27; there were no sex-specific differences in timing or rate of travel ($P = 0.828$) during dispersal. I observed no difference in minimum distance travelled during dispersal ($P = 0.521$) for males (median = 14.3 km) or females (median = 12.0 km). Directions of final dispersal relocations were distributed uniformly around the study area, and marten exhibited a random walk pattern of movement during dispersal. Natural mortality of juvenile marten was high prior to trapping season; however, marten surviving to mid-November had a high probability of surviving to spring. Fur trapping should be conducted as early as possible to minimize additive mortality and increase recruitment of juvenile marten. Local populations of marten should be spaced < 12.0 km to ensure exchange of individuals, thus enhancing viability of metapopulations.

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 will be investigated using a computer model based upon parameter estimates from field data. The model should improve prediction of population responses to management actions and habitat changes. It may also enhance MDIFW's ability to monitor the state's bear population. Model construction and testing will include extensive sensitivity analysis, which should provide insight into the type of data needed, and required precision in data collections for reliable monitoring of population parameters. The model should also become a vehicle for developing and testing statewide population monitoring

techniques. Observed changes in population status of bears living within MDIFW study areas will provide a basis for evaluating harvest-related monitoring techniques. The model could be used to further test the sensitivity of new monitoring techniques over a wide range of population conditions.

PROJECT STATUS: Survival and reproduction data have been analyzed. Several preliminary computer models have been constructed in QuickBasic. Each succeeding model included additional components; the current model describes the life history of female bears in considerable detail. The model is a Leslie matrix design, and accommodates variation in survival during 2 periods (pre-hunting season and hunting season), fluctuating age of first reproduction, and variation in frequency of various-sized litters, litter sex ratios, and litter production. Density dependent survival of subadults is assumed to be the principal factor regulating population growth in the absence of harvest. Sensitivity analysis has begun to evaluate changes in model output with changing parameter values, and indicate needed precision of input data. Sensitivity analysis will continue, utilizing large numbers of simulation runs with progressive alterations of parameter values. Comparisons of simulation results should identify and quantify the model's sensitivity to variation in parameter values. Additional complexity (i.e., stochastic effects and behavioral influences) will be incorporated into the model structure, with progressive sensitivity analysis as appropriate.

FUTURE PLANS: Sensitivity should also help identify minimum acceptable sampling intensities for population parameters. After the model is refined using Spectacle Pond data, it will be tested by starting with data collected on the Bradford study area in central Maine. Comparisons of model output to observed changes in population dynamics on the Bradford area will be made, and if further model refinement is required, data from the Stacyville study area (northcentral Maine) can be utilized for further testing.

INTERACTIONS OF WHITE-TAILED DEER AND COYOTES ON MOUNT DESERT ISLAND, MAINE

Investigator: S. L. Glass

Advisors: D. J. Harrison, Co-Chairperson
A. F. O'Connell, Co-Chairperson
J. R. Gilbert
K. D. Elowe
W. E. Glanz

**Cooperators/
Project
Support:** National Park Service - Acadia National Park
University of Maine

Objectives:

- 1) Estimate cause-specific mortality rates for radio-collared female white-tailed deer on Mount Desert Island.
- 2) Assess patterns of spatial overlap among coyotes and white-tailed deer social groups to determine whether coyotes influence available habitat for deer in Acadia National Park.
- 3) Using mortality rates estimated via objective #1 and a stochastic simulation model, assess the effect of various causes of mortality on population dynamics of deer in Acadia National Park.
- 4) Compare social structure of coyote family groups on Mount Desert Island with mainland coyotes in eastern Maine.

SCOPE: Deer populations in many eastern National Parks have been increasing to the extent that vegetation

and species composition are showing significant negative effects. Acadia National Park (ANP) is an exception; since 1968 no evidence of widespread overbrowsing has been documented. Recent studies suggest that deer populations have declined in ANP since 1980.

Coyotes colonized Mount Desert Island (MDI) in the early 1980's and are potentially a significant predator on deer on MDI. Studies of food habits suggest that the use of deer by coyotes during summer and autumn is high relative to mainland areas. In addition to direct predation, spatial interactions between coyotes and deer may potentially affect deer populations.

From August 1991 to August 1994 we investigated cause-specific mortality of deer, assessed patterns of movement and spatial overlap between coyotes and deer, and examined the social structure of coyotes on MDI.

PROJECT STATUS: Field work was initiated in August 1991. Forty-three coyotes (25 females, 18 males) from 6 different family groups have been captured and equipped with transmitters. Twenty adult deer (13 females, 7 males) also have been equipped with transmitters. Relocations have been obtained 1-3 times per week. Coyote social structure on MDI is characterized by delayed dispersal with at least 1-2 juveniles in each family unit assisting with the raising of the subsequent litter. Mortality sources documented for deer on MDI have been coyotes, drowning, domestic dogs, and vehicles.

FUTURE PLANS: Coyote and deer trapping was concluded in April 1994. Relocations were obtained through August 1994 on all radioed animals. Data analysis will begin during November 1994, with an expected date of project completion of August 1995.

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 Fish 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: The second and last field season is nearly completed. Wetland surveys were done in a second study area as well as repeated in the original study area. Radio-transmitters were again placed on turtles of both species to determine movements and habitat use. These turtles are still being monitored periodically until hibernation when the transmitters will be removed. Nests will be dug up in October to determine clutch sizes and hatching success. Efforts to determine movements and habitat use of hatchlings were unsuccessful due to inclement weather. Data analysis is in progress.

FUTURE PLANS: Finish analyzing data and complete thesis.

HABITAT SELECTION AND INFLUENCE OF FRAGMENTATION ON MARTENS IN NORTHERN MAINE

Investigator: T. D. Chapin

Advisors: D. J. Harrison, Chairperson
W. B. Krohn
S. A. Sader
K. D. Elowe

**Cooperators/
Project
Support:** McIntire-Stennis

Objectives:

- 1) Determine seasonal habitat selection by martens in an untrapped, forested preserve.
- 2) Determine the relationships among characteristics of forest fragments and use intensity by martens in a heavily timber-harvested area.
- 3) Determine characteristics of habitat that influence home range size.
- 4) Compare habitat selection by martens in a continuous, untrapped forest and in an intensively trapped and timber-harvested area.

SCOPE: Some of the highest densities of martens recorded occur in Baxter State Park (BSP), an area of contiguous forest with an abundance of mature hardwoods (beech, birch, and maple). This association seems contrary to the habitat associations that have been developed for martens, based primarily on studies in the western US. Some studies in the eastern United States have documented that martens may use mixed-wood or even hardwood stands extensively. Habitat quality for martens may be related to the amount of coarse woody debris (CWD) on the forest floor. If the amount of CWD is not related to cover type, assessment of habitat selection based on cover types alone may be misleading. Thus, in the west, where softwood forests have more CWD than hardwoods (aspen), cover-type selection probably reflects marten habitat associations. In the east, however, the relationship between cover type and CWD may be less distinct. To better understand the habitat associations of martens in the east, I will assess seasonal habitat selection by martens in a forest preserve and evaluate the findings with respect to relative amounts of CWD in the habitat types.

The literature suggests that extent of forest fragmentation may influence habitat quality for martens. The specific characteristics of fragmentation that affect martens are poorly understood. Martens have been documented to use remnant stands as small as 300 m². However, characteristics such as isolation of stands have not been examined relative to marten use. I will compare spatial characteristics of forest patches, such

as size, shape, and distance to another forest stand, between patches used and unused by martens. I will also relate habitat-based spatial characteristics of home ranges, such as percent logged, or habitat diversity, with size of home range. This relationship will be used as one index of the influence of these habitat variables on population performance.

PROJECT STATUS: To date, 28 non-juvenile residents in Telos and 36 non-juvenile residents in Baxter have been sampled sufficiently to compute 95% MCP home ranges, and potential residents, with < 25 relocations, are being evaluated for inclusion in habitat analyses. Aerial photographs of the Baxter study area (approximately 50 km²) have been interpreted and incorporated in a GIS database, and existing coverages of the Telos Study area are being used. Habitat types have been classified based on canopy height, canopy closure, and species composition, and habitat polygons have been characterized based on presence of spruce budworm infestation.

FUTURE PLANS: Preliminary results have been obtained for most analyses. Thesis preparation will begin in November 1994, and should be completed by March 1995.

MORTALITY OF WHITE-TAILED DEER FAWNS AND RELATIVE SNOWSHOE HARE ABUNDANCE ON MOUNT DESERT ISLAND, MAINE

- Investigator:** R. A. Long
- Advisors:** D. J. Harrison, Co-Chairperson
A. F. O'Connell, Jr., Co-Chairperson
J. R. Gilbert
A. S. White
- Cooperators/
Project
Support:** U.S. National Park Service
- Objectives:**
- 1) Document cause specific mortality rates of white-tailed deer fawns on Mount Desert Island (MDI), Maine.
 - 2) Estimate the relative abundance of snowshoe hare on MDI and compare this with a population from the mainland.

SCOPE: Studies of utilization of key browse species by white-tailed deer (*Odocoileus virginianus*) in 1980 and 1990 on Mount Desert Island, Maine concluded that deer populations were stable or had declined over this period. MDI is closed to all deer hunting and the study's findings are contrary to trends seen in other non-hunted populations in the eastern U.S. where deer numbers have increased in response to the absence or reduction of predators and changes in land management practices. In some places deer densities are at the point where they are negatively affecting natural plant communities and malnourishment is occurring. This is not the case on MDI where studies have shown no over-utilization of vegetation and a healthy deer population. In the mid-1980's a study was initiated to examine cause-specific mortality rates of adult deer and also to investigate deer/coyote interactions on MDI. To augment this study, a companion study was initiated to look specifically at cause specific rates of fawn mortality on MDI utilizing radio-telemetry techniques.

In addition, previous studies of food habits of eastern coyotes (*Canis latrans*) on MDI suggest a lower use of snowshoe hare (*Lepus americanus*) than on the adjacent mainland. Therefore, the relationship between hare density and understory density will be evaluated as an index to the abundance of hares on MDI to determine if the lower use is related to a lower availability. This information will be useful in evaluating differences in social behavior and food use by coyotes on MDI and the adjacent mainland. Additionally,

patterns of relative snowshoe hare abundance and use by coyotes will be compared between MDI and a previous study on the mainland in hopes of gaining some insight into factors affecting the social behavior of coyotes.

PROJECT STATUS: We radio-collared 24 fawns during June and July of 1992-1994 and located each fawn daily until the collar was lost or death occurred. Analyses are not yet complete, however, a wide range of mortality factors have been observed including automobiles, predation by wild canids and domestic dogs, orphaning, and drowning.

We counted snowshoe hare pellets on 1380 pellet plots at the end of each season (leaf-off, leaf-on) in 1994. We also counted understory stems on 552 vegetation plots. Pellet and stem counts will be used to describe the relationship between snowshoe hare density and understory density on MDI. This relationship, combined with previously conducted understory stem counts covering much of the island, will be used to compare the relative abundance of hares on MDI to the adjacent mainland.

FUTURE PLANS: Telemetry data is currently being compiled to allow estimation of cause-specific fawn mortality rates. Hare pellet counts will be regressed on vegetation data and evaluated with respect to stem distributions from MDI and the mainland. The anticipated date of project completion is May 1995.

NUTRITIONAL ECOLOGY OF WHITE-TAILED DEER IN WINTERING AREAS IN MAINE

Investigator: S. S. Ditchkoff

Advisors: F. A. Servello, Chairperson
K. D. Elowe
M. R. Stokes

*Cooperators/
Project
Support:* McIntire-Stennis

Objectives:

- 1) Compare the nutritional status of deer in northern and central Maine during winter.
- 2) Compare the nutritional status of deer in small and large wintering areas in northern Maine during winter.
- 3) Compare relative availability of high quality forage, including litterfall, for deer in harvested and unharvested softwood stands during winter.

SCOPE: Deer wintering areas are critical to the survival of deer during winter in Maine, and therefore it is important that these areas be protected and managed to provide optimal deer winter habitat. By using urine analysis techniques to evaluate the nutritional condition of deer as winter progresses, it may be possible to gain insight into the quality of particular wintering areas. This technique has only recently been developed and has had limited testing in field situations. Thus, the ultimate goal of this portion of the study is to evaluate urine analysis techniques for use in Maine.

Previous research suggests that deer may not be able to subsist solely on hardwood browse during winter, but may require high quality forages such as lichens and litterfall to increase overwinter survival. Yet, typical deer wintering area management prescribes cutting in wintering areas to maintain a variety of timber age classes and increase the biomass of available woody browse, thus reducing, or eliminating, litterfall and lichens previously available to deer.

PROJECT STATUS: I collected urine samples bimonthly from deer populations in 10 wintering areas during January-March 1993. Samples have been analyzed for urea nitrogen, potassium, sodium, phosphorus, and calcium to assess the nutritional status of deer in these wintering areas. During the winter of 1994, I collected litterfall in unharvested softwood stands and estimated woody browse biomass in harvested and unharvested softwood stands in deer wintering areas to compare biomass availability at different diet quality levels.

FUTURE PLANS: Project completion is expected in December 1994.

POPULATION TRENDS AND HABITAT USE OF HARBOR SEALS ALONG THE MAINE COAST

Investigator: M. K. Kenney

Advisors: J. R. Gilbert, Chairperson
W. B. Krohn
J. A. Wilson

**Cooperators/
Project
Support:** National Marine Fisheries Service
Maine Department of Environmental Protection
Maine Department of Inland Fisheries and Wildlife
University of Maine -
Department of Wildlife Ecology

Objectives:

- 1) Estimate population size of eastern Atlantic harbor seals on Maine's coast and compare with the 1982 and 1986 population surveys.
- 2) Document harbor seal distribution and habitat use during pupping and molting seasons to identify high use coastal areas.

SCOPE: Small sections of the coast of Maine have been surveyed for harbor seals since 1971. Two complete censuses of Maine's coastal ledges were conducted in 1981 and 1986 indicating an increase in the population. Most harbor seal pups are born north of the New Hampshire/Maine border during late May and early June at sheltered sites. By August, the pups have dispersed while adults aggregate on the outer ledges to begin their molt.

The National Marine Fisheries Service (NMFS) contracted with the University of Maine to conduct a population survey during pupping season, replicating the 1981 and 1986 June surveys. Both this June survey and an August survey will provide information on habitat use and changes in distribution during these annual periods of stress.

PROJECT STATUS: Survey flights covering the islands and ledges coast of Maine between the Isle of Shoals and the Canadian border were completed during the pupping season in June 1993 and during the molt in August 1993. Counts from the June survey have been entered into the database and a report is being completed for NMFS by December 1993. Slides from the August survey are in the process of being counted.

FUTURE PLANS: Ledge and island characteristics such as size and substrate will be compiled into the database from National Oceanic and Atmospheric Administration charts, National Wetland Inventory maps, and slides. Analysis will include comparisons between pupping and molting sites and sites which remain unused.

**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
W. B. Krohn
J. R. Gilbert
K. D. Elowe
R. J. Seymour
- Cooperators/
Project
Support:** Maine Department of Inland Fisheries and Wildlife
University of Maine -
Department of Wildlife Ecology
Baxter State Park
Maine Forest Service
National Council of the Paper Industry for Air and
Stream Improvement
McIntire-Stennis
- Objectives:**
- 1) Document and compare seasonal habitat selection by martens in an untrapped forest preserve, an untrapped industrial forest, and a trapped industrial forest.
 - 2) Document and compare population characteristics (i.e. home range size, inter- and intra-sexual home range overlap, density, age and sex structure, survival and percent females lactating) of martens in an untrapped forest preserve, an untrapped industrial forest and a trapped industrial forest.
 - 3) Document and compare microhabitat characteristics between forested areas (>6 m in height) with different intensities of use 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 contributed to declines in modern populations as well.

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 will 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: Since May 1994, 43 martens (19 females, 24 males) have been radiocollared on the

three study sites. Relocations were obtained at least 3 times per week via ground and aerial telemetry through 31 August 1994. Martens are currently being monitored 1-3 times per week.

FUTURE PLANS: Martens will be trapped and radiocollared annually through June 1997. Relocations of radiocollared animals will be obtained through April 1998. Microhabitat sampling will occur during summer 1995 and 1996. Data analysis will proceed concurrently with field work. Expected project completion date is August 1998.

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

SCIENTIFIC PUBLICATIONS

- ARTHUR, S.M., T.F. PARAGI, and W.B. KROHN. 1993. Dispersal of juvenile fishers in Maine. Journal of Wildlife Management 57(4):868-874.
- HARTLEB, C.F., J.D. MADSEN, and C.W. BOYLEN. 1993. Environmental factors affecting seed germination of *Myriophyllum spicatum* L. Aquatic Botany 45:15-25.
- HARTLEY, R.W., and J.R. MORING. 1993. Observations of black bass (*Centrarchidae*) confined during angling tournaments: a cautionary note concerning dissolved oxygen. Aquaculture and Fisheries Management 24:575-579.
- KROHN, W.B., S.M. ARTHUR, and T.F. PARAGI. 1994. Mortality and vulnerability of a heavily trapped fisher population. Pages 137-145 (Chapter 8) in S.W. Buskirk, A.S. Harestad, M.G. Raphael, and R.A. Powell (editors). *Martens, sables, and fishers: biology and conservation*. Cornell University Press, Ithaca, NY. 484pp.
- MARKOWSKY, J.K., GLANZ, W., and M.L. HUNTER, JR. 1994. Why do brown tremblers tremble? Journal of Field Ornithology 65(2):247-249.
- MARZLUFF, J.M., R.B. BOONE, and G.W. COX. 1994. Historical changes in populations and perceptions of native pest bird species in the west. Studies in Avian Biology 15:202-220.
- MORING, J.R. 1993. Checklist of the tidepool fishes of Maine. Maine Naturalist 1(3):155-160.
- MORING, J.R. 1993. Effect of angling effort on catch rate of wild salmonids in streams stocked with catchable-size trout. North American Journal of Fisheries Management 13(2):234-237.
- MORING, J.R., G.C. GARMAN, and D.M. MULLEN. 1994. Effects of logging practices on fishes in streams and techniques for protection: a review of four studies in the United States. Pages 194-207 in I.G. Cox (editor). *Rehabilitation of Freshwater Fisheries*. Fishing News Books, Oxford, United Kingdom.
- O'CONNOR, R.J. 1994. Population patterns and process parameters - issues in integrating monitoring and models. Pages 283-300 in R.J. Kendall, and T.E. Lacher, (editors). *Wildlife toxicology and population modeling: integrated studies of agroecosystems*. CRC Press, Boca Raton, FL. (Society for Environmental Toxicology and Chemistry, Washington, D.C.).
- SCHOOLEY, R.L., C.R. MC LAUGHLIN, G.J. MATULA, JR., and W.B. KROHN. 1994. Denning chronology of female black bears: effects of food, weather, and reproduction. Journal of Mammalogy 75(2):466-477.
- VANDERHAEGEN, W.M., W.B. KROHN, and R.B. OWEN, JR. 1993. Effects of weather on earthworm abundance and foods of the American woodcock in spring. Pages 26-31 in J.R. Longcore, and G.F. Sepik (editors). *Proc. 8th American Woodcock Symposium*, U.S. Fish and Wildl. Serv. Biol. Rept. 16, Washington, DC. 139pp.

VANDERHAEGEN, W.M., W.B. KROHN, and R.B. OWEN, JR. 1993. Care, behavior, and growth of captive-reared American woodcocks. Pages 57-65 in J.R. Longcore, and G.F. Sepik (editors). Proc. 8th American Woodcock Symposium, U.S. Fish and Wildl. Serv. Biol. Rept. 16, Washington, DC. 139pp.

VANDERHAEGEN, W.M., R.B. OWEN, JR., and W.B. KROHN. 1994. Metabolic rate of American woodcock. Wilson Bulletin 106(2):338-343.

TECHNICAL AND SEMI-TECHNICAL PUBLICATIONS

BOONE, R.B. and W.B. KROHN. 1993. Assessing biodiversity: a progress report on the Maine Gap Analysis (Abstract). Pages 273 in R.D. Briggs, and W.B. Krohn (editors). Nurturing the northeastern forest-stewardship in a changing culture. Proceedings of a joint meeting of the New England SAF and Maine Chapter of TWS. Maine Agricultural and Forest Exper. Station Misc. Rept. 382, 289pp.

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DE MAYNADIER, P., and M.L. HUNTER, JR. 1994. "Keystone support: a letter to the editor." Bioscience Vol. 44, No. 1.

HARTLEY, M. 1994. Passerine abundance and productivity indices in grasslands managed for waterfowl nesting cover. Trans. 59th No. Am. Wildl. and Natur. Resour. Conf. 322-327.

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HUNTER, M.L., JR. 1994. What is biodiversity? The Maine Scholar 7:65-74.

KELLEY, C., E.O. GARTON, W.B. KROHN, L.S. MILLS, J.M. SCOTT, K. WILLIAMS, and B. CSUTI. 1994. Assessing the predictive ability of Gap Analysis vertebrate distribution maps. In Scott (compiler). A handbook for Gap Analysis, USDI National Biological Survey, University of Idaho, Moscow, ID. Unpaged.

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SPICER, A.V., and J.R. MORING. 1994. 10-4, Salar. Maine Fish and Wildlife 36(2):6-9.

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- COLE, M.B. 1994. Summer movements and habitat use by three size classes of smallmouth bass (*Micropterus dolomieu*) in Green Lake, Maine. Master of Science Thesis, University of Maine, Orono. 95pp.
- ESCHHOLZ, W.E. 1993. Moose activity in clearcuts after conifer release with glyphosate. Master of Science Thesis, University of Maine, Orono. 63pp.
- FROST, H.C. 1994. Reproductive biology of captive fishers. Ph.D. Dissertation, University of Maine, Orono. 114pp.
- GRAY, P.B. 1993. Effects of digestible energy content of winter forages on white-tailed deer nutritional ecology: Implications for measuring forage availability in deer wintering areas. Master of Science Thesis, University of Maine, Orono. 56pp.
- HOCKETT, K.S. 1994. The effects of cover and a model kingfisher on the anti-avian predator response of juvenile Atlantic salmon (*Salmo salar*). Master of Science Thesis, University of Maine, Orono. 135pp.
- KITCHENS, C.G. 1994. Variables affecting habitat use and movements of American black ducks and mallards on the Missisquoi National Wildlife Refuge. Master of Science Thesis, University of Maine, Orono. 72pp.
- McCALL, T.C. 1994. Relationship of beaver management and waterfowl production in southcentral Maine. Master of Science Thesis, University of Maine, Orono. 59pp.
- OYLER, S.J. 1993. Avian bioindicator dynamics. Master of Science Thesis, University of Maine, Orono. 187pp.
- PHILLIPS, D.M. 1994. Spatial characteristics and dispersal of an unexploited population of martens in a forest preserve. Master of Science Thesis, University of Maine, Orono. 94pp.
- RAYMOND, K.S. 1994. Effects of the herbicide glyphosate on the winter nutritional ecology of moose in Maine. Master of Science Thesis, University of Maine, Orono. 95pp.
- STOCKWELL, S.S. 1994. Habitat selection and community organization of birds in eight peatlands of Maine. Ph.D. Dissertation, University of Maine, Orono. 115pp.
- WELCH, L.J. 1994. Contaminant burdens and reproductive rates of bald eagles breeding in Maine. Master of Science Thesis, University of Maine, Orono. 87pp.
- WHITCOMB, S.D. 1993. Population characteristics, patch occupancy, and fall dispersal of spruce grouse on Mount Desert Island, Maine. Master of Science Thesis, University of Maine, Orono. 44pp.

PROFESSIONAL TALKS PRESENTED

- BLACKWELL, B.F., and W.B. KROHN. "Pre-nesting ecology of the double-crested cormorant in the Penobscot River ecosystem: a preliminary report." Slide presentation at the Maine Bird Conference, Farmington, April 16, 1994.

- BLACKWELL, B.F. "Ecology of the double-crested cormorant in the Penobscot ecosystem: emphasis on predation of salmon smolts." Slide presentation on research progress to Maine Department of Inland Fisheries and Wildlife, Maine Atlantic Sea Run Salmon Commission, U.S. Fish and Wildlife Service, and Penobscot Indian Nation, March 16, 1994.
- BLACKWELL, B.F. "Ecology of the double-crested cormorant in the Penobscot ecosystem: emphasis on predation of salmon smolts." Slide presentation on research progress to U.S. Fish and Wildlife Service Hatcheries Division personnel, Craig Brook National Fish Hatchery, Orland, ME, March 17, 1994.
- BOOBAR, L.R., K.E. GIBBS, and J.R. LONGCORE. "Can activity traps assess aquatic insect abundance at the landscape level?" 20th Annual Maine Biological and Medical Sciences Symposium, Bates College, May 19-20, 1994.
- BOOBAR, L.R., K.E. GIBBS, and J.R. LONGCORE. "Efficiency of sweep net, activity trap, and Hess-type samples in capturing macroinvertebrates in Maine ponds." Acadia Entomological Society Meeting, Campobello Island, New Brunswick, Canada, July 18-19, 1994.
- BOONE, R.B. "Remote sensing, GIS and wildlife." Remote Sensing/GIS seminar series, Department of Wildlife, University of Maine, Orono, December 9, 1993.
- BOONE, R.B., and W.B. KROHN. "A framework for testing Maine statewide Gap Analysis." Poster presentation at Fourth Annual National Gap Analysis Workshop, Silverdale, WA, July 19-22, 1994.
- CARTWRIGHT, M.A. "Movement of displaced largemouth bass (*Micropterus salmoides*) in two central Maine lakes." Annual meeting of the Atlantic International Chapter, American Fisheries Society, Rangeley, ME, October 1, 1993.
- CARTWRIGHT, M.A. "Movement of displaced largemouth bass (*Micropterus salmoides*) in two central Maine lakes." Poster presentation at the Northeast Fish and Wildlife Conference, Burlington, VT, May 1-4, 1994.
- CHAPIN, T.D., D.M. PHILLIPS, C.S. MAJOR, and S. NOBLE. "The role of Maine and New Hampshire in recovery of the eastern timber wolf: a preliminary assessment." Poster presentation at Northeast Fish and Wildlife Conference, Burlington, VT, May 1-4, 1994.
- CHILLELI, M., B. GRIFFITH, and D.J. HARRISON. 1994. "Utility of regional furbearer data: the river otter example." First Annual Conference of The Wildlife Society, Albuquerque, NM, September 21, 1994.
- COLE, M.B. "Movements of tagged smallmouth bass." Video presentation at the annual meeting of the Atlantic International Chapter, American Fisheries Society, Rangeley, ME, October 1, 1993.
- COLE, M.B. "Differential summer movements and habitat use of three size classes of smallmouth bass (*Micropterus dolomieu*) in Green Lake, Maine." Poster presentation at the Northeast Fish and Wildlife Conference, Burlington, VT, May 1-4, 1994.
- de MAYNADIER, P. "The role of keystone ecosystems in landscape ecology." Reserve Design Seminar, University of New Hampshire, Durham, November 10, 1993.

- de MAYNADIER, P., and M.L. HUNTER, JR. "Managing for diversity at a landscape scale." Ecosystem Management Conference, Stevens Point, WI, March 4, 1994.
- DITCHKOFF, S.S., and F.A. SERVELLO. "An evaluation of urinalysis as an index to deer wintering area quality." First Annual Conference of The Wildlife Society, Albuquerque, NM, September 23, 1994.
- ELLIOTT, C.A. "Wildlife in riparian zones." 69th Annual Meeting of the New Brunswick Wildlife Federation, Bathurst, New Brunswick, April 9-11, 1994.
- FROST, H.C., and W.B. KROHN. "An evaluation of two indices of parturition in fishers." Slide presentation at the Northeast Fish and Wildlife Conference, Burlington, VT, May 4, 1994.
- HARRISON, D.J. "Potential forest management issues associated with habitat requirements of the marten." Maine Chapter, Association of Consulting Foresters, Bangor, ME, October 12, 1993.
- HARRISON, D.J. "Habitat associations of the marten: does the species deserve spotted owl status?" Paper presented at Conserving Species Dependent on Older Forests: a Population Viability Workshop. Fundy National Park, Alma, NB, October 27, 1993.
- HARRISON, D.J. "Objectives and preliminary results of a study to assess the influence of trapping and forest harvesting on marten populations in northern Maine." Scott Paper Company, Rockwood, ME, December 14, 1993.
- HARRISON, D.J. "A proposal to study the relationships among trapping, forest harvesting, and marten populations in northern Maine." Maine Cooperative Forestry Research Unit Advisory Committee, University of Maine, Orono, January 25, 1994.
- HARRISON, D.J. "Preliminary results from ongoing research to assess influences of forest harvesting and trapping on marten populations in northern Maine." Wildlife Division Meeting, Maine Department of Inland Fisheries and Wildlife, Rockland, ME, April 14, 1994.
- HARRISON, D.J., and T.D. CHAPIN. "Effects of forest fragmentation on martens in northern Maine: preliminary results from ongoing studies." Presentation to National Council of the Paper Industry for Air and Stream Improvement, Albuquerque, NM, September 23, 1994.
- HARTLEB, C. "A thermal and light refuge for planktonic prey and its effects on fish predation." Poster presentation at the Northeast Fish and Wildlife Conference, Burlington, VT, May 4, 1994.
- HARTLEB, C., and J.R. MORING. "Interspecific competition and dietary overlap between nonsalmonid fishes and stocked brook trout." Poster presentation at the annual meeting of the American Fisheries Society, Halifax, NS, August 24, 1994.
- HEPINSTALL, J.A., S.A. SADER, and A. ESTRADA. "Comparisons of tropical rain forest extent in the Sierra de Los Tuxtlas, Veracruz, Mexico: 1976-1990." Poster presentation at the Conservation of Neotropical Migratory Birds in Mexico Conference, Los Tuxtlas, Veracruz, Mexico, November 5-7, 1993.
- HEPINSTALL, J.A. "IDRISI and CISIG: a comparison of low cost GIS packages." National Autonomous University of Mexico, Los Tuxtlas Biological Station, Veracruz, Mexico, November 5-7, 1993.

- HODGMAN, T.P., T.C. McCALL, and R.B. OWEN, JR. "Waterfowl use of wetlands following closure of beaver trapping." 1994 Maine Bird Conference, University of Maine, Farmington, April 16, 1994.
- HUNTER, M.L., JR. "Forest diversity in time and space." USDA Forest Service, Clemson, SC, October 1, 1993.
- HUNTER, M.L., JR. "A landscape-scale approach to ecological values." Yale University, New Haven, CT, October 22, 1993.
- HUNTER, M.L., JR. "A triad approach to forest land use allocation." Munsungan Conference, University of Maine, Orono, January 6, 7, 1994.
- HUNTER, M.L., JR. "Biodiversity research: past, present, and future." USDA Forest Service Scientists, Annapolis, MD, March 8, 1994.
- HUNTER, M.L., JR. "Biodiversity and ecosystem management." Maine Department of Inland Fisheries and Wildlife, Rockland, April 15, 1994.
- HUNTER, M.L., JR., and A. HUTCHINSON. "The virtues and shortcomings of parochialism: Protecting species that are locally rare but globally common." Society for Conservation Biology, Guadalajara, Mexico, June 11, 1994.
- HUNTER, M.L., JR. "Balancing demands for land: A triad approach to land use." Keynote address, Global to local ecological land classification, Thunderbay, Ontario, August 15, 1994.
- JOHNSON, C., and M. CHILELLI. "Wolf reintroduction in Maine: a population viability assessment." Poster presentation at Northeast Fish and Wildlife Conference, Burlington, VT, May 1-4, 1994.
- JOHNSON, C., and W.B. KROHN. "Gap Analysis: applicability in a coastal environment." Poster presentation at National Gap Analysis Workshop, Silverdale, WA, July 21, 1994.
- KROHN, W.B. "Effects of cormorant predation on Atlantic salmon restoration: a preliminary report." Slide presentation to the U.S. Fish and Wildlife Service's Regional Office in Hadley, MA. March 1, 1994.
- KROHN, W.B. "An overview of the USDI National Biological Survey." Invited slide presentation at Wildlife Division Meeting, Maine Department of Inland Fisheries and Wildlife, Rockland, ME. April 14, 1994.
- KROHN, W.B. "Modelling species/habitat relations - how reliable is our knowledge?" Invited slide presentation at Fourth Annual National Gap Analysis Workshop, Silverdale, WA, July 21, 1994.
- MATZ, A. "The rare ones: Acadia's endangered species." Resource Acadia Seminar Series, Acadia National Park, Bar Harbor, ME, August 11-13, 1994.
- MORING, J.R. "Changes in management strategies for Atlantic salmon in Maine, 1871-1993." Symposium on the Uses and Effects of Cultured Fishes on Aquatic Systems, Albuquerque, NM, March 13, 1994.

- MORING, J.R. "Angling effort in streams stocked with catchable-size trout: effects on catches of wild salmonids." Northeast Fish and Wildlife Conference, Burlington, VT, May 4, 1994.
- MORING, J.R. "Residence of grubby (*Myoxocephalus aeneus*) and shorthorn sculpin (*M. scorpius*) in tidepools of Maine." Invited paper at the annual meeting of the American Society of Ichthyologists and Herpetologists, Los Angeles, CA, June 3, 1994.
- MORING, J.R. "Fisheries history - an introduction." Annual meeting of the American Fisheries Society, Halifax, NS, August 24, 1994.
- O'CONNOR, R.J. "Integrating multi-taxon metrics into a synoptic indicator of lake quality." U.S. Environmental Protection Agency Symposium "Results of Recent Research in Ecological Monitoring and Assessment," Research Triangle Park, NC, April 14, 1994.
- O'CONNOR, R.J. "A national assessment of breeding birds and landscape pattern." U.S. Environmental Protection Agency Symposium "Results of Recent Research in Ecological Monitoring and Assessment," Research Triangle Park, NC, April 14, 1994.
- O'CONNOR, R.J., and S. OYLER. "Scale and landscape in the spatio-temporal dynamics of bird species. 1994 North American Ornithological Conference, University of Montana, Missoula, MT, June 21, 1994.
- PHILLIPS, D.M., and D.J. HARRISON. "Density, home-range, and spatial overlap of marten in an industrial forest and forest preserve." Northeast Fish and Wildlife Conference, Burlington, VT, May 3, 1994.
- RAYMOND, K.S., W.E. ESCHHOLZ, F.A. SERVELLO, and B. GRIFFITH. "Effects of the herbicide glyphosate on winter browse availability and utilization by moose." Fiftieth Northeast Fish and Wildlife Conference, Burlington, VT, May 2-4, 1994.
- SADER, S.A. "Remote sensing and GIS tools for monitoring tropical forests in Southern Mexico and Central America." National Autonomous University of Mexico, Los Tuxtlas Biological Station, Veracruz, Mexico, November 5-7, 1993.
- SPRUCE, J.P., S. A. SADER, C.S. ROBBINS, and B.A. DOWELL. "Accuracy of migrant landbird habitat maps produced from Landsat TM data: two case studies in southern Belize." Poster presentation at the Conservation of Neotropical Migratory Birds in Mexico Conference, Los Tuxtlas, Veracruz, Mexico, November 5-7, 1993.
- VICKERY, P. "Population status of grassland birds in Massachusetts and New England." Endangered Species Conference, Massachusetts Audubon Society, Framingham State College, Framingham, MA, November 13, 1993.
- VREELAND, J.K., F.A. SERVELLO, and D.B. GRIFFITH. 1994. "Effects of glyphosate on availability of summer foods for white-tailed deer in Maine." Poster presentation at the 50th Northeast Fish and Wildlife Conference, Burlington, VT, May 2-4, 1994.
- WHITCOMB, S.D., F.A. SERVELLO, and A.F. O'CONNELL, JR. "Patch occupancy and fall dispersal in spruce grouse." Fiftieth Northeast Fish and Wildlife Conference, Burlington, VT, May 2-4, 1994.

WITHAM, J.W. "Use of GIS to facilitate bird territory mapping." The Wildlife Society First Annual Conference, GIS Symposium, Albuquerque, NM, September 23, 1994.

PUBLIC TALKS PRESENTED

CHAPIN, T. "Habitat associations of the American marten: does the species deserve spotted owl status?" Western Maine Forest Forum, Sebattus, ME, December 21, 1993.

de MAYNADIER, P. "Keystone ecosystems and a landscape approach to reserve design." Graduate student seminar in reserve design, University of New Hampshire, Durham, October 1993.

ELLIOTT, C.A. "Bats in Maine." Thorndike Girl Scout troop, Thorndike, ME, March 31, 1994.

ELLIOTT, C.A. Conducted Project WILD Workshop for teachers and students in Montville, ME, April 23, 1994.

ELLIOTT, C.A. "The Coverts Project in Maine." UM Department of Wildlife Seminar Series, Orono, ME, April 25, 1994.

HARRISON, D.J. Media interview with Providence Journal for article on occurrence of wolves in Maine, October 7, 1993.

HARRISON, D.J. Managing the Wild in Acadia: a workshop on integrating research and resource management in Acadia National Park. Personnel and guests of Acadia National Park, Bar Harbor, ME, November 13, 1993.

HARRISON, D.J. Media interview with Ellsworth American, "Deer and coyotes in Acadia Park pose management questions, concerns," published November 18, 1993.

HARRISON, D.J. Media interview with Boston Globe, "Coyotes have gained solid paw-hold in Rhode Island," November 28, 1993.

HARRISON, D.J. Media interview with Maine Sportsman for article on marten research in northern Maine, December 15, 1993.

HARRISON, D.J. Media interview with Maine Times for article "Discussion inches, cautiously, toward killing coyotes to help deer," author: Andrew W. Weegar, January 14, 1994.

HARRISON, D.J. Media interview with Downeast Magazine for article on the American marten, January 18, 1994.

HARRISON, D.J. "Ecology and management of predatory mammals in Maine." Guest lecture in WLM 100, Introduction of Wildlife Resources, University of Maine, Orono, February 9, 1994.

HARRISON, D.J. "Status, ecology, and management of martens in northern Maine." Penobscot County Conservation Association, Brewer, ME, March 4, 1994.

HARRISON, D.J. "How animals cope with winter." Bangor Montessori School, Bangor, ME, March 7, 1994.

HARRISON, D.J. Media interview with Portland Press Herald for article on cougars, March 24, 1994.

- HARRISON, D.J. Media interview with Maine Weekly for article on impacts of mall expansion on wildlife, March 28, 1994.
- HARRISON, D.J. Assisted Vermont Institute of Natural Sciences in developing an informational slide/talk program on the eastern coyote, August 5, 1994.
- HARRISON, D.J. Media interview with Downeast Magazine for article on wolves in Maine, August 17, 1994.
- HARRISON, D.J. Filmed a news segment on current research with American martens that was aired on Channel 7, Bangor, September 29, 1994.
- HARRISON, D.J. Interviewed by Maine Sunday Telegram for article on wolves that appeared in October 16, 1994 edition.
- HODGMAN, T.P. "Survival rates of marten under intense trapping pressure in Northern Maine." Central Maine Chapter of the Maine Trappers Association, February 2, 1994.
- HUNTER, M.L. "Maintaining the spatial and temporal diversity of forests." Ontario Advanced Forestry Program, Dorset, Ontario, July 14, 1994.
- HUNTER, M.L. "Forest diversity in time and space." USDA Forest Service, Clemson, SC, September 17, 1994.
- JOHNSON, C.M. "Plant and soil science." Talk and demonstration given to Penobscot County Conservation Association conservation camp students, Bethel, ME, June 28, 1994.
- JOHNSON, C.M. "Wetland values." Talk given to BIO 470, Wetland and Aquatic Biology, University of Maine, Orono, September 12, 1994.
- JOHNSON, C.M. "Introduction to wetland birds and mammals." Talk given to BIO 470, Wetland and Aquatic Biology, University of Maine, Orono, September 12, 1994.
- KROHN, W.B. "Is the fisher a northern-forest generalist or an old-growth specialist? Lessons from Maine." Slide presentation to Federal and provincial forestry and wildlife officials, forest industry. Fredericton, NB, November 22, 1993.
- KROHN, W.B. "Relations among fishers, snow, and martens: development and assessment of two hypotheses." Talk given to Federal and provincial officials, forest industry, Fredericton, New Brunswick, November 22, 1993.
- KROHN, W.B., and R.B. BOONE. "Regional analysis of biodiversity: Gap Analysis in Maine." Invited slide presentation to New Brunswick Biodiversity Steering Committee, Fredericton, November 22, 1993.
- LONG, R. "Managing the wild in Acadia - field methods." Acadia National Park, Bar Harbor, ME, November 13, 1993.
- LONG, R. "Radio telemetry techniques for studying wildlife." College of the Atlantic Biology Class, Acadia National Park, Bar Harbor, ME, February 23, 1994.

- LONG, R. Filmed an educational video regarding fawn research in Acadia National Park for ANP Environmental Education Program, Bar Harbor, ME, August 19, 1994.
- MORING, J.R. "Ecology of tidepool fishes." Seminar to the Upward Bound Summer Biology Program, University of Maine, June 29, 1994.
- PHILLIPS, D.M. "Relationships of wildlife to habitat." Penobscot County Conservation Association Youth Camp, Bethel, ME, June 30, 1994.
- PHILLIPS, D.M. "Social and spatial characteristics and dispersal of marten in a forest preserve and industrial forest." University of Maine Department of Wildlife Ecology, August 11, 1994.
- SPRUCE, J.P. "Landsat TM data for mapping migrant landbird habitat in Southern Belize." Thesis seminar, University of Maine, Orono.

AWARDS, HONORS, AND APPOINTMENTS

- HUNTER, M.L. Elected to the Board of Governors of the Society for Conservation Biology, March 28, 1994.
- KROHN, W.B. Promoted by the Research Grade Evaluation Panel, USDI National Biological Survey.
- MORING, J.R. Promoted by the Research Grade Evaluation Panel, USDI National Biological Survey.
- MORING, J.R. Elected President of the Fisheries History Section, American Fisheries Society; continued to serve as elected Northeastern Division Representative for the Early Life History Section, and elected to the Nominating Committee, American Fisheries Society.
- O'CONNOR, R.J. Awarded National Research Council Senior Research Associateship for 1993-94 academic year.
- OWEN, R.B. Appointed by the Governor of Maine as Commissioner, Maine Department of Inland Fisheries and Wildlife.
- OWEN, R.B. Awarded the Presidential Public Service Achievement Award by the University of Maine.

