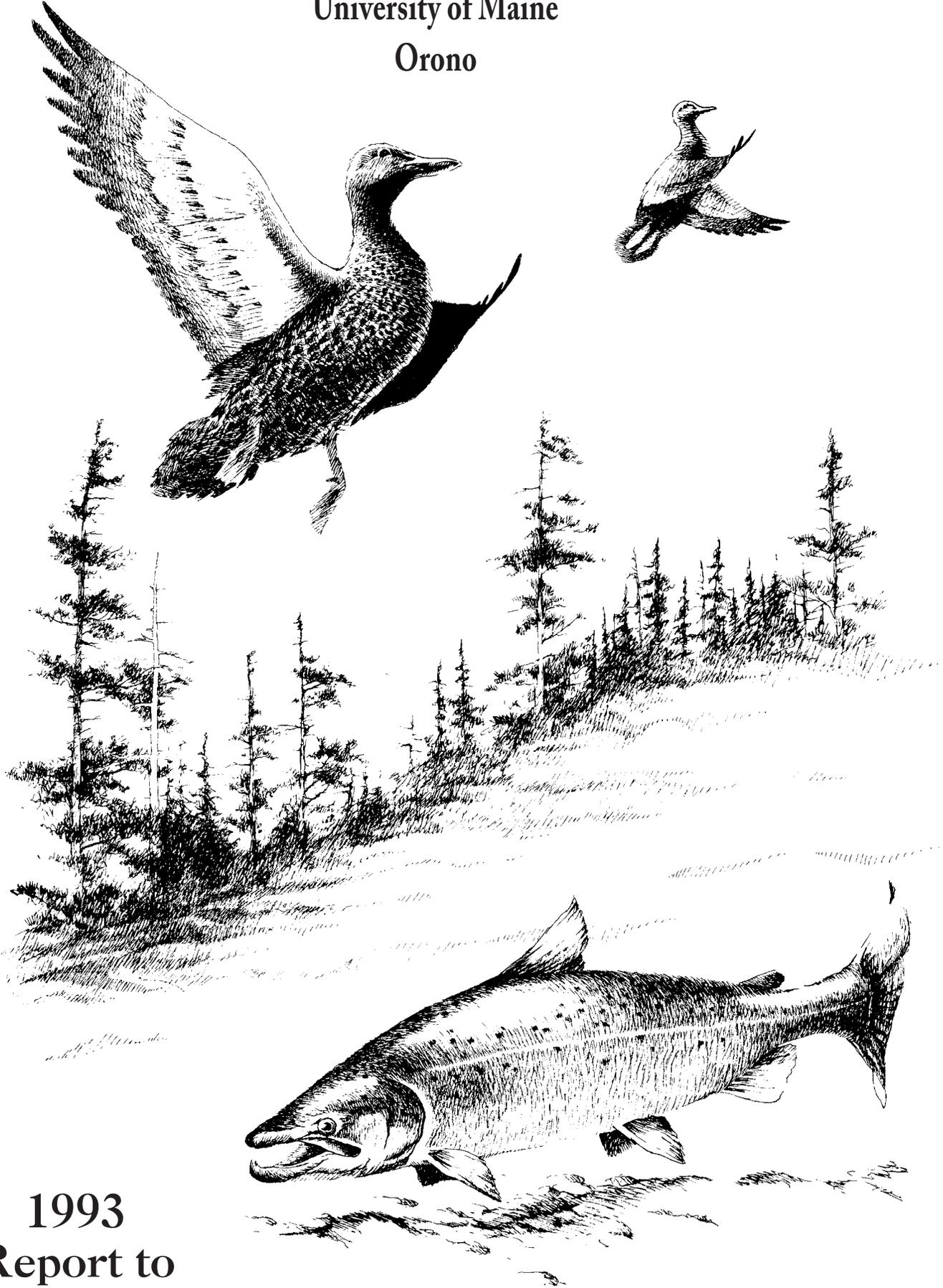


# MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

University of Maine

Orono



1993  
Report to  
Cooperators

—Mark McCollough '86

**MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT**

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



**COOPERATORS**

**UNIVERSITY OF MAINE**

**DEPARTMENT OF INLAND FISHERIES AND WILDLIFE**

**FISH AND WILDLIFE SERVICE, U.S. DEPARTMENT OF THE INTERIOR**

**WILDLIFE MANAGEMENT INSTITUTE**



October 1992 - September 1993



This report details the research objectives, procedures, and findings of numerous investigators. Since data contained may be preliminary and inconclusive, permission to reproduce or publish any of the contents of this report in any way is withheld pending specific authorization from the Unit Leader.

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



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## PERSONNEL AND COOPERATORS

### COORDINATING COMMITTEE

Maine Department of Inland Fisheries and Wildlife  
William J. Vail, Commissioner

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#### Wildlife Management Institute

Rollin D. Sparrowe, President

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#### 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  
MaryEllen Chilelli - Assistant Scientist, Wildlife  
Susan Anderson, Administrative Assistant - Unit (Fisheries) and USFWS-NFCRC  
Maxine L. Horne, Unit Administrative Assistant - Wildlife  
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J. Malcolm Shick, Chairperson, Department of Zoology, College of Sciences, and Professor of  
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James R. Gilbert, Professor of Wildlife and Chairperson, Department of Wildlife, College of Natural  
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Cooperating Associate Professor of Wildlife  
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James A. Sherburne, Director, International Programs and Professor of Wildlife  
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 Malcolm T. Jones, Research Associate, Wildlife

Maine Department of Inland Fisheries and Wildlife:

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 Norman E. Trask, Deputy Commissioner  
 Frederick B. Hurley, Jr., Director, Bureau of Resource Management  
 Gary Donovan, Director, Wildlife Division  
 Peter Bourque, Director, Fisheries and Hatcheries Division  
 George J. Matula, Jr., Supervisor, Wildlife Resource Assessment Group  
 Kendall Warner, Supervisor, Fisheries Research and Management Section

**GRADUATE STUDENTS**

<b>Name</b>	<b>Degree Candidacy</b>	<b>Support</b>
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Bradley Blackwell	Ph.D.	MCFWRU, USFWS
Randall B. Boone	Ph.D.	MCFWRU, USFWS
Merrie A. Cartwright	Ph.D.	U of M, MCFWRU
Theodore Chapin	M.S.	McIntire-Stennis
Michael Cole	M.S.	MDIFW
Phillip de Maynadier	Ph.D.	McIntire-Stennis
Stephen 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 Foss	Ph.D.	N. H. Audubon Society
Herbert C. Frost	Ph.D.	MDIFW, MCFWRU
Brian Gray	M.S.	McIntire-Stennis
Stephen Glass	Ph.D.	ANP
Christopher Hartleb	Ph.D.	MDIFW
Susan Hills	Ph.D.	USFWS-AFWRC
Karen Hockett	M.S.	USFWS
Catherine Johnson	Ph.D.	USFWS
Malcolm T. Jones	Ph.D.	CPM
Lisa Joyal	M.S.	U of M
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Mary Kay Kenney	M.S.	U.S. Natl. Marine Fisheries and DEP
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Laurance Lisle	M.W.C.	Personal Funding
Robert Long	M.S.	Acadia - NPS
Smoot Major	Ph.D.	USEPA
Angela Matz	Ph.D.	Acadia - NPS
Thomas C. McCall	M.S.	Hatch, McIntire-Stennis

Karen McCracken	Ph.D.	U of M
Daniel McKinley	M.S.	USFS
Craig R. McLaughlin	Ph.D.	Personal Funding
Amanda Moors	M.S.	EPA
Deborah Moreau	M.S.	USFWS-CAFL
Ramona Muller-El Hamzaoui	M.W.C.	Intl. Programs Office, CASS Project
Sara Oyler	M.S.	EPA
David Phillips	M.S.	U of M
Michael W. Powell	M.S.	U of M
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Oliver van den Ende	M.S.	USFWS-CAFL
Christopher Vera	M.S.	RCS, SCP
Peter D. Vickery	Ph.D.	NC, MAS, MPCB, MAAS, CB
Linda Welch	M.S.	USFWS
Scott Whitcomb	M.S.	NPS
Andrew A. Whitman	M.S.	U of M

#### DISSERTATIONS AND THESES COMPLETED THIS PERIOD

Student	Degree Candidacy	Support
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Susan Hills	Ph.D.	USFWS-AFWRC
Danie B. McKinley	M.S.	USFS
Amanda Moors	M.S.	EPA
Ramona Muller-El Hamzaoui	M.W.C.	Intl. Programs Office, CASS Project
Christopher Vera	M.S.	RCS, SCP
Oliver van den Ende	M.S.	USFWS-CAFL
Agnes Vanderpool	M.S.	USFWS-CAFL
Peter D. Vickery	Ph.D.	NC, MAS, MPCB, MAAS, CB
Andrew A. Whitman	M.S.	U of M

#### PERSONNEL NOTES

As of September 1, 1993, **DR. JAMES R. GILBERT** was appointed the Chair of the Department of Wildlife when **DR. RAY B. OWEN, JR.** went on leave. Dr. Owen accepted an appointment as Commissioner of the Maine Department of Inland Fisheries and Wildlife.

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

**SUSAN HILLS** received a Ph.D. Sue was a Cooperative Education student from the U.S. Fish and Wildlife Service. She returned to the Alaska Fish and Wildlife Research Center to resume her position with them. **AMANDA MOORS** received an M.S. degree and will continue working on Dr. O'Connor's Lakes Project until December, 1993. **RAMONA MULLER-EL HAMZAOU** received an M.W.C. degree and

returned to Morocco to work in the Peace Corps Office there on a full-time basis. **CHRISTOPHER VERA** received an M.S. degree and is now working with Normandeau Associates. **PETER VICKERY** received a Ph.D. degree and returned to work full time with the Massachusetts Audubon Society. **ANDREW WHITMAN** received an M.S. degree and is working at the Manomet Bird Observatory in Massachusetts. **MARYELLEN CHILELLI**, Assistant Scientist for the Unit, completed her Unit assignment and is working with the Maine Department of Inland Fisheries and Wildlife.

On July 1, 1993 **J. MALCOLM SHICK** replaced **BONNIE WOOD** as Chairperson of the Zoology Department.

The following people have received graduate degrees in Zoology in December or August:

**AGGY VANDERPOOL** and **DAN MCKINLEY** completed their M.S. degrees in Zoology after taking full-time positions, Aggy with West Virginia University Extension Service and Dan with the U.S. Forest Service in Vermont. **OLIVER VAN DEN ENDE** completed his M.S. degree in Zoology and entered the Ph.D. program at Florida Institute of Technology. **MERRIE CARTWRIGHT** completed her M.S. in Zoology and will continue at Maine, working toward a Ph.D.

#### COLLABORATING AGENCIES AND ORGANIZATIONS

Atlantic Salmon Federation - ASF  
 Bangor Hydro-Electric - BHE  
 Baxter State Park - BSP  
 Bowater-Great Northern Paper, Inc. - GNP  
 Champion International Corporation - CI  
 Davis Conservation Foundation - DCF  
 Hirundo Wildlife Refuge - HWR  
 Holt Woodlands Research Foundation - HWRF  
 International Paper Company - IPC  
 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 Laboratory - MIAL  
 Maine Land Use Regulation Commission - MLURC  
 Maine Office of Geographic Information Systems - MOGIS  
 Maine Trappers Association - MTA  
 Nature Conservancy - NC  
     Maine Chapter - NC-MC  
     NE Regional Office  
 National Council of the Paper Industry for Air and Stream Improvement - NCASI  
 National Marine Fisheries Service - NMFS  
 National Rifle Association - NRA  
 New Brunswick Department of Natural Resources and Energy - NBDNRE  
 New England Salmon Association - NESA  
 North American Wildlife Foundation -  
     Delta Waterfowl & Wetland Research Station - DWRS  
 Oak Ridge National Laboratory  
 Penobscot County Conservation Association - PCCA

Resource Conservation Services - RCS  
Sigma Xi  
Signal Fuels, Inc. - SF  
The Nature Conservancy, Maine Chapter - MCTNC  
The Switzer Foundation  
University of Maine - U of M  
    Association of Graduate Students - AGS  
    College of Natural Resources, Forestry, and Agriculture  
    Cooperative Forestry Research Unit (CFRU)  
    Hatch Act Funds - HAF  
    McIntire-Stennis - MS  
    Department of Forest Management - DFM  
    Department of Wildlife - DW  
    Maine Agricultural and Forestry Experiment Station  
    Office of International Programs - OIP  
U.S. Department of Commerce  
    National Marine Fisheries Service  
U.S. Environmental Protection Agency - EPA  
U.S. Fish and Wildlife Service - FWS  
    Alaska Fish and Wildlife Research Center - AFWRC  
    Alaska Regional Office - ARO  
    Conte Anadromous Fisheries Research Laboratory - CAFRL  
    National Fisheries Contaminant Research Center - NFCRC  
    National Fisheries Research Center - Leetown  
    Patuxent Wildlife Research Center - PWRC  
    Region 5, Fish and Wildlife Enhancement - R-5, FWE  
    Region 8, Office of Research Support - R-8, ORS  
    Washington Office - WO  
U.S. Forest Service - USFS  
    Forestry Sciences Laboratory, Corvallis, OR  
    Green Mountain National Forest, Rutland, VT  
    Pacific Northwest Region, Portland, OR  
    White Mountain National Forest, Laconia, NH  
U.S. National Park Service - NPS  
    Acadia National Park  
    Boston Regional Office  
    Cooperative Park Studies Unit

## PROJECT REPORTS

### ENDANGERED AND THREATENED SPECIES:

#### ANALYSIS OF FACTORS AFFECTING POPULATION VIABILITY OF BIRDS

*Investigators:* M. Chilelli  
J. R. Gilbert  
B. Griffith  
W. B. Krohn

*Cooperators/  
Project  
Support:* U.S. Fish and Wildlife Service -  
Region 8, Office of Research Support, WO

*Objectives:*

- 1) Assess the utility of computerized population viability analysis (PVA) in predicting the fate of small populations of wildlife species.
- 2) Use PVA to rank types of species by their susceptibility to extinction based on life history strategy, population size, and environmental variation.

*SCOPE:* PVA only assigns a *probability* of extinction under a specified schedule of vital rates and temporal variation. Because extinction and persistence are both possible, the fate of a single species or single endangered population can neither validate nor reject PVA predictions. Thus, although the PVA process appears reasonable, it is difficult to assess how meaningful the predictions are on a situation specific basis.

To assess the utility of PVA, we will conduct PVA for generalized types of organisms that include several species. PVA predictions can then be compared to the actual fates of a number of small populations of a particular type of organism. If PVA provides reasonable estimates of the actual proportion of populations that become extinct, then validity of the modeling process will be supported. If PVA fails to predict the proportional fates of actual populations, the analyses may identify types of critical input data necessary to improve the accuracy of future PVA.

After identifying the conditions under which a PVA is effective, we will use stochastic simulation modeling to evaluate extinction probabilities of birds by life history strata.

*PROJECT STATUS:* The final report was completed with the executive summary as follows:

Endangered species conservation is a crisis activity, with extinction rates increasing. Whereas theoretical studies and empirical analyses of reintroductions and invasions have clarified general principles affecting population persistence, it is essential to identify specific population levels and vital rates that indicate potential endangerment of species so resources can be focused accordingly. The objectives of this study were to stratify birds by life history patterns, identify population levels and vital rates that indicate risk to endangerment within each strata, and to rank bird species groups according to potential endangerment.

Before we could assess the factors that affect viability of bird populations, we needed to assess the validity of computerized population viability analysis (PVA) to predict the fate of small populations of wildlife species. Validating against field data using currently available simulation models, we found PVA provided realistic estimates of the proportion of populations that actually became extinct. Validity of the modeling process and use of PVA for endangered species planning and management was supported.

During our testing of the PVA process, we noted that available simulation models did not incorporate the flexibility needed to adequately simulate the dynamics of translocated wild populations. We developed the stochastic simulation model TRANSLOC to address these specific needs. TRANSLOC is

unique among commonly used simulation models in incorporating processes that are particular to translocated populations (i.e., specifying vital rates for newly translocated animals separate from those for the existing population). This model should prove useful in evaluating translocation programs, *a priori*.

We used PVA, via TRANSLOC, to rank bird species by their susceptibility to extinction based on life history strategy, population size, and environmental variation. Our working definition of minimum viable population (<50% probability of extinction in 50 years) provided us with a way to rank bird species. We do not imply this as a critical definition of mvp nor is our intent to define mvp for U.S. Fish and Wildlife Service guidelines.

Based on these rankings, population size can be quite large (N = 120-200) and still have a high risk to endangerment. Those populations that meet our arbitrary definition of mvp generally reflect populations with high fecundity and survival rates. Species with lower vital rates or those in more variable environments require larger population sizes to obtain an acceptable probability of persisting. If these required larger population sizes are not feasible because of social organization or habitat limitations, this clearly indicates the need to increase vital rates via habitat manipulation or reduction of other limiting factors if the population is to persist. Biologists need to be aware of the general risk category a particular population falls into and be mindful of the population size and vital rate levels that indicate an increasing concern to that population's persistence. Integrating these rankings with other risk analyses (Gap Analysis, Recovery Plan Assessment) can aid in prioritizing bird species based on need for management activity.

## ANALYSIS OF FACTORS AFFECTING POPULATION VIABILITY AND REINTRODUCTION ATTEMPTS FOR FISHER AND OTHER MAMMALS IN ACADIA NATIONAL PARK

*Investigators:*

J. R. Gilbert  
M. Chilelli  
A. F. O'Connell  
B. Griffith  
W. B. Krohn

*Cooperators/  
Project  
Support:*

U.S. National Park Service -  
Acadia National Park, Bar Harbor, ME  
Regional Office, Boston, ME  
U.S. Fish and Wildlife Service -  
Region 8, Office of Research Support, WO

*Objective:*

Estimate the risk of extinction for small free-ranging or reintroduced populations of mammals across a range of reproductive strategies, home range sizes, and area use patterns.

**SCOPE:** Escalating habitat fragmentation suggests that native wildlife populations will become increasingly restricted to disjunct habitats in the future. The role of National Parks in providing relatively unexploited habitat patches will increase. Habitat patches will contain smaller populations of wildlife species than large contiguous areas of habitat, and these reduced populations will be more susceptible to extinction due to stochastic events. Addition of suitable habitat area to parks may be impossible. Therefore, effective evaluation of the ability of National Parks to sustain viable populations of wildlife species requires 2 analyses. First, estimates of extinction probabilities for small populations of various species are needed; and, second, estimates of success rates of reintroduction programs used for restoration after local extinction are necessary.

**PROJECT STATUS:** A final report is being prepared. Three strata were selected (with representative species) that are of special management concern to Acadia National Park (fisher, black bear, bog lemming). Simulations have been conducted, covering a range of vital rates, variances on those rates, and founder populations sizes. The risk of extinction (e.g., 50% probability extinction in 50 years) has been estimated for each of the 3 representative species restricted by available habitat fragment size(s). Various translocation scenarios have been simulated for each strata. Based on these simulations, species groups will be ranked according to the potential for Acadia National Park to retain viable populations.

**FUTURE PLANS:** This report will be submitted in November 1993 to U.S. Fish and Wildlife Service, Region 8, Cooperative Research Units Center and the U.S. National Park Service.

## 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  
T. A. Haines  
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 effecting 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.

This study includes all known pairs of bald eagles in Maine. Aerial surveys are conducted to determine site occupancy and nesting status. Nonviable eggs and nestling blood and feather samples will be collected and analyzed from all possible sites.

*PROJECT STATUS:* The second and final field season has been completed and 129 nest sites have been visited. Collections included 158 blood samples from 107 productive nests, and 12 nonviable eggs. In total, 161 eaglets were banded. Breast feathers were collected from the eaglets and prey items were collected from in and around each nest site. Fish and water samples were collected from 6 lakes to look at variability in mercury levels.

Chemical analysis has been completed on the blood, feathers, and eggs collected in 1991 and 1992. Significantly elevated levels of mercury were observed in the blood and feathers of eagles nesting along Maine's lakes. Blood and egg samples collected from eagles nesting along the coast had extremely elevated levels of PCBs. This study revealed the highest dioxin equivalent level ever recorded, and the highest levels of mercury and PCBs recorded in eagles. Extreme differences in diet composition were observed between coast versus inland nesting eagles. The coastal nesting eagles consume a diet of other avian species, while the inland birds predominantly prey upon fish. Reproductive histories and production levels have been determined for all recorded territories in the state, representing a 30 year period.

*FUTURE PLANS:* Fish and water samples are currently undergoing analyses. Target date for project completion is December 1993.

## 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:* Department of Wildlife, U of M  
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, food stress, winter stress, home range size 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 below rates of other recovering populations. This 3-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 high levels of persistent compounds (PCBs and organochlorine insecticides) in coastal eagle nestlings (see above).

**PROJECT STATUS:** The 1993 (May through August) field season was used as a preliminary data collection and methods development period. Two adult eagles were captured and radio-tagged, and had blood samples taken for contaminants analysis. The radio-tagged birds were relocated from land, water, and air several times over the course of the summer. Twenty-six eaglets were banded and blood samples for contaminants were taken from 21. Feather samples, age and sex measurements were collected from each bird handled. Prey remains were collected from each nest site, and several specimens of prey (cormorants and seals) 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.

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## **FISHERIES RESOURCES:**

### **COMPARISON OF TWO STREAM HABITAT ASSESSMENT TECHNIQUES IN THE WHITE AND GREEN MOUNTAIN NATIONAL FORESTS**

*Investigator:* D. B. McKinley

*Advisors:* J. R. Moring, Chairperson  
W. B. Krohn  
J. D. McCleave

*Cooperators/  
Project  
Support:* U.S. Forest Service -  
Green Mountain National Forest, Rutland, VT  
White Mountain National Forest, Laconia, NH

*Objectives:*

- (1) Determine what level of sampling segments provides usable estimates compared to current procedures of sampling entire streams.
- (2) Measure habitat shifts by juvenile Atlantic salmon following changes in fish densities.

**SCOPE:** Habitat surveys are an integral part of the fisheries management program on the U.S. National Forests (NF). These surveys are used to quantify existing habitat conditions, identify limiting factors, prescribe enhancement measures (where feasible), and integrate fish habitat management concerns with other proposed land uses (timber, recreations, etc.). This information may be used to develop prescriptions at both the NF level and project planning levels. The focus of the fisheries programs in the White and Green Mountain NF is Atlantic salmon restoration. At present, knowledge of existing habitat capability of most forest streams for this species is fairly general in nature and, in many instances, is unknown. There is a need to determine this capability, along with the identification of opportunities to enhance limiting conditions, where feasible. Therefore, there is a need for intensive habitat surveys on most of the streams on both National Forests. The technical subcommittees for both the Merrimack and Connecticut River Atlantic salmon restoration programs have recommended a methodology to be utilized by the Forest Service for these surveys. This methodology is based on one developed in Maine and cost estimates range from \$466 to \$621 per kilometer (\$750-\$1,000 per mile). Alternative ways to improve habitat survey efficiency need to be explored, especially in light of limited funding for the entire program. One approach which needs to be investigated is the use of representative reaches, whereby the habitat data collected within sample sections of these reaches are assumed to be representative of the entire reach. If this approach is feasible, a larger amount of stream miles could be surveyed for the same amount of money.

**PROJECT STATUS:** All requirements for the degree of Master of Science (in Zoology) were completed in December 1992. An abstract of the thesis follows:

Habitat use and selection were assessed for juvenile Atlantic salmon (*Salmo salar*) in the West Branch of the White River, Rochester, Vermont, and in the Mad River, near Waterville Valley, New Hampshire. Observations were made at approximately monthly intervals from July to late October, 1988. Use and selection were compared between size classes in the same river and the same size class in different rivers. Population densities were manipulated in two study sites in both rivers to assess how density affects habitat selection. Observations were also made at night to determine nocturnal habitat selection.

Small parr (<70 mm) and large parr (>69 mm) were found to segregate by water depth in the West Branch of the White River. Small parr used 16-25 cm depths most frequently while large parr made most frequent use of 26-35 cm depths. Consistent segregation by current speeds was not evident in the West Branch. However, distributions of use of focal current speeds were significantly different for the two size classes. Large parr made more frequent use of slow focal current speeds (0-17 cm/s). Small parr made more frequent use of gravel and small home stones (6-200 mm), while large parr used boulder and larger home stones (100-200) more frequently. Mad River large parr used greater depths (6-100 cm), slower focal current speeds (3-7 cm/s) and larger substrates (boulder and bedrock more frequently than did West Branch large parr. This was attributed to the Mad River being significantly deeper and slower with more boulder and bedrock substrate than the West Branch.

Selection of macrohabitat and microhabitat variables varied between streams and between sites within streams. Consistent selection was only shown for depth. Depths were selected by small and large parr in every site. Large parr selected mid-range depths in both rivers. Depths selected by small (16-35 cm) and large parr (26-45 cm) in the West Branch overlapped considerably. Selection was never exhibited for mean current speeds, while on one occasion selection was observed for focal and maximum current speeds. Selection for focal current speeds by large parr at site 3 in the West Branch and selection for maximum current speeds by small parr at site 1 in the West Branch were attributed to changes in habitat composition during high and low flow periods, respectively.

Population density affected both micro- and macrohabitat selection in the Mad River. At low density (1.4-2.5/100 sq.m.), riffles, runs, and pools were used proportionately, while at high density (3.7-6.3 sw.m.) riffles were avoided, and at existing density (2.5-5.0/100 sq.m.) pools were preferred. At low density, salmon abandoned positions in pools. A narrowing in selection of depths was commensurate with the lower frequency of use of pools at low density. Upper-range depths (>45 cm) were used proportionately at low density, but selected at existing and high densities.

Salmon were found to alter habitat use as temperatures dropped in late summer and fall. When daily low temperatures were <15° C, but midday temperatures reached 15° C, salmon exhibited a temporary sheltering response. In late September, when midday temperatures did not rise above 15° C in the West Branch, salmon moved to deeper and slower positions. They disappeared almost entirely when daytime temperatures fell below 10° C and presumably took shelter in substrate chambers.

Nighttime observations during August in the Mad River showed salmon occupied sheltered positions behind or beneath rubble and boulders or along stream margins. They also used slower current speeds and areas with smaller substrates, including sand and silt, as compared to daytime use.

## MOVEMENTS OF DISPLACED LARGEMOUTH BASS (*MICROPTERUS SALMOIDES*) IN TWO CENTRAL MAINE LAKES

**Investigator:** M. A. Cartwright

**Advisors:** J. R. Moring, Chairperson  
W. E. Glanz  
J. G. Trial

*Cooperators/* Maine Department of Inland Fisheries and Wildlife  
*Project* Penobscot County Conservation Association  
*Support:*

*Objective:* To measure movements and document homing behavior of displaced largemouth bass in two lakes.

*SCOPE:* Little is known of the movement patterns of largemouth bass in boreal environments. In particular, it is not known whether displaced bass are able to return to original points of capture or, if so, how quickly they are able to return. In addition, the angling season is open during the spawning season for bass. There is evidence for smallmouth bass that, when the adult is removed from the nest and eggs or fry are unprotected, mortality can be extremely high. There are no studies concerning largemouth bass, particularly in boreal waters. Radio tags were placed on captured largemouth bass to determine movements during spawning times and non-spawning times in two lakes, Webber Pond and Cobbosseecontee Lake.

*PROJECT STATUS:* All requirements for the degree of Master of Science (in Zoology) were completed in August 1993. An abstract of the thesis follows:

Bass angling tournaments are an integral part of the largemouth bass (*Micropterus salmoides*) fishery in Maine. Therefore, knowledge of the impacts of tournament practices, such as displacement, on the distribution and reproductive success of largemouth bass is important for effective management.

This study used radiotracking to quantify the movements of displaced largemouth bass and determine the effects of season, displacement distance, and holding time on the movement patterns and homing tendencies of this species in Maine. Largemouth bass in Maine do possess homing ability, which they will employ depending on the circumstances. The likelihood of a displaced fish returning to the initial site of capture was influenced by displacement distance and holding time; increasing either parameter decreased the probability of return.

Larger fish had greater tendencies to home ( $p = 0.024$ ), as did spawning fish (59% returned, compared to the 27% return seen after the spawning season). There was a similar seasonal effect on the return times of the homing fish. In contrast to the homing fish, fish that did not return exhibited consistent movement patterns, establishing home ranges similar to those of undisplaced fish. Thus, it seemed that decisive homing occurred, and displacement in general influenced population distribution through the creation of new home ranges by non-homing fish.

Displacement also affected reproductive ability. Although returns were higher during spawning season, 41% of spawning fish did not return to the nest site, and an additional 18% exhibited return times that probably exceeded the time a nest would be viable in the absence of a guardian male. Thus, displacement can potentially impact spawning success of largemouth bass, although this effect may be lessened by reducing holding time and displacement distance.

## DOWNSTREAM MORTALITY OF ATLANTIC SALMON SMOLTS IN THE PENOBSCOT RIVER, MAINE

*Investigator:* A. M. Vanderpool

*Advisors:* J. R. Moring, Chairperson  
 W. E. Glanz  
 I. L. Kornfield  
 J. D. McCleave  
 J. G. Trial

*Cooperators/* U.S. Fish and Wildlife Service - CAFRL  
*Project* Association of Graduate Students  
*Support:* Atlantic Salmon Federation

**Objective:** Document the timing, routes, and mortality in downstream migrating smolts of Atlantic salmon in the Penobscot River, Maine.

**SCOPE:** The Atlantic salmon restoration program has high natural visibility and priority. Yet, returns to United States rivers have been quite low, averaging only 0.6% from smolt to returning adult in the Penobscot River, Maine, and only 0.2 to 0.3% in the Merrimack and Connecticut rivers of southern New England. This excessive mortality can occur during the downstream passage of smolts in the river, in the estuary, and on the high seas. Of these, the downstream portion may be the least difficult to assess. This project tracks radio-tagged smolts from their upstream release site to the lower Penobscot River.

**PROJECT STATUS:** All requirements for the degree of Master of Science (in Zoology) were completed in December 1992. An abstract of the thesis follows:

Restoration of Atlantic salmon, *Salmo salar*, is a priority with the U.S. Fish and Wildlife Service and several state agencies in New England. Yet, information on the downstream passage phase of the life history, when smolts are migrating to the sea, is limited, particularly in the Penobscot River, Maine. Migratory patterns and timing of smolt movements were assessed by placing radio tags on smolts in 1990 and 1991 and releasing them at Howland, about 91 km upstream from the river mouth. Tracking was most successful in 1991 when 30 live and two dead (to assess drifting rates) fish were released in groups of three to six. Releases were made weekly between April 13 and May 18, 1991, and fish movements were tracked by airplane and by vehicles on streamside roads. Fish released in April generally moved quickly into the main channel of the river, though 47% of the signals ceased or became stationary within 10 km of the release site, either through predation, battery failure, or cessation of migratory behavior. Only 3% of these one-year-old smolts of hatchery origin were tracked in excess of 40 km downstream. Total distances tracked on different dates were significantly different. Movement patterns were also compared to environmental conditions and the out-migration peak was determined using a time lapse video camera at self-release ponds.

**PREDATION ON ATLANTIC SALMON SMOLTS (*SALMO SALAR*)  
BY SMALLMOUTH BASS (*MICROPTERUS DOLOMIEU*)  
AND CHAIN PICKEREL (*ESOX NIGER*) IN THE PENOBSCOT RIVER, MAINE**

**Investigator:** O. van den Ende

**Advisors:** J. R. Moring, Chairperson  
W. E. Glanz  
J. G. Trial

**Cooperators/  
Project  
Support:** U. S. Fish and Wildlife Service - CAFRL  
Maine Atlantic Sea-Run Salmon Commission

**Objective:** Document the source and extent of predation on juvenile Atlantic salmon by freshwater fishes in the Penobscot River.

**SCOPE:** Several species of freshwater fishes, particularly chain pickerel, smallmouth bass, and fallfish, are known to prey on juvenile Atlantic salmon. Survival of Atlantic salmon from smolts to returning adults averages 0.6%, or less, in the Penobscot River. Part of this mortality is likely due to predation by freshwater fishes, either on juveniles or on smolts on their downstream migration. This project documents the extent and source of this predation by fishes in the Penobscot River.

**PROJECT STATUS:** All requirements for the degree of Master of Science (in Zoology) were completed in August 1993. An abstract of the thesis follows:

This study utilized field data, experimental work, and a bioenergetics model to estimate losses of Atlantic salmon smolts (*Salmo salar*) to predation by smallmouth bass (*Micropterus dolomieu*) and chain pickerel (*Esox niger*) in the Penobscot River, Maine. Field investigations carried out during the spring of 1992 on a section of the Penobscot River yielded information on the food habits of the two predatory fishes. Consumption and growth data of smallmouth bass and chain pickerel fed salmon smolts and other prey were obtained from experimental work. The total daily predation rate on salmon smolts by smallmouth bass and chain pickerel populations in the Penobscot River was estimated using a fish bioenergetics model.

Diet analyses of the two predatory fishes from the Penobscot River, Maine, revealed that insects, fishes other than smolts, and crayfish were the most important prey organisms for smallmouth bass while smolts, other fishes, and insects made up more than 90% of the food of chain pickerel. No captured smallmouth bass consumed smolts.

Smallmouth bass ate significantly more golden shiners, *Notemigonus crysoleucas*, at 15° C than at 10° C. At both 10 and 15° C, smallmouth bass preferred small (mean weight: 2.3 g) over large (14.9 g) golden shiners. Smolts were also eaten at a greater rate at 15° C than at 10° C. Smallmouth bass did not feed at 5° C.

Chain pickerel daily consumption of salmon smolts was the lowest at 5° C, increased to a maximum at 10° C, and decreased again at 15° C. With the exception of data collected at 5° C, daily consumption was consistently lower for chain pickerel than that of smallmouth bass.

Estimates of field data and experimental work in conjunction with a bioenergetics model predicted that the Penobscot River chain pickerel population consumed approximately 232, 328, and 249 smolts per day at 5°, 10°, and 15° C, respectively. Total predation by smallmouth bass was 7 smolts/day at 10° C, 9 smolts daily at 15° C, and 10 smolts/day for the season (April 18 through June 18).

Smallmouth bass are probably not a major predator on salmon smolts in the Penobscot River due to morphological constraints of the bass and low feeding rates during early spring when smolts are stocked. In contrast, the chain pickerel could be a significant predator of smolts, as it is an adept piscivore and feeds actively at low temperatures.

## 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. New funding allowed us to examine in detail the fish communities of two coastal tidepools. In addition, several papers were published in 1993 and a paper and a seminar were presented.

**FUTURE PLANS:** Work dealing with intertidal movements of sculpins will continue in 1994, along with experiments on Atlantic seasnail feeding and innovative fish marking techniques. At least one invited paper is planned for presentation at a special symposium on intertidal fishes. 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 1994.

### 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/  
Project  
Support:* U.S. Fish and Wildlife Service - CAFRL  
Penobscot County Conservation Association  
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. A final report was completed in early 1993.

*FUTURE PLANS:* M.S. thesis completion is expected in May 1994.

## SUSCEPTIBILITY OF ATLANTIC SALMON SMOLTS TO PREDATION BY DOUBLE-CRESTED CORMORANTS

*Investigator:* K. S. Hockett

*Advisor:* 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 work has been completed and a thesis is being prepared.

*FUTURE PLANS:* M.S. thesis completion is expected by December 1993.

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## DAILY AND SEASONAL MOVEMENTS OF SMALLMOUTH BASS

- 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 not 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:** Some additional tracking will continue until late November, after which data will be analyzed.

**FUTURE PLANS:** A Master of Science thesis is expected by May 1994.

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## 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 first field season has been completed and analysis of extensive samples will continue over the winter.

*FUTURE PLANS:* A second field season will commence in late spring 1994, and a final season will examine biomanipulation and the role of competition. A Ph.D. dissertation is expected in December 1995.

## **HABITAT RESOURCES:**

### **HABITAT SELECTION OF GRASSLAND BIRDS IN MAINE**

*Investigator:* P. D. Vickery

*Advisors:* M. L. Hunter, Jr., Chairperson  
W. E. Glanz  
G. L. Jacobson  
N. T. Wheelwright  
A. S. White

*Cooperators/  
Project  
Support:* The Switzer Foundation  
Maine Chapter of The Nature Conservancy  
Maine Department of Inland Fisheries and Wildlife

*Objectives:*

- 1) Identify the species composition and relative abundance of birds found nesting on blueberry barrens throughout Maine.
- 2) Identify the vegetational requirements of birds nesting on blueberry barrens.
- 3) Determine the impact of habitat alteration on the avian community on these barrens.

*SCOPE:* Though blueberry barrens comprise a relatively small part of Maine's total acreage, these areas form a special ecosystem with a distinctive breeding avifauna. At least five species that breed primarily in this habitat are noted by the Maine Department of Inland Fisheries and Wildlife as Endangered or in need of some level of protection or monitoring. Bird-life has coexisted with blueberry management for many decades, but recent introduction of herbicides on blueberry barrens has significantly altered vegetation and appears to have a detrimental effect on some species nesting in this ecosystem.

The Kennebunk Plains, an extensive sandplain grassland in southern Maine, was formerly managed for commercial blueberry production but has recently been purchased by the State of Maine as habitat for rare and endangered species. The unique breeding bird community found there has been studied for seven years. Species breeding at this site include: upland sandpiper, horned lark, bobolink, eastern meadowlark, vesper sparrow, savannah sparrow, and grasshopper sparrow. The latter species is a rare nesting bird throughout New England and is experiencing significant, long-term declines throughout its range.

**PROJECT STATUS:** All requirements for the Ph.D. degree (in Wildlife) were completed in August 1993. The abstract follows:

This thesis explores several aspects concerning the population status and habitat requirements of grassland birds in Maine and the Northeast. In the first chapter, I examined the population status of grassland birds in New England and New York, and concluded that, in general, grassland birds were among the most threatened in the Northeast. Several species, including Upland Sandpipers and Grasshopper Sparrows, are listed as endangered, threatened, or of special-concern by state wildlife authorities in all seven states within the New England - New York region.

The second chapter examined important components of the process by which grassland birds select breeding sites. This eight-year study was conducted on a 240 hectare site in southern Maine that was actively managed for commercial blueberry production. Several species, such as Eastern Meadowlark and Bobolink, prefer thicker graminoid vegetation, whereas Upland Sandpipers, Horned Larks and Vesper Sparrows prefer sites with sparser vegetation. Commercial blueberry management, especially the use of herbicides, can adversely affect breeding densities of several species for as many as six years.

The third chapter examined the importance of habitat area to grassland birds. I censused 90 grassland-barren sites in coastal Maine which ranged in size from <1 to >400 hectares. Although many grassland bird species occupy territories of less than 2 hectares, most species of grassland birds were area sensitive, i.e., they only occupied larger sites for breeding. Upland Sandpipers were the most sensitive to area and were rare in fields <50 hectares large. Grasshopper Sparrows were also sensitive to area and were rare in fields <50 hectares large. Grasshopper Sparrows were also sensitive to area, and reached 50% incidence in sites 100 hectares large.

In Chapter Four, I conducted an experimental manipulation to see if grassland birds were limited by the lack of song perches. I found that placement of artificial of song perches on degraded habitat had no effect on the density of breeding birds. These results suggest that simple efforts to remediate population declines of threatened grassland birds are unlikely to be successful.

## FRUGIVORY AND SEED DISPERSAL OF FLESHY FRUITING PLANTS IN A NORTHERN TEMPERATE FOREST

- Investigator:* A. A. Whitman
- Advisors:* M. L. Hunter, Chairperson  
A. S. White  
W. E. Glanz
- Cooperators/  
Project* Holt Woodlands Research Foundation  
University of Maine
- Support:* Association of Graduate Students  
Sigma Xi
- Objectives:*
- 1) Determine fruit production and phenology in an oak-pine forest.
  - 2) Determine dispersal strategies of fleshy fruiting plants in an oak-pine forest.
  - 3) Compare the quality of seed dispersal by birds to that of foxes.

**SCOPE:** In a northern temperate forest, little is known about fruit biomass of fleshy fruiting plants, their phenology, or the relative importance of frugivore-plant interactions to plants or animals. In this study, I determined patterns in fruit biomass, reproduction, phenology, and fruit characteristics of fleshy-fruiting plants, and investigated the dispersal ecology of *Aralia nudicaulis* (wild sarsaparilla) in order to understand the ecology of fleshy-fruiting plants and the importance frugivore-plant interactions to plants and animals.

**PROJECT STATUS:** All requirements for the degree of Master of Science (in Wildlife Management) were completed in December 1992. An abstract of the thesis follows:

In a northern temperate forest, I determined patterns in fruit biomass, reproduction, phenology, and fruit characteristics of fleshy-fruited plants, and investigated the dispersal ecology of *Aralia nudicaulis* (wild sarsaparilla) in order to understand the ecology of fleshy-fruited plants and the importance frugivore-plant interactions to plants and animals.

(1) I measured fruit biomass from 1987-1990 to determine which environmental factors affected fruit biomass. Total fruit biomass and fruit biomass of shrub species increased after logging because removal of canopy increased light. Weather may have affected fruit biomass; weather in the year of peak biomass was unique among the four years. Unlike other sites, herb species contributed more to total fruit biomass in intact forest than shrub species did. Total fruit biomass was similar to that in other northern forests but less than in southern forests.

(2) I measured fruiting phenology from July to October 1987. Richness of species in fruit peaked in August but fruit biomass peaked in July and September. Major avian frugivore abundance was correlated with richness of species in fruit and fruit-removal rates of 14 species. Fruiting plants probably compete for dispersers as fruit-removal rates were less when fruit biomass was high. Small mammals were seed dispersers and predators but not a consistent selective force on phenology. Fruiting phenology was associated with plant family. Fruiting phenology patterns in temperate forests may strongly reflect constraints imposed by physiology, climate, and phylogeny and only weakly reflect selective forces imposed by disperser abundance and competition.

(3) Three types of disperser syndromes emerged to define endpoints of a disperser-gradient triad: species that were dispersed by bird/large carnivorous mammals, by birds/small mammals, and by birds only. Species of the first group are woody species of edge/gap habitats, fruit early, offer a high reward by producing large fruits with low seed mass, have high dispersal rates, and were limited to three families. Forest herbs that yield a moderate reward by producing fruits of a moderate size and seed mass, and had low removal rates constitute the second group. The third group fruits late and offers a small reward by producing small fruits with large seed mass. This paradigm recognized the implicit role of phylogeny in determining seed dispersers and fruit characters.

(4) Birds and red foxes differed in their dispersal of *A. nudicaulis*. Foxes removed up to 30% of fruit and birds removed the rest. Foxes deposited seeds at densities more likely to be detected by seed predators but less likely to be completely consumed as compared with seed densities of bird-deposited seeds. Foxes may be better dispersers than birds because they deposit seeds along trails where germination and seedling survival were greater than in forest sites and canopy gaps to which birds probably disperse seeds.

(5) Soil conditions, forest structure and composition of each site, and large disturbances (e.g., harvest gap > 100m<sup>2</sup>) affected *A. nudicaulis* ramet age structure, recruitment, and growth more than subtle and temporally varying factors such as tree fall gaps, canopy defoliation, climate, and growth of overstory trees.

## EFFECTS OF LANDSPREADING PULP AND PAPER MILL SLUDGE IN MAINE FORESTLAND ON WILDLIFE POPULATIONS

<i>Investigator:</i>	C. J. Vera
<i>Advisors:</i>	F. A. Servello, Chairperson W. E. Glanz R. J. O'Connor
<i>Cooperators/ Project Support:</i>	Resource Conservation Services, Inc. Scott Paper Company

- Objectives:*
- 1) Determine the effects of landspreading pulp and paper mill sludge on the density, diversity, and species composition of breeding birds.
  - 2) Determine the effects of landspreading pulp and paper mill sludge on the relative abundance, diversity, and species composition of small mammals and amphibians.
  - 3) Determine the effects of landspreading pulp and paper mill sludge on invertebrate abundance and vegetative species composition and structure and examine the relationships of these effects with breeding bird, small mammal, and amphibian population changes.

*SCOPE:* The U.S. pulp and paper industry produces nearly 4 million dry tons of sludge per year. Approximately 70% of this sludge is currently landfilled. However, environmental concerns and government regulation of landfilling have stimulated interest in alternative sludge management practices.

Land application is an alternative which currently accounts for 8% of sludge produced. Pulp and paper mill sludge contain a range of organic matter, nitrogen, phosphorus, and lime which may improve soil structure and enhance forest regeneration. However, sludges applied to forestlands may affect wildlife populations through habitat modification and possibly through direct toxic effects. There have been few studies on the effects of landspreading pulp and paper mill sludge on forest sites representative of those used in Maine. This study will determine the effects of landspreading sludge in regenerating forestlands on wildlife populations.

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

I studied the effects of landspreading pulp and paper mill sludge in regenerating forest stands on populations of breeding birds, small mammals, and amphibians and on habitat characteristics, and invertebrate abundance (food resources for insectivorous vertebrates). Eight study sites were selected in western Maine and paired based on vegetative structure and composition in summer 1989. Sludge was applied to 1 randomly selected site from each pair in fall 1990. Pre-treatment and post-treatment population and habitat studies were conducted on treatment and control sites in summer 1990-1992. Population estimates were compared using repeated measures ANOVA, and a significant year x treatment interaction was considered evidence of a treatment effect.

Breeding bird diversity was high on all sites in all years. Thirty-four bird species established territories, and white-throated sparrows (*Zonotrichia albicollis*), common yellowthroats (*Geothlypis trichas*), magnolia warblers (*Dendroica magnolia*), and alder flycatchers (*Empidonax alnorum*) occurred consistently on all sites in all years. Total breeding bird density did not differ among years ( $P=0.14$ ) and there was no year x treatment interaction ( $P=0.26$ ). Small mammals were abundant on all sites (11 species), and masked shrews (*Sorex cinereus*) and red-backed voles (*Clethrionomys gapperi*) were the most abundant species in all years. Total small mammal abundance differed among years ( $P=0.01$ ), but was similar on treatment and control groups and there was no year x treatment interaction ( $P=0.36$ ). Because densities of most species were low, I analyzed effects on groups of breeding bird and small mammal species with similar feeding or nesting habits (guilds). The abundance of several foraging and nesting guilds and individual species did change (positive and negative) following sludge application, but evidence suggests that these changes were due to minor habitat alteration. Amphibians were not abundant on either treatment or control sites.

Because many species of breeding birds and small mammals occurred inconsistently and at low densities, I cannot conclude that effects due to sludge application did not occur. However, abundance of most species was similar on treatment and control sites which suggests that large negative effects are not likely.

Habitat characteristics exhibited little change after sludge application (increased foliage below 1.0 m on sludge amended sites) and total invertebrate abundance (food resources for insectivores) was similar on treatment and control sites after sludge application.

In addition to the lack of overt effects on wildlife populations, several lines of evidence suggest that sludge did not have a direct effect on individuals or populations: 1) 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin

(TCDD) and 2, 3, 7, 8 tetrachlorodibenzofuran (TCDF) concentrations were low in shrews and bird egg tissues studied by Martin (1991), 2) earthworms, considered a major pathway for transfer of TCDD and TCDF to some small mammal and birds species, were rare, 3) some small mammal populations increased substantially despite the presence of sludge, and 4) I found no evidence of effects on reproduction in red-backed voles.

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## USE OF LANDSAT TM DATA FOR MAPPING MIGRANT LANDBIRD HABITAT IN SOUTHERN BELIZE

- Investigator:* J. P. Spruce
- Advisors:* S. A. Sader, Chairperson  
M. K. Beard-Tisdale  
T. B. Brann  
M. L. Hunter, Jr.
- Cooperators/  
Project* U.S. Fish and Wildlife -  
Patuxent Wildlife Research Center
- Support:* Department of Forest Management, U of M
- 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) Develop a habitat classification approach suitable for regional applications on an operational basis.

**SCOPE:** Human-induced habitat change is occurring throughout the tropics, and the impact of land use change on migratory land birds is believed to be significant yet difficult to quantify. Evaluation of habitat availability and use by migratory birds wintering in the neotropics is being done using data from satellite remote sensing and field surveys of bird habitat use. This two-staged approach allows a method to estimate regional trends in bird/habitat associations, and is less expensive to apply regionally, compared to ground-based methods.

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

The Neotropics include several natural and human-maintained habitats used by overwintering migrant landbirds. The recent decline of many forest-dwelling avian migrants is believed to be related in part to neotropical deforestation and land use change. However, spatio-temporal trends in neotropical habitat availability and avian migrant use are generally not known. Such information is needed to assess the impact of neotropical habitat change on migrant landbirds. Previous studies indicate that Landsat TM data may be useful for mapping broadly defined neotropical habitats but map accuracy assessments have been limited to one study area in Costa Rica.

This study investigated the use of Landsat TM data for mapping migrant landbird habitat in southern Belize. Image processing of Landsat TM data and field checks were applied to produce georeferenced habitat maps for two study areas (Toledo and Stann Creek). Locational and non-site-specific map accuracy was evaluated by stratified random sampling and statistical analysis of satellite classification (SCR) versus air photo interpretation results (PIR) for the overall classification and individual classes. The effect of classification scheme specificity on map accuracy was also assessed. A decision criteria was developed for the minimum acceptable level of satellite map performance (i.e. classification accuracy and scheme specificity). A satellite map was deemed acceptable if it had a useful degree of classification specificity, plus either an adequate overall locational agreement ( $\geq 70\%$ ) and/or non-site-specific agreement

(Chi Square goodness of fit test results indicating insufficient evidence to reject the null hypothesis that the overall classification distribution for the SCR and PIR are equal).

For the most detailed revised satellite map, overall locational agreement ranged from 52% (5 habitat classes) for the Toledo to 63% (9 classes) for the Stann Creek. For the least detailed revised satellite map, overall locational accuracy ranged from 91% (2 classes) for Toledo to 86% (5 classes) for Stann Creek. Considering results from both locational and non-site-specific accuracy assessment, the most detailed yet sufficiently accurate classification for both study sites included low/medium/tall broadleaf forest, broadleaf forest scrub and herb-dominated opening. For these classifications, the overall locational agreement was 72% for Toledo (4 classes) and 75% for Stann Creek (7 classes). This level of classification accuracy and precision is adequate for aiding many analyses of migrant landbird habitat use. This is good news for ornithologists assessing migrant landbird habitat use in moist and wet life zones of the Neotropics.

## 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 (> 10cm 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 1993, 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 1994 field season will replicate the 1993 field season with additional work on 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:** U.S. Fish and Wildlife Service -  
National Fisheries Contaminant Research Center -  
Columbia, MO  
National Fisheries Research Center - Leetown

**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:** The general objectives of this study are to determine the importance of atmospheric input of mercury on mercury content of fish, and the effects of within-stream processing of inorganic mercury to methyl mercury. Specifically, the total, acid-labile, and methyl mercury content of stream water, sediments, and benthic invertebrates will be measured periodically to assess the seasonal and stream chemistry influence on availability of methyl mercury to fish. Models will be used to assess the importance of diet versus direct uptake of mercury. The working hypothesis is that stream temperature, acidity, and dissolved organic carbon (DOC) content influence either the chemical or microbiological methylation of mercury, or the uptake of methyl mercury by biota, and that the diet is the major route of uptake.

*FUTURE PLANS:* Three projects are currently underway, two of them just starting. One Master of Science thesis is expected in December 1993, two others in August 1994.

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### EFFECTS OF DIGESTIBLE ENERGY CONTENT OF WINTER FORAGES ON WHITE-TAILED DEER NUTRITIONAL ECOLOGY: IMPLICATIONS FOR FORAGE-BASED CARRYING CAPACITY IN DEER WINTERING AREAS

*Investigator:* P. B. Gray

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

*Cooperators/  
Project  
Support:* McIntire-Stennis

*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:* Digestion trials using 9 white-tailed deer were conducted at the University of Maine Captive Wildlife Research Facility during the winter of 1991. Deer were fed winter browse diets spanning a range of digestible energy intake. Samples of 6 forage species were collected within a deer wintering area to examine intraspecific variation in quality due to shading, plan form, browsing, and stem size. Thirteen forage species were collected to examine interspecific variation in forage quality during winter. Laboratory analyses are complete and data analyses are in progress.

*FUTURE PLANS:* Thesis completion in Fall 1993.

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### MOOSE ACTIVITY 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/  
Project  
Support:* Maine Cooperative Forestry Research Unit  
Maine Cooperative Fish and Wildlife Research Unit  
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:* Twelve 20 to 80 ha regenerating clearcuts scheduled for glyphosate treatment were selected as study sites for the study of 1-2 year post-treatment effects. Nineteen older sites (14 treatment and 5 control) were selected for study of 7-10 year post-treatment effects. Pre-treatment aerial and ground surveys of moose and moose tracks were completed in winter 1991. In summer 1991, 6 short term sites were treated with glyphosate. Ground surveys were performed in winter of 1992 and 1993 and analysis of track counts and habitat characteristics was completed in summer 1993.

*FUTURE PLANS:* Completion of thesis is scheduled for December 1993.

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## EFFECTS OF GLYPHOSATE ON 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/  
Project  
Support:* Maine Cooperative Forestry Research Unit  
Maine Cooperative Fish and Wildlife Research Unit  
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:* The project is nearly complete. Twelve young clearcuts were surveyed in winter 1991 for browse availability and utilization. In August 1991, 6 of these were randomly chosen and operationally sprayed. The remaining 6 served as controls. These sites were surveyed again during the winters of 1992 and 1993. Nineteen older clearcuts (14 sprayed, 5 unsprayed) were also similarly surveyed during the winters of 1992 and 1993. Browse samples were collected and analyzed for nutritional quality.

*FUTURE PLANS:* Data analyses will be completed in the fall of 1993. Thesis completion is expected in May 1994.

## 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. Maps and/or photos have been acquired for all towns.

**FUTURE PLANS:** Editing the road database for approximately 90% of the study area is the next step. Editing should be completed by late 1993. Analysis of harvest, access, and habitat data will be performed in 1994. Processing of satellite imagery is complete. Coverages have been generated from roads data for approximately 2/3 of the study area. Most primary and some secondary roads data are in coverages for the remaining 1/3. All spatial data have been clipped to coincide with the boundaries of the study area.

## 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.

**STATUS:** Two field seasons have been completed with a third and final one in progress. 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 may be 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 are being designed for October 1993 based on preliminary results from analysis of both field observations and the long-term data sets, and may include 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:** The final field season is in progress. Data analysis continues, and dissertation completion is targeted for May 1994.

## AMPHIBIAN HABITAT USE AND DISPERSAL IN A FRAGMENTED FOREST

*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 Experiment Station  
McIntire-Stennis

*Objectives:*

- 1) Identify forest habitat variables of potential importance to terrestrial amphibians.
- 2) Investigate the influence of forest-clearcut edges on the habitat use of resident and dispersing amphibians.
- 3) Determine the importance of logging roads as a potential barrier to the movements of amphibians and small mammals.

**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.

The degree to which human disturbance in a forested landscape serves as a barrier to dispersal is poorly understood with work having been conducted mainly on birds and mammals, two highly vagile taxa. In order to better understand the importance of barriers as isolating mechanisms, this study will quantify amphibian and small mammal response to Maine's forest roads and clear-cuts.

*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. In addition to distance from edge, habitat data was collected around each pitfall trap in 1993 including litter depths, canopy cover, ground cover, vegetation strata and nearest distance to suitable cover objects. 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 red-backed 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, however variability was high and further replication is needed in 1994.

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, heavily used logging road was studied in 1993 (the Stud Mill Road) for which analysis is not yet complete.

*FUTURE PLANS:* Monitoring will be continued at previously established forest-edge transect sites, and one or two additional locations will be chosen to expand the current "high-low" contrast gradient of edge types. Two of the study sites are likely to be clearcut by their owner during the 1993-94 winter, allowing an opportunistic comparison of pre- and post-disturbance amphibian and small mammal responses. Further replication of the powerline/forest edge dispersal experiment will be made in 1994 with the addition of both cultured American toad (egg masses unavailable in 1993) and wood frog larvae. An examination of potential road barriers to dispersal will be continued in the 1994 season by either selecting a new logging road replicate, intermediate in size to the previous sites, or by examining the Stud Mill Road again using an experimental dispersal design similar to the powerline edge work described above.

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## NEW ENGLAND BIODIVERSITY PROJECT (EMAP)

*Investigators:*

R. J. O'Connor  
M. L. Hunter Jr.  
R. B. Owen, Jr.  
S. A. Sader  
A. A. Whitman  
H. Devaul

*Cooperators/  
Project  
Support:*

U.S Environmental Protection Agency

*Objective:*

The primary objective of the project is to relate extant data on bird distribution in New England to landscape characterization of the region. The final report will recommend to the EPA on how best to utilize this information within the framework of the national EMAP project.

**SCOPE:** The U.S. Environmental Protection Agency is currently developing a nation-wide monitoring program known as EMAP (Environmental Monitoring and Assessment Program). This project evaluates extant bird and habitat data in order to make recommendations for bird and habitat monitoring protocols for use in the EMAP program.

**PROJECT STATUS:** This project has three objectives: (1) to evaluate current bird monitoring schemes and determine their usefulness and potential biases; (2) to compare extant and new habitat data and determine the relative usefulness of different methods of monitoring bird habitats; (3) to determine whether guilds of bird species are useful in designing monitoring schemes.

Two studies investigated whether the BBS monitors bird populations in a relatively unbiased manner. In the first study, time-limited bird censuses were conducted by searching for birds in 0.0625 sq. mile blocks away from roads ("checkplots") and the trends were compared to bird data from adjacent USFWS Breeding Bird Survey routes (BBS). Uncommon bird species and forest interior bird species were more frequently detected by the checkplot method than the BBS but the edge, wetland, and agricultural species were more frequently detected by BBS, the latter largely because checkplots were deliberately located away from roads. However, the checkplot method was discarded because it took more than 60 minutes to record 75% of the bird species per checkplot.

In a second study, 29 EPA hexagons (64 km<sup>2</sup> each) were surveyed for birds using 20 five-minute, limited area point counts per hexagon. Hexagons were selected to cover the range of the principal ecoregions in New England. Within each hexagon, census points were placed so as to census a variety of habitats yet be representative. Habitat data were also gathered at each census location. Analysis of the bird data is in progress but an initial analysis of the habitat data revealed that three forest types and hayfields dominated over 50% of the census points and that hayfields and mixed forest were disproportionately recorded along roads and away from roads, respectively.

The second component of the project compared extant and new habitat data to determine the usefulness of each in monitoring bird habitats. All sources of habitat data were sampled near or on BBS routes and came from three sources: USGS land use / land cover data ("LUDA") from the mid-1970s (54 BBS routes), point habitat data previously determined by EPA staff from aerial photography data ("EPIC") of the mid-1980s (same 54 BBS routes), and percent cover habitat data from each BBS bird census point ("BBS habitat") collected by this project in 1991 (73 BBS routes). All three methods were moderately comparable in the habitats that they indicated. However, dominant habitats indicated BBS habitat data better matched LUDA and EPIC data at all scales than vice versa. Moreover, bird abundance was better correlated with BBS habitat data than with LUDA and EPIC data. Thus, our BBS habitat protocol appears to better measure bird habitats than LUDA and EPIC data. The last phase of this component includes comparing bird population and habitat changes from the late 1960s to the mid-1980s.

The third component of this investigation was to determine the usefulness of a guild approach to monitoring bird population and their habitats. We adapted algorithms used in pattern recognition in robotics to classify species on the basis of the similarity of their attributes. These algorithms were used to group species on the basis of their habitat use and yielded more successful groupings (as judged by two expert field ornithologists) than did alternative conventional clustering programs. The new approach has many advantages over traditional methods, both in removing subjectivity and in handling a variety of attribute data structures. A preliminary guild classification was developed based on an analysis of life history data using the new algorithms.

**FUTURE PLANS:** An analysis of bird population and habitat changes from the 1960s to the 1980s will be completed by November. Work is currently underway finishing analyses in progress and report writing culminating in a final report in December 1992.

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**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.
- 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.

**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 affects of global climate change on vegetation in conservation lands.

**PROJECT STATUS:** As Maine Gap Analysis enters its 19<sup>th</sup> month, we are developing our species synopses in earnest. After many reviews, we have essentially finalized the species synopsis format we will be using to characterize the range and habitat associations of vertebrates that breed in Maine. We acquired the DeGraaf et al. database from the University of Vermont, and crosswalked it to the system we are using to identify habitat use. Initial range maps have been created for all amphibians, reptiles, mammals, and a subset of birds. Templates for ecological information and initial habitat matrices have been developed for all species cited in the DeGraaf database.

We have compiled existing vegetation maps from 60 areas throughout Maine, representing about 4% of the area of the state. We have maps from 25 state Wildlife Management Areas, three areas of the Maine Bureau of Public Land, maps from 27 townships that are owned by two of our cooperators, Bowater Inc. (n=15) and Champion International (n=12), and digital coverages for 5 additional areas. For each of the areas, a corresponding National Wetland Inventory map was acquired, if available, and one or more stereographic pairs of NAPP color-infrared photographs were purchased for each area, in cooperation with the Northern Forest Lands Council. The information available was shipped to the University of Massachusetts for use in training and verification of the vegetation map. We will be conducting some ancillary tests of the quality of the vegetation map, after the primary tests by Dr. Finn are completed. We have several sets of habitat data for about 20 Maine lakes, and a similar number of Breeding Bird Survey Routes, where colleagues visited to classify the vegetation. These data will be compared to the habitats shown in the existing vegetation map.

We acquired from the Maine Department of Inland Fisheries and Wildlife (MDIFW) their database storing records of occurrences of threatened and endangered species. A contract using Maine Gap Analysis funds has provided MDIFW with a small amount of funds, to be used to update species occurrences and add additional species to this database. We funded a pilot project, in cooperation with MDIFW, which entailed digitizing the mapped deer wintering areas and wading waterfowl habitats in southcentral Maine.

The Maine State Planning Office has completed a revision of the Conservation Lands of Maine maps. The maps are produced at 1:250,000 scale, and include all federal and state conservation lands. In this revision, lands owned by large conservation groups (e.g., The Nature Conservancy, The Audubon Society) are included. The Planning Office is adding the updates and revisions to the existing conservation land digital coverage.

Boone attended a week-long Advanced ARC/INFO course, taught by ESRI in Augusta, Maine, and developed a proposal for his doctoral research.

*FUTURE PLANS:* Through the following year, we will complete the species synopses for vertebrates in Maine, and have them reviewed by experts. Models will be developed that predict species distributions. Ancillary data (e.g., elevation, soils) will be acquired for the state.

## GIS ASSESSMENT OF VERTEBRATE SPECIES DIVERSITY IN COASTAL MAINE

*Investigator:* C. M. Johnson

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

*Cooperators/  
Project  
Support* U.S. Fish and Wildlife Service  
University of Maine  
Maine Department of Inland Fisheries and Wildlife  
Maine Office of Geographic Information Systems

*Objectives:*

- 1) Develop range maps of vertebrate species breeding and wintering in coastal Maine, using available literature and expert review.
- 2) Develop habitat models for aquatic species (e.g. fish and seabirds) and for terrestrial species inhabiting insular environments (e.g. terrestrial mammals).

- 3) Compare individual species occurrence predictions derived from insular habitat models to those made using statewide terrestrial habitat models, where available.
- 4) Create species richness maps for various groups of species inhabiting the Maine coast, and compare them to areas managed for natural vegetation, to identify gaps in biodiversity protection. Also, compare areas exhibiting high vertebrate species richness during winter with those found for the breeding season.

**SCOPE:** A Gap Analysis is currently underway for the State of Maine, identifying areas of high vertebrate species richness and their associations with terrestrial vegetation types. Terrestrial Gap Analyses rely primarily on the association between vertebrate species and their vegetation (habitat) associations to make predictions regarding species occurrences. While vegetation also may play an important role in predicting distributions of aquatic species, other variables may be as or more important. Thus, a variety of biotic and abiotic variables, including such factors as island size and human disturbance levels, will be used to formulate species-habitat models for the coastal environment. These models will be used to predict seasonal (breeding and wintering) distributions of vertebrate species, including some fishes, along the entire Maine coast.

A second, more refined analysis will be completed for the Penobscot Bay area. While the mapping scale of this analysis will be the same, 1:24,000, the vegetation classifications will contain more detail and the minimum mapping unit will be smaller than that used for the entire coastline.

**PROJECT STATUS:** Since the beginning of the project in June of this year, our effort has concentrated on laying the groundwork for later stages of the research. We have purchased a computer (486/66 Mhz Tri-CAD) and associated software necessary to complete the analysis. Johnson completed an introductory course in ARC/INFO and attended the 1993 National Gap Analysis Workshop meeting to become familiar with techniques used by other states in completing their terrestrial Gap Analyses. National Wetlands Inventory (NWI) maps and NOAA maps have been acquired for the entire coastline, along with 1:24,000 USGS quadrangle maps for the intensive study area.

We also have begun to compile a library of geographic material for the coastal analysis. In addition to the 100k digitized coverages acquired for the Maine State Gap Analysis, we have purchased 24k USGS coverage for the Maine coastline, describing: hydrology, transportation networks and the coastline. We also have digitized NWI mapping for approximately half of our intensive study area and are planning to acquire the remainder of this coverage in the near future. We are awaiting the availability of Maine Geologic Environment Mapping, currently being digitized by the state. All geographic data will be maintained using the same standards as those set for the State Gap Analysis project and used by the state GIS office.

Winter range maps have been developed for migratory bird species wintering in Maine, using Christmas Bird Count (CBC) data collected over the past 15 years and other available literature. Winter species-habitat relationships currently are being developed for these species. We have begun collecting and organizing both published and unpublished documents for use in refining these relationships and in developing insular species-habitat models for species breeding and/or wintering in coastal Maine. We also are working with the Maine Department of Inland Fisheries and Wildlife (MDIFW) to develop an up-to-date, comprehensive historical database for seabirds nesting in the Penobscot Bay area.

**FUTURE PLANS:** Develop seasonal range maps and species-habitat models for aquatic and insular vertebrates in coastal Maine. Complete the seabird database and obtain other, detailed databases for use in testing the insular species-habitat models (e.g., MDIFW coastal wildlife surveys and specific fish assemblage studies).

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## 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:* U.S. Fish and Wildlife Service -  
Patuxent Wildlife Research Center  
Department of Forest Management, U of M

*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) Develop a habitat classification approach suitable for regional applications on an operational basis.

*SCOPE:* Human-induced habitat change is occurring throughout the tropics, and the impact of land use change on migratory land birds is believed to be significant yet difficult to quantify. Evaluation of habitat availability and use by migratory birds wintering in the neotropics is being done using data from satellite remote sensing and field surveys of bird habitat use. This two-staged approach allows a method to estimate regional trends in bird/habitat associations, and is less expensive to apply regionally, compared to ground-based methods. GIS techniques are being used to aid evaluation of regional trends.

*PROJECT STATUS:* Landsat TM satellite data has been processed to produce a habitat availability map for a southeast Guatemala study site. Additional analyses of habitat availability and change detection have been produced for a Veracruz, Mexico study site. Maps and aerial photographs have been acquired to aid in habitat classification and analysis. Habitat classifications are being modified on the basis of knowledge gained from field visits and interpretation of air photos, maps and statistical measures of satellite data multi-spectral characteristics. Hepinstall assisted USFWS biologists in mist netting surveys and field checking preliminary habitat maps of the southeast Guatemala site during a five week field season in early 1993. Spruce's thesis on the Belize habitat mapping accuracy has been completed. An annual report to the U.S. Fish and Wildlife Service was submitted in October 1993.

*FUTURE PLANS:* The project will focus on analyzing trends in habitat availability and migrant habitat use at the Guatemala study site. U.S. Fish and Wildlife Service co-investigators will complete a final report on Belize survey of habitat availability and avian migrant habitat use during fiscal 1994. The USFWS, University of Maine, and National Autonomous University of Mexico are co-organizing an international symposium on conservation of migratory birds in Mexico to be held in Catemaco, Mexico, November 5-7, 1993.

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## 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:* Office of International Programs, U of M

- Objectives:*
- 1) To examine the distribution and abundance of wintering avifauna in Lake Mehdiya and associated marshlands.
  - 2) To determine temporal and seasonal (fall and winter) differences in habitat use by wintering waterfowl.
  - 3) To determine the relation between habitat variables (e.g., vegetation cover and density, water depth) and waterfowl use of the site.
  - 4) To assess the impacts of grazing and recreation activities on wintering waterfowl populations.
  - 5) To 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:* At present, efforts are being concentrated on obtaining funds for the project.

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

### **TOWARDS AN AVIAN INDEX OF BIOTIC INTEGRITY FOR LAKES**

*Investigator:* A. Moors

*Advisors:* R. B. Owen, Jr., Co-chairperson  
 R. J. O'Connor, Co-chairperson  
 J. R. Moring

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

- Objectives:*
- 1) Examine the possibility of using birds as an index of biotic integrity on selected lakes in New England.
  - 2) Examine bird distribution in relation to shoreline habitat.
  - 3) Identify disturbance factors related to reduced bird species richness or altered species composition on degraded lakes.

*SCOPE:* Birds can be excellent bioindicators, as demonstrated by eggshell thinning in relation to pesticide contamination. Research on avian bioindicators of water quality has previously focused on waterfowl. How water quality affects the total bird community (terrestrial and aquatic species) is poorly known. Because both water quality and bird presence are related to the vegetation surrounding a water body, the avifauna may provide an economic way of monitoring its health. This project investigates whether censusing the local bird communities can provide sufficiently accurate and precise assessment of the quality of individual lakes to allow their use as response indicators within the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP).

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

Research on avian bioindicators of water quality has previously focused on waterfowl. How water quality affects the entire bird community (terrestrial and aquatic species) is poorly known. The avifauna of a lake may provide an economic way of monitoring its health because both water quality and bird presence are related to the vegetation surrounding a water body. I investigated whether surveys of lake bird communities can provide a sufficiently accurate assessment of the quality of individual lakes to allow their use as response indicators within the USEPA Environmental Monitoring and Assessment Program (EMAP).

Twenty lakes chosen by EMAP staff to reflect environmental gradients across New England were surveyed in 1991. Bird and habitat distribution were recorded between June 1 and July 3 and the resulting bird metrics were compared to the amount of human disturbance on the shoreline and to water chemistry measurements. Five avian indicators that were correlated with the extent of lake degradation were developed from the 1991 data. One indicator was based on species richness, one on the number of individuals, and four were based on guilds.

These indicators were tested on data from 26 lakes surveyed during June 1992. These lakes were part of a probability sample of surface waters drawn from lakes on the EMAP grid and were located in New England, New York, and New Jersey. The species richness indicator did not work as well as expected, in part because the test sample included a disproportionate number of large cold-water lakes that were under-represented in the 1991 sample. The four other indicators and one based on the factor score coefficients from a principal components analysis on the 1991 data were able to rank lakes according to disturbance and water chemistry measurements.

## BIRDS OF MAINE'S PEATLANDS

- 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 "value" to wildlife from smaller, non-commercially valuable peatlands.
  - 4) 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:* Birds were censused in eight Maine peatlands of varying types and sizes during May and June of 1984. Eight distinct vegetation types occurred in the peatlands. A variable-width transect method was used to census birds and estimate densities from a modified Emlen method and the Fourier Series Estimator in program TRANSECT.

During the two-year study, 104 bird species were identified. Bird species richness ranged from 48 to 81 per peatland and from 46 to 76 per vegetation type. Overall bird density ranged from 4 to 11 birds per ha in each peatland, and from 3 to 19 birds per ha in each vegetation type. Densities of each species in each peatland and vegetation type were highly variable, and most species were abundant in only a few types of vegetation. Densities ranged from 1 to 160 birds per 40 ha, with the common yellowthroat being the most abundant species in 5 of 8 peatlands and 4 of 8 vegetation types.

Foliage height diversity (FHD, vertical heterogeneity of vegetation) was the best predictor of bird species composition (BSC), bird species richness (BSR), bird species diversity (BSD), and bird density (BD) in eight types of peatland vegetation. As foliage height diversity increased, bird species composition changed, species richness increased, species diversity increased, and density increased.

Neither type nor size of a peatland affected species composition, richness, diversity, or bird density in a predictable pattern. Bird species richness in eight peatlands was best related to the interacting variables of peatland-FHD and PVD. Thus, horizontal heterogeneity of vegetation seems to be as, or more, important than vertical vegetation structure in influencing BSR and BD in peatlands. The high number of species recorded in peatlands relative to other habitats lends support to the hypothesis that patchiness, rather than foliage height diversity, is most important in influencing bird diversity.

*FUTURE PLANS:* Revise and complete thesis.

## HABITAT USE BY BLACK DUCKS AND MALLARDS ON MISSISQUOI NATIONAL WILDLIFE REFUGE

*Investigator:* C. G. Kitchens

*Advisors:* J. R. Longcore (Field Advisor)  
R. B. Owen, Jr., Chairperson  
W. E. Glanz

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

*Objective:* To 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:* The field work was completed in December 1991. Data analyses and preparation of the thesis is underway. Key findings were that disturbance from hunting affected use of habitats by waterfowl. Effects of disturbance were based on 608 exact locations in 1990 and 1,738 locations in 1991. In 1990 Palustrine emergent wetlands (PEW) were used in proportion to availability by marked black ducks and mallards only during the before-hunting interval, but in greater proportion during the hunting and after-hunting periods. The Lacustrine emergent wetlands (LEW) (where considerable hunting activity occurred) were used in proportion only by male black ducks. In 1991 with the larger sample disproportional use was more evident, wherein PEW habitats were used in greater proportion than available by all marked ducks during all intervals. For Palustrine scrub shrub (PSS) habitats, they were used in proportion by all marked ducks in all intervals. LEW habitats were used disproportionately more during the closure between the split hunting seasons by all groups of marked ducks, suggesting that ducks moved back into habitats as hunting ceased. Furthermore, for the 1991 data, habitats where hunting was not allowed were used by all marked ducks for all intervals in greater proportion than available. Conversely, habitats where hunting was allowed were used less than their availability by all groups of marked ducks in all intervals. Mean size of home range decreased for black ducks when hunting began, but increased slightly for marked mallards. In contrast, mean size of home range increased substantially for black ducks during the after-hunting interval, but decreased for marked mallards. Maximum straight-line distances flown by marked ducks decreased during hunting and increased after hunting, again suggesting that hunting activities substantially affected habitats used by staging waterfowl.

*FUTURE PLANS:* The thesis will be completed by December 1993.

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## BREEDING ECOLOGY OF GREATER SCAUP IN THE SAINT JOHN RIVER VALLEY, NEW BRUNSWICK

*Investigator:* D. H. Kusnierz

*Advisors:* R. B. Owen, Jr., Chairperson  
W. B. Krohn  
W. E. Glanz  
F. P. Kehoe, Ex-Officio

*Cooperators/  
Project  
Support:* North American Wildlife Foundation -  
Delta Waterfowl and Wetlands Research Station  
New Brunswick Department of Natural Resources and Energy

- Objectives:*
- 1) Determine the effects of nest markers on nesting success of Greater scaup.
  - 2) Identify habitat characteristics of nest sites selected by female Greater scaup.
  - 3) Document incubation rhythms of Greater scaup nesting among colonial larids.
  - 4) Determine food habits and habitat use of juvenile Greater scaup.

*SCOPE:* U. S. Fish and Wildlife Service surveys indicate that scaup breeding populations are at an all-time low, yet the breeding biology of Greater scaup in North America still remains unstudied. The vast majority (75%) of nesting occurs in remote areas of Alaska; however, an island nesting colony was discovered in 1984 within a traditional spring-fall staging area of the Saint John River, New Brunswick, Canada. This broad-base study attempts to determine what requirements are necessary to successfully establish a breeding colony of Greater scaup. The study will provide the first in-depth insight into the nest site habitat selection, incubation behavior, and juvenile feeding ecology and habitat use of Greater scaup in North America.

*PROJECT STATUS:* All data have been collected. Habitat characteristics, including soil moisture, vegetative cover, species and height, and distance to water, edge of cover were measured at 167 nests and 246 random sites. The same variables were measured four times in 1991 at 25 nest sites from the previous year. These measurements will be used to follow temporal changes in habitat at nests and backdate characteristics to time of nest initiation. Behavior during incubation was monitored at 12 nests. Observations were made from a blind to examine scaup-gull interactions when broods dispersed from the islands. Surveys from fixed wing aircraft and boats were conducted to identify habitats used by broods. Habitats were sampled to quantify physical characteristics including water depth, foods available and vegetation types. In addition, 18 juveniles were collected to identify foods consumed. Food items were analyzed to determine energy and protein content.

Data analysis is nearly complete and thesis preparation is underway. The first two chapters have been drafted and two more are planned.

*FUTURE PLANS:* Complete thesis.

## ECOLOGY OF THE DOUBLE-CRESTED CORMORANT IN THE PENOBSCOT RIVER ECOSYSTEM WITH 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* U. S. Fish and Wildlife Service -  
WO, Federal Aid

*Support:* Maine Department of Inland Fisheries and Wildlife  
Maine Atlantic Sea-Run Salmon Commission

- Objectives:*
- 1) Monitor movements of radio-tagged cormorants to determine distances between roosting and foraging areas, time of roost departure and return, and 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 before, during, and after the migration of Atlantic salmon smolts through the ecosystem.
- 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 considered 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.

One 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:** The 1993 field season complemented census and collection efforts that began in 1992. In addition, cormorants were monitored at dams to determine numbers present at intervals and how these areas are used.

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, 1993. Census data are being analyzed, but immediate indications are that cormorant numbers were fewer than in 1992. Further, peak numbers on the Penobscot River occurred in late May and early June, later than in 1992. Weather conditions and river flow rate from April through June will be examined as possible factors affecting cormorant arrival and dispersal along the Penobscot. Again, adult cormorants arrived before subadults and contributed to the in-river predation on Atlantic salmon smolts.

Cormorant use of dams as foraging and loafing areas was discovered during the 1992 aerial censuses. During the 1993 smolt run observations points were established at four dams and behavioral data taken during census periods. Cormorant use of dams during 1993 is, as was discovered in 1992, disproportionate with use of free-flowing sections. These data are being analyzed for type and intensity of use by cormorants of dams and areas around dams.

To examine variation in diet with location and time, 149 cormorants were shot along the Penobscot River. Stomach contents data of cormorants killed at dams will be compared to those data from cormorants collected on free-flowing sections of the Penobscot. Also, prey items regurgitated by nestling cormorants were collected on nine island breeding colonies in Penobscot Bay during July. Analysis of food samples is ongoing and will be completed this spring. An updated research protocol for 1994 will be submitted to the graduate committee and cooperators for comments and discussion.

**FUTURE PLANS:** The third and final field season will begin in April 1994. Again, special emphasis will be placed on estimating cormorant days of predation at dams relative to specific river segments. However, radio-telemetry will be used to obtain individual behavior patterns and document movements of cormorants during the smolt migration. As in the previous field seasons, aerial surveys will provide a means of comparing predation pressure at specific points on the Penobscot River as well as the changes in cormorant use of the system with the approach of the breeding season.

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## 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:** The applicability of Taylor Power Law was evaluated for the distribution of bird species within the coterminous United States. This analysis confirmed that the variance of each species' abundance varied predictably over space and time as predicted by Taylor Power Law. Computer simulations were used to determine the probabilities of observing certain combinations of Taylor Power Law parameters, thus providing a theoretical basis for the assessment of the patterns present in the empirical data.

**FUTURE PLANS:** Target date for project completion in December 1993.

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

*Investigator:* L. J. Boobar

*Advisors:* K. E. Gibbs, Chairperson  
 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:* The study was initiated in April 1993. About 30 wetlands were selected in the agricultural landscape and 15 in the forested landscape. Landowner permission to construct elevated platforms from which to observe female ducks with broods was obtained. At the same time, 14 wetlands (7 in each landscape) were randomly selected for invertebrate sampling. Sampling with activity traps was conducted on 26-27 May, 15-16 June, and 6-7 July. On these latter two dates, one wetland (Moore Brook Flowage) was sampled by two additional methods, a cylinder sampler and a sweep net. On 23-26 July, all ponds were sampled with a sweep net, and one pond (Ginn Brook Flowage) was also sampled at that time with a cylinder sampler and a sweep net for further evaluation of techniques. Additional experiments to evaluate the sensitivity of the activity traps to capture certain taxa (dragonfly larva, water bugs) were conducted in aquaria or field enclosures. All invertebrates from activity traps have been sorted and 1/3 identified. Arrangements have been made for a specialist to verify identifications of the Corixidae and negotiations are underway with other collaborators for verifying identifications of other taxa. In early July, water samples were obtained from all ponds sampled for invertebrates and most of those ponds harboring waterfowl broods.

*FUTURE PLANS:* Samples will be sorted and data evaluated to guide the sampling for next year. The graduate student will pursue his academic program during the semester.

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## NATIONAL PATTERNS OF BIRD ABUNDANCE AND DIVERSITY

*Investigators:* Raymond J. O'Connor  
 Malcolm 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 and programs such as Gap Analysis can prove to be costly. 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:* In addition to our existing database of Breeding Bird Survey (BBS) data, we have obtained the AVHRR land cover characteristics for the coterminous United States. Preliminary analyses evaluating methodologies for interpolating the BBS data to adjacent EMAP hexagons are ongoing. Oak Ridge National Laboratory, Environmental Sciences Division, is preparing an analysis of landscape metrics using the land cover characteristics derived from the AVHRR satellite imagery.

*FUTURE PLANS:* Develop models of bird distributions using BBS data and land cover characteristics from the AVHRR data. Develop maps of avian richness for the coterminous United States from the resulting individual species distribution maps. Evaluate the effects of altering the coarseness of land cover designations on the correlations with bird species distribution. Final project report will be submitted in August 1994.

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

#### **THE EFFECT OF SPATIAL AND TEMPORAL VARIABILITY ON POPULATION ASSESSMENT OF PACIFIC WALRUSES**

*Investigators:* S. Hills

*Advisors:* J. R. Gilbert, Chairperson  
W. E. Glanz  
W. A. Halteman  
M. L. Hunter, Jr.  
W. B. Krohn

*Cooperators/  
Project  
Support:* U.S. Fish and Wildlife Service -  
R-8, AFWRC

*Objectives:*

- 1) Techniques development and evaluation:
  - a) Adapt existing satellite telemetry technology to walrus, including packaging, sensors, and attachment procedures.
  - b) Develop immobilization techniques for walrus on pack ice.
- 2) Determine the effect of behavioral patterns of walruses (herd composition, distribution, movements, and behavior) on the existing population estimates.
- 3) Determine the distribution and movements of walruses relative to pack ice distribution, bathymetry, and other environmental parameters.
- 4) Evaluate the past censuses of walruses in relation to the distribution information collected on objectives 2 and 3.

*SCOPE:* Existing walrus population estimates fail to account for herd composition, movement, distribution, and behavioral patterns. Sampling effort is shared by the U.S. and the U.S.S.R., and population estimates are attempted once every five years. Sampling effort currently lacks coordination and design and, therefore, lacks credibility; results are limited to determining overall population trend. Adaptation and implementation of available satellite telemetry techniques to walrus will potentially address the majority of the problems associated with current estimates, and thus help to provide a more reliable data base for management.

*PROJECT STATUS:* All requirements for the Ph.D. degree (in Wildlife) were completed in December 1992. The abstract follows:

To estimate the proportion of the Pacific walrus (*Odobenus rosmarus divergens*) population not seen during aerial surveys, satellite-linked transmitters (Platform Transmitter Terminals (PTTs) acquired data on the movements and behavior of individual walruses. Pacific walruses were immobilized for attachment of PTTs. Four immobilizing drugs and 4 delivery systems tested; etorphine delivered by a CO<sub>2</sub>-powered dart gun was most effective. The performance of the 27 PTTs deployed was analyzed. Location accuracy was insufficient to know whether a walrus was hauled out or in the nearby water. Both location and saltwater switch sensor information were needed to determine haulout patterns.

Terrestrial haulouts are usually at traditionally-used sites, so variability in the counts of walruses is primarily temporal. The proportion of the population hauled out was estimated from PTTs on individual walruses. The presence of walruses with PTTs (n = 9) on the haulout beaches of Bristol Bay in 1990 was positively correlated with the number of walruses hauled out. Environmental variables explained little of the variation in the number of walruses hauled out. Generally, rising barometric pressure for the previous 1-4 days, low wind speed, increasing rate of change of the tide, and wind direction that put the haulout in the lee were associated with larger numbers of walruses on the haulout.

The number of walruses hauled out on ice is estimated from aerial surveys. Habitat variables (i.e., water depth, bottom type, ice cover, and water mass type) on which the survey area could be stratified were examined in relation to presence or absence of walruses. Walruses were unlikely to be found hauled out over water deeper than 60 m, or in areas covered by 7/8-8/8 ice. Some reduction in variance of estimates from future surveys may be possible if the survey area were stratified on the basis of water depth. Post-survey stratification based on ice cover might help reduce variance if the proportion of the entire survey area in various ice cover categories were known.

The number of surveys needed to detect a trend in population numbers of Pacific walruses with different risks of Type I and Type II errors was calculated. Estimates from the current survey methods had large variances and the time to detect a trend would be too long for meaningful management decisions. With the variance due to the proportion of the population not counted added, the number of surveys needed was increased. Aerial surveys with methods currently available will not yield sufficiently precise and accurate population estimates for management goals.

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**A SURVEY OF BEAR HUNTERS IN MAINE:  
DO HUNTER CHARACTERISTICS AFFECT  
OPINIONS REGARDING HUNTING REGULATIONS?**

*Investigator:* R. M. Muller-El Hamzaoui

*Advisors:* J. A. Sherburne, Co-Chairperson  
K. J. Boyle, Co-Chairperson  
J. R. Gilbert

*Cooperators/  
Project  
Support:* Maine Department of Inland Fisheries and Wildlife  
Office of International Programs, U of M

*Objectives:*

- 1) Design a survey to address the following issues:
  - a) Bear hunting effort and success rates by hunting method and WMU.
  - b) Bear hunter attitudes about past and current bear hunting policies.
  - c) Hunter interest and effort in providing input on bear hunting issues to MDIFW.
- 2) Evaluate hunter attitudes about past and current bear hunting policies, and interest and effort in providing input on bear hunting issues to MDIFW.

*SCOPE:* Black bear hunting as a controlled and regulated hunt in Maine began in the 1930s. Since 1931 the bear harvest season has fluctuated widely from year-long seasons from 1942-1965, to a five month season, to a split season between the spring and the fall months, to the current three month season, which is restricted by law.

Throughout this time, most of the data concerning the status of the bear population in the state of Maine have been gathered via harvest data. Very little data have actually been collected on the numbers of hunters pursuing bear, their hunting effort, and their success rates. This past year, 1990, was the first year that a special bear hunting permit was required in order to better evaluate bear hunting effort and success rates in the state of Maine.

MDIFW is interested in the preparation of a bear hunter survey which can be administered on a yearly basis in order to provide them with accurate information concerning hunting effort and success rates by various hunting methods and in the different Wildlife Management Units.

*PROJECT STATUS:* All requirements for the degree of Master of Wildlife Conservation were completed in May 1993. An abstract of the report follows:

The field of wildlife management requires that professionals have information in two key areas. One component is biological and ecological information on populations and habitat conditions. The second is evaluations of the resource users' expectations and concerns.

In recent years, the Maine Department of Inland Fisheries and Wildlife (MDIFW) has implemented several changes in bear hunting regulations to counter a steady increase in the harvest of Maine's black bears. These include changes during the 1980s and a number of major changes starting with the 1990 hunt.

After the 1990 hunt, resident and nonresident hunters of Maine' black bear were surveyed with regard to their opinions on past (since 1980), current (1990) and proposed hunting regulations. Results of this study reveal that certain hunter characteristics are more likely to influence a hunter's opinion about regulations than others.

Pre-1980 hunting experience was one characteristic which significantly influenced hunters' opinions about past hunting regulations. Those with prior experience also did not agree with past changes. Prior hunting experience also influenced some responses to current and proposed regulations, but was not as pronounced as with past regulations. Success during the 1990 bear hunt did not influence hunters' opinions

about policies. The method of hunting used by a hunter, such as around natural food sources, over setbail, or with hounds, had a significant influence on how they reacted to both current and proposed regulations which affected their hunting method.

An open-ended section of the survey asked hunters to explain why they rated hunting regulations as they had. This information gives the manager insight into what factual information or ideas the bear hunter has about Maine's black bear population and why they approve or disapprove of certain past and proposed hunting regulations. Since bear hunting regulations have changed substantially since 1980, this type of information gives managers an idea of how past changes were received by the hunters and what type of response they can expect from the various hunter groups on proposed regulation changes.

## 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.

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## 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 km<sup>2</sup> 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:* Field work has been completed, data analyzed, and the thesis successfully defended. Final thesis and manuscripts are forthcoming.

## 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:* Most information on fisher reproduction came from fur farms before 1930. Between 1950 and 1970 several investigators studied fisher reproduction, primarily from data collected from carcasses of trapper caught animals. Common reproductive indices for fisher 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:** Fourteen animals (3 males, 11 females) were captured and brought into captivity during the fall of 1992, for a total of 72 fishers handled during the study (41 wild-caught and 31 captive-born). Blood was collected for hormone profiles bimonthly from 23 animals during the 1993 breeding season. Mammary measurements, vaginal smears, and vulva measurements were taken weekly from females during the breeding season. Semen was collected weekly from males by electroejaculation between January and June to determine the peak of sexual activity. Two litters were born during the spring 1993 and growth measurements were taken until August. As of October 1993, all fishers were released or given to zoos or wildlife game facilities.

**FUTURE PLANS:** All the data have been collected. Data analysis has begun. Target date for project completion is December 1993.

## ECOLOGY OF SPRUCE GROUSE IN ACADIA NATIONAL PARK AND ON MOUNT DESERT ISLAND

*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:** Areas of potential habitat have been identified from cover maps, and surveys of spruce grouse abundance were completed in spring 1992 and 1993. Female spruce grouse were equipped with radio transmitters and monitored during nesting and brood rearing in 1992 and 1993 to determine nesting success and productivity. In August-December 1992, 9 juvenile spruce grouse were equipped with radio transmitters and monitored during dispersal to determine habitat use.

**FUTURE PLANS:** Analysis of data is completed and a final report to cooperators is being produced. M.S. thesis completion anticipated in December 1993.

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

- Investigator:* S. L. Glass
- Advisors:* D. J. Harrison  
A. F. O'Connell  
J. R. Gilbert  
K. D. Elowe  
W. E. Glanz
- Cooperators/  
Project  
Support:* National Park Service-  
Acadia National Park  
Department of Wildlife, U of M
- 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, to 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 1980s and are potentially a significant predator on deer on MDI. Studies of food habits suggest that the use of deer by coyotes is high relative to mainland areas. In addition to direct predation, spatial interactions between coyotes and deer may potentially affect deer populations.

We plan to investigate cause-specific mortality of deer, assess patterns of movement and spatial overlap between coyotes and deer, examine the social structure of coyotes on MDI, and develop a stochastic simulation model for deer on MDI.

**PROJECT STATUS:** Field work was initiated in August 1991. Thirty-nine coyotes (24 females, 15 males) from 6 different family groups have been captured and equipped with transmitters. Seventeen adult deer (12 females, 5 males) have also been equipped with transmitters. Relocations have been obtained 1-3 times per week. Mortality sources documented for deer on MDI have been coyotes, drowning, domestic dogs, and vehicles.

**FUTURE PLANS:** Coyote and deer trapping will continue through April 1994. Relocations will be obtained through summer 1994 on all radioed animals. Data analysis will begin during June 1994, with an expected date of project completion of May 1995.

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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  
Department of Wildlife, U of M  
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 (eg. 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 km<sup>2</sup> 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 affect 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 document characteristics of dispersal (eg. 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:** Since October 1990, 97 martens have been equipped with radio-collars in the Baxter study area. Over 3,500 relocations were obtained by livetrapping, ground and aerial telemetry, and walk-in observations. Sufficient data are available to document spatial characteristics for 36 resident adult (> 1 year) martens (21m,15f) from the population in Baxter State Park. Comparisons will be made with 28 resident adult martens (14m,14f) from the study area adjacent to the park. Dispersal characteristics will be analyzed with data from twenty-nine nonresident martens (12m,17f).

**FUTURE PLANS:** Ground and aerial monitoring of radio-collared martens will continue until February 1994. The expected date of project completion is August 1994.

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### 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 Foundation  
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.

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## HABITAT SELECTION BY MARTENS IN A FOREST PRESERVE AND INFLUENCE OF FRAGMENTATION ON MARTENS IN NORTHERN MAINE

- Investigator:* T. Chapin
- Advisors:* D. J. Harrison, Chairperson  
W. B. Krohn  
S. A. Sader  
K. D. Elowe
- Cooperators/  
Project* McIntire-Stennis  
Maine Department of Inland Fisheries and Wildlife
- Support:* National Council of the Paper Industry for Air and Stream Improvement
- 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 continuous 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 United States. Some eastern studies have reported selection for conifer habitats, but sample sizes have been too small for widespread application of results. Habitat quality for martens seems to 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. Therefore, 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 not be so distinct. To better understand the habitat associations of martens in the east, I will assess seasonal habitat selection by martens at two spatial scales: 1) use of habitats in the home range relative to habitat availability in the home range, and 2) proportions of habitats in home range relative to availability of habitats on the landscape. I will measure CWD to develop a relationship between CWD and cover type and evaluate the findings of cover type selection.

It is well documented that clearcutting negatively influences habitat quality for martens. The specific characteristics of clearcuts that affect martens is not well documented. Katnik (1992) documented a negative edge effect in summer-autumn on a study area in northern Maine characterized by intensive trapping and timber harvesting. Martens in forested habitats were farther from a forest-nonforest edge than expected, and martens in open areas were closer to the edge than expected. Other researchers have documented that in winter, marten tracks in clearcuts are straighter and more direct than in forested habitats, indicating that martens may venture into cuts but do not forage in them. I will relate spatial characteristics of forest patches, such as size, shape, and distance to another forest stand, to the use intensity of those patches by martens. I will also relate spatial characteristics of habitat, such as proportion of clearcuts or ecotones in home range, with size of home range, to help identify the effects of forest harvesting patterns on use of habitats by martens.

**PROJECT STATUS:** To date, 3,397 radio locations of juvenile, transient, and resident martens have been collected in the BSP study area. Aerial photographs of the study area (approximately 50 km<sup>2</sup>) have been purchased, and photo interpretation is being contracted to a private consultant. The habitat classification scheme is as follows: softwoods, hardwoods, softwood-dominated mixed, and hardwood-dominated mixed stands will be delineated, as will be spruce bogs, cedar swamps, alder thickets, open wetland (beaver flows, marshes), and camps and gravel pits. Spruce budworm kills will also be delineated separately, and will be characterized by the species composition of the remaining trees, and percent closure and height of residual cover.

Habitat and relocation data from Katnik's study have been converted to ARC/INFO, a polygon-based Geographic Information System and are ready for analyses. Katnik (1992) collected 1944 radio locations on juveniles, transients, and 28 nonjuvenile residents.

**FUTURE PLANS:** Analyses of fragmentation effects in the treatment study area (timber harvesting and trapping) will be performed in fall 1993. Habitat selection analyses in the BSP study area will begin in winter 1994. Project completion is expected by December 1994.

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

- Investigator:** R. A. Long
- Advisors:** D. J. Harrison, Co-Chairperson  
A. F. O'Connell, Jr., Co-Chairperson  
J. R. Gilbert
- Cooperators/  
Project  
Support:** U.S. National Park Service  
Acadia National Park  
Department of Wildlife, U of M
- Objectives:**
- 1) Document cause specific mortality rates of white-tailed deer fawns on Mt. 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 Mt. 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 Eastern populations where deer numbers have increased in response to the absence or reduction of predators. In some cases deer densities are at the point where they are negatively affecting natural plant communities and deer malnourishment is occurring. This is not the case on MDI where studies have shown no over-utilization of vegetation and a physically healthy deer population. In the mid-1980's a study was begun 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. 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 16 fawns during June and July of 1992-1993 and located each 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. Snowshoe hare pellets have been removed from 1200 pellet plots and understory stems counted on 240 vegetation plots in an effort 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:** Winter trapping and radio-collaring of does will continue in early 1994 in hopes of increasing the number of fawns we will capture during the last field season in Summer 1994. Hare pellets will be counted and removed from the established plots in May 1994 and again in September 1994, reflecting winter and summer hare numbers in various habitats. The estimated date of project completion is May 1995.

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

*Investigator:* S. S. Ditchkoff

*Advisors:* F. A. Servello  
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 the state of Maine.

Previous research suggests that deer may not be able to subsist solely on hardwood browse during winter. They may require high quality forages such as lichens and litterfall. Yet, typical deer wintering area management prescribes cutting in wintering areas to increase the amount of available hardwood browse, thus possibly reducing litterfall and lichen availability.

**PROJECT STATUS:** Urine samples were collected bimonthly from deer populations in 10 wintering areas during January-March 1993. Samples are being analyzed for urea nitrogen, potassium, sodium, phosphorus, and calcium to determine population nutritional condition.

*FUTURE PLANS:* During the winter of 1994, a study of forage availability, including litterfall, will be conducted on harvested and unharvested spruce-fir stands in deer wintering areas.

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## 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  
Department of Wildlife, U of M

*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.

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

SCIENTIFIC PUBLICATIONS

- ARTHUR, S.A., R.A. CROSS, T.F. PARAGI, and W.B. KROHN. 1992. Precision and utility of cementum annuli for estimating ages of fishers. Wildlife Society Bulletin: 20(4):402-405.
- BOGACZYK, B.A., and M.W. LANKESTER. 1992. The significance of patent infections of *Parelaphostrongylus tenuis* in moose (*Alces alces*). Abstracts of the 28th North American Moose Conference, Ontario, Canada, May 11-15, 1992.
- BOGACZYK, B.A., W.B. KROHN, and H.C. GIBBS. 1993. Factors affecting *Parelaphostrongylus tenuis* in white-tailed deer (*Odocoileus virginianus*) from Maine. Journal of Wildlife Diseases 29(2):266-272.
- GARMAN, G.C., and J.R. MORING. 1993. Diet and annual production of two boreal river fishes following clearcut logging. Environmental Biology of Fishes 36:301-311.
- HUNTER, M.L., JR. 1993. Of puffins and parochialism: why is it important to conserve species that are locally rare, but globally common? Maine Naturalist 1:39-42.
- HUNTER, M.L., JR., J. GIBBS, and S. MELVIN. 1993. Snag availability and communities of cavity nesting birds in tropical versus temperate forests. Biotropica 25:236-241.
- HUNTER, M.L., JR. 1993. Managing biodiversity in forests at large spatial and temporal scales. Pages 102-112 in D. Kuhnke, ed., *Birds in the boreal forest*. Forestry Canada, Edmonton, Alberta.
- HUNTER, M.L., JR. 1993. An overview of biodiversity in forest ecosystems. Pages 7-13 in D. Kuhnke, ed., *Birds in the boreal forest*. Forestry Canada, Edmonton, Alberta.
- HUNTER, M.L., JR. 1993. Natural fire regimes as spatial models for managing boreal forests. Biological Conservation 65:115-120.
- KROHN, W.B. 1992. Sequence of habitat occupancy and abandonment: potential standards for testing habitat models. Wildlife Society Bulletin 20(4):441-442.
- KROHN, W.B., P.O. CORR, and A.E. HUTCHINSON. 1992. Status of the American Eider with special reference to northern New England. U.S. Fish and Wildlife Service, Research 12, Washington, DC. 12pp.
- KROHN, W.B., R.B. ALLEN, J.R. MORING, and A.E. HUTCHINSON. 1992. Double-crested cormorants in New England: population and management histories (Abstract). Colonial Waterbird Society Bulletin 16(2):48-49.
- MORING, J.R. 1993. Anadromous stocks. Pages 553-580 in: C.C. Kohler and W.A. Hubert (eds.), "Inland Fisheries Management in North America". American Fisheries Society, Bethesda, MD.
- MORING, J.R. 1993. Records of long-range, downstream movements of stocked rainbow trout (*Oncorhynchus mykiss*). Fisheries Research 16:195-199.

- MORING, J.R. 1993. Rock gunnels in intertidal waters of Maine. Maine Naturalist 1:17-26.
- MUGANGU, T.E., and M.L. HUNTER, JR. 1992. Aquatic foraging by hippopotamus: response to a food shortage? Mammalia (Paris) 56:345-349.
- O'CONNELL, A.F., JR., D.J. HARRISON, B. CONNERY, and K.B. ANDERSON. 1992. Food use by an insular population of coyotes. Northeast Wildlife 49:36-42.
- O'CONNOR, R.J. 1992. The analysis of geographical scale and population processes in bird population monitoring data. Pages 929-960 in D.H. McKenzie, D.E. Hyatt, and V.J. McDonald (eds.) "Ecological Indicators". Elsevier Applied Science, New York.
- O'CONNOR, R.J., and R.B. BOONE. 1992. A retrospective study of agricultural bird populations in North America. Pages 1165-1186 in D.H. McKenzie, D.E. Hyatt, and V.J. McDonald (eds.) "Ecological Indicators". Elsevier Applied Science, New York.
- O'CONNOR, R.J. 1992. Impact of agricultural intensification on bird populations in Britain. Pages 1556-1557 in D.H. McKenzie, D.E. Hyatt, and V.J. McDonald (eds.) "Ecological Indicators". Elsevier Applied Science, New York.
- RUDNICKY, T., and M.L. HUNTER, JR. 1993. Reversing the fragmentation perspective: effects of clearcut size on bird species richness in Maine. Ecological Applications 3:357-366.
- RUDNICKY, T., and M.L. HUNTER, JR. 1992. Avian nest predation in clearcuts, forests, and edges in a forest-dominated landscape. Journal of Wildlife Management 57(2):358-364.
- SCHOOLEY, R.L., and C.R. McLAUGHLIN. 1992. Observer variability in classifying forested habitat from aircraft. Northeast Wildlife 49:10-16.
- VICKERY, P.D., M.L. HUNTER, JR., and J.V. WELLS. 1992. Use of a new reproductive index to evaluate relationship between habitat quality and breeding success. The Auk 109:697-705.
- VICKERY, P.D., M.L. HUNTER, JR., and J.V. WELLS. 1992. Is density an indicator of breeding success? The Auk 109:706-710.
- YONZON, P., and M.L. HUNTER, JR. 1992. Ecological study of the red panda in the Nepal-Himalaya (In Japanese). Zoo and Aquarium Topics from Abroad 2:35-38.
- HUNTER, M.L., JR. and P. YONZON. 1993. Altitudinal distributions of birds, mammals, people, forests, and parks in Nepal. Conservation Biology 7:420-423.

#### TECHNICAL AND SEMI-TECHNICAL PUBLICATIONS

- CHILELLI, M., D.B. GRIFFITH, and J. R. GILBERT. 1992. Analysis of factors affecting population viability of birds. Final Report to U.S. Fish and Wildlife Service Cooperative Research Units Center, Region 8, Washington, DC. 97pp.
- HARRISON, D.J. 1993. A landscape approach to habitat quality assessment: a case study with American martens. Pages 10-12 in *Methodology for Deriving Quantitative Definitions of Forest Wildlife Habitat*, New Brunswick Department of Natural Resources and Energy, Fredericton.

- HUNTER, M.L., JR., J. ALBRIGHT, and J. ARBUCKLE (eds.). *The amphibians and reptiles of Maine*. Maine Agricultural Experiment Station Bulletin 838. 188pp.
- HUNTER, M.L., JR. 1993. Biodiversity goes public. Review of "The diversity of life" by E. O. Wilson. Conservation Biology 7:208-209.
- KROHN, W.B., and D.J. HARRISON. 1993. *Martes* research in Maine. *Martes Working Group Newsletter* 1(1):2-3.
- MOREAU D.A., and J.R. MORING. 1993. Refinement and testing of the Habitat Suitability Index model for Atlantic salmon. Final report to the U.S. Fish and Wildlife Service, Conte Anadromous Fish Research Center. 50pp.
- MORING, J.R. 1992. Book review of: "Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats", edited by W. R. Meehan. Western Journal of Applied Forestry 7(3):64.
- MORING, J.R., and R.A. HARTLEY. Tournament-related mortalities are linked to size of tournament, season, and species of bass. U.S. Fish and Wildlife Service, Research Information Bulletin No. 60, Washington, D.C. 2pp.
- PHILLIPS, D.M., T. CHAPIN, and K.D. ELWE. 1993. The American marten. Maine Fish and Wildlife 35(2):2-4.
- VANDER HAEGEN, M., and W.B. KROHN. 1992. Winter weather affects breeding energetics of American woodcocks. U.S. Fish and Wildlife Service, Research Information Bulletin No. 79, Washington, D.C. 2pp.
- WITHAM, J., M.L. HUNTER, JR., J. E. MOORE, A. KIMBALL, and A. WHITE. 1993. Long-term study of an oak-pine forest ecosystem: Techniques manual for the Holt Research Forest. Maine Agricultural Experiment Station Tech. Bull. 153. 164pp.

#### THESES AND DISSERTATIONS

- CARTWRIGHT, M.A. 1993. Movements and spawning success of displaced largemouth bass. Master of Science thesis, University of Maine, Orono. 77pp.
- HILLS, S. 1992. The effect of spatial and temporal variability on population assessment of Pacific walrus. Ph.D. Dissertation, University of Maine, Orono. 217pp.
- McKINLEY, D.B. 1992. Habitat use and selection by juvenile Atlantic salmon in two National Forest streams in Vermont and New Hampshire. Master of Science thesis, University of Maine, Orono. 109pp.
- MOORS, A.K. 1993. Towards an avian index of biotic integrity for lakes. Master of Science thesis, University of Maine, Orono. 199pp.
- MULLER-EL HAMZOU, R.M. 1993. A survey of bear hunters in Maine: do hunter characteristics affect opinions regarding hunting regulations? Final report, Master of Wildlife Conservation, University of Maine, Orono. 118pp.

- SPRUCE, J.P. 1993. Landsat TM data for mapping migrant landbird habitat in southern Belize. Master of Science thesis, University of Maine, Orono. 121pp.
- VAN DEN ENDE, O. 1993. Predation on Atlantic salmon smolts (*Salmo salar*) by smallmouth bass (*Micropterus dolomieu*) and chain pickerel (*Esox niger*) in the Penobscot River, Maine. Master of Science thesis, University of Maine, Orono. 95pp.
- VANDERPOOL, A.M. 1992. Downstream mortality of Atlantic salmon smolts in the Penobscot River, Maine. Master of Science thesis, University of Maine, Orono. 60pp.
- VERA, C.J. 1993. Effects of landspreading pulp and paper mill sludge in Maine forestland on wildlife populations. Master of Science thesis, University of Maine, Orono. 59pp.
- VICKERY, P. 1993. Habitat selection of grassland birds in Maine. Ph.D. Dissertation, University of Maine, Orono. 124pp.
- WHITMAN, A.A. 1992. Frugivory and seed dispersal of fleshy fruiting plants in a northern temperate forest. Master of Science thesis, University of Maine, Orono. 214pp.

#### PROFESSIONAL TALKS PRESENTED

- BOONE, R.B., and M.L. HUNTER, JR. "The use of individual-based models to examine landscape permeability." Conservation in Working Landscapes 20th Annual Natural Areas Conference, Orono, ME, March 23, 1993.
- BOONE, R.B., and W.B. KROHN "An analysis of biodiversity in Maine: GIS assessment of terrestrial vertebrate diversity." Poster presentation to the annual meeting of the Northeastern Society of American Foresters and the Maine Chapter of The Wildlife Society, April 20, 1993.
- CARTWRIGHT, M.A. "Movements of displaced largemouth bass (*Micropterus Salmoides*) in two central Maine lakes". Annual Meeting of the Atlantic International Chapter, American Fisheries Society, Rangeley, ME, September 20, 1993.
- CHILELLI, M., J.R. GILBERT, and A. O'CONNELL. "Population viability analyses of native mammals in Acadia National Park, Maine." 49th Annual Northeast Fish and Wildlife Conference, Atlantic City, NJ, April 18-21, 1993.
- COLE, M.B. Narrated a video on smallmouth bass at the Annual Meeting of the Atlantic International Chapter, American Fisheries Society, Rangeley, ME, September 19, 1993.
- DE MAYNADIER, P., and M.L. HUNTER, JR. "The role of keystone ecosystems in landscape ecology." The Natural Areas Conference, University of Maine, Orono, June 1993.
- ELLIOTT, C.A. Chaired session entitled "Enhancing wildlife habitat through forest management" at Nurturing the Northeastern Forest: A Conference on Stewardship in a Changing Culture, Portland, ME, March 3-5, 1993.
- ELLIOTT, C.A. "The Coverts Project in Maine -- Progress Report." Paper presented at the Coverts Regional Symposium, Grafton, VT, May 6, 1993.

- ESCHHOLZ, W.E., K.S. RAYMOND, F.A. SERVELLO, and D.B. GRIFFITH. "Effects of glyphosate use on winter habitat and nutritional ecology of moose in Maine." Poster presented at the 49th Northeast Fish and Wildlife Conference, Atlantic City, NJ, April 19-22, 1993.
- GRAY, P.B., and F.A. SERVELLO. 1993. "Relationship of diet digestible energy to food intake in white-tailed deer: Implications for assessing winter food availability." Poster presented at the 49th Annual Northeast Fish and Wildlife Conference, Atlantic City, NJ, April 19-22, 1993.
- HARRISON, D.J. "Interactions among marten populations, forest harvesting and research: a review of ongoing research." National Council of the Paper Industry for Air and Stream Improvement, Greenville, ME, October 6, 1992.
- HARRISON, D.J., D.D. KATNIK, and K.D. ELWE. "Habitat selection by martens: landscape implications for a forest specialist." Nurturing the Northeastern Forest: A Conference on Stewardship in a Changing Culture, Portland, ME, March 3-5, 1993.
- HARRISON, D.J. "A landscape level approach to habitat quality assessment: a case study with American martens." Paper presented at Workshop on Methodology for Deriving Quantitative Definitions of Forest Wildlife Habitat, New Brunswick Department of Natural Resources and Energy, Fredericton, March 15, 1993.
- HARRISON, D.J. "Habitat selection by wide-ranging carnivores: at what scale should we measure?" Department of Wildlife Seminar, University of Maine, Orono, May 3, 1993.
- HARRISON, D.J. "A landscape approach for assessing habitat relationships of forest carnivores." Paper given at the International Union of Game Biologists XXI Congress - Forests and Wildlife, Halifax, Nova Scotia, August 19, 1993.
- HARTLEB, C.F. "The effects of a thermocline and light gradients on the feeding behavior of pumpkinseed sunfish (*Lepomis gibbosus*)." University of New Hampshire Seminar Series, Durham, NH, November 18, 1992.
- HIGGINS, J.C., F.A. SERVELLO, and A.F. O'CONNELL. "Population and habitat of flying squirrels in Acadia National Park, Maine." Poster presented at the 49th Northeast Fish and Wildlife Conf., Atlantic City, NJ, April 19-22, 1993.
- HODGMAN, T.P., D.J. HARRISON, D.D. KATNIK, and K.D. ELWE. "Survival of martens under intense trapping pressure in Maine." Poster presentation at the International Union of Game Biologists XXI Congress - Forests and Wildlife, Halifax, Nova Scotia, August 19, 1993.
- HUNTER, M.L., JR. "Forest diversity in time and space." USDA Forest Service, Clemson University, SC, September 25, 1992.
- HUNTER, M.L., JR. "Biodiversity and forest management." Bureau of Indian Affairs, Bangor, ME, October 16, 1992.
- HUNTER, M.L., JR. "New forestry in New England." Joint conference of Society of American Foresters and The Wildlife Society, Portland, ME, March 3, 1993.
- HUNTER, M.L., JR. "A triad approach to land use allocation." Resources Nepal Forum, Kathmandu, Nepal, April 2, 1993.

- HUNTER, M.L., JR. "Lessons for conservation from paleoecology." Bowdoin College Biology Department Seminar, Brunswick, ME, April 29, 1993.
- HUNTER, M.L., JR. "Biodiversity inventories with volunteers: the Maine Amphibian and Reptile Atlas Project." Society for Conservation Biology Conference, Phoenix, AZ, June 10, 1993.
- HUNTER, M.L., JR. "Biodiversity in the marine realm." Darling Marine Center, Walpole, ME, June 15, 1993.
- HUNTER, M.L., JR. "Biological diversity in managed forests." Natural Areas Conference, University of Maine, Orono, June 23, 1993.
- HUNTER, M.L., JR. "The effects of forest fragmentation on the distribution and movement of birds." International Union of Game Biologists Congress, Halifax, Nova Scotia, August 16-18, 1993.
- HUNTER, M.L., JR. "The biological landscape." Creating a forestry for the 21st century, Portland, Oregon, August 24, 1993.
- JONES, M.T., and R.J. O'CONNOR. "Land use patterns and population fluctuations of North American landbirds." Annual meeting of the American Society of Zoologists, Vancouver, British Columbia, December 30, 1992.
- JONES, M.T. "Spatio-temporal patterns of avian species richness in New England." Conservation in Working Landscapes, 20th annual Natural Areas Conference, University of Maine, Orono, June 22-26, 1993.
- KATNIK, D.D., D.J. HARRISON, and T.P. HODGMAN. "Landscape--and stand-level habitat selection by American martens on commercial forestland in Maine." Paper presentation at the International Union of Game Biologists XXI Congress - Forests and Wildlife, Halifax, Nova Scotia, August 19, 1993.
- KROHN, W.B., R. ALLEN, J. MORING, and A. HUTCHINSON. "Double-crested cormorants in New England: Population and management histories." Slide presentation at the Conference on Biology and Management of the Double-crested Cormorant. University of Mississippi, Oxford, October 14-17, 1992.
- KROHN, W.B., R.B. BOONE, and K.D. ELWE. "Relations among fishers, snow, and martens: development and evaluation of two hypotheses." Slide presentation at the International Union of Game Biologists XXI Congress - Forests and Wildlife, Halifax, Nova Scotia, August 19, 1993.
- McCALL, T., T.P. HODGMAN, and R.B. OWEN, JR. "Dynamics of beaver populations in relation to wetlands and waterfowl in south-central Maine." Poster presentation given at Nurturing the Northeastern Forest: A Conference on Stewardship in a Changing Culture, Portland, ME, March 3-5, 1993.
- McCALL, T., T.P. HODGMAN, and R.B. OWEN, JR. "Dynamics of beaver populations in relation to wetlands and waterfowl in south-central Maine." Northeast Fish and Wildlife Conference, Atlantic City, NJ, April 19-22, 1993.
- MOORS, A. "Birds as an index of biotic integrity of lakes in New England." Northeast Wildlife Graduate Student Conference, February 5-7, 1993.

- MOREAU, D.A., and J.R. MORING. "A habitat suitability index model for holding pools of adult Atlantic salmon." Annual Meeting of the Atlantic International Chapter, American Fisheries Society, St-Gregoire, Quebec, September 27, 1992.
- MORING, J.R., and P.H. NICHOLSON. "Attraction of fishes to artificial habitat in a Maine pond." 1993 Northeast Fish and Wildlife Conference, Atlantic City, NJ, April 19, 1993.
- MORING, J.R. "Seasonal changes in environmental conditions and fish communities in two Maine tidepools." Annual Meeting of the American Society of Ichthyologists and Herpetologists, Austin, TX, May 30, 1993.
- MORING, J.R. "Angling effort in streams stocked with catchable-size rainbow trout: effects on catch rates and catches of wild salmonids." Annual Meeting of the American Fisheries Society, Portland, OR, August 29, 1993.
- O'CONNOR, R.J. "An ecological perspective of avian pesticide field studies." Avian radio telemetry in support of pesticide field studies - a Pellston Workshop sponsored by the Society for Environmental Toxicology and Chemistry, Asilomar, CA, January 6-8, 1993.
- OWEN, R.B., JR. "Introduction to Maine and the University." Conservation in Working Landscapes, 20th annual Natural Areas Conference, University of Maine, Orono, June 22-26, 1993.
- OYLER, S.J. "Conservation strategies and reserve designs for rare plants." Conservation in Working Landscapes, 20th annual Natural Areas Conference, University of Maine, Orono, June 22-26, 1993.
- SERVELLO, F., W. ESCHHOLZ, and K. RAYMOND. "Herbiciding for softwood release: enhancing moose habitat." Joint conference of Society of American Foresters and The Wildlife Society, Portland, ME, March 3, 1993.
- SERVELLO, F., W. ESCHHOLZ, and K. RAYMOND. 1993. "Softwood release with herbicides: Enhancing moose habitat?" Joint conference of Society of American Foresters and The Wildlife Society, Portland, ME, March 3, 1993.
- VERA, C.J., F.A. SERVELLO, and J.SHEEHAN. "Effects of landspreading pulp and paper mill sludge in Maine forestland on wildlife populations." Poster presented at the 49th Northeast Fish and Wildlife Conference, Atlantic City, NJ, April 19-22, 1993.
- VERA, C.J., F.A. SERVELLO, and J. SHEEHAN. "Effects of landspreading pulp and paper mill sludge in Maine forestland on wildlife populations." Poster presented at Joint conference of Society of American Foresters and The Wildlife Society, Portland, ME, March 3, 1993.
- VICKERY, P. "Habitat and area requirements of grassland birds in Maine." Grasshopper Sparrow Workshop, Avon Park Air Force Base, Avon Park, FL., March 11, 1993.
- VICKERY, P., and S. MELVIN. "Area and habitat requirements of grassland birds in Maine." Workshop on Regionally Threatened Grassland Birds of New England and Long Island, Massachusetts Audubon Society, S. Natick, MA, February 26, 1993.
- WHITCOMB, S.D. "Population ecology of spruce grouse on Mount Desert Island, Maine." Northeast Wildlife Graduate Student Conference, Durham, NH, February 5-7, 1993.

- WHITCOMB, S.D., F.A. SERVELLO, and A.F. O'CONNELL. "Population ecology of spruce grouse on Mount Desert Island, Maine." Northeastern Fish and Wildlife Conference, Atlantic City, NJ, April 19-22, 1993.
- WHITCOMB, S.D., F.A. SERVELLO, and A.F. O'CONNELL. "Population ecology of spruce grouse on Mount Desert Island, Maine." Seventh annual meeting of Society for Conservation Biology, Tempe, AZ, June 9-13, 1993.
- WHITCOMB, S.D., F.A. SERVELLO, and A.F. O'CONNELL. "Population ecology of spruce grouse on Mount Desert Island, Maine." Poster presented at the Natural Areas Conference, University of Maine, Orono, June 23, 1993.
- WHITCOMB, S.D., F.A. SERVELLO, and A.F. O'CONNELL. "Patch occupancy and fall dispersal of spruce grouse." Seventh annual meeting of Society for Conservation Biology, Tempe, AZ, June 9-13, 1993.
- WHITCOMB, S.D., F.A. SERVELLO, and A.F. O'CONNELL. "Population ecology of spruce grouse on Mount Desert Island, Maine." Poster presented at Joint conference of Society of American Foresters and The Wildlife Society, Portland, ME, March 3, 1993.
- WHITCOMB, S.D., F.A. SERVELLO, and A.F. O'CONNELL. "Population ecology of spruce grouse on Mount Desert Island, Maine." Poster presented at the 49th Northeast Fish and Wildlife Conference, Atlantic City, NJ, April 19-22, 1993.

#### PUBLIC TALKS PRESENTED

- BLACKWELL, B. "Ecology of the double-crested cormorant in the Penobscot River ecosystem." Veazie Salmon Club, Veazie, ME, November 18, 1992.
- BLACKWELL, B. "Ecology of the double-crested cormorant in the Penobscot River ecosystem - with emphasis on predation of Atlantic salmon smolts." Progress report presented to the Technical Advisory Committee of the Maine Atlantic Sea-Run Salmon Commission, Augusta, ME, January 21, 1993.
- BLACKWELL, B. "Ecology of the double-crested cormorant in the Penobscot River ecosystem." Holbrook Island Sanctuary, Maine Dept. of Conservation, S. Brocksville, ME, July 11, 1993.
- BOONE, R.B. "Common birds of the Pacific Northwest." Talk given to Danebo Grade School Third Grade Class, Eugene, OR, May 11, 1993.
- BOONE, R.B. "Simulating grizzly bear movements through Trail Creek watershed, Montana, using diffusion models." Department of Wildlife, University of Maine, Orono, September 27, 1993.
- CARTWRIGHT, M.A. "Movements of displaced largemouth bass." Zoology Department Colloquium seminar, University of Maine, September 25, 1992.
- CARTWRIGHT, M.A. "Movements of displaced largemouth bass." Meeting of the Maine Department of Inland Fisheries and Wildlife, Fish Division, Orono, ME, February 11, 1993.

- CHAPIN, T., R.B. BOONE, and T.P. HODGMAN. "Wildlife research: defining habitat needs of Maine's pine marten." Maine Scholars' Days, Orono, ME, May 19, 1993.
- CHILELLI, M. "Population viability analysis of birds." Department of Wildlife, University of Maine, Orono, April 5, 1993.
- ELLIOTT, C.A. "The Coverts Project in Maine." Slide talk presented to the Penobscot County Conservation Association, Brewer, ME, Nov. 5, 1992.
- ELLIOTT, C.A. "Wild about wildlife." Two 1-hour sessions presented at the workshop Expanding Your Horizons in Science and Mathematics, sponsored by the University of Maine Cooperative Extension and held at the University of Maine, Orono, ME, March 9, 1993.
- ELLIOTT, C.A. "Careers in wildlife biology and management." Slide talk presented to 4-H members, leaders, and parents attending 4-H Day at the University of Maine, Orono, ME, April 3, 1993.
- ELLIOTT, C.A. "4-H Earth Connections Workshop." Three-hour workshop presented to students at the College of the Atlantic, Bar Harbor, ME, April 13, 1993.
- ELLIOTT, C.A. "Careers in wildlife biology and management." Four one-hour talks presented at the Searsport Middle School Career Day, Searsport, ME, May 14, 1993.
- ELLIOTT, C.A. "Project WILD Workshop." Six-hour workshop presented to participants in the Orono Mathematics and Science Summer Academy, University of Maine, Orono, July 6, 1993.
- ELLIOTT, C.A. "The Coverts Project in Maine Workshop." Three-day workshop to train Coverts Project Cooperators, conducted at Tanglewood 4-H Camp, Lincolnville, ME, August 26-29, 1993.
- ELLIOTT, C.A. "Dead and dying woody material: its importance to wildlife." Half-hour presentation to students at John Bapst High School, Bangor, ME, September 8, 1993.
- ELLIOTT, C.A. "Ecology, wildlife biology, and wildlife management." Four-hour slide talk and field session with participants at the University of Maine Cooperative Extension Forestry Camp, Tanglewood 4-H Camp, Lincolnville, ME, September 15, 1993.
- ELLIOTT, C.A. "Ecosystems and wildlife habitat." Three 1-hour presentations to students in Grades 4-6 participating in the First Annual Beacon Math/Science Camp, Houlton High School, September 22, 1993.
- ELLIOTT, C.A. "Wildlife in your woodlot." Slide talk presented at the Common Ground Fair, Winslow, ME, September 25, 1993.
- ELLIOTT, C.A. "Project WILD and 4-H Earth Connections Workshop." Six-hour workshop for Coverts Project Cooperators and other educators, Tanglewood 4-H Camp, Lincolnville, ME, September 26, 1993.
- GLASS, S.L. "Coyote and deer research on Mount Desert Island." Lions Club, Bar Harbor, ME, March 10, 1993.
- GLASS, S.L. "Coyote and deer research on Mount Desert Island." Town Hill Volunteer Fire Department, Town Hill, ME, April 10, 1993.

- GLASS, S.L. "Coyote and deer research on Mount Desert Island." Acadia National Park Administrative Staff, Acadia National Park, ME, April 15, 1993.
- GLASS, S.L. "Large animal capture and immobilization." University of Maine Wildlife Summer Camp, Acadia National Park, ME, May 14, 1993.
- GLASS, S.L. "Coyote and deer research on Mount Desert Island." Tenth grade science class, Mount Desert Island High School, ME, May 21, 1993.
- GLASS, S.L. "Coyote and deer research on Mount Desert Island." Rotary Club, Bar Harbor, ME, August 4, 1993.
- GLASS, S.L. Interview with Channel 7 News on coyote and deer research on Mount Desert Island, Bangor, ME, September 16, 1993.
- HARRISON, D.J. Interviewed November 1, 1992 by Associated Press for articles on coyotes in Maine that appeared in Portsmouth Herald, Sunday Sun-Journal (Lewiston), Maine Sunday Telegram, Portland Press Herald during November 1992.
- HARRISON, D.J. Interviewed with Wayne Reilly of Bangor Daily News for feature article on wildlife conservation in Maine's forests. The article entitled "Balancing act in the woods: Is Maine's spotted owl the pine marten?" appeared 11/21/92 in the Maine Weekend, Bangor Daily News.
- HARRISON, D.J. Interview with Milton Gross of Ellsworth American for an article on predator-prey research conducted by U of M at Acadia National Park, December 1, 1992.
- HARRISON, D.J. "The pine marten in Maine: could it be the next spotted owl?" Penobscot Chapter of the Maine Audubon Society, Brewer, February 5, 1993.
- HARRISON, D.J., D.M. PHILLIPS, and T. CHAPIN. Sponsored a "Media Day" and held a press conferences to discuss ongoing research with American martens. This resulted in news coverage on 4 television networks, 3 newspapers, and several radio stations. September 1, 1993.
- HARRISON, D.J., and S. GLASS. Television interview and filming of activities related to studies of white-tailed deer and coyote populations in Acadia National Park, Channel 7 (Bangor) on September 16, 1993.
- HARRISON, D.J. Conducted interviews with Maine Sunday Telegram, Portland Press Herald, Lewiston Sun-Journal, Providence Journal, and Associated Press regarding the occurrence of wolves in Maine, the identification of a recent wolf-like canid shot in northern Maine, and research at University of Maine on suitability of habitats in northern Maine to support wolves.
- HARRISON, D.J. Interviewed with Portland Press Herald for article on status of recently established coyote populations in southern Maine and with Bangor Daily News on coyote-deer interactions.
- HARRISON, D.J. "The role and effectiveness of predator control to enhance game populations." Spring meeting of Maine Chapter of The Wildlife Society, Brewer.
- HARRISON, D.J. Served on a panel debating issues associated with restoring wolf populations to Maine. Sponsored by the Student Chapter and Maine Chapter of The Wildlife Society, April 5, 1993.

- HARTLEB, C. "The effects of a thermocline and light gradients on the feeding behavior of pumpkinseed sunfish (*Lepomis gibbosus*)." Zoology Department Colloquium seminar, University of Maine, November 13, 1992.
- HOCKETT, K. "Response of Atlantic salmon fry to bird predators." Zoology Department Colloquium seminar, University of Maine, Orono, March 26, 1993.
- HODGMAN, T.P. "Western rangelands." Talk given to WLM 200, Ecology, University of Maine, Orono, December 2, 1992.
- HODGMAN, T.P. "Summer jobs and graduate school in wildlife management." Talk given to University of Maine, Student Chapter of The Wildlife Society, University of Maine, Orono, November 11, 1992.
- HODGMAN, T.P. "A wildlife management career." Talk given to science class at Weatherbee Middle School, Hampden, ME, February 10, 1993.
- HODGMAN, T.P. "Herbivore food habits analysis." Talk and demonstration given to WLM 450, Wildlife Habitat Relationships, University of Maine, Orono, October 5 and 6, 1992.
- HODGMAN, T.P. "Principles of range management." Talk given to FTY 460, Managing Forests for Multiple Use, University of Maine, Orono, October 21, 1992.
- HODGMAN, T.P. "A wildlife biologist profile: what is a wildlife biologist?" A workshop presented during 4-H Teen Conference, University of Maine, Orono, February 20, 1993.
- HUNTER, M.L., JR. "Biodiversity in northern forests." Aiken's Lecture Series, University of Vermont, November 11, 1992.
- HUNTER, M.L., JR. "A triad approach to forest land use." Maine Forests Products Council, Old Town, January 14, 1993.
- HUNTER, M.L., JR. "What is biodiversity woodlot?" Owner's Forum, Ellsworth, ME, April 16, 1993.
- KROHN, W.B. Interviewed for a segment called "Secrets of the Fisher" describing the cooperative research ongoing at the University of Maine by the Maine Cooperative Fish and Wildlife Research Unit and the Maine Department of Inland Fisheries and Wildlife. Part of Maine's Fish and Wildlife, a weekly series appearing in fall 1993 on Maine Public Broadcasting.
- KROHN, W.B. "An overview of Atlantic salmon research at the Maine Cooperative Fish and Wildlife Research Unit." Progress report presented to the Technical Advisory Committee of the Maine Atlantic Sea-Run Salmon Commission, Augusta, ME, January 21, 1993.
- KROHN, W.B. Moderated a panel discussion on "Wolves in Maine - Is reintroduction (introduction) possible?" Sponsored by the Student Chapter and Maine Chapter of The Wildlife Society, April 5, 1993.
- MATZ, A., R.B. OWEN, JR., and A. O'CONNELL. "University of Maine researchers track bald eagles on coast." News release on Maine Public Radio, July 23, 1993.
- MCCALL, T., R.B. OWEN, JR., and T. HODGMAN. Interviewed for article on beaver research in June issue of Downeast magazine.

- MORING, J.R. "Fishes of Maine." John Graham School, Veazie, ME, October 8, 1992.
- MORING, J.R. "Great trails to the west." Bangor High School, Bangor, ME, April 9, 1993.
- MORING, J.R. "Ecology of tidepool fishes: adaptations to life in the intertidal zone." Upward Bound Summer Biology Program, University of Maine, Orono, June 30, 1993.
- MORING, J.R. Interviewed by Maine News Service for a radio news release on the Atlantic salmon fishing off Greenland. Interview was distributed to and broadcast on several Maine radio stations, August 6, 1993.
- MORING, J.R. Interviewed for a Maine Public Radio story on zebra mussels, September 24, 1993.
- MORING, J.R. Interviewed by the Morning Sentinel, September 29, 1993 for an Associated Press story on mussels later carried in the Bangor Daily News and two NBC affiliates.
- OWEN, R.B., JR. "International conservation." Bangor Rotary Club, Bangor, ME, December 8, 1992.
- OWEN, R.B., JR., and F. SERVELLO. Interviewed by the Maine Sunday Telegram for article "The Survivors" which appeared December 20, 1992.
- OWEN, R.B., JR. "Issues in international conservation." Altrusa Club, Bangor, ME, January 21, 1993.
- OWEN, R.B., JR. "Environmental quality, bald eagles, and public policy." College of Natural Resources, University of Rhode Island, S. Kingston, RI, April 16, 1993.
- OWEN, R.B., JR. "Students and wildlife professionals." Northeast Wildlife Student Conclave, S. Kingston, RI, April 18, 1993.
- OWEN, R.B., JR., and B. BURGASON. Conducted an ecology workshop at the Maine High Adventure Boy Scout Training Session, Matagamon Lake, ME, June 8 and 9, 1993.
- OWEN, R.B., JR. "Endowments for academic departments." Campaign for Maine Volunteers, Bangor, ME, June 16, 1993.
- OWEN, R.B., JR. "Contaminants in Maine eagles." Interview featured on Michigan Public Radio.
- OWEN, R.B., JR. and T. HODGMAN. "Maine beaver." Interview on National Public Radio, July 29, 1993.
- PHILLIPS, D.M. "Ecology of the American marten - Are populations in Maine stable?" Veazie Salmon Club, January 28, 1993.
- PHILLIPS, D.M. "Marten ecology and research in Baxter State Park and surrounding area." Maine Trappers Association - Central Maine Chapter, Palmyra, ME, March 3, 1993.
- PHILLIPS, D.M. "Marten ecology and research in Baxter State Park and surrounding area." Baxter State Park visitors and staff, August 3, 1993.
- VAN DEN ENDE, O. "Fish predators of Atlantic salmon smolts." Zoology Department Colloquium seminar, University of Maine, Orono, September 25, 1992.

- VAN DEN ENDE, O. "Fish predators of Atlantic salmon smolts." Meeting of the Technical Advisory Committee to the Maine Atlantic Sea-Run Salmon Commission, East Orland, ME, July 20, 1993.
- VICKERY, P. "Breeding ecology and conservation of regionally threatened grassland birds." Zoology Seminar Series, Connecticut College, New London, CT, November 5, 1992.
- VICKERY, P. "Habitat requirements and conservation needs of regionally threatened grassland birds." Massachusetts Bird Conference, Andover, MA, November 21, 1992.
- WELCH, L. "Environmental contaminants in Maine bald eagles." Veazie Salmon Club, Veazie, ME, January 25, 1993.
- WELCH, L. Interviewed by the Providence Phoenix (RI) for article on environmental contaminants in Maine bald eagles, April 30, 1993.
- WELCH, L. Interviewed by the Boston Globe for an article of environmental contaminants in Maine bald eagles. Article appeared in July 4 issue of Boston Globe Magazine, additional article appeared in Casco Bay Weekly.
- WELCH, L. "Endangered species and contaminants." Talk given to 6 classes of Dexter Middle School children during Earth Festival Activities.
- WELCH, L. Interviewed by the University of Maine "Snapshots" Program on contaminants in bald eagles, July 1, 1993.
- WELCH, L. Interviewed on WERU radio station on contaminants in Maine bald eagles, September 28, 1993.
- WELCH, L. Interviewed by the Manchester Union Leader, Manchester, New Hampshire, about environmental contaminants in Maine bald eagles, September 30, 1993.
- WHITCOMB, S.D. "Status of spruce grouse research on Mount Desert Island, ME." Talk given to Dick Hayden, Asst. Secretary of the Interior, at Acadia National Park, ME, January 26, 1993.
- WHITCOMB, S.D., "Population ecology of spruce grouse on Mount Desert Island, Maine." Talk given at 55th annual Sportsman's Show, Orono, ME, March 5, 1993.
- WHITCOMB, S.D., "Status of spruce grouse on Mount Desert Island." Talk given to Advanced Biology Class, Mount Desert Island High School, ME, May 12, 1993.
- WHITCOMB, S.D. "Population ecology of spruce grouse on Mount Desert Island." Talk given to Downeast Chapter of Audubon Society, Southwest Harbor, ME, July 15, 1993.

#### AWARDS, HONORS, AND APPOINTMENTS

- CARTWRIGHT, M.A. Received the Horace Bond Fisheries Scholarship from the Penobscot County Conservation Association.
- ELLIOTT, C.A. Elected President of the Maine Chapter of The Wildlife Society, April 1992.

FOSS, C. Received a Switzer Environmental Fellowship, and is the third University of Maine student to do so since the program's inception in 1988.

HUNTER, M.L., JR. Appointed to Editorial Board of Conservation Biology.

MOORS, A. Received the George F. Dow and Fred Griffiee Scholarship given by the Maine Agricultural Experiment Station for outstanding research, December 17, 1992.

MORING, J.R. Received a Special Achievement Award from the U.S. Fish and Wildlife Service.

MORING, J.R. Elected Northeastern Division representative for the Early Life History Section, American Fisheries Society.

OWEN, R.B., JR. Elected representative from the Northeast Section of The Wildlife Society to the Wildlife Society Governing Council, January 1993.

OWEN, R.B., JR. Elective Vice-President, Maine Nature Conservancy, Fall 1992.

OWEN, R.B., JR. Received an award for professional achievement from the Maine Chapter of The Wildlife Society, April 5, 1993.

VICKERY, P. Awarded \$20,000 grant contract from the Nature Conservancy (Florida Chapter) to determine habitat requirements of the federally endangered Florida Grasshopper Sparrow.

VICKERY, P. Awarded \$25,000 Switzer Environmental Leadership Grant jointly with the Massachusetts Audubon Society.

