

**DEPARTMENT OF WILDLIFE ECOLOGY AND  
MAINE COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT**

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University of Maine

Maine Department of Inland Fisheries and Wildlife

U.S. Geological Survey- Biological Resources Discipline

Wildlife Management Institute



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Compiled and Edited by  
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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 Leader, Maine Cooperative Fish and Wildlife Research Unit, and Chair, Department of Wildlife Ecology.

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## PERSONNEL AND COOPERATORS

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### Dissertations and Theses Completed this Period

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Emily G. Schilling	Ph.D.	MOHF, MDIFW, WLE, SBE, NSFRF, MCFWRU

### Personnel Notes

**FREDERICK BEAUDRY** received his Ph.D. degree in Wildlife Ecology in December 2007 and is currently working as a Post-doctoral Research Associate for the University of Wisconsin–Madison, Department of Forest and Wildlife Ecology.

**SEAN BLOMQUIST** received his Ph.D. degree in Wildlife Ecology in May 2008 and is currently working as a Post-doctoral Associate for Tennessee Tech University, Biology Department.

**STEPHEN FERNANDES** received his M.S. degree in EES in August 2008 and is currently working as a water quality specialist for the Montana Department of Environmental Quality.

**NATALIA POLITI** received her Ph.D. degree in Wildlife Ecology in May 2008 and is currently a Professor of two undergraduate Biology licentiate courses: Vertebrates and Conservation Biology at the National University of Jujuy.

**EMILY SCHILLING** received her Ph.D. degree in EES in August 2008 and is currently exploring post-doctoral research opportunities and completing manuscripts from her dissertation research.

## Collaborating Agencies and Organizations

American Philosophical Society	APS
American Society of Ichthyologists and Herpetologists	ASIH
Androscoggin River Watershed Council	ARWC
Centro de Ecologia Aplicada and CONAMA (National Environment Commission)	CEACONAMA
Environmental Solutions Initiative, Senator George J. Mitchell Center	ESI
Fulbright and State Organization of the Americas	FSOA
Houlton Band of Maliseet Indians	HBMI
Huber Resources Corporation	HRC
Lowe's Home Center, Inc.	LHC
Maine Agricultural and Forest Experiment Station	MAFES
Maine Atlantic Salmon Commission	MASC
Maine Audubon Society	MAS
Maine Bureau of Parks and Lands	MBPL
Maine Department of Environmental Protection	MDEP
Maine Department of Inland Fisheries and Wildlife	MDIFW
Maine Department of Marine Resources	DMR
Maine Department of Transportation	MDOT
Maine Forest Service, Policy and Management Division	MFS
Maine Outdoor Heritage Fund	MOHF
Manomet Center for Conservation Sciences	MCCS
National Audubon Society	NAS
National Council on Air and Stream Improvement	NCASI
National Fish and Wildlife Foundation	NFWF
National Marine Fisheries Service	NMFS
National Oceanic and Atmospheric Administration	NOAA
National Park Service	NPS
National Science Foundation	NSF
National Science Foundation - Research Fellowship	NSFRF
New Hampshire Department of Environmental Services	NHDES
Norcross Wildlife Foundation	NWF
Senator George J. Mitchell Center for Environmental and Watershed Research	CEWR
Stantec, Inc.	STAN
The Nature Conservancy	TNC
The Nature Conservancy - Maine Chapter	TNCME
Town of Newry	NEWRY
Trout Unlimited	TU
U.S. Environmental Protection Agency	EPA
United Nations Educational, Scientific, and Cultural Organization	UNESCO
University of Georgia - Savannah River Ecological Laboratory	SREL
University of Maine	UM
University of Maine - Alumni Association	UMAA
University of Maine - Association of Graduate Students	AGS
University of Maine - Department of Wildlife Ecology	WLE
University of Maine - Ecology and Environmental Sciences Program	EES
University of Maine - Maine Cooperative Forestry Research Unit	CFRU
University of Maine - McIntire-Stennis	MCS
University of Maine – School of Biology and Ecology	SBE
University of Maine – School of Forest Resources	FTY
University of Missouri	UMS
U.S. Fish and Wildlife Service	FWS
U.S. Fish and Wildlife Service – Eastern Brook Trout Joint Venture	FWS-EBTJV
USGS - Maine Cooperative Fish and Wildlife Research Unit	MCFWRU
USGS - Biological Resources Discipline	BRD
Wagner Forest, Sunday River Inn, Caribou Springs	WF

Wildlife Conservation Society  
WWF--World Wide Fund For Nature

WCS  
WWF



## ENDANGERED AND THREATENED SPECIES

### Road Mortality Risk for Spotted (*Clemmys gattata*) and Blanding's (*Emys blandingii*) Turtle Populations

*Investigator:* F. Beaudry

*Advisors:* M. L. Hunter, Co-chair  
P. G. deMaynadier, Co-chair  
J. M. Rhymer  
D. J. Harrison  
D. Hiebeler

*Cooperators/  
Project Support:* Maine Department of Transportation  
University of Maine - Department of Wildlife Ecology  
Maine Department of Inland Fisheries and Wildlife  
Maine Outdoor Heritage Fund  
U.S. Fish and Wildlife Service  
US Environmental Protection Agency  
The Nature Conservancy  
Norcross Wildlife Foundation

*Objectives:*

- 1) Evaluate habitat selection and seasonal movement patterns of spotted and Blanding's turtles in Maine.
- 2) Develop a GIS-based model to identify turtle-road hotspots, which will allow targeting current mitigation needs and modeling avoidance planning during future projects.
- 3) Develop a predictive model of spotted and Blanding's turtle persistence and road mortality rates linked to a spatially-explicit population viability analysis.
- 4) Complete a comprehensive review of road conservation mitigation options suitable for endangered turtles in southern Maine.

#### SCOPE

Recent population analyses of several freshwater turtle species indicate that as little as 2-3% additive annual mortality of adults is unsustainable, leading ultimately to local population extinction. As such, road-kill may prove to be the single most important factor threatening the extinction of the Spotted (*Clemmys gattata*) and Blanding's (*Emys blandingii*) turtle in Maine. There is increasing emphasis on the part of federal and state transportation authorities to minimize and mitigate impacts to wildlife populations from road construction and improvement projects. To this end, the project objectives outlined above are designed to help identify the extent and significance of road impacts to endangered turtles in Maine as a precursor towards a) designing strategic mitigation measures for problem road sections, and b) identifying remaining roadless remnants of the landscape where long term turtle population viability remains highest.

#### PROJECT STATUS

All requirements for a PhD were met in December 2007. The abstract of the dissertation follows:

The life history strategy of long-lived turtle species and their movement ecology make them especially vulnerable to evolutionary novel sources of adult mortality such as roadkill. Declining throughout their range, spotted (*Clemmys gattata*) and Blanding's turtles (*Emydoidea blandingii*) are exposed to high road densities in southern Maine, where individuals visit a large number of wetlands yearly. To better understand the mechanisms influencing these movements and the associated road mortality risk, I examined spotted and Blanding's turtle seasonal habitat use at the wetland scale. Significant variables associated with wetland use reflected seasonal differences in needs for food resources, thermoregulation and cover and were often best captured by productive, longer-hydroperiod vernal pools.

Based on inter-wetland movement characteristics at three spatial scales, I then examined the spatial distribution of roadkill risk for spotted and Blanding's turtles. Movement tortuosity at the scale of a single movement event demonstrated high spatial variability, potentially limiting the effectiveness of mitigation measures implemented at very fine spatial scales. A gravity model of wetland interactions identified road mortality hot spots at the road segment scale, and a spatially explicit population viability analysis revealed that demographic risk varied widely among populations. Road segment and population scale mitigation interventions are most likely to be effective.

Road mortality risk varied not only spatially, but also temporally. To identify periods of high mortality risk, or hot moments, and assess their consequences at the population level, factors influencing risk were identified and integrated in

viability simulations. A road mortality hot moment for Blanding's turtles in Maine is late June, in part because of the longer movements by females during that period. These findings assist in the implementation of temporally-explicit road mitigation measures.

Finally, specific approaches to road mortality mitigation for amphibians and reptiles were reviewed including tunnels, overpasses, barrier fencing, road signage, and other methods. While many of these mitigation strategies are becoming increasingly popular for reducing road mortality risk, few have been tested for success. A science-based approach to determining project locations, the use of mitigation measures appropriate for the targeted species, and a well-designed evaluation of the projects effectiveness will maximize positive conservation returns.

### **Spatial and Temporal Dynamics of Habitat Supply for Canada Lynx (*Lynx canadensis*) and American Martens (*Martes americana*) on Commercial Forestlands in Maine**

*Investigator:* E. Simons

*Advisors:* D. J. Harrison, Co-chair  
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*Cooperators/  
Project Support:* University of Maine - Department of Wildlife Ecology  
USGS - Maine Cooperative Fish and Wildlife Research Unit  
U.S. Fish and Wildlife Service  
Maine Department of Inland Fisheries and Wildlife  
University of Maine - Maine Cooperative Forestry Research Unit  
Maine Agricultural and Forest Experiment Station  
National Council on Air and Stream Improvement  
University of Maine – School of Forest Resources  
The Nature Conservancy - Maine Chapter  
Huber Resources Corporation

*Objective:*

- 1) Develop a retrospective time series (1988-2004) of predicted occurrence for Canada lynx and American martens in northern Maine.
- 2) Evaluate and compare spatial and temporal variability in the broad-scale pattern of predicted occurrence of Canada lynx and American martens in northern Maine, and correlate spatio-temporal variation to landscape change due to past forest management.
- 3) Develop a set of future (25+ years) time series based on alternative future forest management scenarios exploring tradeoffs between fiber and wildlife habitat objectives.
- 4) Determine how future (25+ years) forest management may affect the township-scale pattern and spatial variability of Canada lynx and American martens habitat supply and predicted occurrence in Maine.

#### **SCOPE**

This project will use predictive species occurrence models to evaluate the effects of forest management on the spatio-temporal dynamics of habitat quantity and distribution for the Canada lynx (*Lynx canadensis*) and the American marten (*Martes americana*) in northern Maine. Forest management affects both stand- and landscape-scale forest structure, the combined effects of which will have short- and long-term consequences for forest dependent wildlife, such as lynx and martens. Because both species are area sensitive and are known to respond to landscape change at large spatial scales, it is important to evaluate habitat change at a large-scale. Managing for a species' habitat should incorporate enough area to allow for a relatively constant supply of habitat, even though it may move around on the landscape as a result of landscape change. Also, one can expect that patterns of lynx and marten occupancy will be affected differentially by landscape change because of dissimilarities in their habitat requirements.

Maine in particular provides an interesting setting for studying the effects of forest management on landscape change and on lynx and marten habitat supply because Maine is greater than 90% forested, and the vast majority (97%) of Maine's forestlands are privately owned. Consequently, changes to regulations governing timber-harvesting practices can affect the entire area occupied by lynx and martens in Maine. Following the 1989 Maine Forest Practices Act (MFPA), trends in

commercial timber harvesting have shifted towards increasing reliance on partial harvesting in Maine's Acadian Forest. Partial harvests now account for approximately 96% of the annual harvest. Lynx, along with its primary prey the snowshoe hare (*Lepus americanus*), are associated with early-successional forest, the availability of which has likely decreased since the implementation of the MFPA and the reduction in the total area being clear-cut annually. Martens in Maine have been shown to use a variety of mid- to late-successional forest types, but there is a threshold, defined by 30% canopy closure and 18 m<sup>2</sup>/ha basal area, below which martens are considerably less likely to use a forest stand. Partial harvests may result in the loss of the within-stand vertical and horizontal structure martens require.

This project will use both satellite imagery and stand-scale forest simulation to determine how forest management affects the habitat supply of lynx and martens in Maine, and to provide a tool for forest managers to use in managing for lynx and marten habitat in the future. In collaboration with two laboratories in the School of Forest Resources, we will develop two time series datasets that will be used as the basis for applying logistic regression models for predicting probability of occurrence by lynx and martens. We will develop a retrospective time series (1988-2004) of species occurrence maps based on Landsat Thematic Mapper (TM) satellite imagery classified according to the Maine GAP land cover map and modified using NDVI-based change detection techniques to identify harvests. We will also develop a prospective time series of species occurrence maps based on the projections of stand maps for select townships 25-50 years into the future given a range of future management scenarios. With these time series, we can determine the short- and long-term effects of forest management on the pattern and spatial variability of predicted occurrence of lynx and martens. By evaluating specific alternative forest management strategies, this analysis will allow us to make recommendations to forest managers concerning the maintenance or creation of lynx and marten habitat. In evaluating the spatio-temporal dynamics of lynx and marten habitat supply in Maine, this project will provide a better understanding of the relationships between forest management, landscape change, and occurrence patterns of wide ranging forest carnivores.

#### PROJECT STATUS

The satellite-based retrospective time series analyses for lynx and marten habitat supply 1973-2007 have been completed. Development of the satellite-derived stands maps used in the future projections of lynx and marten habitat supply and the first set of projections of forest structure under alternative forest management scenarios are also complete.

#### FUTURE PLANS

We are currently evaluating the effects of the alternative forest management scenarios on lynx and marten habitat supply. The expected completion date of this project is May 2009.

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### Taxonomic and Population Status of the Clayton's Copper Butterfly (*Lycaena dorcas claytoni*)

*Investigator:* E.S. Knurek

*Advisors:* J.M. Rhymer, Co-chair  
F.A. Drummond, Co-chair  
C.S. Loftin

*Cooperators/  
Project Support:* Maine Outdoor Heritage Fund  
Maine Department of Inland Fisheries and Wildlife  
U.S. Fish and Wildlife Service  
The Nature Conservancy  
American Philosophical Society

*Objective:*

- 1) Determine taxonomic status of Clayton's copper butterfly as a distinct subspecies from the nominate Dorcas copper, through morphological and genetic analyses and comparison with nominate species and other closely related Lycaenids.
- 2) Estimate size of Clayton's copper subpopulations in Maine, and establish a baseline for future population monitoring.

#### SCOPE

Clayton's copper butterfly (*Lycaena dorcas claytoni* Brower) was first discovered in Maine and described as a distinct subspecies in 1940, morphologically different and geographically isolated from the nominate subspecies, Dorcas copper (*Lycaena dorcas dorcas* Kirby) and other closely related Lycaenids. In 1997, Clayton's copper was listed as endangered in

Maine because it is known from few sites statewide, is found in abundance at only 1-2 sites, occurs only in an uncommon habitat type, and its entire global range is nearly confined to Maine.

Basic information about Clayton's copper taxonomy and population status is necessary to effectively manage this endangered species. The subspecific status of Clayton's copper is in question, especially since the taxonomic distinction between Clayton's copper and Dorcas copper has never been quantified. This taxonomic uncertainty must be resolved to delineate appropriate management units for conservation. Additionally, except for at Maine's largest site, censuses to estimate population size have never been done. Without development of a baseline population estimate, species status cannot be accurately assessed, trends cannot be monitored, and recovery goals cannot be developed.

This study will conduct detailed morphological and genetic analyses to determine if Clayton's copper is taxonomically distinct from Dorcas copper and develop population estimates, establishing a baseline for future population monitoring. These data will aid in determining the national and global conservation status of Clayton's copper and informing conservation planning and recovery efforts.

#### *PROJECT STATUS*

Clayton's copper, Dorcas copper, Florus copper (*Lycaena dorcas florus*), Purplish copper (*Lycaena helloides*), and Bog copper (*Lycaena epixanthe*) specimens were collected for morphological and molecular genetic analyses. Clayton's copper specimens were obtained from six populations throughout Maine. Bog copper specimens from four locations where they co-occur with Clayton's copper in Maine and three locations in Minnesota. Dorcas copper specimens were obtained from four populations in Michigan and five in Minnesota. Florus copper specimens were obtained from three locations in Wyoming, two in Montana, and two in Colorado. Purplish copper specimens were obtained from two locations in Colorado and one location in Wyoming. Preliminary morphological measurements have been done for Clayton's and Dorcas copper museum specimens from the Smithsonian National Museum of Natural History and the Canadian National Collection of Insects, Arachnids and Nematodes, as well as on the location of vein intersections of bleached wings for recently collected specimens. To examine immature stages of Clayton's copper, larvae were collected and reared to adulthood in the laboratory and eggs were collected and photographed using scanning electron microscopy. Preliminary molecular genetic analysis indicates little difference in a portion of the mitochondrial gene cytochrome oxidase subunit 1 (COI) between Clayton's and Dorcas coppers. Clayton's copper populations were assessed using line-transect sampling at six sites throughout the flight period in Summer 2007 and eight sites in Summer 2008. Analysis of transect counts to derive population estimates for 2008 is currently underway.

#### *FUTURE PLANS*

Complete analysis of Summer 2008 transect counts and compare with Summer 2007, including analysis of temperature data across sites. Continue molecular and morphological laboratory work with collected specimens to distinguish Clayton's copper from other closely related butterflies, including specimens from Canada. Write thesis and defend by August 2009.

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### **Landscape Planning Initiative for Northern Maine Using Area Sensitive Umbrella Species: A Wildlife Habitat-Based Approach to Forestland Planning Across Large Ownerships in Northern Maine**

*Investigators:* A. K. Fuller  
D. J. Harrison  
W. B. Krohn

*Cooperators/  
Project Support* The Nature Conservancy  
USDA Natural Resources Conservation Service

*Objectives:*

- 1) Quantify and map current and past habitat conditions for marten and lynx across TNC ownerships.
- 2) Apply spatial optimization tools to harvesting plans to identify tradeoffs among lynx and marten habitat, forest management objectives, and special habitat features.
- 3) Quantify the net conservation benefit for lynx and marten relative to the baseline forest conditions (2009), a no-harvest option, and draft forest harvest plan developed by TNC foresters. Quantify, model, and map the anticipated habitat conditions for lynx and marten for the end of the 10-year plan (2009-2019).

*SCOPE:*

The Maine Chapter of The Nature Conservancy (TNC) is enrolled in the Healthy Forest Reserve Program of the USDA Natural Resources Conservation Service. Under this program, TNC proposes to manage their extensive forestlands in northwestern Maine consistent with providing adequate habitat for Canada lynx, a species of early forests, and the American marten, a species associated with mid-successional and older forests. Research at the University of Maine has shown that landscape-scale habitat conservation directed at these 2 species would disproportionately benefit 86% (n = 111) of vertebrate species co-occurring in the forests of northern Maine. The issue of providing habitats in managed forestlands consistent with providing both vertebrate biodiversity and forest products is an issue that extends throughout Maine and the Acadian forests of eastern North America where commercial forestry is a major economic activity. How exactly to provide a temporally and spatially dynamic matrix of habitats for both sustainable habitats and wood products is complex; thus, an operational method has not been developed. Ongoing research at the University of Maine has developed predictive models of occurrence for both lynx and marten based on landscape and stand-scale conditions. These tools provide the rough framework on which an interactive, habitat-based, moving matrix approach to forestlands planning could be developed. The goals of this project are to develop, implement, and evaluate a landscape-scale habitat-management system useful in sustainable management of the forestlands owned and managed by TNC and other interested participants of the Healthy Forest Reserve Program.

*PROJECT STATUS:*

We are developing a forest cover map of the TNC ownership based on 2004 Landsat Thematic Mapper (TM) satellite imagery. We used change detection work using the TM data (1988-2004) and Multispectral Scanner data (1973-1988) to evaluate biomass increase or decrease. Previous research at the University of Maine identified heavy and light harvest intensity classes using the magnitude of the normalized difference moisture index (NDMI) across the 1-3 year intervals. The NDMI is an equation using near-infrared and middle-infrared bands from the satellite imagery. We cross-walked the forest cover map to habitat currencies relevant to Canada lynx and American marten and compared the satellite-derived maps with the landowner forest cover maps to determine which map to use for all future modeling. This decision was based on three field visits in which we sampled 99 stands measuring variables important for marten and lynx (e.g., tree height, canopy closure, basal area). We contracted with James W. Sewall Company to provide photo interpretation of a sub-sample of areas that appeared to be problematic based on our field visits. This external contract is scheduled for completion in mid-November 2008. We will be using a combined approach by interfacing data from the time series (harvest information) with landowner forest cover maps (typing information) to develop a final vegetation map relevant to the habitat currencies important for martens and lynx. We have provided three project updates to sponsors to date (September 2007, December 2007, and May 2008).

*Future Plans:*

We will be using the Remsoft Spatial Planning System to translate forest harvest planning goals and alternatives into spatially-explicit management scenarios developed around lynx and marten habitat requirements. We will apply spatial optimization tools to identify tradeoffs among lynx and marten habitat and forest management objectives. The final report will include a 10-year management plan for TNC incorporating the habitat requirements of lynx and marten and fiber objectives. This project is scheduled for completion by 30 September 2009.

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**Variation in Snowshoe Hare Densities as Related to Forest Harvesting Practices and Canada Lynx Home Ranges**

*Investigator:* S.A. Scott

*Advisors:* D.J. Harrison, Co-chair  
W.B. Krohn, Co-chair  
W.B. Halteman  
W.J. Jakubas

*Cooperators/  
Project Support:* University of Maine – McIntire Stennis  
University of Maine – Maine Cooperative Forestry Research Unit  
U.S. Fish and Wildlife Service  
USGS - Maine Cooperative Fish and Wildlife Research Unit  
University of Maine – Department of Wildlife Ecology  
Maine Department of Inland Fisheries and Wildlife  
National Council for Air and Stream Improvement  
Maine Agricultural and Forest Experiment Station

- Objective:*
- 1) Understand the relationship between forest management, natural succession, and other exogenous population process on hare densities in the Acadian forest.
  - 2) Investigate the consequences of empirical changes in hare populations on the probability of lynx occurrences.
  - 3) Quantify the density of snowshoe hare in the home range of reproductive female lynx and determine the relationship between lynx home range size and changing hare density.

### *SCOPE*

Snowshoe hare (*Lepus americanus*) is the primary prey of Canada lynx (*Lynx Canadensis*) and is an important prey species for a number of other forest predators. Lynx population dynamics, survival, and recruitment are closely tied to snowshoe hare availability. Lynx and snowshoe hare populations in the boreal forest cycle with 8 to 11 year periodicity, 5 to 25 fold changes in amplitude, and geographic synchrony over large areas. The nature of lynx and snowshoe hare population dynamics in the contiguous U.S.A. is unclear, and whether or not hares and lynx cycle in the Acadian forest has not been studied. The Federally threatened species status of the lynx mandates that conservation efforts be developed to lead to recovery of the species. The importance of snowshoe hare in the diet of lynx necessitates that ecological relationships between snowshoe hare, lynx, and their habitats be considered in lynx conservation activities.

The largest population of lynx in the contiguous U.S.A. occurs in Maine. Timber harvesting is the predominant land use practice affecting lynx and snowshoe hare habitat. Harvest activities alter the composition and structure of forests, thereby affecting the quality and availability of snowshoe hare and lynx habitat. Forest practices have changed significantly since passage of the Maine Forest Practices Act in 1989, with recent harvests relying predominantly on partial harvest methods. Regenerating conifer forests generated from earlier clearcut practices have repeatedly been shown to contain the highest snowshoe hare densities. Future quality hare habitat may be limited due to low creation of regenerating conifer clearcuts and succession-induced changes to existing stands. The reduction in quality hare habitat will most likely result in lower snowshoe hare abundance, with possible negative consequences for lynx populations.

This research contributes to long-term investigations in to the effects of forest management on snowshoe hare density and aspects of Canada lynx ecology in the industrial forests of Maine. Previous studies have quantified stand-level snowshoe hare densities for specific forest types. This study will provide additional and up to date hare density estimates across four major forest types, provide a comprehensive analysis of the temporal and spatial patterns of hare density fluctuations, and quantify succession-induced changes in vegetation structure and the effects on hare density. Maine Department of Inland Fisheries and Wildlife (MDIFW) has been conducting a lynx research project which began in 1999 to document movements, survival, habitat use, and reproduction of lynx. Another study by MDIFW began in 2003 to document lynx occurrence across northern Maine. Results show a possible increase in adult mortality and a decline in lynx productivity since 2003. Lynx demographic changes, in combination with a recent observed decline in snowshoe hare densities, suggest that hare densities may have dropped below a critical threshold required for lynx reproduction and survival. Studies in other areas have documented an increase in lynx home range size during periods of decreased hare abundance. This study will use hare density data and results from the MDIFW lynx projects to investigate the consequences of fluctuating hare abundance on the density of hares within lynx home ranges, changes in the size of home ranges during low hare abundance, and the density of hares necessary for lynx reproduction.

### *PROJECT STATUS*

Hare density estimates were determined using biannual fecal pellet counts for four of the major forest types present on the landscape: 1) established regenerating conifer clearcuts; 2) partially harvested stands (including shelterwood and selection cut methods); 3) mature mixed deciduous-coniferous stands; 4) and mature deciduous stands. Surveys during May-June provide winter hare estimates and surveys during September-October provide summer estimates. I have completed hare fecal pellet counts for the winters of 2006-07 and 2007-2008, and the summers of 2006, 2007, and 2008. Counts were completed on 36 previously established survey grids in partial harvest (n = 21) and regenerating conifer (n = 15) stands in the Telos and Clayton study areas, and on newly established survey grids on second-growth mature coniferous (n = 7) and second-growth mature mixed deciduous-coniferous (n = 5) stands in the Telos study area.

I measured vegetation structure characteristics in all stands types and developed a photo catalog of all stands during the summer of 2008. Vegetation measurements in regenerating conifer stands will be used in an analysis of the consequences of forest succession on hare density. Data collection is complete for this research.

I have completed data analysis for objective 1 and began writing.

### *FUTURE PLANS*

I will complete the thesis early in 2009.

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## FISHERIES RESOURCES

### Alternative Methods for Enumerating Juvenile Atlantic Salmon (*Salmo salar*) and Studying Their Distribution in Maine Rivers

*Investigator:* S. L. Fleming

*Advisors:* K. E. Webster, Co-chair  
J. R. Trial, Co-chair  
J. F. Kocik  
J. Zydlewski

*Cooperators/  
Project Support:* Maine Atlantic Salmon Commission  
National Marine Fisheries Service  
USGS - Maine Cooperative Fish and Wildlife Research Unit

*Objectives:*

- 1) Test three alternative techniques for estimating juvenile Atlantic salmon populations in Maine rivers as possible replacements for electrofishing.
- 2) Develop density distributions of juvenile Atlantic salmon as related to physical parameters of sites.

#### SCOPE

Atlantic salmon populations in eight Maine rivers have been placed on the Endangered Species List. The common method of assessing stream populations of juvenile salmon is backpack electrofishing – a potentially harmful technique. This project observes juvenile Atlantic salmon in various river conditions using the less invasive techniques of snorkeling, streamside viewing, and overhead observation. In addition, while conducting the snorkeling technique, locations of fishes were flagged and density distributions for the site were analyzed.

#### PROJECT STATUS

All fieldwork has been completed and data are being analyzed.

#### FUTURE PLANS

A manual detailing method for conducting juvenile Atlantic salmon surveys using the snorkeling technique will be prepared for the Maine Atlantic Salmon Commission. A Master of Science thesis is expected to be completed in early 2009.

### The Critical Conflict between Brook Trout (*Salvelinus fontinalis*) and Smallmouth Bass (*Micropterus dolomieu*) in the Rapid River

*Investigator:* C. A. L. Jackson

*Advisors:* J. Zydlewski, Chair  
G. Zydlewski  
C. Loftin

*Cooperators/  
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit  
Maine Department of Inland Fisheries and Wildlife  
Maine Outdoor Heritage Fund  
Trout Unlimited

*Objectives:*

- 1) Describe the movements of juvenile brook trout, smallmouth bass, and Atlantic landlocked salmon in the Rapid River system.
- 2) Construct an artificial stream to observe and describe interactions between brook trout and smallmouth bass.
- 3) Develop a model to examine affects of hooking mortality on brook trout population

sustainability.

### SCOPE

The Rapid River in western Maine has supported one of the most prominent brook trout (*Salvelinus fontinalis*) fisheries in Maine. Illegally introduced smallmouth bass have quickly become a dominant ecological force in the Rapid River system and are believed to compete with the native brook trout. The nature and extent of the competition is poorly characterized, but thermal refuges may be a limiting resource for the Rapid River fish. This interaction is further complicated by the presence of landlocked Atlantic salmon (*Salmo solar*). A general overlap in habitat use by these three species may allow a complex inter-specific species competition. To identify regions of use by each of these three species, an intensive telemetry study was initiated in late spring 2005. Tracking and relocation of tagged individuals were accomplished on a weekly basis from initial tagging through the life of the tag.

In order to assess the effects of intensive fishing in this system, the effects of catch and release on native brook trout are also being evaluated. In coordination with the State, angler survey data are being used to model potential impacts of intense fishing pressures on age/class structure and survival risk.

### PROJECT STATUS

Juvenile brook trout, smallmouth bass (*Micropterus dolomieu*), and landlocked Atlantic salmon movement data were collected and have been analyzed. The mortality model (Objective 2) is currently being developed and tested

### FUTURE PLANS

A Master of Science thesis is expected to be completed in early 2009.

## **Evaluation of Dennys and Penobscot River Smolt (*Salmo salar*) Performance: Does Brood Stock Rearing Technique Affect Behavior and Physiology?**

*Investigator:* R. Spencer

*Advisors:* J. Zydlewski, Chair  
G. Zydlewski  
J. Trial  
J. McCleave

*Cooperators/  
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit  
Maine Atlantic Salmon Commission  
U.S. Fish and Wildlife Service

*Objectives:*

- 1) Compare the physiologic and development of smolts reared from Penobscot River brood stock (from seawater origin) and Dennys River brood stock (from domesticated parr).
- 2) Compare the development of migratory behavior in smolts reared from Penobscot River brood stock and Dennys River brood stock.

### SCOPE

In the Dennys River, efforts to boost adult recruitment through smolt (*Salmo salar*) stocking have had poor results. The question is why. Smolt to adult returns are clearly influenced by many variables that can, for hatchery fish, be categorized as being related to successful emigration or ocean survival. In a general sense, time at sea can be argued to be a commonality between systems within a region. Therefore, potential differences in the smolt experience need to be understood to promote survival.

Do these survival differences represent smolt-specific rearing practices or river-specific environmental conditions? Or could the rearing practices used to produce Dennys smolts simply produce poorly performing smolts? Smolts produced for the Dennys are unique in their production by necessity. Because of the minimal returns, brood stock are captured as parr and reared to adulthood in captivity (whereas in the Penobscot brood stock relies on adult returns). The influence of artificial husbandry techniques on the next generation remains poorly characterized. Smolt quality has been assessed in previous broods of Dennys fish using physiological indicators of smolt performance (McCormick, unpublished data) but migratory performance is difficult to quantify. Physiological parameters associated with smolting are clearly indirect indicators of performance potential. Simultaneous use of physiological and behavioral assessment could generate a clearer picture of smolting.

It is the goal of this study to directly compare the physiological and behavioral development of smolts reared from Penobscot River brood stock (from seawater origin) and Dennys River brood stock (from domesticated parr). This project is consistent with the priorities to evaluate stocking programs and fish quality repeatedly identified by the NRC and in the Draft Atlantic Salmon Recovery Plan. The work would be conducted at Green Lake National Fish Hatchery and still have direct implications for management practices. Specifically, the results of this study will help either identify smolt production as a potential concern or further focus attention on the environment of the Dennys system.

#### *PROJECT STATUS*

This study was carried out and completed in 2005.

#### *FUTURE PLANS*

A Master of Science thesis is expected to be completed in early 2009.

### **Investigation into the Distribution and Abundance of Atlantic Sturgeon (*Acipenser oxyrinchus*) and Other Diadromous Species in the Penobscot River, Maine**

*Investigators:* S. Fernandes

*Advisors:* G. Zydlewski, Co-chair  
M. Kinnison, Co-chair  
J. Zydlewski

*Cooperators/  
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit  
National Oceanic and Atmospheric Administration

*Objectives:* Determine the presence and seasonal distribution of Atlantic sturgeon in the Penobscot River.

#### *SCOPE*

Information about the presence and seasonal distribution of Atlantic sturgeon (*Acipenser oxyrinchus*) in the Penobscot River will be collected. This information is important to the ongoing status review on this species and will provide information that can be used to determine the effects of dam removal on the redistribution of diadromous species in the river.

This study will be concentrated on the Penobscot River from the mouth of the river to immediately below the Veazie Dam. The sturgeon research protocols developed by the National Marine Fisheries Service for studying Atlantic and short nose sturgeon will be followed. Gillnets and possibly trammel nets will be set in areas in which Atlantic sturgeon are believed to be present (either from anecdotal reports or in areas of suitable habitat). The study will be initiated in the fall of 2005 with initial assessments of likely habitat, planning of survey activities and possible test net developments. Full net surveys will commence in spring and summer 2006 and continue through fall during periods when water conditions permit safe capture and handling of sub adult and adult Atlantic sturgeon. Healthy sub adult and adult Atlantic sturgeon will be tagged with internal ultrasonic "acoustic" transmitters and will be tracked to determine seasonal distribution within the river.

#### *PROJECT STATUS*

All requirements for a Master's degree were met in August 2008. The abstract of the thesis follows:

There is historical evidence of the Penobscot River supporting an Atlantic (and likely shortnose) sturgeon population. Historically, the Penobscot River supported a population of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and likely shortnose sturgeon (*Acipenser brevirostrum*). Aside from fishery landings prior to the early 1900s, the status of these populations is largely unknown. This study was initiated in 2006 to address the presence, abundance, distribution, and movement patterns of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and shortnose sturgeon (*Acipenser brevirostrum*) in the Penobscot River system using capture and acoustic telemetry.

Thirty-five Atlantic sturgeon and 151 shortnose sturgeon were captured with stationary gill nets, measured, tagged, and released. A subset of 8 Atlantic and 40 shortnose sturgeon were implanted with acoustic transmitters and tracked using a passive array of acoustic receivers throughout the river, estuary and bay from June 2006 to November 2007 to examine movement patterns. Atlantic sturgeon moved into the estuary in the summer and concentrated into a 1.5 km reach until emigrating in the fall; Atlantic sturgeon did not overwinter in the estuary. Shortnose sturgeon were present year-round in

the estuary. An overwintering aggregation of shortnose sturgeon formed in the upper Penobscot estuary each year. They remained in this area from mid-October, 2006 to mid-April, 2007. In the spring fish all shortnose sturgeon left the overwintering site, moved downstream, and aggregated in the lower estuary. Many of these individuals moved upstream slowly as a group over the course of the summer to about 2 km downstream of the lowest dam in August before moving into the overwintering site. In the spring/early summer, shortnose sturgeon also immigrated and emigrated; emigration also occurred during a short window in the fall. In 2007 two Atlantic and ten shortnose sturgeon that had been acoustically-tagged in the Penobscot River system were detected by an acoustic array operated by the Maine Department of Marine Resources in the Kennebec River. Additionally, several shortnose sturgeon that had been tagged with PIT tags in the Kennebec River in 1998 and 1999 were recaptured in the Penobscot estuary in 2007. Since shortnose sturgeon are not known to make wide coastal migrations, this new information has important implications for management of populations throughout their range. For example, this is particularly important with reference to currently used abundance estimation techniques using closed system models. The information gathered in this study has provided previously unknown information regarding Atlantic and shortnose sturgeons in an unstudied part of their range. This is critical to listing/delisting decisions of both species, and also offers baseline data on these populations prior to a planned large-scale dam removal project that will make historical habitat available.

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### **Investigating the Decline of Whitefish (*Coregonus clupeaformis*) in Maine**

*Investigators:* D. Gorsky

*Advisor* J.E. Marsden  
J. Zydlewski  
Y. Chen  
L. Kling  
M. Kinnison

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

*Objectives:*

- 1) Understand the basic movement patterns of whitefish in key systems.
- 2) Compile historic data of whitefish presence and smelt introductions in Maine waters.
- 3) Assess the likelihood that smelt and whitefish are directly competing.

#### **SCOPE**

Lake whitefish (*Coregonus clupeaformis*) is a salmonid species with considerable fisheries importance in Maine. Many Maine lakes once had strong whitefish populations but over the past few decades creel survey and inventory data indicate a marked decline (Basely, personal communications). During this same period of time, smelt have been introduced into many of these waters. The correlation between these events has spurred concerns that smelt introductions are causal to the whitefish declines. The few systems with relatively robust populations (e.g., Clear Lake) are currently being tapped as a source of hatchery supplementation.

Approaches to address these three core objectives are in progress and are in close coordination and collaboration with MDIFW biologists.

#### **PROJECT STATUS**

This study has been initiated and movement data is in the process of being analyzed. Competition studies were initiated in 2007 and will be continued in 2009.

#### **FUTURE PLANS**

A Ph. D. dissertation is expected to be completed in 2010.

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### **Understanding the Competitive Interactions of Smallmouth Bass and Atlantic Salmon Juveniles**

- Investigators:* R. Wathen
- Advisor* S. Coghlan, Co-chair  
J. Zydlewski, Co-chair  
J. Trial
- Cooperators/  
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit  
Maine Department of Inland Fisheries and Wildlife  
University of Maine
- Objectives:*
- 1) Construct an artificial stream to study interactions of small mouth bass and salmon in a controlled setting.
  - 2) Conduct field surveys to assess the impact of small mouth bass on habitat selection of juvenile Atlantic salmon.

### *SCOPE*

Predation and direct competition by invasive small mouth bass are thought to significantly impact the population dynamics of Atlantic salmon in many Maine Rivers. The nature of this competition, however, is poorly characterized. An artificial stream comprised of a mixture of pool and riffle micro-habitats has been constructed at the Aquaculture Resource Center at the University of Maine. Juvenile salmon and smallmouth bass will be placed in this artificial stream where their movement, position choice, and feeding behavior will be observed (by video and through PIT tag identification) under different flow conditions. These data are necessary to determine potential effects of mitigation efforts.

In order to corroborate and augment studies in the laboratory, field assessment of habitat choice by Atlantic salmon has been carried out using snorkeling survey techniques. Open systems containing both species in sympatry and allopatry have been assessed; habitat choice information will be analyzed with respect to the density of smallmouth bass in the system. Furthermore, a controlled invasion experiment was conducted in the summer of 2008. This experiment examined the changes in habitat use of Atlantic salmon parr after juvenile smallmouth bass were introduced into the system. This experiment will be repeated in the summer of 2009.

### *PROJECT STATUS*

This study has been initiated in 2007. The artificial stream is completed and tests have been on-going since summer 2008. Field methods have been tested in 2007, and the first field season was conducted during the summer of 2008. A final field season will be completed by fall 2009.

### *FUTURE PLANS*

A Master of Science thesis is expected to be completed in 2010.

## **Changes in Fish Community Structure and Function in Response to Dam Removal in the Sedgeunkendunk Stream Watershed**

- Investigators:* C. Gardner
- Advisor* S. Coghlan, Co-chair  
J. Zydlewski, Co-chair  
Third TBD
- Cooperators/  
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit  
National Oceanic and Atmospheric Administration  
University of Maine
- Objectives:*
- 1) Quantify population abundance, biomass, and size structure of resident fish species in representative habitats/reaches in treatment sites (presumably affected by barrier removal) and control sites (presumably unaffected by barrier removal) both before and after dam removal takes place.
  - 2) Test for differences in fish community structure, total fish biomass, and secondary

- production attributable to barrier removal.
- 3) Conduct size-spectra analysis as an indicator for changing patterns of energy flow attributable to barrier removal.

### *SCOPE*

The manipulation and/or disturbance of an ecosystem can have numerous effects on both the biotic and abiotic constituents found within that ecosystem. Monitoring how the biotic and abiotic components respond to a manipulation and/or disturbance within their habitat is a critical component necessary for our understanding of ecosystem response to such changes. Additionally, because restoration projects can involve a combination of active and passive restoration techniques, each with some level of uncertainty, it is critical to implement a well-designed monitoring plan that may be re-evaluated at various intervals due to the temporal and spatial scales of restoration projects. This work is to develop an approach for monitoring restoration of the fish community in the Sedgeunkedunk watershed to be coordinated with a system-wide monitoring project already underway. This system is scheduled to have two dams removed in 2008 and 2009; if ecosystem response can be understood, then ultimately we may be able to increase our ability to manage Maine's native fish communities adaptively in such situations.

### *PROJECT STATUS*

This study has been initiated in 2007.

### *FUTURE PLANS*

A Master of Science thesis is expected to be completed in 2011.

## **Impacts of Riparian Characteristics on Terrestrial Invertebrate Input and Brook Trout Bioenergetics**

**AND**

## **Influence of Coarse Woody Debris Addition and Brook Trout Relocation on Stream Communities**

*Investigators:* P. Damkot

*Advisor:* S. Coghlan, Chair  
J. Zydlewski  
K. Simons

For: Impacts of Riparian Characteristics on Terrestrial Invertebrate Input and Brook Trout Bioenergetics

*Cooperators/* University of Maine – Department of Wildlife Ecology

*Project Support:* Maine Cooperative Fish and Wildlife Research Unit

- Objectives:*
- 1) Evaluate the influence of riparian characteristics on terrestrial invertebrate input and quantify the resultant energetic input available for brook trout consumption.
  - 2) Quantify the availability of aquatic invertebrates in stream benthos and drift and the resultant energetic input available for brook trout consumption.
  - 3) Assess foraging selectivity in brook trout and quantify the relative amounts of energy provided by aquatic and terrestrial invertebrates.
  - 4) Integrate data with an existing bioenergetics model and simulate the effects of riparian forest structure on brook trout energetics.

For: Influence of Coarse Woody Debris Addition and Brook Trout Relocation on Stream Communities

*Cooperators/* University of Maine – Department of Wildlife Ecology

*Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit  
Maine Department of Inland Fisheries and Wildlife  
Maine Bureau of Parks and Lands  
U.S. Fish and Wildlife Service – Eastern Brook Trout Joint Venture  
Androscoggin River Watershed Council  
National Fish and Wildlife Foundation  
Town of Newry

Maine Department of Environmental Protection  
Wagner Forest, Sunday River Inn, Caribou Springs

- Objectives:*
- 5) Quantify the effects of CWD addition on brook trout, aquatic insects, and streamside salamanders in brook trout stream.
  - 6) Quantify the effects of brook trout relocation and/or CWD addition on aquatic insects and salamanders in fishless streams.

#### *SCOPE*

Maine contains the largest intact, wild populations of eastern brook trout in the United States. The fate of these fish is linked inextricably to the surrounding watershed, as riparian forests maintain suitable stream temperatures and physical habitat, facilitate aquatic prey production, and provide terrestrial prey subsidies critical for trout survival, growth, and reproduction. However, because most brook trout streams in Maine flow through privately-owned land managed for commercial timber harvest, disturbances to the structural integrity of the riparian forest are common but their resultant effects on brook trout often are not known or considered. Without adequate knowledge of the effects of forest harvesting and regeneration patterns on brook trout in these streams, resource managers lack a critical piece of the puzzle when projecting outcomes of various management scenarios. We developed a project to investigate the role that riparian forest structure plays in determining growth and production of brook trout in sensitive habitats – that is, headwater streams in the White Mountains region of western Maine surrounded by economically-valuable forests. Specifically, we will quantify the effects of various riparian forest characteristics (e.g., along gradients of canopy cover, basal area, stem density, and coniferous/deciduous dominance) on stream temperature, aquatic prey abundance, and terrestrial prey input, and ultimately link these factors to brook trout growth and production.

#### *PROJECT STATUS*

During the summer of 2008, we chose sites on eight headwater streams in western Maine and northeastern New Hampshire with a gradient of deciduous and coniferous riparian stand dominance, presumably reflective of logging history, ranging from 99% deciduous and 1% coniferous to 80% coniferous and 20% deciduous. We sampled each stream three times throughout the summer, with 24-hour sampling cycles. During each sampling interval, we collected benthic macroinvertebrates in four Surber samples, drifting aquatic invertebrates every six hours with four ½-hour drift net sets, and terrestrial invertebrates using six pan traps deployed for the entire 24-hour period. In addition, we collected 10-22 brook trout stomach samples for diet analysis by gastric lavage. Laboratory work will be performed throughout the winter to enumerate and identify invertebrates and quantify energy availability and consumption. These data will then be integrated with an existing bioenergetics model to predict how brook trout growth would be affected by riparian forest alterations and climate change.

#### *FUTURE PLANS*

A Master of Science thesis is expected to be completed in 2010.

### **Understanding the Ecology of Sea-Run Brook Trout in Acadia National Park**

*Investigators:* D. Kazyak

*Advisor* J. Zydlewski  
B. Letcher  
S. Coghlan

*Cooperators/  
Project Support:* USGS - Maine Cooperative Fish and Wildlife Research Unit  
USGS -Biological Resources Discipline  
National Park Service  
University of Maine  
Maine Department of Inland Fish and Wildlife

*Objectives:* Characterize the basic movement patterns of brook trout in a small coastal stream with PIT tag technology.

#### *SCOPE*

The iconic brook trout has suffered from the effects of habitat degradation, competition with non-native species and population fragmentation throughout its range during recent decades. These effects have been characterized succinctly in the Trout Unlimited produced status report for the “Eastern Brook Trout Joint Venture” (comprised of fish and wildlife agencies from 17 states, U.S. Geological Service, U.S. Forest Service, U.S. Fish and Wildlife, the National Park Service, the Office of Surface Mining , many conservation organizations and academic institutions). Maine was identified as the last stronghold for this valuable sport fish in the Unites States. Among Maine management agencies and the public, there is emerging interest in understanding and protecting the ecological integrity and diversity of this species, particularly with regard to life history variation.

Historically, coastal streams have supported anadromous runs of brook trout, but this life history form is presumed to have declined precipitously from their once historic distribution range. However, the status of anadromous populations is largely unknown for most Maine waters. Likewise, survival rates, recruitment and movement characteristics within and among neighboring stream systems represent significant data gaps impeding successful fisheries management. This project is aimed at collecting such basic information in communication and cooperation with regional stakeholders.

#### *PROJECT STATUS*

This study was initiated in 2007 to include and will be expanded to include two stream systems in 2008.

#### *FUTURE PLANS*

A Master of Science thesis is expected t be completed in 2011.

## **HABITAT RESOURCES**

### **Environmental Factors Associated with Unique Lake Communities in Maine**

#### *Investigators:*

E. Schilling  
K. DeGoosh  
D. Anderson (Research Associate)

#### *Advisors:*

For Emily Schilling (Ph. D. student):  
C. S. Loftin, Chair  
A. Huryn  
K. Webster  
P. Vaux  
J. Trial

For Katie DeGoosh (M. S. student):  
C. S. Loftin, Co-chair  
K. Webster, Co-chair  
D. Anderson  
A. Dieffenbacher-Krall  
M. Kinnison

#### *Cooperators/ Project Support*

Maine Outdoor Heritage Fund  
Maine Department of Inland Fisheries and Wildlife  
University of Maine - Department of Wildlife Ecology  
University of Maine – School of Biology and Ecology  
National Science Foundation - Research Fellowship  
USGS - Maine Cooperative Fish and Wildlife Research Unit

#### *Objectives:*

- 1) Determine the effects of the introduction of fish on macroinvertebrate communities of fishless lakes in Maine.
- 2) Identify attributes of macroinvertebrate communities that indicate fishlessness.
- 3) Identify geomorphic and geographical factors controlling the distribution and abundance of fishless lakes in Maine.
- 4) Build GIS-based models predicting the probability that a given lake is fishless.
- 5) Assess the accuracy of the models using macroinvertebrate indicator species.

## SCOPE

Throughout much of the 20<sup>th</sup> century, the introduction of game fish to inland waters of the United States and Canada was conducted at a furious pace. The goal of these introductions was generally to enhance game-fishing opportunities. In some cases, lakes and streams with native fish species, such as members of the Cyprinidae, were stocked with other species considered more desirable as game fish. In other cases, lakes and streams that were truly “fishless” were stocked. Until recently, fishless lakes were viewed as having little or no value to society, as indicated by the term “barren” that was widely used to describe them. Over the past several decades, however, there has grown a considerable body of knowledge supporting views of such “barren” water bodies as habitats for uniquely structured animal communities, as excellent trophic habitats for waterfowl, and as landscape-level source habitats for amphibians and other biota.

Over the past several decades, financial support for the documentation and management of the biodiversity and ecological integrity of public lands has increased. This has resulted in considerable effort toward the enumeration, conservation, and restoration of fishless lakes. However, accurate estimates of the number and distribution of these habitats, prior to the widespread stocking efforts of the mid- to late 20<sup>th</sup> century, are few. Estimates for six of Canada’s western mountain parks indicate that over 20% of their lakes have been altered through introductions of non-native fish. The situation in the United States is more extreme. Fewer than 45% of the 16,000 high lakes in the western mountains remain un-stocked, although 95% were naturally fishless. The rehabilitation of stocked lakes is now a priority for national park management in North America.

Maine Department of Inland Fisheries and Wildlife (MDIFW) has documented at least 30 fishless ponds in Maine; many ponds currently with fish are known to have been fishless prior to stocking. Documented fishless ponds and stocked but previously fishless ponds (and perhaps previously fishless ponds that were stocked and are now populated with naturalized stock) occur throughout the state, many in watershed headwaters. This wide distribution suggests that other fishless ponds likely exist. The ability to predict the likelihood that a particular pond is currently or historically fishless based on its landscape setting and geomorphic features would assist the MDIFW in balancing recreational management objectives with the responsibility to protect unique wildlife habitats. We will sample invertebrates in ponds in selected regions of Maine that are currently “fishfull” and compare those with ponds that have various degrees of fishlessness (naturally and those with a history of stocking). These data will be combined with geomorphic and geographic information to develop GIS-based models predicting locations of ponds that are most likely, naturally fishless. Macrovertebrate indicator species will be used to assess the accuracy of model predictions during subsequent field sampling. We will also develop and apply methodologies to document the historic presence or absence of fish in lakes predicted to be fishless but found to contain fish, to confirm model predictions.

## PROJECT STATUS

Invertebrate and fish surveys of fishless-fishfull lake pairs: Emily Schilling defended her dissertation and graduated in August 2008. The abstract follows:

Widespread fish stocking has led to a worldwide decline in naturally fishless lakes and their associated communities. Little is known about the historical distribution or native communities of these freshwater ecosystems. The objectives of this study were to: 1) develop a quantitative method to remotely detect naturally fishless lakes in Maine, 2) conduct a landscape-scale assessment of unique attributes of fishless lake macroinvertebrate communities, 3) identify macroinvertebrate bioindicators of fish absence, and 4) assess effects of introduced fish on native macroinvertebrates. I identified two physiographic types of naturally fishless lakes in Maine: kettle lakes in the eastern lowlands and foothills and headwater lakes in the central and western mountains. Landscape-scale geomorphic and geographic factors correlated with fish absence were identified with GIS, and the likelihood that a particular lake is fishless was estimated with stepwise logistic regression. Regression models predicted that 4% (131) of 3281 lakes (0.6-10.1ha) in the two study regions were naturally fishless. Twenty-one lakes were visited and sampled with gillnets and paleolimnological techniques to confirm current and historical fish absence, respectively. Models correctly predicted historical fish absence in 71% of the lakes, yet fish surveys indicated that many lakes now contain fish. Macroinvertebrates were sampled in 16 fishless and 18 fish-containing lakes to identify unique attributes of fishless lake communities. Macroinvertebrates in fishless lakes were more speciose and abundant, especially large, active and free-swimming taxa. *Graphoderus liberus*, *Hesperocorixa* spp., *Dineutus* spp., *Chaoborus americanus*, *Notonecta insulata* and *Callicorixa* spp. were identified as robust indicators of fish absence that were effectively collected with light traps. Fourteen historically fishless – now stocked – lakes were sampled to assess effects of introduced fish. Stocked lakes supported dramatically reduced macroinvertebrate abundance and species richness than currently fishless lakes. These effects were more pronounced in headwater than kettle lakes, likely due to sparse littoral habitat structure and intense stocking regimes. Maine’s naturally fishless lakes provide habitat for a unique suite of organisms that thrive in the absence of fish predation. Fishless lakes warrant protection from fish introductions, and recovery of stocked fishless lakes will enhance conservation of this resource.

Paleolimnological study of fishless-fishfull lake pairs: Katie DeGoosh defended her thesis and graduated in August 2007. The thesis abstract follows:

Development and application of a paleolimnological inference model to identify historically fishless lakes in Maine. Knowledge of historical conditions provides baseline information to ecologists and resource managers for assessing environmental change, predicting system responses, and developing management goals. During the last century, fish introductions for recreational purposes were widespread, obscuring natural fish distributions in Maine lakes. The goal of this study was to use paleolimnological techniques to identify lakes that currently contain fish but may have been historically, naturally fishless lakes. I developed a paleolimnological inference (PI) model using the assemblage of phantom midges (*Chaoborus*) in surface sediments from a standard calibration set of 21 Maine lakes. Patterns of mandible density and *Chaoborus* mandible distribution in fishless and fish-containing lakes indicate that relative abundance of *C. americanus*, rather than its presence alone, was the best indicator of a fishless lake in Maine. The PI model, developed using logistic regression, accurately classified fishless lakes 84% of the time. To further evaluate use of the model, we analyzed the *Chaoborus* assemblages in sediment samples from cores that were chronologically dated with <sup>210</sup>Pb collected at three historically fishless lakes with documented fish introductions. We were able to verify the lakes were historically fishless with the PI model. Then, the PI model was applied to sediment cores from 15 lakes in the region to identify lakes that currently contain fish but may have been fishless historically. The PI model suggested that 10 of the study lakes had  $\geq 57\%$  probability that they historically were devoid of fish populations. This research establishes an approach for identifying historical fish absence in lakes using paleolimnology and is an integral step in planning adaptive management strategies for Maine's historically fishless lakes.

### Characteristics of the Presettlement Forest of Northern Maine

*Investigators:* L. J. Mitchner

*Advisors:* W. B. Krohn, Co-chair  
A. S. White, Co-chair  
C. V. Cogbill  
R. S. Seymour  
J. S. Wilson  
J. A. Hepinstall (unofficial)

*Cooperators/  
Project Support:* The Nature Conservancy  
University of Maine - Department of Wildlife Ecology  
University of Maine – Ecology and Environmental Sciences Program  
USGS - Maine Cooperative Fish and Wildlife Research Unit

*Objectives:*

- 1) Determine the frequency, distribution and composition of the presettlement vegetation along survey lines in northern Maine.
- 2) Develop and test new methods for predicting estimated relative abundance of dominant species from abiotic factors.
- 3) Document the type, frequency, and severity of disturbance events along the township lines, prior to significant European settlement.
- 4) Test the likelihood of specific disturbances across the landscape.
- 5) Develop and test a new method for detecting sample bias in the MLO records.

### SCOPE

Understanding the pattern and process of presettlement vegetation is important to scientists and land managers alike. This understanding is especially important in regions, such as northern Maine, where extensive logging, or other anthropogenic disturbance, has removed much of the original forest cover leaving little basis for relating the mature post-settlement vegetation to the original presettlement vegetation. Given the lack of original forest cover, the influence of disturbance on the presettlement forest is not easily discernible. The General Land Office (GLO) surveys conducted prior to and during early settlement serve as a means to reconstruct the forest composition associated disturbance regimes. The GLO surveys in Maine cover much of northern Maine at township-level resolution. These surveys, once entered into a Geographic Information System (GIS) can be combined with present-day environmental data from the Maine Office of GIS (Maine OGIS) to analyze the presettlement species-environment relationship. Statistical modeling of the species-environment relationship will result in a landscape scale model of presettlement forest conditions. Spatially explicit

knowledge of the vegetation composition and the disturbance agents of the presettlement forest can, therefore, serve as a baseline for both ecological and silvicultural programs.

#### *PROJECT STATUS*

The first chapter documents who surveyed which townships, and when, along with the methods used. Witness tree selection in the Northwest Maine is the focus of the second chapter. Chapter three examines the methodology break in the survey that masks a biogeographic shift in forest composition in northern Maine. The utility of survey notes in reconstructing Maine's disturbance history are the focus of chapter four. Random forest was used to model the forest at the species and cover type analysis in chapter five.

#### *FUTURE PLANS*

Completion of the dissertation is scheduled for the summer of 2009.

### **A Long-Term Forest Ecosystem Study**

*Investigators:* M. L. Hunter, Jr.  
A. J. Kimball  
A. S. White  
J. W. Witham

*Cooperators/  
Project Support:* Holt Woodlands Research Foundation  
University of Maine - 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, inter annual, 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. Too 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 on a 120 ha, red oak-white pine woodlot in Arrowsic, Maine, called the Holt Forest. We have selected a 40 ha tract and divided it into forty 1-ha blocks with 20 ha serving as a control area and 20 ha as an experimental area.

Our primary objective is to describe the structure of the plant and animal community. We are undertaking (1) a 100% inventory of trees (>10 cm DBH) and intensive inventories of tree regeneration, (all trees are being individually numbered and on 12 tracts, mapped); (2) a complete description of the vascular plant vegetation using the relevé technique; (3) an inventory of all breeding bird territories; (4) small mammal trapping; (5) salamander cover object counts; (6) estimates of seed and fruit production; (7) general surveys of canopy insect abundance. 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 25 years, we have begun to understand how the community changes seasonally and from year to year; this is the essence of the third objective.

#### *PROJECT STATUS*

In 2008, our twenty-sixth field season, tasks 3, 4, 5, 6, 7, above were completed, new trees in the 20 mapped blocks found during the 2007 inventory were mapped, inventory corrections were made.

#### *FUTURE PLANS*

The 2009 field season will cover all the parameters measures annually. In addition, we will continue our inventory of tree regeneration and update our vascular plant vegetation data.

## Using Algae to Evaluate the Condition of Maine's Streams and Rivers

*Investigators:* T. J. Danielson

*Advisors:* C. S. Loftin, Chair  
D. Courtemanch  
S. Brawley  
F. Drummond  
J. Stevenson

*Cooperators/  
Project Support* University of Maine - Department of Wildlife Ecology  
Maine Department of Environmental Protection  
U S Environmental Protection Agency  
Houlton Band of Maliseet Indians  
Manomet Center for Conservation Sciences  
USGS - Maine Cooperative Fish and Wildlife Research Unit

*Objectives:*

- 1) Develop analytical tools to evaluate the condition of stream algal communities across a gradient of conditions ranging from minimally disturbed streams to those that have been highly degraded.
- 2) Build a model to predict stream classification attainment based on algal community attributes.

### SCOPE

The state of Maine Department of Environmental Protection currently evaluates the conditions of Maine's streams and rivers by sampling communities of aquatic macroinvertebrates at specific locations. This information is used with supporting chemical, physical, and landscape data to determine if streams and rivers are achieving aquatic life goals assigned to them under the State's Water Classification System (e.g., Class A, Class B, Class C). In this project, we will develop bio-assessment methods that examine stream algal communities and their relationships with water quality conditions. We will also develop a model to predict if streams attain assigned classes (e.g., Class A) based on characteristics of their algal communities.

### PROJECT STATUS

Data analysis is currently underway.

### FUTURE PLANS

Dissertation completion is expected mid 2009.

## Developing and Implementing Vernal Pool Conservation Plans at the Local Level Using Citizen-Scientists

*Investigators:* Damon Oscarson

*Advisors:* A.J.K. Calhoun, Chair  
M.W. Klemens  
J. Daigle

*Project Support* Wildlife Conservation Society

*Objectives:*

- 1) Prepare four town case studies and helped each town develop vernal pool conservation plans.
- 2) Test the validity of citizen-scientist data and developed a profile of successful volunteers to aid others in their recruitment strategy.
- 3) Revisit towns to determine how each town implemented the data collected in 2003.
- 4) Conduct a GIS analysis comparing BDP Tier ranked pools to State of Maine Significant Vernal Pools.

- 5) Spatially analyze BDP Tier ranked pools.

### *SCOPE*

Use of citizen-scientists to collect data on natural resources is gaining credibility globally and is now considered a valuable tool in the conservation tool box. We conducted town-wide vernal pool inventories using citizen-scientists in four New England towns (USA) using the voluntary best development practices (BDPs) for vernal pools. We tested the efficacy of using citizen-scientists to collect field data on vernal pools using published BDP guidelines. Steps included pool mapping and inventory, training of citizen-scientists, vernal pool field assessments, and guiding town development of local conservation strategies using data provided by the project. Potential vernal pools were remotely identified and photointerpreted. Partnerships among the University of Maine, the towns, and non-governmental organizations were forged to implement the project in Spring, 2003. Local coordinators in each town recruited volunteer citizen-scientists to conduct ground assessments. Volunteer training sessions were held prior to and during the field season. Fifty-two citizen-scientists surveyed and assessed 262 vernal pools. Quality control tests in the field confirmed that citizen-scientist data on amphibian egg mass counts were not significantly different from data gathered by biologists. Each pool was given a conservation priority rating based on the BDP assessment. Data were entered into a Geographic Information System database and delivered to each town. All towns initiated conservation plans and are developing conservation mechanisms to protect pools recognized as having conservation priority. Town strategies ranged from amending existing ordinances to improve wetland protection to incorporation of vernal pool resources into larger biodiversity mapping and planning projects. These four case studies illustrate that vernal pool conservation initiatives can be developed in local communities using the skills of trained citizen-scientists to collect accurate data. Communities are then better able to incorporate pool conservation strategies into the local planning and regulatory processes.

### *PROJECT STATUS*

Vernal pool conservation initiatives were initiated in Falmouth, Maine, USA, and three Connecticut towns: Farmington, Simsbury, and Suffield. We established partnerships with environmental non-governmental organizations (ENGOs) to facilitate project logistics and conservation planning activities. Potential vernal pools were remotely identified on aerial photographs. Citizen-scientist volunteers were recruited and trained in Spring 2003. Volunteers surveyed potential vernal pools in early April 2003 in Connecticut and mid-April 2003 in Maine. Data were collected on egg mass numbers by species and condition of the terrestrial habitat within 30 m of the breeding pool. Presence of breeding amphibian species, state-listed species, and other pool indicators (spermatophores, egg masses, larvae) were observed and documented. Fifty-two citizen-scientists surveyed and assessed 262 vernal pools. Quality control test were conducted on volunteers in the field. We worked closely with each town to assist and observe the development of plans to focus protection efforts on high priority pools. Pools were assessed using the Vernal Pool Assessment Sheet (Table 1) in the BDP Manual and were based on two parameters: 1) biological rating of the pool and 2) condition of the adjacent terrestrial habitat within 230 m of the pool. GIS analysis was conducted through Fall 2003 and Spring 2004. I presented the results of the study to the Conservation Commission in each town. Surveys were generated to collect data on citizen-scientist who worked on the project during Fall 2003. Each town was provided with a GIS database of the surveyed pools and their Tier ratings to be used in conservation planning. We asked each volunteer to complete a questionnaire. The purpose of the questionnaire was to create a profile of successful volunteers based on characteristics such as age, town residence time, local involvement, outdoor interest, and knowledge. Another goal of the questionnaire was to determine what motivated volunteers to participate in this project and what affect the project might have had on their community involvement.

### *FUTURE PLANS*

The next step for Spring of 2009 is to revisit each town to assess how and if they have utilized the data collected in 2003. Interviews with town staff, conservation commissions, consultants and other stakeholders will be conducted to determine what impact these data have had to create changes in site plan reviews, comprehensive plan drafting, and regulatory changes. Further GIS analysis will be conducted on some of the town pools. I will compare the BDP Tier ranked pools to the Maine Significant Vernal Pools in the Town of Falmouth to analyze their distribution, see how they differ and discuss the impact. Project completion is expected for Spring 2009.

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## **Changes in Vegetative Composition, Structure and Function Following Silvicultural Management in Softwood Forested Wetlands with Respect to the Attitudes of Foresters and Loggers**

*Investigators:* Gordon Moore

*Advisors:* A.J.K. Calhoun, Chair

M.L. Hunter, Jr.  
 J. Leahy  
 A. Kimball  
 K. Lausten, ex-officio

*Cooperators/* Maine Forest Service, Policy and Management Division  
*Project Support:* University of Maine – Department of Wildlife Ecology

- Objectives:*
- 1) Provide baseline data on vegetative and hydro-geologic changes in evergreen forested wetlands in northern Maine following timber harvesting.
  - 2) Baseline data will be used in the creation of a rapid assessment procedure for forested wetlands and vernal pool wetlands and habitat management guidelines (HMG) containing options for foresters, loggers and landowners with respect the management of forested wetland resources.
  - 3) The motivations of foresters and loggers are an important component of any best management process (BMP), as these practitioners must be willing to sign on to the BMPs (HMGs) in order to see them applied. Their attitudes and beliefs will be surveyed in order to best create workable best management practices and to understand the motivations in this population with respect to forested wetlands.
  - 4) Rapid monitoring protocols will be created and tested to monitor the outcome of forestry operations in forested wetlands and isolated forested wetlands (vernal pools) and the product will be added onto the Maine Forest Service's existing monitoring protocol for timber harvest operations.

### *SCOPE*

The importance of appropriate forested wetland management increases as the demand for timber resources and pressure for development continue to escalate. Forested wetlands are important sites for the retention of flood water, wildlife habitat, organic filters which produce clean water and for the production of timber. Forested wetland losses continue to be problematic and additional information as to their function and perceptions of their value are necessary to arrest further ecosystem degradation. The boundaries of forested wetlands are often poorly delineated on National Wildlife Inventory maps, and as these maps are the standard for many regulatory mapping schemes these wetlands are overlooked by regulatory agencies in Maine and other states. Current protection for these sites is limited and silvicultural Best Management Practices, while well intended, do not adequately protect the function of forested wetlands. This project evaluates the effects of timber harvesting management on the functions of evergreen forested wetlands dominated by Black Spruce, *Picea mariana* and Red Spruce, *Picea rubens* and isolated forested wetlands (vernal pools) in Maine. In this study, we evaluate (1) the attitudes and knowledge of foresters and loggers and (2) the on the ground effects of these on the functions of the resource. To address objective (1) foresters will be interviewed regarding their attitudes and beliefs about wetlands and forested wetlands. The interviews will be followed up with a mailed survey questionnaire on the same topic. Secondly I will investigate the vegetation and hydrology of 3 evergreen softwood palustrine forested wetlands in north western Maine from pre-harvest through several temporal stages post harvest with a primary goal of discerning the changes to the complexity and structure of these vegetative communities. I anticipate two products from this work: a rapid monitoring protocol for forested wetlands and isolated forested wetlands (vernal pool) which will be created as an addition to the existing protocol for monitoring forestry Best Management Practices (BMPs) currently being utilized by Maine Forest Service and several northeastern states; and for the creation of a Habitat Management Guidelines for timber harvesting in palustrine forested wetlands which will be viewed as an update and augmentation to the existing BMPs for timber harvest operations in forested wetlands .

### *PROJECT STATUS*

Conducting a review of scholarly and applied literature 1) focused on psychological tendencies, attitudes and beliefs with respect to natural resources issues as understood through the theory of planned behavior and 2) examine the effects on palustrine forested softwood wetlands, which have been altered by timber harvesting.

Conducting a pilot interview process with selected forestry practitioners with a pending evaluation and interpretation of the interview data. Testing the theory of planned behavior.

A rapid assessment procedure for vernal pools following timber harvest management on the adjacent areas has been created and tested through one field season. Collected data is currently in the process of assessment and analysis.

Sites and have been identified and initial monitoring of vegetation and hydrologic changes through inventory and shallow well (piezometers) have been initiated. Data is currently incomplete, and will require at least one more field season.

### FUTURE PLANS

Thesis seminar is anticipated in the winter 2008/2009. Other key tasks are as follows:

Continue to review the literature, on qualitative inquiry and research design and vegetative and hydrologic research design and analysis; finish the interview/survey instrument; complete the interview process with foresters and loggers anticipated in the fall of 2009; complete the installations of piezometers and monitoring through the fall of 2010; vegetative analysis will be completed during the summer field season 2009; create report on the first field season and analysis of vernal pool monitoring data winter 2008/2009; complete and edit rapid assessment procedure for vernal pools following timber harvesting and analyze the data set in the fall of 2009; create rapid assessment procedure for palustrine forested wetland spring 2009 and conduct monitoring in the field during the summer 2009; and begin development of habitat management guidelines with respect to palustrine forested wetlands fall 2009.

### Is *Myriophyllum heterophyllum* a Threat to the Ecology of Maine's Lakes?

*Investigators:* Jacolyn Bailey

*Advisors:* A.J.K. Calhoun  
A. Dieffenbacher-Krall  
C.S. Loftin  
D. Buckley

*Cooperators/  
Project Support:* Maine Department of Environmental Protection  
University of Maine - Department of Wildlife Ecology  
New Hampshire Department of Environmental Services

*Objectives:*

- 1) Document fish, amphibian, and invertebrate communities in native macrophyte beds and managed and unmanaged non-native milfoil beds.
- 2) Measure the relative abundance and presence/absence for each of three taxa: fish, amphibians, and invertebrates.
- 3) Measure plant community composition and structure in native macrophyte beds and managed and unmanaged non-native macrophyte communities.
- 4) Determine if there are differences in communities in native macrophyte beds and managed and unmanaged invasive macrophyte beds.
- 5) Determine potential differences in these communities among control techniques.

### SCOPE

Variable-leaf watermilfoil, (*Myriophyllum heterophyllum*) is an invasive aquatic plant that grows in thick, dense mats which clog boat motors and deter people from water-related activities. Although it may be a nuisance for water recreation, its effect on the natural ecosystem of a lake as perceived by lake-fauna is not documented in the literature. Does variable-leaf milfoil change the community dynamics of lake aquatic beds? Much of the research on invasive aquatic plants has focused on control techniques used for management. However, understanding the effect these species are having on the aquatic ecosystems they are invading is an equally important, but less researched part of the management strategy.

The most commonly implemented management techniques include benthic mats, hand removal, and diver-assisted suction harvesting. Benthic mats block sunlight from reaching the invasive plants which eventually decompose, but they are nonselective and all covered plants, including natives, are killed. Hand removal involves SCUBA divers removing by hand the entire plant including roots and placing the plant material in a bag which is brought to the water's surface to boats. Diver-assisted suction harvesting is similar to hand-removal except it utilizes a vacuum tube to draw the plant material up to a harvesting boat. All of these methods can spread numerous plant fragments, which cause new growth, and have negative effects on the aquatic environment including mortality of aquatic organisms and physical disruptions. These findings were corroborated in our previous research on milfoil control methods, where we observed mortality to macroinvertebrates, amphibians, reptiles and small fish. Physical disruptions included resuspension of substrate which could potentially result in the release of heavy metals or nutrients sequestered in the sediments.

Through this study we hope to determine whether variable-leaf watermilfoil is changing the community structure of the habitat it has invaded and whether the control methods used to manage variable-leaf watermilfoil adversely harm the aquatic communities where they are implemented.

*PROJECT STATUS*

Site surveys, selection and set up implemented during the summer of 2008. Community composition data will be collected during the summers of 2009-2011. Dissertation research proposal is currently under development.

*FUTURE PLANS*

Field studies are planned for 2009, 2010, 2011, with project completion in 2012.

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**Collaboration and Local Natural Resource Management: Integrating Theory and Practice Using Vernal Pool Conservation Planning in Maine**

*Investigators:* Jessica Jansujwicz

*Advisors:* A.J.K. Calhoun, Co-chair  
R. Lilieholm, Co-chair  
J. Acheson  
R. Judd  
L. Lindenfeld

*Cooperators/  
Project Support:* Senator George J. Mitchell Center for Environmental and Watershed Research  
University of Maine - School of Forest Resources

*Objectives:*

- 1) Develop the historical context for local natural resource management; construct the ecological, political and social environment that in recent years has become particularly conducive to collaborative natural resource planning.
- 2) Discuss the theoretical underpinnings of collaboration, addressing the hypothetical benefits, expected outcomes and critical concerns.
- 3) Consider the limitations of past and current approaches used to evaluate collaboration in practice.
- 4) Develop an integrated performance evaluation framework to measure success and failure of collaborative initiatives.
- 5) Offer a practical example to examine the social and environmental outcomes of collaborative vernal pool conservation planning in Maine.
- 6) Evaluate the role of collaboration in shaping the character of local-level planning efforts.
- 7) Provide insight on the barriers and opportunities for using collaboration as a management tool for protecting natural resources on private lands.

*SCOPE*

Managing natural resources for the common good is a thorny issue, particularly when private lands are involved. All levels of government and the private sector continue to grapple with this issue, struggling to find the right balance between public and private interests in land. To reconcile these diverse interests, there has been a growing trend toward more inclusive, participatory efforts to involve multiple stakeholders in local land use planning decisions. This collaborative model has become an important cornerstone for a rapidly increasing number of federal, state, and local natural resource and environmental programs addressing wetlands, wildlife, endangered species, water quality and other watershed management concerns. At the heart of this movement is the theory that collaborative natural resource planning can temper the confrontational politics of conventional regulatory approaches and overcome the limitations of traditional planning tools, offering an alternative strategy to achieve government-mandated environmental objectives.

A collaborative, “bottom-up” approach, however, is not without critics and there is a lively debate over the merits of collaboration. As popularity for an inclusive, participatory planning strategy continues to rise, skepticism follows, prompting calls for a more formal evaluation of the effectiveness of collaborative processes in decision-making for land management. Responding to this call for better empirical analysis, a growing number of studies offer criteria against which collaborative efforts can be evaluated in practice. While recent studies have led to a better understanding of the process of collaboration, few empirical studies focus on both the social and environmental outcomes of collaborative natural resource planning. My research aims to fill this gap in the literature by using an integrated performance evaluation framework to investigate and link the process and outputs of the Vernal Pool Working Group, a government-initiated collaborative planning initiative in Maine, with social and environmental outcomes.

*PROJECT STATUS*

Conducting an intensive review of scholarly and applied literature focused on the following: theory and practice of collaborative resource management, community based conservation, civic environmentalism, watershed partnerships and grassroots ecosystem management; theories of participatory democracy, civic engagement, community capacity, and social capital. Papers, books, and conference proceedings regarding institutional analysis, private lands management and the property rights movement have also been reviewed. Theoretical benefits and constraints of collaborative, community-based conservation were drawn from a diverse and continually evolving literature in conservation biology, ecology, resource economics, political science, sociology, and public policy and administration.

Participated in meetings with relevant stakeholders regarding vernal pool conservation initiatives in Maine. Attended public hearings on proposed vernal pool ordinances in Falmouth, Maine.

#### *FUTURE PLANS*

Thesis proposal seminar anticipated in January; continued review of the literature, concentrating on qualitative inquiry and research design; develop interview/survey instrument; complete Human Subjects Review; and interviews and/or surveys anticipated by Summer 2009.

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### **Conserving Vernal Pools through Community Based Conservation**

*Investigators:* Dawn Morgan (Masters Student)

*Advisor:* A.J.K. Calhoun

*Committee:*

K. Bell

L. Morin

L. Hertz

*Cooperators/*

*Project Support:*

Environmental Solutions Initiative, Senator George J. Mitchell Center

University of Maine - Department of Wildlife Ecology (Teaching Assistantship)

National Audubon Society

Maine Audubon Society

Stantec Inc.

*Objective:* To coordinate proactive mapping of vernal pools and encourage conservation of natural resources at the town level in Maine.

#### *SCOPE*

Vernal pools are small seasonal wetlands that fill with spring rains and generally dry down by the summer's end. They are critical breeding habitat for species adapted to life in temporary waters, including fairy shrimp, spotted and blue spotted salamanders, and wood frogs, and provide food to upland wildlife as well. Because of their small size and ephemeral nature, vernal pools are often overlooked by regulatory agencies and are rapidly being filled for development. As a result, vernal pools are among the most threatened wetland types in the northeastern US. While a number of northeastern states have been proactive in their attempt to maintain the functional value of vernal pools, the Maine legislature was the first to recognize a subset of vernal pools (Significant Vernal Pools) as Significant Wildlife Habitat, a status that allows both the pool to be protected and a portion of the adjacent upland habitat as well. As of September 2007, pools that meet certain biological criteria (based on egg mass abundance of key species and presence of listed species) are deemed to provide Significant Wildlife Habitat and as such are regulated under the Maine Natural Resource Protection Act. The state is unable to pre-map these resources, so it is incumbent upon private landowners to determine if they harbor Significant Vernal Pools prior to developing their land. The most efficient and cost-effective way to ensure the long-term viability of vernal pool resources is through local planning initiatives that move management from a reactive crisis mode to a proactive planning mode. The intention of this project is to work with citizenry and town officials in Orono, Maine, to inventory and assess vernal pool resources using trained citizen scientists, and to encourage the Town to incorporate vernal pools into a natural resource database for conservation planning purposes. Since we started this project, six additional towns, influenced by the State legislation, have contacted us for help in proactively mapping their vernal pools. Given our limited resources, it became clear that our project should expand its purpose to include development of a *Maine Municipal Guide to Vernal Pool Conservation* designed to provide pertinent information on vernal pool ecology and the process of using citizen scientists to map and assess pools. This *Guide* will also outline options for using a vernal pool data layer in conjunction with other spatial data layers to initiate conversations about natural resource planning. Feedback from the towns (Orono, Veazie,

Brunswick, Wayne, and Scarborough) that are currently working with us will provide guidance in developing this document.

#### *PROJECT STATUS*

Mapping initiatives are underway in the towns of Orono, Veazie, Brunswick, Wayne, and Scarborough. A recently awarded grant from The National Audubon Society will provide matching funds for up to nine additional towns to participate in this process. Creation of the *Maine Municipal Guide to Vernal Pool Conservation* and associated training materials are in progress.

#### *FUTURE PLANS*

Continued development of the Maine Municipal Guide to Vernal Pool Conservation during fall 2008 and spring 2009. Outreach and field work with towns during spring and summer 2009. Project completion fall 2009.

### **Spatial Relationships between Burn Patterns, Pre-Burn Vegetation Composition and Distribution, and Short-Term Vegetation Recovery in Okefenokee National Wildlife Refuge, Georgia**

*Investigators:* C. S. Loftin

*Project Support* U.S. Fish and Wildlife Service-Okefenokee National Wildlife Refuge  
University of Maine - Department of Wildlife Ecology  
USGS - Maine Cooperative Fish and Wildlife Research Unit

*Objectives:*

- 1) Describe fire severity and fire spatial patterns resulting from the 2007 wildfires in ONWR.
- 2) Compare the burn pattern descriptive analysis with vegetation classifications based on archived and newly acquired satellite imagery and aerial photography.
- 3) Compare pre- and post-burn vegetation classifications with archived spatial data of land cover, hydrology, and fire to identify relationships of vegetation recovery and site condition history.

#### *SCOPE*

Fire perimeter maps developed from thermal imagery captured while the swamp was burning during summer 2007 provide a time series of fire movement across the swamp. These maps present the impression of a uniform burn, yet the fire-severity map (USGS, unpubl. data) produced following post-fire sampling along the swamp perimeter indicates a diverse burn intensity pattern. Comparison of these fire perimeter and burn severity maps with vegetation maps (Loftin 1998, McCloskey 2006) developed from aerial photography [1977, MacCaffrey and Hamilton (1984); 1952, Loftin (1998)], merged SPOT multispectral and panchromatic satellite imagery collected during 1990, 2001 and 2.5 m SPOT imagery collected during June 2007 after much of the swamp burned, and newly acquired imagery during 2008 will improve our understanding of vegetation burn and recovery patterns in the swamp. This analysis also will provide a foundation data layer describing the pre- and post burn swamp landscape for other researchers' reference in their studies.

#### *PROJECT STATUS*

Digital aerial photography and SPOT satellite imagery were collected during summer 2008. Classification of this imagery currently is underway

#### *FUTURE PLANS*

Completion of a 2007 vegetation map of Okefenokee National Wildlife Refuge is expected by late spring 2009, and comparison of vegetation and burn perimeter maps will be completed by late summer 2009

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

#### **Population Trends of Marsh Birds of Management Concern in Maine**

*Investigator:* J. Hayden

*Advisors:* F. A. Servello, Co-chair  
C. S. Loftin, Co-chair  
T. P. Hodgman  
W. E. Glanz

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

*Objectives:*

- 1) Determine long and short-term change in proportions of wetlands occupied by five species of breeding marsh birds in Maine.
- 2) Determine detection rates of least bitterns during call- response surveys.
- 3) Determine rates for major reproductive parameters of least bitterns in Maine including clutch size, hatchability, nest success, and chick survival to day 15.
- 4) Determine home range size of least bitterns in Maine.

### *SCOPE*

Webless marsh birds, such as rails and bitterns, are generally recognized as being among the least studied and understood avian groups because of their secretive nature. Over the last several decades, several species have been in apparent decline, but information on population trends is limited. Previous surveys for marsh birds performed in 73 wetlands during 1989-1990 and 125 wetlands during 1998-2001 provide an excellent opportunity to measure short and long-term changes in wetland occupancy for these species. In the present study I will be re-surveying previous sites to document temporal changes in wetland use by the Least Bittern (*Ixobrychus exilis*), Sora (*Porzana carolina*), Virginia Rail (*Rallus limicola*), American Bittern (*Botaurus lentiginosus*), and Pied-billed Grebe (*Podilymbus podiceps*) in Maine. The Least Bittern is of particular concern in Maine, because its numbers have declined in Maine recently.

### *PROJECT STATUS*

Field work for the project was completed in late July of 2005 with a total of 75 sites being surveyed across southern, central and eastern Maine. Of these 75 sites, 37 had originally been surveyed in 1989-1990 and 38 sites had originally been surveyed in 1998-2000. Virginia Rail was the most frequently encountered species. Overall, wetland occupancy was greater for Virginia Rails and American Bitterns, and less for Least Bitterns than in earlier surveys. Wetland occupancy for Soras and Pied-Billed Grebes was similar between periods. Only seven individual Least Bitterns were detected in 2005-2006. These individuals were found in five separate wetlands and breeding pairs were observed at only one site. Detection probabilities were relatively high for each of the species.

Rainfall and temperature patterns did not differ substantially among survey periods, and these factors likely did not influence the occupancy trends that we observed. Habitat conditions had not changed substantially in sites previously occupied by Least Bitterns.

Preliminary analysis of data on habitat use suggests that Least Bittern presence was strongly associated with wetlands that had large areas of emergent vegetation along with some open water, whereas wetlands dominated by shrub vegetation were avoided. Least bitterns were not sensitive to wetland size. Pied-billed Grebes were strongly associated with large wetlands dominated by open water and having some emergent vegetation. The likelihood of a wetland supporting Pied-billed grebes increased greatly when total wetland area was >400 hectares and there was at least 20% open water. Soras and Virginia Rails were strongly associated with the availability of emergent vegetation, but Soras also nested in wetlands containing a large component of shrub vegetation, whereas Virginia Rails selected against wetlands dominated by shrub vegetation or open water. The presence of American Bitterns was strongly related to the area of shrub vegetation in wetlands.

Final analyses will focus on quantifying habitat thresholds values or other probability of occurrence relationships that will provide valuable information for assessing impacts of environmental perturbation on these marsh birds.

### *FUTURE PLANS*

Thesis writing is nearing completion and the project is expected to be finished early in 2009.

### **Seabird Activity Patterns Potentially Affected by Aquaculture Operations in Maine.**

*Investigator:* M. Parsons

*Advisors:* F. A. Servello, Co-chair  
C. S. Loftin, Co-chair  
J. Sowles  
J. Gilbert  
W. Halteman

*Cooperators/  
Project Support:* Maine Department of Marine Resources  
USGS - Maine Cooperative Fish and Wildlife Research Unit  
Maine Agricultural and Forest Experiment Station  
University of Maine – Department of Wildlife Ecology

*Objectives:*

- 1) Collect baseline information on activity patterns and behavior during nesting and brood-rearing for selected seabird species to inform future studies about aquaculture-seabird interactions in Maine.
- 2) Develop methods and techniques for monitoring selected seabird species to identify and document effects of aquaculture-related disturbance.

**SCOPE:**

The Seabird-Aquaculture Technical Working Group identified high priority research areas to better understand aquaculture affects on seabirds, including effects of disturbance and predation by gulls attracted to the vicinity of seabird nesting islands by aquaculture operations, and direct effects of disturbance on seabird behavior and productivity by human activity associated with operations. There are no published studies of effects of aquaculture operations on seabird nesting islands in Maine or elsewhere. There is a relatively large body of literature on effects of human activities, specifically research and monitoring, on seabird behavior, however, these results are not directly applicable to aquaculture issues. The existing research also is criticized for measuring changes in animal behavior as evidence of negative effects on seabirds without quantified changes in fitness (e.g., survival or reproduction). Documenting the consequences of behavioral changes on fitness is integral to understanding the true cost of these activities to seabird productivity. Information on the “natural” patterns of variability in seabird behaviors will be needed to develop study designs for determining effects of aquaculture operations in future studies. Understanding variation caused by tides, local weather and other environmental factors will be an important part of that need. Although some of these patterns can be documented by observers, fieldwork logistics and limited funds will restrict active observation. Remote sensing tools (e.g., cameras, temperature sensors, movement monitoring) potentially provide a means to increase sample (nest) replicates while minimizing human-caused disturbance that confounds the study results. Our study combines active observer and passive recording to document seabird activity on selected coastal islands during the nesting and brood-rearing periods. Documenting baseline behaviors of selected seabird species will require an assessment of procedures and techniques for monitoring seabird behavior and responses to direct and indirect disturbances resulting from aquaculture operations. These approaches must avoid biases caused by investigator activities. Remote monitoring equipment provides opportunity to minimize investigator disturbance, however, this equipment must be evaluated for reliability in marine environments and for use with seabird species and behaviors of interest.

**STATUS:**

We have completed a first field season of monitoring selected seabird species on Jordan's Delight Island. Data collected with cameras and temperature loggers currently are being organized and analyzed to determine their reliability for use during summer 2009.

**FUTURE PLANS**

Field studies are planned for 2009, with project completion in 2010.

**WILDLIFE RESOURCES - OTHER THAN MIGRATORY BIRDS**

**Priority Sites for Chilean Wetlands Conservation**

*Investigator:* P. A. Palacios

*Advisors:* M. L. Hunter Jr., Co-chair  
A. J. K. Calhoun, Co-chair

C. Loftin  
W. Krohn  
J. Swenson

*Cooperators/  
Project Support:* Fulbright and State Organization of the Americas  
Centro de Ecología Aplicada and CONAMA (National Environment Commission)

*Objectives:*

- 1) Identify priority areas for wetland conservation, based on spatial information.
- 2) Use a systematic tool for conservation that could be replicated to other areas.
- 3) Compare the method of using spatial information prioritization criteria with the “expert’s opinion” methodology.

#### *SCOPE*

The goal of my doctoral research is to identify priority areas for wetland conservation in Chile, using GIS as a tool to analyze threats and condition of these areas. Prior to this project, priority areas for wetland conservation in Chile have been selected based solely on expert opinion. More specifically, I will use GIS to combine layers of digital information about Chilean wetland types distribution with information about vulnerability and condition, to find areas that should be prioritized for wetland conservation in three political regions of Chile (one northern, one central and one southern). These maps will be systematically compared to the conservation priority area maps developed by the Chilean National Environment Commission, using expert opinion methodology.

#### *PROJECT STATUS*

Proposal is in review process by advisory committee.

The results of the classification for Chilean wetlands are published at the National System of Environmental Information website: [http://www.sinia.cl/1292/articles-41115\\_recurso\\_1.pdf](http://www.sinia.cl/1292/articles-41115_recurso_1.pdf)

#### *FUTURE PLANS*

Identify priority areas for wetland conservation.

### **Relative Fitness and Behavioral Compensation of Amphibians in a Managed Forest**

*Investigator:* S. M. Blomquist

*Advisors:* M. L. Hunter, Jr., Chair  
A. J. K. Calhoun  
D. J. Harrison  
C. S. Loftin  
A. S. White

*Cooperators/  
Project Support:* National Science Foundation  
University of Maine - McIntire-Stennis  
University of Missouri  
University of Georgia - Savannah River Ecological Laboratory  
University of Maine - Association of Graduate Students  
University of Maine - Alumni Association  
American Society of Ichthyologists and Herpetologists

*Objectives:* Determine potential ultimate and proximate mechanisms behind loss of local amphibian populations in forested wetland ecosystems altered by forest harvesting by asking 2 questions: 1) What are the effects of terrestrial habitat alteration on the relative fitness of wood frogs (*Rana sylvatica*)? 2) Do adult amphibians change their movement patterns and habitat selection in response to alteration of the terrestrial habitat?

#### *SCOPE*

This project is part of the Land-use Effects on Amphibian Populations (LEAP) project currently underway at the University of Maine, Orono. Land-use practices, such as forest harvesting, that reduce the quality of terrestrial habitat

surrounding a pond may threaten the persistence of a local amphibian population and may disrupt dispersal between local populations within the metapopulation. LEAP involves 4 replicates of 4 forest harvesting treatments (clearcut with coarse woody debris [CWD] removed, and clearcut with CWD retained, 50% canopy cover partial cut, and uncut forest) centered on amphibian breeding ponds. In pond-breeding amphibian metapopulations, most individuals in a local population are philopatric to their natal breeding site and use the terrestrial habitat surrounding the breeding pond for foraging and overwintering. The treatments extend 164 m from the pond's center to capture 95% of amphibians in that local population.

I will use a linear series of experiments on the eggs, larvae, metamorphs, juveniles, and adults of wood frogs and conduct breeding experiments with adult wood frogs to calculate components of relative fitness: survival and reproductive success, for each treatment. Wood frog larvae reared in aquatic mesocosms in each treatment will be transferred to terrestrial pens in the same treatment and allowed to mature. Because wood frogs live only 3-5 years, I will be able to assess the relative fitness for these frogs.

Habitat selection will be assessed for frogs at the subpatch (4th order), patch (3rd order), and home range (2nd order) based on locations of radio-tracked, wild wood frogs and northern leopard frogs (*Rana pipiens*) and fluorescent powder tracking or string trailing. The habitat choices and movements of wild wood frogs and northern leopard frogs within the LEAP array will allow me to assess ways in which animals with different habitat preferences could behaviorally compensate for a potentially stressful environment. These choices will be directly related to body condition and survival of the tracked frogs. Based on habitat choice at the home range scale, the condition and survival of that individual can be compared to the survival and condition of animals penned in that treatment. The strength of this design is that it allows assessment of fitness and habitat choice in amphibians. This link has not been made previously for amphibians.

#### PROJECT STATUS

All requirements for a Ph.D. were met in May 2008. The abstract of the dissertation follows:

Habitat loss and degradation are two of the most important factors leading to the imperilment of species worldwide including amphibians, but mechanisms underlying these changes are poorly understood. To understand the fitness potential of harvested forests, I conducted studies of a forest specialist, *Rana sylvatica* (Wood Frogs) and compared these results with those from identical studies with an open canopy specialist, *R. pipiens* (Northern Leopard Frogs) in response to an unharvested control and three forest harvesting treatments: clearcutting (with removal of all merchantable timber > 10 cm diameter), clearcutting with coarse woody debris retention, and partial harvesting with removal of < 25% canopy cover. First, I used radio telemetry data collected on 72 adult *R. sylvatica* and 40 *R. pipiens* and logistic regression modeling to assess habitat selection. Second, I predicted and quantified the plasticity of the two frogs with respect to survival, time to metamorphosis, and growth rate. My results suggest that *R. pipiens* may use clearcut areas during the spring and summer that are within migration distance of breeding and overwintering habitats if dense ground vegetation has regenerated. However, the fitness potential of the clearcut treatments for *R. sylvatica* is lower than that of the forested treatments, and coarse woody debris retention may ameliorate some of the effects of clearcut harvesting. Further, partial harvesting with removal of < 25% canopy cover is a forest management technique that may not adversely influence the fitness of *R. sylvatica*. Larval *R. sylvatica* from open canopy treatments reached a minimum size and metamorphosed earlier than other treatments, but ultimately, juveniles attained the same mass in all four treatments; open canopy treatments, however, had 35 ± 2% fewer survivors than forested treatments. In contrast, survival of *R. pipiens* larvae increased with decreasing canopy cover, increasing water temperature, and increasing food availability, and juveniles remained larger and had higher survival in open canopy treatments. In summary, the treatments induced opposing changes in the fitness correlates at the aquatic and terrestrial life stages of *R. sylvatica* but not *R. pipiens*. Further, each species selected different harvest treatments, and harvesting affected the habitat selection of both species at multiple scales.

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#### The Loss of Mature Neotropical Montane Forests and Its Effect on Cavity-Nesting Avifauna

*Investigator:* N. Politi

*Advisors:* M. L. Hunter, Chair  
F. A. Servello  
W. B. Krohn  
C.E. Burns  
A. S. White

*Cooperators/* Fulbright and State Organization of the Americas  
*Project Support:* United Nations Educational, Scientific and Cultural Organization

Wildlife Conservation Society  
 University of Maine - McIntire-Stennis  
 WWF--World Wide Fund For Nature

- Objectives:*
- 1) Determine the density and characteristics of trees and stands with cavities and assess which features are important in nest site selection (tree level and stand level).
  - 2) Determine the effects of forestry practices on: a) structure of the cavity-nesting guild, b) cavity density and selection, and c) interactions among cavity-nesters.

#### *SCOPE*

Only a small percentage of the total forested land can be set aside as reserves to conserve biodiversity and management of forests outside reserves will determine the fate of much biodiversity. A balance must therefore be reached between biological diversity and forest uses. In order to meet this challenge, there is a need for sound scientific knowledge specifying the characteristics necessary to maintain functioning forest ecosystems and how to manage for them. The overall goal is to study the composition and function of the avian cavity-nesting community and the dynamics of cavity formation as a basis for developing a forest management system that will sustain biodiversity in national parks and surrounding areas in the Yungas montane forests of Argentina.

#### *PROJECT STATUS*

Field work for the project is finished. We have carried out four years of field surveys: December 2003, from June to August 2004, December 2004, from June until September 2005, throughout 2006, and 2007. The first three surveys have helped us adjust methodologies and determine the sites where we are currently conducting our project. We have selected five control sites (three in the piedmont and two in montane forest) and six harvested sites (three in the piedmont and three in the montane forest). Our data suggest that primary cavity excavators (mainly woodpeckers) is a keystone species in this forested ecosystem, providing nesting sites for cavity nesters in the piedmont and montane forest. We have also been able to identify tree species and characteristics that seem to favor cavity formation. These surveys have also made us realize that in order to maintain mature forests managements guidelines should be urgently implemented since forests are being lost at an alarming rate. Furthermore, most forests are managed through regulations by the Argentine governments that address the timber resource but with no consideration for wildlife.

#### *PROJECT STATUS*

All requirements for a PhD were met in May 2008. The abstract of the dissertation follows:

Forests that are not managed sustainably eventually lose their economic and ecological value and are more likely to be converted to other land-uses. Avian cavity nesters are particularly sensitive to logging operations and therefore, I used this guild to determine the effect of selective logging on subtropical montane forests of the Andes and to inform management recommendations. Montane forests have an elevation gradient that defines different forest types and I studied two of these: the piedmont (400-750 m above sea level) and the cloud forest (1500-2200 m). In both forest types, I found significantly fewer avian cavity nesters and fewer usable cavities in harvested treatments than in control forests. Usable cavities represented less than 1.00 % of the total stem density in control treatments of both forest types, and were less abundant in harvested treatments (0.15 % of the total stems in piedmont and 0.54 % in cloud forest). Most of the usable cavities in the piedmont were found in 30-50 cm DBH trees (mean  $\pm$  SE: 44.51 $\pm$ 22.64) and in the cloud forest in trees > 60 cm DBH (70.69 $\pm$ 25.84). Usable cavities in the piedmont were more likely to occur in *Calycophyllum multiflorum* trees, while in the cloud forest they were likely to occur in *Blepharocalyx gigantea* trees. After two breeding seasons, 44% of the usable cavities in the piedmont and 57% in the cloud forest were no longer usable. Snags in the cloud forest have a greater probability of retaining usable cavities than snags in the piedmont. Cavities used by birds for nesting were not a random subset of all available cavities. In both the piedmont and cloud forests, as mean plot DBH increased there was a greater probability of encountering a nest and cavities excavated by woodpeckers were used more often than expected according to their availability. To assure the conservation of cavity-nesting birds, logging operations should retain trees with usable cavities. However, solely retaining certain tree species of a particular DBH will not be sufficient and it is necessary to retain trees likely to harbor usable cavities in the future and those selected by birds for breeding.

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#### **Examination of Mercury Contamination in Northern Two-Lined Salamanders (*Eurycea bislineata*) and Slimey Sculpin (*Cottus cognatus*) Inhabiting Watersheds in Coastal Maine**

*Investigators:* C. S. Loftin

J. Zydlewski  
A. Elskus

*Cooperators/  
Project Support:* Maine Outdoor Heritage Fund  
USGS-Maine Cooperative Fish and Wildlife Research Unit  
USGS - S. O. Conte Anadromous Fish Research Laboratory, Leetown Science Center  
University of Maine – Department of Wildlife Ecology

*Objectives:*

- 1) Quantify mercury contamination levels in two species (northern two-lined salamander larvae and slimey sculpin) found in similar trophic positions,
- 2) Characterize and compare the ratio of methylmercury (toxic form) and total mercury in these two species from different watersheds, and
- 3) Determine if a direct relationship exists between the bioaccumulation of total mercury and methylmercury in northern two-lined salamander and slimey sculpin.

### SCOPE

Concentrations of mercury in larval northern two-lined salamanders (*Eurycea bislineata*) in eastern Maine were documented by Bank (2005), and this work suggested that the species might be a useful indicator of mercury contamination in streams. The utility of an indicator species, however, is limited by range and density. In areas where two-lined salamanders are absent or few in numbers, other species must be assayed. The slimey sculpin is a species that might be used as a complementary indicator. Sculpin inhabit the stream benthos and, like the two-lined salamander, do not range far during their life history. This species has a 1-2 year juvenile period, feeds on benthic invertebrates and small fish, and provides food for trout, salmon, and other larger fish. Similarities between sculpin and two-lined salamander food habits and use of stream habitat suggest that mercury bioaccumulation levels may also be similar. Both species are prey for other stream biota (e.g., fish, waterbirds, and otter) and thus transfer methyl mercury accumulated in their tissues to higher trophic levels. The synergistic utility of these two animals as complimentary indicator species depends on establishing a relationship between the mercury bioaccumulation in areas where both species exist. Such information will allow greater comparison of contamination patterns throughout Maine and also provide valuable insights as to the degree of mercury contamination in the selected streams. We will collect northern two-lined salamander larvae and juvenile sculpin to determine the degree and extent of mercury contamination in selected coastal watersheds in Waldo, Hancock, Washington, and Penobscot Counties in Maine.

### PROJECT STATUS

The research was completed in 2008 and a summary follows:

The primary purpose of this study was to use stream-dwelling biota (e.g., northern two-lined salamander larvae, slimey sculpin) to quickly assess stream mercury contamination. During July 2006 we surveyed 25 streams for larval northern two-lined salamanders and slimey sculpin in Penobscot, Washington, and Piscataquis Counties. We found very few of either species in any of the streams. Given that our purpose was to use easily collected, stream-dwelling biota as a rapid-assessment tool for mercury contamination, we selected alternate, easily captured target species [water striders (*Aquarius remigis*) and “minnows” (blacknose dace *Rhinichthys atratulus*; northern redbelly dace *Phoxinus eos*; pearl dace, *Semotilus margarita*; creek chub, *Semotilus atromaculatus*; lake chub, *Couesius plumbeus*; common shiner, *Luxilus cornutus*; golden shiner, *Notemigonus crysoleucas*] that were abundant in these streams. The collected fish (“minnows” hereafter) represent a typical assemblage found in low order streams. We selected water striders because there was precedence for use of this species as a possible mercury sentinel in low order streams. Total mercury concentrations in water striders collected from small streams draining gold mine tailings in New Brunswick, Canada, were correlated with mercury concentrations in brook trout (*Salvelinus fontinalis*) collected from the same site (Jardine et al. 2005).

Ratios of methyl to total mercury were similar in the collected striders and minnows, and striders contained lower mean concentrations of mercury than minnows. Except for two streams (Burdin and Buzzell), methyl and total mercury concentrations were generally similar among the taxa. Methyl and total mercury in the fish assemblage in these two streams exceeded concentrations in striders. Total and methyl mercury concentrations generally were more variable in the fish than striders, which may reflect their longer lifespan (striders <2 years, fish species 2-4 years). There was some inconsistency in relationships of mercury concentrations among streams; samples of both taxa with the greatest methyl and total mercury concentrations were not collected in the same stream. These organisms should not be used, therefore, as a predictor of mercury concentration in the other taxa in a particular stream, but can be a relative indicator of mercury contamination in the stream. Jardine et al. (2005) found a significant relationship between total mercury concentrations in striders and brook trout in New Brunswick streams. This relationship is influenced by the range of concentrations in their study; if samples from the collection site closest to the mine tailings were removed from their dataset, the relationship between trout and strider total mercury concentrations would have been weaker and thus more similar to our results.

Although we did not document consistent relationships between strider and minnow mercury concentrations in these streams, the concentrations of these contaminants in the streams we sampled are at least in the range of those reported in New Brunswick, Canada, streams, by Jardine et al. (2005). At least one fish from four of the streams we sampled contained concentrations of total mercury exceeding those reported in brook trout by Jardine et al. (2005), and at least one fish collected in our study from Lowell Brook contained total mercury concentrations that exceeded those in trout collected below the New Brunswick, Canada, mine tailings site. Similarly, at least one of our striders from Lowell Brook contained total mercury concentrations exceeding those measured in striders collected near the mine tailings site. Given our small sample size and geographically and temporally restricted study, it would be prudent to sample striders in more streams in the area and over a longer period. The concentrations of total and methyl mercury in striders and minnows collected from the sampled streams suggest that this contaminant is likely widespread in the foodweb of small streams throughout this region of Maine; population level effects of this level of contamination on biota in these streams remain unknown.

### **An Investigation of the Maintenance of Eucalcemia in the Setting of Disuse and Anuria in Hibernating Black Bears**

*Investigators:* Rita Seger

*Advisors:* F. Servello, Co-chair  
R. Causey, Co-chair  
W. Halteman  
W. Glanz  
A. Bushway  
C. Rosen  
W. Jakubas

*Cooperators/  
Project Support:* University of Maine - Ecology and Environmental Sciences Program  
Maine Department of Inland Fisheries and Wildlife

*Objectives:*

- 1) Compare radiographs of bears obtained late in active season to those obtained during hibernation, to determine whether bears experience immobility-induced bone loss during hibernation.
- 2) Compare serum markers of bone resorption and formation in black bears during hibernation and active season to determine the degree of bone turnover in hibernating bears.
- 3) Evaluate effects of age, sex, body condition, lactation, parity, and genetics on bone turnover and bone mass in black bears.
- 4) Measure hormones involved in calcium homeostasis and bone metabolism (vitamin D, PTH, calcitonin, IGF-I and leptin) in active and hibernating bears to elucidate patterns related to season, age, sex, and adiposity.
- 5) Evaluate hypothetical mechanisms by which hibernating bears maintain normal serum calcium in the setting of immobility with absence of urination.
- 6) Compare the above findings to human and laboratory animal models to elucidate unique features of calcium homeostasis and bone metabolism in black bears.

#### *SCOPE*

The ability to respond to mechanical strain is a fundamental property of bone, and maintenance of bone mass requires mechanical strain. Skeletal unloading results in prompt, extensive bone loss, with release of calcium into the bloodstream. Excess calcium must be eliminated in urine in order to avoid high serum calcium, with resultant physiological havoc. Hibernating black bears remain nearly immobile and go without urinating for several months, yet their serum calcium remains in the normal range. Therefore it appears that bears either possess the unique ability to avoid immobility-induced bone loss, or else they have a mechanism for reapplying bone mineral to the skeleton to prevent hypercalcemia. Relatively little is known about ursine bone metabolism.

This project will use radiographic and biochemical analyses to provide a picture of bone metabolism and calcium homeostasis in free-ranging black bears. The bears are trapped in the springtime and radiocollared by the Maine Department of Inland Fisheries and Wildlife, then subsequently handled in their winter dens. Radiographs will also be obtained using hunter-killed bears in autumn. In order to construct a coherent picture of bone metabolism in this species, the following list of analyses is initially planned on approximately 100 bears: serum total calcium, phosphate, albumin, creatinine, osteocalcin, bone-specific alkaline phosphatase (BSAP), degradation products of C-terminal telopeptides of

Type-I collagen (CTX) , PTH, calcitonin, 25(OH) D, and calcitriol, IGF-I, and leptin. Radiographs of the forepaws will be obtained on approximately 140 bears. With this information it will be possible to evaluate five alternative hypothetical mechanisms that might explain the maintenance of normal serum calcium in hibernating bears. Elucidating the ursine mechanism of maintaining normal serum calcium in the setting of immobility with absence of urination has potential to inform medical research into normal bone metabolism and to shed light on a variety of skeletal pathologies.

#### *PROJECT STATUS*

During the time interval October 2007 through September 2008, data analysis has been completed: Digital x-ray radiogrammetry has been performed on forepaw radiographs of 167 female bears, and bone growth curves have been constructed for three seasons. Serum samples from 168 female bears have been used for the panel of biochemical analyses, with a variable number of samples used for each analysis. Correlations between the bone metabolic markers have been analyzed. Writing is in progress.

#### *FUTURE PLANS*

The project will be completed by late December 2008, with results submitted in the form of a Ph.D. dissertation by Rita L. Seger, M.D.

### **Assessing the Diet of the American Black Bear (*Ursus Americanus*) In Maine Using Stable Isotope Analysis**

*Investigators:* Rita Seger  
F. Servello  
W. Jakubas

*Cooperators/  
Project Support:* University of Maine - Ecology and Environmental Sciences Program  
Maine Department of Inland Fisheries and Wildlife

*Objectives:*

- 1) Measure stable isotopes of nitrogen, sulfur and carbon in plants (including specific black bear foods), herbivores, and black bears, to determine signatures for each trophic level.
- 2) Use the signature(s) of nitrogen  $\pm$  sulfur and/or carbon to assess the contribution of carnivory to the assimilated protein of Maine black bears.
- 3) Assess determinants of carnivory by comparing isotope signatures between age and sex classes, and between bears from three study areas in Maine that differ by types of available foods.
- 4) Compare nitrogen signatures across the course of hibernation to assess whether protein turnover during hibernation may change the nitrogen signature of red blood cells.

#### *SCOPE*

Black bears are highly omnivorous. The historical range of the American black bear (*Ursus americanus*) includes forested biomes across North America, encompassing a wide variety of food resources. The diet of black bears in Maine has not been thoroughly investigated, but is known to include greens, buds and catkins, hard and soft mast, invertebrates, neonatal ungulates, winter- and road-killed carcasses, human crops and garbage, and hunters' baits. In other parts of their range, black bear predation is an important source of mortality to neonatal ungulates. The significance of black bear predation on moose calves and deer fawns in Maine is unknown.

This project will use stable isotopes analysis to assess the contribution of carnivory to the assimilated protein of free-ranging black bears in Maine. The analysis will use blood clot that is available, collected in vacuum tubes with no additive, from bears radiocollared by the Maine Department of Inland Fisheries and Wildlife, and sampled by phlebotomy for a separate project in which the serum was used. Samples were collected during spring trapping season (mid-May through late June), and during winter denning (mid-January through late March), 2005-2007.

Findings will be compared between three study areas that differ in their moose and deer populations and in other available foods. Age and sex classes of bears will be compared, to evaluate the hypothesis that adult males are the most carnivorous black bears in Maine. The impact of hibernation on the 15-nitrogen signature will be assessed to determine whether analyses will require adjustment for hibernation.

#### *PROJECT STATUS*

Stable isotope analysis has been performed on samples from 15 plants, 10 herbivores, and 50 bears. Data analysis is in progress, including obtaining baseline average signatures for plants, herbivores, subadult bears and large male bears during

spring, and hibernating bears. Preliminarily, large males bears show a substantial degree of carnivory during spring, when ungulates are calving/ fawning. Duration of hibernation does not appear to alter the nitrogen signature. Marked differences are apparent between the three study areas and between seasons.

#### *FUTURE PLANS*

Data analysis is in progress. Additional sampling will be guided by the results.

### **Amphibian Communities Associated with Fishless Lake Environments in Maine**

*Investigators:* A. Shearin

*Advisors:* C.S. Loftin, Co-chair  
A. J. K. Calhoun, Co-chair  
W. Glanz  
W. Halteman  
K. Simon

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

*Objectives:*

- 5) Characterize amphibian communities of fishless and fish-containing lakes in Maine.
- 6) Determine egg mass origin affects *Ambystoma maculatum* resistance to predation.
- 7) Determine effects of fishless lake and vernal pool predators on survival of *Ambystoma maculatum* eggs and larvae collected from vernal pools, fishless lakes, and fish-containing lakes.

#### *SCOPE*

Lakes with natural and stocked fish populations support invertebrate communities that differ from those naturally without fish (Schilling et al. 2009, DeGoosh 2007). The introduction of fish to historically fishless lakes also may affect the amphibian species that reside, breed, or feed in these water bodies. Introduced fish may affect amphibian species abundance and composition by changing food resources, eating the amphibians, eating aquatic insects that prey on amphibians, and by altering the pond habitat so that amphibian breeding and refuge sites are modified. Amphibian species that are palatable to fish, for example, may be consumed by fish or may avoid fish by altering their movements in the landscape to locate alternative fishless sites. Ponds stocked with fish may become biological sinks for amphibian populations that continue to use the water bodies for egg-laying in spite of the presence of fish, resulting in their offspring, or the adults themselves, being consumed by fish. It is not clear whether there are mechanisms in naturally fishless ponds stocked with fish that allow amphibians to persist in these modified environments. Habitat characteristics such as structural complexity and egg laying sites as well as characteristics of eggs masses may affect breeding success in these permanent water bodies. Through this study, we hope to identify characteristics of spotted salamander egg masses occurring in fishless and fish-containing lakes and adjacent vernal pools and features of these habitats that make them suitable or unsuitable habitat for this vernal pool species.

#### *PROJECT STATUS*

Fishless and fish-containing lake pairs in Downeast Maine were surveyed for amphibian occurrence with audio and visual surveys during summer 2007 and 2008. Field and lab methods for egg mass predator enclosure experiments were developed during summer 2008. Surveys and experimental work will be completed during 2009.

#### *FUTURE PLANS*

Field studies are planned for 2009 with dissertation completion in 2010.

### **Considering Water Quality and Mercury Effects on Amphibians In Vernal Pools: A Pilot Study In Acadia National Park, Maine**

*Investigators:* C.S. Loftin  
A.K. Calhoun

*Advisors:* S.J. Nelson  
K. Simon  
A. Elskus

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

*Objectives:*

- 1) Describe the water chemistry of short-hydroperiod amphibian breeding pools;
- 2) Characterize relationships among vernal pool chemical and physical environments (e.g., pool substrate, forest cover type, size, hydroperiod);
- 3) Document the presence and bioaccumulation of Hg in vernal pool food webs; and
- 4) Identify relationships between the vernal pool chemical environment and amphibian developmental condition.

**SCOPE:**

Vernal pools are a unique wetland type at tremendous risk due to habitat degradation and loss, a situation that has triggered recent legislation in Maine aimed at vernal pool conservation. Vernal pools host a diversity of biota (e.g., wood frogs [*Rana sylvatica*], ambystomatid salamanders [*Ambystoma* spp.], fairy shrimp [*Eubranchipus* spp.]) adapted to larval development in temporary waters, but these wetlands are endangered by a subtle threat to their function: non-point source pollution. Our study examines one such potential “invisible” risk in Acadia National Park (ANP), Maine: the role of mercury (Hg) in the broader context of vernal pool water chemistry and its effects on amphibian larval development. Our overarching goal is to understand the vernal pool chemical environment, the transport of Hg through vernal pool biota, the linkages between food web structure and Hg concentration in biota, and the potential toxicity of Hg to amphibians in vernal pools of the northeastern U.S. where atmospheric deposition of Hg is a well-documented phenomenon. We will characterize the chemical environment (including Hg) of short-hydroperiod vernal pools in ANP, including potentially large Hg contributions from snow and seasonal snow melt. Changes in Hg concentrations in the water, leaf litter, biofilm, sediment, and developing embryos and larvae will be determined over time. The pattern of mercury in these compartments will be linked to the food web structure of vernal pools using stable isotope analysis to identify potential pathways of Hg transport among and bioaccumulation in vernal pool biota. Developmental abnormalities in amphibian embryos and larvae and time-to-metamorphosis will be related to vernal pool chemistry and food web structure. This exploratory research project will contribute to our knowledge about relationships between chemistry and biology in pool environments. This information will lead to refined hypotheses for future studies about potential synergistic interactions of the vernal pool chemical environment and changing climate patterns on amphibian population viability. This information could be applied to regions outside the Park to aid in conservation of pools with risks of chemical pollution due to physical setting or pool chemistry.

**STATUS:**

Water, sediment, litter, and biota were sampled from snow melt to dry-up in four vernal pools at Acadia National Park during spring-early summer 2008. Sample analysis is underway.

**FUTURE PLANS:**

This study provides baseline and preliminary data for a more comprehensive study for a future proposal.

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**Breeding and Terrestrial Habitat Requirements of the Eastern Spadefoot (*Scaphiopus Holbrookii*) and Pure-Diploid Blue-Spotted Salamander (*Ambystoma Laterale*) In Eastern Connecticut**

*Investigators:* Kevin J. Ryan

*Advisor:* A.J.K. Calhoun  
*Committee:* M.W. Klemens  
J. Zydlewski  
B. Timm

*Project Support:* Lowe's Home Center, Inc.

- Objectives:*
- 1) Document terrestrial habitat movements of adult eastern spadefoot toads and blue-spotted salamanders to and from breeding wetlands.
  - 2) Document breeding philopatry.
  - 3) Identify juvenile dispersal rates and orientation from natal wetlands.
  - 4) Quantify juvenile recruitment.
  - 5) Document non-breeding habitat use and home-range size of both juveniles and adults.
  - 6) Estimate breeding population size.
  - 7) Describe burrowing ecology (eastern spadefoot).

### SCOPE

The proposed research will provide valuable information on two New York and Connecticut State-listed species, the eastern spadefoot (*Scaphiopus holbrookii*) (Special Concern and Endangered, respectively) and the pure-diploid blue-spotted salamander (*Ambystoma laterale*) (Special Concern and Threatened, respectively). Both species merit scientific investigation as information on the terrestrial ecology of both animals is sparse. Our results will help to determine best management practices for mitigation of developments affecting habitat for these and other pool-breeding species that depend on adjacent terrestrial habitats for the majority of their lives.

A review of the literature on spadefoots yielded numerous publications on the species dating back to the late-1800s (Smith 1879; Abbott 1884; Pike 1886; Hargitt 1888). Most early accounts document their characteristic explosive breeding events (which are now known *not* to occur on a rhythmic, annual basis). These early accounts also characterized the curious fossorial (belowground) nature of these animals as well as the amazingly rapid development of their tadpoles. A small number of papers in the 1940s and 50s began to take a closer look at spadefoots (Bragg 1945; Richmond 1947; Gosner and Black 1954, 1955; Pearson 1955, 1957; Hansen 1958), the most comprehensive being written by Pearson (1955). Since Pearson, numerous papers have been published regarding various aspects of spadefoot life history, however the majority of studies on the eastern spadefoot (the only species east of the Mississippi River) have been based in the South, where the animals are much more commonly encountered than in more northern latitudes; few, if any, studies have focused on northern populations. In New England, eastern spadefoot populations are particularly localized, usually being found at scattered sites in river valleys at elevations below 200 feet (Klemens 1993). These types of habitats are also preferred sites for human habitation, and many of these already localized populations have been extirpated due to urban/suburban development.

Data on eastern spadefoot ecology are sparse, and considerably less exist on the blue-spotted salamander, especially the rarer pure-diploid populations. The vast majority of published material pertains to the hybridization of the blue-spotted salamander with its close relative, the Jefferson salamander (*Ambystoma jeffersonianum*) which produces populations consisting of a wide array of genetic combinations (up to genetic pentaploids) (Bogart and Klemens 1997). These populations consist almost entirely of females, which are capable of reproducing gynogenetically (sperm fertilizes an ovum, but does not contribute genetic material) (Klemens 1993). In southern New England hybrid populations are far more abundant than populations of genetically-pure parental species (Klemens 1993). Previous studies working with either "bluespots" or "Jeffersons" recognize that hybrids exist, however make no attempt to describe their ecology based on the actual genetic makeup of the populations they are working with. Karyotyping work previously conducted by Klemens (unpublished data) indicate that the populations of blue-spotted salamanders at our project sites (in eastern CT) are genetically-pure. As with the spadefoots, an excellent opportunity exists here to collect valuable information on the ecology of a State-listed species. We know of no published information on the ecology and terrestrial habitat needs of blue spotted-salamanders, an important vernal pool species throughout New England and Atlantic Canada. Data on its non-breeding habitat are directly applicable to management of vernal pool habitats to ensure long-term viability of pool-breeding species.

### PROJECT STATUS

This spring, summer and fall were the first of two field seasons at our two study sites ("Lowe's" and "Shinkiewicz"); the first serves as a reconnaissance (base-line data) field season. We installed 390 pit-fall traps - 1870 m of arrays at the Shinkiewicz site in a fashion that compartmentalizes the different habitat types present allowing us to inventory amphibian species, breeding population sizes, and their movement patterns. Pit-fall traps also have been repaired, modified, and reinstalled at the Lowe's site. Pit-fall trapping at both sites is supplemented by nocturnal searches during rain events, both on the roads surrounding and on the grounds of the field sites.

A research proposal is currently being written with information obtained from the first field season.

### FUTURE PLANS

Further field-based data collection will continue in the spring, summer, and fall of 2009. The project is scheduled to be completed in 2010.

## **PUBLICATIONS, THESES AND DISSERTATIONS, PROFESSIONAL AND PUBLIC PRESENTATIONS, AND AWARDS**

### **Scientific Publications**

- Bahn, V. 2008. Failure to find the relationship between dispersal and spatial autocorrelation in species abundance. *Journal of Negative Results - Ecology and Evolutionary Biology*, 5: 1-13.
- Bahn, V., W. B. Krohn, and R. J. O'Connor. 2008. Dispersal leads to spatial autocorrelation in species distributions: a simulation model. *Ecological Modeling*, 213 (3-4): 285-292.
- Bailey, J. E. and A. J. K. Calhoun. 2008. Comparison of three physical management techniques for controlling variable-leaf milfoil in Maine Lakes. *Journal of Aquatic Plant Management* 46:163-167.
- Baldwin, R. F., P. G. deMaynadier, and A.J.K. Calhoun. 2007. *Rana sylvatica* Predation. *Herpetological Review* 38:194-195.
- Blomquist, S.M., J.D. Zydlewski and M.L. Hunter Jr. 2008. Efficacy of PIT tags for tracking the terrestrial anurans *Rana pipiens* and *Rana sylvatica*. *Herpetological Review* 39:174-179.
- Burns, C.E. and J.S. Gear. 2008. Effects of habitat loss on populations of white-footed mice: Testing matrix model predictions with landscape-scale perturbation experiments. *Landscape Ecology*. 23:817-31.
- Calhoun, A.J.K. and P.G. deMaynadier. 2008. Science and conservation of vernal pools in northeastern North America. CRC Press, Boca Rotan, Florida, USA.
- Calhoun, A. J. K. 2007. Principles for conserving wetlands in the context of landscape management. Pages 429-444 In: Hobbs, R. and D. B. Lindenmayer (eds.) Managing and Designing Landscapes for Conservation: Moving from Perspectives to Principles.
- Calhoun, A.J. K. and P. Reilly. 2008. Conserving vernal pool habitat through community based conservation. Pages 319-341 In: Calhoun, A. J. K. and P.G. deMaynadier (eds). Science and Conservation of Vernal Pools in Northeastern North America. CRC Press.
- Coghlan Jr., S.M., G. R. Cain, and N. H. Ringler. 2007. Prey selection of Atlantic salmon and rainbow trout coexisting in a natural stream. *Journal of Freshwater Ecology* 22(4):591-607.
- Cornelius C., K. Cockle, N. Politi, I. Berkunsky, L. Sandoval, L. Rivera, M.L. Hunter, Jr. and K. Martin. 2008. Cavity nesting birds in neotropical forests: cavities as a potentially limiting resource. *Ornitologia Neotropical* 19:253-268.
- Cunningham, J., A.J.K. Calhoun, and W. E. Glanz. 2007. Pond-breeding amphibian species richness and breeding habitat selection in a beaver-modified landscape. *Journal Wildlife Management* 71: 2517-2526
- Gahl, M.K. and A.J.K. Calhoun. 2008. Landscape setting and risk of *Ranavirus* mortality events. *Biological Conservation* 141:2679-2689.
- Gibbs, J., M.L. Hunter, Jr. and E. Sterling. 2008. Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. 2nd edition. Blackwell Publishing, Oxford, United Kingdom, 328 pp.
- Gear, J.S. and C.E. Burns. 2007. Evaluating effects of low quality habitats on regional population growth in *Peromyscus leucopus*: Insights from field-parameterized spatial matrix models. *Landscape Ecology* 22:45-60.
- Hunter, M.L. Core principles for using natural disturbance regimes to inform landscape management. In D. Lindenmeyer and R. Hobbs (editors). Managing and designing landscapes for conservation. Blackwell Science, Oxford, United Kingdom.
- Hunter, M.L. 2008. Valuing and conserving vernal pools as small-scale ecosystems. Pages 1-8 In A.J.K. Calhoun and P. deMaynadier, editors. Science and conservation of vernal pools in northeastern North America. CRC Press, Boca Raton, Florida, 363 pp.

- Kneeland, S.K. and J.M. Rhymer. 2008. Determination of fish host use by wild populations of rare freshwater mussels using a molecular identification key to identify glochidia. *Journal of the North American Benthological Society* 27: 150-160.
- L.M. Puth and C.E. Burns. 2008. New York's nature: A review of the status and trends in species richness across the metropolitan region. *Diversity and Distributions*. Published Online First, doi 10.1111/j.1472-4642.2008.00499.x
- Lindenmayer, D., R. Hobbs, R. Montague-Drake, A.J.K. Calhoun, M.L Hunter, et al. 2007. A checklist for ecological management of landscapes for conservation. *Ecology Letters* 11:78-91.
- Nelson, S.J., K.B. Johnson, K.C. Weathers, C.S. Loftin, I.J. Fernandez, J.S. Kahl, D.P. Krabbenhoft. 2008. Deposition, re-emission, and evasion: Mercury mass fluxes in winter at Acadia National Park, Maine, USA. *Applied Geochemistry* 23: 384-398.
- Patrick, D.A., A.J.K. Calhoun, and M.L. Hunter. 2008. The importance of understanding spatial population structure when evaluating the effects of silviculture on spotted salamanders (*Ambystoma maculatum*). *Biological Conservation* 141:807-814.
- Patrick, D.A., E.B. Harper, M.L. Hunter Jr, and A.J.K. Calhoun. 2008. Terrestrial habitat selection and strong density-dependent mortality in recently metamorphosed amphibians. *Ecology* 89:2563-2574.
- Rhymer, J.M. 2008. Hybridization, Introgression and the Ecological Management of Threatened Species. Chapter 9 in Conservation Biology: Evolution in Action (S.P. Carroll and C.W. Fox, editors). Oxford University Press.
- Schilling, E. G., C. S. Loftin, K. E. DeGoosh, A. D. Huryn, and K. E. Webster. 2008. Predicting the historical distributions of naturally fishless lakes. *Freshwater Biology* 53:1021-1035.
- Shrimpton, M., J. Zydlewski, and W. Heath. 2007. Effects of sediment load on the smolt physiology in ocean type Chinook salmon. *Aquaculture* 273:269-276.
- Windmiller, B. and A.J.K. Calhoun. 2008. Conserving vernal pool wildlife in urbanizing landscapes Pages 233-253 In: Calhoun, AJK and P.G. deMaynadier (eds). Science and Conservation of Vernal Pools in Northeastern North America. CRC Press.
- Wood, S.A., S. Brault, and J.R. Gilbert. 2007. 2002 Aerial Surveys of Grey Seals in the Northeastern United States. Pages 117-121 In Grey Seals. North Atlantic Marine Mammal Conservation Organization. Copenhagen, Denmark.

#### **Technical and Semi-Technical Publications**

- Burns, C.E. 2008. Charismatic microfauna: The case of the golden mouse. *Journal of Mammalian Evolution*. Published Online First, doi 10.1007/s10914-008-9080-z.
- Calhoun, A. 2008. Education CD on vernal pool identification and assessment filmed for training public in conforming to new vernal pool state regulations
- Contreras M., Oyola N. , Palacios P. and Figueroa A. 2007. Protección y Manejo Sustentable de Humedales Integrados a la Cuenca Hidrográfica. Center of Applied Ecology (CEA) and National Environment Commission (CONAMA). <http://www.sinia.cl/1292/article-41115.html>.
- Fuller, A. K., D. J. Harrison, and B. J. Hearn. 2007. Application and testing of models to predict probability of occupancy and density of endangered Newfoundland martens. Final Contract Report to Canadian Forest Service and the Western Newfoundland Model Forest, 75 pp.
- Harrison, D., W. Krohn, L. Robinson, and J. Homyack. 2007. Temporal and spatial relationships among hares, lynx and forestry. Pages 53-57 in CFRU Annual Report 2005-2006, Maine Agricultural and Forest Experiment Station Miscellaneous Report 440, University of Maine, Orono, Maine.
- Holbrook, C., Zydlewski, J., Kinnison, M. 2007. Migration of Adult Atlantic salmon. Final Report to the West Enfield Fund.
- Krohn, W., and C.S. Loftin, eds. 2008. Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife Ecology – 2007 Report to Cooperators, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, Maine. 38 pp.
- Loftin, C.S., A.D Huryn, E.G. Schilling, and K.E. DeGoosh. 2008. Environmental factors associated with unique lake communities in Maine. Report to Maine Outdoor Heritage Fund, 9 pp.

- Loftin, C.S., J. Zydlewski, and A. Elskus. 2008. Examination of mercury contamination in northern two-lined salamanders and slimy sculpin inhabiting watersheds in coastal Maine. Report to Maine Outdoor Heritage Fund, 15 pp.
- Robinson, L., W. Krohn, and D. Harrison. 2007. Responses of snowshoe hare and Canada lynx to forest harvesting in northern Maine. Pages 58-64 in CFRU Annual Report 2005-2006, Maine Agricultural and Forest Experiment Station Miscellaneous Report 440, University of Maine, Orono, Maine.
- Schilling, E.G., C.S. Loftin, and A.D. Huryn. 2008. Effects of fish introductions on the geographic distribution and native invertebrate fauna of naturally fishless lakes in Maine, Report to the Maine Department of Inland Fisheries and Wildlife, 23 pp.
- Simons, E., K. Legaard, D. Harrison, S. Sader, J. Wilson, W. Krohn, and L. Robinson. 2007. Predicting responses of forest landscape changes on wildlife umbrella species. Pages 48-52 in CFRU Annual Report 2005-2006, Maine Agricultural and Forest Experiment Station Miscellaneous Report 440, University of Maine, Orono, Maine.
- White, A.S., and M. L. Hunter, Jr. 2007. Defining old growth. News Quarterly, *New England Society of American Foresters* 68 (4):8-9, 11.
- Zydlewski, J. Studies on Lake Whitefish in Maine. 2007. Annual Report to the Maine Department of Inland Fisheries and Wildlife.
- Zydlewski, J. and C.S. Loftin. 2008. Using dendrochronology and stable isotopes to document historical deposition of marine derived nutrients in the Penobscot River Basin, Maine. Report to Penobscot Indian Nation, 4 pp.

### **Theses and Dissertations**

- Beaudry, F. 2008. Road mortality risk for spotted and Blanding's turtle populations. Ph.D. Dissertation, University of Maine, Orono, Maine, 141 pp.
- Blomquist, S.M. 2008. Relative fitness and behavioral compensation of amphibians in a managed forest. Ph.D. Dissertation, University of Maine, Orono, Maine, 185 pp.
- Fernandes, S. 2008. Investigation into the distribution and abundance of Atlantic sturgeon (*Acipenser oxyrinchus*) and other diadromous species in the Penobscot River, Maine. M.S. Thesis, University of Maine, Orono, Maine, 100 pp.
- Politi, N. 2008. Selective logging in subtropical montane forests of the Andes: its effect on cavity nesting birds. Ph.D. Dissertation, University of Maine, Orono, Maine, 143 pp.
- Schilling, E.G. 2008. Effects of fish introductions on the geographic distribution and native invertebrate biodiversity of naturally fishless lakes in Maine. Ph.D. Dissertation, University of Maine, Orono, Maine, 138 pp.

### **Professional Talks Presented**

- Blomquist, S.M. 2008. Forest management alters multi-scale habitat selection and breeding success of *Rana sylvatica*. Joint Meeting of the American Society of Ichthyologists and Herpetologists, American Elasmobranch Society, the Herpetologists' League, and the Society for the Study of Amphibians and Reptiles. Montreal, Quebec, Canada. 27 July 2008.
- Blomquist, S.M. 2008. Forest management alters multi-scale habitat selection and breeding success of *Rana sylvatica*. University of Maine Graduate Student Research Expo. Orono, Maine. 15 April 2008.
- Burns, C.E. Current and future impacts of climate change in terrestrial ecosystems and the importance of landscape-scale management. Invited talk at the US Dept of Interior Conference: Climate Change in the Northeast: Preparing for the Future, Amherst, Massachusetts. June 2008.
- Burns, C.E. Fire and large herbivores in South African savanna grasslands. Wildlife Ecology Departmental Seminar, University of Maine, Orono, Maine. February 2008.
- Burns, C.E., A.D. Zinn, N. Govender, G.M. Buis, and M.D. Smith. The ecology of fear: Herbivore habitat preferences in fire-managed savanna grasslands. International Society for Behavioral Ecology, Ithaca, New York. August 2008.
- Calhoun, A.J.K. 2008. Community based Conservation of vernal pools in Maine. *Northeast Natural History Conference*, Albany, New York.
- Calhoun, A.J.K. 2008. Vernal pool science and regulation: planning for pools. *Maine Coast Heritage Trust Annual Meeting*. Brunswick, Maine.

- Calhoun, AJK. 2007. Conserving vernal pools in human-dominated landscapes. Symposium: *The Wildlife Society Annual Meeting*. Tucson, Arizona.
- Calhoun, AJK. *US Army Corps of Engineers*. Invited workshop for ACOE enforcement personnel: training for vernal pool field assessments, Concord, Massachusetts. March 20, 2008.
- Calhoun, AJK. *Maine State Planning Office: coastal and land use teams*. Invited lecture: Vernal pool ecology and management in Maine. Augusta, Maine. March 25, 2008.
- Calhoun, AJK. *Department of Environmental Protection*. Invited workshop with Phillip deMaynadier, Maine Department of Inland Fisheries and Wildlife. Vernal pool training for Code Enforcement Officers. Brunswick, Maine. April 24, 2008.
- Calhoun, AJK *Ecology and Environmental Sciences Seminar, UMaine*. Guest Lecture with Mac Hunter. Making a Difference: Advice on a Career in Conservation. University of Maine, Orono, Maine. April 3, 2008.
- Calhoun, AJK *School of Forest Resources, UMaine*. Invited lecture with Gordon Moore. Vernal pool conservation in working forests. University of Maine, Orono, Maine. March 28, 2008.
- Fernandes, S., G. Zydlewski, M. Kinnison and J. Zydlewski. Annual movement and migration patterns of Atlantic and shortnose sturgeons in the Penobscot River, Maine. Atlantic Salmon Research Forum. Orono, Maine. January 8, 2008.
- Fuller, A. K., and D. J. Harrison. Foraging paths reveal scale-dependent habitat decisions by Canada lynx. Paper presented at Canada Lynx on the Border, Biological and Political Realities for Conservation Planning: An International Workshop, Grand Portage, Minnesota. October 26, 2007.
- Fuller, A. K., D. J. Harrison, and B. J. Hearn. Application and testing of models to predict probability of occupancy and density of endangered Newfoundland martens. Presented to Newfoundland Marten Recovery Team, Corner Brook, Newfoundland. January 4, 2008.
- Fuller, A. K., D. J. Harrison, and B. J. Hearn. Spatial responses to habitat loss in two isolated populations of forest martens. Invited talk in the Ecology, Evolution, and Behavior seminar series. Virginia Tech. University, Blacksburg, Virginia. February 1, 2008.
- Fuller, A. K., D. J. Harrison, and W. B. Krohn. Landscape planning initiative for northern Maine using area sensitive umbrella species: an overview. Presented to Beginning with Maine Forest Landscape Planning Steering Committee. Orono, Maine. October 17, 2007.
- Fuller, A. K., D. J. Harrison, and W. B. Krohn. Landscape planning initiative for northern Maine using area sensitive umbrella species. Invited presentation to the USDA Natural Resources Conservation Service and U.S. Fish and Wildlife Service on workshop on their cooperative Healthy Forest Research Program, Bangor, Maine. July 1, 2008.
- Harrison, D. J. Effects of forest practices on habitat for wintering deer. Workshop and field tour for Maine Cooperative Forestry Research Unit Advisory Committee. Northern Maine. October 10, 2008
- Harrison, D. J. The influence of predators on overwintering deer survival: interactions with habitat. Invited Presentation at Deer Wintering Areas Workshop, Orono, Maine. December 10, 2007.
- Harrison, D. J. Wildlife in winter. Presentation at Fields Pond Nature Center, Brewer, Maine. January 8, 2008.
- Harrison, D. J., A. K. Fuller, and E. Simons. Trends in habitat supply for wildlife species whose habitat requirements are not addressed using coarse-filter umbrella species approaches, with a focus on deer wintering areas. Presentation to Advisory Committee, Maine Cooperative Forestry Research Unit, Orono, Maine. April 9, 2008.
- Harrison, D. J., and W. B. Krohn. Use of Umbrella Species as a Basis For a Wildlife Habitat Supply Planning Process for Commercial Forestlands in Northern Maine. Interagency Steering Committee of Maine's 'Beginning with Habitat' Program," University of Maine, Orono, Maine. October 17, 2007
- Harrison, D. J., W. B. Krohn, L. L. Robinson, S. Scott, A. K. Fuller, and C. L. Hoving. Temporal and spatial variation in snowshoe hare densities in eastern North America: relationships to lynx and forest management. Canada Lynx on the Border: Biological and Political Realities for Conservation Planning. International Workshop Organized by the University of Minnesota, Grand Portage, Minnesota. October 24, 2007.

- Harrison, D. J., W. B. Krohn, S. Scott, A. K. Fuller, L. Robinson, and C. L. Hoving. Stand-scale management to increase hare and lynx use of managed forests. Invited presentation at a workshop on Bridging Science and Stewardship sponsored by the Maine Cooperative Forestry Research Unit, Brewer, Maine. May 14, 2008.
- Harrison, D. J., W. Krohn, and A. K. Fuller. Long-term monitoring of snowshoe hare populations to inform stand- and landscape-scale forest management and recovery planning for Canada lynx in Maine. Presentation to Advisory Committee, Maine Cooperative Forestry Research Unit, Orono, Maine. April 9, 2008.
- Holbrook, C., J. Zydlewski, and M. Kinnison. Effects of hydroelectric dams on survival and behavior of migrating Atlantic salmon smolts in the Penobscot River, Maine. Atlantic Salmon Research Forum. Orono, Maine. January 8, 2008.
- Hunter, M. L. The role of assisted colonization in adapting to climate change. Adaptation to Climate Change Workshop, Minneapolis Minnesota. June 6, 2008.
- Hunter, M.L. Effects of forestry on amphibians: a 15-year retrospective from Maine. School Forest Resources University of Maine Seminar. Orono, Maine. November 30, 2007.
- Johnson, J., Baumsteiger, J., Zydlewski, J., Hudson, M. and Ardren, W. Genetic Analysis of Sympatric Sea-run and Resident Coastal Cutthroat Trout in the Columbia River. Western Division of the American Fisheries Society. Portland, Oregon. June 2008.
- Krohn, W.B. and D. J. Harrison. Efforts by the University of Maine to Integrate Wildlife Habitats into Land Conservation Planning: A Brief History. Interagency Steering Committee of Maine's 'Beginning with Habitat' Program, University of Maine, Orono, Maine. October 17, 2007.
- Krohn, W. B., and E. R. Simons. Using historical data to determine the contemporary distribution of Canada lynx: a cautionary note. Canada Lynx on the Border: Biological and Political Realities for Conservation Planning. International Workshop Organized by the University of Minnesota, Grand Portage, Minnesota. October 24, 2007.
- Mitchner, L. J., A. S. White, and W. B. Krohn. Some Characteristics of the Presettlement Forest of Northern Maine. American Association of Geographers, 2008 Annual Meeting, Boston, Massachusetts. April 21, 2008.
- Kurth, J.E., C.S. Loftin, J. Zydlewski, and J. Rhymer. Multi-stage approach using population surveys and pit tags to assess suitability of translocation sites for freshwater mussels threatened by impending dam removal. Invited presentation to the Annual Meeting of the North American Benthological Association, Salt lake City, Utah. May 25-30, 2008.
- Palacios, P. A., Contreras M., Oyola N., Hunter, M. L. Jr., and Calhoun A. J. K. Funciones de Los Humedales Chilenos: Amenazas y Conservacion. Invited presentation to the Limnic systems and anthropic perturbations symposium at the Joint Meeting of the Chilean and Argentinean Ecological Societies, La Serena, Chile. September 30-October 4, 2007.
- Parsons, M., C.S. Loftin, and F. Servello. Assessment of disturbance responses by nesting seabirds on a coastal island in Maine. Presentation to the Gulf of Maine Seabird Working Group, Bangor, Maine. March 12, 2008.
- Schilling, E.G., C.S. Loftin, and A.D. Huryn, K.E. DeGoosh. Assessing the geographic distribution and invertebrate biodiversity of naturally fishless lakes in Maine, USA. Presentation to the Annual Meeting of the International Association of Landscape Ecologists, Madison, Wisconsin. April 6-10, 2008.
- Schilling, E.G., C.S. Loftin, and A.D. Huryn. Habitat on the brink? Assessing the geographic distribution and invertebrate biodiversity of naturally fishless lakes in Maine. Presentation to the Minnesota Chapter of the Society for Conservation Biology, Lanesboro, Minnesota. March 8-9, 2008.
- Seger, R.L. Wolff's Law and the Black Bear. Presented at the Thirteenth Annual New England Bone Club Meeting, Kennebunkport, Maine. October 18, 2007.
- Seger, R.L. Bear Bones. Presented at the Thirteenth Annual Maine State Symposium on Osteoporosis, Carrabasset Valley, Maine. January 27, 2008.
- Simons, E. M. Trends in American marten habitat on the commercial forestlands of northern Maine. Presented at the Annual Meeting of the New England Regional Council on Forest Engineering, Orono, Maine. March 10, 2008.
- Simons, E. M., L. Robinson, D. J. Harrison, W. B. Krohn, and K. R. Legaard. Ecological factors associated with landscape-scale occurrences of Canada lynx in northern Maine. Paper presented at Canada Lynx on the Border, Biological and Political Realities for Conservation Planning: An International Workshop, Grand Portage, Minnesota. October 24, 2007.

- Spencer, R., J. Zydlewski and G. Zydlewski. Comparison of migratory urge and gill Na<sup>+</sup>,K<sup>+</sup>-ATPase activity of Atlantic salmon (*Salmo salar*) smolts from Dennys and Penobscot River stocks. Atlantic Salmon Research Forum. Orono, Maine. January 8, 2008.
- Wathen, R. A., S. M. Coghlan, J. Zydlewski, and J. G. Trial. 2008. A Controlled Invasion: Do Exotic Smallmouth Bass Compete for Habitat With Atlantic Salmon? Presented at the American Fisheries Society Annual Conference, Ottawa, Canada. August 21, 2008.
- Zydlewski, G., J. Zydlewski and S. Lashua. Long-term seawater performance and scale circuli deposition of Atlantic salmon smolts. Atlantic Salmon Research Forum. Orono, Maine. January 8, 2008.
- Zydlewski, J. Sea-run brook trout and striped bass. characterizing connectivity with the sea. Invited to presentation to Maine Sea Grant Policy Advisory Committee. June 5, 2008.

### **Public Talks Presented**

- Burns, C.E. On being a wildlife ecologist. Guest lecture to Old Town High School Science Club, Old Town, Maine. November 2007.
- Burns, C.E. On being a wildlife ecologist. Guest lecture to the Student Chapter of The Wildlife Society, University of Maine, Orono, Maine. April 2008.
- Burns, C.E. Protecting biodiversity in an increasingly urban world: An assessment of urban impacts on flora and fauna in and around New York City. Lecture to Earthwatch Institute research volunteers, New York, New York. May 17, June 21, July 5 and 19, and August 2, 2008.
- Calhoun A. and M. Hunter. Making a Difference: Advice on a Career in Conservation. Eco-Eco Forum, School of Economics, University Maine, Orono, Maine. April 3, 2008.
- Calhoun, A.J.K. Town of Brunswick. Training workshops for vernal pool mapping and conservation project. Brunswick, Maine. March 26, (televised locally) 2008.
- Calhoun, A.J.K. Town of Scarborough. Training workshop for vernal pool mapping and conservation project. Scarborough, Maine. April 2, 2008.
- Calhoun, A.J.K. Towns of Brunswick and Scarborough. Field workshop for vernal pool assessments. Brunswick, Maine. April 15, 2008.
- Calhoun, A.J.K. Town of Orono. Training workshops for vernal pool mapping and conservation project. April 21, 2008.
- Coghlan Jr., S.M., R. A. Wathen, and J. Zydlewski. Interactive ecology of Atlantic salmon and smallmouth bass in Maine rivers. Presented at Maine Sportsmen's Show / Trout Unlimited, Augusta, ME. March 29, 2008.
- Hunter, M.L. Biodiversity: buzzword or fundamental concept? Merrymeeting Bay Chapter of the National Audubon Society, Brunswick Maine. March 25, 2008.
- Hunter, M.L. Biodiversity: buzzword or fundamental concept? Distinguished Lecturer for Science Day. University of Maine at Presque Isle. November 6, 2007.
- Krohn, W. B. Historical Ecology of the White-tailed Deer in Maine. Munsungan Workshop on Deer Wintering Areas in Maine, Maine Cooperative Forestry Research Unit, Stillwater, ME. December 10, 2007.
- Krohn, W. B. Joshua Gross Rich (1820-1897): Western Maine Pioneer and Wildlife Writer, Invited presentation to the Rangeley Lakes Regional Historical Society, Rangeley, ME. August 13, 2008.
- Servello, F. Regional Limiting factors for white-tailed deer populations in wintering areas: foods and nutrition. Munsungan Workshop Series, Cooperative Forestry Research Unit and Center for Sustainable Forests, University of Maine. December 10, 2007.
- Simons, E.M., D. J. Harrison, W. B. Krohn, K. Legaard, and S. Sader. Landscape indicators of forest biodiversity: Using American marten, Canada lynx, and snowshoe hares to evaluate retrospective trends in habitat supply across northern Maine. Invited presentation at a workshop on Bridging Science and Stewardship sponsored by the Maine Cooperative Forestry Research Unit, Brewer, Maine. May 14, 2008
- Simons, E. M, D. J. Harrison, Krohn, W.B., K. R. Legaard, S. A. Sader, and J. S. Wilson. Predicting responses of forest landscape change on wildlife umbrella species. Presentation to Advisory Committee, Maine Cooperative Forestry Research Unit, Bangor. April 7, 2008.

- Simons, E.M., D. J. Harrison, and W. B. Krohn. Ecological factors associated with landscape-scale occurrence of Canada lynx in northern Maine. *Canada Lynx on the Border: Biological and Political Realities for Conservation Planning*. International Workshop Organized by the University of Minnesota, Grand Portage, Minnesota. October 24, 2007.
- Witham, J. *Wildlife Ecology in Your Backyard* for University of Maine Cooperative Extension, Androscoggin and Sagadahoc Counties. March 29, 2008.
- Witham, J. *From Forest to Farm and Back Again: Holt Research Forest, Arrowsic*. Town History Series, Patten Free Library, Bath, Maine. January 26, 2008.
- Witham, J. *Introduction to Wildlife Ecology* for University of Maine Cooperative Extension, Androscoggin and Sagadahoc Counties. October 13, 2007.
- Witham, J. Hosted Forest Ecology class from Unity College for tour of Holt Research Forest. April 2, 2008.

### **Workshops**

- Hunter, M. and A. Calhoun. Advice for newcomers workshop. Society for Conservation Biology Conference, Chattanooga, TN. July 11, 2008.
- Witham, J. Hosted Maine Mycological Association for a Mushroom Foray at the Holt Research Forest. October 6, 2007.

### **Awards, Honors, and Appointments**

- Blomquist, S.M. 2008. American Society of Ichthyologists and Herpetologists Frederick H. Stoye Award for Conservation.
- Calhoun, A. 2008. College of Natural Sciences, Forestry and Agriculture, University of Maine Outstanding Public Service Award.
- Fuller, A. K. 2008. The Wildlife Society Leadership Institute.
- Hunter Jr., M.L. 2007. Distinguished Service Award of the Society for Conservation Biology conferred in Port Elizabeth, South Africa.
- Krohn, W. 2007. Superior Performance Award from the U.S. Geological Survey's Cooperative Unit Program for research productivity, for professional recognition of his research on forest carnivores.
- Loftin, C. 2007. Superior Performance Award from the U.S. Geological Survey Cooperative Unit Program for research productivity.
- Simons, E. M. 2007. George F. Dow and Fred Griffee Award for outstanding graduate research from the Maine Agricultural and Forest Experiment Station.

### **Television, Radio, and Newspaper Interviews and Articles**

- Calhoun, A. *Bangor Daily News* - Orono, Veazie eager to map vernal pools: project with University of Maine could aid landowners developing property containing wetlands. April 2, 2008.
- Calhoun, A. *The Forecaster* - "Council endorses tightened natural resources policies." June 5, 2008.
- Harrison, D. J. *Defenders Magazine* - Provided scientific advisement to article on coyotes and wolves in eastern North America.
- Harrison, D. J. *Fosters Daily Democrat* - Contributed to article on domestic cat mortality from wildlife interactions.
- Harrison, D. J. *National Wildlife Magazine* - Contributed to an article featuring our lynx research.
- Harrison, D. J. Phyliss Austin - interview for book on Baxter State Park.
- Harrison, D. J. *Portland Press Herald* - frequent interviews on wildlife habitat and Plum Creek development issues.
- Krohn, W.B. *National Wildlife Magazine* - Contributed to an article featuring our lynx research.
- Wathen, R A. Channel 7 News - Interview about the research investigating competition between Atlantic salmon and smallmouth bass.