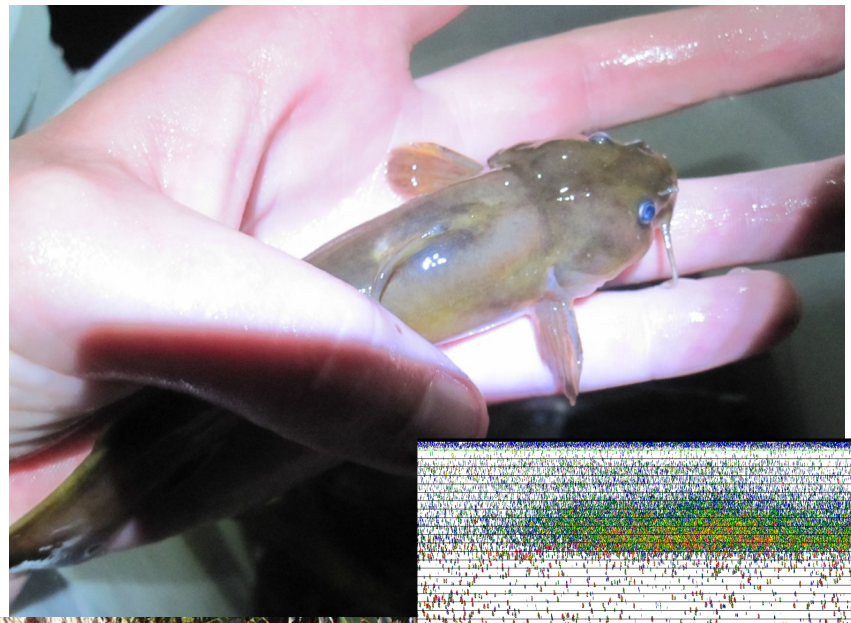
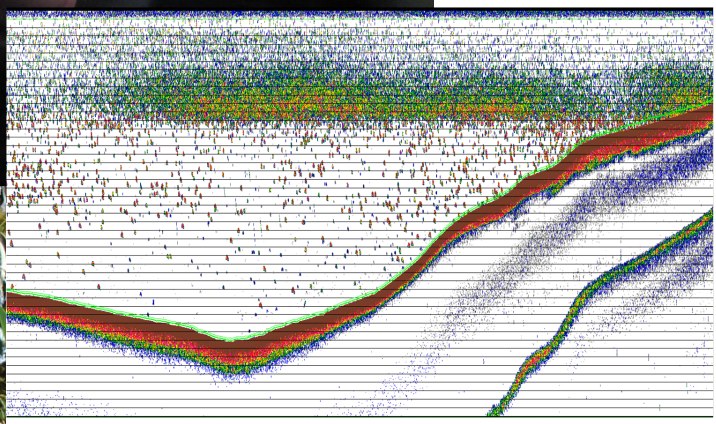
2010-2011 Unit Report

# Vermont Cooperative Fish and Wildlife Research Unit





In Cooperation With

- U.S. Geological Survey
- Vermont Department of Fish and Wildlife
- University of Vermont
- Wildlife Management Institute

# Vermont Cooperative Fish and Wildlife Research Unit

**2010-2011**
**Report of Activities**

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**Cover photos clockwise from top: Stonecat captured on the Great Chazy River in 2011; Acoustic transects with YOY rainbow smelt targets concentrated at thermocline; Wildlife acoustics recording device for remote monitoring of birds, amphibians, insects and bats.**

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# Program Direction Statement

The Vermont Cooperative Fish and Wildlife Research Unit is located at the University of Vermont (UVM) in Burlington, Vermont, and is housed on campus in The Rubenstein School of Environment and Natural Resources. Overall goals of the Unit are (i) to address technical and research needs of federal fish and wildlife agencies, the Vermont Department of Fish and Wildlife, the University of Vermont, and other federal, state, and private entities; (ii) to participate in the education of graduate students and advanced undergraduate students at the University of Vermont; and (iii) to disseminate findings of research conducted by Unit personnel, graduate students, and cooperators. Unit personnel coordinate Unit activities with federal fish and wildlife agencies, the Vermont Department of Fish and Wildlife, and other agencies and groups involved in the management of natural resources.

Research by current Unit personnel is directed primarily toward aquatic and terrestrial ecosystems within the state of Vermont. Unit research is conducted in the context of a comprehensive, ecosystems approach that recognizes the importance of ecological and human interactions among species and their habitats. Research activities focus on the biology/ecology of fish, mammal, and bird species, and the biological consequences of human impacts on aquatic and terrestrial systems.

Research in these areas is conducted by Unit personnel who possess technical expertise in fish/aquatic ecology, landscape ecology, species/habitat associations, bioenergetics modeling, population viability modeling, and hydroacoustics technology.

To achieve the Unit research goals, Unit personnel aggressively pursue funding sources for projects of scientific merit that advance our knowledge of natural resources and their management. This involves both field and laboratory studies in which integrated research is conducted with colleagues at UVM and elsewhere. Along with these studies, Unit activities include enhancement of methodological and analytic capabilities at UVM in the areas of fish and wildlife biology.

Unit Leader Donna Parrish and Assistant Unit Leader Terri Donovan

Unit educational goals are achieved in several ways, including the teaching of formal courses at the graduate and upper undergraduate level. Courses recently taught by Unit personnel include Ecology of Fishes, Population Dynamics and Modeling, and Occupancy Modeling and Estimation. Several on-line courses have been developed in collaboration with the U.S. Fish and Wildlife Service National Conservation Training Center. Unit staff also participate in the classroom through presentation of guest lectures and seminars. Unit staff act as advisors for graduate students, and are involved as committee members on graduate research committees. To the extent possible, Unit personnel also participate in training and education programs for personnel in the Vermont Department of Fish and Wildlife.

Our vision for this Unit is to provide the best possible science to natural resource management agencies for the restoration of habitats and recovery and sustainability of Vermont's fish and wildlife species. In achieving our vision, we will continue to conduct research that is highly relevant to and valued by managers and policy makers.

November 2011

# *Aquatic Research Project Narratives*

## POPULATION MODELING OF ATLANTIC SALMON IN VERMONT TRIBUTARIES OF THE CONNECTICUT RIVER

**Principal Investigators:** Donna L. Parrish, Martha E. Mather (USGS-Kansas Coop Unit), and Elizabeth A. Marschall (The Ohio State University)

**Project Cooperators:** National Marine Fisheries Service and Vermont Department of Fish and Wildlife

**Project Period:** 1 August 2002 – 31 July 2010

**Objective:** To develop a population model that will be useful in exploring various restoration strategies for Atlantic salmon in Vermont.

**Synopsis:** Conservation and restoration of animal populations in the face of disruptions to migrations is a growing problem. Anthropogenic barriers along migration paths can delay migrations or increase their duration, which may weaken the value of adaptations in migration timing. To understand the interaction of dams (as barriers along a migration path), seasonally changing environmental conditions, timing of Atlantic salmon (*Salmo salar*) downstream migration, and ultimate migration success, we used ten years of river temperature and discharge data as a template upon which we simulated downstream movement of salmon. Atlantic salmon is a coolwater species whose downstream migrating smolts must complete migration before downstream river temperatures become too warm. We found that dams had a local effect on survival as well as a survival effect that was spatially and temporally removed from the encounter with the dam. By delaying smolts until temperatures downstream had reached lethal or near-lethal temperatures, dams served to disrupt the match between completion of migration and the window of appropriate migration conditions. Our simulations showed that this spatially and temporally removed effect is at least as important as the local effects of dams in determining smolt migration success in the presence of dams. We also considered smolts from different tributaries, varying in distance from the river mouth, to assess the potential importance of locally adapted migration timing on the effect of barriers. Our results demonstrated that migration-initiation temperature affected modeled smolt survival differentially across tributaries, with the success of smolts from upstream tributaries being much more variable across years than that of smolts with less migration distance to travel. As a whole, these results point to the importance of broadening our spatial and temporal view when managing migrating populations: consider not only how many individuals never make it across migration barriers, but also the spatially and temporally removed consequences of delays at the barriers for those individuals that successfully navigate them.

**Project Status:** Completed.

## DEVELOPING A SAMPLING PROTOCOL AND CONDUCTING GENETIC ANALYSES FOR MUDPUPPIES IN LAKE CHAMPLAIN

**Principal Investigators:** Donna L. Parrish and C. William Kilpatrick (Co-PI on genetics portion)

**Graduate Student:** Isaac Chellman (M.S. Student)

**Project Cooperator**: Vermont Department of Fish and Wildlife

**Project Period**: 1 January 2008 – 31 December 2010

**Synopsis:** The mudpuppy (*Necturus maculosus*) is a large, fully aquatic salamander that holds a rare status in Vermont and is classified as a high priority species of greatest conservation need. This research was undertaken to assess baseline mudpuppy population biological parameters in Vermont, including abundance, survivorship, and genetic diversity. To assess population demographic parameters, we used mark-recapture techniques in which mudpuppies were sampled using modified, baited minnow traps set during two winter-spring periods (2008-2009 and 2009-2010) in the Lamoille River, which was treated with TFM in early October 2009. Each mudpuppy was marked with a passive integrated transponder (PIT) tag, and released after collecting morphological measurements and a tissue sample for genetic analyses. No changes occurred in survivorship and male abundance between sampling periods. However, female abundance decreased between the two sampling periods and there was a change in sex ratio from 50:50 in 2008-2009 to male-biased in 2009-2010. To investigate genetic diversity, we sequenced mitochondrial DNA from tissue samples collected in the Lake Champlain basin and other systems in the Northeast. Phylogeographic analysis placed Connecticut River samples in a cluster separate from all other Northeast samples. Unique haplotypes were found in several systems, including the Great Chazy River, NY; Scriba Creek, NY; Grand River, OH; and Connecticut River, MA. These results may help inform management in the Northeast to meet conservation goals.

**Project Status**: Completed.

**Mudpuppy observed in stream.**

**RECRUITMENT DYNAMICS OF YOUNG-OF-YEAR RAINBOW SMELT AND ALEWIFE IN LAKE CHAMPLAIN**

**Principal Investigators:** Donna L. Parrish, Lars G. Rudstam and Patrick J. Sullivan (Cornell University), and Bernie Pientka (VTFW)

**Graduate Student:** Paul W. Simonin (M.S. Student, UVM, 2007-2010 and Ph.D. Student, Cornell University, 2009-2013)

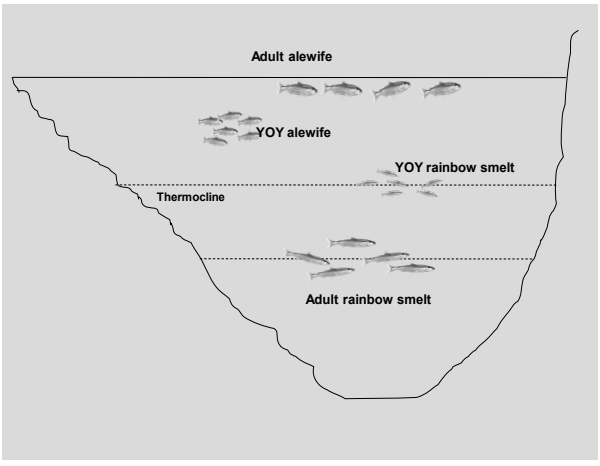
**Project Cooperators**: Lake Champlain Sea Grant and Vermont Department of Fish and Wildlife

**Project Period**: 1 June 2007 – 31 January 2010

**Synopsis**: Rainbow smelt (*Osmerus mordax*) were historically the dominant pelagic planktivore in Lake Champlain. This study extends and complements our work of 2001 and 2002 by focusing on young-of-year (YOY) rainbow smelt and the recent pelagic invader, alewife (*Alosa pseudoharengus*). Our goal is to understand habitat use and seasonal dynamics of these two fish populations. We quantified adult and particularly young-of-year (YOY) rainbow smelt and alewife distribution and abundance temporally in relation to their physical environment. We used hydroacoustic equipment, trawls, and gill nets to observe fish over inshore-to-offshore transects during day and night. Each trip we also collected temperature, dissolved oxygen, pH, conductivity, and light data throughout the water column, and recorded continuous surface light levels. Surveys were conducted every two to three weeks from June to October of 2007 and 2008.

Our study expands the current knowledge base in several ways by providing a uniquely comprehensive description of seasonal and diel dynamics of interacting cannibalistic populations in relation to physical habitat gradients. This explicit understanding of physical – biotic connections and species behavior clarifies our understanding of fish population dynamics and informs decisions regarding Lake Champlain and other systems.

**Project Status**: Completed.




**Cartoon illustrating summer distribution of rainbow smelt and alewife at night in Lake Champlain.**

**NON-NATIVE ALEWIFE AND NATIVE RAINBOW SMELT IN LAKE CHAMPLAIN: A MODELING APPROACH TO DESCRIBE INTERACTIONS AND SYSTEM-WIDE CONSEQUENCES**

**Principal Investigators:** Donna L. Parrish, Lars G. Rudstam and Patrick J. Sullivan (Cornell University), and Bernie Pientka (VTFW)

**Graduate Student:** Paul W. Simonin (M.S. Student, UVM, 2007-2010 and Ph.D. Student, Cornell University, 2009-2013)

**Project Cooperators**: Lake Champlain Sea Grant and Vermont Department of Fish and Wildlife

**Project Period**: 1 February 2009 – 31 January 2014

**Objectives:** 1) To develop a model of YOY rainbow smelt and alewife survival through their first summer that includes explicit attention to changes in spatial distributions of cannibalistic predators (adult alewife and rainbow smelt) and prey (YOY alewife and rainbow smelt) in Lake Champlain, 2) Using the results of objective (1), develop a coupled, age-structured population dynamics model of alewife and rainbow smelt in Lake Champlain, and 3) Evaluate the likely effects of the expansion of alewife on rainbow smelt and the greater Lake Champlain ecosystem.

**Synopsis**: The recent dramatic increase in alewife population size in Lake Champlain is presumably affecting all aspects of the pelagic food web in the lake. Alewife are increasing predation pressure on YOY rainbow smelt and potentially decoupling the strong relationship between adult and YOY rainbow smelt. At the same time, alewives are a buffer for salmonid predation on both YOY and adult rainbow smelt. Recent reductions in sea lamprey induced mortality of salmonids in Lake Champlain is leading to increased survival of salmonids, which is expected to impose a higher demand on the forage base. We will explore such possibilities through scenarios using our rainbow smelt – alewife model. To predict these effects, a size- and age-structured model that includes explicit considerations of the spatial dynamics of each size and age group is required.

**Project Status**: Ongoing.

## MODELING THE EFFECTS OF CLIMATE CHANGE ON ANADROMOUS FISH POPULATIONS IN THE CONNECTICUT RIVER

**Principal Investigators:** Donna L. Parrish, Martha E. Mather (USGS-Massachusetts Coop Unit), and Elizabeth A. Marschall (The Ohio State University)

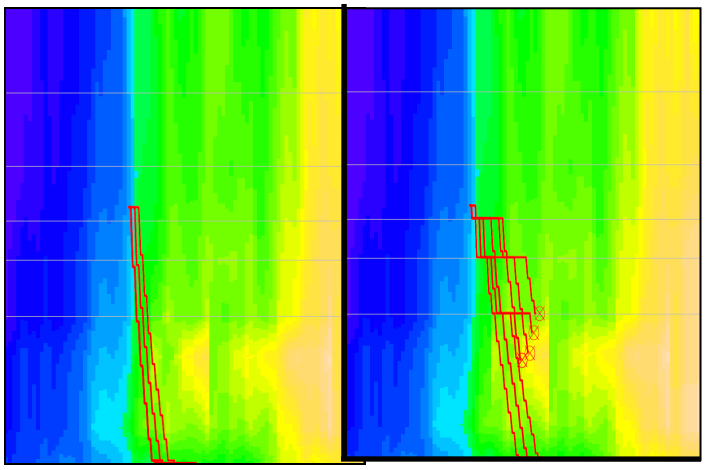
**Project Cooperators:** National Marine Fisheries Service and Vermont Department of Fish and Wildlife

**Project Period:** 1 August 2011 – 31 July 2015

**Objective:** To develop a population model that will be useful in exploring various restoration strategies for Atlantic salmon in Vermont.

**Synopsis:** Previously we explored how temperature, discharge, and the indirect effects of dams (by creating delays in migration) were related to survival of Atlantic salmon smolts. Thus, here we propose to model Atlantic salmon to forecast survival of migratory fish in relation to increased temperature and fluctuating discharges. We may also be able to work on modeling upstream as well as downstream migration. Our results will be useful in predicting the effect of future thermal regimes and river flow conditions during migration of various fish species in the mainstem Connecticut River. We may also be able to compare some of our modeling results in the Connecticut to the Merrimack and Penobscot rivers. From this research, we will be better able to predict the range of conditions in the future that will allow for successful migration through the river.

**Project Status:** New.



**Simulations of Atlantic salmon smolts migrating (red lines) downstream—left panel without dams and right panel with dams. An X marks where a smolt dies during the migration. Fish most often die when encountering hotspots (yellow) caused by delay at dams not the dams themselves.**

## ASSESSMENT OF STONECAT (*NOTURUS FLAVUS*) POPULATIONS IN THE MISSISQUOI AND LAPLATTE RIVERS OF VERMONT

**Principal Investigator:** Donna L. Parrish

**Graduate Student:** Elizabeth Puchala (M.S. Student)

**Project Cooperator:** Vermont Department of Fish and Wildlife

**Project Period:** 1 June 2011 – 31 December 2014

**Objective:** To increase our knowledge of the current status of identified stonecat populations in the Missisquoi and LaPlatte rivers including estimates of abundance, age and size structures, population and suitable habitat distributions, survival rates, and other information critical to assessing the likelihood of long-term stonecat population persistence and viability faced with mortality resulting from lampricides and other threats.

**Synopsis:** Stonecat *Noturus flavus* are known to populate two rivers in Vermont, the Missisquoi and LaPlatte rivers located in the Lake Champlain watershed, and as such is a state listed endangered species and species of greatest conservation need. Little is known about stonecat populations in Vermont including their abundance and other population parameters in the Missisquoi and LaPlatte rivers, distribution and habitat availability and use, and population viability and persistence. This project will assess stonecat populations in both rivers resulting in quantifying population parameters necessary to assessing risks to populations. The project will also identify risk assessment models that offer opportunities for further evaluation of the likelihood of sustaining stonecat populations in Vermont in the face of possible sources of mortality.

**Project Status:** New.

**Juvenile stonecat collected in Missisquoi River in July 2011.**

# *Terrestrial Research Project Narratives*

**THE INFLUENCE OF FOREST ATTRIBUTES ON INDICATORS OF BIODIVERSITY: ESTABLISHING GUIDELINES FOR SUSTAINABLE FOREST MANAGEMENT**

**Principal Investigators**: Therese M. Donovan, William Keeton and Thomas McEvoy (UVM Rubenstein School)

**Post-Doctoral Associate**: Scott Schwenk

**Project Cooperator**: Northeastern States Research Cooperative (USDA)

**Project Period**: 1 September 2008 - 1 September 2010

**Synopsis**: Today's forests are managed for multiple purposes, including timber production, biodiversity conservation, and carbon sequestration. Challenges arise in managing for multiple ecosystem services because of conflicting endpoints. A practice that maximizes one objective, such as timber production, is unlikely to simultaneously maximize all other ecosystem services. Additional challenges arise in quantifying and comparing values of different services. How can board feet harvested, carbon stored, and biodiversity level be compared to allow an informed management decision?

The Vermont Cooperative Fish and Wildlife Research Unit applied Multi-Criteria Decision Analysis to simultaneously consider three objectives in managing Vermont forests: storing carbon, producing timber and wood products, and sustaining bird biodiversity. Researchers used a computer model, the Forest Vegetation Simulator, to simulate four forest management prescriptions (no harvest, clearcut, shelterwood, and single-tree selection) on 42 northern hardwood sites over 100 years. For each simulation, we estimated carbon storage, timber production, and biodiversity implications for 51 terrestrial bird species.

Results indicated that multiple objectives for forest services could be accommodated, but trade-offs occurred. When a greater preference for carbon storage was applied, management prescriptions involving less intense harvesting were favored. Conversely, greater preference for timber production favored management with a high intensity of harvesting. A diversity of silvicultural approaches is likely to be preferable to any single approach in meeting multiple objectives for forest ecosystem services.

**Project Status:** Completed.

**.DESIGNING SUSTAINABLE LANDSCAPES IN THE NORTH ATLANTIC LANDSCAPE CONSERVATION COOPERATIVE: DEVELOPMENT OF WILDLIFE HABITAT RELATIONSHIP MODELS FOR TERRESTRIAL VERTEBRATES**

**Principal Investigator:** Therese M. Donovan

**Post-Doctoral Associate**: Scott Schwenk

**Project Cooperator**: U.S. Fish and Wildlife Service

**Project Period**: 1 August 2010 - 31 September 2011

**Synopsis**: The goals of the North Atlantic Landscape Conservation Cooperative (LCC) are to assess the current capability of habitats in the North Atlantic LCC to support sustainable wildlife populations, to predict the impacts of landscape-level changes on the future capability of these habitats to support representative species, and to target conservation programs to most effectively and efficiently achieve habitat objectives.

To help achieve these goals, the Vermont Cooperative Fish and Wildlife Research Unit has been developing habitat relationship models for representative wildlife species. This project focuses on non-game species, such as the wood thrush. However, the Unit is also developing habitat suitability (HSI) models for selected game species, including black bear, fisher, and bobcat.


An HSI model provides a score from 0 to 1 for each pixel in the LCC, where higher scores indicate higher suitability. The predictor variables for the HSI models include readily derivable GIS datasets for the entire North Atlantic LCC at a spatial resolution of 30 m, such as landcover, elevation, rainfall, etc. The species-specific HSI scores for a species are likely to be altered in the next 100 years due to climate change, human population growth, and forest change. The North Atlantic LCC models will help quantify these potential changes in habitat suitability for a large number of wildlife species.

**Project Status:** Completed.

**STRUCTURED DECISION MAKING FOR LAND USE PLANNING IN VERMONT: INTEGRATING SOCIAL AND ECOLOGICAL OBJECTIVES**

**Principal Investigators**: Therese M. Donovan, Robert Manning (UVM Rubenstein School), John Austin (VTFW), and Doug Walker (Placeways)

**Graduate Student**: Charles Bettigole (M.S. Student)

**Project Cooperator**: Northeastern States Research Cooperative (USDA)

**Project Period**: 1 January 2010 - 30 June 2012

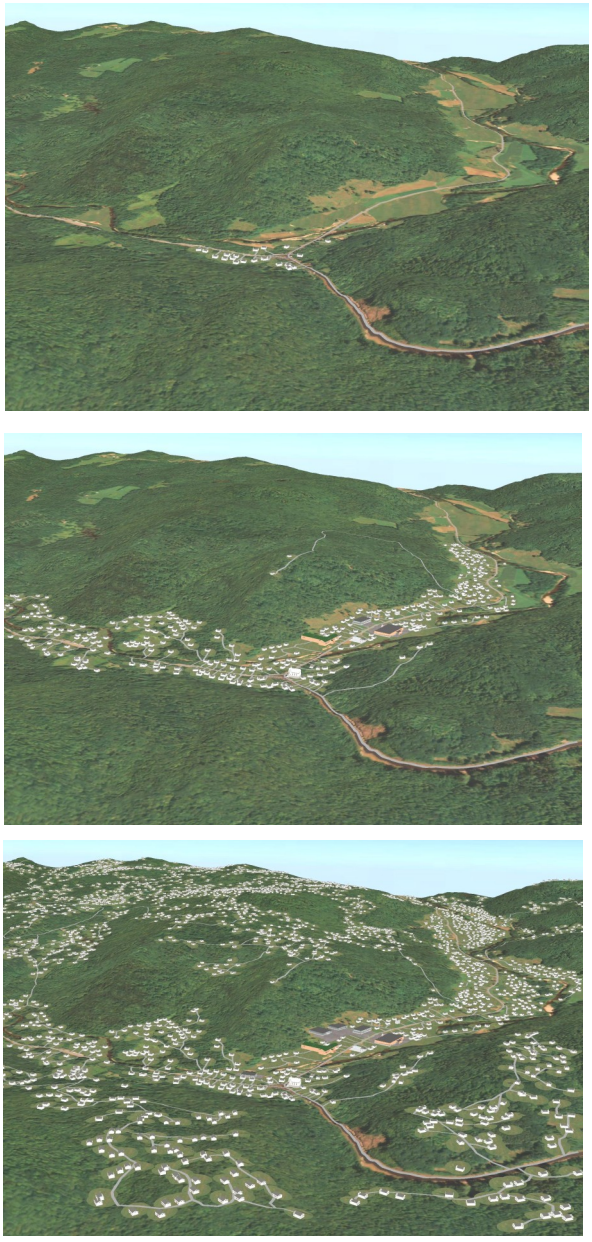
**Synopsis**: The most serious threat to native wildlife species in the Northern Forest is the conversion of natural lands to development. Many wildlife species that live in the Northern Forest require large areas to carry out their life cycle, suggesting a landscape scale approach is needed to ensure long term biological conservation. However, top-down landscape level planning is challenging in the Northern Forest, where the majority of lands are under private ownership, resulting in landscape patterns that are driven from the bottom-up. That is, individual decisions made by local land owners and towns acting in their own interest collectively determine landscape quality for wildlife species, for better or worse. The issue of how to design a landscape that meets the needs of multiple interests is inherent in the town planning process. Often, however, wildlife is a silent stakeholder in this process.

The goal of this project is to develop a prototype of a Structured Decision Making (SDM) process that will bring wildlife to the table in local town planning efforts. The first phase of the Structured Decision Process is to develop measurable objectives such as "Maintain at least 40% of the town as forest." This example contains both an indicator (level of forest cover in a town) and a standard (40%).

To establish objectives (indicators and standards) for development in towns across Vermont, we developed a visual preference survey that utilized CommunityViz and Google Earth software (see figure to right). Survey respondents were asked to rate the acceptability of visual images of varying levels of development, agriculture and natural lands within their local community. Data were also collected with respect to age, income, sex, and home town. We used a stratified random sample of Vermont residents and mailed the survey to 4000 home owners in the summer of 2011. To date, >1600 responses have been received.

"Norms of acceptability" of development are being estimated for each town in Vermont, based on survey results, which provide the level of development that is deemed "acceptable" by residents. Given these norms, the Vermont Cooperative Fish and Wildlife Research Unit is assessing the likely ecological consequences of these "norms" for a variety of forest-dependent wildlife species. This process will, for the first time, allow state biologists to evaluate how planning objectives for a collection of local towns will likely impact landscape quality for wildlife species.

**Project Status**: Ongoing.



**Example images depicting different levels of development in a hypothetical town, to which survey respondents rated their "level of acceptability."**

**PREDICTING IMPACTS OF FUTURE HUMAN POPULATION GROWTH OF DEVELOPMENT ON FOREST-DEPENDENT WILDLIFE SPECIES**

**Principal Investigators**: Therese M. Donovan and David Theobald (Colorado State)

**Graduate Student**: Michelle Brown (M.S. Student)

**Project Cooperator**: U.S.D.A. McIntire-Stennis

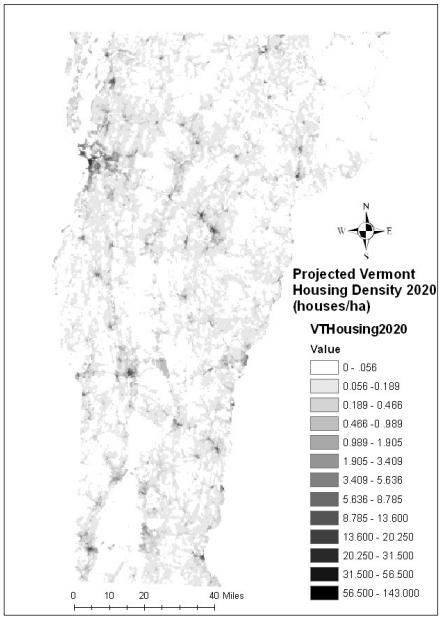
**Project Period**: 1 January 2009 - 30 September 2012

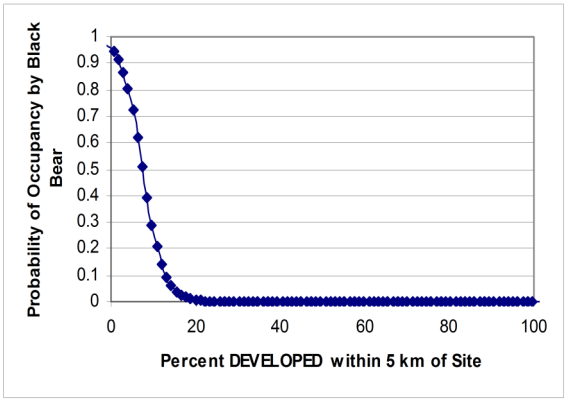
**Synopsis**: Forest loss is perhaps the most important contemporary issue in the Northeast for wildlife species. Given increasing forest loss and fragmentation, the "problem" of how native fauna will respond to eminent land-use change is widespread, and requires tools and methods for understanding population responses as well as management recommendations for conservation. This study integrates wildlife habitat modeling with GIS models of human population growth to quantify how various forest-dependent wildlife species will respond to projected increases in human population growth (year 2050) for the state of Vermont. The Vermont Cooperative Fish and Wildlife Research Unit is collaborating with Dr. David Theobald (Colorado State University) on this work.

The first analysis involves estimating changes in housing density across Vermont to the year 2050, accomplished through a population growth model called SERGoM (Spatially Explict Regional Growth Model). With projected changes in human housing, researchers can predict the increase in developed land cover classes and road density as a result of human growth. These two factors (% development and road density) are known to affect the abundance and distribution of several different wildlife species in Vermont. Finally, given changes in road density and development, researchers are quantifying the likely impact of human growth on occupancy probability for several forest-dependent species.

The study will advance conservation planning by: 1) providing GIS layers on the contemporary distribution (probability of occurrence) for selected forest-dependent species; and 2) providing GIS layers that quantify risk for these same species given future human population growth and development.

**Project Status**: Ongoing.




**Projected housing density for Vermont in the year 2050 (top). Increases in housing density will increase the percent developed landcover classes in Vermont (bottom), which in turn will decrease black bear occurrence.**

**ACOUSTICAL MONITORING OF BIODIVERSITY AND PHENOLOGY: A PILOT WILDLIFE MONITORING PARTNERSHIP FOR ADAPTIVE MANAGEMENT**

**Principal Investigators**: Therese M. Donovan and Brian Mitchell (NPS)

**Graduate Students**: Cori Brauer (M.S. Student) and Jon Katz (Ph.D. Student)

**Project Cooperators**: National Park Service, National Phenology Network, and Vermont Department of Fish and Wildlife

**Project Period**: 1 February 2010 - 31 December 2013

**Synopsis**: A primary principle guiding the management of the state and federal lands is to conserve and enhance habitats that support a full range of native flora and fauna. Two serious forces threaten the viability of native flora and fauna today: land use change and global climate change.

Confronting these resource management challenges requires, first and foremost, robust data to accurately predict how biodiversity will respond to land-use and climate change, and a process that links this information to planning efforts and resource management in a continual way (i.e., adaptive management). The first step in this process, gathering and monitoring biodiversity data, is extremely challenging. First, the sampling area is vast. Second, not all wildlife species can be monitored; many are secretive or rare and are not easily counted by humans (e.g., black bears). Third, even if a few, target species were monitored, field-based monitoring by humans across the entire state of Vermont would be cost prohibitive.

One potential solution to these challenges is to establish an acoustical monitoring network, where 1) vocalizations made by indicator wildlife species are recorded continually at sampling stations located throughout the sampling area, 2) recorded sounds are delivered to a central database where computers are used to identify species-specific sounds, and 3) the acoustical data can be accessed and used by natural resource managers in a structured decision making/adaptive management framework.

Our goal in this pilot effort is to field test acoustical techniques, database development, computer-automated animal identification, and programmatic methodologies. Data were collected at 12 sites in the Northeast (Vermont and Maine) in the summers of 2010 and 2011. Through this study, we hope to identify opportunities and constraints for establishing a large-scale acoustic monitoring program in Vermont. This pilot study is a partnership between the National Park Service, the National Phenology Network, the Vermont Department of Fish and Wildlife, and the Vermont Cooperative Fish and Wildlife Research Unit.

**Project Status:** Ongoing.


**Remote acoustic recording devices for monitoring amphibians, birds, bats, and insects. Top photo: Commercially available unit available from Wildlife Acoustics, Inc. Middle photo: Home-made recording device. Bottom: Sample species recordings in both time– and frequency-domain (source: Wildlife Acoustics, Inc.)**

**USING RELATIONAL DATABASES TO IMPROVE STRUCTURED DECISION MAKING FOR NATURAL RESOURCE MANAGEMENT**

**Principal Investigator**: Therese M. Donovan

**Graduate Students**: Jonathan Cummings (Ph.D. Student) and Kurt Rinehart (Ph.D. Student)

**Project Cooperators**: Vermont Department of Fish and Wildlife and U.S. Geological Survey

**Project Period**: 1 June 2009 – 30 September 2012

**Synopsis**: A major initiative of the USGS Cooperative Research Unit (CRU) Program is to teach and apply formal structured decision making approaches to the management of natural resources. Structured decision making, or SDM, is "an organized approach to identifying and evaluating creative options and making choices in complex decision situations." In the context of natural resource management, SDM is designed to deliver insight to natural resource decision makers about how well their management objectives may be satisfied by potential alternative courses of action. The SDM process generally involves identifying the natural resource management problem, setting management objectives, identifying potential alternative management actions, estimating the likely consequences of each alternative (often through rigorous quantitative modeling), and then weighing each alternative and identifying trade-offs among alternatives. When the same decision problem is tackled on a recurrent basis, new (updated) information is used to provide fresh perspectives on alternatives, their likely outcomes, and trade-offs. "Adaptive management" is the application of SDM approaches when a decision problem is iterative.

The primary goal of this project is to improve the decision making processes used by both state biologists and land use planners in managing and conserving wildlife and habitat. This project has several interconnected objectives: 1) develop a relational database to support, organize and manage the Department's wildlife data, as well as data collected for wildlife research through the USGS Cooperative Research Unit at the University of Vermont and through other sources; 2) Provide a website that facilitates the exchange of data among different projects; 3) Develop habitat suitability maps for target harvest species (black bear, fisher, bobcat) and predict how these species distributions may change in the face of climate, forest, and land use change in the next 100 years; and 4) Evaluate several, alternative methods for estimating abundance of target harvest species based on harvest records, and develop an adaptive management framework for linking harvest with population trends. This project is a critical first step in achieving the overarching goal of improved, science-based conservation management of wildlife and habitat both through Fish and Wildlife Department programs as well as through technical assistance programs to land use planners and decision-makers.

**Project Status:** Ongoing.


**The Steps of Structured Decision Making. Source: http://www.structureddecisionmaking.org/**

**The bobcat (*Lynx rufus*) is one of the focal species for which adaptive management plans are being developed.**

# *Peer-Reviewed Publications*

Cornell, K., and T. Donovan. 2010. Effects of spatial habitat heterogeneity on habitat selection and annual fecundity for a forest songbird. Landscape Ecology 25:109-122.

Cornell, K. L, and T. M. Donovan. 2010. Scale-dependent mechanisms of habitat selection for a migratory passerine: An experimental approach. Auk 127:899-908.

Donovan, T.M., M.D. Freeman, A. Howard, K. Royar, H. Abouelezz, and R. Mickey. 2012. Quantifying home range habitat requirements for bobcats (*Lynx rufus*) in Vermont. Biological Conservation: *in press.*

Duerr, A., D. E. Capen, and T. M. Donovan. 2012. Energetic considerations for managing double-crested cormorants on Lake Champlain. Journal of Great Lakes Research: *in press.*

Howe, E., J. E. Marsden, T. M. Donovan, and R. Lamberson. 2012. A life cycle approach to modeling sea lamprey population dynamics in the Lake Champlain basin to evaluate alternative control strategies. Journal of Great Lakes Research: *in press.*

Long, R. A., T. M. Donovan, P. MacKay, J. S. Buzas, and W. J. Zielinski. 2010. Predicting carnivore occurrence using data collected with multiple, noninvasive methods. Landscape Ecology 26:327-340.

Marschall, E.A., M.E. Mather, D.L. Parrish, G. Allison, and J. McMenemy. 2012. Migration delays caused by anthropogenic barriers: modeling dams, temperature, and success of migrating salmon smolts. Ecological Applications 22: *in press.*

Mather, M.E., D.L. Parrish, and J.M. Dettmers. 2012. Now that you have great results, where should you submit your manuscript? *In* Writing for Natural Resources Journals. C. Jennings, B. Vondracek, and T. Lauer, Editors. American Fisheries Society, Bethesda, MD. *in press.*

Schwenk, W. S., and T. M. Donovan. 2011. A multi-species framework for landscape conservation planning. Conservation Biology 25:1010-1021.

Shustack, D. P., A. M. Strong, and T. M. Donovan. 2010. Habitat use patterns of Bobolinks and Savannah Sparrows in the northeastern United States. Avian Conservation and Ecology 5(2): 11. [online] URL: http://www.ace-eco.org/vol5/iss2/art11/

# *Scholarly Activities*

## EDUCATIONAL MATERIALS:

**The VTCFWRU Spreadsheet Project** http://www.uvm.edu/envnr/vtcfwru/spreadsheets/ Peer-reviewed spreadsheet, MARK, and PRESENCE exercises that focus on a variety of ecological and parameter estimation problems.

**Principles of Modeling On-line Course** https://sharepoint.uvm.edu/sites/modeling/default.aspx Co-instructed by Tony Starfield and Terri Donovan. This course was developed in concert with the BLM National Training Center and the National Conservation Training Center. It consists of instructional videos, paired with weekly group modeling challenges. Participants include both graduate students and professionals from USFWS and USGS.

**Introduction to Occupancy Modeling http://www.uvm.edu/rsenr/vtcfwru/spreadsheets/?Page=occupancy/occupancy.htm.** Co-instructed by Terri Donovan, Lew Coggins, and Kurt Rinehart with support from the BLM National Training Center and the National Conservation Training Center. This course pairs lectures, spreadsheet exercises, and homework to provide students a foundation in maximum likelihood estimation of occupancy and detection probability.

## TECHNICAL ASSISTANCE

River Sampling Workshop, 11-14 July 2011. Workshop led by four Missouri Department of Conservation biologists. Workshop was organized through a collaboration of Vermont Fish and Wildlife and the Vermont Unit.

Rubenstein School Graduate Program Database. Manage and write scripts for tracking multiple facets of the graduate program.

# *Scholarly Activities*

**TECHNICAL REPORTS:**

Chellman, I.C., and D.L. Parrish. 2010. Developing methods for sampling mudpuppies in Vermont tributaries of Lake Champlain. Final Report. State Wildlife Grants Program, Vermont Fish and Wildlife, Waterbury.

Collins, M., M. C. Runge, K. A. Rinehart, E. E. Crone, J. Dillon, G. Fitzpatrick, T. Hicks, W. Messinger, C. B. Schultz, and D. C. Brewer. 2011. Monitoring design for Fender's blue butterfly. Case study from Structured Decision Making Workshop, National Conservation Training Center, Shepherdstown, WV, 24-28 January 2011.

Granfors D., M. Eaton, T. Donovan, T. Boucher, D. Jerry, J. Jorgenson, S. Kovach, C. Markon, K. Moos, K. Murphy, R. Platte, A. Robertson, D.C. Brewer, S.J. Converse, and S. Morey. 2011. A Unified Approach to Vegetation Inventory and Mapping in Alaska. USFWS/USGS Structured Decision Making Workshop, Sacramento, CA, USA, 17-21 October 2011.

Donovan, T. M., W. S. Schwenk, and W. Keeton. 2011. The influence of forest attributes on indicators of biodiversity: Establishing guidelines for sustainable forest management. Final Report for the Northeastern States Research Cooperative.

**THESIS:**

Chellman, Isaac C. 2011. Population demographics and genetic diversity of mudpuppy (*Necturus maculosus*) population in Vermont. Master's thesis, University of Vermont, Burlington, VT. Advisor: Donna L. Parrish

# Presentations

Butryn, R.S., D.L. Parrish*, D.M. Rizzo, and B.C. Wemple. Summer temperatures and the distribution of brook trout in Vermont streams. 66th Annual Meeting of the Northeast Fish and Wildlife Conference, Newton, MA, 25-27 April 2010.*Presenter

Chellman, I.C., and D.L. Parrish. Sampling strategies and population estimation of mudpuppies (*Necturus maculosus*) in the Lamoille River, Vermont. 66th Annual Meeting of the Northeast Fish and Wildlife Conference, Newton, MA, 25-27 April 2010.

Katz, J., C. Brauer, T. Donovan, and B. Mitchell. A comparison of acoustic monitoring methods in the northern woodlands of the Northeast. Northeast Regional Phenology Network Citizen Science and Phenology Workshop, Durham, NH, 16-17 November 2010.

Mather, M.E., E.A. Marschall*, and D.L. Parrish. Predicting interactive effects of climate change and dams on success of downstream-migrating salmon. Fish and Climate Change, The Fisheries Society of the British Isles Annual Symposium, Belfast, UK, 26-30 July 2010. *Presenter

Schwenk, W.S., and T.M. Donovan. 2010. Factors associated with landbird occupancy and species richness across Vermont, USA. American Ornithologists' Union Annual Meeting, San Diego, CA, 7-11 February 2010.

Simonin, P.W., L.G. Rudstam, P.J. Sullivan, D.L. Parrish, and B. Pientka. Physical gradients to population dynamics: distribution, cannibalism, and mortality of rainbow smelt in Lake Champlain. 95th Ecological Society of America, Pittsburgh, PA, 1-6 August 2010.

Simonin, P.W., S. Tideman, B. Pientka, L.G. Rudstam, P.J. Sullivan, and D.L. Parrish. Uncertainty in hydroacoustic-derived fisheries data: an analysis of simulation hydroacoustic-trawl surveys. A Joint Special Workshop of the Acoustical Society of America and the American Fisheries Society: Acoustic Challenges in Aquatic Ecosystem Assessment, Seattle, WA, 25-27 May 2011. (Poster presentation.)

Simonin, P.W., S. Tideman, B. Pientka, L.G. Rudstam, P.J. Sullivan, and D.L. Parrish. Reducing uncertainty in pelagic fish assessments: an analysis of hydroacoustic- and trawl-derived data. 141st Annual Meeting of the American Fisheries Society, Seattle, WA, 4-8 September 2011. (Poster presentation.)

# River Sampling Workshop

**Pictured are some of the participants in the River Sampling Workshop held 11-14 July 2011. Workshop was led by Missouri Department of Conservation (MDC) biologists and was organized by Donna Parrish (VTCFWRU), Bernie Pientka and Ken Cox (VTFW). From left to right kneeling: Ken Cox, Betsy Puchala (VTCFWRU), Dave Ostendorf (MDC). Back row from left to right: Chris Bernier and Brian Chipman (VTFW), Micah Kieffer (USGS-Conte Lab), Dave Herzog and Bob Hrabik (MDC), Bernie Pientka, Jason Crites (MDC), and Donna Parrish. Participants not pictured are: Chet Mackenzie, Joel Flewelling, Dave Gibson, Eric Palmer, and Mark Ferguson (VTFW), Rich Langdon (VTDEC), Emily Zollweg (NYDEC), Doug Facey (St. Michael's) and Nick Staats (USFWS).**

*Vermont Cooperative Fish & Wildlife Research Unit*