Report of Activities
2007 & 2008
NORTH CAROLINA COOPERATIVE
FISH AND WILDLIFE RESEARCH UNIT
Front cover photo: Sanderlings at Cape Lookout National Seashore (Photo: Nathan Tarr).
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Above photos, from top: Daniel Kuefler, Nick Haddad, and Catherine Frock track rare butterflies at Ft. Bragg with data scopes (Photo: Nick Haddad); Sirajo goby (Photo: Patrick Cooney); Oystercatcher chicks at Cape Lookout National Seashore (Photo: Shiloh Schulte); Stream in Great Smoky Mountains National Park (Photo: Becky Keller).
We at the North Carolina Cooperative Fish and Wildlife Research Unit are pleased to provide this summary of our activities and accomplishments over the past two years. During this period, we have conducted and facilitated 56 research projects, of which 40 were conducted directly by Unit scientists, and 16 were undertaken by cooperating faculty at North Carolina State University. We place great value on the collaborative relationships that we have developed across institutional boundaries to address multidisciplinary research questions. We are also proud of the role that the Unit serves in facilitating research by our colleagues that utilizes the expertise and knowledge of scientists from a number of departments, colleges, and programs within the University, as well as from our cooperating natural resource agencies.

Our research includes innovative solutions to traditional fish, wildlife, and natural resource management issues, but spans broadly into the fields of conservation biology, landscape ecology, ecosystem processes, toxicology, and microbiology. Our field sites are concentrated in North Carolina, but span from coast to coast in the United States and extend into the Caribbean. This report includes summaries of research ranging in subject from threatened and endangered invertebrates, fishes, herps, birds, wolves, and marine mammals; invasive aquatic and terrestrial species; and the effects of anthropogenic inputs and contaminants on aquatic ecosystems; to broad-scale effects of land management, conservation planning, and restoration; quantitative population and community dynamics; and innovative sampling technology and statistical inference of research results. Much of this research includes graduate student participation; 34 graduate students were advised and mentored by Unit scientists during this period, and 11 have completed their degrees and are pursuing higher degrees or are actively employed in their respective fields.

The past two years have brought ongoing change in the administration and staff of our cooperators, which has been exciting and rich with opportunity to build new collaborative relationships and strengthen those existing. The U.S. Fish and Wildlife Service was integrated into our Cooperative Agreement as a formal Unit cooperator, and our home Department in the University was renamed from Zoology to Biology. This period has been productive and successful for the North Carolina Unit, and in this report, we share a listing of our research products and make them available upon request. The achievements of our scientists, staff, and students have been recognized by others with a number of formal awards that are listed within, and we share those honors with our cooperators and partners that facilitated them.

The success to date of the North Carolina Unit is largely due to strong, synergistic relationships with our cooperators, partners, colleagues, and friends — and we look forward to continuing those associations to exceed our past accomplishments. Please contact any individual investigator if you would like more information on the research summarized in this report. We also welcome your comments on our past activities and seek your input on the direction that we plan to pursue in the future — please contact us.

The Scientists and Staff of the North Carolina Cooperative Fish and Wildlife Research Unit
MISSION STATEMENT

The goals of the North Carolina Cooperative Fish and Wildlife Research Unit are to address the research and technical needs of the U.S. Geological Survey, the U.S. Fish and Wildlife Service, the National Park Service, the North Carolina Wildlife Resources Commission, North Carolina State University, and other appropriate agencies and organizations; to contribute to the quality education of advanced and graduate fisheries and wildlife students at North Carolina State University; and to disseminate the results of research conducted by Unit scientists, staff, students, and cooperators. To advance these goals, the Unit scientists will vigorously pursue funding for projects having scientific merit and those that provide valuable information for natural resource management. Unit personnel will collaborate with cooperators in jointly conducting research and educating graduate students.

The North Carolina Unit will focus on the identification, assessment, interpretation, and alleviation of the effects of current or potential environmental changes or perturbations on fish, wildlife, and natural resources. Through a combination of basic and applied research, the Unit will pursue innovative solutions to natural resource questions. Although some work may be species oriented, community and ecosystem studies will be emphasized. This will require a team approach to hypothesis testing research, involving Unit and University personnel as investigators. When cause-effect relationships are not demonstrable in the field, laboratory or controlled field studies will be conducted.

Educational goals will be achieved by teaching graduate level courses, chairing graduate committees, delivering guest lectures and seminars, and sponsoring or participating in short courses and workshops for cooperators when appropriate.
COOPERATORS AND PERSONNEL

COOPERATING AGENCIES

UNITED STATES GEOLOGICAL SURVEY
12201 Sunrise Valley Drive
Reston, Virginia 20192
Byron K. Williams, Chief, Cooperative Research Units
Kevin G. Whalen, Deputy Chief, Cooperative Research Units
W. James Fleming, Supervisor

NORTH CAROLINA STATE UNIVERSITY
North Carolina Agricultural Research Service
100 Patterson Hall
Raleigh, North Carolina 27695-7643
Sylvia M. Blankenship, Associate Dean and Interim Director
Winston M. Hagler, Jr., Assistant Director

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION
1751 Varsity Drive
NCSU Centennial Campus
Raleigh, North Carolina 27606
Gordon S. Myers, Executive Director
Mallory G. Martin, Assistant Director
Robert L. Curry, Chief, Division of Inland Fisheries
David T. Cobb, Chief, Division of Wildlife Management

UNITED STATES FISH AND WILDLIFE SERVICE
Southeast Region
1875 Century Boulevard Northeast
Suite 400
Atlanta, Georgia 30345
Sam D. Hamilton, Regional Director
Cynthia K. Dohner, Deputy Regional Director

WILDLIFE MANAGEMENT INSTITUTE
1101 14th Street, N.W., Suite 801
Washington, D.C. 20005
Steven A. Williams, President
Richard E. McCabe, Executive Vice President
Donald F. McKenzie, Field Representative

UNIT PERSONNEL

SCIENTISTS
Thomas J. Kwak, Unit Leader, Fisheries, Professor, Departments of Biology and Forestry and Environmental Resources
Jaime A. Collazo, Assistant Unit Leader, Wildlife, Professor, Departments of Biology and Forestry and Environmental Resources
Joseph E. Hightower, Assistant Unit Leader, Fisheries, Professor, Department of Biology
Theodore R. Simons, Assistant Unit Leader, Ecology, Professor, Departments of Biology and Forestry and Environmental Resources

SUPPORT STAFF
Wendy J. Moore, Program Assistant
Mary M. Wilson, Office Assistant
Kyle T. Rachels, Research Technician

POSTDOCTORAL RESEARCH ASSOCIATES
Mathew W. Alldredge
C. Ashton Drew
F. Michael Holliman
Edward J. Laurent
Sarah E. Mabey
Jason D. Riddle
Raymond A. Webster

RESEARCH STAFF
Robert A. Adair
Curtis M. Belyea
Patrick B. Cooney
Todd S. Earnhardt
Alexa J. McKerrow
Matthew J. Rubin
Adam J. Terando
Steve G. Williams
NORTH CAROLINA STATE UNIVERSITY
COOPERATING FACULTY

Heather M. Cheshire, Department of Forestry and Environmental Resources
W. Gregory Cope, Department of Environmental and Molecular Toxicology
Nicholas M. Haddad, Department of Biology
Richard A. Lancia, Department of Forestry and Environmental Resources
Elizabethann O’Sullivan, Department of Political Science and Public Administration
Kenneth H. Pollock, Departments of Biology and Statistics
Roger A. Powell, Department of Biology
Wayne P. Robarge, Department of Soil Science
Michael K. Stoskopf, Department of Clinical Sciences, College of Veterinary Medicine

COLLABORATORS
David Allen, North Carolina Wildlife Resources Commission
Keith Ashley, North Carolina Wildlife Resources Commission
Tom Augspurger, U.S. Fish and Wildlife Service
Hugh Barwick, Duke Energy Company
Doug Besler, North Carolina Wildlife Resources Commission
Gary Breckon, University of Puerto Rico

Sue Cameron, North Carolina Wildlife Resources Commission
Mark Cantrell, U.S. Fish and Wildlife Service
Jose Chabert, Puerto Rico Department of Natural Resources
Jeff Cordes, National Park Service
Sam Droege, U.S. Geological Survey, Patuxent Wildlife Research Center
Marshall Ellis, North Carolina Division of Parks and Recreation
Steve Fraley, North Carolina Wildlife Resources Commission
Kay Franzreb, U.S. Department of Agriculture, Forest Service, Clemson University
Walker Golder, National Audubon Society
William Gould, International Institute of Tropical Forestry
Bob Graham, Dominion North Carolina Power
J. Barry Grand, Alabama Cooperative Fish and Wildlife Research Unit
Martha Groom, University of Washington
Christopher G. Guglielmo, University of Montana
Susan M. Haig, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Oregon State University
Ryan Heise, North Carolina Wildlife Resources Commission
Kevin Hining, North Carolina Wildlife Resources Commission
Bob Jenkins, Roanoke College
Mark Johns, North Carolina Wildlife Resources Commission

Above photo shows field research site of King Rail study (see page 29) conducted by Jaime Collazo and Ashton Drew (Photo: Ashton Drew).
Chris Kelly, North Carolina Wildlife Resources Commission
Pete Kornegay, North Carolina Wildlife Resources Commission
R. Wilson Laney, U.S. Fish and Wildlife Service
Keith Langdon, National Park Service, Great Smoky Mountains National Park
Allen R. Lewis, University of Puerto Rico
Craig Lilyestrom, Puerto Rico Department of Natural and Environmental Resources
Jim Lyons, U.S. Geological Survey, Patuxent Wildlife Research Center
Marcia Lyons, National Park Service
Ken Manuel, Duke Energy Company
Jeff Marcus, North Carolina Wildlife Resources Commission
Mallory Martin, North Carolina Wildlife Resources Commission
Frank Moore, University of Southern Mississippi, Hattiesburg
Jim Nichols, U.S. Geological Survey, Patuxent Wildlife Research Center
Allan O’Connell, U.S. Geological Survey, Patuxent Wildlife Research Center
Scott Pearson, Mars Hill College, Mars Hill, North Carolina
Franklin Percival, Florida Cooperative Fish and Wildlife Research Unit
James Peterson, Georgia Cooperative Fish and Wildlife Research Unit
Kerry Rabenold, Purdue University
David Rabon, U.S. Fish and Wildlife Service
Michael Rikard, National Park Service
Andy Royle, U.S. Geological Survey, Patuxent Wildlife Research Center
John Sauer, U.S. Geological Survey, Patuxent Wildlife Research Center
David R. Smith, U.S. Geological Survey, Leetown Science Center
Wayne Starnes, North Carolina Museum of Natural Sciences
Brian Strong, North Carolina Division of Parks and Recreation
Bryn Tracy, North Carolina Division of Water Quality
Scott Van Horn, North Carolina Wildlife Resources Commission
Jeffrey R. Walters, Virginia Polytechnic Institute and State University
Christian Waters, North Carolina Wildlife Resources Commission
Mike Wicker, U.S. Fish and Wildlife Service
David Yow, North Carolina Wildlife Resources Commission

Angel Hammers and Michael Fisk radio track robust redhorse in the Pee Dee River, North Carolina.
Cooperative Research Units Scientific Excellence Award
Awarded to Theodore R. Simons in 2007 for extraordinary scientific accomplishments associated with his collaborative research initiative to identify and quantify sources of measurement and misclassification error in avian count data.

Wings Across the Americas Award
Jaime A. Collazo and collaborators were recognized in 2007 for their contributions to the conservation of the Puerto Rican Parrot (*Amazona vittata*) and understanding of the ecology of the Pearly-eyed Thrasher (*Margarops fuscatus*). Awarded by the U.S. Forest Service.

College of Agriculture and Life Sciences Award for Excellence
Awarded to Wendy J. Moore in 2008 by the College of Agriculture and Life Sciences, North Carolina State University.

North Carolina State University Award for Excellence
Awarded to Wendy J. Moore in 2008 by North Carolina State University.

Wildlife Management Institute Administrative Excellence Award

Academic Promotion to Full Professor
Thomas J. Kwak was promoted to the rank of Full Professor of Biology (and Forestry and Environmental Resources) at North Carolina State University.
U.S. Department of Interior STAR Awards
Received by Unit staff for superior performance.

Richard L. Noble Best Student Paper Award
Awarded to A. Brad Garner (T.J. Kwak, advisor) in 2007 for their presentation at the Joint Meeting of the North Carolina and Virginia Chapters of the American Fisheries Society. February 27-28, Danville, Virginia.

Richard L. Noble Best Student Paper Award

Best Student Platform Presentation Award
Tamara J. Pandolfo (W.G. Cope, advisor) received the Best Student Platform Presentation Award at the 17th Annual Meeting of the Carolinas Chapter of the Society of Environmental Toxicology and Chemistry, Morehead City, North Carolina, April 3-5, 2008.

Student Presentation Award
Allison Leidner (N.M. Haddad, advisor) earned third place in the student award competition at the Society for Conservation Biology Annual Meeting in 2008.

Graduate Student Symposium Outstanding M.S. Presentation in Zoology Award
Awarded to Jessica R. Brewster (T.J. Kwak, advisor) in 2007.
CURRENT STUDENTS

Unit scientists serve as major advisor or co-advisor for these master’s and doctoral graduate students. Students attend North Carolina State University unless otherwise noted.

Elissa Buttermore, M.S., Fisheries and Wildlife Sciences .............................................. Kwak
Timothy Ellis, Ph.D., Fisheries and Wildlife Sciences ........................................... Hightower/Buckel
Scott Favrot, M.S., Fisheries and Wildlife Sciences ............................................. Kwak
J. Michael Fisk, M.S., Fisheries and Wildlife Sciences ........................................... Kwak
Sarah Friedl, M.S., Fisheries and Wildlife Sciences ........................................... Hightower/Buckel
Julie Harris, Ph.D., Fisheries and Wildlife Sciences ........................................... Hightower
Monica Iglesia, M.S., Zoology ............................................................................. Collazo
Rebecca Keller, Ph.D., Zoology .............................................................................. Simons
Matthew Krachey, Ph.D., Zoology ........................................................................ Hightower/Pollock
Kevin Magowan, M.S., Fisheries and Wildlife Sciences ................................ Hightower
Elizabeth Martin,* Ph.D., Wildlife, Ecology, and Conservation .................. Collazo/Percival
Jason Mays, M.S., Fisheries and Wildlife Sciences ........................................... Kwak/Cope
Lisa Paine, M.S., Zoology ..................................................................................... Collazo/McKerrow
Joshua Raabe, Ph.D., Fisheries and Wildlife Sciences ....................................... Hightower
Shiloh Schulte, Ph.D., Zoology ............................................................................. Simons
Amy Schwarcer,* M.S., Wildlife, Ecology, and Conservation .................. Collazo/Percival
Joseph Smith, M.S., Fisheries and Wildlife Sciences ........................................... Hightower
William Smith, Ph.D., Fisheries and Wildlife Sciences .................................. Kwak
Mary “Edye” Strickland, M.S., Zoology ................................................................. Collazo
Michael Waine, M.S., Fisheries and Wildlife Sciences ....................................... Hightower
Arielle Waldstein, M.S., Zoology ............................................................................. Simons
Benjamin Wallace, M.S., Fisheries and Wildlife Sciences .................................. Kwak
Daniel Weaver, M.S., Fisheries and Wildlife Sciences ....................................... Kwak

* University of Florida
RECENT GRADUATES

Nathan Bacheler, Ph.D., Zoology...........................................Hightower/Buckel  
Fall 2008, Postdoctoral researcher,  
Oregon State University

Jerome Brewster, M.S., Zoology...........................................Simons  
Spring 2007, Research Technician,  
N.C. State University

Jessica Brewster, M.S., Fisheries and Wildlife Sciences.................Kwak  
Fall 2007, Asst. District Fishery  
Biologist, N.C. Wildlife Resources  
Commission

Christin Brown, M.S., Fisheries and Wildlife Sciences.................Kwak  
Summer 2008, Instructor and  
Marine Sciences Coordinator,  
Cape Hatteras High School

A. Brad Garner, M.S., Fisheries and Wildlife Sciences.................Kwak  
Fall 2008, Asst. Fishery Biologist,  
Wyoming Game and Fish Department

Claudia Lombard, M.S., Zoology........................................Simons/Collazo  
Summer 2007, Biologist, U.S. Fish and  
Wildlife Service, Sandy Point National  
Wildlife Refuge, U.S. Virgin Islands

Alexa McKerrow, Ph.D., Botany.........................................Fall 2007, Collazo/Wentworth  
Biologist, U.S. Geological Survey

Stephen Midway, M.S., Fisheries and Wildlife Sciences................Kwak/Aday  
Fall 2008

Kelsey Obernuefemann, M.S., Fisheries and Wildlife Sciences........Collazo  
Spring 2008, Research  
Technician, N.C. State University

Krishna Pacifici, M.S., Zoology.........................................Spring 2007, Simons/Pollock  
Ph.D. Candidate, University of Georgia

Nathan Tarr, M.S., Fisheries and Wildlife Sciences......................Simons  
Fall 2008

Marvin Morales uses radio telemetry to track Swainson's Warblers at the Roanoke River National Wildlife Refuge, North Carolina.
COMMITTEE PARTICIPATION

Unit scientists serve as committee members, but not as major advisors, for these students.

Collazo  Nathan Bacheler, Ph.D.  Veronica Miller, M.S.  Shiloh Schulte, Ph.D.  Jose Sustache, M.S.  Nathan Tarr, M.S.  Catherine Thompson, M.S.

Kwak  Chris Derolf, M.S.  Julianne Harris, Ph.D.  Shad Mosher, M.S.  Tamara Pandolfo, M.S.  Robert Heth, Ph.D.  Sean Peffer, M.S.  Joe Smith, M.S.

Hightower  Kyle Adamski, M.S.  Christina Durham, M.S.  Brad Garner, M.S.  Darren Parsons, Ph.D.  William Smith, M.S.  Jessica Thompson, Ph.D.  Jun Yoshizaki, Ph.D.

Simons  Neil Chartier, Ph.D.  Claudia Lombard, M.S.  Mat Mcgowan, Ph.D.  Kelsey Obernuefemann, M.S.  Salina Kovach, M.S.  Corey Shake, M.S.
COURSES TAUGHT

Fisheries Techniques and Management
Kwak
Summer 2007, Summer 2008

Hierarchical Species-Habitat Analysis and Conservation
Collazo
Spring 2007

Management of Small Impoundments
Co-taught by Hightower and Kwak
Summer 2008

Ornithology
Simons
Spring 2007

Quantitative Fisheries Management
Hightower
Fall 2006, Fall 2008

Topics in Species-Habitat Modeling
Collazo
Fall 2008

Fisheries and Wildlife students practice electrofishing techniques during Fisheries Techniques and Management course field exercises.
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A multi-stage survey protocol for shortnose sturgeon

Shortnose sturgeon historically occurred in Atlantic Coast rivers from Saint John River, New Brunswick, Canada to St. John’s River, Florida. However, combinations of habitat loss and overfishing resulted in the populations in most rivers being extirpated or substantially reduced in abundance. The goal of this study is to develop an improved survey methodology combining side-scan sonar, DIDSON multibeam sonar, and (in year 2 or later) gill netting. Side-scan sonar provides very high resolution images of bottom structure and topography and can cover large areas quickly. Side-scan images can be reviewed to determine whether sturgeon sized targets (~0.7 m and larger) are present within an area. A DIDSON multibeam sonar can be deployed at locations of sturgeon-sized fish targets, in order to make a preliminary estimate of the fraction of sturgeon-sized targets that are in fact sturgeon (shortnose or Atlantic sturgeon). Sturgeon can be identified to genus on short-range DIDSON images based on their unique shape and fin positions. If these hydroacoustic techniques prove effective, the project scope would be expanded to include gill netting, in order to ground-truth the side-scan and DIDSON data. Gill-net data (year 2 or later) would be used to estimate the proportion of sturgeon-sized sonar targets that were shortnose sturgeon in order to estimate population size. PIT-tagging of gill-netted shortnose sturgeon would be done in order to obtain capture-recapture estimates of population size, for comparison with the hydroacoustic estimates.

INVESTIGATOR Joseph E. Hightower
STUDENT Jared Flowers, Ph.D. Candidate, Fisheries and Wildlife Sciences
LOCATION North Carolina and South Carolina coastal rivers
DURATION 9/1/2008–8/31/2011
SPONSOR National Marine Fisheries Service

Acute and reproductive effects of emerging contaminants on freshwater mussels

A wide variety of chemical contaminants that are relative newcomers to the environment or have long been present but their environmental impacts unknown are generally being classified as “emerging contaminants.” Many of these chemicals are associated with municipal wastewater and have been demonstrated to have hormonal activity or cause endocrine system disruption in fish and aquatic invertebrates. Unfortunately, very little is known about the toxic (lethal or sublethal) effects of these compounds, particularly on native freshwater mussels. To address this knowledge gap, we will use laboratory toxicity tests with representative mussel species exposed to several hormonally active emerging contaminants such as ethynylestradiol (synthetic estrogen), fluoxetine (the active ingredient in Prozac™, an antidepressant drug), perfluorinated chemicals (used extensively in production of stain-resistant coatings on numerous consumer products), and 4-nonylphenol (a common surfactant). In addition to acute toxicity testing with mussel glochidia and juveniles, our novel approach will investigate reproductive effects at the individual and population levels by testing the endocrine response of the adult mussels. Additionally, we will determine effects of the emerging contaminants on the transformation success of glochidia when they attach to fish and metamorphose into juveniles. This project will greatly expand the toxicity data base for native freshwater mussels and emerging contaminants with differing modes of action. Successful completion of this project will provide the U.S. Fish and Wildlife Service and other resource managers and decision makers with the information needed to assess mussel sensitivity to emerging contaminants, which will help to improve the conservation and management of this valuable, but imperiled faunal group.

INVESTIGATOR W. Gregory Cope
LOCATION N.C. State University
DURATION 8/25/2008–12/31/2010
SPONSOR U.S. Fish and Wildlife Service

Assessing benefits to migratory fishes of habitat restored by dam removal

The goal of this study is to examine the migration and spawning habitat used by American shad and other migratory species in the Little River, North Carolina, following the removal of three dams since 1998. Migration is being monitored using a resistance board weir that spans the river channel and is pervious to water but prevents fish from migrating upstream or downstream. Fish are funneled into either the upstream or downstream live cage, counted for abundance, measured, often tagged, and then released in the direction they were migrating. In 2008, PIT tag antennas were constructed at various distances upstream to monitor movement of PIT-tagged American shad. The array of antennas will provide information on use of restored upstream habitat, fish passage, migratory cues (e.g., flow and water temperature), and the distribution of tagged fish in the Little River, including the proportion that reaches Atkinson Mill Dam. This information can be used to refine and develop models that predict the impacts of dam removals on other river systems.

INVESTIGATOR Joseph E. Hightower
STUDENT Joshua Raabe, Ph.D. Candidate, Fisheries and Wildlife Sciences
LOCATION Little River (Neuse River tributary), North Carolina
DURATION 8/23/2006–9/30/2010
SPONSOR U.S. Fish and Wildlife Service

Map showing former locations of Lowell, Rains and Cherry Hospital dams.
Assessing risk of electrofishing mortality and sublethal effects to freshwater mussels

The decline of the freshwater mussel fauna in the U.S. has led to nationwide efforts to identify research, management, and conservation measures for maintenance and recovery. In North Carolina, over 50% of the freshwater mussel species are threatened with extinction. Mussels are not targeted by electrofishing, but it is routinely employed in aquatic environments where freshwater mussels occur. The goal of this research was to evaluate the effects of electrofishing on freshwater mussels at various life stages. In a controlled laboratory environment, we examined the consequences of exposure to two typical electrofishing currents for the survival of adult and early life stages of three unionid species. The outcomes suggest that electrical exposure associated with typical electrofishing poses little direct risk to freshwater mussels. Adult mussel survival and behavior was not adversely affected by electrical exposure. Glochidia showed minimal reduction in viability after exposure. Metamorphosis from glochidia to free-living juvenile mussels was not impaired after electric exposure of infested host fish, and survival of juvenile mussels was not influenced by exposure. Any minimal risk to mussels must be weighed against the benefits gained by using the gear for scientific sampling of fish in the same waters.

INVESTIGATORS
Thomas J. Kwak
F. Michael Holliman
W. Gregory Cope
Jay F. Levine

LOCATION
N.C. State University

DURATION

SPONSOR
N.C. Wildlife Resources Commission

Assessing the exposure and relative sensitivity of native freshwater mussels to environmental stressors and laboratory conditions

The goal of this project was to provide information on the exposure and relative sensitivity of native freshwater mussels to selected chemical and environmental stressors and laboratory conditions. Specific objectives were to: (1) evaluate the relative toxicity of three fungicides (chlorothalonil, pyraclostrobin, propiconazole) by conducting standard acute toxicity tests with glochidia and juveniles of the fatmucket, Lampsis siliqueoida, (2) assess the relative sensitivity of mature fatmucket glochidia taken from gravid female mussels that have been held under laboratory conditions for greater than six months to mature fatmucket glochidia taken from gravid female mussels freshly collected (within one week) from the field, (3) assess the relative sensitivity of fatmucket juveniles produced and reared in the laboratory for 2 to 3 months to fatmucket juveniles produced in the laboratory and reared in cages in a natural stream for 2 to 3 months, (4) evaluate the routes and pathways of exposure for all three life stages (glochidia, juveniles, adults) of native freshwater mussels to environmental contaminants, in a life history context, by critically evaluating the available literature, and (5) evaluate the relative sensitivity of glochidia and juvenile native freshwater mussels to a range of common and extreme water temperatures that may be encountered during summer periods.

INVESTIGATOR
W. Gregory Cope

STUDENTS
Tamara J. Pandolfo, M.S.,
Environmental Toxicology
Erin C. Tracy, B.S., Biochemistry

LOCATION
N.C. State University

DURATION
5/1/2006–12/30/2008

SPONSOR
U.S. Environmental Protection Agency

Assessment of fish passage barriers in Puerto Rico rivers

Knowledge of the occurrence and structure of natural and artificial barriers to fish and invertebrate migration is critical to managing Puerto Rico rivers for native aquatic diversity. Yet no comprehensive inventory of such barrier structures exists. Objectives of this project are to compile existing information on Puerto Rico fish passage barriers, perform site visits on selected barriers, search for undocumented barriers, and develop a comprehensive document and web site describing known natural and artificial fish passage barriers. These findings will then be incorporated into associated research and modeling to describe and understand patterns of native and introduced fishes of Puerto Rico to facilitate conservation of native amphidromous fish and invertebrate species. The results will assist management agency biologists and planners in island-wide assessment and conservation planning for aquatic fauna that may be influenced by fish barriers.

INVESTIGATOR
Thomas J. Kwak

STAFF
Patrick B. Cooney

LOCATION
Puerto Rico

DURATION
8/25/2008–9/30/2011

SPONSOR
U.S. Fish and Wildlife Service

Don Bocas Dam impounds the Río Arecibo (River) to form Lago Dos Bocas (Lake) in Puerto Rico. Such dams form barriers to amphidromous fish migration.
Atmospheric ammonia chemistry and dry deposition of ammonia at Pocosin Lakes National Wildlife Refuge

Monitoring of ambient atmospheric chemistry continued at several locations at the Pocosin Lakes National Wildlife Refuge in 2008. In 2007, transects of passive samplers for ammonia (ALPHA® samplers) detected a gradient in ambient concentrations downwind of a large-scale animal production facility (egg-laying operation) ~2500 m distant from the southern boundary of the refuge. Weekly integrated concentrations of ammonia at the refuge boundary were between 1 and 2.5 μg NH₃-N m⁻³, which is double to triple background concentrations measured in 2005 and 2006 prior to the stocking with birds at the facility (< 0.5 μg NH₃-N m⁻³). At a transect located on private property within ~500 m of the poultry facility, the measured weekly integrated concentrations of ammonia ranged from 3.5 to 6.5 μg NH₃-N m⁻³. The observed gradient in measured ammonia concentrations is consistent with the expected decrease in ambient concentrations as one moves away from a strong point source for emissions.

Annular denuder technology was used to continue to monitor background ambient atmospheric chemistry (NH₃, HCl, HONO, HNO₃, ammonium-based aerosols of Cl⁻, NO₃⁻ and SO₄²⁻) ~5 miles north of the egg-laying facility. Data indicated no significant change in background ambient atmospheric chemistry in 2007, supporting the conclusion that the elevated ammonia concentrations being detected at the southern boundary of the refuge arise from a strong, nearby source of ammonia. In 2008, monitoring with the passive samplers and the annular denuder technology was suspended due to the wildfire in a large portion of the Pocosin Lakes National Wildlife Refuge. Sampling was restarted in October 2008.

CONTAMINANTS IN INVASIVE FRESHWATER FISHES: SNAKEHEADS AND FLATHEAD CATFISH

Snakeheads, the freshwater fish family Channidae, are native to Africa and southern Asia, but they have been transported and introduced widely beyond their native range. The flathead catfish, Pylodictis olivaris, is native to the Mississippi, Rio Grande, and Mobile drainages, but has been introduced widely throughout the U.S. in 18 states. Unfortunately, the contaminant load in invasive snakeheads and flathead catfish from self-sustaining North American populations has not been measured or reported. Objectives of this research are to focus on determining and interpreting contaminant loads for these two invasive fish species. Tissue from northern snakeheads, Channa argus, from the Potomac River, Virginia, and flathead catfish from the Cape Fear River basin, North Carolina, will be analyzed. Spatial patterns and those related to fish size will be described and findings interpreted relative to human fish consumption standards. Analyses will include organic (e.g., chlorinated pesticides, PCBs) and inorganic contaminants (e.g., metals). Results will also be interpreted in association with stable isotope analyses of these samples that will provide information on trophic relations of these fishes. The trophic and contaminant findings will fill complementary gaps in our knowledge of these species and the associated trophic interactions and human consumption consequences.

INVESTIGATORS
Thomas J. Kwak, W. Gregory Cope, Damian Shea

STAFF
J. Michael Fisk

LOCATION
N.C. State University

DURATION

SPONSOR
U.S. Geological Survey
Development of habitat suitability index models for American shad

Habitat Suitability Index Models (HSI Models) are needed for effective management of anadromous fish species. Species of special management emphasis include American shad, river herring, striped bass, American eel, shortnose sturgeon, and Atlantic sturgeon. HSI Models are needed for characterization of riverine habitat quality and suitability, and to support environmental impact assessment and development of sound mitigation alternatives. The goal of this project is to develop an improved HSI Model for American shad in southeastern river basins. The American shad HSI Model should provide guidelines for assessment of habitat quality for spawning, egg and larval development, and juvenile development in riverine habitats. The HSI Model should allow for assessment of instream flow alteration effects on habitat suitability and availability, and be readily usable with the Instream Flow Incremental Methodology and Physical Habitat Simulation methodology, and other mesohabitat assessment approaches. Among the research approaches will be to develop a database of river and watershed characteristics. If spawning grounds are known, a database will be developed specifically for spawning locations. Statistical models will be used to determine which characteristics best predict historical run size and location of spawning grounds.

INVESTIGATOR  Joseph E. Hightower
STUDENTS  Joshua Raabe, Ph.D. Candidate, Fisheries and Wildlife Sciences
Julianne Harris, Ph.D. Candidate, Fisheries and Wildlife Sciences
LOCATION  N.C. State University
SPONSOR  National Marine Fisheries Service

Effects of intensive grass carp stocking on reservoir invasive plants and native fishes

The practice of stocking sterile grass carp, Ctenopharyngodon idella, in lentic and lotic waters has become an accepted management practice to biologically control submerged aquatic macrophytes. However, the efficacy of such practice is not clear in large reservoirs for unpalatable plant species. We evaluated high-density grass carp stocking in a reservoir for control of parrot-feather, Myriophyllum aquaticum, an invasive aquatic plant that is not preferentially consumed by grass carp, and the associated effects on water quality and native fishes. Lookout Shoals Lake, a piedmont North Carolina reservoir, was stocked with triploid grass carp at a density of 100 fish per vegetated hectare. Parrot-feather biomass in the lake was significantly reduced three months after grass carp stocking, compared to biomass in in-situ exclosures. We evaluated the native fish community using seasonal shoreline electrofishing before and after grass carp stocking and found effects only related to yellow perch, Perca flavescens. This research was conducted cooperatively with biologists of Duke Energy Company and the North Carolina Wildlife Resources Commission, and our results demonstrate that intensive grass carp stocking can control an invasive aquatic plant that is not preferentially consumed by grass carp, and reveal associated changes in water quality and fish distributions.

INVESTIGATOR  Thomas J. Kwak
STUDENT  A. Brad Garner, M.S., Fisheries and Wildlife
LOCATION  Lookout Shoals Lake, North Carolina
SPONSOR  N.C. Wildlife Resources Commission, Duke Energy, N.C. Wildlife Habitat Foundation

Fishery population and habitat assessment in Puerto Rico streams

Puerto Rico is widely known for its marine sport and commercial fisheries, but the freshwater habitats of the island also support a substantial number of fishes, many of which provide recreational and subsistence fishery values, yet receive little attention by fisheries scientists. We completed research to evaluate stream and river fish and habitat sampling techniques and to develop standardized sampling protocols. We also modeled patterns in occurrence and abundance of stream and river fish populations as related to physical habitat, including instream habitat, water quality, riparian and watershed attributes, and river regulation. Ongoing objectives include obtaining more extensive quantitative estimates for fish populations and their habitat. We will explore a biotic index that may be employed to classify riverine habitat. We will analyze contaminant concentrations in fish, their foods, and habitats to assess environmental effects and consumption risks. And we will study the ecology and migration of amphidromous fishes to better define management units and scale. Finally, we will synthesize findings from these objectives and patterns in the occurrence and abundance of stream and river sport fish populations as related to physical and biotic habitat toward a better understanding of fish biology, ecology, and management.

INVESTIGATOR  Thomas J. Kwak
STUDENTS  Christin H. Brown, M.S., Fisheries and Wildlife
Elissa N. Buttermore, M.S. Candidate, Fisheries and Wildlife
William E. Smith, Ph.D. Candidate, Fisheries and Wildlife
STAFF  Patrick B. Cooney
J. Michael Fisk
LOCATION  Puerto Rico
DURATION  11/10/2004–10/31/2010
SPONSOR  Puerto Rico Department of Natural and Environmental Resources
Hydroacoustic monitoring of anadromous fishes in the Roanoke River

Anadromous fishes spend the majority of their adult lives in the ocean and make yearly migrations (runs) into coastal rivers to spawn. These species are targeted by commercial and recreational fisheries both in the ocean-estuarine environment and during their runs into coastal rivers. Information on abundance of these important species is needed in order to properly regulate harvests and to assess the effectiveness of rebuilding efforts. The primary objective of this study is to estimate the size of spawning runs of American shad, striped bass, and other anadromous species within the Roanoke River. A related objective is to gain a detailed understanding of migratory behavior in order to design an effective monitoring program and interpret the hydroacoustics data. Another project goal is to evaluate the effectiveness of a multibeam sonar (DIDSON) for characterizing the spatial distribution of upstream migrants and for identifying upstream migrants to species (based on size and morphology).

INVESTIGATOR  Joseph E. Hightower
STUDENTS  Michael Waine, M.S. Candidate, Fisheries and Wildlife Sciences
LOCATION  Roanoke River, North Carolina
DURATION  7/1/2007–6/30/2013
SPONSOR  N.C. Wildlife Resources Commission

Interaction of stocked trout with native nongame stream fishes

Stocking surface waters with hatchery-reared trout (Salmonidae) to support local recreational fisheries is common practice among state and federal agencies in the United States. The positive recreational and economic effects of trout stocking and associated fisheries have been widely recognized for decades. However, potential negative consequences to native fauna and ecosystems are of recent concern to fishery managers and the angling public, but the mechanisms and significance remain poorly understood. The goal of this research is to gain an understanding of the interactions between stocked trout and native nongame fishes in the stream environment. Our primary objective will be to quantify changes in fish density, distribution, and habitat use of nongame fishes as affected by the presence of stocked trout, relying primarily on snorkeling techniques in a BACI (Before-After-Control-Impact) study design in treatment and reference river reaches. A secondary objective will be to qualitatively assess direct negative interactions between trout and nongame fishes. Results may be used to inform and guide management actions to improve resource management strategies and to educate fishery constituents and the public. The ultimate result will be better scientific understanding, public awareness, and improved sport fishing, while maintaining biodiversity in our rivers.

INVESTIGATOR  Thomas J. Kwak
STUDENT  Daniel M. Weaver, M.S. Candidate, Fisheries and Wildlife Sciences
LOCATION  North Toe River and other North Carolina mountain trout streams
DURATION  7/1/2007–4/1/2011
SPONSOR  N.C. Wildlife Resources Commission

Migratory behavior of diadromous fishes in the Roanoke River

Several studies conducted by the NC Cooperative Fish and Wildlife Research Unit have examined fish migration and habitat use, in order to better understand how upstream dams might be affecting anadromous fishes. One current study uses hydroacoustics to examine migration timing and abundance for hickory shad, American shad, and striped bass. Preliminary results indicate that the method can be used to count upstream migrants and to obtain detailed information about spatial and temporal patterns of migration. Results of the hydroacoustic study will be important for management, once the reliability of the estimates has been validated. For example, the estimates of American shad run size will be used to guide a restoration program for American shad. This project is intended to complement the ongoing hydroacoustic project by supporting additional focused research on the effectiveness of split-beam sonar. Experimental work has been conducted in hatchery ponds and within the Roanoke River using known-size fish. Another approach has been to compare split-beam and multi-beam (DIDSON) sonars to determine the relative performance of the two systems.

INVESTIGATOR  Joseph E. Hightower
STUDENTS  Kevin Magowan, M.S., Fisheries and Wildlife Sciences  Michael Waine, M.S. Candidate, Fisheries and Wildlife Sciences
LOCATION  Roanoke River, North Carolina
DURATION  8/22/2006–6/30/2011
SPONSOR  U.S. Fish and Wildlife Service
Movement and spawning of American shad transported above dams on the Roanoke River

American shad populations are in decline all along their native range and loss and degradation of spawning habitat may be a cause. On the Roanoke River, American shad presently spawn below the lowest dam, located at Roanoke Rapids. Previously, this population migrated and spawned farther upstream, possibly resulting in higher historical abundances. Above Kerr Lake, the third most downstream dam on the Roanoke River, it has been suggested that there is suitable spawning habitat for American shad. To examine movement patterns of American shad released into reservoirs above the Roanoke Rapids Dam and to identify possible spawning activity in the Staunton River, American shad were collected by electrofishing at Roanoke Rapids, transported, tagged with ultrasonic transmitters, and released into Lake Gaston, Kerr Lake, and the Roanoke (Staunton) River above Kerr Lake. Movements of tagged fish were determined by both stationary receivers and manual tracking. Oblique plankton sampling was done to detect spawning. Based on 2007 results, about 80% of all transported American shad survived to be released the following morning. Higher survival occurred earlier in the season and when water temperatures were lower. Some tagged individuals passed through either Kerr and or Gaston dams and short term mortality of passed fish appeared to be between 5 and 32%. Almost 15% of all tagged fish released in Lake Gaston migrated to the tailrace of Kerr Dam. Approximately 26% of all tagged American shad released in Kerr Lake migrated up to Clarksville, VA, and almost 10% migrated into either the lower Dan or Staunton rivers. Analysis of 2008 results is ongoing.

INVESTIGATOR Joseph E. Hightower
STUDENT Julianne Harris, Ph.D. Candidate, Fisheries and Wildlife Sciences
LOCATION Roanoke River, North Carolina
SPONSOR N.C. Wildlife Resources Commission, Dominion

Population dynamics and ecology of introduced flathead catfish

The flathead catfish, Pylodictis olivaris, has been introduced to Atlantic slope rivers throughout the eastern U.S. Given its rapid dispersal and growth rates and carnivorous food habits, fishery managers and anglers have been concerned with the impacts that introduced flathead catfish may exert upon native fish assemblages and fisheries. The goal of this research was to gain an understanding of population dynamics, predator-prey relations, and other aspects of flathead catfish biology and ecology to develop empirical relationships to estimate changes in fish population dynamics and assemblage structure associated with introduced flathead catfish occurrences. Phase 1 (1999–2003) results include varying flathead catfish population sizes among rivers, frequent and often distant migration rates, highly selective habitat use within each river, and diets consisting of freshwater and marine fishes and invertebrates. Phase 2 (2003–2007) research described flathead catfish seasonal migration, home ranges, and habitat use. Trophic studies demonstrated opportunistic feeding and revealed no flathead catfish predation on imperiled fishes. Results of this research identify practical management scales for this species and may be used to increase public awareness and to guide physical and biotic manipulations and other management actions to improve resource management strategies.

INVESTIGATORS Thomas J. Kwak, Joseph E. Hightower, Richard L. Noble, James A. Rice
STUDENTS William E. Pine, Ph.D., Zoology; Edward G. Malindzak, M.S., Fisheries and Wildlife; Jessica R. Brewster, M.S., Fisheries and Wildlife
STAFF D. Scott Waters, J. Michael Fisk
LOCATION Coastal Plain and Piedmont rivers of North Carolina
DURATION 7/1/1999–9/30/2007
SPONSOR N.C. Wildlife Resources Commission

Population size of American Shad and Striped Bass in the Roanoke River

The goal of this study is to estimate the number of adult American shad and striped bass returning to the Roanoke River to spawn. Split-beam hydroacoustic monitoring has been carried out during March-May of 2004–2007. Tracks of upstream-migrating fish were readily discernible from ambient noise. Electrofishing and gill-netting were used to estimate the species composition of upstream-migrating fish. Estimates for American shad for 2004–2007 ranged from 7,054 to 37,349, compared to striped bass estimates ranging from 118,778 to 216,971. The largest uncertainties regarding the hydroacoustic monitoring are the cross-channel distribution of upstream migrants. Using hydroacoustics to estimate run sizes appears to be feasible, but improvements to the study design are needed. Further validation will improve both accuracy and precision of estimates, and allow fishery managers to use hydroacoustic results with confidence in making management decisions.

INVESTIGATOR Joseph E. Hightower
STUDENTS Kevin Magowan, M.S., Fisheries and Wildlife Sciences; Michael Waine, M.S. Candidate, Fisheries and Wildlife Sciences
LOCATION Roanoke River, North Carolina
SPONSOR N.C. Wildlife Resources Commission

Images show a school of upstream-migrating fish as detected using a DIDSON (left) and split-beam sonar (right).
Reproductive ecology and habitat relations of the robust redhorse

The suckers, family Catostomidae, are a diverse group of fishes facing numerous threats from human impacts, and scientists concur that research should be incorporated into conservation planning. The robust redhorse, *Moxostoma robustum*, was lost to science until it was rediscovered in 1980, 110 years after its description. Habitat loss and spawning disruption by dams were identified by the Robust Redhorse Conservation Committee (RRCC) as a threat to the species. Recent work by the Yadkin/Pee Dee Technical Working Group of the RRCC identified spawning habitat in shoals and side-channels downstream of Blewett Falls Dam in the Pee Dee River, North Carolina. We initiated cooperative research to improve understanding of robust redhorse reproductive and habitat ecology to ensure long-term survival and population enhancement. Objectives are to quantitatively describe changes in robust redhorse spawning habitat before and after implementing a spring minimum flow from Blewett Falls Dam, describe how robust redhorse use habitat before and after minimum flows are established, and assess how flow augmentation may affect survival of viable eggs. This ongoing, collaborative research will improve our overall understanding of a little-known and rare fish, that may require protection or compel other management activities in this and other regulated river systems.

**INVESTIGATOR**

Joseph E. Hightower

**STUDENT**

Julianne Harris, Ph.D. Candidate, Fisheries and Wildlife Sciences

**LOCATION**

Roanoke River, North Carolina

**DURATION**


**SPONSORS**

N.C. Wildlife Resources Commission, Dominion

The Roanoke Rapids Dam in North Carolina is the present extent of upstream migration for anadromous fish in the Roanoke River. The dam’s tailrace was constructed adjacent to the original river channel, which is called the bypass reach. Starting in 2004, Dominion/North Carolina Power (Dominion) began releasing water into the bypass reach to provide additional fish habitat. During the period when this study was conducted (Spring of 2005 and 2006), discharge into the bypass reach was 325 cfs except for 10 days at 500 cfs. To determine whether anadromous fishes used this restored habitat for spawning, sampling for adult fish, eggs and larvae was completed from the start of March to the end of May, 2005 and 2006, in the bypass reach, tailrace, and main river channel. Adults were collected by a fishwheel in the Roanoke Rapids tailrace in 2005 and main river channel in 2006 and by electrofishing in the lower, middle (2006 only), and upper areas of the bypass reach. Eggs and larvae were collected by plankton tows and spawning pads in the bypass reach and in the main river channel. Hickory shad and blueback herring were the only anadromous species to spawn in the bypass reach. American shad and striped bass were not observed to spawn in the bypass reach; however, adult American shad were collected in the fishwheel and eggs were collected in the main river channel. Few adults and only one egg of striped bass were collected from main river sites. No anadromous fish eggs were collected in the upper or middle bypass reach. Over the next few years, spring flows will be increased to determine optimum levels for spawning of anadromous fish in the bypass reach.

**INVESTIGATOR**

Thomas J. Kwak

**STUDENT**

J. Michael Fisk, M.S. Candidate, Fisheries and Wildlife

**LOCATION**

Pee Dee River, North Carolina and South Carolina

**DURATION**

8/1/2007–6/30/2010

**SPONSORS**

N.C. Wildlife Resources Commission, Progress Energy Carolinas
Reproductive ecology and life history of the Carolina madtom

The Carolina madtom, *Noturus furiosus*, is an imperiled, endemic southeastern catfish that is experiencing declines presumably associated with habitat loss. Presently, the species may be nearing extirpation in about half of its native range (i.e., one of two Atlantic watersheds). We investigated Carolina madtom habitat use, focusing on the occupancy of natural habitat, as well as introduced, artificial cover. In six study reaches in the Tar and Neuse river basins of North Carolina, the Carolina madtom occupied microhabitats nonrandomly, most frequently inhabiting water that was shallow with moderate bottom velocity over coarse sand substrate. All occupied microhabitats included physical cover, with cobble found most frequently. We developed for the first time empirical habitat suitability functions for the species. Our findings also demonstrate significant use of introduced artificial cover, a pattern confirmed in laboratory choice studies; when presented four cover choices (three natural, one artificial), Carolina madtom selected the artificial cover unit over half the time. Given its State Threatened status and limited distribution, our results have implications for conservation and restoration of this endemic species. Successful management and conservation of the Carolina madtom is dependent upon protecting Tar basin habitat, identifying Neuse basin impacts, and restoring Neuse basin populations.

INVESTIGATORS
D. Derek Aday
Thomas J. Kwak

STUDENT
Stephen R. Midway, M.S.,
Fisheries and Wildlife

LOCATION
Tar and Neuse river basins,
North Carolina

DURATION

SPONSOR
N.C. Wildlife Resources Commission

Sicklefin redhorse reproductive and habitat ecology

The sicklefin redhorse is a recently recognized fish of the sucker family Catostomidae. It is among the largest undescribed animal species in North America, and virtually nothing is known of its biology and ecology. It is endemic to the Hiwassee and Little Tennessee river systems of North Carolina and Georgia and is sufficiently rare that it is a candidate for endangered species protection. Spawning and reproduction are known to be a life-history bottleneck for stream fishes, and improved understanding will be a critical step toward ensuring the fish’s survival. Using a combination of methods (resistance-board weirs, prepositioned electrofishing, and radio telemetry), we quantified migration patterns and habitat selection of the sicklefin redhorse and other related redhorse species in the Hiwassee River system in the mountains of western North Carolina, with the ultimate outcome of protecting the physical and biotic environments to ensure the long-term survival and enhancement of the sicklefin redhorse. This research delineated important habitats for this species and elucidated critical ecological processes required to sustain this population of a rare and imperiled fish. The results will be used by management and regulatory agencies to set guidelines and priorities for dam operation and licensing in the Tennessee River basin.

INVESTIGATOR
Thomas J. Kwak

STUDENT
Scott D. Favrot, M.S. Candidate,
Fisheries and Wildlife

LOCATION
Little Tennessee and Hiwassee river systems, North Carolina

DURATION
9/1/2002–10/31/2008

SPONSORS
U.S. Fish and Wildlife Service,

Carolina madtom found in Contentnea Creek, Neuse River Basin, near Lucama, North Carolina.
Spawning activity of anadromous fishes in the Cape Fear River

Anadromous fish were historically an important resource within the Cape Fear River basin but populations have experienced significant declines. The striped bass population remains among the lowest of North Carolina’s coastal rivers. Only a small population of Atlantic sturgeon and a few shortnose sturgeon are present in the system today. These declines have been attributed to the same variety of anthropogenic effects (overfishing, pollution, development, dam construction) that have impacted many other Atlantic coastal rivers. In the Cape Fear River, three low-head lock and dam structures were constructed between 1913 and 1934 by the United States Army Corp of Engineers (USACOE) for the purpose of commercial navigation. Fish ladders were constructed at each of the three lock and dam structures, but anadromous fish were unsuccessful at utilizing them. Subsequently, in 1962, a program was implemented through an agreement among the North Carolina Wildlife Resources Commission (NCWRC), USACOE, and United States Fish and Wildlife Service (USFWS) to use the lock at each dam to move fish upstream to continue their spawning run. The goal of this project is to characterize the current patterns of migration and spawning activity for American shad and striped bass within the Cape Fear River. Tracking the movements of sonic-tagged fish, along with conducting egg and larval fish surveys, will help to identify areas of concentrated spawning activity, uncover patterns and preferences in habitat characteristics, and further assess the impact of the three dams on their distribution. Ultimately, the new data provided by this study will serve as a useful tool to aid in management decisions regarding the recovery of this extremely important resource.

INVESTIGATOR      Joseph E. Hightower
STUDENT           Joseph Smith, M.S. Candidate, Fisheries and Wildlife Sciences
LOCATION          Cape Fear River, North Carolina
SPONSOR           U.S. Army Corps of Engineers

Stream trout ecology and management in North Carolina State Parks

Coldwater stream trout fisheries are among the most important in terms of angling, economics, and scenic value, yet they are commonly managed based on historical practices or following standardized protocols without specific knowledge or a scientific basis. Research is ongoing to gather quantitative information on the population and production dynamics of stream-dwelling trout in North Carolina State Parks. The goal of the research is to better understand the ecological and biological processes associated with these populations and to form an objective information base to form fisheries and ecosystem management strategies, planning, and implementation. Specific project objective are to conduct intensive sampling and quantify critical population parameters of stream trout populations, assemblies of nongame fishes, water quality and instream habitat characteristics, and to present these results in an applied context toward guiding management strategies for trout fisheries and stream ecosystems in North Carolina State Parks. Results will be compared to other stream trout populations, and the amount of biomass that may be available for harvest by angling will be estimated. These findings will allow managers to predict the likely outcome of altering management strategies among streams to select the most appropriate approaches within the ecological limits of each stream.

INVESTIGATOR      Thomas J. Kwak
STUDENT           Benjamin C. Wallace, M.S. Candidate, Fisheries and Wildlife Sciences
LOCATION          Stone Mountain State Park, North Carolina
DURATION          7/1/2007–6/30/2010
SPONSOR           N.C. Department of Environment and Natural Resources

The geographic relationship of mortality events of carp species in North Carolina

This study examines spatial and environmental factors and their relationship to patterns in mortality events affecting carp across the United States. Data on 79 mortality events have been collected. Diagnostic data on these mortality events are very limited. Research is being conducted to help optimize the ability to develop state level participation in the data collection effort. A GUI relational GIS based database is being constructed to enhance evaluation of patterns of mortality events in relation to major physical factors and weather events. This will provide a tool for more proactive management of carp health issues in the United States.

INVESTIGATOR      Michael K. Stoskopf
STUDENT           Maria Serrano, D.V.M., M.S. Candidate, Fisheries and Wildlife Sciences
LOCATION          N.C. State University
DURATION          9/1/2006–9/30/2008
SPONSOR           U.S. Fish and Wildlife Service
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Adaptive management of horseshoe crabs and shorebirds in Delaware Bay: Predictive modeling and implementation

The Delaware Bay serves as both an important spawning area for Atlantic Horseshoe Crabs and a migratory stopover site for Red Knots during their spring migration from Tierra Del Fuego, Argentina, to the Canadian Arctic. The migrating birds depend on large numbers of Horseshoe crab eggs on the beaches of the Delaware Bay to refuel and prepare for the last leg of their epic migration. From 2000 to 2003, a massive decline in Red Knot abundance was observed, and managers and biologists have speculated that the decline is in part due to harvest of breeding adult Horseshoe Crabs in the Bay which led to fewer eggs available for Red Knot consumption. We are developing harvest optimization models to maximize Horseshoe Crab harvest in the bay, constrained by Red Knot population viability, for a structured decision making and adaptive harvest management approach to manage the situation. We are using the program ASDP (developed by Bruce Lubow and the USGS) to model the Delaware system in an Adaptive Stochastic Dynamic programming environment. We are using 11 years of mark resight and recapture data of red knots in the Bay in a multi-state open robust design analysis to evaluate Red Knot annual survival contingent upon weight gain during the stopover period. The results of these analyses will be used to parameterize the Red Knot population components of the ASDP model.

INVESTIGATORS: Jaime A. Collazo, David Smith, James Nichols
POSTDOCTORAL RESEARCHER: Conor McGowan
LOCATION: Delaware Bay, Delaware
DURATION: 8/25/2008–12/31/2010
SPONSOR: U.S. Geological Survey

Assessing the relationship between acid precipitation, calcium depletion, and avian productivity in Great Smoky Mountains National Park

The goal of this research is to examine the effects of acid precipitation on two groups of high elevation terrestrial animals in the southern Appalachians. Acid precipitation remains high in eastern forests, and is considered a critical environmental stress. We are working with Dark-eyed Juncos, Junco hyemalis, to quantify the effects of acid deposition and subsequent calcium depletion on the reproductive success of high elevation songbirds. We are testing for links between acid deposition and calcium content in junco eggshells collected in 2006. In 2007 and 2008, we monitored nesting success in both control and treatment plots, where calcium (crushed oyster shell) was added. As terrestrial snails are the birds' primary calcium source, we are also examining the diversity and abundance of snail populations across 60 plots in the high elevation spruce-fir habitat. In addition, we are examining morphometric differences in the same snail species across two different scales. Accordingly, we estimated the proportion of patches inhabited by snails and what habitat features are associated with snail abundance in both control and treatment plots, where calcium (crushed oyster shell) was added. A better understanding of how avian communities respond to acid deposition and subsequent calcium depletion can provide insights into the effects of acid deposition at the landscape scale.

INVESTIGATOR: Theodore R. Simons
STUDENT: Rebecca Keller, Ph.D. Candidate, Zoology
LOCATION: Great Smoky Mountains National Park and Blue Ridge Parkway, North Carolina and Tennessee
SPONSOR: U.S. Forest Service

Avian conservation in north-central forested habitats in Puerto Rico

This project sought to assess bird and plant communities at a landscape level, specifically, a better understanding of how avian abundance varies across karstic landscapes and what habitat features are associated with such variability (e.g., habitat components at different scales). Accordingly, we estimated density and patch occupancy for resident avian species occurring in the karst region of Puerto Rico. Thirty-nine avian resident species were recorded during surveys. Population estimates were estimable for 16 species. Estimates of patch occupancy were estimable for 12 species. These data are being used to identify unique community assemblages and factors influencing their abundance and distribution across the landscape, guide regional conservation planning, assess habitat suitability for endangered species, habitat restoration, and serve as testing grounds for innovative avian sampling techniques (e.g. estimation of detection probability).

INVESTIGATOR: Jaime A. Collazo
STUDENT: Jessica Gleffe, M.S., Zoology
LOCATION: Puerto Rico
SPONSOR: Puerto Rico Department of Natural and Environmental Resources

Park intern with Dark-eyed Junco in Great Smoky Mountains National Park.
Baseline assessment of neotropical migrant landbird stopover habitat in the lower Chesapeake Bay region for conservation planning and protection

This project is closely connected with a companion collaboration between NC State researchers, The Nature Conservancy, the Center for Conservation Biology at the College of William and Mary, and Patuxent Wildlife Research Center, entitled, N-POL Bird-Radar Study on the Eastern Shore of Virginia. Together, these two projects are designed to assess available stopover habitat in the lower Chesapeake Bay region. In this study, researchers conducted analyses of NEXRAD data from the Wakefield, Virginia, radar station (Station AKQ), collected during the 2003 and 2004 fall migration. Data were screened for weather contamination and other irregularities, and the resulting analysis provides an overview of migratory landbird exodus within an area described by the sweep of the radar between 15 km and 105 km from the AKQ station. NEXRAD reflectivity has not been quantitatively calibrated for bird densities, so the data are presented on a relative percentile scale, which allows for identification of those areas that support the greatest relative numbers of landbird migrants within the region. Researchers provided this analysis to collaborators at the Center for Conservation Biology to develop a model of the characteristics of the habitats associated with migrant exodus. The final integrative analysis was completed in January 2007.

INVESTIGATOR Theodore R. Simons
POSTDOCTORAL RESEARCHER Sarah Mabey
LOCATION N.C. State University
SPONSOR The Nature Conservancy

Bird and bat migration over Appalachian ridges in the Mid-Atlantic region: Weather surveillance radar component

This project is a small component of a larger collaboration between scientists with the U.S. Geological Survey and the U.S. Fish and Wildlife Service to identify and describe broad scale patterns of migratory landbird movements through the southern Appalachian ridges during both spring and fall passage. The goal of this work is to assess the value of Doppler weather surveillance radar data for discriminating direction and volume of nocturnal migration traffic across the Appalachian region. Researchers assessed and processed NEXRAD data from the Pittsburgh, Roanoke, Virginia, Knoxville, Tennessee, and Charleston, West Virginia, radars for spring and fall 2005, and conducted a training session with collaborators to train them in the use and interpretation of Doppler weather surveillance radar. Preliminary assessment of the data indicates that songbird migrant movements along the southern Appalachian is characterized by a high degree of variability in directionality. Researchers will meet with partners at Patuxent Wildlife Research Center this winter to finalize their analysis of this large radar dataset.

INVESTIGATOR Theodore R. Simons
POSTDOCTORAL RESEARCHER Sarah Mabey
LOCATION N.C. State University
SPONSOR U.S. Geological Survey

Aerial surveys have been one of the more common survey methods when dealing with manatees in part due to the large spatial extent aircraft can cover. Aerial surveys need to account for the imperfect detection probability caused by this sampling method. Imperfect detection probability can be the result of several sources: observer error, environmental issues such as glare and water turbidity, unavailable animals present in the location etc. Unavailable animals are animals that are impossible to be seen, for example, if an animal is too far below the water surface. There are several common approaches that allow the detection probability to be estimated for aerial surveys. In this protocol, we advocate the use of repeated counts in high use areas around the coastline of Puerto Rico. The survey we propose begins with the designation of zones of high and low density. The areas of high density include Ceiba, Guayama, Guayanilla and Mayaguez, these specific regions of interest will be covered in more detail. Low density zones will be flown over once in transit to high density zones. High density zones will have multiple passes (repeats), preferably five, but fuel or other concerns may limit the number of passes. The next stage of the research will be to analyze data from a pilot study under this protocol using hierarchical Bayesian modeling of the repeated counts.

INVESTIGATORS Kenneth H. Pollock
Jaime A. Collazo
STUDENT Matthew J. Krachey, Ph.D.
Candidate, Zoology
LOCATION N.C. State University
SPONSOR U.S. Fish and Wildlife Service

Design and analysis of Antillean manatee aerial surveys in Puerto Rico

Three West Indian manatees foraging on seagrass.
Designing sustainable landscapes for bird populations in the eastern United States

The goal of this project is to develop a consistent methodology to enhance the capacity of states, joint ventures and other partners to assess and design sustainable landscape conservation for birds and other wildlife in the eastern United States. Specifically, this project will develop and implement a framework and tools to: (1) assess the current capability of habitats in ecoregions in the eastern United States to support sustainable bird populations; (2) predict the impacts of landscape-level changes (e.g., from urban growth, conservation programs, climate change) on the future capability of these habitats to support bird populations; (3) target conservation programs to effectively and efficiently achieve objectives in State Wildlife Action Plans and bird conservation plans and evaluate progress under these plans; and (4) enhance coordination among partners during the planning, implementation and evaluation of habitat conservation through conservation design. We are modeling urban growth and vegetation dynamics, including the impacts of climate change for the Southern Atlantic Migratory Bird Initiative (SAMBI) Region. Bird occupancy models will be used to evaluate the influence of land use scenarios and climate change. Collaborators at Auburn University will help communicate the results to a broad audience through decision support tools produced in collaboration with Wildlife Biologists throughout the SAMBI region. Currently, we are finalizing the urban growth modeling, testing the vegetation dynamics models with climate change parameters and identifying species modeling methods based on the Breeding Bird Survey and datasets from the Southeast Gap Analysis Project.

INVESTIGATORS
Jaime A. Collazo

STAFF
Alexa McKerrow, Steve Williams, Matt Rubino, Todd Earnhardt, Adam Terando, and Zac Arcaro

LOCATION
Eastern United States

DURATION
1/1/2008–12/31/2010

SPONSOR
U.S. Fish and Wildlife Service

Ecological studies of fishers on managed landscapes in northern California

The current status of the fisher, Martes pennanti, as a candidate species for federal listing under the Endangered Species Act and concern over its absence from a substantial portion of its historic range led to a plan to reintroduce fishers onto lands in northern Sierra Nevada Mountains where fishers were extirpated ca 100 years ago but where habitat has recovered. These fishers will be monitored intensively to document survival, establishment of home ranges, movements, reproduction, and use of habitats. This reintroduction will improve the conservation status of fishers in California and will provide insight into how fishers use managed landscapes. Reintroduction will place naive fishers on a landscape supplied with appropriate habitat and prey. Thus, this reintroduction provides the perfect opportunity to test general optimality models related to use of habitats, spacing of home ranges, and reproductive success of males. My research team will: (1) document survival, reproduction and use of habitat by fishers during the first 5 years following release; (2) predict use of habitat by fishers using 5 models and to evaluate the predictions using data on actual use of habitat by fishers; (3) predict placement, sizes, and shapes of home range using models of optimal home range choice and test the predictions using data on actual use of space by fishers; (4) predict patterns of breeding by males from home range placement and familiarity with landscapes and to test those predictions using data on paternity of fishers born in the study area; and (5) conduct a parallel study of fishers in the Klamath Mountains on lands owned by Timber Products Company, thereby gaining comparative information for a population that has never been extirpated.

INVESTIGATOR
Theodore R. Simons

STUDENT
Arielle Waldstein, M.S.

LOCATION
Cape Lookout National Seashore, North Carolina

DURATION

SPONSOR
U.S. Geological Survey

Ecology of raccoons within Cape Lookout National Seashore, North Carolina, and the efficacy of raccoon removal as a management tool for protecting rare, threatened, and endangered species

In many coastal areas, high raccoon densities have been shown to correlate with high levels of nest failure in several threatened and endangered species. At Cape Lookout National Seashore, there is increasing concern that if raccoon populations are not managed to reduce predation, these species will suffer an increasing risk of extinction and extirpation. The goals of this study are to determine the basic ecology of raccoons on South Core Banks in 2007 and 2008, estimate the population size, and evaluate the response of raccoon, shorebird, and turtle populations to an experimental removal of raccoons in December 2008. Results from a large-scale mark-recapture study and radio-telemetry are currently being analyzed to establish baseline conditions for the raccoon population pre-removal. Data are being continually collected by the National Park Service to establish nesting success pre and post-raccoon-removal on the Seashore. The results of this study will provide important information about the efficacy of predator removal to protect threatened and endangered species.

INVESTIGATOR
Roger A. Powell

LOCATION
Sierra Nevada Mountains, California

DURATION
2/5/2008–9/30/2012

SPONSOR
U.S. Fish and Wildlife Service

Fisher and hare.
Estimating detection probabilities for community assessment and population monitoring

We conducted a series of validation experiments to simulate bird census conditions, vary a range of factors that affect detection probabilities, and evaluate observer performance when most birds are identified by sound. This system, also known as “All Bird Radio,” consists of a laptop computer and a radio transmitter to control a set of player and speaker devices. We found that methods of estimating detection probability that require the localization of auditory detections are subject to large measurement and misclassification errors. Therefore, the uncertainty surrounding estimates of avian diversity or abundance based on distance, double-observer, and time of detection methods is probably higher than currently reported by most practitioners. Approaches to account for this uncertainty in abundance models clearly are needed. In practice, modern methods may exceed observer abilities in many cases. Therefore, simplified protocols (e.g., single species surveys, occupancy approaches) that reduce the demands on human observers may ultimately yield better results. Regardless, abundance and occupancy estimates based on point count data should always incorporate adjustments for variations in detection probability. No single approach will necessarily be the best for all species. Practitioners should carefully consider the biology (e.g., movement rates, vocalization rates, surrounding environmental conditions) of the species under investigation when deciding upon the most appropriate sampling method.

INVESTIGATORS
Theodore R. Simons
Kenneth H. Pollock

POSTDOCTORAL RESEARCHERS
Mat Alldredge
Ray Webster

LOCATION
N.C. State University

DURATION

SPONSORS
U.S. Fish and Wildlife Service
U.S. Geological Survey
N.C. Wildlife Resources Commission

Evaluating American Oystercatchers as indicators of resource conditions in coastal North Carolina

Natural communities in coastal regions are under increasing pressure from human use, introduced predators, and habitat change. The American Oystercatcher, Haematopus palliates, is a useful focal species to study the effect of rapid anthropogenic change on coastal ecosystems. American Oystercatchers are long-lived shorebirds that breed from Maine to Florida and are closely tied to intertidal ecosystems throughout the year. Recent evidence of population declines in several states is raising concern over the status of their populations. In 1995, a study of breeding American Oystercatchers was initiated on Cape Lookout National Seashore to examine factors affecting nesting success. Subsequent research expanded the study area to include all nesting oystercatcher pairs on Cape Lookout and Cape Hatteras National Seashores and expanded the scope of the work to investigate survival, fidelity, movement, disturbance and predation. Our research goals are to (i) understand the factors affecting the reproductive success of American Oystercatchers in North Carolina, (ii) develop population models that incorporate the effects of humans, predators, and environmental conditions on population trends, and (iii) identify range-wide patterns of adult migration and juvenile dispersal.

INVESTIGATOR
Theodore R. Simons

STUDENT
Shiloh Schulte, Ph.D.
Candidate, Zoology

LOCATION
Cape Lookout and Cape Hatteras National Seashores

DURATION
7/15/2002–6/30/2008

SPONSOR
National Park Service

Evaluation of the Red Wolf Adaptive Management Plan project

This project involves two meetings per year of the red wolf adaptive management advisory team (RWRIT) to assess and make suggestions about the adaptive management plan for red wolf species. Members of the RWRIT are Karen Beck, Todd Fuller, and E. Gese, Frederick Knowlton, Dennis Murray, Michael Stoskopf, Will Waddell, and Lisette Waits. Invited guests attend each meeting to add insight or particular expertise. These have included graduate students of team members, field team biologists and outside experts. In each meeting, the RWRIT evaluates data available on wolf genetics, demographics, health and other areas of interest and makes recommendations to the field team. Detailed minutes of the meeting are taken and carefully edited by the entire RWRIT and then distributed to the Red Wolf Project Leader, as confidential advice to be implemented and distributed at their discretion. Progress to date includes increased pup production, improved protocols for telemetry effort, and identification of key knowledge needed to further improve the management of the wolves. Current issues of concern are aging demographics of known breeding pairs and losses of wolves to automobile collision and gunshot. Methods of remote meeting and data assessment process for the RWRIT are being evaluated.

INVESTIGATOR
Michael K. Stoskopf

STUDENTS
Karen Beck, D.V.M., Ph.D.
Comparative Biomedical Sciences
Anne Ballman (née: Acton), Ph.D.,
Comparative Biomedical Sciences

LOCATION
Alligator River National Wildlife Refuge, North Carolina

DURATION

SPONSOR
U.S. Fish and Wildlife Service
Field validation of King Rail habitat models in the Roanoke-Tar-Neuse-Cape Fear Ecosystems

By performing field validation of our King Rail model, we will test and improve the model while also assessing the value and uncertainty associated with using expert opinion within a Bayesian Belief Network model in support of Strategic Habitat Conservation. In Spring 2008, we successfully completed the first year of this two-year model validation effort by performing three replicate surveys at 102 marsh sites. The sites, located within 100 km of housing provided by Pocosin Lakes NWR and Back Bay NWR, offered a stratified random sample based on marsh area, distance to mapped open water, and land cover context within 1 km. These characteristics represented variables that local experts ranked as important, but about which they expressed uncertainty regarding the specific influence on King Rail site occupancy. King Rail were detected at 16 sites and a preliminary occupancy analysis in PRESENCE suggests that King Rail occupancy trends favor larger patches interspersed with abundant water, but may avoid interior habitat (greater than 250 m from mapped water). However, the second year’s data will be necessary to achieve adequate sample size to perform the final analysis.

INVESTIGATOR Jaime A. Collazo
POSTDOCTORAL RESEARCHER C. Ashton Drew
LOCATION Pocosin Lakes National Wildlife Refuge, North Carolina, and Back Bay National Wildlife Refuge, Virginia
DURATION 1/23/2007-12/31/2008
SPONSOR U.S. Fish and Wildlife Service

Incorporating estimates of detection probability into the Breeding Bird Survey protocol: assessment of current sampling methods

The Breeding Bird Survey (BBS) is a unique roadside survey that includes over 3,000 routes per year throughout the United States and Canada. Currently, BBS methods do not allow for the estimation of detection probability for any species. In this context, detection probability is the probability that an individual bird is present within the sample area and/or available for detection given it is present and/or detected given it is available. Failure to account for imperfect detection (i.e., situations in which detection probability < 1.0) may lead to poor inference and management decisions. In 2008, we solicited BBS volunteers from Georgia to New York to pilot two alternative sampling methods on their routes: unreconciled double-observers and repeated visits. In North Carolina, a field crew of 6 highly experienced biologists also piloted these two methods along with distance sampling and time-of-detection on 12 routes. Preliminary results from the work in North Carolina suggest large discrepancies exist between observers in the number of birds counted/stop as well as other data collected such as wind conditions and the number of cars that pass during the count. Additionally, car counts are a poor predictor of noise levels along BBS routes. Finally, observers often differ substantially in their detection probabilities and these differences are not consistent among species or methods used for estimating detection probabilities. Forthcoming analyses and models should provide important guidance as to which methods may be most effective for incorporating estimates of detection probability into the BBS protocol.

INVESTIGATOR Theodore R. Simons
Kenneth H. Pollock
POSTDOCTORAL RESEARCHER Jason Riddle
LOCATION Eastern United States
DURATION 9/1/2006-12/31/2011
SPONSOR U.S. Geological Survey

Investigating the productivity, territory size, and food base of the Swainson’s Warbler in an irregularly flooded bottomland hardwood system

The objective of this research is to investigate factors influencing Swainson’s warbler (SWWA) nest survival in habitat considered to be of regional significance. Field work was conducted in 2006-2008, with a final field season planned in 2009. Nests were continuously monitored for parental activity, disturbances that influence nest survival, and predators that depredate nests. In addition, nest-site selection, territory size, and the potential impacts of the lower Roanoke River’s altered flood regime were considered as factors influencing nest survival. To date, 217 SWWA have been captured and color-banded, and 67 birds have been radio tracked. Seventy-two nests have been monitored, and vegetation sampling has taken place at each nest. No flooding has occurred during a field season. Results are currently being analyzed and can be incorporated in future large-scale adaptive ecosystem management plans with the goal of restoring and enhancing bottomland forest and floodplain communities in the Southeast. On a smaller scale, results can be used to make informed decisions when developing strategic habitat management plans for current and future holdings of the Roanoke River National Wildlife Refuge, North Carolina, and other conservation lands along the lower Roanoke River. Preliminary results have been presented at the Southeast Partners In Flight conference (11/2007) and the U.S. Fish and Wildlife Coastal Carolina/Southeastern Virgiana Strategic Habitat Conservation Team Meetings (01/2008, 10/2008).

INVESTIGATORS Richard A. Lancia
Theodore R. Simons
STUDENT Neil Chartier, Ph.D. Candidate, Fisheries and Wildlife Sciences
LOCATION Roanoke River National Wildlife Refuge, North Carolina
DURATION 7/1/2005-9/30/2009
SPONSOR N.C. Wildlife Resources Commission
U.S. Fish and Wildlife Service

Staff from the U.S. Fish and Wildlife Service train King Rail field crew.
Shorebirds utilize sites for resting and refueling between migration flights along North Carolina’s barrier islands where beach driving is a prominent activity. Our objective was to measure the effects of vehicle disturbance on shorebird behavior and habitat use at South Core Banks, a barrier island that is part of Cape Lookout National Seashore. Observational disturbance studies have found that disturbance effects are confounded with environmental and habitat effects, so we employed a before-after-control-impact (BACI) experimental study design with replication to isolate disturbance effects. We found that disturbance decreased site use by shorebirds, all birds, and Black-bellied Plovers, *Pluvialis squatarola*. The two most abundant species of shorebird at our study sites, Sanderlings, *Calidris alba*, and Willets, *Catoptrophorus semipalmatus*, did not show significant decreases in abundance in response to disturbance, but disturbance influenced Sanderling activity by decreasing the proportion of time that they spent roosting and increasing the proportion of time that they spent active. We concluded that vehicle disturbance influences shorebirds’ use of ocean beach habitat for roosting during the nonbreeding season and that experimental BACI study designs provide a practical tool for measuring the effects of disturbance on wildlife, without the confounding that affects purely observational approaches.

**Non-lethal molecular diagnostic sampling of captive Red Wolves**

Molecular assays targeting a single region of both canine distemper virus and canine parvovirus have been developed. Each assay has been tested on several vaccines to assess detection limits and assay specificities. Prolonged storage studies have demonstrated that each virus can be detected in vaccine-inoculated feces at least 6 months after storage. Induction of natural fecal viral shedding was attempted in adult red wolves and naive coyote pups to estimate the virus detection window. No reliable viral shedding was detected in adults presumably due to effects of circulating antibodies but fecal shed vaccine virus was detected in stools of coyote pups. Positive controls from suspected field infections of canine parvovirus, feline panleukopenia and canine distemper virus are being collected and tested with the assays. Paired fecal and blood samples have been collected annually from several free-ranging carnivore species in eastern North Carolina for testing. This non-invasive method of evaluating pathogen presence in ecosystems provides an additional tool for habitat health risk assessment and disease management in wild carnivores.

**N-POL bird-radar study on the eastern shore of Virginia**

In the past year, we have completed our second season of data collection with the N-POL radar in Oyster, Virginia. During the 2005 fall migratory period, we collected data on over 50 nights yielding viable data for 30 migration events. These data include two nights of continuous dusk to dawn scans. The data have been processed and translated to a GIS-compatible format. Analysis of the data from both fall 2004 and 2005 has begun. Researchers and collaborators from the Center for Conservation Biology at the College of William and Mary are currently working on the final data analysis for this project that will integrate data from ground surveys of landbird migrants, detailed vegetation and forest cover surveys, and N-POL radar data. Researchers have prepared preliminary analyses of 2004 N-POL radar data for The Nature Conservancy and U.S. Geological Survey partners. Patterns of migratory songbird exodus from a single season indicate that migrants are not evenly distributed across the lower Delmarva Peninsula. However, final interpretation of these patterns will depend on our integrative analysis.

**INVESTIGATOR** Theodore R. Simons
**STUDENT** Anne Ballman (née: Acton), Ph.D., Comparative Biomedical Sciences
**LOCATION** Alligator River National Wildlife Refuge, North Carolina
**DURATION** 7/1/2004–9/30/2007
**SPONSOR** U.S. Fish and Wildlife Service

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Juvenile Sanderling at Cape Lookout National Seashore.
Planning level survey for at-risk amphibian species

We assessed the status of tiger salamanders and gopher frogs at Ft. Bragg by searching for new wetland breeding sites and continuing surveys at five previously known populations of tiger salamanders and two previously known populations of gopher frogs. We found that approximately 170 tiger salamanders breed each winter, and that at least 100 gopher frogs breed at two ponds when conditions are favorable. Despite the presence of breeding adults, very few larvae survived to metamorphosis. We searched 60% of the base for new populations of these rare amphibians and developed a predictive model to map potential breeding sites across the base. This map will help us prioritize habitat to protect or restore these populations. We studied the movements of tiger salamanders and gopher frogs to understand habitat use in uplands. We used fluorescent dye-powders to track the movements of animals as they left breeding ponds and found that they migrated to burrows or tunnels under woody debris. A second study followed the movements of 3 adult tiger salamanders and 2 gopher frogs using radio telemetry. We followed animals for up to 80 days, and again found heavy use of burrows and woody debris. These results highlight the importance of maintaining upland habitat features for at-risk amphibian species.

INVESTIGATOR Nick M. Haddad
POSTDOCTORAL RESEARCHERS Nicole Thurgate Laura Vogel
STUDENT Will Fields, Ph.D. Candidate, Zoology
LOCATION Ft. Bragg, North Carolina
SPONSOR U.S. Army, XVIII Airborne Corps & Ft. Bragg

Research for maintenance of the St. Francis Satyr butterfly population on Ft. Bragg

This agreement funded the fifth and sixth years of our monitoring and research on the endangered St. Francis’ satyr butterfly, *Neonympha mitchelli francisci*. This award funded a period of synthesis in which we: (1) published the first account of St. Francis’ satyr natural history and population ecology since it was first described more than 25 years ago; (2) published a rigorous assessment of how to monitor St. Francis’ satyr and other rare butterfly species; and (3) completed a major effort to understand habitat requirements for St. Francis’ satyr. Taken together, our results will strengthen monitoring and management of St. Francis’ satyr butterfly now and in the future. As to St. Francis’ satyr population monitoring in 2006 and 2007, population sizes remained constant, but lower than their all time highs. Changes in butterfly population sizes within individual colonies can be explained by natural dynamics of their habitats, including fire, succession, and especially the activities of beaver. We made progress in understanding habitat dynamics for the butterfly through detailed surveys of plant communities in wetlands and through spatial analysis to remotely identify suitable habitat. In 2006 and 2007, we successfully reared the related Georgia satyr, *Neonympha areolata*, and this effort will improve our ability to raise St. Francis’ satyr.

INVESTIGATOR Nick M. Haddad
POSTDOCTORAL RESEARCHERS Nicole Thurgate Laura Vogel
STUDENT Becky Bartel, Ph.D., Zoology
STAFF Daniel Kuefler, Jessica Abbott, Megan Chesser, John McAllister, Quinn Mortell, Catherine Frock, Noa Davidai
LOCATION Ft. Bragg, North Carolina
SPONSORS U.S. Army, XVIII Airborne Corps & Ft. Bragg
Strategic Environmental Research and Development Program

Nick Haddad (right) and Daniel Kuefler restore habitat for the endangered St. Francis’ satyr butterfly by controlling beaver dams.
Species assessments and conservation scores: revision of the Puerto Rico and U.S. Virgin Islands Bird Conservation Plan

Puerto Rico and the Virgin Islands harbor over 284 species of birds; 16 of them are endemics. As an increasing human population progressively infringes on habitat quantity, and in many cases undermining its quality, the need to identify opportunities to protect and, if need be, manage habitat for avian species becomes a conservation priority. In concert with this need, we are revising the “Puerto Rico and the U.S. Virgin Islands Bird Conservation Plan.” This plan covers the Bird Conservation Area 69 within the Atlantic Coast Joint Venture. Population and habitat objectives will be finalized this year with the aid of the Puerto Rico and U.S. Virgin Islands Gap Analyses. Ultimately, the goal of the Plan is to provide commonwealth, state, federal and non-governmental institutions with guidelines to target their resources for avian conservation more effectively and efficiently.

INVESTIGATOR
Jaime A. Collazo

STUDENT
Kelsey Oberneufemann,
M.S., Zoology

LOCATION
Puerto Rico and
U.S. Virgin Islands

DURATION
10/1/2006–12/31/2008

SPONSOR
U.S. Fish and Wildlife Service
Status and ecology of the Northern Pine Snake, Southern Hognose Snake, Tiger Salamander, and Carolina Gopher Frog on Ft. Bragg, North Carolina

We researched four rare amphibian and snake species at Ft. Bragg, North Carolina. We monitored four breeding populations of tiger salamanders, all of which occurred in human created wetlands. We established a monitoring protocol using drift fences. The total adult population size of tiger salamanders on base was approximately 170 individuals. Successful reproduction occurred in only one breeding pond in one of two years. That breeding occurs in human-created ponds suggests that new wetlands could be created and restored to enhance and expand existing populations. We radio-tagged 19 northern pine-snakes and tracked their movements across Ft. Bragg. Home ranges sizes were higher than any others reported for this species. Snakes were highly concentrated on the western side of the base in the preferred longleaf pine and herbaceous habitats. A defining feature of snake microhabitats was stump holes, particularly old light wood stumps that remain for decades after pine trees are harvested. At Ft. Bragg and other locations that support pine-snakes, maintenance of typical burning regimes, conservation of sandy habitats, and preservation of stump-holes would benefit existing populations. As to our other two target species, southern hognose snakes and Carolina gopher frogs occurred in such low numbers that we were unable to study them.

INVESTIGATOR Nick M. Haddad
STUDENT Will Fields, Ph.D. Candidate, Zoology
STAFF Dave Woodward, Nicole Thurgate, Noa Davidai, Megan Chesser, John McAllister, Jessica Abbott, Brian Hudgens
LOCATION Ft. Bragg, North Carolina
SPONSORS U.S. Army, XVIII Airborne Corps & Ft. Bragg
U.S. Fish and Wildlife Service

Testing model assumptions and development of a statistical framework for a regional Adaptive Management Program for migratory shorebirds

This project investigated the influence of impoundment location within a protected area and the timing of impoundment draw downs on habitat use by migrating Semipalmated Sandpipers, Calidris pusilla. We found that prey biomass was negatively correlated with movement; conversely, the amount of accessible habitat was positively correlated with movement. There was a significantly greater movement rate of birds from Fast to Slow drawdown units than from Slow to Fast units. Taken together, we found no advantage for Fast treatments. At a larger scale, birds moved to and remained in wetland clusters of higher prey density and accessible habitat. Movement rates suggested that clusters ~2.5 km apart were functionally connected; those at 4.1 km were not (ψ ≤ 0.05). We recommend slow, staggered drawdowns among functionally connected wetland units so that managers can continually provide accessible habitat while reducing energy expenditures.

INVESTIGATOR Jaime A. Collazo
STUDENT Kelsey Oberneufemann, M.S., Zoology
LOCATION Tom Yawkey Wildlife Center, South Carolina
DURATION 6/7/2004–6/30/2008
SPONSOR U.S. Geological Survey

Above: Carolina gopher frog, a federal species of concern; left: Kelsey Oberneufemann closes mist net after shorebird banding session at Tom Yawkey Wildlife Center.
The impacts of habitat fragmentation on the population genetics of a rare butterfly, *Atrytonopsis* new species 1

A potentially new species of butterfly, *Atrytonopsis* new species 1 (informally called the crystal skipper), is endemic to sand dunes along a 30-mile stretch of barrier islands in North Carolina. Urban development surrounds many butterfly populations, which could limit the movement of individuals between populations, thereby reducing the viability of the species. Our research objectives are to determine the way in which urbanization affects *Atrytonopsis* movement and to identify appropriate conservation strategies. We studied the effects of urbanization on *Atrytonopsis* using a combination of behavioral observations, mark-recapture studies, and population genetic studies. All three lines of research point to the same preliminary conclusion: natural barriers, such as ocean inlets and maritime forest, serve as barriers to *Atrytonopsis* movement, while anthropogenic barriers are relatively permeable. For example, residential developments landscaped with native vegetation provides suitable habitat and promotes butterfly movement between habitat patches. Consequently, our conservation recommendations for *Atrytonopsis* are to focus on preserving as much habitat as possible, rather than explicitly targeting habitat corridors that connect existing *Atrytonopsis* populations. Specifically, retaining small undeveloped areas, maintaining wide dune lines, and encouraging homeowners to use natural landscaping all could help promote butterfly movement.

INVESTIGATOR Nick M. Haddad
STUDENT Allison Leidner, Ph.D.
LOCATION Bogue Banks, North Carolina
DURATION 5/1/2006–12/31/2008
SPONSOR U.S. Fish and Wildlife Service

Use of molecular genetic markers to enhance restoration of an endangered species, St. Francis’ satyr butterfly

The St. Francis’ satyr butterfly, *Neonympha mitchellsii francisci*, is a federally endangered species that exists only in several colonies within and outside of artillery impact areas on Ft. Bragg in North Carolina. Restoring and managing sustainable populations of St. Francis’ satyrs will require a thorough understanding of historical and current population sizes, and influential processes such as disturbance and dispersal between populations within and outside artillery impact areas. This project’s objective is to develop and identify useful molecular genetic markers and non-lethal DNA sampling techniques to infer the extent of genetic exchange between colonies of St. Francis satyr butterflies occurring inside the restricted impact area and the more accessible colonies outside the restricted zone. These microsatellite genetic markers and innovative techniques will also expand our current understanding of demographic processes such as population bottlenecks and expansions that can influence population dynamics and patterns of genetic variation.

INVESTIGATOR Nick M. Haddad
POSTDOCTORAL RESEARCHER Laura Vogel
LOCATION Ft. Bragg, North Carolina
DURATION 9/22/2008–5/31/2010
SPONSOR U.S. Army, XVIII Airborne Corps & Ft. Bragg

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Crystal Skipper at Fort Macon.
An exploration of literature on data selection within natural resource agencies

Development and demonstration of pre- and post-prescribed fire fuel models on North Carolina coastal plain wildlife refuges and surrounding areas

Development of population and habitat objectives for FWS Trust Resources in the Roanoke-Tar-Neuse-Cape Fear Ecoregion of the South Atlantic Migratory Bird Initiative Project Area

Regionalization of Gap Analysis data within the southeastern United States

Research to advance Gap Analysis Program data and applications in the eastern United States

Validity testing and evaluation of the Gap program with targeted user groups using accepted social science research and evaluation methods

Trout lilies at Great Smoky Mountains National Park.

R. Partida
An exploration of literature on data selection within natural resource agencies

This research focused on a thorough examination of literature pertaining to factors which may influence data selection for use in the natural resource policy process. This work built on previous research, entitled Validity testing and evaluation of the Gap Analysis Program (GAP) with targeted user groups using accepted social science research methods, but sought to expand the scope of previous research to a larger audience. The literature review suggests possible organizational and environmental factors which influence data selection within a natural resource agency field office. Among potential organizational factors are age of the field office, management practices employed, and past data use experiences. Among potential environmental factors are outside data marketing efforts, public involvement in the decision-making process, and the data selection decisions of other field offices. Scholarly literature suggests that organizational factors may be examined by studying the relevance of neo-institutional theory on field office data selection, while environmental factors may be studied through the lens of diffusion theory. The findings of this research are being empirically tested in an independently funded dissertation study which is not associated with the U.S. Geological Survey.

INVESTIGATOR  Elizabethann O’Sullivan  
STUDENT  Jay Gerlach, Ph.D. Candidate, Public Administration  
LOCATION  N.C. State University  
SPONSOR  U.S. Geological Survey

Development and demonstration of pre- and post-prescribed fire fuel models on North Carolina coastal plain wildlife refuges and surrounding areas

As a result of past fire exclusion policies and practices, wildland fire fuel loading in the Coastal Plain of the southeastern United States has become a hazard to life, property, ecosystem health, and the habitat of threatened and endangered species. This fire risk is currently impacting wildlife management planning throughout the region, and specifically on the Alligator River and Pea Island National Wildlife Refuges and the Air Force Dare County Bombing Range in Dare County, North Carolina. The overall goal of this project was to enhance wildland fuel loading information and models. Work was performed in cooperation with personnel from the U.S. Fish and Wildlife Service and from Alion Science and Technology. Our primary role was to provide support for field work and development of a GIS database for use in the Joint Fire Science Project (JFSP). Among the tasks performed by a technician on site in Manteo and a graduate student at North Carolina State University were: monitoring fuel moisture for fire behavior prediction; delineating vegetation maps from aerial photography; reconciling polygon boundaries between existing and new vegetation maps; collecting, processing and analyzing field data for the JFSP; serving as crew member during research prescribed burns; and creating a website to document and display aspects of this project [http://wildlandfirescience.alionscience.com/index.html]

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SPONSOR  U.S. Fish and Wildlife Service

Development of population and habitat objectives for FWS Trust Resources in the Roanoke-Tar-Neuse-Cape Fear Ecoregion of the South Atlantic Migratory Bird Initiative Project Area

This is a three-year pilot project to step-down population and habitat objectives from national to ecoregional and refuge levels in support of Strategic Habitat Conservation. Therefore, we are developing and testing methods to enhance the predictive resolution of species distribution models. Bayesian Belief Networks are a class of models commonly employed in situations where risk-prone, value-laden decisions must be made with incomplete data and therefore are well suited to the complexities and uncertainties inherent to population and habitat management. In our models, initial beliefs constructed from literature review and expert opinion, can then be tested and updated with each season’s field data. Furthermore, the sampling design of the annual monitoring survey is developed to distinguish different sources of error (e.g., inaccurate maps, incomplete knowledge, or false expert assumptions) to help managers and researchers better allocate limited resources to gradually shift from expert-based to data-based decision support when setting population and habitat objectives.

INVESTIGATOR  Jaime A. Collazo  
POSTDOCTORAL RESEARCHER  C. Ashton Drew  
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SPONSOR  U.S. Geological Survey

Prescribed fire at Pocosin Lakes National Wildlife Refuge.
Regionalization of Gap Analysis data within the southeastern United States

The Southeast Gap Analysis Project (SEGAP; http://www.basic.ncsu.edu/segap/) was a regional effort of the U.S.G.S. National Gap Analysis Program. The goal for GAP is to provide datasets (land cover, vertebrate species models, and land stewardship) and tools for use in conservation planning. The primary objective for Southeast Gap was to create detailed land cover and animal modeling datasets that are ecologically meaningful and consistent across the region. The SEGAP study area intersects 14 states, with nine of those being completely mapped. The Southeast Gap Datasets are available for download, with the vertebrate species models available for review. Additional analyses based on these data include work by the Environmental Protection Agency's Regional Vulnerability Analysis, the state wildlife agencies' for Wildlife Action Plans, U.S. National Park Service's fire fuels models, and our own Multi-state Conservation Grant Project. To disseminate the information, the Gap Online tool (GO) was developed at the N.C. Cooperative Fish and Wildlife Research Unit. The tool is a GIS web application that provides users with a streamlined interface for accessing GAP datasets. Users of the tool do not need GIS software or expertise to develop maps and tables quantifying the conservation of biodiversity across the landscape.

INVESTIGATOR Jaime A. Collazo
POSTDOCTORAL RESEARCHER Ed Laurent
STUDENT Alexa J. McKerrow, Ph.D., Botany
STAFF Steve Williams, Todd Earnhardt, Matt Rubino, Curtis Belyea
LOCATION N.C. State University
SPONSOR U.S. Geological Survey

Research to advance Gap Analysis Program data and applications in the eastern United States

This project is addressing several research needs. These include identifying methods to standardize the mapping of vegetation across the entire Eastern U.S. in collaboration with The Nature Conservancy, improve vegetation mapping techniques and building protocols for updating and maintenance of high resolution land cover information in collaboration with the U.S. Forest Service’s LANDFIRE Project, identify effective methods to develop land cover maps in a hierarchical framework in collaboration with the Multi-Resolution Land Characteristics Consortium, and assist in the implementation of the National Vegetation Classification Standard so that ecologists across the country use a common language to describe and inventory vegetation in collaboration with the Federal Geographic Data. In addition, local research efforts include the application of Light Detection and Ranging data to characterize stand structure in Longleaf, Pinus palustris, and Pond Pine, Pinus serotina, Woodlands, and modeling species-habitat relationships with new techniques (e.g., occupancy models, MaxEntrophy) to better inform conservation planning in North Carolina and throughout the eastern United States.

INVESTIGATOR Jaime A. Collazo
STUDENT Zac Arcaro, M.S., Natural Resources
Monica Iglecia, M.S. Candidate, Biology
Lisa Paine, M.S., Candidate, Biology
STAFF Alexa McKerrow, Steve Williams, Todd Earnhardt, Matt Rubino
LOCATION N.C. State University
DURATION 9/26/2006–9/30/2011
SPONSOR U.S. Geological Survey

Validity testing and evaluation of the Gap program with targeted user groups using accepted social science research and evaluation methods

In 2004, the U.S. Geological Survey (USGS) and Gap Analysis Program (GAP) sought to assess the real life natural resource policy value of GAP within the state of North Carolina. A two-part process evaluation of NC-GAP was conducted. Part one involved a survey of potential North Carolina users of the Gap Ecosystem Data Explorer (GEDE) Tool. Survey results exposed a need to disseminate GAP data via the internet, improve GEDE resolution, and offer the Tool in an ARC 9.0 version. Part two included interviews and a focus group consisting of several biologists and managers in an attempt to assess the natural resource policy process. Results informed GAP staff that biologists serve as scientific advocates to their managers in the policy process, and there exists a marked need for easily accessible and accurate GAP data. An extension of this research was granted for the purposes of further analyzing results and laying the foundation for dissertation research pertaining to the real life applicability of GAP data and why these data are chosen for use in the natural resource policy process.

INVESTIGATOR Elizabethann O’Sullivan
STUDENT Jay Gerlach, Ph.D. Candidate, Public Administration
LOCATION N.C. State University
DURATION 7/19/2004–10/31/2006
SPONSOR U.S. Geological Survey

Land Cover

182 map units

S. Williams

Vertebrate Species Distribution

614 species

known ranges

and predicted distributions

S. Williams

Stewardship

32 agencies, 40,000 parcels

S. Williams

Southeast Gap map products.
**PUBLICATIONS AND PRESENTATIONS**

**JOURNAL ARTICLES**


Herring, G. and J.A. Collazo. Site characteristics and prey abundance at foraging sites used by Lesser Scap (Aytha affinis) wintering in Florida. Southeastern Naturalist. In Press.


TECHNICAL REPORTS


BOOKS AND BOOK CHAPTERS


THESES AND DISSERTATIONS


PRESENTATIONS AND SEMINARS


PUBLICATIONS AND PRESENTATIONS


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UNITED STATES GEOLOGICAL SURVEY
UNITED STATES FISH AND WILDLIFE SERVICE
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