

*USGS  
South Carolina  
Cooperative  
Fish and Wildlife  
Research Unit*

*Report of Activities  
November 2002 -  
November 2004*

*Cooperating Agencies*

*U.S. Geological Survey  
South Carolina Department  
of Natural Resources  
Clemson University  
Wildlife Management Institute*

*South Carolina Cooperative Fish  
& Wildlife Research Unit  
Department of Forestry &  
Natural Resources  
Clemson University  
Clemson, SC 29634  
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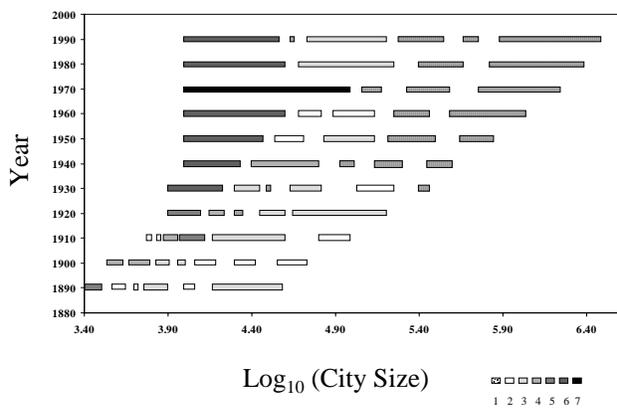




Wintering flock of American Oystercatchers at Cape Romain NWR (see P. 31).



Southeastern fox squirrel on a coastal South Carolina golf course (see P. 33).



Discontinuities in city size distributions for the southwestern U.S., 1890-1990. Shading indicates % of cities within a cluster: (1) 0-5%, (2) 5-10%, (3) 10-20%, (4) 20-40%, (5) 40-60%, (6) 60-80% and (7) 80-100% (see P. 30).



Ichthyoplankton sampling in the Savannah River (see P. 8 & 13)



Adult gopher tortoise, Camp Shelby MS (see P. 18 & 23). Robust redhorse in breeding coloration (see P. 13)



Front Cover (top to bottom): Kate Manry, Ph.D. student, surveying for Carolina bogmint in the Congaree National Park. Tim Grabowski, Ph. D. candidate, releasing a rare robust redhorse on the Savannah River. Felicia Sanders, SCDNR Biologist, treating brown pelican nests at Cape Romain NWR.

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Homer Collins, USDA-APHIS, Gulfport, Mississippi  
Catherine Greenberg, U. S. Forest Service  
Bill Hulslander, Congaree National Park  
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U.S. Fish and Wildlife Service, Migratory Bird Management Office  
U.S. Fish and Wildlife Service, Region 4, Red-cockaded Woodpecker Field Office  
U.S. Fish and Wildlife Service, Region 4, Carolina Sandhills National Wildlife Refuge  
U.S. Fish and Wildlife Service, Region 4, Santee National Wildlife Refuge  
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U.S. Fish and Wildlife Service, Warm Springs Fish Technology Center  
U.S. Fish and Wildlife Service, Bears Bluff National Fish Hatchery  
U.S. Forest Service, Southern Forest Experiment Station  
U.S. Forest Service, Kootenai National Forest  
USGS GAP Analysis Program  
USGS/BRD National Wetlands Research Center  
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National Fish and Wildlife Foundation  
Duke Power Corporation  
National Wild Turkey Federation  
South Carolina State Ports Authority  
Normandeau and Associates  
U.S. Golf Association

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Jan Sendzimir, International Institute for Applied Systems Analysis, Austria  
Craig Stow, University of South Carolina  
J. Whitfield Gibbons, Savannah River Ecology Laboratory

### **Recent Graduates:**

Jim Berdeen, Ph.D. (Otis)  
Tim Davis, Ph.D. (Allen co-advisor, advisor P. M. Horton)  
Michelle Duncan, M.S. (Isely)  
Deborah Epperson, Ph.D. (Allen)  
Samuel T. Finney, M.S. (Isely)  
Travis Hinkleman, M.S. (Allen)  
Karen Kinkead, Ph.D. (Otis)  
Jill LaBram, M.S. (Allen)  
Tiffany E. Lee, M.S. (Isely)  
Leslie Parris, M.S. (Allen)  
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Jason Slater, M.S. (Allen)  
Kristi Simpson, M.S. (Allen co-advisor, advisor A. Johnson)  
Drew G. Trested, M.S. (Isely)

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Katherine Manry, Ph.D. (Allen)  
Kristin Meehan, M.S. (Jodice)  
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### **Research Technicians, Work Study and Student Workers:**

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Heather J. Ferguson  
Caroline C. Hinkleman  
Jonas LaPointe  
Joseph Lauerman  
Quenton Lupton  
Victoria L. Restrepo  
Donnelle Schwalm  
Mark Vukovich

# Projects in Fisheries Science



Implanting a radio transmitter in a robust redhorse.

## ***Shortnose sturgeon movement and spawning in the Santee-Cooper River system***

Principal Investigators: J. Jeffery Isely, SCCFWRU  
Michelle Duncan, M.S. Candidate  
Samuel Finney, M.S. Candidate  
Douglas W. Cooke, S.C. Department of Natural Resources

Project Duration: May 1999 - December 2002

Funding: S.C. Department of Natural Resources  
Santee-Cooper Power  
Clemson University  
S.C. Cooperative Fish and Wildlife Research Unit  
U.S. Fish and Wildlife Service  
National Marine Fisheries Service

Project Location: Santee-Cooper River system, Monks Corner, SC

Status: Completed

Historically, the Santee River supported large runs of anadromous fish. The creation of the Santee-Cooper Lakes and subsequent flow alterations to the system significantly altered population characteristics and species distributions. Currently, it is believed that Pinopolis Dam on the Cooper River serves as a significant barrier to migration of anadromous shortnose sturgeon (*Acipenser brevirostrum*). Researchers have documented the failure of the navigation lock to pass sturgeon, as well as spawning activity by shortnose sturgeon in the tailrace of the dam. The objectives of this study are to further characterize spawning in relation to microhabitat and flow, and to quantify the behavior of shortnose sturgeon in the lock. Additionally, the migratory behavior of shortnose sturgeon artificially passed above the dam is being investigated. In the Spring of 2002, preliminary studies investigating spawning and migration were undertaken. A total of 50 egg collectors and 5 ichthyoplankton nets were deployed in the tailrace. Over 500 shortnose sturgeon eggs were collected in March, 2002. The effect of flow and temperature are currently being evaluated. Also, two shortnose sturgeon were surgically fitted with radio transmitters and released above the lock and dam. These fish rapidly migrated to historic spawning areas, and returned down river after water temperatures increased to levels above normal spawning preferences. Additional studies were conducted to evaluate the behavior of American shad and blueback herring in the lock during passage events using advanced sonic telemetry techniques that allow the accurate three-dimensional location of fish. Data are currently being analyzed and the study will be repeated in the spring of 2003.

## ***Movement and passage of American shad at the New Savannah Bluff Lock and Dam***

Principal Investigators: J. Jeffery Isely, SCCFWRU  
Michael M. Bailey, M.S. Candidate

Project Duration: May 1999 - December 2002

Funding: S.C. Department of Natural Resources  
U.S. Fish and Wildlife Service  
S.C. Cooperative Fish and Wildlife Research Unit

Project Location: Savannah River, Augusta, GA

Status: Completed

Dams have served as substantial obstacles to anadromous fish migrations. However, the effectiveness of locks in facilitating up-stream passage has not been fully evaluated. In 2001, we implanted 50 migrating adult American shad (*Alosa sapidissima*) with radio transmitters in the vicinity of the New Savannah Bluff Lock and Dam, a low-head regulator facility on the Savannah River, and monitored movement and passage during the period of annual upstream spawning migration. After transmitter implantation, 46 % exhibited fall back behavior but resumed upstream migrations within 21 d, 14% exhibited fall back behavior and did not later resume upstream migration, 16% exhibited fall back behavior and either died or expelled their transmitter, and 24% remained in the vicinity of dam. In order to facilitate fish passage, the lock was operated continuously for 8 hours one day per week. One lock cycle consisted of a one-half hour period of attraction flow with the lock doors open, followed by a normal lock event, followed by a one-half hour period when the upstream lock door were left open. Of those fish remaining or returning to the dam after transmitter implantation, 49% passed upstream through the lock. We conclude that an aggressive locking schedule with an attraction flow may be an effective method of facilitating upstream passage of American shad in some situations. The study was repeated in 2002 and data are currently being analyzed.

## ***Movement of contaminated fish between Savannah River Site streams and the Savannah River***

Principal Investigator: J. Jeffery Isely, SCCFWRU  
Tucker A. Jones, M.S. candidate  
Dean E. Fletcher, Savannah River Ecology Laboratory  
Mike H. Paller, Westinghouse Savannah River Technology Center  
Susan A. Dyer, U.S. Department of Energy

Duration: June 1999 - May 2003

Funding Source: Westinghouse Savannah River Corporation

Project Location: Savannah River Site, SC

Status: Completed

Fish consumption represents a potentially important biotic pathway for exposure of humans and other biota to contaminants resulting from Savannah River Site (SRS) operations and uncontrolled releases. Quantifying the risk of off-site exposure associated with fish migration requires the evaluation of fish movement from contaminated areas of the SRS to the Savannah River. The largemouth bass (*Micropterus salmoides*) a common predatory fish in SRS streams is highly sought by anglers. The species is also suspected to migrate to and from SRS streams particularly Steel Creek in association with reproduction and feeding, and changes in water level and temperature. Adult largemouth bass (n=87; 264-692 mm total length) were collected from Steel Creek, South Carolina by electrofishing between May 1999 and December 2000, and surgically implanted with individually-identifiable pulse-coded radio transmitters. Positions were determined bi-weekly for seasonal analysis by triangulation. Selected largemouth bass were located seasonally at least every two hours for a continuous 24-h period. Largemouth bass moved less between tracking periods, independent of season, in the upper narrower section of Steel Creek than in the lower broader section of Steel Creek and the Savannah River. Of the 1386 relocations of largemouth bass, 136 suggested displacement of fish from one home range to another. Individual fish established new home ranges an average of 1.7 (0 - 9) times. Over 50% of displacements occurred on 14 specific occasions during the study. When displacements were observed, largemouth bass moved to areas with more suitable habitat based on their preferred temperature ranges more often than to areas with lower or similar habitat suitability. Largemouth bass moved shorter distances on an hourly basis in the upper, narrower sections of Steel Creek than in the lower, wider sections of Steel Creek and the Savannah River. The correlation between establishing new home ranges and water temperature and level by largemouth bass in Steel Creek indicates that these environmental factors strongly affect the seasonal and diel activity of largemouth bass in this system.

## ***A behavioral comparison of wild and hatchery-reared adult shortnose sturgeon on the Savannah River***

Principal Investigators: J. Jeffery Isely, SCCFWRU  
Drew G. Trested, M.S. Candidate  
Tiffany Lee, M.S. Candidate  
Vince Mudrak, U.S. Fish and Wildlife Service

Project Duration: January 2002 - December 2003

Funding: S.C. Cooperative Fish and Wildlife Research Unit  
U.S. Fish and Wildlife Service

Project Location: Savannah River, SC and GA

Status: Completed

Researchers involved in the recovery efforts for endangered shortnose sturgeon (*Acipenser brevirostrum*) are hampered by an inability to locate sufficient numbers of individuals to identify essential fish habitat and determine population parameters within many of the river systems in the South Atlantic. The use of “sentinel fish” to identify local populations, although effective, has been limited. Although it may be possible to use hatchery-reared fish for this purpose, the potential for genetic contamination from hatchery stocks has led to the cautious use of hatchery fish in the wild. To overcome potential negative impacts of genetic contamination, the development of sterilization techniques that will allow the use of hatchery-reared fish in field, as well as validating that sterilized hatchery fish behave in a similar manner to wild fish is essential to the advancement of the recovery of shortnose sturgeon populations. In this study, we compare the migratory behavior of adult sterile and non-sterile hatchery reared shortnose sturgeon with that of wild shortnose sturgeon in the Savannah River. In the spring of 2002, we implanted 10 wild fish and up to 6 fish from each of four hatchery-reared treatments (diploid, triploid, sterilized by complete gonad removal, and sterilized by partial gonad removal and duct ligation) and released them in the Savannah River. Fish were located several times each week during the spawning migration and will be located twice monthly during the remainder of the life of the transmitters. To date, no apparent differences in river location, microhabitat selection, or movement rates have been observed between hatchery and wild fish. Additional hatchery fish will be stocked in the fall of 2002. The study will be repeated in the spring of 2003, and data collection efforts will continue through the spring of 2004.

## ***Yolk proteins and free amino acids in Acipenseriformes***

Principal Investigators: J. Jeffery Isely, SCCFWRU  
R. Nigel Finn, University of Bergen  
A. Ferrara, Nichols State University  
J. Dean, USFWS Natchitoches National Fish Hatchery  
H. J. Fyhn, University of Bergen

Project Duration: May 2001 - December 2003

Funding: S.C. Cooperative Fish and Wildlife Research Unit  
U.S. Fish and Wildlife Service  
Norwegian Fisheries Research Council

Project Location: Aquatic Animal Research Facility, Clemson University  
University of Bergen, Norway

Status: Completed

Acipenseriformes can be found throughout the northern hemisphere in both marine and freshwater environments, although almost all spawn in freshwater. Their origin dates back to the late Devonian with modern genera appearing in the Triassic – a time when teleosts first began appearing in the marine fossil record. Like many of the early evolving teleosts, certain Chondrostei undertake legendary spawning migrations back to the freshwater environment in which they originated. The adults evolved osmoregulatory adaptations that permitted their exploratory and eventual habitual excursions to the marine environment, but were bound by the osmotic requirements of their eggs to return to their native freshwater for spawning. Recent studies have shown that the pelagic eggs of marine teleosts hydrolyse high molecular weight yolk proteins (lipovitellins) to generate a large pool of free amino acids (FAA) causing oocyte hydration. We have argued that this is a key adaptation that pre-adapts the embryos for development in the hyperosmotic seawater. We have also found that freshwater salmonids degrade high molecular weight yolk proteins during the endogenous larval phase suggesting a possible heritage for the mechanism now active during the final oocyte maturation of marine teleosts with pelagic eggs. Our research focus concerns the origin of this mechanism, and we conducted this study in order to characterize the situation in representatives of the two living families of Acipenseriformes. The SDS-PAGE shows the presence of a yolk protein at ~110 kD in 3 of the 4 extant sturgeon genera (Acipenseridae: *Huso huso*, *Acipenser ruthenus*, *Scaphyrhynchus platorhynchus*) as well as in the paddlefish (Polyodontidae: *Polyodon spathula*). Cell water and FAA contents remained low, and no yolk proteolysis occurred during final oocyte maturation. During ontogenesis of the shovelnose sturgeon, however, a substantial hydration was observed particularly during post-hatch development. Although an increase in body FAA content occurred during the growth phase no yolk proteolysis was noted during early development of the shovelnose sturgeon. In conclusion, a 110 kD yolk protein, reminiscent of that in teleost yolk was found in these ancient Acipenseriformes, although no signs of the proteolytic events associated with the oocyte hydration mechanism of marine teleosts were observed.

# ***Spatial and Temporal Habitat Segregation by Spawning Fishes in the Savannah River, South Carolina and Georgia***

Principal Investigators: J. Jeffery Isely, SCCFWRU  
Tim Grabowski, Ph.D. Candidate, Dept. Biological Sciences,  
Clemson University

Project Duration: May 2002 - December 2005

Funding: S.C. Cooperative Fish and Wildlife Research Unit  
U.S. Fish and Wildlife Service  
US Army Corps of Engineers

Project Location: Savannah River, North Augusta, SC.

Status: Ongoing

Six catostomid species including the imperiled robust redhorse (*Moxostoma robustum*) inhabit the lower Savannah River. Each of these species is dependent to differing degrees upon main channel gravel bars for spawning substrate. Catostomids in the lower Savannah River have ready access to only two main channel gravel bars. Despite the importance of these features, little is known about how the different species utilize gravel bars. We used visual observation, prepositioned grid electrofishers, and drift nets to determine the degree of spatial and temporal segregation in the use of this habitat. We were able to evaluate spawning activity in three species: spotted sucker (*Minytrema melanops*), notchlip redhorse (*M. collapsum*), and robust redhorse. No temporal overlap was observed in habitat use by adult fishes. Adults of a given species were present on the bar for discrete periods of time (approx. 15-21 days) followed by a lapse of 14-20 days with no spawning individuals observed. Different species showed a high degree of spatial overlap on the gravel bar with similar requirements of substrate and flow. Our preliminary conclusion is that no interference occurs among species and other factors such as habitat availability and density dependent effects, such as egg predation and intraspecific nest superimposition, may be effecting catostomid populations.

## ***Behavior of adult striped bass in relation to hydroelectric operations***

Principal Investigators: J. Jeffery Isely, SCCFWRU  
Shawn P. Young, Ph.D. student

Project Duration: May 2002 - December 2005

Funding: S.C. Cooperative Fish and Wildlife Research Unit  
US Army Corps of Engineers

Project Location: J. Strom Thurman Reservoir, Calhoun Falls, SC.

Status: Ongoing

We conducted telemetry studies of adult striped bass (*Morone saxatilis*) during the summer of 2003 and 2004 to relate summer diel movement of adult striped bass to diel changes of water quality within the tailwater during normal power generation and during current pumped-storage operation at Richard B. Russell Dam, J. Strom Thurmond Reservoir, South Carolina-Georgia. We also monitored environmental conditions, temperature and dissolved oxygen, to evaluate the affect of current pumped storage on tailwater habitat. Preliminary results indicate no significant differences in movement or summer distribution, between the daily periods of no generation, hydro-electric generation, and pumped-storage. Overall daily activity was significantly greater during continuous 24-hr telemetry than daily activity reported for telemetry performed on a bi-monthly basis. There was no conditioned response to the daily flow-regime from hydroelectric discharge. A high proportion of striped bass utilized the tailwater as a summer seasonal refuge or made periodic excursions into the tailwater throughout the summer, showing no apparent avoidance of pumped-storage operations. The use of pumped storage raised minimum water temperatures 2-3°C in the tailwater during summer compared to previous summers with no pumped-storage. However, the temperature increase did not raise water temperatures outside the range considered optimal for striped bass habitat.

## ***Behavior of post-tournament released striped bass***

Principal Investigators: J. Jeffery Isely, SCCFWRU  
Shawn P. Young, Ph.D. student

Project Duration: May 2004 - December 2005

Funding: S.C. Cooperative Fish and Wildlife Research Unit

Project Location: J. Strom Thurman Reservoir, Calhoun Falls, SC.

Status: Ongoing

Recently, new opportunities to study post-tournament dispersal and post-tournament live-release behavior of striped bass (*Morone saxatilis*) have come about due to a shift from harvest-oriented to live-release fishing tournaments. We initiated a telemetry study in November 2004 at J. Strom Thurmond Reservoir, SC-GA, to quantify striped bass dispersal from tournament weigh-in sites; striped bass dispersal to original capture sites; and long-term post-tournament survival (> 120 d). Preliminary results indicate that 80% of live-released striped bass survive capture, transport, and transmitter implantation. Striped bass disperse from post-tournament release sites within 7d. However, none of the study fish has returned to their original capture site.

# Projects in Wildlife & Ecological Science



Brown Pelican Chick at Marsh Island, Cape Romain NWR, SC

## *Impacts of fire ants on herpetofauna populations*

Principal Investigators: E.P. Wiggers, Nemours Wildlife Foundation  
Craig R. Allen, SCCFWRU  
P. M. Horton, Director Sandhill Research & Education Center &  
Clemson Institute for Economic & Community Development  
Jason Slater, M.S. student (graduated), Department of Aquaculture,  
Fisheries and Wildlife, Clemson University

Project Duration: January 2000 – December 2002

Funding Sources: Nemours Foundation  
National Fish and Wildlife Foundation

Project Location: Southeastern South Carolina

Status: Completed

There is a growing body of information suggesting many populations of herpetofauna are in decline. Possible factors contributing to the decline include habitat loss, impacts of invasive species, disease and parasites, commercial exploitation, global climate change, and pollution. As a taxonomic group, herpetofauna have received limited research focus by biologists and consequently little empirical data exist to understand which, or if any of these, factors are contributing to their decline. The red-imported fire ant is an exotic species that has invaded herpetofauna habitats in the southern United States and studies have shown many vertebrates are directly or indirectly vulnerable to predation by this ant. We conducted a manipulative experiment whereby red-imported fire ant abundance was reduced on 5, 200-400 acre study sites and not controlled on 5 similar, paired sites. Prior to treatments neither fire ant nor reptile and amphibian abundance differed between treated and untreated areas. Treatments significantly reduced fire ant populations. Reptile and amphibian abundance was greater on treated areas following fire ant reductions ( $P = 0.02$ ) with the average number of captures per sampling period on treated sites = 201 and on untreated sites captures = 115. Capture rate for reptiles and amphibians was also higher on treated sites ( $P = 0.055$ ; average capture rate/day on treated sites = 2.02 and on untreated sites = 1.06). Species richness (the number of species) was also consistently higher on treated sites following fire ant population reductions ( $P = 0.03$ ), with an average richness/site for treated sites = 11, and on untreated sites = 7. We conclude that fire ants impact herpetofauna populations.

## ***The effect of red imported fire ants on Gopherus polyphemus at Camp Shelby, Mississippi***

Principal Investigators: Deborah Epperson, Ph.D candidate (graduated), Department of Aquaculture, Fisheries and Wildlife, Clemson University  
Craig R. Allen, SCCFWRU  
Dan Wojcik, USDA-ARS, Gainesville, Florida

Duration: May 1997 - December 2003.

Funding: Department of Defense via the Mississippi Natural Heritage Program and The Nature Conservancy.

Project Location: Camp Shelby, Mississippi

Status: Completed

The potential impacts of red imported fire ants (*Solenopsis invicta*) on gopher tortoise (*Gopherus polyphemus*) hatchling survivorship, gopher tortoise burrow commensals, and upland invertebrates were investigated at Camp Shelby Training Site in southern Mississippi. Camp Shelby Training Site is located almost entirely on the DeSoto National Forest and contains the largest metapopulation of gopher tortoises in the federally threatened portion of the range. Ten sites, 20 to 40 hectares in size, containing gopher tortoise colonies were selected and paired based on habitat similarities and tortoise densities. We used a fenoxycarb (LOGIC®) fire ant bait to reduce fire ant densities on a randomly chosen member of each pair. Prior to the initial treatment, pre-treatment (summer 1997, spring 1998) invertebrate data were collected using 0.1 ha mound counts, burrow vacuums and baits, UV light traps and 200-meter transects. Fire ant baits were applied in the spring of 1998, spring and fall of 1999, and in the spring of 2000. Data were collected twice annually (spring and fall) in 1998, 1999, and 2000. Based on mound count and transect data, there were no significant differences in *S. invicta* densities between sites prior to treatments. Significant differences were observed in fire ant densities after treatment. Species richness of burrow commensals was higher in treated areas ( $P = 0.0015$ ). Gopher tortoise hatchlings ( $N = 48$ ) were fitted with radio transmitters after emergence from the nest and radio-located daily until no longer alive. Hatchling survivorship was greater at treated sites.

## ***Landscape predictors of fire ant occurrence and spatial risk assessment of endangered species from fire ants***

Principal Investigators: C. R. Allen, SCCFWRU  
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Development  
J. McCreadie, Department of Entomology, Clemson University  
Dan Wojcik, USDA-ARS, Gainesville, Florida  
Dave Otis, SCCFWRU  
Elise Schmidt, SC Department of Natural Resources  
Leslie Parris, M.S. student (graduated), Department of  
Aquaculture, Fisheries and Wildlife, Clemson University

Duration: July 1998 - May 2003

Funding Source: Enhancement of Research and Extension Programs in  
Imported Fire Ant Biology  
USGS National Gap Analysis Program

Project Location: Statewide, South Carolina

Status: Completed

Fire ants negatively impact a number of endangered vertebrate and invertebrate species. Assessment of impacts on individual species would be time consuming and costly. This project conducts a state-wide risk assessment of threatened and endangered species to fire ant impacts by investigating the spatial co-occurrence of fire ants and endangered species. This project also investigates landscape level predictors of fire ant distribution at the state level. Our objectives are to: 1) Develop a risk assessment model that predicts threatened and endangered species most at risk to fire ant impacts because of co-occurrence at the landscape scale, 2) Develop a model that predicts fire ant distribution at the landscape scale, and 3) Provide data to the South Carolina Gap Analysis Program for the first statewide GIS coverage of ant diversity.

Fire ants (and other ants) have been sampled throughout the state of South Carolina. Sampling was stratified by ecoregion (sandhills, coastal plain, piedmont, mountains) and by SC Gap Analysis landcover. Each habitat patch was sampled by establishing a linear transect consisting of multiple sample points which consisted of bait samples and pitfall traps. The results of bait sampling was used to accomplish objectives one and two (fire ant risk assessment and landscape predictors) while bait and pitfall samples will be used to accomplish goal three. Data from bait samples has been used in conjunction with landscape elements to construct a logistic regression model that identifies significant landscape element predictors of fire ant patch occupancy and which creates a predictive model applicable across the state. Risk assessment was accomplished by overlaying the results of the predictive model of fire ant distribution with the models of rare and endangered vertebrates and invertebrates developed by the South Carolina Gap program.

## ***Improving vertebrate modeling in Gap Analyses: incorporating minimum viable populations and metapopulations in patchy environments***

Principal Investigators: C. R. Allen, SCCFWRU  
Elise Schmidt, Ft. Lauderdale Research and Education Center  
Alan Johnson, Forestry & Natural Resources, Clemson University  
Kristi Simpson, M.S. student (graduated), Department of  
Aquaculture, Fisheries and Wildlife, Clemson University

Duration: August 2001 – May 2004

Funding Source: USGS-Biological Resources Division

Project Location: Statewide, South Carolina

Status: Completed

High resolution maps of broad extent, such as those generated for Gap Analyses, create new problems in species mapping, especially by potentially inflating errors of commission. Commission errors are likely to be high when creating species models based simply on species-habitat associations. A habitat patch as small as 30 m may be identified as a discrete unit. However, a discrete 30-m patch (or one much larger) in isolation will likely not support individuals of a species, and considerably larger patches will not support viable populations of many vertebrates.

Protecting biodiversity requires sustaining populations of species into the foreseeable future. Protecting species requires sufficient habitat to support a minimum viable population over time. Incorporating home range and dispersal distances should increase the accuracy of species models by reducing the commission error rates. We incorporated information on the home range and dispersal distances of mammals to estimate minimum critical areas (MCA) to support minimum viable populations (MVP) for each mammal species in the state of Florida. However, while we believe those models were an improvement, they were extremely crude and better models are attainable. Patches of suitable habitat too small to support a MVP may still be occupied if multiple patches form a network that in aggregate is large enough to support a viable population. This project will refine Gap vertebrate models by incorporating MCA methods across multiple patches, other simple metapopulation modeling, and functional connectivity.

The methods we developed demonstrate the usefulness of approaches that incorporate the consideration of minimum areas for viable populations, and critical patches of habitat. Our methodology accounts for viable populations based on minimum critical areas and is improved to include areas in networks of patches that can be incorporated quite simply in all Gap Analyses. Determination of functional connectivity and the identification of patches critical for maintaining functional connectivity will have more specific application in guiding and weighing land-use and conservation decisions applied to particular patches.

## ***Long-term monitoring of small mammals and herpetofauna at the Savannah River Site: development of sampling protocols and assessment of predictive models***

Principal Investigators: Craig R. Allen, SCCFWRU  
Dave Otis, SCCFWRU  
Jodi Bock, Jill LaBram, and Amanda Peck, M.S. Students (all graduated), Department of Aquaculture, Fisheries and Wildlife, Clemson University

Project Duration: August 1998 - August 2004.

Funding Source: U.S.D.A. Forest Service – Savannah River

Project Location: Savannah River Site, South Carolina

Status: Completed

Understanding the effects of landscape change on animal populations requires knowledge of the change in populations over time and the variation in population estimates across space. This requires; (1) long-term monitoring of populations at a level sufficient to detect change when it occurs, and (2) knowledge of landscape change so that changes in habitats and landscapes can be separated from other external or internal drivers of change in animal abundance.

The Savannah River Site (SRS) has developed matrices of mammals x habitat and herpetofauna x habitat that allow for the prediction of animal occurrence across the entire site. To be most useful, predictions from such a matrix must be tested to verify their accuracy. Accuracy assessment of spatial models must account for commission and omission errors, the spatial nature of the models, and the temporal nature of habitat use by sampling through time.

We sampled small and medium-sized mammals at the SRS for 5 years, assessed the predictability of the existing spatial models (the mammal matrix), and tested that model against two others. In order to accomplish these goals we investigated the spatial and temporal variability in mammal populations across the SRS. To do so, we established a preliminary protocol of sampling, collected up to five years of sampling data, and analyzed that data to determine the spatial and temporal variability therein. Understanding population variability across space will allow us to conduct analyses of the necessary sample size required to detect changes over time. However, the detection and separation of temporal variability from directional change in population levels can be accomplished only with long-term monitoring. Concomitant collection of landcover/habitat data along with animal community data may allow for the determination of the causes of change, which may be due to either changes in habitat quality or changes in animal community structure.

## ***Effects of hydrology restoration and landscape pattern on amphibians in Carolina bays on the Savannah River Site***

Principal Investigators: David Otis, SCCFWRU  
Karen Kinkead, Ph.D. candidate (graduated), Department of  
Biological Sciences, Clemson University

Duration: July 1999 - December 2003

Funding Sources: U.S. Forest Service, Savannah River Site

Project Location: Savannah River Site, Aiken County, SC

Status: Completed

This project studied the effects of wetland restoration on amphibian populations. These wetlands were Carolina bays located on the Savannah River Site, located near Aiken, S.C. The Savannah River Site is a National Environmental Research Park owned and operated by the U.S. Department of Energy. The study sites included three reference bays (functionally intact), three control bays (with active drainage ditches), six treatment bays (restored during 2001), and four bays near two of the treatment bays (in effect creating two metapopulations).

Amphibians at each bay were captured, marked, and released between January and July, 2000-2003. Pre-restoration occurred during 2000. The bays were restored prior to the trapping season in 2001, and 2002 and 2003 being post-restoration years. Each bay was partially encircled with drift fences and pitfall traps. Amphibians were given batch marks that designated the year and bay of capture.

A total of 43,432 amphibians of 24 species were captured during the study. While I documented a decrease in salamander populations during this study, the restoration appears to have provided additional breeding habitat for several anuran species. In addition, I presented survival estimates for 2 salamander species, *Ambystoma maculatum*, and *A. talpoideum*. These estimates were lower than previously reported for these species, however two years of this study were conducted during drought conditions which may have impacted these results. In addition, we presented information on environmental variables and responses of *A. opacum*, and *A. talpoideum*, as well as 2 species of anurans, *Bufo terrestris*, and *Scaphiopus holbrooki*.

*Ambystoma* species are believed to be highly philopatric, returning to the natal pond to breed. I examined the genetic structure of two species, *A. talpoideum* (mole salamanders) and *A. opacum* (marbled salamanders) in 16 Carolina bays. Amplified fragment length polymorphisms (AFLP) were used to determine genetic variation within and among populations of salamanders separated by distances of 150 m to 25 km. Although this technique was capable of verifying variation between the species, we were unable to document genetic structure at the population level for either of these species.

## ***Metabolic rates of free-ranging gopher tortoises: a pilot study***

Principle Investigators: Patrick Jodice, SCCFWRU  
Deb Epperson, The Nature Conservancy  
G. H. Visser, Centre for Isotope Research, University of  
Groningen, The Netherlands

Duration: June 2003 to December 2004

Funding Sources: Department of Defense  
Mississippi Natural Heritage Program

Project Location: Camp Shelby, MS

Status: Completed

Gopher tortoises (*Gopherus polyphemus*) have been the focus of considerable research efforts during the past decade and a great deal has been learned regarding their ecology and management. Traditionally, research on species in decline such as gopher tortoises has focused on ecological questions that examine population trends, habitat use, foraging ecology, and human impact. One area of research that is often overlooked, however, is reproductive energetics. We conducted a pilot study of gopher tortoise energetics at Camp Shelby, MS. A successful pilot project would allow us to develop a more directed and efficient research program and would provide us with additional insights by which to assess the health of populations. Pursuit of a pilot study prior to a more complete research effort is necessary because field studies of energetics have yet to be conducted on gopher tortoises.

We report the first measurements of field metabolic rates (FMRs) and water influx rates (WIRs) in free-ranging adult Gopher Tortoises (*Gopherus polyphemus*). We used the doubly labeled water (DLW) method to measure FMR in six adult tortoises during the nonbreeding season in south-central Mississippi, USA. Mass-specific FMR ranged from 30.1 - 54.3 kJ kg<sup>-1</sup> day<sup>-1</sup> while mass-specific WIR ranged from 9.8 - 26.6 ml H<sub>2</sub>O kg<sup>-1</sup> day<sup>-1</sup>. Neither rate differed between the sexes during our sampling period. These rates appear to be higher than those measured in Desert Tortoises (*Gopherus agassizii*) in the southwestern USA but within the range of those measured in Box Turtles (*Terrapene carolina*) from the southeastern USA, the only other chelonians for which FMR and WIR have been measured in free-ranging individuals. We used retrospective power analyses and data from the DLW isotope analyses to develop guidelines for sample sizes and duration of measurement intervals, respectively, for larger-scale energetic studies in this species.

## ***Rare species survey for the Chattahoochee River National Scenic Waterway acquisitions***

Principal Investigators: Craig R. Allen, SCCFWRU  
Kate Manry, Ph.D. Student, Department of Biological Sciences,  
Clemson University

Duration: January 2003 - December 2004

Funding Source: United States Fish and Wildlife Service

Project Location: Chattahoochee River National Scenic Waterway

Status: Completed

We conducted rare plant surveys in the newly acquired land of the Chattahoochee River National Recreation area to document the presence or absence of Federal and State protected plant species including: *Amphianthus pusillus* (Federal threatened), *Aster georgianus* (Federal candidate), *Cypripedium acaule* (State unusual), *Cypripedium parviflorum var. pubescens* (State unusual), *Hexastylis shuttleworthii var. harperi* (State unusual), *Hydrastis canadensis* (State threatened), *Isoetes melanospora* (Federal endangered), *Melanthium woodii* (State rare), *Rhus michauxii* (Federal endangered), *Schisandra glabra* (State threatened), *Sedum pusillum* (State threatened), *Waldsteinia lobata* (State threatened). A rare species survey will assist the Fish and Wildlife Service and the National Park Service in developing land management plans to ensure rare plant conservation. If rare plants are identified near National Park Service boundaries, land acquisition could be altered to include protection for those populations.

We visited eight study sites covering ca. 81 ha to ascertain the community types that were present in the area. Several visits were made during 2004. Any rare plant occurrences were noted and locations recorded on a GPS unit. We systematically searched all suitable habitats within the area of interest on foot during appropriate blooming periods (about 4 times/year). For each population or site that was found, the following information was recorded: the number of plants, the size or other measure of plant vigor, reproductive status, co-occurring species, unique habitat characteristics, and habitat condition (evidence of past or ongoing disturbance, or of perceived threats to the habitat). Within four of the newly acquired areas, we found a total of four rare species on the list including: *Cypripedium acaule* (Pink ladyslipper), *Melanthium woodii* (Woods bunchflower), *Schisandra glabra* (Baystar vine), and *Hydrastis canadensis* (Goldenseal). We also found many occurrences of Ginseng (*Panax quinquefolium*) at one of the sites. A report is being prepared for the Chattahoochee River National Recreation Area.

## *Analysis of Northwestern Montana Old Growth Data*

Principle Investigators: Patrick Jodice, SCCFWRU  
Jim Berdeen, SCCFWRU, Ph.D. Candidate (graduated), Dept. of  
Aquaculture, Fisheries & Wildlife, Clemson University

Duration: August 2003 to March 2005

Project Location: SCCFWRU

Status: Ongoing

We are conducting exploratory data analysis on forest stand composition in the Kootenai National Forest to provide guidelines for assigning designated old growth status. Statistical patterns of vegetation variables are being used to develop guidelines that can be used to assign stands a classification of 'Old growth', 'Replacement Old Growth', or 'Not Old Growth'. Vegetation characteristics being examined include % decadence, # snags/ha in various DBH classes, # live trees/ha in various DBH classes, % canopy closure, and biomass of down woody debris/ha. Preliminary analyses indicate highly variable results in some cases, often because of limited sample sizes. Some regional habitat groups had few stands surveyed while others had many stands surveyed. We are also conducting a power analysis to estimate the number of stands/regional habitat group that should be surveyed to obtain reliable results.

## ***Energy density and proximate composition of selected prey of wintering American Oystercatchers***

Principle Investigators: Patrick Jodice, SCCFWRU  
Felicia Sanders, SCDNR

Duration: October 2003 to June 2005

Project Location: Cape Romain NWR

Status: Ongoing

Cape Romain NWR supports one of the largest concentrations of wintering American Oystercatchers on the east coast of North America. Previous and ongoing research, conducted by the SCDNR and the SCCFWRU, has demonstrated the importance of Cape Romain NWR to wintering oystercatchers and has identified important roosting and foraging habitats within the Refuge. Although primary prey during winter months are readily identifiable, little is known about the quality of those prey items. In many species, diet quality can play an important role in determining the health and survival of individuals and hence can affect population dynamics. We collected samples of primary prey items from various locations within the Refuge throughout the nonbreeding season. These samples are being analyzed in the laboratory at Clemson University. We are measuring energy density, water content, and lipid content and will compare these among prey species and within prey species among locations and dates. These data will provide insights into the possible role that diet may play in the ecology of wintering oystercatchers.

## ***Optimizing field management for the wintering grassland bird community in the coastal plain of South Carolina***

Principal Investigators: Ryan Noel, USFWS  
James B. Berdeen, Ph.D. Candidate (graduated), Department of  
Aquaculture, Fisheries and Wildlife, Clemson University  
Patrick Jodice, SCCFWRU

Project Duration: September 2002 - December 2005

Funding: U. S. Fish and Wildlife Service

Project Location: Santee National Wildlife Refuge, SC

Status: Ongoing

Santee NWR was established for the management of wintering waterfowl, and has used the farming of row crops (predominantly corn) and winter flooding of fields as the primary means of attracting waterfowl. Recently, it has become increasingly difficult to use this management practice at Santee NWR because (A) low crop prices have made it difficult to retain a contract farmer, and (B) a shortage of available refuge staff has resulted in many fields remaining fallow. Thus, this Refuge will focus farming efforts predominantly on fields that can be flooded to attract waterfowl, and will manage the remaining upland field sites for grassland birds and American woodcock (*Scolopax minor*). Management will be targeted toward grassland birds and woodcock because of long-term population declines, which in some cases are thought to have been influenced by the declines in habitat quality of wintering areas. However, there is a need to critically assess the influence of various treatments on vegetation structure and the value of treated fields to different avian species, especially those of high conservation concern.

Santee NWR applied 3 treatments (winter mow, winter burn, control) to 24 fields between January and March 2002. We will conduct a mark-recapture study in these fields between December 2002 and February 2003 to estimate the abundance, site fidelity, recapture rates, and winter survival rates of grassland birds. We will use empirical data to develop models of habitat relationships and population parameters associated with each treatment type. We will use this empirical data to develop a model of the optimal habitat management strategy for grassland birds and woodcock, with those species assigned high Partners-in-Flight (PIF) assessment scores given more weight in the model. Our project will address the following research questions: 1) Does treatment type and dominant soil type influence vegetation characteristics, 2) Are species richness and species-specific patterns of abundance, site fidelity, and winter survival influenced by treatment type, vegetation characteristics, patch size, dominant soil type, and distance to the nearest wetlands, 3) What is the detectability of American woodcock during crepuscular flight surveys, and 4) What is the optimal field management scheme to benefit grassland birds wintering at Santee NWR? This project continues with data collection in the winter of 2004/2005.

## ***A review of the nutritional stress hypothesis in marine birds***

Principle Investigators: Patrick Jodice, SCCFWRU  
Daniel D. Roby, Oregon Coop. Fish & Wildlife Research Unit

Duration: November 2002 to June 2005

Funding Sources: North Pacific Marine Mammal Research Consortium

Project Location: Clemson University

Status: Ongoing

Nutritional stress is defined as a negative physiological and/or behavioral state resulting from suboptimal quantity or quality of food available to an animal. It has been hypothesized that nutritional stress may be responsible, in whole or in part, for the decline of Steller sea lions (*Eumetopias jubatus*) during the past three decades in western Alaska. Our goal was to assess the potential impact of nutritional stress on marine bird populations within the range of the Steller sea lion in Alaska. We reviewed published literature as well as agency reports and examined spatial and temporal trends in measures of reproductive effort, reproductive success, and population trends of seabirds in relation to ocean conditions, forage fish availability, and diet quality. The data we have examined indicate that in the northern Gulf of Alaska and Southeastern Bering Sea, some seabird populations have experienced fluctuations in prey resources that have contributed to nutritional stress in the majority of its members. Preliminary results indicate that nutritional stress was manifested in several Alaska seabird taxa through declines in foraging behavior, physiological condition, productivity, and population trends. These results are also supported by a review of laboratory studies and controlled field experiments that demonstrate the negative impacts of nutritional stress on nestling growth rates, nestling and adult body condition, and reproductive performance.

## ***Feral hog management plan development, impact monitoring, and initial management implementation for Congaree National Park, South Carolina***

Principal Investigators: Craig R. Allen, SCCFWRU  
William Conner, Dept. Forestry & Natural Resources  
Scott Zengel, Ph.D. candidate, Department of Forestry and  
Natural Resources, Clemson University

Duration: June 2000 - December 2005

Funding Source: National Park Service

Project Location: Congaree National Park, South Carolina

Status: Ongoing

Congaree National Park contains the largest and most significant remaining tracts of virgin and old-growth bottomland hardwood wetlands in the United States, and has been recognized as a "Wetland of International Importance" by the Ramsar Convention and as an "International Biosphere Reserve" by UNESCO. The park was established primarily for the protection and preservation of the unique and pristine old-growth bottomland hardwood ecosystem it contains. The park also contains rare plant communities, unique cultural resources, designated wilderness, and recreational resources. Non-native feral hogs (*Sus Scrofa*) are placing unique natural, cultural, and recreational resources of Congaree National Park at risk: wetland communities, native vegetation, streams and aquatic habitats, rare and endangered species, historic earthen-work structures, and hiking trails are subject to severe damage from extensive hog rooting and other destructive behaviors.

This project will provide recommendations and alternatives for the management of hogs and hog impacts at the park. The specific objectives of this project are to: (1) develop a management plan and Environmental Assessment of hog management options for Congaree NP; (2) establish a monitoring program to quantify current hog impacts and provide comparisons once management efforts are underway; and (3) implement the first two years of hog management effort.

## ***Cross-scale structure and scale breaks in complex systems***

Principal Investigators:	Craig R. Allen, SCCFWRU Ahjond Garmestani, Ph.D. Student, Policy Studies Program, Clemson University
Duration:	January 1999 –December 2005
Funding Source:	James S. McDonnell Foundation – 21 <sup>st</sup> Research Award, Studying Complex Systems The Resilience Alliance
Project Location:	Clemson University
Status:	Ongoing

The representation of complex systems has focused upon their hierarchical organization and the scaling of physical, biological, ecological and social phenomena. Much attention has focused on discovering universal laws, which have provided powerful heuristics and the formalization of scaling laws. Our research has been motivated by the discovery of regular patterns of deviation from scaling laws and the continuous distributions of attributes of complex systems. These suggest that systems organize over discrete ranges of scale, and that organization abruptly shifts with changes in scale. If this is so, scaling laws serve only as the baseline from which to measure those departures, and those departures indicate 'scale breaks' (transitions) between scales of structure in complex systems. Patterns of scale breaks from a scaling law baseline may provide clues of the processes that lead to the emergence of the scaling relationships themselves.

Complex systems, such as ecosystems, urban systems, and regional economic systems, emerge unpredictably without the influence of central control but as a result of adaptive behavior by their component, interacting agents. Urban systems exhibit spatial patchiness in their social and economic infrastructure. Thus, urban systems, much like ecosystems, are subject to a hierarchy of structure and processes that govern the function and growth of cities at a variety of scales. Urban size distributions have been described by Zipf's law or the rank-size rule, which imply invariant growth processes across scales. Zipf's law predicts that city-size distributions will have a continuous distribution, and conform to the restraints of a power law. The desire to fit data to linear models obscures deviations from the broad strokes of power laws. Departures from linear relationships are indicative of important pattern that may reveal information about the organization and resilience of complex systems.

# ***Impact of human disturbance on foraging ecology of shorebirds and wading birds in Cape Romain National Wildlife Refuge***

Principal Investigators: David L. Otis, SCCFWRU  
Peter Paton, University of Rhode Island  
Kim Peters, Ph.D. candidate, Dept. Biol. Sci., Clemson University

Duration: July 1998 - December 2005

Funding Sources: U.S. Fish and Wildlife Service

Project Location: Cape Romain National Wildlife Refuge, SC

Status: Ongoing

Cape Romain National Wildlife Refuge (CRNWR) is considered one of the most important sites on the U.S. east coast for non-breeding shorebirds and wading birds. A dramatic increase in boating activity on the refuge over the last decade, associated with an increase in recreational shrimp baiting, has precipitated concerns about disturbance to migrating and wintering birds. We are examining the effects of recreational boat traffic on: 1) behavior and habitat use of wading birds in tidal creeks, 2) habitat use of roosting shorebirds, and 3) habitat use, movement, and behavior of American oystercatchers (*Haematopus palliatus*).

We sampled wading bird distributions in 12 creeks, yielding a total of 177 samples (1999-2000). We also conducted general sampling at 42 roost sites, yielding a total of 857 samples (1999-2002). A draft report depicting avian distributions and temporal abundance patterns across the refuge was delivered to the refuge in October 2004. We also examined the association between flushing and local habitat use among 6 wading bird species in tidal creeks on the Refuge. Experimental cumulative boat intrusion caused approximately 50% of individuals to abandon a tidal creek with the exception of snowy egrets, which tended to increase in number during disturbance events. Snowy egret flushing response was significantly lower than the response exhibited by yellow-crowned night heron and tri-colored heron. Patterns of flushing response appear to vary among species with no clear relationship between flushing and habitat use.

We observed Oystercatcher vigilance behavior from September-December 2002 on the Refuge. Oystercatchers increased vigilance in response to aerial predators and exhibited highest vigilance rates during simultaneous peaks in boating disturbance and Osprey (*Pandion haliaetus*) activity. Due to this temporal overlap of stimuli, it is difficult to interpret what may have been driving the increased vigilance observed. Forage rates appeared to be primarily driven by habitat and tidal stage, indicating that time lost to vigilance did not effectively reduce intake.

We outfitted 77 oystercatchers with transmitters in 2002. We are currently in the process of examining roost, foraging site, and flock fidelity, and relating habitat use to general patterns of disturbance on the refuge.

## ***Reproductive ecology of brown pelicans in South Carolina***

Principle Investigators: Patrick Jodice, SCCFWRU  
Felicia Sanders, SCDNR  
Lisa Ferguson, M.S. student, Department of Forestry and Natural Resources, Clemson University

Duration: January 2004 to December 2005

Funding Sources: Start-up Funds, State Base Funds

Project Location: Cape Romain National Wildlife Refuge, SC  
Crab Bank, Charleston Harbor, SC

Status: Ongoing

Several islands off the coast of South Carolina have historically served as important breeding locations for many species of seabirds, including royal terns (*Sterna maxima*) and brown pelicans (*Pelecanus occidentalis carolinensis*). Since the late 1960s, the South Carolina Department of Natural Resources (SCDNR) has conducted annual nest counts of seabird breeding colonies. The census data indicates a steady drop in the number of royal terns and brown pelican nests at colonies within the state over the past fifteen seasons. It is unclear whether there has been a true drop in the reproductive population of brown pelicans, a shift to breeding locations outside the state, or a change in breeding phenology. Factors within SC breeding locations that may be contributing to these possible population events are poorly understood. In an effort to elucidate the apparent decline, this research project was initiated to explore factors previously demonstrated to impair reproductive success within seabird colonies.

The objectives of this project are to investigate the role of ectoparasites (i.e. ticks) on growth rates and survival of pelican chicks, to assess pelican diet quality (i.e. energy density and lipid content of common prey items). Marsh Island (Bulls Bay, Cape Romain National Wildlife Refuge) and Crab Bank (Charleston Harbor) were selected as study sites. During the 2004 field season, approximately 48 pelican nests were monitored within each colony. A control group of approximately 24 pelican nests received one treatment of the insecticide Rabon, as per SCDNR protocol. The remaining study nests were not treated with insecticide, and thus acted as a means for examining the effects of this tick control protocol. Growth measurements and degree of tick infestation were recorded for each chick within all monitored nests. We also measured baseline plasma corticosterone levels (which tend to be positively related to physiological stress) of nest-bound chicks on Marsh Island in Bull's Bay, South Carolina. Additionally, diet items were collected from nest bowls, regurgitations, and foraging areas for diet quality analysis. Results from the 2004 season are currently being analyzed. Similar protocols will be implemented for the 2005 field season. We also monitored royal tern nesting and collected royal tern diet samples.

## ***Assessing the conservation value of golf courses for fox squirrels in coastal South Carolina***

Principle Investigators: Patrick Jodice, SCCFWRU  
Kristin Meehan, M.S. student, Department of Forestry and Natural Resources, Clemson University

Duration: June 2004 to August 2006

Funding Sources: US Golf Association

Project Location: Coastal South Carolina

Status: Ongoing

The fox squirrel (*Sciurus niger*) is a charismatic species that appears to be declining in numbers and is experiencing loss of native habitat throughout the southeastern US. Fox squirrels are known to inhabit golf courses throughout the southeastern US and in some situations attain very high population densities. This research investigates the relationships between the abundance of fox squirrels on golf courses in coastal South Carolina and various landscape and habitat variables. The research will occur along the South Carolina coast because the rapid pace of landscape change there is frequently associated with golf course developments; as such the presence of fox squirrels provides a unique opportunity to define golf course management and development plans that offer high conservation value as well as an opportunity to create a flagship conservation program for golf courses. This region is the fastest growing area of the state, has a national reputation as a golf destination, and, given the number of courses in this region, has the potential to serve as a model for maintaining adequate habitat for a highly visible species that may benefit from urban habitats if they are properly managed. The specific objectives are to: (1) survey a representative sample of golf courses from the South Carolina coast for fox squirrel presence and abundance; (2) collect data on landscape metrics and habitat features from these same courses; (3) develop statistical models that relate fox squirrel abundance to landscape and habitat variables, and (4) develop management recommendations for fox squirrel habitat on existing and developing courses.

The project was initiated in mid-June 2004. During summer and fall 2004 we collected various spatial data layers that will be used for the landscape analysis. We are currently developing the mail-survey for golf course superintendents. This survey inquires about the willingness of courses to participate in the research and also will collect basic information regarding course layout and squirrel presence. Once these surveys are returned course selection will occur. Our next objective is to begin developing the survey methodology for fox squirrels. This will be initiated in late October 2004. Data collection (i.e., surveys of squirrels on golf courses) will begin in earnest in spring 2005 and will also occur in fall 2005.

## ***Carolina bogmint at Congaree National Park: distribution mapping and population status assessment***

Principal Investigators: Craig R. Allen, SCCFWRU  
Joan Walker, USFS  
Kate Manry, Ph.D. Student, Department of Biological Sciences,  
Clemson University

Duration: January 2004 - December 2007

Funding Source: National Park Service

Project Location: Congaree National Park

Status: Ongoing

Carolina bogmint (*Macbridea caroliniana*) is a globally imperiled plant species and federal species of concern found in the seepage forest wetland community at Congaree National Park. Carolina bogmint is also the most globally imperiled species occurring within the Park. There are only about 30 extant occurrences of Carolina bogmint documented world-wide. Three of these occurrences are reported for the Congaree National Park. The Congaree bogmint population is also likely the largest in existence. Congaree Swamp seepage forest also represents what is probably the best example of natural habitat conditions for this species. The seepage forest is considered a globally imperiled ecological community type, and is the most imperiled wetland community type occurring at the Park. Potential threats to the bogmint population at Congaree include disturbance by wild hogs and invasion of non-native plant species. In addition, it is possible that some management activities at the park, such as boardwalk construction or maintenance, recreational use, and research activities could locally impact bogmint occurrences. Considering the importance of the Congaree Swamp bogmint population to the long-term conservation of the species, and the potential threats identified, basic information concerning the distribution, status and condition of this species within the park is greatly needed, as is a better understanding of potential threats. The geographic distribution of bogmint within the Swamp is not currently known as has never been mapped, and the population size and reproductive biology of this rare species have never been investigated. Furthermore, detailed examination of natural habitat conditions and native and non-native plant species occurring with bogmint have not been conducted.

Project goals are to: 1) Develop a distribution map of Carolina bogmint for Congaree National Park, 2) Estimate the size of the bogmint population at the park, 3) Determine the reproductive status of the population, 4) Document specific habitat conditions in areas that contain bogmint, 5) Identify the native and non-native plants most frequently co-occurring with bogmint, 6) Examine the frequency, abundance, and severity of hog disturbance in bogmint areas and the effects of hog activity on bogmint populations, and 7) Monitor the above parameters over a three-year period. We are currently in the second year of collecting data in the field.

## **Peer Reviewed Publications:**

- Allen, C. R. Predictors of introduction success in the South Florida avifauna. 2004. *Biological Invasions: in press.*
- Allen, C. R., D. Epperson and A. Garmestani. 2004. The impacts of fire ants on wildlife: a decade of research. *American Midland Naturalist* 152:88-103.
- Allen, C. R., Garmestani, A., LaBram, J., Peck, A., and L. Provost. 2004. When landscaping goes bad: the incipient invasion of *Mahonia bealei* in the Southeastern United States. *Biological Invasions: in press.*
- Allen, C. R., L. Gunderson, and A. R. Johnson. 2004. The use of discontinuities and functional groups to assess relative resilience in complex systems. *Ecosystems: in press.*
- Allen, C. R., and C. S. Holling. 2002. Cross-scale structure and scale breaks in ecosystems and other complex systems. *Ecosystems* 5:315-318.
- Allen, C. R., and D. A. Saunders. 2002. Variability between scales: predictors of nomadism in birds of an Australian Mediterranean-climate ecosystem. *Ecosystems* 5:348-359.
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- Duncan, M. M., J. J. Isely, and D. W. Cooke. 2004. Evaluation of Shortnose Sturgeon Spawning in the Pinopolis Dam Tailrace, South Carolina. *North American Journal of Fisheries Management* 24:932-938.

- Forys, E. A., and C. R. Allen. 2002. Functional group change within and across scales following invasions and extinctions in the Everglades ecosystem. *Ecosystems* 5:339-347.
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- Garmestani, A. S., C. R. Allen, J. A. Labram, and A. E. Peck. 2004. Laboratory observations of red imported fire ant (Hymenoptera: Formicidae) predation upon eastern tent caterpillars (Lepidoptera: Lasiocampidae). *Journal of Entomological Science* 39: 472-473.
- Grabowski, T. B., J. J. Isely, and R. Weller. 2004. Age and growth of flathead catfish in the Altamaha River, Georgia. *Journal of Freshwater Ecology* 19:411-417.
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- Isely, J. J., and T. B. Grabowski. 2004. Occurrence, size, and tag retention of sneaker male hatchery rainbow trout. *North American Journal of Aquaculture* 66:234-236.
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- Johnson, A. R., C. R. Allen, and K. A. N. Simpson. 2004. Estimating functional connectivity of wildlife habitat and its relevance to ecological risk assessment. Pages XX-XX *in* Kapustka, L. A., H. Gilbraith, M. Luxon, and G. R. Biddinger, eds. *Landscape ecology and wildlife habitat evaluation: critical information for ecological risk assessment, land-use management*

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Sendzimir, J., C. R. Allen, L. Gunderson and C. Stow. 2003. Implications of body mass patterns: linking ecological structure and process to wildlife conservation and management. Pages 125 - 152 *in*, Bissonette, J. and I. Storch, eds. *Landscape ecology and resource management: linking theory with practice*. Island Press, Washington, DC.

Schaffler, J. J., J. J. Isely, and W. E. Hayes. 2002. Habitat Use by Striped Bass in Relation to Seasonal Changes in Water Quality in a Southern Reservoir. *Transactions of the American Fisheries Society* 131:817-827.

Sciera, K. L., J. J. Isely, J. R. Tomasso, and S. J. Klaine. 2004. Influence of multiple water-quality characteristics on copper toxicity to fathead minnows (*Pimephales promelas*). *Environmental Toxicology and Chemistry* 23:xx-xx.

Suryan, R.M., D.B. Irons, M. Kaufman, P.G.R. Jodice, D.D. Roby, J. Benson, E.D. Brown. 2002. Short-term fluctuations in forage fish availability and the effect on prey selection and brood-rearing in the black-legged kittiwake. *Marine Ecology Progress Series* 236:273-287.

Young, S. P., and J. J. Isely. 2002. Striped Bass Annual Site Fidelity and Habitat Utilization in J. Strom Thurmond Reservoir, South Carolina-Georgia. *Transactions of the American Fisheries Society* 131:828-837.

Young, S. P., and J. J. Isely. 2004. Temporal and Spatial Estimates of Adult Striped Bass Mortality from Telemetry and Transmitter Return Data. *North American Journal of Fisheries Management* 24:1112-1119.

Zettler, J. A., T. M. Mcinnis, jr., C. R. Allen, and T. P. Spira. 2002. The biodiversity of fungi in red imported fire ant (Hymenoptera: Formicidae) mounds. *Annals of the Entomological Society of America* 95:487-491.

Zettler, J. A., M. D. Taylor, C. R. Allen, and T. P. Spira. 2004. Consequences of forest clear cuts for native and non-indigenous ants. *Annals of the Entomological Society of America* 97:513-518.

### **Presentations at Scientific Meetings:**

Allen, C. R. 2002. Cross-scale structure and scale breaks in ecosystems and other complex systems. Clemson University Zoology Seminar Series, Clemson, SC. Invited.

- Allen, C. R. 2003. Predicting the vulnerability of endangered species at the scale of landscapes: relating ecological processes of community organization to statistical patterns of body mass size in terrestrial animal species assemblages. International Institute for Applied Systems Analysis, Vienna, Austria. Invited.
- Allen, C. R. 2003. Proactive management: dodging remedial actions with predictive research. 7th International Conference on the Ecology and Management of Alien Plant Invasions, Ft. Lauderdale, FL. Invited presentation and panel member, management and research interface.
- Allen, C. R. 2003. A snake in the garden: the ecological effects of biological invasions. Wofford University Seminar Series, Spartanburg, SC. Invited.
- Allen, C. R. 2004. Remote sensing techniques for fire ants in the USA. International Fire Ant Management Workshop, Brisbane, Australia. Invited.
- Allen, C. R. 2004. International Congress of Entomology. Invited Co-chair and presenter, Invasions by social insects symposium, World Congress of Entomology, Brisbane, Australia.
- Allen, C. R. 2004. Discontinuities and innovation in complex systems. Third Annual CSIRO Complex Systems Science Workshop, Coff's Harbour, Australia. Invited keynote presentation.
- Allen, C. R., W. Conner and S. Zengel. 2004. Wild pig habitat use and disturbance in floodplain wetlands and adjacent uplands at Congaree National Park, South Carolina. Biology, Management and Control of Wild Pigs Symposium, Augusta, Georgia. Invited.
- Allen, C. R., A. S. Garmestani, J. Labram, A. E. Peck, and L. Prevost. 2003. When landscaping goes bad: the incipient invasion of *Mahonia bealei* in the Southeastern United States. 7th International Conference on the Ecology and Management of Alien Plant Invasions, Ft. Lauderdale, FL.
- Allen, C. R., and L. B. Parris. 2002. A spatial risk assessment for endangered species from fire ant impacts. Annual Meeting of the Australian Ecological Society, Cairns, Australia. Invited.
- Allen, C. R., J. Sendzimir, and G. D. Peterson. 2003. Cross-scale structure and resilience in animal communities. Annual Meeting of the Ecological Society of America, Savanna, Georgia.
- Aranguren, A, D. E. Brune, T. E. Schwedler, J. J. Isely, and A. G. Eversole. 2004. A model of channel catfish growth in the partitioned aquaculture system. Annual Meeting of the World Aquaculture Society, Honolulu, HI.
- Bielmyer, G. K., J. R. Tomasso, R. Arnold, J. J. Isely, and S. J. Klanie. 2003. A model system for studying the effects of roof and rainwater characteristics on copper concentrations. Annual Conference of the Society for Environmental Toxicology and Chemistry, Austin, TX.

- Davis, T. S., C. R. Allen, P. M. Horton, and L. B. Parris. 2004. Modeling distributions and richness of ant species in South Carolina, USA. World Congress of Entomology, Brisbane, Australia.
- Duncan, M., J. J. Isely, and D. C. Cooke. 2003. Spawning activity of migrating adult shortnose sturgeon in the Pinopolis Lock and Dam tailrace: preliminary results. Georgia Chapter of the American Fisheries Society annual Meeting. Rome, GA.
- Duncan, M., J. J. Isely, and D. C. Cooke. 2003. Spawning activity of migrating adult shortnose sturgeon in the Pinopolis Lock and Dam tailrace: preliminary results. South Carolina Chapter of the American Fisheries Society annual Meeting. McCormick, SC.
- Epperson, D. M., and C. R. Allen. 2003. Impacts of red imported fire ants on gopher tortoises and their associated burrow commensal fauna. Annual Meeting of the Ecological Society of America, Savanna, Georgia.
- Garmestani, A., C. R. Allen, and K. M. Bessey. 2003. Discontinuities in urban systems over time. Annual Meeting of the Ecological Society of America, Savanna, Georgia.
- Grabowski, T. B., and J. J. Isely. 2003. Movement of robust redhorse in the Savannah River. South Carolina Chapter of the American Fisheries Society annual Meeting. McCormick, SC.
- Grabowski, T. B., and J. J. Isely. 2004. Movement of robust redhorse in the Savannah River. South Carolina Chapter of the American Fisheries Society annual Meeting. Georgetown, SC.
- Grabowski, T. B., and J. J. Isely. 2004. Movement of robust redhorse in the Savannah River. Georgia Chapter of the American Fisheries Society annual Meeting. Athens, GA.
- Grabowski, T. B., and J. J. Isely. 2004. Movement of robust redhorse in the Savannah River. South Carolina Chapter of the American Fisheries Society annual Meeting. Georgetown, SC.
- Grabowski, T. B., and J. J. Isely. 2004. Spatial and temporal habitat segregation by spawning fishes in the Savannah River. Invited speaker. Nicholls State University, Thibodaux, LA.
- Grabowski, T. B., and J. J. Isely. 2004. Spatial and temporal habitat segregation by spawning fishes in the Savannah River. Department of Biological Sciences Seminar Series. Clemson, SC.
- Grabowski, T. B., and J. J. Isely. 2004. Spatial and temporal habitat segregation by spawning fishes in the Savannah River. Southern Division 4th Annual Fisheries Student Colloquium. St. Augustine, FL
- Grabowski, T. B., and J. J. Isely. 2004. Spatial and temporal habitat segregation by spawning fishes in the Savannah River. Invited speaker. 58<sup>th</sup> Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. Hilton Head, SC. 2004

- Grabowski, T. B., and J. J. Isely. 2004. Savannah River robust redhorse research update. 10<sup>th</sup> Annual Meeting of the Robust Redhorse Conservation Committee. McCormick, SC.
- Grabowski, T. B., and J. J. Isely. 2004. Spatial and temporal habitat segregation by spawning fishes in the Savannah River. Southeast Ecology, Evolution, and Population Genetics. Swannanoa, NC.
- Grabowski, T. B., and J. J. Isely. 2004. Spatial and temporal habitat segregation by spawning fishes in the Savannah River. Invited speaker. 2004 North American Native Fishes Association National Convention. Columbia, SC.
- Grabowski, T. B., and J. J. Isely. 2004. Spatial and temporal habitat segregation by spawning fishes in the Savannah River. 28<sup>th</sup> Annual Larval Fish Conference. Clemson, SC.
- Grabowski, T. B., and J. J. Isely. 2004. Seasonal and diel movements and habitat use of robust redhorse in the Savannah River, South Carolina-Georgia. Natural Resources Research Symposium. Clemson University, Clemson, SC 2004.
- Grabowski, T. B., and J. J. Isely. 2004. Seasonal and diel movements and habitat use of robust redhorse in the Savannah River, South Carolina-Georgia. 2004 Southeastern Ecology and Evolution Conference. Atlanta, GA.
- Grabowski, T. B., and J. J. Isely. 2004. Seasonal and diel movements and habitat use of robust redhorse in the Savannah River, South Carolina-Georgia. Joint Meeting of the American Fisheries Society, South Carolina Chapter and South Carolina Fishery Workers Association. Georgetown, SC. 2004.
- Hinkelman, T. M., S. C. Loeb, and C. R. Allen. 2003. Tent or bunker: woody debris facilitates lability in refuge selection behavior by cotton mice. Annual Meeting of the Ecological Society of America, Savanna, Georgia.
- Isely, J. J. 2003. Season movement of striped bass in relation to temperature and oxygen. Western Washington University. Bellingham, WA. (Invited presentation).
- Isely, J. J., D. G. Trested, K. Ware, and R. Bakal. 2003. Movement of hatchery-reared shortnose sturgeon in the Savannah River. Shortnose Sturgeon Recovery Conference, Savannah, GA. (Invited presentation).
- Isely, J. J., D. G. Trested, K. Ware, and R. Bakal. 2004. Movement of hatchery-reared shortnose sturgeon in the Savannah River. Gulf Sturgeon Recovery Conference, New Orleans, LA. (Invited presentation).
- Isely, J.J. 2004. Surgical implantation of telemetry devices. Shortnose Sturgeon Recovery Conference, Savannah, GA. (Invited presentation).
- Isely, J.J. 2004. Surgical implantation of telemetry devices. Gulf Sturgeon Recovery Conference, New Orleans, LA. (Invited presentation).

- Jodice, P.G.R. 2003. Reproductive energetics of marine birds in the northern Gulf of Alaska: examining factors constraining recovery from the Exxon Valdez oil spill. Environmental Toxicology Seminar Series, Clemson University, Clemson, SC. Invited.
- Jodice, P.G.R. 2004. Nutritional Ecology and Reproductive Energetics of Piscivorous Seabirds: Lipids, Junk-food, and Nutritional Stress. Fort Johnson Marine Science Center Seminar Series, Charleston, SC. Invited.
- Jodice, P.G.R. 2004. Assessing the conservation value of golf courses for fox squirrels along the South Carolina coast. U.S. Golf Association Annual Research Meeting, Atlanta, GA.
- Jodice, P.G.R., and D.D. Roby. 2004. Nutritional stress in Alaskan seabirds: A review of the evidence. Pacific Seabird Group Annual Meeting, La Paz, Baja California Sur.
- Jodice, P.G.R., D.D. Roby, R. Suryan, D.B. Irons, G. H. Visser, M. Kaufmann, and K. R. Turco. 2002. Effects of foraging behavior and time-activity budgets on field metabolic rates of black-legged kittiwakes. Pacific Seabird Group Annual Meeting, Santa Barbara, CA.
- Johnson, A. R., and C. R. Allen. 2003. Estimating functional connectivity of wildlife habitat and its relevance to ecological risk assessment. American Society of Testing and Materials Annual Meeting, Kansas City, MO.
- LaBram, J., A. Peck, and C. R. Allen. 2003. Application of an accuracy assessment method for Gap Analysis models. Annual Meeting of the Society of Conservation Biology, Duluth, MN.
- Lenhardt, M., P Cakic, J. Kolarevich, and J. Isely. 2003. Impact of Iron Gates I and II construction on Acipenseridae populations in the Danube River. Ecohydrology and Physical Fish Habitat Modification Symposium. Mondsee, Austria.
- Peck, A., J. LaBram and C. Allen. 2003. Description of an accuracy assessment method for Gap Analyses models. Annual Meeting of the Society of Conservation Biology, Duluth, MN.
- Roby, DD, D.E. Lyons, R.M. Suryan, P.G.R. Jodice, and K. Collis. 2004. Junk food, regime shifts, and nesting failures: sorting out what matters in seabird-forage fish dynamics. Northwest Section of The Wildlife Society, Girdwood, Alaska. Invited.
- Sciera, K. L., J. J. Isely, J. R. Tomasso, and S. J. Klaine. 2003. Influence of Water Quality Characteristics on Copper Toxicity to Larval Fathead Minnows (*Pimephales promelas*). Annual Conference of the Society for Environmental Toxicology and Chemistry, Austin, TX.
- Simpson, K. A. N, A. R. Johnson and C. R. Allen. 2003. A presumptive risk assessment: exposure of mammals to agricultural pesticides in South Carolina, USA. Society of Environmental Toxicology and Chemistry 24<sup>th</sup> Annual Meeting, Austin, TX.
- Simpson, K., A. R. Johnson and C. R. Allen. 2003. Estimating functional connectivity for terrestrial mammals in fragmented habitats: a GIS-based approach. The 18th Annual

Symposium U.S. Chapter of the International Association for Landscape Ecology, Banff, Canada.

Suryan, R.M., D.B. Irons, E.D. Brown, P.G.R. Jodice, and D.D. Roby. 2003. Site-specific factors affecting productivity of an upper trophic level marine predator: bottom-up, top-down, and mismatch effects on reproduction in a colonial seabird. North Pacific Marine Science Organization, Honolulu, HI.

Taylor, M., J. Zettler, and C. R. Allen. 2003. Experimental introductions of fire ants change native ant populations. Annual Meeting of the Ecological Society of America, Savanna, Georgia.

Trested, D. G., J. J. Isely, and R. S. Bakal. 2003. A behavioral comparison of wild and hatchery-reared adult shortnose sturgeon on the Savannah River: preliminary results. Georgia Chapter of the American Fisheries Society annual Meeting. Rome, GA.

Vanderwoude, C., and C. R. Allen. 2002. Ecological effects of *Solenopsis invicta* in USA and Australia. Annual Meeting of the Australian Ecological Society, Cairns, Australia. Invited.

Weeks, B. and C. R. Allen. 2004. Wild pig food habits. Biology, Management and Control of Wild Pigs Symposium, Augusta, Georgia. Invited.

Zettler, J., and C. R. Allen. 2003. Ants reduce oviposition success of gulf fritillaries on *Passiflora incarnata*. Annual Meeting of the Ecological Society of America, Savanna, Georgia.

### **Graduate Theses and Dissertations:**

Berdeen, J. B. 2004. Harvest dynamics of mourning doves in the Coastal Plain of South Carolina. Ph.D., Clemson University Department of Aquaculture, Fisheries and Wildlife.

Duncan, M. 2003. Spawning activity of migrating adult shortnose sturgeon in the Pinopolis Lock and Dam tailrace. M.S., Clemson University Department of Aquaculture, Fisheries and Wildlife.

Epperson, D. M. 2003. Impact on the non-native *Solenopsis invicta* on *Gopherus polyphemus* and its burrow commensals. Ph.D., Clemson University Department of Aquaculture, Fisheries and Wildlife.

Finney, S. 2003. Movement of artificially passed shortnose sturgeon through a southeastern reservoir. M.S., Clemson University Department of Aquaculture, Fisheries and Wildlife.

Hinkelman, T. 2004. Behavioral responses of cotton mice to large amounts of coarse woody debris. M.S., Clemson University Department of Forestry and Natural Resources.

- Kinkaid, K.E. 2004. Demographic Responses of Amphibians to Wetland Restoration in Carolina Bays on the Savannah River Site. Ph.D., Clemson University Department of Biological Sciences.
- LaBram, J. 2004. Long-term monitoring of reptiles and amphibians at the Savannah River Site: development of sampling protocols and assessment of predictive models. M.S., Clemson University Department of Aquaculture, Fisheries and Wildlife.
- Lee, T. 2003. Movement of juvenile and adult robust redhorse in the Savannah River. M. S. Aquaculture, Fisheries and Wildlife Sciences.
- Myers, E. 2002. Impact of red imported fire ants (*Solenopsis invicta*) on northern bobwhite (*Colinus virginianus*) populations and insect abundance. M.S., Clemson University Department of Aquaculture, Fisheries and Wildlife.
- Parris, L. 2002. Spatial risk assessment of threatened and endangered species to red imported fire ant impacts in South Carolina. M.S., Clemson University Department of Aquaculture, Fisheries and Wildlife.
- Peck, A. 2004. Long-term monitoring of small mammals at the Savannah River Site: development of sampling protocols and assessment of predictive models. M.S., Clemson University Department of Aquaculture, Fisheries and Wildlife.
- Simpson, K. 2004. Functional connectivity in Gap mammal models, and application to risk assessment. M.S., Clemson University Department of Environmental Toxicology.
- Slater, J. 2002. Impacts of the red imported fire ant (*Solenopsis invicta*) on herpetofauna populations. M.S., Clemson University Department of Aquaculture, Fisheries and Wildlife.
- Trested, D. G. 2003. A behavioral comparison of wild and hatchery-reared adult shortnose sturgeon on the Savannah River. M.S., Clemson University Department of Aquaculture, Fisheries and Wildlife.

## **Teaching:**

### Isely

WFB840 Fish Management, Fall 2003, 3 credits

### Jodice

WFB 861/BIOSC 871. Ecological Energetics, Fall 2003, 3 credits

WFB 861, Foundations of Ecology, Fall 2004, 3 credits

### Allen

WFB 861/BIOSC 871 Ecology of Biological Invasions, Spring 2003, 3 credits

WFB 861/ENTOX 863 Landscape Ecology, Spring 2004, 3 credits

## **Graduate Committee Service:**

### Isely

Antonio Aranguren, Ph.D., Aquaculture, Fisheries and Wildlife Biology

### Jodice

Ah Jond Garmestani, Ph. D., Policy Studies

John Livingston, M.S., Biological Sciences

David Zabriskie, M.S., Forestry and Natural Resources

### Allen

Shane Mathews, M.S., Aquaculture Fisheries and Wildlife

Josh Bast, M.S., Entomology

Jim Berdeen, Ph.D, Aquaculture Fisheries and Wildlife

Kelly Gunnell, Ph.D., Biological Sciences

Shala Hankison, Ph.D., Biological Sciences

## **Professional and Faculty Service:**

### Isely

President, Early Life History Section, American Fisheries Society.

Member, Governing Board, American Fisheries Society.

Member, Management Committee, American Fisheries Society.

Member, Santee River and Coastal Drainage Liaison Committee. National Water Quality Assurance Board. 1994 - present.

Host, 28<sup>th</sup> Annual Larval Fish Conference

Member, Steering Committee, 27<sup>th</sup> Annual Larval Fish Conference.

Member, Robust Redhorse Conservation Committee.

Member, SACS Assessment Committee for the Ph.D. Degree Program in AFW.

Faculty Advisor, Clemson Student Subunit of the American Fisheries Society.

Faculty Advisor and Coach, Clemson Offshore Fishing Team.

### Jodice

Chair, Publications Committee, Pacific Seabird Group. 2002-2004.

Member, Naming and Vision Committee, Forestry and Natural Resources, 2003.

Member, Peer Review Panel, Delaware Bay shorebird/horseshoe crab assessment report, USFWS & Atlantic States Marine Fisheries Commission, 2003.

Board Member, The Access Fund, Boulder CO, 2002-2004.

### Allen

Associate Editor (Macro and Landscape Ecology), Conservation Ecology.

Board of Directors, The Resilience Alliance.

Member, Geographic Information Committee, Clemson University

Member, Conservation Science Review Panel, Sustainable Ecosystems Institute

Executive Committee (ex-officio member), Program for Policy Studies, Clemson University.

## **Professional Awards:**

Jeff Isely, Graduate Student Government Award for Excellence in Graduate Teaching.

Deb Epperson, MacDonald Fellowship recipient.

Tim Grabowski, Sally Richardson Best Student Paper Award recipient, 28<sup>th</sup> Annual Larval Fish Conference

Travis Hinkleman, Sigma Xi grant recipient.

Leslie Parris - Biodiversity Grant recipient. NASA-MSU Professional Enhancement Award recipient. Best Student Poster Award recipient, American Society for Photogrammetry and Remote Sensing, mid-south region technical meeting.

Kristi Simpson, NASA-MSU Professional Enhancement Award recipient.