Florida Cooperative Fish and Wildlife Research Unit

Annual Report
January – December 2013

2013 Annual Report Dedicated to

Bill Pine

Bill Pine grew up in Huntsville, Alabama, and from an early age showed a curiosity about aquatic systems that remains with him today. As a young man he wrote a letter to E.O. Wilson and received a warm response from this world-renowned ecologist. It must have made a strong impression on the young lad, because as an adult, Bill has built a vibrant research program investigating diverse attributes of river and estuarine systems spanning from North Carolina to the Grand Canyon. Here in Florida, Bill has been a staunch advocate for science-based management of natural resources, and he has made amazing progress. His work has had strong implications for management of freshwater flows in our rivers for both fish and shellfish populations. Bill has been willing to tackle the big issues facing our state, such as the recent problems with oyster populations in Apalachicola Bay, as well as a range of environmental issues facing anadromous fishes on both the east and west coasts (e.g., Gulf sturgeon, American shad). Perhaps Bill's strongest asset is his ability to work with people from varied backgrounds. He has integrated research among the Florida Cooperative Fish and Wildlife Research Unit, the Department of Wildlife Ecology and Conservation, and the Fisheries and Aquatic Sciences program. Bill has been a valued collaborator to the FWC, USGS, and the USFWS. He works hard to network diverse stakeholders to find innovative solutions to natural resource problems. As a valued friend, we in the Florida Coop Unit honor Bill for his collaboration, his enthusiasm, and his love for working with all of us. We look forward to many more years of collaboration!

Bill Pine out-fishes his N.C. State Mentor, Rich Noble.
Photo Credit: Mike Allen

COOPERATING AGENCIES:

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

UNIVERSITY OF FLORIDA

U.S. FISH & WILDLIFE SERVICE

U.S. GEOLOGICAL SURVEY

WILDLIFE MANAGEMENT INSTITUTE

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2013 PROJECT DESCRIPTION

Frontispiece by WEC Master's student, Rebecca C. Wilcox

FLORIDA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT INTRODUCTION

The Florida Cooperative Fish and Wildlife Research Unit was established in 1979 as one of the first combined units. The purpose of the Florida Unit is to provide for active cooperation in the advancement, organization, and conduct of scholarly research and training in the field of fish and wildlife sciences, principally through graduate education and research at the University of Florida. The Florida Unit has the mission to study wetland ecosystems within the state. Florida is a low relief, sub-tropical peninsula that is ecologically fragile. Though abundant, Florida's water resources are under increasing pressure from a burgeoning human population. Domestic, recreational, and development needs threaten Florida's water / wetland resources. In following its program directive, the Florida Unit has developed a research program that addresses management issues with approaches spanning species to ecosystem perspectives. Specifically, this Unit conducts detailed investigations of aquatic-terrestrial ecosystem interfaces and their component fish and wildlife resources.

Between 1979 and 2012, over 300 projects totaling more than $50 million were funded through the Unit. These projects covered a wide variety of fish, wildlife, and ecosystem subjects and have involved over 50 line, affiliate, and adjunct faculty members as principal and co-principal investigators. Unit staff have their own research projects which accounted for about 1/3 of the total effort. Projects associated with the Unit have resulted in over 400 publications, 125 technical reports, 100 theses and dissertations, and 175 presentations. Cooperation has been the Florida Unit's strength. As a Cooperative Research Unit of the U.S. Geological Survey, serves as a bridge among the principal cooperators, such as the University of Florida, the Florida Fish and Wildlife Conservation Commission (FFWCC), the U.S. Geological Survey (USGS), the U.S. Fish and Wildlife Service (FWS) and the community of state and federal conservation agencies and non-governmental organizations. Evidence of this role is the Unit's funding which has included contributions from FFWCC, 12 BRD research labs and centers, 12 offices within the USFWS Southeast Region, the University of Florida, U.S. Army Corps of Engineers, U.S. Navy, U.S. Department of Agriculture, U.S. Air Force, U.S. National Park Service, Environmental Protection Agency, St. Johns River Water Management District, South Florida Water Management District, U.S. AID, World Wildlife Fund, The Nature Conservancy, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, BRD, Florida Wildlife Federation, National Audubon Society, Florida Alligator Farmers' Association, American Alligator Farmers' Association, Florida Fur Trappers' Association, and other private contributions. Many Unit projects involve multiple investigators from several agencies. This cooperative interaction stimulates continuing involvement of funding sources, provides for student contacts with potential employers and agency perspectives, and directs transfer and application of research results.

RESEARCH MISSION STATEMENT

2013 Photo Contest Winner, Jean Olbert, FL CRU – "Good Morning Hydrilla"

"The mission of the Florida Cooperative Fish and Wildlife Research Unit is to conduct detailed investigations of wetlands and their component fish and wildlife resources, emphasizing the linkages with both aquatic and terrestrial ecosystems. This charge will include research at a range of levels including populations, community, and ecosystems, and will emphasize the interaction of biological populations with features of their habitat, both natural and those impacted by human activities."

UNIT COORDINATING COMMITTEE

Jack Payne- Vice President for Agriculture and Natural Resources, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.

Nick Wiley- Executive Director, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Kevin Whalen- Supervisor, Cooperative Research Units, U.S. Geological Survey, Roundhill, Virginia.

Cynthia Dohner- Regional Director, U.S. Fish and Wildlife Service Southeast Region, Atlanta, Georgia.

Steven Williams- President, Wildlife Management Institute, Gardners, Pennsylvania.

BIOGRAPHICAL PROFILES OF UNIT SCIENTISTS

H. Franklin Percival – Unit Leader, Courtesy Associate Professor, Department of Wildlife Ecology and Conservation and College of Natural Resources and the Environment at the University of Florida. His research interests lie in wetland wildlife, and he has conducted long term collaborative projects on various aspects of alligator and migratory bird biology. He has teamed with geomaticists and aeronautical engineers to develop an unmanned aerial vehicle for assessment of wildlife populations and habitats. He has a special interest in natural resources administration, especially multidisciplinary, collaborative, and interagency research programs.

Raymond R. Carthy – Assistant Unit Leader, Courtesy Assistant Professor, Department of Wildlife Ecology and Conservation and College of Natural Resources and the Environment at the University of Florida. His research centers on ecology of endangered species. His research interests involve reproductive ecology and physiology of coastal and wetland herpetofauna, with current focus on marine and freshwater turtles. He is also involved in research on threatened upland species and in conservation management oriented studies.

Wiley M. Kitchens – Associate Unit Leader, Ecologist, Courtesy Professor, Department of Wildlife Ecology and Conservation and College of Natural Resources and the Environment at the University of Florida, retired at the end of 2013. Dr. Kitchens' expertise was wetlands ecology with an emphasis on conservation and restoration of wetlands ecosystems. His research had focused on the endangered snail kite, a wetland dependent species endemic to the Everglades and lacustrine wetlands of Central and South Florida. Given its endangered status and the generally perturbed state of these wetlands the approach has been to document population trends, demography, and movement patterns of the kites in response to habitat structure and quality in these wetlands. The overall goal is provide restoration managers information pertinent to the restoration of these systems.

COOPERATIVE UNIT PERSONNEL

M. Gay Hale, BA – Administrative Assistant, Florida Cooperative Fish and Wildlife Research Unit, Department of Wildlife Ecology and Conservation, University of Florida. Responsible for administrative details of $3.75M annual research program as well as supervision of staff; student activities, personnel, budgets, research work orders, contracts and grants within University, fiscal reports, travel, purchasing, payables, vehicles (State/Federal), website, and other related functions.

Hannah Taylor- Office Assistant, Florida Cooperative Fish and Wildlife Research Unit. She is primarily responsible for purchasing card processes, property management, and federal vehicle reporting. She also oversees safety training records and manages the Unit website through the Digital Measures system in addition to occasional field technician duties.

Janet Fay– Student Assistant, Florida Cooperative Fish and Wildlife Research Unit. She is primarily responsible for purchasing card processes within the University financial system, and the tracking and recording of spent funds on all grants and state funds. She also maintains the database and helps with general office procedures.

COOPERATORS

University of Florida

Amr Abh-Elraham, Robert Ahrens, Michael S. Allen, Karen A. Bjorndal, Alan B. Bolten, Lyn Branch, Matthew J. Cohen, Robert M. Cubert, Nancy Denslow, Bon A. Dewitt, Robert Fletcher, Peter. C. Frederick, Bill Guiliano, John Hayes, Eric Hellgren, Aaron Higer, Mark Hostetler, Peter G. Ifju, Elliot R. Jacobson, Susan Jacobson, Steven Johnson, Michael Kane, Paul A. Klein, Leda Kobziar, Martha Monroe, Frank Mazzotti, Robert McCleery, Debbie Miller, Madan Oli, Todd Osborne, Elizabeth Pienar, William (Bill) Pine, Carrie Reinhart-Adams, Christina Romagosa, Carlos H. Romero, J. Perran Ross, Scott E. Smith, Marilyn G. Spalding, Benjamin WIlkinson

Florida Fish and Wildlife Conservation Commission

Joe Benedict, Joan Berish, Arnold Brunell, Janell Brush, Larry Campbell, Cameron Carter, Patrick Delaney, Terry Doonan, Harry J. Dutton, Jim Estes, Rebecca Hayman, Lindsay Hord, Richard Kiltie, Julien Martin, Henry Norris, Tim O'Meara, Stephen W. Rockwood, Scott Sanders, Lawson Snyder, Rio Throm, Zach Welch, Nick Wiley, Blair Witherington, Allan R. Woodward

U.S. Geological Survey

Beverly Arnold, G. Ronnie Best, Jaime A. Collazo, Paul Conrads, Michael Conroy, Donald L. DeAngelis, Robert M. Dorazio, Susan Finger, Kristen Hart, Tara Y. Henrichon, James Hines, Fred Johnson, William L. Kendall, Meg Lamont, Catherine Langtimm, Lynn W. Lefebvre, Cynthia S. Loftin, Elizabeth Martin, Kelly McDonald, Clinton Moore, James D. Nichols, Kenneth G. Rice, Michael Runge, John Sauer, J. Michael Scott, Daniel Slone, Pamela Telis, Kenneth WIliams

U.S. Fish and Wildlife Service

Daniel Barrand, Laura Brandt, Billy Brooks, Pam Darty, Andrew Gude, Stan Howarter, Chuck Hunter, Michael Jennings, John Kasbohm, Mike Legare, Shannon Ludwig, Fred Martin, Lorna Patrick, John Robinetter, Heath Rauschenberger, Sandra Sneckenberger, Paul Souza, Heather Tipton, Paul Tritaik, Russell Webb, Kathy Whaley, Larry Woodward

U.S. Army Corps of Engineers

Kristin A. Farmer, Michael T. Hensch, John K. Kilpatrick, Jon S. Lane, Jon M. Morton, Gina Ralph, Glenn G. Rhett, David J. Robar, Adam N. Tarplee, Damon A. Wolfe, Victor L. Wilhelm

St. Johns Water Management District

Roxanne Conrow, Mike Coveney, Steven Miller, James Peterson

U.S. Air Force

Bruce Hagedorn

U.S. Parks Service

Bob Miller

University of Central Florida

Dean Bagley, Llewellyn M. Erhart, Ross Hinkle, Marshall Tappen, Betsy von Holle, John Weishampel

University of Idaho

Janet Rachlow

Idaho Fish and Game

Pete Zagar

Boise State University

Jennifer Foorbey

Washington State University

Lisa Shipley

University of West Florida

Phillip C. Darby

National Park Service

Leonard Pearlstine

South Florida Water Management District

Christa Zweig

Innovative Health Applications LLC

Eric D. Stolen, David Breininger

Environmental Project

Ritchie Moretti, Sue A. Shaf

Others

Russell Hall, Tommy C. Hines, Lovett E. WIlliams

Research Personnel 2013
(Names in red are supervised by Percival, Kitchens, and/or Carthy)

Post-Doctoral Associates:

Dan Gwinn, PhD
Supervisor: Mike Allen
Research: Climate change impacts on Florida freshwater fisheries

Margaret Lamont, PhD
Supervisor: Ray Carthy
Research: Examining how coastal species, such as sea turtles and shorebirds, are affected by natural and anthropogenic dynamics of barrier island systems and oil spill effects on sea turtles.

Jennifer Seavey, PhD
Supervisor: Robert Fletcher and Bill Pine
Research: Climate change, sea-level rise, and biodiversity

Ross Tsai, PhD
Supervisor: Peter Frederick
Research: Wading Bird Colony Location, Size, Timing and Wood Stork and Roseate Spoonbill Nesting Success

Christa Zweig, PhD
Supervisor: Wiley Kitchens and Franklin Percival
Research: Climate change research in coastal wetlands in the Big Bend area of Florida and snail kite habitat changes and how they affect population.

Research Associates:

Mike Cherkiss, MS
Position: Wildlife Biologist/ Crocodile and Python Project Manager
Research: American alligator and crocodile monitoring and assessment program, (MAP). IFAS, Fort Lauderdale Research and Education Center

Melissa Ann DeSa, MS
Position: Project Coordinator
Research: Climate change in the northern Gulf of Mexico: impacts on coastal plant and small mammal communities

Brian Jeffrey, MS
Position: Wildlife Biologist/Alligator Project Manager
Research: American alligator and crocodile monitoring and assessment program, (MAP). IFAS, Fort Lauderdale Research and Education Center

Kyle Pias, MS
Position: Wildlife Biologist
Research: Nesting Habitat & Nest Failures of Everglade Snail Kite on Kissimmee Lakes

Brail Stephens, MS
Position: Wildlife Biologist/Supervisor
Research: Sea Turtle & Escarpment Monitoring, Loggerhead Nest Content Collection, Marine Debris

Graduate Students:

Abraham Balmori
Degree: MS, Mechanical and Aerospace Engineering
Graduation Date: August 2014
Research: Airframe development and improvement
Advisor: Peter Ifju

Matthew Burgess
Degree: PhD, Wildlife Ecology and Conservation
Graduation Date: August 2014
Research: Collection of Digital Serial Imagery in Support of Aquatic Invasive Species Program and CERP
Advisor: H. Franklin Percival

Chris E. Cattau
Degree: PhD, Wildlife Ecology and Conservation
Graduation Date: May 2014
Research: Foraging ecology and energetics of snail kites
Advisor: Wiley Kitchens

Mike Dodrill
Degree: M.Sc., Aquatic Sciences
Graduation Date: August 2013
Research: Assessing natal sources of juvenile native fish in Grand Canyon
Advisor: Bill Pine

Colton Finch
Degree: M.Sc., Aquatic Sciences
Graduation Date: August 2013
Research: Assessing natal sources of juvenile native fish in Grand Canyon
Advisor: Bill Pine

Nia Haynes
Degree: PhD, Wildlife Ecology and Conservation
Graduation Date: August 2016
Research: Effects of Coastal Dynamics and Climate on Loggerhead Turtle Nest Success and Management
Advisor: Susan Jacobson

Jame McCray
Degree: PhD, Wildlife Ecology and Conservation
Graduation Date: August 2014
Research: Wildlife legislation and management in Florida: Sea turtles, a test case for creating effective policy
Advisor: Madan Oli and Ray Carthy

Jessica McKenzie
Degree: M.S., Wildlife Ecology and Conservation
Graduation Date: December 2015
Research: Human Dimensions of Sea Turtle Conservation
Advisor: Ray Carthy

Jean M. Olbert
Degree: M.S., Wildlife Ecology and Conservation
Graduation Date: May 2013
Research: Nest predation analysis of snail kites.
Advisor: Wiley Kitchens

Brian E. Reichert
Degree: PhD, Wildlife Ecology and Conservation
Graduation Date: May 2014
Research: Snail kite monitoring of population demographics; exploring senescence and other aspects of survival.
Advisor: Wiley Kitchens

Ellen Robertson
Degree: PhD, Wildlife Ecology and Conservation
Graduation Date: December 2016
Research: Endangered snail kites and interactions with apple snail prey species.
Advisor: Robert Fletcher

Merrill Rudd
Degree: M.Sc., Fisheries and Aquatic Sciences
Graduation Date: August 2013
Research: Resolving Uncertainty in Natural Mortality and Movement rates of Gulf of Mexico sturgeon
Advisor: Bill Pine

Adia Sovie
Degree: MS, Wildlife Ecology and Conservation
Graduation Date: August 2015
Research: Translocation of Marsh Rabbits to Everglades National Park
Advisor: Robert McCleery

Tyler Ward
Degree: PhD, Mechanical and Aerospace Engineering
Graduation Date: May 2016
Research: UAS payload construction and data processing of digital imagery
Advisor: Peter Ifju

Travis Whitley
Degree: PhD, Mechanical and Aerospace Engineering
Graduation Date: May 2016
Research: UAS Autopilot development
Advisor: Peter Ifju

Rebecca Wilcox
Degree: MS, Wildlife Ecology and Conservation
Graduation Date: August 2015
Research: Linking Snail Kite Foraging Activity, Habitat Quality, and Critical Demographic Parameters to Guide Effective Conservation Efforts in the southern Everglades
Advisor: Robert Fletcher

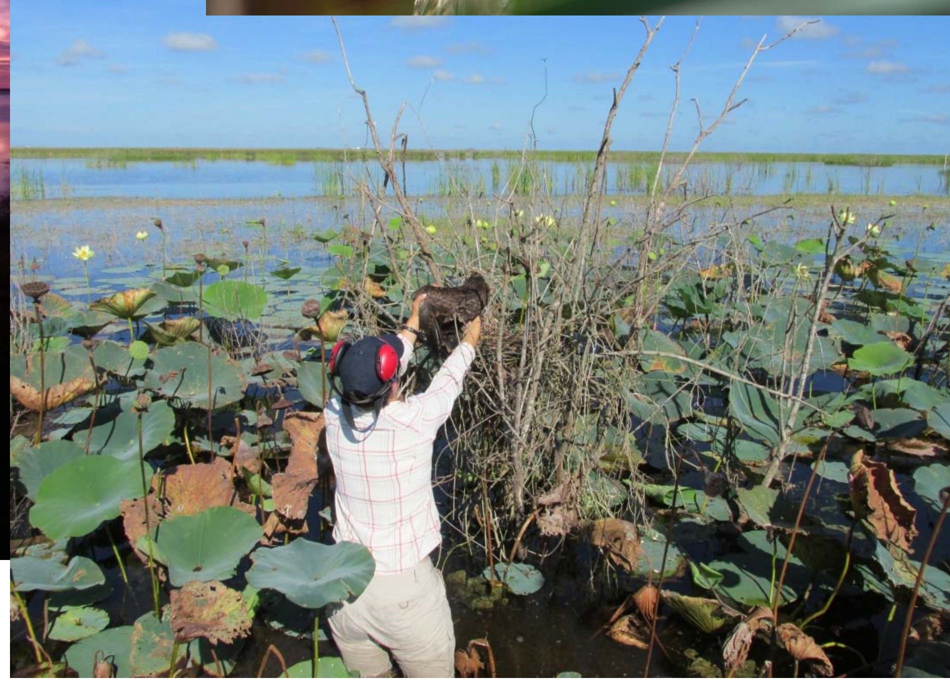
Yun Ye
Degree: PhD, School of Forest Resources and Conservation, Geomatics
Graduation Date: May 2016
Research: Computer recognition algorithms for UAS imagery
Advisor: Scot Smith

Technicians:

Gareth Blakemore
Adam Daughtery
Jesse Durrance
Whitney Haskell
Rodney Hunt
Michael Rochford
David Seay
Rachel Smith
Brittany Burtner
Matthew Denton
Dillon Everidge
Forest Hayes
Steven Marr
Daniel Schulman
Danielle Sims
Chris Stewart
Daniel Cavanaugh
Ryan Deibler
Caitlin Hackett
Adam Hoyt
Emily Pifer
Teague Scott
Lisa Sinclair
Bradford Westrich


Current Projects
Cooperative Research

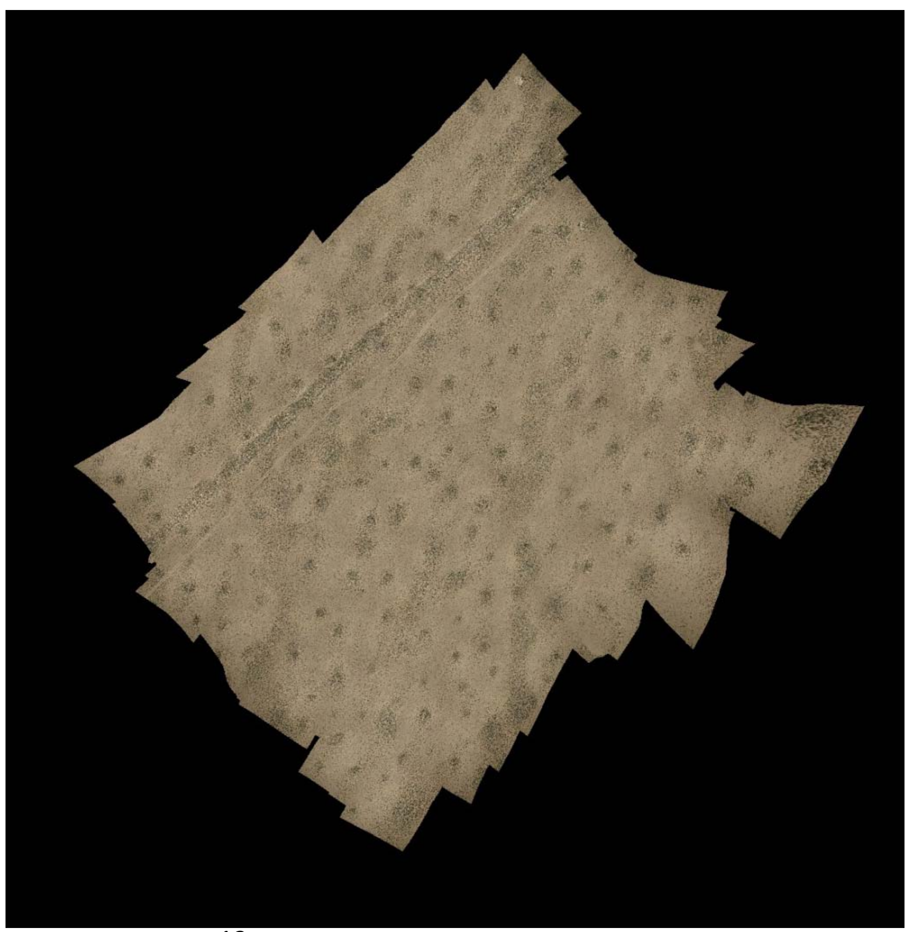




Modeling the tradeoffs within Food, Fear & Thermal Scapes to explain habitat use by mammalian herbivores

Principal Investigator: H. Franklin Percival
University of Idaho Principal Invstigator: Janet Rachlow
Funding Agency: NSF/University of Idaho
Expected Completion: 12/31/2015 (UF PJ#00108818)
Graduate Students: M. Burgess

The University of Idaho (UI), Boise State University (BSU), and Washington State University (WSU) have been working under a cooperative agreement with financial support from the United States Bureau of Land Management and the National Science Foundation to conduct research aimed at better understanding the habitat and ecology of the endangered pygmy rabbit (*Brachylagus idahoensis*). As part of this research, the group has collaborated with the University of Florida (UF) Unmanned Aircraft Systems Research Program to conduct low-altitude flights over sagebrush-steppe habitats using a small unoccupied aircraft to collect digital imagery to address several goals of the remote sensing portion of the research. One goal is to capture high-resolution digital images that can be used to measure the concealment of rabbits from predators which is provided by the sagebrush species. Another goal is to collect digital aerial photographs that may help indicate the quality of various sagebrush species as food resources for pygmy rabbits. As part of the effort to understand the animal's habitat needs, the work aims to create maps of habitat quality that will be matched with patterns of habitat use by the animals. The first mission took place during June 2013, and a second mission in January 2014. The flights within each mission will be used to compare vegetative concealment and diet quality between summer and winter seasons.



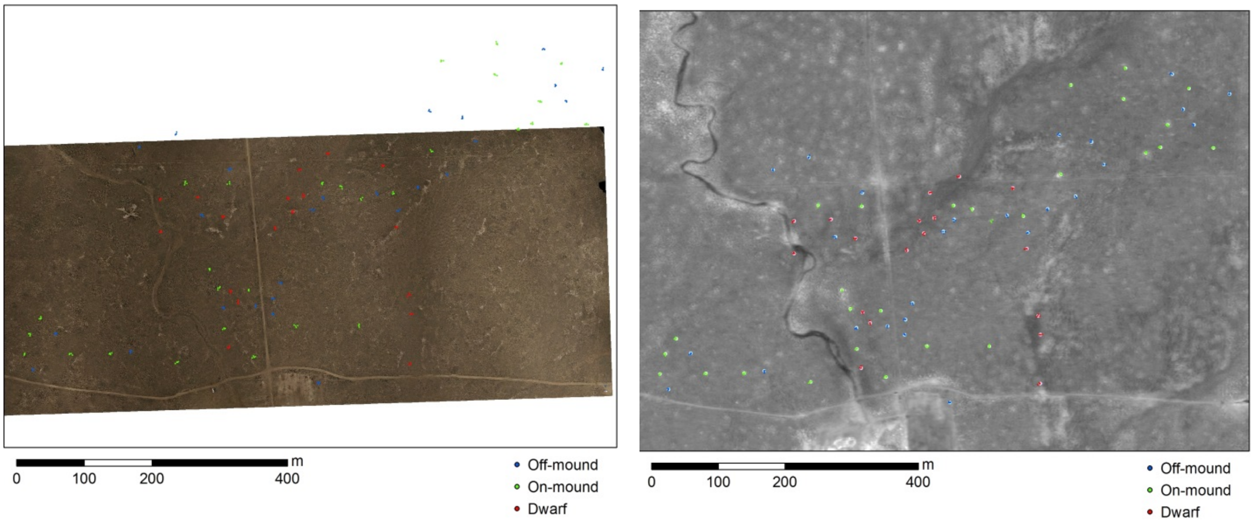
Among the interesting potentials of UAS imagery of endangered pygmy rabbit habitat in Idaho is habitat analysis. Note in this mosaic of a small portion of the Cedar Gulch, ID study area that vegetation density appears to be measurably different on the higher elevations of the naturally occurring mounds and the abandoned railroad bed in the image. The UF SFRC Geomatics program and Idaho collaborators are working toward digital soultuions to measuring extents and differences of sagebrush habitat as well as more precise 3D solutions to image interpretation.

The summer mission conducted in June 2013 at two research study sites in Idaho resulted in a total of nine flights (five in the visible color spectrum, and four in the color-infrared spectrum). The four days of fieldwork yielded a total flight time of six hours and 19 minutes; just over 42 minutes per flight on average. During the nine flights, 8,534 total ≈10 MP .jpg images were captured, occupying 42.5 GB of digital drive space. The imagery collected covered roughly 115 Ha of targeted sagebrush-steppe habitat, and had a ground resolution of approximately 2.3-2.5 cm/pixel. The UFUASRP learned a tremendous amount of information about the Nova 2.1 aircraft performance during these flights as this was the first time the aircraft had been flown over an area with ground-level altitudes significantly higher than sea level. Flying at an effective altitude of 10,000 ft (considering actual altitude and record breaking high temperatures) was a challenge and we learned that minimally a longer propeller (17 as opposed to 15 inches) is required for the plane to operate satisfactorily. We will fly there again in summer 2014 when we can explore different lengths and pitches of propellers. In addition, the auto-land feature of the autopilot had been in use prior to last summer 2013 flights. It was deployed necessarily and successfully on each of the nine landings. The only possibility for landing was a rocky, two-rut road carved through sagebrush. Consistently landing a plane with a nine-foot wingspan on a 12 foot wide runway by remote control would not have been possible.

The UF UAS team was at home in record high temperatures in June in Idaho. In January, Idaho collaborators equipped the Gators with gaiters and taught them the difference between a balaclava and baklava.

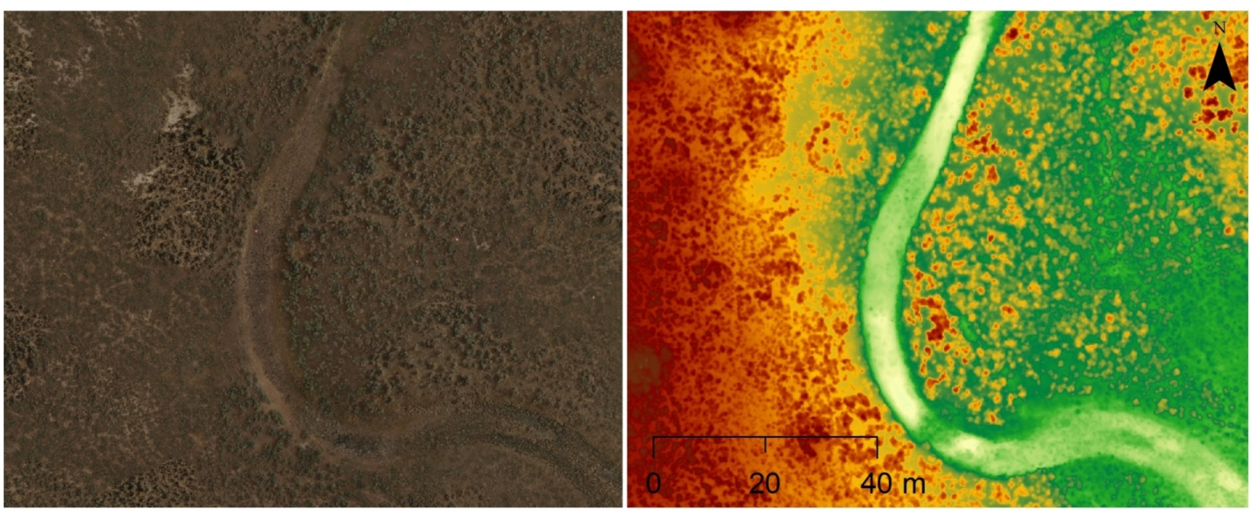
The winter mission conducted January 2014 at three sites resulted in 12 flights (all visible color) and additional 11, 379 images covering over 150 Ha of habitat and occupying 56.7 GB of digital hard drive space. Having improved auto-landing and operating at higher altitudes, there were other challenges. Extreme cold and its effects on batteries, other mechanical components, and Floridians were predictable. Idaho collaborators provided some resolutions in advance and the entire team improvised in the field to accommodate a successful mission. The new challenge of flying an additional study area having mountains on 3 sides required many hours of extra programming of the autopilot to accommodate tighter turns to both avoid hitting the mountains and achieve level, straight flight by the time the plane returned over the target area.

Fortunately, the software for post-processing aerial imagery has recently and dramatically improved. Visible spectrum imagery mosaics were of good quality, and since December 2013, the products are considerably better. As the software and computing power continue to improve over the next few months, the imagery mosaics produced should be even more remarkable. Future analyses of the imagery will include mosaicking the color-infrared spectrum imagery, and superimposing those mosaics on and off the visible-spectrum mosaics. Additionally, three-dimensional digital surface models constructed using two-dimensional imagery by the post-processing software will be utilized for comparisons to ground-based models constructed from terrestrial-based data that were simultaneously collected during the summer 2013 field season. Collaborators from Boise State University, Washington State University, University of Idaho, and UF are all using the data in different manners. Plans are being made currently for the summer 2014 field mission.

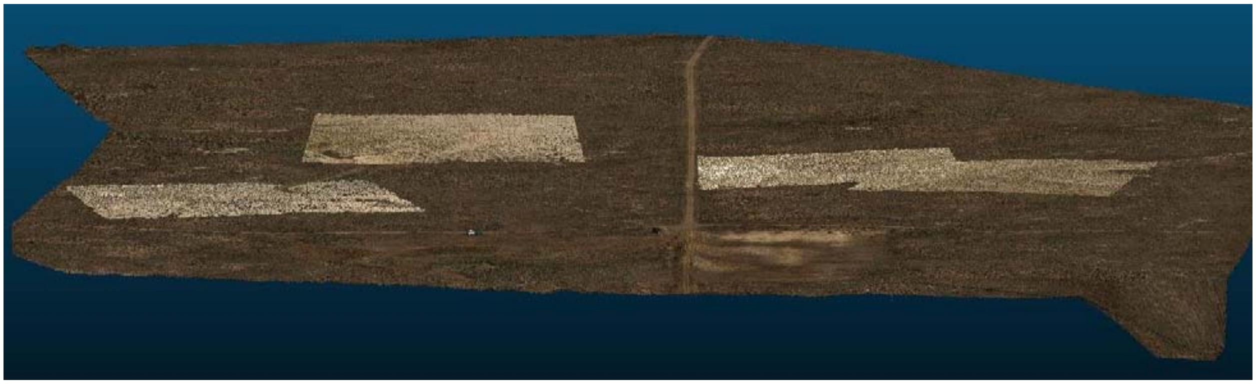


Patches from sample strata over UAV data (2.5cm-resolution, left) and NAIP NDVI (1m-resolution, right).

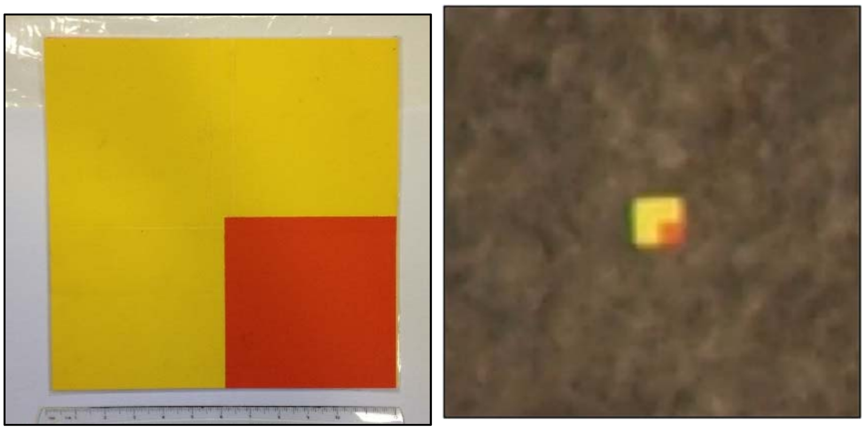
For NAIP: possibility to scale classification of low patches (dark areas) and mounds (bright spots) to areas where we don't have UAV data.



Close-up of UAV imagery (left) and digital surface model (right), showing potential for classification of shrubs for food types and cover. [M.A. Burgess, UF]



Point cloud/digital surface model with TLS scans on top (whiter areas). [J. Lonneker, UI]



Ground control points (coverboards) used to help assess pygmy rabbit concealment by sagebrush, and to aid in post-processing the aerial imagery into mosaics. [M.A. Burgess, UF]

Testing natural resource applications using a small unmanned aircraft system

Principal Investigator: H. Franklin Percival
Funding Agency: USGS
Expected Completion: 08/31/2014 (RWO#284, UF PJ#00102993)
Graduate Students: M. Burgess

The need for cost-effective monitoring of wildlife populations and habitat is common to natural resource managers in state and federal agencies as well as NGOs. The University of Florida Unmanned Aircraft Systems Research Program (UFUASRP) was the first in the United States (US), and possibly the world, to custom design a small Unmanned Aircraft System (sUAS) explicitly for natural resources assessment and monitoring. After 12 years of development the UFUASRP is currently working with its fifth-generation of sUAS, the Nova 2.1. The Nova 2.1 has significant advantages in portability, ease of use, and mission flexibility when compared to larger Unmanned Aircraft Systems (UAS) and differs from other sUAS in that the latter focus on intelligence, surveillance, and reconnaissance whereas the Nova 2.1 is a precision natural resources surveying tool. Of the remaining hurdles for deployment, the most important is testing applications of the tool with state of art statistical and analytical techniques. In addition, FAA regulations limit the use of UAS in scope and scale as well as user requirements. We investigate practical tools to overcome some of these requirements.

OBJECTIVES

1) Assess the potential advantages and limitations of the UF Nova 2.1 sUAS as a scientific tool to augment and assist in existing natural resource data collection and estimation efforts.

The evolution of the Nova 2.1 was spawned by rapid technological developments such as miniaturization of digital cameras, new frontiers in battery and materials technology, and the rapid development of high capacity memory components. While this has meant many teams are developing UAS worldwide, the UF effort has always been driven by the desire to solve specific ecological questions. Now that the Nova 2.1 is aeronautically and electronically stable, the next big frontiers are image postprocessing, machine learning, image recognition, novel statistical techniques, and application driven adaptations.

The Nova 2.1 is beginning to be deployed in a variety of real world applications. The repeated overlay capability has already provided a handy, quantitative solution to a long standing problem of estimating turnover in colonial nesting birds. Florida Coop Unit faculty and students have also teamed with the University of Idaho to evaluate fine scale characteristics of pygmy rabbit habitat, and estimate burrow density. In collaboration with Idaho Fish and Game, the UAS will be used to estimate Chinook salmon redd density in relation to habitat characteristics, and to estimate white pelican colony size. Computer scientists and ecologists and the University of Central Florida will be using UAS data to estimate nesting sea turtle population size and to differentiate beach tracks of loggerhead, green and leatherback turtles. CEMML (Colorado State University) is teaming with UF to assess waterbird distribution and abundance at the Patuxent Naval Air Station. The Mote Marine Laboratory in southwest Fl will use UAS data to estimate abundance and size class distributions of assemblages of rays near Sarasota. The USGS Southeast Ecological Science Center and FL Fish and Wildlife Conservation Commission are collaborating to provide novel statistical techniques for estimating abundance from UAS data.

UAS have huge potential as a tool to fill the gap between a biologist on the ground with a pair of binoculars, and satellite imagery. The examples above illustrate that UAS also have the ability to provide wildlife ecologists not just static images, but highly accurate and repeatable GIS products. This opens the door to investigations at a novel and extremely appropriate geographic scale for wildlife, and the ability to produce statistically robust results. When coupled with the ability to fly in remote areas dangerous for manned aircraft, and remove human safety from the picture, UAS could turn out to be as important to ecologists and managers as satellite imagery has been.

2) To test the photogrammetric parameters of the UF Nova 2.1 optical payload deployed on a Cessna© 172-model Skyhawk™.

A limitation of sUAS technology is its range and deployment in situations where sample points or targets of interest are widely separated. Examples are surveys of manatees (Trichechus sp.) at warm-water refugia or salmon (Oncorhynchus sp.) redd surveys in the Snake River, Idaho/Washington. The targets may be separated by scores of miles within a range of their 150 mile or greater extent and must be surveyed within a small temporal window. The sUAS might deliver very appropriate data but logistics obviate their use over such a large extent. The Nova 2.1 payload on a manned aircraft might deliver data that are far superior to ocular estimates of human observers, and also eliminate the need for trained observers in the manned aircraft. The photogrammetric solutions might vary from that of the

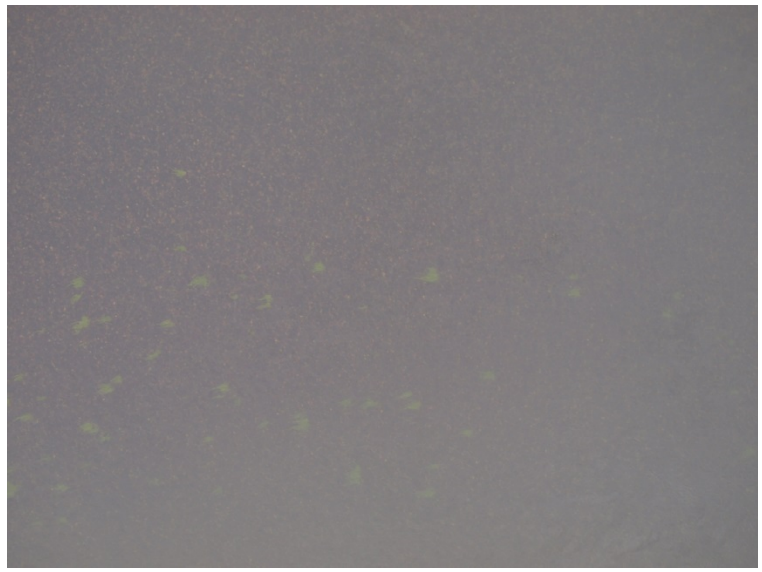
Nova 2.1 because of the difference in the high-precision of programmed flight plans of the sUAS versus that of a human-piloted aircraft.

UF's aeronautical engineers produced drawings and constructed an aluminum box of aircraft standards to contain the Nova 2.1 payload. In 2011-12, we worked with a local FAA Designated Engineering Representative to secure a FAA Supplemental Type Certificate for attaching the box to a Cessna 172M owned by our collaborator, Avian Research And Conservation Institute (ARCI) . Subsequently we have gained approvals for attachments to a Bell 407 helicopter (courtesy of South Florida Water Management District) and a Bell 206 helicopter (courtesy of Hillcrest Aviation, Lewiston, ID, Idaho Power and Light C., Idaho Fish and Game). All of these attachments proved to be aeronautically and photogrammetrically unobtrusive. There was no interference with flight characteristics of the aircraft. Attachments provided a clear nadir view for the camera, there was no vibration to affect the imagery, and satellite reception was adequate for the GPS. The technique holds great promise especially when used for transects. Our current payload fires too slowly for the greater airspeed of all the aircraft tested plus resolution (10 mp) suffers above 200m for some applications. Our team currently is working on a new payload which promises to have smaller intervals between shutter openings and 18 mp images. More detailed analyses of imagery taken over a great blue heron colony (Cessna 172), salmon redds (Bell 206), Everglades habitat and wading birds (Bell 407)are currently being accomplished. We will have opportunities in 2014 to test all 3 aircraft with the new payload.

The UAS payload has been installed with FAA permissions in a Cessna 172 M (Avian Research and Conservation Institute), a Bell 206 helicopter (Hillcrest Aviation, Inc), and a Bell 407 helicopter (South Florida Water Management District).

3) To test the efficacy of deploying "day" pilots for the UAS ground crew.

Among many FAA regulations for sUAS field deployment is the requirement for three individuals as a ground crew: a UAS pilot, a ground station operator, and a qualified visual observer to constantly search for potential aircraft incursions. In addition the sUAS pilot must possess at least a current private pilot's license and a Class II Medical clearance. Maintaining manned pilots on payroll is a complication in addition to considerable expense in most situations. We tested our ability to employ a pilot dually trained in flying remote control and manned aircraft on an as-needed daily basis. Our pilot is certified to pilot multi-engine and single engine aircraft and has a commercial pilot's license. Those certifications are far in excess of the requirement. The pilot successfully gained competence in first computer remote control (RC) flight training, small off the shelf RC aircraft, and finally the Nova 2.1. His personal schedule is such that we have been very successful in scheduling his time to match our needs. As long as that requirement exists, we believe that an operational program can definitely benefit from such an arrangement. The pilot familiarity with FAA regulations also has been instrumental in more effectively gaining the Supplemental Type Certificate for the Cessna 172, submitting NOTAMS prior to flights, and submitting COA requests. The FAA has gained increasing confidence in our ability to work within their guidelines. We believe that our pilot's IFR competence as well as the addition of a transponder to our aircraft will enable us to fly in some sites heretofore unavailable to us.



Chinook salmon redds in the Snake River, ID are clearly visible in imagery taken from the Bell 407 attachment of the payload box to a cargo basket.

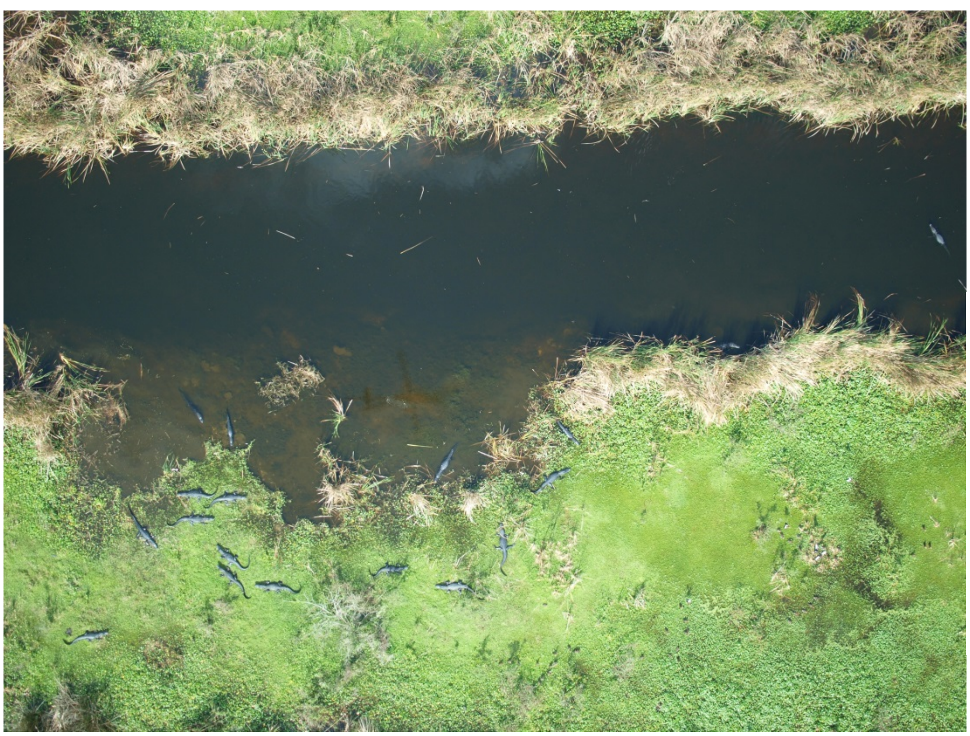


Image from low level flight of the South Florida Wildlife Management's Bell 407 equipped with the UAS payload mounted on the step. Features such as altitude, gps location, transect width, and alligator length, are measureable in the geo-referenced image.

Remote sensing of sea turtle tracks: development and application of computer vision algorithms

UF Principal Investigator: H. Franklin Percival
UCF Principal Investigators: Betsy von Holle, Marshall Tappen, John Weishampel
Funding Agency: SIRI/UCF
Expected Completion: 12/31/2013 (UF PJ#00110145)
Graduate Students: M. Burgess

This project focuses on developing recognition technologies that can locate and estimate sea turtle nests in aerial imagery gathered from unmanned aircraft systems (UAS). Access to sufficient, reliable data on wildlife populations is a key factor limiting the development of novel models of animal populations and a better understanding of the dynamics of those populations. Without sufficient data, it is impossible to verify whether better models of animal populations are more accurate or just over-fitting the data. Because of the burden of enormous data sets, the potential of UAS cannot be realized without recognition algorithms that free conservationists from the burden of sifting through all of the imagery. While UAS are seeing increasing expectations in conservation, post-processing tools such as recognition technologies have not progressed to the point where it is possible to reliably and automatically process the imagery. This project will drive the development of these recognition algorithms by focusing on the detection of sea turtle nesting sites from digital imagery. Teams of computer scientists and wildlife ecologists will gather the data necessary to train and test new recognition systems that can detect and classify sea turtle nests in aerial imagery. Ecologists will gather and annotate aerial images of sea-turtle nesting sites. These images will be used by computer vision researchers to create new recognition algorithms for identifying nesting sites in aerial images, distinguishing nesting sites from abandoned sites, and distinguishing the nesting sites of different species of sea turtles. This research has the potential to revolutionize how conservation data are gathered and used. Robust recognition technologies will make it possible to use certain UAS to survey wildlife more frequently and over larger areas.

Imagery from the payload in the BOS (Box on Step) on a Cessna 172M is being used to provide estimates of sea turtle crawls

Although our hope was to deploy UAS over the dense turtle nesting beaches of the Archie Carr National Wildlife Refuge, we were unable to secure an FAA Certificate of Authority to fly the UAS. We abbreviated the original total length of the survey area to accommodate the FAA issue of restricted airspaces on the north and south ends of the refuge. Managing humans on the beach was insufficient to ameliorate concerns of human activity on the beach. Finally, homes and condos near the beach were an additional concern. It is possible that we might soon or eventually be able to obtain a COA because of FAA's increased experience with our system. Nevertheless, we gained FAA approval to fit an aluminum box containing the UAS camera payload to a specific Cessna 172 fixed-wing manned aircraft. Previous tests indicated that it might be possible to obtain sufficient imagery to conduct this research.

We scheduled the aircraft vendor for collecting data over 3 days in July 2013. The aircraft was in Gainesville, the refuge was near Melbourne, and it was the wettest July in history. We got only a few hours of flights. We obtained enough data to prove the concept and University of Central Florida computer scientists are making progress with algorithm development. A manned aircraft has to fly higher and faster with much less control than does a sUAS with an autopilot. Nevertheless we were able to fly enough to get several mosaics of portions of the beach. Either we will ultimately be able to fly the UAS over that nest-rich refuge or the Cessna 172 method can be improved technologically and operationally. Aerospace engineers and geomaticists are working on a new payload with an 18 megapixel camera and associated hardware and software which will allow faster shutter speeds (thus more overlap for mosaicking) and higher resolution at similar altitudes. Having more favorable weather will allow more extensive and intensive coverage to provide more images for mosaicking.

Small Unmanned Aerial Systems for Wildlife Management and Habitat Assessment

UF Principal Investigator: H. Franklin Percival
Colorado State University Principal Investigator: Lee Barber
Funding Agency: DOD/Legacy
Expected Completion: 08/31/2014 (UF PJ#00104660)
Graduate Students: M. Burgess

The collection of aerial imagery from small Unmanned Aircraft Systems (sUASs) flying at low altitude within strictly restricted airspace at the Patuxent River Naval Air Station (PAX NAS), Webster Field, and the Bloodsworth Island Naval Gunnery Range provides an installation-specific response to these challenges, demonstrating a "civilian" application of proven military technology using an approach that is applicable to all military installations with restricted airspace. The UF sUAS platform, Nova 2.1, has a payload which records low-altitude, high-resolution, precision-georeferenced aerial imagery. These data will be collected and analyzed to provide decision support to airfield and range operations. Objectives include mapping canopy heght and vegetative cover for forested and scrub –shrub wetlands and to delineation of uplands that might exist within those wetlands at Webster Field; evaluating the effectiveness of an sUAS for estimating the number of nesting birds within the great blue heron (*Ardea herodias*) rookery on Bloodsworth Island at a specific point in time , evaluating the effectiveness of an sUAS for estimating winter populations of migratory waterfowl at a specific point in time at selected areas within or adjacent to Bloodsworth Island to inform Bird Aircraft Strike Hazard (BASH) assessments and predict environmental impacts of aviation operations, define specific survey methodologies to serve as a foundation for use of sUASs on other military installations to provide scientifically defensible, statistically valid wildlife population estimates and vegetation mapping as an alternative to less rigorous wildlife counts and rapid habitat assessments.

The PAX NAS, Webster Field and Bloodsworth Island are extremely busy military operations and also within the influence of the airspace managed for Washington, DC. Our sUAS and operation are smaller than to which PAX NAS is accustomed. The challenge so far has not been in effecting our mission in the field but to gain permission to fly in that airspace. That permission is forthcoming and we will collect necessary data in summer 2014 and winter 2015. The contract is currently being amended to accommodate the delays encountered. Military and civilian operations at PAX NAS and Webster Field have been most accommodating. We have an excellent collaborative relationship with the Center for Environmental Management of Military Lands, Colorado State University. The US FWS Blackwater National Wildlife Refuge has been gracious in providing logistical support for our flights at Bloodsworth Islands.

Optimal Management of Migratory Bird Habitat and Harvest

Principal Investigator: H. Franklin Percival
Funding Agency: USGS
Expected Completion: 08/14/2016 (RWO#272, UF PJ#00096823)

Optimal management of wildlife habitats and harvests depends on the ability of a manager to take periodic actions, which are conditioned both on the current state of the resource and on anticipated future resource conditions. Optimal solutions to these "sequential-decision problems" can often be calculated, provided there are clearly articulated management objectives, a set of alternative management actions, one or more models of resource dynamics, and a resource-monitoring program. This approach has been applied successfully to the national management of mallard harvests and to the local management of habitat for the threatened Florida scrub-jay. Managers are considering modifications to both programs, however. In the case of scrub-jays, habitat-restoration activities have failed to produce optimal conditions for scrub-jays in some areas of Merritt Island National Wildlife Refuge. Thus, there is a need to take advantage of recently acquired data concerning the dynamics of scrub habitat to develop more effective management strategies. In the case of mallards, it is the timing of decisions that may change. A draft Environmental Impact Statement suggests that there would be administrative benefits of shortening the timeframe of the regulatory process, such that hunting regulations would be issued each year prior to the availability of annual monitoring data. The potential impacts of this change on the mallard population and on allowable levels of harvest are largely unknown, however.

OBJECTIVES:
The objectives of this study focus on understanding the implications of resource models and decision timing on optimal management decisions and expected performance. Specifically, this study will:

A) Modify the existing optimization algorithms to account for potential changes in the models used to inform scrub-jay and mallard management; and

B) Evaluate the implications of those changes for managers, the resource, and resource users.

PROGRESS:

We have computed optimal management strategies for oak (*Quercus* spp.) scrub at Merritt Island National Wildlife Refuge (MINWR). We found that managers would have to consider the option of cutting up to two potential territories (20 ha) of tall-mix scrub each year in each management unit in addition to the option of prescribed burning in order to keep scrub-jay abundance from declining. The optimal management strategy prescribes cutting when there is any tall-mix scrub, burning only when the unit is dominated by optimal-closed scrub, and doing nothing when there is no tall-mix and a relatively homogenous mix of the other scrub types. Of particular concern in this study was the creation and maintenance of open scrub in areas with a legacy of fire suppression. Burning under ideal conditions in these areas can apparently create openings, but it did not appear to be particularly effective at setting back scrub height. Thus, linear, plowed openings that the refuge has created in some areas may be cause for concern if the openings act as fire lines, further impeding the spread of fire within a management unit. The program currently in place to monitor scrub habitat and the demographic responses of scrub-jays is seen as essential to the delivery and evaluation of future management efforts on the refuge.

With mallards our concern is with the adaptive management of resource harvesting, subject to partial system observability. Partial observability often stems from sampling or measurement error in monitoring programs, but here we focus on the lack of monitoring information about system state at the time a decision must be made. Consequently, we must evaluate policy value *V* by conditioning directly on the previous year's system state, regulatory decision, and model weights. Implementation of this approach was conducted using the software MDPSolve (© Paul Fackler). Implementation of the preferred alternative of the SEIS appears to make the adaptive management policy much more liberal. This result is counter-intuitive (more uncertainty usually tends to make harvest policies more conservative) and several hypotheses have been advanced to explain the result: (1) distribution of population size - the predicted population size is assumed to be distributed log-normal (increasing variance means an increasing mean); (2) the closed-season constraint - with more variance the policy becomes more knife edged (few intermediate regulations), and more of the state space gets Liberal but more of the state space can't get Closed because of this constraint; (3) non-linear vital rate and/or utility functions - especially the population-utility function for mallards that incorporates a population goal; add more variance to population predictions and the expected utility declines (because of the non-linear utility function); and (4) resilience - if there's a (greater) chance the population will be higher than the mean, then capitalize on it by selecting Liberal. If Liberal is the "wrong" choice, the effects are short-lived and you can always correct next year. The idea is that as the prediction variance grows, you have less control over the population. If you have less control, you might as well go for the most harvest. These four hypotheses are currently being tested.

SUMMARY:

Many problems in wildlife management can be described formally as Markov decision processes (MDPs). This study seeks to apply MDPs to the optimal management of mallard harvests and the conservation of scrub-jay habitat.

Optimal Control Strategies for Invasive Exotics in South Florida

Principal Investigator: H. Franklin Percival
Funding Agency: USGS
Expected Completion: 08/14/2016 (RWO#273, UF PJ#00096829)

Within the constraints of their budgets, responsible agencies must routinely make tradeoffs inherent in controlling the spread of invasives; e.g., monitoring abundance in well-established areas vs. monitoring potential sites for colonization, eradicating large infestations vs. eradicating newly colonized sites, and monitoring populations vs. implementing control measures. There are also temporal tradeoffs that must be considered because decisions made now produce a legacy for the future (e.g., how long to wait before implementing controls). These tradeoffs can be investigated formally within the context of a decision theoretic framework, which can identify optimal actions based on management goals and constraints, available budgets and the demography of the invasive population. A key advantage of a decision-theoretic framework is the ability to make optimal decisions in the face of various sources and degrees of uncertainty, such as the rate at which an invasive will colonize new areas or the variable effectiveness of control measures. The product of this approach is a state-dependent management strategy that prescribes an optimal action for each time period for each possible state of the system. In this case, the state of the system would be characterized by extant knowledge of the spatial distribution and abundance of the target invasive. The state-dependent strategy can also be adaptive, as predicted and observed system responses are compared over time. The goal of this study is to apply decision science to the control of invasive species.

OBJECTIVES:
The goal of this study is to apply decision science to the control of invasive species. Specifically, this study will:

A) develop a decision-making framework that has generic application for controlling invasives;

B) parameterize that framework for illustrative purposes using relevant information on one (or several related) invasive species in South Florida; and

C) derive an optimal control strategy for that (those) species and, if possible, evaluate its expected performance relative to control strategies being used or contemplated.

PROGRESS:
The research is to be conducted principally by a postdoctoral associate, but it has required two years to recruit a suitable candidate. The skillset desired is highly competitive, thus the protracted search. Although a candidate has now been identified, we are expecting additional delays because the person is not a U.S. citizen and requires a visa.

SUMMARY:
With the number of established exotic species now numbering well into the hundreds in South Florida, the potential impact of invasives has emerged as a high-priority issue in planning the restoration and conservation of the Greater Everglades. The problem can be framed generally as a Markov decision process for which optimal solutions can be derived, even in the face of various sources and degrees of uncertainty.

Southeastern Adaptive Management Group (SEAMG)

Principal Investigator: H. Franklin Percival
USGS Collaborators: Fred Johnson and Robert Dorazio
Funding Agency: FWCC/USGS/FWS
Expected Completion: 09/30/2013 (UF PJ#00104907)

The Southeastern Adaptive Management Group (SEAMG) was created in 2001 for the purpose of achieving a better science-based approach to wildlife conservation and management. The principal mission of the group is "To better integrate research and management for the purpose of improving how natural resource management decisions are made. As part of this mission, the SEAMG is responsible for exploring and developing quantitative tools that 23 improve and facilitate the integration of research and management. A distinguishing feature of the SEAMG is that it seeks ways to achieve a heightened level of integration between researchers and managers. At this level of integration, management actions themselves are viewed as opportunities for learning through experimentation, and the selection of management actions generally includes compromises between the (possibly) long-term value of learning and the short-term value of achieving more immediate management objectives. However, practical considerations also are expected to constrain the selection of management actions in most, if not all, resource management problems. A truly integrated program of research and management potentially offers great rewards; however, it is far more difficult and more costly to achieve than the more common situation where research is conducted in support of management without any direct involvement in the selection of alternative management actions. The SEAMG is interested in finding ways to achieve higher levels of integration in the activities researchers and managers to improve the decisions in problems of natural resource management and conservation. Institutional arrangements for establishment and operation of the SEAMG are described in a formal Cooperative Agreement among signatories of the U.S. Geological Survey (USGS), the U.S. Fish and Wildlife Service (USFWS), and the Florida Fish and Wildlife Conservation Commission (FFWCC). It is guided by a Steering Committee Statistics and the Program for Environmental Statistics at the University of Florida. SEAMG scientists interact loosely with scientists and managers of cooperating organizations to solve problems of natural resource management.

Coastal Ecosystems and Climate Change: Effects on Habitat and Species

Principal Investigator: Raymond Carthy
Funding Agency: USGS/Eglin AFB
Expected Completion: 12/31/2013 (RWO#276, UF PJ#00100245)
Biological Technicians: Brail Stephens, Caitlin Hackett, David Seay
Interns: Garrett Alverez, Kelia Axler, Maddy Jacobs, Alex Nicely, Megan Rasmussen, Philip Rodgers, Brandi Rubek

As the global climate changes it could have significant effects on coastal habitat and species that rely on this habitat for survival. Warmer temperatures and rising seas can increase beach erosion, altering oceanographic patterns and influencing sand temperatures. These changes to the coastal environment may greatly affect species such as sea turtles. Sea turtles spend most of their life at sea but rely on coastal habitat for one critical life-history phase: nesting. Changes to beach topography, sand temperatures and oceanographic patterns may impact nesting success, change incubation rates and influence nesting site fidelity. Determining the effects of climate change on nesting sea turtles will help provide proper management for this threatened species.

OBJECTIVES:
This project aims to contribute to a long-term study on impacts of climate change and help elucidate specific components of sea turtle ecology by:

A) Continuation of a long-term tagging study and nest monitoring

B) Investigating effects of changes in beach morphology on sea turtle movements during the inter-nesting period

C) Examining effects of erosion debris fields on nesting success
- Identification and GIS mapping of Coast Guard Station debris onshore and off-shore
- Statistical comparison of mean number of false crawls in debris areas versus non-debris areas

D) Researching effects of climate change on reproductive parameters

PROGRESS:

Data was collected from May through October 2013 and are currently being summarized. During the 2013 season, 47 nests were deposited on Cape San Blas and 77 non-nesting emergences were documented. Turtles were observed laying 20 of those 47 nests (43%). Those 20 nests were deposited by 13 individual turtles. Locations of all emergences (nesting and non-nesting) were recorded using a hand-held GPS. In addition, the locations of all debris from the Cape spit to the Stump Hole were documented using the same GPS. All debris locations were entered into a database and a comparison of turtle emergences and debris locations is being conducted. Nests were observed daily and the day of hatching recorded for all possible hatching events to document incubation length. Finally, three days after hatching or after 80 days incubation, all nests were excavated.

Initial comparisons between the number of false crawls and location of debris indicate no significant relationship (Figure 2). Further analyses are being conducted to investigate this relationship in more detail.

Initial analyses indicate turtles using this beach show very low site fidelity. Of the approximately 450 turtles tagged as part of this long-term project, only 7% have returned to nest again in subsequent years.

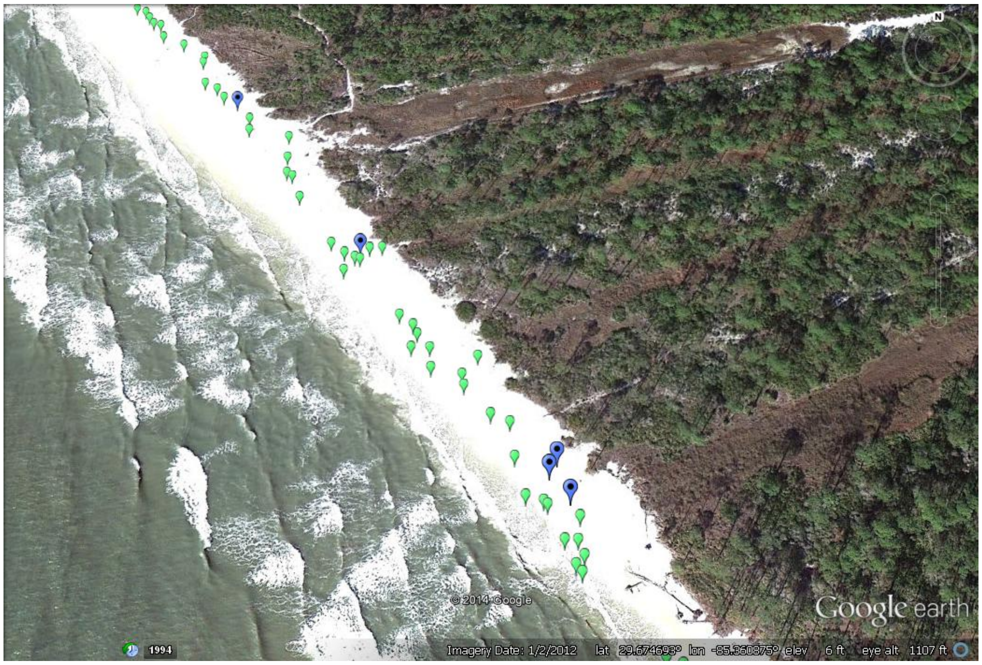


Figure 2. Location of turtle nests (blue icons) and anthropogenic and natural (downed trees and stumps) debris (green icons) on a stretch of beach along Eglin Air Force Base property on Cape San Blas.

SUMMARY:
As the global climate changes it could have significant effects on coastal habitat and species that rely on this habitat for survival. Warmer temperatures and rising seas can increase beach erosion, altering oceanographic patterns and influencing sand temperatures which may greatly affect species such as sea turtles.

Effects of Shoreline Armoring Structures on Nesting Loggerhead Turtles

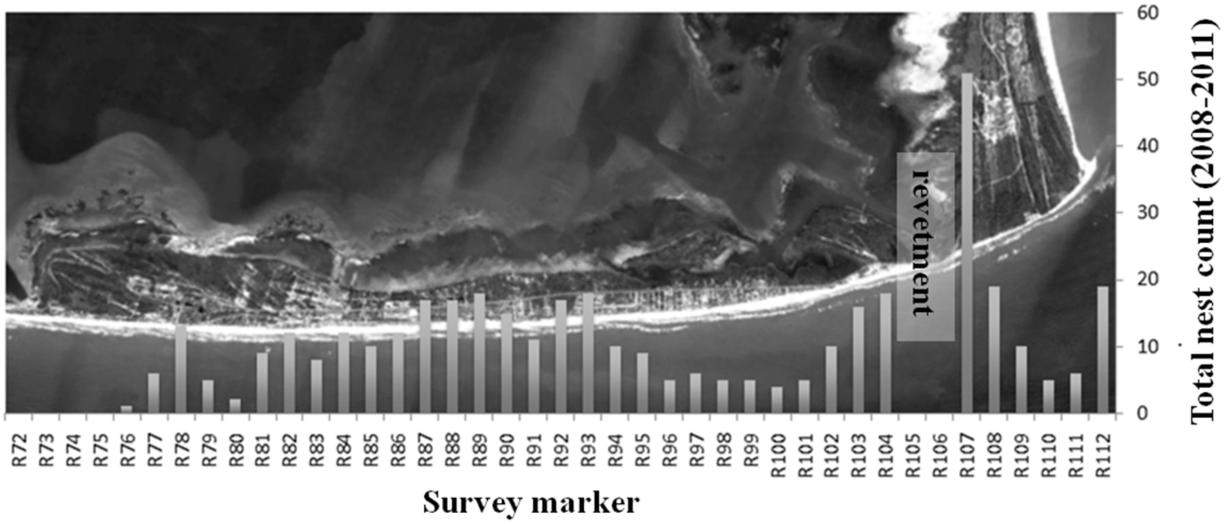
Principal Investigator: Raymond Carthy
Funding Agency: FL DOT
Expected Completion: 06/30/2013 (UF PJ#00094704)

As coastlines change due to sea level rise and an increasing human presence, understanding how species, such as marine turtles, respond to alterations in habitat is necessary for proper management and conservation. Survey data from a major nesting beach in the northern Gulf of Mexico, where a revetment was installed, was used to assess spatial distribution of loggerhead emergences. Through use of Quadrat analysis and piecewise linear regression with breakpoint, we present evidence to suggest that nest site selection in loggerheads is determined in the near-shore environment, and is correlated to characteristics such as wave height, alongshore currents, depth and patterns of erosion and accretion. Above average nest counts were found in areas with relatively strong alongshore currents, relatively small waves, a steep offshore slope and the largest historical rates of erosion. Areas of relatively dense nesting also corresponded to areas of low nesting success. Both nesting and non-nesting emergences were clustered immediately adjacent to the revetment and at other eroding sites along the beach. These results suggest that alterations to the near-shore environment from activities such as construction of a jetty, dredging or installation of pilings, may impact sea turtle nest distribution alongshore. We also show that piecewise linear regression with breakpoint is a technique that can be used with geomorphological and oceanographic data to predict locations of nest clumping and may be useful for managers at other nesting beaches.

OBJECTIVES:
To illuminate factors influencing loggerhead nesting, we aimed to characterize the spatial distribution of emergences along the SJP and quantify the shoreline change and pattern of sediment movement on this important nesting beach.

PROGRESS:
As coastlines change due to sea level rise and an increasing human presence, understanding how species, such as marine turtles, respond to alterations in habitat is necessary for proper management and conservation. Survey data from a major nesting beach in the northern Gulf of Mexico, where a revetment was installed, was used to assess spatial distribution of loggerhead emergences. Through use of Quadrat analysis and piecewise linear regression with breakpoint, we present evidence to suggest that nest site selection in loggerheads is determined in the nearshore environment, and by characteristics such as wave height, alongshore currents, depth and patterns of erosion and accretion. Areas of relatively dense nesting were found in areas with relatively strong alongshore currents, relatively small waves, a steep offshore slope and the largest historical rates of erosion. Areas of relatively dense nesting also corresponded to areas of low nesting success. Both nesting and non-nesting emergences were clustered immediately adjacent to the revetment and at other eroding sites along the beach. These results suggest that alterations to the nearshore environment from activities such as construction of a jetty, dredging or installation of pilings, may impact sea turtle nest distribution alongshore. We also show that piecewise linear regression with breakpoint is a technique that can be used with geomorphological and oceanographic data to predict locations of nest clumping and may be useful for managers at other nesting beaches.

Photographs of the beach near R107 on Cape San Blas, Florida in (a.) 1998 and (b.) 2010 showing the location of a revetment built in 1996 to protect the road. Two years after its construction, sea turtle nesting habitat was still available in front of the revetment however beach erosion subsequently resulted in landward migration of the beach causing removal of all sand in front of the revetment. The revetment now sticks out into the Gulf. The large number of stumps and trees that cover this stretch of beach are also evident in these photos.



Alongshore variation in total nest counts from 2008-2011 along the entire St. Joseph Peninsula, Florida. The location of a revetment is also shown.

SUMMARY:

This project is complete. The final report has been submitted to the Florida Department of Transportation.

Incubation Temperatures of Loggerhead Turtle Nests on NW Florida Beaches

Principal Investigator: Raymond Carthy

Funding Agency: USFWS

Expected Completion: 3/31/2013 (RWO#266, UF PJ#00089684)

The ratio of males to females in a population is an important feature of population structure. Sex ratio directly relates to reproductive rate and adaptive capability of a population (Ridley 1993) and is necessary for determining size, status, and dynamics of the population. For all species of sea turtles, basic knowledge of natural existing sex ratios has been missing until recently and is still not complete for most nesting groups. Sex determination of sea turtles is dependent upon the temperature at which the eggs are incubated (Yntema and Mrosovsky 1982). Several features of nesting beaches have been shown to impact incubation temperatures therefore understanding temperatures of the beach in which eggs incubate is critical to our knowledge of sex ratios.

Factors influencing temperatures of nesting beaches include beach orientation, position of the nest on the beach, weather conditions, and sand characteristics (Hays et al. 1995, Leslie et al. 1996, Ackerman 1997). Northwest Florida provides reproductive habitat for a small but genetically distinct group of loggerhead turtles. This area is higher in latitude than the more productive nesting beaches on Florida's east coast and generally has whiter, finer grain sand beaches than the east coast. It is unknown whether these characteristics influence incubation temperatures, and thereby sex ratios, of sea turtle nests in Northwest Florida.

OBJECTIVES:

1) Determine sand temperatures and loggerhead nest incubation temperatures in Northwest Florida

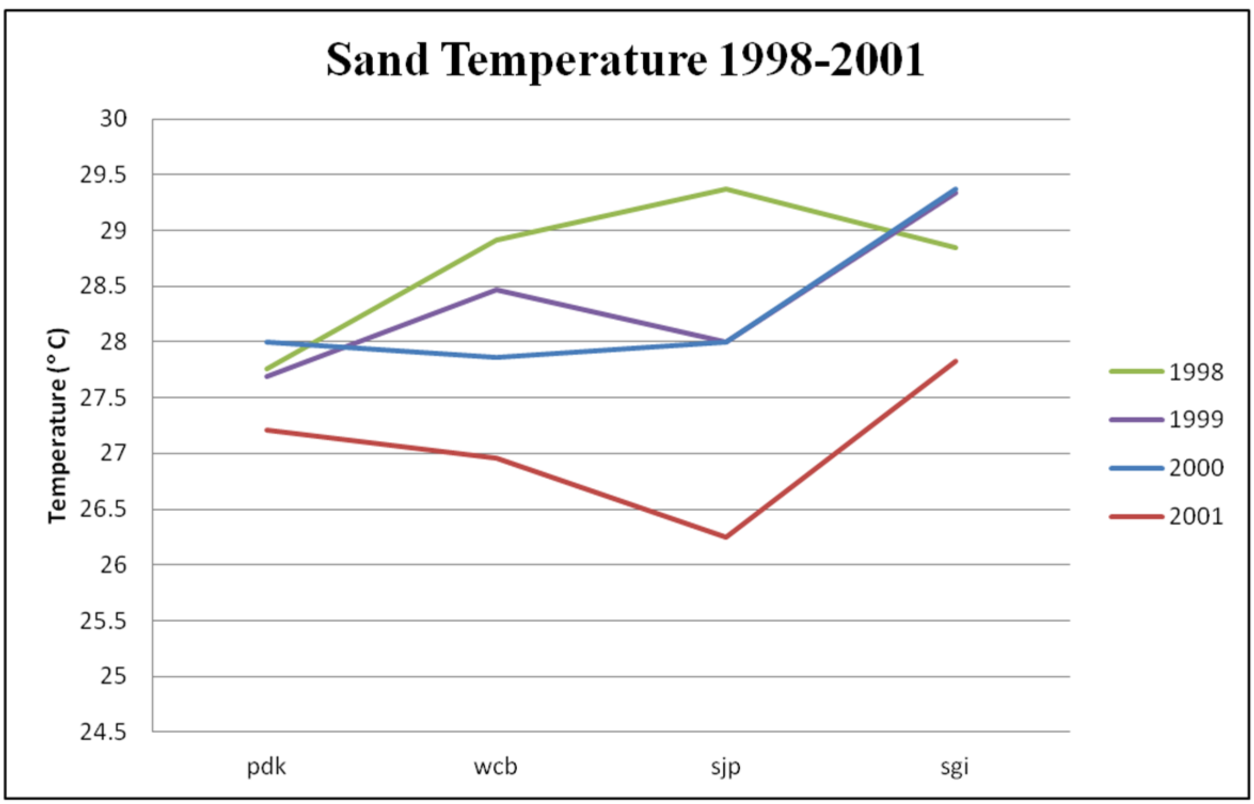
2) Determine the relationship between sand temperatures and incubation temperatures
3) Examine variations in incubation rates, sand temperatures, and incubation temperatures at several nesting beaches throughout Northwest Florida.

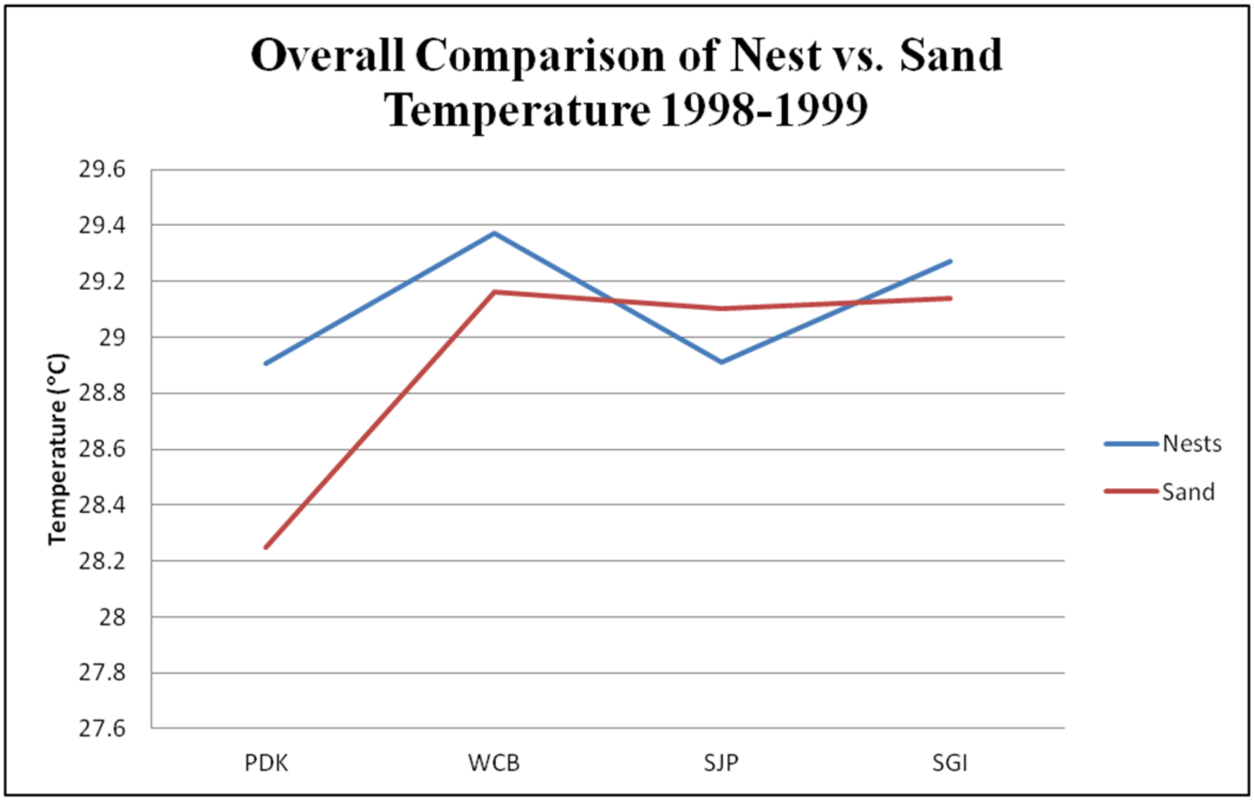
PROGRESS:
Data have been analyzed and the manuscript is in preparation with an expected submission date to USGS Internal Review of July 1, 2014.

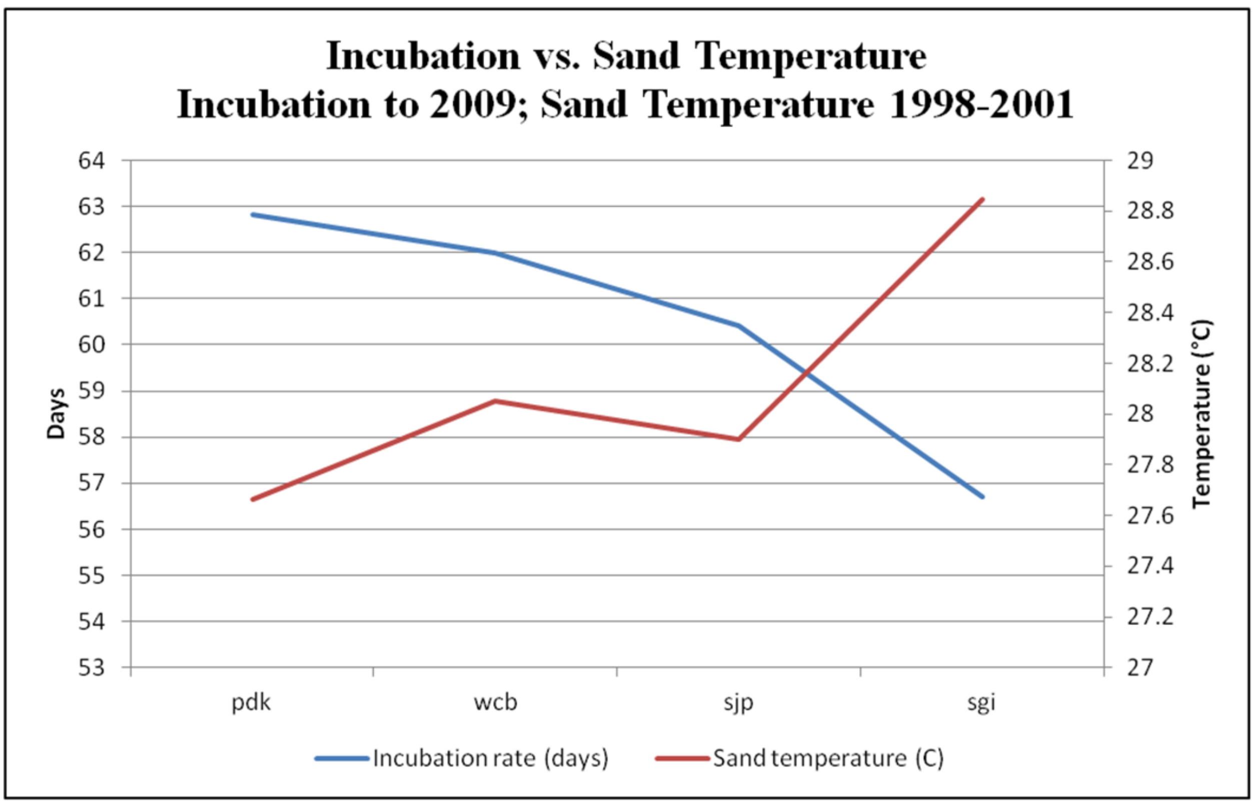
SAND TEMPERATURES: 1998-2001
Results indicated that mean sand temperatures from 1998-2001 along the Florida Panhandle increased from west to east, with warmer sand temperatures on St. George Island (28.8° C) and cooler sand temperatures on all sites west (Perdido Key 27.7° C, Walton County Beach 28.1° C, and St. Joseph Peninsula 27.9° C; $p \leq 0.05$. This trend occurred within each year also with a few exceptions; in 1998 Walton County Beach (28.86° C) was not different than St. George Island (28.85° C) and in 2000, while St. George Island was warmer than all other sites (29.37° C), Perdido Key (28.00° C), Walton County Beach (27.86° C), and St. Joseph Peninsula (28.00° C) were statistically similar ($p \geq 0.05$). Sand temperatures also differed among years with 2001 (27.2° C) being significantly cooler than 1998 (28.7° C), 1999 (28.4° C), and 2000 (28.3° C).

NEST TEMPERATURES: 1998-1999
Results indicated that nest temperatures increased from west to east, with mean nest temperatures warmer on St. George Island (30.2° C) and cooler at all sites west (28.8° C) ($p \leq 0.05$). Within year results were similar with nest temperatures warmer on St. George Island than all other sites in both 1998 and 1999 ($p \leq 0.05$).

INCUBATION RATES
Mean incubation rates were shorter on St. George Island (57 days) than Perdido Key (63 days), Walton County Beach (62 days), and St. Joseph Peninsula (60 days) ($p \leq 0.05$).







SUMMARY:
Northwest Florida beaches support a genetically distinct group of nesting loggerhead turtles but are higher in latitude than the more productive nesting beaches on Florida's east coast and generally have whiter, finer grain sand beaches than the east coast. It is unknown whether these characteristics influence incubation temperatures of sea turtle nests, and thereby sex ratios of the resulting hatchlings, in Northwest Florida.

Sea Turtle & Escarpment Monitoring

Principal Investigator: Raymond Carthy
Funding Agency: MRD Associates
Expected Completion: 8/31/2014 (UF PJ#00104186)

The Florida Cooperative Fish and Wildlife Research Unit (Coop Unit) at the University of Florida has been conducting sea turtle surveys along Cape San Blas at the southern tip of the St. Joseph Peninsula since 1994. Prior to these surveys, little was known about species, nesting densities, site fidelity and distribution of nesting in this region. Since we initiated our surveys, our data has helped determined that the group of loggerhead turtles nesting in Northwest Florida is genetically distinct from loggerheads nesting throughout the southeast and that the St. Joseph Peninsula supports the greatest nesting density of these unique turtles. Our surveys involve nest marking, data collection, nest relocation, screening for predators when necessary, and hatching inventories. In 1998, the Coop Unit initiated a saturation tagging program that involves nightly surveys for nesting turtles. When a nesting female is encountered, she is tagged and morphometric data are collected. Tagging the turtle enables us to individually identify nesting females which helps estimate population size, site fidelity, and movement patterns. Since 1998, more than 500 turtles have been tagged. The Coop Unit will use the knowledge and many of the methods gained from conducting surveys for 18 seasons along Cape San Blas to survey nesting turtles on the adjacent 7.5 km along the St. Joseph Peninsula.

As sea levels rise, coastal habitat erodes and humans utilize various techniques to reduce erosion from damaging or destroying their homes and investments. Beach nourishment is rapidly becoming the primary method used to restore highly eroded beaches. However, effects of an ongoing nourishment project on nesting sea turtles are largely unknown. Data collected during this project will provide valuable information regarding effects of beach nourishment on abundance and distribution of sea turtle nests, nesting success, and hatching success.

OBJECTIVES:
Determine the effects of an active beach nourishment project on:

1) Nesting distribution
2) Nesting abundance
3) Nesting success, and
4) Hatching success of sea turtles nesting along the St. Joseph Peninsula

PROGRESS:

Interim reports have been submitted to the members of the funding agency and the Gulf County Board of Commissioners. The first nest observed along the St. Joseph Peninsula (SJP) in 2013 occurred on May 23. During the 2013 nesting season, 95 loggerhead nests and one green nest were deposited along SJP. The last nest of the season was observed on August 20.

No tropical systems affected SJP nesting this season which contributed to a successful hatching season. Success of all nests was 63%. Success of the one green turtle nest was 93%. The mean incubation rate of all loggerhead nests was 66 days; the green nest hatched after 67 days incubation.

	C. caretta (Loggerhead)	*C. mydas* (Green)
Total # of Nests	95	1
Total # of Non-Nesting Emergences (False Crawls)	57	0
Date of First Documented Nest	05/23/2013	07/31/2013
Date of Last Documented Nest	08/20/2013	07/31/2013
Total # of Nests Left in Place	95	1
Total # of Nests Relocated	0	0

	C. caretta (Loggerhead)	*C. mydas* (Green)
# of Nests Inventoried	79	1
Total # of Hatched Nests	63	1
Total # of Unhatched Nests	25	0
Total # of Hatchlings in Nest	69	0
Total # of Empty Shells	5042	131
Total # of Pipped Eggs	53	0
Total # of Whole Eggs	2741	10
Total # of Damaged Eggs	322	0
Average Hatching Success % (#emerged/#eggs laid)	63%	93%
Average Incubation Length (date laid to first emergence)	66 days	67 days

SUMMARY:

As sea levels rise and coastal erosion increases, beach nourishment is rapidly becoming the primary method used to restore this habitat and protect homes and investments. Data collected during this project will provide valuable information regarding effects of beach nourishment on abundance and distribution of sea turtle nests, nesting success, and hatching success

Loggerhead Nest Content Collection to Determine Impacts from the Deepwater Horizon Spill

Principal Investigator: **Raymond Carthy**
Funding Agency: NRDA/USGS
Expected Completion: 7/31/2014 (RWO#277, UF PJ#00100817)
Graduate Students: Jessica McKenzie

Potential impacts of oil and dispersants from the Deepwater Horizon/Mississippi Canyon 252 (MC 252) Oil Spill on Gulf coast loggerhead sea turtles (Caretta caretta) may range from mortality to sub lethal stress and chronic impairment, including potential deleterious effects on reproduction and recruitment. Response and cleanup efforts may also cause impacts to nesting turtles, their nests, and hatchlings. Sub lethal or latent effects, such as harm to the reproductive system, would not be detectable by physical examination. Nesting turtles and post-hatchlings may also be subject to continued exposure and adverse effects if oil, dispersant, and associated chemicals persist in the marine environment, including the marine food web. Indirect impacts from potential habitat degradation and loss of prey resources may reduce survival and reproduction. The purpose of this project was to assist in documenting associated impacts of the MC 252 spill to the adult, hatchling and egg life stages of loggerhead sea turtles.

OBJECTIVES:

1) Determine habitat use of adult nesting female loggerheads through satellite telemetry.
2) Assess post-spill nesting activity by comparing numbers, density and distribution of nests to previously recorded levels.
3) Collect data on site fidelity, size, growth rates and fecundity using flipper tagging and pit tagging to supplement our long-term assessment of vital rates for this loggerhead subpopulation,
4) Assess sea turtle hatching success and hatchling production.
5) Train volunteers and interns in sea turtle survey and research activities, and examine efficacy of public conservation education and outreach techniques

PROGRESS:
Samples were collected from nests deposited on the St. Joseph Peninsula and were then successfully transferred to the appropriate office along with all of the associated paperwork. Because of the ongoing court case associated with this oil spill, no details regarding samples or results of our work are provided to us. All details are confidential.

SUMMARY:
Potential impacts of oil and dispersants from the Deepwater Horizon/Mississippi Canyon 252 (MC 252) Oil Spill on Gulf coast loggerhead sea turtles (Caretta caretta) may range from mortality to sub lethal stress and chronic impairment, including potential deleterious effects on reproduction and recruitment. This project has assisted ongoing efforts to document any impacts to loggerheads nesting in the northern Gulf of Mexico.

Doris Duke Charitable Foundation
National Educational Partnership for Conservation

Participation of women in the natural resources and conservation professions has improved dramatically in the recent decades, but only very modest gains have been made in increasing racial and ethnic diversity of the conservation field. Diversification of the conservation workforce is essential for the long-term protection of the environment for a suite of reasons.

- Solving the complex and accelerating problems of habitat loss, climate change, threats to biodiversity, and other conservation challenges will require innovative and imaginative solutions. The probability of identifying and implementing creative solutions will be greatly enhanced when a diverse workforce consisting of people from a broad range of backgrounds that will bring new ideas, perspectives, experiences, and knowledge to the table.

- Diversifying the conservation workforce will enhance the ability to identify and serve the needs of a broadly diverse society, enabling better and more sustainable solutions, increasing public support, increasing membership and engagement in conservation organizations, expanding the pool of conservation volunteers, building broader and more effective networks, and accessing additional resources (Bonta and Jordan 2007).

- In an increasingly diverse society, disciplines that draw from a narrow ethnic and racial slice of the population are likely to be undervalued by society. Given our changing demographics and the environmental challenges we face, fostering expertise and appreciation of conservation science across the demographic breadth of society may be key to long-term success of conservation programs.

A bottleneck in efforts to diversify the conservation science workforce is recruitment and graduation of undergraduates. Only 10% of conservation-related undergraduate degrees are typically awarded to minority students (Severson 2012), despite their earning approximately 24% of all undergraduate degrees (KewelRamani et al. 2007). In undergraduate courses in the field, the few minority students are isolated and their educational experience as well as that of other students lacks the full participation of broadly diverse peers, to their own and other students' learning detriment. These issues of isolation and inadequate representation are mirrored in the conservation workforce; in 2002 racial and ethnic minorities made up only 11% of the staff and 9% of the boards of major conservation organizations (Stanton 2002). To help create a more broadly diverse learning environment for all students and fuel the pipeline for a more diverse workforce, we propose to establish a national partnership in conservation science to increase enrollment and graduation of students who demonstrate a commitment to including individuals from groups that are under-represented in conservation fields, and a record of accomplishments in this through their work, service, or learning-related activities. Our partnership will be structured to provide those students with the necessary training, research and workforce experiences, social and academic support, and mentorship to transition to successful leadership positions in the field. A secondary objective will be to document and disseminate our diversity inclusion recruitment model and success with the ultimate goal of expanding diversity inclusion recruitment efforts at undergraduate institutions across the US. Successful approaches to the recruitment, attainment, and retention of minority students in the conservation sciences include active participation in field research, internships, strong social support networks, mentoring, and attendance at professional meetings (Baker 2000). We will provide these experiences as essential components of our proposed program for all students in the program.

Overall Program Structure:

Our program is built on a partnership of five universities (Cornell University [CU], North Carolina State University [NCSU], The University of Arizona [UA], The University of Florida [UF], and The University of Idaho [UI]), their affiliated USGS Cooperative Fish and Wildlife Research Units (CRUs), the USFWS National Conservation Training Center (NCTC), and a suite of state, federal, and tribal fish and wildlife conservation agencies. The university partners were consciously selected based on 1) experience with and desire to advance diversity in conservation science; 2) geographic breadth to create a national network; 3) presence of a CRU with strong research opportunities in line with program goal; and 4) institutional and faculty commitment to create a successful program. The fundamental structure of the program is as follows:

- Students will be recruited into the program during their sophomore year.

- Students accepted in the program will complete their Junior and Senior year at one of the partner universities – each year 30 students will be recruited into the program (6 per university).
- The summer between their Sophomore and Junior year will begin with a 1-week orientation at the National Conservation Training Center (NCTC) in West Virginia.
- Following the orientation the students will return to their home institutions to spend the remainder of the summer working with their faculty mentor and Cooperative Research Unit graduate students on individualized field-based research projects.
- During their Junior year, students will be mentored by university faculty and graduate students and will participate in a 1-credit, distance based course and social networking.
- During the summer between the Junior and Senior year students will complete targeted internships with state, federal, or tribal fish and wildlife agencies.
- During their Senior year, students will be mentored by university faculty and graduate students and will participate in a 1-credit, distance based course and social networking with a strong focus on career and graduate school options.
- During their Senior year, students will reconvene as a group one final time, at a national meeting.

DDCF funding will enable program support for 2 cohorts of students (60 students) to complete the program at the five partner universities. While we believe that this would, in and of itself, have a tremendous impact on the profession, our intent would be to use this funding as a foundation to build a long-term program that continues beyond the period of DDCF funding, and that grows to include other university and program partners over time. The first UF cohort of students has been selected, and we are currently designing the curriculum for their summer research and field experience.

Effects of Coastal Dynamics and Climate on Loggerhead Turtle Nest Success and Management

Principal Investigator: **Ray Carthy**
Co-Principal Investigator: Susan Jacobson
Funding Agency: USGS
Expected Completion: 9/30/2014 (RWO#285, UF PJ#00110535)
Graduate Students: Nia Haynes

Sea turtle nesting beaches in the southeastern U.S. are vulnerable to a variety of anthropogenic, ecological and climatic stressors. Nesting success in these unique and diverse beach habitats is becoming increasingly dependent on management interventions. In response to coastal development, predation, high tidal fluctuations, erosion, and risk of inundation, actions may range from protected area designation down to nest relocation. The purpose of this project is to develop a better understanding of specific responses to nesting beach stressors, by both sea turtles and humans. This will be accomplished by surveying of sea turtle nesting and utilizing an array of monitoring techniques for the physical environment. A secondary objective of the project is to provide an educational training experience for the undergraduate interns involved in the Doris Duke Conservation Scholarship Program. The project will provide partial support for a Ph.D. student who will carry out the primary research, and will provide partial support for another Ph.D. student whose research focuses on barriers to diversity in the natural resources profession and mechanisms to overcome the barriers. The latter student will be involved in recruitment and training of the undergraduate interns that will assist in the field research, and will evaluate that process as well as the success of the internship program as a part of her dissertation research. The graduate students will identify a group of potential sub-projects that together converge into the larger project and then guide the interns in conducting the field activities related to subprojects. At the end of the season, the grad students will synthesize the results of these sub-projects into a cohesive whole. The graduate students will evaluate the effectiveness of the internship program as a model for future projects and will fully document the process, outcomes, and lessons learned from the program. At this point in time, the undergraduate interns have been recruited, and research sites on the east and west coasts of Florida have been selected.

Demographic, Movement and Habitat of the Endangered Snail Kite in Response to Operational Plans in Water Conservation Area 3A

Principal Investigator: **Wiley Kitchens**
Funding Agency: U.S. ACOE (Jacksonville); USGS
Expected Completion: 3/31/2015 (UF PJ#00088028)
Graduate Students: Chris Cattau, Brian Reichert, Jean Olbert, Kyle Pias, Ellen Robertson
Technicians: Thomas Bacher, Melissa Desa, Lauren Diaz, Ryan Diebler, Whitney Haskell, Brian Jeffrey, Andre Revell, Teague Scott, Rachel Smith, Bradford Westrich

This report concentrates on demographic data collected during 2012, but also incorporates data collected since 1992. Recent demographic results reveal that snail kite abundance has drastically declined since 1999, with the population essentially halving from 2000 to 2002 and again from 2006 to 2008. Each of these two periods of population decline coincided, in part, with a severe regional drought throughout the southern portion of the kites' range. The 2001 drought significantly, yet temporarily, affected adult survival, especially for kites within the Everglades region, and the nesting patterns and lack of recruitment that have been observed since that time give us special concern about the recovery of the snail kite population. A life table response experiment (LTRE) has shown that 80% of the reduction in the stochastic population growth rate is attributable to adult fertility (i.e., the product of (1) young fledged per adult and (2) juvenile survival). Preliminary results from a population viability analysis (PVA) conducted in 2010 predict a 95% probability of population extinction within 40 years. These results are especially concerning, as they indicate an increased risk of extinction when compared to results from a previous PVA conducted in 2006. Recent analyses also provide indications of an aging population with problems inherent to older individuals, including increased adult mortality rates and decreased probabilities of attempting to breed, both of which have been shown to be exacerbated during times of harsh environmental conditions.

Multiple factors may be limiting the reproductive ability of the kites and reducing the carrying capacity of several of the wetland units throughout the state, and the reasons for this severe decline in population viability are probably tied to both short-term natural disturbances (e.g., drought) and long-term habitat degradations (e.g., the conversion of wet prairies to sloughs in WCA3A). There has been a notable decline in snail kite production from two critical snail kite habitats, WCA3A and Lake Okeechobee. No young were fledged in WAC3A in 2001, 2005, 2007, 2008, or 2010. In 2012, only one successful nest, which fledged one young, was observed in WCA3A. The decline in breeding activity and success observed in WCA3A over recent years may reflect deteriorating habitat quality. Conditions suitable to snail kite reproduction in Okeechobee, on the other hand, may have improved over the past few years. In 2010, nesting was observed on Okeechobee for the first time since 2006. Then in both 2011 and 2012, Okeechobee was the third most productive wetland (in terms of kite reproduction) range-wide.

The relatively low reproductive output from Okeechobee (1997-2010) and WCA3A (2001-present) has left the kite population heavily concentrated in and dependent upon the Kissimmee River Valley, particularly Lake Toho, which accounted for 41% of all successful nests and 57% of all fledged young that were documented on a range-wide basis from 2005-2010. In 2012, Toho accounted for 25% and 24% of all successful nests and fledged young, respectively. In 2011, an unprecedented amount of breeding activity occurred on East Toho, which was utilized heavily by breeding kites again in 2012, accounting for 27% and 30% of all successful nests and fledged young, respectively.

While the estimated population size for 2012 (i.e., 1218 is up from 925 individuals in 2011 and from 826 in 2010) along with the increased number of fledglings counted during the 2011 and 2012 breeding seasons are encouraging trends, it remains unclear whether such trends signify the beginning of a recovery phase. In this report we detail new findings related to snail kite demography, movement, and foraging. We also make specific recommendations that may help guide management decisions aimed at increasing their population growth rate.

OBJECTIVES:

Snail Kite survival depends on maintaining hydrologic conditions that support these specific vegetative communities and subsequent apple snail availability in at least a subset of critically-sized wetlands across the region each year (Bennetts et al., 2002; Martin et al., 2006). The historical range of the Snail Kite once covered over 4000 km2 (2480 mi2) in Florida, including the panhandle region (Davis & Ogden, 1994; Sykes et al., 1995), but since the mid-1900s it has been restricted mainly to the watersheds of the Everglades, Lake Okeechobee, Loxahatchee Slough, the Kissimmee River Valley (KRV), and the Upper St. Johns River of the central and southern peninsula (Fig. 1). After several decades of landscape fragmentation and hydroscape alteration, the kite population is now confined to a fragmented network of freshwater wetlands that remain within its historical range, and the viability of the population rests entirely on the conditions and dynamics of these wetland fragments (Bennetts & Kitchens, 1997; Martin, 2007). The Snail Kite is unique in that it is the only avian species that occurs throughout the central and south Florida ecosystem and whose population in the U.S. is restricted to freshwater wetlands in this region. The dependence of the Snail Kite on these habitats makes it an excellent barometer of the success of the restoration efforts currently underway (Kitchens et al., 2002) (e.g. USFWS Multi-Species Transition Strategy for Water Conservation Area 3A, 2010).

Wetland habitats throughout central and southern Florida are constantly fluctuating in response to climatic or managerial influences, resulting in a mosaic of hydrologic regimes and vegetative communities. Snail Kites respond to these fluctuations demographically and through movements within the network of wetlands in central and southern Florida (Bennetts & Kitchens, 1997; Kitchens et al., 2002; Martin et al., 2006, 2007a, 2007b). In order to optimize conservation strategies for the complex system inhabited by the Snail Kite in Florida, it is essential to have a thorough understanding of the kite's ability to move among wetlands, their resistance and resilience to disturbance events (e.g., droughts), and the demographic effects that specific management actions and other habitat changes have on the kite population.

The objective of this research is to monitor the birds' response to environmental changes (anthropogenic and natural) focusing on the most critical demographic parameters: survival, reproduction, recruitment, and population growth rate. Because those demographic parameters are heavily influenced by the behavior of the birds (i.e. their ability to move and select suitable habitats), movement studies constitute the other major aspect of the research. There are 2 overarching objectives: 1) to evaluate the underlying mechanisms and processes driving the population dynamics of the kites; 2) to provide reliable estimates of demographic parameters and movement probabilities to upgrade management models to optimize management decisions.

PROGRESS:

Mark-recapture models provide a powerful framework for estimating critical demographic (survival, population growth rate) and movement parameters. The recent advances in modeling allow for the combination of mark recapture and radio telemetry information, providing better estimates of survival and movement rates, and increasing power of statistical inferences (Williams et al 2002, Nasution et al. 2001).

By utilizing the long-term band-resight dataset, which began in 1976, we are able to identify senescence rates among the aging cohorts of the snail kite population. Senescence is defined as an increasing intrinsic rate of death, and is common among wild populations. Understanding how severe environmental conditions (such as droughts) disproportionally impact the survival probabilities of older snail kites will help to refine vital rates that are critical to our monitoring efforts.

Preliminary findings:

- Snail kites are more philopatric than previously anticipated.
- Preliminary aircraft radio surveys have also enabled us to obtain more precise survival estimates during dry wetland conditions.
- Our analyses of radio telemetry, using multistate models, indicate that snail kite movements are not as extensive as previously thought especially between habitats that have been altered by fragmentation.
- Our study also highlights the importance of taking into consideration the fact that kites movement are both distance dependent and affected by fragmentation, when managing the hydrology of wetlands used by this species.
- Snail kites do experience increased rates of mortality in their oldest ages
- Breeding probabilities of birds in different age classes are differentially affected by drought.
- All young fledged and radioed in the Kissimmee Chain of Lakes (KCOL) in 2008, stayed in the KCOL through the entire year.

SUMMARY:

The objective of this research is to monitor the birds' response to environmental changes (anthropogenic and natural) focusing on the most critical demographic parameters: survival, reproduction, recruitment, and population growth rate. Because those demographic parameters are heavily influenced by the behavior of the birds (i.e. their ability to move and select suitable habitats), movement studies constitute the other major aspect of the research. There are 2 overarching objectives: 1) to evaluate the underlying mechanisms and processes driving the population dynamics of the kites; 2) to provide reliable estimates of demographic parameters and movement probabilities to upgrade management models to optimize management decisions.

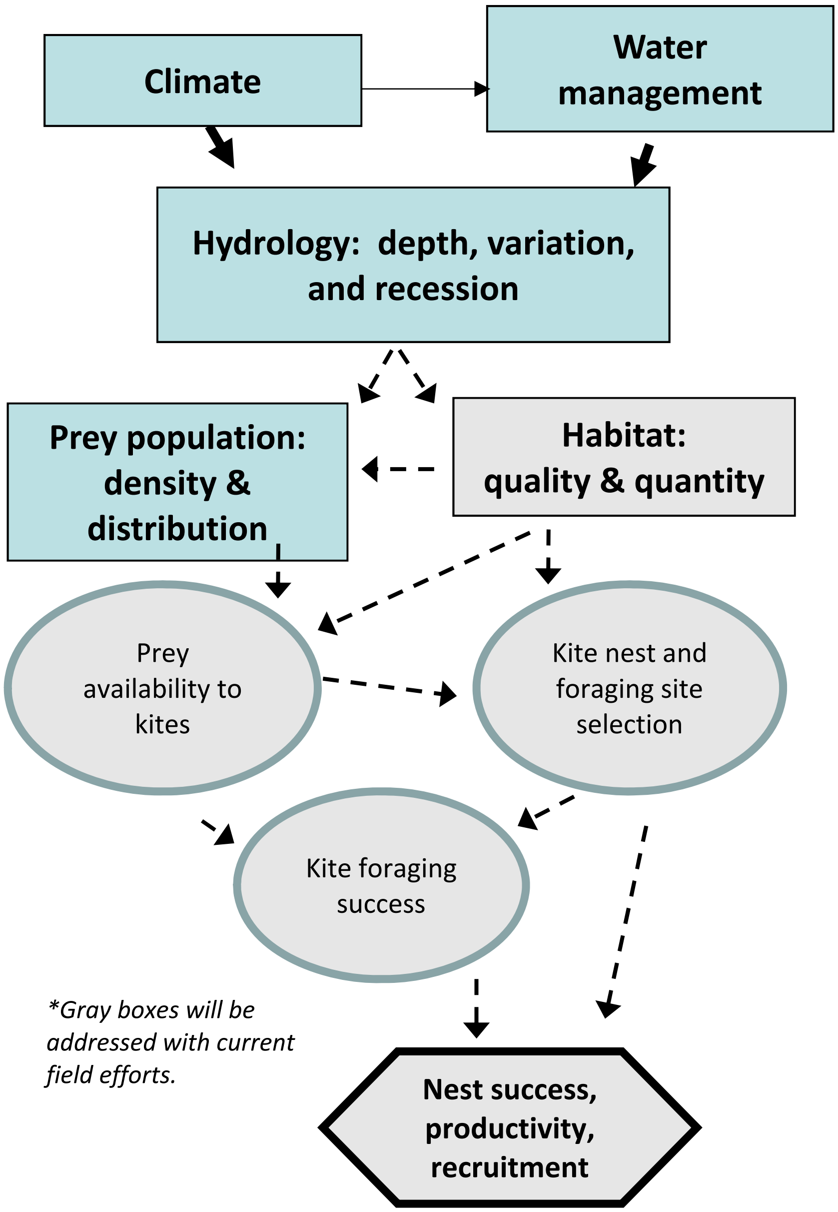
Linking Snail Kite Foraging Activity, Habitat Quality, and Critical Demographic Parameters to Guide Effective Conservation Efforts in the Southern Everglades

Principal Investigator: **Wiley Kitchens**
Funding Agency: USGS
Expected Completion: 06/07/2015 (RWO#269, UF PJ#00088726)
Graduate Students: Rebecca Wilcox
Technicians: Brittany Burtner, Daniel Cavanaugh, Ryan Diebler, Elizabeth Sinclair

Recent demographic studies reveal alarming trends in the snail kite population in Florida. Kite numbers have drastically declined since 1999, with the population essentially halving from 2000 to 2002 and again from 2006 to 2008. Concurrent with the population decline is a corresponding decline in nesting attempts, nest success, and the number of young fledged. A number of factors have likely contributed to these observed declines, including short-term natural disturbances (e.g., drought) and long-term habitat degradations (e.g., the conversion of wet prairies to sloughs in WCA3A). In relation to maintaining the long-term stability of the snail kite population, WCA3A is commonly recognized as stronghold for kite reproduction. However, snail kite reproduction in WCA3A sharply decreased after 1998. Given that reproduction may be largely limiting snail kite population growth and recovery, it is critical to understand the factors affecting reproduction in WCA3A. Natural resource managers currently lack a fully integrative approach to managing hydrology and vegetative communities with respect to the apple snail and snail kite populations. This report presents the status of our progress on (1) the integrated data synthesis effort, linking existing snail kite and apple snail data, and (2) the targeted field research being conducted to fill critical information gaps in our understanding of the interactions between/among hydrology, vegetation, snails and kites.

OBJECTIVES:
The endangered snail kite (Rostrhamus sociabilis) is a wetland-dependent species feeding almost exclusively on a single species of aquatic snail, the Florida apple snail (Pomacea paludosa). The viability of the kite population is therefore dependent on the hydrologic conditions (both short-term and long-term) that (1) maintain sufficient abundances and densities of apple snails, and (2) provide suitable conditions for snail kite foraging and nesting, which include specific vegetative community compositions. Many wetlands comprising the range of the snail kite are no longer sustained by the natural processes under which they evolved (USFWS 1999, RECOVER 2005), and hence, are not necessarily characteristic of the historical ecosystems that once supported the kite population (Bennetts & Kitchens 1999, Martin et al. 2008). In addition, natural resource managers currently lack a fully integrative approach to managing hydrology and vegetative communities with respect to the apple snail and snail kite populations.

Figure 1. Conceptual model of environmental and biological variables affecting key demographic parameters of the snail kite population.



Given the critically endangered status of the snail kite and the dependence of the population growth rate on adult fertility (Martin et al. 2008), it is imperative that we improve our understanding of how hydrological conditions effect kite reproduction and recruitment. In relation to maintaining the long-term stability of the snail kite population, WCA3A is commonly recognized as one of the 'most critical' wetlands comprising the range of the kite in Florida (see Bennetts & Kitchens 1997, Mooij et al. 2002, Martin et al. 2006, 2008). However, snail kite reproduction in WCA3A sharply decreased after 1998 (Martin et al. 2008), and alarmingly, no kites were fledged there in 2001, 2005, 2007, or 2008. Furthermore, Bowling (2008) found that juvenile movement probabilities away (emigrating) from WCA3A were significantly higher for the few kites that did fledge there in recent years (i.e. 2003, 2004, 2006) compared to those that fledged there in the 1990s. The paucity of reproduction in and the high probability of juveniles emigrating from WCA3A are likely indicative of habitat degradation (Bowling 2008, Martin et al. 2008), which may stem, at least in part, from a shift in water management regimes (Zweig & Kitchens 2008).

Given the recent demographic trends in snail kite population, the need for a comprehensive conservation strategy is imperative; however, information gaps (Fig. 1) currently preclude our ability to simultaneously manage the hydrology in WCA3A with respect to vegetation, snails, and kites. While there have been significant efforts in filling critical information gaps regarding snail kite demography (e.g., Martin et al. 2008) and variation in apple snail density to water management issues (e.g., Darby et al. 2002, Karunaratne et al. 2006, Darby et al. 2008), there is surprisingly very little information relevant for management that directly links variation in apple snail density with the demography and behavior of snail kites (but see Bennetts et al. 2006). The U.S. Fish and Wildlife Service (USFWS) and the Florida Fish and Wildlife Conservation Commission (FWC) have increasingly sought information pertaining to the potential effects of specific hydrological management regimes with respect to the apple snail and snail kite populations, as well as the vegetative communities that support them.

PROGRESS:

This study is complementary to the demographic study entitled "Continued Studies of the Demography, Movement, Population Growth and Extinction Parameters of the Snail Kite in Florida". In order to address the aforementioned objectives, we are currently analyzing the integrated historic snail kite and apple snail data, along with pertinent data related to hydrology and vegetation, as we attempt to elucidate environmental and biological variables affecting key demographic parameters of the snail kite population. We are also conducting further field research on snail kite habitat use, foraging activity, survival and reproduction that is necessary to fill the critical information gaps identified in Figure 1.

Integrated Synthesis of Existing Data

The Florida Cooperative Fish and Wildlife Research Unit (Coop) has conducted range-wide monitoring of the snail kite population since 1992 and has a wealth of demographic and behavioral data. Dr. Darby from the University of West Florida has sampled snail densities at various sites throughout the range of the snail kite from 2002 to present; however, snail sampling is time/labor intensive and was often conducted on a limited scale to address specific research questions, thus the historic snail data is spatiotemporally sporadic, with only a few sites sampled during multiple consecutive years. Dr. Darby has provided us the complete datasets for all snail sites sampled in WCA3A from 2002-2010 (except 2008 in which no snail sampling occurred) so our current integrated synthesis analyses will focus on historic data from WCA3A.

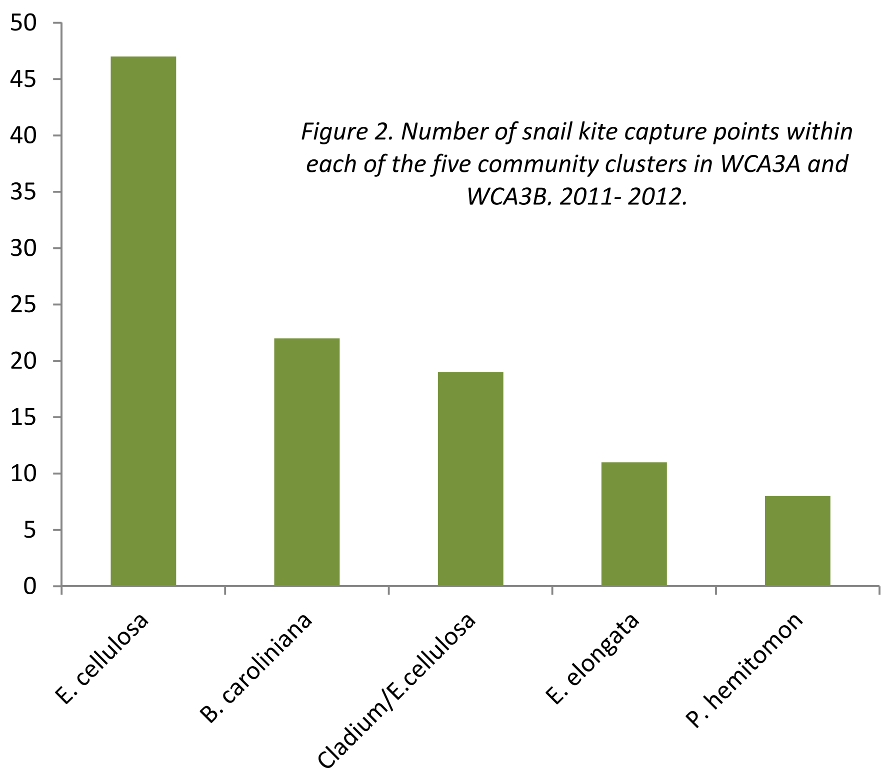


Figure 2. Number of snail kite capture points within each of the five community clusters in WCA3A and WCA3B. 2011- 2012.

We linked nesting data collected by the long-term snail kite monitoring program with 44 spatiotemporally-overlapping native snail density estimates collected in WCA3A from 2002–2010. We found evidence that key components of kite breeding biology–nest density and number of young fledged per successful nest–were positively related to snail density. While previous studies have shown that capture times for individual foraging kites begin to level off as snail densities exceed approximately 0.4 snails/m2, we found continued numerical responses in these reproductive parameters at higher snail densities. At occupied sites (i.e., snail sampling sites in which ≥1 snail kite nest was present within a 2-km radius during the primary sampling period: March–May) the average snail density was 0.45 snails/m2 (SE = 0.12, n = 17), while at unoccupied sites it was 0.12 snails/m2 (SE = 0.02, n = 27). Along the snail density gradient from 0.2 to 0.4 to 1.2 snails/m2, model predictions indicated that (1) the probability of kites nesting within 2 km of a snail sampling site increases from 0.48 to 0.69 to 0.90, (2) local nest abundance of occupied sites increases from 4 to 7 to 16 nests, and (3) the probability of a successful nesting attempt fledging more than one young increases from 0.02 to 0.07 to 0.43. We found no evidence of a snail density effect on nest survival.

Determining the survival, movement probabilities, foraging polygons, snail capture rates, capture vegetation and nesting home ranges of kites

Foraging observations were conducted on breeding snail kites in WCA 3A throughout the 2011-2013 breeding seasons. During the observation period the length of time of each activity performed by the observed bird (perching, flying, foraging, sitting on nest, etc.) would be recorded to the nearest second. Additionally, spatial locations of perches, snail capture points, and attempted capture points were estimated using a rangefinder and digital compass. The dominant vegetation type at each was visually identified. Nests were revisited every 3-4 days, and observations were completed if the nest had not failed or fledged young. The spatial points were used to calculate 95% kernel polygons using ABODE in ArcGIS 9.3. These polygons and the associated foraging points were provided to Dr. Phil Darby, who then sampled them and determined a snail density for each polygon (2011-2012). Vegetation was sampled at various capture points from each observed nest, and snail shells underneath snail kite perches were collected and measured.

- From February to May 2011, 21 nests were observed. Snail densities were estimated for four breeding snail kite home ranges.
- From March to October 2012 observations were conducted on snail kites associated with 17 different nests. Snail densities were measured in WCA 3B.

From January to October 2013 observations were conducted on snail kites associated with over 50 different nests.

Additionally, vegetation sampling occurred at foraging points within each home range in 2011-2013. Analysis of 2011-2012 data shows that the dominant foraging community in both WCA3A and WCA3B was E. cellulosa (by more than twice the next community), followed by B. caroliniana, and C. jamaicense/E. cellulosa (Fig. 2). Using the landscape-scale data, we developed a multistate model to hindcast the availability of kite foraging habitat from 1996-2009 (Zweig and Kitchens in press), and in concert with the foraging data, we demonstrate that the most important kite foraging community (E. cellulosa) has been decreasing over time since approximately 2001.
We will continue to examining the relationships between, foraging rates, home range area, vegetation communities, and snail densities.

SUMMARY:
Information gaps (identified in Figure 1) currently preclude our ability to simultaneously manage hydrology with respect to vegetation, snails and kites in WCA3A. Synthesizing and analyzing available overlapping datasets, as well as collecting additional targeted data, will help elucidate key components in this system's dynamics, which will aid management decisions for WCA3A and improve recovery planning efforts for the endangered snail kite.

American Alligator Distribution, Size, and Hole Occupancy and American Crocodile Juvenile Growth and Survival

Principal Investigator: **Frank Mazzotti**
Co-Principal Investigator(s): **Kristen Hart, Laura Brandt, Michael Cherkiss**
Funding Agency: USGS
Expected Completion: 3/31/15 (RWO#268, UF PJ#00089760 & 00090420)
Graduate Students: Jeffrey Beauchamp
Biological Technicians: Rafael Crespo, Michelle Curtis, Seth Farris, Sara Williams, Ed Metzger, Michael Rochford

The Water Resources Development Act (WRDA) of 2000 authorized the Comprehensive Everglades Restoration Plan (CERP) as a framework for modifications and operational changes to the Central and Southern Florida Project needed to restore the South Florida ecosystem. Provisions within WRDA 2000 provide for specific authorization for an adaptive assessment and monitoring program. A Monitoring and Assessment Plan (MAP) (RECOVER 2004, 2006) has been developed as the primary tool to assess the system-wide performance of the CERP by the REstoration, COordination and VERification (RECOVER) program. The MAP presents the monitoring and supporting research needed to measure the responses of the South Florida ecosystem to CERP implementation.

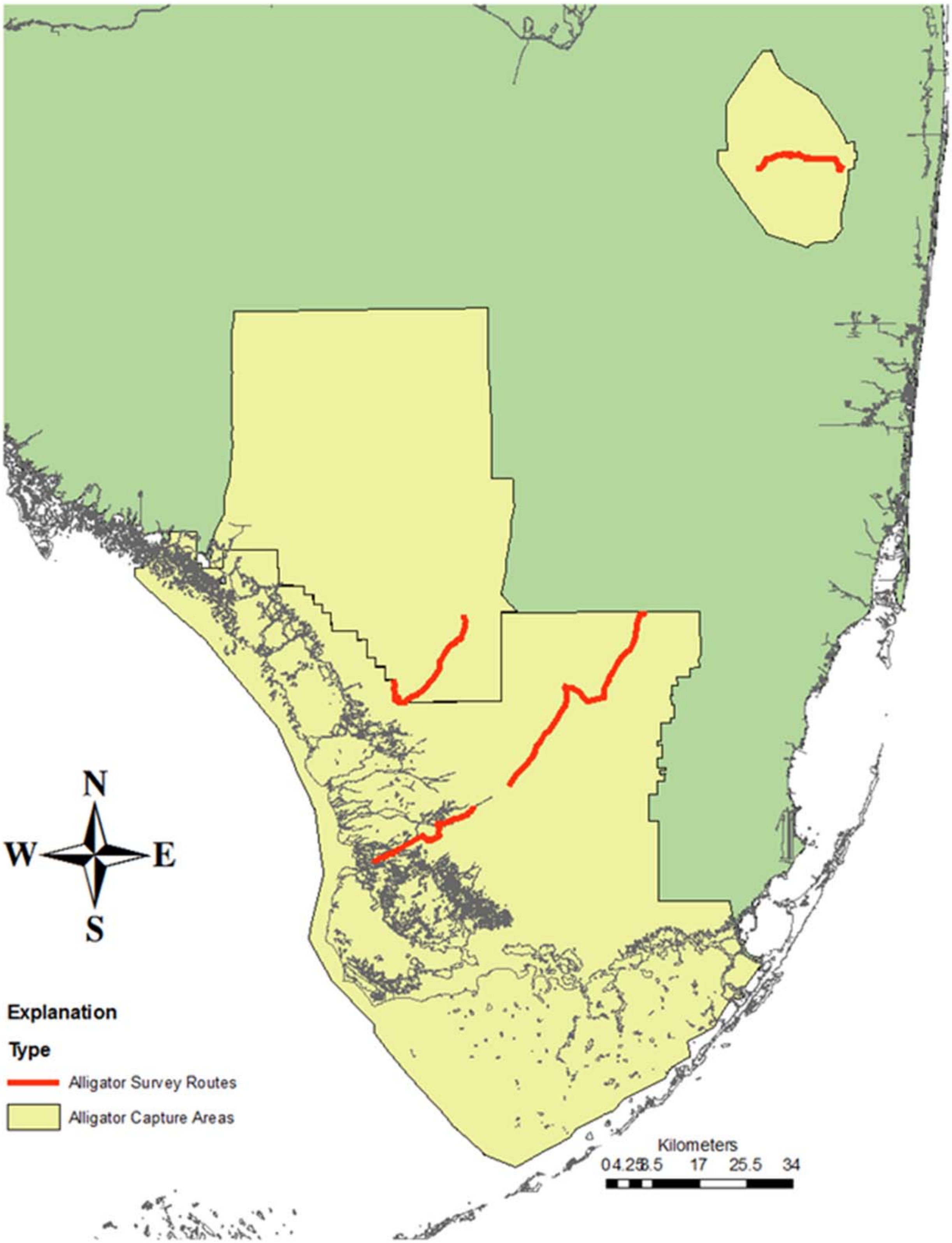
At all life stages, crocodilians integrate biological impacts of hydrologic conditions (Mazzotti and Brandt 1994, Mazzotti 1999, Mazzotti and Cherkiss 2003, Rice et al. 2005). Florida's two native species of crocodilians—the American alligator (Alligator mississippiensis) and the American crocodile (Crocodylus acutus)—are important indicators of health of the Everglades ecosystem because research has linked three key aspects of Everglades' ecology to them: (1) top predators such as crocodilians are directly dependent on prey density, especially aquatic and semi-aquatic organisms, and thus they provide a surrogate for status of many other species, (2) drier (nests) and wetter (trails and holes) conditions created by ecosystem engineers like alligators provide habitat for plants and animals that otherwise would not be able to survive. This increases diversity and productivity of Everglades marshes (Kushlan and Kushlan 1980, Palmer and Mazzotti 2004, Campbell and Mazzotti 2004) and, therefore, alligator monitoring can indicate overall health of the marsh (3) the distribution and abundance of crocodilians in estuaries is directly dependent on timing, amount, and location of freshwater flow (Dunson and Mazzotti 1989, Mazzotti and Dunson 1989); crocodiles and alligators exhibit an immediate response to changes in freshwater inputs into the estuaries.

RECOVER's conceptual ecological models (CEMs) for the Total System, Biscayne Bay, Southern Marl Prairies, Ridge and Slough, and Mangrove Estuarine ecosystems identify three major stressors to wetlands that are affecting populations of alligators and crocodiles: (1) water management practices (affecting hydrology); (2) agricultural and urban development (affecting habitat loss and hydrology); and (3) decreased freshwater flow to estuaries (affecting salinity regimes) (U.S. Army Corps of Engineers (USACE) 2004). Results of this proposed MAP project will increase certainty of CEM linkages hypothesizing population responses to the restoration of freshwater flow and salinity patterns in estuaries and the return of more natural hydro patterns in interior wetlands and alligator holes.

Restoration success or failure can be evaluated by comparing recent and future trends and status of crocodilian populations with historical population data and model predictions, as stated in the CERP hypotheses related to alligators and crocodiles (CERP MAP section 3.1.2.5 and 3.1.2.6, USACE 2004). Importantly, these data can be used in an analysis designed to distinguish between effects of CERP and those of non-CERP events such as hurricanes or droughts. The CERP and RECOVER MAP hypotheses and goals related to crocodilians are as follows:

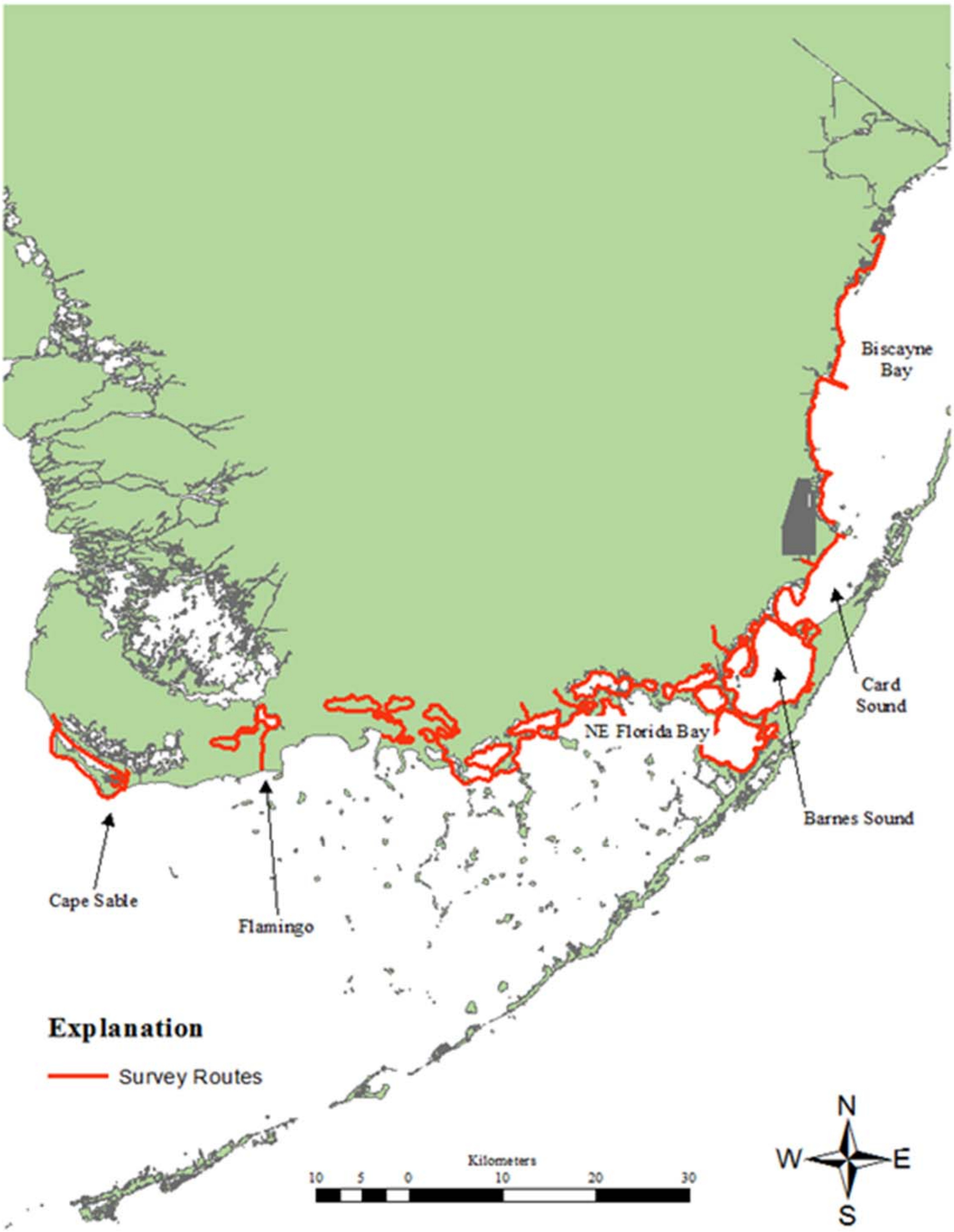
Alligators

- Restoration of hydropatterns (depth, duration, distribution, and flow) in Southern Marl Prairies/Rocky Glades will expand the distribution and abundance of reproducing alligators and active alligator holes and will restore the keystone role of alligator holes as refugia for aquatic fauna.
- Restoration of estuarine salinity regimes will expand distribution and abundance of reproducing alligators into oligohaline portions of estuaries.
- Restoration of hydropatterns in ridge and slough landscape will sustain current populations of alligators and improve body condition of alligators in ridge and slough landscape



Crocodiles

- Restoration of freshwater flows and salinity regimes to estuaries will increase growth and survival of crocodiles.
- Restoration of location of freshwater flow will result in an increase in relative density of crocodiles in areas of restored flow, such as Taylor Slough/C-111 drainage.



Concerns about these indicators relate primarily to their respective roles as top predator, keystone species, and ecosystem engineer (American alligator), and top predator, flagship species, estuarine dwelling, and federally threatened species (American crocodile). Reproduction, growth, and survival of crocodilians are dependent on food availability—birds, mammals, fish, and macroinvertebrates, which in turn are dependent on hydrologic conditions. Loss of flow and relatively dry hydrologic conditions resulting from water management practices over the past several decades, and loss of habitat (due partly to reduced areas of inundation, increased dry downs, and increased salinization) in portions of the Everglades have adversely affected alligators and crocodiles (Mazzotti and Brandt 1994, Mazzotti and Cherkiss 2003, Rice et al. 2005, Mazzotti et al. 2009). Loss of habitat in Southern Marl Prairies and Rocky Glades and reduction in depth and period of inundation in remaining Everglades wetlands have reduced abundance of alligators and alligator holes in these habitats (Craighead 1968). Other areas are impacted by ponding and altered timing of increased water depths, resulting in nest flooding (Kushlan and Jacobsen 1990) and reduced body condition (Dalrymple 1996). Reduced prey availability throughout the system as a result of hydrologic alterations corresponds with lower growth, survival, and reproduction of alligators (Mazzotti and Brandt 1994).

Both alligators and crocodiles have been affected by loss of freshwater flow to estuaries. This loss of flow corresponds with a reduction in distribution and abundance of alligators (Craighead 1968). Although there are higher numbers of crocodiles in more places today than when the species was declared endangered, virtually all of the increase is due to crocodiles occupying and nesting in man-made habitats such as the Turkey Point Power Plant site and along the East Cape Canal (Mazzotti and Cherkiss 2003, Mazzotti et al. 2007). The mangrove back-country of northeastern Florida Bay has consistently been considered core habitat of the American crocodile in Florida (Kushlan and Mazzotti 1989, Mazzotti 1999, Mazzotti et al. 2007). Today this physically unaltered area suffers from diversion of fresh water (McIvor et al. 1994). This area also has the lowest rates of growth and survival of crocodiles anywhere in Florida (Mazzotti and Cherkiss 2003, Mazzotti et al. 2007).

Because of its unique geographic location and subtropical climate, the Greater Everglades is the only place in the world where both alligators and crocodiles occur. The most important factors affecting regional distribution and abundance of these crocodilians are loss of habitat, changing hydroperiod, altered water depth, and changing salinity (Mazzotti and Brandt 1994, Mazzotti 1999, Mazzotti and Cherkiss 2003, Rice et al. 2005, Mazzotti et al. 2007). Water management has changed the pattern of water levels in the southern Everglades, causing unnatural flooding events and mortality of alligator nests (Kushlan and Jacobsen 1990). Increasing drought frequency and depth of drying have reduced the suitability of Southern Marl Prairie and Rocky Glades habitats and occupancy of alligator holes by alligators. Increasing drought frequency and depth of drying have also increased the time required for fish and macroinvertebrate populations to recover to levels considered representative of the historical Everglades (Trexler et al. 2003). When drying events occur repeatedly at less than a 3- to 8-year interval, fish and macroinvertebrate populations are continually recovering from past droughts and may fail to reach densities sufficient to sustain large predators such as alligators (Loftus and Eklund 1994, Turner et al. 1999, Trexler et al. 2005). Diminished prey density is correlated with lower growth and reproductive rates for alligators in the Everglades compared to other parts of their range (Mazzotti and Brandt 1994). Repeated drying events may also wipe out entire age classes, as alligators are forced to congregate in remaining bodies of water where they may suffer from predation and cannibalism.

Changes in water salinity patterns also affect populations of crocodilians (Dunson and Mazzotti 1989, Mazzotti and Dunson 1989). Although American crocodiles are more tolerant of saltwater than alligators, both species prefer fresh to brackish water (Mazzotti 1983). The distribution of alligators in estuaries has been affected by intrusion of saltwater (Craighead 1968, Mazzotti and Brandt 1994). In northeastern Florida Bay occurrence of alligators corresponds with presence of fresh water (Mazzotti

1983). Regionally, lack of fresh water has been correlated with lower growth and survival of crocodiles (Moler 1992, Mazzotti and Cherkiss 2003, Mazzotti et al. 2007).

In a particularly encouraging finding, Mazzotti et al. (2007) reported that after Buttonwood and East Cape canals in Everglades National Park were plugged in the 1980s to reduce saltwater intrusion into interior areas of Whitewater Bay and Cape Sable, crocodiles responded positively by increasing local nesting effort and success. This clear result suggests that restoring historical salinity patterns in estuaries can have a positive effect on this indicator species and that long-term monitoring is effective at determining population-level responses. It also indicates that nesting phenology, effort, and success should be added to growth and survival as monitoring parameters.

OBJECTIVES:

1) Monitor changes in alligator populations resulting from restoration over short-term (body condition), medium-term (distribution, relative density, hole occupancy) and long-term (demography) temporal scales
2) Monitor changes in growth, survival, body condition, relative density, and nesting of crocodiles in response to CERP projects.

PROGRESS:

Alligator captures: A total of 67 (29 female and 38 male) alligators were captured in the spring at 4 areas (A.R.M. Loxahatchee National Wildlife Refuge and 3 areas in Everglades National Park). Of those captured, 45 were new individuals and 22 were recaptured individuals. Captured alligators ranged from 116.5 cm to 273.6 cm total length. A total of 77 (36 female and 41 male) alligators were captured in the fall. Of those captured, 57 were new individuals and 20 were recaptured individuals. Captured alligators ranged from 139.1 cm to 304.1 cm total length.

Alligator Surveys: Spring alligator surveys were conducted in 4 marsh and 1 estuary areas. Alligator encounter rates ranged from 0.0/km to 7.8/km in the marsh/estuary. Fall alligator surveys were conducted in 4 marsh and 1 estuary areas. Alligator encounter rates ranged from 0.1/km to 3.4/km.

Alligator Hole Occupancy: Not conducted in 2013.

Crocodile Surveys: Surveys performed from Biscayne Bay and Key Largo west along most of the accessible coastal and estuarine shoreline to Cape Sable in ENP between January and March 2013 resulted in 95 crocodile observations, 9 alligator observations and 73 indistinguishable eyeshines (Figure 2). Twenty-eight captures were made of crocodiles, with 16 recaptures. Personnel at TP and FWC originally marked one each, and the University of Florida originally marked the remaining 14. The spotlight surveys to complete 2013 (October – December) are still underway and not included in the results presented here.

Crocodile Nesting: One hundred and nineteen confirmed nests were located for the 2013 nesting season during University of Florida surveys, 117 within ENP, one successful nest located on Lower Matecumbe and one removed by FWC at the request of the property owner. In addition, five successful nests were located at the Crocodile Lake National Wildlife Refuge by refuge staff and 25 were located at the Turkey Point Power Plant Site by FPL staff. For nests recorded by the University of Florida and whose fate was known, fifty-eight percent (99) were successful, 16% (19) were depredated by raccoons or failed for unknown reasons and one clutch was removed from the nest site. A total of 363 hatchlings were captured from nests within ENP.

SUMMARY:
Hydrology influences alligator encounter rates, body condition and crocodile juvenile growth and survival in the Everglades

Resource use by the Florida manatee in the Northern Gulf of Mexico

Principal Investigator: **Robert Fletcher**
Funding Agency: USGS
Expected Completion: 8/31/16 (RWO#274, UF PJ#00096834)
Graduate Students: Catherine Haase

Florida manatees range along the Gulf of Mexico coast from Florida to Texas and migrate to peninsular Florida for the winter. Florida manatees inhabit the northern range of their species distribution, and are therefore frequently exposed to water temperatures below their thermal comfort zone. Manatees thermoregulate by inhabiting natural and artificial warm-water sites, such as thermal outflows from power plants. There is only one artificial warm-water site along the coast of southwestern Florida, so habitat use in this region is not well understood. Preliminary work with telemetry data suggest the occurrence of naturally forming inverted thermal haloclines (trapping of warm salt water underneath cool freshwater flows), which provide thermal refuge for manatees in this area. Understanding the distribution and resource use of manatees in this area will be valuable for managing manatee habitat in the onset of power plant closures and removal of artificial warm-water sites. We will use existing data on manatee habitat use and movement to better understand resource selection of this endangered species in this region.

OBJECTIVES:

A) Identify specific resources used by manatees, including descriptions of freshwater, forage, and warm water availability in the southwestern coast of Florida
B) Using GPS telemetry, determine the extent of movements and seasonal site fidelity among identifiable manatees in these areas
C) Identify and assess warm water sites that are available for over-wintering manatees. Particular attention will focus on the mechanisms and reliability of these sites.
D) Compare habitat usage of the natural warm-water sites to artificial sites in the northern part of Florida.

PROGRESS:
The Ph.D. student completed her first year and developed a preliminary proposal with proposed questions, objectives, and methodologies. Previously collected data has been organized and is ready to start preliminary analyses using movement models to meet the second objective. Permits for deploying water quality sensors in the Everglades have been submitted and waiting approval; once approved, water quality sensors will be deployed in 12 sites identified as potential thermal refuges for manatees to collect temperature, salinity, and tidal date for use in identifying thermal refuge characteristics.

SUMMARY:
Understanding resource selection in terms of thermoregulatory responses of thermally sensitive species is critically important for appropriate management aimed at recovering endangered populations. This project aims on understanding thermoregulatory use of warm-water sites and how best to implement management for the continuation of these suitable sites.

Resolving Uncertainties in Natural Mortality and Movement Rates of Gulf of Mexico Sturgeon

Principal Investigator: **Robert Ahrens**
Co-Principal Investigator(s): **Bill Pine**
Funding Agency: National Marine Fisheries Service
Expected Completion: 06/30/2014 (RWO#275, UF PJ#00095689)
Graduate Students: Merrill Rudd

The Gulf of Mexico sturgeon (Acipenser oxyrinchus desotoi) or Gulf sturgeon was federally listed in 1991 by NOAA Fisheries and the U.S. Fish and Wildlife Service (56FR 49653). Gulf sturgeon are a subspecies of the Atlantic sturgeon (A.o. oxyrinchus) (Vladykov 1955). Gulf sturgeon range across the Gulf coast from Florida to the Mississippi River (Grunchy and Parker 1980, Wooley and Crateau 1985). They spend winters in estuarine and marine habitats and much of the rest of the year in coastal rivers (Odenkirk 1991, Foster 1993, Clugston et al. 1995).

A variety of life-history, feeding ecology, movement, genetics, and population viability studies have been conducted on Gulf sturgeon throughout their native range (Huff 1975, Mason and Clugston 1993, Carr et al. 1996, Stabile et al. 1996, Sulak and Clugston 1999, Zehfuss et al. 1999, Fox et al. 2000, Pine et al. 2001, Berg 2004, Kynard and Parker 2004, Ross et al. 2004, Pine et al. 2006). Collectively these studies provide a baseline of information about basic Gulf sturgeon life history attributes and relative snapshots of the status of Gulf sturgeon stocks in individual rivers. Though significant advances have been made in the synthesis of information for Gulf sturgeon, the 2009 assessment (Pine and Martell 2009) identified large uncertainty in natural mortality rate estimates from life-history characteristics and traditional passive (PIT) tagging programs. This uncertainty propagates through the assessment and leads to divergent predicted population trajectories and current stock status. Pine and Martell (2009) and the gulf sturgeon working group identified the resolution of these natural mortality and movement rates as high priority.

To address this uncertainty, in 2009 NMFS launched a large-scale cooperative acoustic telemetry tagging program, with the goal of tagging 20 individual sturgeon in five core rivers across the Gulf of Mexico (GOM) with long-life (5-year) acoustic tags. A large network of acoustic receivers was deployed in rivers of key management interest throughout the GOM including critical habitat rivers Suwannee, Apalachicola, Choctawhatchee, Yellow, Escambia, Pascagoula, and Pearl rivers as well as the Ochlockonee and Blackwater rivers. Rivermouth receiver arrays monitor the movements of these tagged individuals into and out of their river habitats in order to improve estimates of exchange rates between management units and current estimates of natural mortality rates. This array has been tracking acoustically tagged Gulf sturgeon since fall 2010.

We have developed robust analytical techniques to evaluate the information from the acoustic array and utilize the new information to update the stock assessment and recovery plan for this species. We chose a multistate model for analysis due to its ability to marine and river-specific survival rates, transition probabilities, and detection probabilities (Schaub et al. 2004, Nichols and Kendall 1995).

OBJECTIVES:
The objectives of this project are to produce (1) an analytical tool for estimating natural mortality and movement rates from acoustic tag data, (2) recommendations for revising and updating current telemetry programs, (3) comparison of mortality estimates with current available estimates. (4) Incorporate new information on natural mortality rates into population assessment to revise stock status estimates and provide a framework to establish recovery targets.

PROGRESS:

We directly estimated site fidelity and natural mortality rates for the threatened Gulf sturgeon across a large portion of their range in the northern Gulf of Mexico using acoustic telemetry methods and a simulation-tested multi-state mark-recapture model. Our results suggest that fidelity rates to riverine habitats used during spring and summer are high, but natural mortality rates vary widely. Our results are highly relevant for managing this species. First, the high fidelity rates, coupled with supporting genetic analyses, suggest that management of individual riverine populations of Gulf sturgeon should be considered. Second, the high variation in natural mortality rates suggests that some populations may be experiencing higher mortality rates than others. The reasons for these differences in mortality are unclear, but are an important area of future research because higher mortality rates may impede recovery of some Gulf sturgeon populations to stated management targets.

The stock reduction analysis used to assess Gulf sturgeon status has been revised to allow for population assessment at the level of spawning river. Using an age-structured mark-recapture modeling framework (ASMR), we found that abundance and recruitment trends were increasing or stable in both river systems over the past 25 years. Natural mortality rates in both riverine populations, using priors from direct estimates based on telemetry studies, were estimated to be much lower than previous studies, but similar to values expected based on fish life history theory. We assessed bias in abundance, recruitment, and survival estimates due to errors in the initial age assignment of tagged fish (age-at-first-capture), and found that this bias is minimal with appropriate assumptions of error structure and a robust analytical framework. Uncertainty in age assignment influenced age-1 recruitment estimates more than other parameters, since age assignment determines brood year. An important finding is that estimates of key demographic parameters, such as abundance and mortality, are likely more strongly influenced by changes in sampling programs than the bias caused by erroneous age-at-first-capture assignment. The results of this study highlight the necessity to minimize variation in sampling programs in order to limit uncertainty surrounding demographic parameters necessary to make inferences on trends in stock status used to inform management of fish stocks.

SUMMARY:

Resolving the uncertainty in Gulf sturgeon natural mortality and movement rates between river systems within the Gulf of Mexico is critical for assessing the status and setting recovery targets for this ESA-listed threatened species. The resulting analytical framework is an interesting application of large-scale acoustic telemetry relevant to fish and wildlife meta-populations and breeding site fidelity.

Climate Response and Fire History of Slash Pine on Blackbeard Island and Wassaw National Wildlife Refuge, Savannah Coastal Refuges Complex

Principal Investigator: **Leda Kobziar**
Funding Agency: USGS
Expected Completion: 3/1/2014 (RWO#278, UF PJ#00101141)
Graduate Students: Brenda Thomas, Kathryn King
Biological Technicians: James Camp, Michelle Budny

The most extensive areas of maritime forest in the US are found along the Atlantic Coast of South Carolina and Georgia. Much of the original forest has fallen to development. Of the forest that is left, 65% is found in Georgia, and few ecological studies have been conducted in these forests due to their isolation. As a result, managers question what form management should take to conserve these forests, particularly regarding the use of prescribed fire and the appropriate management response to wildfire.

Anthropogenic disturbances further complicate management considerations. Lowering of groundwater levels by aquifer withdrawal for industry and residential use in the Savannah, GA area has impacted wetlands on Blackbeard Island and Wassaw NWRs. The effects of this drawdown on the island ecosystems are as yet unknown, and coupled with sea level rise, resulting changes in island hydrology may influence vegetation and fuels structure and quality. This project seeks to provide a foundation for present-day management of the islands in the context of historical fire regimes, and present and future changes in island hydrology and vegetation.

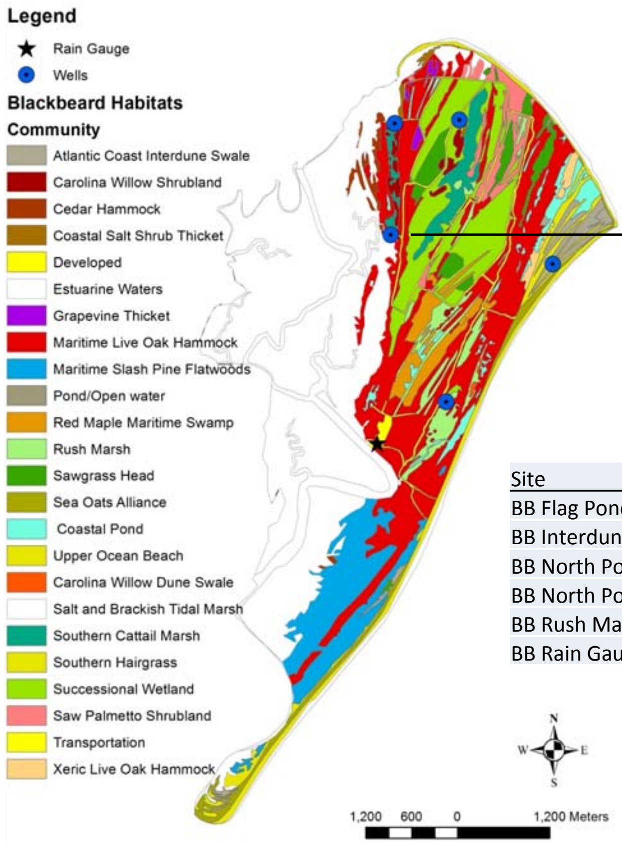
Problem Statement:
Predictions of sea-level rise suggest an increase of 39 cm along the coasts of South Carolina and Georgia and 58 cm at Blackbeard and Wassaw Islands National Wildlife Refuges (NWR) by 2100. Additionally, climate change may mean warmer temperatures as well as more severe droughts and floods, and even wildfire ignitions. Any salinity-induced changes in forest structure, composition, and productivity are likely to alter the behavior and effects of fire in these systems. Although presently many coastal forests are characterized by longer fire return intervals than their inland counterparts (e.g. 10-15 vs. 2-6 years in coastal slash pine vs. inland pine flatwoods), a number of possible mechanisms may significantly increase or decrease fire frequencies. First, sudden mortality of large areas, combined with vigorous regrowth of more salt-tolerant species, may compound fuel loads and increase fire risk. Regardless of whether fire then occurs, changes in water demand due to altered evapotranspiration and rainfall interception rates may produce feedbacks that further exacerbate salinity-induced forest mortality, risk of fire, or both. Alternative scenarios exist wherein fire reduces the vigor of vegetation growth, thus reducing demand on soil freshwater pools and, in effect, lowering salinity and the resulting stress on those communities. Further, fire may alter vegetation composition or successional trajectories to result in communities that display either more, or less, resistance to salinity increases in the soil. Finally, long periods without fire may cause ecosystem water use to increase, increasing local susceptibility to salt stress at the ecosystem scale. This project seeks to provide the historical fire data and present-day vegetation composition and structure, as well as hydrology data, to help inform management decision making and conservation of these unique forests.

OBJECTIVES:

1) Determine the historical fire regimes on Blackbeard Island and Wassaw NWRs, including fire return intervals and seasonality of fires prior to European settlement of the area.
2) Quantify the historical and present-day climate response of slash pine on Blackbeard Island and Wassaw NWRs.
3) Enumerate management recommendations in the context of historical fire regimes and climate response of slash pine, considering possible ecological impacts of climate change.
4) Establish baseline data for groundwater and salinity levels, and document the floristic composition of the plant community to determine impacts of altered hydrology associated with climate change/sea-level rise and anthropogenic activities.

PROGRESS:
Sampling for this project was completed during the spring and fall of 2013 when transportation was available. Research teams made three trips to the islands to finish collecting tree cores, sampling vegetation composition and coverage, and download weather station and water monitoring data from both Wassaw and Blackbeard islands.
Data from a network of monitoring wells installed in the spring and fall of 2012 continued to be collected over the course of 2013. These data are being used on Wassaw and Blackbeard Islands to establish baseline data for shallow groundwater and salinity levels in coordination with assessing vegetation communities (Fig. 1). As described previously, the wells were constructed of 1- and 2-

Blackbeard Equipment Summary

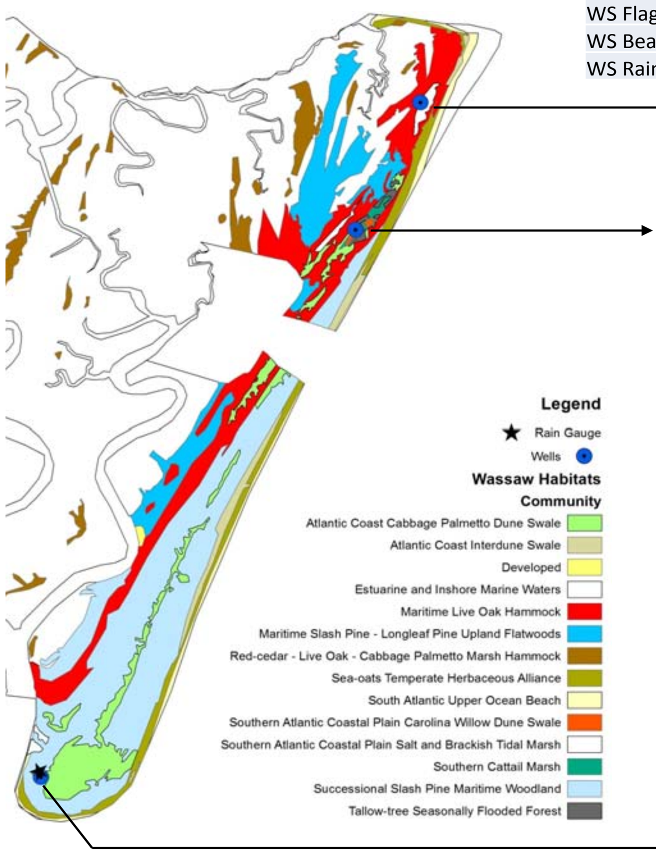


BB North Pond South

Site	Lat	Lon	X	Y	Monitoring
BB Flag Pond	31.52772	81.19779	481222.9	3488106	Level, Salinity
BB Interdunal Wetland	31.51078	81.27833	482441.6	3486226	Level, Salinity
BB North Pond North	31.52731	81.20669	480377.1	3488062	Level, Salinity
BB North Pond South	31.51417	81.20722	480324.3	3486605	Level, Salinity
BB Rush Marsh	31.49453	81.19953	481050.9	3484427	Level
BB Rain Gauge	31.48963	81.20904	480146.8	3483886	Rain

Wassaw Equipment Summary

Site	Lat	Lon	X	Y	Monitoring
WS South Swale	31.86167	81.00028	499973.8	3525103	Level, Salinity
WS Flag Pond	31.89639	80.95167	504570.5	3528952	Level, Salinity
WS Beach Pond	31.90472	80.94111	505568.1	3529877	Salinity
WS Rain Gauge	31.86222	81.00028	499973.8	3525164	Rain



WS Flag Pond

WS Beach Pond

WS South Swale

WS Rain Gauge

Inch PVC pipe, dug by hand using a bucket auger, and outfitted with Solinst "Edge" water level (pressure) inch PVC pipe, dug by hand using a bucket auger, and outfitted with Solinst "Edge" water level (pressure) loggers and Hobo U-24 electrical conductivity (EC) sensors. Additionally, one Solinst "Edge" barometric pressure logger was installed in a dry well on each island to correct for the effect of barometric pressure. A rain gauge was added to each island in late 2012 and monitored through 2013, so that at least one year's worth of precipitation data could be added to help illuminate results.

From late 2012 to early 2013, a baseline vegetation survey was conducted on Blackbeard and Wassaw islands. The objectives of the survey were to 1) describe the current condition of vegetative communities as a baseline for comparison with future restoration efforts and/or natural changes, and 2) ground-truth the existing NatureServe plant community shapefile. Since Blackbeard Island has a greater diversity of habitats and Wassaw contains a subset of those habitats, Blackbeard was sampled more intensively in order to maximize efficiency.

For every community type included in the sampling, our team established a permanent monitoring plot in which all species were identified and percent cover was estimated. After the sampling was completed, the team conducted a walk-through of the community, collecting and recording all species not found within the plot. During this walk-though, a qualitative description of the vegetation was recorded. Within each community type, plot locations were randomly generated using ArcGIS. At each plot location, GPS coordinates were recorded and a numbered tag was assigned to the plot. The tag is attached to a piece of rebar about a foot long, which was hammered into the ground until the top was flush with the ground surface. In the future, the plots can be located using GPS and a metal detector. The vegetation at each point was sampled using a nested plot system: a 1m-diameter circular plot (herbaceous understory vegetation) nested within a 2m-diameter circular plot (woody shrubs with dbh <10cm and palmettos). All plants within the plots were identified to species, and percentage cover for each plant species was estimated.
Vegetation and hydrological data are being analyzed in preparation for the Final Report. An example for one community is presented below:

Example: Blackbeard Island Vegetative Communities
The Georgia DNR/NatureServe Community Shapefile delineates fifteen plant communities on Blackbeard Island (Figure 1, Table 1), ranging from tidal salt marsh (the largest community type) to upland forest types and xeric dune assemblages.

Community Type	**Acreage**
Salt and Brackish Tidal Marsh	2121.0
Maritime Live Oak Hammock	1154.1
Successional Herbaceous Wetland	469.2
Maritime Slash Pine Upland Flatwoods	400.9
Rush Marsh	163.1
Red Maple Maritime Swamp Forest	134.1
Sawgrass Head	129.6
Southern Cattail Marsh	123.6
South Atlantic Coastal Pond	120.7

Southern Hairgrass Herbaceous Alliance	112.2
Atlantic Coast Interdune Swale	95.9
Sea Oats Temperate Herbaceous Alliance	91.9
Carolina Willow Shrubland	46.4
Cedar – Live Oak – Palmetto Hammock	39.8
Xeric Live Oak Hammock	30.2
Coastal Salt Shrub Thicket	15.2
Grapevine Thicket	14.2
Carolina Willow Dune Swale	3.7
Sand Cordgrass Herbaceous Vegetation	2.9

Table 1. Blackbeard Island Vegetative Communities by Acreage. Community designations (denoted by common name here) and acreages derived from Georgia DNR/NatureServe shapefile provided by USFWS.

Maritime Live Oak Hammock

This community, which is the dominant forest type on Blackbeard island, is characterized by an overstory of mature live oak (*Quercus virginiana*) and a midstory dominated by saw palmetto (*Serenoa repens*), and cabbage palm (*Sabal palmetto*). The hammocks on the northern part of the island have very low ground layer diversity due to thick palmetto cover, whereas the hammocks on the southern part of the island have a less shrubby understory with more herbaceous cover. The maritime hammock in which the permanent plot was established is on the southern end of the island, and the understory is dominated by a few late-successional grass, sedge, and shrub species of high floristic quality. The NatureServe map was accurate with respect to the boundaries of this community.

Permanent Monitoring Point Data Summary – Maritime Live Oak Hammock

Species	Common name	Family	Successional category	Frequency in range	% cover
1m herbaceous plot					
Chasmanthium laxum	slender woodoats	Poaceae	Late Successional	occasional	25
Dichanthelium dichotomum	cypress witchgrass	Poaceae	Late Successional	common	2
Scleria georgiana	slenderfruit nutrush	Cyperaceae	Late Successional	occasional	10
2m shrub plot					
Quercus virginiana	live oak	Fagaceae	Late Successional	frequent	1
Sabal palmetto	cabbage palm	Arecaceae	Late Successional	frequent	5
Vitis aestivalis	summer grape	Vitaceae	Late Successional	frequent	5
Species recorded outside plots					

Ilex opaca	American holly	Aquifoliaceae	Late Successional	occasional	--
Persea borbonia	red bay	Lauraceae	Late Successional	frequent	--
Vaccinium arboreum	sparkleberry	Ericaceae	Late Successional	frequent	--

Summary:

Hydrology: Patterns of salinity and water level appear to be related to composition of functional groups in surrounding vegetation. Daytime declines in water level due to evapotranspiration (ET) and nighttime increases in water levels continue to suggest a positive inflow of groundwater, either from shallow groundwater from the surrounding watershed, or resulting from upward flow from a deeper aquifer layer.

Vegetation: The complex relationships between fire history, tree growth rates, vegetation communities, and hydrology are being analyzed for the final report and in preparation for publication submission.

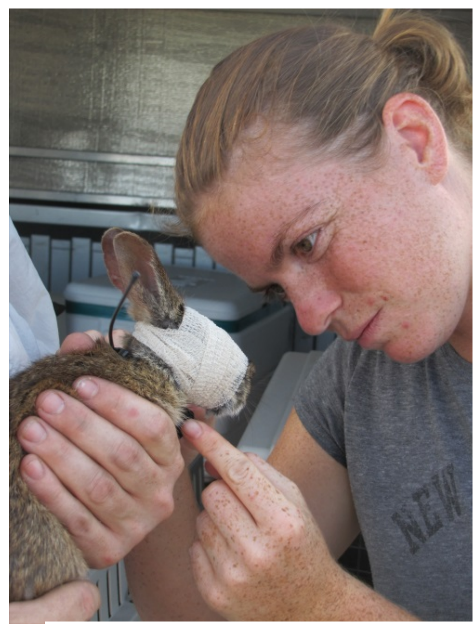
Translocation of Marsh Rabbits to Everglades National Park

Principal Investigator: **Robert McCleery**
Funding Agency: USGS
Expected Completion: 12/31/2014 (RWO#281 & #282, UF PJ#00101991 & #00102799)
Graduate Students: Adia Sovie
Biological Technicians: Elizabeth Dancer, Charlotte Robinson, Austin Waag, Michelle McEachern

Declines in mammal sightings in south Florida's Everglades National Park (ENP) over the last 10 years appear to correspond with the increased observations of invasive Burmese pythons (*Python molurus bivitatus*). We assessed the influence of pythons and other environmental factors on the distribution of marsh rabbits by sampling 84 randomly located plots of suitable habitat across south Florida from February 2013- May 2013. The distribution of marsh rabbits was best explained by a model with one variable, the distance from the origin of python invasion, Flamingo, FL, used to measure the influence of pythons. From this model the probability of occurrence for marsh rabbits was ≈ 0 in the vicinity of Flamingo and increased to > 0.93 150 km in any direction. In addition, we investigated the impact of pythons on marsh rabbit survival by translocating marsh rabbits to ENP. For comparisons we established two control populations in areas believed to be free of pythons. For the first control population we captured, radio-tagged and released rabbits at the site of capture. For a second procedural control population, we captured, radio-tagged, and translocated rabbits to a "python-free" site. In total, we tracked 94 marsh rabbits from 14 September 2012 to 27 July 2013. We estimated and compared known-fate survival using Kaplan-Meier survival curves and causes of mortality using cumulative incidence risk among treatments and sexes. Additionally, we used extensive systematic pellet surveys to determine that the reintroduced marsh rabbits in ENP failed to establish a self-sustaining population, despite high overwinter survival and successful breeding. The procedural control showed constantly lower survival then the other sites. Rabbits in ENP also had a significantly different survival curves than the control site (p=0.03) with ENP rabbits displaying higher rates of survival at the beginning of the study and lower rates of survival at the end of the study. Pythons were the dominant predator of our marsh rabbits in ENP, responsible for 77% (n=17) of known mortalities. In contrast, in control sites mammals were the dominant predator of rabbits, responsible for at least 50% (n=23) of mortalities. We only recorded 1 rabbit mortality from a mammal in ENP (5%). There was considerable seasonal variation in rates of survival of marsh rabbits when we consider only mortalities caused by pythons. Survival followed a distinct pattern with high weekly survival (S = 1.00) during the initial 6 week period, lower weekly survival (S = 0.98, CI 0.96-0.99) during a 30 week period of water levels below 750 cm in major sloughs or average weekly temperature below 25 °C, and low weekly survival (0.76, CI 0.59-0.86) when rabbits had been on the site > 6 weeks and temperatures > 25 °C and water levels were > 750cm. One explanation for this pattern is that high water levels concentrate rabbits on small areas of higher elevation. This, in turn, concentrates rabbit runs, latrines and other environmental cues that may have attracted pythons during times of their greatest activity. Regardless of the mechanism for this pattern, our research provides strong experimental evidence that pythons are responsible for reductions of mammals in the Greater Everglades Ecosystem. The continued removal of mammals from the system coupled with the replacement of the mammalian predator community with pythons undoubtedly has had, and will continue to have, strong cascading effects on the Everglades system.

OBJECTIVES:

- Evaluate the influence of environmental factors on the current distribution of marsh rabbits in south Florida.
- Reintroduce marsh rabbits to ENP and evaluate success of the population
- Quantify the impact of pythons on marsh rabbit survival in south Florida



Adia Sovie, Masters Candidate UF radio collars a marsh rabbit
Photo Credit – Elizabeth Dancer

PROGRESS:

Between March 20th and May 30th we conducted pellet counts at 84 random sites throughout the Greater Everglades ecosystem (GEE). We detected marsh rabbit fecal pellets at 31 of these sites. Detection probability was high (p = 0.84), our best detection model was the null model {psi(.)p(.)}, indicating no difference in detection between observers. Our best occupancy model included a variable considering the distance to the python introduction site. This model had substantial support over the null model and all other models (> 30 AIC, w_i =1) and the 95% CI of the parameter estimate for distance to Flamingo did not include 0 (β = 0.05 $\pm$ 0.005). Occupancy was positively correlated with distance from Flamingo increasing from psi (Ψ) 0 to > 0.93 over 150 km.

We captured and radio-collared 94 rabbits between September 14, 2012 and July 27, 2013. We translocated 45 rabbits to treatment (ENP) and procedural control (LOX) sites and captured and released 49 rabbits at our control site (FAK). Between September 14th, 2012 and January 3, 2013 we released 10 males and 5 females at CPT, 6 males and 9 females at ETS, and 4 females and 11 males at LOX.

In February 2013, we conducted pellet count surveys over 5 ha at the CPT (Coastal Prairie Trail) and ETS

(Eastern Taylor Slough) release sites. We detected juvenile and adult pellets at both locations. Adult pellet density was higher at the ETS study site (x= 3.06 per m^2) then at the CPT study site (x = 0.77 per m^2 ; $p = 0.01$) but we did not detect a significant difference between juvenile pellet densities ($p = 0.41$) (Table 3, Figure 8). In December 2013, we conducted 18 months post release pellet count surveys on the 5 ha surveyed in February 2013 and an additional 10ha and did not detect marsh rabbit pellets at ETS or CPT

SUMMARY:

Our results provide strong empirical support for the hypothesis that pythons are the cause of mammal declines in ENP. Our models suggest that no rabbits exists in the core area of the python invasion (<60km from Flamingo) and yet in wetlands > 150 km from the epi-center of the python invasion, the probability of marsh rabbit occurrence approaches 100%.

Although the drastic changes in marsh rabbit occurrence with distance from Flamingo supports the hypothesis that pythons are responsible for mammal decline in south Florida, this relationship was correlative rather than causative. Nonetheless, our reintroduction experiment in the GEE more clearly establishes pythons as the causative agent of mammal declines. Pythons were by far the dominant predator of rabbits in ENP, accounting for 77% of overall mortalities and 89% of mortalities for which a predator could be identified. This was in stark contrast to our control sites where rabbits were not depredated by pythons, and mammalian predators accounted for 50% of all rabbit mortalities. Only one rabbit mortality in ENP could be attributed to mammals. These results were consistent with reports suggesting the python invasion has led to drastic reductions of mammalian carnivores in ENP (Dorcas et al. 2012).

Assessing fish responses to water releases from Glen Canyon dam

Principal Investigator: **Bill Pine**
Funding Agency: USGS
Expected Completion: 08/31/2015 (RWO#283, UF PJ#00102863)
Graduate Student: Kristen Pearson

The USGS-Grand Canyon Monitoring and Research Unit facilitates, coordinates, and conducts a large number of research projects with numerous cooperators related to the biological, cultural, and physical resources of Grand Canyon. Currently RWO 282 as well as other work funded to the University of Florida by USGS-GCMRC ("Nearshore Ecology Project") has helped to provide additional information and analytical approaches to understanding juvenile fish population dynamics in Grand Canyon. A key need is to better integrate the historical and current data frames of research, particularly related to research efforts in the Little Colorado and mainstem Colorado Rivers related to humpback chub movement and survival. This information is then used to inform management actions to improve humpback chub population viability such as experimental water releases from Glen Canyon Dam.

OBJECTIVES:

A key need is to better integrate the historical and current data frames of research, particularly related to humpback chub movement and survival between the Little Colorado and mainstem Colorado rivers. We are working to better integrate this knowledge through assisting GCMRC staff and cooperators with data analyses including assessing trends in juvenile humpback chub from long-term capture-recapture programs in the mainstem Colorado River and Little Colorado River for juvenile humpback chub.

PROGRESS:
We estimated abundance and apparent survival of juvenile humpback chub in a ~2.5km study reach of the Colorado River below Glen Canyon dam. The most supported model (lowest AICc) of apparent survival is one in which survival is estimated separately for each study year (69, 46, and 30% for 2009, 2010, and 2011, respectively). All flow-dependent models (based on water releases from Glen Canyon dam) were poorly supported. Abundance of juvenile humpback chub in our study reach using both closed and open population methods fluctuated but generally increased during 2009-2011, with ranges of 338-4,042 and 1,537-7,006 individuals for closed and open models, respectively. Changes in apparent survival and abundance may reflect broader trends or simply represent inter-annual variation. Simulations demonstrated that our analytical approach should provide reasonable apparent survival and abundance estimates for juvenile humpback chub.

We also met with USGS Colorado Cooperative Fish and Wildlife Research Unit staff to discuss how to integrate their ongoing analyses of humpback chub recaptures from autonomous PIT tag antennas with ongoing USFWS capture-recapture efforts in the Little Colorado River. Currently the analytical framework is to use the recapture only framework of a Cormack-Jolly-Seber model to estimate survival from the PIT tag data only. We discussed using a Barker style model to estimate abundance as well by incorporating information from the USFWS sampling program concurrently with the PIT tag antenna recaptures. This is ongoing.

SUMMARY:
Our work also demonstrates that some individuals are surviving, growing, and recruiting in the mainstem Colorado River, a habitat formerly considered a sink for juveniles. These results are significant and demonstrate how new field efforts can inform operations of one of the most important dams in the US as well as aid in managing endangered fish populations in regulated rivers worldwide.

Genomic Analysis of Peripheral Blood Cells from Sturgeon Exposed to Oil and Oil-Related Chemicals

Principal Investigator: **Dr. Nancy Denslow**
Funding Agency: USGS
Expected Completion: 12/31/2014 (RWO#279, UF PJ#00103064)

This project is a small part of a larger project that is designed to supplement on-going field investigations of potential injury to adult Gulf sturgeon from the Deepwater Horizon (MC 252) Oil Spill. The main objective of the overall project is to develop a fish health assessment for gulf sturgeon. This will be done by first conducting a controlled, laboratory exposure of a surrogate sturgeon species to MC 252 oil for generation of positive-control blood samples. The exposure of these fish to overall PAHs will be quantified chemically to know the actual dose of exposure. The blood samples will be evaluated for DNA injury via flow cytometry and for immune dysfunction by measuring genomic responses. The specific portion of the project that will be performed at UF is to develop cDNA sequence information for immune dysfunction using next generation DNA sequencers and to use this information to create a microarray to quantify the immune gene expression dysfunction. Samples from laboratory exposed surrogate sturgeon species and oil exposed gulf sturgeon species will be evaluated by the microarray.

OBJECTIVES:
The specific objectives of the project at the University of Florida are to develop cDNA sequence information for liver, kidney and blood cells of the surrogate species Atlantic sturgeon and cDNA sequence from white blood cells of gulf sturgeon and then to use the sequence to create a microarray

for evaluating oil exposure in the gulf sturgeon species. The following specific objectives were developed for the project:

SOW 1. Preparation of Gulf sturgeon sequencing data

- a. Prepare normalized cDNA library from Gulf sturgeon blood samples.
- b. High throughput sequencing of the normalized cDNA from Gulf sturgeon using the 454 and the illumina massively parallel DNA sequencers at ICBR.
- c. Assembly and probe design

SOW 2. Microarray analysis

SOW 3. Verification of expression by Q-PCR

SOW 4. Reporting of the Results

PROGRESS:

Task 1: Obtain high quality RNA from Gulf Sturgeon and Atlantic Sturgeon blood and tissue samples. We have completed this task. Originally we had issues getting high quality RNA from white and red blood cells. The white blood cells worked best. Eventually, we developed a method to extract high quality RNA from red blood cells as well. The trick was to perform the extractions twice and then to use a cleanup column to remove matrix components that interfered with UV spectrometry readings. This approach has yielded RNA of sufficient quality for microarray analysis.

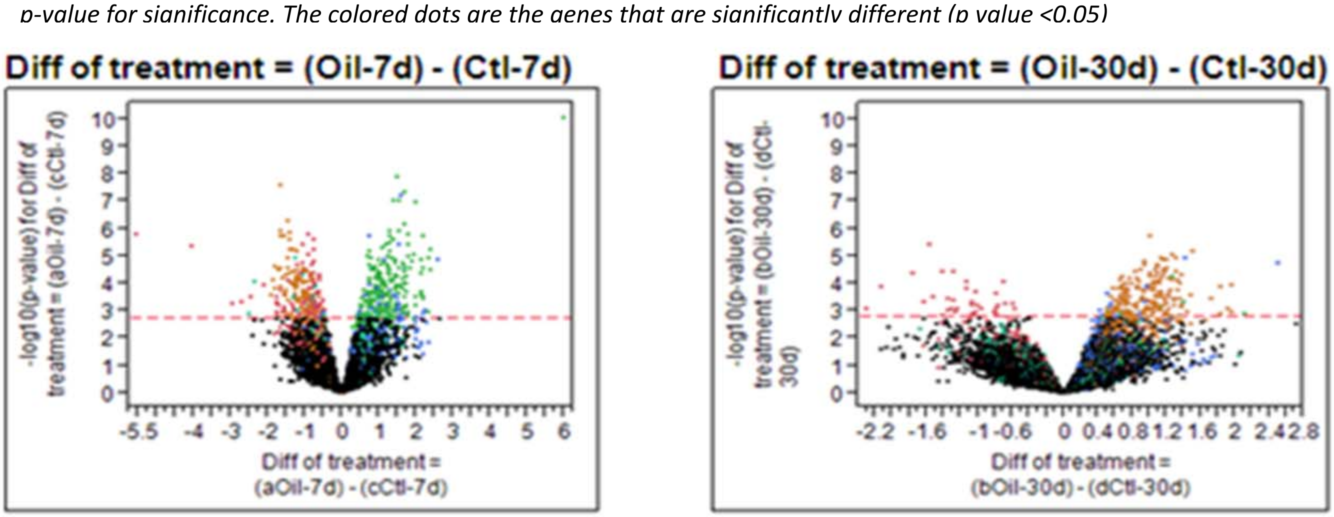
Task 2: To obtain a normalized cDNA library of Gulf Sturgeon and Atlantic Sturgeon. We have completed this task. Staff at ICBR performed this part of the project. We obtained over 8,000 high quality sequences with very good annotation for the Atlantic and Gulf sturgeon.

Task 3: To annotate the Gulf Sturgeon and Atlantic Sturgeon gene sequences. We have completed this task. Dr. Fahong Yu at the ICBR was able to assemble the high throughput sequencing reads and annotate both the gulf sturgeon and atlantic sturgeon transcriptomes.

Task 4: To design and use a microarray for Gulf/Atlantic Sturgeon. We have completed this task. Dr. Fahong Yu re-designed a second "immuno" microarray for shovelnose sturgeon for the laboratory exposures. This microarray was enriched with genes for the immune system. Then using the same format, he designed a microarray for the gulf sturgeon and used Atlantic

sturgeon sequences for genes that were lacking in the gulf sturgeon library. We tried to make the microarrays comparable to the "immuno" microarray.

Figure 1. Volcano plots showing changes in gene expression in white blood cells of shovelnose sturgeon exposed to oil for (A) 7 days and (B) 30 days. The volcano plot is the negative log of the p value on the Y-axis and log (2) of the gene expression on the x axis. The higher the number on the Y-axis the lower the p-value. Negative numbers on the x axis are genes that are down regulated and positive numbers are for genes that are up regulated. The doted line shows the p-value for significance. The colored dots are the genes that are significantly different (p value <0.05)



We performed microarray analysis on shovelnose sturgeon white blood cell samples from the laboratory exposure study. Samples of white blood cells were analyzed after 7 and 28 days of exposure to oil. Interestingly, many more genes were altered in the 7 day exposure group than at 28 days, suggesting that the fish had adapted to the oil conditions by 28 days (Fig. 1).

Some of the biological processes that are most affected for each of the treatment groups are shown in Table 1 along with their p-value from a Fisher Exact Test statistical analysis. It is clear that exposure to oil increases DNA recombination, suggesting that there has been some DNA damage to the white cells. In addition inflammation is unregulated as are several stress pathways.

Gene Ontology – Biological Process

- 7 day Oil vs Control

GO Process	P-Value
go:0006310; dna recombination	2.1171E-05
go:0007076; mitotic chromosome condensation	2.91392E-05
go:0006954; inflammatory response	0.002053514
go:0001666; response to hypoxia	0.002951717
go:0006968; cellular defense response	0.003205354
go:0007159; leukocyte adhesion	0.003205354
go:0008633; activation of pro-apoptotic gene products	0.011203422
go:0042744; hydrogen peroxide catabolic process	0.01920149
go:0030218; erythrocyte differentiation	0.032782696

- 30 day Oil vs Control

GO Process	P-Value
go:0006457; protein folding	3.46493E-05
go:0006310; dna recombination	4.47712E-05
go:0000724; double-strand break repair via homolo	0.009550017
go:0006950; response to stress	0.010415132
go:0010212; response to ionizing radiation	0.022187827
go:0030224; monocyte differentiation	0.022187827
go:0050852; t cell receptor signaling pathway	0.031521191
go:0042744; hydrogen peroxide catabolic process	0.033173443

Table 1. Biological Processes that are most affected by exposure to oil.

We are in the process of analyzing the red blood cells now and should have this analysis completed by mid-April.

We have also selected the gulf sturgeon samples from the field and are preparing high quality RNA samples from these for analysis by microarray in the near future.

Task 5: Verification of expression by QPCR. This task has not been completed as we are waiting microarray results for the field samples. We have selected a few genes and have primer sequences for these. We plan to select 5-6 additional genes for primer design once the field samples are assayed.

Task 6: Reporting of results. We have been in close communication with the laboratory of Dr. Don Tillitt. We shared the sequences (8,000 contigs for each, Atlantic Sturgeon and Gulf Sturgeon) with the Tillitt lab and are strategizing for how to go forward with the project. The final report will be delayed because the project has been delayed.

SUMMARY:

Initial studies by collaborators suggest that there is immune dysfunction in fish that were exposed to the oil from the Deep Water Horizon spill into the Gulf of Mexico. The Gulf Sturgeon are an endangered species and immune dysfunction is likely to result in major health issues for these sturgeons, possibly impacting them at the population level. Data from the microarrays suggests that exposure to oil causes cellular injury, including DNA damage and oxidative stress.

Genomic analysis of tissues from sturgeon exposed to oil and oil-related chemicals

Principal Investigator: **Dr. Nancy Denslow**
Funding Agency: USGS
Expected Completion: 12/31/2014 (RWO#286, UF PJ#00110588)

This project is part of the overall assessment by USGS to determine potential injury to Gulf sturgeon from exposure to oil from the Deepwater Horizon oil spill in 2010. This portion of the project is to investigate changes in gene expression in livers from animals that were exposed to Macondo oil in the laboratory. The liver samples are from the same animals that provided blood samples. The overall objective of this project was to investigate gene expression changes in the liver of laboratory exposed fish. The gene expression changes will be correlated with changes in red and white blood cells from the same fish.

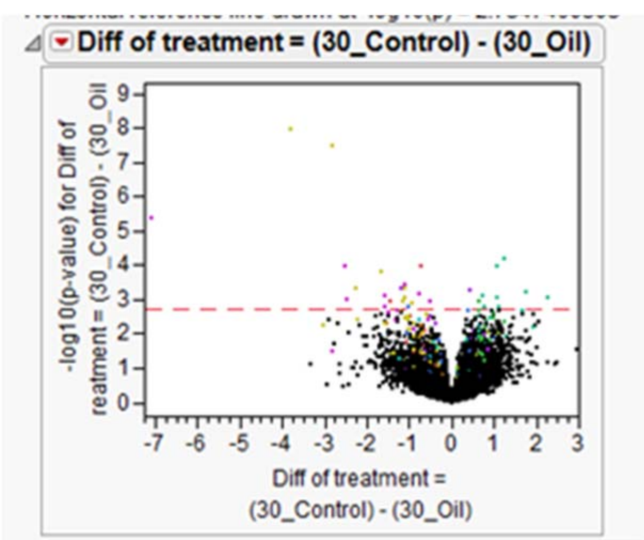
OBJECTIVES:

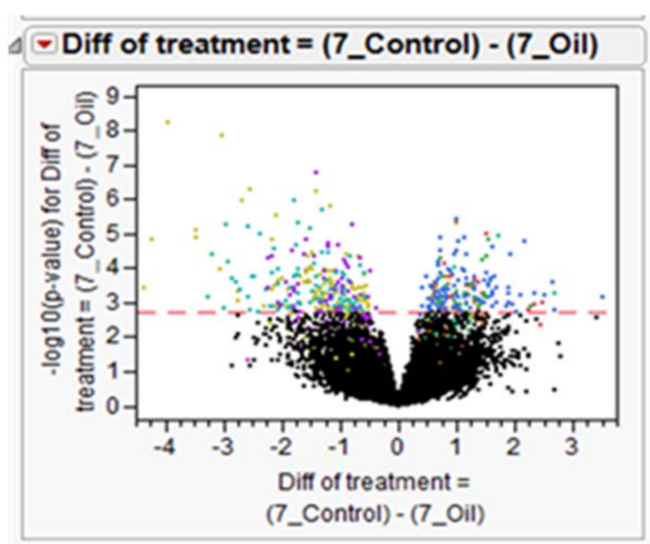
SOW 1: Microarray analysis of sturgeon liver samples from fish exposed to oil compared to control fish
SOW 2: Verification of expression by Q-PCR
SOW 3: Pathway analysis of genes that are altered by oil exposures.

PROGRESS:

SOW 1: Completed

We prepared high quality total RNA and have performed the microarray analysis. We got excellent results that match the results seen for the white blood cells. The 7-day exposure seemed to cause more changes in gene expression than the 30-day exposure (Fig. 1), suggesting that the fish acclimate somewhat to the exposures by sub-chronic exposure to oil.





Gene Ontology – Molecular Function

- 7 day Oil vs Control

GO Function	P-Value
go:0003906; dna-(apurinic or apyrimidinic site) lyase activity	1.74E-06
go:0003684; damaged dna binding	0.004107

- 30 day Oil vs Control

GO Function	P-Value
go:0016491; oxidoreductase activity	0.000162
go:0005179; hormone activity	0.001065
go:0016493; c-c chemokine receptor activity	0.031815
go:0016494; c-x-c chemokine receptor activity	0.031815

Using a strict interpretation of the data with a p value < 0.05 and a FDR of 5% and looking only at genes that are changed by >1.2-fold, we found 157 genes changed in fish exposed to oil for 7 days compared to controls and only 12 genes in fish exposed for 30 days.

In Table 2, we list the cell processes that are most affected by the treatments. As for the white blood cells, we see DNA damage as one of the processes affected by oil exposure. At 30 days we see more generalized repair.

SUMMARY:
It is important to note that the changes see in gene expression in the liver are similar to changes seen in white blood cells in the same animals. These animals were exposed to known concentrations of oil in a laboratory setting. These samples will serve as a comparison for the changes we see in wild Gulf sturgeon that have been exposed intermittently to oil. Data from microarrays suggests the exposure causes DNA damage and immune dysfunction.

Reassessing the status of the endangered Florida salt marsh vole, Phase 1 and 2

Principal Investigator: **Robert McCleery**
Funding Agency: US FWS
Expected Completion: 9/30/2013 (UF PJ#00105158)

Executive Summary:
We have made significant advances in both predicting and detecting the presence of the endangered Florida salt marsh vole. Using a remote sensing model based on known vole locations and our ecological knowledge of vole habitat, we delineated 271 ha of potential habitat patches along the coast of the Big Bend, FL. To validate this broad habitat model we randomly sampled potential habitat (35 sites) with a

novel camera trap. From camera trapping we estimated voles occurred on 0.254 (95% CI 0.115- 0.473) of the potential habitat (68 ha). Modeling the occupancy of voles we found that increased height of vegetation increased of probability of vole occurrence. Additionally we used classification and regression tree (CART) model to further pinpoint voles preferences within our broad habitat model. The CART model indicated that voles are found in patches > 0.5 ha and with a percent cover of *S. alterniflora* between do we understand the vole's use of habitat, population dynamics, or response to management. Our ability to study the species has been hindered by the accessibility of their habitat, the vole's patchy distribution, and adequate trapping techniques. Nonetheless, recent successes by the USGS and the University of Florida have shown that it is possible to conduct meaningful research on the voles and significantly increase our knowledge of this rare species. Our intent is to provide missing life history information and determine the extent of the vole along the Big Bend, all of which could lead to reassessing the status of the vole. We also have the ability to concurrently monitor for the Gulf salt marsh mink (*Neovison vison halilimnetes*), that was common in the early 1900's but has recently only been identified in the Big Bend area by road kill and few other sightings. A mink was recently captured in vole bucket camera traps indicating another opportunity should traps baited specifically for mink prove useful. The mink is of particular regional interest as a mammal species of greatest conservation need for the Florida Fish and Wildlife Conservation Commission. Mink are indicative of excellent marsh habitat, water quality, and undisturbed areas. This is an excellent opportunity to monitor for two important marsh species, and will provide LSNWR leadership the information they need to manage for Florida salt marsh voles and mink currently and in the face of sea level rise-related changes to the refuge.

Objectives:

These objectives address two of the five management goals for LSNWR: to expand scientifically based monitoring and research to support management decisions regarding wildlife habitat and populations; and to restore, conserve and enhance the natural abundance, and ecological function of refuge habitat, with an emphasis on managing habitat to benefit threatened and endangered species. These also address several of the USFWS Vole Recovery Plan objectives.

1) Determine the extent of vole habitat and occurrence along the LSNWR and Waccasassa Bay State Park.

2) Estimate the size of the populations within LSNWR: The number of failed attempts to detect voles leads us to believe that, like many rodent populations, voles fluctuate both seasonally and annually. To better understand these dynamics and the factors influencing them, we will establish a long term monitoring grids on Long Cabbage Key and 4 other sites that will be trapped 1 time a year for 5 nights.

3) Determine extent of vole patch use: We know that voles are found in patches of *Distichlis/Spartina* habitat throughout the salt marsh, but other subspecies of meadow vole (*Microtus pennsylvanicus*) have been detected in different vegetative communities within tidal marshes (Harris 1953). Thus, we are uncertain as to the extent of vole habitat usage and the factors limiting their distribution in the marsh.

4) Understand vole movements and behavior: We will radio-track 10-15 voles at random times in 5 vole sites for 6 weeks to determine their habitat preference, their home range, and movement during tides.

5) Evaluate the potential to monitor for the Gulf salt marsh mink with camera traps, another rare species that is indicative of good habitat and water quality.

6) Develop primers for the salt marsh vole that will allow for future studies using on population dynamics using molecular techniques.

Objective 1: We used remote sensing and spatial models to determine the extent of vole habitat and occurrence along the LSNWR and Waccasassa Bay.

To determine the extent of vole habitat, first, we developed a predictive map of potential vole habitat. We developed the map by obtaining RGB aerial photography of the Big Bend (0.3 m resolution) from the state of Florida, and mosaicking the images using ERDAS Imagine software, creating one image from the mouth of the Suwannee River to 7 km south of the Waccasassa River. We generated 30 training samples from patches of known vole habitat (*S. alterniflora* and *D. spicata* mix) and used these samples to classify the full extent of our coastline image using spectral and texture characteristics with Feature Analyst for ArcGIS 10.1. We deleted all polygons under 0.25 hectares, as that was what we considered the smallest useable habitat patch for the vole. In total, the estimated that there were 271 ha of potential habitat within our study site (Figure 1).

17 and 43%. Additionally, we used 6 nights of live trapping data for a trapping grid on Long Cabbage Key to estimate a population of 26 (95% CI 20 - 48) individuals. With a patch size of 1.6 ha we roughly estimated the density of voles on Long Cabbage to be 16.25 voles/ha. However, it is important to note that this patch likely represents the highest possible range of voles densities, as our other areas produced few or no captures. To determine if voles used vegetative communities other than those from our model (dominated by *S. alterniflora* and *D. spicata*) we conducted a gradient study. We found that vole activity decreased significantly with distance into the *Juncus sp.* community (B = -0.0103, SE =0.0014, $p < 0.001$) suggesting that vole activity is indeed centered on patches of *S. alterniflora*/*D. spicata* vegetation. Nonetheless, the reduction in vole activity across the ecotone was gradual and the *Juncus sp.* community was clearly utilized by voles. Trapping on 35 sites for voles we detected mink on 13 sites and estimated their rate of occupancy on our study site to be high at 0.64 (95% CI 0.25- 0.90). Finally, we developed microsatellite markers and screened them on 20 voles from Long Cabbage Key

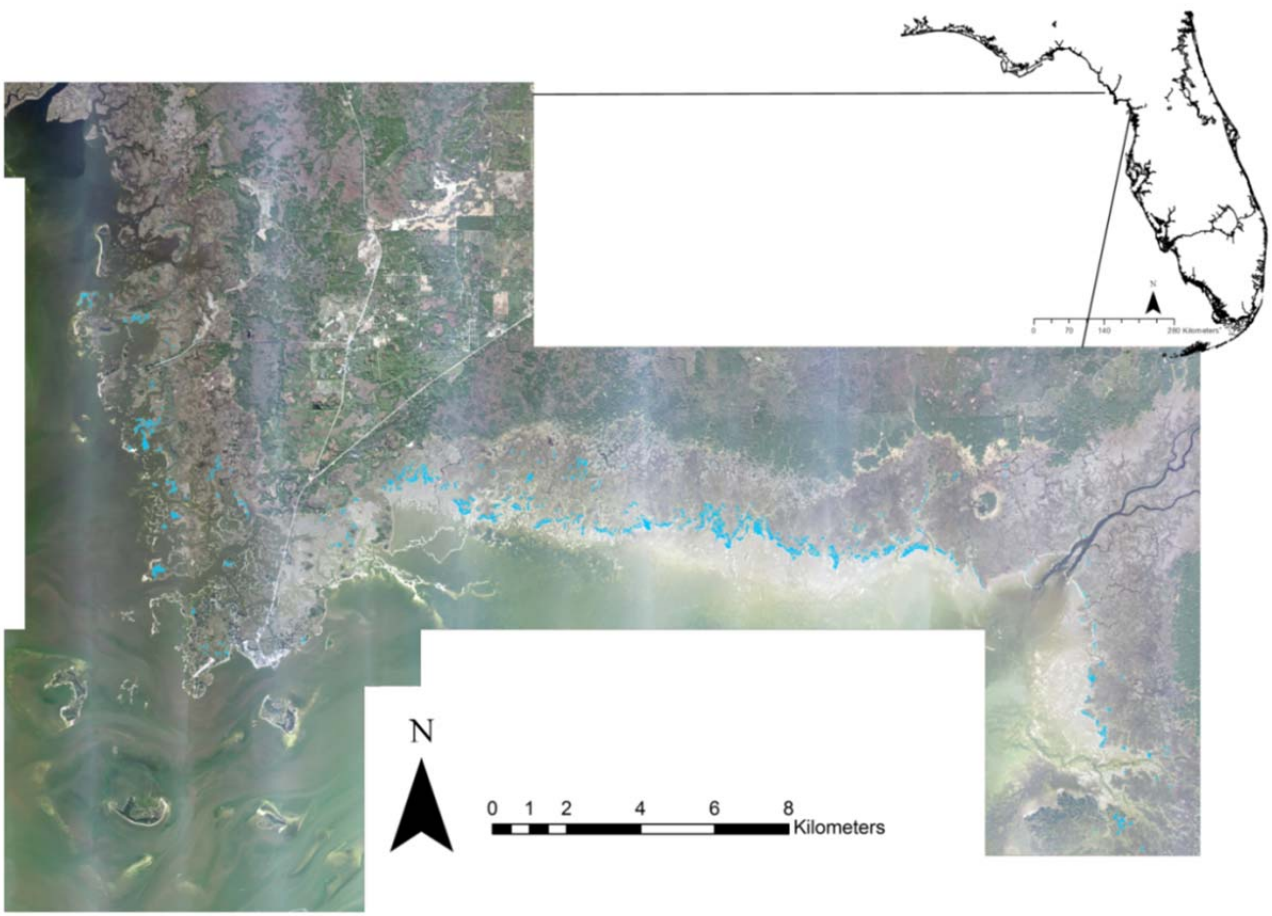


***Figure 1**. Model of potential Florida salt marsh vole habitat (blue polygons) from spectral and texture characteristics from RGB aerial imagery (shown) on the west coast of Florida, USA*

(N=17) and E-421 (N=3). Marker development was successful in detecting polymorphism within and among vole samples and will provide a useful suite of markers for future efforts in understanding the geographic and biotic factors structuring vole populations and those limiting or facilitating connectivity among habitat patches.

Purpose:

The federally endangered Florida salt marsh vole (*Microtus pennsylvanicus dukecampbelli*) is possibly the least understood endangered mammal in North America (Hotaling et al. 2010). The lack of information on the vole greatly constrains managers' abilities to conserve this endangered species. This subspecies of meadow vole (*M. pennsylvanicus*) is known from only three sites in Levy County, Florida. Since 1979, when this subspecies was discovered, only 43 individuals have been captured. This is mostly from the type location in the Waccasassa Bay area, 3 from Raleigh Island, and 2 from Long Cabbage Key in the Lower Suwannee and Cedar Keys National Wildlife Refuge (LSNWR). The LSNWR captures are within 5 miles of the original capture site, suggesting that the vole may persist throughout the salt marshes of central Florida's gulf coast. Other than captures at these three sites, we know nothing about the species' distribution throughout the salt marshes of the Big Bend, particularly LSNWR, nor

To evaluate this habitat model we randomly selected 35 random polygons (Table 1) and trapped them for 7 nights with 20 cameras traps (4900 trap nights) to detect vole presence. Voles were 'captured' at 8 of these sites. Together with 5 confirmed vole sites we discovered in 2012 we effectively increased the known number of sites by more than 500% (Figure 2), doubling the size of the vole's known range. Still, to better understand what environmental features voles were utilizing we collected vegetation data at 29 of the 35 site and used this information along with remotely collected data to further refine our habitat model using occupancy and classification and regression tree modeling.

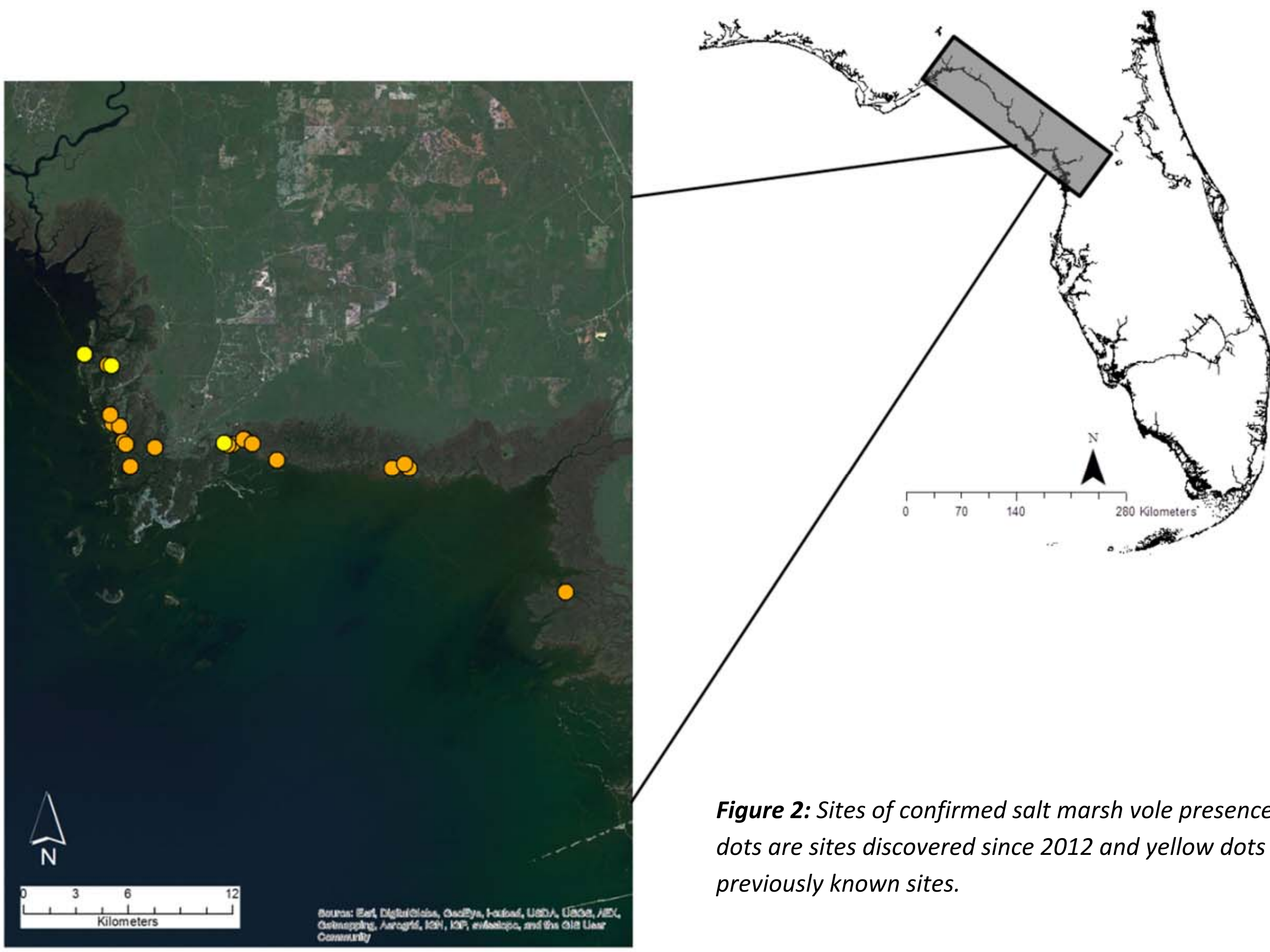


Figure 2: *Sites of confirmed salt marsh vole presence. Orange dots are sites discovered since 2012 and yellow dots are previously known sites.*

We used an occupancy modeling approach to determine the features that were influencing the detection and occurrence of vole. First, we examined variables that we believed would influence the probability of finding a vole if it was present (*p*:detection). We compared models that accounted for variation in the probability of detecting a vole during the first night (*first night*), each night (*night*), and during the second half of the capture session after voles became acclimated to the traps (*increase*: night 4-7). We also evaluated models that compared patch size (*area*), percent cover of *S. alterniflora* (*spart*). Based on AIC scores our best model (Table 2) suggested that the amount of *Spartina sp*. in a patch decreased the probability of detecting a vole and that the probability of detecting a vole increased during the second half of the trapping session. Overall the probability of detecting a vole (if it was present) on one of the 20 camera traps increased from 0.43 per night (nights1-3) to as high as 0.70 (nights 4-7). Thus, the overall probability of detecting a vole if it was present after 7 nights of trapping was approximately 0.99.

Table 1. Coordinates of 35 randomly selected sites (UTM, WGS83) from remote sensing model for Florida salt marsh vole. The table shown presence (1) of voles and mink on each site.

Site	Zone	X	Y	Vole presence	Mink Presence
10	17 R	298933	3234031	0	0
11	17 R	299694	3229389	0	0
12	17 R	298575	3230560	1	0
17	17 R	297966	3232485	0	0
A-143	17 R	305597	3229370	0	0
B-221	17 R	316045	3227940	0	0
C-220	17 R	315017	3227960	0	0
D-421	17 R	300002	3228143	0	1
E-130	17 R	306508	3229695	1	0
F	17 R	325060	3220658	0	0
F-411	17 R	299366	3230500	0	0
G	17 R	325186	3220228	0	0
G-418	17 R	301395	3229283	0	1
H	17 R	324552	3219987	1	1
H-207	17 R	315772	3228196	0	1
I-141	17 R	307000	3229456	0	0
J	17 R	323859	3218151	0	0
J-407	17 R	298802	3231090	1	1
K	17 R	324579	3217995	1	0
K-191	17 R	308411	3228515	0	1
L	17 R	325398	3217881	0	1
M	17 R	326219	3218089	0	0
N	17 R	327325	3217499	1	0
O	17 R	299687	3233453	0	0
P	17 R	298849	3231310	1	1
Q	17 R	307941	3228820	0	1
R	17 R	308453	3228910	0	1
R-396	17 R	298701	3234055	0	0

S	17 R	319399	3227820	0	0
T	17 R	309299	3228870	0	0
U	17 R	311389	3228200	0	0
V	17 R	315595	3228242	0	1
W	17 R	317252	3227970	0	1
X	17 R	305877	3229520	0	1
Y	17 R	324712	3224504	1	0

Table 2. *Comparison of models for the detection (p) of voles with occupancy (psi) held constant, on vole camera trapping grids. Models ranked based on relative AIC scores. Models included parameters that varied over time (first night, night, increase) and by site(spart, area)*

Model	AIC	ΔAIC	AIC wgt
psi(.),p(spart, increase)	94.08	0	0.504
psi(.),p(spart)	95.12	1.04	0.2997
psi(.),p(area)	97.58	3.5	0.0876
psi(.),p(increase)	98.6	4.52	0.0526
psi(.),p(.)	99.31	5.23	0.0369
psi(.),p(first night)	101.07	6.99	0.0153
psi(.),p(night)	103.78	9.7	0.0039

After determining which model best explained the factors influencing the detection (p) of voles we used it as a base model to evaluate the factors influencing the occurrence (psi) of voles. In addition to the percent cover of *S. alterniflora* (spart) and the size of the patch (area), we evaluated models that accounted for distance to tree line (*distKM*), percent cover of *D. spicata* (*dist*) and *Juncus sp*. (*juncus*), average height of the vegetation (*veg ht*), and visual obstruction (*vo*: a measure of vegetation density).

We found that the height of vegetation (*veg het*) was the best model for predicting the occurrence of voles within our broader habitat model (Table 3). There was a positive relationship between vegetation height and the occurrence of voles with the probability of occurrence increasing to > 50 % with vegetation > 73 cm (Figure 3). The increased vegetation height might be important for voles to provide cover and to create tunnels as they move through the marsh. Research suggests that increase vegetative cover appears to be important to meadow vole survival in other environments (Adler and Wilson 1988).

The overall, probability of vole occurrence in the area covered by our broad habitat model was 0.254 (95% CI 0.115- 0.473). As such, we believe that this endangered species previously known from only 3 locations likely occupies approximately 68 ha of marsh habitat around cedar key Florida.

Model	AIC	ΔAIC	AIC wgt
psi(veg ht),p(spart, increase)	93.29	0	0.2779
psi(.),p(spart, increase)	94.08	0.79	0.1872
psi(vo),p(.spart, increase)	94.4	1.11	0.1595
psi(area),p(spart, increase)	95.45	2.16	0.0944
psi(juncus),p(spart, increase)	95.98	2.69	0.0724
psi(dist),p(spart, increase)	96.04	2.75	0.0703
psi(distKM),p(spart, increase)	96.07	2.78	0.0692
psi(spart),p(spart, increase)	96.07	2.78	0.0692

Table 3. *Comparison of models for the occupancy of voles (psi) with detection (p) held constant, on vole camera trapping grids. Models are ranked based on their relative AIC scores. Model included variables that varied by patch (cover from S. alterniflora [spart], D. spicata [dist] and Juncus sp. [juncus], size of the patch [area], distance to tree line [distKM], average height of the vegetation [veg ht], and visual obstruction [vo])*

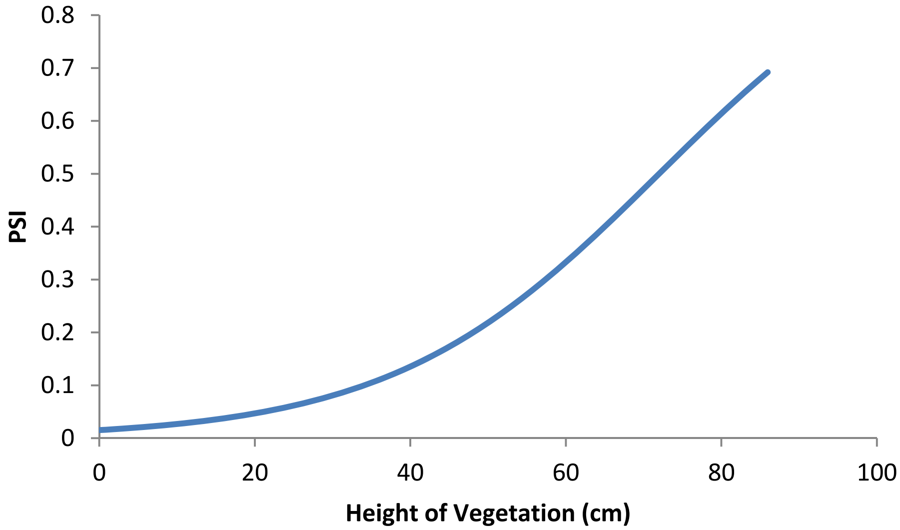


Figure 3. Predicted response of vole occupancy (PSI) as a function of vegetation height from the best fitting model of vole occupancy (PSI).

To further understand what areas were most likely to have voles within our broader habitat model we developed an additional predictive model of salt marsh vole habitat. We created this model for using a CART model with the program Salford Predictive Modeler v 7.0. CART models utilizes a non-parametric, machine-learning approach that partitions data into previously defined classes (voles present or voles absent) by environmental characteristics (vegetation data, habitat patch size, distance from site to the shoreward tree line, and spatial position) and develops a decision tree-like structure used to predict presence or absence at unknown data points.

The model we developed (Figure 4) performed exceptionally well with an overall predictive rate of 93%. The two most important variables were patch area and percent cover of *S. alterniflora*. The CART model indicated that voles were found in patches predicted > 0.5 ha and with a *S. alterniflora* cover of between 17 and 43%. This model along with our occupancy model provides excellent guidance for identifying vole habitat within our broader habitat model. We will re-parameterize our original model to exclude patches < 0.50 ha; however, on the ground data collection will be necessary to determine if the patches have the appropriate vegetation height and *S. alterniflora* cover.

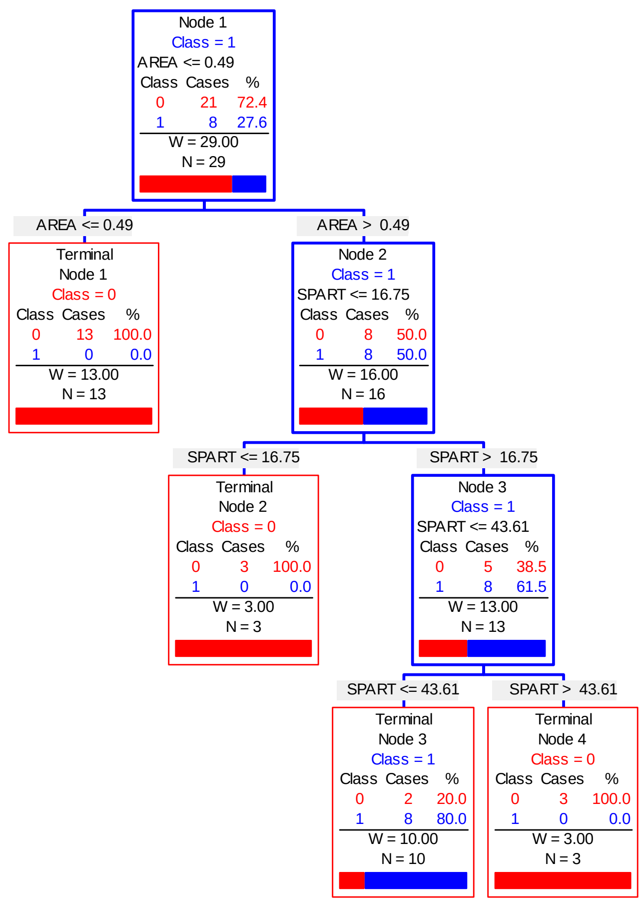


Figure 4. *Classification and regression tree model for salt marsh vole habitat. Class 0 = habitat with no surveyed voles and class 1 = habitat with confirmed vole sightings. Model indicates that voles are found in patch sizes above 0.5 ha and with a percent cover of Spartina alterniflora between 17 and 43%.*

Objective 2: We live trapped at 5 locations known (from camera trapping) to have voles. At each site we established a 96 trap grid in 8 x 12 configuration with traps spaced 10 m apart. Traps were placed on floats to accommodate daily tides and baited with a bird seed mixture. Each gird was trapped for at least 4 nights. We individually marked each rodent that was captured and recorded their species, sex, weight, and hind foot length.

After 4 days of trapping we recorded rice rats (*Oryzomys palustris*) on all the grids but only 2 of the girds recorded vole captures (Table 3) with most of those captures occurring on Long Cabbage key. In an effort to at least generate a reliable population estimate for Long Cabbage Key we extended the trapping session for 2 additional nights (6 total) to obtain more recaptures. In total, we captured and tagged 17 voles from Long Cabbage Key and 4 from patch E-421.

To estimate the population size on the patch of habitat on Long Cabbage Key we developed Huggins mark and recapture models in program MARK (White and Burnham 1999) that accounted for factors that influence the probability of capture (vole behavior, size, and sex and the influence of trap nights). Our best model indicated that the individual night of trapping had a strongest influence on the probability of capturing a vole, ranging from 0.04 – 0.39 depending on the night. From this model we estimated a population of 26 (95% CI 20 - 48) individual. With a patch size of 1.6 ha we roughly estimated the density of voles in this area to be 16.25 voles/ha. However, it is important to note that this patch likely represents the highest possible range of voles densities, as our other areas produced few or no captures.

Table 4: *Summary of number of animals captured and tagged during live-trapping. Site names correspond with sites from Table 1.*

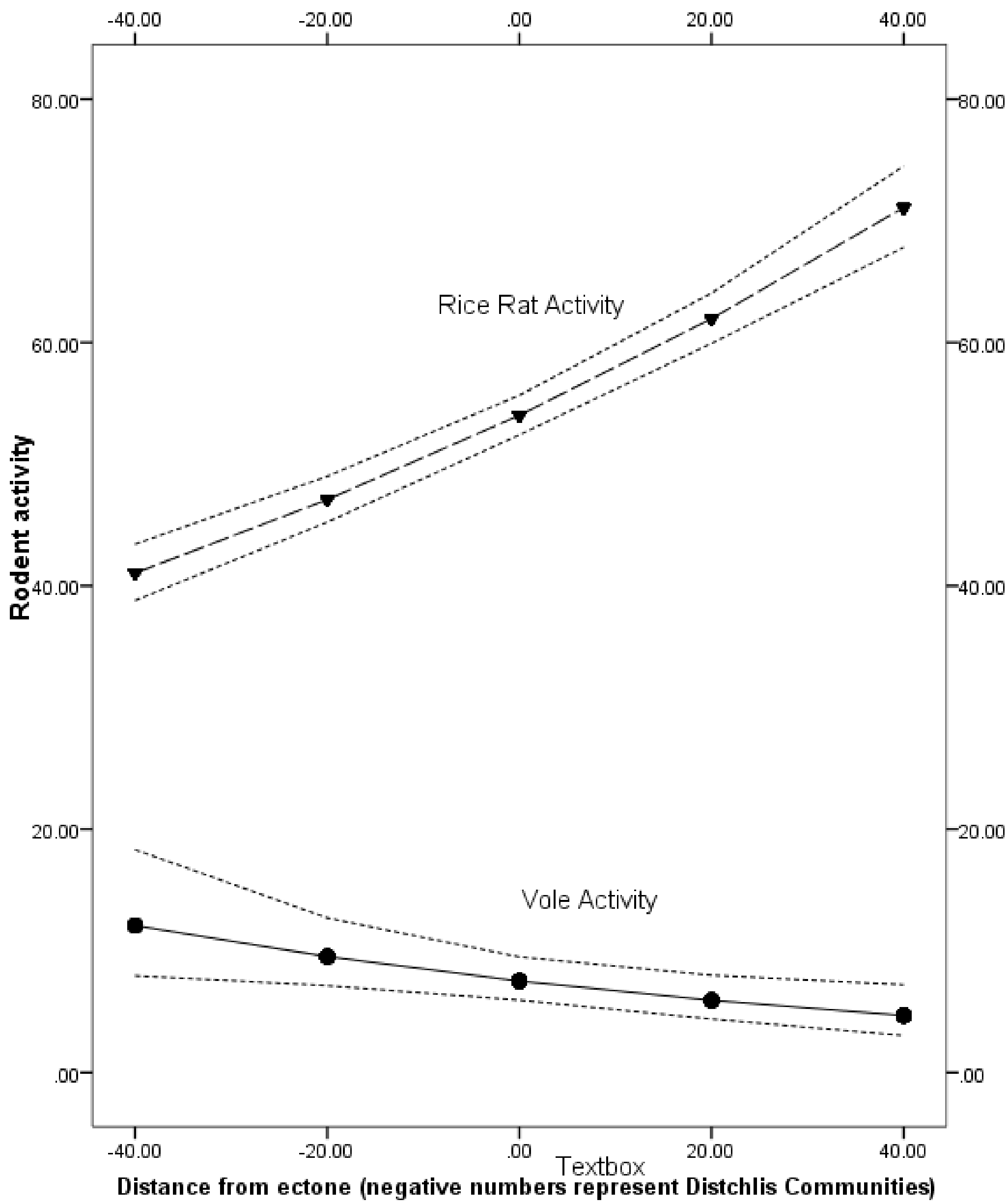
Site	Cotton rat	Rice rat	Vole
E-130	0	12	0
D-421	0	1	4
Long Cabbage	5	26	17
J-407	0	10	0
12	0	6	0

Objective 3: All of our habitat models assume that vole do not occur outside of patches that are dominated by *S. alterniflora* and *D. spicata*. To test if voles use other vegetative communities we conducted a gradient study to examine the activity levels of voles and rice rats. We established four transects on 5 sites of known vole occurrence. Each transect consisted of 5 camera traps placed in a line running across an ecotone, from a *S. alterniflora*/*D. spicata* patch into a patch dominated by *Juncus sp.* The cameras were spaced 20 m apart, starting 40 m in the *S. alterniflora*/*D. spicata* patch and running 40 m into the *Juncus sp*. community. We trapped each transect for 7 nights. We recorded independent activity events for voles and rice rats when an individual was observed After a picture we did not record another new detection until the same species had not been pictured for 15 minutes.

To analyze our results we used a generalized-linear mixed model to determine if vole and rice rat activity changed across the ecotone. Using a mixed modeling approach allowed us to account for the lack of independence among cameras on the same transect. Using only sites where voles were captured (4 of the 5 sites) we found that vole activity decreased significantly with distance into the *Juncus sp.* community (B = -0.0103, SE =0.0014, $p < 0.001$). Alternatively, rice rats showed greater activity and increased significantly with distance into the *Juncus sp.* community (B = 0.0069, SE =0.0005, $p < 0.001$) (Figure 5).

Our results suggest that vole activity is indeed centered on patches of *S. alterniflora/D. spicata* vegetation. Nonetheless, the reduction in vole activity across the ecotone was gradual and the *Juncus sp.* community was clearly utilized by voles. As such, the amount of habitat available to voles may be greater than what we estimated with our models. However, further research will be needed to determine if *Juncus sp.* communities are sub-optimal habitat for voles. Additionally, it will be important to understand why voles concentrate their activity in *alterniflora/D. spicata* vegetation, food resources, cover or other factors such as completion from rice rats.

Figure 5. Predicted and 95% CI values from a generalized-linear mixed model of vole and rice rate activity across an ecotone from S. alterniflora/D. spicata into Juncus sp.



Objective 4: We attempted to capture voles and fit them with a radio collar to observe habit use, movements and behavior, but the sensitivity of the vole to handling (and subsequent mortalities) led us to discontinue this part of the study. Future studies should not try and radio tag females in late March and early April at the height of their reproductive period and should consider anesthetizing the animals prior to handling.

Objective 5: Trapping on 35 sites for voles we detected mink on 13 sites (Table 1, Figure 6). We generated the only known photographs of the Gulf salt marsh mink in its native habitat (Figure 7) and believe we have an excellent tool to further investigate their distribution and ecology. From our preliminary analysis we estimated the probability of detecting a mink if it was present to be 0.11 for a survey night (20 camera trap grid) and 0.56 for week long survey. Additionally, we estimated the rate of occupancy of mink on our study site to be high at 0.64 (95% CI 0.25- 0.90).

There was no obvious relationship between vole and mink on our sites but out preliminary analysis suggested the probability of mink occurrence was negatively correlation with the amount of *D. spicata* cover on grid and positively correlated with the amount of *Juncus sp* on the trapping grid. This might suggest that mink are more common in the areas where rice rats activity is greatest. Regardless for the reason for this pattern it is clear that mink were relatively common within our study site.

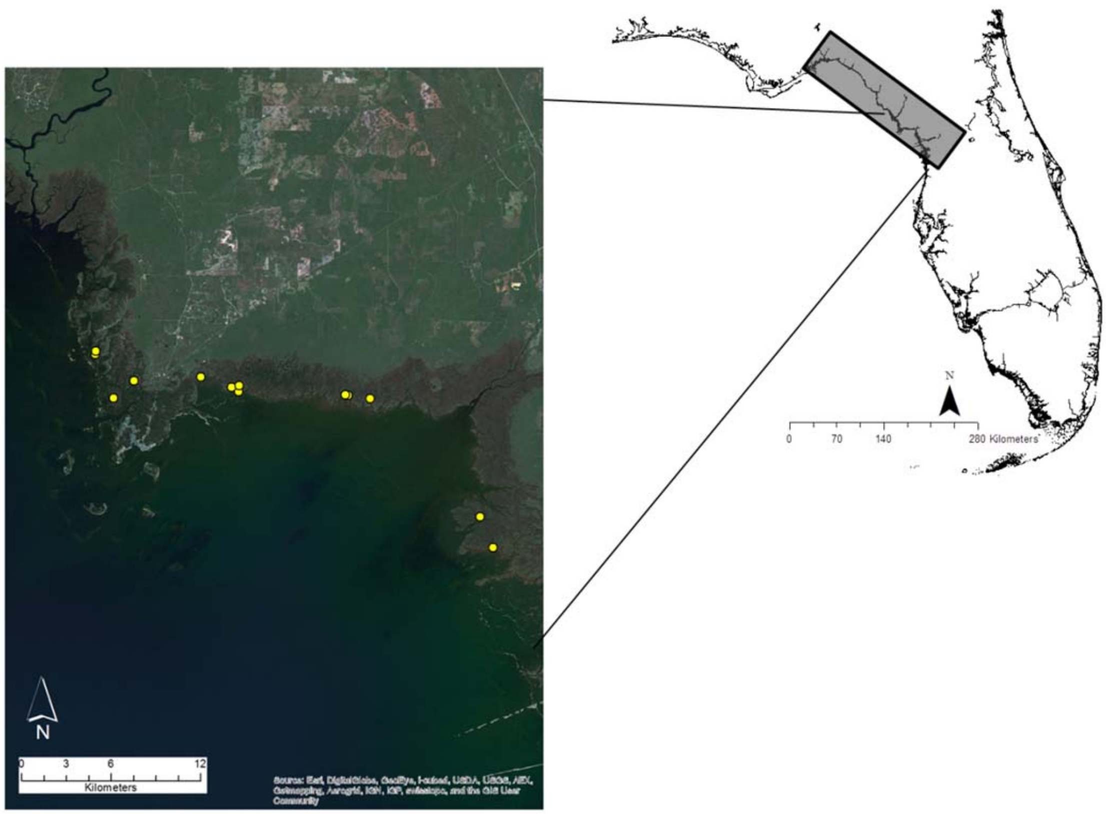


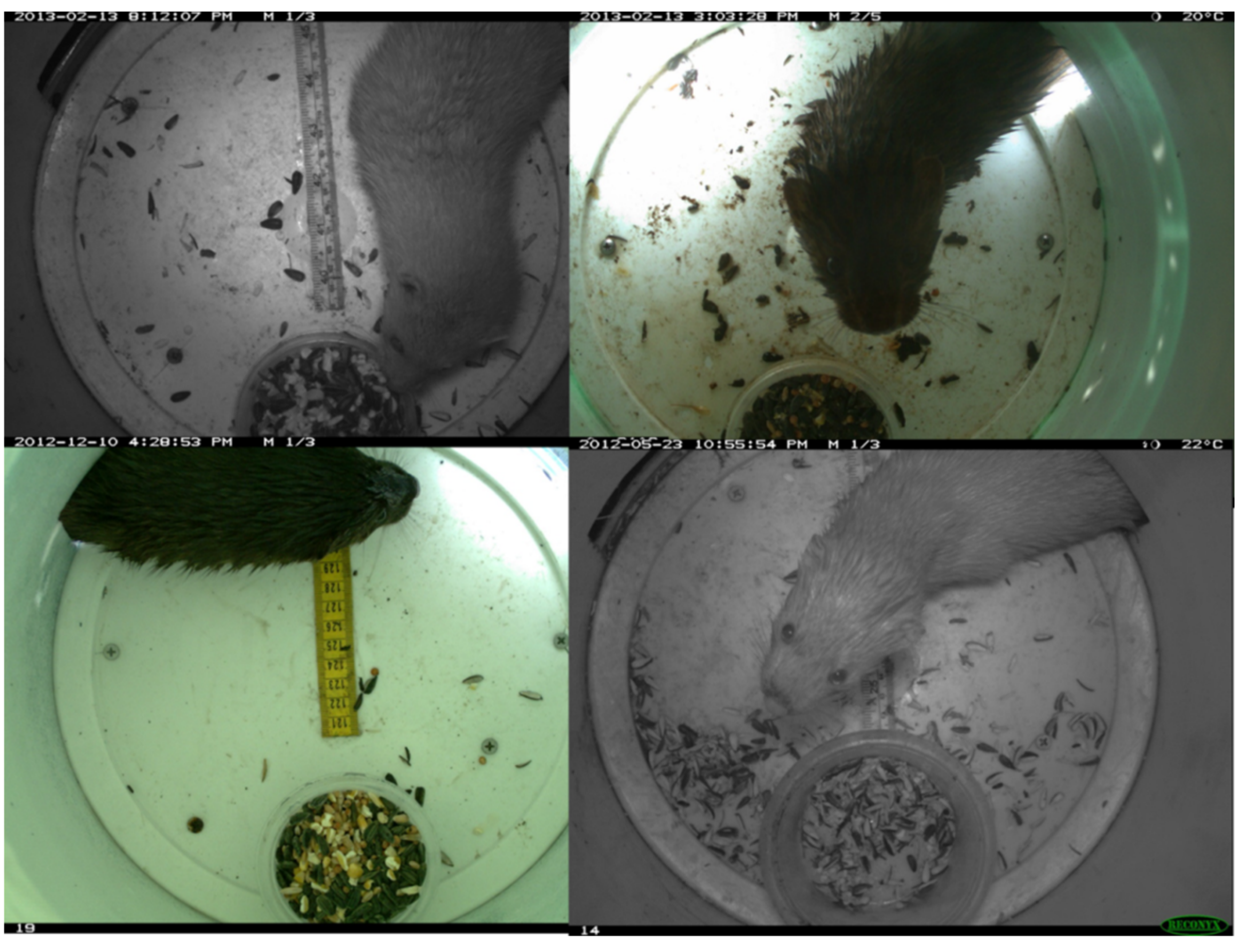
Figure 6. *Confirmed sites where Gulf salt marsh mink are present.*

Objective 6: Future research into distribution and demographics of salt marsh voles could be enhanced with the inclusion of genetic tools to evaluate genetic population structure, sub-population connectivity, and to evaluate population history (among other objectives). To this end, we developed microsatellite markers and screened them on 20 voles from Long Cabbage Key (N=17) and E-421 (N=3).

Genomic DNA for sequencing was extracted from muscle tissue (University of Florida Museum of Natural History, voucher #32239) using the Qiagen DNeasy 96 Blood and Tissue kit, spin-column protocol (Qiagen, Valencia, California, USA). We used single molecule real-time sequencing (SMRT, PacBio), performed at the University of Michigan to obtain sequences for microsatellite searches. Sequence reads were searched for repeats using Msatcommander 0.8.2 (Faircloth 2008). We limited our search of 8798 sequence reads for repeats to di-tri- and tetra-nucleotides with 14 repeats. We restricted our loci for primer design to longer repeats due to the lack of polymorphism at protein loci (Woods et al. 1982), which may reflect genetic-level reduced polymorphism. In addition, the primary future objective is studying population connectivity, therefore we targeted loci with greater potential for variation, at the risk of biasing neutral genetic diversity indices.

Twenty-one of thirty microsatellite loci with di- tri- and tetra-nucleotide repeat motifs (Table 1) were characterized via polymerase chain reaction (PCR). Nine loci either failed to amplify or had problematic peak morphology and were not considered further. PCR amplifications and thermocycler conditions followed those in Saarinen et al. (2010). We used GENEPOP on the Web (v.4.2; http://genepop.curtin.edu.au; accessed Dec 23, 2013) to test for linkage disequilibrium (LD) and deviations from Hardy–Weinberg equilibrium (HWE), applying Bonferroni corrections for multiple tests (= 0.05). We calculate allelic diversity and heterozygosity statistics using GenAlEx 6.5 (Peakall and Smouse 2006). We used LDNe 1.31 to estimate the unbiased contemporary effective population size (N_e) of Long Cabbage Key voles.

The Long Cabbage vole population was in HWE overall (^{2} = 16.95, df = 30, P = 0.97), with no deviations from HWE. The population was in LD, with no significant locus-by-locus pairwise comparisons after Bonferroni correction. The number of alleles at each locus (Long Cabbage Key) averaged 2.81; H_O averaged 0.390 and HE averaged 0.361. We observed five private alleles at five loci (Table 1) in the three voles sampled from E-421. Given the relatively large size of the Long Cabbage sample, the private alleles detected in E-140 suggest that these loci will useful in detected differentiation at scales < 7 kms. The N_e estimate was 10.7 (95% C.I 6.1-20.1). This estimate is within the expected range for N_e given the demographic estimate of number of individuals of 26 as the Ne/N ratio is expected to be well less than 0.5 in most endangered species (Kalinowski and Waples 2002). It is important to note that this estimator reflects the effective size of the breeding population that produced the sampled generation, and assumes that genotyped individuals were adults. Deviations from this (i.e. structured age classes) could result in over-estimates of N_e. Regardless, the effective population size appears to be low for this patch.



In summary, marker development was successful in detecting polymorphism within and among vole samples and will provide a useful suite of markers for future efforts in understanding the geographic and biotic factors structuring vole populations and those limiting or facilitating connectivity among habitat patches.

Locus	**Repeat motif**	**Primer sequence (5'–3')[1]**	**Size**	***A****	A_E	H_O/H_E	F_{IS}
Mp2573	$[AAG]_{41}$	TGGCCCTGAATTGTTATTTGA CAGACATACAGATACAGACACATGC	220-244	7(8)	4.38	0.824/0.772	-0.067
Mp15592	$[GT]_{33}$	TGGCCCTGAATTGTTATTTGA CAGACATACAGATACAGACACATGC	196-202	3(4)	1.83	0.353/0.455	0.224
Mp17138	$[GA]_{37}$	AAATGCTTATGGTGGGCAAC CTCTCTCCCCACACCCACTA	160-170	3	1.35	0.294/0.258	-0.141
Mp23837	$[AG]_{37}$	GAACAAGAACGAAAGAACAAATGA CTGGTGAGTGCTCCCAAGAT	223-231	4	2.17	0.647/0.538	-0.203
Mp38784	$[GT]_{28}$	GCTCTCGGTTGGTGTACCTC TTGTGGCCCATTGAATTCTT	263-267	2	2	0.647/0.500	-0.294
Mp54234	$[CCT]_{17}[GCT]_8$	CGCAGTTAGGAATGATGTGC TCCTCCAGTGGTCCTCTGTC	190	1			
Mp54953	$[AC]_{16}$	AGCCAGGAAACAAAAGAGCA GGCAAAACAGGGACATTAACA	201	1			
Mp57264	$[CTAT]_{16}$	GACCCACTGCTATGAACACG GGGCACAGGTGAAGGTGTAG	234-250	3(4)	1.57	0.438/0.361	-0.211
Mp58282	$[GT]_{15}[GA]_{30}$	GGCATGGGAGTAAACTCAGC CACTAAGCCCAGACAATGGAA	246-254	4	2.65	0.625/0.623	-0.003
Mp59727	$[CA]_{17}$	CCATGGCTCAATCTGGAAAT CCTGGTCTCCTCTGGTGGTA	251	1			
Mp65596	$[GT]_{11}[GA]_{31}$	GTTCAGTCAGGCACCCTCTC GGCAGGGCAGAGAGAGAATA	250-262	5(6)	2.28	0.563/0.561	-0.003
Mp70418	$[GA]_{35}$	TTCAACATCCAGCTGTCCTG CCAGGCCAGTATTCCTCTGT	222-234	3	1.92	0.529/0.479	-0.105
Mp79656	$[CTTT]_{20}$	TGACTTCCTCCTTGGCAAAT GAAGCATTTGTTTAAGCTGGCTA	207-231	3(4)	2.04	0.588/0.510	-0.153
Mp80523	$[CTTT]_{18}$	TGAAGACATCCAGGTTTGGAC CACAGCAAACCCTGTCTTGA	247-267	5(6)	3.18	0.706/0.685	0.030
Mp84995	$[GGAA]_{19}$	ACTGGGGATCAGGTGTTCAG GGGAAGAGGTGGGGAGATAG	243-251	3	2.93	0.688/0.658	-0.045
Mp108309	$[TG]_{16}$	GGCCACTGCAACCAATACTT ATCAGAGAGTGCCTGCCCTA	251-257	2(3)	1.13	0.118/0.111	-0.063
Mp108477	$[CA]_{18}$	AAGTTGTCTGGCCTCCACAT AGAGGAGGAAGCAAGGAGGT	265-269	2	1.49	0.412/0.327	-0.259
Mp134208	$[AAG]_{28}[CAG]_9$	GCAGGTGGATCGCTGTAAGT GGCTTCTTGGAAATGGATGA	223-247	4	3.93	0.765/0.746	-0.026
Mp146156	$[AC]_{17}$	GCAAGTGGGAATTGGAGAGA TCTGCGTATGTGCTTGCTTC	268	1			
Mp154780	$[GCT]_{16}$	CTTTGCCTGCAGAACAAGGT AACCTCTGAGCCACCTCTCC	227	1			
Mp158180	$[AC]_{17}$	CAAGCCCGACAATCTGAGTT CATGGCTGCTGAATCCTACA	244	1			
Long Cabbage Key loci combined				2.81	1.94	0.390/0.361	-0.092
Unnamed key loci combined				1.81	1.59	0.373/0.264	-0.399
Total sample loci combined				2.31	1.77	0.382/0.313	-0.228

Table 1 Characterization of 21 microsatellite loci developed for Florida salt marsh vole from 20 voles sampled at Long Cabbage Key, FL and E-140.
* Value for number of alleles is how for Long Cabbage Key and in parentheses, for E-140. Indicates that 1Forward primer has a 5' tag CACGACGTTGTAAAACGAC. Size refers to the length of the amplified alleles. A = number of alleles detected, number in parentheses include alleles found in 3 samples from; AE = effective number of alleles; HO/HE = observed/expected heterozygosity; FIS = inbreeding index.

1. Winter Feeding Ecology of Black Skimmers on the Florida Gulf Coast,
   PI: L.D. Harris; Personnel: B. Black; Completion Date: 1981

2. Sinter Food Habits and Factors Influencing the Winter Diet of River Otter in North Florida.
   PI: L. Cooley; Completion Date: December 1983

3. Feeding Ecology of the Common Moorhen (*Gallinula Chloropus*) and Purple Gallinule *Porphyrula Martinica*) on Orange Lake, Florida. PI: R. Mulholland; Completion Date: December 1983

4. Monitoring River Otter Population: Scent Stations vs Sign Indices. PI: M. Robson;
   Completion Date: December 1983

5. Aspects of the Thermal Biology and Ecological Considerations of the Blue Tilapia.
   PI: J.A. McCann; Personnel: A.V. Zale; Completion Date: December 1984

6. Winter Food Habits & Factors Management Influencing the Winter Diet of River Otter in North Florida.
   PI: H.F. Percival; Personnel: L.S. Cooley

7. Habitat Preference of Early Life Stages of Fishes in Orange Lake, Florida With an Evaluation of Alligator Sampling Methods –Winter Ecology of Ring-Necked Ducks in North-Central FL.
   PI: H.F. Percival, J. Thul; Personnel: C.W. Jeske; Completion Date: August 1985

8. Reproductive Behavior & Florida Wild Turkey (Meleagris Gallopavo Osceola) Nesting.
   PI: L. Williams; Completion Date: December 1985

9. Evaluation of Alligator Hatchlings Removal From Wild Populations in Florida.
   PI: H.F. Percival; Personnel: M.L. Jennings, Completion Date: March 1986

10. Nest Site Selection and Habitat Use by Largemouth Bass. PI: R.W. Gregory; Personnel:
    N.A. Bruno; Completion Date: December 1984

11. Research/ Management Plan For The Crystal River West Indian Manatee Population Levy & Citrus Counties, FL. PI: R.W. Gregory, H.F. Percival; Completion Date: December 1983

12. Site-Specific Reduction of Manatee Boat/Barge Mortalities in Florida. PI: H.F. Percival,
    R.W. Gregory; Personnel: M.F. Kinnaird; Completion Date: May 1984

13. Mitigation of Fish & Wildlife Values in Rock-mined Areas of S. Florida. PI: R.W. Gregory,
    H.F. Percival; Personnel: R.W. Repenning; Completion Date: August 1984

14. Wildlife Values of Southeastern Bottomland Forests. PI: L.D. Harris; Completion Date: September 1984

15. The State of Knowledge of Gray Fox Harvest. PI: R.F. Labisky, S.R. Humphrey, H.F.Percival; Personnel: J.A. Hovis; Completion Date: January 1984

16. Foraging Habitat Requirements of The Red=Cockaded Woodpecker in Pine Habitats of North Florida.
    PI: R.F. Labisky; Personnel: M.L. Porter; Completion Date: September 1984

17. Habitat Suitability Index Models for Gulf of Mexico Coastal. PI: R.W. Gregory, H.F. Percival;
    Personnel: R. Mulholland; Completion Date: November 1984

18. Effect of Nutrient Leaching on Fish Spawning & Nursery Habitat in Great Lakes Nearshore Water.
    PI: R.W. Gregory, H.F. Percival; Personnel: L.C. Brasel; Completion Date: November 1984

19. Development of Hybrid Grass Carp Production Techniques. PI: J.V. Shireman; Completion Date: September 1984

20. Conceptual Model of Salt Marsh Management on Merritt Island, Florida. PI: C.L. Montague, H.F. Percival; Personnel: A.V. Zale; Completion: December 1984

21. Studies of Grass Carp in Aquatic Weed Control. PI: J.V. Shireman; Completion Date: October 1984

22. Factors Affecting Reproductive Success of Sea Turtles on Cape Canaveral Air Force Base. PI: R.F. Labisky; Completion Date: September 1984

23. Ecology & Management of Impounded Coastal Wetlands of The Georgia Bight. PI: C.L. Montague, H.F. Percival; Personnel: A.V. Zale; Completion: June 1985

24. Status Survey of the Rosemary Wolf Spider in Florida. PI: J. Reiskind; Completion Date: April 1985

25. Determination of the Food Habits of Manatees. PI: G.B. Rathbun, H.F. Percival; Personnel: L.A. Hurst, Completion Date: August 1985

26 Evaluation of Captive Breeding & Reintroduction of the Flroida Panther. PI: J.F. Eisenbert; Completion Date: June 1985

27. Biometrical support For GFC's Gainesville Research Laboratory. PI: H.F. Percival: Personnel: C.L. Abercrombie, T.O'Brien; Completion Date: June 1985

28. Black Bear Habitat Variables. PI: L.H. Harris, D. Maehr; Personnel: C.W. Jeske; Completion Date: July 1985

29. Status Survey of the Florida Grasshopper Sparrow. PI: M.L. Delany, H.F. Percival; Personnel: J. Cox; Completion Date: March 1985

30. Status Survey of the Schaus' Swallowtail in Florida. PI: T.C. Emmel; Completion Date: March 1985

31. Population Index & Mark/Recapture Methodology For the West Indian Manatee In Florida. PI: H.F. Percival, Completion Date: August 1985

32. Effects of Low Altitude Training Flights on Florida's Brown Pelican & Wading Bird Colonies. PI: M.W. Collopy, B.B. Black, P.G. Bohall; Completion Date: January 1985

33. Habitat Use & Management of Sherman's Fox Squirrel. PI: S.R. Humphrey; Personnel: A.T. Kantola; Completion Date: June 1986

34. Evaluation of Electro-fishing Systems for Quantitative Sampling of Blue Tilapia. PI: H. Schramm; Completion Date: May 1986

34. Pancreatic Necrosis Virus as a Pathogen of Striped Bass. PI: R.W. Gregory, W.M. Kitchens, J.V. Shireman; Personnel: S. Wechsler; Completion Date: May 1987

35. Production, Sterility, & Food Habits of Bighead Carp. PI: J.V. Shireman; Completion Date: July 1987

36. Evaluation of Population Parameters of Black Duck. (RWO27) PI: H.F. Percival, M.J. Conroy, M. Haramis; Personnel: D.G. Krementz, B.R. Charest; Completion Date: July 1987

37. Status of the Cape Sable Seaside Sparrow in East Everglades. PI: W.R. Marion; Personnel: T.O'Meara; Completion Date: September 1987

38. Evaluation & Control of Bird Damage to Rice. PI: M. Avery, H.F. Percival, P. Lefebvre; Personnel: D. Daneke; Completion Date: December 1987

39. The Ecology & Management of Impounded Coastal Wetlands of the Georgia Bight: Workshop (RWO33) PI: C.L. Montague, H.F. Percival; Personnel: A.V. Zale; Completion Date: September 1987

40. Movement & Survival of Captive-Reared Gharials in the Narayani River, Nepal. PI: H.F. Percival; Personnel: T.M. Maskey; Completion Date: December 1988

41. Egg Viability From Four Wetlands in Florida. PI: H.F. Percival, A.R. Woodward: Personnel: M.L. Jennings; Completion Date: April 1988

42. The Ecology & Management of Hydric Hammocks (RWO24). PI: S.R. Humphrey; Personnel: S. Vince; Completion Date: July 1988

43. A Comparison of Passerine Feeding Habits in Two Tidal marsh Communities (RWO30). PI: G.W. Tanner, W.M. Kitchens; Personnel: L. Peterson; Completed: January 1989

44. Population Analysis & Roosting & Feeding Flock Behavior of Blackbirds Damaging Sprouting Rice in SW Louisiana. PI: R.R. Labisky, N.R. Holler; Completion: September 1989

45. Performance of the Female Habitat Use, Movements, Migration Patterns, & Survival Rates of Sub- Adult Bald Egles in Florida. PI: M.W. Collopy; Personnel: P.B. Wood; Completion Date: December 1991

46. Effectiveness of Wildlife Crossing Structures on Alligator Alley (I-75) For Reducing Animal/Auto Collisions. PI: S.R. Humphrey; Personnel: M.L. Foster; Completion Date:December 1991

47. Impact Assessment of Grass Delivery Program on Wading Carp (RWO34). PI: J.V. Shireman, W.M. Kitchens; Completion Date: September 1989

48. Status Survey of Three Florida Lizards (RWO35). PI: P. Moler, H.F. Percival, R.F. Labisky; Personnel: K. Enge; Completion Date: October 1986

49. Vegetation Management for Key Deer (RWO36) PI: S.R. Humphrey G.W. Tanner: Personnel: J. Wood, P. Carlson; Completion Date: December 1989

50. Status Survey of Seven Florida Mammals: Micro Cottontail Rabbit, Micro Cotton Rat, SE Beach Mouse, Goff's Pocket Gopher, Anastasia Island Cotton Mouse and Beach Mouse (RWO37). PI: S.R. Humphrey, M. Bentzien; Completion Date: July 1987

51. Relative Abundance, Size Class, Composition, & Growth Patterns of Wild Green Turtles at the Culebra Archipelago, Puerto Rico (RWO38) PI: J.A. Collazo, H.F. Percival; Personnel: T. Tallevast; Completion Date: December 1989

52. Effects of Modified Water Bird Nesting Success & Foraging Dispersion in Water Conservation. PI: M.W. Collopy; Personnel: P.D. Frederick, Completion Date: April 1988

53. Effects of the Modified Water Delivery Program on Nest Site Selection & Nesting Success of Snail Kites in Water Conservation Area 3A (RWO40). PI: M.w. Collopy, s. Beissinger; Personnel: R. Bennett's; Completion Date: February 1988

54. Comparative Graminoid Community Composition & Structure Within the Northern Portion of Everglades
Nat'l Park, NE Shark River Slough, Water Conservation Area 3A & 3B (RWO41)
PI: G.W. Tanner; Personnel: J.M. Wood; Completion Date: November 1986

55. Human/Wildlife Interaction J.N. "DING" Darling Nat'l Wildlife Refuge (RWO42).
PI: S.R. Humphrey, H.F. Percival; Personnel: M.V. Klein; Completion Date: June 1989

56. Status Survey of Two Florida Seaside Sparrows (RWO43). PI: K. McNab, V. MacDonald;
Completion Date: October 1988

57. Soil/Plant Correlation Studies in Florida (RWO46). PI: G.R. Best, W.M. Kitchens; Completion
Date: March 1987

58. Reproductive cycles in Striped Bass Maintained in Recirculation Silos: Histological Analysis.
PI: L.J. Guillette, Jr.; Personnel: C.A. Goudie; Completion Date: October 1986

59. Aquatic Plant Management Technology Improvement (RWO47). PI: J.C. Joyce, W.T. Haller;
Personnel: V. Ramey, T. Willard; Completion Date: April 1988

60. Effects of Ground Water Levels Upon Reproduction success of American Crocodiles In Everglades
Nat'l Park (RWO50). PI: F.J. Mazzotti; Completion Date: April 1989

61. Factors Affecting Productivity & Habitat Use of Florida SandHill Cranes: An Evaluation of Three
Areas in Central Florida as Potential Reintroduction Sites for a Mommigratory Population of Whooping Cranes. PI: M.W. Collopy; Personnel: M. Bishop; Completion: October 1988

62. Manatee Protection Project: Survey of Boat Usage Patterns. PI: J.W. Hutchinson, J.W. Alba;
Completion Date: September 1988

63. An Evaluation of Manatee Distribution Patterns in Response to Public Use Activities, Crystal River,)
Florida. (RWO52) PI: W.M. Kitchens; Completion Date: December 1989

64. An Evaluation of Cumulative Impacts to the Habitat of The West Indian Manatee, Crystal River
Nat'l Wildlife Refuge (RWO53) PI: W.M. Kitchens; Personnel: L.G. Pearlstine, C.Buckingham; Completion Date: December 1989

65. Status Survey of The Florida Saltmarsh Vole (RWO54) PI: C.A. Woods; Personnel: L. Hay-Smith;
Completion Date: September 1988

66. Impact of Mosquito Control Pesticides on the Endangered Schaus Swallowtail & Related Insects in
The Florida Keys (RWO56) PI: T.C. Emmel; Personnel: P. Eliazar; Completion Date: Jan 1989

67. Effects of Mosquito Control Pesticides on Non-Target Organisms in the Florida Keys (RWO57)
PI: D.H. Habeck; Personnel: M. Hennessey; Completion Date: October 1989

68. Development of Guidance Manual For Monitoring Water Quality & Vegetative Changes on Nat'l
Wildlife Refuges (RWO58) PI: W.M. Kitchens; Completion Date: December 1988

69. Applicability & Comparison of Satellite Image Data to Delineation of Cover type in The Lower Suwannee River
Region (RWO60) PI: W.M. Kitchens; Completion Date: December 1988

70. Distribution & Population Structure of Sea Turtles Inhabiting The Cape Canaveral Entrance
Channel (RWO62) PI: A.B. Bolten, K.A. Bjorndal; Completion Date: December 1991

71. Determination of the Causes of Low Response with the Water Fowl Hunter Questionnaire &

Estimation of the Resultant Biases (RWO76) PI: H.F. Percival; Personnel: R.J. Barker, P.H. Geissler: Completion Date: September 1990

72. The Ecology of Manatees in Georgia with Emphasis on Cumberland Sound (RWO65) PI: H.F. Percival, B.J. Zoodsma; Completion Date: December 1990

73. Scientific Review of Alligator Export Proposals to USFWS (RWO69) PI: H.F Percival; Personnel: P.N. Gray, F. Nunez-Garcia; Completed: July 1990

74. Fish Community Structure in Naturally Acid Florida Lakes (RWO73) PI: W.M. Kitchens; Personnel: C.A. Jennings, D.E. Canfield, Jr.; Completed: July 1990

75. Development & Application of A Habitat Succession Model For the Wetland Complex of the Savannah river Nat'l Wildlife Refuge (RWO30) PI: W.M. Kitchens; Personnel: L.G. Pearlstine, P. Latham, L. Peterson, G. Tanner; Completion Date: December 1990

76. Plant species Association Changes & Interactions Across a Gradient of Fresh, Oligohaline & Mesohaline Tidal Marsh of the Lower Savannah River (RWO30) PI: W.M. Kitchens; Personnel: P.J. Latham; Completion Date: December 1990

77. Biology of Florida's Mottled Duck. PI: H.F. Percival; Personnel: P.N. Gray; Completed: May 1992

78. Modeling Waterfowl Harvest & The Effects of Questionnaire Non-response on Harvest Estimate. PI: H.F. Percival; Personnel: R.J. Barker, J.D. Nichols; Completion Date: May 1992

79. Environmental Influences on Reproductive Potential & Clutch Viability of the American Alligator From Seven Study Sites in Florida. PI: H.F. Percival; Personnel: G.R. Masson; Completion Date: July 1992

80. Nesting Biology of the American Alligator in Florida. PI: H.F. Percival; Personnel: K.G. Rice; Completion Date: September 1992

81. Alligator Egg Viability & Population Trends on Lake Apopka, Florida. PI: H.F. Percival, L.J. Guillette, Jr.; Personnel: G.R. Masson, K.G. Rice, Completed: June 1993

82. Alligator Nest Production Estimation in Florida. PI: H.F. Percival; Personnel: K.G. Rice, A.R. Woodward; Completion Date: August 1992

83. Habitat Use By Migratory Shorebirds at the Cabo Rojo Salt Flats, Puerto Rico (RWO78) PI: J.A. Collazo, H.F. Percival; Personnel: J.S. Grear; Completion Date: August 1992

84. Wading Bird Use of Wastewater Treatment Wetlands in Central Florida (RWO83) PI: P.C. Frederick; Completion Date: December 1992

85. Evaluating The Regional Effects of Citrus Development on The Ecological Integrity of South-West Florida. PI: F.J. Mazzotti, W.M. Kitchens; Personnel: L.A. Brandt, L.G. Pearlstine; Completion Date: May 1992

86. Workshop in Florida Manatee (*Trichechus Mantus*) Population Biology (RWO88) PI: T.J. O'Shea, H.F. Percival; Personnel: B.B. Ackerman; Completed: October 1993

87. Issues & Options Related to Management of Silver Springs Rhesus Macaques. PI: C.L. Montague, H.F. Percival; Personnel: J.F. Gottgens; Completed: December 1993

88. Sea Turtles Inhabiting The Kings Bay, St. Mary's Entrance Channel: Distribution & Population Structure (RWO72) PI: K.A. Bjorndal, A.B. Bolten; Completed: September 1983

89. Wading Bird Nesting Success Studies in The Everglades (RWO110) PI: P.C. Frederick,

Completed: December 1993

90. Captive Propagation & Restoration Ecology of The Endangered Stock Island Tree Snail (RWO94) PI: T.C. Emmel; Completion Date: October 1993

91. Status Monitoring & Experimental Reintroduction of The Endangered Schaus Swallowtail (RWO84) PI: T.C. Emmel, P.J. Eliazar, M.C. Minno; Completed: September 1993

92. Conservation Status of The Freshwater Mussels of The Apalachicola River Basin (RWO86) PI: J.D. Williams; Personnel: J.C. Brim-Box; Completion Date: October 1993

93. Statistical Aspects of Line Transect Sampling (RWO68) PI: K.M. Portier, Completed: 1993

94. A Geographic Information System Model of Fire Damage & Vegetation Recovery in The Loxahatchee Nat'l Wildlife Refuge. PI: W.M. Kitchens; Personnel: J.E. Silveira, J.R. Richardson; Completion Date: December 1993

95. Mercury Concentrations in Blood & Feathers of Nestling Bald Eagles (RWO108) PI: P.B. Wood; Personnel: J.H. White, A. Steffer, H.F. Percival; Completed: December 1994

96. Effects of Artificial Lighting on Nesting Adult & Hatchling Sea Turtles (RWO75) PI: K.A. Bjorndal, A.B. Bolton; Personnel: B.E. Witherington; Completed: September 1994

97. Summary Report of Air Quality Studies Done at Chassahowitzka Nat'l Wildlife Refuge (RWO102) PI: E.R. Allen; Completion Date: June 1994

98. Evaluations of The Efficacy of Exotics as Aquaculture & Management Species in Florida (RWO109) PI: J.V. Shireman; Personnel: J.E. Weaver, K. Opusbynski; Completed Date: February 1994

99. Assessing The Impact of Vehicular Traffic on Beach Habitat & Wildlife, Cape San Blas, FL PI: H.F. Percival; Personnel: J.H. Cox, Jr., S.V. Colwell; Completion Date: June 1994

100. Early Life History & Relative Abundance of Sturgeon In The Suwannee River (RWO61) PI: J.V. Shireman, J.P. Clugston, A.M. Foster; Completion Date: October 1994

101. Distribution, Population Structure & Exploitation of Sea Turtles in The Bahamas (RWO67) PI: K.A. Bjordnal, A.B. Bolton; Completion Date: September 1994

102. Sea Turtle Populations in The Eastern Gulf of Mexico: Biology, Distribution & Population Structure (RWO77) PI: K.A. Bjordnal, A.B. Bolten; Personnel: J.R. Schmidt; Completion Date: September 1994

103. Distribution & Status of The Red-Cockaded Woodpecker on The Eglin Air Force Base, Florida. PI: H.F. Percival, R.J. Smith; Completion Date: March 1994

104. Factors Affecting Abundance of Spotted Sea trout & Year-Class Strength (RWO81) PI: H.F. Percival, N.A. Funicelli, J.V. Shireman; Completion Date: June 1994

105. Re-establishment of the Anastasia Island Beach Mouse (*Peromyscus Polionotus Phasma*) PI: S. Humphrey; Personnel: P.A. Frank; Completion Date: January 1994

106. Captive Propagation and Habitat Reintroduction for the Schaus Swallowtail Following Hurricane Andrew. PI: T.C. Emmel; Personnel: J.C. Daniels A. Sourakov, P.J. Eliazar; Completion Date: September 1994

107. Development Abnormalities of the Reproductive System of Alligators From Contaminated & Control Lakes in Florida. PI: H.F. Percival; Completion Date: May 1994

108. Land Management Practices in the Mountain Region of Puerto Rico: Monitoring Bird Reproductively in Carite State Forest PI: H.F. Percival; J.A. Collazo; Personnel: F. Nunez-Garcia; Completion Date: December 1995

109. Methods For Determining change in Wetland Habitats in Florida (RWO95) PI: W.M. Kitchens; Personnel: J. Silviera, W. Bryant; Competed: September 1995

110. Population Ecology of Bartram's Ixia (RWO101) PI: G.W. Tanner; Personnel: A. Miller; Completed: October 1995

111. Maintenance, Propagation, and Restoration of the Endangered Stock Island Tree Snail Following Hurricane Andrew (RWO106). PI: T.C. Emmel; Personnel: K.A. Schwarz, R.A. Worth, N.D. Eliazar; Completion Date:: October 1995

112. Changes in Salinity & Vegetation Following Re-establishment of Natural Hydrology on the Lower Savannah River (RWO117). PI: W.M. Kitchens; Personnel: P.J. Latham, L.P. Peterson; Completion Date: March 1995

113. Follow-Up of a 14 Year Old Crested Wetland/Upland Landscape on Phosphate-Mined Land in Central Florida (RWO120) PI: G.R. Best, W.M. Kitchens; Completed: March 1995

114. Trends, Status & Aspects of Demography of The Red-Cockaded Woodpecker in The Sandhills of Florida's Panhandle (RWO124). PI: H.F. Percival; Personnel: J.L. Hardesty, R.J. Smith; Completion Date: March 1995

115. Status & Distribution of The Florida Scrub Jay on Cape Canaveral, Flordia (RWO127) PI: H.F. Percival; Personnel: J.L. Hardesty, D.B. McDonald; Completion Date: May 1995

116. Mercury Contamination in Great Egrets in Southern Florida (RWO132). PI: P.G. Frederick; Personnel: M.G. Spaulding, M.S. Sepulveda: Completed: September 1995

117. The Acute Toxicity of Malathon to Glochidia & Freshwater Mussels (RWO133) PI: E.J. Philips; Personnel: A.E. Keller; Completion Date: March 1995

118. The Role of Environmental Contaminants in The Prevalence of Fish Infected With A Wading Bird Parasite (RWO134). PI: D.J. Forrester; M.G. Spaulding; Personnel: D. Morrison; Completion Date: September 1995

119. Development of an Ecologically Stable Cost Efficient Biological Water Treatment system & Technology Transfer System (RWO135) PI: J.V. Shireman; Personnel: N.A. Furnicelli; Completion Date: September 1995

120. Status & Distribution of the Florida Scrub Jay on Cape Canaveral, FL (RWO136) PI: H.F. Percival; Personnel: D.B. McDonald, J.L. Hardesty; Completed: October 1995

121. Disruption of Endocrine Function & Reproductive Potential By Environmental Contaminants on Lake Apopka's Alligators & Other Taxa (RWO137) PI: H.F. Percival; Personnel: L.J. Guillette, T.S. Gross, K.G. Rice; Completed: October 1995

122. The Epidemiology of Upper Respiratory Tract Disease in Desert Tortoises at Three Sites in The California Deserts (RWO138) PI: M. Brown; Personnel: I.M. Schumacher, P.A. Klein; Completion Date: April 1995

123. The Relationships Between Host Plant & Habitat For The Distribution of Three Potentially Endangered S. Florida Butterfly Species (RWO145) PI: T.C. Emmel; Personnel: R.A. Worth;

Completion Date: September 1995

124. Snail Kite Census PI: W.M. Kitchens; Completion Date: December 1995

125. Refinement of Population Estimation Techniques For Wild Turkeys YR 3.
PI: G.W. Tanner; Completion Date: June 1995

126. Egg Viability, Sexual Development, Hatchling Viability & Growth in Alligators From Lake Apopka & Lake Beauchair. PI: H.F. Percival; Personnel: C.L. Abercrombie, A.R. Woodword, K.G. Rice; Completion Date: July 1995

127. Mineral Interactions Between embryo, Eggshell & Substrate in Developing Sea Turtles (RWO92)
PI: K.A. Bjorndal; Personnel: A.B. Bolten, R.R. Carthy; Completion Date: August 1996

128. Ecological Correlates of Red-cock Woodpecker Foraging Preference, Habitat Use, & Home Range Area on Eglin Air Force Base, Florida (RWO99) PI: H.F. Percival; Personnel: R.J. Smith, J.L. Hardesty; Completion Date: March 1996

129. Understory Response to Longleaf Pine-Sandhill Restoration Techniques (RWO111)
PI: G.W. Tanner; Personnel: J.L. Hardesty, Completion Date: March 1996

130. Habitat Associations, Reproduction, and Foraging Ecology of Audubon's Crested Caracara in South-Central Florida (RWO114). PI: S.R. Humphrey; Personnel: J.L. Morrison, S.M. McGehee; Completion Date: May 1996

131. Landscape Dynamics of Scrub Lizard on Avon Park Air Force Range (RWO122)
PI: L.C. Branch; Personnel: D.G. Hokit, B.M. Stith; Completion Date: September 1996

132. Post Hurricane Density & Recovery Status of the Key Largo Woodrat and Cotton Mouse (RWO123)
PI: H.F. Percival; Personnel: K. Miller, B.W. Keith; Completion Date: August 1996

133. Evaluation of Sampling and Analytical Protocols for Manatee Capture-Recapture and Telemetry Data (RWO125) PI: H.F. Percival; Personnel: L.W. Lefebvre: Completed: July 1996

134. Community Response to Restoration Techniques in Degraded Florida Sandhill Systems (RWO 128)
PI: G.W. Tanner; Personnel: D.R. Gordon, H.F. Percival; Completion Date: March 1996

135. Marine Turtle Nesting Biology & Assessment of Anthropogenic Disturbances to Hatchling Orientation at Eglin Air Force Base (RWO129) PI: H.F. Percival; Personnel L.G. Pearlstine, Completion Date: April 1996

135. Necropsies of Ill and Dying Desert Tortoises From California and Elsewhere in The Southwestern United States (RWO131) PI: B.L. Homer; Personnel: E.R. Jacobson, K.H. Berry; Completed: March 1996

137. Potential Effects of Endocrine Disrupting Contaminants (RWO140)
PI: T.S. Gross; Personnel: H.F. Percival, K.G. Rice, A.R. Woodward; Completed: June 1996

138. Interactions Among Cavity Dependent Species in Longleaf Pine Forests: The Roles of Snags and Red-Cockaded Woodpecker Cavities (RWO143) PI: J.D. Harris; Personnel: R. Costa, J.J. Kappes, Jr.; Completion Date: August 1996

139. Habitat Assessment in a Landscape Context: Analysis of The Factors Affecting The Distribution & Abundance of Florida Scrub Lizard (RWO156) PI: L.C. Branch; Personnel: D.G. Hokit, Completion Date: April 1996

140. Estimation & Environmental Correlates of Survival & Dispersal of Snail Kites in Florida.
PI: W.M. Kitchens; Personnel: P.C. Darby; Completion Date: February 1996

141. Egg Viability & Population Trends of Lake Apopka Alligators: Relation Ships Among Populations & Biographical Parameters. PI: H.F. Percival; Personnel: K.G. Rice; Completed: July 1996

142. Evaluation of S.R.46 Wildlife Crossing.
PI: H.F. Percival; Personnel: J.C. Roof, J.B. Wooding; Completion Date: May 1996

143. An Ecosystem Approach To Public Education & Information at Eglin Air Force Base (RWO107)
PI: S.K. Jacobson; Personnel: S.B. Marynowski; Completion Date: September 1997

144. Genetic Analysis of Sea Turtle Populations in The Western Atlantic Ocean With Emphasis on The Southeast United States (RWO115) PI: B.W. Bowen, A.B. Bolten; Completion Date: June 1997

145. Cape San Blas Ecological Study (RWO126)
PI: W.M. Kitchens, H.F. Percival, R.R. Carthy; Completion Date: August 1997

146. Enhancement & Evaluation of a Designated Watchable Wildlife Site (RWO130)
PI: J.M. Schaefer, S.K. Jacobson; Completion Date: January 1997

147. Research Objectives to Support The S. Florida Ecosystem Initiative-Water Conservation Areas, Lake Okeechobee & The East-West Waterways (RWO139) PI: W.M. Kitchens;
Completed: September 1997

148. Trends, Status and Aspects of Demography of The Red=Cockaded Woodpecker in the Sandhills of Florida's Panhandle, PartII (RWO146) PI: H.F. Percival, J.L. Hardesty; Personnel: K.E. Gault, L.F. Phillips; Completion Date: March 1997

149. Use of Unionid Mussels as Bioindicators of Water Quality in Escambia Conecuh River System (RWO149) PI: E.Philps; Personnel: A. Keller; Completion Date: June 1997

150. Captive Propagation & Experimental Reintroduction of Florida's Schaus Swallowtail (RWO151)
PI: T.C. Emmel; Personnel: J.P. Hall, K.M. Wilmott, J.C. Daniels; Completed: December 1997

151. Testing & Implementation of Selected Aquatic ecosystem Indicators in The Mississippi River System, 1995: Potential Effects of Endocrine Disrupting Contaminants (RWO153)
PI: T.S. Gross; Completion Date: September 1997

152. Wading Bird Population Monitoring, Environmental Correlates of Adult Foraging Success & Measurement of Nesting Energetic Needs in The Everglades: Part I (RWO158)
PI: P.C. Frederick; Personnel: J.Surkick, J.Salantas; Completion Date: April 1997

153. Marine Turtle Conservation on The Caribbean Coast of Nicaragua (RWO171)
PI: L.J. Guillette, Jr.; Personnel: C.L. Campbell; Completed: December 1997

154. Evaluating The Ecological Role of Alligator Holes In The Everglades Landscapes.
PI: E.J. Mazzotti, H.F. Percival; Personnel: L.A. Brandt; Completion Date: December 1997

155. Two GIS & Land Use Analysis of Freshwater Mussels in The Apalachicola River Drainage (RWO164) PI: J. Mossa; Personnel: J. Howard; Completion Date: July 1997

156. Egg Viability & Population Trends of Lake Apopka Alligators. PI: H.F. Percival; Personnel: K.G. Rice; Completion Date: July 1997

157. Effect of Marine Pollution on Juvenile Pelagic Sea Turtles (RWO66) and Biology of and the Effects of Marine Debris (RWO118) PI: K.A. Bjorndal; A.B. Bolten; Completed: June 1998

158. Enhancement of Natural Dune building & Re-vegetation Processes on Santa Rosa Island (RWO159)
PI: D.L. Miller, Mack Thetford; Completion Date: August 1998

159. Pathogenic, Molecular, and Immunological Properties of Herpersvirus Associated with Green Turtle Fibropapillomatossis: Phase I Virus Isolation & Transmission (RWO161) PI: P.A. Klein; Completion Date: June 1998

160. Migrations & Habitat Use of Sea Turtles in The Bahamas (RWO166). PI: K.A. Bjornal, A.A. Bolten: Completion Date: September 1998

161. Population Genetic Structure of Marine Turtles In The Southeastern United States and Adjacent Caribbean Region (RWO167) PI: B.W. Bowen, A.L. Bass; Completed: June 1998

162. Distribution and Abundance of Sensitive Wildlife at Avon Park Air Force Base Range (RWO169)
PI: R. Franz; Completed: December 1998

163. Red-Cockaded Woodpecker Cavities & Snags in Longleaf Pine Forest: Cavity Nester Use & Nesting Success (RWO170) PI: K.E. Sieving; Completion Date: September 1998

164. Plant & Invertebrate Community Responses to Restoration Techniques In Degraded Florida Sandhills: YR3 Post-Treatment (RWO174) PI: G.W. Tanner, D.R. Gordon; Completed: July 1998

165. Demographics, Genetic Relationships & Impacts From Rd Imported Fire Ants on The Florida Grasshopper Sparrow (RWO175A) PI: H.F. Percival; Completion Date: March 1998

166. Red Imported Fire Ants on The Endangered Florida Grasshopper Sparrow (RWO175B)
PI: H.F. Percival, Completion Date: June 1998

167. Wading Bird Population Monitoring, Environmental, Correlates of Adult Foraging Success & Measurements of Nestling Energetic Needs in The Everglades Phase II (RWO176)
PI: P.C. Frederick; Completion Date: April 1998

168. Population characterization of Kemp's Ridley Sea Turtles in The Big Bend Area, Gulf of Mexico, Florida Monitor, Assess, and Predict Status of Impacts to Protected Species & Their Ecosystems (RWO177) PI: R.R. Carthy; Completion Date: September 1998

169. Breeding & Reintroduction of The Endangered Schaus Swallowtail (RWO179)
PI: T.C. Emmel; Completion Date: July 1998

170. Estimating Survival & Movements in Snail Kite Population (RWO183)
PI: W.M. Kitchens, R.E. Bennetts; Completion Date: July 1998

171. Tree Island Biological Inventory: Landscape Level Assess and Determination of Island Aream Shape & Vegetation Zones (RWO184) PI: W.M. Kitchens, L.A. Brandt; Completion Date: September 1998

172. Biological Diversity in Florida: And Evaluation of Potential Species in Relation to Habitat and Existing Reserves (RWO 98) PI: W.M. Kitchens, L.G. Pearlstine, S.E. Smith, J.L. Hardy; Completion Date: September 1998

173. Improving Survey Methods and Assessing Impoundment Effects on Waterfowl Ecology at the Merritt Island National Wildlife Refuge (RWO 186) PI: R.R. Carthy; Completion Date: June 1999

174. Effects of Prescribed Fire on Soil Nutrients, Forage Quality and Plant Community Composition and on Breeding Bird Communities on the Florida Panther NWR (RWO 168) PI: M.B. Main; Completion Date: July 1999

175. Florida Gap Analysis (RWO 187) PI: L.G. Pearlstine, S.E. Smith; Completion Date: December 1999

176. Modeling and Simulation Support for ATLSS (RWO 154a) PI: P.A. Fishwick; Completion Date: December 1999

177. The Effect of Everglades Food Items (Prey) on Crocodilian Growth Development and Fertility (RWO 154b) PI: P.T. Cardielhac; Completion Date: December 1999

178. American Alligator Distribution, Thermoregulation and Biotic Potential Relative to Hydroperiod in the Everglades National Park (RWO 154c) PI: H.F. Percival, K.G. Rice; Completion Date: December 1999

179. Nesting, Growth and Survival of American Crocodiles in Northeastern Florida Bay, Everglades National Park- Phase I (RWO 178) PI: F.J. Mazzotti, L.A. Brandt; Completion Date: April 2000

180. Creation of Upland Cover Map of Florida PI: L.G. Pearlstine, W.M. Kitchens; Completion Date: August 1999

181. Orientation of Digital Aerial Images and Protocol Development PI: L.G. Pearlstine, S.E. Smith; Completion Date: April 1999

182. Produce a Manual of Sea Turtle Research and Conversation Techniques PI: K.A. Bjorndal, A.B. Bolten; Completion Date: July 1999

183. Wildlife Refuge Waterfowl Survey Database (RWO 202) PI: R.R. Carthy, E. McMichael, R. Subramaniya; Completion Date: December 2000

184. Movements, Spatial Use Patterns and Habitat Utilization of Radio-Tagged West Indian Manatees (*Trichechus Manatus*) Along the Atlantic Coast of Florida and Georgia (RWO 163) PI: H.F. Percival, B.J. Deutsch, L.W. Lefebvre; Completion Date: July 2000

185. Pathogenic, Molecular and Immunological Properties of a Virus Associated with Sea Turtle Fibropapillomatosis, Phase II: Viral Pathogenesis and Development of Diagnostic Assays (RWO 180) PI: P.A. Klein, E.R. Jacobson, D.R. Brown, S.S. Coberly, D. Bagley; Completion Date: June 2000

186. Dry Down Tolerance of Florida Apple Snail (*Pomacea Paludosa*): Effects of Age and Season (RWO 182) PI: H.F. Percival, P.C. Darby, Z.C. Welch; Completion Date: August 2000

187. Effects of Coastal Erosion on Nesting sea Turtles Along the Florida Panhandle (RWO 185) PI: R.R. Carthy, M.M. Lamont; Completion Date: May 2000

188. A Comparison Between the Population of the Potential Tumor-Promoting Dinoflagellate, Prorocentrum SPP and the Incidence of Fibropapillomatosis in Green Turtles (*Chelonia Mydas*) in Florida and Hawaii PI: R.R. Carthy, Y.C. Anderson; Completion Date: December 1999

189. Incubation Temperatures and Sex Ratios of Loggerhead Sea Turtles (*Caretta Caretta*) Hatched on Northwest Florida Beaches (RWO 197a) PI: R.R. Carthy, M.L. Maglothin; Completion Date: Aug. 2000

190. Biology of Nesting Sea Turtles Along the Florida Panhandle (RWO 197b) PI: R.R. Carthy, M.M. Lamont; Completion Date: August 2000

191. A Comparison Between Hawaii and Florida: The Potential Link Between the Tumor-Promoting Dinoflagellate, Prorocentrum SPP and the Prevalence of Fibropapillomatosis in Green Turtles (RWO 210) PI: R.R. Carthy, Y.C. Anderson; Completion Date: December 2000

192. Feeding Ecology and Habitat Affinities of Kemp's Ridley Sea Turtles in the Big Bend, Florida (RWO 189) PI: R.R. Carthy, J.S. Staiger; Completion Date: August 2001

193. Time Lapse Landscape Ecology: Merritt Island National Wildlife Refuge (MINWR) (RWO 189) PI: R.R. Carthy, J.B. Wooding, W.J. Barichivich; Completion Date: December 2001

194. Application of the Species at Risk Conservation for the Florida Army National Guard at Camp Blanding Training Site, Clay County, Florida (RWO 201) PI: R.R. Carthy, C.J. Gregory, A.J. Gruschke, L.G. Pearlstine; Completion Date: August 2001

195. Hydrological Characterization of the White River Basin (RWO 203) PI: W.M. Kitchens; Personnel: M.A. Craig, M.R. Wise; Completion Date: September 2000

196. A Multimodel Implementation Supporting ATLSS: Across Trophic Level System Simulation (RWO 204) PI: P.A. Fishwick; Personnel: R.M. Cubert, L.K. Dance; Completion Date: December 2001

197. Relations of Environmental Contaminants, Algal Toxins and Diet with the Reproductive Success of American Alligators on Florida Lakes (RWO 193) PI: H.F. Percival, T.S. Gross; Personnel: B. Bradford; Completion Date: August 2001

198. Further Strategies for Evaluating the Etiological Role of a Tumor-Associated Herpesvirus in Marine Turtle Fibropapillomatosis (RWO 194) PI: E.R. Jacobson, P.A. Klein; Personnel: D.A. Bagley, S.S. Coberly, R. Hirschman; Completion Date: September 2001

199. Evaluation of Desert Tortoises in and Around Fort Irwin for Exposure to a Tortoise Herpesvirus (RWO 196) PI: E.R. Jacobson, P.A. Klein; Personnel: F.C. Origgi, S. Tucker; Completion Date: April 2001

200. Response of Nesting Seat Turtles and Foraging Shorebirds to Barrier Island Dynamics (RWO 206) PI: P.C. Frederick; Personnel: J.D. Semones, R.A. Hylton, G.A. Babbitt, J.A. Heath; Completion Date: April 2002

201. Ecological Inventory of Moody Air Force Base and Surrounding Properties (Z 038) PI: W.M. Kitchens; Personnel: C.J. Gregory, M.M. Lamont; Completion Date: March 2003

202. Ecological Inventory of Moody Air Force Base and Surrounding Properties (Z 039) PI: R.R. Carthy; Personnel: C.J. Gregory; Completion Date: March 2003

203. Large Scale Habitat Monitoring for Migratory Birds: Digital Video Mosaics in Multi-Level Images (RWO 215) PI: B.D. Dewitt, L.G. Pearlstine; Personnel: G. Trull, S.R. Gonzales, G.P. Jones, IV; Completion Date: August 2003

204. Inventory and Monitoring of the Amphibians of Everglades National Park, Big Cypress National Preserve and Virgin Islands National Park (RWO 208) PI: H.F. Percival, K.G. Rice, R.R. Carthy, J.D. Nichols; Personnel: C.D. Bugbee, M.E. Crockett, A.D. Dove, B. Jeffrey, A.J. Maskell, J.H. Waddle; Completion Date: December 2003

205. American Alligator Distribution, Thermoregulation and Biotic Potential Relative to Hydroperiod in the Everglades (RWO 199) PI: H.F. Percival, K.G. Rice; Personnel: M.D. Chopp, A.G. Finger, P. George, B. Jeffrey, M.T. Tuten; Completion Date: December 2003

206. Sereopidemiological Studies of Herpesvirus-Associated Diseases of Marine Turtles: Fibropapillomatosis and Lung-Eye-Trachea Disease (RWO 213) PI: R.R. Carthy, P.A. Klein, E.R. Jacobson; Personnel: D.A. Bagley, S.S. Coberly (Curry), R. Hirschman; Completion Date: December 2003

207. An Estimate of Population Age Structure for Gulf of Mexico Sturgeon, Acipenser O. Desotoi, on the Yellow River (RWO 214) PI: M.S. Allen; Personnel: J. Berg; Completion Date: December 2003

208. Contaminant Screening to Investigate Wildlife Mortality on Lakes in Central Florida (RWO 196) PI: H.F. Percival, J.P. Ross; Personnel: Y. Temsiripong; Completion Date: April 2003

209. Hibernation vs Migration Overwintering Strategies of Juvenile Sea Turtles in the Florida Panhandle (UF Project #00037385) PI: R.R. Carthy, E. McMichael; Personnel: R. Scarpino; Completion Date: August 2004

210. Estimation of Critical Demographic Parameters of the Florida Snail Kite During and After Drought Conditions (RWO 216) PI: W.M. Kitchens; Personnel: J. Martin, C. Cattau, C. Rich, D. Piotrowicz; Completion Date: December 2004

211. Demographic Movement and Habitat Studies of the Endangered Snail Kite in Response to Hydrological Changes (RWO 207) PI: W.M Kitchens; Personnel: J. Martin, C. Cattau, A. Bowling, D. Huser, M. Conners; Completion Date: March 2005

212. Monitoring of Wading Birds Nesting Activity in WCAS I, II and II of the Everglades and Study of Wood Stork Survival and Movements (RWO 218) PI: P.C. Frederick; Personnel: R. Hylton, J.D. Sermones, M. Bokach, J. Heath, J. Simon, K. Williams; Completion Date: March 2005

213. Evaluation of Sea Turtle Hatchling Disorientation and Assessment of Techniques for Minimizing Lighting Impacts at Tyndall AFB, Bay County Florida (RWO 217) PI: R.R. Carthy; Personnel: R. Scarpino; Completion Date: March 2005

214. Partnership in Case Studies for Training and Outreach (UF Project #00050944) PI: H.F. Percival, M. Monroe; Personnel: K. Bender; Completion Date: August 2005

215. Continued Vegetation Monitoring of the Savannah River Tidally Influenced Marshes PI: W.M. Kitchens; Personnel: K. Lindgren, Z. Welch; Completion Date: December 2005

216. Geomorphic Assessment of Channel Changes along a Modified Floodplain Pascagoula Basin, Mississippi PI: J. Mossa; Personnel: D. Coley, J. Rasmussen, R. Godfrey, A. Villegas; Completion Date: December 2005

217. Geomorphic Assessment of Channel Changes along a Modified Floodplain Pascagoula Basin, Mississippi PI: J. Mossa; Personnel: J. Williams; Completion Date: June 2006

218. Factors Affecting Population Density and Harvest of Northern Bobwhite (*Colinus Virginianus*) in Babcock/ Webb Wildlife Management Area, Charlotte County, Florida PI: H.F. Percival, R. Dimmick, M. Oli; Personnel: S. Dimmick, S. Brinkley, J. Hostetler, G. Coker, A. Brinkley, C. Jones; Completion Date: June 2006

219. Cost and Accuracy of Analysis of Gopher Tortoise Population Estimation Techniques PI: R.R. Carthy, M. Oli; Personnel: E. Langan, J. Wooding, S. Nomani, E. Cantwell, K. Miller, M. Voight; Completion Date: July 2006

220. Surveys of Snail Kite Breeding and Habitat Use in the Upper St. John’s River Basin PI: W.M. Kitchens; Personnel: J. Martin, C. Cattau, A. Bowling, S. Stocco, B. Reichert; Completion Date: February 2006

221. Qualitative Analysis Supporting Reptile and Amphibian Research in Florida’s Everglades PI: H.F. Percival, F. Mazzotti; Personnel: M. Miller; Completion Date: August 2006

222. Sea Turtle Habitat Use and Interactions with Humans in the Coastal Zone PI: R.R. Carthy; Personnel: R. Scarpino; Completion Date: August 2006

223. Southeastern Adaptive Management Group (SEAMG) PI: H.F. Percival, R. Dorazio, F. Johnson; Completion Date: June 2006

224. Development of Unmanned Aerial Vehicles for Assessment Wildlife Populations and Habitats Phase 2 PI: H.F. Percival, B. Dewitt, P. Ifju, L. Pearlstine; Personnel: J. Duberstein, D. Grant; Completion Date: December 2006

225. Toho V-A Proposal to Document Floral and Faunal Succession Following Alternative Habitat in a Large Central Florida Lake PI: W.M. Kitchens; Personnel: J. Brush, M. Desa, C. Enloe, J. Reyes; Completion Date: June 2006

226. Population Structure of a Loggerhead Turtle (*Caretta Caretta*) Nesting Colony in Northwestern Florida as Determined Through Mitochondrial DNA Analysis PI: R.R. Carthy; Personnel: R. Scarpino; Completion Date: April 2006

227. Conservation, Ecology and Propagation of Florida *Orchidacea Eulophia Alta* (*Linnaeus*) FA WCWRR and RENDLE PI: M. Kane; Completion Date: December 2006

228. Rapid Delineation of Provenance for Florida Sea Oats Used for Beach and Dune Stabilization PI: M. Kane; Personnel: N. Philman, P. Sleszynksi, S. Stewart, D. Dutra; Completion Date: September 2006

229. Radio Telemetry and Mark Recapture Studies of Demographic, Movement and Population Dynamics of Endangered Snail Kites (RWO 221) PI: W.M. Kitchens; Completion Date: March 2006

230. Wading Bird Colony Local, Sizing, Timing, & Wood Stork Nesting Success Cost & Accuracy PI: P. Frederick; Completion Date: October 2006

231. Development of Unmanned Aerial Vehicles for Assessment of Wildlife Population and Habitat Phase 2 PI: H.F. Percival; Personnel: A. Watts, S. Bowman; Completion Date: December 2006

232. Assessing Belowground Consequences of Forest Dieback and Climate Change in Coastal Cypress Swamps PI: H.F. Percival; Completion Date: July 2006

233. Vegetative Habitat Responses to Hydrological Regimes in Everglades Water Conservation Area 3A PI: W.M. Kitchens; Personnel: C. Zweig, E. Powers, T. Hotaling, S. Fitz-William; Completion Date: September 2006

234. Gopher Tortoise Population Estimation Techniques PI: R.R. Carthy; Personnel: E. Langan, J. Wooding, S. Nomani; Completion Date: May 2006

235. Floral and Faunal Succession Following Alternative Habitat Restoration Techniques in a Large Central Florida Lake (PJ50773) PI: W.M. Kitchens; Personnel: Melissa Desa, C. Enloe, B. Shoger, A. Schwarzer; Completed: June 2007

236. American Alligator Distribution, size, and Hole Occupancy and American Crocodile Juvenile Growth and Survival (RWO225) PI: H.F. Percival, Frank Mazzotti; Personnel: M Cherkiss; Completion Date: April 2007

237 Radio Telemetry & Mark Recapture studies of Demography, Movement & Population Dynamics of The Endangered Snail Kite (53729) PI: W.M. Kitchens; Personnel: C.Cattau, A.Bowling: Completed December 2006

238. Continued Snail Kite Monitoring Studies: Population Growth, Extinction, and Movement Patterns. (RWO231) PI: W.M. Kitchens; Completion Date: November 2007

239. Status, Ecology, Propagation Science & Recovery of Imperiled FL Orchidaceous: Habenaria Distans. PI: M. Kane: Completed Date: November 2007

240. Update Marsh Succession Model & Provide Technical Assistance Savannah Harbor Expansion (60411) PI: W.M. Kitchens; Completion Date: April 2006

241. St. George Island Lighting Project. PI: R.R. Carthy; Completion Date: July 2006.

242. Vegetation Habitat Responses to Hydrologic Regimes In Everglades Water Conservation Area 3A PI: W.M. Kitchens, C. Zweig; Personnel: T. Hotaling, P. Wetzel, S. Fitz-Williams Completion Date: March 2008 (53972)

243. American Alligator Distribution, Size, and Hole Occupancy & American Crocodile Juvenile Growth and Survival. PI: H.F. Percival, F.J. Mazzotti; Completion Date: June 2007 (50174)

244. Conservation, Ecology & Propagation of Florida Orchidaceae-Eulophia alta and Cyrtopodium punctatum. PI: M. Kane; Personnel: T. Johnson, D. Dutra Completion Date: December 2007

245. Snail Kite Population Studies: Demography, Population Trends, and Dispersal Relative to Environmental correlates, and Habitat Sudies PI: W.M. Kitchens. Completion Date: February 2008

246.Lake Apopka North Shore Restoration Area Alligator Monitoring Study. PI: H. Franklin Percival. Co-PI: R. Carthy. Personnel: R. Throm, E. Lamivee. Completion Date: February 2008.

247. Lake Apopka North Shore Restoration Area Amphibian Monitoring Study. PI: Raymond R.Carthy Co-PI:H.F. Percival. Personnel: R. Throm, E. Lamivee. Completion Date: February 2008.

248. Continued Snail Kite Monitoring Studies: Demographic, Population Growth, Extinction and Movement Parameters. PI: Wiley M. Kitchens. Personnel: B. Reichert, C. Cattau, A. Bowling. Completion Date: March 2008.

249. Status, Ecology, and Conseration of Rare and Endangered Florida Orchidaceae-Bletia purpurea. PI: M. Kane. Personnel: S. Stewart, T. Johnson, d. Dutra, P. Kauth. Completion Date: June 2008.

250. Radio Telemetry and Mark-Recapture Studies of Demographic, Movement and Population Dynamics of the Endangered Snail Kit. PI: W.M. Kitchens. Personnel: Br. Reichert, C. Cattau, A. Bowling. Completion Date: June 2008

251. Technical Assistance for Continuing Development of Content for Focal Species Website and Bird Conservation Node Website. PI: H. F. Percival. Personnel: E. Martin, A. Schwarzer. Completion Date: July 2008.

252. Evaluating Endocrine Disruption in Fish Exposed to Waters at Turkey Creek. PI: N. Denslow; Co-PI: N. Sazbo. Personnel: R. Weil, I. Knoebl. Completion Date: September 2008.

253. Assessment of Beach Compaction and Associated Effects on Loggerhead Sea Turtles (Caretta caretta) Nesting on Natural and Nourished Beaches in Northwest Florida. PI R. Carthy; Co-PI: M. Lamont; Personnel: Lori Brinn, J. Solis. Completion Date: September, 2008.

254. Effects of Environmental Mercury Exposure on Development and Reproduction in White Ibises. PI: P. Frederick; Personnel: N. Jayasena. E. Adams, L. Straub, B.J. Sampson. Completion Date: September 2008

255. ERDC Participation in 2008 USACE UAS Program. PI: H.F. Percival. Co-PI: P. Ifju, B. Dewitt, S. Smith. Personnel: A. Watts, J. Perry, W. Bowman, M. Morton. Completion Date: September 2008.

256. An Assessment of the Use of Unmanned Aerial Systems for Surveys of Wading Birds in the Everglades.

PI: P. Frederick. Personnel: A. Watts, A Abd-Elrahman, A. Mohamed, B. Wilkinson, J. Perry, K. Lee, Y. Kaddoura. Completion Date: September 2008.

257. St. Joseph Peninsula Beach Restoration Project. PI: R. Carthy, Co-PI: M. Lamont. Personnel: F. Solis, J. Solis, M. Weisel, C. Warner. Completion Date: October 2008.

258. To Document Floral and Faunal Succession Following Alternative Habitat Restoration Techniques in a Large Central Florida Lake Tohopekaliga. PI: W.M. Kitchens; Personnel: Melissa DeSa, Zach Welch Carolyn Enloe, Brad Shoger, Amy Schwarzer. Completion Date: December 2008.

259. Adaptive Habitat Management for Florida Scrub-Jays at Merritt Island National Wildlife Refuge. PI: H. F. Percival; Co-PI: F. Johnson. Completion Date: December 2008.

260. Assessing the Effects of Coastline Alteration on Sea Turtle Nesting and Faunal Assemblages at Cape San Blas, Florida. PI: R. Carthy, Co-PI: M. Lamont, Personnel: R. Scarpino, C. Warner, J. Solis, F. Solis Michelle Weisel, L. Brinn. Completion date: March, 2009.

261. Development of a Sea Turtle Education Program for Gulf County, FL. PI: R. Carthy. Co-PI: M. Lamont. Completion Date: March 2009.

262. Regional Distribution of Soil Nutrients – hierarchical Soil Nutrient Mapping for Improved Ecosystem Change Detection. PI: T. Osborne. Co-PI: M. Cohen. Personnel: S. Lamsal, B. White. Completion Date: March 2009.

263. Monitoring of Wading bird Reproduction in WCAS 1, 2, and 3 of the Everglades – UAV. PI: H. F. Percival. Personnel: A. Watts, J. Perry, M. Burgess, S. Ingley. Completion Date: March 2009.

264. Science Fellowship for Assessment of Coastal Habitats and Listed Species. PI: Raymond R. Carthy Co-PI: M. Lamont. Completion Date: April 2009.

265. Historic Pond Restoration in the Florida Panther National Wildlife Refuge. PI: C. Reinhardt-Adams. Co-PI: M. Kane. Personnel: S. Stewart, D. Watts, N. Steigerwalt, C. Wiese, S. McCauley. Completion Date: May 2009.

266. Rapid Delineation of Provenance for Florida Sea Oats Used for Beach and Dune Stabiliation. PI: M. Kane. Personnel: N. Philman, P. Sleszynski, S. Stewart, D. Dutra. Completion Date: June 2009.

267. Ecology and Conservation of Snowy Plovers In the Florida Panhandle. PI: Steven Johnson. Completion Date: June 2009

268. Wildlife Usage and Habitat Development on Spoil Islands in Lake Tohopekaliga, Florida. PI: W. M. Kitchens Personnel: Melissa DeSa, Carolyn Enloe, Brad Shoger, Amy Schwarzer, Jonathan Chandler. Completion Date: August 2009.

269. Techniques for Field Establishment and Reintroduction of Calopogon tuberosus var. tuberosus. PI: M. Kane. Co-PI: P. Kauth. Completion Date: August 2009.

270. Conservation of South Florida's Orchids—Developing Reintroduction Methods for Eight Native Species Including the State Endangered Ghost Orchid (Dendrophylax lindenii). PI: M. Kane. Personnel: D. Dutra, P. Kauth, T. Johnson, N. Philman. Completeion Date: August 2009.

271. Wading Bird Colony Location, Size, Timing and Wood Stork Nesting Success. PI: P. Frederick. Personnel: J. Simon, K. Williams. Completion Date: September 2009.

272. Development of Unmanned Aerial vehicles for Assessment of Wildlife Populations and Habitats: Phase 3. PI: H.F. Percival; Co-PI: P. Ifju; Personnel: M. Burgess. Completion Date: December, 2009.

273. Experimental Evaluation of a Habitat Enhancement Project for Fish and Wildlife at Gant Lake, Florida. PI: W.M. Kitchens: Co-PIs: M. Allen, H.F. Percival. Completion Date: December, 2009.

274. Structured Decision Making, Ecological Thresholds and the Establishment of Management Trigger Points. PI: W.M. Kitchens. Research Staff: J. Martin. Completion Date: December 2009.

275. An Assessment of Gulf Sturgeon Population Status in the Gulf of Mexico. PI: W. Pine. Research Staff: H. Jared Flowers. Completion Date: December 2009.

276. Spectral and response Assessment of Turtle-Friendly Lighting Study. PI: R. Carthy. Co-PI: M. Lamont. Research Staff: F. Solis, J. Solis. Completion Date: April 2010.

277. Supplement to "Directing Succession Through Adaptive Management in National Wildlife Refuges: Reed Canary. PI: C. Reinhart-Adams. Research Staff: L. Cobb, D. Haskell. Completion Date: July 2010.

278. Factors Affecting Population Density & Harvest of Northern Bobwhite. PI: M. Clark. Co-PI: T. Osborne. Graduate Student: D. Watts. Research Staff: T. Oh, J. Vogel. Completion Date: September 2010.

279. Ridge-Slough Mosaic in Response to Climate Change and Water Management. PI: M. Clark. Co-PI: T. Osborne. Graduate Student: D. Watts. Research Staff: T. Oh, J. Vogel. Completion Date: September 2010.

280. Adaptive Management of Gulf Coast Salt Marshes Considering the Sea Level Rise and Recovery of the Endangered Florida Salt Marsh. PI: F. Percival. Research Staff: M. Burgess. Completion Date: September 2010.

281. Surveys of Snail Kite Breeding and Habitat Use in the Upper St. Johns River Basin. PI: W. Kitchens. Graduate Students: J. Olbert, K. Pias. Completion Date: December 2010.

282. Monitoring of Wading Bird Reproduction In WCAs 1,2,3 of the Everglades. PI: P. Frederick. Research Staff: J. Simon, C. Winchester, L. Venne. Completion Date: December 2010.

283. Gopher Tortoise Population Survey for St. Marks NWR- Line Transect Distance Sampling. PI: R. Carthy. Co-PI: M. Lamont. Completion Date: August 2011.

284. Population Genetic Analysis and Assessment of Hybridization between Calopogon tuberosus var. tuberosus and var. Simsonii. PI: M. Kane. Co-PI: P. Kauth. Completion Date: August 2011.

285. Interplanting of Grass Species Among Native Vegetation to Reduce or Eliminate Aircraft Bird Strike Incidence by Dove at Hurlburt Field. PI: Bill Pine. Completion Date: September 2011.

286. Strategic Habitat Conservation for the Florida Scrub-Jay at Merritt Island National Park. PI: Franklin Percival. Research Staff: M. Walters, F. Johnson. Completion Date: September 2011.

287. Assessing Natal Sources of Juvenile Native Fish in Grand Canyon: A Test with Flannelmouth Suckers and Other Native Fish. PI: Bill Pine. Completion Date: September 2011.

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288. St. Joe Beach Restoration. PI: R. Carthy. Research Staff: S. Farris, C. Hackett, M. Lamont, J. McKenzie, B. Stephens. Completion Date: January 2012.

289. Effects of Climate Change on Barrier Island Habitat and Nesting Sea Turtles. PI: R. Cathy. Co-PI: M. Lamont. Research Staff: A. Daniels, J. Gross, J. Hill, J. Kime, E. Nordberg, H. Ronco, N. Williams, B. Stephens, S. Farris. Completion Date: May 2012.

290. Directing Succession Through Adaptive Management in National Wildlife Refuges: Reed Canary Grass Control and Transition to Wetland Forests and Meadows. PI: C. Reinhart-Adams. Co-PI: S. Gatowitsch, E. Lonsdorf, F. Percival. Completion Date: July 2012

291. Foraging & Nesting Habitat Characteristics, Exotic snail utilization and nest failures of the Everglade Snail kite on the Kissimmee Chain of Lakes. PI: W. Kitchens. Research Staff: K. Pias, J. Olbert. Completion date: December 2012.

292. Nesting, Recruiting, and Foraging Ecology of the Florida Snail Kite in Lake Tohopekaliga. PI: W. Kitchens. Research Staff: K. Pias, J. Olbert. Completion Date: March 2013.

293. The Effects of Shoreline Armoring Structures on Nesting Loggerhead turtles. PI: R. Carthy. Completion Date: March 2013.

294. Incubation temperatures of loggerhead turtle (caretta caretta) nests on NW Florida Beaches. PI: R. Carthy. Research Staff: M. Lamont, B. Stephens. Completion Date: March 2013.

295. A Land of Flowers on a Latitude of Deserts: Aiding Conservation Management of Florida's Biodiversity by Using Predictions from Down-Scaled AOGCM Climate Scenario in Combination with Ecological Modeling. PI: F. Percival. Research Staff: C. Zweig. Completion Date: May 2013

296. Alligator Capture Database. PI: Franklin Percival. Research Staff: A. Subramaniam Ravi. Completion Date: June 2013.

297. SE Adaptive Management Group (SEAMG). PI: Franklin Percival. Completion Date: June 2013

298. Collection of Digital Aerial Imagery in Support of Aquatic Invasive Species Program and CERP. PI: F. Percival. Research Staff: M. Burgess. Completion Date: June 2013.

299. Socio-Cultural Constructions of Values and Attitudes Toward Wildlife and Nature: Attracting Underrepresented Groups to Wildlife Professions. PI: S. Jacobson. Research Staff: N. Haynes. Completion Date: June 2013.

300. Management of Functionally Connected Dune Habitat for Endangered Beach Mice on Fragmented Landscapes. PI: L. Branch. Co-PI: D. Miller, M. Stoddard. Completion Date: July 2013.

301. Coastal ecosystems and Climate Change: Effects on Habitat and Species. PI: R. Carthy. Completion Date: December 2013.

302. Translocation of Marsh Rabbits to Everglades National Park. PI: R. McCleery. Completion Date: December 2013.

Publications 2013

Williams,N.C., Bojorndal, K. A., Lamont, M.M., Carty, R.R. 2013. Winter diets of immature green turtles (Chelonia mydas) on a northern feeding ground: integrating stomach contents and stable isotope analyses.

Fletcher, R.J. Jr., A. Revell, B.E. Reichert, W.M. Kitchens, J.D. Dixon, and J.D. Austin. 2013.
Network modularity reveals critical scales for connectivity in ecology, evolution, and conservation. Nature Communications. DOI: 10.1038/ncomms3572.

Cattau, C. E., P. C. Darby, R. J. Fletcher, and W. M. Kitchens. 2013. Reproductive response of the endangered snail kite to variations in prey density. Journal of Wildlife Management.

Zweig, C. L., R. Dorazio, and W. M. Kitchens. 2013. Reconstructing historic habitat with multistate models. Ecological Applications.

Elston, LM, JH Waddle, KG Rice, and HF Percival. 2013 Co-ocurrence of Invasive Cuban treefrogs and native treefrogs in PVC pipe refugia. Herpetological Review. 024733

Rosenblatt, A.E., M.R. Heithaus, F.J. Mazzotti, M.S. Cherkiss and B.M. Jeffery. 2013. Intrapopulation variation in activity ranges, diel patterns, movement, and habitat use if American alligators in a subtropical estuary. Estuarine Coastal and Shelf Science. Vol. 135, 182-190.

<u>Presentations 2013</u>

Carthy, R. Engineering Solutions to Aid in the Preservation of Sea Turtles, University of Florida, United States (June 20, 2013).

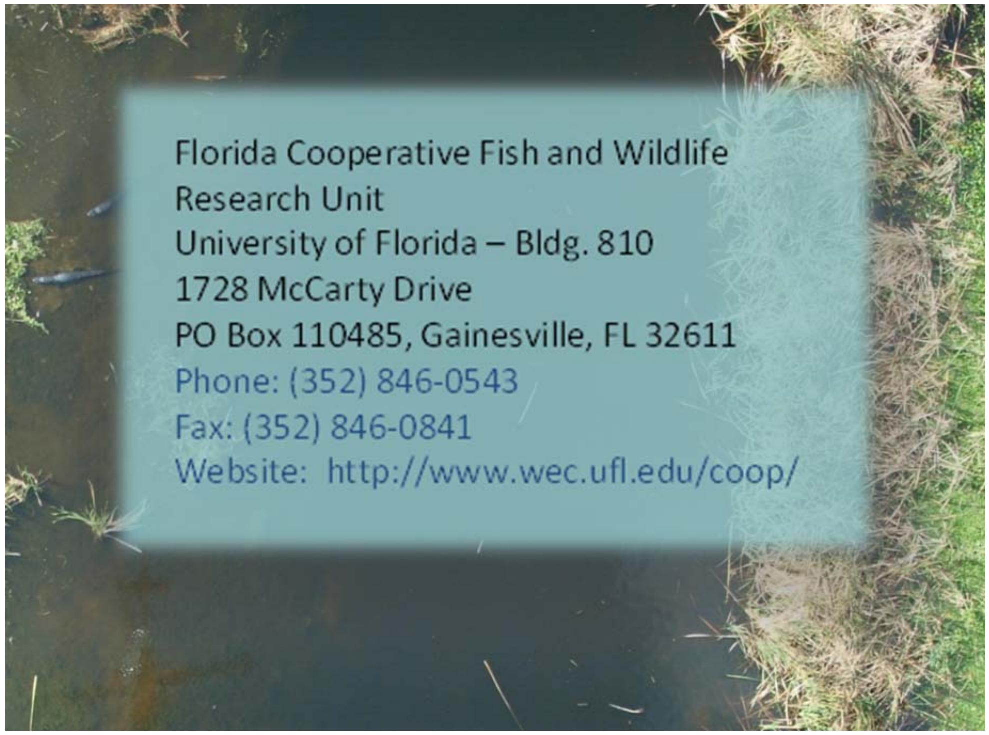
McCleery, R.A., A. Sovie, R. Reed, K. Hart. 2013. Evaluating the impacts of Burmese pythons on marsh rabbits throughout the greater everglades. Large Constrictor Workshop, Homestead, FL.

Sovie, A., R. A. McCleery, R. Reed, K. Hart. 2013. Are pythons causing the decline of rabbits in the greater everglades. Big Cypress Research Symposium, Big Cypress National Preserve, Ochpee, FL.

Cherkiss, M., F. Mazzotti, K. Hart, L. Brandt, B. Jeffery, J. Beauchamp and R. Crespo. 2013. The American crocodile in Florida: Endangered Species Recovery and Ecosystem Restoration. Presented at the American Crocodile Workshop, Keys Gate Golf and Country Club, Homestead, 15 February 2013.

Beauchamp, J.S., Hart, K.M., Mazzotti, F., Cherkiss, M., Jeffery, B., Crespo, R. 2013. The spatial ecology of the American Crocodile in Everglades National Park. Presented at the American Crocodile Workshop, Keys Gate Golf and Country Clug, Homestead, FL. 15 February 2013.

Pine, W.E. III. 2013. Nearshore Ecology of Grand Canyon Fish. Department of Fish, Wildlife and Conservation Biology, Colorado State University, Ft. Collins, Colorado.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