PHOTO BY ALAN CRESSLER, USGS

The Southeast Climate Adaptation Science Center (SE CASC) is one of eight regional Climate Adaptation Science Centers managed by the U.S. Geological Survey National Climate Adaptation Science Center.
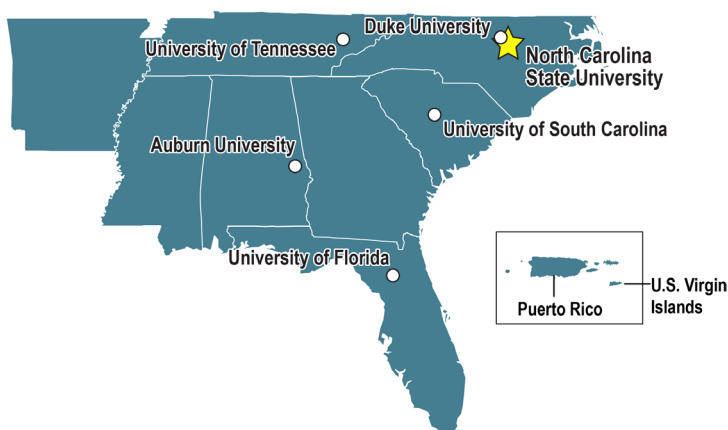**We work with natural and cultural resource managers to gather the scientific information and build the tools needed to help fish, wildlife, and ecosystems adapt to the impacts of climate change.**

Since it began operation in 2010, the SE CASC has been organized to accomplish three goals:

➤ Provide decision-focused, research-based information that supports transparent global change adaptation decisions;

➤ Convene conversations among decision makers, scientists, and managers about key ecosystem adaptation decisions;

➤ Build the capacity of natural resource professionals, university faculty, and students to understand and frame natural resource adaptation decisions and develop and use research-based information to make adaptation decisions.

Starting in 2017, NC State University continued as the lead university host for the SE CASC, engaging five new institutions as part of a university consortium.

OUR CONSORTIUM

Duke University
University of Tennessee
North Carolina State University
University of South Carolina
Auburn University
University of Florida
Puerto Rico
U.S. Virgin Islands

## SOUTHEAST CLIMATE ADAPTATION SCIENCE CENTER RESEARCH

Research funded by the Southeast Climate Adaptation Science Center encompasses a range of science activities that advance understanding of the **exposure** and **impacts** of global change on resources that matter to our partners and to framing decisions about **adaptation** strategies, emphasizing principles of co-production.

Get more information and keep up with our work
> secasc.ncsu.edu

On March 23, 2018, with the passage of the Fiscal Year 2018 budget, our name was changed from the Southeast Climate Science Center (SE CSC) to the Southeast Climate Adaptation Science Center (SE CASC). Our mission remains the same.

SOUTHEAST CLIMATE ADAPTATION SCIENCE CENTER PROJECTS

Actionable Science
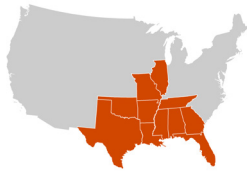
## ESTIMATING FUTURE WATER AVAILABILITY AND STREAM-FLOW IN THE SOUTHEAST

Regional hydrologic model provides managers historical and potential future information on water availability and timing in the Southeast.

Estimates of water flows in streams are critical to inform natural resource managers of water availability for both human and ecological needs. Monitoring flow using a streamgage provides information about the amount and timing of surface water resources. Hydrologic models can be used to estimate streamflow for streams without gages. This research developed a method to group watersheds that are gaged with watersheds that are not gaged to provide accurate estimates of water availability regionally. Various models, techniques, and data were used to group watersheds across the southeastern United States based on their response to climate and their landscape setting. The result is consistent regional estimates of water availability for current and potential future climate and land cover in the Southeast.

Investigator: Jacob LaFontaine, USGS GA Water Science Center **Collaborators:** GCPO LCC **End Date**: Sep 2016

> secasc.ncsu.edu/science/future-water
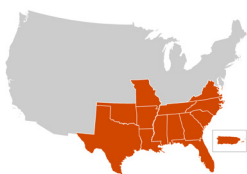
SOUTHEAST GLOBAL CHANGE MONITORING PORTAL

Metadata portal connects users to centralized biological, chemical, & physical data important for assessing global change in the Southeast.

Detecting change in ecosystems requires observations of living and non-living components over time. Many organizations make observations that are relevant to understanding global change processes, but the data are often not easily discoverable by other interested scientists and managers. This multi-phase project created a centralized web-based portal that allows users to discover, search, and connect to many types of environmental and biological data relevant to characterizing potential effects of climate and land use change on land, water, and wildlife in the Southeast. Data resources can be visualized and searched by types of measurements and/or by geographic criteria, increasing the usefulness of data collection efforts by a broad range of organizations.

Investigators: Damian Shea and Cari Furiness, NCSU **Collaborators:** AppLCC, CLCC, GCPO LCC, GCP LCC, PFLCC, SALCC **End Date**: Sep 2017

> secasc.ncsu.edu/science/gcmp/

MODELING FUTURE TEMPERATURE AND PRECIPITATION FOR PUERTO RICO AND THE U.S. CARIBBEAN

Understanding local impacts of global climate changes in tropical island ecosystems lays the foundation for sound climate adaptation decisions.

This research project developed a suite of dynamically downscaled projections for Puerto Rico and the U.S. Caribbean region. The framework provides a unique opportunity to advance knowledge about climate change impacts on island ecosystems in the global tropics. The resulting simulations fill a critical need for climate change information in Puerto Rico and the broader U.S. Caribbean by enabling future estimates of likely deviations from known ranges of species' thermal/moisture optima. This work furthers scientific understanding of local responses to global climate change and provides a basis for a robust decision-making approach to climate adaptation in the Caribbean LCC.

Investigators: Adam Terando, SE CSC, and Jaime Collazo, USGS NC Coop Unit **Collaborators**: UNC-CH, USFS, FL State Univ, CLCC **End Date**: Sep 2016

> secasc.ncsu.edu/science/caribbean-projections/

DOWNSCALING CLIMATE PROJECTIONS TO UNDERSTAND FUTURE TEMPERATURE AND PRECIPITATION PATTERNS IN THE SOUTHEAST
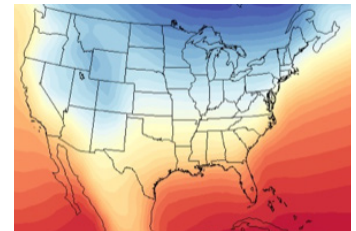

Climate projections at usable scales help inform climate impacts and adaptation strategies.

Researchers generated a series of datasets that provide projections of climate change at appropriate spatial scales to directly address specific management questions. These climate change projections are the result of statistically downscaling output from global climate models used in the Intergovernmental Panel on Climate Change Assessment Report 5. The datasets include not only daily temperature and precipitation, but other variables such as surface winds, humidity, and solar radiation that are needed in hydrologic and ecological modeling. Two products that cover the continental United States, one at a 4-km resolution and the other at a 6-km resolution, have been completed. This project also assessed how well the global climate models reproduce the Southeast's 20th century climate.

Investigators: Phil Mote, OR State Univ, and John Abatzoglou, Univ of ID **End Date**: Oct 2014

> secasc.ncsu.edu/science/se-downscaled-climate/
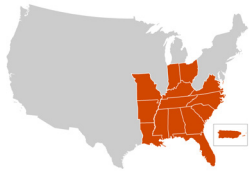
DEVELOPING LONG-TERM URBANIZATION SCENARIOS AS PART OF SOUTHEAST REGIONAL ASSESSMENT PROJECT


Regional modeling projects future changes in region due to urbanization, an important global change process that influences conservation decisions.

The southeastern U.S. spans a broad range of physiographic settings and has exceptionally high levels of faunal diversity, but many of these ecosystems are increasingly under threat due to rapid human development and climate change. Traditional urban growth models are very localized and data-intensive and lack the capability to be applied across large regions. Researchers modified the model framework and calibrations of the USGS SLEUTH urban growth model to develop urbanization scenarios as part of the Southeast Regional Assessment Project. This multi-phase project effort developed long-term urbanization modeling for the South Atlantic, Gulf Coastal Plains and Ozarks, and Appalachian LCCs, then extended modeling into the footprint of the Caribbean LCC.

Investigator: Jaime Collazo, USGS NC Coop Unit **Collaborators**: NCSU, USGS **End Date**: Sep 2014

> **secasc.ncsu.edu/science/ urbanization-scenarios/**
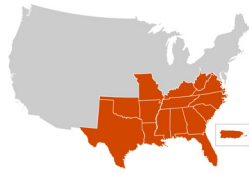
EVALUATING THE USE OF MODELS FOR PROJECTING FUTURE WATER FLOW IN THE SOUTHEAST


Evaluation of seven hydrological models shows that more local-scale calibration predicts streamflow better than simple regional models.

Assessing the impact of flow alteration on aquatic ecosystems has been identified as a critical area of research nationally and in the Southeast. This project produced a synthesis and evaluation of seven hydrologic models in the southeastern region of the U.S., including all states of the Southeastern Association of Fish and Wildlife Agencies and Puerto Rico. It provides Landscape Conservation Cooperatives and other resource managers with a useful database of who is doing what, where, how, and how well in terms of hydrological modeling for global change impact studies across the Southeast.

Investigators: Jonathan Kennen, USGS NJ Water Science Center, and Stacy Nelson, NCSU **Collaborators**: USFS, CLCC, GCPO LCC, GCP LCC, PFLCC, SALCC **End Date**: Jul 2013

> **secasc.ncsu.edu/science/ hydro-model-evaluation/**
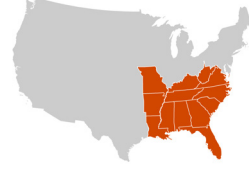
## EVALUATING DOWNSCALED CLIMATE MODELS FOR PROJECTING FUTURE CHANGES IN THE SOUTHEAST

Many downscaled climate models exist using different methods, accuracy, & confidence for impact & adaptation analysis. Guidelines on best practices are included.

To better assess how climate change may affect multiple sectors, including ecosystems, climatologists have created climate projections that contain information from global climate models translated to regional or local scales. The goals of this project were to assess needs of ecologists in the Southeast for downscaled climate projections, synthesize information available, and evaluate a selection of downscaled climate projections based upon the needs of the ecological community in the Southeast. The project created a guide that provides scientific information and guidance to enable resource managers and others to make science-based climate change adaptation decisions. Web-based tools guiding downscaled product selection were also developed.

Investigators: Ryan Boyles and Adrienne Wootten, NCSU **Collaborators**: USGS, FL State Univ **End Date**: Dec 2013

> **secasc.ncsu.edu/science/ downscaling-synthesis/**
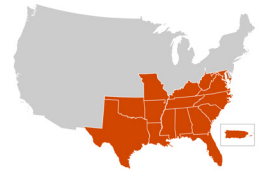
IDENTIFYING SCIENCE NEEDS FOR SOUTHEASTERN GRASSLANDS

Collecting specific data on threatened species in the Southeast's grassland regions assists managers in better conserving these vulnerable ecosystems.

Grasslands in the southeastern U.S. are home to rare plant and animal species, hosting a wealth of biodiversity. Extensive agriculture, urbanization, and fire suppression have reduced the Southeast's grasslands by approximately 90% and climate change will impose additional stress on this diverse ecosystem. Scientific and conservation professionals will collaborate to explore challenges facing grassland conservation by clarifying research and data needs of USFWS and state agencies for Species Status Assessments of imperiled grassland species. This project will produce a report that specifies the types of data and analysis most needed to help grassland managers restore, conserve, and manage these ecosystems into the future.

Investigators: Jennifer Cartwright, USGS Lower MS Gulf Water Science Center, and Dwayne Estes, Southeastern Grasslands Initiative **Collaborators**: SGI **End Date**: May 2020

> **secasc.ncsu.edu/science/ se-grasslands/**

Actionable Science

FUTURE HABITAT CONDITION SCENARIOS FOR WILDLIFE IN THE IMPERILED PINE ROCKLAND ECOSYSTEM


Assessment of habitat conditions in south Florida's pine rockland ecosystem will support conservation and management of rare, endemic, and at-risk species.

The pine rockland ecosystem provides critical habitat for numerous plant and animal species, many of which are endangered. However, this area of south Florida is threatened by saltwater intrusion from hurricanes and sea-level rise. This project will evaluate habitat conditions for the rim rock crowned snake and the key ringneck snake, two species being considered for federal listing. Researchers will identify potential future changes in habitat that could result from different management actions and environmental conditions. They will then explore the potential impacts of these habitat changes on the species. Although this project focuses on two species of snakes, the results can inform the conservation, management, and recovery of other at-risk species found in the ecosystem.

Investigator: Susan Walls, USGS WARC **Collaborators:** USFWS **End Date:** Feb 2020

> secasc.ncsu.edu/science/ pine-rocklands/
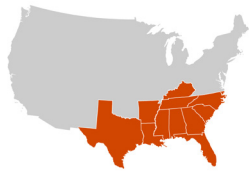
SCENARIOS OF FUTURE PATTERNS OF URBANIZATION, CLIMATE ADAPTATION, AND LANDSCAPE CHANGE

Researchers will explore how the existing flow of people into the Southeast will interact with the potentially increasing drive to move away from the coast as climate conditions change.

As human populations grow, demand for urbanized areas will increase, and scientists can help natural resource managers plan for these changes by creating models that predict patterns of future urbanization. This project will build on prior efforts to develop more comprehensive scenarios of future urbanization patterns in the Southeast. The scenarios will consider the increasing redistribution of people from coastal and low-lying areas as they become more vulnerable to climate change and existing migration flows from other parts of the country into the Southeast. The resulting scenarios and maps of potential future urban change will allow natural resource decision makers to anticipate upcoming hotspots of urbanization and population movement.

Investigators: Ross Meentemeyer, NCSU and Adam Terando, SECASC **End Date:** Oct 2021

> secasc.ncsu.edu/science/ se-future-urbanization/

## THE FUTURE OF CULTURALLY IMPORTANT SPECIES IN NORTH AMERICA

Engagement with Indigenous stakeholders will support identification of the future of culturally important species as climate conditions change.

Global change is leading to major shifts in the abundance, distribution, and life history of culturally important species to the Indigenous peoples of North America. This has concomitant effects on their value to the peoples for whom they are most culturally important. Using an approach known as climate-analogue mapping, researchers will examine regions currently experiencing the specific climate conditions that are expected to be experienced on Tribal lands in the future, as a means of forecasting potential future climate conditions for Tribal lands. A Tribal needs assessment listening session will also be conducted to determine which species and phenomena should be studied, at what scale should they be studied, and what management decisions would be most relevant to tribes.

Investigator: Rob Dunn, NCSU **Collaborators:** USET, Univ of MD, CSU **End Date:** Apr 2020

> secasc.ncsu.edu/science/ culturally-impt-species/
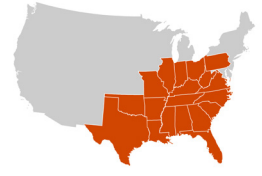
ASSESSMENT OF WATER AVAILABILITY AND STREAMFLOW CHARACTERISTICS IN THE SOUTHEAST
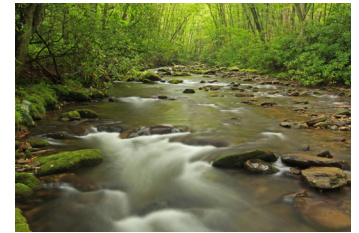

Hydrologic models combine data from gaged and ungaged watersheds to forecast current and potential future changes to water availability in the Southeast.

To effectively plan for and adapt to future climate and land cover conditions, managers require information on streamflow variability that could impact the distribution and quantity of water resources. Flow can be monitored in a stream with a stream gage, which provides information about the amount and variability of surface water resources at a location. Not every stream has a gage, so hydrologic models can be used to provide estimates of streamflow characteristics. This project will use a modeling approach that groups watersheds that are gaged with watersheds that are not gaged to provide accurate estimates of water availability for all watersheds in the southeastern United States under current and potential climate and land cover conditions.

Investigator: Jacob LaFontaine, USGS South Atlantic WSC **Collaborators:** USGS Lower MS Gulf Water Science Center **End Date:** Aug 2020

**> secasc.ncsu.edu/science/ water-availability/**
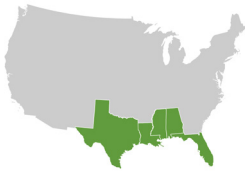
COMMUNICATING FUTURE SEA-LEVEL RISE SCENARIOS FOR GULF COAST NATIONAL WILDLIFE REFUGE AND NATIONAL PARK LANDS

Customized fact sheets will communicate the risks of sea-level rise through 2100 in the northern Gulf of Mexico's national wildlife refuges and parks.

Low-lying public lands along the northern Gulf of Mexico coast are vulnerable to sea-level rise. Coastal planners and resource managers in the region have requested customized information that can be used to concisely communicate the risks. In this project, researchers will develop fact sheets outlining potential sea-level rise scenarios for the region through 2100, and the potential impacts of these varying amounts of sea-level rise on the missions of national wildlife refuge and national park lands along the U.S. Gulf Coast. Researchers will draw from existing information on regional and global sea-level rise scenarios and associated projections of high-tide flooding to develop customized fact sheets for 38 national wildlife refuges and 9 National Park Service lands.

Investigator: Michael Osland, WARC **Collaborators**: NGoM Sentinel Site Cooperative **End Date**: Oct 2019

> secasc.ncsu.edu/science/ngom-sealevelrise
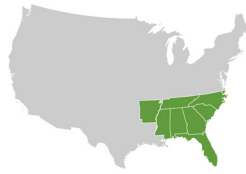
EFFECTS OF URBANIZATION ON THE CONSERVATION VALUE OF FORESTS

Studying urban forest habitat quality in response to urbanization will highlight the role that urban forests can play in achieving conservation goals.

Urbanization in the Southeast U.S. is a primary threat to threatened and endangered species. As urbanized areas expand, they encroach on preserved areas, like national wildlife refuges, and divide forests into smaller fragments. Forests located next to cities are exposed to high temperatures, pollution, pests, and invasive plants that threaten forest health. However, forests located within urban and suburban areas – "urban forests" - support diverse plant and animal life, and could play an increasingly important role in conservation as urbanization continues. This project will synthesize information on how higher temperatures and pollution affect urban forest habitat quality, identify knowledge gaps that impede forest management, and propose future research directions to fill those gaps.

Investigators: Steve Frank, NCSU **End Date**: Apr 2020

**> secasc.ncsu.edu/science/forest-fragments/**
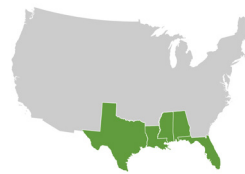
ECOLOGICAL AND MANAGEMENT IMPLICATIONS OF MANGROVE MIGRATION IN THE NORTHERN GULF OF MEXICO

The Mangrove Migration Network will curate data to forecast the ecological impacts of mangrove expansion in the northern Gulf of Mexico.

In response to warming winter temperatures, mangroves are expected to continue migrating northward at the expense of salt marshes. Coastal wetland managers need information and tools that will enable them to forecast the ecological impacts of these shifts. Researchers will leverage a community-curated data network called the Mangrove Migration Network to examine damage and mortality temperature thresholds for several mangrove species common to the region. Workshops will be held with managers to identify issues related to mangrove restoration and management in coastal wetlands. The results will help land managers better understand what is happening on the lands they manage, and evaluate alternative restoration activities that involve migrating mangroves.

Investigator: Michael Osland, WARC **Collaborators**: Mangrove Migration Network **End Date**: Jul 2020

> secasc.ncsu.edu/science/mangrove-migration/
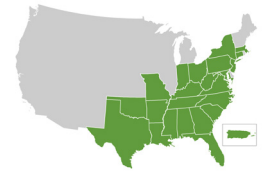
## ASSESSING CLIMATE-SENSITIVE ECOSYSTEMS IN THE SOUTHEASTERN UNITED STATES

For 12 SE US ecosystems analyzed for climate vulnerability, 5 are highly & 6 are moderately vulnerable. Strategies for management were developed.

The Southeast supports a unique diversity of ecosystems that provide important benefits such as habitat for wildlife and plants, water quality, and recreation. Researchers assessed climate change vulnerability for twelve ecosystems in the southeastern U.S. and Caribbean by synthesizing data and literature related to three components of vulnerability: climate sensitivity, climate change exposure, and adaptive capacity. A qualitative vulnerability rating for each ecosystem was developed and critical management actions for reducing the vulnerability of each ecosystem were identified. Of the twelve ecosystems assessed, five were rated as having high vulnerability, six had moderate vulnerability, and one had low vulnerability.

Investigators: Jaime Collazo and Bill Wolfe, USGS **Collaborators**: AppLCC, CLCC, GCPO LCC, GCP LCC, PFLCC, SALCC, NatureServe, NCSU **End Date**: Dec 2013

> secasc.ncsu.edu/science/vulnerable-ecosystems/

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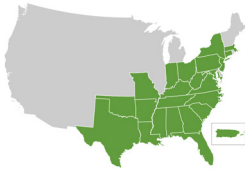
PROVIDING SCIENCE FOR THE CONSERVATION OF ANIMALS IN THE SOUTHEASTERN LONG-LEAF PINE ECOSYSTEM

Range-wide models and partnerships will inform conservation actions for at-risk amphibian and reptile species in the longleaf system.

The longleaf pine ecosystem supports several animal species that are a priority for review to determine if they are threatened or endangered due to losses or changes in habitat. These include the gopher tortoise, striped newt, gopher frog, southern hognose snake, and Florida pine snake. This project involves collaborations with other partners conducting species assessments to identify conservation actions expected to improve the status of these five at-risk species across their range. Using input from this partner network, models will link the status of each species with features of the landscape to produce range-wide models of species status across jurisdictions.

Investigator: Clinton Moore, USGS GA Coop Unit **Collaborators**: USF-WS, NPS, USFS, DoD, SEAFWA, PFL-CC, SALCC, UGA **Co-sponsors**: NRCS, GCPO LCC **End Date**: Dec 2019

> secasc.ncsu.edu/science/longleaf-at-risk-species/

CLIMATE CHANGE IMPLICATIONS FOR THE CONSERVATION OF AMPHIBIANS IN TROPICAL ENVIRONMENTS


Research assesses eco-physiological limits & adaptive capacity of 3 endangered frog species. Decision framework will aid conservation strategies.

Investigators are collecting occupancy data for several amphibian species to quantify the effects of climate on the distribution and persistence of several amphibian species and to serve as ecological input for an optimal decision-making framework for a habitat conservation strategy that ensures the long-term persistence of amphibians and reptiles in Puerto Rico in the advent of climate change. In conjunction with downscaled climate projections, this work will increase understanding of the level of dependence and key uncertainties between climate (particularly moisture-related variables) and the distribution and persistence of species of conservation concern.

Investigator: Jaime Collazo, USGS NC Coop Unit **Collaborators**: NCSU, UNC-CH, CLCC, PRDENR; Univ of PR **End Date**: Aug 2020

> secasc.ncsu.edu/science/pr-amphibian-conservation/
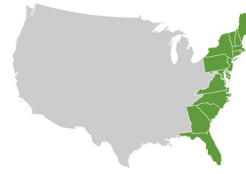
CONSEQUENCES OF URBANIZATION AND CLIMATE CHANGE ON HUMAN AND ECOSYSTEM HEALTH

Urban trees can tell us a lot about future forest health. Insect response to warming is more variable in southern cities.

This project investigated how tree selection at the local scale affects biodiversity and ecosystem services. Expanding to the regional scale, the study will determine the extent to which trees in cities can be used to predict heat-related threats to rural forests. Ongoing investigations of heat-related stress and pest outbreaks in urban and rural forests will provide management recommendations. Specific goals are to: 1) determine tree (and arthropod) characteristics that affect tree-dependent biodiversity, tree herbivory, and resilience of both trees and biodiversity to warming; and 2) understand how urbanization (and heat) influences pest populations in order to predict future distributions of pests (and loss of biodiversity) in natural forests.

Investigators: Steve Frank and Rob Dunn, NCSU **Collaborators**: SALCC **End Date**: Aug 2019

> secasc.ncsu.edu/science/urbanization-consequences/

FORESTS OF THE FUTURE: INTEGRATED ASSESSMENT OF CLIMATE CHANGE AND ECOSYSTEM DIVERSITY

Long-term forest warming enables integrated study of climate change impacts on insect & soil microbial communities & ecological processes.

Estimates of extinction rates and population losses attributable to climate change are often based on modeled biogeographic distributions, which rely on simple relationships between present-day distributions of species and climate variables to estimate distributions of species under future climate. Remarkably few experimental manipulations of the effects of changes in climate, and in particular temperature, have been conducted on animal populations and communities or on ecological processes dependent on their dynamics. This work built upon the longest-running, largest-scale forest warming experiment in the world to synthetically consider the effects of warming on diverse taxonomic and functional groups, from fungi and bacteria to herbivores and plant pathogens.

Investigator: Rob Dunn, NCSU **Collaborators**: USGS, SE CSC, NPS, SAL-CC **End Date**: Sep 2017

> secasc.ncsu.edu/science/future-forests/

FOUNDATIONAL SCIENCE AREAS: EXPOSURE, IMPACTS, ADAPTATION

TREE EATERS: PREDICTING THE RESPONSE OF HERBIVORES TO THE INTEGRATED EFFECTS OF URBAN AND GLOBAL CHANGE


Cities can be sentinels of climate change. Urban warming and drought stress combine to increase abundance of some pests.

This multi-phase project used urban warming as a proxy for global warming to develop predictive models of how warming influences beneficial and pest insects for cities in the Southeast and across the east coast more generally. The investigators were also able to predict how tree health will respond to these changes in insect communities. Comparing project results to those garnered from herbarium specimens (many insects can be found on herbarium specimens) showed that the effects of urban warming match those of climate change through time. A second body of work built on these discoveries to consider how to protect trees and forests from the pests that do better with warming.

Investigators: Rob Dunn and Steve Frank, NCSU **Collaborators**: SALCC **End Date**: Sep 2015

> secasc.ncsu.edu/science/tree-eaters/
**> secasc.ncsu.edu/science/climate-wildlife/**
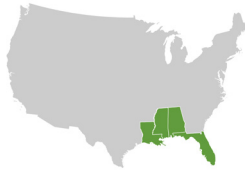
ECOLOGICAL IMPLICATIONS OF MANGROVE FOREST MIGRATION IN THE SOUTHEASTERN U.S.

Warmer winters will transform coastal wetland ecosystems: mangrove forests (trees) will expand northward and replace salt marshes (grasses).

Coastal wetlands purify water, protect coastal communities from storms, sequester (store) carbon, and provide habitat for fish and wildlife; they are also vulnerable to climate change. Changes in winter climate (warmer temperatures and fewer freeze events) may transform coastal wetlands in the northern Gulf of Mexico, as mangrove forests are expected to expand their range and replace salt marshes. This research specifically investigated the impact of mangrove forest migration on coastal wetland soil processes. Results indicate that mangrove forest expansion will bring about both above- and below-ground ecosystem changes. The most striking and apparent changes will occur above ground as forests develop and replace grasslands.

Investigator: Michael Osland, USGS WARC **Collaborators**: USGS, Univ of LA, GCPO LCC **End Date**: Sep 2014

> secasc.ncsu.edu/science/se-mangrove-migration
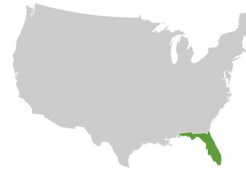
THE VULNERABILITY OF SEA TURTLE NESTING BEACHES TO CLIMATE CHANGE IN THE SOUTHEAST

Comparisons of historical sea turtle nesting habitats with projected changes in beaches give managers guidance for conserving vulnerable turtles.

This project assessed the vulnerability of key sea turtle nesting beaches to climate change in the Southeast. Researchers examined previous records of sea turtle nesting locations in the Southeast to identify the characteristics of these beaches, then predicted the future suitability of these beaches for nesting based on projected climate change. Identifying locations where beach habitat will no longer be suitable for nesting will help managers determine what action needs to be taken to protect loggerheads. Some of the nesting beaches used by loggerheads are also used by other endangered sea turtles, such as the Kemp's ridley, green, and leatherback sea turtles. Therefore, this project provides information for multiple species of national conservation concern.

Investigator: Kristen Hart, USGS **Collaborators**: USGS, Univ of FL **End Date**: Apr 2014

> secasc.ncsu.edu/science/sea-turtle-nesting/

IMPACT OF OCEAN WARMING AND ACIDIFICATION ON GROWTH OF REEF-BUILDING CORALS

Growth patterns in coral skeletons, much like growth rings in trees, can serve as important archives for the reconstruction of past ocean conditions.

Coral reefs are some of the most biologically rich and economically valuable ecosystems in the world. This study identified differences in climate vulnerability among three important reef-building coral species. Coral cores were used to examine variability in ocean temperature and coral growth over the past century. The work was a part of a larger effort to investigate the response of corals to changing ocean conditions in the Florida/Caribbean region and inform resource management decisions regarding reef restoration and species protection policies. Results show that a chemical signature in corals can estimate temperature well as long as corals with very slow growth rates are avoided, providing a proxy to understand past sea water conditions in the western Atlantic.

Investigator: Ilsa Kuffner, USGS **End Date**: Jan 2013

> secasc.ncsu.edu/science/coral-vulnerability/

Actionable Science

SYNTHESIZING CLIMATE CHANGE IMPACTS ON WILDLIFE HEALTH AND IDENTIFYING ADAPTATION STRATEGIES


A searchable database will be created to help identify gaps in knowledge about the impacts of climate change on wildlife health.

The goal of this project is to review and synthesize existing information on the impacts of climate change on fish and wildlife health across North America. Researchers will develop a searchable database containing this information, and will use that database to identify gaps in knowledge and unique areas of concern. Through a symposium with DOI scientists and stakeholders, including resource managers, state agencies, and Tribes, researchers will define near-term science priorities for better understanding the impacts of climate change on wildlife health and will identify potential adaptation strategies.

Investigator: Erik Hofmeister & Jonathan Sleeman, USGS NWHS End Date: Jul 2019

> secasc.ncsu.edu/science/wildlife-health
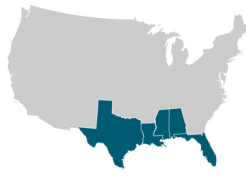
IDENTIFYING CONSERVATION OBJECTIVES FOR THE GULF COAST HABITATS OF THE BLACK SKIMMER AND GULL-BILLED TERN

Models will derive conservation objectives for Black Skimmer and Gull-billed Tern, which typify sustainable gulf habitats & other at-risk birds.

This research, part of a large regional project, focuses on the Black Skimmer and Gull-billed Tern, two species identified as representative of sustainable gulf habitats and designated as USFWS Species of Conservation Concern and Gulf Coast Joint Venture Priority Species. They are also characteristic of a variety of other beach and barrier-island nesting birds whose nesting habitats are threatened by sea-level rise. Statistical models will link each bird's population abundance to habitat characteristics that could be influenced by different management actions and will use this information to identify conservation objectives under different conservation scenarios.

Investigator: James Cronin, USGS WARC Collaborators: GCPO LCC, GCP LCC, PFLCC, SALCC, SC CSC, USFWS, GCJV End Date: Sep 2019

> secasc.ncsu.edu/science/gulf-coast-habitats

ENHANCING THE CAPACITY OF COASTAL WETLANDS TO ADAPT TO SEA-LEVEL RISE AND COASTAL DEVELOPMENT

In response to sea-level rise, coastal wetlands will migrate landward at the expense of upslope and upriver ecosystems.

This project built on a recent study that identified areas where coastal wetlands may adapt via landward migration along the northern Gulf of Mexico coast, one of the most sea-level-rise-sensitive and wetland-rich regions of the world. This project produced customized landscape conservation-design products focused on landward migration corridors for coastal wetlands. Environmental managers can use this scientific information to enhance the adaptive capacity of coastal wetlands in the face of sea-level rise and coastal development, protecting these ecosystems and the critical economic and ecological benefits that they provide.

Investigator: Michael Osland, USGS WARC Collaborators: GCPO LCC, GCP LCC, PFLCC, SALCC, SC CSC End Date: Mar 2018

> secasc.ncsu.edu/science/coasatal-wetlands-slr

CLIMATE CHANGE ADAPTATION FOR COASTAL NATIONAL WILDLIFE REFUGES

Collaborative engagement will address complex social, economic, and ecological impacts of global change in coastal South Carolina.

This multi-phase project partners with the South Carolina Low-Country Wildlife Refuge Complex to engage local communities, agencies, and organizations in understanding shared values and interests, strategies to adapt to current and future changes, and areas of collaboration or conflict. Project goals are: 1) produce state-of-the-art science that is useful for those working to protect coastal resources in South Carolina; 2) collectively describe plausible futures that can identify robust adaptation strategies and serve as a basis for communication among diverse stakeholders; and 3) foster greater understanding and collaborative decision making among those that benefit from and value Cape Romain and surrounding area. The first phase of the project developed a prototype decision framework.

Investigators: Mitchell Eaton, SE CSC; Fred Johnson and Julien Martin, USGS WARC Collaborators: USFWS, USGS, NCSU, NE CSC, DJ Case, MBL End Date: Aug 2019

> secasc.ncsu/edu/science/coaststal-wildlife-refuges

## PROTECTING CULTURAL RESOURCES IN THE FACE OF CLIMATE CHANGE

Framework for making robust decisions about protecting threatened cultural resources is being developed at Cape Lookout, with plans to expand.

Climate change is challenging the long-term persistence of many cultural resources. For example, those located in coastal areas, such as historic lighthouses, are threatened by sea-level rise, shoreline erosion, and more frequent severe storm events. To address the critical gap, to identify the impacts of climate change on cultural resources, researchers developed a strategy to aid decision makers in climate adaptation planning efforts. The strategy integrates assessments of the relative significance of specific cultural resources and their vulnerability to climate change. It was pilot tested with a subset of buildings listed on the National Historic Register at Cape Look National Seashore, located on North Carolina's barrier islands.

Investigator: Erin Seekamp, NCSU **Collaborators**: SE CSC, NPS, SALCC **End Date**: Sep 2017

> secasc.ncsu.edu/science/ cultural-resources
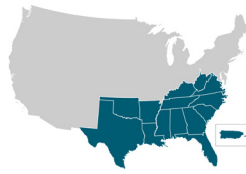
VITAL FUTURES: CONSERVATION ADAPTATION PLANNING FOR LANDSCAPE AND CLIMATE CHANGE IN THE SOUTHEAST

Regional conservation adaptation planning will be facilitated by coordination of climate-aligned goals, strategies, and principles of partners.

This project will support the efforts of the Southeast Conservation Adaptation Strategy, which aims to develop a collaborative network of conservation partners, shared conservation goals, and regional strategies to manage fish, wildlife, and other natural resources into the future. To help accomplish these goals, the project team will evaluate existing conservation plans and expected land and climate change impacts, and in collaboration with the Southeast conservation community, identify opportunities to incorporate landscape and climate change considerations into state and regional conservation actions.

Investigators: Kirstin Dow, Univ of SC; Bruce Stein, NWF **Collaborators**: GCPO LCC, GCP LCC, PFLCC, SALCC **End Date**: Dec 2019

> secasc.ncsu.edu/science/ vital-futires

## DYNAMIC RESERVE DESIGN IN THE FACE OF CLIMATE CHANGE AND URBANIZATION

Guidance was developed to optimize the acquisition of lands to meet reserve objectives in the face of dynamic urbanization and growth.

Reserve design is a process that must address ecological, social, and political factors to identify parcels of land in need of protection to sustain wildlife populations and other natural resources. Making land acquisition choices is challenging because it occurs over a long timeframe and involves consideration of future conditions such as climate and urbanization changes. The Everglades Headwaters National Wildlife Refuge hosts several threatened and endangered species and habitats. This study combined a structured decision making framework, optimal solution theory, and forecasts of population growth from urbanization models to design optimal configurations for the refuge and to guide land acquisition prioritization.

Investigator: Stephanie Romañach, USGS WARC **Collaborators**: USGS, Univ of FL, USFWS **End Date**: Aug 2015

> secasc.ncsu.edu/science/ dynamic-reserve-design
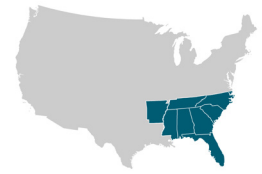
DEVELOPING A CONSERVATION DECISION GUIDANCE LIBRARY FOR SOUTHEAST CONSERVATION ADAPTATION STRATEGY


Longleaf pine management plans need better development of action and implementation protocols and improved decision problem definition methods.

A priority of the Southeast CASC is to support the planning and implementation of Southeast Conservation Adaptation Strategy. This project examined the decision-making context, decision-making process, and management planning associated with the restoration of open pine ecosystems in the Southeast. The quality of 35 management plans from federal, state, and NGOs were evaluated along with results of manager interviews. Newer plans were better than older ones. Researchers also developed a questionnaire that may be used in future research projects to evaluate how socio-structural drivers and personalities of decision makers influence their decision making.

Investigators: Nils Peterson and Fred Cubbage, NCSU **Collaborators**: GCPO LCC, SALCC **End Date**: Jun 2015

> secasc.ncsu.edu/science/ conservation-decision-library

Actionable Science
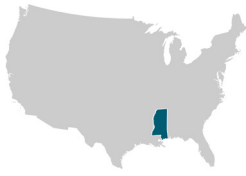
STRUCTURED DECISION MAKING AS A TOOL FOR COASTAL RESTORATION: A CASE STUDY ON SHIP ISLAND, MISSISSIPPI


Barrier island restoration project was used to develop a decision-making framework that can be expanded to other coastal adaptation projects.

Under the Mississippi Coastal Improvements Program, the US Army Corps of Engineers will place up to 22 million cubic yards of sand to restore the physical integrity of Ship Island. Researchers solicited input from project stakeholders, scientists, and engineers and incorporated this information, along with modeling and quantitative analysis, into a framework to inform decision making, should the island incur storm damage while the restoration is underway. This structured decision-making process yielded management recommendations that can be quickly and effectively implemented, while helping participants maximize the island's future resilience. It also led to a general decision framework and process that can be expanded and adapted for other barrier island and coastal restoration projects.

Investigator: Greg Steyer, USGS WARC **Collaborators**: GCPO LCC **End Date**: May 2015

> secasc.ncsu.edu/science/ sdm-ship-island
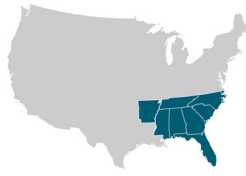
TURNING UNCERTAINTY INTO USEFUL INFORMATION FOR CONSERVATION DECISIONS

Project synthesizes information about and guidance for communicating and using uncertainty in making conservation decisions.

One of the most pervasive problems facing natural resource managers and science communicators is the existence of numerous social and ecological uncertainties. The objective of this project was to help facilitate strategic decision support and synthesize the state of the science related to communicating and using uncertain information in conservation decision making. This tool was developed through interdisciplinary interactions and a comprehensive literature review with a focus on climate change in the southeastern U.S. Researchers produced a fact sheet that discusses the pervasiveness of uncertainty, the importance of understanding varying perceptions of uncertainty, and avenues for progress in the presence of uncertainty and differing risk tolerances.

Investigators: Brian Irwin, USGS GA Coop Unit **Collaborators**: MI State Univ, USGS, GCPO LCC, PFLCC, SAL-CC **End Date**: Jun 2016

> secasc.ncsu.edu/science/ utilizing-uncertainty

A HANDBOOK FOR RESOURCE MANAGERS TO UNDERSTAND AND UTILIZE SEA-LEVEL RISE AND COASTAL WETLAND MODELS


Coastal managers and planners will appreciate this condensed resource guide of sea-level rise science and models for predicting impacts on coastal ecosystems.

The goal of this project was to collate science and models pertaining to the effects of sea level on coastal wetlands into a format that would be accessible and useful to resource managers. Researchers conducted training sessions with coastal managers at federal agencies to evaluate managers' needs and understanding of concepts, data, and modeling tools for projecting sea-level rise and its impact on coastal habitats and wildlife. Based on this feedback, researchers developed a handbook summarizing existing information and tools and their respective characteristics, uses, and limitations. The resulting handbook provides a user-friendly guide to understanding the current state of knowledge and tools suitable for managing coastal wetlands.

Investigator: Thomas Doyle, USGS WARC **Collaborators**: NOAA, NPS **End Date**: Jul 2015

> secasc.ncsu.edu/science/ slr-handbook
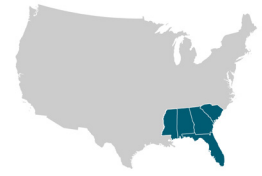
SCIENCE TO SUPPORT ADAPTIVE LANDSCAPE PLANNING AND DECISION MAKING FOR GOPHER TORTOISE CONSERVATION

Statewide tortoise population will be supported by decision support tool to efficiently guide conservation actions and reserve design.

This project developed a decision support system for the iterative selection of conservation actions that leads to a viable landscape supporting the statewide gopher tortoise population and associated species and communities of interest. This work resulted in an integrated system of databases, computer algorithms, and monitoring designs that provides a mostly automated process for decision making under uncertainty and for acquiring information to reduce uncertainty. Researchers incorporated elements of the structured decision-making process around predictive models of habitat suitability and population connectivity to guide the design of conservation reserves that promote persistence of the tortoise within Georgia.

Investigator: Clinton Moore, USGS GA Coop Unit **Collaborators**: GA DNR, UGA, FL FWC, AL DCNR, US-FWS, Jones Center **End Date**: Dec 2018

> secasc.ncsu.edu/science/ gopher-tortoise

FOUNDATIONAL SCIENCE AREAS: EXPOSURE, IMPACTS, ADAPTATION

ENHANCING COASTAL ADAPTATION PLANNING AT GULF ISLANDS NATIONAL SEASHORE


New model will be implemented to help managers evaluate the vulnerability of cultural and natural resources and assess management options.

Rapidly changing processes, including sea-level rise, storm surge, and urbanization have created challenges for managing cultural and natural resources in the Gulf Islands National Seashore. Managers require realistic estimates of the vulnerability of these resources and the likelihood of potential harmful consequences of exposure to these threats. This project will improve the ability of park managers to use a model that considers the effects of the exposure of resources to threats and the costs and benefits of various management actions. Estimates of the frequency of storm events that would result in saltwater inundation of cultural resources will be developed, enabling managers to assess their management options.

Investigator: P. Soupy Dalyander, USGS St. Petersburg Coastal & Marine Science Center Collaborators: NCSU, NPS, SE CASC End Date: Aug 2019

> secasc.ncsu.edu/science/gulf-islands-adaptation
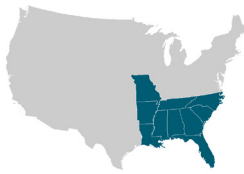
ECOSYSTEM SERVICES MAPPING DATASETS

By mapping the supply and demand of ecosystem services, target areas for conservation can be identified to maintain those services.

The goal of this project is to map the supply of ecosystem services (where natural ecosystems have the capacity to provide a certain product or service that could be of use to people) and the demand for those services (where people or other entities that use the product or service exist) at the landscape level across the southeastern United States. This project uses data from publicly available, national-scale sources wherever possible to allow the analyses to be easily adapted to other areas of the U.S. The resulting datasets were used to generate metrics for pilot ecosystem accounts and to identify target areas for conservation and restoration. The target areas can be used to identify where conservation of natural areas is particularly important to maintain ecosystem services and to communicate with the public by illustrating the local benefits of natural ecosystems.

Investigator: Lydia Olander, Duke Univ End Date: Dec 2019

> secasc.ncsu.edu/science/ecosystem-services

TURNING THE SCIENCE OF CONNECTIVITY INTO ACTION: FINDING MODEL CONSISTENCY AND IDENTIFYING PRIORITY HABITATS FOR CONSERVATION

Future connectivity in the Southeast will decrease, and outlining priorities and trade-offs for conservation and management responses is key.

Maintaining connectivity between habitats and wildlife populations will be a key management strategy for conserving biodiversity in the Southeast into the future. This multi-phase project assessed which connections are most important for management actions in the face of climate change and urbanization. Investigators modeled and mapped connectivity for three animals that inhabit bottomland forests, and showed key connections in the landscape both currently and in the future. Key core habitats and links in longleaf pine habitat were identified, and a practical application for assessing the trade-offs between preserving connectivity and budget constraints was generated.

Investigator: Nick Haddad, NCSU Collaborators: SALCC, PFLCC, GCPO LCC, AppLCC End Date: Jun 2017

> secasc.ncsu.edu/science/connectivity-into-action

WHERE TO FIND OUR SCIENCE PRODUCTS

Science supported by the Southeast Climate Adaptation Science Center results in publications in peer-reviewed journals and reports.

Check out our publications database
> secasc.ncsu.edu/publications/journal-articles-and-reports/

Research is summarized in:

Fact Sheets
> secasc.ncsu.edu/publications/fact-sheets

Research Highlights
> secasc.ncsu.edu/category/research-highlights

Tools can be found on:

Resources page
> secasc.ncsu.edu/resources

Actionable Science

SE CASC PROJECTS INITIATED IN FY2019

The Southeast CASC is excited about our new projects to address management questions in the region. These projects are in the process of getting initiated and we look forward to sharing the results as they become available.

Science funding decisions are guided by annual science priorities developed with input from key federal, state, and tribal partners in the Southeast.

SE CASC science is directed at science-based management actions supportive of priorities taken by DOI bureaus (especially the US Fish and Wildlife Service and the National Park Service in the Southeast) and state fish and wildlife agencies. Consultation with these partners identified three science themes supportive of Department of the Interior Secretarial Priorities:

Exposure: Improve partner understanding of what climate and land use change processes and associated biophysical stressors will look like on the land and water they manage.

Impacts: Improve partner understanding of ecosystem, habitat, and species impacts of climate and land use change, as well as the understanding of how these changes affect resources of specific concern to resource managers.

Adaptation: Increase partner understanding of, and access to, practical guidance for framing and making smart climate and land use change adaptation decisions.

FACILITATING ACCURATE AND EFFECTIVE APPLICATION OF MARSH MODELING OUTPUTS
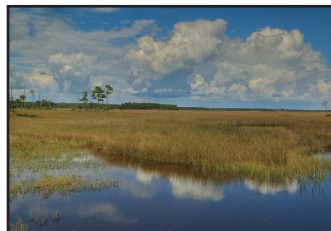
This project aims to initiate a paradigm shift in the approach and interpretation of coastal marsh models to enhance natural resource management.

A retrospective analysis comparing model predictions against historical marsh conditions with a known elevation data is the only approach to elucidate strengths and areas of improvement in the models and has not been performed to date. This large effort will be accomplished in distinct, achievable phases. Phase 1, proposed here, will convene a workshop among top marsh modelers to 1) inventory available data sources required for marsh models, 2) scope an approach to an 'apples-to-apples' comparison across the range of coastal marsh system models, aimed at exploring differences in their prediction of marsh conditions under climate change, and 3) deliver to managers guidance on how best to utilize the existing marsh tools to inform land management decisions.

Investigator: Sarah Spiegler, NCSU
Collaborators: NOAA, NCCOS, NGOM SSC, MSU **End Date**: Sep 2020
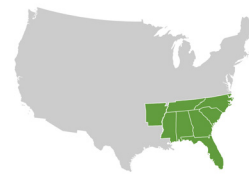
ANALYSIS AND VISUALIZATION OF CLIMATE INFORMATION TO SUPPORT USFWS SPECIES STATUS ASSESSMENTS

USFWS scientists in the Southeast will be develop a web-based framework to enhance the accuracy, quality, and scientific rigor of SSAs.

In partnership with scientists from the USFWS, this project will develop and test data products that will assist USFWS biologists in their efforts to incorporate climate information into SSAs, including how the climate factors and thresholds that most affect species vary year-to-year, how they are expected to change in the future, and the uncertainties associated with those changes. Researchers will also develop and test the efficacy of using a web-based collection of maps and data layers for interpreting climate vulnerability of wildlife and their habitats. Each map product will focus on the most relevant climate and ecology metrics that predict species viability for a location, and include explanatory and interpretive materials. Regular input from USFWS scientists will ensure that the information is accessible, useful, and usable.

Investigator: Kathie Dello, SCO NC
Collaborators: USGS, NCSU, Auburn Univ **End Date**: Sep 2021

> **secasc.ncsu.edu/science/ssa-climate**
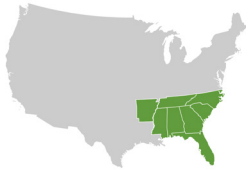
IMPACTS OF SEA LEVEL RISE & ASSOCIATED SALINITY CHANGES ON AT-RISK FRESHWATER MUSSELS & THEIR HABITATS IN ATLANTIC COASTAL RIVERS

Researchers will investigate the adaptation and vulnerability potential of a native freshwater mussel to various climate-induced scenarios.

The objectives of this study are to assess the vulnerability of the Tidewater Mucket (Leptodea ochracea), an imperiled freshwater mussel species that resides in lower Atlantic Slope coastal drainages to salinity by conducting standard sensitivity tests with early life stages (e.g., larvae, juveniles) of the mussel under controlled laboratory conditions; to determine the potential effects of natural riverine salinity gradients on adult mussels by conducting a reciprocal transplant experiment with salinity adapted and non-salinity adapted mussels; and to develop a risk-based scenario of mussel salinity tolerances in existing occupied habitats incorporating predictions in sea level rise and projected salinity ranges.

Investigator: Gregory Cope, NCSU **Collaborators**: USGS, USFWS, NC WRC, VDGIF, UGA, **End Date**: Jan 2022

STRATEGIC HABITAT CONSERVATION AND ADAPTIVE STRATEGIES FOR THE CONSERVATION OF COQUI FROGS IN PUERTO RICO


Researchers will help the recovery of two endangered "coqui" species, while also reducing the risk that 14 other coqui species would be added to the Endangered Species list.

For this next research stage, this project will: (1) characterize the ability of the three representative species, plus the endangered E. juanriveroi, to cope with environmental stresses using a combination of laboratory and field experiments; (2) map the genetic structure of these species to learn about connections between different populations and identify centers of genetic diversity; and (3) assist agencies in the development of conservation strategies centered on two potential adaptation actions: relocating species to new habitats (i.e. translocations) and identifying habitats that could potentially be resilient to climate change.

Investigator: Jaime Collazo, USGS NC Coop Unit **Collaborators**: Univ of PR-Mayaguez, Smithsonian, E IL Univ, SE CASC **End Date**: Jun 2022

> **secasc.ncsu.edu/science/ coqui-conservation**
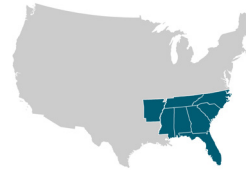
BEST PRACTICES FOR PROJECT DESIGN: EFFECTIVELY ADDRESSING NATURAL RESOURCE MANAGEMENT NEEDS

Project will identify design characteristics that most effectively deliver useful results to managers while advancing knowledge.

The importance of evaluation for improving the efficacy of research programs is increasingly recognized. Previous evaluation studies of actionable science for natural resource management focused on qualitative approaches that are difficult to scale. This project will emphasize quantitative approaches suitable for evaluating larger numbers of projects. Assessment will be based on two criteria: how useful project results are for natural resource managers, and to what degree they advance scientific understanding. This evaluation approach will be applied to projects funded by the SE CASC in Phase 1, first collating available information from documentary sources and also supplementing this with a primary survey of SE CASC partners.

Investigators: Paul Armsworth, UT **Collaborators**: Auburn Univ, USGS, NCSU **End Date**: Sep 2021

secasc.ncsu.edu/science

Organization Abbreviations

AL DCNR = Alabama Department of Conservation and Natural Resources
AppLCC = Appalachian Landscape Conservation Cooperative
Auburn Univ = Auburn University
CLCC = Caribbean Landscape Conservation Cooperative
Coop Unit = Cooperative Fish and Wildlife Research Unit
CSU = Colorado State University
DoD = US Department of Defense
Duke Univ = Duke University
E IL Univ = Eastern Illinois University
FL FWC = Florida Fish and Wildlife Commission
FL State Univ = Florida State University
GA DNR = Georgia Department of Natural Resources
GCJV = Gulf Coast Joint Venture
GCP LCC = Gulf Coast Prairie Landscape Conservation Cooperative
GCPO LCC = Gulf Coastal Plains and Ozarks Landscape
        Conservation Cooperative
MBL = Marina Biological Laboratory
MI State Univ = Michigan State University
MSU = Mississippi State University
NCCOS = National Centers for Coastal Ocean Science
NCSU = North Carolina State University
NC WRC = North Carolina Wildlife Resources Commission
NE CSC = Northeast Climate Science Center
NGOM SSC = Northern Gulf of Mexico Sentinel Site Cooperative
NOAA = National Oceanic and Atmospheric Administration

NPS = National Park Service
NRCS = Natural Resources Conservation Service
NWF = National Wildlife Federation
OR State Univ = Oregon State University
PFLCC = Peninsular Florida Landscape Conservation Cooperative
PRDNER = Puerto Rico Department of Natural and Environmental Resources
SALCC = South Atlantic Landscape Conservation Cooperative
SC CSC = South Central Climate Science Center
SCO NC = State Climate Office of North Carolina
SEAFWA = Southeastern Association of Fish and Wildlife Agencies
SGI = Southeastern Grasslands Initiative
UGA = University of Georgia
UNC-CH = University of North Carolina at Chapel Hill
Univ of FL = University of Florida
Univ of LA = University of Louisiana at Lafayette
Univ of ID = University of Idaho
Univ of MD = University of Maryland
Univ of PR = University of Puerto Rico
Univ of SC = University of South Carolina
USFS = US Forest Service
USFWS = US Fish and Wildlife Service
USGS = US Geological Survey
UT = University of Tennessee at Knoxville
VDGIF = Virginia Department of Game and Inland Fisheries
WARC = Wetland and Aquatic Research Center

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