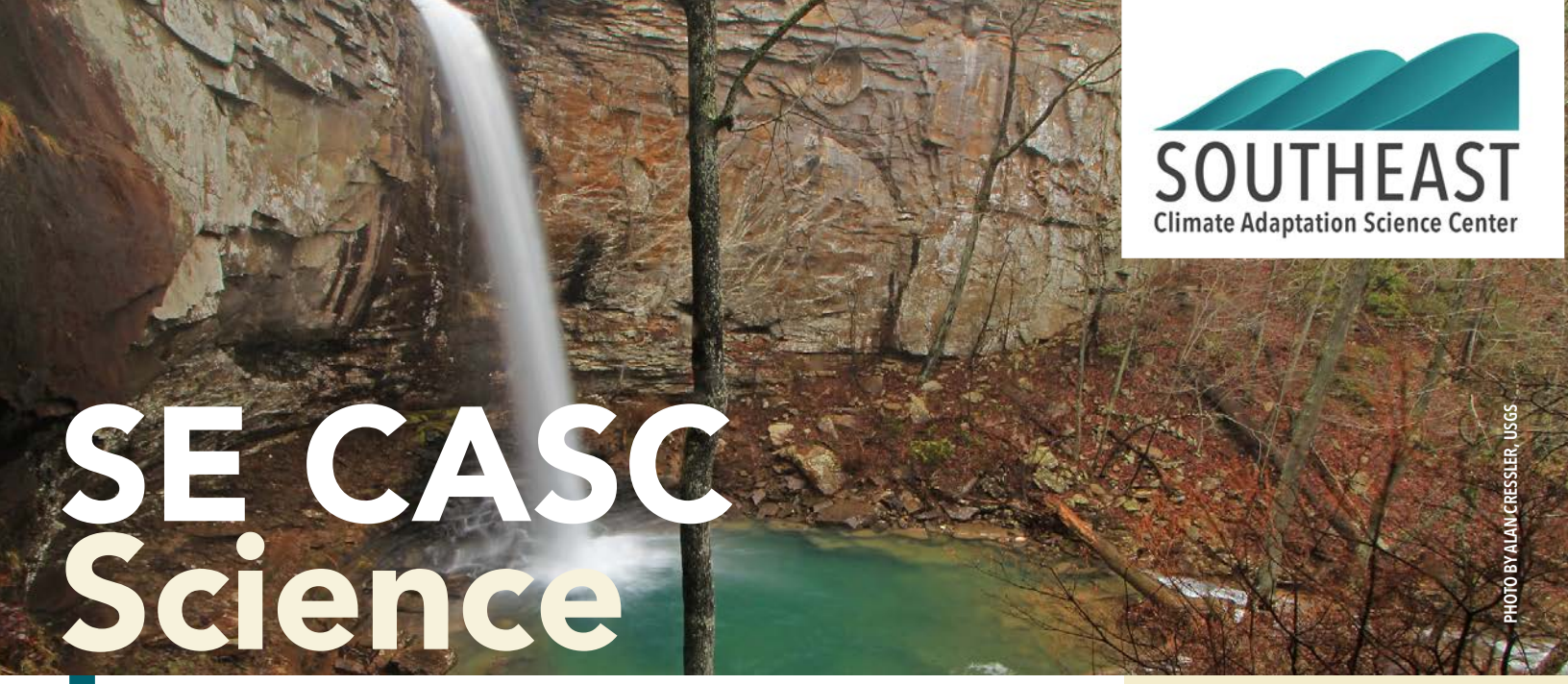


SOUTHEAST
Climate Adaptation Science Center

SE CASC Science

PHOTO BY ALAN CRESSLER, USGS

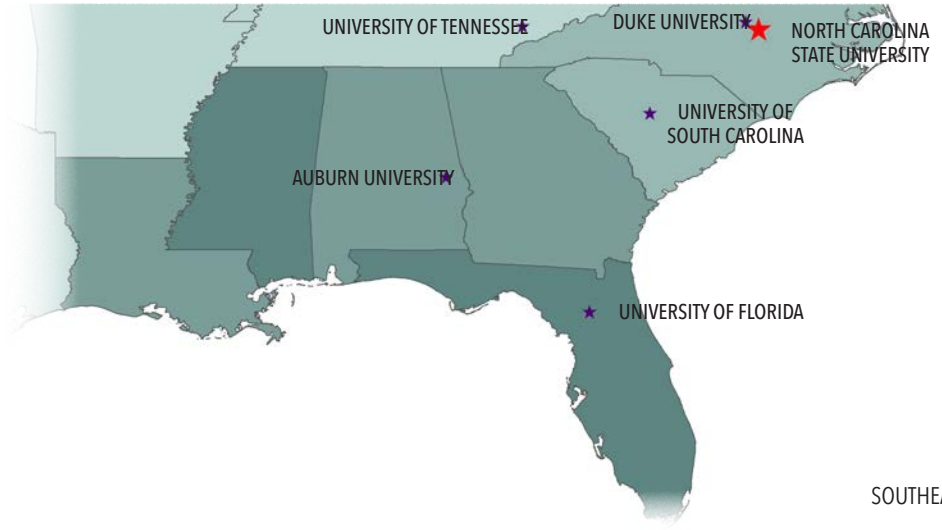
The Southeast Climate Adaptation Science Center (SE CASC) is one of nine regional Climate Adaptation Science Centers managed by the U.S. Geological Survey National Climate Adaptation Science Center. We work with natural and cultural resource managers and other partners to conduct research that provides the scientific information and decision-making tools they need to understand and adapt to the effects of climate change on fish, wildlife, water, land, and people.

SE CASC does this by:

- Producing decision-focused, research-based information that supports transparent global change adaptation decisions;
- Convening conversations among decision makers, scientists, and managers about key ecosystem adaptation decisions;
- Building the capacity of natural and cultural resource professionals, university faculty, and students to frame and make adaptation decisions.

North Carolina State University acts as the university host for the SE CASC, leading a consortium of five academic institutions.

OUR CONSORTIUM



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

Learn more about our science planning:
GO.NCSU.EDU/SECASC-SCIENCE-PLANNING

Actionable Science

ESTIMATING FUTURE WATER AVAILABILITY AND STREAMFLOW IN THE SOUTHEAST

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

Streamflow estimates are critical to inform natural resource managers of water availability for both human and ecological needs. Streamgages provide information about the amount and timing of surface water resources. Hydrologic models can be used to estimate streamflow for streams without gages. This project developed a method to match watersheds that are gaged with ungaged watersheds to provide accurate estimates of water availability regionally. Watersheds across the southeastern United States were grouped based on their responses to climate and their landscape settings, providing 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/

DEVELOPMENT OF THE GLOBAL CHANGE MONITORING PORTAL: PROVIDING RESOURCE MANAGERS WITH GLOBAL CHANGE MONITORING DATA

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 multiphase 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 landuse change on land, water, and wildlife in the Southeast. Data resources were 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 2016

> secasc.ncsu.edu/science/gcmp/

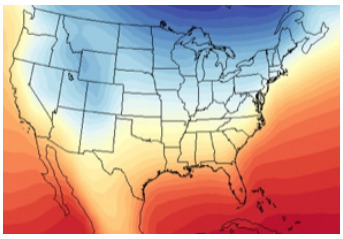
MODELING FUTURE TEMPERATURE AND PRECIPITATION FOR PUERTO RICO AND THE U.S. CARIBBEAN

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

This project developed a suite of dynamically downscaled climate 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 or moisture needs. 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 region. Investigators: Adam Terando, SE CASC, 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 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. The two products cover the continental United States at 4-km and 6-km resolution. 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 animal 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 cannot 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 multiphase 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 streamflow alteration on aquatic ecosystems is 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 LCCs 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: Sep 2013

> secasc.ncsu.edu/science/downscaling-synthesis/

CLARIFYING SCIENCE NEEDS FOR SOUTHEASTERN GRASSLANDS

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

Southeastern U.S. grasslands 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 explored conservation challenges by clarifying research and data needs of USFWS and state agencies for Species Status Assessments (SSAs) of imperiled grassland species. Through structured workshops and extensive literature review, reseach priorities were contextualized to help inform the SSA process under the U.S. Endangered Species Act. This scientific needs assessment can help guide future research on southeastern grassland species and ecosystems to support effective grassland conservation. Investigators: Jennifer Cartwright, USGS Lower MS Gulf Water Science Center, and Dwayne Estes, SGI Collaborators: SGI End Date: April 2021

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

Actionable Science

DEVELOPING FUTURE HABITAT CONDITION SCENARIOS FOR WILDLIFE IN IMPERILED PINE ROCKLAND ECOSYSTEM OF SOUTH FLORIDA

Assessment of habitat conditions in this pine rockland ecosystem supports 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 evaluated habitat conditions for the rim rock crowned snake and the key ringneck snake, two species being considered for federal listing. Researchers identified potential future changes in habitat that could result from different management actions and environmental conditions. They then explored the potential impacts of these habitat changes on the species. This information can be used by the USFWS to help make decisions abou the need to protect these species under the Endangered Species Act and could inform the conservation, management, and recovery of other at-risk species found in the pine rockland ecosystem. Investigator: Susan Walls, USGS WARC Collaborators: USFWS End Date: Mar 2020

> secasc.ncsu.edu/science/pine-rocklands/

IMPROVING SCENARIOS OF FUTURE PATTERNS OF URBANIZATION, CLIMATE ADAPTATION, AND LANDSCAPE CHANGE IN THE SOUTHEAST

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, SE CASC End Date: Apr 2023

> 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 examined regions currently experiencing specific climate conditions that are expected for Tribal lands to help in forecasting potential conditions. A Tribal needs assessment listening session was conducted with Southern and Eastern Tribal Nations 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. This relationship-building can serve as a foundation for building future collaborations to assess the vulnerability of culturally significant species to climate change.Investigator: Rob Dunn, NCSU Collaborators: USET, Univ of MD, CSU End Date: Apr 2021

> secasc.ncsu.edu/science/culturally-impt-species/

ASSESSMENT OF WATER AVAILABILITY AND STREAMFLOW CHARACTERISTICS IN THE SOUTHEASTERN U.S. FOR CURRENT AND FUTURE CLIMATIC, LANDSCAPE CONDITIONS

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: Sep 2023

> secasc.ncsu.edu/science/water-availability/

AN ASSESSMENT OF INVASIVE SPECIES RANGE SHIFTS IN THE SOUTHEASTERN U.S. AND ACTIONS TO MANAGE THEM

Statistical models will help predict the spread of invasive species under future climate change scenarios, informing future management strategies.

Species are moving as they respond to climate change. This includes many native species, but also species with high costs to society such as disease vectors, pests, and nonnative invasive species (a species that is not native to a location and is spreading with the tendency of causing damage to native plants and animals). Currently there are hundreds of invasive species with relatively restricted ranges in the southeastern U.S., but as the climate changes these species are expected to expand their ranges to new regions. Researchers will use statistical models to predict the spread of invasive species under different scenarios of future climate change severity to understand where they will spread, how they will get there, and when they are expected to arrive. Working with scientists, managers, and wildlife biologists, researchers will also consider how management strategies can be used to stop or slow the spread of invasive species. Investigator: Brett Scheffers, Univ of FL Collaborators: USGS WARC, FL FWC, USFWS End Date: Dec 2023

> secasc.ncsu.edu/science/invasive-species/

FACILITATING ACCURATE AND EFFECTIVE APPLICATION OF MARSH MODELING OUTPUTS

This project contributes to 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 known elevation is necessary to elucidate strengths and areas of improvement in coastal marsh models and has not been performed to date. This large effort will be accomplished in distinct phases. This phase convened a workshop among top marsh modelers to inventory available data sources required for marsh models, 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 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: May 2022

> secasc.ncsu.edu/science/marsh-model-application/

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

COMMUNICATING FUTURE SEA-LEVEL RISE SCENARIOS FOR GULF COAST NATIONAL WILDLIFE REFUGE AND NATIONAL PARK LANDS

Customized fact sheets 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 worked with the Northern Gulf of Mexico Sentinel Site Cooperative to develop fact sheets outlining potential sea-level rise scenarios for the region through 2100, including their potential impact on the missions of federally-managed lands along the U.S. Gulf Coast. Researchers drew from existing information on regional and global sea-level rise scenarios to develop customized information sheets for 54 federally-managed lands in the region – National Wildlife Refuges, National Park Service lands, and National Estuarine Research Reserves. Investigator: Michael Osland, WARC Collaborators: NGoM Sentinel Site Cooperative End Date: Mar 2020

> secasc.ncsu.edu/science/ngom-sealevelrise

EFFECTS OF URBANIZATION ON THE CONSERVATION VALUE OF FORESTS

Increasing urbanization in the SE underscores the conservation value of urban forests that support animal and plant diversity.

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 synthesized information on how higher temperatures and pollution affect urban forest habitat quality, identified knowledge gaps that impede forest management, and proposed future research directions to fill those gaps. Investigators: Steve Frank, NCSU End Date: Apr 2020

> secasc.ncsu.edu/science/forest-fragments/

IDENTIFYING THE ECOLOGICAL AND MANAGEMENT IMPLICATIONS OF MANGROVE MIGRATION IN THE NORTHERN GULF OF MEXICO

Northward expansion of cold-sensitive species like mangroves due to warming winters causes ecological transformations and impacts management.

In response to warming winter temperatures, mangroves are migrating northward at the expense of salt marshes. Coastal wetland managers need information and tools to help forecast the ecological impacts of these shifts. Researchers leveraged data and information from a community-curated data network called the Mangrove Migration Network to refine temperature thresholds for mangrove range expansion in a warming climate and produced a review article examining the effects of that expansion and the displacement of salt marshes on wetland ecosystem services, such as carbon sequestration, wildlife habitat, storm protection, erosion reduction, water purification, fisheries support, and recreation. These products will help environmental managers anticipate the effects of mangrove exansion and develop strategies to address those impacts. Investigator: Michael Osland, WARC Collaborators: Mangrove Migration Network End Date: Jul 2021

> 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 a variety of ecosystems in the southeastern U.S. and Caribbean by synthesizing data and literature related to 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. This project also produced a professional paper describing detailed climate vulnerability information for small, "island"-like ecosystems in the Southeast, such as rock outcrops, depression wetlands, and isolated grassland types. 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/

PROVIDING SCIENCE FOR THE CONSERVATION OF ANIMALS IN THE SOUTHEASTERN LONGLEAF PINE ECOSYSTEM

Range-wide models and partnerships 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 gopher tortoise, striped newt, gopher frog, southern hognose snake, and Florida pine snake. In collaboration with Federal, State, and other partners, species assessments were conducted to identify conservation actions expected to improve the status of these five at-risk species across their range. Researchers linked the status of each species with features of the landscape to produce range-wide models and predictive maps of habitat suitability for each species. Collectively, the results can aid partners in implementing effective conservation strategies and inform status designation decisions of the USFWS. Investigator: Clinton Moore, USGS GA Coop Unit Collaborators: USFWS, NPS, USFS, DoD, SEAFWA, PFLCC, 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 collected 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 under climate change. In conjunction with downscaled climate projections, this work increases understanding of the level of dependence and key uncertainties between climate (particularly moisture-related variables) and the distribution and persistence of amphibian species of conservation concern. This research contributes to a decision framework developed by NCSU scientists that can assist decision makers in determining when and where to implement conservation actions to maximize species persistence. 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 determined 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 were 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 influence 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, relying 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 ecological processes dependent on their dynamics. This work built upon the world's longest-running, largest-scale forest warming experiment to consider the effects of warming on diverse taxonomic and functional groups, from fungi and bacteria to herbivores and plant pathogens. Researchers found a significant impact on ecosystems at sites in North Carolina and Massachusetts with effects differing by region and organism. Investigator: Rob Dunn, NCSU Collaborators: USGS, SE CASC, NPS, SALCC End Date: Sep 2017

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

Actionable Science

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 insects 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 benefit from warming. Investigators: Rob Dunn and Steve Frank, NCSU Collaborators: SALCC End Date: Sep 2015

> secasc.ncsu.edu/science/tree-eaters/

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, especially 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 a vulnerability assessment of coastal nesting habitat 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/

ANALYSIS AND VISUALIZATION OF CLIMATE INFORMATION TO SUPPORT USFWS SPECIES STATUS ASSESSMENTS

USFWS scientists in the Southeast will 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 2023

> 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.

This study aims to assess the vulnerability of the Tidewater Mucket (Leptodea ochracea), an imperiled freshwater mussel species that lives 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 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. The outcomes of this research will provide actionable management and conservation information for maintaining these highly imperiled, but valuable molluscan resources. Investigator: Gregory Cope, NCSU Collaborators: USGS, USFWS, NC WRC, VDGIF, UGA, End Date: Aug 2023

> secasc.ncsu.edu/science/slr-freshwater-mussels/

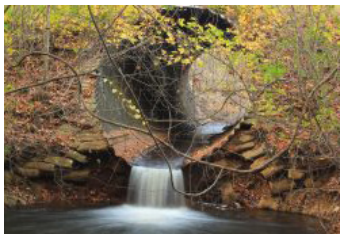
UNDERSTANDING IMPACTS ON SOUTHEASTERN GRASSLANDS FROM CLIMATE CHANGE, URBAN EXPANSION, AND INVASIVE SPECIES

Examining how climate change, invasive species, urbanization, and changing fire dynamics will affect management options in SE grasslands.

Much of the biodiversity of the SE U.S. is found in grasslands, but many grassland types have suffered 90% loss from fire suppression and urban sprawl. Remaining grasslands now face emerging threats from invasive species and climate change. Addressing science needs identified by grassland managers, the project examines how these dynamics will affect management options, constraints, and opportunities. This project will analyze 8 to 10 grassland ecosystems and perform field experiments in tall-grass prairie to examine interacting effects of climate change and invasive species. Results will include future projections for climate conditions, invasive species (including species that could arrive in particular grasslands by mid-century), urbanization risks, and constraints on prescribed burning. Investigators: Jennifer Cartwright, USGS, Dwayne Estes, Evan Rehm, and Reed Noss, Austin Peay St Univ Collaborators: SGI End Date: Sep 2023

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

SHIFTS IN THE DISTRIBUTION AND ABUNDANCE OF INVASIVE FISH AND IMPACTS ON NATIVE FISH COMMUNITIES IN TENNESSEE AND CUMBERLAND RIVER BASINS



Analyzing impacts of climate and land-cover change on fish invasion will inform climate adaptation decisions for native fish in Tennessee and Cumberland River Basins

As streams warm and streamflow dynamics in the SE change due to climate and land-cover changes, previously unsuitable habitats may become hospitable for invasive species. Warmwater and large-river adapted invasive species may move upstream as previously too-cold or low-flow habitats become welcoming environments, likely impacting native fishes and dependent local economies like fishing and tourism. The Tennessee and Cumberland River Basins, located across 7 different US states, are important in terms of total, narrow-ranged, and at-risk fish species richness. This study will investigate the effect of climate and land-cover change on fish invasions and impacts on native fish to support climate adaptation decisions and strategic science needs of natural resource agencies and managers. Investigator: Xingli Giam, UT Collaborators: USGS, TWRA, TVA End Date: Sep 2023

> secasc.ncsu.edu/science/invasive-fish/

Actionable Science

SCIENCE TO INFORM MANAGEMENT OF MANGROVE ECOSYSTEMS UNDERGOING SEA LEVEL RISE AT DING DARLING NATIONAL WILDLIFE REFUGE, FL

Tracking mangrove responses to environmental changes will allow researchers to forecast future impacts to mangrove wetlands in Florida.

Mangroves are forested tidal wetlands that provide important ecosystem services, including aesthetic value, storm protection, food provisioning, recreation, critical wildlife habitat, and biological carbon sequestration. Mangrove wetlands are being lost due to human development and sea level rise. This project will forecast future impacts to mangrove wetlands in Ding Darling National Wildlife Refuge in Florida by tracking surface elevation change and responses to sea level rise. Researchers will add nutrients such as nitrogen and phosphorus to patches of mangrove forests currently undergoing sea level rise to simulate eutrophication. Results will be used to help DOI resource managers understand future changes and how management activities might alter the vulnerability of mangrove wetlands to environmental changes. Investigators: Ken Krauss, Judith Drexler, Karen Thorne, Emily Pindilli, Eric Ward, USGS End Date: Dec 2022

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

BROOK TROUT POPULATION RESPONSES TO CLIMATE VARIATION ACROSS THE SOUTHEAST

Researchers use groundwater data, statistical models, & population vulnerability to characterize climate impacts on SE brook trout populations.

The project aims to characterize the varying impact of climate change on brook trout populations in the Southeast. Brook trout are the only native salmonid in the region, but their populations have suffered the biggest declines. Brook trout persist in small, isolated headwater streams of the Appalachian Mountains. Researchers will evaluate the utility of GIS-derived indices of groundwater input (i.e., thermal stability) using stream temperature data at >200 locations, and develop a spatially explicit Bayesian hierarchical model that accounts for removal sampling data (>300 locations) to synthesize population responses to climate variation. Relative importance of several habitat characteristics will be tested, in particular groundwater influences as a driver to sustain trout populations. Products will include a regional data set from multiple sources, statistical models, and trout population vulnerability maps. Investigators: Yoichiro Kanno, CSU, and Mevin Hooten, USGS Collaborators: NC WRC, NPS, USFS End Date: Jun 2024

> secasc.ncsu.edu/science/brook-trout/

FUTURE OF FIRE: DEVELOPING A WARNING SYSTEM TO IDENTIFY CHANGING PRESCRIBED BURN OPPORTUNITIES IN FIRE-ADAPTED HABITATS OF THE SE

Synthesis of changing fire dynamics across the U.S. will help natural resource managers prepare for and adapt to climate change impacts.

Substantial evidence suggests the role of fire in ecosystems is likely to change with a changing climate. Changing fire patterns pose natural-resource management challenges, and decision makers increasingly require information about potential changes in fire regimes to effectively prepare for and adapt to climate change impacts. An effective forward-looking fire science synthesis is urgently required to reflect the changing dimensions of human fire management, recognizing that fire causes, effects, impacts, and management are all interrelated components of a social-ecological-hydrological system with the potential for profound ecological transformation. To meet this need, the project team will conduct a synthesis of changing fire dynamics across the United States and will relate these changes to natural resource management. Investigator: Jaime Collazo, NCSU Coop Unit Collaborators: SE CASC End Date: May 2023

> secasc.ncsu.edu/science/future-of-fire/

CLARIFYING SCIENCE NEEDS FOR DETERMINING IMPACT OF CLIMATE CHANGE ON HARMFUL ALGAL BLOOMS IN SE U.S.

Understanding harmful algal blooms and the role of climate and environmental changes will inform future water-resource management decisions.

Many SE U.S. lakes, streams and reservoirs are important drinking water sources and recreational, agricultural, and ecological sites. Unfortunately, harmful algal blooms are becoming more common in these waters, adversely affecting human and animal health. While it is clear that nutrients stimulate algae growth, it isn't clear if there are other parameters that stimulate the development of harmful algal blooms. Researchers will review the literature to summarize current knowledge and gather knowledge and concerns from scientists and reservoir managers in the Southeast to provide water-resource managers with a clearer picture of the role of climate change and other environmental parameters in algal blooms. The report will also identify knowledge gaps and topics that need further study. Investigators: Tom Byl, Jennifer Cartwright, and Champagne Cunningham, USGS LMG WSC, and De'Etra Young, TN State Univ End Date: Mar 2023

> secasc.ncsu.edu/science/harmful-algal-blooms/

ASSESSING CLIMATE VULNERABILITY OF WILD TURKEYS ACROSS THE SE U.S.

Researchers assess climate impacts on nest initiation and survival to help managers project and adapt to climate impacts on wild turkey reproduction.

Precipitation and temperature shifts in a changing climate can lead to changes in food and cover for wildlife, including species that are hunted. Wild turkey is a culturally and economically important game species that has dramatically declined in abundance throughout the SE U.S. Researchers are using >10 years of reproduction data from six states to explore the combined effects of climate and hunter harvest on wild turkeys to help guide localized harvest regimes (e.g., timing of the hunting season). They will assess the relative importance of short-term weather events, longer-term weather shifts, and extreme weather events like hurricanes on the timing of nest initiation and survival across the entire region to help managers make projections about the influence of climate on reproduction in wild turkeys, informing changes in hunter harvest timing and bag limits if needed. Investigators: Krishna Pacifici and Chris Moorman, NCSU, Bret Collier, LSU, and Michael Chamberlain, UGA Collaborators: SE CASC End Date: Jul 2023

> secasc.ncsu.edu/science/wild-turkey-climate-vulnerability/

INTEGRATING SEA LEVEL RISE SCENARIOS INTO EVERGLADES RESTORATION PLANNING

Incorporating sea level rise in restoration planning enables managers to prepare for future environmental changes and project implementation.

Everglades restoration efforts are likely to be impacted by climate-induced sea level rise. Resource managers and restoration planners need tools to confidently incorporate scenarios into their plan evaluations. This project will work with multiple stakeholders to identify restoration questions that need to consider sea level rise, provide information on choosing scenarios most relevant to each unique project, and provide the methodology to incorporate chosen sea level rise scenarios into current planning processes through ecological models. Incorporating sea level rise scenarios into Everglades restoration project planning will better determine whether projects will maintain or improve the Everglades' ecological integrity. And stakeholders can use these tools to improve their ability to decide between competing restoration plans as Comprehensive Everglades Restoration Plan projects continue to be implemented across the landscape. Investigators: Laura D'Acunto and Stephanie Romañach, USGS Collaborators: USACE, USFWS, SFWMD End Date: Sep 2023

> secasc.ncsu.edu/science/everglades-slr/

INFORMING MANAGEMENT OF WATERFOWL HARVEST IN A CHANGING CLIMATE

Optimization tool will allow resource managers to compare existing adaptive harvest management models and climate change projections to inform hunting regulations.

Current wildlife management practices are informed by population monitoring data from the past to determine key ecological relationships and make predictions about future population status. In most cases, including the regulation of waterfowl hunting in North America, these forecasts assume that relationships observed in the past will remain the same. But climate change is influencing wildlife populations in dynamic and uncertain ways, and observations of the past are poor predictors of the future. This project will lay the theoretical groundwork for incorporating climate change projections into current adaptive harvest management frameworks used to set U.S. hunting regulations for North American waterfowl. Researchers will develop an optimization tool for resource managers to measure potential costs of continuing existing hunting regulations in the face of climate change effects on populations. Investigator: Michael Runge, USGS Eastern Ecological Science Center Collaborators: USFWS, Univ of MO, USGS EESC End Date: Jun 2023

> secasc.ncsu.edu/science/waterfowl-harvest-management/

IDENTIFYING CONSERVATION OBJECTIVES FOR GULF COAST HABITATS OF THE BLACK SKIMMER AND GULL-BILLED TERN

Models 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, focused 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. Researchers developed statistical models to help identify habitat conservation objectives and actions for bird species taking into account different conservation scenarios that might occur in response to sea-level rise. The statistical models linked each bird's abundance to habitat characteristics that could be influenced by different management actions. This information could be used to identify conservation objectives under different conservation scenarios. Investigator: James Cronin, USGS WARC Collaborators: GCPO LCC, GCP LCC, PFLCC, SALCC, SC CASC, USFWS, GCJV End Date: Sep 2019

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

Actionable Science

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 land scape 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 CASC 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 partnered 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. Research topics, originating from discussions with Partnership members, focused on quantifying key drivers of change including localized sea-level rise (SLR) predictions, estimates of hurricane inundation amplified by SLR, urban growth trends and forecasts, and management impacts. Additional research included efforts to inform coastal planning through the development of models for understanding salinity dynamics, land-use change and its effects on flooding, ecosystem services, forest management, and the impacts of uncertainty and risk on long-term investments in land protection. Investigators: Mitchell Eaton, SE CASC; Fred Johnson and Julien Martin, USGS WARC Collaborators: USFWS, USGS, NCSU, NE CASC, 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 was 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 and identify the impacts of climate change on cultural resources, researchers developed a strategy to aid decision makers in climate adaptation planning efforts. The decision making framework, Optimal Preservation (OptiPres) Model, 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 Lookout National Seashore, located on North Carolina's barrier islands. Investigator: Erin Seekamp, NCSU Collaborators: SE CASC, NPS, SALCC, USGS, NCSU End Date: Dec 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 supported 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 evaluated existing conservation plans and expected land and climate change impacts, and in collaboration with the Southeast conservation community, identified 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-futures

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 time frame 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

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, SALCC End Date: Jun 2016

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

Actionable Science

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 hand book 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: Mar 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, USFWS, Jones Center End Date: Dec 2018

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

ENHANCING COASTAL ADAPTATION PLANNING AT GULF ISLANDS NATIONAL SEASHORE

and assess management options.

Rapidly changes, 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 resources and the likelihood of potential harmful consequences of exposure to threats. This project enhanced ongoing research at Gulf Islands National Seashore related to cultural resource adaptation planning and identified priorities for future research to better conserve the cultural and natural resources on the barrier islands. The project should (a) enhance efficiency in adaptation planning of vulnerable coastal resources and (b) enable future funding decisions based on research priorities that will help predict changes of barrier islands and reduce the negative impacts associated with improperly placed dredge material. Investigator: Erin Seekamp, NCSU, and Jim Flocks, USGS St. Petersburg Coastal & Marine Science Center Collaborators: NPS, SE CASC End Date: Jun 2021

> 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: Jul 2023

> 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. 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 now 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. Results facilitate realistic decisions about key areas of connectivity in the southeastern US and more effective conservation in the face of challenges such as changing climate and limited resources. Investigator: Nick Haddad, NCSU Collaborators: SALCC, PFLCC, GCPO LCC, AppLCC End Date: Jun 2017

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

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.

This project will: (1) characterize the ability of the three representative species, plus the endangered E. juan riveroi, 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. The results of this research will help inform decision making on when it is best to begin consideration of translocations versus continuing to manage a population in its existing locations. Investigator: Jaime Collazo, USGS NC Coop Unit Collaborators: Univ of PR-Mayaguez, Smithsonian, E IL Univ, SE CASC End Date: Jun 2023

> 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 SE CASC-funded projects, collating available information from documentary sources and supplementing with a primary survey of SE CASC partners. These analyses will ensure that public funding for science is more effectively invested by improving future project designs to maximize the chance for project success. Investigators: Paul Armsworth, UT Collaborators: Auburn Univ, USGS, NCSU End Date: Mar 2023

> secasc.ncsu.edu/science/project-evaluation/

UNDERSTANDING PRESCRIBED FIRE MANAGEMENT IN THE CONTEXT OF CLIMATE CHANGE AND LANDSCAPE TRANSFORMATION

Project will analyze fire managers' opinions about preferable burn conditions and anticipated restrictions due to urbanization and climate change.

Prescribed burning is a primary tool used to reduce wildfire risk and manage ecosystems to achieve a range of ecological, economic and societal goals. Fire managers' ability to use prescribed fire as a management tool is complicated in regions such as the Southeast because of rapid population growth, extensive suburban development, and changing climate, which restrict prescribed burning while also highlighting the necessity of an active prescribed fire management regime to reduce wildfire risk. To help make decisions in light of these factors, scientists need to document the current conditions under which practitioners are willing to burn, restrictions to active fire management, and how restrictions may change given potential scenarios of urbanization and climate change. Investigator: John Kupfer, Univ of SC Collaborators: TTRS, Univ of SC, UNC-G, SE CASC End Date:Dec 2022

>secasc.ncsu.edu/science/prescribed-fire-management/

Actionable Science

EVALUATING ECOSYSTEM-BASED ADAPTATION OPTIONS FOR COASTAL RESILIENCE

Evaluating instances of coastal ecosystem-based adaptation will inform the current state of knowledge and research needs for future investments in coastal areas.

The fast pace of change in coastal zones, the trillions of dollars of investment in human communities in coastal areas, and the myriad ecosystem services that natural coastal environments provide make managing climate-related risks a massive challenge for coastal states and territories. Evaluating the costs and the benefits of alternative adaptation strategies in the near term is critical to taxpayers, decision-makers, and the biodiversity of the planet. To explore the potential to scale up application of coastal ecosystem-based adaptation approaches, researchers will synthesize case studies and experience to identify best practices and remaining knowledge gaps. They also will develop and test a framework to evaluate the effectiveness of adaptation efforts across spatial and temporal scales, articulate the current state of knowledge and practice of ecosystem-based adaptation, and propose a research agenda for future investments. Investigator: Katharine Jacobs and Richard Moss, Univ of AZ End Date: Jun 2023

> secasc.ncsu.edu/science/ecosystem-based-adaptation/

ACCOUNTING FOR ECOLOGICAL IMPACTS OF CLIMATE CHANGE IN STATE WILDLIFE ACTION PLANS: COMPARING MODEL-BASED AND INDEX-BASED VULNERABILITY ASSESSMENTS

Comparing the use of models and index-based scoring approaches for measuring climate impacts will support species vulnerability consensus.

State wildlife agencies and partners use State Wildlife Action Plans to coordinate and guide management activities aimed at protecting species and to identify factors putting species and their habitats at risk, including current and future climate change. Researchers use models to simulate how future climate change will impact species. In contrast, natural resource managers involved in wildlife action plans tend to favor index-based scoring approaches to understand the risks to and vulnerability of species. This project will compare the two methods. Researchers will examine where the methods agree in determinations about species vulnerability, evaluate where any disagreements originate, and recommend how the two can be combined to arrive at consensus determinations about species vulnerability. Investigators: Paul Armsworth, Mona Papes, and Xingli Giam, UT End Date: Dec 2023

> secasc.ncsu.edu/science/climate-change-swaps/

IMPROVING SUPPORT FOR REGIONAL CONSERVATION EFFORTS IN THE SOUTHEASTERN ASSOCIATION OF FISH AND WILDLIFE AGENCIES REGION

Understanding regional conservation efforts' viability by surveying individuals within SEAFWA will improve conservation impact in the Southeast.

This project proposes to address the primary gap in knowledge around viability of regional responses to wildlife conservation initiatives by surveying state agency leadership and field biologists from across the SEAFWA states. The research team will address three questions. First, this project will measure which elements of wildlife conservation respondents are willing to engage in at a regional level, and how much they are willing to push for a regional response for each element. Second, this project will ask respondents what assistance is most valuable for developing regional responses. Third, this project will ask participants to list perceived costs and benefits associated with regional planning for each element. Investigators: Nils Peterson, Lincoln Larson, Kathryn Stevenson, and Erin Seekamp, NCSU, Mallory Martin and Louise Vaughn, USFWS, and Paul Armsworth, UT End Date: Jul 2023

> secasc.ncsu.edu/science/regional-conservation/

INFORMING CLIMATE-ADAPTIVE FOREST MANAGEMENT FOR BREEDING BIRD HABITAT IN SOUTHERN APPALACHIANS

Assessment of forest dynamics and bird habitats under future management and climate change scenarios will allow partners to improve long-term conservation plans.

Climate change is likely to affect forest structure – and bird habitat suitability – due to shifts in temperature, precipitation, and disturbance. Uncertainty around climate change impacts on threatened species and what options are most likely to be effective in adapting management plans to the future limits long-term planning. A simulation model of forest dynamics coupled with models of bird habitat will be used to assess the potential for management strategies to maintain habitat into the future. Researchers will develop forecasts for priority bird conservation areas and habitat maps under several management scenarios and climate projections, informing long-term planning by estimating threats to birds, quantifying the potential for interventions to mitigate those threats, and identifying priority management areas. Investigators: Robert Scheller and Samuel Flake, NCSU, and Tina Mozelewski, U Mass Collaborators: TNC, USFS, Audubon, AMJV, NC WRC, Cornell Lab End Date: Dec 2023

> secasc.ncsu.edu/science/forest-bird-habitat/

WATER, WATER EVERYWHERE: ADAPTING WATER CONTROL OPERATIONS AND FLOODPLAIN CONSERVATION PLANNING TO GLOBAL CHANGE

Incorporating climate change projections into watershed models can better inform management decisions for Southeast water control operations.

Floodplain hydrology in the U.S is often managed on short time scales, creating uncertainty in future floodplain conditions. Floodplains managers are concerned about future floodplain maintenence for many reasons, including habitat health. Using North Carolina's Roanoke watershed as a case study, the project team will develop transferable products using quantitative, scenario-based modeling to assess ongoing climate change and key impacts, uncertainties, and risks. The team will analyze climate change impacts at Roanoke reservoir through 2099, connect findings to floodplain and fisheries health, and aim to help the Nature Conservancy, the USACE Sustainable Rivers Program, and others manage resources. Investigators: Simeon Yurek & Charlie Stillwell, USGS, Barbara Doll, Jack Kurki-Fox, & Wilson Laney, NCSU, Julie DeMeester, Danica Schaffer-Smith, Chuck Peoples, & Brian Boutin, TNC, Mitch Eaton, USGS Collaborators: USACE, USFWS, NC WRC, ECU, Duke Univ End Date: May 2024

> secasc.ncsu.edu/science/floodplain-management/

EXAMINING DIVERSE MANAGEMENT OBJECTIVES AND BROADENING STAKEHOLDER ENGAGEMENT FOR CLIMATE ADAPTATION PLANNING OF NPS HISTORIC STRUCTURES

Continuing to improve the OptiPres Model will help National Park Service managers adapt to climate change while protecting cultural resources.

As sea level rise and storm-related flooding and erosion threaten our nation's cultural heritage, there is a critical need to ensure that climate change adaptation decisions are transparent and informed by the people whose heritage is tied to those resources. This project will enhance an existing decision support framework for adaptation planning in coastal National Parks that enables managers to consider complex tradeoffs over a 30-year period under different budget scenarios. Researchers will focus on Cape Lookout National Seashore to incorporate different climate change effects, associated damage to historic buildings, and strategies for recovery and adaptation into the OptiPres Model, enhancing its ability to inform adaptation actions for historic structures. Investigators: Erin Seekamp, NCSU, Xiao Xiao, AZ St Univ, and Mitch Eaton, SE CASC Collaborators: WIG, NPS, Sialia Env End Date: Aug 2024

> secasc.ncsu.edu/science/historic-structure-adaptation/

DEVELOPING CAVE CONSERVATION MANAGEMENT TOOLS BY EXPLORING MICROCLIMATES AND BIODIVERSITY PATTERNS

Researchers will use insights from surveys and other data to identify climate-informed management actions for conserving rare cave species.

Cave-dwelling species have evolved to live in relatively stable climates, so they may be especially sensitive to climate change. However, it is unclear how surface climate change will affect cave climates and the species that rely on them, because caves are remote environments that have long been difficult to study. The project will engage federal, state, and NGO scientists and managers in nine southeastern states surveying cave climates and cave-dwelling species. Measures of forest cover density will clarify its role in moderating cave environments as surface climate changes, creating important climate refugia. With insights from new and previously published studies, the team will create a toolbox of possible management actions for conserving cave ecosystems and cave-dwelling species threatened by climate change. Investigators: Skylar Hopkins, NCSU, and Matt Niemiller, UAH Collaborators: TNC, NPS, NC WRC, AL DCNR, TWRA, TVA, USFWS, NSS End Date: Jul 2024

> secasc.ncsu.edu/science/cave-microclimates/

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Organization Abbreviations

AL DCNR = Alabama Department of Conservation and Natural Resources
AMJV = Appalachian Mountains Joint Venture
AppLCC = Appalachian Landscape Conservation Cooperative
Auburn Univ = Auburn University
Austin Peay St Univ = Austin Peay State University
AZ St Univ = Arizona State 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
LMG WSC = Lower Mississippi-Gulf Water Science Center
LSU = Louisiana State University
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 CASC = Northeast Climate Adaptation 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
NSS = National Speleological Society
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 CASC = South Central Climate Adaptation Science Center
SCO NC = State Climate Office of North Carolina
SEAFWA = Southeastern Association of Fish and Wildlife Agencies
SGI = Southeastern Grasslands Initiative
Sialia Env = Sialia Environmental, Inc
TN State Univ = Tennessee State University
TNC = The Nature Conservancy
TTRS = Tall Timbers Research Station
TVA = Tennessee Valley Authority
TWRA = Tennessee Wildlife Resources Agency
UAH = University of Alabama at Huntsville
UGA = University of Georgia
U Mass = University of Massachusetts-Amherst
UNC-CH = University of North Carolina at Chapel Hill
UNC-G = University of North Carolina at Greensboro
Univ of AZ = University of Arizona
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 MO = University of Missouri
Univ of PR = University of Puerto Rico
Univ of SC = University of South Carolina
USACE = US Army Corps of Engineers
USFS = US Forest Service
USFWS = US Fish and Wildlife Service
USGS = US Geological Survey
UT = University of Tennessee at Knoxville
UTA = University of Texas-Austin
VDGIF = Virginia Department of Game and Inland Fisheries
WARC = Wetland and Aquatic Research Center
WIG = Water Institute of the Gulf

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