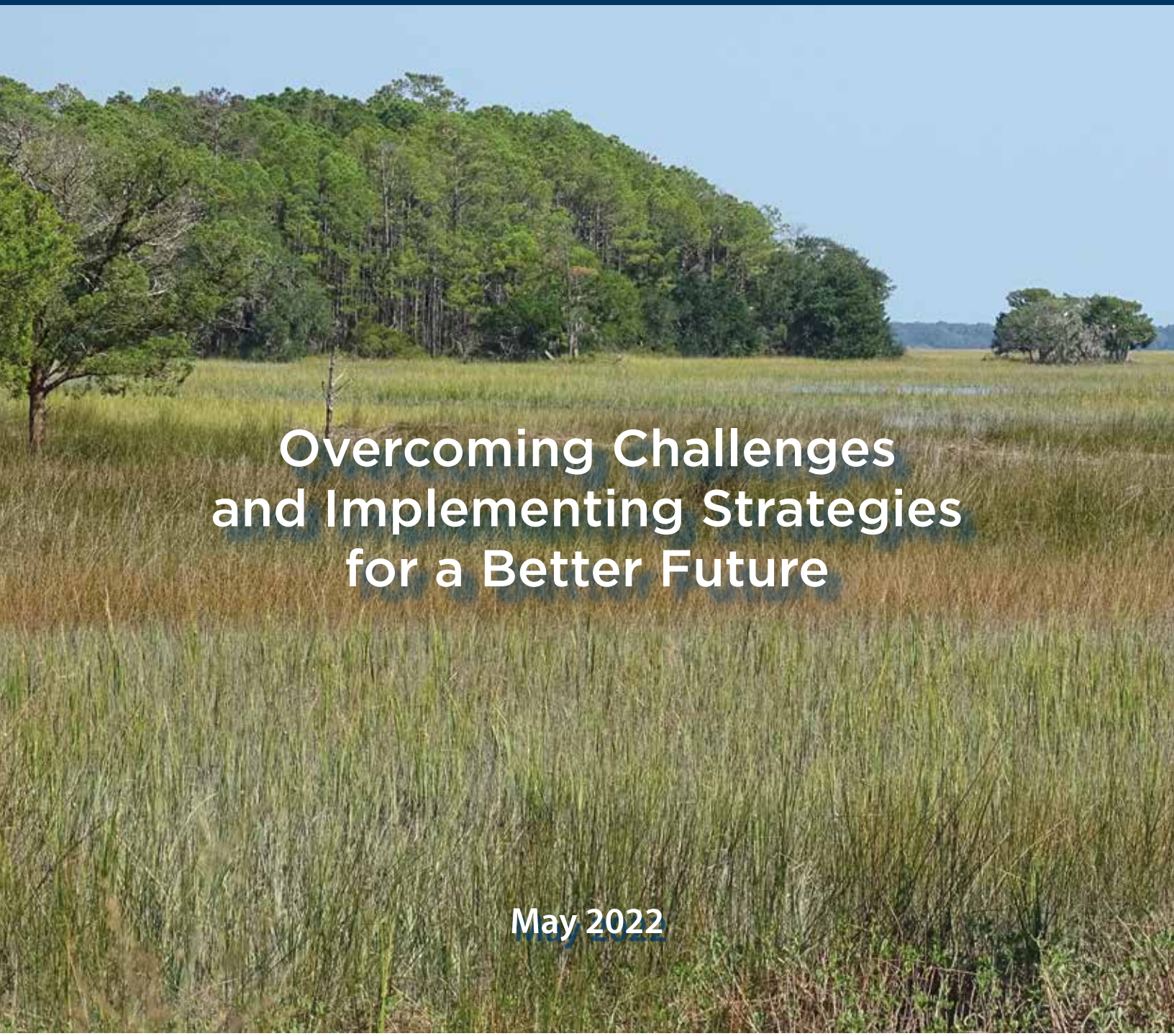
RESILIENT COASTAL FORESTS OF *South Carolina*



Overcoming Challenges and Implementing Strategies for a Better Future

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Resilient Coastal Forests Study Overview

Our coastal forests provide important ecological, historical, and cultural values for our nation. They provide us with fuel, lumber, sustenance, drinking water, recreation, cleaner air, shade and respite from a busy world. South Carolina is fortunate to have a thriving forest industry and abundant forest cover across public and private lands. However, in order to realize all these benefits into the future, we need to be aware of the many challenges ahead in having healthy, thriving and abundant forests both in rural areas and, in our cities, and towns.

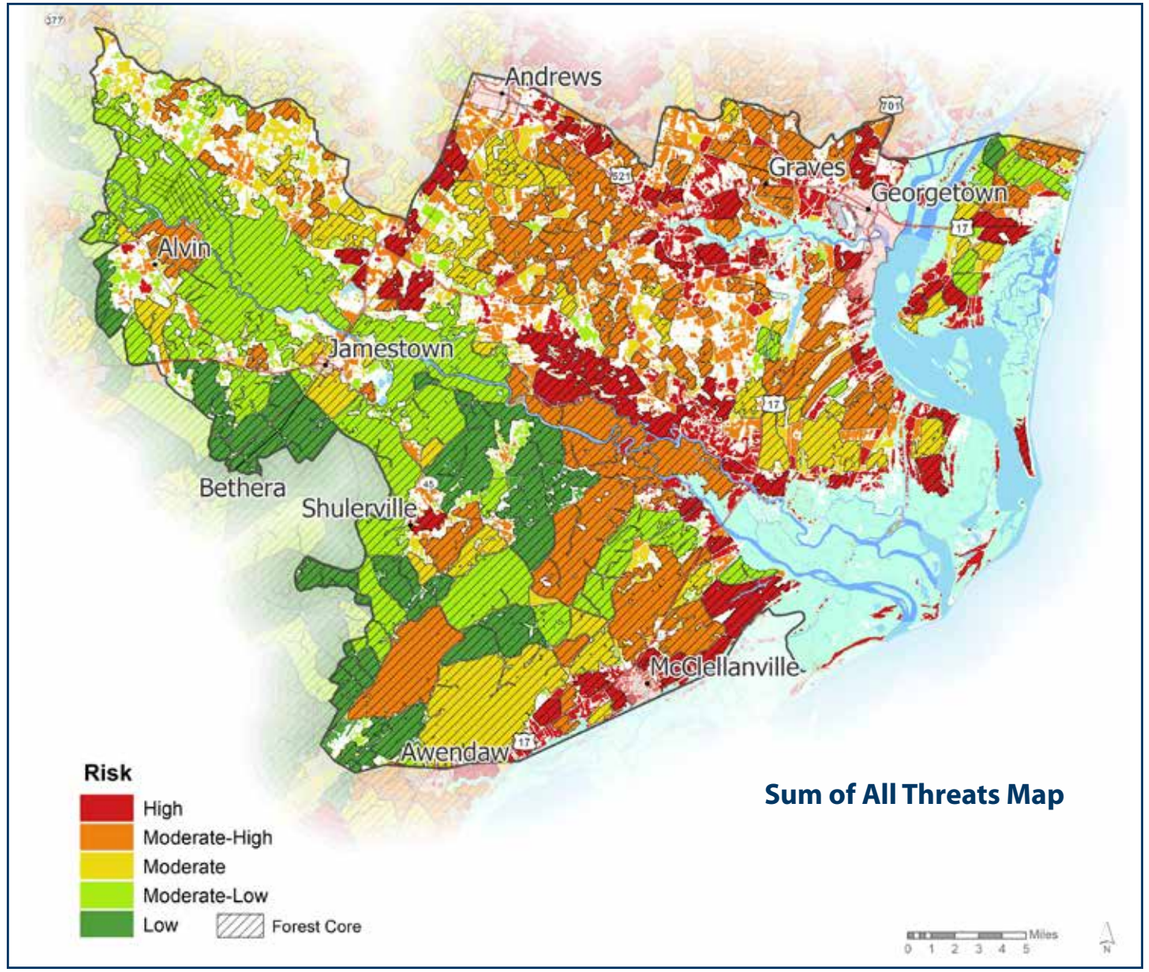
The Green Infrastructure Center and the South Carolina Forestry Commission developed this study of coastal forest resiliency. The Resilient Coastal Forests (RCF) project was created to model threats in tandem to understand their impacts, and more importantly, to determine how to adapt forest planning to meet these challenges. Coastal forests are already relatively resilient to several of the natural threats studied in this plan; for example, forests can recover after a low-to-moderate severity fire or a storm that blows down a stand of trees. However, a combination of threats can reduce the resiliency of the forest system such as when salt spray from storm surge stresses and weakens a forest making it more susceptible to pine beetle kill. That resultant dead forest no longer provides the same ecosystem service functions (carbon sequestration, habitat, etc.) and benefits (cleaning the water and air).

New risks from unprecedented challenges such as sea-level rise and climate change are impacting our forests, while growth along U.S. coastal areas is leading to forest clearing. More than 29% of the total U.S. population, lived in coastal areas in 2017, a 15.3% increase since the year 2000. Weather-related threats such as hurricanes, flooding and wildfire are increasing in intensity and frequency as global temperatures increase. Storms fueled by these increasing temperatures are affecting the distribution and life cycles of plants, animals, pests and diseases which can cause unforeseen impacts to coastal forest health. Land use changes and forestland conversions, whether from thousands of acres of new utility scale solar facilities or development, are reducing our state's forest cover.

While growth will happen and new energy sources are necessary, we can grow and develop in patterns that reduce conflicts with healthy forests and protect one of our state's most important rural economic sectors -- forestry and forest products. The pressures from climate, development, and a lack of clear strategies for forest protection or regeneration require that federal, state and local governments, conservation groups, universities, businesses, forest landowners and community members understand what is at stake and what could be lost.

> **A combination of threats can reduce the resiliency of the forest system. 9,872 acres (3%) of coastal forest in the study area are at HIGHEST RISK from multiple threats. 178,424 acres (55%) of coastal forests are at MODERATE to HIGH RISK from 3 or more threats.**

To understand the extent and quality of our coastal forests and to determine whether, where and how these forests are at risk, this Resilient Coastal Forests (RCF) study reviewed sections of four counties (Berkeley, Charleston, Georgetown, and Williamsburg), one city (City of Georgetown) and three towns (Andrews, Jamestown and McClellanville) and the adjacent barrier islands to take a landscape-scale look at the challenges and needs facing the Southeast's coastal forests. The RCF study includes an assessment of coastal forest resources and assets, an analysis of the benefits forests provide, an evaluation of the various threats and their level of risk to coastal forests, local and state stakeholder interests, and the values of coastal forests and recommended management strategies to mitigate or adapt to future impacts. For example, forests in the study area are capturing 1,834,900 tons of carbon annually while storing 45,608,100 tons more of carbon – a key strategy for slowing climate change. They are also capturing 3.2 billion gallons of stormwater for every 2-inch rainfall event, while supporting 364 species of terrestrial vertebrates, 24 federally or state listed threatened or endangered species, and providing for a forest economy with $13 billion worth of wood products statewide. These are just some of the many benefits provided.



Sum of All Threats Map

Each forest threat – Sea-level Rise, Storms, Wildfire, Development, Utility-Scale Solar Development, Invasive Species, Pests and Disease, and Fragmentation – was evaluated for its impacts to woodlands and high value forests along with an analysis of the severity and cumulative threat risk for all the threats together. These threats have been mapped for the study area to showcase the highest risk areas along with strategies adopted by participating local governments and state agencies to begin to address them. All data created for this project have been shared with local governments along with a guide to using the data to address threats and increase resiliency to adapt to these threats.

There are many actions that we can take to make our forests more resilient, so that they can undergo changes and still function as healthy forests. Even though species may change over time, they can recover from disturbances, and they can adapt to changes both in the short and long term. Each local government and state agency has a set of recommended next steps. We hope this report and study will help state agencies and local governments consider how one threat is accelerated by another and better coordinate both long term actions and immediate responses. An accompanying guide to this report covers how to conduct forest resiliency planning for all of our state's coastal forests so that we can make them as resilient as possible and be able to enjoy and benefit from healthy forests into the future.

Introduction: Why Our Coastal Forests Are at Risk

A fundamental objective of this study is to understand the nature of the threats that coastal forests experience, evaluate the extent and severity of those risks on the landscape and engage stakeholders to develop resource management strategies and actions to adapt to or mitigate the impacts of those threats.

While many of our Atlantic Coastal forests have been cleared many times over: first for fuel or hunting by Native Americans; then by European navies, who found abundant wood for ship building; then by colonists who cleared them for fuel and farmlands; and today, as an important supply of myriad wood products. However, in recent years, we have also come to appreciate their importance for the ecological and recreational services they provide, such as for wildlife, walking trails, habitat for forest species, recharging aquifers, cleaning the air and buffering coastal communities and farmland from storms. Today, we recognize the values forests provide as "ecosystem services" and that we need them, if our coastal regions are to survive and thrive.

STUDY AREA FAST FACTS

527,066
Acres in Coastal Forest Study Area

361,987
Acres of Total Forest Cover (69%) of the Study Area.

178,424
Acres of Forest Areas at Risk of 3 or More Threats — 55% of Coastal Forests

12,652
Total Population of Counties and Incorporated Cities

7,742
Acres Total Urban Area (cities and towns)

2,419
Acres of Urban Tree Canopy

Longleaf pines forests are biologically rich habitats that are a threatened forest type within the study region.

Coastal forests hold special values. They support high biological diversity in regions with habitats ranging from upland forests to swamps, salt marshes and dunes. These forests provide habitats critical for resident species of birds, amphibians, reptiles and mammals, but they also serve as important stopover sites for migratory birds. Coastal forests are the dominant terrestrial habitat in the Atlantic and Southern Coastal Plain, and they include unique forest types, such as maritime forests and longleaf pine savannas, which support high biodiversity of species.

Many coastal communities rely on forests for their economic values. Whether it is for the timber or wood products' industries or for recreation and tourism, these forests support local economies. Furthermore, humans have a deep, intrinsic relationship and history with forests. They are part of our culture, myths and spiritual traditions. They support our heritage sites and can transport an individual "back in time" for an immersive experience to commune with nature or to imagine the landscape as our ancestors might have seen it.

Yet, despite our understanding of the many benefits provided by coastal forests, we need to realize there are wide ranging threats that could possibly impact their abundance, distribution, health, composition and intactness. New risks from unprecedented challenges, such as sea-level rise and climate change, are threatening our forests, at precisely the same time as the rate of development along the U.S.'s coastal areas are leading to forest clearing at an unprecedented pace, in order to make room for new housing, roads and industry. Around 94.7 million people, or approximately 29.1% of the total U.S. population, lived in coastline counties in 2017; this represents a 15.3% growth since 2000.[1]

While weather-related threats, such as hurricanes, flooding and wildfires have impacted our coastal forests for millennia, they are now increasing in both intensity and frequency as global temperatures increase. For example, researchers from MIT have documented a significant increase in hurricane activity in the Atlantic since the mid-19th century.[2] Increasing global temperatures also influence the distribution and life cycles of plants, animals, pests and diseases, and can cause unforeseen impacts to coastal forest health. Even some widespread climate solutions to address greenhouse gas emissions, such as development of utility-scale solar energy, may conflict with coastal forests as land that is now forested is sought for new solar farms. This represents a conundrum for climate policy – should we lose a carbon sink when we cut down forests and thus release carbon back into the atmosphere, in order to build large solar farms to provide clean energy sources that release less carbon?

Forests provide opportunities for recreation.

The pressures from climate, development and a lack of clear strategies for forest protection or regeneration require that federal, state and local governments, conservation groups, universities, businesses, forest landowners and community members understand what is at stake and what could be lost. When it comes to adaptation strategies, the authors of this study recommend increasing forest resiliency through the implementation of a broad range of adaptation options, including changes in how we plan for future growth and development.

Forestry is South Carolina's leading industry in employment, supporting more than 98,000 people and contributing more than $21 billion to the state's economy.

Forests help define historical sites such as Hampton Plantation State Historic Site.

Coastal forests are being killed by salt spray and flooding, leaving behind "ghost forests" or stands of dead forests.

Coastal Forest Trends

The Fourth National Climate Assessment report (2018) on Impacts, Risks and Adaptation in the United States notes that the ability of U.S. forests to continue to provide goods and services is threatened by climate change and associated increases in extreme events and disturbances. For example, the report notes that severe drought and insect outbreaks have killed hundreds of millions of trees across the United States. In addition, from 2011 to 2020, there were 62,805 wildfires on average in the U.S., that impact 7.5 million acres annually.[3] Approximately 45,000 wildfires, covering 1 million acres, burn every year in the Southeastern U.S. and a recent study by NOAA suggests the risk of very long fire periods will increase by 300% in this region by the middle of the century (2041-2070). And, although the Southeast region of the US Forest Service covers only thirteen states, including Puerto Rico and the U.S. Virgin Islands, the region leads the nation in the number of annual wildland fire ignitions.[4] According to the Southern Region of the U.S. Forest Service, "This management challenge is exacerbated by rapid population growth, rapid expansion of wildland urban interface (WUI) areas, and the fragmentation of land ownership in the region."

Recent insect-caused mortality appears to be outside the historical context and is likely related to climate change; however, it is unclear if the apparent climate-related increase in fire-caused tree mortality is outside the range of what has been observed over centuries of wildfire occurrence. Drought and extremely high temperatures can cause heat-related stress in vegetation and, in turn, reduce forest productivity and increase mortality. The rate of climate warming is likely to influence forest health (that is, the extent to which ecosystem processes are functioning within their range of historic variation) and competition between trees, which will affect the distributions of some species. Large-scale disturbances (over thousands to hundreds of thousands of acres) that cause rapid change (over days to years) and more gradual climate change effects (over decades) will alter the ability of forests to provide ecosystem services, although alterations will vary greatly, depending on the tree species and local biophysical conditions.

The U.S, Environmental Protection Agency's study "What Climate Change Means for South Carolina" (August, 2016) notes that "Higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in South Carolina, although the composition of trees in the forests may change. More droughts would reduce forest productivity, and climate change is also likely to increase the damage from insects and disease… Loblolly pine trees dominate forests in most of the state, while oak, gum, and cypress trees are common in northeastern South Carolina… Changing the climate may alter the composition of forests throughout the state to more closely reflect the oak and white pine forests found today in the mountains."

Furthermore, rising sea levels will inundate coastal forests, driving marshes farther up river estuaries and inundating protective beaches, including barrier islands. Thus, according to the EPA:

- A higher water level makes it more likely that storm waves will wash over a barrier island or open new inlets. Eroding shores will threaten homes throughout the South Carolina coast unless people take measures to prevent shore erosion.
- Hurricane wind speeds and rainfall rates are likely to increase as the climate continues to warm. Charleston and the barrier islands are especially vulnerable to the impacts of storms and sea-level rise.
- Since 1958, the amount of precipitation during heavy rainstorms has increased by 27% in the Southeast, and the trend toward increasingly heavy rainstorms is likely to continue.

During a series of RCF project webinars hosted by the Green Infrastructure Center, state and regional foresters noted that flooding from hurricanes was "a big killer of trees because of extended periods of standing water and the inundation of salt water from storm surges." In some areas, it is very difficult to conduct burn activities where smoke may drift onto nearby major highways. Furthermore, storms, hurricanes and other high-wind events cause a build-up of big fuel loads, which require state forestry departments to send in clean-up teams to reduce those fuel loads and the resultant risks. Wind

Forests are impacted not just by changes to climate but also by the many decisions made by local planners and state agencies.

is the primary driver for downed trees in these coastal areas, which builds up even more deadwood and makes access more difficult for management activities. However, it's important to understand that forests are impacted not just by changes to climate but also by the many decisions made by local planners and state agencies. Forests that become fragmented by roads or development are more susceptible to impacts and pressures from human behaviors such as fire or invasive species that spread from backyards into nearby forests. Roads that break up forests are a major cause for invasive species that can be transported on trucks or blown in through newly created openings in the forest. Decisions about where to place roads, how to zone the land or even whether permits are required for urban tree removals all have an impact on the extent and health of our rural and urban forests.

Forests that become fragmented by roads or development are more susceptible to impacts and pressures from human behaviors such as fire.

Bamboo is an invasive species that can spread when backyards break into forest boundaries.

Coastal Forest Resiliency Defined

This study emphasizes three characteristics of resiliency, as identified in the scientific literature (Carpenter, et al 2001; Walker, et al 2002; Holling and Gunderson 2002):

1. The amount of change the system can undergo and still retain the same controls on structure and function.
2. The degree to which the system is capable of self-organization.
3. The ability to build and increase the capacity for learning and adaptation.

The first characteristic is key to a natural ecosystem's resiliency. Coastal forests are already relatively resilient to several of the natural threats studied in this plan, for example forests can recover after a low-to-moderate severity fire or a storm that blows down a stand of trees. However, a combination of threats can reduce the resiliency of the system, such as when salt spray from storm surge stresses and weakens a forest, making it more susceptible to pine beetle kill. The resultant dead forest no longer provides the same ecosystem service functions (carbon sequestration, habitat, etc.) or benefits (cleaning the water and air).

The degree to which the system is capable of self-organization is essentially the ability of the forest to recover from a particular threat. A forest that is being slowly harmed as the result of multiple threats is more susceptible to a high-severity fire, which could wipe out that forest entirely. Fire could also leave it more vulnerable to colonization by invasive plant species, which may, in turn, affect its ability to regenerate. Another example is when coastal forests are cleared for development, in which case the forest is completely unable to regenerate itself. Therefore, the amount of change (e.g., severity and combination of individual or multiple threats) affects the ability of a forest to recover from the various threats it is facing.

The third characteristic concerns both a natural and human element. Species vary in their ability to learn new behavior and adapt to changes in their surroundings. For example, in coastal forests, animal species and even some tree species will migrate further north as global temperatures increase. Whether a species can adapt to changes in its environment is thus a key resiliency factor.

Laurel wilt is quickly spreading among the redbay tree population and wiping out this understory tree species.

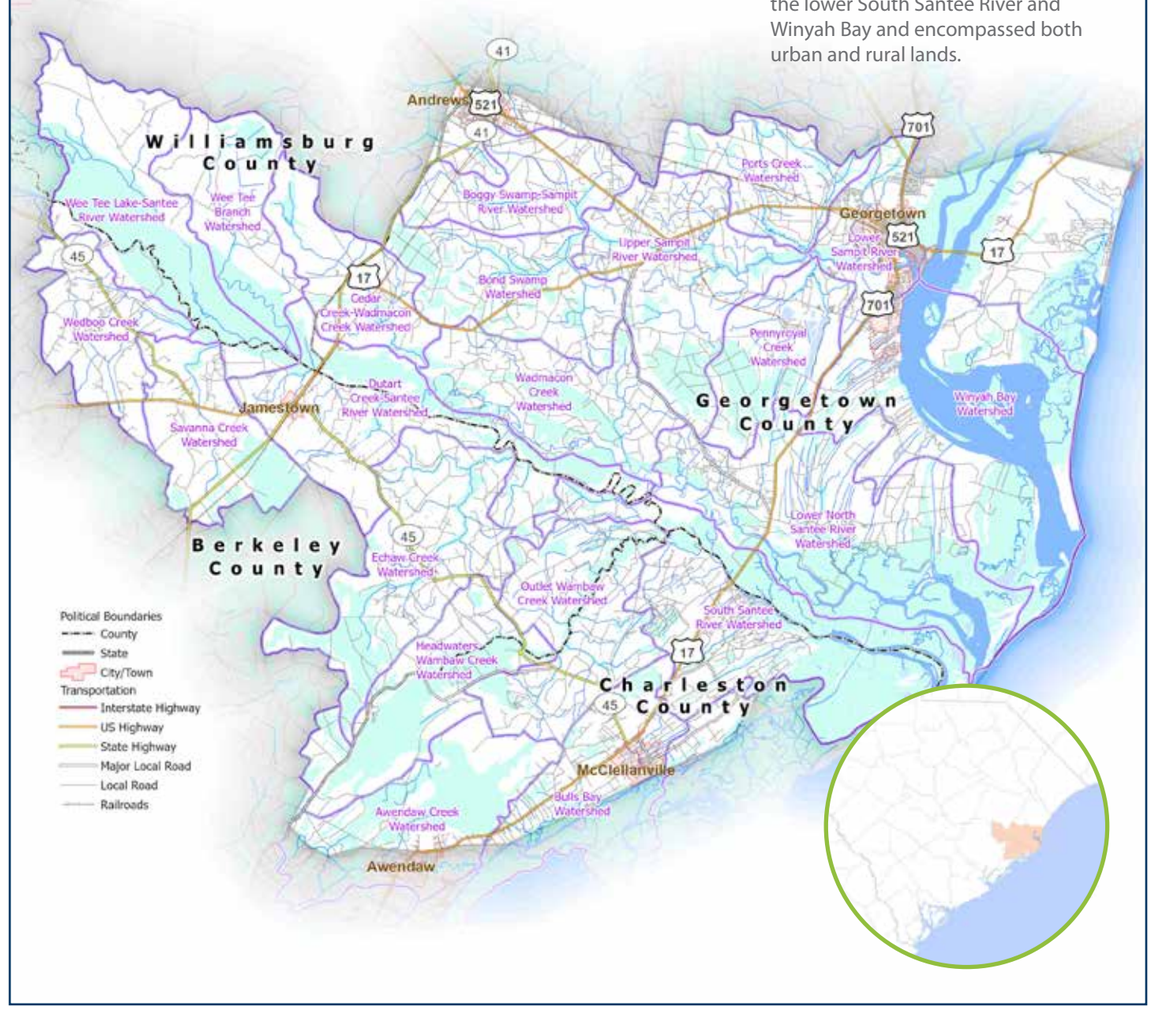
Introduced species such as the Redbay Ambrosia Beetle can spread new diseases.

South Carolina Study Area

The study area for South Carolina is comprised of 4 counties in part (Berkeley, Charleston, Georgetown and Williamsburg), 1 city (Georgetown) and 3 towns (Andrews, Jamestown and McClellanville). The study area boundary was chosen by staff with the South Carolina Forestry Commission and contains a mix of rural, suburban and urban land uses. The study area is bisected by the Santee River, with the vast majority of land south of the river under federal ownership within the Francis Marion National Forest. To the north of the Santee River is a mix of private commercial forestland and agriculture. Urban land uses mainly occur along U.S. Highway 17 and U.S. Highway 251 with the rest of the study area having a rural character. The coastline is made up of several wildlife refuges and reserves under various federal, state and nongovernmental organizational ownerships which protect marine and estuary resources and maritime forests. A mix of land uses, ownership status and urban growth patterns was chosen to evaluate different development pressures on coastal forests.

The South Carolina Resilient Coastal Forest Study Area

The South Carolina study area spanned the lower South Santee River and Winyah Bay and encompassed both urban and rural lands.



Community Engagement

State Advisory committee (SAC)

The State Advisory Committee is comprised of multiple state agencies that have expertise and an interest in the coastal forests of South Carolina. They helped guide the project and provided feedback on early iterations of the threat models for coastal forests. They also shared state agencies' priorities and strategies related to coastal forests

Local Advisory Committee (LAC)

A Local Advisory Committee included local governments, nonprofits, academic institutions, county foresters and local residents within the study area. Its members met regularly and provided input and feedback for the threat-risk analysis, identified cultural and human values that increased value ranks for certain forest cores, developed prioritization analyses and brainstormed strategies that were then implemented by a number of the stakeholders.

> Local knowledge of the forests informed identification of threats, challenges and opportunities in the study area.

Public Engagement

The project planned for significant public engagement, and, in the early phases of the project, public meetings were planned to discuss local stakeholders' concerns regarding coastal forests. The Covid-19 pandemic prevented meaningful public engagement because of policy restrictions for public meetings; the closing of public spaces, such as libraries, schools and government offices; and the reluctance of the public to attend in-person meetings. While online meetings were more easily held with agencies, they were a difficult method for engaging the various local governments and communities in the study area. Once the pandemic eased, meetings resumed, allowing for new strategies to be developed.

Modeling Forest Cores

Sixty-nine percent of the study area is currently covered by forests, with evergreen forests and wooded wetlands comprising the predominant forest types in the region, at 32% and 35% respectively (see Table 1, next page).

FAST FACT:

There are a total of 361,987 acres of forest in the study area.

Land Cover Map

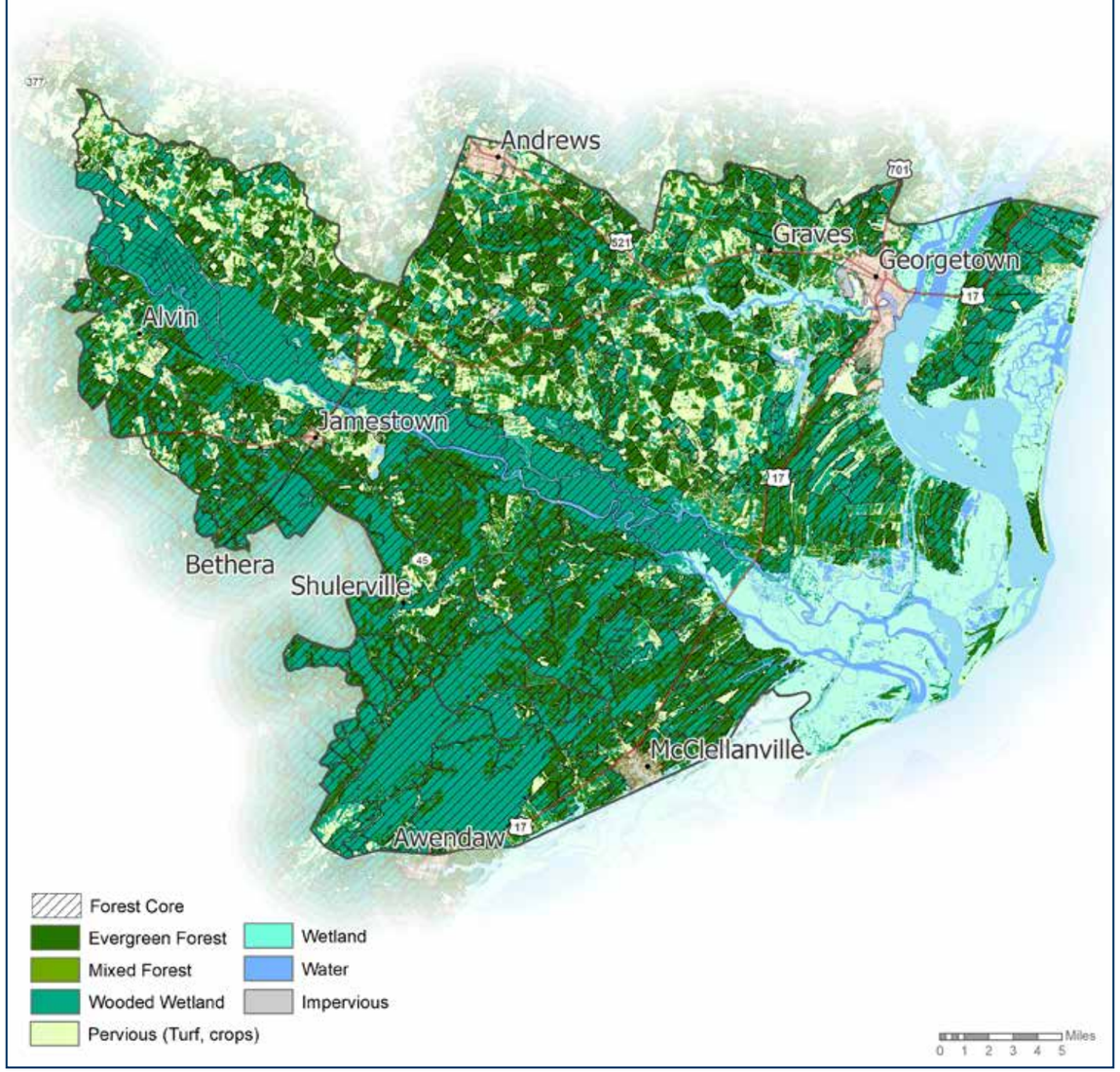
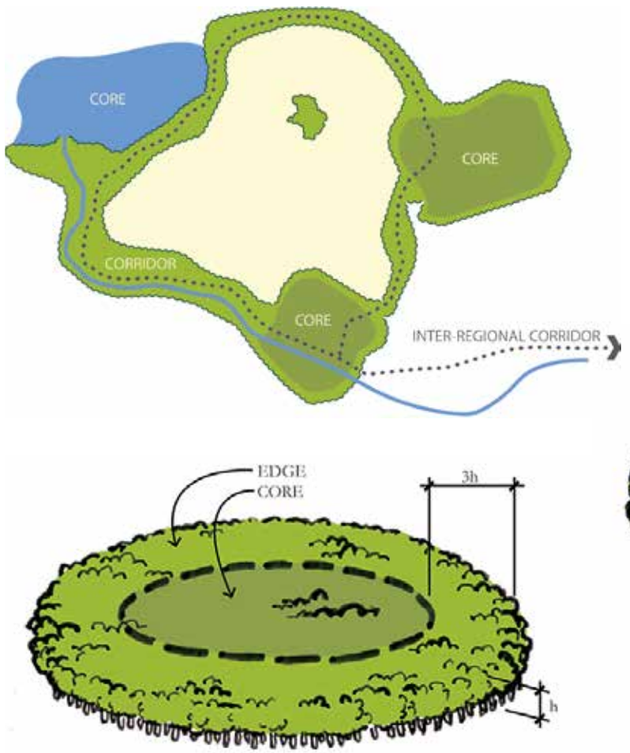
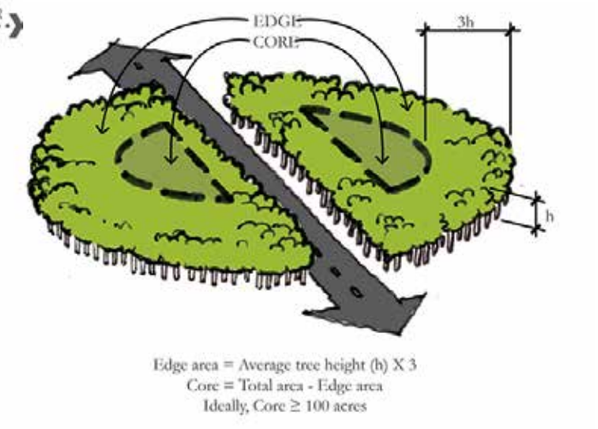


Table 1: Total acres and percent of land cover in the study area, by forest type

Land Cover Type	Acres	% Cover
Deciduous Forest	7,765	1.5%
Evergreen Forest	170,053	32%
Mixed Forest	241	.05%
Wooded Wetland	183,928	35%
Wetland	54,668	10%
Pervious	70,010	13%
Impervious	1,101	0.2%
Developed	5,899	1%
Water	33,401	6%
TOTAL	527,066	100%

Source: National Land Cover Database 2016





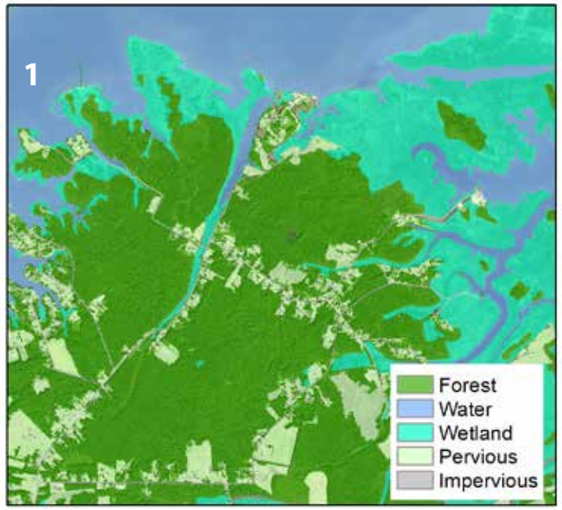
Edge area = Average tree height (h) X 3
Core = Total area - Edge area
Ideally, Core ≥ 100 acres

Forest cores were modeled using National Land Cover Database 2016 land cover data. To be a core, the forest must encompass more than 100 acres of intact woodland – large enough to provide adequate foraging and nesting habitat for interior forest dwelling birds and to support a range of other wildlife species. Large, intact forest cores are less impacted by disturbances and can better support area-sensitive and extinction-prone species because they retain larger populations, and their habitat is less likely to degrade through time (Ewers et al 2006).

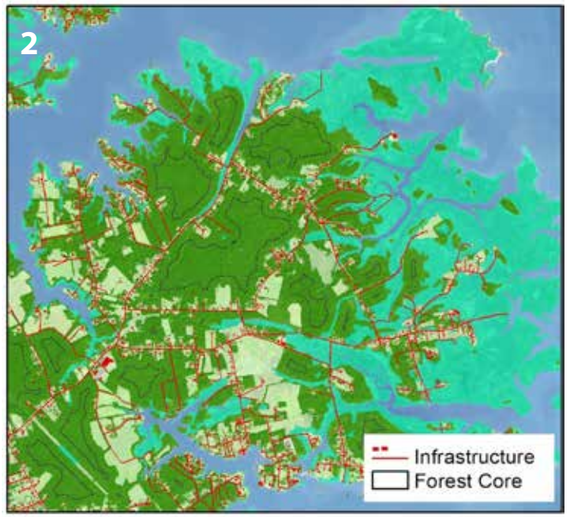
Forest fragments or woodlands less than 100 acres (known as patches) were also mapped to aid in identification of corridors or pathways for species to migrate across the landscape, as well as areas that could buffer the coast from storms. These fragments, while not ideal forest habitat, can provide quality forest refugia for some species.

Large, intact forest cores are less impacted by disturbances and can better support area-sensitive and extinction-prone species. When roads bisect habitats the remaining areas may be too small to be considered a core.

These cores were modeled on the landscape by using aerial imagery to identify forest land cover. It was then determined how intact the forests were by identifying features that fragmented them, such as roads, buildings, transmission corridors, large rivers, and so on. These features bisect the forest into smaller units (see maps).

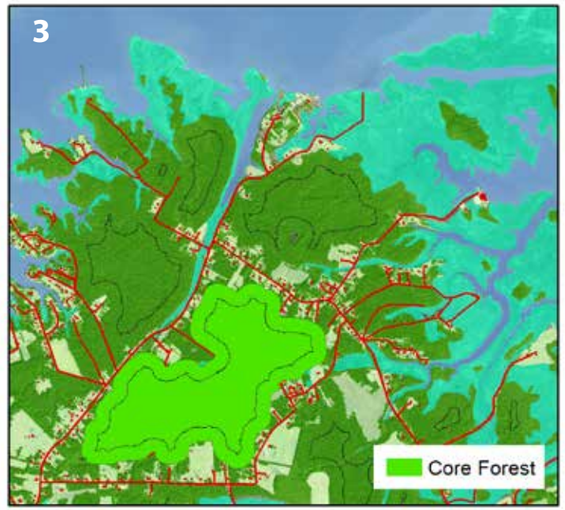


Land Cover



Forests are buffered in 300 ft from forest edge and significant Infrastructure.

The modeling process calculates the amount of interior forest left after fragmenting features are identified. If enough forest interior (>100 acres) remains, then it becomes a forest core.



Where buffer results in a core area greater than 100 acres the forest is identified as a Core Forest. Otherwise the core area less than 100 acres is classified as a Forest Core Fragment.

Forest Cores and Woodlands

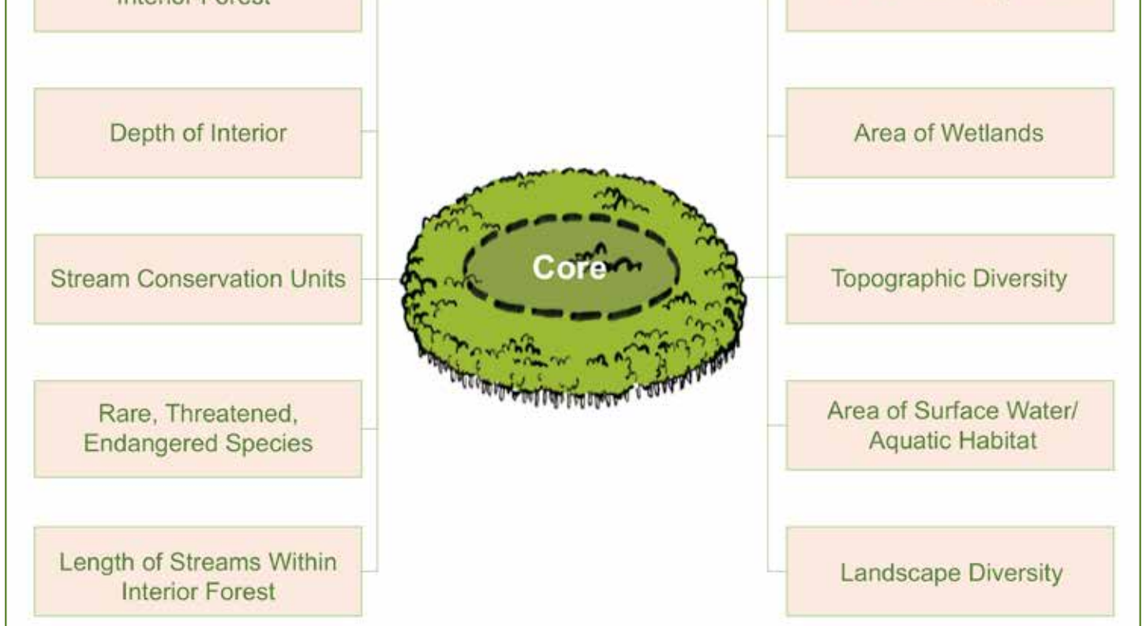
Ranking Coastal Forests

In addition to forest geometry and extent, coastal forest cores were ranked based on two overarching factors: environmental attributes and cultural or human values. Assigning attributes and values to each forest core allows for the identification and prioritization of specific high-quality and high-value forest habitat during strategy development. The Green Infrastructure Center recognizes some forests will be impacted or lost and that resources for management or conservation are limited. Ranking forests for the values they provide allows land-use planners, agency officials and site managers to prioritize specific forests that best meet management goals and objectives, while providing the highest value for species.

Environmental And Ecological Rankings

The first level of rankings used landscape-based environmental and ecological attributes. Examples of environmental attributes data used to rank forest cores include the number of wetlands found within a core; the presence of rare, threatened or endangered species; species richness; soil diversity; the length of stream miles; and topography. These factors all influence the diversity of plants, insects, animals and other biota within a forest core.

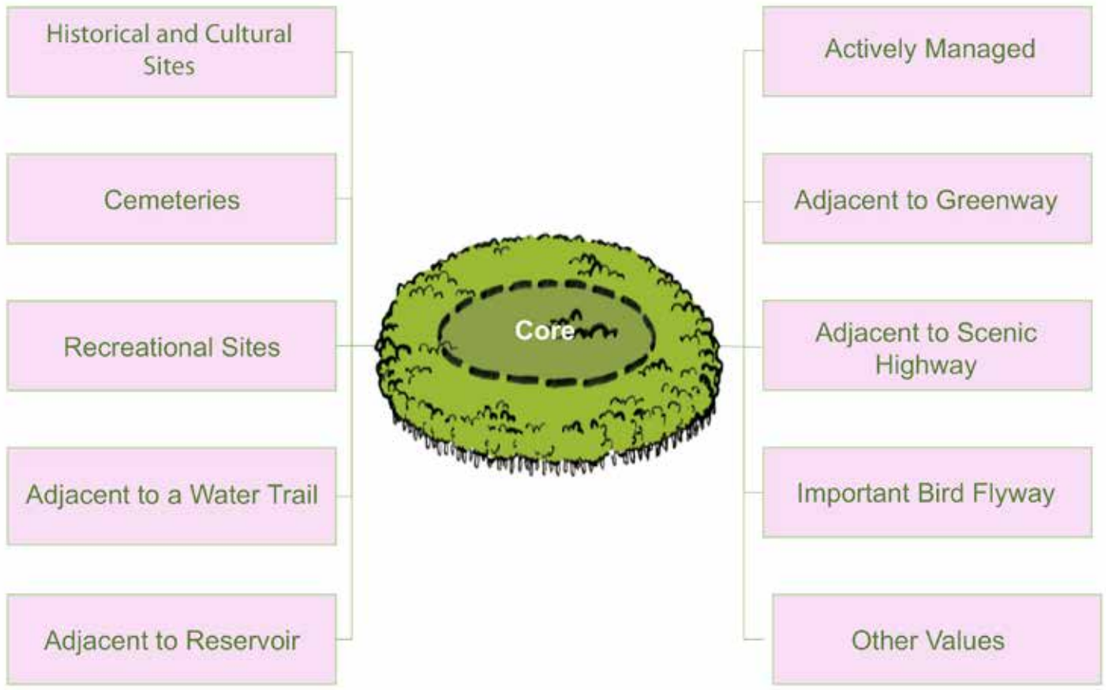
Types Of Data Used To Score The Environmental Ranks For Forest Cores.



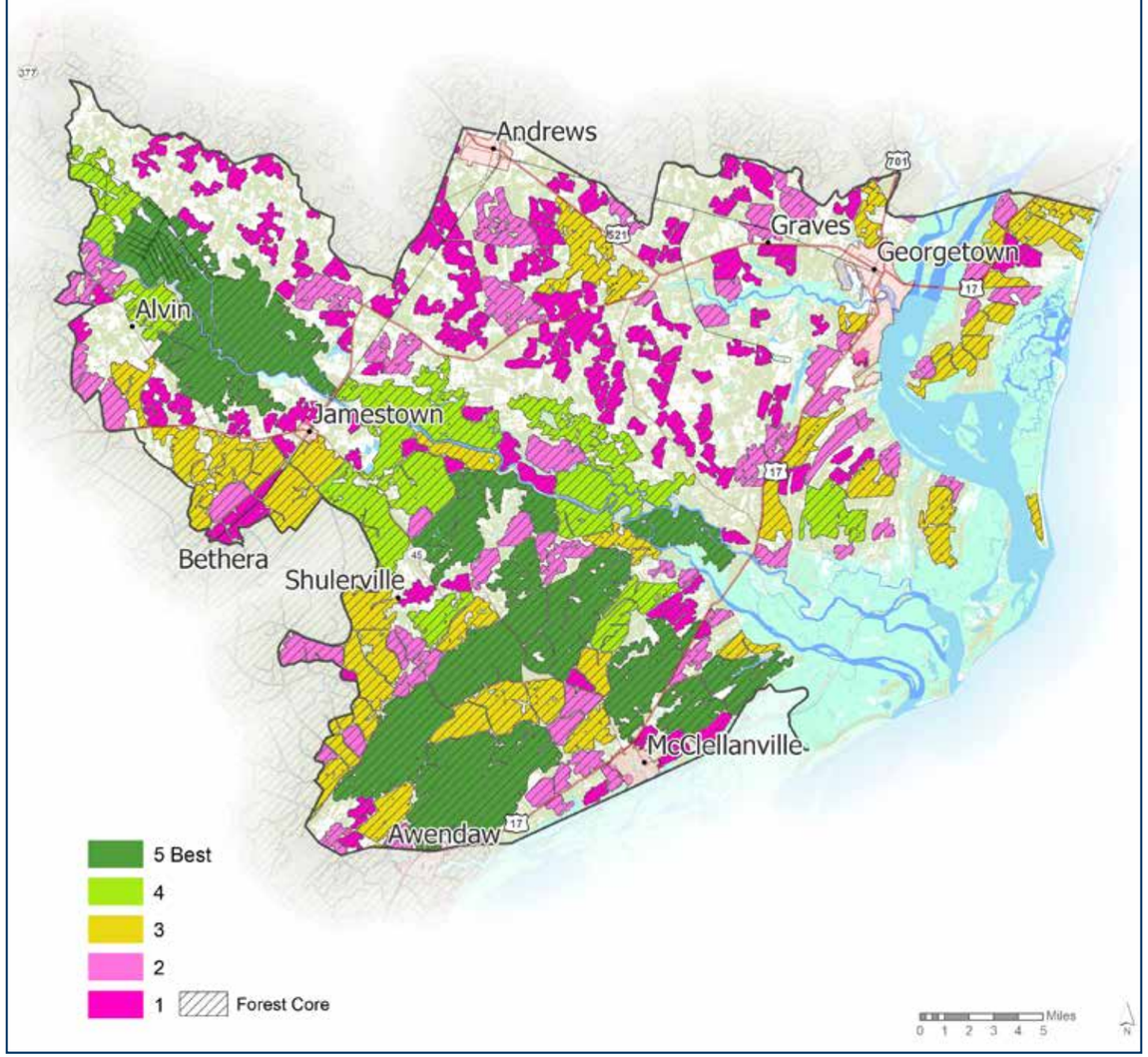
Cultural (Human Values) Rankings

The second level of rankings include those cultural or human values people assign to the natural landscape, specifically coastal forests. Examples of human values incorporated into the ranking systems include forests supporting reservoirs or drinking water protection zones; recreational sites and parks; cemeteries; greenways; trails or bikeways; scenic views; and cultural or historical structures, properties and related features.

Types Of Data Used To Score The Cultural Ranks For Forest Cores.



Forest Cores Ranked By Environmental And Human Values



These forest cores show the combined ranks from the human and environmental data.

Urban Tree Canopy

Coastal forests also include urban woodland and tree canopies found in the cities and towns within the region. Urban forests have unique challenges compared to large, forested landscapes. The urban environment can be an inhospitable place for many tree species, with spaces designed and built with little regard for adequate tree growth and health. Other urban infrastructure can create conflicts with trees, such as powerlines, water and sewer pipes, and land uses that don't support trees. In addition, many species are ill-suited for survival in urban environments, with the added heat stress, salt, soil compaction and mechanical injuries.

While urban forests are also subjected to many of the same threats as large intact forests, these smaller forests have more edge area than interior, making them more susceptible to disturbance, and thus to pest infestations and diseases – especially where the forest contains an over-abundance of one particular species of tree. If one tree species is overly abundant, it can be wiped out quickly if a pest is introduced that impacts that particular tree species. For example, crape myrtles are a common coastal tree planted in cities and towns but they may become susceptible to an insect that causes crape myrtle bark scale (*Acanthococcus lagerstroemiae*) a recently introduced pest from Asia that began infestations in Texas in 2004 and has been detected in Richland County. For more see https://hgic.clemson.edu/factsheet/crapemyrtle-bark-scale/

Urban forests are also at a much higher risk for development and many urban natural areas are degraded by non-native plants and animals that take over and colonize areas more aggressively, wiping out native species. Urban forests also require specialized emergency response plans to identify trees and limbs at risk of falling before storms, to pre-establish cleanup procedures and to have plans already in place to rapidly reforest damaged areas.

To better manage these forests, the urban tree canopy of every town and city in the study area was mapped using high-resolution imagery, since land cover changes occur at a much smaller scale in a city or town than in a rural forested area, so greater detail and accuracy are required. Possible planting areas and potential tree canopy were

Urban canopy makes towns cooler and more livable.

mapped to understand where additional trees could be planted and to allow municipalities to strategically plan for future plantings. Tree canopy values for each city or town are shown in Table 2.

Values for the area of urban forests can also be used to calculate the many community benefits or "ecosystem services" they provide, such as reducing air and water pollution, sequestering carbon, mitigating urban heat island effects and reducing stormwater runoff and flooding. The mapped canopy, along with multiplier values from the scientific literature, allowed for quantifying many of those benefits, which were reported in a "Benefits of Coastal Forests" assessment as part of this project.

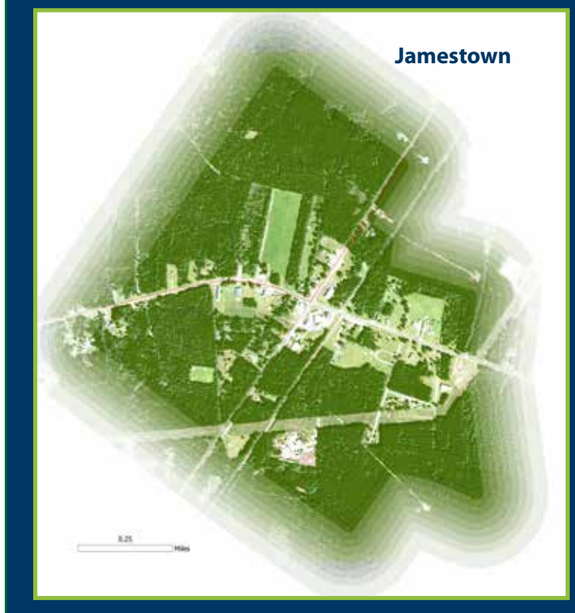
Table 2: Current tree canopy (in acres, percent) and potential tree canopy (percent).

Locality	Tree Canopy (TC) (Acres)	Current %TC	Potential %TC
Andrews	226	28%	42%
Georgetown	1,103	37%	47%
Jamestown	234	64%	77%
McClellanville	856	59%	63%

Local Tree Canopy Maps

Andrews

Georgetown



Jamestown

McClellanville

The Benefits of Coastal Forests

GIC has produced a benefits report for each study area's assets, as they relate to coastal forests. The report analyzed the benefits provided by coastal forests for the environment and the communities that live in and around them. These benefits can be used to justify decisions to protect or conserve forests; for local planning or zoning decisions; public education; and to build support for forest conservation or replanting. Forests also provide a tremendous benefit for the local economy, whether through forestry products, protecting water supplies, providing for recreation and tourism, or buffering residents from road noise, and thereby improving house prices.

What do we mean by benefits?

Coastal forests provide valuable benefits that are also called "ecosystem services." These services are further classified into supporting services, regulating services, provisioning services and cultural services. Each type of service is dependent on the functional role a forest plays in the environment and for human society. Supporting services include nutrient cycling, soil formation, pollination and habitat, while regulating services include air and water purification, decomposition, carbon sequestration and storage, and flood protection. Provisioning services, oftentimes referred to as ecosystem goods, are tangible forest products, such as timber, paper, medicines, foods, or biofuels. Cultural services examples include recreation, science and education; historical or natural heritage sites; and spiritual practices associated with natural places and their symbolic values.

The study area's land cover was mapped using remote sensing techniques from aerial photographs and geographical information system (GIS) data layers publicly available or shared by committee partners from national, state and local groups. Rural areas were mapped at a 10-meter pixel resolution, while urban areas were mapped at the finer resolution of 1-meter pixels. Benefits calculations were derived from the land cover and by using published multipliers from the U.S. Forest Service's i-Tree multipliers specific for the study region (i-Tree County multipliers). Other values were sourced from local partners or published datasets.

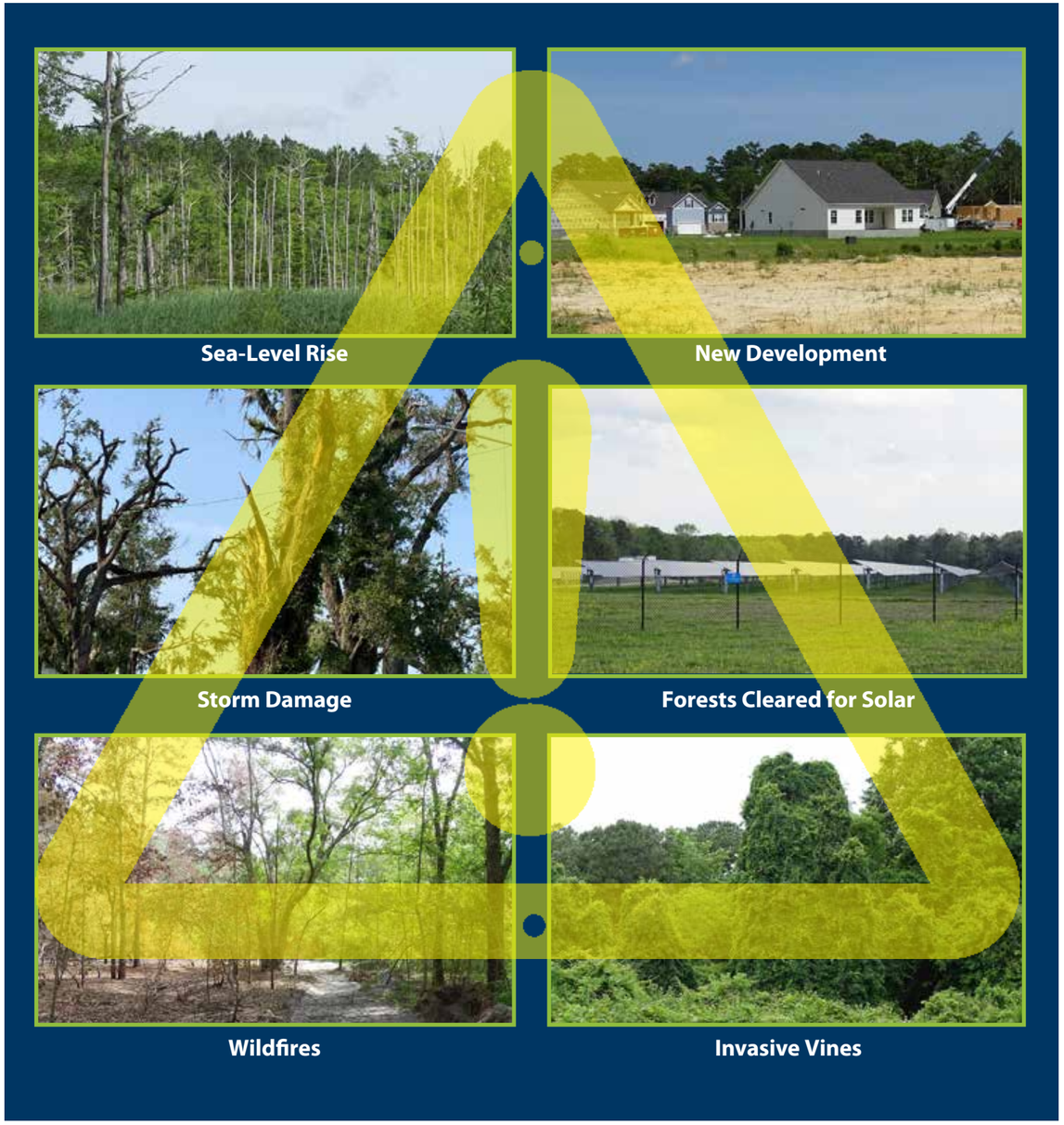
Fast Facts

Annual Benefits Provided by Forests in the Study Area:

Climate	**1,834,900** tons of carbon sequestered annually **45,608,100** tons of carbon stored (total)
Air Quality	**Substances removed from the atmosphere** **103,000 lbs.** of carbon monoxide **1,171,400 lbs.** of nitrogen dioxide **23,172,800 lbs.** of ozone **743,200 lbs.** of 2.5 micrometers particulate matter **6,054,000 lbs.** per year 10 micrometers particulate matter **727,600 lbs. per year** sulphur dioxide
Water Quality	**Pollutants prevented from reaching streams and rivers** **735,400 lbs.** of nitrogen **40,100 lbs.** of phosphorous **24,900 tons** of sediment **764 miles** of streams have forest buffers
Flooding	**3.2 billion gallons** of stormwater per 2-inch rainfall event captured
Biodiversity	**364 species** of terrestrial vertebrates supported **24** federally or state listed threatened or endangered species protected
Forest Economy	**$13 billion** worth of output (statewide)
Culture and Heritage	**17** known historical or cultural sites within 200 yards of a forest

Threats and Risks

Threats were modeled to the year 2060, looking approximately 40 years into the future, since some threats increase in severity over time, and mitigation programs often take decades to implement. The key take-away is that many threats can be mitigated or prevented if we are aware of them and able to take the necessary actions, such as changing zoning or planting more trees to buffer our coastal landscapes to withstand storms.



42,766 acres of forest

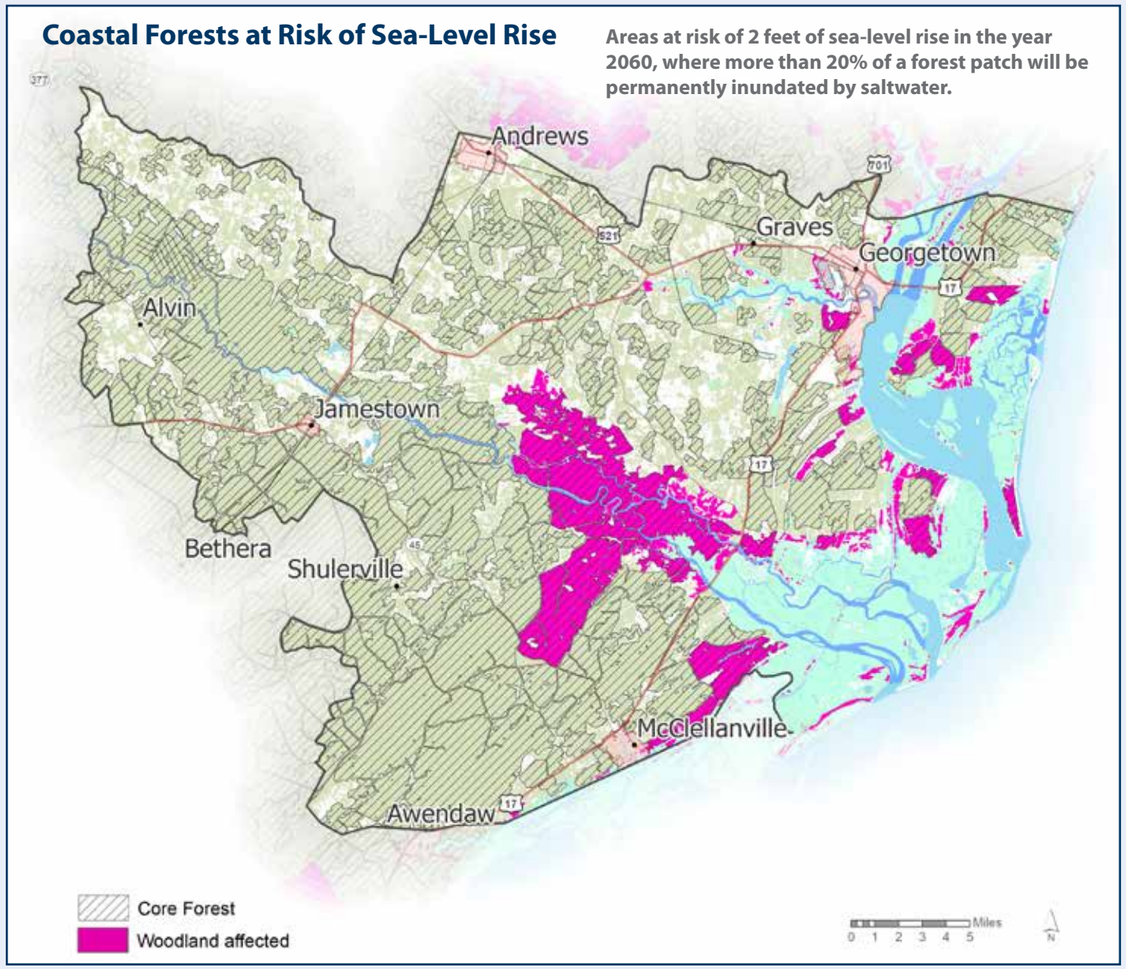
(13%) of the study area are at HIGH RISK from 2-ft sea-level rise.

In South Carolina, the land surface is sinking, so the observed rate of sea-level rise relative to the land is greater than the global average rise in sea level. If the oceans and atmosphere continue to warm, sea level is likely to rise one-to-four feet in the next century along the coast of South Carolina (EPA 2016). In addition, the rate of sea-level rise appears to be accelerating (NOAA 2022 Sea-Level Rise Technical Report).

For this study, NOAA's (2017 data) intermediate projected value of 2 feet of sea-level rise by the year 2060, was obtained from data at the Springmaid Pier Gauge. Coastal forests where 20% or more of the forest would likely be permanently inundated by saltwater were classified as "high risk."

Coastal Forests at Risk of Sea-Level Rise

Areas at risk of 2 feet of sea-level rise in the year 2060, where more than 20% of a forest patch will be permanently inundated by saltwater.



The saltwater intrusion into these forests and the subsequent death of the trees results in "ghost forests" of dead trees.

The rationale for that assessment applied by this report's authors is that, once these forests are significantly reduced in total size, the remaining forest is impacted from adjacent saltwater and salt air intrusion, including into the aquifer for the forest, all of which pose serious challenges for coastal forests.

The saltwater intrusion into these forests and the subsequent death of the trees results in a problem of "ghost forests," where dead skeletal trees bleached from the sun give them a ghostly appearance. The rise in sea level and decline in coastal forests leads to such ecosystems transitioning into salt marshes or brackish tidal wetlands. This poses significant challenges for coastal riparian forests along tributaries that feed into the Santee and Waccamaw Rivers, and ultimately the Atlantic Ocean. These riparian forests are critical habitats for rare, threatened and endangered species, such as the wood stork (*Mycteria americana*) and provide linkages to other forest habitats further inland. In addition, wide forest buffers capture and delay nonpoint source pollution

Communities are already dealing with impacts from sea-level rise (2021) including to their urban forests.

Rising seas are killing coastal forests.

runoff. If these forests are degraded or destroyed, it can limit their ability to filter these pollutants, further compromising the water quality of these rivers. Current riparian buffer zones will need to expand beyond their existing boundaries to account for forest loss and migration as a result of sea-level rise. Upland forests will also need to be identified, protected and perhaps expanded, in order to compensate for future change and loss. Forestry staff should start using sea-level rise maps with landowners when planning for forest management or harvest in coastal areas, in order to support long-term resource decisions, since some will be killed by regular inundation before they are ready for harvest.

GIC Recommendations

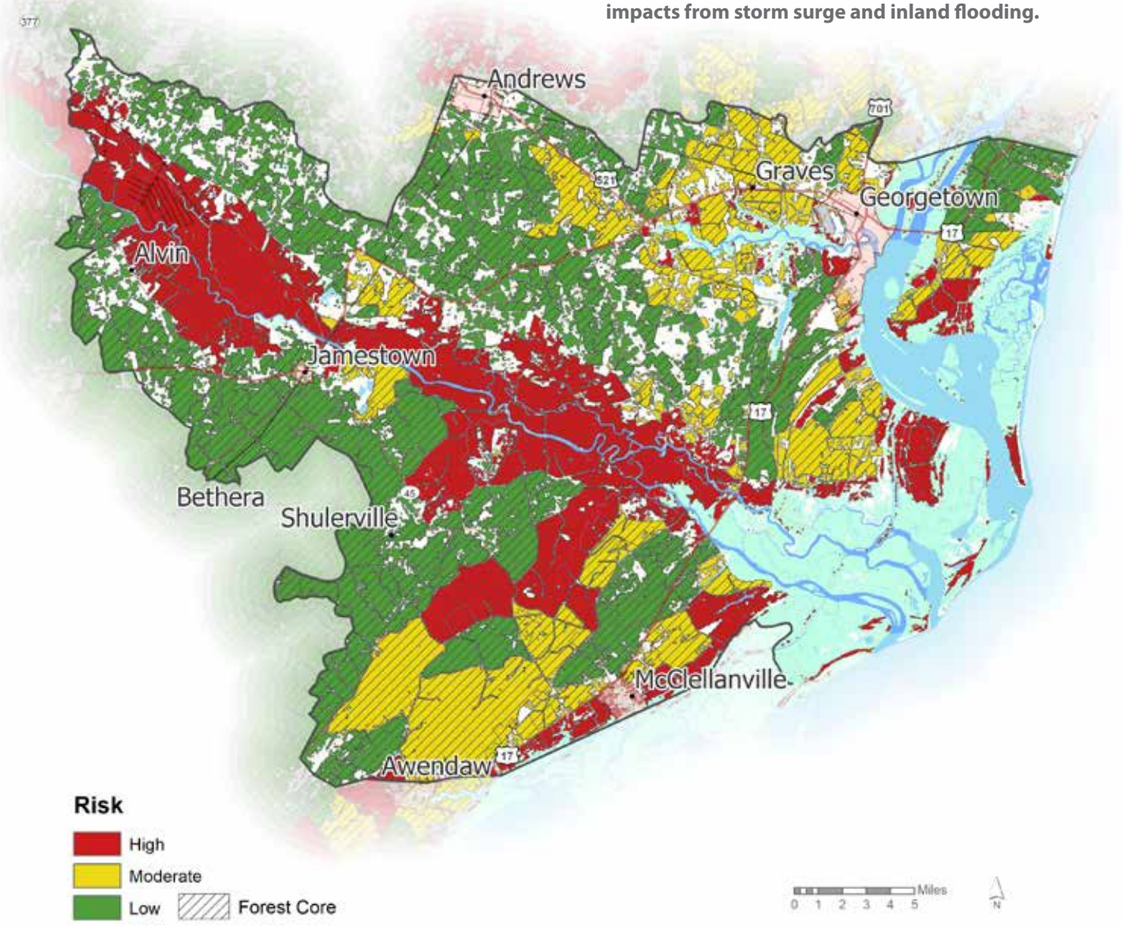
- Increase forest buffer widths along shorelines and along riparian areas to account for landward migration of water.
- Plant new forest buffers further upland to account for sea-level rise and marsh migration.
- Use sea-level rise in resource management decisions. For example, shorten rotation periods in timber operations; select faster growing species; and consider alternative land uses, as wetter areas will be more difficult and potentially more destructive to future harvests.

101,100 acres of forest

(31%) in the study area are at HIGH RISK from storms

Coastal forest high ground in the region is eroding at much faster rates because of higher wave action, sea-level rise, storm surge and the stress and mortality of trees. The International Panel on Climate Change's Working Group 1 released a report "Climate change: the physical science basis" that indicated that storm intensity globally will likely increase by 1-10% and global rainfall rates would likely increase 10-15% within about 60 miles of the storm under a 3°F warming scenario (IPCC 2007). Factoring in evidence that hurricanes are slowing down upon reaching landfall implies an increase in the destructive potential per storm, assuming no reduction in storm size (Kossin 2019).

Coastal Forests at Risk of Storms



Coastal forests at risk of storms, including impacts from storm surge and inland flooding.

Storm surge models from the National Oceanic Atmospheric Administration (NOAA) show saltwater surges reaching up to 35 miles inland of the Santee River to as high as Alvin, South Carolina, flooding coastal forest swamps. The resultant surge floods coastal forests with saltwater, effectively creating toxic soil conditions that kill the trees and leave standing dead or downed debris. Salt spray can further stress trees, making them more susceptible to pests and disease and increasing overall mortality. Increased precipitation from storms also increases the likelihood of downstream flooding and higher levels of erosion and sediment deposition into the estuary. This scenario played out in 1989 when Hurricane Hugo made landfall in the region, blowing down large swaths of coastal forest and flooding the region for weeks, making it nearly impossible to salvage timber, and resulting in heavy fuel loads that raised wildfire risk to dangerous levels.

Storm surge traveling up river valleys floods forests with saltwater that kills the trees, resulting in a "ghost" forest.

Studies show that storm intensity is increasing making storms more damaging and new data suggest that storm frequency is also increasing.

GIC Recommendations

- Preserve natural land cover in the 100-year floodplains.
- Localities should adopt green infrastructure plans, which can also lower their Community Rating System score if they also include protecting rare species as a goal, thus saving on insurance rate costs.
- Emergency planning should include the urban forest — preparation, cleanup and restoration — especially as it relates to storm readiness, response and long-term recovery.
- Establish a fund for tree inventories and tree-risk assessments (at least Level 1) for urban forests.
- Increase the number of living shoreline projects to buffer communities and forests from storm surges. (see Appendix for grant sources).
- Increase the width and extent of shoreline forest buffers.
- Plant more salt-tolerant species in urban settings. (See Appendix for a list of salt spray and saline soil tolerant species.)

WILDFIRES

167,521 acres

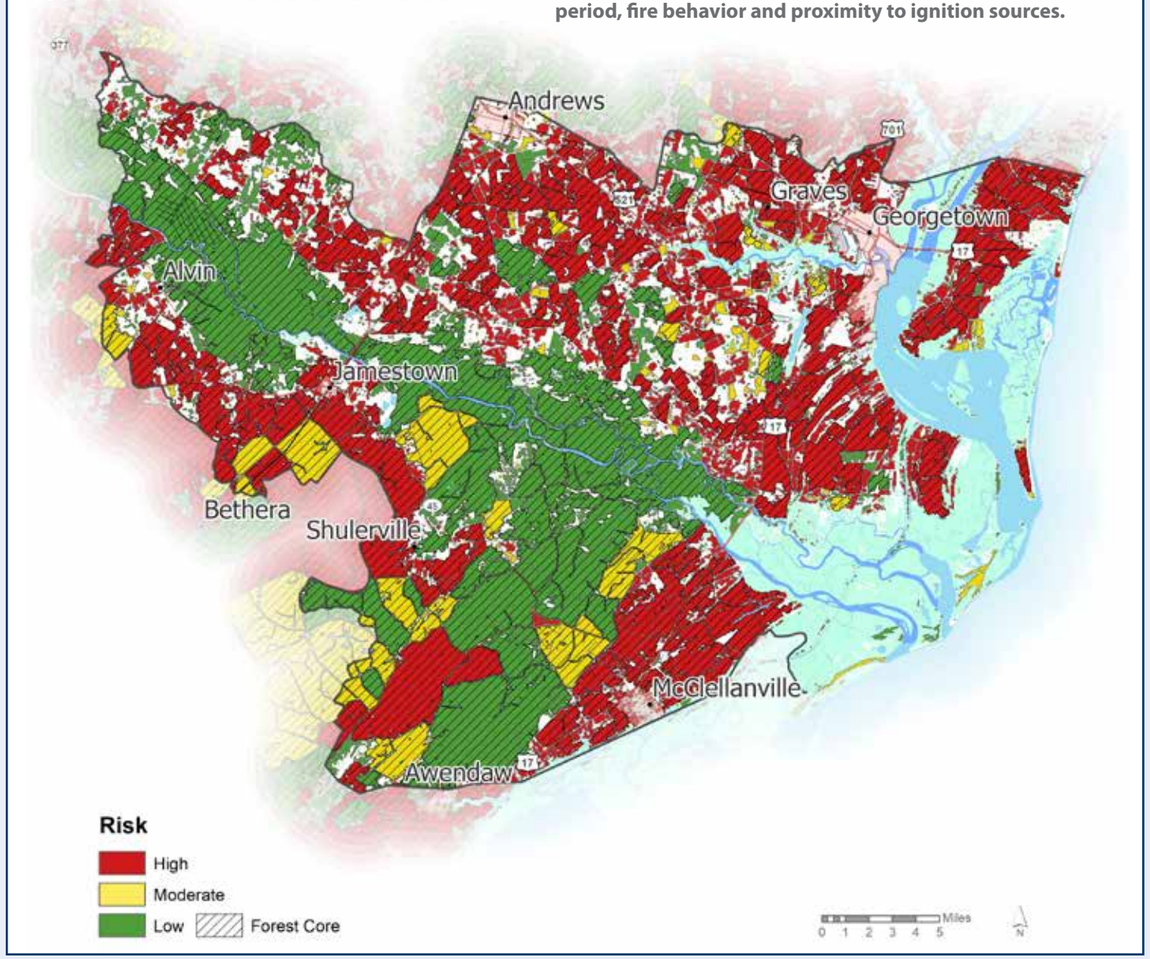
(52%) of the study area are at HIGH RISK from wildfire.

Wildfire is a reoccurring component of the coastal forests of the Southern U.S. Historically, coastal forests would periodically burn as a result of weather events, such as lightning strikes or from human-caused fires. These fires were typically low-to-moderate severity understory fires that removed some of the understory brush, making room for new species to grow, new seeds to germinate, the recycling of nutrients back into the soil and the opening of meadow areas for animals to forage. Longleaf pine forests and savannas adapted to this frequent low-severity fire regime, resulting in a highly productive and biodiverse system. However, around the turn of the 20th century, forest managers across the United States started to suppress fire on the landscape for public safety, rather than allowing it to burn. This practice created an imbalance in ecosystems where a fire-climate dependent relationship had previously evolved. The result has been a buildup of vegetation or "fuel" that leads to hotter and more widespread fires that are harder for fire managers and firefighters to control. In addition, an invasive tall reed species such as phragmites can provide ladder fuel— allowing wildfires to reach the crowns of trees, thus creating more destructive fires.

Further complexity is added by an ever-increasing proximity of human communities to wildlands. As development continues to press into wilderness areas, more homes and infrastructure are put at risk by wildfire. In addition, forest resource managers are finding it harder to set prescribed fires because of shorter weather windows for safely controlling the operations. Coupled with more residents, housing and roads to consider during burns, plus the resultant smoke, fire managers have many challenges to overcome for even a single burn. This creates a backlog of forest land to be burned, which in turn creates positive feedback loops. Fewer prescribed burns mean an increase in fuel loads, which increases the risk of a more catastrophic fire, which in turn increases the risk of harm to human communities that occupy the wildland urban interface (WUI).

Coastal Forests at Risk of Wildfire

Coastal forests' risk from wildfire, based on fuel loads, fire period, fire behavior and proximity to ignition sources.



Coastal forests' risk from wildfire, based on fuel loads, fire period, fire behavior and proximity to ignition sources.

The wildland urban interface (WUI) is the zone between wildlands and urban areas. As people move into and develop these areas, risks from fire or wildlife and human conflicts increase.

GIC Recommendations

- Utilize reverse 911 or apps to communicate when to burn or not to burn, or when prescribed burns are happening in the area, so people can tell the difference between planned fires and wildfires.
- Create co-ops for burning and logging on clusters of private, small forestland owners.
- Consider fire risk in comprehensive planning and discourage development in fire prone areas. Include fire risk maps in the Comprehensive Plan.
- Real estate agents and realtors could provide forestry agency brochures about prescribed fires when a new resident purchases a home in the Wildland Urban Interface (WUI).
- Educate developers about Firewise design principles and provide talks to local realtors and builders.
- Change state Firewise education programs from reactive to proactive – conduct outreach efforts to target those HOAs that are at risk, but unlikely to know about or ask for such education.
- Reach out to the South Carolina Chapter of the American Planning Association and to coastal planners to educate them about the Firewise program.

DEVELOPMENT

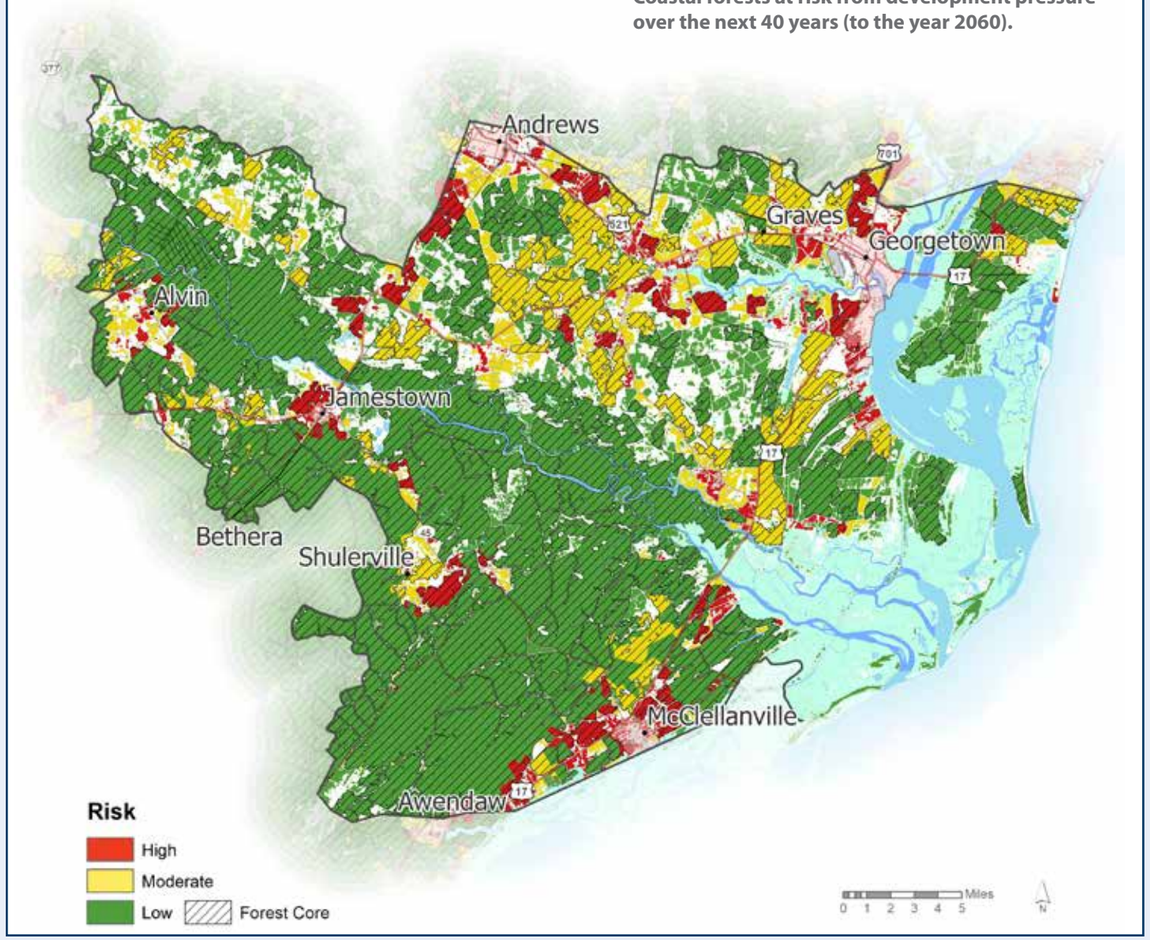
27,314 acres

(8%) of the study area are at HIGH RISK from development pressure

Development is a major threat to coastal forests because it represents permanent conversion of the forest to hardscape and lawns. The Southern Forest Resource Assessment predicted that suburban residential and commercial development would convert 19 million acres of forest into urban hardscape between 2020 and 2040, and at the same time increase forest fragmentation (Wear 2002). Coastal areas of the Southeast are seeing the highest rates of migration of people into the coastal countryside,

Coastal Forests at Risk of Development

Coastal forests at risk from development pressure over the next 40 years (to the year 2060).



When development occurs within forested landscapes, it can fragment the forest, leaving patches that are too small for forest wildlife to thrive and inappropriate for harvest.

despite increased frequency and severity of climate-related factors, such as flooding, sea-level rise and storms. Mild temperatures, relatively cheap and available land, new industries and proximity to the Atlantic Ocean are all highly desired qualities attracting new people. Meanwhile, in many rural areas of the coast, codes and policies have not kept pace with this development boom. Within the study region, 2016 land cover included more than 7,000 acres of impervious surfaces. The continued conversion of forest land to impervious surfaces will further exacerbate many of the environmental challenges from stormwater runoff, urban heat island and habitat loss.

The extent of the potential problem is evident when one realizes that the study area currently has 1,484 land parcels of between 10-50 acres, which make up more than 33,369 acres (7% of total land cover) of the study area. While forested parcels of 20 or more acres can support small but viable forestry activities and provide at least some connectivity across the landscape, if a parcel is too small or isolated, it may not be easy to contract with timber harvesters unless it has large, high-quality trees. Meanwhile, those parcels of 10 acres or less, unviable for sustained forestry, are the most vulnerable to further subdivision or development.

As more land is developed, ensuring that pockets of woodland remain within new developments and that new trees are planted is critical to mitigating stormwater and urban heat. While infilling of new housing within existing urban areas is a key strategy to avoid more development of rural lands, those infill designs should ensure that trees and stormwater mitigation features are included in their landscape designs.

Distribution of trees across urban areas is another key concern since "tree equity" is also important. Trees are often much scarcer in low-income and minority communities in urban areas. This lack of equal access to shade trees and the many benefits they provide means that some areas lack "tree equity." Community education and outreach, planting trees in low-canopied neighborhoods, and conducting tree inventories and maintenance are actions that can balance and equalize canopy coverage across cities and towns. For more, see GIC's guide to community tree planting campaigns on our website at www.gicinc.org.

GIC Recommendations

- Establish appropriate zoning to protect trees and forests, such as Rural or Conservation classes or Ag and Forestal Districts that acknowledge high-value natural resources, such as forests.
- Have a robust tree ordinance that includes all the key elements needed to ensure adequate tree care and prevent unnecessary removals. http://gicinc.org/PDFs/Planners_ForestToolkit_2021.pdf
- Establish active tree planting campaigns or initiatives. Educate the public on the importance of planting the next generation of trees so that older canopies don't die all at once when they reach the end of their lifecycles.
- Host tree giveaway events for residents to encourage them to plant on private property.
- Land trusts should use the RCF maps and data to identify places for possible conservation easements..
- Local governments experiencing high growth should consider establishing Purchase of Development (PDR) programs to compensate landowners for keeping their lands in forests and avoiding growth in areas that are not served adequately by infrastructure or schools.
- Consider a stormwater utility fee that rewards residents and businesses by giving stormwater credits when trees are planted. Example: City of Rock Hill, SC.
- Establish tree protection ordinances during the construction of new development.

Conservation Subdivision (Cluster Development) Ordinance

If conservation is a key objective, then at least 50% of the site should be conserved as open space. Some communities set low thresholds of 20-30%, which do not provide the necessary habitat and connectivity needed on the landscape. The ordinance should also include provisions that limit the percentage of regulated lands or primary areas (wetlands, floodplains, steep slopes, etc.) to be calculated as part of the required open space. This allows for more upland forest habitat to be included as part of the conserved open space, which provides greater habitat diversity for wildlife and can mitigate potential impacts from long-term future threats (sea-level rise, more severe floods, etc.).

Coastal communities are growing, with new development being built.

The cluster ordinance should also limit the percentage, or exclude altogether, stormwater best management practices (BMPs), such as dry ponds, from the open space calculation and limit or prohibit developed open space, such as tennis courts, golf courses and athletic fields.

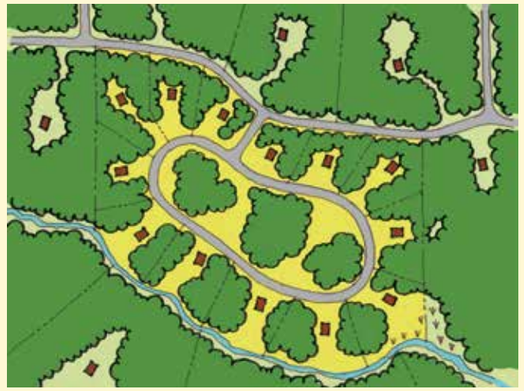
A few example standards used by Oconee County and Dorchester County in their conservation subdivision ordinance include:

- A minimum of 50 percent of the gross area shall be preserved as green space. (Oconee County).
- At least half of the lots shall directly abut conservation land or face conservation lands from across the street. (Oconee County)
- Areas used for stormwater management ponds are not considered common open space and shall not count toward minimum requirement or be used for bonus density. (Dorchester County)
- Nine-foot (9') lawn verge on both sides of street measured from back of curb to edge of sidewalk. (Dorchester County)
- Canopy street trees shall be planted every fifty feet (50') on average. (Dorchester County)
- Pedestrians shall have easy access to common open space. (Dorchester County)
- Covenants and restrictions governing the preservation of green space, wetlands and other sensitive lands shall be recorded with the final subdivision plat prior to any sales. A statement assigning the homeowners association responsibility for maintaining the conservation land shall be clearly placed on the final subdivision plat. (Oconee County)
- All conservation lands shall be contiguous, to provide for integrated open space throughout the subdivision, excluding thoroughfares. Long, thin strips of conservation land (less than 150 feet in width) shall be prohibited. (Oconee County)

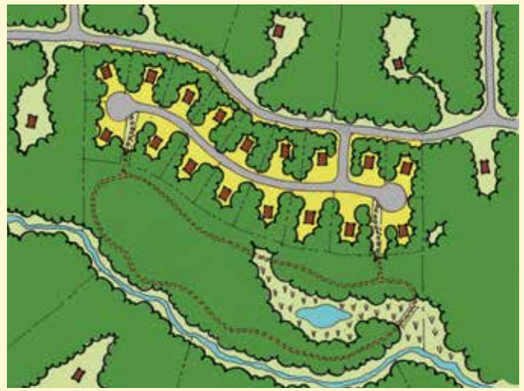
Some forested areas are slated to be sold and are likely to be developed in the coming decades.

In addition, incentives should be offered to developers to increase the amount of open space within a cluster or conservation development through an increase in density (percentage) or density bonus points for saving priority habitats, such as protecting mature forest, connectivity corridors or increasing widths for buffer and tree lawns. The following density bonuses in Oconee and Dorchester Counties illustrate these points:

- Lot size may be reduced to 10,000 square feet provided that a nontraditional septic system is approved by the South Carolina Department of Health and Environmental Control (DHEC). (Oconee County)
- An increase in green space by at least 15 percent shall permit the developer to decrease the minimum lot size by 20 percent (to 8,000 square feet). (Oconee County)
- For every 5% additional open space from land included within the net calculated developable acreage (including wetland buffers), a 2% bonus density may be applied, or fraction thereof up to 8%. (Dorchester County)
- If cul-de-sacs or dead-end roads (not including connections for future connectivity) are not utilized within the subdivision, a 5% bonus density may be applied. (Dorchester County)
- If the development includes a trail system throughout the neighborhood as passive open space, a 2% bonus density may be applied per the Zoning Administrator. (Dorchester County)



This is an example of a bad cluster development. While each parcel preserves half in open space, the result leaves the forest fragmented.



In this example the cluster development allows for connectivity of the forest across the landscape while allowing the same number of houses. Cluster developments with open space sell faster and for better profit margins than developments without open space included.

- For land set aside for community facility use totaling above ten (10) acres a 7.5% bonus density may be applied. (Dorchester County)

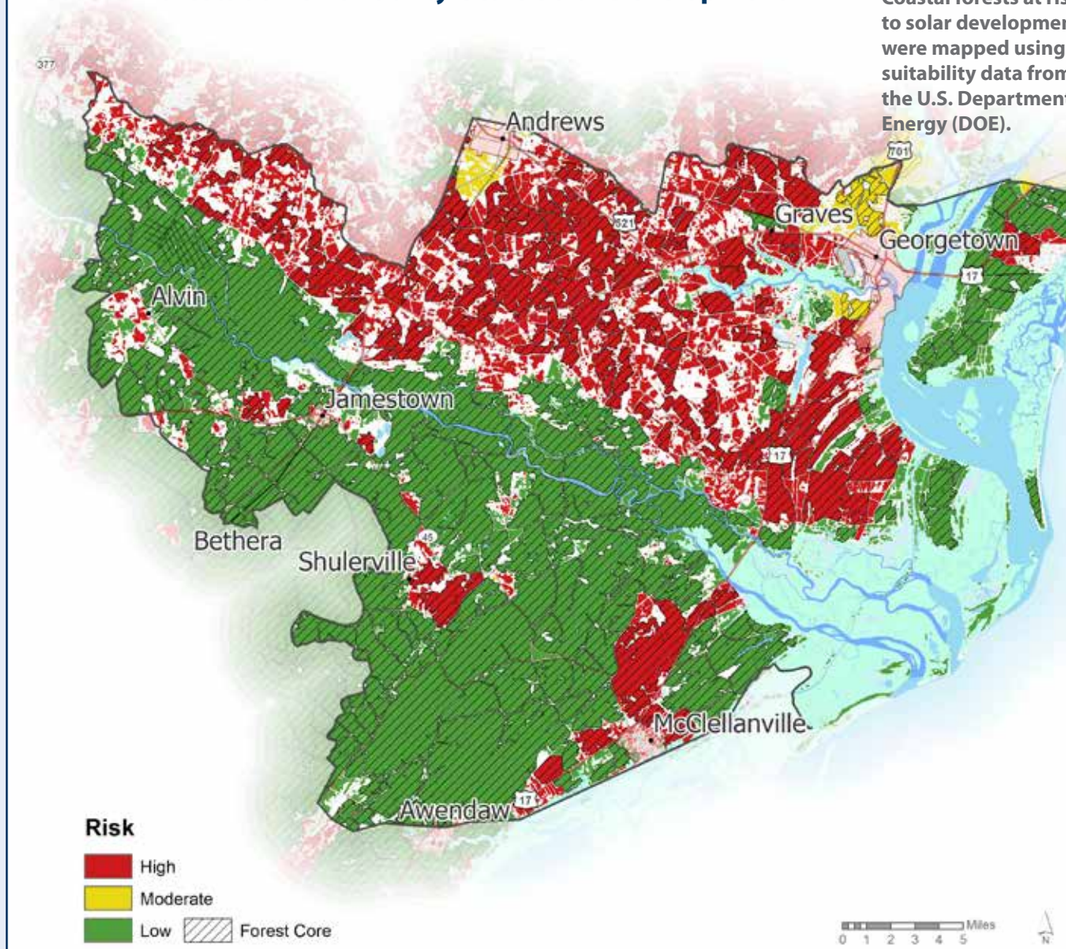
UTILITY-SCALE SOLAR DEVELOPMENT

116,661 acres (36%) of the study area's forests are at HIGH RISK from utility-scale solar development.

Solar development was identified as a threat to coastal forests mid-way through the RCF project when Virginia, and to a lesser extent South Carolina, saw an increase in permit applications for utility-scale solar development. Many of the applications included clearcutting forests to make room for the installation of panels, with some sites proposing clearance of hundreds or thousands of acres of forest. While the local governments in the South Carolina study area were not observing an influx of utility-scale solar development permit applications yet, many of the local stakeholders felt it was prudent to have guidance from the state to update their zoning ordinances. While solar energy development is critical to reducing U.S. dependence on fossil fuels, forests provide important carbon sequestration and storage functions necessary to mitigate the Earth's existing atmospheric carbon dioxide levels, so clearing forests for solar panels makes little sense. Carbon stored in the forest is also released if cleared trees are also burned.

Other concerns from utility-scale solar development include the panels themselves and the lack of regulation of surface runoff. While the ground beneath the panels is pervious and often vegetated with low-growing grasses or shrubs, concentrated sheet flow from panels can cause significant water quality and erosion concerns, especially when compared to the previous forest cover. Virginia has recently mandated stormwater plans for utility-scale solar sites and South Carolina should do the same.

Coastal Forests at Risk of Utility-Scale Solar Development



Coastal forests at risk to solar development were mapped using site suitability data from the U.S. Department of Energy (DOE).

The transition to greater sources of clean energy is resulting in forestland conversion to utility scale solar. Forest lost to solar farms will likely accelerate into the future unless policies are adopted to discourage large solar arrays on forested lands.

GIC Recommendations

- Zoning ordinance or solar overlay for utility-scale solar.
  - **Site locations**
    - — Avoid prime agricultural soils.
    - — Avoid steep slopes.
    - — Avoid wetland-rich areas and disturbance of riparian buffers.
    - — Discourage utility-scale solar on forested land.
    - — Avoid floodplains.
  - **Site design**
    - — Require a stormwater management plan for the site that factors in contribution to impervious area from the panels themselves.
    - — Require pollinator-attracting species seed mixes.
    - — Buffer open waterways by 100 feet of native vegetation.
    - — Require 100-foot vegetated screening buffers around the site.
    - — Consider wildlife-permeable fencing with openings to allow passage for smaller mammals or foraging birds, such as quail.
    - — Avoid breaking up and disconnecting remaining trees in surrounding forests
- Require mitigation of forest site impacts by requiring that new trees be planted offsite.
- Establish a clause that preemptive forest clearing under the guise of forestry will result in a three-year delay in permits for solar facilities.
- Analyze site suitability for utility scale solar farms at a regional scale.
- Develop a strategy for utility scale solar farms that minimizes impacts to natural resources.
- Incentivize solar development on marginal or other non-greenfield lands.
- Include solar locations (appropriate/inappropriate designations) in the Comprehensive Plan.
- Develop guidance for solar developers to create better habitat around solar panel sites. For examples, see South Carolina's Technical Guidance for the Development of Wildlife and Pollinator Habitat at Solar Farms, link: https://www.dnr.sc.gov/solar/assets/pdf/solarHabitatGuide.pdf

INVASIVE SPECIES, PESTS AND DISEASE

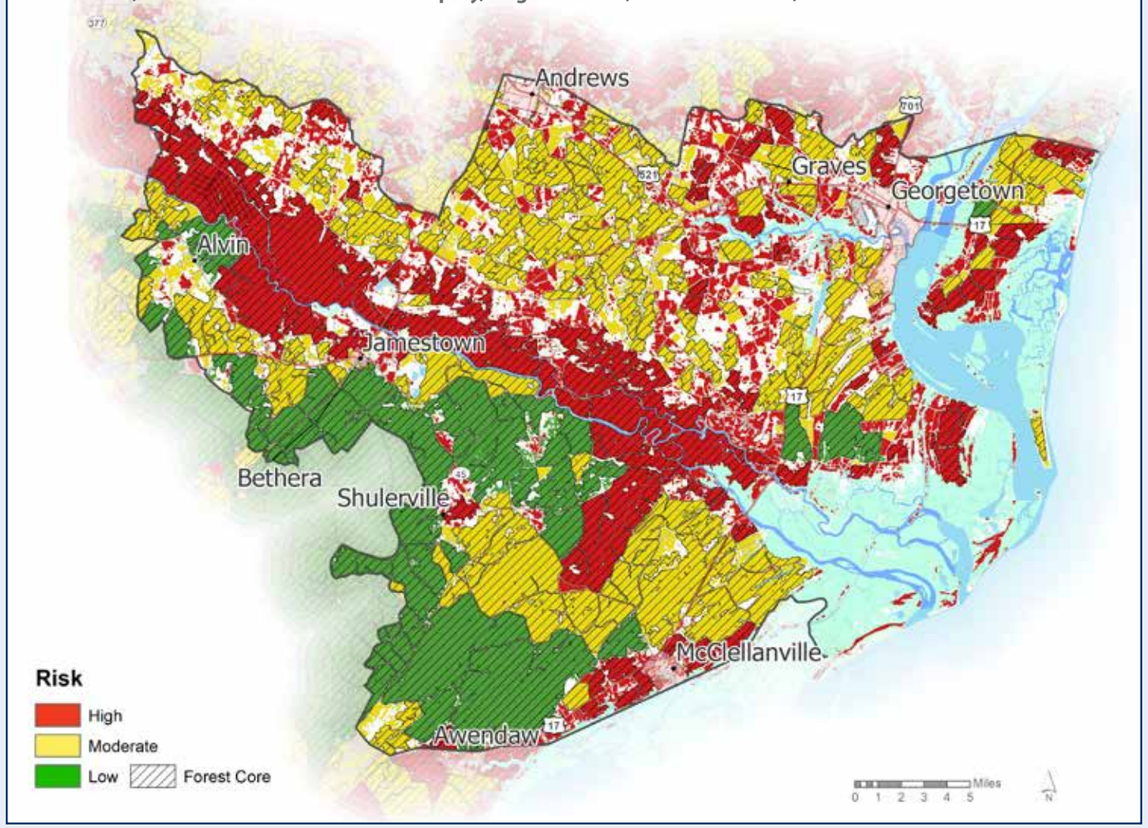
125,580 acres (39%) of the study area's forests are at HIGH RISK of impacts from invasive species, pests and disease.

In this study, invasive species, pests and diseases were lumped together since many of the stressors and factors causing the introduction, establishment and spread of non-native plants and animals are the same factors that lead to pest and disease outbreaks. Examples of stressors are heat, drought, salt spray, wind, fragmentation, land cover disturbance and vector pathways, such as proximity to urban development, roads and streams.

Climate change could increase harm from pests and diseases, such as oak dieback, or from the emerald ash borer, as trees become weaker as a result of unsuitable temperatures, rainfall and other climate conditions. For example, warmer temperatures could result in new insects and pathogens moving into the area that were excluded before. According to the EPA:

Coastal Forests at Risk of Invasive Species, Pests and Disease

This map shows potential places where invasive species, pests and disease could become established, based on such stressors as salt spray, fragmentation, land disturbance, etc.



A variety of non-native, invasive species such as rattlebox (*Sesbania punicea*) can alter the species composition and degrade the quality of forest habitat.

Climate change could alter the frequency and intensity of forest disturbances such as insect outbreaks, invasive species, wildfires, and storms. These disturbances can reduce forest productivity and change the distribution of tree species. In some cases, forests can recover from a disturbance. In other cases, existing species may shift their range or die out. In these cases, the new species of vegetation that colonize the area create a new type of forest (EPA 2017).

According to a 2007 International Union for Conservation of Nature (IUCN) Red List Fact Sheet (available at https://www.iucn.org/sites/dev/files/import/downloads/species_extinction_05_2007.pdf), invasive species are a leading cause in the loss of biodiversity and extinction of species globally. Invasive plants and animals alter ecosystems by displacing or replacing native species through competition of resources, such as light, water and space. They can increase the risk of fire by creating greater biomass and more flammable fuels in the forest understory, such as phragmites or cogon grass.

Many invasive plants support fewer species of insects than native plants. Other species have allelopathic properties – they exude chemicals into the soil that inhibit other plants from germinating or getting established. They can also proliferate to the degree that they choke or smother other plants or trees, causing them to die prematurely.

The small redbay tree (*Persea borbonia*) is a key host plant for the palamedes swallowtail. However, the redbay ambrosia beetle has been attacking and inadvertently killing redbays along the southern Atlantic Coast. The beetle is a vector which carries a fungal disease called laurel wilt which infects the understory tree and kills it. Laurel wilt has significantly reduced the population size of redbay trees in the Southern Atlantic Region.

GIC Recommendations

- Disallow or remove invasive species from landscape ordinances. It is OK to have non-native, non-invasive species of trees included.
- Increase biodiversity in urban settings. Include a minimum number of different species required in landscape plans (e.g., no less than five different types of street trees).
- Build capacity with local and regional nurseries to grow and promote native plants. Consider having a special "natives" section. However, these campaigns are only as successful as the number of nurseries that participate, so work with local and regional nurseries is needed to convince them to stop selling invasive plant species and start showcasing natives.
- Encourage landowners to remove invasive tree species, such as Bradford pear, from their properties. (See the Clemson's Bradford Pear Bounty program under the State Stakeholders section.)
- Place signage discouraging outside sources of firewood in managed campgrounds. Example: Don't Move Firewood Campaigns. For any program or signage, clarify from how far away (e.g., a mile).
- Educate landowners about timing the use of pesticides with regard to pollinators to avoid harming them. For more, see the Clemson Cooperative Extension's articles on:
  - —Native Pollinators, at: https://hgic.clemson.edu/factsheet/native-pollinators/
  - —Pollinator Gardening, at https://hgic.clemson.edu/factsheet/pollinator-gardening/
  - —Less Toxic Insecticides, at:(https://hgic.clemson.edu/factsheet/less-toxic-insecticides/ This evaluates use of less toxic insecticides, such as soaps and oils, botanical insecticides, essential oils, microbial insecticides, minerals and insect growth regulators.

FRAGMENTATION

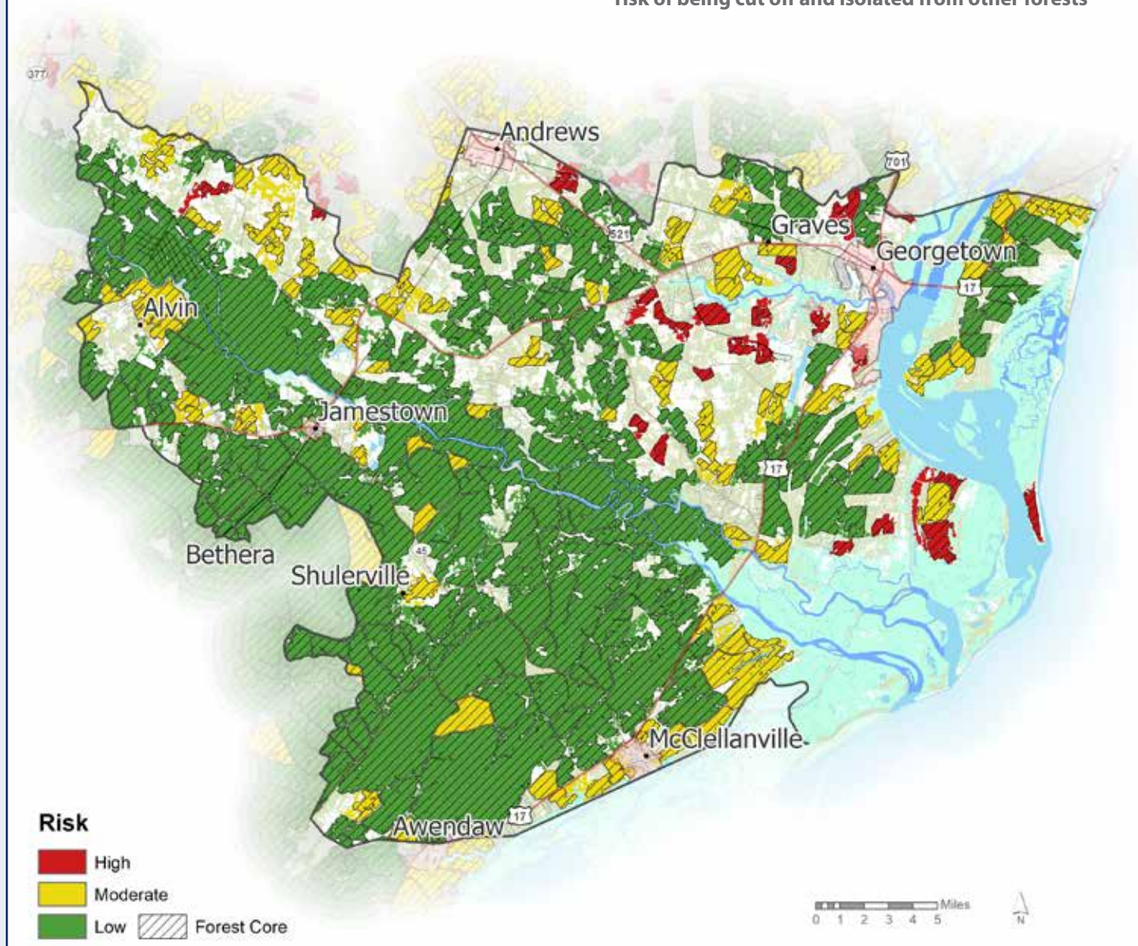
1,130 miles of roads are in the study area, and roads contribute significant barriers to wildlife movement across the landscape.

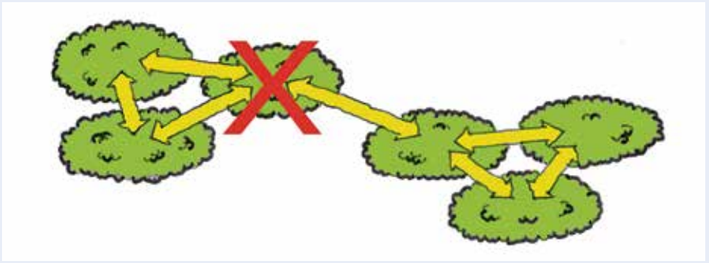
Fragmentation is one of the leading causes of decline in Southern U.S. forests, primarily as a result of development (Hanson, et al 2010). Studies show that a more connected landscape is a more resilient landscape, since species populations are not isolated by habitat fragmentation. E.O. Wilson was an early researcher of this phenomena in his Theory of Island Biogeography, in which he noted that isolated mangroves recovered far more slowly that those that were closer together (1967). If range expansion is restricted, populations may become more vulnerable to the effects of climate change and extreme weather events (Ewers, et al 2006).

Too often, planning at the landscape scale is lacking. Local authorities create area plans without looking at the bigger picture, or they designate large swaths of land as rural, or as a development area, without assessing the many considerations that can affect the health of that landscape.

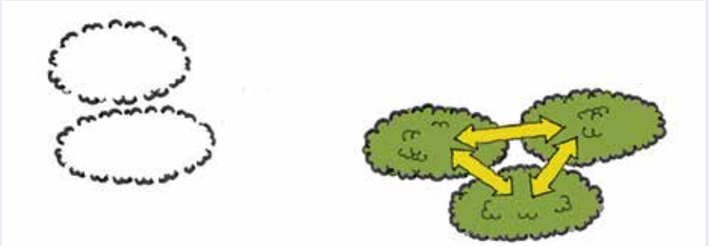
Coastal Forests at Risk of Fragmentation

The forests identified in red are those that are at most risk of being cut off and isolated from other forests





When cores are destroyed it prevents species from accessing other available forest habitat, causing those forest cores to decline.

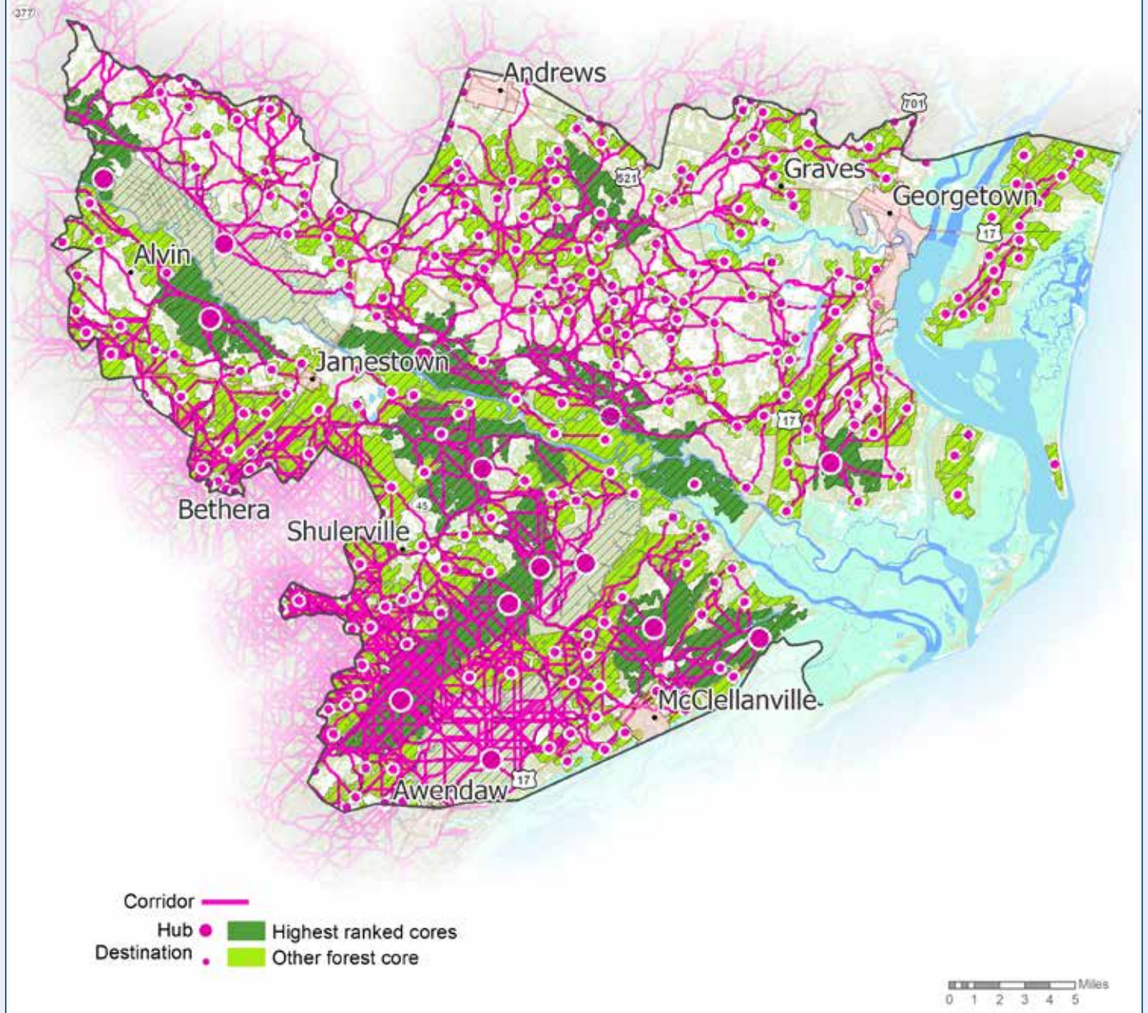


Human infrastructure such as roads, transmission corridors and development, fragment the forest into smaller pieces which provide less overall interior forest habitat. Disturbed areas are also more likely to be overtaken by invasive plants.

FRAGMENTATION *CONTINUED*

Coastal Forest Corridors

The least resistant pathways or corridors for species to move across the landscape.



Multiple, cumulative impacts arise from the variety of decisions humans make, from land use to built infrastructure. A prime example is road construction. Most of the state's roads have been built without regard to the impacts on the movement of species across the landscape. Roads are the biggest contributing factor to fragmenting forest habitat and are a significant factor in the mortality of species as they try to cross them. It is estimated that several million birds are killed annually in vehicle collisions on U.S. roads (Loss, et al 2014). With over 1,130 miles of roads in the study area, roads contribute barriers to wildlife movement across the landscape.

An objective of this study was to analyze the degree of isolation and fragmentation of forest core habitats and then to model corridor locations for species to migrate safely across the landscape. The goal is to increase connectivity and safe passage for wildlife along these routes.

Roads not only fragment habitat, but they also inhibit species from migrating safely across the landscape.

GIC Recommendations

- Create more animal crossings/bridges/tunnels for safe passage of both people and wildlife. In areas with higher water tables along the coast, consider wildlife bridges.
- Localities should incorporate conservation overlays or large lot zoning to protect areas with high-value forests or important silvicultural areas.
- Prioritize land easements by considering corridors' data as a criterion for land to be protected.
- Plant hedges, shrubs or wildflower meadows along road rights-of-ways to fill in the clearing of trees. Custom mixes can be made to deter deer.
- Site future roads to reroute around high-valued forest cores and habitats by considering habitat cores maps as part of long-range road planning (6-year plans).
- Identify key forest cores and corridors in comprehensive plans and regional plans.
- Finish connecting the remaining sections of the East Coast Greenway and better maintain existing sections that are overgrown.

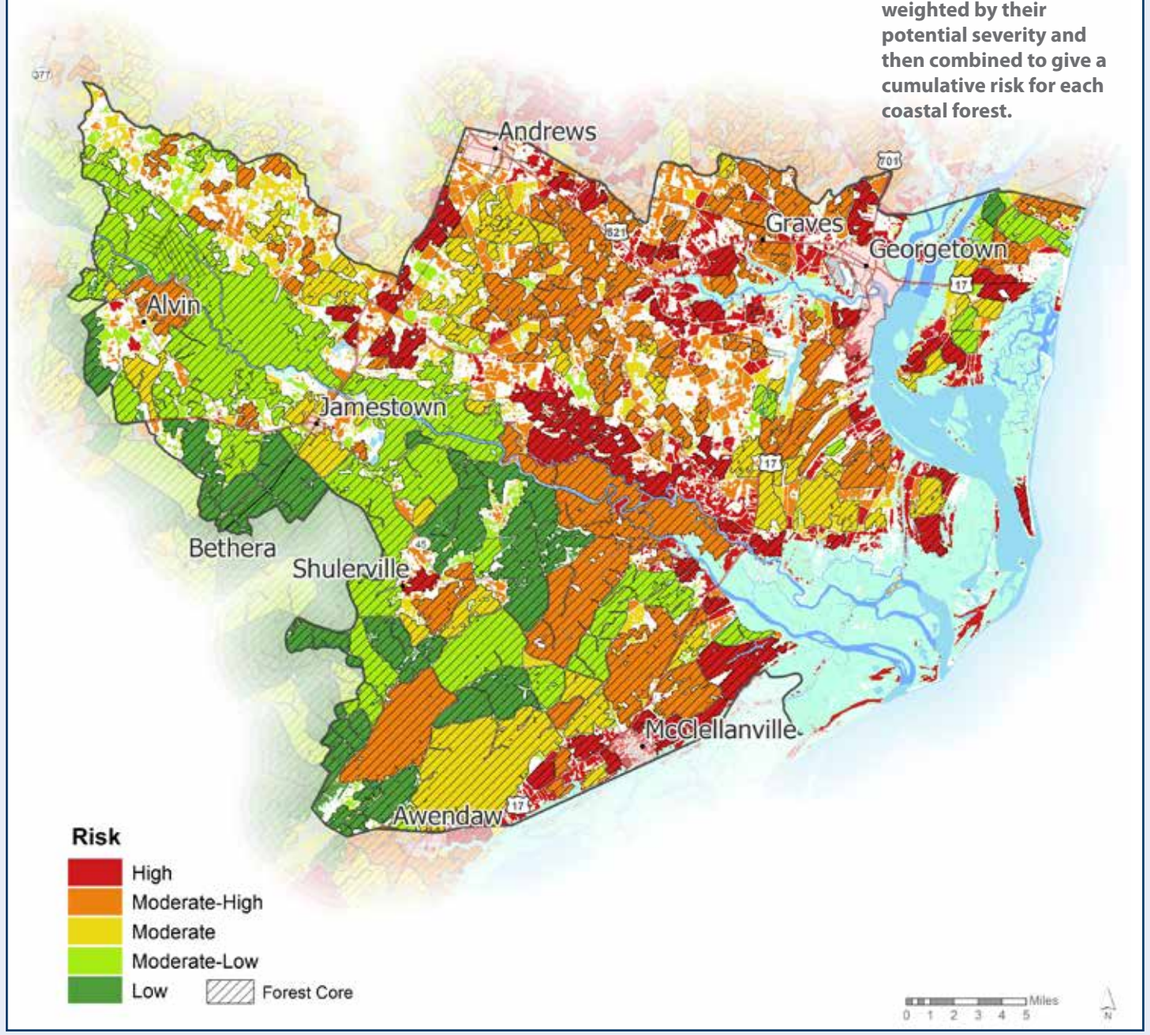
SEVERITY AND CUMULATIVE THREAT RISK

9,872 acres (3%) of coastal forest in the study area are at HIGH RISK from *multiple* threats.

178,424 acres (55%) of coastal forests are at MODERATE to HIGH RISK from 3 or more threats.

Cumulative Risk from All Threats to Coastal Forests

All threats were weighted by their potential severity and then combined to give a cumulative risk for each coastal forest.



In addition to evaluating threats individually, cumulative risks were mapped to depict the severity of multiple simultaneous impacts. Certain threats can create feedback mechanisms in which one threat can exacerbate another or create environmental conditions that support the introduction of a new threat. A prime example is sea-level rise, which allows non-native, invasive grasses such as phragmites to colonize the area and spread into adjacent forests or towards nearby housing developments. These non-native, invasive grasses are more combustible and wildfire spreads more quickly through them. This altered fire behavior can jeopardize homes in newly built communities that are encroaching upon the WUI.

Drought can also weaken trees and make a forest more susceptible to wildfire or insect outbreaks. Similarly, wildfire can make a forest more vulnerable to pests (CCSP 2008; USGCRP 2014). The EPA notes that the combination of such threats can have an accelerator effect upon trees in general; disturbances can interact with one another, or with changes in temperature and precipitation, all of which can increase risks to forests.

This study also considered the severity of impacts to coastal forests by threat. Not all threats are equal; some result in permanent changes, while others, such as wildfire and storms, are recovered from more rapidly. To account for differences in severity and permanency of the threat, each one was given a weight proportional to the severity of its impacts, with more permanent and severe impacts assigned higher weights and less permanent or severe impacts assigned lower weights. To account for the situation where multiple threats occur, individual risks were layered on top of one another, resulting in a cumulative risk score, to indicate which coastal forests are facing the greatest danger. See the Cumulative Risk Map at left.

Forests damaged by severe storms may be recolonized by non-native, invasive species.

Table 3: Recommended strategies for coastal forests and how they mitigate or adapt to one or more threats.

Threat / Strategy	Sea-level Rise	Storms	Wildfire	Development	Solar	Invasive Species, Pests & Disease	Fragmentation
Preserve natural land cover in the 100-year floodplains.	X	X		X	X	X	X
Increase forest buffer widths along shorelines and along riparian areas.	X	X					X
Plant forest buffers further upland to account for sea-level rise.	X	X				X	X
Use sea-level rise in resource management decisions.	X			X	X		
Use green infrastructure planning to lower Community Rating System scores.	X	X					X
Increase the number of living shorelines projects.	X	X					
Plant more salt-tolerant species in urban settings.	X	X				X	
Seek conservation easements for high-value forests and woodlands identified in this study.	X		X	X	X		X
Establishing Purchase of Development Rights programs and use those funds to protect highest-value and greatest-risk forest cores.	X		X	X	X		X
Include the urban forestry in emergency plans (inventory, recovery).		X	X	X			
Fund tree inventories and tree risk assessments for urban forests.		X				X	
Establish active tree planting campaigns or initiatives and educate the public on the importance of planting the next generation of trees.		X		X		X	
Consider a stormwater utility fee that includes tree planting as a mitigation measure.		X		X			
Provide replacement trees for landowners who remove invasive tree species. Ex: Bradford Pear		X				X	
Use Reverse 911 or a similar app to alert the public when prescribed burns are happening in the area.			X	X			
Establish co-ops for burning and logging on clusters of private, small forestland owners.			X	X		X	
Include fire risk maps in the comprehensive plan and zoning decisions.			X	X			X
Provide real estate agents/brokers with information on prescribed fires when a new resident purchases a home in the WUI.			X	X			
Educate developers on Firewise design principles.			X	X			
Promote Firewise education and conduct greater outreach and promotion in general (most homeowners have never heard of this).			X	X			
Incorporate conservation overlays or large lot zoning for rural area protection.			X	X	X		X

Table 3: Recommended strategies for coastal forests and how they mitigate or adapt to one or more threats.

Threat / Strategy	Sea-level Rise	Storms	Wildfire	Development	Solar	Invasive Species, Pests & Disease	Fragmentation
Require a minimum number of different tree species in landscape plans (e.g., at least 5 types of street trees).				X		X	
Establish tree protection ordinances during the construction of new development.				X			
Establish appropriate zoning that acknowledges high-value natural resources, such as forests, and that provide incentives for conservation.				X	X		X
Have a robust tree ordinance.				X		X	
Host tree giveaway events for residents to encourage them to plant on private property.				X		X	
Prevent preemptive forest clearing under the guise of forestry by imposing a 3-year waiting period for permit approvals for development of solar facilities.				X	X		
Prioritize land conservation easements for parcels that contain important habitat cores or corridors.				X	X		X
Establish a solar panel zoning ordinance or overlay to where a utility scale solar farm is/is not appropriate, as well as site plan requirements.					X		X
Require offsite mitigation for forests impacted by solar projects.					X		X
Conduct regional analysis of site suitability for utility-scale solar farms.					X		X
Incentivize solar development on marginal or compatible lands.					X		X
Include solar panel sites in the Comprehensive Plan.					X		X
Create better wildlife and pollinator habitat on solar sites.					X	X	
Build capacity with local and regional retail nurseries to sell and promote native plants.						X	
Work with local and regional nurseries to stop selling invasive plants and highlight native species instead.						X	
Discourage bringing firewood from outside the region into managed campgrounds, state forests or parks.						X	
Educate landowners on the timing of pesticides with regard to pollinators.						X	
Plant hedges, shrubs or wildflower meadows along road rights-of-ways to fill in areas where trees have been cleared.						X	X
Create animal crossings/bridges/tunnels for safe wildlife passage.							X
Site future roads to route them around high valued forest cores and habitats.							X

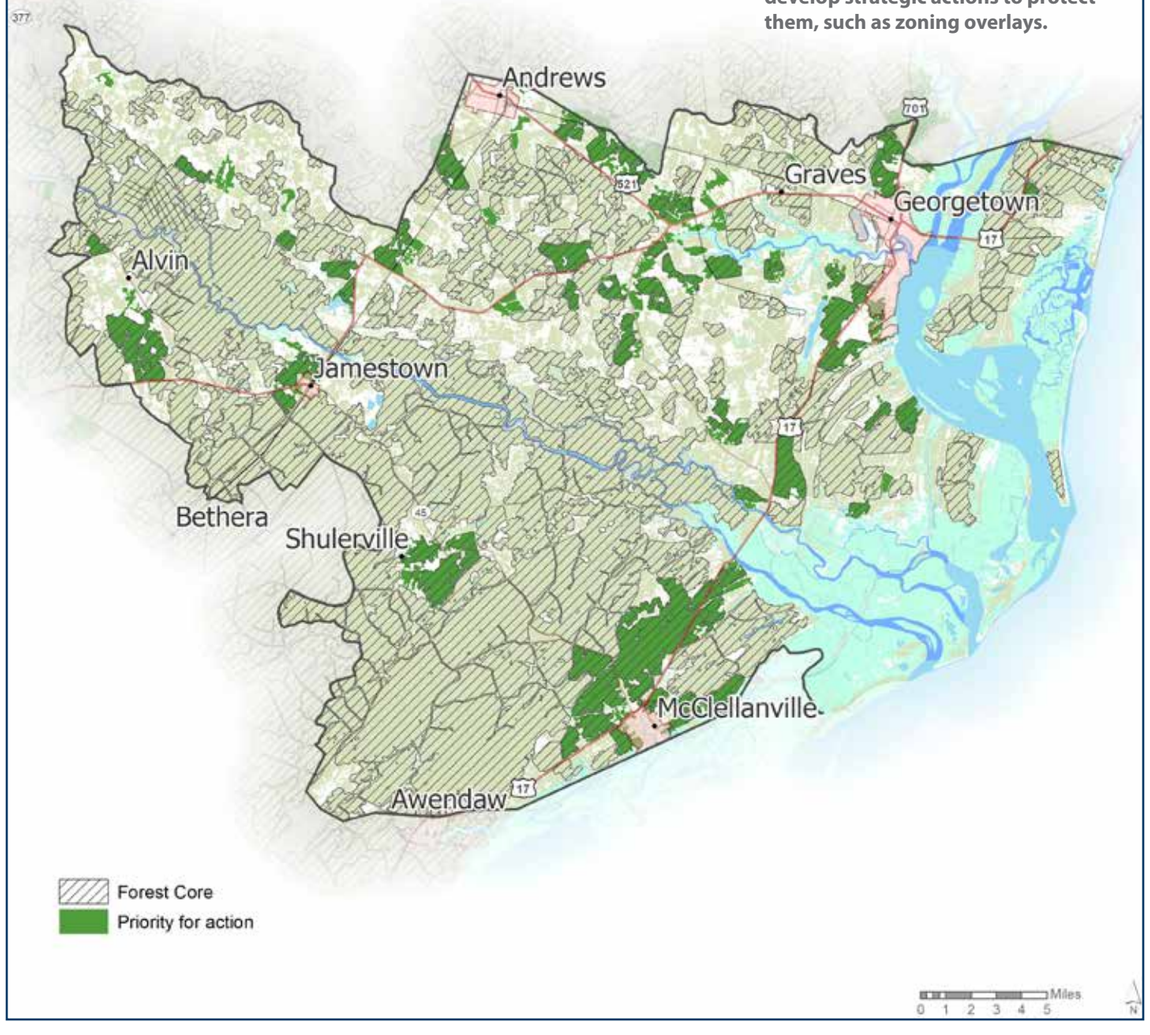
Prioritizing Coastal Forests

The final phase of the RCF study was to develop a prioritization scheme to inform local strategies for coastal forests. The scheme used forest core ranks and relative risks from threats to identify those cores or woodlands that should be protected or restored. Since utility-scale solar farming is an emerging concern in the region, GIC evaluated which highest-ranked forest cores and woodlands were at the greatest risk from solar development. Communities can use the data for forests that are at high risk from solar development by delineating a solar overlay to indicate areas where solar panel development is appropriate, or to create zoning or special use permit conditions to apply to new solar panel developments. An additional strategy would be to limit the number, or total extent of, solar projects in an area to prevent excess forest loss and fragmentation.

Another evaluation examined those coastal forests that provided the greatest amount of connectivity and had moderate-to-high-risk for solar or urban development. As key connectors, loss of these forests as corridors will significantly impact the ability of wildlife to migrate across the landscape.

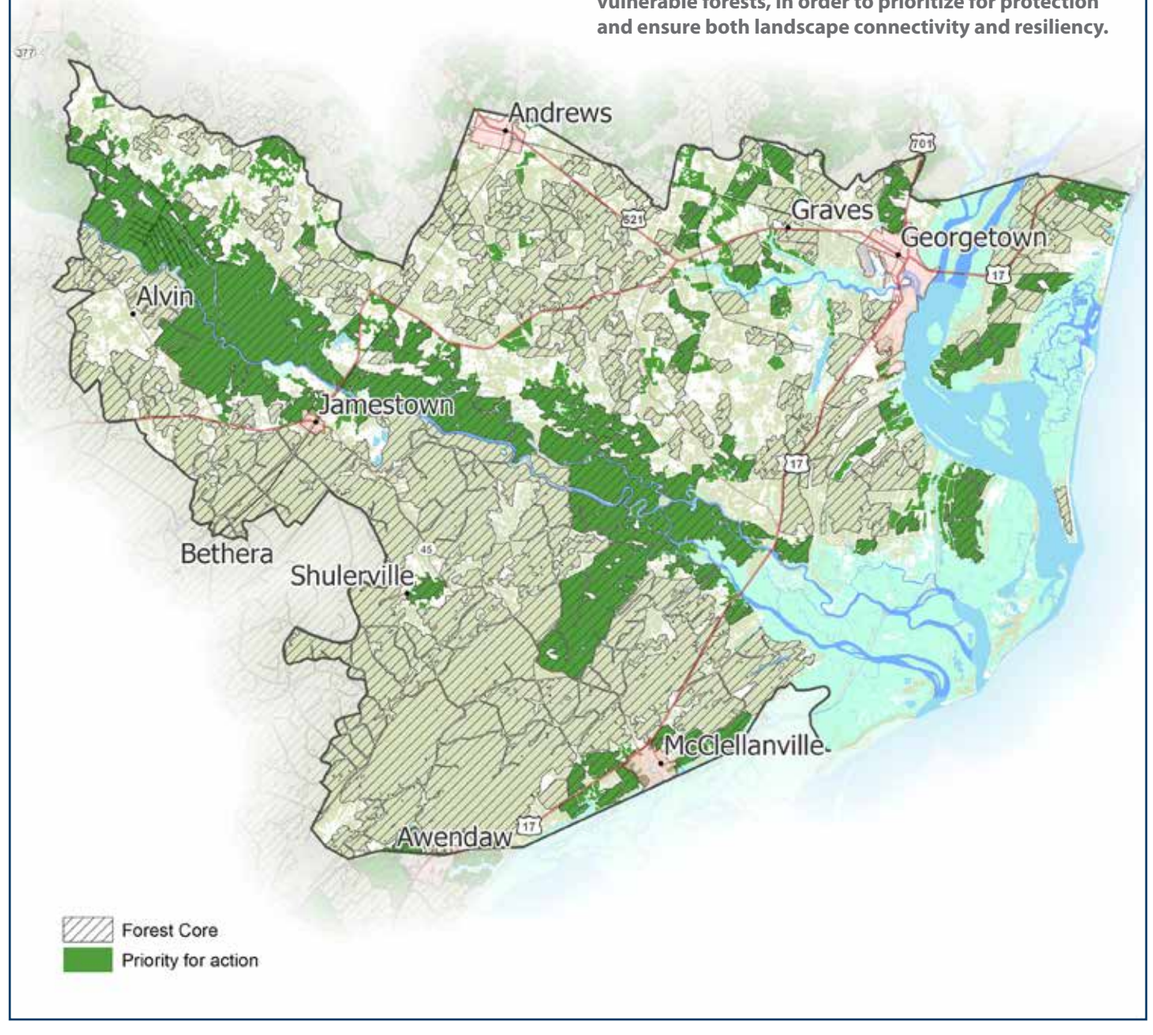
Highest Ranked Coastal Forests at Risk of Development

Using the risk and forest rank data, stakeholders can identify high-value forest assets that are vulnerable and develop strategic actions to protect them, such as zoning overlays.



Highest Valued Coastal Forests with the Highest Risk of Multiple Threats

Using risk and forest rank data, stakeholders can identify both the most valuable and the most vulnerable forests, in order to prioritize for protection and ensure both landscape connectivity and resiliency.



Local Stakeholder Strategies

As the project spanned several years, study communities were able to begin and, in some cases, to complete the recommended strategies developed during local workshops and in consultation with GIC. Other recommended strategies are beginning or on-going.

Berkeley County

Strategy 1: Rezone and swap properties to protect interior forest habitat.

During the project, Berkeley County received a rezoning request to swap forestland on the margins of the national forest for two parcels deeper into Francis Marion National Forest. This swap would increase the interior integrity of the national forest and mitigate land-use conflicts deeper in the interior forest.

Strategy 2: Incorporate conservation planning, Firewise and fire planning into the Comprehensive Plan.

The Public Works Director is interested in conducting a tree risk assessment in priority zones of the county to aid in faster response times post-disaster.

Strategy 3: Work with community groups interested in a greenbelt fund for the county.

The Coastal Conservation League and other regional conservation organizations are pushing county leadership to adopt a greenbelt funding mechanism similar to the one Charleston County established to purchase lands for open space and protection.

Berkeley-Charleston-Dorchester Council of Government (BCDCOG)

Strategy 1: Support rural communities' comprehensive planning efforts.

The BCD Council of Governments provides technical planning support to the counties and rural towns within their service region. This allows less-resourced and smaller communities to create better plans for their communities.

Strategy 2: Serve as convener for a regional green infrastructure and statewide plan.

The BCD COG is partnering with GIC and the South Carolina Forestry Commission to work with regional stakeholders to develop a regional green infrastructure plan that will be stitched together with other regional plans to create a statewide plan. The COG is providing data, reviewing maps and creating strategies in coordination with local stakeholders to inform the regional plan.

Charleston County

Strategy 1: Work with county resiliency committee.

The county established a Resiliency Committee to develop strategies and priorities to mitigate environmental hazards. Through funding from the South Carolina Forestry Commission (SCFC), GIC mapped high-resolution land cover (1-meter) for the entire county. These data allow the county to identify areas vulnerable to extreme heat, stormwater and flooding impacts and to inform the committee's strategies. During a workshop with the committee, several members voiced their position that preserving coastal forests was a priority.

Strategy 2: Strategically acquire more land through the county's Greenbelt Program.

In 2016, voters renewed the popular Greenbelt Program, which generates revenue from a $0.005 sales tax to purchase open space and conservation lands. This fund has protected over 23,000 acres of land, with 10,900 acres now used for public parks and greenspaces. The county continues to identify regional properties of interest and can use both the data produced from this project and the regional green infrastructure plan to support those efforts.

Strategy 3: Implement the Community Wildfire Protection Plan (CWPP).

The county created a Community Wildfire Protection Plan (CWPP) with the South Carolina Forestry Commission's Firewise program staff. The plan assesses and mitigates the risk of wildfire to communities and residents within the WUI. Mitigations range from appropriate landscaping, to hazard fuel reductions, to outreach and education.

Strategy 4: Reverse 911 or better outreach in rural forested areas about prescribed fires.

The county could benefit from a reverse 911 program that warns residents near the site of a prescribed burn to anticipate smoke in their area. Residents often complain about smoke impacts from prescribed burns. Each community needs to be educated or informed through signage about prescribed fires occurring in forest lands close to them, that they are going to have smoke and that these prescribed fires will reduce the long-term potential for larger, more dangerous fires, and thereby safeguard their homes.

City of Georgetown

Strategy 1: Provide trees to citizens to expand canopy on priivate lands.

During the project, using plantable areas data provided by GIC, the City of Georgetown secured a grant from the Arbor Day Foundation. The city in partnership with International Paper gave away 700 trees to residents, focusing on flood-resistant and salt-tolerant trees that will also make good residential yard trees. GIC staff provided a list of species to the city to fit those criteria.

Strategy 2: Provide better growing space standards for trees in the historic district.

The historic waterfront is well treed and provides a draw for tourists and shoppers, so tree canopy retention is important for the area's scenic qualities. However, the city is having issues with tree roots obstructing stormwater pipes and plans to establish better guidance and standards for tree wells in the historic district, particularly along Front Street.

Strategy 3: Create a street tree ordinance.

The city currently regulates the removal and replacement of trees on private property but lacks a street tree ordinance. Updating the tree ordinance to include street trees can provide better guidance to the public on the types of species and sizes of trees preferred for the rights-of-way.

Strategy 4: Plant more trees in the entrance corridors to the city.

Staff have identified medians at city entrance corridors where more trees can be planted for beautification.

Tree pits need to be sized correctly for large canopy trees. A good rule of thumb is at least 1000 cubic feet of soil so that trees do not become rootbound.

Georgetown County

Strategy 1: Amended the tree ordinance to preserve more canopy on-site after development.

During the project, the county amended its tree ordinance in fall of 2021 to preserve more tree canopy after development. This included decreasing the size requirement for grand trees from a 30-inches diameter at breast height (dbh) to a 24-inches dbh. Site plans that request removal of grand trees within commercial or multi-family developments must obtain prior approval from the Tree Board. The ordinance also required at least 10 trees per acre, or a total of 100 inches dbh to meet the canopy requirements.

Strategy 2: Increase the width of buffer yards around parking lots.

The county increased buffer yard widths from 5 feet to 15 feet around parking lots. The goal is to increase overall canopy on site through increased buffer yard widths. To date, not enough new development projects have been constructed under these recent regulations to determine their effectiveness on tree survival rates.

Strategy 3: Increase the buffer widths around salt and freshwater wetlands.

The current regulations for buffers are a 15-feet setback from the critical highwater mark around saltwater wetlands. The county would like to expand this standard to include freshwater wetlands and increase buffer widths to 50 feet around residential and 100 feet around commercial developments. These increased widths, if forested, will better protect wetlands from nonpoint source pollution and provide additional protection and resiliency against storms.

Strategy 4: Secure grant funding to write a resiliency focus for their comprehensive plan.

The county secured funding from the South Carolina Office of Resiliency to write a new resiliency clause that is now required in localities' Comprehensive Plans. County staff hope to see more conservation in the Comprehensive Plan as a result of this new requirement.

Town of McClellanville

Strategy 1: Replace over-mature pecan trees with other storm-resistant species.

The town has very old and mature pecan trees that are dangerous in storms because of their brittle wood. Pecan trees have a cultural value in the community, so transitioning to storm-resistant trees may be challenging. As the town adds more trees, they are primarily planting live oaks.

Strategy 2: Educate residents and landowners about the harm from invasive species and non-native plants.

The town's tree committee identified the problem of wisteria and other invasive vines that are overpowering and smothering the community's trees. The town is continuing to work on the removal of these invasive vines and planning for more public education and outreach to residents and businesses about how harmful invasive species are to the urban forest.

Strategy 3: Acquire several parcels to create a new open space park called the Village Green.

The town used Charleston County Greenbelt funds to purchase two parcels totaling 4.67 acres to protect wetlands and upland hardwood habitat. The sites will be connected through a boardwalk and provide walking, hiking and biking opportunities and will connect to existing pedestrian infrastructure.

Acquiring greenspace for the community provides, not only a higher quality of life, but also protects a community's natural heritage. The Deerhead Oak is an ancient oak tree revered by the community.

Williamsburg County and The Nature Conservancy

Strategy 1: Developed prescribed fire cooperatives for forest landowners.

The Nature Conservancy has developed prescribed fire cooperatives with forest landowners in Williamsburg County. The goal is to bundle enough small, forested properties together to make it more efficient and affordable for them to burn larger, more contiguous tracts and capitalize on ideal weather-appropriate burning days.

The Nature Conservancy

Well-treed historic districts, such as downtown Georgetown, SC, inspire tourists and shoppers to visit and spend money.

CASE STUDY: Francis Marion National Forest

Background

Francis Marion National Forest is named after the American Revolutionary War Commander Francis Marion, who used the wooded swamps as a staging ground to disrupt British supply chains during the war. The forestland spans nearly 295,000 acres and is comprised of pine stands, wildlife-rich bald cypress swamps and is home to the endangered red-cockaded woodpecker (*Leuconotopicus borealis*), a habitat specialist bird that requires large tracts of old growth forest (particularly longleaf pine forest) that periodically burns and clears out understory forest vegetation and woody debris. For a large national forest in the Southeastern U.S., it is surprisingly intact, with few non-native and invasive species issues since there was no recent farming or land disturbance before becoming a national forest.

In 1989, Hurricane Hugo, a category-4 storm, hit the South Carolina coast, causing significant blowdowns, flooding and damage to coastal forests. Nearly one-third of forest cover in the Francis Marion National Forest was leveled, with much of the vegetative debris left unsalvageable. The resulting tree and shrub regeneration, along with huge volumes of downed woody debris created a high-risk of catastrophic wildfire. The Forest Service spent considerable effort and many years mechanically mulching and reducing these fuels and using the resulting biomass as a local power source (USFS website).

The forest is located in between two major metropolitan areas, the Charleston Metropolitan Area, lying approximately 40 miles to the south, and the Myrtle Beach Metropolitan area located approximately 30 miles to the north. The forest's popularity and relatively cheap land prices have resulted in increased population migration to the region and new development growth, particularly in the WUI, where residential development abuts wilderness. The increased proximity of development to the forest creates challenges for managers, especially related to prescribed burning. The national forest is broken up into two management areas, one where burning is designated or allowed and another where they cannot burn because of the risk to nearby developments.

A revised final forest management plan was signed in 2017 with monitoring every five years on the progress of the plan. A monitoring report for 2022 was created for release later in the year. To access a PDF copy of the management plan, see: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd530182.pdf

Challenges

Climate Change and Logging

In the early to mid-2000s, forest harvest was easier because the region was in a drought and conditions were drier. However, currently, wetter seasons are slowing tree thinning and harvest. Forest managers are having difficulty finding weather windows for harvesting, when soils are dry enough to allow in heavy equipment to harvest the fallen trees. Forest managers have also witnessed signs of declining tree health where trees are deprived of soil oxygen at sites that have been repeatedly over-saturated. These conditions have also disrupted commercial timber harvests and sales. Some tracts that have been sold have not yet been harvested because of these on-going saturated conditions.

Wildfire

The burn season is Feb 1st through the end of May, with April through May allocated for prescribed burns in the growing season. However, forest managers have noticed that it is becoming much harder to conduct prescribed burns in the national forest during the growing season. For example, in 2021 they burned well over 30,000 acres. However, fires have been curtailed because the public has become concerned about the potential impact on wildlife such as the bobwhite quail.

As mentioned already, the national forest is broken up into two management areas (Management Area 1 and Area 2). Forest managers can burn in Management Area 1, where most of the longleaf pine habitat conversion is located. In Management Area 2, they have fallen behind in establishing longleaf pine habitat.

Management area 2 contains more WUI areas and smaller tracts that make it harder logistically to conduct prescribed fires. For example, between Highway 17

Longleaf pine forests need frequent low-severity fire to clear out competing vegetation and reduce hazardous fuels.

and the coast there are no large, contiguous blocks of forest to burn, which makes it hard to manage in desired 3-4-year burn cycles. This lack of burnable land is preventing staff from converting loblolly to longleaf sites because longleaf pine needs frequent fire to maintain it. Therefore, longleaf pine transition is not underway in these areas and instead they are emphasizing timber management and both regeneration and younger forest age classes.

The Covid-19 pandemic also led to a reduction in the number of acres burned annually because of an inability to share vehicles, lack of the resources needed for contact tracing and the increased danger of respiratory exposure to smoke. Additionally, the fire season in the Western U.S. is diverting such resources as detailers and aviation support from East Coast fire management. Furthermore, Forest Service Staff are uncertain whether they can meet the prescribed burn quota because of additional complicating factors, such as climate change, development and strained federal resources.

Invasive species

While invasive species are not a major challenge for the forest, they are still present and pose risks to its health. Japanese climbing fern (*Lygodium japonicum*), which can colonize a variety of habitats from floodplain forests and wetlands to pinewood flats, spreads via spores easily transported by the wind. It can climb trees and act as a "ladder fuel," carrying fire from the forest floor to the upper canopy. Another species, cogon grass (*Imperata cylindrica*), is a perennial that invades the forest understory and displaces native species. It can increase the severity of forest fires because it is highly flammable and burns at a higher temperature, increasing the risk of wildfires spreading into the canopy and exacerbating damage to the trees. To date, it has been found only in a few spots and staff have been able to contain it. In general, the forest managers do not apply a lot of herbicides or pesticides because frequent rainfall in the coastal area tends to wash it away too quickly to have the desired effect. Instead, staff have been using herbicides and pesticides primarily for integrated pest management (IPM), though they have recently used it to establish a plantation forest.

Photo by Steve Hillebrand, USFWS, on Pixnio.

Cogon grass can form thick, dry fuels that increase the risk of wildfire damage of forests.

CASE STUDY: Francis Marion National Forest *(continued)*

Storms

Hurricanes have always been a part of the forest's environment. In 1989, about 80% of the red cockaded woodpecker population was killed or displaced by Hurricane Hugo. The storm leveled nearly one-third of the forest and resulted in both an increase in wildfires and southern pine beetle damage. It also created a single-age class of the forest since regeneration of new tree cover has happened all at once. Over the last 30 years, this single-age class has matured, so that, today, there is a lack of young forest or early successional forest habitat. Forest managers hope to increase age-class diversity within the forest to make it more resilient to disturbance. If another powerful storm were to hit in the near future, the lack of age diversity within the forest will make it less well positioned to recover quickly.

> **In 1989, about 80% of the red cockaded woodpecker population was killed or displaced by Hurricane Hugo.**

Development

Over recent decades, many new housing developments have sprung up near the forest's border. For example, the Cainhoy Neighborhood of the City of Charleston has approved a 9,000-acre tract of forest for new development. This development could result in up to 50,000 additional people living in the WUI. Another large forest tract near the forest, known as Keystone, is also slated for development, with the possibility of another 5,000 houses built.

The greater the surrounding urban density, the harder it is for the national forest to be managed with prescribed fire. Newer residents tend to not be familiar with or understand prescribed burns and the need for fire as part of a healthy forest ecosystem. Instead, residents may resent smoke and view it as a nuisance and a public health hazard, and also worry about the fire spreading outside of the forest and damaging private property. Furthermore, these days, far more cars are passing along Highway 17, which goes through the forest, the danger of smoke impacts to road visibility can completely restrict doing a burn altogether.

Photo by Lance Cpl. Matthew K. Hacker

The red cockaded woodpecker prefers longleaf pine forests with an open understory, making this type of habitat important for its survival.

As the boundary around the national forest continues to see increased urban development, necessary management practices, such as prescribed burns become much harder to do safely.

Strategies

The primary objective of the current forest management plan is to manage for longleaf pine ecosystems through maintenance or restoration. Forest managers are thinning and burning areas of the forest to create and maintain longleaf pine habitat to achieve additional objectives, including providing adequate woodpecker and salamander habitat. Other strategies include identification and protection of bottomland hardwood forests from wildfire and using mechanical means to convert forests from loblolly pine to native hardwood forest.

The national forest is trying to extend the burn season further into the summer (June and July) to achieve its objectives, but the weather remains a limiting factor. The SCFC manages the air quality permits for prescribed burns and it has category ratings for smoke dispersion. During lower category ratings, the national forest won't burn, but with higher category ratings the smoke rises higher into the atmosphere. These higher categorical burn days are less frequent in the summer, which can limit the ability to conduct large acreage burns later in the season.

There are a few upsides to more nearby developments in the Charleston area. The Francis Marion National Forest is receiving additional properties from required mitigation through an agreement with the Army Corps of Engineers. When an entity, such as Boeing or the Port Authority, need to mitigate impacts, the Corps reaches out through their partnership to identify properties suitable for mitigation. Over the last four years, the forest has acquired 4,000 acres of new holdings, mostly through the mitigation. One example is the Fairlawn Plantation, a large property located at the headwaters of the Wanda River, which could be acquired in phases over the next ten years.

To increase the resiliency of the forest to a catastrophic storm, forest managers are establishing younger age-classes of trees to achieve a greater diversity within the forest by using commercial thinning to removing selected trees. Having a diverse range in forest ages helps significantly with forest recovery following a damaging storm. For example, if part of a mature forest is lost to a storm or fire, wildlife can access nearby forest habitat of similar type and structure, and it can take less time for mature forest habitat to be replaced as younger trees of varying ages and species grow up to replace them.

Currently, the national forest does not have specific strategies for addressing the impact of sea-level rise. However, the adjacent Cape Romain National Wildlife Refuge wants to acquire more upland just west of Highway 17, since most of the refuge's marshland will be impacted by rising seas.

Although the Frances Marion National Forest has many management challenges, staff are doing their best to help the forest recover from past disturbances and to make it more resilient to future challenges and impacts.

CASE STUDY: Hobcaw Barony Research Forest

The former plantation site is now a private reserve that provides opportunities to study coastal resources.

Enslaved people-built cabins, a church and a community at Hobcaw Barony. These historical sites are at-risk from storms.

Background

The Belle W. Baruch Foundation is a non-profit organization and owner of Hobcaw Barony, a former plantation that is now a private reserve comprising 16,000-acres dedicated to research and education. The property includes over 70 cultural sites, such as cemeteries, former slave cabins and historic homes. Established in 1964 as a trust upon the death of Belle Wilcox Baruch, its primary mission is to conserve the unique natural and cultural resources of the South Carolina coast. The University of South Carolina created the Belle W. Baruch Institute for Marine & Coastal Sciences, Clemson hosts the Baruch Institute of Coastal Ecology and Forest Science, and Coastal Carolina and Francis Marion National Forest jointly created the Belle Baruch Institute for South Carolina Studies. Today, Hobcaw Barony hosts researchers from 50 colleges, universities and research organizations from around the world. More information on the research performed on Hobcaw Barony can be found at: www.hobcawbarony.org/research

The Hobcaw Barony site and interpretive center provide education about coastal ecology for nearby schools and the 25,000 annual visitors who visit the site. As the area attracts many residents who are new to the coastal landscape, the site provides an invaluable resource for education about how the landscape functions and how to manage it. Seniors also volunteer and gain knowledge, along with a chance to interact with their neighbors and other avian, terrestrial and aquatic residents of the site. Programs such as their summer camps and "wood magic" field days are also inspiring the next generation of landscape managers and ecologists.

Many species such as this great egret rely on quality coastal forests and marshes for habitat.

The palamedes swallowtail butterfly depends on redbay trees as its host tree and the tree's decline will likely affect the abundance of this native butterfly.

Challenges

A key challenge for South Carolina's coastal forests found at Hobcaw Barony is the continued decline of the redbay tree and its cascading effect on other creatures. Redbay is being killed by laurel wilt. A highly visible victim of this disease is the palamedes swallowtail (also called the laurel swallowtail) since redbay is the butterfly's preferred tree on which to lay its eggs. These brown swallowtails with yellow-streaked wings are usually abundant in redbay forests. So, as this understory tree wilts and dies, it also affects the butterfly that depends upon it.

As a coastal landscape, the Hobcaw Barony reserve is also threatened by coastal storm impacts. Hurricane Hugo made landfall as a category-4 storm with maximum winds of 135-140 mph and a minimum central pressure of 934 millibars (27.58 inches of Hg). Studies conducted to measure salt in the forest soils showed that concentrations still remained high more than a decade later.[1] The storm created less damage to the marsh area than anticipated, even though it hit at high tide. However, the forests suffered greatly, with the most severe damage occurring in the mixed bottomland hardwood sites on Rutledge soils (sandy, silicious thermic Typic Humaquepts), as well as those forests along the salt marsh boundaries that bore the brunt of wind and wave action. Using basal area as a measure of loss, researchers found that "43% of pond pine, 35% of water oak, 17% of loblolly pine, 11 % of longleaf pine and 3% of live oak were heavily damaged" (Gardner et al, 1992). The salinization of the soils also mobilized ammonium from soil storage, as a result of ion exchange with seawater cations and disrupted the nitrogen cycling processes which are essential to forest health. Plant production and biomass (living material) of these coastal trees are limited by the lack of nitrogen, which they need to make proteins, DNA, RNA and chlorophyll, in order to carry out photosynthesis to feed the tree, so disruptions to this cycle can interrupt tree growth and function. For the first six months following the storm, while flying insects and birds returned relatively quickly, reptiles and amphibians remained significantly lower.

Researchers and ecologists have studied the long-term impacts of saltwater spray and storm damage from Hurricane Hugo since 1989.

Although we know that the rate of sea-level rise is accelerating, seas have been rising for decades. A study looking at aerial images of the marsh over the past 60 years showed that, "There has been a clear progression of marsh into the forested wetland in the Strawberry Swamp watershed during the past 60 years. Throughout that period, there has been a steady rise of relative sea level along this portion of the SC Coast" (Williams et al, 2012). Recent studies led by Dr. Till Hanebuth from the Coastal Geosystems Research Lab show that sea-level rise for Georgetown County is accelerating. Dr. Hanebuth's research shows that the water level at the Georgetown lighthouse at the entrance to Winyah Bay rose 21.6 inches since 1898 and at Hagley Landing on the Waccamaw River, the water level rose 15 inches since 1998 and he noted that the increase at Hagley is higher than the 3-inch global rise in the sea level. The increase at Winyah Bay is higher than the rise in Charleston harbor of 15.3 inches over the same period (Swenson 2022). Increased

[1] Personal field communications with Dr. Bo Song.

Photo courtesy of Hobcaw Barony

An aerial view of Hobcaw Barony

As salt water intrusion increases soil salinity levels, bald cypress and other sensitive trees will continue to decline.

sea level rise may be accelerated because the land may also be subsiding. Land elevations can decrease as a result of water withdrawals, starving coastal deltas of sediments as it is developed; or there can be a combination of both factors. The Foundation's director George Chastain noted that, "Over the last 20 years, there has been an amplitude of tide increase and we are seeing prior 4-foot tides now coming in at 6 feet. Tide gauges are documenting this dramatic increase."

While the Coastal Geosystems Research Lab continues to study the causes to help guide solutions to determine where and how the marsh should be allowed to progress, the landward migration of the marsh will continue, and likely accelerate, leading to more forest conversion to marshes at the Hobcaw Barony site. According to staff, 180 acres of the 8,000 acres of forest have converted to marsh since they have been observing the landscape and this will continue to occur.

According to Dr. William Conner, a Clemson forestry professor working in coastal environments for many decades and now with the Baruch Institute, at 2 parts of salt per thousand (ppt) in the soil, bald cypress trees begin to decline, while tree species that are more sensitive, such as gums, ashes and maples, begin to decline at 1 ppt. In the Strawberry Swamp watershed, salinity was introduced in the past by some large storm surge events and when researchers began studying the system in 2014, soil salinity levels were nearly 5 ppt. Dr. Conner has observed the slow mortality of trees as salt continues to rise up the water table, and noted that, "The longer salt remains in the landscape, whether from storms or salinity changes in surface and groundwater, the more likely it is that the trees will not recover." While large storms and high rainfall events since 2015 to 2022 have diluted salt levels to 2-3 ppt, that is still a high level and the slow mortality of trees continues to be observed.

And, of course, hurricanes will continue to occur and will remain part of a dynamic coastal environment. As of May 24, 2022, NOAA predicted the 2022 Atlantic hurricane season would be above normal, "making 2022 the seventh consecutive above-normal season," according to NOAA Administrator Dr. Rick Spinrad. NOAA predicted the year will see between 14 and 21 named storms and listed the causes of the greater storm activity as the ongoing La Niña conditions, a warmer than normal Atlantic sea surface temperature, weaker tropical Atlantic trade winds, and an enhanced African monsoon – all of which feed the strongest and longest hurricanes.

CASE STUDY: Hobcaw Barony Research Forest *(continued)*

Staff have increased the use of prescribed burns at the research reserve to control understory fuel loads, and also to restore a healthy, native understory.

Strategies

Hobcaw Barony is working to return its landscape to as natural a state as possible. Foundation and Institute staff operate in a variety of facilities including specialized labs to support research, meeting and classroom space, and maintenance and storage buildings. As part of this program, they have conducted prescribed burns to help restore longleaf pine stand habitat. These stands would burn naturally on their own, except that humans have suppressed fire for a long time. Burning of the understory allows for native plants to return while also reducing fire risks. Due to the difficulty of scheduling and proximity of neighbors and US 17, prescribed burns are augmented with mechanical understory removal and some herbicide treatments. The Foundation also logs some stands on a set rotation schedule.

Outreach, although slowed during the COVID pandemic, continues to be made within the surrounding communities through teaching by the Clemson Extension Service, as well as the many tours and lectures available at the site. Chastain lamented that, despite the Foundation's educational mission, it will still need to strike a balance between welcoming the public and protecting the sensitive ecology of the site. New ways to reach the public through messaging, news stories and creative field tours are continually being tried to reach the diversity of stakeholders living around the center. "We hope we are making a difference," Chastain said. He explained that management efforts, such as burning to restore longleaf pine habitat, is not always understood or accepted as a valid strategy by the public, so staff need to do more work on public relations around these issues, especially as development growth continues nearby as more people move into this dynamic and unfamiliar coastal landscape.

State Stakeholder Strategies

Following are the strategies identified by state agencies who participated in the Resilient Coastal Forests Project. In addition, where necessary, GIC has identified strategies for the agency to consider. Those additional strategies are only GIC's recommendations and may or may not be endorsed by the agency.

Clemson University

Strategy 1: Bradford pear bounty.

The Clemson Extension's Bradford Pear Bounty Program, a collaboration between Clemson Cooperative Extension, South Carolina Forestry Commission and local sponsors, offers homeowners in South Carolina a free native tree in exchange for the removal of a Bradford pear from their property. Bradford pear trees have been widely planted in the state for years, but they often break in storms and contribute to the spread of this invasive Callery pear. To date, there have been seven events, with each event averaging 250-400 trees removed and replaced. Event organizers find homeowners want to remove their Bradford pears but are unsure of what to plant in their place, so this program offers them appropriate planting options and planting advice, as well as a motivation to remove their pear trees.

Bradford pears are an invasive tree species that can spread beyond urban plantings into native forests. They have very weak wood, which makes them susceptible to breakage during storms, causing them to become dangerous.

To set up a similar program, David Coyle, head of the Clemson Extension's Bradford Pear Bounty Program offers the following tips:

- Establish a partnership between government, university, private and local officials/organizations and determine who will be responsible for which aspects of the program.
- Determine where to purchase and obtain appropriate replacement trees.
- Ensure a thorough advertising strategy to get the word out with print/electronic/tv/radio media.
- Utilize a program website to advertise and track registrations.
- Ensure there are extra volunteers for the day of the event to help with logistics, such as staffing the registration table, helping people determine which tree species to adopt and helping put trees into vehicles.
- Plan for an efficient event with clear processes since most people don't want to stay a long time.
- Follow up with surveys to determine the impact of the program (was the replacement planted, how did it work for the site).

Strategy 2: Certified Solar Habitat Program

Led by Clemson Extension in partnership with the SC Department of Natural Resources, the Department of Fertilizer Regulation and Certification Services (FRCS) and Audubon South Carolina, the solar certification program provides a framework to plant and maintain pollinator habitats at solar farms. The program offers yearly training for environmental consultants, utilities, solar developers and landowners in how to establish and manage pollinator habitats. A site representative must attend the training to receive certification. Solar developers must submit site preparations and plans for review to the FRCS, which will also inspect the sites after two growing seasons to evaluate if criteria standards have been met. Link: https://www.clemson.edu/public/regulatory/fert-seed/solar/index.html

South Carolina Forestry Commission (SCFC)

Strategy 1: Greater diversification of the forest.

This means not only increasing the species composition and type of forest habitat, but also how forest landowners can diversify their management goals and forest resources. The SCFC provides free consultation services for landowners with forestland between 10-1,000 acres, including helping them develop a forest management plan based on their goals and objectives.

Strategy 2: Develop a statewide green infrastructure plan.

The SCFC funded GIC to partner with the ten Councils of Government (COG), regional bodies that support community and transportation planning efforts across the state, to develop regional green infrastructure plans that will be stitched together across the COGs to form a statewide habitat network. Each region has a stakeholder group that helps prioritize and develop strategies to maintain connectivity and conserve habitat. When completed, the plan will help regions and agencies further increase landscape resiliency in the state by planning for and maintaining a connected landscape. This project was launched in the fall of 2021 and mapping and prioritizing the landscape network is underway, as of the time of writing.

Strategy 3: Continue to train staff in tree risk assessment qualifications in order to assist communities with post-storm recovery.

South Carolina currently does not have an Urban Forest Strike Team (UFST), a specially trained group of foresters who assist communities, in the aftermath of a major storm or disaster, identify which trees are hazardous and need to be proactively pruned or removed on public properties and rights-of-way. However, the state can request a team from another state to assist in an emergency.

Currently, there are not many certified arborists serving in state government positions. To better prepare the state for storm preparation, response and recovery, the SCFC is training more state staff to become certified and achieve tree risk-assessment qualification (TRAQ) training. Indeed, the state forest health specialists were going through this training at the time of writing. Many municipalities recognize the value of the training and are sending staff to acquire these qualifications. However, this effort is in its very early stages, since it takes time to adequately train staff in these highly specialized disciplines. The state's goal is to have in-house resources to deploy to communities in need following storms. In the past, post-disaster communities have been hesitant to request UFSTs from other states, with the thought that bringing in people who are unfamiliar with the area could cause more confusion during disaster response and recovery.

The SCFC is partnering with landowners to maximize forest resources on the Coastal Plain.

Strategy 4: Develop Community Wildfire Protection Plans with communities within the wildland-urban interface (WUI).

Community Wildfire Protection Plans (CWPP) bring cooperative groups together, such as county and local officials, to develop land with Firewise principles in mind. The goal is to get developers to think about wildfire risk in their design layout prior to beginning construction, in order to mitigate potential risks. The Forestry Commission can also support communities in the development of a Community Wildfire Protection Plan (CWPP). The goal of these plans is to educate the public about wildfire risk, focus on collaborative decision-making and implement wildfire mitigation strategies in wildland-urban interface communities. Charleston County is an example community from the study area that has developed a CWPP.

Strategy 5: Map the extent of "ghost forests" throughout the state.

The SCFC's Forest Health Division is collaborating with other Southeastern coastal states on a project to map the extent of ghost forests. Currently, not enough is known about the acreage of these ghost forests or of forestland that could potentially become ghost forests as sea level rises and both flooding and storms continue to impact coastal forests. Drones could be used to accelerate this mapping. This RCF report has highlighted the importance of conducting such work.

The Wildland Urban Interface (WUI)

The wildland urban interface (WUI) is the zone between wildlands and urban areas. As people move into and develop these areas, risk from fire or wildlife and human conflicts increase. As the Southeast becomes hotter, fires also become more likely as climate change warms the planet. As noted in the introduction to this report, NOAA predicts that the risk for very large fires in the Southeastern U.S. will increase by 300% by mid-century (2041-2070). Fire safety is a concern when developing within wooded landscapes. As development encroaches into rural areas, wildfire threats become more of an issue, given the intersection of climate change, encroachment by highly flammable invasive grasses (phragmites and cogon grass) and the lack of fire stations in remote rural areas. These factors require us to provide more standards and education for developers and more guidance for homeowners on how to reduce risks to life and property. Therefore, it is important for communities within these zones to establish standards for building and landscape designs to fortify and create defensible areas around housing that is located in the WUI.

NOAA predicts that the risk for very large fires in the Southeastern U.S. will increase by 300% by mid-century.

Landscaping and building standards should follow the National Firewise Program standards (See: https://www.scfc.gov/protection/fire-prevention/wildland-urban-interface/). These provisions should be recommended for subdivisions, cluster housing and conservation developments in rural zones.

Photo courtesy of GFC.

Prescribed burn. Good fires prevent bad ones.

GIC Recommendations

(in addition to those identified by the agency).

■ **Develop a messaging and marketing campaign to promote the Firewise program across the state.**
According to the South Carolina Forestry Commission, almost 642 communities in the state have been assessed as having a High to Extreme Risk rating for wildfire. To date, 213 communities have completed a Community Wildfire Protection Plan (CWPP), but many communities remain unfamiliar or do not know about the program, although they could benefit from it. In addition, the public and many housing and subdivision developers are not familiar with Firewise design principles. These individuals are responsible for the majority of private land development decisions. By messaging and marketing the program more widely and broadly, more communities and developers are likely to adopt these principles and practices in developments. Utilize the risk maps from this report to address silvicultural sites that may be lost.

■ **Use the data from this Resilient Coastal Forests project to evaluate forests at risk, especially those subject to multiple threats.**
Consider which forests would benefit from additional actions, such as: working with land trusts to place a voluntary conservation easement; conducting more targeted landowner outreach; and working more closely with local governments to identify areas that are at risk, so that localities can initiate appropriate zoning changes or use such tools as the purchase of development rights. Consider conducting this type of study for all of the coastal forests in South Carolina.

■ **Help localities recognize and plan for healthy forests in long range and master plans.**
Provide model language for urban and rural forests that can be included in local Comprehensive Plans and promote use of the Comprehensive Planning Guide GIC produced for SCFC. Utilize the Planner's Forest Toolkit created for South Carolina to help localities find and implement the most effective codes and policies for forests and urban trees. See the South Carolina Forestry Commission's website for these guides.

NFPA FIREWISE USA® RESIDENTS REDUCING WILDFIRE RISKS

■ **Update advice to landowners for higher risk coastal forests.**
Provide coastal foresters with risk maps where silviculture is no longer viable because of sea-level rise, so as to avoid investing in sites where trees will be lost before harvest. Provide suggestions for how to effectively communicate this to landowners now, so as to avoid wasted time and money planting trees that will not be viable for harvest later. Include forest and trees in the emergency management planning process.

■ **Collaborate with the South Carolina Office of Resiliency on forest management.**
The newly created South Carolina Office of Resiliency (SCOR) can be an integral partner for the Forestry Commission since forest protection and management is a key component of any resiliency strategy. The SCOR was tasked in its first year to focus on flooding issues across the state but, moving forward, they are interested in addressing other hazards, such as heat, storms and climate. The SCFC's efforts to build relationships and work in urban communities on green infrastructure issues makes them a valuable partner in community-based planning.

South Carolina Department of Natural Resources (DNR)

Strategy 1: Utilize and promote guidance on designing solar sites for pollinator habitat.

In 2018, South Carolina passed the South Carolina Solar Habitat Act. This legislation allows the SC DNR to establish a framework for a voluntary solar habitat certification program and guidance for assisting solar developers in establishing pollinator-friendly habitat. The agency developed a guide for pollinator-friendly solar site design that can be found at: https://www.dnr.sc.gov/solar/assets/pdf/solarHabitatGuide.pdf

Strategy 2: Establish corridors and redundancy of habitats.

The DNR is establishing a system of redundant habitat types within their portfolio of lands to increase resiliency. Resiliency, redundancy and representation (RRR) is the strategy. For example, in a scenario where one site's habitat is wiped out due to a storm or wildfire, another area can repopulate or provide refugia for wildlife. This system also benefits by being well-connected through a network of corridors. The state wildlife action plan and the forest action plan both cite the need for a connected landscape. The SC DNR helps localities with Comprehensive Plans and works with them on establishing wildlife corridors. The agency is participating as a stakeholder and advisor in the South Carolina Statewide Green Infrastructure Map and Plan project.

Strategy 3: Plan for land acquisitions that account for future sea-level rise.

The agency currently writes acquisitions for properties in the coastal zone and examine whether the site has potential for marsh migration. There are also places on coastal river systems where there could be future marshes. Sea-level rise could also impact the extent of the salt wedge upstream, which may affect tree species composition, however certain individual cypress trees are more tolerant of salt. State agencies are in discussion on, "How far ahead do we plan?" (for example, 30 or 50 years). These agencies are bringing in people to workshop and discuss this topic.

Strategy 4: Update the state's prohibitive species list.

The DNR is working with the SC Exotic Pest Plant Council to get their list of invasive species up-to-date. Once that list is updated, the agency and other partners will make recommendations for regulated plants. There is a constant challenge of addressing known pests and the popularity of some species in the horticultural industry— for example Autumn fern. However, some species will be more easily added to the list, since there is wide agreement on their potential for harm.

Plant tags can help consumers more easily identify which native plants to buy.

GIC Recommendations *(in addition to those identified by the agency)*

■ **Collaborate with agencies and municipalities on utility-scale solar development issues.**

The South Carolina DNR is at the forefront of examining the land use challenges that a transition to clean energy production could have for the landscape. Its work to establish design guides for more eco-friendly solar utility sites is a prime example. However, there is a greater need for collaboration between the SCFC and municipalities to develop policies or ordinances with municipalities, in order to prevent forest conversion to utility-scale solar. Currently, solar developers are preferring shrub-scrub and scraggy pine habitats, which are also valuable habitats for rare, threatened and endangered species, such as the gopher tortoise, so forest loss is not the only concern – wildlife, birds and amphibians are also at risk. Other issues include inadequate regulation of stormwater on site; for example, panels are not considered impervious surfaces when managing surface flow. Virginia has recently required such standards for localities and South Carolina should follow its example.

Local governments have requested better guidance on solar panel farms, especially related to better stormwater management design and site mitigation. Current solar development standards across all three states studied by GIC lack sufficient guidance or enhanced regulations of stormwater runoff from large-scale solar panel installations. Virginia is in the process of developing stormwater standards for such panels and has issued the following guidance:

> *Solar panels are to be considered unconnected impervious areas when performing post-development water quantity calculations using the hydrologic methods specified in the Virginia Stormwater Management Program Regulation.* [6]

Collaborating with state agencies and municipalities to get ahead of solar development pressure will help conserve the most important habitats and connectivity on the landscape.

■ **Collaborate with state institutions, NGOs and retail nurseries to develop a statewide campaign to promote the sale and use of native plants.**

The SC DNR already works closely with many state and regional partners to promote greater species habitat (see the Solar Certified Habitat Program above under Clemson University). The SC Audubon Society has promoted the adoption of native plants statewide by listing native plant nurseries and creating planter tags to promote their use and help consumers easily identify native plants at participating nurseries. The state could bring in other state and regional partners, such as Clemson University Extension and the Native Plant Society to broaden the campaign's reach through wider promotion and coordination. Link: https://sc.audubon.org/conservation/native-nurseries

■ **Collaborate with agencies and other partners on updating the noxious weed list more frequently and include pest species from further south**.

The local stakeholders in the RCF project expressed a need to more easily and frequently update the regulated pest species list for the state. As more species are being introduced in the landscape due to increased disturbances and interstate commerce, along with expanded ranges of more southerly species migrating further north, it will be important in the future to adapt the list to these new threats. By making it easier to get species on these lists sooner, it can empower localities to adopt landscape codes and ordinances prohibiting them in reviewed plans.

■ **Redefine eligibility criteria for land acquisition of wetlands and uplands to account for sea-level rise impacts.**

Right now, under current state rules, state agencies cannot acquire uplands for future mitigation and adaption to sea-level rise or flooding since funding sources require a percentage of existing wetlands be covered by the purchase. As sea-level rise and increased flooding due to climate change alter the hydrology of sites, particularly along the coast, it limits the ability of agencies to acquire future sites suitable for wetland restoration and coastal marsh migration. A concurrent regional, multi-state planning initiative called the South Atlantic Salt Marsh Initiative (SASMI) also identified this policy as a limiting factor. The current policy also fails to account for the expansion of suitable sites for coastal forest migration and restoration.

South Carolina Parks, Recreation and Tourism (SC PRT)

DISCOVER

Strategy 1: Update existing and create new forest management plans for state parks.

The State Parks division recently hired a full-time forester to update old forest management plans and create new ones for specific park properties. These management plans will inform maintenance activities, such as thinning overcrowded timber, eradicating invasive species and prescribed burns. Through active management, the agency can promote healthier forests and reduce risk.

Strategy 2: Continue to educate the public about forest resources and management.

State parks have made a significant investment in educational programming, particularly in public interactions, with millions of visitors each year. Staff bring up forest management challenges and issues (storms, wildfire, invasive species, etc.) when they engage with the public. The agency is also expanding its reach by collaborating with other agencies to get information out to the public.

Strategy 3: Promote the "Don't Move Firewood!" Campaign.

South Carolina State Parks, the Forestry Commission and Clemson University all participate in the campaign to educate residents and visitors alike to not transport and burn firewood from other regions. Several wood-boring or wood-nesting pest species, such as the emerald ash borer, Asian longhorned beetle, gypsy moth and redbay ambrosia beetle are a cause for concern for state forests. The goal is to prevent the spread and introduction of these pests in the landscape. South Carolina State Parks bans the import of outside firewood in its campgrounds.

GIC Recommendations

■ **Increase the visibility of signage on locally sourced firewood.**
Parks should incorporate signage into their educational materials to ensure visitors understand the need to only use locally sourced firewood and be aware of signs that their firewood may be harboring pest species. In addition, this signage should be located where firewood is sold on-site and posted at all campgrounds to maximize visibility.

■ **Collaborate with adjacent landowners on management issues.**
For all public lands, collaborating with adjacent landowners on resource issues is critical for the success of public land management. State agencies are starting to coordinate with private property owners on their boundaries for management activities, such as prescribed burns and invasive species management. However, there is more that needs to be done, such as direct outreach to engage with municipalities and large landowners who border public lands.

This joint campaign informs visitors across South Carolina to discourage moving firewood that could be infected with pests.

South Carolina Office of Resiliency (SCOR)

Strategy 1: Develop a plan to address issues of flooding and sea-level rise statewide.

The newly created office was tasked with collaborating on resiliency planning and flood mitigation statewide. The office convened several committees with state agencies and stakeholders to discuss flood and sea-level rise issues and to create a resiliency plan to mitigate their impacts. The resiliency plan is anticipated for release in summer of 2022.

South Carolina Floodwater Commission

Strategy 1: Power Plant Initiative

The Floodwater Commission is a task force created by the Office of the Governor to study floodwater issues in the state and develop solutions to mitigate their impact. One result of this commission has been an initiative called Power Plant, a statewide effort to plant 10 million trees over the next 10 years through partnerships with "citizens, students, churches, non-profits, municipal governments, private sector partners and other civic-minded organizations and volunteers." More information about this statewide tree planting campaign can be found at: https://powerplantsc.com/

Many places exist on private property where it is possible to plant additional trees. Part of this project mapped planting spots for trees in urban coastal communities.

South Carolina Department of Transportation (SC DOT)

GIC Recommendations

■ **Stop clearing the right-of-way 100 feet of forest and trees.**
Local stakeholders brought attention to SCDOT's recent extension of its practice of clearing trees from rights-of-way (ROW) out to 100 feet. This was very concerning for the group because they felt the clearings were excessive and consequently attracting more deer to the roadside, thereby increasing the traffic hazard. The local stakeholders brainstormed strategies to mitigate the effects of a 100-foot clearance, such as planting pollinator habitat or softening the forest edge by planting a mix of shrub thickets to discourage deer from frequenting the roadside.

■ **Install wildlife tunnels and bridges and require their consideration in all projects.**
The recent bipartisan Federal Infrastructure Bill passed by Congress appropriated $350 million dollars for Wildlife Crossing Pilot Programs to all 50 states. These funds are a real opportunity to maintain connectivity for wildlife on the landscape. Utilizing the forest corridors data, wildlife bridges could mitigate some of the potential wildlife-motorist interactions from projects.

■ **For road planning, use South Carolina's forest cores data to prevent bisecting cores by rerouting (if possible) around important, high-value habitat.**
SCDOT can identify alternate routes and integrate green infrastructure and habitat core data into major infrastructure planning. The agency can identify opportunities to reroute around high-value habitat when they participate in the state stakeholder committee for the South Carolina Statewide Green Infrastructure Map and Plan.

■ **Acquire or restore existing habitat cores for mitigation projects.**
SCDOT has to conduct mitigation to offset the disturbance caused by new road construction. Conducting restoration plantings in high-value cores or acquiring cores and corridors identified as at risk could help it use its mitigation funds wisely. It can also replant corridors to make them more useable by wildlife or to serve as part of a future greenway network.

Next Steps

GIC completed the resilient forest strategic recommendations for all three states— Virginia, South Carolina and Georgia— in spring, 2022. An accompanying guide to planning for resilient forests describes how to replicate the process for any coastal forest region across coastal communities in the Southeast. Those interested in learning more, or working with GIC on the outcomes and ideas from this report, should contact GIC through its website at www.gicinc.org.

The purpose of this project was to show how interacting threats can accelerate the rate of forest loss. Agencies are often divided by issue, such as fire, invasive species, recreation, floodplain management or natural areas. Agencies that are "stove piped" in this manner, between one another and within their own agencies, may not be focused on the severity of threats if issues are seen as singular. However, the issue of coastal forest resiliency crosses multiple agencies and departments. Thus, while the interactions necessary to better manage these landscapes and management actions may not be happening as well as they could be at present, greater inter-departmental cooperation could be readily implemented.

All of the threats examined in this study need to be considered across multiple topics and agencies. For example, development fragments the landscape, which provides more vectors for invasive species whether planted in a backyard, introduced through a new road project, or facilitated by a new development, all of which make the landscape more susceptible to colonization by invaders. In order to arrive at solutions, the causes of the many threats examined need to be considered together.

> **"Unless we practice conservation, those who come after us will have to pay the price of misery, degradation and failure for the progress and prosperity of our day."**
>
> —Gifford Pinchot,
> conservationist and first Chief of the US Forest Service

The best use of this report would be regular consultation of the data layers by localities, agencies, land trusts and other conservation groups and all the data have been provided to participating localities.

As this has been a multi-year project, improvements and new strategies are already underway in part or across the entire region as a result of this work. Longer term outcomes will see the adoption of resiliency as a central goal for coastal forests, as well as changes to planting plans, acquisition of uplands to make up for loss of lower-elevation forests, greater awareness of the need to adapt forest management to a changing climate and changes to local codes, such as the newly adopted utility scale solar zoning regulations that were adopted by some localities during this process. As Comprehensive Plans are updated by local governments, this work must also make its way into their long-range goals for the future.
In summary, while we can never fully know what the future holds for our forests, by being aware of emerging trends, forest values and threats, we can plan better for them and, hopefully, have more resilient coastal forests for our future. In the words of Gifford Pinchot, conservationist and first Chief of the US Forest Service:

Unless we practice conservation, those who come after us will have to pay the price of misery, degradation and failure for the progress and prosperity of our day. The vast possibilities of our great future will become realities only if we make ourselves responsible for those realities.

Appendixes

Salt Tolerant Tree Species

Common name	Scientific name	Type of salt tolerance
Hedge maple	*Acer campestre*	Salt spray
Sycamore maple	*Acer pseudoplatanus*	Salt spray
Horse chestnut	*Aesculus hippocastanum*	Salt spray
Red buckeye	*Aesculus pavia*	Saline soils
Paper birch	*Betula papyrifera*	Salt spray
Gray birch	*Betula populifolia*	Salt spray
Catalpa	*Catalpa speciosa*	Salt spray
Hackberry	*Celtis laevigata*	Salt spray
White fringetree	*Chionanthus virginicus*	Saline soils
Lavalle hawthorne	*Crataegus x lavallei*	Salt spray
Japanese cedar	*Cryptomeria japonica*	Salt spray
Common persimmon	*Diospyros virginiana*	Saline soils, salt spray
Ginkgo	*Ginkgo biloba*	Salt spray
Honeylocust	*Gleditsia triacanthos*	Saline soils, salt spray
Kentucky coffeetree	*Gymnocladus dioicus*	Salt spray
American holly	*Ilex opaca*	Salt spray
Black walnut	*Juglans nigra*	Saline soils, salt spray
Eastern red cedar	*Juniperus virginiana*	Saline soils, salt spray
Goldenraintree	*Koelreuteria paniculata*	Saline soils, salt spray
Common larch	*Larix decidua*	Salt spray

Common name	Scientific name	Type of salt tolerance
Sweetgum	*Liquidambar styraciflua*	Salt spray
Southern magnolia	*Magnolia grandiflora*	Saline soils, salt spray
Sweetbay magnolia	*Magnolia virginiana*	Saline soils
Black gum	*Nyssa sylvatica*	Salt spray
Austrian pine	*Pinus nigra*	Salt spray
Longleaf pine	*Pinus palustris*	Salt spray
Japanese black pine	*Pinus thunbergiana*	Saline soils, salt spray
White poplar	*Populus alba*	Saline soils, salt spray
Carolina cherry laurel	*Prunus caroliniana*	Saline soils
Black cherry	*Prunus serotina*	Salt spray
White oak	*Quercus alba*	Saline soils
Bur oak	*Quercus macrocarpa*	Saline soils, salt spray
Pin oak	*Quercus palustris*	Saline soils
Willow oak	*Quercus phellos*	Salt spray
English oak	*Quercus robur*	Salt spray
Northern red oak	*Quercus rubra*	Saline soils
Live oak	*Quercus virginiana*	Saline soils, salt spray
Black locust	*Robinia pseudoacacia*	Saline soils, salt spray
Weeping willow	*Salix alba*	Salt spray
Corkscrew willow	*Salix matsudana*	Salt spray
Japanese pagoda tree	*Sophora japonica*	Salt spray
Japanese tree lilac	*Syringa reticulata*	Saline soils, salt spray
Baldcypress	*Taxodium distichum*	Saline soils, salt spray
Chastetree	*Vitex angus-castus*	Saline soils

Funding Opportunities

Arbor Day Foundation, Tree City USA Designation Benefits: Access to Grants and Funding Opportunities: https://www.arborday.org/programs/tdgreenspacegrants/.

Duke Energy Foundation: https://www.duke-energy.com/community/duke-energy-foundation/south-carolina

Longleaf Alliance: Planting Funds for longleaf pine seedlings: https://longleafalliance.org/longleaf-planting-funds/

National Fish and Wildlife Foundation Grants: https://www.nfwf.org/programs

- **Acres for America** leading public-private land conservation partnership. https://www.nfwf.org/programs/acres-america
- **Bring Back the Native Fish** protects sensitive native fish species across US. https://www.nfwf.org/programs/bring-back-native-fish
- **Conservation Partners Program** provides funding to support technical assistance to private landowners to maximize benefits of Farm Bill programs. https://www.nfwf.org/programs/conservation-partners-program
- **Five Star Urban Waters Restoration Grant Program** seeks to address water quality issues in priority watersheds. https://www.nfwf.org/programs/five-star-and-urban-waters-restoration-grant-program
- **Longleaf Landscape Stewardship Fund** supports longleaf pine restoration projects. https://www.nfwf.org/programs/longleaf-landscape-stewardship-fund
- **National Costal Resilience Fund** restores natural infrastructure to protect coastal communities that enhance habitats for fish and wildlife. https://www.nfwf.org/programs/national-coastal-resilience-fund
- **Resilient Communities Fund** investments in green infrastructure to prepare communities for future environmental challenges. https://www.nfwf.org/programs/resilient-communities-program

National Park Service: The Land and Water Conservation Fund State and Local Assistance Program. https://www.scprt.com/recreation/recreation-grant-programs/land-and-water-conservation-fund

Natural Resources Conservation Service (NRCS), **South Carolina:** https://www.nrcs.usda.gov/wps/portal/nrcs/main/sc/programs/financial/

South Carolina Department of Health and Environmental Control (DEHC): https://scdhec.gov/environment/businesses-communities-go-green/environmental-loans-grants-businesses-communities

- Clean Up Assistance Grant
- Nonpoint Source Pollution Grant
- State Revolving Fund

South Carolina Department of Natural Resources (DNR): Flood Mitigation Assistance Grants https://www.dnr.sc.gov/water/flood/mitgrants.html

South Carolina Emergency Management Division: https://www.scemd.org/recover/mitigation/

- Hazard Mitigation Grant Program
- Flood Mitigation Assistance Program
- Building Resilient Infrastructure and Communities Program

The South Carolina Energy Office: https://energy.sc.gov/incentives/grants

South Carolina Forestry Commission (SCFC)

- **Urban Forestry Grants for Technical Assistance to SC Municipalities** https://www.scfc.gov/management/urban-forestry/urban-forestry-grants/
- **Cost Share and Incentive Programs** https://www.scfc.gov/management/landowner-services/cost-share-programs/
- **Wildland Urban Fuels Mitigation Projects** https://www.scfc.gov/wp-content/uploads/2021/03/grant-application-for-WUI-fuels-mitigation-projects.docx
- **Publications referenced in this guide** are found under Green Infrastructure' projects and resources at this link: https://www.scfc.gov/management/urban-forestry/

USDA FSA Conservation Programs: https://www.fsa.usda.gov/programs-and-services/conservation-programs/index

U.S. Fish and Wildlife Service: https://www.fws.gov/service/financial-assistance

- National Coastal Wetlands Conservation Grants
- John H. Prescott Marine Mammal Rescue Assistance Grant Program
- Urban Bird Treaty Grant
- Traditional Conservation Grants
- Habitat Conservation Plan (HCP) Planning Assistance Grants
- Habitat Conservation Plan (HCP) Land Acquisition Grants
- Recovery Land Acquisition Grants
- Webless Migratory Game Bird Grants
- North American Wetlands Conservation Act (NAWCA) Grants
- Partners for Fish & Wildlife (PFW)-75-90% cost share to landowners for habitat improvements. https://www.fws.gov/program/partners-fish-and-wildlife

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