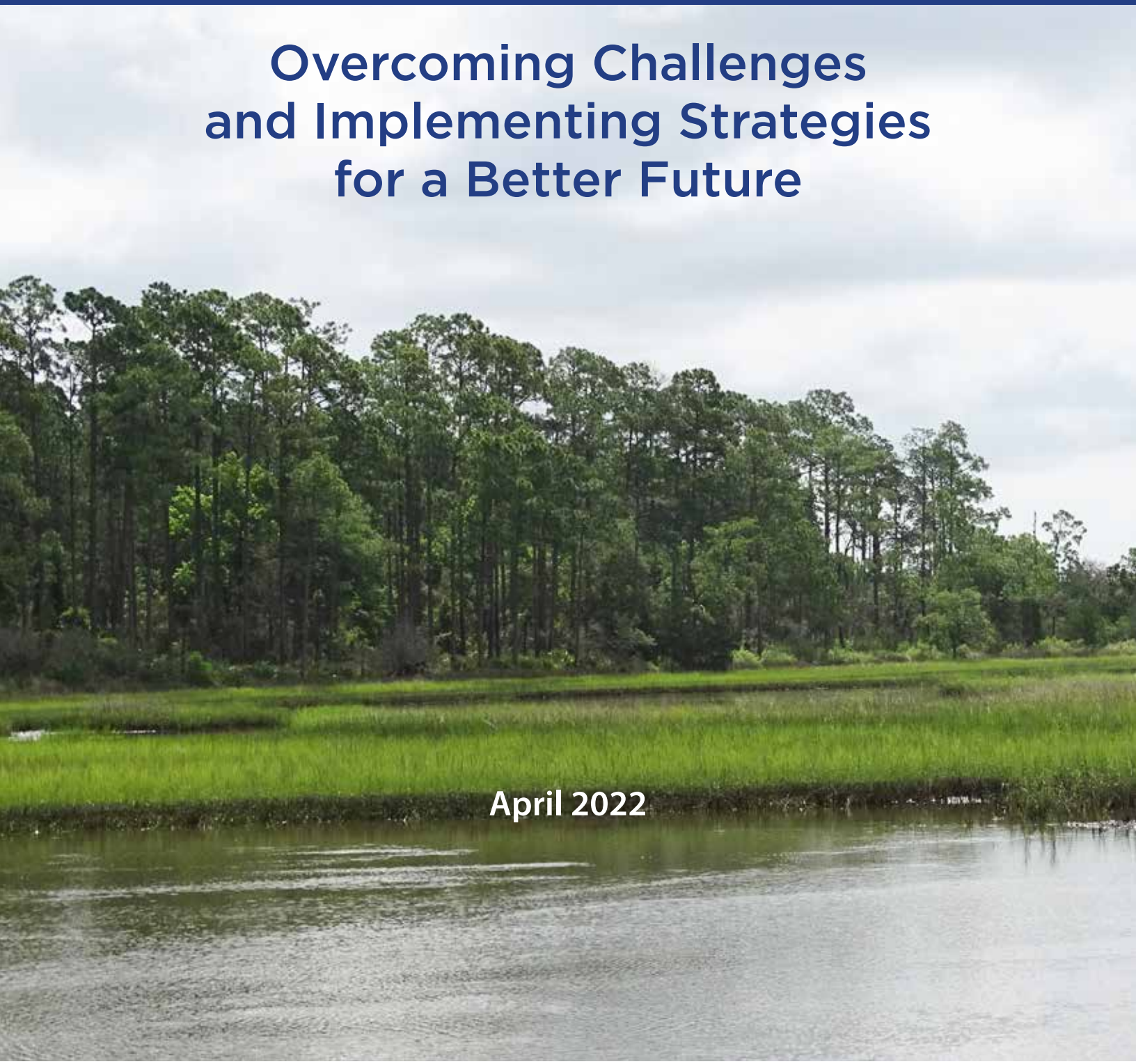
RESILIENT COASTAL FORESTS OF GEORGIA

Overcoming Challenges and Implementing Strategies for a Better Future



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Special thanks to the state and local stakeholder committee members
who provided expertise and collaboration on this project.

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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. Georgia 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 Georgia 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).

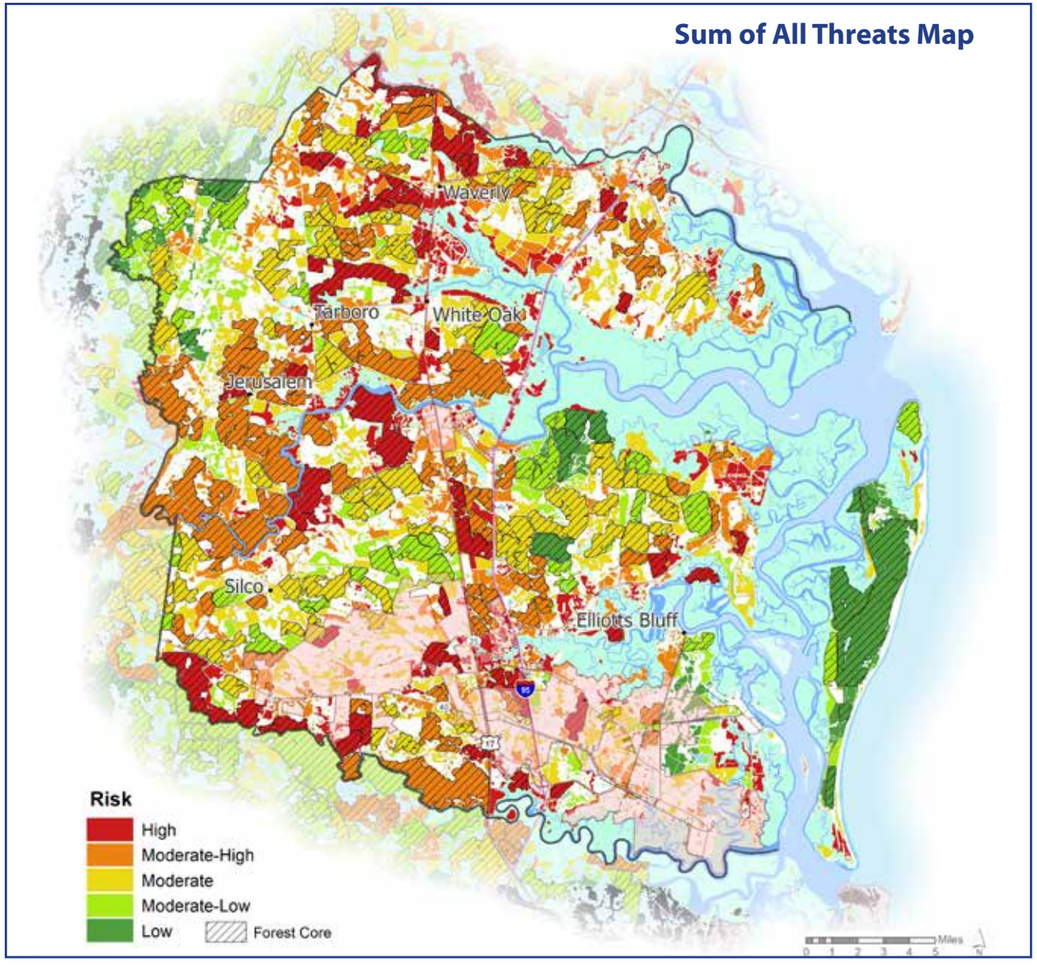
New risks from unprecedented challenges such as sea-level rise and climate change are impacting our forests, while growth along U.S. coastal areas is leading to forest clearing. More than 29% of the total U.S. population, lived in coastal areas in 2017, a 15.3% increase since the year 2000. Weather-related 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. 37,312 acres (20%) of coastal forest in the study area are at HIGHEST RISK from multiple threats. 154,062 acres (81%) 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) pilot study of Camden County GA, three cities located within the boundary and the adjacent barrier islands was created 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 1,319,200 tons of carbon annually while storing 32,200,000 tons more of carbon – a key strategy for slowing climate change. They are also capturing 3.9 billion gallons of stormwater for every 2-inch rainfall event, while supporting 355 species of terrestrial vertebrates, 37 federally or state listed threatened or endangered species, and providing for a forest economy with $14,326,000 worth of wood products. 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 our state agencies and our local governing bodies 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

This Resilient Coastal Forests (RCF) pilot study of coastal forests was designed to take a landscape-scale look at the challenges facing the Southeast's coastal forests and to make suggestions as to what can be done. The 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 recommended management strategies to mitigate or adapt to future impacts.

The study examined a section of Georgia's coastal forest that covered Camden County, its barrier islands and three cities within the lower watershed of the Satilla and St. Marys Rivers.

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.

STUDY AREA FAST FACTS

417,984
Acres in Coastal Forest Study Area

227,469
Acres of Total Forest Cover (54%) of the Study Area.

154,062
Acres of Forest Areas at Risk of 3 or More Threats — 81% of Coastal Forests

91,245
Total Population of Counties and Incorporated Cities

41,759
Acres Total Urban Area (cities and towns)

19,182
Acres of Urban Tree Canopy

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, when they represent 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.

Live oaks are a major species component of maritime forests which 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 economy. Whether it is for the timber or wood products' industries or for recreation and tourism, these forests support the landscape and 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 is 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]

Weather-related threats, such as hurricanes, flooding and wildfires are increasing in 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 is sought for new solar farms. This represents a conundrum for climate policy – should

Forests help define historical sites such as this first community established by formerly enslaved men and women.

Forestry is Georgia's second leading industry in employment, employing more than 47,000 people and generating more than $23 billion in direct output.

Forests provide opportunities for recreation such as along the Coastal Georgia Greenway.

we lose a carbon sink as we cut down forests and thus release carbon back into the atmosphere, in order to build large solar farms to provide clean energy sources?

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.

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 an annual average of 62,805 wildfires in the U.S., that impact an average of 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.[5]

The U.S., Environmental Protection Agency's study "What Climate Change Means for Georgia" (August, 2016) notes that:

> *"Warmer temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Georgia, 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. But longer growing seasons and increased carbon dioxide concentrations could more than offset the losses from those factors. Forests cover about half of the state, with oak-pine forests common in the north, loblolly-shortleaf pine forests common in the center, and longleaf-slash pine forests common in the south. Changing the climate may enable oak-pine forests to become the most common forest type throughout the state."*

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

- Climate change will likely alter the frequency and intensity of forest disturbances, including wildfires, storms, insect outbreaks and the occurrence of invasive species.
- The productivity and distribution of forests could be affected by changes in temperature, precipitation and the amount of carbon dioxide in the air.
- Climate change will likely worsen the problems already faced by forests from land development and air pollution.

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, "the ground is so saturated in spring that not much of anything can be done." Saturated landscapes also make it difficult to perform management actions to reduce fire risks such as prescribed burns, which usually take place during the "leaf-off" season, so as to minimize harm to trees. Foresters noted that, while these areas are

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

against fire risk, with Interstate 95 slicing through the region, it is very difficult to conduct burn activities where smoke may drift onto that major highway. 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 risk. Wind 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 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

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

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

colonization by invasive plant species, which may, in turn, affect its ability to regenerate. Another example would be coastal forest land cleared for development, in which case a 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.

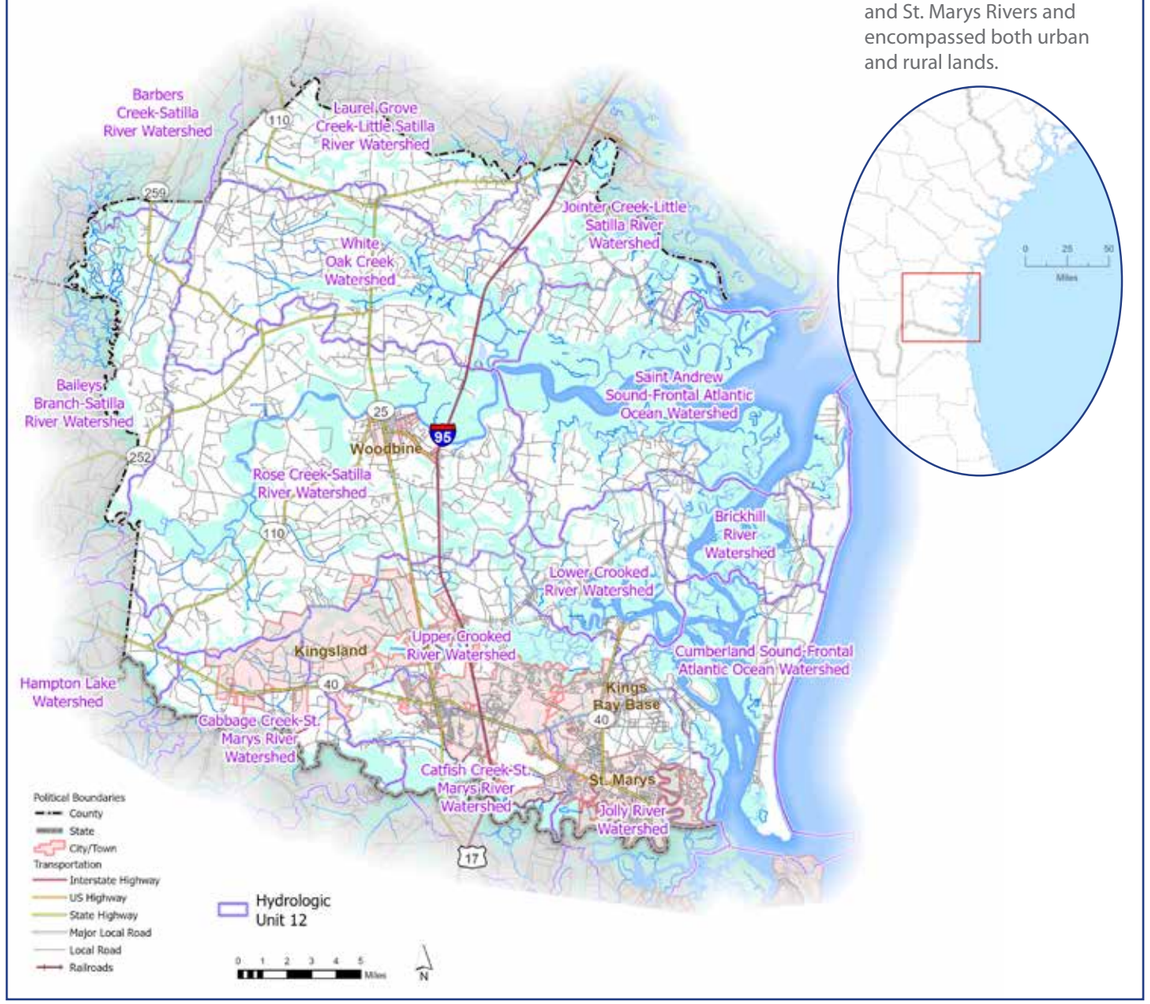
The third characteristic concerns both a natural and human element. Species vary in their ability to learn new behavior and adapt to changes in their surroundings. For example, in coastal forests animal species, and even some tree species will migrate further north as global temperatures increase. Whether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

Georgia Study Area

The study area for Georgia was composed of Camden County and three cities (Kingsland, St. Marys and Woodbine) and a military base (Kings Bay Naval Base) within the lower watershed of the Satilla and St. Marys Rivers as well as the barrier islands including a National Park on Cumberland Island. The study area boundary was chosen by the Georgia Forestry Commission and contains a mix of rural, suburban and urban land uses. The cities are clustered in the southern half of the county, south of the Satilla River and mostly east of Interstate 95, while the western and northern half of the county are predominantly rural in character. Cumberland Island National Seashore is located to the east directly facing the Atlantic Ocean and requires access by ferry or boat to reach the island. A mix of land uses and development patterns was chosen to represent the myriad pressures facing coastal forests and the different challenges and opportunities they face.

The Georgia Resilient Coastal Forest Study Area

The Georgia study area spanned the lower Satilla and St. Marys Rivers 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 Georgia. 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.

Public engagement

The project plan allowed for significant public engagement and, in the early phases of the project, public meetings were planned to discuss challenges local stakeholders were facing with regards to coastal forests. However, 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 municipal buildings; 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.

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

Modeling Forest Cores

FAST FACT:

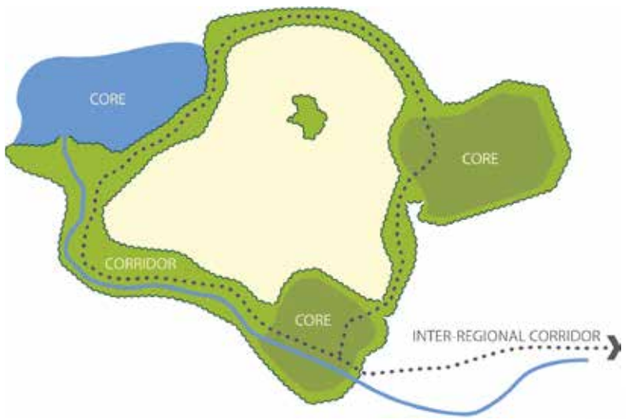
There are a total of 227,469 acres of forest in the study area.

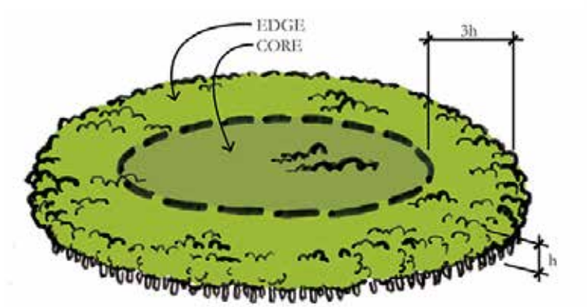
Land Cover Map

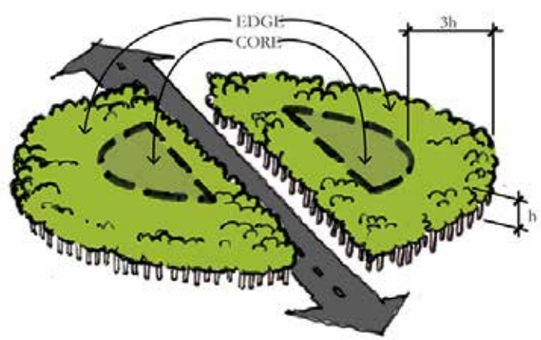
Table 1: Total acres and percent of land cover in the study area, by forest type

Land Cover Type	Acres	% Cover
Deciduous Forest	1,505	.36%
Evergreen Forest	112,920	27%
Mixed Forest	140	.03%
Wooded Wetland	112,904	27%
Wetland	78,265	19%
Pervious	79,060	19%
Impervious	7,552	2%
Developed	9,222	2%
Water	16,416	4%
TOTAL	407,869	100%

Source: National Land Cover Database 2016







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

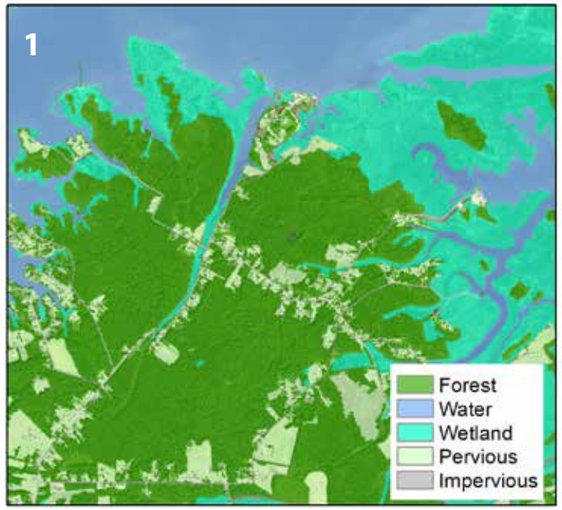
Fifty-four percent of the study area is currently covered by forests, with evergreen forests and wooded wetlands comprising the predominant forest types in the region, at 27% each (see Table 1).

Forest cores were modeled using National Land Cover Database 2016 land cover data. To be a core, the forest should 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).

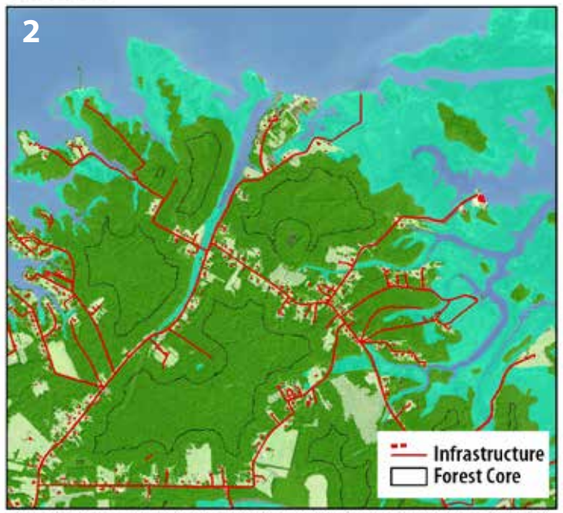
Forest fragments or woodlands less than 100 acres (known as patches) were also mapped to aid in identifying corridors or pathways for species to migrate across the landscape, as well as areas that could buffer the coast from storms. These fragments, while not ideal forest habitat, can provide quality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

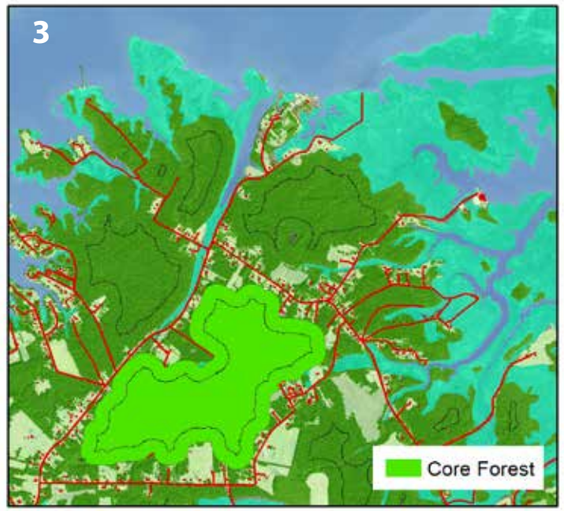


Land Cover



Forest are buffered in 300 ft from forest edge and signifigant 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

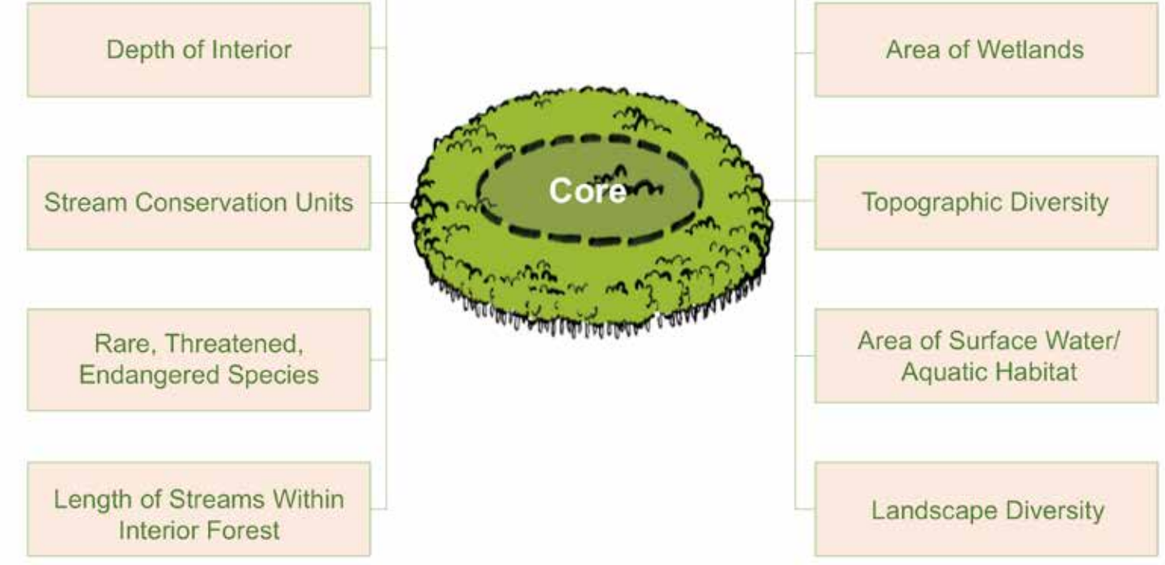
Ranking Coastal Forests

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 included 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.

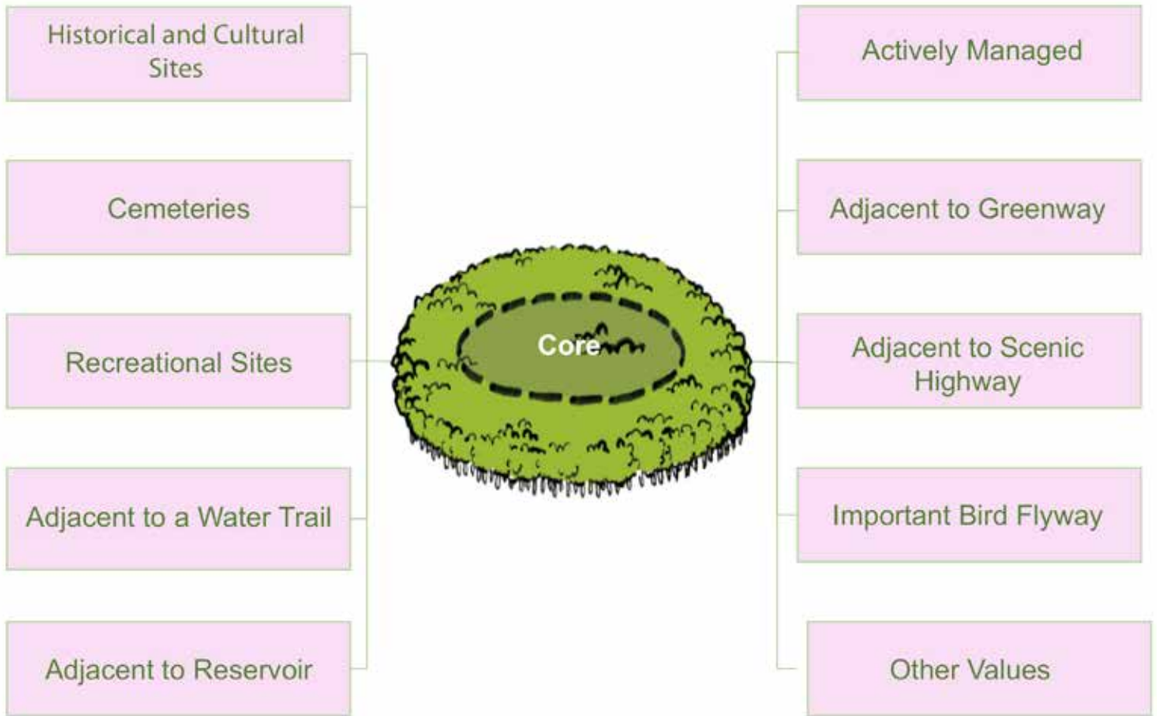


Cultural (human values) rankings

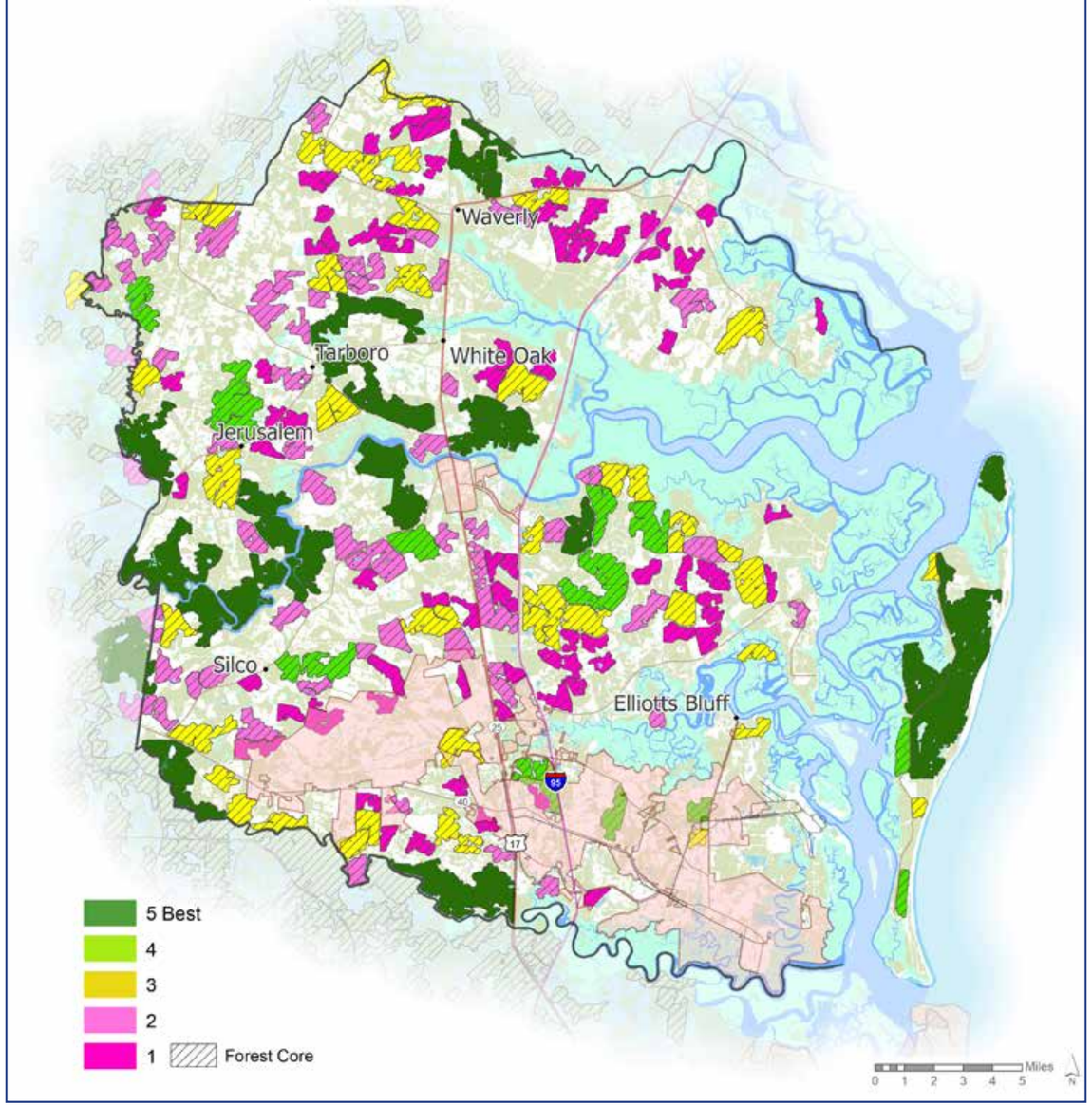
The second level of rankings include those cultural or human values people assign to the natural landscape, specifically coastal forests. Examples of human values incorporated into the ranking systems include forests supporting reservoirs or drinking water protection zones; recreational sites and parks;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

Camping on Cumberland Island is a social value forests provide.

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 since begun to affect parts of Georgia around the City of Augusta. 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.

Urban canopy makes towns cooler and more livable.

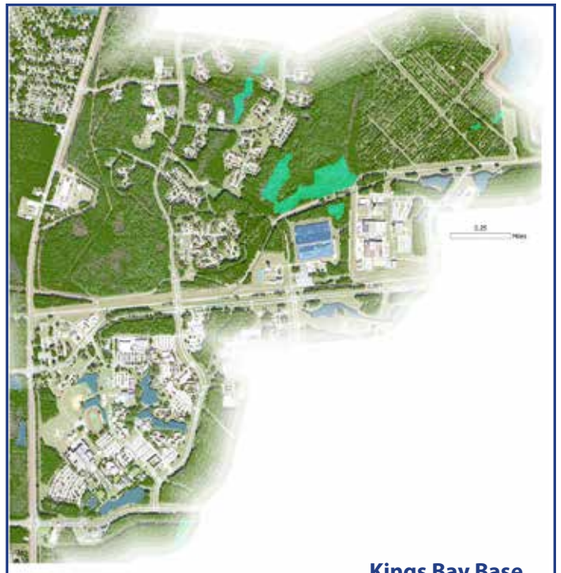
Possible planting areas and potential tree canopy were mapped to understand where additional trees could be planted and to allow municipalities to strategically plan for future plantings. Tree canopy values for each city or town are shown in Table 2.

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).

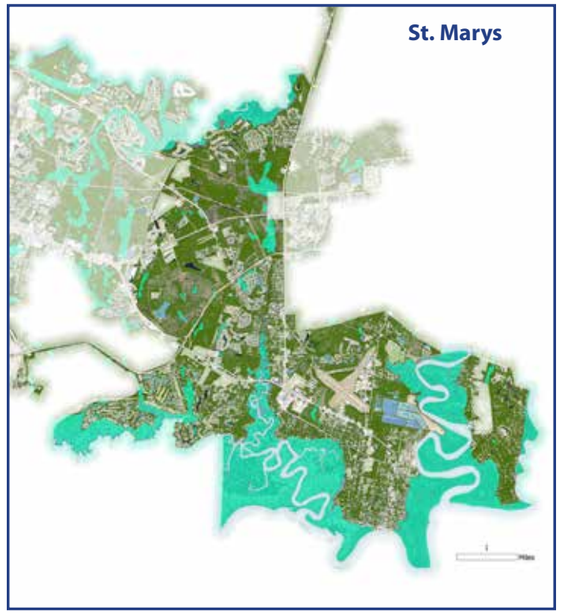
Locality	Tree Canopy (TC) (Acres)	Current %TC	Potential %TC
Kings Bay Base	349	29%	61%
Kingsland	12,545	45%	75%
St. Marys	4,310	40%	74%
Woodbine	765	48%	74%

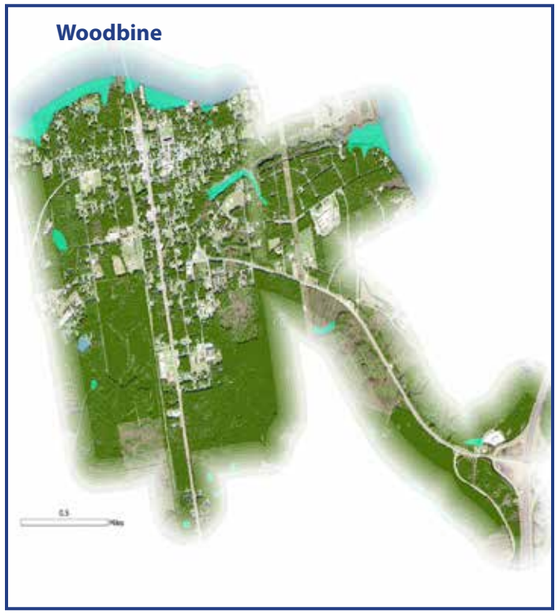
Local Tree Canopy Maps



Kings Bay Base

Kingsland





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 analyzes the benefits coastal forests provide, both to the environment and the communities that reside within 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 i-Tree multipliers specific for the study region (i-Tree County multipliers). Other values were sourced from local partners or published datasets.

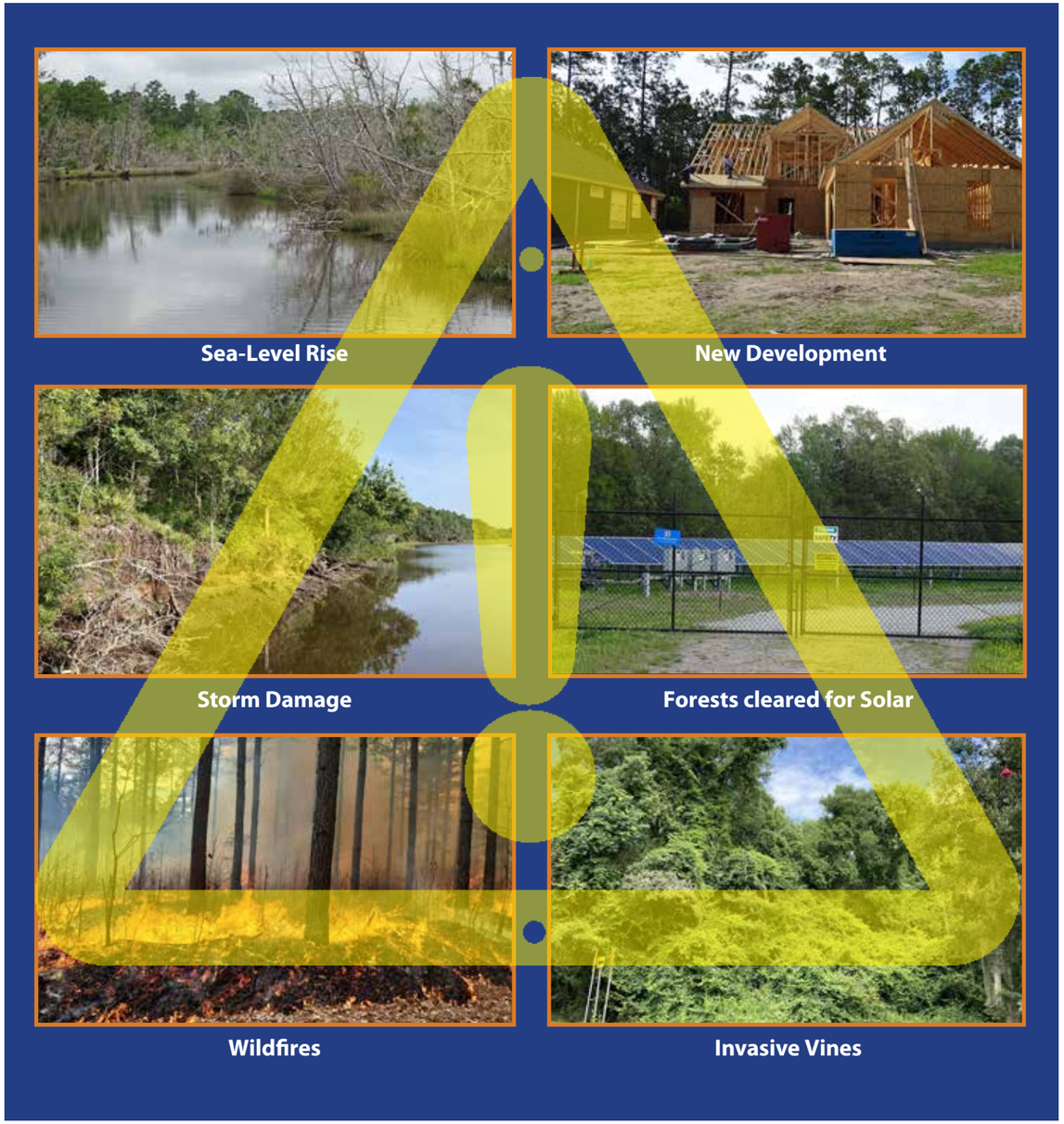
Fast Facts

Annual Benefits Provided by Forests in the Study Area:

Climate	**1,319,200** tons of carbon sequestered annually **32,201,400** tons of carbon stored (total)
Air Quality	**Substances removed from the atmosphere** **102,800 lbs.** of carbon monoxide **2,422,400 lbs.** of nitrogen dioxide **16,171,000 lbs.** of ozone **745,700 lbs.** of 2.5 micrometers particulate matter **4,987,400 lbs. per year** 10 micrometers particulate matter **734,400 lbs. per year** sulphur dioxide
Water Quality	**Pollutants prevented from reaching streams and rivers** **1,041,500 lbs. of nitrogen** **59,600 lbs. of phosphorous** **32,000 tons of sediment** **193 miles** of streams have forest buffers
Flooding	**3.9 billion gallons** of stormwater per 2-inch rainfall event captured
Biodiversity	**355 species** of terrestrial vertebrates supported **37** federally or state listed threatened or endangered species protected
Forest Economy	**$14,326,200** worth of wood products
Culture and Heritage	**3** 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 forests and withstand storms.



SEA-LEVEL RISE

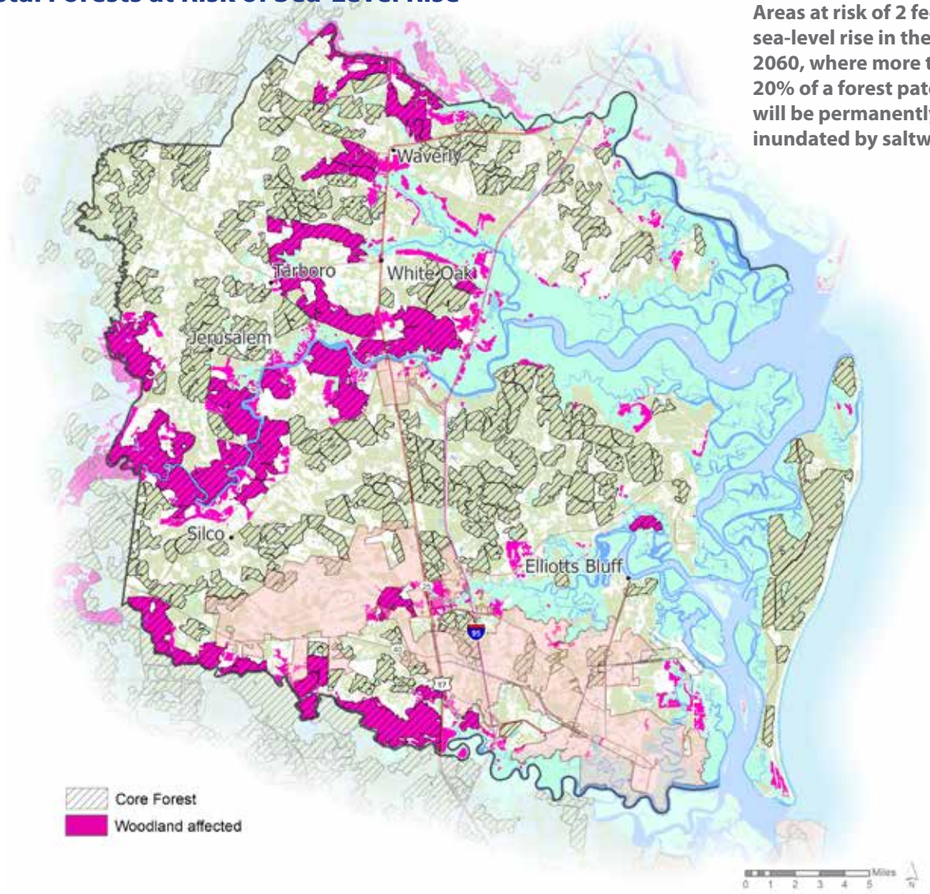
47,018 acres of forest

(25%) of the study area are at HIGH RISK from 2-ft sea-level rise.

Sea level is rising more rapidly in Georgia than along most coasts because the land is sinking. As 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 Georgia. Rising sea level submerges wetlands and dry land, erodes beaches, and exacerbates coastal flooding. (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, obtained from data at the Fernandina Beach Gauge was used. 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 creates "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.

"As the Georgia coastline is the western-most point of the east coast, it creates the Georgia Bight, which causes a large tidal range of about 8 feet. This tidal range is higher than neighboring states to the north and to the south, where Florida and North Carolina typically see a range of 2-4 feet. " (GMC 2022). This increase in tidal elevation pushes saltwater farther inland compared to other areas of the South Atlantic Coast and sea-level rise will exacerbate it even further in the future. 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 Satilla and East Rivers and ultimately the Atlantic Ocean. These riparian forests are a critical component in achieving water quality goals

Infrastructure and forests currently (2021) at risk from king tides in the study area.

Rising seas are killing coastal forests.

in the Satilla River's and St. Mary River's Total Maximum Daily Load (TMDL) Implementation plans which identify nonpoint surface runoff as contributors to these impaired waterbodies. Without wide forest buffers capturing and delaying runoff, these rivers will continue to receive nonpoint source pollution. Current riparian buffer zones will need to expand beyond their existing boundaries to account for forest loss 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 now with landowners when forest planning in coastal areas, in order to support long-term resource management decisions, including which areas to plant for future harvesting, 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.

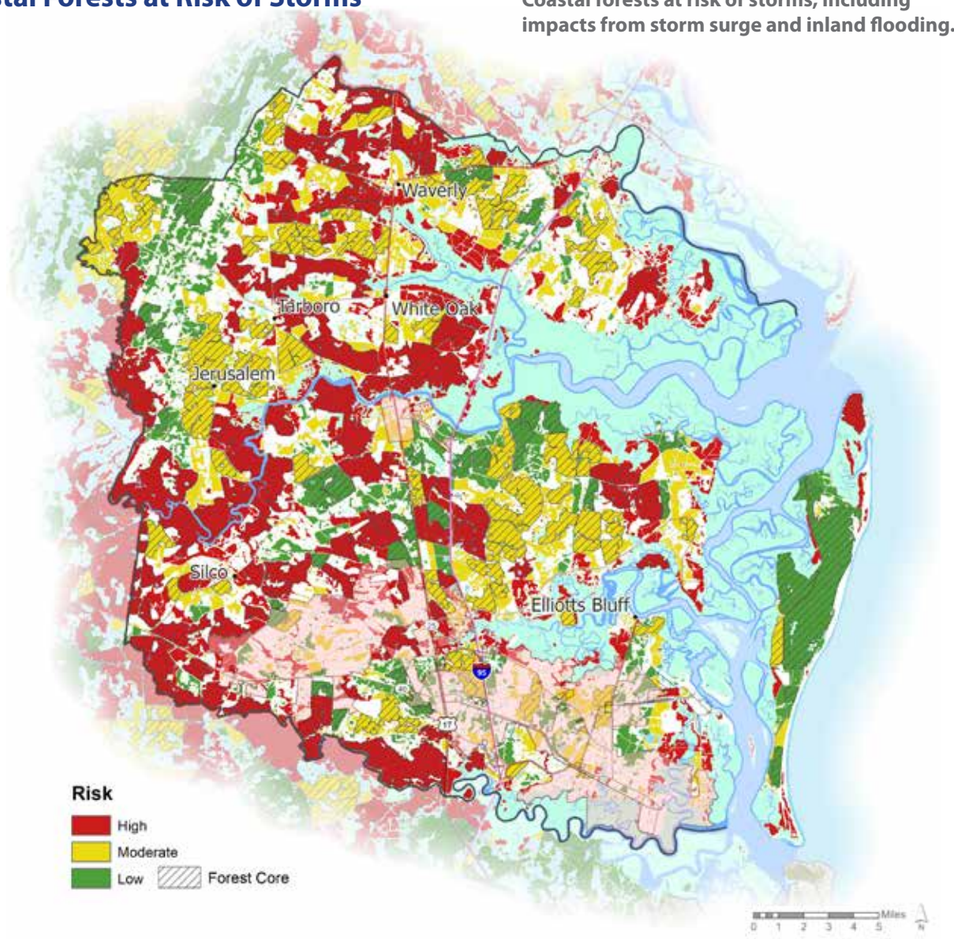
90,353 acres of forest

(47%) in the study area are at HIGH RISK from storms

Coastal forest cliffs in the region are 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 33 miles inland from the coast in some of the highest risk areas. Crooked River State Park is an example where significant coastal cliff erosion can be seen. The erosion of those cliffs increases the flow of sediment into the rivers, increases the opportunity for invasive species, such as phragmites, to colonize remaining mud flats, and reduces the buffering potential forests provide for both surface runoff and future storms. Salt spray and saltwater flooding 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.

Wave action from storms undercuts forested coastal bluffs causing significant erosion.

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.
- 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

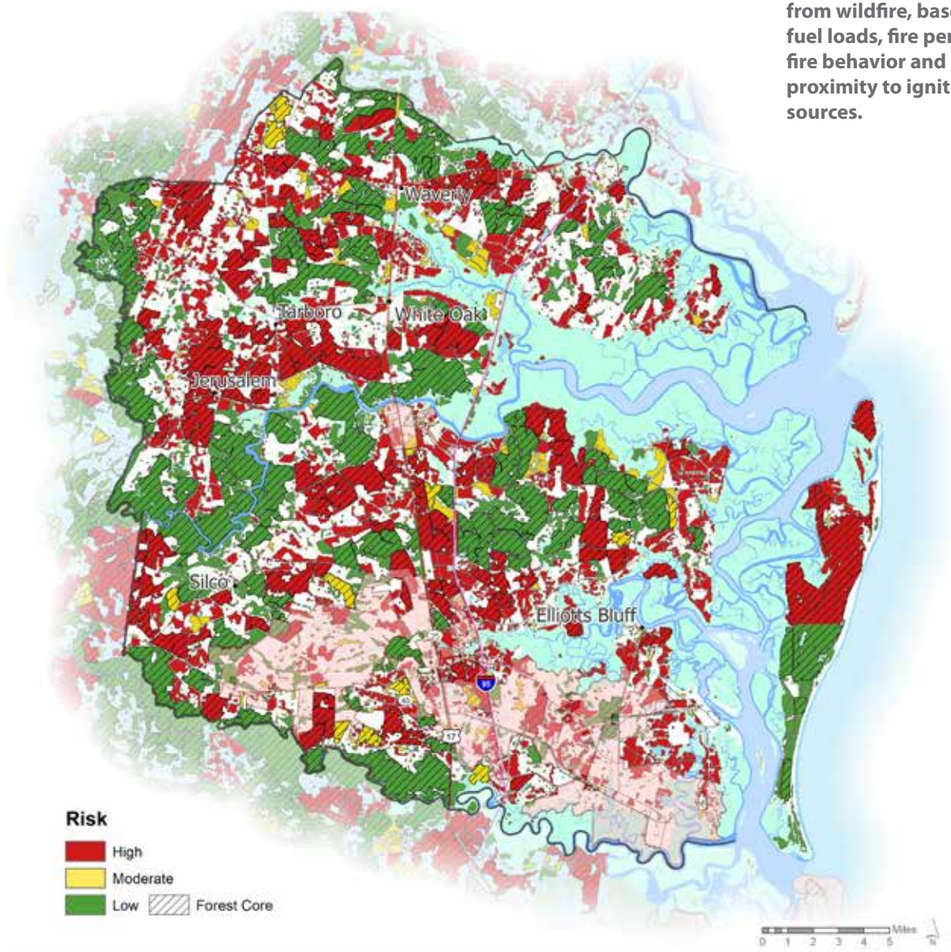
100,339 acres

(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 due to 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 of 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 means 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.

Longleaf pine forests and savannah species have adapted to frequent but low-severity fires to recycle nutrients and reduce competition for nutrients resulting in greater forest productivity.

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.
- 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 Georgia Chapter of the American Planning Association and local planners to educate them about the Firewise program.

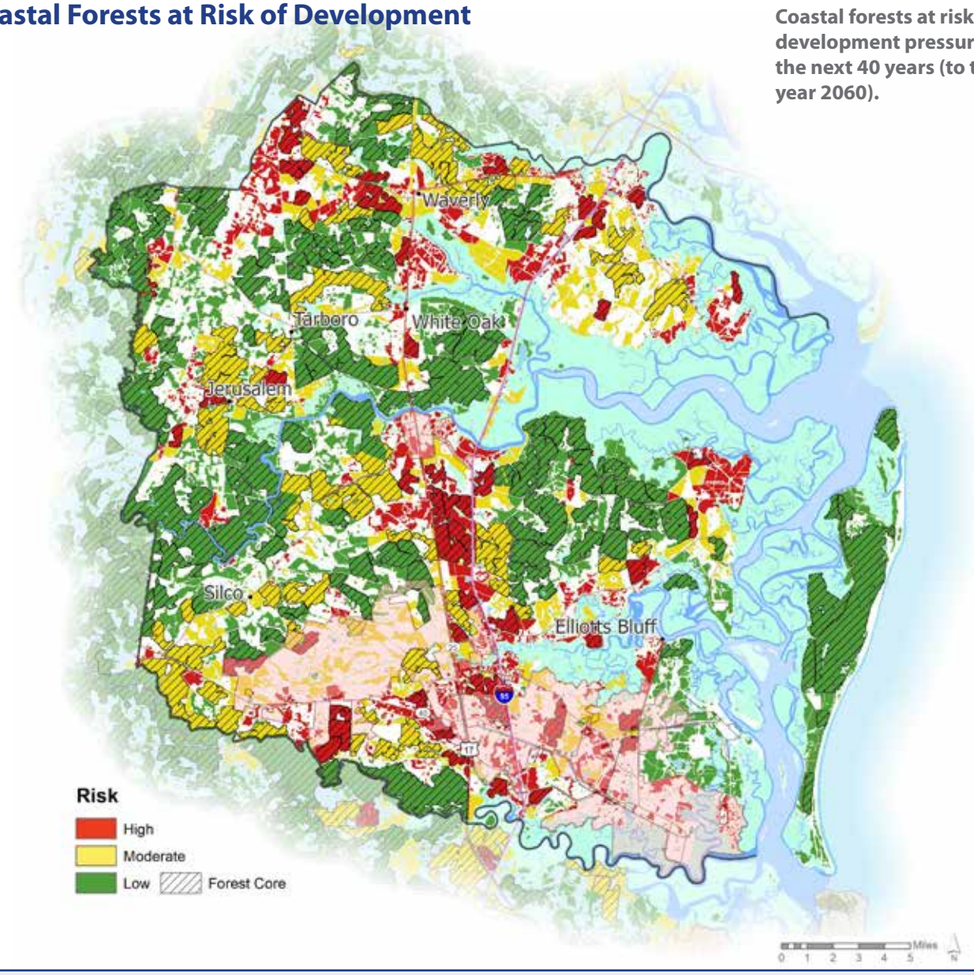
DEVELOPMENT

38,862 acres

(20%) 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 South are seeing the highest rates of migration of people into the coastal countryside, 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 16,774 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.

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.

The extent of the potential problem is evident when one realizes that the study area currently has 1,426 land parcels of between 10–50 acres, which make up more than 28,128 acres (9% 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 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. 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-canopy 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 to seek 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: Harrisonburg, VA.
- Establish tree protection ordinances during the construction of new development.

Coastal areas are experiencing increased development and population growth.

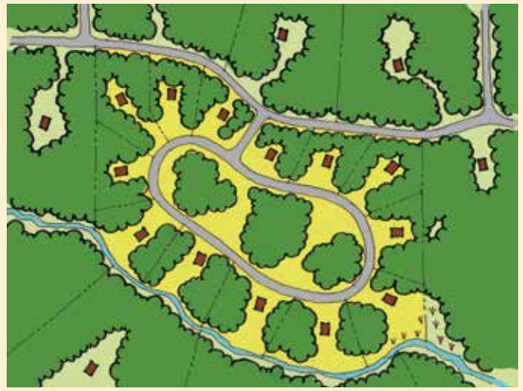
Conservation Subdivision (Cluster Development) Ordinance

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.).

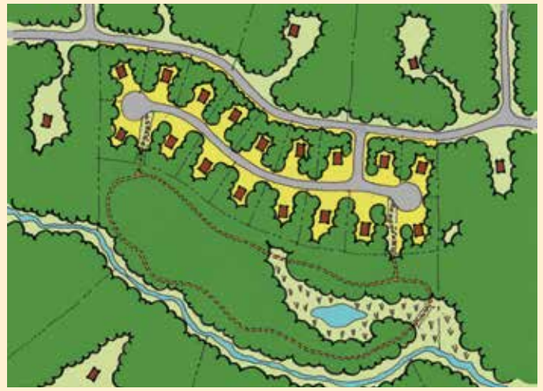
The cluster ordinance should also limit the percentage, or exclude altogether, stormwater best management practices (BMPs), such as dry ponds, from the open space calculation and limit or prohibit developed open space, such as tennis courts, golf courses and athletic fields.

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

- Open space shall be at least 50% or more of the total site. (Oconee County)
- At least 10% of the Greenspace shall consist of land that is suitable for building, as defined herein. (Cherokee County)
- Individual open space parcels generally shall be larger than three acres. (Oconee County)
- The open space shall be an integrated part of the project rather than an isolated element and fragmentation of the open space shall be minimized. (Oconee County)
- To the extent practicable, Greenspace shall be preserved in larger, contiguous, and connected tracts so as to provide uninterrupted habitat. The Greenspace should adjoin any neighboring areas of Greenspace, other protected areas, and non-protected natural areas that would be candidates for inclusion as part of a future area of protected greenspace. (Cherokee County).



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

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 City of Savannah's code illustrate these points:

- Project provides a Wetland and/or Marsh Buffer width greater than the 35-foot minimum. Density bonus of 0.2% per one (1) foot increase in the buffer width. Trails shall be permitted within the excess buffer area. No impervious surfaces shall be permitted.
- Project includes a minimum seven (7) foot wide tree lawn with canopy trees along all streets. Plantings shall meet the minimum planting standards of the City (City Code Part 4, Chapter 10, Landscape and Tree Ordinance).

Some forested areas already have the utilities and infrastructure installed, so these forests are likely to be developed in the coming decades.

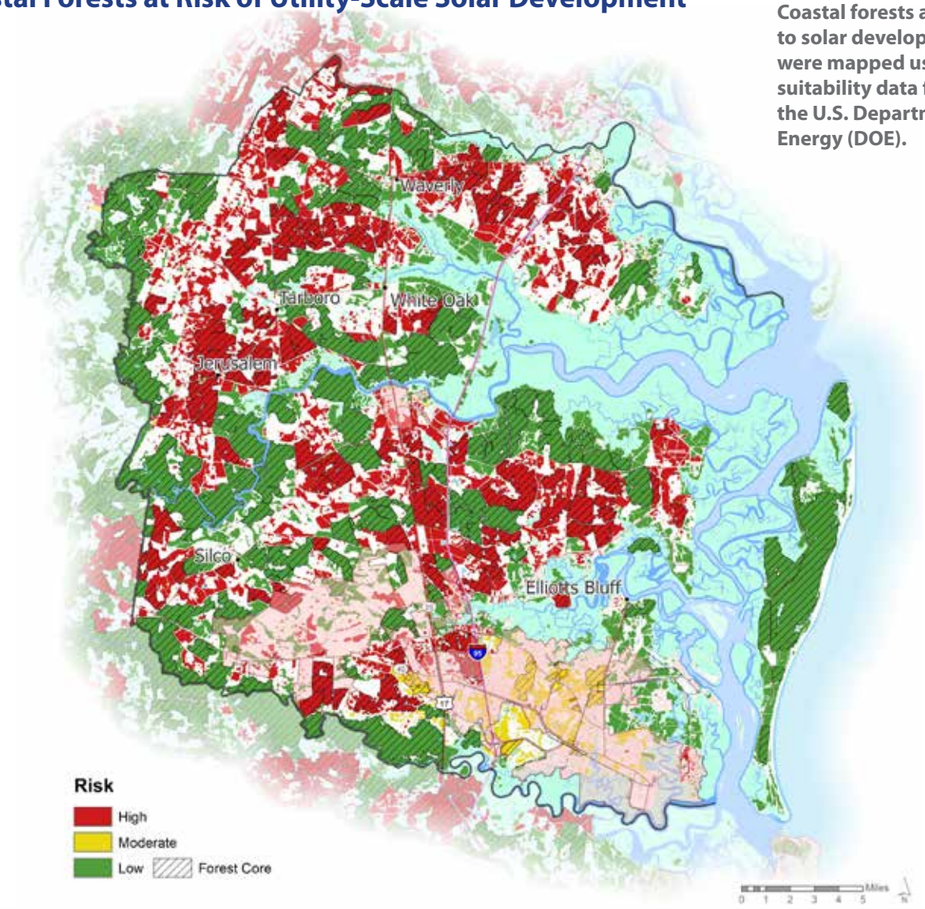
UTILITY-SCALE SOLAR DEVELOPMENT

77,938 acres (41%) 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 a dramatic 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 Georgia 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. According to The Nature Conservancy, "solar energy accounts for 2% of Georgia's energy portfolio. If that percentage grows to 20% or higher, solar facilities could occupy more than 75,000 additional acres of land. The conversion of this land to solar generation could exact a heavy toll on environmentally sensitive habitat and the wildlife and people who depend on that land" (The Nature Conservancy 2021). A recent report found that 21% of solar farms in Georgia were developed on land classified as evergreen forest (NASA DEVELOP et al 2017). 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. Carbon stored in the forest is also released if cleared trees are 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.

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 – fencing with openings to allow passage for smaller mammals or foraging birds, such as quail.
    - — Avoid breaking up and disconnecting remaining trees from 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 better guidance to solar developers to create better habitat on solar panel sites. For example, see Georgia Tech's The Georgia Model Solar Zoning Ordinance Guide: https://lpdd.org/wp-content/uploads/2021/05/2018-07-30_mso_guide_final.pdf or the Virginia Department of Conservation and Recreation's Pollinator-Smart Comprehensive Manual: https://www.dcr.virginia.gov/natural-heritage/document/solar-site-comprehensive-manual.pdf.

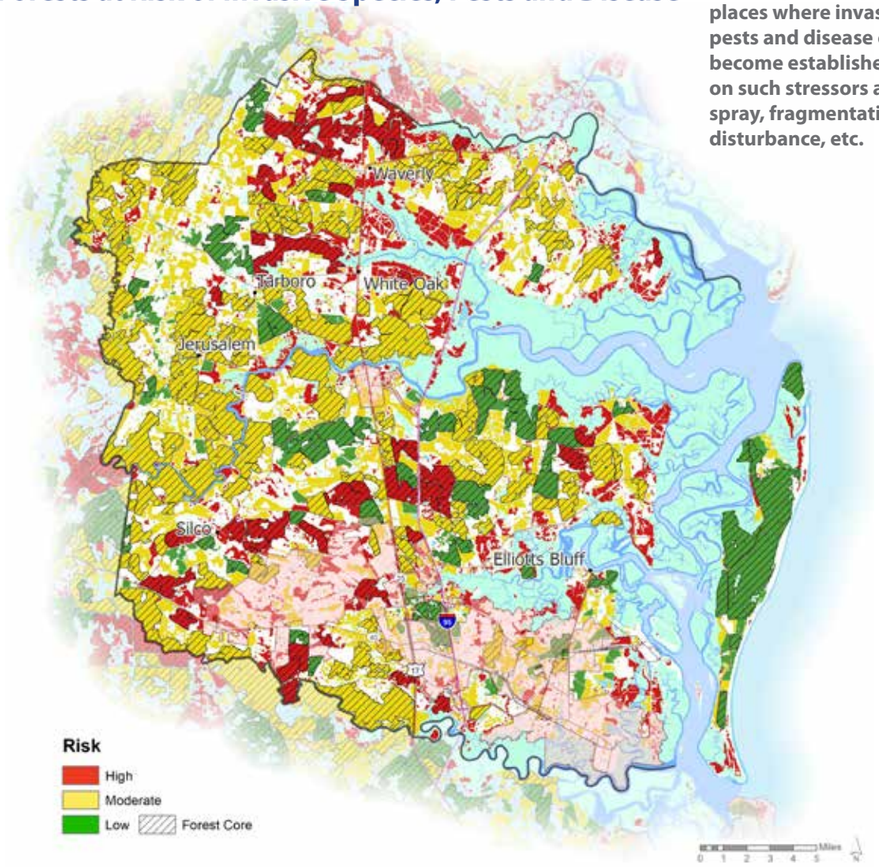
INVASIVE SPECIES, PESTS AND DISEASE

51,083 acres (27%) 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:
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).

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.

According to a 2007 International Union for Conservation of Nature (IUCN) Red List Fact Sheet, 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 red bays 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. For example, laurel wilt has significantly reduced the population size of redbay trees on Big Cumberland Island.

GIC Recommendations

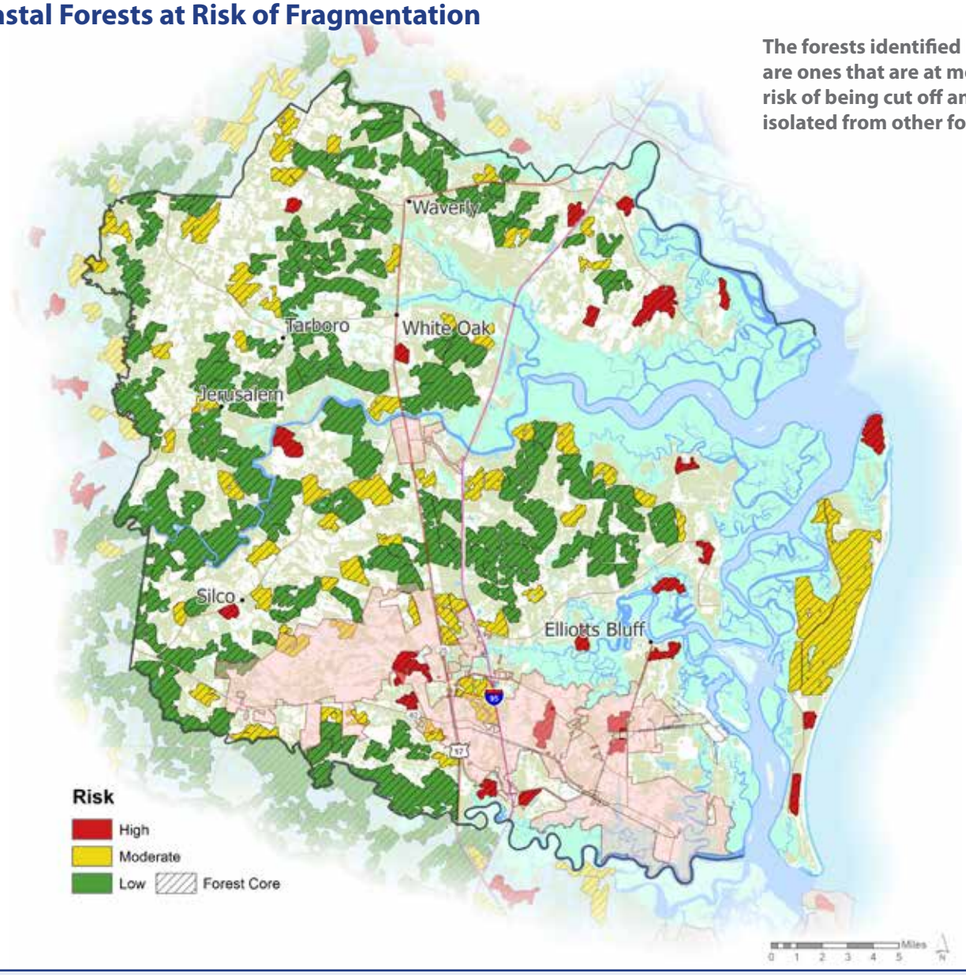
- Disallow or remove invasive species from landscape ordinances. It is OK to have non-native, non-invasive species of trees included.
- Increase biodiversity in urban settings. Include a minimum number of different species required in landscape plans (e.g., no less than five different types of street trees).
- Build capacity with local and regional nurseries to grow and promote native plants. Consider having a special "natives" section. An example is the VA Eastern Shore's Plant Native's Campaign, in which they successfully worked with nurseries to create tags and designate display areas showcasing native species. However, these campaigns are only as successful as the number of nurseries who participate, so work with local and regional nurseries to convince them to stop selling invasive plant species and to start showcasing natives.
- Bradford Pear Bounty is a program where landowners remove bradford pears from their properties and submit documentation (a photo) proving it was removed in order to receive a free replacement native tree suitable for the site. Bradford pear trees are an Asian tree that split easily in windstorms and are unsuitable for coastal areas. This program is active through Clemson University in South Carolina and could be replicated in Georgia.
- 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 on timing the use of pesticides with regard to pollinators to avoid harming them. For more see Protecting Georgia's Pollinators: https://bees.caes.uga.edu/content/dam/caes-subsite/honey-bee-program/documents/PollinatorBookletforWeb2-2016.pdf, a state plan for promoting a large, healthy and diverse pollinator workforce. Also, the University of Georgia's Cooperative Extension has an article on habitat management to attract pollinators and beneficial insects for reduced need for pesticides. titled *The Eco-Friendly Garden: Attracting Pollinators, Beneficial Insects, and Other Natural Predators*— https://secure.caes.uga.edu/extension/publications/files/pdf/B%201456_3.PDF

FRAGMENTATION

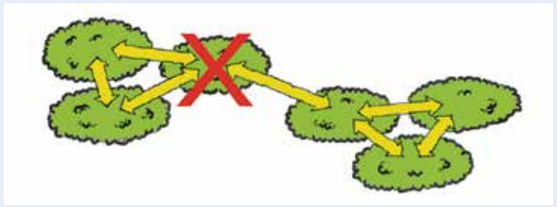
1,208 miles of roads are in the study area, and roads contribute significant barriers to wildlife movement across the landscape.

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 when 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).

Coastal Forests at Risk of Fragmentation



The forests identified in red are ones 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.

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.

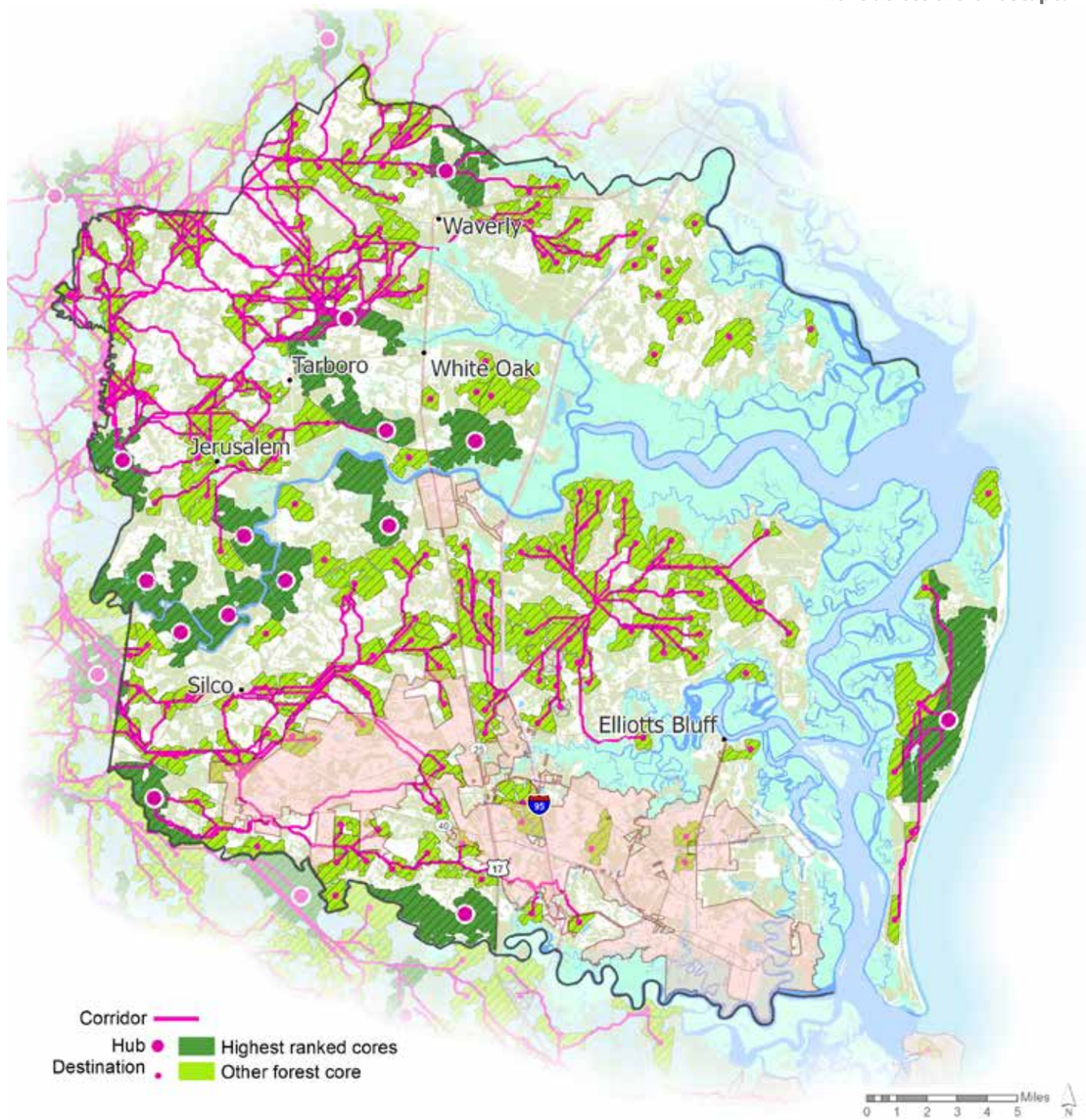
Multiple, cumulative impacts arise from the variety of decisions humans make, from land use to building infrastructure. A prime example is road construction. Most of the state's roads have been built without regard to the impacts on the movement of species across the

Human infrastructure such as roads, transmission corridors and development, fragment the forest into smaller pieces which provide less overall interior forest habitat.

FRAGMENTATION

Coastal Forest Corridors

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



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

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 busy roads. It is estimated that several million birds are killed annually in vehicle collisions on U.S. roads (Loss, et al 2014). With over 1,208 miles of roads in the study area, roads contribute barriers to wildlife movement across the landscape.

An objective of this study was to analyze how isolated and fragmented forest core habitat is, and then to model where corridors exist for species to migrate safely across the landscape. The goal is to increase connectivity and safe passage for wildlife along these routes.

GIC Recommendations

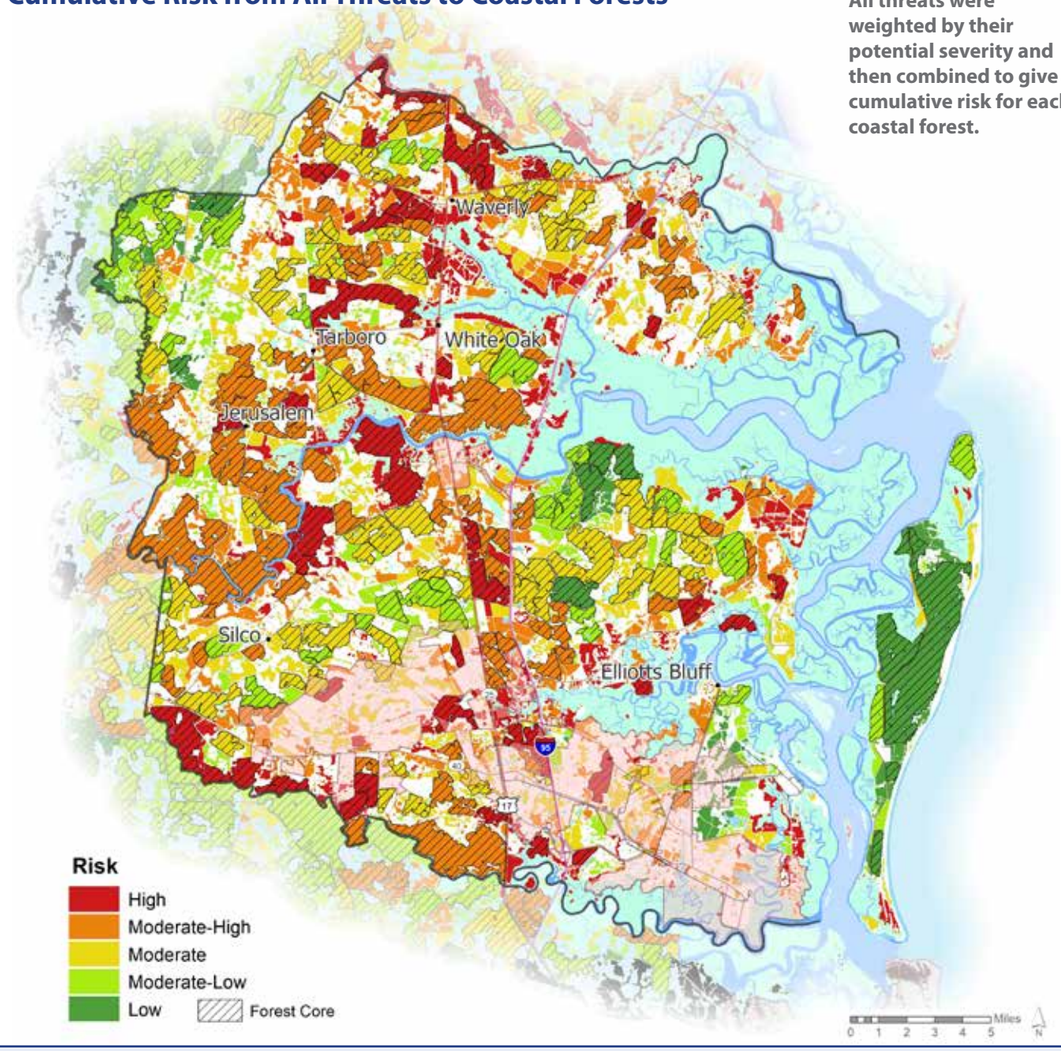
- Create more animal crossings/bridges/tunnels for safe passage of both people and wildlife. In areas with higher water tables along the coast, consider wildlife bridges.
- Localities should incorporate conservation overlays or large lot zoning to protect areas with high-value forests or important silvicultural 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.

SEVERITY AND CUMULATIVE THREAT RISK

37,312 acres (20%) of coastal forest in the study area are at HIGHEST RISK from *multiple* threats.

154,062 acres (81%) 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 understand the severity of multiple simultaneous impacts. Certain threats can create feedback mechanisms where 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. 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 into the wildland-urban interface.

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, to 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 cumulative map risk 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

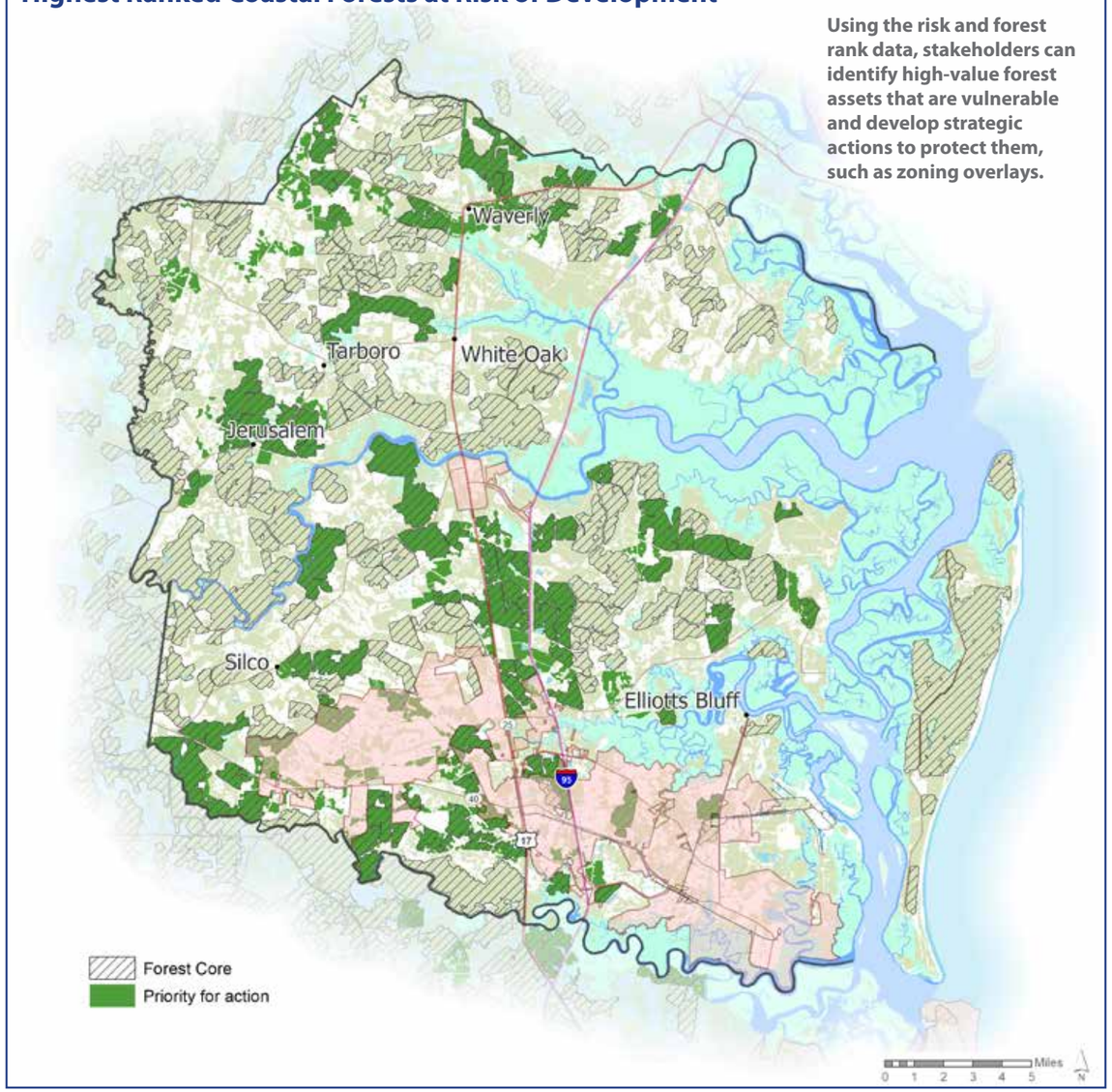
Prioritizing Coastal Forests

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 which cores or woodlands 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 at high risk from solar development either to delineate a solar overlay, which indicates areas where solar panel development is appropriate, or to create zoning or special use permit conditions to apply to new solar panel developments. Another 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 would significantly impact the ability of wildlife to migrate across the landscape.

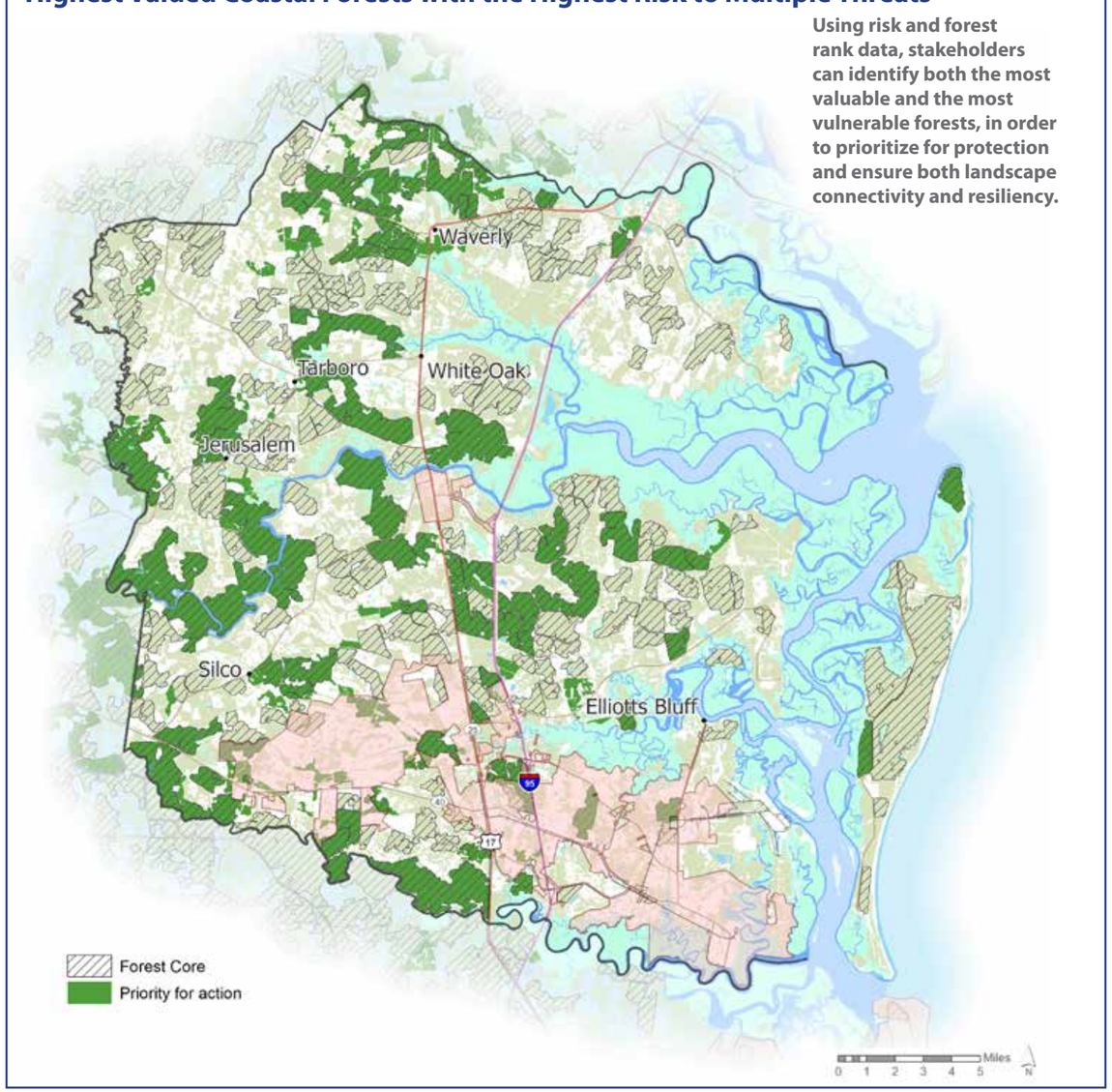
Highest Ranked Coastal Forests at Risk of Development

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 to 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

Camden County

Strategy 1: Maintain trees in the county's ROWs to avoid conflicts.

Camden County's Public Works right-of-way crew monitors for risky limbs and trees and mitigates as and when it can. The crew had to cut limbs 50-60 feet high for clearance as semi-trucks were clipping and damaging trees as they traveled the road.

Strategy 2: Conduct a tree risk assessment for faster storm response after a disaster.

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: Support strategic buyouts and land acquisition that prioritize flood-prone properties and provide habitat migration connections.

The county identified this as a long-term strategy in the adopted Disaster Recovery and Redevelopment Plan, finalized in 2021, and in the Camden Resiliency Plan, to be released in 2022. The resilient coastal forest data, such as highly ranked coastal forest cores and corridors, could be used by county staff and administrators as one of several criteria when prioritizing and determining which properties to purchase as part of their buyout program.

Strategy 4: Create a cluster ordinance that protects the rural character and open space of the county.

The creation of a cluster ordinance has been identified in the county's 10-year Strategic Plan to encourage smart growth. The goal is to protect the rural character and quality of the county, while also addressing flooding and stormwater challenges from land cover change. This type of policy is aligned with the strategies identified by the Camden Resiliency Plan.

Strategy 5: Facilitate future marsh migration and restoration opportunities.

The region is concerned with rising sea levels and the subsequent drowning and displacement of tidal marshes. There is an interest by the county and another regional conservation effort called the South Atlantic Salt Marsh Initiative (SASMI) to further assess marsh migration, identify opportunities for restoration and allow for marsh migration. These buffer preservation areas need to also account for future forest migration, particularly along river corridors.

City of Kingsland

Strategy 1: Establish a solar array ordinance that protects green infrastructure assets.

Kingsland established a solar array ordinance in 2019 that utilizes many of the standards for solar development GIC identified earlier in this report. These include:

- Large-scale, ground-mounted solar is permitted only by special use permit.
- Must submit a plan that includes a topographic map indicating wetlands, vegetative cover, floodplains and watersheds.
- Must submit a topographic map of stormwater conditions that indicates areas of potential erosion.
- Must submit maps from the Georgia Department of Natural Resources, U.S. Department of Fish and Wildlife and the National Oceanic and Atmospheric Administration that identify state endangered, threatened or candidate species on, or adjacent to, the property.
- Must submit a map from the U.S. Department of Agriculture Natural Resources Conservation Service that identifies prime farmland and farmland of statewide importance on the property.

Nature-based solutions, such as this bioswale, capture stormwater runoff while also providing wildlife habitat.

- Regarding landscaping and tree preservation, subsection 140.8.2, which is on the Vegetation Preservation and Protection Plan and is part of the Tree Removal and Conservation of Vegetation subsection, states:

  4. *On undeveloped land (where building permits have not been issued or subdivisions approved), it is forbidden to destroy more than 25% of the trees on any one parcel of real estate within a five-year period. The developer must specify the location of existing trees of a certain size, indicating those which will remain and those which will be removed. All changes in grade must be indicated. Provisions for protecting trees during development must be specified. The builder is required "to erect suitable protective barriers around all trees specified to be maintained and shall not allow storage of equipment, materials, debris, or fill be placed in this area, except as may be necessary for a reasonable time, if no other storage space is available.*

Strategy 2: Enhance city owned parks in the Summerfield neighborhood with green infrastructure.

As identified in the Camden Resiliency Plan, the Summerfield neighborhood suffers from repeated flooding and stormwater drainage issues. As part of a holistic strategy, the city plans to invest in green infrastructure enhancements in its neighborhood parks, such as tree plantings and bioswales.

Strategy 3: Plant trees in the historical downtown district.

The city is looking for funding opportunities to increase tree canopy in the historic downtown area. This district is at the intersection of two major highways and is impacted by a lot of truck traffic. The Georgia Department of Transportation is exploring a bypass option to redirect truck traffic away from downtown. If this occurs, the city can reduce road widths in the downtown and install both bioswales and tree wells, which will help reduce stormwater issues, shade and cool the district, calm traffic, improve the pedestrian shopping experience and beautify this historical area.

City of St. Marys

Strategy 1: Developed a tree ordinance for commercial properties.

The city adopted a tree ordinance specifically for commercially zoned properties. The biggest impact is in the application for new construction. The city already has a tree ordinance for other types of development, such as residential subdivisions, and for publicly owned and maintained trees.

Strategy 2: Establish a tree ordinance for front yard trees on private properties.

The city is interested in expanding its current tree ordinance to include private residential trees, particularly front yard trees. The Georgia Forestry Commission's coastal forester is helping them find model ordinances they can use as exemplars to craft a new ordinance. The idea of regulating private residential trees is not without precedent in St. Marys. For example, the local historic preservation committee has authority over private property within the designated historic districts and can regulate trees on those properties.

Strategy 3: Implement the stormwater utility fee and provide credits for tree planting.

The city passed a stormwater utility ordinance in the fall of 2021. As of publication (April 2022), the city has not begun implementation. The ordinance allows for a stormwater utility fee, which will support stormwater management and green infrastructure investments, similar to recent bioswale projects in the downtown waterfront. The city does not have a specific stormwater credit option for trees, but it does give credits for other best management practices, such as rain gardens and bioswales. If possible, these projects should include tree plantings for added benefit. In addition, some communities use trees as stormwater credits for onsite mitigation of stormwater. One example, Pine Lake, GA, offers 10 gallons of water credit per inch of tree diameter at breast height (DBH) for preserving existing trees under 12″ DBH, and 20 gallons of credit per inch of DBH is given for preserving existing trees over 12" DBH.

Bioswales can include tree plantings for added function and benefit.

Strategy 4: Update city tree inventory and develop an urban forest management plan.

The city's tree inventory was done many years ago and needs to be updated. A state arborist tagged trees in the downtown area, most of them large and mature live oaks. The Georgia Forestry Commission (GFC) will be offering new grants and guidelines for technical support. St. Marys could use matching funds to bring in a certified arborist to update the inventory and help write a management plan. The Public Works Director is including these matching funds within the town's annual budget for future GFC grant funds.

City of Woodbine

Strategy 1: Continue to invest in the river walk and Coastal Georgia Greenway.

The City of Woodbine has invested significantly into a greenway that runs through the heart of the city, along with an elevated boardwalk that provides access and recreation along the Satilla River, which is a regional blueway. The city has planted new trees along the greenway to support this recreational asset in the community.

Strategy 2: Review and update the tree ordinance.

The City of Woodbine has been a Tree City USA since 2004 and received growth awards every year since 2007. The city has an active tree board and adopted tree ordinance; however, city staff wish to review and update the ordinance.

TREE CITY USA®

The City of Woodbine is planting and maintaining trees along its section of the greenway.

CASE STUDY: Kings Bay Naval Base, Department of Defense

Background

Kings Bay Naval Base is located in Camden County, GA, and is the home port for those U.S. Navy ballistic missile nuclear submarines that are part of the Atlantic Fleet. The base was built on historic land that had extended over several old plantations, but prior to that had been inhabited by pre-Columbian Indians. It is also famous for several military engagements during the War of 1812-14. The base was originally built in the mid to late 1950s. In the 1990s, it added a natural resources manager to comply with the Sikes Act, which requires resource management on military bases. The 16,000-acre base has more than 6,000 acres of upland forestland and approximately 7,000 acres of wetlands and marshland. Prior to the navy's acquisition, slash pine had been planted on the majority of the site. Today, the base is a mix of maritime forest, longleaf pine forest and slash pine. Forestry is an active use of the site, with 50 acres of trees harvested, either annually or bi-annually.

The navy's resource manager monitors the gopher tortoise population and their burrows for use by other wildlife.

Challenges

Managing the natural resources on a military base is challenging due to the multiple, and often conflicting, land uses. In 2015, a solar panel array was installed through a federal program to increase energy resiliency on military bases. However, the solar panel site is currently leased to Georgia Power, which sells the power to their customers. The 250-acre solar field occupies land that was cleared of longleaf pine forest to make room for the panels.

The wastewater treatment plant sprays effluent across 500-600 acres of forest land, which has saved it $40 million dollars in the tertiary costs of constructing a treatment plant. As a result, these forests can't be harvested, because of the network of PVC pipes and multiple openings for those pipes, all of which fragment the forest habitat. The pipes also prevent the use of prescribed fire as a management tool.

Shifting budget priories and funding make it difficult to manage the forests' ecosystems, which often need long-term, consistent monitoring and management. For example, monitoring the health and longevity of the threatened gopher tortoise population requires consistent time, equipment and multiple years of study. The gopher tortoise is considered a keystone species, and is an indicator of longleaf pine ecosystem health. Certain management strategies are also more expensive; for example, establishing a longleaf pine forest requires intensive site preparation. More passive regeneration techniques, such as leaving seed trees behind on harvested sites, does nothing to speed up tree species conversion (for example converting slash pine to longleaf pine).

The North River runs through the base and a small section is eroding near the infrastructure for a power line. According to the base's resource manager, the amount of sediment delivered by the river has tripled in recent years and has accelerated the amount of dredging necessary to maintain adequate depth for the submarines. This is, in part, because of the base's large jetty, which extends into the East River to ensure depth for submarines, but which restricts the channel width, causing water to move faster and churn up more sediment.

A large dredge disposal area called Crab Island is used to deposit sediment spoils. The naval base borders the Crooked River State Park, which is also losing several feet of shoreline every year to coastal bluff erosion and contributing to sediment loads. The dredge piles have also become a seedbank source for invasive species introductions, which are a constant concern for the base. Chinese tallow has moved into the forest understory, where it excludes other native species. However, the base has a good population of pond spice (*Litsea aestivalis*). Within the base's facilities, trees and understory shrubs, such as the palmetto, are growing too close to existing structures, increasing the risk of wildfire. The navy outsources all of the landscaping maintenance around housing and facilities, so there are low levels of control on the landscaping. Establishing standards for landscaping using Firewise principles could make the base safer.

Coastal erosion in Crooked River State park is contributing ever-increasing sediment loads that the navy has to dredge to maintain base operations.

Strategies

The base burns its upland areas every 3-5 years through prescribed burns, with some areas that need more intensive management burned annually. Prescribed burns are challenging because the wind needs to be from the west toward the Atlantic Ocean to avoid smoke impacts on nearby residents. The Georgia Forestry Commission has created wildfire breaks to prevent unintended wildfire outbreaks from expanding.
The resource manager would like to move from slash pine (loblolly) forests to longleaf pine, but has minimal authority over the forestry program. There are some recent clear-cut sites where longleaf pine is being replanted. This has higher wildlife, recreational and aesthetic values compared to other southern pine species. Longleaf pine also has greater insect, disease and fire resistance; and longleaf yields higher forest product values compared to other pines (Franklin 2009). The base is engaged in a variety of monitoring programs to assess the natural resources and these programs have increased. Invasive species are surveyed and then, if applicable, controlled with herbicides. Beginning in 2017, at five year intervals, maritime forests have been surveyed using vegetation transects with help from the state of Georgia, which enables long-term vegetation changes to be observed.

The navy leases land where solar panels are sited. The land was formerly an upland longleaf pine forest.

Converting to a completely longleaf pine forest would help the threatened gopher tortoise, the population of which is currently under 300 individuals, which is not considered a viable population. Burrows are surveyed every five years and trail cameras monitor both tortoise movement and other species using the burrows.

The navy uses a variety of techniques to regenerate stands of slash pine and convert recently harvested stands to longleaf pine forest.

CASE STUDY: Cumberland Island National Seashore, National Park Service

Background

Cumberland Island National Seashore is a park and wilderness area just off the coast of southern Georgia and lies within the study area. Most of the island is managed primarily by the National Park Service. Today, the 36,000 acre park is split nearly evenly, with 18,000 acres of wetlands and marshland and 18,000 acres of upland. This upland is primarily maritime forest, but also pine forest, scrub-shrub and coastal dunes. Geologically the oldest part of the island, the north end is the highest point, rising 35 feet above sea level. This part of the island received its wilderness designation in 1983. Formerly a getaway location for the Carnegie family and their friends, the island's protection was established through numerous land agreements and conservation easements. Many of the historic structures on the island stand in good condition, but some are being reclaimed by vegetation, such as the hollowed-out and fire-destroyed Dungeness Ruins, one of the former Carnegie family mansions.

Today, the island is famous for its rich habitat. Live oak and laurel oak maritime forests cover its southern half, transitioning to a mix of longleaf and slash pine forests and shrub-scrub vegetation in the north. The island is a refuge and nesting ground for many coastal species, including sea turtles, which nest by the thousands on its protected shoreline.

Further north of the main island is another protected isle, Little Cumberland Island, which is a critical international migratory stopover for birds making the journey to and from their northern breeding grounds.

The fire management approach on the main island between 1972 to 2012 was fire suppression. However, the scrub vegetation and longleaf pine forests are fire dependent and the lack of fire began to take a toll on their ecology. The north end of the island, where wilderness was established, gets more wildfires, resulting in more longleaf pine in this section of the park.

A prominent problem on the island today are the many non-native species that were introduced onto the island over the years, mostly by the Carnegies and their friends, including, horses, pigs, cows and turkeys. Feral pigs are especially problematic and are very destructive, digging up the forest floor. The wild horse population is between 140-160 individuals and is a domestic breed that suffers from starvation because it is overpopulated and not native to the island. The last cows were free range grazing in the 1980s, but they are no longer present. Turkeys were brought over in the 1990s and released for hunting. Other wildlife, such as coyotes, have also found their way over to the island. Several tracts of the tung tree were planted by landowners for oil production in the early 20th century, but all of its parts are poisonous, including the fruit and the seeds, although some parts of the tree have been used for medicinal purposes in the past.

Wild horses were introduced onto the island by humans.

Park staff set up bait trapping stations to capture and euthanize feral hogs that damage the forest.

Challenges

Of all of the threats identified by park staff on the island, fire and storms are predicted to be the biggest threats over the next 40-60 years. The strategy for fire has mostly entailed wildfire suppression. Cabbage palm and saw palmetto, which are abundant in the maritime forests on the island, do not burn unless there are high velocity winds. This has resulted in the build up a thick duff layer and dense understory, with subsequent high fuel loads on the southern half of the island, which increases fire risk in the event of drought.

Recent hurricanes have battered the island, but the storms of 2016 and 2017 were very destructive to the island's trees. Hurricane Matthew (2016) knocked down many weak trees and the National Park Service contracted arborist crews to assist with cleanup. A year later, Hurricane Irma took down more trees. Additional impacts from salt spray have weakened and killed pine trees near the beach. Storms and sea level rise are also eroding Christmas Creek, which separates Big Cumberland Island from Little Cumberland Island. The continued channel erosion is widening the breach and further disconnecting these two forested habitat areas from each other.

Compounding the park's fire and storm challenges are outbreaks of insect pests. The invasive redbay ambrosia beetle spreads laurel-wilt disease, which is killing understory tree species. Indeed, most of the redbay canopy died in the mid-2000s. Another beetle, the eastern six-spined engraver beetle (or Ips beetle; *Ips calligraphus calligraphus*) is also killing pine trees. Both beetles are known as bark beetles because they burrow underneath pine bark, damaging the vascular tissue. They typically attack stressed or weakened trees, such as those weakened by salt-spray or fire.

Strategies

To overcome decades of fire suppression in a fire-dependent landscape, the former Fire Management Officer (FMO) rewrote the park's fire plan to split the island into management blocks that would allow for fires to burn. These blocks were also designated into 5-year fuel treatment plans. In some management blocks the park is using prescribed fire to open up the understory and encourage gopher tortoise habitat. These areas have burned three times in the last six years and have dramatically reduced understory biomass that can lead to highly damaging wildfires. Within the last five years, the prescribed fire treatment program has become more robust. However, because the NPS also has to protect cultural resources, areas of the park adjacent to historic structures or near private residents, such as the Plum Orchard houses, are treated by masticating (grinding up) understory vegetation to reduce fire fuel.

Park staff use prescribed fire on the island to control forest fuels; and to reduce fuels around residences and historical structures they mechanically mulch the wood.

Studies of invasive species on the island have revealed the presence of at least 70 invasive species. Salt cedars sit on the edges of shorelines and Chinese tallow is in the forest understory. Chinese tallow and other invasive vegetation are spot treated and have been mostly knocked back, while several tracts of tung trees planted by the Carnegies have been cut to stumps and treated with herbicides.

The island's feral hogs are voracious eaters that cause significant damage to the forest understory by digging and rooting. Over a 20-year period, the NPS staff have used planned hunts and trapping to reduce their population from a high of 5,000 hogs to a population of about 150 individuals that have, as yet, evaded eradication efforts.

One example of cultural artifacts that remain on the island is the historic Dungeness Ruins, a former mansion of the Carnegies. Several tracts of tung trees planted by the Carnegies have been cut to stumps and treated with herbicides.

The southern half of the island is predominantly maritime forest, which is a mix of live oaks, cabbage palms and saw palmetto.

Studies of invasive species on the island have revealed the presence of at least 70 invasive species.

In the 1990s, bobcats were reintroduced to support a healthy predator population on the island, but they are suffering the effects of inbreeding, so the park is planning to introduce new females to the island to add to their genetic diversity.

Cumberland Island exemplifies the difficulty of trying to manage what is both a cultural and natural landscape. There are some members of the public who do not like the use of prescribed fire, who feel the park staff should be feeding the wild horses or who do not like the idea of killing the hogs. Natural fires still have to be suppressed if they get to close to historic structures built by the Carnegies when the island was mostly their private enclave. Conflicts over when and how to manage the landscape will continue but the reintroduction of prescribed fire is making the landscape safer for people and more conducive to the native plants and animals that are endemic to this barrier island ecosystem.

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 strategies are only GIC's recommendations and may or may not be endorsed by the agency.

Georgia Forestry Commission (GFC)

Strategy 1: Partner with local governments to create storm-ready urban forests.

The GFC's Urban and Community Forestry Program is placing more emphasis on storm preparedness and recovery in the coming years. The program will invite communities to do more work in this area through technical support grants and partnerships.

Strategy 2: Encourage longleaf pine restoration.

The GFC works with forest landowners to plant longleaf pine on select sites to increase this forest community's presence in the coastal landscape. Historically, longleaf pine woodlands and savannas were the dominant forest type found on drier uplands of the coastal plain. Drier upland sites are highly sought-after locations for urban development, putting pressure on remaining forests and limiting opportunities for restoration.

Strategy 3: Educate landowners about good forest stewardship.

The development in Camden County has changed significantly and parcel size is trending downwards. GFC is promoting reforestation on appropriate sites and educating landowners on how to be better stewards of the land. Typical landowner sites they work with are between 20-40 acres, but they will work with landowners of any size parcel. Examples of better land use management strategies on which they educate landowners are how to manage prescribed burns for hazard fuel reduction and longleaf pine restoration.

Urban Forest Strike Team

The Georgia Forestry Commission's Urban Forest Strike Team (UFST) is a specially trained group of foresters who assist in communities in the aftermath of a major storm or disaster to identify which hazardous trees should be removed from public property. These foresters and city arborists are specifically trained to identify trees that meet the Federal Emergency Management Agency's (FEMA) criteria for hazardous trees and branches. By having them assess the damages to the urban forest, it increases the efficiency of the cleanup efforts and ensures a community follows FEMA's reimbursement guidelines. Additionally, deploying UFST has the added benefit of sparing trees that are not at risk thus preserving the numerous environment services such as shade, stormwater management and clean air they provide. Oftentimes a tree's risk can be mitigated with just proper pruning and not removal. Well-trained and experienced assessors can make these judgment calls in the field instead of debris haulers and cleanup crews who may not have the specialized training. Overall this prevents the unnecessary removal of trees and spares any further loss in tree canopy post-disaster during the cleanup phase. Follow this link: https://urbanforestrysouth.org/products/newsletters/articles/georgia2019s-urban-forestry-strike-team-helps-communities-affected-by-hurricane-michael for more information on the Georgia Forestry Commission's Urban Forest Strike Team response during Hurricane Michael.

GFC is partnering with landowners to restore longleaf pine forests on the Coastal Plain.

Strategy 4: Map the extent of "ghost forests" throughout the state.

The GFC's Forest Health Division is collaborating with other southern coastal states on a project to map the extent of ghost forests. Currently, not enough is known about the acreage that is considered ghost forest or forest land 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.

Strategy 5: Increase public awareness of the Firewise program.

The GFC has joined community meetings in Camden County to educate and increase public awareness of the national Firewise program. An agency goal is to conduct better outreach and education to Homeowner Associations (HOAs) about the Firewise approach to reducing fire damage risks.

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 South 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 with 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, necessitates more standards and education for developers, and homeowners' guidance on how to reduce risk to life and property.

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

It is important for communities located in these zones to establish standards for buildings and landscape design to fortify and create defensible areas around housing located in the wildland-urban interface (WUI). Landscaping and building standards should follow the National Firewise Program standards (Link: https://gatrees.org/fire-prevention-suppression/firewise-usa-program/). These provisions could be recommended for subdivisions, cluster housing or conservation developments in rural zones. For example, Jekyll Island, GA incorporated Firewise standards into their recent code update.

Photo courtesy of GFC.

Prescribed burn. Good fires prevent bad ones.

GIC Strategic Recommendations

(in addition to those identified by the agency)

■ **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 the Georgia Forestry Commission to place a voluntary conservation easement through the Working Forest Conservation Easement program; 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.

■ **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. Consider funding a Planner's Forest Toolkit similar to that created for South Carolina to help localities find and implement the most effective codes and policies for forests and urban trees.

■ **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.

Georgia Department of Natural Resources (DNR)

Strategy 1: Establish vegetated buffers to protect shorelines from sea level rise.

DNR is interested in protecting coastal shorelines from sea level rise and storms by planting vegetation to buffer the effects of wind and waves that are causing damage and erosion of habitats.

Strategy 2: Promote more salt tolerant and resilient native plants in landscaping.

Native plants are more resilient to local conditions which, in coastal areas, often translates to greater tolerance to salt spray. DNR, along with University of Georgia's Camden County Extension, are promoting the use of native plants in landscaping.

Strategy 3: Plan for ecosystem services in developments and landscapes.

A key issue is the sustainability of ecosystems and landscapes in relation to development. The agency wants to see a broader shift around the idea of regional and site scale landscapes. The landscape and its ecosystems are a function of many of the environmental benefits upon which coastal communities rely. These ideas need to be integrated into the planning process for communities.

Strategy 4: Update the Statewide Wildlife Action Plan (SWAP).

DNR is going to update the Statewide Wildlife Action Plan (SWAP) soon and the Satilla River has been identified as an important wildlife corridor in the state. The models and data produced by this study should be used by the state in the plan update and should incorporate the need to identify corridors that will still be viable after sea level rise has impacted the coasts.

Wild turkeys have taken up residence in a stalled development project in Camden County.

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

■ **Change rules for wetland percentages in acquired uplands that will be affected by sea level rise.** 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 in 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. It also fails to account for the expansion of suitable sites for coastal forest migration and restoration.

■ **Adopt a noxious weed law**. Georgia is one of four states in the United States that does not have a noxious weed law, which would give the state the authority to add to or remove species from a regulated list of plant and animal species in an effort to limit their introduction, sale and spread. The state law would also give guidance to local governments on what species to regulate and control, for instance in landscape ordinances and development plans. Georgia is particularly vulnerable because of its proximity to Florida, where many invasive species are migrating further northward as global warming expands their habitable range. Local governments should focus on controlling the spread of invasive species, not only because they exacerbate other environmental issues, such as flooding and storm impacts, but because they also destroy the aesthetic and natural areas that bring in tourist dollars. Local invasive species ordinances can be a tool to control their introduction and spread. Florida's Noxious Weed Law could provide a model for Georgia when it comes to developing regulations to protect its agricultural and natural assets from the harmful impacts of invasive species.[6]

■ **Improve guidance and rules for utility-scale solar siting**. Local governments requested better solar guidance, 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 as result of the solar panels. 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.*[7]

Results observed from other utility-scale solar sites show an increase in directed surface flow from the panels that causes gully formation and increased erosion. Georgia Tech's The Georgia Model Solar Zoning Ordinance Guide provides some guidance and standards for Georgia communities to consider when developing their own ordinance.

Preventing excessive runoff from large solar sites will help protect water qualiy in Georgia's coastal creeks.

University of Georgia Extension (UGA)

Strategy 1: Protect and map maritime forest extent.

The Georgia Department of Natural Resources mapped a small extent of maritime forest habitat within Camden County, as part of a broader assessment of habitats statewide in 2010. Additionally, the National Park Service mapped the extent of maritime forests on Cumberland Island National Seashore, as part of the Southeast Coast Networks' Inventory and Monitoring program. However, both of these efforts account for only a fraction of the existing maritime forest habitat, and so further efforts are needed to quantify its full extent and remaining acreage.

Strategy 2: Georgia Green Landscape Stewards Program.

The County Extension runs an educational certification program on the benefits of native landscaping, water quality, biodiversity, soils and low-impact design standards for the environment. Residents and businesses can get their properties or projects certified by reviewing educational components, evaluating the landscape using a scorecard and submitting the results to the extension service for review. For more on how to become a Georgia Green Steward, see: https://site.extension.uga.edu/georgiagreen/

Strategy 3: Georgia Native Plant Initiative (GNPI).

The GNPI is a networking and publicity program for native plants in Georgia. The initiative is a collaboration between growers, landscapers, garden clubs, vegetation managers and native plant societies to elevate the use and application of native plants in Georgia's landscapes. The University of Georgia State Botanical Garden hosts information on the Georgia Native Plant Initiative. The website provides information to the public on native plant nurseries, invasive species management, pollinators and how to landscape for native habitat. For more, see: https://botgarden.uga.edu/conservation-science/georgia-native-plant-initiative/

Strategy 4: Control air potato vine infestation and continue to provide education for invasive species management.

The extension service and Georgia Forestry Commission are partnering to fight the invasive air potato vine (Dioscorea bulbifera), a heart-shaped leaf vine that climbs and smothers trees and native vegetation in Camden County. Several control methods work, but the introduction of the biocontrol insect, the air potato beetle, is showing success at reducing the vine's population. In addition, the County Extension Service is a trusted and go-to resource for communities looking for more information on invasive species, pests and disease identification and management.

GIC Recommendations

The Georgia Native Plant Initiative has built a network and portal for educational resources; however, the website does not highlight how retailers are promoting this initiative to customers. One way would be to push further into the nursery retail space by expanding the collaboration with nurseries that do not identify solely as native plant nurseries. By partnering with these nurseries and encouraging them to showcase native plants at the front-facing retail areas with tags and information on the benefits of native plants, it could reach more Georgia residents. Another possible technique would be the development of a marketing campaign that had a greater outreach to the general public.

The Nature Conservancy (TNC)

Strategy 1: Developed a solar site suitability tool for Georgia.

The Nature Conservancy has developed a Georgia Low Impact Solar Siting Tool (GA LISST) in partnership with the Georgia Department of Natural Resources, University of Georgia and NASA DEVELOP to identify sites that are preferred for the impacts of solar development and sites that should be avoided completely because of sensitive habitats or such endangered species as the gopher tortoise. This tool is for the entire state and, while solar is not currently a major threat in Camden County, having tools like this can help localities direct solar development to more appropriate sites. For more, see: https://tnc.maps.arcgis.com/apps/webappviewer/index.html?id=f989b93ec9e54488ba925b478b7dab9e

Strategy 2: Camden County Resiliency Plan.

The Nature Conservancy secured a National Fish and Wildlife Foundation (NFWF) grant to work with local stakeholders in Camden County on flood resiliency. This project complimented the efforts of resilient coastal forests by elevating the role of trees and forests as green infrastructure strategies. The project had a robust local stakeholder and public engagement process that included such local governments and regional landholders as Kings Bay Naval Base and the Cumberland Island National Seashore. Through their planning process, short, medium and long-term projects were identified and ranked for implementation priority using a matrix tool and reported in a workplan. Several of the strategies identified by the local stakeholders are cross-referenced between this plan and Resilient Coastal Forests. A Flood Awareness Tool was developed and can be found at: https://www.co.camden.ga.us/1048/Flood-Awareness-Tool.

The Georgia Low Impact Solar Siting Tool (GA LISST) helps direct localities to sites that are preferred for solar development and avoid sites that have sensitive habitats or endangered species such as the gopher tortoise.

Strategy 3: Marsh migration site suitability tool.

TNC analyzed coastal habitat resiliency and developed a tool to identify the suitability for coastal marsh migration on the landscape in response to sea-level rise, existing development and projected future development (to the year 2100). A report "Resilient Coastal Sites for Conservation in the South Atlantic US" summarizes the study and methodology along with strategies to mitigate and adapt coastal marshes to future threats. For more, go to the Resilient Coastal Sites tool.

Strategy 4: Working with local governments in Camden County to update their CRS score.

TNC is developing a tool with the local governments in the study area to update and lower their existing Community Rating System (CRS) score with the Federal Emergency Management Agency (FEMA) by identifying and prioritizing undeveloped open space for flood management. By lowering the score, property owners can have their flood insurance premiums lowered, saving on the cost of insuring their property against flood damage. TNC will start to work with Camden County and the City of St. Marys to update their current CRS scores and work with the City of Kingsland which is enrolling in the program now. A link to the program can be found here: https://crs.tnc.org/.

Sentinel Landscapes Partnership

Strategy 1: Permanently protected Cabin and Ceylon Bluffs and other priority areas.

According to the Sentinel Landscapes Partnership website:

> *The Sentinel Landscapes Partnership is a coalition of federal agencies, state and local governments, and non-governmental organizations that works with private landowners to advance sustainable land management practices around military installations.*

The partnership in Camden County (which includes The Nature Conservancy, the Kings Bay Naval Base, Open Spaces Institute and GA DNR) permanently protected two high-valued forest cores in the study area, Cabin Bluffs and the Ceylon tract, starting in 2017. These parcels contain a mix of important habitats: maritime forests, longleaf pine forests, and freshwater and saltwater tidal marshes, along with supporting rare and threatened species, such as the gopher tortoise, wood storks and red-cockaded woodpeckers. See: https://sentinellandscapes.org/ .

Strategy 2: Manage two cost-share prescribed fire programs for landowners.

The partnership has started a pilot project through Natural Resources Conservation Service grant funding with the Longleaf Alliance to run two prescribed fire cost-share programs. The goal is to increase the use of prescribed fire as a management tool by private landowners to reduce forest understory fuels. To learn more about the program, see: https://longleafalliance.org/wp-content/uploads/2021/09/GSL-FY22-Cost-Share-Program-Flyer.pdf

Georgia Department of Transportation (GDOT)

GIC Recommendations

- **For road planning, use Georgia's forest cores data to prevent bisecting cores by rerouting (if possible) around important, high-value habitat for the proposed Highway 17 bypass.**
GDOT is considering creating a bypass to reroute truck traffic around the City of Kingsland west of Highway 17. This area west of the city has several forest cores that could be impacted, with some moderately ranked as of important ecological value. GDOT should consult the GIS data and maps produced by this study when delineating the route for the new bypass to avoid bisecting, and thereby eliminating, key coastal forest habitat.

- **Acquire or restore existing habitat cores for mitigation projects.**
GDOT 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 GDOT use its mitigation funds wisely. Since a new bypass is being proposed around the City of Kingsland, mitigation could support local coastal forest habitat restoration.

- **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 be designed for the proposed Highway 17 bypass and mitigate some of the potential wildlife-motorist interactions from the project.

Satilla Riverkeepers

Strategy 1: Maintain wide forest buffers along major river corridors.

Forest buffers 600 meters or wider offer the best protection from flood waters and provide the optimal safe passage for species to migrate along corridors. They also protect the viewshed of the river for recreational boaters and paddlers. The Satilla River is an important regional water trail and several communities highlighted it for eco-tourism and recreational value.
The Satilla River Project should work with landowners to encourage forest buffer plantings along the river.

The Satilla River is an ecological, economic and cultural resource for the region.

Next Steps

GIC will have completed the resilient forest strategic recommendations for all three states – Virginia, South Carolina and Georgia – by Spring, 2022. A guide to planning for resilient forests will describe 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 that are "stove piped" between one another and within their own agencies may not be focused on the severity of threats when issues are seen as singular. Agencies are often divided by issue, such as fire, invasive species, recreation, floodplain management or natural areas. 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. The causes of the many threats examined need to be considered together, in order to arrive at solutions.

> **"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. 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 whole region, as a result of this work. Longer term outcomes for this work will see the adoption of resiliency as 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. As comprehensive plans are updated, this work must also make its way into 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
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/.

Georgia Audubon Society Conservation Grants: Annual Grants to Fund Efforts for Bird Habitat Conservation, at: https://www.georgiaaudubon.org/habitat-restoration-fund.html

Georgia Department of Natural Resources:
https://gadnr.org/grants

- Coastal Incentive Grants Program
- Georgia Conservation Tax Credit Program
- Georgia Outdoor Stewardship Program
- Land and Water Conservation Fund (National Park Service)
- Outdoor Recreation Legacy Partnership Program
- Recreational Trails Program

Georgia Emergency Management and Homeland Security Agency:
https://gema.georgia.gov/plan-prepare/hazard-mitigation

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

Georgia Environmental Protection Division:
https://epd.georgia.gov/outreach/grants

- Regional Water Plan Seed Grants
- Nonpoint Source Implementation Grant

Georgia Forestry Commission:

- Georgia ReLeaf Program— funding for tree planting or tree giveaway projects that benefit veterans, contribute to tree equity, or projects in storm-damaged communities. https://gatrees.org/urban-community-forestry/georgia-releaf-grant-program/
- Making the Shade Program— funding for trees at playgrounds and schools. https://gatrees.org/urban-community-forestry/making-the-shade-program/
- Community Forestry Assistance Program— https://gatrees.org/urban-community-forestry/community-forestry-assistance-program-cfap/
- Cost Share and Incentive Programs— https://gatrees.org/forest-management-conservation/cost-share-incentive-programs/

Georgia Sentinels Landscape Partnership
Prescribed Fire Cost-Share Program: https://longleafalliance.org/wp-content/uploads/2021/09/GSL-FY22-Cost-Share-Program-Flyer.pdf. Partnership with the Longleaf Alliance to increase the number of acres of prescribed fire used in forest management.

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

Natural Resources Conservation Service (NRCS)

- Conservation Stewardship Program: Conservation Easement Grant Program with the Natural Resources Conservation Service (NRCS).
- Agricultural Conservation Easements Program: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/

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://gadnr.org/lwcf

Robert W. Woodruff Foundation:
https://woodruff.org/grants-program/program-areas/environment/

USDA Natural Resources Conservation Service Georgia: https://www.nrcs.usda.gov/wps/portal/nrcs/main/ga/programs/financial/

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

U.S. Fish and Wildlife Service:
Partners for Fish & Wildlife (PFW): 75-90% cost share to landowners for habitat improvements. https://www.fws.gov/program/partners-fish-and-wildlife

Waters for Georgia Program:
https://www.georgiapower.com/community/apply-grant/environmental-water-grant.html

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