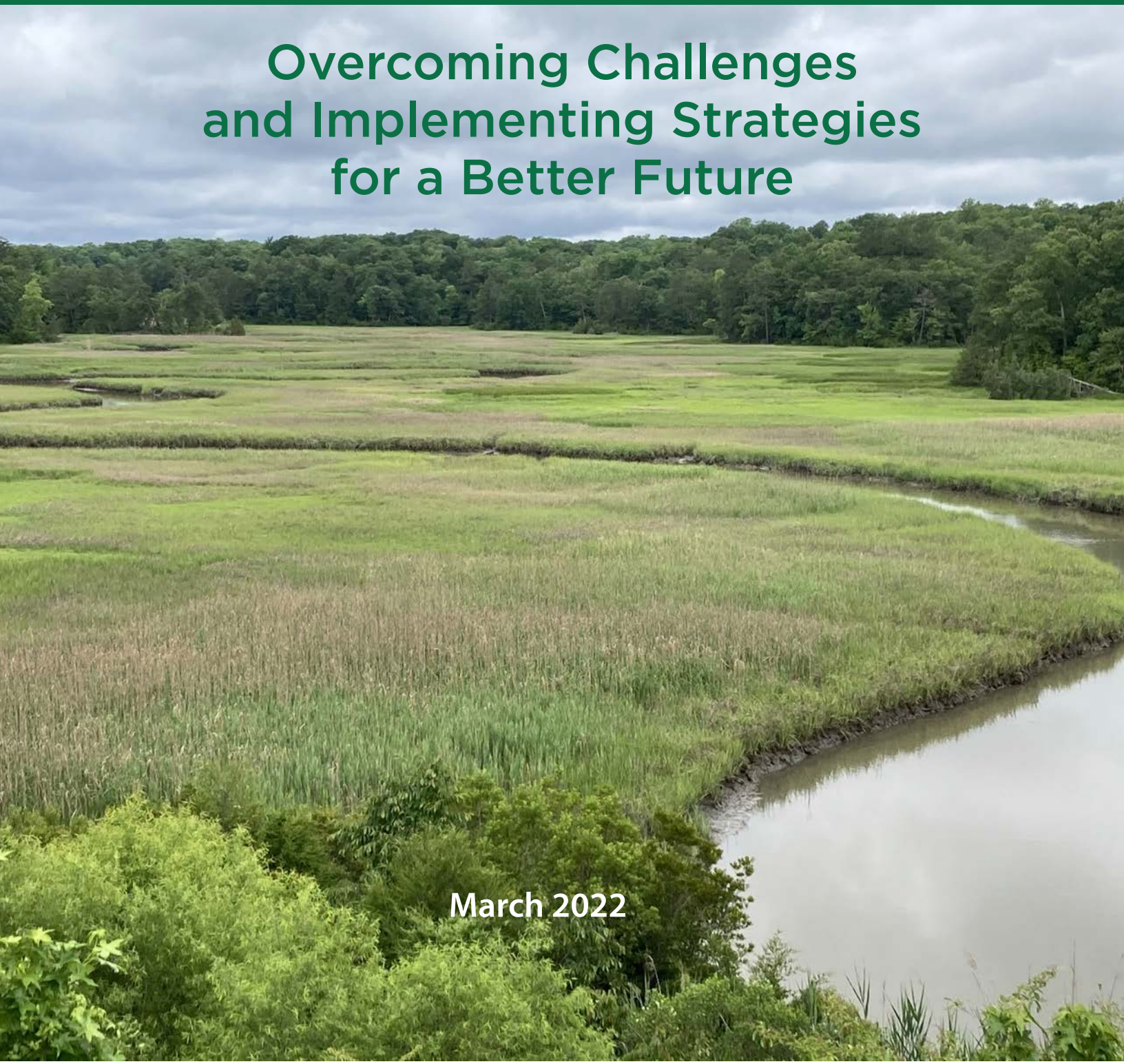
RESILIENT COASTAL FORESTS OF VIRGINIA

Overcoming Challenges and Implementing Strategies for a Better Future



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provided expertise and collaboration on this project.

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Gloucester County
New Kent County
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Wetlands Watch
Tidewater Soil and Water Conservation District
Middle Peninsula Planning District Commission (PDC)
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Contents

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. The Commonwealth of Virginia 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 Virginia Department of Forestry 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).

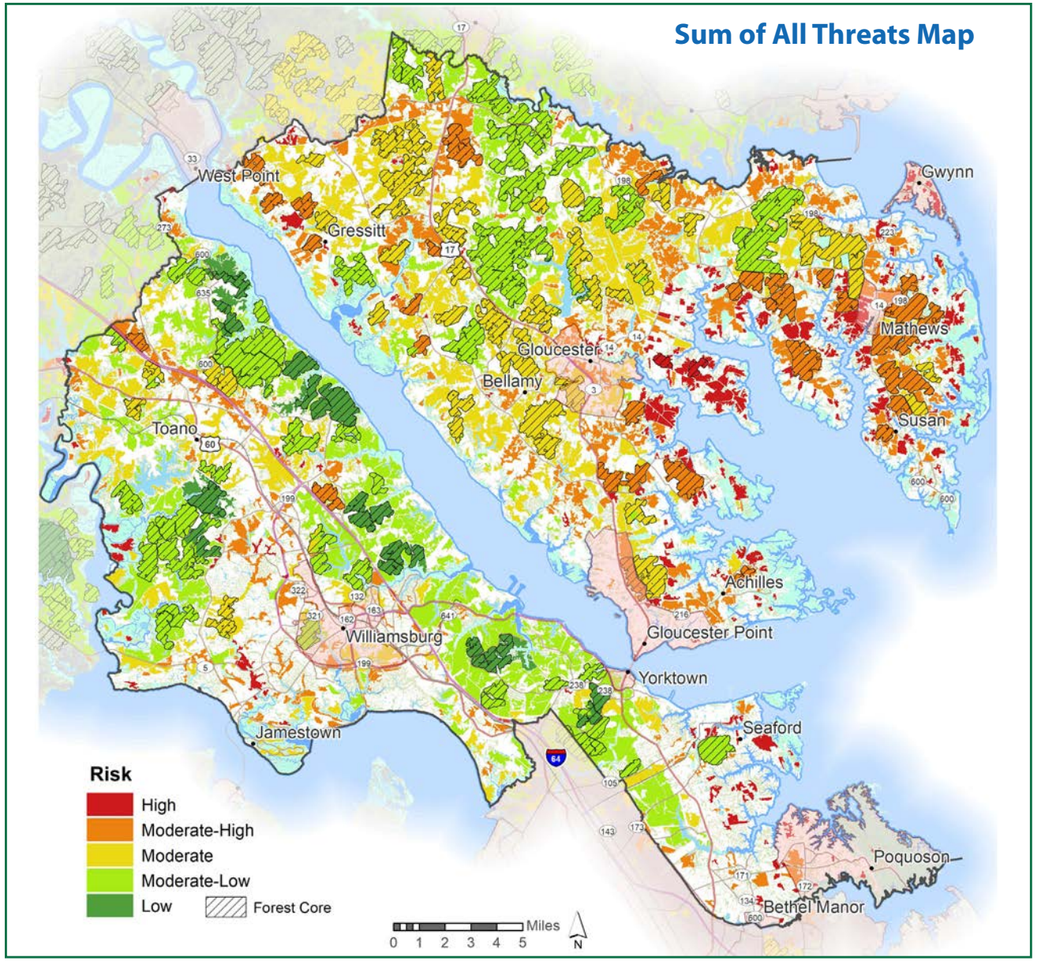
New risks from unprecedented challenges such as sea-level rise and climate change are impacting our forests, while growth along the U.S.'s coastal areas is leading to forest clearing. More than 29% of the total U.S. population, lived in coastal areas in 2017, a 15.3% increase since the year 2000. Weather-related 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. 12,008 acres (3%) of coastal forest in the study area are at HIGHEST RISK from multiple threats. 127,939 acres 54% 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 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 790,000 tons of carbon annually while storing 32,500,000 tons more of carbon – a key strategy for slowing climate change. They are also capturing 2.5 billion gallons of stormwater for every 2-inch rainfall event, while supporting 330 species of terrestrial vertebrates, 10 federally or state listed threatened or endangered species, and providing for a forest economy with $10,425,000 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 a 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 the recommended management strategies to mitigate or adapt to future impacts.

The study examined a section of Virginia's coastal forest that covered six counties and eight towns and cities within the lower watershed of the York River.

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 who will develop resource management strategies and actions to adapt to or mitigate the impacts of those threats.

STUDY AREA FAST FACTS

407,869
Acres in Coastal Forest Study Area

237,501
Acres of Total Forest Cover (58%) of the study area.

127,939
Acres of Forest Areas at Highest Risk — 54% of Coastal Forests

23,228
Acres Total Urban Area (Cities and Towns)

10,678
Acres of Urban Tree Canopy

218,002
Total Population of Counties and Incorporated Cities

While many of our Atlantic Coastal forests have been cleared many times over: first for fuel or game 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 for 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 is a rare 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

Forestry is Virginia's third leading industry, generating more than $21 billion and employing more than 108,000 people.

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

Forests provide opportunities for recreation.

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.

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. 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 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. 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 Southeastern region 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. According to the Southern Region of the U.S. Forest Service, "This management challenge is exacerbated by rapid population growth, rapid expansion of wildland urban interface (WUI) areas, and the fragmentation of land ownership in the region."

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

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

> *"Climate change will likely increase the risk of drought in some areas and the risk of extreme precipitation and flooding in others. Increased temperatures alter the timing of snowmelt, affecting the seasonal availability of water. Although many trees are resilient to some degree of drought, increases in temperature could make future droughts more damaging than those experienced in the past. In addition, drought increases wildfire risk, since dry trees and shrubs provide fuel to fires. Drought also reduces trees' ability to produce sap, which protects them from destructive insects, such as pine beetles."*

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." 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.

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

However, it's important to understand that forest 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 killed as the result of multiple threats is more susceptible to a high-severity fire, which could wipe out that forest entirely. Fire could also leave it more vulnerable to colonization by invasive plant species, which may, in turn, affect its ability to regenerate. Another example 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 behaviour 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.

Pine beetles infest a forest stand in Gloucester County.

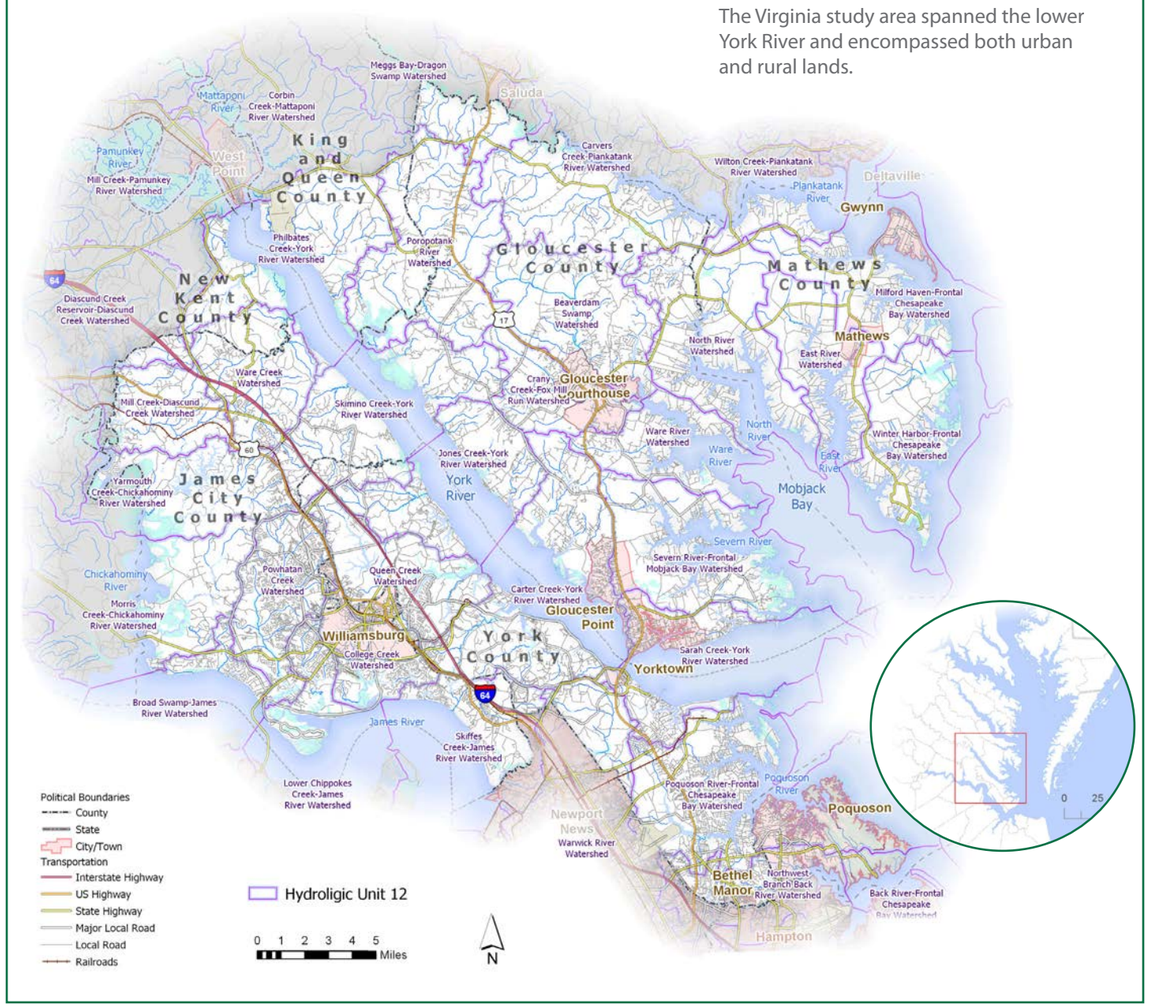
Virginia Study Area

The study area for Virginia was composed of six counties (Gloucester, James City, King and Queen, Mathews, New Kent and York Counties) either entirely or partially and eight towns or cities (Bethel Manor, Gloucester Courthouse, Gloucester Point, Gwynn, Mathews, Poquoson, Williamsburg and Yorktown) within the lower watershed of the York River. The study area boundary was chosen by the Virginia Department of Forestry and contains a mix of rural, suburban and urban land uses.

The counties and towns north of the York River are predominantly rural in character, while the counties, towns and cities south of the York River experience higher density and exhibit more urban growth patterns. 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 Virginia Resilient Coastal Forest Study Area

The Virginia study area spanned the lower York River 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 Virginia. 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, several public meetings were held to introduce residents to coastal forests and the challenges they were facing. 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 multitude of communities in the study area. An additional challenge for community engagement was the size of the study area, encompassing as it did six counties and eight cities and towns spread over a wide area that was, in turn, separated by the York River.

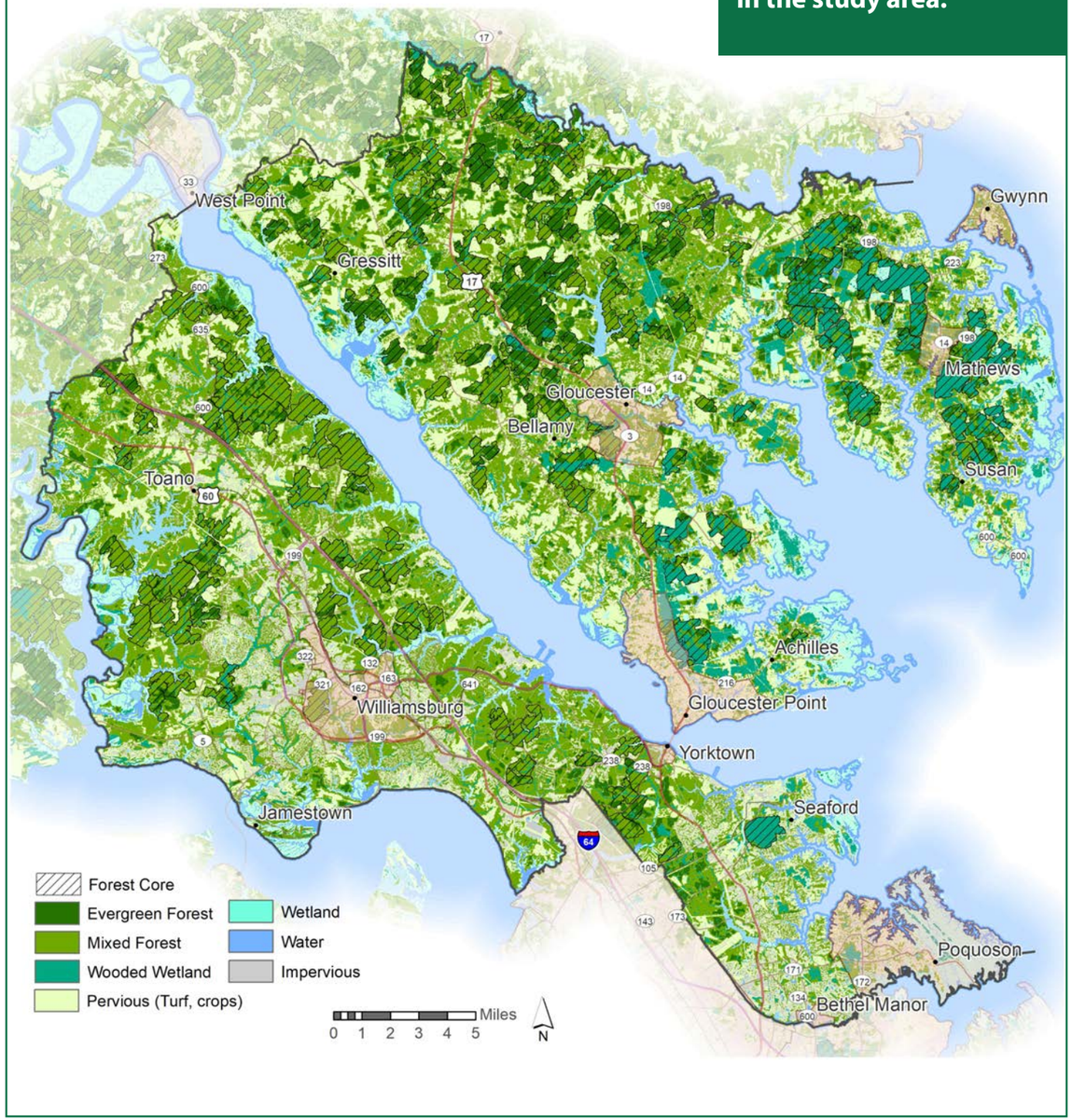
Local knowledge of the forests was key to identifying threats, challenges and opportunities in the study area.

Modeling Forest Cores

FAST FACT:

There are a total of 237,501 acres of forest in the study area.

Land Cover Map



Fifty-eight percent of the study area is currently covered by forests, with mixed forests comprising the predominant forest type in the region, at 41% (see Table 1).

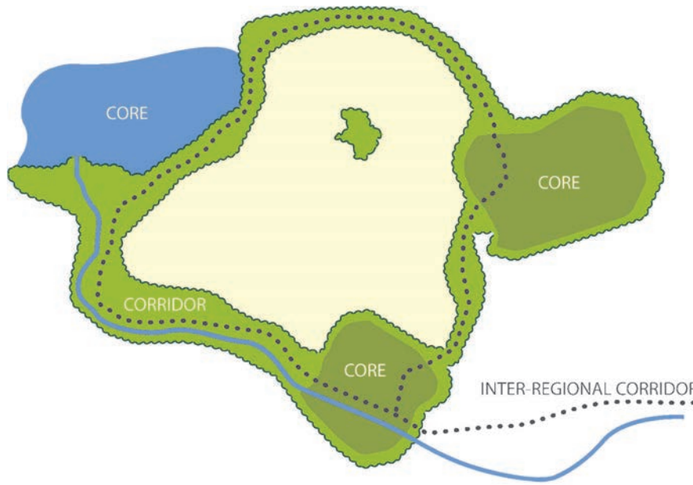
Table 1: Total acres and percent of land cover in the study area, by forest type

Land Cover Type	Acres	% Cover
Evergreen Forest	34,201	8%
Mixed Forest	166,284	41%
Wooded Wetland	37,016	9%
Wetland	31,041	8%
Pervious	90,644	22%
Impervious	32,761	8%
Water	15,922	4%
Total	**407,869**	**100%**

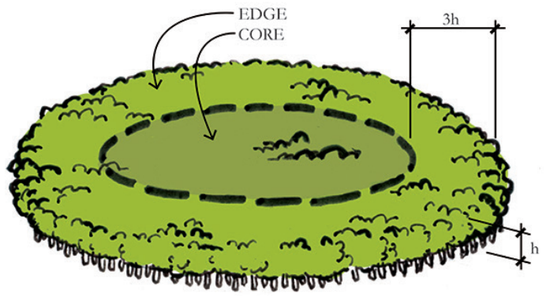
Source: Virginia Natural Landscape Assessment (VaNLA)

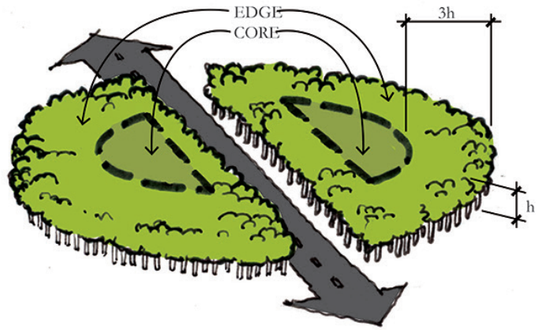
Forest cores were modeled using Virginia Natural Landscape Assessment (VaNLA) land cover data. To be a core, the forest should encompass more than 100 acres of intact woodland – large enough to provide adequate foraging and nesting habitat for interior forest dwelling birds and to support a range of 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.



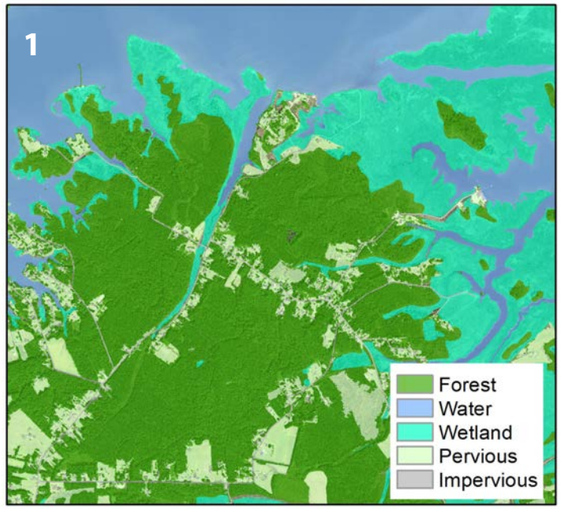
Large, intact forest cores are less impacted by disturbances and can better support area-sensitive and extinction-prone species. When roads bisect habitats the remaining areas may be too small to be considered a core.



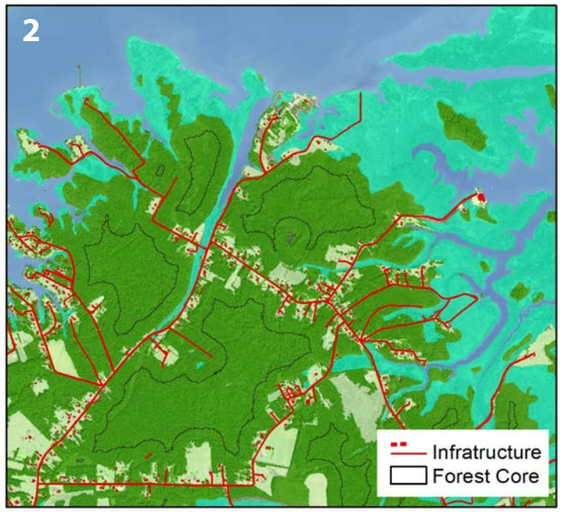


Edge area = Average tree height (h) X 3
Core = Total area - Edge area
Ideally, Core ≥ 100 acres

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).

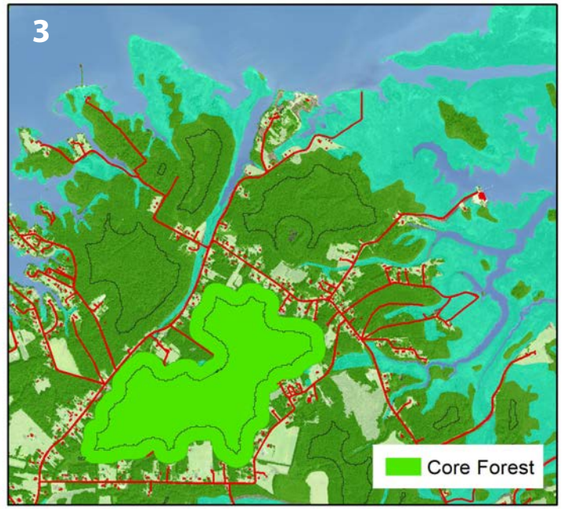


Land Cover



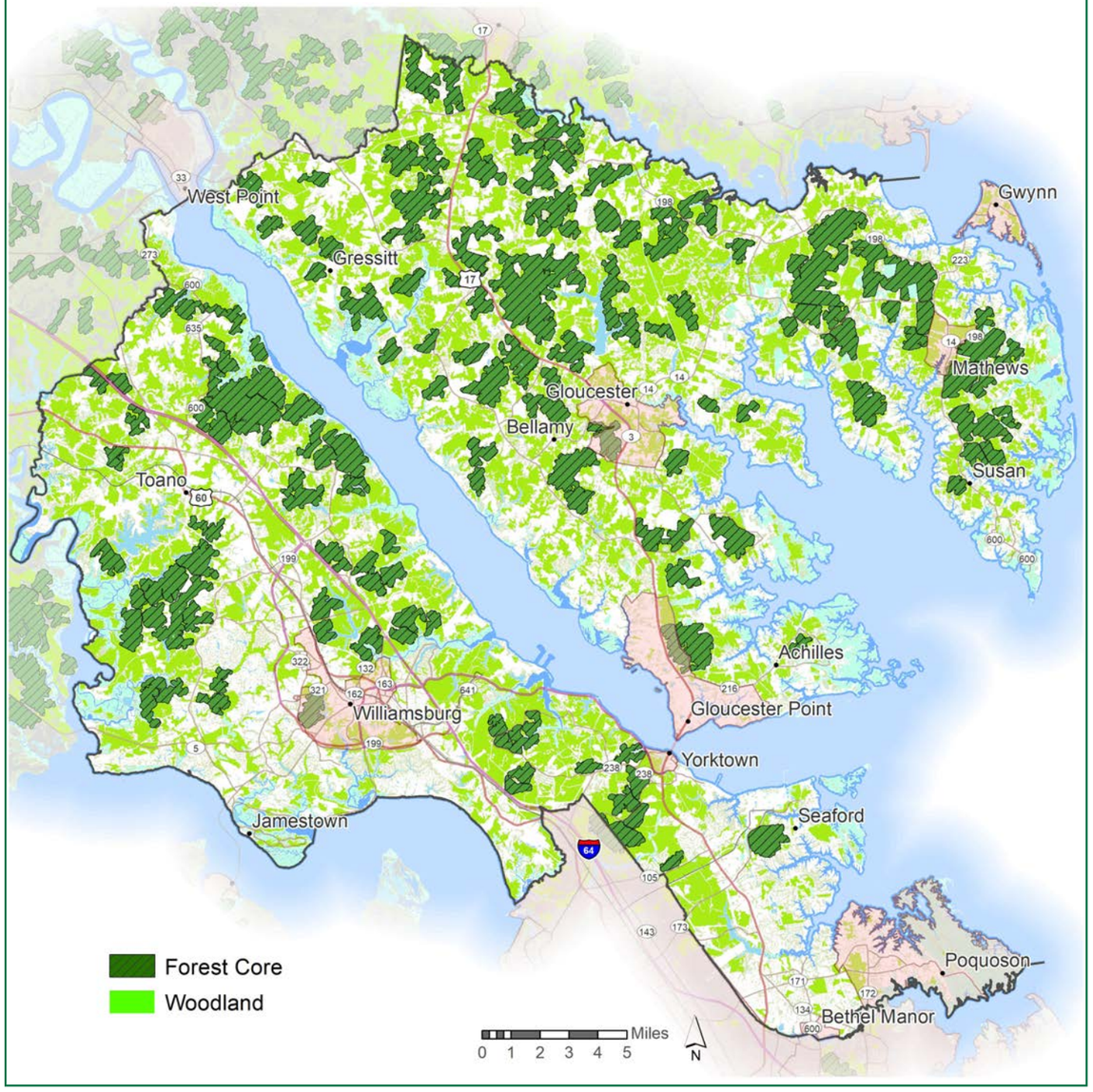
Forest are buffered in 300 ft from forest edge and signifigant infrastructure.

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



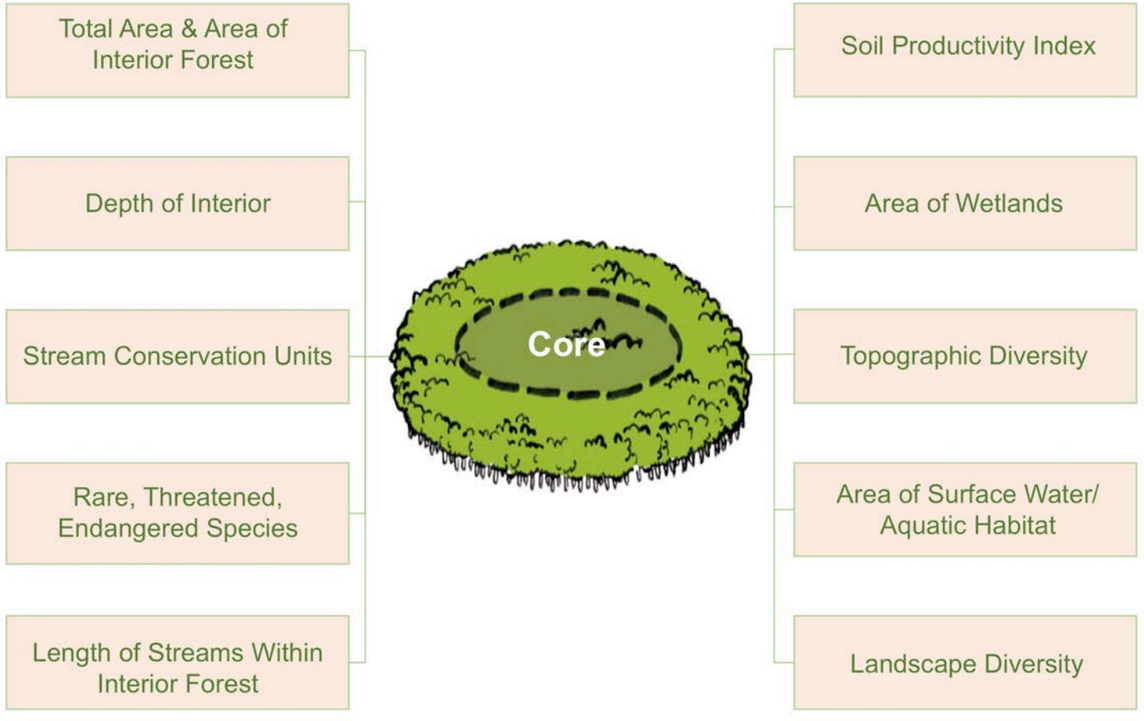
Ranking Coastal Forests

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.

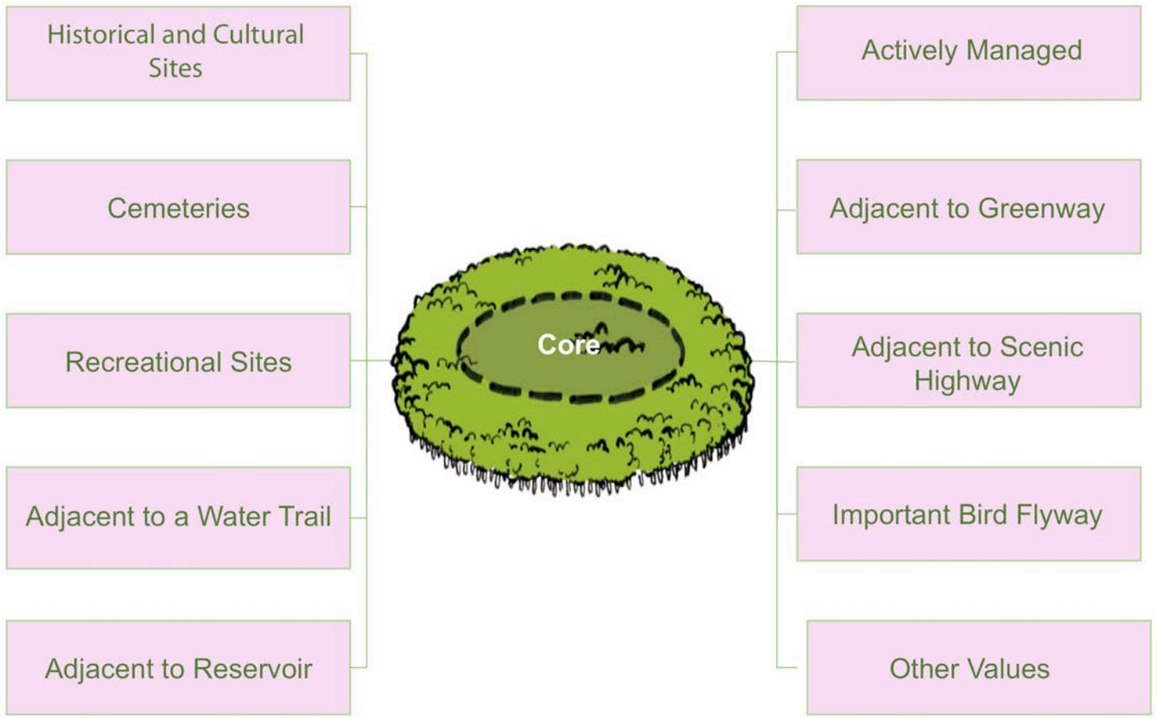
Types Of Data Used To Score The Environmental Ranks For Forest Cores.



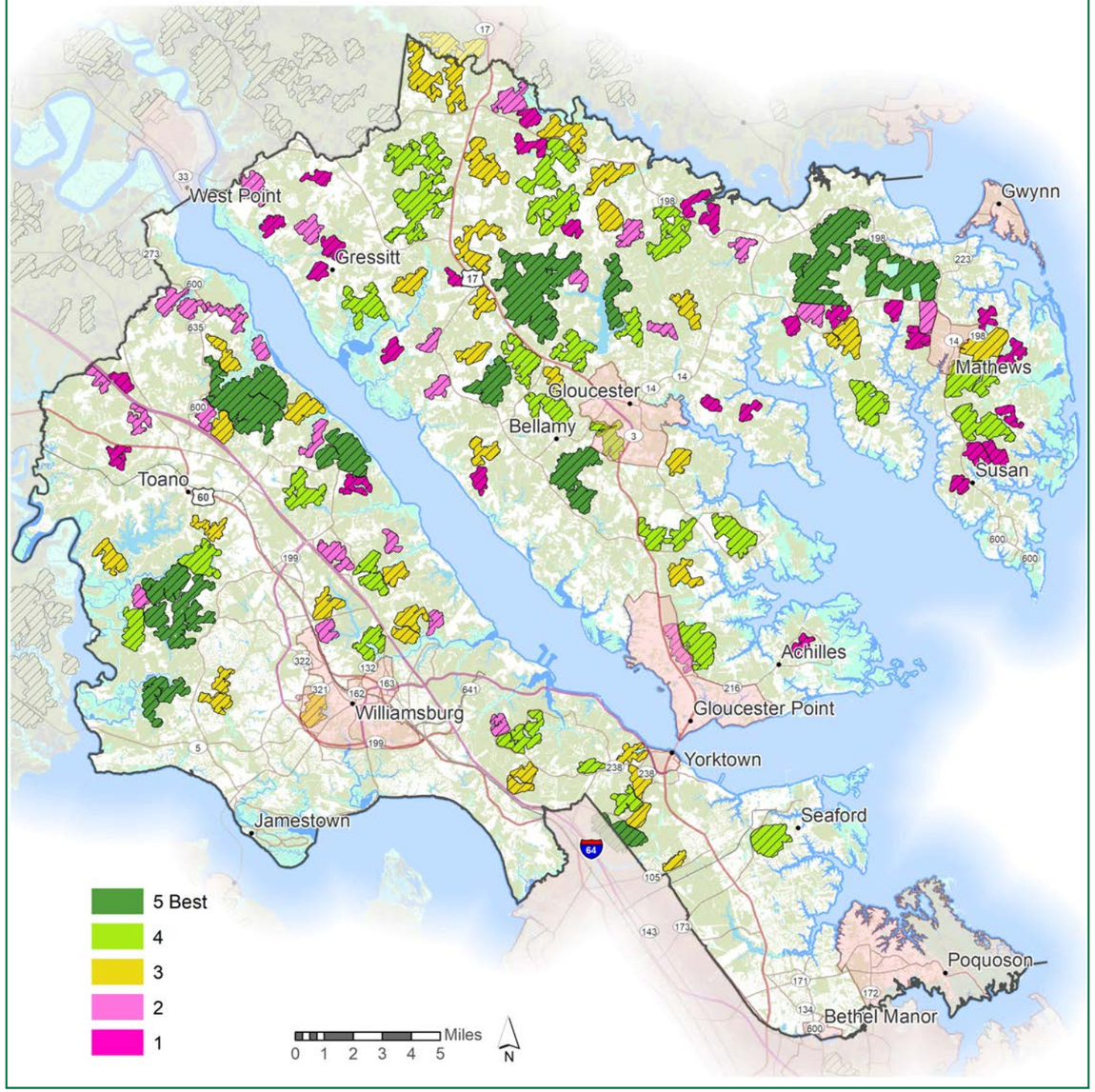
Cultural (human values) rankings

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.

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 included 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 their 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 our 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 it 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 the southeastern tip of Virginia. For more see https://hgic.clemson.edu/factsheet/crapemyrtle-bark-scale/

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

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

Urban canopy makes towns cooler and more livable.

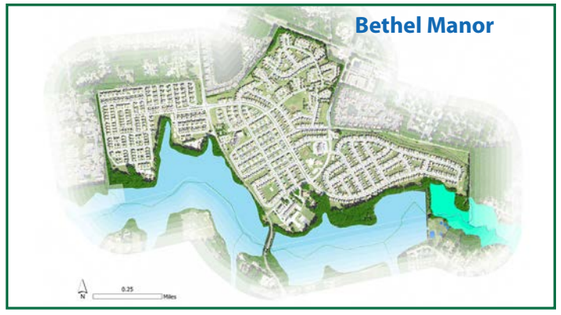
planted and to allow municipalities to strategically plan for future plantings. Tree canopy values for each city or town are shown in Table 2.

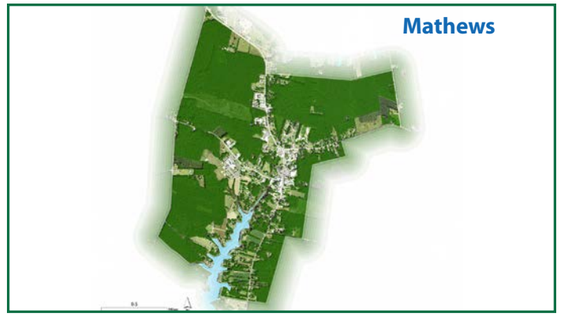
Values for the area of urban forests can also be used to calculate the many community benefits or "ecosystem services" they provide, such as reducing air and water pollution, sequestering carbon, mitigating urban heat island effects and reducing stormwater runoff and flooding. The mapped canopy, along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

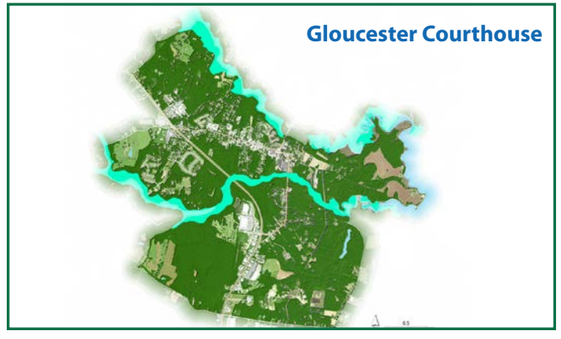
Table 2: Current tree canopy (in acres, percent) and potential tree canopy (percent).

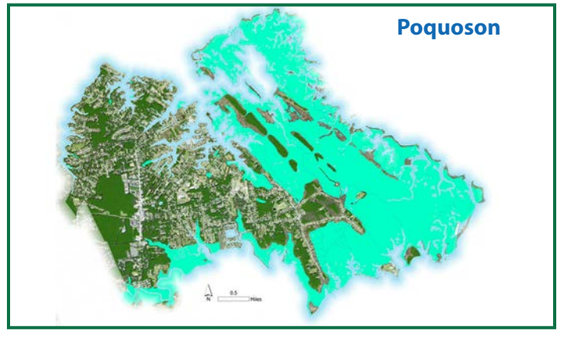
Locality	Tree Canopy (TC) (Acres)	Current %TC	Potential %TC
Bethel Manor	25	14.1%	34.1%
Gloucester Courthouse	2,633	63.9%	77.5%
Gloucester Point	1,895	42.7%	73.9%
Gwynn	619	52.7%	84.3%
Mathews	886	69.7%	83.6%
Poquoson	1,578	40.2%	61.1%
Williamsburg	2,845	61.2%	68.9%
Yorktown	197	61.3%	74.5%

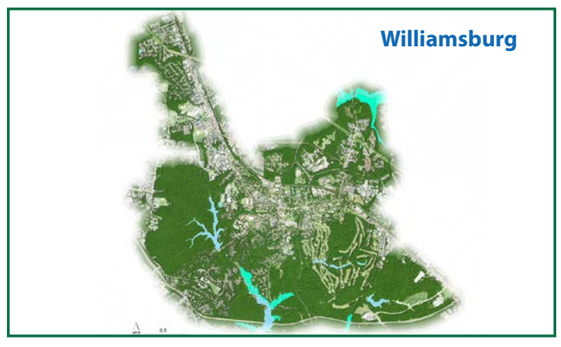
Local Tree Canopy Maps

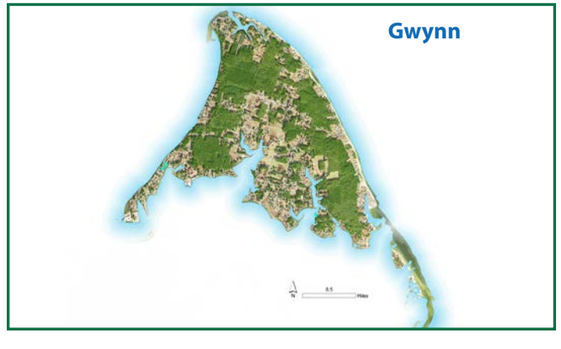












The Benefits of Coastal Forests

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	**790,000** tons of carbon sequestered annually **32,500,000** tons of carbon stored (total)
Air Quality	**Substances removed from the atmosphere** **75,400 lbs.** of carbon monoxide **1,300,000 lbs.** of nitrogen dioxide **14,500,000 lbs.** of ozone **590,000 lbs.** of 2.5 micrometers particulate matter **2,800,000 lbs. per year** 10 micrometers particulate matter **2,200,000 lbs. per year** sulphur dioxide
Water Quality	**Pollutants prevented from reaching streams and rivers** **731,000 lbs. of nitrogen** **46,600 lbs. of phosphorous** **17,900 tons of sediment** **761 miles of streams have forest buffers**
Flooding	**2.5 billion gallons** of stormwater per 2-inch rainfall event captured
Biodiversity	**330 species** of terrestrial vertebrates supported **10 federally or state listed threatened or endangered species protected**
Forest Economy	**$10,425,000** worth of wood products
Culture and Heritage	**61** 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

New Development

Storm Damage

Forests cleared for Solar

Wildfires

Invasive Vines

SEA LEVEL RISE

2,000 acres

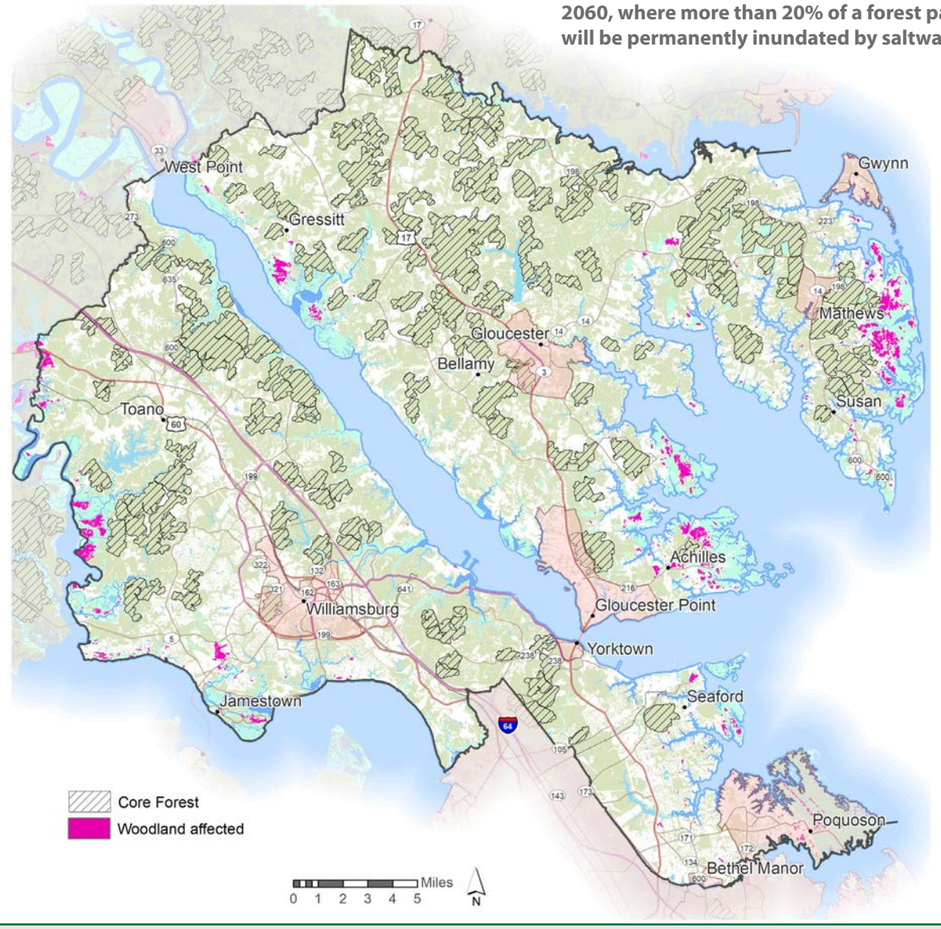
of coastal forest are at HIGH RISK of sea level rise by the year 2060.

Sea level is rising more rapidly along Virginia's shores than in most coastal areas because the land is also sinking. As the oceans and atmosphere continue to warm, sea level along the Virginia coast is likely to rise between sixteen inches and four feet in the next century (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 3 feet of sea-level rise by the year 2060, obtained from data at the Sewell Point 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 3-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".

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

The EPA report also raises concerns about the infiltration of salt water into freshwater systems, leading to the salination of freshwater aquifers and extensive die-back of coastal forests:

> *As sea level rises, salt water can mix farther inland or upstream in bays, rivers and wetlands. Because water on the surface is connected to ground water, salt water can also intrude into aquifers near the coast. Soils may become too salty for farms or forests. For example, some of the freshwater swamps along the York River's tidal tributaries have standing dead trees that were killed by saltwater intrusion made possible by rising sea level* (EPA 2016).

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

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

Rising seas are killing coastal forests.

tidal wetlands. This poses significant challenges for coastal riparian forests along tributaries that feed into the Chesapeake Bay. These riparian forests are a critical component in achieving the water quality goals in the State's Watershed Implementation Plan (WIP) for the Chesapeake Bay. 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 this future change and loss. Virginia Department of Forestry staff should start using sea-level rise maps now in forest planning with landowners 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.

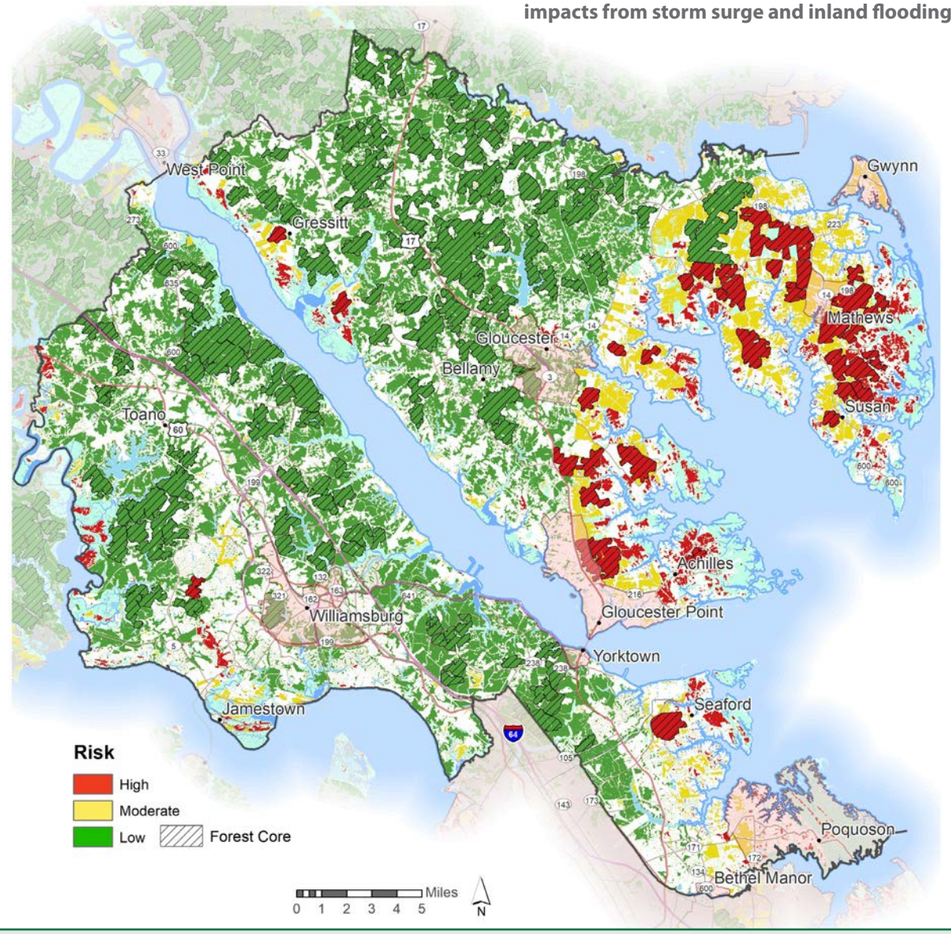
STORMS

42,609 acres
of forest (18%) 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.



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

Storm surge models from the National Oceanic Atmospheric Administration (NOAA) show saltwater surges reaching up to three miles inland from the coast. York 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 Chesapeake Bay, 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 Bay.

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, 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.)

Salt spray and prolonged flooding stress trees and ultimately leads to their death, causing the phenomenon called "ghost forests."

WILDFIRES

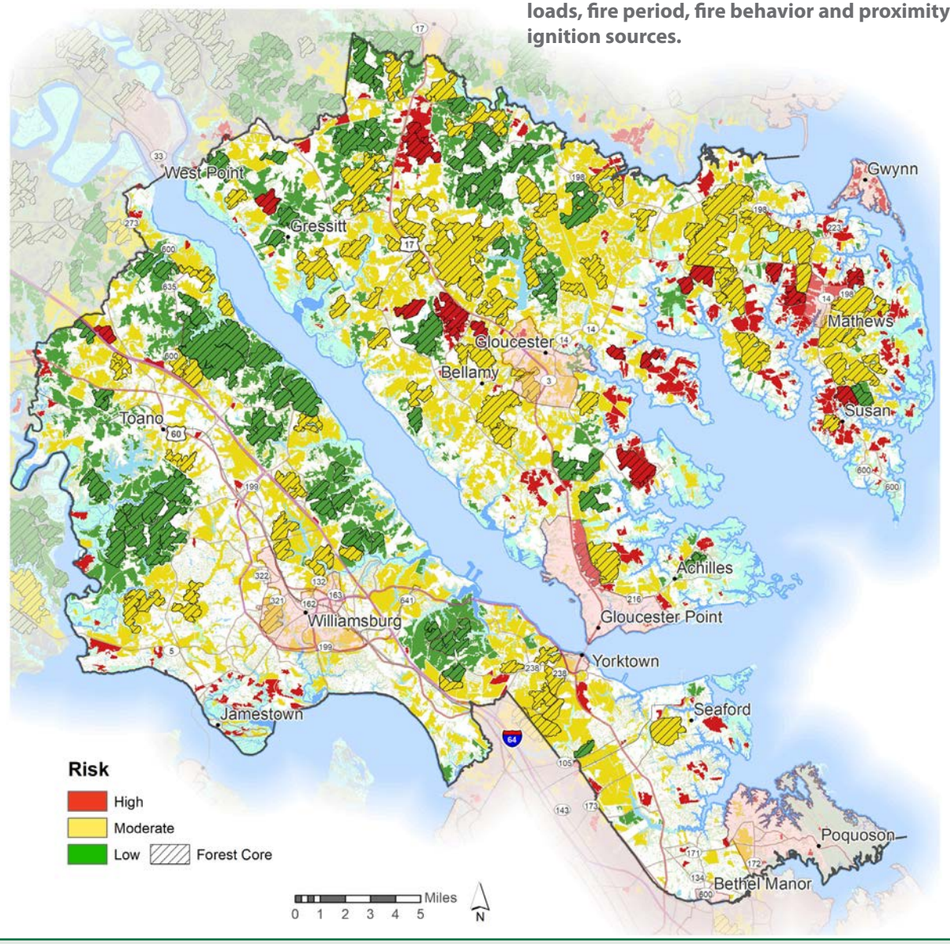
21,573 acres

(9%) 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 or 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.

Coastal Forests at Risk of Wildfire

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



Severe wildfires kill trees not adapted to withstand high heat, wiping out stands of forests.

> **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.**

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).

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).

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

DEVELOPMENT

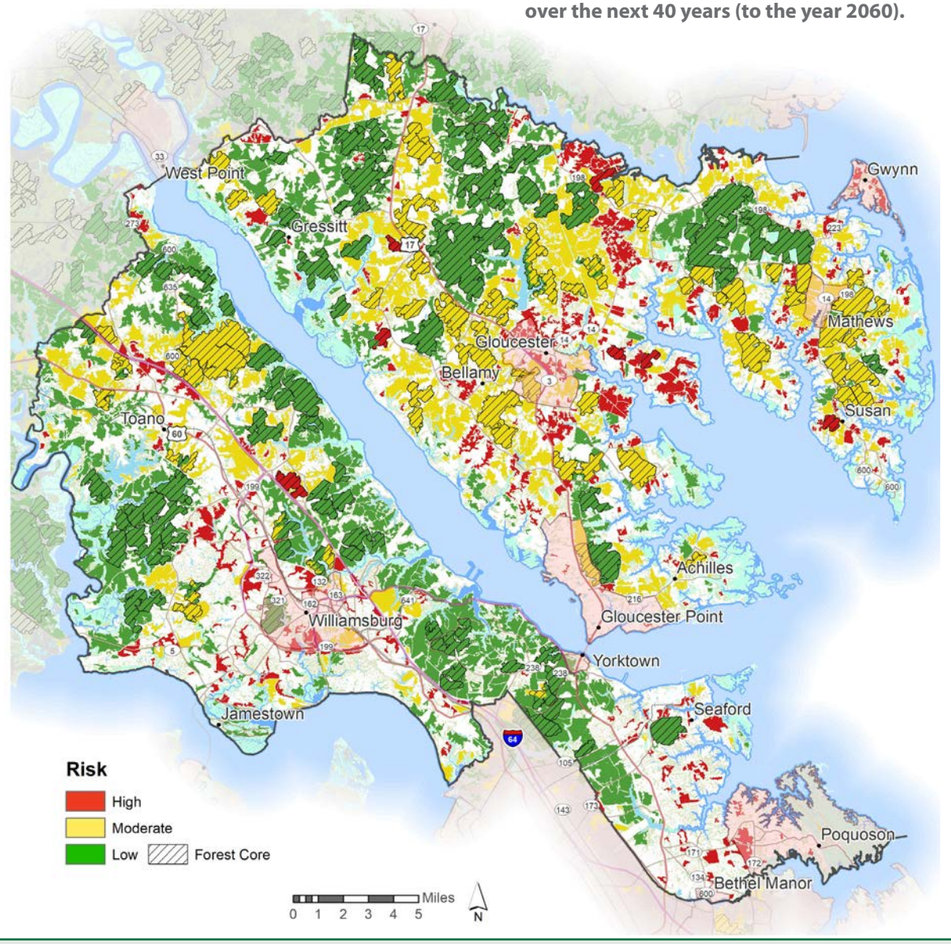
21,757 acres

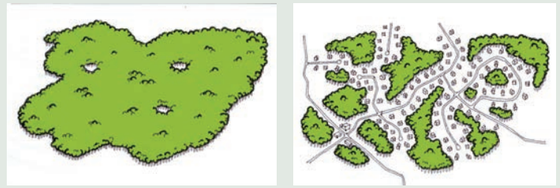
(9%) of the study area are at HIGH RISK from development pressure.

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 Chesapeake Bay and 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, 2015 land cover included more than 33,000 acres of impervious surfaces. The continued conversion of forest land to impervious surfaces will further exacerbate many of the environmental challenges from stormwater runoff, urban heat island and habitat loss.

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 4,034 land parcels of between 10–50 acres, which make up more than 79,803 acres (3% 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 gicinc.org.

GIC Recommendations

- Establish appropriate zoning to protect tees 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.

DEVELOPMENT

Coastal areas are experiencing increased development and population growth.

Cluster Development Ordinance

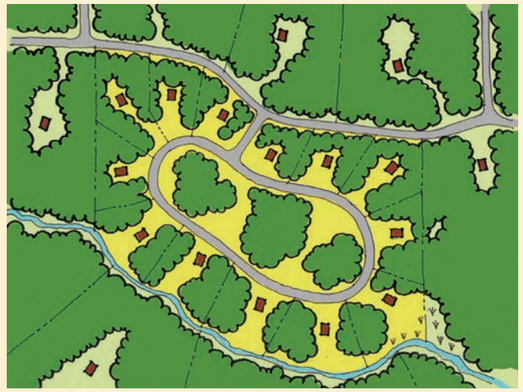
The State of Virginia changed the cluster development law in 2006 and again in 2011 to make it allowable as a by-right development in certain high-growth areas, while limiting the ability of localities to exclude sensitive habitats or resource protection areas in density calculations, mapping or inventorying sensitive features, such as steep slopes or buffers, or prohibiting land disturbance in designated open space. Any localities with a land use zoning ordinance that allowed for clustering prior to June 2004 was grandfathered in, but localities who adopt the new code must prohibit identification of sensitive areas, such as steep slopes or designated buffers on the site plan. This means that many localities have to violate their own ordinances, such as steep slope protections, in order to adopt the newer state code.

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 (wetlands, floodplains, 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.).

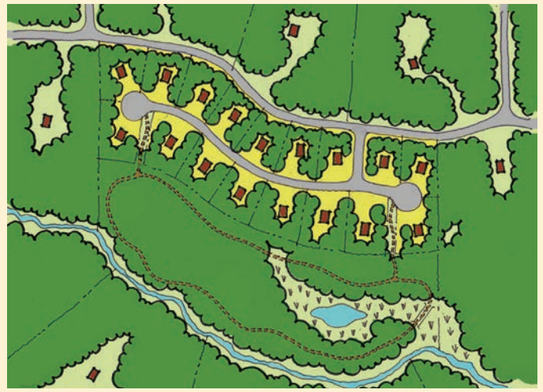
The cluster ordinance should also limit the percentage, or exclude altogether, stormwater best management practices (BMPs), such as dry ponds, from the open space calculation and limit developed open space, such as tennis courts, golf courses and athletic fields.

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 priority habitats, such as protecting mature forest or connectivity corridors. A few example standards used by James City County in its development code for density bonus points include:

- Preserving a single area of healthy, mature, mixed hardwood forestland at least two acres in size within the developable portion of the site.
- Preserving at least one of the following environmentally related conservation features. It must constitute at least five percent of the developable area of the site:
  - 100-foot buffers around non-RPA wetland features (isolated wetlands), intermittent streams, or from floodplain zones A or AE (where not already part of the RPA), or from the edge of the RPA buffer.
  - Soils in hydrologic groups A and B, as defined by the USDA, and as verified on-site by a licensed geotechnical engineer (retain at least 50 percent of these soils on site).
  - A conservation area, as identified by an approved watershed management plan.
  - Wildlife habitat corridors that protect a corridor at least 100 feet in width from one protected area (on or off the cluster property) to another protected area and consist of mature forestland.



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.

Fire safety is an additional 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 cogongrass) and the lack of fires stations in remote rural areas, necessitate more standards and education for developers and homeowners' guidance on how to reduce risk to life and property. Landscaping and building standards, such as Firewise, which show how to fortify and create defensible areas around housing located in the wildland-urban interface (WUI), are needed. These provisions could be recommended for subdivisions, cluster housing or conservation developments in rural zones.

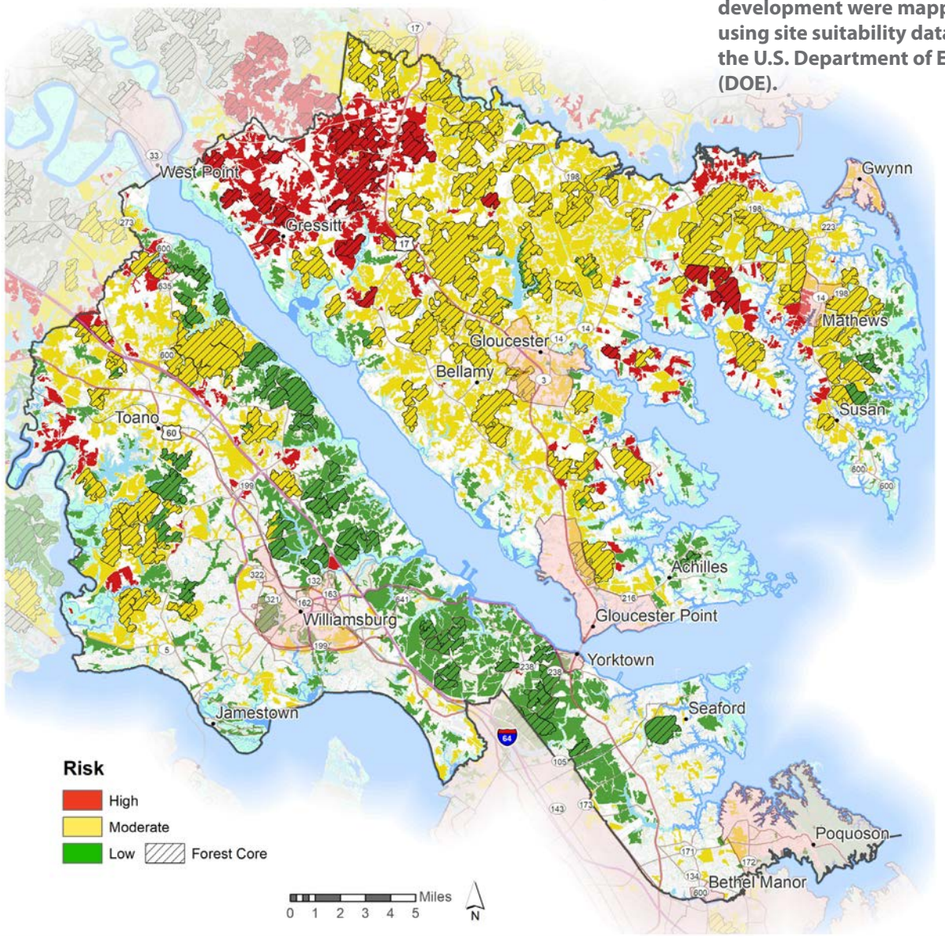
UTILITY-SCALE SOLAR DEVELOPMENT

25,627 acres (11%) 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 Gloucester County 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. According to the Piedmont Environmental Council, 58% of utility-scale solar projects are occurring on forested lands, while nearly 25% occur on crop land in Virginia. 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.

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. Since this study began in 2019, thousands of acres of forestland have been cleared for solar development.

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.

As a result of the RCF project the high-value forest cores map was used by Gloucester County to identify tracts for protection or regulation. The county then developed an ordinance for utility-scale solar development with standards for where these solar facilities are appropriate or inappropriate. More information on Gloucester County's solar ordinance is found in the strategies section of this plan.

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.
    - — 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.
- Create better habitat on solar panel sites. See Virginia Department of Conservation and Recreation's Pollinator-Smart Comprehensive Manual.

INVASIVE SPECIES, PESTS AND DISEASE

8,361 acres (3.5%) 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:

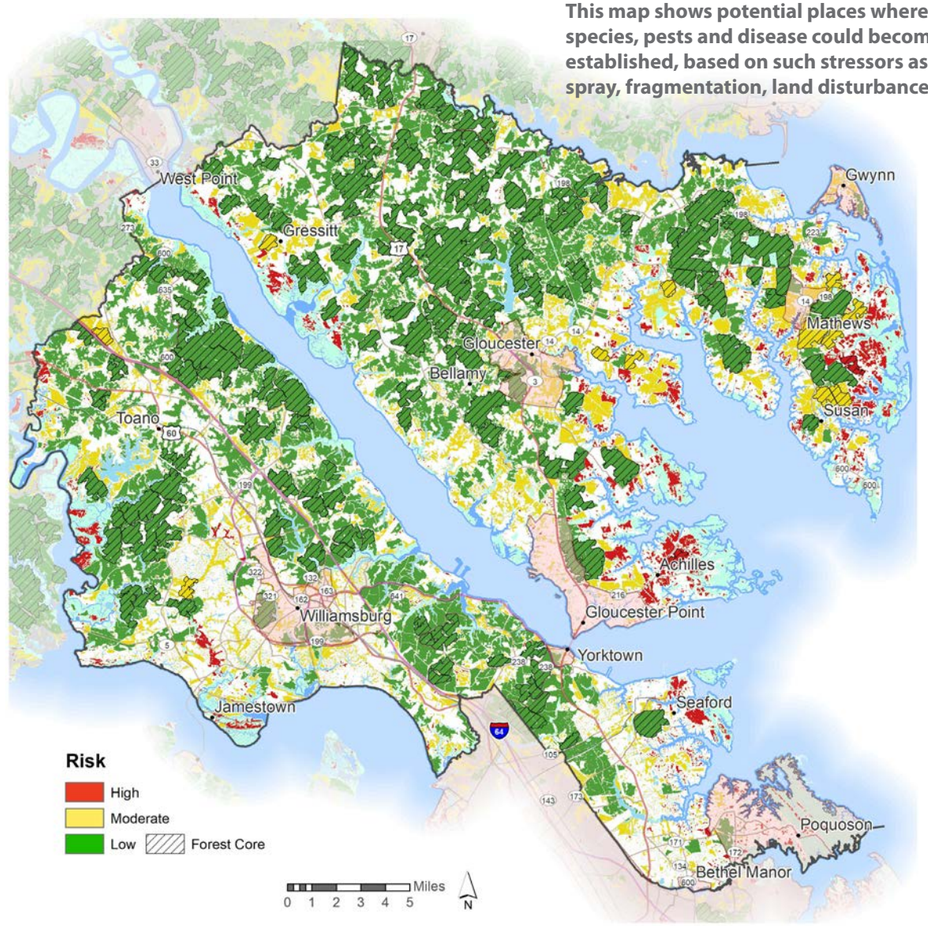
> *Climate change could alter the frequency and intensity of forest disturbances such as insect outbreaks, invasive species, wildfires, and storms. These disturbances can reduce forest productivity and change the distribution of tree species. In some cases, forests can recover from a disturbance. In 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).*

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 cogongrass. A coastal forester, Robbie Lewis noted about fire, "Virginia is also experiencing saltwater creep, which allows for thick thatches of phragmites or greenbrier to invade forests and other land cover. It is a problem near housing because they dry out with short-term drought and carry fire so quickly it's difficult to stop it after ignition. Phragmites is a key ladder fuel to the upper canopy."[1]

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.

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.



Southern pine beetle is a native insect pest species that burrow under the bark of trees and stress large tracts of coastal forests.

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. There is also a Plant Natives Campaigns for Hampton Roads, 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 Virginia.
- 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 https://www.vdacs.virginia.gov/pdf/BMP-plan.pdf

[1] GIC Webinar on Fire and related risks to the Forests of the Eastern US: 5.28.2020.

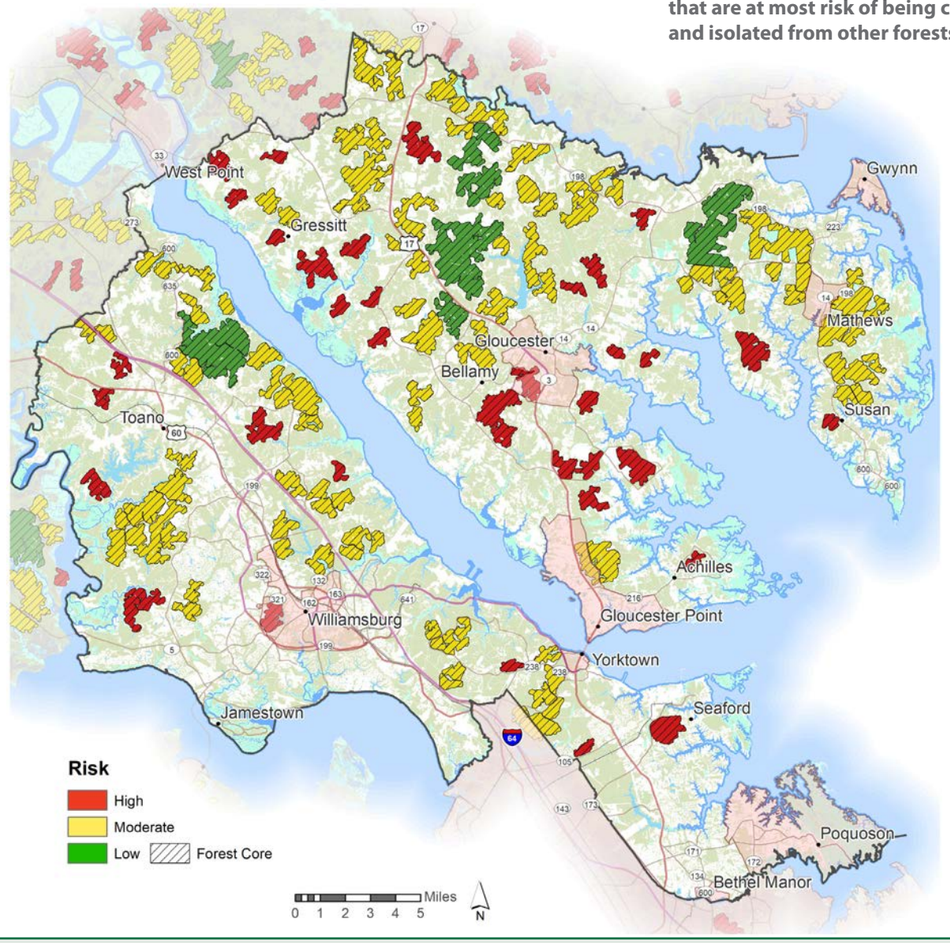
FRAGMENTATION

2,640 miles of roads are in the study area, 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

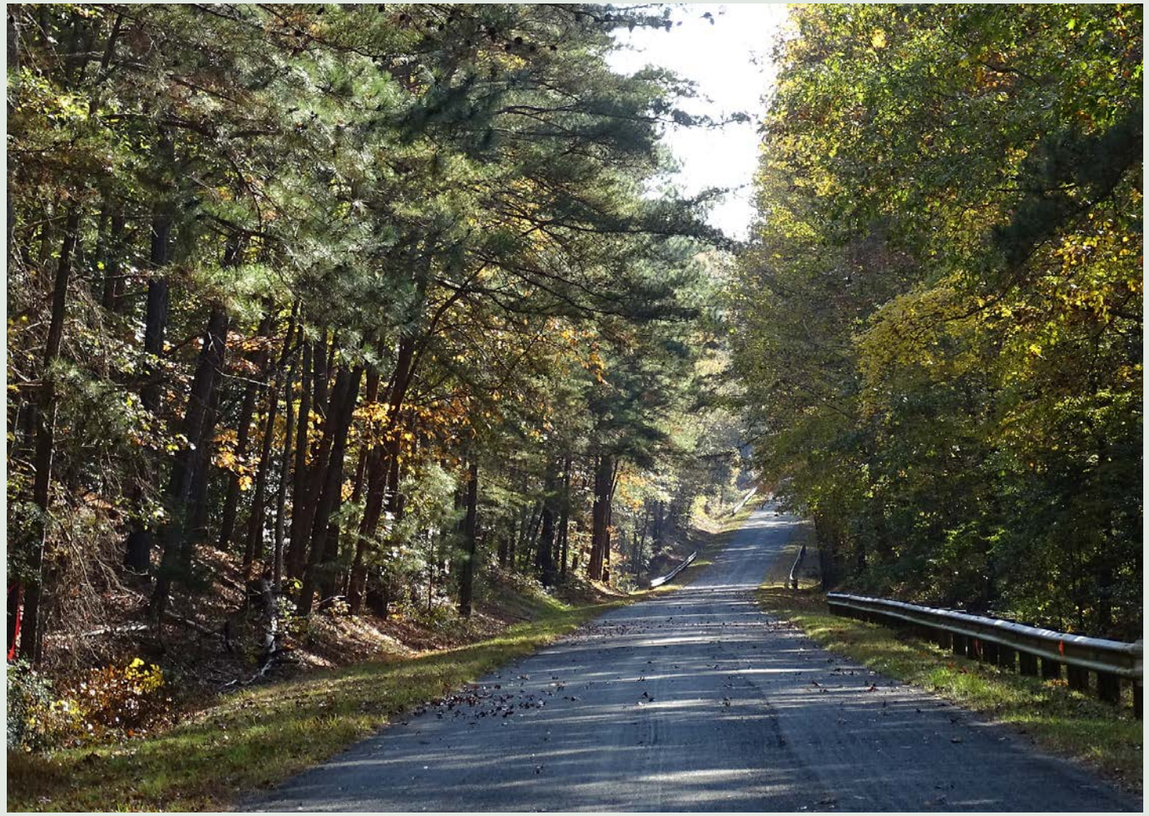
The forests identified in red are ones that are at most risk of being cut off and isolated from other forests.



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 landscape. Roads are the biggest contributing factor to

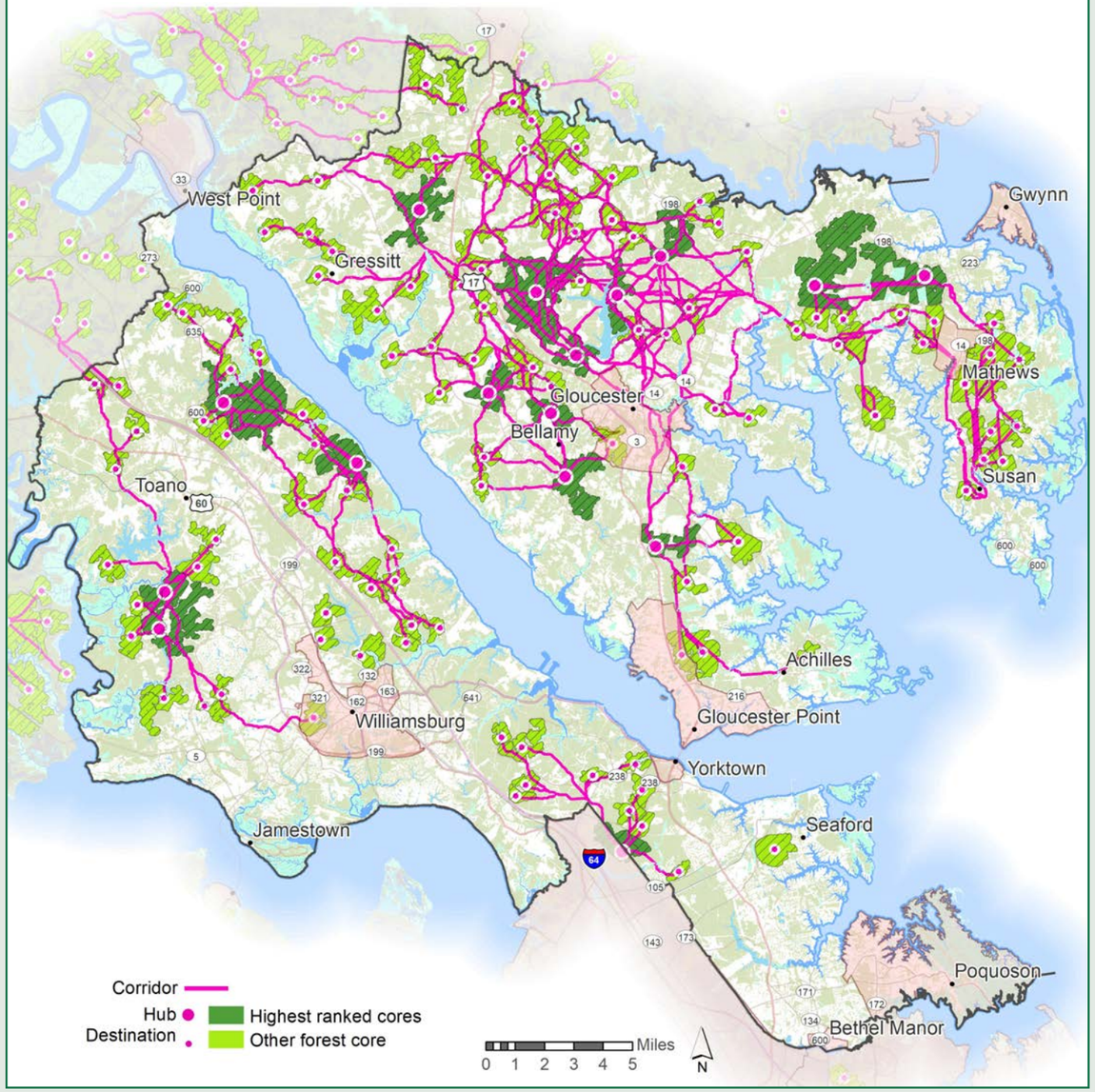


Roads fragment the forest into smaller pieces, which provide less overall interior forest habitat

FRAGMENTATION

Coastal Forest Corridors

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



Human infrastructure such as transmission corridors and development, fragment the forest into smaller pieces, reducing the interior forest habitat.

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 2,640 miles of roads in the study area, roads contribute significant 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.

The Virginia Transportation Research Council constructed and studied the mortality effects when wildlife fencing

Wildlife fencing installed to guide deer towards two underpasses along a section of Interstate resulted in a 92% reduction in vehicle crashes at the two crossing sites.

was installed to guide deer towards two underpasses along a section of Interstate 64 near Charlottesville. The result was a 410% increase in deer crossings at the box culvert and 71% at the bridge underpass, and an average reduction of 92% in vehicle crashes at the two crossing sites. The benefits from crash reduction exceeded the fencing costs in 1.8 years, and fencing resulted in an average saving of more than $2.3 million per site over the 25-year lifetime of the fencing (2020). The Virginia Safe Wildlife Corridors Action Plan, due out by fall 2022 should take note of the value of these structures in saving the lives of both people and wildlife.

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.

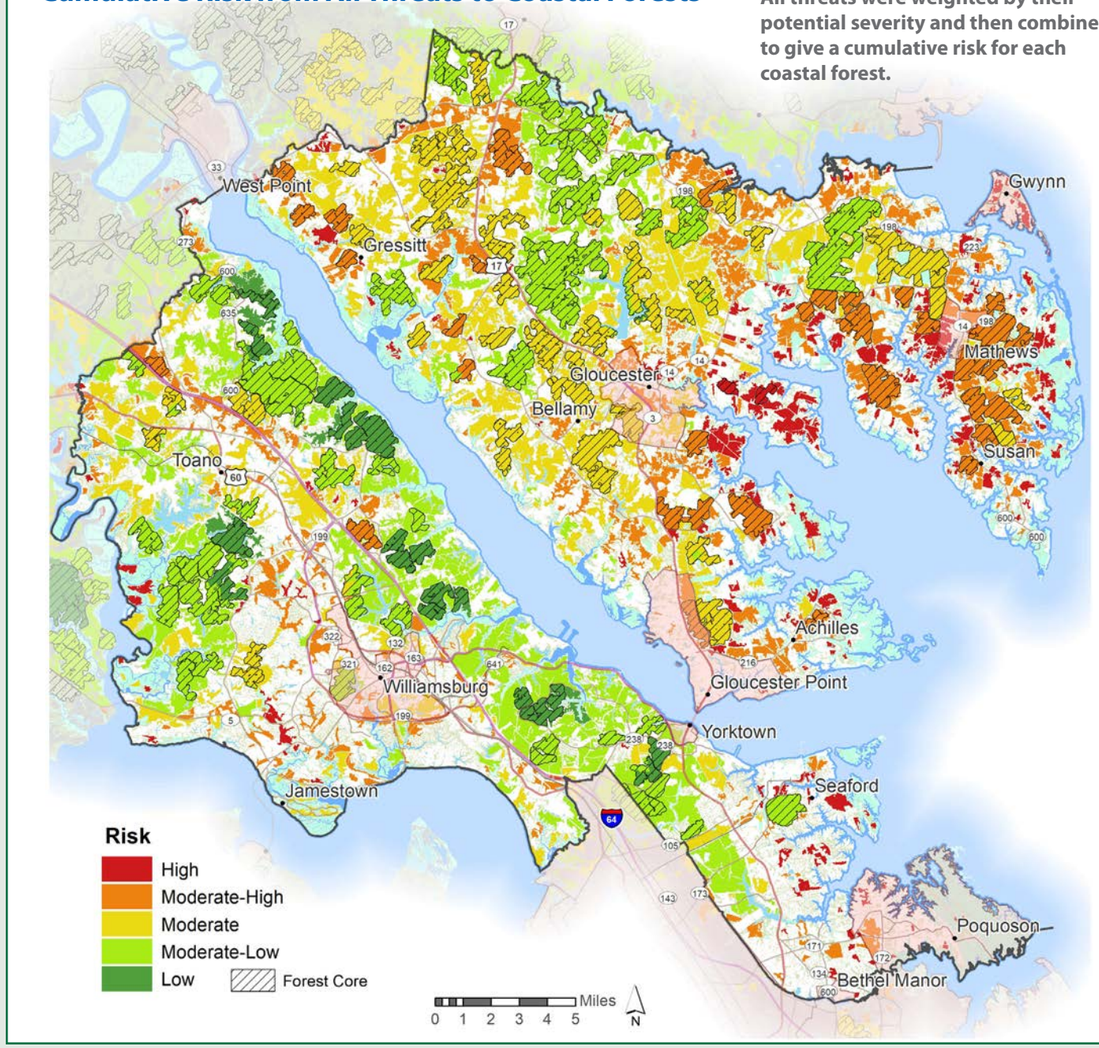
SEVERITY AND CUMULATIVE THREAT RISK

12,008 acres **(3%) of coastal forest in the study area are at HIGHEST RISK from *multiple* threats.**

127,939 acres **54% 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 the cumulative risk map at left.

Sea-level rise allows invasive grasses such as phragmites to colonize the area creating higher severity or more frequent fire risk.

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 (or use VaNLA maps and ConserveVA to locate those elsewhere in Virginia).	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 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

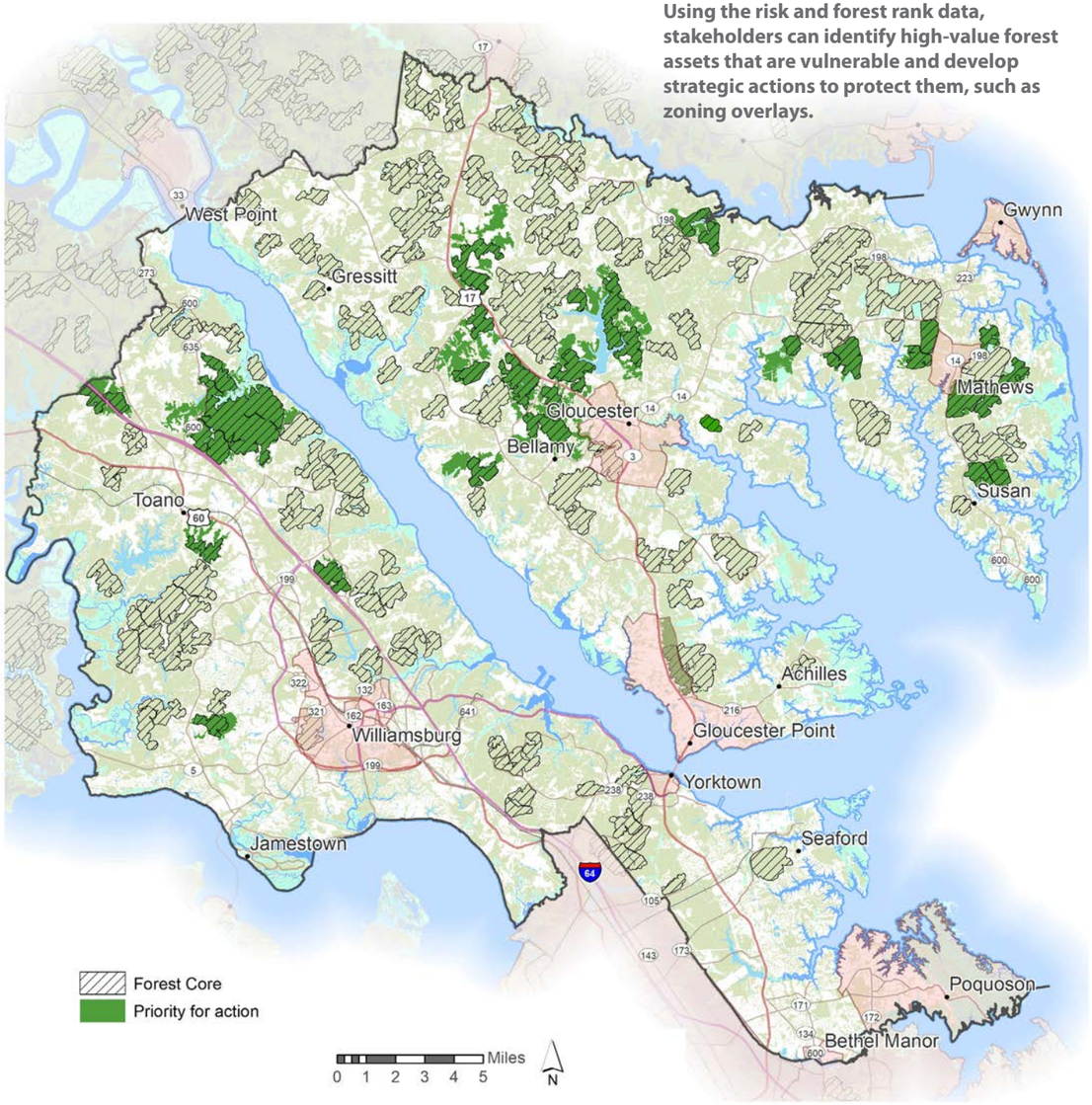
Prioritizing Coastal Forests

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 to delineate a solar overlay indicating 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 coastal forests that provided the greatest amount of connectivity and also 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.

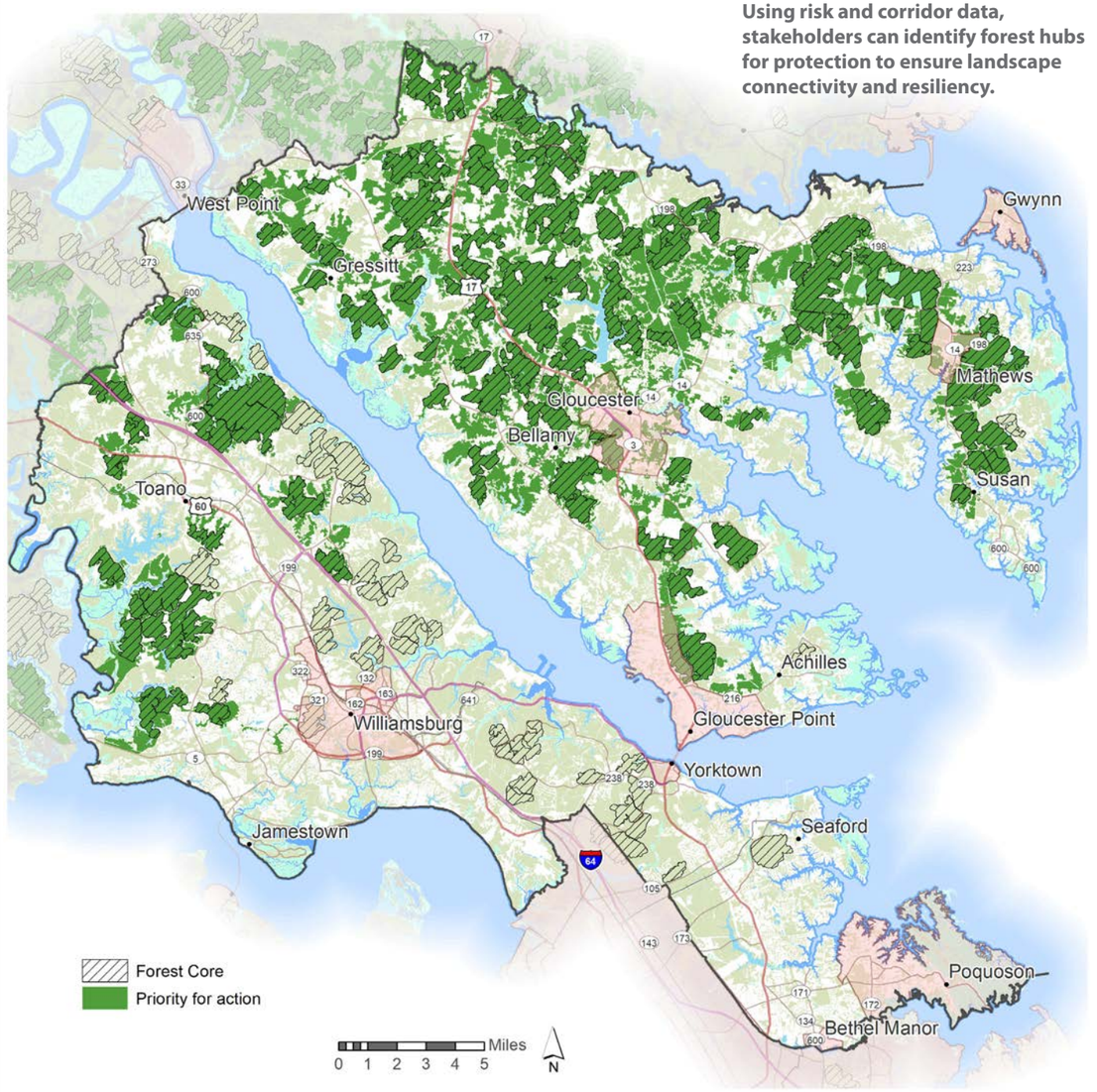
Highest Ranked Coastal Forests at Risk of Solar Development

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.



Important Coastal Forest Landscape Connectors at Risk

Using risk and corridor data, stakeholders can identify forest hubs for protection to ensure landscape connectivity and resiliency.



Local Stakeholder Strategies

City of Poquoson

Strategy 1: Provide safety to the City of Poquoson from storms and sea-level rise.

The city is interested in nature-based flood and storm mitigation strategies, such as living shorelines. They are exploring funding options, such as the Riparian Forest Buffer Tax Credit Fund, for grant opportunities for habitat restoration and marsh augmentation. Habitat restoration projects can integrate local species of plants that better withstand storm surge in areas at risk from sea-level rise.

Strategy 2: Promote natural amenities and the urban forest to the public.

The city wants to plant more trees to take up stormwater and clean polluted runoff. Species of trees identified that take in large amounts of water are evergreen species known for thriving in wet conditions, such as the loblolly bay, loblolly pine and white cedar. Other tree planting goals are to improve tree coverage in existing parks with a variety of species and a diversity of ages.

The city recognizes the need for engagement efforts that foster civic identity, intergenerational activities, education and recreational opportunities. The city could enlist volunteers in its short- and long-term care and maintenance of trees in parks. Maintenance of new tree plantings and the control of invasive species and diseases that may negatively impact tree growth will ensure long-term survivability.

Strategy 3: Obtain Tree City USA Designation.

Poquoson is in the unique position of being able to leverage its 57% tree canopy cover as an asset to further promote and grow the community by obtaining Tree City USA designation. This designation can help secure grants and other diverse funding sources (from private partners, for example) that are not otherwise available to localities.

Strategy 4: Adopt a Tree Preservation Ordinance.

Currently, there are no ordinances governing tree planting, preservation or care in the city. An ordinance should cover permits for landowners seeking to clear land or remove individual trees and a plan to replace lost trees. A tree preservation ordinance is also a requirement for Tree City USA designation.

Gloucester County

Strategy 1: Develop a solar development ordinance.

Gloucester County adopted a utility-scale solar development ordinance in 2021 (during this project). The ordinance limits utility-scale and community-scale solar development by requiring a conditional use permit in Rural Countryside (RC-1) and Suburban Countryside (SC-1), and it also restricts solar farms in all other zoning classes. The ordinance also stipulates that no more than 2% of the land area in either RC-1 or SC-1 can be permitted for utility-scale solar sites.

Strategy 2: Rewrite the cluster ordinance.

The county now requires forested subdivisions with 50 lots or more to have dry hydrants. These utilize a nearby body of water tap for suppressing wildfires. The county has secured grants to install these in some rural areas. It is also interested in rewriting the cluster ordinance to better protect and conserve habitat. Currently, the county requires forest conservation in four rural conservation zones. For developments of 15 acres or greater, lot arrangements and layouts must be in large, contiguous blocks with open space and conservation areas contiguous both on and off site. Stream corridors and contiguous wetland habitats can provide linkages for these corridors.

Strategy 3: Develop a green infrastructure plan to create corridors.

Gloucester County is interested in developing its own green infrastructure plan to identify corridors and connect the county's natural and cultural assets into a network. One example mentioned by county staff was to connect Machicomoco State Park to other important cultural and protected sites nearby, such as the Rosewell and Fairfield Plantations.

James City County

Strategy 1: Develop a Natural and Cultural Assets Map and Plan.

James City County is in the process of developing a Natural and Cultural Assets Map and Plan, along with more detailed and specific strategies. One use for the plan would be to help the county prioritize sites for purchase of development rights by using landscape-scale data to establish criteria for protection.

Strategy 2: Develop guidance on solar landscaping standards.

The county wants to codify landscaping standards for utility-scale solar developments to make them wildlife and pollinator friendly. Virginia's Department of Conservation and Recreation published a comprehensive manual on how to incorporate pollinator habitat into solar site design.

Strategy 3: Local government supports education of new forest landowners.

James City County staff are taking an online course through Virginia Tech on ways to assist forest property owners to make the most of their property. Staff want to learn more about how to help forest landowners. This could be an opportunity to support greater collaboration between county government and Virginia Department of Forestry's regional foresters.

Strategy 4: Opportunities for carbon markets.

The county is interested in providing financial opportunities to forest landowners through carbon markets. The Virginia State Industrial Development and Revenue Bond Act already empowers localities "to authorize the creation of industrial development authorities by the localities in the Commonwealth…" The Act allows localities to establish and participate in carbon markets and pool landowners into these markets… "It is the further intent… to facilitate and support landowner access to carbon markets through aggregation of landowners to reach a size that attracts the investment of private capital." Therefore, any locality that wants to establish a carbon market within their jurisdiction is given legal support by the State Legislature.

Mathews County

Strategy 1: Increase minimum lot sizes for rural agricultural and forestall lands.

Much of the undeveloped land in Mathews County is in large tracts of forest and agricultural lands. These are important natural features that need to be carefully managed in order to maintain the overall environmental quality and visual character of the landscape. The county suggests increasing minimum lot sizes, along with establishing agricultural and forestall districts to preserve agricultural and forest lands for production.

Strategy 2: Conservation development design principles.

Much of the demand for residential development will likely continue to be oriented towards the waterfront. Due to the environmental sensitivity of these lands, more environmentally friendly design and siting of buildings are needed. The county would like to see new residential buildings and subdivisions incorporate conservation and low-impact design for parcels, as well as more support for natural systems.

Strategy 3: Increase public awareness of risks of storm surges and sea-level rise.

The county recognizes the vulnerability of Gwynn's Island, West Mathews and Bayside to storm surge and flooding. A public campaign is needed to develop and publish materials to increase awareness of the risks to property and life during storm surges and long-term risks related to sea level rise. Long term, the county may need to consider assistance to help relocate residences and businesses.

Strategy 4: Update the county's hazard mitigation plan regularly.

The county wants to work with the residents of Bayside to improve community response to storm hazards and ensure that the county's hazard mitigation plan is updated on a regular basis. The coastal forest risk data can be incorporated into the hazard mitigation plan.

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

York County

Strategy 1: Update landscape ordinance to remove invasive species.

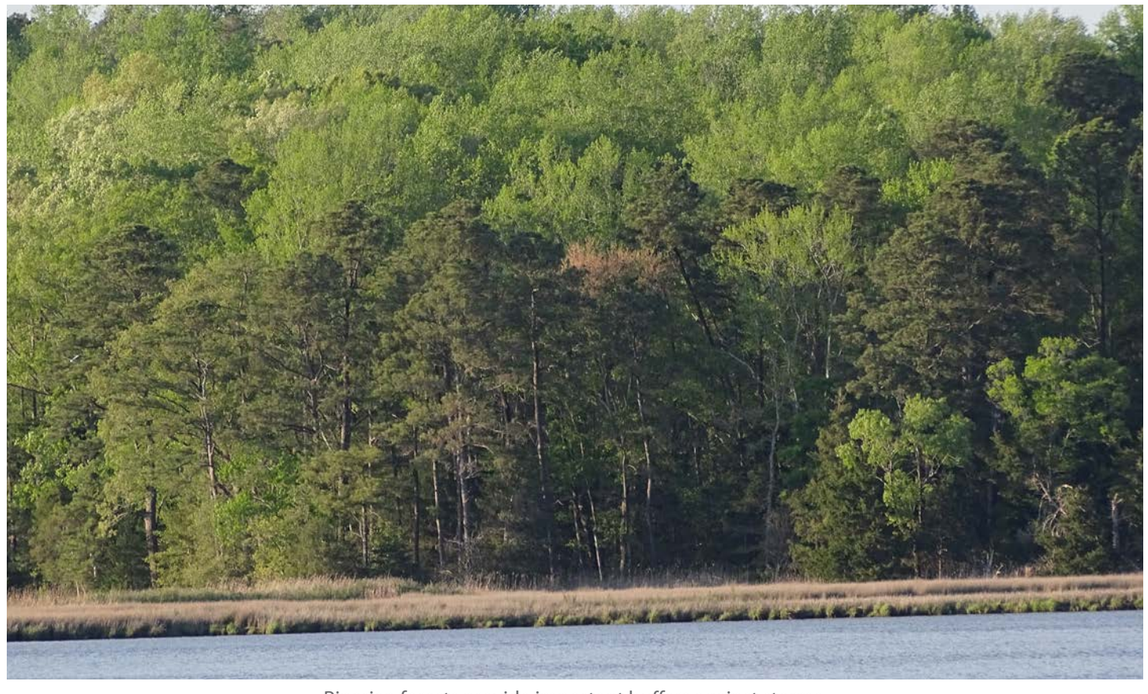
During this study, York County worked with the Virginia Department of Forestry to review the county's landscape ordinance and recommended species list. The community forester recommended increasing the number of native species and adding planting specifications to ensure healthy tree growth. One example was reducing the caliper size of planting stock from 3 inches to 2 inches. Larger caliper stock is more expensive and requires more irrigation. Smaller caliper trees establish as fast or faster than larger caliper trees, so there not much advantage in planting larger stock. Invasive or non-native species with invasive potential were recommended for removal with replacement from a list of native tree species. The community forester also stated that more large shade trees were needed in the county and suggested adopting stronger language to encourage large shade trees where space allows. Expanding the number of medium-sized trees on the native species list was also suggested.

Strategy 2: Update the comprehensive plan to include forest cores data.

The county is in the process of updating its Comprehensive Plan, which will incorporate some of the threats, such as sea-level rise, from this study. The county plans to add the highest-valued habitats data, along with modeled corridors, into the environmental section of the Comprehensive Plan and to recommend preserving more tree canopy in those areas.

Strategy 3: Identify conservation opportunities in the county.

The southern part of York County is full of residential development. The county has urban tree canopy data for this area that shows there are significant opportunities for planting more trees there. In contrast, the northern part of the county, which is near the naval facilities and the state park, is more rural but is also experiencing urban development pressure near Highway 199 and Interstate 64. The resilient coastal forest data can be used to help identify and protect key forests in the area.



Riparian forests provide important buffers against storms.

Case Study: Jamestowne Island, National Park Service

Background

Land on the historic Jamestown Island is a combination of woods and wetlands and has historically been managed as agricultural land, mostly for grazing, before being acquired by the National Park Service in 1934.

If sea-level rise occurs as predicted, the entire Jamestowne Island may disappear in 100 years. Park staff already close some roads during king tide events. The park's natural resources division is studying the hydrology of the island and has just (2021) completed a four-year groundwater study with the US Geological Survey. The study evaluated sea-level rise effects on the freshwater lens, (the water table that floats above the denser saltwater), which extends into the Bay, in order to determine if the lens of freshwater is being pushed further upstream as a result of saltwater intrusion. They discovered that, at Black Point, the headland on the island, the groundwater has become acidic from mixing with saltwater.

Jamestowne Island is also subjected to microbursts and strong winds that rush upriver and can topple large trees. The saltwater intrusion, along with more frequent and prolonged flooding, is also killing the native forest cover of loblolly pines. The ridges, or fingers, of upland that extend into the river and Bay are becoming saturated, steadily changing its forest cover into marshland.

With forest cover declining on the island, many species that require forest habitat will be displaced.

Indeed, marshes already cover two-thirds of the original island and, as seas rise, they will continue to expand, resulting in further loss of forest and impacts on wildlife. In addition, phragmites is replacing native saltmarsh vegetation, increasing the fire risks described earlier in this report. Other invasive species include stilt grass, wisteria and bamboo, which also degrade biodiversity in the understory.

The invasive grass phragmites spp. quickly replaces coastal forest habitat lost to storms or sea-level rise.

Breakers and living shorelines are being used by park staff to slowdown coastal shore erosion and keep water from penetrating further upland.

Park staff have already armored the shoreline to prevent further damage to resources, but these strategies are only effective in the short term.

The small red bay tree (*Persia palustris*) is a key host plant for the palamedes swallowtail and the park staff are monitoring the tree to ensure that the red bay ambrosia beetle does not get onto the island, since it has been decimating red bays along the southern Atlantic Coast. Although staff have tried to address erosion by establishing living shorelines, they continue to erode. Archeological sites, such as Glass House ruins, which are at 4 feet above sea level, are continually threatened by storm surges and rising seas. Sandbags are the only line of defense to prevent water coming into the ruins and damaging its artifacts.

Many of the threats Jamestowne Island faces are compounding, since they accelerate each other. For example, a fire management plan is in progress to address the downed trees caused by salt and other stressors since they add fuel loads that increase the risk of high-intensity crown fires that could impact the cultural resources on the island. However, those downed logs create habitat for salamanders, beetles and reptiles, which are also important to the park, so the challenge is how to reduce dangerous fuel sources while not overly disturbing endangered animal habitats.

Strategies

The park's resource manager conducts soil chemistry analyses, vegetation transects and remote sensing analysis to identify stressors in the forest canopy. While park staff can revegetate upland sites, there are no tangible actions to address marsh migration and flooding. They hope to relocate/recreate some artifacts and sites, but funds for vegetation or habitat restoration are rarely included in project budgets.

While breakers and armored shorelines have been installed to weaken wave action along the headlands, they are temporary tactics supported by mitigation funds from the Dominion VA Power transmission lines constructed across the island's viewshed. Marsh restoration, living shorelines and the eradication of phragmites continue to be primary goals for the island. Other invasive species are managed on an ad hoc basis, as funding permits. Long term, park staff are considering where they can relocate amphibians, reptiles and other wildlife when the forests are completely gone. The natural and cultural assets strategy currently underway in James City County could assist the park with this challenge.

Case Study: Newport News Park, Waterworks Public Water Utility

Background

Waterworks is a public water utility for the City of Newport News which supplies drinking water to 400,000 people. Newport News Park is the largest municipal park east of the Mississippi River and comprises 7,800 acres of recreational activities. It has abundant and diverse of species, with more than 200 bird species and over 80 species of reptiles and amphibians observed. The Waterworks utility manages the watershed through a mix of forest management practices including timber harvesting. The well-managed forest results in high-quality water for its two reservoirs. Although water quality and biodiversity are primary goals, timber sales since the mid-1980s have brought in an additional $2 million in revenue. Since the site is a drinking water source, no herbicides are used in prepping sites for reforestation. The utility also monitors forest plots, studies groundwater and conducts reforestation plantings, mulching and invasive species control. The forest is also used to absorb sprayed, treated wastewater because, with over 950 acres of forestland, it has a large enough land base and operational funds to do the work. In fact, it is the only water utility company in the state with this type of program. The sediments nourish the forest, rather than fill up landfills, saving Waterworks $2.5 million annually.

Waterworks replants or uses natural regeneration techniques to ensure forest cover is retained in the watershed.

The water utility company sprays waste sediment generated during the water purification process into the forest, which absorbs the excess effluent and reduces the need to landfill waste sediments.

Challenges

As the manager of a large forest, the utility has to address the typical suite of invasive plants that impact forests, including Japanese stilt grass, phragmites, tree of heaven, bamboo, privet and wisteria. Maintenance of public trails results in spreading the seeds of undesirable species. While gypsy moth infestations were a problem in the mid-1980s, it has not been seen recently. They have also been fortunate with Southern pine beetle, which had its last heavy infestation in 1993. Another pest, the emerald ash borer, is not a significant concern as ash trees make up less than 5% of the tree mix. The main tree species are red maple (25%) and sweet gum, although they manage for a diversity of softwoods and hardwoods for timber harvesting.

Browsing deer have seriously affected natural oak regeneration, so the herd was culled in 2020, but there have been problems with illegal hunting. Other threats include fire, although most fires are no more than 2 acres. Fires are caused by humans, rather than lightning strikes. Prescribed fires cannot be used as tool to reduce fire risk because of smoke concerns with nearby airports, military installations and residential development. This was a similar problem for many forests in the study area.

Downed trees from winds also cause significant impacts and increase fire risks. For example, while Hurricane Isabel in 2003 only had winds of 37 mph, the resultant tree loss required hiring a contractor to salvage log the fuel load.

Strategies

Timber sale revenues are used for new forest land acquisition or replanting. New lands are also purchased to further protect water quality. For example, the utility purchased a gas station, demolished it, pulled up the asphalt and planted trees. They also work with nearby property owners, such as a nearby horse farm, in which the landowner agreed to put 75 acres into a conservation easement in a high-growth urban area to protect the forest. The utility also works with state agencies, such as Virginia's Department of Conservation and Recreation, which manages the Grafton Ponds Preserve within the park for the rare, threatened and endangered species found there.

The airport is another partner in the forest's management. It allows the utility to plant short rotation (15-20 years) pine forests near the airport to reduce mowing activities. By keeping the tree heights to a 40-60 feet maximum, requirements for aviation safety and operations are thereby met. The utility's forest managers usually prescribe 20-30 year rotations for most of their forest stands and regularly thin out pine stands to resist the Southern pine beetle. They also manage some forest acreage for hardwoods and recently harvested an over-mature stand, which they then allowed to naturally regenerate with native oaks.

A firewood stand selling local wood is set up in the managed campground, helping prevent outside pest introductions.

The forest manager also started a firewood program in the campground to ensure that outside firewood was not brought into the park, bringing with it outside invasive species such as the Asian Longhorn Beetle. Tree crews from the city bring trees they have removed, and Waterworks resells them as firewood for campers.

By owning and managing the landscape around a municipal water supply in forest, the city can continue to reap the rewards of having less costly treatment for its drinking water. A study by the American Water Works Association found that a 10% increase in forest cover reduced treatment costs for drinking water by 20% (Barten and Ernst 2004). Similar findings were also noted in a 2017 study (Warziniack et al 2017). The Forests to Faucets Program is a model that can be followed by drinking water utilities that want to have the benefits of forested land cover but may not own the substantial land base that Waterworks does. For more see https://www.fs.fed.us/ecosystemservices/FS_Efforts/forests2faucets.shtml

The USDA studied the role of state and private forest (SPF) lands in protecting and replenishing drinking water in southern states. They found that "of the 7,582 surface drinking water intakes in the study area, 6,897 (91.0 percent) received some portion of their water from SPF lands, with 4,526 (65.6 percent) receiving 20 percent of their water from SPF lands. Forests are a vital source for both drinking water storage and cleansing.

State Stakeholder Strategies

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

Virginia Department of Forestry (DOF)

Strategy 1: Hardwood initiative.

Area foresters should continue their work with forest landowners in the region to encourage the establishment of hardwood forest stands. This initiative financially supports landowners who want to plant upland hardwoods but need additional help in getting hardwood stands established, either through funding or technical support. Although hardwood trees take longer to mature and thus have a longer rotation before they can be harvested, hardwood trees bring higher dollar value and can support a greater diversity of species.

Strategy 2: Longleaf pine restoration.

The VA DOF is working with forest landowners to plant longleaf pine on select sites to increase the presence of this forest community in the coastal landscape. Historically, longleaf pine woodlands and savannas were minimally abundant this far north in Virginia on the coastal plain, with records indicating they were more abundant in southeast Virginia, especially in the communities of Isle of Wight, Southampton, Suffolk and Chesapeake.

DOF is partnering with landowners to restore longleaf pine forests in the Coastal Plain.

DOF staff are collecting live oak acorns to propagate live oaks for Virginia.

Strategy 3: Live oak acorn collection.

Virginia is the northernmost range for live oak, *Quercus virginiana*, and maritime forest communities have been mapped for the region. Acorns are being collected from known populations to establish nursery stock for replanting live oak in coastal Virginia.

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

The DOF'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 the sea level rises and both flooding and storms continue to impact coastal forests. Drones could be used to accelerate this mapping.

Strategy 5: Plant trees and educate the public in urban areas.

Tree planting is a main focus for the DOF's Urban Forest Program. The program also emphasizes educating the general public on the benefits of trees and forests, as well as collaborating with local governments on urban forest issues. For example, DOF urban forest staff are adjusting tree species selections to recommend more salt-tolerant trees in coastal areas, such as a recent site on Tangier Island, where cedars and live oaks were planted.

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

■ **Increase staff capacity and technical support from the DOF.**
The Virginia Urban and Community Forestry Program consists of two full time staff and a coordinator. Multiple legislative priorities in the state have called for more technical support from the Virginia DOF since smaller towns and rural counties don't have arborists on staff. The state should provide more funding and more state sources of funds to allow additional staff to help with forest and tree concerns in developing areas (in addition to the regional and coastal foresters working on silvicultural issues). The state should also provide more state funds for technical support grants or opportunities to provide assistance to localities.

■ **Increase support for forest buffer planting and outreach coordination.**
Coastal areas are seeing challenges as marsh migration and storms kill or weaken coastal trees. New areas may need to be made available to plant healthy forest buffers, along with new planting projects to ensure that Virginia can meet its commitments for new forested stream buffers. The state has already acknowledged it will fall short of its Watershed Implementation Goal for 2025 to establish forest buffers along streams and estuaries. More funding and a Chesapeake Bay-wide coordination system are needed to grow more seedling stock, install more buffers and conduct more landowner outreach, along with tracking methods to ensure that messaging and methods are optimal for gaining landowner participation. A database is needed to help track outreach successes or needs. The state also needs to help with seedling stock through the their growing sites, such as opening up the New Kent County site to growing more trees, especially as that site is in the coastal plain. At press time, GIC was working with the State Forester to evaluate these options.

■ **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 Virginia DOF to place a voluntary conservation easement through the DOF's easement program, conduct more targeted landowner outreach and work more closely with local governments to identify areas that are at risk, so that localities can initiate appropriate zoning changes or add areas to Ag and Forestal Districts, 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. The DOF conducted an evaluation of whether and how localities mentioned trees and forests, as well as specific strategies found in Comprehensive Plans in coastal localities. This study could be repeated, but should also include recommendations by the DOF as to why, where and how to include forests for both urban and rural areas.

■ **Promote wider buffers for wildlife.**
Incentivize landowners to increase riparian buffer widths (to 100 feet) for wildlife movement and increased water quality benefits. DOF foresters provide advice to landowners, including adding stream buffers for water quality. However, they could suggest that buffers for wildlife passage be wider since the 30-foot agricultural standard is not wide enough to meet the needs of many larger animals or interior forest birds.

■ **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.

Coastal Zone Management (CZM)

Strategy 1: Land acquisition of high ecological valued lands.

This program annually sets aside money to preserve corridors on the landscape or acquires properties for migratory wildlife. Land ranked as having high ecological value are identified using the Coastal VEVA GIS tool. CZM partners with other state agencies, such as DWR or DCR on acquisitions.

Strategy 2: Lower Chickahominy Watershed Collaborative.

DOF staff are on a working group that is examining land conservation in the region. The DOF and PlanRVA are also conducting GIS analysis of forestry cover in the watershed. There is interest from state, tribal, regional and local governments, as well as several NGOs (environmental advocacy, land trusts, etc.) to replicate the Virginia Resilient Coastal Forest pilot study in the Lower Chickahominy watershed, but it would be an entirely separate project from the forest cover analysis and require additional funding.

Strategy 3: Support Planning District Commissions on issues, such as promoting native plants or urban forestry to reduce heat islands.

Strategy 4: Contribute to the development of the Virginia Coastal Resilience Master Plan.
https://www.dcr.virginia.gov/crmp/plan

Strategy 5: Continue to look for opportunities to leverage multiple funding sources and align federal, state, regional and local habitat restoration goals.

Department of Environmental Quality (DEQ)

Strategy 1: Better protection of individual mature trees along the coast.

In the Tidewater Region, the state is focused on the protection of mature trees in buffers and giving them a legal definition that can be applied in local zoning ordinances. This will further the goal of maintaining mature trees on site during the development process. Another focus is how to protect mature trees in living shoreline projects. In some projects, trees are removed to establish the living shoreline. If possible, the DEQ would prefer to see more mature trees preserved in living shoreline projects to help buffer shorelines.

Strategy 2: Increase tree planting and riparian forest buffers in the watershed.

The DEQ is concerned with the loss of riparian buffers. The Chesapeake Bay Restoration Program is planting a lot of trees to meet the Watershed Implementation Plan's Phase 3 goals. There are 31 outcomes in the agreement, which include goals for urban tree planting, riparian buffers and wetland restoration.

Strategy 3: Renew the Bay Partnership Agreement.

In 2021, the State of Virginia updated and signed the Bay Partnership Agreement, renewing its role and commitment to restoring the Chesapeake Bay.

GIC Recommendations for DEQ

■ **Adopt individual trees as Best Management Practices (BMP) for stormwater credit**.

The DEQ is in the process of developing specific regulations to implement the recommendations of the expert panel established by the legislature. GIC served on the expert panel. The DOF is now working with the DEQ to develop specific standards for how to credit urban trees. By including trees in the State's BMP clearinghouse, it gives more flexibility to localities and developers to manage stormwater on-site by protecting and preserving the mature tree canopy. GIC supports the adoption of trees as part of the BMP clearinghouse.

■ **Plant wider buffers that can contribute to wildlife corridors in addition to water quality benefits.**

When lands are available, especially on State-owned properties, establishment of wider buffers (100 feet or greater) will provide more buffering from storms and better wildlife connectivity.

Wider riparian buffer plantings will support better wildlife movement and enhance water quality benefits.

Department of Wildlife Resources (DWR)

Strategy 1: Acquire properties adjacent to existing long-leaf pine savannahs.

The DWR is pursuing land acquisitions in the region with coastal forests identified as a priority for the agency. The agency is interested in expanding the current range of longleaf pine savannah habitat.

Strategy 2: Establish vegetative buffers upland of wetlands.

New forest habitat should be established upslope of wetlands to replace forests lost from marsh migration due to rising seas.

Strategy 3: Establish 50-100 ft vegetative buffers around agricultural or timber harvest areas and developments.

Wider buffers withstand wind impacts better, which is a major concern for coastal forests

Strategy 4: Riparian buffers- buffers should be planted with more species that will tolerate flooding.

Planting more salt-tolerate and wetland adapted species will help to ensure buffer survival.

Strategy 5: Maintain Forest health.

The State's 2015 Wildlife Action Plan for the Hampton Roads and Middle Peninsula Regions calls for coastal landowners to use more tree species within their native range, use a mix of species, use trees with ability to withstand higher salinity, drought, and increased temperatures, and prevent unnecessary site disturbance.

GIC Recommendations for DWR

■ **Continue to plan corridors throughout the region and state.**

Use the maps produced for this study to identify corridors between high-values cores and between cores that are at higher risk because of their isolation. DWR is currently working on the Virginia Safe Wildlife Corridor Plan to allow more safe passage over or under roadways to support wildlife and reduce accidents. GIC encourages the state to move quickly from study to implementation since past VADOT studies of wildlife tunnels have already shown dramatic reductions in wildlife-caused crashes.

■ **Collaborate more with the planning community and local governments.**

Several other state agencies, such as the DOF and the DWR need to collaborate more closely through dedicated agency staff who can work with local planning staff. Since development is a major driver of species habitat loss, especially of coastal forests, greater collaboration can provide planning staff with the knowledge and expertise to minimize the impact of development on species. DWR staff should conduct outreach to local governments to make them more aware of the services and knowledge they can provide.

■ **Continue to work more with landowners on wildlife habitat projects and more widely promote successful projects.**

The DWR currently trains the public through programs such as the master naturalists. However, it could reach more people by speaking at more state events and hosting more webinars for the general public to attend. The Green Growth Toolbox is an example of a program open to planners, developers and the public that the wildlife agency in North Carolina runs and a similar program would be of great benefit to Virginia.

Virginia Department of Transportation (VDOT)

Strategy 1: Develop a statewide Wildlife Corridor Action Plan.

Both VDOT and the DWR are finishing traffic and wildlife studies on the impacts of wildlife crossings. Fencing to direct wildlife to crossings has been erected along sections of Interstate 64. A committee to develop a statewide Corridor Wildlife Action Plan is in process, with an anticipated release date of the Fall 2022.

GIC Recommendations for VDOT

■ **Greater need for constructed wildlife tunnels and bridges.**

The recent bipartisan Federal Infrastructure Bill passed by Congress appropriated $350 million dollars for Wildlife Crossing Pilot Programs to all 50 states. VDOT should apply for these funds.

■ **For road planning, use Virginia's cores data to prevent bisecting cores by rerouting (if possible) around important, high-value habitat.**

Each region in Virginia adopts a six-year transportation improvement plan. Cores maps can be consulted as part of that planning process to avoid excessive habitat destruction.

■ **Acquire or restore existing habitat cores for mitigation projects**.

VDOT 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 VDOT use its mitigation funds wisely.

Department of Conservation and Recreation (DCR)

Strategy 1: Wildlife and pollinator friendly habitat design standards for utility-scale solar projects.

The Virginia Department of Conservation and Recreation (DCR) created a guide on landscaping standards for incorporating more wildlife-friendly elements in utility-scale solar panel developments. The guide can be found following this Link. Specific elements include ground covers that support a variety of flowers for pollinators, encourage the protection of adjacent habitats, and install or keep wildlife features that do not interfere with facility operations, such standing dead trees, downed logs and other wildlife structures. The plant species for pollinator-friendly solar assemblies also do a better job at controlling runoff and erosion from the panels.

GIC Recommendations for DCR

■ **Coastal parks should use thicker buffers along shorelines to reduce coastal erosion.**
Parks such as the York River State Park need to provide more land for forest buffers to reduce impacts to facilities and provide better resistance against coastal erosion.

■ **Work with adjacent landowners to reduce invasive species.**
The staff can better educate landowners adjacent to wildlife management areas, state parks and other state lands to remove invasive species and plant only non-invasive species in their yards.

Pollinator populations are in decline, so creating pollinator-friendly habitat is key.

A Great Blue Heron along the York River.

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 South. 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. For example, James City County now has a county-wide strategy under development for natural and cultural assets, and other counties have expressed an interest in developing more detailed plans. Poquoson has already participated in a detailed green infrastructure study with students from the University of Virginia through a course taught by one of this report's authors, and larger urban resiliency plans are funded for cities such as Hampton, Virginia, which lies just to the south of this study area.

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, such as the newly adopted utility scale solar zoning regulations that were adopted during this process. 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
Horsechestnut	*Aesculus hippocastanum*	Salt spray
Red buckeye	*Aesculus pavia*	Saline soils
Paper birch	*Betula papyrifera*	Salt spray
Gray birch	*Betula populifolia*	Salt spray
Catalpa	*Catalpa speciosa*	Salt spray
Hackberry	Celtis laevigata	Salt spray
White fringetree	*Chionanthus virginicus*	Saline soils
Lavalle hawthorne	*Crataegus x lavallei*	Salt spray
Japanese cedar	*Cryptomeria japonica*	Salt spray
Common persimmon	*Diospyros virginiana*	Saline soils, salt spray
Ginkgo	*Ginkgo biloba*	Salt spray
Honeylocust	*Gleditsia triacanthos*	Saline soils, salt spray
Kentucky coffeetree	*Gymnocladus dioicus*	Salt spray
American holly	*Ilex opaca*	Salt spray
Black walnut	*Juglans nigra*	Saline soils, salt spray
Eastern red cedar	*Juniperus virginiana*	Saline soils, salt spray
Goldenraintree	*Koelreuteria paniculata*	Saline soils, salt spray
Common larch	*Larix decidua*	Salt spray

Common name	Scientific name	Type of salt tolerance
Sweetgum	*Liquidambar styraciflua*	Salt spray
Southern magnolia	*Magnolia grandiflora*	Saline soils, salt spray
Sweetbay magnolia	*Magnolia virginiana*	Saline soils
Black gum	*Nyssa sylvatica*	Salt spray
Austrian pine	*Pinus nigra*	Salt spray
Longleaf pine	*Pinus palustris*	Salt spray
Japanese black pine	*Pinus thunbergiana*	Saline soils, salt spray
White poplar	*Populus alba*	Saline soils, salt spray
Carolina cherrylaurel	*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 pagodatree	*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

Alliance for the Chesapeake Bay and Chesapeake Forest Fund Tree Planting Program:
Funds Private landowners to plant trees on open land.

Arbor Day Foundation, Tree City USA Designation Benefits: Access to Grants and Funding Opportunities.

Audubon Society Conservation Grants: Annual Grants to Fund Efforts for Bird Habitat Conservation.

Virginia DOF:
https://dof.virginia.gov/financial-assistance-programs/

- Mountains to Bay Buffer Program with the Chesapeake Bay Foundation.
- Virginia Trees for Clean Water Grant Program.
- Urban and Community Forestry Grant Program.
- Riparian Buffer Tax Credit Program.

Virginia DCR
https://www.dcr.virginia.gov/grants-funding

- Planning and Recreation Resources Grants and Funding.
- Virginia Land Conservation Foundation.
  —Aids in buying properties from individuals by matching up to 50% of total project costs, so that the land can be designated for conservation-based efforts.
- Agricultural cost-share and tax credit programs.

Virginia DCAS

- Agriculture and Forestry Industries Development (AFID) Fund.

Natural Resources Conservation Service (NRCS)

- Conservation Stewardship Program: Conservation Easement Grant Program with the Natural Resources Conservation Service (NRCS).
- Agricultural Conservation Easements Program

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

- Acres for America – leading public-private land conservation partnership.
- Bring Back the Native Fish – protects sensitive native fish species across US.
- Chesapeake Bay Stewardship Fund – helps local communities clean up and restore polluted waterways.
- Conservation Partners Program – provides funding to support technical assistance to private landowners to maximize benefits of Farm Bill programs.
- Five Star Urban Waters Restoration Grant Program – seeks to address water quality issues in priority watersheds.
- Longleaf Landscape Stewardship Fund – supports longleaf pine restoration projects.
- National Costal Resilience Fund – restores natural infrastructure to protect coastal communities that enhance habitats for fish and wildlife.
- Resilient Communities Fund – investments in green infrastructure to prepare communities for future environmental challenges.

National Park Service:
The Land and Water Conservation Fund State and Local Assistance Program.
https://www.dcr.virginia.gov/recreational-planning/lwcf

USDA Conservation Innovation Grants Virginia:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/va/programs/financial/cig/

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.

Virginia Soil and Water Conservation Districts: Virginia Conservation Assistance Program

Virginia Department of Environment:
Living Shoreline Loan Program – Local governments are eligible for loans to construct living shorelines, including the costs of design and planning.

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