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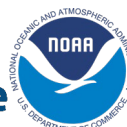
Pocomoke State Forest Climate Change Adaptation and Resilience Planning Guide

Supporting natural resources in the
face of climate change



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For questions about this plan please contact
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This adaptation and resilience plan for Pocomoke State Forest is the summary of many site visits, virtual meetings, conferences, and conversations. Over the course of two years, we have worked together to identify climate change impacts and adaptation opportunities at Pocomoke State Forest using many state tools and collaborative thinking. Thank you to everyone who believed in this plan and contributed your ideas and time!

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The technical advisory committee acknowledges the historical and continuing connection between Indigenous peoples and their native lands. Pocomoke State Forest is located on the ancestral land of the Pocomoke Indian Nation who shared this area through their relations and whose descendants are thriving.

The facilities and services of the Maryland Department of Natural Resources are available to all without regard to race, color, religion, sex, sexual orientation, age, national origin, or physical or mental disability. This document is available in alternative format upon request. This report was prepared by Kate Vogel using Federal funds from NOAA, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce.

Executive Summary

This plan serves as a climate change adaptation and resilience planning outline that will build upon already existing climate efforts for Pocomoke State Forest. Current resources in place include the [Pocomoke State Forest Sustainable Forest Management Plan](#). Pocomoke State Forest is located on the Eastern Shore at an elevation of about 30 feet, with 18,198 acres adjacent to the Chesapeake Forest. The Forest represents a unique coastal system that expands across much of the eastern shore, experiencing climate change threats from increasing temperatures, sea level rise, saltwater intrusion, and invasive species. Timber and hunting combined bring in \$150,000 on average every year. Pocomoke State Forest is home to many rare, threatened, and endangered species. For conveying the ecological significance of Pocomoke, this document uses [Hickory Point](#), a natural heritage area, as the key example, which is host to over 300 unique species. Vulnerable species at Pocomoke include many herbaceous and woody plants, in addition to species of insects such as the Palamedes swallowtail and a dysticid beetle.

Climate Impacts to Forest Resources:



Natural Resources

Sea level rise and increased precipitation are two prevalent concerns at Pocomoke, with more frequent inundation impacting vegetation and leading to species changes. Invasive species are also a concern as they compete with natives and impact forest management and timber sales.



Infrastructure

Infrastructure that is vulnerable to the threats of climate change at Pocomoke includes water control structures, gravel roads and parking lots. Precipitation increases runoff and flooding and can damage roads and structures. Culverts on site already have been flooding, which decreases trail and road access.



Recreation

Climate change impacts recreation at Pocomoke by impacting access points such as the shad landing launch and trail washouts.



Human Resources

Impacts to human resources include increasing pressure on Forest staff to respond to problems that may arise from sea level rise, flooding, and invasive species. Climate change may also impact harvest amounts, impacting revenue.



Cultural and Historical Resources

There are no known cultural or historical resources located on site, though the Nassawango Iron Furnace Archaeological Site is located nearby. If any are identified in future the advisory committee will look at issues and impacts to forest management and timber sales.

There are many opportunities for climate adaptation and resilience. To protect natural resources, active invasive species management and monitoring should be ongoing. Additionally, increasing vegetative buffers and redirecting water flow to reduce flooding can help both plants and animals and infrastructure. Infrastructure options include elevating and reinforcing roads in addition to relocating or mobilizing infrastructure. Overall, increasing climate preparedness will allow staff to accurately and preemptively increase resilience at Pocomoke.

Key Recommendations



Restore and monitor wetlands



Monitor and manage invasive species



Increase vegetative buffers



Assess roads and culverts and prioritize areas for restoration



Habitat & trail maintenance



Continue planning for climate change adaptation

Efforts currently underway to protect Pocomoke's valuable resources include active sustainable timber harvesting, invasive species management, and conservation efforts.

Current partners involved with enhancing resiliency at Pocomoke State Forest include MD DNR Chesapeake and Coastal Service, The Nature Conservancy, Maryland's Coastal Bays Program and the Delmarva Restoration and Conservation Network (DRCN). Additionally, timber sale partners represent an essential aspect of forest management. Pocomoke staff are continuing to engage in regional capacity and partnership building to identify future partnerships.

Introduction/Overview

The Maryland Forest Service at Pocomoke State Forest has partnered with Chesapeake and Coastal Service to prepare a climate change adaptation and resilience planning guide for Pocomoke that evaluates climate hazards, impacts from climate change, and potential adaptation strategies and implementation opportunities. It is intended that this guidance document will support forest staff in decision making and resilience planning and will be used in coordination with the already existing Sustainable Forest Management Plan.

Objective and Resilience Statement

This document will provide recommendations and solutions that support Pocomoke State Forest's climate change resilience statement: to conserve and foster an appreciation of the natural resources of Pocomoke State Forest and to continue to provide recreational and timber harvesting opportunities for as long as possible in a sustainable manner.

RESILIENCE STATEMENT

To conserve and foster an appreciation of the natural resources of Pocomoke State Forest and continue providing recreational and timber harvesting opportunities for as long as possible in a sustainable manner.

Document Organization

Throughout this document climate change impacts to Pocomoke will be separated into five categories including impacts to: natural resources, infrastructure, recreation, human resources, and cultural resources. Each category is described below.



Natural resources: flora and fauna of the forest, in addition to the Pocomoke River



Infrastructure: physical and organizational structures and facilities located at Pocomoke, such as roads and buildings



Recreation: opportunities for visitor engagement



Human resources: number of employees, staff time, and financial resources



Cultural resources: historical information and archaeological sites

For each category described above, two scenarios are described in detail: no action and adaptation options and opportunities.

No climate action: analyzes the impacts of climate change to the specific resource category if no mitigation or adaptation actions are taken (i.e., "business as usual")

Adaptation opportunities: discusses potential adaptation and resilience opportunities to respond to and address the previously analyzed impacts of climate change

POCOMOKE STATE FOREST CLIMATE CHANGE ADAPTATION AND RESILIENCE PLANNING GUIDE

Note: for the purpose of this document, Hickory Point will be used as a focal example for natural resources valuation.

Background

Pocomoke State Forest, located on the eastern shore of Maryland in Worcester, Somerset, and Wicomico counties, is one of the largest forests in the state, with 18,198 acres adjacent to the Chesapeake Forest. Compared to the Chesapeake Forest, Pocomoke State Forest contains many older tracts of forestland still in their natural state. Pocomoke has nearly 5,000 acres of cypress and hardwood forest that borders a scenic state river, the Pocomoke River, and two state designated Wildlands, Cypress Swamp (Hickory Point) and Pocomoke River. Two natural heritage areas (NHA) are located at Pocomoke, including Hickory Point Cypress Swamp NHA, and the Mattaponi NHA.

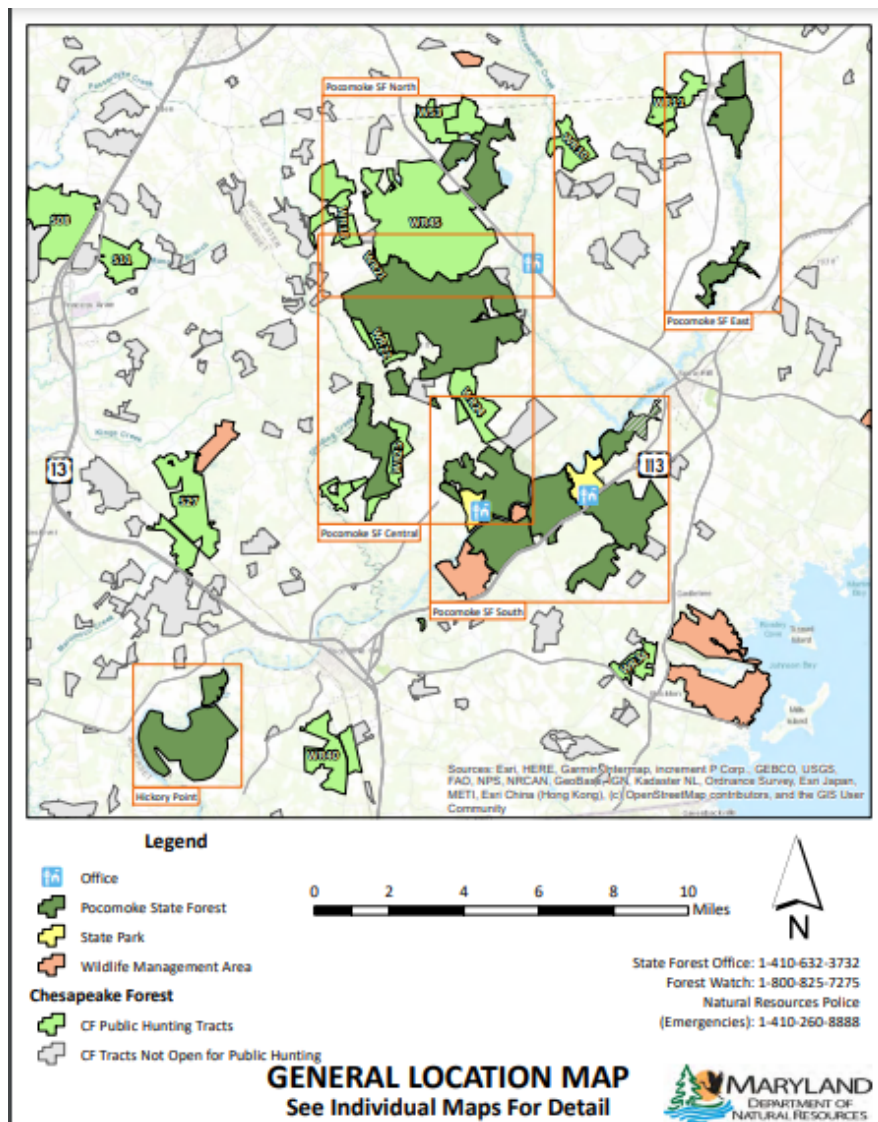
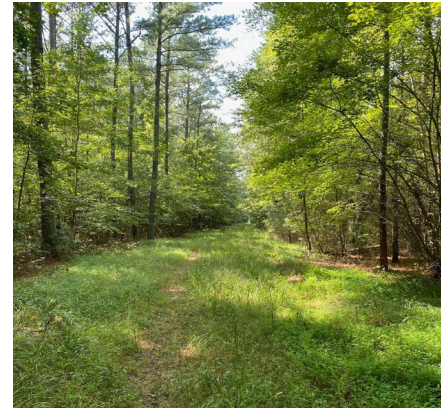


Figure 1: This is a general location map for Pocomoke State Forest.

Physical Description

The Pocomoke State Forest is composed of mature mixed pine-hardwood, bottomland hardwood, and bald-cypress forests. In general, the mixed pine-hardwood, hardwood, and bald cypress stands are older, mature forests, while loblolly pine stands are more evenly distributed across all age classes. Complex ecosystems exist throughout the Pocomoke State Forest due to the wide variety of habitats within the forest system including: inland sand dunes and coastal ridge woodlands, non-riverine swamps, Atlantic white cedar swamps, Delmarva bays, bald cypress swamps, and vernal pools.



This is a view of one of Pocomoke State Forest's Trails.

State Forest Assets and Resources

Pocomoke State Forest is known for its vast forest stands, hunting, and hiking trails. Annually, timber harvested from Pocomoke accounts for approximately \$150,000.

Heavily used infrastructure at Pocomoke includes roads, bridges, and parking lots. Other infrastructure includes the forestry office, boat ramps, primitive campsites, and hiking trails.

There are many recreational activities available at Pocomoke State Forest including numerous trails for hiking, mountain biking, and horseback riding. Back country camping and water access for activities such as kayaking, canoeing and paddle boarding are also available at Pocomoke. The area is also used for hunting and fishing. Species that are most frequently hunted include wild turkey, white-tailed deer, and gray squirrels. Less common species found in open areas include eastern cottontail rabbit, bobwhite quail, mourning dove, and American woodcock. Wood ducks and mallards are the most common species hunted on open water.

Hickory Point

One of the most unique places at Pocomoke State Forest is Hickory Point. Hickory Point Cypress Swamp is the largest and most intact example of a southern swamp ecosystem in Maryland and will be used as a focal point to discuss natural resources management throughout this document. It occupies over 2,000 acres and is estimated to provide habitat for more than 300 species of vascular plants and animals, some of which reach the northern limits of their distribution at this site. Much of the biological diversity can be attributed to a variety of habitats present that include oak-loblolly pine forests, mixed oak-heath forests, tidal bald cypress forests, Atlantic white cedar swamps, and tidal shrublands and marshes. The swamp is regarded as a northern extension of the Great Dismal Swamp in Virginia and North Carolina, mainly for its extensive bald cypress and Atlantic white cedar swamps. A focal point of this natural area is a large oxbow swamp that was once part of an old bend of the Pocomoke River. Over time this meander was cut off and the oxbow gradually filled with organic sediments, eventually transitioning to the peat swamp that is present today.

Hickory Point Cypress Swamp
County: Worcester

BioNet Tier: 1
Size: 3,196 ac

Key Wildlife Habitats

- Tidal Freshwater Marsh and Shrubland
- Tidal Forest
- Coastal Plain Floodplain
- Coastal Plain Oak-Pine Forest

Important Features

- State designated wildlands
- Atlantic White Cedar Swamp (state rare natural community type)
- Tidal Bald Cypress Forest and Woodland (state rare natural community type)
- Atlantic white cedar (*Chamaecyparis thyoides*, watchlist)
- Forest interior dwelling bird species
- Red bay (*Persea palustris*, state-listed as Endangered)



The globally rare natural community found in Hickory Point is characterized by Atlantic white cedar, swamp tupelo, red maple, sweet pepperbush, sphagnum mosses, and Maryland's largest population of red bay (*Persea palustris*, state listed as Endangered). The population of red bay is highly significant because it is host plant to the Palamedes swallowtail (*Papilio palamedes*, state listed as Endangered), and known to inhabit only this location in Maryland. This butterfly and other butterfly species, which are attracted by nearby mistletoe plants, can be seen flying along a nearby road, but they rarely are found outside of the swampy area where their host plants grow.



This photo shows Red Bay (*Persea palustris*), state listed as Endangered.

North of the oxbow swamp, extensive tidal forests of bald cypress and gum trees border the Pocomoke River and are known to support rare plants such as southern twayblade (*Listera australis*, watchlist), pale mannagrass (*Torreyochloa pallida*, watchlist), and white spikerush (*Eleocharis albida*, state rare), which grow in shallow water or moist soil in the swamp. Sphagnum grows around the bases of trees.

The tidal marshes and shrublands found along this portion of the Pocomoke River range from fresh to slightly brackish. This range of salinities allows the marshes and shrublands to support a diverse flora. Several rare plants occur within this marsh, such as gibbous panic-grass (*Sacciolepis striata*, state-listed as Endangered), southern wild rice (*Zizaniopsis miliacea*, state-listed as Endangered), and shoreline sedge (*Carex hyalinolepis*). Small-fruit beggarticks (*Bidens mitis*, state-listed as Endangered) can be found blooming in these marshy areas. The upland habitat within this natural area includes oak-pine forest, oak-heath forest, and a managed loblolly pine forest. This natural area includes a wide range of Eastern Shore habitat types, with many diverse wildlife communities existing in proximity and providing habitat for

many rare aquatic and upland plant and animal species. Even the dry, sandy roadside areas of this habitat are home to rare species: near the edge of the swamp, roadside areas provide habitat for downy milkpea (*Galactia volubilis*, watchlist).

Vernal pools can be found in the upland edge of the swamp under a canopy of black gum, red maple, and bald cypress trees. An uncommon dysticid beetle (*Hoperius planatus*, state rare) has been discovered in such vernal pools.



This shows the view looking towards Hickory Point.

Categorizing Climate Change Impacts and Threats to Resources

In 2019 Chesapeake and Coastal Service partnered with Salisbury University's Eastern Shore Regional GIS Cooperative to highlight areas of Maryland that are vulnerable to climate change. Ranking ecological vulnerability (EV) and climate vulnerability (CV) using factors such as precipitation rates, sea level rise, rare, threatened and endangered species, and habitats, the study scored habitats on a scale of 0-100, with a higher score representing greater vulnerability.

Pocomoke State Forest was identified as one of the most vulnerable state lands in Maryland due to the rare, threatened, and endangered (RTE) species and sensitive habitats present. Located across the southern eastern shore of Maryland, primarily in Worcester County, Pocomoke State Forest provides an ideal opportunity for beginning to understand climate adaptation in state forests. Figure 5, highlighted below, shows areas of Pocomoke State Forest that are most vulnerable to climate change including Hickory Point (southwest corner of map) and the Pocomoke River, two designated state wildlands areas protected under passive management. In general, the most vulnerable and ecologically valuable areas of Pocomoke occur near the Pocomoke River.

POCOMOKE STATE FOREST CLIMATE CHANGE ADAPTATION AND RESILIENCE PLANNING GUIDE

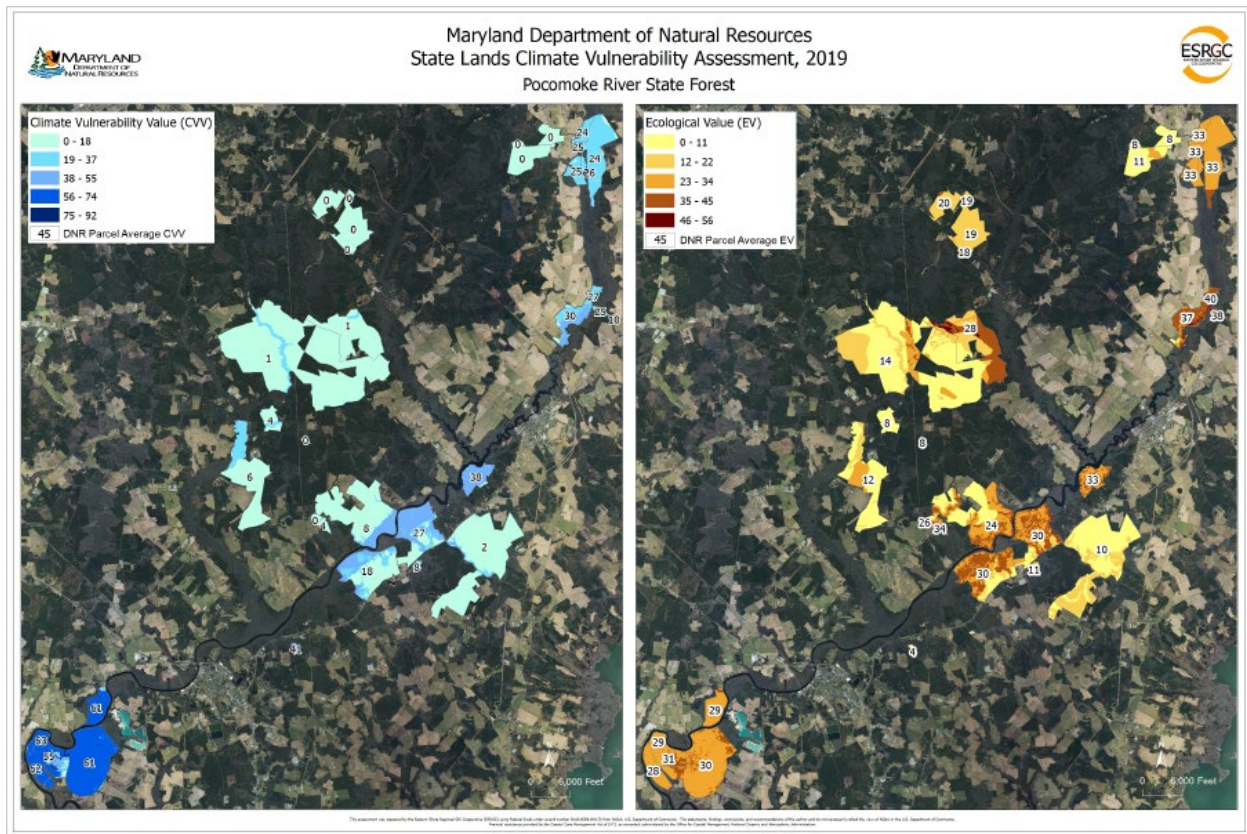


Figure 2: Hickory Point, located in the bottom left parcel shown on this map, was selected as an area of interest due to it scoring highly on the climate vulnerability value index and ecological value index.

The assets and opportunities at Assateague State Park are vulnerable to increasing temperatures, rising sea level, changing precipitation patterns, and increasing storm frequency.

Temperature

Temperatures in Maryland have already increased by an average of 2.5°F since the beginning of the 20th century. Increasing temperatures at Pocomoke will impact the natural resources on site, visitor health, and safety. Changing temperatures encourage unique species migrations, meaning that invasive species could be a potential problem for native species and timber harvesting. Increasing temperatures may also lead to increased drought and wildfires due to low precipitation and high evapotranspiration rates.

Sea Level Rise, Nuisance Flooding and Saltwater Intrusion

Following the Guidance for Using Maryland's 2018 Sea Level Rise (SLR) Projections, RSLR is predicted to be near 2.0 feet (0.61m) by 2050, and 4.3 feet (1.31m) by 2100 based on data derived by Kopp et.al for the Cambridge, Maryland NOAA tide gauge. The sea level rise predictions were selected using the step-by-step approach laid out in the guidance and considered the planning area, plan horizon and the flood risk tolerance. It was determined that the flood risk tolerance for Pocomoke is medium flood risk tolerance meaning that across the forest there is the intent to adapt to projected impacts and to tolerate some inundation. There may be specific projects that happen within forest boundaries that have either a higher tolerance

to flood risk (ok to get flooded more frequently) and some that have a low tolerance to flood risk (cannot get wet). These projects will be evaluated on an individual basis using the Guidance for Using Maryland's 2018 SLR projections. The Maryland SLR projections are legislatively mandated to be updated every 5 years with the next update to occur in 2023. At that time it is advisable to review the RSLR predictions for 2050 and 2100 to see if amendments need to be made. For more information about the step-by-step framework and how the RSLR were selected please refer to the Guidance document.

Two concerns related to increasing sea level rise include increased nuisance flooding and the potential for saltwater intrusion. Nuisance flooding already occurs during high tide. With an increased water volume in the Chesapeake Bay, tides are likely to encroach further inland and remain at high tide for longer periods (NOAA, 2022).

CLIMATE IMPACTS

- Increasing temperatures
- Changing precipitation patterns
- Increased flooding
- Increasing invasive species
- More frequent storms
- Biodiversity declines
- Increased disease risk
- Changes in crop production

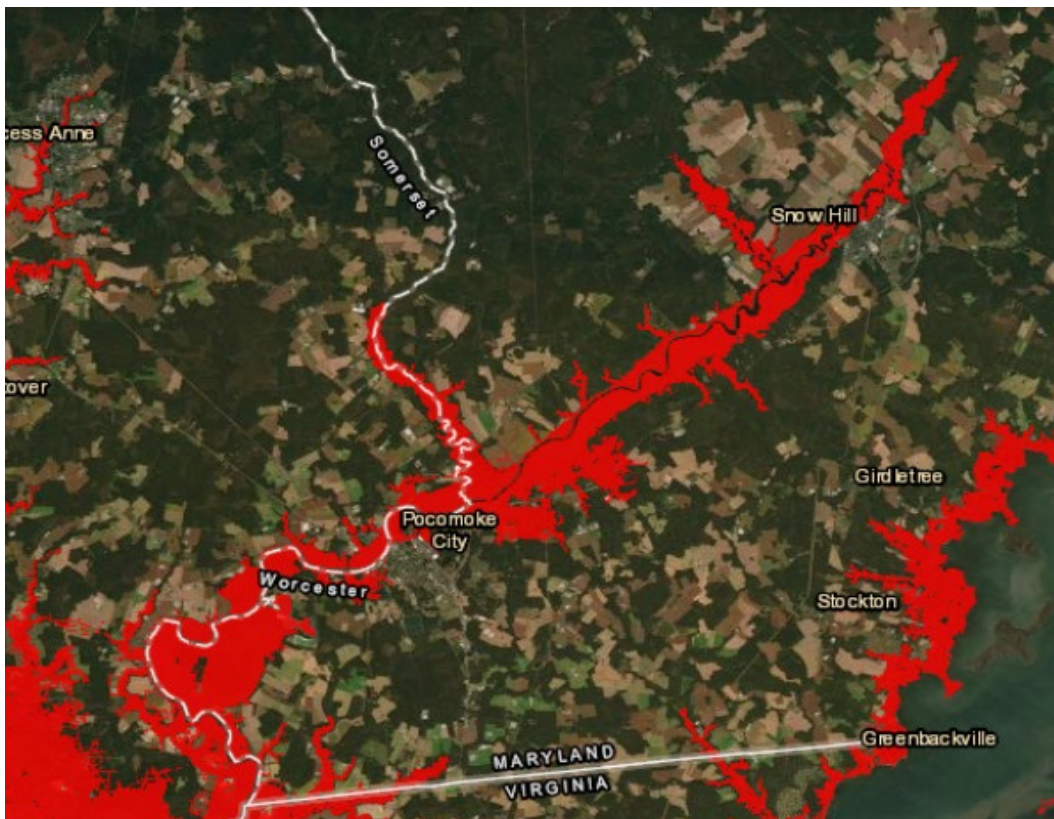


Figure 3: shows areas that are currently subject to tidal flooding (in red), often called “recurrent or nuisance flooding.”

Saltwater intrusion is likely to the surficial aquifer (shallow, unconfined) and depend on the susceptibility of the lower elevations to inundation from sea-level rise, storm surge, or brackish-water migration through ditching. Areas that are less than 2m above sea level rise are very susceptible to saltwater intrusion, especially due to increasing rates of tidal inundation. Increasing salinization from saltwater intrusion may have an impact on marsh vegetation and its chance of survival, impacting biodiversity and habitat availability.

Changing Precipitation Patterns

Annual mean precipitation has been above average for the last two decades. The Projected Intensity-Duration-Frequency (IDF) Curve Data Tool for the Chesapeake Bay Watershed and Virginia shows how precipitation patterns may change across the state under low (RCP 4.5) and high (RCP 8.5) emissions scenarios by the end of the century. For example, the Worcester County projections show that small, frequent storms (having a 2-year return period or 50% chance of being exceeded in any given year) that currently generate 2.92 inches of rainfall over 12 hours may generate a median of 3.27 inches under the low emissions scenario and 3.42 inches under the high emissions scenario by year 2100. Increasing precipitation could lead to numerous problems on site including increased flooding of roads, parking lots, and trails, further decreasing access to recreational and agricultural resources. Increased precipitation also leads to increased nutrient runoff, erosion, and sedimentation. It is possible that this expected increase in precipitation may impact timber stands.

Storm Frequency

While tropical storms and hurricanes are not expected to increase due to climate change, there is an expected increase in the frequency and intensity of more severe storms. More extreme storms lead to increased flooding and damaging winds, placing natural resources, recreation, and infrastructure at risk.

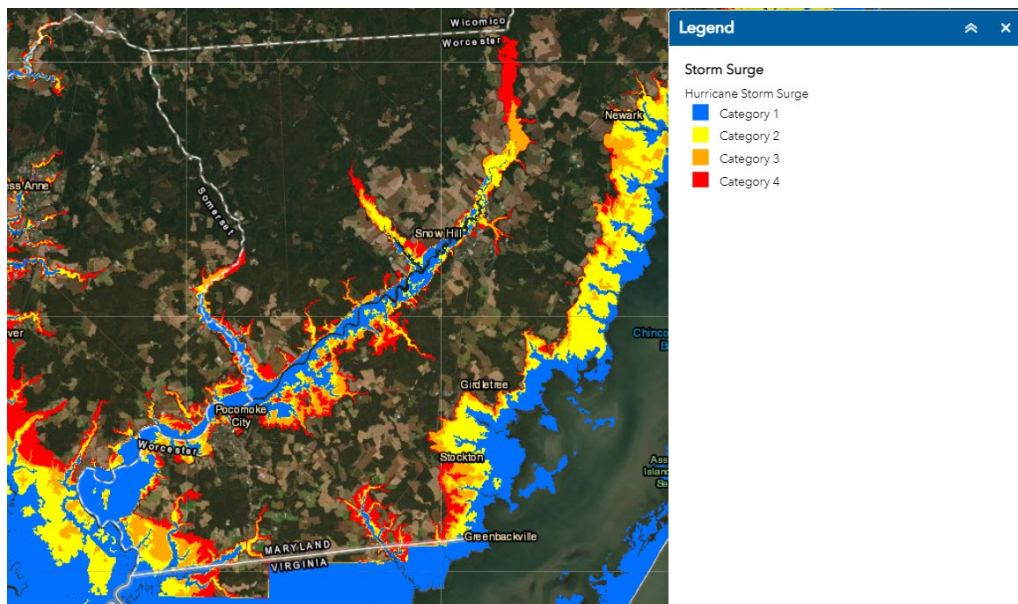


Figure 4: This image shows where hurricane storm surge is predicted to occur (Coastal Atlas, 2016).

Climate Impacts on Forest Resources



This is a photo of standing water at Pocomoke State Forest.

Climate Impacts on Forest Resources

Pocomoke is home to very diverse ecosystems, which are susceptible to different forms of climate change throughout the forest. Pocomoke State Forest is going to experience a wide variety of climate impacts due to the diverse type and location of its forest ecosystems. Future sea level rise is expected to impact areas of the forest as river levels increase, changing forest dynamics and influencing marsh migration. Roads already experience flooding and washout, making management operations more difficult. Hickory Point is one of the most vulnerable sites at Pocomoke State Forest and is a priority for restoration based on the need to protect high quality watersheds. Monitoring and removing invasive species are current natural resources management strategies that will continue in the need to address climate change. The following information represents the next level attempt to address climate change concerns and opportunities.



This image is of Hickory Point.

Hickory Point Natural Resources

Maryland DNR's models of sea level rise indicate nearly all of the land mass of Hickory Point Cypress Swamp is vulnerable to inundation except for the upland forest. The rare habitats that would be most affected are the Atlantic White Cedar Swamp, Tidal Bald Cypress Forest and Woodland, and the Tidal Oligohaline Marsh and Shrubland. The Palamedes Swallowtail butterfly was run through the CCVI and found to be extremely vulnerable. The host plant for this butterfly is Red Bay which is at the northern part of its range in Maryland, but its sensitivity to climate is unknown. Generally, it is thought that southern species may extend their range northward as the climate warms. However, mortality from laurel wilt further south may affect the distribution of Red Bay and likewise the butterfly. Another southern butterfly known as the Great Purple Hairstreak has as its host mistletoe and is indexed by CCVI as moderately vulnerable. Host sensitivity of mistletoe to climate is not known.

Swamp Tupelo is a variety of black gum that is found in tidal swamps at Hickory Point. As found in Chapter 6c appendices of the State Wildlife Action Plan, this tree may be negatively affected by changing climate, according to the Climate Change Tree Atlas Adaptability Rankings, more so than the models indicated. Appendix 6e Predictions of Species-Specific Habitat Shift due to Climate Change in the Northeast (Modified from the Climate Change Bird Atlas, Matthews et al. 2007, <http://www.fs.fed.us/nrs/atlas/>) identified that Prothonotary Warbler is likely to increase with climate change and Louisiana Waterthrush will likely shift downward.



No Climate Action: Natural Resources

The Eastern Shore of Maryland is dominated by southern yellow pine and pine-hardwoods which are expected to be largely unaffected by climate change. Depending on the scenario and species, changing climate conditions could result in a change in rotation length of timber stands. Increased average temperatures may result in the increased incidence of pests, disease, and fire, which will affect the composition of the forest and complicate their management. An increase in severe weather events with high winds and precipitation will impact operations, forest structure, and biology. The Pocomoke River is susceptible to sea level rise, making Pocomoke vulnerable to saltwater intrusion. The various climate impacts will interact with systems differently, potentially having cascading effects on ecosystems.

Wildlife Habitat and Impacts

The marsh at Hickory Point is primarily composed of *Phragmites australis*, an invasive species that is effective at outcompeting native plants. Common throughout the majority of Pocomoke, other invasive species include wisteria, Japanese Knotweed, mile a minute, and Japanese Stiltgrass. Invasive species can outcompete native species, decreasing natural habitat availability for wildlife and promoting instability in the ecosystem. The forest floor is constantly evolving, and during periods of die off due to temperature or sea level rise, for example, the invasive *Phragmites* is likely to dominate.

Timber stands are currently managed in a sustainable way, though temperature, precipitation changes, and worsening storms may impact management strategies due to changing growth and survival rates of both young and old trees.



This image depicts invasive species present at one location in the forest.



Sea level rise and increasing saltwater inundation are predicted to be the greatest climate change threats to Pocomoke State Forest, especially as they impact Pocomoke's first line of defense, Hickory Point. Any vegetation that is susceptible to saltwater intrusion and increasing inundation is likely to experience declines in biodiversity. The effects of sea level rise on Hickory Point may have a cascading effect on biodiversity throughout the forest. In addition to sea level rise, changing precipitation patterns will also impact wildlife. Some areas, such as the Pocomoke River Wildlands, may see increased flooding and longer periods of inundation, continuing to lead to unstable shorelines, diminishing habitat sizes, and loss of natural resources.



This figure shows flooding throughout the forest after a rainstorm.

Forest Fires

Changing climatic conditions such as increasing temperatures and changing precipitation patterns could have a negative impact on natural resources. Increased drought periods create conditions for more forest fires, which lead to increased erosion and flooding and decreased biodiversity. Swamp Tupelo, found at Hickory Point, is vulnerable to drought and fire. Wetland habitats at Pocomoke currently protect vulnerable plant and animal species of greatest conservation need from the effects of drought (Harrison 2015, pers. comm.) (SWAP).

Ecosystem Services

Saltwater inundation and sea level rise that leads to vegetation loss impacts the forest's ability to reduce flooding, improve water quality, and store carbon.



Adaptation Options and Opportunities: Natural Resources

There are many opportunities to respond to climatic threats to natural resources at Pocomoke State Forest. Recognizing that different parts of the Forest will have different climate change threats, these are some broad recommendations.

Wildlife

To address sea level rise and storm surge at Hickory Point, it is necessary to create an environment that is resilient to climate change. Removing invasive species and replanting with native species that are more resilient to warming temperatures will help habitats transition. Increasing monitoring and using landscape scale restoration grants will be essential in understanding biodiversity changes and allow staff to move forward their sustainable management.

To respond to inundation and sea level rise to prevent habitat and biodiversity loss, restoration efforts should be considered. High quality sites have already been prioritized for restoration. Efforts to restore headwaters could relieve climate stressors and flood impacts downstream, though monitoring efforts should be increased to understand how conditions vary as ecosystems change downstream.

Enhancing stream buffers with native vegetation that can endure longer periods of inundation and act as a transitional species will be important for allowing streambank stabilization. Buttonbush is known to be more tolerant of frequent inundation and saltwater intrusion and could be one example of a plant to allow for ecosystem transition.

Areas of Pocomoke that may be destined to become ghost forests could be considered for preemptive marsh migration management strategies. For Hickory Point specifically, timber management is prohibited due to its Wildlands designation. Any action to actively manage timber resources in this area would require action via the Governor and state legislature. In other non-Wildlands areas throughout the forest, as long as the harvest area is outside of the 50' stream buffer, limited harvests are allowed and should be considered to respond to climate change.

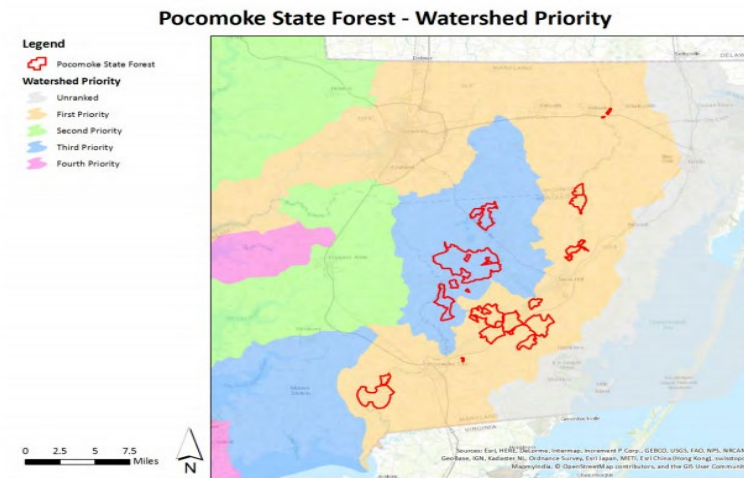


Figure 5: Watersheds on Maryland’s Lower Eastern Shore, illustrating priority levels for restoration. Hickory point is in the bottom left zone (PSF Management Plan, 2018).

Forest Fires

Pocomoke State Forest participates in sustainable timber harvesting as a strategic response to climate change that doubles as a form of revenue generation. The Pocomoke State Forest Sustainable Forest Management Plan was last updated in 2018 and is revised as necessary. Continuing to observe trends in forest health will inform forest staff on best management practices, and the potential need to plant more climate tolerant species in the future. Prescribed burns are also a valuable strategy enacted at Pocomoke for forest management and restoring ecosystem health.

Becoming more resilient to forest fires requires advanced preparedness and strategic planning. The placement of water pumps should be analyzed and assessed so that staff know where to locate pumps and how to use them in a fire emergency. Additionally, roads should be maintained as much as possible to allow access to fire roads.

Firewise Living is also a valuable program that protects the resources on Pocomoke’s land. Pocomoke is expected to be vulnerable to increasing forest fires, which means that visitors to the forest and nearby homeowners need to understand the concerns regarding forest fires. Staff should continue seeking out opportunities to collaborate with the Firewise Living program to ensure that climate change is factored into programming.

Ecosystem Services

Overall, increasing monitoring efforts is key to addressing the loss of wildlife, changing habitats, and declining ecosystem services. Understanding how water quality changes as the climate changes, and how carbon sequestration is impacted by warming temperatures and vegetation loss can help Forest staff prioritize solutions.



FOREST STREAMS
CLIMATE CHANGE IMPACTS AND ADAPTATIONS

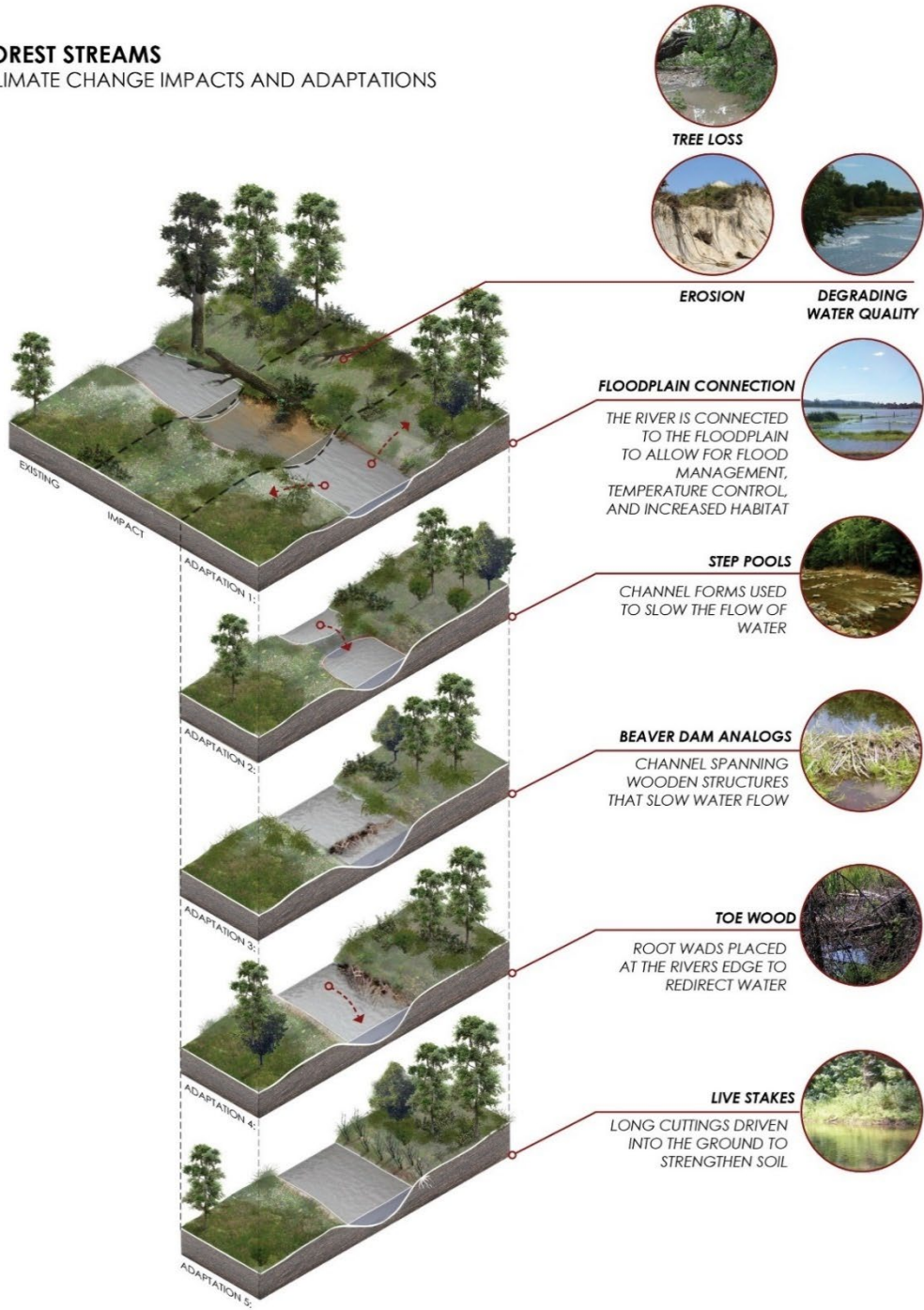


image courtesy of UMD School of Architecture, Planning & Preservation

Figure 6: Summary of Climate Impacts and Adaptation Opportunities in Pocomoke



Infrastructure

The primary infrastructure at Pocomoke includes roads and parking lots. Other infrastructure includes offices, boat ramps, disabled hunter access areas, a campsite area, and soft launches. Roads in the Forest are a combination of boardwalks, dirt, and gravel roads which are essential to transporting timber, emergency vehicle access, and reaching places to achieve management goals, such as removing invasive species. Many of the roads at Pocomoke have a significant portion of their surface at or below 3 meters (10 feet) elevation. Pocomoke is susceptible to sea level rise from 0-2 feet (coastal atlas), especially in areas near the Pocomoke River. Many of the boat launches and parking areas are located in or near areas expected to be impacted by sea level rise, impacting recreational activities on site.

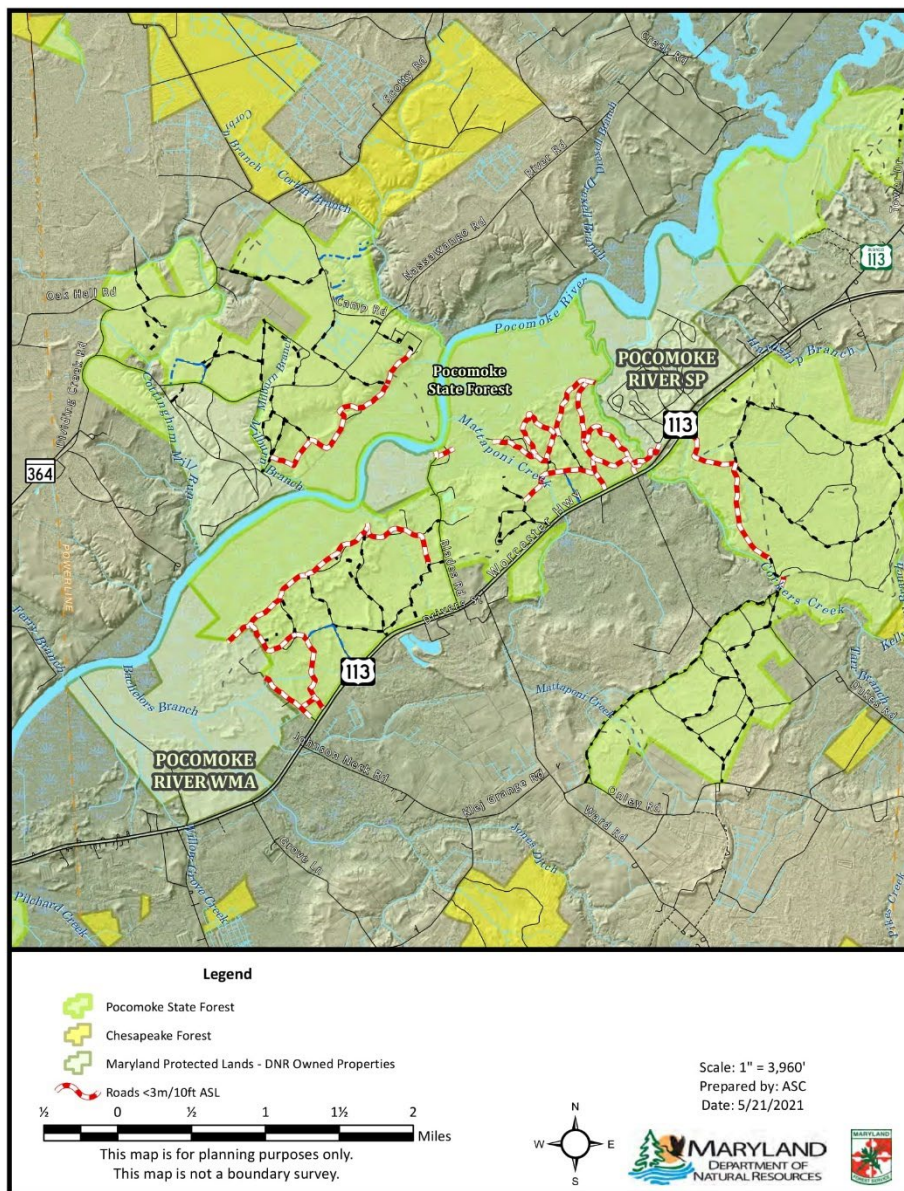


Figure 7: Map showing roads below 3m/10ft of elevation.



No Climate Action: Infrastructure

If the infrastructure at Pocomoke State Forest is at risk, almost all operations on site would be impacted, as the roads at Pocomoke are essential for traveling the 18,000 acres of the Forest.

Roads

Road and trail maintenance is a priority for management. An increase in flooding and worsening storms have compromised Pocomoke's water control structures, culverts, and roads, leading to washout, erosion, pipe failures, and unsafe road conditions. Decreased site access impacts fire control, invasive species management, and timber harvesting. Damaged and flooded roads also will pose dangers to pedestrians and horseback riders.



Example of road conditions after rain.

Parking lots at Pocomoke will likely experience more frequent flooding as well, impacting access to the Forest and leading to faster degradation of roads. Rutting in the roads is becoming a more common occurrence.



This shows how much erosion can occur when a water control structure is damaged.



Access Points

Sea level rise and higher high tides are impacting public access areas to land based and water based recreational opportunities. The soft launch at shad landing will likely be unrecognizable in the face of sea level rise, changing how visitors engage with the area, and decreasing space for more visitors to park.



This shows the soft launch at Blades, which is prone to flooding.

Buildings

Pocomoke has very few buildings on site, with the exceptions of the main offices and other shed and garage areas. According to the coastal atlas, these areas do not appear to be susceptible to sea level rise, though access roads to the buildings may become limited. Older buildings will be impacted by storm surge.

Fire pumps and placements

In their current locations, fire pumps and placements may occasionally be inaccessible due to flooding and road washouts.

Adaptation Options and Opportunities: Infrastructure

Overall

In addressing infrastructure challenges at Pocomoke State Forest, there is a need to re-evaluate how projects are funded and prioritized on site. Continuing conversations to determine project timelines and construction guidelines will be important for ensuring that there are funds and processes in place for when infrastructure is impacted by storms or sea level rise. It is our recommendation that the impacts from climate change

in the next 20-30 years be considered in current planning conversations, since the process of being selected for infrastructure improvement is very selective.

Roads

Road improvements and maintenance should be a priority at Pocomoke. Monitoring areas that are susceptible to flooding and documenting damage will be important for showing areas for adaptation opportunities. This could be challenging with the vast road systems that exist within the forest system but using tools such as water gauges and drone surveying could help capture flooding trends.

Using vegetation buffers near roadways could also prevent or slow gravel washout from occurring. Plant roots help absorb water before it reaches the roadways. Reinforcing roads with hardened structures may reduce water from pooling at the base of the roads as well. Allowing for drainage at the road surface will protect roads in the long term. As restoration and improvement to infrastructure occurs, increasing the size of culverts to account for increases in precipitation and streamflow will be imperative.

Increasing permeability of the parking lots at Pocomoke and using vegetative buffers could reduce flood risks and redirect water flow to minimize long term damage to parking lots. Elevating parking areas or providing alternative parking areas could also be long-term solutions to continually provide access to the Forest without compromising infrastructure. Increasing communication with visitors about inaccessible areas and infrastructure will become important as storm events increase.

STORM IMPACTS TO ROADWAYS
CLIMATE CHANGE IMPACTS AND ADAPTATIONS

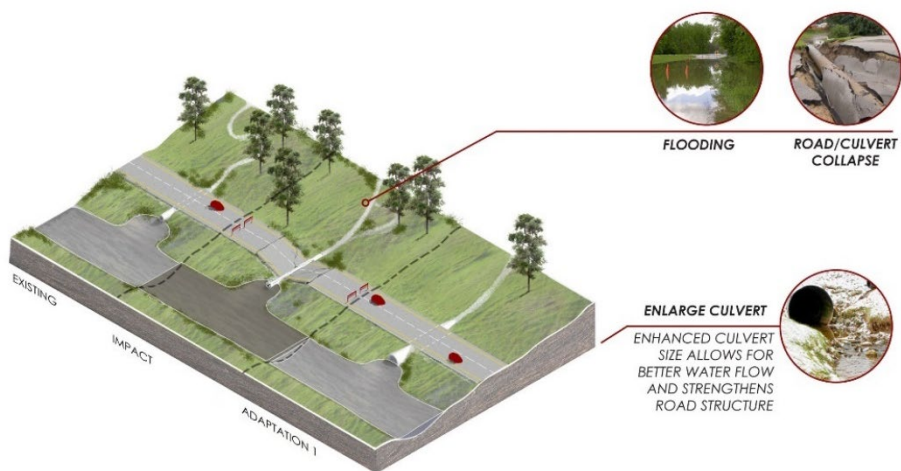


image courtesy of UMD School of Architecture, Planning & Preservation

Figure 8: Shows enlarging culverts to respond to increasing precipitation.

Buildings

Some infrastructure at Pocomoke that is expected to be repaired in the coming years may not be as impacted by storm surges and sea level rise as other areas on site, which could lead to the need to amend scopes of works.

Fire Access

Becoming more resilient to forest fires requires advanced preparedness and strategic planning. The placement of water pumps should be analyzed and assessed, so that in case of a fire emergency all staff know where to locate pumps and how to use them. Additionally, roads should be maintained as much as possible to allow access to fire roads.

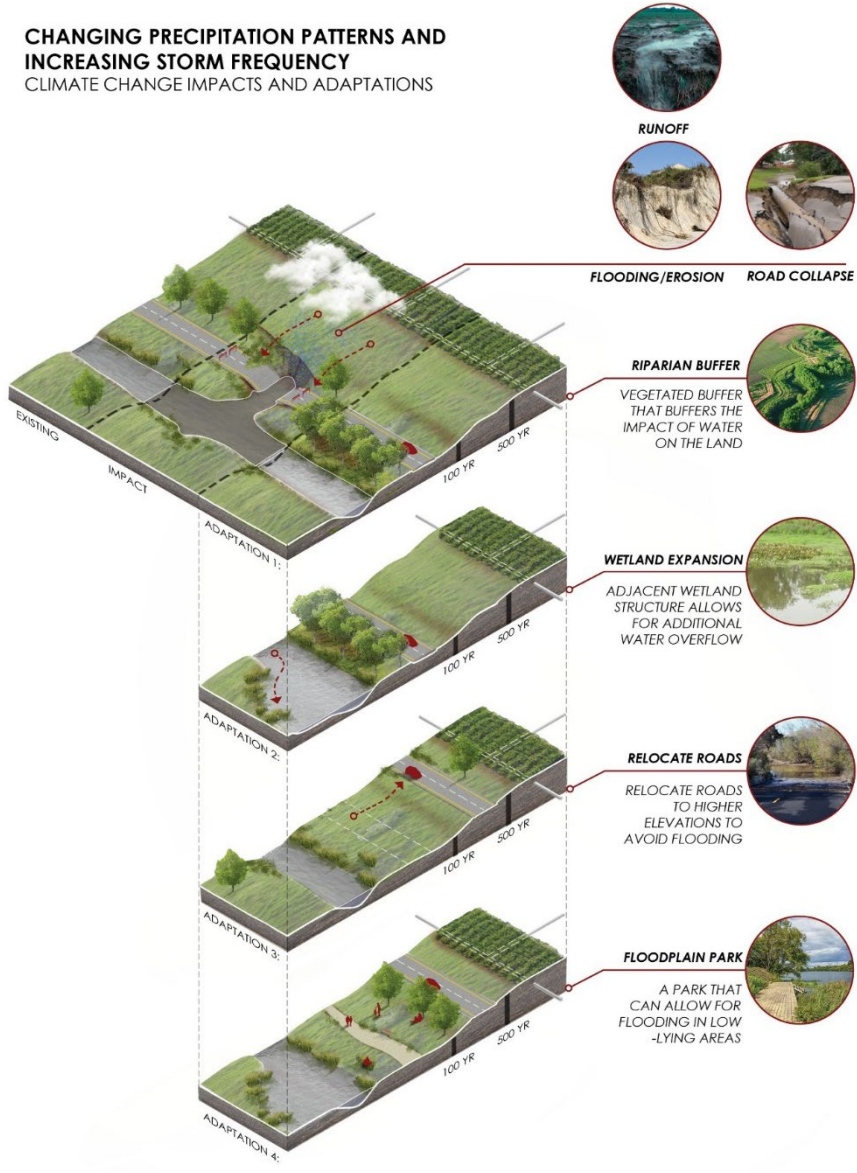


image courtesy of UMD School of Architecture, Planning & Preservation

Figure 9: This shows adaptation options for increased flooding of roadways.



Recreation

Pocomoke State Forest is known for its recreational opportunities, including horseback riding, hunting, boating, kayaking and canoeing, hiking and biking. Trails and access points located closest to the Pocomoke River are likely susceptible to 0-2 feet of sea level rise. Hunting opportunities likely will be adaptable to changing conditions.

No Climate Action: Recreation

Access

Under a 0–2-foot sea level rise scenario (coastal atlas), parts of the Hudson-Tarr Bike Trail and Mattaponi Soft Launch may be underwater or subject to frequent flooding. The Milburn landing trail (pictured below) also could be susceptible to flooding in areas near the Pocomoke River.

Soft boat launches are in areas likely to be impacted by sea level rise. Accessing the soft boat launches and trail might become more difficult as water levels increase.

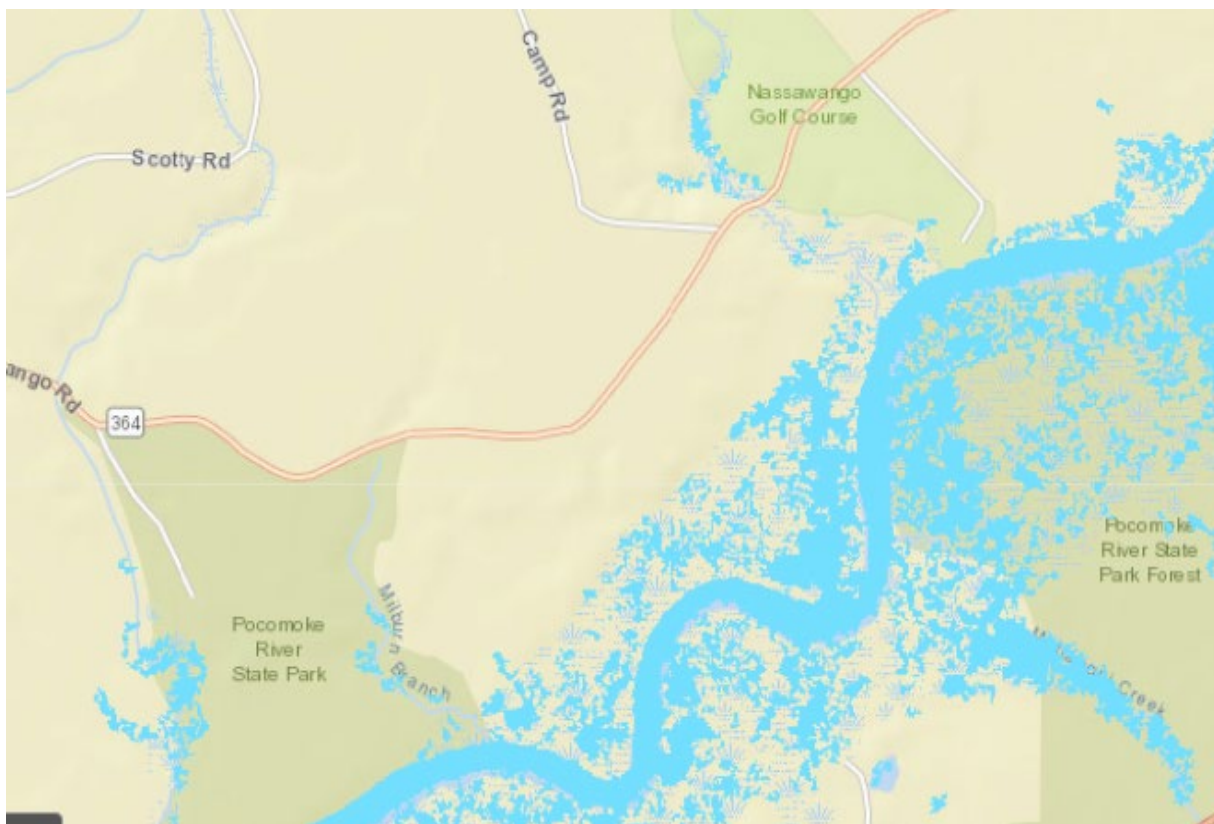


Figure 10: This image shows areas underwater during 0-2 feet of sea level rise (Coastal Atlas, 2019).



In areas where there has been increased precipitation and flooding, trail washout might become more common, making the area unsafe or inaccessible for Forest guests.



This shows an area where a culvert failed and had to be removed. The incident was reported by a visitor when they noticed flooding on the trail making the site inaccessible.

Hunting

The species hunted at Pocomoke State Forest are not considered rare, threatened, or endangered. Hunting opportunities should remain constant, though access to areas might be impacted by storms and sea level rise.



Adaptation Options and Opportunities: Recreation

Access

To preserve access to trails, trail maintenance and monitoring should be considered. Elevating pathways or creating alternative routes during periods of high water would allow for recreational opportunities to continue without significant changes.

Although the soft boat launches will still be accessible, vegetative reinforcements might be necessary for bank stabilization. Additionally, signage might have to be moved as water levels increase.



This shows the access point at Shad Landing, a vulnerable area.

Hunting

Increasing communication with hunters about access points that have been impacted by storms and flooding will be important as more road washouts are expected with increasing precipitation.



Cultural Resources

Pocomoke State Forest does not have any known cultural resources on site, but adjacent to the State Forest is the Nassawango Iron Furnace Archaeological Site, which was registered in 1975. The site appears to only be vulnerable to climate change at levels of sea level rise beyond five feet and to category four storm surges (coastal atlas).

Adaptation Options and Opportunities: Cultural Resources

Although the Nassawango site is not located within Pocomoke State Forest, restoration efforts to reduce flooding from the Pocomoke River could reduce future climate impacts to the Nassawango resources.



This image shows the Nassawango Iron Furnace.



Human Resources/Economy

One of the biggest challenges for staff currently is invasive species management. As temperatures warm, conditions will be favorable for an increase in invasive species and decreased native biodiversity. This places an increased demand on staff to monitor and remove invasive species while promoting native plant growth.

As infrastructure degrades with sea level rise and increasing and worsening storms, Pocomoke staff are responsible for fixing urgent problems in the roads in order to access sites.

Another concern is wildfire management. Wildfires are predicted to increase on the eastern shore by 50%, further leading to dangerous management conditions and placing increased stress on Forest managers (Climate.Park.Change Data). Staff currently manage forest stressors with their sustainable forest management strategies. This practice will continue and be modified as necessary in the face of climate change.

No Climate Action: Human Resources

Invasive Species

Invasive species management is time consuming, and without updated invasive species management plans invasive species could become overwhelming for Forest staff. If unaddressed, invasive species could lead to decreased biodiversity, impacting other resources and operations on site.

Timber harvesting

Timber harvesting is an essential aspect of the work done at Pocomoke State Forest. Harvesting capacity has remained constant, but an increase in invasive species can diminish the value of the wood and place time constraints on forest staff, impacting the harvesting schedule and survivability of timber.

Planning

Without including changing climatic conditions into management decisions, disasters such as wildfires will put a greater demand on forest staff as they will have to reprioritize management decisions and address the consequences of wildfires, such as erosion, increased flooding, and greater operational costs.

Adaptation Options and Opportunities: Human Resources

Invasive Species

Efforts to control invasive species need to be calculated and timely. Understanding where invasive species occur and what treatments are most effective for management is going to be essential so that staff can feel prepared to respond to emerging issues. Continuing to map invasive species occurrence is essential, and analyzing where invasive species are most dangerous will allow staff to prioritize where management techniques are implemented.



Timber Harvesting

Continuing to update the Pocomoke Sustainable Forest Management Plan is going to be an essential tool for Forest staff as species change with increasing temperatures and biodiversity is impacted by invasive species. Increasing monitoring will help staff identify changes in biodiversity early on and allow for necessary changes in decision making to accommodate seasonal shifts and habitat changes.

Planning

Including changing climatic conditions such as increasing wildfires and changing precipitation patterns will allow Forest staff to prepare in advance for dangerous conditions to ensure the best conservation practices and safety at Pocomoke State Forest.

Recommendations for Future Planning

Monitoring and forecasting will be essential for climate change adaptation and resilience at Pocomoke State Forest. Collecting data on saltwater intrusion and forest loss will facilitate an understanding of how quickly forest composition is changing. In turn, this will help Forest staff prioritize restoration projects and areas. Monitoring invasive species will also assist Forest staff in understanding how physical removal is working and how invasive species are impacting Forest resources.



This shows a prescribed burn at Pocomoke State Forest.

Existing Efforts

Existing efforts to address climate change at Pocomoke State Forest include sustainable forest management, intense invasive species management and monitoring. Areas vulnerable to climate change have been identified and analyzed using mapping tools. Forest staff have also been participating in regional climate efforts and training sessions so they are better equipped for climate planning.

Long Term Goals

Five years

Monitoring and mapping are priorities for the next five years. It is necessary to understand where areas might be experiencing more frequent flooding in addition to where invasive species are occurring. Installing water gauges in the river and throughout the Forest will assist in monitoring when periods of high water occur, allowing for more informed decisions about habitat management. Future studies could include how soil is accreting or eroding, storing carbon and methane and how vegetation is changing over time at Hickory Point.

Ten years

In the next ten prioritizing infrastructure projects to adapt or withstand climate changes will be paramount. Roads that are experiencing flooding and inhibiting access to timber harvesting and management areas should be the first to be reconstructed to prevent delays in management and to maintain recreational opportunities. Culvert sizes should be increased to account for precipitation changes.

Fifteen years

In the next fifteen years it is expected that invasive species management will be a priority unless it is controlled. The Pocomoke State Forest Sustainable Forest Management Plan should be updated within the next 10-15 years to address temperature changes and biodiversity shifts.

Fifty years

Using the Cambridge tide gauge, Pocomoke State Forest might be susceptible to 2.0 feet of SLR by 2050. To prepare for sea level rise it will be necessary to plant native species and vegetative buffers to allow for habitat changes.

One hundred years

Using the Cambridge tide gauge, Pocomoke State Forest might be susceptible to 4.3 feet of SLR by 2100. The most vulnerable roads may need to be elevated or re-routed, and ghost forest management protocols should be in place.

Identifying Projects and Partners

Pocomoke State Forest is already collaborating with many external partners. Continued and future partnerships could include:

- Working with MD DNR's Trust Fund to address forest and wetland restoration
- Local watershed organizations to increase capacity for monitoring
- Collaborating with the Fish and Wildlife Service to increase monitoring
- Ducks Unlimited to protect wetland habitats
- Resource Conservation and Development
- The Nature Conservancy
- Partner with MDA to evaluate disease and insect susceptibility.
- Universities to study water quality, vegetation changes, and soil health

Overall Conclusions

Although Pocomoke is a large tract of land, there are key impacts from climate change that can be addressed in all parts of the forest. Roads are susceptible to flooding and invasive species are threatening biodiversity throughout the forest. Infrastructure that is susceptible to increased flooding and sea level rise should be prioritized and climate change should be a consideration when repairing or replacing infrastructure in Pocomoke. In areas heavily trafficked by visitors, alternative routes should be planned. Wildfire risk is going to increase throughout the eastern shore, having the potential to impact timber harvests and native species. Developing invasive species management plans that include increasing the number of native species will decrease compromised ecosystem services. Learning more about wildfire risk and areas that will be most vulnerable will also serve to protect biodiversity and forest staff.



This image shows cypress trees in Pocomoke State Forest.

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Thank you!

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kate.vogel@maryland.gov, (410)-934-2005, for questions.

DNR Website: dnr.maryland.gov

Additional telephone contact information

1. Toll free in Maryland: 877-620-8367

2. Out of state call: 410-260-8367

TTY Users call via the MD Relay



The Chesapeake and Pocomoke State Forest sign.



Appendix A: Key Terms

Adaptation: the process of adjusting to current or expected climate change and its effects

Climate change: a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels

Ecosystem services: the benefits provided by ecosystems that contribute to making human life both possible and worth living

Land manager: the area lead responsible for program implementation and decision making on site

Old Growth Forest: forests that have developed over a long period of time, essentially free from catastrophic disturbances

Resilience: the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate

Rare, threatened, and endangered animals: abbreviated as RTE, these animals include species occurring in Maryland that are on the federal list of Endangered and Threatened Wildlife and Plants under the Endangered Species Act (ESA), species currently on the State's Threatened and Endangered Species list, and additional species that are considered rare or under assessment by the Wildlife and Heritage Service

State Wildlands: are designated by the Legislature of Maryland as preservation systems with limited and restricted management activities

Wetlands of Special State Concern (WSSC): These wetlands contain prime examples of unique habitats

Natural Heritage Areas: Two Natural Heritage Areas are found within the boundaries of Pocomoke State Forest: Hickory Point Cypress Swamp and the Mattaponi area.

Appendix B: Climate Change Impacts & Adaptation Table

The following table highlights some of the climate threats and impacts at Pocomoke State Forest, in addition to short term and long-term adaptation and resilience options.

Climate Change Threat	Impact	Opportunities for Adaptation and Enhancing Resilience (Short term on the left and long term on the right)	
Increasing Temperature	Increased drought	Increase monitoring	Plant climate tolerant species
	Increased likelihood of forest fires due to drought	Staff training and preparedness through development of a wildfire plan	Maintain forest buffers, promotion of the Firewise Living program
	Decreased capacity for carbon sequestration	Restoration of forested wetlands	Increased monitoring
	Changing species distribution	Plant climate tolerant vegetation	Increased monitoring, use of drones
Sea Level Rise	Saltwater inundation leading to loss of trees, invasive species, and the conversion of forests into salt marshes	-Restoration -Control <i>Phragmites</i> -Restore water control structures -Review timing of harvesting	-Increased land acquisition -Review harvesting policies (CAC policy to remove trees) -Allow for swamp expansion -Monitor how higher water impacts ecosystem services (buffers)
	Higher tides leading to loss of road access	-Enhance vegetation buffers near roads -Berms	-Transition from road access to water access -Construction policy and CAC for prioritizing road restoration and dead tree removal
Worse storms and increasing winds	Breakdown of buildings	Vegetation buffers	Architectural study of resilient buildings
Increased precipitation	Flooding of roads → decreased access	-Monitor road damage -Redirect water flow -Riparian buffer zones	-Engineering and construction policy changes: enlarge culverts, design for future, prioritize roads, review POS funding (new vs maintenance)
	Flooding of campsites	Communication system with campers	Relocate campsites
Biodiversity Declines	Impacts to forest health, potential declines in habitat	Sustainable timber harvesting	Increased monitoring to understand habitat mosaics and promote adaptive forest management
Increased Disease Risk	Increased mosquitoes and pests	-Reduce spawning grounds -Fill in ditches	Partner with MDA to evaluate disease and insect susceptibility