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Assateague State Park Climate Change Adaptation and Resilience Planning Guide

Protecting long-term resources and opportunities in a sustainable manner

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For questions about this plan please contact kate.vogel@maryland.gov.

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Acknowledgments

This adaptation and resilience plan for Assateague State Park is the culmination of many site visits, virtual meetings, and conversations. Over the course of a year, we have worked together to identify climate change impacts and adaptation opportunities for Assateague State Park. The dedicated committee members are listed below - thank you for your time and energy!

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The technical advisory committee acknowledges the historical and continuing connection between Indigenous peoples and their native lands. Assateague is located on the ancestral land of the Algonquian people whose descendants are thriving and include the Assateague People of Delmarva.

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.

Letter from the Author

It is a great honor to take on the challenge of writing a climate adaptation and resiliency plan for one of the most visited state parks in the state of Maryland. Assateague State Park is a stunning area with complex ecosystems that have been integrated into every aspect of recreation, providing opportunities for wonder and engagement to thousands of visitors every year. Despite the intensity of environmental management in this fragile ecosystem, it is people who define the experiences at Assateague. People, and horses that is. As with any environmental management opportunity, one decision can influence many other aspects of a closely intertwined system. Assateague is a barrier island, a state park, a campground, an educational facility, and a place of employment. Assateague is special for many different reasons, which is why it is so important to us to learn how we can protect, enhance, and adapt this island as best as we can in the face of climate change. This climate change plan was created for the people who visit Assateague, the unique wildlife that lives on the island, and the people who do their best every day to continue making it an incredible place to visit. This climate change plan is *not* a management strategy for protecting or removing the wild horses, and it is not a recreational guide. Rather this plan aims to identify climate threats and impacts, categorize the changing assets, and propose adaptation strategies to conserve and foster an appreciation of the natural, cultural, and historic resources of Assateague State Park and to continue to provide recreational opportunities for as long as possible in a sustainable manner. It is my intention that this plan will be used as a starting place and guide for short-term and long-term climate change planning on Assateague Island.

In any good system, no part functions without another. To my mentor Sandi Olek - thank you for guiding me through the NOAA Coastal Management Fellow process during the start of a pandemic and for showing me how much fun there is to be had in letting your curiosity flow. To Angela Baldwin - thank you for your time, energy and enthusiasm in planning site visits, facilitating technical advisory committee meetings, talking with students, and letting me experience the incredible campsites you have to offer. You are a natural resource champion through and through. Thank you to Bill Hulslander for sharing resources and expertise from Assateague Island National Seashore. I also want to acknowledge four students and two professors from the University of Maryland School of Architecture, Planning and Preservation: Yan Ferris Konan, Jihee Lee, Nick Christopher Dibella, Samantha Kei A Jamero, Jana Vandergoot and Michael Ezban. Every UMD image in this report was carefully crafted by this team and they did amazing work. Henk Nieboer and Tom Wilms - thank you for taking the time to brainstorm climate solutions with a stranger from the United States. To all others who helped me on this plan - whether it was participating in the technical advisory committee, proofreading my reports, coming on site visits with me, or hiring me on full time before the project was even finished – thank you so much for your support. I hope you all feel as inspired as I do by the solutions we can achieve when we all dream together and figure out how to make it happen.

Kate Vogel, Coastal Resilience Planner

Executive Summary

This plan serves as a climate change adaptation and planning outline for Assateague State Park. Assateague State Park is one of the most visited state parks in the state of Maryland, bringing in over $1,000,000 to the state annually. As a barrier island lined by both the Atlantic Ocean and Maryland's coastal bays, it is one of the most vulnerable areas to the impacts of climate change. As such, it is imperative to find ways to adapt to the threats of climate change and protect Assateague's natural resources for years to come.

Climate Impacts to Park Resources:

Natural Resources

Assateague's natural resources are at severe risk due to climate change. Wildlife and nesting habitats are impacted by sea level rise and storms. On the Atlantic Ocean side, intensifying and more frequent storms and sea level rise lead to erosion. The low-lying marshes are sensitive to frequent inundation and increasing salinities result in saltwater intrusion and sea level rise.

Infrastructure

Vulnerable infrastructure at Assateague includes everything from the ranger station and day-use buildings to the campsites, dunes and dune crossings. Other infrastructure includes the roads, bathhouses, registration building, gift shop, concession stand, marina, and campsites, which may be severely impacted by climate change. Increased precipitation, sea level rise, and storm surge will lead to more flooding and faster degradation of these hard structures.

Recreation

Climate change will impact every recreational opportunity at Assateague. Recreational opportunities are threatened by increasing temperatures, sea level rise, worsening storms, and changing precipitation patterns. Park closures due to storms may become more frequent, and there may be decreased access to campsites and the beach. Warming temperatures may impact public health.

Human Resources

Already limited staff capacity will be tested by climate change impacts as more resources and hours are dedicated to cleanup and restoration after storms. Economically, climate change may negatively impact Assateague as it limits resources and access for park visitors.

Cultural and Historical Resources

The Rackliffe house located at Assateague State Park is potentially vulnerable to the impacts of saltwater intrusion, increasing temperature, and worsening storms which all threaten to increase the rate of degradation onsite.

Options exist within the next five to twenty years to increase the resiliency of natural resources and infrastructure at the park to better withstand the impacts of climate change. These strategies include restoration, allowing for more walk-in campsites to reduce staff demands, elevating and reinforcing buildings, or relocating infrastructure. Continuing to assess options and develop plans over the long-term is key to adaptive management at Assateague.

Priority Recommendations

Increase Sand Bypassing	•Needs to be fully funded •Maximize sand quantities deposited •Extend beyond the 2028 expiration
Conduct Dune Monitoring and Stabilization	•Hire a coastal geologist to assess dune health and provide recommendations •Conduct drone monitoring
Hire a Design Engineer	•Redesign campgrounds to account for vulnerability, walk-in sites, and parking
Monitor Marshes and Stabilize Shorelines	•Analyze living shoreline potential •Monitor restoration success
Acquire More Land	•Assess properties that can be used for future campsites and recreational opportunities
Assess State Highways	•Work with MDOT SHA to assess the vulnerability and resilience of the Stephen Decatur Highway and Verrazano Bridge
Improve Infrastructure	•Long-term infrastructure improvements that prioritize climate resilience and enhance ongoing projects

Ongoing efforts include sand bypassing performed near the Ocean City inlet and deposited at the northern end of the island by the United States Army Corps of Engineers. Through natural processes this sand is transported on the shoreline of both the state park and national park, helping to build up the beach and dunes. Capital improvement and critical maintenance projects redesign, restore, or rebuild infrastructure to account for previous flooding incidents.

Current partners involved with enhancing resiliency at Assateague State Park include the Maryland Department of Natural Resources, the Maryland Coastal Bays Program, the National Park Service, the United States Army Corps of Engineers, Maryland State Highway Authority, the Maryland Department of Transportation, The Nature Conservancy, among others.

Introduction/Overview

The Maryland Park Service at Assateague State Park has partnered with Chesapeake and Coastal Service to prepare a climate change adaptation and resilience planning guide for Assateague that evaluates climate hazards, impacts from climate change, and potential adaptation strategies and implementation opportunities. It is intended that this guide will support park staff in decision making and resilience planning.

RESILIENCE STATEMENT

To conserve and foster an appreciation of the natural, cultural, and historic resources of Assateague State Park and to continue providing recreational opportunities in a sustainable manner.

Objective and Resilience Statement

This document will provide recommendations and solutions that support Assateague State Park's climate change resilience statement: to conserve and foster an appreciation of the natural, cultural, and historic resources of Assateague State Park and to continue providing recreational opportunities in a sustainable manner.

Document Organization

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

Natural resources: flora and fauna of the park, in addition to the Sinepuxent Bay and coastal dunes

Infrastructure: physical and organizational structures and facilities located at Assateague, 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

Background

Assateague State Park is a barrier island on the eastern shore of Maryland. At 855 acres, the park spans 2 miles of shoreline and is located between the north and south ends of Assateague Island Seashore, which is managed by the National Park Service. The park, home to diverse wildlife and unique ecosystems, and a gorgeous dune-lined beach, is a major part of the Atlantic flyway, and mammals such as Sika deer and wild horses roam to visitor's enjoyment. One of Maryland's most visited state parks - Assateague provides valuable benefits to the Maryland economy and numerous recreational opportunities.

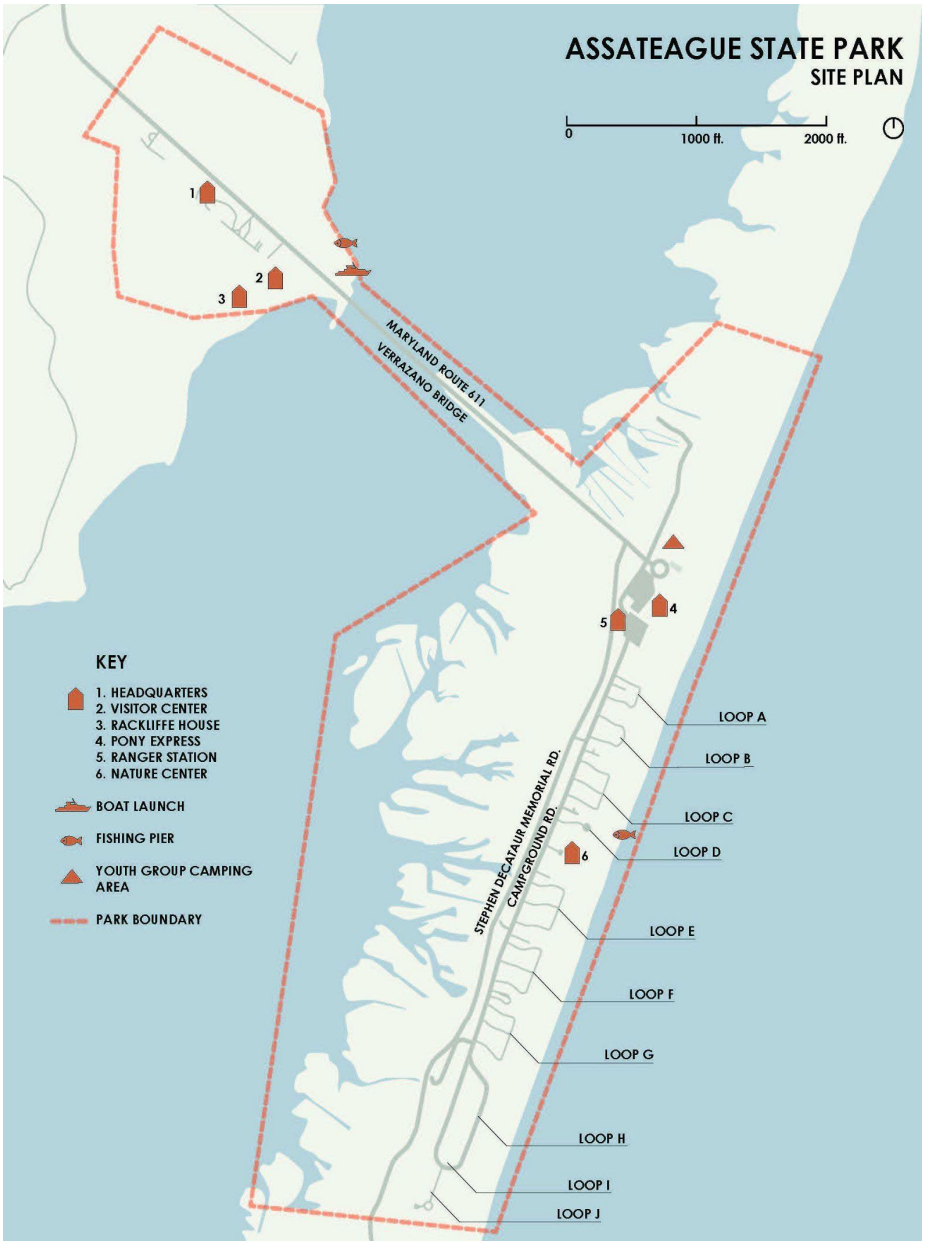


Figure 1: This figure from the UMD School of Architecture, Planning and Preservation shows an overview of the Assateague State Park and a closer look at assets located on site.

Physical Description

Bordered by the National Seashore from the north and south, Assateague State Park is defined by the Atlantic Ocean on the east and the Sinepuxent Bay on the west. The coastal bay marsh is host to valuable wildlife habitats which offer flood protection and food for many flora and fauna. The landscape is characterized by sandy beaches, salt marshes, and maritime forests that are inhabited by terrestrial wildlife such as white-tailed deer, sika deer, wild horses, and migratory and resident birds. Aquatic species of the Atlantic Ocean and coastal bays include whales, dolphins, sea turtles, sharks and numerous species of saltwater and brackish water fish and aquatic invertebrates. Additionally, the federally listed endangered piping plover's only remaining nesting area in Maryland is Assateague, mostly occurring on the National Park property. The state park also hosts many campsites and plenty of areas for recreation, from walking trails to day use picnic areas.

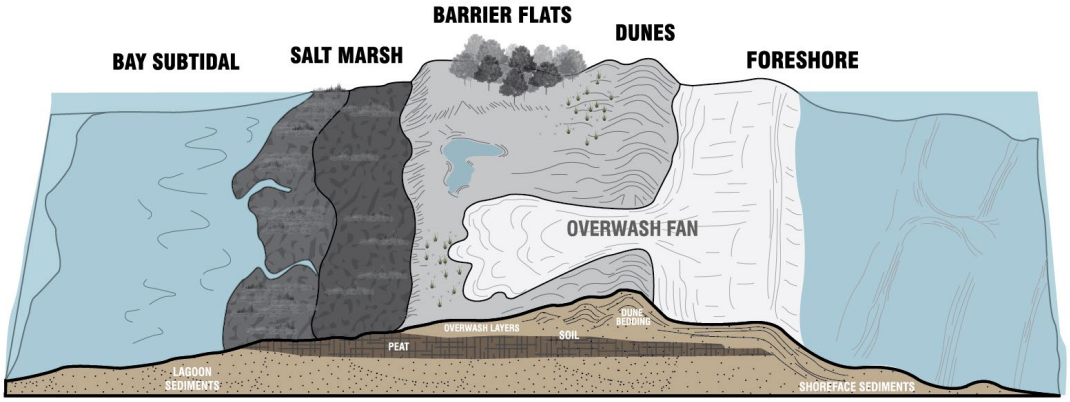


Figure 2: This figure depicts Assateague Island's physical features, UMD.

Park Assets and Resources

Assateague is known for its natural resources and recreational opportunities. The beach-front camping experience is unbeatable, as visitors get to enjoy views of the ocean and Sinepuxent Bay while camping at the foot of dunes. Many wildlife have made Assateague their home including wild horses, deer, fox, turtles, birds and more. The plants and animals at Assateague rely on the dune habitats for their food and shelter.

Visitors appreciate, and undoubtedly impact, the natural resources on site. In 2022, Assateague had over 1.8 million visitors. Visitors take advantage of opportunities for swimming, surfing, fishing, boating, kayaking and paddleboarding on the Atlantic side. The Sinepuxent Bay provides opportunities for canoeing, kayaking, fishing, crabbing, sightseeing, and boating, along with many other recreational activities. Hiking and biking trails exist within the park, in addition to a nature center and nature-themed play areas for children. The ranger station, bathhouses, gift shop, concessions, roads, and marina are all valuable infrastructure resources that exist to help improve the visitor experience. Located on the mainland of Assateague is the Rackliffe House, a DNR owned 18th century coastal plantation house. All of these resources combine to make Assateague a very unique state park. The revenue generated by Assateague State Park is an asset to the state; in both 2022 the annual revenue generated by the park was over $1,900,000.

The park has eleven full-time classified staff members, including a Park Manager, Assistant Park Manager, Park Services Supervisor, Maintenance Supervisor, Administrative Specialist, one lead Park Ranger, three Park Rangers and two Park Technicians. In addition, Assateague has one long-term contractual Park Technician, and one year-round Maryland Conservation Corps supervisor and a supporting crew of five members from October through early August. They provide operational support to the park with programming and maintenance projects.

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.

Assateague State Park was identified as one of the most vulnerable state lands in the state of Maryland. This is due to its geography as a thin barrier island on the coast of the Atlantic Ocean, with vulnerable coastal bays. Figure 3, highlighted below, shows areas at Assateague that are most vulnerable to climate change. These areas include the coastal bays and the shoreline, with the highest scoring ecological values occurring at the junction between the coastal bays and the dunes and on the mainland. Barrier islands such as Assateague are reshaped over time by constant changes in shifting sands, dunes and shorelines, but climate change is accelerating these cycles.

CLIMATE IMPACTS

- Increasing temperatures
- Sea level rise
- Changing precipitation patterns
- Increased flooding
- Increasing invasive species
- More frequent storms
- Biodiversity declines
- Increased disease risk

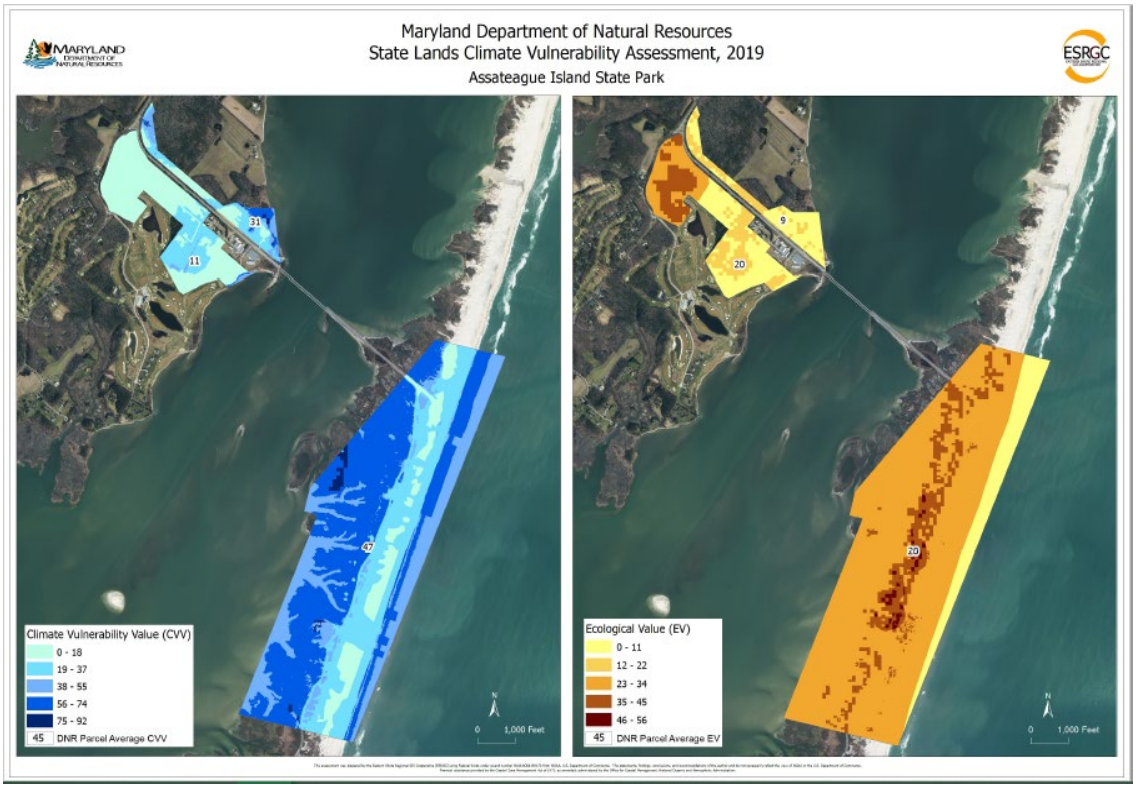


Figure 3: This map demonstrates that the Sinepuxent bay and dunes are vulnerable to climate change. Scores range from 56-80 on the climate vulnerability value index. The high ecological values come from rare, threatened, and endangered (RTE) species, ranging from 25-56/100 as the highest EV scores.

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 Assateague will impact the natural resources on the island as well as visitor health and safety. Heat stress could become more common. Changing temperatures encourage unique species migrations, meaning that invasive species could be a potential problem for native species found on site.

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 4.4 feet (1.34m) by 2100 based on data derived by Kopp et.al for the Lewes, Delaware 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 the park is **medium** flood risk tolerance meaning that across the park there is the intent to adapt to projected impacts and to tolerate some inundation. There may be specific projects that happen within park 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. It is advisable at that time the RSLR predictions for 2050 and 2100 be evaluated and 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 other concerns related to increasing sea level rise include increased high tide flooding and the potential for saltwater intrusion. High tide flooding is already occurring during extreme high tide events, including those not associated with larger scale storms (sunny day flooding). This contributes to exacerbating sand displacement on the island. Additionally, increasing salinization from saltwater intrusion attributed to sea level rise may have an impact on marsh vegetation and its chance of survival, thus impacting biodiversity and habitat availability.

Figure 4: This map shows areas that are currently subject to tidal flooding (in red), often called "recurrent or nuisance flooding."

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 resources. Increasing precipitation may also lead to increased dune erosion.

Storm Surge

While the number of tropical storms and hurricanes is not expected to increase due to climate change, there is an expected increase in the intensity including wind speeds, rainfall amounts, and duration. There is also an increase predicted in the frequency and intensity of storms. More extreme storms lead to increased flooding and damaging winds, placing natural resources, recreation, and infrastructure at risk. The dunes that protect the island are already susceptible to extreme erosion during large storms. During tropical storms, evacuations are initiated.

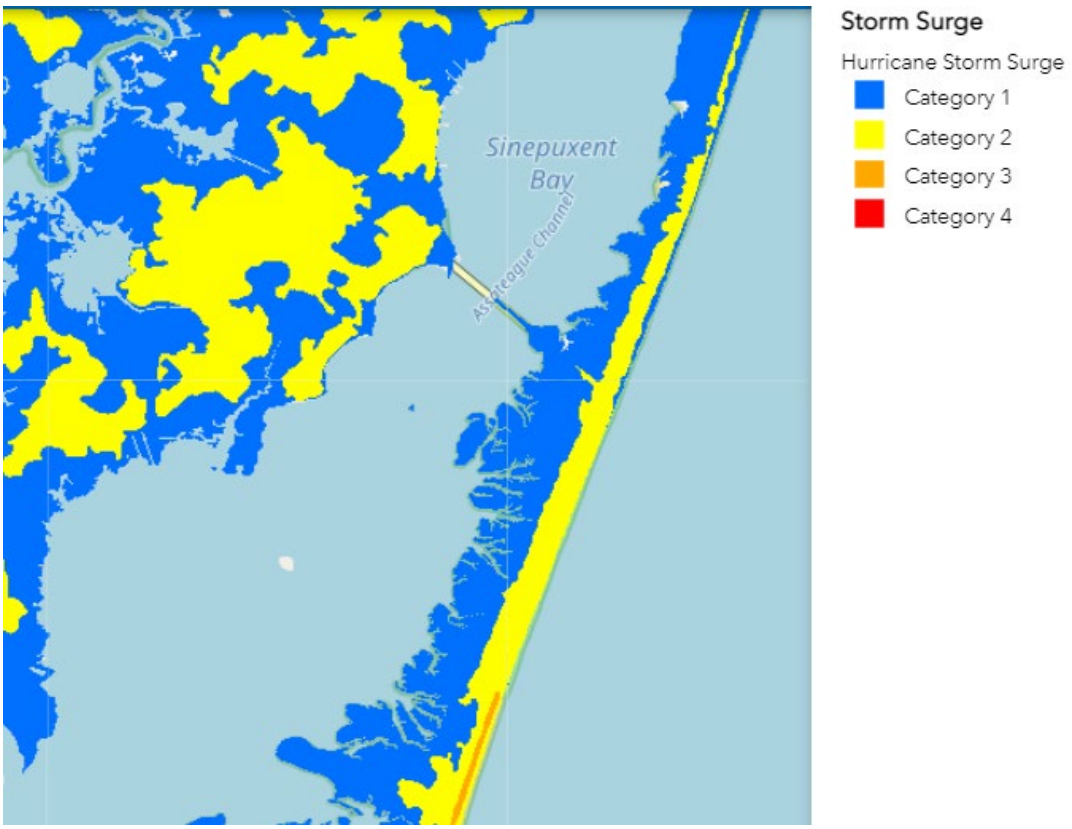


Figure 5: This image shows where hurricane storm surge is predicted to occur (Coastal Atlas, 2016).

Climate Impacts on the Resources of Assateague State Park

This is a photo of dune erosion after winter storm Jonas in 2016.

Climate Impacts on Park Resources

The following section of the report will be separated into five categories: natural resources, infrastructure, recreation, human resources, and cultural resources. For each category, there is an analysis of climate impacts to the resource if nothing is done to specifically address predicted climate change impacts (no climate action), and an analysis of adaptation options to mitigate the climate impacts (adaptation options and opportunities).

Climate change is already impacting Assateague. While changing climate happens slowly, one storm can lead to heavy damage in just a matter of hours at Assateague. Assateague is unique in that every climate impact can be seen and felt by the public, creating an urgent need to understand how climate change will impact park resources including: natural resources, infrastructure, recreation, human resources, and cultural resources. Creating an opportunity for adaptation to enhance resilience of Assateague State Park will not only benefit the environment, but also Maryland's citizens and economy.

Natural Resources

Assateague State Park is known for its beaches and unique dune ecosystems. Natural resources on Assateague Island include a range of plant and animal species, including three rare, threatened, and endangered (RTE) species, and over 80 wild horses. The northern end of the island has natural dunes, with man-made, ocean facing primary dunes spanning the two miles of the state park. Various bird and turtle species nest at Assateague, including the RTE loggerhead turtle. The Sinepuxent Bay is highly diverse with marsh and forest habitats.

The wild horses are not native to Assateague but are important to acknowledge as notable wildlife to the island. The horses eat native vegetation, they live in the dunes and marshes, and their population numbers fluctuate from year to year. Maintaining the natural processes of the barrier island by maintaining and monitoring natural vegetation and conducting dune and shoreline restoration will not be possible without considering the impacts the wild horses have on the ecosystem. Protecting the natural resources at Assateague must include an analysis of the impacts and opportunities of managing the wild horse population while prioritizing restoration and protecting rare dune ecosystems.

Assateague is host to many unique species and ecosystems, which classifies the island as a place of high ecological significance. Ecological significance is determined by an area's rare, threatened, or endangered plant and animal species. The more species there are, the greater ecological significance. Ecological significance is scored by BioNet and divided into tiers from 1-5, with a BioNet Tier 1 score indicating an area is critically significant for biodiversity conservation. There are many native plants found at Assateague, which contribute to Assateague's ecological significance. These include wax myrtle (*Myrica cerifera*), northern bayberry (*Myrica pensylvanica*), blackberry (*Rubus argutus*), and salt marsh cordgrass (*Spartina alterniflora*).

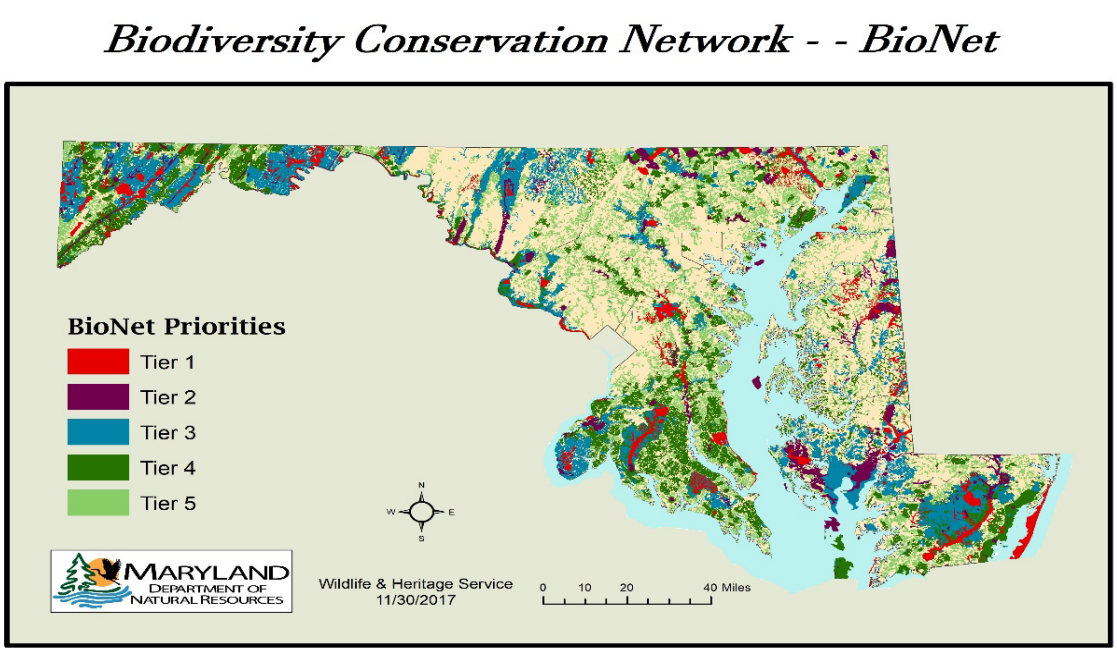


Figure 6: This figure shows the BioNet Priorities across the state of Maryland. Assateague is a Tier 1 ecosystem.

Seabeach Amaranth (*Amaranthus pumilus*)

Assateague State Park encompasses portions of three Bionet Tier 1 Ecological Sensitive Areas. To the north of Rt. 611 lies Assateague Island North. Seabeach Amaranth (*Amaranthus pumilus*) is a globally imperiled plant and critically imperiled in Maryland. Seabeach Amaranth occurs at the northernmost portion of the state park and is an annual herb of natural areas of barrier island beaches and inlets. It formerly occurred on barrier island beaches from Massachusetts to South Carolina but has been eliminated from much of its historical range. The largest stands are in New York and the Carolinas, and smaller populations exist in Delaware, Maryland, Virginia, and New Jersey. Many threats exist, including construction of seawalls and dune fencing, development, heavy recreational use, and off-road vehicle traffic. It is difficult to afford protection because of the dynamic nature of the habitat and the fugitive nature of the biology of the species. Continued research is needed to determine the impact of off-road vehicles and other threats common across the species range. Since 2002, this species has been steadily declining in Delaware, Maryland, New Jersey, New York, and Virginia.

South of Rt. 611 lies the Tier 1 Ecologically Sensitive Area known as Assateague Island South, which contains Beach Plum (*Prunus maritima*) and Shortleaf Beardgrass (*Gymnopogon brevifolius*). Beach Plum has a restrictive range, only found along the Atlantic Coast from Maryland north to Maine. It is intolerant of shade, severe sand erosion or deposition, or intense and repeated trampling of roots by people. It now occupies half of its original range with the rest fragmented. This plant is difficult for long-term management outside of large natural or semi-natural barrier dune preserves.


Beach Plum (*Prunus maritima*)

Shortleaf Beardgrass can be found from southern New Jersey south to southern Florida, west to Louisiana and Arkansas, and disjunct in Kentucky in the Highland Rim and Texas. This fire-dependent plant inhabits sandhills, pine savannas, prairies, dry woodlands, and calcareous glades. It grows in dry and moist sandy loam in these environments as well as human disturbed habitats such as along back roads.


Shortleaf Beardgrass (*Gymnopogon brevifolius*)

On the mainland of Worcester County just south of Rt. 611 is the Tier 1 Ecologically Sensitive Area known as Lower Sinepuxent Neck. No known rare species occur on park property, however, Slender Plume Grass (*Saccharum baldwinii*) is listed as endangered by the state of Maryland and occurs to the southwest of park property in this natural area.


Slender Plume Grass (*Saccharum baldwinii*)

Seabeach Amaranth is indexed by the CCVI as moderately vulnerable to climate change. The CCVI was not run for Beach Plum because it was not a globally rare species (G1-G3) but given the habitat it is relegated to and the threat of severe storms and beach erosion, it is likely vulnerable. Shortleaf beardgrass is likely not vulnerable given that it occurs in a dry habitat that is fire dependent. Not surprisingly, it is the coastal beach habitat and tidal marshes and woodlands that are most vulnerable to climate change.

Assateague is home to over 80 wild horses. The horses have been on the island for as long as it has been colonized, providing a welcoming site to visitors, and an ecological disturbance to the park. There are many horse-human conflicts every year, as horses fight visitors for their food and water, or visitors get too close to the ponies. The horses rely on the native grasses and marsh water for their sustenance, which can be harmful to dune stabilization, as they contribute to erosion and harm vegetation used for holding sand in place. Many species of birds nest at Assateague including egrets, herons, and pipers. Loggerhead sea turtles have begun nesting at Assateague as warming waters have provided a safe habitat.

Invasive species are also prevalent on the island. Notable invasive species include *Phragmites australias and* Asiatic sand sedge (*Carex kobomugi).*

Horses climb the dune at Assateague State Park.

No Climate Action: Natural Resources

The environments found at Assateague State Park are unique. As climate change impacts increase on the island, there is likely to be decreased native species associated with habitat loss. The dunes that protect the island are especially vulnerable to climate change, and many species on the island rely on their health to survive.

Shoreline and Dunes

Storms and higher tides are leading to severe dune erosion that is predicted to get worse with intensifying storms and flooding. The dunes at Assateague were constructed to 14.5 feet high, which fluctuates throughout the year. Current impacts of relative sea level rise (RSLR) are being observed through data collected by the National Park Service. The latest survey conducted in 2018 showed that the shoreline of Assateague Island is eroding or being submerged at a rate of 1.6-4.92 ft/yr (0.5-1.5 m/yr). Twice a year, the United States Army Corps of Engineers (USACOE) performs dredging in the Ocean City inlet and deposits it on the northern end of Assateague Island National Seashore as part of a federally funded habitat restoration project. The sand bypassing helps to slow erosion, but as storm surge intensifies it will also lead to increased dune erosion at a rate that is higher than the accretion of the deposited sand. These factors combined will lead to decreased biodiversity. Storms, wind, and waves are pulling sand from the dunes and beaches at increasing rates, also leading to the thinning of the beach. There is already signage on the dunes that warns visitors that dune ecosystems are fragile and should not be walked upon. These signs are important to protecting the dunes and are increasingly becoming covered with sand, reducing their visibility. If the dunes are unable to function as designed, many systems will be negatively impacted.

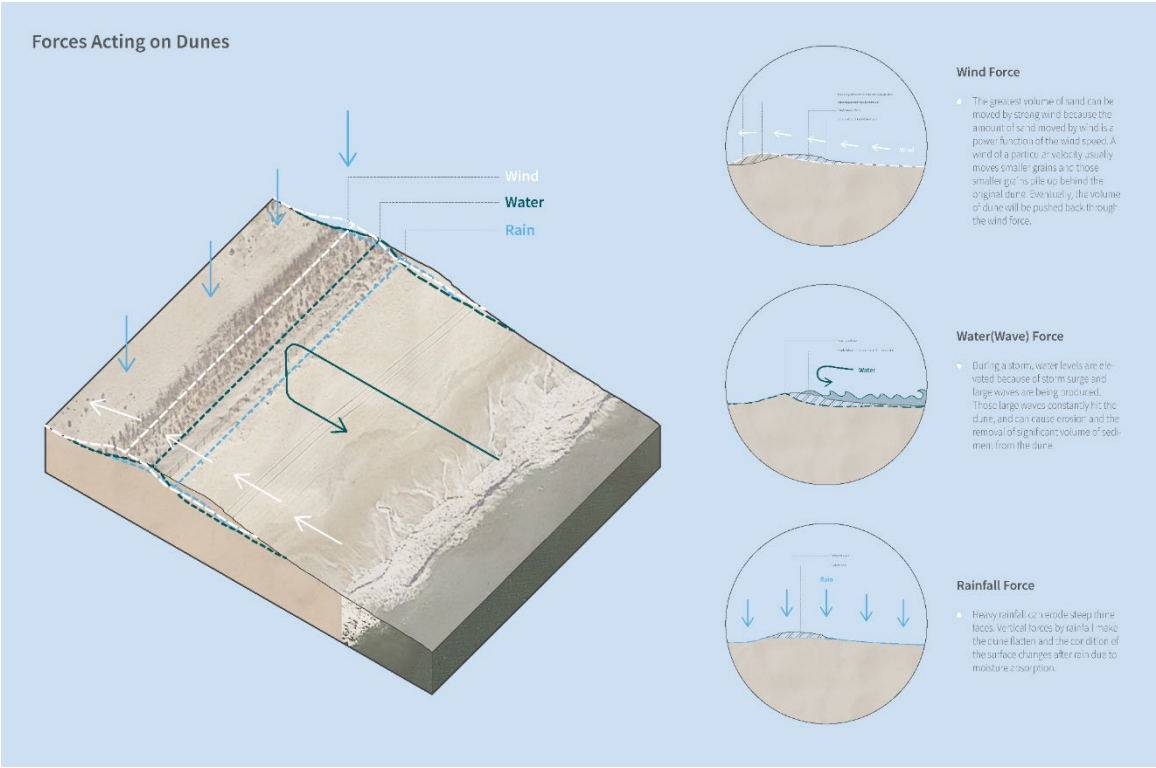


Figure 7: This shows existing forces on the dunes, UMD.

Naturally, visitors will congregate near the bathhouses and concession stands. This leads to high concentrations of people at the base of the dunes and people walking where they should not, requiring constant maintenance. Visitors also view the dunes as fun play areas, which harms dune vegetation. Additionally, the wild horses are drawn to areas with food, which results in the trampling of native plants and can impact erosion of the dunes. The horses significantly impact the success of dune restoration efforts as they eat freshly planted vegetation and often ignore fencing to keep them off the dunes.

Coastal Bays

Highly vulnerable to sea level rise, ecosystems in Sinepuxent Bay are very likely to be negatively impacted by climate change. The low lying marshes are supported by plants that can only grow under certain depths and salinities of water, as such sea level rise is a major concern in the marshes. The coastal bays are at risk of more frequent flooding and saltwater intrusion, leading to a loss of habitat and a decrease in biodiversity as plants succumb to salinization. The coastal bays play an important role in protecting ecosystem services on the island, and as they flood, their ability to function decreases. Assateague's wild horses are frequently observed in the coastal bays as well and increasing saltwater intrusion could decrease their available habitat and food resources. Mosquito ditches can still be seen in the drone footage of Assateague State Park. Created in the 1900's to reduce areas available for mosquitoes to breed, the mosquito ditches now promote instability in the marsh, as they create internal pools that are drowning out marsh plants.

Wildlife

Wildlife at Assateague is going to be impacted by all climate change threats. Aquatic species in Sinepuxent bay are at risk of losing their habitat due to sea level rise, and as water temperatures increase, the environment may become unsuitable to meet their needs. Submerged aquatic vegetation (SAV) may also be more susceptible to climate change with warming temperatures and increasing salinity. Increasing temperatures in the area will increase competition amongst wildlife for shade and freshwater.

Species distributions are likely to change and have already been noted. This is due to sea level rise, ocean acidification, ocean warming and other climate effects. Loggerhead sea turtles have started nesting at Assateague, with waters being warm enough now to provide ideal breeding conditions. Saltwater intrusion, warming temperatures, and habitat loss in marsh and dune areas can be attributed to future vegetation loss. Seabeach Amaranth is an example of a species vulnerable to severe storms and beach erosion. Declining vegetation increases dune erosion, making it more difficult for new plants to establish. The images below depict how vegetation might be impacted with climate change.

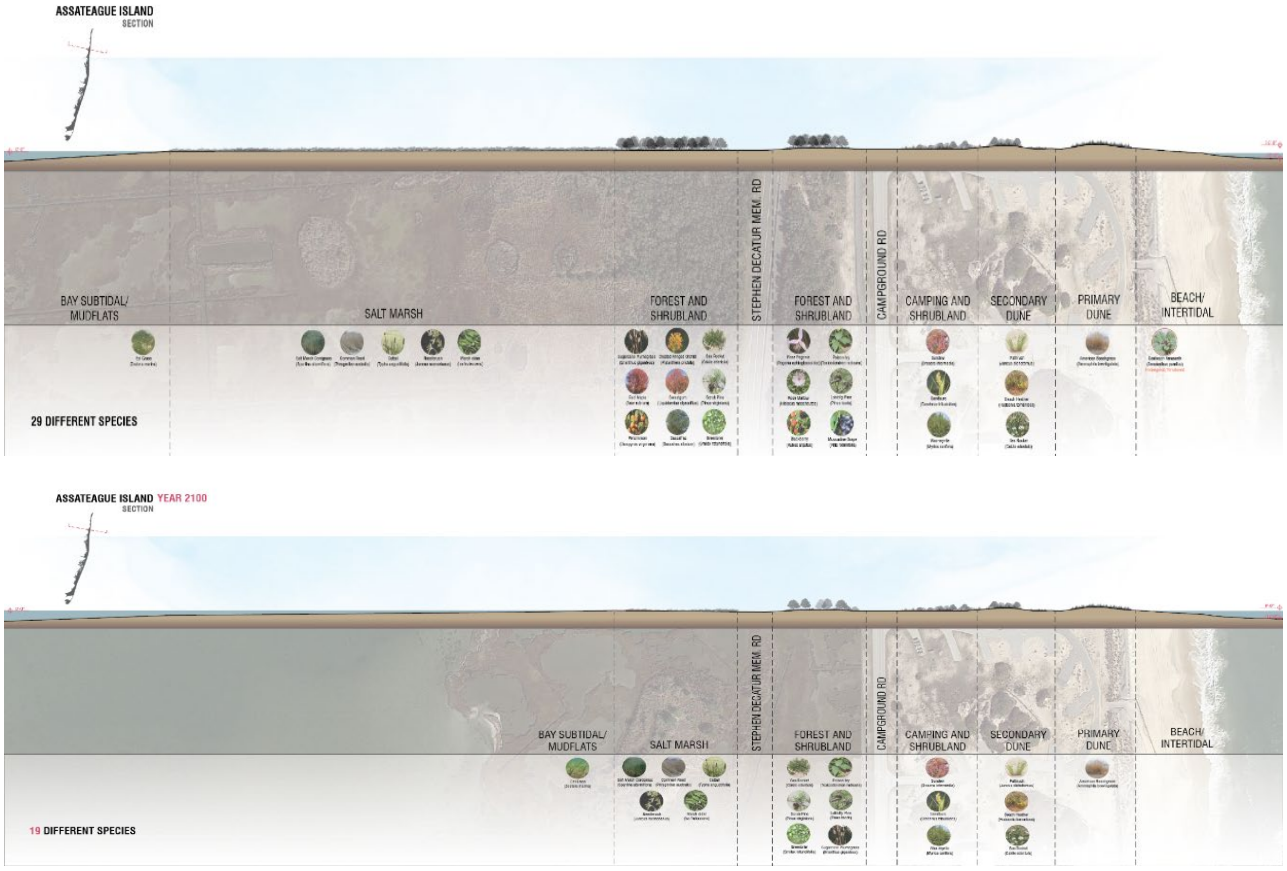


Figure 8: This shows how sea level rise will widen Sinepuxent Bay and lead to forest and shrubland die off and salt marsh migration, UMD.

Human/wildlife conflicts may result due to changes in species distributions. Horses and native species are in increasing danger of being impacted by humans. Habitat availability may change for the horses as the coastal bays become inundated, which in turn may increase the occurrences of human/wildlife conflicts between visitors and the wild horses. Visitors may also impact turtle nesting sites, both unknowingly and out of curiosity. Loggerhead sea turtles are endangered and as they start nesting more at Assateague, failing to protect them on the beach could further threaten populations. Additionally, visitor complaints about nuisance species such as mosquitos, flies, and ticks are already increasing.

Increasing temperatures are predicted to impact species distribution as well. The patterns of migratory birds are changing due to warming temperatures and longer summers, and food availability is predicted to decrease as drought conditions increase. The birds at Assateague also rely heavily on the dune ecosystems and functioning coastal bays to provide nesting habitat. Increasing erosion and inundation may lead to a decline of available habitat for the birds. Alternatively, temperature changes may also increase species biodiversity, as the waters surrounding Assateague warm, they may provide habitats for species previously incapable of surviving in the cooler island waters.

Adaptation Options and Opportunities: Natural Resources

Adaptation opportunities exist that will lessen the impacts of climate change at Assateague State Park and encourage stabilization of the ecosystems found on site.

Shoreline and Dunes

Increasing the amount of sand bypassing and extending the project beyond 2028 is a high priority adaptation recommendation.

The dune systems at Assateague protect the infrastructure and recreational opportunities available at Assateague, while also providing diverse habitats. According to the National Park Service, the Assateague Island system is currently only receiving about half of the sand it needs to have a healthy dune system, which is why it is essential that the sand bypassing that the United States Army Corps of Engineers (USACE) continues (Bill Hulslander, 2021)*. Right now, there is federal funding allocated to the Assateague restoration project through 2028. Ideally, sand bypassing would be increased to reduce beach erosion and prevent dune starvation, which ultimately leads to decreasing dune stability and increasing habitat loss. Increasing dune vegetation will also assist in the stabilization of the dunes.

*Sand bypassing is widely recognized as one of the best options for replenishing lost sand due to erosion from wave energy, storms, sea level rise, and high tide flooding. It is important to note that in the case of Assateague, the sand that is used comes from Maryland's coastal bays and the inlet channel. In the coastal bays, this sand provides valuable nesting islands and habitat for bird species. One recommendation is to conduct a study of how the sand bypassing impacts habitat and to identify mitigation strategies that will provide alternative nesting islands, while allowing beach replenishment to occur.

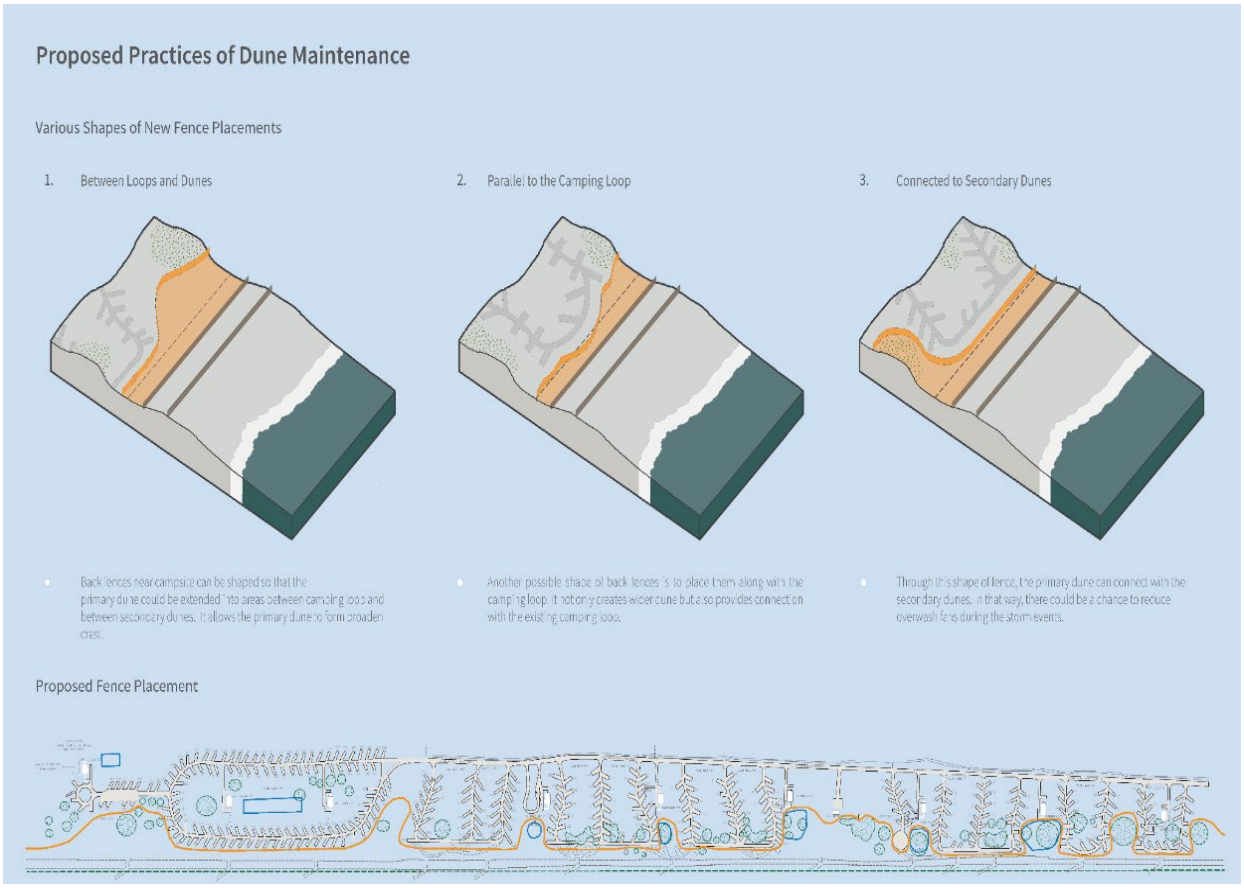


Figure 9: This shows proposed practices of dune maintenance, UMD.

Conducting dune monitoring and stabilization with the help of an engineer and drone footage is a high priority adaptation recommendation.

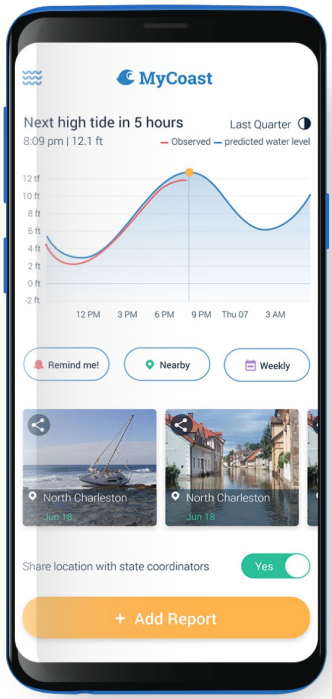
Monitoring the dunes for stability, migration and sustainability must be a priority to better understand how the dunes change seasonally, in order to help park staff calculate erosion and dune movement. A study should be initiated under the expertise of a scientist/engineer in the geophysical field to review the current primary dune and provide recommendations for best practices to improve dune health and stability. Regular preventative maintenance should be conducted to ensure that the dune is at peak health to withstand storm and wind damages that may occur. This can be done through acquisition of heavy equipment to enable park staff to complete these actions and/or through a regular maintenance contract with an outside vendor as is done in Ocean City, Maryland. Another way to improve dune monitoring is using drones. There is an opportunity for park staff to partner with members of CCS to perform seasonal drone monitoring, although the long-term goal is to have a member of the Assateague park staff become certified to perform the monitoring, so that it can occur more consistently. Staff in CCS have estimated that the initial drone survey may cost $543.00 for the first sampling event and $245.00 for each additional day and are also working with the Eastern Shore Regional GIS Collaborative (ESRGC) at Salisbury University to assess the potential for surveying at Assateague. Continuing to collaborate with the National Park service will help to facilitate monitoring and dune restoration.

Educating the public is another powerful way to protect dune ecosystems, since visitors to Assateague can unknowingly contribute to dune degradation. The University of Maryland has suggested that an educational landscape be designed with an example dune so that visitors can learn about the dune's benefits and how and why to protect them. There could be signage and interactive activities to teach the public about wildlife that relies on the dunes and about the storm protection that dunes offer.

Although the beach is only two miles, facilitating the spread of visitors will also decrease impacts to the dunes. Spreading out visitors decreases the impact to dunes in one concentrated area by reducing the likelihood of visitors walking in protected areas or disturbing more fragile parts of the dunes.

This image shows an example of the ranger station being redesigned as an L-shaped building with an educational dune landscape in the front, UMD.

Monitoring can also occur on site with the assistance of community science. Using an app called "MyCoast", camp hosts, visitors, and park staff can easily document flooding and storm damage that has occurred on site. The pictures and data from MyCoast are publicly available and could be used to help prioritize projects in areas where damage is occurring more frequently. One option is to include QR scan codes in public areas, such as bathhouses and near the concession stands that would take users to the MyCoast app (in both English and Spanish). Monitoring dunes and flooding is very important for understanding dune movement, campsite sand coverage, and flooding. Having this knowledge will allow park staff to know exactly which sites and dunes are unsustainable, thus impacting future management decisions.



Monitoring marshes and conducting shoreline stabilization is a high priority adaptation recommendation.

Coastal Bays

Restoring the mosquito ditches and native plantings will reduce depth and sediment loss and facilitate salt marsh establishment and migration.

Assateague State Park should also continue partnering with the Maryland Coastal Bays Program to maintain and enhance monitoring and restoration of the Sinepuxent Bay. Understanding the health of the aquatic vegetation facilitates an understanding of the habitat changes happening on site and will allow park staff to continue making management decisions that can protect the bay, such as living shoreline projects.

This shows an area of Assateague's mainland that has been selected for a living shoreline.

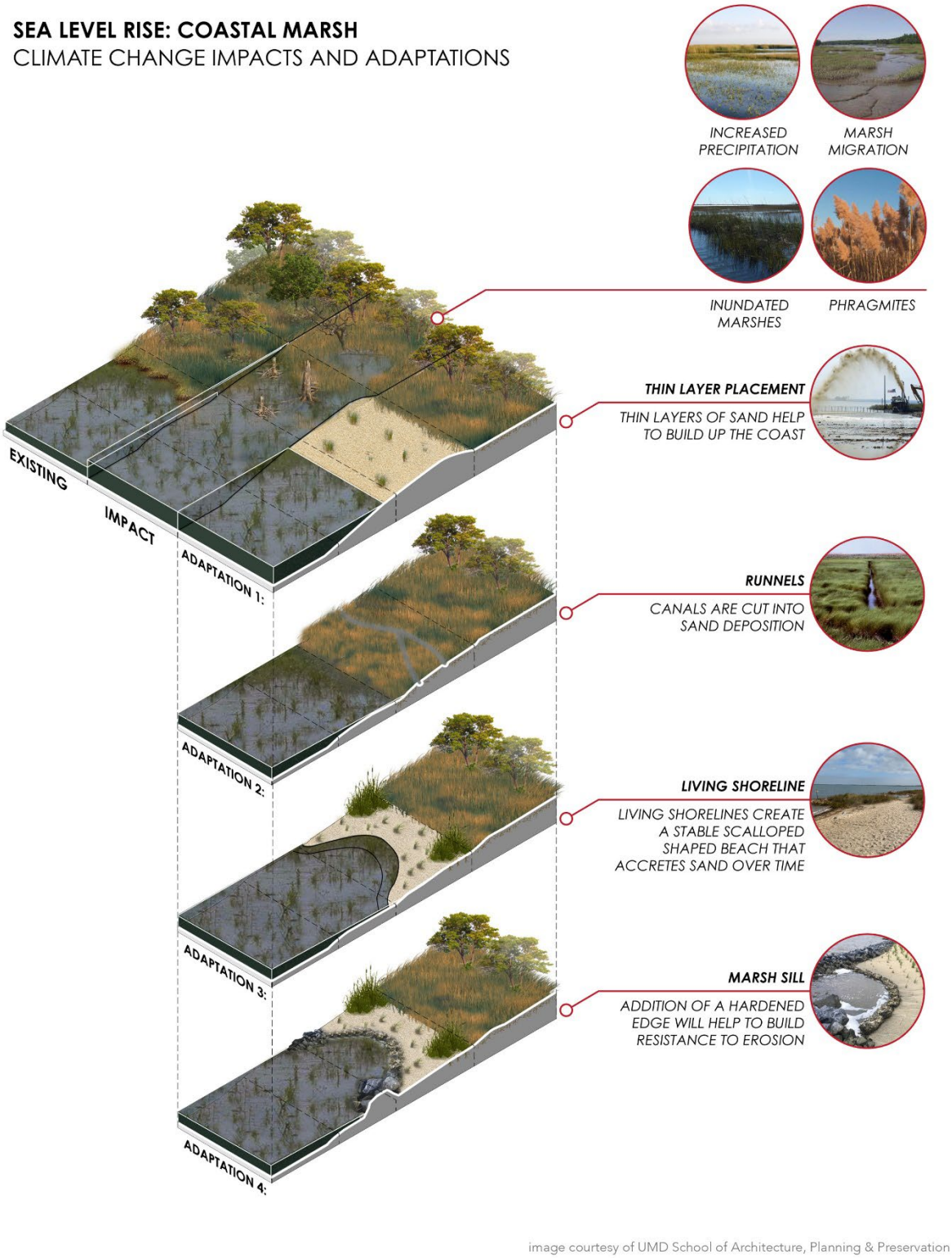


Figure 10: This image depicts opportunities for shoreline restoration and adaptation, UMD.

Wildlife

Monitoring of habitats is going to be increasingly important as climate change decreases habitat stability across the island. Drone monitoring could facilitate understanding of how both flora and fauna are changing on site.

To respond to vegetation loss on site, there are opportunities for marsh restoration, dune restoration, and increasing tree plantings throughout the park.

For human/wildlife conflicts, especially those between the wild horses and visitors, there is the potential to hire personnel who will be directly responsible for educating visitors about horse safety and preventative actions. Regarding increasing turtle nesting, it will be beneficial to create a communication system for Park visitors so that they understand which areas to avoid. For example, using signage to indicate turtle nesting sites will be important to reduce human/wildlife conflicts.

Example sign from Tampa Bay.

Habitat restoration and conservation, such as increasing shading using trees on the island, could protect wildlife from some effects of increasing temperatures. Restoring the coastal bays through vegetation plantings could also provide refuge for species.

Infrastructure

Infrastructure at Assateague is essential to the visitor experience as it includes everything from the roads and parking lots to the visitor center and camper registration building. With over 330,000 campers annually, buildings and roads located at Assateague are frequently used.

Infrastructure includes:

- Campsites
  - 337 paved
  - 5 walk-ups
  - 40 sites with electric hookups
  - Dump Station
- Day use areas
  - Visitor Center
  - Gift shop
  - Concessions Stand
  - Five shade shelters
- Dunes with dune fencing and railings
- Ranger station
- 10 Bathhouses
- Marina (located on the mainland)
- Marina Comfort Station (restrooms)
- Dune crossings
- Entry kiosks
- Parking areas
- 7 miles of paved roads
- Trails/bike paths
- Rackliffe House
- Headquarters building
- Maintenance Complex
- Ranger office

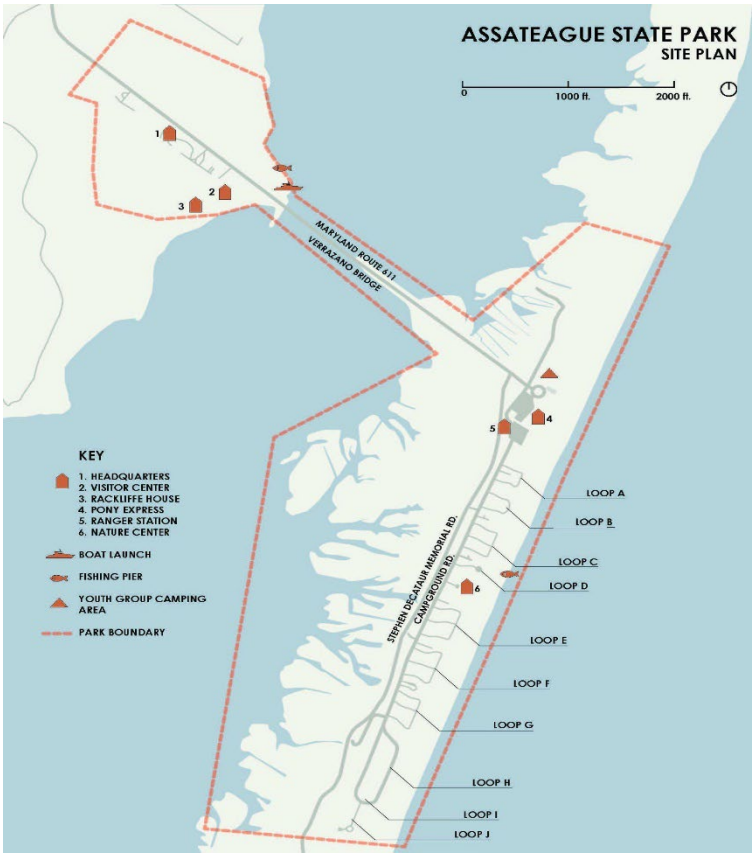


Figure 11: Updated Assateague State Park Map, UMD.

Buildings on site, including the ranger station, visitor center, bathhouses, giftshop, and concession stand are all susceptible to the impacts of climate change. Strong winds can threaten the integrity of buildings, carrying sand and debris that lead to faster deterioration. More frequent and intense rainstorms can weaken structural integrity as well.

The campsites at Assateague are becoming increasingly vulnerable to climate change, especially those closest to the beach. Storms are moving sand onto roads and sites at increasing rates at the east end of the camping loops, making access difficult. During periods of high wind and rain, park staff have been removing sand from access areas, such as boardwalks and campground loops up to twice a week. Some campsites are also flooding more often, due to intense and more frequent storms. Campsites that allow RV camping are in high demand,

which requires large camping loops and areas free of sand. Sand covered sites and roads make driving more difficult for guests, and flooding on sites could impair the ability of guests to access amenities.

The marina, while vulnerable to sea level rise, is protected by a recently restored living shoreline. Access to the marina may become impaired or limited in the face of climate change.

Portions of the Stephen Decatur Highway (MD 611) from MD 376 to the Verrazano Bridge, owned by the MD State Highway Authority, are vulnerable to at least 2 feet of flooding from sea level rise within the 2050 Mean Higher High Water (MHHW), 25-year (4% Annual Chance) storm condition. Under increased precipitation scenarios, the low-lying roads at Assateague are vulnerable to increased flooding and saltwater intrusion from storm events and higher tides, which would greatly impact vehicular ingress and egress to Assateague Island.

No Climate Action: Infrastructure

If no action is taken to increase resiliency of the infrastructure at Assateague, it is likely that it will continue to face increased damage from storms including wind damage, sand accretion and erosion, and weakened infrastructure. Failing to reduce road flooding and damage will decrease access to the state park, campgrounds, and day-use areas. Repair and maintenance costs will continue to increase.

Buildings

Without enhancing the resilience of buildings on site, buildings could become unsafe or inaccessible for guests before, after, or during storms. Saltwater intrusion may also impact the water quality on site, impacting drinking water and leading to the faster breakdown of infrastructure, such as pipes.

Campsites

The campsites at Assateague are already suffering from changing climatic conditions. Often, sand is shifting onto campsite driveways from the dunes during periods of high wind, after storms, or slowly over time. This is especially true of the campsite loops that are located at the foot of the dune. Unfortunately, sand on the campsites and loops decreases accessibility and increases the likelihood of vehicles getting stuck in the sand. Alternatively, without sand accretion, campsite sand volume decreases, resulting in more vegetation rather than sandy camp pads. Balancing sand volume at the campsites is a time consuming task.

This shows flooding at one of the campsites.

Roads, Parking Lots and Boardwalks

Roads, parking lots, and dune crossovers are impacted by changing conditions at Assateague daily. Roads and parking lots are susceptible to flooding during storms and intense precipitation events, and during high tide. High winds and more frequent storms are also moving sand at greater rates, decreasing accessibility for guests. Maintaining the roads, parking lots and boardwalks is expensive and consumes a large amount of staff time, and decreased access can impact visitor's wellbeing. As the time it takes to repair infrastructure increases, the ability to respond to public and wildlife concerns decreases. Impaired roadways impact all manners of enjoying Assateague State Park, and lead to inaccessible areas and inequitable road access.

This picture shows sand covering the boardwalk at one of the campsite loops. Handrails are covered with sand and safety signs are nearly covered.

Overall, there are going to be increasing maintenance costs to repair and replace damaged infrastructure.

Adaptation Options and Opportunities for Infrastructure

There are many opportunities for adaptation at Assateague to enhance infrastructure resiliency. These opportunities should be considered a priority, as the inability to access roadways, campsites and the beach prevents other management from happening, such as ensuring public safety and protecting wildlife habitats.

Overall

Regarding infrastructure opportunities at Assateague, overall, there is a need for a benefit cost analysis that will address the costs of dune restoration and campsite maintenance versus acquiring and developing on nearby properties to reduce damage to property and increase access during weather events. This analysis should include an estimate of the current and future carrying capacity of the island as sand continues to accrete and erode as the island changes over time. This would allow for an accurate estimate of how many campsites need to be protected and maintained.

Designing buildings using climate resilient principles and keeping flooding in mind is a high priority adaptation recommendation.

Buildings:

Infrastructure on state lands is separated into two categories: non-critical and critical infrastructure. Non-critical infrastructure includes buildings such as the gift shop at Assateague, as it does not contain equipment related to public health. Critical infrastructure includes bathhouses and the ranger station, where the first aid station is located. According to Coast Smart Council construction guidelines, if a building is considered non-critical infrastructure, it should be elevated at least three feet. Critical infrastructure should be elevated to at least four feet above the base flood elevation. All buildings should be adjusted with the two feet of freeboard or more as required by the Coast Smart Council construction guidelines.

Additionally, new Maryland Coast Smart regulations require that any State projects over $500,000 for construction apply 3 feet of inundation vertically and horizontally to all projects. When combining the Digital Elevation Model and the Coast Smart Climate Ready Action Boundary (CS-CRAB) using the CRAB tool, a new elevation estimate is generated, which becomes the required CS-CRAB elevation for new construction.

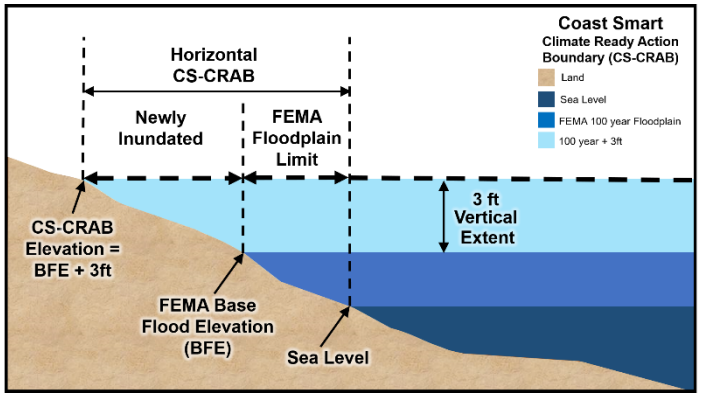


Figure 12: Illustration of how the CRAB works.

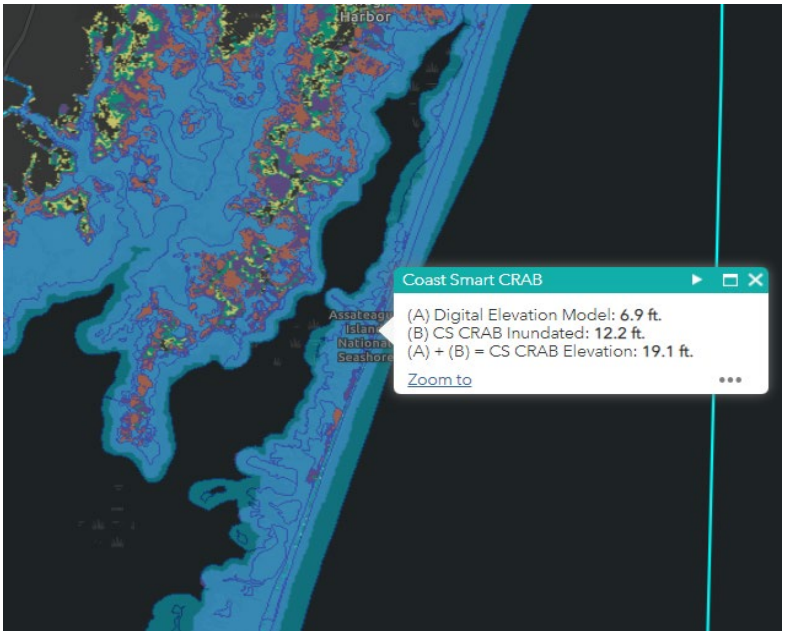


Figure 13: Example of using CRAB at Assateague State Park.

Another potential consideration is that newly constructed buildings at Assateague could be mobile buildings. The ability to move critical infrastructure off site prior to bad weather will increase the longevity of the buildings and protect critical operating equipment. New construction is also required to be both wet proof and dry proof and account for hurricanes according to the Coast Smart Council construction guidelines. This is important to improve the integrity of the infrastructure, protect equipment, and protect those working and recreating in and around the buildings.

Hiring a design engineer to redesign campsites and roads to account for vulnerability, walk-in sites and parking is a high priority adaptation recommendation.

Campsites:
Enhancing the resiliency of campsites should be a priority at Assateague. Options for increasing resiliency include providing more sites for walk-in camping, which in turn would reduce the demand on park staff to provide continued maintenance and sand removal at paved and electric serviced campsites, where RV camp loops require more staff time. Sites considered for electric hookups should be those least vulnerable and in the western portions of the campground. Ultimately, land acquisition should be considered as an option to provide additional safe camping opportunities and reduce maintenance costs of the campsites.

ACQUISITION CONSIDERATIONS

Near Assateague
Water access
Not residential
100-300 acres
Tier 1: walking/biking distance
Tier 2: within 20–25-minute drive
Contiguous protected area
Access from main road
Mix of habitat types
Medium flooding tolerance

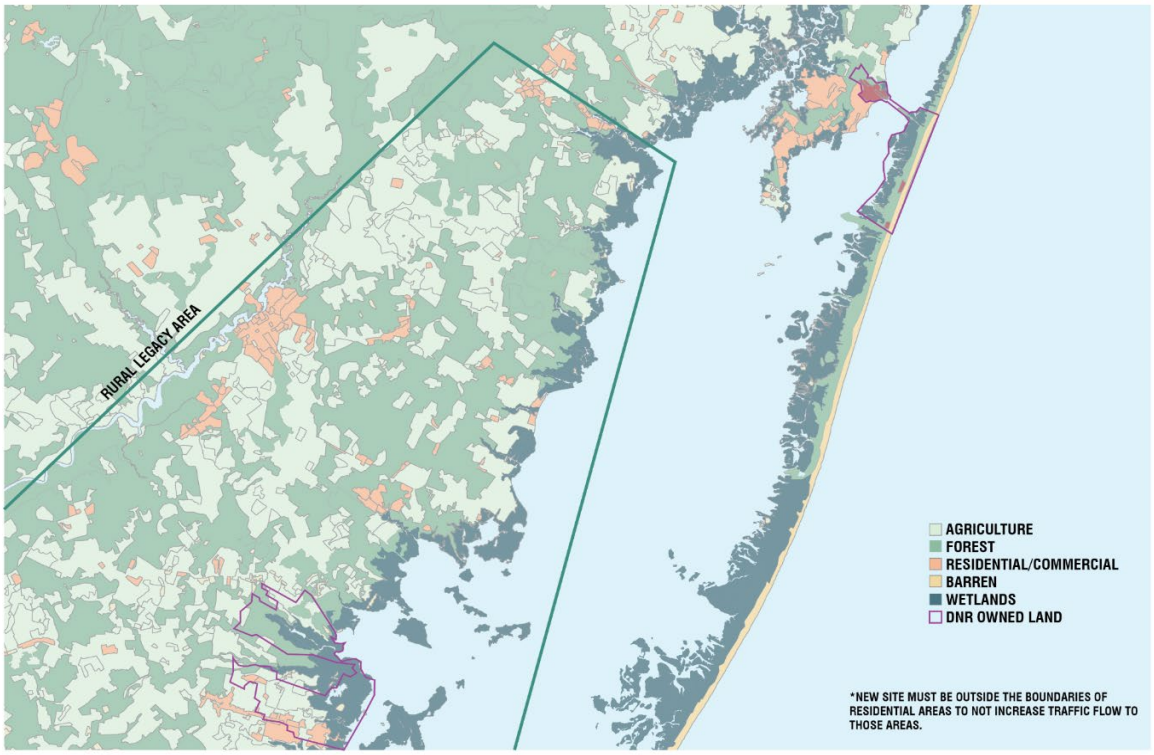


Figure 14: This shows land use surrounding Assateague State Park, UMD.

Roads, Parking Lots, and Boardwalks

To combat increased flooding on roads and campsites, one option would be to decrease impervious surfaces in parking lots. The Assateague Island National Seashore uses oyster shells instead of pavement, which has helped to redirect water flow and reduce areas where water is pooling on roads.

Acquiring new properties west of the island for recreation and camping is a high priority adaptation recommendation.

This shows an example of what crushed oyster shells look like.

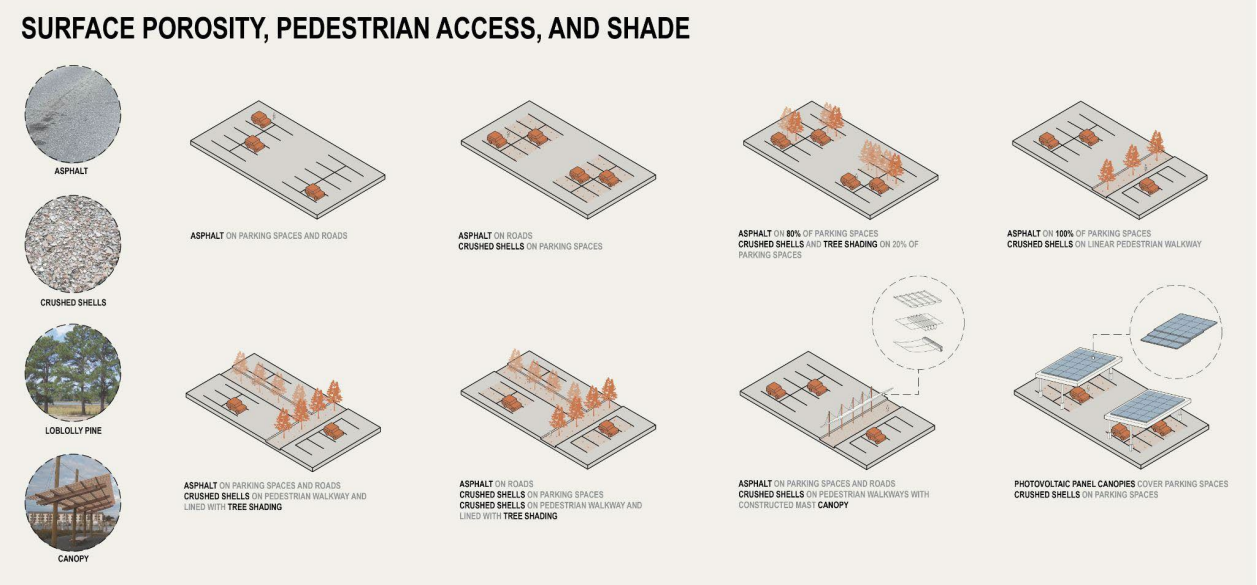


Figure 15: This shows proposed options for addressing flooding and increasing temperatures to preserve road conditions and improve the visitor experience, UMD.

One suggestion to monitor precipitation impacts on roadways would be increasing the use of the MyCoast app, which is designed to track flooding from storms, high tide, and nuisance flooding. Visitors could be engaged using QR codes and encouraged to share resources and communicate with park staff. The MyCoast App and other forms of monitoring could be used to specifically identify areas that experience the most flooding during storm events and high tide.

Assessing the vulnerability of the 611 causeway and the Verrazano bridge is a high priority adaptation recommendation.

To enhance the resiliency of the 611 causeway and the Verrazano bridge, staff should partner with the State Highway Authority and Worcester County to perform continued monitoring. Protecting Assateague protects the residents of Worcester County by supporting an ecosystem that reduces flooding and storm damage to communities. It is also essential that the Verrazano bridge remains protected as it is the only way to get on and off the island during a storm or flood. In Worcester County's hazard mitigation and nuisance flood planning there is an opportunity to conduct an analysis of the integrity and vulnerability of the Verrazano bridge and the 611 causeway, and to assess future alternatives for getting to the island. Living shorelines on either side of the bridges may reduce wave energy and flooding. After the construction of the living shoreline on the mainland is complete monitoring should occur to ensure the success of restoration.

As of 2022, the contact at MDOT SHA for structural analysis is Rod Thornton, rthornton@mdot.maryland.gov. MDOT's Climate Change Resilience Strategy policy should also be reviewed to identify adaptation opportunities for enhancing roadway resilience. For more information contact the Climate Risk and Resiliency Program Manager, Jessica Shearer, jshearer.consultant@mdot.maryland.gov.

Creating a communication system such as the Florida Speed Alerting System to educate guests on unsafe bridge conditions or using MyCoast to send alerts will be essential for maintaining public safety. Examples could include wind alarms on the bridge, emergency text alerts for those within a three-mile radius of the island, or flags to signal dangerous conditions.

Long Term Planning:
In the long term, overall monitoring of infrastructure will be essential in understanding which infrastructure is the most vulnerable to climate change. Staff should keep detailed maintenance logs and photographic evidence of weather events and impacts to guide future decisions. Measuring the time it takes to respond to weather events and remove sand or fix campsites and parking lots will help assess how much staff time is spent on regular infrastructure maintenance and upkeep versus repairs and cleanup resulting from weather events.

A study should be done on existing park infrastructure such as road networks and parking areas. It is necessary that options are provided that will maximize camping opportunities and outweigh the cost of new road alignments keeping in mind that walk-in campsites will continue to require visitor parking, though not directly at/on the campsite. Walk-in campsites reduce the need to continuously remove sand from roads.

Creating a survey to allow visitors to communicate their climate ideas and concerns about proposed solutions with park staff will promote community engagement and could help park staff identify creative opportunities and priorities for visitors to the park.

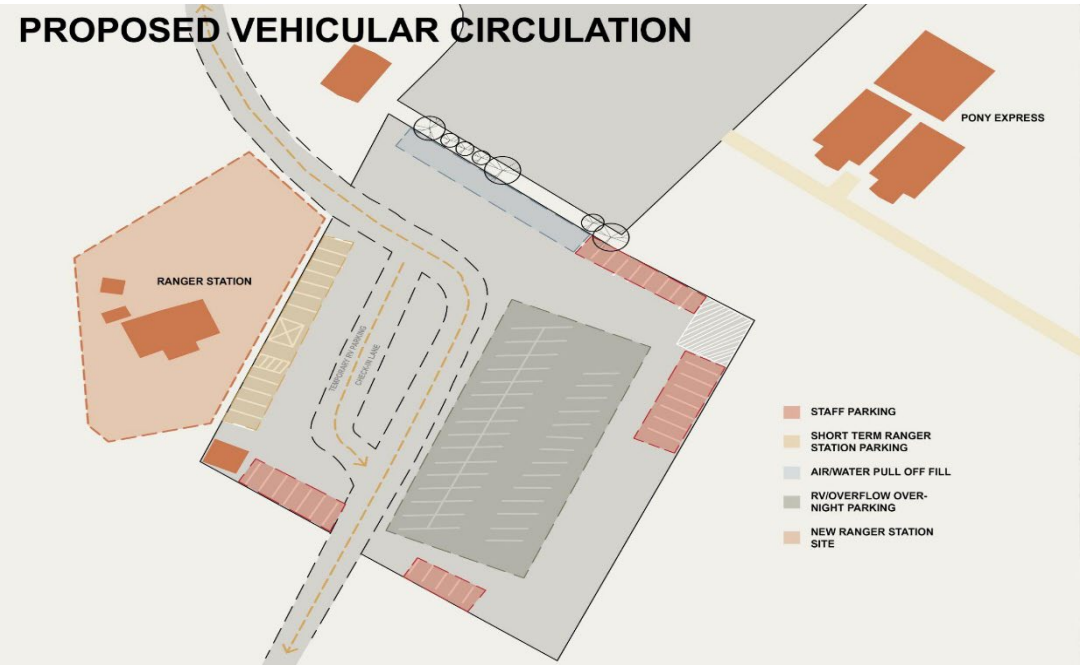


Figure 16: This shows proposed vehicular circulation that would allow visitors to engage differently with the site while also facilitating improved traffic flow, UMD.

Recreation

Assateague State Park offers a wide range of recreational resources, both on the Atlantic Ocean and Sinepuxent Bay, with activities ranging from those that are water-based, such as swimming, surfing, fishing, clamming, crabbing and canoe/kayaking, to land-based activities such as beachcombing, hiking, bicycling, birdwatching and wildlife viewing. Recreational opportunities at Assateague are invaluable to visitors, local residents, the state of Maryland and the Maryland Park Service. Annually, tourism at Assateague contributes over $1,000,000 to the park service and together with Assateague Island National Seashore, contributes over $100,000,000 to the local economy (Angela Baldwin, Park Manager). However, data, research and recent experience show that almost all aspects of the visitor and recreational experience will be impacted by climate change.

No Climate Action: Recreation

Access

Unpredictable weather and increasing and worsening storms may make it difficult for visitors to access or enjoy the park's full resources while visiting. Higher-than-normal tides, rough and dangerous surf conditions and storm damage to infrastructure may force the park's temporary closure, preventing access to visitors altogether due to unsafe conditions.

Increasing sand on roads and pathways from wind and storms limits road access and can make accessing amenities such as the restrooms difficult. Sand covering transportation routes makes driving, walking, and using devices with wheels very difficult. Camping at Assateague is going to look very different in the future. Sites might become inaccessible due to dune migration or flooding, and there may be more occurrences of having to evacuate campsites as storms become more frequent. Flooding and sand deposition are also increasing in several campground areas, which negatively impacts the visitor experience as it puts visitors in danger and limits access.

Sand covering the handrails on the dune crossing to the beach.

Temperature

Increasing temperatures resulting from a changing climate pose health risks to guests at Assateague State Park and visitors may spend less time at the park if they are experiencing discomfort from the heat. As a result of increasing temperatures, the beach may become overcrowded as more visitors recreate near the water versus at their campsites. Additional foot traffic to, from, and on the beach creates prolonged disturbances to the dunes and beach area, impacting a number of ecosystems.

Day and overnight campers may have difficulty accessing shade or electric hookups for cooling devices due to increased demand. Hotter temperatures over longer durations (heat waves) means that there is an increased interest in RV camping, as RV's are equipped with air conditioning and interior and outdoor spaces which provide shelter from the sun. In 2022, visitors expressed concern over a lack of electric hookups available to campers to provide air conditioning during the hottest months of the year.

Discomfort, heat stress and dehydration experienced by visitors also will increase the demand on park staff, creating a need for additional staffing, and possible medical training to equip park staff for responding to heat-related illnesses and injuries. Funding medical training to prepare staff for climate stressors is recommended.

Human-Wildlife Conflicts

As natural resources are impacted by climate change, so too are wildlife. Animals, including Assateague's wild horse, naturally become more aggressive when their sources of food and freshwater are more scarce or difficult to access. This puts both the wildlife and humans at risk.

As our climate changes, wildlife are forced to adapt, resulting in new species in new places. This has already been seen in the nesting habits of loggerhead turtles and the migration of bull sharks and bottlenose dolphins moving farther north (Wilkinson, 2018). New species in our waters and on our lands bring new human/wildlife conflicts and concerns, which may require changes to infrastructure and increased staffing resources.

Horses grazing at a campsite at Assateague State Park.

Adaptation Options and Opportunities for Recreation

Although recreation is highly impacted by climate change, there are many opportunities to protect our existing and increase recreational opportunities.

Maintaining trails and enhancing communication to protect visitor safety is a high priority adaptation recommendation.

Access:

Visitor safety is the number one priority for park staff. Clear communication before and during visits to Assateague can facilitate a mutual understanding between park guests and staff regarding current conditions, such as heat, storm impacts and campsite conditions. Monitoring sites and trails will allow staff to pinpoint areas of concern, so they will be able to identify projects or areas that need to be temporarily closed. To respond to a decreasing shoreline, there is potential for the area of swimmable beach protected by lifeguards to be extended to the north and south, allowing visitors to spread out over a greater distance.

Figure 17: Proposed modifications to campsites to allow for dune migration, decreased sand deposition, and increased usability, UMD.

Temperature:

Educating visitors about the dangers of excessive heat is going to be very important as temperatures increase. Campsite reservation emails should continue to include reminders about the importance of sun protection and hydration, and areas to access drinking water and shade should be clearly marked in the day-use areas. Park-provided shade tents for visitors and additional electrical hookups for campers should be considered.

Closing certain areas of the beach to allow for ecological regeneration and to avoid disturbance from increasing guest use could prevent damage to natural resources. In situations of overcrowding, it will also be important to have clearly marked signs showing visitors where they can and cannot walk or congregate to preserve natural resources and guest experiences.

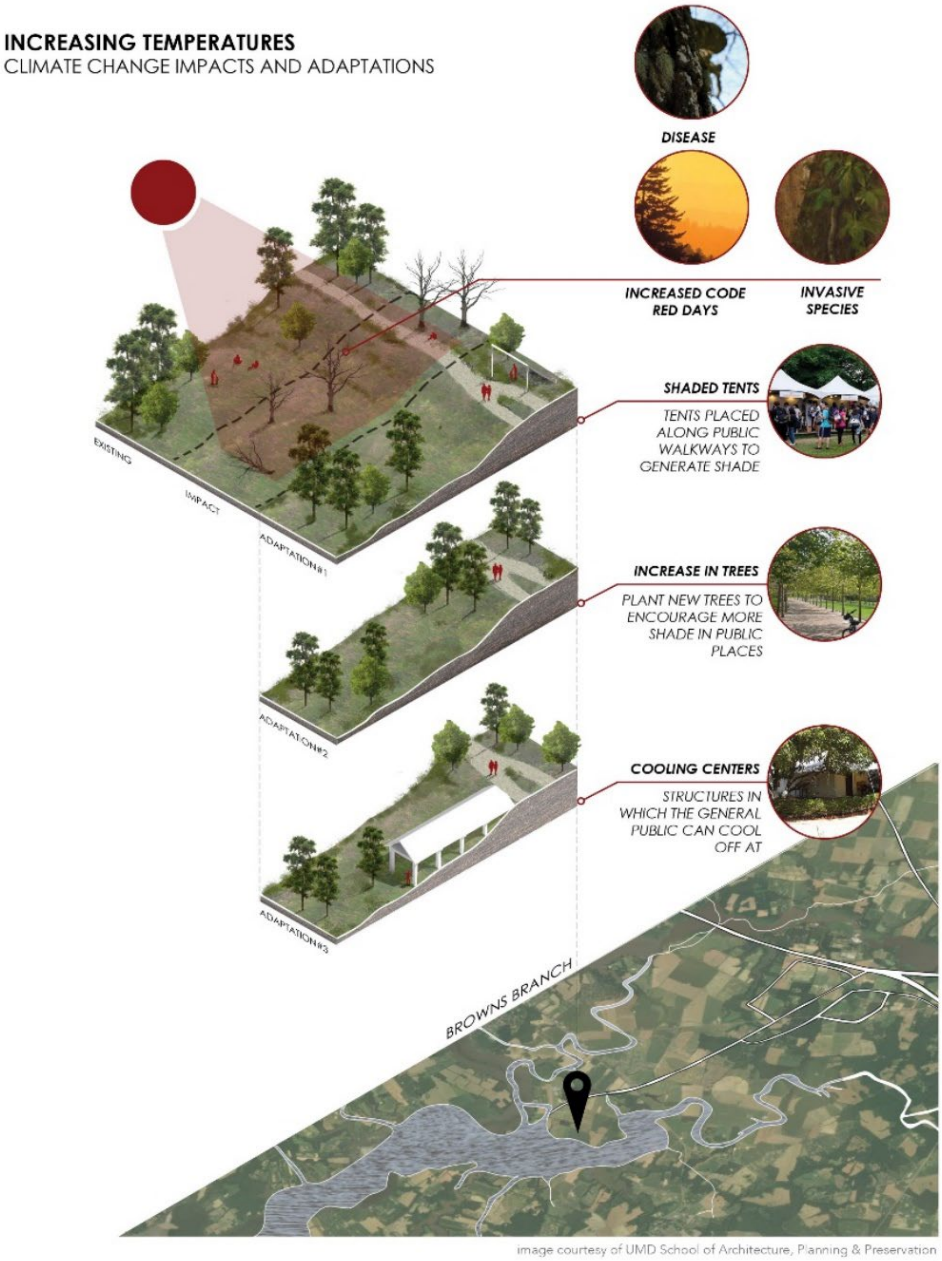


Figure 18: Potential adaptation options to respond to temperature include shaded tents, increasing tree cover and providing cooling centers and water fountains, UMD.

Education:
Educating visitors about climate impacts and ways they can contribute to mitigating these impacts is essential to the park's sustainability. Additional language included in registration emails, park guides and brochures, increasing climate signage on park grounds and creating a social media campaign would further visitor engagement and education.

Another option is to have interactive opportunities available on site for park visitors. For example, having a sample dune ecosystem on display for the public could help people understand the dunes' ecological significance, how dunes move, and how humans cause damage to the dunes. Overall, increased signage throughout the park is essential for creating a sense of stewardship at the park.

This image proposes an educational terrace and dune experience to increase engagement, UMD.

Human-Wildlife Conflicts
Educating visitors about the park's wild residents is the best way to limit human-wildlife conflicts. One option to reach visitors before arriving at the park is to include information about wildlife on the state park's individual web page. Examples could include how and why to avoid turtle nesting sites, why it is dangerous to feed animals and how to properly store and dispose of trash and food waste. This information could also be included in camper registration packets, park signage, park alerts and social media posts. Continuing to enforce existing penalties for failing to adhere to wildlife regulations is of the utmost importance for visitor and wildlife safety. It is well known that the wild horses of Assateague are beloved, but this attraction can be dangerous for the guests and ponies. On-site presentations at the day use building could help educate visitors about the history of the horses and why it is so important to follow the park rules for their safety.

Human Resources and Economy

Climate change is already leading to increased demands of park staff. As more damaging storm events occur there will be a greater need to be ready to repair damage more often, which will increase financial costs and place a burden on already limited staff resources.

No Action Scenario for Human Resources

If procedures are not implemented to prepare staff for changing climatic conditions, park staff are going to be overwhelmed by the new challenges. Site maintenance is going to become more frequent, and visitors may have more health and amenities concerns. Maintenance also becomes more difficult as vehicles age, compromising job performance, emergency response capacities, and customer service.

This shows a staff member removing sand from the dune crossing, an activity which is becoming more frequent.

Developing communication systems and protocols to keep staff safe is a high priority adaptation recommendation.

Adaptation Options and Opportunities for Human Resources

Overall, the ability of staff to respond to climate change threats and visitor concerns will be better facilitated with the addition of new staff members. Hiring a partner liaison, an additional ranger and one additional park technician would improve efficiency. The addition of specific heavy equipment including a bulldozer and mechanical equipment for installing dune fencing would improve staff ability to maintain and repair dunes and improve efficiency. Alternatively or in addition, an ongoing/yearly maintenance contract with a vendor would be beneficial to conduct regular preventative maintenance, surveying and repair work for maintaining and stabilizing the dune.

To help categorize how much staff time it is costing to perform climate related maintenance, staff should maintain a maintenance log of when they performed irregular activities and how long these activities took. For example, sand removal is increasing. Performing an economic analysis of the staff time and cost of moving sand and maintaining beach access paths will help assess the benefits of doing this long term. Documenting and monitoring maintenance efforts is important for tracking site changes over time.

To respond to health emergencies such as heat stroke, staff can prevent the events from happening by providing educational resources for visitors in addition to opportunities for shade, cooling, and drinking water. Teaching park staff to recognize signs of heat stress in visitors will also be important.

Cultural Resources

American Indians have a strong tie to Assateague history, as the island was used by Coastal Plain Indians for harvesting food, including shellfish. Interpretive information is provided at the nature center and Rackliffe House, an 18th century restored plantation house, operated under the Maryland Department of Natural Resources Curatorship program by the Rackliffe House Trust. Recently historic artifacts and building foundations were discovered on the property.

The Rackliffe House appears to be vulnerable to sea level rise at approximately five feet of sea level rise (NOAA Sea Level Rise Viewer). It is also vulnerable under category 2 storm surges. The Stephen Decatur (Route 611) causeway is vulnerable to sea level rise, which could impact access to this historic site.

No Action Scenario for Cultural Resources

Under a no action scenario, assets at the Rackliffe House will likely be protected from sea level rise, though a higher water table due to sea level rise could lead to saltwater inundation of formerly freshwater resources. This could affect daily operations on site.

Although currently only limited archeological resources have been found on site as of October 2022, saltwater intrusion is likely to degrade any historical artifacts that may exist on the site underground.

Performing additional archaeological studies to understand climate impacts on historical resources is a high priority adaptation recommendation.

Adaptation Options and Opportunities for Cultural Resources

Enhancing the shorelines with vegetated buffers could reduce erosion and saltwater intrusion and increase natural filtering of the water to reduce the impacts of salt on cultural sites.

Performing additional archaeological studies will help park staff understand the historical resources at risk from climate change on site. If the Rackliffe House is found to be vulnerable or is experiencing inundation, elevating this site or moving it to a new area could serve as adaptation options.

Overall Conclusions

As one of the most visited parks in the state of Maryland, Assateague State Park serves as a prime example of a state land that is vulnerable to climate change with many options for enhancing resilience. Natural resources are impacted in all areas of the park, with the Atlantic coast being vulnerable to increasing sea level rise, higher than normal tides, and dune and beach erosion. Sinepuxent Bay is vulnerable to sea level rise, storm surge, warming water temperatures, increased salinization, and decreasing biodiversity. All wildlife on the island that depends on these resources and habitats may suffer from decreased resource and habitat availability. Vegetation shifts may occur, with some species disappearing entirely.

OVERALL CONCLUSIONS

Natural resources are at risk

Impacted infrastructure decreases recreational opportunities

As climate impacts worsen there is an increasing demand on park staff

Infrastructure is at risk, which impacts the quality and availability of recreational opportunities. Storms with excessive or extreme winds and rain are impacting campsites and roads, decreasing access for visitors. A study should be conducted to determine future changes to the campground layout including locations for walk-in campsites, parking areas, and relocation of park roads. A study should also be conducted with the expertise of scientists and/or engineers in the geophysical field to provide recommendations for dune stabilization to optimize health and viability of the primary dune.

Efforts should be made to increase the quantities of sand deposited during the ACOE sand bypassing project. This should include consideration from the state of Maryland to provide funding to support this project. Sand accreted through the bypassing project will help strengthen the beach and dune ecosystems, providing necessary habitat for flora and fauna, and protecting the visitor experience. Since sand replenishment is not an option at Assateague State Park, this project is the most critical and has the most potential for increasing sustainability and resiliency for the park and should be supported and enhanced to the greatest extent possible.

Continued coordination with the National Park Service will help to protect the natural resources at Assateague, including partnering on regular monitoring performed by NPS Staff.

Creating resilient infrastructure that serves a second purpose of passive education for visitors to the state park will allow Assateague to be an example for the rest of the state. Infrastructure that takes solar and wind energy into account for design purposes will save money on energy costs that could potentially be used elsewhere at the Park. Facilitating the transition of campsites to walk in campsites will allow more flexibility for campsite locations, decreasing maintenance concerns about sand on roads from increasing winds. Ideally a traffic engineer could assist in identifying infrastructure and other design needs as they relate to climate change and could help create plans to mitigate the high maintenance demands after storm damage.

Priority Recommendations

Increase Sand Bypassing	•Needs to be fully funded •Maximize sand quantities deposited •Extend beyond the 2028 expiration
Conduct Dune Monitoring and Stabilization	•Hire a coastal geologist to assess dune health and provide recommendations •Conduct drone monitoring
Hire a Design Engineer	•Redesign campgrounds to account for vulnerability, walk-in sites, and parking
Monitor Marshes and Stabilize Shorelines	•Analyze living shoreline potential •Monitor restoration success
Acquire More Land	•Assess properties that can be used for future campsites and recreational opportunities
Assess State Highways	•Work with MDOT SHA to assess the vulnerability and resilience of the Stephen Decatur Highway and Verrazano Bridge
Improve Infrastructure	•Long-term infrastructure improvements that prioritize climate resilience and enhance ongoing projects

Existing Efforts

Efforts to maintain the natural resources and recreational and cultural opportunities at Assateague State Park remain ongoing. Park staff are frequently in communication with the Assateague Island National Seashore about their efforts to restore the dune habitat on the northern end of the island, which benefits both entities. Communication should continue between both parks to ensure that the greatest resiliency opportunities are being met. The partnership between the National Park Service and State Park are essential to adapting to climate change on the island.

Assateague is also making efforts to reduce impervious surfaces to address flooding, in addition to making buildings climate resilient. Two University of Maryland PALS studios redesigned the ranger station, bathhouses and concession stands on site. These architectural designs, meant to compliment the construction timeline already in place, proposed innovative, climate resilient buildings that will engage visitors in new ways while also being flood resistant.
Monitoring efforts are also in place. In the summer of 2021, the Maryland Coastal Bays Program surveyed Sinepuxent Bay. Geological surveying is also ongoing.

Long Term Goals

This section provides recommendations for the next five years through 2100. There is no question that Assateague will be negatively impacted by climate change, and these recommendations should assist the transition to a more resilient state park.

Five years

Within the next five years, the ranger station at Assateague State Park will be renovated, and plans are in place to renovate the day-use area bathhouse. These buildings will engage visitors and will be more resilient in the face of more frequent and/or more extreme storms.

Hiring an engineer is also recommended to provide guidance on how to change campsite and campground road configuration to allow for continued recreation in a sustainable manner.

Working together to support the Army Corps of Engineers sand bypassing project to ensure the maximum amount of sand is deposited should be a priority.

Studies should be conducted with the expertise of scientists and engineers in the geologic field to look at current dune structures and make recommendations for strategies and best practices for stabilizing these. This would include actions such as placement of dune fencing, relocation of sand, positioning of crossovers and handrails, and size/scale of dunes. Monitoring activities would also be part of this project to determine rates of erosion/accretion and movement of the dune westward over time. Park leadership should work with DNR's Engineering and Construction division to enable regular preventative maintenance actions and fast response as needed to storm damages. This can be done through acquisition of appropriate heavy equipment for park staff and/or through contracting a vendor to provide services such as is done in Ocean City, Maryland.

Efforts in partnership with DNR's Land Acquisition and Planning Department should continue with the goal of acquiring suitable property or properties for relocating campsites in the future.

Increasing monitoring must occur to understand how climate change is going to continue affecting Assateague State Park.

LONG TERM GOALS

Increase sand bypassing

Conduct an analysis to assess the carrying capacity and future of the campsites

Renovate buildings with climate resilient principles

Increase monitoring to understand biodiversity and water quality changes

Enhance communication and alert systems for visitors

Identify properties for land acquisition and create pathways between these properties and Assateague

Plan for sea level rise – 2.0 feet by 2050 and 4.4 feet by 2100

Increase partnerships and educational outreach to enhance research and public engagement

Learning how fast the coastal bays and dunes are changing will determine next courses of action. Studying saltwater intrusion in the area will also prove essential in understanding how resources and biodiversity may be impacted on site.

Ten years

In ten years, it may become pertinent to relocate campsites and roads that are encroached upon by the migrating dune and have become covered in sand or that have experienced frequent flooding. Moving campsites will provide opportunities to allow for westward dune migration and enhanced shoreline stability. It will likely become necessary to reduce the total number of campsites. Those that are stable and located farthest to the west will likely be able to remain accessible for RVs. Those located to the east will likely need to transition to walk-in campsites that are provided with picnic tables and campfire rings but do not offer an adjacent parking spot or electric hookups. Parking areas for these campsites will need to be provided. It is uncertain if these can be provided on the island or if a mainland site will be necessary.

Efforts in partnership with DNR's Land Acquisition and Planning Department should continue with a goal of acquiring and developing suitable properties for relocating campsites.

Working together to support the Army Corps of Engineers sand bypassing project to ensure the maximum amount of sand is deposited should be a priority. Advocacy for continued funding for this project should occur along with considerations for providing state funding.

Fifteen years

Expanding the Army Corps of Engineers sand bypassing project to ensure the maximum amount of sand is deposited should be a priority. Advocacy for continued funding for this project should occur along with considerations for providing state funding. Continuing to monitor the Verrazano Bridge and the causeway entering the park for how they are being impacted by storms should be considered as a 15-year priority. Creating a communication system for visitors to alert them to the safety of the bridge as well as the campground, beach, and public access areas is going to be important, especially as storms become more frequent and stronger.

Monitoring of the living shorelines can inform the success rate of the projects and be used to guide decisions regarding continued restoration versus retreat.

Efforts in partnership with DNR's Land Acquisition and Planning Department should continue with a goal of acquiring and developing suitable property or properties for relocating campsites. To maintain a campsite inventory near the current number (345), plans should be underway for the development of an alternative site, particularly for RV camping.

Fifty years

Plans to acquire land on the mainland have already been discussed to support the goal of maintaining and increasing recreational opportunities while allowing amenities to change. This will be a direct response to sea level rise on site. Using the Lewes, Delaware tide gauge for

relative sea level rise predictions, sea level rise in this area is predicted to be at or near 2.0 feet (0.61m) by 2050.

RV camping and access will likely have limitations at this time and the park and campground roads may need to be reconfigured and located only in higher areas away from the ocean and bay.

One hundred years

Using the Lewes, Delaware tide gauge for relative sea level rise predictions, sea level rise in this area is predicted to be at or near 4.4 feet (1.34m) by 2100. It is possible that in one hundred years there will be a need for alternative transportation to the island and while on the island. This will be based on sea level rise and how the dunes at Assateague have changed. Camping on the mainland may also be the new normal for the State Park. Likely all RV camping will need to be relocated to a mainland site by this time. Some walk-in camping may still be feasible though parking may be limited or located off site. Parking for day use visitors may also be impacted and may require relocation.

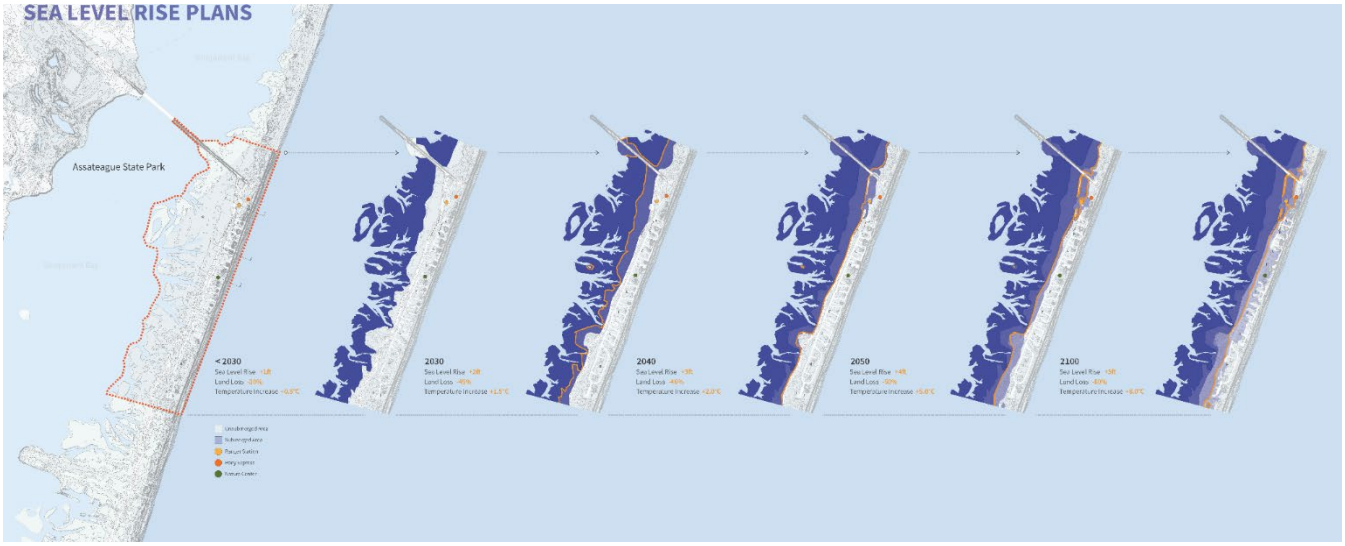


Figure 19: This shows sea level rise impacting Assateague Island by 2100, UMD.

Recommendations for Future Planning

There are many options to implement climate change adaptation and resilience options at Assateague State Park.

As storm events intensify and increase in frequency and sea levels rise, promoting the USACOE sand bypassing project should be prioritized by both the state park and national park to protect the resources and opportunities that exist on the barrier island. Collaboration and work should be done to maximize the quantities of sand to be deposited and fully fund this project as well as continuing it beyond the initial expiration date. Protecting Assateague State Park and Assateague Island National Seashore protects communities and the local economy.

Transitioning away from structured areas for camping on the island may also provide for continued recreational opportunities while decreasing repair costs, staff demands and access problems for visitors camping with RVs and other wheeled camping units. This would include realigning the current campground and reconfiguring it to address the most vulnerable areas. This would result in creation of more walk-in campsites, reconfiguration of campground roads, and redevelopment of parking areas. This would also include looking into land acquisition on the mainland to create more opportunities for parking and transportation to the island, as well as for mainland camping opportunities.

Redirecting visitor flow to the beach and fencing the dune could allow for dune restoration and provide opportunities for dune grasses to establish. These add stabilization to the dune structure. Reducing visitor access to areas of the beach reduces temptation for the wild horses to cross the dunes here and could allow park staff to focus time on other critical maintenance projects in other areas of the state park.

Increased monitoring is an essential factor in understanding how and where resources are being impacted by climate change at the park. The use of drones should be implemented to monitor vegetation and shoreline changes of the coastal bays. Maintaining collaboration with the Maryland Coastal Bays Program should occur to share data and compare trends over time and partner on future shoreline restoration projects. Drone surveying should also be implemented to monitor how the dunes and Atlantic shoreline are impacted by storm events and change over time. This will inform strategies for dune protection including dune fence placement, optimal height, and width for sustainability to erosion, and preventative, maintenance actions. The use of MyCoast and other community engagement opportunities can and should be encouraged to begin collecting data on how the site is changing daily.

Increasing educational opportunities for visitors is an important and passive way to spread awareness about climate change impacts on at the park. Educating visitors can promote stewardship on the island and advocacy for funding needed to protect and stabilize resources.

Overall, Assateague State Park will see significant changes over the next 10-100 years due to climate change. The goal will be to continue to provide opportunities for recreation on the island well into the future. Visitors will have to adapt their recreational uses as the island changes but will be able to find many ways to enjoy the unique qualities that make Assateague so special.

Partners

Current partners involved with enhancing resiliency at Assateague State Park include the Maryland Department of Natural Resources, the Maryland Coastal Bays Program, the National Park Service, the United States Army Corps of Engineers, Maryland State Highway Authority, the University of Maryland, Salisbury University, the Maryland Department of Transportation, and The Nature Conservancy, among others.

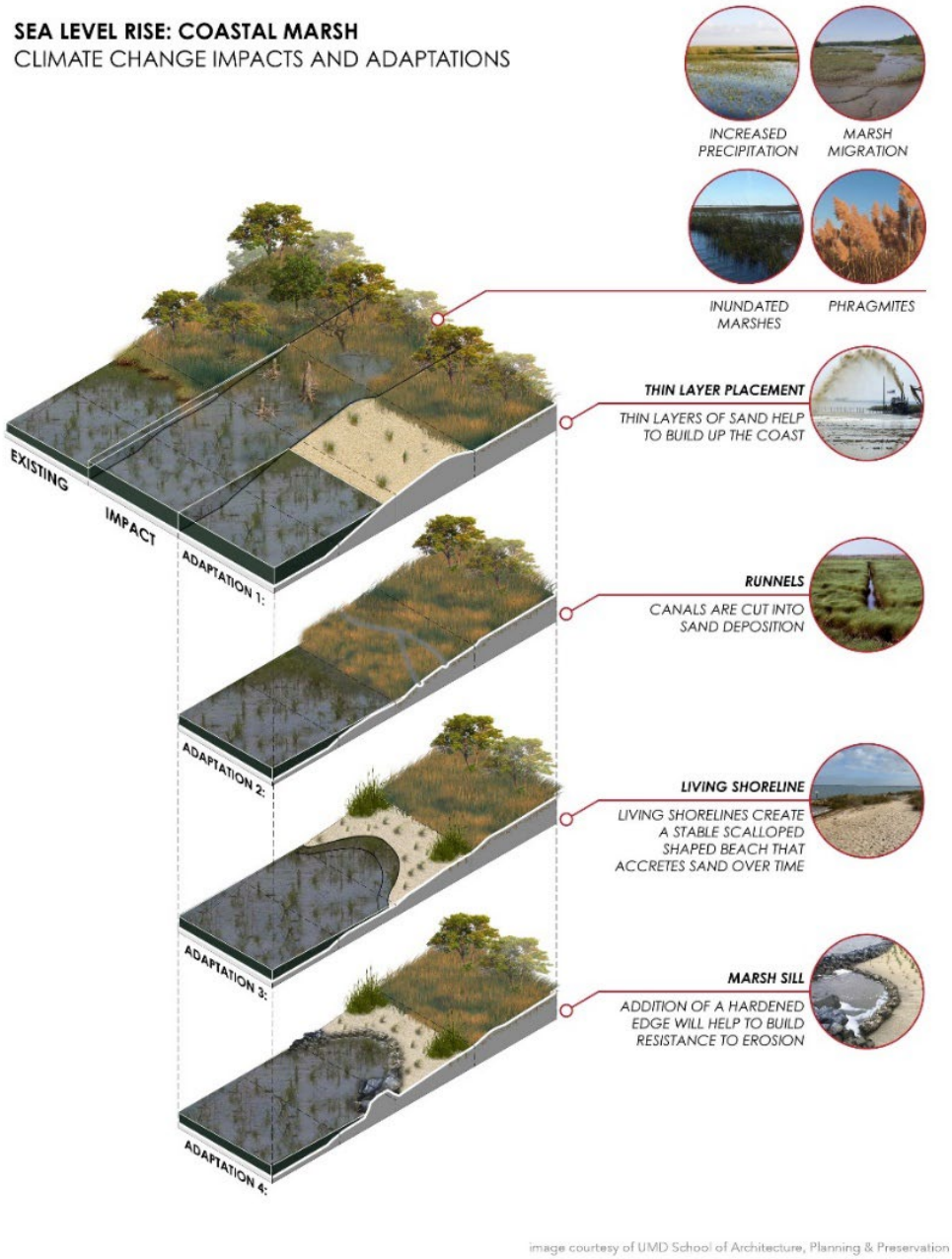


Figure 20: This shows potential marsh restoration projects that would involve multiple partners at Assateague State Park.

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Thank you!

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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

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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

Dune migration: the process of migration by erosion on the windward side and deposition on the lee side

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

Living Shoreline: protected and stabilized shoreline that is made of natural materials such as plants, sand, or rock

Relative Sea Level Rise: the change in the level of the ocean relative to the land at a particular location.

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

Sand Bypassing: the man-induced transfer of sand from jetty fillets, shoals, or navigation channel to downdrift beaches to mitigate erosion problems and protect beach and dune ecosystems

Tide Gauge: a device for measuring the change in sea level relative to a vertical datum

Appendix B: Impacts and Adaptation Opportunities Summary

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

Climate Change Impacts & Adaptation Opportunities

Climate Change Threat	**Impact**	**Opportunities for Adaptation and Enhancing Resilience**	
		Short Term	*Long Term*
Increasing Temperature	Heat stress and health implications	Educational campaigns First aid training	Increase shade tents and tree coverage Adjust work schedules to avoid hottest times of day
	Increased sea turtle nesting (human-wildlife conflicts)	Raise awareness and use nesting signs	Beach closures, nesting pathways, monitoring
	Changing species ranges leading to increased insect outbreaks	Educational campaigns on pests and repellents	Increase monitoring Habitat restoration to reduce mosquito ditching
Sea Level Rise	Shoreline erosion and decreased beach access	Vegetative buffers and living shorelines	Increased sand bypassing Monitor staff hours for maintenance
	Saltwater inundation	Increase native plants	Encourage marsh migration Prepare infrastructure for saltwater maintenance
	Loss of biodiversity	Increased monitoring	Plant and protect dune vegetation
	Marsh loss	Increased monitoring	Allow for dune over wash Assess construction requirements
Worse storms and increasing winds, changing precipitation patterns	Dune loss	Replenish dunes with dredge material	Allow for dune migration Create new dune crossings
	Loss of campsites	Educational outreach	Land acquisition Temporary campsites
	Beach loss	Beach closures Vegetation buffers	Increase sand bypassing Assess long-term impacts of horses
	Breakdown of buildings	Identify resilient infrastructure techniques	Relocate buildings Mobile buildings
	Loss of vegetation inland bays	Stabilize dunes	Bay restoration and living shorelines
	Flooding of roads, decreased access	Redirect water flow Increase pervious surfaces	Ensure that infrastructure designs account for climate change
	Flooding of campsites	Pipes to redirect flow Pervious surfaces	Land acquisition Decrease RV camping
Biodiversity Declines	Loss of RTE species	Increase RTE protection on site	Monitoring
	Habitat loss	Habitat restoration Increase monitoring	Plant climate tolerant species Land acquisition