National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Fort Monroe National Historic Park

Natural Resource Condition Assessment

Natural Resource Report NPS/FOMR/NRR—2018/1604

ON THE COVER
North Beach Area at Fort Monroe National Monument, Virginia.
Todd Lookingbill, University of Richmond

Fort Monroe National Historic Park

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Natural Resource Report NPS/FOMR/NRR—2018/1604

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March 2018

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Lookingbill, T., K. Engelhardt, C. Geraghty, N. Hatchel, D. Kitchen. 2018. Fort Monroe National Monument: Natural resource condition assessment. Natural Resource Report NPS/FOMR/NRR—2018/1604. National Park Service, Fort Collins, Colorado.

NPS 250/142910, March 2018

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Executive Summary

Fort Monroe National Monument is located at the tip of the Virginia Peninsula in Hampton, Virginia. The area known as Old Point Comfort was formed from a modified barrier island system, and is connected to Buckroe Beach in the north via a narrow sand spit. The beaches were formed by longshore drift, are partially protected by dunes, and are an important ecological and recreational asset. The site includes the largest stone fort built in the United States and was formally added to the National Park System in 2011, recognizing millennia of human interactions with this landscape.

Natural resources within the 325-acre park boundary include an ecologically diverse and productive saltmarsh cordgrass wetlands within Mill Creek. Marsh birds, shorebirds, songbirds, and other bird species can be observed in the park in greater abundance and diversity than any other group of animals. The park is home to approximately 30 species of mammals and 250 species of plants. Over 130 southern live oaks (*Quercus virginiana*), including the nearly 500-year old Algernourne oak, are characteristic of the historic monument. Management issues of concern include rising sea level, the effects of increasingly frequent and intense coastal storms, history of military use, water quality degradation, introduction of exotic species, air pollution, habitat fragmentation, and the impacts of recreational use.

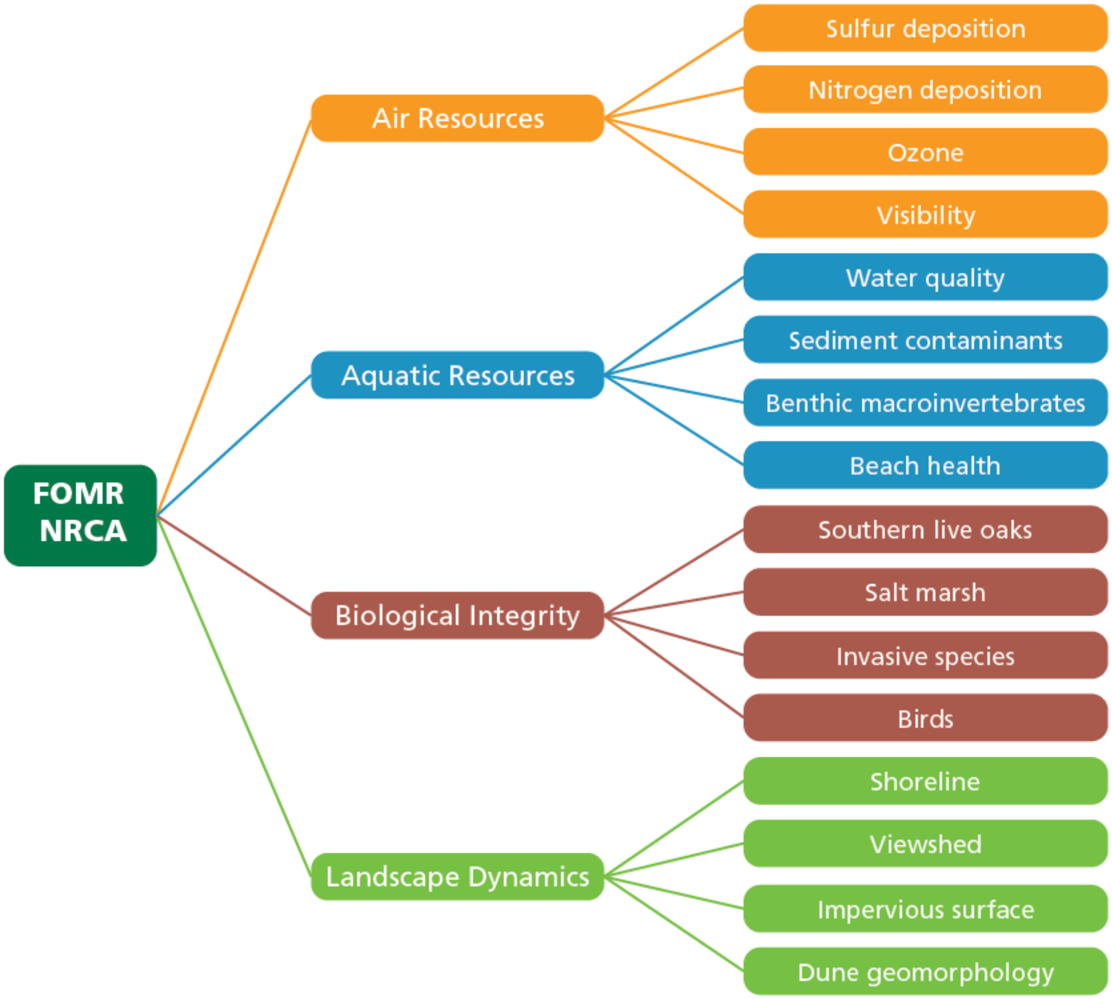
Aerial image of Fort Monroe National Monument, Virginia (Photo credit: National Park Service).

Natural Resource Condition Assessments (NRCAs) assess and report on park resource conditions and are meant to complement traditional issue and threat-based resource assessments. NRCAs report on current conditions, trends, and critical data gaps for a subset of park natural resource indicators. This analysis is designed to help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about park natural resources to varied audiences. The goal of this report is to deliver science-based information that is credible and has practical uses for a variety of park decision-making, planning, and partnership activities.

Data for the NRCA were compiled for the park to assess four different categories of resources (air, water, biota, and landscape) and to calculate an overall park-level condition score. Data sets were obtained from multiple divisions within the National Park Service (NPS) including the Northeast Coastal and Barrier Network Inventory and Monitoring (NPS I&M) Program, the Air Resources Division, and the park itself. Other important sources of data included the Fort Monroe Authority, the US Army Corps of Engineers, the US Fish and Wildlife Service, the City of Hampton, the Boy Scouts of America, and the National Oceanic and Atmospheric Administration. Additional expertise was provided by Fort Monroe officials and experts who have worked in the park and surrounding area.

Strong collaboration with park staff was essential to the success of this assessment. Project collaboration and exchange of data occurred throughout the project by way of scoping meetings, site visits, and follow-up conference calls. Outcomes of these discussions helped identify natural resources to be included in the assessment, identify key indicators to assess the condition of these resources, assign desired or target values for the indicators, and interpret findings. These meetings also provided the context of current conditions and background information not necessarily available in published form.

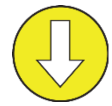
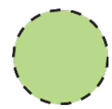
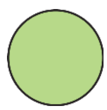
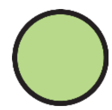
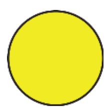
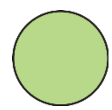
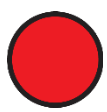
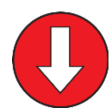
Although the park is not part of any NPS I&M networks at this time, efforts were made to select indicators consistent with those used in that program. NPS I&M ecological monitoring aggregates indicators into broad ‘vital signs’ categories including the following four, which formed the basis of the Fort Monroe NRCA: Air Quality, Water Quality, Biotic Integrity, and Landscape Dynamics. After consultation with park staff and experts, a total of 16 indicators, four for each vital sign category, were used in this assessment. Each indicator assessment includes detailed information on indicator relevance, metrics used to quantify indicator condition, reference thresholds, assessment of current condition and trend, and an assessment of data gaps and level of confidence for that indicator. Reference thresholds ideally were ecologically based and derived from the scientific literature. However, when data were not available to support peer-reviewed ecological thresholds, regulatory and management-based thresholds were used. In some cases, thresholds were determined based on best professional judgment in cooperation with park staff. In all instances, the source of the threshold used is clearly stated in the report.



Indicators used in the assessment of Fort Monroe National Monument.

Final condition scores were calculated based on the percentage of sites or samples that met or exceeded threshold values for each indicator. An indicator attainment score of 100% reflected that the indicator at all sites and at all times met the threshold identified to maintain natural resources. Once attainment was calculated for each indicator, unweighted means were calculated to determine the condition of each vital sign category and for the park as a whole. In other words, indicators were not treated differently in the final park assessment based on differences in their confidence ratings or any other considerations. Indicators were assigned a qualitative rating corresponding to the quantitative score based on standardized NPS NRCA reporting: significant concern (0-33% reference condition attainment), moderate concern (34-66% reference condition attainment), and good condition (67-100% reference condition attainment). Indicators also were color coded according to standard NPS NRCA symbology: red (significant concern), yellow (moderate concern), and green (good condition) (Table E1).

Table E-1. Results of the Natural Resource Condition Assessment of Fort Monroe National Monument.

Priority resource or value	Indicator of concern	Condition status and trend	Attainment	Priority resource or value	Indicator of concern	Condition status and trend	Attainment
Air quality	Sulfur deposition		30%	**Biological integrity**	Southern live oaks		64%
Air quality	Nitrogen deposition		0%	**Biological integrity**	Salt marsh		67%
Air quality	Visibility		0%	**Biological integrity**	Invasive species		27%
Air quality	Ozone		46%	**Biological integrity**	Birds		71%
Aquatic resources	Water quality		67%	**Landscape dynamics**	Shoreline		71%
Aquatic resources	Sediment contaminants		64%	**Landscape dynamics**	Viewshed		76%
Aquatic resources	Benthic macroinvert-ebrates		5.5%	**Landscape dynamics**	Impervious surfaces		0%
Aquatic resources	Beach health		99%	**Landscape dynamics**	Dune geomorph-ology		84%

The condition of the natural resources of Fort Monroe National Monument were assessed to be of "moderate concern", attaining 48% of desired threshold scores. Air quality was identified as the most highly degraded resource, warranting "significant concern." Unfortunately, air quality degradation is a regional issue over which park management has limited control. However, the park can play a leading role in regional education of the causes and consequences of air pollution. It is also important to note the improving trends in regional air quality (wet nitrogen deposition, wet sulfur deposition, visibility, and ozone).

The condition of aquatic resources for the park was assessed as being of "moderate concern." Trends could only be calculated for beach health, which is in stable condition. The data record is relatively short for the other indicators, or temporal data could only be obtained for outside of the park, highlighting the need to establish a monitoring program for aquatic resources in the park. The condition of benthic macroinvertebrate communities is of “significant concern” and continued monitoring would be especially useful for this indicator.

Biotic resources were assessed as being of “moderate concern.” The southern live oak population is a significant resource that warrants continued and increased monitoring and management on a regular basis. The salt marshes in Mill Creek are in “good” condition, however, they may disappear completely by 2100 or sooner if current trends continue or accelerate. Salt marsh extent and sediment accretion and erosion should be closely monitored in the future. In general, more basic data collection is needed on biotic resources such as birds, mammals, herpetofauna, and terrestrial invertebrates.

Landscape dynamics in the park were assessed as being of “moderate concern.” Confidence in the assessment of these resources was moderate, and would be increased by developing a time-series of high-resolution, classified land cover imagery specific to the park. Data collection priorities also could include the implementation of a noise and light pollution monitoring protocol. Future threats to the park include further residential and commercial development in the region, energy development, increased highway expansion, and associated vehicular traffic.

Acknowledgments

This report benefitted from feedback and collaboration with Terry Brown, Kirsten Talken-Spaulding, and Aaron Firth at Fort Monroe National Monument. Christine Arnott provided guidance and support on the Natural Resource Condition Assessment process. Brianne Walsh completed the coordination, layout assistance, and copyediting of the final document. Marian Norris, Peter Sharpe, Amanda Babson, Holly Salazer, Sheila Colwell, Kristoffer Hewitt, Christopher Beagan, Sara Nerone and Claire Sbardella provided formal reviews of earlier drafts of the report. Mark Perreault, David Wilcox, Robert Orth, Jeff Allenby, Robert Reali, Josh Gillespie, Darcy Sink and Andrew Heyes provided additional data and feedback. Tracey Tien assisted with the viewshed analysis. The following students contributed to initial research and development of the report as part of their Living and Learning Experience, and we are extremely grateful: Taiyaba Ali, Joora Baek, Ellen Brooks, Sarah Carroll, Michael Cevallos, Margaret Foster, Anna Gonye, Anna Hakkenberg, Jinny Kang, Margaret Latimer, Mariah Maki, Jeffrey Noble, Jessica Patel, Tyler Pike, Helen Richardson, and Tongyu Wang.

1. NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks." NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

> ***NRCAs Strive to Provide…***
>
> - *Credible condition reporting for a subset of important park natural resources and indicators*
> - *Useful condition summaries by broader resource categories or topics, and by park areas*

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement—not replace—traditional issue-and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- Are multi-disciplinary in scope;[1]
- Employ hierarchical indicator frameworks;[2]
- Identify or develop reference conditions/values for comparison against current conditions;[3]
- Emphasize spatial evaluation of conditions and GIS (map) products; [4]
- Summarize key findings by park areas; and [5]
- Follow national NRCA guidelines and standards for study design and reporting products.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for

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[1] The breadth of natural resources and number/type of indicators evaluated will vary by park.

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-up response (e.g., ecological thresholds or management "triggers").

[4] As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.

[5] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.
Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions, but, in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Important NRCA Success Factors

- *Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline*
- *Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ⇨ indicators ⇨ broader resource topics and park areas)*
- *Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings*

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park’s desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

NRCA Reporting Products…

Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

- *Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations* ***(near-term operational planning and management)***
- *Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values* ***(longer-term strategic planning)***
- *Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public* ***("resource condition status" reporting)***

Over the next several years, the NPS plans to fund an NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information visit the NRCA Program website.

[6]An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

[7] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

[8] The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human value

2. Introduction and Resource Setting

2.1. History and Enabling Legislation

On November 1, 2011, Fort Monroe was formally added to the National Park System as a national monument. This designation recognizes millennia of human interactions with the landscape on Old Point Comfort.

2.1.1. Pre-European Settlement

Archeological evidence suggests that American Indians used the Mid-Atlantic region for 10,000 years before Europeans arrived. The survival of Early Archaic (8000 to 6000 BCE) and Middle Archaic (6000 to 2500 BCE) people was dependent on the plants and animals of the region. Prior to European colonization, the area now known as Old Point Comfort was a strategic location for Native American tribes. The southeast shore of Virginia, including Old Point Comfort, was inhabited by the Powhatan Confederacy, whose populations demonstrated an increasing dependence on agriculture (NPS 2011).

2.1.2. European Arrival

In 1607, Captain Christopher Newport led his group of colonists towards the inlands of Virginia. Among the settlers reaching the mouth of the James River was Captain John Smith. Owing to a deep water channel adjacent to land, the settlers could safely land and therefore named the spit Old Point Comfort, writing: “Wee rowed over to a point of Land, where wee found a channell, and sounded six, eight, ten, or twelve fathom: which put us in good comfort. Therefore wee named that point of Land, Cape Comfort” (Narratives of Early Virginia, observations by George Percy).

In 1609, the region was considered so vital for shipping that British settlers constructed Fort Algernourne to protect the area. The site was also the location of the August 1619 arrival of the *White Lion* and the first reported "20 and odd" enslaved Africans to set foot on English North America. An accidental fire in March of 1612 destroyed the fort. In approximately 1728, Fort George was constructed to protect the area from French and Spanish invasions. It, too, was destroyed, this time by a hurricane in 1749 (NPS 2011).

The first permanent lighthouse was built in 1802 to alert ships that the mainland was near. The 54-foot lighthouse is one of the oldest remaining structures on Old Point Comfort. During the War of 1812, the lighthouse temporarily fell into British hands when the British sailed uncontested up the Chesapeake Bay to Washington, DC.

After the war, the United States decided to construct a new series of forts, known as the Third System Fortifications, to increase its coastal defense system. Designed as the first and largest of the Third System Fortifications, construction of Fort Monroe began in 1819 on Old Point Comfort. Fort Monroe’s 2,394-yard perimeter encompassed 63 acres, and its ramparts, casemates, and gates were enclosed by a wet moat. Designed as a bastioned work with seven fronts, holding 380 gun mounts and a complement of more than 2,600 men in time of war, the fort was deemed close to impregnable from land and sea. Construction on Fort Monroe was completed more than a decade later by enslaved workers, contractors, and military convict labor. A young Lieutenant Robert E. Lee was stationed at

Fort Monroe to help supervise the final phases of its construction, and he continued work on Fort Calhoun from 1831 to 1834 (NPS 2011).

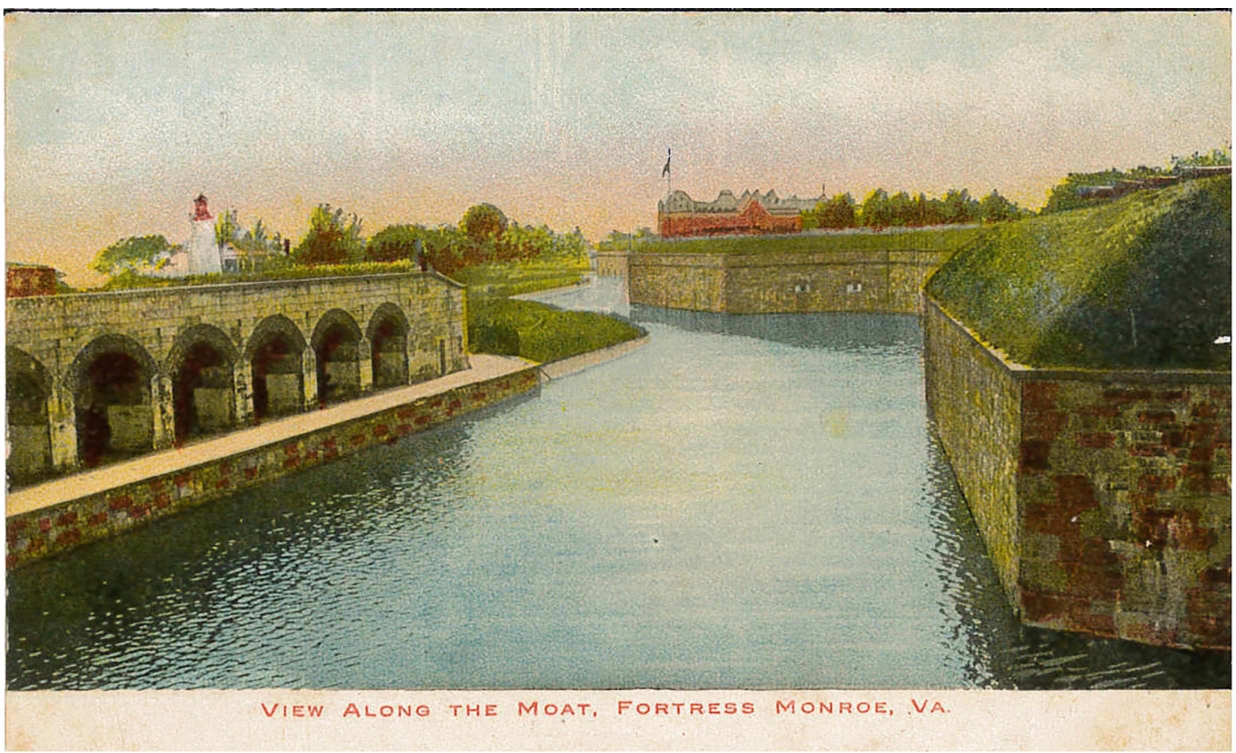
Old Point Comfort lighthouse is the second oldest lighthouse in the Chesapeake Bay region, and the oldest still in use (Photo credit: Jim Comiskey, National Park Service).

2.1.3. American Civil War Years

On May 23, 1861, three enslaved men escaped to Fort Monroe seeking freedom with the Union Army. During the American Civil War, the fort remained in Union hands even though it was surrounded by Confederate Virginia. The fort's commander, Major General Benjamin Butler, a lawyer by profession, refused to recognize the asylum seekers as escaped slaves under the Fugitive Slave Act of 1850, reasoning that Virginia had seceded and was no longer part of the United States; therefore the Fugitive Slave Act did not apply. Because the Confederacy considered enslaved persons as property and were using enslaved men in their war effort, Butler further argued these freedom seekers would be considered property and retained as 'contraband of war.' Soon, whole communities of men, women, and children known as 'contraband camps' formed in areas near Union forces (Klein 2010). Following the 'Contraband Decision,' more escaped slaves sought and were granted refuge on the army post as long as they worked for the Union military. Fort Monroe was thus nicknamed Freedom's Fortress, as it sheltered more than 10,000 freedom seekers. When the war ended in 1865, former Confederate President Jefferson Davis was brought to Fort Monroe and placed in Casemate No. 2, which became his cell for the first four and a half months of his two-year internment. Casemate No. 2 is part of the Fort Monroe Authority's Casemate Museum. After the war, individuals from the ‘contraband community’ remained in the area, and new African American neighborhoods, churches, schools, and other institutions were created near the fort in Phoebus and downtown Hampton, including what would become Hampton University (NPS 2011).

2.1.4. Post-Civil War Era

During Reconstruction, the facilities of Fort Monroe were renovated, expanded, and modernized. From 1907 to 1946, Fort Monroe served as the US Army’s Coast Artillery School following the separation of Coast Artillery and Field Artillery disciplines. During World War I, the fort remained an important coastal fortification. Civilian activities on Old Point Comfort included the construction of the new Chamberlin Hotel in 1929 and founding of the Casemate Museum in 1951. An airfield, known as Walker Airfield, was added in 1951. During the years of 1973 to 2011, Fort Monroe was the US Army’s Training and Doctrine Command Headquarters. In 2005, the Defense Base Closure and Realignment Commission (BRAC) recommended that the post be closed, which ultimately took place in September 2011. Because of earlier agreements, the closure of Fort Monroe began a process to return much of the 565 acres back to the Commonwealth of Virginia (NPS 2011).



Historic view along the moat of Fort Monroe from around 1900. On the left is the Water Batter, which no longer stands, and in the distance is the fort’s Flagstaff Bastion, Old Point Comfort Lighthouse, and Chamberlin Hotel (Photo credit: National Park Service, Fort Monroe Authority’s Casemate Museum).

2.1.5. Enabling Legislation

Fort Monroe was recognized as a National Historic Landmark in 1960 as a result of the National Historic Preservation Act. Following the BRAC decision to close the post, the Virginia General Assembly created the Federal Area Development Authority in 2007 to consider how to utilize the area. In 2009, as part of the BRAC procedure, and to fulfill requirements of Section 106 of the National Historic Preservation Act, the Department of the Army entered into a programmatic agreement with the Virginia State Historic Preservation Office, the Advisory Council on Historic Preservation, the Commonwealth of Virginia, the Fort Monroe Authority, and the National Park Service to define a process for the evaluation, transfer, and future protection of Fort Monroe's historic resources. In addition to tasks required of the Army as part of the closure process, the programmatic agreement stipulated that the Commonwealth of Virginia would manage and develop the site in a manner that would preserve and protect its status as a National Historic Landmark, and that it would seek to reuse historic buildings and maintain public access to Fort Monroe's historic, natural, and recreational attractions. Explicit in the agreement was the requirement that the Commonwealth and the Fort Monroe Authority would take no action that would preclude the use of Fort Monroe as a National Park or entering into an affiliated partnership with the National Park Service. In 2011, Virginia Governor Bob McDonnell sent a letter to Secretary of the Interior Ken Salazar to transfer portions of Commonwealth of Virginia land, once received, to the National Park Service in order to establish Fort Monroe as a new unit of the National Park Service. President Obama officially established Fort Monroe as a national monument through the 1907 Antiquities Act on November 1, 2011 (NPS 2011).

The purpose of Fort Monroe National Monument is to preserve, protect and provide for the appropriate public use of historical, natural, and recreational resources of Old Point Comfort, strategically located at the mouth of the Chesapeake Bay, and interpret its storied history in the European colonization of our nation, exploration of the bay, slavery in America, and the struggle for freedom and the defense of our nation.

2.2. Geographic Setting

2.2.1. Location

Fort Monroe National Monument is located on a 2.6 mile spit in Hampton, Virginia, on the southeastern tip of the Virginia Peninsula, between Mill Creek to the west and the Chesapeake Bay to the east (Figure 2-1). The 325-acre park resides in the Coastal Plain of Virginia near the mouth of the James River. About 80 miles southeast of Richmond and 2.8 miles south of the downtown area of the City of Hampton, Fort Monroe National Monument resides on Old Point Comfort within the City of Hampton (SAIC 2012).

Figure 2-1. Aerial image of Fort Monroe National Monument (Source: ESRI).

2.2.2. Geomorphology and Land Use

Old Point Comfort is formed from a modified barrier island system, and is connected to Buckroe Beach in the north via a narrow sand spit (Beard et al. 2009). The spit was formed by longshore drift during post-glacial times after the sea level rose. Sand still naturally moves along the shore face tracking the increasing water depth and associated increasing wave energy along the line from North-South (Figure 2-2). This movement created the beaches that are present now. It also causes natural beach erosion and deposition, much of which is seasonal. During the winter, sand moves both off-shore and along-shore. There are no major sand bars or shoals of sand offshore. Sand that is moved off-shore during the winter storms does not remain in place, and is therefore unavailable to move back onshore over the summer when wave intensity decreases.

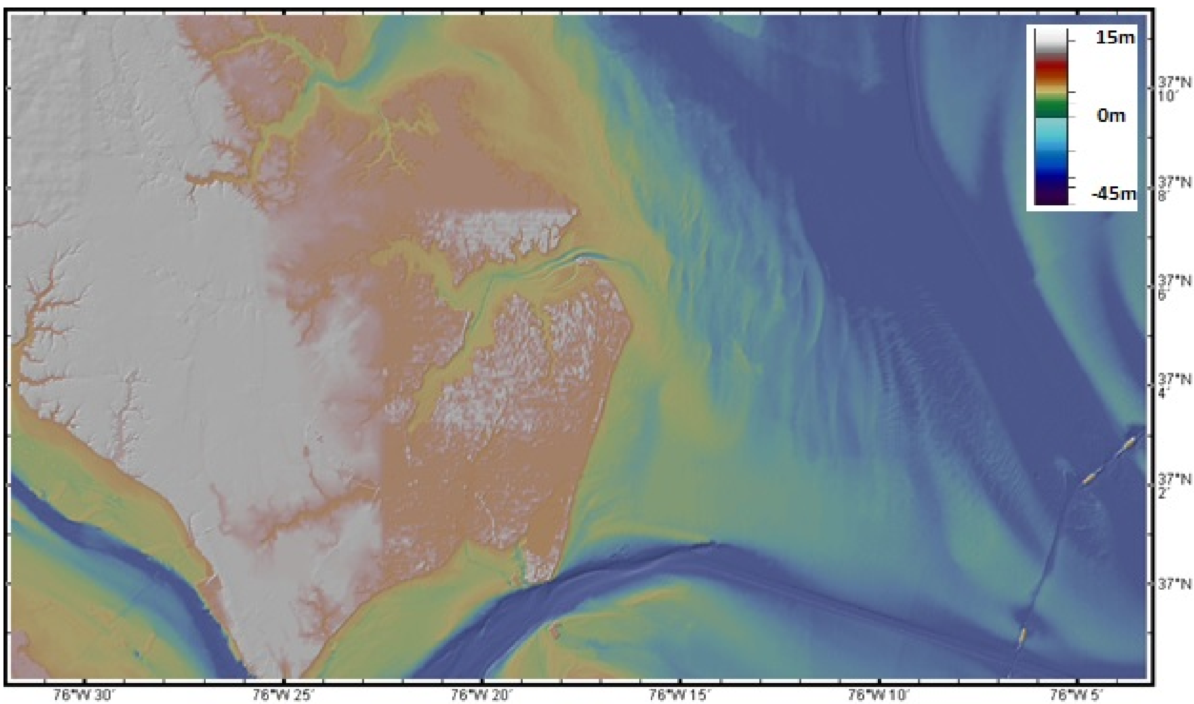


Figure 2-2. Water depth offshore of Fort Monroe National Monument (Source: U.S. Bathymetry 10m resolution for VA beach).

The southeastern portion, where the fort is located, is the most developed area of the park. This area was built up for development with artificial fill. The central portion is less developed, containing three batteries and a recreational facility. The northern area is mostly undeveloped with unpaved areas and coastal landscapes. Along the shore, groins interrupt the natural migration of sand, and reduce erosion. Sand accumulates behind the groin to form a steeper beach. A highly productive 53-acre salt marsh is located on the western side of the park (NPS 2011) (Figure 2-3). Land cover in the surrounding vicinity of the park is predominantly turf grass and impervious surfaces from development (Figure 2-4). Those areas in the region that have not been converted to human uses are mostly along the coastal regions (Figure 2-5). Plum Tree Island is a 3,500-acre National Wildlife Refuge managed by the U.S. Fish and Wildlife Service that is located approximately 5 miles from the Fort Monroe National Monument northern boundary (Figure 2-6).

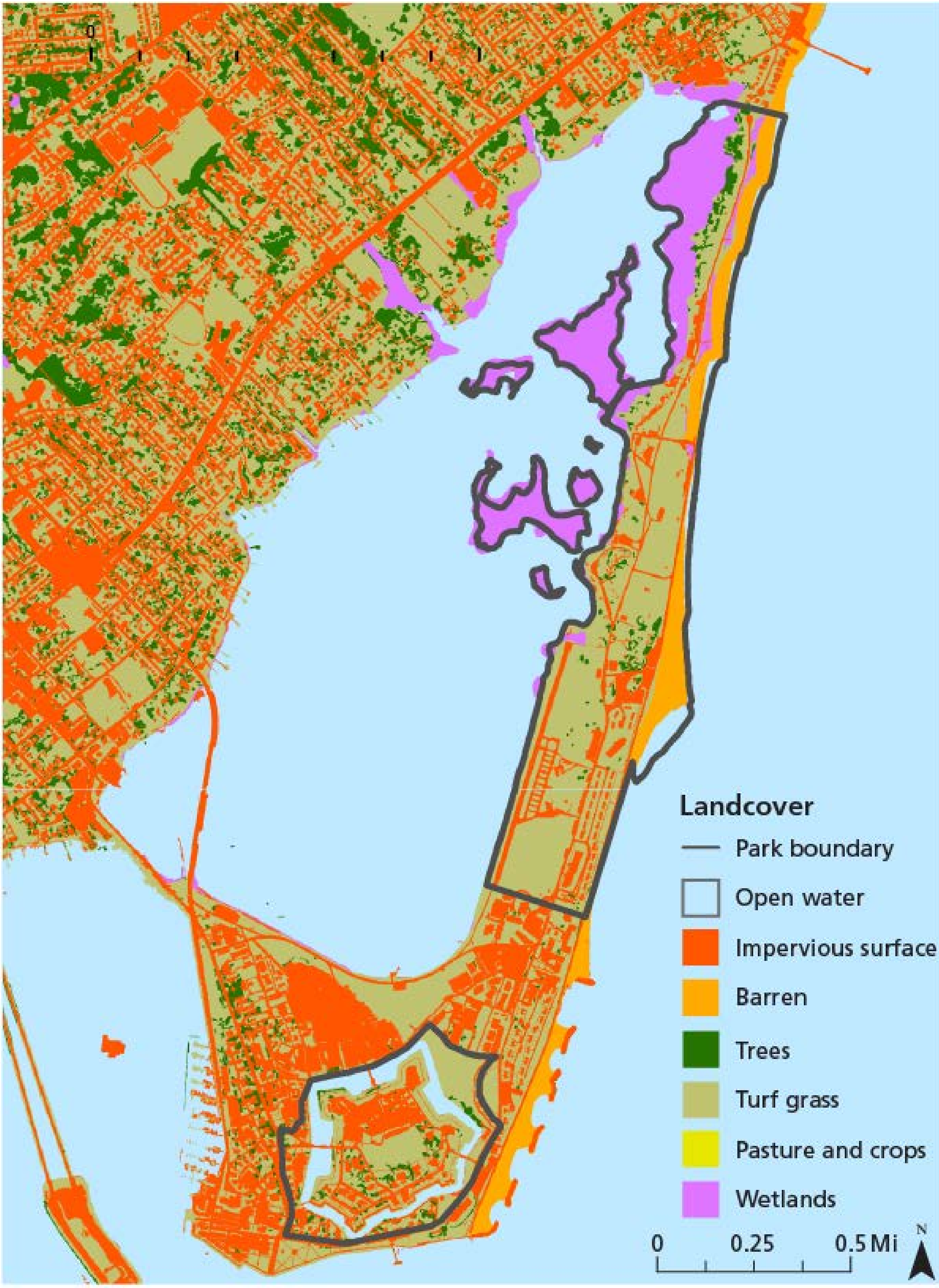


Figure 2-3. Land cover in and around Fort Monroe National Monument (Source: VGIN 2016).

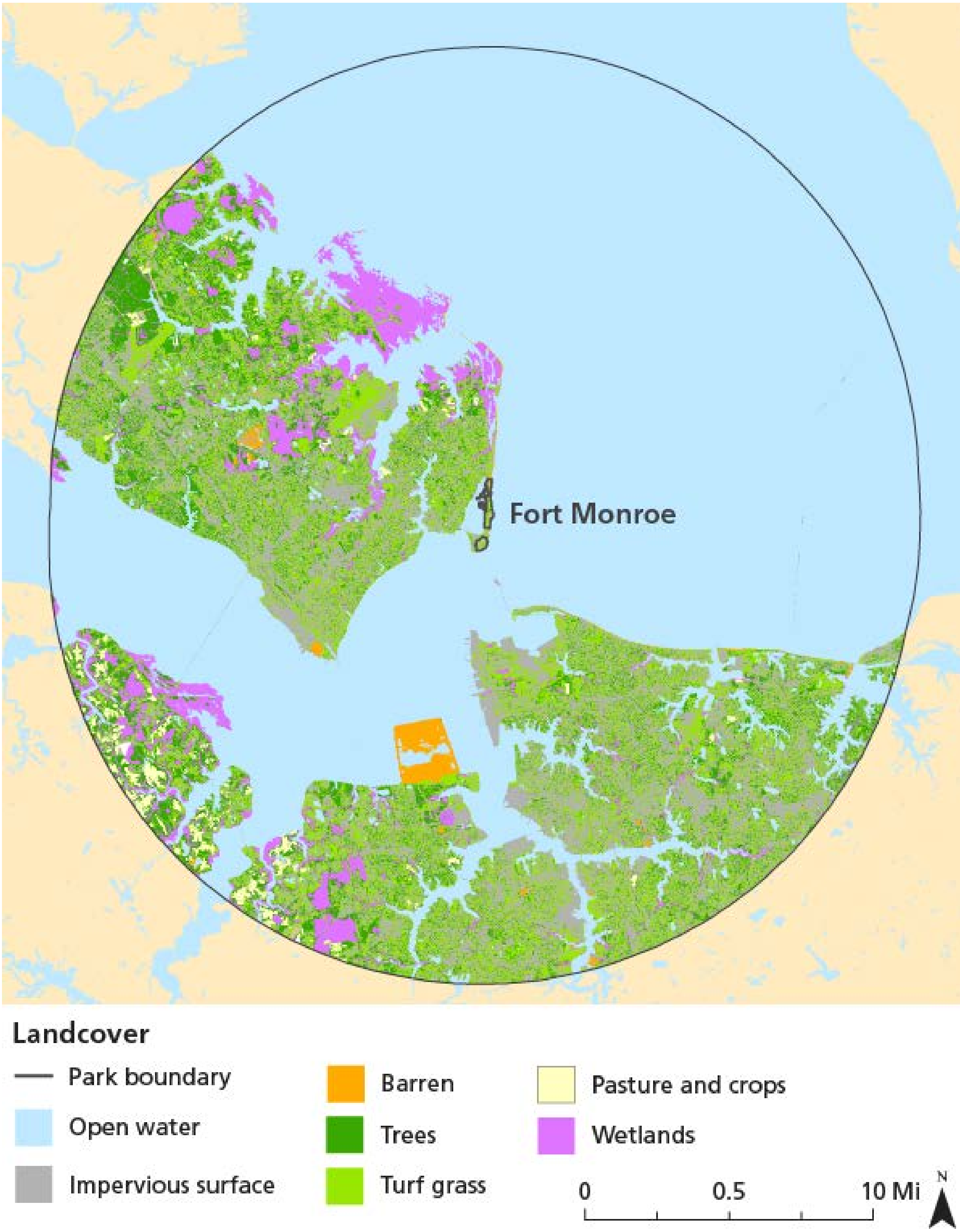


Figure 2-4. Land cover within a 30km radius around Fort Monroe National Monument (Source: VGIN 2016).

Figure 2-5. Natural and converted land cover within a 30km radius around Fort Monroe National Monument (Source: 2011 National Land Cover Dataset).

Figure 2-6. Protected areas within a 30km radius of Fort Monroe National Monument (Source: PAD-US 2012).

2.2.3. Climate

The park enjoys a temperate climate, with warm summers and cool winters. From 1901-2002, Fort Monroe experienced an average temperature of 14.7°C. Precipitation is relatively consistent year-round, with an average of approximately 46 inches per year, including 6 inches of annual snowfall (Southeast Regional Climate Center 2015). Since 1995, the Hampton area has experienced decreasing levels of annual precipitation (Gonzalez 2012).

Looking out over Fort Monroe in the winter (Photo credit: National Park Service).

2.2.4. Population and Socioeconomic Conditions

In 2014, the population of the City of Hampton was estimated at 136,879 people, of which approximately 43% were Caucasian, 49.8% African American, 5.3% Hispanic, and 2.4% Asian. An estimated 11.5% of the population was under the federal poverty level (US Census Bureau 2015). The greater Hampton Roads Metropolitan Statistical Area (MSA) is home to more than 1.5 million individuals. The MSA includes seven counties and nine cities, covering 249 square miles (VBED 2015). Old Point Comfort itself is home to approximately 1,000 people. According to 2014 tax data, the average household income on the Old Point Comfort peninsula was $97,000. The average household income for the Hampton Roads MSA was $63,000.

The NPScape landscape monitoring program (NPS 2014) tracks trends in housing density in buffer regions surrounding parks. Past, present, and future housing projections are derived from the Spatially Explicit Regional Growth Model, SERGoM (NPS 2015b). The high regional density and rapid rates of growth are evident from these projections at both the 30km (Figure 2-7) and 3km (Figure 2-8) scales.

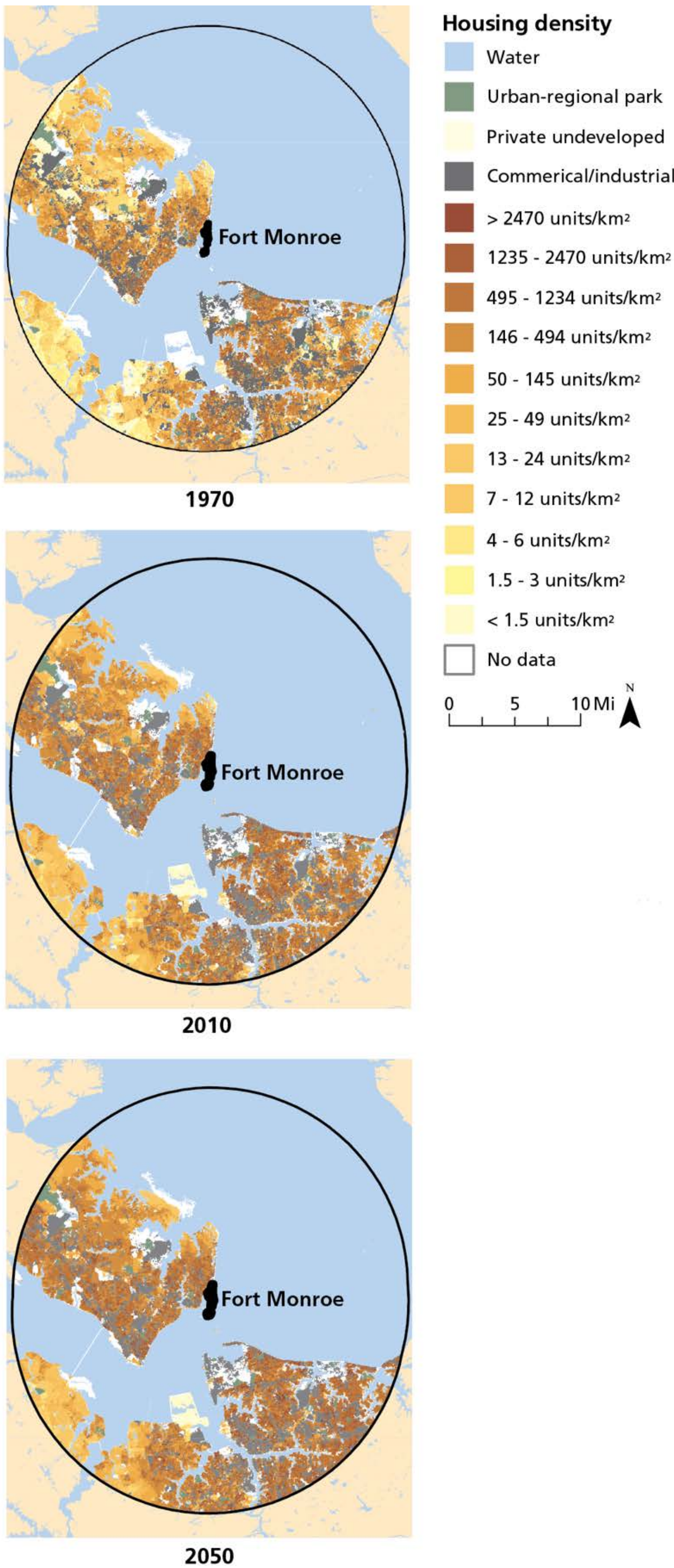


Figure 2-7. Housing density within a 30km radius of Fort Monroe National Monument (Source: NPS 2015d).

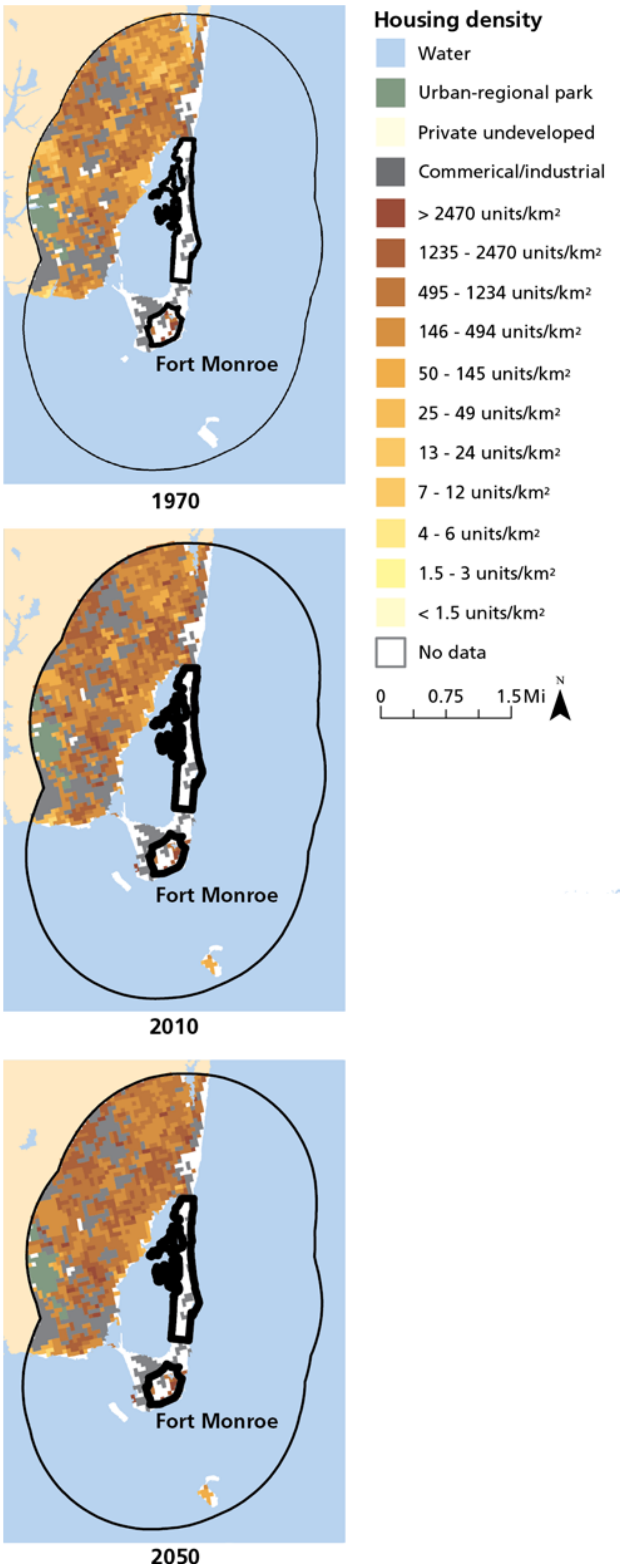
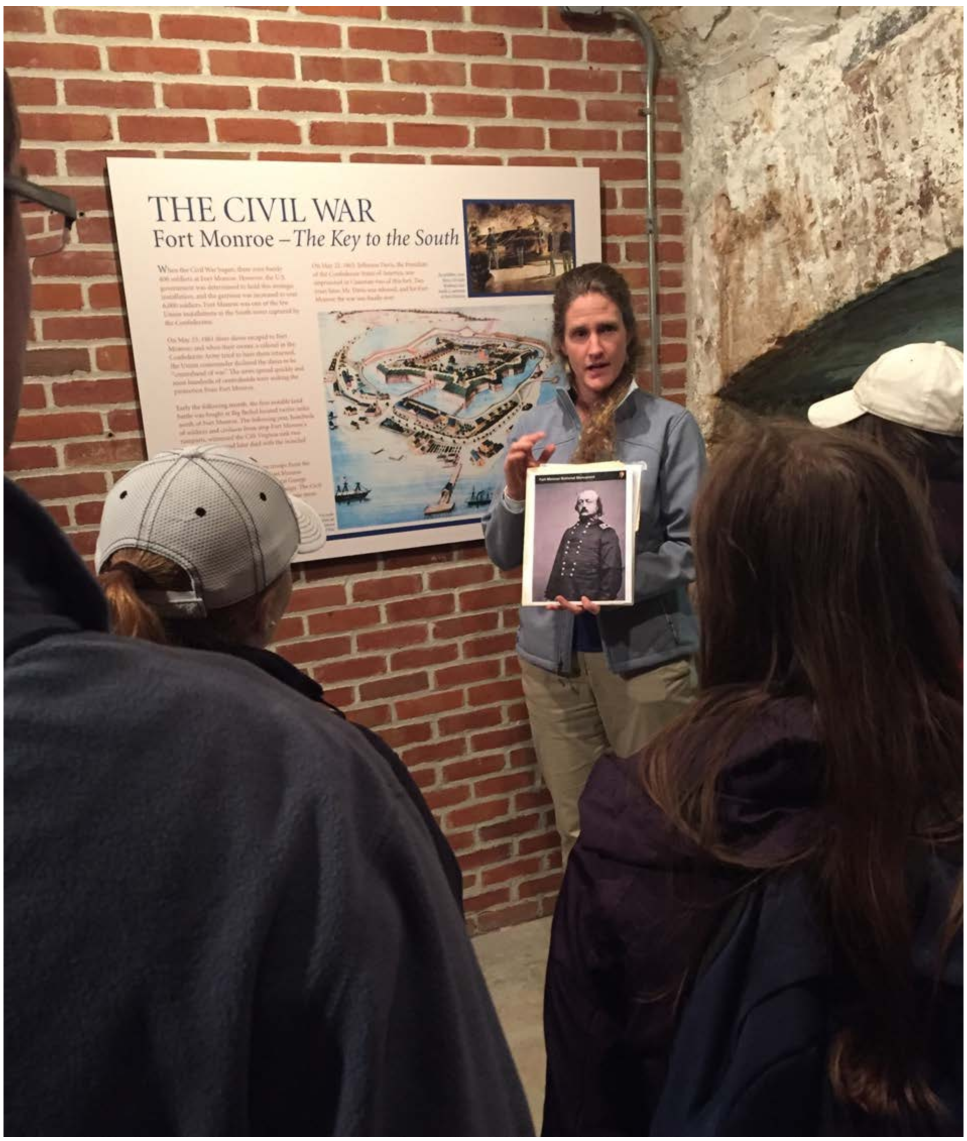


Figure 2-8. Housing density within a 3km radius of Fort Monroe National Monument (Source: NPS 2015d).

2.2.5. Visitation Statistics

Visitation to Fort Monroe has continually increased since its establishment in 2011. A 2014 study of Fort Monroe visitation recorded 81,313 recreational visits, which, when adjusted for visitor group size and visitor re-entries, results in an estimated 23,937 group trips (Cook 2015). More than 60% of these visitors lived within 30 miles, with 19% living on the Virginia peninsula. A majority of the visitors were from Virginia (78%). The most common visitor activities included exploring the North Beach area and trails (51%), walking along Outlook Beach (64%), visiting the Casemate Museum (55%), and visiting the fort's grounds (51%). Visitor spending was estimated to contribute $389,000 per year to the local community (Strawn and Le 2014).



A popular visitor destination at Fort Monroe is the Casemate Museum, which chronicles the history of the military at Fort Monroe and includes Casemate 2, where former Confederate States of America President Jefferson Davis was incarcerated for several months during 1865 (Photo credit: Todd Lookingbill, University of Richmond).

2.3. Natural Resources

2.3.1. Ecological Units and Watersheds

Watershed Context

Fort Monroe National Monument is located in both the Hampton Roads and Lynnhaven-Poquoson watersheds near the mouth of the James River where it empties into the Chesapeake Bay (Figure 2-9). The Chesapeake Bay is the largest and most biologically diverse estuary in the United States. It is home to over 3,600 species of plants, fish, and animals (Commonwealth of Virginia 2005). The Chesapeake Bay watershed covers over 64,000 square miles and is home to 18 million people. It encompasses parts of six states (Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia) and the District of Columbia, and contains 11,684 miles of shoreline (CBP 2012).

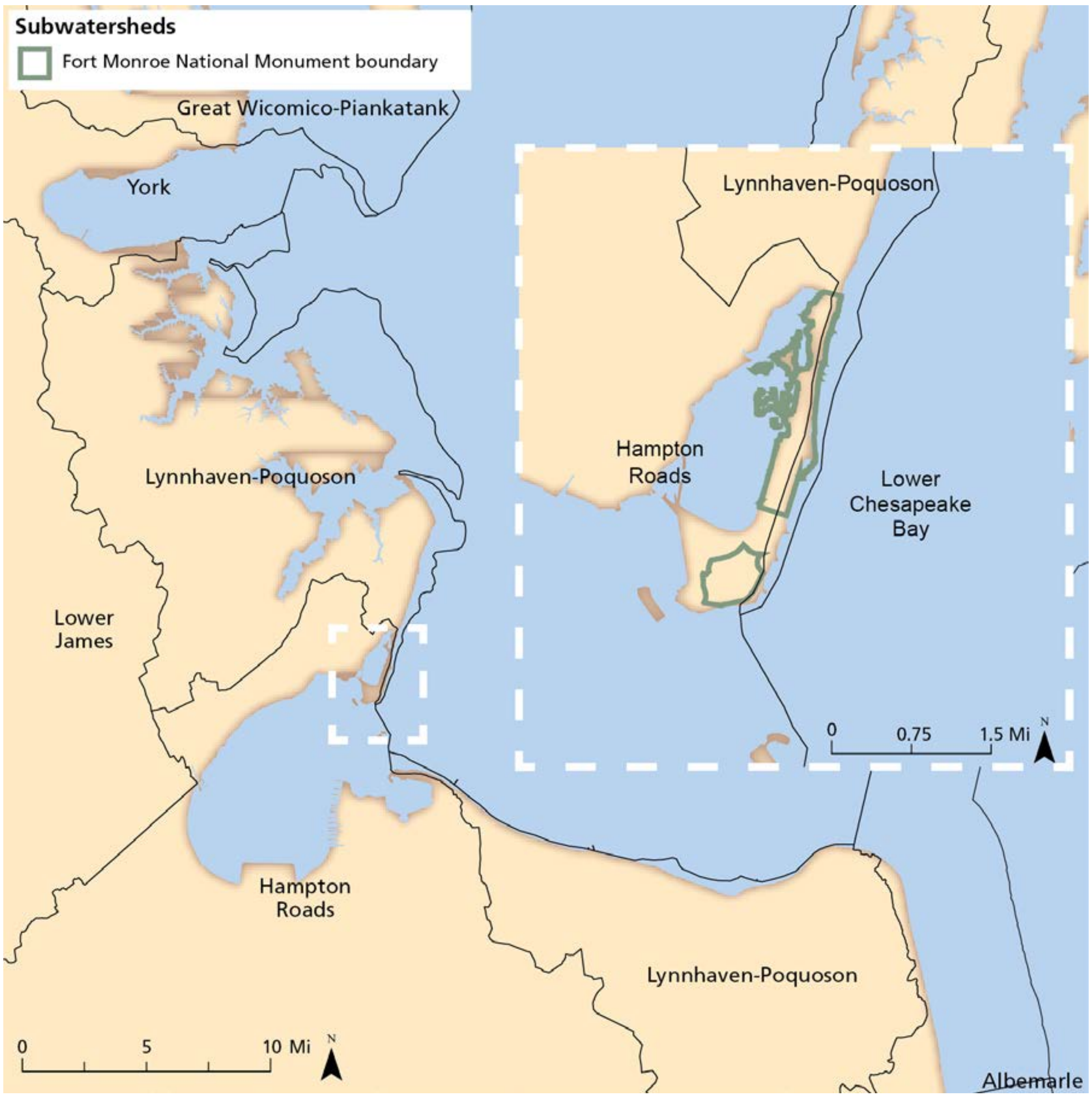


Figure 2-9. Subwatersheds within the region of Fort Monroe National Monument (Source: National Hydrography Dataset).

The James River watershed includes an area of just over 10,000 square miles, located almost entirely within the Commonwealth of Virginia. Land use within the James River watershed includeds forest (71%), agriculture (7%), urban areas (5%), open water (4%), and wetlands (3%) (Commonwealth of Virginia 2005). The majority of urban areas within the James River watershed are located in the eastern portion of the state. The Lynnhaven-Poquoson and Hampton Roads watersheds are smaller subcoastal basins located within the much larger James River watershed (Figure 2-9). Most of the park is located within the Hampton Roads watershed, but the eastern shore of the peninsula is located in the Lynnhaven-Poquoson watershed. The Lynnhaven-Poquoson watershed covers 64 square miles. The majority of its 150 miles of shoreline are privately owned, and the watershed contains 4,478 waterfront homes (Hampton Roads PDC 2012). The Hampton Roads watershed is twice as large as the Lynnhaven-Poquoson. The Hampton Roads region is home to over 1.5 million people and is among the top 40 largest metropolitan statistical areas in the country (U.S. Census Bureau 2015). The individuals in this area are particularly dependent on the waters of the Chesapeake Bay for commerce and military activities (Hampton Roads PDC 2012).

Geology and Topography

Fort Monroe National Monument is located on the southeast end of the Virginia Peninsula. The peninsula is part of the Atlantic Coastal Plain and contains sediment from the Early Cretaceous period, the Late Cretaceous period, the Tertiary period, and the Quaternary period. These sediment deposits resulted in the creation of a wedge of thickening sediments that extends from the Piedmont to the continental shelf and is composed of a thick layer of non-marine deposits covered by a thinner layer of marine deposits (SAIC 2012). This sediment wedge extends across Fort Monroe National Monument and for almost 65 miles off the shore of Virginia (Meng and Harsh 1988). The comet asteroid impact zone associated with the creation of the Chesapeake Bay is located at the edge of Fort Monroe National Monument and affects the regional groundwater flow patterns and chemistry (SAIC 2012). Old Point Comfort itself is comprised primarily of beach sand and unconsolidated material (Figure 2-10).

Geological processes created a wide, sandy beach at Fort Monroe National Monument (Photo credit: Todd Lookingbill, University of Richmond).

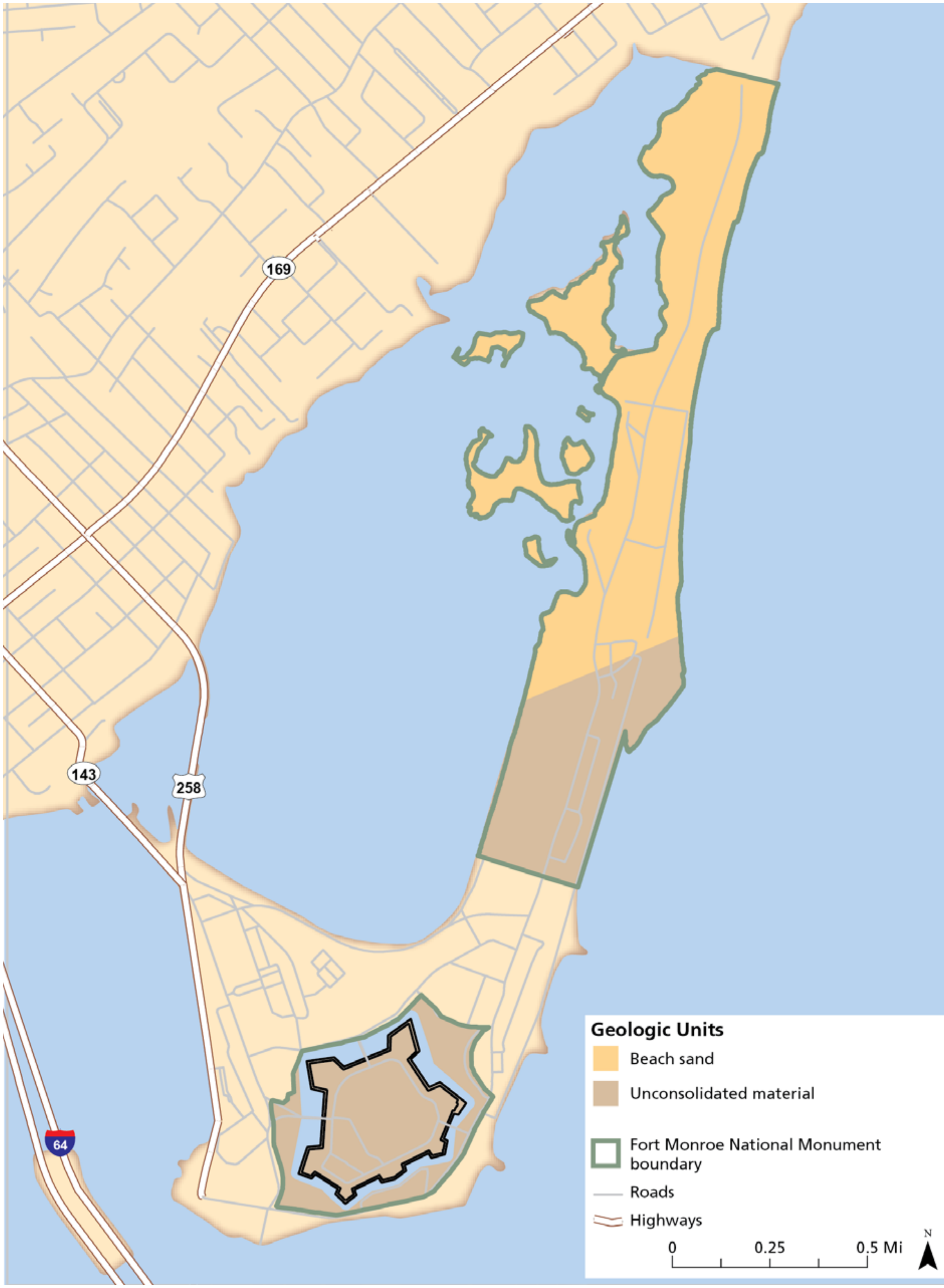


Figure 2-10. Geologic units within Fort Monroe National Monument (Source: USGS Mineral Resources 2016).

Marine erosion and deposition that occurred throughout this area's geological history created a wide, sandy beach at the barrier spit of Fort Monroe National Monument. This barrier spit contains deposits of quaternary sand. Granite basement rock, located at 2,246 feet beneath the land surface, underlays the majority of Fort Monroe National Monument. Owing to this underlying geology, the topography of Fort Monroe National Monument is generally flat and only rises 14 feet above mean sea level across Old Point Comfort (SAIC 2012) (Figure 2-11).

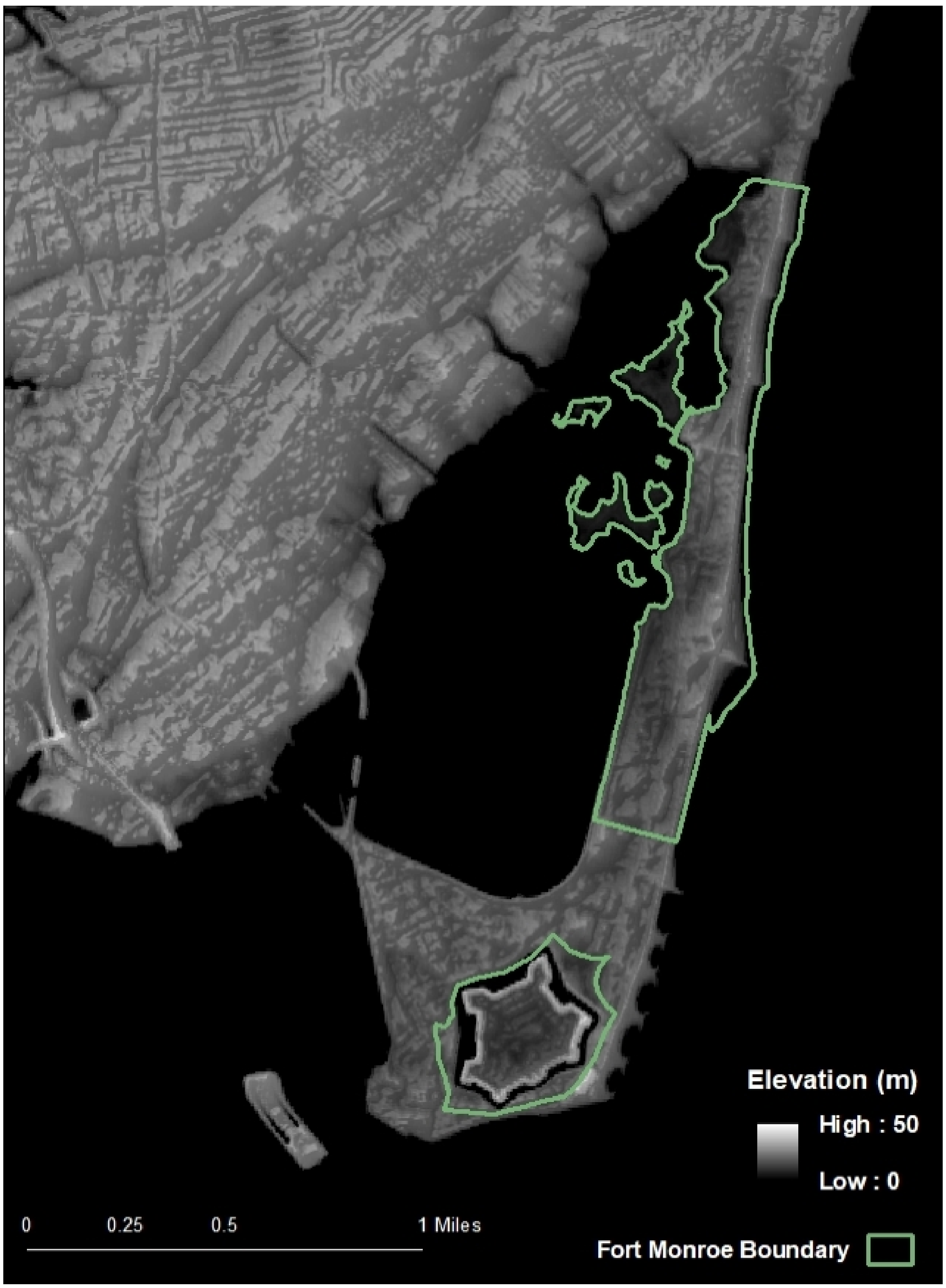


Figure 2-11. Topography of Fort Monroe National Monument (Source: National Elevation Dataset 2016).

Soils

According to the Soil Survey Geographic (SSURGO) online database, five types of soil underlay the park: Seabrook-Urban land complex (65.7%), Udorthents-Dumps complex (14.9%), Bohicket muck (10.8%), Lawnes loam (4.4%), and beaches (3.9%) (Figure 2-12). The Seabrook-Urban land complex is characterized by sandy alluvial sediments and consists of fine sand. It is generally located in cultivated areas. The Udorthents-Dumps complex is composed of disturbed soil or fill. Bohicket muck contains loamy and clayey alluvial sediments that are characterized by soil that is not very permeable and formed in marine sediments in tidal marshes. These soils are flooded frequently by seawater. Lawnes loam contains herbaceous organic materials over loamy alluvial sediment and is very poorly drained. Beaches contain sandy marine deposits (USDA 1995). The soil present at Fort Monroe National Monument was produced by water-transported parent material. Many of the geological features that are present are a result of the alluvial material and marine sediments that were transported to Fort Monroe National Monument by twice-daily tides (SAIC 2012).

Figure 2-12. Soil types present within Fort Monroe National Monument (Source: Natural Resources Conservation Service 2016).

Surface Waters

Three main sources of surface water influence the park (Figure 2-13). The moat surrounding the fort has a water surface area of 19 acres (US Army Corps of Engineers 2003). The tidal basins of Mill Creek abut the park along 17,000 feet of shoreline. The 16,000 feet of shoreline adjacent to the Chesapeake Bay and Hampton Roads Harbor add a significant amount of additional contact with surface water (SAIC 2012). The majority of the water exchange at Fort Monroe National Monument is between the Fort Monroe moat and Mill Creek via tides (US Army Corps of Engineers 2003).

The moat at Fort Monroe (Photo credit: Todd Lookingbill, University of Richmond).

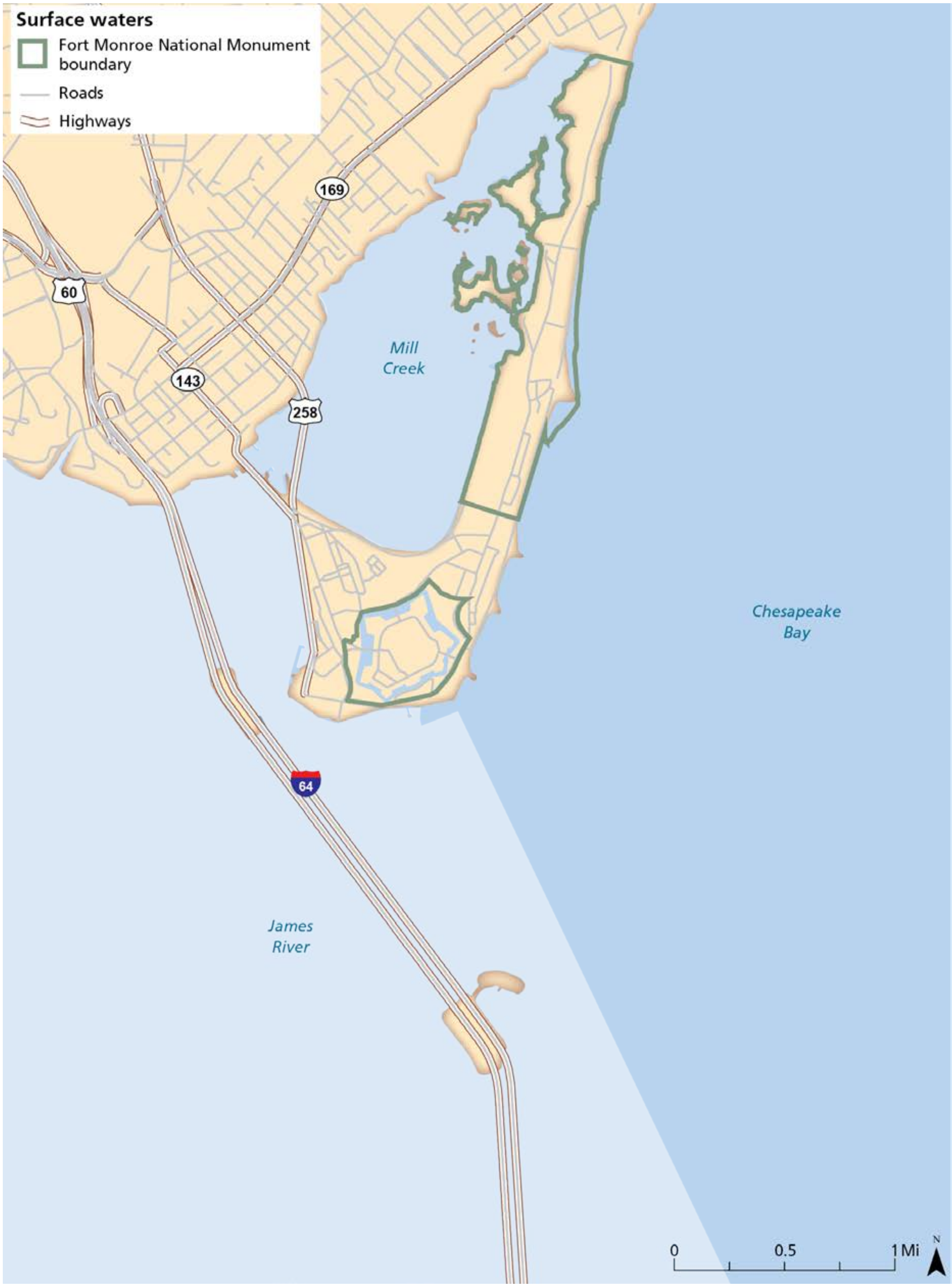


Figure 2-13. Surface water bodies surrounding Fort Monroe National Monument (Source: National Hydrography Dataset 2016).

Groundwater
Several aquifers underlie the park, including the water table aquifer (10 to 20 feet below the surface), the Yorktown aquifer (40 to 50 feet below the surface), the Eocene-Upper Cretaceous aquifer (320 to 440 feet below the surface), and the Lower Cretaceous aquifer (570 to 630 feet below the surface) (SAIC 2012). All of the groundwater is significantly affected by the tides (Waller Associates, Inc. 2005). None are potable owing to the salinity of the Chesapeake Bay and Hampton Roads Harbor ranging between 14 to 20.5 ppt at Sewells Point station approximately 5 miles south of Mill Creek at Naval Station Norfolk. This surface water salinity influences groundwater sodium concentrations ranging from 42.5 to 264 ppm (SAIC 2008). Water with sodium concentrations above 100 ppm is not typically suitable for potable water, industrial use, or agricultural purposes (Alth 1992).

2.3.2. Resource Description

Flora
As of 1998, Fort Monroe National Monument was home to 249 plant species including 136 native species and 113 introduced species (Galvez et al. 1998). Common grass species include Bermuda grass (*Cynodon dactylon*), and fescues (*Festuca* sp.). Common tree and shrub species include black cherry (*Prunus serotina*), American sycamore (*Platanus occidentalis*), pin oak (*Quercus palustris*), southern live oak (*Quercus virginiana*), eastern red cedar (*Juniperus virginiana*), Norway spruce (*Picea abies*), loblolly pine (*Pinus taeda*), longleaf pine (*Pinus palustris*), and crepe myrtle (*Lagerstroemia* sp.), among others (US Army Corps of Engineers & Fort Monroe 2005). A list of plant species at Fort Monroe National Monument can be found in Galvez et al. (1998), including an assessment of plant status (common, rare, occasionally present, and intentionally planted).

Over 130 southern live oaks grow within the interior of Fort Monroe. One of these trees is the Algernourne Oak, a 450-plus-year-old southern live oak with a basal diameter of 90 inches and a height of over 60 feet (Dosmann and Aiello 2013). Several small wooded areas, some of them holding southern live oaks, are also located in the northern portion of the park (Figure 2-14).

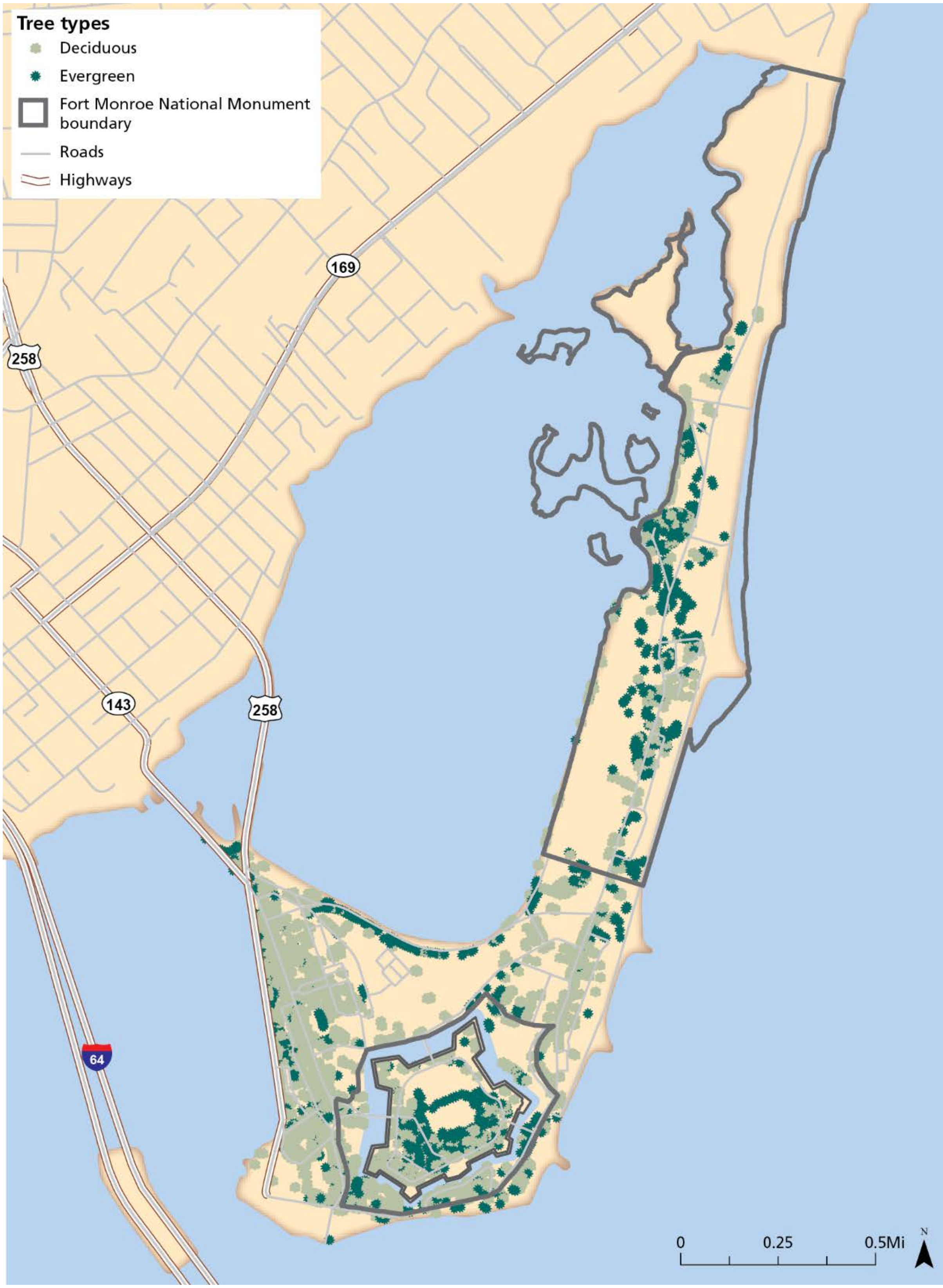


Figure 2-14. Individual trees within Fort Monroe National Monument (Source: U.S. Fish and Wildlife Service 2005).

The southern live oaks at Fort Monroe National Monument are located within the northern limits of their natural range (Photo credit: Todd Lookingbill, University of Richmond).

Wetlands

Eighty acres of wetlands are located within the boundaries of Fort Monroe National Monument and represent an important habitat of the park, filtering water, protecting the shoreline from erosion, and providing valuable habitat for aquatic and terrestrial species (US Army Corps of Engineers 2009). The majority of these wetlands (~85%) are located in Mill Creek (Tiner et al. 1998) and are classified as emergent estuarine wetland, which is the most common type of wetland in the United States (Tiner 1999). This salt marsh is dominated by salt-marsh cord grass (*Spartina alterniflora*), but also includes groundsel bush (*Baccharis halmifolia*), marsh elder (*Iva frutescens*), giant cordgrass (*Spartina cynosuroides*), saltmeadow hay (*Spartina patens*), and saltgrass (*Distichlis spicata*) (REMSA 2004; US Army Corps of Engineers 2009).

Wetlands provide important habitat within Fort Monroe National Monument (Photo credit: Amanda Babson, National Park Service).

Fauna

Terrestrial fauna observed within Fort Monroe National Monument include 29 species of squirrels, rabbits, rats, mice, muskrats, otters, opossums, raccoons, and other mammals. At least 30 species of waterfowl also visit the area as part of their migration route in the winter, including ducks, gulls, geese, and swans. Wading birds, such as the great blue heron (*Ardea herodias*), sanderling (*Calidris alba*) and sandpipers (*Scolopacidae*), are commonly sighted in and around Fort Monroe National Monument. Large birds of prey, such as osprey (*Pandion haliaetus*) and bald eagles (*Haliaeetus leucocephalus*), can also be sighted. The eastern brown pelican (*Pelecanus occidentalis carolinensis*) is also frequently sighted after populations rebounded from pesticide poisoning in the late 1950s and early 60s.

Fish species commonly observed in the waters surrounding the park include tautog (*Tautoga onitis*), flounder (*Pleuronectidae*), rockfish (*Sebastes*), spot (*Leiostomus xanthurus*), trout (*Salmoninae*), Atlantic croaker (*Micropogonias undulatus*), and cobia (*Rachycentron canadum*) (US Army Corps of Engineers & Fort Monroe 2005). Mill Creek is considered an important area for the nursing and development of anadromous fish offspring. The park is not rich in amphibians and reptiles because of its fragmentation and overall lack of large habitat patches for these species.

Rare, threatened, and endangered species

Several species within Fort Monroe National Monument are protected either on the federal or state level. These species reside in the park all year, migrate through, or live in the waters surrounding the park. The shortnose sturgeon (*Acipenser brevirostrum*) is federally endangered and three species of turtles – the threatened loggerhead sea turtle (*Caretta caretta*), the endangered leatherback sea turtle (*Dermochelys coriacea*), and the endangered Kemp’s ridley sea turtle (*Lepidochelys kempii*) – all reside in the waters surrounding Fort Monroe National Monument but do not breed on the peninsula (USAEC & Fort Monroe 2005).

Several species are also considered threatened by the Commonwealth of Virginia. These species include the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), and gull-billed tern (*Gelochelidon nilotica*) (US Army Corps of Engineers 2010). The piping plover (*Charadrius melodus*) is both federally and state threatened and uses areas in and around Fort Monroe National Monument to nest. The great egret (*Ardea alba*), the yellow-crowned night heron (*Nyctanassa violacea*), and the least tern (*Sterna antillarum*) have also been spotted at Fort Monroe National Monument and have received special concern status by the Virginia Department of Conservation and Recreation (USAEC & Fort Monroe 2005).

2.3.3. Resource Issues Overview

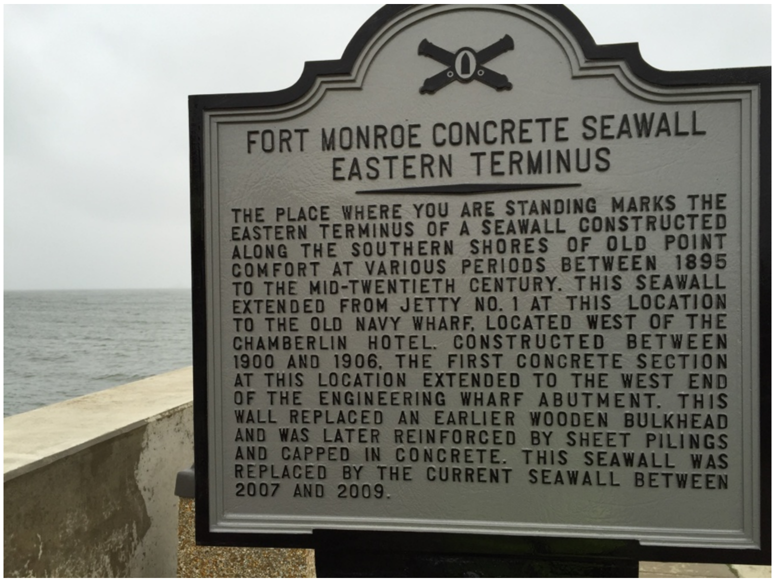
Fort Monroe National Monument has had a long, complex history of human use, which has caused numerous modifications to the land. The integrity of the site is also tied to its setting within the rapidly urbanizing Hampton Roads region. Underlying all of these anthropogenic influences are the natural resource attributes and stressors associated with being located on a barrier spit within the Chesapeake Bay ecosystem.

Development

Urban growth and development within and surrounding the park are major influences on park natural resources. Regional development threatens the quality of air, water, soundscapes, viewsheds, and night skies. The lack of dark night skies has ecological impacts on wildlife habitat quality, species interactions, and migration patterns. Park soundscapes have also been highly degraded in parks throughout the US owing to development outside park boundaries (Miller 2008). In addition to their wildlife impacts, both light and noise pollution can distract visitors from their appreciation of the park's natural resources and the purpose of its cultural areas—the tranquility of historic settings and the solemnity of memorials, ruins, and sacred sites.

Human modifications of the natural landscape within the park include the fort, moat, and housing and other structures created by the Army, especially in the southern portion of the park. The northern section of the park has been augmented with artificial fill, an airstrip, buildings, and an RV park. A seawall extends along a large portion of the eastern boundary with the Chesapeake Bay. The southern portion of the Mill Creek waterfront has been hardened with concrete caps (Beard et al. 2009). Advocates for economic growth on the peninsula have called for an increase in development along the shoreline and beachfront. Mill Creek has also become a popular location for powerboat racing and competitive sailing. Other potential stressors to park waters include boat traffic from the marina on Old Point Comfort and runoff from neighboring residential communities.

The significant cultural resources contained within the park provide an important backdrop to the management of natural resources at the site. Fort Monroe National Monument has been described as one large archeological site with more than 24 individually identified locations of interest (NPS 2015a). Along with the well-documented military history of the peninsula, substantial evidence of Native American settlements exists (NPS 2015a). Environmental revitalization of the resources, such as beach and salt marsh area, must account for the preservation of these cultural and historical sites of interest. Similarly, any archeological excavation of the historical artifacts found on the property could potentially impact the park's natural resources.



Human modifications, such as sea walls and hardened shorelines, are prevalent throughout Fort Monroe National Monument (Photo credit: Amanda Babson, NPS).

Landfill

From the 1930s to the mid-1950s, approximately 27 acres of the Dog Beach area of Fort Monroe National Monument were used as a landfill, receiving construction debris, trash, solid waste, and incinerator ash. A nearby incinerator, which operated into the 1960s, is also believed to have dumped ash within the southern boundary of Dog Beach Landfill (SAIC 2012). Since the dump lacked a seal, carcinogens, toxic metals, and other toxic compounds are prevalent in the soil, groundwater, and flora (SAIC 2012). The risk to humans is relatively low due to the passage of time and sedimentation on top of the landfill site, but includes pesticides and carcinogens in the soil, chromium and polychlorinated biphenyls in groundwater, and contamination of aquatic organisms that humans consume. A biological assessment of the site suggests that otters, shrews, and kestrels may have been most affected by toxins (SAIC 2012). Though currently capped, increased precipitation, storm surge, and sea-level rise could mobilize contaminates into the Chesapeake Bay and Mill Creek ecosystems.

Climate Change

As global warming is likely to directly affect Fort Monroe National Monument, which is surrounded by water on nearly all sides by the James River, Mill Creek, and Chesapeake Bay. In recorded history, less than ten tropical depressions, tropical storms, and subtropical storms have struck within ten miles of the park. None of the recorded storms since 1841 have made landfall at the fort with hurricane intensity. The number and severity of storms in the Northern Atlantic, however, has increased in the last century and is expected to continue to increase (Bender et al. 2010). Unsheltered areas, like the sand bars and Mill Creek, are considered highly susceptible to increased storm surges (Caffrey 2012). Increased storm activity can directly alter habitat structure and the succession of plant communities (Michener et al. 1997) (Figure 2-15).

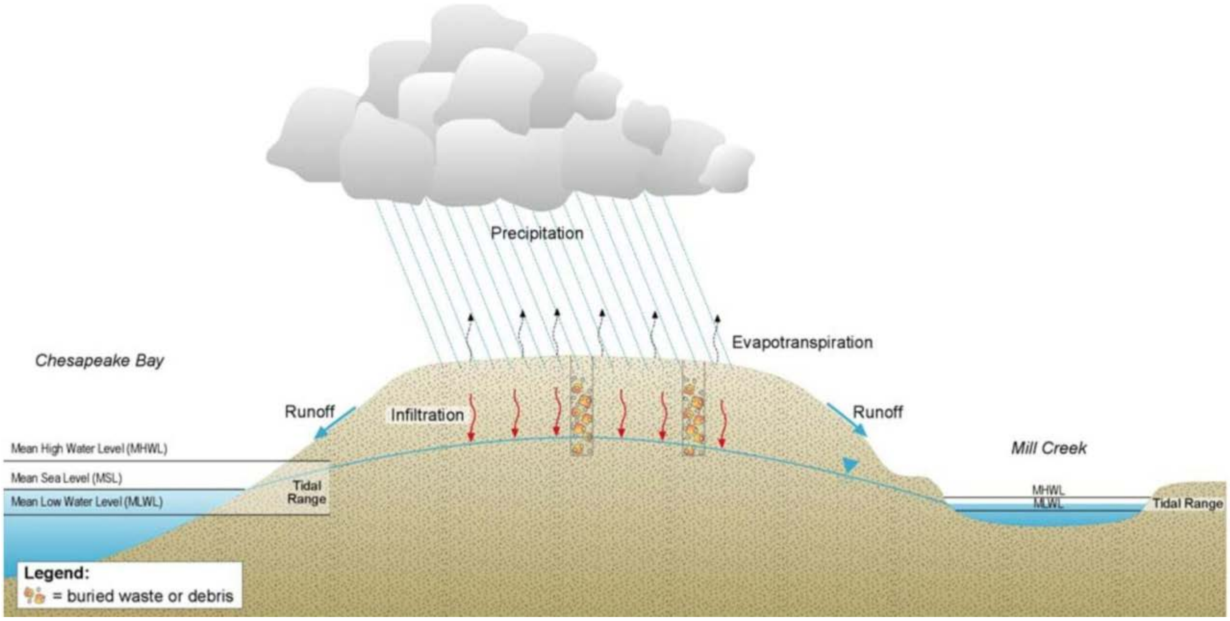


Figure 2-15. Conceptual diagram of climate change consequences at Fort Monroe National Monument (Source: SAIC 2000).

Sea level rise will likely exacerbate the effects of increased storm frequency and intensity. In the last century, average sea level on park properties has risen 14 inches, and is expected to increase an additional 7 inches by 2030 (Caffrey 2012). Rising sea level particularly affects the salt marsh, flora and fauna next to Mill Creek, and the beach. The increase in sea level results in greater storm surge heights, leading to shoreline erosion and loss of habitat, infrastructure, and archaeological and cultural sites. A sea wall runs along nearly 75% of the bayfront, and the southern Mill Creek waterfront is hardened with concrete caps (Beard et al. 2009). Thus, the natural movement of shoreline that occurs with other barrier island landforms has been largely absent from Fort Monroe National Monument for many years.

Combined with increased erosion (Francese 2011), elevated sea levels can lead to greater saltwater intrusion affecting groundwater salinity and the flora and fauna that depend on low salinity for habitat or reproduction. If sea level increases to the point where the ocean water begins to intrude into Mill Creek, vegetation and aquatic life that thrive in lower salinity environments may be at risk. Loss of salt marsh, ephemeral sand bars, and coastal vegetation may result. Resident wildlife of Fort Monroe National Monument could be particularly impacted if they are unable to migrate off Old Point Comfort as habitat becomes unsuitable (SAIC 2012). The park is already challenged to nurture healthy amphibian and reptile populations because of its limited habitat and restrictions to species movements caused by development (Galvez et al. 1998).

While annual rainfall totals have increased regionally over the past decade, they have decreased slightly for the 50-km^2 area including Fort Monroe National Monument (Gonzalez 2012). Future projections for Fort Monroe call for very little change in precipitation (Gonzalez 2012). In contrast, warming temperatures will bring significant impacts. Between 1901 and 2002, average temperature at Fort Monroe increased 1^{o}C, and the rate of increase in temperature is projected to accelerate by three to five times over the next century (Gonzalez 2012).

Invasive Species

The biological invasion of non-native plants, animals, and pathogens represents another threat to the natural heritage of national parks. The number of non-native species in national parks has been correlated with the number of visitors (Allen et al. 2009). Positive correlations have also been documented between climate change and the invasions of national parks in the eastern US (Fisichelli et al. 2014). Approximately 70% of documented invasive species on park lands are plants, however non-native, invasive aquatic wildlife also represent a significant threat to fish diversity in national parks (Lawrence et al. 2011).

According to a 1998 biological inventory, only 55% of the 249 plant species found at Fort Monroe National Monument were native (Galvez et al. 1998). In total, 113 different exotic plant species were found in the park, including red lovegrass (*Eragrostis secundiflora*) and the common reed (*Phragmites australis*). These two species, in particular, are of concern to the park’s dune and wetland ecosystems, respectively. These plants and other invaders have the ability to outcompete native species, damage infrastructure, and compromise viewsheds. Although introduced plants pose a significant threat to the native species of Old Point Comfort, eradication is difficult because landscaping around human structures often uses plants from non-native environments.

2.4. Resource Stewardship

2.4.1. Management Directives and Planning Guidance

Because Fort Monroe National Monument was established in 2011, few natural resource monitoring programs are currently in place. Most park planning directives to date have been centered around the park’s historic and cultural value. With limited ecological data collection protocols in place, the park is in the beginning stages of assessing its resources and developing appropriate management plans for those resources.

In creating the 2015 foundation document, park staff worked with regional NPS staff to develop a list of fundamental resources and values (NPS 2015a). Each resource was evaluated for its overall significance to the park, viable opportunities presented by the resource, and any possible threats. Major natural resources identified include the Old Point Comfort shoreline and maritime sights and sounds in the Hampton Roads Harbor and Mill Creek. The importance of these natural assets is described through the benefits they provide to visitors. Views of the ocean from Old Point Comfort and the vista from Fort Monroe overlooking the northern side of Old Point Comfort are recognized as significant historical resources. Mill Creek’s shore is considered an indigenous cultural landscape. The beach areas provide valued recreational outlets.

Future directives include assessing the impact of rising sea level on all cultural and natural resources; working with scientists and arborists to study the southern live oaks on the property including the Algernourne Oak; partnering with conservation groups to inventory and monitor other natural elements of the park; and expanding educational initiatives about climate change to become certified as a Climate Friendly Park (NPS 2015a). The US Army is responsible for mitigating environmental damage from decades of Army activities. These mitigation efforts provide a backdrop to any future environmental management actions at the site.

2.4.2. Status of Supporting Science

The NPS Inventory and Monitoring (I&M) Program was established in 1998 to observe natural resources within 270 parks aggregated into 32 ecoregional networks throughout the country (Fancy et al. 2008). Fort Monroe National Monument falls geographically into the Northeast Coastal and Barrier Network (NCBN), a region stretching from Virginia to Massachusetts. Network staff catalogue data, perform data analysis, synthesis, and monitoring, and advise park planners on how to best protect resources.

The NPS I&M Program has designated 12 core inventories that detail the conditions of water, landforms, climate, wildlife distribution, and other park resources. Through continued 'Vital Signs Monitoring', regional staff then track physical, chemical, and biological processes of park ecosystems that represent overall park health. The NCBN tracks 18 Vital Sign indicators that have been divided into five categories: estuarine eutrophication, salt marsh change, geomorphic change, visitor use and impact, and landscape change (Stevens et al. 2005). At this time, Fort Monroe National Monument is not one of the eight parks in the NCBN at which these monitoring protocols are implemented.

No current plans are in place to initiate a regular natural resources monitoring program at Fort Monroe National Monument. Without long-term monitoring to track natural resource conditions, Fort Monroe National Monument lacks information that could potentially benefit the park in its management decision-making process.

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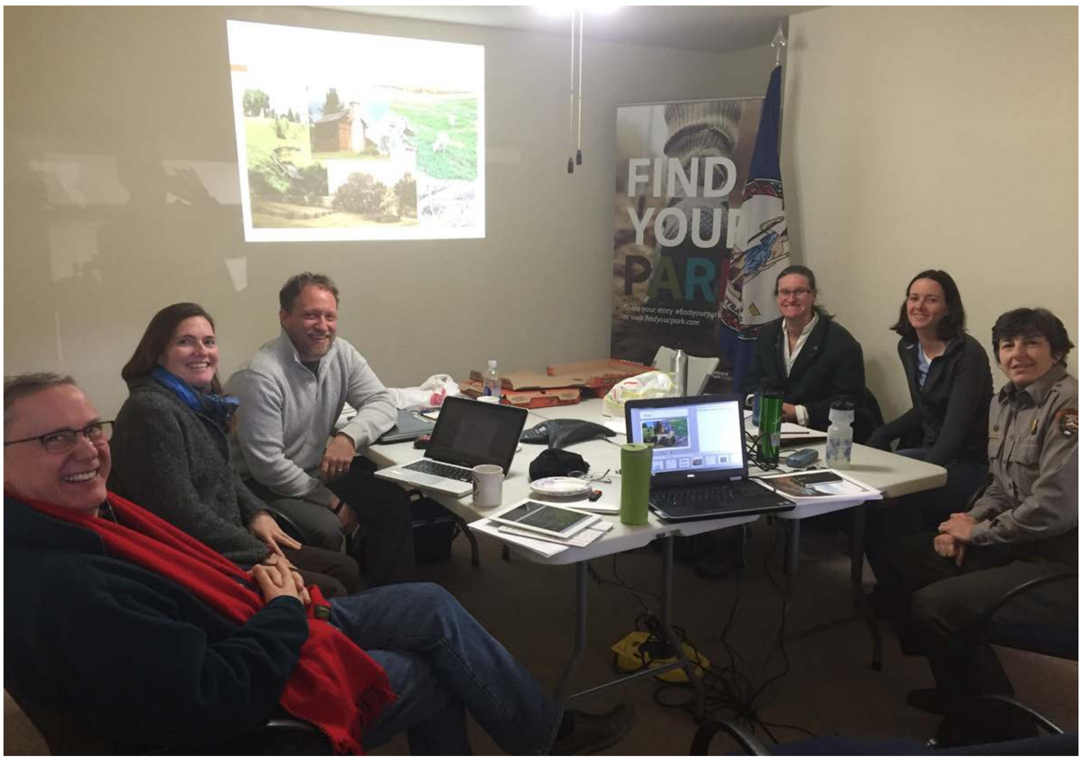
3. Study Scoping and Design

3.1. Preliminary Scoping

Preliminary scoping of the Fort Monroe National Monument Natural Resource Condition Assessment (NRCA) began in January 2016 with a meeting of park staff, Northeast Region National Park Service (NPS) personnel, and ecologists with expertise on the area. At the meeting, the historical background and geographic layout of the park were discussed, along with its natural and cultural resources, stressors to those resources, and current and future management goals. A preliminary list of all of the park's natural resources was made to provide a starting point for determining what indicators would be studied in the NRCA.



Participants at the initial scoping meeting at Fort Monroe National Monument in January 2016 (Photo credit: Todd Lookingbill, University of Richmond).

After the kickoff meeting, collection of data and background information on the park began. Data for park resources were organized into an electronic library primarily comprised of management reports, data files, geospatial data (GIS), and aerial imagery. Much of the data and information was obtained from different branches of the NPS, including the Northeast Coastal and Barrier Network Inventory and Monitoring (NPS I&M) Program, the Air Resources Division, and the park itself. Other important sources of data included the Fort Monroe Authority (FMA), the United States Army Corps of Engineers (USACE), the US Fish and Wildlife Service (USFWS), the City of Hampton, Virginia, the Boy Scouts of America, and the National Oceanic and Atmospheric Administration (NOAA).

Additional expertise was provided by local experts who have worked in the park and surrounding area.

The data and information collected after the initial meeting informed the selection of the final suite of natural resource indicators. These indicators were finalized at a meeting in March 2016, although data collection continued during and after this time. Discussion with park personnel and the NPS I&M program were important in deciding on the indicators and reference conditions to be used. Efforts were made to integrate indicators from the NPS I&M Vital Signs framework into this assessment when possible. Collaboration with park and regional natural resource staff was essential to the success of this assessment.

3.2. Study Design

3.2.1. Indicator Framework, Focal Study Resources and Indicators

Indicators form the basis of this condition assessment. The NPS I&M Program has previously developed a number of ecological monitoring indicators grouped as "Vital Signs" to represent key physical, chemical, and biological elements and processes of park ecosystems that are representative of the overall health or condition of park resources. The I&M Vital Sign categories are:

1) Air and Climate
2) Water
3) Biological Integrity
4) Landscapes
5) Human Use
6) Geology and Soil

For the purpose of determining natural resource condition in Fort Monroe National Monument, the first four of these categories were used, though general features of "human use" and "geology and soil" are discussed throughout the report. For each category, three or four specific indicators were evaluated as part of the assessment.

Detailed information on indicator relevance, metrics used, methods, reference condition, current condition, and trend are provided for each indicator in Chapter 4. Each indicator section also contains an assessment of data gaps and the level of confidence of the assessment for that indicator, which is given as a qualitative rating (i.e., high, moderate, low) based on best professional judgment. Indicators were not treated differently in the final park assessment based on differences in their confidence ratings, but this information on confidence may be useful for interpretation of the results and for prioritizing future data needs.

3.2.2. Reporting Areas

The focus of the reporting area for the NRCA was the Fort Monroe National Monument presidential boundary. This boundary includes two separate sections as delineated in the Foundation Document (NPS 2015): the Fort district and the North Beach district (Figure 3-1).

Figure 3-1. Map of Fort Monroe National Monument showing separate districts (Source: NPS 2015).

For some of the indicators, no distinction in data reporting and assessment was made between the two districts. However, for several indicators, reporting was conducted separately for each district, and many focused solely on one district or the other. All data used for the final assessment of park condition were collected from within the park, with the exception of air quality data, which were taken from the closest air monitoring stations.

3.2.3. General Approach and Methods

A total of 16 indicators and 27 metrics were reviewed in this assessment (Table 3-1). The approach for assessing resource condition within the park required establishment of a reference condition for each metric. In ideal situations, reference conditions were derived from scientific literature. However, where there was not sufficient data available to use peer-reviewed reference conditions, thresholds were determined based on best professional judgment in cooperation with park staff. More detailed information about reference conditions and the confidence in condition assessments for each indicator can be found in the "Reference Condition" and "Data Gaps and Confidence" sections in Chapter 4.

Table 3-1. Summary of indicators and metrics evaluated for Fort Monroe National Monument.

Resource Category	Indicator of Concern	Specific Measure
Air	Wet Nitrogen Deposition	Deposition Rate
	Wet Sulfur Deposition	Deposition Rate
	Visibility	Haze Index
	Ozone	Air Quality Index
Water	Chesapeake Bay Water Quality	Chlorophyll α
	Chesapeake Bay Water Quality	Dissolved Oxygen
	Chesapeake Bay Water Quality	Water Clarity
	Chesapeake Bay Water Quality	Nitrogen
	Chesapeake Bay Water Quality	Phosphorus
	Mill Creek Water Quality	Metals in Surface Water
	Moat Water Quality	Metals in Surface Water
	Moat Water Quality	Metals in Sediments
	Moat Water Quality	Benthic Macroinvertebrates
	Beaches	*Enterococci* Colonies
Biota	Southern Live Oaks	Crown Health
	Southern Live Oaks	Seedling Recruitment & Survival
	Southern Live Oaks	Population Size
	Salt Marsh	Areal Extent
	Invasive Species	*Phragmites*

Table 3-1 (continued). Summary of indicators and metrics evaluated for Fort Monroe National Monument.

Resource Category	Indicator of Concern	Specific Measure
Biota (continued)	Invasive Species	Proportion of Nonnative Species
	Birds	Number of Species
Landscape	Hardened Shorelines	Length of Stable Shoreline
	Hardened Shorelines	Length of Hardened Shoreline
	Viewshed	Percent Undeveloped
	Impervious Surfaces	Percent Impervious Surfaces
	Dune Geomorphology	Span of Dune Vegetation

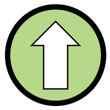
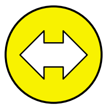
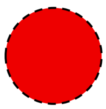
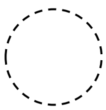
The methods used to calculate metric scores varied between indicators. These methods are described in detail in the "Data and Methods" sections of Chapter 4. Where more than one metric was used for an indicator, the mean of the metric scores was taken as the overall indicator score. Similarly, the individual indicator scores were averaged to determine the overall condition score for each Vital Sign category, and then for the park itself. Metric, indicator, and overall condition scores are presented in Chapter 4 and Chapter 5.

Metrics were assigned a qualitative rating corresponding to the quantitative score based on recommended NPS guidance (Table 3-2, Table 3-3): Significant concern (0-33% reference condition attainment), Moderate concern (34-66% reference condition attainment), and Good condition (67-100% reference condition attainment). Key findings and recommendations were summarized for each Vital Sign category in Chapter 5.

Table 3-2. Indicator symbols used to indicate condition, trend, and confidence in the assessment.

Condition Status		Trend in Condition		Confidence in Assessment	
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

Table 3-3. Example indicator symbols and descriptions.

Symbol Example	Description of Symbol
	Resource is in good condition; its condition is improving; high confidence in the assessment.
	Condition of resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.
	Condition of resource warrants significant concern; trend in condition is unknown or not applicable; low confidence in the assessment.
	Current condition is unknown or indeterminate due to inadequate data, lack of reference value(s) for comparative purposes, and/or insufficient expert knowledge to reach a more specific condition determination; trend in condition is unknown or not applicable; low confidence in the assessment.

3.3. Literature Cited

National Park Service. 2015. Foundation document: Fort Monroe National Monument. U.S. Department of the Interior. July 2015.

4. Natural Resource Conditions

4.1. Air Resources

Fort Monroe National Monument is located near and downwind from major industrial and urban areas. As amended in 1977 in the Clean Air Act, the US Congress set a national goal of preventing any future and remedying current impairment of visibility in any Class I federal areas where that impairment is caused by manmade pollution. Although Fort Monroe National Monument is not a Class I park, the National Park Service still seeks to protect and improve air quality conditions within the park. Despite improvements in air quality under the Clean Air Act over the past few decades, Fort Monroe National Monument's visibility and air resources are still degraded relative to estimated natural or pre-industrial background conditions.

Four indicators were used to assess air quality within Fort Monroe National Monument: wet sulfur deposition, wet nitrogen deposition, visibility, and ground level ozone (4th highest 8-hour concentration and maximum 3-month 12-hour W126). Data used for this assessment were provided by the National Park Service Air Resource Division collated from a variety of national programs (Table 4-1).

Table 4-1. Indicators and sources of data used in assessment of air quality resources within Fort Monroe National Monument.

Indicator	Agency	Site	Source
Sulfur & Nitrogen Deposition	NADP/NTN	Fort Monroe National Monument; Assateague Island National Seashore	http://nadp.sws.uiuc.edu
Visibility	NPS Air Resource Division	Fort Monroe National Monument; Assateague Island National Seashore	https://nature.nps.gov/air/maps/airatlas
Ozone	EPA CASTNET	Fort Monroe National Monument; Assateague Island National Seashore	http://epa.gov/castnet/javaweb/index.html

Air quality data were compared to reference condition values sourced from the National Park Service Natural Resource Program Center – Air Resource Division (Taylor 2017). Current conditions were determined by comparing the latest five years of data available for each indicator to reference conditions to obtain a percent attainment of reference conditions (Table 4-2). Because data were not available for Fort Monroe before 2010, trend was assessed using data for the following nearby park, which had a longer data record:

- Assateague Island National Seashore: Located approximately 100 miles from Fort Monroe National Monument, the two coastal parks are located in the same geographic context. Data are available from this park dating back to 2005.

Table 4-2. Air quality reference conditions used to assess air resource condition of Fort Monroe National Monument.

Air quality indicator	Number of sites	Period of observation	Reference conditions	Percent attainment applied
Wet sulfur deposition (kg/ha/yr)	1	2011-2015	< 1; 1-3; > 3	< 1 = 100% 1-3 = 0-100% scaled linearly > 3 = 0%
Visibility (dv)	1	2011-2015	<2; 2-8; > 8	<2 = 100% 2-8= 0-100% scaled linearly > 8 = 0%
Wet nitrogen deposition (kg/ha/yr)	1	2011-2015	< 1; 1-3; > 3	<1 = 100% 1-3 = 0-100% scaled linearly >3 = 0%
Ozone (ppb)	1	2011-2015	< 60; 60-70; >70	< 60 = 100% 60-70= 0-100% scaled linearly >70 = 0%
Ozone (W126; ppm-hrs)	1	2011-2015	< 7; 7-13; >13	< 7 = 100% 7-13= 0-100% scaled linearly >13 = 0%

4.1.1. Wet Sulfur Deposition

Relevance and Context

Sulfate emissions in the US have changed significantly within the last century (Figure 4-1). With an increase of 19.8 million short tons between 1900 and 1978, the majority of sulfates originated from the generation of electricity. The Clean Air Acts of 1970 and 1990 have contributed to the more recent decline in sulfates (Driscoll et al. 2001). By 1998, sulfates in the US decreased to 17.8 million metric tons from a high of 28.8 million metric tons (Driscoll et al. 2001, NADP/NTN). Sulfur dioxide emissions at plants affected by Phase 1 of Title IV of the Clean Air Act Amendments of 1990 decreased by 38% from 1995 to 1997 when compared to 1993-1994. Wet sulfate deposition decreased an average of 2.4-4.0 kg/ha/yr in a large portion of the eastern US (Lynch et al. 2000).

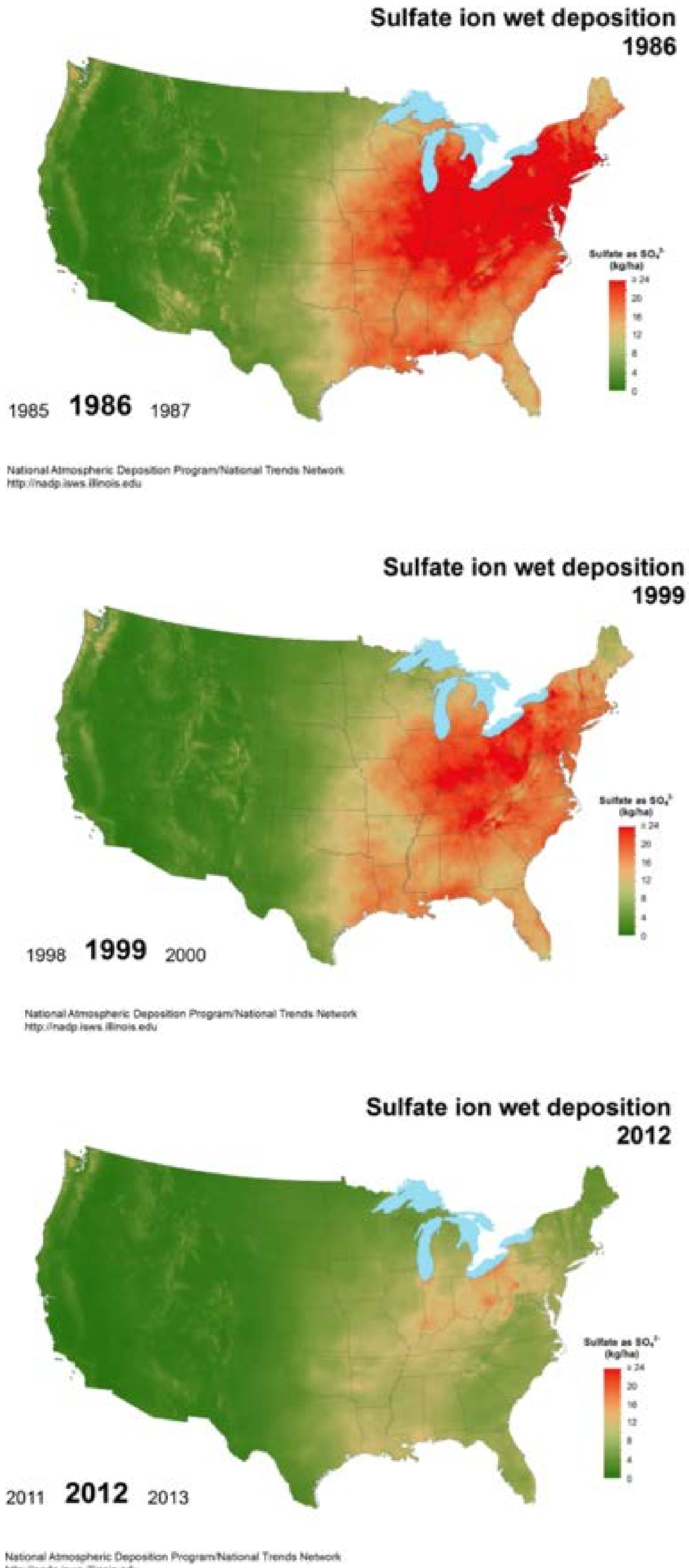


Figure 4-1. Changes in sulfate ion wet deposition level averages in the United States from 1986 through 2012 (Source: NADP/NTN).

Sulfates can cause an array of harmful ecological effects. Sulfur deposition can lead to eutrophication of waterways resulting in declines in fish and vegetation diversity (Driscoll et al. 2001) that can cascade through the aquatic and terrestrial food web. Sulfates can also be deposited into terrestrial soil, changing biogeochemical processes, species interactions, and hence community structure (Porter and Morris 2007).

Data and Methods

Data used for the assessment were statistically interpolated by the National Park Service Air Resources Division (NPS ARD) from the closest NADP/NTN monitoring stations for the central point within Fort Monroe National Monument. This single value was assessed against the reference condition. For current condition, the average annual total sulfur wet deposition for the five-year period from 2011-2015 was used. For assessment of trends, data were not available specifically for the park. The closest available estimate from NPS ARD was for Assateague Island National Seashore (NADP/NTN site #MD18). Trends were assessed based on the Assateague data from 2005-2015 (NPS ARD 2016).

Reference Condition

Natural background sulfur deposition in the Eastern US is 0.5 kg/ha/yr, which equates to a wet deposition of approximately 0.25 kg/ha/yr (Porter and Morris 2007, Taylor 2017). NPS ARD established wet sulfur deposition guidelines of <1 kg/ha/yr indicating good condition and >3 kg/ha/yr indicating significant concern. For this assessment, ≥3 kg/ha/yr was considered to be of significant concern (score of 0%), deposition rates ≤ 1 kg/ha/year were considered to represent good condition (attainment score of 100%), and deposition rates between 3 kg/ha/yr and 1 kg/ha/yr were scaled linearly from 0% to 100% attainment between these reference points.

Current Condition and Trend

The current condition for sulfur depostion in the monument is of Significant Concern (30% attainment based on comparison to threshold values). The five-year average wet sulfur deposition value determined for Fort Monroe National Monument from 2011-2015 was 2.4 kg/ha/yr. Total wet sulfur deposition has decreased in the region over the past (Figure 4-2). The trend is therefore considered to be improving. This trend is consistent with air quality improvements across the US since the sulfate reduction provision of the Clean Air Act (Lynch et al. 2000).

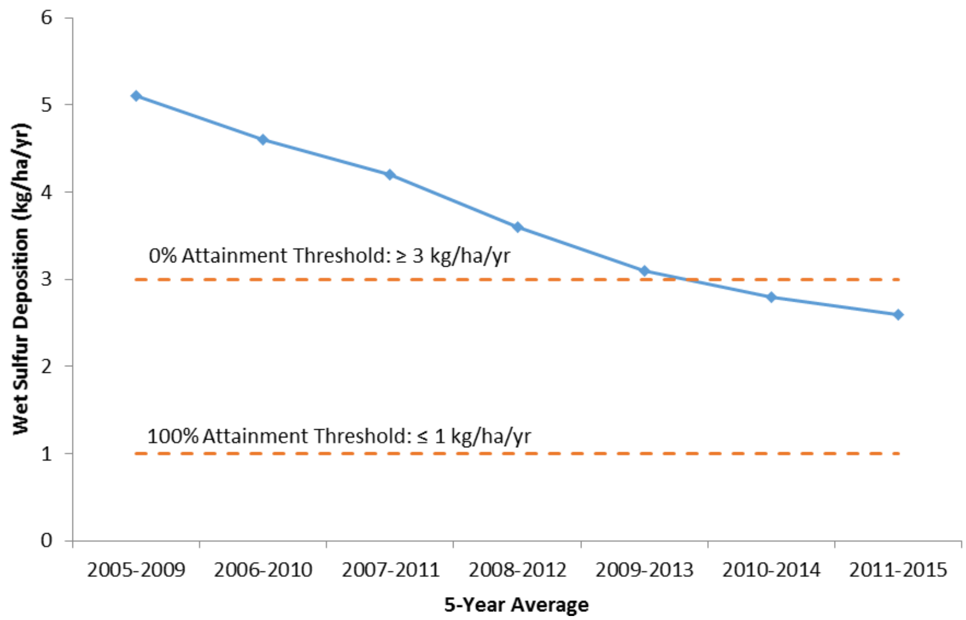


Figure 4-2. Five-year trends in total wet sulfur deposition (kg/ha/yr) for nearby Assateague Island National Seashore (Source: NPS ARD 2016).

Data Gaps and Level of Confidence

Air quality data for Fort Monroe National Monument are not collected directly onsite but are spatially interpolated from monitoring stations located outside the park. Considerations in evaluating potential error introduced by the interpolation process include generally high local variability in wind and meteorological conditions of coastal areas and the proximity of the site to urban and industrial areas. Similarly, historical data are not yet available for the park and small spatial errors are likely associated with the assessment of trend, which is derived from a location approximately 100 miles away from Fort Monroe National Monument. However, given the agreement with regional air quality patterns and the strict NPS protocols used to derive the estimates, the confidence in the assessment is high.

Sources of Expertise

- Air Resources Division, National Park Service; http://www.nature.nps.gov/air/
- Holly Salazer, National Park Service air resources coordinator for the Northeast Region.

Literature Cited

Driscoll C. T., G. B. Lawrence, A. J. Bulger, T. J. Butler, C. S. Cronan, C. Eagar, K. F. Lambert, G. E. Likens, J. L. Stoddard, and K. C. Weathers. 2001. Acidic deposition in the Northeastern United States: Sources and inputs, ecosystem effects, and management strategies. *Bioscience* 51(3):180-198.

Lynch, J.A., V.C. Bowersox, and J.W. Grimm. 2000. Changes in sulfate deposition in Eastern USA following implementation of Phase I of Title IV of the Clean Air Act Amendments of 1990. *Atmospheric Environment* 34:1665-1680.

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Taylor, K.A. 2017. National Park Service air quality analysis methods: August 2017. Natural Resource Report NPS/NRSS/ARD/NRR — 2017/1490/ National Park Service, Fort Collins, Colorado.

4.1.2. Wet Nitrogen Deposition

Relevance and Context

Depending on the chemical form and amount in the environment, nitrogen can serve as a nutrient, enhancing growth and productivity, or as a toxin, causing ecological damage or harming human health. Wet deposition (i.e., rain and snow) carries nitrate and ammonium. Once deposited, pollutants can have significant effects on ecosystems and humans (Porter and Morris 2007). Nitrogen oxides contribute to the formation of ozone, which damages plant leaves and reduces crop yields. Near urban or industrial air pollution sources, high nitrogen dioxide concentrations can irritate human lung tissues and lower resistance to influenza or other respiratory infections. Nitrogen deposition can lead to eutrophication of aquatic environments, which can decrease the abundance of bottom-dwelling fish and submersed aquatic plants. Other effects include the disruption of biogeochemical cycling, changes to aquatic and terrestrial vegetation structure, and loss of biodiversity (Driscoll et al. 2001, Porter and Johnson 2007). Fort Monroe National Monument is susceptible to these impacts owing to its location near urban and industrial areas.

Data and Methods

Data used for the assessment were statistically interpolated by the National Park Service Air Resources Division (NPS ARD) from the closest NADP/NTN monitoring stations for the central point within Fort Monroe National Monument. This single value was assessed against the reference condition. For current condition, the average annual total sulfur wet deposition for the five-year period from 2011-2015 was used. For assessment of trends, data were not available specifically for the park. The closest available estimate from NPS ARD was for Assateague Island National Seashore (NADP/NTN site #MD18). Trends were assessed based on the Assateague data from 2005-2015 (NPS ARD 2016).

Reference Condition

The reference condition for total nitrogen wet deposition is the deposition of nitrogen that occurs naturally without anthropogenic influences. Natural background total nitrogen deposition in the Eastern US is estimated at 0.5 kg ha-1 yr-1 (Porter and Morris 2007, NPS ARD 2010). Deposition rates less than 1 kg ha^{-1} yr^{-1} are considered to be harmless to ecosystems (Fenn et al. 2003). NPS ARD established wet nitrogen deposition guidelines of <1 kg/ha/yr indicating good condition and >3 kg/ha/ yr indicating significant concern. For this assessment, ≥ 3 kg/ha/yr was considered to be of significant concern (score of 0%), deposition rates ≤ 1 kg/ha/year were considered to represent good condition (attainment score of 100%), and deposition rates between 3 kg/ha/yr and 1 kg/ha/yr were scaled linearly from 0% to 100% attainment between these reference points.

Current Condition and Trends

The current condition for nitrogen depostion in the monument is of Significant Concern (0% attainment based on comparison to threshold values). Fort Monroe National Monument has a five-year (2011-2015) average wet nitrogen deposition value of 3.7 kg ha^{-1} yr^{-1}, which fails to meet the minimum threshold of 1 kg ha^{-1} yr^{-1}. Data from nearby Assateague Island National Seashore indicate a slight improving trend (Figure 4-3). This change is consistent with a nationwide reduction in emissions over the past decades (Driscoll et al. 2001). The trend is also consistent with declining wet nitrogen deposition trends observed in most Eastern US parks (NPS ARD 2010). However, large reductions in wet nitrogen deposition are still required to reduce negative impacts on natural resource conditions (Porter and Johnson 2007).

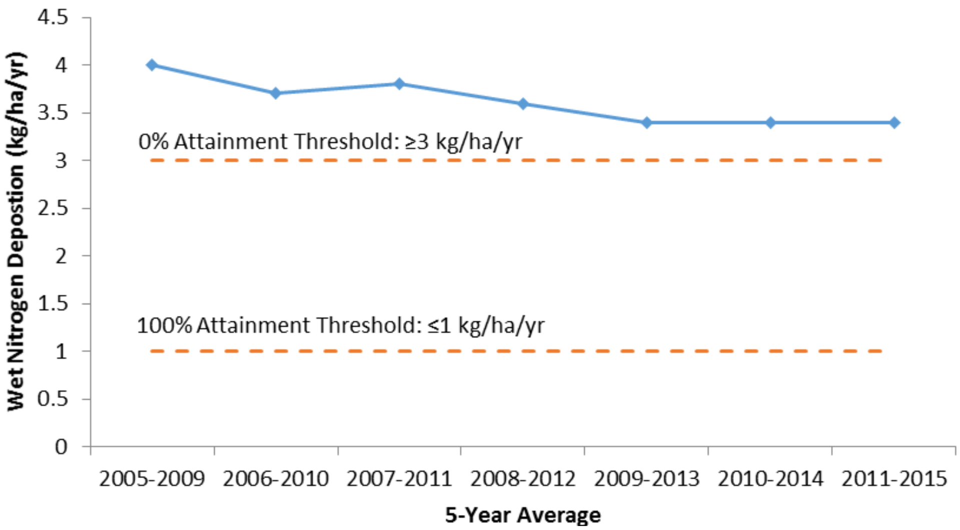

Figure 4-3. Five-year trends in total wet nitrogen deposition (kg/ha/yr) for nearby Assateague Island National Seashore (Source: NPS ARD 2016).

Data Gaps and Level of Confidence

Air quality data for Fort Monroe National Monument are not collected directly onsite but are spatially interpolated from monitoring stations located outside the park. Considerations in evaluating potential error introduced by the interpolation process include generally high local variability in wind and meteorological conditions of coastal areas and the proximity of the site to urban and industrial areas. Similarly, historical data are not yet available for the park and small spatial errors are likely associated with the assessment of trend, which is derived from a location approximately 100 miles away from Fort Monroe National Monument. However, given the agreement with regional air quality patterns and the strict NPS protocols used to derive the estimates, the confidence in the assessment is high.

Sources of Expertise

- Air Resources Division, National Park Service; http://www.nature.nps.gov/air/
- Holly Salazer, National Park Service air resources coordinator for the Northeast Region.

Literature Cited

Driscoll C. T., G. B. Lawrence, A. J. Bulger, T. J. Butler, C. S. Cronan, C. Eagar, K. F. Lambert, G. E. Likens, J. L. Stoddard, and K. C. Weathers. 2001. Acidic deposition in the northeastern United States: Sources and inputs, ecosystem effects, and management strategies. *BioScience* 51(3):180-198.

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National Park Service, Air Resource Division. 2016. 5-year average wet deposition estimates. National Park Service air quality estimates. National Park Service. Denver, CO. Available at: https://www.nature.nps.gov/air/data/products/parks/index.cfm (accessed 21 December 2017).

Porter, E., and S. Johnson. 2007. Translating science into policy: Using ecosystem thresholds to protect resources in Rocky Mountain National Park. *Environmental Pollution* 149:268-280.

Porter, E., and K. Morris. 2007. Wet deposition monitoring protocol: Monitoring atmospheric pollutants in wet deposition. Natural Resource Technical Report NPS/NRPC/ARD/NRTR–2007/004. National Park Service, Fort Collins, CO.

4.1.3. Visibility

Relevance and Context

The Clean Air Act includes reduced visibility as an indicator of broader air quality degradation linked to human activities (U.S. EPA 2004a). Visibility is defined either as the maximum distance that one can see a black object against the vista, or alternatively, as a parameter for measuring an individual's ability to perceive and enjoy distant landscapes (Malm 1999). Decreased visibility can have quantifiable impacts on visitor experiences (Loomis and Garnand 1986), and the National Park Service has prioritized visibility and the protection of scenic vistas in recent decades (NPS 1986). The major cause of reduced visibility in the Eastern U.S. is sulfate particles released from coal combustion (National Research Council 1993, Lin et al. 2012). Particulate matter less than 2.5 m in diameter (PM 2.5) are emitted as smoke from power plants, gasoline and diesel engines, wood combustion, steel mills, forest fires, and chemical reactions, and these particles also can negatively affect visibility (Cheung et al. 2005). The Clean Air Act visibility goal requires improvement for visibility on the 20% haziest days and no degradation on the 20% clearest days (U.S. EPA 2004b).

Data and Methods

Data used for the assessment were statistically interpolated using Inverse Distance Weighting (IDW) from nearby Interagency Monitoring of Protected Visual Environments (IMPROVE) haze monitoring stations to the central point within Fort Monroe National Monument. The haze index, measured in deciviews (dv), indicates the difference between current group 50 visibility (the mean value of the 40th – 60th percentile data) and the natural group 50 visibility (estimated visibility in the absence of human-caused visibility impairment) (U.S. EPA 2003, Taylor 2017). The current condition for the park was assessed using the average haze index value for the five-year period from 2011-2015 (NPS ARD 2016). For assessment of trends, data were not available specifically for the park, and trends were assessed based on data from nearby Assateague Island National Seashore from 2005-2015 (NPS ARD 2016).

Reference Condition

Condition was assessed by comparing the haze index to National Park Service Division of Air Resources prescribed thresholds (NPS ARD 2010). A haze index ≥ 8 dv above natural visibility was considered significant concern, indicating poor visibility with a 0% attainment score. Haze index scores ≤ 2 dv above the natural visibility condition were considered to be in good condition, with a 100% attainment score. Index scores 2-8 dv above a natural visibility condition were scaled linearly from 0 to 100% between these two reference points.

Current Condition and Trends

The current condition for visibility in the monument is of Significant Concern (0% attainment based on comparison to threshold values). The National Park Service Air Atlas (2016) notes that Fort Monroe National Monument is not located in the worst region of the country in terms of visibility (Figure 4-4 and Figure 4-5). Still, the park does not meet acceptable visibility standards. The adjusted five-year average visibility from 2011-2015 was 8.3 dv, which exceeds the threshold of 8 dv.

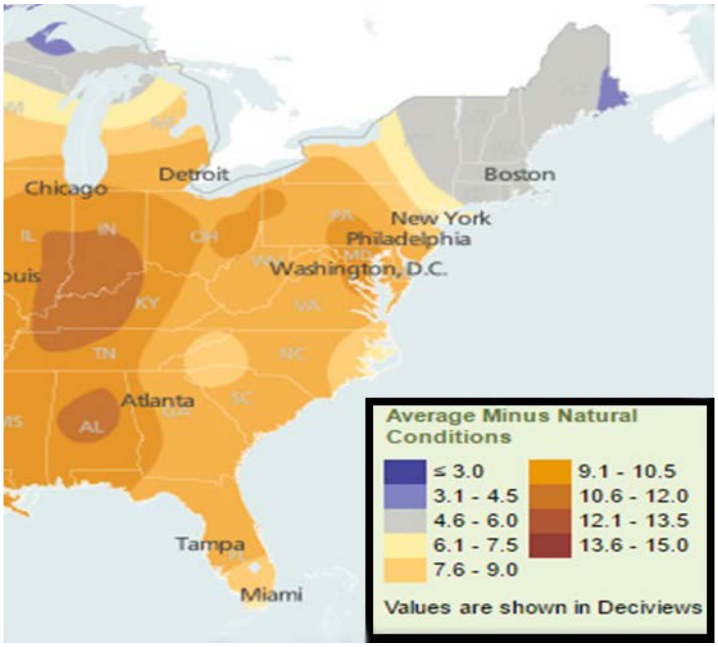

Figure 4-4. Regional haze patterns for the Eastern U.S. (Source: NPS Air Atlas 2016).

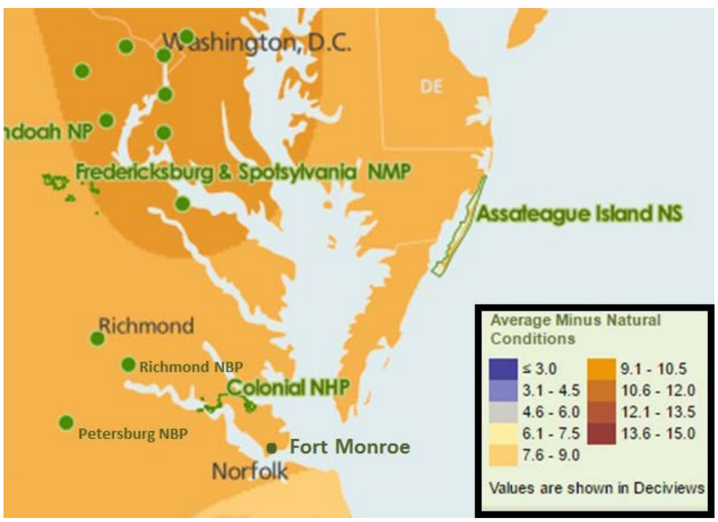

Figure 4-5. Haze patterns for parks in the Mid-Atlantic U.S. (Source: NPS Air Atlas 2016).

Assateague Island National Seashore exhibited similarly low visibility during the sample period, but conditions are improving (Figure 4-6). Given the geographic proximity of the two parks, the trend for Fort Monroe National Monument was assessed as improving.

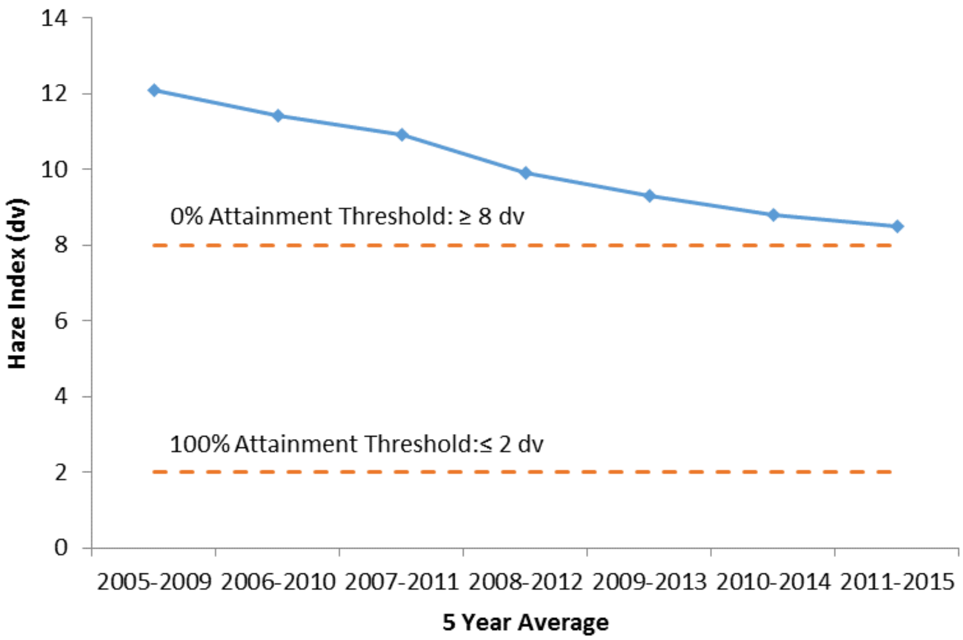

Figure 4-6. Five-year trends in visibility (dv) for nearby Assateague Island National Seashore (NPS ARD 2016).

Data Gaps and Level of Confidence

Air quality data for Fort Monroe National Monument are not collected directly onsite but are spatially interpolated from monitoring stations located outside the park. Considerations in evaluating potential error introduced by the interpolation process include generally high local variability in wind and meteorological conditions of coastal areas and the proximity of the site to urban and industrial areas. Similarly, historical data are not yet available for the park and small spatial errors are likely associated with the assessment of trend, which is derived from a location approximately 100 miles away from Fort Monroe National Monument. However, given the agreement with regional air quality patterns and the strict NPS protocols used to derive the estimates, the confidence in the assessment is high.

Sources of Expertise

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- Holly Salazer, National Park Service air resources coordinator for the Northeast Region.

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4.1.4. Ozone

Relevance and Context

Ground-level ozone is a secondary atmospheric pollutant that forms through a sunlight-driven chemical reaction between nitrogen oxides and volatile organic compounds. These precursor emissions develop largely from burning fossil fuels (Haagen-Smit and Fox 1956). Visitor experience and visitor and employee health and safety are, or can be, impaired when summertime ozone exposures exceed the human health protection standards established by the U.S. Environmental

Protection Agency. Ozone causes a number of health-related issues such as lung inflammation and reduced lung function. Ozone concentrations of 120 parts per billion (ppb) can be harmful with only short exposure during heavy exertion such as jogging, while similar symptoms can occur from prolonged exposure to concentrations of 80 ppb ozone (McKee et al. 1996). A national review of the human health standard for ozone concluded that levels between 60 and 70 ppb would likely be protective of most of the population although very sensitive groups (e.g., elderly and children) may be impacted at lower levels (U.S. EPA 2007). Ozone concentrations above these values are well documented in the eastern parts of the United States (Figure 4-7).

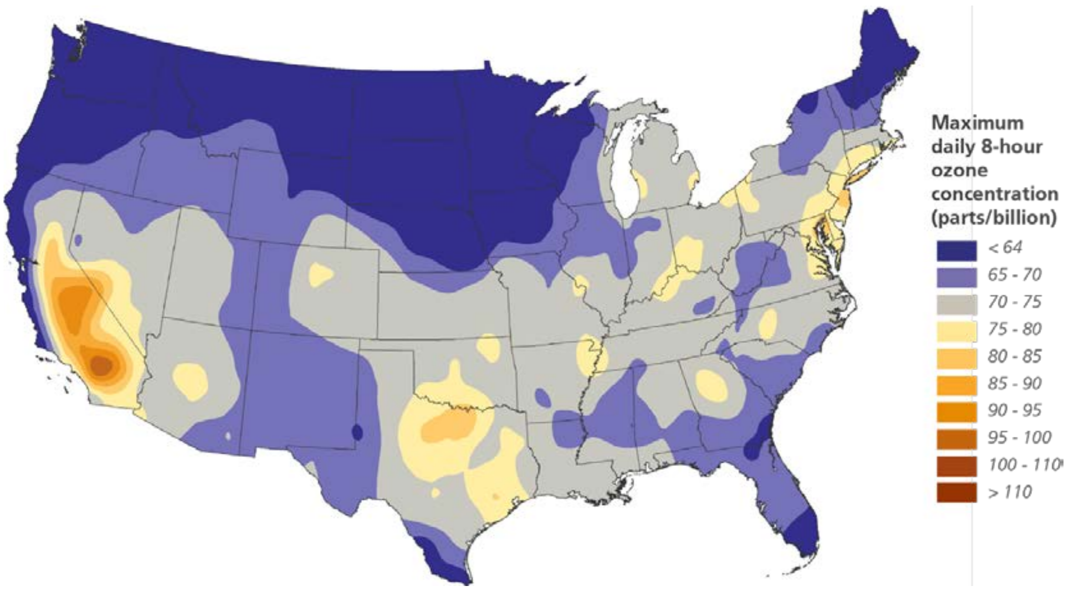

Figure 4-7. U.S. distribution of ozone concentrations from 2005-2009 (Source: http://www.nature.nps.gov/air/maps/AirAtlas/ozone.cfm).

In 2010, the U.S. Environmental Protection Agency proposed strengthening the primary (human health) standard to a value in the range of 60-70 ppb, and establishing a separate secondary (welfare) standard to protect vegetation, based on an ecologically relevant indicator, the W126. Some plant species are more sensitive to ozone than humans. Elevated ozone exposure levels can damage plant leaves, especially when soil moisture levels are moderate to high. Under these conditions, plants have their stomata open, allowing gas exchange for photosynthesis, but also allowing ozone to enter. In a study of 28 plant species exposed to ozone for 3-6 weeks, foliar impacts, including premature defoliation were reported in all species at ozone concentrations between 60-90 ppb (Kline et al. 2008). As a consequence, much of the vegetation at Fort Monroe National Monument may be vulnerable to elevated ozone concentrations.

<u>Data and Methods</u>

Ozone levels were estimated from the Clean Air Status and Trends Network (CASTNET) (http://epa.gov/castnet). Ground-level ozone is regulated under the Clean Air Act, and the U.S. Environmental Protection Agency is required to set National Ambient Air Quality Standards for ozone (US EPA 2004). The ozone standard is violated when the annual fourth-highest daily maximum 8-hour ozone concentration is greater than 70 ppb (U.S. EPA 2007, NPS ARD 2010):

- ≤ 60.0 ppb indicates good ambient ozone condition (100% attainment)
- > 70 ppb warrants significant concern (0% attainment)

Condition attainment scores were scaled linearly from 0 to 100% between the two reference points.

NPS ARD also looks at the W126 ozone metric as a more biologically relevant measure to assess the risk for ozone-induced foliar damage to sensitive plants. The W126 metric preferentially weights the higher ozone concentrations most likely to affect plants and sums all of the weighted concentrations during daylight hours. The highest 3-month period that occurs during the growing season is reported. Values less than 7 parts per million-hour (ppm-hrs) are considered safe for sensitive plants (or 100% attainment of reference condition). The following criteria for assessing potential impacts to park resources has been adopted for this assessment (NPS ARD 2010):

- ≤ 7 ppm-hr indicates good ambient ozone condition (100% attainment)
- > 13 ppm-hr warrants significant concern (0% attainment)

Condition attainment scores were scaled linearly from 0 to 100% between the two reference points.

Both the annual fourth-highest daily maximum 8-hour concentration (averaged over five years) and the plant-exposure indicator, W126, were used to assess ozone condition within the park. Data from the 5-year average covering the years 2011-2015 were used for the assessment of current condition. Percent attainment scores for the two separate ozone metrics were averaged together to get the final indicator score. Data for the park were only available for this single snapshot in time. For assessment of trends, estimates of the annual 4th highest daily maximum 8-hour concentration dating back to 2005 were attained from nearby Assateague Island National Seashore.

Current Condition and Trend

The current condition for ozone in the monument is of Moderate Concern (46% attainment based on comparison to threshold values). The 5-year average of the annual 4th highest daily maximum 8-hour concentration between 2011 and 2015 for Fort Monroe National Monument was 68.1 ppb, which resulted in 19% reference condition attainment. The 5-year average of the maximum 3-month 12-hour W126 between 2011 and 2015 for Fort Monroe National Monument was 8.6 ppm-hrs, which resulted in 73% reference condition attainment of reference condition (Figure 4-8). Averaging these two attainment values yields an overall condition score of 46%.

Ozone levels in the region have been generally decreasing over the past decade of monitoring (Figure 4-8). This trend is consistent with the 10-year trend reported in NPS's 2009 Annual Performance and Progress report (NPS ARD 2010), which found no park units in the Eastern U.S. showing degrading trend, many parks showing no trend, and a majority showing significant or possible improvement in atmospheric ozone concentration (Figure 4-9; NPS ARD 2010).

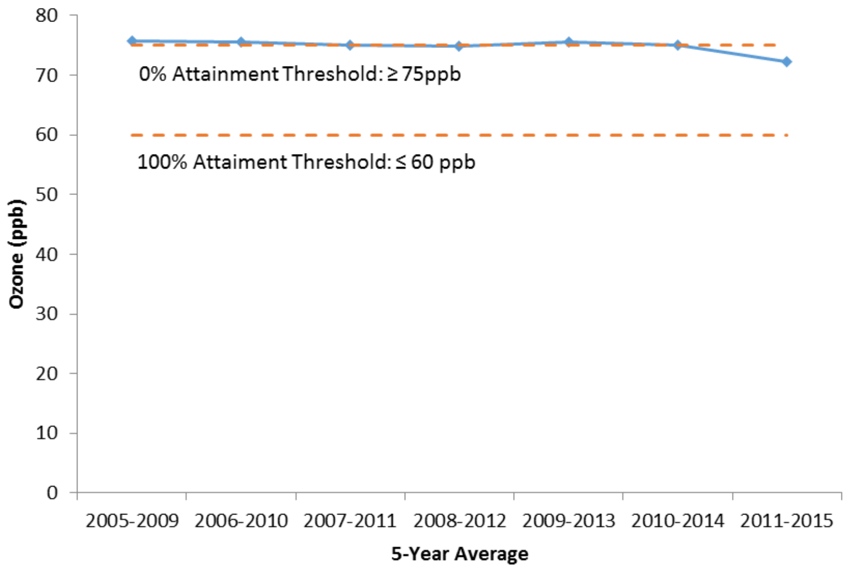

Figure 4-8. Five-year trends in the 4th highest daily maximum 8-hr concentrations (ppb) for nearby Assateague Island National Seashore (NPS ARD 2016).

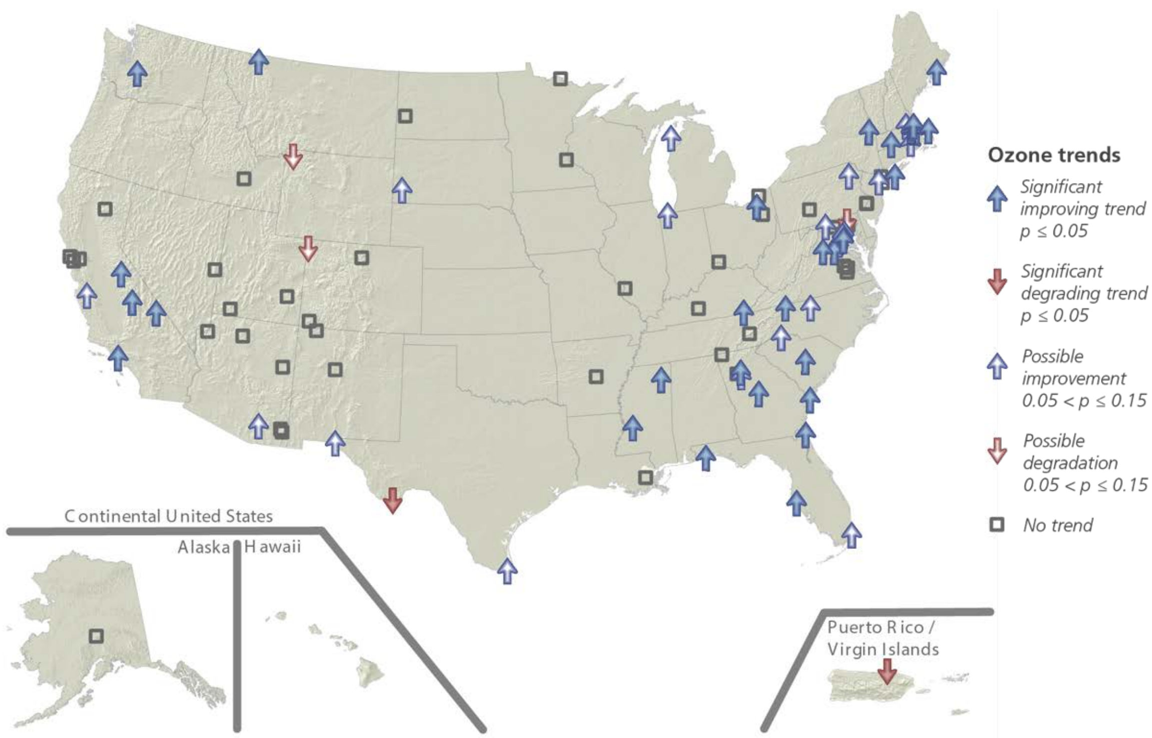

Figure 4-9. Trends in ozone concentrations from 1999-2008 for U.S. national parks (Source: NPS ARD 2010).

Data Gaps and Level of Confidence

Air quality data for Fort Monroe National Monument are not collected directly onsite but are spatially interpolated from monitoring stations located outside the park. Considerations in evaluating potential error introduced by the interpolation process include generally high local variability in wind and meteorological conditions of coastal areas and the proximity of the site to urban and industrial areas. Similarly, historical data are not yet available for the park and small spatial errors are likely associated with the assessment of trend, which is derived from a location approximately 100 miles away from Fort Monroe National Monument. However, given the agreement with regional air quality patterns and the strict NPS protocols used to derive the estimates, the confidence in the assessment is high.

Sources of Expertise

- Air Resources Division, National Park Service; http://www.nature.nps.gov/air/
- Holly Salazer, National Park Service air resources coordinator for the Northeast Region.

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4.2. Aquatic Resources

Aquatic resources at Fort Monroe National Monument are abundant as Fort Monroe is located at the tip of the Virginia Peninsula that overlooks the Chesapeake Bay. As such, it is surrounded by water with approximately 16,000 feet of shoreline facing south towards Hampton Roads Harbor and east towards the Chesapeake Bay and 17,000 feet facing west towards Mill Creek. Local waters at Fort Monroe National Monument are fed by twice-daily tides, 46 inches of average annual rainfall, and 6 inches of average annual snowfall (US Army Corps 2010). Despite abundant water features, no potable groundwater underlies Fort Monroe owing to salinity of the Chesapeake Bay and Hampton Roads Harbor that influence the aquifers (SAIC 2008).

The moat at Fort Monroe is a unique water feature that served as a water barrier between the Fort and its outlying defenses. The moat is noted in the Fort Monroe National Monument Foundation Document as the last moat built in a military fort in the United States (NPS 2015). It is therefore identified as one of Fort Monroe's fundamental resources. Because the moat surrounds Fort Monroe's main historical structure, the water within the moat is important to assess as one of the most visible natural resources on the property. Excavated in 1821 and finished in the 1830s, the moat covers approximately 19 acres and is connected to Mill Creek via piping (Beard et. al 2009) that allows passive tidal exchange through sluice gates. Its width varies from 50 to 250 feet (Leidos 2016). Average water depth was 8 feet when first constructed but since then, sediments have been deposited to change the bottom contours of the moat (Leidos 2016). The moat is crossed by three vehicular bridges and one pedestrian bridge.

Fort Monroe moat (Photo credit: Todd Lookingbill, University of Richmond).

The Fort Monroe moat exchanges water with Mill Creek, a tidal embayment with a total water and wetland surface area of 1.25 square miles (Melchor 1983). Most of this embayment is located outside the boundaries of Fort Monroe National Monument except for approximately 85 acres that are classified as wetlands (Leidos 2016). Yet, hydrological dynamics dictate that aquatic resources within Mill Creek interact with the resources within Fort Monroe National Monument's boundary. Mean tidal range as measured at the NOAA tidal station at Sewells Point is 2.43 feet. These twice-daily tides can move water particles several miles in one tidal cycle. Thus, Mill Creek frequently exchanges water with the lower Chesapeake Bay through the Hampton Roads Harbor located at the mouth of the James River. Mill Creek was once a breeding ground for oysters and anadromous fish (Melchor 1983) and used to support productive submerged aquatic vegetation (SAV) beds. No oysters were found in a 1998 survey (Galvez et al. 1998), but at lower tides oysters can be observed near the kayak launch in Mill Creek (W. Robert Kelly, personal observation). Attempts to reintroduce SAV beds, such as eelgrass (*Zostera marina*) and widgeongrass (*Ruppia maritima*), have failed (Leidos 2016) most likely owing to poor water quality, which plagues not only Mill Creek but the Chesapeake Bay region as a whole.

Fort Monroe Mill Creek area (Photo credit: Beard et al. 2009).

Nearly two miles of beach border the Chesapeake Bay and present opportunities for outdoor recreation (Beard et al. 2009). In the Dog Beach area, the beaches grade landward into active and vegetated dunes. These are the only active dunes on the property. South of Dog Beach, and extending past the Wherry Quarter into the Historic Village area, the beaches are separated from the rest of the property by a concrete promenade that also serves as a seawall. The length and width of the beaches at Fort Monroe National Monument has increased subsequent to recent construction of breakwaters and augmentation with dredged sand.

Four categories of indicators were used to assess the aquatic resources at Fort Monroe National Monument, including water quality, sediment contaminants, benthic macroinvertebrates, and beach health (Table 4-3):

- water quality (nutrients, metals, pesticides, polychlorinated biphenyl (PCB), semivolatile organic compounds (SVOC));
- sediment contaminants (metals, pesticides, PCB, SVOC);
- benthic macroinvertebrates (Benthic Index of Biotic Integrity derived from Shannon-Wiener index, total abundance, abundance of pollution-indicative taxa, abundance of pollution-sensitive taxa, abundance of deep deposit feeders, and abundance of carnivores and omnivores); and
- beach health (*Enterococci* colony forming units).

Data for water quality, sediment contaminants, and benthic macroinvertebrates were sourced from the remedial investigation report for the Fort Monroe moat (Leidos 2016) and to some extent from the Dog Beach landfill remedial investigation report (SAIC 2012). Data for beach health was sourced from the Virginia Department of Health.

Fort Monroe National Monument beach area (Photo credit: Amanda Babson, NPS).

Table 4-3. Indicators and sources of data used in assessment of aquatic resources within Fort Monroe National Monument, Virginia.

Category	Indicator	Agency	Source	# of sites	Sample size	Period
Water quality	Chlorophyll a	Chesapeake Bay Program	CB Water quality monitoring program	1	252	1986 - 2013
	Dissolved oxygen	Chesapeake Bay Program	CB Water quality monitoring program	1	252	1986 - 2013
	Water clarity	Chesapeake Bay Program	CB Water quality monitoring program	1	252	1986 - 2013
	Total nitrogen	Chesapeake Bay Program	CB Water quality monitoring program	1	252	1986 - 2013
	Total phosphorus	Chesapeake Bay Program	CB Water quality monitoring program	1	252	1986 - 2013
	Aluminum	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Arsenic	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Barium	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Cadmium	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Cobalt	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Copper	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Iron	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Lead	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Manganese	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Silver	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Vanadium	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Zinc	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Pesticides	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Polychlorinated biphenyl	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
	Semivolatile organic compounds	Leidos	SAIC 2012, Leidos 2016	13	13	2007, 2009
Sediment contaminants	Arsenic	Leidos	Leidos 2016	20	20	2007, 2009
	Cadmium	Leidos	Leidos 2016	20	20	2007, 2009
	Chromium	Leidos	Leidos 2016	20	20	2007, 2009

Table 4-3 (continued). Indicators and sources of data used in assessment of aquatic resources within Fort Monroe National Monument, Virginia.

Category	Indicator	Agency	Source	# of sites	Sample size	Period
Sediment contaminants (continued)	Cobalt	Leidos	Leidos 2016	20	20	2007, 2009
	Copper	Leidos	Leidos 2016	20	20	2007, 2009
	Iron	Leidos	Leidos 2016	20	20	2007, 2009
	Lead	Leidos	Leidos 2016	20	20	2007, 2009
	Manganese	Leidos	Leidos 2016	20	20	2007, 2009
	Mercury	Leidos	Leidos 2016	20	20	2007, 2009
	Nickel	Leidos	Leidos 2016	20	20	2007, 2009
	Selenium	Leidos	Leidos 2016	20	20	2007, 2009
	Zinc	Leidos	Leidos 2016	20	20	2007, 2009
	Pesticides	Leidos	Leidos 2016	20	20	2007, 2009
	Polychlorinated biphenyl	Leidos	Leidos 2016	20	20	2007, 2009
	Semivolatile organic compounds	Leidos	Leidos 2016	20	20	2007, 2009
Benthic macroinvertebrates	Shannon-wiener index	Leidos	Leidos 2016	6	6	2009
	Total abundance	Leidos	Leidos 2016	6	6	2009
	Abundance pollution-indicative taxa	Leidos	Leidos 2016	6	6	2009
	Abundance pollution-sensitive taxa	Leidos	Leidos 2016	6	6	2009
	Abundance deep deposit feeders	Leidos	Leidos 2016	6	6	2009
	Abundance carnivores and omnivores	Leidos	Leidos 2016	6	6	2009
Beach health	Enteroccoci colonies	Local health department	Virginia Department of Health	2	218	2010 - 2015

4.2.1. Water Quality

Relevance and Context

In 2010, the EPA identified high levels of nutrients such as nitrogen and phosphorous as significant threats to the Chesapeake Bay with potential effects ranging from excessive algal growth to decreased water clarity and levels of dissolved oxygen (EPA 2010). Increases in nutrient loading to the bay have resulted in high levels of phytoplankton, whose decay produces a dissolved oxygen deficit. Phytoplankton, dissolved organic carbon, as well as suspended sediments restrict sunlight penetration through the water column such that submersed aquatic vegetation may not establish, survive, or develop vigorous populations. Hence, a stable state that is dominated by phytoplankton is now a common observation (Kirwan 2012), including estuarine areas around Fort Monroe National Monument. Fish and shellfish require dissolved oxygen concentrations of at least 5 mg/L to survive, but increasing eutrophication is creating a poor environment for aquatic life (EPA 2003). Effects on aquatic life cascade through the food-web to affect the resident and migratory bird populations that use aquatic environments for food and habitat.

Potential sources of nutrients that have the highest impact on eutrophication include agricultural operations, rain and storm water runoff, wastewater treatment centers, and excessive fertilizer use on lawns and gardens. Although pollution has decreased slightly in the past 3 years, the EPA deemed the progress insufficient and began the implementation process of a Total Maximum Daily Load (TMDL) or “pollution diet” for the Chesapeake Bay in 2010 (EPA 2010). As a whole, the Chesapeake Bay received a moderate health score from EcoCheck in 2013, but specific areas such as the James River and surrounding Lower Bay, which are of interest to this assessment, have moderate and moderately good scores for overall water quality (EcoCheck 2013).

In addition to nutrients, metals, pesticides, polychlorinated biphenyl (PCB), volatile and semivolatile organic compounds (VOC and SVOC) can contaminate water and be toxic to aquatic fauna. Water contamination is of most concern for the moat at Fort Monroe (Leidos 2016) and for areas within Mill Creek adjacent to Dog Beach Landfill (SAIC 2012). Specifically, the Fort Monroe moat served as the main sanitary sewer for nearly 70 years until a modern sewage system was built in the late 19th century. To this day, the moat serves as a stormwater feature as thirty storm sewers drain into the moat. The primary sources of potential chemical contamination are current runoff from roads and bridges, the historical storm sewers, and a historical industrial discharge point from a building that serviced vehicles and heavy equipment (Leidos 2016). Dog Beach Landfill, located in the North Beach portion of Fort Monroe National Monument, is an unlined landfill that was in operation until the mid-1960’s (SAIC 2012). It covers approximately 27 acres. The landfill received, among other waste, ash from an incinerator for household and office trash from the mid-1940s through the 1960s (SAIC 2012). This landfill was the focus of a remedial investigation (SAIC 2012) to identify potential contaminants.

Dog Beach landfill mounds with fox at Fort Monroe National Monument (Photo credit: Todd Lookingbill, University of Richmond).

Data and Methods

Levels of nutrients that can contribute to eutrophication of Fort Monroe National Monument water resources have not been measured for samples collected within its boundary. However, twice daily tides mix water from the Chesapeake Bay with waters of Mill Creek such that water quality at Fort Monroe National Monument is in part impacted by current water quality of the Chesapeake Bay (NPS 2015). Therefore, in the absence of nutrient data collected within Fort Monroe National Monument boundaries, one of the Chesapeake Bay Water Quality Monitoring Program sites located directly south of Fort Monroe at the southern-most sampling station of Old Point Comfort at the mouth of the James River (LE5.5-W) was used to estimate water quality at Fort Monroe. The water quality monitoring program assesses water quality each year with water samples that are analyzed for chlorophyll *a* (µg/L), dissolved oxygen (DO mg/L), water clarity measured as Secchi depth (m), total nitrogen (TN mg/L), and total phosphorus (TP mg/L) (Figure 4-10). Data from the site are analyzed each year with the EcoCheck protocol developed for the Mid-Atlantic Tributary Assessment Coalition (EcoCheck 2013) to develop a health index for the Chesapeake Bay, its tributaries, and specific sites. Since 1986, data have been collected for the James River 7-11 times per year during periods of interest for each metric (EcoCheck 2013).

Figure 4-10. Location of Chesapeake Bay Water Quality Monitoring Program sampling site LE5.5-W marked as red circle (Map Source: 2009 U.S. Army Corps of Engineers wetland delineation map).

Chlorophyll *a* is used as a measure of phytoplankton biomass that is controlled by water temperature and availability of light and nutrient resources. Higher levels of phytoplankton biomass may result in high turbidity and reduced dissolved oxygen levels (EcoCheck 2013). Data for chlorophyll *a* were collected by the Chesapeake Bay Water Quality Monitoring Program from March to May and July to September up to 8 times per year. Dissolved oxygen (DO) is a critical indicator to most aquatic life. Low DO levels in the Bay's main stem are primarily controlled by the quantity of organic matter and nutrients flowing out of the Susquehanna River during the preceding spring (EcoCheck 2013). Data for DO were collected from June to September up to 7 times per year. Water clarity measures how much light penetrates through the water column. It can be measured with a Secchi disk, a turbidimeter, or water samples that measure suspended and dissolved solids. Water clarity is dependent on the amount of particles and colored organic matter present. This indicator is essential in driving the distribution and abundance of submerged aquatic plant beds and phytoplankton (EcoCheck 2013). Data for water clarity were collected by the Chesapeake Bay Water Quality Monitoring Program from March to November up to 11 times per year. Total nitrogen results from runoff and atmospheric pollution. High levels of nitrogen can lead to eutrophication, which can contribute to poor DO and health of other organisms (EcoCheck 2010). Data for total nitrogen were collected by the Chesapeake Bay Water Quality Monitoring Program from April to October up to 8 times per year. Phosphorus and sediment pollution are linked because phosphorus attaches to sediment particles during aerobic conditions but dissolves when water and sediments become anaerobic. Too much phosphorus can lead to plankton blooms and decreased DO levels (EcoCheck 2013). Data for total phosphorus were collected by the Chesapeake Bay Water Quality Monitoring Program from April to October up to 8 times per year.

Leidos (formerly Science Applications International Corporation – SAIC) conducted a remedial Investigation of the moat at Fort Monroe in 2007-2010 (Leidos 2016) to investigate the potential presence of chemical constituents that may pose a risk to human health or the environment. Towards this goal, water samples were collected in 2007 (n=7) and 2009 (n=6) from thirteen different locations in the moat as well as from six reference locations in Mill Creek, six locations near the sluice gates in Mill Creek (Figure 4-11), and six locations within Mill Creek adjacent to Dog Beach Landfill (Figure 4-12). Samples were analyzed for metal, pesticides, polychlorinated biphenyl (PCB), semi-volatile organic compounds (SVOC) in filtered and unfiltered water.

Figure 4-11. Sampling locations within the Fort Monroe moat (Source: Leidos 2016).

Figure 4-12. Locations of six sampling sites within Mill Creek at Fort Monroe National Monument (Source: SAIC 2010).

<u>Reference Condition</u>

The mouth of the James River and Fort Monroe are located within the polyhaline salinity regime (Chesapeake Bay Program 2012). Thus, threshold values for chlorophyll *a* (spring ≤ 2.8 μg/L-1 and summer ≤ 4.5 μg/L-1; Lacouture 2006; Buchanan 2006), water clarity (≥ 2.0 meters; Lacouture 2006; Buchanan 2006), total nitrogen (≤ 0.5 mg L-1; EcoCheck 2011), and total phosphorus (≤ 0.05 mg L-1; Eco Check 2011) need to account for the high water salinity in and around Fort Monroe. The threshold values for DO vary based on water depth, which is classified as open water at the mouth of the James River where samples were collected. The DO threshold for June to September is ≥ 3.0 mg/L^{-1} (EPA 2003).

Individual contaminant concentrations (metals) were compared to standard published screening criteria. Remedial investigation reports for the Fort Monroe moat and the Dog Beach landfill (SAIC 2012, Leidos 2016) primarily used freshwater criteria from Virginia Freshwater Quality Standards (Table 4-4). If those were not available, the remedial investigation used Virginia Saltwater Quality and National Standards. Owing to the polyhaline salinity regime of Fort Monroe waters, this NRCA uses marine benchmarks employed by NOAA (Screening Quick Reference Table – SQuiRTs;

Buchman 2008). These marine threshold values were compared to thresholds published by EPA Region 3 (Biological Technical Assistance Group – BTAG; Pluta 2006). Because EPA marine thresholds are absent for many analytes, NOAA marine threshold values were used. Which benchmarks are chosen affects the scoring of some individual metals but does not substantially influence the overall condition score.

Table 4-4. Published benchmarks for metal concentrations in water samples. NOAA marine thresholds were chosen for this NRCA.

			Fresh		Marine	
Metal	**Units**	**RI***	**EPA**	**NOAA**	**EPA**	**NOAA**
Aluminum	ug/L	87	87	87	N/A	87**
Arsenic	ug/L	150	5	150	12.5	36
Barium	ug/L	4	4	3.9	N/A	200
Cadmium	ug/L	1.1	0.25	0.25	0.12	8.8
Cobalt	ug/L	23	23	3	N/A	1
Copper	ug/L	9	9	9	3.1	3.1
Iron	ug/L	300	300	1000	N/A	50
Lead	ug/L	14	2.5	2.5	8.1	8.1
Manganese	ug/L	120	120	80	N/A	100
Silver	ug/L	3.2	3.2	0.36	0.23	0.95
Vanadium	ug/L	20	20	19	NA	50
Zinc	ug/L	120	120	120	81	81

*RI = threshold values used for water samples in two Remedial Investigation reports for the Fort Monroe moat (Leidos 2016) and Dog Beach landfill (SAIC 2012).

**Freshwater standard was used because a threshold value for aluminum in marine water is not published. The marine threshold would likely be lower as aluminum concentrations in marine waters are naturally low (A. Heyes personal communication).

Four of the 16 metals analyzed (calcium, magnesium, potassium, and sodium) are major ions in seawater. No marine benchmarks are published for these four major ions, and freshwater benchmarks do not adequately represent condition in the saltwater environment of Fort Monroe National Monument. They were therefore not included in the assessment of water resources condition. Zinc was only analyzed for moat and sluice gate samples. All samples passed; however, scores for Zinc were not included to not inflate the moat and sluice gate scores compared to the Mill Creek and Dog Beach scores. Remedial investigation reports (Leidos 2016, SAIC 2012) did not include detection limits for each analyte. Therefore, when analytes were undetected, the lowest reported value across all samples was used as the entry. In all cases, this value fell below the threshold for the analyte.

Condition scores were based on average values for each analyte that then were compared to threshold values. For contaminants, such as metals, which were analyzed at multiple sites, scores based on mean values were compared to scores based on percent of sites below a threshold value.

Current Condition and Trend

Water condition at Fort Monroe National Monument was scored as Good Condition (67%) based on an average of the assessment scores for the Chesapeake Bay samples (60% based on analysis of chlorophyll *a*, dissolved oxygen, water clarity, total nitrogen, and total phosphorus in water) and contaminant data from the moat and Mill Creek samples (75% based on analysis of aluminum, arsenic, barium, cadmium, cobalt, copper, iron, lead, manganese, silver, vanadium, zinc, pesticides, PCBs, and SVOCs in water).

Data collected by the Chesapeake Bay Water Quality Monitoring Program (EcoCheck 2013) at location LE5.5-W showed that chlorophyll *a* and water clarity failed EcoCheck thresholds whereas dissolved oxygen and total nitrogen and phosphorus passed the thresholds. The overall score for nutrients is therefore 60% (Table 4-5).

Table 4-5. Summary of data collected at location LE5.5-W (36.999° latitude, -76.313° longitude) from the Chesapeake Bay Monitoring Program's Water Quality Monitoring Program in 2013 (Source: EcoCheck 2013).

Location	Indicator	Month	Mean	EcoCheck threshold	Pass / fail	Score
LE5.5W	Chlorophyll a (µg/L)	July – September	7.616	≤ 4.5 µg/L	Fail	0%
LE5.5W	Dissolved oxygen (mg/L-1)	June – September	6.819	≥ 3.0 mg/L-1	Pass	100%
LE5.5W	Water clarity (secchi depth m)	April – October	0.950	≥ 2.0m	Fail	0%
LE5.5W	Total nitrogen (mg/L-1)	April – October	0.411	≤0.5 mg/L-1	Pass	100%
LE5.5W	Total phosphorus (mg/L-1)	April – October	0.038	≤0.05 mg/L-1	Pass	100%

Chlorophyll *a* scores for the James River have been fluctuating since monitoring began in 1986, with an extreme low score in 1997 and a declining trend since 2010 (Figure 4-13). Current trends show that the James River has the best chlorophyll *a* score in comparison to the rest of the Bay (Eco Check 2013). DO scores overall have been fairly high to excellent since monitoring began in 1986 (Figure 4-14), with the lowest occurring in 2003. Current trends show that DO scores have been increasing in the James since 2011. Compared to trends for the overall bay, DO scores in the James have been consistently higher (Eco Check). Water clarity conditions in the James River have fluctuated along a deteriorating trend since 1986 and have been in poorer condition than the Bay as a whole since then (Figure 4-15; EcoCheck 2013). Total nitrogen scores for the James River significantly decreased in 1994, increased in 2003, and decreased again in 2004 (Figure 4-16). Current trends show an improving condition for total nitrogen levels since 2010. However, the James River has maintained a relatively good condition as its scores have still been higher than the Bay as a whole since the early 1990s (EcoCheck 2013). Total phosphorus scores have been low in comparison to the rest of the Bay since 1986 (Figure 4-17), but have improved significantly in 1997. Since then, phosphorus levels have fluctuated with current conditions reflecting an improving trend since 2011, but still remaining in much poorer condition than the Bay as a whole (EcoCheck 2013).

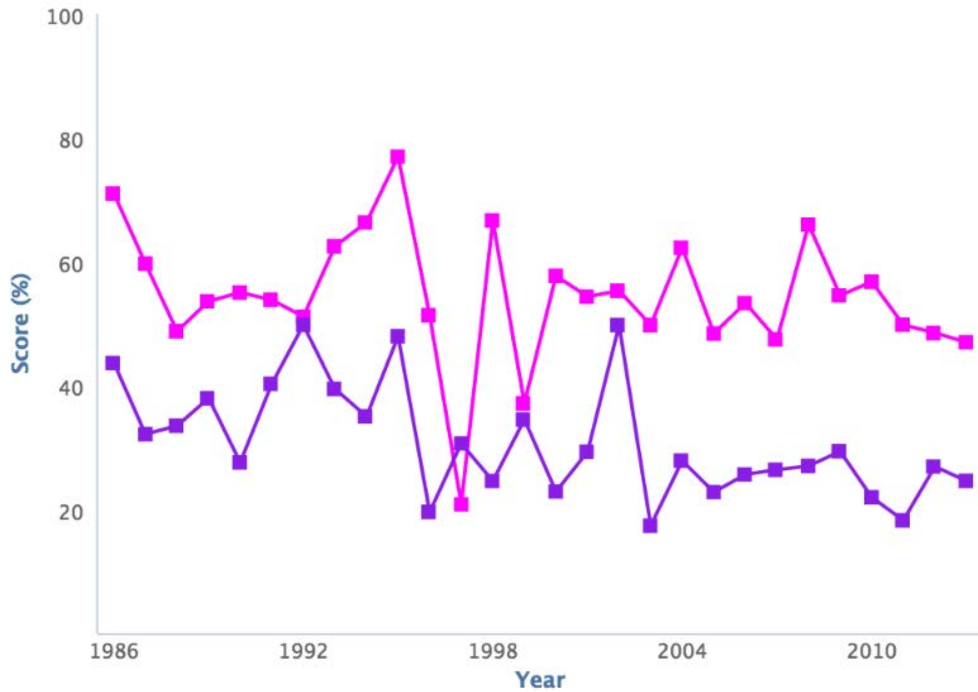

Figure 4-13. Trends in chlorophyll *a* in the James River (pink) and the Chesapeake Bay (purple) since 1986 (Source: EcoCheck 2013).

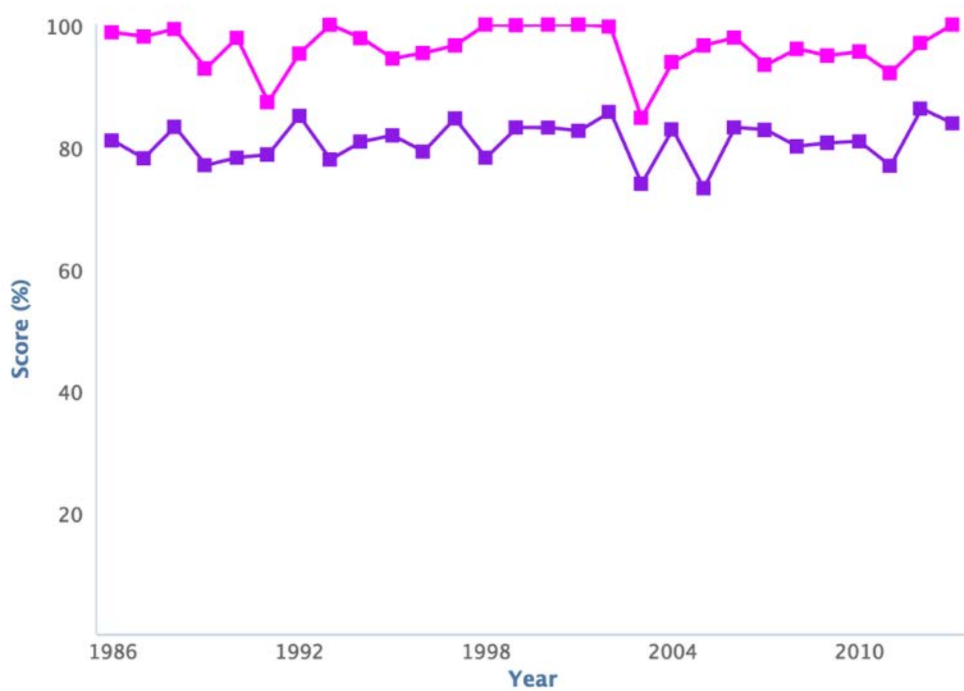

Figure 4-14. Trends in dissolved oxygen (DO) in the James River (pink) and the Chesapeake Bay (purple) since 1986 (Source: EcoCheck 2013).

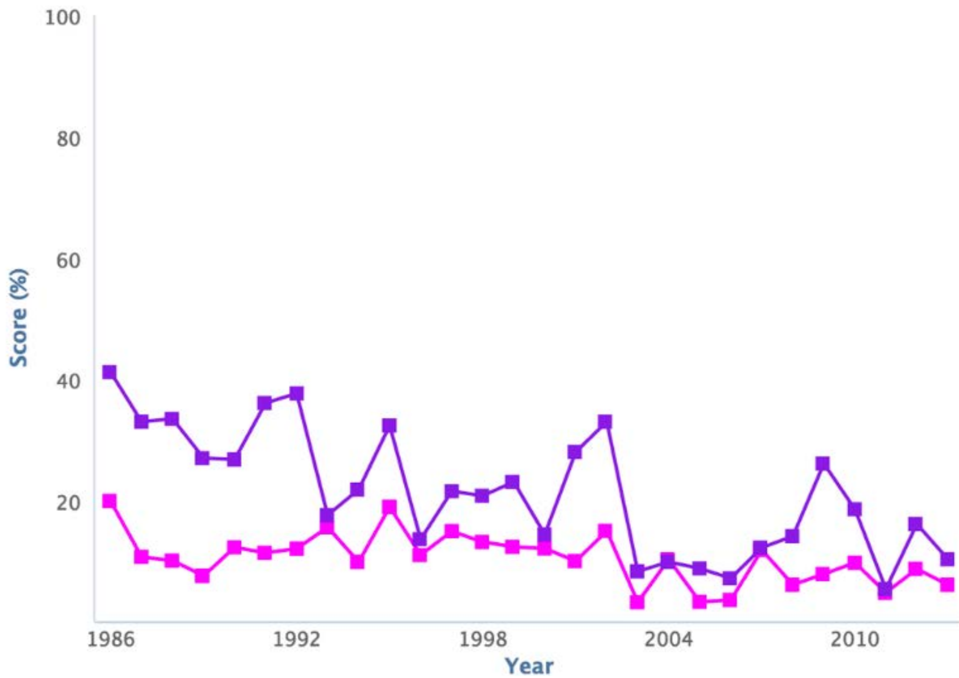

Figure 4-15. Water clarity trends in the James River (pink) and the Chesapeake Bay (purple) since 1986 (Source: EcoCheck 2013).

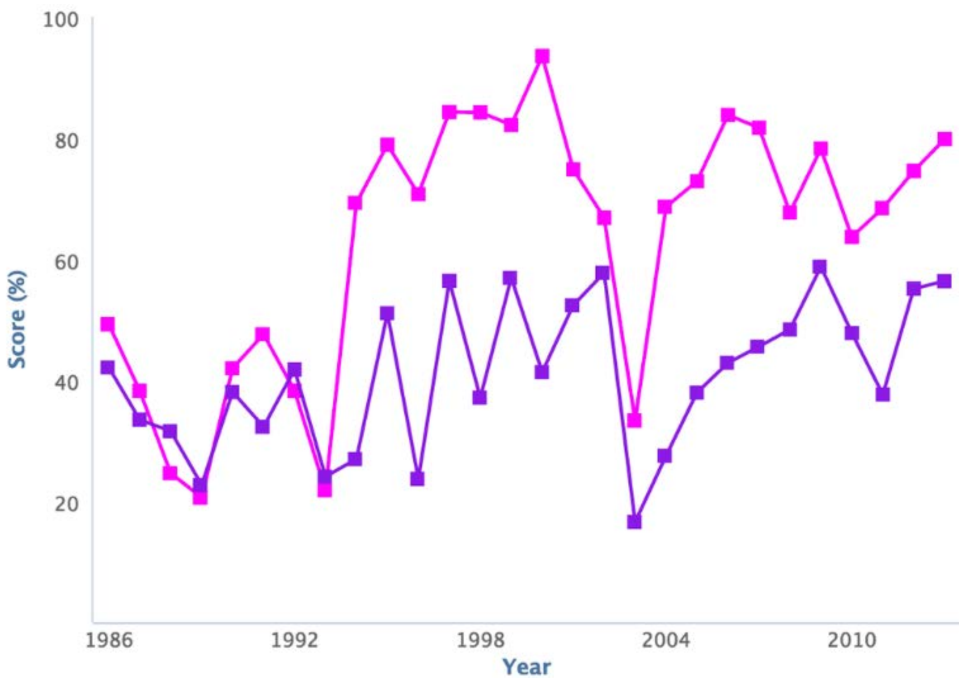

Figure 4-16. Total nitrogen in the James River (pink) and the Chesapeake Bay (purple) since 1986 (Source: EcoCheck 2013).

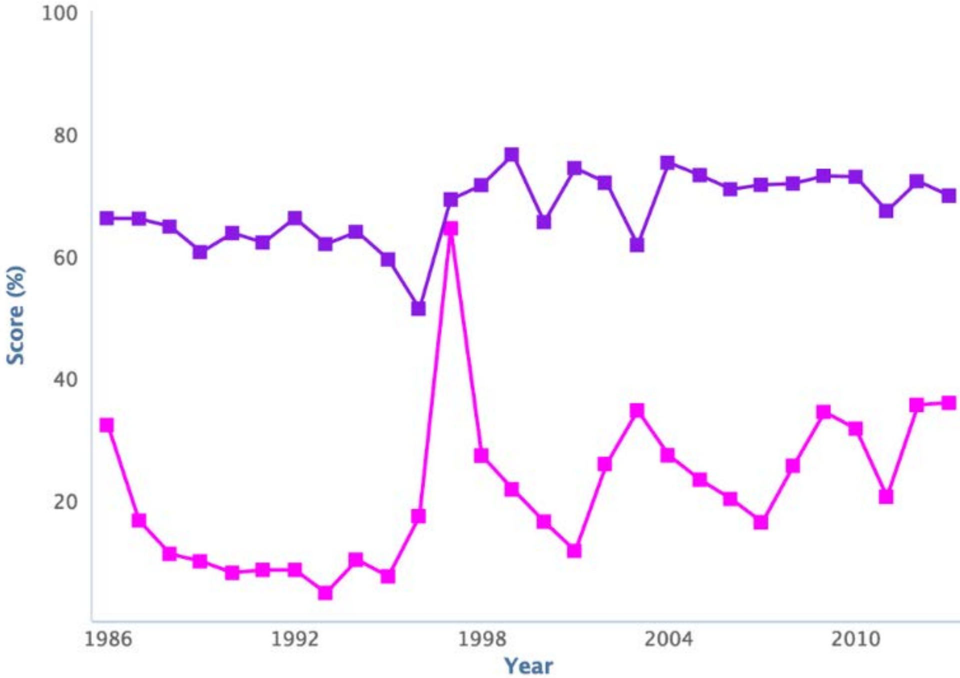

Figure 4-17. Total phosphorus trends in the James River (pink) and the Chesapeake Bay (purple) since 1986 (Source: EcoCheck 2013).

Sixteen metals were frequently detected in water samples across all sampling areas. Eleven of these were used in the condition assessment (samples were not analyzed for zinc at all locations, and sodium, magnesium, calcium, and potassium are common ions in the marine environment and have no marine benchmarks) (Table 4-6 and 4-7). Pesticides, PCBs and SVOCs (benzoic acid) were detected in very small amounts at some locations but were significantly below any thresholds (Leidos 2016). Using NOAA marine benchmarks for metals, water contamination at Fort Monroe National Monument received an overall score of 75%.

Most metals passed threshold criteria, except for aluminum, cobalt, and iron, which failed the criteria at each location. Cadmium failed the criteria within Mill Creek, as well as at the sluice gates that connect the moat to Mill Creek.

Table 4-6. Attainment of threshold values for 6 sites each within the moat, sluice gate area, Mill Creek, and Dog Beach in 2009, at Fort Monroe National Monument.*

Location	Indicator	NOAA SQuiRTs	Unfiltered Mean	Score	Filtered Mean	Score	Average Score	Location Score
Moat	Aluminum	87	560.00	0	331.67	0	0	80
	Arsenic	36	5.56	100	5.88	100	100	
	Barium	200	28.50	100	28.13	100	100	
	Cadmium	8.8	7.56	100	7.52	100	100	
	Cobalt	1	1.27	0	1.26	0	0	
	Copper	3.1	2.51	100	1.92	100	100	
	Iron	50	443.33	0	177.17	0	0	
	Lead	8.1	7.20	100	4.87	100	100	
	Manganese	100	16.58	100	10.88	100	100	
	Silver	0.95	0.28	100	0.31	100	100	
	Vanadium	50	2.83	100	2.47	100	100	
	Zinc	81	32.82	100	28.40	100	100	
Sluice Gates	Aluminum	87	577.50	0	441.33	0	0	71
	Arsenic	36	7.41	100	7.30	100	100	
	Barium	200	27.15	100	26.85	100	100	
	Cadmium	8.8	9.88	0	9.47	0	0	
	Cobalt	1	1.39	0	1.43	0	0	
	Copper	3.1	2.46	100	3.14	100	100	
	Iron	50	309.00	0	168.00	0	0	
	Lead	8.1	N/A	N/A	N/A	N/A	N/A	
	Manganese	100	11.05	100	8.58	100	100	
	Silver	0.95	0.32	100	0.42	100	100	
	Vanadium	50	3.11	100	2.75	100	100	
	Zinc	81	29.03	100	28.40	100	100	
Mill Creek	Aluminum	93	1159.67	0	599.50	0	0	71
	Arsenic	36	7.20	100	7.17	100	100	
	Barium	200	28.72	100	28.52	100	100	
	Cadmium	8.8	11.17	0	11.07	0	0	
	Cobalt	1	1.51	0	1.48	0	0	
	Copper	3.1	1.31	100	2.25	100	100	
	Iron	50	739.67	0	264.17	0	0	
	Lead	8.1	5.50	100	6.34	100	100	

*Data from 2007 were not used because many analytes included missing values. Each score was averaged across filtered and unfiltered water samples collected at each site. Pesticides, PCBs and SVOCs were not detected or detected at very low levels and were included each at 100% attainment in the calculation of overall scores.

Table 4-6 (continued). Attainment of threshold values for 6 sites each within the moat, sluice gate area, Mill Creek, and Dog Beach in 2009, at Fort Monroe National Monument.*

Location	Indicator	NOAA SQuiRTs	Unfiltered Mean	Score	Filtered Mean	Score	Average Score	Location Score
Mill Creek (continued)	Manganese	100	15.58	100	10.46	100	100	71
	Silver	0.95	0.37	100	0.42	100	100	
	Vanadium	50	3.80	100	3.20	100	100	
	Zinc	81	N/A	N/A	N/A	N/A	N/A	
Dog Beach	Aluminum	67	744.33	0	377.33	0	0	79
	Arsenic	36	6.70	100	6.63	100	100	
	Barium	200	28.15	100	28.23	100	100	
	Cadmium	8.8	7.04	100	7.44	100	100	
	Cobalt	1	1.51	0	1.51	0	0	
	Copper	3.1	2.32	100	1.72	100	100	
	Iron	50	552.33	0	114.70	0	0	
	Lead	8.1	N/A	N/A	5.22	100	100	79
	Manganese	100	14.40	100	6.82	100	100	
	Silver	0.95	0.42	100	0.38	100	100	
	Vanadium	50	3.52	100	2.79	100	100	
	Zinc	81	N/A	N/A	N/A	N/A	N/A	
Fort Monroe National Monument								75

*Data from 2007 were not used because many analytes included missing values. Each score was averaged across filtered and unfiltered water samples collected at each site. Pesticides, PCBs and SVOCs were not detected or detected at very low levels and were included each at 100% attainment in the calculation of overall scores.

Data Gaps and Level of Confidence

Data from the Chesapeake Bay Water Quality Monitoring Program site LE5.5-W were assessed for the NRCA owing to the monitoring station's proximity to Fort Monroe and because data for Fort Monroe National Monument were absent. It can be argued, however, that temporal monitoring data of water quality outside park boundaries in the James River are too variable and therefore do not contribute to the assessment of trends within the park. The analysis of conditions and trends at LE5.5-W reflects the status of the Hampton Harbor region, not the location at LE5.5-W exclusively, and it is unclear how conditions measured at LE5.5W represent conditions within Mill Creek. Our confidence in data at LE5.5-W representing water quality within Fort Monroe is therefore low. Confidence would be greatly enhanced by establishing a water monitoring program that monitors water quality in waters within the Fort Monroe National Monument boundary, including the moat, shorelines, tidal channels and intertidal habitats.

Confidence in contaminant concentrations is high given the high spatial resolution of the data. The identification of threshold values proved problematic because marine benchmarks were not available for some analytes and differed from freshwater thresholds, which did not seem adequate to represent the polyhaline conditions of the waters at Fort Monroe. However, exploring scores established using freshwater and marine benchmarks did not substantially change the overall score, only the scoring of individual analytes (e.g., cadmium scores higher using marine benchmarks than freshwater benchmarks).

Combining the confidence ratings for the Chesapeake Bay monitoring samples and the contaminant data yields an overall rating of moderate for this indicator.

Sources of Expertise

- Andrew Heyes, University of Maryland Center for Environmental Science Chesapeake Biological Lab

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4.2.2. Sediment Contaminants

Relevance and Context

The aquatic habitats at Fort Monroe National Monument are strongly shaped by its sediment, which are removed from areas exposed to wave action and high water velocities and deposited in areas that are more sheltered. Sediments are deposited in the Fort Monroe moat, which is sheltered and therefore conducive to sediment accumulation. A bathymetric survey of the moat (Leidos 2016) showed that water depths ranged from 2 feet over several shoal-like areas in the northwestern corner of the moat to 8.2 feet at the bottom of the sluice way in the northeastern area of the Moat (Leidos 2016). Water depths were generally at 4-5 feet below North American Vertical Datum of 1988. Thickness of sediments deposited since construction of the moat was near zero in some areas to 5 feet deep near the northern sluice way, with average sediment depth between 2-3 feet. Sediment accumulation since 1929 was 1-1.6 feet. The most significant influence on bathymetry appears to be storm water runoff and tidal exchange that carries sediments from the estuary and deposits it in the moat. Overall, extrapolation of a calculated sedimentation rate over the entire 180-year history of the moat suggests an overburden of 3.2 feet above the engineered bottom of the moat.

A builder of habitat, sediments also have the capacity to accumulate metals, pesticides, polychlorinated biphenyl (PCB), and volatile and semi-volatile organic compounds (VOC and SVOC) that can be toxic to aquatic fauna. Thus, remedial investigations of the Fort Monroe moat and the Dog Beach landfill (Leidos 2016, SAIC 2012) intensively studied contaminants in the Fort

Monroe sediments. These data provide the basis for the natural resource conditions assessment of sediments at Fort Monroe National Monument.

<u>Data and Methods</u>
Leidos (2016) conducted a remedial investigation of the moat at Fort Monroe in 2007 and 2009 to investigate the potential presence of chemical constituents that may pose a risk to human health or the environment in surface sediment. Twenty surface sediment samples (n=7 in 2007 and n=13 in 2009) were collected from the moat. Sediments were also collected from six locations along the center axis of Mill Creek, six locations near the sluice gates in Mill Creek, and six sites within Mill Creek adjacent to Dog Beach landfill. Because the Mill Creek samples were collected at locations outside park boundaries, data from the three Mill Creek locations were only used for comparative purposes but did not enter into the condition score (for the assessment of the water quality indicator, in contrast, the Mill Creek samples were included in the scoring because water is more mobile than sediments). All sediment samples were analyzed for semi-volatile organic compounds (SVOC), pesticides, polychlorinated biphenyl (PCB) Aroclors, PCB congeners, and metals.

<u>Reference Condition</u>
Individual contaminant concentrations (metals, pesticides, PCB, VOC, SVOC) were compared to standard published screening criteria. Remedial investigation reports for the Fort Monroe moat and the Dog Beach landfill (SAIC 2012, Leidos 2016) primarily used freshwater criteria published by the EPA Region 3 Biological Technical Assistance Group (BTAG). We compiled freshwater and marine benchmarks employed by EPA Region 3 BTAG (Pluta 2006b) and by NOAA (Screening Quick Reference Table – SquiRTs; Buchman 2008) for comparative purposes (Table 4-7). Owing to the polyhaline salinity regime of Fort Monroe waters, we used the NOAA marine benchmark as the reference condition. Because NOAA and EPA do not publish a threshold value for iron (Buchman 2008), we used the threshold value published in the remedial investigation of the Fort Monroe moat and Dog Beach landfill (SAIC 2012, Leidos 2016). Condition scores for each contaminant were based on percent of sites above the threshold value. The average condition scores for all contaminants was calculated for 2007 and 2009, and the final score was calculated as the average of these two years.

Table 4-7. Compiled threshold values for sediment metals in freshwater and marine environments. NOAA marine thresholds were chosen for this NRCA.

			Fresh		Marine
Metal	**Units**	**RI***	**EPA**	**NOAA**	**NOAA**
Arsenic	mg/kg	9.8	9.8	5.9	7.24
Cadmium	mg/kg	0.99	0.99	0.596	0.68
Chromium	mg/kg	43.4	43.4	37.3	52.3
Cobalt	mg/kg	50	N/A	50	10
Copper	mg/kg	31.6	31.6	35.7	18.7
Iron	mg/kg	20000	N/A	N/A	N/A

***** RI = Remedial Investigation report (Leidos 2016).

Table 4-7 (continued). Compiled threshold values for sediment metals in freshwater and marine environments. NOAA marine thresholds were chosen for this NRCA.

Metal	Units	RI*	Fresh		Marine
			EPA	NOAA	NOAA
Lead	mg/kg	35.8	35.8	35	30.24
Manganese	mg/kg	460	N/A	460	260
Mercury	mg/kg	0.18	0.18	0.174	0.13
Nickel	mg/kg	22.7	22.7	18	15.9
Selenium	mg/kg	2	N/A	N/A	1
Silver	mg/kg	1	N/A	0.5	0.73
Zinc	mg/kg	121	121	123	124

***** RI = Remedial Investigation report (Leidos 2016).

Current Condition and Trend

Sediment within the moat was assessed as being Moderate Concern (64% attainment) based on an average of the scores from 2007 (71%) and 2009 (57%). Metal concentrations within moat samples that were above threshold values in 2009 included arsenic, cadmium, copper, iron, lead, mercury, and zinc (Table 4-8). The condition of the moat sediments in 2009 was much lower compared to the condition of the Mill Creek sites (Table 4-9) as assessed by the percent of samples in 2009 that attained values above the threshold. In addition, several SVOCs were detected with substantially higher levels within the moat compared to the Mill Creek sites (Leidos 2016).

Table 4-8. Mean sediment concentrations (mg/kg) for metals for 20 sites within the Fort Monroe moat.

Location	Indicator	NOAA Marine Reference	Mean		
			2007	2009	Across Years
Moat	Arsenic	7.24	3.84	7.58	6.32
	Cadmium	0.68	0.21	0.83	0.59
	Chromium	52.3	14.84	28.11	23.05
	Cobalt	10	2.99	6.23	4.99
	Copper	18.7	31.98	66.71	53.48
	Iron	20000*	13060	24082	19883
	Manganese	260	71.10	122.37	102.84
	Mercury	0.13	3.78	0.64	1.84
	Nickel	15.9	7.43	15.32	12.31
	Selenium	1	1.39	0.86	1.06
	Zinc	124	114.83	267.61	209.41

Table 4-9. Attainment of sediment threshold values in 2007 (n=7) and 2009 (n=13 for moat and n=6 for each of the other locations) for Fort Monroe based on percent of sites above threshold value.

Analyte	Moat 2007	Moat 2009	Sluice Gates 2009	Mill Creek 2009*	Dog Beach 2009*
Arsenic	100	46	100	83	83
Cadmium	100	38	100	100	83
Chromium	100	92	100	100	100
Cobalt	100	85	100	100	100
Copper	43	23	100	83	83
Iron	100	31	100	83	83
Lead	14	15	100	83	83
Manganese	100	100	100	100	100
Mercury	14	23	100	83	100
Nickel	100	54	100	100	83
Selenium	0	69	100	0	100
Zinc	57	31	100	83	83
Pesticide	100	100	100	100	100
PCB Aroclor	100	100	N/A	N/A	83**
SVOC	30	41	68	78	85
Average	71	57	98	84	90

* Sites near the sluice gates, the central axis of Mill Creek, and Dog Beach were sampled in 2009 only and are included for comparison.

**PCB Aroclor concentrations were not reported for the sleuce gates and Dog Beach samples.

Contamination appeared to be higher in 2009 than in 2007; however, no trend in sediment contaminants was established because two data points in time are insufficient to assess a rigorous trend.

Pesticides, SVOCs, and PCBs are not listed owing to many ‘undetected’ values that hinder examination of mean values (but they are included in Table 4-9, which provides the number of sites above a threshold value rather than mean contaminant values). *Threshold from remedial investigation of the Fort Monroe moat and Dog Beach landfill (SAIC 2012, Leidos 2016).

<u>Data Gaps and Level of Confidence</u>

Confidence in the assessment of sediment contaminant concentrations is moderate. The spatial distribution of the data is good but little is known about temporal trends. Future monitoring of sediment contaminant levels would be needed to assess trends. Additional information that would be valuable for a comprehensive assessment of sediment resources would be how much sediment is supplied to the tidal salt marshes at Fort Monroe National Monument, as well as how much sediment is deposited through time along Fort Monroe shorelines and within the marshes. Sediment erosion tables could be established to monitor trends in sediment deposition and erosion.

The identification of threshold values proved problematic. Earlier remedial investigation reports used EPA freshwater criteria (SAIC 2012, Leidos 2016). However, owing to the polyhaline salinity regime of Fort Monroe waters, we concluded that marine criteria were more appropriate and therefore relied on NOAA marine SQuiRTs benchmarks as the reference condition. An alternative approach would have been to compromise by averaging the freshwater and marine thresholds. For comparative purposes, we provide both sets of thresholds in Table 4-7. We also provide information on sediment contamination in Mills Creek (Table 4-9), but did not use those data in the quantitative scoring of indicator condition because Mill Creek samples were collected outside park boundaries.

Sources of Expertise

- Andrew Heyes, University of Maryland Center for Environmental Science Chesapeake Biological Lab

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4.2.3. Benthic Macroinvertebrates

Relevance and Context

Benthic macroinvertebrates are known to respond to changes in the environment and are therefore often used as indicators to evaluate the condition of ecosystems. Some benthic macroinvertebrates are tolerant of a wide range of conditions and may therefore be poor indicators of specific conditions but their presence may indicate that a degraded condition may be present. Other taxa are intolerant of a wide range of conditions and their presence indicates that a certain condition may be present, such as degraded water or sediment quality. The relative proportions of related taxa or feeding groups can indicate the kinds of conditions prevailing in aquatic habitats.

Benthic macroinvertebrates are considered to be integrators of aquatic habitats and conditions because they respond as individuals and populations to the sum of habitat conditions in which they live. Over short time frames measured in days, individuals of some groups may die in response to a pollution event. Over moderate time frames measured in months or years, individuals or populations may not thrive under sustained poor conditions. Over long time frames measured in decades, species may be lost or gained depending on sustained impacts. Thus, the structure of benthic macroinvertebrate communities integrate across varying time scales to provide an assessment of short, moderate, and long-term conditions of aquatic resources.

Edotea triloba, a benthic macroinvertebrate present at Fort Monroe National Monument (Photo credit: InvertEBase Data Portal).

Data and Methods

Six sediment samples were collected from the moat for benthic community analysis and sediment grain size in 2009 (Leidos 2016). Samples were sieved through a 0.5mm mesh screen. Organisms retained on the screen were preserved in 10% formalin and stored at 4°C until laboratory analysis. In the laboratory, invertebrate specimens were sorted by type, identified, and enumerated. Organisms were identified to the lowest possible taxonomic level, which was typically to the level of genus/species. Samples were subsampled when taxa were abundant. The total number of individuals identified at each station was normalized by the sample area to obtain the total number of individuals per square meter. The sample area was calculated as the product of the total area sampled for sediments (0.04 m^2 × 3 replicates) and the fraction of the total sediment sample that was sieved for benthic community analysis (5.1 L / (3.7 L × 3 replicates)). Species richness (total number of taxa), abundance (total number of individuals and number of individuals per feeding group), Shannon-Wiener diversity index (H') and the Shannon-Wiener (also called Pielou's) evenness index (J') were calculated for each sample.

Reference Condition

The condition of benthic macroinvertebrate communities were assessed using the Chesapeake Bay benthic index of biotic integrity (B-IBI) (Llanso and Dauer 2002), which is used by the Maryland Department of Natural Resources and the Virginia Department of Environmental Quality to evaluate the ecological condition of a sample. B-IBI scores are calculated by comparing values (metrics) of key benthic attributes to reference values of non-degraded conditions in similar habitat types (Table 4-10).

Table 4-10. Thresholds of Benthic Index of Biotic Integrity (B-IBI) scores for polyhaline sand and mud (Source: Llanso and Dauer 2002).

	Polyhaline sand sites			Polyhaline mud sites		
B-BIBI Score	**1**	**3**	**5**	**1**	**3**	**5**
Shannon-wiener	<2.7	2.7-3.5	>3.5	<2.4	2.4-3.3	>3.3
Abundance (#/m^2)	<1500 or >8000	1500-3000 or >5000-8000	>3000-5000	<1000 or >8000	1000-1500 or >3000-8000	>1500-3000
Abundance of pollution-indicative taxa (%)	>15	5-15	<5	>20	5-20	<5
Abundance of pollution-sensitive taxa (%)	<25	25-50	>50	<30	30-60	>60
Abundance of deep deposit feeders (%)	<10	10-25	>25	N/A	N/A	N/A
Abundance of carnivores and omnivores (%)	N/A	N/A	N/A	<25	25-40	>40

The scoring of benthic community metrics uses thresholds established from reference data distributions (Llanso and Dauer 2002). These thresholds were established as the 5th and 50th percentile values of reference sites. For the Shannon-Wiener index, percent abundance of pollution-sensitive taxa, percent abundance of deep deposit feeders, and percent abundance of carnivores and omnivores, a score of 1 was assigned to a metric when the metric fell below the 5th percentile of reference values, a score of 3 was assigned for values between the 5th and 50th percentile, and a score of 5 was assigned for values above the 50th percentile. An upper threshold corresponding to the 95th percentile of reference sites was used for abundance of pollution-indicate taxa because higher percentages would be expected in degraded habitats. Total abundance of individuals responds bimodally to pollution (Pearson and Rosenberg 1978). Thus, upper and lower thresholds are employed for this metric, including a score of 1 assigned to values that were below or above the 5th and 95th percentile, a score of 3 assigned to values between the 5th and 25th as well as between the 75th and 95th percentile, and a score of 5 assigned to values between the 25th and 75th percentiles. Benthic community condition was scored based on 4 levels – meets goals (average B-IBI score > 3), marginally degraded (B-IBI 2.7-2.9), degraded (B-IBI 2.1-2.6), and severely degraded (B-IBI < 2). A B-IBI score >3 was considered as 100% attained (Good Condition), scores between 2.7 and 2.9 were scored as 66% attained (Moderate to Good Condition), scores of 2.1-2.6 were scored as 33% attained (Significant Concern to Moderate Condition), and a B-IBI score <2 was assessed as 0% attained (Significant Concern).

Current Condition and Trend

The condition of benthic macroinvertebrates were assessed as Significant Concern (5.5% attainment). Twenty-three taxa were collected from the six moat samples. Species richness ranged from 2 to 15 species per sample and community density ranged from 91 to 11,196 individuals per m^{-2}. The most commonly encountered taxa were polychaete worms. Benthic community abundance was dominated by pollution-indicative taxa for five of the six moat samples. Benthic communities at the remaining stations were balanced between pollution sensitive and pollution tolerant species.

B-IBI values depend on salinity regime and substrate type. The average salinity recorded at the National Oceanic and Atmospheric Administration (NOAA) Physical Oceanographic Real-Time System® (PORTS ®) station at Sewells Point (station I.D. 8638610) for September and October 2009 was 20.5 practical salinity units (psu). Sewells Point station is approximately five miles south of Mill Creek at Naval Station Norfolk. Thus, salinity is somewhat uncertain, since the moat receives flows from tides as well as stormwater. Because B-IBI are dependent on salinity, scores may change if salinity in the moat is actually in the low or high mesohaline range (Llanso and Dauer 2002). Substrate type of three of the moat stations consisted of silty sand (“sand”) with a sand content of 78 - 82% and 11 - 22% fines. The other three moat stations were sandy silt (“mud”) with a sand content of 4 – 20% and 80 – 95% fines. Thus, three moat locations were classified as polyhaline mud and three as polyhaline sand (Table 4-11).

Five of six moat sites were scored as severely degraded (B-IBI values less than 2.0). The sixth site was classified as degraded (B-IBI values between 2.1 and 2.6). Thus, average attainment of condition across the six sites was 5.5%. The benthic community assessment is based on only one sample in time and thus trend could not be calculated.

Table 4-11. Calculation of the Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI; Llanso and Dauer 2002) within Fort Monroe moat samples.

Category	Index	Polyhaline sand sites			Polyhaline mud sites		
Raw Values	Shannon-wiener	1.68	0.1	1.28	1.45	0.7	1.33
	Abundance (#/m^2)	163	833	10978	453	1014	91
	Abundance of pollution-indicative taxa (%)	11.1	97.8	70	84	100	60
	Abundance of pollution-sensitive taxa (%)	33.3	0	7.1	8	0	20
	Abundance of deep deposit feeders (%)	22.2	0	71.3	52	32.1	80
	Abundance of carnivores & omnivores (%)	11.1	2.2	6.8	12	0	0
B-IBI Scoring	Shannon-wiener	1	1	1	1	1	1
	Abundance (#/m^2)	1	1	1	1	3	1
	Abundance of pollution-indicative taxa (%)	3	1	1	1	1	1
	Abundance of pollution-sensitive taxa (%)	3	1	1	1	1	1
	Abundance of deep deposit feeders (%)	3	1	5	N/A	N/A	N/A
	Abundance of carnivores & omnivores (%)	N/A	N/A	N/A	3	1	1
Average B-IBI Score		2.2	1	1.8	1.4	1.4	1
Condition		Degraded	Severely degraded	Severely degraded	Severely degraded	Severely degraded	Severely degraded

Data Gaps and Level of Confidence

Confidence in the assessment of benthic macroinvertebrate communities at Fort Monroe National Monument is high because scores are based on six samples that all provide similar results. Thresholds are well developed and based on reference conditions (Llanso and Dauer 2002). Some uncertainties remain (see below) but do not significantly affect confidence in the assessment. The assessment was based on only one sampling in time. Benthic invertebrates should be monitored over time to assess whether the benthic index of biotic integrity changes through time and whether management actions improve values.

B-IBI methods are based on data collected from the Chesapeake Bay, not a moat bounded by stone walls that receives water and sediment input through storm drains and relies on sluice gates for water and sediment exchange with larger surrounding areas. Tidal flushing of the moat is restricted by the sluice gate; this restricted flushing coupled with relatively high sediment organic carbon concentrations (Leidos 2016) creates the potential for anoxic bottom waters and sediments within the moat. Further, the moat is a highly artificial environment and lacks the typical physical processes that would otherwise dominate benthic community composition. Thus, the Chesapeake Bay reference conditions may not adequately reflect the habitat within the moat. Nevertheless, judging from the macroinvertebrates within moat samples, the moat does not present a hospitable environment for many organisms that would otherwise inhabit waters of the Chesapeake Bay.

The Chesapeake Bay B-IBI was developed based on a database of samples collected during the summer, which was defined as July 15 through September 30 (Weisberg et al. 1997, Alden et al. 2002). Benthic community samples from Fort Monroe were collected slightly outside the index period, between September 29 and October 4, 2009. The B-IBI, however, has been found to be very stable over time, with an overall correlation of 0.97 between the first and second sampling visits to a single site during the same summer (Weisberg et al. 1997). Therefore, exceeding the end of the index period by 4 days should have a limited effect on the validity of the B-IBI results.

Sources of Expertise

- Robert Hilderbrand, University of Maryland Center for Environmental Science Appalachian Lab

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4.2.4. Beaches

Relevance and Context

The beaches at Fort Monroe National Monument are an important natural resource that impact visitation numbers for the park, especially for local visitors who have already toured the historic places and wish to visit solely for recreation. The beaches contain batteries from the old defensive structure of the fort, creating a unique experience for visitors. For the beaches to be available for recreational use such as swimming, they must not pose a health risk to users (Gaffield et al. 2003).

Beach area at Fort Monroe National Monument (Photo credit: Eric Breitkreutz).

Enterococci bacteria serve as indicators for fecal contamination in salt and brackish waters. *Enterococci* are not harmful themselves, but suggest that other potentially harmful organisms may be present. High levels of *Enterococci* bacteria indicate an increased health risk to recreational water users. The most common recreational water illnesses are gastrointestinal and may cause vomiting, diarrhea, nausea, abdominal pain, or fever. These illnesses result from swallowing water contaminated by disease-causing organisms. Contact with contaminated water can also cause upper respiratory (ear, nose and throat), and wound infections. Young children, the elderly, and those with a weakened immune system are particularly vulnerable to recreational water illnesses.

Data and Methods

Since 2004, the Virginia Department of Health has monitored beach water at up to 46 public beaches in Virginia during the swimming season from mid-May to mid-September. Beaches were visited weekly, including beaches at Fort Monroe National Monument (since 2010) and Buckroe Beach immediately to the north of Fort Monroe National Monument (Figure 4-18). Samples were analyzed for *Enterococci* bacteria using EPA-approved Clean Water Act test methods.

Figure 4-18. Location of beaches at Fort Monroe National Monument and Buckroe Beach.

Reference Condition

Bacteria outbreaks often originate from bathing sources such as pools, water parks, lakes, and beaches, which has prompted the Environmental Protection Agency to designate guidelines for the testing of recreational water sources as well as implementing thresholds for the amount of bacteria present before the area is considered unsafe for use. Although any levels of *Enterococci* can cause an infection, the threshold level set by Virginia's Water Quality Standards for *Enterococci* that significantly increases the risk of infection is 104 colonies per 100 mL.

Current Condition and Trend

Beach health was assessed as being in Good Condition (99% attainment). Across 108 and 110 samples that were collected between 2010 and 2015, only one and three samples exceeded threshold values at the beaches of Fort Monroe National Monument and Buckroe Beach, respectively (Table 4-12). Thus, across a 6-year time period, Fort Monroe National Monument beaches were closed for only one day in 2014 and reopened the following day when levels were normal (107 of 108 samples were below threshold of concern. *Enterococci* bacteria levels are generally low at Fort Monroe National Monument and one third the levels reported at Buckroe Beach. *Enterococci* bacteria levels have been stable through time.

Table 4-12. *Enterococci* colony forming units per 100 mL water sample collected weekly during the swimming season (mid-May to mid-September) at the beaches of Fort Monroe National Monument and Buckroe Beach from 2010 to 2015 (Source: Virginia Department of Health http://166.67.66.226/epidemiology/DEE/BeachMonitoring/data/).

	Fort Monroe National Monument		Buckroe Beach		
Year	**Number of colonies per 100 mL**	**Advisories**	**Number of colonies per 100 mL**	**Advisories**	**Score**
2010	8.12	0	38.65	1	100
2011	10.47	0	18.17	1	100
2012	3.94	0	5.83	0	100
2013	3.17	0	11.83	0	100
2014	19.4	1	41.85	1	100
2015	5.36	0	23.16	0	100
Average	**8.41**	**0.17**	**23.25**	**0.5**	**100**

Data Gaps and Level of Confidence

Confidence in the beach health condition and trend assessment is high owing to the long-term monitoring program implemented by the Virginia Department of Health.

Sources of Expertise

- Virginian Department of Health

Literature Cited

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4.3. Biotic Resources

Fort Monroe National Monument contains important biotic resources that require joint management with many of the cultural resources for which the monument is so well-known. The salt marsh environment within the Fort Monroe National Monument boundary serves as food web support and habitat for a variety of plant and animal species. However, the health of this marsh is under increasing threat from sea-level rise and the encroachment of non-native plant species, especially the common reed (*Phragmites australis*). The park is also home to a stable and diverse bird population of over eighty species that are residential as well as migratory. Birds make up the majority of Fort Monroe National Monument's wildlife diversity and provide insight into the health of wildlife and the availability of habitat within the park. The southern live oak (*Quercus virginiana*) trees that are present in the park are of historical importance, exemplified by the 400-500 year old Algernourne Oak that acts as a symbol of the park and is a major draw for visitors. Southern live oaks at Fort Monroe are significant biologically owing to their drought tolerance, location at the northern range limit of the species, and ability to withstand hurricanes.

The four indicators that were used to assess the condition of Fort Monroe National Monument's biota include southern live oak abundance and health, the extent and composition of marsh vegetation, the extent and spread of invasive species, and bird diversity. The southern live oaks represent a species of special concern, while the cordgrass-dominated salt marshes comprise a high-value natural system. Invasive species represent a potential threat to the ecosystem, while the bird population provides insight into the health of fauna within the park. Data used to determine the condition of these indicators at Fort Monroe National Monument were sourced from publicly available aerial imagery, marsh delineations and surveys conducted by the Virginia Institute of Marine Science, the US Fish and Wildlife Service and the US Army Corps of Engineers, and flora and fauna surveys conducted by the US Fish and Wildlife Service and other state and private organizations (Table 4-13). The scientists and citizens who have collected these data have devoted significant time and effort to obtaining, managing, and summarizing the information used in this report.

Table 4-13. Indicators and sources of data used in the assessment of biotic resources within Fort Monroe National Monument.

Indicator	Agency	Source	Year of Data Collection
Southern Live Oaks	US Fish and Wildlife	GIS data	2005
	Boy Scouts of America	Hard copy map	2009
	University of Richmond	Field survey	2016
Salt Marsh	Virginia Institute of Marine Science	Barnard 1975	1975
	US Fish and Wildlife Service	Tiner et al. 1998	1998

Table 4-13 (continued). Indicators and sources of data used in the assessment of biotic resources within Fort Monroe National Monument.

Indicator	Agency	Source	Year of Data Collection
Salt Marsh (continued)	US Army Corps of Engineers	USACE wetland delineation	2009
	National Aeronautical and Space Administration	GIS Aerial Imagery	1953-2012
	US Fish and Wildlife Service	GIS Aerial Imagery	2002-2015
	Virginia Institute of Marine Science	Galvez et al. 1998	1998
Invasive Species	US Fish and Wildlife Service	Galvez et al. 1998	1998
	US Fish and Wildlife Service	Lingenfelser et al. 2003	2003
Birds	US Fish and Wildlife Service	Galvez et al. 1998	1998
	US Fish and Wildlife Service	Lingenfelser et al. 2003	2003

4.3.1. Southern Live Oaks

Relevance and Context

Considered a cultural and historic symbol of Fort Monroe National Monument, the southern live oak (*Quercus virginiana*) is also an important indicator for the health of the ecosystem. Southern live oak is a broadleaf tree native and iconic to the Southeastern United States (Qi and Xiao 2003). It retains its dark green and leathery leaves until new leaves emerge in the spring, but defoliation may be sooner in marginal environments (Kurz et al. 1962). It is a resilient species with high drought and aerosol salt tolerance (Gilman and Watson 2006). Further, this tree species is able to withstand sustained high winds owing to its deep and widespread root system and low center of gravity, important traits in coastal areas that experience frequent hurricanes (Duryea and Kampf 2007). Because the southern live oak is adaptive, resistant, and resilient to environmental change, its population dynamics is considered an excellent indicator of ecosystem health (Gilman and Watson 1994). Fort Monroe National Monument supports a large southern live oak population that has been present for several centuries given the age of some living trees.

The most significant tree in the park is the Algernourne Oak, which is named after Fort Algernourne, the earliest ancestor of Fort Monroe National Monument. The Algernourne Oak is the oldest and largest southern live oak in Fort Monroe and a major draw for visitors (NPS 2015). The tree has a 230-cm basal diameter, a height of over 18 meters, and an estimated spread of nearly 30 meters (Dosmann and Aiello 2013). At an estimated 450 years old, the Algernourne Oak was alive when only Native Americans were present at Old Point Comfort and witnessed both the Revolutionary War and the Civil War. It is thought that many historical figures such as Robert E. Lee could have sat under the very tree at one point in history (Dosmann and Aiello 2013).

Algernourne Oak (Photo credit: Ellen Brooks, University of Richmond).

Fort Monroe National Monument is located along the northern range boundary of southern live oaks (Figure 4-19; Byron 2005). With climate change predicted to increase the number and intensity of hurricanes, the southern live oak population at Fort Monroe National Monument may come under increased pressure from natural disasters. A native species to the park, the southern live oak acts as a species of special concern for the area and has both environmental and historical significance.

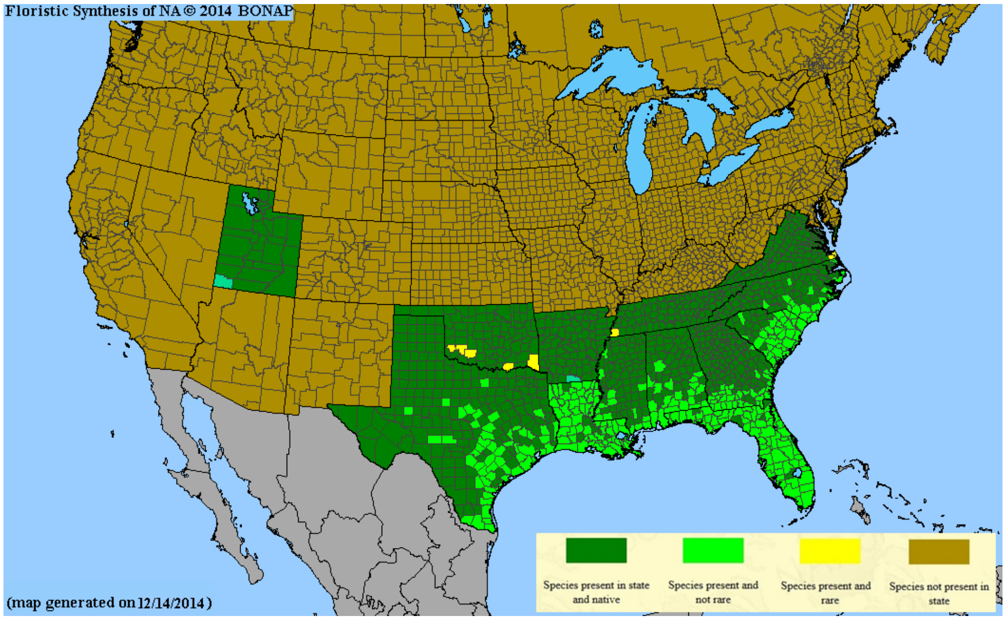
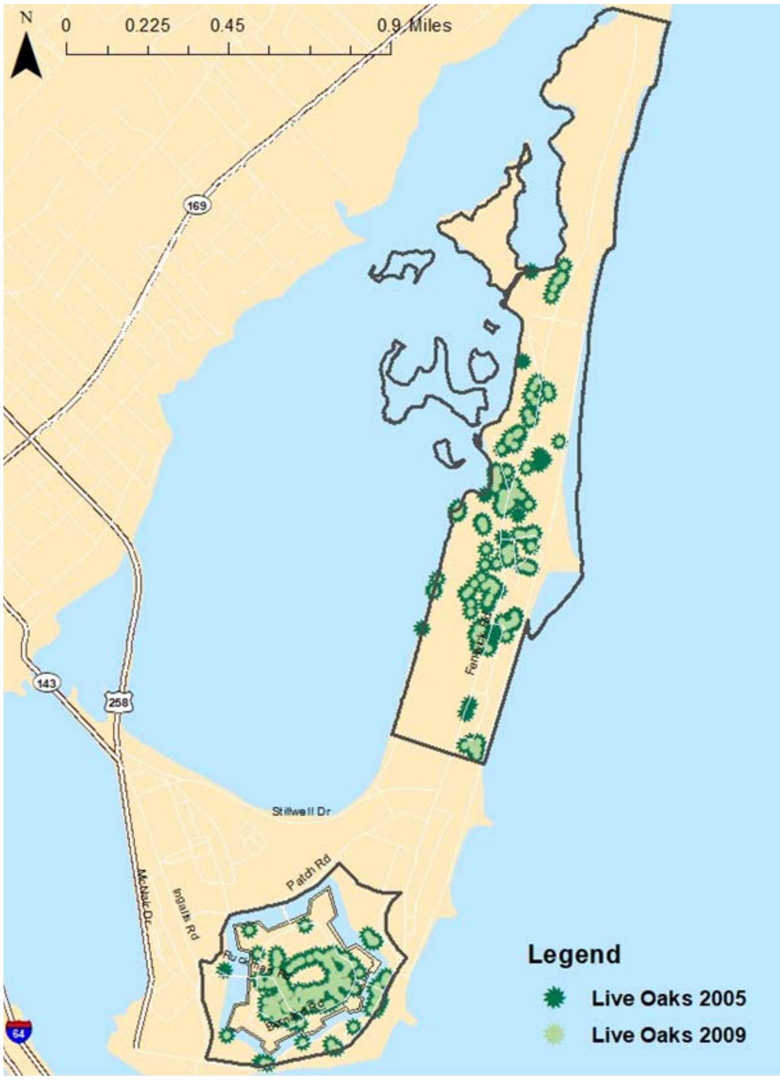


Figure 4-19. Range map of southern live oaks in North America (Source: Biota of North America Program).

<u>Data and Methods</u>

Population data for the southern live oak were based on surveys collected from three separate parties in 2005, 2009, and 2016. In 2001, the tree care company Hubbard Brothers, Inc. documented 504 southern live oak trees and 143 willow oaks (*Quercus phellos*) at Fort Monroe National Monument (Urban Forest Management Plan 2004). Geographical positions of the trees were not recorded and no electronic or hard copy datasheets are available. Therefore, these data were not included in the NRCA. A floral survey conducted by the US Fish and Wildlife Service between September 2002 and September 2003 documented 2,071 individual trees or clusters of trees, comprising 92 tree species (Lingenfelser et al. 2003). On September 18, 2003, Hurricane Isabel damaged or felled many of these trees (estimated at around 200; SAIC 2004) such that the USFWS conducted a follow-up survey in 2005 to update maps to account for damage by Hurricane Isabel. Pre-hurricane data do not provide a reliable estimate of population size because individual oaks within tree clusters were not censused. The GIS data from the 2005 survey, therefore, provide the first population census used for the NRCA. Boy Scout Troup 31 conducted another survey of all southern live oaks, willow oaks, and American elms in 2009. Location of trees was documented on a hard copy map. No digital data on tree height, trunk diameter, and width of branch mass could be found even though the data were recorded. The 2009 survey map was digitized at the University of Richmond by matching trees to the GIS spatial data from the 2005 USFWS survey (Figure 4-20).



* Solid green symbols show trees that are present in 2005 but absent in 2009.

Figure 4-20. Southern live oaks from surveys of tree species in 2005 (USFWS) and 2009 (Boy Scouts).

In addition, a third southern live oak survey was conducted by the University of Richmond in June 2016 (Figure 4-21). This survey also used the 2005 data as a baseline for location data. Google Earth images and fieldwork were used to verify tree locations. Trees were not documented in three sections of the North Beach area: the sand dunes just north of the Paradise Ocean Club, the northernmost portion of the park beyond the fence (north of the wildlife viewing platform), and the wetland area along Mill Creek in the northern part of the park near the wildlife viewing platform. Access to the first two areas was restricted and blocked off by fences, and the third area was obstructed by impassible terrain. Using Google Earth imagery, the number of live oaks in the inaccessible areas may be as many as 150 but no fewer than 60 depending on how many other large tree species are present in the area.

After the 2016 field survey, several corrections were made to both the 2005 (USFWS) and 2009 (Boy Scouts of America) datasets. Several large trees were located in the 2016 survey that were not shown in one or both of the historical data sets, but that had clearly been mature trees when the previous surveys had been conducted. This resulted in two additional trees reported for the 2005 USFWS survey and 9 additional trees reported for the 2009 Boy Scout survey.

During the 2016 survey, size, crown health, and seedling recruitment data were collected for 125 trees within the fort district of the park. Eleven trees in this portion of the park were not surveyed due to fences and other obstructions that prevented access (Figure 4-21).

Figure 4-21. Southern live oaks recorded in 2016 for Fort District of Fort Monroe National Monument (Source: University of Richmond).

Stem diameter was recorded for each tree at breast height (DBH). For trees with a fork below 1.37 m, each fork was measured independently, and the tree was assigned an overall DBH of the square root of the sum of each of the squared trunk diameters ($\sqrt{\sum_i^n i^2}$).

Crown health was assessed while walking in a circle around the tree. An estimate was made of the percentage of the foliage that was intact (no holes, ragged edges, off-color spots, bumps, or deformities). This estimate was used to assign a foliage health class to the tree (Class 1: 90-100%

intact, Class 2: 50-89%, Class 3: 15-49%, Class 4: 0.1-15%, Class 5: dead and standing at angle > 45° or broken off at > 1.37 m).

Seedling recruitment was assessed by recording the number of seedlings within a 10-m radius of each tree.

Reference Condition

The baseline reference condition used to assess the size of the southern live oak population was the number of trees recorded in the 2005 USFWS survey. This metric was scored at 100% attainment if the number of trees recorded in the most recent (2016) survey were equal to or greater than the number observed in the baseline survey. In the case of a declining population, the attainment score was calculated as the average annual survival rate.

Seedling recruitment, growth, and survival are important for the sustainability of populations such that if mortality occurs, new trees must be recruited into the population. Southern live oaks mature in several decades depending on the environment but may live for several centuries. The growth rate of live oaks is reported as 60-75 cm per year in height (Clemson Cooperative Extension) and 0.8 cm per year in diameter (Cavendar-Bares et al. 2004). Assuming trees mature at diameters greater than 30 cm, recruitment was scored based on the size structure of the population observed in 2016 and the presence or absence of seedlings in that data set. Seedling recruitment was assigned a score of 100% if at least 10% of the trees in the survey had seedlings in their immediate understory. Seedling growth and survival was reported by the presence of younger trees and scored at 100% if at least 10% of the population of trees surveyed were in the 0-30 cm DBH size class.

Crown health is both a measure of tree health and a valuable aesthetic resource for the park. The metric was scored by assigning a weight to each class (Class 1 = 100%, Class 2 = 50%, Class 3-5 = 0%), multiplying the fraction of surveyed trees in each class by its corresponding weight, and summing these values. Thus, crown health was scored at 100% attainment if all trees had excellent (Class 1) crown health. The metric was scored as 0% attainment if all trees were in Classes 3-5.

Current Condition and Trends

The overall score for southern live oaks is Moderate Concern (64%) based on the average of the metric scores for population size (98%), seedling recruitment (100%), seedling survival (0%) and crown health (60%) with an overall declining trend.

The population size of southern live oaks is declining for the park. The number of trees decreased from 379 in 2005 to 324 in 2009, with close to 14 trees lost per year (Table 4-14) for an annual survival rate of 96%. The rate of decline slowed for the years 2009-2016, and during these seven years only 11 trees, or 1.5 trees per year, were lost. The overall annual survival rate from 2005-2016 was 98%.

Trees within the fort district of the park had a slightly higher annual survival rate compared to those of the park overall for the 11-year period (Table 4-14). However, the rate at which trees were lost within the fort was much greater during the 2009-2016 period, accounting for 100% of overall tree mortality within that period.

Table 4-14. Number of southern live oak trees observed in three surveys within the fort area (delineated by the moat) and within the entire Fort Monroe National Monument.

Year	Fort	Park
2005	152	379
2009	147	324
2016	136	313

Of the 136 trees in the moat area, only 125 were accessible for surveying during the 2016 survey (DBH measurements were not taken on an additional three of these trees). Twenty-three of these (or 18%) had seedlings within a 10-m radius with a total of 233 documented seedlings. Many of these seedlings are likely sprouts from root collars and roots. The age structure of the population is late successional with more than 50% of the trees greater than 60 cm DBH (Table 4-15). Given the longevity of the southern live oak, the overall shape of this age distribution is not unexpected and one would expect a high proportion of the trees to be large. Yet, no trees in the 2016 survey had a DBH < 20 cm and only 10 trees were < 30 cm DBH. This skewed age structure suggests that the mortality rate between seedling stage and age 25 years (assuming a growth of 0.8 cm per year) is very high. Given the high incidence of live oak seedlings, the score for seedling recruitment is 100%, but the growth and survival of these seedlings is very low (0% attainment).

Table 4-15. Number of southern live oaks within individual size classes from 2016 survey of Fort Monroe National Monument (Source: University of Richmond).

Diameter (cm)	# of Trees
1-10	0
11-20	0
21-30	10
31-40	6
41-50	12
51-60	27
61-70	10
71-80	16
81-90	7
91-100	13
>100	21
Total	122

The crown health of the trees sampled in 2016 was of moderate concern. Thirty-seven percent of all trees were in excellent condition (Class 1) and 47% were in moderate (Class 2) condition. Thus, the overall score for crown health was 60% (Table 4-16).

Table 4-16. Number of southern live oak trees in each crown health category from 2016 survey of Fort Monroe National Monument (Source: University of Richmond).

Class	Description	Count	Fraction	Weight	Score
Class 1	90-100% intact branches	46	0.37	100%	36.8%
Class 2	50-89% intact branches	59	0.47	50%	23.6%
Class 3	15-49% intact branches	13	0.10	0%	0%
Class 4	0.1-15% intact branches	5	0.04	0%	0%
Class 5	dead and standing at angle > 45° or broken off at > 1.37 m	2	0.02	0%	0%
Total					**60%**

Data Gaps and Level of Confidence

Confidence in the assessment of the southern live oak indicator is moderate. Despite differences in sample designs, data collection format, and expertise (USFWS personnel, Boy Scouts, university students), there is good agreement among the three datasets used in the analysis. However, data collected prior to Hurricane Isabel in 2003 were not sufficiently detailed and documented to be included in the analysis. Pre-hurricane data do not provide a reliable estimate of population size because individual oaks within tree clusters were not censused. It is likely that the mortality rate of southern live oaks was higher following this storm than the annual rate reported here. Any future increase in frequency and intensity of these powerful storms could have a damaging effect on the southern live oak population and their potential impacts should be closely monitored.

Additional uncertainties are associated with the digitization of historic data, the lack of detailed recruitment data, and the use of best professional judgement in establishing some of the thresholds of concern. Regular, even annual, surveys of the flora within Fort Monroe National Monument using GIS mapping are recommended to allow future assessments of the health and population trends of the southern live oak population. All areas of the park should be included in these surveys. These surveys could be used to help guide potential planting of seedlings in areas that have seen mortality and limited recruitment and to direct tree care that cuts out dead branches and introduces a fertilization schedule. Finally, southern live oaks at Fort Monroe National Monument are located at the northern extent of the species' range. Genetic analysis of the population would determine how it is related to other populations further south and whether the population is isolated or connected to them. This information could help in determining whether southern live oaks at Fort Monroe National Monument can maintain a sustainable and thriving population as they confront future threats.

Sources of Expertise

- Patrick Baldwin, College of William and Mary and Virginia Native Plant Society
- Christopher Beagan, Historical Landscape Architect, Olmsted Center for Landscape Preservation
- Dewey Blyth, Troop 31 Boy Scouts of America
- Hubbard Brothers, Inc. Tree Care

- John McCloskey, Fish and Wildlife Biologist, U. S. Fish and Wildlife Service, Virginia Field Office, Gloucester VA.

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4.3.2. Salt Marsh

Relevance and Context

Tidal marshes are important natural resources within estuarine landscapes. These critical resources reduce shoreline erosion, improve water quality, act as carbon sinks, and support commercially important fisheries (Barbier et al. 2011). Yet, more than half of marshes in the US have been altered or destroyed in the last century (Dahl 1990, Craft et al. 2009, Pendleton et al. 2012), and more continue to be lost as sea levels rise (e.g., Church and White 2006, Jevrejeva et al. 2008, Woodworth et al. 2009, Gehrels and Woodworth 2013) and developed shorelines provide few opportunities for landward migration (Kirwan and Megonigal 2013). In the 21st century, salt marshes will be impacted by rising water levels (Gonzalez 2012) with salt marshes within the Chesapeake Bay region already showing signs of decline (Kirwan et al. 2010, Kirwan and Megonigal 2013).

The salt marshes at Fort Monroe National Monument are located within Mill Creek (Figure 4-22), which is a large, shallow body of water that is exposed to twice daily tides of 0.75 m amplitude. The average salinity recorded at the National Oceanic and Atmospheric Administration (NOAA) Physical Oceanographic Real-Time System® (PORTS ®) station at Sewells Point (station I.D. 8638610) approximately five miles south of Mill Creek is 20.5 practical salinity units (psu). The Mill Creek southern portion faces a shore wall composed of concrete and other hard materials, whereas the northern portion is more natural (Beard et al. 2009). Dredging occurred in Mill Creek in 1918, which removed sediments to transform the mouth of Mill Creek from a depth of 1.5 m to a depth of a little over 7 m.

Figure 4-22. Historic aerial photo of the marsh islands from 1953 and a recent aerial image from 2012, at Fort Monroe National Monument.

The salt marshes at Fort Monroe National Monument are one of the park's most prominent natural resources. The marshes are classified as Group One (Barnard and Silberhorn 1975), which describes wetlands that "have the highest values in productivity and wildfowl and wildlife utility and are closely associated with fish spawning and nursery areas. They also have high values as erosion inhibiters, are important to the shellfish industry and are valued as natural shoreline stabilizers. Group One marshes should be preserved."

Data and Methods

Tidal marsh inventories of Mill Creek were conducted in 1975 by the Virginia Institute of Marine Science (Barnard and Silberhorn 1975), in 1994/95 by the US Fish and Wildlife Service (Tiner et al. 1998) and in 2009 by the US Army Corps of Engineers (USACE 2009). The 1975 tidal marsh inventory used aerial photographs and topographic maps to identify locations of wetlands and observe vegetation patterns (Barnard and Silberhorn 1975). Patterns were validated through further ground surveys. The 1975 wetland inventory documented 71.1 acres of wetlands within Mill Creek of which 67 acres of wetlands were within the Fort Monroe National Monument boundary. An additional 4.1 acres of fringing marsh occurred along the western shoreline of Mill Creek outside of Fort Monroe National Monument boundaries (Barnard and Silberhorn 1975).

Tiner et al. (1998) subsequently conducted a wetlands inventory at Fort Monroe National Monument using conventional photointerpretation techniques to delineate wetlands with 1:40,000 scale color infrared photography dated 1994 and 1995. This inventory documented 85.2 acres of wetlands at Fort Monroe National Monument. Of this total extent, most was emergent estuarine wetlands (65.4 acres).

In 2009, the Norfolk District Corps of Engineers Regulatory Office completed a wetland delineation at Fort Monroe National Monument (USACE 2009). The delineation was verified using methodology from the USACE 1987 Wetlands Delineation Manual (USACE 1987); the Regional Supplement to the Corps of Engineers Wetlands Delineation Manual: Atlantic and Gulf Coastal Plain Region (USACE 2008); and positive indicators of wetland hydrology, hydric soils, hydrophytic vegetation, and the presence of a mean high water mark observed in the field (USACE 2009). The 2009 wetland delineation, which included a slightly different property boundary and a more expansive area than the previous wetlands investigations (USACE 2009), documented 8.95 acres of nontidal emergent wetlands and shrub-scrub wetlands, 53.5 acres of tidal wetlands, and 79.96 acres of tidal waters (from the property boundary to the mean high water mark).

Estimates of the extent of wetland derived from the three historic snapshots in time were extended to the period between 1937 and 2015 using aerial imagery obtained from the Virginia Institute of Marine Science (VIMS) and the National Aeronautics and Space Administration (NASA). For each data frame, wetlands were delineated and areal extent calculated using ArcGIS. Area of fringing marshes along Dog Beach was not calculated because boundaries between wetland and upland were often hard to assess with confidence without field validation.

The composition of marsh vegetation at Fort Monroe National Monument based on the 1975 study of Mill Creek salt marshes (Barnard and Silberhorn 1975), a 1998 biodiversity study (Galvez et al. 1998) and a follow-up biodiversity study in 2003 (Lingenfelser et al. 2003). The 1975 study documented dominant marsh species for different marsh segments but did not comprehensively document biodiversity. The 1998 biodiversity used a visual walk-through approach and listed species frequency as "occasional", "rare", or "common" (Galvez et al. 1998). The 2003 study applied GIS methods to separate Fort Monroe National Monument into spatial polygons and determined if plant species had been missed in the 1998 survey for each of the polygons (Lingenfelser et al. 2003). Marsh islands located within Mill Creek were bisected on foot and all herbaceous and woody plants encountered were identified to species.

<u>Reference Condition</u>

The reference condition for marsh extent is based on the 1975 survey (Barnard and Silberhorn 1975). The extent reported in 1975 was considered the baseline level. Current condition was calculated as the percent of 1975 marsh that was remaining the period extending from 2011 to 2015. Trend was reported using the marsh extent estimates from 1937 to 2015. It was categorized as positive if the amount of marsh was increasing, and negative if the amount had decreased.

<u>Current Condition and Trends</u>

Marsh condition was scored as Good Condition (67% attainment) with a declining trend. The three historic studies (Barnard and Silberhorn 1975, Tiner et al. 1998, USACE 2009) suggested a decrease in Fort Monroe National Monument salt marsh extent from 67 acres in the mid-1970's to 65.4 acres in the mid-1990's to 53.5 acres in 2009. The average marsh extent for the most recent five years of data (2011-2015) was 28.77 acres, which is 67% of the marsh extent recorded in the 1975 baseline survey (Table 4-17).

Table 4-17. Recent estimates of marsh extent in Fort Monroe National Monument (Source: VIMS) compared to 1975 estimate (Barnard and Silberhorn 1975).

Year	1975	2011	2012	2013	2014	2015	5 Year Average (2011-2015)
Acres	43.00	29.50	28.98	28.64	28.66	28.07	28.77
% Remaining							67%

Since the first historic image from 1937 to the present, salt marsh extent at Fort Monroe National Monument decreased from 59 acres to 28 acres (Figure 4-23); thus, more than half of the marsh was lost in less than a century. On average, 0.35 acres are lost each year. These data show a strongly negative downward trend, which is similar to declines observed at Blackwater Wildlife Refuge for the past few decades (Ball 2012). If the declining trend continues at this same rate, salt marshes will no longer exist at Fort Monroe National Monument in Year 2095.

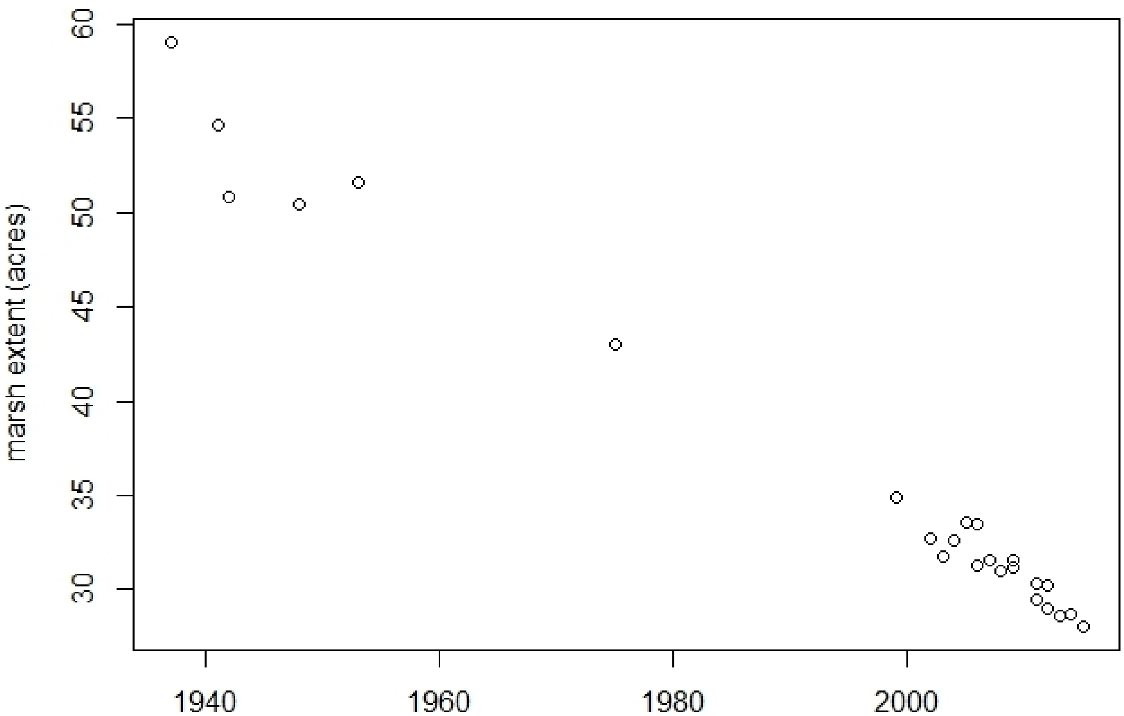

Figure 4-23. Marsh extent in Mill Creek estimated from aerial images dating from 1937-2012 (Source: NASA), 2002-2015 (Source: VIMS), and 1975 survey (Source: Barnard and Silberhorn 1975).

Species composition within the salt marshes at Fort Monroe National Monument is typical for salt marsh communities in the mid-Atlantic region (Table 4-18). Barnard and Silberhorn (1975) documented five species or genera within the salt marshes of Mill Creek with 64% occurring as cordgrass, 26% as black needlerush, and the rest as saltbushes, sea lavender, and saltwort. Galvez et al. (1998) observed 249 plant species at Fort Monroe National Monument, of which 13 were marsh plants. The more thorough surveys by Lingenfelser et al. (2003) documented 380 plant species within the entire park and 13 marsh species. Species identity was consistent among surveys except for Salicornia species. Of the 13 species, five were common including *Baccharis halimifolia*, *Borrichia frutescens*, *Iva frutescens*, *Spartina cynosuroides* and *Spartina patens*.

Table 4-18. Marsh species observed in Fort Monroe National Monument during three surveys in 1975 (Barnard and Silberhorn 1975), 1998 (Galvez 1998), and 2003 (Lingenfelser et al. 2003).

Scientific name	Common name	1975	1998	2003	Frequency
Atriplex patula	spear saltbush	X	X	X	Occasional
Baccharis halimifolia	Groundseltree	X	X	X	Common
Borrichia frutescens	bushy seaside tansy	–	X	X	Common
Distichlis spicata	Saltgrass	–	X	X	Occasional
Iva frutescens	marsh-elder	–	X	X	Common
Juncus roemerianus	needlegrass rush	X	X	X	Occasional
Limonium carolinianum	sea-lavender	X	X	X	Occasional

Table 4-18 (continued). Marsh species observed in Fort Monroe National Monument during three surveys in 1975 (Barnard and Silberhorn 1975), 1998 (Galvez 1998), and 2003 (Lingenfelser et al. 2003).

Scientific name	Common name	1975	1998	2003	Frequency
Salicornia europeae	common glasswort	–	X	–	Rare
Salicornia maritima	slender glasswort	–	X	X	Occasional
Salicornia virginica	Virginia glasswort	–	–	X	Rare
Spartina alterniflora	smooth cordgrass	X	X	X	Occasional
Spartina cynosuroides	big cordgrass	X	X	X	Common
Spartina patens	saltmeadow cordgrass	X	X	X	Common
Symphyotrichum tenuifolium	perennial saltmarsh aster	–	X	X	Occasional

Data Gaps and Level of Confidence

Confidence is high that the salt marshes at Fort Monroe National Monument are declining in size and are therefore severely degrading. What is not clear is what is causing the decline. Filling this data gap would require monitoring the sediment load of Mill Creek as well as sediment accretion of the marshes through time with sediment erosion tables and other approaches. Although confidence is high that the salt marshes support typical salt marsh plant communities, the data are inadequate to determine whether species abundances, or the high marsh/low marsh balance that species can indicate are shifting in response to rising water levels, changes in marsh area, or nutrient loading.

Sources of Expertise

- Robert Orth, Virginia Institute of Marine Science
- Dave Wilcox, Virginia Institute of Marine Science

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4.3.3. Invasive Species

<u>Relevance and Context</u>

Invasive species are defined as plants that are intentionally or accidentally introduced by human activity into an area where they cause harm to both natural resources and economic activities. They are often brought to new areas by humans or animals and can greatly impact the environment in which they are found (Saltonstall 2003). With global commerce and transportation increasing, invasive plant species are becoming an ever increasing problem (Mack et al. 2000). Invasive plant species can lower biodiversity, change nutrient cycling and productivity, degrade wildlife habitat, and alter wetland hydrology (Zedler and Kercher 2004, Swearingen and Saltonstall 2010). Invasive plants are also more likely to form monotypic stands in wetlands than in other environments, making them an even greater threat in these locations (Zedler and Kercher 2004).

In 2008, the National Park Service estimated that more than 2.6 million acres, over 5% of park lands, were dominated by non-native species (NPS 2008). The natural and cultural resources on these lands, including Fort Monroe National Monument, are at significant risk. Non-native plant species are of particular concern at Fort Monroe National Monument owing to its past history as a military post. This prior land use resulted in considerable traffic and disturbance during construction and occupation of the post (Lingenfelser et al. 2003). These factors create opportunities for invasive species to colonize and spread (Zedler and Kercher 2004) within Fort Monroe National Monument.

Of all of the invasive plant species located in Fort Monroe National Monument, the common reed (*Phragmites australis*) poses the greatest ecological threat due to its ability to spread aggressively and quickly (Lingenfelser et al. 2003). *Phragmites* is a widespread invasive species and is found in many marsh systems world-wide. Once established, it is able to rapidly take over wetlands by creating dense patches and crowding out native species (Swearingen and Saltonstall 2010).

Phragmites at Fort Monroe National Monument (Photo credit: Anna Hakkenberg, University of Richmond).

Japanese honeysuckle (*Lonicera japonica*) is also prevalent in the park and is found in almost all natural areas (Lingenfelser et al. 2003). The common reed and the Japanese honeysuckle are both so well established within the park and region that eradication would be extremely difficulty and is unlikely. Additional species that are considered invasive have been planted historically or were used as landscaping plants within the national monument boundary. These species have the potential to spread to the natural areas of the park and disrupt the natural setting (Lingenfelser et al. 2003).

Data and Methods

Data used to assess condition for the resource were from 1998 (Galvez et al. 1998) and 2003 (Lingenfelser et al. 2003) flora surveys conducted at Fort Monroe National Monument. Data from the 1998 survey were collected through visual encounter survey. Areas within the park were walked in a systematic manner and all flora noted (Galvez et al. 1998). In the 2003 survey, a stratified random design was used to identify flora, including invasive species. Total acreage of *Phragmites australis* was also estimated in the 2003 survey (Lingenfelser et al. 2003).

To assess and score the overall threat of invasive species in the park, the percent of native species that were present was calculated from the 1998 survey (Galvez et al. 1998). This overall percentage of native species gives an estimate of the extent of the infestation by non-native species within the park. The percent of marsh habitat that was *Phragmites*-free in the 2003 survey was also calculated (Lingenfelser et al. 2003). The presence of *Phragmites* was used as an estimate for the overall health of the park because it is the invasive species that posed the greatest threat to ecological health. The two scores obtained were then averaged to give an overall condition assessment of invasive species in the park.

Since repeat data were not available to assess the more current condition of invasive species within the park, trend could not be assessed using data specific to Fort Monroe National Monument. Therefore, trend was assessed using regional information concerning patterns of *Phragmites* growth in coastal areas where the invasion has been largely left untreated.

Reference Condition

The reference value for nativeness of the flora in the park was 100% when all species were native and calculated as % native when non-native species were present. To assess the condition of *Phragmites* within the park, it was determined that the extent of *Phragmites* should not exceed 2% of the total marsh area. This reference condition was used because even a small change in native flora can be detrimental to an ecosystem as a whole with a species as aggressive as *Phragmites*. Therefore, it was determined that 2% or less cover of *Phragmites* would still allow for the success of the native marsh vegetation (Faber-Langendoen 2008). Anything at or below 2% cover was considered 0% attainment; below 2% cover was considered 100% attainment.

Current Conditions and Trends

The current condition of invasive species in the park is of Significant Concern (27% attainment) based on percent native species within the park flora (55% attainment) and percent cover of *Phragmites* in the high marsh (0% attainment). Trend is assessed as degraded based on observed trends of *Phragmites* invasions in the region.

The survey from 1998 (Galvez et al. 1998) documented 113 introduced species, which was 45% of total species present at Fort Monroe National Monument. The 2003 survey (Lingenfelser et al. 2003) identified 5 of these species as being of greatest concern. These include Japanese honeysuckle (*Lonicera japonica*), white mulberry (*Morus alba*), fragrant honeysuckle (*Lonicera fragrantissima*), tree-of-heaven (*Ailanthus altissima*), and the common reed (*Phragmites australis*). Japanese honeysuckle was the most widespread invader, located in almost all of the natural areas. White mulberry and fragrant honeysuckle were frequently found adjacent to Mill Creek within Dog Beach. Tree-of-heaven was locally abundant along the shoreline on the east side of the main entrance. Although it was contained in a small area in 2003, it has the potential to spread rapidly due to its aggressive nature.

Ocular field reconnaissance from 2003 showed that 3 to 5 acres of high marsh area are dominated by *Phragmites*. *Phragmites* is located from the fence line at the northern terminus of the park, down the Mill Creek shoreline, to the playground behind the picnic shelter (Lingenfelser et al. 2003). This area invaded by *Phragmites* represents 3.5-5.9% of the total area of the marsh environment at Fort Monroe National Monument, which represents a 0% attainment of the threshold for *Phragmites*.

The trend of invasive species, especially *Phragmites*, is assumed to be declining, indicating that cover of invasive species is increasing. This assumption was made considering that no efforts have been made to reduce or eliminate invasive species within the park. This assumption is further supported by research conducted on *Phragmites* in other coastal areas of the Chesapeake Bay. These studies have found, for example, an increase in *Phragmites* patch area of 25 times in 25 years if left untreated (McCormick et al. 2010).

Data Gaps and Level of Confidence

Although the 1998 and 2003 flora surveys are useful in providing information regarding the presence of various invasive species within Fort Monroe National Monument, they do not provide quantitative data to rigorously evaluate the extent of invasive species spread except in the case of *Phragmites*. Both of these surveys are over a decade old and changes in invasive species spread and composition could be substantial in that time period. The presence and extent of invasive species at Fort Monroe National Monument should be monitored and mapped to determine whether and how invasive species are spreading. Confidence in the trend of this assessment is low due to a lack of more recent data to compare the current presence of invasive species to the 1998 and 2003 surveys.

Sources of Expertise

- Kevin Heffernan, Virginia Department of Conservation and Recreation

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4.3.4. Birds

<u>Relevance and Context</u>
Fort Monroe National Monument is home to a diverse community of wildlife, from aquatic invertebrates to land mammals. In addition to their intrinsic value, these animals represent important natural resources for the park because they provide visitors with the opportunity to engage in wildlife-related activities, such as fishing and wildlife viewing.

Between the Chesapeake Bay shoreline and Mill Creek salt marsh habitats, birds can be observed in the park in greater abundance and diversity than any other group of animals (Galvez et al. 1998). Marsh birds, shorebirds, songbirds, and others can be seen regularly in the area. Fort Monroe National Monument is located in a major migratory flyway, and many species - such as the yellow-crowned night-heron (*Nyctanassa violacea*) - are only present during certain times of year. Others - including the double-crested cormorant (*Phalacrocorax auritus*) - are year-round residents. As a result of this high biodiversity, bird watching is a popular wildlife-related activity in the park. The potential benefits to local economies of bird watching as a high-value, low-investment activity are well-documented (Hvenegaard et al. 1989)

Birds were not always abundant at Fort Monroe National Monument. In the late nineteenth and early twentieth centuries, bird hunting around the Chesapeake Bay for commercial and sporting purposes reached its peak. Over-harvesting, combined with habitat destruction, led to the rapid decline of a number of species. Although many populations have rebounded, these historic trends serve as a reminder of how sensitive bird populations are to the impacts of human activity. Today, major stressors to bird populations in Fort Monroe National Monument include destruction of food resources and habitat, especially shallow-water habitats like that of Mill Creek (Perry et al. 1996); heavy metal poisoning, including lead poisoning that results from recreational use of lead (Mateo et al. 1997, Di Giulio and Scanlon 1984); and proximity to urban and suburban development (DeLuca et al. 2004). The sensitivity of bird populations, combined with the wide variety of birds that have recently been documented and the relative ease of their documentation, makes bird diversity a useful natural resources indicator for Fort Monroe National Monument.

Data and Methods

The primary data used in this NRCA were the results of two bird surveys conducted by the US Fish and Wildlife Service (USFWS) in 1996 (Galvez et al. 1998) and 2009-2010 (Condon et al. 2010). The 1996 survey included a systematic walkthrough during the spring of 1996 using binoculars and sounds to identify bird species, a mid-winter air surveys of waterfowl in the area, and literature searches to identify species that may have been missed during the walkthrough. The 2009-2010 survey was conducted over ten days including breeding surveys in June 2009 and migration surveys in September/October 2009 and April/May 2010. Methods included mist-netting (weather permitting), point counts in specific areas, and park-wide visual/aural surveys.

Reference Condition

A quantitative value for the resource condition was calculated by determining the percentage of the species observed in 1996 that were still present in 2009-2010. A score of 100% would mean that every species that was present in 1996 was observed again during the 2009-2010 surveys.

Current Condition and Trends

Bird diversity at Fort Monroe National Monument was assessed as being in Good Condition (71% attainment). No trend could be determined as only two studies were available.

A total of 78 species were documented in 1996 (Galvez et al. 1998) and 89 species in 2009/10 (Condon et al. 2010). Thirty-three species were present in 2010 that were not documented in 1996, and 22 species observed in 1996 were not documented in 2010 (Table 4-19). Although the total number of species documented in 2010 is greater than those documented in 1996, only 71% of the 1996 species were present for the 2010 survey.

Table 4-19. Bird species observed in one survey but not the other at Fort Monroe National Monument (Sources: Galvez et al. 19987, Condon et al. 2010).

Species	Observed in 1996, but not 2009/2010	Observed in 2009/2010, but not in 1996
American coot	✓	–
American kestrel	✓	–
American redstart	–	✓

Table 4-19 (continued). Bird species observed in one survey but not the other at Fort Monroe National Monument (Sources: Galvez et al. 19987, Condon et al. 2010).

Species	Observed in 1996, but not 2009/2010	Observed in 2009/2010, but not in 1996
bald eagle	–	✓
barn owl	✓	–
black-bellied plover	✓	–
blackburnian warbler	–	✓
black-capped chickadee	✓	–
black-throated green warbler	–	✓
blue grosbeak	–	✓
blue-headed vireo	–	✓
brant	✓	–
brown creeper	–	✓
Carolina wren	–	✓
cedar waxwing	–	✓
chimney swift	–	✓
common bobwhite	✓	–
cooper's hawk	–	✓
dark-eyed junco	✓	–
downy woodpecker	–	✓
eastern bluebird	–	✓
eastern phoebe	–	✓
field sparrow	–	✓
gadwall	✓	–
golden-crowned kinglet	–	✓
great-crested flycatcher	–	✓
greater yellowlegs	–	✓
green-winged teal	✓	–
hairy woodpecker	–	✓
hooded merganser	–	✓
horned grebe	✓	–
house wren	✓	–
marsh wren	✓	–

Table 4-19 (continued). Bird species observed in one survey but not the other at Fort Monroe National Monument (Sources: Galvez et al. 19987, Condon et al. 2010).

Species	Observed in 1996, but not 2009/2010	Observed in 2009/2010, but not in 1996
northern gannet	✓	–
northern rough-winged swallow	–	✓
pied-billed grebe	✓	–
purple finch	✓	–
red-bellied woodpecker	–	✓
red-breasted nuthatch	✓	–
rose-breasted grosbeak	–	✓
ruby-crowned kinglet	–	✓
ruddy turnstone	✓	–
semipalmated plover	–	✓
semipalmated sandpiper	–	✓
sharp-tailed sparrow	✓	–
swamp sparrow	–	✓
tree swallow	✓	–
tundra swan	✓	–
white-crowned sparrow	–	✓
willow flycatcher	–	✓
winter wren	–	✓
wood thrush	–	✓
yellow-bellied sapsucker	–	✓

Several threatened and endangered species of birds were observed in the surveys (Galvez et al. 1998, Condon et al. 2010). The federally and state-threatened piping plover (*Charadrius melodus*) nests in the region. It is sighted infrequently at Fort Monroe National Monument (one to five observations per year), but has not been observed nesting in the park (SAIC 2012). Other state-threatened species observed at Fort Monroe National Monument include the peregrine falcon (*Falco peregrinus*) and gull-billed tern (*Gelochelidon nilotica*) (Galvez et al. 1998). The bald eagle (*Haliaeetus leucocephalus*) is protected by the Federal Bald and Golden Eagle Protection Act. Many of the birds are protected by the Migratory Bird Treaty Act.

Brown pelican at Fort Monroe National Monument (Photo credit: Ellen Brooks, University of Richmond).

Other species documented in the surveys are listed as species of special concern in Virginia (Galvez et al. 1998, Condon et al. 2010). The clapper rail (*Rallus crepitans*), sanderling (*Calidris alba*), semipalmated sandpiper (*Calidris pusilla*), black skimmer (*Rynchops niger*), willow flycatcher (*Empidonax traillii*), and wood thrush (*Hylocichla mustelina*) are on the yellow WatchList, which includes species that are either declining or rare and are species of national conservation concern (Condon et al. 2010). The least tern (*Sternula antillarum*) is included on the red WatchList, which includes species that are declining rapidly and/or have small populations or limited ranges and face major conservation threats (Condon et al. 2010). The least tern nests in colonies in shallow depressions in an open sandy area, gravelly patch, or exposed flat. It migrates out of the area in fall. Breeding colonies have not been found at Fort Monroe National Monument (SAIC 2012). The brown creeper (*Certhia americana*), brown pelican (*Pelecanus occidentalis*), golden-crowned kinglet (*Regulus satrapa*), great egret (*Ardea alba*), and winter wren (*Troglodytes hiemalis*) are also considered species of special concern in Virginia.

Data Gaps and Level of Confidence

The confidence in the assessment of this indicator is low. Although the two US Fish and Wildlife Service surveys used rigorous and well-documented methods, they provide only two snapshots in time. Data from Audubon Society Christmas Bird Counts or USGS Breeding Bird Surveys could potentially augment currently available data. It is not clear whether the difference in species detected for each year is due to detectability or other factors such as regional population decreases or localized habitat changes. Additional data and study of the bird resources of the park could also be used to develop a more scientifically based reference condition.

Sources of Expertise

- Ed Gates, University of Maryland Center for Environmental Science Appalachian Laboratory

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4.4. Landscape Dynamics

In addition to its rich historical context, the Fort Monroe National Monument landscape is defined by its shoreline and beaches; sweeping views of the Chesapeake Bay; human structures and development; and forest, grassland and wetland ecosystems. Combined, these elements present a diverse and dynamic mosaic of landscape features that require careful consideration and management. Due to its intensive historical uses, most of the landscape has been imprinted by human modifications. These modifications include buildings and parking lots that reduce water infiltration and bulkheads and seawalls that have armored the shore. Four categories of indicators were used to assess landscape dynamics in Fort Monroe National Monument including shoreline erosion and naturalness, viewshed, impervious surfaces, and dune geomorphology. Specific metrics analyzed for these indicators were as follows:

- percentage of shoreline affected by erosion;
- percentage of shoreline that is natural;
- amount of different land cover types within the park visible from park overlooks and observation points;
- percentage of the park in impervious surface land covers; and
- height and width of dune vegetation.

Data used for this assessment were sourced from the Comprehensive Coastal Inventory Program (CCI), Virginia Institute of Marine Science (VIMS), National Park Service, US Geological Survey and Google Earth Imagery (Table 4-20).

Table 4-20. Indicators and sources of data used in the assessment of landscape dynamics within Fort Monroe National Monument.

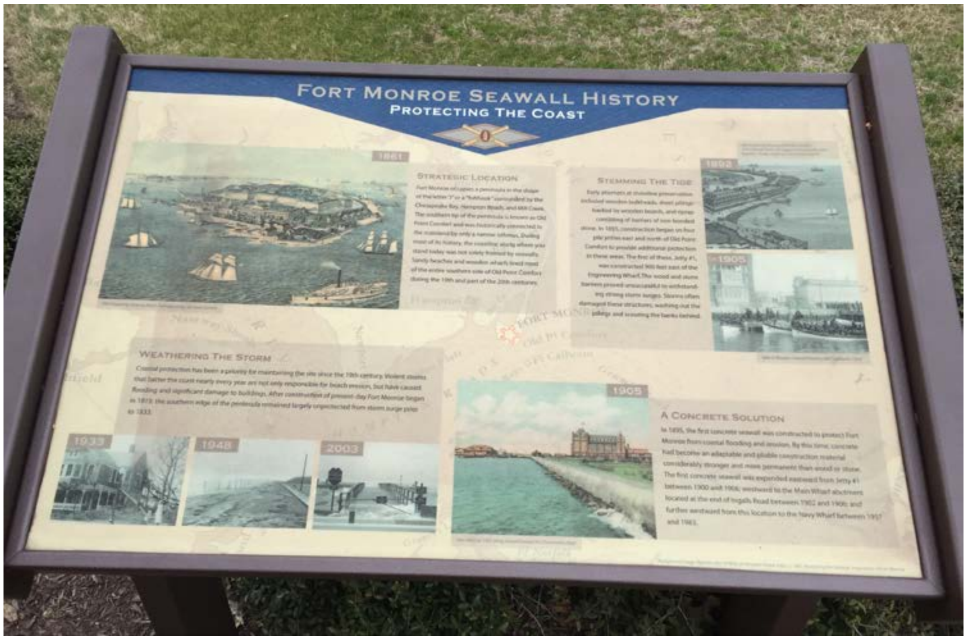
Indicator	Metric	Agency	Source	Year of Data Collection
Shoreline	Erosion and naturalness of shoreline	Comprehensive Coastal Inventory Program, National Park Service	Digital Shoreline Inventory Report, NPS Preliminary Discussion Draft	2016
Viewshed	View from Flagstaff Bastion Overlook, North Fork ramparts, and wildlife observation platform	U.S. Geological Survey, National Park Service	National Land Cover Dataset, Map of Park Overlook and Observation Sites	2011
Impervious Surfaces	Percent of area that is impervious	U.S. Geological Survey	National Land Cover Dataset	2011
Dune Geomorphology	Span of dune vegetation	Google	Google Earth Imagery (version 7)	2006-2014

4.4.1. Shoreline

Relevance and Context

Fort Monroe National Monument's military history has influenced the management of its shorelines since the fort's original construction in 1819. Man-made structures have been employed to help manage erosion including concrete sea walls, groins, bulkheads, riprap, and marsh toes (Fort Monroe Authority 2010). These "non-living" hardened shorelines can act to degrade wetlands and related ecosystems dependent upon the interconnections of land and water at the terrestrial-aquatic interface (Chesapeake Bay Foundation 2007).

Detrimental effects of hardened shorelines include disruption to geological and biological processes, especially to wetlands that act as natural filtration and flood protection systems. Creation of shoreline structures can lead to habitat loss and the reduction of sensitive marine organisms. Bulkheads and seawalls can play a valuable role in stabilizing uplands and protecting infrastructure, but they can also aggravate passive erosion of sandy beaches, which is more likely to occur at armored shoreline during times of sea level rise (O'Connell 2010).



Signage documenting seawall history at Fort Monroe National Monument (Photo Credit: Todd Lookingbill, University of Richmond).

"Living shorelines," a technique to prevent erosion that involves planting native wetland grasses, shrubs, and trees along the tidal line, provides an alternative to hardened shorelines (VIMS 2010). This type of shoreline is generally more aesthetically pleasing to seasonal coastal tourists and helps protect against rapidly rising sea levels. Economically, living shorelines are more affordable over long periods of time due to lower construction costs (Moon 2012). They can improve water quality by acting as pollution filters, create wildlife habitat, absorb wave energy so that underwater grasses can grow in the sub-tidal zone, and shade the shore, which helps keep water temperatures cool and increase oxygen levels for fish. While living shorelines (or natural infrastructure) are ecologically beneficial, the process of removing existing structures and implementing the new living shoreline are often expensive and time consuming. Additionally, the vegetation involved with this methodology must compete with invasive species; initial design and ongoing maintenance plans are crucial to success (Beavers et al. 2016).

Data and Methods

Data for the assessment of this indicator were derived from the Digital Shoreline Inventory Report, produced by the Comprehensive Coastal Inventory Program (CCI). Published by the Center for Coastal Resources Management at the Virginia Institute of Marine Sciences (VIMS), the data were collected by areal imaging techniques and field observations. A subset of data from the CCI was used to map the shores of the North Beach section of Fort Monroe National Monument. Shoreline was categorized as stable, unstable or transitional. Shoreline segments were additionally categorized as either natural shoreline or hardened shoreline.

Additional information was taken from a National Park Service report on evaluating the interactions between structures and coastal landforms and habitats at the park (Nordstrom and Jackson 2016). The report assessed the possibility of removing shoreline structures based on their condition.

Reference Condition

The reference condition was based on a shoreline that is natural and has, on average, a stable sediment budget with seasonal variability. Thus an attainment score of 100% would mean that there was no hardened shoreline present and none of the shoreline was characterized as transitional or unstable. The percentage of shoreline that met each of these conditions was calculated separately and then averaged to compute a park score. The NPS assessment of the existing structures along the park shoreline provides further insight into the condition of each structure and suggested whether or not it should be removed. No data were available to assess trend for this indicator.

Current Condition and Trend

The current condition of the shoreline of Fort Monroe National Monument is assessed as in Good Condition (71% attainment) based on the percent considered stable with minimal erosion risk (72% attainment) and the percent that is natural and not hardened (70%).

The North Beach district of Fort Monroe National Monument has over 11,000 meters of shoreline. Of that shoreline, about 72%, including the Mill Creek marsh islands, experience minimal erosion and are considered stable (Figure 4-24). Approximately 28% are considered transitional, and no length of shoreline within the park boundary is considered unstable (VIMS 2011). The attainment score for erosion risk was 72%.

Bulkheads, marsh toe, riprap and unconventional structures (i.e., hardened shoreline) make up 30% of the shoreline. The distribution of natural shoreline is not uniform. The marsh islands in Mill Creek have been left predominantly untouched without human intervention (80% natural shoreline). The Mill Creek shoreline is a combination of mainly concrete riprap in the grasses in the south end and scrub-shrub wetland (Figure 4-25). Grass bank and scrub-shrub can be used as natural fortification measures, and have been used effectively as riprap or marsh toe hardening techniques (VIMS 2011). The hardest paved structure forms the seawall against the Chesapeake Bay and is listed as transitional erosion area. The Chesapeake Bay shoreline along the eastern edge of the park is only 41% natural shoreline. Park management recognizes the difficulty in changing hardened shoreline due to the possibility of sudden erosion rate change that could damage waterfront cultural sites (Nordstrom and Jackson 2016). The attainment score for hardened shoreline is 70%.

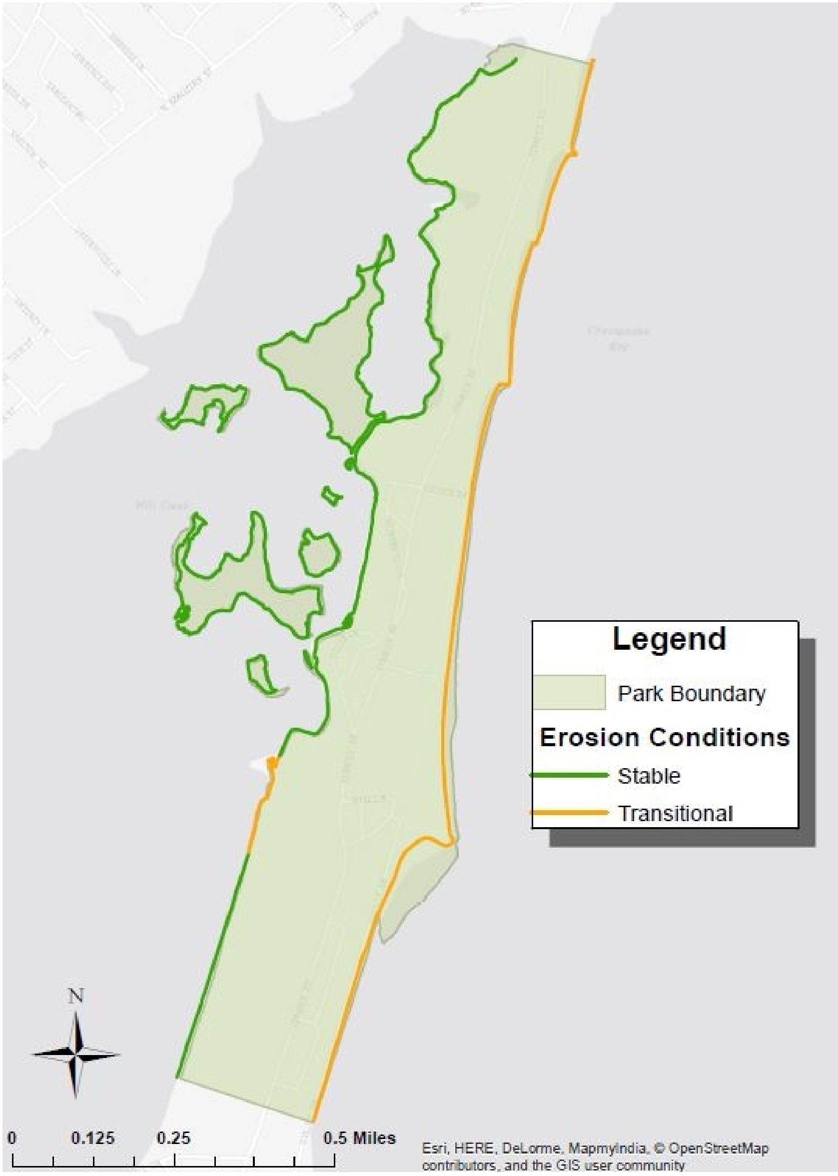


Figure 4-24. Erosion conditions of shoreline in the northern unit of the park (Data source: VIMS 2011).

Figure 4-25. Natural vs hardened shoreline in Fort Monroe National Monument (Data source: VIMS 2011).

Of the structures that make up the hardened shoreline, those in the southern section of the park would result in the most change to high-value park infrastructure (Nordstrom and Jackson 2016). Replacing wall 6 with natural barriers would require the break-down of the landing strip that is currently in that area, and erosion would likely threaten the nearby road (Figure 4-26). The issues are similar for wall 7, whose removal could help the natural sediment accrual but would require the removal of large parts of the promenade and park buildings.

Figure 4-26. Walls and groins along Fort Monroe National Monument's shoreline (Figure from Nordstrom and Jackson 2015).

In the North Beach section, walls 1-4 were deemed to have little effect on the natural processes and therefore were considered low priority for removal. Wall 8 was considered to be one of the best candidates for removal as the area along this wall is not used for park facilities or tourism purposes. The removal of wall 8 could potentially undermine the road there, but otherwise the area could be allowed to evolve naturally. The NPS assessment concluded that a shift toward adaptive management would increase ecosystem resilience but would likely be incompatible with stable resources in the northern segment (Nordstrom and Jackson 2016).

Data Gaps and Level of Confidence

The level of confidence in the assessment of this indicator is high. Data used for the analysis include information obtained by examining aerial imagery of Fort Monroe National Monument taken by NASA and 2014 satellite imagery taken from Google Maps. In addition, reports and data documenting shoreline conditions have been generated by researchers working with park management to do field research including field visits to each of the structures. The VIMS datasets were published relatively recently in 2011 along with metadata files, a full report, a historical report, maps, and tables.

Groins along the beach on the Chesapeake Bay, Virginia (Photo credit: Maggie Latimer, University of Richmond).

Sources of Expertise

- Amanda Babson – Coastal Climate Adaptation Coordinator for the Northeast Region, National Park Service

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4.4.2. Viewshed

Relevance and Context

Wildlife and landscape viewing is an integral part of the national park experience and a major reason why people visit national parks (Miller and Wright 1999). The importance of park vistas and associated scenery was captured in the National Park Service Organic Act (16 U.S.C. l) mission "to conserve the scenery and the natural and historic objects and the wild life therein." The mapping of viewsheds, defined as the area of land visible from a geographically specific vantage point, also contributes to landscape protection planning (La Rosa 2011). Calculating the percentage of a viewshed with undesirable properties provides a quantitative description of visual stress on a landscape (Komp et al. 2012). This information can be used in park planning activities and in building future partnerships with neighboring land owners. However, defining desirable properties can be a subjective and difficult process, because what is preferable is intrinsically anthropocentric and varies by individual. As guidance, multiple studies indicate that recreational visitors tend to prefer natural compared to developed landscapes (Han 2010, Kearney et al. 2008, Sheppard 2001).

Wildlife observation platform (Photo credit: Stephanie Wang, University of Richmond).

Flagstaff Bastion Overlook (Photo credit: Todd Lookingbill, University of Richmond).

Data and Methods

The composition of the land cover within the viewshed was quantified from three commonly visited viewpoints in the park: the Flagstaff Bastion Overlook, the North Fort rampart, and the wildlife observation platform in the northern section of the park. The percentage of the viewable land from the three vistas that was undeveloped was used to assess the park's viewsheds for desirability by visitors.

The analysis was conducted using ESRI's Spatial Analyst Viewshed Tool in ArcGIS 10.1. Three input datasets were required: a digital elevation model (DEM), a land cover map, and the geographic coordinates of the points in which a person would be viewing the landscape (Figure 4-27). A DEM for the park was derived from the National Elevation Dataset (NED). Land cover was taken from the Virginia Geographic Information Network (VGIN 2016). The land cover dataset is made up of 1-m raster pixels, each assigned a land type classification. For the purposes of this analysis, the following classes of undeveloped land were identified in the study extent: Barren Land (Class ID 31), Forest (Class ID 41), Individual Trees (Class ID 42), Turf Grass (Class ID 71), and Wetlands (Class ID 91). The percent undeveloped land was derived by calculating the percent of pixels of these types within the area viewable from the three vista points. Locations of the three terrestrial observation points of interest were attained from Fort Monroe National Monument.

In the interest of only examining the areas within the park, all outputs were clipped to the park boundary for the final analysis. A second set of maps were generated for comparative purposes only that identified the land cover within the area viewable from the three vistas extending up to 3km from the park boundary.

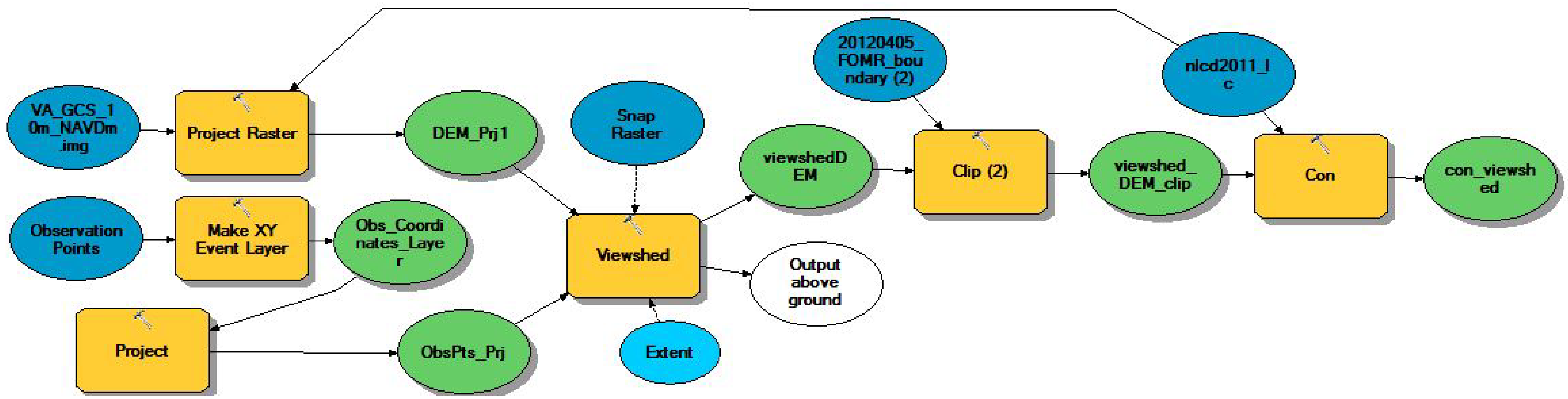

Figure 4-27. ArcGIS ModelBuilder schematic summarizing the methods used for the viewshed analysis at Fort Monroe National Monument.

Reference Condition

Other national parks have established reference conditions for this indicator based on the amount of developed visible area deemed undesirable by park staff. For example, in a viewshed assessment of Capulin Volcano National Monument (Bennetts et al. 2011), less than 5.0% developed land was considered an acceptable level of development within the park's natural scenic viewshed. For Shenandoah National Park, this small level of development was considered overly restrictive, and a threshold of less than 15% developed land was adopted (Costanzo et al. 2016). Because of the long history of human land uses at Fort Monroe National Monument, even a threshold of 15% development was deemed too stringent. Instead, the current condition score was calculated as the raw percent of viewable area that was in an undeveloped land class. This value was not compared to any threshold. Trend was not assessed for this indicator because the detailed land cover data used for the assessment were only available for 2016.

Current Condition and Trend

The park viewshed was assessed as in Good Condition (76% attainment) based on the amount of visible land cover from the observation points that was undeveloped (Figure 4-28). The largest land cover class was turf grass (51% of the total visible land). Mill Creek and associated wetlands represent a substantial natural feature viewable from the wildlife observation platform. High densities of development were concentrated on Bernard Road, near the North Gate.

Including viewable areas within 3km of the park boundary in the analysis (Figure 4-29) decreased the percent of visible land cover that was undeveloped from 76% (Figure 4-30) to 60% (Figure 4-31). The fort is surrounded by high density development in the Historic Village zoning district to the west and North Gate to the north. Existing and any future development within the Wherry Quarter (labeled in Figure 4-28) has the potential to degrade the continuity of the viewshed from the southern to the northern sections of the park.

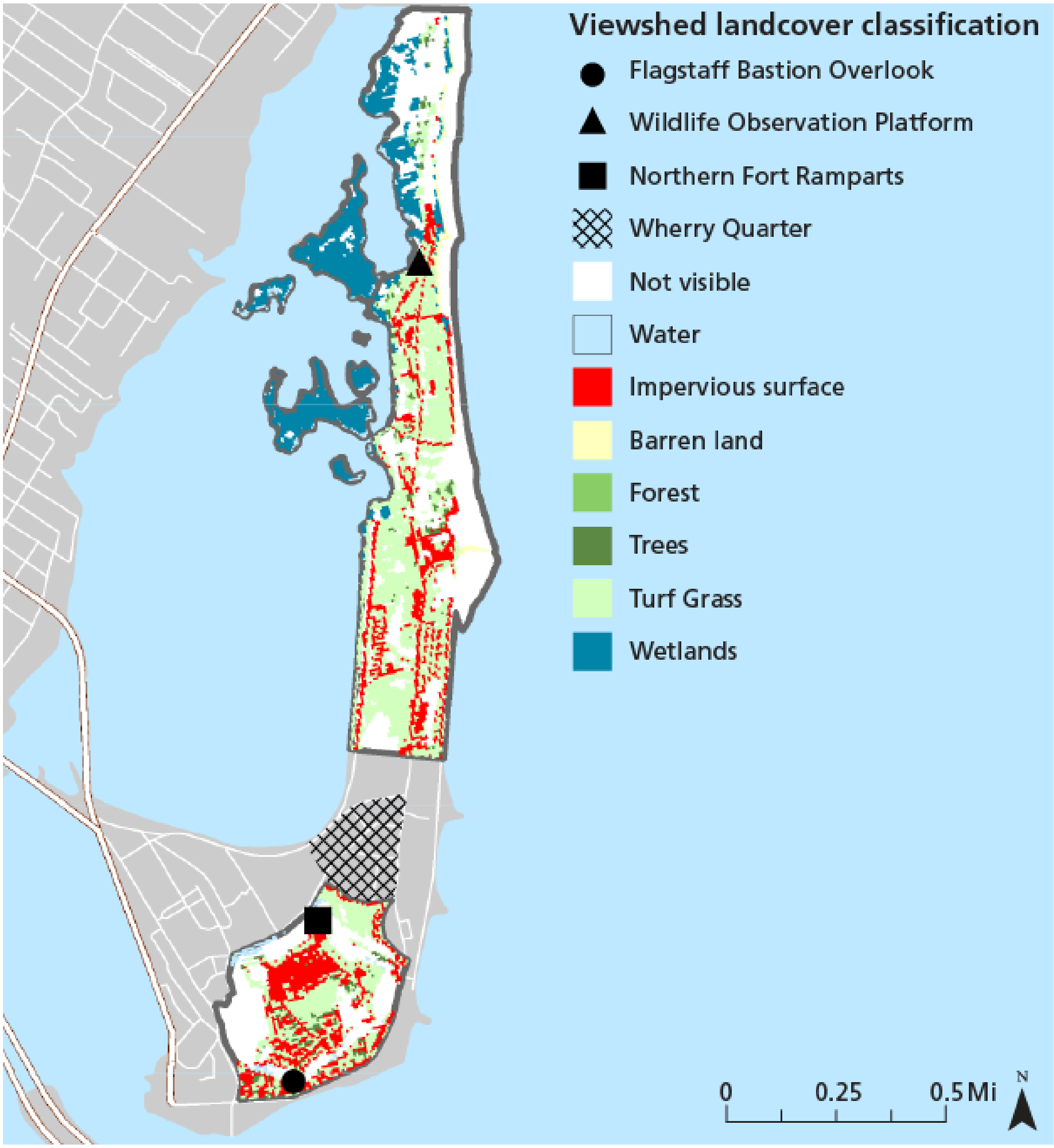

Figure 4-28. Land cover observable in the park from three observation vistas at Fort Monroe National Monument (Data source: VGIN 2016).

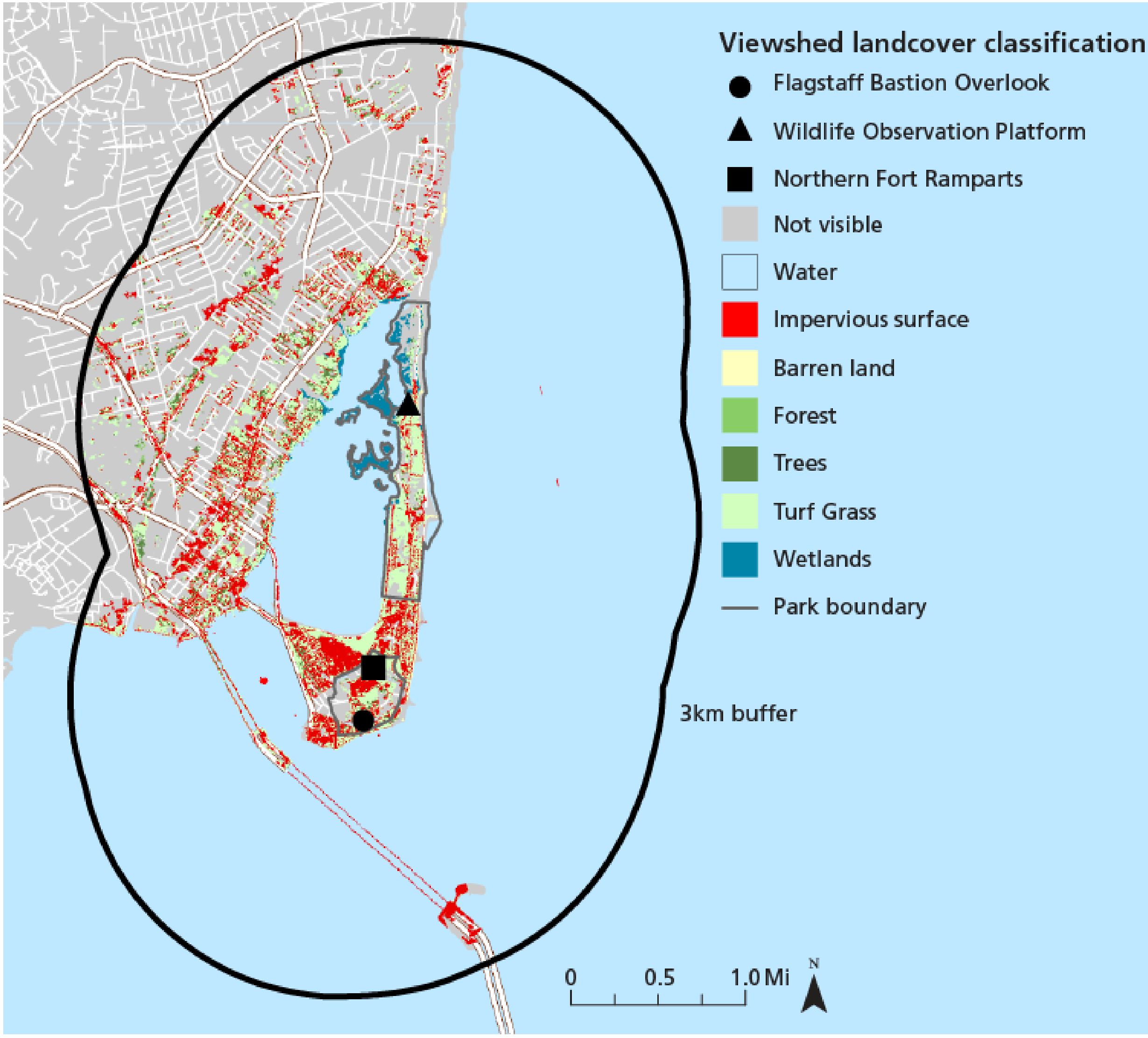

Figure 4-29. Land cover observable in the park and 3km buffer from three observation vistas (Data source: VGIN 2016).

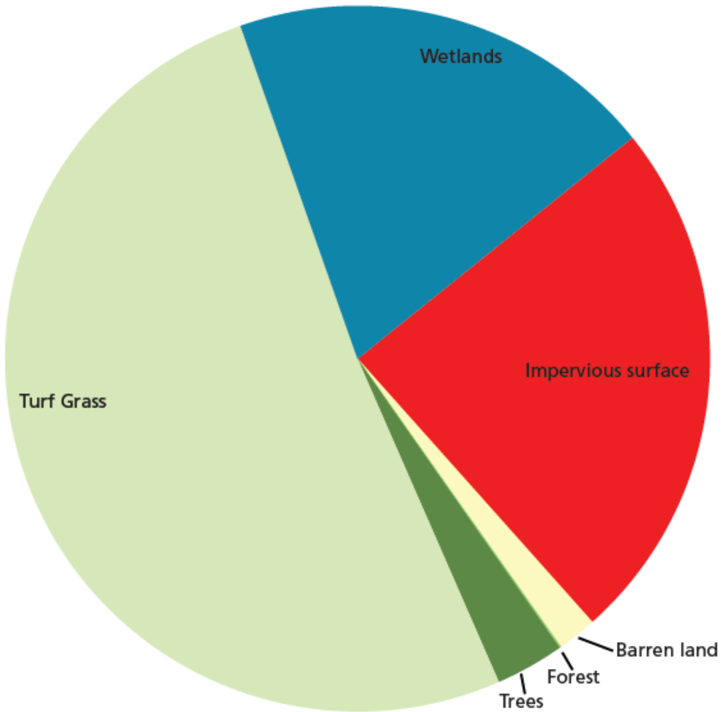

Figure 4-30. Distribution of land cover in the park viewable from three observation vistas (Source: VGIN 2016).

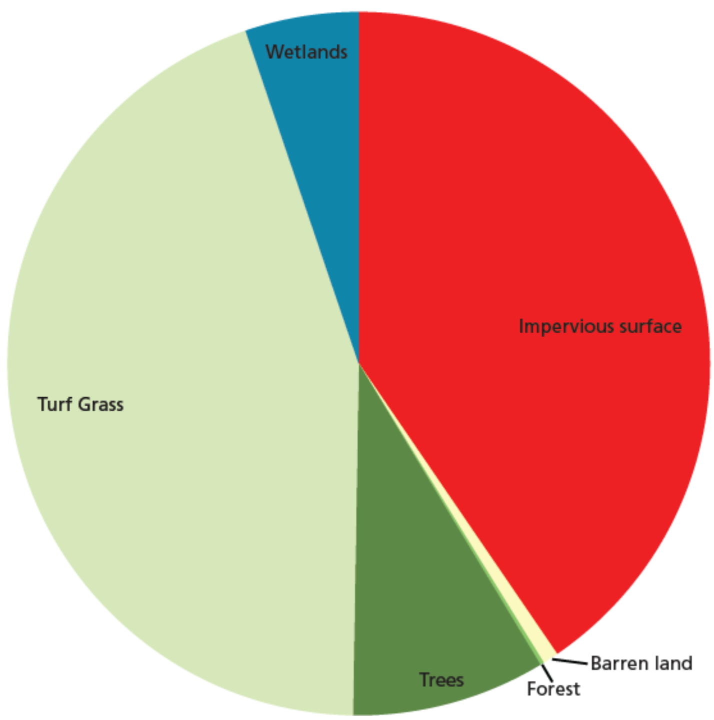

Figure 4-31. Land cover in park and 3km buffer observable from three observation vistas (Source: VGIN 2016).

Data Gaps and Level of Confidence

Confidence in this indicator is assessed as moderate. The three vista points chosen for the analysis represent different vantage points from within the two major geographic areas of the park and are representative of diverse visitor experiences. However, the assessment does not fully capture all vista points within the park's boundaries (e.g., viewsheds from the perspective of visitors to park beaches). The analysis does not include an assessment of trend because Commonwealth of Virginia land cover data is only available for one point in time. However, it is likely that the viewshed is degrading based on regional-scale trends (Homer et al. 2015 and see the Impervious Surfaces section of this report). Although not included in the formal scoring of current condition, changes in land cover and development activity outside park boundaries influence the park viewshed. For context, the analysis of the land cover within the visible viewshed located within a 3km buffer of the park boundaries is presented. Lastly, the lack of a park-specific threshold or desired condition for this indicator is a source of uncertainty that could be addressed with additional research on park visitor experiences.

Sources of Expertise

- NPScape Monitoring Program, Natural Resource Program Center, Inventory and Monitoring Division. Fort Collins, Colorado. http://science.nature.nps.gov/im/monitor/npscape/

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4.4.3. Impervious Surfaces

<u>Relevance and Context</u>

Impervious surfaces are materials such as roads, rooftops, and compacted soils that prevent water from infiltrating the soil. The amount of impervious surface cover on a landscape is directly correlated with the amount of urban development, and this measure is frequently used as an indicator of the impacts of human modifications of the landscape on environmental conditions, specifically, changes in water quantity and quality (Arnold and Gibbons 1996).

By preventing water from seeping into the ground, impervious surfaces increase the quantity and velocity of storm water runoff from a watershed (Brinson et al. 2013). This altered hydrology in urbanized watersheds can lead to increased peak flow rates and annual discharge volumes (Boggs and Sun 2011). The increased flashiness of surface runoff can ultimately also lead to increased erosion (Arnold and Gibbons 1996).

Pervious pavers in Fort Monroe National Monument (Photo credit: Todd Lookingbill, University of Richmond).

Impervious surfaces also facilitate the conveyance of pollutants into waterways by preventing water from percolating into the soil where it would undergo natural pollutant processing (Arnold and Gibbons 1996). Moreover, there is less groundwater recharge in watersheds with high impervious cover, potentially resulting in reduced base flow conditions in streams. As a consequence of these changes, impervious surface cover has been found to have a greater effect on sensitive macroinvertebrates than even the disruption of riparian buffers (Walsh et al. 2007).

These characteristic set of effects are referred to collectively as the “urban stream syndrome” (Walsh et al. 2005). Percent impervious surface, therefore, can provide a good approximation of watershed and aquatic habitat degradation, even within areas of relatively little development (Gergel et al. 2002). Although there are pervious pavers within the park, and relatively large patches of turf grass, which do allow some infiltration, these surfaces do not absorb as much water as a mature forest land (Brabec 2002).

Data and Methods

Impervious surface data were taken from the Virginia Geographic Information Network (VGIN) land cover dataset (VGIN 2016). The land cover dataset is made up of 1-m raster pixels, each assigned a land type classification. For the purposes of this analysis, two of those classifications were considered impervious surfaces: Impervious Extracted (Class ID 21) and Impervious Local Datasets (Class ID 22). The percent imperviousness was derived by calculating the percent of pixels within the park boundary of these types. This percentage was then compared to threshold values to assess current condition.

Trend was assessed using the National Land Cover Database (NLCD) for the years 2001, 2006 and 2011. This dataset contains 30-m raster pixels that have been classified into 101 possible values (0-100% impervious surface cover) (Homer et al. 2015). This dataset was used for trend only. The NLCD classification occurs at regional scales with overall accuracy of approximately 80% but has the potential for higher error rates at local scales (Wickham et al. 2013). For example, there are portions of beach in this dataset that have been misclassified as impervious surfaces. While the results of the NLCD are informative of general temporal trends, they should not be used to pinpoint any specific changes.

Reference Condition

Many studies have documented threshold type effects on different ecosystem resources at relatively low impervious surface cover. A study in Georgia showed significant increases in nutrients, including nitrate and sulfate, in watersheds with greater than 5% impervious surface cover (Schoonover and Lockaby 2006). Watersheds with 3–5% cover have shown significant changes in stream flow (Yang et al. 2010). In a Maryland study, impervious surface cover as low as 0.5–2% resulted in the decline of the majority (80%) of stream taxa, while 2–25% cover showed a decline in 100% of the taxa (King et al. 2011). Habitat degradation has been recorded for watersheds with 4-9% impervious surface (Hicks and Larson 1997), and the loss of sensitive aquatic invertebrate taxa has been documented at 2.5–15% impervious cover (Utz et al. 2009). Other studies, have found declines in species diversity when 10-15% of the watershed is impervious (Booth and Reinhelt 1993), including fish diversity declines between 10-12% (Schueler and Galli 1992), and plant diversity loss at 10% (Taylor 1993).

Based on the range of thresholds provided in the literature, this assessment used a reference condition of less than 2% of the total area represented an attainment score of 100% and impervious surface totaling greater than 10% represented an attainment score of 0%. Percent impervious surface between 10% and 2% were scored linearly from 0-100%.

Current Condition and Trend

The current condition for impervious surface was assessed as Significant Concern (0% attainment). Based on the impervious surface values from the 2016 VGIN land cover dataset, Fort Monroe National Monument had 19% impervious surface coverage. This amount is well above the ecological threshold of 10% impervious surface cover. Much of the impervious surface is found in the southern section of the park, where the largest proportion of military structures are located (Figure 4-32). The impervious surface cover in the park is similar to the amount in the 3km buffer around the park (16%) and in the 30km buffer zone (21%) (Figure 4-33).

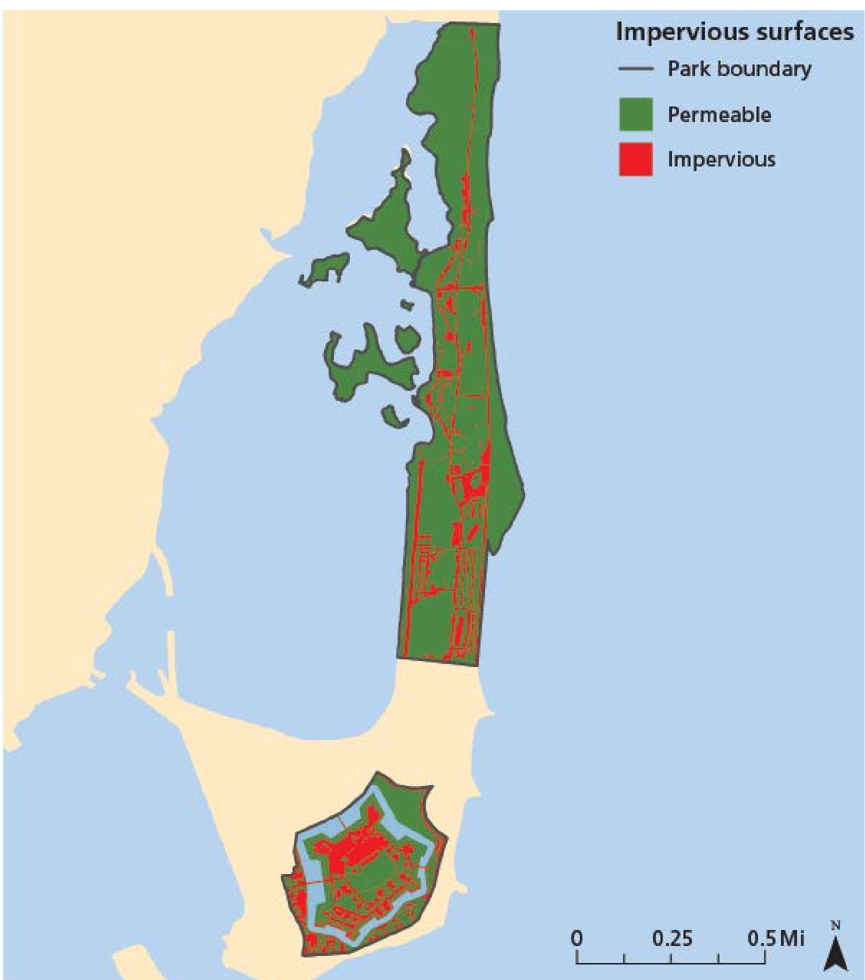

Figure 4-32. Impervious surface cover for Fort Monroe National Monument (Data source: VGIN 2016).

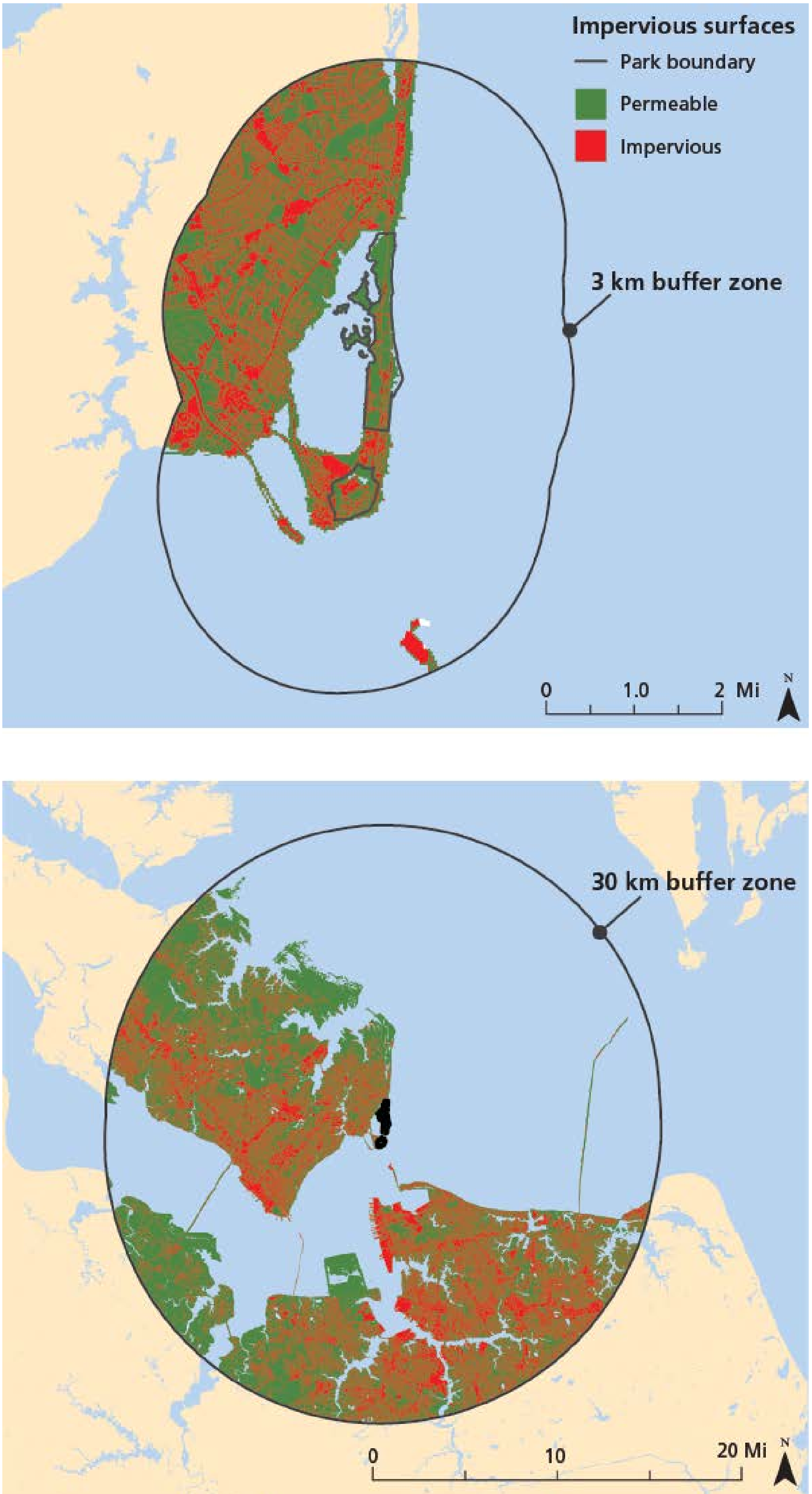

Figure 4-33. Impervious surface cover in context: 3km (top) and 30km (bottom) buffer zone (Data source: VGIN 2016).

The total amount of impervious surface has been increasing in the past decade (Figure 4-34), which indicates the condition of this indicator is getting worse. It is likely that most of this increase in impervious cover has occurred within the Fort District of the park (Figure 4-35). It is important to reiterate that NLCD values are provided for analysis of trend only. The estimates derived from the VGIN data have greater accuracy for the park.

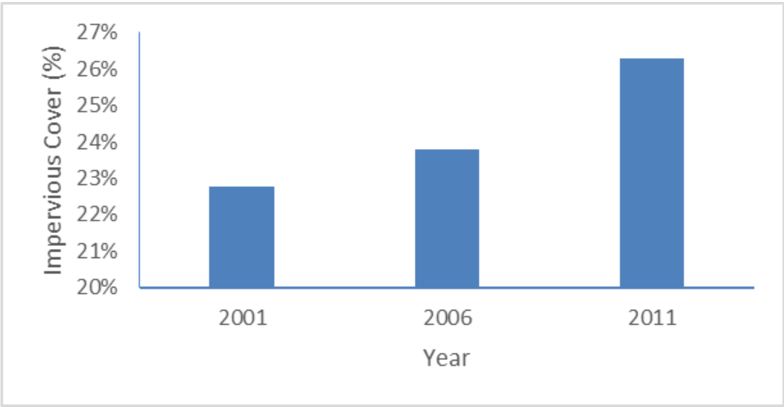

Figure 4-34. Change in impervious surface cover for Fort Monroe National Monument from 2001 to 2011 (Data source: NLCD).

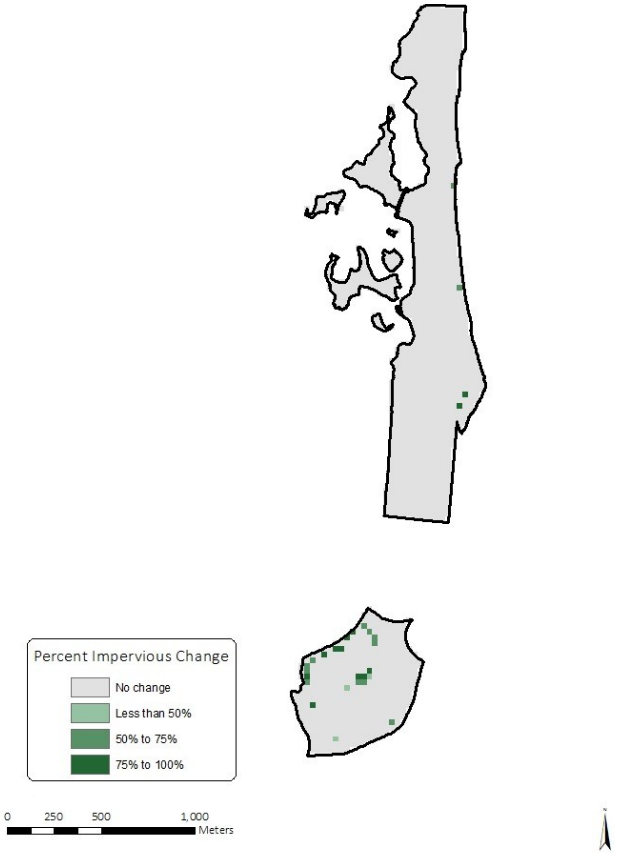

Figure 4-35. Change in impervious surface area for Fort Monroe National Monument between 2001-2006 (Source: NLCD).

Data Gaps and Level of Confidence

Confidence in this indicator is assessed as moderate. Development of the VGIN land cover dataset was a local, collaborative effort that incorporated data from numerous local governmental agencies and organizations. Although the confidence in that classification is high, those data represent a single snapshot in time. The confidence in the trend for this indicator is much lower. It is likely that numerous impervious surface misclassifications in the NLCD affected the change detection in this analysis. In any case, the percentage of impervious surface detected in the park is well above the 10% impervious surfaces threshold. As negative ecological outcomes may be experienced at much lower densities, it is highly likely that the park is being negatively impacted by the amount of impervious cover.

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4.4.4. Dune Geomorphology

<u>Relevance and Context</u>

As Fort Monroe National Monument is located on a narrow spit of land, which functions as a modified barrier island, shoreline/landscape stability and thus dune geomorphology is vitally important when assessing the overall integrity of the park. Barrier islands possess fairly unique qualitative properties as geomorphic systems. One important feature is cross-shore sediment transport, which causes barrier island systems to dynamically shift and migrate as sea level changes, sediment supply changes, and wave action occurs (Stutz and Pilkey 2005). Due to the presence of the fort and surrounding structures on Old Point Comfort, this dynamic shifting of the modified barrier island is not desirable. The dunes are an important indicator of these processes and critical to the overall sustainability of the park landscape.

Dunes are formed through a multi-faceted process as wind, waves, and currents interact with sediments to produce mounded accumulations of sand (Martinez and Psuty 2004). Dunes typically build up parallel to the shoreline in an upward and outward manner. As the mounded structure builds and vegetation cover increases, sand is trapped and the stability of the dune system increases (Sloss et al. 2012). Sand dunes are important to any shoreline, acting as protective barriers against flooding, mitigating the erosion that occurs due to wind and waves, and minimizing shoreline migration (Virginia Marine Resources Commission 1993, United Nations Environment Programme 2006, VIMS 2009). Through these mechanisms, dunes help to maintain and reinforce coastal integrity. Additionally, dunes reduce the effects of wind energy on nearby properties and landforms, and in this way they further stabilize the structural stability of a shoreline (VIMS 2009). Coastal dunes also make coastal areas more attractive, increasing their aesthetic value to beach visitors (Virginia Marine Resources Commission 1993).

Dunes present at Fort Monroe National Monument's North Beach area (Photo credit: Anna Gonye, University of Richmond).

Data and Methods

Analysis of satellite imagery of dunes was completed using Google Earth version 7. Dunes in the North Beach boundary area were investigated, as these are the only large dune areas within the boundaries of the park. The dunes were divided into three units, separated by the groins that were put in place as part of the shoreline modification program, with the northern-most shoreline parcel designated “Dune Area 1”. Google Earth imagery was used to measure the horizontal span of dune vegetation at three different locations within each dune unit, as dune vegetation is a strong indicator of dune health and activity. Additionally, Google Earth was used to determine maximum dune elevation at the three measurement points and these values were compared to beach elevation in order to approximate dune height. Current condition was evaluated using satellite imagery from April 2014. Images from April 2006 and April 2011 were used to quantify the change in dune vegetation and relative dune elevation over time.

Reference Condition

The reference condition used to assess dune activity was that dune vegetation should span at least 50 feet wide where possible (Psuty and Rohr 2000). Dune elevation should be at least 8 to 15 feet above the beach along the shoreline encompassed within the park boundaries (Psuty and Rohr 2000). Although barrier island dune systems are often less extensive and more ephemeral than the conditions prescribed here, a stable dune system at Fort Monroe National Monument is essential to fortify the park against waves, overwash, and flooding. It is highly undesirable for shoreline movement or flooding to occur. Attainment scores were calculated as the percent of the different dune measurements that met reference condition thresholds. Scores were calculated separately for dune width and height, and the two values were averaged to compute the final indicator score.

Current Condition and Trend

The current condition of dunes in the park was assessed as Good Condition (84% attainment). For the April 2014 sample, dune width in Dune Area 1 (Figure 4-36) and Dune Area 3 (Figure 4-38) had vegetation spanning at least 50 feet at all of the markers tested. Only the first two markers in Dune Area 2 did not have vegetation that spanned at least 50 feet (Figure 4-37). This is a 78% attainment of the reference condition for dune vegetation span. Dune height at all markers ranged from 8 feet to 10 feet at all markers in 2014 except for marker 1 in Dune Area 1, which had a height of 4 feet. These measurements represent an 89% attainment of the reference condition for dune height. Averaging the width and height values together results in an overall indicator current condition score of 84%.

Figure 4-36. Dune Area 1, North Beach Area. Vegetation span and dune height were measured at each red marker (Source: Google Earth 7.1).

Figure 4-37. Dune Area 2, North Beach Area. Vegetation span and dune height were measured at each red marker (Source: Google Earth 7.1).

Figure 4-38. Dune Area 3, North Beach Area. Vegetation span and dune height were measured at each red marker (Source: Google Earth 7.1).

In Dune Area 1, dune width at all three markers increased between 2006 and 2014. Dune height remained comparatively constant. In the second dune area, dune width also increased at all three markers, and dune height remained relatively consistent from 2006 to 2014. In the third and southern-most dune area, dune width increased between 2006 and 2014, and dune height experienced little change over the eight-year timespan (Table 4-21a-c).

Table 4-21a. Dune Area 1 vegetation span and approximate heights of North Beach dunes in Fort Monroe National Monument.

	Dune Vegetation Span (ft)			Dune Vegetation Height (ft)		
Marker	**2014**	**2011**	**2006**	**2014**	**2011**	**2006**
1	59.83	59.61	9.39	4	6	4
2	59.43	52.63	27.48	10	10	10
3	78.78	51.23	29.44	9	8	8

Table 4-21b. Dune Area 2 vegetation span and approximate heights of North Beach dunes in Fort Monroe National Monument.

	Dune Vegetation Span (ft)			Dune Vegetation Height (ft)		
Marker	**2014**	**2011**	**2006**	**2014**	**2011**	**2006**
1	46.22	32.46	13.84	10	9	10
2	31.52	31.05	14.51	10	10	9
3	85.1	78.21	40.58	10	9	9

Table 4-21c. Dune Area 3 vegetation span and approximate heights of North Beach dunes in Fort Monroe National Monument.

	Dune Vegetation Span (ft)			Dune Vegetation Height (ft)		
Marker	**2014**	**2011**	**2006**	**2014**	**2011**	**2006**
1	53.89	35.47	13.89	8	8	8
2	79.04	72.45	50.16	9	10	10
3	138.71	142.35	155.42	9	10	9

Since 2006, the trend in dune vegetation span has improved, with the width of the vegetated areas increasing at all markers measured in all three dune areas. The trend in dune elevation seems to be stable, with almost no change occurring between 2006 and 2014. The overall trend was assessed as stable.

Data Gaps and Level of Confidence

Confidence in the analysis of this indicator is moderate. Although the Google Earth satellite imagery is considered high quality, the assessment is based entirely on this imagery. Due to their shape and orientation toward the road, it is possible that some or all of these dunes are berms. This would greatly affect the dune height as well as its ability to migrate landward. Confidence would be improved by the examination of dune conditions in the field. It also would be desirable to analyze imagery from a wider span of years at smaller time intervals in order to gain a more complete picture of changes in dune vegetation over time.

Sources of Expertise

- C. Scott Hardaway, Virginia Institute of Marine Science

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5. Discussion

5.1. Fort Monroe National Monument Context for Assessment

The resources of Fort Monroe National Monument possess aesthetic, cultural, economic, and scientific values. The condition of natural resources in the park must be considered in the context of all of these values in addition to its geography, legislative mission, and history. For example, the park's founding documents require park management to protect certain historical conditions, including the preservation of the moated fortress and other historical landmarks.

The condition of the natural resources of the Fort Monroe National Monument have been assessed systematically through consulting with relevant stakeholders on the assessment approach; compiling available data for resources and stressors; identifying suitable metric indicators of resource condition; using available literature and expert opinion to develop thresholds for these metrics; and deriving a percentage score for each of the indicators. Based on this information, this final chapter summarizes the key conditions, stressors, and threats to resources within the park. It further provides recommendations for better understanding these resources and maintaining or improving their future condition.

5.2. Park Natural Resource Condition

We provide here a summary of the condition scores for each of the following four categories of natural resources within Fort Monroe National Monument: Air, Water, Biota, and Landscape Dynamics. The natural condition of the park has been assessed based on 16 indicators representing these categories as outlined in Chapter 3. The detailed methods and final assessment of the conditions and trends were provided for each indicator in Chapter 4. In this chapter, we present the key findings for each indicator based on a direct consideration of the assessment findings. Recommendations were compiled in collaboration with NPS natural resource personnel.

5.2.1. Air Resources

The condition of air quality in Fort Monroe National Monument was assessed as being of **"significant concern"** based on an average attainment score of 19% (Table 5-1). Confidence in this assessment is *high* based on the rigorous monitoring protocols in place by the NPS Air Resources Division. The length and temporal resolution of the air quality data allows clear assessment of trends. However, it is worth noting that the assessment is based on data collected outside the park. Though current air quality conditions at Fort Monroe National Monument, as well as the region as a whole, are degraded, trends for the past decade indicate that conditions are improving for all indicators.

Air quality degradation is not an issue specific to Fort Monroe National Monument. Park management efforts to directly improve regional air quality are likely to have minimal impact for most contaminants. However, the park can play a leading role in regional education of the causes and consequences of air pollution. These include human health issues, plant defoliation, water acidification, and altered nutrient cycling.

Table 5-1. Summary of air resource indicators and threshold attainment for Fort Monroe National Monument.

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Sulfur Deposition	30%	Significant Concern	Improving
Nitrogen Deposition	0%	Significant Concern	Improving
Visibility	0%	Significant Concern	Improving
Ozone	46%	Moderate Concern	Improving
Air Resources	**19%**	**Significant Concern**	**Improving**

Table 5-2. Key findings and recommendations for air resources in Fort Monroe National Monument.

Resource Category	Key Findings	Recommendations
Air Resources	• Regional degradation of air quality • Improving conditions for many indicators	• Spread awareness throughout the region • Educate the public on the causes and effects of air pollution

5.2.2. Aquatic Resources

The condition of aquatic resources for the park was assessed as being of "**moderate concern**" based on an average attainment of 59% for all indicators (Table 5-3). Trends could only be calculated for beach health, which is in stable condition. The data record is relatively short for the other indicators, or temporal data could only be obtained for outside of the park, highlighting the need to establish a monitoring program for aquatic resources in the park (Table 5-4). Confidence in the assessment of this vital sign category is considered *moderate* based on limited data availability for sites within the park that are replicated in time. The condition of benthic macroinvertebrate communities is of significant concern such that increased monitoring would be especially useful for this indicator (Table 5-4).

Table 5-3. Summary of aquatic resource indicators and threshold attainment for Fort Monroe National Monument.

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Water Quality	67%	Good	Not Available
Sediment Contaminants	64%	Moderate Concern	Not Available
Benthic Macroinvertebrates	5.5%	Significant Concern	Not Available
Beach Health	99%	Good	Stable
Aquatic Resources	**59%**	**Moderate Concern**	**Not Available**

Table 5-4. Key findings and recommendations for aquatic resources in Fort Monroe National Monument.

Resource Category	Key Findings	Recommendations
Water Resources	• Water quality in generally good condition • Sediment in the moat is contaminated by some metals and SVOCs • Benthic macroinvertebrates in the moat in degraded condition • Beach health in good condition	• Establish a water quality monitoring program within the national monument boundaries that interfaces with Chesapeake Bay monitoring • Monitor metal contamination in the moat • Monitor benthic macroinvertebrates as an integrative measure of sediment quality

5.2.3. Biotic Resources

The condition of biotic resources was assessed as being of "**moderate concern**" based on average attainment of 57% for the four indicators (Table 5-5). Confidence in the assessment for these resources is *moderate* owing to the general lack of data and continuous monitoring. The southern live oak population is a significant resource for the park but may be slowly degrading. The population needs to be monitored and managed on a regular basis. Another significant resource are the salt marshes in Mill Creek, which are eroding and may disappear by 2100 or sooner if current trends continue or accelerate. Salt marsh extent and sediment accretion and erosion need to be monitored to determine the processes that erode the marshes. Fort Monroe National Monument supports many non-native species including the highly invasive *Phragmites*. It is therefore recommended to establish a treatment program for problematic species such as *Phragmites* in high marsh areas and sand spurs in recreational lawn areas. Bird populations are in good condition but may degrade with the loss of local and regional marsh extent. Thus, bird diversity and populations of species of special concern should be monitored on a regular basis using standard protocols. In addition, more basic data collection is needed on biotic resources such as mammals, herpetofauna, and terrestrial invertebrates (Table 5-6).

Table 5-5. Summary of biotic resource indicators and threshold attainment for Fort Monroe National Monument.

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Southern Live Oaks	64%	Moderate Concern	Degrading
Salt Marsh	67%	Good	Degrading
Invasive Species	27%	Significant Concern	Degrading
Birds	71%	Good	Not Available
Biotic Resources	**57%**	**Moderate Concern**	**Degrading**

Table 5-6. Key findings and recommendations for biological integrity in Fort Monroe National Monument.

Resource Category	Key Findings	Recommendations
Biological Integrity	• Southern live oak population in good condition but degrading • Salt marsh of excellent quality but extent severely degrading • High percent of invasive plant species and presence of *Phragmites* in the high marsh • Birds in good condition but monitoring data are needed to assess population trends, especially for wetland species and species of special concern • Lack of data for mammals, herpetofauna, and fish	• Conduct surveys of the tree populations on regular basis and manage southern oaks for crown health and recruitment throughout the park • Monitor salt marsh extent using remote sensing and field based approaches and measure sediment accretion and erosion • Establish an invasive species monitoring program, especially for *Phragmites* and develop a treatment program • Establish a rigorous bird monitoring program • Establish monitoring and survey efforts for mammals and herpetofauna

5.2.4. Landscape Dynamics

The condition of landscape dynamics were assessed as being of “**moderate concern**” based on an average attainment of 58% for all indicators (Table 5-7). Confidence in the assessment was *moderate*, and would be increased by developing a time-series of high resolution land cover classification specific to the park. There are a number of components of the landscape that were not assessed and that would benefit from further data collection (Table 5-8). For example, the historic vistas, soundscape, and night skies are resources of high value to the park, but the current condition and trajectory of these resources cannot be quantified at this time due to lack of data. Future threats to the visual and acoustic landscape might include increases in drones, water shuttles, and firework displays in and around the park. Additional future threats to the park include further residential and commercial development in the region, energy development, increased highway expansion, and associated vehicular traffic.

Table 5-7. Summary of landscape dynamic indicators and threshold attainment for Fort Monroe National Monument.

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Shoreline	71%	Good	Not Available
Viewshed	76%	Good	Not Available
Impervious Surfaces	0%	Significant Concern	Degrading
Dune Geomorphology	84%	Good	Stable
Landscape Dynamics	**58%**	**Moderate Concern**	**Not Available**

Table 5-8. Key findings and recommendations for landscape dynamics in Fort Monroe National Monument.

Resource Category	Key Findings	Recommendations
Landscape Dynamics	• Dune geomorphology and shoreline conditions are generally good • Impervious surfaces are high with likely negative impacts to water quality and quantity in the watershed • As a small park, outside influences impact the visual landscape • Development in the region is high and increasing • Light and sound pollution are likely concerns but currently no data are available to assess	• Develop or attain access to a time-series of high-resolution land cover imagery for the site • Monitor and work with neighbors to minimize impacts from development outside the park boundaries; increase community awareness of potential concerns • Consider actions to mediate the high proportion of land covered by impervious surfaces • Gather data on night skies and soundscapes

5.3. Overall Park Condition

The overall condition of Fort Monroe National Monument was assessed as being of "**moderate concern**" based on an average attainment of 48% for the four vital sign categories assessed (Table 5-9). Indicators in the best condition include beach health and dune geomorphology. Air indicators are of significant concern but improving. Benthic macroinvertebrates in the moat, invasive species including *Phragmites* in Mill Creek, and the large amount of impervious surfaces are also significant concerns. Several other indicators are in good or moderate condition but near thresholds of concern and potentially degrading over time, including the southern live oak population, salt marsh extent, and the park's visual viewshed. Finally, more data would be useful to assess trends for resources such as birds, water quality, and sediments.

Table 5-9. Summary of park vital signs including attainment average of indicators for Fort Monroe National Monument.

Vital Sign	Reference Condition Attainment	Current Condition	Confidence in Assessment
Air Resources	19%	Significant Concern	High
Water Resources	59%	Moderate Concern	Moderate
Biological Integrity	57%	Moderate Concern	Moderate
Landscape Dynamics	58%	Moderate Concern	Moderate
Fort Monroe National Monument	**48%**	**Moderate Concern**	**Moderate**

NPS 250/142910, March 208

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