National Park Service
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Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Fort Frederica National Monument, Georgia

Natural Resource Report NPS/NRSS/WRD/NRR—2012/516

ON THE COVER
Fort Frederica.
Photograph by: Jessica L. Dorr, Conservation Management Institute, Virginia Tech

Natural Resource Condition Assessment

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Publisher's Note: Some or all of the work done for this project preceded the revised guidance issued for this project series in 2009/2010. See Prologue (p. xxii) for more information.

Executive Summary

The goal of this assessment is to provide an overview of natural resource condition status to allow Fort Frederica National Monument (NM) to effectively manage National Park Service (NPS) trust resources through Resource Stewardship Strategies (RSS) and General Management Plans. An ancillary benefit is that it will aid the park in meeting government reporting requirements, such as the land health goals under the Government Performance Results Act (GPRA). This assessment is primarily based on existing data and information from the NPS Inventory & Monitoring Program, and from other Federal and State natural resource agencies.

A natural resource assessment should provide a concise, understandable, and accurate summary of the condition of the ecological system. Reporting on this ecological condition will provide for better decision-making (Young and Sanzone 2002). As such we found that collaborating with decision-makers was an important part of this project.

Precise measurements and objective analysis are preferred for assessing the condition of natural resources. Wherever possible, we used quantitative data and established thresholds, but in some cases only qualitative measures were available to rate important categories. Rather than remove these categories all together, we simply report on the type of data that was available and the methods used to compare these data to a desired condition. In all cases, straightforward tables, charts, maps, and geospatial data are provided to summarize findings.

The National Park Service (NPS) monitors the condition of their natural resources using an ecological monitoring framework that has been widely used among other agencies (Fancy et al. 2008). There are six basic level 1 categories: 1) air and climate; 2) geology and soils; 3) water; 4) biological integrity; 5) human use; and 6) ecosystem pattern and process. This framework is based on earlier work including the Environmental Protection Agency's ecological condition framework that uses similar essential ecological attributes as their upper-level categories (Young and Sanzone 2002). We found the NPS categories to be uncomplicated and intuitive. This framework is also familiar to NPS personnel and will allow the users to compare current vital sign monitoring plans to this assessment. We have, however, reorganized the NPS framework to go from small-scale (broad) to large-scale (detailed) analysis, beginning with a primary threat and stressor, ecosystem pattern and process (landscapes).

Throughout this assessment, several data under each natural resource category are given a condition status score. Some of these scores are based on predesigned systems, but all have been cross referenced to a good, fair, poor scoring system (Table 1).

Table 1. Condition status scoring system for Fort Frederica National Monument Natural Resource Assessment.

Score	*Range*	*Midpoint*
Good	0.67 - 1.00	0.84
Fair	0.34 - 0.66	0.5
Poor	0.00 - 0.33	0.17

In addition, we provide a data quality rating based on three categories, *thematic*, *spatial*, and *temporal*. We gave *thematic* a 1 or 0 (yes or no) based on whether these data were from the best available source. *Spatial* received a 1 or 0 based on the spatial proximity of these data (park data or out of park data). We also gave *temporal* a 1 or 0 based on how recent these data were acquired. *Temporal* was somewhat dependent on data type, but generally, if the data were from the last 5 years, they received a 1. A sample is shown in Table 2. These tables are combined and an overall condition status is reported in the conclusion of this document. The user can also access these scores in the provided spreadsheet to view calculations, update data, and modify importance ratings as management goals change.

Table 2. Example condition status table. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), s*patial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Data Quality***		
		Thematic	*Spatial*	*Temporal*
		1	0	0
Condition Group A	Good	1 out of 3		
		1	1	0
Condition Group B	Fair	2 out of 3		
		1	1	1
Condition Group C	Poor	3 out of 3		

The overall condition status for Fort Frederica NM is in the good range (0.67; close to fair; Table 3). Midpoint scores were averaged for each NPS ecological monitoring framework level 2 category (Fancy et al. 2008) to come up with the overall condition status for the monument. The data quality scores were summed for each category.

Landscape dynamics, fire dynamics, human effects, visitor use, hydrology, and geology and soils scored in the good range. Landscape, fire, and human effects are broad-scale assessment categories upon which Fort Frederica NM has limited management influence. Consistent reporting and collaboration are essential for these categories. Visitor use is relatively consistent and this fort is visited at an average level compared with other forts managed by the NPS. Only stream flow maintenance had a negative correlation in the hydrology section. Soils have remained relatively consistent with the only limiting factor being the flooding frequency.

Biological integrity (biotic) received a fair rating. The species assemblages present do not appear to reflect the more complete biotic communities observed in the surrounding area. This is perhaps due to the unique salt marsh habitat present at the monument and may be due in part to a lack of comprehensive survey efforts. Other categories that scored in the fair range included climate and water quality. Climate and water quality are categories that will need coordination with other management organizations to improve. Collecting additional water quality data within park boundaries would allow better assessment of in-park resources.

The only category in this assessment to receive a poor rating was air quality. Despite a fair ozone exposure score, the poor rating was a result of high levels of estimated atmospheric deposition and poor visibility due to a high Haze Index score. Similar to landscape, fire, and human effects, air quality is a broad-scale assessment category upon which Fort Frederica NM has limited management influence.

Spatial proximity and thematic (best source) are the limiting factors in data quality. Thematic is often in the fair range for data quality, mostly due to needing more local-scale data. This National Monument was established primarily to protect cultural resources, so a minimal amount of natural resource data has been collected on-site. There are plans to map vegetation communities and continue species and community inventory and monitoring. An observation that was present in several of the assessment categories is the importance of coordination with outside management organizations. It was also noted in several categories that additional local-scale data collection could improve assessment and management.

The good, fair, poor scoring system (Table 1) has its limitations. It is somewhat subjective, especially when pre-established thresholds and criteria were missing. However, in most cases we were able to find thresholds from other agencies or peer-reviewed publications. We make note of the cases where established rating systems or thresholds were not available. With these caveats in mind, we effectively reported on the condition status of important natural resource management categories while providing further information on data quality.

Table 3. Overall condition status summary for Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), *spatial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Score***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Landscape dynamics total			0	3	0
	Good	0.84	3 out of 9		
Fire dynamics total			0	1	1
	Good	0.84	2 out of 3		
Human effects total			1	2	2
	Good	0.84	5 out of 6		
Visitor use total			0	1	1
	Good	0.84	2 out of 3		
Air quality total			3	1	3
	Poor	0.28	7 out of 9		
Climate total			5	1	5
	Fair	0.57	11 out of 15		
Hydrology total			0	6	6
	Good	0.73	12 out of 18		
Water quality total			4	0	0
	Fair	0.63	5 out of 12		
Soil total			3	3	3
	Good	0.73	9 out of 9		
Biotic total			5	1	6
	Fair	0.39	12 out of 18		
FOFR overall			21	19	28
	Good	0.67	68 out of 102		

This project provided a comprehensive amount of organized tabular data and many geospatial data layers and maps that will aid in the management of Fort Frederica NM. These data are provided on an accompanying disk and can be used to compare current status to future conditions. This is merely a first step to compiling data and reporting on current condition status, data gaps, and threats and stressors. A well-established assessment protocol will include follow-up and future analysis.

Acknowledgements

This project would not have been possible without the help of personnel from Fort Frederica National Monument, NPS Southeast Region, Southeast Coast Network, and various departments at Virginia Tech. We would like to thank the following people for their contribution to this assessment effort:

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Prologue

Publisher's Note: This was one of several projects used to demonstrate a variety of study approaches and reporting products for a new series of natural resource condition assessments in national park units. Projects such as this one, undertaken during initial development phases for the new series, contributed to revised project standards and guidelines issued in 2009 and 2010 (applicable to projects started in 2009 or later years). Some or all of the work done for this project preceded those revisions. Consequently, aspects of this project's study approach and some report format and/or content details may not be consistent with the revised guidance, and may differ in comparison to what is found in more recently published reports from this series.

Abbreviations

AQI	Air Quality Index
BBS	Breeding Bird Survey
BOD	Biological Oxygen Demand
BMP	Best Management Practice
C-CAP	Coastal Change Analysis Program
CMI	Conservation Management Institute at Virginia Tech
CRD	Coastal Resources Division
CWA	Clean Water Act
DDT	Dichloro-Diphenyl-Trichloroethane
DEM	Digital Elevation Model
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphorus
DNR	Department of Natural Resources
DO	Dissolved Oxygen
DRG	Digital Raster Graphic
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
EPD	Environmental Protection Division
ERL	Effects Range Low
ESRI	Environmental Systems Research Institute
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FOFR	Fort Frederica National Monument
GA	Georgia
GAP	Gap Analysis Program
GDD	Growing Degree Days
GeoMAC	Geospatial Multi-Agency Coordination Group
GFC	Georgia Forestry Commission
GIS	Geographic Information System
GMP	General Management Plan
GPRA	Government Performance Results Act
HSI	Hazardous Site Inventory
HUC	Hydrologic Unit Code
I&M	Inventory and Monitoring
LMER	Land Margin Ecosystem Research
LTER	Long-Term Ecological Research
MLRA	Major Land Resource Area
NB	National Battlefield
NCA	National Coastal Assessment
NCDC	National Climatic Data Center
NESDIS	National Environmental Satellite, Data, and Information Service
NHD	National Hydrologic Data
NM	National Monument
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service

NRCS	Natural Resources Conservation Service
NTCHS	National Technical Committee for Hydric Soils
NWI	National Wetlands Inventory
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PDSI	Palmer Drought Severity Index
PPM	Parts per million
RSS	Resource Stewardship Strategies
SC	South Carolina
SCP	Southern Coastal Plain
SERCC	Southeast Regional Climate Center
SSURGO	Soil Survey Geographic
TD	Tropical Depression
TS	Tropical Storm
U.S.	United States
UGA	University of Georgia
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey

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1.0 Introduction

The goal of this assessment is to provide an overview of natural resource condition status to allow Fort Frederica National Monument (NM) to effectively manage National Park Service (NPS) trust resources through Resource Stewardship Strategies (RSS) and General Management Plans. An ancillary benefit is that it will aid the park in meeting government reporting requirements, such as the land health goals under the Government Performance Results Act (GPRA). This assessment is primarily based on existing data and information from the NPS Inventory & Monitoring Program, and from other Federal and State natural resource agencies.

A natural resource assessment should provide a concise, understandable, and accurate summary of the condition of the ecological system. Reporting on this ecological condition will provide for better decision-making (Young and Sanzone 2002). As such we found that collaborating with decision-makers was an important part of this project.

An iterative process was implemented to collect and synthesize data and meet with NPS staff. We collaborated on what was important for their particular assessment, park, and watershed. Additional data was then collected and the process repeated itself to further refine and identify additional natural resource issues and objectives for this assessment.

Precise measurements and objective analysis are preferred for assessing the condition of natural resources. Wherever possible, we used quantitative data and established thresholds, but in some cases only qualitative measures were available to rate important categories. Rather than remove these categories all together, we simply report on the type of data that was available and the methods used to compare these data to a desired condition. In all cases, straightforward tables, charts, maps, and geospatial data are provided to summarize findings.

2.0 Park and Resources

2.1 Bio-geographic and Physical Setting

2.1.1 Park Location and Size

Fort Frederica NM is located in the Coastal Plain of Georgia, 12 miles northeast of the city of Brunswick on Saint Simons Island in Glynn County (Figure 1). St. Simons Island is the second largest of Georgia's barrier islands. The monument has two separate sites that they manage, totaling approximately 282 acres. Fort Frederica headquarters, visitor center, and historic structures compose the primary management area (Figure 1). This main site is on a bluff overlooking the Frederica River and adjacent coastal tidal marshes. The Bloody Marsh Battle Site is located 6 miles south of these headquarters and is a small, 7.5 acre site, commemorating this battle (National Park Service 2002).

2.1.2 Park Plans and Objectives

The purpose of Fort Frederica National Monument is to preserve and protect the historical, archeological, and scenic resources associated with colonial Frederica and to use those resources to educate, interpret, explain and illustrate the role of Fort Frederica in American history (National Park Service 2002).

The mission of the National Monument is more than preserving the physical remnants of Frederica. It is also important to preserve its unique sense of antiquity and to use this time capsule as a tool to educate present and future generations about the nation's colonial past. Mission Goals include:

1. All cultural resources and their relationships with the land are protected and preserved.
2. Visitors safely enjoy and are satisfied with the availability, accessibility, diversity, and quality of park facilities, services, and appropriate recreational opportunities.
3. Fort Frederica National Monument uses current management practices, systems, and technologies to accomplish its mission.
4. Fort Frederica National Monument increases its managerial capabilities through volunteerism, partnerships and grants (National Park Service 2002).

A land exchange took place with Christ Church of Saint Simons Island in 2006. This exchange of 6 acres for 8.7 acres occurred to allow for further protection of unstudied cultural resources on the 8.7 acre addition. The primary objective of this land is preserving and interpreting historical or archeological resources identified on the site, while a secondary objective is preserving and interpreting its natural resources (National Park Service 2006).

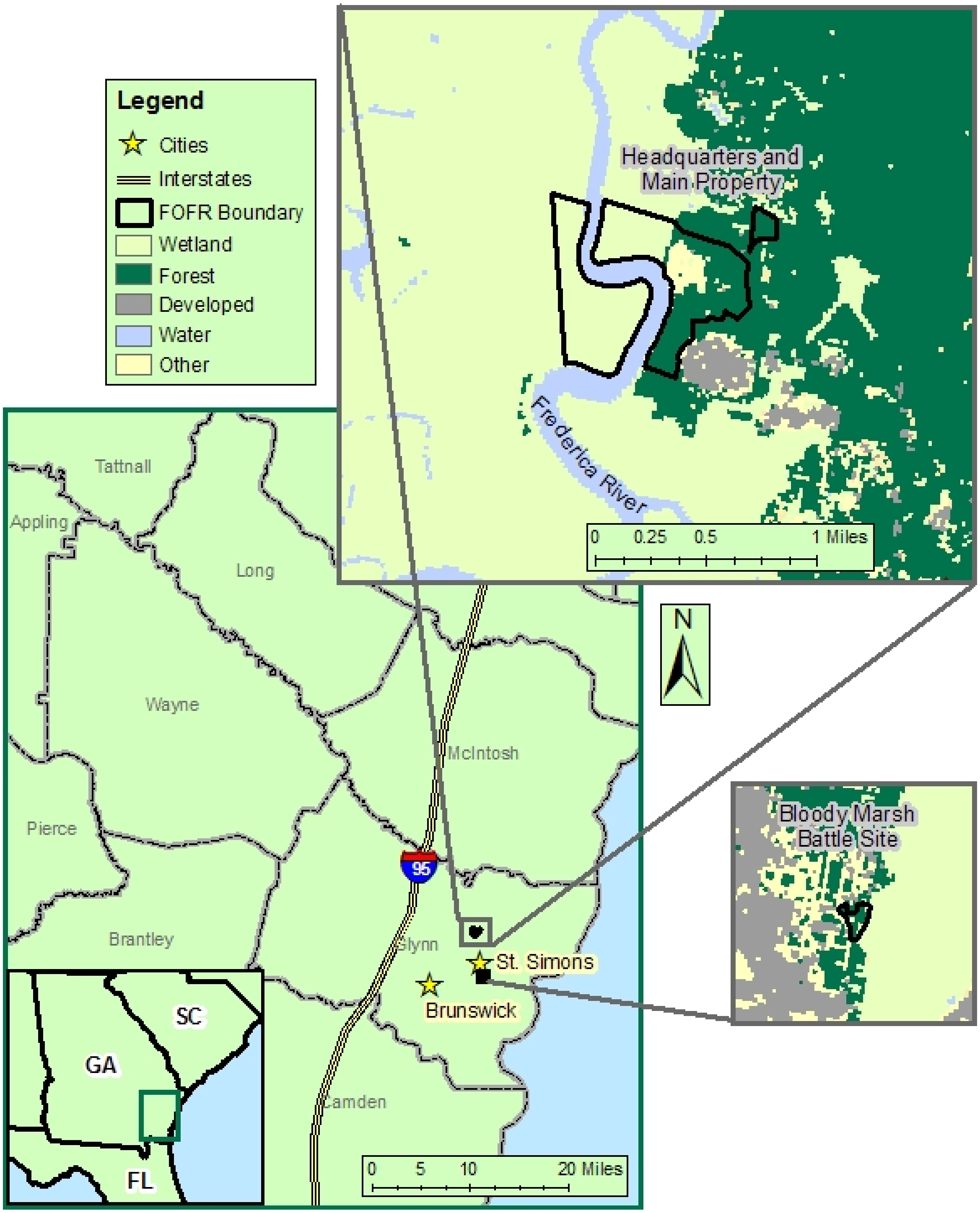

Figure 1. Fort Frederica National Monument is located on St. Simons Island, the second largest barrier island in Georgia.

2.1.3 Climate

The climate of the St. Simons Island region of the Georgia Coastal Plain is temperate, semitropical with hot, humid summers and mild winters. The average annual temperature of the area is 68.3 degrees Fahrenheit (°F), with a mean maximum temperature of 77.9°F and mean minimum temperature of 58.7 °F. The coolest month on average is January, at 43.0°F, and the warmest month is July, at 91.0°F (Georgia Automated Environmental Monitoring Network 2008). Lowest and highest recorded temperatures were 6°F in 1985 and 104°F in 1986. The wettest month is September with an average of 6.24 inches of precipitation. Half (46%) of the rain falls during the months of June through September (The Weather Channel 2008). Major storms are somewhat of a concern as this area is brushed or hit by a tropical system every 3.81 years (Hurricane City 2008). The growing season averages 286 days with the last spring freeze normally occurring in late February and first fall freeze normally occurring in early December (UGA State Climate Office 2008).

2.1.4 Geology, Landforms, and Soils

The Coastal Plain region is composed of undeformed sedimentary rock layers whose ages range from the Late Cretaceous to the present Holocene sediments of the coast. Beneath Coastal Plain sediments are harder igneous and metamorphic rocks, such as those found in the Piedmont. Usually referred to as the "basement," these hard rocks occur at greater and greater depths toward the south and east, reaching depths of up to 10,000 feet or more beneath the modern Georgia coast (Frazier 2007). Sediment from the upper Piedmont region eroded into the Coastal Plain over the past 100 million years. In addition to recent alluvium, organic and marine deposits make up some of the sediment found in the Coastal Plain (UGA Department of Geology 2008). Human-dredged and deposited sediments are abundant along the coastlines. Specifically, the coastal region at Fort Frederica NM is a Pleistocene-aged marine barrier island deposit and a Holocene-aged marine organic tidal marsh deposit.

The majority of Fort Frederica NM acreage is in native tidal marsh. The General Management Plan (National Park Service 2002) states that there are 130 acres of marshes in the main Fort Frederica site, with an additional 5 acres of marsh at the Bloody Marsh Battle Site. We found a total of 170 acres of wetlands based on a classification that is explained further in 3.1.1 Landscape Dynamics section. The second largest cover type we found is approximately 90 acres of upland forest. Most of the forested acres within the monument are dominated by loblolly pine. Some areas are reverting to a cover type similar to pre-colonial times, a mixture of oak and hardwood forest (National Park Service 2002). There are old roadbeds, a power line right-of-way, and yacht club foundations in the forested area south of the historic town site. The Bloody Marsh Battle Site has about 3 acres of upland forest (National Park Service 2002).

According to Soil Survey Geographic (SSURGO) data from the USDA Natural Resources Conservation Service (2006), 57.5% of the soil is *Bohicket-Capers association*, 28.0% is *Cainhoy fine sand*, 4.8% is *Pottsburg sand*, 4.4% is *Pelham loamy sand*, 2.4% is *Rutlege fine sand*, 1.8% is *Mandarin fine sand*, and 1.1% is water. Additional information on these soils can be found in 3.5.1 Geology and Soils section.

2.1.5 Surface Water and Wetlands

The Frederica River is the main river that passes through Fort Frederica NM boundaries, separating the salt marsh property to the west. Other nearby rivers and creeks include the

MacKay River, Dunbar Creek, Crooked Creek, and Jove Creek (Figure 2). The Frederica River and MacKay River are tidal in nature, join to form St. Simons Sound, and separate St. Simons Island from the mainland. All of Fort Frederica NM and these surrounding waterways are in the Cumberland-St. Simons, Georgia subbasin, hydrologic unit code (HUC) 03070203.

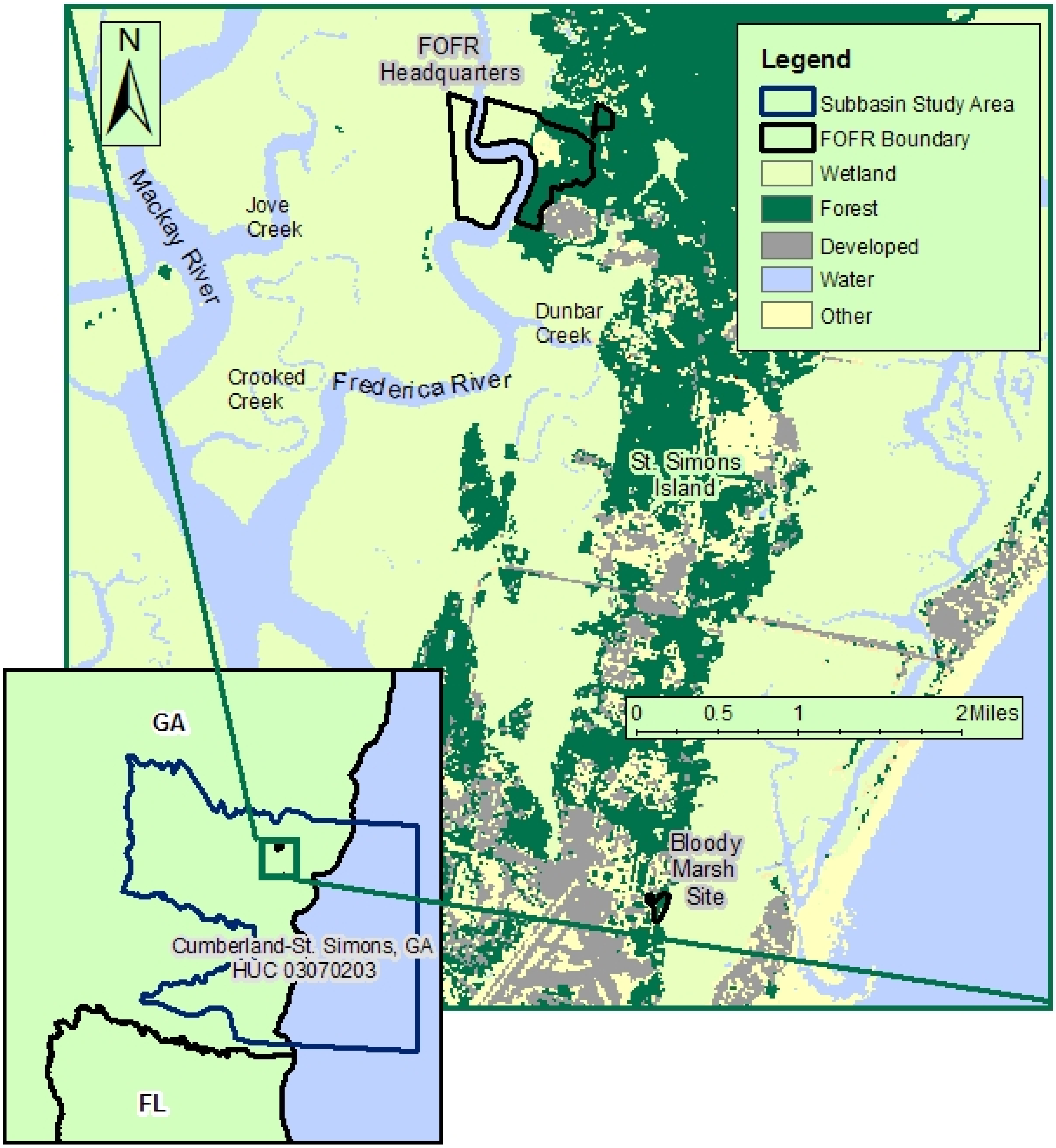

Figure 2. Water resources and hydrologic unit boundary at Fort Frederica National Monument.

As mentioned previously, we found 170 acres of wetlands within the monument boundaries. According to the General Management Plan (National Park Service 2002), these are at least partially tidal freshwater marshes, inland from salt marshes and mangrove swamps. These wetlands are important globally and support a myriad of aquatic plants and animals. As development along the coast and threats of rising sea level from climate change continues, importance will be placed on maintaining wetlands.

2.2 Regional and Historic Context

2.2.1 Regional History and Land Use

The region surrounding Fort Frederica NM has a rich history stretching back to early Native American occupation. These areas provided an abundance of aquatic resources that were ideal for subsistence of early people. Pottery dating to 2200 B.C. has been documented in the area (National Park Service 2006). In the early 16th century, Spanish missions were established from Florida to South Carolina. The tribes in the area were known as Timucuans by the Spanish, but Mocama and Guales were the local tribe names. Eventually Spanish control diminished due to the growth of the British colony of Charles Town (later Charleston) to the north. This led to the establishment of the final of the 13 British colonies, Georgia, in 1733.

The total population for year 2000 in the St. Simons subdivision of Glynn County was 14,654, while the 1990 total was 12,905. More recent data for St. Simons was not available, so we looked at the Brunswick, Georgia Metropolitan Statistical Area (MSA). The city of Brunswick sits approximately 5.5 miles southwest of St. Simons. This MSA ranked 337th out of 363 MSAs nationwide, with 101,792 people in the 2007 population estimate (U.S. Census Bureau 2009b). The fastest growing county in the region is Camden County, which went from 30,167 to 48,689 individuals from 1990 to 2007, a 61% increase. Following Camden County is nearby Brantley County, with a 39% increase from the 1990 census to 2007 population estimates, and McIntosh and Wayne counties, with respective population increases of 32% and 30% between 1990 and 2007. The county in which Fort Frederica NM is located, Glynn County, experienced the lowest population growth in the region, with an increase of 20% between 1990 and 2007. In the Satilla River Basin as a whole, the population increased by one percent per year between 1975 and 1995 and is projected to increase at a faster than average growth rate through 2050 (GA DNR Environmental Protection Division 2002).

Forestry and its products are a major land use and commodity within the Satilla River basin, with approximately 3,365,100 acres of commercial forest land (GA DNR Environmental Protection Division 2002). There were 464,292 acres of agricultural land in 1997 in the Satilla River Basin, but Glynn County has less than 10% of the county in farmland (GA DNR Environmental Protection Division 2002).

2.2.2 Site History

Some areas around Fort Frederica were cleared by native people for agriculture before the fort and town were established. Some written accounts state that the forested areas were evergreen, oak, and mixed hardwood forests. The British settled in the area and built the town under the direction of General James Oglethorpe from 1736 to 1748 (National Park Service 2002). This was a highly contested region between Great Britain, France, and Spain. The nearby Battle of Bloody Marsh in 1742 secured Great Britain’s hold on this region. The town supported the military with skilled settlers and had a population of up to 1,000 individuals at its height (National Park Service 2008a). Frederica fell into disrepair after 1749, and most of the buildings were destroyed in a fire in 1758 (National Park Service 2008b).

Fort Frederica NM was established in 1945 after local residents became interested in preserving the site. This monument preserves the colonial British town and fortification of Fort Frederica that were key in the plight of Great Britain against Spanish colonization (National Park Service 2002).

2.3 Unique and Significant Park Resources and Designations

2.3.1 Unique Resources

There are several significant historical park resources at Fort Frederica NM. There is a large diversity of colonial archeological resources and the site is important in the establishment of archeology science and education. This monument commemorates the effective end of Spanish claim to Georgia and the Carolinas. At various times this site was home to General James Oglethorpe, first Governor and founder of the British colony of Georgia, and John and Charles Wesley, the founders of Methodism (National Park Service 2002). It is possible that the remains of General Oglethorpe's only house in the new world is located on the newly acquired Christ Church land (National Park Service 2006). There are no unique resources of natural resource significance listed in plans and reports, but this site is protecting a tidal marsh and upland forest and is home to a myriad of native wildlife species.

2.3.2 Special Designations

Fort Frederica NM has no special natural resource designations, however it is listed on the National Register of Historic Places (National Park Service 2002).

3.0 Condition Assessment (Interdisciplinary Synthesis)

The National Park Service (NPS) monitors the condition of their natural resources using an ecological monitoring framework that has been widely used among other agencies (Fancy et al. 2008). There are six basic level 1 categories: 1) air and climate; 2) geology and soils; 3) water; 4) biological integrity; 5) human use; and 6) ecosystem pattern and process. This framework is based on earlier work including the Environmental Protection Agency's ecological condition framework that uses similar essential ecological attributes as their upper-level categories (Young and Sanzone 2002). We found the NPS categories to be uncomplicated and intuitive. This framework is also familiar to NPS personnel and will allow the users to compare current vital sign monitoring plans to this assessment. We have, however, reorganized the NPS framework to go from small-scale (broad) to large-scale (detailed) analysis, beginning with a primary threat and stressor, ecosystem pattern and process (landscapes).

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Table 2. Example condition status table. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), s*patial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Data Quality***		
		Thematic	*Spatial*	*Temporal*
		1	0	0
Condition Group A	Good	1 out of 3		
		1	1	0
Condition Group B	Fair	2 out of 3		
		1	1	1
Condition Group C	Poor	3 out of 3		

3.1 Ecosystem Pattern and Process

3.1.1 Landscape Dynamics

Managing the entire landscape as opposed to individual species or community types is a recommended step to maintain ecosystem health. With that in mind, the landscape as a whole was considered at Fort Frederica NM. Ecosystems do not often function within the small political boundaries in which regulating bodies are constrained. Fort Frederica NM is a relatively small park unit, so we chose to first look at the monument within its watershed context and then examine the finer-scale park property.

3.1.1.a Current condition:
Study area:
The broad study area that we chose was based on the National Hydrologic Data (NHD) and includes Cumberland-St. Simons, Georgia subbasin, hydrologic unit code (HUC) 03070203. The NHD geospatial layers do not further delineate this subbasin into specific watersheds. This study area covers almost all of Glynn County and part of Camden, Brantley, and Wayne Counties, Georgia (Figure 3).

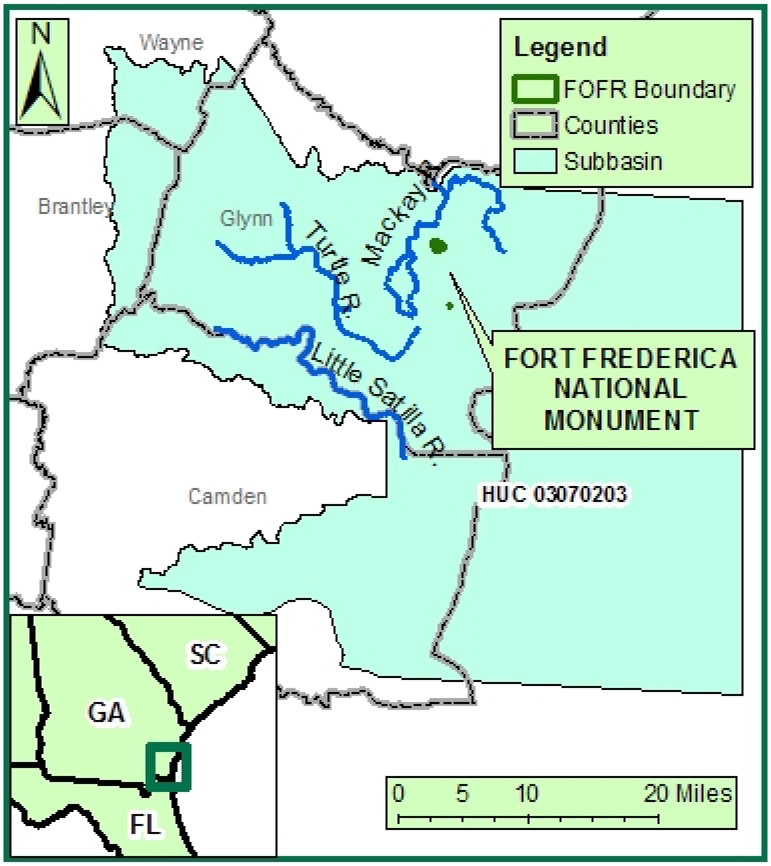

Figure 3. The subbasin study area examined for the Fort Frederica NM Natural Resource Assessment.

Land cover:
When looking at land cover, there are several possible data sources that could be used. We chose the newest, most complete and detailed classification from the National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP). These data are part of the overall National Land Cover Dataset, but are more detailed around the coastal regions (National Oceanic and Atmospheric Administration 2008a). We examined these data in the overall subbasin study area outlined above and within the Fort Frederica NM boundary. Because the monument contains a relatively small area, the spatial resolution of C-CAP for analysis within the park boundary was questionable. Consequently, we (Conservation Management Institute at Virginia Tech, CMI) also performed a more detailed classification using heads-up digitizing over 1999 digital orthophotos from the Georgia GIS Data Clearinghouse (Georgia State Base Map Framework 1999). This delineation was performed at a minimum 1:10,000 scale and polygons were attributed using photointerpretation and the C-CAP classification schema. More detailed spatial data preparation methods can be found in Appendix A: Land cover calculation methods.

The total land area within the subbasin study area is approximately 612,000 acres. Of this total acreage, 24.6% or 150,313 acres is Evergreen Forest. This class represents a comparable 31.7% or 89.6 acres in the FOFR CMI classification (31.3% NOAA C-CAP, Table 3, Figure 4). The largest represented class in the FOFR CMI classification is Estuarine Emergent Wetland, at

57.8% or 163.3 acres (55%, NOAA C-CAP), while the subbasin study area is composed of only 16.1% or 98,359 acres of this class. This differing comparison is not surprising, considering the study area extends approximately 30 miles inland, causing a greater diversity and differing inland cover types compared to the small and strictly coastal nature of Fort Frederica NM. Contrasting the relative make-up of cover-types within the subbasin study area allows the opportunity to see where this coastal park fits within the broader landscape.

Table 3. Land cover (from CMI classification and 2001 NOAA C-CAP) totals and percent of total within Fort Frederica National Monument (FOFR) boundary and in the subbasin study area containing FOFR. "FOFR Acres (CMI)" are the number of acres of each cover type within FOFR as delineated by the Conservation Management Institute at Virginia Tech (CMI). "FOFR Acres (NOAA)" are the number of acres of each cover type within FOFR as classified by the National Oceanic and Atmospheric Administration (NOAA 2008a) Coastal Change Analysis Program (C-CAP). "Study Area Acres" are the number of acres of each cover type within the subbasin study area as classified by the NOAA. In each case, "%" refers to the percent of the total acreage of FOFR or the subbasin study area.

Land Cover Classification	*FOFR Acres (CMI)*	*FOFR % (CMI)*	*FOFR Acres (NOAA)*	*FOFR % (NOAA)*	*Study Area Acres*	*Study Area %*
Estuarine Emergent Wetland	163.3	57.8	155.7	55.0	98359	16.1
Evergreen Forest	89.6	31.7	88.7	31.3	150313	24.6
Pasture/Hay	17.9	6.3	17.8	6.3	2851	0.5
Palustrine Forested Wetland	7.6	2.7	6.9	2.4	57106	9.3
Water	2.3	0.8	5.3	1.9	187965	30.7
Low Intensity Developed	1.5	0.5	0.4	0.2	12451	2.0
Mixed Forest	0.2	0.1	0.7	0.2	2052	0.3
Estuarine Scrub/Shrub Wetland	0.0	0.0	2.9	1.0	863	0.1
Palustrine Scrub/Shrub Wetland	0.0	0.0	1.6	0.5	15172	2.5
Grassland	0.0	0.0	1.1	0.4	17122	2.8
Developed Open Space	0.0	0.0	0.9	0.3	9574	1.6
Scrub/Shrub	0.0	0.0	0.7	0.2	33676	5.5
Deciduous Forest	0.0	0.0	0.4	0.2	516	0.1
Palustrine Emergent Wetland	0.0	0.0	0.0	0.0	11896	1.9
Bare Land	0.0	0.0	0.0	0.0	3949	0.6
Unconsolidated Shore	0.0	0.0	0.0	0.0	3602	0.6
Medium Intensity Developed	0.0	0.0	0.0	0.0	2320	0.4
High Intensity Developed	0.0	0.0	0.0	0.0	1873	0.3
Cultivated	0.0	0.0	0.0	0.0	313	0.1
Estuarine Forested Wetland	0.0	0.0	0.0	0.0	36	0.0

A more significant comparison was examining the cover type percentages in the coastal region of the study area (the coastal study area) and with other protected areas in the nearby coastal region (Table 4). The coastal study area is a smaller subset of the original subbasin study area which includes the subbasin as far inland as the Fort Frederica NM boundaries. These acreages and percentages show that Fort Frederica NM is protecting a minor amount of the Estuarine Emergent Wetland in the coastal region of the subbasin. The coastal conservation areas that we examined included Jekyll Island State Park, managed by Jekyll Island Authority, and four separate Sea Island Hammocks Natural Areas and Pelican Spit Natural Area, managed by Georgia Department of Natural Resources.

Despite its small size, the monument is holding 9.4% (171 acres) of the total protected wetlands in conservation areas in the coastal study area (1810 acres). There is an additional 56,752 acres of wetlands in the coastal region of the study area that is not owned and under direct protection by a conservation organization. Despite the fact that tidally influenced marshes and waterways are protected under the Coastal Marshlands Protection Act (GA DNR Coastal Resources Division 2008), these areas are still under development pressure and permits can be acquired to alter these wetlands. With that in mind, Fort Frederica NM and other conservation areas may play a larger role in the protection of Georgia coastal natural areas as population and development pressures increase.

Table 4. Comparison of cover types (from CMI classification and 2001 NOAA C-CAP) within Fort Frederica National Monument boundary, coastal study area, and coastal conservation areas. "FOFR Acres (CMI)" are the number of acres of each cover type within FOFR as delineated by the Conservation Management Institute at Virginia Tech (CMI). "Coastal Area Acres (NOAA)" are the number of acres of each cover type within the coastal study area as classified by the National Oceanic and Atmospheric Administration (NOAA 2008a) Coastal Change Analysis Program (C-CAP). "Coastal Conservation Acres (NOAA)" are the number of acres of each cover type within the coastal conservation areas as classified by the NOAA. In each case, "%" refers to the percent of the total acreage of either FOFR, coastal study area, or coastal conservation areas.

Land Cover Classification	*FOFR Acres (CMI)*	*FOFR % (CMI)*	*Coastal Area Acres (NOAA)*	*Coastal Area % (NOAA)*	*Coastal Conservation Acres (NOAA)*	*Coastal Conservation % (NOAA)*
Estuarine Emergent Wetland	163.3	57.8	55024	50.1	1303.9	27.8
Evergreen Forest	89.6	31.7	13363	12.2	1979.7	42.1
Pasture/Hay	17.9	6.3	302	0.3	18.5	0.4
Palustrine Forested Wetland	7.6	2.7	1861	1.7	157.5	3.4
Water	2.3	0.8	24046	21.9	99.9	2.1
Low Intensity Developed	1.5	0.5	3894	3.5	232.2	4.9
Mixed Forest	0.2	0.1	239	0.2	13.3	0.3
Developed Open Space	0.0	0.0	3077	2.8	461.2	9.8
Unconsolidated Shore	0.0	0.0	1702	1.6	84.7	1.8
Bare Land	0.0	0.0	1160	1.1	20.0	0.4
Scrub/Shrub	0.0	0.0	1140	1.0	45.6	1.0
Medium Intensity Developed	0.0	0.0	842	0.8	29.6	0.6
Grassland	0.0	0.0	816	0.7	48.3	1.0
Palustrine Emergent Wetland	0.0	0.0	731	0.7	114.8	2.4
Palustrine Scrub/Shrub Wetland	0.0	0.0	703	0.6	59.8	1.3
High Intensity Developed	0.0	0.0	550	0.5	9.8	0.2
Estuarine Scrub/Shrub Wetland	0.0	0.0	238	0.2	3.3	0.1
Deciduous Forest	0.0	0.0	55	0.0	11.1	0.2
Cultivated	0.0	0.0	11	0.0	4.2	0.1
Estuarine Forested Wetland	0.0	0.0	5	0.0	0.0	0.0
Total	282.4	100	109757	100	4697.3	100

Vegetation:
In addition, we reclassified and examined the land cover data to quantify “natural vegetation,” “semi-natural vegetation,” and “unnatural vegetation” within the subbasin study area and within the monument boundary (Appendix A). “Natural vegetation” dominates the relative land area of the subbasin study area and an even greater relative area of Fort Frederica NM (Table 5, Figure 5). Only 0.5% of the monument is in “unnatural vegetation,” while its subbasin study area is composed of 4% “unnatural vegetation.”

Table 5. Comparison of natural, semi-natural, and unnatural vegetation (reclassified from CMI classification and 2001 NOAA C-CAP) at Fort Frederica National Monument and in the subbasin study area. “FOFR Acres” are the number of acres of each vegetation type within FOFR as delineated by the Conservation Management Institute at Virginia Tech (CMI). “Study Area Acres” are the number of acres of each vegetation type within the subbasin study area as classified by the NOAA. In each case, “%” refers to the percent of the total acreage of either FOFR or the subbasin study area.

Vegetation Classification	*FOFR Acres*	*FOFR %*	*Study Area Acres*	*Study Area %*
Natural Vegetation	260.6	93.1	387109.6	92.9
Semi-natural Vegetation	17.8	6.4	12738.7	3.1
Unnatural Vegetation	1.5	0.5	16643.7	4.0

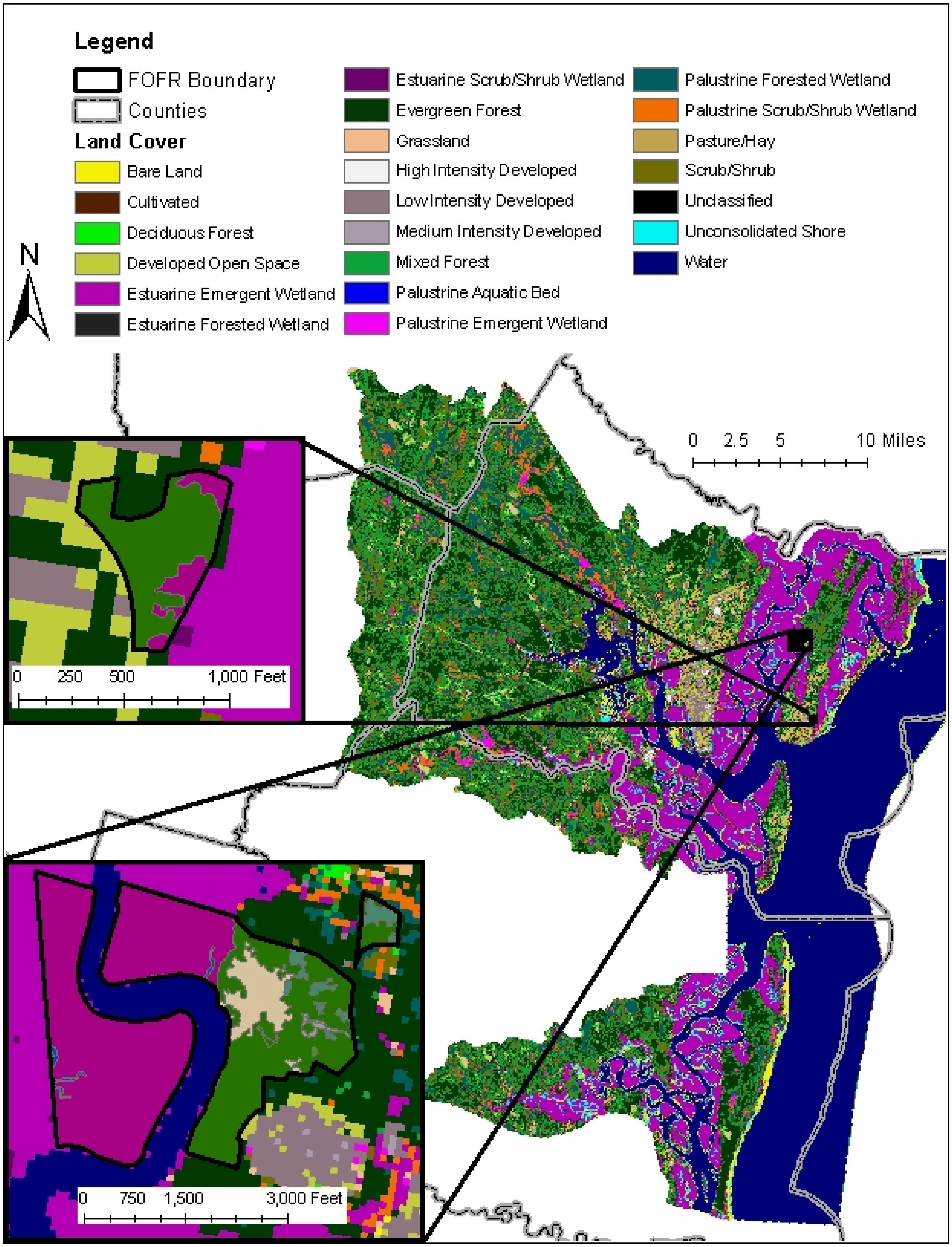

Figure 4. Land cover (from CMI classification in detailed insets and 2001 NOAA C-CAP) at Fort Frederica National Monument and subbasin study area.

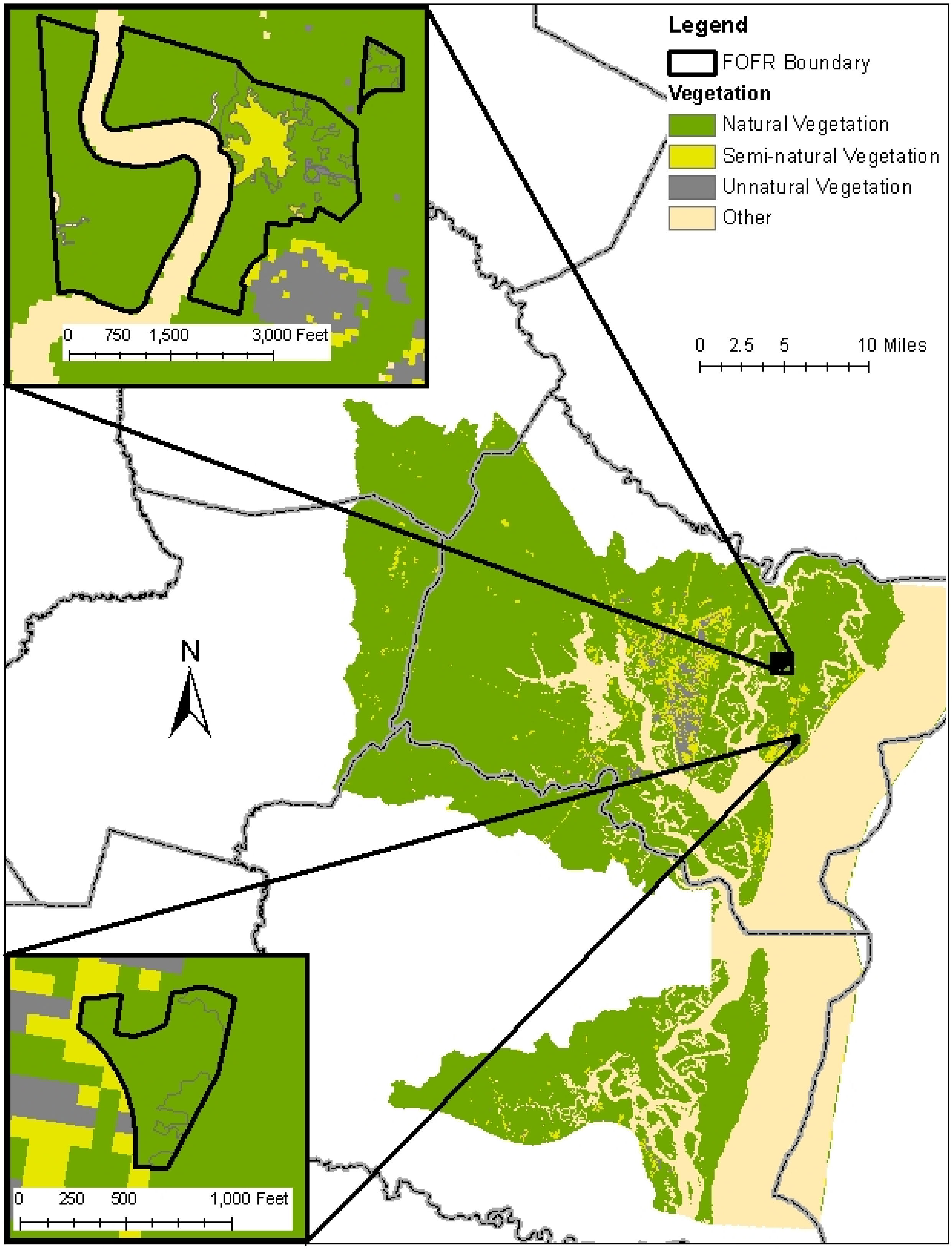

Figure 5. Vegetation reclass (from CMI classification in detailed insets and 2001 NOAA C-CAP) for Fort Frederica National Monument and subbasin study area.

3.1.1.b Resource threats and stressors:
Threats and stressors to landscape dynamics are plentiful and often serve as primary threats to other natural resource categories examined in this assessment. Several were mentioned in the previous condition status and all are related. They include human population growth, unstructured development, and overutilization of natural resources, all of which often lead to habitat fragmentation and wetland loss.

Land cover changes have been evident throughout the subbasin study area (Table 6). There was a 15% increase from 1996 to 2001 in developed areas within the study area. These changes will directly impact Fort Frederica NM as even relatively small protected natural areas fall under increased pressure to accommodate much of their region's natural processes and biodiversity.

Table 6. Land cover change (from 1996 and 2001 C-CAP) in the subbasin study area containing Fort Frederica National Monument and surrounding watersheds.

Land Cover Classification	*Study Area Acres 1996*	*Study Area % 1996*	*Study Area Acres 2001*	*Study Area % 2001*	*Percent Change 1996 - 2001*
Deciduous Forest	295	0.0	516	0.1	75.0
Palustrine Scrub/Shrub Wetland	10040	1.6	15172	2.5	51.1
Scrub/Shrub	23730	3.9	33676	5.5	41.9
Palustrine Emergent Wetland	8694	1.4	11896	1.9	36.8
Pasture/Hay	2106	0.3	2851	0.5	35.4
Grassland	12833	2.1	17122	2.8	33.4
Cultivated	280	0.0	313	0.1	11.7
Bare Land	3574	0.6	3949	0.6	10.5
Mixed Forest	1885	0.3	2052	0.3	8.9
Low Intensity Developed	11587	1.9	12451	2.0	7.5
Developed Open Space	9095	1.5	9574	1.6	5.3
Estuarine Scrub/Shrub Wetland	820	0.1	863	0.1	5.2
High Intensity Developed	1784	0.3	1873	0.3	4.9
Medium Intensity Developed	2220	0.4	2320	0.4	4.5
Estuarine Forested Wetland	36	0.0	36	0.0	1.9
Water	187562	30.6	187965	30.7	0.2
Estuarine Emergent Wetland	98213	16.0	98359	16.1	0.1
Evergreen Forest	168217	27.5	150313	24.6	-10.6
Palustrine Forested Wetland	64801	10.6	57106	9.3	-11.9
Unconsolidated Shore	4237	0.7	3602	0.6	-15.0

3.1.1.c Critical knowledge or data gaps:
To assess in-park landscapes, a more comprehensive, detailed scale map of vegetation communities would be an ideal addition to the broader scale land cover on which this analysis was primarily based. National Park Service has a service-wide vegetation mapping initiative (National Park Service 2008e), and current plans will have final maps available for Fort Frederica NM in 2012 (Curtis 2008). We could also draw more thorough conclusions with more

recently acquired data (Table 7). The detailed classification we performed used dated imagery, nearly 10 years old, and was done relatively fast, with no fieldwork, verification, or accuracy assessment. With that said, it was much more accurate than the NOAA C-CAP classification (30 by 30 meter pixel resolution) at the more detailed park scale.

3.1.1.d Condition status summary

The land cover comparison to coastal study area condition status is good because Fort Frederica NM is protecting a greater percentage of wetland and forest cover types than the coastal study area (Table 7). The monument is also protecting a larger relative area of wetlands than the coastal conservation areas, so this condition status is in the good range (Table 7). The forested percentage within Fort Frederica NM boundaries is slightly less, but wetlands made up for this disparity. Natural and semi-natural vegetation make up the bulk of the relative land area of Fort Frederica NM, so vegetation comparison to subbasin study area also received a good condition status (Table 7).

Table 7. Landscape dynamics condition status summary within Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), *spatial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Midpoint***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Land cover comparison to coastal study area			0	1	0
	Good	0.84	1 out of 3		
Land cover comparison to coastal conservation areas			0	1	0
	Good	0.84	1 out of 3		
Vegetation comparison to subbasin study area			0	1	0
	Good	0.84	1 out of 3		
Landscape dynamics total			0	3	0
	Good	0.84	3 out of 9		

3.1.1.e Recommendations to park managers:

Landscape scale initiatives take collaboration from all parties involved. Continuing to build on partnerships with other conservation organizations and land managers (Table 8) will promote broad-scale collaboration efforts.

Table 8. List of the coastal conservation areas, organizations, and contact information.

	Conservation Area	*Organization*	*Webpage*
1.	Jekyll Island State Park	Jekyll Island State Park Authority	http://www.stateparks.com/jekyll_island__authority.html
2.	Sea Island Hammocks Natural Areas	GA DNR	http://www.gadnr.org/
3.	Pelican Spit Natural Area	GA DNR	http://www.gadnr.org/

3.1.2 Fire and Fuel Dynamics

Fire exclusion practices have drastically changed the natural fire processes that took place in many ecosystems across the United States (U.S. Geological Survey 2000). Fire is now being used more actively in managing natural landscapes such as historical prairies and pine savannahs in the Coastal Plain of the Southeastern U.S. (Waldrop et al. 1992, U.S. Geological Survey 2000). Chinese tallow (*Sapium sebiferum*) and other Southeastern invasive exotic species may also be controlled with appropriately timed controlled burns (Zouhar et al. 2008). Although Fort Frederica NM does not currently have a natural fire regime, the park has developed a fire management plan in accordance with NPS Wildland Fire Management Guidelines (DO-18), which states that all parks with vegetation that can sustain fire must have a fire management plan (National Park Service 2004b). The fire management plan allows park administrators to capitalize on the benefits of fire in maintaining a natural landscape and enhancing natural and cultural resources, while simultaneously protecting visitors and employees, and minimizing threats to park resources and adjacent lands.

In addition, Fort Frederica NM has recently made management decisions to avoid prescribed fire (Spear 2008). Mechanical treatment is the preferred management alternative to eliminate pine bark beetle infested and dying pines. Mechanical treatments will aid in the reestablishment of the historic oak overstory and prevent or slow the spread of invasive species. This is a more cost effective and manageable alternative to fire for the monument.

3.1.2.a Current condition:

Despite the Southeastern Coastal Plain having an active fire regime and history, fire has not been a major concern at Fort Frederica NM. There has been 1 fire recorded at Fort Frederica NM since 1972 (Table 9). This was a relatively small fire, covering an area of about one acre. There were three fires within 20 miles of the monument reported by the Geospatial Multi-Agency Coordination Group (GeoMAC 2008) since 2000 (Figure 6).

Table 9. Wildfires reported at Fort Frederica National Monument from 1/1/1972 to 12/31/2007, at the National Fire and Aviation Management Web Application (National Wildfire Coordinating Group 2008).

WFMI ID	Fire Name	NPS ID	Protection Type	Date	Acres	Cause	Owner
226856	N/A	5001	NPS land under NPS protection	1/7/1975	1	Miscellaneous	NPS

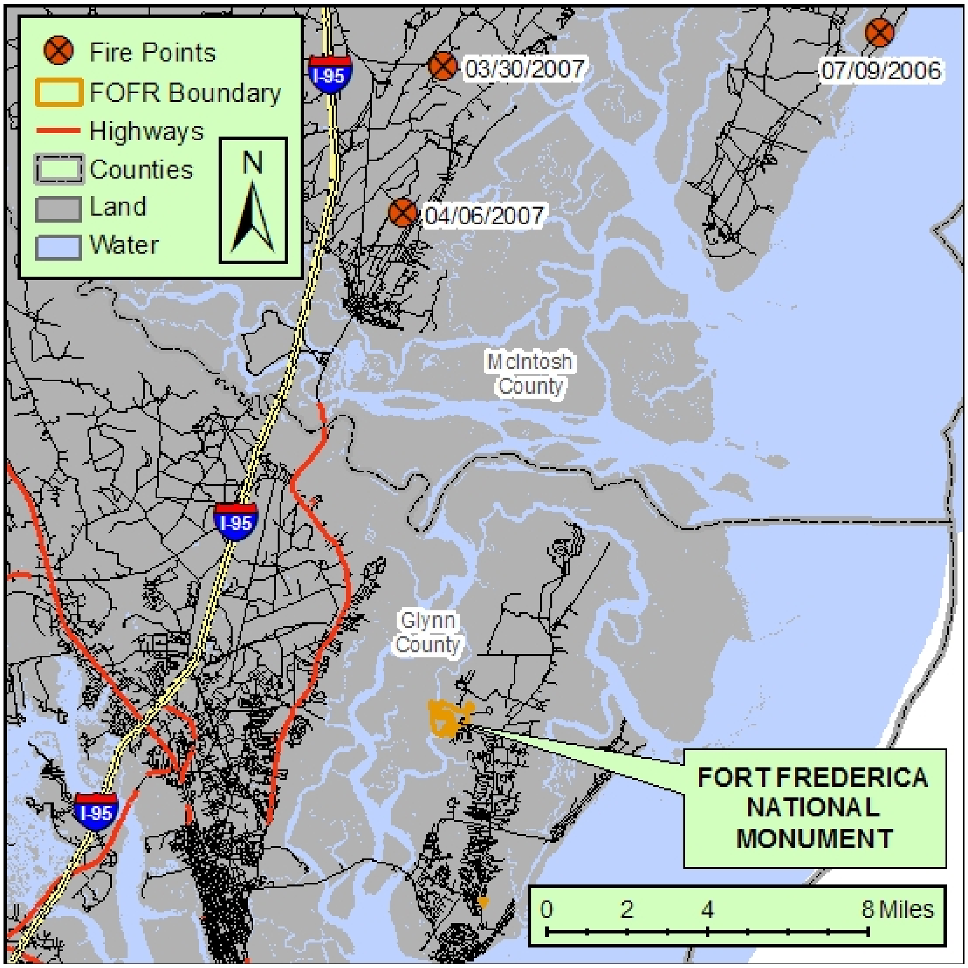

Figure 6. Wildfire sites and the dates they occurred, from 2000 to 2007 (GeoMAC 2008), within 20 miles of Fort Frederica National Monument.

According to a simulated historical fire severity model (USDA Forest Service 2006), low severity fires accounted for the majority of fire occurrences on half of the acreage at Fort Frederica NM (Figure 7), while replacement severity fires accounted for the majority of fires on the other half of the monument (Figure 8). Mixed severity fires accounted for a very small percentage of fires (Figure 7). Low severity fires cause less than 25% average replacement of dominant biomass, mixed severity fires cause between 25 and 75% replacement, and replacement severity fires cause greater than 75% average replacement of dominant biomass. Approximately half of Fort Frederica NM is in the Fire Regime Condition Class II (Figure 9), meaning there is moderate departure from historic vegetation. These data are intended to be used at a landscape scale (USDA Forest Service 2006), so caution should be taken with analysis of these data at a larger, more detailed scale within Fort Frederica NM boundaries.

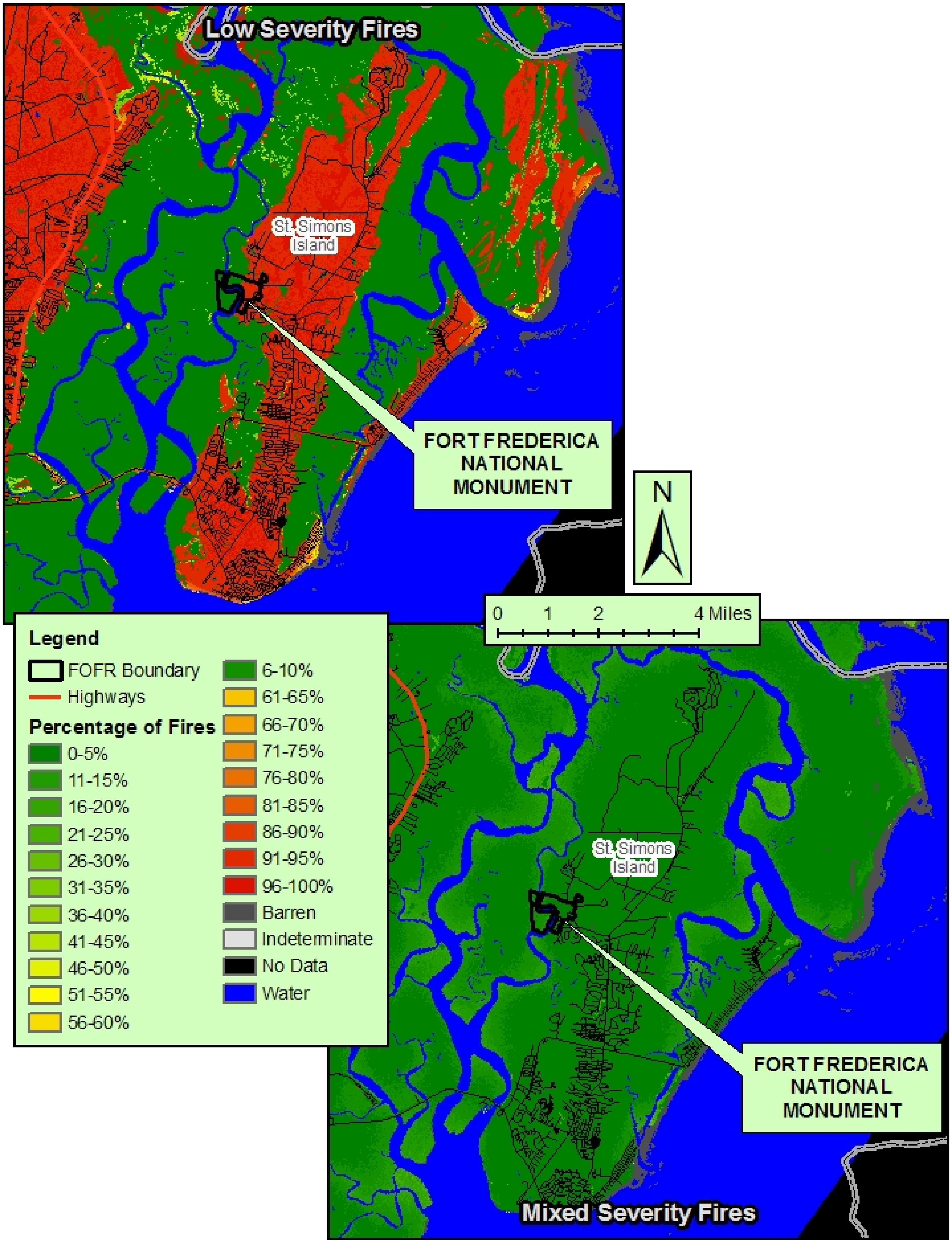

Figure 7. Simulated historical percent of low and mixed severity fires according to LANDFIRE (USDA Forest Service 2006) in the region of Fort Frederica National Monument.

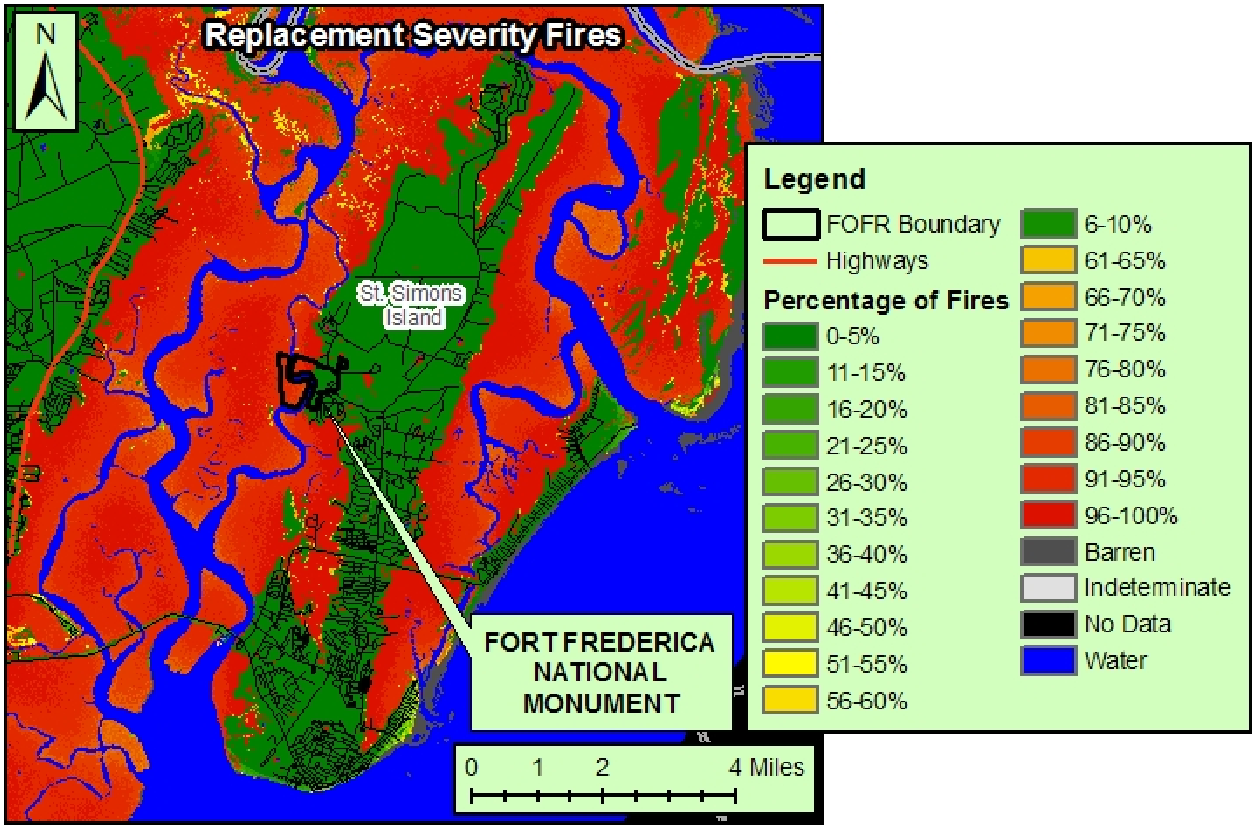

Figure 8. Simulated historical percent of replacement severity fires according to LANDFIRE (USDA Forest Service 2006) in the region of Fort Frederica National Monument.

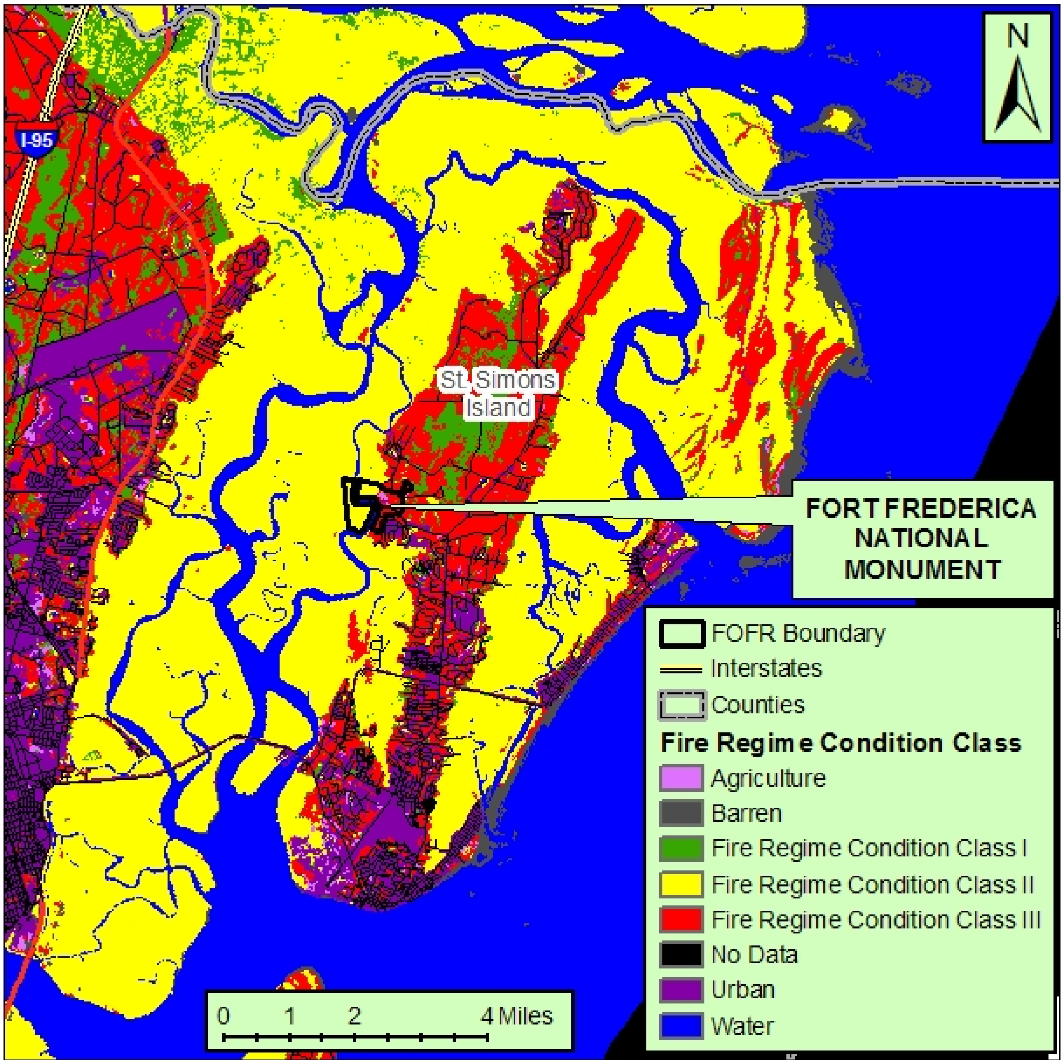

Figure 9. Departure between current vegetation condition and reference vegetation condition according to LANDFIRE (USDA Forest Service 2006) in the region of Fort Frederica National Monument. Fire Regime Condition Class I is low departure from historic vegetation; Condition Class II is moderate departure from historic vegetation; and Condition Class III is high departure from historic vegetation.

3.1.2.b Resource threats and stressors:
Fuel types (Figure 10) and fuel loads are an existing threat and stressor that should be monitored at Fort Frederica NM. As dead and dry plant materials build up, the risk of more catastrophic fire events increases (U.S. Geological Survey 2000).

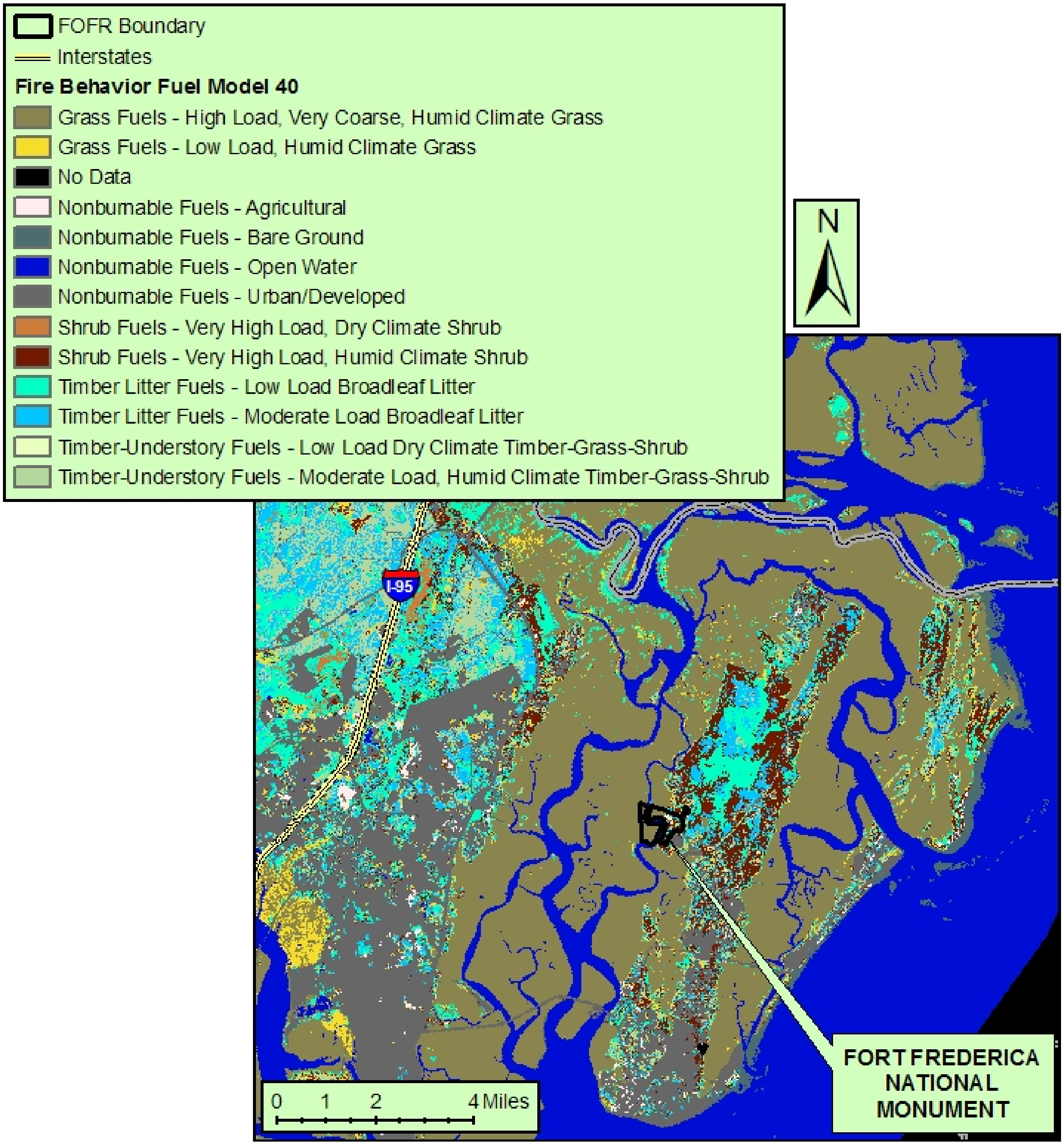

Figure 10. Wildfire fuel types according to LANDFIRE (USDA Forest Service 2006) in the region of Fort Frederica National Monument.

3.1.2.c Critical knowledge or data gaps:

As mentioned before, there is a data gap since there are no detailed, large-scale vegetation maps available for Fort Frederica NM. With a current vegetation map, we could more thoroughly assess the role of fire in the vegetation communities.

3.1.2.d Condition status summary
Fire and fuel dynamics received a good condition status because there were very few recorded fires at the monument or in the region (Table 10). If fires were to occur, half of the property is predicted to be low severity. In addition, approximately half of Fort Frederica NM exhibits moderate departure from historic vegetation, placing it in Fire Regime Condition Class II.

Table 10. Fire condition status summary for Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), s*patial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Midpoint***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Fire dynamics total			0	1	1
	Good	0.84	2 out of 3		

3.1.2.e Recommendations to park managers:
Fort Frederica NM should continue to record fire occurrence information with the National Wildfire Coordinating Group. The only recorded fire was in 1975.

The Wildland Fire Assessment System (USDA Forest Service 2008) has a Fire Danger Rating website: http://www.wfas.net/content/view/17/32/
A daily observed (current) fire danger class and a forecasted fire danger class can be viewed for the United States as well as regional subsets.

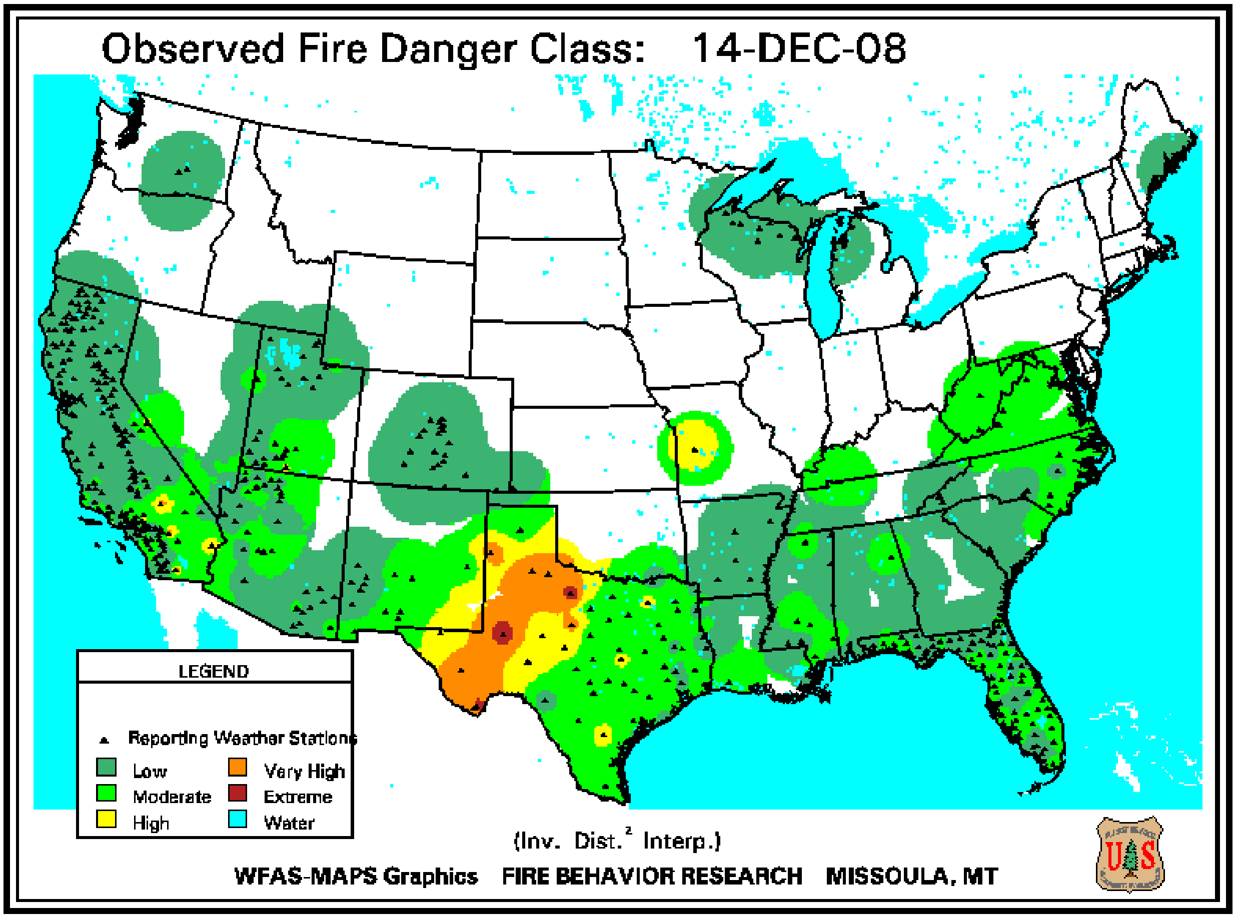

Figure 11. A recent observed fire danger class map for the United States (USDA Forest Service 2008).

3.2 Human Use

3.2.1 Non-point Source Human Effects

In the region of Fort Frederica NM, human population and resulting development pressures are growing. This encroachment of human population and development is arguably the most important threat or stressor the monument must consider. Development may lead to increasing point and non-point source pollution, affecting air and water quality. Increased vehicle emissions can occur as more people move to the area. In-park biological integrity may also be stressed from these outside influences.

3.2.1.a Current condition:

We examined two factors to assess the current condition of human effects in the Fort Frederica NM area. First, census data was obtained from the U.S. Census Bureau and trends were analyzed. The second factor we examined was relative impervious surfaces within the Fort Frederica NM boundary and in the broad, subbasin study area.

Human population:
Although seemingly intuitive, several studies have quantitatively researched the relationship between human population and the degradation of the world's natural resources (Jones and Clark 1987, Forester and Machlist 1996, McKinney 2001, Parks and Harcourt 2002, Cardillo et al. 2004). In a 2001 study, nonnative plant and fish diversity were negatively correlated with human population (McKinney 2001). Parks and Harcourt (2002) found that the probability of species extinction around western U.S. National Parks was significantly correlated with the surrounding human population density.

Fort Frederica NM is situated on St. Simons Island, within Glynn County, Georgia. Although St. Simons is the closest city to Fort Frederica NM, Brunswick is the county seat for Glynn County and the principal city of the Metropolitan Statistical Area (MSA) encompassing Glynn County. The 2007 population estimate for Brunswick, Georgia MSA was 101,792 people, ranking 337th out of 363 MSAs nationwide (U.S. Census Bureau 2009b). The city of Brunswick sits approximately 5.5 miles southwest of St. Simons. Relatively moderate population increases from U.S. Census Bureau (2009a) data were evident in this region (Figure 12). The fastest growing county in the subbasin study area is Camden County, which went from 30,167 to 48,689 individuals from 1990 to 2007, a 61% increase. Following Camden County is nearby Brantley County, with a 39% increase from the 1990 census to 2007 population estimates, and McIntosh and Wayne counties, with respective population increases of 32% and 30% between 1990 and 2007. The county in which Fort Frederica NM is located, Glynn County, experienced the lowest population growth in the region, with an increase of 20% between 1990 and 2007.

Along with population change, a good indicator of human effects on natural resources is population density. Glynn County totaled by far the highest population density in the study area in 2007 with 49 people/square km. Nearby Camden County is the second highest with 24 people/square km. The remaining counties in the region were similarly low, with densities ranging from 8 to 17 people/square km (Figure 13).

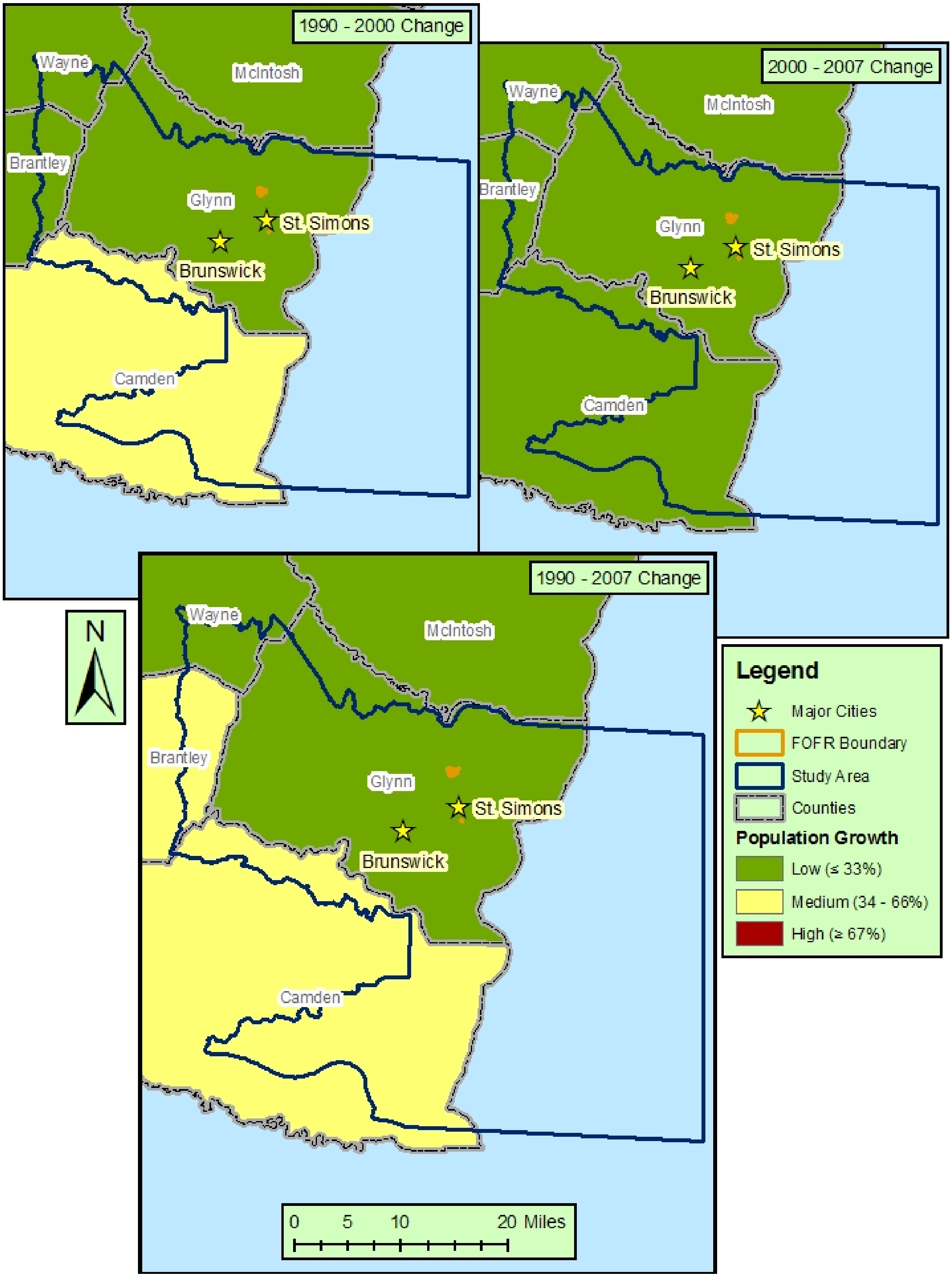

Figure 12. Human population change in counties surrounding Fort Frederica National Monument (U.S. Census Bureau 2009a).

Figure 13. Human population density (people per square kilometer, 2007) for counties surrounding Fort Frederica National Monument (U.S. Census Bureau 2009a).

Impervious surface:
Studies have shown that increased impervious surface leads to degradations in water quality, hydrology, habitat structure, and aquatic biodiversity (Schueler 2000, Hurd and Civco 2004). In a review of eighteen studies that related stream quality to urbanization, Schueler (2000) suggests using three management categories (Table 11) to group streams by percent impervious surface.

Table 11. Schueler (2000) related percent impervious cover to management category.

Impervious Cover	*Management Category*
1 to 10% impervious	Sensitive streams
11 to 25% impervious	Impacted streams
26 to 100% impervious	Non-supporting streams

We used these groups to find the potential quality within Fort Frederica NM and within the subbasin study area (Table 12, Figure 14). The Cumberland-St. Simons (HUC 03070203) subbasin contains Fort Frederica NM and has a relatively low percentage of impervious surfaces (Table 12, Figure 14). It is not surprising that the highest concentration of impervious surface in the subbasin occurs in the areas surrounding the cities of St. Simons and Brunswick. The subbasin study area is below the 10% impervious threshold, with 7.8% impervious cover, and was therefore classified as sensitive. Likewise, we have classified Fort Frederica NM as sensitive, with impervious cover within Fort Frederica NM at 1.96%, well below the 10% threshold.

Table 12. Impervious surface totals for Fort Frederica National Monument and the subbasin study area. Management category from Schueler 2000.

Watershed/ Subbasin	*Pervious (acres)*	*Impervious (acres)*	*Total (acres)*	*Percent Impervious*	*Management Category*
Cumberland-St. Simons (03070203)	433657	36579	470237	7.8	Sensitive streams
Fort Frederica NM	277.5	5.6	283.1	1.96	Sensitive streams

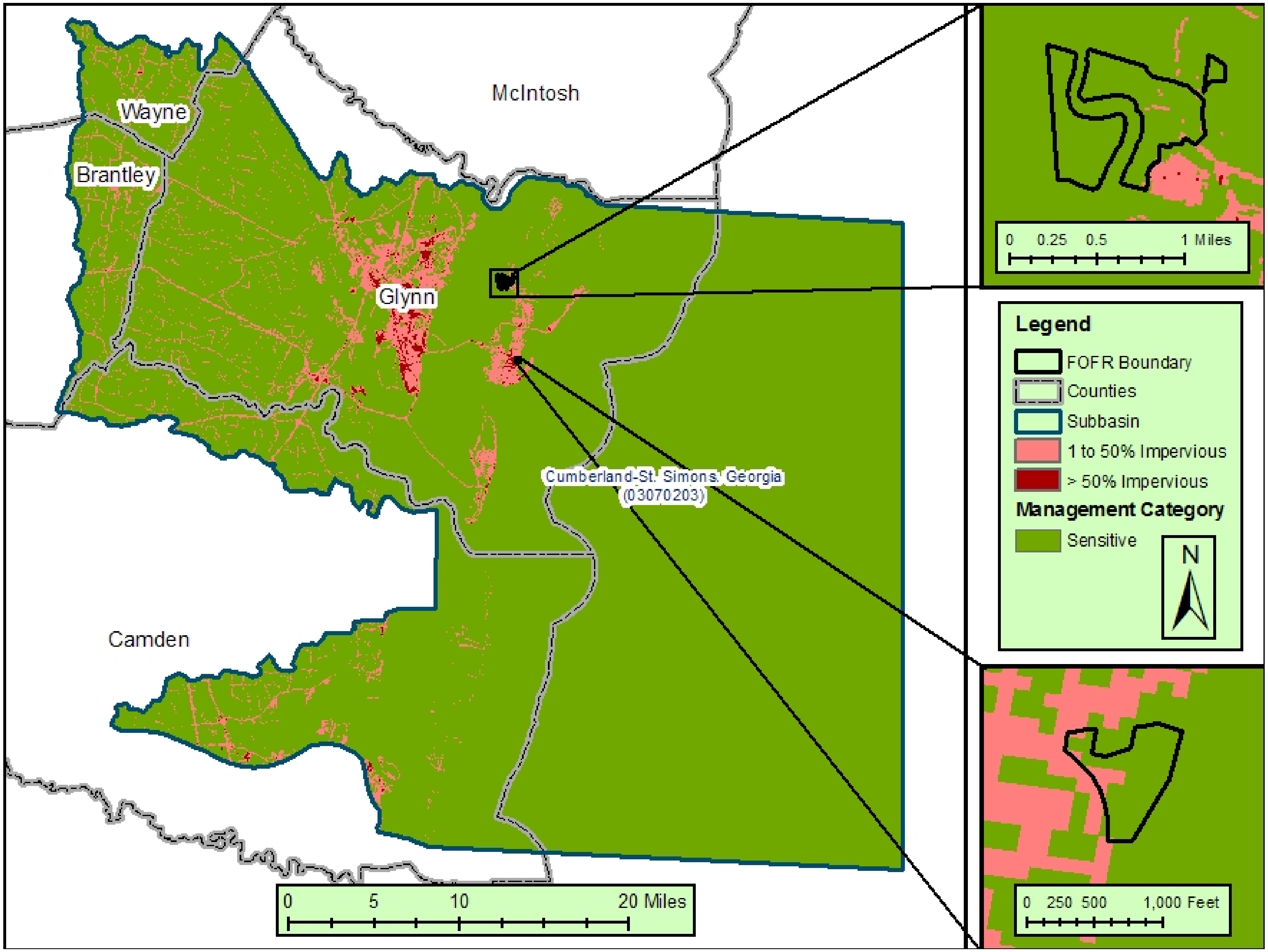

Figure 14. Impervious surface (from National Land Cover Database 2001) in the subbasin study area containing Fort Frederica National Monument.

3.2.1.b Resource threats and stressors:
The condition assessments for human effects, described in the previous section, are threats and stressors to several natural resources within the monument. We started with these broad-scale conditions so they can be applied as threats and stressors to several of the following natural resource categories. Rapid population increases can lead to unstructured, unplanned development, higher population densities, and overutilization of natural resources.

In a recent report by Applied Technologies and Management (2006), it is projected that the remaining vacant lots in the currently developed areas on St. Simons Island will fill in and that previously undeveloped land, primarily in the northern part of the Island will be built out with residential developments (ATM 2006). This development to the north will be especially important to Fort Frederica NM because the area north of Frederica Road where it intersects with Lawrence Road (adjacent to and upstream from Monument boundaries) has a projected growth rate of approximately 200%, or about 10% annually from 2005 to 2025. ATM (2006) reports that in 2005 there were 940 acres planned for development in this northern part of the Island, compared to only 125 acres planned for development in the remainder of the Island. This pattern indicates that with approximately 90% of the southern half of the Island already built out, ongoing and future development will be concentrated in the unused lands in the northern half.

3.2.1.c Critical knowledge or data gaps:
U.S. Census Bureau population data is a good source of information, but assigning resource thresholds to these data was a challenge that was not easily supported with current literature for the Southeastern U.S. We used somewhat arbitrary thresholds for population growth and density in assigning low, medium, and high impacts to the natural resource. These thresholds can easily be changed as more quantitative relationships are formulated for this area of the U.S.

Broad, small-scale remotely sensed data were a good source for this assessment category. Unfortunately they may be less accurate at the larger scale (more detailed) park level. This was a continual challenge in several of our assessment categories since Fort Frederica NM is a fairly small park (282 acres). When spatial scale was questionable, we gave thematic a zero for data quality. Table 13 shows the summary of condition status and data quality.

3.2.1.d Condition status summary
Human population condition status is in the good range because population growth has been slow in this region and population density is relatively low (Table 13). Impervious surface coverage was below the 10% threshold for the subbasin study area and within the park so it also received a good rating (Table 13).

Table 13. Human effects condition status summary for Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), s*patial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Midpoint***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Human population			1	1	1
	Good	0.84	3 out of 3		
Impervious surface			0	1	1
	Good	0.84	2 out of 3		
Human effects total			1	2	2
	Good	0.84	5 out of 6		

3.2.1.e Recommendations to park managers:
Higher population densities have been correlated with a myriad of environmental impacts. However, focusing development and human population growth restrictions on high population centers may not be the most productive course. Studies have found that nonnative species introductions (McKinney 2001) and species extinctions (Balmford 1996) occur more rapidly in fast-growing, lower human populated areas as opposed to highly populated areas. Thus, it may be prudent to focus structured development, nonnative species, and other natural resource education campaigns on low population centers with a high potential for growth.

Although human population increase and development is, in most cases, an outside threat unmanageable by the park, there are instances in which park interpretation and education can play a large role in surrounding resource protection. In addition, focusing efforts on sustainable development and limiting impervious surfaces within park boundaries is important for in-park resource management. These campaigns may also increase the knowledge and perceived importance of structured development within surrounding locales.

3.2.2 Visitor and Recreation Use

The National Park Service was established to provide for its visitors. The NPS mission is to "preserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations." In fact, the top guiding principle to accomplish this mission is excellent service for park visitors and partners (National Park Service 2008c). Visitors are no doubt the primary reason the NPS exists and continues to be an important part of this country.

Visitor and recreation use however has been shown to negatively affect the other half of the NPS mission which is to protect natural and cultural resources. Several studies have shown a negative correlation between outdoor recreation and the various natural resources covered in this assessment (Taylor and Knight 2003, Wood et al. 2006, Park et al. 2008). As visitation to parks increases, these two parts of the mission often work against each other.

3.2.2.a Current condition:

The number of visitors per year to Fort Frederica NM was steadily on the rise and experienced a peak in visitation in 1979. For the past 20 years, however, visitor levels have been on a slight decline (Figure 15). Visitation is relatively constant throughout the year with spikes occurring in March and April (Figure 16). Fort Frederica NM was tenth out of 21 in the number of visitors to NPS Forts in 2007 (Table 14) and 18th out of 68 National Monuments visited in 2007.

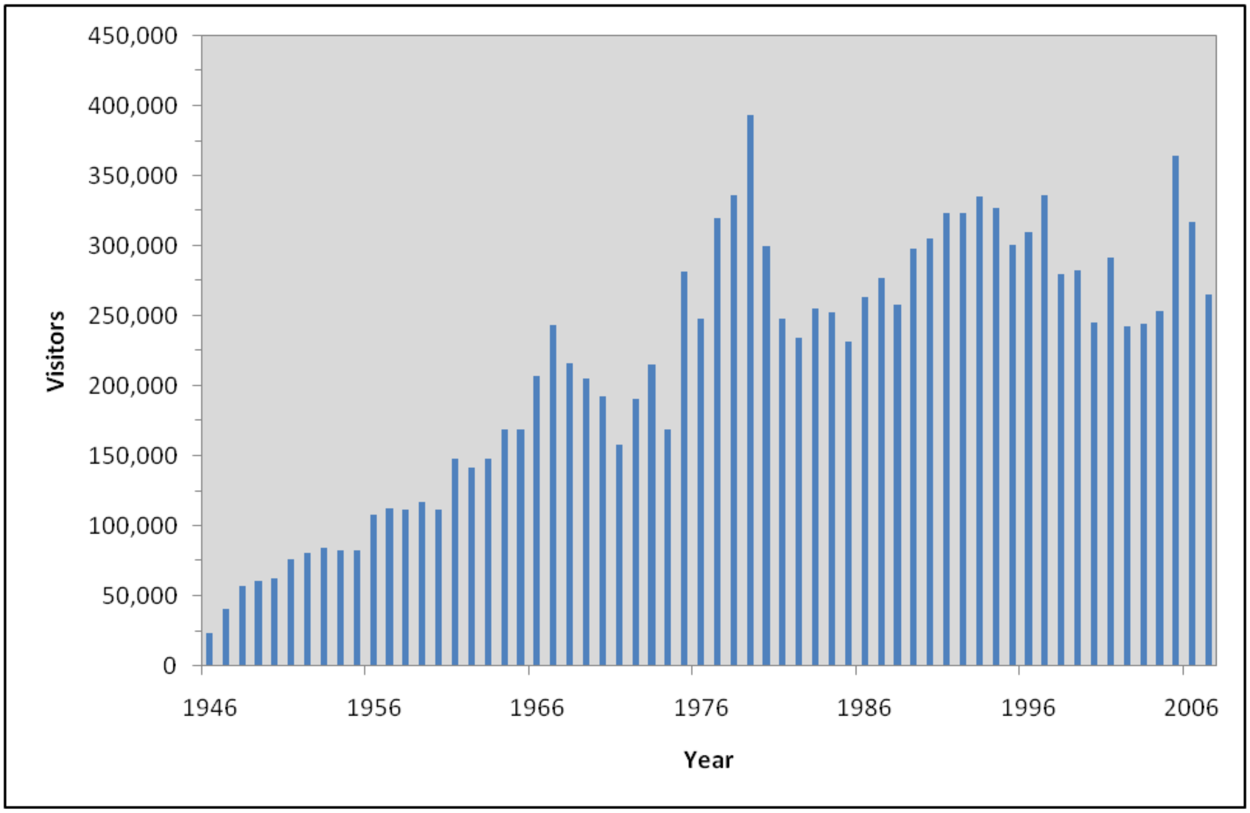

Figure 15. Number of visitors per year to Fort Frederica NM from 1946 to 2007. Data from NPS (2008d).

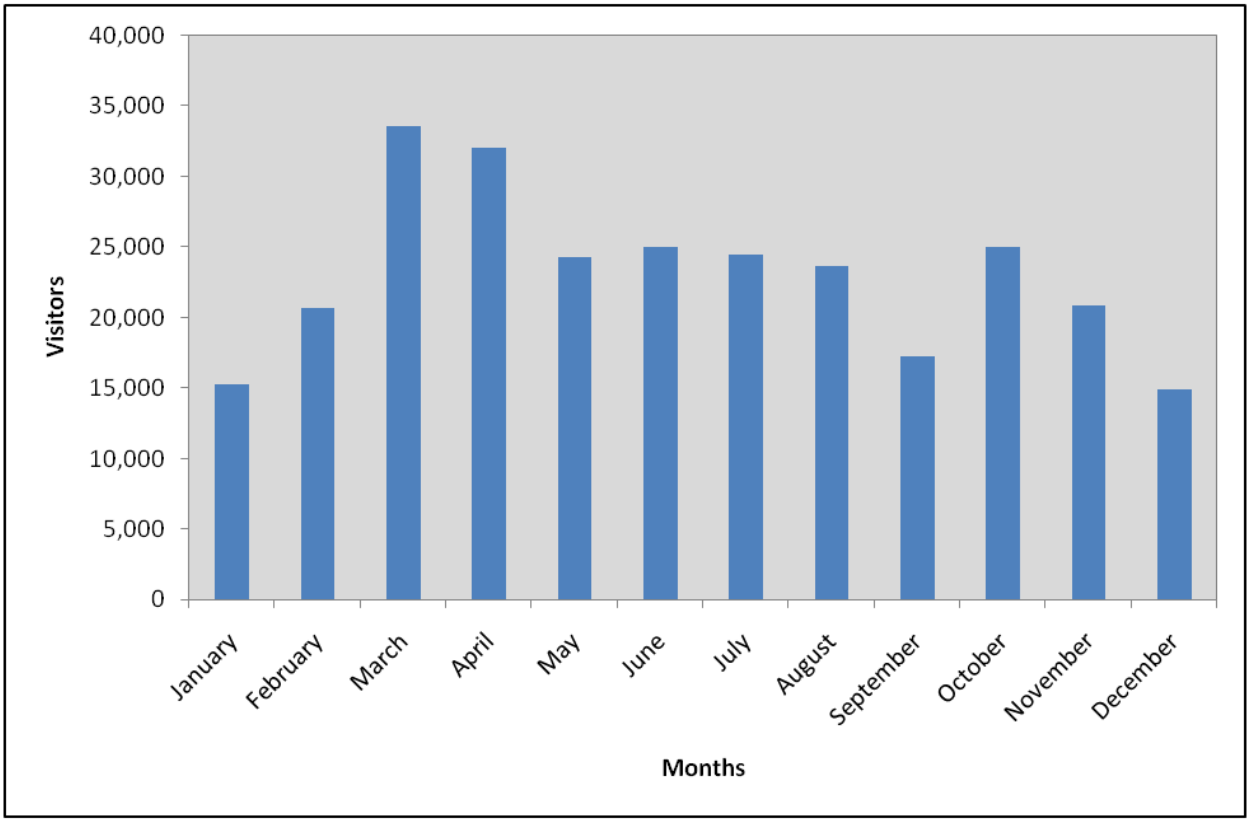

Figure 16. Average monthly visitors (from the past 10 years, 1998-2007) to Fort Frederica National Monument. Data from NPS (2008d).

Table 14. Number of National Park Service Fort visitors in 2007 in ranked order.

Park	*Visitors*	*% of Fort visitors*	*Rank*
Fort Point NHS	1,552,141	21.8	1
Fort Matanzas NM	830,672	11.7	2
Fort Sumter NM	788,838	11.1	3
Fort Vancouver NHS	682,645	9.6	4
Castillo de San Marcos NM	632,048	8.9	5
Fort McHenry NM & HS	574,924	8.1	6
Fort Necessity NB	353,296	5.0	7
Fort Raleigh NHS	321,717	4.5	8
Fort Pulaski NM	317,349	4.5	9
Fort Frederica NM	264,586	3.7	10
Fort Caroline NMEM	250,616	3.5	11
Fort Donelson NB	233,205	3.3	12
Fort Smith NHS	83,850	1.2	13
Fort Stanwix NM	59,643	0.8	14
Fort Davis NHS	51,435	0.7	15
Fort Laramie NHS	40,263	0.6	16
Fort Larned NHS	30,471	0.4	17
Fort Scott NHS	22,314	0.3	18
Fort Union Trading Post NHS	12,405	0.2	19
Fort Union NM	10,534	0.1	20
Fort Bowie NHS	10,027	0.1	21
Fort Total	7,122,979	100.0	

3.2.2.b Resource threats and stressors:
Visitor and recreation use is itself a threat and stressor to the natural resources of Fort Frederica NM. With that said visitor use statistics and current data do not indicate that this is a large threat to natural resources within its boundaries.

3.2.2.c Critical knowledge or data gaps:
An examination of in-park degradation due to visitor use would be a good addition to these analyses. Trail spatial data or on-the-ground impact surveys would help to quantify the effects of visitor use on the natural resources. These data were not available (Table 15).

3.2.2.d Condition status summary:
Visitor use is in the good range for condition status because statistics do not indicate a sharp increase in visitors and this fort was visited at an average level compared with other forts managed by the National Park Service (Table 15).

Table 15. Visitor use condition status summary for Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), s*patial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	Condition Status	Midpoint	Data Quality		
			Thematic	*Spatial*	*Temporal*
Visitor use total			0	1	1
	Good	0.84	2 out of 3		

3.2.2.e Recommendations to park managers:
We recommend continuing to collect visitor use statistics and identify and monitor trends in recreation. Collecting additional visitor statistics and recreation use parameters, such as percent trail degradation would be a useful addition to data and analysis.

3.3 Air and Climate

3.3.1 Air Quality

The U.S. Environmental Protection Agency (EPA) requires monitoring of six pollutants considered harmful to human health and the environment. The six "criteria" pollutants are listed below (U.S. Environmental Protection Agency 2008b). The first two are considered problematic in hundreds of counties across the U.S., and the last four are of concern only in a handful of locations at most.

Ozone (O_3) is "good up high but bad nearby." Ozone high in the atmosphere protects us from ultraviolet (UV) radiation, but ozone at ground-level can negatively affect plant populations and can cause respiratory irritation when humans or animals breathe it. Symptoms include coughing, wheezing, breathing difficulties, inflammation of the airways, and aggravation of asthma. Ozone is not directly emitted; rather it is formed from reactions involving volatile organic compounds and nitrogen oxides in the presence of sunlight.

Particulate matter (PM) is subdivided into two categories by size:
Fine particulate matter ($PM_{2.5}$) consists of particles smaller than 2.5 micrometers. For comparison, the average human hair is 70 micrometers in diameter. Fine particles can be inhaled deeply into the lungs and can cause respiratory irritation and, over the long term, are associated with elevated levels of cardiovascular disease and mortality. Particles also obscure visibility and affect global climate. Fine particles are generated by combustion; major sources include industry and motor vehicles. Such particles can also be formed in the atmosphere through reactions involving gases.
Coarse particulate matter (PM_{10}) consists of particles smaller than 10 micrometers. They may cause respiratory irritation. Coarse particles stem from grinding and other mechanical processes and include wind-blown dust.

Sulfur dioxide (SO_2) originates mostly from coal combustion and causes respiratory irritation. It also contributes to acid rain and particle formation.

Carbon monoxide (CO) is a colorless, odorless gas that is formed during incomplete combustion of fuels. Its major sources include vehicles and fires. Exposure to high levels of carbon monoxide can cause dizziness, headaches, confusion, blurred vision, and ultimately coma and death.

Lead (Pb) is a metal found in particles and can adversely affect the nervous system, kidney function, immune system, reproductive and developmental systems and the cardiovascular system. In children, it has been found to lower IQ. Lead originates mainly from the processing of metals in industry.

Nitrogen dioxide (NO_2) is a brownish gas that is generated during high-temperature combustion. It is a member of a family of chemicals called nitrogen oxides, or NO_x. Major sources of NO_x include coal-fired power plants, industrial boilers, and motor vehicles. Like ozone, it causes respiratory irritation. It is also important because it can react to form ozone and particles, contribute to acid rain, deposit into water bodies and upset the nutrient balance, and degrade visibility.

The National Ambient Air Quality Standards are levels not to be exceeded for each pollutant (U.S. Environmental Protection Agency 2008a). Air quality is summarized for the public in terms of the Air Quality Index (AQI, Table 16), a scale that runs from 0 to 500, where any number over 100 is considered to be unhealthy (AirNow 2008a). Based on measurements or predicted levels of pollutants, an AQI is calculated for each of the criteria pollutants, and the highest value is reported to the public.

Table 16. The Air Quality Index (AQI) is a cross-agency U.S. Government venture whose purpose is to explain air quality health implications to the public.

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51-100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

Environmental effects
In addition to health, air pollution has also been shown to impact visibility, vegetation, surface waters, soils, and fish and wildlife at National Park Service sites in the Southeast Coast Network. In 2003, the National Park Service conducted an Air Quality Inventory and Monitoring Assessment of the Southeast Coast Network that reported on atmospheric deposition of compounds that can affect acidity, nutrient balances, and wildlife in surface waters; air toxics; surface water chemistry in the context of acidification due to atmospheric deposition; fine particulate matter and ozone; and ozone-sensitive plant species (National Park Service 2003). The report concluded that although only two of the seventeen parks have monitors on-site, existing monitors within ~100 miles are sufficiently representative. Only two parks, Congaree National Park and Moores Creek NB, were deemed extremely sensitive to acidification from atmospheric deposition. Ozone concentrations were high enough in all parks to potentially cause plant damage.

The NPS Air Resources Division (ARD) has developed methods and target values to evaluate air quality conditions important for natural resource planning and management. The ARD approach to air quality assessment includes thresholds for ozone, atmospheric (wet) deposition in the form of nitrogen and sulfur, and visibility (National Park Service 2007). Based on certain criteria, these categories are given a score of "good," "moderate," or "significant concern." Although Fort Frederica NM does not have any air quality monitoring stations on-site, the ARD interpolates data from all available monitors in the region into five-year averages. This document utilizes the most recent data interpolations from the 2003 – 2007 period for ozone, wet deposition, and visibility.

3.3.1.a Current condition:
Monitoring sites:
Georgia's state environmental agency operates three air quality monitoring sites in Glynn County, within ~15 km of Fort Frederica National Monument. They measure O_3, $PM_{2.5}$, PM_{10}, and SO_2. Table 17 and Figure 17 show the air quality index in 2007 for each of the pollutants measured. Blank cells mean that the pollutant was not measured at the site.

Table 17. Air quality index in 2007 at monitoring sites near Fort Frederica National Monument. Blank cells mean that the pollutant was not measured at the site

Site ID	*Common name*	*State*	*County*	*City*	*Latitude*	*Longitude*	O_3	$PM_{2.5}$	PM_{10}	SO_2	*CO*	NO_2
131270004	Arco Pump Station	GA	Glynn	Brunswick	31.180688	-81.504787			57			
131273001	Brunswick Coastal College	GA	Glynn	Brunswick	31.184983	-81.485332						
131270006	Risley Middle School	GA	Glynn	Brunswick	31.169530	-81.496046	80	99		7		

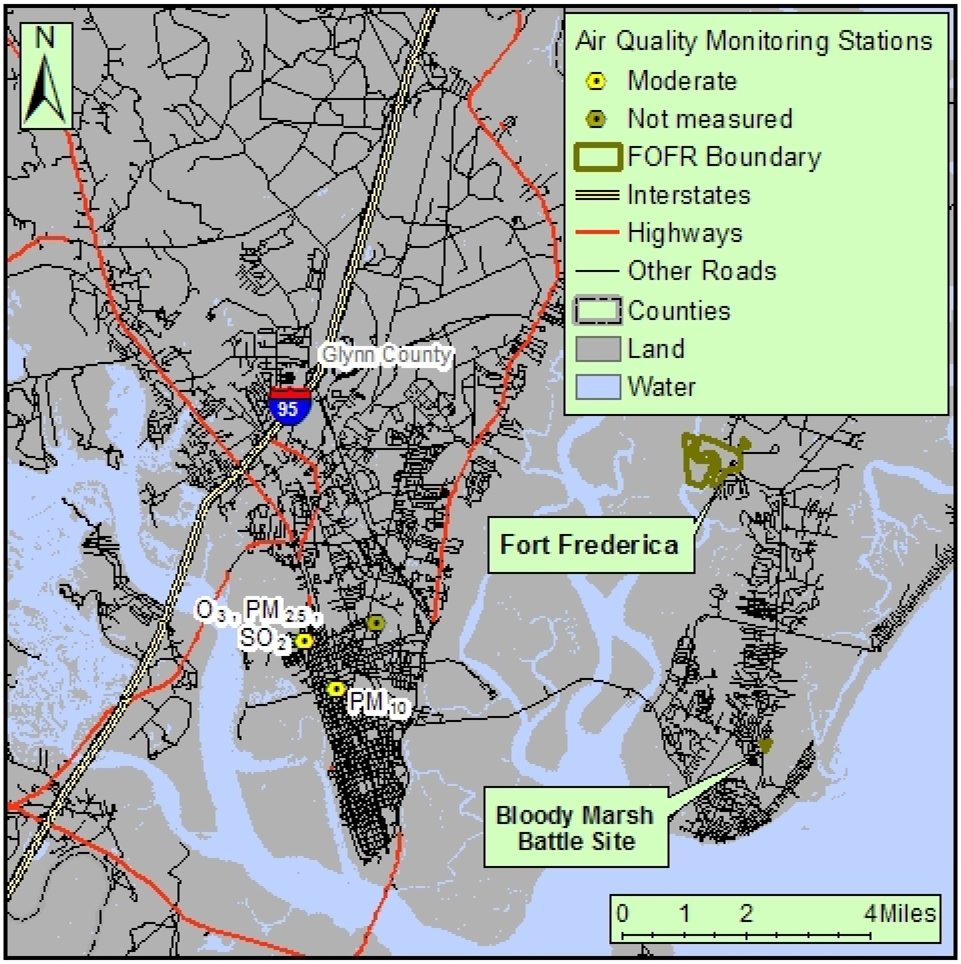

Figure 17. Air quality monitoring sites near Fort Frederica National Monument. Green indicates "Good" air quality, while yellow indicates "Moderate" air quality at these sites in 2007.

There are multiple standards, over varying averaging periods, for some criteria pollutants. In some cases, the standard is based on the annual average while in others, it is based on a maximum (or 4th-highest or 98th percentile) in a year. Furthermore, some standards are based on averages over multiple years. The exact details are provided in the footnotes of the National Ambient Air Quality Standards table (U.S. Environmental Protection Agency 2008a). For each of the pollutants, we selected the traditionally more problematic averaging period, extracted the relevant average or high concentration from the EPA's Air Quality System Data Mart (U.S. Environmental Protection Agency 2008d), and converted it to an Air Quality Index value using the AQI calculator (AirNow 2008b). The values shown in Table 17 correspond to metrics described below.

O_3: 8-hour average, 4th highest in a year
$PM_{2.5}$: 24-hour average, 98th percentile in a year
PM_{10}: 24-hour average, maximum in a year
SO_2: 24-hour average, maximum in a year

Air quality trends:
Trends in ozone and fine particulate matter, two pollutants posing a serious risk to health, are shown in Figure 18 and Figure 19. The figures show the number of times the national standard was violated in a year, known as "exceedances," on the left axis and an indicator of the highest concentration in a year on the right axis. The air quality standards are based on the 4th highest concentration in a year for ozone and the 98th percentile concentration for $PM_{2.5}$. Ignoring the very highest concentration in a year allows for unusual events that may cause anomalies.

The ozone measurements shown are from the Risley Middle School site. For the past 3 years, ozone exceedances have occurred infrequently, only once in 2006. The EPA standard for 8-hour ozone is based on the 4th highest measurement in a year, and this metric has been decreasing slightly over time and has fallen below the standard of 0.075 ppm for the last three years.

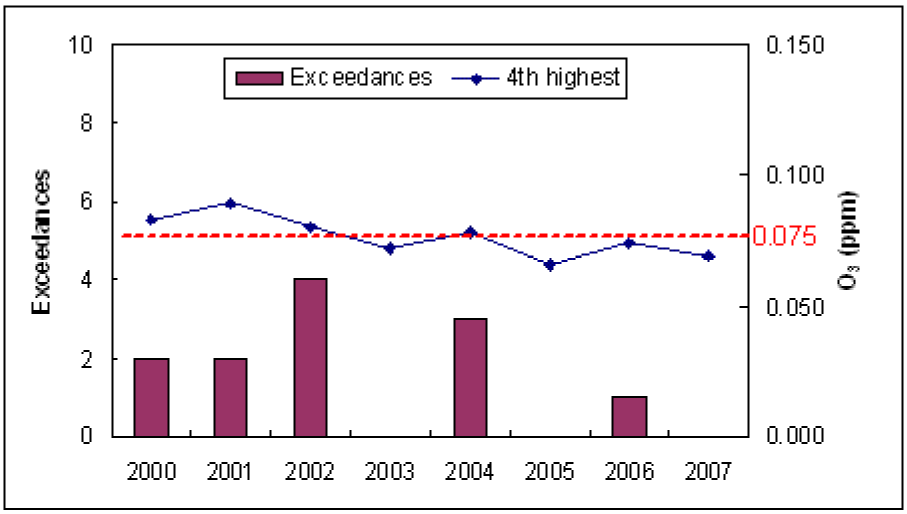

Figure 18. 8-hour average ozone (O_3) exceedances for Fort Frederica National Monument.

The $PM_{2.5}$ measurements shown are also from the Risley Middle School site (Figure 19). The EPA standard for 24-hour $PM_{2.5}$ is based on the 98th percentile of measurements in a year, and this metric has fluctuated between 20 and 40 micrograms per cubic meter, compared to the standard of 35. Even though the 98th percentile concentration was greater than the 24-hour standard in 2004 and 2007, official exceedances did not occur because they are determined over three-year averages.

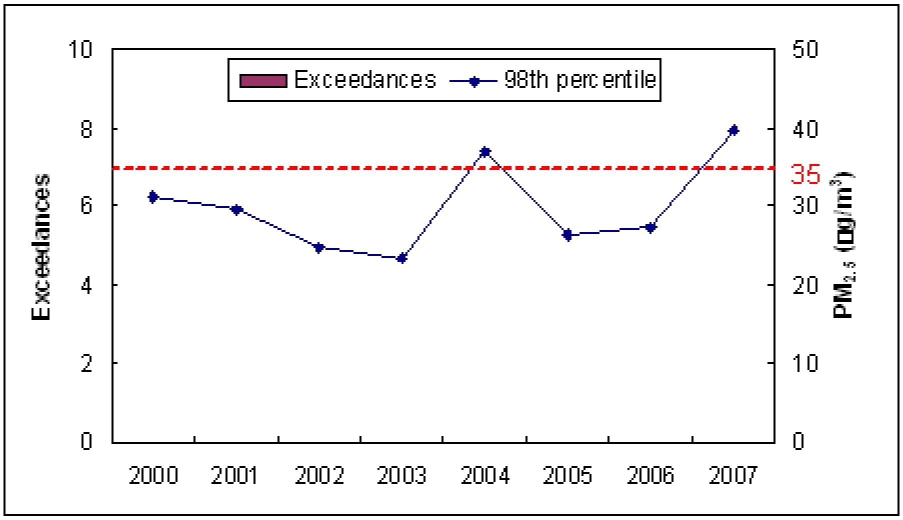

Figure 19. 24-hour average fine particulate matter ($PM_{2.5}$) exceedances for Fort Frederica National Monument.

Air quality forecast:
The location nearest Fort Frederica NM with a daily air quality forecast is in Macon, GA, which is approximately 200 miles northwest of Fort Frederica NM (AirNow 2008c). The year round AQI forecast is provided regionally for ozone (O_3) and locally for fine particulate matter ($PM_{2.5}$). The Macon forecast is a reasonable indicator for Fort Frederica, but because of the large distance between the locations the forecast may not always apply directly to Fort Frederica NM.

Ozone (O_3):
The ARD criterion for ozone utilizes the newly revised 2008 national standard for ozone air quality as a baseline. The national standard requires that the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 75 parts per billion (ppb) (U.S. Environmental Protection Agency 2009). In assessing air quality within national parks, the ARD mandates that if the interpolated five-year average of the fourth-highest daily maximum 8-hour average ozone concentrations is greater than or equal to 76 ppb, then ozone is classified as a "significant concern" in the park. If the interpolated five-year average is between 61 ppb and 75 ppb, concentrations greater than 80-percent of the national standard, then the park is classified as "moderate." To receive a "good" ozone rating, a park must have a five-year average ozone concentration less than 61 ppb (concentrations less than 80-percent of the national standard). Table 18 illustrates how ARD uses the five-year average concentrations to classify ozone air quality conditions in national parks. The ARD mandates for ozone air quality are designed to reflect the idea that simply meeting the national standard does not guarantee "unimpaired" parks for future generations.

Table 18. Air Resources Division ozone air quality condition classifications and corresponding condition status. The 5-year average ozone concentration at Fort Frederica NM was 69.95 ppb.

ARD Condition	*Condition Status*	*Ozone concentration (ppb)*
Significant Concern	Poor	≥ 76
Moderate Concern	Fair	61 – 75
Good Condition	Good	≤ 60

Vegetation sensitivity to ozone is also taken into consideration when conducting air quality assessments in national parks. A 2004 vegetation risk assessment identified ten plant species present at Fort Frederica NM that are sensitive to ozone (National Park Service 2004a). This risk assessment indicated that the risk of injury to plants is low at Fort Frederica NM due to relatively low ozone levels and the regular occurrence of mild to severe drought, which inhibits ozone uptake by plants. The 2004 report also identifies four bioindicator species that can be monitored at Fort Frederica NM to indicate increased ozone injury to vegetation. The ARD uses the vegetation risk evaluation to modify the average ozone concentration air quality condition status when assigning parks a final ozone condition rating. If a park is evaluated as a high risk of plant injury, the ARD would assign that park the next more severe ozone condition status (i.e., reclassify "moderate" to "significant concern").

Atmospheric Deposition:

The ARD uses wet deposition in evaluating atmospheric conditions in national parks, primarily due to the general lack of available dry deposition data. Using wet deposition data, however, may be problematic for accurately assessing atmospheric deposition in parks situated in arid climates where dry deposition data would prove to be more useful. In the continental United States, wet deposition is calculated by multiplying nitrogen (N from nitrate and ammonium ions) or sulfur (S from sulfate ions) concentrations in precipitation by a normalized precipitation value. The precipitation values, obtained from the PRISM database, are normalized over a 30-year period to minimize interannual variations in deposition caused by interannual fluctuations in precipitation (Oregon State University 2008). The nitrogen and sulfur deposition concentrations used for interpolation are obtained from the National Atmospheric Deposition Program (University of Illinois at Urbana-Champaign 2009). The ARD takes natural background deposition estimates and deposition effects on ecosystems under consideration when evaluating atmospheric deposition conditions. Table 19 illustrates how the ARD rates atmospheric deposition conditions according to the amount of estimated wet deposition at a park. Estimates of natural background deposition for total deposition are approximately 0.25 kilograms per hectare per year (kg/ha/yr) in the West and 0.50 kg/ha/yr in the East, for either N or S. For wet deposition only, this is roughly equivalent to 0.13 kg/ha/yr in the West and 0.25 kg/ha/yr in the East. Although the proportion of wet to dry deposition varies by location, wet deposition is at least one-half of the total deposition in most areas. Certain sensitive ecosystems respond to levels of deposition on the order of 3 kg/ha/yr total deposition, or about 1.5 kg/ha/yr wet deposition (Fenn et al. 2003, Krupa 2003).

Table 19. Air Resources Division wet deposition condition classifications and corresponding condition status. The wet deposition values refer to either nitrogen or sulfur individually, not the sum of the two. The total wet nitrogen deposition at Fort Frederica NM is estimated at 2.86 kg/ha/yr; total wet sulfur deposition is estimated at 4.08 kg/ha/yr.

ARD Condition	*Condition Status*	*Wet Deposition (kg/ha/yr)*
Significant Concern	Poor	> 3
Moderate Concern	Fair	1 – 3
Good Condition	Good	< 1

Visibility:
Individual park scores for visibility are based on the deviation of the current Group 50 visibility conditions from estimated Group 50 natural visibility conditions, where Group 50 is defined as the mean of the visibility observations falling within the range between the 40^{th} and 60^{th} percentiles. Natural visibility conditions are those that have been estimated to exist in a given area in the absence of anthropogenic visibility impairment. Visibility is described in terms of a Haze Index, a measure derived from calculated light extinction, and expressed in deciviews (dv) (U.S. Environmental Protection Agency 2003). Visibility worsens as the Haze Index increases. The visibility condition is expressed as:

Visibility Condition = (current Group 50 visibility) –
(estimated Group 50 visibility under natural conditions)

As illustrated in Table 20, parks with a visibility condition estimate of less than two dv above estimated natural conditions receive a "good" visibility condition classification. Those parks with visibility condition estimates between two and eight dv above natural conditions are classified as "moderate," and parks with visibility condition estimates greater than eight dv above natural conditions are classified as a "significant concern." While the dv ranges for each category are somewhat subjective, they reflect as nearly as possible the variation in visibility conditions across the visibility monitoring network.

Table 20. Air Resources Division visibility condition classifications and corresponding condition status. The current Group 50 deviation at Fort Frederica NM is 12.22 dv.

ARD Condition	*Condition Status*	*Current Group 50 – Estimated Group 50 Natural (dv)*
Significant Concern	Poor	> 8
Moderate Concern	Fair	2 – 8
Good Condition	Good	< 2

Environmental effects:
Using the methods developed by the ARD discussed above, the air quality condition status at Fort Frederica NM takes into account ozone concentration, wet atmospheric deposition, and visibility. The 5-year (2003 – 2007) average ozone concentration was 69.95 ppb, earning the park a "moderate" or "fair" ozone condition rating (Table 18). The 2004 vegetation risk assessment indicated that Fort Frederica NM is at low risk for plant injury, and the ARD consequently maintained the original ozone air quality condition status of "moderate."

Atmospheric deposition at Fort Frederica NM has been classified as a “significant concern” or “poor” condition status (Table 19). Although the total wet nitrogen deposition, estimated at 2.86 kg/ha/yr, fell within the “moderate concern” or “fair” condition status, the wet sulfur deposition, estimated at 4.08 kg/ha/yr, was high enough to warrant an overall “significant concern” classification for wet atmospheric deposition. There is no current information to indicate whether ecosystems at Fort Frederica NM are sensitive to nitrogen or sulfur deposition, but deposition is elevated. Nitrogen deposition, in particular, may affect the integrity of vegetation communities at Fort Frederica NM because excess nitrogen has been found to encourage growth of invasive plant species at the expense of native species.

The visibility condition at Fort Frederica NM is classified as a “significant concern” because the current Group 50 visibility is 12.22 dv above estimated Group 50 natural conditions (Table 20).

Trends cannot be evaluated from the interpolated 5-year averages utilized by the ARD. However, the NPS ARD evaluates 10-year trends in air quality for parks with on-site or nearby monitoring. Maps in the most recently available progress report show trends in ozone, deposition, and visibility that can be used to discern regional trends (National Park Service 2007). For the period 1996 – 2005, ozone concentrations and nitrogen and sulfur deposition in the Southeast appear to be decreasing, while visibility is relatively unchanged.

3.3.1.b Resource threats and stressors:

Threats to the monument's air quality include new point sources, such as power plants and large industrial facilities that are located upwind. Emissions from such sources can travel hundreds of kilometers and influence the monument's air quality. Additionally, development near the monument could lead to an increase in vehicle traffic and its associated emissions that could impact the monument's air quality.

3.3.1.c Critical knowledge or data gaps:

An air monitoring site on the monument's property would provide the best information about its air quality. Such sites are expensive to install and maintain; however, it is feasible that if a nearby monitoring site needs to be relocated, the state environmental agency might be willing to consider moving it to the monument. The spatial component of data quality received a zero for atmospheric deposition and visibility because the available data could be more local (Table 21). There are, however, monitoring stations within 10 miles of Fort Frederica NM for ozone so we gave this data quality component a one.

3.3.1.d Condition status summary

From the environmental and natural resource management perspective, air quality at Fort Frederica is poor overall (Table 21). As previously discussed, a 2004 risk assessment determined that the ozone threat to vegetation at Fort Frederica NM is low. Risk of plant injury is low, despite periodic elevated ozone exposure at the park, because the low soil moisture conditions that prevail during periods of high ozone exposure limit stomatal uptake of ozone (National Park Service 2004a).

The NPS Inventory and Monitoring (I&M) Program is currently conducting risk assessments to evaluate the threats from several sources. The assessments will evaluate nitrogen deposition (complete in late 2009), acidic deposition from nitrogen and sulfur (complete in 2010), and mercury deposition (complete in 2010) in national parks. These I&M assessments will be available on the NPS ARD website and will assist managers in determining what park resources are at risk from air pollution, and what type of air quality monitoring might be needed.

Table 21. Air quality condition status summary for Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), s*patial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Midpoint***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Ozone			1	1	1
	Fair	0.5	3 out of 3		
Atmospheric Deposition			1	0	1
	Poor	0.17	2 out of 3		
Visibility			1	0	1
	Poor	0.17	2 out of 3		
Air quality total			3	1	3
	Poor	0.28	7 out of 9		

3.3.1.e Recommendations to park managers:
Collaborative efforts are needed to tackle the region's air pollution. Park managers are urged to participate in and to promote regional-scale approaches to improve the area's air quality and visibility through the organizations listed in Table 22.

Table 22. List of recommended air quality organizations to participate with and promote regional approaches.

	Organization	*Webpage*
1.	Visibility Improvement State and Tribal Association of the Southeast (VISTAS)	http://www.vistas-sesarm.org/
2.	EPA Region 4	http://www.epa.gov/region4/air/index.htm
3.	Georgia Department of Natural Resources - Environmental Protection Division - Air Protection Branch	http://www.georgiaair.org/

3.3.2 Climate

Climate is the long-term pattern and processes of weather events for a given location. Climate is one of the most significant abiotic factors dictating biotic components anywhere on the Earth.

There is much interest in climate recently due to increasing temperatures and changing weather patterns across the globe (Blaustein et al. 2001, Walther et al. 2002, Corn 2005). Such changes have the potential to impact natural resources by shifting dominant vegetation communities, impacting animal species at the frontiers of their range, and impacting fundamental ecosystem processes.

We included some basic assessments on the climate of the landscape around Fort Frederica NM. This information can be used to provide some insight into potential direct and indirect impacts a changing climate might have on their natural resources. These data may be useful for establishing future thresholds and climatic goals.

3.3.2.a Current condition:
Climate is a complex amalgam of long-term weather events. Our assessment includes several of these factors examined over the long term (> 30 years). We attempted to narrow the suite of factors down to those metrics where data was available and long-term trends were easily established. These include temperature, precipitation, available moisture, phenology through growing degree days, and extreme weather events (e.g., hurricanes) which act as agents of major landscape change and disturbance ecology.

Temperature:
We used data provided by the Southeast Regional Climate Center (SERCC 2008) to assess temperature change for Fort Frederica NM. The SERCC is a regional climate center headquartered at the University of North Carolina at Chapel Hill and is directed and overseen by the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) and National Environmental Satellite, Data and Information Service (NESDIS). Nearby St. Simons Island, Georgia is one of the cities available for long-term climate information summaries provided through the SERCC Historical Climate Summaries product. This product allows access to annual, monthly, and daily climate information including mean temperature (The Southeast Regional Climate Center 2008).

We used the “monthly average temperature” option to examine annual temperature trends as well as seasonally for Winter (December – February), Spring (March – May), Summer (June – August), and Fall (September – November) seasons. The range of dates for which data were available was 1948 – 2008; however, due to incomplete data for the years of 1948 and 2008, this assessment utilizes data from 1949 – 2007.

The mean annual temperature for St. Simons Island, Georgia has increased approximately 0.16 degrees Fahrenheit (°F) per decade (mean = 67.61 °F) from 1895 to 2007 (Figure 20). This observed trend was similar for all four seasons (Figure 21 through Figure 24). The most potentially biologically significant increase was observed during the fall season with temperatures increasing one degree approximately every 30 years.

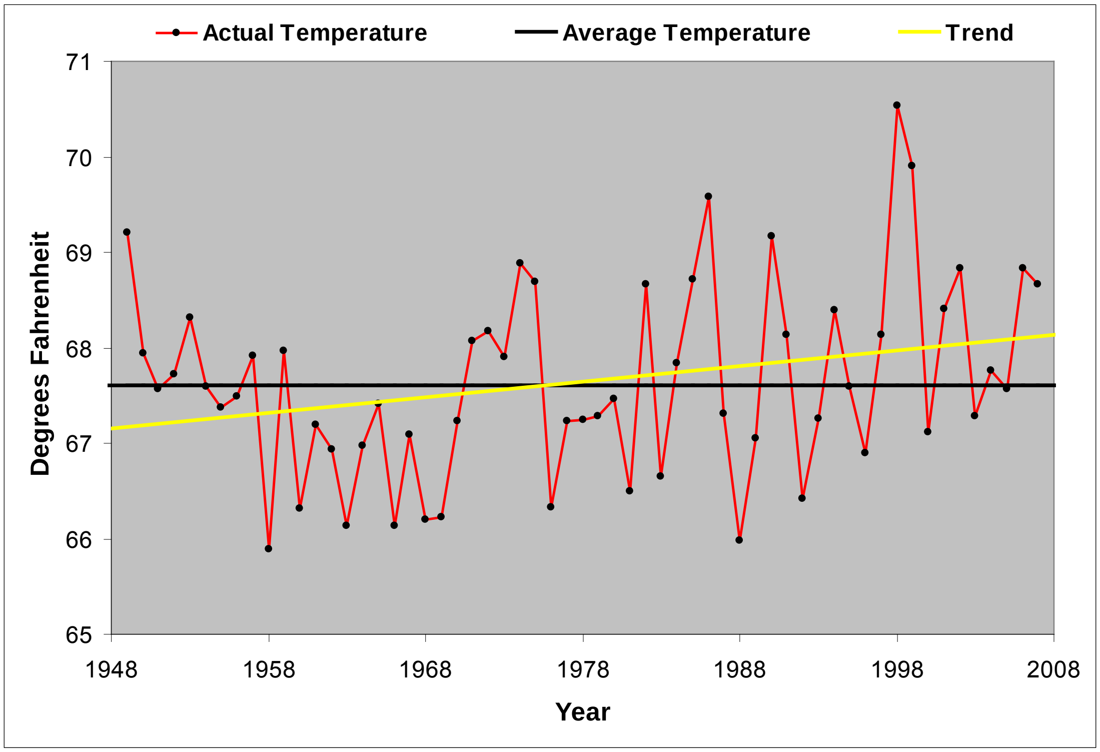

Figure 20. Mean annual temperature for St. Simons Island, GA from 1949 to 2007. The mean annual temperature is 67.61 °F. The trend is 0.16 °F per decade.

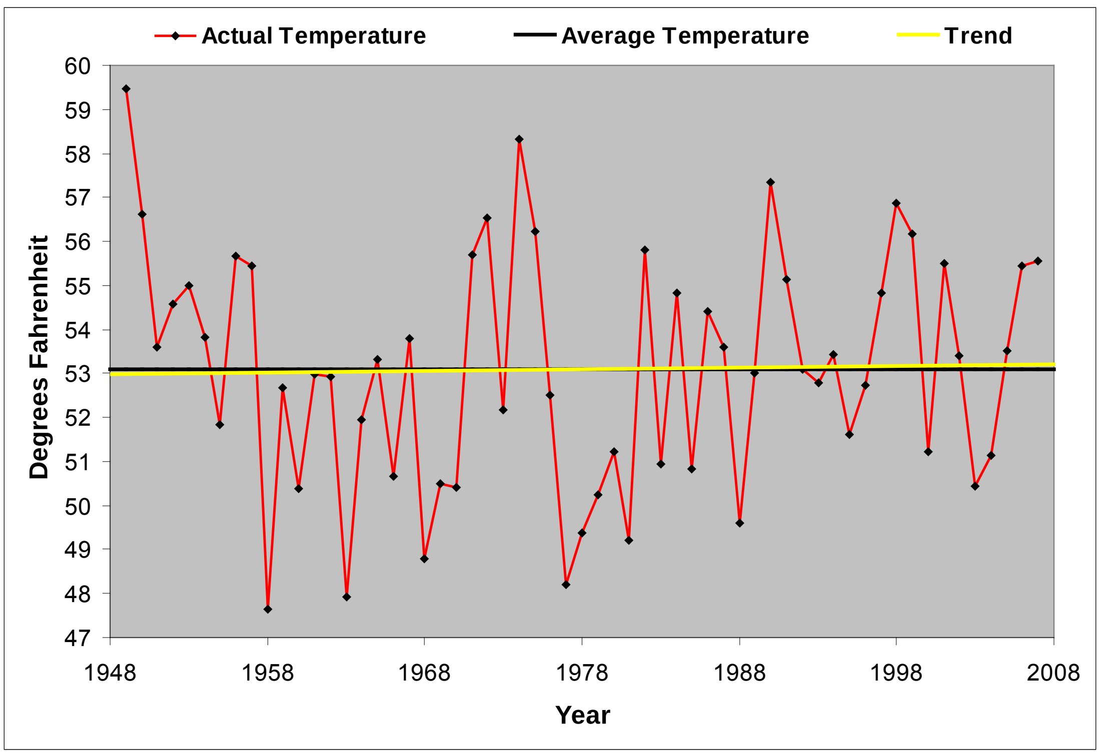

Figure 21. Winter temperature for St. Simons Island, GA from 1949 to 2007. The mean temperature was 53.10 °F. The trend is 0.04 °F per decade.

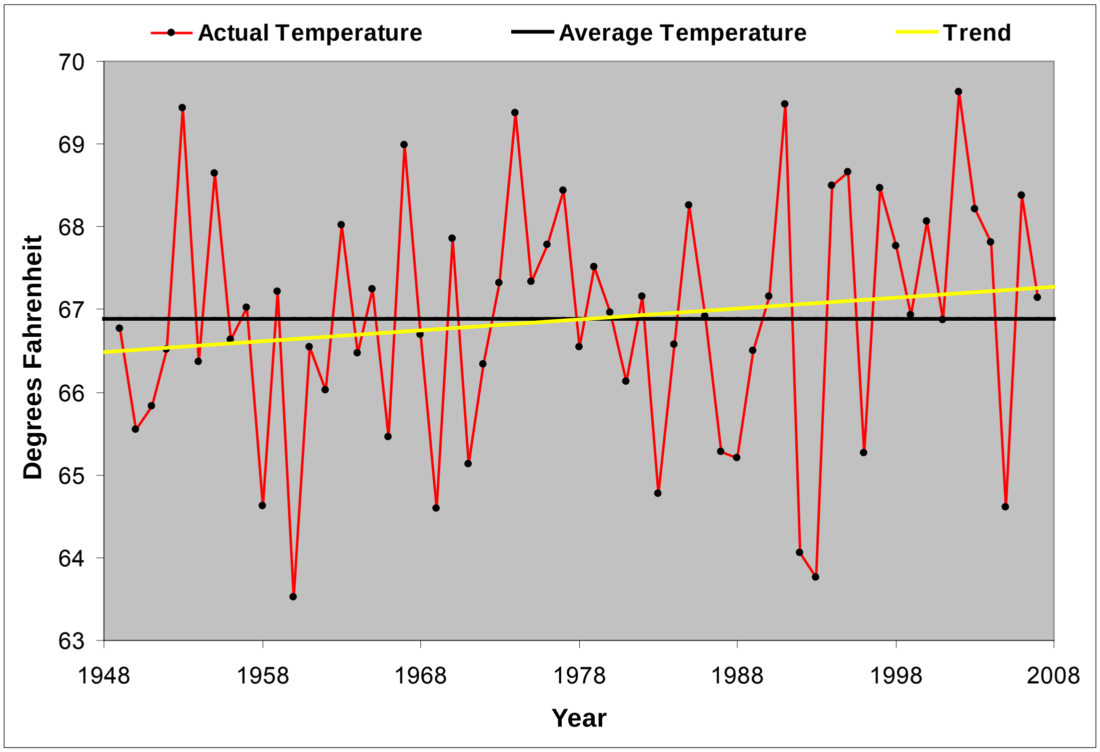

Figure 22. Spring temperature for St. Simons Island, GA from 1949 to 2007. The mean temperature was 66.88 °F. The trend is 0.13 °F per decade.

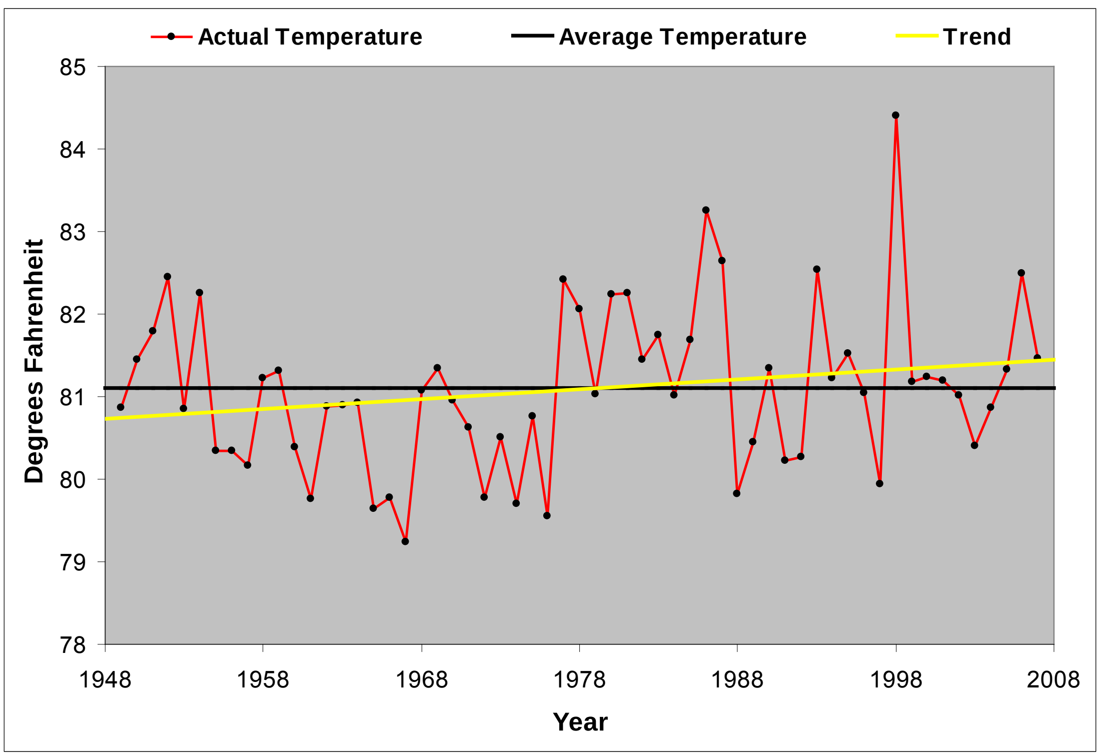

Figure 23. The summer temperature for St. Simons Island, GA from 1949 to 2007. The mean temperature was 81.10 °F. The trend is 0.12 °F per decade.

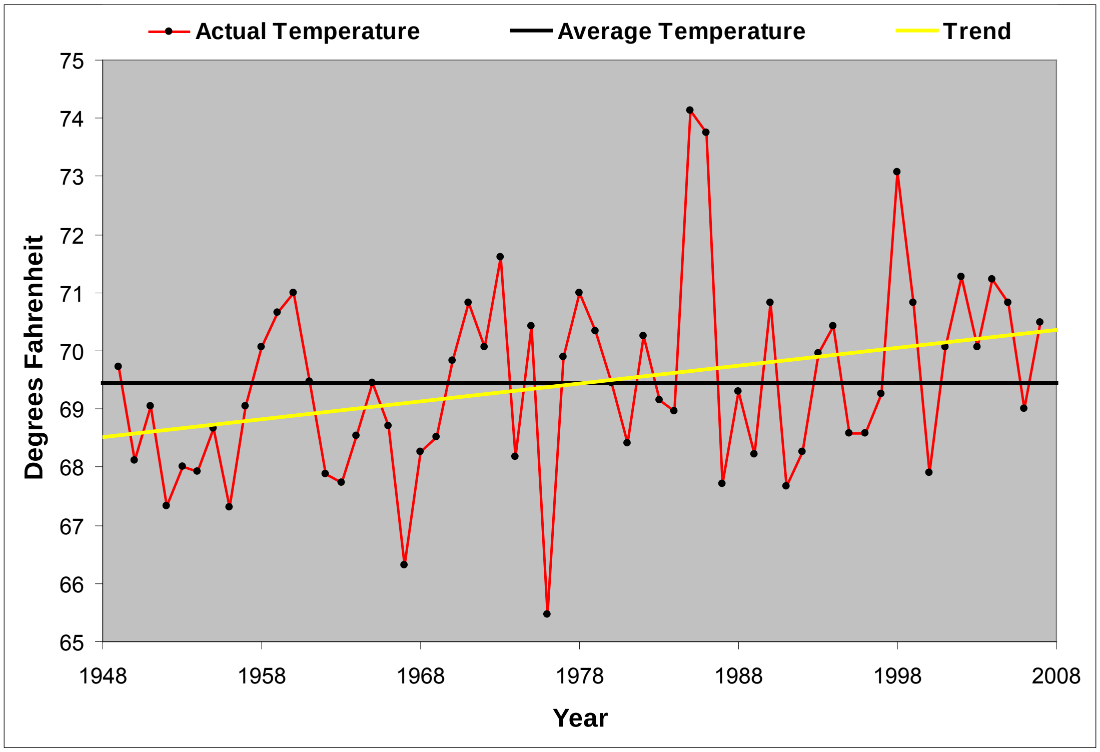

Figure 24. The fall temperature for St. Simons Island, GA from 1949 to 2007. The mean temperature is 69.44 °F. The trend is 0.31 °F per decade.

Precipitation:
Similar analyses were conducted for precipitation using data collected at St. Simons Island, GA. The annual precipitation at St. Simons Island shows variation through time and has a decreasing trend of approximately 1.30 inches per decade (Figure 25).

We also examined precipitation seasonally (as described in temperature above) for winter, spring, summer, and fall from 1949 to 2007 (Figure 26 through Figure 29).

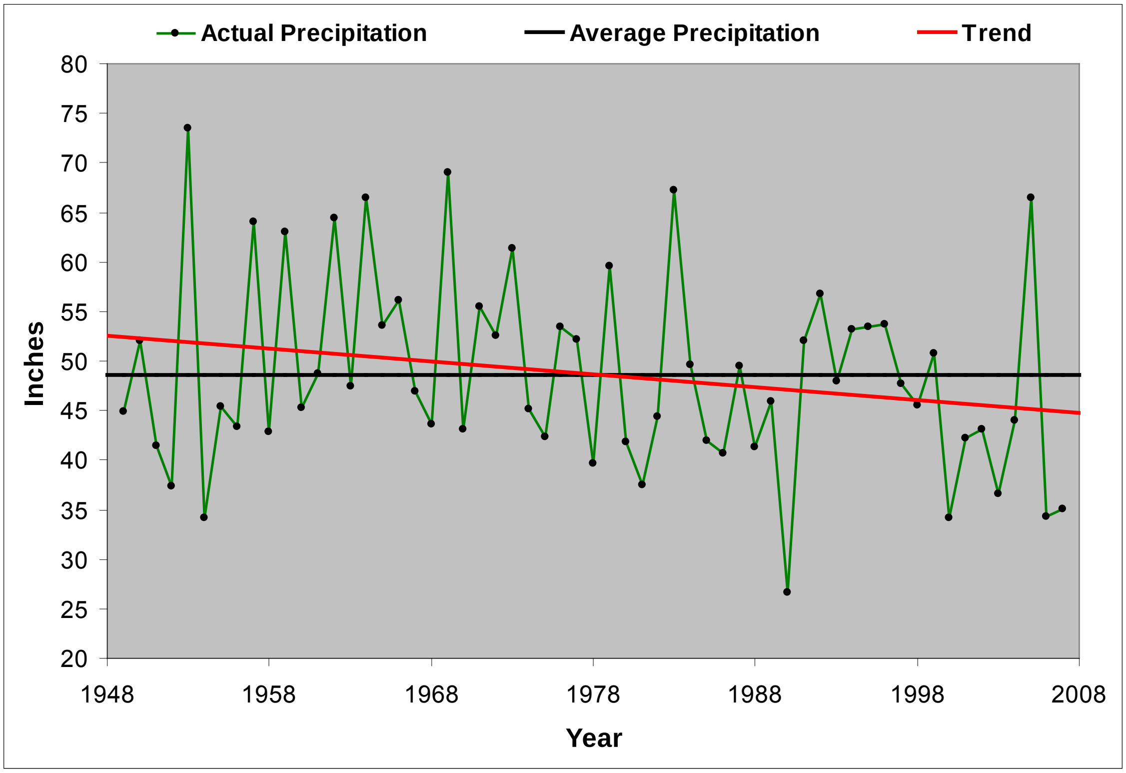

Figure 25. Annual precipitation for St. Simons Island, GA. The mean annual precipitation is 48.65 inches with a decreasing trend of 1.30 inches per decade.

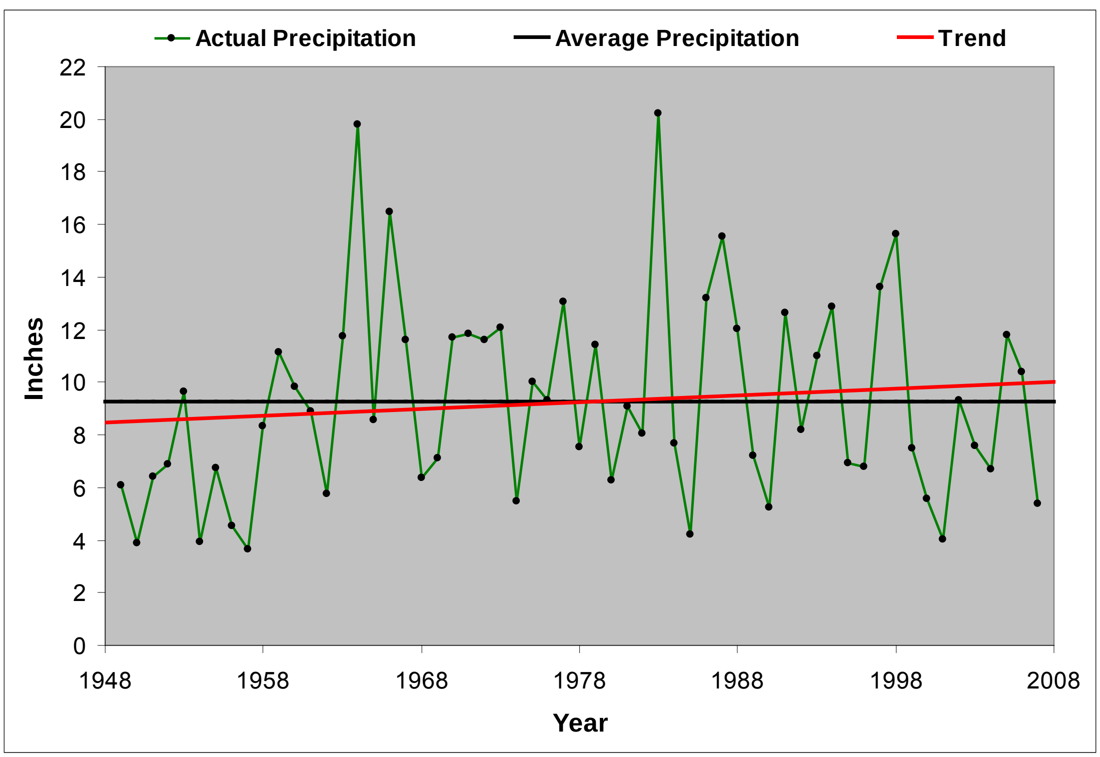

Figure 26. The winter precipitation for St. Simons Island, GA from 1949 to 2007. The mean precipitation is 9.26 inches. The trend is 0.26 inches per decade.

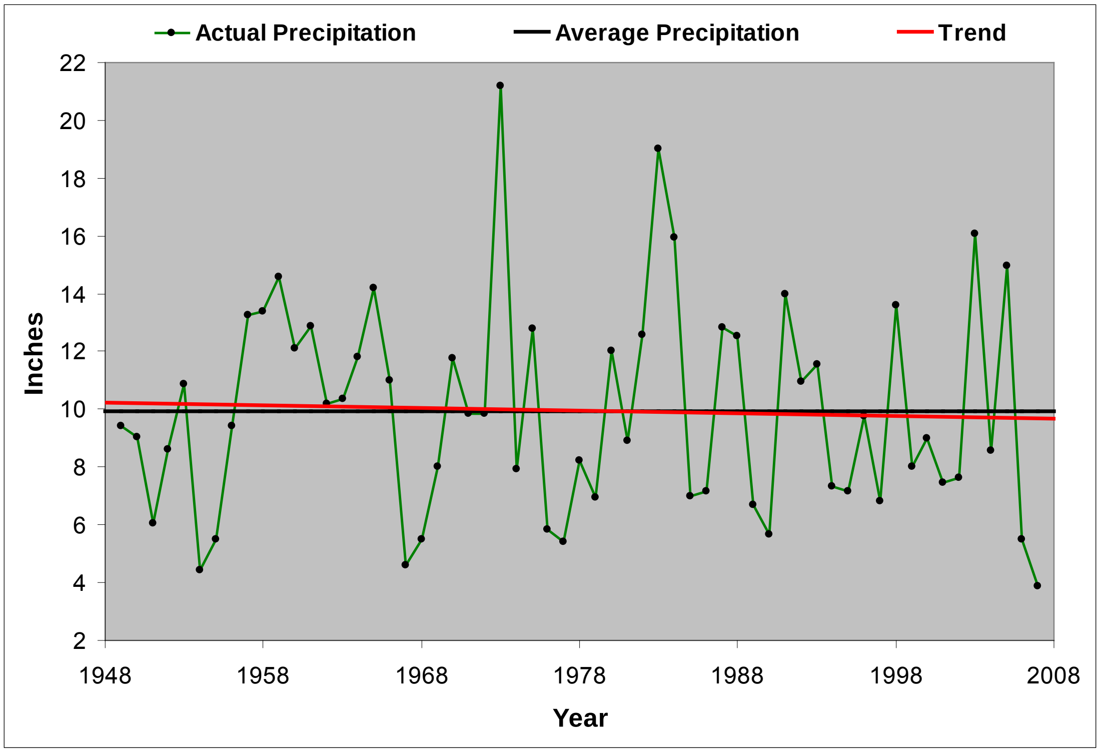

Figure 27. The spring precipitation for St. Simons Island, GA from 1949 to 2007. The mean precipitation is 9.93 inches. The trend is -0.09 inches per decade.

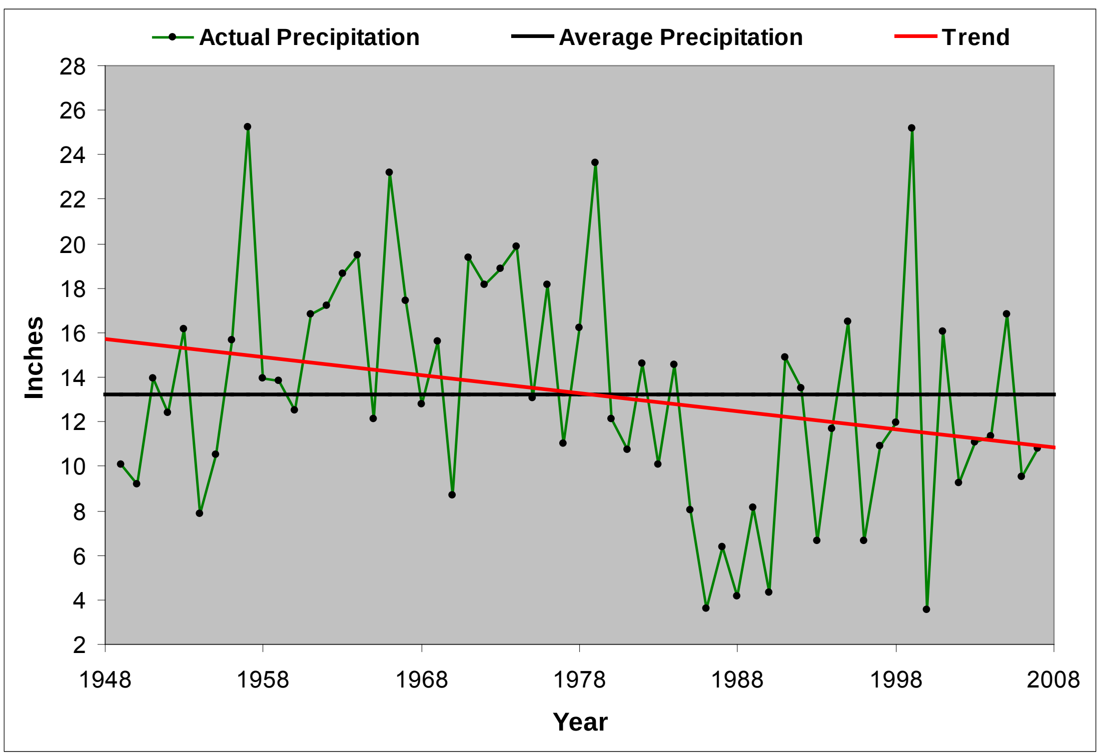

Figure 28. The summer precipitation for St. Simons Island, GA from 1949 to 2007. The mean precipitation is 13.23 inches. The trend is -0.81 inches per decade.

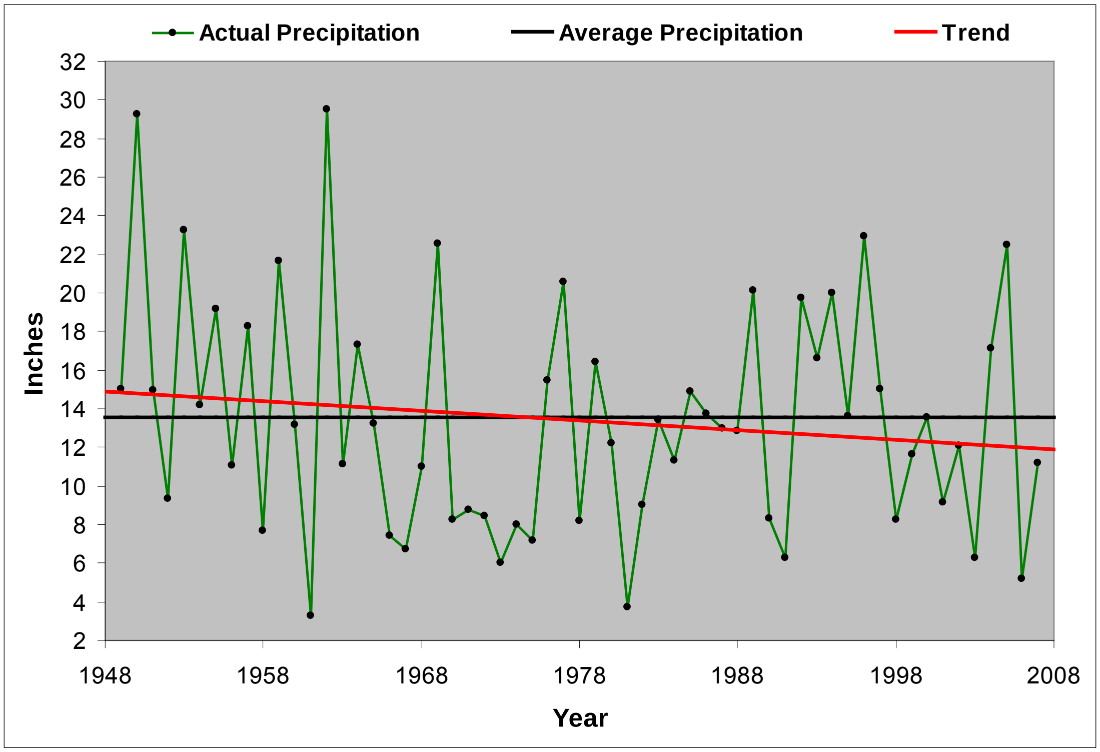

Figure 29. The fall precipitation for St. Simons Island, GA from 1949 to 2007. The mean precipitation is 13.53 inches. The trend is -0.49 inches per decade.

Overall, the trend for precipitation is decreasing. However, precipitation for the winter period is actually increasing over time. The overall trend is significant given the observed increase in temperatures for the same seasonal period. Taken together, it is reasonable to assume that increasing temperatures and decreasing precipitation will result in a decrease in available water and an increase in drying. This may lead to more frequent or increasingly severe drought conditions that will impact biotic resources, particularly during extremes.

Moisture:
We also summarized information on drought severity using monthly data from NOAA for coastal Georgia (Savannah) from 1900 to 2007 (Figure 30). Drought severity was measured with the Palmer Drought Severity Index (PDSI, also as the Palmer Drought Index [PDI]). The PDSI attempts to measure the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months.

The PDSI values reflect the severity of drought and are classified into several levels (Table 23). We used these classes for each monthly PDSI value from 1900 to 2007, and then determined the proportion of months in each class for each 9-year period for ease of comparison (Figure 30

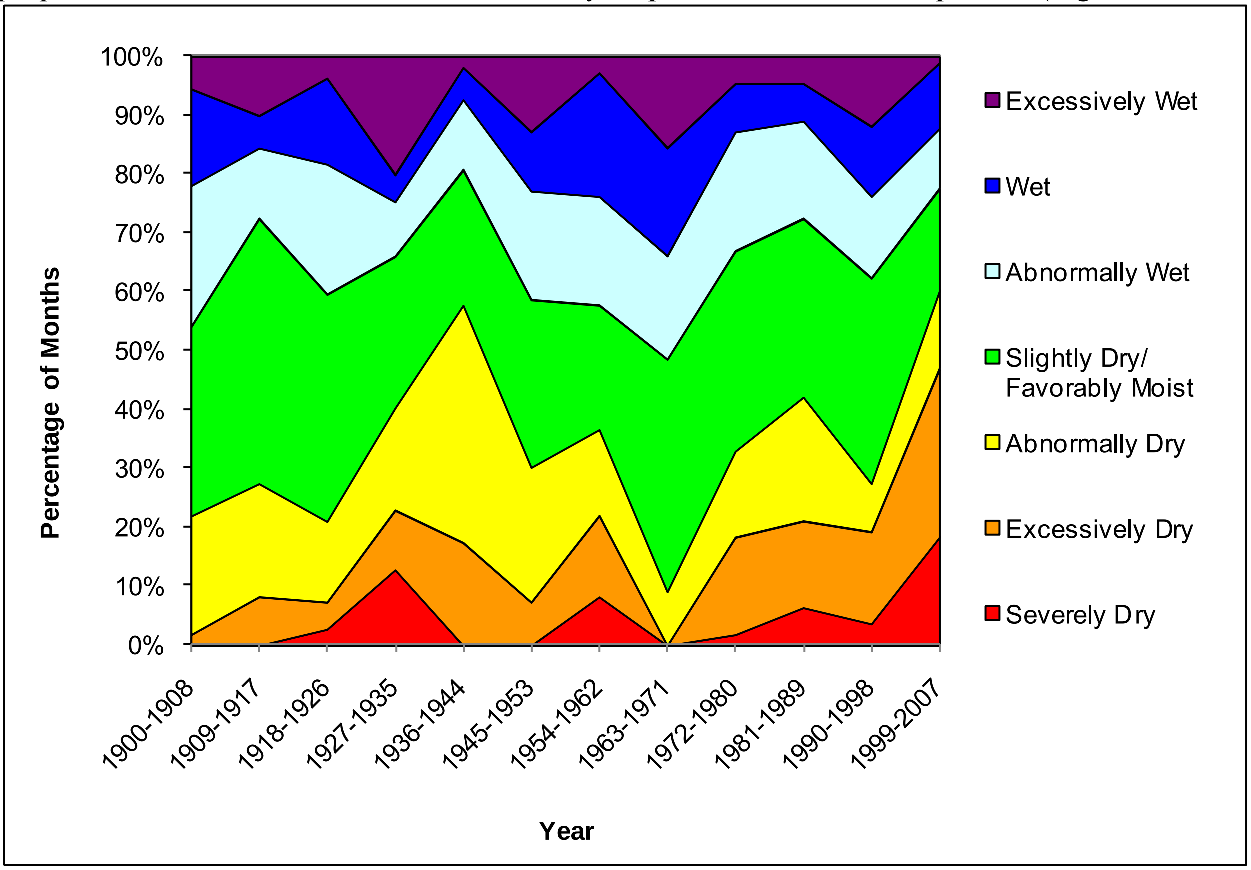

Figure 30).

Table 23. Classification used for Palmer Drought Severity Index (PDSI) values.

PDSI Range	Class Description
-3 or less	Severely Dry
-2 to -3	Excessively Dry
-1 to -2	Abnormally Dry
-1 to 1	Slightly Dry/Favorably Moist
1 to 2	Abnormally Wet
2 to 3	Wet
3 or greater	Excessively Wet

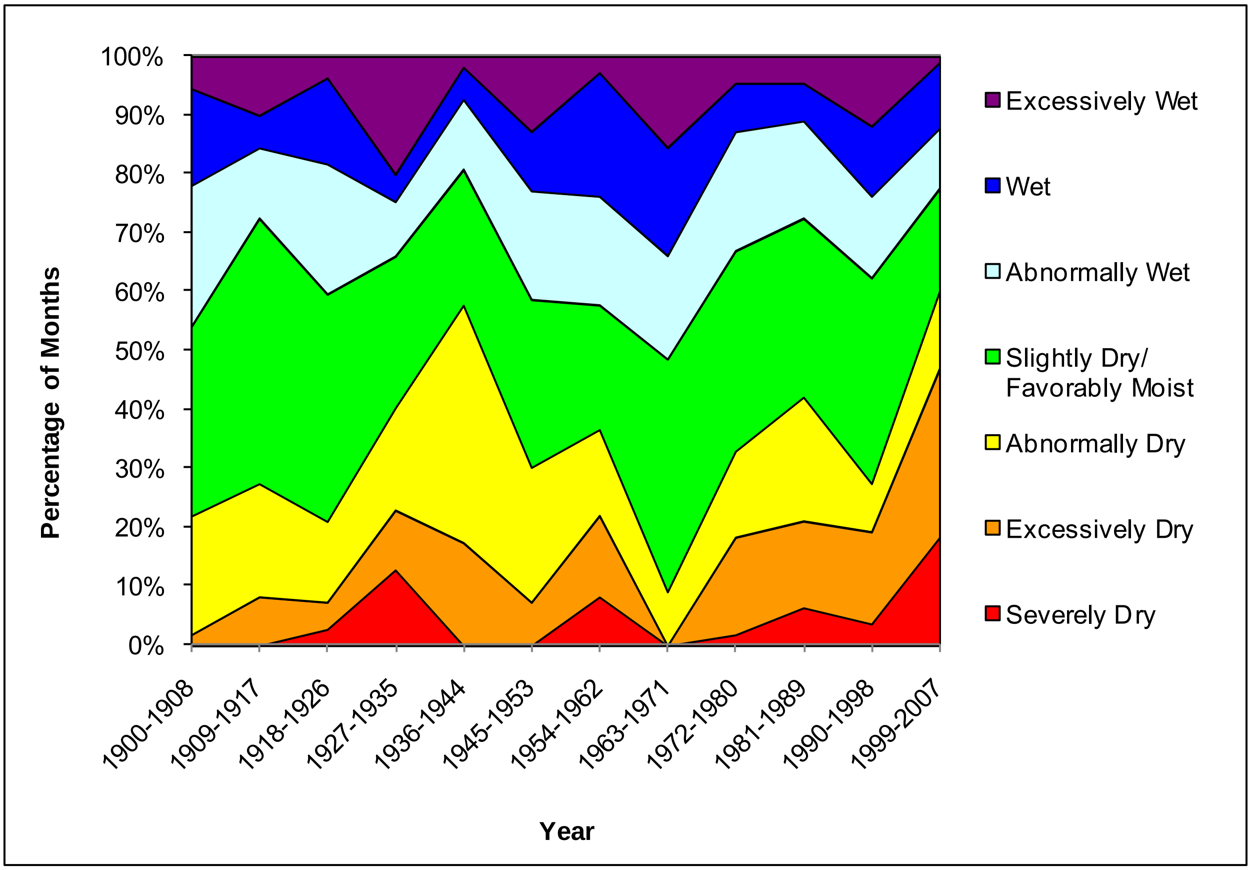

Figure 30. PDSI value for coastal Georgia (Savannah) for 9-year periods from 1900 to 2007.

The data indicate a clear increase in the proportion of months classified as "excessively dry" or "severely dry" since 1971. The red and orange bands increase in width relative to the classes at the wetter end of the scale after that period. It is also evident that drought severity has fluctuated greatly in the past. This supplies additional support to our observations that increasing temperature and decreasing precipitation may lead to increased instance of drought conditions.

Phenology (growing degree days):

Temperature and precipitation have seasonal variation. The patterns of seasonal variation in these abiotic factors impact the biological processes of all local biota. These cycles are reflected in the timing of migration, flowering, and the birth of young. The study of such cycles and seasonal timing is termed "phenology" and changes in these annual cycles can provide information regarding important issues like the length of the growing season.

The best metric available for recording the passage of phenological time are "growing degree days." Growing degree days (GDD) can vary depending on the reference temperature corresponding to the species or process of interest, but the reference temperature is often set to 40 °F. At this temperature, plants can photosynthesize, and typically this equates to growing season. GDDs cannot be equated to calendar days, they are their own unit of measure. In this case, GDDs accumulate anytime the average temperature is more than 40 °F.

We calculated the approximate number of GDDs per month for Fort Frederica NM by using monthly mean temperature data for weather collection stations in nearby St. Simons Island, Georgia. Monthly temperature was available from 1949 to 2007 and was used to calculate the monthly GDD total with a simple formula:

$$GDD = (T_m - 40)\, D_m$$

Where GDD = Growing degree days

T_m = monthly mean temperature

D_m = number of days in month

The number of GDDs for each month were summed to determine the approximate number of GDDs per year. These values were plotted against time (year) to illustrate the long-term trends in the numbers of GDDs at Fort Frederica NM (Figure 31).

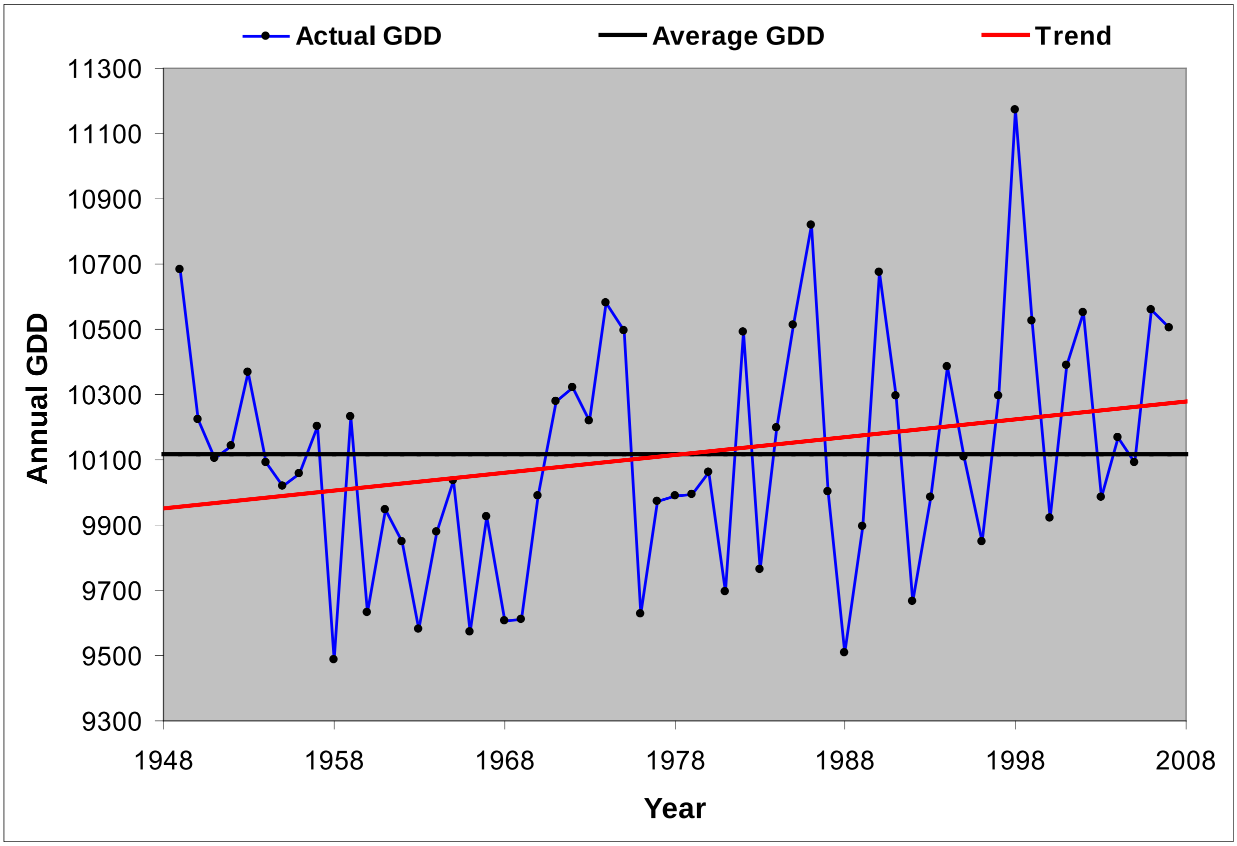

Figure 31. The total growing degree days (GDD) per year for St. Simons Island, GA from 1949 to 2007. The long term mean annual growing degree total is 10115.17 (black line). The red trend line indicates an increasing trend (R^2= 0.07).

We observed an increase in the number of GDDs that may indicate an increase in the growing season through time. To better illustrate this, we elected to examine the same data in terms of phenology. Much research has been completed equating phenological events to growing degree days (McMaster and Wilhelm 1997, University of Massachusetts Extension 2008, Virginia Tech FORSITE 2008). We attempted to put this in the context of a calendar year by selecting an arbitrary GDD threshold (1200 GDD) and estimating the date at which that number of GDDs was achieved. This would be analogous to estimating the specific date a phenological event was to occur (e.g., the blooming of dogwood trees).

Since our source data is as monthly mean daily temperature, we calculated the total monthly accumulated GDD by multiplying the mean daily temperature by the number of days in the month. We then set a reference number of GDDs at 1200 to approximate a springtime phenological event. Historically, this value was achieved during the month of either March or April. We used the total GDD accumulated for the year through March 31 (sum of January, February, and March) then calculated the difference from 1200.

We estimated the number of days required to achieve the 1200 GDD by calculating the slope of the line for the appropriate month. If the difference was positive, we estimated the exact date where 1200 was achieved by determining the slope of the line between the total GDD for March and the total for April. If negative, the same procedure was used between February and March. This permitted us to use the most accurate daily rate in our estimation.

Using this process we determined the calendar date that 1200 GDD was achieved for each year in the dataset and plotted it over time (Figure 32).

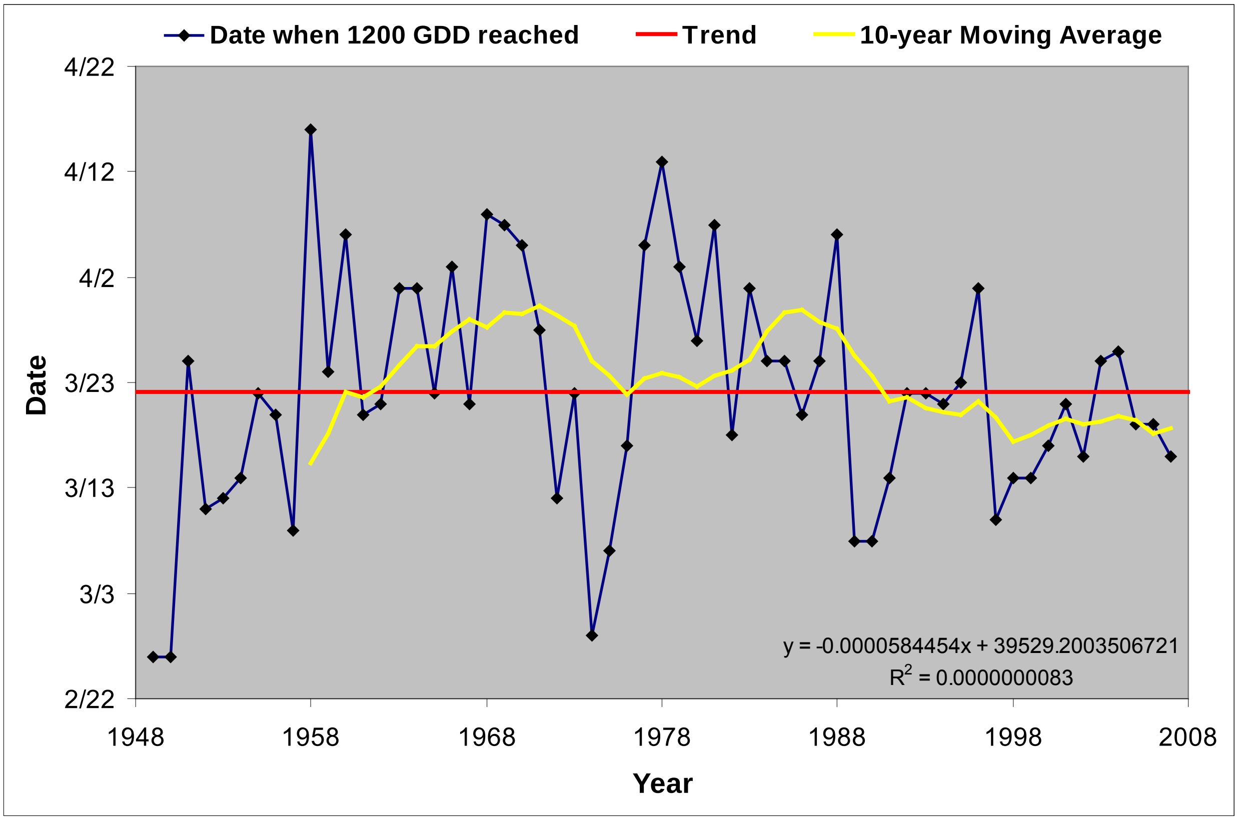

Figure 32. The approximate date when 1200 GDD has been reached for each year (1949 – 2007). The slight decreasing trend indicates that this date is arriving earlier each year (trend is -0.0006 days per decade).

Although slight, the decreasing trend illustrates that the phenology of Fort Frederica NM may be advancing which, in turn, may allow species found in warmer climates with longer growing seasons to expand into this area while perhaps limiting more northern species. However, the annual variation for this factor is high, making the correlation for this trend extremely weak ($R^2 = 8.3x10^{-9}$). More detailed information is needed.

Extreme weather events:
To observe extreme weather events and trends, we obtained historic storm tracks from NOAA's Coastal Services Center (National Oceanic and Atmospheric Administration 2008b). We acquired storm data from 1851 to 2007, which was loaded into a GIS. We then selected all storms that occurred within 100 nautical miles (nm) of the Fort Frederica NM park boundary to assess those storms which were most likely to have an impact on the ecosystems and processes associated with the park.

Each storm category is defined as a separate event, so we combined storms that occurred on successive days into one storm event and maintained the most severe storm rating assigned to any one of the storms. This was necessary to accurately and efficiently understand storm frequency and the impacts of extreme weather on Fort Frederica NM and the surrounding areas. Additionally, it is worth noting that storms were not named until around 1950. In our assessment, we included storms rated as tropical depressions (TD), tropical storms (TS), and category 1 through 4 hurricanes. There were no Category 5 hurricanes in the historical data that came within 100nm of Fort Frederica NM.

Storms categorized as tropical depressions are those with maximum sustained winds of 38 mph or less. Tropical storms are those with maximum sustained winds of 39 to 73 mph (U.S. Department of Commerce 2001). The Saffir/Simpson Hurricane Scale (Table 24) rates and categorizes hurricanes on a scale of 1 through 5 based on wind speeds (Blake et al. 2007). A major hurricane is any storm categorized as 3, 4, or 5 on the Saffir/Simpson Scale.

Table 24. Saffir/Simpson Hurricane Scale (Blake et al. 2007).

		Typical Characteristics of Hurricanes by Category			
Scale Number (Category)	*Wind Speed (mph)*	*Millibars*	*Inches*	*Surge (feet)*	*Damage*
1	74 – 95	> 979	> 28.91	4 to 5	Minimal
2	96 – 110	965 - 979	28.50 - 28.91	6 to 8	Moderate
3	111 – 130	945 - 964	27.91 - 28.47	9 to 12	Extensive
4	131 – 155	920 - 944	27.17 - 27.88	13 to 18	Extreme
5	> 155	< 920	< 27.17	> 18	Catastrophic

Upon analyzing the historic hurricane data, we were able to better understand the frequency and magnitude of extreme weather events affecting Fort Frederica NM. We observed the data in terms of monthly occurrence as well as yearly occurrence. Figure 33 through Figure 35 illustrates various combinations of storm activity during the annual monthly cycles, while Figure 36 through Figure 38 illustrates various combinations of storm activity broken down decennially to adequately facilitate illustration and interpretation.

The majority of all storm activity within 100nm of Fort Frederica NM occurs later in the year, between the months of August and October, with September experiencing the most (Figure 33). When the storms are divided into groups designated as either major or minor, these findings remain constant. Breaking the storms into groups, however, illustrates that minor storms (TD, TS, or Cat 1 or 2 hurricanes) pose a greater threat to Fort Frederica NM than do major storms (Figure 34).

Dissecting the data further, we were able to illustrate the frequency of each storm category and the potential impacts on Fort Frederica NM. According to the data, the monument is affected most by tropical storms, followed by Cat 1 hurricanes, both of which are relatively minor storm systems (Figure 35).

The annual data, combined into ten-year blocks, permits the interpretation of historic storm trends and the potential for projecting future storm activity and potential impacts on Fort Frederica NM. When all storm categories are combined, the data show that storm activity is on a relative decline (Figure 36). The graphic also illustrates that although the trend is declining, storm activity peaks an average of every twenty years since the 1940 – 1949 decennial block. Based on these data alone, storm activity should peak in the 2000 – 2009 decennial block and continue the historic downward trend in the next decade.

When the annual data is split into major and minor storms, it is evident that while Fort Frederica NM is threatened more by minor storms than major storms, it is nevertheless experiencing a diminishing amount of storm activity (Figure 37). The graph illustrates that while minor storm activity is decreasing overall, Fort Frederica NM has experienced a peak every twenty years since the 1940 – 1949 decennial block. According to the trends, minor storms should peak in the 2000 – 2009 decennial block and continue to decline in the following decade. The data also suggests that Fort Frederica NM may expect a major storm event in the coming years. The trends for major storm indicate that activity peaks every seventy years, with the last peak occurring in the 1960 – 1969 decennial block.

Splitting the annual data into its primary components permits the observation of each storm category and its trends since 1851 (Figure 38). Fort Frederica NM has historically been affected most by Tropical Storms, followed by a secondary influence from Cat 1 hurricanes. The data also illustrates that Fort Frederica NM is experiencing an increasing trend in Tropical Depressions while experiencing fewer storms in other categories.

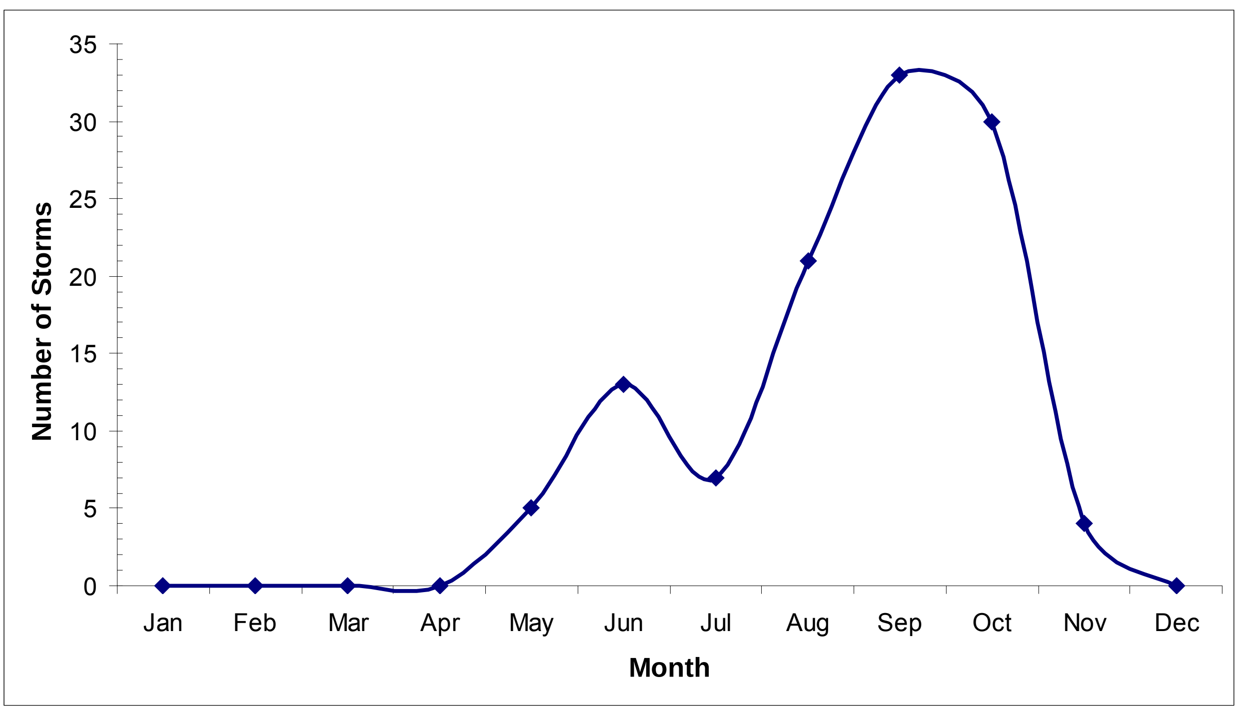

Figure 33. Total number of all storms per month (1851 – 2007) occurring within 100 nautical miles of Fort Frederica National Monument.

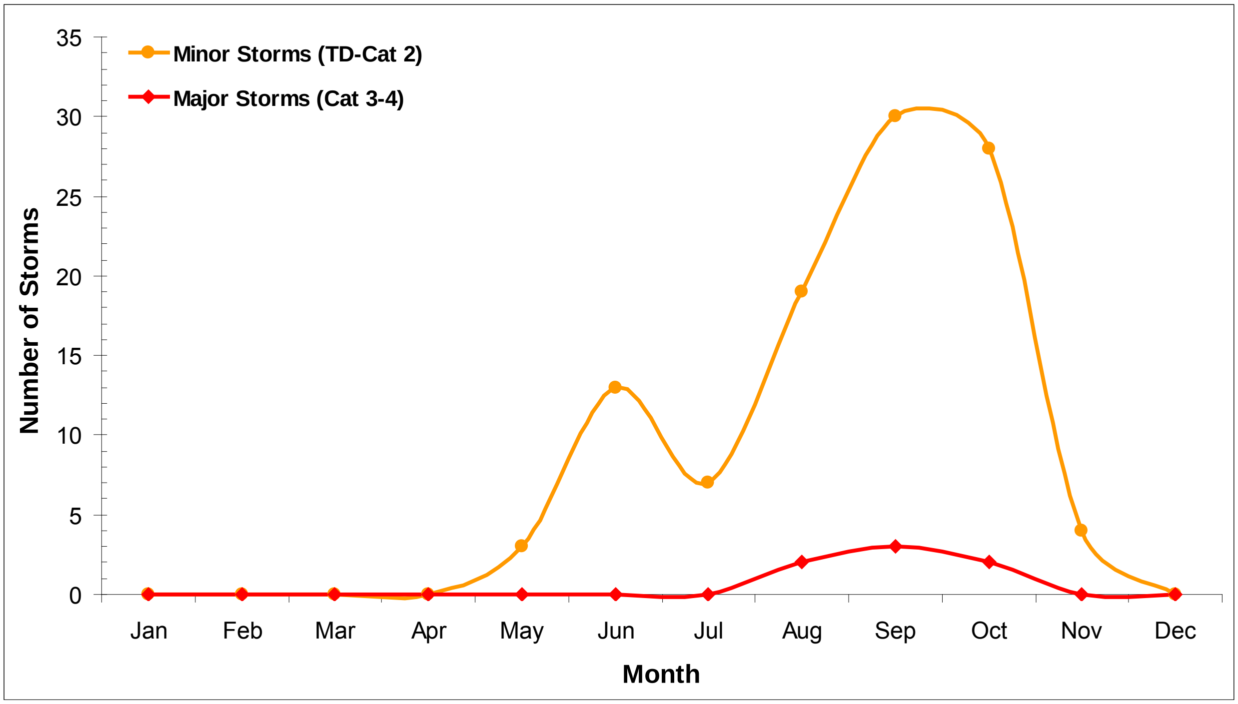

Figure 34. Total number of major and minor storms per month (1851 – 2007) occurring within 100 nautical miles of Fort Frederica National Monument.

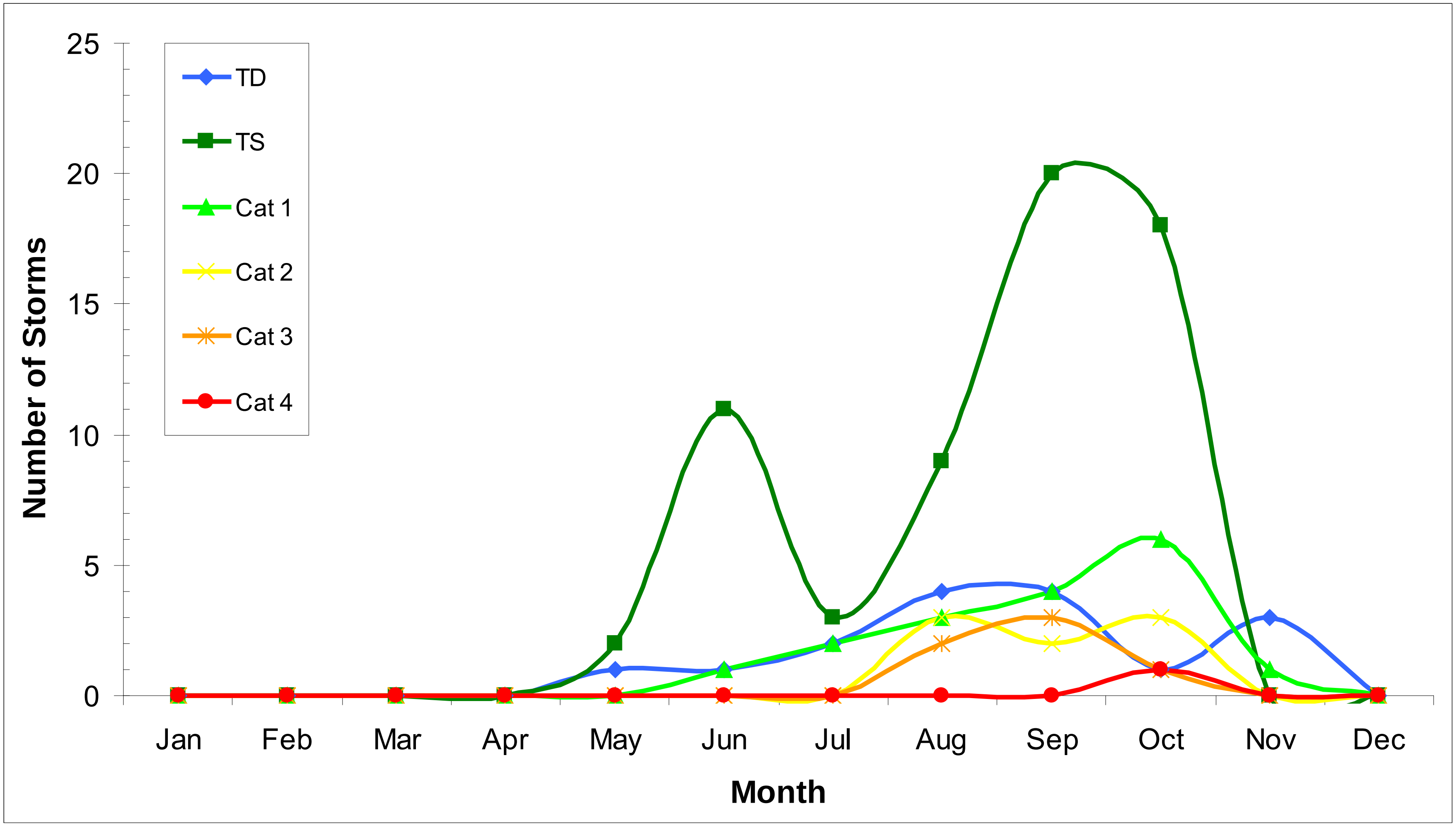

Figure 35. Total number of storms by category per month (1851 – 2007) occurring within 100 nautical miles of Fort Frederica National Monument. Tropical depressions (TD) have 38 mph sustained wind speeds or less, tropical storms (TS) have 39 to 73 mph wind speeds, and the remaining hurricane categories (1 – 4) are from Saffir/Simpson Hurricane Scale (Table 24).

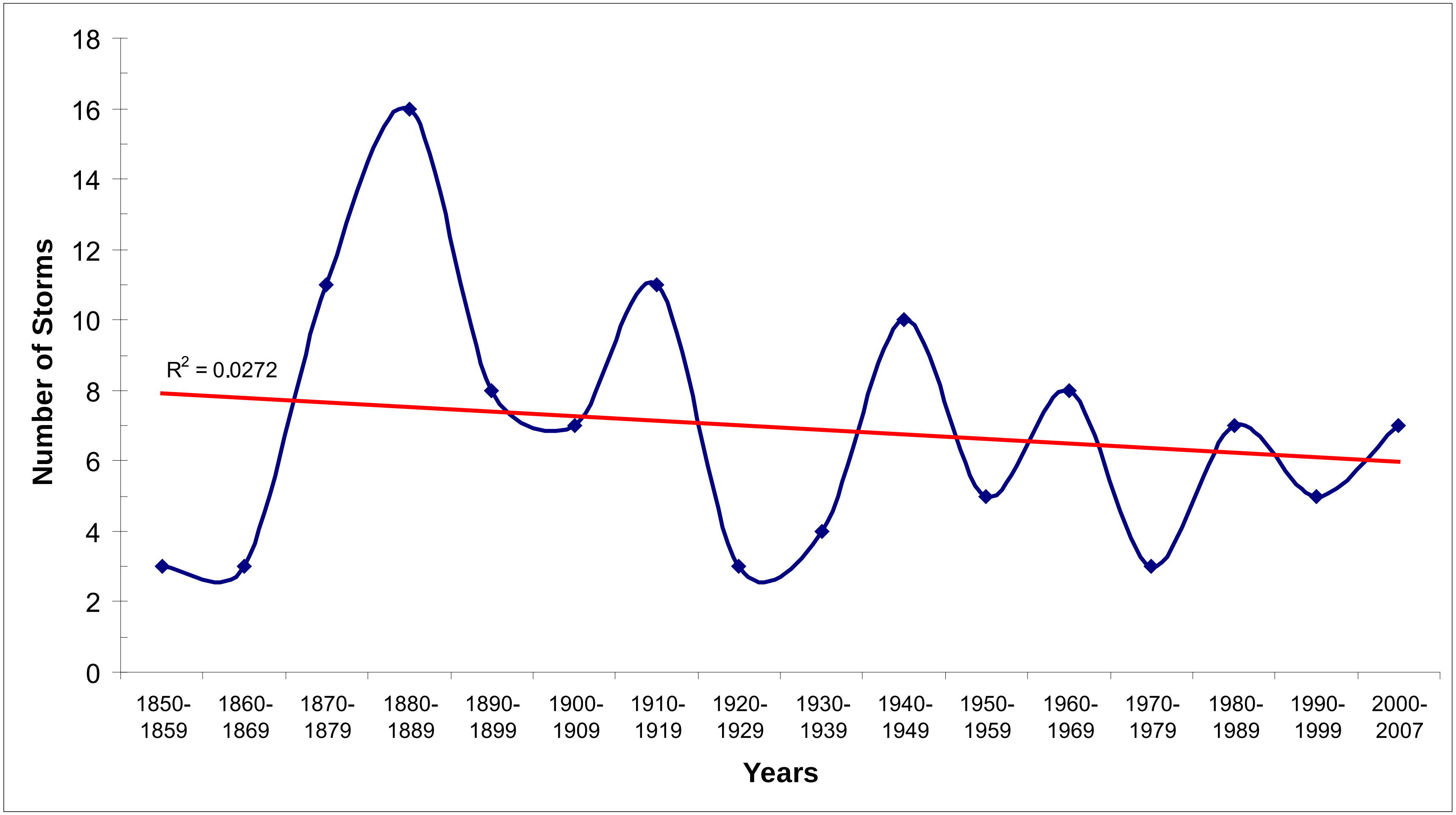

Figure 36. Total number of all storms per decade (1851 – 2007) occurring within 100 nautical miles of Fort Frederica National Monument.

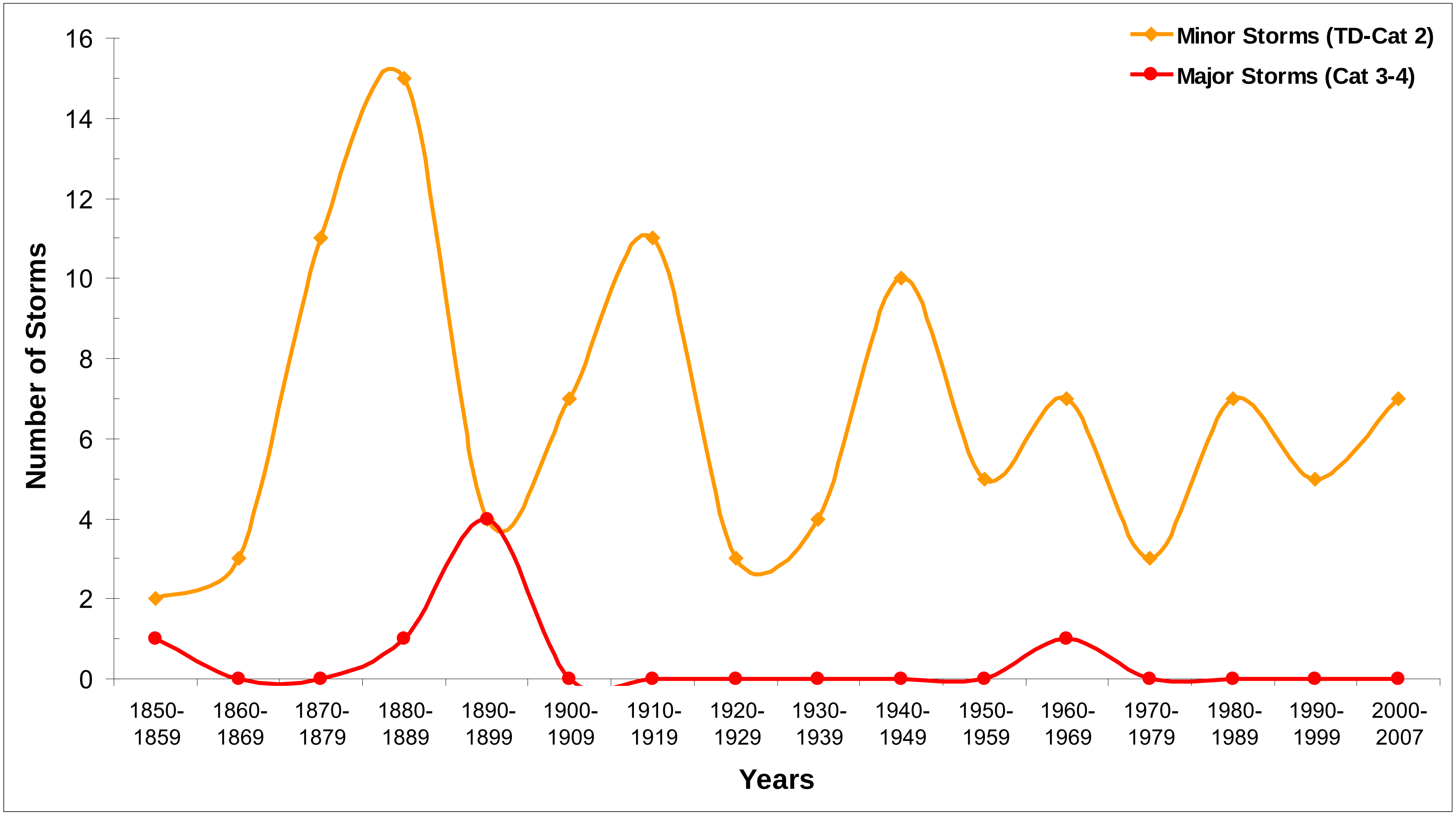

Figure 37. Total number of major and minor storms per decade (1851 – 2007) occurring within 100 nautical miles of Fort Frederica National Monument.

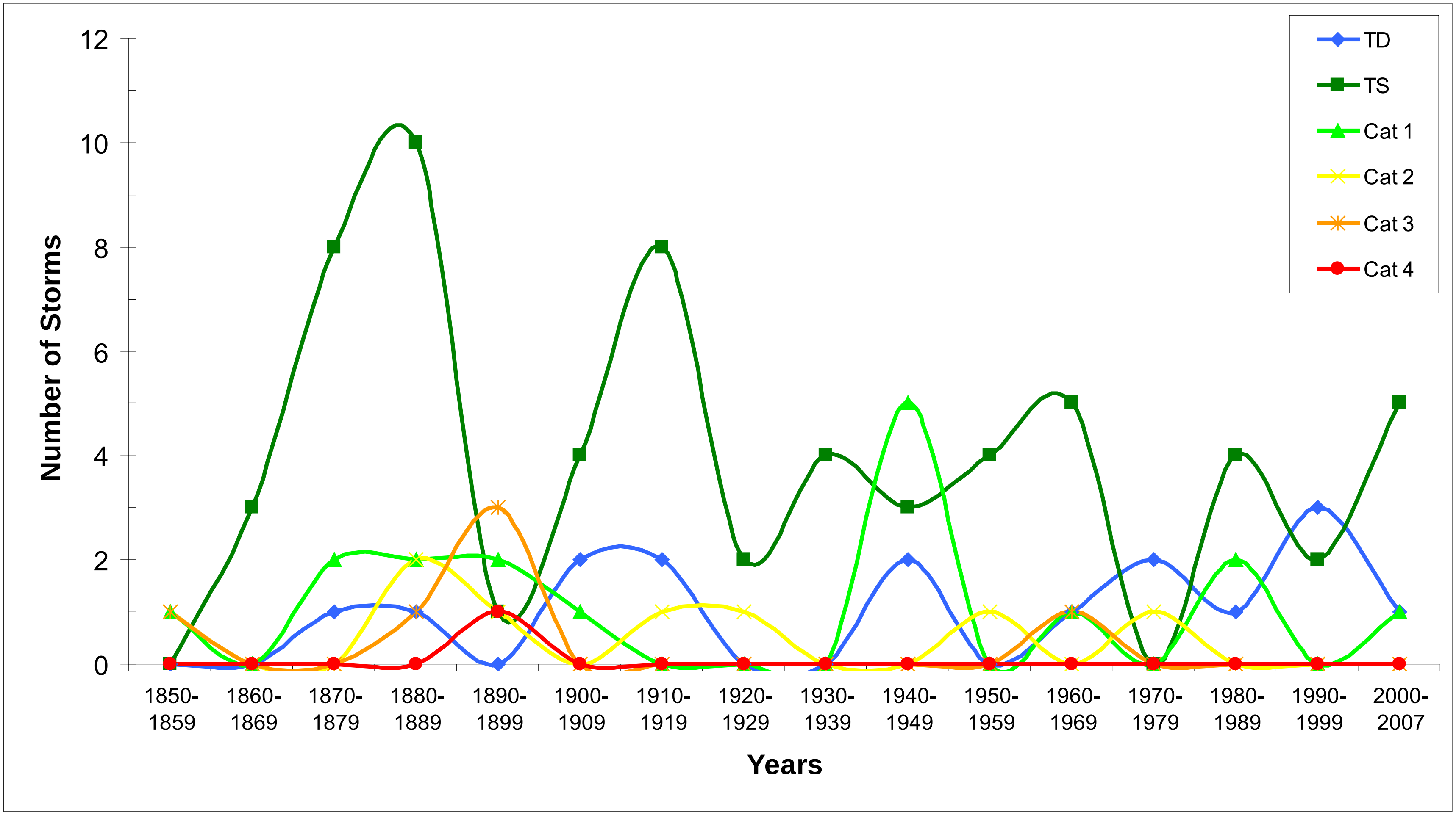

Figure 38. Total number of storms by category per decade (1851 – 2007) occurring within 100 nautical miles of Fort Frederica National Monument. Tropical depressions (TD) have 38 mph sustained wind speeds or less, tropical storms (TS) have 39 to 73 mph wind speeds, and the remaining hurricane categories (1 – 4) are from Saffir/Simpson Hurricane Scale (Table 24).

3.3.2.b Resource threats and stressors:
The threat of changing climate is real, and research points to the high likelihood of broad ecological impacts as a result. How these changes will impact specific park resources is yet unknown, but they are likely to be comprehensive. That is not to say that those changes will be catastrophic. While specific biota or processes will be impacted, climate change may not result in extinctions or degradations.

Perhaps the most important and immediate trend to consider is the increase in likelihood of drier summer periods and the impact this may have on the salt marsh. Particularly given the recent linkages identified with stressed salt marshes and susceptibility to the periwinkle (see threats and stressors section under 3.6 Biological Integrity). This could have an immediate impact on the salt marsh communities at Fort Frederica NM.

3.3.2.c Critical knowledge or data gaps:
Data quality is relatively good for the climate categories. We gave spatial a zero because these data were not collected at Fort Frederica NM itself (Table 25). All the data used for climate were taken from datasets for nearby St. Simons Island, Georgia. It is unlikely that the climate at Fort Frederica NM varies much from this data, but without climate variable information taken on-site, this remains a critical assumption. Since climate is the product of long-term weather variables, simply initiating weather data collection now will not yield useful information for some time unless it is used to calibrate the dataset available for St. Simons Island.

It would be advisable for the park to maintain basic phenological information. This could be used along with data gathered throughout the region to quantify the changing phenology over a reasonably short time frame. The park can easily identify specific events (e.g., the appearance of the first bloom) that should be monitored and recorded annually as part of other ongoing activities.

Assigning condition status was a bit a challenge for this assessment category. Although we have tracked and displayed these data in a thorough manner, there are little historical or experimental outcomes to compare these climatic and extreme weather events to (Table 25).

3.3.2.d Condition status summary:
Temperature is in the fair range for Fort Frederica NM because of a slight increasing trend that was evident in the data (Table 25). The condition status was also fair for precipitation due to a decreasing trend (Table 25). Moisture's condition status was fair because the increase in the proportion of months classified as "excessively dry" or "severely dry" since 1971 (Table 25). Phenology is in the fair range due to the observed increase in the number of growing degree days that may indicate an increase in the growing season through time (Table 25). Extreme weather events, however, received a condition status of good because storm activity is on a relative decline and the majority of those storms are relatively minor (Table 25).

Table 25. Climate condition status summary for Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), *spatial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Midpoint***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Temperature			1	0	1
	Fair	0.5		2 out of 3	
Precipitation			1	0	1
	Fair	0.5		2 out of 3	
Moisture			1	0	1
	Fair	0.5		2 out of 3	
Phenology (GDD)			1	0	1
	Fair	0.5		2 out of 3	
Extreme weather events			1	1	1
	Good	0.84		3 out of 3	
Climate total			5	1	5
	Fair	0.57		11 out of 15	

3.3.2.e Recommendations to park managers:
Simple measures to monitor the climate changes at Fort Frederica NM should be considered. This does not require a comprehensive or expensive program, but simply a dedicated effort to raise awareness of the changes on the park as they occur. We recommend:

- attention to the summer season temperature and precipitation to anticipate the threat of marsh stress and the potential for it contributing to salt marsh dieback.

- participation in national and regional investigations into phenological changes. The US National Phenology Network (http://www.usanpn.org/) provides information and protocol for low-cost programs.

3.4 Water

3.4.1 Hydrology

Hydrologic issues at Fort Frederica NM are wide and varied. The unique interaction of coastal water processes in conjunction with the Frederica River estuary and arrangement of wetlands make for a complicated array of hydrologic function. We examined these first within the context of the wetlands through a National Wetlands Inventory assessment protocol (Tiner 2003a). In addition, there are local hydrologic issues that are important to the park, including the potential for oil spills in the region and drainage concerns at the park entrance.

3.4.1.a Current condition:
There are 165 acres of wetlands at Fort Frederica NM according to the U.S. Fish and Wildlife Service, National Wetlands Inventory (NWI). NWI designed a straightforward way of assessing

watershed function in a spatial context using available NWI classifications. The newer wetland landscape position, landform, water flow path, and waterbody type descriptors (LLWW) (Tiner 2003b) are also needed to perform this correlation. There are ten functions that NWI has designed to evaluate wetlands. These are: 1) surface water detention, 2) coastal storm surge detention, 3) streamflow maintenance, 4) nutrient transformation, 5) sediment and other particulate retention, 6) shoreline stabilization, 7) provision of fish and shellfish habitat, 8) provision of waterfowl and waterbird habitat, 9) provision of other wildlife habitat, and 10) conservation of biodiversity.

The criteria that were developed by Tiner (2003a) have been reviewed by wetland specialists working in Maryland, Delaware, New York, and Maine. These criteria may need to be modified slightly for Georgia, but we work under the assumption that these functional analyses will operate similarly for the Southeastern U.S. The first 6 functions are covered in this hydrology section.

Surface water detention:
The majority of Fort Frederica NM wetlands are highly rated for surface water detention (Table 26, Figure 39). These wetland types have been shown to provide flood storage and reduce downstream floods and flood heights (Tiner 2003a).

Table 26. Surface water detention correlation to National Wetland Inventory classification within Fort Frederica NM.

NWI Correlation	*Acres*	*% of FOFR Wetlands*
High	164.6	99.82
Not Correlated/Poor	0.3	0.18
	164.9	100.00

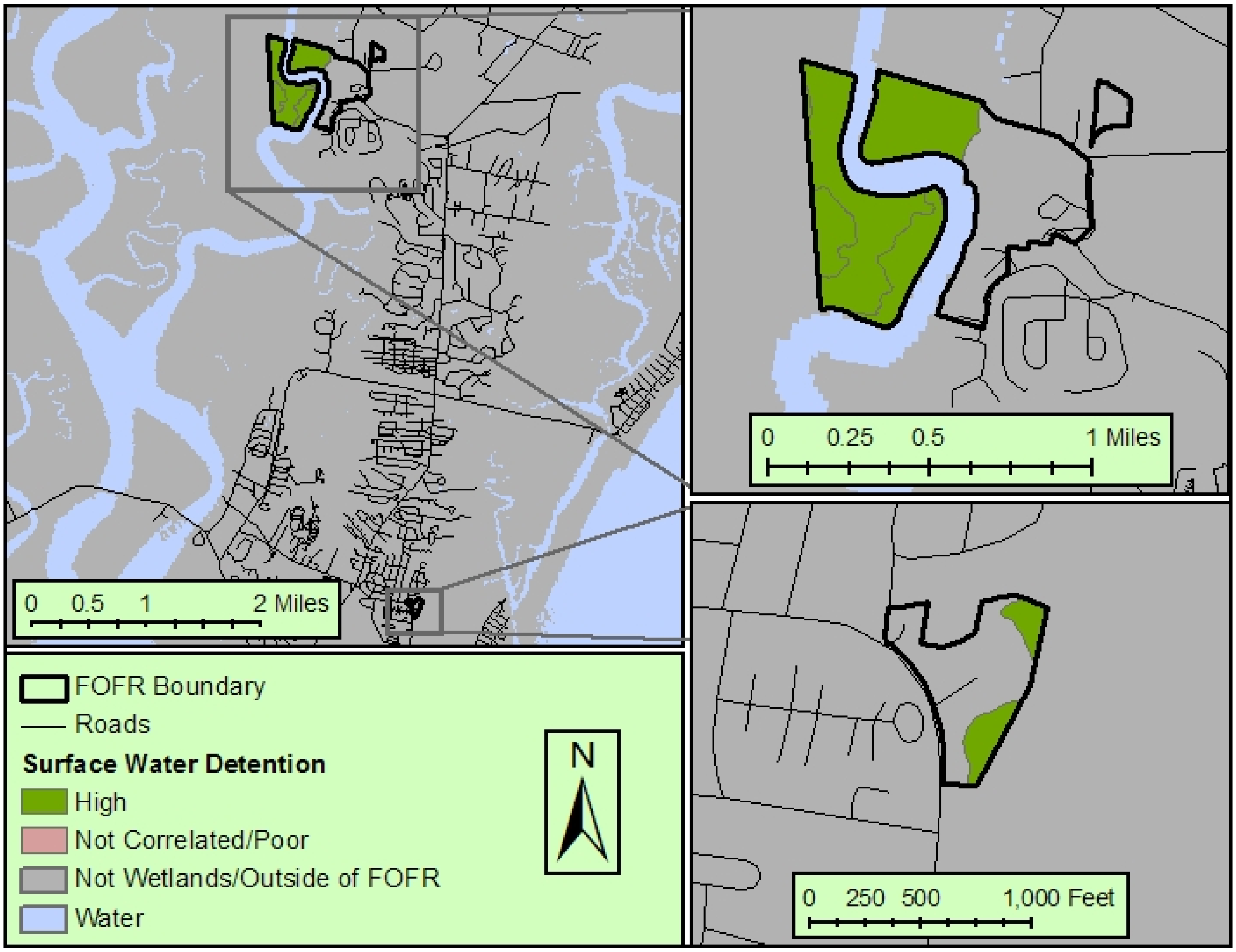

Figure 39. Surface water detention correlation to National Wetland Inventory classification within Fort Frederica NM.

Coastal storm surge detention:
Table 27 and Figure 40 illustrate that Fort Frederica NM wetlands are almost 99% capable of offering high levels of coastal storm surge detention. These are wetlands that will function as temporary water storage under the pressure of large storms such as hurricanes and tropical storms (Tiner 2003a).

Table 27. Coastal storm surge detention correlation to National Wetland Inventory classification within Fort Frederica NM.

NWI Correlation	*Acres*	*% of FOFR Wetlands*
High	162.7	98.64
Not Correlated/Poor	2.2	1.36
	164.9	100.00

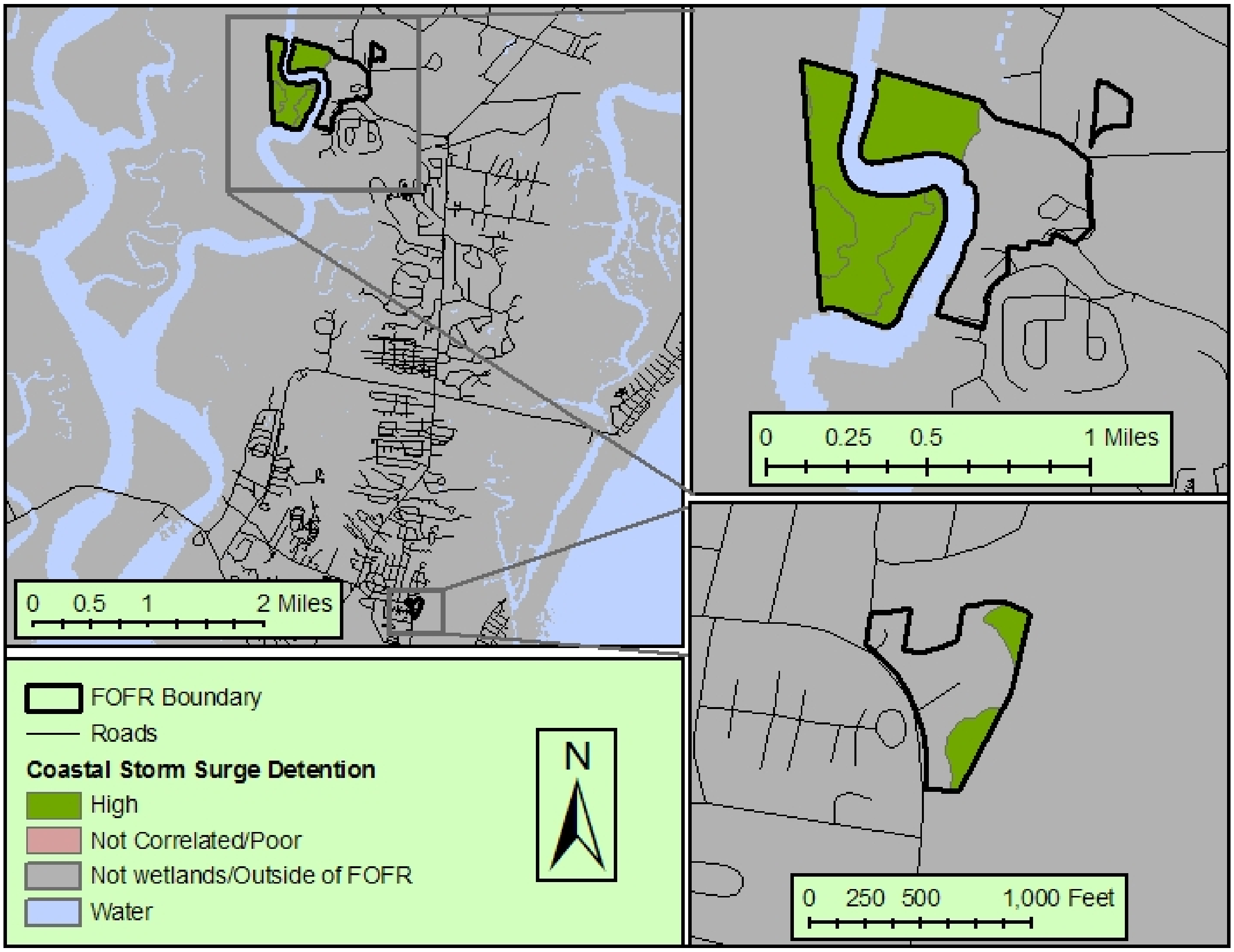

Figure 40. Coastal storm surge detention correlation to National Wetland Inventory classification within Fort Frederica NM.

Streamflow maintenance:
The coastal location of Fort Frederica NM precludes it from offering much in the way of streamflow maintenance (Table 28, Figure 41). Headwater wetlands, far upstream from the monument, operate to increase streamflow (Tiner 2003a).

Table 28. Streamflow maintenance correlation to National Wetland Inventory classification within Fort Frederica NM.

NWI Correlation	*Acres*	*% of FOFR Wetlands*
Not Correlated/Poor	164.9	100.00

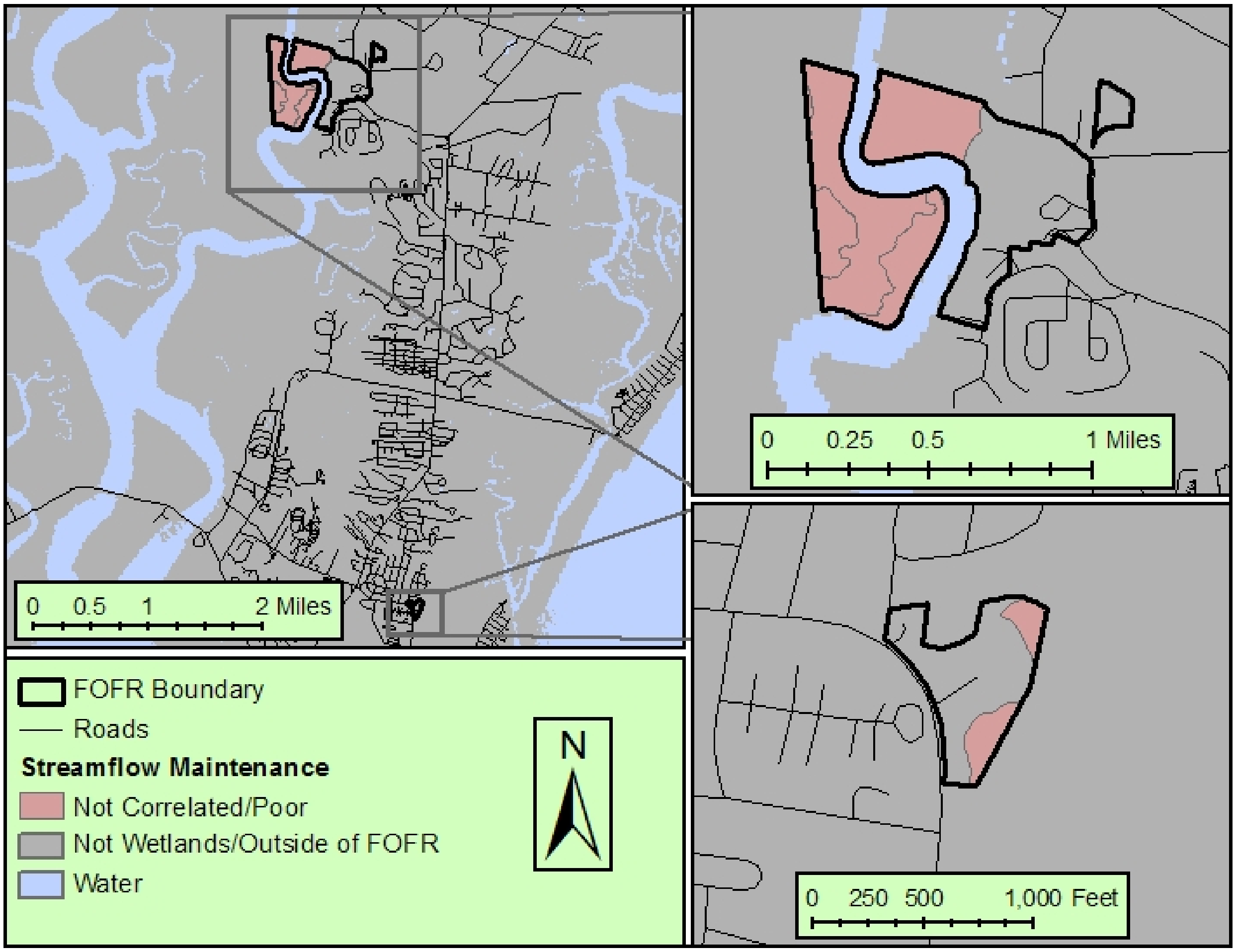

Figure 41. Streamflow maintenance correlation to National Wetland Inventory classification within Fort Frederica NM.

Nutrient transformation:

Nutrient transformation occurs most readily in permanently flooded wetlands whereas temporarily flooded wetlands have only moderate potential (Tiner 2003a). Nutrients increase the biological oxygen demand (BOD) and therefore lower DO concentrations in water and have consistently ranked as one of the top causes of water degradation in the U.S. (U.S. Environmental Protection Agency 2008e). Ninety-nine percent of the wetlands at Fort Frederica NM are highly or moderately correlated with nutrient transformation (Table 29, Figure 42). The irregularly exposed wetlands and subtidal rivers/streams do not offer much in the way of nutrient transformation because they are continuously saturated and anaerobic.

Table 29. Nutrient transformation correlation to National Wetland Inventory classification within Fort Frederica NM.

NWI Correlation	*Acres*	*% of FOFR Wetlands*
High	162.7	98.64
Moderate	0.3	0.20
Not Correlated/Poor	1.9	1.17
	164.9	100.00

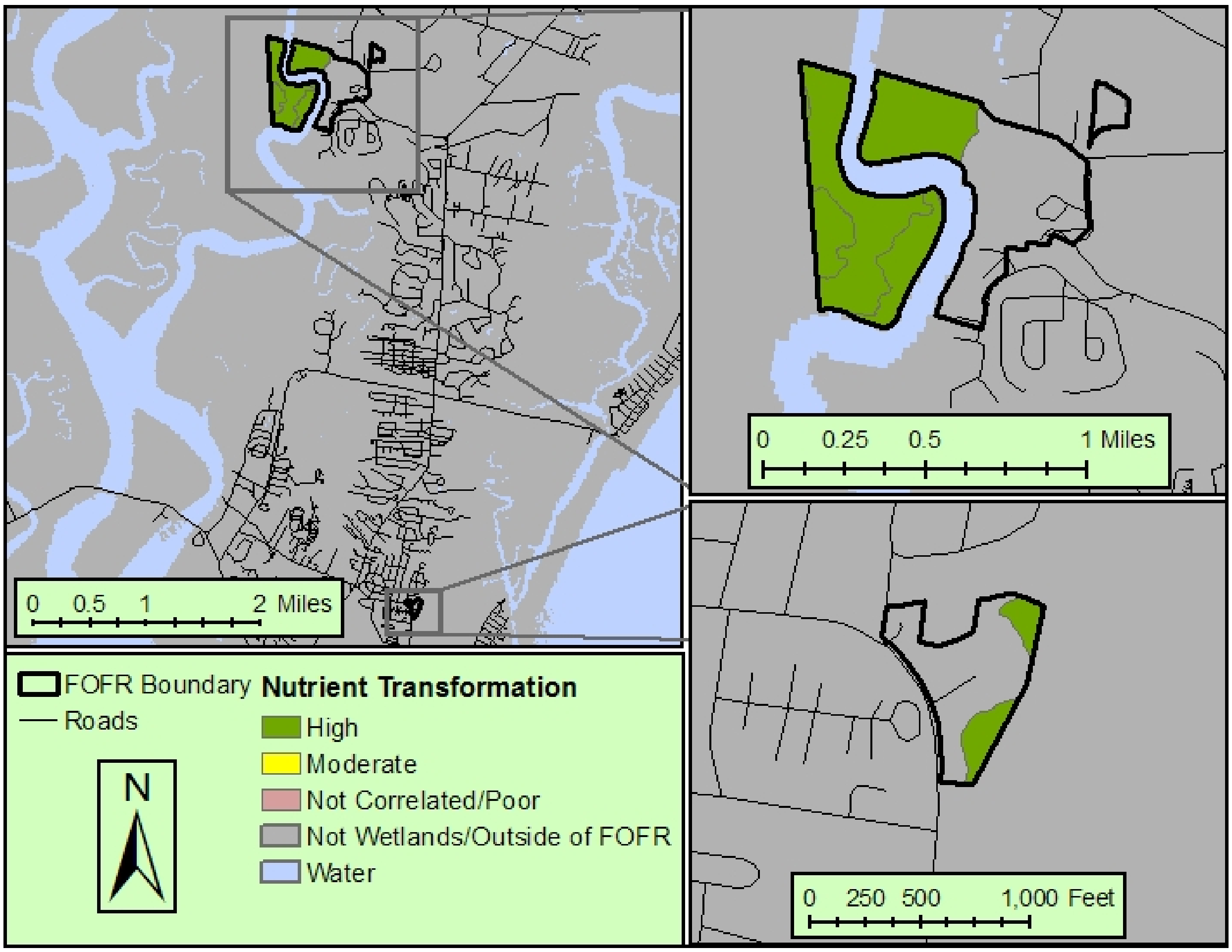

Figure 42. Nutrient transformation correlation to National Wetland Inventory classification within Fort Frederica NM.

Sediment and other particulate retention:
There is a high correlation of wetlands at Fort Frederica NM (nearly 99%) with the retention of sediments and other particulates (Table 30, Figure 43). Water quality is supported through this wetland function (Tiner 2003a). Maintenance of healthy native vegetation is an important way to insure that sediment and particulate retention is maximized.

Table 30. Sediment and other particulate retention correlation to National Wetland Inventory classification within Fort Frederica NM.

NWI Correlation	*Acres*	*% of FOFR Wetlands*
High	162.7	98.64
Not Correlated/Poor	2.2	1.36
	164.9	100.00

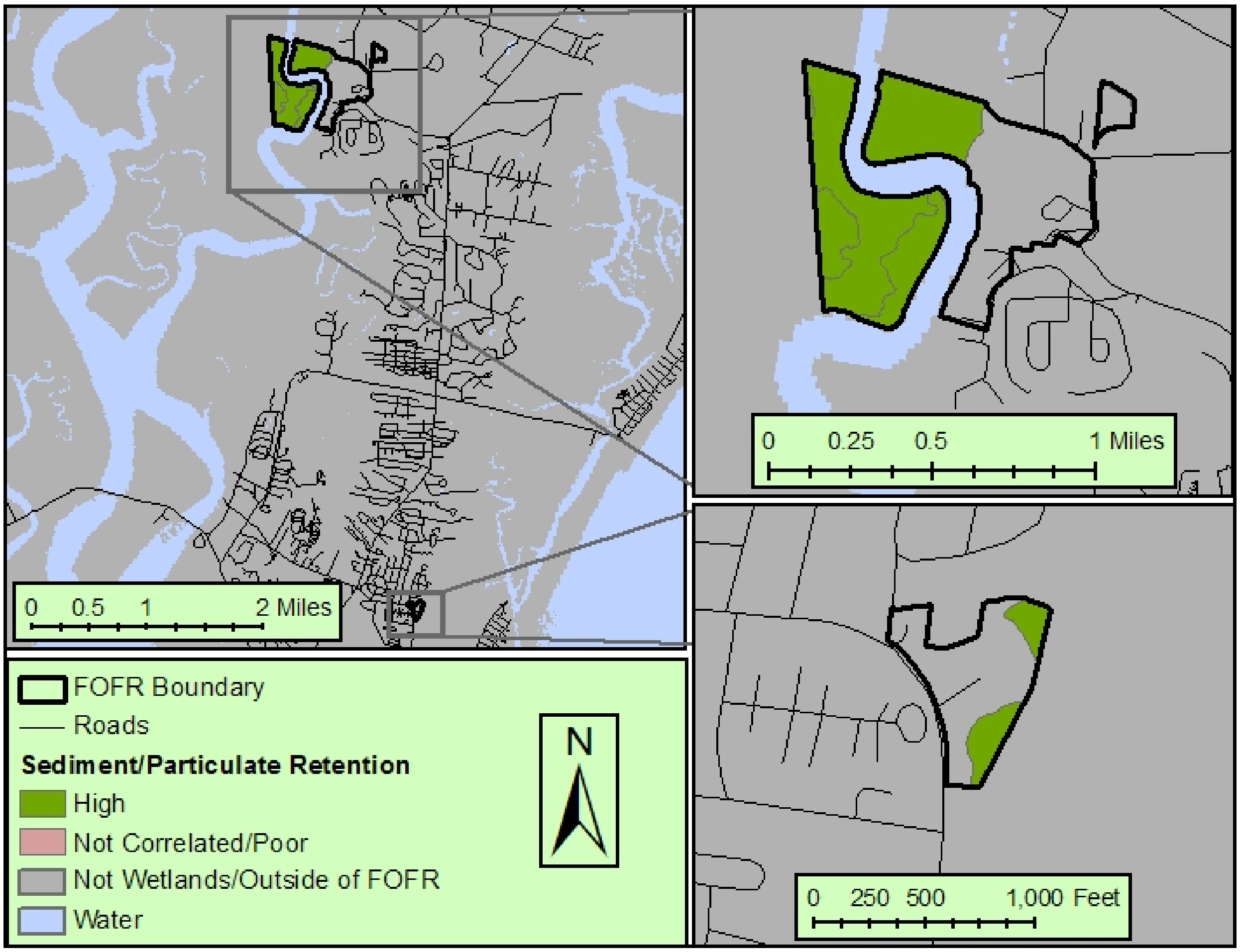

Figure 43. Sediment and other particulate retention correlation to National Wetland Inventory classification within Fort Frederica NM.

Shoreline stabilization:

According to the Fort Frederica General Management Plan (National Park Service 2002), the U.S. Army Corps of Engineers formerly dredged the Frederica River when it was a part of the Intracoastal Waterway. This possibly contributed to riverbank erosion at Fort Frederica NM. Despite some evident erosion, NWI correlation (Tiner 2003a) shows a high level of shoreline stabilization functionality within the wetlands of Fort Frederica NM (Table 31, Figure 44).

Table 31. Shoreline stabilization correlation to National Wetland Inventory classification within Fort Frederica NM.

NWI Correlation	*Acres*	*% of FOFR Wetlands*
High	162.7	98.64
Not Correlated/Poor	2.2	1.36
	164.9	100.00

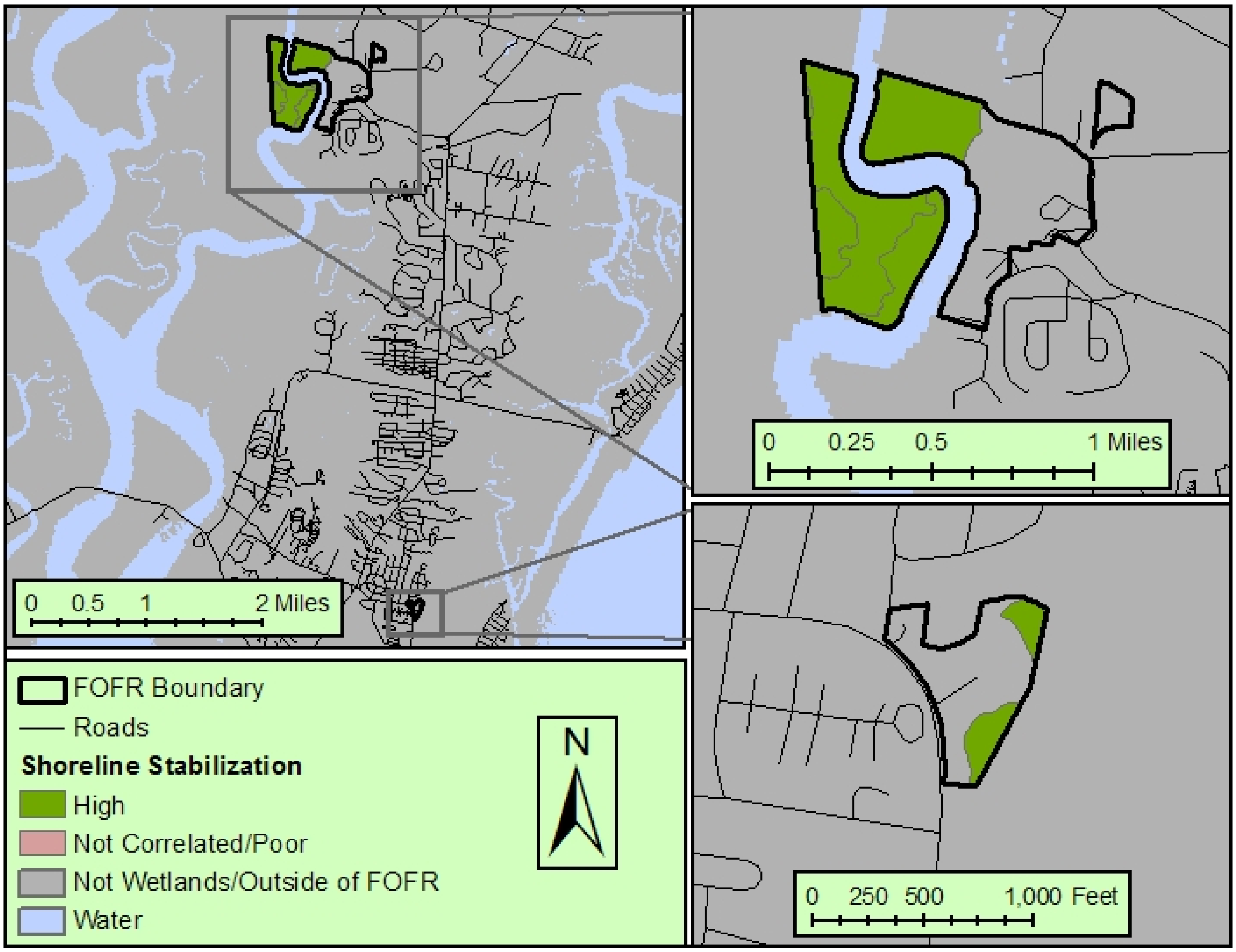

Figure 44. Shoreline stabilization correlation to National Wetland Inventory classification within Fort Frederica NM.

3.4.1.b Resource threats and stressors:

Sea level rise and flooding are a real concern at Fort Frederica NM. A recent study (Craft et al. 2009) showed that salt marshes on the Georgia coast may decline in area by 20 to 40% due to predicted sea level rise in this century. Craft et al. (2009) also predicted that under a mean scenario, tidal freshwater marshes will increase by 2% and under a maximum scenario they will decline by 39%. The mean scenario assumes a 52-cm (1.7-foot) increase in sea level, resulting in an overall 184 km^2 loss of Georgia tidal marsh.

We examined the effect of a 2-foot and 4-foot storm surge or sea-level rise on the land area of Fort Frederica NM (Figure 45). In a 2-foot surge, the area of water increased from 24 to 25 acres, or 8.6% to 8.9% of Fort Frederica NM area. In a 4-foot surge, the area of water increased to 157 acres, putting 56% of Fort Frederica NM under water. The Federal Emergency Management Agency (2008) also shows Fort Frederica NM under the 100-year hazardous flood area (Figure 46).

Other threats and stressors include the potential for oil spills and flooding concerns at the main entrance to the park. It appears that drainage decreased after the church was constructed across the street causing additional flooding at park entrance during heavy rains.

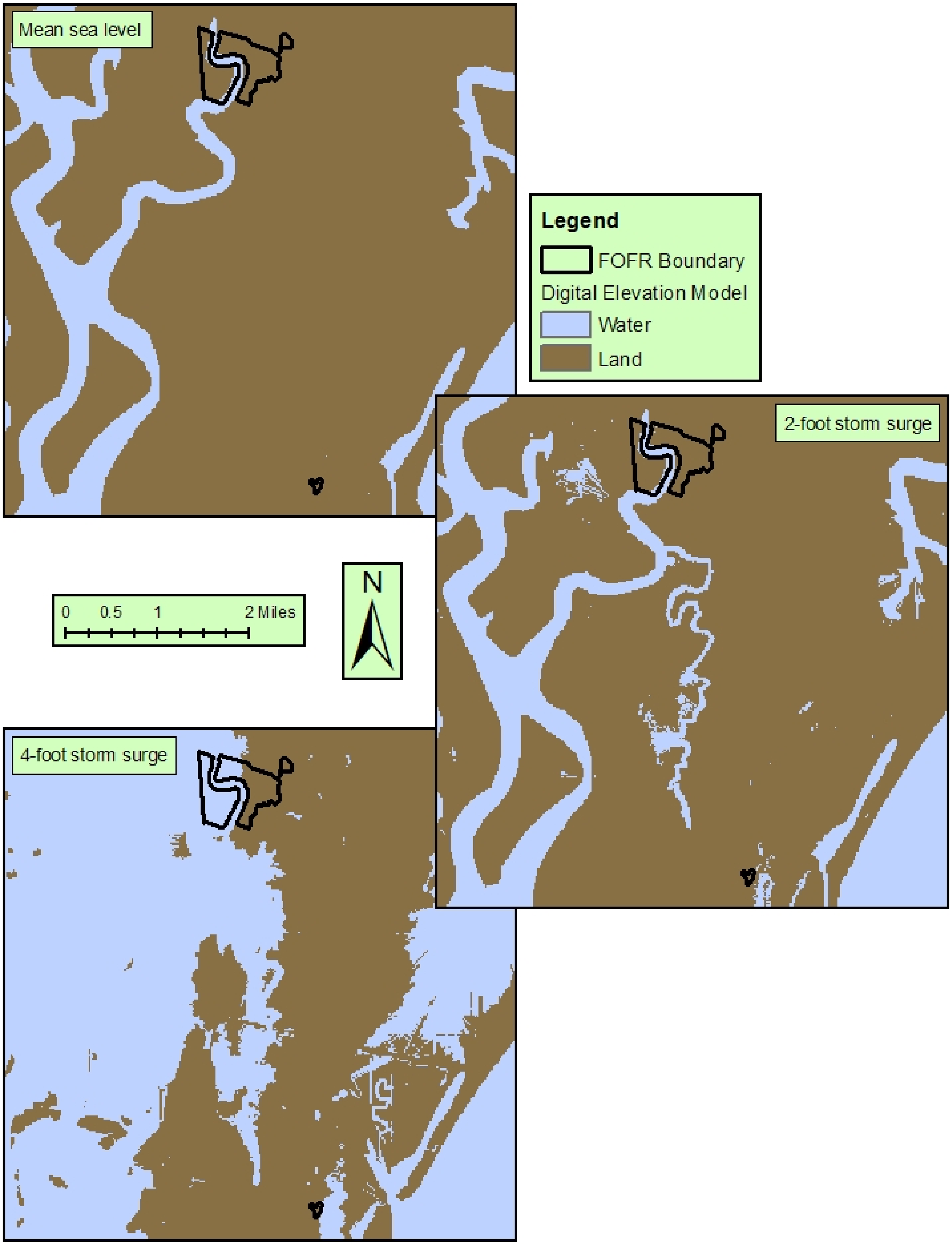

Figure 45. Digital elevation model (DEM) of Fort Frederica National Monument region showing mean sea level, and approximate two foot, and four foot storm surge.

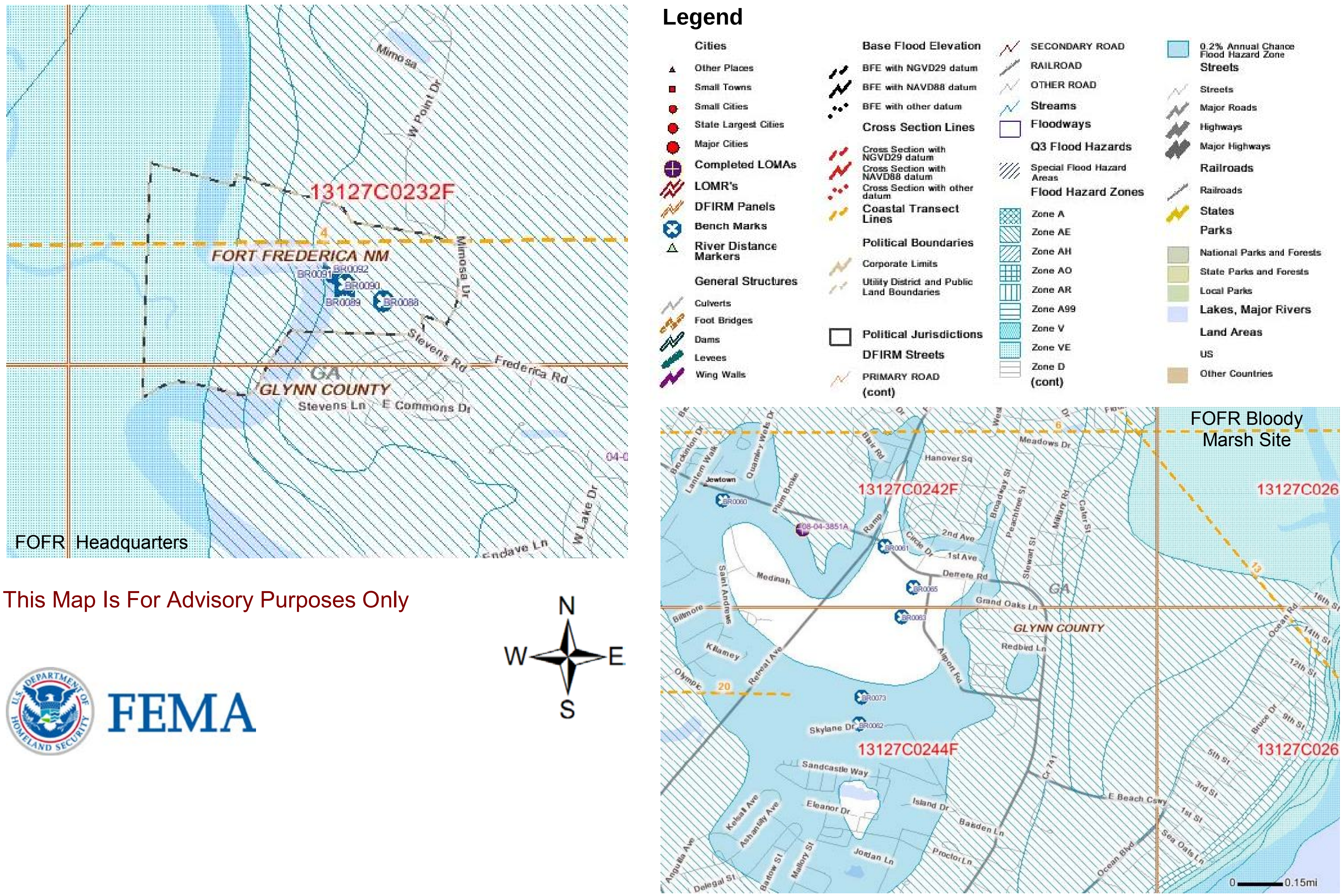

Figure 46. Federal Emergency Management Agency (FEMA, 2008) flood maps for the Fort Frederica National Monument region, showing all areas are under 100-year flood hazard in which base flood elevations have been determined (Zone AE).

3.4.1.c Critical knowledge or data gaps:
Data quality is relatively good for this assessment category (Table 32). Local-scale wetland and hydrology analysis, specific to Fort Frederica NM, would add detail to this assessment. When spatial scale was questionable, we gave thematic a zero for data quality. Table 32 shows the summary of condition status and data quality.

3.4.1.d Condition status summary
Surface water detention, coastal storm surge detention, nutrient transformation, sediment and other particulate retention, and shoreline stabilization are all in the good range because the majority of Fort Frederica NM wetlands were highly rated for these assessment categories (Table 32). The monument wetlands do not offer much in the way of streamflow maintenance so this category is rated poor (Table 32).

Table 32. Hydrology condition status summary for Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), s*patial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Midpoint***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Surface water detention			0	1	1
	Good	0.84	2 out of 3		
Coastal storm surge detention			0	1	1
	Good	0.84	2 out of 3		
Streamflow maintenance			0	1	1
	Poor	0.17	2 out of 3		
Nutrient transformation			0	1	1
	Good	0.84	2 out of 3		
Sediment and other particulate retention			0	1	1
	Good	0.84	2 out of 3		
Shoreline stabilization			0	1	1
	Good	0.84	2 out of 3		
Hydrology total			0	6	6
	Good	0.73	12 out of 18		

3.4.1.e Recommendations to park managers:
We recommend avoiding excavation in the tidal marshes as well as filling and building on the tidal marsh soils. An additional proactive step would be to work with neighbors to avoid future flooding concerns from development pressure.

3.4.2 Water Quality
All of Fort Frederica NM and its surrounding waterways are in the Cumberland-St. Simons, Georgia subbasin, hydrologic unit code (HUC) 03070203. This subbasin is within the Satilla

River basin (the northern portion of HUC 030702, Figure 47). This basin drains a total area of 3,940 square miles (10,205 km^2) (GA DNR Environmental Protection Division 2002).

The Frederica River is the main river that passes through Fort Frederica NM boundaries, separating the salt marsh property to the west. Other nearby rivers and creeks include the MacKay River, Dunbar Creek, Crooked Creek, and Jove Creek (Figure 48). The Frederica River and MacKay River are tidal in nature, join to form St. Simons Sound and separate St. Simons Island from the mainland.

As mentioned previously, we found 170 acres of wetlands within the monument boundaries. According to the General Management Plan (National Park Service 2002), these are at least partially tidal freshwater marshes, inland from salt marshes and mangrove swamps. These wetlands are important globally and support a myriad of aquatic plants and animals.

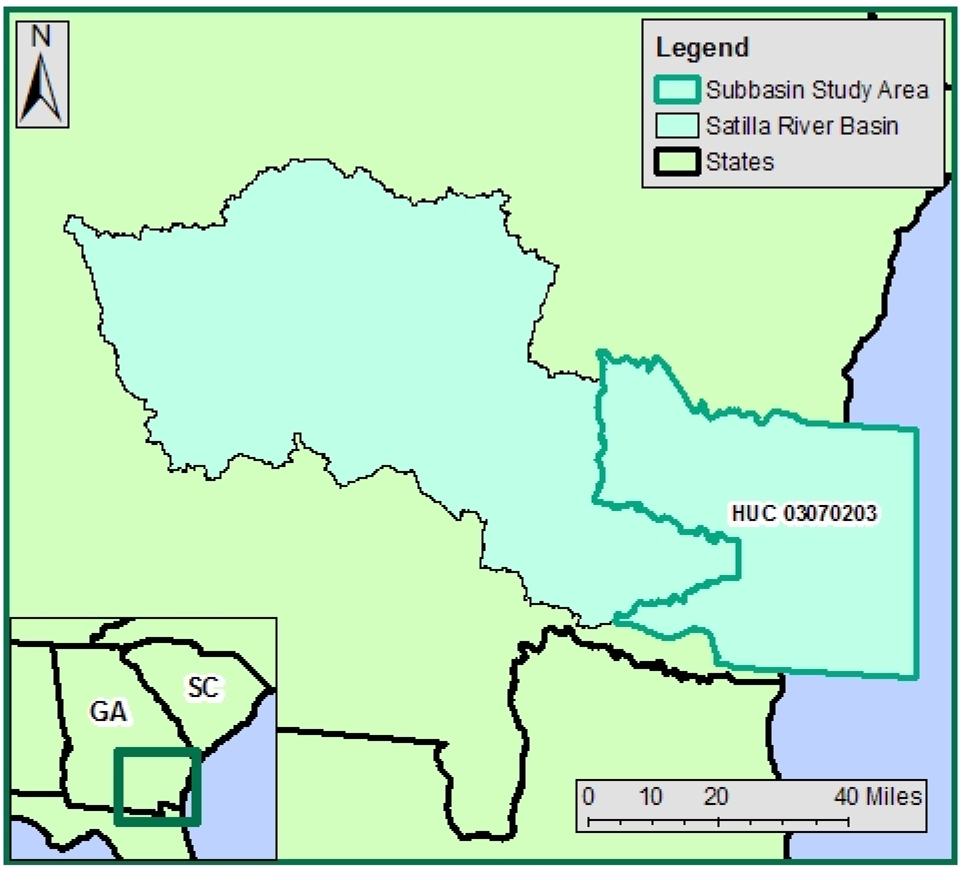

Figure 47. Location of the Satilla River Basin (3,940 square miles) in Georgia.

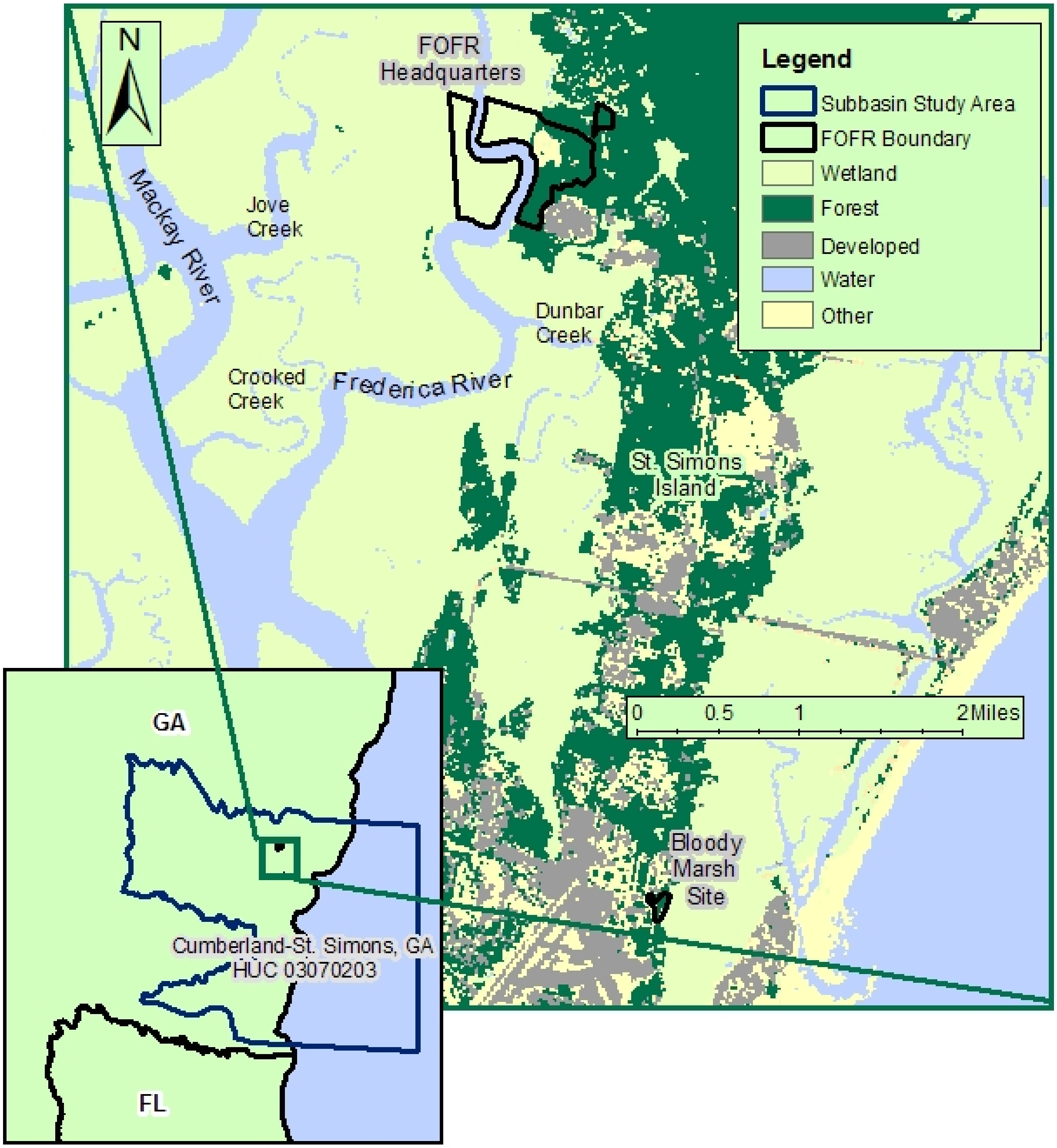

Figure 48. Water resources and hydrologic unit at Fort Frederica National Monument.

3.4.2.a Current condition:

Dissolved oxygen (DO):

Dissolved oxygen (DO) is a relative measure of volume of oxygen, O_2, dissolved in water, and is often measured in mg/l. It is considered relative because temperature, pressure, and salinity, affect the capacity of water to hold oxygen. Both high (i.e. supersaturation) and low DO concentrations can be harmful in aquatic systems, though low DO concentrations are more common. Low DO concentrations may result from excess organic matter in aquatic systems, as aerobic (oxygen-consuming) decomposition breaks down organic material. Low dissolved oxygen levels are most prevalent during the warm summer months when water temperatures rise and mixing of the water column is reduced.

The Georgia Environmental Protection Division (EPD) collected DO data from 7 sites in the subbasin containing Fort Frederica (HUC 3070203) on 6 different occasions between February 24 and May 10, 2005. Dissolved oxygen concentrations ranged from 5.06 to 8.96 mg/l and averaged 7.1 ± 1.2 mg/l. DO concentrations inherently vary by time of day along with the photosynthetic activity of aquatic vegetation, with the lowest DO levels occurring at sunrise. Most samples were taken midday and so likely do not represent daily minimums. One hundred percent of the DO measurements at all sites exceeded the Georgia EPD Water Quality Standard of 4 mg/l, and all averages per site exceeded the minimum daily average standard of 5 mg/l (Table 33, Figure 49). Georgia water quality standards are presented in Table 34. The Georgia DNR Designated Use Classification for the surface waters in and around Fort Frederica NM is "Fishing" (Table 34). All data collected are available through the STORET operational data management system for storage and retrieval of water quality data (U.S. Environmental Protection Agency 2008c).

Table 33. Average Dissolved Oxygen (DO) concentrations (mg/l) per sample site in HUC 03070203 (Figure 49) February 24 – May 10, 2005. Data from STORET (U.S. Environmental Protection Agency 2008c).

Station Name	*Station ID*	*Latitude*	*Longitude*	*DO (mg/l)* $\bar{x}$
Brunswick River - U.S. Highway 17	7005801	31.1164	-81.4858	7.3 ± 1.1
Dunbar Creek - 1.3 miles u/s of creek mouth, St. Simons Island	7120001	31.1905	-81.389397	7.3 ± 2.0
Dupree Creek - Confluence W/ Terry Creek; Brunswick	7006401	31.1642	-81.47	7.2 ± 1.3
Seventeen Mile Creek at State Road 32 near Douglas	7005501	31.1436	-81.4975	7.9 ± 0.3
Turtle River - Georgia Highway 303	7005201	31.1869	-81.5314	7.0 ± 0.8
Turtle River off Hermitage Island	7004001	31.2203	-81.5642	6.8 ± 1.0
Yellow Bluff Creek at U.S. 25	7004501	31.21508	-81.51685	6.0 ± 0.9

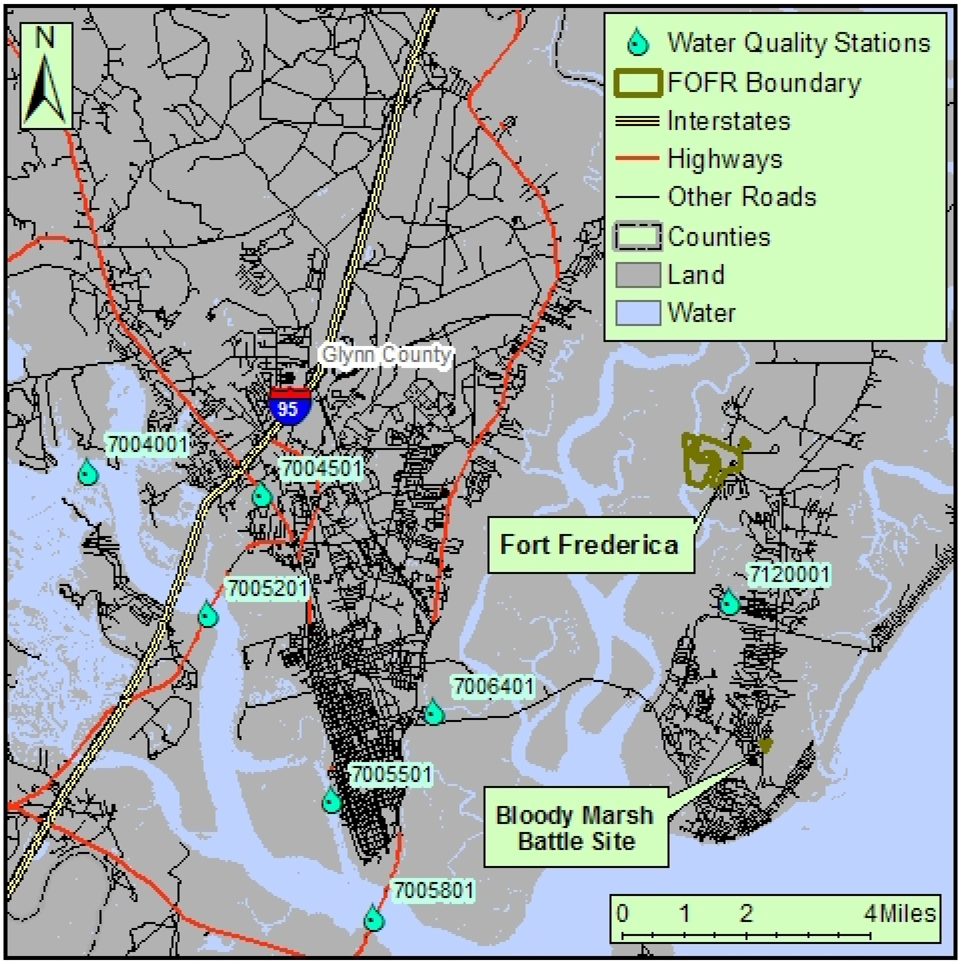

Figure 49. Water quality monitoring stations in the Fort Frederica National Monument region.

Table 34. Water quality standards from Georgia Department of Natural Resources, Environmental Protection Division.

Use Classification	*Bacteria (fecal coliform)*	*Dissolved Oxygen, DO*	*pH*	*Temp*
Drinking Water	May-Oct < 200 colonies/100 ml as geometric mean; Nov-Apr <4000 colonies/100 ml (instantaneous max)	>5 mg/l daily average; Not <4 mg/l at all times	Between 6.0 and 8.5	< 90 F
Recreation	Coastal waters: 100 colonies/100 ml; Other: 200 colonies/100 ml	>5 mg/l daily average; Not <4 mg/l at all times	Between 6.0 and 8.6	< 90 F
Fishing	May-Oct < 500 colonies/100 ml as geometric mean; Nov-Apr <4000 colonies/100 ml (instantaneous max)	>5 mg/l daily average; Not <4 mg/l at all times	Between 6.0 and 8.7	< 90 F
Coastal Fishing	May-Oct < 500 colonies/100ml as geometric mean; Nov-Apr <4000 colonies/100 ml (instantaneous max)	Site Specific	Between 6.0 and 8.8	< 90 F
Wild River	No Alteration of natural WQ			
Scenic River	No Alteration of natural WQ			

Georgia has no nutrient standards, except on a few lakes.

The Satilla River Basin Management Plan (GA DNR Environmental Protection Division 2002) found that the water use classification of fishing was not fully supported in two estuarine areas in HUC 03070203. The 2008 USEPA 305(b)/303(d) listing cites a 10 square mile area of St. Simons Sound due to dissolved oxygen concentrations less than designated use standards. Low dissolved oxygen was attributed to both point and nonpoint sources. Dissolved oxygen may be lower in some of these areas due to natural conditions.

Much work is currently underway to support assessment of compliance with designated use standards for many coastal streams in Glynn County by determining "natural DO" levels. GA EPD's goal is to have assessments completed by the end of 2011 (GA DNR Environmental Protection Division 2008).

Based on these findings, dissolved oxygen concentration does not seem to be a problem affecting water quality in the HUC 03070203 near Fort Frederica NM.

Nutrients:
According to the U.S. EPA, nutrient pollution, especially from nitrogen and phosphorus, has consistently ranked as one of the top causes of water degradation in the U.S. (U.S. Environmental Protection Agency 2008e). Nutrients can lead to an increase the biological oxygen demand (BOD) and therefore lower DO concentrations in water. This process occurs because nutrients stimulate the growth of algae and other aquatic plants, which eventually die. Once dead, this organic material is decomposed by oxygen-consuming processes, resulting in low DO. Nutrients often enter aquatic systems from agricultural runoff, storm water runoff, waste-water treatment plants, and septic systems (U.S. Environmental Protection Agency 2008f).

Georgia has not yet developed water quality standards for nutrients, but the U.S. EPA's National Coastal Condition Report II (U.S. Environmental Protection Agency 2005) does establish some criteria for nutrient levels for U.S. coastal waters (Table 35) and classifies samples as "good," "fair," or "poor," based upon their nutrient concentrations.

Table 35. Water quality assessment criteria for nutrient concentrations as developed for the National Coastal Condition Report II (USEPA 2005). DIN refers to total dissolved inorganic nitrogen. DIP refers to total dissolved inorganic phosphorous.

	Good	*Fair*	*Poor*
DIN	< 0.1 mg N/l	0.1 - 0.5 mg N/l	> 0.5 mg N/l
DIP	< 0.01 mg P/l	0.01 - 0.05 mg P/l	> 0.05 mg P/l

GA EPD tested samples gathered at 4 different sites in HUC 3070203 for nitrogen concentrations from February 2001 through December 2004. Comparison to the USEPA 2005 criteria (Table 35) shows that 36% of the 278 samples tested would fall into the good range, while 64% would be considered fair, and none would be poor (Table 36).

Table 36. Nitrogen (N) concentrations from GA EPD samples collected in HUC 3070203 (Figure 49) February 2001-December 2004 grouped by USEPA (2005) assessment standards. Data from STORET (U.S. Environmental Protection Agency 2008c).

Station Name	*Station ID*	*N*	*Value <0.1 mg/L*	*Value 0.1-0.5 mg/L*	*Value >0.5 mg/L*
Brunswick River - U.S. Highway 17	7005801	90	53%	47%	0%
Turtle River - Georgia Highway 303	7005201	90	24%	76%	0%
Turtle River off Hermitage Island	7004001	90	27%	73%	0%
Yellow Bluff Creek at U.S. 25	7004501	8	75%	25%	0%
TOTAL:		278	36%	64%	0%

However, nitrogen exists in water in many forms, including inorganic, organic, dissolved and particulate. Dissolved inorganic nitrogen (DIN) often refers to the sum of nitrate, nitrite, and ammonium concentrations in a water sample (Dodds 2002). GA EPD data for HUC 3070203 documents nitrogen levels in terms of "Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N", but do not specify the sample fraction as "total" or "dissolved" nor specifically identify data as a measure of DIN. Therefore, more information is needed before conclusive assessment of these data can be made.

Samples were also collected at those same 4 sites and analyzed to establish phosphorus concentrations between February 2001 and August 2004. Comparison to the USEPA 2005 standards (Table 35) shows that more than 99% of the 248 samples tested would fall into the poor range (Table 37).

Table 37. Phosphorus (P) concentrations from GA EPD samples collected in HUC 3070203 (Figure 49), February 2001-August 2004, grouped by USEPA (2005) assessment standards. Data from STORET (U.S. Environmental Protection Agency 2008c).

Station Name	*Station ID*	*n*	*Value <0.01 mg/L*	*Value 0.01-0.05 mg/L*	*Value >0.05 mg/L*
Brunswick River - U.S. Highway 17	7005801	80	0%	0.8%	99%
Turtle River - Georgia Highway 303	7005201	80	0%	0%	100%
Turtle River off Hermitage Island	7004001	80	0%	0%	100%
Yellow Bluff Creek at U.S. 25	7004501	8	0%	0%	100%
TOTAL:		248	0%	0.8%	99%

Excess phosphorus levels in surface water can lead to the process of eutrophication, when increased nutrient concentrations promote excessive algal/plant growth and decay that can cause lack of oxygen and severe reductions in water quality, fish, and other animal populations.

However the samples reflected in GA EPD STORET data for phosphorus were analyzed in terms of Total Phosphorus (P) and the USEPA 2005 standard in Table 35 is based on Dissolved Inorganic Phosphorus (DIP) so application of the standard to these data is in question. Total phosphorous is a measure of all phosphorus present in a sample regardless of form, and DIP is a measure of phosphorus in a sample after being filtered through a 0.45 micron filter (U.S. Environmental Protection Agency 1983). This means that these total phosphorus values may or may not be higher than they would be in terms of DIP.

In December 2000, the USEPA published a guide that presents EPA's nutrient criteria for Rivers and Streams in Nutrient Ecoregion XIV (includes coastal Georgia) as a means to support compliance with water quality standards consistent with section 303(c) of the Clean Water Act (CWA). Nutrient criteria for reference stream conditions are given as a means to compare observed conditions with conditions of surface waters that are ideal, or minimally impacted by human activities. These reference criteria are provided in terms of Total Phosphorus (P) specific to conditions in the Eastern Coastal Plain in aggregate (P = 0.031 mg/L), and a range of reference conditions specific to the Middle Atlantic Coastal Plain (P = 0.007 – 0.053). Total phosphorus data reflected in Table 37 range from 0.04 – 0.22 mg/L, meaning that 0% of the data meet the aggregate reference condition and >99% exceed the upper limit of the specific reference range, suggesting that phosphorus levels as indicated by these data may pose a potential problem in HUC 3070203.

Bacterial contamination (fecal coliform):
Fecal coliform bacteria contamination is the most common form of bacterial contamination in many water bodies. Its presence in aquatic environments is a human health hazard and may indicate the presence of other dangerous pathogens as well. Fecal coliform bacteria often enter waterways through the direct discharge of untreated (or insufficiently treated) human waste and agricultural and municipal runoff.

There are 3 major municipal wastewater treatment facilities permitted to discharge more than one million gallons per day or greater in HUC 3070203: Brunswick Academy discharging into Academy Creek, Jekyll WPCP discharging into Jekyll River, and on Saint Simons Island itself discharging into Dunbar Creek. No discharge violations were reported from January 2001 through January 2005 (GA DNR Environmental Protection Division 2006).

Georgia water quality standards require that fecal coliform levels be established based on the geometric mean of no less than four samples collected within 30 days and not less than 24 hours apart. Of the EPA STORET data for sample points in Fort Frederica's subbasin that met these criteria (Sept 2001-December 2003) all locations fell well below the most stringent standard of 100 colonies/100ml (Table 38).

Where samples are not adequate to calculate geometric means, the USEPA's Listing Guidance can be used to assess bacterial data. Water bodies are determined not to be supporting designated use if more than 10% of the single samples exceeded the USEPA's recommended review criteria for bacteria of 400/100ml during the months of May through October, and 4,000/100ml during the months of November through April (GA DNR 2008). Since these data are not in terms of geometric mean they cannot be used to assess compliance with GA State Water Quality Standards but can be used to determine if a water body is meeting its EPA 305(b)/303(d) designated use standards. 100% of the EPA STORET data for sample points in Fort Frederica's subbasin (February 2001 – June 2004) fell well below the review criteria (Table 39). No data exceeded the 4000 colonies/100ml instantaneous maximum standard.

Table 38. Georgia Environmental Protection Division water quality data with calculated geometric mean for fecal coliform in HUC 3070203, Glynn County, GA (Figure 49). Data from STORET (U.S. Environmental Protection Agency 2008c).

Station Name	*Station ID*	*Geometric Mean (MPN*)*	*Date*
Brunswick River - U.S. Highway 17	7005801	9.21	Sept/Oct 2001
		1.95	Jan 2002
		0.90	July 2002
		2.32	Oct 2002
		1.95	Mar 2003
		0.90	June 2003
		2.32	Sept 2003
		0.90	Dec 2003
Turtle River - Georgia Highway 303	7005201	1.95	Feb/Mar 2001
		13.03	June 2001
		4.24	Sept/Oct 2001
		5.70	Jan 2002
		0.90	July 2002
		5.05	Oct 2002
		5.33	Mar 2003
		1.95	June 2003
		4.24	Sept 2003
		0.90	Dec 2003
Turtle River off Hermitage Island	7004001	4.24	Sept/Oct 2001
		4.24	Jan 2002
		0.90	July 2002
		0.90	Oct 2002
		20.12	Mar 2003
		4.70	Sept 2003
		1.95	Dec 2003

* MPN=Most Probable Number

Table 39. Water quality data for fecal coliform in HUC 3070203, Glynn County, GA for which geometric mean could not be calculated. Data from STORET (U.S. Environmental Protection Agency 2008c).

Station Name	*Station ID*	*Latitude*	*Longitude*	*# of samples*	*% MPN >400/100ml*	*Date*
4H Camp (Jekyll)[1]	JIS	31.01419	-81.424	52	0	Jan 2003
				38	2.6	Jan 2004
5th St. Crossover (SSI)[1]	SIF	31.13572	-81.384977	22	4.5	Apr 2004
Blythe Island Regional Park Sandbar[1]	BIRP	31.1524167	-81.5612667	5	0	Apr 2004
Brunswick River - U.S. Highway 17[2]	7005801	31.1164	-81.4858	7	0	Feb-Aug 2001
				4	0	Apr/Dec 2002
				7	0	Apr/June 2004
Capt. Wylly (Jekyll) near Beachview[1]	JIWY	31.063161	-81.404438	23	4.3	Apr 2004
Convention Center (Jekyll)[1]	JIM	31.0486492	-81.408999	52	1.9	Jan 2003
				38	5.3	Jan 2004
East Beach Old Coast Guard (SSI)[1]	SIM	31.1439947	-81.3700082	53	1.9	Jan 2003
				36	2.8	Jan 2004
Jekyll North at Dexter Lane[1]	JIN	31.07717	-81.401755	52	1.9	Jan 2003
				36	2.7	Jan 2004
Massengale (SSI)[1]	SIMA	31.140415	-81.3766692	35	2.9	May 2003
				36	0	Jan 2004
Pelican Spit (off Sea Island)[1]	PSPT	31.2103667	-81.2976	5	0	Apr 2004
Sea Island North[1]	SEN	31.19763	-81.3297718	52	1.9	Jan 2003
				19	5.3	Jan 2004
Sea Island South[1]	SES	31.1811385	-81.3449922	52	1.9	Jan 2003
				19	0	Jan 2004
South Dunes (Jekyll)[1]	JISD	31.0318	-81.41495	24	4.2	Apr 2004
St. Andrews Picnic Area (Jekyll)[1]	JISA	31.021	-81.4349	35	5.7	May 2003
				45	13.3	Jan 2004
St. Simons Island Lighthouse[1]	SIS	31.1334738	-81.3937063	52	0	Jan 2003
				35	2.9	Jan 2004
Turtle River - Georgia Highway 303[2]	7005201	31.1869	-81.5314	7	0	Apr/June 2004
Turtle River off Hermitage Island[2]	700401	31.2203	-81.5642	7	0	Feb-Aug 2001
Turtle River off Hermitage Island[2]	700401	31.2203	-81.5642	4	0	June 2003
Turtle River off Hermitage Island[2]	700401	31.2203	-81.5642	7	0	Apr/June 2004
Twelfth St. Goulds Inlet[2]	SIN	31.1520055	-81.3658548	52	5.8	Jan 2003
				35	2.9	Jan 2004

[1]Georgia Coastal Resources Division (datum NAD 83)

[2]Georgia Environmental Protection Division (datum unknown)

In January 2006, the state of Georgia identified eighteen (18) stream segments located in the Satilla River Basin as having limited water quality due to fecal coliform. However, none of those occurred in HUC 3070203 where Fort Frederica is located (GA DNR Environmental Protection Division 2006). In 2008, the GA EPD Integrated 305(b)/303(d) List reports fecal coliform levels in excess of the fishing use standard for a 5 mile stretch of the Brunswick River citing non-point/unknown sources and urban runoff/urban effects (GA DNR Environmental Protection Division 2008).

The presence/abundance of enterococci bacteria are often used in water quality assessment of marine waters as an indicator of human pathogens. The risk to swimmers of contracting gastrointestinal illness seems to be predicted better by enterococci than by fecal coliform bacteria, since the die-off rate of fecal coliform bacteria is much greater than the enterococci die-off rate (U.S. Environmental Protection Agency 2001). The GA EPD (2008) 305(b)/303(d) list reports 4 coastal beaches in Glynn County as not supporting their designated uses due to the enterococci bacteria levels in excess of standard criterion (Table 40, Figure 50).

Table 40. Beaches in Glynn County, GA reported with enterococci levels in excess of standards required to support their designated uses (GA DNR Environmental Protection Division 2008).

Reach Name [Data Source]	*Reach Location*	*Use*	*Extent (miles)*
Blythe Island Sandbar Beach [5]	South Brunswick River from Hwy 303 Bridge to Blythe Island Regional Park	fishing	0.9
Jekyll Island-Clam Creek Beach [5]	Clam Creek to Old North Picnic Area	fishing	1.9
Jekyll Island-St. Andrews Beach [5]	Macy Lane to St. Andrews Picnic Area	fishing	0.8
Saint Simons Island-North Beach at Goulds Inlet [5]	St. Simons Island 15th Street to 10th Street (East Beach Area)	recreation	0.4

Based on available information, bacterial contamination does not seem to be a problem affecting water quality in and around Fort Frederica NM, but may be of concern in isolated areas in the HUC 3070203 subbasin and elsewhere within the Satilla watershed.

Contaminants:
Contaminants are substances such as metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides. One hundred twenty six of these "toxic pollutants" are listed in the Clean Water Act as Priority Pollutants. These substances enter waterways through storm water runoff, industrial discharges, agricultural runoff, sewage treatment and atmospheric deposition. Once present in aquatic systems, they may concentrate in sediment and bottom-dwelling organisms. Many of these substances pose a risk to human health and aquatic systems.

In general, data on priority pollutants/organic chemicals and metals from any one given site are infrequent owing to the specific sampling techniques required. EPA STORET data for Fort Frederica's watershed does not list such data.

Georgia's 2008 305(b)/303(d) list reports contaminants in excess of designated use standards for fishing in 8 coastal streams/rivers in Glynn County (Table 41, Figure 50).

Table 41. Coastal streams/rivers in Glynn County, GA reported with contaminants in excess of designated use standards by GA EPD (2008)

Reach Name [Data Source]	Reach Location	Criterion Violated	Potential Causes	Extent (miles)
Back River [1,9]	1 mile above confluence with Terry Creek to Torras Causeway, Brunswick	SB, FCG (toxaphene like chlorinated camphenes)	I1, I2	1
Gibson Creek [1,5]	Brunswick	PCBs, Hg, SB, FCG (PCBs)	I2	2
Purvis Creek [1,5]	Brunswick	Hg, Cd, PCBs, CFB, SB, FCG (PCBs)	I1,I2	2
Terry and Dupree Creeks [1,3,5,9,55]	Terry and Dupree Creeks North of Torras Causeway to confluence with Back River, Brunswick	SB, FCG (toxaphene like chlorinated camphenes), DO	I1,I2,NP	3
Terry Creek [1,5]	South of Torres Causeway to Lanier Basin, Brunswick	SB, FCG (PCBs)	I1,I2	1
Turtle River System [1,55]	Brunswick: Turtle River, Buffalo River, and South Brunswick River	SB, FCG (PCBs), DO	I1,M	21

Criterion Violated	Potential Causes
DO = Dissolved Oxygen	NP = Non-point/Unknown Source
FC = Fecal Coliform Bacteria	I1 = Industrial Facility Point source
SB = Shellfishing ban	I2 = Industrial Facility Non-point source
FCG = Fish Consumption Guidance	UR = Urban Runoff/Urban Effects
PCB	M = Municipal Facility
Hg = Mercury	
Cd = Cadmium	
CFB = Commercial Fishing Ban	

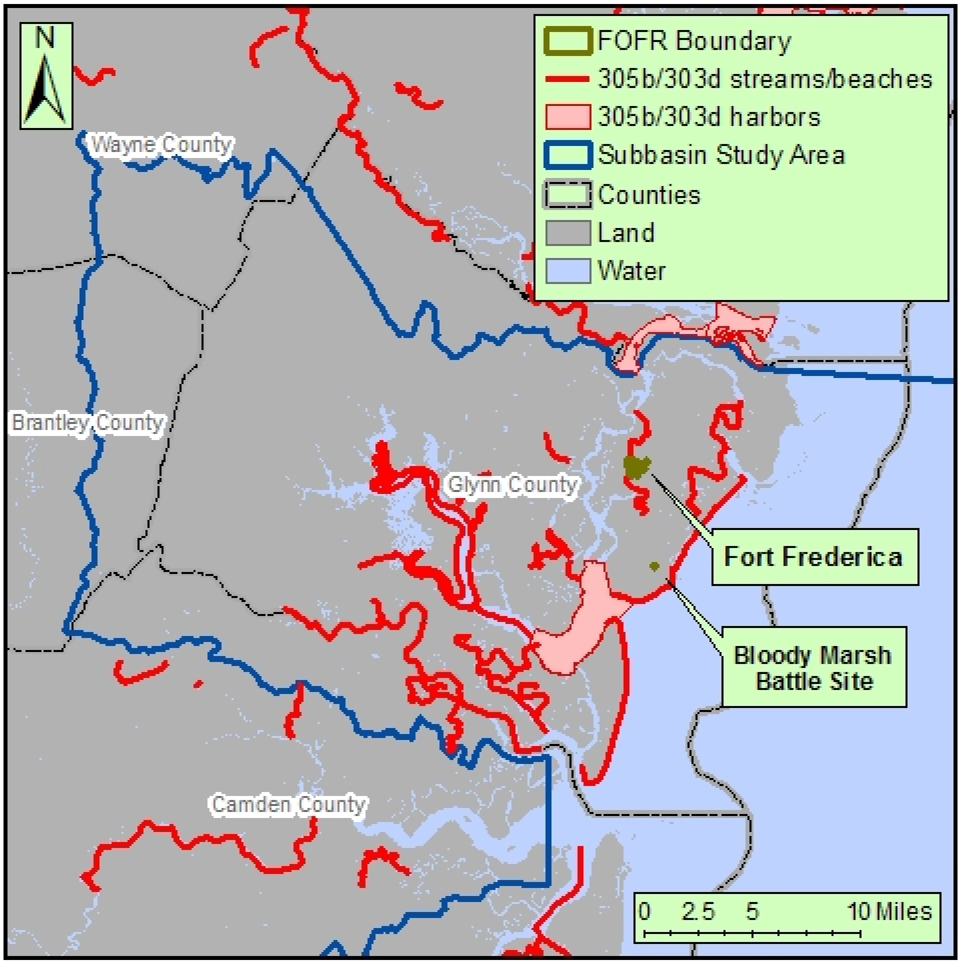

Figure 50. Streams/rivers/beaches and harbors/sounds in Glynn County and subbasin study area listed as 305b/303d by GA EPD (2008).

Conclusions about the effect of contaminants on water quality at Fort Frederica NM are difficult to make based on available information. GA EPD has documented the presence of toxic pollutants in adjacent water systems, many attributed to nonpoint sources. Many of the problems appear to be downstream of the monument and may be associated with the population centers at Brunswick. However, since it is very difficult to identify specific input locations (i.e. industrial, urban, agricultural sources) it is reasonable to presume that water systems in and around Fort Frederica are subject to at least some of the same influences.

3.4.2.b Resource threats and stressors:
Water quality at Fort Frederica NM is largely the result of influences from both point and nonpoint sources that originate outside its 282-acre boundary. Point source pollution originates from a single point or location, such as wastewater treatment plants and industrial outflows. Within the Satilla River basin and Glynn County there are numerous point sources of pollutants, including hazardous waste sites and an EPA regulated wastewater discharge site on Saint Simons Island. For a current list of EPA regulated point source sites refer to the EPA's Envirofacts Warehouse, http://www.epa.gov/enviro/index.html.

Nonpoint source pollution is any contaminant that that does not originate from a point source. In the Satilla River basin, nonpoint sources include urban (i.e. storm water runoff) and agricultural runoff. Runoff often contains the same pollutants as point source discharges. However, since nonpoint sources of pollution do not come from any specific location, they are typically harder to control and pose more complex management challenges.

At least once a year GA EPD publishes the Hazardous Site Inventory (HSI). The HSI is a list of sites in Georgia where there has been a known or suspected release of a regulated substance above a reportable quantity and which have yet to show they meet state clean-up standards found in the Rules for Hazardous Site Response. The July 2008 report shows that there are 16 such sites in the region around Fort Frederica NM (Figure 51). Additional information regarding the Hazardous Sites Response Program, the Rules for Hazardous Site Response and an electronic version of the HSI can be found on the GA EPD web site at http://www.gaepd.org/Documents/hazsiteinv.html. Information about sites listed on the HSI is available by contacting the Hazardous Sites Response Program at (404) 657-8600.

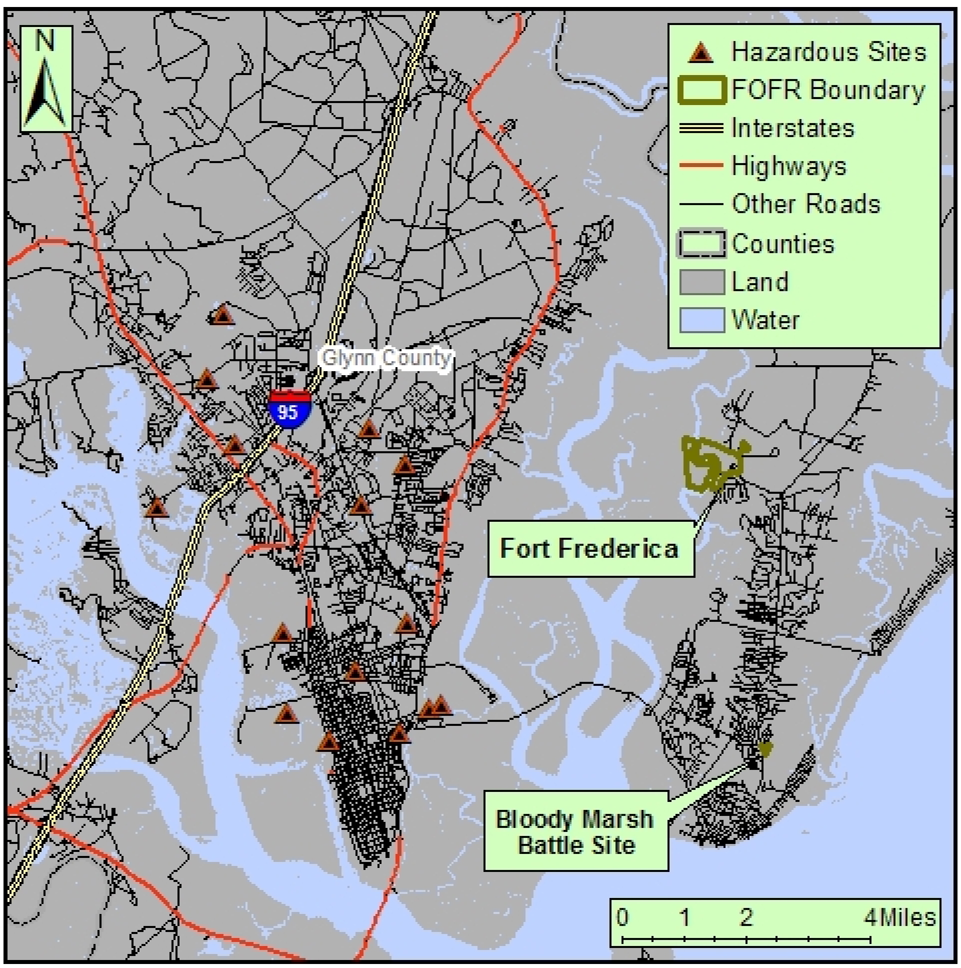

Figure 51. Hazardous sites in Glynn County, surrounding Fort Frederica National Monument. These sites are recorded by the Georgia Environmental Protection Division (EPD) and have released or are suspected to have released a regulated substance without a state sanctioned clean-up procedure.

Silvicultural operations are also sources of potential stressors, particularly excess sediment loads to streams. These risks, however, can be minimized by adherence to Best Management Practices (BMPs). The Georgia Forestry Commission (GFC) conducts statewide BMP implementation surveys to determine to what extent forestry BMPs are being implemented and assess their effectiveness in minimizing erosion. In a 1998 survey, the GFC evaluated 30 sites (4,381 acres) within the Satilla River Basin and found that overall, the percentage of applicable BMPs implemented was 92 percent and the percentage of acres in compliance with BMPs was 99.8 percent. According to the Water Quality in Georgia 1998 Report, no streams were identified in the Satilla Basin as impacted due to commercial forestry activities (GA DNR Environmental Protection Division 2002).

An additional and emerging stressor to water quality in and around Fort Frederica NM comes from increasing development pressure in the area (in the Human Effects section see 3.2.1.b Resource threats and stressors:). This changing land use upstream of monument boundaries has the potential to locally impact water quality from increased sediment loads from development activities to long-term increased inputs from septic systems, greater proportion of impervious surfaces, and associated urban runoff.

3.4.2.c Critical knowledge or data gaps:

The quality of this assessment of the water resource on Fort Frederica NM is diminished by exclusive reliance on data gathered from outside monument boundaries (Table 42). Available data can give some insight into water quality conditions in HUC 3070203 as a whole, but it is not clear as to what extent those conditions are reflected on a local scale. In some cases the data available is not easily evaluated against state standards. Reliance on data from external sources also influences its temporal value, in that current conditions may or may not be reflected in older data.

3.4.2.d Condition status summary

Available data do not indicate water quality problems due to low dissolved oxygen levels. Dissolved oxygen concentrations in the samples collected in HUC 03070203 well exceed GA EPD minimum standards, putting dissolved oxygen in the good condition status range (Table 42). The nutrients category fell between the fair and poor range because nitrogen is fair and phosphorus is poor (Table 42). While nutrient levels for nitrogen fall midrange in the standards, conclusions here are not as clear due to potential incompatibility of the data as it applies to the standard. Phosphorus levels appear to fall well outside the recommended range, suggesting that phosphorus nutrient levels are too high in parts of the subbasin. This gave phosphorus a poor condition status. All measures of fecal coliform levels were found to be well below review criteria, thus placing it in the good range (Table 42). Fecal coliform may, however, be of concern in isolated areas in the subbasin. There is no data available for pollutant contaminants at Fort Frederica NM but documented problems have been attributed to nonpoint sources in the area, thus giving contaminants a fair condition status (Table 42).

Table 42. Water quality condition status summary within Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), *spatial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Midpoint***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Dissolved oxygen			1	0	0
	Good	0.84	1 out of 3		
Nutrients (N/P)			1	0	0
	Fair/Poor	0.34	1 out of 3		
Fecal coliform bacteria			1	0	0
	Good	0.84	1 out of 3		
Contaminants			1	0	1
	Fair	0.5	2 out of 3		
Water quality total			4	0	1
	Fair	0.63	5 out of 12		

3.3.2.e Recommendations to park managers:
We highlight the water quality specific recommendations in Table 43.

Table 43. Recommendations to improve water quality and monitoring at Fort Frederica National Monument.

1.	Work towards improved regional cooperation
2.	Initiate regular water quality monitoring at Fort Frederica NM
3.	Collect additional water quality information
4.	Improve access to state and federal water quality data and improved metadata

3.5 Geology and Soils

3.5.1 Geology and Soils

As outlined in 2.0 Park and Resources section of this report, the Coastal Plain region is composed of undeformed sedimentary rock layers whose ages range from the Late Cretaceous to the present Holocene sediments of the coast. Beneath Coastal Plain sediments are harder igneous and metamorphic rocks, such as those found in the Piedmont. Usually referred to as the "basement," these hard rocks occur at greater and greater depths toward the south and east, reaching depths of up to 10,000 feet or more beneath the modern Georgia coast (Frazier 2007). Sediment from the upper Piedmont region eroded into the Coastal Plain over the past 100 million years. In addition to recent alluvium, organic and marine deposits make up some of the sediment found in the Coastal Plain (UGA Department of Geology 2008). Human-dredged and deposited sediments are abundant along the coastlines. Specifically, the coastal region at Fort Frederica NM is a Pleistocene-aged marine barrier island deposit and a Holocene-aged deposit of marine and organic tidal marsh (Figure 52).

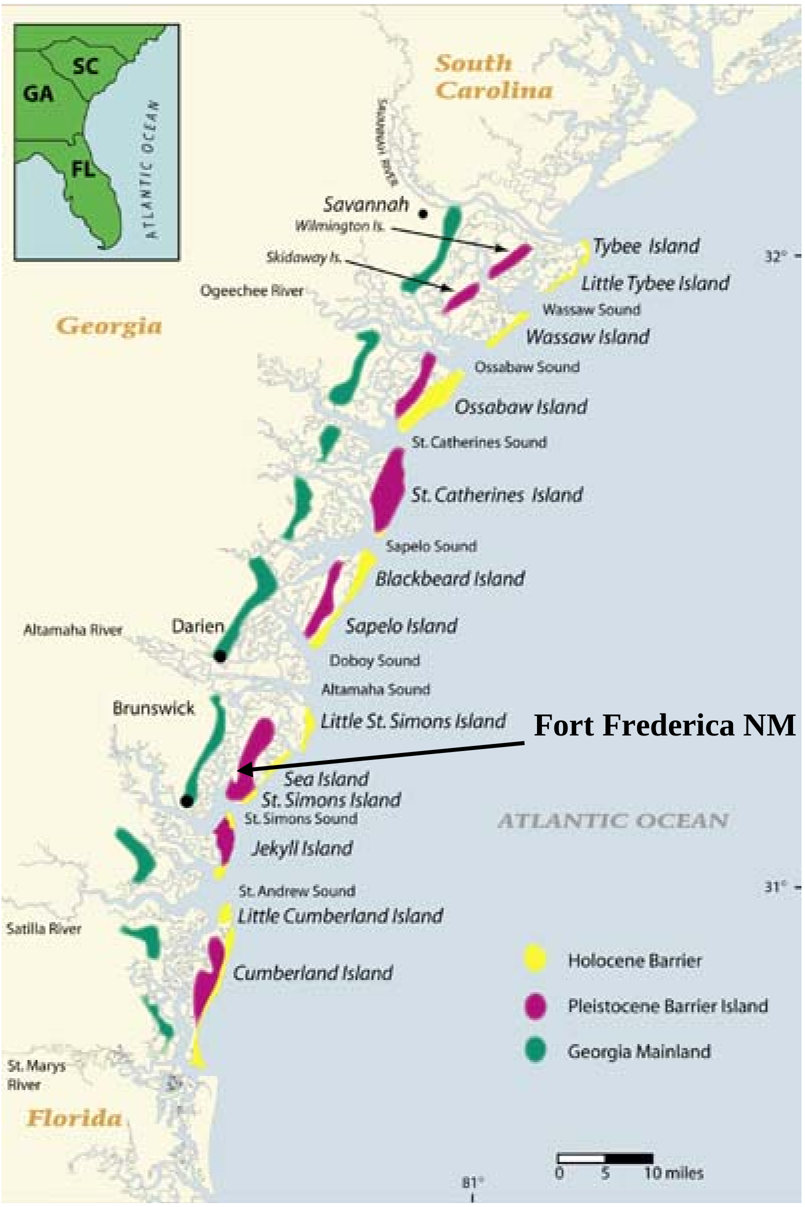

Figure 52. Lower Coastal Plain Map, with arrow showing the location of Fort Frederica National Monument, at the edge of organic tidal flats and a Pleistocene-aged barrier island. The Lower Coastal Plain extends for sixty-five to seventy miles between the Savannah and St. Marys Rivers and contains the remains of older and higher shorelines and dunes west of the present coast. Courtesy of V. J. Henry (Seabrook 2006).

The eastern part of Fort Frederica NM is on Saint Simons Island, a large, natural barrier island that is covered by native vegetation. The majority is in woodland, with some open areas where old roadbeds, a power line right-of-way, and foundations are found. The western half of the National Monument is located in a tidal marsh (Figure 53).

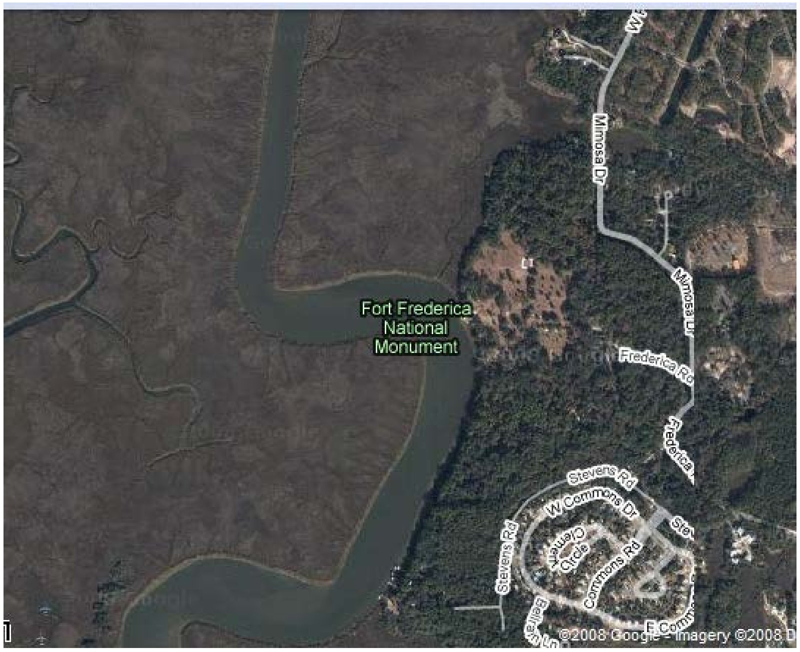

Figure 53. A satellite view of Fort Frederica National Monument, Glynn County, Georgia (Google 2008).

3.5.1.a Current condition:
We compared a 1911 soil survey (Table 44, Figure 54) to the current soil data from the Soil Survey Geographic Data Base (SSURGO, Table 45, Figure 55) to see what changes had occurred. The SSURGO soil data have a version date of December 27, 2006 and are available in GIS format (USDA Natural Resource Conservation Service 2006). Current SSURGO data were compiled by the National Park Service but there was a change in the boundary to Fort Frederica NM since these data were published, so we used the original soil survey from the USDA Natural Resource Conservation Service (2006). The 1911 soil survey by the U.S. Department of Agriculture was obtained from an on-line collection at University of Alabama (USDA Bureau of Soils 1911). The 1911 soil data were aligned to digital raster graphics (DRG) topographic maps, using the georeferencing tools in ArcGIS (ESRI 2006). We surveyed Brunswick East, Sea Island, Darien, and Altamaha Sound 1:24,000 topographic maps that made up Fort Frederica NM or were in close proximity to the boundary. Published data was also used along with photo interpretation to assess both current soil resources and changes.

The soil survey program was near its inception in 1911. The 1911 soil data were obtained by reconnaissance survey methods using a limited set of soil series choices. The “Leon fine sand” that made up about 35% of the area in the 1911 survey is a poorly drained soils found on low-lying flats in the Atlantic Coastal Plain (Figure 54). When found in depressional areas, it is very poorly drained. The Leon series is sandy throughout and contains a black subsoil accumulation of organic carbon-aluminum compounds. Leon does not occur on the 2006 soil survey (Figure 55). Instead, the same areas mapped as Leon in the northern part of the national monument are now separated into Pelham, Pottsburg, and Rutlege soils. “Pelham loamy sands” are poorly drained and have a sandy surface over a loamy subsoil with clay accumulation. “Pottsburg sands” are somewhat poorly or poorly drained and have a thick sandy surface over a black subsoil accumulation of organic carbon-aluminum compounds. The Pottsburg soils have a sandy surface more than 30 inches thick, while the Leon soils have a sandy surface less than 30 inches thick. The soils are otherwise similar. “Rutlege fine sands” are very poorly drained and have a thick dark surface high in organic carbon with a sandy subsurface. Rutlege soils do not have a developed subsoil horizon like Leon, Pelham, or Pottsburg. “Cainhoy fine sands” are somewhat excessively drained deep sandy soils with a deep subsoil accumulation of organic carbon-aluminum compounds. The Cainhoy soils are similar to Pottsburg soils but are better drained. The four soil series that replace the Leon soils were all established after the 1911 soil survey was completed. In the southern part of the national monument, part of the Leon soil was remapped to “Mandarin fine sand” and part to “Rutlege fine sand”. Mandarin soils are very similar to Leon soils except they are somewhat poorly drained rather than poorly drained. Mandarin was established after the 1911 soil survey. The change in soil mapping is due to closer inspection of the soils in the newer survey with additional choices of soil series for the soil mappers.

The “Norfolk fine sand” that made up about 35% of the area in the 1911 survey consists of well drained soils on sloping uplands. Norfolk soils have a loamy subsoil with clay accumulation. The clays are dominantly low-activity clays that are inherently infertile and have low capacity to absorb nutrients. Norfolk soils are now mapped further inland on higher, older, more highly weathered parts of the Coastal Plain. Areas mapped in the northern part of the monument in 1911 as Norfolk are now mapped as “Cainhoy fine sands”. Cainhoy soils are somewhat excessively drained deep sandy soils with no subsoil accumulation of clay but with a deep subsoil accumulation of organic carbon-aluminum compounds. Cainhoy soils were established after the 1911 survey. In the southern part of the monument, the Norfolk soils are now mapped as Mandarin soils. The change in soil series must be due to inaccurate mapping (Figure 54 and Figure 55).

The “Tidal marsh” (Transquaking soils) that made up about 30% of the area in the 1911 survey consists of very poorly drained organic soils on tidal marshes. The Transquaking soil is now mapped in the upper East Coast in Maryland and is also not representative of the soils in the area. The areas are now mapped as “Bohicket-Capers Association”. Bohicket and Capers soils were established after the 1911 survey and do not have thick organic sediment at the surface. The change in soil mapping is due to additional choices of soil series for the soil mappers. There is a small shift in the soil boundary between the uplands and the tidal marsh. The shift is towards the tidal marsh and may represent some minor filling or earth-moving during development in the southern part of the monument. However, no spoil areas were identified on the topographic maps.

Figure 54 and Figure 55 indicate a difference in the meander pattern of the tidal stream. The difference could be from using a more accurate base map for the soil survey in 2006, or a change in the location of the stream, or both. The change in stream location is not logical where the stream touches the upland soil, because the stream incision could not have extended the upland soil into the marsh. The opposite could occur. Where the stream may have widened its meander bend in the tidal marsh, the change would not be detectible in the soil resources. Therefore, the likely change is an improvement in the base map (Figure 54 and Figure 55).

Table 44. Historic soil survey (1911) classification and approximate percent of total acreage for Fort Frederica National Monument.

Soil Code	*Classification Name*	*Description*	*Extent w/in FOFR*
Lf	Leon fine sand	The Leon series consists of very deep, moderately to moderately slowly permeable, poorly and very poorly drained soils on upland flats and depressions. They formed in sandy marine sediments of the Atlantic and Gulf Coastal Plain. Slopes range from 0 to 5 percent.(1)	≈ 35%
Nf	Norfolk fine sand	The Norfolk series consists of very deep, well drained, moderately permeable soils on lower, middle, or upper coastal plains uplands with slopes ranging from 0 to 10 percent. Parent material consists of marine deposits or fluviomarine deposits (deposits near the mouth of a river, formed by the combined action of river and sea).(2)	≈ 35%
Tm	Tidal marsh	The Transquaking series consists of very deep, very poorly drained soils flooded by tidal waters. Permeability is rapid in the organic deposits and slow in the mineral material. Parent material consists of organic deposits underlain by loamy mineral sediments. These soils are on coastal plains in brackish estuarine marshes along tidally influenced rivers and creeks with slopes ranging from 0 to 1 percent. (Transquaking soils were previously mapped as Tidal Marsh miscellaneous areas. These soils become ultra acid when drained).(3)	≈ 30%

(1) http://www2.ftw.nrcs.usda.gov/osd/dat/L/LEON.html

(2) http://www2.ftw.nrcs.usda.gov/osd/dat/N/NORFOLK.html

(3) http://www2.ftw.nrcs.usda.gov/osd/dat/T/TRANSQUAKING.html

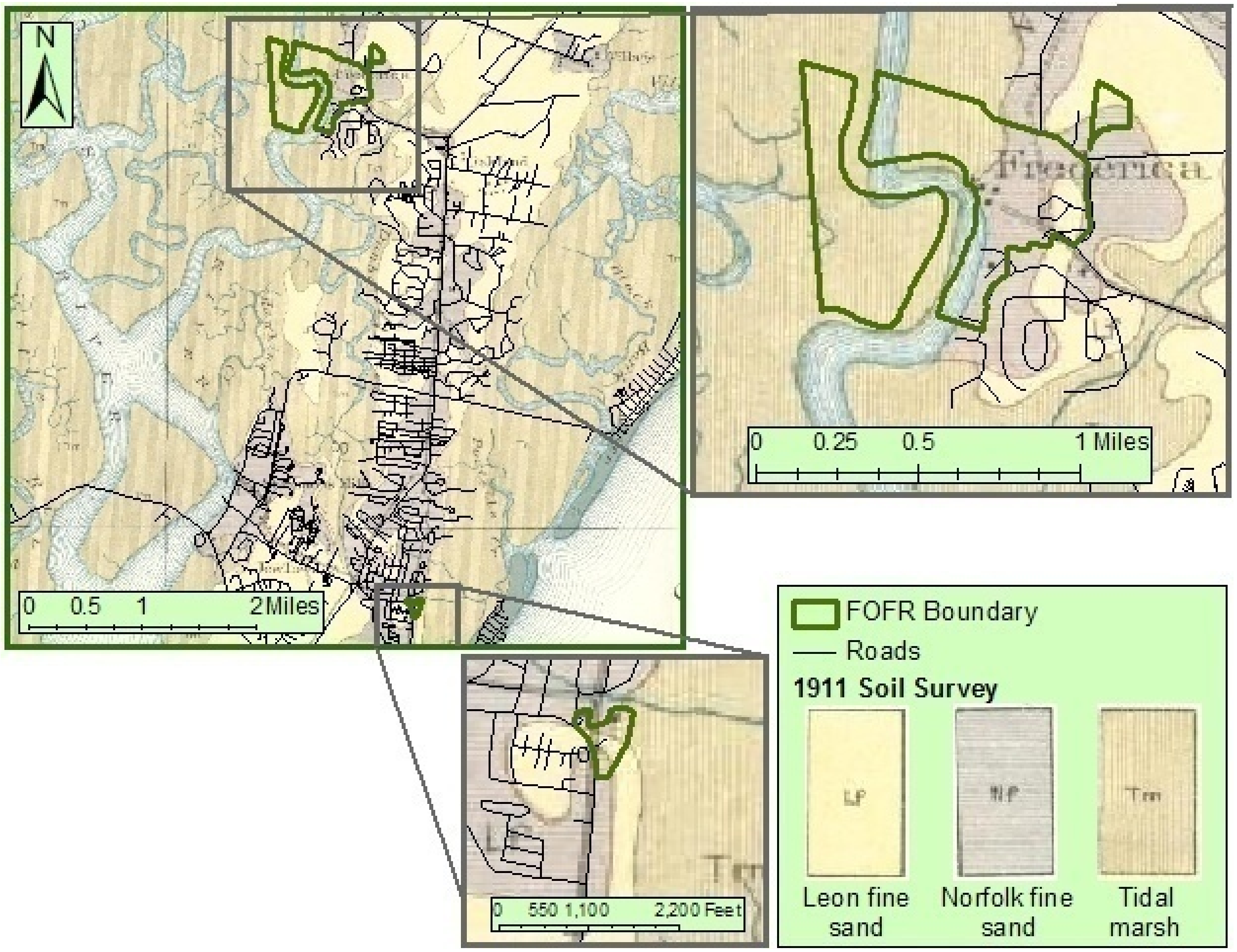

Figure 54. Extent of historic soil survey (1911) at Fort Frederica National Monument, Georgia.

In the 2006 soil survey, there are six soil classes for Fort Frederica NM. These are “Bohicket-Capers association”, “Cainhoy fine sand, 0 to 5 % slopes”, “Mandarin fine sand”, “Pelham loamy sand”, “Pottsburg sand”, and “Rutlege fine sand” (Table 45, Figure 55). The park does not contain Prime Farmland or Farmland of Statewide Importance. There are no Highly Erodible Lands in the park.

Clayey tidal marsh soils such as Bohicket and Capers contain reduced sulfides and are called cat clays because of the formation of a gray and yellow pattern when they are exposed to oxygen by dredging or ditching. The gray is the background color of the subaqueous, reduced soil and the yellow mottles are iron-sulfates (jarosite) formed by oxidation and precipitation of sulfides in the exposed sediment. The formation of jarosite leads to release of sulfuric acid and thus lowers the pH to levels too low to support native vegetation, until the soil pH is raised through additions of calcium or leaching of sulfates.

Table 45. Current soil survey (2006) classification, acreages, and percent of total acreage for Fort Frederica National Monument.

Map Symbol	*Map Unit Name*	*Description*	*FOFR Acres*	*FOFR %*
BO	Bohicket-Capers association	Bohicket – Very deep, very poorly drained soil is on broad level tidal flats. Mostly clayey throughout. Flooded twice daily by sea water and continuously saturated. Permeability is very slow and available water capacity is very low. Capers – Very deep, very poorly drained soil on broad level tidal flats. Clayey to a depth greater than 5 feet. Commonly flooded by ocean tides and continuously saturated. Permeability is very slow and available water capacity is very low. [5]	162.2	57.5
CaB	Cainhoy fine sand, 0 to 5 % slopes	Very deep, excessively drained soil on uplands. Soil is sandy throughout. Permeability is rapid and available water capacity is low.[6]	78.9	28.0
Ma	Mandarin fine sand	Very deep, somewhat poorly drained soil on ridges and knolls. Soil is sandy throughout. Organic stained layers are within 30 inches of the surface. Seasonal high water table occurs at a depth of 1.5 to 3.5 feet. Permeability is rapid except in the organic hard pan layers where it is moderate. Available water capacity is low.[7]	5.2	1.8
Pe	Pelham loamy sand	Pelham (Pelham, flooded) –Very deep, poorly drained soil along drainageways. The subsoil is loamy and extends to a depth greater than 5 feet. Seasonal high water table occurs at a depth of 0 to 1.0 foot. Flooding is common. Permeability is moderate and available water capacity is low.[8]	12.5	4.4
Po	Pottsburg sand	Pottsburg (Hurricane) –Very deep, somewhat poorly drained soil on low-lying uplands. Textures are sandy throughout. Organic stained layers occur below a depth of about 51 to 79 inches. Seasonal high water table occurs at a depth of 2 to 3.5 feet. Permeability is moderately rapid and available water capacity is low.[9]	13.5	4.8
Ru	Rutlege fine sand	Very deep, very poorly drained soil on upland flats. Sandy throughout. A seasonal high water table occurs at a depth of 0 to 0.5 foot. Slopes are 0 to 2 percent. Permeability is rapid and available water capacity is low.[10]	6.7	2.4
W	Water	Water	3.2	1.1
	Total		282.2	100.0

[4] http://www2.ftw.nrcs.usda.gov/osd/dat/B/BOHICKET.html

[5] http://www2.ftw.nrcs.usda.gov/osd/dat/C/CAPERS.html

[6] http://www2.ftw.nrcs.usda.gov/osd/dat/C/CAINHOY.html

[7] http://www2.ftw.nrcs.usda.gov/osd/dat/M/MANDARIN.html

[8] http://www2.ftw.nrcs.usda.gov/osd/dat/P/PELHAM.html

[9] http://www2.ftw.nrcs.usda.gov/osd/dat/P/POTTSBURG.html

[10] http://www2.ftw.nrcs.usda.gov/osd/dat/R/RUTLEGE.html

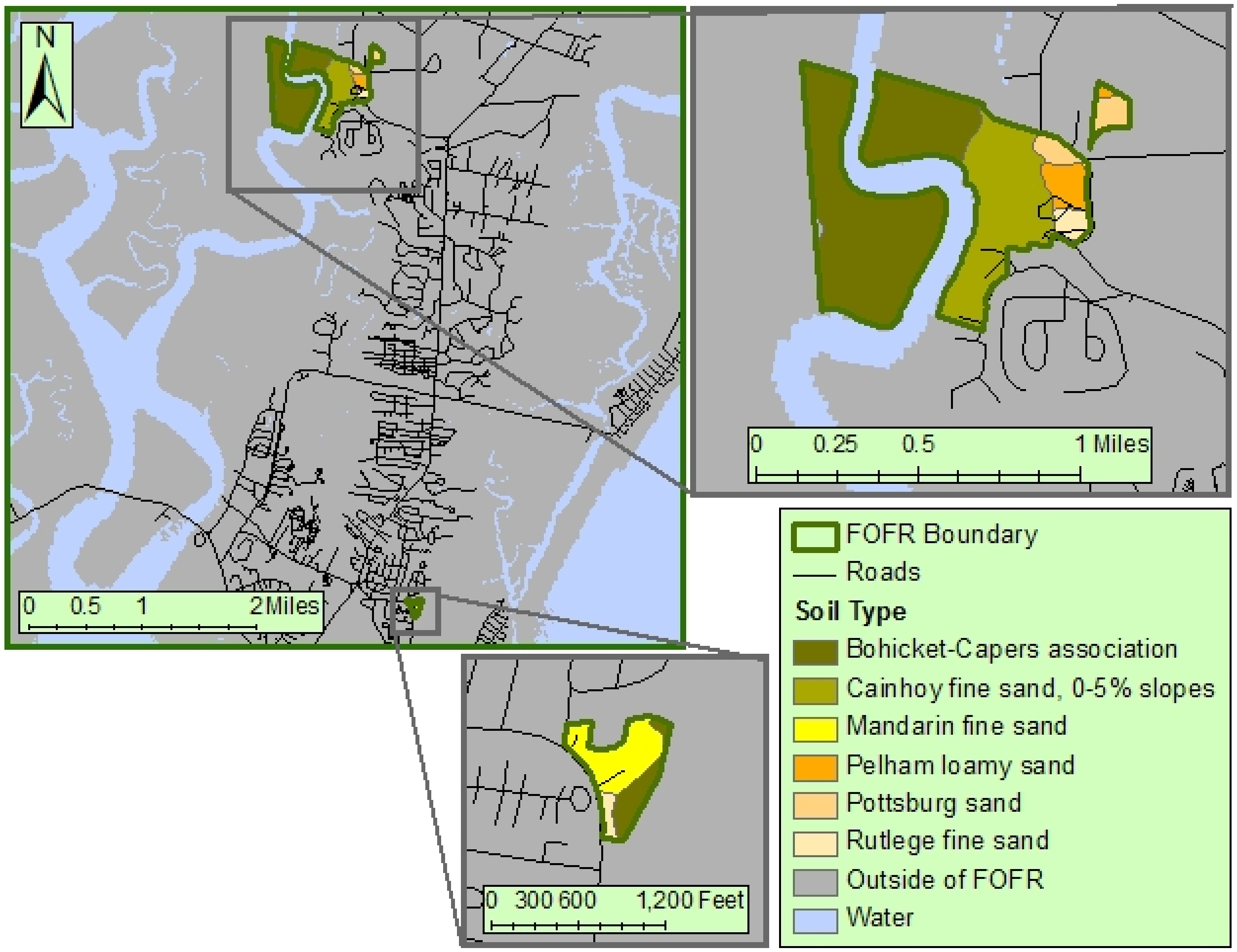

Figure 55. Extent of current soil survey (2006) at Fort Frederica National Monument.

Several soil-based assessments can be assembled from current soil data using the soil database (USDA Natural Resource Conservation Service 2006) and an extension that runs on ArcGIS (ESRI 2006), the USDA Natural Resource Conservation Service Soil Data Viewer (2008). The soil assessments that we found most useful for park included, potential erosion hazard for off-road, off trail traffic (Table 46, Figure 56, Appendix C); flooding frequency class (Table 47, Figure 57, other water features listed in Appendix C); drainage class (Table 48, Figure 58, Appendix C); hydric rating (Figure 59, Appendix C); soil features (Appendix C); and camp area, picnic area, and playground ratings (Appendix C); and paths, trails, and golf fairways (Appendix C). Explanations from USDA Natural Resource Conservation Service Soil Data Viewer (2008) follow with more detail in Appendix C.

Potential erosion hazard (off-Road, off-Trail):

"Ratings indicate the hazard or risk of soil loss from off-road and off-trail areas after disturbance activities that expose the soil surface, and are based on slope and soil erodibility factor K. The soil loss is caused by sheet or rill erosion in off-road or off-trail areas where 50 to 75 percent of the surface has been exposed by logging, grazing, mining, or other kinds of disturbance.

The hazard is described as "slight", "moderate", "severe", or "very severe". A rating of "slight" indicates that erosion is unlikely under ordinary climatic conditions; "moderate" indicates that some erosion is likely and that erosion-control measures may be needed; "severe" indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised; and "very severe" indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical." (USDA Natural Resource Conservation Service 2008)

Table 46. Potential erosion hazard (off-road, off-trial) according to soil characteristics at Fort Frederica National Monument. *Slight* means erosion is unlikely under ordinary climatic conditions.

Potential Erosion	*Acres*	*% of FOFR*
Not rated	3.2	1.13
Slight	279.0	98.87
	282.2	100.00

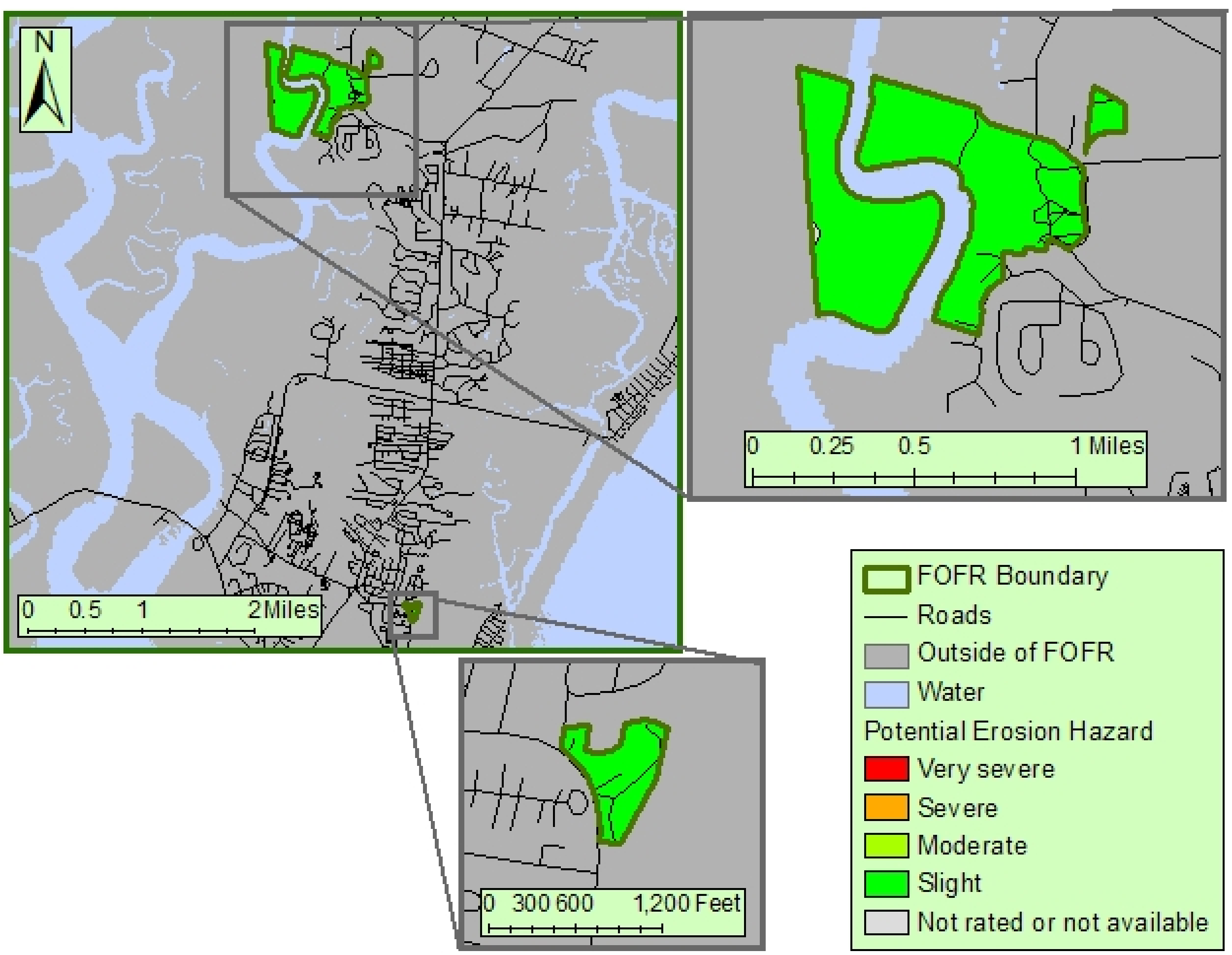

Figure 56. Potential erosion hazard (off-road, off-trial) according to soil characteristics at Fort Frederica National Monument. *Slight* means erosion is unlikely under ordinary climatic conditions; *moderate* means that some erosion is likely and that erosion-control measures may be needed; *severe* means that erosion is very likely, erosion-control measures advised; and *very*

severe means that significant erosion is expected, loss of soil productivity and off-site damage likely.

Flooding frequency class:
"Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Flooding frequency class is the number of times flooding occurs over a period of time and is expressed as a class. Flooding Frequency Classes are based on the interpretation of soil properties and other evidence gathered during soil survey field work. The classes are:

None - Flooding is not probable, near 0 percent chance of flooding in any year or less than 1 time in 500 years.
Very rare - Flooding is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year).
Rare - Flooding is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year).
Occasional - Flooding occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year).
Frequent - Flooding is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year).
Very frequent - Flooding is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year)."
(USDA Natural Resource Conservation Service 2008)

Table 47. Flooding frequency according to soil characteristics at Fort Frederica National Monument. *None* means flooding is not probable; *frequent* means flooding is likely to occur often; and *very frequent* means flooding is likely to occur very often under normal weather conditions.

Flooding Frequency	*Acres*	*% of FOFR*
None	107.4	38.07
Frequent	12.5	4.44
Very Frequent	162.2	57.49
	282.2	100.00

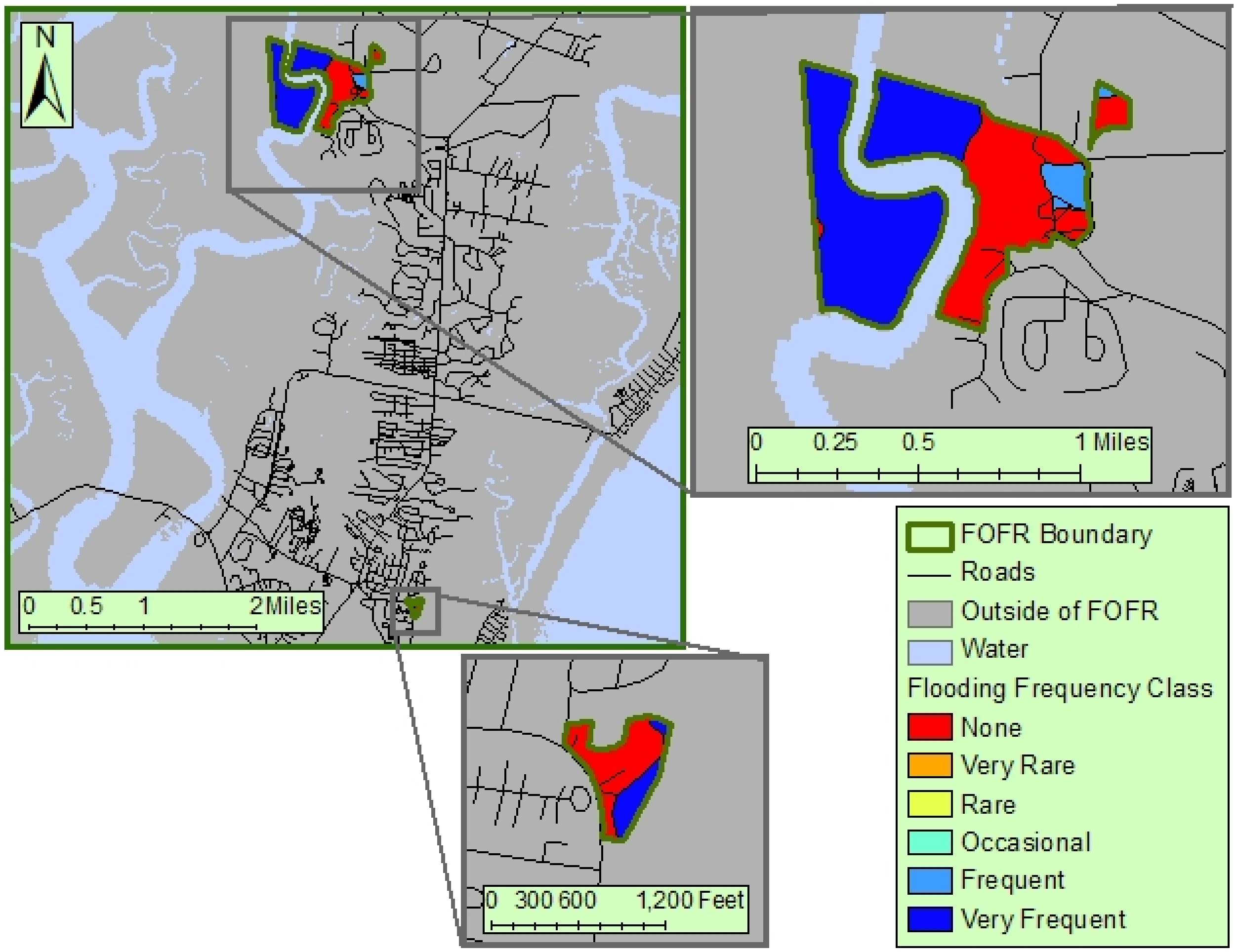

Figure 57. Flooding frequency according to soil characteristics at Fort Frederica National Monument. *None* means flooding is not probable; *very rare* means flooding is very unlikely; *rare* means flooding is unlikely but possible under unusual weather conditions; *occasional* means flooding occurs infrequently under normal weather conditions; *frequent* means flooding is likely to occur often; and *very frequent* means flooding is likely to occur very often under normal weather conditions.

Drainage class:
"Drainage class (natural) refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized – excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained." (USDA Natural Resource Conservation Service 2008)

Table 48. Drainage classes according to soil characteristics at Fort Frederica National Monument.

Drainage Class	*Acres*	*% of FOFR*
Not rated	3.2	1.13
Excessively drained	78.9	27.95
Somewhat poorly drained	18.7	6.63
Poorly drained	12.5	4.44
Very poorly drained	168.9	59.84
	282.2	100.00

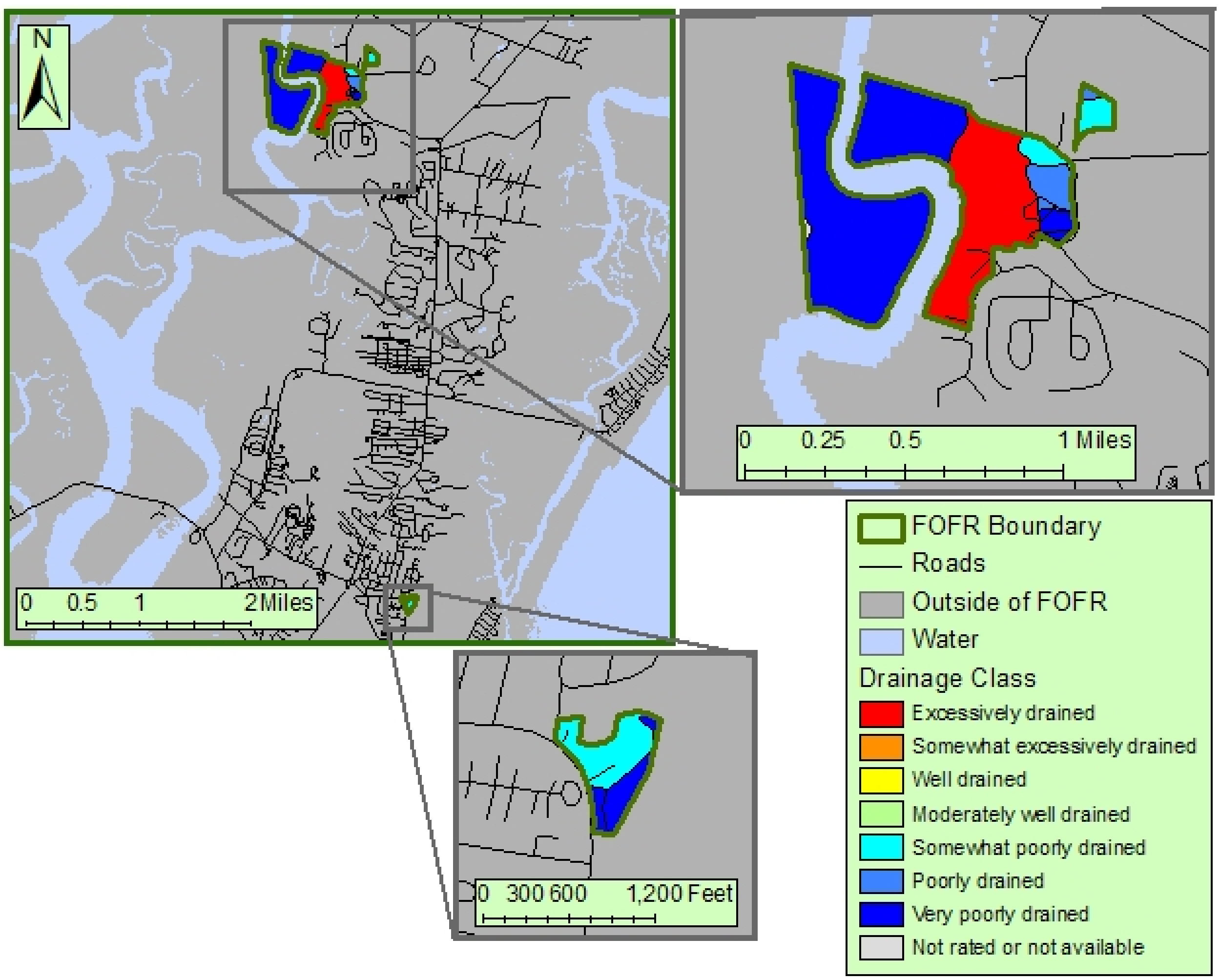

Figure 58. Drainage classes according to soil characteristics at Fort Frederica National Monument.

Map unit hydric rating:

"This rating provides an indication of the proportion of the map unit that meets criteria for hydric soils. Map units that are dominantly made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the higher positions on the landform, and map units dominantly made up of nonhydric soils may have inclusions of hydric soils in the lower positions on the landform

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation. . .

. . . If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. . . .” (USDA Natural Resource Conservation Service 2008)

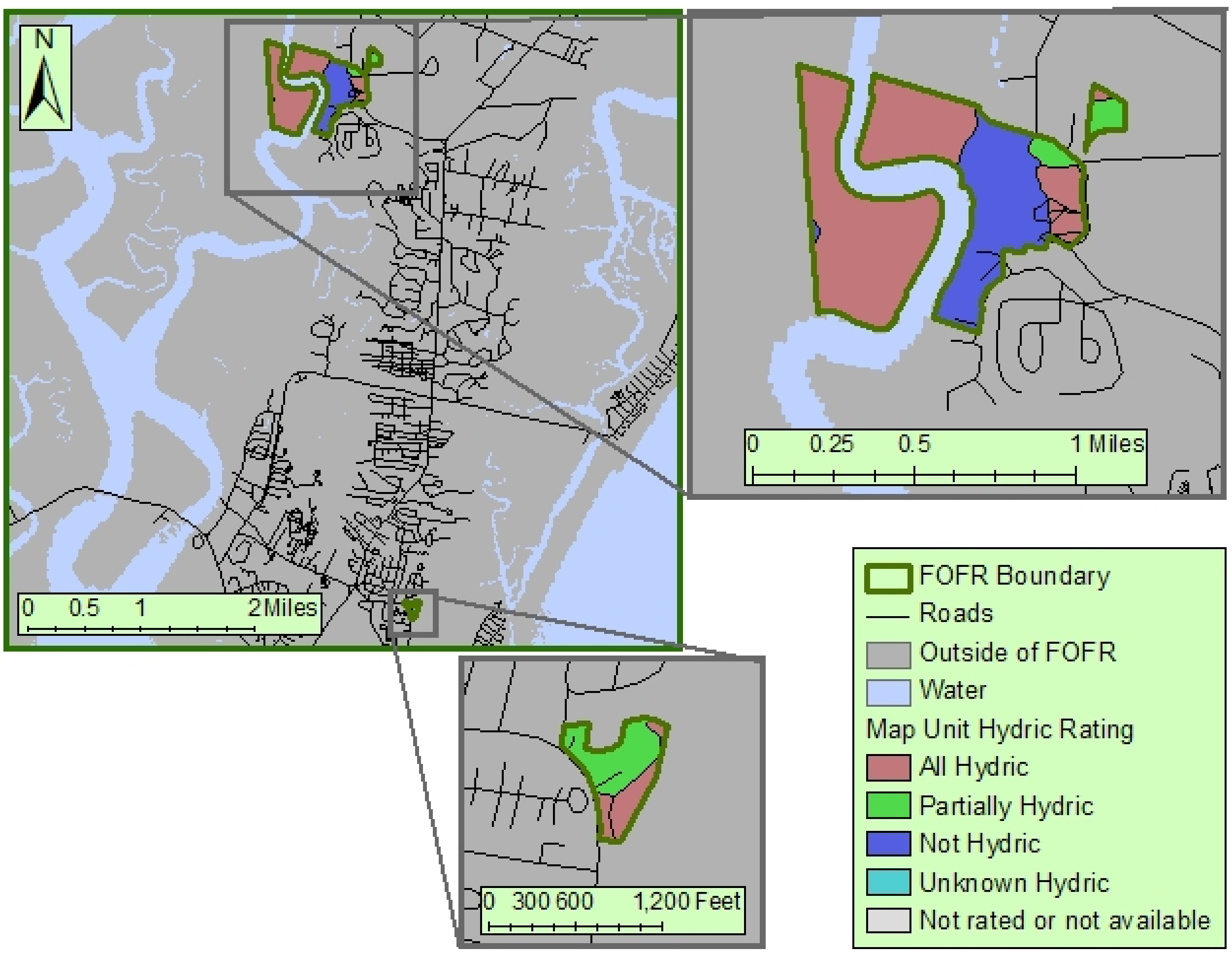

Figure 59. Hydric rating according to soil characteristics at Fort Frederica National Monument.

3.5.1.b Resource threats and stressors:
The exposure of acid-sulfate soils such as Bohicket and Capers to oxygen will create an ultra-acidic soil and release acid mine drainage that are toxic to all forms of life. This threat will diminish as sea level rises or as the acids are leached from the soils over time. Also, as sea level rises, high salinity may kill upland vegetation, or cause a shift in the marsh streams towards the

uplands, causing bank erosion. In addition, erosion of shorelines may occur from wakes of passing boats, especially the upland shore near the historic fort foundations. The threat of rising sea levels and erosion is covered in more depth in the Hydrology section (3.4.1 Hydrology).

3.5.1.c Critical knowledge or data gaps:
Data quality is good in all cases (Table 49). Local scale, specific soil analysis to Fort Frederica NM may be appropriate to add detail to soil characteristics.

3.5.1.d Condition status summary
Soil properties did not appear to change that drastically from the 1911 soil survey so soil change is in the good range for condition status (Table 49). However, improvements in soil series choices and mapping technologies were evident in the data. Potential erosion hazard is slight for the majority of soils so this category is rated in the good range (Table 49). Slightly more than half of Fort Frederica NM has a very frequent flooding frequency class while drainage class mirrored these findings with very poorly drained characteristics in the same soils. Consequently flooding frequency and drainage class were combined and received a fair condition status (Table 49).

Table 49. Soil condition status summary for Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), *spatial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Midpoint***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Soil change			1	1	1
	Good	0.84	3 out of 3		
Potential erosion			1	1	1
	Good	0.84	3 out of 3		
Flooding frequency and drainage class			1	1	1
	Fair	0.5	3 out of 3		
Soil total			3	3	3
	Good	0.73	9 out of 9		

3.5.1.e Recommendations to park managers:
We recommend controlling erosion on the upland shoreline in the northern portion of the monument. We also advise avoiding excavation in the tidal marshes as well as filling and building on the tidal marsh soils. These soils have low strength and the potential to produce ultra-acidic properties. Tidal flooding and high salinity are a problem in the marsh areas. Park managers should plan for shoreline erosion, damage from storm tides, and park egress during tropical storms. Measures should be taken to protect eroding shorelines. Park managers should be aware of and follow all wetland protection regulations.

3.6 Biological Integrity

3.6.1 Focal Communities and At-risk Biota

The species of plants and animals found within the boundary of Fort Frederica NM are the product of numerous factors. The principal natural land cover classes found on the monument are coastal wetlands and evergreen forest. These classes of vegetation are no doubt comprised of several different plant communities which vary related to wetness, salinity, and management history among other factors.

These communities can be described and classified using the National Vegetation Classification Standard (U.S. Geological Survey 2008b) and will be available as part of the Fort Frederica NM Vegetation Characterization Project. The most dominant vegetation communities on Fort Frederica NM include estuarine emergent wetlands and evergreen forest.

The complete assemblage of species, plants and animals, at Fort Frederica NM is a direct result of several different types of vegetation, land use, and hydrologic communities that occur within its boundary. Estuarine emergent wetlands are the land cover type that comprises the majority of Fort Frederica NM acreage. However, the species assemblages observed on Fort Frederica NM are certainly the product of other communities (natural or anthropogenic) in the landscape surrounding the monument.

Ideally, an assessment of the biotic communities at Fort Frederica NM would consist of the complete range of plants and animals known to occur within the monument as well as the full suite of species found on pristine tracts of similar habitat in the same landscape. The biotic assessment would be performed on the full spectrum of animals and plants from each taxonomic class. Species absences or species located that were not part of that suite of native species, would represent decreases in biotic integrity from the reference scenario.

Such a complete assessment is beyond the scope of this project. We can, however, use existing datasets for a few of these taxa to permit some insight as to the likely state of biotic communities at Fort Frederica NM. There have been just a few investigations of animals and plants at Fort Frederica NM over the past 20-plus years (Table 50).

These studies have been synthesized into a species information base by the NPS (Certified Organisms: NPSpecies 2008). With this system, users can extract predicted species lists for each park in the system including Fort Frederica NM. We utilized this database to generate list of species (by-taxa) expected to occur within Fort Frederica NM. These lists were reviewed and corrected as necessary and used in this project as current species lists.

Table 50. List of available animal and plant surveys at Fort Frederica National Monument.

Year	*Community target for survey*	*Author(s)*
2003	Reptiles and Amphibians	Tuberville, T. D., J. D. Willson, M. E. Dorcas, and J. W. Gibbons
1985	Plants	Bratton, S. P.
2003	Plants (St. Simons Island)	Rodgers III , J. C. and K. C. Parker
2005	Plants	Schmidt, J. P.

Attempts at locating and utilizing appropriate reference datasets for comparison to Fort Frederica NM community information were more problematic. Such information is either not readily available, or is considered suspect for these purposes. Without defensible reference community assemblages, any assessments drawn using them would be suspect. We elected to focus on those communities for which the most defensible information was available. We also looked to the existing NPS Inventory and Monitoring (I&M) Vital Signs Program for the Southeast Coastal Network to provide some guidance as to which species communities were considered important enough for future monitoring efforts.

The I&M program has specifically identified forest breeding birds and amphibians as communities of interest for that program. Relatively sound community information can be obtained for these groups and work on and around Fort Frederica NM for these communities has been done relatively recently.

3.6.1.a Current condition:

Avian communities:

The avian community at Fort Frederica NM is reported to contain 82 species, however only one is listed as a confirmed "breeder"[1]. Due to the limited data available on breeding birds on Fort Frederica, we elected to compare this suite of species to that of known breeders from the surrounding landscape.

The reference list of breeding birds was synthesized from data compiled as part of the ongoing USGS Breeding Bird Survey (BBS) effort (U.S. Geological Survey 2008c). We selected BBS routes from the surrounding landscape that had several years of survey data in them from 1966-2007 (Figure 60). We selected 11 routes for building the reference species list.

[1] There are a number of native species listed with breeding status "unknown" or exotic species that were omitted from this analysis.

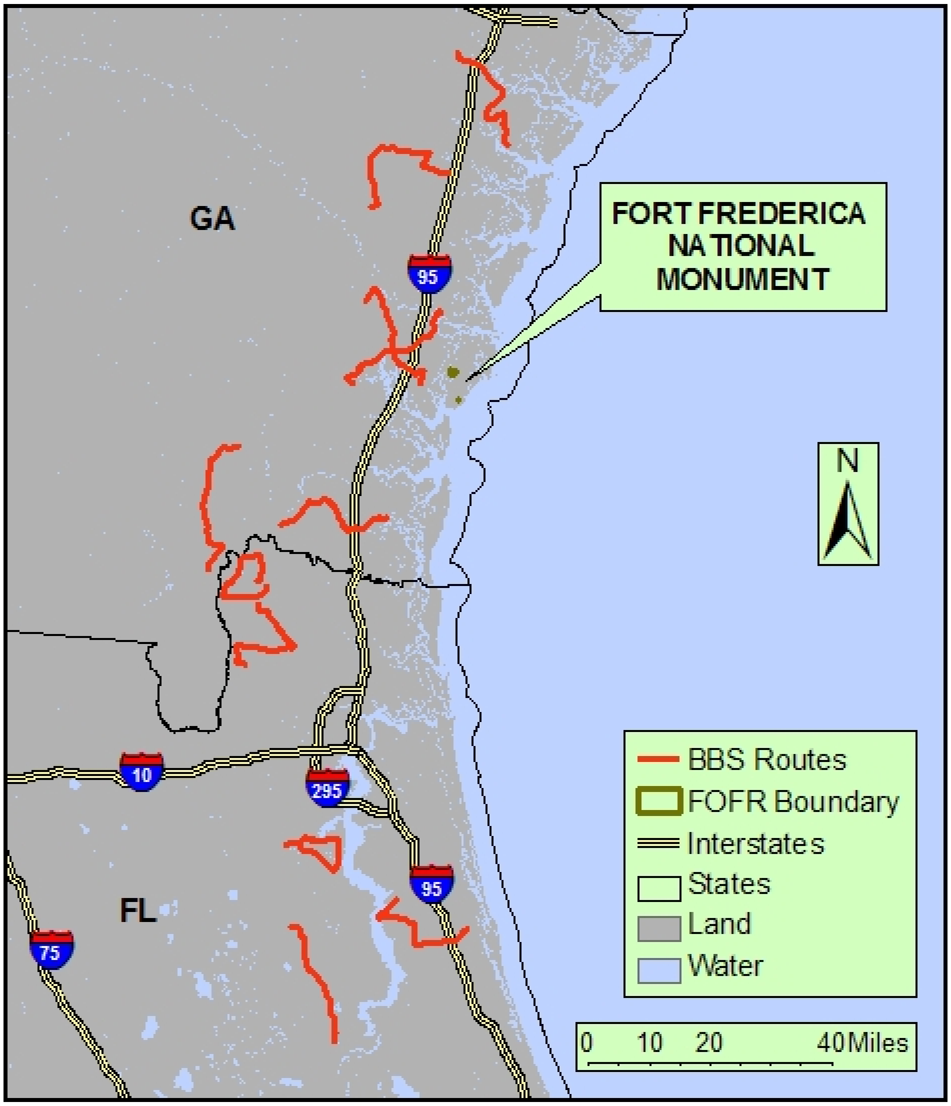

Figure 60. USGS Breeding Bird Survey Routes in the area surrounding Fort Frederica National Monument that were chosen for the assessment.

We compiled the total number of species seen on each route over the 42-year period. We then counted the number of routes on which a species was observed during that period. Those species seen on at least eight routes were used to compile the reference breeding bird route for the region.

A total of 80 species were identified as breeding in the landscape surrounding Fort Frederica NM. We then cross-referenced this list to the avian list obtained for Fort Frederica NM. A total of 48 species were found on both lists. The Jaccard Index of Similarity between the reference breeding bird list and the bird list from Fort Frederica NM was 0.42.

The Jaccard Index of Similarity is a simple method for comparing species diversity between two different samples or communities (Krebs 1999). The value is calculated by dividing the number of species found in both samples (a) by the number found in only one sample or the other (b, c):

$S_j = \quad a / (a+b+c)$

There were 16 species listed present at Fort Frederica NM not found on at least eight of the 11 routes used to compile the reference list. Of these, none were observed on BBS routes at all. Upon further review, it was evident that these species tended to utilize Fort Frederica NM in the winter or as stopover habitat during migration, so we elected to calculate two Jaccard Index of Similarity scores; one that included those species and one that did not. If we removed those 16 species thought to be under-represented in the reference list, the index score was determined to be 0.49.

Another means for assessing the biotic condition of the birds at Fort Frederica NM was to examine the population trends for each species. From a management perspective, Fort Frederica NM would like to see each species either at, or moving towards, population levels desired for management. These levels will differ depending on the status of the species. For example, we assume that rare species populations would be desirable if they are increasing. The opposite would be true of exotic or nuisance species.

Using the BBS data, we were able to establish observation trends for 48 species known to be present at Fort Frederica NM. For each species, we calculated the number of times the species was observed each year over the course of the surveys, then calculated a regional average by dividing the total observed by the total number of routes that were completed in that year. In years that a route was completed but the species was not observed, we recorded a 0 value. We then plotted the mean number of observations against the years and used linear regression to create a trend line for each species. We then determined if the observed trend was significant by testing if the slope of the line was significantly different from 0. If so, it was classified as either “increasing” or “decreasing” for the period.

We calculated this slope value for two periods. The first was for the entire survey period (1966 – 2007). The second period was for the last 15 years only (1992 – 2007). Comparisons between these periods will allow us to determine if any non-significant long-term trends are changing more recently.

We categorized trends as “acceptable” or “unacceptable” by using a simple management matrix for each class of species in the set (Table 51). These three classes were species of “concern,” “nuisance,” or “breeder.” These values were used to determine the overall management acceptability of population trends for the bird community.

Table 51. Management matrix used to categorize trend combinations.

Period 1	*Period 2*	*Management Evaluation*		
1966-2007	*1992-2007*	*Concern*	*Nuisance*	*Breeders*
Increasing	Increasing	Acceptable	Unacceptable	Acceptable
Decreasing	Increasing	Acceptable	Unacceptable	Acceptable
Not significant	Increasing	Acceptable	Unacceptable	Acceptable
Increasing	Decreasing	Unacceptable	Acceptable	Unacceptable
Decreasing	Decreasing	Unacceptable	Acceptable	Unacceptable
Not significant	Decreasing	Unacceptable	Acceptable	Unacceptable
Increasing	Not significant	Unacceptable	Uncceptable	Acceptable
Decreasing	Not significant	Unacceptable	Acceptable	Unacceptable
Not significant	Not significant	Unacceptable	Unacceptable	Acceptable

A total of 25 of the 48 (~ 52%) species were deemed "acceptable" based on their observed trends in the landscape surrounding Fort Frederica NM. The remaining species observation trends were deemed "unacceptable" in light of the management classifications placed on them.

This result suggests that nearly half of the breeding birds in the landscape surrounding, and perhaps including, Fort Frederica NM are experiencing either long or short term declines that may increase their conservation priority in the future. It is important to note that this does not provide any proof that these species are declining on Fort Frederica NM. There is no long term data on breeding bird observations at Fort Frederica NM. However, if these species continue to decline over the local landscape, their continued presence as breeding birds at Fort Frederica NM may be jeopardized.

Amphibian communities:

The amphibian community at Fort Frederica NM has been identified specifically in the Southeastern Coastal Network I&M Draft Study Plan (National Park Service 2000). Amphibians are of particular interest in biotic condition analysis due to their sensitivity to their surrounding environment. Recent declines in amphibian populations elsewhere in the Southeast make them of further interest as part of this assessment.

Amphibians were recently inventoried at Fort Frederica NM along with reptiles (Tuberville et al. 2005). Tuberville et al. (2005) employed a variety of survey methods aimed at compiling the most comprehensive list of amphibians resident at the monument. Our assessment was completed using the amphibian species documented during this effort. A total of six species of amphibian (all anurans) were observed for Fort Frederica NM as part of this survey. This study suggests that 23 additional amphibian species (11 anurans, 12 salamanders) have ranges coincident with Fort Frederica NM but were not observed. Presumably this is due to a lack of specific local-scale habitat conditions (e.g., fresh water, pine barrens) that these species require. The Jaccard Similarity Index between the observed species and the potential assemblage is 0.26. However, this value represents the most conservative application of this score. A number of these are clearly without habitat at Fort Frederica NM and should be excluded from the reference potential assemblage. A detailed vegetation map was not yet available for Fort Frederica NM, so we were unable to obtain the local scale information needed to exclude species for lack of habitat.

We elected to use species-habitat distribution models published by the Georgia Gap Analysis Program (UGA Institute of Ecology and GA Cooperative Fish & Wildlife Research Unit 2003). These models were synthesized with a combination of literature review, historical records, and expert review. The resulting species-habitat models were applied to real landscapes using a land cover map derived from satellite imagery. Predicted species distributions were then attributed to specific EMAP hexagons and mapped for the entire state (UGA Institute of Ecology and GA Cooperative Fish & Wildlife Research Unit 2003). Fort Frederica NM is located within the EMAP hexagon number 2693. We extracted the frog and salamander species whose distributions placed them within this hexagon and used that as a reference list (Appendix D).

A total of 38 species were identified from the GA-GAP models as potentially occurring within the hexagon coincident with Fort Frederica NM. Of these, six species were documented at Fort Frederica NM. The Jaccard Similarity Index was calculated as 0.15 between Fort Frederica NM amphibians and the GA-GAP derived reference set (Table 56).

These indices reflect a relatively low overlap between the amphibians present at Fort Frederica NM relative to similar vegetation communities. That is, areas outside of the monument with similar habitat characteristics will have more species than were observed here. Since the monument is surrounded by salt water, the movement of amphibians from mainland populations to the islands is difficult. So, although Fort Frederica NM has relatively few frogs and salamanders, this may be due to its isolation from potential mainland immigrants rather than a degraded habitat condition.

Reptile communities:
We completed a community composition analysis for reptiles similar to our methods for amphibians. Reptiles were surveyed recently (Tuberville et al. 2005) along with amphibians using similar methods.

A total of 15 reptiles were found on Fort Frederica NM. The survey suggests the potential for 31 additional species with overlapping ranges (although habitat may not be found on the monument). This yields the most conservative Jaccard Similarity Index of 0.48.

As with amphibians, we elected to utilize predicted distributions of reptile species from the GA-GAP (Appendix D). The GA-GAP models predict the occurrence of 61 species in all. All 15 species observed at Fort Frederica NM are included, so the Jaccard Similarity Index was calculated at 0.25.

We decided to do a last comparison by synthesizing a list of reptiles that would be expected to utilize the salt marsh habitats only and compare that to the list of reptiles for Fort Frederica NM. Only two species of reptiles on Fort Frederica are expected to utilize salt marsh habitats. Since the salt marsh communities have persisted over much longer periods of time, we expected that the species assemblage would more closely overlap a reference list. We generated a reference list of reptiles from Gibbons (1978 as cited in Wiegert and Freeman 1990). This list contains six species that are ubiquitous in coastal salt marshes throughout the southeast. Of these six species, two (American alligator and diamondback terrapin) have been documented at Fort Frederica NM (Jaccard Similarity Index = 0.33, Table 56).

Mammal communities:
The mammal community at Fort Frederica NM is relatively small. There are 15 species on the monument including one marine mammal (West Indian manatee). Two species, the domestic cat (*Felis catus*) and dog (*Canis familiaris)* are non-native species.

We used the GA-GAP species distribution models as a reference list for comparison of mammals (Appendix D). GA-GAP models predicted the presence of 45 species in the Fort Frederica NM area (did not include marine mammals). Twelve terrestrial species (excluding non-native species) observed on Fort Frederica NM were predicted by the GA-GAP models with a Jaccard Similarity Index of 0.27.

Wiegert and Freeman (1990) also provided a list of salt marsh mammals (derived from Sanders 1978) found in the salt marshes of the southeast. We identified those species on Fort Frederica NM that were likely present due to the salt marsh and compared it to this list. The Fort Frederica NM list contained eight of the 14 species on the reference list with a Jaccard Similarity Index of 0.57.

Other communities:
There are several other key biotic communities that should be examined as part of this assessment. For the salt marsh vegetation communities, these include fish (especially breeding salt marsh species) and invertebrates (crabs and bivalves in particular). For both upland areas and salt marsh, plants are important as well.

Doyle (2009) performed an analysis of the aquatic condition for Fort Frederica NM. The analysis compared native fish species documented on Fort Frederica NM to native fish that occur in the watersheds based on NatureServe data. Percent similarity of native fish collected in the NPS unit was 0.13 (3/24, Table 56).

The biotic species list compiled from the NPS biotic database (Certified Organisms: NPSpecies 2008) indicates there are 21 fish species that utilize Fort Frederica NM habitats for some period of their annual or seasonal life requisites (Table 52). Without recent field-verified studies, it is difficult to draw assessment conclusions about these biotic groups. Factors such as abundance, distribution, and health for each group or species provide the information necessary to begin to assess their condition.

Table 52. Species abundances and breeding status of documented species on FOFR.

Taxonomic Group	*Number of species with unknown abundance*	*Number of species documented breeding on FOFR*
Fish	21	unknown
Birds	82	1
Mammals	0	12
Herpetofauna	21	unknown
Invertebrates	data not available	--
Mussels	data not available	--
Plants	184	--

At-risk biota:
At-risk biota refers to those species that are listed as threatened or endangered (T&E) under the authority of the Endangered Species Act (U.S. Fish and Wildlife Service 2008). We took this a step further to identify those species that are listed in the State of Georgia as endangered, threatened, rare, or high priority in the southern coastal plain under the GA Comprehensive Wildlife Conservation Strategy (GA DNR Wildlife Resources Division 2005). In addition, these species were cross referenced to NatureServe's global and state rankings (NatureServe 2008). The bird list was also cross referenced to the Partners in Flight Priority Species (Partners in Flight 2005) and Audubon WatchList (National Audubon Society 2007). Appendix E through Appendix J contain complete species lists with associated state and global ranks and federal and state status.

There have been seven high priority species documented at Fort Frederica NM (Table 53). This is 4.5% of the total number of high priority species identified for the Southern Coastal Plain of Georgia in the Comprehensive Wildlife Conservation Strategy (GA DNR Wildlife Resources Division 2005).

Table 53. Total number of species documented at Fort Frederica National Monument, number of high priority species from the GA Comprehensive Wildlife Conservation Strategy, and % of high priority species within Georgia that are found at Fort Frederica NM.

Taxonomic Group	*# species documented at FOFR*	*# unconfirmed species*	*# SCP high priority species***	*# high priority species at FOFR*	*% high priority species at FOFR*
Plants	198	65	88	2	2
Fish	21	--	5	0	--
Amphibians	6	--	7	0	--
Reptiles	15	--	17	1	--
Birds	82	--	27	3	11
Mammals	15	--	10	1	10
Invertebrates	--	--	8	--	--

*Including non-native species
** GA DNR Comprehensive Wildlife Conservation Strategy list - Southern Coastal Plain (SCP) Ecoregion

According to the Fort Frederica NM Fire Plan (2004), the U.S. Fish and Wildlife Service and the Georgia Department of Natural Resources acknowledged that the following federally- or state-listed threatened or endangered species could potentially occur within park boundaries:

- Bald eagle (*Haliaeetus leucocephalus*), state-listed endangered
- Eastern indigo snake (*Dyrmarchon corais*), federally- and state-listed threatened
- Gopher tortoise (*Gopherus polyphemus*), state-listed threatened
- Peregrine falcon (*Falco peregrinus anatum*), state-listed endangered
- West Indian manatee (*Trichechus manatus*), federally- and state-listed endangered
- Wood stork (*Mycteria americana*), federally- and state-listed threatened

Of the above-listed species, only the West Indian manatee and wood stork have been documented within park boundaries. The West Indian manatee was observed on two occasions during the summer of 1990 in the Frederica River at the foot of the King's Magazine. No designated critical habitat exists at the park (National Park Service 2004b). The wood stork is documented present on the park, but its abundance and residency are unknown.

3.6.1.b Resource threats and stressors:
The biotic communities and at-risk species of Fort Frederica NM are under constant stress from agents within and outside the monument. These threats and stressors have the ability to reduce the natural resource condition with the monument. Therefore, it is important that managers and decision makers at Fort Frederica NM identify those threats, how they may affect the natural resource condition, and how severe and imminent they may be.

Habitat change:
Some of the threats to the natural biotic communities and at-risk species of Fort Frederica NM can be observed within its administrative boundary. Some of the most immediate and potentially severe threats to biotic diversity are related to habitat change.

Habitat degradation and loss factors are caused by internal or external agents. Some of the most immediate threats and/or stressors to habitat degradation and loss within Fort Frederica NM are:

1. salt marsh dieback
2. invasive species

Salt marsh dieback was first observed in Louisiana in 2000. Since that time, much research effort has been directed at determining what environmental factors and conditions contribute to the degradation and extirpation of salt marsh communities. One of those factors was determined to be over-abundant populations of salt marsh periwinkle, a spiral-shelled snail, (*Littoraria irrorata*) during periods of drought-stress (Silliman et al. 2005).

Periwinkles are a primary food source of the blue crab (*Calinectes sapidus*) which is harvested commercially throughout its range on the southeast coast. Unchecked by blue crab predation, periwinkle population can grow to over 2500 per square meter (Silliman and Bertness 2002). At these densities, the grazing activities of periwinkles can be detrimental to the dominant salt marsh plant species (*Spartina alterniflora, Juncus roemerianus*) and lead to the condition known as "brown marsh." Particularly when *S. alterniflora* productivity is reduced due to drought stress conditions (Silliman et al. 2005).

We examined the available literature to determine if a threshold population value for salt marsh periwinkle could be established. This threshold represents the upper limits of "healthy" population density. When exceeded, the potential for degradation of the salt marsh habitat increases. We used the values published in several peer-reviewed articles (Silliman and Zieman 2001, Silliman and Bertness 2002, Silliman et al. 2005) to establish the relationship between periwinkle density and degradation of the salt marsh.

In general, periwinkle densities can have a significant impact on salt marsh communities at densities of 100 – 600 per square meter (Silliman et al. 2005) depending on other factors such as increased salinity due to drought conditions. In other controlled experiments, Silliman and Bertness (2002) found that periwinkles at medium density (~ 600 per square meter) can be sufficient to greatly reduce salt marsh biomass over a growing season (Figure 61).

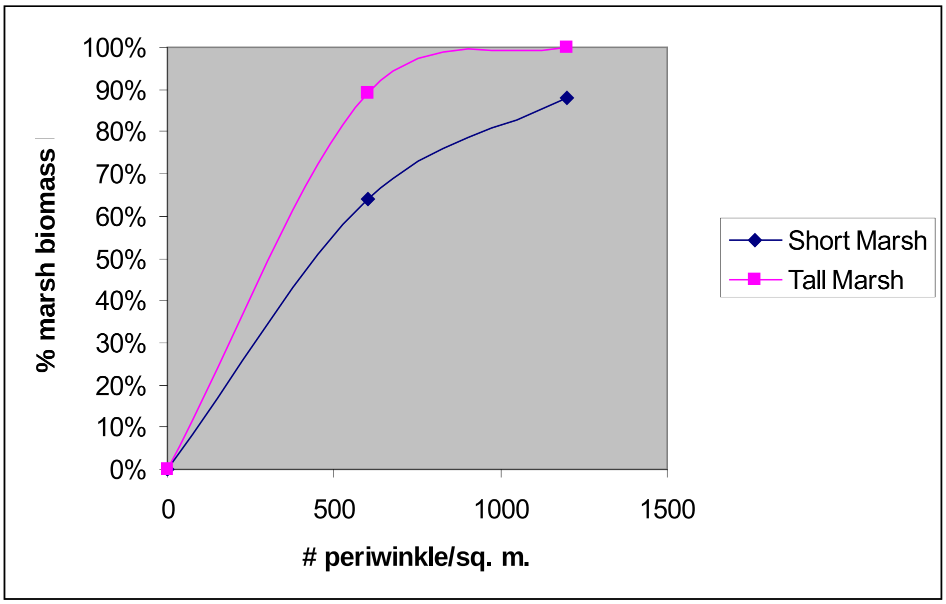

Figure 61. Number of periwinkles per square meter versus percent marsh biomass from a controlled study (Silliman and Bertness 2002).

The abundance of periwinkle is locally variable, and Fort Frederica NM does not presently have a monitoring protocol or program in place. The closest available datasets for periwinkle abundance were collected by the Georgia Coastal Ecosystems LTER (GCE LTER 2008). Periwinkle populations were estimated in the field using variable-sized quadrats during the fall of each year starting in 2003 (Table 54). We included only those sites described as dominated by *Spartina.* The fall mean density for the four years we examined was approximately 140 per square meter (std. dev. 34.4). This would indicate that periwinkle densities were approaching numbers that could lead to brown marsh especially in dry years.

We used this information as a surrogate for periwinkle populations at Fort Frederica NM. However, we do not truly know how well these values reflect the true population, so the results should be used with caution.

Table 54. Periwinkle density for fall collection sites on the Georgia Coastal LTER between 2003 and 2006.

Year	Mean No. (per m^2)
2003	169.9
2004	95.5
2005	127.9
2006	163.0

Invasive species:
Invasive species, particularly those that are exotic, have the potential to degrade native species and their habitat. They occupy habitat niches that would otherwise support native species, thereby degrading species communities.

Invasive species are present at Fort Frederica NM (Table 55). Invasive plant species comprise 18% of all plant species at Fort Frederica NM, by far the greatest proportion among taxa with data. Per discussions with park personnel the species currently posing the largest threat to habitat at Fort Frederica NM are wisteria (*Wisteria sinensis*) and Japanese honeysuckle (*Lonicera japonica*). According to the Fort Frederica NM Fire Management Plan (2004), *Daubentonia punicea* and privet (*Ligustrum* spp.) are also threats to the natural habitats at the monument.

Table 55. Proportion of invasive species by taxa at Fort Frederica National Monument.

Taxonomic Group	*# Native species*	*# Non-native species*	*% Non-native*
Plants	163	35	18
Fish	21	1	5
Amphibians	5	1	17
Reptiles	15	0	0
Birds	82	0	0
Mammals	13	2	13

External threats and stressors:
There are many external threats to the biotic communities of Fort Frederica NM from factors external to the boundaries, and management authority of the NPS. These factors have been covered extensively in previous sections and include:

1. Impact of nearly 300,000 visitors per year (3.2.2 Visitor and Recreation Use).
2. Potential construction of new marinas near the monument affecting West Indian manatee habitat.
3. Potential decline of salt marsh habitat in the future due to sea level rise as discussed in the Water Section (3.4 Water).

3.6.1.c Critical knowledge or data gaps:
The biotic communities of Fort Frederica NM may be unique in this landscape given salt marsh habitat present on the monument. Therefore, the species assemblages present do not appear to reflect the more complete biotic communities observed in the surrounding area. Relatively low

similarity scores for all taxa may reflect the relatively low diversity on Fort Frederica NM as a result.

However, a lack of comprehensive survey efforts certainly contributes to some of the observed differences. Similarity index scores for birds, for example, may increase with more comprehensive data from within the monument. These surveys should not only focus on species inventory, but should also address abundance which, over time, will provide better information to complete biotic community assessments. Table 56 shows the summary of condition status and data quality for Fort Frederica NM.

The following are specific knowledge gaps identified:

1. Unknown abundance of the majority of all faunal species, particularly population size and residency of most bird species (especially species utilizing the salt marsh habitat).
2. *Littoraria* density in *Spartina* marsh areas.
3. Extent of invasive plant species.

3.6.1.d Condition status summary

The Jaccard similarity index scores were cross referenced to report on the condition status for each of the major taxa (Table 56). An additional rating was added for bird trend acceptability based on the percentage of observed trends that were deemed “acceptable” in the landscape surrounding Fort Frederica NM. Bird trend acceptability received a fair condition status and the overall condition status for biological integrity is in the fair range (Table 56).

Table 56. Biological integrity condition status summary for Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), *spatial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 1).

Category	***Condition Status***	***Score Midpoint***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Bird community composition		(0.42 to 0.49)	1	0	1
	Fair	0.5	2 out of 3		
Bird trend acceptability		52%	1	0	1
	Fair	0.5	2 out of 3		
Amphibian community		(0.15 to 0.26)	1	0	1
	Poor	0.17	2 out of 3		
Reptile community		(0.25 to 0.48)	1	0	1
	Fair	0.5	2 out of 3		
Mammal community		(0.27 to 0.57)	1	0	1
	Fair	0.5	2 out of 3		
Fish community		0.13	0	1	1
	Poor	0.17	2 out of 3		
Biological integrity total			5	1	6
	Fair	0.39	12 out of 18		

3.6.1.e Recommendations to park managers:

Park managers at Fort Frederica NM are aware of the need for long-term monitoring data. However, there are several factors limiting park personnel to conduct needed surveys and monitoring programs.

If surveys were conducted over several years where population trend data were available, Fort Frederica NM personnel would be better able to assess habitat quality. The following are recommended projects for Fort Frederica NM when the opportunity arises:

1. Inventory and monitoring of fauna inhabiting or utilizing the marsh environment.
2. Implement simple periwinkle survey protocols (e.g., Georgia Coastal LTER invertebrate surveys).
3. Monitor trends in land condition both inside and outside of the park.
4. Native plant restoration, elimination and monitoring of invasive plant species.
5. Develop and/or strengthen relationship with GA DNR, Audubon, and other groups.

4.0 Summary and Conclusion

The overall condition status for Fort Frederica NM is in the good range (0.67; close to fair; Table 58). Midpoint scores were averaged for each NPS ecological monitoring framework level 2 category (Fancy et al. 2008) to come up with the overall condition status for the monument. The data quality scores were summed for each category.

Landscape dynamics, fire dynamics, human effects, visitor use, hydrology, and geology and soils scored in the good range. Landscape, fire, and human effects are broad-scale assessment categories upon which Fort Frederica NM has limited management influence. Consistent reporting and collaboration are essential for these categories. Visitor use is relatively consistent and this fort is visited at an average level compared with other forts managed by the NPS. Only stream flow maintenance had a negative correlation in the hydrology section. Soils have remained relatively consistent with the only limiting factor being the flooding frequency.

Biological integrity (biotic) received a fair rating. The species assemblages present do not appear to reflect the more complete biotic communities observed in the surrounding area. This is perhaps due to the unique salt marsh habitat present at the monument and may be due in part to a lack of comprehensive survey efforts. Other categories that scored in the fair range included climate and water quality. Climate and water quality are categories that will need coordination with other management organizations to improve. Collecting additional water quality data within park boundaries would allow better assessment of in-park resources.

The only category in this assessment to receive a poor rating was air quality. Despite a fair ozone exposure score, the poor rating was a result of high levels of estimated atmospheric deposition and poor visibility due to a high Haze Index score. Similar to landscape, fire, and human effects, air quality is a broad-scale assessment category upon which Fort Frederica NM has limited management influence.

Spatial proximity and thematic (best source) are the limiting factors in data quality. Thematic is often in the fair range for data quality, mostly due to needing more local-scale data. This National Monument was established primarily to protect cultural resources, so a minimal amount of natural resource data has been collected on-site. There are plans to map vegetation communities and continue species and community inventory and monitoring. An observation that was present in several of the assessment categories is the importance of coordination with outside management organizations. It was also noted in several categories that additional local-scale data collection could improve assessment and management.

The good, fair, poor scoring system (Table 57) has its limitations. It is somewhat subjective, especially when pre-established thresholds and criteria were missing. However, in most cases we were able to find thresholds from other agencies or peer-reviewed publications. We make note of the cases where established rating systems or thresholds were not available. With these caveats in mind, we effectively reported on the condition status of important natural resource management categories while providing further information on data quality.

Table 57. Condition status scoring system for Fort Frederica National Monument Natural Resource Assessment.

Score	*Range*	*Midpoint*
Good	0.67 - 1.00	0.84
Fair	0.34 - 0.66	0.5
Poor	0.00 - 0.33	0.17

Table 58. Overall condition status summary for Fort Frederica National Monument. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), *spatial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively (see Table 57).

Category	***Condition Status***	***Score***	***Data Quality***		
			Thematic	*Spatial*	*Temporal*
Landscape dynamics total			0	3	0
	Good	0.84	3 out of 9		
Fire dynamics total			0	1	1
	Good	0.84	2 out of 3		
Human effects total			1	2	2
	Good	0.84	5 out of 6		
Visitor use total			0	1	1
	Good	0.84	2 out of 3		
Air quality total			3	1	3
	Poor	0.28	7 out of 9		
Climate total			5	1	5
	Fair	0.57	11 out of 15		
Hydrology total			0	6	6
	Good	0.73	12 out of 18		
Water quality total			4	0	0
	Fair	0.63	5 out of 12		
Soil total			3	3	3
	Good	0.73	9 out of 9		
Biotic total			5	1	6
	Fair	0.39	12 out of 18		
FOFR overall			21	19	28
	Good	0.67	68 out of 102		

This project provided a comprehensive amount of organized tabular data and many geospatial data layers and maps that will aid in the management of Fort Frederica NM. These data are provided on an accompanying disk and can be used to compare current status to future conditions. This is merely a first step to compiling data and reporting on current condition status, data gaps, and threats and stressors. A well-established assessment protocol will include follow-up and future analysis.

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Appendices

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Appendix A: Land cover calculation methods.

We used "Extract by Mask" in ArcToolbox (ESRI 2006) to clip each land cover dataset to the study areas. In some cases when the study areas went into another state, multiple datasets were mosaicked (combined) in ERDAS Imagine (Leica Geosystems Geospatial Imaging 2004). In some cases we performed grid reclassification and relabeling of class name to simplify and to make the raster files that were produced more useable.

NOAA Coastal Change Analysis Program Classification Scheme (National Oceanic and Atmospheric Administration 2008a):

Uplands
Consisting of areas above sea level where saturated soils and standing water are absent. Also, the Hydrologic regime is not sufficiently wet to support vegetation associated with wetlands. Upland features are divided into classes such as High, Medium, Low Intensity Development, Cultivated land, Grassland, Pasture/ Hay, Barren land, Scrub/Shrub, Dwarf Shrub, Deciduous, Evergreen and Mixed Forest.

2- *Developed, High Intensity* – Includes highly developed areas where people reside or work in high numbers. Impervious surfaces account for 80 to 100 percent of the total cover.
Characteristic land cover features: Large commercial/industrial complexes and associated parking, commercial strip development, large barns, hangars, interstate highways, and runways.

3- *Developed, Medium Intensity* – Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 to 79 percent of the total cover.
Characteristic land cover features: Small buildings such as single family housing units, farm outbuildings, and large sheds.

4- *Developed, Low Intensity* – Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 21 to 49 percent of total cover.
Characteristic land cover features: Same as Medium Intensity Developed with the addition of streets and roads with associated trees and grasses. If roads or portions of roads are present in the imagery they are represented as this class in the final land cover product.

5- *Developed, Open Space* – Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover.
Characteristic land cover features: Parks, lawns, athletic fields, golf courses, and natural grasses occurring around airports and industrial sites.

6- *Cultivated Crops* – Areas used for the production of annual crops. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
Characteristic land cover features: Crops (corn, soybeans, vegetables, tobacco, and cotton), orchards, nurseries, and vineyards.

7- *Pasture/Hay* – Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle and not tilled. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
Characteristic land cover features: Crops such as alfalfa, hay, and winter wheat.

8- *Grassland/Herbaceous* – Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Characteristic land cover features: Prairies, meadows, fallow fields, clear-cuts with natural grasses, and undeveloped lands with naturally occurring grasses.

9- *Deciduous Forest* – Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Characteristic species: Maples (*Acer*), Hickory (*Carya*), Oaks (*Quercus*), and Aspen (*Populus tremuloides*).

10- *Evergreen Forest* – Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
Characteristic species: Longleaf pine (*Pinus palustris*), slash pine (*Pinus ellioti*), shortleaf pine (*Pinus echinta*), loblolly pine (*Pinus taeda*), and other southern yellow (*Picea*); various spruces and balsam fir (*Abies balsamea*); white pine (*Pinus strobus*), red pine (*Pinus resinosa*), and jack pine (*Pinus banksiana*); hemlock (*Tsuga canadensis*); and such western species as Douglas-fir (*Pseudotsuga menziesii*), redwood (*Sequoia sempervirens*), ponderosa pine (*Pinus monticola*), Sitka spruce (*Picea sitchensis*), Engelmann spruce (*Picea engelmanni*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*).

11- *Mixed Forest* – Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
Characteristic species: Those listed in 9 and 10.

12- *Scrub/Shrub* – Areas dominated by shrubs less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.
Characteristic species: Those listed in 9 and 10 as well as chaparral species such as chamise (*Adenostoma fasciculatum*), chaparral honeysuckle (*Lonicera interrupta*), scrub oak (*Quercus beberidifolia*), sagebrush (*artemisia tridentate*), and manzanita (*Arctostaphylos spp.*).

Wetlands
Areas dominated by saturated soils and often standing water. Wetlands vegetation is adapted to withstand long-term immersion and saturated, oxygen-depleted soils. These are divided into two salinity regimes: Palustrine for freshwater wetlands and Estuarine for saltwater wetlands. These

are further divided into Forested, Shrub/Scrub, and Emergent wetlands. Unconsolidated Shores are also included as wetlands.

13- *Palustrine Forested Wetland* – Includes all tidal and nontidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent.
Characteristic species: Tupelo (Nyssa), Cottonwoods (*Populus deltoids*), Bald Cypress (*Taxodium distichum*), American elm (*Ulmus Americana*), Ash (*Fraxinus*), and tamarack.

14- *Palustrine Scrub/Shrub Wetland* – Includes all tidal and non tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent. The species present could be true shrubs, young trees and shrubs, or trees that are small or stunted due to environmental conditions (Cowardin et al. 1979).
Characteristic species: Alders (*Alnus spp*.), willows (*Salix spp*.), buttonbush (*Cephalanthus occidentalis*), red osier dogwood *(Cornus stolonifera*), honeycup (*Zenobia pulverenta*), spirea (*Spiraea douglassii*), bog birch (*Betula pumila*), and young trees such as red maple (*Acer rubrum*) and black spruce (*Picea mariana*).

15- *Palustrine Emergent Wetland (Persistent)* – Includes all tidal and nontidal wetlands dominated by persistent emergent vascular plants, emergent mosses or lichens, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Plants generally remain standing until the next growing season. Total vegetation cover is greater than 80 percent.
Characteristic species: Cattails (*Typha spp*.), sedges (*Carex spp.*), bulrushes (*Scirpus spp.*), rushes (*Juncus spp*.), saw grass (*Cladium jamaicaense*), and reed (*Phragmites australis*).

16- *Estuarine Forested Wetland* – Includes all tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
Characteristic species: Red Mangrove (*Rhizophora mangle*), Black Mangrove (*Avicennia germinans*) and White Mangrove (*Languncularia racemosa*)

17- *Estuarine Scrub / Shrub Wetland* – Includes all tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
Characteristic species: Sea-myrtle (*Baccharis halimifolia*) and marsh elder (*Iva frutescens*).

18- *Estuarine Emergent Wetland* – Includes all tidal wetlands dominated by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens). Wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent and that are present for most of the growing season in most years. Perennial plants usually dominate these wetlands. Total vegetation cover is greater than 80 percent.

Characteristic species: Cordgrass (*Spartina spp.*), needlerush (*Juncus roemerianus*), narrow leaved cattail (*Typha angustifolia*), southern wild rice (*Zizaniopsis miliacea*), common pickleweed (*Salicornia virginica*), sea blite (*Suaeda californica*), and arrow grass (*Triglochin martimum*).

19- *Unconsolidated Shore* – Unconsolidated material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms representing this class.
Characteristic land cover features: Beaches, bars, and flats.

20- *Barren Land* – (rock/sand/clay) Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earth material. Generally, vegetation accounts for less than 10 percent of total cover.
Characteristic land cover features: Quarries, strip mines, gravel pits, dunes, beaches above the high-water line, sandy areas other than beaches, deserts and arid riverbeds, and exposed rock.

21- *Open Water* – All areas of open water, generally with less than 25 percent cover of vegetation or soil.
Characteristic land cover features: Lakes, rivers, reservoirs, streams, ponds, and ocean.

Table A-1. Vegetation reclassification of C-CAP land cover to quantify "natural vegetation", "semi-natural vegetation", and "unnatural vegetation".

Vegetation Class	*C-CAP Class*
Natural Vegetation	Deciduous Forest
	Estuarine Emergent Wetland
	Estuarine Forest Wetland
	Estuarine Shrub/Scrub Wetland
	Evergreen Forest
	Grassland
	Mixed Forest
	Palustrine Emergent Wetland
	Palustrine Forested Wetland
	Palustrine Shrub/Scrub Wetland
	Shrub/Scrub
Semi-natural Vegetation	Cultivated
	Pasture/Hay
	Developed Open Space
Unnatural Vegetation	High Intensity Developed
	Low Intensity Developed
	Medium Intensity Developed
Other	Bare Land
	Unconsolidated Shore
	Water

Appendix B: Hydrology calculation methods.

The 7.5-minute Digital Elevation Model (DEM) raster datasets were produced by the U.S. Geological Survey (2008a), and were obtained from the GeoCommunity website. We used "Extract by Mask" in ArcToolbox (ESRI 2006) to clip each DEM raster to the park boundaries. In some instances, the study areas of interest were contained in multiple quadrangles. In such cases, each raster dataset was clipped to the park boundary using the "Extract by Mask" tool and subsequently merged into one dataset using "Mosaic to New Raster" in ArcToolbox. Having clipped the DEM data to the park boundaries, the data were then reclassified, symbolized, and labeled to illustrate mean sea level, two-foot storm surges, and four-foot storm surges. Each reclassification permitted the analysis of changes in the acreage and percentage of land/water extent in each of the figures.

Appendix C: Soil series description and soil ratings.

Brief Map Unit Description

Fort Frederica National Monument, Georgia

[Only those map units that have entries for the selected description categories are included in this report]

Map unit: BO - Bohicket-Capers association

Description category: SOI

The components in this map unit occur in a regular and repeating pattern.

BOHICKET (BOHICKET, FLOODED)--This very deep, very poorly drained soil is on broad level tidal flats. This soil is mostly clayey throughout. It is flooded twice daily by sea water and is continuously saturated. Permeability is very slow and available water capacity is very low.

CAPERS (CAPERS, FLOODED)--This very deep, very poorly drained soil is on broad level tidal flats. It is clayey to a depth greater than 5 feet. Flooding is common by ocean tides and is continuously saturated. Permeability is very slow and available water capacity is very low.

Map unit: CaB - Cainhoy fine sand, 0 to 5 percent slopes

Description category: SOI

CAINHOY--This very deep, excessively drained soil is on uplands. The soil is sandy throughout. Permeability is rapid and available water capacity is low.

Map unit: Ma - Mandarin fine sand

Description category: SOI

MANDARIN--This very deep, somewhat poorly drained soil is on ridges and knolls. It is sandy throughout. Organic stained layers are within 30 inches of the surface. A seasonal high water table occurs at a depth of 1.5 to 3.5 feet. Permeability is rapid except in the organic hard pan layers where it is moderate. Available water capacity is low.

Map unit: Pe - Pelham loamy sand

Description category: SOI

PELHAM (PELHAM, FLOODED)--This very deep, poorly drained soil is along drainageways. The subsoil is loamy and extends to a depth greater than 5 feet. A seasonal high water table occurs at a depth of 0 to 1.0 foot. Flooding is common. Permeability is moderate and available water capacity is low.

Map unit: Po - Pottsburg sand

Description category: SOI

POTTSBURG (HURRICANE)--This very deep, somewhat poorly drained soil is on low-lying uplands. It is sandy throughout. Organic stained layers occur below a depth of about 51 to 79 inches. A seasonal high water table occurs at a depth of 2 to 3.5 feet. Permeability is moderately rapid and available water capacity is low.

Map unit: Ru - Rutlege fine sand

Description category: SOI

RUTLEGE--This very deep, very poorly drained soil is on upland flats. It is sandy throughout. A seasonal high water table occurs at a depth of 0 to .5 foot. Slopes are 0 to 2 percent. Permeability is rapid and available water capacity is low.

Potential Erosion Hazard (Off-Road, Off-Trail)

Aggregation Method: Dominant Condition
Tie-break Rule: Higher

Fort Frederica National Monument, Georgia
Survey Area Version and Date: 3 - 07/16/2006

Map symbol	Map unit name	Rating	Component name and % composition Rating reasons
BO	Bohicket-Capers association	Slight	Bohicket 80% Capers 20%
CaB	Cainhoy fine sand, 0 to 5 percent slopes	Slight	Cainhoy 100%
Ma	Mandarin fine sand	Slight	Mandarin 95% Rutlege 5%
Pe	Pelham loamy sand	Slight	Pelham 100%
Po	Pottsburg sand	Slight	Pottsburg 95% Rutlege 5%
Ru	Rutlege fine sand	Slight	Rutlege 100%
W	Water	Not rated	Water 100%

Potential Erosion Hazard (Off-Road, Off-Trail)

Rating Options

Attribute Name: Potential Erosion Hazard (Off-Road, Off-Trail)

Ratings indicate the hazard or risk of soil loss from off-road and off-trail areas after disturbance activities that expose the soil surface, and are based on slope and soil erodibility factor K. The soil loss is caused by sheet or rill erosion in off-road or off-trail areas where 50 to 75 percent of the surface has been exposed by logging, grazing, mining, or other kinds of disturbance.

The hazard is described as "Slight", "Moderate", "Severe", or "Very severe". A rating of "Slight" indicates that erosion is unlikely under ordinary climatic conditions; "Moderate" indicates that some erosion is likely and that erosion-control measures may be needed; "Severe" indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised; and "Very severe" indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical.

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value to represent the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. The components in the map unit name represent the major soils within a map unit delineation. Minor components make up the balance of the map unit. Great differences in soil properties can occur between map unit components and within short distances. Minor components may be very different from the major components. Such differences could significantly affect use and management of the map unit. Minor components may or may not be documented in the database. The results of aggregation do not reflect the presence or absence of limitations of the components which are not listed in the database. An on-site investigation is required to identify the location of individual map unit components.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be generated. Aggregation must be done because, on any soil map, map units are delineated but components are not.The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie.

The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Water Features

Fort Frederica National Monument, Georgia

[Depths of layers are in feet. See text for definitions of terms used in this table. Estimates of the frequency of ponding and flooding apply to the whole year rather than to individual months. Absence of an entry indicates that the feature is not a concern or that data were not estimated]

Map symbol and soil name	Hydrologic group	Surface runoff	Months	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface water depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
BO:										
Bohicket	D	---	January	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			February	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			March	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			April	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			May	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			June	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			July	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			August	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			September	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			October	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			November	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
			December	0.0	>6.0	0.0-3.0	Very brief	Frequent	Very brief	Very frequent
Capers	D	---	January	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			February	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			March	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			April	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			May	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			June	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			July	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			August	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			September	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			October	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			November	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
			December	0.0	>6.0	0.0-1.0	Very long	Frequent	Very brief	Very frequent
CaB:										
Cainhoy	A	---	Jan-Dec			---	---	None	---	None

Water Features

Fort Frederica National Monument, Georgia

Map symbol and soil name	Hydrologic group	Surface runoff	Months	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface water depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
Ma:										
Mandarin	C	---	June	1.5-3.5	>6.0	---	---	None	---	None
			July	1.5-3.5	>6.0	---	---	None	---	None
			August	1.5-3.5	>6.0	---	---	None	---	None
			September	1.5-3.5	>6.0	---	---	None	---	None
			October	1.5-3.5	>6.0	---	---	None	---	None
			November	1.5-3.5	>6.0	---	---	None	---	None
			December	1.5-3.5	>6.0	---	---	None	---	None
Rutlege	B/D	---	January	0.0-0.5	>6.0	---	---	None	---	None
			February	0.0-0.5	>6.0	---	---	None	---	None
			March	0.0-0.5	>6.0	---	---	None	---	None
			April	0.0-0.5	>6.0	---	---	None	---	None
			May	0.0-0.5	>6.0	---	---	None	---	None
			December	0.0-0.5	>6.0	---	---	None	---	None
Pe:										
Pelham	B/D	---	January	0.0-1.0	>6.0	---	---	None	Brief	Frequent
			February	0.0-1.0	>6.0	---	---	None	Brief	Frequent
			March	0.0-1.0	>6.0	---	---	None	Brief	Frequent
			April	0.0-1.0	>6.0	---	---	None	---	None
			December	---	---	---	---	None	Brief	Frequent
Po:										
Pottsburg	C	---	January	2.0-3.5	>6.0	---	---	None	---	None
			February	2.0-3.5	>6.0	---	---	None	---	None
			March	2.0-3.5	>6.0	---	---	None	---	None
			April	2.0-3.5	>6.0	---	---	None	---	None
			November	2.0-3.5	>6.0	---	---	None	---	None
			December	2.0-3.5	>6.0	---	---	None	---	None

Water Features

Fort Frederica National Monument, Georgia

Map symbol and soil name	Hydrologic group	Surface runoff	Months	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface water depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
Po:										
Rutlege	B/D	---	January	0.0-0.5	>6.0	---	---	None	---	None
			February	0.0-0.5	>6.0	---	---	None	---	None
			March	0.0-0.5	>6.0	---	---	None	---	None
			April	0.0-0.5	>6.0	---	---	None	---	None
			May	0.0-0.5	>6.0	---	---	None	---	None
			December	0.0-0.5	>6.0	---	---	None	---	None
Ru:										
Rutlege	B/D	---	January	0.0-0.5	>6.0	---	---	None	---	None
			February	0.0-0.5	>6.0	---	---	None	---	None
			March	0.0-0.5	>6.0	---	---	None	---	None
			April	0.0-0.5	>6.0	---	---	None	---	None
			May	0.0-0.5	>6.0	---	---	None	---	None
			December	0.0-0.5	>6.0	---	---	None	---	None
W:										
Water	---	---	Jan-Dec			---	---	None	---	None

Drainage Class

Aggregation Method: Dominant Condition
Tie-break Rule: Higher

Fort Frederica National Monument, Georgia
Survey Area Version and Date: 3 - 07/16/2006

Map symbol	Map unit name	Rating
BO	Bohicket-Capers association	Very poorly drained
CaB	Cainhoy fine sand, 0 to 5 percent slopes	Excessively drained
Ma	Mandarin fine sand	Somewhat poorly drained
Pe	Pelham loamy sand	Poorly drained
Po	Pottsburg sand	Somewhat poorly drained
Ru	Rutlege fine sand	Very poorly drained
W	Water	

Drainage Class

Rating Options

Attribute Name: Drainage Class

Drainage class (natural) refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized -- excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. These classes are defined in the "Soil Survey Manual."

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value to represent the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. The components in the map unit name represent the major soils within a map unit delineation. Minor components make up the balance of the map unit. Great differences in soil properties can occur between map unit components and within short distances. Minor components may be very different from the major components. Such differences could significantly affect use and management of the map unit. Minor components may or may not be documented in the database. The results of aggregation do not reflect the presence or absence of limitations of the components which are not listed in the database. An on-site investigation is required to identify the location of individual map unit components.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be generated. Aggregation must be done because, on any soil map, map units are delineated but components are not.The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie.

The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Map Unit Hydric Rating

Aggregation Method: Absence/Presence
Tie-break Rule: Lower

Fort Frederica National Monument, Georgia
Survey Area Version and Date: 3 - 07/16/2006

Map symbol	Map unit name	Rating
BO	Bohicket-Capers association	All Hydric
CaB	Cainhoy fine sand, 0 to 5 percent slopes	Not Hydric
Ma	Mandarin fine sand	Partially Hydric
Pe	Pelham loamy sand	All Hydric
Po	Pottsburg sand	Partially Hydric
Ru	Rutlege fine sand	All Hydric
W	Water	Not Hydric

Map Unit Hydric Rating

Rating Options

Attribute Name: Map Unit Hydric Rating

This rating provides an indication of the proportion of the map unit that meets criteria for hydric soils. Map units that are dominantly made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the higher positions on the landform, and map units dominantly made up of nonhydric soils may have inclusions of hydric soils in the lower positions on the landform.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2003) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and others, 2002).

Aggregation Method: Absence/Presence

Aggregation is the process by which a set of component attribute values is reduced to a single value to represent the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. The components in the map unit name represent the major soils within a map unit delineation. Minor components make up the balance of the map unit. Great differences in soil properties can occur between map unit components and within short distances. Minor components may be very different from the major components. Such differences could significantly affect use and management of the map unit. Minor components may or may not be documented in the database. The results of aggregation do not reflect the presence or absence of limitations of the components which are not listed in the database. An on-site investigation is required to identify the location of individual map unit components.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be generated. Aggregation must be done because, on any soil map, map units are delineated but components are not.The aggregation method "Absence/Presence" returns a value that indicates if, for all components of a map unit, a condition is always present, never present, partially present, or whether the condition's presence or absence is unknown. The exact phrases used for a particular attribute may vary from what is shown below.

"Always present" means that the corresponding condition is present in all of a map unit's components.

"Never present" means that the corresponding condition is not present in any of a map unit's components.

"Partially present" means that the corresponding condition is present in some but not all of a map unit's components, or that the presence or absence of the corresponding condition cannot be determined for one or more components of the map unit.

"Unknown presence" means that for components where presence or absence can be determined, the corresponding condition is never present, but the presence or absence of the corresponding condition cannot be determined for one or more components.

The result returned by this aggregation method quantifies the degree to which the corresponding condition is present throughout the map unit.

Tie-break Rule: Lower

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Soil Features

Fort Frederica National Monument, Georgia

[Absence of an entry indicates that the feature is not a concern or that data were not estimated]

Map symbol and soil name Concrete	Restrictive layer				Subsidence		Potential for frost Hardness	Risk of corrosion	
	Kind	Depth	to top	Thickness				action	Uncoated
	Kind Concrete	Depth	to top	Thickness	Hardness	Initial	Total	action	Uncoated
	Kind	to top	Thickness	Hardness				steel	
		In	*In*		*In*	*In*			
BO:									
Bohicket	---	---	---	---	---	6-12	---	High	High
Capers	---	---	---	---	3-6	4-8	---	High	High
CaB:									
Cainhoy	---	---	---	---	---	---	---	Low	Moderate
Ma:									
Mandarin	---	---	---	---	---	---	---	Moderate	High
Rutlege	---	---	---	---	0	---	---	High	High
Pe:									
Pelham	---	---	---	---	---	---	---	High	High
Po:									
Pottsburg	---	---	---	---	---	---	---	Low	Moderate
Rutlege	---	---	---	---	0	---	---	High	High
Ru:									
Rutlege	---	---	---	---	0	---	---	High	High
W:									
Water	---	---	---	---	---	---	---	---	---

Camp Areas, Picnic Areas, and Playgrounds (GA)

Camden and Glynn Counties, Georgia

[The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Map symbol and soil name	Pct. of map unit	Camp areas (GA)		Picnic areas (GA)		Playgrounds (GA)	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
BO:							
Bohicket	80	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Ponding	1.00	Depth to saturated zone	1.00
		Sodium content	1.00	Depth to saturated zone	1.00	Sodium content	1.00
		Salinity	1.00	Sodium content	1.00	Salinity	1.00
		Flooding	1.00	Salinity	1.00	Flooding	1.00
		Ponding	1.00	Slow water	1.00	Ponding	1.00
Capers	20	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Ponding	1.00	Depth to saturated zone	1.00
		Flooding	1.00	Depth to saturated zone	1.00	Flooding	1.00
		Ponding	1.00	Slow water	1.00	Ponding	1.00
		Slow water	1.00	Too clayey	1.00	Slow water	1.00
		Too clayey	1.00	Flooding	0.60	Too clayey	1.00
CaB:							
Cainhoy	100	Very limited		Very limited		Very limited	
		Too sandy	1.00	Too sandy	1.00	Too sandy	1.00
						Slope	0.13
Ma:							
Mandarin	95	Very limited		Very limited		Very limited	
		Too sandy	1.00	Too sandy	1.00	Too sandy	1.00
Rutlege	5	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Too sandy	1.00	Depth to saturated zone	1.00
		Too sandy	1.00	Depth to saturated zone	1.00	Too sandy	1.00
Pe:							
Pelham	100	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Flooding	1.00	Too sandy	0.79	Flooding	1.00
		Too sandy	0.79	Flooding	0.40	Too sandy	0.79
Po:							
Pottsburg	95	Very limited		Very limited		Very limited	
		Too sandy	1.00	Too sandy	1.00	Too sandy	1.00
Rutlege	5	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Too sandy	1.00	Depth to saturated zone	1.00
		Too sandy	1.00	Depth to saturated zone	1.00	Too sandy	1.00

Camp Areas, Picnic Areas, and Playgrounds (GA)

Camden and Glynn Counties, Georgia

Map symbol and soil name	Pct. of map unit	Camp areas (GA)		Picnic areas (GA)		Playgrounds (GA)	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
Ru:							
Rutlege	100	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Too sandy	1.00	Depth to saturated zone	1.00
		Too sandy	1.00	Depth to saturated zone	1.00	Too sandy	1.00
W:							
Water	100	Not Rated		Not Rated		Not Rated	

Camp Areas, Picnic Areas, and Playgrounds (GA)

The soils of the survey area are rated in this table according to limitations that affect their suitability for camp areas, picnic areas, and playgrounds. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the recreational uses. “Not limited” indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. “Somewhat limited” indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. “Very limited” indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation also are important. Soils that are subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

The information in this table can be supplemented by other information, for example, interpretations for dwellings without basements, for local roads and streets, and for septic tank absorption fields.

“Camp areas” require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The ratings are based on the soil properties that affect the ease of developing camp areas and the performance of the areas after development. Slope, stoniness, and depth to bedrock or a cemented pan are the main concerns affecting the development of camp areas. The soil properties that affect the performance of the areas after development are those that influence trafficability and promote the growth of vegetation, especially in heavily used areas. For good trafficability, the surface of camp areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, saturated hydraulic conductivity (Ksat), and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, Ksat, and toxic substances in the soil.

“Picnic areas” are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The ratings are based on the soil properties that affect the ease of developing picnic areas and that influence trafficability and the growth of vegetation after development. Slope and stoniness are the main concerns affecting the development of picnic areas. For good trafficability, the surface of picnic areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, Ksat, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, Ksat, and toxic substances in the soil.

“Playgrounds” require soils that are nearly level, are free of stones, and can withstand intensive foot traffic. The ratings are based on the soil properties that affect the ease of developing playgrounds and that influence trafficability and the growth of vegetation after development. Slope and stoniness are the main concerns affecting the development of playgrounds. For good trafficability, the surface of the playgrounds should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, Ksat, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, Ksat, and toxic substances in the soil.

Paths, Trails, and Golf Fairways (GA)

Camden and Glynn Counties, Georgia

[The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Map symbol and soil name	Pct. of map unit	Paths and trails (GA)		Golf fairways	
		Rating class and limiting features	Value	Rating class and limiting features	Value
BO:					
Bohicket	80	Very limited		Very limited	
		Depth to saturated zone	1.00	Ponding	1.00
		Ponding	1.00	Flooding	1.00
		Too clayey	1.00	Salinity	1.00
		Flooding	0.60	Sodium content	1.00
				Depth to saturated zone	1.00
Capers	20	Very limited		Very limited	
		Depth to saturated zone	1.00	Ponding	1.00
		Ponding	1.00	Flooding	1.00
		Too clayey	1.00	Depth to saturated zone	1.00
		Flooding	0.60	Droughty	1.00
				Sulfur content	1.00
CaB:					
Cainhoy	100	Very limited		Somewhat limited	
		Too sandy	1.00	Droughty	0.69
Ma:					
Mandarin	95	Very limited		Somewhat limited	
		Too sandy	1.00	Droughty	0.33
Rutlege	5	Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Too sandy	1.00	Droughty	0.76
				Too sandy	0.50
Pe:					
Pelham	100	Very limited		Very limited	
		Depth to saturated zone	1.00	Flooding	1.00
		Too sandy	0.79	Depth to saturated zone	1.00
		Flooding	0.40	Droughty	0.13
Po:					
Pottsburg	95	Very limited		Very limited	
		Too sandy	1.00	Droughty	1.00
				Too sandy	0.50

Paths, Trails, and Golf Fairways (GA)

Camden and Glynn Counties, Georgia

Map symbol and soil name	Pct. of map unit	Paths and trails (GA)		Golf fairways	
		Rating class and limiting features	Value	Rating class and limiting features	Value
Po:					
Rutlege	5	Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Too sandy	1.00	Droughty	0.76
				Too sandy	0.50
Ru:					
Rutlege	100	Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Too sandy	1.00	Droughty	0.76
				Too sandy	0.50
W:					
Water	100	Not Rated		Not rated	

Paths, Trails, and Golf Fairways (GA)

The soils of the survey area are rated in this table according to limitations that affect their suitability for paths, trails, and golf fairways. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the recreational uses. “Not limited” indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. “Somewhat limited” indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. “Very limited” indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation also are important. Soils that are subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

“Paths and trails” for hiking and horseback riding should require little or no slope modification through cutting and filling. The ratings are based on the soil properties that affect trafficability and erodibility. These properties are stoniness, depth to a water table, ponding, flooding, slope, and texture of the surface layer.

“Golf fairways” are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. Irrigation is not considered in the ratings. The ratings are based on the soil properties that affect plant growth and trafficability after vegetation is established. The properties that affect plant growth are reaction; depth to a water table; ponding; depth to bedrock or a cemented pan; the available water capacity in the upper 40 inches; the content of salts, sodium, or calcium carbonate; and sulfidic materials. The properties that affect trafficability are flooding, depth to a water table, ponding, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer. The suitability of the soil for traps, tees, roughs, and greens is not considered

Appendix D: Reference species lists from habitat distribution models published by the Georgia Gap Analysis Program (UGA Institute of Ecology and GA Cooperative Fish & Wildlife Research Unit 2003).

GA GAP Amphibians:

Flatwoods salamander
Marbled salamander
Mole salamander
Tiger salamander
Two-toed amphiuma
Southern dusky salamander
Southern two-lined salamander
Slimy salamander complex
Mud salamander
Many-lined salamander
Striped newt
Red-spotted/Central newt
Dwarf siren
Lesser siren
Greater siren
Southern chorus frog
Ornate chorus frog
Greenhouse frog
Green frog/bronze frog
River frog
Carpenter frog
Gopher frog
Dwarf salamander
Southern toad
Fowler's toad
Southern cricket frog
Cope's gray treefrog
Green treefrog
Pine woods treefrog
Barking treefrog
Squirrel treefrog
Spring peeper
Little grass frog
Eastern narrowmouth toad
Eastern spadefoot toad
Bullfrog
Pig frog
Southern leopard frog

GA GAP Reptiles:

Loggerhead
Chicken Turtle
Diamondback Terrapin
Box Turtle
Slider
Striped Mud Turtle
Eastern Mud Turtle
Gopher Tortoise
Florida Softshell
Green Anole
Brown Anole
Fence Lizard
Five-lined Skink
Southeastern Five-lined Skink
Broadhead Skink
Ground Skink
Six-lined Racerunner
Scarlet Snake
Black Racer
Ringneck Snake
Indigo Snake
Corn Snake
Yellow/Black/Gray Rat Snake
Mud Snake
Rainbow Snake
Eastern Hognose Snake
Black/Eastern Kingsnake
Coachwhip
Plainbelly Water Snake
Banded Water Snake
Rough Green Snake
Pine Woods Snake
Red-bellied Snake
Ribbon Snake
Eastern Garter Snake
Rough Earth Snake
Coral Snake
Cottonmouth
Eastern Diamondback Rattlesnake
Canebrake/Timber Rattlesnake
Pigmy Rattlesnake
Snapping Turtle
Spotted Turtle
Florida Cooter
Stripeneck/Loggerhead Musk Turtle
Common Musk Turtle
Spiny Softshell
American Alligator
Slender Glass Lizard
Island Glass Lizard
Eastern Glass Lizard
Mimic Glass Lizard
Mole Skink
Southern Hognose Snake
Milk snake
Scarlet kingsnake
Brown Water Snake
Pine Snake
Glossy Crayfish Snake
Black Swamp Snake
Brown Snake

GA GAP Mammals:

Seminole bat
Hoary bat
Northern yellow bat
Evening bat
Rafinesque's big-eared bat
Brazilian free-tailed bat
Eastern cottontail
Eastern fox squirrel
Southern flying squirrel
Southeastern pocket gopher
American beaver
Eastern harvest mouse
Golden mouse
Black rat
Norway rat
House mouse
Coyote
Red fox
Common gray fox
Common raccoon
Long-tailed weasel
Mink
Eastern spotted skunk
Striped skunk
Northern river otter
Bobcat
White-tailed deer

Appendix E: The following species lists (Appendix F through Appendix J) have been cross-referenced to NatureServe's global and state rankings (NatureServe 2008); and the GA DNR listings for endangered, threatened, or rare species (GA DNR Wildlife Resources Division 2008). These are further explanations of the rank and status abbreviations.

NatureServe Ranks (NatureServe 2008)

Global Ranks:
G#G#: NatureServe Global Conservation Status Rank, Range Rank - A numeric range rank (e.g., G2G3) is used to indicate the rank of uncertainty in the status of a species or community. Ranges cannot skip more than one rank (e.g., GU should be used rather than G1G4).

G1: Critically Imperiled
At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.

G2: Imperiled
At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.

G3: Vulnerable
At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.

G4: Apparently Secure
Uncommon but not rare; some cause for long-term concern due to declines or other factors.

G5: Secure
Common; widespread, and abundant.

State Ranks:
S#S#: NatureServe Subnational Conservation Status Rank - Range Rank-A numeric range rank (e.g., S2S3) is used to indicate the range of uncertainty about the status of the species or community. Ranges cannot skip more than one rank (e.g., SU should be used rather than S1S4).

S?: Unranked
State/Province conservation status not yet assessed.

S1: Critically Imperiled
Critically imperiled in the state or province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state or province.

S2: Imperiled
Imperiled in the state or province because of rarity due to very restricted range, very few

populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state or province.

S3: Vulnerable
Vulnerable in the state or province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

S4: Apparently Secure
Uncommon but not rare; some cause for long-term concern due to declines or other factors.

S5: Secure
Common, widespread, and abundant in the state or province.

GA DNR listings for endangered, threatened, or rare species (GA DNR Wildlife Resources Division 2008)

Federal Status (From US Fish and Wildlife Service):
LE: Listed as endangered. The most critically imperiled species. A species that may become extinct or disappear from a significant part of its range if not immediately protected.

LT**:** Listed as threatened. The next most critical level of threatened species. A species that may become endangered if not protected.

PE or PT: Candidate species currently proposed for listing as endangered or threatened.

C: Candidate species presently under status review for federal listing for which adequate information exists on biological vulnerability and threats to list the taxa as endangered or threatened.

PDL: Proposed for delisting.

E(S/A) or T(S/A): Listed as endangered or threatened because of similarity of appearance.

(PS): Indicates "partial status" - status in only a portion of the species' range. Typically indicated in a "full" species record where an infraspecific taxon or population has U.S. ESA status, but the entire species does not.

State Status (From Georgia Department of Natural Resources):
E: Listed as endangered. A species which is in danger of extinction throughout all or part of its range

T: Listed as threatened. A species which is likely to become an endangered species in the foreseeable future throughout all or parts of its range.

R: Listed as rare. A species which may not be endangered or threatened but which should be protected because of its scarcity.

U: Listed as unusual (and thus deserving of special consideration). Plants subject to commercial exploitation would have this status.

Appendix F: Plant species documented at Fort Frederica National Monument or species that may be present in the park. These species have been cross referenced to the GA Comprehensive Wildlife Conservation Strategy (GA DNR Wildlife Resources Division 2005) high priority species in the southern coastal plain (SCP); and the GA DNR listings for endangered, threatened, or rare species (GA DNR Wildlife Resources Division 2008). See reference or Appendix E for explanation of abbreviations.

Scientific Name	***Common Name(s)***	***Abundance***	***Nativity***	***Weedy?***	***Management Priority***	***SCP high priority species***	***Global Rank***	***State Rank***	***Federal Status***	***State Status***
Present in Park:										
Chaerophyllum tainturieri	chervil, hairy-fruit chervil, hairyfruit chervil	Unknown	Native	No	No					
Hydrocotyle bonariensis	largeleaf pennywort	Abundant	Native	No	No					
Hydrocotyle umbellata	manyflower marshpennywort, umbrella pennyroyal	Unknown	Native	No	No					
Ptilimnium capillaceum	herbwilliam, threadleaf, mock bishopweed	Unknown	Native	No	No	YES	G5	SH		
Sanicula canadensis	Canada sanicle, Canadian blacksnakeroot	Unknown	Native	No	No					
Aralia spinosa	angelicatree, devil's walkingstick, devils walkingstick	Unknown	Native	No	No					
Arisaema dracontium	green dragon, greendragon	Unknown	Native	No	No					
Sabal minor	dwarf palmetto	Unknown	Native	No	No					
Sabal palmetto	cabbage palm, cabbage palmetto	Unknown	Native	No	No					
Serenoa repens	saw palmetto	Unknown	Native	No	No					
Ambrosia artemisiifolia	annual ragweed, common ragweed, low ragweed	Unknown	Native	No	No					
Baccharis angustifolia	saltwater false willow	Unknown	Native	No	No					
Baccharis halimifolia	eastern baccharis	Unknown	Native	No	No					
Borrichia frutescens	bushy seaoxeye, bushy seaside tansy	Unknown	Native	No	No					
Carphephorus odoratissimus	vanillaleaf	Unknown	Native	No	No					
Cirsium horridulum var. horridulum	yellow thistle	Unknown	Native	No	No					

Scientific Name	*Common Name(s)*	*Abundance*	*Nativity*	*Weedy?*	*Management Priority*	*SCP high priority species*	*Global Rank*	*State Rank*	*Federal Status*	*State Status*
Cirsium nuttallii	Nuttall's thistle	Unknown	Native	No	No					
Conyza bonariensis	asthmaweed, flaxleaved fleabane, hairy fleabane	Unknown	Native	No	No					
Conyza canadensis	Canadian horseweed, horseweed, horseweed fleabane	Unknown	Native	No	No					
Elephantopus elatus	tall elephantsfoot	Unknown	Native	No	No					
Elephantopus nudatus	naked elephantfoot, smooth elephantsfoot	Unknown	Native	No	No					
Erigeron quercifolius	oakleaf fleabane	Unknown	Native	No	No					
Eupatorium capillifolium	dogfennel	Unknown	Native	No	No					
Facelis retusa	annual trampweed	Unknown	Non-Native	No	No					
Gamochaeta pensylvanica	Pennsylvania everlasting	Unknown	Native	No	No					
Iva frutescens	bigleaf sumpweed, Jesuit's bark	Unknown	Native	No	No					
Krigia virginica	Virginia dwarfdandelion	Unknown	Native	No	No					
Melanthera nivea	snow squarestem	Unknown	Native	No	No					
Mikania scandens	climbing hempvine, climbing hempweed	Unknown	Native	No	No					
Pluchea rosea	rosy camphorweed	Unknown	Native	No	No					
Pyrrhopappus carolinianus var. georgianus		Unknown	Native	No	No					
Solidago odora	anisescented goldenrod, fragrant goldenrod	Unknown	Native	No	No					
Sonchus asper	perennial sowthistle, prickly sowthistle, spiny sowthistle	Unknown	Non-Native	No	No					
Symphyotrichum tenuifolium	perennial saltmarsh aster	Unknown	Native	No	No					
Taraxacum officinale	blowball, common dandelion, dandelion, faceclock	Unknown	Non-Native	No	No					
Verbesina occidentalis	yellow crownbeard	Unknown	Native	No	No					
Verbesina	iceweed, Virginia crownbeard,	Unknown	Native	No	No					

Scientific Name	Common Name(s)	Abundance	Nativity	Weedy?	Management Priority	SCP high priority species	Global Rank	State Rank	Federal Status	State Status
virginica	white crownbeard									
Youngia japonica	oriental false hawksbeard	Unknown	Non-Native	No	No					
Batis maritima	saltwort, turtleweed	Unknown	Native	No	No					
Tillandsia usneoides	Spanish moss	Abundant	Native	No	No					
Specularia perfoliata		Unknown	Native	No	No					
Cardamine hirsuta	hairy bittercress	Unknown	Non-Native	No	No					
Lepidium virginicum	peppergrass, poorman pepperweed, Virginia pepperweed	Unknown	Native	No	No					
Opuntia humifusa	devil's-tongue, pricklypear	Unknown	Native	No	No					
Cerastium glomeratum	sticky chickweed	Unknown	Non-Native	No	No					
Paronychia baldwinii ssp. riparia	Baldwin's nailwort	Unknown	Native	No	No					
Spergularia salina	salt sandspurry	Unknown	Native	No	No					
Stellaria media	chickweed, common chickweed, nodding chickweed	Unknown	Non-Native	No	No					
Salicornia virginica	Virginia glasswort	Unknown	Native	No	No					
Ilex glabra	inberry, inkberry	Common	Native	No	No					
Ilex myrtifolia	myrtle dahoon	Unknown	Native	No	No					
Ilex opaca	American holly	Unknown	Native	No	No					
Ilex vomitoria	yaupon	Abundant	Native	No	No					
Tradescantia ohiensis	bluejacket, Ohio spiderwort	Unknown	Native	No	No					
Cornus florida	flowering dogwood	Unknown	Native	No	No					
Nyssa sylvatica	black gum, black tupelo, blackgum	Unknown	Native	No	No					
Cycas revoluta	sago palm	Unknown	Non-Native	No	No					
Carex longii	Long's sedge	Unknown	Native	No	No					

Scientific Name	***Common Name(s)***	***Abundance***	***Nativity***	***Weedy?***	***Management Priority***	***SCP high priority species***	***Global Rank***	***State Rank***	***Federal Status***	***State Status***
Cyperus croceus	Baldwin's flatsedge	Unknown	Native	No	No					
Cyperus pseudovegetus	marsh flatsedge	Unknown	Native	No	No					
Cyperus retrorsus	pine barren flatsedge	Unknown	Native	No	No					
Cyperus strigosus	stawcolored flatsedge, strawcolored nutgrass	Unknown	Native	No	No					
Eleocharis vivipara	viviparous spikerush	Unknown	Native	No	No					
Rhynchospora colorata	starrush whitetop	Unknown	Native	No	No					
Rhynchospora miliacea	millet beaksedge	Unknown	Native	No	No					
Scleria triglomerata	whip nutrush	Unknown	Native	No	No					
Agrostis stolonifera	carpet bentgrass, creeping bent, creeping bentgrass	Unknown	Non-Native	No	No					
Arundinaria gigantea	giant cane	Occasional	Native	No	No					
Cenchrus longispinus	burgrass, field sandbur, innocent-weed	Unknown	Native	No	No					
Chasmanthium laxum	slender woodoats, spike uniola	Unknown	Native	No	No					
Chasmanthium sessiliflorum	longleaf spikegrass, longleaf woodoats	Unknown	Native	No	No					
Cynodon dactylon	Bermudagrass	Unknown	Non-Native	No	No					
Dichanthelium commutatum	variable panicgrass	Unknown	Native	No	No					
Dichanthelium strigosum var. leucoblepharis	roughhair rosette grass	Unknown	Native	No	No					
Distichlis spicata	desert saltgrass, inland saltgrass, marsh spikegrass	Unknown	Native	No	No					
Glyceria striata	fowl manna grass, fowl mannagrass	Unknown	Native	No	No					
Oplismenus hirtellus	bristle basketgrass	Unknown	Native	No	No					

Scientific Name	*Common Name(s)*	*Abundance*	*Nativity*	*Weedy?*	*Management Priority*	*SCP high priority species*	*Global Rank*	*State Rank*	*Federal Status*	*State Status*
Paspalum laeve	field paspalum	Unknown	Native	No	No					
Piptochaetium avenaceum	blackseed needlegrass, blackseed speargrass	Unknown	Native	No	No					
Poa annua	annual blue grass, annual bluegrass, walkgrass	Rare	Non-Native	Yes	No					
Sorghum halepense	Johnson grass	Unknown	Non-Native	No	No					
Spartina alterniflora	Atlantic cordgrass, saltmarsh cordgrass, smooth cordgrass	Unknown	Native	No	No					
Spartina bakeri	sand cordgrass	Unknown	Native	No	No					
Spartina cynosuroides	big cordgrass	Unknown	Native	No	No					
Sphenopholis obtusata	prairie wedgegrass, prairie wedgescale	Unknown	Native	No	No					
Stenotaphrum secundatum	St. Augustine grass, St. Augustinegrass	Unknown	Native	No	No					
Lonicera japonica		Occasional	Non-Native	Yes	Yes					
Lonicera sempervirens	trumpet honeysuckle	Unknown	Native	No	No					
Diospyros virginiana	common persimmon, eastern persimmon, Persimmon	Unknown	Native	No	No					
Sideroxylon tenax	tough bully	Unknown	Native	No	No					
Symplocos tinctoria		Unknown	Native	No	No					
Vaccinium arboreum	farkleberry, tree sparkleberry, tree-huckelberry	Unknown	Native	No	No					
Vaccinium corymbosum	highbush blueberry	Unknown	Native	No	No					
Vaccinium elliottii	Elliott's blueberry	Unknown	Native	No	No					
Vaccinium fuscatum	black highbush blueberry	Unknown	Native	No	No					
Cnidoscolus stimulosus	finger rot	Unknown	Native	No	No					
Croton willdenowii	two-fruit rushfoil, Willdenow's croton	Unknown	Native	No	No					

Scientific Name	Common Name(s)	Abundance	Nativity	Weedy?	Management Priority	SCP high priority species	Global Rank	State Rank	Federal Status	State Status
Triadica sebifera	Chinese tallow tree, Florida aspen, popcorn tree	Rare	Non-Native	No	No					
Amorpha herbacea	clusterspike false indigo	Unknown	Native	No	No					
Centrosema virginianum	butterflypea, spurred butterfly pea	Unknown	Native	No	No					
Cercis canadensis	eastern redbud, Redbud	Unknown	Native	No	No					
Chamaecrista fasciculata var. fasciculata	sleepingplant	Unknown	Native	No	No					
Chamaecrista nictitans var. nictitans	partridge pea	Unknown	Native	No	No					
Clitoria mariana	Atlantic pigeonwings, pidgeonwings	Unknown	Native	No	No					
Desmodium incanum	tickclover	Unknown	Native	No	No					
Desmodium paniculatum	narrow-leaf tick-trefoil, panicled tickclover	Abundant	Native	No	No					
Desmodium tenuifolium	slimleaf ticktrefoil	Unknown	Native	No	No					
Erythrina herbacea	eastern coralbean, redcardinal	Unknown	Native	No	No					
Lespedeza hirta	hairy lespedeza	Unknown	Native	No	No					
Lespedeza X manniana	Mann's lespedeza	Unknown	Native	No	No					
Medicago arabica	spotted burclover, spotted medick	Unknown	Non-Native	No	No					
Medicago polymorpha	bur clover, burclover, California burclover, toothed medick	Unknown	Non-Native	No	No					
Sesbania punicea	rattelbox, rattlebox	Unknown	Non-Native	Yes	No					
Trifolium campestre	Field (Big-hop) clover, field clover, large hop clover	Unknown	Non-Native	No	No					
Trifolium repens	Dutch clover, ladino clover, white clover	Unknown	Non-Native	No	No					
Vicia	garden vetch	Unknown	Non-	No	No					

Scientific Name	***Common Name(s)***	***Abundance***	***Nativity***	***Weedy?***	***Management Priority***	***SCP high priority species***	***Global Rank***	***State Rank***	***Federal Status***	***State Status***
angustifolia			Native							
Wisteria sinensis	Chinese wisteria	Common	Non-Native	Yes	No					
Castanea pumila	Allegeny chinkapin, chinkapin, northern catalpa	Unknown	Native	No	No					
Quercus nigra		Unknown	Native	No	No					
Quercus virginiana	live oak	Unknown	Native	No	No					
Nerium oleander	oleander	Unknown	Non-Native	No	No					
Geranium carolinianum	Carolina crane's-bill, Carolina geranium	Unknown	Native	No	No					
Oxalis rubra	Oxalis rubra, windowbox woodsorrel	Unknown	Non-Native	No	No					
Oxalis stricta	common yellow oxalis, erect woodsorrel, sheep sorrel, sourgrass	Unknown	Native	No	No					
Oxalis violacea	purple woodsorrel, violet wood-sorrel, violet woodsorrel	Unknown	Native	No	No					
Liquidambar styraciflua	sweetgum	Unknown	Native	No	No					
Platanus occidentalis	American sycamore, sycamore	Unknown	Native	No	No					
Carya glabra	pignut hickory	Unknown	Native	No	No					
Carya illinoinensis	pecan	Unknown	Native	No	No					
Juncus roemerianus	needlegrass rush	Unknown	Native	No	No					
Salvia lyrata	lyreleaf sage	Unknown	Native	No	No					
Stachys floridana	Florida betony, Florida hedgenettle	Unknown	Native	No	No					
Callicarpa americana	American beautyberry	Common	Native	No	No					
Lantana camara	lantana, largeleaf lantana	Unknown	Non-Native	Yes	No					
Phyla nodiflora	frog fruit, sawtooth fogfruit, turkey tangle, turkey tangle fogfruit	Unknown	Native	No	No					

Scientific Name	*Common Name(s)*	*Abundance*	*Nativity*	*Weedy?*	*Management Priority*	*SCP high priority species*	*Global Rank*	*State Rank*	*Federal Status*	*State Status*
Cinnamomum camphora	camphor laurel, camphor tree, camphortree	Unknown	Non-Native	Yes	No					
Persea borbonia	redbay	Unknown	Native	No	No					
Sassafras albidum	sassafras	Unknown	Native	No	No					
Yucca aloifolia	aloe yucca	Unknown	Native	No	No					
Iris hexagona	Dixie iris	Unknown	Native	No	No					
Sisyrinchium rosulatum	annual blue-eyed grass, annual blueeyed grass	Unknown	Native	No	No					
Leucojum aestivum	summer snowflake	Unknown	Non-Native	No	No					
Narcissus X medioluteus	primrose peerless	Unknown	Non-Native	No	No					
Nothoscordum bivalve	crowpoison	Unknown	Native	No	No					
Smilax auriculata	earleaf greenbrier	Unknown	Native	No	No					
Smilax smallii	lanceleaf greenbrier, small greenbrier	Unknown	Native	No	No					
Asimina parviflora	smallflower pawpaw	Unknown	Native	No	No					
Magnolia virginiana	sweetbay	Unknown	Native	No	No					
Morella cerifera	wax myrtle, waxmyrtle	Unknown	Native	No	No					
Lagerstroemia indica	crapemyrtle	Unknown	Non-Native	No	No					
Juniperus virginiana var. silicicola	coast juniper, coastal redcedar, southern red-cedar	Unknown	Native	No	No					
Pinus taeda	loblolly pine	Unknown	Native	No	No					
Plantago major	broadleaf plantain, buckhorn plantain, common plantain	Unknown	Native	No	No					
Plantago virginica	paleseed Indianwheat, Virginia plantain	Unknown	Native	No	No					
Rumex acetosella	common sheep sorrel, field sorrel, red (or sheep) sorrel	Unknown	Non-Native	No	No					
Woodwardia areolata	chainfern, netted chainfern	Unknown	Native	No	No					

Scientific Name	*Common Name(s)*	*Abundance*	*Nativity*	*Weedy?*	*Management Priority*	*SCP high priority species*	*Global Rank*	*State Rank*	*Federal Status*	*State Status*
Pteridium aquilinum	bracken, bracken fern, brackenfern, northern bracken fern	Unknown	Native	No	No					
Osmunda cinnamomea	cinnamon fern	Unknown	Native	No	No					
Polypodium polypodioides		Unknown	Native	No	No					
Pteris etata		Unknown	Non-Native	No	No					
Thelypteris dentata	downy maiden fern, mountain woodfern	Unknown	Native	No	No					
Samolus valerandi ssp. parviflorus	seaside brookweed, smallflower water pimpernel, water brookweed	Unknown	Native	No	No					
Cocculus carolinus	Carolina coralbead, Carolina snailseed, redberry moonseed	Unknown	Native	No	No					
Parthenocissus quinquefolia	American ivy, fiveleaved ivy, Virginia creeper, woodbine	Unknown	Native	No	No					
Vitis aestivalis	summer grape	Unknown	Native	No	No					
Vitis rotundifolia	muscadine, muscadine grape	Abundant	Native	No	No					
Pittosporum tobira	Japanese cheesewood	Unknown	Non-Native	No	No					
Prunus caroliniana	Carolina laurelcherry	Unknown	Native	No	No					
Prunus serotina	black cherry, black chokecherry	Unknown	Native	No	No					
Prunus umbellata	flatwood plum, hog plum	Unknown	Native	No	No					
Rubus trivialis	southern dewberry	Unknown	Native	No	No					
Cephalanthus occidentalis	buttonbush, common buttonbush	Unknown	Native	No	No					
Galium hispidulum	coastal bedstraw	Unknown	Native	No	No					
Galium lanceolatum	lanceleaf wild licorice	Unknown	Native	No	No					
Houstonia procumbens	roundleaf bluet	Unknown	Native	No	No					
Acer rubrum	red maple	Unknown	Native	No	No					

Scientific Name	Common Name(s)	Abundance	Nativity	Weedy?	Management Priority	SCP high priority species	Global Rank	State Rank	Federal Status	State Status
Rhus copallinum	flameleaf sumac	Unknown	Native	No	No					
Toxicodendron radicans	eastern poison ivy, poison ivy, poisonivy	Unknown	Native	No	No					
Ruellia caroliniensis	Carolina wild petunia	Unknown	Native	No	No					
Bignonia capreolata	cross vine, crossvine	Unknown	Native	No	No					
Campsis radicans	common trumpetcreeper, cow-itch, trumpet creeper	Unknown	Native	No	No					
Polypremum procumbens	juniper leaf	Unknown	Native	No	No					
Ligustrum japonicum	Japanese privet	Occasional	Non-Native	Yes	Yes					
Ligustrum sinense	Chinese privet, common chinese privet	Occasional	Non-Native	Yes	Yes					
Gratiola virginiana	roundfruit hedgehyssop, Virginia hedgehyssop	Unknown	Native	No	No					
Nuttallanthus canadensis	Canada toadflax	Unknown	Native	No	No					
Veronica arvensis	common speedwell, corn speedwell, rock speedwell	Unknown	Non-Native	No	No					
Ipomoea cordatotriloba var. cordatotriloba	cotton morningglory, sharppod morningglory, tievine	Unknown	Native	No	No					
Ipomoea sagittata	saltmarsh morning-glory, saltmarsh morningglory	Unknown	Native	No	No					
Solanum carolinense	apple of Sodom, bull nettle, Carolina horsenettle, devil's tomato	Unknown	Native	No	No					
Hypericum hypericoides	St. Andrew's cross, St. Andrews cross	Unknown	Native	No	No					
Maclura pomifera	osage-orange	Unknown	Non-Native	No	No					
Morus rubra	red mulberry	Unknown	Native	No	No					
Celtis laevigata	sugar berry, sugar hackberry, sugarberry	Unknown	Native	No	No					
Boehmeria	small-spike false nettle	Unknown	Native	No	No					

Scientific Name	Common Name(s)	Abundance	Nativity	Weedy?	Management Priority	SCP high priority species	Global Rank	State Rank	Federal Status	State Status
cylindrica										
Helianthemum carolinianum	Carolina frostweed	Unknown	Native	No	No					
Helianthemum corymbosum	pinebarren frostweed	Unknown	Native	No	No					
Viola affinis	Arizona bog violet, lecontes violet, sand violet	Unknown	Native	No	No					
Probably Present:										
Conyza canadensis var. pusilla	Canadian horseweed	NA	Native	No	No					
Erigeron strigosus	Daisy Fleabane, prairie fleabane, rough fleabane	NA	Native	No	No					
Gamochaeta purpurea	spoon-leaf purple everlasting	NA	Native	No	No					
Gnaphalium obtusifolium		NA	Native	No	No					
Sonchus oleraceus	annual sowthistle, common sow-thistle	NA	Non-Native	No	No					
Rorippa nasturtium-aquaticum	watercress	NA	Non-Native	No	No					
Opuntia ficus-indica	indian fig, Indian-fig, tuna cactus	NA	Non-Native	No	No					
Cerastium holosteoides var. vulgare		NA	Non-Native	No	No					
Mollugo verticillata	carpetweed, green carpetweed	NA	Non-Native	No	No					
Phytolacca americana	American pokeweed, common pokeweed, inkberry, pigeonberry	NA	Native	No	No					
Fimbristylis thermalis	hot springs fimbry	NA	Native	No	No					
Galactia volubilis	downy milkpea	NA	Native	No	No					
Robinia pseudoacacia	black locust, false acacia, yellow locust	NA	Native	No	No					

Scientific Name	Common Name(s)	Abundance	Nativity	Weedy?	Management Priority	SCP high priority species	Global Rank	State Rank	Federal Status	State Status
Trifolium carolinianum	Carolina clover	NA	Native	No	No					
Vicia caroliniana	Carolina vetch	NA	Native	No	No					
Quercus austrina	bastard white oak	NA	Native	No	No					
Quercus hemisphaerica	Darlington oak, Darlington's oak	NA	Native	No	No					
Cynanchum angustifolium	gulf coast swallow-wort, Gulf coast swallowwort	NA	Native	No	No					
Oxalis dillenii ssp. filipes	Dillen's oxalis	NA	Native	No	No					
Juncus coriaceus	leathery rush	NA	Native	No	No					
Monarda clinopodia	white bergamot	NA	Native	No	No					
Salvia azurea	azure blue sage, blue sage	NA	Native	No	No					
Salvia coccinea	blood sage	NA	Native	No	No					
Scutellaria elliptica	hairy skullcap	NA	Native	No	No					
Scutellaria incana	hoary skullcap	NA	Native	No	No					
Teucrium canadense	American germander, hairy germander, wood sage	NA	Native	No	No					
Zephyranthes atamasca	Atamasco lily	NA	Native	No	No					
Pontederia cordata	pickerelweed	NA	Native	No	No					
Smilax bona-nox	saw greenbrier	NA	Native	No	No					
Smilax glauca	cat greenbrier	NA	Native	No	No					
Smilax pumila	sarsparilla vine	NA	Native	No	No					
Sida rhombifolia	arrowleaf sida, cuban jute, Cuban-jute	NA	Native	No	No					
Cuphea carthagenensis	Colombian waxweed	NA	Non-Native	No	No					
Rhexia alifanus	savannah meadowbeauty	NA	Native	No	No					
Gaura angustifolia	southern beeblossom	NA	Native	No	No					

Scientific Name	*Common Name(s)*	*Abundance*	*Nativity*	*Weedy?*	*Management Priority*	*SCP high priority species*	*Global Rank*	*State Rank*	*Federal Status*	*State Status*
Listera australis	southern twayblade	NA	Native	No	No					
Argemone albiflora	bluestem pricklypoppy	NA	Native	No	No					
Plantago sparsiflora	pineland plantain	NA	Native	No	No	YES	G3	S2		
Polygonum hydropiperoides	swamp smartweed	NA	Native	No	No					
Polygonum persicaria	ladysthumb smartweed, smartweed, spotted knotweed	NA	Native	No	No					
Ampelopsis arborea	peppervine	NA	Native	No	No					
Agrimonia parviflora	harvestlice, manyflowered groovebur	NA	Native	No	No					
Geum canadense	white avens	NA	Native	No	No					
Potentilla simplex	common cinquefoil, oldfield cinquefoil, oldfield fivefingers	NA	Native	No	No					
Prunus angustifolia	Chickasaw plum	NA	Native	No	No					
Pyrus communis	common pear, pear	NA	Non-Native	No	No					
Diodia teres	poor joe, poorjoe, rough buttonweed	NA	Native	No	No					
Galium obtusum	blunt-leaf bedstraw, bluntleaf bedstraw, bristly bedstraw	NA	Native	No	No					
Galium pilosum	hairy bedstraw	NA	Native	No	No					
Galium tinctorium	dye bedstraw, stiff marsh bedstraw	NA	Native	No	No					
Catalpa speciosa	northern catalpa	NA	Non-Native	No	No					
Ligustrum amurense	Amur privet	NA	Non-Native	No	No					
Paulownia tomentosa	princess tree, princesstree, royal paulownia	NA	Non-Native	No	No					
Verbascum thapsus	big taper, common mullein, flannel mullein, flannel plant	NA	Non-Native	No	No					
Dichondra carolinensis	Carolina ponysfoot, grass ponyfoot	NA	Native	No	No					

Scientific Name	***Common Name(s)***	***Abundance***	***Nativity***	***Weedy?***	***Management Priority***	***SCP high priority species***	***Global Rank***	***State Rank***	***Federal Status***	***State Status***
Phlox carolina	thickleaf phlox	NA	Native	No	No					
Physalis viscosa	grape groundcherry, groundcherry, starhair groundcherry	NA	Native	No	No					
Hypericum cistifolium	roundpod St. Johnswort	NA	Native	No	No					
Hypericum crux-andreae	atlantic st. peter's-wort, St. Peterswort	NA	Native	No	No					
Hypericum mutilum	dwarf St. Johnswort	NA	Native	No	No					
Ficus carica	common fig, edible fig, fiku, piku	NA	Non-Native	No	No					
Lechea mucronata	hairy pinweed	NA	Native	No	No					
Passiflora incarnata	purple passionflower	NA	Native	No	No					
Viola lanceolata	bog white violet, lanceleaf violet	NA	Native	No	No					
Viola palmata	early blue violet, trilobed violet	NA	Native	No	No					

Appendix G: Fish species documented for Fort Frederica National Monument.
These species have been cross referenced to the GA Comprehensive Wildlife Conservation Strategy (GA DNR Wildlife Resources Division 2005) high priority species in the southern coastal plain (SCP); NatureServe's global and state rankings (NatureServe 2008); and the GA DNR listings for endangered, threatened, or rare species (GA DNR Wildlife Resources Division 2008). See reference or Appendix E for explanation of abbreviations.

Scientific Name	***Common Name(s)***	***Abundance***	***Residency***	***Nativity***	***SCP high priority spp.***	***Global Rank***	***State Rank***	***Federal Status***	***State Status***
Alosa mediocris	bonejack, fall herring, freshwater taylor, hickory jack	Unknown	Unknown	Native					
Brevoortia tyrannus	Atlantic menhaden, bugfish, bunker, fatback	Unknown	Unknown	Native					
Dorosoma petenense	threadfin shad	Unknown	Unknown	Native					
Anchoa mitchilli	bay anchovy	Unknown	Unknown	Native					
Fundulus heteroclitus	Mummichog	Unknown	Unknown	Native					
Fundulus majalis	striped killifish	Unknown	Unknown	Native					
Gambusia affinis	mosquitofish, western mosquitofish	Unknown	Unknown	Native					
Poecilia latipinna	sailfin molly	Unknown	Unknown	Native					
Syngnathus scovelli	Gulf pipefish	Unknown	Unknown	Native					
Mugil cephalus	black mullet, gray mullet, striped mullet	Unknown	Unknown	Native					
Mugil curema	silver mullet, white mullet	Unknown	Unknown	Native					
Oligoplites saurus	leatherjack, leatherjacket	Unknown	Unknown	Native					
Eucinostomus argenteus	spotfin mojarra	Unknown	Unknown	Native					
Evorthodus lyricus	lyre goby	Unknown	Unknown	Native					
Bairdiella chrysoura	silver perch	Unknown	Unknown	Native					
Leiostomus xanthurus	Spot	Unknown	Unknown	Native					
Symphurus plagiusa	blackcheek tonguefish	Unknown	Unknown	Native					
Paralichthys lethostigma	southern flounder	Unknown	Unknown	Native					
Lepisosteus oculatus	shortnose gar, spotted gar	Unknown	Unknown	Native					
Ameiurus catus	white bullhead, white catfish	Unknown	Unknown	Native					
Chilomycterus schoepfii	burrfish, porcupinefish, striped burrfish	Unknown	Unknown	Native					

Appendix H: Herpetofauna (amphibian and reptile species) documented for Fort Frederica National Monument.
These species have been cross referenced to the GA Comprehensive Wildlife Conservation Strategy (GA DNR Wildlife Resources Division 2005) high priority species in the southern coastal plain (SCP); NatureServe's global and state rankings (NatureServe 2008); and the GA DNR listings for endangered, threatened, or rare species (GA DNR Wildlife Resources Division 2008). See reference or Appendix E for explanation of abbreviations.

Scientific Name	***Common Name(s)***	***Abundance***	***Residency***	***Nativity***	***SCP high priority spp.***	***Global Rank***	***State Rank***	***Federal Status***	***State Status***
Amphibian species present in the park:									
Bufo terrestris	Southern Toad	Unknown	Unknown	Native					
Hyla gratiosa	Barking Treefrog	Unknown	Unknown	Native					
Hyla squirella	Squirrel Treefrog	Unknown	Unknown	Native					
Eleutherodactylus planirostris	Greenhouse Frog	Unknown	Unknown	Non-Native					
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad	Unknown	Unknown	Native					
Scaphiopus holbrookii	Eastern Spadefoot	Unknown	Unknown	Native					
Amphibian species found near the vicinity of the park:									
Acris gryllus	Southern cricket frog								
Bufo quercicus	Oak toad								
Hyla chrysoscelis/ versicolor	Gray/Cope's gray treefrog								
Hyla cinerea	Green treefrog								
Hyla femoralis	Pine woods treefrog								
Pseudacris crucifer	Spring peeper								
Pseudacris nigrita	Southern chorus frog								
Pseudacris ocularis	Little grass frog								
Rana catesbeiana	Bullfrog								
Rana clamitans	Green frog								
Rana utricularia	Southern leopard frog								
Ambystoma opacum	Marbled salamander								
Ambystoma talpoideum	Mole salamander								
Ambystoma tigrinum	Eastern tiger salamander								
Amphiuma means	Two-toed amphiuma								
Desmognathus auriculatus	Southern dusky salamander								
Eurycea cirrigera	Southern two-lined salamander								

Scientific Name	Common Name(s)	Abundance	Residency	Nativity	SCP high priority spp.	Global Rank	State Rank	Federal Status	State Status
Eurycea quadridigitata	Dwarf salamander								
Notophthalmus viridescens	Red spotted newt								
Plethodon glutinosus complex	Slimy salamander								
Pseudotriton montanus	Mud salamander								
Siren intermedia	Lesser siren								
Siren lacertian	Greater siren								
Reptile species present in the park:									
Alligator mississippiensis	alligator, American Alligator, Florida alligator, gator	Unknown	Unknown	Native					
Ophisaurus ventralis	Eastern Glass Lizard	Unknown	Unknown	Native					
Cemophora coccinea	Scarlet Snake	Unknown	Unknown	Native					
Coluber constrictor	Eastern racer, black racer	Unknown	Unknown	Native					
Elaphe guttata	Corn Snake	Unknown	Unknown	Native					
Elaphe obsolete	Eastern rat snake	Unknown	Unknown	Native					
Lampropeltis getula	Common, Eastern Kingsnake	Unknown	Unknown	Native					
Storeria occipitomaculata	Red-bellied Snake, Redbelly Snake	Unknown	Unknown	Native					
Thamnophis sirtalis	Common Garter Snake	Unknown	Unknown	Native					
Anolis carolinensis	Green Anole	Unknown	Unknown	Native					
Eumeces laticeps	Broad-headed Skink, broadhead skink	Unknown	Unknown	Native					
Scincella lateralis	Ground Skink, Little Brown Skink	Unknown	Unknown	Native					
Cnemidophorus sexlineatus	Six-lined Racerunner	Unknown	Unknown	Native					
Deirochelys reticularia	Chicken Turtle	Unknown	Unknown	Native					
Malaclemys terrapin	Diamondback Terrapin	Unknown	Unknown	Native	YES	G4	S3		
Reptile species found near the vicinity of the park:									
Alligator mississippiensis	Alligator								
Kinosternon baurii	Striped mud turtle								
Kinosternon subrubrum	Eastern mud turtle								
Terrapene Carolina	Eastern box turtle								
Eumeces egregious	Mole skink								
Eumeces fasciatus	Five-lined skink								

Scientific Name	Common Name(s)	Abundance	Residency	Nativity	SCP high priority spp.	Global Rank	State Rank	Federal Status	State Status
Eumeces inexpectatus	Southeastern five-lined skink								
Ophisaurus attenuatus	Slender glass lizard								
Ophisaurus compressus	Island glass lizard								
Ophisaurus mimicus	Mimic glass lizard								
Sceloporus undulates	Fence lizard								
Agkistrodon contortrix	Copperhead								
Agkistrodon piscivorus	Cottonmouth								
Crotalus adamanteus	Eastern diamondback rattlesnake								
Crotalus horridus	Canebrake rattlesnake								
Diadophis punctatus	Ringneck snake								
Drymarchon corais	Eastern indigo snake								
Heterodon platirhinos	Eastern hognose snake								
Heterodon simus	Southern hognose snake								
Lampropeltis triangulum	Scarlet kingsnake								
Masticophis flagellum	Coachwhip								
Micrurus fulvius	Coral snake								
Nerodia erythrogaster	Plainbelly water snake								
Nerodia fasciata	Banded water snake								
Opheodrys aestivus	Rough green snake								
Pituophis melanoleucus	Pine snake								
Rhadinaea flavilata	Pine woods snake								
Sistrurus miliarius	Pigmy rattlesnake								
Storeria dekayi	Brown snake								
Thamnophis sauritus	Ribbon snake								
Virginia striatula	Rough earth snake								
Virginia valeriae	Smooth earth snake								

Appendix I: Bird species documented for Fort Frederica National Monument.
These species have been cross referenced to the GA Comprehensive Wildlife Conservation Strategy (GA DNR Wildlife Resources Division 2005) high priority species in the southern coastal plain (SCP); NatureServe's global and state rankings (NatureServe 2008); and the GA DNR listings for endangered, threatened, or rare species (GA DNR Wildlife Resources Division 2008). See reference or Appendix E for explanation of abbreviations. Bird species were also cross referenced to the Partners in Flight Priority Species (Partners in Flight 2005) and Audubon WatchList (National Audubon Society 2007).
* FOFR management priority species

Scientific Name	***Common Name(s)***	***Abundance***	***Residency***	***Nativity***	***Priority spp.***	***Audobon WatchList***	***Global Rank***	***State Rank***	***Federal Status***	***State Status***
Present in Park:										
Lophodytes cucullatus	Hooded Merganser	Unknown	Unknown	Native						
Archilochus colubris	Ruby-throated Hummingbird	Unknown	Unknown	Native						
Buteo lineatus	Red-shouldered Hawk	Unknown	Unknown	Native						
Haliaeetus leucocephalus	Bald Eagle	Unknown	Unknown	Native	SCP		G4	S2	PS:LT, PDL	E
Pandion haliaetus	Osprey	Unknown	Unknown	Native						
Ardea alba	Great Egret	Unknown	Unknown	Native						
Ardea herodias	Great Blue Heron	Unknown	Unknown	Native						
Botaurus lentiginosus	American Bittern	Unknown	Unknown	Native						
Bubulcus ibis	Cattle Egret	Unknown	Unknown	Native						
Butorides virescens	Green Heron	Unknown	Breeder	Native						
Egretta thula	Snowy Egret	Unknown	Unknown	Native						
Cathartes aura	Turkey Vulture	Unknown	Unknown	Native						
Coragyps atratus	Black Vulture	Unknown	Unknown	Native						
*Mycteria Americana**	Wood Stork*	Unknown	Unknown	Native	SCP		G4	S2	(PS:LE)	E
Gavia immer	Common Loon	Unknown	Unknown	Native						
Larus delawarensis	Ring-billed Gull	Unknown	Unknown	Native						
Sterna forsteri	Forster's Tern	Unknown	Unknown	Native						
Pelecanus occidentalis	Brown Pelican	Unknown	Unknown	Native						
Phalacrocorax auritus	Double-crested Cormorant	Unknown	Unknown	Native						
Podilymbus podiceps	Pied-billed Grebe	Unknown	Unknown	Native						
Zenaida macroura	Mourning Dove	Unknown	Unknown	Native						
Megaceryle alcyon	Belted Kingfisher	Unknown	Unknown	Native						
Coccyzus americanus	Yellow-billed Cuckoo	Unknown	Unknown	Native						

Scientific Name	*Common Name(s)*	*Abundance*	*Residency*	*Nativity*	*Priority spp.*	*Audobon WatchList*	*Global Rank*	*State Rank*	*Federal Status*	*State Status*
Coccyzus erythropthalmus	Black-billed Cuckoo	Unknown	Unknown	Native						
Rallus longirostris	Clapper Rail	Unknown	Unknown	Native		YES				
Bombycilla cedrorum	Cedar Waxwing	Unknown	Unknown	Native						
Polioptila caerulea	Blue-gray Gnatcatcher	Unknown	Unknown	Native						
Thryothorus ludovicianus	Carolina Wren	Unknown	Unknown	Native						
Corvus ossifragus	Fish Crow	Unknown	Unknown	Native						
Cyanocitta cristata	Blue Jay	Unknown	Unknown	Native						
Agelaius phoeniceus	Red-winged Blackbird	Unknown	Unknown	Native						
Cardinalis cardinalis	Northern Cardinal	Unknown	Unknown	Native						
Carduelis tristis	American Goldfinch	Unknown	Unknown	Native						
Dendroica coronate	Yellow-rumped Warbler	Unknown	Unknown	Native						
Dendroica discolor	Prairie Warbler	Unknown	Unknown	Native	PIF	YES				
Dendroica dominica	Yellow-throated Warbler	Unknown	Unknown	Native						
Dendroica palmarum	Palm Warbler	Unknown	Unknown	Native						
Dendroica petechia	Yellow Warbler	Unknown	Unknown	Native						
Dendroica pinus	Pine Warbler	Unknown	Unknown	Native						
Icterus spurious	Orchard Oriole	Unknown	Unknown	Native						
Junco hyemalis	Dark-eyed Junco	Unknown	Unknown	Native						
Mniotilta varia	Black-and-white Warbler	Unknown	Unknown	Native						
Molothrus ater	Brown-headed Cowbird	Unknown	Unknown	Native						
Parula Americana	Northern Parula	Unknown	Unknown	Native	PIF					
Passerella iliaca	Fox Sparrow	Unknown	Unknown	Native						
Pipilo erythrophthalmus	Eastern Towhee	Unknown	Unknown	Native						
Piranga rubra	Summer Tanager	Unknown	Unknown	Native						
Quiscalus major	Boat-tailed Grackle	Unknown	Unknown	Native						
Quiscalus quiscula	Common Grackle	Unknown	Unknown	Native						
Setophaga ruticilla	American Redstart	Unknown	Unknown	Native						
Spizella passerine	Chipping Sparrow	Unknown	Unknown	Native						

Scientific Name	*Common Name(s)*	*Abundance*	*Residency*	*Nativity*	*Priority spp.*	*Audobon WatchList*	*Global Rank*	*State Rank*	*Federal Status*	*State Status*
Sturnella magna	Eastern Meadowlark	Unknown	Unknown	Native						
Wilsonia citrine	Hooded Warbler	Unknown	Unknown	Native	PIF					
Zonotrichia albicollis	White-throated Sparrow	Unknown	Unknown	Native						
Zonotrichia leucophrys	White-crowned Sparrow	Unknown	Unknown	Native						
Lanius ludovicianus	Loggerhead Shrike	Unknown	Unknown	Native	SCP		G4TEQ	S?		
Hylocichla mustelina	Wood Thrush	Unknown	Unknown	Native	PIF	YES				
Sialia sialis	Eastern Bluebird	Unknown	Unknown	Native						
Turdus migratorius	American Robin	Unknown	Unknown	Native						
Baeolophus bicolor	Tufted Titmouse	Unknown	Unknown	Native						
Parus carolinensis	Carolina Chickadee	Unknown	Unknown	Native						
Regulus calendula	Ruby-crowned Kinglet	Unknown	Unknown	Native						
Regulus satrapa	Golden-crowned Kinglet	Unknown	Unknown	Native						
Sitta carolinensis	White-breasted Nuthatch	Unknown	Unknown	Native						
Dumetella carolinensis	Gray Catbird	Unknown	Unknown	Native						
Mimus polyglottos	Northern Mockingbird	Unknown	Unknown	Native						
Toxostoma rufum	Brown Thrasher	Unknown	Unknown	Native						
Contopus virens	Eastern Wood-Pewee	Unknown	Unknown	Native						
Empidonax minimus	Least Flycatcher	Unknown	Unknown	Native						
Myiarchus crinitus	Great Crested Flycatcher	Unknown	Unknown	Native						
Sayornis phoebe	Eastern Phoebe	Unknown	Unknown	Native						
Tyrannus tyrannus	Eastern Kingbird	Unknown	Unknown	Native						
Vireo griseus	White-eyed Vireo	Unknown	Unknown	Native						
Colaptes auratus	Northern Flicker	Unknown	Unknown	Native						
Dryocopus pileatus	Pileated Woodpecker	Unknown	Unknown	Native						
Melanerpes carolinus	Red-bellied Woodpecker	Unknown	Unknown	Native						
Melanerpes erythrocephalus	Red-headed Woodpecker	Unknown	Unknown	Native		YES				
Picoides pubescens	Downy Woodpecker	Unknown	Unknown	Native						
Picoides villosus	Hairy Woodpecker	Unknown	Unknown	Native						

Scientific Name	***Common Name(s)***	***Abundance***	***Residency***	***Nativity***	***Priority spp.***	***Audobon WatchList***	***Global Rank***	***State Rank***	***Federal Status***	***State Status***
Sphyrapicus varius	Yellow-bellied Sapsucker	Unknown	Unknown	Native						
Bubo virginianus	Great Horned Owl	Unknown	Unknown	Native						
Strix varia	Barred Owl	Unknown	Unknown	Native						

Appendix J: Mammal species documented for Fort Frederica National Monument.

These species have been cross referenced to the GA Comprehensive Wildlife Conservation Strategy (GA DNR Wildlife Resources Division 2005) high priority species in the southern coastal plain (SCP); NatureServe's global and state rankings (NatureServe 2008); and the GA DNR listings for endangered, threatened, or rare species (GA DNR Wildlife Resources Division 2008). See reference or Appendix E for explanation of abbreviations.

Scientific Name	***Common Name(s)***	***Abundance***	***Residency***	***Nativity***	***SCP high priority spp.***	***Global Rank***	***State Rank***	***Federal Status***	***State Status***
Trichechus manatus	West Indian manatee	Unknown	Unknown	Native	YES	G2	S1S2	LE	E
Odocoileus virginianus	white-tailed deer	Common	Breeder	Native					
Canis familiaris	domestic dog (feral)	Uncommon	Vagrant	Non-Native					
Felis catus	domestic cat (feral)	Rare	Vagrant	Non-Native					
Lontra Canadensis	northern river otter	Uncommon	Breeder	Native					
Mustela vison	American mink	Uncommon	Breeder	Native					
Procyon lotor	common raccoon, northern raccoon, raccoon	Common	Breeder	Native					
Didelphis virginiana	Virginia opossum	Common	Breeder	Native					
Scalopus aquaticus	eastern mole	Common	Breeder	Native					
Sylvilagus floridanus	eastern cottontail	Common	Breeder	Native					
Sylvilagus palustris	marsh rabbit	Common	Breeder	Native					
Neotoma floridana	eastern woodrat	Uncommon	Breeder	Native					
Oryzomys palustris	marsh rice rat	Common	Breeder	Native					
Sciurus carolinensis	eastern gray squirrel	Common	Breeder	Native					
Dasypus novemcinctus	long-nosed armadillo, nine-banded armadillo	Common	Breeder	Native					

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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