National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Terrestrial Vegetation Monitoring at Fort Pulaski National Monument

2019 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2021/1339

ON THIS PAGE
A stately live oak (*Quercus virginiana*) growing in the center of a marsh hammock island on the western edge of Fort Pulaski National Monument. NPS photo / M. Forbes Boyle, SECN.
ON THE COVER
Elizabeth Rico, SECN Biological Technician, traverses a saltmeadow cordgrass (*Spartina patens*) marsh plot located outside the walls of Fort Pulaski. NPS photo / M. Forbes Boyle, SECN.

Terrestrial Vegetation Monitoring at Fort Pulaski National Monument

2019 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2021/1339

M. Forbes Boyle and Elizabeth Rico

Southeast Coast Inventory and Monitoring Network
National Park Service
Cumberland Island National Seashore
101 Wheeler Street
Saint Marys, Georgia 31558

December 2021
U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the Southeast Coast Network website and the Inventory and Monitoring Reports and Publications. If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Boyle, M. F., and E. Rico. 2021. Terrestrial vegetation monitoring at Fort Pulaski National Monument: 2019 data summary. Natural Resource Data Series NPS/SECN/NRDS—2021/1339. National Park Service, Fort Collins, Colorado. https://doi.org/10.36967/nrds-2288716.

NPS 348/177981, December 2021

Contents

Figures

Tables

Appendices

Acknowledgments

Special thanks go to the staff at Fort Pulaski National Monument for assisting with this monitoring effort. Laura Waller, the Integrated Resource Program Manager, provided much needed logistical support prior to the field season and remained helpful throughout project implementation.

Special thanks also to Candice Wyatt (Natural Resource Technician) and Jean Butchart (park intern) for showing us around and assisting with field work. Finally, Miguel Roman gave our vegetation monitoring team a boat ride to better access tidal plots located on the western half of the park.

Candice Wyatt, FOPU Natural Resource Technician, helps with field work at Fort Pulaski National Monument. NPS photo / SECN staff.

Executive Summary

The Southeast Coast Network (SECN) conducts long-term terrestrial vegetation monitoring as part of the nationwide Inventory and Monitoring Program of the National Park Service (NPS). The vegetation community vital sign is one of the primary-tier resources identified by SECN park managers, and monitoring is currently conducted at 15 network parks (DeVivo et al. 2008). Monitoring plants and their associated communities over time allows for targeted understanding of ecosystems within the SECN geography, which provides managers information about the degree of change within their parks' natural vegetation.

2019 marks the first year of conducting this monitoring effort on four SECN parks, including Fort Pulaski National Monument (FOPU). Twelve vegetation plots were established at Fort Pulaski National Monument in August. Data collected in each plot included species richness across multiple spatial scales, species-specific cover and constancy, species-specific woody stem seedling/sapling counts and adult tree (greater than 10 centimeters [3.9 inches {in}]) diameter at breast height (DBH), overall tree health, landform, soil, observed disturbance, and woody biomass (i.e., fuel load) estimates.

This report summarizes the baseline (year 1) terrestrial vegetation data collected at Fort Pulaski National Monument in 2019. Data were stratified across two dominant broadly defined habitats within the park (Maritime Tidal Wetlands and Maritime Upland Forests and Shrublands). Noteworthy findings include:

- Sixty-six vascular plant taxa were observed across 12 vegetation plots, including six taxa not previously known from the park. Plots were located on both Cockspur and McQueen's Island.
- The most frequently encountered species in each broadly defined habitat included:
    - Maritime Tidal Wetlands: smooth cordgrass (*Spartina alterniflora*), perennial saltmarsh aster (*Symphyotrichum tenuifolium*), and groundsel tree (*Baccharis halimifolia*)
    - Maritime Upland Forests and Shrublands: yaupon (*Ilex vomitoria*), southern/eastern red cedar (*Juniperus silicicola + virginiana*), and cabbage palmetto (*Sabal palmetto*).
- Four non-native species identified as invasive by the Georgia Exotic Pest Plant Council (GA-EPPC 2018) were found during this monitoring effort. These species (and their overall frequency of occurrence within all plots) included: Japanese honeysuckle (*Lonicera japonica*; 17%), bahiagrass (*Paspalum notatum*; 8%), Vasey's grass (*Paspalum urvillei*; 8%), and European common reed (*Phragmites australis*; 8%).
- Two rare plants tracked by the Georgia Department of Natural Resources (GADNR 2013) were found during this monitoring effort. These include Florida wild privet (*Forestiera segregata*) and Bosc's bluet (*Oldenlandia boscii*).
- Southern/eastern red cedar and cabbage palmetto were the most dominant species within the tree stratum of the Maritime Upland Forest and Shrubland habitat type. Species that dominated the sapling and seedling strata of this type included yaupon, cabbage palmetto, groundsel tree, and Carolina laurel cherry (*Prunus caroliniana*).
- The health status of sugarberry (*Celtis laevigata*)—a typical canopy species in maritime forests of the South Atlantic Coastal Plain--observed on park plots appeared to be in decline, with most stems experiencing elevated levels of dieback and low vigor. Over the past decade, this species has been experiencing unexplained high rates of dieback and mortality throughout its range in the Southeastern United States; current research is focusing on what may be causing these alarming die-off patterns.
- Duff and litter made up the majority of downed woody biomass (fuel loads) across FOPU vegetation plots.

List of Terms

Aspect: The compass direction that a slope faces.

Basal Area (BA): The cross-sectional area of woody stems at DBH; used to describe the amount of area occupied by a single or group of stems. BA is expressed in this report as m^2/ha (square meters per hectare).

Coarse Woody Debris (CWD): Downed woody stems on the ground that are either lying prone on the ground, or at least one end of the broken bole of a dead tree is touching the ground at an angle of greater than 45° from vertical. Coarse woody debris includes pieces of wood greater than 8 centimeters (3.1 inch [in]) in diameter (approximately 1,000-hour fuel class).

Constancy: The percentage of plots in a given data set in which a species occurs.

Cover: The vertical projection of vegetation from the ground as viewed from above, and in this protocol is estimated as a percentage of area that covers the ground above the ground surface (areal cover).

Density: The number of individual woody stems in a given area.

DBH: Diameter at breast height of an individual woody stem, or 1.37 meters (4.5 feet [ft]) above the ground surface.

Duff: An organic fuel layer that lies below the litter layer and above mineral soil. It is made up of litter material that has decomposed to the point where individual pieces are no longer identifiable. In general, the duff layer is darker than the litter layer.

Fine Woody Debris (FWD): Pieces of wood less than 8 centimeters (3.1 in) in diameter. They are either (1) not attached to the woody stem where they once grew and have fallen to the ground, (2) not attached to the stem where they once grew and are supported off the ground by live or dead material, or (3) attached to stems of woody material that are themselves considered 'dead' and 'down.' Fine woody debris is composed of the following fire size classes: 1-hour fuels (0–0.64 centimeters [0–0.2 in]), 10-hour fuels (0.64–2.54 centimeters [0.2–1 in]), and 100-hour fuels (2.54–8.1 centimeters [1–3.2 in]).

Global / State Status: Conservation status assessment ranks developed by NatureServe and individual state Natural Heritage Programs used to determine the extinction risk of species and ecosystems at the global and state scales. Global codes are as follows:

- G1: Critically imperiled-very high risk of extinction
- G2: Imperiled-high risk of extinction
- G3: Vulnerable-moderate risk of extinction
- G4: Apparently Secure-fairly low risk of extinction
- G5: Secure-very low risk of extinction

Growth Form: The shape and physical appearance of a species, reflecting site conditions and genetics. In this report, the following growth forms, following definitions set by USDA (2020), are used:

- Tree: a perennial, woody plant with a single stem (trunk), normally greater than 4–5 meters (13.1–16.4 ft) in height
- Shrub: a perennial, multi-stemmed woody plant that is usually less than 4–5 meters (13.1–16.4 ft) in height
- Vine: a twining or climbing plant with relatively long stems; can be woody or herbaceous
- Herb/Forb: a plant without significant woody tissue and lacking significant thickening by secondary woody growth
- Graminoid: a grass or grass-like plant; includes grasses (**Poaceae**), sedges (*Cyperaceae*), and rushes (*Juncaceae*).

Litter: An organic fuel layer made up of twigs, dead grasses, recently fallen leaves, and pine or other needles where the individual pieces are still identifiable and not altered by decomposition.

Sapling: Any live woody stem greater than 1.37 meters (4.5 ft) in height but less than 10 centimeters (3.9 in) in diameter at breast height (DBH).

Seedling: Any live woody stem with at least two true leaves that are less than 1.37 meters (4.5 ft) tall.

Slope: The rise and fall of a land surface.

Species Richness: The overall number of species, or group of species, within a defined area.

Terrain Shape Index (TSI): A quantitative expression of the geometric shape (ranging from concave to convex) of the land surface. Negative TSI values indicate convex shape, positive values indicate concavity, and values around 0 indicate flat surfaces.

Tree: Any woody stem more than 1.37 meters (4.5 ft) in height and greater than or equal to 10 centimeters (3.9 in) in diameter at breast height (DBH). This term is also used to describe a specific growth form (see Growth Form above).

Introduction

Overview

Vegetation communities are the primary drivers of a range of ecological processes and are integral to the proper function of park ecosystems. Moreover, vegetation communities integrate the biological and physical environment—they serve as the foundation for food webs, provide wildlife habitat for many species, function as a carbon sink, produce oxygen, and cycle nutrients and energy through an ecosystem. Parks within the Southeast Coast Network (SECN) host a diverse assemblage of plants and terrestrial communities. Vegetation communities vary widely across network parks. Approximately 180 vegetation associations (i.e., fine-resolution floristic description), as defined by the National Vegetation and Classification Standard, Version 2.0 (FGDC 2008), occur in SECN park units. A diversity of vegetation types is found in these parks, including dry grassland dunes, maritime oak and pine dominated forests, pyrogenic pine flatwoods, black and brown water floodplain forests, and Piedmont upland forests.

Vegetation communities are dynamic entities whose species composition, abundance, distribution, and structure are influenced by environmental factors and the impacts over time by natural and anthropogenic disturbances. For communities to be considered 'natural,' native species must be predominately distributed across the landscape as a consequence of disturbance factors (i.e., stressors) or site condition (i.e., environmental factors; e.g., soil nutrients, landform; Comer et al. 2003). The timing, type, and extent of a disturbance generally evoke a distinguishable response in vegetation across the landscape (Turner et al. 1990; Foster et al. 1998). Natural disturbance processes in SECN parks include those brought about by fire regimes and weather patterns (e.g., hurricanes and drought), while anthropogenic influences include landscape fragmentation, fire suppression, altered hydrology, shifts in seasonal weather patterns, and non-native species introduction.

Determining trends in vegetation communities over time and identifying plant stressors is vital to understanding the ecological health of terrestrial ecosystems within SECN parks. Collectively, this information can be used to guide management actions that sustain park's ecological integrity and support plant conservation across a diversity of spatial scales. The Southeast Coast Network collects long-term data on vegetation communities within its parks using a protocol that is largely based on the forest monitoring approaches used by the Cumberland Piedmont Network and Gulf Coast Network.

This report provides a summary of data collected in August 2019 at Fort Pulaski National Monument (FOPU) as part of the SECN's terrestrial vegetation monitoring effort. This report is intended to provide park resource managers and partners with (a) baseline information on the composition, abundance, and structure of vegetation across broad habitat types, (b) documentation of observable stressors to park vegetation resources, and (c) a summary of ancillary data associated with terrestrial ecosystems (e.g., soil nutrient status and fuel abundance).

Monitoring Objectives

The overall objective of this effort is: *to detect meaningful changes in species composition and vegetation structure within natural and semi-natural vegetation communities of SECN parks and determine whether these changes are correlated with trends in key stressors.*

The data presented herein are from the first iteration of sampling activities in Fort Pulaski National Monument utilizing the recently published SECN terrestrial vegetation monitoring protocol (Boyle et al. 2019). For this 'baseline' status report, 2019 data were synthesized to answer the following questions across broad habitat types within the park:

- How does species richness vary across terrestrial vegetation communities?
- What is the status of composition and abundance among native versus non-native species?
- What are the most common plants encountered during the monitoring effort, and conversely, were there rare species detected?
- In forests, woodlands, and shrublands, what is the relative frequency of woody seedlings, saplings, and subcanopy or canopy species?
- Do observable stressors appear to impact vegetation communities?
- What is the current condition of soil nutrient chemistry and fuel volume?

Methods

Study Area

Fort Pulaski National Monument (FOPU) is located east of Savannah, Georgia along the Savannah River and only a few miles from the river's junction with the Atlantic Ocean (Figure 1). The 2,276 hectares (5,623 acres [ac]) park is located on two islands, Cockspur and McQueen's, that have been greatly impacted by human intervention over the past 300 years. The largest of the two islands that make up Fort Pulaski National Monument is McQueen's Island, most of which is composed of tidal salt marsh. McQueen's Island is the site of U.S. Highway 80, which was constructed in 1923 adjacent to a railroad (built in 1887) to connect Savannah with Tybee Island, Georgia. Cockspur Island, which includes the site of the fort, was selected as an early American defensive position in the 18th century and the construction of the fort began in the early 19th century. During this time, a vast network of drainage canals and dikes were installed on the island surrounding the fort. Much of the vegetation was removed during the Civil War-era in order to maintain visibility. The environment of Cockspur Island has also been impacted by spoil material accumulation from dredging efforts within the Savannah River and nearby associated waterways. Prior to these environmental impacts to the site, Cockspur Island likely supported some degree of coastal hammock forest, as well as tidal shrubland and marsh (Govus 1998).

Since the abandonment of the fort in the late 19th century, Cockspur Island has transitioned into maritime forest and shrubland, manicured lawn and grassland, and early successional dredge spoil habitat. Dominant woody plants located on the island include cabbage palmetto (*Sabal palmetto*), southern/eastern red cedar (*Juniperus silicicola + virginiana*), yaupon (*Ilex vomitoria*), and wax-myrtle (*Morella cerifera*). Although there are a few small scale upland hammock forests that have developed on McQueen's Island, the dominant broadly defined habitat on this portion of the park is tidal marsh—composed of smooth cordgrass (*Spartina alterniflora*), black needlerush (*Juncus roemerianus*), big cordgrass (*Spartina cynosuroides*), and saltgrass (*Distichlis spicata*).

Recent vegetation surveys of Fort Pulaski National Monument document a high proportion of non-native species, owing to the park's highly disturbed landscape and its position adjacent to heavily used coastal navigation routes (Govus 1998). Eighteen non-native species that were also categorized as invasive—a concern to park managers—were found on the park during the last full park plant inventory in 1997 and 1998, in which 256 species were documented (Govus 1998). These included alligator-weed (*Alternanthera philoxeriodes*), camphortree (*Cinnamomum camphora*), Japanese privet (*Ligustrum japonicum*), Chinese tallow-tree (*Triadica sebifera*), and Johnson grass (*Sorghum halepense*). During the Southeast Coast Network's pilot vegetation monitoring effort in 2010, three non-native invasive plants listed as problematic (Category 1, 2, or 3) by the Georgia Exotic Pest Plant Council (GA-EPPC 2018) were located in monitoring plots (Byrne et al. 2012). These included chinaberry (*Melia azedarach*), bahia grass (P*aspalum notatum*), and Vasey grass (*Paspalum urvillei*). Other threats to FOPU vegetation resources are related to water quality degradation due to the heavy industrial development along the upper portions of the Savannah River between the park and the city of Savannah (DeVivo et al. 2008). Continued heavy shipping traffic within and associated dredging of the Savannah River channel contribute to elevated levels of shoreline erosion along the northern end of Cockspur Island (DeVivo et al. 2008).

Despite these stressors, the maritime forests and tidal grasslands have developed and continue to develop at Fort Pulaski National Monument to provide habitat for a variety of wildlife and plant species with coastal affinities. Populations of the Georgia significantly rare Florida wild privet (*Forestiera segregata*) and its associated rare community have been recently documented in the park (Govus 1998). Fort Pulaski National Monument has 306 known vascular plant species, subspecies, and varieties according to NPSpecies (2019). Govus (1998) recorded 256 vascular plant taxa in their 1997 and 1998 floristic survey of the park. In a pilot vegetation monitoring effort by the Southeast Coast Network (SECN), 30 taxa were detected across four sites in the park (Byrne et al. 2012).

Figure 1. Southeast Coast Network terrestrial vegetation monitoring plot locations within Fort Pulaski National Monument.

Sampling Design

The Southeast Coast Network monitors vegetation in long-term plots located in natural and semi-natural habitats of targeted parks, including Fort Pulaski National Monument. Sample size (i.e., number of plots) is determined by a combination of factors, including (1) priority plots are located in broadly defined habitats that cover more than 30% of the total area of park's natural and semi-natural vegetation (i.e., dominant and co-dominant habitat); (2) the number of priority plots is scaled according to the overall size of dominant/co-dominant mapped polygons, such that the distribution of plots is between 1 and 25 per 100 hectares (247 ac) of these habitat types; (3) the secondary sample target is any broadly defined habitat that cover between 1 and 30% of a park's natural and semi-natural vegetation; (4) each of the secondary sample target habitat types is allotted four plots.

Twelve vegetation plots were established and sampled at Fort Pulaski National Monument in August 2019 (Figure 1). These plots were located in the following broadly defined habitats of the park: Maritime Tidal Wetlands (7 plots) and Maritime Upland Forests and Shrublands (5 plots). Plot locations were determined using the generalized random-tessellation stratified (GRTS) sampling methodology, which creates a spatially balanced array of sample points across an area of interest while maintaining flexibility in a project's sample size (Stevens and Olsen 2004).

Nomenclature Standard, Growth Form Determination, and Conservation Status

Species nomenclature for this report follows the *Flora of the Southern and Mid-Atlantic States* (Weakley 2019). Every attempt was made to identify all plants to species, variety, or subspecies; when this was not possible, the lowest level of identifiable taxa (e.g., genera, family) was used. Occasionally, a taxonomic concept was created by 'lumping' several species of the same genus of known occurrence within a park. For example, both southern red cedar (*Juniperus silicicola*) and eastern red cedar (*J. virginiana*) occur on the park; both species occur in abundance in the natural and semi-natural habitats targeted by this monitoring effort; the species can often be difficult to distinguish based on vegetative features; and, finally, no other species within the genus Juniperus are known to occur within the park. A taxonomic concept was created—*Juniperus* [*silicicola* + *virginiana*]—that combined the two species into a single concept. This 'lumped' taxon is of finer scale taxonomic resolution than if these records had been identified as Juniperus sp. Once the final list was determined, each species was cross-referenced with the USDA Plants Database (USDA 2020) to determine growth form, native status, federal/state noxious status, and to provide a unique common name. When a single taxon linked to multiple growth forms, the lead author subjectively chose a single growth form to link with the taxa. The species list was also cross-referenced with the 782 rare plant element records in Georgia to determine the state and federal conservation status (e.g., Endangered, Threatened) of each species.

Sampling Methodology

The vegetation plot layout for this monitoring effort is based upon the plot design used by the Carolina Vegetation Survey (Peet et al. 1998; Lee et al. 2008) and the Cumberland Piedmont Network (White et al. 2011). The plot array consists of a 20 × 20 meters (65.6 × 65.6 ft) bounded square with multiple nested sampling frames ranging from 1 square meter (10.8 square feet [ft^2]) to 400 square meters (4,305.5 ft^2), three 25 meters (82.0 ft) fuel transects that cross both inside and outside the bounded square, and three soil sample frames located adjacent to the bounded square (Figure 2).

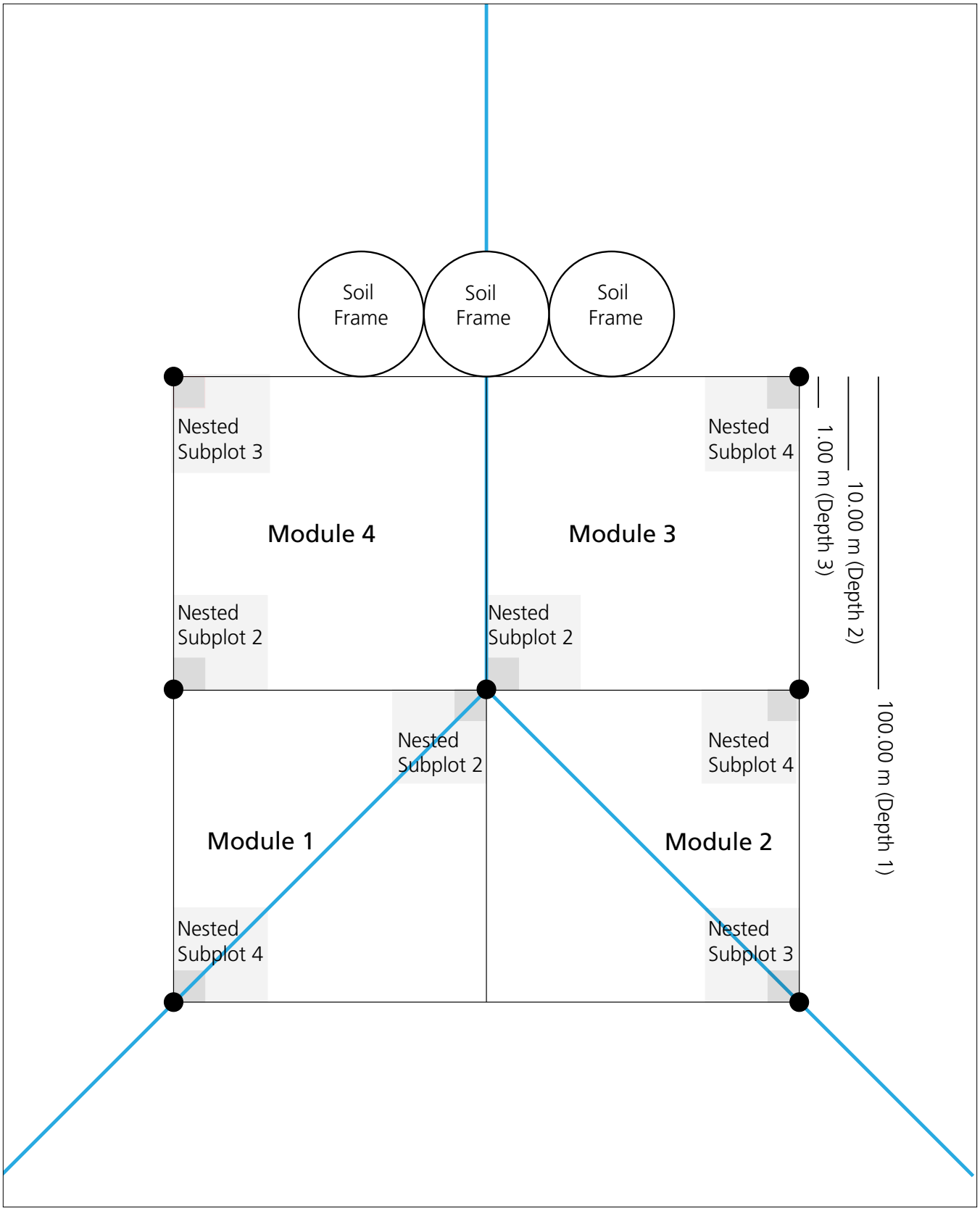

Figure 2. The layout of the sampling plot for the Southeast Coast Network, which is a modified version of the standard Level 5 Carolina Vegetation Survey plot. Ideal location of rebar used as permanent structures to monument the plot are black shaded circles. Blue lines represent location of the three 25-meter (82-foot) fuel transects.

Vascular plant species presence was determined at three scales within each of the four 100 square meters (1,076.4 ft^2) modules: the 1 square meter (10.8 ft^2) nested depth, the 10 square meters (107.6 ft^2) nested depth, and the full modular depth. The nested depth 'quadrats' were located in two of four corners within each module. For each species either rooted in or overhanging a module, an areal cover value was assigned using the cover class codes developed by the Carolina Vegetation Survey (Peet et al. 1998; Table 1).

Table 1. Vascular plant cover metrics of the Carolina Vegetation Survey (Peet et al. 1998) and used by the SECN Terrestrial Vegetation Monitoring protocol.

Cover Class	Cover Range (%)	Geometric Mean
1	0–0.1	0.03
2	0.1–1	0.32
3	1–2	1.41
4	2–5	3.16
5	5–10	7.07
6	10–25	15.81
7	25–50	35.36
8	50–75	61.24
9	75–95	84.41
10	95–100	97.47

Individual woody stem data were also calculated within each module. For each stem greater than or equal to 10 centimeters (3.9 in; tree) in diameter at 1.4 meters (4.5 ft) linear distance from the ground layer, its species, DBH, and health status was recorded. Within the two 10 square-meter (107.6 ft^2) nested depth 'quadrats' used for detecting overall species presence (see above), each woody stem that reached 1.4 meters (4.5 ft) in linear distance from the ground layer but was less than 10 centimeters (3.9 in) in diameter at this height (sapling) was identified to species and DBH was determined. Finally, each woody stem less than 1.4 meters (4.5 ft) in linear distance from the ground layer (seedling) was identified to species and a height class was determined (5–15 centimeters [2–5.9 in]; 15–30 centimeters [5.9–11.8 in]; 30–50 centimeters [11.8–19.7 in]; or 50–137 centimeters [19.7–53.9 in) within the two 1 square meter (10.8 ft^2) nested depth 'quadrats' used for detecting overall species presence (see above).

Surface fuels were assessed at each plot site using the planar transect method for the standard fuel size classes (1-hour [0-0.6 cm], 10-hour [0.6-2.5 cm], 100-hour [2.5-7.6 cm], and 1000-hour [> 7.6 cm]), and duff and litter depths (Brown 1974). Counts of each fuel size class were tallied across three fuel transects, with diameter and decay class recorded for each piece of 1000-hour fuel.

Additional site characteristics were also measured at each plot. Elements taken from the center of each plot included dominant slope, aspect, and terrain shape; basic hydrological condition; and presence and abundance of disturbance indicators. General canopy conditions were assessed, including canopy closure and average height. Closure was measured from the center of each module using a spherical densiometer, and height was taken from three representative trees within (or just outside) the plot. Soil samples were collected from the upper 10 centimeters (0.3 ft) of mineral soil in three sampling frames located adjacent to each vegetation plot. These samples were combined by plot upon return from the field and dried prior to shipping to a soil testing laboratory for standard nutrient analysis. Each plot was qualitatively assigned to one or two National Vegetation Classification (NVC) vegetation association types that best matched the sample site. Finally, two-dimensional photo points were taken with a point and shoot camera at the western and eastern center edge of each plot; a third photo point was made from the plot center using a 360-degree camera.

Results and Discussion

Sixty-six vascular plant species were detected during this monitoring effort (Appendix A), including six taxa not detected in previous lists documented in Govus (1998), Byrne et al. (2012), or NPSpecies (2019; Table 2, Figure 3). One notable species new to the park (and perhaps new to Chatham County, Georgia) is Bosc's bluet (*Oldenlandia boscii*)—an herbaceous perennial known across its range from river and pond shores and whose current conservation status within Georgia is listed as Imperiled (S2; GADNR 2013). Overall native richness ranged from two to 17 species per plot, and non-native plants were encountered in eight of the 12 plots (Table 3, Figure 4). The following species listed as invasive by the Georgia Exotic Pest Plant Council (GA-EPPC 2018) were observed on monitoring plots: Japanese honeysuckle (*Lonicera japonica*; Category 1: an exotic plant that is a serious problem in Georgia natural areas), bahiagrass (*Paspalum notatum*; Category 2: an exotic plant that has significant potential to become a serious problem in Georgia), Vasey's grass (*Paspalum urvillei*; Category 3: an exotic plant that is a minor problem in Georgia, but is known to be problematic in adjacent states), and common reed (*Phragmites australis*; Category 3). What follows is a synopsis of vegetation and environmental data stratified by each of the broadly defined habitats sampled within the park.

Table 2. Vascular plant species, subspecies, or varieties not reported from Govus (1998), Byrne et al. (2012), or NPSpecies (2019) but found at Fort Pulaski National Monument in 2019 through this current monitoring effort.

Scientific Name	Common Name[1]	Growth Form[1]	Native Status[1]	Georgia Nonnative Invasive Status[2]	Global Rank[2]	State Rank[2]
Euphorbia cyathophora	fire on the mountain	Forb/herb	Native	–	G5	S4
Oldenlandia boscii	Bosc's mille graines	Forb/herb	Native	–	G5	S2
Phragmites australis	common reed	Graminoid	Non-native	Category 3	G5	Exotic
Poa	bluegrass	Graminoid	Unknown	–	n/a	n/a
Sacciolepis striata	American cupscale	Graminoid	Native	–	G5	SNR
Pluchea odorata	sweetscent	Subshrub, Forb/herb	Native	–	G5	SNR

[1] Information obtained from the PLANTS database (USDA 2020)

[2] Conservation Status (G4: Apparently Secure; G5: Secure; SNR: Not Yet Accessed) obtained from NatureServe Explorer 2.0 (NatureServe 2020)

Figure 3. Several species were added to the Fort Pulaski plant list due to this monitoring effort, including saltmarsh fleabane (*Pluchea odorata*), pictured in the foreground (pink/purple flowers). The other plant pictured, dominating the site, is groundsel tree (*Baccharis halimifolia*).

Table 3. Vascular plant species richness across multiple spatial scales on Southeast Coast Network vegetation plots located on Fort Pulaski National Monument. The data are summarized by total number of native versus non-native species/plot, and by vegetative growth forms (T: tree, S: shrub, V: vine, H: herbs/forbs, G: graminoids). Growth form information was obtained from the USDA Plants Database (USDA 2020).

Broadly Defined Habitat	Plot	Native[1]	Non-native[1]	Unknown[1]	T[1]	S[1]	V[1]	H[1]	G[1]	T[2]	S[2]	V[2]	H[2]	G[2]	T[3]	S[3]	V[3]	H[3]	G[3]	T[4]	S[4]	V[4]	H[4]	G[4]
Maritime Tidal Wetlands	FOPU002	4.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	0.0	0.0	0.0	1.0	2.5	0.0	0.0	0.0	0.6	2.1	0.0	0.0	0.0	0.6	1.8
	FOPU004	13.0	2.0	1.0	0.0	2.0	1.0	6.0	7.0	0.0	1.3	0.3	4.5	5.0	0.0	0.4	0.1	2.4	2.6	0.0	0.3	0.1	0.5	1.5
	FOPU005	2.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.3	1.0	0.0	0.0	0.0	0.1	0.5	0.0	0.0	0.0	0.0	0.4
	FOPU006	3.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	0.0	0.0	0.0	1.0	2.0	0.0	0.0	0.0	1.0	2.0	0.0	0.0	0.0	0.8	1.8
	FOPU007	15.0	3.0	1.0	2.0	1.0	1.0	12.0	3.0	1.0	1.0	0.3	6.5	2.5	0.3	1.0	0.1	3.1	1.8	0.1	0.6	0.1	1.4	0.9
	FOPU008	2.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.3	0.0	0.0	1.0	0.0	0.3	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0
	FOPU011	5.0	1.0	1.0	0.0	1.0	0.0	2.0	4.0	0.0	0.3	0.0	0.8	2.5	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	1.3
	average	6.3	0.9	0.4	0.3	0.7	0.3	3.3	3.0	0.1	0.4	0.1	2.0	2.4	0.0	0.2	0.0	1.0	1.6	0.0	0.1	0.0	0.5	1.2
	standard deviation	5.4	1.2	0.5	0.8	0.8	0.5	4.3	2.1	0.4	0.5	0.1	2.5	1.3	0.1	0.4	0.1	1.2	0.7	0.0	0.2	0.1	0.5	0.5
Coastal Plain Open Uplands	FOPU065	17.0	2.0	0.0	8.0	3.0	4.0	4.0	0.0	5.0	1.8	2.0	1.5	0.0	1.9	1.3	0.3	0.4	0.0	0.3	0.4	0.3	0.3	0.0
	FOPU066	15.0	1.0	0.0	6.0	2.0	1.0	7.0	0.0	4.5	1.3	1.0	3.8	0.0	1.9	0.5	0.3	1.9	0.0	0.5	0.3	0.0	0.4	0.0
	FOPU067	13.0	1.0	0.0	3.0	3.0	0.0	5.0	3.0	2.5	1.5	0.0	2.0	1.5	1.6	0.5	0.0	0.8	0.4	1.0	0.3	0.0	0.4	0.1
	FOPU068	16.0	2.0	2.0	5.0	2.0	3.0	5.0	5.0	2.8	1.3	2.0	2.5	3.5	1.5	1.1	0.3	1.0	1.1	0.5	0.6	0.1	0.6	0.6
	FOPU070	9.0	1.0	0.0	6.0	1.0	3.0	0.0	0.0	4.3	1.0	1.5	0.0	0.0	2.8	0.9	0.5	0.0	0.0	1.8	0.8	0.0	0.0	0.0
	average	14.0	1.4	0.4	5.6	2.2	2.2	4.2	1.6	3.8	1.4	1.3	2.0	1.0	1.9	0.9	0.3	0.8	0.3	0.8	0.5	0.1	0.3	0.2
	standard deviation	3.2	0.5	0.9	1.8	0.8	1.6	2.6	2.3	1.1	0.3	0.8	1.4	1.5	0.5	0.3	0.2	0.7	0.5	0.6	0.2	0.1	0.2	0.3

[1] Total species richness at the full plot (400 square meters [4,305.6 ft^2]) depth

[2] Mean species richness at the modular (100 square meters [1,076.3 ft^2]) depth

[3] Mean species richness at the nested 10 square meters (107.6 ft^2) depth

[4] Mean species richness at the nested 1 square meter (10.8 ft^2) depth

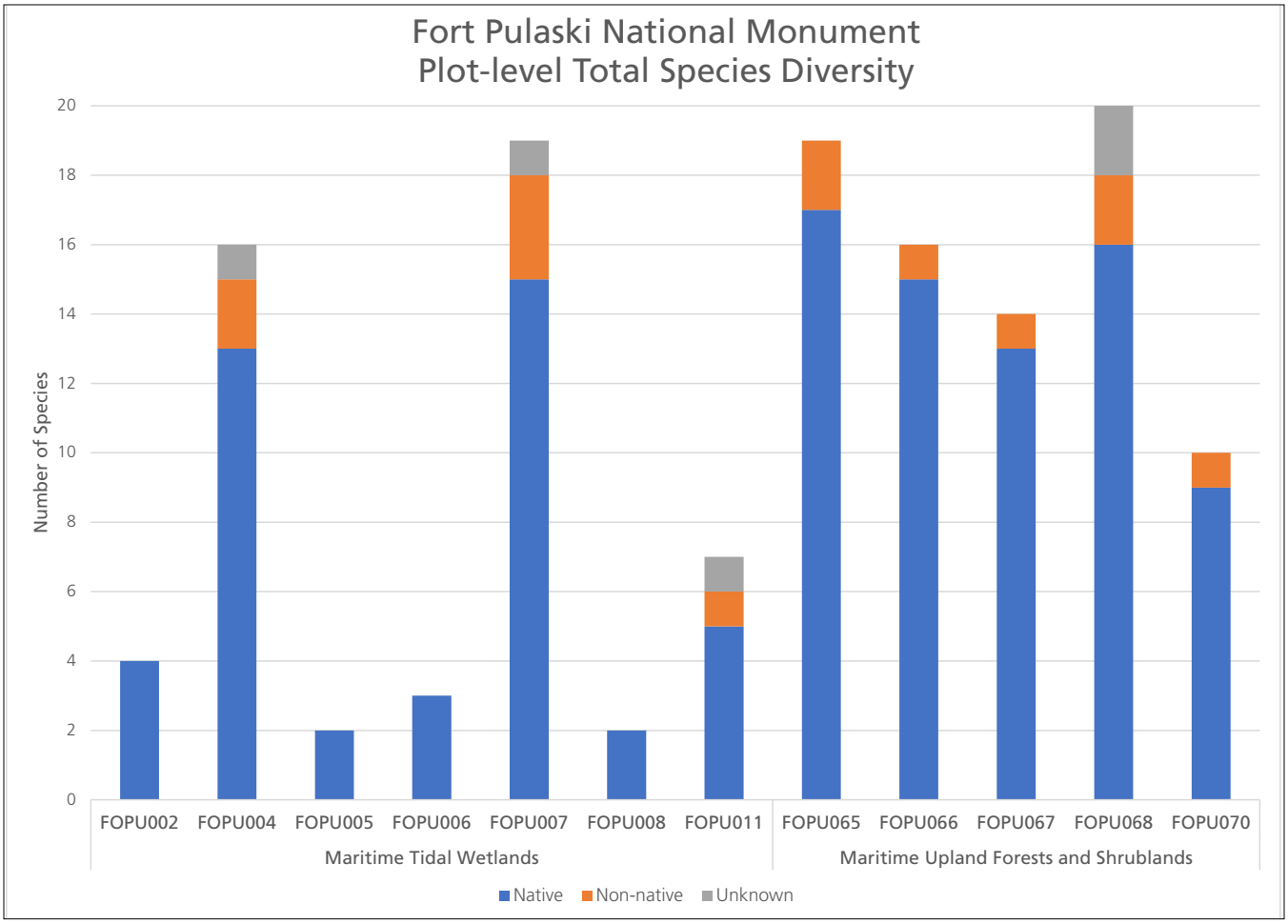

Figure 4. Native and non-native species diversity at the 400 square meter (4,306 ft^2)-scale on vegetation monitoring plots of Fort Pulaski National Monument.

Maritime Tidal Wetlands

This broadly defined habitat type includes both graminoid- and herbaceous-dominated marshes as well as forested swamps all influenced by tidal patterns, salinity fluctuations, and sediment deposition (Figure 5). Tidal salt marshes, along with their embedded salt pans, are located along maritime rivers and estuaries, and exhibit the highest salinity levels among Maritime Tidal Wetlands. This habitat type also includes freshwater and oligohaline marshes that occur upstream from salt marshes; these communities typically occur as narrow bands situated between tidal rivers and tidal swamps and bottomland forests. Most of the natural vegetation at Fort Pulaski National Monument is composed of tidal salt marshes, occurring along the edges of Cockspur Island and throughout McQueen's Island. Vegetation associations sampled at the park that belong to this broadly defined habitat type include (descriptions from NatureServe 2020):

- Coastal Salt Shrub Thicket (CEGL003920; 1 plot): Tidal shrublands occurring on elevated areas along and within salt marsh edges, typically serving as the fringe between upland forests and high marsh zones. (Global Status: G4—Apparently Secure; State [GA] Status: No Status Rank)
- Southern Atlantic Coast Salt Marsh (CEGL004191; 2 plots): Tidal marshes typically dominated by a monoculture of smooth cordgrass that experience regular daily fluctuations of flood events; commonly referred to as 'low salt marsh' because these sites incur longer submergence compared to other tidal zones. (Global Status: G5—Secure; State [GA] Status: No Status Rank)
- Atlantic Big Cordgrass Salt Marsh (CEGL004195; 2 plots): Tidal, oligohaline marshes typically composed of nearly pure stands of big cordgrass; occurring as narrow bands along tidal creeks; occasionally, these associations can have higher species diversity than tidal salt marshes. (Global Status: G4—Apparently Secure; State [GA] Status: No Status Rank)
- Mid and Southern Atlantic High Salt Marsh (CEGL004197; 1 plot): Tidal marshes that experience irregular flooding and are at slightly higher elevations than adjacent, regularly flooded low salt marshes; typically dominated by saltmeadow cordgrass (Spartina patens). (Global Status: G4—Apparently Secure; State [GA] Status: No Status Rank)
- Tidal Southern Red-cedar Woodland (CEGL007166; 1 plot): Oligohaline woodlands occurring along tidal creeks with a canopy dominated by southern red-cedar; this community type was described from coastal North Carolina and Georgia, and found between 25–35 kilometers (15.5–21.9 miles [mi]) from the ocean; it is unknown if the plot sampled at Fort Pulaski National Monument represents a version of this association that has experienced heavy mortality of southern red-cedar and other canopy trees or if this is another successional type occurring on a Cockspur Island dredge spoil site. (Global Status: G1—Critically Imperiled; State [GA] Status: No Status Rank)

This broadly defined habitat was located on Cockspur and McQueen's Islands.

Figure 5. Seven Maritime Tidal Wetland sites were sampled during this monitoring effort. These communities ranged from graminoid-dominated marshes adjacent to the Savannah River to shrublands and former forests (note in the image the dead standing red-cedar) within the interior of Cockspur Island.

Species Diversity and Abundance

Native species richness ranged from two to 15 (mean = 6.3), and collectively graminoid and herbaceous species represented the most diverse growth forms across all spatial scales of this broadly defined habitat type (Table 3, Figure 5). Non-native species were found in three of the seven plots, and included the following invasive plants: bahiagrass, Vasey's grass, and common reed. A complete species list, along with constancy and average cover per species, is located in Appendix B, Table B-1. Species with high constancy in this habitat are listed below, by growth form:

Shrubs

- Groundsel tree (*Baccharis halimifolia*; 57%)

Herbs/Forbs/Graminoids

- Smooth cordgrass (57%)
- Perennial saltmarsh aster (*Symphyotrichum tenuifolium*; 57%)
- Saltgrass (43%)
- Big cordgrass (43%)

Most of the vascular plant species observed in these plots are common throughout coastal Georgia. However, the state listed Bosc's bluet (*Oldenlandia boscii*) was observed in one of the Maritime Tidal Wetland plots on Cockspur Island.

Woody Stem Metrics

There were no live woody stems woody stems greater than or equal to 10 centimeters (3.9 in) DBH (trees) found within Maritime Tidal Wetland plots at Fort Pulaski National Monument during this monitoring effort (Table 4). Numerous large standing dead stems of southern red-cedar were located in plot FOPU004 (Figure 5); it is uncertain what caused the heavy mortality of trees observed within this site. Sapling and seedling density were also low to nonexistent in this broadly defined habitat of the park. One plot (FOPU007), located on the southeastern corner of Cockspur Island, had a high density of groundsel tree (Appendix B, Table B-2).

Table 4. Woody stem abundance and canopy metrics on Southeast Coast Network vegetation plots located in Fort Pulaski National Monument [m—meters; ha—hectares].

Broadly Defined Habitat	Plot	Tree Basal Area (m^2/ha)	Tree Density (400 m^2)	Sapling Basal Area (m^2/ha)	Sapling Density (80 m^2)	Seedling Density (8 m^2)	Mean Canopy Cover (%)	Mean Height (m)
Maritime Tidal Wetlands	FOPU002	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	FOPU004	0.0	0.0	0.0	0.0	1.0	0.0	0.0
	FOPU005	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	FOPU006	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	FOPU007	0.0	0.0	0.8	94.0	10.0	0.0	2.0
	FOPU008	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	FOPU011	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	average	0.0	0.0	0.1	13.4	1.6	0.0	0.3
	standard deviation	0.0	0.0	0.3	35.5	3.7	0.0	0.9
Maritime Upland Forests and Shrublands	FOPU065	32.0	15.0	0.4	19.0	17.0	67.0	13.0
	FOPU066	36.0	58.0	0.0	4.0	4.0	57.0	15.0
	FOPU067	31.0	30.0	0.6	47.0	17.0	60.0	9.0
	FOPU068	20.0	11.0	1.3	62.0	26.0	62.0	10.0
	FOPU070	40.0	23.0	1.5	80.0	95.0	70.0	12.0
	average	31.9	27.4	0.8	42.4	31.8	63.0	11.8
	standard deviation	7.5	18.6	0.6	31.0	36.2	5.2	2.1

Disturbance and Threats

The most frequent and noticeable disturbance type affecting this habitat type was associated with artificial drainage ditches and levees on the eastern side of Cockspur Island (Table 5). The hydrologic processes that maintain and promote natural Maritime Tidal Wetlands have been greatly affected by the land use history on Cockspur Island, including fort construction and frequent dredge spoil build-up. Ditches and levees hold water in some areas, while carrying water away in others. There are also effects to these vegetation communities associated with a fluctuating water table, which may explain the heavy mortality of southern red-cedar on the southern end of the island.

Tidal wetland plots on Steve McQueen's Island adjacent to the Savannah River probably resemble the most artificially unaltered habitat within the park, although they have been and continue to be affected by wave action and other environmental factors brought on by the maritime trade along the river channel. Two of the Maritime Tidal Wetland sites on the western end of McQueen's Island represent 'low' salt marsh (Southern Atlantic Coast Salt Marsh), while the other two represent oligohaline tidal marsh (Atlantic Big Cordgrass Salt Marsh).

Non-native species, including those identified as invasive by the Georgia Exotic Pest Plant Council (GA-EPPC 2018), were found in three of the seven Maritime Tidal Wetland plots at Fort Pulaski National Monument. Although only listed as a Category 3 invasive within the state, common reed is a wetland species that is known to have severe effects to native marsh plants in other parts of its range (e.g., North Carolina). Continued monitoring of these plots will detect the trajectory of this invasive plant, as well as others, and determine how these changes affect native species diversity.

Table 5. Disturbance observations and abundance (% cover) measured on vegetation monitoring plots in Fort Pulaski National Monument.

Broadly Defined Habitat	Plot	Logging	Drainage Ditch	Trash
Maritime Tidal Wetlands	FOPU002	–	–	–
	FOPU004	–	100	–
	FOPU005	–	–	–
	FOPU006	–	–	–
	FOPU007	–	100	–
	FOPU008	–	–	–
	FOPU011	–	100	–
Maritime Upland Forests and Shrublands	FOPU065	10	–	–
	FOPU066	10	–	10
	FOPU067	–	–	–
	FOPU068	–	–	–
	FOPU070	–	–	–

Geomorphology and Soil

Plots located within Maritime Tidal Wetlands in Fort Pulaski National Monument occurred on flat slopes with straight shapes (terrain shape indices = 0; Table 6). Standing water was observed on half of these sites during the sampling event in August, however, flooding and/or inundation is probably common at other times during the year on all these sites. All plots along McQueen's Island experience some degree of daily tidal fluctuations from the Savannah River; tidal wetlands on Cockspur Island have been maintained and to some degree created by the alteration of the island's geomorphology over the past several centuries. Some of these sites are influenced as much by groundwater fluctuations as daily tidal impacts from the Savannah River. Overall, soils within these sites were strongly acidic, with pH values ranging from 3.2 to 6.3 (mean = 4.8; Table 7). All soil nutrients, except calcium, were higher in Maritime Tidal Wetland plots than Maritime Upland Forests and Shrubland plots (Table 7).

Table 6. Local landform and hydrologic condition from vegetation monitoring plots at Fort Pulaski National Monument.

Broadly Defined Habitat	Plot	Slope (°)	Aspect (°)	TSI[1] (°)	Landform Type	Water Source	Submerged (%)
Maritime Tidal Wetlands	FOPU002	0	–	0	tidal flat	Permanent water	10
	FOPU004	0	–	0	basin/sag pond	Flood zones	0
	FOPU005	0	–	0	tidal flat	Permanent water	30
	FOPU006	0	–	0	tidal flat	Permanent water	0
	FOPU007	0	–	0	flat plain	Flood zones	0
	FOPU008	0	–	0	tidal flat	Permanent water	20
	FOPU011	0	–	0	flat plain	Ditch/Canal	0
Maritime Upland Forests and Shrublands	FOPU065	0	–	0	rolling upland	Flood zones	0
	FOPU066	0	–	0	rolling upland	Flood zones	0
	FOPU067	0	–	0	flat plain	Flood zones	0
	FOPU068	0	–	0	flat plain	Flood zones	0
	FOPU070	0	–	0	flat plain	Flood zones	0

[1] Terrain Shape Index: the larger the value, the higher degree of microsite concavity; the lower the value, the higher degree of microsite convexity; "0" values indicate a completely flat shape.

Table 7. Soil nutrient status from vegetation monitoring plots at Fort Pulaski National Monument. The Mehlich III method was used to obtain volume of exchangeable cations and extractable minor elements within soil samples. Methods to obtain other soil chemistry metrics (e.g., total exchange capacity [TEC], pH, and organic matter content [OM]) can be found on the Brookside Laboratories, Inc website (BL 2021).

Broadly Defined Habitat	Plot	TEC (ME/100g)	pH H^2O 1:1	OM (%)	P[1]	Ca[1]	Mg[1]	K[1]	Na[1]	B[1]	Fe[1]	Mn[1]	Cu[1]	Zn[1]	Al[1]
Maritime Tidal Wetlands	FOPU002	177.15	4.90	12.33	57.00	1289.00	2136.00	672.00	12525.00	3.55	271.00	30.00	1.13	4.08	333.00
	FOPU004	100.72	4.70	15.17	49.00	1078.00	1341.00	595.00	5337.00	3.11	324.00	6.00	1.64	3.17	689.00
	FOPU005	471.45	3.20	15.83	19.00	985.00	2333.00	760.00	11297.00	2.81	807.00	33.00	< 0.20	16.02	630.00
	FOPU006	120.41	5.50	12.55	62.00	1456.00	1908.00	759.00	11834.00	3.82	352.00	20.00	0.60	3.23	329.00
	FOPU007	51.13	4.60	4.89	37.00	608.00	1025.00	444.00	1637.00	1.13	457.00	10.00	< 0.20	3.93	397.00
	FOPU008	36.06	6.30	4.41	37.00	722.00	937.00	290.00	4202.00	2.00	457.00	9.00	0.41	1.67	95.00
	FOPU011	156.45	4.20	31.83	35.00	1205.00	1191.00	388.00	6898.00	1.91	533.00	17.00	0.39	4.57	534.00
	average	159.05	4.77	13.86	42.29	1049.00	1553.00	558.29	7675.71	2.62	457.29	17.86	0.83	5.24	429.57
	standard deviation	146.97	0.98	9.15	14.73	303.85	563.99	186.77	4253.00	0.97	178.69	10.51	0.54	4.84	204.46
Maritime Upland Forests and Shrublands	FOPU065	34.03	8.20	9.29	44.00	4619.00	901.00	276.00	374.00	2.64	46.00	55.00	1.10	3.84	46.00
	FOPU066	40.98	8.30	8.63	33.00	5905.00	876.00	153.00	574.00	2.34	29.00	40.00	1.08	4.99	29.00
	FOPU067	18.60	6.60	2.76	40.00	1010.00	508.00	143.00	1596.00	1.62	163.00	14.00	0.53	0.80	91.00
	FOPU068	2.75	7.10	1.35	9.00	190.00	127.00	45.00	117.00	0.32	53.00	7.00	0.69	1.39	55.00
	FOPU070	13.43	5.90	6.37	34.00	1361.00	271.00	71.00	234.00	0.62	137.00	13.00	0.48	1.06	72.00
	average	21.96	7.22	5.68	32.00	2617.00	536.60	137.60	579.00	1.51	85.60	25.80	0.78	2.42	58.60
	standard deviation	15.50	1.03	3.52	13.62	2493.45	348.97	90.04	593.47	1.02	60.14	20.68	0.30	1.88	23.86

[1] Anions (P: Phosphorous); Exchangeable Cations (Ca: Calcium, Mg: Magnesium, K: Potassium, Na: Sodium); Extractable Minors (B: Boron, Fe: Iron, Mn: Manganese, Cu: Copper, Zn: Zinc, Al: Aluminum). Data reported in parts per million (ppm).

Maritime Upland Forests and Shrublands

Maritime forests and shrublands of the South Atlantic outer Coastal Plain are located on stabilized dunes of barrier islands and ridges and bluffs of mainland settings adjacent to the coast (Figure 6). These upland communities are typically protected from tidal inundation, but occasionally can flood during strong storm surge. More persistent natural disturbances include aerosol salt spray, strong winds, and sandy, low productive soils. These conditions are more pronounced on the forest edges of Maritime Upland Forests and Shrublands, where they border ocean and dune habitat or salt marsh habitat. Vegetation associations sampled at Fort Pulaski National Monument that belong to this broadly defined habitat type include (descriptions from NatureServe 2020):

- South Atlantic Coastal Shell Midden Woodland (CEGL3525; 3 plots): Forests that occur on calcareous sands, shell hashes, Native American shell middens, and natural shell deposits, typically occurring between marsh and other matrix maritime forests. (Global Status: G2—Imperiled; State [GA] Status: S1?—Critically Imperiled)
- Southern Red-cedar – Live Oak – Cabbage Palmetto Marsh Hammock (CEGL007813; 2 plots): Forests that occur on small islands surrounded by tidal salt marsh along the South Atlantic Coast from North Carolina to northeastern Florida. The canopy typically is dominated by southern red-cedar, along with live oak (*Quercus virginiana*), cabbage palmetto, and sugarberry (*Celtis laevigata*). (Global Status: G3—Vulnerable; State [GA] Status: No Status Rank)

This broadly defined habitat is on Cockspur and McQueen's Islands.

Figure 6. Five Maritime Upland Forest and Shrubland sites were sampled during this monitoring effort, including calciphilic woodlands of shell deposits dominated by a southern red-cedar canopy and the state imperiled (S2) Florida wild privet within the subcanopy.

Species Diversity and Abundance

Native species richness ranged from nine to 17 (mean = 14.0) within vegetation plots of this broadly defined habitat type, and all plots had at least one non-native species present (Table 3 and Figure 5). Tree species were the most diverse growth form within this habitat across all spatial scales—full plot to 1 square meter (10.8 ft^2) nested quadrat (Table 3). The invasive Japanese honeysuckle was observed in two of the five plots. The Georgia state imperiled Florida wild privet, which had been documented at Fort Pulaski National Monument in earlier floristic inventories, was located on both marsh hammock plots of McQueen's Island and in one upland forest plot on Cockspur Island. Species with high constancy are listed below, by growth form (Appendix B, Table B-1):

Trees

- Southern/eastern red cedar (100%)
- Cabbage palmetto (71%)
- Sugarberry (80%)
- Tough bully (*Sideroxylon tenax*; 80%)

Shrubs

- Yaupon (100%)
- Groundsel tree (80%)

Vines

- Saw greenbriar (*Smilax bona-nox*; 80%)

Herbs/Forbs/Graminoids

- Seaside goldenrod (*Solidago mexicana*; 80%)

Woody Stem Metrics

Total BA and density of trees ranged from 20.4 to 30.5 m^2/ha and 11 to 58 stems per plot, respectively, in Maritime Upland Forests and Shrubland plots (Table 4). Dominant canopy species included southern/eastern red cedar (mean BA = 27.83 m^2/ha, mean density = 783 stems/ha) and cabbage palmetto (mean BA = 19.07 m^2/ha, mean density = 208 stems/ha) (Appendix B, Table B-2). Canopy cover within these sites ranged from 57 to 70%, and canopy height ranged from 9 to 15 meters (Table 4). Sapling density ranged from four to 80 stems/80 m^2, with an average of 42.4, and seedling density ranged from four to 95 stems/8 m^2, with an average of 31.8 across all plots (Table 4). Dominant sapling species included cabbage palmetto and yaupon; dominant seedlings included yaupon and Carolina laurel cherry (*Prunus caroliniana*) (Appendix B, Table B-2).

Based on stem count, southern/eastern red cedar comprised 69% of the relative abundance among species within the tree stratum, and cabbage palmetto comprised 18%; cabbage palmetto and yaupon dominated the sapling stratum; and yaupon and Carolina laurel cherry dominated the seeding stratum. (Figure 7).

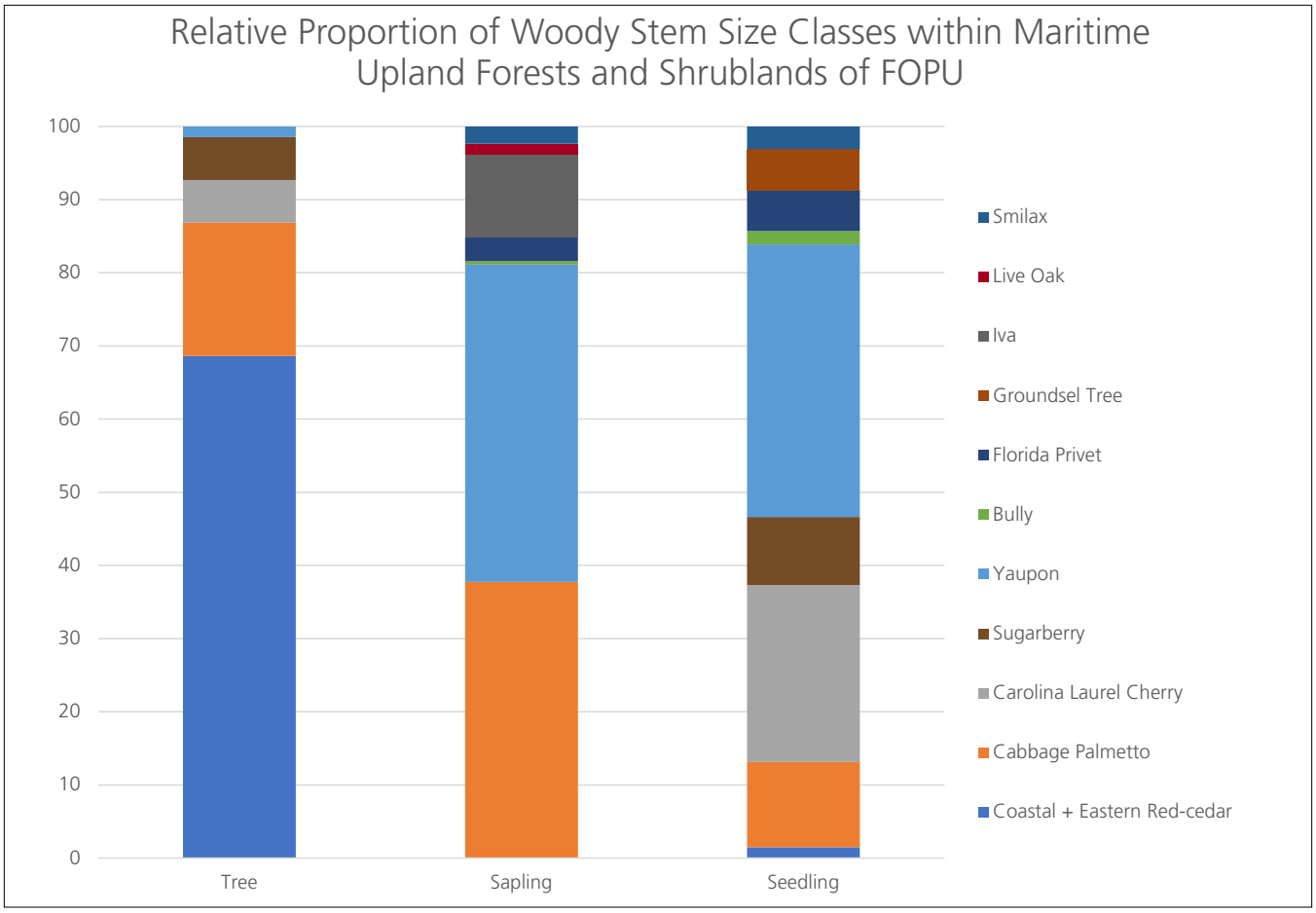

Figure 7. Relative proportion of species groups across three woody stem strata—trees, saplings, and seedlings—within Maritime Upland Forest and Shrubland vegetation monitoring plots of Fort Pulaski National Monument.

Of the 144 trees measured in Maritime Forest and Shrubland plots during this sampling effort, only seven (5%) were identified as dead (Figure 8). Most were southern/eastern red cedar. Some degree of tree mortality is not uncommon in these forested habitats. However, the decline in tree vigor and high rates of dieback could be a future concern for forested ecosystems of the park, particularly with one species—sugarberry. For more than a decade, the southeastern United States has experienced high rates and widespread die-off of sugarberry with no known causal agent (Poole et al. 2021). Based on the data from SECN vegetation plots, sugarberry comprises roughly 6% of the tree stems, and was not observed in sapling or seedling quadrats (Figure 7). Of the eight sugarberry trees measured on our vegetation plots, five were given a vigor code other than 'healthy,' and all had more than 10% dieback (Figure 9). Because of limits with this monitoring effort (e.g., there is no systematic effort to identify all insect pests or tree pathogens within a site/plot) and the uncertain nature in the widespread decline in sugarberry, it cannot be determined whether these observations are related to the larger-scale threat. However, future monitoring efforts should detect the trends in overall decline of this species on these plots.

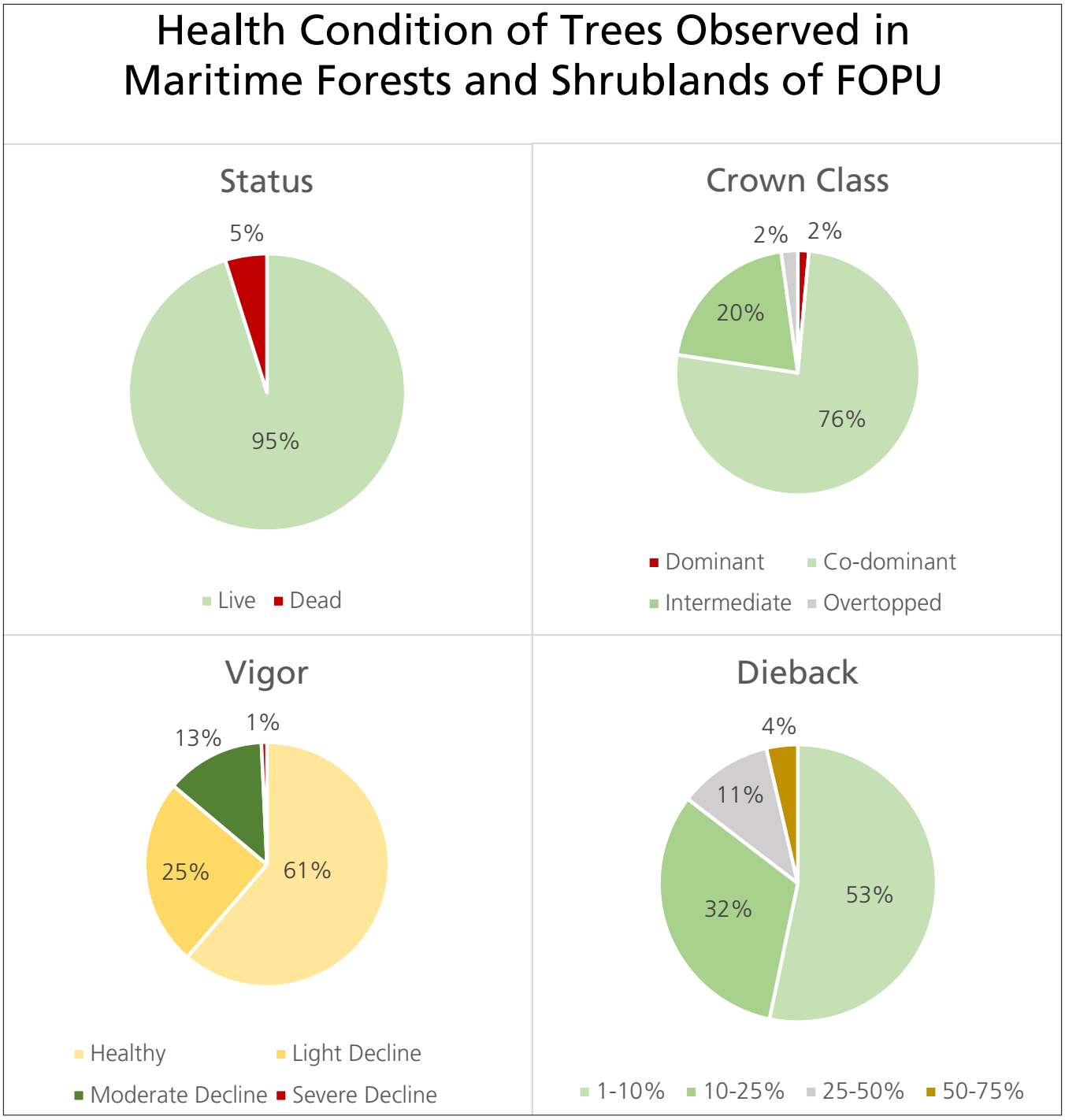

Figure 8. Health condition of woody stems greater than or equal to 10 centimeters (3.9 in) DBH ('trees') measured on Maritime Upland Forest and Shrubland vegetation monitoring plots of Fort Pulaski National Monument.

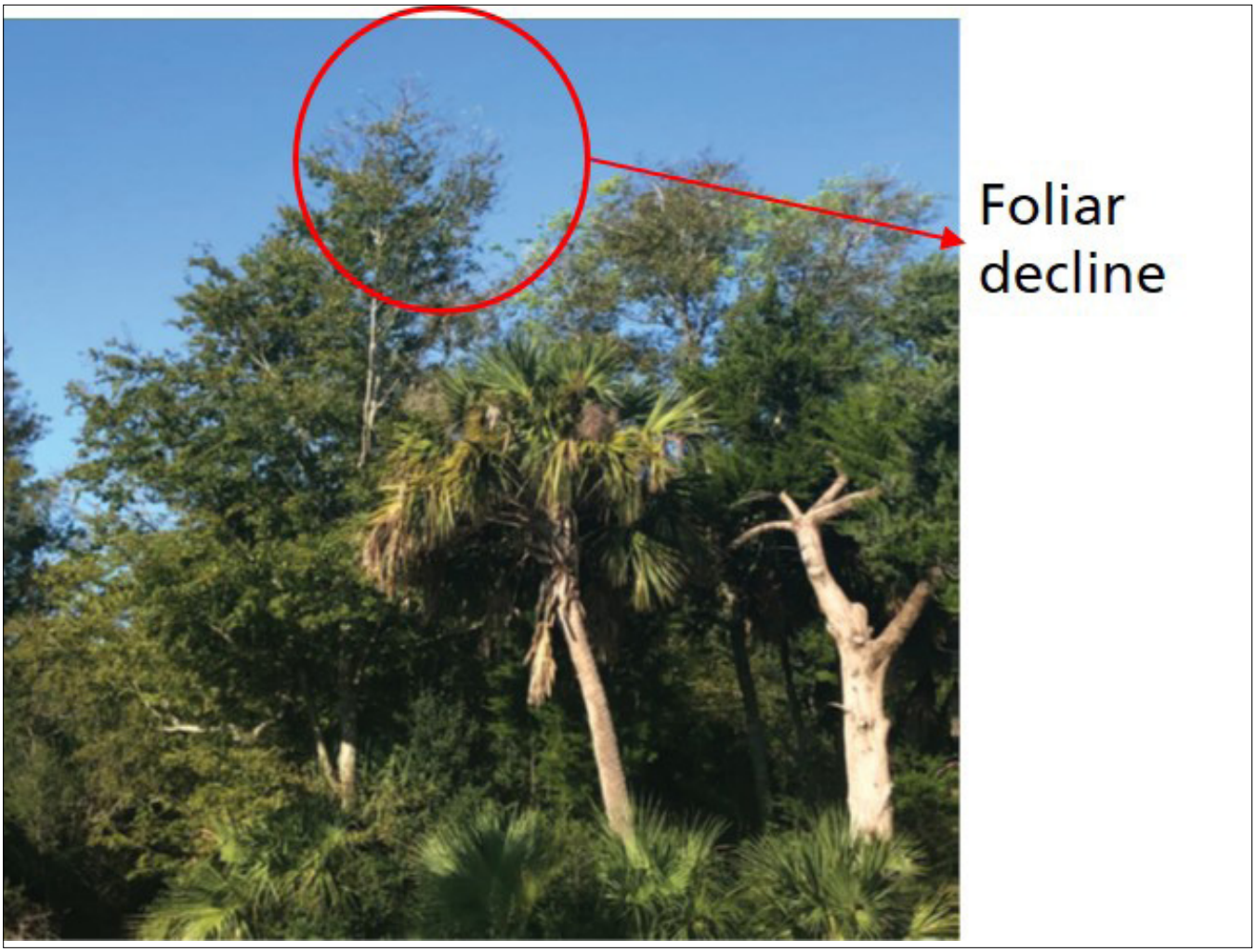

Figure 9. An individual sugarberry located on Fort Pulaski National Monument with observable leaf dieback in late summer. NPS photo / Candice Wyatt.

Disturbance and Threats

There were relatively few observed community-level disturbances on plots in Maritime Upland Forest and Shrubland habitat at Fort Pulaski National Monument. There were recent cut southern/eastern red-cedar stumps observed on both plots of McQueen's Island, and trash was found on one of these plots, probably due to the close proximity of U.S. Highway 80. Both sites were classified as shell midden woodlands—a critically imperiled vegetation association within Georgia (NatureServe 2020). This community is different from other maritime forests in the South Atlantic Coast due to the high site density of shell within the soil, which results in higher pulses of calcium within the substrate than in the surrounding landscape. Calciphilic (~calcium-loving) plants are often found in these communities, along with other species of typical maritime forests. It is uncertain the origin of these calciphilic woodlands at Fort Pulaski National Monument, in terms of their age and origin (e.g., developed naturally or by prehistoric Native Americans). Land maps from the late 19th century, however, suggest there was little dry upland on McQueen's Island (NPS 1995); this suggests these woodlands are relatively young and not of Native American origin. Regardless of age, these woodlands are extremely rare within the South Atlantic Coast. The examples at Fort Pulaski National Monument are well-developed and protected from events such as coastal development that threaten this community type in other parts of its range. Another potential threat to these woodlands is the alteration of native composition from the affects of invasive species (e.g., Chinese tallow-tree (*Triadica sebifera*). Chinese tallow-tree has been documented in the park in earlier plant surveys (e.g., Govus 1998), but it was not observed during this monitoring effort. Japanese privet (*Ligustrum japonicum*) was observed during the Govus (1998) inventory on McQueen's Island shell middens but not during this monitoring effort.

Geomorphology and Soil

Plots located within Maritime Upland Forests and Shrublands at Fort Pulaski National Monument occurred on flat upper slopes of Cockspur and McQueen's Island, and well above the mean high tide zone (Table 6). Like many sites along the South Atlantic coastal strand, flooding can occur even in these upland sites during extreme storm events associated with high tides. The soils of this broadly defined habitat at the park have a fairly neutral pH (average = 7.2), with soils on McQueen's Island shell midden plots having a moderately alkaline pH (> 7.9; Table 7). There were elevated levels of calcium within these McQueen's Island plots, which explains the presence of certain calciphilic species (e.g., Florida wild privet).

Fuel Load Estimates

Fuel loads were estimated on all FOPU plots except those tidal wetland plots on McQueen's Island directly adjacent to the Savannah River and exposed to daily tidal fluctuations (Figure 10). Fuel loads at Fort Pulaski National Monument ranged from 2.2 to 25.6 tons per acre (average = 9.54; Figure 10). Most of the fuel load volume on these sites is comprised of duff and litter and standing live vegetation (not measured). All fuel variables, including fine woody debris (FWD) (e.g., 1-, 10-, 100-hour diameter classes, coarse woody debris (CWD) (1,000-hour diameter class), duff, and litter were highly variable between plots. High variability in fuel loads is related to different vegetation structure and disturbance history between sites.

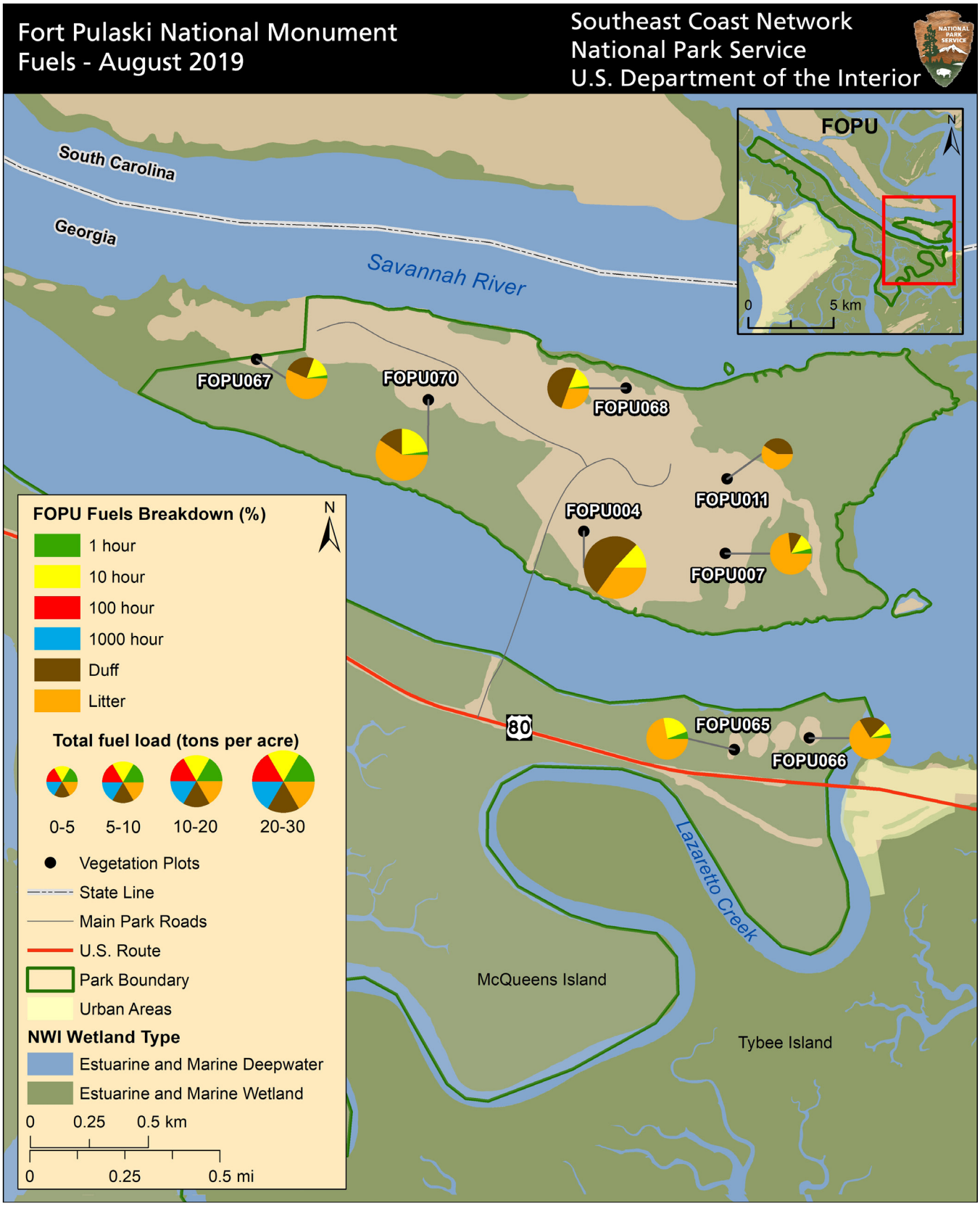

Figure 10. Fuel load estimates from vegetation monitoring plots located at Fort Pulaski National Monument.

Literature Cited

Boyle, M. F., M. B. Gregory, M. W. Byrne, P. Capece, and S. Corbett. 2019. Terrestrial vegetation monitoring in Southeast Coast Network parks: Protocol implementation plan. Natural Resource Report NPS/SECN/NRR—2019/1930. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2263392 (last accessed January 2021).

Brookside Laboratories, Inc (BL). 2021. Soil Analysis. Available at: https://www.blinc.com/services/soil-analysis (last accessed January 2021).

Brown, J. K. 1974. Handbook for inventorying downed woody material. USDA For. Sew. Gen. Tech. Rep. INT-16, 24 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Byrne, M. W., S. L. Corbett, and J. C. DeVivo. 2012. Vegetation community monitoring at Fort Pulaski National Monument, 2010. Natural Resource Data Series NPS/SECN/NRDS—2012/252. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2184034 (last accessed March 2021).

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of the United States: a working classification of U.S. terrestrial systems. Arlington, VA: NatureServe.

DeVivo, J. C., C. J. Wright, M. W. Byrne, E. DiDonato, and T. Curtis. 2008. Vital signs monitoring in the Southeast Coast Inventory & Monitoring Network. Natural Resource Report NPS/SECN/NRR—2008/061. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/660552 (last accessed January 2021).

Edmiston, J. E. 1963. The ecology of the Florida pine flatwoods. Ph.D. dissertation. University of Florida, Gainesville, Florida.

Federal Geographic Data Committee (FGDC). 2008. National vegetation classification standard, version 2: vegetation subcommittee, Federal Geographic Data Committee. FGDC-STD-005-2008 (Version 2).

Foster, D. R., G. Motzkin, and B. Slater. 1998. Land-use history as long-term broad-scale disturbance: Regional forest dynamics in central New England. Ecosystems 1:96–119.

Fraedrich, S. W., T. C. Harrington, R. J. Rabaglia, M. D. Ulyshen, A. E. Mayfield, III, J. L. Hanula, J. M Eickwort, and D. R. Miller. 2008. A fungal symbiont of the redbay ambrosia beetle causes a lethal wilt in redbay and other Lauraceae in the southeastern USA. Plant Disease 92:215–224.

Georgia Department of Natural Resources (GADNR). 2013. Wildlife Conservation Section Biotics Database. Wildlife Resources Division, Social Circle, Georgia. Available at: http://www.georgiawildlife.com (last accessed March 2021).

Georgia Exotic Pest Plant Council (GA-EPPC). 2018. List of non-native invasive plants in Georgia. Available at: https://www.gaeppc.org/list/ (last accessed March 2021.

Govus, T.E. 1998. Fort Pulaski National Monument inventory, final report, part A: plants. Atlanta, Georgia. 68 pp.

Heyward, F. 1939. Some moisture relationships of soils from burned and unburned longleaf-pine forests. Soil Science 47: 313–325.

Intergovernmental Panel on Climate Change (IPCC). 2019. Choices made now are critical for the future of our ocean and cryosphere (web article). Available at: https://www.ipcc.ch/2019/09/25/srocc-press-release/ (last accessed March 2021).

Lee, M. T., R. K. Peet, S. D. Roberts, and T. R. Wentworth. 2008. CVS-EEP protocol for recording vegetation, all levels of plot sampling, version 4.2. Carolina Vegetation Survey. Available at: http://cvs.bio.unc.edu/protocol/cvs-eep-protocol-v4.2-lev1-5.pdf (last accessed January 2021).

National Park Service (NPS). 1995. Resource management plan, Fort Pulaski National Monument. National Park Service, Savannah, Georgia.

NatureServe. 2020. NatureServe Explorer 2.0: an online encyclopedia of life [web application]. NatureServe, Arlington, Virginia. Available at: https://explorer.natureserve.org/ (last accessed January 2021).

NPSpecies - The National Park Service Biodiversity Database. 2020. Secure online version. Available at: https://irma.nps.gov/NPSpecies/ (last accessed January 2021).

Peet, R. K., T. R. Wentworth, and P. S. White. 1998. The North Carolina Vegetation Survey protocol: a flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262–274.

Poole, E.M., M.D. Ulyshen, S. Horn, P. Anderson, C. Bates, and C. Barnes. 2021. Progression of sugarberry (Celtis laevigata) dieback and mortality in the Southeastern United States. Journal of Forestry. fvab005, https://doi.org/10.1093/jofore/fvab005 (last accessed March 2021).

Robinson, L.G. 2018. Natural Heritage Program list of rare plant species of North Carolina, 2018, rev: October 19, 2018. North Carolina Natural Heritage Program. 175 pp.

Sorrie, B. A., and A. S. Weakley. 2001. Coastal Plain plant endemics: phytogeographic patters. Castanea 66:50–82.

Stevens, D. L., and A. N. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of American Statistical Association 99(465):262–278.

Turner, II, B. L., W. C. Clark, R. W. Kates, J. F. Richards, J. T. Mathews, and W. B. Meyer, editors. 1990. The earth as transformed by human action: Global and regional changes in the biosphere over the past 300 years. Cambridge University Press, Cambridge, United Kingdom.

U.S. Department of Agriculture (USDA), Natural Resources Conservation Service. 2020.The PLANTS Database.. National Plant Data Team, Greensboro, N.C. 27401-4901 USA. Available at: http://plants.usda.gov (last accessed Janaury 2021).

van der Valk, A.G. 1975. The floristic composition and structure of foredune plant communities of Cape Hatteras National Seashore. Chesapeake Science 16(2):115–126.

Weakley, A. S. 2019. Flora of the southern and mid-Atlantic states: working draft of 2019. University of North Carolina Herbarium (NCU), Chapel Hill, North Carolina.

White, R., C. Nordman, L. Smart, T. Leibfreid, B. Moore, R. Smyth, and T. Govus. 2011. Vegetation monitoring protocol for the Cumberland Piedmont Network, Version 1. Natural Resource Report NPS/CUPN/NRR—2011/XXX. National Park Service. Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2192468 (last accessed January 2021).

Appendix A. Vascular Plants Observed During the 2019 Southeast Coast Network Terrestrial Vegetation Monitoring Effort at Fort Pulaski National Monument

Table A-1. Vascular plant species present in 12 vegetation monitoring plots at Fort Pulaski National Monument, August 2019.

Order	Family	Scientific Name	Common Name[1]	Native Status[1]	Federal T/E Status[1]	Growth Form	Georgia T/E Status[2]	State Invasive Status[3]
Arecales	Arecaceae	*Sabal palmetto*	cabbage palmetto	Native	–	Tree	–	–
Asterales	Asteraceae	*Baccharis halimifolia*	eastern baccharis	Native	–	Tree, Shrub	–	–
Asterales	Asteraceae	*Borrichia frutescens*	bushy seaside tansy	Native	–	Subshrub	–	–
Asterales	Asteraceae	*Erigeron bonariensis*	asthmaweed	Non-native	–	Forb/herb	–	–
Asterales	Asteraceae	*Erigeron pusillus*	Canadian horseweed	Native	–	Forb/herb	–	–
Asterales	Asteraceae	*Eupatorium capillifolium*	dogfennel	Native	–	Forb/herb	–	–
Asterales	Asteraceae	*Eupatorium serotinum*	lateflowering thoroughwort	Native	–	Forb/herb	–	–
Asterales	Asteraceae	*Euthamia hirtipes*	flat-top goldentop	Native	–	Forb/herb	–	–
Asterales	Asteraceae	*Iva frutescens var. frutescens*	Jesuit's bark	Native	–	Subshrub, Forb/herb	–	–
Asterales	Asteraceae	*Mikania scandens*	climbing hempvine	Native	–	Vine, Forb/herb	–	–
Asterales	Asteraceae	*Pluchea odorata*	sweetscent	Native	–	Subshrub, Forb/herb	–	–
Asterales	Asteraceae	*Solidago mexicana*	seaside goldenrod	Native	–	Forb/herb	–	–
Asterales	Asteraceae	*Symphyotrichum tenuifolium*	perennial saltmarsh aster	Native	–	Forb/herb	–	–
Asterales	Asteraceae	*Taraxacum officinale*	common dandelion	Non-native	–	Forb/herb	–	–
Batales	Bataceae	*Batis maritima*	turtleweed	Native	–	Subshrub	–	–
Bromeliales	Bromeliaceae	*Tillandsia usneoides*	Spanish moss	Native	–	Vine, Forb/herb	–	–
Campanulales	Campanulaceae	*Wahlenbergia marginata*	southern rockbell	Non-native	–	Forb/herb	–	–
Capparales	Brassicaceae	*Lepidium virginicum*	Virginia pepperweed	Native	–	Forb/herb	–	–
Caryophyllales	Cactaceae	*Opuntia mesacantha*	devil's-tongue	Native	–	Shrub	–	–
Caryophyllales	Chenopodiaceae	*Atriplex prostrata*	triangle orache	Non-native	–	Forb/herb	–	–
Caryophyllales	Chenopodiaceae	*Salicornia ambigua*	chickenclaws	Native	–	Forb/herb, Shrub	–	–
Caryophyllales	Phytolaccaceae	*Phytolacca americana*	American pokeweed	Native	–	Forb/herb	–	–
Celastrales	Aquifoliaceae	*Ilex vomitoria*	yaupon	Native	–	Tree, Shrub	–	–
Cyperales	Cyperaceae	*Bolboschoenus robustus*	sturdy bulrush	Native	–	Graminoid	–	–
Cyperales	Cyperaceae	*Cyperus polystachyos*	manyspike flatsedge	Native	–	Graminoid	–	–
Cyperales	Cyperaceae	*Cyperus retrorsus*	pine barren flatsedge	Native	–	Graminoid	–	–
Cyperales	Cyperaceae	*Fimbristylis castanea*	marsh fimbry	Native	–	Graminoid	–	–

[1] Information obtained from the PLANTS database (USDA 2020)

[2] Information obtained from Georgia Wildlife Conservation Section Biotics Database (GADNR 2013)

[3] Information obtained from the Georgia Exotic Pest Plant Council (GA-EPPC 2018)

Table A-1 (continued). Vascular plant species present in 12 vegetation monitoring plots at Fort Pulaski National Monument, August 2019.

Order	Family	Scientific Name	Common Name[1]	Native Status[1]	Federal T/E Status[1]	Growth Form	Georgia T/E Status[2]	State Invasive Status[3]
Cyperales	Cyperaceae	*Scleria triglomerata*	whip nutrush	Native	–	Graminoid	–	–
Cyperales	Poaceae	*Andropogon tenuispatheus*	bushy bluestem	Native	–	Graminoid	–	–
Cyperales	Poaceae	*Distichlis spicata*	saltgrass	Native	–	Graminoid	–	–
Cyperales	Poaceae	*Eremochloa ophiuroides*	centipede grass	Non-native	–	Graminoid	–	–
Cyperales	Poaceae	*Eustachys petraea*	pinewoods fingergrass	Native	–	Graminoid	–	–
Cyperales	Poaceae	*Paspalum distichum*	mudbank crowngrass	Native	–	Graminoid	–	–
Cyperales	Poaceae	*Paspalum notatum*	bahiagrass	Non-native	–	Graminoid	–	Category 2
Cyperales	Poaceae	*Paspalum urvillei*	Vasey's grass	Non-native	–	Graminoid	–	Category 3
Cyperales	Poaceae	*Paspalum vaginatum*	seashore paspalum	Native	–	Graminoid	–	–
Cyperales	Poaceae	*Phragmites australis*	common reed	Non-native	–	Graminoid	–	Category 3
Cyperales	Poaceae	*Poa*	bluegrass	Unknown	–	Graminoid	–	–
Cyperales	Poaceae	*Poaceae*	Grass Family	Unknown	–	Graminoid	–	–
Cyperales	Poaceae	*Sacciolepis striata*	American cupscale	Native	–	Graminoid	–	–
Cyperales	Poaceae	*Setaria magna*	giant bristlegrass	Native	–	Graminoid	–	–
Cyperales	Poaceae	*Spartina alterniflora*	smooth cordgrass	Native	–	Graminoid	–	–
Cyperales	Poaceae	*Spartina cynosuroides*	big cordgrass	Native	–	Graminoid	–	–
Cyperales	Poaceae	*Spartina patens*	saltmeadow cordgrass	Native	–	Graminoid	–	–
Dipsacales	Caprifoliaceae	*Lonicera japonica*	Japanese honeysuckle	Non-native	–	Vine	–	Category 1
Ebenales	Sapotaceae	*Sideroxylon tenax*	tough bully	Native	–	Tree, Shrub	–	–
Euphorbiales	Euphorbiaceae	*Euphorbia cyathophora*	fire on the mountain	Native	–	Forb/herb	–	–
Fabales	Fabaceae	*Vachellia farnesiana*	sweet acacia	Native	–	Shrub, Tree	–	–
Fagales	Fagaceae	*Quercus virginiana*	live oak	Native	–	Tree	–	–
Geraniales	Oxalidaceae	*Oxalis stricta*	common yellow oxalis	Native	–	Forb/herb	–	–
Liliales	Agavaceae	*Yucca aloifolia*	aloe yucca	Native	–	Tree, Shrub	–	–
Liliales	Smilacaceae	*Smilax auriculata*	earleaf greenbrier	Native	–	Shrub, Vine	–	–
Liliales	Smilacaceae	*Smilax bona-nox*	saw greenbrier	Native	–	Shrub, Vine	–	–
Myrtales	Onagraceae	*Oenothera laciniata*	cutleaf evening primrose	Native	–	Forb/herb	–	–

[1] Information obtained from the PLANTS database (USDA 2020)

[2] Information obtained from Georgia Wildlife Conservation Section Biotics Database (GADNR 2013)

[3] Information obtained from the Georgia Exotic Pest Plant Council (GA-EPPC 2018)

Table A-1 (continued). Vascular plant species present in 12 vegetation monitoring plots at Fort Pulaski National Monument, August 2019.

Order	Family	Scientific Name	Common Name[1]	Native Status[1]	Federal T/E Status[1]	Growth Form	Georgia T/E Status[2]	State Invasive Status[3]
Pinales	Cupressaceae	*Juniperus [silicicola + virginiana]*	eastern redcedar	Native	–	Tree	–	–
Rhamnales	Vitaceae	*Muscadinia rotundifolia* var. *rotundifolia*	muscadine	Native	–	Vine	–	–
Rhamnales	Vitaceae	*Nekemias arborea*	peppervine	Native	–	Shrub, Vine	–	–
Rhamnales	Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	Native	–	Vine	–	–
Rosales	Rosaceae	*Prunus caroliniana*	Carolina laurelcherry	Native	–	Tree, Shrub	–	–
Rosales	Rosaceae	*Rubus*	blackberry	Unknown	–	Forb/herb	–	–
Rubiales	Rubiaceae	*Oldenlandia boscii*	Bosc's mille graines	Native	–	Forb/herb	S2?	–
Sapindales	Rutaceae	*Zanthoxylum clava-herculis*	Hercules' club	Native	–	Tree, Shrub	–	–
Scrophulariales	Oleaceae	*Forestiera segregata*	Florida swampprivet	Native	–	Shrub, Tree	S2	–
Solanales	Convolvulaceae	*Ipomoea sagittata*	saltmarsh morning-glory	Native	–	Vine, Forb/herb	–	–
Solanales	Solanaceae	*Physalis walteri*	Walter's groundcherry	Native	–	Forb/herb	–	–
Urticales	Ulmaceae	*Celtis laevigata*	sugarberry	Native	–	Tree, Shrub	–	–

[1] Information obtained from the PLANTS database (USDA 2020)

[2] Information obtained from Georgia Wildlife Conservation Section Biotics Database (GADNR 2013)

[3] Information obtained from the Georgia Exotic Pest Plant Council (GA-EPPC 2018)

Table B-1. Constancy and average cover class for all vascular plant species observed in 12 Southeast Coast Network vegetation monitoring plots. Broad Habitat Type Codes are as follows: MTW = Maritime Tidal Wetlands (seven plots) and MUFS = Maritime Upland Forests and Shrublands (five plots). Cover classes are as follows: 1: 0–0.1%, 2: 0.1–1%, 3: 1–2%, 4: 2–5%, 5: 5–10%, 6: 10–25%, 7: 25–50%, 8: 50–75%, 9: 75–95%, 10: 95–100%.

Species	MTW Constancy	MTW Cover	MUFS Constancy	MUFS Cover
Andropogon tenuispatheus	–	–	20	1
Atriplex prostrata	14	1	20	1
Baccharis halimifolia	57	5	80	2
Batis maritima	29	3	–	–
Bolboschoenus robustus	14	7	–	–
Borrichia frutescens	29	3	40	4
Celtis laevigata	–	–	80	5
Cyperus polystachyos	14	1	–	–
Cyperus retrorsus	–	–	20	2
Distichlis spicata	43	6	20	4
Eremochloa ophiuroides	–	–	20	3
Erigeron bonariensis	–	–	40	2
Erigeron pusillus	–	–	20	2
Eupatorium capillifolium	14	1	–	–
Eupatorium serotinum	14	6	–	–
Euphorbia cyathophora	–	–	20	2
Eustachys petraea	–	–	20	3
Euthamia hirtipes	14	2	20	2
Fimbristylis castanea	–	–	20	3
Forestiera segregata	–	–	60	4
Ilex vomitoria	14	2	100	6
Ipomoea sagittata	14	1	–	–
Iva frutescens var. *frutescens*	–	–	20	3
Juniperus [silicicola + virginiana]	–	–	100	7
Lepidium virginicum	–	–	40	2
Lonicera japonica	–	–	40	2
Mikania scandens	14	2	–	–
Muscadinia rotundifolia var. rotundifolia	–	–	20	2
Nekemias arborea	–	–	20	2
Oenothera laciniata	–	–	20	1
Oldenlandia boscii	14	1	–	–
Opuntia mesacantha	–	–	20	2
Oxalis stricta	–	–	20	1
Parthenocissus quinquefolia	–	–	40	2
Paspalum distichum	14	1	–	–

Table B-1 (continued). Constancy and average cover class for all vascular plant species observed in 12 Southeast Coast Network vegetation monitoring plots. Broad Habitat Type Codes are as follows: MTW = Maritime Tidal Wetlands (seven plots) and MUFS = Maritime Upland Forests and Shrublands (five plots). Cover classes are as follows: 1: 0–0.1%, 2: 0.1–1%, 3: 1–2%, 4: 2–5%, 5: 5–10%, 6: 10–25%, 7: 25–50%, 8: 50–75%, 9: 75–95%, 10: 95–100%.

Species	MTW Constancy	MTW Cover	MUFS Constancy	MUFS Cover
Paspalum notatum	14	2	–	–
Paspalum urvillei	14	3	–	–
Paspalum vaginatum	14	5	–	–
Phragmites australis	14	2	–	–
Physalis walteri	14	2	–	–
Phytolacca americana	14	1	20	2
Pluchea odorata	29	4	–	–
Poa	14	2	–	–
Poaceae	–	–	20	2
Prunus caroliniana	–	–	40	6
Quercus virginiana	–	–	60	2
Rubus	29	2	20	2
Sabal palmetto	14	5	100	6
Sacciolepis striata	–	–	20	2
Salicornia ambigua	14	2	–	–
Scleria triglomerata	14	2	–	–
Setaria magna	14	3	–	–
Sideroxylon tenax	–	–	80	2
Smilax auriculata	–	–	40	3
Smilax bona-nox	–	–	80	2
Solidago mexicana	14	2	80	2
Spartina alterniflora	57	6	–	–
Spartina cynosuroides	43	8	–	–
Spartina patens	14	9	–	–
Symphyotrichum tenuifolium	57	3	–	–
Taraxacum officinale	29	2	–	–
Tillandsia usneoides	–	–	20	1
Vachellia farnesiana	14	1	–	–
Wahlenbergia marginata	–	–	20	1
Yucca aloifolia	–	–	20	1
Zanthoxylum clava-herculis	–	–	40	2

Table B-2. Basal area (BA, m^2/ha) and density (count/ha) of woody vascular plant species observed in 12 Southeast Coast Network vegetation monitoring plots. Broad Habitat Type Codes are as follows: MTW = Maritime Tidal Wetlands (seven plots) and MUFS = Maritime Upland Forests and Shrublands (five plots).

Species	MTW Tree BA	MTW Tree Den	MTW Sapling BA	MTW Sapling Den	MTW Seedling Den	MUFS Tree BA	MUFS Tree Den	MUFS Sapling BA	MUFS Sapling Den	MUFS Seedling Den
Baccharis halimifolia	–	–	0.03	1446	2188	–	–	–	–	3750
Celtis laevigata	–	–	–	–	–	4.19	67	–	–	6250
Forestiera segregata	–	–	–	–	–	–	–	0.03	175	3750
Ilex vomitoria	–	–	–	–	313	0.16	17	0.05	2300	25000
Iva frutescens var. *frutescens*	–	–	–	–	–	–	–	0.06	600	0
Juniperus [silicicola + virginiana]	–	–	–	–	–	27.83	783	0.00	–	1000
Prunus caroliniana	–	–	–	–	–	1.91	67	0.00	–	16250
Quercus virginiana	–	–	–	–	–	–	–	0.01	75	0
Sabal palmetto	–	–	0.00	232	–	19.07	208	0.06	2000	7813
Sideroxylon tenax	–	–	–	–	–	–	–	0.00	25	1250
Smilax auriculata	–	–	–	–	–	–	–	0.00	75	1250
Smilax bona-nox	–	–	–	–	–	–	–	0.00	50	833

NPS 348/177981, December 2021

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525