



Vegetation Mapping at Castillo de San Marcos National Monument

Photointerpretation Key and Final Vegetation Map

Natural Resource Report NPS/SECN/NRR—2019/2010



ON THE COVER

View of Castillo de San Marcos National Monument, November 5, 2014

Photo Credit: David L. Cotten

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This report received formal peer review by subject-matter experts who were not directly involved in the development or pilot implementation of the project. Peer review was conducted by highly qualified individuals with subject area technical expertise and was overseen by a peer review manager.

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Executive Summary

The University of Georgia Department of Geography's Center for Geospatial Research (CGR), with the support of the National Park Service (NPS) Vegetation Mapping Inventory (VMI) Program, described and mapped vegetation at Castillo De San Marcos National Monument (CASA). This mapping effort was accomplished through collaboration with the NPS Southeast Coast Network (SECN), the North Carolina office of NatureServe (Durham, N.C.), and Amec-Foster-Wheeler Environmental & Infrastructure, Inc.

A final vegetation map for Castillo de San Marcos National Monument was created to represent the vegetation occurring within the park during 2012. This product is the final of four steps necessary to produce an accurate vegetation map based upon aerial photographs. This includes the determination of the community element global (CEGL) codes (2008) and acquisition of aerial imagery (2012), using the aerial imagery, with five ground truthing points (2014), to create a draft vegetation map, performing an accuracy assessment (2015), and then using all the available information to create a final vegetation map (2018).

The total mapping area encompassed the entire boundary of the monument plus an additional 500-meter (1,640-foot [ft]) buffered area. Using one NatureServe vegetation plot, color-infrared aerial photos, and data collected in the field, vegetation communities were delineated and assigned attributes. Using dominant vegetation classes and secondary vegetation classes, as well as modifiers to describe the diversity of species, detailed vegetation maps were created for Castillo de San Marcos NM. Polygons and attributes within the 500-meter (1,640-ft) buffer were created on a broader scale using a system based on the Anderson Level II classification scheme which includes anthropogenic and land use/land cover (LULC) classes. Within the monument, the more detailed National Vegetation Classification System (NVCS) was used.

The most common class found in Castillo de San Marcos NM is the combination class 14002 (4701—Bermuda Grass Semi-natural Pasture and 4883—St. Augustine Grass Herbaceous Vegetation). This class covers approximately 60% of the Monument. The smallest class in the park is the combination class 13008 (3956—Saltwort—Woody Glasswort Dwarf—shrubland 3956 and 2278—Salt Flat (Woody Glasswort Type), covering less than 0.5% of the entire park. A rigorous accuracy assessment was conducted on the four map classes within the boundary of Castillo de San Marcos NM representing floristic types within the National Vegetation Classification System. Results showed an 80% map accuracy and a kappa rating of 100% using 10 accuracy assessment points.

The products generated from this project include vegetation maps, a photointerpretation key, summary statistics of each vegetation class, and a detailed geodatabase with digital maps.

Introduction

Castillo De San Marcos National Monument Vegetation Mapping Project

As part of the National Park Service (NPS) Vegetation Inventory Program (Schmoldt et al. 1994; Fancy et al. 2009), the University of Georgia Center for Geospatial Research (CGR) in the Department of Geography was asked to produce vegetation maps of eight park units in the NPS Inventory and Monitoring Program Southeast Coast Network (SECN) using mapping standards defined under the National Vegetation Classification System (NVCS) (Jennings et al. 2009). Under Task Agreement # P13AC01319, the University of Georgia Center for Geospatial Research agreed to analyze existing leaf-on color infrared (CIR) aerial photography to develop photointerpretation keys, accuracy assessment study plans, final digital maps of vegetation, geodatabases and associated metadata in accordance with NPS vegetation mapping standards, and field verification surveys in accordance with standard mapping practices. The Castillo De San Marcos National Monument (CASA) Vegetation Mapping project was coordinated by the University of Georgia Center for Geospatial Research between 2014 and 2018, with assistance from the National Park Service (NPS) Southeast Coast Network, the North Carolina office of NatureServe (for the vegetation classification portion of the project), and Amec-Foster-Wheeler Environmental & Infrastructure, Inc. (for accuracy assessment).

While the National Vegetation Classification System intends to capture stable vegetation categories, either man-made or natural disturbances may change some areas during the seven years required to produce a vegetation map. For example, changes in non-tree dominated areas, which are typically wetlands in this region, may shift annually depending upon local weather, or cover by invasive exotics may change rapidly. More importantly, these natural and anthropogenic changes will likely continue in the future. Therefore, the vegetation map should be evaluated as a snapshot of the park in 2012.

Vegetation Mapping Inventory Program

The Vegetation Mapping Inventory (VMI) Program is an effort by the National Park Service to classify, describe, inventory, and map vegetation communities in more than 280 national park units across the United States. The primary objective of the Vegetation Mapping Inventory Program is to produce high-quality, standardized maps and associated data sets of vegetation and other land-cover occurring within parks. Since vegetation species and communities are unique from park to park, the inventory of these resources assists park managers on a wide array of management issues. For more information about the Vegetation Mapping Inventory Program, visit the program website (see NPS 2015).

NPS Southeast Coast Inventory and Monitoring Network

National Park managers across the country need a broad-based understanding about the status and trends of park natural resources. The NPS Inventory & Monitoring Division (IMD) systematically gathers and analyzes information on the plants, animals, and ecosystems that are within parks.

Parks use this information for planning, research, education, and to help guide decisions related to park management. Results are also shared with other agencies, researchers, and scientists. The IMD staff and networks share a set of common goals, established when the division was first launched.

- Inventory the natural resources under National Park Service stewardship to determine their nature and status.
- Monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other, altered environments.
- Establish natural resource inventory and monitoring as a standard practice throughout the National Park system that transcends traditional program, activity, and funding boundaries.
- Integrate natural resource inventory and monitoring information into National Park Service planning, management, and decision making.
- Share National Park Service accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives.

To accomplish these goals, more than 280 parks with significant natural resources were grouped into the 32 IMD networks, which were determined based on geography and shared natural resource characteristics. The network organization increases collaboration among parks, information sharing, and economies of scale in natural resource inventory and monitoring (NPS 2018a).

The Southeast Coast Network includes 17 parks with significant natural resources, in 15 administrative units. The network extends along the Atlantic Coast from the North Carolina-Virginia border southward to Cape Canaveral, Florida and inland to Atlanta, Georgia and the Alabama Coastal Plain. The network's purpose is to provide parks with data and information about their natural resources, and to help with information sharing in natural resource monitoring (NPS 2018b).

Location of Castillo de San Marcos National Monument

Castillo de San Marcos National Monument (CASA) is located on the banks of the Matanzas River in St. Augustine, Florida (Figure 1). It encompasses approximately 8.1 hectares (20 acres [ac]) and was established in 1924 to protect cultural resources. The fort was constructed by the Spanish between 1672 and 1695. In 1900 the fort was taken off the active list of U. S fortifications. Congress renamed the fort to its Spanish name in 1942 (Manucy 2014).

The monument is located on the banks of the Matanzas River. Castillo de San Marcos NM is bounded on the north, west, and south by the urban area of St Augustine, Florida. The park is dominated by the fort itself with the vast majority of vegetation dominated by maintained grassy areas.



Castillo de San Marcos National Monument Park Boundary



Figure 1. Location of Castillo de San Marcos National Monument with buffer area and its position relative to the State of Florida and St. Johns County.

Vegetation Classification System

The task agreement for mapping required that the National Vegetation Classification System (NVCS) be used for areas inside each park. The National Vegetation Classification System was developed by the Nature Conservancy (Anderson et al. 1998; Grossman et al. 1998). It is primarily based upon vegetation rather than climatic or edaphic factors. It emphasizes the existing natural vegetation and recognizes that vegetation communities form a continuum. The system has seven hierarchical levels so that vegetation can be described at multiple scales, depending upon the amount of information available. Higher levels can be broken down to lower levels as more information is available; conversely, lower levels can be aggregated to upper levels. The five upper levels (formation class, formation subclass, formation group, formation subgroup, and formation) describe vegetation physiognomy rather than actual species composition and are a modification of the UNESCO World Physiognomic Classification of Vegetation (UNESCO 1973). The two lowest levels (the alliance and association) are determined by floristic composition. The alliance level is determined by the species composition of the dominant or diagnostic species in the most prevalent stratum. A diagnostic species does not have to be dominant. For example, *Nyssa biflora* (swamp tupelo) is a characteristic species found in the Sweetgum–Tuliptree Brownwater Floodplain Forest but is not a dominant species. The association level is determined by diagnostic species in all strata (tree canopy, subcanopy, tall-shrub, short-shrub, herbaceous, non-vascular, vine/liana, and epiphyte), recognizing that each of these strata may not occur in every association. The tallest stratum may not be the diagnostic/dominant stratum. The association level is assigned a unique community element global code (CEGL). The CEGL code for the vegetation association is the target vegetation classification specified in the task agreement.

The dominant species in the tallest stratum are always visible in leaf-on aerial photographs. If the tallest stratum is dense, with a closed canopy, then the shorter subcanopy and understory layers are obstructed from the camera's view and are not visible. In vegetation communities where the tallest stratum is open, other strata will be visible in the aerial photograph. In some cases, a CEGL code can be determined solely by identifying its location (e.g., along a ridge or on the south slope) and viewing the uppermost stratum. In other cases, a lower stratum (or strata) not visible in the aerial photography must be used to determine CEGL code. In such cases, it is impossible to use only aerial photographs recorded during leaf-on conditions to accurately determine the NVCS code at the association level. If it was not possible to determine the association-level class, a second vegetation was assigned as a supplement to the dominant vegetation code.

Prior to the University of Georgia Center for Geospatial Research's photointerpretation, NatureServe conducted field surveys in accordance with standard practices (Jennings et al. 2009) to create a list of NVCS CEGL codes as a combined reference and key for the following National Monuments and Preserve: Timucuan Ecological and Historic Preserve, Fort Caroline National Monument, Castillo de San Marcos National Monument and Fort Matanzas National Monument, see Table 1 (NatureServe 2009). Their detailed report includes a dichotomous key for separating the CEGL codes described for Castillo de San Marcos NM (Appendix A). Many of the couplets in the dichotomous key relied upon differences in the dominant vegetation in the tallest stratum or the presence/absence of diagnostic

species. However, some couplets relied upon lower strata which may not be evident in the aerial photographs and/or edaphic factors¹ (e.g. soil pH) which would not be evident in leaf-on CIR photographs. The NatureServe report also includes comprehensive descriptions of diagnostic species for each CEGL code, and additional information on both the global and local expressions of the vegetation community type.

Table 1. Land cover classes found within the park area of Castillo de San Marcos National Monument during the initial assessment based on the National Vegetation Classification System.

Code	Description
2278	Salt Flat (Woody Glasswort Type)
3956	Saltwort - Woody Glasswort Dwarf-shrubland
4701	Bermuda Grass Semi-Natural Pasture
4883*	St. Augustine Grass Herbaceous Vegetation

* Vegetation class found within 1 NatureServe plot contained within Castillo de San Marcos NM.

In general, the National Vegetation Classification System is best suited to natural or semi-natural vegetation communities that have been relatively undisturbed long enough for vegetation communities to develop in accordance with the environmental and climatic conditions of the site (Anderson et al. 1998; Grossman et al. 1998). Areas that are regularly or extensively disturbed by logging, fire, wind damage, exotic insects, exotic vegetation, and human activities are not easily classified with the National Vegetation Classification System. For this reason, the University of Georgia Center for Geospatial Research augmented the NVCS classes identified by NatureServe as occurring in Castillo de San Marcos NM to include additional disturbed, managed, successional, and modified classes, along with alphanumerical modifiers to provide detailed information to users of the vegetation databases and maps. Modifiers to the NVCS classes reflected variations of a particular NVCS class that are characteristic for the local site, but atypical of the global NVCS description.

The task agreement also required mapping a 500-meter (1,640-ft) buffer around each park. The buffer area contained extensive areas of human influence; consequently, the National Vegetation Classification System was not applicable. Buffer areas were therefore mapped using guidelines derived from the Anderson Level II classification system, which includes human influences and water categories (Anderson et al. 1976).

In summary, the monument was initially mapped to the association (CEGL) level of the National Vegetation Classification System, while the buffer area was more appropriately mapped using Anderson Level II guidelines, Table 2. Modifiers to these classification systems were used, as appropriate, to ensure a meaningful classification system for this park, Table 3. The complete

¹ Vegetation tends to reflect edaphic factors. Yet if the indicator vegetation is not visible in the aerial photograph, edaphic factors cannot be inferred.

vegetation classification system used for Castillo de San Marcos NM is provided in the Final Vegetation Mapping and Summary Statistics section of this report.

Table 2. Land cover/land use classes found within the buffer of Castillo de San Marcos National Monument.

Code	Description
11	Residential
12	Commercial and Services
14	Transportation, Communications, and Utilities
16	Mixed Urban or Built-up Land
17	Other Urban or Built-up Land
53	Bays and Estuaries
62	Nonforested Wetlands
73	Sandy Areas other than Beaches

Table 3. Modifiers used throughout the park area of Castillo de San Marcos National Monument.

Code	Description
HI	Human Influence
QUE	Includes Oaks

Vegetation Mapping Workflow

The general workflow for this vegetation mapping followed a series of steps, including:

1. Define CEGL codes within the study area based upon plot-level ground data (completed by NatureServe)
2. Contact park staff to discuss their needs and concerns as applicable to the final vegetation map, obtain any existing background information on management activities to include in a GIS database (see below), and arrange access
3. Collect base data and construct a GIS foundation geodatabase
 - a. Collect and inventory the aerial photographs
 - b. If needed, scan and orthorectify the aerial photographs
 - c. Obtain available GIS layers on exotic plant removal or prescribed burns that may affect vegetation communities
4. Create an initial photointerpretation key
 - a. Overlay NatureServe Vegetation Survey points on photos
 - b. Examine photos to understand signatures of vegetation communities as identified by ELCodes or CEGL number
5. Perform initial delineation of vegetation communities on CIR aerial photographs, supplemented by other leaf-off imagery (see Table 4) using photointerpretation from both stereo-pairs and 2D imagery by heads-up GIS methods
 - a. Identify spectral signatures dissimilar to the example spectral signatures around the NatureServe ground plots so that vegetation can be evaluated in field visits
6. Field visits
 - a. Schedule field trips to the site to visit specific areas where questions exist
 - b. Verify vegetation communities present
 - c. Reconcile photo signature with NatureServe CEGL code
 - d. Refine classification as necessary with reference to field work and ongoing communication with park staff regarding results
 - e. If needed, assign additional CEGL numbers or combine certain CEGL numbers if specific classes exist within the park that were not discovered by the NatureServe Vegetation Survey or were indiscernible through aerial interpretation
7. Refine and extend photointerpretation key and delineation of polygons
 - a. As needed, print photos and vegetation polygons for review and refinement
8. Prepare draft deliverable products

- a. Prepare draft GIS files
 - b. Clean up line work and attribute tables
 - c. Compute statistics for vegetation polygons
 - d. Prepare metadata for vegetation polygon files
 - e. Finalize photointerpretation keys
9. Accuracy Assessment
 - a. Using accuracy assessment guidelines points are chosen for a separate team to visit and quantify
 - b. Overlay Accuracy Assessment data points on photos and draft vegetation maps
 - c. Calculate percent accuracy and kappa for the polygons
10. Prepare final deliverable products
 - a. Prepare final GIS files
 - b. Clean up line work and attribute tables using accuracy assessment data as a guide
 - c. Compute statistics for vegetation polygons
 - d. Prepare metadata for vegetation polygon files
 - e. Finalize photointerpretation keys

Note that steps 4–7 reflect an iterative, rather than a linear, process. Steps 1, 2, and 3 are self-explanatory; the detailed workflow for the other steps, as pertains to the mapping of Castillo de San Marcos National Monument, is described below.

Table 4. Data sets, descriptions, source, date, and scale imported into the Geodatabase.

Dataset	Description	Source	Date	Scale/Resolution
County Boundary	Outline of St. Johns	US Census Bureau via FGDL	2011	n/a
Park Boundary	Outline of CASA	NPS via FGDL	2012	n/a
Parcels	Florida Parcel Data by County	FDOR via FGDL	2014	n/a
Vegetation Plots	Sample Vegetation Locations	NatureServe	2006-07	n/a
DEM	30-m resolution USGS Digital Elevation Model	University of Florida GeoPlan Center via FGDL	2012	15 meters (49.2 ft)
Color Infrared Imagery	Color Infrared Imagery	Aero-Metrics via NPS	2012	1 foot (0.3 meters [m])
True Color Imagery	True Color Imagery	FDOT	2010	1 foot (0.3 m)
True Color Imagery	True Color Imagery	FDOT	2014	0.8 feet (0.2 m)

Base Data and GIS Geodatabase Construction

Relevant publicly available GIS data sets that cover the study area were downloaded and archived on a local server in the University of Georgia Center for Geospatial Research. Data sets include roads, hydrology, boundary files (political and NPS), digital elevation models (DEMs), and additional aerial photographs. These data are available from sources such as the NPS Integrated Resource Management Applications (IRMA) portal, the Florida Geographic Data Library, the U.S. Geological Survey National Map, and the National Oceanic and Atmospheric Administration Digital Coast websites. Trail network and exotic plant removal data sets were also obtained. These layers are not publicly available and were obtained through NPS contacts. The data sets used to populate the foundation GIS database were from different sources, compiled for different reasons, and may not be in the same map projection. The task agreement specified that the spatial data be projected to the Universal Transverse Mercator (UTM) Coordinate System, North American Datum of 1983 (NAD83). Where necessary, data sets were projected to UTM Zone 17. Finally, a geodatabase in ArcGIS 10.2 format was created as a container to store and organize the data. Details of this database are presented in Figure 2.

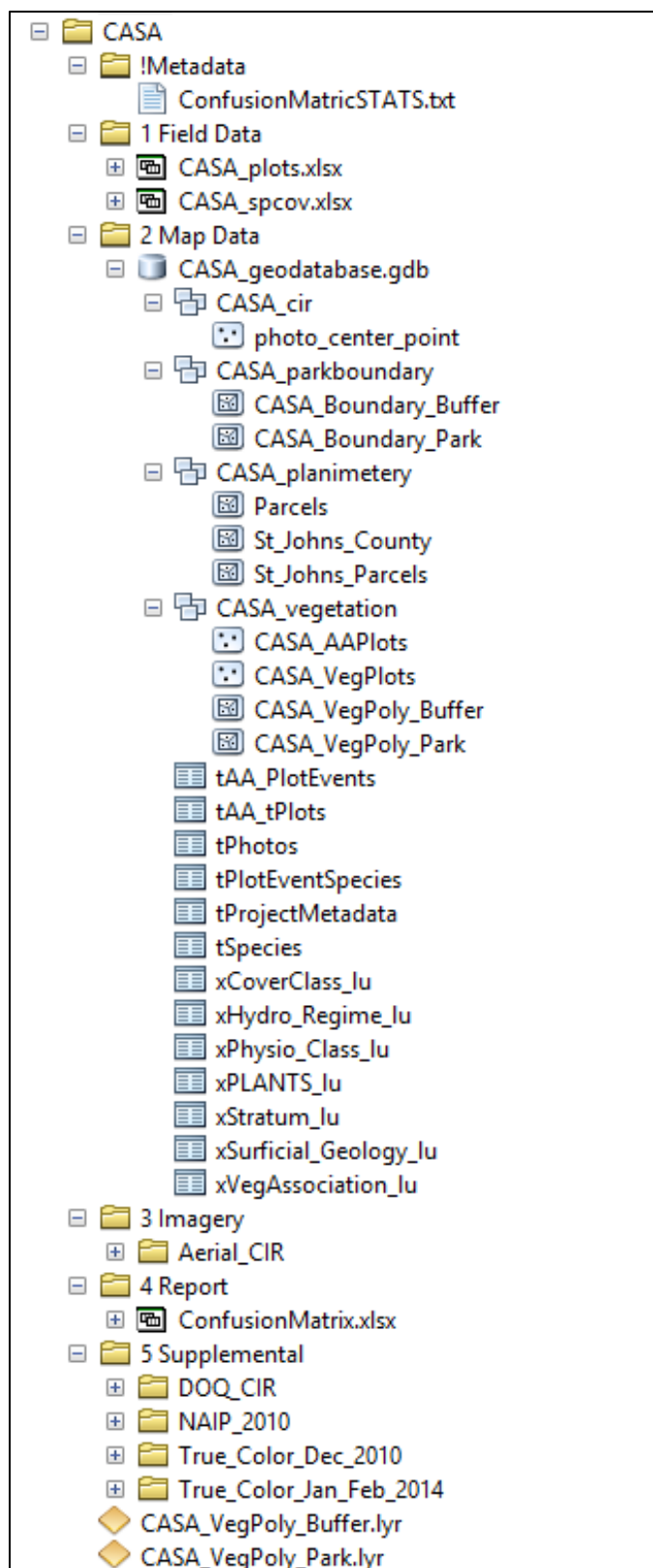


Figure 2. Foundation Geodatabase created for Castillo de San Marcos National Monument.

Color infrared (CIR) aerial photographs of the park at 1:12,000 scale was acquired by Aero-Metric, Inc. on May 11, 2011. These photos were scanned and converted to digital orthophotographs at 0.3-meter (1 ft) resolution before they were delivered to the National Park Service. Digital orthophotographs and hardcopy photographs in both film transparency and paper print formats were provided to the University of Georgia Center for Geospatial Research. A total of three photos in one flight line was required to cover Castillo de San Marcos NM (Figure 3 and Appendix B).

The mapping area was split in two sections: park and buffer. The park was defined as the area within the prescribed monument boundaries while the buffer pertained to the region within 500 meters (1,640 ft) outside of the park boundary. Detailed vegetation mapping using CEG codes was performed within the park whereas more general mapping using a revised Anderson-type II hierarchical classification scheme was used in the buffer area.



Figure 3. NatureServe vegetation plot and aerial photo center points for Castillo de San Marcos National Monument, shown with park boundary and 500-meter (1,640-ft) park buffer.

Initial Photointerpretation Key and Vegetation Delineation

Classifying the different vegetation communities within the park was aided using a photointerpretation key. The initial photointerpretation key was based upon the NCVS vegetation classes at the association level. These associates were determined by NatureServe through independent plot level vegetation surveys in accordance with standard NVCS field methods (Jennings et al. 2009). Plot level species presence or abundance was used to assign a four-digit CEGL number. The results of the survey are reported in Appendix A for the singular plot location and CEGL code, as well as its description and field notes. The vegetation associations for Castillo de San Marcos were determined by NatureServe from one plot. The University of Georgia Center for Geospatial Center visited five points to interpret the CIR signatures of these vegetation associations to delineate vegetation. The accuracy assessment of The University of Georgia Center for Geospatial Center's vegetation map included 10 accuracy assessment points, eight of which were used for analysis of the park.

The NatureServe vegetation plot point was overlaid on the CIR aerial photographs and the photo signature was examined. Many CEGL codes are not represented in Castillo de San Marcos NM, as the key combined four parks (Timucuan Ecological and Historic Preserve, Fort Caroline National Monument, Castillo de San Marcos National Monument and Fort Matanzas National Monument) into one key, with the acknowledgement not all vegetation classes would be represented in each park (NatureServe 2008). The National Vegetation Classification System recognizes that vegetation communities form a continuum both within and between CEGL codes; spectral signatures are also likely to reflect this natural variation.

The photointerpretation key was developed to assist in the extension of the signatures at the plot level to the remainder of the park. The key noted color, tree crown shapes and sizes, texture, context, and any other characteristics that could help to differentiate one community from the others on the spectral signature of the leaf-on CIR aerial photography. The orthophotographs were examined on-screen in heads-up mode using the ArcGIS software. Where needed, the hardcopy photographs were viewed in stereo/3D using a light table and a mirror stereoscope. This method is excellent for using relative heights of the trees and terrain to assist in determining the vegetation community and to delineate the boundaries of the individual features.

This key was later expanded to include more detailed descriptions of each class. The strength and intensity of the image were described using color (varying from green to pink to purple), tone (light to dark), and texture (fine to coarse). Other categories were based on canopy structure such as pattern (open to dense canopy) and height (short to tall). The remaining categories were used to express how the different codes are interrelated. These include shape (elongated to broad), size (based on total area, average size, and standard deviations of the polygons in a given class), location (relative to specific areas in the park), association (communities typically found near the specific class), and comments (to express any hints or issues that may arise). Also included are images taken from the field to provide a ground level perspective that can be compared to the sample image chips taken from the airborne CIR images. The NatureServe summary of the vegetation association and its

distribution both globally and within the park are included for each class following the visual cue description.

The CEGL codes are listed in ascending numerical order in the key. While the National Vegetation Classification System is hierarchical, the numbering system for the codes is not hierarchical. Thus, it is impossible to determine physiognomy, species composition, or edaphic factors (e.g. soil saturation or inundation, soil pH, slope) from the CEGL code alone.

Using ArcGIS software, standard GIS methods, and a minimum mapping unit (MMU) of 0.5 hectares (1.2 ac), preliminary lines were drawn to delineate areas of uniform signature. Where the vegetation communities were clearly identifiable, polygons were tagged with the appropriate CEGL code. Where confusion existed, the polygons were tagged with an 'unknown' code until field visits could determine the appropriate CEGL code.

Field Surveys and Ground Truth

In developing the photointerpretation keys and delineating vegetation communities based upon their CIR signatures, a several signatures were found that did not easily match the signature from the NatureServe survey of one plot. These areas required field visits to clarify vegetation communities.

Field work and ground truthing for Castillo de San Marcos NM took place November 5, 2014. Field visits were aimed at giving specific attention to representative habitats, rare and important communities, areas that have been managed, disturbed, or invaded, and plots previously surveyed by NatureServe to collect data on canopy species composition, diagnostic species for the National Vegetation Classification System, and terrain, similar to NatureServe's "Quick Plot" surveys.

Field crews carried paper field maps with the UTM grid coordinates, elevations, roads, rivers, initial vegetation polygons with CEGL codes, and points of interest superimposed on CIR photographs. They also used a Trimble Geo 6000 Xh Global Positioning System (GPS) handheld receiver loaded with similar GIS layers. On some trips, an Apple iPad 4 with a geoPDF (Wuthrich 2006; Pardue 2008) replaced paper field maps. The geoPDF gave the user both a higher level of detail of the original CIR compared paper maps, along with the ability to determine location in real-time using the device's internal GPS relative to the overlay of the line work.

At each sampling site, researchers recorded GPS position, species data, canopy cover, and topography (e.g. relative slope and aspect) inside an area between 250 and 1,000 square meters (2,691 and 10,764 square feet [ft²]), based upon visual uniformity. Also noted were the presence of exotics, evidence of past or present human influence (e.g., agriculture, grazing, logging, mowing, exotic vegetation removal, old home sites), damage by insects, wild hogs, blow down, or fire. Prior to leaving a sampling location, researchers determined the primary association type, i.e. CEGL code (Grossman et al. 1994; Anderson et al. 1998; Grossman et al. 1998). Some sites were located in a mixed area indicative of an ecotone or an area of successional recovery. In such cases, secondary associations were determined in addition to dominant associations. Tertiary modifiers were often determined as well. For this reason, all polygons have the possibility of having a secondary association and a modifier in addition to the required dominate association. In cases where

researchers were unable to determine a clear match to a NVCS CEGL in the field, more detailed notes were taken to assign an appropriate CEGL or CGR-created class (e.g., a managed, damaged, human influence, or successional class) after further review of CIR signatures. The dominate associations used in Castillo de San Marcos NM can be found in Table 5 and the modifiers can be found in Table 3.

Table 5. Land cover classes found within the park area of Castillo de San Marcos National Monument based on the National Vegetation Classification System.

Code	Class	Description
13008 ^a	3956 & 2278	3956-Saltwort - Woody Glasswort Dwarf-shrubland / 2278-Salt Flat (Woody Glasswort Type)
14002 ^a	4701 & 4883	4701-Bermuda Grass Semi-Natural Pasture / 4883-St. Augustine Grass Herbaceous Vegetation
9993 ^b	Nonvegetated Cover	Rocky Shore
9994 ^b	Nonvegetated Cover	Cultural
9996 ^b	Nonvegetated Cover	Sand
9997 ^b	Nonvegetated Cover	Park Road
9998 ^b	Nonvegetated Cover	Park Structure or Building or Parking
9999 ^b	Nonvegetated Cover	Open Water

^a Not an NVCS Code. This value is a combination of two or more NVCS codes.

^b Not an NVCS Code.

The GPS points collected in the field were superimposed on CIR images in ArcMap. Field points were used in conjunction with the aerial photographs to refine vegetation delineation and assigned classification attributes (dominant CEGL, secondary CEGL, and modifiers, as appropriate).

One field visit/investigation occurred, and five discrete point locations were collected at Castillo de San Marcos NM (Table 6 and Figure 4).

Table 6. Field visit and number of data points collected for Castillo de San Marcos NM.

Date (2014)	Team Member(s)	Number of Data Points
November 5	N. K. O'Hare, D. L. Cotten, B. P. Adams	5
Total	—	5



CASA Data Collection Points

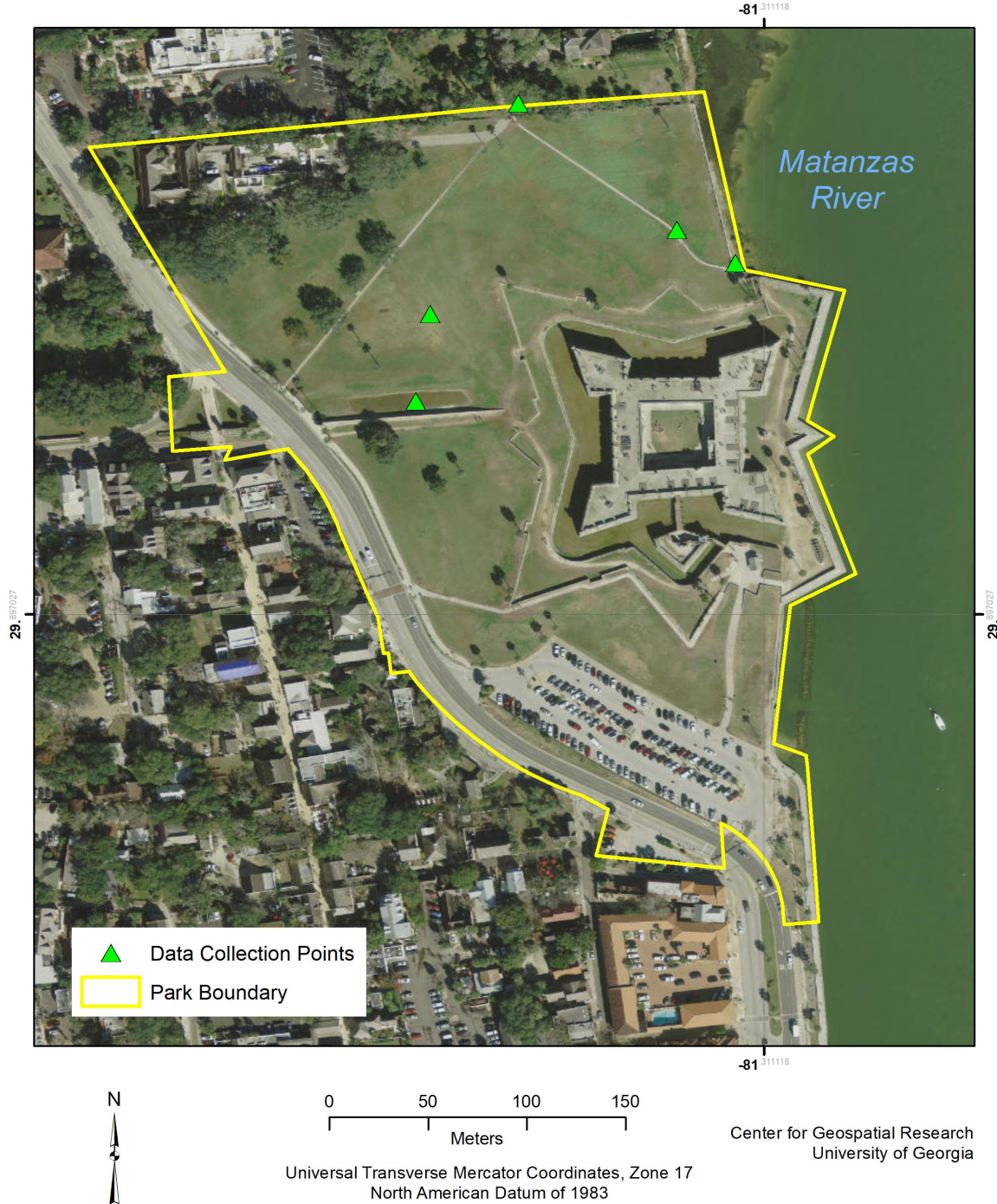


Figure 4. Field data collection locations from Castillo de San Marcos National Monument overlaid on visual imagery.

Photointerpretation and GIS Methods

The industry-standard GIS software, ArcGIS, offers a variety of methods and procedures to do most common mapping tasks. For the purposes of this project, photointerpretation was performed using heads-up digitizing methods in ArcGIS 10.2 using the CIR digital orthophotographs as the primary source material. Lines were drawn on-screen delineating the boundaries between different classes of vegetation. Where ecotones between features were broad, the line was drawn in the middle of the transition area. While the minimum mapping unit for this project was one half of a hectare (1.2 ac), features smaller than this threshold that were distinct and could be easily mapped were delineated.

As vegetation areas were delineated with vector lines, points were digitized within each delineated area. These points were assigned attribute information such as the dominate vegetation (a CEGL value if located within the park or an Anderson-type code for the buffer), secondary vegetation, a modifier, the interpreter's initials, the date, the confidence of the classification, and other relevant information.

After the line work was completed and points attributed, the lines were converted to polygons and the attributes assigned to each polygon by joining the tables of the point features and polygons based on spatial location. In this operation, the attributes of the point closest to the polygon were assigned to that polygon. A 'distance' field was also assigned which indicates the distance of the point location from the polygon. If the distance was zero, the point was inside the polygon. Any other value greater than zero meant that the point used to populate the attribute fields was outside of the polygon. Consequently, the 'distance > 0' values were used as flags to select and examine polygons that were not properly attributed. Where necessary, additional points were added to the database to complete the map. The process was repeated until all polygons were properly attributed.

The initial draft maps were plotted at large scale on 'E-size' size' (34 × 48 inches [86.4 × 121.9 centimeters {cm}]) paper such that the hollow polygons with their respective CEGL labels were overlaid on the original aerial photographs. Each polygon was individually inspected by a person not directly involved in the original mapping to make sure that the line work followed the vegetation feature properly, and that the CEGL codes were consistent with spectral signature. Edits were marked on the hardcopy maps and then applied to the database within ArcGIS. This review process was repeated to ensure completeness.

Additional editing and refinement were performed as necessary using information collected during the field surveys.

Final Vegetation Mapping and Summary Statistics

A total of four NVCS CEGL association level vegetation communities were found in Castillo de San Marcos NM; these four were combined to create two separate combination classes due to lack of differentiation in aerial imagery and spectral signature. Six non-CEGL codes were used to describe areas of human influence or non-vegetation (Table 5).

In the buffer zone, there were eight distinct Anderson level II codes (Table 2). The park was further classified using modifiers (Table 3). These modifiers were generated by the University of Georgia Center for Geospatial Research to provide additional information regarding species content or areas with a large human influence. These classes and modifiers were used to produce a final vegetation map (Figure 5).



CASA Park Vegetation and Buffer Classes

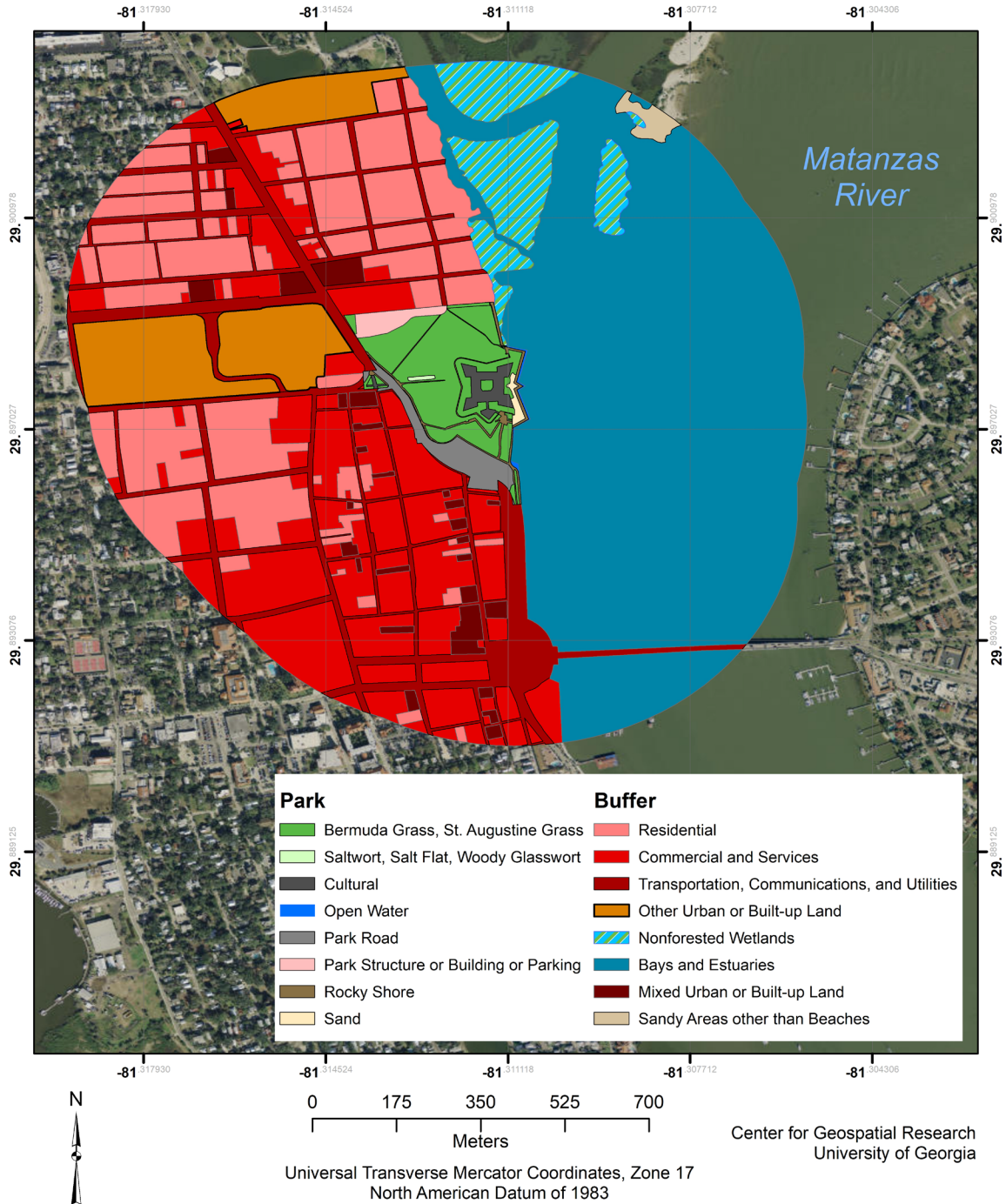


Figure 5. Vegetation map of Castillo de San Marcos National Monument.

The most common class found in Castillo de San Marcos NM is the combination class 14002 (4701—Bermuda Grass Semi-Natural Pasture and 4883—St. Augustine Grass Herbaceous Vegetation). This class covers approximately 60% of the Monument. The smallest class in the park is the combination class 13008 (3956—Saltwort—Woody Glasswort Dwarf-shrubland 3956 and 2278—Salt Flat (Woody Glasswort Type), covering less than 0.5% of the entire park. The remaining area of the Monument is covered by non-NVCS classes, with park roads dominating at 15% of total area coverage. Rocky Shores and Cultural classes each cover approximately 7% of the total area (Table 7, Figure 6).

Within the buffer region of Castillo de San Marcos NM, the dominating class is Bays and Estuaries encompassing 39% of the total buffer area. Commercial and Services is the second most common class at approximately 18%, followed by Residential at slightly above 17% and Transportation, Communications, and Utilities at 11% (Table 8, Figure 7).

Table 7. Community element global code (CEGL) classes, frequency of occurrence, mean area, total area, and percentage of total area within the park boundary of Castillo de San Marcos National Monument [ha—hectares].

CEGL	Description	Frequency	Mean Area (ha)	Total Area (ha)	Percentage of Total Area
14002 ^a	4701-Bermuda Grass Semi-Natural Pasture 4883-St. Augustine Grass Herbaceous Vegetation	24	0.20	4.91	60.52
9997 ^b	Park Road	3	0.42	1.26	15.57
9993 ^b	Rocky Shore	3	0.19	0.58	7.14
9994 ^b	Cultural	2	0.29	0.57	7.06
9998 ^b	Park Structure or Building or Parking	1	0.54	0.54	6.60
9996 ^b	Sand	1	0.13	0.13	1.58
9999 ^b	Open Water	2	0.04	0.08	1.01
13008 ^a	3956-Saltwort - Woody Glasswort Dwarf-shrubland 2278-Salt Flat (Woody Glasswort Type)	1	0.04	0.04	0.47
Total	–	37	–	8.11	100.0%

^a Not an NVCS Code. This value is a combination of two or more NVCS codes.

^b Not an NVCS Code.

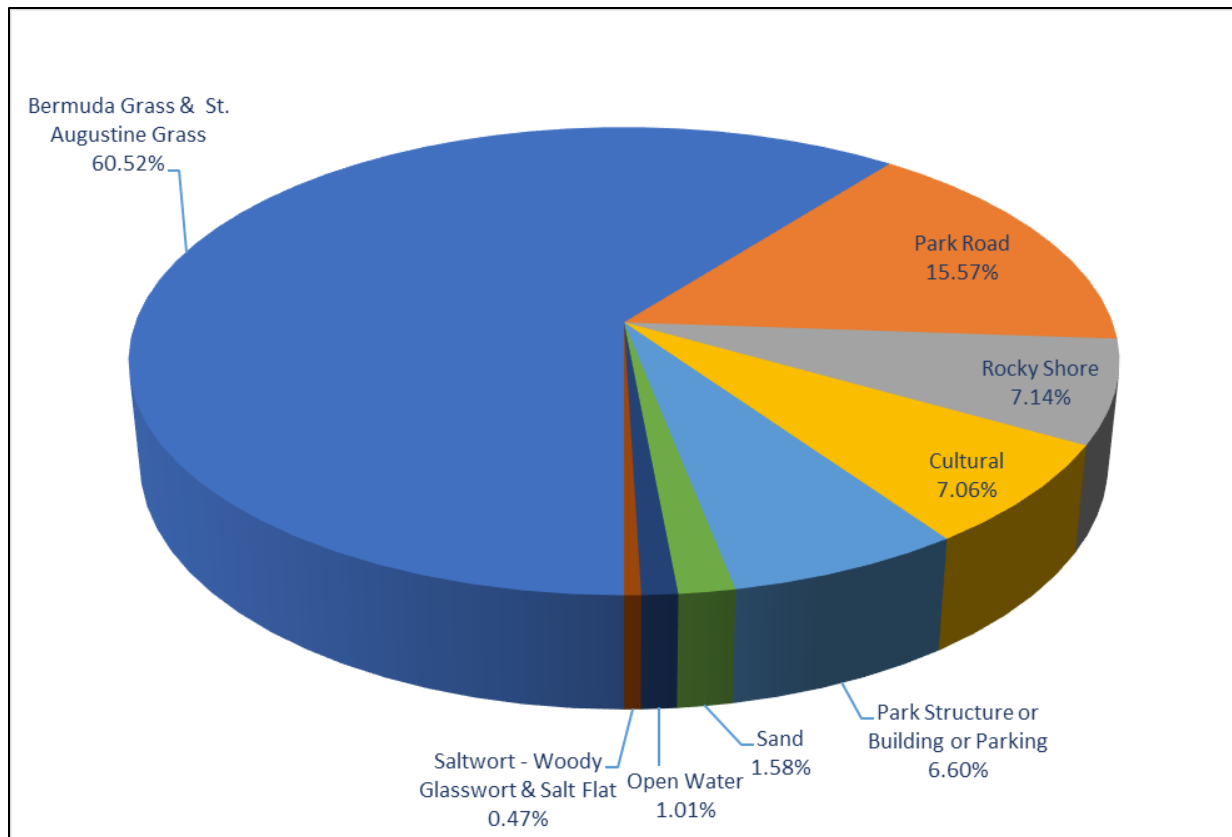


Figure 6. Park vegetation classes as a percentage of total area.

Table 8. Land use/land cover class, frequency of occurrence, mean area, total area, and percentage of total area within the buffer area of Castillo de San Marcos National Monument [ha—hectares].

Class	Frequency	Mean Area (ha)	Total Area (ha)	Percentage of Total Area
Bays and Estuaries	3	18.51	55.52	39.07
Commercial and Services	78	0.33	25.50	17.94
Residential	62	0.40	24.68	17.37
Transportation, Communications, and Utilities	3	5.27	15.82	11.13
Other Urban or Built-up Land	3	3.42	10.26	7.22
Nonforested Wetlands	5	1.38	6.92	4.87
Mixed Urban or Built-up Land	28	0.10	2.90	2.04
Sandy Areas other than Beaches	1	0.52	0.52	0.37
Total	183	–	142.11	100.0

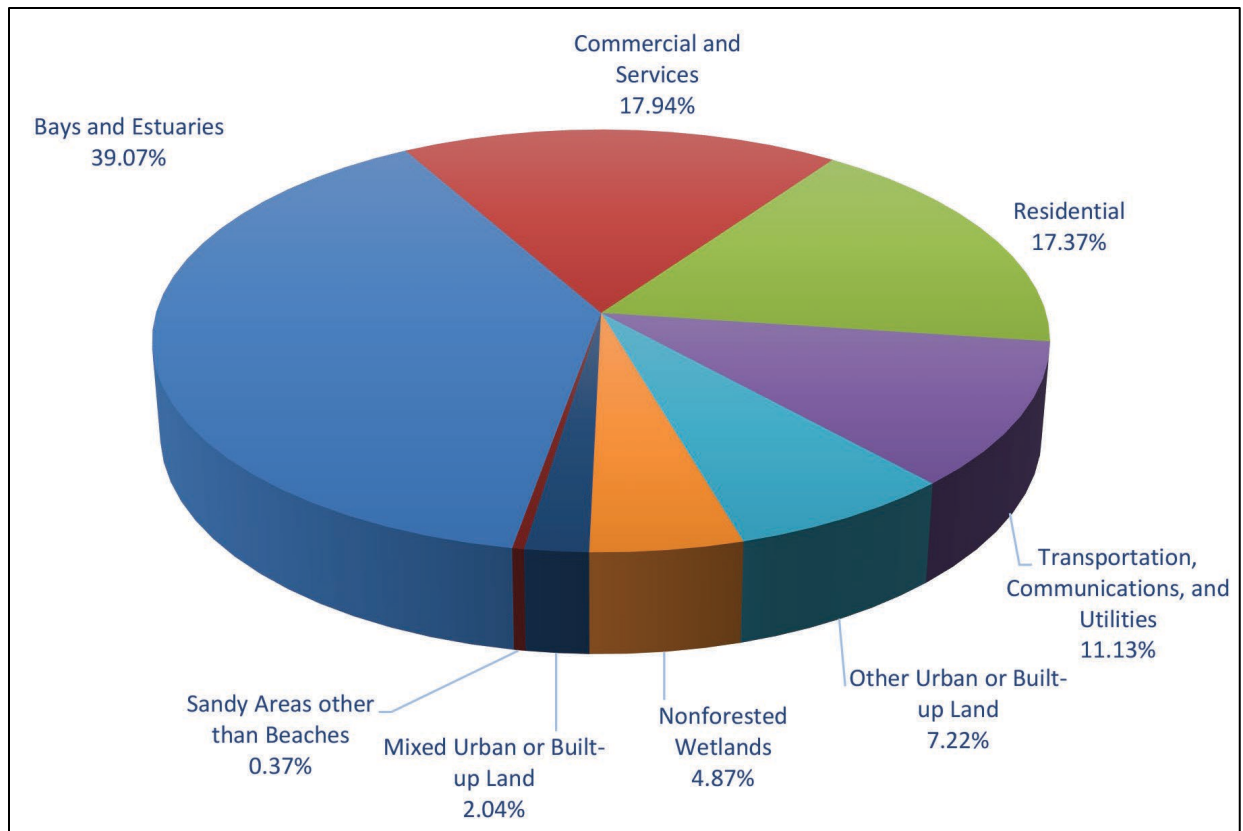


Figure 7. Buffer classes organized by relative size found in Castillo de San Marco National Monument.

Modifiers were utilized throughout the park to further enhance the classification system. The modifier system was based on whether the area was heavily influence by anthropogenic factors (HI) or the appearance of oaks where they generally do not occur (QUE; Table 9).

Table 9. Modifiers used throughout the park and buffer areas, including frequency of occurrence, mean area, and total area [ha—hectares].

Code	Description	Frequency	Mean Area (ha)	Total Area (ha)
HI	Human Influence	1	0.02	0.02
QUE	Includes oaks	1	0.74	0.74
Total	–	2	–	0.76

Accuracy Assessment

Point Selection

As a part of the total mapping effort, a separate accuracy analysis of the thematic contents of the vegetation maps is required. Only classes with CEGLE codes assigned and only polygons that fall within the prescribed park boundary are evaluated. To accomplish this, a set of points is selected to represent the distribution and rarity of the mapped vegetation classes. The number of accuracy assessment (AA) sample points per class depends on the total area (in hectares) of the particular vegetation class within the map area, according to the rule set established by the National Park Service for this purpose (Lea and Curtis 2010):

- Classes with < 8.33 ha
 - 5 points per class
- Classes with ≥ 8.33 AND < 50 ha
 - number of points is $0.6 \times$ the area in ha
- Classes with ≥ 50 ha
 - 30 points per class

Protocol dictates that the points be randomly distributed and stratified by class. For example, if 30 points are required for a particular class, those 30 points should be randomly distributed within all the polygons of that particular class. The distribution of classes, the number of polygons, and the areas of each class is given in Table 7.

Point Acquisition

The Accuracy Assessment points were collected on November 18, 2015 by J. Ryan and I. Weber. Figure 8 shows the locations of these points and Appendix C has the detailed information gathered at each of the 10 half a hectare (1.2 ac) accuracy assessment plot locations.



CASA Accuracy Assessment Plots



Figure 8. Accuracy Assessment plot locations in Castillo de San Marcos National Monument.

Accuracy of Vegetation Map

Once the accuracy assessment plot data were received, they were overlaid on top of the draft vegetation maps to determine the accuracy of the map. This process entailed determining whether predicted vegetation classes matched observed accuracy assessment plots. To ensure the most accurate assessment was made, all the AA plots went through a series of quality assurance and quality control (QA/QC) processes that considered numerous factors in determining if the accuracy assessment plots were placed in locations representative of their polygons. Plots that were deemed unrepresentative of the polygons in question were removed from the final analysis. The different QA/QC categories are presented in Table 10, and the final accuracy assessment is presented in Table 11a–b.

Table 10. Breakdown of how the AA plots are related to the vegetation polygons and 2012 imagery.

Type	Code	Number	Status for Final Analysis
Perfect match – primary codes matched	L1	7	Retained
Perfect match - secondary code match	L2	1	Retained
Temporal Error – changes since images were acquired	T1	2	Retained
Total	–	10	10 used for analysis

Table 11a. Confusion matrix for the accuracy assessment. The rows are the expected vegetation class as predicted by the photo interpretation conducted by the UGA Center for Geospatial Research, and the columns are the observed vegetation class at the AA point.

Vegetation Class	4883	13008	14002	Total
4883	0	2	0	2
13008	0	3	1	3
14002	0	0	5	5
Total	0	5	5	10

Table 11b. Accuracy and error for the confusion matrix. Overall accuracy is 80. Kappa rating is 95.

Accuracy / error type	4883	13008	14002
Producer Accuracy	0 ^b	60 ^b	100 ^a
Omission Error	100	40	100
User Accuracy	0 ^b	100 ^a	100 ^a
Commission Error	100	0	0

^a Green represents accuracy greater than or equal to 70%

^b Red represents accuracy less than 70%

Quality Assurance of AA Plots

The AA plots were divided into three categories to better understand issues regarding representativeness of accuracy assessment plot locations within Castillo de San Marcos (Table 10): (L1-L2) if AA plots were assigned the same CEGL code as the polygon they fell in. Each point was given a primary CEGL code and an optional secondary CEGL code created by the Ryan and Weber field team. The Center for Geospatial Research (CGR) team created a primary vegetation code and an optional secondary vegetation code. (L1) occurred when there was a match between the primary CEGL code and primary vegetation code, (L2) if the match occurred between the secondary CEGL code and vegetation code, (T1) if successional areas influenced the AA plot, since the imagery and AA plots differed by three years.

The AA plot locations were randomly selected within a given polygon, therefore, there was no guarantee that they landed in a location representative of either the polygon or of the plant associations included within the polygon's map unit. For example, an AA point could easily land in a small gully, an inclusion that is too small to map, i.e. less than the minimum mapping unit (0.5 hectares [1.2 ac]), or an ecotone where trees are invading a shrub land. To account for these situations, field observers were tasked with determining not only the vegetation within the AA sample area, but the surrounding area as well. These instances included AA plots that fell inside of an ecotone or inclusion, or in an anomalous situation such as in a gully or sandy area (McManamay et al. 2012).

Discrepancies between vegetation communities caused by changing seasons/years were also considered. These AA plots were labeled "temporal error" (T1). Two instances were found since the accuracy assessment was done three years after the aerial imagery was flown and some areas in the park changed vegetation classes over that time. Discrepancies such as these were expected, due to vegetation changes over time. These two instances occurred in AA Plot Code 0007 and 0008. Both were labeled as NCVS CEGL code 4883—St. Augustine Grass Herbaceous Vegetation, but were labeled by CGR as 13008—a combination code representing NVCS Codes 3956—Saltwort—Woody Glasswort Dwarf—shrubland and 2278—Salt Flat (Woody Glasswort Type).

All available data was used to create a final vegetation classification for Castillo de San Marcos NM and the confusion matrix for the park is shown in Table 11a–b. All 10 AA points were used to assess the map based on the 2012 imagery. The overall assessment showed an 80% accuracy and a kappa rating of 100% using the 10 AA points.

Conclusion

A final vegetation map for Castillo de San Marcos was created to represent the vegetation occurring within the park during 2012. This product represents the final of four steps necessary to produce an accurate vegetation map based upon aerial photographs. This includes the determination of the CEGLE codes (2008) and acquisition of aerial imagery (2012), using aerial imagery, with ground truthing (2014), to create a draft vegetation map, performing an accuracy assessment (2015), and then using all the available information to create a final vegetation map (2018).

The most common class found in Castillo de San Marcos is a mix of Bermuda Grass Semi-Natural Pasture (4701) and St. Augustine Grass Herbaceous Vegetation (4883). This mixed class covers 60% of the park. In the 500-meter (1,640-ft) buffer zone surrounding the park, three-quarters of the area is covered by Bays and Estuaries (39%), Commercial and Services (18%), and Residential (17%).

Producing an accurate vegetation map based on color infrared imagery is a lengthy process and can take three to seven years to complete. During this time, disturbances may change some areas significantly. As a result, conclusions made from ground observations that were conducted during the middle or end of the overall process may be different from conclusions made from interpreting aerial photographs that were collected at the onset of the project.

Literature Cited

- Anderson, J. R., E. E. Hardy, J. T. Roach, and R. E. Witmer. 1976. A land use and land cover classification system for use with remote sensor data. Geological Survey Professional Paper 964. U.S. Government Printing Office, Washington, D.C., USA.
- Anderson, M., P. Bourgeron, M. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D. Grossman, and S. Landaal. 1998. International classification of ecological communities: Terrestrial vegetation of the United States. Volume II. The National Vegetation Classification System: List of types. The Nature Conservancy, Arlington, Virginia, USA.
- Fancy, S. G., J. E. Gross, and S. L. Carter. 2009. Monitoring the condition of natural resources in US national parks. *Environmental Monitoring and Assessment* 151:161-174.
- Grossman, D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, Crawford, K. Goodin, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: Terrestrial vegetation of the United States. Volume I. The National Vegetation Classification System: Development, status, and applications. The Nature Conservancy, Arlington, Virginia, USA.
- Grossman, D. H., K. L. Goodin, and C. L. Reuss, editors. 1994. Rare plant communities of the conterminous United States: An initial survey. The Nature Conservancy, Arlington, Virginia, USA.
- Jennings, M. D., D. Faber-Langendoen, O. L. Loucks, R. K. Peet, and D. Roberts. 2009. Standards for associations and alliances of the U.S. National Vegetation Classification. *Ecological Monographs* 79(2):173-199.
- Lea, C., and A. C. Curtis. 2010. Thematic accuracy assessment procedures: National Park Service Vegetation Inventory, version 2.0. Natural Resource Report NPS/2010/NRR—2010/204.
- Manucy, A. 2014. The Building of Castello de San Marcos: National Park Service Interpretive Series, History No. 1. United States Government Printing Office, Washington, District of Columbia
- McManamay, R. H., S. L. Corbett, and A. C. Curtis. 2019. Field procedures for vegetation mapping accuracy assessment: Cape Lookout National Seashore and Cape Hatteras National Seashore—Version 1.0. Standard Operating Procedure. NPS/SECN/SOP—1.4.17. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2266071> (last accessed September 2019).
- NatureServe. 2008. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. U.S.A. Data current as of 20 February 2008.

- NatureServe. 2009. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Associations and Alliances of Ocmulgee National Monument. NatureServe, Arlington, Virginia, USA.
- National Park Service (NPS). 2015. Vegetation inventory. NPS Inventory and Monitoring. Available at: <https://www.nps.gov/im/vegetation-inventory.htm> (last accessed August 2019).
- National Park Service (NPS). 2018a. NPS Inventory and Monitoring. Available at: <https://www.nps.gov/im/about.htm> (last accessed August 2019).
- National Park Service (NPS). 2018b. NPS Southeast Coast Inventory & Monitoring Network. Available at: <https://www.nps.gov/im/secn/index.htm> (last accessed August 2019).
- Pardue, J. 2008. The GeoPDF file; a new solution for the digital publication, distribution, and collaboration of geospatial data. 30 pages. U. S. Geological Survey, Reston, VA, USA.
- Schmoldt, D. L., D. L. Peterson, and D. G. Silsbee. 1994. Developing inventory and monitoring programs based on multiple objectives. *Environmental Management* 18(5):707–727.
- UNESCO. 1973. International Classification and Mapping of Vegetation. Series 6. Ecology and conservation. United Nations Educational, Scientific, and Cultural Organization, Paris, France.
- Wuthrich, D. 2006. Data sharing with geoPDFs. *Geospatial Solutions* 16:34–35.

Appendix A. NatureServe Vegetation Plot Locations and Notes

Table A-1. Field data acquired by G. Shultz in March of 2007.

Plot Code	Field X	Field Y	Provisional	Elcode	Environment	Leaf Type	Leaf Phenology	Physiological Class
TIMU84	469870	3307620	Ruderal (lawn)	4883	–	Graminoid	Perennial herb	Herbaceous vegetation

Appendix B. Flight Line Information

Table B-1. CASA flight line and photo numbers and photo center coordinates (UTM Zone 17, NAD83). Photos were acquired by Aero-Metric at 1:12,000 scale on May 11, 2012.

Flight line	Photo	Easting	Northing
1	1-94	470116.9545	3308603.7282
1	1-95	470124.8921	3307532.1636
1	1-96	470116.9545	3306428.8489

Appendix C. Accuracy Assessment

Table C-1. Data points acquired by J. Ryan and I. Weber, November 18, 2015.

AA_Event	AA_Code	Event Date	Surveyors	GPS Error	Primary Co	AA Photos	General_Co	AA Update	AA User
CASA_AA_000101	CASA_AA_0001	11/18/2015	Joy Ryan, Irene Weber	0.800000012	CEGL004883	TRUE	ClassComments parking lot to north	12/21/2015	Daniel Gwartney
CASA_AA_000301	CASA_AA_0003	11/18/2015	Joy Ryan, Irene Weber	0.100000001	CEGL004883	TRUE	–	12/21/2015	Daniel Gwartney
CASA_AA_000501	CASA_AA_0005	11/18/2015	Joy Ryan, Irene Weber	0.100000001	CEGL004883	TRUE	a shell observed	12/21/2015	Daniel Gwartney
CASA_AA_000701	CASA_AA_0007	11/18/2015	Joy Ryan, Irene Weber	0.400000006	CEGL004883	TRUE	disturbed site, difficult to get best fit. St augustine grass continues to the N beyond polygon	12/21/2015	Daniel Gwartney
CASA_AA_000901	CASA_AA_0009	11/18/2015	Joy Ryan, Irene Weber	0.100000001	CEGL004883	TRUE	depleted matrix	12/21/2015	Daniel Gwartney
CASA_AA_000201	CASA_AA_0002	11/18/2015	Joy Ryan, Irene Weber	0.100000001	CEGL004883	TRUE	two palms includes two steps into covered way and moat. Grass stressed	12/21/2015	Daniel Gwartney
CASA_AA_000401	CASA_AA_0004	11/18/2015	Joy Ryan, Irene Weber	0.100000001	CEGL004883	TRUE	hit rock or shell	12/21/2015	Daniel Gwartney
CASA_AA_000601	CASA_AA_0006	11/18/2015	Joy Ryan, Irene Weber	0.100000001	CEGL003956	TRUE	similar to pts 7&8, 0.7 ha: same fr pts 8;7;6	12/21/2015	Daniel Gwartney
CASA_AA_000801	CASA_AA_0008	11/18/2015	Joy Ryan, Irene Weber	0.200000003	CEGL004883	TRUE	small linear wetland disturbed site redoxat 4"	12/21/2015	Daniel Gwartney

AA_Event	AA_Code	Event Date	Surveyors	GPS Error	Primary Co	AA Photos	General_Co	AA Update	AA User
CASA_AA_001001	CASA_AA_0010	11/18/2015	Joy Ryan, Irene Weber	0.200000003	CEGL003956	TRUE	some redox	12/21/2015	Daniel Gwartney

Appendix D. Photointerpretation Key

The photointerpretation key describes the attributes of the color infrared (CIR) images used to delineate the vegetation association CEGL codes found within the park. For each CEGL, a CIR image chip from within the park is included. For most CEGL codes, we also included a ground based digital photo of the vegetation, taken within the park. The standard visual cues to interpret and distinguish vegetation are described, including color, tone, texture, and pattern. When applicable, we also include comments on location within the park or topographic position. If there were other vegetation associations within the park that appeared similar on the CIR photographs, traits used to distinguish between similar vegetation associations are described.

The Vegetation Description for the CEGL within the park was copied directly from NatureServe (2009) to provide plot level information on species composition, dominance, characteristic species, and percent estimate of vegetation cover in understory, midstory, and/or canopy. It also includes the Global Description and geographic distribution. A separate literature cited section of the references from NatureServe (2009) text that was directly copied into the photointerpretation key is included at the end of this appendix.

Saltwort—Woody Glasswort Dwarf—shrubland; Woody Glasswort—(Saltwort, Saltgrass) Dwarf—Shrubland

Attributes, descriptions, and a map are shown in Table D-1 and Figure D-1.

Table D-1. Attributes and descriptions for Saltwort—Woody Glasswort Dwarf—shrubland; Woody Glasswort—(Saltwort, Saltgrass) Dwarf—Shrubland.

Attribute	Description
CEGL Code	(13008)3956;2278
CommunityName	Saltwort—Woody Glasswort Dwarf—shrubland; WoodyGlasswort—(Saltwort, Saltgrass) Dwarf-Shrubland
Color	Gray to light pink
Tone	Light to medium
Texture	Coarse
Pattern	Patchy, uneven
Height	Short
Shape	Sparse to dense coverage
Size	Very small, only one area represented in park
Comments	In areas of high human influence



Figure D-1. Map showing Saltwort—Woody Glasswort Dwarf—shrubland; Woody Glasswort—(Saltwort, Saltgrass) Dwarf—Shrubland ([13008] 3956; 2278).

Summary

Castillo de San Marcos National Monument Vegetation:

(3956) The dwarf-shrub *Batis maritima* (turtleweed) dominates the closed herbaceous layer (100% cover); additional species include *Sarcocornia perennis* (chickenclaws), *Borrichia frutescens* (bushy seasidetansy), *Avicennia germinans* (black mangrove), and the graminoid *Spartina alterniflora* (smooth cordgrass). **(2778)** This association was not documented at Timucuan Ecological and Historic Preserve as part of this project, although it is possible that it does occur at the park.

Global Vegetation:

(3956) This community is dominated by *Batis maritima* (turtleweed) sometimes in association with *Sarcocornia perennis* (chickenclaws), *Sporobolus virginicus* (seashore dropseed), *Borrichia frutescens* (bushy seaside tansy), *Suaeda linearis* (annual seepweed), *Suaeda conferta* (beach seepweed) (in southern Texas), *Lycium carolinianum* (Carolina desert-thorn), *Spartina spartinae* (gulf cordgrass), *Sesuvium portulacastrum* (shoreline seapurslane), and *Blutaparon vermiculare* (silverhead). Algal mats of blue-green and sometimes green algae are characteristically present, visible even in densely vegetated pannes. **(2278)** This community is strongly dominated by *Borrichia frutescens* (bushy seaside tansy). Other characteristic species may include *Spartina patens* (saltmeadow cordgrass), *Iva frutescens* (Jesuit's bark), *Distichlis spicata* (inland saltgrass), *Schoenoplectus robustus* (sturdy bulrush), *Sporobolus virginicus* (seashore dropseed), *Monanthochloe littoralis* (shoregrass), *Sarcocornia perennis* (chickenclaws), *Limonium carolinianum* (Carolina sealavender), *Lycium carolinianum* var. *quadrifidum* (Carolina desert-thorn), *Rayjacksonia phyllocephala* (camphor daisy), and *Batis maritima* (turtleweed). In Texas, *Spartina patens* (saltmeadow cordgrass) is a less important component of this community, but it often forms a fringe along the upper margin.

Bermuda Grass Herbaceous Vegetation; St. Augustine Grass Herbaceous Vegetation

Attributes, descriptions, and a map are shown in Table D-2 and Figure D-2.

Table D-2. Attributes and descriptions for Bermuda Grass Herbaceous Vegetation; St. Augustine Grass Herbaceous Vegetation.

Attribute	Description
CEGL Code	(14002)4701;4883
CommunityName	Bermuda Grass Herbaceous Vegetation; St. Augustine Grass Herbaceous Vegetation
Color	Tan to pink
Tone	Light to medium
Texture	Coarse
Pattern	Patchy
Height	Short
Shape	Sparse to dense coverage
Size	One of the most common classes; very large patches with large variations of color and coverage possible.
Comments	For this park, in areas of high human influence

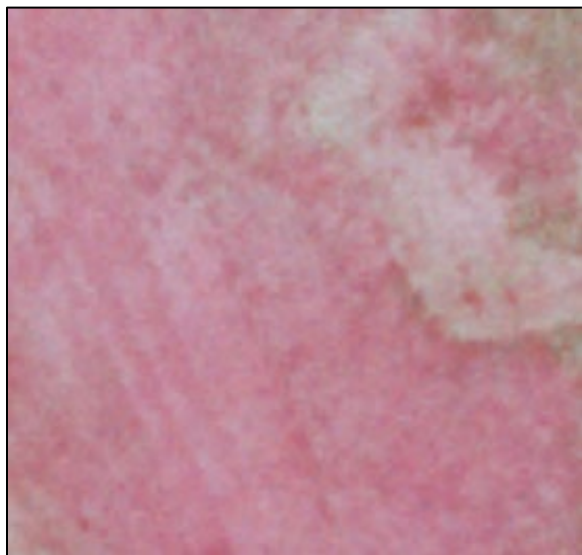


Figure D-2. Map showing Bermuda Grass Herbaceous Vegetation; St. Augustine Grass Herbaceous Vegetation.

Summary

Castillo de San Marcos National Monument Vegetation:

(4701) Vegetation is dominated by the exotic grass *Cynodon dactylon* (Bermudagrass) in the very dense (90% cover) herbaceous layer. Additional species include mostly native species, such as *Eupatorium capillifolium* (dogfennel), *Helianthemum carolinianum* (Carolina frostweed), *Heterotheca subaxillaris* (camphorweed), *Lechea sessiliflora* (pineland pinweed), *Nuttallanthus*

canadensis (Canada toadflax), *Oenothera laciniata* (cutleaf evening-primrose), and *Solidago odora* var. *chapmanii* (Chapman's goldenrod), among others. In addition, there is a very sparse (10%) emergent tree layer (2–10 meters [6.6–32.8 feet {ft}]) of *Juniperus virginiana* (eastern redcedar), *Prunus serotina* (black cherry), *Quercus hemisphaerica* (Darlington oak), and *Quercus virginiana* (live oak), and a very sparse (10%) shrub layer (1–5 meters [3.3–16.4 ft]) that includes *Baccharis halimifolia* (eastern baccharis), *Ilex vomitoria* (yaupon), *Persea borbonia* (redbay), *Prunus angustifolia* (Chickasaw plum), *Rubus trivialis* (southern dewberry), *Sabal palmetto* (cabbage palmetto), and *Sideroxylon tenax* (tough bully). Vines (5%) include *Smilax auriculata* (earleaf greenbrier) and *Vitis rotundifolia* (muscadine). Evidence of disturbance includes past clearing for a golf course and the presence of exotic species. **(4883)** The continuous herbaceous layer (100% cover) is clearly dominated by *Stenotaphrum secundatum* (St. Augustine grass). Additional species include native species *Ambrosia artemisiifolia* (annual ragweed), *Drymaria cordata* (whitesnow), and *Hydrocotyle umbellata* (manyflower marshpennywort), and exotic species *Cynodon dactylon* (Bermudagrass), *Medicago lupulina* (black medick), *Oxalis corniculata* (creeping woodsorrel), *Paspalum notatum* (bahiagrass), and *Poa annua* (annual bluegrass). A total of 24 species were recorded from one sampled plot.

Global Vegetation:

(4701) Vegetation is dominated by the introduced grass *Cynodon dactylon* (Bermudagrass), with various remnant native species. Although originally planted, *Cynodon dactylon* (Bermudagrass) maintains itself spontaneously and is considered weedy or "semi-natural" as opposed to cultivated. Examples from Florida may include the native species *Eupatorium capillifolium* (dogfennel), *Helianthemum carolinianum* (Carolina frostweed), *Heterotheca subaxillaris* (camphorweed), *Lechea sessiliflora* (pineland pinweed), *Nuttallanthus canadensis* (Canada toadflax), *Oenothera laciniata* (cutleaf evening-primrose), and *Solidago odora* var. *chapmanii* (Chapman's goldenrod), among others. In addition, *Juniperus virginiana* var. *silicicola* (southern redcedar), *Prunus serotina* (black cherry), *Quercus hemisphaerica* (Darlington oak), and *Quercus virginiana* (live oak), may be present as a sparse tree layer, and a very sparse shrub layer may that include *Baccharis halimifolia* (eastern baccharis), *Ilex vomitoria* (yaupon), *Persea borbonia* (redbay), *Prunus angustifolia* (Chickasaw plum), *Rubus trivialis* (southern dewberry), *Sabal palmetto* (cabbage palmetto), and *Sideroxylon tenax* (tough bully). Vines may include *Smilax auriculata* (earleaf greenbrier) and *Vitis rotundifolia* (muscadine). **(4883)** This association is dominated by *Stenotaphrum secundatum* (St. Augustine grass) occurring either as a monoculture or with a mix of native and non-native species, including the native species *Ambrosia artemisiifolia* (annual ragweed), *Drymaria cordata* (whitesnow), and *Hydrocotyle umbellata* (manyflower marshpennywort), and exotic species *Cynodon dactylon* (Bermudagrass), *Medicago lupulina* (black medick), *Oxalis corniculata* (creeping woodsorrel), *Paspalum notatum* (bahiagrass), and *Poa annua* (annual bluegrass).

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