

Floristic Survey of Castillo de San Marcos National Monument, St. Augustine, Florida

WENDY B. ZOMLEFER* and DAVID E. GIANNASI

Department of Plant Biology, University of Georgia, Athens, Georgia 30602-7271

ABSTRACT

Castillo de San Marcos National Monument, St. Augustine, Florida, is administered by the National Park Service, United States Department of the Interior, and comprises 8.5 ha (20.5 acres) including the moat and expansive embankment (glacis) surrounding the historic fortress, as well as landscaping adjacent to parking lots and park headquarters. A floristic survey was conducted to provide park service personnel with a vouchered plant species checklist for the entire park, including the flourishing flora supported by the 10 m (33 ft) tall fort walls. Four intensive collecting trips conducted in 2003–04 yielded 153 species of plants in 129 genera of 61 families, including 56 species growing on the coquina walls of the fortress. Asteraceae, Poaceae, and Fabaceae had the largest number of species. Diagrams of the fort and photographs of representative plant species on the shellstone walls are also provided. Control measures for the wall vegetation are briefly discussed.

INTRODUCTION

Castillo de San Marcos National Monument, administered by the National Park Service (NPS, United States Department of the Interior), is located in St. Augustine, St. Johns County, Florida, along State Road (S. R.) A1A/San Marco Ave., north of the city's central plaza (Figure 1A, B). The irregularly shaped park, ca. 8.5 ha (20.5 acres), is bounded along the west by S. R. A1A, and to the east, by Matanzas Bay and includes the original historic Castillo de San Marcos fortress with attendant grounds plus the park headquarters (northwest corner) and parking lots (Figure 1C; Brown 1997). The Castillo de San Marcos, the oldest standing European fortification in the United States, was built at the northern edge of the colonial Spanish settlement. Modern St. Augustine has expanded around it in all directions. To the north, west, and south, the site of the fort is a rolling grassy area with a few planted trees, and a seawall separates the Castillo from Matanzas Bay along the east side. The park is open to the public every day (except on Christmas) and hosts over a million visitors a year (NPS 2004). No floristic surveys had been previously conducted for this NPS controlled area.

Brief History of Castillo de San Marcos National Monument

St. Augustine (San Agustín), founded by Pedro Menéndez de Avilés in 1565, was established to protect Spanish shipping along the primary sea route between the New World and Europe. Construction of the permanent fortress, Castillo de San Marcos, began in 1672 and was completed in 1695 (Manucy 1943, NPS 1993). Spain maintained control over St. Augustine until 1763: Florida subsequently became a diplomatic pawn involving several treaties among England, Spain, and/or the United States (see Gold 1969).

Florida was first transferred to the British (first Treaty of Paris), and St. Augustine became the capitol of the province of East Florida (Gannon 2003). The Castillo, renamed Fort St. Mark, became regimental headquarters for directing assaults on the southern colonies during

* email address: wendyz@plantbio.uga.edu

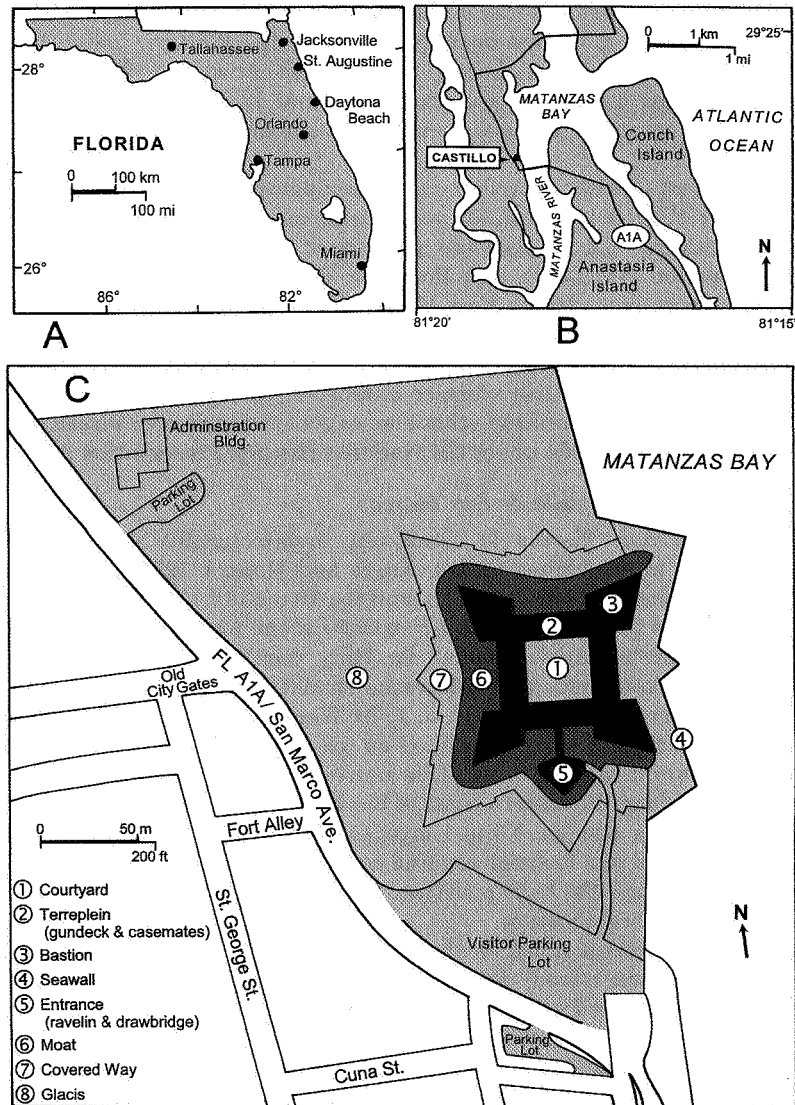


Figure 1. Location, park boundaries, and components of Castillo de San Marcos National Monument. A. Location of St. Augustine, St. Johns County, Florida. B. General location of Castillo de San Marcos in St. Augustine along S. R. A1A. C. Castillo de San Marcos National Monument park property (shaded), comprising 8.5 ha (20.5 acres); components of the Castillo structure discussed in text labeled. A and B modified from DeLorme (1997); C modified from Arana and Manucy (1977), Brown (1997), and Maynard (2002).

the American Revolutionary War. The fort was also used as a prison for rebel colonists (including three signers of the Declaration of the Independence).

Florida was transferred back to Spain in 1783 as part of negotiations ending the American Revolutionary War, and the Castillo was uninhabitable by the time Spain ceded Florida to the United States in 1821. Numerous structural problems included cracks in the masonry walls and rainwater leaking through the gundeck (roof) into the vaults below (a habitual problem). Congress allocated funds for some repair in 1832 after local citizens protested the Army's neglect (Bearss and Paige 1983, Krakow 1986). The fortress, renamed Fort Marion (after

Revolutionary War General Francis Marion), served as a military base and as a prison for exiled Native Americans during the Second Seminole War and the Western Indian Wars (1875–78, 1886–87) and for enemy soldiers during the Spanish American War (1898). The War Department began giving guided tours of the fort around 1848, which were in great demand especially during incarceration of the western Indians who sold native crafts to the tourists (Krakow 1986).

In 1884, President Chester A. Arthur signed an appropriation for restoration and historic preservation of Fort Marion, and the fort was decommissioned as an active military base in 1900. In 1924 President Calvin Coolidge proclaimed Fort Marion a national monument (Executive Proclamation No. 1713), and President Franklin D. Roosevelt issued Executive Order No. 6166 in 1933, transferring Fort Marion (and other military parks and cemeteries) from the War Department to the National Park Service, Department of the Interior. The original name, Castillo de San Marcos, was restored by Congress in 1942 (Krakow 1986). Over the past seventy years, the NPS has overseen extensive restoration with such a high level of historical integrity that the fortress and other elements of the park were placed on the National Register of Historic Places in 1966 under the National Historic Preservation Act (Brown 1997).

Design and Composition of Castillo de San Marcos

The Castillo de San Marcos is significant architecturally as the oldest masonry fortification remaining in the United States (Arana and Manucy 1977). The perimeter of this large impregnable fortress is 457 m (1,500 ft), and the 10 m (33 ft) high walls vary in thickness from 3 to 4.3 m (10 to 14 ft) at the base to 1.5 m (5 ft) at the top (Figure 2A, B). The walls are constructed of blocks of “coquina” (Spanish for “tiny shell”), a soft limestone conglomerate comprising coarsely broken shells and calcareous sandstone naturally cemented together by precipitated calcium carbonate (Schmidt et al. 1979, Waterbury 1993). The major component of coquina is *Donax variabilis*, a small colorful clam (ca. 1.0 to 2.5 cm [0.4 to 1.0 in] long) that inhabits shallow waters along the coast. This native shellstone formed stratigraphic layers (Anastasia formation) along the eastern coast of Florida during changes in sea levels during an interval of the Pleistocene Age (ca. 0.5 to 1 mya; Cooke 1945). The unusual stone has unique properties for construction of a fortress: coquina compresses and absorbs the impact of cannon ball hits without crumbling—the balls penetrate the wall only a few centimeters or bounce off, causing little damage to fort structure.

Blocks of coquina were quarried for the Castillo from pits in present-day Anastasia State Recreation Area (Anastasia Island) and then ferried by barge across Matanzas Bay to St. Augustine. The stone is wet and yellow when quarried; the hard, protective, and grayish patina (as seen in Figures 3 and 4) takes several decades to develop. Mortar for the coquina blocks was made of lime from burnt oyster shells, mixed with sand and water. A waterproof coating of white lime plaster (seven parts lime to five parts sand) originally covered the interior and exterior fort walls (Bearss and Paige 1983). After the Castillo was built, wealthy citizens began to use coquina for their homes, and after two centuries, most of the quality stone had been quarried.

The Spanish term “castillo” (castle) refers to the fortress’ superficial similarity to medieval European castles with turrets, moats, and drawbridges. The designer, Cuban engineer Ignacio Daza, incorporated a type of fortress construction (the “bastion” system) prevalent in Europe at that time, which is particularly appropriate for the flat terrain of Florida (Arana and Manucy 1977). The overall stellar outline of the Castillo (Figures 1C, 2A, 3A) is formed by diamond-shaped projections (bastions) at each corner, a design element that eliminates blind spots for the watchtower sentries situated at each bastion point. The square central courtyard of the fort is bordered by a series of numerous small bombproof vaults for storing provisions and ammunition (Figure 2A, B). These vaulted casemates form the main walls of the fort and support the wide gundeck (terreplein), the roof of the Castillo (Figure 2B). Embrasures at intervals along the top of the wall provide openings for cannons. On the south side of the Castillo, a triangular masonry structure (ravelin) connects the drawbridge to the only entrance (Figures 1C, 2A, 3A).

A seawall comprising coquina faced with granite to the high water mark protected the eastern fort walls from the tides of Matanzas Bay (Figures 1C, 3A). The shellstone-lined moat

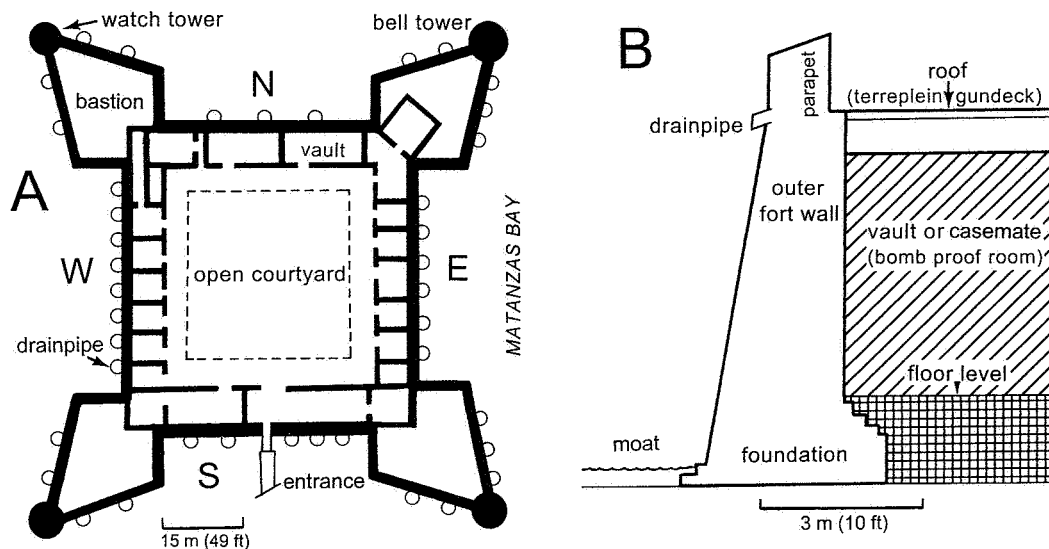


Figure 2. Diagrams of Castillo de San Marcos. A. Generalized floor plan of fort; circles = position of drainpipes (scuppers; Zomlefer, pers. obs.); vaults (casemates): solid lines = original rooms (1680's), dashed line = expanded perimeter (1750's); N, S, E, W = north, south, east, and west, respectively. B. Longitudinal section of fort wall. A based on Arana and Manucy (1977) and Brown (1997); B modified from Arana and Manucy (1977).

(ca. 12.8 m [42 ft] wide; 2.4 m [8 ft] deep) originally surrounded the fortress on all sides but was filled in on the east side in 1842 (Brown 1997). The Spanish kept the moat dry and used it as a domestic animal pen during sieges; whenever the fort was under land attack, the moat was filled with sea water by opening flood gates along the seawall (see Figure 3B). Bordering the moat on the north, west, and south sides is a flat grassy area ("covered way" or "covert way;" Figures 1C, 3A) bounded by a masonry retaining wall 1.5 m (5 ft) tall that protected soldiers leaving the fort. A large sloped lawn extends beyond the covered way. This man-made embankment (glacis; Figure 1C), kept free of tall vegetation, provided a clear view of the surrounding land for the fort's defenders and also protected the lower fort wall from enemy cannon fire.

METHODS

The authors led four intensive field trips in 2003 (30–31 May, 30 July, 28 September) and 2004 (14 April) to collect plant specimen vouchers in triplicate using standard field and herbarium techniques (under collecting permit #CASA-2003-SCI-0002) with assistance of personnel listed in the acknowledgments. A complete set of vouchers are deposited at GA, and one duplicate set, at FLAS. The second duplicate set has not yet been distributed pending resolution of issues concerning NPS ownership of voucher specimens. The majority of plants were identified by the authors; Lisa M. Kruse identified most grasses and sedges, and Walter S. Judd provided the moss determinations. The floras of Wunderlin and Hansen (2000, 2003) and Godfrey and Wooten (1979, 1981) were primary sources for vascular plant identification, supplemented by Breen (1963) for the mosses.

RESULTS AND DISCUSSION

Floristics

The 246 numbered collections of mosses (four collections), ferns (six), gymnosperms (three), and angiosperms (233) comprise 153 species (plus one variety), including 56 species on the fortress walls, 38 in the moat, 20 on the glacis, and 58 from other disturbed areas, mainly flower beds around park headquarters and parking lots (see ANNOTATED LIST OF PLANTS

below). Also included are 22 species planted in the park (indicated as “CULT”) and three tree species on adjacent private property with branches overhanging into the park (indicated as “o”). The largest families are Asteraceae (18 spp.), Poaceae (17 spp.), Fabaceae (10 spp.), Cyperaceae (8 spp.), Rubiaceae (7 spp.), and Euphorbiaceae (6 spp.). With completion of this survey, we have vouchered 41 new county records for St. Johns County, Florida, according to Wunderlin and Hansen (2004). No Florida endemics (Wunderlin and Hansen 2004) nor any state/federally listed endangered/threatened plants (Coile and Garland 2003, United States Fish and Wildlife Service 2004) were found.

Excluding the 16 cultivated exotics, the remaining 58 introduced species represent 42% of the total and include eight listed as invasive exotics (Florida Exotic Pest Plant Council [FLEPPC] 2004). Six (*Asparagus aethiopicus*, *Cinnamomum camphorum*, *Lygodium japonicum*, *Melia azedarach*, *Panicum repens*, and *Sapium sebiferum*) are ranked as Category I (invasive exotics altering native plant communities by displacing native species, changing community structures/ecological functions, or hybridizing with natives), and two, *Pteris vittata* and *Sphagneticola trilobata*, as Category II (invasive exotics increasing in abundance/frequency but not yet altered Florida plant communities to the extent shown by Category I plants). *Asparagus aethiopicus* (Sprenger’s asparagus fern), *Lygodium japonicum* (Japanese climbing fern), *Sphagneticola trilobata* (creeping oxeye), and seedlings of *Melia azedarach* (Chinaberrytree) and *Sapium sebiferum* (popcorn tree) were growing in the flower beds of park headquarters; on subsequent trips, the Japanese climbing fern and the creeping oxeye had been weeded out. Branches of one cultivated tree of *Cinnamomum camphora* (camphortree) hang over into the park from adjacent private property. *Panicum repens* (torpedograss) occurs in the moat and sporadically in the flower beds around the main parking lot. The cliff fern *Pteris vittata* (Chinese ladder brake), a significant arsenic hyperaccumulator (Ma et al. 2001), is one of the dominant species on the Castillo walls (Figure 4H) and has long rhizomes deeply penetrating the precious coquina. This species also grows on the coquina walls of nearby Fort Matanzas (Zomlefer et al. 2004).

In general, the flora of Castillo de San Marcos National Monument comprises an eclectic selection of common lawn and roadside weedy species of northeastern Florida—for example, the southern side of the glacis bordering the park entrance is a pure (mowed) stand of *Ambrosia artemisiifolia*. The glacis overall comprises species such as *Amaranthus viridis*, *Cynodon dactylon*, *Dichondra carolinensis*, *Drymaria cordata*, *Physalis walteri*, *Stellaria media*, and *Trifolium repens*; flower beds support weedy species such as *Chamaesyce hypericifolia*, *Emilia sonchifolia*, *Oxalis corniculata*, *Phyllanthus tenellus*, *Portulaca pilosa*, and *Stachys floridana*. Common wetland plants, such as *Bacopa monnieri* (Figure 3G), *Cyperus retrorsus*, and *Samolus valerandi* (Figure 4M, N) grow in the moat as well as on Castillo walls where they are concentrated along damp scupper rivulets (see Figure 3B, E) and shaded wall-bastion corners. Common roadside plants occurring on the wall include *Amaranthus hybridus*, *Andropogon glomeratus* (Figure 3C), *Bidens alba*, *Boerhavia diffusa* (Figure 3F), *Chamaesyce maculata*, *Chenopodium ambrosioides*, *Conyza canadensis* (Figure 4A), *Erigeron quercifolius* (Figure 4B, C), *Lepidium virginicum*, and *Medicago lupulina*.

→

Figure 3. Several views of the Castillo de San Marcos and representative plants growing on the fort walls (scales approximate). A. Aerial view of Castillo de San Marcos from the east side. B. North face of the northeastern bastion (note water in moat and vegetation strips under two drainpipes). C. *Andropogon glomeratus*, top of east face of southwestern bastion (10 m high), $\times 1/60$. D. *Andropogon virginicus*, ledge near top of south wall (9 m), $\times 1/50$. E. *Parthenocissus quinquefolia*, diagonally trailing vine under drainpipe along west face of northwestern bastion, greatly reduced. F. *Boerhavia diffusa*, south wall (2 m), $\times 1/5$. G. *Bacopa monnieri*, east wall (1 m), $\times 1$. H. *Symphyotrichum subulatum*, arching from top of west wall (10 m), $\times 1/30$. I. *Parietaria floridana*, south wall (1 m), $\times 1/5$. J. *Adiantum capillus-veneris*, south wall (1 m), $\times 1/2$. K. *Tortella humilis*, north wall (1 m), $\times 1/3$. Photo credits: A: Aerial photograph of Castillo de San Marcos by Henry Hird, III (© 2002, Historic Print and Map Co., St. Augustine, Florida; <http://www.historicprint.com/>), used with permission; B-F, H-K: W. B. Zomlefer; G: Lisa A. Kruse.



Parietaria floridana (Figure 3I), *Pilea microphylla* (Figure 4G), the ferns (*Adiantum capillus-veneris* [Figure 3J] and *Pteris vittata* [Figure 4H]), and the mosses (*Bryum coronatum* and *Tortella humilis* [Figure 3K]) predominate along the entire wall system. Several species are restricted to particular wall faces (probably due to local edaphic conditions): east side (facing the water)—*Bacopa monnieri*, *Conyza canadensis* var. *pusilla*, and *Erigeron quercifolius*; south—*Conyza canadensis* var. *canadensis*; west—*Andropogon glomeratus* and *Symphyotrichum subulatum* (Figure 3H); and north—*Erigeron quercifolius*, *Pluchea odorata* (Figure 4I), *Samolus valerandi*, and *Symphyotrichum subulatum*. Growth forms of the wall plants often differ from typical forms of the species: vine-like and growing up against the wall (e.g., *Boerhavia diffusa*), dangling downwards and forming long cascades (e.g., *Commelina erecta*, *Parietaria floridana*, *Phyla nodiflora* [Figure 4F]), upright and parallel to wall faces (e.g., *Eustachys petraea*, *Paspalum urvillei*, *Sporobolus indicus*, *Pluchea odorata*, *Solanum americanum* [Figure 4K, L]), or forming tight compact cushions in wall ledges (*Adiantum capillus-veneris*, *Bacopa monnieri*, *Chamaesyce maculata*, *Pilea microphylla*, and the mosses, *Bryum coronatum* and *Tortella humilis*). Diminutive specimens of species such as *Conyza canadensis*, *Cyperus retrorsus*, *Erigeron quercifolius*, *Lepidium virginicum*, *Portulacca oleracea* (Figure 4J), *Samolus valerandi*, and *Youngia japonica*, cling to tiny mossy ledges. Our survey also found seedlings of two woody species, *Baccharis halimifolia* and *Ulmus alata*, established in the wall.

Plant Control on the Historic Coquina Walls

The species inhabiting the fortress walls particularly interest National Park personnel who are concerned with controlling plant coverage to prevent further decomposition of the historic coquina, a nonrenewable resource. This coarsely grained shellstone is very absorptive with interstices providing ducts for water. When oven dried, the limestone rapidly absorbs water up to 20% of its weight, indicating high capillary potential (Clifton 1980). Abrasion resistance varies depending on moisture: when dry, the surface shell fragments become isolated and brittle, and when moist, the fragments bond to form a dense and cohesive material.

The fort has suffered recurrent water seepage as cracks allow water penetration into the stone fabric (Rands et al. 1984). The damp moat also contributes to degradation of the fortress base. Water maintained in the moat from 1938 to 1996 was subsequently drained to ensure the structural integrity the fort. However, the ditch is still very moist and sometimes contains some standing water depending on rainfall and the tides (see Figure 3B). Deterioration of the masonry (coquina, lime plaster, and mortar) varies according to location within the fort. For example, the stone surface is noticeably scoured under the dripping drainpipes mounted on the terreplein (see Figure 3B, E). Other weathering forces include exposure to wind and air pollution, as well as human (tourist) contact.

The deteriorating, but aesthetically appealing, "mossy walls" of the Castillo have long been romanticized (see descriptions and engravings in Bryant [1872]). Tourists of all ages still express much interest in the flora on the external fort walls (Zomlefer and Giannasi, pers. obs.). Historically (circa 1930's–1950's), one casemate of the fortress was maintained as the "Fern Room" with the interior walls and ceiling completely covered by lush growth of *Adiantum capillus-veneris* (Crowe 1940). During that era, the NPS did not waterproof this section of the terreplein over the vault so that moisture would continue percolating through the walls to nourish the delicate ferns below.

Figure 4. Representative plants growing on the Castillo walls, continued (scales approximate). A. *Conyza canadensis* var. *canadensis*, along top of south wall (10 m), $\times 1/6$. B. C. *Erigeron quercifolius*: habit, east wall (1.5 m) $\times 1/8$; head, $\times 2\ 1/2$. D., E. *Houstonia procumbens*: habit, north wall (1.5 m), $\times 1\ 1/2$; flower, $\times 3$. F. *Phyla nodiflora*, south wall (2.5 m), $\times 1/10$. G. *Pilea microphylla*, south wall (1.5 m), $\times 2/3$. H. *Pteris vittata*, south wall (1.5 m), $\times 1/10$. I. *Pluchea odorata*, near top of north wall (10 m), $\times 1/5$. J. *Portulacca oleracea*, within cracks along south wall (0.5 m), $\times 1/2$. K., L. *Solanum americanum*: habit, south wall (1 m), $\times 1/6$; detail of fruit, $\times 1/3$. M., N. *Samolus valerandi* subsp. *parviflorus*: habit, north wall (0.5 m), $\times 1/3$; flower, $\times 2$. Photo credits: A, B, H, I, M: W. B. Zomlefer; C-E, N: Alexander Reynolds; F, J-L: D. E. Giannasi; G: Lisa A. Kruse.



Rands et al. (1984) investigated mechanisms of nutrient leaching by water in coquina and documented so-called algal microorganisms growing on the Castillo walls and their effects on coquina decomposition. They analyzed pH, calcium, magnesium, and orthophosphate-P content and found that water flowing through coquina has a high pH due to exclusion of atmospheric CO₂ and supersaturation of calcite and hydroxyapatite. The ca. 10 species of "algae" (cyanobacteria [7 spp.]; diatoms [*Diatoma hiemale*, *Navicula* sp.]; green algae [*Pleurastrum* sp.]) formed extensive populations on the walls and benefited from the leached nutrients, mainly phosphorus, silicates, and carbonates.

Weathering has created small cracks and ledges along the entire wall system, which collect water and promote growth of mosses and small cushions of vascular plants. These accumulate soil around them, allowing other plants with larger root systems, such as *Erigeron quercifolius*, *Samolus valerandi*, and *Youngia japonica*, to become established via rootstocks deeply penetrating the shellstone. In spite of difficult environmental conditions on the wall, these plants were healthy and vigorously grew over the summer of 2003, eventually producing spores or seeds. Water seeping through the coquina walls evidently provides adequate moisture and nutrients for these mosses and vascular plants.

The original white lime plaster coating waterproofed the walls and prevented plant growth, but this protective layer has long ago eroded, although some traces persist on a few wall faces (e.g., Figure 3B, E). Unfortunately, recoating the entire fort with lime, a historically accurate solution [see recommendations by Clifton (1980)], would be prohibitively expensive at this time (G. Wilson, pers. comm.). The 1996 Resource Management Plan (Brown 1997) for the park recommended routine removal of vegetation from the coquina walls of the fort (and related structures) to ensure structural stability, and a mason meticulously removed plants manually from the walls on a regular schedule (R. Dean, pers. comm.). During our study (late fall 2003), a crew physically extracted plants from some walls, while NPS personnel in conjunction with chemists and archivists from Harpers Ferry Center/Conservation and Texas A & M University (see Woodcock and Bischoff 2004) experimented with herbicide sprays on other faces (mainly under the drainpipes). Plants grew back almost as soon as they were physically removed (R. Dean, pers. comm.). The algaecide GreenClean™, evidently not a systemic herbicide for vascular plants, killed all the above-ground growth on the walls, but basal rosettes of *Erigeron quercifolius* regrew quickly from embedded rootstalks. As of this writing, the researchers have tentatively concluded that Roundup® buffered with sodium bicarbonate has been the most effective treatment to control vegetation without coquina damage, as long as pH levels are carefully monitored.

National Park Service administrators expected our Castillo inventory to include very few plant species due to the urban location and high degree of ground maintenance of the park. However, the extensive flora growing on historic coquina was astonishing, particularly the altered growth forms of some plants as compared to their terrestrial representatives (discussed above). Reduction in size (e.g., *Samolus valerandi*, Figure 4M, N), dramatic cascading habits (e.g., *Phyla nodiflora*, Figure 4F), and/or vertical growth along the wall (e.g., *Boerhavia diffusa*, Figure 3F) belie considerable morphological plasticity in many of these adaptable species. Given the tenacity of the wall flora to return even after herbicidal treatment, the fort has potential as a vehicle for ecological interpretation. Using this vertical flora as part of the grounds tour with supporting documentation and/or guidebook would expand the public's interest in the Castillo beyond basic historical aspects of the structure.

ANNOTATED LIST OF PLANTS

A list of 153 plant species (plus one variety), representing 129 genera in 61 families is here compiled from *Giannasi & Zomlefer* specimens (collection numbers in *italic*) in alphabetical order by family within four major groups (mosses, ferns, gymnosperms, and angiosperms). Genera, species, and infraspecific taxa are alphabetical within each family. Scientific nomenclature and common names follow Wunderlin and Hansen (2003); exceptions are vernacular names of a few horticultural plants (not included in their flora) that conform to Huxley

(1992). Family circumscriptions for ferns and gymnosperms follow Flora of North America Editorial Committee (1993), and for the angiosperms, Angiosperm Phylogeny Group (2003).

Boldface collection number = collection from the walls of the Castillo; underlined taxa = new vouchered St. Johns County records for vascular plants according to on-line species list by Wunderlin and Hansen (2004); * = exotic (Wunderlin and Hansen 2003); invasive exotics (FLEPPC 2004): [CAT I] = Category I; [CAT II] = Category II; CULT = cultivated; habitat/locality data: D = disturbed areas (flower beds and/or lawn around park headquarter buildings and parking lots), G = glacies ("lawn" or artificial embankment surrounding the fortress), M = moat, O = overhang on park property, W = walls of the Castillo. Relative abundance: C = common (generally abundant throughout a particular habitat; species easily found); O = occasional (locally common and/or several individuals distributed within a habitat; species not too difficult to locate); I = infrequent (sporadic occurrence of a small number of individuals; species relatively scarce and not easily found); R = rare (very few individuals encountered).

MOSSES

BRYACEAE

Bryum coronatum Schwaegr.—W; C; **387c, 590a**

POTTIACEAE

Tortella humilis (Hedw.) Jenn., Twisted moss—W; C; **387b, 590b**; (Figure 3K)

FERNS

POLYPODIACEAE

Pleopeltis polypodioides (L.) E. G. Andrews & Windham
var. *michauxiana* (Weath.) E. G. Andrews & Windham,
Resurrection fern—G; O; 351

PTERIDACEAE

Adiantum capillus-veneris L., Venus'-hair fern—W; C; **151, 189, 576**; (Figure 3J)
Pteris vittata* L., Chinese ladder brake—[CAT II], W; C; **150; (Figure 4H)

SCHIZAEACEAE

**Lygodium japonicum* (Thunb.) Sw., Japanese climbing fern—[CAT I], D; R; 210

GYMNOSPERMS

CUPRESSACEAE

Juniperus virginiana L., Red cedar—G; R; 340

ZAMIACEAE

**Cycas revoluta* Thunb., Sago palm—CULT; 718
Zamia pumila L., Florida arrowroot—CULT; 331

ANGIOSPERMS

AGAVACEAE

Yucca aloifolia L., Spanish bayonet—CULT; 336

AIZOACEAE

Sesuvium portulacastrum (L.) L., Shoreline sea-purslane—M; O; 373

ALTINGIACEAE

Liquidambar styraciflua L., Sweetgum—G; R; 240

AMARANTHACEAE

Amaranthus hybridus* L., Slim amaranth—W; I; **194b
Amaranthus viridis* L., Slender amaranth—D, M, W; C; **138, 194a, 349
Chenopodium ambrosioides* L., Mexican tea—W; I; **185

AMARYLLIDACEAE

**Zephyranthes rosea* Lindl., Leli di San Jose—G; R; 350 (A few plants; likely not naturalized.)

APIACEAE

Ptilimnium capillaceum (Michx.) Raf., Mock bishops-weed—D, M, W; O; **145, 353, 361, 702**

APOCYNACEAE

**Catharanthus roseus* (L.) G. Don, Madagascar periwinkle—CULT; 580

AQUIFOLIACEAE

Ilex vomitoria Aiton, Yaupon—CULT; 235

ARALIACEAE

Hedera helix* L., English ivy—W; R; **179, 366
Hydrocotyle bonariensis Comm. ex Lam., Largeleaf marshpennywort—D, M; O; 160, 339
Hydrocotyle verticillata Thunb., Whorled marshpennywort—D; I; 386, 573

ARECACEAE

Sabal palmetto (Walter) Lodd. ex Schult. & Schult. f., Cabbage palm—CULT; 387a

ASPARAGACEAE

**Asparagus aethiopicus* L., Sprenger's asparagus-fern—[CAT I], D; I; 216, 332

ASTERACEAE

Ambrosia artemisiifolia L., Common ragweed—D, G, M, W; C; 170, 329, **370**
Baccharis halimifolia L., Groundsel tree—W, R; **690** (Seedling.)
Bidens alba (L.) DC. var. *radiata* (Sch. Bip.) R. E. Ballard ex Melchert, Beggarticks—W, R; **692**

Conyza canadensis (L.) Cronquist var. *canadensis*, Canadian horseweed—D, w; c; **158, 338**; (Figure 4A)
Conyza canadensis (L.) Cronquist var. *pusilla* (Nutt.) Cronquist, Dwarf Canadian horseweed—w; o; **374**
Eclipta prostrata (L.) L., False daisy—D, w; i; **154, 225**
Emilia sonchifolia* (L.) DC., Lilac tasselflower—D; i; **223, 707
Erechtites hieracifolius (L.) Raf. ex DC., American burnweed—w; r; **181, 378**
Erigeron quercifolius Poir., Oakleaf fleabane—M, w; c; **156, 157, 384, 700**; (Figure 4B, C)
Eupatorium capillifolium (Lam.) Small ex Porter & Britton, Dogfennel—w; r; **683**
Gamochaeta antillana (Urban) A. Anderberg, Narrowleaf purple everlasting—D, g; i; **195, 715b** [*Gamochaeta falcata* (Lam.) Cabrera, misapplied (R. Wunderlin, pers. comm.), as in Wunderlin and Hansen (2003): The correct name for the species in the southeastern United States is clarified by Nesom (2004).]
Gamochaeta purpurea (L.) Cabrera, Spoonleaf purple everlasting—D, g; i; **701, 715a**
Pluchea odorata (L.) Cass., Sweetscent—w; o; **183, 359**; (Figure 4I)
Pyrrhopappus carolinianus (Walter) DC., Carolina desertchicory—D; i; **218**
Sonchus oleraceus* L., Common sowthistle—D, w; o; **162, 227, 703, 708
Sphagneticola trilobata* (L.) Pruski, Creeping oxeye—[CAT II], CULT; **211
Symphotrichum subulatum (Michx.) G. L. Nesom [= *Aster subulatus* Michx.], Annual saltmarsh aster—w; o; **379, 572**; (Figure 3H)
Taraxacum officinale* Weber ex F. H. Wigg., Common dandelion—M, w; i; **146, 171
Youngia japonica* (L.) DC., Oriental false hawksbeard—D, M, w; o; **159, 196, 209, 685

BALSAMINACEAE

Impatiens balsamina* L., Garden balsam—CULT; **346

BRASSICACEAE

Capsella bursa-pastoris* (L.) Medik., Shepherd's purse—M; i; **691
Coronopus didymus* (L.) Sm., Lesser swinecress—w; r; **147c
Lepidium virginicum L., Virginia pepperweed—M, w; o; **139, 147b, 184**

BROMELIACEAE

Neoregelia spectabilis* (Moore) L. B. Sm., Painted fingernail—CULT; **584
Tillandsia recurvata (L.) L., Ballmoss—G; o; **236**
Tillandsia usneoides (L.) L., Spanish moss—G; o; **237**

CANNABACEAE

Celtis laevigata Willd., Sugarberry—D; r; **233**

CARYOPHYLLACEAE

Drymaria cordata (L.) Willd. ex Schult., Drymary—D, G; o; **200, 589, 712**
Spergularia marina* (L.) Griseb., Salt sandspurry—M; i; **164, 684
Stellaria media* (L.) Vill., Common chickweed—D, G; o; **713

COMMELINACEAE

Commelina erecta L.; Whitemouth dayflower—w; o; **153, 174, 199**
Tradescantia ohiensis Raf., Bluejacket—D, M; i; **215, 695, 719**

CONVOLVULACEAE

Dichondra caroliniensis Michx., Carolina ponysfoot—G; i; **201**
Ipomoea cordatotriloba Dennst., Tievine—M; o; **570**

CYPERACEAE

Cyperus compressus L.; Poorland flatsedge—M; r; **167**
Cyperus polystachyos Rottb.; Manyspike flatsedge—M; o; **168, 172a, 358**
Cyperus retrorsus Chapm.; Pinebarren flatsedge—M, w; o; **187, 360**
Cyperus rotundus* L., Nutgrass—D; i; **220
Cyperus strigosus L., Stawcolored flatsedge—D; i; **587**
Cyperus surinamensis Rottb., Tropical flatsedge—M; i; **169, 172b, 364**
Eleocharis flavescens (Poir.) Urb., Yellow spikerush—M; o; **165**
Kyllinga brevifolia* Rottb., Shortleaf spikesedge—G; i; **588

EUPHORBIACEAE

Acalypha gracilens A. Gray, Slender threeseed mercury—w; i; **357**
Chamaesyce hirta (L.) Millsp., Pillpod sandmat—D; i; **325**
Chamaesyce hypericifolia (L.) Millsp., Graceful sandmat—D; i; **221, 567**
Chamaesyce maculata (L.) Small, Spotted sandmat—w; o; **147a, 148, 368b**
Chamaesyce prostrata (Aiton) Small, Prostrate sandmat—w; i; **368a**
Sapium sebiferum* (L.) Roxb., Popcorn tree—[CAT I], D; r; **239 (Sterile seedling.)

FABACEAE

Chamaecrista nictitans (L.) Moench var. *aspera* (Muhl. ex Elliott) H. S. Irwin & Barneby, Sensitive pea—M, w; o; **385, 574**
Desmodium incanum* DC., Zarzabacoa comun—M, w; o; **178, 375
Galactia volubilis (L.) Britton, Downy milkpea—D; i; **326**
Indigofera spicata* Forssk., Trailing indigo—D; i; **581
Medicago lupulina* L., Black medick—M, w; i; **149, 686, 694
Medicago polymorpha* L., Burr clover—D; i; **709
Melilotus albus* Medik., White sweetclover—M; i; **383
Melilotus indicus* (L.) All., Indian sweetclover—w; i; **693
Trifolium repens* L., White clover—G; c; **204
Vigna luteola (Jacq.) Benth., Hairypod cowpea—M; o; **191, 356**

FAGACEAE

Quercus virginiana Mill., Live oak—G; i; **241**

GERANIACEAE

Geranium carolinianum L., Carolina cranesbill—M; o; **698**

HEMEROCALLIDACEAE

- **Hemerocallis lilioasphodelus* (L.) L., Yellow daylily—CULT; 213

JUNCACEAE

- Juncus megacephalus* M. A. Curtis, Bighead rush—M; o; 376

JUGLANDACEAE

- **Carya illinoensis* (Wangenh.) K. Koch, Pecan—CULT; 238

LAMIACEAE

- Salvia lyrata* L., Lyreleaf sage—D, w; c; 186, 205
Stachys floridana Shuttlew. ex Benth., Florida hedge-nettle—D; o; 208, 711

LAURACEAE

- **Cinnamomum camphora* (L.) J. Presl, Camphortree—[CAT I], CULT, o; 342

MAGNOLIACEAE

- Magnolia grandiflora* L., Southern magnolia—CULT; 231, 337

MALVACEAE

- **Hibiscus syriacus* L., Rose of Sharon—CULT; 217
Malvastrum corchorifolium (Desr.) Britton ex Small, False mallow—D; i; 140
Malvastrum coromandelianum (L.) Garcke, Threelobe false mallow—w; r; 365

MELIACEAE

- **Melia azedarach* L., Chinaberrytree—[CAT I], D; r; 328 (Seedling.)

MORACEAE

- **Morus alba* L., White mulberry—CULT, o; 341
Morus rubra L., Red mulberry—D; r; 335 (Seedling.)

NYCTAGINACEAE

- Boerhavia diffusa* L., Red spiderling—w; c; 144, 175, 382; (Figure 3F)

OLEACEAE

- Forestiera segregata* (Jacq.) Krug & Urb., Florida swamp-privet—O; r; 343
Osmanthus serrulatus Rehd., Sweet olive—CULT; 348

ONAGRACEAE

- Gaura angustifolia* Michx., Southern beeblossom—w; o; 190
Ludwigia octovalvis (Jacq.) Raven, Mexican primrosewillow—M; o; 575

OXALIDACEAE

- Oxalis corniculata* L. (incl. *O. stricta* L.), Common yellow woodsorrel—D, w; o; 155, 173, 330
Oxalis rubra A. St.-Hil., Windowbox woodsorrel—D; i; 714

PHYLLANTHACEAE

- **Phyllanthus tenellus* Roxb., Mascarene Island leaf-flower—D; i; 222, 352
Phyllanthus urinaria L., Chamber bitter—D; r; 327

PITTOSPORACEAE

- **Pittosporum tobira* (Thunb.) Aiton, Japanese cheese-wood—CULT; 137, 706

PLANTAGINACEAE

- Bacopa monnieri* (L.) Pennell, Herb-of-grace—w; o; 163; (Figure 3G)
Linaria canadensis (L.) Chaz., Canada toadflax—D; i; 717

POACEAE

- Andropogon glomeratus* (Walter) Britton et al., Bushy bluestem—w; i; 380; (Figure 3C)
Andropogon virginicus L., Broomsedge bluestem—w; r; 592; (Figure 3D)
Cynodon dactylon (L.) Pers., Bermudagrass—CULT; 203
Dactyloctenium aegyptium (L.) Willd. ex Asch. & Schweinf., Durban crowfootgrass—D; o; 564
Digitaria bicornis (Lam.) Roem. & Schult., Asia crabgrass—D; o; 333
Eleusine indica (L.) Gaertn., Indian goosegrass—D, M; o; 192b, 565, 577
Eragrostis elliottii S. Watson, Elliott's lovegrass—M; o; 354
Eustachys petraea (Sw.) Desv., Pinewoods fingergrass—w; i; 355, 569
Oplismenus hirtellus (L.) P. Beauv., Woodsgrass—D; o; 226
Panicum repens L., Torpedograss—[CAT I], D, M; i; 371, 563
Paspalum notatum Flügge var. *saurae* Parodi, Bahia grass—M; o; 192a
Paspalum urvillei Steud., Vaseygrass—M, w; o; 177, 372, 381, 571, 578
Poa annua L., Annual bluegrass—M; o; 166, 699
Sphenopholis obtusata (Michx.) Scribn., Prairie wedge-scale—M; o; 687
Sporobolus indicus (L.) R. Br. var. *indicus*, Smutgrass—w; i; 193
Stenotaphrum secundatum (Walter) Kuntze, St. Augustine grass—M, w; c; 176, 377
Zea mays L. subsp. *mays*, Corn—M; r; 579 (One seedling; not naturalized.)

PORTULACACEAE

- **Portulaca amilis* Speg., Paraguayan purslane—D; i; 229
Portulaca oleracea L., Little hogweed—w; i; 182, 197; (Figure 4J)
Portulaca pilosa L., Pink purslane—D; i; 230

ROSACEAE

- **Rhaphiolepis indica* (L.) Lindl., Indian hawthorn—CULT; 582, 705

RUBIACEAE

- Cephalanthus occidentalis* L., Common buttonbush—CULT; 586
Diodia virginiana L., Virginia buttonweed—D; i; 212
Galium uniflorum Michx., Oneflower bedstraw—D; i; 219

Houstonia procumbens (J. F. Gmel.) Standl., Innocence—
D, W, i; **688**, **716**; (Figure 4D, E)
**Oldenlandia corymbosa* L., Flattop mille grains—D, W, i;
362, **568**
**Richardia brasiliensis* Gomes, Tropical Mexican clover—
D, G, W, o; **198**, **228**, **242**
Spermacoce assurgens Ruiz & Pav., Woodland false
buttonweed—D; i; **566**

RUSCACEAE

Liriope spicata* Lour., Monkey-grass—CULT; **334

SANTALACEAE

Phoradendron leucarpum (Raf.) Reveal & M. C. Johnst.,
Oak mistletoe—G; r; **344**

SAPOTACEAE

Sideroxylon tenax L., Tough bully—D; r; **232**, **345**

SMILACACEAE

Smilax auriculata Walter, Earleaf greenbrier—D; r; **234**
Smilax bona-nox L., Saw greenbrier—D; r; **347**

SOLANACEAE

Physalis walteri Nutt., Walter's groundcherry—D, G, o;
202, **206**
Solanum americanum Mill., American black night-
shade—D, W, o; **152**, **180**, **710**; (Figure 4K, L)

THEOPHRASTACEAE

Samolus valerandi L. subsp. *parviflorus* (Raf.) Hultén,
Pineland pimpernel—M, W, c; **161**, **367**, **697**; (Figure
4M, N)

ULMACEAE

Ulmus alata Michx., Winged elm—W; r; **689** (Seedling.)

URTICACEAE

Parietaria floridana Nutt., Florida pellitory—M, W, c; **141**,
188, **363**, **696**; (Figure 3I)
Parietaria praetermissa Hinton, Clustered pellitory—D; r;
224
Pilea microphylla (L.) Liebm., Artillery plant—W; c; **142**,
369; (Figure 4G)

VERBENACEAE

**Lantana montevidensis* (Spreng.) Briq., Trailing shrub-
verbena—CULT; **214**
Phyla nodiflora (L.) Greene, Turkey tangle fogfruit—M, W,
c; **143**, **704**; (Figure 4F)

VITACEAE

Cissus trifoliata (L.) L., Sorrelvine—D; i; **207**
Parthenocissus quinquefolia (L.) Planch., Virginia creep-
er—D, W, r; **583**, **591**; (Figure 3E)
Vitis aestivalis Michx., Summer grape—D; r; **585**

ACKNOWLEDGMENTS

We thank Kelly A. Bettinger, William Carromero, Lisa M. Kruse, and Alexander Reynolds for enthusiastic assistance in the field; Kelly also carefully maintained specimen lists, organized field supplies, and alerted us to recent studies on arsenic hyperaccumulation in *Pteris vittata*. Walter S. Judd kindly provided the moss identifications and constructive criticisms of the manuscript, and Lisa M. Kruse determined most grass and sedge species. We greatly appreciate the invaluable support and cooperation of National Park Service personnel: Joe DeVivo, Network Coordinator; Gordon (Gordie) Wilson, Superintendent; David Parker, Site Supervisor and Chief of Resource Management; Andrew Rich, Park Ranger; and Ronnie Dean, Biological Science Technician. A special thank-you goes to Dean E. Garrison, Facility Manager, for arranging forklift retrieval of *Andropogon virginicus* (Figure 3D) and *Parthenocissus quinquefolia* (Figure 3E) specimens perched high up on the thirty-foot fortress walls. Kent D. Perkins and Richard P. Wunderlin provided careful reviews of the manuscript; Henry Hird, III (Historic Print and Map Co., St. Augustine, Florida) generously granted permission to reprint his aerial photograph of the Castillo (Figure 3A); J. Steve Davis at the University of Florida lent us publications concerning his studies of coquina composition and microorganisms on Castillo walls, and Kerik D. Cox assisted with the digitized graphics. We are grateful to the Department of Plant Biology, University of Georgia, for the use of a departmental vehicle for three trips to transport supplemental field supplies and personnel. This survey was funded by National Park Service contract agreement J2114-03-0006 (PI D. E. Giannasi and coPI W. B. Zomlefer).

LITERATURE CITED

- Angiosperm Phylogeny Group. 2003. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. Bot. J. Linn. Soc. 141:399–436.
Arana, L.R. and A. Manucy. 1977. The building of Castillo de San Marcos. Eastern National Park and Monument Association for Castillo de San Marcos National Monument, St. Augustine, Florida.
Bearss, E.C. and J.C. Paige. 1983. Historic structure report for Castillo de San Marcos National Monument,

- St. Johns County, Florida. Denver Service Center, National Park Service, United States Department of the Interior, Denver, Colorado.
- Breen, R.S. 1963. Mosses of Florida. University of Florida Press, Gainesville, Florida.
- Brown, J.D. 1997. Castillo de San Marcos National Monument historic resource study. National Park Service, United States Department of the Interior, Southeast Region, Atlanta, Georgia. (Available at: <http://www.nps.gov/casa/pphtml/documents.html>. Cited 30 June 2004.)
- Bryant, W.C. (ed.). 1872. Picturesque America. Volume I. D. Appleton and Company, New York, New York.
- Clifton, J.R. 1980. Material problems in the preservation of Fort Matanzas. p. 469–480. In: Schesventer, G., C.C. Frazier, L.A. Arana, E.C. Bearss, R.W. Copeland, G. Cummins, J.C. Paige, and T.L. Wong (eds.). Historic structure report for Fort Matanzas National Monument, St. Johns County, Florida. Historic Preservation Branch, National Park Service, United States Department of the Interior, Denver, Colorado.
- Coile, N.C. and M.A. Garland. 2003. Notes on Florida's endangered and threatened plants. Botany Contribution 38, 4th ed. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, Florida.
- Cooke, C.W. 1945. Geology of Florida. Geol. Bull. 29, Florida Geological Survey, Tallahassee, Florida.
- Crowe, F.H. 1940. Nature decorates an interior. The Regional Review, National Park Service, Region One, Volume 5 (4–5). (Reprint available at: http://www.cr.nps.gov/history/online_books/regional_review/rr-intro.htm/. Cited 30 June 2004.)
- DeLorme [publishers] (ed.). 1997. Florida atlas and gazetteer. DeLorme, Yarmouth, Maine.
- Flora of North America Editorial Committee. 1993. Flora of North America. Volume 2. Pteridophytes and gymnosperms. Oxford University Press, New York, New York.
- Florida Exotic Pest Plant Council (FLEPPC). 2004. Florida Exotic Pest Plant Council's 2003 list of invasive species. (<http://www.fleppc.org/Plantlist/03list.htm/>. Cited 30 June 2004.)
- Gannon, M. 2003. Florida: a short history, rev. ed. University Press of Florida, Gainesville, Florida.
- Godfrey, R.K. and J.W. Wooten. 1979. Aquatic and wetland plants of the southeastern United States. Monocotyledons. University of Georgia Press, Athens, Georgia.
- Godfrey, R.K. and J.W. Wooten. 1981. Aquatic and wetland plants of the southeastern United States. Dicotyledons. University of Georgia Press, Athens, Georgia.
- Gold, R.L. 1969. Borderline empires in transition: the triple-nation transfer of Florida. Southern Illinois University Press, Carbondale, Illinois.
- Huxley, A. (ed.). 1992. The new Royal Horticultural Society dictionary of Gardening. Stockton Press, New York, New York.
- Krakow, J.L. 1986. Administrative history of Castillo de San Marcos National Monument and Fort Matanzas National Monument. United States Department of the Interior, National Park Service, Washington, D.C.
- Ma, L.Q., K.M. Komar, C. Tu, W. Zhang, Y. Cai, and E.D. Kennelley. 2001. A fern that hyperaccumulates arsenic. *Nature* 409:579.
- Manucy, A.C. (ed.). 1943. The history of Castillo de San Marcos and Fort Matanzas, from contemporary narratives and letters. Source Book Series. Number 3. United States Department of the Interior, National Park Service, Washington, D.C.
- Maynard, C.W. 2002. Castillo de San Marcos. Rosen Publishing Group, New York, New York.
- National Park Service (NPS). 1993. Castillo de San Marcos: a guide to the Castillo de San Marcos National Monument, Florida. Handbook 149, Division of Publications, National Park Service, Department of the Interior, Washington, D.C.
- National Park Service (NPS). 2004. Castillo de San Marcos. (<http://www.nps.gov/casa/>. Cited 30 June 2004.)
- Nesom, G.L. 2004. New distribution records for *Gamochaeta* (Asteraceae: Gnaphalieae) in the United States. *Sida* 21:1175–1185.
- Rands, D.G., J.S. Davis, and L.R. Arana. 1984. Chemical and biological processes in coquina of Castillo de San Marcos National Monument. *Schweiz. Z. Hydrol.* 46:109–116.
- Schmidt, W., R.W. Hoenstine, M.S. Knapp, E. Lane, G.M. Ogden, and T.M. Scott. 1979. The limestone, dolomite and coquina resources of Florida. Report of Investigation 88, Bureau of Geology, Division of Resource Management, Florida Department of Natural Resources, Tallahassee, Florida.
- United States Fish and Wildlife Service. 2004. Species information: threatened and endangered animals and plants. (<http://www.fleppc.org/Plantlist/03list.htm>. Cited 30 June 2004.)
- Waterbury, J.P. 1993. Coquina. Townet Press, Inc., St. Augustine, Florida.
- Woodcock, D.G. and J. Bischoff. 2004. Conference on vegetation control at historic sites. (<http://home.earthlink.net/~demelza/>. Cited 30 June 2004.)

- Wunderlin, R.P. and B.F. Hansen. 2000. Flora of Florida. Volume 1. Pteridophytes and gymnosperms. University Press of Florida, Gainesville, Florida.
- Wunderlin, R.P. and B.F. Hansen. 2003. Guide to the vascular plants of Florida, 2nd ed. University Press of Florida, Gainesville, Florida.
- Wunderlin, R.P. and B.F. Hansen. 2004. Atlas of Florida vascular plants. (<http://www.plantatlas.usf.edu/>. Cited 30 June 2004.) [S.M. Landry and K.N. Campbell (application development), Florida Center for Community Design and Research.] Institute for Systematic Botany, University of South Florida, Tampa, Florida.
- Zomlefer, W.B., D.E. Giannasi, W.S. Judd, L.M. Kruse, and K.A. Bettinger. 2004. A floristic survey of Fort Matanzas National Monument, St. Johns County, Florida. *Sida* 21:1081–1106.

Received July 8, 2004; Accepted October 11, 2004.