

Chapter 13

Northeast Florida

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Description of the region

The coast of Northeast Florida (Figure 13.1) is a mosaic of interconnected estuarine habitats that includes salt marshes, mangroves, salt barrens, oyster reefs, and open water. Barrier islands, sand ridges, and dunes are found along the coast, protecting the extensive salt marshes by buffering energy from Atlantic waves, tides, and winds. The coast consists of multiple parallel terraces; these paleoshorelines were formed by sea-level oscillations during the Pleistocene Epoch (Frazel 2009). Major river systems include the Nassau, St. Johns, Guana, Tolomato, and Matanzas rivers. The St. Johns River has the largest watershed in Florida and is often described as a series of interconnected lakes with a slow northward flow (USNPS 1996). The northeast coast of Florida experiences a larger tidal range than do the southeast and Gulf coasts, and this range decreases from north to south. Spring tidal range is 1.9 m (6.4 ft) in the St. Marys River on the Georgia border, 1.4 m (4.5 ft) at the St. Johns River mouth, and 1.0 m (3.4 ft) at the Ponce de Leon Inlet (NOAA 2017). Relatively large distances between tidal inlets (e.g., 75 km/47 mi between the Matanzas and Ponce de Leon inlets) strongly influence tidal exchange and produce pronounced tidal nodes that define the point of convergence between waters from adjacent inlets. Nor'easters, tropical storms, and hurricanes bring strong waves to the region and cause extensive erosion along the coast. Strong hurricanes (e.g., Hurricane Matthew in 2016 and Hurricane Irma in 2017)

can couple storm surges with high precipitation, with the resulting inundation exacerbating coastal erosion.

The hydrology of the northeast coast of Florida has been altered by the Intracoastal Waterway, dikes, drainage ditches, dredging, and inlet stabilization (Frazel 2009). While the Nassau River lacks channels and stabilization structures, the location of tidal channels and the shape of Nassau Sound changed significantly during the last century in response to a decrease in sediment supply and the shoreline stabilization of the St. Marys and St. Johns rivers (USNPS 1996, Browder and Hobensack 2003). The hydrology of the St. Johns River was changed by the construction of the Fulton Cut, dredging and deepening of the river mouth, and construction, in 1886, of the Jacksonville Harbor jetties, which caused the Fort George Inlet to migrate north and erode the southern end of Little Talbot Island. The Guana Dam was built in 1957 across the Guana River to improve hunting and fishing grounds. The St. Augustine Inlet, originally located 120 m (400 ft) south of its present position, was modified in 1940 to improve navigation, and jetties were built on either side to stabilize the inlet. The Matanzas Inlet remains largely natural, having experienced no dredging and only minimal hardening, although the construction of the Intracoastal Waterway reduced current velocity through the inlet and increased sediment deposition, such that the channel west of the inlet must be dredged regularly (Frazel 2009).

In addition to changing the hydrology, many of these same alterations led to the direct loss of habitat. For

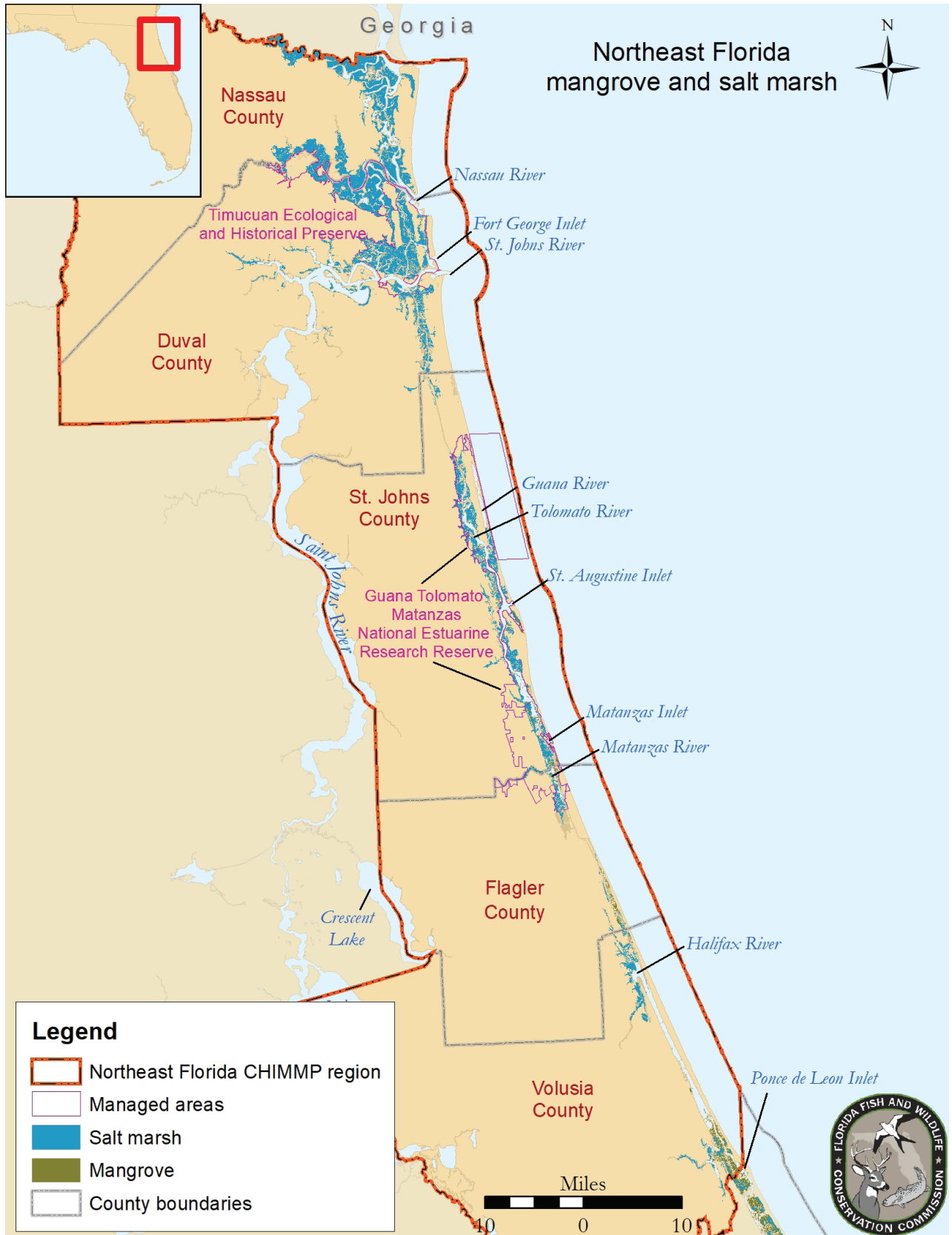


Figure 13.1. Salt marsh and mangrove extent in Northeast Florida. Data source: SJRWMD 2014 land-use/land-cover data, based on FLUCCS classifications (FDOT 1999, SJRWMD 2019). See maps below for further detail of wetland extent.

example, dredging for the construction of the Intracoastal Waterway often cut through coastal wetlands, converting them to open water. The dredge spoil was regularly deposited in adjacent wetlands, converting them to uplands (Crawford 2006). From St. Johns River to the Ponce de Leon Inlet, more than 560 ha (1,400 ac) of spoil remains on historic wetlands (SJRWMD, unpublished data). Similarly, mosquito ditching from the 1950s through the early 1970s left transecting ditches and patches of upland in coastal wetlands in the form of spoil piles (Rey et al. 2012). Restoration has focused on such impacts in Northeast Florida, but restoration extent is limited.

Groundwater is extracted at multiple depths in Northeast Florida including from the Floridan aquifer, deep artesian wells, and a shallow layer of freshwater (Frazel 2009, GTMNERR 2009). The Floridan aquifer is about 610 m (2,000 ft) thick and is located approximately 30 m (100 ft) below the soil surface in Volusia County and more than 152 m (500 ft) below the soil surface near the Georgia border (Scott and Hajishafie 1980). Water levels in the Floridan aquifer monitoring wells dropped 7.5–9 m (25–30 ft) from the 1940s to 2001 due to increasing and ongoing urban and agricultural withdrawal (Spechler 2002). Saltwater intrusion is a concern for freshwater supplies, particularly on the barrier islands (USNPS 1996, Frazel 2009).

Nassau and Duval counties

Nassau and Duval counties include the largest estuarine marsh system on the east coast of Florida (USNPS 1996, 2016). The St. Johns, Fort George, and Nassau rivers flow directly into the Atlantic Ocean after receiving waters from numerous meandering tributaries in the extensive salt marsh (Figure 13.2). Because of the close association between urban and industrial areas and estuarine wetlands in the St. Johns River Basin, these wetlands receive freshwater that is low in dissolved oxygen and high in nutrients and other pollutants (UNF and JU 2014, Pinto et al. 2019). While annual mean dissolved oxygen concentrations meet acceptable limits, minimum concentrations in tributaries of the St. Johns River are of concern, particularly during the summer (Pinto et al. 2019). Total nitrogen has declined since the mid-1990s as a result of decreased nitrogen loading in the watershed. While mean concentrations of total nitrogen and total phosphorus are below target reference concentrations, 1.2% of total nitrogen measurements from the Lower St. Johns River and 4.4% of measurements from tributaries exceeded reference concentrations (Pinto et al. 2019). For total phosphorus, 20.5% and 22.8% of measurements exceeded

reference concentrations in the Lower St. Johns River and tributaries, respectively (Pinto et al. 2019).

Protected areas in Nassau and Duval counties include multiple state parks (Big and Little Talbot Island, Fort George Island, Kathryn Abbey, and Amelia Island) and preserves (Nassau River–St. Johns River Marshes Aquatic Preserve and Fort Clinch State Park Aquatic Preserve). The Timucuan Ecological and Historic Preserve covers 18,600 ha (46,000 ac) and contains extensive smooth cordgrass (*Spartina alterniflora*) and black needlerush (*Juncus roemerianus*) salt marshes (Figure 13.2). The preserve lies in the southeastern reaches of the Atlantic Coastal Plain and includes the outflows of the Nassau and St. Johns rivers (USNPS 1996, 2016). This area is dominated by marshes due to the cold winter temperatures limiting mangrove survival, but a few pioneer mangroves were noted in 2016 at Fort George Inlet, at 30.41 °N (Cavanaugh et al. 2019). Records by Bartram, Muir and other naturalists from the late 18th to the mid-19th centuries (Cavanaugh et al. 2019) show that mangroves had been spotted between extreme freeze events as far north as Fernandina Beach (30.67 °N, record from 1867 as reported in Muir 1914) and Amelia Island (29.9 °N, record from 1766 as reported in Bartram and Harper 1943).

St. Johns, Flagler, and Volusia counties

Several reserves, state parks, and preserves are found along the northeast coast, including the Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR). The reserve comprises 31,060 ha (76,760 ac) of relatively undeveloped coastal and estuarine habitat and encloses a narrow (east–west), bar-bounded estuarine ecosystem that spans approximately 56 km (35 mi) north to south (Figure 13.3). Approximately 1,350 ha (3,350 ac) of submerged lands near St. Augustine were added to the reserve in March 2020. The northern component is associated with the Tolomato and Guana river estuaries, while the southern component incorporates the Matanzas River estuary. The GTMNERR is positioned at an ecotone with salt marsh in the north (dominated by smooth cordgrass) and mangroves in the south (dominated by black mangroves, *Avicennia germinans*, with increasing cover of red mangroves, *Rhizophora mangle*, along lower-elevation coastal wetland margins) (Zomlefer et al. 2006, Leitholf 2008, Frazel 2009, Williams et al. 2014). The cordgrass-dominated low marsh is mixed with and adjacent to high-marsh species including black needlerush, glasswort (*Salicornia* spp.), and saltwort (*Batis maritima*). About 20% of the land in the GTMNERR watershed is salt marsh; the remainder is pinelands, shrub

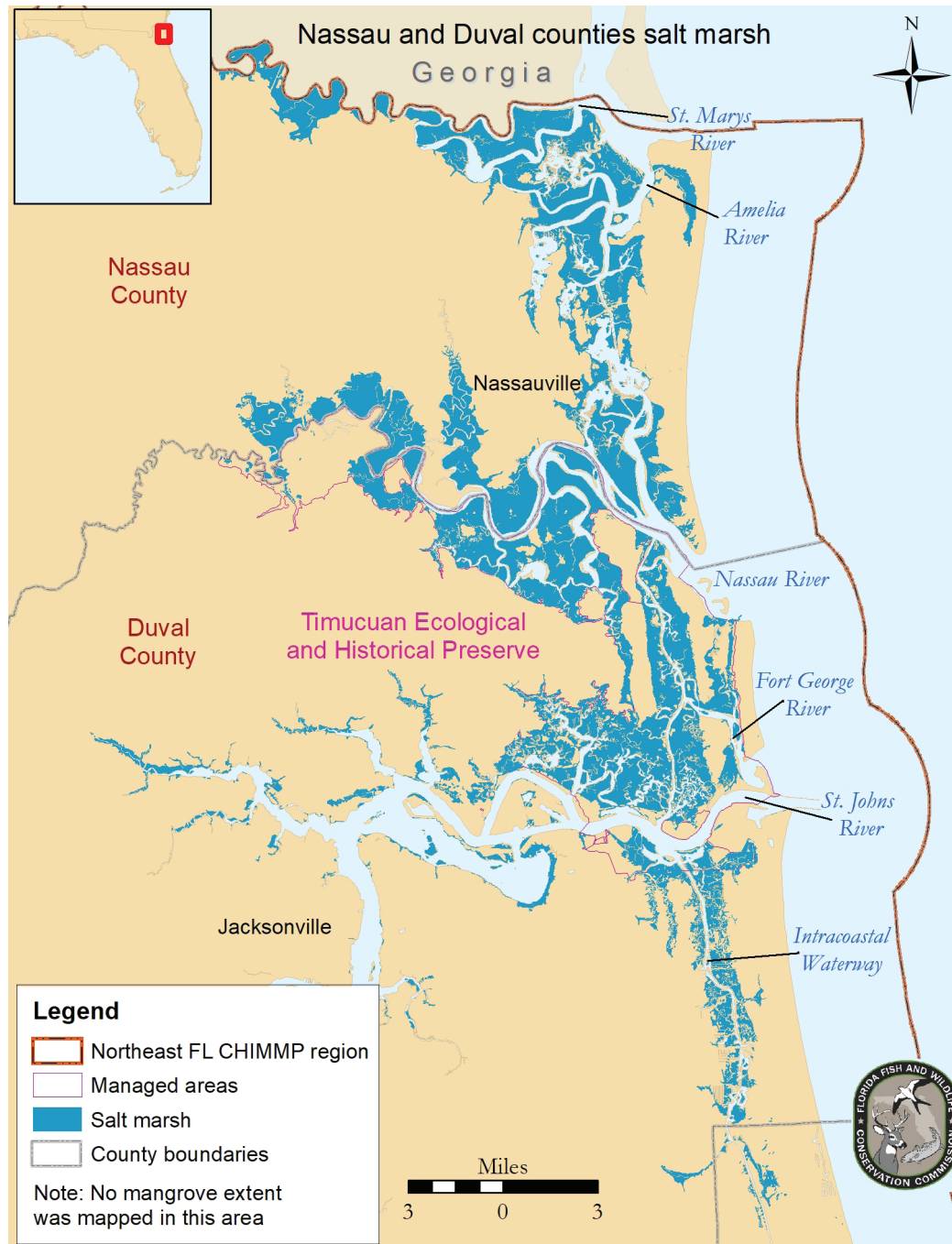


Figure 13.2. Salt marsh extent in Nassau and Duval counties. Data source: SJRWMD 2014 land-use/land-cover data, based upon FLUCCS classifications (FDOT 1999, SJRWMD 2019).

and brushlands, hardwood hammocks, and barren lands. Oyster reefs are common in lower intertidal zones, while muddy and sandy tidal flats, barren of vegetation, can be found along channels and creeks (Frazel 2009). Piles of dead oyster shell, known as shell rakes, also line the Intracoastal Waterway in many places because of reef erosion from vessel wakes (Figure 13.4; Grizzle et al. 2002, Wall et al. 2005, Garvis et al. 2015, Safak et al. 2020b). While landward movement of the shell rakes displaces wetland

habitat and changes the flow of tidal creeks, the shell rakes provide nesting habitat for shorebirds such as the American Oystercatcher (*Haematopus palliatus*).

The primary factor regulating the dominance of mangroves or salt marsh vegetation in coastal wetlands is temperature. In South Florida, mangrove forests thrive and outcompete salt marsh vegetation because the shade of the trees slows growth of other vegetation (Lugo and Snedaker 1974, Odum et al. 1982). The northernmost

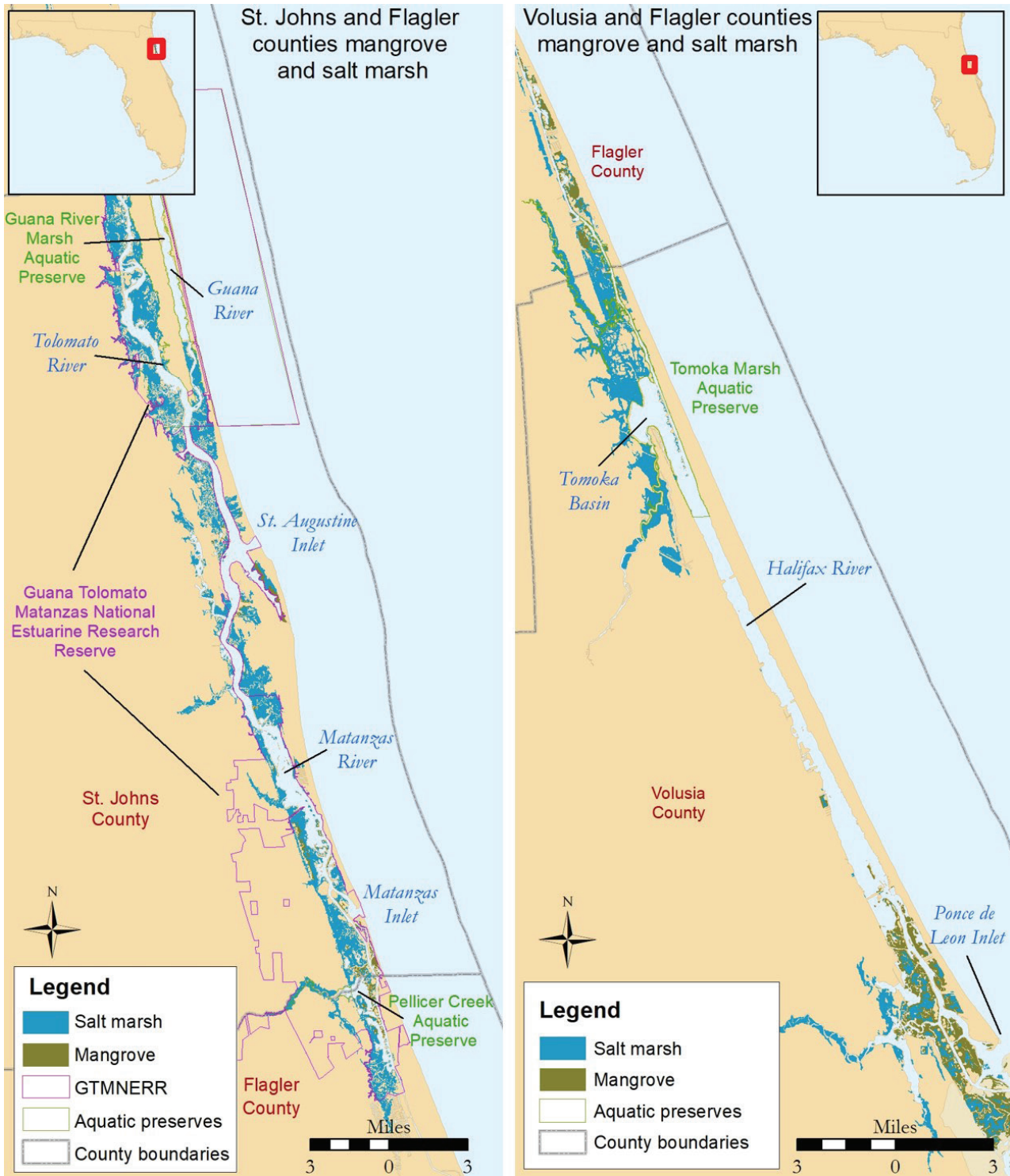


Figure 13.3. Salt marsh and mangrove extent in St. Johns, Flagler, and Volusia counties. Data source: SJRWMD 2014 land-use/land-cover data, based upon FLUCCS classifications (FDOT 1999, SJRWMD 2019).

occurrence of mangrove trees is also limited by the frequency of severe freezes in winter (Cavanaugh et al. 2019) and the spread of propagules, which can be dispersed more widely by hurricanes (Kennedy et al. 2020). The central to northeast coast of Florida has shifted from pe-

riods of mangrove dominance to salt marsh dominance several times since the mid-1850s (Rodriguez et al. 2016, Cavanaugh et al. 2019). More recently, cold events in 1962, the late 1970s, and the 1980s led to uneven mangrove mortality along the east coast of Florida as far south as West



Figure 13.4. Example of a shell rake adjacent to a smooth cordgrass (*Spartina alterniflora*) salt marsh in the GTMNERR. Shell rakes are often caused by oyster reef erosion from boat wakes. Photo credit: Nikki Dix.

Palm Beach (Odum and McIvor 1990). The moderate cold events in 2000/2001 and 2010/2011 were not severe enough to cause widespread mangrove mortality on the east coast (Cavanaugh et al. 2019). As evident in land-use/land-cover maps created by the St. Johns River Water Management District (SJRWMD), mangrove acreage has increased in recent decades (Figures 13.5 and 13.6, Table 13.1) and in part reflects recovery from the cold-event mortalities of the 1960s through the 1980s (Giri and Long 2014, Cavanaugh et al. 2019). Although parts of the current expansion involve previously occupied mangrove habitats, a comparison with historical records shows that mangroves' northern limit is expanding further north (Williams et al. 2014). Once established, mangroves rapidly shade out herbaceous vegetation, as evidenced by the 69% increase in mangrove cover at Merritt Island in only 7 years (Doughty et al. 2016). Similarly, Simpson et al. (2019) found that, in some plots in Northeast Florida, cover changed from marsh to mangrove in only 3 years (Simpson et al. 2019). Nutrient enrichment may further facilitate mangrove growth and encroachment into salt marsh ecosystems (Simpson et al. 2013, Dangremond et al. 2019).

The overlapping distribution of salt marsh and mangrove habitats in Northeast Florida provides a unique opportunity to examine effects of climate change and sea-level rise on the distribution and diversity of emergent intertidal vegetation, ecosystem services, and associated fauna in this transitional zone (Kelleway et al. 2017). Numerous fish, invertebrate, bird, and reptile species rely



Figure 13.5. Example of the amount of mangrove proliferation into salt marshes between 2006 (top) and 2018 (bottom) along the Matanzas River. Images from Google Earth.

upon these diverse estuarine habitats as a refuge from predators and habitat for foraging, reproduction, and nursery habitat (Odum and McIvor 1990, Kneib 1997, Sheaves 2005, Walker et al. 2019, Schwarzer et al. 2020). Changes in the habitat ranges of mangroves and salt marshes may significantly impact numerous organisms and predator-prey interactions throughout the estuary, since dominant vegetation is one of the most important factors determining the ecological function of coastal wetlands (Weinstein et al. 1997, Walker et al. 2019). Mangrove expansion is additionally expected to increase carbon sequestration in coastal wetlands in Northeast Florida (Doughty et al. 2016, Simpson et al. 2017, 2019, Vaughn et al. 2020).

Ongoing experiments in the region are assessing how global warming and sea-level rise will influence wetland plant growth and surface elevation (<https://www.wetfeet-project.com/>, Chapman et al. 2021). Previous studies at Merritt Island National Wildlife Refuge have shown that warming temperatures facilitated mangrove expansion (Coldren et al. 2019) and increased salt marsh growth,

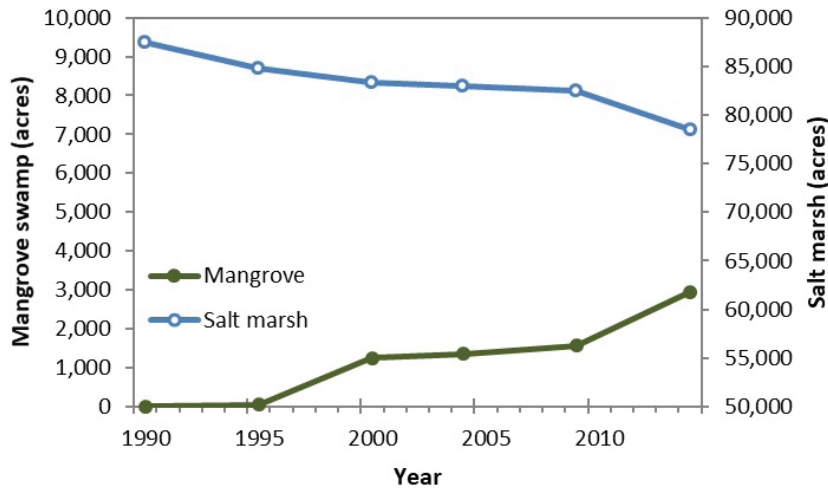


Figure 13.6. Extent of mangrove swamps and salt marshes in Northeast Florida. Source: SJRWMD 2019.

Table 13.1. Extent of mangrove swamps (FLUCCS 6120) and salt marshes (FLUCCS 6420) in Northeast Florida. Data source: SJRWMD 2019.

Year	Mangrove (ha)	Mangrove (ac)	Salt marsh (ha)	Salt marsh (ac)
1990	2	4	35,416	87,515
1995	23	56	34,317	84,800
2000	508	1,256	33,706	83,290
2004	550	1,360	33,583	82,985
2009	637	1,573	33,382	82,489
2014	1,191	2,943	31,777	78,523

particularly in summer (Coldren et al. 2016). The relative distribution and condition of salt marsh and mangrove habitats may also have implications for the region's resilience to storm surge and sea-level rise, as mangroves have been shown to provide better wave attenuation and erosion protection than salt marsh vegetation (Doughty et al. 2017).

Threats to coastal wetlands

- **Coastal development:** Rates of population growth vary widely along the coast of Northeast Florida. The population of Duval and Volusia counties grew 11–12% between 2010 and 2019, which was below the statewide average of 14% (U.S. Census 2019). Nassau and Flagler counties exceeded statewide growth rates and grew 20%, while the St. Johns County population

grew almost 40%. Demand for waterfront access increases with population growth, and construction of marinas and waterfront properties is one of the greatest threats to coastal wetland habitat and water quality (Frazel 2009). Increased urban development harms coastal wetlands due to filling of marshes, construction of docks and bulkheads, increased erosion and water pollution, growing demand for freshwater, and increased recreational and boating use of coastal waters and wetlands. Mitigation is a common means of compensating for development of wetland habitat, but the wetlands created or restored in mitigation do

not always perform as well as the original, undisturbed wetland (Moreno-Mateos et al. 2012, UNF and JU 2014, Pinto et al. 2019). Damage by vehicles is another impact of human use of natural regions, and unauthorized off-road traffic can cause long-term damage in salt marshes.

- **Climate change and sea-level rise:** Sea-level rise is expected to exacerbate shoreline erosion and result in landward migration of coastal wetlands. When the Sea Level Affecting Marshes Model (SLAMM) was applied to the GTMNERR area with scenarios of 0.2–1.6 m (0.7–5.2 ft) of sea-level rise, it projected that changes to vegetation land cover would extend 2–5 km (1.2–3.1 mi) inland (Linhoss et al. 2015). Coastal wetland acreage will be lost where topography or coastal development hinders landward migration or sediment accretion does not keep pace with sea-level rise (Scavia et al. 2002, Linhoss et al. 2015). Sediment accretion is dependent on rates of local peat development and sediment deposition (Cahoon et al. 2020). Low suspended sediment delivery in the St. Johns River and in marshes along the Intracoastal Waterway highlight the importance of local peat development (UNF and JU 2014, Pinto et al. 2019, Vaughn et al. 2020). Local elevation monitoring indicates that many coastal wetlands are not keeping pace with sea-level rise (see GTMNERR monitoring section below).

The altered hydrology brought on by sea-level rise and changes to freshwater availability can hinder ecosystem services provided by wetlands, for example, by slowing primary production and nutrient removal (Scavia et al. 2002, Craft et al. 2009). Additionally, the decline in the frequency of cold events continues

to facilitate the northern expansion of mangroves. If temperature does not limit mangrove growth, the trees eventually replace salt marsh, altering their relative coverage (Lugo and Snedaker 1974, Odum et al. 1982, Col-dren et al. 2019).

- **Altered hydrology:** Hydrology has been altered locally by the construction of mosquito ditches, dikes, dams, and other water-control structures (Frazel 2009), though restoration efforts have moderated some of their hydrologic effects (Rey et al. 2012). Dredged ditches and channels result in saltwater intrusion into the freshwater zone. Roads and trails (particularly highway A1A) function as levees along the shore, preventing natural sheet flow, concentrating runoff, and frequently diverting freshwater runoff from wetlands (FDEP 2008a, FDEP 2008b). The increases in salinity expected as a result of sea-level rise and increasing public demand for freshwater (UNF and JU 2014) may be outside the tolerances of dominant vegetation, particularly in freshwater and transitional wetlands. Dredged shipping channels and shoreline hardening around inlets also alter sediment delivery and hydrology, resulting in blocked water flow in regions such as the Fort George River (USNPS 2016).
- **Erosion:** The sandy beaches and barrier islands of Northeast Florida are dynamic and active shorelines. Wave energy, storms, boat traffic, and vehicular traffic on the beach all contribute to erosion and modification of the shoreline (Frazel 2009, Silliman et al. 2019). Coastal erosion is a significant problem along the Intracoastal Waterway due to high wave energy from boat wakes, converting salt marshes and oyster beds into tidal flats and shell rakes (Figure 13.4; Safak et al. 2020b). While wave energy, storms, and the migration of barrier islands are natural phenomena, shoreline migration and erosion threaten development and navigation along the coast, prompting shoreline stabilization and restoration projects (Herbert et al. 2018, Safak et al. 2020a, 2020b). Inlet stabilization and shoreline hardening change the foci of erosional forces, destabilizing other locations and threatening coastal wetlands (Browder and Hobensack 2003).
- **Water quality:** Water quality in the St. Johns River has been considerably degraded, particularly adjacent to highly industrialized districts including paper mills and landfills. Nonpoint sources of pollution include stormwater runoff and poorly functioning septic systems (USNPS 1996, Wicklein 2004). High nutrient concentrations have been observed in the upstream reaches of the Nassau River, St. Johns River, and Clapboard

Creek (Gregory et al. 2011, Pinto et al. 2019). Other water-quality concerns include excess nutrients, organic and heavy-metal pollution, bacterial growth, and high turbidity due to increased suspended solids (USNPS 1996, Wicklein 2004, UNF and JU 2014, Pinto et al. 2019). Improvements have been made to water quality, in part due to improved wastewater treatment and removal of septic tanks, and fecal coliform bacteria and nutrient concentrations have declined in the St. Johns River, although algal blooms remain frequent (UNF and JU 2014, Pinto et al. 2019).

Other regions where water quality has diminished include the Tolomato River, San Sebastian River, Guana River, and Pellicer Creek in St. Johns and Flagler counties and the dredged canals along the Palm Coast (Haydt 2003, FDEP 2008c). The concentrations of heavy metals, nutrients, algal biomass, coliform bacteria, and dissolved oxygen fall beyond recommended limits. Sedimentation, a growing number of septic systems, aging wastewater infrastructure, and the quality of urban stormwater runoff are also concerns along the Guana, Tolomato, and Matanzas rivers (Haydt 2003, FDEP 2008c).

High nutrient concentrations have been found to increase aboveground biomass at the expense of root systems in coastal wetlands, decreasing soil stability and increasing risks of vegetation mortality (Lovelock et al. 2009, Deegan et al. 2012). High nitrogen concentrations can also increase mangrove growth, which may facilitate mangrove encroachment into salt marsh ecosystems (Simpson et al. 2013, Dangremond et al. 2019). But interactions among many factors and the tendency of tidal marshes to resist disturbances up to a threshold make it difficult to predict the ultimate impacts of increasing nutrients in coastal wetlands (Kirwan and Megonigal 2013).

Mapping and monitoring efforts

Water management district mapping

SJRWMD has conducted regular land-use/land-cover mapping since 1990 using aerial orthophotography (Figure 13.6, Table 13.1). Updates were made to the 2009 LULC maps using 2013–2016 digital orthophotography to create the 2014 LULC map shown in Figures 13.1–13.3 (SJRWMD 2019). The minimum mapping unit for wetlands was 0.2 ha (0.5 ac). Land features were categorized according to the Florida Land Use and Cover Classification System (FDOT 1999) and outlined in the SJRWMD photointerpretation key (SJRWMD 2018).

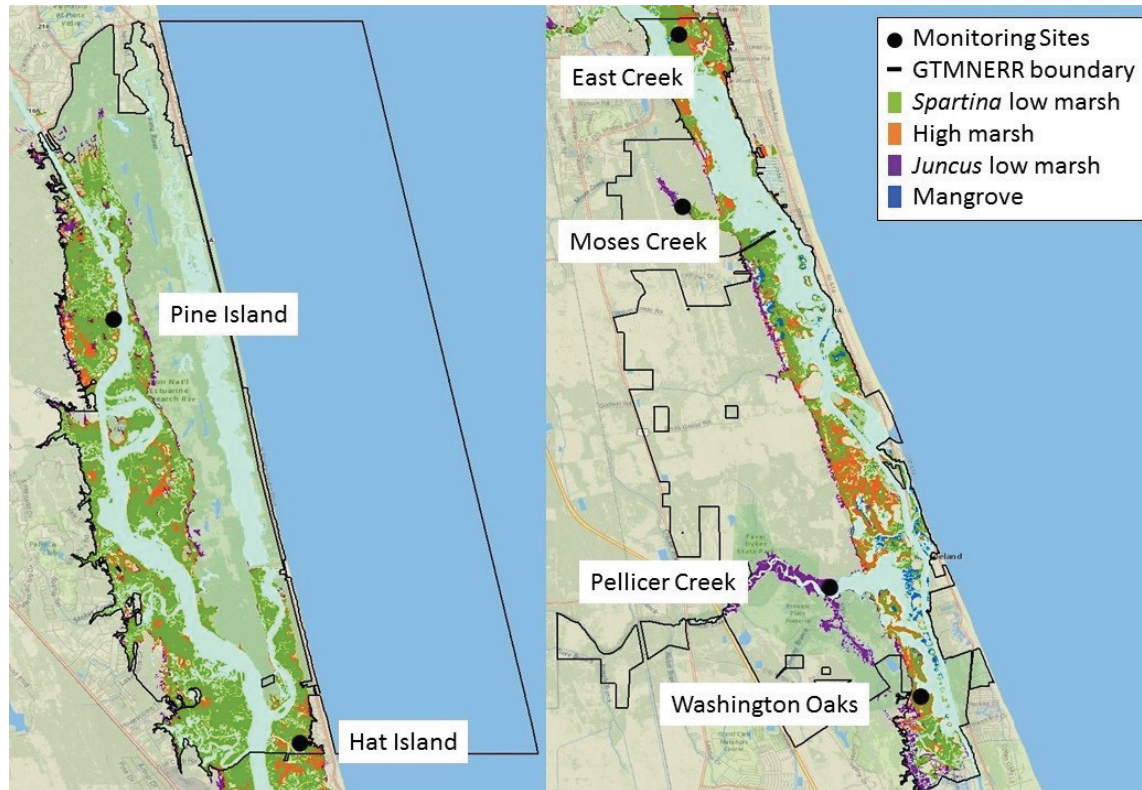


Figure 13.7. Long-term vegetation and surface elevation monitoring sites within GTMNERR.

Guana Tolomato Matanzas National Estuarine Research Reserve monitoring

Salt marsh and mangrove sites are monitored in the GTMNERR as part of the national System-Wide Monitoring Program, which is designed to study ecological characteristics and dynamic responses to local and global changes (NOAA 2011). GTMNERR has monitored emergent vegetation and elevation at six permanent, salt marsh-dominated sites (Figure 13.7) twice per year since 2012 using a combination of protocols (Folse and West 2004, Curtis 2013, Moore 2013); for a more complete description of monitoring protocols, see Chapter 1 of this report. Components of monitoring include permanent vegetation plots, used to measure canopy height and species percent cover, and rod surface elevation tables (SETs) used to monitor change in marsh surface elevation. Of the six marsh monitoring sites, the northernmost four are dominated by smooth cordgrass. One of the southern sites (Pellicer Creek) receives significant freshwater flow and is dominated by black needlerush; the other southern site (Washington Oaks) is dominated by saltwort. From 2012 to 2019, vegetation cover and canopy height were relatively stable with intra- and interannual variability generally greater than long-term change. Notable exceptions included increasing black mangrove cover and

height at two sites (East Creek and Washington Oaks). Change in relative surface elevation over time has been variable among and within sites, but only 3 of 18 SETs have shown increases in elevation that would allow the marshes to keep up with the rate of local sea-level rise (Figure 13.8).

Mangroves are monitored annually at two sites following a scaled-back version of the mangrove-specific protocols in Moore (2013) (see Chapter 1 of this report). As of 2019, mangroves were not present in any of the plots at the northernmost site on the Tolomato River, but black mangroves cover was increasing near those plots. At the southern site near Matanzas Inlet, black mangroves have increased in cover (from 20% in 2012 to 34% in 2019), and stem density (from 6.5 stems/m² in 2012 to 25.5 stems/m² in 2019). On shore-to-upland transects, vegetative zones with heightened mangrove cover and stem density have shifted landward.

Weather (e.g., temperature, wind speed and direction, light, and precipitation) and water quality parameters (temperature, salinity, dissolved oxygen, pH, Secchi depth, total suspended solids, turbidity, chlorophyll *a*, nitrate, nitrite, ammonium, total nitrogen, orthophosphate, total phosphorus, and fecal coliform bacteria) are also monitored throughout the reserve using standard National Estuarine Research Reserve System protocols.

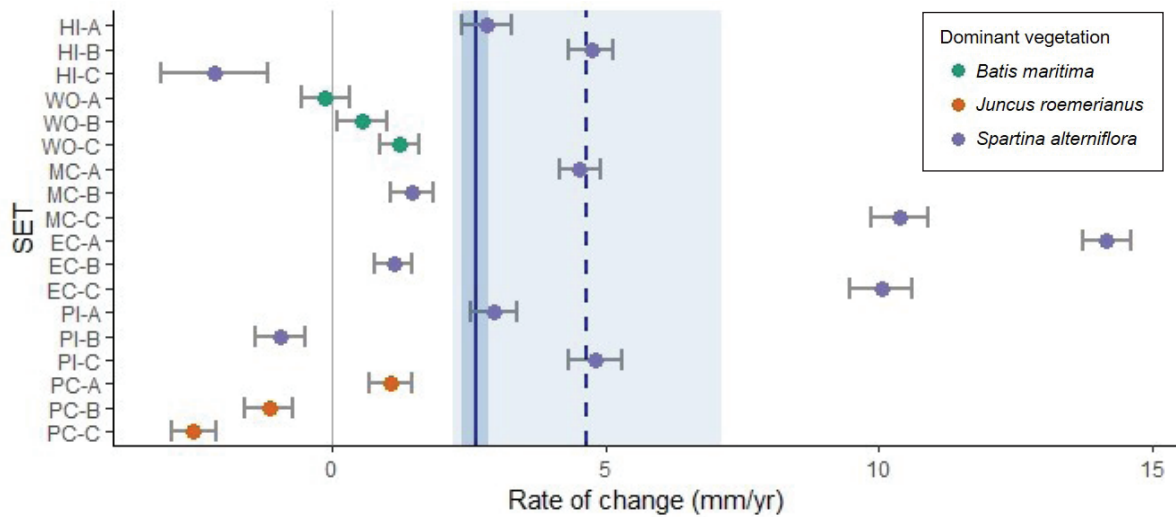


Figure 13.8. Change in wetland surface elevation (means with 95% confidence intervals) from 2013 to 2019 at GTMNERR long-term monitoring sites (HI = Hat Island, WO = Washington Oaks, MC = Moses Creek, EC = East Creek, PI = Pine Island, PC = Pellicer Creek; see Figure 13.7 for site locations) relative to sea-level rise measured at Mayport, FL (NOAA National Water Level Observation Network station 8720218, based on data from 1928 to 2018). Long-term sea-level rise (2.62 ± 0.25 mm/yr) is shown by the solid line with dark shading; 19-year water level change (4.66 ± 2.47 mm/yr) is shown by the dashed line with light shading. Source: GTMNERR.

A significant portion of the vegetation, weather, and water quality data and metadata is available at <http://nerds-data.org/> or may be obtained by contacting the research coordinator at GTMNERR.

National Park Service salt marsh elevation monitoring and vegetation mapping

The National Park Service's Southeast Coast Inventory and Monitoring Network monitors surface elevation and sediment accretion in several coastal wetlands across the southeastern United States. Monitoring includes the deployment of soil surface elevation via SETs (Lynch et al. 2015). In Northeast Florida, monitoring is done at eight parks, including the Timucuan Ecological and Historic Preserve and Fort Matanzas National Monument. A full description of the program can be found at <https://home.nps.gov/im/secn/saltmarsh.htm>.

The Ocean and Coastal Resources Branch of the National Park Service completed a geospatial mapping project designed to classify and quantify the extent of black needlerush and *Spartina* spp. in Timucuan Preserve. Areal cover by other classes such as water, trees, upland vegetative communities, and salt flats were also mapped. Color infrared orthoimagery (2012), LiDAR data (2007), and Trimble eCognition software were used to accomplish this object-based image analysis. This technique groups

neighboring homogeneous pixels and then uses contextual properties to allow the analyst to classify a landscape (Cantor 2014). The dataset can be downloaded at <https://data.doi.gov/dataset/timucuan-ecological-and-historic-preserve-salt-marsh-classification>.

SJRWMD and GTMNERR detailed emergent vegetation mapping

Salt marsh and other tidal communities were mapped by the St. Johns River Water Management District within the GTMNERR using 2006 orthophotography and 2004 digital orthophoto quarter quads. Classifications of land cover were species-specific for mangroves and herbaceous plants (Kinser et al. 2008). Figure 13.9 shows an example of the detail and high resolution of this mapping effort.

In 2019, the GTMNERR initiated an effort to update the emergent vegetation mapping effort that was previously conducted in 2007. This effort followed the guidelines in the National Oceanic and Atmospheric Administration (NOAA) habitat mapping and change plan (Garfield et al. 2013) and included all portions of the GTMNERR with the exception of offshore areas. The habitat map was generated from National Agriculture Imagery Program source imagery (1-m resolution) using a combination of techniques including supervised semi-automated classification and manual digitization. For

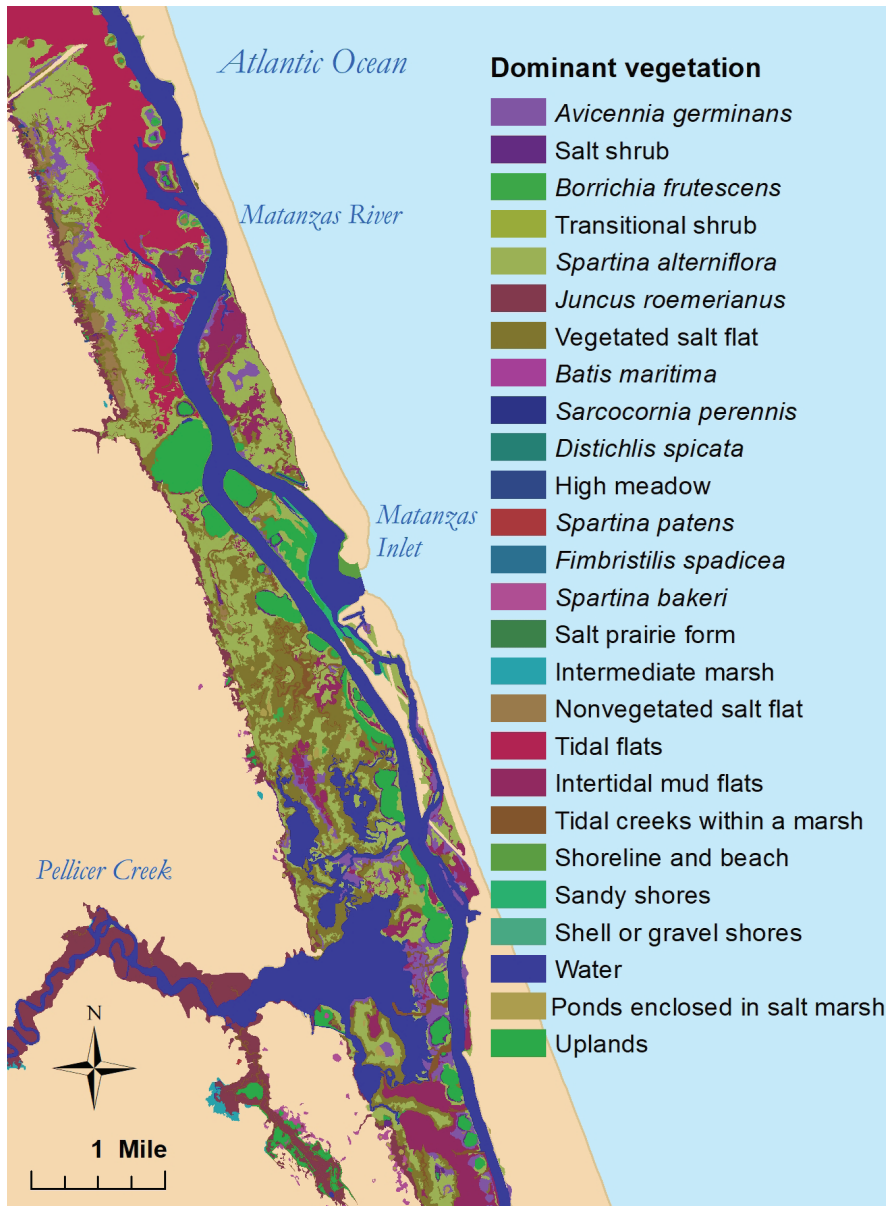


Figure 13.9. Example of detailed land cover and emergent vegetation mapping performed by the SJRWMD in the GTMNERR (Kinser et al. 2008).

assessing accuracy, a novel remote-sensing protocol was tested for its ability to increase the efficiency and minimize the impact of in situ accuracy data point collection on sensitive habitats. The final map product including inland open water bodies yielded 19 habitat classifications with overall accuracy and kappa-statistic estimates of 85.5% and 82.3%, respectively. A separate analysis of the same map, but excluding open water, produced an overall accuracy of 84.5% and a kappa-statistic estimate of 80.5%. The map is expected to be available in 2021 at the NERRS centralized data management office website (<http://nerrscdm.org/>).

Recommendations for protection, management, and monitoring

The numerous parks and preserves in Northeast Florida list specific recommendations for their jurisdictions. Selected examples are listed below. The most common recommendations include restoring the natural hydrology and sediment delivery processes, reducing sediment and habitat erosion, converting armored shorelines into living shorelines, and restoring or protecting wetlands.

- Monitor wetlands along the Lower St. Johns River to determine the cumulative effect of incremental wetland loss to overall function and ecosystem services (UNF and JU 2014). Remaining wetlands should be preserved, enhanced, or restored as needed.
- Improve St. Johns River water quality, restore and protect natural systems, preserve the flood plain, maintain natural hydrology, and improve erosion control (SJRWMD et al. 2008).
- Model and monitor the hydrology and water quality of the rivers adjacent to the Timucuan Ecological and Historic Preserve. Restore and protect living shorelines in the region (Gregory et al. 2011).

- Monitor and protect natural resources that have altered hydrology due to ditches and roads in the Fort George Island Cultural State Park and Amelia Island State Park. Restore salt marsh and continue monitoring and removal of invasive vegetation (FDEP 2008a, 2008b).
- The draft 2021–2031 GTMNERR management plan (GTMNERR, unpublished) includes several strategic action items related to coastal wetlands:
 - **Monitoring recommendations:** Monitor status and trends of salt marsh and mangrove habitat structure including areal extent and characteristics of sediment and vegetation structure. Identify and quan-

tify primary causes of habitat change (structure, function, areal extent or condition). Prioritize and quantify ecosystem services (e.g., carbon storage/sequestration, habitat provision, water filtration, food provision) provided by natural habitats.

- **Restoration recommendations:** Enhance inshore fisheries habitat by increasing marsh width through various shoreline protective methods. Prioritize habitat restoration targets that could mitigate or improve loss of habitat or ecosystem services. Investigate, test, and assess new estuarine restoration treatments that mitigate or improve loss of habitat or ecosystem services.
- **Outreach recommendations:** Develop and provide training or information on biodiversity elements to internal staff, partner agencies, and land managers regarding topics such as native species, invasive species, mapping technologies, and restoration techniques. Communicate causes of habitat, species, and ecosystem service loss to decision makers with the anticipation that natural resource conservation be incorporated into municipality action plans when possible.

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General references and additional regional information

Florida Department of Environmental Protection
map of water quality assessments, total maximum
daily loads, and best management action plans:

<https://fdep.maps.arcgis.com/home/webmap/viewer.html?webmap=1b4f1bf4c9c3481fb2864a415fbeca77>

National Park Service salt marsh elevation monitoring:

<https://home.nps.gov/im/secln/saltmarsh.htm>

Planning for sea-level rise in the Matanzas Basin: <https://planningmatanzas.org/>

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