Ecological site R156AY310FL
Subtropical Tidal Saline Wetlands of Miami Ridge/ Atlantic Coastal Strip

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General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

MLRA notes

Major Land Resource Area (MLRA): 156A–Florida Everglades and Associated Areas

This area makes up about 7,749 square miles (20,071 square kilometers) and is entirely in Florida. It is located at the southern tip of the State and has shoreline on both the Atlantic Ocean and the Gulf of America. Lake Okeechobee borders the MLRA to the north. Aside from sugar cane plantations in the north, the Everglades National Park, Big Cypress National Preserve, and the Big Cypress Seminole Indian Reservation comprise this area. Historical ditching, berming, and canals prevent natural water flow through this delicate ecosystem. To mitigate this, extensive restoration efforts have been implemented. Urban sprawl from Miami and cities to its north on the Atlantic Ridge has encroached along the eastern boundary of this area. Most of the MLRA has resisted urbanization because of a water table that is at or near the surface, a considerable acreage of unstable organic soils, and its identity as a national treasure.

About one-third of this area is in Native American reservations, national parks, game refuges, or other large holdings. Cypress forests are extensive in the area, but mangrove forests are widespread along the eastern and southern coasts. A large part of the area is open marsh. Much of the area is used for hunting, fishing, and other recreational activities. The cropland in the area is used mainly for winter vegetables, but citrus fruits, avocado, and papaya are grown on the better drained soils. Sugarcane is an important crop on the organic soils south of Lake Okeechobee. The acreage of improved pasture is increasing. Beef cattle are the principal kind of livestock, but dairying is an important enterprise locally. Urbanization is extensive along the eastern coast.

The major soil resource concerns are wind erosion, maintenance of the content of organic matter and productivity of the soils, and management of soil moisture and soil subsidence. Conservation practices on cropland generally include conservation crop rotations, cover crops, nutrient management, pest management, water-control structures, surface drainage systems (field ditches, mains, and laterals), pumping plants, and irrigation water management (including micro irrigation systems and surface and subsurface irrigation systems). Conservation practices on pasture and rangeland generally include prescribed grazing, brush management, pest management, prescribed burning, and watering facilities. Conservation practices on forestland generally include forest stand improvement, firebreaks, pest management, prescribed burning, and management of upland and wetland wildlife habitat.

LRU notes

There is not an official LRU for the MLRA 156A area. For the time being the technical team recommended to add the four terrestrial physiographic provinces ecoregions (Big Cypress, Everglades, Southern Coast and Islands, and Miami Ridge / Atlantic Coastal Strip) and one subaqueous ecoregion (Coastal Marine and Estuarine) on this section. This PES occurs within the Miami Ridge / Atlantic Coastal Strip ecoregion.

The Miami Ridge/Atlantic Coastal Strip Ecoregion, sea level to 20 m (0 to 66 ft) in elevation, is a heavily urbanized region, with coastal ridges on the east and flatter terrain to the west that grades into the Everglades. The western side originally had wet and dry prairie marshes on marl and rockland and sawgrass marshes, but much of it is now covered by cropland, pasture, and suburbs. To the south, the Miami Ridge extends from near Hollywood south to Homestead and west into Long Pine Key of Everglades National Park. It is a gently rolling rock ridge of oolitic limestone that once supported more extensive southern slash pine forests and islands of tropical hardwood hammocks. The northern part of the region is a plain of pine flatwoods and wet prairie, and coastal sand ridges with scrub vegetation and sand pine. There are very few natural lakes in the region, but three types of ponded surface waters occur: 1) Pits dug deep into underlying "rock" containing water that is clear, high pH and alkaline, with moderate nutrients; 2) Shallow, surficial dug drains that are darker water; and 3) flow-through lakes (e.g., Lake Osborne) that are colored and nutrient rich.

Classification relationships

All portions of the geographical range of this site falls under the following ecological / land classifications including:

-Environmental Protection Agency's Level 3 and 4 Ecoregions of Florida: 76 Southern Florida Coastal Plain; 76C Miami Ridge/ Atlantic Coastal Strip (Griffith, G. E., Omernik, J. M., & Pierson, S. M., 2013)

-Florida Natural Area Inventory, 2010 Edition: Marine and Estuarine Vegetative Wetlands; Salt Marsh, Mangrove Swamp (FNAI ,2010)

-Soil Conservation Service, 26 Ecological Communities of Florida: 18- Salt Marsh, 19-Mangrove Swamp (Florida Chapter Soil and Water Conservation Society, 1989)

Ecological site concept

The Subtropical Tidal Saline Wetlands of Miami Ridge/ Atlantic Coastal Strip ecological community occurs in flat, wet, intertidal and supratidal coastal zones along relatively low energy coastlines. Intertidal zones include saltwater adapted species such as mangroves and saltmarsh cordgrass, with flooding frequency, soil salinity, wave energy, temperature, and substrate being the main influencers of size and extent of these areas. The main source of water is from the ocean, where saltwater reduces species competition, and from rainfall and runoff from adjacent uplands, which flushes salt from the swamp and delivers nutrients. These communities help protect other inland communities by absorbing the brunt of tropical storms and hurricanes and mitigating coastal erosion. The major threat to this ecological site is sea level rise, which is pushing these saltwater adapted communities further inland as they run out of natural space and are forced to compete with more freshwater tolerant species. This ecological site is very fragile and subject to urbanization due to the desirable location along the Miami Rock Ridge, much of this site has been eradicated and is now major cities such as Miami, Hollywood, and Fort Lauderdale.

Associated sites

R156AY500FL	**Subaqueous Haline Estuarine Habitats of MLRA 156A** The Subtropical Haline Estuarine Habitats of MLRA 156A occurs in the lowest point in the landscape and a subaqueous concept. This site is typically immediately adjacent in the presence of low wave energy action due to the protected nature of this site.
R156AY320FL	**Subtropical Freshwater Non-Forested Wetlands of Miami Ridge/ Atlantic Coastal Strip** The Subtropical Freshwater Non-Forested Wetlands of Miami Ridge / Atlantic Coastal Strip is found in slightly higher terrestrial landscape positions and is driven solely by freshwater inputs. Vegetative structure may be similar to the salt marsh state with the presence of freshwater tolerant species only.

Similar sites

R156AY110FL	**Subtropical Tidal Saline Wetlands of Southern Coast and Islands** The Subtropical Tidal Saline Wetlands of Southern Coast and Islands occurs in a separate ecoregion which have lower amounts of urbanization and slightly lower amounts of rainfall. Species composition and structure are similar. Resource concerns are reflected differently and require different management needs.

R156AY220FL	**Subtropical Freshwater Non-Forested Glades Marshes and Slough Wetlands of Everglades** The Subtropical Freshwater Non-Forested Glades Marshes and Slough Wetlands of Everglades occurs in a separate ecoregion which have slightly lower amounts of rainfall and lower elevation. Species composition and structure are driven solely via freshwater input. Soils will be highly organic with the absence of saline influence.
R156AY230FL	**Subtropical Marl Prairies of Everglades** The Subtropical Marl Prairies of Everglades occurs in a separate ecoregion which have slightly lower amounts of rainfall and lower elevation. Species composition and structure are driven solely via freshwater input. Soils will have a marl surface texture with the absence of saline influence.

Table 1. Dominant plant species

Tree	(1) *Rhizophora mangle* (2) *Avicennia germinans*
Shrub	(1) *Conocarpus erectus* (2) *Symphyotrichum tenuifolium*
Herbaceous	(1) *Salicornia bigelovii* (2) *Monanthochloe littoralis*

Physiographic features

Subtropical Tidal Saline Wetlands of Miami Ridge / Atlantic Coastal Strip are dominated by linear mangrove swamps, tidal flats, and tidal marshes occurring in intertidal positions along low-wave energy coastal landscapes. Low-wave energy areas include within estuarine systems or along the protected side of barrier islands, areas that are protected from high-energy waves and intense salt spray. These communities may occur as narrow strips to vast expanses, the size of which depends on coastal elevation changes and tidal influence. Tidal flooding is very frequent and will be brief to very brief. Flooding may be less frequent in further protected communities in a larger basin and limited to storm events and spring tides, but the common driving factor of speciation of these habitats are dominantly saline tolerant plant communities in low-energy coastal areas.

Mangrove swamps in this MLRA are delineated by seven major community types, driven by physiographic location and distinguishable by local patterns of tides and terrestrial surface drainage. These include the following: Overwash Islands, Fringe Forests, Riverine Forests, Basin Forests, Hammock Forests, Scrub / Dwarf Forests, and Buttonwood Forests. These unique community variations will occur within the mangrove swamps state and will often grade into one another based off slight variations in landscape position and microtopography. These community variations however will not transition from one to another, as represented in the state and transition model as isolated communities.

Salt Marshes in this MLRA are also delineated by four major community types, driven by physiographic location and distinguishable by local patterns of tides and terrestrial surface drainage. These include: Intertidal Marshes, Salt Pans, High Marsh, and Buttonwood Transitional Zones. These unique community variations will occur within the salt marshes state and will often grade into one another based off slight variations in landscape position and microtopography. These community variations however will not transition from one to another, as represented in the state and transition model as isolated communities.

The Miami Ridge/ Atlantic Coastal Strip ecoregion falls under one major geographic unit, the Pleistocene series Miami Limestone, oolitic facies consisting of white to orangish gray, poorly to moderately indurated, sandy, oolitic limestone (grainstone) with scattered concentrations of fossils and bryozoan facies consisting of white to orangish gray, poorly to well indurated, sandy, fossiliferous limestone (grainstone and packstone). This formation is highly porous and permeable and is part of the Biscayne Aquifer of the surficial aquifer system (Scott, 2001). Geologic substrate plays little to no role in the development of this ecological site, which is driven by the highly adapted saltwater tolerant species which are able to physically and chemical alter the substrate they grow on.

Table 2. Representative physiographic features

Geomorphic position, flats	(1) Talf (2) Rise
Geomorphic position, terraces	(1) Tread
Slope shape across	(1) Linear
Slope shape up-down	(1) Concave (2) Linear
Landforms	(1) Coastal plain (2) Island (3) Marine terrace > Barrier island (4) Marine terrace > Mangrove swamp (5) Marine terrace > Salt marsh
Runoff class	High to very high
Flooding duration	Extremely brief (0.1 to 4 hours) to very brief (4 to 48 hours)
Flooding frequency	Very frequent
Ponding duration	Very brief (4 to 48 hours) to brief (2 to 7 days)
Ponding frequency	Occasional to frequent
Elevation	0–3 ft
Slope	0–1%
Ponding depth	0–36 in
Water table depth	0–6 in

Aspect	Aspect is not a significant factor

Climatic features

The climate of MLRA 156A is subtropical, with mild winters and hot wet summers. The average annual precipitation of this MLRA is 37 to 62 inches (950 to 1,565 millimeters). About 60 percent of the precipitation occurs from June through September. Most of the rainfall occurs during moderate intensity, tropical storms that produce large amounts of rain from late spring through early autumn. Late autumn and winter are relatively dry. The average annual temperature of the MLRA is 74 to 78 degrees F (23 to 26 degrees C). The freeze-free period of the MLRA averages 355 days and ranges from 345 to 365 days.

The following tables and graphs consist of specific climate stations found within the range of this ecological site within this MLRA.

Table 3. Representative climatic features

Frost-free period (characteristic range)	365 days
Freeze-free period (characteristic range)	365 days
Precipitation total (characteristic range)	56-64 in
Frost-free period (actual range)	365 days
Freeze-free period (actual range)	365 days
Precipitation total (actual range)	51-68 in
Frost-free period (average)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	60 in

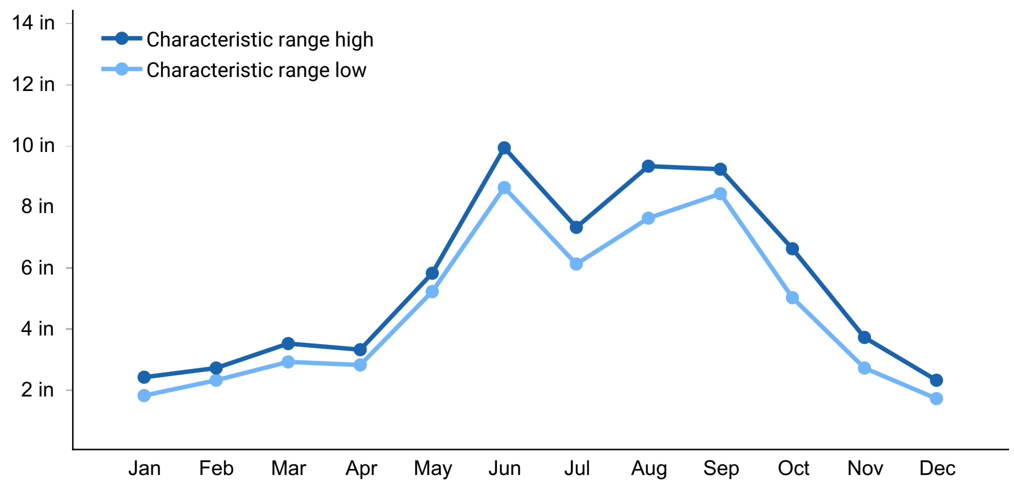


Figure 1. Monthly precipitation range

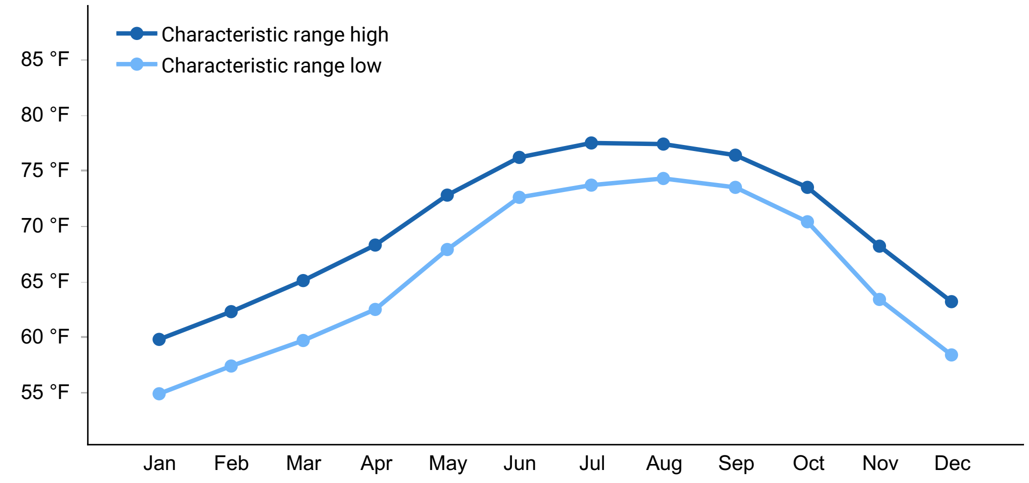


Figure 2. Monthly minimum temperature range

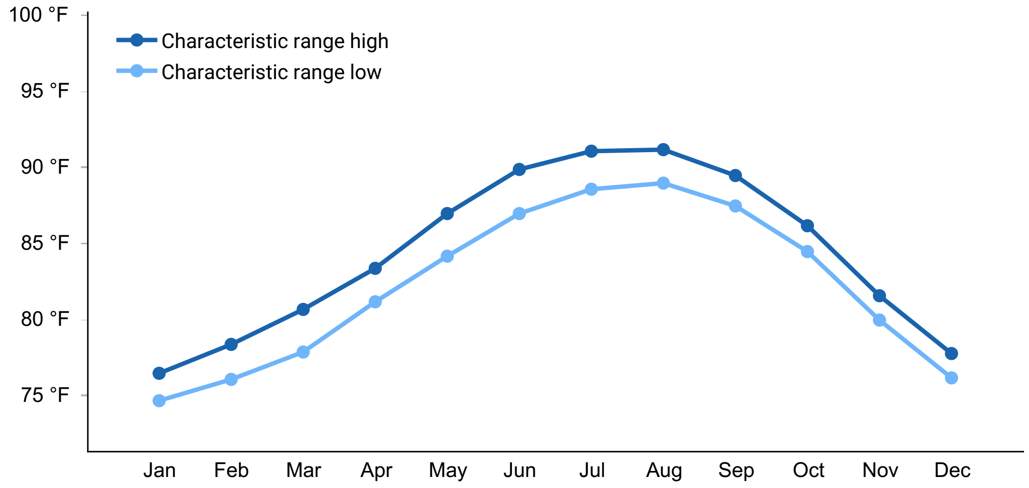


Figure 3. Monthly maximum temperature range

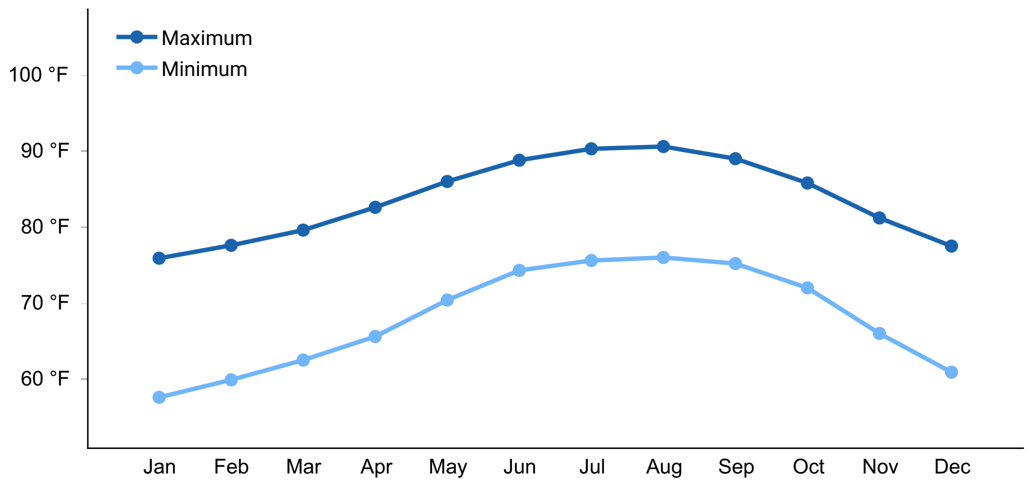


Figure 4. Monthly average minimum and maximum temperature

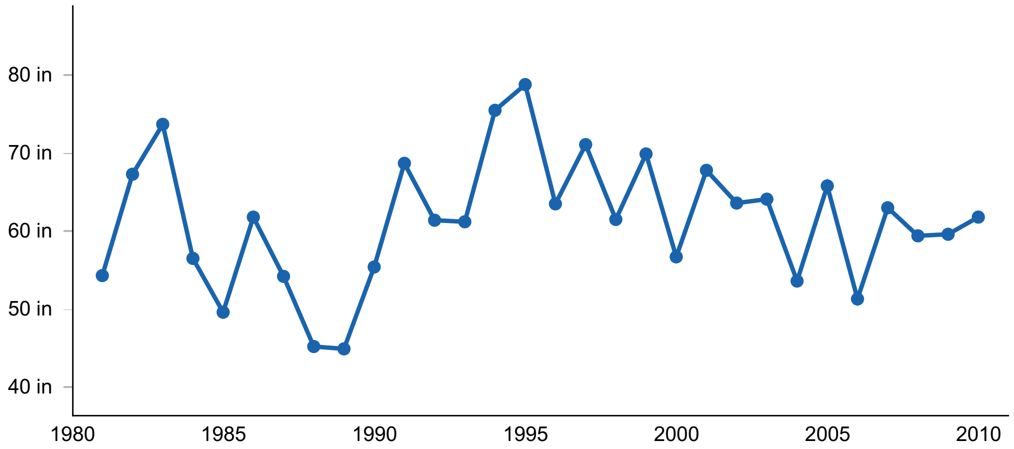


Figure 5. Annual precipitation pattern

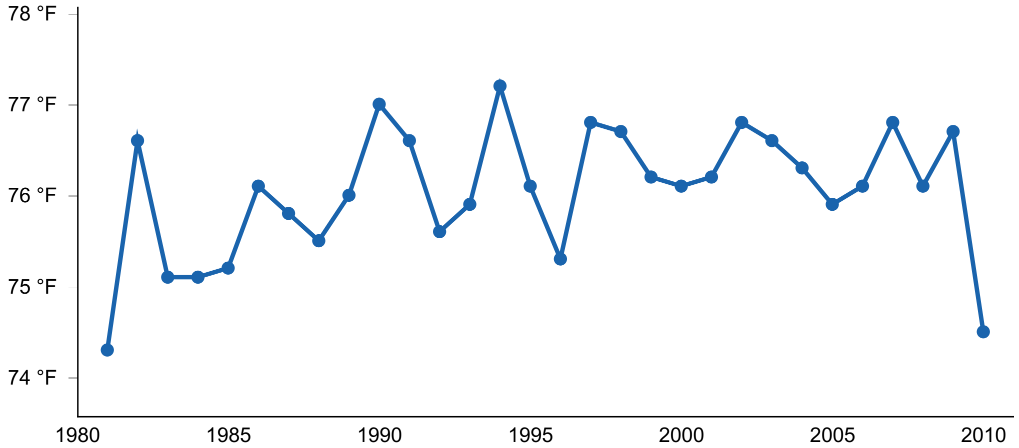


Figure 6. Annual average temperature pattern

Climate stations used

- (1) MIAMI NWSFO [USC00085667], Miami, FL
- (2) MIAMI WSO CITY [USW00012859], Miami, FL
- (3) CAPE FLORIDA [USC00081306], Key Biscayne, FL
- (4) HIALEAH [USC00083909], Miami, FL
- (5) MIAMI BEACH [USW00092811], Miami Beach, FL
- (6) MIAMI OPA LOCKA AP [USW00012882], Opa Locka, FL
- (7) HOLLYWOOD NORTH PERRY AP [USW00092809], Hollywood, FL
- (8) WESTON [USC00089511], Fort Lauderdale, FL
- (9) FT LAUDERDALE [USC00083163], Fort Lauderdale, FL
- (10) LOXAHATCHEE NWR [USC00085184], Boynton Beach, FL
- (11) ROYAL PALM RS [USC00087760], Homestead, FL
- (12) HOMESTEAD GEN AVIATION [USC00084095], Homestead, FL
- (13) PERRINE 4W [USC00087020], Miami, FL
- (14) MIAMI KENDALL TAMIAMI EXEC AP [USW00012888], Miami, FL

Influencing water features

The Atlantic Ocean is the only major influencing saline water feature to this ecosite. Daily tides flush the system and bring in new nutrients, with high spring tides flushing the supratidal zone, limiting growth to only saltwater tolerant species within the inter- and supratidal zones. Low-energy waves also promotes plant growth as well as seedling and propagule establishment. Whereas high-energy waves can prevent the deposition of fine sediments and cause erosion of the sediment bank along the shore during times of extreme weather events such as hurricanes and tropical storms. In the Miami Ridge ecoregion, tidal wetlands are often found along the sheltered side of estuaries and canals with low-energy wave action, with the exposed side supporting high energy coastal communities such as beaches and dune systems. An example of this is along the islands of Biscayne National Park, the Atlantic side supports high-energy coastlines while the estuarine side supports tidal wetlands.

Different zones of vegetation mark different salinity levels in which species to grow. In mangrove swamps, red mangroves often border the water, followed by black, white, then button mangrove, with red mangrove being able to tolerate longer periods of saltwater inundation. As the transition moves upland to a button mangrove community, more freshwater species are able to compete due to flushing from upland sources via sheet flow from freshwater rainfall. In salt marshes, intertidal marshes are able to tolerate greater saltwater inundation and thus have saltwater tolerant species whereas high marshes are able to tolerate both freshwater and saltwater species due to upland source via sheet flow. Increased salinity levels due to sea level rise push mangrove and salt marsh communities further inland at the expense of other upland communities.

Wetland description

Wetland Description: Cowardian
System: Estuarine
Subsystem: Intertidal
Class: Emergent Wetland / Forested

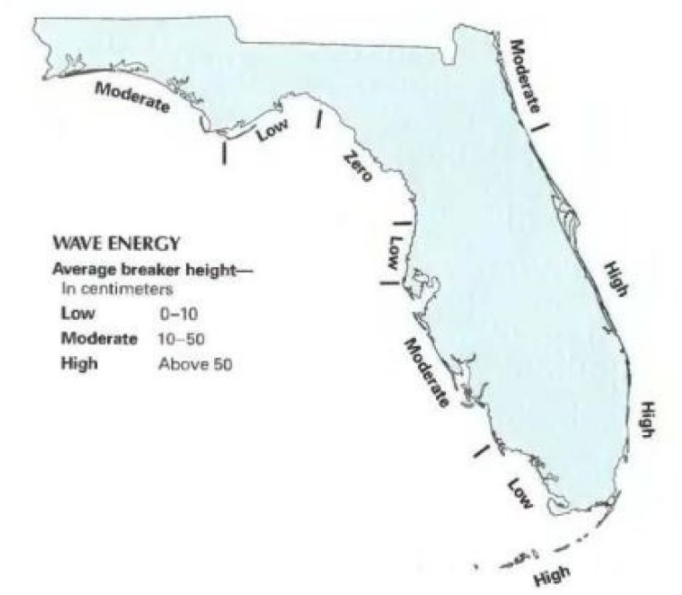


Figure 7. Wave Energy (Average Breaker Height) in Florida modified from Fretwell et al. 1996. The MRR ecoregion falls under high wave energy, resulting in the coastal areas adjacent to the ocean high wave energy, except in sheltered areas.

Soil features

Soils associate with this ecological site occur in the isohyperthermic soil temperature regime of MLRA 156A. The isohyperthermic soil temperature regime has mean annual soil temperatures of 22 °C (72^{0}F) or more and a difference between mean summer and mean winter soil temperatures of less than 5 °C (41^{0}F) at 50 cm (20 inches) below the surface.

Soils in this ecological site are typically anoxic, highly organic, saline, hydric soils. These vegetative communities are able to grow on many types of substrates and often alter the substrate through peat formation and by altering patterns of sedimentation. Low energy shorelines accumulate fine-grained sediments such as mud and silt, whereas high—energy shorelines are characterized by sandy sediments. These communities alter the sediment through peat deposition, and it is not unusual to find up to several meters of thick peat under well-established systems. The peat is predominantly formed through undecayed root materials or herbaceous litter. Many of these soils are often slightly alkaline to alkaline. These organic soils have a high salinity, neutral reaction, and high sulfur content. Some of these soils are soft and will not support the weight of a person or a large animal. Tidal action causes saturation of the soil with salt water and inundation to a depth of a few inches. Much of this area has been urbanized in this ecoregion due to high real estate value of property near the water, and have been cleared and had multiple feet of fill put on top before undergoing urbanization. Representative soils for these communities include Crandon.

Table 4. Representative soil features

Parent material	(1) Marine deposits (2) Herbaceous organic material (3) Residuum–limestone
Surface texture	(1) Highly organic, mucky, peaty (2) Highly organic, marly sand
Drainage class	Very poorly drained
Permeability class	Rapid
Depth to restrictive layer	10–40 in
Soil depth	70 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-80in)	5–15.7 in
Calcium carbonate equivalent (0-80in)	0–3%
Electrical conductivity (0-80in)	24–50 mmhos/cm
Sodium adsorption ratio (0-80in)	20–24
Soil reaction (1:1 water) (0-80in)	4.8–6
Subsurface fragment volume <=3" (0-80in)	10%
Subsurface fragment volume >3" (0-80in)	0%

Ecological dynamics

The information presented in this ecological site description (ESD) and state-and-transition model (STM) were developed using archaeological and historical information, published and unpublished scientific reports, professional experience, consultation with technical experts, and NRCS inventories and studies. The information presented represents a complex set of plant community dynamic and environmental variables. Not all scenarios or plants are represented and included. Key indicator plants, animals, and ecological processes are described to help guide land management decisions and actions.

Despite the broad variation of natural vegetation compositional and structure, the unifying features of this PES are frequent flooding and high saline environments occurring in low energy coastal areas. Both are affected by flooding regimes dominated by either astronomical tides or meteorological tides and are subject to zonation based on tidal flooding influence, soil salinity, temperature and elevation.

We have identified two major community variants within this ecological site:

1. Salt Marsh - - Salt marsh is a largely herbaceous community that occurs in the portion of the coastal zone affected by tides and seawater and protected from large waves, either by the broad, gently sloping topography of the shore, by a barrier island, or by location along a bay or estuary. Salt marsh may have distinct zones of vegetation, each dominated by a single species of grass or rush. More halophytic species dominates the seaward edge and borders of tidal creeks, areas most frequently inundated by the tides. The landward edge of the marsh is influenced by freshwater influx from the uplands and may be colonized by a mixture of high marsh and inland species. A border of salt-tolerant shrubs often marks the transition to upland vegetation or low berms along the seaward marsh edge.

Salt marshes are found in flat, protected waters usually within the protection of a barrier island, estuarine system, or along other protected and low-energy coastlines. Salt marshes have gradual slopes of 0 to 1% that determine the extent of the intertidal zone, with gentle slopes reducing wave energy and providing greater areas for plants to colonize. Slopes too flat can cause poor surface drainage resulting in pooling and high salinities, preventing the establishment of seedlings and inhibiting plant growth. Whereas slopes too steep can promote erosion and the transport of fine-grained sediments from uplands to marsh areas. Situated between the land and the sea, salt marshes experience the effects of both salt and fresh water. As tide water's flood over a marsh, suspended sediment settles out and accumulates around the stems of plants. Rivers and other upland sources also contribute sediments to the marsh by continually transporting and redepositing sediment. Tidal flushing is important in maintaining the exchange of saline waters in salt marshes, with oligotrophic conditions leading to invasion of cattails while hypersaline conditions can stress plants and inhibit growth or cause plant death. Within the salt marsh community there are four major community types resulting from different elevations and geographic differences, they are: Salt pans, intertidal marshes, grassy salt marshes, and buttonwood transitions.

Flooding frequency and soil salinity are the two major environmental factors that influence salt marsh vegetation. Needle rush and saltmarsh cordgrass both tolerate a wide range of salinities, but cordgrass is found where the marsh is flooded almost daily, whereas needle rush is found where the marsh is flooded less frequently. Saltmarsh cordgrass dominates the low marsh (portion below mean high water level), whereas needle rush occupies the high marsh (portion above mean high water level). Both species tend to form taller stands along tidal creeks where salinity is lower and shorter stands where salinity is higher. Salt marshes are very biologically productive communities as well, but greater biomass is usually produced at lower salinities (10 to 20 parts per thousand [ppt]), with marsh salinity ranging from 0.5 ppt to that of seawater (35 ppt) normally but can fluctuate due to high or low tide levels. The base of the food chain is supplied not only by the rooted plant matter, but also by algae and detritus found on the stems of plants, on the sediment surface, and suspended in the water column of pools and tidal creeks.

Natural disturbances on salt marshes include fires, storms and hurricanes, drought, and floods. These events usually have a short-term, localized effect on salt marsh habitat and the community is generally able to recover fairly quickly. When these disturbances occur closely together, or are coupled with human induced impacts, the effects can be catastrophic to the salt marsh community. Fires usually do not permanently affect salt marshes but may temporally affect soil composition, species composition and biomass. Natural fires occurs sporadically in salt marshes, either by spreading from nearby uplands or from lightning strikes in the marsh itself and are limited by natural barriers such as tidal creeks and salt pans. Most salt marshes are affected by the storm surge more than the flooding or strong winds caused by tropical storms. One of the most significant impacts to salt marshes from hurricanes is the potential for rapid invasion of exotic vegetation into disturbed areas, like Australian pine (Casurina equisetifolia) and Brazilian pepper (*Schinus terebinthifolius*). Sea-level change is an important long-term influence on all salt marshes. Depending on the rate and extent of local sea-level change, salt marsh systems will respond differently. If rates of sea-level rise are slow, some salt marsh vegetation will migrate upward and inland and grow without much change in composition. If rates are too high, the salt marsh may be overgrown by other species, particularly mangroves, or converted to open bodies of water. If there is no accretion of inorganic sediment or peat, the seaward portions of the salt marsh become flooded so that marsh grass drowns and marsh soils erode; portions of the high marsh become low marsh; and adjacent upland areas are flooded at spring tide, becoming high marsh.

2. Mangrove Swamps- A dense forest occurring along relatively flat, low wave energy, marine and estuarine shorelines. The dominant plants of mangrove swamp are red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erectus*). Mangrove swamps often exist with no understory, although shrubs such as seaside oxeye (*Borrichia arborescens*, *B. frutescens*) and vines including gray nicker (*Caesalpinia bonduc*), coinvine (*Dalbergia ecastaphyllum*), and rubbervine (*Rhabdadenia biflora*), and herbaceous species such as saltwort (*Batis maritima*), shoregrass (*Monanthochloe littoralis*), perennial glasswort (*Sarcocornia perennis*), and giant leather fern (*Acrostichum danaeifolium*), where present, occur most commonly in openings and along swamp edges.

These four mangrove species can occur either in mixed stands or often in differentiated, monospecific zones that reflect varying degrees of tidal influence, levels of salinity, and types of substrate. Red mangrove often dominates the lowest (or deep-water) zone, followed by black mangrove in the intermediate zone, and white mangrove and buttonwood in the highest, least tidally influenced zone. Buttonwood often occupies an ecotone, or transition zone, to the adjacent upland community. The density and height of mangroves and the diversity of associated herbaceous species can vary considerably within a mangrove swamp. Mangroves typically occur in dense stands but may be sparse, particularly in upper tidal reaches where salt marsh species predominate. Mangroves may range from trees more than 80 feet (25 m) tall to dwarf shrubs growing on solid limestone rock, but most commonly exist at intermediate heights of 10 to 20 feet tall (3 to 7 m). Within the mangrove community there are seven major community types resulting from different landform position, these are: Overwash mangrove forests, Fringe mangrove forests, Riverine mangrove forests, Basin mangrove forests, Hammock forests, Scrub or dwarf forests, and Buttonwood forests (Odum et al., 1982).

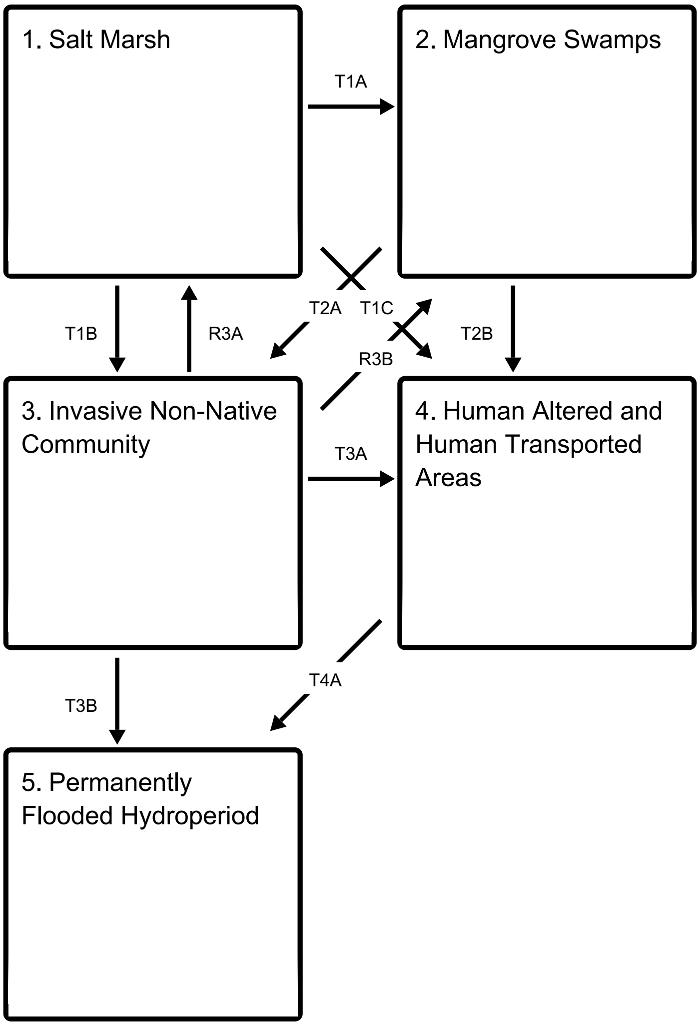
Temperature, salinity, tidal fluctuation, substrate, and wave energy are five physical factors influencing the size and extent of mangrove swamps. Mangroves require an average annual water temperature above 66F (19C) to survive. They do not tolerate temperatures below freezing or temperatures that fluctuate widely over the course of a year. Mangroves are facultative halophytes; they do not require saltwater for growth but are able to tolerate high salinity and outcompete vascular plants that do not have similar salt tolerances. Mangroves have adapted to saltwater environments by either excluding or excreting salt from plant tissues. These specializations allow mangroves to flourish in a competition-free habitat where other woody plants are excluded by their sensitivity to salt. These species utilize a variety of mechanisms to maintain suitable salt balance, including salt-exclusion, where freshwater is separated at the root via reverse osmosis, and salt-secretion, where salt glands on the leaf surface excrete excess salt (Odum et al.,1982). While they can survive and grow in freshwater, mangroves are usually not found in large stands under such conditions in nature because they succumb to competition. Water fluctuations, both fresh- and salt-water, help shape mangrove swamp systems. Freshwater, through runoff from adjacent uplands or from rivers, flushes salt from the swamp and delivers needed nutrients, while tidewaters push mangrove propagules landward and reduce competition by freshwater species. However, reducing estuarine salinity by increasing freshwater inputs and flushing chemical pollutants from adjacent uplands have resulted in the destruction of some mangrove swamp areas and the invasion by non-mangrove and non-native species. This community is sensitive to colonization by exotic species such as Brazilian pepper (Schinus terebitnthifolius), carrotwood (*Cupaniopsis anacardioides*), seaside mahoe (*Thespesia populnea*), latherleaf (*Colubrina asiatica*), and Australian pine (*Casuarina equisetifolia*).

The long-lived floating red mangrove propagules are dispersed by water and require a relatively short time for root development allowing them to establish quickly in new areas. The prop-roots of red mangroves, the extensive pneumatophores (aerial roots) of black mangroves, and the dense root mats of the white mangrove help to trap sediments and organic litter and recycle nutrients both from upland areas and from tidal import. This process is an effective means of stabilizing land in coastal environments as well as providing substrate for the attachment of, and shelter for, numerous marine and estuarine organisms. This, along with the continuous shedding of mangrove leaves and other plant components, produce as much as 80 percent of the total organic material available in the aquatic food web. Though mangrove swamps help protect other inland communities by absorbing the brunt of tropical storms and hurricanes and by preventing coastal erosion, these storm events and periodic freezing temperatures have an influence on the stature of mangrove species and generally drive succession within mangrove swamps. Often when canopy damage is incurred following a storm event, new mangrove propagules regenerate in their place. Mangrove swamps are especially vulnerable to climate change impacts such as rising sea levels and the increasing intensity and frequency of tropical weather systems. Mangrove forests differ from other vegetative communities in not experiencing traditional succession and instead experience replacement succession as a function of sea level rise, pushing towards inland communities. Waves along high energy coastlines discourage mangrove establishment and reduce anaerobic sediment accumulation, in which mangroves thrive.

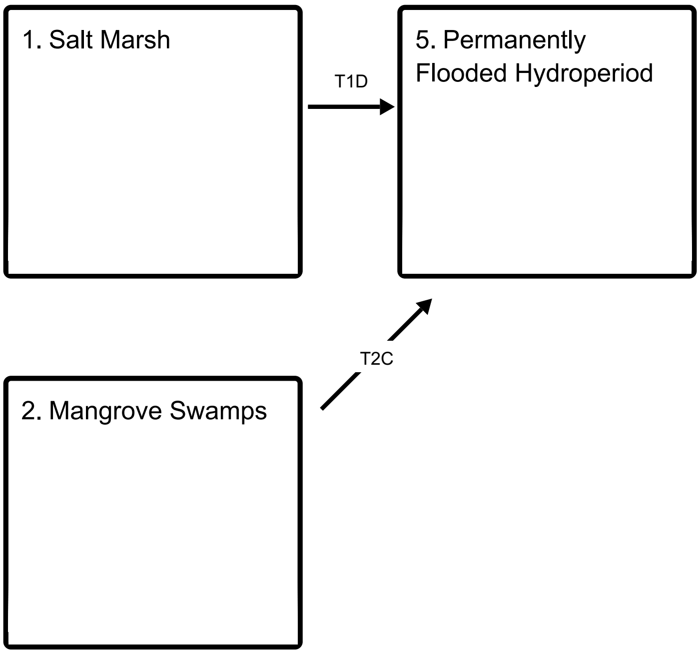
Unconsolidated Substrate are also an important habitat within this ecosite. Characterized as expansive, relatively open areas of subtidal, intertidal, and supratidal zones which lack dense populations of sessile plant and animal species, Unconsolidated Substrates are unsolidified material and include coralgal, marl, mud, mud/sand, sand or shell. Unconsolidated Substrates are important in that they form the foundation for the development of other Marine and Estuarine Natural Communities when conditions become appropriate. Unconsolidated Substrate Communities are associated with and often grade into Mangrove Swamps or Salt Marshes in this ecosite. This is a highly fluctuating community and is altered by storm events, with numerous management plans that include beach reestablishment and coastal stabilization projects. Unconsolidated sediments can originate from organic sources, such as decaying plant tissues (e.g., mud) or from calcium carbonate depositions of plants or animals (e.g., coralgal, marl and shell substrates). Marl and coralgal substrates are primarily restricted to the southern portion of the state. These communities are typically seen as tidal or mud flats and have high contents of acid sulfates.

State and transition model

Ecosystem states



States 1, 5 and 2 (additional transitions)



T1A - Mangrove Encroachment Inland

T1B - Invasion of Non-Native / Exotic Species

T1C - Human Alteration / Transportation of Materials

T1D - Increase in Long-Term Hydroperiod

T2A - Invasion of Non-Native / Exotic Species

T2B - Human Alteration / Transportation of Materials

T2C - Increase in Long-Term Hydroperiod

R3A - Mechanical / Biological / Chemical Removal of Species

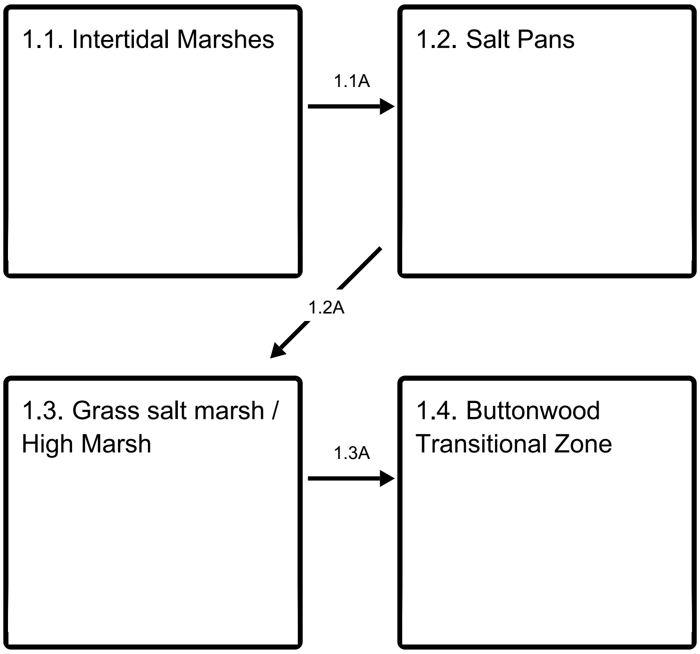
R3B - Mechanical / Biological / Chemical Removal of Species

T3A - Human Alteration / Transportation of Materials

T3B - Increase in Long-Term Hydroperiod

T4A - Increase in Long-Term Hydroperiod

State 1 submodel, plant communities

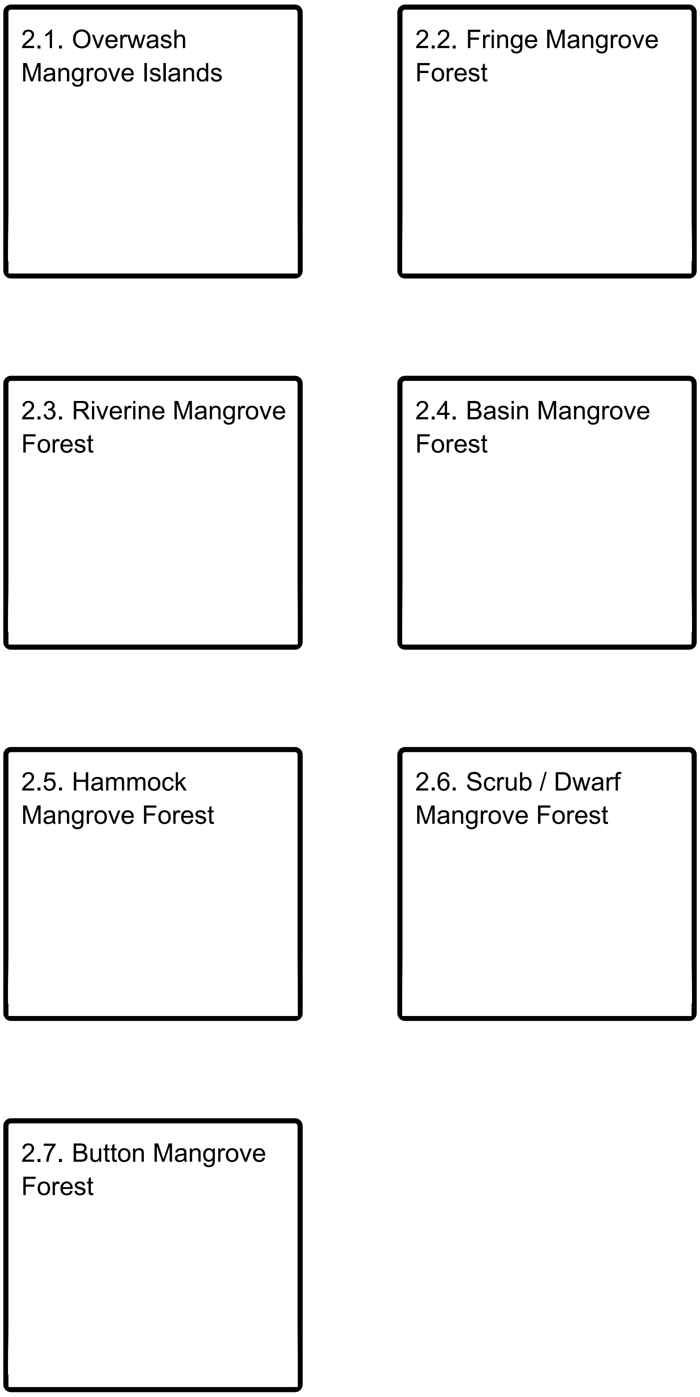


1.1A - Increase in Elevation

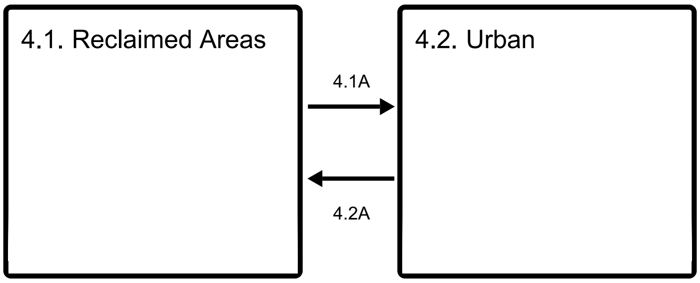
1.2A - Increase in Elevation

1.3A - Increase in Elevation

State 2 submodel, plant communities



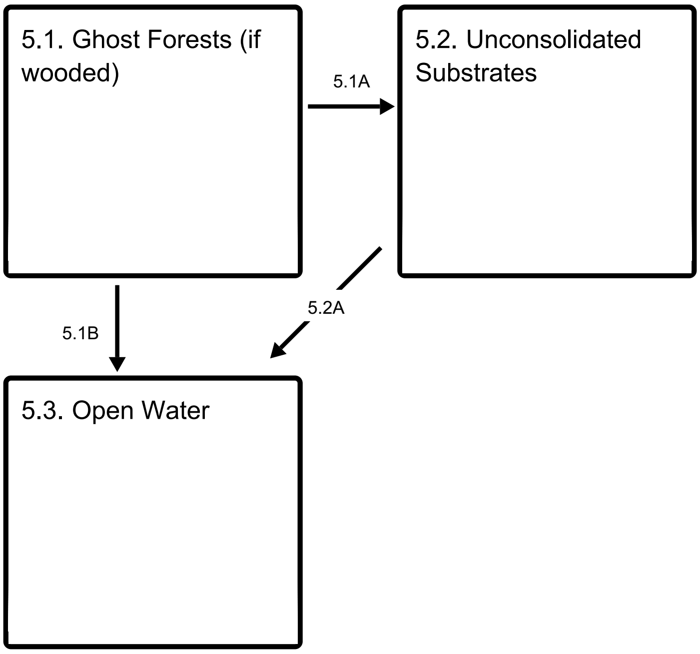
State 4 submodel, plant communities



4.1A - Urban Development

4.2A - Land Reclamation

State 5 submodel, plant communities



5.1A - Soil Aeriation

5.1B - Permanent Flooding

5.2A - Permanent Flooding

State 1
Salt Marsh

These are largely herbaceous communities that occurs in the portion of the coastal zone affected by tides and seawater and protected from large waves, either by the broad, gently sloping topography of the shore, by a barrier island, or by location along a bay or estuary. Salt marsh may have distinct zones of vegetation, each dominated by a single species of grass or rush. More halophytic species dominates the seaward edge and borders of tidal creeks, areas most frequently inundated by the tides. The landward edge of the marsh is influenced by freshwater influx from the uplands and may be colonized by a mixture of high marsh and inland species. A border of salt-tolerant shrubs often marks the transition to upland vegetation or low berms along the seaward marsh edge. The following communities are mentioned separately due to their slight differences in different landscape positions. These often grade into one another but many times can not transition to one another.

Characteristics and indicators. These are characteristic of grasses and herbaceous species directly adjacent to a saline or brackish body of water with large layers of undecayed organic material.

Dominant plant species

- eastern baccharis (*Baccharis halimifolia*), shrub
- saltwater false willow (*Baccharis angustifolia*), shrub

- Jesuit's bark (*Iva frutescens*), shrub
- Carolina desert-thorn (*Lycium carolinianum*), shrub
- smooth cordgrass (*Spartina alterniflora*), grass
- gulf cordgrass (*Spartina spartinae*), grass
- needlegrass rush (*Juncus roemerianus*), grass
- fimbry (*Fimbristylis*), grass
- Jamaica swamp sawgrass (*Cladium mariscus ssp. jamaicense*), grass
- saltmeadow cordgrass (*Spartina patens*), grass
- sand cordgrass (*Spartina bakeri*), grass
- hurricanegrass (*Fimbristylis cymosa*), grass
- lavender thrift (*Limonium carolinianum*), other herbaceous
- perennial saltmarsh aster (*Symphyotrichum tenuifolium*), other herbaceous
- wand lythrum (*Lythrum lineare*), other herbaceous
- shoreline seapurslane (*Sesuvium portulacastrum*), other herbaceous
- tree seaside tansy (*Borrichia arborescens*), other herbaceous
- narrowleaf yellowtops (*Flaveria linearis*), other herbaceous
- salt heliotrope (*Heliotropium curassavicum*), other herbaceous

Dominant resource concerns

- Bank erosion from streams, shorelines, or water conveyance channels
- Subsidence
- Organic matter depletion
- Concentration of salts or other chemicals
- Ponding and flooding
- Salts transported to surface water
- Salts transported to ground water
- Plant productivity and health
- Plant structure and composition

Community 1.1
Intertidal Marshes

This community is found in the lowest elevation zone consisting primarily of halophytic species of herbs and grasses. This zone is flooded by daily tidal fluctuations.

Dominant plant species

- red mangrove (*Rhizophora mangle*), tree
- black mangrove (*Avicennia germinans*), tree
- white mangrove (*Laguncularia racemosa*), tree
- cordgrass (*Spartina*), grass
- saltgrass (*Distichlis*), grass
- pickleweed (*Salicornia*), other herbaceous
- turtleweed (*Batis maritima*), other herbaceous

Community 1.2
Salt Pans

Also known as salt flats, these are bare, exposed, or water-filled depressions in a salt marsh, often covered by thin layers of blue-green algae. These have high salinity levels which prevent most vascular vegetation growth, allowing only a few species of halophytes to survive. These form in high marshes where where evaporation concentrates large amounts of salts in the substrate or in depressions of the intertidal zone and retain water even during low tide.

Dominant plant species

- dwarf saltwort (*Salicornia bigelovii*), other herbaceous
- Virginia glasswort (*Salicornia depressa*), other herbaceous

Community 1.3
Grass salt marsh / High Marsh

This community is situated on slightly higher elevations and is flooded primarily by spring or storm tides.

Dominant plant species

- rush (*Juncus*), grass
- fimbry (*Fimbristylis*), grass
- seaside tansy (*Borrichia*), other herbaceous
- sea lavender (*Limonium*), other herbaceous
- perennial saltmarsh aster (*Symphyotrichum tenuifolium*), other herbaceous
- loosestrife (*Lythrum*), other herbaceous
- seapurslane (*Sesuvium*), other herbaceous

Community 1.4
Buttonwood Transitional Zone

This zone occurs at the highest elevation within a salt marsh an is flooded primarily during storm tides. This is the transitional zone towards a more terrestrial community. It is dominated by buttonwood canopy and established dense cover of halophytes and grasses in the understory.

Dominant plant species

- button mangrove (*Conocarpus erectus*), tree
- saltgrass (*Distichlis*), grass
- seashore dropseed (*Sporobolus virginicus*), grass
- bushy seaside tansy (*Borrichia frutescens*), other herbaceous

Pathway 1.1A
Community 1.1 to 1.2

This transition is driven by a slight increase in elevation.

Pathway 1.2A
Community 1.2 to 1.3

This transition is driven by a slight increase in elevation.

Pathway 1.3A
Community 1.3 to 1.4

This transition is driven by a slight increase in elevation.

State 2
Mangrove Swamps

These are dense forests occurring along relatively flat, low-wave energy, marine and estuarine shorelines. These species are dominated by mangroves, and often found in mixed stands or in differentiated, monospecific zones that reflect differences in tidal influence, salinity, and / or type of substrate. The following communities are mentioned separately due to their slight differences in different landscape positions. These often grade into one another but many times can not transition to one another.

Dominant plant species

- red mangrove (*Rhizophora mangle*), tree
- black mangrove (*Avicennia germinans*), tree
- white mangrove (*Laguncularia racemosa*), tree
- button mangrove (*Conocarpus erectus*), tree

Dominant resource concerns

- Bank erosion from streams, shorelines, or water conveyance channels
- Subsidence
- Organic matter depletion
- Concentration of salts or other chemicals
- Ponding and flooding
- Salts transported to surface water
- Salts transported to ground water
- Plant productivity and health
- Plant structure and composition
- Terrestrial habitat for wildlife and invertebrates
- Aquatic habitat for fish and other organisms

Community 2.1
Overwash Mangrove Islands

Overwash Islands are small islands and narrow extensions of larger and masses (spits) that are "overwashed" on a daily basis during high tide and have high rates of organic export. These islands often develop as concentric rings of tall mangroves around smaller mangroves and a permanent, usually hypersaline, pools of water. All species of mangroves may be present, but red mangroves usually dominate. Maximum height of the mangroves is about 7 m (23 feet). These communities are particularly sensitive to the effects of ocean pollution.

Dominant plant species

- red mangrove (*Rhizophora mangle*), tree
- black mangrove (*Avicennia germinans*), tree
- white mangrove (*Laguncularia racemosa*), tree
- button mangrove (*Conocarpus erectus*), tree

Community 2.2
Fringe Mangrove Forest

Fringe mangrove forests are found along protected shorelines, on narrow berms along the coastline or in wide expanses along gently sloping beaches, along some canals, rivers, and lagoons. If a berm is present, the mangroves may be isolated from freshwater runoff and then have to depend completely on rainfall, the sea, and groundwater for their nutrient supply. These forests are best defined along shorelines whose elevations are higher than mean high tide. Maximum height of the mangroves is about 10 m (32 feet).

Dominant plant species

- red mangrove (*Rhizophora mangle*), tree
- black mangrove (*Avicennia germinans*), tree
- white mangrove (*Laguncularia racemosa*), tree
- button mangrove (*Conocarpus erectus*), tree

Community 2.3
Riverine Mangrove Forest

Tall, productive riverine mangrove forests are found along the edges of coastal rivers and creeks, often several miles inland from the coast. These wetlands may be dry for a considerable time, although the water table is generally just below the surface. These forests export a significant amount of organic matter because of their high productivity. They are affected by freshwater runoff from adjacent uplands and from water, sediments, and nutrients delivered by the adjacent river. They can be significantly affected by upstream activity or stream alteration. The combination of adequate fresh water and high inputs of nutrients from both upland and estuarine sources cause these systems to be generally very productive, supporting large (16- 26 m) mangrove trees. Salinity in this community is usually lower than the other mangrove communities. The flushing of freshwater during wet seasons causes salts to be leached from the sediments.

Dominant plant species

- red mangrove (*Rhizophora mangle*), tree
- black mangrove (*Avicennia germinans*), tree
- white mangrove (*Laguncularia racemosa*), tree
- button mangrove (*Conocarpus erectus*), tree

Community 2.4
Basin Mangrove Forest

Basin mangrove forests occur in inland depressions, or basins, often behind fringe mangrove forests and in drainage depressions where water is stagnant or slowly flowing. These forests are often isolated from all but the highest tides and yet remain flooded for long periods once tide water does flood them. These forests are often dominated by black mangroves and white mangroves and the ground surface is often covered by pneumatophores from these trees. Trees may reach 15 m (49 feet) in height.

Dominant plant species

- red mangrove (*Rhizophora mangle*), tree
- black mangrove (*Avicennia germinans*), tree
- white mangrove (*Laguncularia racemosa*), tree
- button mangrove (*Conocarpus erectus*), tree

Community 2.5
Hammock Mangrove Forest

These forests occur as isolated, slightly raised tree islands in the coastal fringe of the Florida Everglades and have characteristics of both basin and scrub mangroves. They are slightly raised as a result of the buildup of peat in what was once a slight depression in the landscape. The peat has accumulated from many years of mangrove productivity, actually raising the surface from 5 to 10 cm above the surrounding landscape. All species of mangroves may be present, trees rarely exceed 5 m (16 feet) in height.

Dominant plant species

- red mangrove (*Rhizophora mangle*), tree
- black mangrove (*Avicennia germinans*), tree
- white mangrove (*Laguncularia racemosa*), tree
- button mangrove (*Conocarpus erectus*), tree

Community 2.6

Scrub / Dwarf Mangrove Forest

Scrub or dwarf mangrove forests are dominated by scattered, small (often less than 2 m tall) mangrove trees growing in an environment that is probably nutrient poor. These nutrient poor environments can be on a sand soil or limestone marl. Hypersaline conditions and cold at the norther extremes of the mangrove's ranges can produce "scrub", or stressed mangrove trees, in riverine, fringe, or basin mangrove forests. Some of these forests are inundated by seawater only during spring tides or storm surges and are often flooded by freshwater runoff in the rainy season. These are an intermix of small red mangrove trees with marsh vegetation such as sawgrass and rush.

Dominant plant species

- red mangrove (*Rhizophora mangle*), tree
- black mangrove (*Avicennia germinans*), tree
- white mangrove (*Laguncularia racemosa*), tree
- button mangrove (*Conocarpus erectus*), tree
- Jamaica swamp sawgrass (*Cladium mariscus ssp. jamaicense*), grass
- needlegrass rush (*Juncus roemerianus*), grass

Community 2.7
Button Mangrove Forest

Button mangrove forests are dominated by button mangrove and often exist in the upper tidal areas, especially where mangrove swamps transition to rockland hammock. They can be open prairie like communities with button mangrove scattered in the overstory and an understory dominated by saltwater tolerant perennials.

Dominant plant species

- red mangrove (*Rhizophora mangle*), tree
- black mangrove (*Avicennia germinans*), tree
- white mangrove (*Laguncularia racemosa*), tree
- button mangrove (*Conocarpus erectus*), tree
- oxeye daisy (*Leucanthemum vulgare*), other herbaceous
- Carolina desert-thorn (*Lycium carolinianum*), other herbaceous
- lavender thrift (*Limonium carolinianum*), other herbaceous

State 3
Invasive Non-Native Community

This state consists of Florida Department of Agriculture and Consumer Services (FDACS) Non-Native Category 1 Species list . More information on these species list can be found: https://www.fdacs.gov/content/download/63140/file/Florida%E2%80%99s_Pest_Plants.pdf or by contacting the UF / IFAS Center for Aquatic and Invasive Plants (http://plants.ifas.ufl.edu/), the UF / IFAS Assessment of Non-native Plants in Florida's

Natural Areas (https://assessment.ifas.ufl.edu/), or the FWC Invasive Plant Management Section (http://myfwc.com/wildlifehabitats/invasive-plants/). This community will not represent every possibility of invasive species but rather the most common in these areas.

Characteristics and indicators. Non-native species include species that exist outside of Florida's native range and introduced to the state by people, weather, or any other means.

Resilience management. This state can be found as a part of any other state and can completely destroy the native habitat if not properly managed. Restoration to natural communities after exotic invasion include practices such as mechanical, biological, and chemical removal.

Dominant resource concerns

- Subsidence
- Concentration of salts or other chemicals
- Nutrients transported to surface water
- Plant productivity and health
- Plant structure and composition

State 4
Human Altered and Human Transported Areas

These areas include soils that were intentionally and substantially modified by humans for an intended purpose, commonly for terraced agriculture, building support, mining, transportation, and commerce. The alteration is of sufficient magnitude to result in the introduction of a new parent material (human-transported material) or a profound change in the previously existing parent material (human-altered material). They do not include soils modified through standard agricultural practices or formed soils with unintended wind and water erosion. When a soil is on or above an anthropogenic landform or microfeature, it can be definitely be associated with human activity and is assigned to a unique taxa, usually found as an "Urban land complex" within that communities' natural soil properties (e.g., Udorthents-Urban Land complex, 0-2% slopes).

Characteristics and indicators. Evidence of these areas include soils with manufactured items (e.g. artifacts) present in the profile, human altered-materials (e.g., deeply excavated or deeply plowed soil) or human-transported material (e.g., fill), and position on or above anthropogenic landforms (e.g., flood-control levees) and microfeatures (e.g., drainage ditches). Detailed criteria regarding the identification of anthropogenic (artificial) landforms, human-altered materials, and human-transported material are in the "Keys to Soil Taxonomy" (Soil Survey Staff, 2014).

Dominant resource concerns

- Compaction
- Ponding and flooding

- Seasonal high water table
- Emissions of greenhouse gases (GHGs)
- Objectionable odors
- Plant productivity and health
- Plant structure and composition

Community 4.1
Reclaimed Areas

Reclaimed areas are areas that have been modified through anthropogenic means that are restored to a natural or second-hand natural community. Areas that can be reclaimed are any intensity urban areas, and may be required to be reclaimed after urban use (e.g., constructed shorelines that have been reclaimed to native habitat). These practices include the identification, removal, and stockpiling soil materials before altering the land, and revegetation and replacement of soil materials after altering the land. This also applies to nearby urban areas that have been adversely affected by the anthropogenic activities.

Community 4.2
Urban

This urban community consists of development for human use. Urban areas include a variety of land uses, e.g., inner city or urban core, industrial and residential areas, cemeteries, parks, and other open spaces; the overall function which may benefit the quality of human life. These often form an urban soil mosaic, where the natural landscape has been fragmented into parcels with distinctive disturbance and management regimes and, as a result, distinctive characteristic soil properties. Within this community there are three different levels of urbanization, based off population dynamics, residential density, and intensity of development. These are labeled as low-intensity, medium-intensity, and high-intensity urban areas, which can eventually be split apart into its own separate state. Low-intensity urban areas may consist of single dwelling homes with little impact on the surrounding community which still somewhat represents the natural community (e.g., represents natural landscape, hydrology, and vegetation) , other examples of this are urban parks, cemeteries, or campgrounds with little urban development. Medium-intensity urban areas consist of larger urban dwellings with some natural features, but have been modified to meet urban needs (e.g., towns). High-intensity urban areas are areas of heavily modified areas with complete alterations of the natural landscape, hydrology, and vegetation to support a very large population, which once constructed is permanently altered (e.g., metropolis areas/ active mines).

Pathway 4.1A
Community 4.1 to 4.2

This shift in communities is driven by clearing and developing the land for the desired community.

Pathway 4.2A
Community 4.2 to 4.1

This transition is driven by the revegetation, reestablished hydrology, and replacement of displaced soil materials after altering the land.

State 5
Permanently Flooded Hydroperiod

This state describes the impact of increased hydroperiods from anthropogenic or natural causes that creates an altered hydrologic state resulting in permanent flooding. The impact of this causes destruction of the terrestrial community and may in time shift to a subaqueous community.

Characteristics and indicators. This state is characterized by permanent water levels in an area that was previously in an intertidal zone.

Resilience management. This is a final state and unlikely and improbable to go back to the original reference state.

Dominant resource concerns

- Seasonal high water table
- Terrestrial habitat for wildlife and invertebrates

Community 5.1
Ghost Forests (if wooded)

Ghost forests are the remains of a wooded vegetated community after changes in the long term hydroperiod (primarily sea level rise or artificial impoundment) permanently saturate the root system and becomes too saline for the species tolerance. They appear as standing dead wood representing where once the living vegetation stood. Evidence of previous shorelines may be found in subaqueous soil cores as root matter or a buried organic horizon.

Community 5.2
Unconsolidated Substrates

These are expansive, relatively open areas of subtidal, intertidal, and supratidal zones which lack dense populations of sessile plant and animal species, Unconsolidated Substrates are unsolidified material and include coralgal, marl, mud, mud/sand, sand or shell. Unconsolidated Substrates are important in that they form the foundation for the development of other Marine and Estuarine Natural Communities when conditions become appropriate. Unconsolidated Substrate Communities are associated with and often grade into Mangrove Swamps or Salt Marshes in this ecosite. Unconsolidated sediments can originate from organic sources, such as decaying plant tissues (e.g., mud) or from calcium carbonate depositions of plants or animals (e.g., coralgal, marl and shell substrates). Marl and coralgal substrates are primarily restricted to the southern portion of the state. These communities are typically seen as tidal or mud flats and have high contents of acid sulfates.

Resilience management. This is a highly fluctuating community and is altered by storm events, with numerous management plans that include beach reestablishment and coastal stabilization projects.

Community 5.3
Open Water

This is the final state and is when alteration of the natural hydroperiod has left an area permanently flooded. No terrestrial vegetation representative of the reference state will be present but may support rooted submerged aquatic vegetation (SAV) species if proper growth conditions are met.

Pathway 5.1A
Community 5.1 to 5.2

This is driven by soil aeration which causes rapid oxidation within the community. This allows the soil to produce sulfates and cause rapid decomposition, leaving behind an area of unconsolidated substrates.

Pathway 5.1B
Community 5.1 to 5.3

This is caused by anthropogenic or natural increases in hydroperiods causing the area to be permanently flooded.

Pathway 5.2A
Community 5.2 to 5.3

This is caused by anthropogenic or natural increases in hydroperiods causing the area to be permanently flooded.

Transition T1A
State 1 to 2

This mechanism is driven by land encroachment, in which mangrove communities are able to move landward as their growth conditions change (e.g., increase salinity, decreased freshwater, sea level rise, more intense tidal flooding). Mangroves are well adapted to various salinities and are able to rapidly colonize and area.

Constraints to recovery. Shifts to mangrove communities are usually seen with changes in sea level rise, and recovery back to salt marshes are typically unseen due to the success of mangroves in more hostile saline conditions.

Transition T1B
State 1 to 3

The invasion of non-native or exotic species can be driven by a multitude of different environmental factors such as changes in natural hydroperiods or in fire regimes. Typically once a change in one of the two factors mentioned above occurs, non-native or exotic invasive species become established and begin to compete with native species for habitat and nutrients.

Constraints to recovery. Recovery from non-native or exotic invasive species may be difficult due to many adaptations which allow them to survive and outcompete in intolerable conditions. Localized knowledge for each species must be known for best removal of it without harming the native environment, and often different treatments must be applied over one given area.

Context dependence. Growth of non-native and exotic invasive species can be rapid following a change in a natural stressor such as fire frequency or natural hydroperiods which might have once kept the invasive species at bay.

Transition T1C
State 1 to 4

This transition is driven by the alteration and/ or transportation of materials via anthropogenic means.

Transition T1D
State 1 to 5

This is driven by increased hydroperiods, both anthropogenic and natural, which causes long-term flooding and permanently altering the state.

Transition T2A
State 2 to 3

The invasion of non-native or exotic species can be driven by a multitude of different environmental factors such as changes in natural hydroperiods or in fire regimes. Typically once a change in one of the two factors mentioned above occurs, non-native or exotic invasive species become established and begin to compete with native species for habitat and nutrients.

Constraints to recovery. Recovery from non-native or exotic invasive species may be difficult due to many adaptations which allow them to survive and outcompete in intolerable conditions. Localized knowledge for each species must be known for best removal of it without harming the native environment, and often different treatments must be applied over one given area.

Context dependence. Growth of non-native and exotic invasive species can be rapid following a change in a natural stressor such as fire frequency or natural hydroperiods which might have once kept the invasive species at bay.

Transition T2B
State 2 to 4

This transition is driven by the alteration and/ or transportation of materials via anthropogenic means.

Transition T2C
State 2 to 5

This is driven by increased hydroperiods, both anthropogenic and natural, which causes long-term flooding and permanently altering the state.

Restoration pathway R3A
State 3 to 1

Mechanical, biological, and chemical removal strategies include removing the non-native and exotic invasive species through various mechanisms. Localized knowledge for individual non-native or exotic invasive species is needed for specific management. Sometimes introduction of fire regimes may prevent or stop the growth of non-native or exotic invasive species, but many species are fire tolerant. Mechanical removal might include roller chopping, harvesting, or cutting and removal of invasive species. Chemical removal might include aerial dispersal from planes, or basal bark injection treatments.

Context dependence. Mechanical, biological, and chemical removal of non-native and exotic invasive species is a time dependent process, with both removal types taking long times to be considered effective.

Restoration pathway R3B
State 3 to 2

Mechanical, biological, and chemical removal strategies include removing the non-native and exotic invasive species through various mechanisms. Localized knowledge for individual non-native or exotic invasive species is needed for specific management. Sometimes introduction of fire regimes may prevent or stop the growth of non-native or exotic invasive species, but many species are fire tolerant. Mechanical removal might include roller chopping, harvesting, or cutting and removal of invasive species. Chemical removal might include aerial dispersal from planes, or basal bark injection treatments.

Context dependence. Mechanical, biological, and chemical removal of non-native and exotic invasive species is a time dependent process, with both removal types taking long times to be considered effective.

Transition T3A
State 3 to 4

This transition is driven by the alteration and/ or transportation of materials via anthropogenic means.

Transition T3B
State 3 to 5

This is driven by increased hydroperiods, both anthropogenic and natural, which causes long-term flooding and permanently altering the state.

Transition T4A
State 4 to 5

This is driven by increased hydroperiods, both anthropogenic and natural, which causes long-term flooding and permanently altering the state.

Additional community tables

Animal community

This ecological site supports many organisms through the supporting vegetation both above and below the water.

In mangrove swamps, the extensive root systems, muddy bottoms, and open waters are home to multiple species that are well adapted to the variations in water levels, temperature, and salinity. Salt Marshes support more upland species that are both present in lowland and adjacent terrestrial habitats. These species include:

Invertebrates: snails, barnacles, bryozoans, tunicates, mollusks, sponges, polychaetae worms, isopods, amphipods, shrimps, crabs, and jellyfish all live on or in close proximity of the mangrove root system. The mangrove tree crab (Aratus pisoni) lives in the canopy of primarily red mangrove trees and feeds on the leaves. Horseshoe crabs (Limulus polyphemus) can also be found in this system as they are adapted to low oxygen waters, and seen feeding on algae, other invertebrates, and dead organisms.

Fish: Mangrove roots and shallow waters provide important nursery habitats for fish, providing shelter from predators until juveniles are large enough to avoid predators. Some species move in and out of the mangrove swamps as seasonal changes of water alter the levels of salinity. Species found in this system include common snook (Centropomus undecimalis), Jacks (Caranx spp.), sheepshead (Archosargus probatocephalus), grunts (Haemulon spp.), gobies (Gobiosoma spp.), schoolmasters (Lutjanus apodus), gray snappers (Lutjanus griseus), and small goliath grouper (Epinephelus itajara) as well as many other species of fish can be found among the tangled roots of red mangroves. Tarpon (Megalops atlanticus) cruise in waters adjacent to mangrove roots. The spotted seatrout (Cynoscion nebulosus) also thrive in mangroves and can tolerate high turbidity, taking advantage of the prey fish in the mangroves and seagrass beds. The Florida gar (Lepisosteus platyrhincus) is a top-level carnivore, feeding on a variety of smaller fishes. Gray snapper (Lutjanus griseus), spotted seatrout, and red drum (Sciaenops ocellatus) are among the species that utilize this area as nursery areas.

Reptiles: American Alligator (Alligator mississippiensis) and American Crocodile (Crocodylus acutus) are both residents of mangrove habitats, with crocodiles relying heavily on this community for survival. Its range has decreased dramatically due to the destruction of habitat and increased human activity. Snakes include mangrove water snake (Nerodia clarkia compressicauda), Eastern indigo snake (Drymarchon coaris couperi), Rough Green snake (Opheodrys aestivus carinatus), Florida green water snake (Nerodia floridana), rosy rat snake (Elaphe guttata rosacea), Florida king snake (Lampropeltis getula floridana), and Atlantic saltmarsh snake (Nerodia clarkia taeniata). Anoles include the green anole (Anolis carolinensis), brown anole (Anolis sagrei), and the bark anole (Anolis distichus), all of which reside within mangroves and feed on insects. Freshwater species of turtles are found near the headwater of riverine mangrove systems, while sea turtles are found further out towards fringe and Overwash forests. These turtles use mangrove swamps as juvenile nurseries, receiving protection from predators as well as an area rich in food. These species include: the ornate diamondback terrapin (Malaclemys terrapin macrospilota and M. t. rhizophorarum), the loggerhead turtle (Caretta caretta), green sea turtle (Chelonia mydas), Hawksbill sea turtle (Eretmochelys imbricata) and the Atlantic ridley sea turtle (Lepidochelys kempii).

Amphibians: Only three amphibians are known to occur in this community due to the inability of osmoregulation in saltwater as well as lack of detailed surveys in low salinity regions. These species include the giant toad, squirrel treefrog (Hyla squirella), and the introduced Cuban treefrog (Osteopilus septentrionalis).

Birds: This community provides a habitat for many bird species, including open water for predatory birds, mudflats for probing shoreline birds, and deep water for long-legged birds to wade in. Some species include great egret (Casmerodius albus), roseate spoonbill (Platalea ajaja), limpkin (Aramus guarauna), American bittern (Botaurus lentiginosus), white ibis (Eudocimus albus), great blue heron (Ardea herodias), yellow-crowned night heron (Nyctasnassa violacea), canvasback (Aythya valisineria), double-crested cormorant (Phalacrocorax auritus), purple gallinule (Porphyrula martinica), anhinga (Anhinga

anhinga), brown pelican (Pelecanus occidentalis), mallard (Anas platyrhynchos), pintail (Anas acuta), and lesser scaup (Aythya affinis). Birds of prey include permanent and seasonal residents, include the southern bald eagle (Haliaeetus leucocephalus leucocephalus), osprey (Pandion haliaetus), Peregrine falcon (Falco columbarius), barred owl (Strix varia), Barn owl (Tyto alba), great horned owl (Bubo virginianus), American kestrel (Falco sparverius), red-shouldered hawk (Buteo lineatus), red-tailed hawk (Buteo jamaicensis), Black vulture (Coragyps atratus), Turkey vulture (Cathartes aura), Cooper's hawk (Accipter cooperii), and the marsh hawk (Circus cyaneus).

Mammals: Mammals in this system contain permanent and seasonal residents. They include the Florida panther (Felis concolor), striped skunk (Mephitis mephitis), raccoons (Procyon lotor), Mink (Mustela vision), river otter (Lutra canadensis), Bobcat (Lynx rufus), key deer (Odocoileus virginianus clavium), cotton rats (Sigmodon hispidus), marsh rice rat (Oryzomys palustris) and silver rice rats (O. argentatus). Marine mammals are found along the waterways surrounding this community, these species include bottlenose dolphins (Tursiops truncates) and manatees (Trichechus manatus), feeding on fishes and seagrasses or other submerged aquatic plants adjacent to this community.

Hydrological functions

Surface waters associated with this ecological site are characterized by a wide range of salinities from freshwater to above 30 ppt, low macro-nutrients concentrations (primarily phosphorous), relatively low oxygen concentrations, and frequently increased water color and turbidity. This eco site is influenced by the tides and from surficial fresh water sources such as rain. The vegetation depends on tides to wash sediment to estuaries or river deltas to support zonation and establishment as well as importing nutrients and oxygen and decreasing salt accumulation. Freshwater, through runoff from adjacent uplands or from rivers, flushes salt from the swamp and delivers needed nutrients.

This community is very fragile to the effects of sea level rise. Based off sedimentation rates of clastic materials and peat formation, since the last interglacial stage nearly 4,000 years ago sea levels stood 10 feet low than the present, supporting larger areas of mangrove communities (Scholl, 1964). While the rise of sea level is increasing roughly 1/8th of an inch per year (NOAA), mangroves seaward and landward margins begin to retreat landward if unobstructed. With the right influencing factors mangroves can outcompete other species and encroach on other ecological communities such as salt marshes. If obstructed, this community will become smaller until it can no longer be supported and disappears, leaving behind a ghost forest.

This ecological site is also very sensitive to the effect of water pollution. This is mainly from local factors such as herbicide pollution from upstream farms leaching into the groundwater or surficial runoff or oil spills. These effects can cause red and brown tides, decreasing the water quality surrounding mangrove communities, or coating mangrove roots in oil that limits the transport of oxygen to underground roots. Studies have also started to show the pneumatophores can trap anthropogenic objects such as plastic bags and bottle which can have negative impacts on the animal communities that survive within the water column. This ecosite receives very high runoff amounts from uplands due to the extent of urbanization within the Miami Ridge.

During periods of storm events such as hurricanes and tropical storms, mangrove swamps and salt marshes absorb much of the impact of the waves and wind, protecting inland communities. During these events, waves lose energy as they pass through the tangled above-ground roots, grasses, and branches, losing their ability to remove sediments from the system. In extreme events the mangrove system can be damaged and remove canopy trees, creating open areas that can be recolonized by propagules over time. However, mangrove swamp areas do not always regenerate to their historical state, they can grade into mud flats after catastrophic damage. This is because mangrove roots aerate the soil and when total destruction occurs redox potential decreases and sulfide concentrations increase due to lack of aeration, leaving the soil uninhabitable.

Recreational uses

This ecological community is a highly protected community but is still open to many forms of recreation. Recreation uses in these areas include fishing, wildlife viewing and photography, boating, canoeing, kayaking, and airboat/eco tours.

Wood products

In 1996, the Florida Department of Environmental Protection implemented the Mangrove Trimming and Preservation Act. This act protects mangroves from being removed, trimmed, or disturbed unless a permit is obtained from the Florida Department of Environmental Protection.

Other products

Due to the proximity of the ocean and salinity levels, this area has little to no value as agriculture or rangeland. This area was once destroyed for large scale urban development but has since ceased since the 1996 Mangrove Trimming and Preservation Act. Areas further inland along basin or riverine mangrove swamps have been developed in the early 1900s along the Miami rock ridge and have since been destroyed.

Other information

Along the Miami Ridge coastline where mangrove swamps and salt marshes may be present, it is common to see parallel channels dug in the habitat for mosquito control. These mosquito ditches were dug during the initial urbanization of the area and can increase the flow of water through these systems.

Inventory data references

Information presented was derived from NRCS clipping data, current and historical literature, field observations, and personals contacts with local, state and federal partners. This is a provisional level ESD and is subject to change as more information becomes available, for any questions please contact your local NRCS office.

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	04/14/2025
Approved by	Matthew Duvall
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

2. **Presence of water flow patterns:**

3. **Number and height of erosional pedestals or terracettes:**

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

5. **Number of gullies and erosion associated with gullies:**

6. **Extent of wind scoured, blowouts and/or depositional areas:**

7. **Amount of litter movement (describe size and distance expected to travel):**

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

14. **Average percent litter cover (%) and depth (in):**

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

17. **Perennial plant reproductive capability:**