Florida Keys Wildlife and Environmental Area (Monroe County) Photo by Amy Jenkins

Tidal Swamp

Description: Tidal swamp is a dense forest occurring along relatively flat, low wave energy, marine and estuarine shorelines. The dominant plants of tidal swamp are red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erectus*). These four 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 (Odum and McIvor 1990). 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 (Odum et al. 1982).

The density and height of mangroves and the diversity of associated herbaceous species can vary considerably within a tidal swamp. Mangroves typically occur in dense stands but may be sparse, particularly in upper tidal reaches where tidal 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). Tidal 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.

Tidal swamp occurs in flat coastal areas along saline or brackish portions of rivers, the edges of low-energy estuaries (Wunderlin and Hansen 2000), and the seaward fringes of tidal marshes and rockland hammocks. Soils are generally anaerobic and saturated with brackish water at all times, becoming inundated during high tides. Tidal swamp occurs on a wide variety of soils, ranging from sands and mud to solid limestone rock. Soils in South Florida are primarily calcareous marl muds or calcareous sands and, along the Central Florida coastline, siliceous sands (Odum et al. 1982). In older tidal swamps containing red mangroves, a layer of peat can build up from decaying plant material (mostly red and black mangrove roots), covering the soil (Odum et al. 1982).

Characteristic Set of Species: red mangrove, black mangrove, white mangrove, buttonwood

Rare Species: Rare plants occurring within tidal swamps include golden leather fern (*Acrostichum aureum*), worm-vine orchid (*Vanilla barbellata*), and several epiphytes such as banded wild-pine (*Tillandsia flexuosa*), powdery catopsis (*Catopsis berteroniana*), dollar orchid (*Encyclia boothiana* var. *erythronioides*), clamshell orchid (*Encyclia cochleata* var. *triandra*), and ribbon fern (*Nevrodium lanceolatum*). Most of these rare plant species are restricted to South Florida. Tidal swamp provides important habitat for many rare animal species, including mangrove gambusia (*Gambusia rhizophorae*), opossum pipefish (*Microphis brachyurus*), mangrove rivulus (*Rivulus marmoratus*), American crocodile (*Crocodylus acutus*), mangrove terrapin (*Malaclemys terrapin rhizophorarum*), white-crowned pigeon (*Patagioenas leucocephala*), mangrove cuckoo (*Coccyzus minor*), great white heron (*Ardea herodias occidentalis*), black-whiskered vireo (*Vireo altiloquus),* roseate spoonbill (*Sterna dougallii*), reddish egret (*Egretta rufescens*), brown pelican (*Pelecanus occidentalis*), key rice rat (*Oryzomys palustris* pop. 3), Key Vaca raccoon (*Procyon lotor auspicatus*), and manatee (*Trichechus manatus*). Rare invertebrates occurring in tidal swamp include mangrove long-horned beetle (*Heterachthes sablensis*), tropical buckeye butterfly (*Junonia evarete*), and mangrove root crab (*Goniopsis cruentata*).

Range: Within the United States, tidal swamps are common along the Gulf of Mexico coastline, in the tropical latitudes (south of Latitude 27) of Florida and Texas (Odum et al. 1982). Similarly functioning mangrove forests occur along protected marine (salinity = 30-37 parts per thousand [ppt]) and estuarine (salinity = 0.5-30 ppt) shorelines throughout the tropical and subtropical regions of the world. Several estimates indicate that Florida has nearly 500,000 acres (200,000 ha) of tidal swamp, most of which occurs in the southern peninsula (Odum and McIvor 1990). Nearly two-thirds of the tidal swamp in Florida occurs within Everglades National Park (Olmsted and Loope 1984). Tidal swamps in Florida occur along both coasts where they are buffered by barrier island formations. Tidal swamps are most extensive from Cedar Key in Levy County southward along the Gulf coast, and from Ponce de Leon Inlet in Volusia County southward along the Atlantic coast. The three mangrove species and buttonwood have different ranges and tolerances for freezing temperatures. Black mangroves are the most freeze-tolerant, occurring in dense stands as far north as Cedar Key on the Gulf coast. They occur more as scattered shrubs further north along the Florida Panhandle coast and on the Atlantic coast as far north as St. Johns County. Red and white mangroves have lower cold tolerance, occurring as dense forests only as far north as Cape Canaveral on the Atlantic coast and Tarpon Springs on the Gulf coast. Both species have been reported as scattered shrubs further north in protected areas (Odum and McIvor 1990; Zomlefer et al. 2006). The most luxuriant growth of mangroves is found in the Ten Thousand Island area of southwest Florida. Buttonwood is perhaps the least cold-tolerant species, suffering severe twig and stem damage at temperatures below 30F (Madison and Waldberg 2009). Scattered, populations exist northward from the Keys along the Atlantic coastline to Merritt Island and to Hernando County on the west coast (Nelson 1996).

Natural Processes: Temperature, salinity, tidal fluctuation, substrate, and wave energy are five physical factors influencing the size and extent of tidal 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 have adapted to saltwater environments by either excluding (red mangrove) or excreting (black and white mangrove and buttonwood) salt from plant tissues (Odum and McIvor 1990). This specialization allows mangroves to flourish in a competition-free habitat where other woody plants are excluded by their sensitivity to salt. Red mangrove is unable to grow in soil salinities greater than 60 ppt, while white and black mangroves can tolerate higher salinities around 80 to 90 ppt (Cintron et al. 1978). 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 (Odum and McIvor 1990).

Water fluctuations, both fresh- and saltwater, help shape tidal 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 (Odum and McIvor 1990). The long-lived floating mangrove propagules are dispersed by water and require a relatively short time for root development allowing them to establish quickly in new areas (Odum and McIvor 1990). Waves along high energy coastlines discourage mangrove establishment and reduce anaerobic sediment accumulation, in which mangroves thrive (Odum and McIvor 1990).

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 (Odum and McIvor 1990). This process was once thought to serve in land- or island-building but, more accurately, is an effective means of stabilizing land in coastal environments (Odum and McIvor 1990). The root structures also provide 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. In fact, tidal swamps are generally among the most productive forests in the world (Odum and McIvor 1990).

In addition to providing habitat for many rare species (listed above), tidal swamps function as nursery grounds for many of Florida's commercially and recreationally important fish and shellfish such as common snook (*Centropomus undecimalis*), shrimp, several species of grouper, and snapper (Thayer et al. 1987; Hettler, Jr. 1989). Tidal swamps and isolated mangrove islands also provide important roosting and nesting areas for substantial populations of wading birds and shorebirds.

Though tidal swamps help protect other inland communities by absorbing the brunt of tropical storms and hurricanes and by preventing coastal erosion (Teas 1977; Alongi 2002), these storm events and periodic freezing temperatures have an influence on the stature of mangrove species and generally drive succession within tidal swamps (Olmsted and Loope 1984; Smith, III et al. 1994). Often when canopy damage is incurred following a storm event, new mangrove propagules regenerate in their place (Smith, III et al. 1994). However, there are examples in Everglades National Park where, after catastrophic storm events, tidal swamp areas do not always regenerate to their historical state. Following the catastrophic damage caused by Hurricane Donna in 1960, areas of former tidal swamp remained for decades as mud flats (Smith, III et al. 1994). Smith suggests that this could be due to the fact that red and black mangrove roots aerate the soil and, when total destruction occurs, redox potential decreases and sulfide concentrations increase due to the lack of aeration, leaving the soil uninhabitable by any vascular plant. Storms can also move sand into mangroves in overwash areas and kill trees. Tidal swamps are especially vulnerable to climate change impacts such as rising sea levels and the increasing intensity and frequency of tropical weather systems (Doyle et al. 2003).

Community Variations: Lugo and Snedaker (1974) recognized several variations of tidal swamps in Florida. These include (1) overwash swamps found on islands frequently inundated by tides; (2) narrow fringe swamps, located along waterways and the edges of islands and keys, that are often exposed to the stresses of high winds and therefore do not achieve the highest stature; (3) tall-statured mangrove swamps near the mouths of river floodplains that receive daily salt water flushes; (4) swamps in isolated depressions that are slightly inland from the coastline and often colonized by black and white mangroves; (5) tidal swamps located on isolated topographic rises; and (6) dwarfed swamps that occur over hard substrates, such as limestone marl, which are extensive in the Florida Keys.

There are additional variations that occur within Florida. Extensive forests dominated by buttonwood often exist in upper tidal areas, especially where tidal swamp transitions to rockland hammock. These buttonwood forests often have an understory dominated by sea oxeye daisy, christmasberry (*Lycium carolinianum*), and Carolina sealavender (*Limonium carolinianum*). Additionally, salt flats or barrens can form within tidal swamp as mangrove-free zones in areas where water flushing (either tidal or freshwater) is infrequent and salinity is beyond the tolerance of mangrove species (Odum and McIvor 1990).

Associated Communities: Tidal swamps are closely associated with, and often grade into, seagrass beds, unconsolidated substrate, tidal marsh, shell mound, coastal berm, maritime hammock, Keys tidal rock barren, and other coastal communities. Seagrass beds and unconsolidated substrates are usually found in the sub-tidal regions surrounding tidal swamps. Extensive areas of tidal swamp in South Florida, most notably along the southwest coast, exist in close association with tidal marsh community (Odum et al. 1982). Tidal marshes can occur intermixed with tidal swamp (Olmsted and Loope 1984) and are often found along the inland boundary of tidal swamps. While they are dominated by graminoids, tidal marshes may contain mangrove species or buttonwood as minor components. Floodplain swamp can occur in tidally-influenced areas at the mouth of large rivers, especially in North Florida and in the peninsula just inland from tidal swamp. These floodplain swamps occur at salinities <0.5 ppt and are dominated by bald cypress (*Taxodium distichum*), swamp tupelo (*Nyssa sylvatica* var. *biflora*), green ash (*Fraxinus pennsylvanica*), and sweetbay (*Magnolia virginiana*) but lack mangrove species or buttonwood. Keys tidal rock barren contains scattered dwarfed mangroves and buttonwood over a limestone rock or marl substrate with patches of low, salt-tolerant herbaceous species, including seaside oxeye, perennial glasswort, saltwort, shoregrass, saltgrass (*Distichlis spicata*), seashore dropseed (*Sporobolus virginicus*), and marsh fimbry (*Fimbristylis spadicea*). It differs from tidal swamp by its extensive exposed limestone. Tropical hardwood species occupy coastal berm, rockland hammock, and shell mound, communities which may be surrounded by tidal swamp. Coastal berm occurs on sand ridges on the edges of low-energy coastlines and may support mangrove species and buttonwood as minor components, as well as other species not found in tidal swamp such as joewood (*Jacquinia keyensis*) and pride-of-big-pine (*Strumpfia maritima*). Tidal swamps do not develop in freshwater systems where mangrove species are easily outcompeted by other woody plants (Odum and McIvor 1990).

Management Considerations: Tidal swamps have been, and continue to be, areas of environmental concern because many acres were destroyed through diking and flooding, ditching for mosquito control, and dredging and filling activities. Common disturbances in tidal swamps are old mosquito ditches that drain water from a swamp and alter its hydrology. Mangroves may perish if their root systems are permanently covered with water or fill dirt for an extended period of time, depriving the roots of adequate oxygen (Odum and McIvor 1990). The 1985 "Mangrove Trimming and Preservation Act" (Florida Statute 403.9321 - 403.9333) provides specific legal protection for mangroves by regulating their removal and trimming (The Florida Senate 2009). However, mangroves continue to face survival pressure resulting from oil spills, altered tidal flows, and changes in the quantity, quality, and timing of the fresh water input as a result of development in adjacent uplands. Reducing estuarine salinity by increasing freshwater inputs and flushing chemical pollutants from adjacent uplands have resulted in the destruction of some tidal swamp areas and the invasion by non-mangrove and non-native species. Tidal swamps are sensitive to colonization by exotic species such as Brazilian pepper (*Schinus terebinthifolius*), carrotwood (*Cupaniopsis anacardioides*), seaside mahoe (*Thespesia populnea*), latherleaf (*Colubrina asiatica*), and Australian pine (*Casuarina equisetifolia*).

Replanting mangroves is an easy task, but restoring tidal swamp community function is difficult and considerable time is required before faunal species reestablish themselves (Alongi 2002). Restoring tidal flow and natural hydrology to tidal swamps can include dike removal and/or reconnecting the swamp to tidal flow via culverts. The best management practices includes preventing further destruction of existing tidal swamps and maintaining a natural flow of fresh and salt water into these areas.

Reference Sites: Everglades National Park (Miami-Dade and Monroe Counties), Ten Thousand Islands (Collier County), Rookery Bay National Estuarine Research Reserve (Collier County), Charlotte Harbor Preserve State Park (Charlotte and Lee Counties), Florida Keys Wildlife and Environmental Area (Monroe County)

Global and State Rank: G5/S4

Crosswalk and Synonyms:

Davis	9/Mangrove Swamp Forests and Coastal Marshes
SCS	19/Mangrove swamp
Myers and Ewel	Mangrove forests
FLUCCS	6120/Mangrove Swamp

References:

Alongi, D.M. 2002. Present state and future of the world's mangrove forests. Environmental Conservation 29:331-349.

Cintron, G., A.E. Lugo, D.J. Pool, and G. Morris. 1978. Mangroves of arid environments in Puerto Rico and adjacent islands. Biotropica 10:110-121.

Doyle, T.W., G.F. Girod, and M.A. Books. 2003. Modeling mangrove forest migration along the southwest coast of Florida under climate change. Pages 211-222 in Z.H. Ning, R.E. Turner, T. Doyle, and K. Abdollahi, editors. Preparing for a changing climate: the potential consequence of climate variability and change: Gulf Coast region. Gulf Coast Climate Change Assessment Council, Baton Rouge, Louisiana.

Hettler, W.F., Jr. 1989. Food habits of juveniles of spotted seatrout and gray snapper in western Florida Bay. Bulletin of Marine Science 44:155-162.

Lugo, A.E., and S.C. Snedaker. 1974. The ecology of mangroves. Annual Review of Ecological Systems 5:39-64.

Madison, M. and J. Waldberg. 2009. The Knowledge of Bonsai Forums. URL: http://www.knowledgeofbonsai.org/species_specific/buttonwood.php

Nelson, G. 1996. The Shrubs and Woody Vines of Florida: A Reference and Field Guide. Pineapple Press Inc, Sarasota.

Odum, W.E., and C.C. McIvor. 1990. Mangroves. Pages 517-548 in R.L. Myers and J.J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando.

Odum, W.E., C.C. McIvor, and T.J. Smith, III. 1982. The ecology of the mangroves of south Florida: a community profile. FWS/OBS-81/24. United States Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

Olmsted, I.C., and L.L. Loope. 1984. Plant communities of Everglades National Park. Pages 167-184 in P.J. Gleason, editor. Environments of South Florida: Present and Past II. Miami Geological Society, Coral Gables.

Smith, T.J., III, M.B. Robblee, H.R. Wanless, and T.W. Doyle. 1994. Mangroves, hurricanes, and lightning strikes. Bioscience 44:256.

Teas, H.J. 1977. Ecology and restoration of mangrove shorelines in Florida. Environmental Conservation 4:51-58.

Thayer, G.W., D.R. Colby, and W.F. Hettler, Jr. 1987. Utilization of the red mangrove prop root habitat. Marine Ecology - Progress Series 35:25-38.

The Florida Senate. 2009. The Florida Senate website. URL: http://www.flsenate.gov/Welcome/index.cfm?CFID=120927317&CFTOKEN=16710813

Wunderlin, R.P., and B.F. Hansen. 2000. Flora of Florida. Volume I. Pteridophytes and Gymnosperms. University Press of Florida, Gainesville.

Zomlefer, W.B., W.S. Judd, and D.E. Giannasi. 2006. Northernmost Limit of *Rhizophora mangle* (Red Mangrove; Rhizophoraceae) in St. Johns County, Florida. Castanea 71:239-244.