

Guide to the
Natural Communities of Florida
2010 Edition



Cover Photograph:

Mesic flatwoods at Triple N Ranch Wildlife Management Area, Osceola County (Gary Knight)

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PREFACE

In 2007, with funding from the Florida Department of Environmental Protection (FDEP), Division of State Lands, the Florida Natural Areas Inventory (FNAI) began a process of updating the "Guide to the Natural Communities of Florida" (the Guide), which had been only slightly modified since it was first published in 1990 by FNAI and the Florida Department of Natural Resources (now FDEP). The current update includes only the forty-five land-based communities (23 terrestrial and 20 palustrine communities, plus tidal marsh and tidal swamp in the marine and estuarine category), leaving the remaining communities to be updated at a later time, except for the updating of species names. The purpose of the update is to clarify distinctions between communities by listing characteristic species and features distinguishing similar communities, as well as to add information for each community on variations throughout its range (with common variants noted specifically), range, natural processes, management, exemplary sites, and references. The resulting 2010 Guide contains the original marine, estuarine, lacustrine, riverine, and subterranean communities, plus the updated 46 land-based communities, with 9 new community names added – alluvial forest, glades marsh, Keys cactus barren, Keys tidal rock barren, limestone outcrop, shrub bog, slough marsh, upland mixed woodland, and upland pine, and 8 original community names deleted (their names being changed or their concepts being subsumed under other communities) – bog, coastal rock barren, floodplain forest, freshwater tidal swamp, prairie hammock, swale, upland mixed forest, and upland pine forest. A complete crosswalk between the 1990 Guide and the 2010 Guide and vice versa is provided here with further explanation of changes made (Appendix 1).

The updated, land-based natural communities are grouped according to a new organization, emphasizing similarities in species composition, structure, and landscape position. Also included in the 2010 Guide are a list of altered landcover types and their definitions (Appendix 2). These are habitats that have been severely impacted by humans and do not fit into FNAI's Natural Community Classification. Altered landcover types can be used to describe the most common non-natural habitats observed on conservation lands in Florida.

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INTRODUCTION

This document presents the hierarchical classification of 81 Natural Communities, developed by the Florida Natural Areas Inventory (FNAI) and identified as collectively constituting the original, natural biological associations of Florida. A Natural Community (NC) is defined as a distinct and recurring assemblage of populations of plants, animals, fungi and microorganisms naturally associated with each other and their physical environment.

The 2010 FNAI natural community classification groups natural communities into categories based on a combination of vegetation, landscape position, and hydrology. The categories, such as “hardwood forested uplands” are meant to be an intuitive grouping of similar natural communities that allows the user to apply a broader level name to an area when the community determination is uncertain. In some cases, an intermediate group (ex. “Cypress/Tupelo”) is identified for further clarification. At the finest level, variants (if any) are described within the community accounts. These variants are optional descriptions that can be used to convey more specific information about an individual community occurrence. For example, a swamp found at the mouth of a river might be designated “floodplain swamp – freshwater tidal swamp variant.” Variants have the same ranking as the natural community of which they are a part. The treatment of each of the 46 communities updated in 2010 follows the outline below.

- **Description** – gives an overall picture of the community with a description of the general vegetation structure and composition, landscape position, soils, hydrology, salinity, and/or fire.
- **Characteristic Set of Species** – short list of typical species.
- **Rare Species** – a discussion of rare species for which the community is critical habitat. This is not meant to be an exhaustive list.
- **Range** – discussion of Florida range and notes on the distribution of similar communities elsewhere in the US or worldwide.
- **Natural Processes** – a discussion of important natural processes including fire, hydrology, etc.
- **Community Variations** – discussion of commonly occurring variation, both regional and within community.
 - **Variant** – names and short descriptions of notable variants of the natural community. These are informal names that are meant to convey further information about specific community occurrences. Their ranks are the same as that of the entire community.
- **Associated Communities** – addresses similar and/or adjacent communities and gives guidelines for recognition.
- **Management Considerations** – addresses fire recommendations and any other management oriented issues stemming from disturbance of natural processes.
- **Exemplary Sites** – these may be specific place names or managed areas (full name) with county listed in parentheses.
- **Global and State Ranks** – current ranking of community by FNAI.
- **Crosswalk and Synonyms** – crosswalk to other classifications and a list of synonyms commonly found in the literature
- **References** – cited in text

The classification of the remaining (primarily aquatic) communities that were not updated remains unchanged. These communities are grouped into Lacustrine, Riverine, Subterranean, and Estuarine and Marine categories. A second level of the hierarchy splits the Estuarine and Marine categories into Natural Community Groups, including Faunal, Floral, and Substrate-based.

Natural Communities are characterized and defined by a combination of physiognomy, vegetation structure and composition, topography, land form, substrate, soil moisture condition, climate, and fire. They are named for their most characteristic biological or physical feature. Natural Communities could be further subdivided into Plant Communities based on the dominant plant species. This level of subdivision is not presented in this document.

FNAI uses several criteria, including area covered and number of occurrences, to determine the relative rarity and threat to each community type; these are summarized into a global and a state rank, the G and S ranks, respectively. Most G ranks for NCs are tentative, pending more information from comparison and coordination with other states

and countries. Three NCs are given the highest rarity ranking (G1/S1): upland glade, Keys cactus barren, and pine rockland. The first two, being confined to limestone outcrops in wooded landscapes, are naturally of limited extent; the third occurs in the Miami-Dade urban area and has been largely altered for human use. Twelve NCs are ranked at the second most endangered level (G2/S2). Six of these are of naturally limited extent: slope forest, seepage slope, sinkhole, limestone outcrop, shell mound, and strand swamp, and six have been largely altered for human use: dry prairie, wet prairie, scrub, scrubby flatwoods, upland mixed woodland, and rockland hammock. With the exception of wet prairie and seepage slope which are found in adjacent states, all of these rarest NCs are largely confined to Florida.

Several other classification systems are in use in Florida, with four principal ones that cover the entire state. The widely used FLUCCS (Florida Land Use, Cover, and Forms Classification System) system, is a general purpose mapping system, devised by the Florida Department of Transportation, that includes both natural and altered (i.e., residential areas, farmland, pastures, etc.) categories that are distinguishable on aerial photographs. This system is used by the five Florida Water Management Districts to produce periodically updated, digitized maps of the entire state interpreted from current aerial photography. The Florida Land Cover map produced by the Florida Fish and Wildlife Conservation Commission (FWC) uses mechanical interpretation of satellite imagery (2003) to produce a single statewide map using 23 natural categories and 16 human-modified categories. More recently the FWC developed the Florida Land Cover Classification System (2009), a hierarchical classification consisting of more than 200 classes that integrates the FNAI system with FLUCCS. This classification is the basis for Cooperative Land Cover Map (FNAI 2010), a statewide digital map that incorporates FLUCCS, high quality site-based land cover, and improvements to focal community maps through aerial photo review. A finer-scale plant community level of classification called the U. S. National Vegetation Classification (USNVC), developed by The Nature Conservancy (and now maintained by NatureServe) for conservation purposes and continuously updated, uses dominant plant species to define its finest units, called “associations”, of which it has recognized over 350 in Florida.²⁸⁷ NatureServe has also grouped the associations into ecological systems, based on geographic location and landform, of which there are 73 in Florida.

The FNAI classification seeks to encompass all natural assemblages at a scale that is useful for mapping natural areas and communication about land management. It differs from the FLUCCS and the FWC landcover systems in its lack of non-natural categories and its greater detail in natural categories. It differs from the associations of the USNVC Classification in not being based on dominant species and from the ecological systems of NatureServe in not being based on geographic area of the state in which the assemblage occurs.

The FNAI classification is meant to be relatively stable in order to facilitate its usage in state conservation efforts. However, we believe that the guide should also remain flexible and dynamic to incorporate up-to-date information. Future editions of the Guide will be released as new data and research accumulate.

NATURAL COMMUNITY SHORT DESCRIPTIONS

HARDWOOD FORESTED UPLANDS – mesic or xeric forest dominated mainly by hardwood trees.

Slope Forest (G2?/S1) – steep slope on bluff or in sheltered ravine within the Apalachicola drainage; sand/clay substrate; mesic-hydric; central Panhandle; rare or no fire; closed canopy of mainly deciduous species; American beech, Florida maple, white oak, Ashe's magnolia, southern magnolia, spruce pine, Shumard's oak.

Upland Hardwood Forest (G5/S3) – upland with sand/clay and/or calcareous substrate; mesic; Panhandle to central peninsula; rare or no fire; closed deciduous or mixed deciduous/evergreen canopy; American beech, southern magnolia, hackberry, swamp chestnut oak, white oak, horse sugar, flowering dogwood, and mixed hardwoods.

DRY UPLAND HARDWOOD FOREST – on dry slopes or along upper slopes with sand/clay substrate; mesic; temperate; rare fire; closed canopy; laurel oak and/or live oak and/or pignut hickory, southern magnolia, shortleaf pine, loblolly pine, and/or mixed hardwoods.

Mesic Hammock (G3/S3?) – flatland with sand/organic soil; mesic; primarily central peninsula; occasional or rare fire; closed evergreen canopy; live oak, cabbage palm, southern magnolia, pignut hickory, saw palmetto.

PRAIRIE MESIC HAMMOCK – Isolated stands within a matrix of pyrogenic vegetation; occasional fire; live oak, cabbage palm, saw palmetto.

Rockland Hammock (G2/S2) – flatland with limestone substrate; mesic; southern peninsula and Keys; rare or no fire; closed canopy of evergreen mixed tropical hardwoods; gumbo limbo, pigeon plum, stoppers.

THORN SCRUB – along ecotones or within openings in rockland hammock; low-statured; dominated by spiny species; saffron plum, blackbead, hog plum, buttonwood, plus other common rockland hammock species.

Xeric Hammock (G3/S3) – upland with deep sand substrate; xeric; primarily eastern Panhandle to central peninsula; rare or no fire; closed canopy of evergreen hardwoods; sand live oak, saw palmetto.

HIGH PINE AND SCRUB – hills with mesic or xeric woodlands or shrublands; canopy, if present, open and consisting of pine or a mixture of pine and deciduous hardwoods.

Upland Mixed Woodland (G2/S2) – upland with loamy soils; mesic-xeric; central Panhandle to extreme northern central peninsula; occasional fire (variable but as little as two up to 20 year interval); open to partially closed canopy over an open understory of mixed herbs and scattered shrubs; mixture of southern red oak, mockernut hickory, and longleaf or shortleaf pine with other mixed hardwoods; wiregrass infrequent.

Upland Pine (G3/S2) – upland with sand/clay substrate; mesic-xeric; Panhandle to extreme northern central peninsula; frequent fire (1-3 years); savanna of widely spaced pines over primarily herbaceous understory; longleaf pine and/or loblolly pine and/or shortleaf pine, southern red oak, wiregrass.

Sandhill (G3/S2) – upland with deep sand substrate; xeric; Panhandle to central peninsula; frequent fire (1-3 years); savanna of widely spaced longleaf pine and/or turkey oak with wiregrass understory.

Scrub (G2/S2) – upland with deep sand substrate; xeric; statewide except extreme southern peninsula and Keys, mainly coastal in Panhandle; occasional or rare fire (usually 5-20 years); open or dense shrubs with or without pine canopy; sand pine and/or scrub oaks and/or Florida rosemary.

ROSEMARY SCRUB – on the driest ridge crests, particularly at the southern end of the Lake Wales Ridge and on Panhandle barrier islands; occasional or rare fire (10-40 years); dominated by Florida rosemary with large areas of bare sand visible between the shrubs.

SAND PINE SCRUB – on ridges throughout the state; rare fire (20-80 years); canopy of sand pine and an understory of the three shrubby oaks, or less commonly, Florida rosemary.

PINE FLATWOODS AND DRY PRAIRIE – mesic or hydric pine woodland or mesic shrubland on flat sandy or limestone substrates, may have a hard pan that impedes drainage.

Wet Flatwoods (G4/S4) – flatland with sand substrate; seasonally inundated; statewide except extreme southern peninsula and Keys; frequent fire (2-4 years for grassy wet flatwoods, 5-10 years for shrubby wet flatwoods); closed to open pine canopy with grassy or shrubby understory; slash pine, pond pine, large gallberry, fetterbush, sweetbay, cabbage palm, wiregrass, toothache grass.

CUTTHROAT GRASS FLATWOODS – on and near the Lake Wales Ridge; frequent fire (2-4 years); widely scattered pines over cutthroat grass and/or other hydrophytic herbs.

CABBAGE PALM FLATWOODS – on shelly sand or where limestone is near the surface; central to southern peninsula; pine canopy over cabbage palm understory.

Mesic Flatwoods (G4/S4) – flatland with sand substrate; mesic; statewide except extreme southern peninsula and Keys; frequent fire (2-4 years); open pine canopy with a layer of low shrubs and herbs; longleaf pine and/or slash pine, saw palmetto, gallberry, dwarf live oak, wiregrass.

Scrubby Flatwoods (G2/S2?) – flatland with sand substrate; xeric-mesic; statewide except extreme southern peninsula and Keys; occasional fire (5-15 years); widely scattered pine canopy over saw palmetto and scrub oaks; longleaf pine, sand live oak, myrtle oak, Chapman's oak, saw palmetto, wiregrass.

Pine Rockland (G1/S1) – flatland with exposed limestone substrate; mesic-xeric; southern peninsula and Keys; frequent to occasional fire (3-7 years); open pine canopy with mixed shrubs and herbs in understory; South Florida slash pine, palms, mixed tropical and temperate shrubs, grasses, and herbs.

Dry Prairie (G2/S2) – flatland with sand soils over an organic or clay hardpan; mesic-xeric; central peninsula; annual or frequent fire (1-2 years); treeless with a low cover of shrubs and herbs; wiregrass, dwarf live oak, stunted saw palmetto, bottlebrush threeawn, broomsedge bluestem.

COASTAL UPLANDS – mesic or xeric communities restricted to barrier islands and near shore; woody or herbaceous vegetation; other communities may also occur in coastal environments.

Beach Dune (G3/S2) – active coastal dune with sand substrate; xeric; statewide; rare or no fire; marine influence; open herbaceous vegetation with no canopy; sea oats, railroad vine, bitter panicum, and/or mixed salt-spray tolerant grasses and herbs.

Coastal Berm (G3/S2) – old bar or storm debris with sand/shell substrate; xeric-mesic; southern peninsula and Keys; rare or no fire; marine influence; variable vegetation structure; mixed tropical herbs, shrubs, and trees.

Coastal Grassland (G3/S2) – coastal flatland behind dunes with stable sand substrate; mesic-hydric; statewide excluding Keys; occasional fire; marine influence; herbaceous vegetation with no canopy; salt-tolerant grasses and herbs; sea oats, bitter panicum, camphorweed, hairawn muhly, Gulf bluestem.

Coastal Strand (G3/S2) – stabilized coastal dune with sand substrate; xeric; peninsula; rare fire; marine influence; primarily dense shrubs; saw palmetto in temperate coastal strand or seagrape and/or saw palmetto in tropical coastal strand.

Maritime Hammock (G3/S2) – stabilized coastal dune with sand substrate; xeric-mesic; statewide but rare in Panhandle and Keys; rare or no fire; marine influence; evergreen closed canopy; live oak, cabbage palm, red bay, red cedar in temperate maritime hammock; gumbo limbo, seagrape, and white or Spanish stopper in tropical maritime hammock.

Shell Mound (G2/S2) – small hill of shells deposited by native Americans; mesic-xeric; statewide; rare or no fire; marine influence; closed canopy of mixed hardwoods; soapberry, snowberry, white stopper.

SINKHOLES AND OUTCROP COMMUNITIES – small extent communities in karst features or on exposed limestone.

Upland Glade (G1/S1) – upland with thin clay soils over limestone outcrops; hydric-xeric; central Panhandle only; sparse mixed grasses and herbs with occasional stunted trees and shrubs that are concentrated

around the edge; black bogrush, poverty dropseed, diamondflowers, hairawn muhly, Boykin's polygala, red cedar.

Sinkhole (G2/S2) – karst feature with steep walls; mesic-hydric; statewide; variable vegetation structure.

Limestone Outcrop (G2/S2) – exposed limestone; mesic-hydric; statewide; often with mosses, liverworts, and a diversity of rare ferns.

Keys Cactus Barren (G1/S1) – small openings on flatland with exposed limestone; xeric; restricted to Keys; marine influence; open, herbaceous vegetation with some cacti, agave, and stunted trees; three-spined pricklypear, erect pricklypear, barbed wire cactus, Yucatan fly mallow, Florida Keys indigo, skyblue clustervine, dwarf bindweed.

FRESHWATER NON-FORESTED WETLANDS – herbaceous or shrubby palustrine communities in floodplains or depressions; canopy trees, if present, very sparse and often stunted.

PRAIRIES AND BOGS – short hydroperiod; dominated by grasses, sedges, and/or titi.

Seepage Slope (G2/S2) – on or at base of slope with loamy sand substrate; maintained by downslope seepage, usually saturated but rarely inundated; Panhandle and northern peninsula; frequent fire (1-3 years); dense herbaceous community; wiregrass, wiry beaksedges, flattened pipewort, toothache grass, pitcherplants.

Wet Prairie (G2/S2) – flatland with sand or clayey sand substrate; usually saturated but only occasionally inundated; statewide excluding extreme southern peninsula; frequent fire (2-3 years); treeless, dense herbaceous community with few shrubs; wiregrass, blue maidencane, cutthroat grass, wiry beaksedges, flattened pipewort, toothache grass, pitcherplants, coastalplain yellow-eyed grass.

CUTTHROAT SEEP – eastern and western edges of the Lake Wales Ridge in central Florida; dominated by the endemic cutthroat grass.

CALCAREOUS WET PRAIRIE – in central and south-central peninsula on calcareous soils; Gulf hairawn muhly typically dominant with other calcium-loving species.

PITCHERPLANT PRAIRIE – in the Panhandle on wetter soils; dense stands of tall pitcherplants.

Marl Prairie (G3/S3) – flatland with marl over limestone substrate; seasonally inundated (<4 months); southern peninsula; frequent to occasional fire (2-10 years depending on density of herbs); purple muhly, sawgrass (stunted), spreading beaksedge, black bogrush, Florida little bluestem, and/or mixed grasses, sometimes with dwarf cypress.

Shrub Bog (G4/S3) – wetland on organic soil over sand; soil often saturated and mucky, occasionally shallowly inundated; Panhandle to north peninsula; occasional fire (10-20 years); dense stand of shrubs, trees absent or sparse, sphagnum moss common; titi, black titi, fetterbush, large gallberry, laurel greenbrier, pond pine or slash pine.

MARSHES – long hydroperiod; dominated by grasses, sedges, broadleaf emergents, floating aquatics, or shrubs.

Depression Marsh (G4/S4) – small, isolated, often rounded depression in sand substrate with peat accumulating toward center; surrounded by fire-maintained community; seasonally inundated; still water; statewide excluding Keys; frequent or occasional fire; largely herbaceous; maidencane, sawgrass, pickerelweed, longleaf threeawn, sand cordgrass, peelbark St. John's wort.

Basin Marsh (G4/S3) – basin with peat or sand substrate; seasonally inundated; statewide excluding Keys; occasional fire; largely herbaceous; maidencane, sawgrass, bulltongue arrowhead, pickerelweed, Baker's cordgrass, white water lily, coastalplain willow.

LAKE BOTTOM – marshes on former lake bottoms of “disappearing” lakes in northern Florida, areas that alternate between lake and marsh when the sinkholes draining them are plugged or re-opened; well-known examples are Lake Miccosukee and Paynes Prairie.

Coastal Interdunal Swale (G3/S2) – linear wetlands between dunes on sandy barrier islands; inundated by local rainfall events; Panhandle to central peninsula; herbaceous or shrubby; sawgrass, hairawn muhly, broomsedge, seashore paspalum, Baker's cordgrass, saltmeadow cordgrass, wax myrtle, coastalplain willow.

Floodplain Marsh (G3/S3) – floodplain with organic/sand/alluvial substrate; seasonally inundated; Panhandle to central peninsula; frequent or occasional fire (ca. 3 years, much less frequent in freshwater tidal marshes); treeless herbaceous community with few shrubs; sawgrass, maidencane, sand cordgrass, and/or mixed emergents.

FRESHWATER TIDAL MARSH – river mouth wetland on organic/alluvial substrates; receives pulses of freshwater in response to tides; sawgrass, giant cutgrass.

Slough Marsh (G3/S3?) – broad, shallow channel with sand/peat substrate; seasonally inundated; intermittently flowing water; central to southern peninsula; frequent or occasional fire (3-10 years); sawgrass, maidencane, pickerelweed, and/or mixed emergents.

Glades Marsh (G3/S3) – broad, shallow channel with peat/marl substrate directly overlying limestone; seasonally inundated; stagnant or slow flowing water; Everglades basin, Big Cypress region, and Keys; frequent to occasional fire (3-10 years); sawgrass, spikerush, maidencane, beaksedges, mixed emergents.

KEYS FRESHWATER MARSH – limestone depression; restricted to Florida Keys; may be saline during dry season; sawgrass.

Slough (G3/S3) – broad, shallow channel with peat; inundated except during droughts; flowing water; statewide excluding Keys; rare fire; sparsely canopied or with emergent or floating plants; alligator flag, American white waterlily.

POND APPLE SLOUGH – canopied sloughs dominated by pond apple or Carolina ash, often with abundant epiphytes.

FRESHWATER FORESTED WETLANDS – floodplains or depressions dominated by hydrophytic trees

CYPRESS/TUPELO – dominated entirely by cypress or tupelo, or these species important in the canopy; long hydroperiod.

Dome Swamp (G4/S4) – small or large and shallow isolated depression in sand/marl/limestone substrate with peat accumulating toward center; occurring within a fire-maintained community; seasonally inundated; still water; statewide excluding Keys; occasional or rare fire; forested, canopy often tallest in center; pond cypress, swamp tupelo.

GUM POND – underlain by a clay lens; generally occurs in upland pine; mainly Panhandle; longer hydroperiod and lower fire frequency than cypress-dominated dome swamps; dominated by swamp tupelo.

STRINGER SWAMP – narrow linear swamps; occur within a pyrogenic community along intermittent streams that only flow during heavy rainfall; Panhandle; dominated by pond cypress.

Basin Swamp (G4/S3) – typically large basin wetland with peat substrate; seasonally inundated; still water or with water output; Panhandle to central peninsula; occasional or rare fire; forest of cypress/tupelo/mixed hardwoods; pond cypress, swamp tupelo.

Strand Swamp (G2/S2) – broad, shallow channel with peat over mineral substrate; situated in limestone troughs; seasonally inundated; slow flowing water; vicinity of Lake Okeechobee and southward; occasional or rare fire; closed canopy of cypress and mixed hardwoods; cypress, pond apple, strangler fig, willow, abundant epiphytes.

Floodplain Swamp (G4/S4) – along or near rivers and streams with organic/alluvial substrate; usually inundated; Panhandle to central peninsula; rare or no fire; closed canopy dominated by cypress, tupelo, and/or black gum.

FRESHWATER TIDAL SWAMP – floodplain swamp a river mouth where occasional saltwater intrusion significantly affects vegetation composition; receives pulses of freshwater in response to tides; cypress absent or infrequent; closed/open canopy of swamp tupelo, pumpkin ash, sweetbay.

HARDWOOD – dominated by a mix of hydrophytic hardwood trees; cypress or tupelo may be occasional or infrequent in the canopy; short hydroperiod.

Baygall (G4/S4) – slope or depression wetland with peat substrate; usually saturated and occasionally inundated; statewide excluding Keys; rare or no fire; closed canopy of evergreen trees; loblolly bay, sweetbay, swamp bay, titi, fetterbush.

BAY SWAMP – large or small peat filled depression; mainly eastern Panhandle to central peninsula; forested; dominated by bay species.

SOUTH FLORIDA BAYHEAD – on tree islands in glades marsh on peat substrate; south of Lake Okeechobee in central and southern peninsula; open or closed canopy; swamp bay, sweetbay, dahoon, coastalplain willow, and/or coco plum.

Hydric Hammock (G4/S4) – lowland with sand/clay/organic soil over limestone or with high shell content; mesic-hydric; primarily eastern Panhandle and central peninsula; occasional to rare fire; diamond-leaved oak, live oak, cabbage palm, red cedar, and mixed hardwoods.

COASTAL HYDRIC HAMMOCK – occurring adjacent to coastal marshes; central Panhandle to central peninsula; species composition limited by occasional salt water intrusion; cabbage palm, red cedar, and live oak.

PRAIRIE HYDRIC HAMMOCK – isolated stands of hydric hammock within a pyrogenic community, usually floodplain marsh; shelly sand soils; central and southern peninsula; occasional fire; cabbage palm, live oak, red cedar.

Bottomland Forest (G4/S3) – flatland with sand/clay/organic substrate; usually connected or adjacent to a riverine community; occasionally inundated; Panhandle to central peninsula; rare or no fire; closed canopy of mixed hardwoods; deciduous or mixed deciduous/evergreen; tuliptree, sweetbay, water oak, sweetgum, diamond-leaved oak, red maple, loblolly pine, spruce pine, Atlantic white cedar.

Alluvial Forest (G4/S3) – floodplain with alluvial substrate of sand, silt, clay or organic soil; inundated yearly during growing season; influenced by disturbance from ongoing floodplain processes (deposition of point bars, creation of “ridge and swale” topography); Panhandle to central peninsula; rare or no fire; closed canopy of mainly deciduous trees; water hickory, overcup oak, diamond-leaved oak, green ash, American elm, water locust, river birch.

MARINE and ESTUARINE VEGETATED WETLANDS – intertidal or supratidal zone dominated by herbaceous or woody halophytic vascular plants; salinity >0.5 ppt.

Salt Marsh (G5/S4) – estuarine wetland on muck/sand/or limestone substrate; inundated with saltwater by daily tides; statewide; occasional or rare fire; treeless, dense herb layer with few shrubs; saltmarsh cordgrass, needle rush, saltgrass, saltwort, perennial glasswort, seaside oxeye.

SALT FLAT – salt marsh with much exposed bare soil on slightly higher areas within marsh; high salinity and dry conditions; sparse and stunted cover of succulents and/or shoregrass.

Mangrove Swamp (G5/S4) – estuarine wetland on muck/sand/or limestone substrate; inundated with saltwater by daily tides; central peninsula and Keys; no fire; dominated by mangrove and mangrove associate species; red mangrove, black mangrove, white mangrove, buttonwood.

BUTTONWOOD FOREST – upper tidal area dominated by buttonwood; often transitional to rockland hammock.

Keys Tidal Rock Barren (G3/S3?) – flatland with exposed limestone in supratidal zone; restricted to Keys; no fire; open, mainly herbaceous vegetation of upper salt marsh species and stunted shrubs and trees; buttonwood, christmasberry, perennial glasswort, saltwort, seashore dropseed, shoregrass.

PONDS and LAKES (LACUSTRINE) – non-flowing wetlands of natural depressions lacking persistent emergent vegetation except around the perimeter

Clastic Upland Lake (G3/S2) – generally irregular basin in clay uplands; predominantly with inflows, frequently without surface outflow; clay or organic substrate; Panhandle to northern central peninsula; colored, acidic, soft water with low mineral content (sodium, chloride, sulfate); oligo-mesotrophic to eutrophic.

Coastal Dune Lake (G2/S1) – basin or lagoon influenced by recent coastal processes; predominantly sand substrate with some organic matter; Panhandle; salinity variable among and within lakes, and subject to saltwater intrusion and storm surges; slightly acidic, hard water with high mineral content (sodium, chloride).

Coastal Rockland Lake (G2/S1) – shallow basin influenced by recent coastal processes; predominantly barren oolitic or Miami limestone substrate; southern peninsula and Keys; salinity variable among and within lakes, and subject to saltwater intrusion, storm surges and evaporation (because of shallowness); slightly alkaline, hard water with high mineral content (sodium, chloride).

Flatwoods/Prairie Lake (G4/S3) – generally shallow basin in flatlands with high water table; frequently with a broad littoral zone; still water or flow-through; sand or peat substrate; statewide except extreme southern peninsula and Keys; variable water chemistry, colored to clear, acidic to slightly alkaline, soft to moderately hard water with moderate mineral content (sodium, chloride, sulfate); oligo-mesotrophic to eutrophic.

Marsh Lake (G4/S4) – generally shallow, open water area within wide expanses of freshwater marsh; still water or flow-through; peat, sand or clay substrate; statewide except Keys; variable water chemistry, but characteristically highly colored, acidic, soft water with moderate mineral content (sodium, chloride, sulfate); oligo-mesotrophic to eutrophic.

River Floodplain Lake (G4/S2) – meander scar, backwater, or larger flow-through body within major river floodplains; sand, alluvial or organic substrate; statewide except extreme southern peninsula and Keys; colored, alkaline or slightly acidic, hard or moderately hard water with high mineral content (sulfate, sodium, chloride, calcium, magnesium); mesotrophic to eutrophic.

Sandhill Upland Lake (G3/S2) – generally rounded solution depression in deep sandy uplands; panhandle to southern peninsula; predominantly without surface inflows/outflows; typically sand substrate with organic accumulations toward middle; clear, acidic moderately soft water with varying mineral content; ultra-oligotrophic to mesotrophic.

Sinkhole Lake (G2/S2) – typically deep, funnel-shaped depression in limestone base; statewide; predominantly without surface inflows/outflows, but frequently with connection to the aquifer; clear, alkaline, hard water with high mineral content (calcium, bicarbonate, magnesium).

Swamp Lake (G4/S3) – generally shallow, open water area within basin swamps; still water or flow-through; peat, sand or clay substrate; statewide except Keys; variable water chemistry, but characteristically highly colored, acidic, soft water with moderate mineral content (sodium, chloride, sulfate); oligo-mesotrophic to eutrophic.

RIVERS and STREAMS (RIVERINE) – natural, flowing waters from their source to the downstream limits of tidal influence and bounded by channel banks

Alluvial Stream (G4/S2) – lower perennial or intermittent/seasonal watercourse characterized by turbid water with suspended silt, clay, sand and small gravel; Panhandle; generally with a distinct, sediment-derived (alluvial) floodplain and a sandy, elevated natural levee just inland from the bank.

Blackwater Stream (G4/S3) – perennial or intermittent/seasonal watercourse characterized by tea-colored water with a high content of particulate and dissolved organic matter derived from drainage through swamps and marshes; statewide except Keys; generally lacking an alluvial floodplain.

Seepage Stream (G3/S2) – upper perennial or intermittent/seasonal watercourse with clear to lightly colored water derived from shallow groundwater seepage; panhandle to southern peninsula.

Spring-run Stream (G2/S2) – perennial watercourse with deep aquifer headwaters and clear water, circumneutral pH and, frequently, a solid limestone bottom; panhandle to central peninsula.

SUBTERRANEAN – twilight, middle, and deep zones of natural chambers overlain by the earth's crust and characterized by climatic stability and assemblages of trogloneic, troglophilic, and troglotic organisms.

Aquatic Cave (G3/S3) – cave permanently or periodically submerged; often supporting troglotic crustaceans and salamanders; includes high energy systems which receive large quantities of organic detritus and low energy systems; statewide.

Terrestrial Cave (G3/S2) – cave lacking standing water; often supporting bats, such as *Myotis* spp., and other terrestrial vertebrates and invertebrates; includes interstitial areas above standing water such as fissures in the ceiling of caves; statewide.

MARINE and ESTUARINE – subtidal, intertidal, and supratidal zones of the sea, landward to the point at which seawater becomes significantly diluted with freshwater inflow from the land. (The distinction between the Marine and Estuarine Natural Communities is often subtle, and the natural communities types found under these two community categories have the same descriptions. For these reasons they have been grouped together.)

MINERAL BASED

Consolidated Substrate (G3/S3) – expansive subtidal, intertidal, and supratidal area composed primarily of nonliving compacted or coherent and relatively hard, naturally formed mass of mineral matter (e.g., coquina limerock and relic reefs); statewide; octocorals, sponges, stony corals, nondrift macrophytic algae, blue-green mat-forming algae, and seagrasses sparse, if present.

Unconsolidated Substrate (G5/S5) – expansive subtidal, intertidal, and supratidal area composed primarily of loose mineral matter (e.g., corallgal, gravel, marl, mud, sand and shell); statewide; octocorals, sponges, stony corals, nondrift macrophytic algae, blue-green mat-forming algae and seagrasses sparse, if present.

FAUNAL BASED

Coral Reef (G2/S1) – expansive subtidal area with elevational gradient or relief and occupied primarily by living sessile organisms of the Class Hydrozoa (e.g., fire corals and hydrocorals), Class Anthozoa, and Subclass Zoantharia (e.g., stony corals and black corals); southern peninsula and Keys; includes deepwater bank reefs, fringing barrier reefs, outer bank reefs and patch reefs, some of which may contain distinct zones of assorted macrophytes, octocorals, & sponges.

Mollusk Reef (G3/S3) – substantial subtidal or intertidal area with relief from concentrations of sessile organisms of the Phylum Mollusca, Class Bivalvia (e.g., mollusks, oysters, & worm shells); statewide; octocorals, sponges, stony corals, macrophytic algae and seagrasses sparse, if present.

Octocoral Bed (G2/S1) – expansive subtidal area occupied primarily by living sessile organisms of the Class Anthozoa, Subclass Octocorallia (e.g., soft corals, horny corals, sea fans, sea whips, and sea pens); likely statewide; sponges, stony corals, nondrift macrophytic algae and seagrasses sparse, if present.

Sponge Bed (G2/S2) – expansive subtidal area occupied primarily by living sessile organisms of the Phylum Porifera (e.g., sheepswool sponge, Florida loggerhead sponge and branching candle sponge); statewide; octocorals, stony corals, nondrift macrophytic algae and seagrasses sparse, if present.

Worm Reef (G1/S1) – substantial subtidal or intertidal area with relief from concentrations of sessile, tubicolous organisms of the Phylum Annelida, Class Polychaeta (e.g., chaetopterids and sabellarids); southern peninsula (east coast only); octocorals, sponges, stony corals, macrophytic algae and seagrasses sparse, if present.

FLORAL BASED (mainly subtidal)

Algal Bed (G3/S2) – expansive subtidal, intertidal, or supratidal area, occupied primarily by attached thallophytic or mat-forming prokaryotic algae (e.g., halimeda, blue-green algae); statewide; octocorals, sponges, stony corals and seagrasses sparse, if present.

Seagrass Bed (G3/S2) – expansive subtidal or intertidal area, occupied primarily by rooted vascular macrophytes, (e.g., shoal grass, halophila, widgeon grass, manatee grass and turtle grass); statewide; may include various epiphytes and epifauna; octocorals, sponges, stony corals, and attached macrophytic algae sparse, if present.

COMPOSITE SUBSTRATE

Composite Substrate (G3/S3) – expansive subtidal, intertidal, or supratidal area, occupied primarily by natural community elements from more than one natural community category (e.g., grass bed and algal bed species; octocoral and algal bed species); statewide; includes both patchy and evenly distributed occurrences.

HARDWOOD FORESTED UPLANDS – mesic or xeric forest dominated mainly by hardwood trees



Torrey State Park (Liberty County)

Photo by Gary Knight

Slope Forest

Description: Slope forest is a well-developed, closed canopy forest of upland hardwoods on steep slopes, bluffs, and in sheltered ravines within the Apalachicola River drainage. Slope forests have extremely high tree and shrub diversity,³²⁸ largely because of their mixture of cold temperate and warm temperate elements.¹⁴⁵ Tree density is relatively high, inducing much competition for space, water, sunlight and nutrients. The mostly deciduous canopy commonly includes American beech (*Fagus grandifolia*), Florida maple (*Acer saccharum* ssp. *floridanum*), white oak (*Quercus alba*), tuliptree (*Liriodendron tulipifera*), Shumard's oak (*Q. shumardii*), white ash (*Fraxinus*

americana), black oak (*Q. velutina*). Several evergreen species are common as well, including southern magnolia (*Magnolia grandiflora*), spruce pine (*Pinus glabra*), live oak (*Q. virginiana*), and laurel oak (*Q. hemisphaerica*).

The diverse understory can be moderately dense to sparse and includes smaller canopy species plus American witchhazel (*Hamamelis virginiana*), needle palm (*Rhapidophyllum hystrix*), American holly (*Ilex opaca*), eastern redbud (*Cercis canadensis*), mountain laurel (*Kalmia latifolia*), oakleaf hydrangea (*Hydrangea quercifolia*), basswood (*Tilia americana*), Florida anisetree (*Illicium floridanum*), sourwood (*Oxydendrum arboreum*), Gulf Sebastian bush (*Sebastiania fruticosa*), white fringe tree (*Chionanthus virginicus*), flowering dogwood (*Cornus florida*), horse sugar (*Symplocos tinctoria*), red buckeye (*Aesculus pavia*), silky camellia (*Stewartia malacodendron*), Florida yew (*Taxus floridana*), Ashe's magnolia (*Magnolia ashei*), pyramid magnolia (*Magnolia pyramidata*), and the historically dominant but now declining Florida torreyia (*Torreya taxifolia*).³⁶¹ The herbaceous groundcover is often sparse and composed mainly of shade-tolerant species and spring ephemerals such as partridgeberry (*Mitchella repens*), Florida yam (*Dioscorea floridana*), woodland pinkroot (*Spigelia marilandica*), saw greenbrier (*Smilax bona-nox*), wild blue phlox (*Phlox divaricata*), sarsaparilla vine (*Smilax pumila*), prostrate blue violet (*Viola walteri*), heartleaf noseburn (*Tragia cordata*), switchcane (*Arundinaria gigantea*), trilliums (*Trillium* spp.), Christmas fern (*Polystichum acrostichoides*), and fringed campion (*Silene polypetala*).

The combination of densely shaded slopes and cool, moist microclimates produces conditions that are conducive for the growth of many plant species that are more typical of the Piedmont and Southern Appalachian Mountains.³⁶¹ These include mountain laurel, black walnut (*Juglans nigra*), wild hydrangea (*Hydrangea arborescens*), sweet-shrub (*Calycanthus floridus*), burningbush (*Euonymus atropurpureus*), heartleaf (*Hexastylis arifolia*), common maidenhair fern (*Adiantum capillus-veneris*), smooth Solomon's seal (*Polygonatum biflorum*), liverleaf (*Hepatica nobilis*), white baneberry (*Actaea pachypoda*), perfoliate bellwort (*Uvularia perfoliata*), bloodroot (*Sanguinaria canadensis*), false hellebore (*Veratrum woodii*), Canadian lousewort (*Pedicularis canadensis*), wild comfrey (*Cynoglossum virginianum*), downy rattlesnake plantain (*Goodyera pubescens*), American bladderhut (*Staphylea trifolia*), and eastern leatherwood (*Dirca palustris*).

Slope forest occurs in areas with substantial topographic relief. Soils are generally composed of sands, sandy-clays, or clayey-sands with substantial organics and occasionally calcareous components. The Cody Scarp crosses the range of slope forest near its southern extent along the Big Sweetwater Creek.³⁶¹ The soils above this divide are clayey Miocene soils while the soils to the south are Pleistocene sandy soils. Sandy soils are generally well drained, but clayey soils may shed much of the rainfall and exhibit significant surface water runoff. Thus, soil erosion is often a combination of seepage erosion, which occurs largely from the valley floors up (steepheads), and surface erosion, which occurs largely from the hilltops down.⁴³⁹

Slope forests along the Apalachicola River are included in one of the six biodiversity hotspots in the United States designated by The Nature Conservancy.³⁸⁸ These are relictual forests noted for their admixture of rare plants, coastalplain species, and species more common further north.^{178,328} Ravines along the Apalachicola River north of the Cody Scarp remained above sea level during the Pleistocene, providing a safe refuge for southward-moving northern species. Since the waters of the Apalachicola River originate in the Appalachian Mountains many northern species had a direct conduit to the south during interglacial periods. The cool microclimate created by the narrow, shaded ravines allowed for their persistence during warm periods.

Characteristic Set of Species: American beech, Florida torreyia, Florida yew, Ashe's magnolia, croomia, fringed campion, eastern leatherwood, Shumard's oak, Florida maple

Rare Species: Slope forest is well known for its high diversity of rare plants (approximately 41 species) within a very restricted geographic location. Two Florida endemic tree species, Ashe's magnolia and Florida yew, are present in slope forest.^{188,328} Rare plants characteristic of slope forest include fringed campio, Florida torreyia, Florida yew, croomia (*Croomia pauciflora*), burningbush, bay star-vine (*Schisandra glabra*), Baldwin's spiny-pod (*Matelea baldwyniana*), pyramid magnolia, Ashe's magnolia, eastern leatherwood, narrow-leaved trillium (*Trillium lancifolium*), liverleaf, wood spurge (*Euphorbia commutata*), Godfrey's privet (*Forestiera godfreyi*), American bladderhut, northern prickly ash (*Zanthoxylum americanum*), Florida flame azalea (*Rhododendron austrinum*), and green violet (*Hybanthus concolor*).

Rare animals that occupy slope forest are Apalachicola dusky salamander (*Desmognathus apalachicolae*), copperhead (*Agkistrodon contortrix*), hairy woodpecker (*Picoides villosus*), and worm-eating warbler (*Helminthos vermivorum*). Several rare invertebrates are found in Florida slope forests including the Torreya pygmy grasshopper

(*Tettigidea empedonepia*) and floodplain phanaeus scarab beetle (*Phanaeus triangularis*). The Apalachicola hydroptila caddisfly (*Hydroptila apalachicola*), is restricted to a single slope forest ravine.

Range: Slope forest is restricted to a 35 km stretch along the eastern side of the Apalachicola River in the northern Florida Panhandle and southern Georgia.³⁶¹ In Florida, slope forest occurs south of Lake Seminole in Gadsden and Liberty counties, from the Georgia state line to just north of Bristol, Florida, roughly following the range of Florida torreyia.³⁶¹

Natural Processes: Succession is generally restricted to single tree canopy gaps. Canopy damage on a larger scale can result from occasional hurricanes and strong storms.¹⁹ Fire is rare in these protected mesic forests.⁸³

Slope forest has undergone a drastic change since the 1950s, the near extinction of one of its dominant, understory species, the Florida torreyia.³⁶¹ The decline of the Florida torreyia is thought to be caused by a fungal infection, although no specific pathogen has been identified to date.³⁶¹ It is unclear and probably too early to tell what long-term effects the absence of this tree will have on the community.

Community Variations: Slope forest can vary with topographic location. Higher elevations with deep sandy soils and thinner leaf mantles may exhibit nearly xeric soil conditions. Lower elevations on slopes near cool streams, or where seepage is prevalent, tend to be cooler, and soils may be nearly hydric. Slight changes in soil moisture along the slope gradient are often reflected by different plant species.^{57,224,361} For example, Florida torreyia, Florida anise, mountain laurel, and tuliptree tend to be associated with lower slopes in soils with higher moisture and organic content, while mockernut hickory, laurel oak, and live oak tend to be associated with upper slopes of better-drained, drier soils.^{57,361} The mid-slope is usually dominated by mesic forest species such as American beech, southern magnolia, and Florida maple.

Associated Communities: Apart from its narrow geographic range, slope forest may be distinguished from upland hardwood forest by steep slopes, a richer diversity of species, and a diversity of species more common to the Appalachian region further north. Two rare species, Florida torreyia and Florida yew are endemic to this community type. Slope forest and upland hardwood forest are mesic communities that can occur in close proximity to one another. Slope forest is often associated with, and grades into, upland pine or sandhill at their upper elevations, and baygall or floodplain communities at their lower elevations. Seepage streams commonly occur along the valley floors of slope forest.

Management Considerations: Slope forests are sensitive to direct physical disturbances and to hydrological manipulations that affect seepage and surface water sources. Their steep slopes are highly susceptible to erosion when un-vegetated or damaged. Common disturbances include logging, development, foot or vehicular traffic, and feral hog rooting. Unsightly refuse dumps are frequently located in slope forest ravines and steepheads. This refuse can bury or damage vegetation and impact stream water quality. Impoundments of streams within ravines can also destroy slope forest on adjacent lower slopes.

The unique assemblage of slope forest plants and animals attracts many outdoor enthusiasts. Uncontrolled collecting by hobbyists and professionals could, however, significantly impact populations of some plants and animals. Slope forests are very rare, and should be protected diligently from human-related disturbances. It is also important that adjoining upland communities be maintained. Disturbances such as logging in these uplands can lead to accelerated erosion in the slope forest below.³⁸⁵

Invasive exotic species can be a problem even in the highest quality slope forest. Species that often invade these forests include coral ardisia (*Ardisia crenata*), Chinese privet (*Ligustrum sinense*), Japanese climbing fern (*Lygodium japonicum*), heavenly bamboo (*Nandina domestica*), and silverthorn (*Elaeagnus pungens*).

Exemplary Sites: Apalachicola Bluffs and Ravines Preserve (Liberty County), Torreya State Park (Liberty County)

Global and State Rank: G2?/S1

Crosswalk and Synonyms: The 1990 Natural Community Guide¹²⁶ defined slope forest in a more general sense based primarily on topography. Many forests in the Florida Panhandle and northern peninsula (e.g., Eglin Air Force Base in Okaloosa, Washington, and Santa Rosa counties, and Goldhead Branch State Park in Clay County) that were previously classified as slope forest would be classified as upland hardwood following this update.

Kuchler	112/southern mixed forest included in 113/southern floodplain forest
Davis	4/mixed hardwoods and pines 12/hardwood forests
SCS	5/mixed hardwood and pine 11/upland hardwood hammocks
Myers and Ewel	Temperate hardwood forests - relict forests
SAF	82/loblolly pine - hardwood
FLUCCS	431/beech - magnolia 434/hardwood - conifer mixed 438/mixed hardwoods 439/other hardwoods

Other synonyms: ravine; steephead²²⁴; mesic hardwood hammock, magnolia beech climax forest⁸³; torrey ravines, bluff and slope forests⁴³⁶



Blue Creek Ravine, with seepage stream (Alachua County)

Photo by Katy NeSmith

Upland Hardwood Forest

Description: Upland hardwood forest is a well-developed, closed-canopy forest dominated by deciduous hardwood trees on mesic soils in areas sheltered from fire. It typically has a diverse assemblage of deciduous and evergreen tree species in the canopy and midstory, shade-tolerant shrubs, and a sparse groundcover. Characteristic canopy trees include southern magnolia (*Magnolia grandiflora*), pignut hickory (*Carya glabra*), sweetgum (*Liquidambar styraciflua*), Florida maple (*Acer saccharum* ssp. *floridanum*), live oak (*Quercus virginiana*), laurel oak (*Q. hemisphaerica*), swamp chestnut oak (*Q. michauxii*), southern hackberry (*Celtis occidentalis*), white ash (*Fraxinus americana*), and loblolly pine (*Pinus taeda*). Species commonly found in Florida Panhandle and northern peninsula but not farther south include American beech (*Fagus grandifolia*), white oak (*Q. alba*), and spruce pine (*Pinus glabra*). The midstory layer is composed of younger canopy species as well as small trees, and tall shrubs, such as American holly (*Ilex opaca*), red bay (*Persea borbonia*), American hornbeam (*Carpinus caroliniana*), gum bully (*Sideroxylon lanuginosum*), devil's walkingstick (*Aralia spinosa*), eastern hophornbeam (*Ostrya virginiana*), flowering dogwood (*Cornus florida*), eastern redbud (*Cercis canadensis*), horse sugar (*Symplocos tinctoria*), American strawberrybush (*Euonymus americanus*), silverbells (*Halesia* spp.), winged elm (*Ulmus alata*), black cherry (*Prunus serotina*), basswood (*Tilia americana*). The groundcover is composed of shade-tolerant herbs, graminoids, and vines, such as partridgeberry (*Mitchella repens*), Virginia creeper (*Parthenocissus quinquefolia*), violets (*Viola* spp.), sedges (*Carex* spp.), sarsaparilla vine (*Smilax pumila*), ebony spleenwort (*Asplenium platyneuron*), woodsgrass (*Oplismenus hirtellus*), and longleaf woodoats (*Chasmanthium laxum* var. *sessiliflorum*). Trilliums (*Trillium* spp.) can be found in the groundcover in the Panhandle and northern peninsula.

Upland hardwood forest occurs on rolling mesic hills, slopes above river floodplains, in smaller areas on the sides of sinkholes, and occasionally on rises within floodplains. Limestone or phosphatic rock may be near the surface. Soils are generally sandy clays or clayey sands with substantial organic and sometimes calcareous components. These soils have higher nutrient levels than the sandy soils prevalent in most of Florida. The moisture retention properties of clays and layers of leaf mulch conserve soil moisture and create decidedly mesic conditions. The dense canopy and multiple layers of midstory vegetation restrict air movement and light penetration, which maintains high relative humidity within the community.

Characteristic Set of Species: flowering dogwood, American beech, southern magnolia, white oak, horse sugar

Rare Species: Over fifty species of rare plants occur in upland hardwood forest throughout its range. These include heartleaf (*Hexastylis arifolia*), pygmy-pipes (*Monotropis reynoldsiae*), sweet-shrub (*Calycanthus floridus*), trout lily (*Erythronium umbilicatum*), several species of spiny-pods (*Matelea floridana*, *M. alabamensis*, *M. flavidula*), trailing arbutus (*Epigaea repens*), and the endemic Marianna columbine (*Aquilegia canadensis* var. *australis*). Several animal species reach their southern limit within upland hardwood forest in northern Florida: four-toed salamander (*Hemidactylium scutatum*), copperhead (*Agkistrodon contortrix*), Louisiana waterthrush (*Seiurus motacilla*), American redstart (*Setophaga ruticilla*), worm-eating warbler (*Helmitheros vermivorum*), and eastern chipmunk (*Tamias striatus*).

Range: Upland hardwood forest occurs throughout the southeastern coastal plain from the Carolinas to east Texas.³²⁸ Upland hardwood forest occurs in the Florida Panhandle south to the central peninsula.^{359,416} Upland hardwood forest most commonly occurs within the inland portions of the state.

Natural Processes: Light gap succession is the driving force behind tree recruitment in upland hardwood forest and can happen at many different scales from single tree sized gaps to larger canopy openings.^{57,328} Localized damage from low intensity, naturally occurring fires that creep into the forest edges from surrounding pyrogenic upland communities (e.g., upland pine, sandhill) appears to be a natural part of the forest dynamics of upland hardwood forest; however, fires rarely burn completely through the understory, and even less frequently lead to crown or devastating fires.¹⁹ Hurricanes are another irregular natural process by which the canopy opens and the forest regenerates.¹⁹

Community Variations: Geographic differences in species composition can be noted through the range of this community. Upland hardwood forest of the Panhandle support several herbaceous species that are more common north of Florida, including woodland pinkroot (*Spigelia marilandica*), bloodroot (*Sanguinaria canadensis*), heartleaf (*Hexastylis arifolia*), May apple (*Podophyllum peltatum*), and several species of trilliums (*Trillium underwoodii*, *Trillium decipiens*). In the peninsula, the proportion of evergreens tends to increase and species richness in the canopy decreases as northern deciduous species (e.g. American beech, white oak) reach their southern limits.^{145,328}

Upland hardwood forest is generally considered a mesic forest. However it may occur along a wide range of moisture conditions such as along upper slopes and ecotones along upland communities where it can be dominated by species tolerant of drier conditions (e.g., laurel oak, live oak). Upland hardwood forest occurring in the Mariana Lowlands (e.g., Florida Caverns State Park) is noted for its calcareous slopes and prominent limestone outcrops on rich clayey soils, and abundance of northern spring ephemeral species.^{275,328} Upland hardwood forest species can invade pyrogenic communities where fire is excluded; however the forests that develop in this manner have a mixed species composition representing both community types.⁵⁷ Upland mixed woodland may develop in the ecotone of upland hardwood forest and adjacent sandhill or upland pine in the Panhandle and northern peninsula.

One common variant of upland hardwood forest occurs within Florida.

Variant: DRY UPLAND HARDWOOD FOREST – Occurring along upper slopes of upland hardwood or slope forest, on sandy ridges within more mesic upland hardwood forest, and mostly found in the northern peninsula where upland hardwood forests tend to be drier. This drier and more evergreen forest is dominated by laurel oak in the canopy and also includes live oak, pignut hickory (*Carya glabra*), southern magnolia, wild olive (*Osmanthus americanus*), Carolina laurelcherry (*Prunus caroliniana*), the rare Arkansas oak (*Quercus arkansana*), sparkleberry (*Vaccinium arboreum*), and horse sugar. This variant is distinguished from upland mixed woodland by its closed, evergreen canopy of laurel oak rather than an open mixed canopy of pines and deciduous species such as southern red oak (*Quercus falcata*) and sand post oak (*Quercus margaretta*). This variant may have a live oak component in the canopy but is not dominated by live oak; those forests dominated by live oak are usually better classified as mesic hammock.

Associated Communities: Upland hardwood forest often is associated with and grades into upland pine, slope forest, bottomland forest, or hydric hammock. Upland hardwood forest and slope forest are very similar community types which share characteristic species (e.g., American beech, southern magnolia, white oak) and forest structure. Upland hardwood forest differs from slope forest primarily by its lack of the abundance and high diversity of rare species characteristic of slope forest (e.g., Florida torreya [*Torreya taxifolia*], fringed campion [*Silene polypetal*], Florida yew [*Taxus floridana*]; see slope forest). Upland hardwood forest differs from mesic hammock by the

presence of northern deciduous species in the canopy and subcanopy (e.g. Florida maple, white oak, white ash, swamp chestnut oak), a lack of cabbage palm (*Sabal palmetto*) and saw palmetto (*Serenoa repens*), and a typically diverse canopy that is not dominated by live oak. Upland hardwood forest located in Central Florida, at the southern end of its range (particularly along the Brooksville Ridge), is often difficult to distinguish from mesic hammock as there is a greater overlap of species in this geographic area. Upland hardwood forest differs from hydric hammocks in that the latter generally occupy lower, flat topography, are dominated by hydrophytic species, and lack American beech and white oak. Upland hardwood forests often contain limestone outcrops.

Management Considerations: Upland hardwood forest often occurs near streams, creeks, and rivers and can provide watershed protection.³⁶² Common disturbances include logging, development, foot or vehicular traffic, and feral hog rooting. Unsightly refuse dumps are frequently located in upland hardwood forests. This refuse can bury or damage vegetation and impact stream water quality.

Damage from invasive exotic plants and animals is a common problem in upland hardwood forest. Plant species that often invade these forests include coral ardisia (*Ardisia crenata*), Chinese privet (*Ligustrum sinense*), camphor tree (*Cinnamomum camphora*), Japanese climbing fern (*Lygodium japonicum*), and heavenly bamboo (*Nandina domestica*). Feral hog (*Sus scrofa*) foraging (rutting) damages soil and vegetation, may interfere with forest regeneration, and can lead to erosion problems, especially on slopes.

Exemplary Sites: Florida Caverns State Park (Jackson County), Wakulla Springs State Park (Wakulla County), Ichetucknee River State Park (Columbia County), Withlacoochee State Forest (Hernando County)

Global and State Rank: G5/S3

Crosswalk and Synonyms:

Kuchler	112/Southern Mixed Forest
Davis	4/Mixed Hardwoods and Pines
	12/Hardwood Forests
SCS	11/Upland Hardwood Hammocks
	15/Oak Hammocks
Myers and Ewel	Temperate hardwood forests
SAF	76/Shortleaf Pine - Oak
FLUCCS	431/Beech - Magnolia
	434/Hardwood - Conifer Mixed
	438/Mixed Hardwoods

Other synonyms: upland mixed forest in part¹²⁶; southern mixed hardwood forest¹⁹; mesic hardwood forest²⁷⁵



Salt Lake Wildlife Management Area (Brevard County)

Photo by J. Richard Abbott

Mesic Hammock

Description: Mesic hammock is a well-developed evergreen hardwood and/or palm forest on soils that are rarely inundated. The canopy is typically closed and dominated by live oak (*Quercus virginiana*), with cabbage palm (*Sabal palmetto*) generally common in the canopy and subcanopy. Southern magnolia (*Magnolia grandiflora*) and pignut hickory (*Carya glabra*) may be occasional in the subcanopy. These species become less important where they reach their southern extent just north of Lake Okeechobee. South of this region, the overstory may contain a few tropical species such as gumbo limbo (*Bursera simaruba*) and satinleaf (*Chrysophyllum oliviforme*). Water oak (*Q. nigra*) and laurel oak (*Q. hemisphaerica*) may also be frequent in this community. Other than pignut hickory, only a few deciduous species such as sweetgum (*Liquidambar styraciflua*) and sugarberry (*Celtis laevigata*) are found in the canopy and subcanopy layers. Pine trees, particularly slash pine (*Pinus elliotii*) or loblolly pine (*P. taeda*), may form a sparse emergent layer.

The shrubby understory may be dense or open, tall or short, and is typically composed of a mix of saw palmetto (*Serenoa repens*), American beautyberry (*Callicarpa americana*), American holly (*Ilex opaca*), gallberry (*I. glabra*), sparkleberry (*Vaccinium arboreum*), hog plum (*Ximenia americana*), common persimmon (*Diospyros virginiana*), highbush blueberry (*Vaccinium corymbosum*), Carolina laurelcherry (*Prunus caroliniana*), yaupon (*I. vomitoria*), wild olive (*Osmanthus americanus*), and/or wax myrtle (*Myrica cerifera*). Tropical shrubs such as Simpson's stopper (*Myrcianthes fragrans*), myrsine (*Rapanea punctata*), and wild coffee (*Psychotria nervosa*) are common in more southern mesic hammock. The herb layer is often sparse or patchy and consists of various graminoids, including low panic grasses (*Panicum* spp.), witchgrasses (*Dichantherium* spp.), woodsgrass (*Oplismenus hirtellus*), longleaf woodoats (*Chasmanthium laxum* var. *sessiliflorum*), sedges (Cyperaceae), and whip nutrush (*Scleria triglomerata*), as well as various ferns and forbs such as bracken fern (*Pteridium aquilinum*) and partridgeberry (*Mitchella repens*). Toothpetal false rein orchid (*Habenaria floribunda*) and other ground orchids are occasional.

In the central and southern peninsula, abundant epiphytes on live oaks and cabbage palms are a characteristic feature of mesic hammocks. In addition to the ubiquitous Spanish moss (*Tillandsia usneoides*) and other air-plants (*Tillandsia* spp.), epiphytic ferns such as resurrection fern (*Pleopeltis polypodioides* var. *michauxiana*), golden polypody (*Phlebodium aureum*), and shoestring fern (*Vittaria lineata*) are common in undisturbed stands. The most northern ranging epiphytic orchids in Florida, green fly orchid (*Epidendrum conopseum*) and Florida butterfly orchid (*Encyclia tampensis*), occur in mesic hammock. Vines are common and often abundant, occasionally creating a solid groundcover in disturbed hammocks. Species include muscadine (*Vitis rotundifolia*), sarsaparilla vine (*Smilax pumila*), greenbriers (*Smilax* spp.), yellow jessamine (*Gelsemium sempervirens*), eastern poison ivy (*Toxicodendron radicans*), crossvine (*Bignonia capreolata*) and Virginia creeper (*Parthenocissus quinquefolia*).

Mesic hammock may occur as “islands” on high ground within basin or floodplain wetlands, as patches of oak/palm forest in dry prairie or flatwoods communities, on river levees, or in ecotones between wetlands and upland communities. Historically, mesic hammocks were likely restricted to naturally fire-protected areas such as islands and peninsulas of lakes.¹⁵⁶ Other landscape positions that can provide protection from the spread of fire from one or more directions are thus likely places for mesic hammock development. These include edges of lakes, sinkholes, other depressional or basin wetlands, and river floodplains.

Soils of mesic hammock are sands mixed with organic matter and may have a thick layer of leaf litter. Rock outcrops are common in some hammocks, especially where limestone is near the surface. In South Florida, tree islands in the Everglades occasionally develop mesic hammock on organic soils, while further west in the Big Cypress, soils supporting mesic hammock are sandier.⁴²⁴ Mesic hammocks occupy soils that, although well-drained, maintain high moisture by heavy shading of the ground layer and accumulation of litter.⁴¹⁶ Although mesic hammock is not generally considered a fire-adapted community, some small patches of hammock occurring as islands within marshes or prairies may experience occasional low-intensity ground fires.

Characteristic Set of Species: live oak, southern magnolia, cabbage palm, pignut hickory, American beautyberry

Rare Species: Rare plants occurring in mesic hammock include auricled spleenwort (*Asplenium erosum*), dwarf spleenwort (*Asplenium pumilum*), hammock rein orchid (*Habenaria distans*), Cooley’s water-willow (*Justicia cooleyi*), Florida spiny-pod (*Matelea floridana*), pigmypipes (*Monotropis odorata*), plume polypody (*Pecluma plumula*), terrestrial peperomia (*Peperomia humilis*), pinkroot (*Spigelia loganioides*), green ladies’-tresses (*Spiranthes polyantha*), Peters’ bristle fern (*Trichomanes petersii*), Craighead’s nodding-caps (*Triphora craigheadii*), and Rickett’s nodding-caps (*Triphora rickettii*).

Rare animals that commonly utilize mesic hammocks include eastern diamondback rattlesnake (*Crotalus adamanteus*), eastern indigo snake (*Drymarchon couperi*), Cooper’s hawk (*Accipiter cooperii*), short-tailed hawk (*Buteo brachyurus*), crested caracara (*Caracara cheriway*), swallow-tailed kite (*Elanoides forficatus*), Rafinesque’s big-eared bat (*Corynorhinus rafinesquii*), Florida panther (*Puma concolor coryi*), southeastern weasel (*Mustela frenata olivacea*), Florida long-tailed weasel (*M. f. peninsulæ*), southeastern bat (*Myotis austroriparius*), mangrove fox squirrel (*Sciurus niger avicennia*), and Florida black bear (*Ursus americanus floridanus*).

Range: Mesic hammock occurs throughout most of the Florida peninsula southward to Dade and Collier counties. It also extends north to North Carolina and west through the Florida Panhandle to Texas, although it is uncommon except near the coast in these areas. Mesic hammock is most common in Central Florida, south of the range of most deciduous tree species found in upland hardwood forests; however, these two communities overlap broadly in distribution in the eastern Panhandle, on the Brooksville Ridge, and in the northern peninsula.¹⁴⁵

The term “hammock” often refers to a variety of hardwood forest types. In Florida, the name has been applied specifically to evergreen hardwood forests.¹⁵⁵ Harper¹⁵⁶ noted that this type of vegetation was predominant on peninsulas and islands in the Lake Region of Florida, and contrasted with the pine savannas of the surrounding land.

Natural Processes: Mesic hammocks are not considered fire-adapted communities, although cabbage palms are fire tolerant and live oaks have a limited capacity to re-sprout from rhizomes.^{52,423} These species tend to dominate in small mesic hammocks found in prairies that experience frequent low intensity fires.⁴¹⁶ Destructive ground fires capable of killing most of the hammock vegetation are possible on organic substrates where the upper soil layer may be completely consumed, damaging roots and preventing resprouting.⁴²⁴ Although mesic hammock may develop on many soil types in peninsular Florida if protected from fire, whether naturally or artificially, there is evidence that more fertile soils will support hammocks even in the presence of regular fire.^{160,366}

Mesic hammock can arise in pyrogenic, naturally pine-dominated areas when shielded from fire as a result of human activities, a common example being old home sites overgrown with oaks and cabbage palms. Once mature, oaks and cabbage palms can provide shade and leaf litter that subsequently “fire-proof” an area and allow for the establishment of other hammock species.^{74,79} Hardwoods will also invade from the edges of natural hammocks into pine-dominated communities in the absence of fire. These invading hammocks are generally more species-depauperate than natural hammocks in the understory and often have an emergent pine canopy.⁴¹⁶ Even in areas that are often burned, frequent cool season burn regimes may still allow oak regeneration in pine-dominated communities and lead to hammock development.¹⁸⁷

Mesic hammocks in South Florida contain a variety of tropical species that may be significantly influenced by frost events, although some species may be able to re-sprout from rootstock or surviving branches.⁴¹⁶ Occasional natural disturbances, mainly wind, fire, and flooding, can also lead to variation in floristic composition among sites and across time within a site and maintain a state of non-equilibrium.^{328,416} Infrequent deep floods, even in higher areas along floodplains, can favor live oaks.⁴²³ Mesic hammock occurs across a broad gradient of soil moisture conditions, from somewhat xeric to almost hydric soils, and oak species characteristic of hammocks tend to show a broader tolerance of this range of conditions than do oaks in other habitats.⁵²

Community Variations: Latitude is a primary cause of variation in species composition in mesic hammocks, with southern magnolia and pignut hickory common in central to northern hammocks, but absent from the southernmost hammocks. Tropical species gradually increase in frequency from the central to southern peninsula. Small portions of tree islands in the Everglades region may become dry enough to support a semi-tropical mesic hammock, although most “high hammocks” in South Florida are rockland hammock occurring on limestone.²⁴⁹

Because some mesic hammocks develop as a result of fire exclusion within historically pine-dominated communities, species composition can be dependent on fire history. Vegetation in hammocks of more recent origin is typically intermediate to that of flatwoods communities, with saw palmetto, coastalplain staggerbush (*Lyonia fruticosa*), and shiny blueberry (*Vaccinium myrsinites*) frequent in the understory below an emergent pine canopy.

In addition to the typical form of mesic hammock, two variations are further classified here.

Variants: PRAIRIE MESIC HAMMOCK – Isolated patches of mesic hammock occurring within a larger matrix of pyrogenic vegetation, usually dry prairie or mesic flatwoods, but occasionally on higher rises within a basin marsh, wet prairie, or wet flatwoods. These hammocks may experience low intensity fires on a regular basis, leading to a somewhat species-depauperate canopy of cabbage palm, live oak, or a mixture of the two species, with saw palmetto common in the understory. Also see Hydric Hammock in this guide for description of prairie hydric hammock.

Associated Communities: Mesic hammock differs from hydric hammock by the absence of wetland trees such as sweetbay (*Magnolia virginiana*) and swamp tupelo (*Nyssa sylvatica* var. *biflora*), as well as by the presence of such mesic tree species as southern magnolia and pignut hickory. Live oak is common in both communities. Soils are better drained in a mesic hammock than in a hydric hammock. These two hammock types often occur as intermixed stands.

Xeric hammock is dominated by sand live oak, myrtle oak (*Quercus myrtifolia*), and other species of excessively drained sands. Mesic hammocks that are intermediate with xeric hammocks may include sand live oak (*Q. geminata*) in addition to live oak. Maritime hammock may have nearly identical dominant vegetation but is found exclusively in coastal situations on sand substrates of recent origin.

Upland hardwood forest, the predominant hardwood forest community found in the Panhandle and northern peninsular Florida, has greater tree species diversity, including many deciduous broad-leaved trees such as swamp chestnut oak (*Q. michauxii*), white oak (*Q. alba*), and flowering dogwood (*Cornus florida*). Upland hardwood forest is typically found on loamy or clay-based soils rather than the more sandy soils which support mesic hammock.

Mesic hammocks may be distinguished from tropical rockland hammocks by the dominance of temperate species in the canopy. Rockland hammock is comprised of predominantly tropical woody species, and occurs on limestone or very shallow soils overlying limestone, rather than sandy or organic soils.

Mesic hammock is often a result of anthropogenic fire exclusion in pine-dominated natural communities. Older mesic hammocks should have a canopy of mature live oaks and cabbage palms. Young hammocks are often the result of hardwood invasion into historic pine communities. These areas often have a dense cover of younger mature water oak and laurel oak trees. If the community is altered significantly (and thus can no longer be considered a pine-dominated, fire-maintained system), the resultant community is a successional hardwood forest. This allows some distinction between mature mesic hammocks and vegetation that is clearly second growth.

Management Considerations: Mesic hammocks are of considerable importance to wildlife, providing cover, nesting sites, and hardwood mast. Migratory birds use hammocks for resting cover and foraging, and animals of neighboring wetland communities may take refuge in mesic hammock islands during floods.⁴¹⁶ Many mesic hammocks have experienced disturbances from human activities, especially since these hammocks provide desirable home, camp, and recreation sites. Logging, understory clearing, cattle grazing, and introduction of feral hogs have altered natural mesic hammock canopies and disturbed soils. Cattle trample understory plants as they take refuge from the heat in shaded oak hammocks, and rooting by hogs causes severe soil disturbance.

Past and ongoing disturbance leaves hammocks vulnerable to invasion by a wide variety of exotic invasive plants which compete with native plants and often become the dominant ground or vine cover. Rosary pea (*Abrus precatorius*), coral ardisia (*Ardisia crenata*), air-potato (*Dioscorea bulbifera*), Japanese climbing fern (*Lygodium japonicum*), melaleuca (*Melaleuca quinquenervia*), skunk vine (*Paederia foetida*), guava (*Psidium guajava*), Brazilian pepper (*Schinus terebinthifolius*), tropical soda apple (*Solanum viarum*), bowstring hemp (*Sansevieria hyacinthoides*), wedelia (*Sphagneticola trilobata*), and Caesar's weed (*Urena lobata*) are common exotic pest plants that invade mesic hammocks. EPPC¹¹⁴ reports that these species displace native species in natural habitats or that they have the most potential to do so in the future. Consumption of oak mast by feral hogs also puts stress on native animal species that must compete for food resources. White-tailed deer, turkey, and Florida black bear are negatively impacted, particularly during low mast years.⁴¹⁶

Because mesic hammocks are often associated with wetlands, either occurring as a matrix with hydric communities or as a transition to uplands, hammocks are sensitive to hydrologic alteration in the landscape. An increase in flooding frequency and/or duration can kill most characteristic mesic hammock tree species. Lowered water tables can result in a shift in vegetation to more xeric species or allow intense fires to burn and destroy the hammock. Intense fires can also destroy hammocks, particularly where surrounding uplands have been fire-excluded in the past.^{416,424}

Early aerial photography and accounts of Florida's natural areas show that mesic hammocks originally existed in small, naturally fire-excluded pockets. Widespread fire suppression throughout the 20th century has made this community far more common.⁴¹⁶ Placement of firebreaks around hammocks can disrupt the natural ecotones with surrounding pyrogenic communities. Ecological management and protection of mesic hammock habitats should include limitations on development and grazing, restoration of natural fire regimes and hydrology in the overall landscape, and control of invasive species.

Exemplary Sites: Lake Panasofkee Outlet (Sumter County), Little Big Econ State Forest (Seminole County), Flying Eagle Ranch (Citrus County), Three Lakes Wildlife Management Area (Osceola County), Highlands Hammock State Park (Highlands County), Withlacoochee State Forest (Sumter County), Okaloacoochee Slough State Forest (Hendry County; Prairie Mesic Hammock variant), and Little River Conservation Area (Suwannee County)

Global and State Rank: G3/S3?

Crosswalk and Synonyms: The term “mesic hammock” is often used broadly in the literature to denote any non-bottomland hardwood forest. This classification attempts to split these types into three main groups that are similar to Greller.¹⁴⁵ Greller’s “southern mixed hardwood forest” is broadly comparable to FNAI’s Upland Hardwood Forest, his Temperate Broadleaf Evergreen Forest to FNAI’s Mesic Hammock, and his Tropical Forest to FNAI’s Rockland Hammock. The divisions drawn between these types, however, vary between the two systems.

Kuchler	112/Southern Mixed Forest
Davis	12/Upland Hardwood Forests
SCS	11/Upland Hardwood Hammocks
	15/Oak Hammocks
Myers and Ewel	Temperate Hardwood Forests
SAF	89/Live Oak
	105/Tropical Hardwoods
FLCFC	425/Temperate Hardwood
	426/Tropical Hardwoods
	427/Live Oak

Other synonyms: *Magnolia grandiflora-Quercus virginiana* association (MQa)⁷⁷; TBEF/SMHF – TBEF – TBEF/TRF¹⁴⁵; prairie hammock - in part¹²⁶; high hammock - in part⁵



Matheson Hammock (Miami-Dade County)

Photo by Gary Knight

Rockland Hammock

Description: Rockland hammock is a rich tropical hardwood forest on upland sites in areas where limestone is very near the surface and often exposed. Greater than 120 native tree and shrub species make up the diverse closed canopy and shrub layers, most of which reach the northern extent of their ranges in Florida.^{133,381} The forest floor is largely covered by leaf litter with varying amounts of exposed limestone and has few herbaceous species. Rockland hammocks typically have larger more mature trees in the interior, while the margins can be almost impenetrable in places with dense growth of smaller shrubs, trees, and vines.^{322,439} There are differences in species composition between rockland hammocks found in the Florida Keys and the mainland (see Community Variations below). Typical canopy and subcanopy species include, gumbo limbo (*Bursera simaruba*), false tamarind (*Lysiloma latisiliquum*), pigeon plum (*Coccoloba diversifolia*), false mastic (*Sideroxylon foetidissimum*), strangler fig (*Ficus aurea*), Jamaican dogwood (*Piscidia piscipula*), lancewood (*Ocotea coriacea*), milkbark (*Drypetes diversifolia*), paradisetrete (*Simarouba glauca*), willow bustic (*Sideroxylon salicifolium*), black ironwood (*Krugiodendron ferreum*), inkwood (*Exothea paniculata*), live oak (*Quercus virginiana*), poisonwood (*Metopium toxiferum*), and West Indies mahogany (*Swietenia mahagoni*). Mature hammocks can be open beneath a tall well-defined canopy and subcanopy. More commonly, in less mature or disturbed hammocks, dense woody vegetation of varying heights from canopy to short shrubs is often present. Species that generally make up the shrub layers within rockland hammock include several species of stoppers (*Eugenia* spp.), thatch palms (*Thrinax morrisii* and *T. radiata*), sea torchwood (*Amyris elemifera*), marlberry (*Ardisia escallonioides*), wild coffee (*Psychotria nervosa*), satinleaf (*Chrysophyllum oliviforme*), cabbage palm (*Sabal palmetto*), lignum-vitae (*Guaiaacum sanctum*), hog plum (*Ximenia americana*), soldierwood (*Colubrina elliptica*), two species of blackbead (*Pithecellobium unguis-cati* and *Pithecellobium keyense*), seagrape (*Coccoloba uvifera*), and greenheart (*Colubrina arborescens*). Vines can be common and include eastern poison ivy (*Toxicodendron radicans*), earleaf greenbrier (*Smilax auriculata*), Everglades greenbrier (*Smilax havanensis*), Virginia creeper (*Parthenocissus quinquefolia*), medicine vine (*Hippocratea volubilis*), and redgal (*Morinda royoc*). The typically sparse short shrub layer may include coontie (*Zamia pumila*), and dildoe cactus (*Acanthocereus tetragonus*). Herbaceous species are occasionally present and generally sparse in coverage. Characteristic species include smallcane (*Lasiacis divaricata*), woodsgrass (*Oplismenus hirtellus*) and many species of ferns (i.e., *Nephrolepis biserrata*, and *Thelypteris kunthii*) among others. Epiphytes, including orchids, ferns, and bromeliads, are often common on larger trees.

Rockland hammock occurs on a thin layer of highly organic soil covering limestone on high ground that does not regularly flood,³⁰⁴ but it is often dependent upon a high water table to maintain reservoirs in solution features of the limestone and to keep humidity levels high. Organic acids can dissolve the surface limestone causing collapsed depressions in the surface rock called solution holes.³¹¹ Rockland hammocks are frequently located near wetlands; in the Everglades they can occur on raised peaty platforms above surrounding wetlands; in the Keys they occur inland from tidal flats. They also can occur within a larger matrix of pine rockland, but are now most commonly found as islands surrounded by development or agriculture.

Characteristic Set of Species: gumbo limbo, pigeon plum, stoppers

Rare Species: Rare species are abundant within rockland hammock. Although some widespread rare species occur in rockland hammock as well as many other habitats (e.g. eastern indigo snake [*Drymarchon couperi*]), many rare species of plants and animals, are more specific to this habitat. Most rare plants typical of rockland hammock are tropical plant species more widespread outside the U.S. and have extremely limited distributions within the U.S (Table 1). Characteristic rare animals include Key Largo woodrat (*Neotoma floridana smalli*), Key Largo cotton mouse (*Peromyscus gossypinus* pop. 1), key deer (*Odocoileus virginianus clavium*), white-crowned pigeon (*Patagioenas leucocephala*), mangrove cuckoo (*Coccyzus minor*), black-whiskered vireo (*Vireo altiloquus*), red rat snake, Florida Lower Keys population (*Elaphe guttata* pop. 1), rim rock crowned snake (*Tantilla oolitica*) and Lower Keys ribbon snake (*Thamnophis sauritus* pop. 1). Schaus' swallowtail (*Papilio aristodemus ponceanus*), tree snail (*Liguus fasciatus*), Florida Keys tree snail (*Orthalicus reses nesodyras*), Keys scaly cricket (*Cycloptilum irregularis*) and Strohecker's ivory-spotted long-horned beetle (*Eburia stroheckeri*) are among the many rare invertebrates that inhabit rockland hammock.

Range: Rockland hammocks are globally imperiled and extremely limited in distribution. In Florida, rockland hammock occurs in three general areas: along the southern extreme of the Atlantic Coastal Ridge, also known as the Miami Rock Ridge, which extends from around downtown Miami southwest to Mahogany Hammock in Everglades National Park (Miami-Dade County); throughout the Florida Keys (Monroe County); and to a very limited extent in the Big Cypress Region (Monroe and Collier counties). Similar dry tropical forests occur in the Bahamas and West Indies,^{20,65,322} and the Yucatan peninsula.²⁴⁵ The tremendous development and agricultural pressures in the rapidly urbanizing areas where rockland hammock occurs have greatly reduced the extent of this community. Additionally, remnant pine rockland fragments that occur within developed areas under some conditions can succeed to rockland hammock without fire management.

Natural Processes: Rockland hammock is a rare community that is susceptible to fire, frost, canopy disruption, and ground water reduction. The dense canopy minimizes temperature fluctuations by reducing soil warming during the day and heat loss at night, which helps prevent frost damage to the interior of the hammock.³¹¹ Mesic conditions are further maintained by the hammock's rounded profile, which deflects winds, thus limiting desiccation during dry periods and reducing interior storm damage. Rockland hammock can be the advanced successional stage of pine rockland, especially in cases where rockland hammock is adjacent to pine rockland where hardwood seed rain is high. In such cases, when fire is excluded from pine rockland for 15-25 years it can succeed to rockland hammock vegetation⁴²⁴ that can retain a relict overstory of pine.³⁸¹ Historically rockland hammocks in South Florida evolved with fire in the landscape, fire most often extinguishing near the edges when it encounters the hammock's moist microclimate and litter layer, or a natural moat that can form around hammocks in the Everglades caused by the dissolution of limestone.⁴³⁹ However, rockland hammocks are susceptible to damage from fire during extreme drought or when the water table is lowered. In these cases fire can cause tree mortality and consume the organic soil layer.³⁰⁴ Although rockland hammock can reestablish within 25 years after fire, maximum development of structure and diversity probably requires more than 100 fire-free years. The ecotone between rockland hammock and pine rockland is abrupt when regular fire is present in the adjacent pine rockland. However when fire is removed, the ecotone becomes more gradual as hardwoods from the hammock push out into the pineland.⁴²⁴

Rockland hammocks are also sensitive to the strong winds and storm surge associated with infrequent hurricanes. Canopy damage often occurs, which causes a change in the microclimate of the hammock. Decreased relative humidity and drier soils can leave rockland hammocks more susceptible to fire.²⁴⁵

Community Variations: The hammocks on the Florida Keys tend to be drier than those on the mainland because of increased ocean breezes and lowered rainfall.⁴³⁹ They also have a higher percentage of tropical species in part because many temperate species, such as live oak, swamp bay (*Persea palustris*), sugarberry (*Celtis laevigata*), and

coontie, reach their southern limits on the mainland or in the northern Keys. Many tropical tree species within Florida, such as rough strongbark (*Bourreria radula*) and lignum-vitae only occur in rockland hammocks of the Keys.

In the Keys, there is a structural difference between the rockland hammocks north and south of Big Pine Key. This is at least partially due to differences in geology, ground water salinity and rainfall. The surface rock in the northern Keys from Soldier Key to Big Pine Key is Key Largo Limestone; the south portion from Big Pine Key to Key West is Miami Oolite. The Key Largo limestone is more permeable than the Miami Oolite and therefore hammocks in the upper Keys tend to have higher ground water salinities.³⁴⁵ Rainfall also decreases from the northern to southern Keys.⁴³⁹ Much taller, more developed tree canopies (near 35 feet tall) occur in the northern section, while the hammocks in the southern section are a more scrubby, xeric form of rockland hammock which average less than 20 feet tall.³⁸¹ These often impenetrable hammocks in the southern keys have previously been referred to as “low hammock” or “Keys hammock thicket.”³⁸¹

Within the southern Everglades, rockland hammock rarely may develop in the center of tear-drop shaped islands surrounded by glades marsh (e.g., Grossman and Mahogany Hammocks). In these cases, the hammock develops on organic matter that accumulates on top of the underlying limestone.³¹¹

One common variant of rockland hammock occurs within Florida.

Variant: THORN SCRUB – occurring along the ecotone of rockland hammock with Keys tidal rock barren or Keys cactus barren or within openings in rockland hammock. Thorn scrub is a low-statured scrubby hammock dominated by spiny species such as saffron plum (*Sideroxylon celastrinum*), blackbead, and hog plum as well as buttonwood (*Conocarpus erectus*), blolly (*Guapira discolor*), brittle thatch palm (*Thrinax morissii*), poisonwood, devil’s smooth-claw (*Pisonia rotundata*) and other rockland hammock species. This transition zone is variously referred to as “Keys hammock thicket”⁹³, “transitional thorn woodland”³⁴⁵, or “cactus scrub”¹⁵, in reference to its short stature and the prevalence of spiny species.

Associated Communities: Rockland hammock can grade into glades marsh, mangrove swamp, salt marsh, Keys cactus barren, Keys tidal rock barren, pine rockland, maritime hammock (e.g. Sands & Elliott Keys), or marl prairie. Rockland hammock can be distinguished from pine rockland in having a closed, hardwood canopy rather than an open pine canopy. Rockland hammock can have almost the same structure and species composition as the tropical form of maritime hammock. It differs by being on a rock substrate rather than the sand or shell substrate of barrier islands or high energy coasts. On the mainland in the northern extent of the range of rockland hammock, it can resemble mesic hammock, which is dominated by live oak in the canopy, but may contain some tropical species. Although rockland hammock can include minor temperate canopy components (i.e., live oak, sugarberry), it can be distinguished from mesic hammock by its rocky substrate and dominance of tropical tree species in the canopy.

Management Considerations: Rockland hammock occurs on prime development property and is disappearing rapidly. Many pieces that have been protected through land acquisition programs occur as islands within developed and developing lands. This poses management problems in terms of edge effects (e.g., trash dumping, exotic plant infestation, exotic and feral animal control) and loss of the natural ecotone that forms between the hammock and the adjacent (often fire-maintained) community. Some plants and animals of rockland hammocks (e.g., tree snails, orchids, bromeliads) are susceptible to collection pressures and must be protected from collectors.

Exotics plant species infestations are an ongoing problem in rockland hammock. Species such as Brazilian pepper (*Schinus terebinthifolius*), lead tree (*Leucaena leucocephala*), seaside mahoe (*Thespesia populnea*), latherleaf (*Colubrina asiatica*), and sapodilla (*Manilkara zapota*) invade and displace native species. Dumping of yard waste can lead to the invasion of species such as bowstring hemp (*Sansevieria hyacinthoides*) and golden pothos (*Epipremnum pinnatum*).

Exemplary Sites: Dagny Johnson Key Largo Hammock Botanical State Park (Monroe County Keys), John Pennekamp Coral Reef State Park (Monroe County Keys), Lignumvitae Key Botanical State Park (Monroe County Keys), Matheson Hammock (Miami-Dade County), Royal Palm Hammock, Everglades National Park (Miami-Dade County)

Global and State Rank: G2/S2

Crosswalk and Synonyms:

Kuchler	105/Mangrove 116/Subtropical Pine Forest
Davis	1/Coastal Strand 3/Southern Slash Pine Forests 14/Region of open Scrub Cypress 16b/Everglades Region Marshes, Sloughs, Wet Prairies and Tree Islands
SCS	1/South Florida Coastal Strand 14/Tropical Hammocks
Myers and Ewel	Subtropical Forests - high or rockland hammocks
SAF	105/Tropical Hardwoods 89/Live Oak
FLUCCS	426/Tropical Hardwoods 427/Live Oak

Other synonyms: Low, medium, and high productivity rockland hammock³⁴⁵; evergreen seasonal forest²⁰



Everglades National Park (Miami-Dade County)

Photo by Amy Jenkins

Table 1. Rare plant species (FNAI tracked) in rockland hammock.

Species Occurring on Both the Mainland and Florida Keys	Species Restricted to the Mainland
	<i>Adiantum melanoleucum</i>
<i>Byrsonima lucida</i>	<i>Asplenium x biscaynianum</i>
<i>Calypttranthes zuzygium</i>	<i>Campyloneurum angustifolium</i>
<i>Catopsis berteroniana</i>	<i>Catopsis floribunda</i>
<i>Coccothrinax argentata</i>	<i>Ctenitis sloanei</i>
<i>Colubrina cubensis</i> var. <i>floridana</i>	<i>Eltroplectris calcarata</i>
<i>Encyclia boothiana</i> var. <i>erythronioides</i>	<i>Eupatorium villosum</i>
<i>Eugenia confusa</i>	<i>Ilex krugiana</i>
<i>Gyminda latifolia</i>	<i>Galeandra bicarinata</i>
<i>Hypelate trifolia</i>	<i>Govenia floridana</i>
<i>Jacquinia keyensis</i>	<i>Lantana canescens</i>
<i>Microgramma heterophylla</i>	<i>Licaria triandra</i>
<i>Prunus myrtifolia</i>	<i>Lomariopsis kunzeana</i>
<i>Psychotria ligustrifolia</i>	<i>Macradenia lutescens</i>
<i>Schaefferia frutescens</i>	<i>Oncidium floridanum</i>
<i>Swietenia mahagoni</i>	<i>Passiflora pallens</i>
<i>Thrinax morrisii</i>	<i>Picramnia pentandra</i>
<i>Thrinax radiata</i>	<i>Tectaria coriandrifolia</i>
<i>Vanilla barbellata</i>	<i>Tectaria fimbriata</i>
	<i>Thelypteris reptans</i>
Species Restricted to the Florida Keys	<i>Trichomanes krausii</i>
<i>Bourreria radula</i>	<i>Tropidia polystachya</i>
<i>Canella winteriana</i>	
<i>Cupania glabra</i>	
<i>Cyperus fuliginosus</i>	
<i>Drypetes diversifolia</i>	
<i>Eugenia rhombea</i>	
<i>Guaiacum sanctum</i>	
<i>Guapira floridana</i>	
<i>Hippomane mancinella</i>	
<i>Jacquemontia havanensis</i>	
<i>Manilkara jaimiqui</i>	
<i>Passiflora multiflora</i>	
<i>Phoradendron rubrum</i>	
<i>Pilosocereus bahamensis</i>	
<i>Pilosocereus robinii</i>	
<i>Pisonia rotundata</i>	
<i>Vallesia antillana</i>	



Lake Wales Ridge State Forest (Polk County)

Photo by Gary E. Schultz

Xeric Hammock

Description: Xeric hammock is an evergreen forest on well-drained sandy soils. The low canopy is more or less closed and dominated by sand live oak (*Quercus geminata*), although Chapman's oak (*Q. chapmanii*), turkey oak (*Q. laevis*), bluejack oak (*Q. incana*), sand post oak (*Q. margaretta*), and laurel oak (*Q. hemisphaerica*) may also be common. An emergent canopy of pine, either sand pine (*Pinus clausa*), slash pine (*P. elliotii*), or longleaf pine (*P. palustris*), may be present. Hammocks that are intermediate with mesic hammock may have some live oak (*Q. virginiana*) in the canopy.

The understory is usually open and consists of shrubs characteristic of either sandhill or scrub, depending on the origin of the hammock. Common understory plants include saw palmetto (*Serenoa repens*), myrtle oak (*Q. myrtifolia*), rusty staggerbush (*Lyonia ferruginea*), fetterbush (*L. lucida*), sparkleberry (*Vaccinium arboreum*), deerberry (*V. stamineum*), black cherry (*Prunus serotina*), American beautyberry (*Callicarpa americana*), common persimmon (*Diospyros virginiana*), scrub palmetto (*Sabal etonia*), Hercules' club (*Zanthoxylum clava-herculis*), wild olive (*Osmanthus americanus*) or scrub wild olive (*O. megacarpus*), garberia (*Garberia heterophylla*), Florida rosemary (*Ceratiola ericoides*), and yaupon (*Ilex vomitoria*). The herb layer is generally very sparse or absent, but may contain some scattered wiregrass (*Aristida stricta* var. *beyrichiana*), sandyfield beaksedge (*Rhynchospora megalocarpa*), witchgrass (*Dichanthelium* spp.), or forbs such as sweet goldenrod (*Solidago odora*). Muscadine (*Vitis rotundifolia*) and earleaf greenbrier (*Smilax auriculata*) are common vines. The epiphytes Spanish moss (*Tillandsia usneoides*) and ballmoss (*T. recurvata*) are often abundant.

Xeric hammock typically develops on well-drained sands where fire-exclusion allows for the establishment of an oak canopy. This may occur naturally, when the area has significant barriers to fire, or more commonly, as the result of human intervention. In these areas, xeric hammock can form extensive stands or can occur as small patches within or near sandhill or scrub. Xeric hammock can also occur on high islands within flatwoods or even on a high,

well-drained ridge within a floodplain. Xeric hammock can occur on barrier islands and in other coastal situations, as an advanced successional stage of scrub.

Characteristic Set of Species: sand live oak, saw palmetto; in scrub derived hammocks – myrtle oak, Chapman’s oak; in sandhill derived hammocks – turkey oak, bluejack oak

Rare Species: Xeric hammock is not considered to be critical habitat for any rare plants tracked by FNAI, although some species adapted to scrub or sandhill communities may persist in hammocks.

Several rare animals commonly utilize xeric hammocks for nesting or foraging. These include gopher frog (*Rana capito*), gopher tortoise (*Gopherus polyphemus*), eastern diamondback rattlesnake (*Crotalus adamanteus*), Florida pine snake (*Pituophis melanoleucus mugitus*), short-tailed snake (*Stilosoma extenuatum*), Cooper’s hawk (*Accipiter cooperii*), short-tailed hawk (*Buteo brachyurus*), and Florida black bear (*Ursus americanus floridanus*).

Range: Xeric hammock in Florida is most common in the central peninsula and its range generally corresponds to the ranges of scrub and sandhill. It is less common north of the Cody Scarp where clayey soils create mesic conditions that instead support upland mixed woodland or mesic hammock in the absence of fire. Xeric hammock probably extends into the coastal Carolinas and Mississippi, roughly equaling the extent of sand live oak.

Natural Processes: Sand live oak and myrtle oak are both clonal species which establish large rhizome systems capable of quickly re-sprouting following injury. Sandhills in which fire has been excluded for seven to 16 years can establish clones of these oak species that may then persist even after fire is re-introduced into the community. The thick bark of sand live oak makes the trees somewhat resistant to fire, particularly after the clone exceeds 2.0 meters in height. These oaks may increase carbohydrates in roots in the fall, making them more capable of re-sprouting after winter burns than summer burns.¹⁴⁶ Thus, cool season burns, especially, are not adequate to kill back these clones, and the establishment of an “oak dome” may then allow expansion to a patch of xeric hammock within the sandhill. The resulting shaded habitat of xeric hammocks can allow more fire-intolerant species such as southern magnolia (*Magnolia grandiflora*) to establish.⁷⁷

Xeric hammocks also form from long unburned oak scrub.²²⁸ Sand live oak and other scrub oaks, in the long-term absence of fire, grow upward to eventually form a canopy that shades the understory and creates a layer of leaf litter, covering open patches of sand and leading to more shaded, mesic ground conditions.

Community Variations: Xeric hammocks derived from scrub typically contain Chapman’s oak, myrtle oak, and saw palmetto. In hammocks derived from scrubby flatwoods, saw palmetto may form a dense monospecific shrub layer. If derived from sand pine scrub, emergent sand pine often persists above the oak canopy. Xeric hammock derived from sandhill will often contain turkey oak, bluejack oak, sparkleberry, and remnant wiregrass. Xeric hammocks that develop from scrub in coastal areas, particularly in the Florida Panhandle, often have some slash pine and southern magnolia in the canopy. Younger hammocks may have a remnant, emergent pine canopy, but the shaded oak habitat is not conducive to pine recruitment.

Associated Communities: Xeric hammock may be distinguished from scrub, scrubby flatwoods, or sandhill by the closed or nearly closed canopy of evergreen oaks. Xeric hammock should not be confused with a dense, impenetrable thicket of shrubby oaks (in the case of oak scrub), or a scattered canopy of oaks with a low ground cover still receiving abundant light (in the case of oak-invaded sandhill or scrubby flatwoods). There can be considerable overlap particularly between xeric hammock and oak scrub or scrubby flatwoods that have been protected from fire, allowing the sand live oaks to attain tree size and begin to form a low canopy. Mesic hammock and maritime hammock are also evergreen oak-dominated forests, but they occur on mesic soils and are dominated by live oak rather than sand live oak. Upland mixed woodland is dominated by an open mixture of pine and deciduous oaks, e.g., southern red oak (*Quercus falcata*) and post oak (*Q. stellata*), along with mockernut hickory (*Carya alba*). Successional hardwood forests, which may also develop in fire-excluded areas, are generally dominated by laurel oak or water oak (*Q. nigra*), rather than sand live oak.

Management Considerations: The spreading oak canopy of xeric hammock provides a shady refuge in otherwise open, sunny areas. As a result, hammocks have long been utilized (and disturbed) by humans seeking comfortable homesites or camping and recreation areas. Feral hog rooting and livestock grazing are sources of soil disturbance.

Xeric hammocks, whether of natural or anthropogenic origin, result from years of fire exclusion or lengthened fire return intervals combined with low intensity winter burning. Oak cover produces a relatively incombustible oak litter and increased shading decreases growth of fine herbaceous fuels. Once sand live oaks form a canopy greater than 2.0 meters in height, even hot summer burns may not be sufficient to kill the dome, which can become established after only seven to 16 years of fire exclusion.¹⁴⁶ At that stage, oaks would be killed only through a severe burn during dry conditions. Otherwise, the spread of oaks could be halted through mechanical removal or the use of herbicides if the management intent is the re-establishment of the fire-maintained community that was replaced by the xeric hammock.

The decision to convert a xeric hammock of anthropogenic origin to its historic condition (sandhill, scrub, or scrubby flatwoods) should be site-specific and should factor in management objectives as well as the current condition of the hammock. For example, a hammock derived from sandhill may still support areas of wiregrass groundcover. Restoration of such a hammock would require fewer resources and could halt further decline of the herbaceous layer. Likewise, the presence of rare species that require open habitats (e.g., gopher tortoise, Florida scrub jay, various plant species) would favor the removal of canopy oaks.

Exemplary Sites: Eglin Air Force Base (Walton, Okaloosa, and Santa Rosa counties), Troy Springs Conservation Area (Lafayette counties), Cedar Keys National Wildlife Refuge – Atsena Otie Key (Levy County), Avon Park Air Force Range (Polk and Highlands counties), Lake Wales Ridge State Forest (Polk County), Welaka State Forest (Putnam County)

Global and State Rank: G3/S3

Crosswalk and Synonyms:

Kuchler	112/Southern Mixed Forest
Davis	12/Hardwood Forests
SCS	3/Sand Pine Scrub
	15/Oak Hammocks
Myers and Ewel	Temperate Hardwood Forests
SAF	72/Southern Scrub Oak
FLUCCS	421/Xeric Oak
	425/Temperate Hardwood
	432/Sand Live Oak

Other synonyms: dry woods

HIGH PINE and SCRUB – hills with mesic or xeric woodlands or shrublands; canopy, if present, open and consisting of pine or a mixture of pine and deciduous hardwoods



Apalachee Wildlife Management Area (Jackson County)

Photo by Amy Jenkins

Upland Mixed Woodland

Description: Upland mixed woodland has an open to partially closed canopy of southern red oak (*Quercus falcata*), mockernut hickory (*Carya alba*), post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), and, black oak (*Quercus velutina*), mixed with shortleaf and/or longleaf pines (*Pinus echinata*, *P. palustris*). Pignut hickory (*Carya glabra*) and white oak (*Quercus alba*) may also be present. The subcanopy includes widely spaced shrubs or small trees of flowering dogwood (*Cornus florida*), sparkleberry (*Vaccinium arboreum*), rusty blackhaw (*Viburnum rufidulum*), sassafras (*Sassafras albidum*), and hawthorns (*Crataegus michauxii*, *C. pulcherrima*). There is a dense ground layer of many species of grasses, forbs, and coppicing hardwoods. Typical ground layer species include New Jersey tea (*Ceanothus americanus*), eastern poison ivy (*Toxicodendron radicans*), eastern poison oak (*Toxicodendron pubescens*), little bluestem (*Schizachyrium scoparium*), slender bluestem (*Schizachyrium tenerum*), yellow indiagrass (*Sorghastrum nutans*), silver plumegrass (*Saccharum alopecuroides*), variable witchgrass (*Dichanthelium commutatum*), dogtongue wild buckwheat (*Eriogonum tomentosum*), and oblongleaf twinflower (*Dyschoriste oblongifolia*), as well as many legumes (*Lespedeza* spp., *Desmodium* spp., *Tephrosia virginiana*) and composites (*Ageratina jucunda*, *Liatris graminifolia*, *Solidago* spp.).

Upland mixed woodland occurs on loamy soils on drier sites than upland hardwood forest and is often found in the ecotone between upland hardwood forest and frequently burned sandhill or upland pine where fires burn into the hardwood forest edge. Its dominant hardwood species are more resistant to fire than are those in the upland hardwood forest and less resistant than those of the sandhills.¹⁵⁷

Characteristic Set of Species: southern red oak, mockernut hickory, post oak, shortleaf pine, longleaf pine, flowering dogwood

Rare Species: Rare plants in upland mixed woodland include Flyr's brickell-bush (*Brickellia cordifolia*), Florida spiny-pod (*Matelea floridana*), gentian pinkroot (*Spigelia gentianoides*), and Bluffs blazing star (*Liatris gholsonii*). Rare animal species found in this community include Sherman's fox squirrel (*Sciurus niger shermani*) and two invertebrates, a beetle, *Mycotrupes cartwrighti*, currently known only from the Tallahassee Red Hills area, and a rare butterfly, the golden-banded skipper (*Autochton cellus*) whose food plant, American hogpeanut (*Amphicarpaea bracteata*), is found in this community.

Range: Upland mixed woodland is found in only a limited area in northern Florida from Jackson to Marion counties^{157,158} and extends a short way into southeastern Georgia.⁴³⁶ Its range largely follows the extent of older uplands in Florida where Plio-Pleistocene sediments near the surface give rise to richer soils, containing more clay, than the usual sandy soils found in most of the state. Much of the former area in upland mixed woodland has long been in cultivation, with only fragments remaining today, and its range has had to be reconstructed from historical accounts.^{56,57} Harper¹⁵⁷ lists the dominant species of this community in five of the regions he maps for northern Florida which extend in a northward-curving arc from Jackson County through Liberty, Leon, Jefferson, Madison, Hamilton, Columbia, and Alachua counties to the vicinity of Ocala in Marion County. It has also been reported from Suwannee, Levy and Gilchrist counties.⁹⁴ With the exception of the Tallahassee Red Hills area of Leon County, where it may have been the predominant cover over large areas,^{45,56,220,360} upland mixed woodland occurs primarily in ecotones between sandhill or upland pine and upland hardwood forest.^{101,125,158,160,170,178,215,394}

Outside Florida, similar pine-oak-hickory communities have been described in Texas,^{153,354} Louisiana,⁸² western Arkansas,³⁸³ and the southern Piedmont.^{369,429} These communities differ somewhat from those in Florida in containing more mesic (white oak, sweetgum [*Liquidambar styraciflua*]) or northern (northern red oak [*Quercus rubra*]) species, but tend to occur in similar situations between drier pine-dominated forests and more mesic hardwood forests. Several lines of evidence, including witness trees noted in General Land Office surveys, reconstruction of stand history from age structure all trees in a stand, and old forest maps, suggest these communities were present in presettlement times and are not the result of logging disturbance.^{82,153,354}

Upland mixed woodland occurs on loamy sands or fine sandy loams, e.g., Orangeburg, Lochloosa, and Kendrick soils.^{57,125} These soils are richer in phosphorus, potassium, and calcium than most Florida soils and often contain phosphatic pebbles.⁴⁰⁰

Community Variations: The canopy dominants are found throughout the range of this community, with the exception of shortleaf pine which does not range southward to Alachua or Marion counties where it is replaced by longleaf pine

Natural Processes: Since upland mixed woodland has not recently been recognized as a distinct community in Florida, little research has been done on the effects of fire in it (although fairly extensive research has been done outside Florida). There is evidence in Florida from charcoal accumulation that fires started in the drier and more flammable sandhill or upland pine community and burned into the upland mixed woodland before extinguishing in the moist litter of the more heavily shaded upland hardwood forest.²⁷⁸ Harper¹⁶² surmised that upland mixed woodland naturally burned less frequently than the adjoining longleaf pine and wiregrass communities, perhaps every 10 years, and other authors have proposed fire intervals of one to two decades.³²⁸ Recent research in other states suggests, however, that this is too long an interval. Ware et al.⁴²⁹ cite 5-10 years as an interval for mixed pine oak forest in the piedmont. In the Upper Coastal Plain of Arkansas a similar pine-oak-hickory woodland community is managed with 3 year fire intervals.³⁸³ An upland mixed woodland at Tall Timbers Research Station in the Florida Panhandle is burned on a 2 year interval and supports a high diversity of native herbaceous plants, while maintaining the hardwood component.³⁴⁰

Associated Communities: Upland mixed woodland is distinguished from sandhill and upland pine by the absence, or low cover of, turkey oak (*Quercus laevis*) and wiregrass (*Aristida stricta* var. *beyrichiana*), and the co-dominance of hardwoods such as mockernut hickory and southern red oak with pines. It can be distinguished from upland hardwood forest by the absence or near absence of such mesic hardwoods as American beech (*Fagus grandifolia*)

and southern magnolia (*Magnolia grandiflora*) and the presence of longleaf and/or shortleaf pines, southern red oak, mockernut hickory, and a diverse ground layer dependent on relatively high light intensity.

Management Considerations: Upland mixed woodland probably burned at longer intervals than adjoining sandhill and upland pine, so allowing prescribed fires in the latter to burn into these bordering areas and naturally extinguish would probably be sufficient to maintain them. Where fire-sensitive hardwoods, such as laurel oak (*Quercus hemisphaerica*), sweetgum, and water oak (*Quercus nigra*), have invaded upland mixed woodland in the absence of fire and grown to (fire-proof) tree size, mechanical removal of these invading species may be necessary to open up the canopy and allow light to reach the ground layer.

There is some question as to whether the occurrence of upland mixed woodland is determined by fire frequency alone or by some other factor in the physical environment. One recent study in the Tallahassee Red Hills area found that depth to the Bt soil horizon was less, and mineral nutrients and pH higher, in stands of upland mixed woodland than in stands dominated by longleaf pine and wiregrass.³⁹³

Exemplary Sites: Three Rivers State Park and Apalachee Wildlife Management Area (Jackson County), Elinor Klapp Phipps Park (Leon County), Tall Timbers Research Station (Leon County) Wakulla Springs State Park (Wakulla County), Ichetucknee Springs State Park (Suwannee/Columbia counties), O'Leno State Park (Columbia County), San Felasco Hammock Preserve State Park (Alachua County)

Global and State Rank: G2/S2

Crosswalk and Synonyms:

Kuchler	112/southern mixed forest
Davis	4/forests of mixed hardwood and pine; 6/forests of longleaf pine and xerophytic oaks
SCS	5/mixed hardwood and pine
Myers and Ewel	temperate hardwoods – high hammock zone
SAF	76/shortleaf pine-oak; 82 loblolly pine-hardwood
FLUCCS	414/pine-mesic oak; 423/oak-pine-hickory
Whitney	Temperate hardwood hammock

Other synonyms: southern red oak forest (Dunn 1982), red oak woods (Harper 1915), hardwood-pine woodlands (Burks 1992), shortleaf pine-oak-hickory (Delcourt 1976), upland pine (in part; Florida Natural Areas Inventory and Chicardi 1993), 83-broadleaf deciduous-needleleaf evergreen upland forest (Wharton 1978)



Blue Springs Tract of Twin Rivers State Forest (Hamilton County)

Photo by Carolyn Kindell

Upland Pine

Description: Upland pine is a woodland of widely spaced pines with a sparse to moderate shrub layer and a dense, species-rich groundcover of grasses and herbs, occurring on gently rolling terrain. The canopy is dominated by longleaf pine (*Pinus palustris*); shortleaf pine (*P. echinata*) also may be present. There is an intermittent subcanopy layer of smaller pines, and hardwoods including southern red oak (*Quercus falcata*), blackjack oak (*Q. marilandica*), flowering dogwood (*Cornus florida*), bluejack oak (*Q. incana*), post oak (*Q. stellata*), sassafras (*Sassafras albidum*), laurel oak (*Q. hemisphaerica*), winged sumac (*Rhus copallinum*), common persimmon (*Diospyros virginiana*), sand post oak (*Q. margaretta*), mockernut hickory (*Carya alba*), and sourgum (*Nyssa sylvatica*). Though typically present as low shrubs and occasional midstory trees, these species can form a dense midstory (subcanopy and tall shrubs layers) in areas that have experienced a lack of fire for many years. Shrub cover can vary from sparse to dense, and includes low-growing species such as dwarf huckleberry (*Gaylussacia dumosa*), running oak (*Q. elliotii*), gallberry (*Ilex glabra*), and Darrow's blueberry (*Vaccinium darrowii*). Herbaceous cover varies, from sparse to abundant, dependent upon the density and shading effects of the shrubs. Wiregrass (*Aristida stricta* var. *beyrichiana*) is often dominant, but a high diversity of grasses and forbs may be present; as many as 40-50 species m⁻².²¹⁴ In addition to wiregrass, other common grasses are little bluestem (*Schizachyrium scoparium*), broomsedge bluestem (*Andropogon virginicus*), hairawn muhly (*Muhlenbergia capillaris*), and indiagrass (*Sorghastrum* spp.). Typical forbs include oblongleaf twinflower (*Dyschoriste oblongifolia*), narrowleaf silkgrass (*Pityopsis graminifolia*), pineland silkgrass (*Pityopsis aspera*), scaleleaf aster (*Symphyotrichum adnatum*), bracken fern (*Pteridium aquilinum*), goldenrod (*Solidago* spp.), squarehead (*Tetragonotheca helianthoides*), soft greeneyes (*Berlandiera pumila*), yellow jessamine (*Gelsemium sempervirens*), rice button aster (*Symphyotrichum dumosum*), and often a diverse suite of legumes including sensitive pea (*Chamaecrista nictitans*), sensitive briar (*Mimosa quadrivalvis*), sidebeak pencil flower (*Stylosanthes biflora*), and goat's rue (*Tephrosia virginiana*). Woody vines such as greenbrier (*Smilax* spp.) and summer grape (*Vitis aestivalis*) are occasionally present.

Upland pine primarily occurs on the rolling hills of northern Florida north of the Cody Scarp where the soils, classed as ultisols, are composed of sandy loams and loamy sands with clayey subsoils of Miocene and Pleistocene origin.²⁸³ The presence of clay helps retain soil moisture, creating more mesic conditions than are found on the deep sands that support sandhill. Thus, some plant species (e.g., gallberry, Darrow's blueberry) are found in upland pine that, on more sandy soils, are restricted to lowlands such as mesic flatwoods. Upland pine also occurs in a few locations south of the Cody Scarp in the Florida Panhandle, and in the northern peninsula on soils that are influenced by clays, or where limestone is near the surface (e.g., calcitic and phosphatic influenced clayey soils, Citronelle influenced soils).²⁸³

Characteristic Set of Species: longleaf pine, wiregrass, southern red oak, flowering dogwood, sassafras, and the presence of a high diversity of legume species

Rare Species: Rare plant species in upland pine include chaffseed (*Schwalbea americana*), Barbara's buttons (*Marshallia obovata*), and hairy wild indigo (*Baptisia calycosa* var. *villosa*; only in the western Panhandle). Rare animals include tiger salamander (*Ambystoma tigrinum*), gopher tortoise (*Gopherus polyphemus*), timber rattlesnake (*Crotalus horridus*), red-cockaded woodpecker (*Picoides borealis*), Bachman's sparrow (*Aimophila aestivalis*), hairy woodpecker (*Picoides villosus*), Sherman's fox squirrel (*Sciurus niger shermani*), southern fox squirrel (*S. n. niger*), and eastern chipmunk (*Tamias striatus*). At least one rare invertebrate species, Cartwright's mycotrupes beetle (*Mycotrupes cartwrighti*), appears to be restricted to upland pine and upland mixed woodland in the northern Florida Panhandle above the Cody Scarp.⁸

Range: Upland pine occurs in northern Florida, southern Alabama, and Georgia. In Florida it is primarily in the northern Panhandle in the clay-rich soils north of the Cody scarp²⁸³ from the western Florida boundary to at least Hamilton County. Outside of this geographic range it occurs in areas where upland edaphic conditions are influenced by clays (Alachua and Marion counties) or where limestone is near the surface (e.g., Wakulla Springs State Park in Wakulla County).

Upland pine is part of an extensive mosaic of longleaf pine-associated natural communities that historically dominated the southeastern U.S. coastal plain. In Florida, this longleaf pine mosaic also included sandhills, mesic flatwoods, and wet flatwoods communities. This ecosystem has experienced a 98 percent decline in acreage throughout its range and is considered globally critically endangered.^{295,388} From 1936 to 1995, Florida experienced a 90 percent decline in longleaf pinelands due to conversion to pine plantations, development, and agriculture.²⁰⁶

Natural Processes: Fire is the dominant factor in the ecology of upland pine. Frequent low-intensity ground fires during the growing season reduce hardwood competition and facilitate pine and wiregrass reproduction.²⁸³ The abundance of woody understory species increases with increasing time between fires. The historic fire frequency ranged from one to three years.¹³¹ Without relatively frequent fires water oak (*Q. nigra*), live oak (*Q. virginiana*), sweetgum (*Liquidambar styraciflua*), common persimmon, laurel oak, and other fire-sensitive, fast growing trees invade and shade the otherwise diverse ground layer.

Community Variations: Vast differences in vegetation composition exist between natural upland pine and pinelands that have a history of land clearing, agriculture, or heavy disturbance (often referred to as "old-field pinelands"). In the latter, longleaf pine is often replaced by loblolly pine (*Pinus taeda*) or shortleaf pine, and the wiregrass-dominated groundcover is replaced with old-field species³⁰⁹ such as broomsedges (*Andropogon* spp.), dogfennel (*Eupatorium capillifolium*), and blackberries (*Rubus* spp.). Ostertag and Robertson³⁰⁹ identified 17 species of herbs that could be used as indicators of natural upland pine. A similar suite of herbaceous species was found to be sensitive to disturbance and have low re-colonization rates in a disturbed upland pine in southwest Georgia.²¹¹ Absence of wiregrass is the clearest indicator that an upland pine has a disturbance history.³⁰⁹ These studies both listed goat's rue, oblongleaf twinflower, hairawn muhly, bracken fern, and rice button aster, among others, as indicators of natural upland pine. Additionally, land-use history plays an important role in the effect fire has on community structure; natural pinelands have higher fine fuels and generally higher fire intensity, thus having a greater effect on reduction of cover of woody species than do old-field pinelands with a history of agriculture.³⁰⁹

Associated Communities: Upland pine is associated with and often grades into upland mixed woodland, upland hardwood forest, or sandhill. It differs from upland mixed woodland and upland hardwood forest in being dominated by an open canopy of pines and having a dense herbaceous ground layer, often dominated by wiregrass. Upland hardwood forests have a dense hardwood canopy of mesophytic species such as American beech (*Fagus grandifolia*), southern magnolia (*Magnolia grandiflora*), spruce pine (*P. glabra*), and American holly (*Ilex opaca*)

and lack longleaf pine. Upland mixed woodland is dominated by a partially closed canopy of pines, large oaks (e.g., southern red oak, post oak, and blackjack oak) and mockernut hickory and sparse, if any, wiregrass. Upland mixed woodland can develop in the ecotone between upland pine and upland hardwood forests.⁵⁷ Also, isolated pockets of this more oak-dominated community can also occur within large expanses of upland pine. Upland pine is often confused with sandhill. Sandhill can occur on small sandy rises or caps within upland pine. While these two community types have a large overlap in species, some species of plants such as flowering dogwood, sassafras, and southern red oak more commonly occur in upland pine, while turkey oak, pricklypear (*Opuntia humifusa*), and dogtongue wild buckwheat (*Eriogonum tomentosum*) more commonly occurs in sandhill. Another primary difference between them resides in their soil characteristics (upland pine mostly occurs on sandy loam or loamy sand soils, whereas sandhill occurs on deep sands). Upland pine can be distinguished from mesic flatwoods by its occurrence on rolling hills rather than flatlands and by its lack of saw palmetto (*Serenoa repens*).

Management Considerations: Frequent (1-3 year interval) fires are essential for the maintenance of the upland pine community. Frequent fires reduce ground litter and prevent hardwood and shrub encroachment into the midstory. These effects are essential for the regeneration and maintenance of longleaf pines, as well as the highly diverse herbaceous groundcover that characterizes upland pine communities. Variability in the season, frequency, and intensity of fire may also be important for preserving species diversity, since different species in the community flourish under different fire regimes.^{283,339}

In order to maintain or restore natural historic conditions, prescribed fire should be applied in upland pine on a 1-3 year interval, primarily in the warm season (April – June). Longer fire intervals can lead to a build-up of fuel loads. When fuel loads are increased by an additional 2-3 years of accumulation, studies of fire physics show an exponential gain in heat-release rates which can be lethal to longleaf pine.^{347,403} After long periods without fire, the burning of accumulated duff during very dry conditions can burn live roots growing in the duff and cause pine mortality.⁴²⁰ Where older, larger trees are rare due to past disturbances, reducing dense vegetation and removing duff around the tree bases is one option for protecting these pines in long unburned sites. Lighting multiple low-intensity fires over a period of years, when the duff is relatively moist is another effective means for gradually reducing accumulations of duff and heavier fuels.

In areas where fire exclusion has resulted in heavy hardwood and shrub encroachment, reduction of the midstory by a combination of fire and mechanical or chemical treatments, may be appropriate.⁴³³ However, widespread soil disturbance in longleaf pine-wiregrass communities should be avoided. Soil disturbance encourages the establishment of weedy species and diminishes existing native groundcover, especially wiregrass.^{43,238,334} Provencher et al.³³³ found that prescribed fire in the growing season was the most cost effective method of hardwood midstory removal in sandhills when compared to chainsaw felling and fire, or herbicide treatment and fire. The use of herbicides, while more expensive, had the greatest effect on hardwood mortality when followed with prescribed fire.^{333,433} However, herbicide treatment had negative effects on several non-target species and reduced the overall richness of groundcover species. Provencher³³⁴ also noted that, while chainsaw felling of midstory oaks reduced woody species density, it was no more effective at increasing groundcover diversity than prescribed fire alone.

Where the original native groundcover has been eliminated or severely altered, restoration to its original condition may not be possible or practical. Many species in the groundcover are unlikely to recover naturally once they are lost^{57,71,283} due to the dispersal limitations of many of the dominant herbaceous components.²¹¹ It is labor intensive and sometimes very difficult to propagate and reestablish wiregrass where it has been extirpated.^{71,283} Wiregrass is only one of dozens of groundcover species that are characteristic in natural upland pine systems, making re-establishment of the original plant species diversity, if possible, challenging.

Invasive exotic plant species can be a problem in upland pine through competition for light and nutrients. Cogon grass (*Imperata cylindrica*), mimosa (*Albizia julibrissin*), Japanese climbing fern (*Lygodium japonicum*), Japanese honeysuckle (*Lonicera japonica*), and natal grass (*Melinis repens*) are especially problematic invaders of upland pine.

Exemplary Sites: Blue Springs Tract of the Twin Rivers State Forest (Hamilton County), Blackwater River State Forest (Okaloosa, Escambia, and Santa Rosa counties), Apalachee Wildlife Management Area (Jackson County)

Global and State Rank: G3/S2

Crosswalk and Synonyms:

Kuchler	112/Southern Mixed Forest
Davis	4/Mixed Hardwoods and Pines
SCS	5/Mixed Hardwood and Pine
Myers and Ewel	High pine - clayhill
SAF	70/Longleaf Pine
	75/Shortleaf Pine
	76/Shortleaf Pine - Oak
	80/Loblolly Pine - Shortleaf Pine
	81/Loblolly Pine
	82/Loblolly Pine - Hardwood
FLUCCS	414/Pine - Mesic Oak
	423/Oak - Pine - Hickory

Other synonyms: longleaf pine upland forest⁴³⁶; longleaf pine savannah⁵⁷; southern mesic longleaf woodland³¹⁸; longleaf pine upland forest⁴³⁶



Apalachee Wildlife Management Area (Jackson County)

Photo by Amy Jenkins



Eglin Air Force Base (Okaloosa County)

Photo by Dan Hipes

Sandhill

Description: Sandhill is characterized by widely spaced pine trees with a sparse midstory of deciduous oaks and a moderate to dense groundcover of grasses, herbs, and low shrubs. Sandhill occurs on the rolling topography and deep sands of the Southeastern U.S. Coastal Plain. Typical associations or indicator species are longleaf pine (*Pinus palustris*), turkey oak (*Quercus laevis*), and wiregrass (*Aristida stricta* var. *beyrichiana*). On the southern Lake Wales Ridge, South Florida slash pine (*P. elliotii* var. *densa*) may replace longleaf pine. The midstory trees and low shrubs can be sparse to dense, depending on fire history, and may include turkey oak, bluejack oak (*Q. incana*), sand live oak (*Q. geminata*), sand post oak (*Q. margaretta*), saw palmetto (*Serenoa repens*), sparkleberry (*Vaccinium arboreum*), dwarf huckleberry (*Gaylussacia dumosa*), pricklypear (*Opuntia humifusa*), and gopher apple (*Licania michauxii*). Earleaf greenbrier (*Smilax auriculata*) is the most common woody vine that occurs in sandhill. The greatest plant diversity within sandhill is in the herbaceous groundcover. Dominant grasses, in addition to wiregrass, include other three-awns (*Aristida* spp.), pineywoods dropseed (*Sporobolus junceus*), lopsided indiagrass (*Sorghastrum secundum*), several species of bluestems (*Andropogon* spp.), and little bluestem (*Schizachyrium scoparium*). The latter is especially common in portions of the western Florida Panhandle where it can replace wiregrass.²⁰⁹ Bracken fern (*Pteridium aquilinum*) can be common. Typical forbs include dogtongue wild buckwheat (*Eriogonum tomentosum*) and such Aster family taxa as narrowleaf silkgrass (*Pityopsis graminifolia*), gayfeathers and blazing stars (*Liatris* spp.), coastalplain honeycomb-head (*Balduina angustifolia*), sweet goldenrod (*Solidago odora*), and soft green eyes (*Berlandiera pumila*). Legumes also make up an important component of the sandhill groundcover. Typical species include sidebeak pencil flower (*Stylosanthes biflora*), sensitive brier (*Mimosa quadrivalvis* var. *angustata*), summer farewell (*Dalea pinnata*), milkpeas (*Galactia* spp.), snoutbeans (*Rhynchosia* spp.), spurred butterfly pea (*Centrosema virginianum*), and Atlantic pigeon-wing (*Clitoria mariana*).

Sandhill occurs on crests and slopes of rolling hills and ridges with steep or gentle topography. Soils are deep, marine-deposited, often yellowish sands that are well-drained and relatively infertile. Sandhill is important for aquifer recharge because the porous sands allow water to percolate rapidly with little runoff and minimal evaporation. The deep, sandy soils and a lack of near surface hardpan or water table contribute to a xeric environment. Sandhill requires growing season fires to maintain open structure.

Characteristic Set of Species: longleaf pine, turkey oak, wiregrass

Rare Species: Rare plants in sandhill vary across Florida. Peninsular sandhill supports Florida toothache-grass (*Ctenium floridanum*), clasping warea (*Warea amplexifolia*), scrub stylisma (*Stylisma abdita*), giant orchid (*Pteroglossaspis ecristata*), longspurred mint (*Dicerandra cornutissima*), variable-leaf crownbeard (*Verbesina heterophylla*), and scrub pigeon-wing (*Clitoria fragrans*). Panhandle sandhill supports zigzag silkgrass (*Pityopsis flexuosa*), toothed savory (*Calamintha dentata*), sandhill sedge (*Carex tenax*), pineland hoary-pea (*Tephrosia mohrii*), hairy wild indigo (*Baptisia calycosa* var. *villosa*) and, in the ecotone and upper ridges between sandhill and upland hardwood forest, Arkansas oak (*Q. arkansana*).

Sandhill provides important habitat for many rare animals such as gopher frog (*Rana capito*), gopher tortoise (*Gopherus polyphemus*), eastern indigo snake (*Drymarchon couperi*), Florida pine snake (*Pituophis melanoleucus mugitus*), short-tailed snake (*Stilosoma extenuatum*), Eastern diamondback rattlesnake (*Crotalus adamanteus*), red-cockaded woodpecker (*Picoides borealis*), southeastern American kestrel (*Falco sparverius paulus*), Florida mouse (*Peromyscus floridanus*), and southeastern and Sherman's fox squirrels (*Sciurus niger niger* and *S. niger shermani*, respectively). Several rare invertebrates species occur in sandhill including Florida deepdigger scarab beetle (*Peltotrupes profundus*), Ocala deepdigger scarab beetle (*Peltotrupes youngi*), north peninsular mycotrupes beetle (*Mycotrupes gaigei*), Skelley's june beetle (*Phyllophaga skellei*), pygmy anomala scarab beetle (*Anomala exigua*), McCrone's burrowing wolf spider (*Geolycosa xera*), and several species of melanoplus grasshoppers including pygmy sandhill grasshopper (*Melanoplus pygmaeus*) and Tequesta grasshopper (*Melanoplus tequestae*). The gopher tortoise and southeastern pocket gopher (*Geomys pinetis*) are an especially important keystone species in sandhills. Gopher tortoise burrows are used as shelter by more than 60 species of vertebrates and 300 species of invertebrates¹⁸⁶ and have commensal species of invertebrates. Many invertebrate species, including at least a dozen rare beetle species are commensals in southeastern pocket gopher burrows.³⁷⁰

Range: In Florida, sandhill occurs predominantly in the northern half of the state, extending south to Volusia County along the Atlantic coast, with a disjunct occurrence in Martin County, and to Manatee County on the Gulf coast. In the interior peninsula of Florida, sandhill is concentrated along, but not restricted to, high ridges (e.g., Brooksville and Trail Ridges and extends south along the Lake Wales Ridge to Highlands County.²⁸³

Sandhill was historically widespread on well-drained sands throughout the Southeastern U.S. Coastal Plain and was once a major part of an extensive mosaic of longleaf pine-dominated natural communities. This longleaf pine ecosystem has experienced a 98 percent decline in acreage throughout its range, and is considered critically endangered.^{295,388} From 1936 to 1995, Florida experienced a 90 percent decline in longleaf pinelands due to conversion to pine plantations, development, and agriculture.²⁰⁶

Natural Processes: Fire is a dominant environmental factor in sandhill ecology.²⁸³ Frequency, intensity, and season are important fire characteristics that influence community structure and species composition.²⁸³ Frequent low-intensity ground fires in the growing season reduce hardwood competition and perpetuate pines and grasses.^{326,339} Provencher et al.³³⁵ found that herbaceous and faunal species diversity in sandhill increases with application of prescribed fires in areas where fire had long been excluded. The natural or historic frequency of fire in sandhill is every 1-3 years.¹³¹

In the absence of regular fire, the abundance and density of sandhill shrubs and small trees such as turkey oak increases, and sand live oak, laurel oak (*Q. hemisphaerica*) or sand pine (*P. clausa*) can invade. Lack of fire may ultimately lead to the development of a xeric hammock, turkey oak barrens, or sand pine-dominated sandhill. The resulting dense woody vegetation reduces the herbaceous groundcover and, consequently, the fine fuels needed to carry low-intensity ground fires.

Community Variations: Southern Ridge Sandhill occurs in south-central Florida along the Lake Wales Ridge. It is distinguished by the presence of South Florida slash pine in the canopy, abundant scrub hickory (*Carya floridana*) and evergreen oaks in the understory, and stunted turkey oaks.²⁸⁵ Turkey oak barrens can occur in areas of irregular fire. In sandhill adjacent to scrub, sand live oak, Chapman's oak (*Q. chapmanii*), myrtle oak (*Q. myrtifolia*), and Florida rosemary (*Ceratiola ericoides*) may be present (e.g., Warea Tract of Seminole State Forest). In some examples, the occurrence of these species may reflect invasion as a result of infrequent fire.²⁸³ Several examples of sandhill in Florida support old growth longleaf pine and exemplify the presumed historical community structure and composition (e.g., Eglin Air Force Base, Patterson Natural Area and Extension and Mike Roess Gold Head Branch State Park).

Associated Communities: Sandhill is often associated with and grades into scrub, scrubby flatwoods, mesic flatwoods, upland pine, upland mixed woodland, or xeric hammock. Sandhill differs from scrubby flatwoods by the presence of deciduous midstory oaks (turkey oak, bluejack oak, or sand post oak), and the absence or infrequent occurrence of scrub oaks (Chapman's oak, myrtle oak). Sandhill is distinguished from upland pine (found in northern Florida only) by having sandy rather than clayey or loamy soil texture and by the absence of southern red oak (*Q. falcata*) and flowering dogwood (*Cornus florida*). Upland mixed woodland can develop in the ecotone between sandhill and upland hardwood forests and is dominated by a partially closed canopy of pines, large oaks such as southern red oak, post oak (*Q. stellata*), and blackjack oak (*Q. marilandica*), mockernut hickory (*Carya alba*), and sparse, if any, wiregrass. Long unburned sandhill, in which xeric oaks form a closed canopy, may be indistinguishable from xeric hammock. The presence of longleaf pine, turkey oak, and wiregrass are helpful in distinguishing sandhill from xeric hammock. In some areas, wet prairies or seepage slopes, dominated by cutthroat grass (*Panicum abscissum*) or pitcherplants (*Sarracenia* spp.), occur as wetter inclusions at the bases of sandhill slopes.

Management Considerations: Frequent fires are essential for the conservation of native sandhill flora and fauna. In order to maintain (or restore) natural historic conditions, prescribed fire should be applied in sandhill on a 1-3 year interval. Variability in the season, frequency, and intensity of fire is also important for preserving species diversity, since different species in the community flourish under different fire regimes.^{283,339} Frequent fires reduce ground litter and prevent hardwood and shrub encroachment into the midstory, thereby allowing ample sunlight to reach the forest floor. This is essential for the regeneration and maintenance of longleaf pines, as well as the native grasses, herbs, and low shrubs that characterize sandhill communities. It is important to recognize, however, that too many years of closely spaced burns (≤ 1 year) may decrease species diversity.

By comparison, fires that consistently trend toward longer burn intervals (> 3 years) can allow for a build-up of fuel loads and a greater potential for lethal heat-release temperatures. When fuel loads are increased by an additional 2-3 years of accumulation, studies of fire physics show an exponential gain in heat-release rates which can be lethal to longleaf pine.^{347,403} Unnaturally high tree mortality, particularly of larger, older trees, can be a concern when fire is reintroduced in long-unburned sites with dense midstory and high duff accumulation.⁴²⁰ Reducing dense vegetation and removing duff around larger pines is one option for protecting canopy trees. Application of multiple low-intensity fires over a series of years is another effective means for gradually reducing accumulations of duff and heavier fuels while minimizing tree mortality. These considerations are particularly important in locations where older canopy trees are rare due to past timbering or fire exclusion practices.⁴²⁰

Avoiding widespread soil disturbance, such as mechanical roller chopping, can prevent the establishment of weedy species and protect the existing, established native groundcover.³³⁴ This groundcover, especially wiregrass, is unlikely to recover if it is lost^{71,283} and may require reintroduction through seeding or direct planting, both of which are labor-intensive and expensive.

In areas where fire exclusion has resulted in heavy midstory hardwood and shrub encroachment, reduction of the midstory by fire, or a combination of fire and mechanical or chemical treatment may be appropriate (Hay-Smith and Tanner 1994). In a study comparing three hardwood midstory removal techniques in sandhill (fire alone, mechanical + fire, herbicide + fire), Provencher et al.³³³ found that prescribed fire alone in the growing season was the most cost effective method at Eglin Air Force Base. The use of herbicides (ULW[®] form of hexazinone), while more expensive, has also been effective on hardwood mortality¹⁶⁶ especially when followed with prescribed fire.³³³ This method, however, had negative effects on several understory species in Eglin sandhill, including legumes (Fabaceae), gopher apple, huckleberry, and little bluestem, reduced the overall richness of groundcover species,³³³ and reduced the biomass of wiregrass due to an initial top-kill.¹⁶⁶ Provencher also found that mechanical midstory removal (chainsaw felling of oaks) reduced woody species density but was no more effective at increasing groundcover diversity than burning alone.

Invasive exotic plants are another management concern in sandhill. Cogon grass (*Imperata cylindrica*),⁴¹⁹ centipedegrass (*Eremochloa ophiuroides*), mimosa (*Albizia julibrissin*), and natal grass (*Melinis repens*) are especially problematic invaders of sandhill. Lippincott²⁴¹ found that cogon grass invasion in sandhill reduced soil moisture and increased fuel loads. This ultimately led to higher intensity fires that resulted in greater mortality of juvenile longleaf pine as compared to non-invaded sandhill.

Exemplary Sites: Eglin Air Force Base (Santa Rosa, Okaloosa, and Walton counties), Mike Roess Gold Head Branch State Park (Clay County), “Riverside Island” in the northern half of the Ocala National Forest (Marion County), “Red Hill” on Archbold Biological Station (Highlands County), Wekiwa Springs State Park (Orange County), and portions of the Citrus Tract in Withlacoochee State Forest (Citrus County), Tiger Creek Preserve (Polk County), St. Marks National Wildlife Refuge (Wakulla County)

Global and State Rank: G3/S2

Crosswalk and Synonyms:

Kuchler	112/southern mixed forest
Davis	6/forests of longleaf pine and xerophytic oaks
SCS	4/longleaf pine - turkey oak hills
Myers and Ewel	High pine – sandhill and southern ridge sandhill
SAF	70/longleaf pine
	71/longleaf pine - scrub oak
	72/southern scrub oaks
FLUCCS	412/longleaf pine - xeric oak
	421/xeric oak
Whitney	High pine grasslands



Archbold Biological Station (Highlands County)

Photo by Eric S. Menges



Lake June-in-Winter State Park (Highlands County)

Photo by Dan Hipes

Scrub

Description: Scrub is a community composed of evergreen shrubs, with or without a canopy of pines, and is found on dry, infertile, sandy ridges. The signature scrub species – three species of shrubby oaks, Florida rosemary (*Ceratiola ericoides*), and sand pine (*Pinus clausa*) – are common to scrubs throughout the state. The dominance of these species, however, is variable from site to site. The most common form is oak scrub, dominated by three species of shrubby oaks – myrtle oak (*Quercus myrtifolia*), sand live oak (*Q. geminata*), and Chapman’s oak (*Q. chapmanii*) -- plus rusty staggerbush (*Lyonia ferruginea*) and saw palmetto (*Serenoa repens*). Florida rosemary and sand pine may also be present. On the Lake Wales Ridge in Central Florida, myrtle oak may be replaced by a close relative, scrub oak (*Q. inopina*), especially in un-shaded, lower elevation oak scrubs that grade into mesic flatwoods.¹⁹² Fetterbush (*Lyonia lucida*) and saw palmetto are also more frequent in these lower elevation scrubs, both on the Lake Wales Ridge and at Merritt Island NWR.³⁵⁵ The oaks form a dense cover interspersed with patchy openings that consist of bare sand with a sparse cover of herbs, particularly threeawns (*Aristida* spp.), hairsedges (*Bulbostylis* spp.), and sandyfield beaksedge (*Rhynchospora megalocarpa*), as well as subshrubs such as pinweeds (*Lechea* spp.) and jointweeds (*Polygonella* spp.), and ground lichens (*Cladonia leporina*, *C. prostrata*, *Cladina subtenuis*, and *C. evansii*).

Some scrubs are dominated by Florida rosemary, especially on drier ridge crests. This needle-leaved evergreen shrub is also the main colonizer of recently stabilized dunes on Florida Panhandle barrier islands.¹⁹¹ Rosemary-dominated scrubs tend to retain openings between the shrubs, even long after fire, in contrast to oak-dominated scrubs where vegetation tends to fill in openings with time since fire.^{165,445} Several rare herbs at the southern end of the Lake Wales Ridge that favor these sandy openings are more frequent in rosemary than in oak-dominated scrubs.²⁶⁸

Scrubs dominated by a canopy of sand pine are usually found on the highest sandy ridgelines. The pine canopy may range from widely scattered trees with a short, spreading growth form, to tall thin trees forming a dense canopy of uniform height. The sand pine scrub understory is characterized by either scrub oaks or Florida rosemary.

Scrubs occur on either white (St. Lucie, Archbold), or yellow (Astatula, Paola) low-nutrient, acid sands with little organic matter. Scrub is located on dry, infertile, sandy ridges which often mark the location of former Plio-Pleistocene shorelines.^{228,283,431}

Characteristic Set of Species: myrtle oak, Chapman's oak, sand live oak, scrub oak sand pine, Florida rosemary

Rare Species: Scrub harbors a wealth of species endemic to Florida, many of which are considered rare. Scrubs on the Lake Wales Ridge support 27 rare plant species, 14 of which are shared with scrubs on other peninsular ridges.⁴⁰⁷ An additional ten species are found on near-coastal ridges or inland peninsular ridges other than the Lake Wales Ridge (Table 1). Many species have very narrow ranges, occurring on only a small portion of their respective ridges.

Peninsular scrubs are home to four rare vertebrate animals, including the widely distributed Florida scrub-jay (*Aphelocoma coerulescens*) and scrub lizard (*Sceloporus woodi*), the more narrowly distributed sand skink (*Neoseps reynoldsi*), found only on the Lake Wales Ridge, and blue-tailed mole skink (*Eumeces egregius lividus*), found on the Lake Wales Ridge and in Ocala National Forest. Additional species endemic to scrub and other xeric habitats in Florida include the Florida mouse (*Peromyscus floridanus*) and the short-tailed snake (*Stilosoma extenuatum*). Scrub occurring near the coast (as well as coastal strand and xeric and maritime hammock) are important as refuges for endangered beach mice populations (subspecies of *Peromyscus polionotus*) during and after storm events that destroy the foredunes.³⁹¹ Scrub is also important for gopher tortoise (*Gopherus polyphemus*) and its associated commensals. Roughly 56 arthropods from a wide variety of taxonomic groups are endemic to peninsular scrubs; examples of these include the red widow spider, five wolf spiders, one cockroach, three grasshoppers, two tiger beetles, 12 scarab beetles, two fireflies, one moth, three velvet ants, and three ants.^{84,85}

Range: Scrub is centered in Florida but extends westward on barrier islands to Alabama and Mississippi and small patches are found northward into southeastern Georgia.⁴³⁶ In Florida, scrub tends to be distributed in long, narrow, ridges parallel to coastlines and is scarce or absent from the limestone-dominated southernmost portion of the state.

The largest continuous area of scrub is in the Ocala National Forest (ca. 200,000 acres) in Marion County, with another concentration to the southeast in Lake and Seminole counties. Other relatively large areas of scrub occur on the Lake Wales Ridge, the Atlantic Coastal Ridge, and along the Panhandle coast, including barrier islands. Scrub can also be found in small patches on xeric ridges and soils scattered across the central Florida peninsula. Scrub is rare on barrier islands of the peninsula.¹⁹⁸

Natural Processes: While scrub is a fire-maintained community, it is not easily ignited. Scrub is thought to have burned less frequently than communities with a more easily ignited grassy groundcover, such as sandhill and mesic flatwoods. With direct evidence for the natural range of fire return intervals in scrub largely lacking, upper and lower limits have been inferred from life history traits of the dominant plants or from the requirements of animal species dependent on scrub.^{258,268,270}

Scrub oak-dominated oak scrub on the Lake Wales Ridge likely burned naturally at intervals within 5 and 20 years²⁵⁸ based on the habitat requirements of the Florida scrub-jay. Oak height is a critical limiting factor for Florida scrub-jays which have been documented to abandon territories where the oaks reached >3 m on the Lake Wales Ridge¹¹² and to suffer a net population loss in territories on Merritt Island on the Atlantic coast where patches of oak scrub in their territories were either taller than 1.7 meters or shorter than 1.2 meters.³¹ The lower limit of 5 years is based on the time required for re-sprouting oak stems to reach acorn-bearing height,³⁰⁸ acorns being an important part of the scrub-jay's diet.

Rosemary scrub likely burned at intervals within 10 and 40 years, based on the life history characteristics of Florida rosemary, a species that is killed by fire and must re-establish from seed. The lower limit is set by the age at which rosemary first begins to produce seed and the upper limit by the age at which the shrub begins to die back and seed production declines.¹⁸⁹ Whereas most inland rosemary stands are even-aged and show little or no seedling recruitment between fires, those on the outermost coastal dunes in the Panhandle are uneven-aged and apparently do not require fire for regeneration.¹³⁵

Sand pine scrub in the peninsula may have naturally burned at intervals of more than 10 years based on the life history of the sand pine. The trees are usually killed by fire and must re-establish from seed. Although trees as young as five years may begin producing cones,²⁵¹ it probably takes somewhat longer to produce a crop of seeds

large enough to replace a stand. Experience in Ocala National Forest has shown that two burns within a 10 year period will prevent or reduce sand pine regeneration.⁶⁴ Since the variety of sand pine that grows in the peninsula (*P. clausa* var. *clausa*, also known as the Ocala variety) tends to bear mostly closed cones that open only after a fire, the extreme upper limit of fire return interval would be determined by the longevity of these trees which is about 70 years. After 50 years the pines start to die off (their susceptibility to root rot increases with age). As the canopy opens up shrub oaks, particularly sand live oak and myrtle oak form a midstory 15-20 feet tall.³¹⁰ In the absence of fire, the pines would continue to die off and the understory scrub oaks would grow up to tree height to form a xeric hammock. However, fires within the sand pine community, or from surrounding, more flammable, communities, probably burned into sand pine scrub more frequently than every 80 years, particularly during drought periods, which tend to recur periodically at roughly 20 year intervals following the El Nino Southern Oscillation climate cycle.⁴²¹ Thus in their natural condition large sand pine scrub stands were probably a mosaic of different ages since the last burn. On plat maps and in surveyors' notes for Ocala National Forest produced by the General Land Office surveys in the mid-1800s notations of "scrub" alternate with "spruce pine scrub" ("spruce pine" is the old name for sand pine) and dead pines killed by fire were often noted. Such a mosaic would have provided the open, unshaded areas required by scrub-jays and other rare plant and animal species that occur in scrub.

The variety of sand pine in Panhandle scrubs (*P. clausa* var. *immuginata*, or the Choctawhatchee variety) is open-coned and is therefore capable of maintaining its populations in the absence of fire.³¹⁴ Sand pines are highly susceptible to being killed by salt spray and wind throw from coastal storms. Storm-related disturbances in sand pine scrub along the Panhandle coast play a significant role in stimulating stand regeneration in this region.¹⁸⁰

Scrub occurs on deep nutrient-poor sands. More nutrients are concentrated in the plant biomass of scrubs than in the soils.³⁵⁷ A potentially significant nutrient source is nitrogen-fixing cyanobacteria found in soil crusts in rosemary scrubs. Density of cyanobacteria increases from zero immediately post-fire to a peak 8-15 years post-fire and declines thereafter.¹⁶⁴

Community Variations: Whereas the signature scrub species (myrtle oak, sand live oak, and Chapman's oak) are common to scrubs throughout the state, some variation in species composition exists between Panhandle and peninsular scrubs. Common species found only in Panhandle scrubs are woody goldenrod (*Chrysoma pauciflosculosa*) and false rosemary (*Conradina canescens*). Species that distinguish peninsular from Panhandle scrubs include scrub hickory (*Carya floridana*), garberia (*Garberia heterophylla*), scrub holly (*Ilex opaca* var. *arenicola*), scrub wild olive (*Osmanthus megacarpus*), Feay's palafox (*Palafoxia feayi*), silk bay (*Persea borbonia* var. *humilis*), scrub palmetto (*Sabal etonia*), and hog plum (*Ximenia americana*).

Harper¹⁶¹ noted that scrub on the southern Lake Wales Ridge tended to be more open and often lacked the sand pine canopy common in scrubs further north. This is the same area where oak scrubs are dominated by scrub oak rather than myrtle oak. Stems of the former have been shown to live only four or five years on average, indicative of a situation where it is not likely to be shaded out by competing species.¹⁹³

Some smaller areas of oak scrub on the southern end of Lake Wales Ridge are known locally as "yellow sand scrub" and are characterized by scrub hickory and myrtle oak and the absence of scrub oak. The absence of scrub oak contrasts with most other scrub in this region. Yellow sand scrubs are further distinguished by a suite of rare Florida endemic species, e.g., scrub buckwheat (*Eriogonum longifolium* var. *gnaphalifolium*), Garrett's scrub balm (*Dicerandra christmanii*), different from that found in white sand scrubs²⁷¹ and have higher levels of nitrogen and phosphorus than white sand rosemary scrubs.⁴⁹

Variants:

ROSEMARY SCRUB – Scrub dominated by Florida rosemary (commonly referred to as "rosemary balds"), usually with large areas of bare sand visible between the shrubs. Occupies limited areas on the driest ridge crests, particularly at the southern end of the Lake Wales Ridge and Panhandle barrier islands. Suggested fire return intervals between 15 and 30 years, in contrast to intervals of 3 to 20 years suggested for the typical scrub communities dominated by shrub oaks.

SAND PINE SCRUB – Scrub with a canopy of sand pine and an understory of the three shrubby oaks, or less commonly, Florida rosemary. Found throughout the state but less commonly on the southern end of the Lake Wales Ridge. Probably originally occurred in limited areas somewhat protected from fire. Suggested variable fire return intervals

(between 5 and 40 years) in peninsula to maintain mosaic of different ages; possibly longer intervals in Panhandle due to added disturbance of coastal storms.

Associated Communities: Scrub may be associated with, and grade into, mesic flatwoods, scrubby flatwoods, xeric hammock, sandhill, coastal strand, and maritime hammock. Scrub differs from mesic flatwoods in having little to no cover of slash or longleaf pines, wiregrass (*Aristida stricta*), or such flatwoods shrubs as gallberry (*Ilex glabra*). It differs from scrubby flatwoods in the lack of, or low cover of, the aforementioned species and in having a nearly continuous cover, as opposed to a patchy cover, of scrub oaks (myrtle oak, Chapman's oak, and sand live oak). Scrub is distinguished from xeric hammock by the absence of a closed oak canopy. It differs from sandhill in having little to no cover of wiregrass or deciduous oaks, such as turkey oak (*Quercus laevis*), bluejack oak (*Q. incana*), and sand post oak (*Q. margaretta*), and by lacking a longleaf pine canopy. Scrub differs from coastal strand and maritime hammock in being dominated by myrtle oak and sand live oak and not by live oak (*Quercus virginiana*), cabbage palm (*Sabal palmetto*), buckthorn (*Sideroxylon tenax*), or red bay (*Persea borbonia*), or by tropical species such as Simpson's stopper (*Myrcianthes fragrans*) and seagrape (*Coccoloba uvifera*). Scrub also occurs on acidic rather than calcareous sands. Shrub height in the coastal strand community is controlled by salt spray pruning, rather than the combination of frequent fire and nutrient-deficient soils that characterize scrubs.

Management Considerations: There has been a concerted effort to preserve scrub through land acquisition at the local, state, and federal levels beginning in the late 1980s. At that time, range-wide surveys indicated Florida scrub-jay populations were in decline and rare plant species (including a number of newly described species) were not uniformly distributed in scrubs.⁵⁴ Many scrubs have been preserved through the state land acquisition program which identified projects containing scrub on the Lake Wales Ridge, the Atlantic Coastal Ridge and the Panhandle coast.¹⁰⁹ The United States Fish and Wildlife Service, as well as Brevard, Hillsborough, and Palm Beach counties also purchased important scrub areas. These efforts are ongoing. On the Lake Wales Ridge, for example, 21,500 acres of scrub and sandhill were acquired within the last two decades, with nearly as many acres identified as needing to be preserved.⁴⁰⁷

Much of the scrub recently brought under protection is long unburned, raising the issue of how to manage it. Recommended intervals for prescribed fire in scrub cover a narrower range than the natural limits at which populations of dominant species or scrub-dependent plants and animals begin to decline. Oak scrub is thought to have a range of natural fire return intervals considerably shorter than that of sand pine or rosemary scrub. For *Quercus inopina*-dominated oak scrub, fire return intervals between 8 and 15 years are recommended as optimal for maintaining scrub-jay populations.⁴⁴³ Shorter intervals of 5-12 years have been suggested for the faster-growing yellow sand scrub on the Lake Wales Ridge based on a population viability model for the rare endemic scrub mint (*Dicerandra frutescens*).²⁶⁸ In myrtle oak-dominated scrubs on Merritt Island on the Atlantic coast, Breininger et al.³² suggest natural fire return limits of between 3 and 20 years. They found that scrub-jay territories with patches of scrub burned at intervals between 10-20 years, which would be 1.2-1.7 meters tall,³⁵⁵ surrounded by more frequently burned shorter scrub to be optimal for sustaining scrub-jay populations. Growth rates of scrub oaks are related to burn history and environmental conditions of the site. Long unburned oak scrub may attain heights unsuitable for scrub-jays up to 50 percent faster after fire than regularly burned oak scrub and thus may at first require shorter burn intervals to maintain optimum heights following restoration of burning.³⁵⁶ In addition, small openings, needed by Florida scrub-jays for caching acorns, may need to be artificially restored in long unburned scrubs by piling up fuel to create hotspots that kill the roots of the oaks.³⁵⁶

For rosemary scrub, fire return intervals of 15-30 years, allowing patchy burns to provide refuges for older rosemary plants, have been recommended based on population viability models for wedge-leaved button-snakeroot (*Eryngium cuneifolium*) and other rare endemics found in this community.²⁶⁸

Less is known about the effects of different fire return intervals in sand pine scrub due to lack of prescribed fires in this community, so a variable fire return interval is usually recommended to maintain patches of different ages. Crown fires in sand pine scrub can burn very hot and fast due to the close spacing, uniform height, and resinous needles of sand pines. A 1935 wildfire in Ocala National Forest burned 35,000 acres in four hours.³⁶³ Although prescribed burns have been successfully conducted in sand pine scrub,¹⁴³ other methods have utilized mechanical felling of pines followed by burning which avoids crown fires, while mimicking the natural system in terms of releasing pine seeds, burning off understory oaks, and returning nutrients to the system in the form of ash.⁸⁷ The lowered height of the sand pine scrub canopy following fire opens a time window for Florida scrub-jays to colonize an area until the sand pines again reach a height that excludes them. Oak scrub that has become too tall to burn

under prescribed conditions may also be chopped and burned. By returning the community first to a desired height, the scrub can then be burned under prescribed conditions and within the normal return interval.³⁵⁶

Some scrub species increase (e.g. ground lichens) while others decrease (e.g. wedge-leaved button-snakeroot and other rare herbs) with time between fires. In order to preserve diversity it is important to burn at variable, rather than regular, intervals within the normal limits of fire return intervals for a given type of scrub²⁷⁰ and to maintain spatial variety in fire frequency within scrubs by allowing more frequent fires set in mesic flatwoods to burn into embedded scrubs and naturally extinguish.³²

Exemplary Sites: Topsail Hill State Park (Walton County), Ocala National Forest (Marion County), Lake June-in-Winter State Park and Archbold Biological Station (Highlands County), Merritt Island National Wildlife Refuge (Brevard County), Jonathan Dickinson State Park and Juno Dunes Natural Area (Martin County), Balm Boyette Scrub (Hillsborough County), Starkey Wilderness Park (Pasco County), St. Joseph Peninsula State Park (Gulf County), Lake Wales Ridge Wildlife and Environmental Area (Highlands and Polk counties), Saddle Blanket Lakes Preserve (Polk County), Three Lakes Wildlife Management Area (Osceola County), Cedar Key Scrub State Preserve (Levy County), Dunns Creek Preserve State Park (Putnam County), Yamato Scrub (Palm Beach County)

Global and State Rank: G2/S2

Crosswalk and Synonyms:

Kuchler	115/sand pine scrub
Davis	5/sand pine scrub
SCS	3/sand pine scrub
Myers and Ewel	Scrub – sand pine, oak, and rosemary scrub; slash
	pine scrub
SAF	69/sand pine
FLUUCS	413/sand pine
Whitney	interior scrub

Other synonyms: oak-palmetto scrub³³; scrubby flatwoods sensu Laessle²²⁸ and Abrahamson et al.³

Table 1. Ranges of rare plant species in Florida scrubs (county abbreviations are listed for species with restricted ranges)⁴⁰⁷

Lake Wales Ridge only	Lake Wales Ridge plus other peninsular ridges	Coastal ridges only	Other inland peninsular ridges only
<i>Chrysopsis highlandsensis</i> -HIGH	<i>Bonamia grandiflora</i>	East coast:	<i>Conradina etonia</i> – PUTN
<i>Crotalaria avonensis</i> -- POLK/HIGH	<i>Calamintha ashei</i>	<i>Asimina tetramera</i> – MART/PALM	<i>Dicerandra cornutissima</i> - MARI
<i>Dicerandra christmanii</i> - HIGH	<i>Centrosema arenicola</i>	<i>Conradina grandiflora</i>	<i>Lupinus westianus</i> var. <i>aridorum</i> – ORAN/POLK
<i>Dicerandra frutescens</i>	<i>Chionanthus pygmaeus</i>	<i>Dicerandra immaculata</i> – MART/PALM/STLU	Panhandle coast and inland peninsular ridges
<i>Eryngium cuneifolium</i> -HIGH	<i>Clitoria fragrans</i>	<i>Dicerandra thimicola</i> - BREV	<i>Cladonia perforata</i>
<i>Euphorbia roscens</i>	<i>Conradina brevifolia</i> (sensu Shinnars 1962)	West coast:	
<i>Hypericum cumulicola</i>	<i>Eriogonum longifolium</i> var. <i>gnaphalifolium</i>	<i>Chrysopsis floridana</i>	
<i>Liatris ohlingerae</i>	<i>Lechea divaricata</i>	Panhandle coast:	
<i>Paronychia chartacea</i>	<i>Lechea cernua</i>	<i>Chrysopsis gossypina</i> ssp. <i>cruiseana</i>	
<i>Polygonella basiramea</i>	<i>Nolina brittoniana</i> -	<i>Lupinus westianus</i> var. <i>westianus</i>	
<i>Polygonella myriophylla</i>	<i>Polygala lewtonii</i>	<i>Polygonella macrophylla</i>	
<i>Prunus geniculata</i>	<i>Schizachyrium niveum</i>		
<i>Ziziphus celata</i> (POLK/HIGH)	<i>Stylisma abdita</i>		
	<i>Warea carteri</i>		

PINE FLATWOODS and DRY PRAIRIE — mesic or hydric pine woodland or mesic shrubland on flat sandy or limestone substrates, often with a hardpan that impedes drainage



Avon Park Air Force Range (Polk County) with cutthroat grass (*Panicum abscissum*) understory

Photo by Katy NeSmith

Wet Flatwoods

Description: Wet flatwoods are pine forests with a sparse or absent midstory and a dense groundcover of hydrophytic grasses, herbs, and low shrubs. The pine canopy typically consists of one or a combination of longleaf pine (*Pinus palustris*), slash pine (*P. elliottii*), pond pine (*P. serotina*), or South Florida slash pine (*P. elliottii* var. *densa*). The subcanopy, if present, consists of scattered sweetbay (*Magnolia virginiana*), swamp bay (*Persea palustris*), loblolly bay (*Gordonia lasianthus*), pond cypress (*Taxodium ascendens*), dahoon (*Ilex cassine*), titi (*Cyrilla racemiflora*), and/or wax myrtle (*Myrica cerifera*). Shrubs include large gallberry (*Ilex coriacea*), fetterbush (*Lyonia lucida*), titi, black titi (*Cliftonia monophylla*), sweet pepperbush (*Clethra alnifolia*), red chokeberry (*Photinia pyrifolia*), and azaleas (*Rhododendron canescens*, *R. viscosum*). Saw palmetto (*Serenoa repens*) and gallberry (*I. glabra*), species also found in mesic flatwoods sites, may be present. On calcareous sites cabbage palm (*Sabal palmetto*) is common, both in the subcanopy and shrub layers. Herbs include wiregrass (*Aristida stricta* var. *beyrichiana*), blue maidencane (*Amphicarpum muhlenbergianum*), and/or hydrophytic species such as toothache grass (*Ctenium aromaticum*), Curtiss' sandgrass (*Calamovilfa curtissii*), cutover muhly (*Muhlenbergia expansa*), coastalplain yellow-eyed grass (*Xyris ambigua*), Carolina redroot (*Lachnanthes carolina*), beaksedges (*Rhynchospora chapmanii*, *R. latifolia*, *R. compressa*), and pitcherplants (*Sarracenia* spp.), among others. In central Florida in the vicinity of the Lake Wales Ridge, cutthroat grass (*Panicum abscissum*) can be dominant (see Variants).

Wet flatwoods often occur in the ecotones between mesic flatwoods and shrub bogs, wet prairies, dome swamps, or strand swamps. Wet flatwoods also occur in broad, low flatlands, often in a mosaic with these communities.

The relative density of shrubs and herbs varies greatly in wet flatwoods. Shrubs tend to dominate where fire has been absent for a long period or where cool season fires predominate; herbs are more abundant in locations that are frequently burned. Soils and hydrology also influence relative density of shrubs and herbs. Soils of shrubby wet flatwoods are generally poorly to very poorly drained sands and include such series as Rutledge/Osier; these soils generally have a mucky texture in the uppermost horizon.¹³⁶ Examples of typical soils in grassy wet flatwoods are loamy sands of the Leefield and Plummer Series.⁴¹⁰

Characteristic Set of Species: slash pine, pond pine, large gallberry, fetterbush, sweetbay, wiregrass, toothache grass

Rare Species: Most rare plants are found in grassy wet flatwoods. In the Florida Panhandle these include pine-woods bluestem (*Andropogon arcatus*), southern milkweed (*Asclepias viridula*), Curtiss' sandgrass (*Calamovilfa curtissii*), wiregrass gentian (*Gentiana pennelliana*), Panhandle spiderlily (*Hymenocallis henryae*), white birds-in-a-nest (*Macbridea alba*), bog tupelo (*Nyssa ursina*), Apalachicola dragon-head (*Physostegia godfreyi*), pinewoods wild petunia (*Ruellia pedunculata* ssp. *pinetorum*), and Florida skullcap (*Scutellaria floridana*). In the peninsula of Florida, these include purple honeycomb-head (*Balduina atropurpurea*), Bartram's ixia (*Calydorea coelestina*), hartwrightia (*Hartwrightia floridana*), lake-side sunflower (*Helianthus carnosus*), and cutthroat grass (*Panicum abscissum*). Found in both the Panhandle and peninsula are St. John's blackeyed susan (*Rudbeckia nitida*) and white-flowered wild petunia (*Ruellia noctiflora*).

In Gulf, Liberty, and Gadsden counties, Chapman's rhododendron (*Rhododendron chapmanii*) may be found in shrubby wet flatwoods in ecotones between mesic flatwoods and shrub bogs or basin swamps. In wet flatwoods dominated by cabbage palm, hand fern (*Ophioglossum palmatum*) may be found growing in old leaf bases on cabbage palms and celestial lily (*Nemastylis floridana*) may be evident after recent burns.

Rare animals dependent on this community include three species associated with small wetlands in a flatwoods matrix: the frosted flatwoods salamander (*Ambystoma cingulatum*), found east of the Apalachicola/Flint Rivers, the reticulated flatwoods salamander (*A. bishopi*), found west of these rivers,³¹⁷ and the Panama City crayfish (*Procambarus econfinae*) found only in Bay County. The latter creates burrows in open, temporarily inundated depressions in wet flatwoods associated with redroot, lesser creeping rush (*Juncus repens*), and yellow-eyed grasses.²⁰⁷

Wet flatwoods, like shrub bogs and basin swamps, often occupy large areas of relatively inaccessible land, providing suitable habitat for the Florida black bear (*Ursus americanus floridanus*). In Lee and Charlotte counties in southwest Florida, red-cockaded woodpecker (*Picoides borealis*) colonies are concentrated in wet flatwoods; the mangrove fox squirrels (*Sciurus niger avicennia*) also use this habitat for foraging and nesting.²¹

Range: Wet flatwoods are common throughout most of Florida except at the very southernmost tip in the Everglades and Florida Keys where limestone is near the surface. Outside of Florida, wet flatwoods with similar characteristic species are found in the outer coastal plain from South Carolina to Mississippi,²⁸⁶ with disjunct occurrences in Louisiana and Texas.³⁸

Natural Processes: The variations of vegetation structure and composition of wet flatwoods in Florida likely reflect variations in soil characteristics, hydrology and fire. The general historic fire frequency in pinelands across the southeastern U.S. coastal plain is estimated to be every 1-3 years.¹³¹ This interval is frequent enough to maintain grassy wet flatwoods and inhibit invasion by shrubs⁹¹ and is consistent with management of longleaf pine systems.^{183,231} Wet flatwoods that are naturally shrubbier and dominated by slash pine or pond pine may have had longer fire return intervals, or perhaps a few periods of longer intervals, on the order of 5-7 years,²³¹ or up to 5-10 years,¹⁴⁴ in order to allow the pines to establish and shrubs to proliferate.

South Florida slash pine seedlings have a grass stage and are more tolerant of frequent fire than slash pine found in central and northern Florida. South Florida winters are considerably warmer and drier than those in North Florida and wet flatwoods in this region alternate between being completely flooded to completely dry on a seasonal basis.²¹ Wet flatwoods supporting South Florida slash pines burned at intervals of around 4 years.²³¹

Community Variations: In addition to the widespread type of wet flatwoods, there are two variants.

Variants: CUTTHROAT GRASS FLATWOODS – On and near the Lake Wales Ridge cutthroat grass may replace wiregrass as the dominant species in the ground layer.

CABBAGE PALM FLATWOODS – In some areas where limestone or calcareous substrates are near the surface, cabbage palm may form an understory to the pine canopy. Loblolly pine may also be present. Herbaceous species may include hairawn muhly, sawgrass (*Cladium jamaicense*), saltmeadow cordgrass (*Spartina patens*), black bogrush (*Schoenus nigricans*), blue maidencane, and sand cordgrass (*Spartina bakeri*). Examples of this type, which is sometimes referred to as “sweet flatwoods” in reference to the less acid soils, can be found in at the St. Marks National Wildlife Refuge in coastal Wakulla County, in the upper St Johns River drainage and in inland areas of Charlotte County, among other areas.

Associated Communities: Shrubby wet flatwoods can be similar to shrub bog, but differs in the having only a thin (< 1 inch) layer of muck, if any, and dominance by shrubs other than titi and black titi. The presence of a more than just a few, scattered pines differentiates grassy wet flatwoods from wet prairie and depression marsh. Wet flatwoods can be distinguished from mesic flatwoods by the presence of hydrophytic herbs (such as coastalplain yellow-eyed grass and redroot), shrubs (such as titi, black titi and sweet pepperbush), and trees (sweetbay, swamp bay, and pond cypress) and the absence or low frequency of saw palmetto.

Management Considerations: Fire suppression policies practiced from the 1930s to the 1960s⁴²⁹ allowed shrubs in wet flatwoods to proliferate and to expand into adjacent wet prairies and depression marshes. Evidence from early aerial photographs, surveyors’ notes from the general land office surveys of the mid-1800s, as well as early descriptions in soil surveys, can often help managers determine where shrub and hardwood encroachments have taken place.

Fires at too long intervals (5-10 years) can lead to an increase in woody species cover and decline in grasses and forb cover. It is uncertain whether increased fire frequency alone is adequate to restore areas heavily invaded by shrubs and trees as a result of lack of fire.⁹² In some cases physical removal or mowing of woody vegetation may be necessary; however, these actions are much more costly than prescribed fire and can cause damage to soil structure and desirable vegetation, particularly perennial grasses and forbs. Many factors other than frequency of fire, such as season of fire, pre- and post-fire soil moistures, groundwater levels, weather, and plant size or age at the time of fire, can greatly influence tree mortality⁴²⁵ and vegetation responses to fire.¹⁷ Fire in the growing season can reduce the stature of woody vegetation, particularly hardwoods,³⁹⁰ prevent increases in shrub densities (although it may not reduce stem densities),⁹² and promote flowering of herbaceous groundcover.³²⁶

Drainage, either directly by ditching or indirectly by drawdown of the water table, and soil disturbance render wet flatwoods in South Florida vulnerable to invasion by the exotic melaleuca (*Melaleuca quinquenervia*) which may be difficult to control once established since fire and herbicide treatments stimulate its seed release.²⁰⁵ Other invasive species in wet flatwoods include cogon grass (*Imperata cylindrica*) and Brazilian pepper (*Schinus terebinthifolius*).

Exemplary Sites: Bradwell Bay Unit of Apalachicola National Forest (Wakulla County), Post Office Bay Unit of Apalachicola National Forest (Liberty County), St. Marks National Wildlife Refuge (Wakulla County), Tosohatchee Wildlife Management Area (Orange County), Triple N Ranch Wildlife Management Area (Osceola County), Fred C. Babcock-Cecil M. Webb Wildlife Management Area (Charlotte County), Picayune Strand State Forest (Collier County), Jonathan Dickinson State Park (Martin County)

Global and State Rank: G4/S4

Crosswalk:

Kuchler	112/Southern Mixed Forest
Davis	2/Pine Flatwoods
SCS	/South Florida Flatwoods
	7/North Florida Flatwoods
	8/Cabbage Palm Flatwoods
Myers and Ewel	Flatwoods - wet flatwoods and seepage savannas
SAF	74/Cabbage Palmetto
	84/Slash Pine
	85/Slash Pine - Hardwood
	98/Pond Pine
FLCFC	411/Pine Flatwoods
	419/Other Pines
	428/Cabbage Palm
	622/Pond Pine
	624/Cypress - Pine - Cabbage Palm
	630/Wetland Forested Mixed

Other synonyms: pine savanna⁵⁷; hydric pine flatwoods^{21,136}; boggy flatwoods⁵⁷; wetland pine savannas³⁸



Grass-dominated wet flatwoods, Apalachicola National Forest (Liberty County)

Photo by Gary R. Knight



Cabbage palm flatwoods, St Marks National Wildlife Refuge (Wakulla County) Photo by Ann F. Johnson



Shrub-dominated wet flatwoods, Tate's Hell State Forest
(Franklin County) Photo by Carolyn Kindell



Babcock Ranch (Charlotte County)

Photo by Katy NeSmith

Mesic Flatwoods

Description: Mesic flatwoods is characterized by an open canopy of tall pines and a dense, low ground layer of low shrubs, grasses, and forbs. Longleaf pine (*Pinus palustris*) is the principal canopy tree in northern and Central Florida, and South Florida slash pine (*P. elliottii* var. *densa*) forms the canopy south of Lake Okeechobee. Although slash pine (*Pinus elliottii*) is currently more common than longleaf pine in mesic flatwoods in northern Florida, this a result of invasion by, or planting of, slash pine after logging of longleaf pine followed by a long period of fire exclusion in the early part of the twentieth century.¹³⁴ Early accounts mention slash pine only in wet flatwoods sites.⁵⁷ Characteristic shrubs include saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), coastalplain staggerbush (*Lyonia fruticosa*), and fetterbush (*Lyonia lucida*). Rhizomatous dwarf shrubs, usually less than two feet tall, are common and include dwarf live oak (*Quercus minima*), runner oak (*Q. elliottii*), shiny blueberry (*Vaccinium myrsinites*), Darrow's blueberry (*V. darrowii*), and dwarf huckleberry (*Gaylussacia dumosa*). The herbaceous layer is predominantly grasses, including wiregrass (*Aristida stricta* var. *beyrichiana*), dropseeds (*Sporobolus curtissii*, *S. floridanus*), panicgrasses (*Dichantherium* spp.), and broomsedges (*Andropogon* spp.), plus a large number of showy forbs.

Mesic flatwoods is the most widespread natural community in Florida, covering the flat sandy terraces left behind by former high stands of sea level during the Plio-Pleistocene. Soils are acidic, nutrient-poor fine sands with upper layers darkened by organic matter. Leon, Vero, and Smyrna fine sands are common examples.¹³⁶ Drainage in this flat terrain can be impeded by a loosely cemented organic layer (spodic horizon) formed within several feet of the soil surface. The soils are alternately droughty during dry periods and saturated, or even inundated, after heavy rains

Characteristic Set of Species: longleaf pine or south Florida slash pine, saw palmetto, gallberry, dwarf live oak, wiregrass.

Rare Species: Many rare plants endemic to Florida are found in mesic flatwoods. In the Panhandle these include pine-woods aster (*Aster spinulosus*), scare-weed (*Baptisia simplicifolia*), telephus spurge (*Euphorbia telephioides*), mock pennyroyal (*Hedeoma graveolens*), white birds-in-a-nest (*Macbridea alba*), and narrow-leaved phoebanthus (*Phoebanthus tenuifolius*). Peninsular mesic flatwoods harbor Canby's wild indigo (*Baptisia calycosa* var. *calycosa*), beautiful pawpaw (*Deeringothamnus pulchellus*), Rugel's pawpaw (*Deeringothamnus rugelii*), and variable-leaf crownbeard (*Verbesina heterophylla*). Found throughout Florida are pine-woods bluestem (*Andropogon arctatus*), many-flowered grass-pink (*Calopogon multiflorus*), and Florida beargrass (*Nolina atopocarpa*).

Rare animals in mesic flatwoods include the frosted flatwoods salamander (*Ambystoma cingulatum*), reticulated flatwoods salamander (*A. bishopi*), eastern diamondback rattlesnake (*Crotalus adamanteus*), timber rattlesnake (*Crotalus horridus*), Bachman's sparrow (*Aimophila aestivalis*), red-cockaded woodpecker (*Picoides borealis*), Sherman's fox squirrel (*Sciurus niger shermani*), Big Cypress fox squirrel (*Sciurus niger avicennia*), and Florida black bear (*Ursus americanus floridanus*). Among rare invertebrates, three rare butterflies are found in mesic flatwoods, the Arogos skipper (*Atrytone arogos arogos*), the Loammi skipper (*Atrytonopsis loammi*), and the dusky roadside skipper (*Amblyscirtes alternata*). A long-horned beetle, the yellow-banded typocerus (*Typocerus flavocinctus*) is found in mesic flatwoods only in the central peninsular Florida, where it has been noted on flowers of gallberry and saw palmetto.

Range: Mesic flatwoods occur throughout Florida, except for Monroe County and portions of the Big Cypress and Everglades areas. In the Panhandle north of the Cody Scarp, mesic flatwoods occupy relatively small, low-lying areas. Outside Florida, mesic flatwoods with saw palmetto and slash or longleaf pine are found on the lower coastal plain from South Carolina to Mississippi.²⁸⁶

Natural Processes: Unlike those of sandhill or scrub, plants of mesic flatwoods must be able to withstand the stress of soil saturation or inundation during the wet part of the year, as well as dry conditions at other times.

Mesic flatwoods require frequent fire; all of its constituent plant species recover rapidly from fire and several species require fire to reproduce. South Florida slash and longleaf pines have thick bark to protect them from fire and their seeds need the mineral soil and open sunlight that fire provides to germinate; both form a grass stage for several years after germination that is resistant to fire. Wiregrass requires fire to flower, along with a number of other characteristic herbs, including, but not limited to, whitetop aster (*Oclemena reticulata*), many-flowered grass-pink, crowpoison (*Stenanthium densum*), and grassleaf goldenaster (*Pityopsis oligantha*). Red-cockaded woodpeckers, which nest in cavities in mature living pines, will abandon a nesting site if the midstory becomes too tall and dense, i.e. if fire is excluded for too long.⁶¹ The flatwoods salamander prefers a grassy border around its breeding ponds which is maintained against encroaching shrubs by frequent fire.⁹²

Direct evidence for the natural fire return interval and season in mesic flatwoods comes from a study of fire scars on cross sections of old longleaf pine stumps in mesic flatwoods near the Gulf coast west of Apalachicola.¹⁸³ Scars from 61 fires were recorded over a 189 year period (1679 to 1868). The average fire return interval was 3.2 years, and most fires occurred at two year intervals (42%) with three year intervals having the next highest number (22%). Seventy-two percent of all fires occurred within one to three year intervals and 23% occurred within four to six year intervals. The maximum interval recorded was ten years. Over 95% of all fires Huffman recorded before European settlement in the area (1830) occurred in the growing season.

Community Variations: The major variation in mesic flatwoods is the shift in the dominant canopy species from longleaf pines in North and Central Florida to South Florida slash pine at the latitude of Lake Okeechobee. The dominant species in shrub and herbaceous layers of mesic flatwoods are generally found throughout Florida. Some less abundant species, however, differ with region.⁴⁸ The following species are common in mesic flatwoods in northern Florida and absent from South Florida: slimleaf pawpaw (*Asimina angustifolia*), vanillaleaf (*Carphephorus odoratissimus*), Florida pineland spurge (*Euphorbia inundata*), thistleleaf aster (*Eurybia eryngiifolia*) woolly huckleberry (*Gaylussacia mosieri*), hairy wicky (*Kalmia hirsuta*), grassleaf gayfeather (*Liatris elegantula*), savannah meadowbeauty (*Rhexia alifanus*), and Florida dropseed (*Sporobolus floridanus*). Species found only in peninsular mesic flatwoods include netted pawpaw (*Asimina reticulata*), bigflower pawpaw (*A.*

obovata), tarflower (*Bejaria racemosa*), false vanillaleaf (*Carphephorus odoratissimus* var. *subtropicus*), Garber's gayfeather (*Liatris garberi*), and yellow milkwort (*Polygala rugelii*).

A minor variation is flatwoods on younger barrier islands which tend not to have wiregrass in ground layer, possibly due to lack of development of a spodic layer in the soils. One of the few places where wiregrass is found on a barrier island is the most landward portion of St. Vincent Island (Franklin County) which is geologically the oldest portion of the island.⁸⁶ The understory of flatwoods on more recent portions of barrier islands is usually dominated by shrubs, particularly yaupon (*Ilex vomitoria*), saw palmetto, and gallberry.

Associated Communities: The understory layers of mesic flatwoods are very similar to dry prairie from which it differs primarily in having a pine canopy consisting of more than just a few widely scattered pines. Flatwoods landscapes also tend to be more dissected than that of dry prairie with more forested wetlands that would inhibit the spread of fires.³⁰⁷ Mesic flatwoods is distinguished from shrub bog and wet flatwoods by the absence of wetland shrubs and trees such as sweetbay (*Magnolia virginiana*), large gallberry (*Ilex coriacea*), and titi or black titi (*Cyrilla racemiflora* or *Cliftonia monophylla*). Shrub bog and some wet flatwoods also have a muck or peat layer at the soil surface, not found in mesic flatwoods. Mesic flatwoods differs from scrub and scrubby flatwoods in that it lacks scrub oaks, i.e., sand live oak (*Quercus geminata*), scrub oak (*Q. inopina*), myrtle oak (*Q. myrtifolia*), and Chapman's oak (*Q. chapmanii*). Sandhill and upland pine differ from mesic flatwoods in the presence of deciduous oaks, such as turkey oak (*Quercus laevis*), bluejack oak (*Q. incana*), and southern red oak (*Q. falcata*), and the absence, or sparse cover of, saw palmetto.

Management Considerations: The need for frequent fire (2- to 4-year intervals) to control hardwood and off-site pine invasion of longleaf pine communities has been known for many years,^{134,173} when it was realized that fire exclusion policies of the 1920s and 1930s had resulted in canopy destroying wildfires and lack of pine reproduction on some sites, in contrast to sites that had been regularly winter-burned for grazing. That fire stimulates flowering in many flatwoods herbs and that frequent fire (1-3 years) increases species richness and abundance of herbs were also noted from an early date.²³⁶ Controlled burns in this matrix community will indirectly determine fire frequency and season for all the included communities, such as wet prairie, depression marsh, shrub bog, scrub, etc.³²

Statistics from lightning-caused fires suggest that most areas in Florida would naturally have burned at the beginning of the lightning season.³³⁹ Growing season fires (April to mid-August) are known to be necessary for flowering and seed set in wiregrass.²⁸³ Historically, prescribed burns in early summer were avoided because of higher pine mortality,¹³⁴ unpredictable winds that made it difficult to control the fire, and inferred adverse impacts on bird ground nesting. A more recent long-term study in frequently burned longleaf flatwoods in the Panhandle has shown that season of burn (as distinct from conditions on the day of burn) has no significant impact on longleaf pine growth or mortality.^{139,390} In frequently burned stands variability both in frequency and season of prescribed burning is desirable to allow pine reproduction and maintain herb diversity.³³⁹

In contrast to frequently burned stands, long unburned pine stands have suffered high mortality of sapling and mature pine trees upon reintroduction of prescribed fire in some cases.⁴²⁰ Seventy-one percent of South Florida slash pines over 3 meters tall were killed in prescribed fires in stands that had not burned in the previous 25 years at Archbold Biological Station in south-central Florida, and mortality was not correlated with tree diameter.²⁶⁹ A wildfire that burned a portion of an upland longleaf stand in Alabama that had been unburned for 45 years killed 91 percent of the longleaf pines over 35 centimeters dbh. In the latter case, pine death was not due to needle scorch but root death and damage to the stem cambial layers caused by fire smoldering for days in the duff at the base of large trees. In a subsequent prescribed fire in this stand, mature tree mortality was limited to 4 percent by cutting and removing understory hardwoods and extinguishing smoldering fires in tree duff for several days post-fire.⁴²⁰ Thus, fuel and litter build-up are important considerations in reintroducing fire on long-unburned sites.

Long term experimental plots in mesic flatwoods burned in late winter at 1-, 2-, and 4-year intervals for 44 years at Osceola National Forest in northeast Florida have shown that annual burning increased herbaceous cover relative to shrub cover compared to plots winter burned at 2- or 4-year intervals and increased species richness at smaller scales ($\leq 100 \text{ m}^2$), but not at the largest scale (1000 m^2) measured.¹⁴⁰ Saw palmetto cover decreased but wiregrass cover remained the same in annually burned plots. The authors concluded that long-term, high frequency winter burning can maintain high quality ground cover in mesic flatwoods but early summer burns (while maintaining a high frequency) may be necessary to increase cover of bunchgrasses. Early summer burns, as opposed to those in late

winter, increased the dominance of fall-flowering forbs in a study at St. Marks National Wildlife Refuge in Wakulla County.³²⁶

Wiregrass often does not withstand ground disturbance associated with planting pine plantations for commercial purposes. In some cases where the goal is to restore pine plantations to mesic flatwoods, there may not be enough wiregrass remaining to restore the herbaceous ground cover by frequent fire and natural seeding, especially since wiregrass is known to be a poor colonizer.^{211,324} In such cases direct seeding may be required to restore the wiregrass ground layer. Care should be taken that the wiregrass and other seed used for restoration is not only from the same geographic area but also the same habitat type as the restoration site to maintain geographic genetic diversity⁴²⁷ and to improve chances of survival.^{142,210}

Invasive exotic plants that may cause problems in mesic flatwoods include the shrub, downy rose-myrtle (*Rhodomyrtus tomentosa*), a major problem in South Florida, cogon grass (*Imperata cylindrica*), old world climbing fern (*Lygodium microphyllum*), camphor tree (*Cinnamomum camphora*), and natal grass (*Melinis repens*), all listed as Category I exotics (capable of displacing native species) by the Florida Exotic Pest Plant Council.

Exemplary Sites: Apalachicola National Forest (Liberty and Wakulla counties), Jonathan Dickinson State Park (Martin County), Three Lakes Wildlife Management Area (Osceola and Polk counties), Triple N Ranch Wildlife Management Area (Osceola County), Fred C. Babcock-Cecil M. Webb Wildlife Management Area (Charlotte County), Jennings State Forest (Clay County), Myakka River State Park (Sarasota and Manatee counties), Starkey Wilderness Park (Pasco County)

Global and State Rank: G4/S4

Crosswalk and Synonyms:

Kuchler	112/Southern Mixed Forest
Davis	2/Pine Flatwoods
SCS	6/South Florida Flatwoods
	7/North Florida Flatwoods
	8/Cabbage Palm Flatwoods
Myers and Ewel	Flatwoods - mesic flatwoods
SAF	70/Longleaf Pine
	74/Cabbage Palmetto
	83/Longleaf Pine - Slash Pine
	84/Slash Pine
	111/South Florida Slash Pine
FLUCCS	411/Pine Flatwoods
	414/Pine - Mesic Oak
	428/Cabbage Palm

Other synonyms: pine barrens, pine flatwoods, longleaf pine savanna



Jonathan Dickinson State Park (Martin County)

Photo by Gary Knight

Scrubby Flatwoods

Description: Scrubby flatwoods have an open canopy of widely spaced pine trees and a low, shrubby understory dominated by scrub oaks and saw palmetto, often interspersed with areas of barren white sand. Principal canopy species are longleaf pine (*Pinus palustris*) and slash pine (*P. elliottii*) in northern and Central Florida, and South Florida slash pine (*P. elliottii* var. *densa*) south of Lake Okeechobee. The shrub layer consists of one or more of the four scrub oaks, sand live oak (*Quercus geminata*), myrtle oak (*Q. myrtifolia*), Chapman's oak (*Q. chapmanii*), and scrub oak (*Q. inopina*), and typical shrubs of mesic flatwoods including saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), rusty staggerbush (*Lyonia ferruginea*), fetterbush (*L. lucida*), coastalplain staggerbush (*L. fruticosa*), and deerberry (*Vaccinium stamineum*). The shrub layer of scrubby flatwoods is not solely comprised of oaks; grasses and dwarf shrubs make up a substantial portion of the cover. Grasses include wiregrass (*Aristida stricta* var. *beyrichiana*), broomsedge bluestem (*Andropogon virginicus*), and little bluestem (*Schizachyrium scoparium*); dwarf shrubs include dwarf live oak (*Quercus minima*), runner oak (*Q. elliottii*), dwarf huckleberry (*Gaylussacia dumosa*), gopher apple (*Licania michauxii*), and shiny blueberry (*Vaccinium myrsinites*). A variety of forbs, many typical of drier types of mesic flatwoods, are present including coastalplain honeycomb-head (*Balduina angustifolia*),

narrowleaf silkgrass (*Pityopsis graminifolia*), October flower (*Polygonella polygama*), and sweet goldenrod (*Solidago odora*). Bare sand openings are often present but are generally small.

Scrubby flatwoods occur on slight rises within mesic flatwoods and in transitional areas between scrub and mesic flatwoods. Soils of scrubby flatwoods are moderately well-drained sands with or without a spodic horizon. Examples of soil types include Pomello and Satellite sands.

Characteristic Set of Species: longleaf pine, slash pine (or South Florida slash pine), sand live oak, myrtle oak (or scrub oak), Chapman's oak, saw palmetto, wiregrass

Rare Species: Three rare plants are found primarily in scrubby flatwoods. Florida goldenaster (*Chrysopsis floridana*) and large-plumed beaksedge (*Rhynchospora megaplumosa*) are endemic to west-central Florida, and pine pinweed (*Lechea divaricata*) is endemic to central and southern portions of peninsular Florida. Other rare plants that occur in scrubby flatwoods include Carter's warea (*Warea carteri*) and nodding pinweed (*Lechea cernua*) in the central peninsula, and large-leaved jointweed (*Polygonella macrophylla*) in coastal scrubby flatwoods of the Florida Panhandle.

Scrubby flatwoods are inhabited by many of the same rare animal species found in scrub. These include Florida mouse (*Peromyscus floridanus*), Florida scrub-jay (*Aphelocoma coerulescens*), gopher tortoise (*Gopherus polyphemus*), and associated tortoise commensal species such as the Florida gopher frog (*Rana capito*).⁴¹³

Range: Like scrub, scrubby flatwoods is largely confined to Florida. It occurs throughout the state except in extreme South Florida where limestone is close to the surface.

Natural Processes: Since it has a more continuous ground cover, scrubby flatwoods burns more readily than scrub⁴¹³ and somewhat less readily than mesic flatwoods and it would thus naturally have burned at frequencies intermediate between the two. Light ground fires in the surrounding mesic flatwoods tend to enter the scrubby flatwoods and extinguish, leading to a patchwork of recently burned and unburned portions, a situation which has been found to be favorable for scrub-jays.³²

For oak scrub on the Lake Wales Ridge a natural return interval between 8 and 15 years has been suggested based on requirements of the Florida scrub-jay.⁴⁴³ An interval of 1-5 years is suggested for mesic flatwoods in the same area.²⁵⁸ Since re-sprouting stems of scrub oak (*Quercus inopina*) in this region become reproductive at 3 years and reach peak reproduction at 5 years,³⁰⁸ burning at intervals consistently less than 5 years could diminish acorn production and decrease food available for wildlife. Menges²⁶⁸ observed a lower limit fire return interval in scrubby flatwoods of three years, based on fuel accumulation levels, but commented that frequent fires may exhaust carbohydrate reserves. Thus fire intervals greater than 5 years, but less than 15 years, likely would have been most common in scrubby flatwoods; the intervals were also likely highly variable, dependent upon yearly environmental conditions and fuel accumulation rates.

Community Variations: Scrubby flatwoods on the Lake Wales Ridge may contain scrub oak (*Quercus inopina*) in addition to the other three shrubby oaks commonly found in scrub. In Florida, tarflower (*Bejaria racemosa*), scrubland goldenaster (*Chrysopsis subulata*), fragrant eryngo (*Eryngium aromaticum*), and wild pennyroyal (*Piloblephis rigida*) are found only in peninsular scrubby flatwoods, whereas false rosemary (*Conradina canescens*) and cottony goldenaster (*Chrysopsis gossypina*) are found only in the Panhandle scrubby flatwoods.

Associated Communities: Scrubby flatwoods are associated with and often grade into mesic flatwoods, scrub, dry prairie, or sandhills. Scrubby flatwoods differs from mesic flatwoods and dry prairie in the presence of shrubby oaks characteristic of scrub (i.e., *Quercus myrtifolia*, *Q. geminata*, *Q. chapmanii*, and *Q. inopina*). It differs from scrub in the presence of wiregrass, a greater abundance of saw palmetto, and/or the presence of typical flatwoods shrubs such as gallberry and fetterbushes (*Lyonia* spp.). Structurally it differs from scrub in its lack of a continuous cover of shrubby oaks. Scrubby flatwoods differ from sandhill by the absence or relatively low cover of deciduous oaks such as turkey oak (*Quercus laevis*) or bluejack oak (*Q. incana*).

Management Considerations: Scrubby flatwoods probably naturally had a high variability of fire return intervals intermediate between that for mesic flatwoods and that of scrub. In some areas understory re-growth may be so rapid as to require a temporary fire return interval as short as three years.²⁶⁸ However, intervals of more than 5 years and less than 15 years would allow for maximal acorn production while preventing the oaks from attaining heights

unfavorable to Florida scrub-jays. Within these upper and lower limits, variability in season and frequency of prescribed fires to produce a mosaic of burned and unburned patches would be most desirable for maintaining high biotic diversity in this community. Invasive exotic plants that can displace native species in disturbed scrubby flatwoods include Natal grass (*Melinis repens*), cogon grass (*Imperata cylindrica*), and downy rose-myrtle (*Rhodomyrtus tomentosa*).

Exemplary Sites: Bald Point State Park (Franklin County), Wekiwa Springs State Park (Orange County), Three Lakes Wildlife Management Area (Osceola County), Jonathan Dickinson State Park (Martin County), St. Marks National Wildlife Refuge (Wakulla County), Lake Wales Ridge State Forest (Polk County), Split Oak Forest Mitigation Park Wildlife and Environmental Area (Orange County)

Global and State Rank: G2/S2?

Crosswalk and Synonyms:

Kuchler	112/Southern Mixed Forest
Davis	2/Pine Flatwoods
SCS	6/South Florida Flatwoods
	7/North Florida Flatwoods
Myers and Ewel	Flatwoods - scrubby, xeric, or dry flatwoods
SAF	71/Longleaf Pine - Scrub Oak
	72/Southern Scrub Oak
	84/Slash Pine
	111/South Florida Slash Pine
FLUCCS	411/Pine Flatwoods
	419/Other Pines

Other synonyms: In contrast to this treatment, scrubby flatwoods on the Lake Wales Ridge³ and Welaka area²²⁷ has been defined to include stands with a continuous cover of scrub oaks and little wiregrass. In this treatment such vegetation would be included under scrub.



National Key Deer Refuge (Monroe County)

Photo by Gary Knight

Pine Rockland

Description: Pine rockland is characterized by an open canopy of South Florida slash pine (*Pinus elliotii* var. *densa*) with a patchy understory of tropical and temperate shrubs and palms and a rich herbaceous layer of mostly perennial species including numerous species endemic to South Florida. Outcrops of weathered oolitic limestone, known locally as pinnacle rock, are common, and solution holes may be present. This subtropical, pyrogenic flatland can be mesic or xeric depending on landscape position and associated natural communities. There are differences in species composition between the pine rocklands found in the Florida Keys and the mainland (see Community Variations below).

Pine rockland has an open canopy of South Florida slash pine, generally with multiple age classes. The diverse, open shrub/subcanopy layer is composed of more than 100 species of palms and hardwoods,¹³³ most derived from the tropical flora of the West Indies.³⁸¹ Many of these species vary in height depending on fire frequency, getting taller with time since fire. These include saw palmetto (*Serenoa repens*), cabbage palm (*Sabal palmetto*), silver palm (*Coccothrinax argentata*), brittle thatch palm (*Thrinax morrisii*), wax myrtle (*Myrica cerifera*), myrsine (*Rapanea punctata*), poisonwood (*Metopium toxiferum*), locustberry (*Byrsonima lucida*), varnishleaf (*Dodonaea viscosa*), tetrazygia (*Tetrazygia bicolor*), rough velvetseed (*Guettarda scabra*), marlberry (*Ardisia escallonioides*),

mangrove berry (*Psidium longipes*), willow bastic (*Sideroxylon salicifolium*), winged sumac (*Rhus copallinum*). Short-statured shrubs include running oak (*Quercus elliotii*), white indigoberry (*Randia aculeata*), Christmas berry (*Crossopetalum ilicifolium*), redgal (*Morinda royoc*), and snowberry (*Chiococca alba*). Grasses, forbs, and ferns make up a diverse herbaceous layer ranging from mostly continuous in areas with more soil development and little exposed rock to sparse where more extensive outcroppings of rock occur. Typical herbaceous species include bluestems (*Andropogon* spp.), several species of bluestem (*Schizachyrium gracile*, *S. rhizomatum*, and *S. sanguineum*), arrowleaf threeawn (*Aristida purpurascens*), lopsided indiangrass (*Sorghastrum secundum*), hairawn muhly (*Muhlenbergia capillaris*), Florida white-top sedge (*Rhynchospora floridensis*), pineland noseburn (*Tragia saxicola*), devil's potato (*Echites umbellata*), pineland croton (*Croton linearis*), several species of sandmats (*Chamaesyce* spp.), partridge pea (*Chamaecrista fasciculata*), coontie (*Zamia pumila*), maidenhair pineland fern (*Anemia adiantifolia*), Bahama brake (*Pteris bahamensis*), and lacy bracken (*Pteridium aquilinum* var. *caudatum*).

Pine rockland occurs on relatively flat, moderately to well drained terrain from two to seven meters above sea level.³⁸¹ The oolitic limestone is at or very near the surface, and there is very little soil development. Soils are generally composed of small accumulations of nutrient-poor sand, marl, clayey loam, and organic debris in depressions and crevices in the rock surface. Organic acids occasionally dissolve the surface limestone causing collapsed depressions in the surface rock called solution holes.³¹¹ Drainage varies according to the porosity of the limestone substrate, but is generally rapid. Consequently, most sites are wet for only short periods following heavy rains. During the rainy season, however, some sites may be shallowly inundated by slow-flowing surface water for up to 60 days each year.

Characteristic Set of Species: South Florida slash pine, Christmas berry, maidenhair pineland fern, Florida silver palm, Florida white-top sedge

Rare Species: Pine rocklands are rich with rare and endemic plants (Table 1). Numerous plants endemic to South Florida are found in pine rockland, including 18 species that are restricted to this community such as Carter's small-flowered flax (*Linum carteri* var. *carteri*).²⁶ Some rare plant species of pine rocklands occur throughout the range of pine rockland, such as pineland noseburn and Christmas berry, while other species such as Big Pine partridge pea (*Chamaecrista lineata* var. *keyensis*) and few-flowered fingergrass (*Digitaria pauciflora*) have more restricted distributions (Table 1).

Five federally listed animals, Florida panther (*Puma concolor coryi*), key deer (*Odocoileus virginianus clavium*), key rice rat (*Oryzomys palustris* pop. 1), eastern indigo snake (*Drymarchon couperi*), key ringneck snake (*Diadophis punctatus acricus*), and lower keys rabbit (*Sylvilagus palustris hefneri*), use pine rocklands either for foraging or nesting (Bradley and Gann 1999). Pine rocklands are particularly important foraging habitat for key deer.⁴⁷ Florida leafwing (*Anaea troglodyta floralis*), lesser wasp moth (*Pseudocharis minima*), Bartram's scrub-hairstreak (*Strymon acis bartrami*), and two species of rare katydid (*Belocephalus micanopy* and *Belocephalus sleighti*) are among the many rare invertebrates found in pine rockland.

Range: Pine rockland is globally imperiled and extremely limited in distribution. In Florida, pine rockland occurs along the southern extreme of the Atlantic Coastal Ridge, or the Miami Rock Ridge, which extends from around downtown Miami southwest to Long Pine Key in Everglades National Park (Miami-Dade County); in scattered locations in the lower Florida Keys, most notably and extensively on Big Pine Key (Monroe County); and in a small isolated area in the Big Cypress National Preserve (Monroe and Collier counties). Pine rockland historically occurred in the upper Florida Keys; pine stumps and remnant species characteristic of pine rockland have been found in one area of Key Largo.⁴

Similar physiognomic pinelands occur in the Caribbean, particularly in the eastern Bahama Archipelago on Grand Bahama, Abaco, New Providence, and Andros, with disjunct pinelands in the Caicos Islands.⁶⁵ These communities, while dominated by Caribbean pine (*Pinus caribaea*), are otherwise quite similar in species composition to Florida pine rockland.⁶⁵

Urban development and agriculture have greatly reduced the extent of pine rockland. The condition of some extant pine rocklands has declined because of inadequate management or because they are isolated and confined by surrounding development that restricts the use of prescribed fire, a principal management tool. Everglades National Park supports 80 percent of Florida's remaining pine rocklands in Florida.²⁴⁶ Only about two percent (2,273 acres) of the original Miami-Dade County pine rockland (approximately 126,500 acres) remains outside Everglades National Park.⁴⁰⁸

Natural Processes: Pine rockland is maintained by regular fire, and susceptible to other natural disturbances such as hurricanes, frost events, and sea-level rise.³⁴⁶ Fires historically burned on an interval of around 3 to 7 years^{381,408,424} and was typically started by lightning strikes during the frequent summer thunderstorms.

Presently, prescribed fire must be periodically introduced into pine rocklands to sustain community structure, prevent invasion by woody species, maintain high herbaceous diversity,²⁴⁷ and prevent succession to rockland hammock. The degree of woody understory growth is directly related to the length of time since the last fire. The ecotone between pine rockland and rockland hammock is abrupt when regular fire is present in the system. However when fire is removed the ecotone becomes more gradual and subtle as hammock hardwoods encroach into the pineland.⁴²⁴

Hurricanes and storms can have a major impact on pine rocklands. High winds can significantly affect plant structure or composition by causing canopy and subcanopy mortality,³²⁵ resulting in subsequent stimulation of shrub or herbaceous growth. Pine rocklands near the coast may be temporarily inundated by saltwater during severe storm events which can kill or damage vegetation.^{381,408} Rare frost events bringing below-freezing temperatures can reduce tropical hardwoods. Because tropical and subtropical plants in pine rocklands are more exposed to below-freezing temperatures in the relatively open understory, they are more likely to succumb to freeze damage than their counterparts in sheltered rockland hammocks. The area of pine rockland in the Florida Keys has been reduced since the 1930s.³⁴⁶ This is at least partially due to increased ground and soil salinity resulting from a 15 centimeters local rise in sea-level that has occurred since that time.³⁴⁶

Community Variations: Pine rockland occurs in three distinct areas: the Miami Rock Ridge, the Florida Keys, and the Big Cypress area. The woody understory varies across this range. Big Cypress pine rockland contains more temperate species and is generally wetter than pine rockland on the Miami Rock Ridge or Florida Keys.³⁸¹ The Florida Keys pine rockland is more xeric due to lower rainfall and has a well developed subcanopy of silver palm, brittle thatch palm, and a higher percentage of tropical shrub species since many temperate species, such as running oak and coontie, reach their southern limits on the mainland. Many tropical shrub species such as devil's smooth-claw (*Pisonia rotundata*) do not extend to the mainland. The mainland pine rockland has a more diverse herbaceous layer due to a mixture of temperate species that do not reach the Florida Keys and tropical species not present in the Florida Keys such as tetrazygia.

Associated Communities: Pine rockland occurs mainly in a mosaic with two other natural community types: rockland hammock and marl prairie. Pine rockland grades into and, in the absence of fire, succeeds to rockland hammock. Many species occur in both habitats; these include locustberry, Florida thatch palm, and poisonwood. Pine rockland differs from rockland hammock in having an open pine canopy rather than a closed, hardwood canopy. Pine rockland can also occur within lower, seasonally flooded marl prairies on the Miami Rock Ridge. These marl prairies differ from pine rockland in having no pines, and an understory dominated by grasses and sedges, typically hairawn muhly (*Muhlenbergia capillaris*) and sawgrass (*Cladium jamaicense*), and a minimal cover of shrubs. In areas where pine rockland is close to the ocean it may be bordered by mangrove swamp or salt marsh and can receive flooding by extremely high tides.

Pine rocklands on the northern Miami Rock Ridge grade into scrub and sandhill vegetation where the three communities intermix in areas with deep sands and rock outcrops.³⁸¹ On the northwestern edge of the pine rockland range, in Big Cypress National Preserve, pine rocklands occur in a mosaic with wet flatwoods. Pine rocklands can be distinguished from wet flatwoods, scrub, and sandhills by the presence of exposed limestone rock and the presence of rare plant species characteristic of pine rockland (Table 1).

Management Considerations: Prescribed fire is the most important consideration in pine rockland management and should be administered every 3 to 7 years to maintain community structure and to prevent the community from succeeding to rockland hammock. Although hardwood species are a natural component of pine rockland, without fire they tend to increase in cover and reduce the amount of light penetrating the forest floor.⁴²⁴ Over time, shading from hardwoods will reduce herbaceous diversity, and a period of just 10 years without fire may result in a marked decrease in number of herbaceous species. Exclusion of fire for 25 years will result in gradual hammock development over that time period, leaving a system that is very fire resistant.^{341,424}

Prescribed fire can be difficult to administer because of urban interface issues related to public perception and smoke management. Alternatives to prescribed fire, such as mechanical removal of woody vegetation are less ecologically effective, as they do not mimic post-fire nutrient cycling processes⁴⁰⁸ and the woody debris generated

must be removed to prevent organic soil development.⁴⁰⁸ Use of heavy equipment can damage soils and herbaceous vegetation, and large-scale removal of vegetation debris could inadvertently include removal of non-target species and propagules.

Shading from and competition with invasive exotic plants for limited resources can be a problem in pine rocklands. Brazilian pepper (*Schinus terebinthifolius*), Burma reed (*Neyraudia reynaudiana*), natal grass (*Melinis repens*), and more than 100 other non-native plant species have invaded many pine rocklands.^{330,408} Prescribed fire, herbicide application, and manual removal are all useful tools to remove invasive exotic species. The fragmentation of pine rockland in the Miami area and the Florida Keys increases the risk of invasion by exotic plants along the interface with disturbed or developed areas.

Exemplary Sites: Ludlam Pineland (Miami-Dade County), Navy Wells Park (Miami-Dade County), Long Pine Key in Everglades National Park (Miami-Dade County), National Key Deer Refuge on Big Pine Key (Monroe County)

Global and State Rank: G1/S1

Crosswalk and Synonyms:

Kuchler	105/Mangrove 16/Subtropical Pine Forest
Davis	3/Southern Slash Pine Forests 1/Coastal Strand
SCS	2/South Florida Coastal Strand 9/Everglades Flatwoods
Myers and Ewel	Subtropical Forests - subtropical pinelands
SAF	111/South Florida Slash Pine 74/Cabbage palmetto
FLUCCS	411/Pine Flatwoods 419/Other Pines

Table 1. Rare plant species (FNAI Tracked) in Florida pine rockland.

Species Occurring on Both the Mainland and Florida Keys	Species Restricted to the Mainland
<i>Argythamnia blodgettii</i>	<i>Alvaradoa amorphoides</i>
<i>Basiphyllaea corallicola</i>	<i>Amorpha herbacea</i> var. <i>crenulata</i>
<i>Bourreria cassinifolia</i>	<i>Brickellia mosieri</i>
<i>Byrsonima lucida</i>	<i>Chamaesyce deltoidea</i> ssp. <i>adhaerens</i>
<i>Chamaesyce garberi</i>	<i>Chamaesyce deltoidea</i> ssp. <i>deltoidea</i>
<i>Chamaesyce portieriana</i>	<i>Chamaesyce deltoidea</i> ssp. <i>pinetorum</i>
<i>Coccothrinax argentata</i>	<i>Colubrina cubensis</i> var. <i>floridana</i>
<i>Crossopetalum ilicifolium</i>	<i>Digitaria pauciflora</i>
<i>Forestiera segregata</i> var. <i>pinetorum</i>	<i>Eupatorium villosum</i>
<i>Hypelate trifolia</i>	<i>Galactia pinetorum</i>
<i>Jacquemontia curtissii</i>	<i>Galactia smallii</i>
<i>Jacquinia keyensis</i>	<i>Ilex krugiana</i>
<i>Linum arenicola</i>	<i>Ipomoea microdactyla</i>
<i>Phyllanthus pentaphyllus</i> var. <i>floridanus</i>	<i>Lantana depressa</i> var. <i>depressa</i>
<i>Pteris bahamensis</i>	<i>Linum carteri</i> var. <i>carteri</i>
<i>Sachsia polycephala</i>	<i>Linum carteri</i> var. <i>smallii</i>
<i>Spiranthes torta</i>	<i>Polygala smallii</i>
<i>Stylosanthes calcicola</i>	<i>Ponthieva brittoniae</i>
<i>Thrinax morrisii</i>	<i>Selaginella eatonii</i>
<i>Tragia saxicola</i>	<i>Tephrosia angustissima</i> var. <i>corallicola</i>
<i>Tripsacum floridanum</i>	
Species Restricted to the Florida Keys	
<i>Caesalpinia pauciflora</i>	
<i>Catesbaea parviflora</i>	
<i>Chamaecrista lineata</i> var. <i>keyensis</i>	
<i>Chamaesyce deltoidea</i> ssp. <i>serpyllum</i>	
<i>Odontosoria clavata</i>	
<i>Pisonia rotundata</i>	
<i>Savia bahamensis</i>	
<i>Strumpfia maritima</i>	



Ludlam Pineland (Miami-Dade County)

Photo by Gary Knight



Babcock Ranch (Charlotte County)

Photo by Katy NeSmith

Dry Prairie

Description: Dry prairie is a community of low shrubs and grasses occupying vast, level expanses in three major areas north and west of Lake Okeechobee in south-central Florida. Common shrubs are saw palmetto (*Serenoa repens*), which is often stunted, dwarf live oak (*Quercus minima*), gallberry (*Ilex glabra*), fetterbush (*Lyonia lucida*), shiny blueberry (*Vaccinium myrsinites*), netted pawpaw (*Asimina reticulata*), Atlantic St. John's wort (*Hypericum reductum*), dwarf wax myrtle (*Myrica cerifera* var. *pumila*), and dwarf huckleberry (*Gaylussacia dumosa*).⁴⁸ These are mixed with about an equal proportion of herbs, predominantly wiregrass (*Aristida stricta* var. *beyrichiana*), along with bottlebrush threeawn (*Aristida spiciformis*), hemlock witchgrass (*Dichanthelium portoricense*), broomsedge bluestem (*Andropogon virginicus*), lopsided indianguass (*Sorghastrum secundum*), and cypress witchgrass (*Dichanthelium ensifolium*), plus numerous forbs^{48,174,179,307} including narrowleaf silkgrass (*Pityopsis graminifolia*), milkworts (*Polygala* spp.), meadowbeauties (*Rhexia* spp.), yellow-eyed grasses (*Xyris* spp.), and wild pennyroyal (*Piloblephis rigida*).

Major soils of the dry prairie are poorly drained sandy spodosols with an organic hardpan including the series EauGallie, Myakka, Immokalee, Oldsmar, and Smyrna, as well as alfisols (Malabar soils) with a subsurface clay layer that impedes drainage.³⁰⁷

Characteristic Set of Species: wiregrass, lopsided indianguass, dwarf live oak, shiny blueberry, stunted saw palmetto

Rare Species: Rare plants include many-flowered grass-pink (*Calopogon multiflorus*), beautiful pawpaw (*Deeringothamnus pulchellus*), and giant orchid (*Pteroglossaspis ecristata*). Rare animals include several bird species that prefer open habitat, including Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), Florida burrowing owl (*Athene cunicularia floridana*), crested caracara (*Caracara cheriway*), white-tailed kite (*Elanus leucurus*), and Florida sandhill crane (*Grus canadensis pratensis*). Of these, only the grasshopper sparrow is confined to dry prairie habitat, preferring areas burned less than 24 months previously. Populations of this sedentary, ground nesting species have been declining since 1979.³³² Conversion of dry prairie to pasture and sod farms have accounted for most of the Florida grasshopper sparrow's decline, but it has also declined at Avon Park

Air Force Range, one of three managed areas where it is protected (Three Lakes Wildlife Management Area and Kissimmee Prairie Preserve State Park being the other two), for reasons that are not clear.³³² Dry prairie is also home to a very rare and declining species of butterfly, the arogos skipper (*Atrytone arogos arogos*) which inhabits grasslands in the eastern U.S. and the rare loammi skipper (*Atrytonopsis loammi*), endemic to Florida.

Range: Dry prairie is confined to south-central Florida. Until recently the extent of dry prairie had been in question due to the difficulty in distinguishing natural dry prairie from cutover pinelands.^{2,79,424} Bridges³⁵ produced a map of the pre-settlement extent of the dry prairie using historical sources that includes the Kissimmee River region (Osceola, Okeechobee, Polk, and Highlands counties), the Big Prairie (Desoto, Glades, and Charlotte counties), and the Myakka Prairie (Manatee and Sarasota counties). The presettlement extent of dry prairie encompassed roughly 1.2 million acres. Mesic flatwoods within and surrounding the continuous dry prairie areas mapped by Orzell and Bridges may contain small inclusions of dry prairie¹⁷⁹ as well as areas of very sparse pine cover. Dry prairie in Hendry¹⁶³ and Brevard counties^{160,274} have also been reported in the early literature. Although much has been converted to agriculture and pasture, examples of dry prairie can be found throughout its presettlement range today.

Natural Processes: There is as yet no definitive answer to the question of why dry prairie does not support pines. In examining the current landscape at the pine/prairie border as mapped by the mid-1800s public land surveyors in the Kissimmee Region, Bridges³⁶ noted that mesic flatwoods are often correlated with a greater degree of dissection of the landscape, i.e. with forested streams and swamps giving protection from at least some landscape-level fires, in contrast to the broad, flat prairies with little or no physical impediments to fire. Thus frequency of fire could have inhibited tree growth in the dry prairie region.

Lack of drainage dissection of the landscape could result in flooding of dry prairies more frequently than in the mesic flatwoods. Platt et al.³²⁷ speculate that the stress of fire at the beginning of the rainy season followed immediately by the stress of flooding with the start of the summer rainy season, both of which would have been more frequent events in dry prairie compared to the surrounding flatwoods, may have been sufficient to prevent pine seedlings from becoming established in dry prairies. Thus a suite of conditions including soil impermeability and timing of fire and rain events in south-central Florida may intersect to produce dry prairie landscapes.

Community Variations: The dominant species of dry prairie are fairly uniform throughout its range; drier sites tend to have fetterbush and coastalplain staggerbush (*Lyonia fruticosa*); wetter sites lack these and have Elliott's yellow-eyed grass (*Xyris elliotii*).³⁰⁷

Associated Communities: Often included within dry prairie are islands of scrub or scrubby flatwoods, shallow depression marshes, sometimes bordered by mesic hammocks of live oak (*Quercus virginiana*) and cabbage palm (*Sabal palmetto*); grassy wet prairies without saw palmetto; and islands of mesic flatwoods. Dry prairie differs from scrub and scrubby flatwoods by the absence of scrub oaks, and from mesic flatwoods in the nearly complete absence of pines, stumps, or stump holes. Wet prairies are often found in slightly lower areas within dry prairies and are distinguished from them by the dominance of wiregrass or blue maidencane (*Amphicarpum muhlenbergianum*), the absence of shrubs, and the presence of wetland herbs such as pineland rayless goldenrod (*Bigelovia nudata*), water cowbane (*Oxypolis filiformis*), and slenderfruit nutrush (*Scleria georgiana*). A transitional type between wet and dry prairie consisting of a grassy matrix with circular patches of saw palmetto was identified as a type of wet prairie by.¹¹⁷ Bridges and Orzell³⁰⁷ group it with dry prairie types (wet-mesic alfic prairie NC4) and note that it has a clayey subsoil. Dry prairie is distinguished from marl prairie by the presence of wiregrass, saw palmetto, and dwarf live oak, by the absence of Gulf hairawn muhly (*Muhlenbergia sericea*), and by the presence of sandy rather than marl (calcareous mud) soils.

Management Considerations: Natural fire intervals in dry prairie are very short, on the order of 1-2 years. Preserves with large acreages of dry prairie in isolated areas may need exemptions from general burning restrictions under dry conditions to be able to burn frequently enough for optimal conditions for the Florida grasshopper sparrow. Restoration of long unburned dry prairie may require growing season burns to reduce woody species. Three growing season burns (two in May and one in June) in the space of six years were successful at killing mature live oaks that had invaded dry prairie at Myakka River State Park during 46 years of fire exclusion.¹⁸⁴ However, reducing dense palmetto cover and increasing herbaceous cover in long fire-excluded prairie is more challenging. Although rollerchopping has been employed prior to fire to reduce saw palmetto, such treatment can damage non-target species and lead to introduction of weedy species.

Exemplary Sites: Kissimmee Prairie Preserve State Park (Okeechobee County), Three Lakes Wildlife Management Area (Osceola and Polk counties), Myakka River State Park (Sarasota and Manatee counties), Babcock Ranch Preserve (Charlotte County)

Global and State Rank: G2/S2

Crosswalk and Synonyms:

Kuchler	79/Palmetto Prairie
Davis	13/Grasslands of Prairie Type
SCS	6/South Florida Flatwoods
	7/North Florida Flatwoods
Myers and Ewel	Flatwoods - mesic flatwoods, dry prairies
SAF	N/A
FLUCCS	321/Palmetto Prairies
	310/Herbaceous

Other synonyms: pineland threeawn range



Three Lakes Wildlife Management Area (Osceola County)

Photo by Ann F. Johnson

COASTAL UPLANDS – mesic or xeric communities restricted to barrier islands and near shore; woody or herbaceous vegetation; other communities may also occur in coastal environments



Bald Point State Park (Franklin County)

Photo by Carolyn Kindell

Beach Dune

Description: Beach dune is a predominantly herbaceous community of wide-ranging coastal specialist plants on the vegetated upper beach and first dune above the beach (foredune). This community is usually built by sea oats (*Uniola paniculata*), a perennial rhizomatous grass, whose stems trap the sand grains blown off the beach, building up the dune by growing upward to keep pace with sand burial. Other grasses that can tolerate some sand burial include bitter panicgrass (*Panicum amarum*) and saltmeadow cordgrass (*Spartina patens*). Camphorweed (*Heterotheca subaxillaris*) often grows with sea oats where sand burial is absent or moderate and seacoast marshelder (*Iva imbricata*), a succulent subshrub, is found at the seaward base of the foredune. These species may also occupy the seaward face and crests of taller backdunes or recent storm overwash plains where the sand is not stabilized by vegetation. The upper beach area seaward of the foredune is a less stable habitat, being disturbed annually by high spring tides or storm tides, and is continually re-colonized by annuals such as sea rocket (*Cakile* spp.), crested saltbush (*Atriplex cristata*), and dixie sandmat (*Chamaesyce bombensis*), by trailing species, such as beach morning glory (*Ipomoea imperati*) and railroad vine (*Ipomoea pes-caprae* ssp. *brasiliensis*), and by the salt-tolerant grasses, seashore paspalum (*Paspalum vaginatum*) and seashore dropseed (*Sporobolus virginicus*).

Characteristic Set of Species: sea oats, railroad vine, bitter panicum, beach elder

Rare Species: Rare plant species found in the beach dune community include Godfrey's goldenaster (*Chrysopsis godfreyi*), Gulf Coast lupine (*Lupinus westianus* - in dune blowouts), late flowering beach sunflower (*Helianthus debilis* ssp. *tardiflorus*), hairy beach sunflower (*Helianthus debilis* ssp. *vestitus*), Garber's spurge (*Chamaesyce garberi*), sand-dune spurge (*Chamaesyce cumulicola*), coastal vervain (*Glandularia maritima*), Atlantic Coast Florida lantana (*Lantana depressa* var. *floridana*), coastal hoary-pea (*Tephrosia angustissima* var. *curtissii*),

burrowing four-o'clock (*Okenia hypogaea*), beachstar (*Cyperus pedunculatus*), and sea lavender (*Argusia gnaphalodes*).

Several rare animal species are dependent on beaches for foraging or nesting, including beach mice, shorebirds, and sea turtles. Six subspecies of beach mouse are found on Florida beaches: four along the Panhandle coast, the Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*), the Santa Rosa beach mouse (*P. p. leucocephalus*), the Choctawhatchee beach mouse (*P. p. allopshys*), and the St. Andrews beach mouse (*P. p. peninsularis*); and two along the Atlantic coast, the Anastasia Island beach mouse (*P. p. phasma*) and the southeastern beach mouse (*P. p. niveiventris*).

Many rare shorebirds use Florida beaches for nesting. These include the state-listed snowy plover (*Charadrius alexandrinus*), American oystercatcher (*Haematopus palliatus*), black skimmer (*Rynchops niger*), least tern (*Sterna antillarum*), and roseate tern (*S. dougallii*). The federally listed piping plover (*Charadrius melodus*), which breeds further north, winters along Florida beaches. FNAI-listed shorebirds using beaches include Wilson's plover (*Charadrius wilsonia*), royal tern (*Sterna maxima*), and sandwich tern (*Sterna sandvicensis*).

Florida beaches are one of the three major nesting areas in the world for loggerhead turtles (*Caretta caretta*). Eighty percent of the nests in Florida are found on the Atlantic coast from Brevard to Broward counties. Other rare sea turtles that nest in Florida are the green (*Chelonia mydas*), the hawksbill (*Eretmochelys imbricata*), the leatherback (*Dermochelys coriacea*), and Kemp's Ridley (*Lepidochelys kempii*).

Range: In Florida, sandy coasts with sea oats dunes are continuous on the Atlantic coast from the state line south to Cape Florida, Miami-Dade County, and on the Gulf coast of the peninsula from Anclote Key, Pasco County, south to Cape Romano, Collier County.¹⁹⁸ Between Collier and Dade counties, beaches are discontinuous, being found at two sites on the Florida Keys,²¹⁷ four sites on the islands west of Key West, including the Marquesas²¹⁷ and the Dry Tortugas,⁷⁸ on Cape Sable,²¹⁷ and on a few of the larger outer islands of the Ten Thousand Islands.¹⁹⁷ On the Panhandle coast sea oats dunes extend from the mouth of the Ochlockonee River west to the Alabama border.²⁰⁰ World wide, sea oats dunes are found on sandy shores around the Gulf of Mexico from eastern Mexico north of the Yucatan Peninsula³⁵³ to Florida, Cuba, and the Bahamas⁶⁵ and extend northward along the Atlantic coast to Virginia.³⁸⁷

Natural Processes: Water and wind are the primary environmental forces that shape the ecology of beach dunes. Plants on the foredune are regularly exposed to salt spray and sand burial from onshore winds blowing across the salt water and open sandy beach; plants on the upper beach are subject to these stresses plus occasional inundation by high seasonal or storm tides and periodic destruction by waves. The plants of the beach dune community are adapted to either withstand these stresses or to rapidly re-colonize from seed or vegetative parts following destruction. Storm waves may either erode the seaward face of the foredune, moving sand offshore to form underwater bars, or break through the dune, moving sand inland as an overwash fan.³²³ Dune and upper beach plants colonize this new area haphazardly at first, but gradually become organized into foredune and upper beach zones as waves build the beach back up and wind moves the sand inland to build a new dune ridge. Fertilization from piles of seaweed washed up by the storm helps to speed plant growth and the re-colonization process. Once a new foredune ridge blocks salt spray and plant cover inhibits sand movement, inland herbaceous and eventually woody species can begin to replace the coastal pioneer species of the beach dune community in the backdune area.

Fire is naturally rare in this community. The shoreline location prevents fires from spreading from at least half the possible compass directions, and beach dunes typically lack the necessary fuel loads and continuity to carry fire for appreciable distances.

Community Variations: On Panhandle and North Florida beaches, beach pennywort (*Hydrocotyle bonariensis*) is a common trailing species, especially where deposits of seaweed provide a fertile substrate. Found only on the Panhandle coast is Gulf bluestem (*Schizachyrium maritimum*) which is dominant in the adjacent coastal grassland community but can also be found on the landward slope of the foredune. The tropical portions of the peninsula, from Brevard and Pasco counties southward, are distinguished by the presence of the baybean (*Canavalia rosea*) on the upper beach, and beachberry (*Scaevola plumieri*), bay cedar (*Suriana maritima*), coastal beach sandmat (*Chamaesyce mesembrianthemifolia*), and occasional shrubs of seagrape (*Coccoloba uvifera*) among the sea oats. Found throughout the Atlantic coast is east coast dune sunflower (*Helianthus debilis*) and found only on the tropical portion of the Atlantic coast are seaside joyweed (*Alternanthera maritima*) and beachstar (*Cyperus pedunculatus*).

Associated Communities: Beach dune may be distinguished from coastal grassland by its position above the immediate shoreline and by the dominance of burial-tolerant grasses such as sea oats and bitter panicum. It differs from coastal berm in its position facing the open ocean on a sandy coast rather than on a storm-deposited shell ridge on a mangrove-dominated shoreline. It is distinguished from coastal strand and maritime hammock in being dominated by herbaceous rather than woody species.

Management Considerations: Fires are rare to non-existent in this community. Invasion by the exotic Australian pine (*Casuarina equisetifolia*) following storm disturbance is an ongoing threat especially on the Gulf coast where sand burial may not control it from becoming established above the beach, thus changing the beach dynamics that would lead to natural succession of native vegetation. The natural successional stages following storms are not known for the southerly coasts of the peninsula. Long-term monitoring following removal of Australian pine would be helpful in determining what these stages are for various coastal situations. Certain procedures intended to make the beach more pleasant or accessible for recreational use can interfere with natural processes. Raking seaweed off the beach deprives the plants of nutrients needed for luxuriant growth following storms. In areas with strong onshore winds and stable communities protected by the foredune, paths through the sea oats dunes at right angles to the beach can promote blowouts, allowing a wave of sand to move inland burying existing stable vegetation. This can be prevented by using dune walkovers, or winding paths parallel to the shore. Beach re-nourishment and/or piling sand to make artificial dunes may produce changes both in the beach dune vegetation and in the backdune vegetation, by altering the conditions of salt spray and sand movement to which existing plants are exposed. If restoration plantings are used, care should be taken not to plant coastal endemics outside their range. East coast dune sunflower, for example, is widely available in the nursery trade, but is native only to the Atlantic coast of Florida. If planted on the southwest Gulf coast outside its range, it could hybridize with the rare endemic hairy beach sunflower (*H. debilis* ssp. *vestitus*).

Exemplary Sites: Gulf Islands National Seashore (Okaloosa County); Topsail Hill State Park (Walton County), St Joseph Peninsula State Park, Canaveral National Seashore (Volusia/Brevard County), Anclote Key State Park (Pasco County), Cayo Costa Island State Park (Lee County)

Global and State Rank: G3/S2

Crosswalk and Synonyms:

Kuchler	90/Live oak - Sea oats
Davis	1/Coastal Strand
SCS	1/North Florida Coastal Strand
	2/South Florida Coastal Strand
Myers and Ewel	Coastal Strand
SAF	N/A
FLUCCS	710/Beaches

Other synonyms: upper beach¹⁹⁴; foredune¹⁹⁴



Florida Keys Wildlife and Environmental Area (Monroe County)

Photo by Randy Grau

Coastal Berm

Description: Coastal berm is a short forest or shrub thicket found on long narrow storm-deposited ridges of loose sediment formed by a mixture of coarse shell fragments, pieces of coralline algae, and other coastal debris. These ridges parallel the shore and may be found on the seaward edge or landward edge of the mangroves or further inland depending on the height of the storm surge that formed them. They range in height from 1 to 10 feet. Structure and composition of the vegetation is variable depending on height and time since the last storm event. The most stable berms may share some tree species with rockland hammocks, but generally have a greater proportion of shrubs and herbs.³⁴⁵ Tree species may include gumbo limbo (*Bursera simaruba*), seagrape (*Coccoloba uvifera*), silver palm (*Coccothrinax argentata*), blolly (*Guapira discolor*), milkbark (*Drypetes diversifolia*), sevenyear apple (*Genipa clusiifolia*), and poisonwood (*Metopium toxiferum*). Characteristic tall shrub and short tree species include Spanish stopper (*Eugenia foetida*), hog plum (*Ximenia americana*), white indigoberry (*Randia aculeata*), Florida Keys blackbead (*Pithecellobium keyense*), and saffron plum (*Sideroxylon celastrinum*). Short shrubs and herbs include perfumed spiderlily (*Hymenocallis latifolia*), bayleaf capertree (*Capparis flexuosa*), buttonsage (*Lantana involucrata*), and rougeplant (*Rivina humilis*).^{217,345} More seaward berms or those more recently affected by storm deposition may support a suite of plants similar to beaches, including shoreline seapurslane (*Sesuvium portulacastrum*), saltgrass (*Distichlis spicata*), and seashore dropseed (*Sporobolus virginicus*), or scattered to dense shrub thickets with buttonwood (*Conocarpus erectus*), stunted black, red, and white mangroves (*Avicennia germinans*, *Rhizophora mangle*, and *Laguncularia racemosa*), bay cedar (*Suriana maritima*), wild dilly (*Manilkara jaimiqui*), joewood (*Jacquinia keyensis*), and bushy seaside oxeye (*Borrchia frutescens*).¹¹⁹

Characteristic Set of Species: Coastal berm consists of a mixture of tropical herbs shrubs and trees – it is defined by its substrate of coarse, calcareous, storm-deposited sediment forming long narrow ridges.

Rare Species: Rare plant species found on coastal berm include pride-of-big-pine (*Strumpfia maritima*), joewood (*Jacquinia keyensis*), and wild dilly (*Manilkara jaimiqui*).

Range: Coastal berm is found along low energy coastlines in South Florida and the Florida Keys.

Natural Processes: Coastal berm is deposited by storm waves along low-energy coasts. Their distance inland depends on the height of the storm surge. Tall berms may be the product of repeated storm deposition. Excavation of one berm in the Florida Keys revealed several layers of buried soils, evidence for burial by repeated storms at relatively long intervals.²¹⁷ Coastal berms that are deposited far enough inland and remain long-undisturbed may in time succeed to maritime hammock.

Community Variations: This is a structurally variable community that may appear in various stages of succession following storm disturbance, from scattered herbaceous beach colonizers to a dense stand of tall shrubs.

Associated Communities: Coastal berm is more easily distinguished from neighboring communities by its physical features than by their species composition. It is distinguished from Keys cactus barren and rockland hammock by occurring on coarse calcareous sediments rather than on limestone rock, or soils derived from limestone rock, and is distinguished from Keys tidal rock barren by its elevation above normal tide limits.³⁴⁵ It is distinguished from maritime hammock by its lack of continuous canopy and occurrence on primarily shelly rather than sandy substrates.

Management Considerations: Fires are rare to non-existent in this community. Invasion by the exotics, including Australian pine (*Casuarina equisetifolia*), Brazilian pepper (*Schinus terebinthifolius*), beach naupaka (*Scaevola taccada* var. *sericea*), portia (*Thespesia populnea*), and latherleaf (also known as asiatic colubrina; *Colubrina asiatica*), following storm disturbance is an ongoing threat to this community.

Exemplary Sites: Dagny Johnson Key Largo Hammock Botanical State Park (Monroe County), Long Key State Park (Monroe County); Marquesas Long Beach in Key West National Wildlife Refuge (Monroe County)

Global and State Rank: G3/S2

Crosswalk and Synonyms:

Kuchler	105/mangrove
Davis	9/mangrove swamp forests and coastal marshes
SCS	14/ tropical hammocks
SAF	none
FLUCCS	none
Whitney	beach dune systems-coastal berm

Other synonyms: strand hammock⁷⁸; coastal strand forest³⁴⁵



Tyndall Air Force Base (Bay County)

Photo by Ann F. Johnson

Coastal Grassland

Description: Coastal grassland is a predominantly herbaceous community occupying the drier portions of the transition zone between beach dunes on the immediate coast and communities dominated by woody species, such as coastal strand or maritime hammock, further inland. It occurs primarily on the broader barrier islands and capes along the sandy coasts of Florida. The specialized dune building grasses of the beach dune community, sea oats (*Uniola paniculata*), bitter panicgrass (*Panicum amarum*), and saltmeadow cordgrass (*Spartina patens*), are usually present, along with a variety of other herbaceous species typically found on more stable soils, such as bluestem grasses (*Andropogon* spp., *Schizachyrium* spp.), camphorweed (*Heterotheca subaxillaris*), and earleaf greenbrier (*Smilax auriculata*).¹⁹⁸

Characteristic Set of Species: bluestem species, camphorweed, earleaf greenbrier

Rare Species: Rare plant species of the coastal grassland community include Godfrey's goldenaster (*Chrysopsis godfreyi*), Cruise's goldenaster (*Chrysopsis gossypina* ssp. *cruiseana*), and Gulf Coast lupine (*Lupinus westianus*) in the Panhandle; Sanibel lovegrass (*Eragrostis pectinacea* var. *tracyi*), hairy beach sunflower (*Helianthus debilis* ssp. *vestitus*), and Gulf Coast Florida lantana (*Lantana depressa* var. *sanibelensis*) on the southwest Gulf coast; Garber's spurge (*Chamaesyce garberi*) on Cape Sable in the Everglades; and coastal vervain (*Glandularia maritima*), Atlantic Coast Florida lantana (*Lantana depressa* subsp. *floridana*), coastal hoary-pea (*Tephrosia angustissima* var. *curtissii*), and beachstar (*Cyperus pedunculatus*) on the Atlantic coast.

A number of rare animals use coastal grasslands for foraging and nesting, including six subspecies of beach mouse: four along the Panhandle coast, the Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*), the Santa Rosa beach mouse (*P. p. leucocephalus*), the Choctawhatchee beach mouse (*P. p. allophrys*), and the St. Andrews beach mouse (*P. p. peninsularis*), and two along the Atlantic coast, the Anastasia Island beach mouse (*P. p. phasma*) and the southeastern beach mouse (*P. p. niveiventris*). Three rare shorebirds may nest in coastal grasslands, the snowy plover (*Charadrius alexandrinus*), Wilson's plover (*Charadrius wilsonia*), and American oystercatcher (*Haematopus palliatus*). Four rare invertebrates are found in this community along the Florida Panhandle coast. Woodruff's polyphyllan scarab beetle (*Polyphylla woodruffi*) and barrier island hesperapis bee (*Hesperapis oraria*) are restricted to the coast, and two other beetles (*Gronocarus autumnalis* and *G. inornatus*) also occur inland.

Range: Coastal grassland is found primarily on broader barrier islands and capes along the sandy coasts of Florida. Outside of Florida it occurs westward to the Mississippi barrier islands and northward to the Carolinas.¹⁹⁴

Natural Processes: Coastal grassland develops in two ways: either as a barrier island builds seaward, developing new dune ridges along the shore which protect the inland ridges from sand burial and salt spray, or as a beach recovers after storm overwash and a new foredune ridge builds up along the shore, protecting the overwashed area behind it from sand burial and salt spray. Distance from the coast and the physical barrier of the first dune ridge above the beach (foredune) diminish the intensity of sand burial and salt spray, which affect the coastal grassland community to a lesser extent than they do the beach dune community. If storm waves breach the foredune and spread sand over the coastal grassland, a beach dune community will re-colonize at first. Fertilization from piles of seaweed washed up by the storm helps to speed plant growth and the re-colonization process. Once a new foredune ridge builds up above the beach and plant cover inhibits further sand movement behind this ridge, other herbaceous species can colonize and occur with the coastal pioneer species to form the coastal grassland community. As time passes, absent further storms, the coastal grassland community itself will gradually be replaced by woody species to form scrub, coastal strand, or maritime hammock communities.

Fire is naturally rare and localized in this community with water barriers and sparse fuels combining to limit its spread.

Community Variations: Coastal grassland is well-developed in the Panhandle where it includes a number of species endemic to the stretch of Gulf coast from Florida to Mississippi. These include the dominant grass, Gulf bluestem (*Schizachyrium maritimum*), plus squareflower (*Paronychia erecta*), and coastal sand frostweed (*Helianthemum arenicola*). Other species commonly found in these coastal grasslands are coastal plain honeycomb-head (*Balduina angustifolia*), eastern milkpea (*Galactia regularis*), and Le Conte's flatsedge (*Cyperus lecontei*).²⁰⁰ On the southwest Gulf coast a distinctive coastal grassland community is found on the broad barrier islands fronting Pine Island Sound, e.g., Cayo Costa, North Captiva, and formerly Captiva and Sanibel.⁶³ It consists of a short, dense sward of hairy gramma (*Bouteloua hirsuta*), a western disjunct found in Texas and on the western high plains.²¹⁸ Other species present include beach creeper (*Ernodea littoralis*), erect pricklypear (*Opuntia stricta*), and Gulf Coast Florida lantana (*Lantana depressa* var. *sanibelensis*).¹⁹⁷ The herbaceous flats behind the foredunes at Amelia and Little Talbot Islands in northeast Florida may have more herbs than grasses, including beach pennywort (*Hydrocotyle bonariensis*), seabeach eveningprimrose (*Oenothera humifusa*), camphorweed, and cockspur pricklypear (*Opuntia pusilla*).¹⁹⁹ In the few instances where coastal grassland occurs on the southeast coast, e.g., at Cape Canaveral, St. Lucie Inlet State Park and, and the recently restored Cape Florida, beach-star may be present with other common grasses and forbs in the coastal grassland community.

Associated Communities: Coastal grassland is distinguished from the beach dune community by its position inland from the immediate coastline and the presence of a variety of grasses and forbs, such as bluestem grasses and camphorweed, in addition to the pioneer dune-building grasses such as sea oats. It differs from coastal berm in its position on a sandy coast, rather than on a storm-deposited shell ridge on a mangrove-dominated shoreline. It is distinguished from coastal interdunal swale by the absence of species tolerant of inundation, such as sawgrass (*Cladium jamaicense*) or needle rush (*Juncus roemerianus*) and the predominance of species found on dry sites. Hairawn muhly (*Muhlenbergia capillaris*) may be present in coastal grasslands, but dense stands of it are more characteristic of coastal interdunal swales. Coastal grassland is distinguished from coastal strand and maritime hammock in being dominated by herbaceous rather than woody species.

Management Considerations: Fires are rare in this community. Most coastal species are good colonizers and will re-vegetate a beach naturally after storms. If restoration plantings are used, care should be taken not to plant coastal endemics outside their range. For example, east coast dune sunflower (*Helianthus debilis*) is widely available in the nursery trade, but it is native only to the Atlantic coast of Florida and could hybridize with the endemic hairy beach sunflower on the southwest Gulf coast if planted outside its range. The cultivated lantana (*Lantana camara*), which naturalizes in disturbed sites, regularly hybridizes with the two rare coastal subspecies of *Lantana depressa* and should be removed if found in the vicinity of the rare plants. Invasion by the exotic Australian pine (*Casuarina equisetifolia*) following storm disturbance is an ongoing threat, since it can establish above the upper beach, and interrupt the natural succession of native vegetation. The natural successional sequence following storms is not known for the southerly coasts of the peninsula; long-term monitoring, following removal of Australian pines, would be helpful in determining these stages particularly if done in a variety of coastal situations.

Exemplary Sites: Gulf Islands National Seashore (Okaloosa County), Topsail Hill Preserve State Park (Walton County), St. Joseph Peninsula State Park (Gulf County), Canaveral National Seashore (Volusia/Brevard County), Anclote Key Preserve State Park (Pasco County), Cayo Costa Island State Park (Lee County)

Global and State Rank: G3/S2

Crosswalk and Synonyms:

Kuchler	90/Live oak - Sea oats
Davis	1/Coastal Strand
SCS	1/North Florida Coastal Strand
	2/South Florida Coastal Strand
Myers and Ewel	Dunes and maritime hammocks -transition zone
SAF	N/A
FLUCCS	310/Herbaceous



Guana Tolomato Matanzas National Estuarine Research Reserve (St. Johns County)

Photo by Katy NeSmith

Coastal Strand

Description: Coastal strand is an evergreen shrub community growing on stabilized coastal dunes in the peninsula of Florida, often with a smooth canopy due to pruning by salt spray. It usually develops as a band between dunes dominated by sea oats (*Uniola paniculata*) along the immediate coast, and maritime hammock, scrub, or mangrove swamp communities further inland. On broad barrier islands or prograding coasts, it may also occur as patches of shrubs within a coastal grassland matrix.

Along the Atlantic coast, species composition of coastal strand changes from north to south. Temperate species dominate from the Georgia border south to Cape Canaveral, with dense saw palmetto (*Serenoa repens*) and scattered dwarfed cabbage palm (*Sabal palmetto*) on the seaward edge, which are gradually joined inland by taller shrubs, including tough bully (*Sideroxylon tenax*), yaupon (*Ilex vomitoria*), Hercules' club (*Zanthoxylum clava-herculis*), and shrubby forms of red bay (*Persea borbonia*), red cedar (*Juniperus virginiana*), and live oak (*Quercus virginiana*).¹⁹⁹ From Canaveral southward tropical species become more prevalent, including seagrape (*Coccoloba uvifera*) nearest the coast, joined further inland by Florida swampprivet (*Forestiera segregata*), myrsine (*Rapanea punctata*), buttonsage (*Lantana involucrata*), white indigoberry (*Randia aculeata*), snowberry (*Chiococca alba*), Spanish stopper (*Eugenia foetida*), blolly (*Guapira discolor*), wild lime (*Zanthoxylum fagara*) Florida Keys blackbead (*Pithecellobium keyense*), coco plum (*Chrysobalanus icaco*), coinvine (*Dalbergia ecastaphyllum*), yellow necklace pod (*Sophora tomentosa* var. *truncata*), and gray nicker (*Caesalpinia bonduc*).²⁰¹

Along the southwest coast, where prevailing easterlies do not blow across the water, coastal strand generally does not exhibit the low, even, spray-pruned profile and the expanses of saw palmetto seen on the Atlantic coast. Many of the same tropical species found on the east coast occur here; joewood (*Jacquinia keyensis*) is found only on the west coast and saffron plum (*Sideroxylon celastrinum*), of limited occurrence on the east coast, is common here.²⁰¹

Soils are deep well-drained sands and may be somewhat alkaline, consisting of quartz sand mixed with varying proportions of shell fragments (e.g., Palm Beach sand).

Characteristic Set of Species: saw palmetto, cabbage palm, tough bully, red bay, and live oak are characteristic of temperate coastal strand; seagrape, myrsine, buttonsage, and Florida Keys blackbead characterize tropical coastal strand.

Rare Species: Rare plant species found in coastal strand include Simpson's prickly apple (*Harrisia simpsonii*) on the Atlantic coast and joewood (*Jacquinia keyensis*) plus the highly endangered aboriginal prickly apple (*Harrisia aboriginum*) on the west coast. Species found in openings in coastal strand include coastal vervain (*Glandularia maritima*), Atlantic coast Florida lantana (*Lantana depressa* var. *floridana*), and beach jacquemontia (*Jacquemontia reclinata*) on the Atlantic coast and Gulf coast Florida lantana (*Lantana depressa* var. *sanibelensis*) on the west coast. Among rare animals, gopher tortoises (*Gopherus polyphemus*) are common in this community and southeastern beach mice (*Peromyscus polionotus peninsularis*) may use this community, particularly as a refuge during and after hurricanes.

Range: In Florida, coastal strand is relatively continuous along the sandy portion of the Atlantic coast, patchily distributed on the southwest Gulf coast, and absent on the Florida Panhandle coast where the transition zone is occupied by scrub or coastal grassland communities.¹⁹⁸ Outside of Florida, coastal strand continues north to South Carolina, although a continuous band of shrubs dominated by saw palmetto and cabbage palm are found only on the narrower barrier islands in Florida. To the west, the coasts of Alabama and Mississippi, like the Panhandle, have scrub and coastal grassland communities, rather than coastal strand, interpolated between the sea oats dune above the beach and the more stable inland communities

Natural Processes: Coastal strand is usually the first woody plant community inland from the coast, behind grassy sea oats (*Uniola paniculata*) dunes or coastal grassland and in front of taller maritime hammock on its landward side. Salt spray, blown off the water when the wind speed is high enough to produce white caps (ca. 16 mph), maintains a low, even canopy by killing the most seaward twigs of the shrubs.²⁵ As salt spray is combed out of the wind stream by the more seaward dead twigs, those landward of them can grow a little taller to landward, producing a canopy that slants up away from the coast.²⁵ Eventually, at a certain distance from the coast, the canopy can grow tall enough for a maritime hammock to develop. Storm waves periodically destroy sea oats dunes and the coastal strand behind them, with the resulting bare area being re-colonized first by sea oats and pioneer beach species and then by coastal grassland as the sea oats foredune is re-built and provides some protection from moving sand off the beach. The resulting coastal grassland is in turn invaded by patches of woody species which eventually coalesce into a continuous woody community of coastal strand. The width of the band of coastal strand is determined by the degree of protection from spray provided by the foredune. If the foredune is tall and the land drops away behind it, maritime forest can grow immediately behind it and strand is confined to the top of the dune, as can be seen at MacArthur Beach State Park. If the foredune is low and the land slopes up or is level behind it, strand covers a broader area, as can be seen at Canaveral National Seashore.

There is little information on natural fire frequency in coastal strand. Since saw palmetto is a major component and is known to be very flammable, fires, once started, could spread rapidly. Measurement of the inland penetration of salt spray on the Florida coast might help answer questions as to how this factor might interact with fire in maintaining the low shrubby stature of vegetation, especially on broader sections of the coast, such as at Cape Canaveral where scrub is present on the older dune ridges. On these older ridges, the shell in the sand has been leached away over time, producing an acid, infertile substrate that favors scrub over strand species (Kurz 1942).

Community Variations: In addition to north-south variation discussed above, species composition differs between the Atlantic and Gulf coasts. Coastal strand in Lee County on the west coast is characterized by joewood which does not occur in this community on the Atlantic coast; coastal strand on the east coast from Brevard to Palm Beach counties may be dominated by Simpson's stopper (*Myrcianthes fragrans*), which is rare in strands along the west coast.^{197,201}

Associated Communities: Coastal strand may be distinguished from scrub by the presence of short-statured live oak, calciphilic species such as cabbage palm and Hercules' club, or in the southern portion of the state, by the presence of tropical shrubs. Coastal strand lacks characteristic scrub oaks such as myrtle oak (*Q. myrtifolia*), Chapman's oak (*Q. chapmanii*), and sand live oak (*Q. geminata*), as well as Florida rosemary (*Ceratiola ericoides*). The two communities may occur on adjacent ridges in parts of St. Johns, southern Brevard, and northern Palm Beach counties, where geologically older ridges of acid quartz sand (e.g. Welaka sand) support scrub just inland from younger deposits of quartz sand mixed with shell (e.g. Palm Beach sand)¹⁸¹ that support coastal strand. Both

communities look very similar, since they are dominated by shrubby oak species and are spray-pruned by sea winds. However, in coastal strand, dwarfed live oak (*Quercus virginiana*) predominates, and in scrub, sand live oak (*Q. geminata*) predominates. The difference between scrub and coastal strand in this region is most apparent in April, when the scrub will still appear dark green from the old leaves of the sand live oak, while the coastal strand is light green from the new leaves of live oak, which leaf out earlier than sand live oak.

Coastal strand is distinguished from maritime hammock by the absence of distinct tree canopy and understory layers. It is distinguished from coastal berm and shell mound by its occurrence on sand deposits along a high-energy sandy coast, rather than on a shell deposits along a low-energy, mangrove-dominated coast. It is distinguished from coastal grassland by the dominance of woody, rather than herbaceous species.

Management Considerations: As mentioned, the question of natural fire frequency in this community is unresolved. On the Atlantic coast chopping and burning strand or scrub near the coast has been used to maintain or return these communities to a low stature and prevent them from succeeding to hammock. If there are hammocks inland of these shrub stands, this treatment can suddenly expose the canopy trees to increased salt spray, since it removes the upward slanting shrub canopy that previously combed the spray out of the air before it reached the hammock. Xeric and maritime hammocks along the coast are important resting and feeding sites for migrating songbirds.^{72,272} Chopping and fire may also open the hammock and strand communities to invasion by exotics, particularly if the treatments happen to be followed by natural disturbances which also serve to open up their canopies, such as coastal storms or hard freezes in areas with tropical species present.

Invasion by exotic plants, such as Australian pine (*Casuarina equisetifolia*), Brazilian pepper (*Schinus terebinthifolius*), latherleaf (*Colubrina asiatica*), beach naupaka (*Scaevola taccada*), Burma reed (*Neyraudia reynaudiana*), and carrotwood (*Cupaniopsis anacardioides*) following natural disturbance is an ongoing threat. Although disturbance is a natural process on the coast and native species are presumably adapted to colonize after disturbance, Australian pine can grow taller, closer to the coast, than any native species, thereby pre-empting natural succession from coastal strand to native hammocks.¹⁹⁰ Australian pine has been removed at a number of sites including Keewaydin Island, Don Pedro Island State Park, Lovers Key, Hutchinson Island, and St. Lucie Inlet State Park. Re-colonization by native woody species, such as coinvine (*Dalbergia ecastaphyllum*), should not be interfered with, since the native colonizers help to deter re-invasion by exotics and are likely a successional stage leading to native maritime hammock re-establishment. Areas where Australian pine is removed require monitoring and re-treatment (spot herbicide or hand pulling) to prevent reinvasion, especially until native species become well-established.

Red bay in temperate coastal strand communities has been affected by Laurel Wilt Disease, which is caused by a fungus spread by an exotic wood-boring beetle (*Xyleborus glabratus*) and is fatal to shrubs over 1 inch dbh. Infestations were first discovered in Duval County in 2004 and, by 2009, had spread to Nassau County and southward down the coast as far as St. Lucie County.⁴¹¹ As of 2009, there were no known means of treating diseased trees or controlling the spread of the disease. Wood or mulch from dead infected trees should not be transported to avoid creating new centers of infection. This includes the transport of firewood into, or near, coastal strand for the purposes of outdoor recreational fires (campfires, bonfires).

Exemplary Sites: Guana Tolomato Matanzas National Estuarine Research Reserve – Guana site (formerly Guana River State Park, St. Johns County), Canaveral National Seashore (Volusia/Brevard County), Hollywood North Beach Regional Park (Broward County), Cayo Costa State Park (Lee County)

Global and State Rank: G3/S2

Crosswalk and Synonyms:

Kuchler	90/Live oak - Sea oats
Davis	1/Coastal Strand (in part)
SCS	1/North Florida Coastal Strand
	2/South Florida Coastal Strand
Myers and Ewel	Dunes and maritime hammock-coastal scrub
SAF	N/A
FLUCCS	322/Coastal Scrub
	426/Tropical Hardwoods
Whitney	beach dune systems

Other synonyms: saw palmetto shrubland³⁵¹; scrub zone²¹⁹; cactus thickets, shore hammocks¹⁶¹; maritime shrub community²²



Canaveral National Seashore (Volusia County)

Photo by Ann F. Johnson



Fort Clinch State Park (Nassau County)

Photo by Ann F. Johnson

Maritime Hammock

Description: Maritime hammock is a predominantly evergreen hardwood forest growing on stabilized coastal dunes lying at varying distances from the shore. Species composition changes from north to south with temperate species dominating from the Georgia border to Cape Canaveral and tropical species increasingly prevalent south of Cape Canaveral. From the Georgia border to north of Cape Canaveral, live oak (*Quercus virginiana*), cabbage palm (*Sabal palmetto*), and red bay (*Persea borbonia*) combine to form a dense canopy. The low, streamlined profile deflects winds and generally prevents hurricanes from uprooting the trees. Additional canopy species include pignut hickory (*Carya glabra*) and southern magnolia (*Magnolia grandiflora*). Characteristic subcanopy species are red cedar (*Juniperus virginiana*) and American holly (*Ilex opaca*). Yaupon (*Ilex vomitoria*), tough bully (*Sideroxylon tenax*), wax myrtle (*Myrica cerifera*), and saw palmetto (*Serenoa repens*) are typical shrubs. The herb layer is sparse to absent.¹⁹⁹

South of Cape Canaveral, tropical trees found in the canopy include gumbo limbo (*Bursera simaruba*), false mastic (*Sideroxylon foetidissimum*), inkwood (*Exothea paniculata*), white stopper (*Eugenia axillaris*), strangler fig (*Ficus aurea*) seagrape (*Coccoloba uvifera*), Spanish stopper (*Eugenia foetida*), poisonwood (*Metopium toxiferum*), blolly (*Guapira discolor*), and Florida Keys blackbead (*Pithecellobium keyense*); tropical shrubs include myrsine (*Rapanea punctata*), Simpson's stopper (*Myrcianthes fragrans*), marlberry (*Ardisia escallonioides*), wild coffee (*Psychotria nervosa*), snowberry (*Chiococca alba*), and white indigoberry (*Randia aculeata*).²⁰¹

The same species are found on the Gulf coast of the peninsula of Florida with temperate canopy species with tropical understory shrubs being the prevailing type from Pasco to Lee counties, south of which more tropical trees are found in the canopy, including Jamaican dogwood (*Piscidia piscipula*) which is absent from the east coast.¹⁹⁷

On the Florida Panhandle coast, the forested portions of barrier islands are largely occupied by pine-dominated communities such as scrub, scrubby flatwoods, and mesic flatwoods, and maritime hammock is found only in isolated pockets, often where shell is mixed with the sandy substrate.¹⁹⁴ West of Gulf County, sand live oak (*Quercus geminata*) replaces live oak in the canopy, occasionally mixed with sand pine (*Pinus clausa*) and slash

pine (*P. elliottii*); cabbage palm is absent, having reached its western range limit.²⁰⁰ These hammocks are classified as xeric, rather than maritime, even though they occur on barrier island dunes.

Maritime hammock occurs on deep well-drained acid quartz sands, such as Fripp soils on Little Talbot Island,⁴³⁰ or well-drained, moderately alkaline quartz sands mixed with shell fragments, such as Palm Beach soils²⁶¹ at MacArthur Beach State Park.

Characteristic Set of Species: Live oak, cabbage palm, red bay, and red cedar are characteristic of temperate maritime hammock. Gumbo limbo, seagrape, and white or Spanish stopper are characteristic of tropical maritime hammock.

Rare Species: Rare plant species found in maritime hammock include Biscayne prickly ash (*Zanthoxylum coriaceum*), an understory tree in Broward and Dade counties; silver palm (*Coccothrinax argentata*) in the understory of hammocks from Palm Beach to Dade counties, small-flowered lily thorn (*Catesbaea parviflora*) in the Keys, and the globally imperiled aboriginal prickly apple (*Harrisia aboriginum*) in hammocks on the west coast of the peninsula from Manatee to Collier counties.

Temperate and tropical maritime hammocks serve as crucial resting and foraging areas for songbirds on their fall and spring migrations to and from the tropics.⁷² Though not primary habitat, maritime hammocks are often used by gopher tortoise (*Gopherus polyphemus*).

Range: North of Florida, maritime hammocks dominated by live oak with red bay, and red cedar are well-developed on the broad barriers known as “sea islands” in Georgia and South Carolina²² and extend northward along the Atlantic coast as far as Cape Hatteras, North Carolina.²⁴⁸ Cabbage palm and southern magnolia range north only as far as South Carolina. Within Florida, broad barrier islands of the sea island type support large, well-developed maritime hammock south to Jacksonville. Maritime hammock is relatively continuous along the sandy Atlantic and southwest Gulf coasts of the peninsula and patchy along the Panhandle coast. From Jacksonville southward, the barrier islands narrow and the hammocks occur as relatively thin, discontinuous strips on the inland side of the barrier islands or mainland beaches and, occasionally, on the mainland shore of the lagoons, south to Cape Florida. On the Gulf coast of the peninsula most of the barrier islands and peninsulas are long and narrow with correspondingly small, narrow areas of hammock. Maritime hammock is best developed on the few broad islands, including Caladesi, Cayo Costa, North Captiva, and the inner barrier islands at Stump Pass and Keewaydin Island. Maritime hammock is rare in Franklin and Gulf counties.¹⁹⁸

Natural Processes: Due to their coastal location with water barriers on at least one, if not two sides, fire was probably naturally rare and very spotty in maritime hammock, especially on the narrower barrier islands. Maritime hammocks are principally influenced by wind-borne salt spray, storm waves, and sand burial. Salt spray from both the ocean and bay sides of islands can enter and kill the upper buds, producing smooth, “pruned” canopies of evenly increasing height away from the coast.²⁵ If storm waves destroy the protective dunes seaward of the hammock, sand can blow inland, burying the trees. This process can be seen at Grayton Beach State Park (Walton County) and Fort Clinch State Park (Nassau County). In addition to physical destruction by storm waves, hammock trees are susceptible to being killed by standing salt water deposited in low areas by storm surge.

Community Variations: Although tropical maritime hammocks on the southern Atlantic and Gulf coasts of the peninsula are similar in species composition, the relative dominance of certain understory species is different. For example, white stopper and buttonwood are common in Gulf coast maritime hammocks, while Spanish stopper, inkwood, paradisetree (*Simarouba glauca*), and lancewood (*Ocotea coriacea*) are common in Atlantic coast hammocks. A few species occur only on one coast. Jamaican dogwood is found only in Gulf coast hammocks and blolly and poisonwood are found only in the Atlantic coast hammocks. Harper¹⁶¹ noted that cacti and other spiny species (*Agave sisalana*, *Acanthocereus tetragonus*) were generally more common in the understory of hammocks on the west coast than on the east. These differences may be related to annual rainfall, which on the west coast averages about 4 inches (102 mm) less than on the east coast.⁴⁴²

Associated Communities: Temperate maritime hammock is distinguished from mesic hammock primarily by their occurrence on coastal sand dunes, the presence of red bay in the canopy, and by an even, spray-pruned canopy shape. They can be distinguished from xeric hammocks by the live oak canopy, instead of sand live oak, and by the presence of cabbage palm. They differ from hydric hammock by their occurrence on better drained soils and the absence of signs of flooding in the understory. Tropical maritime hammock can be distinguished from rockland hammock by their occurrence on sand substrate, rather than limestone. They may be similar in species composition to coastal berm, being distinguished primarily by location along a high wave energy sandy coast, rather than a low-

energy mangrove-dominated coast, and the presence of a distinct canopy layer. They are very similar to shell mounds in species composition, being distinguished by their occurrence on a natural sand deposit rather than on pure shell.

Management Considerations: Fires are naturally rare in this community, but probably occurred infrequently on larger barrier islands.³⁰ Fires may weaken the canopy trees making them more susceptible to damage by other coastal stresses, such as salt spray and storm winds. Invasion by exotic Australian pine (*Casuarina equisetifolia*) and Brazilian pepper (*Schinus terebinthifolius*) following storm disturbance is an ongoing threat. Australian pine also colonizes newly formed barrier islands, thereby pre-empting succession to native maritime hammock.¹⁹⁰ Restoration of native woody species following removal of Australian pine has been successful at The Nature Conservancy's Blowing Rocks Preserve and Cape Florida State Park. These efforts have shown that it is best to start with low-growing woody species, rather than trees, in restoring hammock communities to avoid salt spray burn of the foliage in taller species. Existing hammock canopies have also been killed back by salt spray after installation of parking lots exposed them to winds off the water, e.g., Golden Sands County Park.²⁰¹

The composition of temperate maritime hammock has been affected by Laurel Wilt Disease, which is fatal to trees of red bay over 1 inch dbh and is caused by a fungus spread by an exotic wood-boring beetle (*Xyleborus glabratus*). Infestations were first discovered in Duval County in 2004, and by 2009 had south spread along the east coast to St. Lucie County.⁴¹¹ As of 2009, there was no known means of treating diseased trees or controlling the spread of the disease. Wood or mulch from dead infected trees should not be transported to avoid creating new centers of infection. This includes the transport of firewood into, or nearby, coastal strand for the purposes of outdoor recreational fires (campfires, bonfires).

Exemplary Sites: Amelia Island State Park (Nassau County), Sebastian Inlet State Park (Brevard County), MacArthur Beach State Park (Palm Beach County), Gumbo Limbo Nature Center (Palm Beach County), Cayo Costa State Park (Lee County), Rookery Bay National Estuarine Research Reserve-Cannon Island (Collier County)

Global and State Rank: G3/S2

Crosswalk and Synonyms:

Kuchler	90/Live oak - Sea Oats
Davis	1/Coastal Strand
SCS	1/North Florida Coastal Strand
	2/South Florida Coastal Strand
Myers and Ewel	Maritime Forest
SAF	73/Southern Redcedar
	74/Cabbage Palmetto
	89/Live Oak
	105/Tropical Hardwoods
FLUCCS	425/Temperate Hardwood
	426/Tropical Hardwoods
	427/Live Oak
	432/Sand Live Oak
Whitney	beach dune systems

Other synonyms: maritime forest^{22,248}; coastal tropical hammock³⁵¹



Turtle Mound, Canaveral National Seashore (Volusia County)

post-1938 photo, Florida State Archives

Shell Mound

Description: Shell mounds are small hills, usually in coastal locations, composed entirely of shells (clams, oysters, whelks) discarded by generations of Native Americans which support an assemblage of calciphilic plant species. Archeological evidence indicates they were occupied at the time Europeans first landed in Florida. Several are now surrounded by mangroves, evidence that they were built when sea level was lower than today. Originally there were many such shell mounds along coastal lagoons and at the mouths of rivers (and even inland along the St. Johns River), but most were destroyed for road building in the early part of the last century.^{377,386}

A rich calcareous soil develops on the deposited shells which supports a diverse hardwood forest on undisturbed mounds. Central Florida mounds are often characterized by tropical species occurring north of their normal range. On Turtle Mound at Canaveral National Seashore in Volusia County tropical trees such as white stopper (*Eugenia axillaris*), sea torchwood (*Amyris elemifera*), wild lime (*Zanthoxylum fagara*), false mastic (*Sideroxylon foetidissimum*), inkwood (*Exothea paniculata*), and lancewood (*Ocotea coriacea*) were recorded at or near their northern range limits in 1971.²⁹² Freezes eliminated or reduced the populations of many of these by the time the mound was re-sampled several decades later,^{293,386} illustrating that the tropical flora of these northern mounds is in constant flux. Shell mounds on the Cedar Keys in Levy County on the Gulf coast are also northern outposts for tropical species most likely brought in by migrating birds. Tropical species found on these Keys such as white stopper, Florida swampprivet (*Forestiera segregata*), snowberry (*Chiococca alba*), and saffron plum (*Sideroxylon celastrinum*) are all species whose fruits are eaten by migrating birds.^{197,229} Shell mounds in the Florida Panhandle, i.e. on St. Vincent Island and on St. Joseph peninsula, support temperate canopy trees such as live oak (*Quercus virginiana*) and cabbage palm (*Sabal palmetto*) as well as calcium-loving temperate species not found in nearby maritime hammocks on sand, including soapberry (*Sapindus saponaria*) and Carolina buckthorn (*Rhamnus caroliniana*).²⁰⁰ Even south of Tampa and Cape Canaveral, the species composition of shell mound forests tends to

be more strictly tropical than that of maritime hammocks on sandy substrates in the same region, with white stopper, Florida swampprivet, strangler fig, saffron plum, and gumbo limbo being the most commonly encountered woody species.⁶⁰

Rare Species: Rare plant species found on shell mounds include iguana hackberry (*Celtis iguanaea*), spiny hackberry (*Celtis pallida*), southern lip fern (*Cheilanthes microphylla*), aboriginal prickly apple (*Harrisia aboriginum*), yellow hibiscus (*Pavonia spinifex*), and terrestrial peperomia (*Peperomia humilis*).

Characteristic Set of Species: saffron plum, soapberry, snowberry, white stopper

Range: Shell mounds are found along the coast throughout Florida and range westward and northward along the coastlines of the southeastern U.S. In the 1920s botanist John Kunkel Small noted the tropical flora on large shell mounds at Port Orange,³⁷³ Hobe Sound,³⁷³ Herti Point on the south end of Merritt Island,³⁷⁵ Marco island,³⁷⁶ and at the mouths of the Sebastian River,³⁷⁵ Crystal River,³⁷⁶ and Caloosahatchee River.³⁷² As mentioned, most of these were destroyed for road building. Three of the mounds Small described, Turtle and Green Mounds³⁷⁴ near New Smyrna and Madira Bickel Mound³⁷² near Tampa Bay, are preserved in State or Federal parks. Others are features in larger parks, including St. Joseph Bay State Buffer Preserve, Cedar Keys National Wildlife Refuge (North Key and Seahorse Key), Cayo Costa State Park, Charlotte Harbor Preserve State Park (Josselyn Island), Ding Darling National Wildlife Refuge (Wulfert Hammock), and Coconut Point Park (Brevard County).

Natural Processes: The uniquely tropical flora of Central Florida shell mounds is in constant flux, with species being periodically exterminated by freezes and subsequently re-colonizing, most likely via bird dispersal.

Community Variations: North Florida shell mounds have some temperate hammock species such as live oak and cabbage palm, plus calcium-loving temperate species such as soapberry, Carolina buckthorn, and sugarberry (*Celtis laevigata*). Central Florida shell mounds may have a combination of tropical and temperate canopy species with tropical understory species, including white stopper, snowberry, and marlberry (*Ardisia escallonioides*). Further south shell mounds have a predominantly tropical flora in both the canopy and understory.

Associated Communities: Shell mounds may have vegetation similar to tropical or temperate types of maritime hammock, but differ in that they grow on pure shells rather than sand or sand mixed with shell fragments.

Management Considerations: Soil disturbance on shell mounds from old home sites, clearings, potholes from illegal digging, etc. can allow exotic species such as Brazilian pepper (*Schinus terebinthifolius*) and Australian pine (*Casuarina equisetifolia*) to invade. They require patrolling to prevent further loss of the historical resource.

Exemplary Sites: Canaveral National Seashore (Turtle Mound; Volusia County), Tomoka State Park (Volusia County), Green Mound Archaeological Site (Volusia County), Cedar Keys National Wildlife Refuge (North Key; Levy County), Madira Bickel Mound State Archeological Site (Manatee County), Mound Key Archeological State Park (Lee County)

Global and State Ranks: G2/S2

Crosswalk and Synonyms:

Kuchler	90/Live oak - Sea oats 105/Mangrove 112/Southern Mixed Forest
Davis	1/Coastal Strand 9/Mangrove Swamp Forests and Coastal Marshes
SCS	1/North Florida Coastal Strand 2/South Florida Coastal Strand 14/Tropical Hammocks 19/Mangrove Swamp 11/Upland Hardwood Hammocks
Myers and Ewel	Coastal Strand
SAF	73/Southern Redcedar 89/Live Oak 105/Tropical Hardwoods
FLUCCS	425/Temperate Hardwood 426/Tropical Hardwoods 427/Live Oak

Other synonyms: shell midden, Indian midden, Indian mound

SINKHOLES and OUTCROP COMMUNITIES — small extent communities in karst features or on exposed limestone



E.B. glade (Gadsden County) with black bogrush in foreground

Photo by Ann F. Johnson

Upland Glade

Description: Upland glade is a largely herbaceous community with woody inclusions that occurs on thin soils over limestone outcrops on steep topography in Jackson and Gadsden counties. It is found in small openings ranging from 0.1 to 2 acres in size within an otherwise forested landscape. Open portions of upland glade are dominated by black bogrush (*Schoenus nigricans*) and/or other graminoids, such as poverty dropseed (*Sporobolus vaginiflorus*), hairawn muhly (*Muhlenbergia capillaris*), the stoloniferous form of little bluestem (*Schizachyrium scoparium*), pineywoods dropseed (*Sporobolus junceus*), and spreading beaksedge (*Rhynchospora divergens*), with variable amounts of limestone rock exposed. Other characteristic herbs include Cherokee sedge (*Carex cherokeensis*), lanceleaf tickseed (*Coreopsis lanceolata*), cypress witchgrass (*Dichanthelium dichotomum*), false garlic (*Nothoscordum bivalve*), Boykin's milkwort (*Polygala boykinii*), and starrush whitetop (*Rhynchospora colorata*). Areas of thinner soil or bare rock support diamondflowers (*Stenaria nigricans*), Gulf spike-moss (*Selaginella apoda* var. *ludoviciana*), a short turf-like moss (*Weissia jamaicense*), and blue-green algae (*Nostoc* sp.). A set of limestone-loving shrubs and trees on deeper soil within the glade, or on the edges form a shrubby transition to upland hardwood forest. Characteristic woody species include red cedar (*Juniperus virginiana*), eastern redbud (*Cercis canadensis*), sugarberry (*Celtis laevigata*), roughleaf dogwood (*Cornus asperifolia*), white ash (*Fraxinus americana*), yaupon (*Ilex vomitoria*), and winged elm (*Ulmus alata*). Rattan vine (*Berchemia scandens*) is commonly found scrambling over these shrubs and small trees.

Upland glade was first mapped in the course of a survey of the Apalachicola ravines in Gadsden County.²³⁷ More glades have recently been mapped in Jackson County. In Gadsden County upland glade occurs on limestone outcrops of the Miocene Chattahoochee Formation^{266,350} primarily between the 90 and 120 foot contour lines. In

Jackson County upland glade is found primarily on Oligocene Marianna Limestone^{266,282} between the 130 and 150 foot contours.

Upland glade usually occupies areas too small to be distinguished at the scale of county soil survey maps. They may occasionally be shown as rock outcrop symbols within the matrix of the surrounding forest soils. In Gadsden County these matrix soils are Binnsville soils or Cuthbert, Boswell, and Susquehanna soils on moderate to steep slopes.⁴⁰¹ In Jackson County the matrix soils are the Oktibbeha variant rock outcrop complex.⁹⁹

Characteristic Set of Species: black bogrush, poverty dropseed, diamondflowers, hairawn muhly, Boykin's polygala, red cedar

Rare Species: Ten northern species that are listed as rare in Florida, but range widely outside the state, occur on upland glades: green milkweed (*Asclepias viridiflora*), poppy mallow (*Callirhoe papaver*), small-toothed sedge (*Carex microdonta*), Carolina larkspur (*Delphinium carolinianum*), shootingstar (*Dodecatheon meadia*), eastern purple coneflower (*Echinacea purpurea*), little-people (*Lepuropetalon spathulatum*), pinnate-lobed coneflower (*Rudbeckia triloba* var. *pinnatiloba*), nettle-leaved sage (*Salvia urticifolia*), and shade betony (*Stachys crenata*). Eleven other species on upland glades that are rare in Florida but have widespread distributions outside the state also are being considered for listing by FNAI: meadow garlic (*Allium canadense* var. *mobilense*), sideoats gramma (*Bouteloua curtipendula*), smooth oxeye (*Heliopsis helianthoides* var. *gracilis*), Small's ragwort (*Packera anonyma*), narrowleaf mountain-mint (*Pycnanthemum tenuifolium*), pinnate prairie coneflower (*Ratibida pinnata*), poverty dropseed (*Sporobolus vaginiflorus*), western silver aster (*Symphyotrichum sericeum* var. *microphyllum*), Short's aster (*Symphyotrichum shortii*), smooth blue aster (*S. laeve*), and hairyjoint meadowparsnip (*Thaspium barbinode*). Other possible candidates for listing include purple meadowparsnip (*Thaspium trifoliatum*) and golden alexanders (*Zizia aurea*).

Range: Upland glade is found only in Florida and adjacent Decatur County, Georgia⁴²⁸ in two clusters about 30 miles apart. One cluster is in a four-square-mile area northwest of the town of Marianna in Jackson County, totaling 9 sites and 8.5 acres, and the other is an eighteen-square-mile area south and east of the town of Chattahoochee in Gadsden County, totaling 13 sites and 14.5 acres. New sites continue to be found within these areas.

Upland glade in Florida shares many species with other areas to the north and west where limestone is at or near the surface. These include the cedar glades on limestone outcrops in Tennessee, northern Alabama and northwest Georgia,¹⁸ the shallow-soil Black Belt prairies on Selma Chalk in Alabama and Mississippi,³⁵⁸ the Oaky Woods Wildlife Management Area in central Georgia,¹⁰³ and various outcrop and prairie communities in Louisiana^{254,255} and southeastern Texas.³⁹ None of these areas, however, have black bogrush, a dominant species on Florida glades. In the United States this species is found only in Florida, Texas, California and Nevada; it also occurs in western Europe, South Africa, the West Indies and Mexico.³⁸⁴ The cedar glades of Tennessee and northern Alabama are dominated by the annual grass, poverty dropseed^{18,336} and the Black Belt Prairies of Alabama and Mississippi by little bluestem.³⁵⁸ Both these species may also dominate portions of upland glade in Florida. Florida glades have the most species in common with the Black Belt Prairies in Alabama and the Oaky Woods prairies of Georgia which are the closest source of many calcium-loving species on Florida upland glades, being less than 100 miles distant. Species rare in Florida that are also found in these two areas include green milkweed, Carolina larkspur, and pinnate prairie coneflower; species shared with the Georgia Oaky Woods prairies also include smooth oxeye, Small's ragwort, and golden alexanders¹⁰³; those shared with the Black Belt Prairies in Alabama also include small-toothed sedge, nettle-leaved sage, and western silver aster.³⁵⁸

Natural Processes: Soil depth is cited as the factor inhibiting tree and shrub colonization of herbaceous portions of limestone glades in Tennessee and Alabama.^{18,336,337} A small study measuring soil depth and pH on transects across three of the Gadsden County glades⁶⁷ lends support to this hypothesis for the Florida upland glades. Soil depth to hard limestone ranged from 4 to 14 inches in 13 samples taken along transects on the open herbaceous portions of three glades, with most samples falling in the 6 to 8 inch range. These figures are similar to soil depths measured on open glades in Tennessee.¹⁸ Depth to limestone in four samples from the forest immediately surrounding the glades ranged from 21 to over 60 inches.⁶⁷ Soils on the open glade were more alkaline (pH 7.5-7.6) than soil of the surrounding forest (pH 4.8-6.4).⁶⁷ An additional stress on plants on glades is the alternation between wet and dry soils. Soils on the herbaceous portion of the glades are often wet and "mushy" in early spring and become nearly completely dry by fall.

Fire may have swept through upland glades at irregular intervals, especially those that were bordered by longleaf pine-dominated upland pine or sandhill communities that would have naturally tended to burn frequently.

Community Variations: Although upland glades in Jackson and Gadsden counties share dominant and many characteristic species, there is a set of characteristic species that serve to differentiate them. Present on Gadsden, but not Jackson County glades are poppy mallow, small-toothed sedge, littlehip hawthorn (*Crataegus spathulata*), orange coneflower (*Rudbeckia fulgida*), Gulf spike-moss, western silver aster, and Florida bully (*Sideroxylon reclinatum*). Present on Jackson but not Gadsden County glades are *Coreopsis* sp. (narrow, glabrous leaves), Carolina woollywhite (*Hymenopappus scabiosaeus*), Small's ragwort, pinnate-lobed coneflower, and gum bully (*Sideroxylon lanuginosum*). Two species are more common in one or the other county: Florida maple (*Acer saccharum* var. *floridanum*) is more common around glades in Gadsden County; chinquapin oak (*Quercus muehlenbergii*) is more common around glades in Jackson County.

Associated Communities: The woody component of upland glade can be distinguished from the adjacent upland hardwood forest by the presence of red cedar, the concentration of other calciphilic species, and the short stature of the trees and shrubs. Upland glade can be distinguished from mesic flatwoods, which sometimes also has black bogrush in the ground layer where limestone is near the surface, by the presence of green milkweed and other characteristic northern calciphiles and the absence of saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*) and a pine canopy. Occasionally glade-like areas occur within the upland hardwood forest community where limestone is close to, but not at, the surface. These may be small grassy areas with a few of the characteristic glades herbs but without either black bogrush or the other short graminoid species as dominants.

Management Considerations: Although the ecology of the upland glade community has not been studied, it seems a reasonable working hypothesis that soil depth prevents woody colonization on the rockier portions of the glades, such as those areas dominated by diamond flowers and poverty dropseed, as has been proposed for areas of similar vegetation in the Tennessee glades.³³⁶ Portions of the glades supporting taller grasses such as Gulf hairawn muhly and little bluestem may be more susceptible to woody encroachment, since increases in cover of red cedar have been observed at some glades over the course of several decades. Thus it may be that infrequent fires play a role in preventing woody species from shading out the characteristic graminoid dominants, particularly in those glades bordered by pine communities. Occasional droughts may also play a similar role in retarding woody growth on the glade. Casual observation of one burn on a glade indicated that the herbaceous species recovered to pre-burn levels of cover within a year or two, but the question of natural fire interval for this community needs more research. Growing season burns on experimental plots on a glade in Georgia also showed little effect on 14 herbaceous species of conservation concern two years later, but did result in a dramatic decline in populations of young trees on the glade.¹⁰⁰

Threats to upland glades are primarily physical disturbance, since to non-botanists they appear indistinguishable from an artificial clearing in the forest. Only three of the twenty-two known glades are on public lands. Known glades have been lost to road widening, plowing for a game food plot, and limestone mining. In the past, others were probably destroyed by clearing, dumping, and disturbance from being used for parking logging machinery and as staging areas for timber operations. When the soil is disturbed, glades are vulnerable to being colonized by a dense sward of the exotic centipede grass (*Eremochloa ophiuroides*) which effectively precludes re-colonization by native glades species. Other exotics invading disturbed glades include Formosa firethorn (*Pyracantha koidzumii*), and Chinese and glossy privets (*Ligustrum sinense*, *L. lucidum*).

Exemplary Sites: The best developed glades are on private lands (Chalky, Brickyard, and E.B. glades in Gadsden County and Brooks 1 in Jackson County). Only a few glades are on public lands: one small glade in Florida Caverns State Park (Jackson County), and several small glades on lands of the Florida Department of Corrections south of US 90, about one mile east of Chattahoochee; the latter are not specifically managed for protection of their natural resources.

Global and State Rank: G1/S1

Crosswalk and Synonyms:

SAF 73/Southern Redcedar

Other synonyms: cedar glades¹⁸; limestone glades³⁷



Big Dismal Sink (with sinkhole lake; Leon County)

Photo by Ann F. Johnson

Sinkhole

Description: Sinkholes are cylindrical or steep-sided conical depressions that are generally formed by the slumping of soil into subterranean cavities or the solution of limestone near the surface. They are common in areas of karst terrain where the underlying limestone is riddled with solution cavities. Although they may exist within most natural communities across Florida, which has more sinkholes than any other state, they are most often associated with hardwood forest communities such as mesic hammock and upland hardwood forest in the Florida Panhandle and peninsula, or rockland hammock in extreme South Florida.

Sinkhole vegetation is highly variable and usually influenced by the matrix community in which the sinkhole develops. Vertical or steep walls may be mostly devoid of plants. Where soil covers the underlying rock, the vegetative structure may be that of a well-developed forest that is virtually indistinguishable from the surrounding environment. Species distribution along the slope of a sinkhole can be influenced by a number of different factors that vary by sinkhole, such as light availability, temperature, humidity, soil presence and type, drainage and seepage, and steepness of the sinkhole walls.¹⁵⁴ The typically sheltered position of most sinkholes promotes a moist microclimate that is moderated from temperature extremes. Sinkholes with ephemeral standing water, and therefore less likely to support predatory fish, are important breeding sites for many amphibian species.

Characteristic Set of Species: There is no specific set of species associated with sinkholes. Vegetation on the steep slopes can range from almost absent to a well-developed hardwood forest.

Rare Species: Rare plants in sinkholes are usually restricted to the limestone outcrop community, which is often present within sinkholes. Though sinkholes provide important habitat for many rare animal species, none are restricted to these geologic features.

Range: Sinkholes occur throughout Florida^{110,368,439} but are most common in North and Central Florida ranging from Leon and Wakulla counties in the Panhandle, south to the east coast in Flagler County, and southwest into parts of Polk and Highlands counties. Elsewhere in the Panhandle, sinkholes are common in parts of Washington, Holmes, and Walton counties.³⁶⁸ Small dissolution sinkholes, often called solution holes, are frequent in extreme South Florida within rockland hammock, marl prairie, and pine rockland.

Natural Processes: Sinkholes can form in three ways. Dissolution sinkholes form when limestone is dissolved at or near the surface. Ongoing erosional processes result from the chemical and physical actions of underground water, which slowly dissolves the limestone and enlarges these cavities. Subsidence sinkholes, the most common type in Florida, form when the land subsides as limestone beneath is dissolved. These sinkholes develop into bowl-shaped depressions¹¹⁰ which can be shallow or deep. Collapse sinkholes can form when the water level in an underground cavern is lowered, either naturally (e.g., drought) or unnaturally (e.g., water table drawdown), creating a space between the water level and the roof of the cavern, which can cause a collapse of the roof. These sinkholes form rapidly when the weight of overlying sediments cause a collapse into the underground cavity. Where unnatural water manipulations have occurred, collapse sinkholes, such as the 1981 Winter Park Sinkhole may develop rapidly and more frequently.¹¹⁰

Sinkholes generally have higher relative humidity levels and lower light and temperature readings than the surrounding natural community.¹⁵⁴ Whether they form a complete canopy or not, trees on the upper slopes or rim shelter the sinkhole from intense solar radiation. The depression itself also limits the effects of desiccating winds. Standing water in the bottom of the sinkhole, together with seepage from the surrounding uplands, helps to raise and maintain humidity levels. These conditions also buffer temperature extremes, providing frost-free habitats for cold sensitive species. This often allows for a unique mixture of tropical and temperate flora to exist in many Florida sinkholes. The sheltered habitat of sinkholes is also naturally protected from fires. Sinkholes that develop in fire-maintained communities often develop a hardwood canopy.

Sinkholes drain readily and only contain standing water during, or for short periods following, heavy rains. Those that hold water throughout much of the year, drying down only during extreme droughts, are additionally classified as having a sinkhole lake. The size of an individual sinkhole is variable and depends in large part on the local geology and hydrology.

Community Variations: The vegetation of sinkholes varies widely according to the surrounding natural community, geographic location, and sinkhole type and age. The geographic location of a sinkhole within the state also influences the vegetation. Sinkholes in South Florida are dominated by a mostly tropical species assemblage. Northern and Central Florida sinkholes support a diverse array of temperate tree species.

Associated Communities: Sinkholes may occur within most natural community types. In pyrogenic communities, sinkholes may form a natural barrier to fire that allows hardwood species to become established around the edge and upper slope and form an island of upland hardwood forest or mesic hammock.

A sinkhole that holds water throughout most of the year and dries down only during extreme droughts is considered to have an included sinkhole lake. They may co-occur if the upper portions of the limestone are typically above water level, while the lower portions are typically below water level (e.g., Big Dismal Sink, Leon County; see photograph). Additionally, aquatic caves can occur within the sinkhole. Springs can emerge from these aquatic caves into the sinkhole lake.

Management Considerations: Sinkholes are fragile communities, often with steep walls and limited soils. Human activities in the surrounding areas may affect the delicate microclimate of a sinkhole and induce deleterious responses. For example, logging of the surrounding canopy can increase both solar radiation and sedimentation levels. Major soil disturbances in the adjoining uplands could disrupt seepage water sources. Large withdrawals of groundwater could substantially lower water tables and reduce the hydroperiods of sinkholes.

Sinkholes are sometimes used as dumpsites. Because sinkholes drain directly to underground aquifers, refuse dumping should be strongly discouraged. Chemical applications, waste treatments, and spills on the surrounding upland require active monitoring to determine their potential impacts and mitigation requirements.

Invasive exotic species are sometimes problematic in sinkholes. Their establishment is often facilitated by the shaded, humid environmental conditions. Invasive species occurring in sinkholes include coral ardisia (*Ardisia crenata*), skunk vine (*Paederia foetida*), Japanese climbing fern (*Lygodium japonicum*), heavenly bamboo (*Nandina domestica*), giant reed (*Arundo donax*), and air-potato (*Dioscorea bulbifera*). Steep slopes and the presence of sensitive plant and animal species can complicate the treatment of exotic plants. Furthermore, the close connection of sinkholes to aquifers requires especially careful applications of herbicides to avoid groundwater contamination.

Exemplary Sites: Devil's Millhopper State Park (Alachua County), Leon Sinks State Geological Area (Leon County), Falling Waters State Park (Washington County), Withlacoochee State Forest (Citrus County)

Global and State Rank: G2/S2

Crosswalk and Synonyms:

Other synonyms: sink, limesink, banana hole, solution pit, cenote, grotto, doline, chimney hole



Suwannee Ridge Wildlife and Environmental Area
(Hamilton County)

Photo by Paul Russo



Florida Caverns State Park (Jackson County)

Photo by Gary Knight

Limestone Outcrop

Description: Limestone outcrops are unique assemblages of plant species that occur on exposed limestone. Limestone outcrop communities commonly occur in Florida's karst topography and are often found within geologic features such as sinkholes. Limestone outcrops are often covered with mosses, liverworts, ferns or, occasionally, with herbs and shrubs in crevices. Among the more common species are partridgeberry (*Mitchella repens*), Gulf spike-moss (*Selaginella apoda* var. *ludoviciana*), common maidenhair fern (*Adiantum capillus-veneris*), fragrant maidenhair fern (*Adiantum melanoleucum*), netted chain fern (*Woodwardia areolata*), jack-in-the-pulpit (*Arisaema triphyllum*), southern shield fern (*Thelypteris kunthii*), and various species of panicgrass (*Panicum* spp.). A variety of rare ferns may also thrive on the exposed limestone within this community.

Limestone outcrops are common in areas of karst terrain where the limestone is near the surface. In addition to the frequent inclusion of limestone outcrops in sinkholes, they may also be found within hardwood forest communities such as mesic hammock, hydric hammock, slope forest, and upland hardwood forest in the Florida Panhandle and peninsula, and rockland hammock in extreme South Florida.

Characteristic Set of Species: abundant ferns, mosses, and liverworts

Rare Species: Rare plants that may occur on limestone outcrops include ferns that thrive in moist microclimates; these include spleenwort (*Asplenium pumilum*), modest spleenwort (*Asplenium verecundum*), brittle maidenhair fern (*Adiantum tenerum*), sinkhole fern (*Blechnum occidentale*), creeping maiden fern (*Thelypteris reptans*), southern lip fern (*Cheilanthes microphylla*), Peters' bristle fern (*Trichomanes petersii*), and Florida filmy fern (*Trichomanes punctatum* ssp. *floridanum*). Many rare fern species are restricted to limestone outcrops of extreme South Florida such as Hattie Bauer halberd fern (*Tectaria coriandrifolia*), wedgelet fern (*Odontosoria clavata*), holly vine fern (*Lomariopsis kunzeana*), and Kraus' bristle fern (*Trichomanes krausii*). Other interesting rare plant species of limestone outcrops include false rue-anemone (*Enemion biternatum*), Marianna columbine (*Aquilegia canadensis* var. *australis*; only present in the central Panhandle), Craighead's nodding-caps (*Triphora craigheadii*), Rickett's nodding-caps (*Triphora rickettii*), terrestrial peperomia (*Peperomia humilis*), and yellow hibiscus (*Pavonia spinifex*). No rare animals are restricted to this community.

Range: Limestone outcrops occur throughout Florida but are most common in North and Central Florida, in the Panhandle, and in extreme South Florida within the range of rockland hammock, marl prairie, and pine rockland.

Natural Processes: The often sheltered position of limestone outcrops supports a moist microclimate that moderates temperature extremes.

Community Variations: The vegetation of limestone outcrops varies widely according to the surrounding natural community and geographic location. Limestone outcrops in South Florida are dominated by a mostly tropical species assemblage. Northern and Central Florida limestone outcrop communities support a diverse array of temperate species.

Limestone grottoes, often referred to as "fern grottoes," are a type of limestone outcrop that support a diverse flora of mosses, liverworts, ferns, and flowering herbs growing on the exposed limestone. Several fern grottos have been described in the vicinity of the Withlacoochee River and in South Florida.^{12,159,230,371}

Associated Communities: Limestone outcrops may occur within most natural community types and often occur within geologic features such as sinkholes. Limestone outcrops are terrestrial communities, as opposed to rocky tidal areas, which are classified as consolidated substrate.

Management Considerations: Limestone outcrops that occur within sinkholes and grottoes are extremely fragile communities, often with steep limestone walls, limited soils, and numerous rare plants. Human activities in the surrounding areas may affect the delicate microclimate of a sinkhole/grotto and can induce deleterious vegetation responses. For example, logging of the surrounding canopy can increase both solar radiation and sedimentation levels. Major soil disturbances in the adjoining uplands could disrupt seepage water sources.

Several of the most well known grottoes in Florida (i.e., Pineola Fern Grotto [Citrus County], Battle of Wahoo Swamp [Sumter County]) are not protected, have been used as limestone mine areas,²³⁰ and are further threatened by exotic invasive species. Protection of these sites is important not only for the conservation of the rare species that occupy them, but for the preservation of these unique land features.

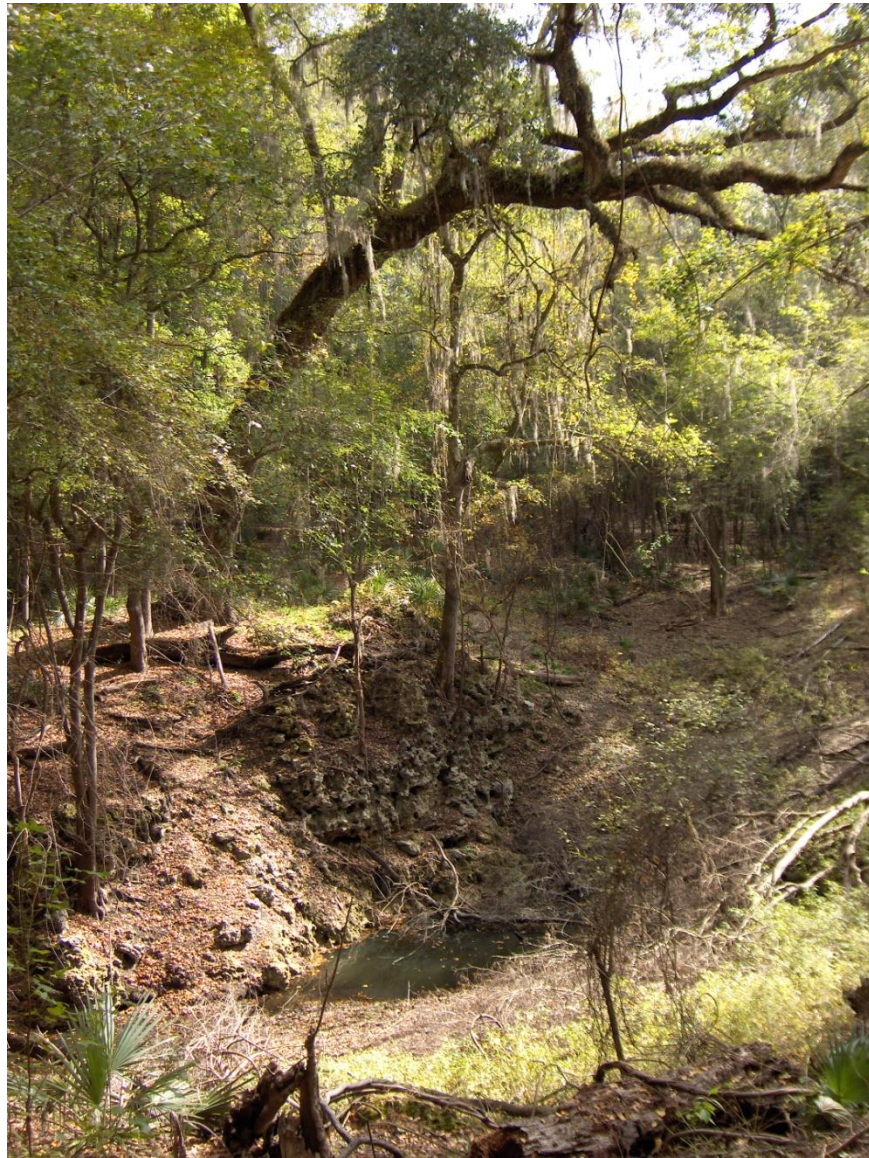
Invasive exotic species are sometimes problematic in areas of limestone outcrops. Their establishment is often facilitated by the shaded, humid environmental conditions. Invasive species occurring in limestone outcrops include coral ardisia (*Ardisia crenata*), skunk vine (*Paederia foetida*), Japanese climbing fern (*Lygodium japonicum*), heavenly bamboo (*Nandina domestica*), giant reed (*Arundo donax*), air-potato (*Dioscorea bulbifera*), Chinese brake fern (*Pteris vittata*), and Cretan brake (*Pteris cretica*). Steep slopes and the presence of sensitive plant and animal species can complicate the treatment of exotic plants.

Exemplary Sites: Devil's Millhopper State Park (Alachua County), Leon Sinks State Geological Area (Leon County), Falling Waters State Park (Washington County), Withlacoochee State Forest (Citrus County), Castellow Hammock Preserve (Dade County), Florida Caverns State Park (Jackson County)

Global and State Rank: G2/S2

Crosswalk and Synonyms:

Other synonyms: sink, limesink, banana hole, solution pit, cenote, grotto, doline, chimney hole



Limestone outcrop within sinkhole, Suwannee Ridge Wildlife and Environmental Area
(Hamilton County) Photo by Paul Russo



Crawl Key (Monroe County)

Photo by Keith Bradley

Keys Cactus Barren

Description: Keys cactus barren is an open, primarily herbaceous community with scattered shrubs on rocky areas of Key Largo limestone with little soil or leaf litter. It occupies larger areas several acres in extent, or may occur as small, scattered patches within the thorn scrub variant of rockland hammock. The vegetation consists of a wide variety of herbaceous and succulent species which characteristically includes cacti, agaves, and several rare herbs. Among the latter are dwarf bindweed (*Evolvulus convolvuloides*), Yucatan flymallow (*Cienfuegosia yucatanensis*), skyblue clustervine (*Jacquemontia pentanthos*), and Florida Keys indigo (*Indigofera mucronata* var. *keyensis*). These frequently occur with grasses and sedges, such as green sprangletop (*Leptochloa dubia*), coral panicum (*Paspalidium chapmanii*), and royal flatsedge (*Cyperus elegans*).^{15,27} Spiny species, particularly the rare three-spined pricklypear (*Opuntia triacantha*), are characteristic but their abundance is variable. Other spiny species include false sisal (*Agave decipiens*), barbed-wire cactus (*Acanthocereus tetragonus*), and erect pricklypear (*Opuntia stricta*). Scattered clumps of stunted trees may be present, including gumbo limbo (*Bursera simaruba*), buttonwood (*Conocarpus erectus*), Spanish stopper (*Eugenia foetida*), and catclaw blackbead (*Pithecellobium unguis-cati*).¹⁵

Characteristic Set of Species: three-spined pricklypear, erect pricklypear, barbed wire cactus, Yucatan fly mallow, Florida Keys indigo, skyblue clustervine, dwarf bindweed

Rare Species: Rare plant species include Yucatan flymallow, dwarf bindweed, Florida Keys indigo, skyblue clustervine, and three-spined prickly pear.

Range: Keys cactus barren is confined to the Florida Keys on limestone bedrock (Key Largo limestone) and is known from only six sites, four on the Upper Keys and two from the southern arm of Big Pine Key which is composed of Key Largo limestone (unlike the rest of Big Pine Key and the other Lower Keys, which are composed of Miami oolite).

Natural Processes: The natural process giving rise to cactus barrens is not known, but since they occur on sites where the thin layer of organic soil over limestone bedrock is missing, they may have formed by soil erosion following destruction of the plant cover by fire, storm, or artificial clearing.

Community Variations: Keys cactus barren is known from only six sites which vary primarily in the degree of shrub cover.

Associated Communities: Keys cactus barren is often surrounded by the thorn scrub variant of rockland hammock, consisting of low woody species such as buttonwood, blolly (*Guapira discolor*), catclaw blackbead, bayleaf capertree, poisonwood (*Metopium toxiferum*), and brittle thatch palm (*Thrinax morrisii*),³⁸¹ forming a transition to the taller rockland hammock upland community.

Management Considerations: Prickly pear cacti in the genus *Opuntia* in this community are vulnerable to attack by the larvae of the cactus moth (*Cactoblastis cactorum*) which was inadvertently introduced from South America in the mid-1990s. Cactus barrens are vulnerable to development, even on public conservation lands, since their vegetation resembles weedy clearings and disturbed areas. Sites that have shown increasing encroachment of woody species over time may require efforts to maintain the open nature of the habitat, which favors the rare herbaceous species. Invasion by the exotic Brazilian pepper (*Schinus terebinthifolius*) is also a problem on some sites.

Exemplary Sites: Conrad's Crazy Cactus Patch at Long Key State Park (Monroe County), Straehly Tract on Big Pine Key in National Key Deer Refuge (Monroe County), Windley Key Fossil Reef Geological State Park (Monroe County)

Global and State Rank: G1/S1

Crosswalk and Synonyms: The community formerly known as “coastal rock barren” has been split into an upland community called “Keys cactus barren” and a tidally-influenced community called “Keys tidal rock barren.”

Other synonyms: coastal rock barren¹²⁶



Long Key State Park (Conrad's Crazy Cactus Patch; Monroe County)

Photo by FNAI

FRESHWATER NON-FORESTED WETLANDS – herbaceous or shrubby palustrine communities in floodplains or depressions; canopy trees, if present, very sparse and often stunted

PRAIRIES AND BOGS – short hydroperiod; dominated by grasses, sedges, and/or titi



Blackwater River State Forest (Santa Rosa and Okaloosa counties)

Photo by Gary Knight

Seepage Slope

Description: Seepage slope is an open, grass-sedge dominated community kept continuously moist by groundwater seepage. It occurs in dissected topography, with 30 to 50-foot elevation differences, and is usually bordered by well-drained sandhill or upland pine communities. Such areas include inland portions of the Panhandle, plus a small area along the St Mary's River in northeast Florida.¹²⁴ Drier portions of seepage slope are dominated by wiregrass (*Aristida stricta*). Other characteristic species include toothache grass (*Ctenium aromaticum*), cutover muhly (*Muhlenbergia expansa*), savannah meadowbeauty (*Rhexia alifanus*), flattened pipewort (*Eriocaulon compressum*), variableleaf sunflower (*Helianthus heterophyllus*), and clubmoss (*Lycopodiella* sp). Wetter portions of seepage slope are dominated by several species of beaksedge, including plumed beaksedge (*Rhynchospora plumosa*), featherbristle beaksedge (*R. oligantha*), and large beaksedge (*Rhynchospora macra*) and are characterized by carnivorous plants such as pitcherplants, sundews and butterworts. Pitcherplants in the Panhandle include yellow trumpets (*Sarracenia flava*), white-top pitcherplant (*S. leucophylla*), sweet pitcherplant (*S. rubra*), and parrot pitcherplant (*S. psittacina*). In northeast Florida, the parrot pitcherplant and hooded pitcherplant (*S. minor*) are found. Sundews include dewthreads (*Drosera tracyi*) in the Panhandle, and pink sundew (*D. capillaris*) and dwarf sundew (*D. brevifolia*) in both the Panhandle and the northeast. Butterworts include Chapman's butterwort (*Pinguicula planifolia*) and primrose-flowered butterwort (*P. primuliflora*) in the Panhandle. Other species found in wetter portions include longleaf threeawn (*Aristida palustris*), Texas pipewort (*Eriocaulon texense*), shortleaf sneezeweed (*Helenium brevifolium*), sandbog deathcamas (*Zigadenus glaberrimus*), golden crest (*Lophiola aurea*), and rush featherling (*Pilea tenuifolia*). Georgia Indian plantain (*Arnoglossum sulcatum*), and switchcane (*Arundinaria gigantea*) are found on edges of seepage slopes where they border shrub bogs. Scattered low shrubs are often present in seepage slopes, including woolly huckleberry (*Gaylussacia mosieri*), gallberry (*Ilex glabra*),

evergreen bayberry (*Myrica caroliniensis*), coastalplain St. John's Wort (*Hypericum brachyphyllum*), and poison sumac (*Toxicodendron vernix*).^{120,195}

A common soil type is Albany loamy sand. The soil is often soft and mucky underfoot, in contrast to the firm texture of the bordering sandhill and upland pine soils. Crayfish chimneys are commonly present.

Characteristic Set of Species: wiregrass, toothache grass, pitcherplants, plumed beaksedge, flattened pipewort, woolly huckleberry

Rare Species: Rare plant species found in Panhandle seepage slopes include naked-stemmed panic-grass (*Dichantherium nudicaule*), dark-headed hatpins (*Eriocaulon nigrobracteatum*) bog button (*Lachnocaulon digynum*), panhandle lily (*Lilium iridollae*), hummingbird flower (*Macranthera flammea*), primrose-flowered butterwort (*Pinguicula primuliflora*), giant water-dropwort (*Oxypolis greenmanii*), yellow fringeless orchid (*Platanthera integra*), white-top pitcherplant (*Sarracenia leucophylla*), sweet pitcherplant (*Sarracenia rubra*), and Harper's yellow-eyed grass (*Xyris scabrifolia*). Purple honeycomb-head (*Balduina atropurpurea*) is a rare plant in northeast Florida seepage slopes.

Range: In Florida seepage slope ranges from the Alabama border eastward to Calhoun County in the Florida Panhandle, plus small areas in the northern peninsula. Outside Florida it is found in Conecuh National Forest in Alabama.

In the western Panhandle (e.g. Blackwater River State Forest and Eglin Air Force Base) seepage slope occurs in rolling hilly topography in slumps or concavities in the hillsides where clay lenses in the otherwise sandy substrate (Pliocene Citronelle Formation) intersect the slope, impeding drainage and causing the soil to be saturated most of the year. In Bay and Calhoun counties in the central Panhandle seepage slopes occur on steep slopes above Juniper and Fourmile Creeks where there is an abrupt transition from sandhill to shrub bog (titi) vegetation along the creek slope. In the northern peninsula they occur as steep narrow ecotones along creeks between shrub bog and flatwoods.²⁰³

Natural Processes: Natural fires enter seepage slopes from surrounding pinelands and burn through when they are dry enough to carry fire. The historic fire interval in the surrounding sandhill or upland pine communities is thought to be 1-3 years (Frost 1998). It may have been slightly longer in seepage slopes which would not always be dry enough to burn completely when the surrounding community burned. In the absence of fire, shrubs and trees begin to invade seepage slopes and shade out the light-loving herbaceous species. A further indication of their dependence on fire is the requirement for fire to stimulate flowering of many herbs characteristic of seepage slopes, including the dominant wiregrass.

Community Variations: In inland portions of Santa Rosa and Okaloosa counties seepage slopes occur on slopes with several species that aren't found in seepage slopes of the eastern Panhandle or northeast Florida, including sweet pitcherplant, shortleaf sneezeweed, and Texas pipewort.

Associated Communities: Seepage slope differs from wet prairie in being situated on slopes in dissected landscapes surrounded by sandhill or upland pine, rather than on level or very gently sloping terraces surrounded by mesic flatwoods. It differs from depression and basin marshes in having a relatively complete cover of wiregrass or wiry beaksedges and in being saturated (at least in the wetter portions) but not inundated. It differs from the grassy form of wet flatwoods in the absence of upland shrubs such as saw palmetto (*Serenoa repens*), dwarf live oak (*Quercus minima*), or gallberry (*Ilex glabra*) and in having no, or only a very sparse, cover of pines.

Management Considerations: In the absence of fire, woody shrubs may encroach on open seepage slopes from both the bordering uplands (e.g. gallberry, wax myrtle [*Myrica cerifera*]) and lowlands (e.g. peelbark St. John's wort [*Hypericum fasciculatum*], titi [*Cyrilla racemiflora*], and black titi [*Cliftonia monophylla*]) and eventually shade out the sun-loving herbaceous species.^{120,203} Seepage slopes are also sensitive to physical alterations to the soil surface which can permanently alter the hydrology.¹⁶⁸ Such disturbances include trampling, driving through them, plowing fire lanes around them, or placing roads and ditches near them. Hog rooting can be a major problem leading to lower plant diversity and the dominance of a few species of fast-growing colonizers, such as Carolina redroot (*Lachnanthes caroliniana*).¹⁹⁵

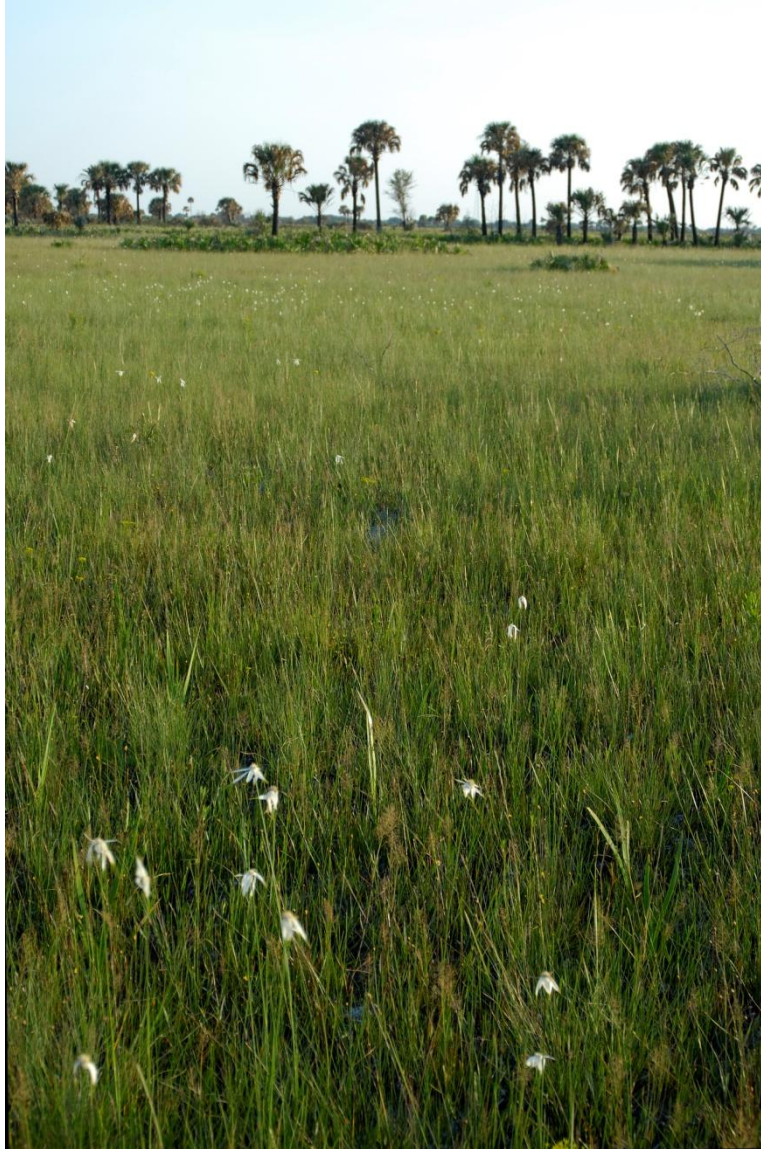
Exemplary Sites: Blackwater River State Forest (Santa Rosa and Okaloosa counties), Eglin Air Force Base (Brier Creek; Okaloosa County), Chipola Experimental Forest (USFS; Calhoun County), Ralph E. Simmons State Forest (Duval County)

Global and State Ranks: G2/S2

Crosswalk and Synonyms:

Kuchler	112/Southern Mixed Forest
Davis	13/Grasslands of Prairie Type
	2/Pine Flatwoods
SCS	23/Pitcher plant bog
Myers	Freshwater Marshes - wet prairies
	Flatwoods - wet flatwoods and seepage savannas
SAF	N/A
FLUCCS	310/Herbaceous
	641/Wet Prairies

Other synonyms: hanging bog; pitcher plant bog¹²⁸; seepage bog⁵⁷



Kissimmee Prairie Preserve State Park (Osceola County)

Photo by Gary Knight

Wet Prairie

Description: Wet prairie is an herbaceous community found on continuously wet, but not inundated, soils on somewhat flat or gentle slopes between lower lying depression marshes, shrub bogs, or dome swamps and slightly higher wet or mesic flatwoods, or dry prairie. It is typically dominated by dense wiregrass (*Aristida stricta* var. *beyrichiana*) in the drier portions, along with foxtail club-moss (*Lycopodiella alopecuroides*), cutover muhly (*Muhlenbergia expansa*), yellow butterwort (*Pinguicula lutea*), and savannah meadowbeauty (*Rhexia alifanus*). In the wetter portions, wiregrass may occur with, or be replaced by, species in the sedge family, such as plumed beaksedge (*Rhynchospora plumosa*), featherbristle beaksedge (*R. oligantha*), Baldwin's nutrush (*Scleria baldwinii*), or slenderfruit nutrush (*S. georgiana*), plus longleaved threeawn (*Aristida palustris*). Also common in wetter areas are carnivorous species, such as pitcher plants (*Sarracenia* spp.), sundews (*Drosera* spp.), butterworts (*Pinguicula* spp), and bladderworts (*Utricularia* spp.). Other characteristic species in this community include toothache grass (*Ctenium aromaticum*), pineland rayless goldenrod (*Bigelowia nudata*), flattened pipewort (*Eriocaulon compressum*), water cowbane (*Oxypolis filifolia*), and coastalplain yellow-eyed grass (*Xyris ambigua*).

Wet prairies in northern Florida and the calcareous variant in south-central Florida are some of the most diverse communities in the United States, with an average of over 20 species per square meter in some places and over 100

total species in any given stand.^{46,208,294,307,426} Factors contributing to this diversity include subtle spatial differences in moisture conditions across the wet prairie and temporal differences in fire and flooding regime from year to year, which favor different species and prevent any one species from excluding the others.

Wet prairie is noted for its many showy flowering herbs including false foxgloves (*Agalinis* spp.), grass pinks (*Calopogon* spp.), pipeworts (*Eriocaulon* spp.), rein orchids (*Platanthera* spp.), milkworts (*Polygala* spp.), meadowbeauties (*Rhexia* spp.), rosegentians (*Sabatia* spp.), yellow-eyed-grasses (*Xyris* spp.), white-top sedge (*Rhynchospora latifolia*), and composites in the genera *Balduina*, *Carphephorus*, *Coreopsis*, *Eupatorium*, *Eurybia*, *Helenium*, *Helianthus*, *Rudbeckia*, *Solidago*, and *Symphytotrichum*. Re-sprouting short shrubs that grow intermixed with the grasses, include two species of St. John's wort (*Hypericum brachyphyllum*, *H. myrtifolium*), evergreen bayberry (*Myrica caroliniensis*) and, in Panhandle Florida, bog tupelo (*Nyssa ursina*). A few stunted trees of slash pine (*Pinus elliottii*), pond cypress (*Taxodium ascendens*), or swamp tupelo (*Nyssa sylvatica* var. *biflora*) may be present. In northern Florida clumps of wetland shrubs such as titi (*Cyrilla racemiflora*), coastal sweet pepperbush (*Clethra alnifolia*), myrtle-leaved holly (*Ilex cassine* var. *myrtifolia*), and large gallberry (*Ilex coriacea*) are also seen.

Wet prairie usually occurs on acidic, nutrient-deficient, saturated soils. Soil series associated with wet prairies in the Panhandle include Plummer fine sands, Rutledge sandy loams, and Bladen sandy loams with clay subsoils.^{410,432} In the Florida peninsula, wet prairies, including those dominated by cutthroat grass,¹⁶ are often found on poorly drained Basinger fine sands.³⁰⁷ Calcareous wet prairies are found in Central and south-central Florida on circum-neutral Felda or Wabasso fine sands with sandy loam subsoils.^{262,307}

Characteristic Set of Species: pitcherplants, wiregrass, blue maidencane, cutthroat grass, wiry beaksedges, flattened pipewort, toothache grass, water cowbane, yellow-eyed grasses, pineland rayless goldenrod

Rare Species: The Panhandle is a hotspot for rare plants of the wet prairie community with 25 out of the 30 rare species found in this community; 12 of these are endemic to the Panhandle (Table 1).

The rare Morse's flightless grasshopper (*Gymnosirtetes morsei*) is known only from open boggy habitats in northern Florida.

Range: Wet prairie occurs throughout Florida except for extreme South Florida where limestone soils predominate.³⁰⁷ Outside Florida, wet prairies (also known as pitcher plant bogs) are found in the southeastern coastal plain from eastern Texas to North Carolina.^{128,256,426} Wet prairies in the Panhandle are closest floristically to other areas in the East Gulf Coastal Plain, i.e. pitcher plant bogs in Mississippi, Alabama, and southwestern Georgia.^{155,294,382}

Natural Processes: Natural fires likely entered wet prairie from surrounding pinelands and burned through them when they were dry enough to carry fire. Hermann¹⁶⁸ estimates a natural fire return interval of 2-3 years where wet prairie vegetation is adjacent to mesic/wet flatwoods or sandhill in the Apalachicola National Forest. A similar fire interval was also determined by Huffman¹⁸³ for mesic flatwoods near the Panhandle coast from an analysis of fire scars on pine stumps. In the absence of fire, shrubs and trees invade wet prairie and shade out the light-loving herbaceous species. A further indication of their dependence on fire is the requirement for fire to stimulate flowering in many wet prairie herbs, including two of the dominant grasses, wiregrass and cutthroat grass.²⁸⁴

The nutrient-poor, acid sands of wet prairie in the Panhandle make these habitats a center for both carnivorous plant diversity and for diversity of arthropod species dependent on them. At least 16 arthropod species are obligate associates of the genus *Sarracenia*³⁵² including three species of moth in the genus *Exyra* (*E. fax*, *E. ridingsii*, and *E. semicrocea*) and a mosquito (*Wyeomyia smithii*).

Community Variations: Species present in Panhandle wet prairies and not in those of the peninsula include thistleleaf aster (*Eurybia eryngiifolia*), Chapman's aster (*Symphytotrichum chapmanii*), Florida pineland spurge (*Euphorbia inundata*), and Chapman's butterwort (*Pinguicula planifolia*). In the peninsula, Curtiss' dropseed (*Sporobolus curtissii*), blue maidencane (*Amphicarpum muhlenbergianum*), cutthroat grass (*Panicum abscissum*), or Gulf hairawn muhly (*Muhlenbergia sericea*) may also be dominants or co-dominants with wiregrass.

Three common variants of wet prairie occur within Florida.

- Variants:**
- CUTTHROAT SEEP** – Wet prairies dominated by the endemic cutthroat grass occur along the eastern and western edges of the Lake Wales Ridge in Central Florida and are characterized by many wildflowers in common with other acidic wet prairie areas. They are maintained in saturated condition by water seeping out from the deep sands of the Lake Wales Ridge onto adjacent lower flat lands.
- CALCAREOUS WET PRAIRIE** – In central and south-central peninsular Florida wiregrass may co-occur with Gulf hairawn muhly as a dominant species in wet prairies where calcareous substrate is not far below the surface and soils are circum-neutral.³⁰⁷ Other calcium-loving species found in these prairies include pineland heliotrope (*Heliotropium polyphyllum*), sweet shaggytuft (*Stenandrium dulce*), and starrush white-top (*Rhynchospora colorata*).
- PITCHERPLANT PRAIRIE** – Wetter portions of wet prairies in the Panhandle are often characterized by dense stands of tall pitcherplants, primarily yellow pitcherplant (*Sarracenia flava*) near the Apalachicola River and white-top pitcherplant (*S. leucophylla*) to the west. Other species of pitcherplants found in this variant include sweet pitcherplant (*S. rubra*), parrot pitcherplant (*S. psittacina*), and Gulf purple pitcherplant (*S. rosea*).

Associated Communities: Wet prairie has many species in common with seepage slope and differs mainly in its occurrence on low, gently sloping terraces surrounded by mesic or wet flatwoods, or dry prairie, rather than on steeper slopes surrounded by sandhill or upland pine communities. Wet prairies are maintained in saturated condition by lateral seepage of groundwater, but, unlike seepage slopes, their water table is not perched above the level of the normal water table. Wet prairie differs from depression and basin marshes in having a relatively complete cover of wiregrass, cutthroat grass, nutrush (*Scleria* sp.), blue maidencane, or wiry beaksedges and in being inundated only to very shallow depth, if at all. It differs from the grassy form of wet flatwoods in having no, or only a very sparse, cover of pines. It differs from the wetter forms of dry prairie in the absence of upland shrubs such as saw palmetto (*Serenoa repens*), dwarf live oak (*Quercus minima*), or gallberry (*Ilex glabra*).³⁰⁷ The calcareous variant of wet prairie differs from marl prairie, which is found in South Florida and may also be dominated by Gulf hairawn muhly, in having a more continuous herbaceous cover, without limestone exposed extensively at the surface, and without standing water or periphyton mats characteristic of marl prairie.⁴²⁴

Management Considerations: In the absence of fire, woody shrubs may encroach on wet prairie from both the bordering uplands (e.g. gallberry, wax myrtle [*Myrica cerifera*]) and wetlands (e.g. peelbark St. John's wort [*Hypericum fasciculatum*], titi [*Cyrilla racemiflora*], and black titi [*Cliftonia monophylla*])¹⁶⁸ and eventually shade out the sun-loving herbaceous species. Hermann¹⁶⁸ cites one area in the Apalachicola National Forest where fire had been absent for 12-15 years (based on ring counts of titi stems), where shrubs had invaded and the cover of herbaceous wet prairie species was reduced to 15-20 percent of the area, compared to 100 percent cover of herbaceous species in a nearby area burned every 2-4 years. A study comparing extent of shrub cover on geo-rectified aerial photographs of Apalachicola National Forest from the 1930s with current aeriels shows expansion of shrubs into formerly grassy areas.¹⁷¹

Wet prairies are sensitive to relatively slight physical alterations to the soil surface which can permanently alter the hydrology.¹⁶⁸ Such disturbances include soil rutting within the prairies caused by trampling, vehicles, plowed fire lanes, or other heavy equipment damage, placing roads and ditches near the prairies and hog rooting. These disturbances can cause major changes in species composition that require expensive restoration to repair.²⁷⁶

Exemplary Sites: Tarkiln Bayou Preserve State Park (Escambia County), Garcon Point Water Management Area (Santa Rosa County), Apalachicola National Forest (Apalachicola Unit; Liberty County), Avon Park Air Force Range (Highlands and Polk counties), Three Lakes Wildlife Management Area and Triple N Ranch Wildlife Management Area (Osceola County), Kissimmee Prairie Preserve State Park (Okeechobee County)

Global and State Rank: G2/S2

Crosswalk and Synonyms:

Kuchler	112/Southern Mixed Forest
Davis	13/Grasslands of Prairie Type
	2/Pine Flatwoods
SCS	10/Cutthroat Seeps
	23/Pitcher plant bog
Myers and Ewel	Freshwater Marshes - wet prairies
	Flatwoods - wet flatwoods and seepage savannas
SAF	N/A
FLUCCS	310/Herbaceous
	641/Wet Prairies

Other synonyms: moist pine barrens¹⁵⁵; grass-sedge savannah⁵⁷; grass-sedge seepage bog⁵⁷; pine savanna¹³²; wet savanna²⁰⁸; pitcher plant bog¹²⁸

Table 1. Rare species in wet prairie community.

Panhandle Endemic	Panhandle and northern peninsula
<i>Arnoglossum album</i>	<i>Asclepias viridula</i>
<i>Cuphea aspera</i>	<i>Linum westii</i>
<i>Eriocaulon nigrobracteatum</i>	<i>Parnassia grandifolia</i>
<i>Gentiana pennelliana</i>	<i>Platanthera integra</i>
<i>Harperocalis flava</i> *	<i>Ruellia noctiflora</i>
<i>Justicia crassifolia</i>	
<i>Nyssa ursina</i>	Northeast Florida
<i>Oxypolis filifolia</i> ssp. <i>greenmanii</i>	<i>Balduina atropurpurea</i>
<i>Physostegia godfreyi</i>	<i>Cleistes divaricata</i>
<i>Pinguicula ionantha</i> *	
<i>Scutellaria floridana</i> *	Peninsular Florida Endemic
<i>Verbesina chapmanii</i>	<i>Hartwrightia floridana</i>
	<i>Helianthus carnosus</i>
Panhandle	<i>Panicum abscissum</i>
<i>Dichanthelium nudicaule</i>	
<i>Lachnocaulon digynum</i>	
<i>Lilium iridollae</i>	
<i>Macranthera flammea</i>	
<i>Parnassia caroliniana</i>	
<i>Sarracenia rubra</i>	
<i>Sarracenia leucophylla</i>	
<i>Xyris scabrifolia</i>	

* Federally listed species



Apalachicola National Forest (Liberty County) - Pitcherplant Prairie variant

Photo by Ann F. Johnson



Everglades National Park (Miami-Dade County)

Photo by Amy Jenkins

Marl Prairie

Description: Marl prairie is a sparsely vegetated (20-40% cover), graminoid-dominated community found on marl substrates in South Florida. It is seasonally inundated (two to four months) to a shallow depth averaging about eight inches. It occupies large areas at intermediate elevations between marshes or dome and strand swamps with longer hydroperiod of six to twelve months, and pinelands or oak-palm hammocks that are seldom flooded.⁴¹⁵ In contrast to the longer hydroperiod marshes, with which it has sometimes been confused, marl prairie is a diverse community which may contain over 100 species, whereas most marsh types have fewer than 20 species.⁴¹⁵ Most of the many species in marl prairie contribute little cover and over 90 percent of the cover is contributed by only two or three dominant species in any given area.³⁰⁴ Dominants may include one or more of the following: Gulf hairawn muhly (*Muhlenbergia sericea*), spreading beaksedge (*Rhynchospora divergens*), Florida little bluestem (*Schizachyrium rhizomatum*), black bogrush (*Schoenus nigricans*), Elliott's lovegrass (*Eragrostis elliottii*), sand cordgrass (*Spartina bakeri*), and a short form of sawgrass (*Cladium jamaicense*).^{149,329} (Taxonomy of *Schizachyrium* and *Muhlenbergia* follows treatments in *Flora of North America*¹¹⁶). Other characteristic species include southern beaksedge (*Rhynchospora microcarpa*), bluejoint panicum (*Panicum tenerum*), Gulfdune paspalum (*Paspalum monostachyum*), rosy camphorweed (*Pluchea rosea*), starrush whitetop (*Rhynchospora colorata*), alligatorlily (*Hymenocallis palmeri*), arrowfeather threeawn (*Aristida purpurascens*), and narrowleaf yellowtops (*Flaveria linearis*).^{149,329}

In the Big Cypress region, widely scattered, stunted pond cypress (*Taxodium ascendens*) is often present in the marl prairie. These trees, sometimes called dwarf, scrub, or hat rack cypress, can have huge buttresses, gnarled bonsai-like crowns, and may be hundreds of years old.¹¹⁵ They are usually less than 12 feet tall with a diameter at breast height of less than 4 inches, and a canopy cover of 33 percent or less.⁴²⁴

Soils are seasonally flooded marls or sandy marls, 2-24 inches deep, underlain by limestone.⁷⁴ Marls are fine white calcareous muds formed from calcite precipitated by a mixture of green algae, blue-green algae, and diatoms, known

as periphyton. These soils are highly alkaline and impermeable, sealing off the underlying limestone and causing water to pond during the wet season. In the rocky glades region of the southeastern Everglades marl prairies occur on exposed limestone bedrock where limestone pinnacles are exposed through the marl soils forming a micro-karst topography.⁴¹⁵

Characteristic Set of Species: purple muhly, sawgrass (stunted), spreading beaksedge, black bogrush, Florida little bluestem

Rare Species: Two rare South Florida endemic species are dependent on marl prairie as their primary habitat: few-flowered fingergrass (*Digitaria pauciflora*) and Cape Sable Seaside Sparrow (*Ammodramus maritimus mirabilis*). Few-flowered fingergrass is a perennial bunchgrass that grows in the ecotone between marl prairie and pine rockland. It is known from only two locations, a large population on Long Pine Key in Everglades National Park and a small, recently discovered population in Big Cypress National Preserve. The Cape Sable Seaside Sparrow is currently found only in marl prairie in the southeastern portion of Big Cypress National Preserve and in the vicinity of Taylor Slough in Everglades National Park.

Other rare plant species endemic to South Florida found in marl prairies include meadow jointvetch (*Aeschynomene pratensis*), narrow-leaved Carolina scalystem (*Elytraria caroliniensis* var. *angustifolia*), and Carter's large-flowered flax (*Linum carteri* var. *smallii*). The dwarf cypress may harbor rare epiphytes, most notably the cowhorn orchid (*Cyrtopodium punctatum*).

Other rare animal species that use marl prairie are southern mink (southern Florida population; *Mustela vision mink*), Florida panther (*Puma concolor coryi*), and the short-tailed hawk (*Buteo brachyurus*), as well as a variety of wading birds that use the shallowly flooded habitat for fishing, including great egret (*Ardea alba*), little blue heron (*Egretta caerulea*), snowy egret (*E. thula*), tricolored heron (*Egretta tricolor*), white ibis (*Eudocimus albus*), and wood stork (*Mycteria americana*). Two West Indian damselflies are found in Florida only in the dwarf cypress in Big Cypress National Preserve, the tail-light damsel (*Chrysobasis lucifer*) and the blue strapped spreadwing (*Lestes tenuatus*).

Range: Within the United States marl prairies are limited to extreme South Florida. Marl prairies with scattered dwarf cypress cover large areas of Big Cypress National Preserve in Collier and Monroe counties. In the Everglades region marl prairie forms the border between the Miami Rock Ridge and the lower slough and glades marsh and occurs in the narrow finger glades on Long Pine Key.

Natural Processes: Marl prairie depends on a short hydroperiod of two to four months. Longer hydroperiods favor the development of peat and the dominance of sawgrass; shorter hydroperiods permit the invasion of woody species.

Marl prairie normally dries out during the winter and is subject to fires at the end of the dry season; the most acres naturally burn in May.¹⁵⁰ Fires at this time (in contrast to dormant season fires) stimulate flowering of the dominant grasses.²⁵⁹ The herbaceous species recover rapidly from fire and biomass reaches pre-fire levels at the end of two years. For the first two years after fire this community will burn only patchily, if at all.¹⁶⁹ Reasons for the presence of dwarf cypress in some marl prairies and not others are unknown.³⁰³ Wade et al.⁴²⁴ estimated dwarf cypress stands in marl prairie burn about once a decade due to low fire-carrying capacity of their sparse understory.

Werner⁴³⁴ found that the Cape Sable seaside sparrow ceased nesting in areas of marl prairie unburned for six or more years, suggesting that the natural fire frequency was less than six years and more than one year, since the community will generally not carry a fire within one year post burn.¹⁶⁹ Marl prairies with sparse cover (generally on shallower soils) may remain suitable for nesting sparrows for longer intervals between fires, up to eight to ten years.^{305,396}

Community Variations: The principal variation in marl prairies is the presence or absence of dwarf cypress.

Associated Communities: Marl prairie is distinguished from calcareous wet prairie, both of which may have Gulf hairawn muhly as the dominant grass, by the presence of calcareous marl, rather than sandy, soil, regular seasonal flooding for several months, and the presence of Gulf dune paspalum and sawgrass. Marl prairie is distinguished from acidic wet prairie by the absence of a sandy substrate and the absence of wiregrass (*Aristida stricta* var. *beyrichiana*).³⁰⁶ Marl prairie is distinguished from glades marsh and slough by its shorter hydroperiod, lack of peat substrate, and higher plant species diversity. Glades marshes near marl prairies may include flats dominated by Gulf Coast spikerush (*Eleocharis cellulosa*) or Tracy's beaksedge (*Rhynchospora tracyi*). Glades marshes on peat

substrates with longer hydroperiods are usually dominated by a single species including maidencane (*Panicum hemitomon*), tall sawgrass, cattails (*Typha* spp.), bulltongue arrowhead (*Sagittaria lancifolia*), pickerelweed (*Pontederia cordata*), or alligatorflag (*Thalia geniculata*).⁴¹⁵

Management Considerations: Several factors have combined to reduce the area of marl prairie outside Everglades National Park and Big Cypress National Preserve. Hydrological modifications have produced an increase in sawgrass marsh at the expense of marl prairie, drainage and lack of fire have allowed invasion of exotic plants, and rock plowing for agriculture on the eastern edge of Everglades National Park has permanently changed the physical environment that formerly supported it.¹⁷⁵

Prescribed fire is needed in marl prairie to prevent the buildup of litter to the point where it lowers the nesting frequency of the Cape Sable seaside sparrow and to control shrub invasion by native species from the adjacent pine rockland, as well as by woody invasives, such as Brazilian pepper (*Schinus terebinthifolius*), Australian pine (*Casuarina equisetifolia*), and melaleuca (*Melaleuca quinquenervia*).^{150,175} Shrubs can also displace rare plant species, such as few-flowered fingergrass.²⁸

Patchy fires are preferable to large scale fires in the Cape Sable Seaside Sparrow habitat, since up to six years after a fire may be needed before the prairie vegetation is again suitable for nesting.³⁹⁶ Since it nests on or within 20 centimeters of the ground from February to July, the breeding success of the Cape Sable seaside sparrow is also sensitive to flooding at the beginning of the wet season. Care should be taken in timing water releases to allow nesting to be completed; timing of water releases also needs to be coordinated with prescribed burns since flooding too soon after a fire can kill resprouting grasses.⁴¹⁵ Due to their soft soils during the wet season marl prairies are also subject to scarring from off-road vehicle tracks.

Exemplary Sites: Big Cypress National Preserve (Collier and Monroe counties), Everglades National Park (Miami-Dade County)

Global and State Rank: G3/S3

Crosswalk and Synonyms:

Kuchler	91/Cypress Savanna
Davis	14/Region of open Scrub Cypress
	17/Wet to Dry Prairie-Marshes on Marl and Rockland
SCS	16/Scrub Cypress
Myers and Ewel	Freshwater Marshes - marl prairie
SAF	100/Pondcypress
FLUCCS	621/Cypress
	641/Freshwater Marshes

Other synonyms: cypress-prairie¹⁴⁹; dwarf cypress⁷⁴; southern coast marsh prairies and marsh prairies, southern Everglades⁷⁹; muhly or *Muhlenbergia* prairie^{149,175}; rocky glades⁴¹⁵



Aucilla Wildlife Management Area (Jefferson County)

Photo by Ann F. Johnson

Shrub Bog

Description: Shrub bog consists of dense stands of broadleaved evergreen shrubs, vines, and short trees, one to five meters tall depending on time since fire, with or without an overstory of scattered pine or bay trees, growing in mucky soil where water is usually less than a foot deep.^{157,364} Characteristic shrubs include titi (*Cyrilla racemiflora*), black titi (*Cliftonia monophylla*), fetterbush (*Lyonia lucida*), large gallberry (*Ilex coriacea*), gallberry (*I. glabra*), wax myrtle (*Myrica cerifera*), and sweet pepperbush (*Clethra alnifolia*), often laced together with laurel greenbrier (*Smilax laurifolia*). Other shrubs that may be present include red chokeberry (*Photinia pyrifolia*), Virginia willow (*Itea virginica*), swamp doghobble (*Leucothoe racemosa*), and myrtle dahoon (*Ilex cassine* var. *myrtifolia*). Taller pines, either pond (*Pinus serotina*), slash (*P. elliotii*), or loblolly (*P. taeda*), may be present. Dense clumps of slash pine may be present in long unburned stands. Other occasional trees that may extend above the shrub layer are loblolly bay (*Gordonia lasianthus*), sweetbay (*Magnolia virginiana*), swamp bay (*Persea palustris*), pond cypress (*Taxodium ascendens*), and stunted red maple (*Acer rubrum*). Herbs are sparse and patchy, confined to sunny openings, and often include tenangle pipewort (*Eriocaulon decangulare*), Virginia chain fern (*Woodwardia virginica*), and pitcher plants (*Sarracenia* spp.). Small areas of open water have floating bladderworts (*Utricularia* spp.).

Shrub bog is found on the border of swamps, in streamhead drainages, and in flat, poorly drained areas between rivers. It often forms the border between the mesic or wet flatwoods communities and dome swamp, basin swamp, or hydric hammock communities. Shrub bog may cover large portions of low-lying areas in the coastal plain known as “bays” (e.g., San Pedro Bay in Madison and Taylor counties and Bradwell Bay in the Apalachicola National Forest). Soils of shrub bogs frequently have an organic muck layer of varying depth at the surface underlain by sand or loamy sands.⁶⁶ Characteristic soil series include Rutledge, Donovan, Surrency, and Lynn Haven depressionals.^{204,410} Sphagnum moss (*Sphagnum* spp.) is common on the ground surface.

Characteristic Set of Species: titi, black titi, sweet pepperbush, fetterbush, large gallberry, laurel greenbrier, pond pine, slash pine

Rare Species: Among rare plants, primrose-flowered butterwort (*Pinguicula primuliflora*) is found along streams through shrub bogs. Panhandle lily (*Lilium iridollae*), hummingbird flower (*Macranthera flammea*), and white-top pitcherplant (*Sarracenia leucophylla*) are found along the edges of shrub bogs in upper stream drainages within upland pine communities in the western Florida Panhandle. Two shrubs, dwarf witch-alder (*Fothergilla gardenii*) and bog spicebush (*Lindera subcoriacea*), which are widespread in the southeast but rare in Florida, are found at the edges of shrub bogs in the western Panhandle. The rare Florida endemic, Chapman's rhododendron (*Rhododendron chapmanii*) is found along the borders of titi-dominated shrub bogs in the central Panhandle.

Rare animals found in shrub bog include two species of frogs found along upper reaches of sandhill streams in the western Panhandle, the endemic Florida bog frog (*Rana okaloosae*) and the pine barrens treefrog (*Hyla andersonii*).²⁶⁵ Extensive shrub bogs provide large acreages of inaccessible natural habitat important for Panhandle populations of the Florida black bear (*Ursus americanus floridanus*).

Range: North of Florida, shrub bogs range from North Carolina through the lower portions of the Atlantic coastal plain to the Okefenokee Swamp in Georgia. In this region they are often referred to as "pocosins," an Algonquin word meaning "swamp on a hill,"³³⁸ and they have been the subject of numerous studies.^{53,216,244,364} Although they share many species with Florida shrub bogs, the more northern shrub bogs have different dominant species and physical characteristics. West of Florida, shrub bogs occur in the lower coastal plain of Alabama and Mississippi.²⁸⁶ In Florida, shrub bogs range throughout the state except for extreme southern Florida. The most extensive shrub bogs are found from the St. Mary's River on the Georgia border south through the Pinhook Swamp portion of Osceola National Forest and John M. Bethea State Forest (Columbia and Baker counties)²⁵³ to Mallory Swamp in Lafayette County²⁰⁴ and westward to the Alabama border.

Natural Processes: Fires starting in the surrounding pinelands burn to the edges of shrub bogs, but burn through them only during drought periods, probably on the order of every 10-20 years.²⁴⁴ The shrubs and bay trees respond to fire by re-sprouting, either from root crowns or rhizomes. During droughts the peat may become dry enough to burn completely, killing the shrubs and producing a mosaic of open water areas and sedge-dominated marshes alternating with shrub bogs.⁵³

Several lines of evidence indicate that shrub bog species have invaded bordering wet prairies and wet flatwoods in the absence of frequent fire. Aerial photographs from the 1930s to 1950s often show a light-colored band of grasses around swamps and shrub bogs in the Panhandle that is replaced by dense shrub vegetation on current aerials.¹⁷¹ Senescent wiregrass (*Aristida stricta* var. *beyrichiana*) can occasionally be found among titi shrubs in shrub bogs where it is too shady for wiregrass to have originated. Coultas et al.,⁶⁹ in sampling soils and vegetation along a transect through a titi swamp in the Apalachicola National Forest, found cut longleaf pine stumps indicating that black titi had invaded about 60 meters into adjacent pine flatwoods vegetation, presumably since the beginning of fire suppression in the 1930s, developing in the process a layer of peat eight inches deep. Drewa et al.⁹¹ noted that shrubs along transects from flatwoods to shrub bog in Florida and Louisiana have broader tolerance limits along the moisture gradient than do herbs, with shrubs tending to extend from both the drier and wetter ends of the transect into the middle. They suggest that relatively frequent fire is the primary factor preventing incursion of shrubs into herbaceous zones.

Community Variations: Variants of shrub bogs occur in particular physiographic situations. These include areas along seepage streams in steeply dissected topography in the Panhandle that are dominated by Florida anise (*Illicium floridanum*). Another example is an unusual area in Osceola National Forest dominated by the northern shrub, willow herb (*Decodon verticillatus*).

Associated Communities: Shrub bog differs from baygall in lacking a closed canopy or subcanopy of bay trees (swamp bay, loblolly bay, sweetbay). It can be distinguished from recently burned baygall in lacking a large re-sprouting component of bay trees and burned tree stumps. Although it may share many species with wet flatwoods, it differs in usually having few or no slash or longleaf pines, in the rarity or absence of saw palmetto (*Serenoa repens*) in the shrub layer, and in the presence of a peat layer on the soil surface. It differs from basin, dome, and floodplain swamps in lacking a canopy of hydrophytic trees, such as pond cypress, swamp tupelo (*Nyssa sylvatica* var. *biflora*), and red maple. It differs from wet prairie and seepage slope in the dominance of shrubby, instead of graminoid species. The presence of remnant clumps of wiregrass can be used to distinguish a shrub-invaded wet

prairie or seepage slope from a natural shrub bog, since light-loving wiregrass would not be able to become established or maintain itself in a natural shrub bog community.

Management Considerations: Physical disturbance in the form of logging, ditching, and planting of pine plantations can favor the spread of shrub bogs at the expense of dome and basin swamps, as well as wet prairies. Historical sources may aid in determining the original extent of shrub bogs in a disturbed landscape, and allow a distinction to be made between natural shrub bog and fire-excluded seepage slope and wet prairie. At Aucilla Wildlife Management Area, for example, historical sources (i.e., 1949 aerial photography, General Land Office surveyors' notes from the mid-1800s and a 1907 soil survey) were used to produce a geo-referenced vegetation map of the pre-disturbance landscape. Similar techniques have been used to map the original natural extent of shrub bog in other areas in North Florida.^{204,208}

Frequent growing season fire in the surrounding pinelands is needed to prevent shrub bog species, particularly black titi, from encroaching on surrounding grassy wet flatwoods, seepage slopes and wet prairies. Once shrubs have expanded into former herbaceous areas, they may be difficult to remove using fire alone. Drewa et al.⁹² found that shrub stem density along a savanna-shrub bog gradient did not decrease even with two growing season fires two years apart. Dormant season fires in the same sites actually increased shrub stem density along the gradient, particularly in species resprouting from root crowns.

Swamp bay, a major component of some shrub bogs, is susceptible to Laurel Wilt Disease, which is caused by a fungus spread by an exotic wood-boring ambrosia beetle (*Xyleborus glabratus*). As of 2009, the infestation had spread to 20 counties in north Florida.⁴¹¹ There is no known means of treating diseased trees or controlling the spread of the disease, although root-flare injections of propiconazole have recently shown promise of providing temporary protection of individual trees.²⁶⁰ Wood or mulch from areas with infected trees should not be transported to avoid creating new centers of infection.

Exemplary Sites: Bradwell Bay Wilderness Area, Apalachicola National Forest (Wakulla County), Mallory Swamp Restoration Area (Suwannee River Water Management District; Lafayette County), Aucilla Wildlife Management Area (Jefferson and Taylor counties), Pinhook Swamp in Osceola National Forest (Baker and Columbia counties)

Global and State Rank: G4/S3

Crosswalk and Synonyms:

SCS	22/Shrub Bog
Myers and Ewel	Freshwater Swamp Forests – titi swamps
FLUCCS	614/Titi Swamps

Other synonyms: scrub-shrub (Okefenokee NWR); shrub swamp (in part; FLUCCS); bay¹⁵⁷; titi swamp⁵⁷

MARSHES – long hydroperiod; dominated by grasses, sedges, broadleaf emergents, floating aquatics, or shrubs



Triple N Ranch Wildlife Management Area (Osceola County)

Photo by Ann F. Johnson

Depression Marsh

Description: Depression marsh is characterized as a shallow, usually rounded depression in sand substrate with herbaceous vegetation or subshrubs, often in concentric bands. Depression marshes typically occur in landscapes occupied by fire-maintained matrix communities such as mesic flatwoods, dry prairie, or sandhill. The concentric zones or bands of vegetation are related to length of the hydroperiod and depth of flooding. The outer, or driest, zone is often occupied by sparse herbaceous vegetation consisting of longleaf threeawn (*Aristida palustris*), beaksedges (*Rhynchospora microcarpa*, *R. cephalantha*, *R. tracyi*, *R. filifolia*, etc.), Elliott’s yellow-eyed grass (*Xyris elliottii*), the subshrub, myrtleleaf St. John’s wort (*Hypericum myrtifolium*), and patches of blue maidencane (*Amphicarpum muhlenbergianum*) or sand cordgrass (*Spartina bakeri*). This sparse zone may be followed downslope by a sparse to dense zone of peelbark St. John’s wort (*Hypericum fasciculatum*), water toothleaf (*Stillingia aquatica*) and scattered herbs, such as fringed yellow-eyed grass (*Xyris fimbriata*), pipeworts (*Eriocaulon compressum* and *E. decangulare*), narrowfruit horned beaksedge (*Rhynchospora inundata*), and Baldwin’s spikerush (*Eleocharis baldwinii*). The innermost, deepest zone is occupied by maidencane (*Panicum hemitomon*), pickerelweed (*Pontederia cordata*), bulltongue arrowhead (*Sagittaria lancifolia*), or sawgrass (*Cladium jamaicense*). Floating-leaved plants, such as white waterlily (*Nymphaea odorata*), may be found in open water portions of the marsh. Depending on depth and configuration, depression marshes can have varying combinations of these zones and species within each zone. Depression marshes within xeric communities such as sandhill or scrub may have outer borders dominated by bluestem grasses, such as *Andropogon brachystachyus*, *A. glomeratus*, or *A. virginicus* var. *glauca*, or tall herbs such as falsefennel (*Eupatorium leptophyllum*). Where stands of these species are sparse, small rosette plants, such as witchgrass (*Dichanthelium* spp.), Small’s bogbutton (*Lachnocaulon minus*), and yellow hatpins (*Syngonanthus flavidulus*), may occupy the spaces between them.

Depression marshes form the characteristic pockmarked landscape seen on aerial photographs of the flat landscapes of the Florida peninsula. They form when the overlying sands slump into depressions dissolved in underlying limestone. These marshes also frequently form an outer rim around swamp communities such as dome swamps. Depression marshes often burn with the surrounding landscape and are seasonally inundated. The deepest zones (dominated by pickerelweed, bulltongue arrowhead or sawgrass) may have a peat substrate and a continuous layer of sphagnum moss, while shallower zones (dominated by peelbark St. John's wort) have a sandy substrate. Maidencane may occur on either sand or peat.⁴⁴¹ Common soil types include depressional phases of Basinger, Pompano, and Myakka fine sand.³

Characteristic Set of Species: longleaf threeawn, sand cordgrass, peelbark St. John's wort, maidencane, sawgrass, pickerelweed, blue maidencane

Rare Species: Rare plant species found in depression marshes include: Elliott's croton (*Croton elliotii*) in the northern Florida Panhandle; karst pond xyris (*Xyris longisepala*), small-flowered meadowbeauty (*Rhexia parviflora*), panhandle meadowbeauty (*Rhexia salicifolia*), and St. Marks yellow-eyed grass (*Xyris panacea*), all endemic to the Panhandle; pondspice (*Litsea aestivalis*), found on edges of depression marshes in northern and western Florida; Curtiss' sandgrass (*Calamovilfa curtissii*), endemic to the western Panhandle with a disjunct occurrence on Merritt Island in Brevard County; piedmont jointgrass (*Coelorachis tuberculosa*) in northwest and Central Florida, and Edison's ascyrum (*Hypericum edisonianum*) and cutthroat grass (*Panicum abscissum*), both endemic to the southern Lake Wales Ridge and vicinity.

Rare animal species include several amphibians, particularly those that require breeding sites that are free of predatory fishes (Moler and Franz 1987); these include the frosted flatwoods salamander (*Ambystoma cingulatum*), reticulated flatwoods salamander (*A. bishopi*), tiger salamander (*Ambystoma tigrinum*), striped newt (*Notophthalmus perstriatus*), and gopher frog (*Rana capito*). More than a dozen other species of frogs and salamanders also breed regularly in depression marshes, and these constitute an important part of the food supply of wading birds and snakes, including the rare eastern indigo snake (*Drymarchon couperi*) and southern hognose snake (*Heterodon simus*).²⁷⁷ Other rare species using this habitat include the Florida sandhill crane (*Grus canadensis pratensis*) and round-tailed muskrat (*Neofiber alleni*). Wading birds, in addition to feeding in depression marshes, use clumps of willows or other trees in the center for roosting or nesting.²⁸⁹

Range: Depression marshes occur throughout Florida, but are uncommon in the Panhandle and in extreme South Florida where marshes (e.g., glades marsh, marl prairie) become the matrix communities and uplands are the included communities.

Natural Processes: Depression marshes are generally thought to be maintained as herbaceous communities against woody invasion by hydrologic fluctuations or by fire or by both.^{51,212} The frequency of fire in depression marshes is a function of the fire frequency in the surrounding matrix community, as well as the fire-carrying characteristics of the marsh vegetation. The very sparse outer zone of some marshes may act as a natural firebreak. There is little data on natural fire frequency in depression marshes. A lack of fire may lead to an increase in shrubs at the expense of herbaceous species. Peroni and Abrahamson,³²⁰ using 1943 and 1981 aerial photography, documented expansion of bordering shrub communities into two depression marshes at Archbold Biological Station during a period of fire exclusion.

Peelbark St. John's wort is killed by fire but germinates readily from seed.^{225,441} It is also killed by prolonged inundation.⁴⁴¹ Thus its prominence in any given depression marsh may fluctuate considerably over relatively short time periods, depending on past rainfall history and time since fire. Long-term sampling of permanent transects would be useful to determine how much depression marsh vegetation fluctuates naturally over time. During periodic droughts, upland species, such as slash pine (*Pinus elliotii*) and dogfennel (*Eupatorium capillifolium*), colonize depression marshes, but are killed during subsequent intervals of prolonged high water.^{1,250}

Community Variations: Depression marshes on the southern end of the Lake Wales Ridge are distinguished by having the endemic cutthroat grass and Edison's ascyrum as dominants. Sawgrass tends to dominate depression marshes near the coast or where limestone is near the surface. Some depression marshes found on the Panacea Unit of St. Marks National Wildlife Refuge have floating islands of soil and vegetation in the center, surrounded by open water with water lilies, and grassy zones of emergent vegetation toward the shores. The floating islands are home to the recently described St. Marks yellow-eyed grass.¹⁰

Associated Communities: Depression marsh is distinguished from wetlands dominated by woody species (shrub bog, dome swamp, basin swamp) by its predominantly herbaceous and concentric zone pattern of vegetation. Depression marsh is distinguished from other herbaceous wetlands (basin marsh, wet prairie, seepage slope) primarily by its occurrence as isolated depressions within fire-maintained matrix communities. It is distinguished from wet prairie, which often borders its upper edges, by its concentric zones of vegetation, and its lack of wiregrass (*Aristida stricta* var. *beyrichiana*). Depression marsh is similar to the upper margins of sandhill upland lakes (“karst ponds”) found in Bay and Washington counties; however, the lakes rarely dry completely, and have a unique flora with several endemic species, including the dominant smoothbark St. John’s wort (*Hypericum lissophloeus*).

Management Considerations: Fires in surrounding communities should be allowed to burn into depression marshes and extinguish naturally or burn through them. Encroachment of shrubs such as coastalplain willow (*Salix caroliniana*), common buttonbush (*Cephalanthus occidentalis*), groundsel tree (*Baccharis halimifolia*), and wax myrtle (*Myrica cerifera*) are typical signs of lack of fire in depression marshes.¹⁸⁴

Physical disturbance, particularly from hog rooting, livestock, or vehicles (e.g., “mud bogging”) can cause serious damage in many marshes; these activities can destroy native species and churn the soil which is often then colonized by pure stands of Carolina redroot (*Lachnanthes caroliana*) and other weedy species. Such physical disturbances can allow invasive exotic plants to get a foothold, including torpedo grass (*Panicum repens*), Peruvian primrosewillow (*Ludwigia peruviana*), common water hyacinth (*Eichhornia crassipes*), and Brazilian pepper (*Schinus terebinthifolius*).

Drying of the marsh, either through artificial drainage or drawn-down of the water table by wells, perhaps also aided by cattle trampling, can allow pasture grasses to invade depression marshes, especially where the surrounding community has been converted to pasture.⁴⁴¹ These include centipede grass (*Eremochloa ophiuroides*), big carpetgrass (*Axonopus furcatus*), bahiagrass (*Paspalum notatum*), and the invasive exotic West Indian marsh grass (*Hymenachne amplexicaulis*).

Exemplary Sites: Munson Sandhills Bike Trail in Apalachicola National Forest (Leon County), Triple N Ranch Wildlife Management Area (Osceola County), Three Lakes Wildlife Management Area (Osceola County), Archbold Biological Station (Highlands County), Fred C. Babcock-Cecil M. Webb Wildlife Management Area (Charlotte County)

Global and State Rank: G4/S4

Crosswalk and Synonyms:

Kuchler	112/Southern Mixed Forest
Davis	13/Grasslands of Prairie Type
SCS	25/Freshwater Marsh and Ponds
Myers and Ewel	Freshwater Marshes - basin or depression marshes
SAF	N/A
FLUCCS	641/Freshwater Marshes
	644/Emergent Aquatic Vegetation

Other synonyms: seasonal pond³; temporary pond²²⁵; flatwoods marsh²²³; isolated ephemeral pond²²⁶



Goethe State Forest (Levy County)

Photo by Paul Russo



St. Marks National Wildlife Refuge (Panacea Unit; Wakulla County)

Photo by Ann F. Johnson



Salt Lake Wildlife Management Area (Brevard County)

Photo by Ann F. Johnson

Basin Marsh

Description: Basin marshes are regularly inundated freshwater herbaceous wetlands that may occur in a variety of situations but, in contrast to depression marshes, are not small or shallow inclusions within a fire-maintained matrix community. Species composition is heterogeneous both within and between marshes but can generally be divided into submersed, floating-leaved, emergent, and grassy zones from deepest to shallowest portions; shrub patches may be present within any of these zones. Common species found in the floating-leaved zone of basin marshes include white waterlily (*Nymphaea odorata*), American lotus (*Nelumbo lutea*), and yellow pondlily (*Nuphar advena*); the emergent zone may have pickerelweed (*Pontederia cordata*), bulltongue arrowhead (*Sagittaria lancifolia*), southern cattail (*Typha domingensis*), sawgrass (*Cladium jamaicense*), and softstem bulrush (*Scirpus tabernaemontani*); the grassy zone is typically characterized by maidencane (*Panicum hemitomon*), smooth beggarticks (*Bidens laevis*), dotted smartweed (*Polygonum punctatum*), and sand cordgrass (*Spartina bakeri*), accompanied by a diverse mixture of less common forbs such as sweetscent (*Pluchea odorata*), spadeleaf (*Centella asiatica*), and lemon bacopa (*Bacopa caroliniana*).¹¹⁷ Coastalplain willow (*Salix caroliniana*), common buttonbush (*Cephalanthus occidentalis*), elderberry (*Sambucus nigra* ssp. *canadensis*), and wax myrtle (*Myrica cerifera*) are common shrubby components. During droughts exposed marsh and lake beds may be colonized by large native weedy species such as southern amaranth (*Amaranthus australis*) and dogfennel (*Eupatorium capillifolium*).²⁵⁰ Occasional isolated areas of salt flat vegetation, including shoreline seapurslane (*Sesuvium portulacastrum*) and perennial glasswort (*Sarcocornia perennis*) occur in the marshes of the St. Johns Basin.¹²² These salt pockets are presumably relict deposits from an earlier geologic episode when the area was an arm of the sea.

Basin marsh occurs in a variety of isolated or mostly isolated depressions. They occur around fluctuating shorelines of lakes, on the former lake bottoms of “disappearing” lakes, at the head of broad, low basins which were former embayments of the sea during times of higher sea level, and as large deep inclusions within pyrogenic upland communities, or as inclusions in non-pyrogenic communities such as hardwood forests or basin swamps. They are regularly inundated with water originating from localized rainfall. While water is generally not flowing, some basin

marshes have outflow, particularly where large marsh systems form the headwaters of rivers, such as the St. Johns. Basin marsh may occur on either sand or peat soils. Common soil series include Ledwith-Wauberg, Wabasso, and Riviera.

Characteristic Set of Species: white water lily, maidencane, sawgrass, bulltongue arrowhead, pickerelweed, sand cordgrass

Rare Species: Rare plants found in basin marshes include Florida corkwood (*Leitneria floridana*), narrowleaf naiad (*Najas filifolia*), and Mexican tear-thumb (*Polygonum meisnerianum* var. *beyrichianum*) in northern Florida, plus piedmont jointgrass (*Coelorachis tuberculosa*) and piedmont water milfoil (*Myriophyllum laxum*) from the Panhandle to south-central Florida. Rare animal species found in basin marshes include American alligator (*Alligator mississippiensis*), snail kite (*Rostrhamus sociabilis plumbeus*), black rail (*Laterallus jamaicensis*), Florida sandhill crane (*Grus canadensis pratensis*), numerous species of wading birds, and round-tailed muskrat (*Neofiber alleni*).

Range: Basin marshes are found throughout the southeastern United States and Florida.

Natural Processes: Natural fires probably occasionally burned basin marshes at the end of the dry season. Dense sawgrass and maidencane marshes will burn even when there is standing water. Frequency of fire varies depending on the hydrology of the marsh and its exposure to fire from surrounding areas. Few studies have indicated the natural fire interval for marshes, except for glades marsh where intervals of 5-7 years are usually mentioned.^{380,424}

Natural seasonal and longer-term fluctuations in water level are important for maintaining the diversity of marsh vegetation. If the water level is artificially stabilized, species such as cattail that can tolerate long periods of inundation will tend to dominate. This was observed when the Kissimmee River was channelized in the 1960s,¹⁴¹ diminishing the invertebrate base of the food chain and causing crashes in the populations of fish, ducks, and wading birds.⁴⁰⁶

Community Variations: Basin marshes occurring in different landscape positions share many of the same wetland herbaceous species, but zonation and dominance of these species vary from place to place. In general there is little species differentiation in marsh vegetation between North and South Florida. Of the more common species, willow herb (*Decodon verticillatus*) is confined to northern Florida and alligatorflag (*Thalia geniculata*) to southern Florida.

Common species in small, shaded depressions in hydric hammock in northern Florida are Florida millet beaksedge (*Rhynchospora miliacea*) and lizard's tail (*Saururus cernuus*). Depressions in basin swamps often are dominated by Walter's sedge (*Carex striata*). Depressions in the Florida Keys occurring in pine rockland and rockland hammock are often dominated by sawgrass and spikerush (*Eleocharis* sp.) and have a peat or calcitic mud substrate.³⁴⁵

Variant: LAKE BOTTOM – Basin marshes may be present on former lake bottoms of “disappearing” lakes in northern Florida. These areas alternate between lake and marsh when the sinkholes draining them are plugged or re-opened. Well-known examples are Lake Miccosukee⁴⁵ and Paynes Prairie.³¹⁶ In addition to the common species mentioned above, the emergent zone of these marshes is characterized by flatsedges (*Cyperus odoratus* or *C. strigosus*), willow herb, smallfruit beggarticks (*Bidens mitis*), and swamp smartweed (*Polygonum hydropiperoides*); and the grassy zone by southern cutgrass (*Leersia hexandra*) and soft rush (*Juncus effusus* ssp. *solutus*). Floating islands of detached peat from the bottom of the lake support floating marshpennywort (*Hydrocotyle ranunculoides*), waterspider false rein orchid (*Habenaria repens*), and frog's bit (*Limnobium spongia*). Patches of hydrophytic shrubs and trees are common. Other marshes that may alternate between marsh and lake are those in shallow erosional valleys in the karst area of western peninsular Florida, such as Lake Tsala Apopka¹²¹ and Lake Panasoffkee.

Associated Communities: Unlike depression marsh, basin marsh is not a small or shallow inclusion in a pyrogenic community, but is either a large landscape feature or an inclusion in an infrequently burned community. It is distinguished from floodplain marsh by its occurrence in a headwaters basin or adjacent depression rather than along a river floodplain subject to periodic flooding from the river drainage, and is distinguished from basin and dome swamps by the dominance of herbaceous and shrubby species, rather than trees. It is distinguished from slough

marsh by the absence of periodic directional water flow and by the absence of a surrounding pyrogenic landscape and from glades marsh by the absence of flow, as well as its occurrence north of the Everglades basin.

Management Considerations: Hydrological alteration is the main threat to marshes in Florida. Ditching and cutting of canals to drain water lowers the water table and dampens the natural fluctuations of water levels in the marsh, altering the vegetation. A lowered water table allows shrubby species such as coastalplain willow to invade the marsh, shading out the herbaceous vegetation. Water table draw-downs for human consumption have been shown to negatively affect nesting success in sandhill cranes in marshes.¹⁰²

Stabilized water levels, along with increased nutrient levels from agricultural runoff, can result in the invasion of exotics, such as water hyacinth (*Eichhornia crassipes*) and Cuban bulrush (*Scirpus cubensis*) which invaded the Kissimmee River marshes after the river was channelized in the 1960s.¹⁴¹

Fire has been used to control the spread of coastalplain willow in the St. Johns River upper basin marshes that were invaded by willow after the water levels were lowered by drainage.²³³ Prescribed burns in marshes have to be conducted with caution to avoid peat fires that will kill the dominant species, especially in areas where the water table has been artificially lowered for human consumption.¹⁷ Another consideration is how completely a marsh area burns. Complete burns of marsh habitat leaving no patches as refuge areas can extirpate animals, such as black rails, snail kites, and round-tailed muskrats, that are dependent on marsh habitat for foraging and nesting.^{234,273}

Exemplary Sites: Lake Miccosukee (Leon and Jefferson counties), Lake Kissimmee State Park (Osceola County), Blue Cypress Lake Conservation Area (St. Lucie County), Three Lakes Wildlife Management Area (Osceola and Polk counties), John C. and Mariana Jones/Hungryland Wildlife and Environmental Area (Martin and Palm Beach counties), Grassy Waters Preserve (Palm Beach County)

Global and State Ranks: G4/S3

Crosswalk and Synonyms:

Davis	13/Grasslands of Prairie Type
	16/Fresh Water Marshes
SCS	25/Freshwater Marsh and Ponds
Myers and Ewel	Freshwater Marshes - basin or depression marshes
SAF	N/A
FLUCCS	641/Freshwater Marshes
	643/Wet Prairies
	644/Emergent Aquatic Vegetation

Other synonyms: prairie (in case of lake bottom)



Timucuan Ecological and Historic Preserve (Duval County)

Photo by Gary E. Schultz

Coastal Interdunal Swale

Description: Coastal interdunal swales are marshes, moist grasslands, dense shrubs, or damp flats in linear depressions formed between successive dune ridges as sandy barrier islands, capes, or beach plains build seaward. Dominant species are quite variable depending on local hydrology, substrate, and the age of the swale. Wetter areas are often dominated by sawgrass (*Cladium jamaicense*), cattail (*Typha* spp.), or needle rush (*Juncus roemerianus*), while shallower areas have a diverse mixture of herbs, including southern umbrellasedge (*Fuirena scirpoidea*), Carolina redroot (*Lachnanthes caroliniana*), spadeleaf (*Centella asiatica*), and broomsedges (*Andropogon virginicus*, *A. glomeratus*).¹⁹¹ Shrubby areas are often dominated by wax myrtle (*Myrica cerifera*), with coastalplain willow (*Salix caroliniana*) on the Atlantic coast; on the Panhandle coast Atlantic St. John's Wort (*Hypericum reductum*) forms clumps on the low flats in the more stable portions of the barrier islands. Moist grasslands may be dominated by hairawn muhly (*Muhlenbergia capillaris*), lovegrass (*Eragrostis* spp.), sand cordgrass (*Spartina bakeri*) or saltmeadow cordgrass (*Spartina patens*). Damp sand flats have a sparse cover of such herbs as yellow hatpins (*Syngonanthus flavidulus*), Le Conte's flatsedge (*Cyperus lecontei*), and Engler's bogbutton (*Lachnocaulon engleri*). Nearer the shore, where swales are exposed to occasional salt water intrusion, they may be dominated by halophytic species such as seashore paspalum (*Paspalum vaginatum*) and marsh fimbry (*Fimbristylis spadicea*). Hurricanes and tropical storms can flood swales with salt water, after which they are colonized for a time by more salt-tolerant species such as needle rush, Gulf Coast spikerush (*Eleocharis cellulosa*), and yellow spikerush (*Eleocharis flavescens*). Loose, blowing sand prevalent after storms favors the spread of saltmeadow cordgrass which tolerates burial better than the other grass species.¹⁹⁶

Coastal interdunal swales are found along sandy coastlines in Florida, principally along the Gulf coast and the northeast Atlantic coast south to Cape Canaveral. The community varies from flooded to completely dry depending on rainfall, as well as on height and area of the surrounding dunes.

Characteristic Set of Species: sawgrass, hairawn muhly, broomsedge, seashore paspalum, sand cordgrass, saltmeadow cordgrass

Rare Species: none

Range: Within Florida, coastal interdunal swales are found along the Panhandle coast from the Alabama border west to the Ochlockonee River and along the Gulf coast from Anclote Key to Cape Romano and on Cape Sable; on the Atlantic coast they are found on the broader barrier islands from the Georgia border south to Cape Canaveral. Outside Florida, coastal interdunal swales with similar vegetation are found on barrier islands north to Virginia and west to Louisiana.²⁸⁷

Natural Processes: Barrier islands are naturally dynamic systems, subject to both building and erosion as sand is delivered or removed by waves. As barrier islands build seaward, a series of dune ridges are formed. The low areas between the dunes are progressively more protected from blowing sand and seawater intrusion, allowing a succession of several associations of herbaceous species, and ending with woody species.¹⁹¹ Salt water intrusion and increased sand movement following storms can set this successional process back to its initial stages, or storm surge and storm waves may obliterate the ridge-swale topography completely, leaving a level plain,¹⁹⁶ which is in turn colonized by the dune grassland community.

Community Variations: Black mangrove (*Avicennia germinans*) may occur in interdunal swales in South Florida.

Associated Communities: Coastal interdunal swale differs from both coastal grassland and beach dune communities in that it lacks species intolerant of inundation, such as sea oats (*Uniola paniculata*), Gulf bluestem (*Schizachyrium maritimum*), and crimson bluestem (*S. sanguineum*).

Management Considerations: Salt water intrusion and sand burial during storm overwash may leave coastal interdunal swales vulnerable to invasion by exotic species, principally torpedo grass (*Panicum repens*) and Chinese tallow (*Sapium sebiferum*) in North Florida and Brazilian pepper (*Schinus terebinthifolius*) and Australian pine (*Casuarina equisetifolia*) in South Florida.

Exemplary Sites: Gulf Islands National Seashore (Okaloosa County), St. George Island State Park (Franklin County), Little Talbot Island State Park (Nassau County), Anastasia Island State Park (Flagler County), Cayo Costa State Park (Lee County), Rookery Bay National Estuarine Research Reserve-Keewaydin Island (Collier County)

Global and State Rank: G3/S2

Crosswalk and Synonyms:

Other synonyms: interdune area²⁰²; transitional zone¹⁹⁴



St. Johns River at Tosohatchee Wildlife Management Area (Orange County)

Photo by Paul Russo

Floodplain Marsh

Description: Floodplain marsh is a wetland community occurring in river floodplains and dominated by herbaceous vegetation and/or shrubs. Sand cordgrass (*Spartina bakeri*), sawgrass (*Cladium jamaicense*), and maidencane (*Panicum hemitomon*) are common dominants, but various other herbs may be found distributed along a hydrologic gradient. Broadleaf emergents and floating plants, particularly bulltongue arrowhead (*Sagittaria lancifolia*), bladderworts (*Utricularia* spp.), pickerelweed (*Pontederia cordata*), yellow pondlily (*Nuphar advena*) occupy the deepest, most frequently flooded sites, and mixed herbaceous stands are found in the somewhat higher portions of the marsh.⁴⁰⁵ In wetter sites, coastalplain willow (*Salix caroliniana*) or common buttonbush (*Cephalanthus occidentalis*) may form shrub thickets. The highest part of the marsh is often a drier, wet prairie-like zone with a large diversity of graminoids and forbs. While the progression from high to low marsh occurs generally from the upland edge to the river edge, these vegetation patches may also be scattered throughout the marsh, which provides a diversity of habitats beneficial to wildlife. Additional herbs can include dotted smartweed (*Polygonum punctatum*), bulrushes (*Scirpus* spp.), common reed (*Phragmites australis*), tickseeds (*Coreopsis* spp.), primrosewillows (*Ludwigia* spp.), fimbries (*Fimbristylis* spp.), spikerushes (*Eleocharis* spp.), flatsedges (*Cyperus* spp.), manyflower marshpennywort (*Hydrocotyle umbellata*), soft rush (*Juncus effusus* ssp. *solutus*), grassleaf rush (*Juncus marginatus*), beaksedges (*Rhynchospora* spp.), rosy camphorweed (*Pluchea rosea*), lemon bacopa (*Bacopa caroliniana*), spadeleaf (*Centella asiatica*), swamp rosemallow (*Hibiscus grandiflorus*), saltmarsh morning glory (*Ipomoea sagittata*), cattails (*Typha* spp.), southern cutgrass (*Leersia hexandra*), and climbing hempvine (*Mikania scandens*).^{233,435} Other than occasional thickets, woody vegetation is generally sparse, although some marshes can be dominated by common buttonbush, coastalplain willow, and/or wax myrtle (*Myrica cerifera*). Occasionally, cabbage palm (*Sabal palmetto*) and other flood tolerant trees are widely scattered in floodplain marsh, becoming more concentrated in the ecotone to adjacent hydric hammocks.

Most floodplain marshes are freshwater (salinity less than 0.5 parts per thousand); however, saltwater may influence marshes near the mouths of rivers (freshwater tidal marsh variant) and in areas where there is upwelling

groundwater that is partly saline. In these situations, dominant species are those tolerant of brackish conditions, particularly sawgrass, sand cordgrass, needle rush (*Juncus roemerianus*), perennial glasswort (*Sarcocornia perennis*), seashore dropseed (*Sporobolus virginicus*), giant cutgrass (*Zizaniopsis miliacea*), and shoreline seapurslane (*Sesuvium portulacastrum*).

Floodplain marshes are found along rivers and streams from just below the headwaters to the freshwater portions of tidally influenced river mouths. They also occur in river overflow channels and lakes with both input and output of river flow. Floodplain marshes are directly influenced by river flooding on an annual or semi-annual basis where most of the marsh is inundated from approximately 120 to 350 days per year.⁴⁰⁶ Soils are typically sand or a thin to thick organic layer over sand and may be saturated for most of the year. Floodplain marsh may burn periodically depending on dominant vegetation.

Characteristic Set of Species: sawgrass, maidencane, or sand cordgrass

Rare Species: The rare lowland loosestrife (*Lythrum flagellare*) is known from floodplain marshes along the Myakka River, and corkwood (*Leitneria floridana*) is known from the freshwater tidal marsh variant of floodplain marsh where sawgrass marsh grades into low levees of floodplain swamp.

Floodplain marshes are important habitat for black rail (*Laterallus jamaicensis*), limpkin (*Aramus guarana*), bald eagle (*Haliaeetus leucocephalus*), and wading birds, particularly great egret (*Ardea alba*), white ibis (*Eudocimus albus*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), black-crowned night-heron (*Nycticorax nycticorax*), yellow-crowned night-heron (*Nyctanassa violacea*), and glossy ibis (*Plegadis falcinellus*). Historically, snail kites (*Rostrhamus sociabilis plumbeus*) were found in floodplain marshes but are now absent, probably due to habitat degradation.³⁹²

Range: Floodplain marsh is most abundant in Central Florida along the St. Johns and historic Kissimmee Rivers, but also occurs at river mouths throughout the state north of Lake Okeechobee. Similar marshes are found throughout the southeast.

Natural Processes: The characteristic herbaceous species re-sprout vigorously following burns, and there is evidence that frequent fire helps to limit shrub invasion.^{233,273} Frequent fires in the freshwater tidal floodplain marshes maintain a sawgrass dominance, but woody species, although widely spaced, often persist in these marshes, coppicing from roots or quickly germinating seedlings.⁵⁸

Flat topography and slow drainage in the largest floodplain marshes create a prolonged inundation period from approximately 120 to 350 days per year with most of the marsh inundated over 250 days.⁴⁰⁶ Hydrology alteration in these systems has sometimes dramatically reduced this hydroperiod. Flood pulses provide oxygenated water to the system and allow small fish and larvae of larger game fish to utilize large portions of the vegetated marsh. The rising and receding water levels help create a variable mosaic of plant communities, and at times of low water, concentrate prey. These areas can be critical feeding sites for wading bird populations, snail kites, and bald eagles.⁴⁰⁶

Community Variations: Within and among floodplain marshes, plant composition can vary based on variation in hydrology, salinity, and fire history. Salt pans that are devoid of vegetation are common in floodplain marshes between Lake Poinsett and Puzzle Lake along the St. Johns River floodplain.

One commonly occurring variant of floodplain marsh is recognized here.

Variant: FRESHWATER TIDAL MARSH – Occurs in river mouths that receive pulses of freshwater in response to tides. Salt and freshwater marsh species intermingle as salt water is diluted by freshwater inflow and tidal fluctuation is damped.^{59,402} These marshes are occasionally influenced by salt water during storms, seasonal high tides, and periods of low river flow. Sawgrass is dominant, forming large stands either directly adjacent to the river, or just behind slightly raised levees of floodplain swamp or hydric hammock vegetation.

Associated Communities: Floodplain marsh is similar in vegetation composition and structure to other freshwater marshes in the state (e.g., depression and basin marshes). The primary feature distinguishing floodplain marsh is its position within a floodplain influenced by river flow, even if only during high flood stages. Basin marshes may

form the headwaters of a river or drain into a riverine system, but do not receive water from the river; floodplain marshes, by contrast lie directly along the river's course and are influenced by river flow. Floodplain marshes (especially the freshwater tidal marsh variant) may occur near salt marshes at river mouths. Although structurally similar to salt marshes, floodplain marshes are tolerant of only slight salinity levels, and do not contain halophytic species such as saltmarsh cordgrass (*Spartina alterniflora*).

Management Considerations: Maintenance or restoration of natural hydrology is an important consideration for floodplain marsh management. Channelization, as has occurred in the large Kissimmee River floodplain, may lead to a loss of plant diversity and more homogeneous plant assemblages as water levels are artificially stabilized.⁴⁰⁵ In the Kissimmee, water control structures removed seasonal fluctuations in water levels and altered natural vegetation structure.¹⁴¹ Channelizing the Kissimmee River also resulted in sharp declines in wading bird and game fish populations, and much of the natural sediment filtration function of the pre-channelized river was lost.⁴⁰⁵ Vegetation in the wettest part of the marsh is probably most sensitive to long-term effects of hydrologic alterations. Wetzel et al.⁴³⁵ showed that seed banks of characteristic species in these zones are greatly diminished following prolonged drainage.

Early work on restoration of the Kissimmee River showed that weedy native and exotic species such as common ragweed (*Ambrosia artemisiifolia*), dogfennel (*Eupatorium capillifolium*), and Caesar's weed (*Urena lobata*) were reduced after stream flow was re-established in the natural river channels.⁴⁰⁵ Fish, wading birds, and waterfowl responded positively, at least partially in response to improvements in invertebrate populations.⁴⁰⁵ A return of seasonal water fluctuations to the Kissimmee River marshes is reported to encourage growth of waterfowl food plants.³²¹

Prescribed fire, in addition to maintenance or restoration of natural hydrology, may aid in reducing shrub cover in floodplain marsh. Burning is often used as a tool to decrease fuel loads and to maintain wildlife habitat and natural community structure.²⁷³

In a marsh along the St. Johns River, Lee et al.²³³ found that although willow encroachment was reduced only slightly by a single dormant season fire, a similar fire within two years significantly decreased willow cover. A well-developed herbaceous understory was needed to carry fire into the willow, and they postulated that thickets where the herb layer had been lost may be impossible to burn. In a similar study, wax myrtle, red maple (*Acer rubrum*), and groundsel tree (*Baccharis halimifolia*) were eliminated and buttonbush cover was significantly decreased by a single prescribed fire in the upper St. Johns River basin.²⁷³

Wildlife responses to prescribed fires should also be considered in implementing a prescribed fire regime in floodplain marsh. Legare et al.²³⁴ surveyed black rail populations following two different prescribed fires in floodplain marsh dominated by sand cordgrass. They suggest that prescribed burns should leave a patchwork of unburned habitat to provide shelter for marsh wildlife. The same recommendation was given by Holder et al.¹⁷⁷ after studying habitat for the dusky seaside sparrow (*Ammodramus maritimus nigrescens*), now extinct. They suggested that the sand cordgrass marshes of the St. Johns River should burn every three years. However, in freshwater tidal marshes, Nyman and Chabreck²⁹⁶ recommend prescribed burns be used only when needed to control woody encroachment, and that fires be conducted in the fall and winter to avoid nesting wildlife and lower the possibility of a peat fire.

Cattle grazing has been a major land use in much of Florida's floodplain marshes.¹⁷⁷ Marshes and wet prairies contain more than 100 species of native plants that cattle will use for forage.³⁴⁹ Holder et al.¹⁷⁷ found that cattle grazing reduced plant diversity in sand cordgrass-dominated floodplain marshes along the St. Johns River, but did not significantly affect the dominant species. In addition to potential negative effects by cattle, feral hog rooting may also contribute to a degradation of marshes.⁴⁴¹ Off-road vehicle use for recreation and hunting is a common occurrence in floodplain marshes, and can cause alteration of the natural vegetation, particularly in sawgrass-dominated marshes.¹³⁷

These and other disturbances, particularly ditching and draining, can facilitate the establishment of invasive exotic plants in the marsh. In particular, torpedo grass (*Panicum repens*), Peruvian primrosewillow (*Ludwigia peruviana*), alligator weed (*Alternanthera philoxeroides*), para grass (*Urochloa mutica*), West Indian marsh grass (*Hymenachne amplexicaulis*), and Caesar's weed are all noxious weeds that are at times dominant in floodplain marsh.

Exemplary Sites: Tosohatchee Wildlife Management Area (Orange County), Kissimmee Prairie Preserve State Park (Okeechobee County), Myakka River State Park (Sarasota County), Apalachicola River Wildlife and Environmental Area (Franklin County)

Global and State Rank: G3/S3

Crosswalk and Synonyms:

Kuchler	113/Southern Floodplain Forest
Davis	13/Grasslands of Prairie Type
	16/Fresh Water Marshes
SCS	25/Freshwater Marsh and Ponds
Myers and Ewel	Freshwater Marshes - riverine or floodplain marshes
SAF	N/A
FLUCCS	641/Freshwater Marshes

Other synonyms: river marsh and freshwater marsh⁴³⁶; freshwater tidal marsh; tidal woods⁵⁸



Okaloacoochee Slough State Forest (Hendry County)

Photo by Gary Knight

Slough Marsh

Description: Slough marsh is a primarily herbaceous community growing in a narrow to broad shallow channel with intermittently flowing water in flat sandy landscapes. Grasses, sedges, and emergent herbs dominate the mainly treeless landscape. Vegetation is found in zones based on length of hydroperiod and depth of flooding. Frequently flooded areas of slough marsh are often dominated by species such as bulltongue arrowhead (*Sagittaria lancifolia*), pickerelweed (*Pontederia cordata*), alligatorflag (*Thalia geniculata*), maidencane (*Panicum hemitomon*), sawgrass (*Cladium jamaicense*), and cattails (*Typha* spp.). Drier marsh zones with less peat accumulation often are dominated by sand cordgrass (*Spartina bakeri*), longleaf threeawn (*Aristida palustris*), beaksedges (*Rhynchospora* spp.), Elliott's yellow-eyed grass (*Xyris elliottii*), narrowfruit horned beaksedge (*Rhynchospora inundata*), and blue maidencane (*Amphicarpum muhlenbergianum*). Other common herbs include rushes (*Juncus* spp.), fimbries (*Fimbristylis* spp.), spikerushes (*Eleocharis* spp.), fringed yellow-eyed grass (*Xyris fimbriata*), pipeworts (*Eriocaulon compressum* and *E. decangulare*), lemon bacopa (*Bacopa caroliniana*), water cowbane (*Oxypolis filiformis*), clustered bushmint (*Hyptis alata*), and Piedmont marshelder (*Iva microcephala*). This species list is based, in part, on McPherson and McCoy,²⁶⁴ Bridges,³⁴ and Florida Natural Areas Inventory.¹¹⁸ Woody species are generally low in cover and include peelbark St. John's wort (*Hypericum fasciculatum*) and water toothleaf (*Stillingia aquatica*). Patches of coastalplain willow (*Salix caroliniana*), common buttonbush (*Cephalanthus occidentalis*), pond apple (*Annona glabra*), and wax myrtle (*Myrica cerifera*) are often scattered in deeper pockets of peat.¹¹⁸

Drought conditions can entirely dry out the marsh and associated sloughs, allowing other herbs to temporarily gain importance. These include southern amaranth (*Amaranthus australis*), dogfennel (*Eupatorium capillifolium*), sugarcane plumegrass (*Saccharum giganteum*), bluestems (*Andropogon* spp.), giant bristlegrass (*Setaria magna*), camphorweed (*Pluchea* spp.), thistles (*Cirsium* spp.), asters (*Symphyotrichum* spp.), and smartweeds (*Polygonum* spp.).

Slough marsh is found in situations that are frequently flooded with slow moving water from upstream sources and local rainfall. They are found in areas of very flat topography, particularly the dry prairie regions of south-central Florida, where freshwater marshes may form linear drainageways that provide a conduit for moving water. Slough marshes may be shallow or slightly deeper with a slough in the center.⁴¹² They are situated on sand or a layer of accumulated peat over sand and are inundated at least during the late summer and early fall.⁷⁹

Characteristic Set of Species: sawgrass, bulltongue arrowhead, sand cordgrass

Rare Species: There are no rare plant species that are characteristic of slough marsh. Rare animal species that use slough marsh include American alligator (*Alligator mississippiensis*), black rail (*Laterallus jamaicensis*), Florida sandhill crane (*Grus canadensis pratensis*), limpkin (*Aramus guarauna*), numerous species of wading birds, and round-tailed muskrat (*Neofiber alleni*).

Range: Slough marsh is restricted to portions of central and southern Florida where exceptionally flat topography and sandy soils create shallow drainage systems. Shallow, sand-bottomed sloughs are common in the flatlands near Lake Okeechobee.⁷⁹

Natural Processes: As in other wetland communities, the frequency of fire in slough marshes is a function of the fire frequency in the surrounding matrix community, as well as the fire-carrying characteristics of the marsh vegetation itself. Sawgrass is particularly efficient at carrying fire, even during periods of inundation. Fire is usually beneficial, not only promoting sawgrass growth, but also benefiting wildlife.⁴²⁴ Several dominant herbaceous plants, particularly maidencane and bulltongue arrowhead, grow vigorously following fire under normal conditions, i.e. when water levels are still near the soil surface.²⁴⁹ It is generally thought that lack of fire in marshes leads to an increase in the shrubby component at the expense of the herbaceous species.^{233,320}

Community Variations: Species composition varies depending on hydroperiod, depth of flooding, and peat accumulation. Since the range of slough marsh is relatively limited, regional variation is not significant.

Associated Communities: There is often a gradual change from linear wet prairies dominated by wiregrass (*Aristida stricta* var. *beyrichiana*) or Gulf hairawn muhly (*Muhlenbergia sericea*) to slough marsh dominated by sand cordgrass or other marsh species. The deeper drainageways of open water or floating plants that remain underwater nearly all year are classified as sloughs. Small prairie hydric hammocks are frequent in the landscape.³⁴ Slough marshes are differentiated from similar basin marsh and depression marsh by their shape and function. Rather than being a collection basin for local rainfall, slough marshes act as drainageways to conduct surface water from large areas of flatlands to floodplains. In the Everglades basin and Big Cypress, glades marsh replaces slough marsh. A substrate of peat or marl deposited directly on a limestone platform distinguishes glades marsh from the sandy slough marshes of nearby regions.

Management Considerations: Slough marshes are highly susceptible to hydrologic alteration. Drainage ditches that quickly move water rather than allowing a slow sheet flow through the marsh have a dramatic effect on community structure. In a review of early land records, Bridges,³⁶ found that sawgrass marsh in the dry prairie region around the Kissimmee has been reduced in recent years. Water table drawn-downs for human consumption have been shown to negatively affect nesting success in sandhill cranes in marshes.¹⁰² Woody species such as wax myrtle, live oak (*Quercus virginiana*), and cabbage palm (*Sabal palmetto*) encroach into artificially drained marshes, especially exploiting the spoil banks along the ditches. In the deeper water of the ditches, the invasive exotic weeds water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata*) commonly invade.³⁴ Where possible, efforts should be made to fill in ditches in order to return the marsh to a more natural state.

Fires in surrounding communities should be allowed to burn into marshes and extinguish naturally or burn through them. Expanding cover of shrubs such as coastalplain willow, common buttonbush, wax myrtle, and groundsel tree (*Baccharis halimifolia*) are signs of lack of fire. Complete burns of marsh habitat leaving no patches as refuge areas can extirpate animals, such as black rails and round-tailed muskrats, that are dependent on marsh habitat for foraging and nesting.^{234,273} The danger of peat fires is a consideration, although, slough marshes are underlain by sand so that long-lasting peat fires are unlikely.

Hog rooting is a serious problem in many marshes; it destroys native species and may also allow invasive exotic plants to get a foothold; common invaders include torpedo grass (*Panicum repens*), Peruvian primrosewillow (*Ludwigia peruviana*), common water hyacinth (*Eichhornia crassipes*), melaleuca (*Melaleuca quinquenervia*), and Brazilian pepper (*Schinus terebinthifolius*). Drainage, perhaps also aided by cattle trampling, can allow weedy pasture grasses to invade marshes, especially where the surrounding community has been converted to pasture.⁴⁴¹ Overgrazing of marshes leads to an increase in cover of carpetgrasses (*Axonopus* spp.) and a decrease of maidencane.³⁹⁵ Other pasture grasses that are often present in grazed marshes include centipede grass (*Eremochloa ophiuroides*), bahiagrass (*Paspalum notatum*), and the invasive exotic West Indian marsh grass (*Hymenachne amplexicaulis*).

Exemplary Sites: Kissimmee Prairie Preserve State Park (Okeechobee County), Okaloacoochee Slough State Forest (Hendry and Collier counties)

Global and State Ranks: G3?/S3?

Crosswalk and Synonyms: The term slough is often used in the literature to refer to any broad shallow channel regardless of the dominant vegetation, particularly in the flatlands of the central and southern peninsula. In reference to natural communities, the FNAI classification restricts the term slough to deep water marsh or open water, while slough marsh is an emergent or graminoid dominated marsh in the sense of Davis (1943) who describes “pond and slough marshes outside the Everglades” and associated wet prairies. Other communities that occupy broad shallow channels in this region include glades marsh and strand swamp.

Davis	13/Grasslands of Prairie Type
	16/Fresh Water Marshes
SCS	26/Slough
Myers and Ewel	Freshwater Marshes - swale
SAF	NA
FLUCCS	641/Freshwater Marshes
	643/Wet Prairies
	644/Emergent Aquatic Vegetation



Everglades National Park (Miami-Dade County)

Photo by Gary Knight

Glades Marsh

Description: Glades marsh is a primarily herbaceous wetland in South Florida, especially in the Everglades basin, that occurs in broad shallow channels or depressions over a substrate of peat or marl that directly overlies limestone. While commonly a dense, tall monoculture of sawgrass (*Cladium jamaicense*), deeper glades marsh may support an array of emergent plants that includes sparse sawgrass, maidencane (*Panicum hemitomon*), Tracy’s beaksedge (*Rhynchospora tracyi*), or Gulf Coast spikerush (*Eleocharis cellulosa*). Various other herbs are common, particularly shortbristle horned beaksedge (*R. corniculata*), other beaksedges, slim spikerush (*E. elongata*), string lily (*Crinum americanum*), alligatorlily (*Hymenocallis palmeri*), creeping primrosewillow (*Ludwigia repens*), bulltongue arrowhead (*Sagittaria lancifolia*), pickerelweed (*Pontederia cordata*), and American cupscale (*Sacciolepis striata*). During periods of high water and in areas transitional to deeper sloughs, floating plants such as big floatingheart (*Nymphoides aquatica*), and bladderworts (*Utricularia* spp.) may be common.^{249,344,424} Drought conditions may allow other herbs to temporarily gain importance, such as southern amaranth (*Amaranthus australis*), dogfennel (*Eupatorium capillifolium*), sugarcane plume grass (*Saccharum giganteum*), broomsedges (*Andropogon* spp.), giant bristlegrass (*Setaria magna*), camphorweeds (*Pluchea* spp.), thistles (*Cirsium* spp.), asters (*Symphyotrichum* spp.), and knotweeds (*Polygonum* spp.). Saltmarsh morning glory (*Ipomoea sagittata*), and white twinevine (*Sarcostemma clausum*) may be found climbing sawgrass blades.²⁴⁹ Woody vegetation is sparse, and generally only found around so-called “gator holes” or near the edges of the many tree islands that dot the landscape of the Everglades. Coastalplain willow (*Salix caroliniana*), coco plum (*Chrysobalanus icaco*), and common buttonbush (*Cephalanthus occidentalis*) are typical of these locations. Cattails (*Typha* spp.) are increasingly abundant in areas of the Everglades where water quality is degraded by agricultural run-off or where water is impounded by roads and canals. In glades marsh with relatively sparse vegetation, mats of algae called periphyton are commonly attached to plants in the water column. This periphyton is often considered calcareous due to the dominance of certain filamentous blue-green algae species.⁴¹

Much of the Florida peninsula south of Lake Okeechobee is a flat limestone plain of fairly recent (Pliocene/Pleistocene) origin with peat and marl substrates deposited directly on the limestone platform. Glades marsh is frequently flooded, and water may be slowly flowing, particularly in the Everglades basin. Soils are often

deep peats that have been deposited over the limestone, but some marshes may be found on marl (calcitic mud). Hydroperiod is typically at least 6 months.³⁰³

Characteristic Set of Species: sawgrass, spikerush, maidencane, beaksedges

Rare Species: Rare species in glades marsh include meadow jointvetch (*Aeschynomene pratensis*) which grows in slightly deeper marsh. South Florida is the only location in the United States for this species. Glades marsh is also important habitat for the American alligator (*Alligator mississippiensis*), considered a keystone species in this community, as the small ponds created or maintained by alligators provide a refuge for fish and invertebrates during droughts.^{73,313} The Everglades are critical habitat for the federally endangered snail kite (*Rostrhamus sociabilis plumbeus*) in Florida, which feeds almost exclusively on apple snails. Other rare birds, such as limpkin (*Aramus guarauna*), and wading birds, particularly great egret (*Ardea alba*), white ibis (*Eudocimus albus*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), least bittern (*Ixobrychus exilis*), wood stork (*Mycteria americana*), black-crowned night-heron (*Nycticorax nycticorax*), and glossy ibis (*Plegadis falcinellus*), and two rare mammals, southern mink (*Neovison vison*, southern Florida population) and round-tailed muskrat (*Neofiber alleni*), utilize glades marsh for foraging and nesting. Glades marsh in the Everglades is the major habitat of at least one rare invertebrate, the Everglades sprite (*Nehalennia pallidula*).

Range: Glades marsh in Florida (and the United States) is restricted to South Florida in four physiographic divisions following Brooks.⁴⁰ It is mainly located in the Everglades basin (Everglades Province), in the associated Taylor Slough and the “southeast saline” marshes (Silver Bluff-Coastal Marsh Terrace Subdivision), and historically in several low-lying sloughs that once traversed the Atlantic Coastal Ridge and provided drainage from the basin eastward during floods. It is also found to a lesser extent in the Florida Keys and Big Cypress Provinces, including Fakahatchee Strand and Picayune Strand. Similar marshes may be found elsewhere in the Caribbean, particularly on the Zapata peninsula in Cuba.

Natural Processes: The Everglades system is relatively young, less than 6,000 years old, as evidenced by the earliest layers of peat deposited in the Holocene. As sea level rose and local rainfall increased, the large depression of the Everglades basin became flooded with freshwater which was confined by the Atlantic Ridge to the east and the higher elevation Big Cypress region to the west.¹³⁸ The broad, slightly sloped Everglades basin is commonly called a “River of Grass,” and while water does move in a general northeast to southwest direction, the rate is slow due to the extremely gentle slope that averages only a three centimeter drop per kilometer over the length of the basin.²²³

The near constant flooding of glades marshes, combined with the warm sub-tropical climate, contributes to a lush growth of sawgrass on slightly higher “ridges” and waterlily (*Nymphaea* sp.) in the lowest sloughs and ponds. The long hydroperiod (>6 months) creates an anaerobic soil environment in which the breakdown of organic material is impeded, and sediments from dead vegetation continually accumulate, forming the characteristic peat soil. This peat deposition is known to have begun at least 5500 years ago near the south end of Lake Okeechobee.¹³⁸ The earliest peat layers are deposited over a layer of marl, indicating a gradual increase in hydroperiod as local rainfall increased and sea levels rose following the Wisconsin glacial maximum.¹³⁸ Although most glades marsh is located on accumulated peat, sometimes several meters thick, the substrate may vary due to soil oxidation, fire, or other factors. Peat layers may be thin or absent, particularly in the southern Everglades, with emergent plants growing directly on marl or sand/marl mixtures.

Periphyton, an algal mat found throughout the Everglades, is an important component of the entire ecosystem. Certain blue-green algae species function to precipitate calcium carbonate and will form a marl substrate. However, the long hydroperiod and deep water of most examples of glades marsh tend to favor non-calcareous rather than calcareous periphyton, and generally leads to a buildup of peat, rather than marl substrates.⁴¹

Fire is a natural component of the glades marsh landscape. Sparse stands of spikerush and beaksedge do not burn frequently⁴²⁴; however, Robertson³⁴¹ noted early observations of lightning strikes that frequently started wildfires in sawgrass and tree islands. Natural fires are most common during the summer months as the frequency of lightning strikes peaks in July, although the largest fires occur in May before water levels are high.¹⁵⁰ However, even during periods of inundation, sawgrass may carry a fire over water. Estimations of the natural fire return interval in the Everglades range from 3 to 10 years with much variability depending on seasonal and longer term weather patterns.^{150,424} Most dominant herbaceous plants in the Everglades, particularly sawgrass, maidencane, and bulltongue arrowhead, grow vigorously following fire under normal conditions, i.e. when water levels are still near

the soil surface.²⁴⁹ Under drought conditions, however, wildfires may burn down the peat layer, destroying sawgrass roots and converting these areas to lower elevation emergent communities or to deeper water sloughs.⁴²⁴ Coastalplain willow, described by Loveless²⁴⁹ as a “fire follower” can quickly become established around burned out peat holes, and its ability to withstand most low intensity fires also can allow it to replace other trees and shrubs destroyed by fire on tree islands.

In areas with a shortened hydroperiod and lack of fire, wax myrtle (*Myrica cerifera*), dahoon (*Ilex cassine*), coastalplain willow, and groundsel tree (*Baccharis halimifolia*) are common invaders and may colonize areas of decadent sawgrass.⁷ Historically, this shift in vegetation may be responsible for the formation of large, cigar-shaped, dahoon-dominated bayheads.¹³⁸

Topographic variation may result not only from severe fires, but also from highs and lows in the underlying limestone bedrock, or from the formation of peat batteries. These batteries are most common in the northeastern Everglades where solid masses of peat become dislodged from the floor of the marsh and drift to a new location, eventually reattaching to the bottom. The topographic high created by the peat formation may become colonized with woody vegetation, especially swamp bay (*Persea palustris*), and can ultimately become a bayhead, while the hole left behind will become a much deeper slough.¹³⁸

The Everglades is an oligotrophic system.²⁹¹ Sawgrass is adapted to low-phosphorus conditions and thus tends to outcompete other plants in these environments.^{290,344} The porous limestone surface underlying the basin allows for some interaction between surface water and ground water within the limestone, leading to a slightly basic surface water environment with high calcium levels.²⁹¹ These conditions lower phosphorus bio-availability and tend to perpetuate sawgrass dominance.³⁴⁴

Salinity is a limiting factor in the southern Everglades, and species composition shifts to halophyte-dominated vegetation of salt marsh or mangrove swamp near Florida Bay.³⁰³ As sea level rises, the freshwater environments of the southernmost Everglades are being replaced by mangroves or salt marsh, as likely happened during the high sea levels of the last interglacial period,¹³⁸ although decreasing freshwater flow caused by water control measures over the past century may also have lead to mangrove expansion.³⁴³

Community Variations: Species composition can vary with slight differences in hydroperiod and maximum water depth. Tall, dense sawgrass stands occur at peat elevations only slightly higher than sparse sawgrass and spikerush stands, amounting to a nine centimeter difference in mean high water level.³⁴⁴ Cattails are common in and near the Everglades Agricultural Area, but there is little historical evidence for this plant being frequent prior to drainage of that area.¹³⁸

One geographically restricted variant of glades marsh occurs within Florida.

Variant: KEYS FRESHWATER MARSH – Sawgrass dominated marsh occupying limestone depressions, primarily in the Lower Keys. Soils are deep peats or calcitic muds that have collected within the limestone basin. Although these wetlands are freshwater habitats for most of the year, they may become saline during the dry season, which allows the establishment of white mangrove (*Laguncularia racemosa*) and buttonwood.³⁴⁵

Associated Communities: Glades marsh frequently grades into marl prairie. These prairies are distinguished from glades marsh by having a shorter hydroperiod (<6 months), a shorter and more regular fire return interval, usually a dominance of Gulf hairawn muhly (*Muhlenbergia sericea*) or short sawgrass, and a higher diversity of associated species than are found in glades marsh.³⁰⁵ Glades marsh often occurs around or adjacent to sloughs, which are deeper drainage ways that remain underwater almost year round and are dominated by waterlily. Glades marsh, marl prairie and slough may be closely associated and form complex mosaics.

All freshwater marsh communities in Florida, including glades marsh, are similar in vegetation composition, and other marsh types may have flowing water, especially during periods of heavy rainfall. However, other freshwater marshes are typically located on sand or peat overlying sand, rather than peat or marl deposited directly on limestone. In the increasingly saline environment towards the coast, glades marsh and marl prairie grade into salt marsh and mangrove swamp, sometimes forming large zones of overlap where red mangrove (*Rhizophora mangle*) and/or buttonwood (*Conocarpus erectus*) becomes increasingly frequent or where the freshwater marsh species are

gradually replaced by upper salt marsh halophytic herbs such as cordgrasses (*Spartina* spp.), saltgrass (*Distichlis spicata*), and shoreline seapurslane (*Sesuvium portulacastrum*).^{90,343}

Management Considerations: The Everglades has a long history of anthropogenic manipulation of natural processes. Maintenance of a more natural hydrologic regime is the single most critical factor in preserving/restoring glades marsh. Drainage of the historic Everglades began in the late 1800s, evolving over time into an extensive system of canals and levees that provide flood protection and create agricultural land.^{240,379} Immediately south of Lake Okeechobee, the deep peat soils have been cultivated in vegetables, sugarcane, and sod for most of the last century. Roughly 50 percent of the original extent of the Everglades has been converted to agricultural land or development, while the remaining wetlands have been compartmentalized by roads and canals.⁸⁰

Armentano¹¹ noted that changes in vegetation dominance can occur quickly as water levels and hydroperiod are altered. North of Tamiami Trail in the Water Conservation Areas, an increase in hydroperiod and water depth has altered the historic spatial extent of Everglades vegetation by converting large areas of former sawgrass to emergent vegetation and sloughs, and creating favorable conditions for the spread of cattails.⁷ A combination of deeper flooding and increased phosphorus as a result of altered hydrology and surface water run-off from agricultural areas encourages the growth of cattails. Newman²⁹⁰ demonstrated that cattails show a greater increase in growth than either sawgrass or spikerush under both higher water levels and increased phosphorus concentrations. This growth differential subsequently leads to a shift in dominance and expansion of cattail marshes. Conversely, further south, in the Shark River Slough, decreased flow has led to the expansion of sawgrass into historically wetter areas.³⁰² Increased phosphorus levels also have an effect on periphyton growth, causing a shift from calcareous blue-green algae to filamentous green algae.²⁶³

Modification to the amount and timing of natural flow in the Everglades is also implicated in bird population declines. Nesting wading bird populations (great egret, wood stork, tricolored heron, white ibis, snowy egret) have decreased by as much as 90 percent from the 1930s to the 1980s.³⁰⁰ Snail kites that rely almost entirely on apple snails for food have also declined. Bennetts et al.²³ suggest that snail kites benefit from a hydrologic regime that maintains open water to promote apple snail populations, but that is not so wet as to eliminate woody vegetation entirely.

Fire is usually beneficial, not only in promoting sawgrass growth, but also by benefiting wildlife.⁴²⁴ However, evidence suggests that drainage-induced shifts in hydrology have led to more severe, peat destroying fires, particularly in southern Everglades where flow has been reduced.³⁰³

Hydrologic alteration has also facilitated the spread of invasive exotic plants. Brazilian pepper (*Schinus terebinthifolius*) is a widespread exotic that has gone from being almost absent in the mid-1950s to a severe threat, forming monotypic stands, particularly in agricultural areas.⁷ Melaleuca (*Melaleuca quinquenervia*), introduced in the early 20th century as part of the overall plan for draining the Everglades, underwent explosive growth, forming large monotypic stands in a variety of habitats including glades marsh. Two insects have been released as biological control agents for melaleuca and have been shown to be effective in reducing growth of this exotic.⁴⁰⁴ Mechanical, physical, and herbicidal methods of removal are also required for the control of these species.²⁴

Exemplary Sites: Everglades National Park (Miami-Dade and Monroe counties), Everglades and Francis Taylor Wildlife Management Area (Miami-Dade, Broward, and Palm Beach counties)

Global and State Rank: G3/S3

Crosswalk and Synonyms: A source of confusion in the literature is the use of the term “wet prairie” to refer to longer hydroperiod marshes.^{249,424} The FNAI classification restricts the use of the term “prairie” to communities with a shorter hydroperiod than most marshes. See USFWS⁴¹⁵ for further discussion on this terminology.

Kuchler	92/Everglades
Davis	16a/Everglades Saw Grass Marshes
	16b/Everglades Region Marshes, Sloughs, Wet Prairies, and Tree Islands
SCS	24/Sawgrass Marsh
Myers and Ewel	Freshwater Marshes - swale
SAF	NA
FLUCCS	641/Freshwater Marshes
	643/Wet Prairies

Other synonyms: wet prairie (Loveless 1959), slough, river of grass, glades



Everglades Wildlife and Environmental Area (Broward County)

Photo by Paul Russo

Slough

Description: Sloughs are the deepest drainageways within swamps and marsh systems. They are broad channels inundated with slow moving or nearly stagnant water, except during extreme droughts. The vegetation structure is variable with some sloughs dominated by floating aquatics, others by large emergent herbs, and still others by a low or sparse canopy. Canopied sloughs are characterized by various swamp species, particularly Carolina ash (*Fraxinus caroliniana*) and coastalplain willow (*Salix caroliniana*), with or without a mixture of large emergent herbs and floating aquatic plants. In south Florida, pond apple (*Annona glabra*) is a frequent canopy component, and can withstand somewhat deeper water than Carolina ash.¹⁴ Canopied sloughs in floodplains in the northern Florida peninsula and Panhandle often contain ogeechee tupelo (*Nyssa ogeche*) and planer tree (*Planera aquatica*). Other common woody species include cypress (*Taxodium* spp.) and common buttonbush (*Cephalanthus occidentalis*). Where emergent herbs are present, alligatorflag (*Thalia geniculata*), bandana-of-the-Everglades (*Canna flaccida*), pickerelweed (*Pontederia cordata*), bulltongue arrowhead (*Sagittaria lancifolia*), giant cutgrass (*Zizaniopsis miliacea*), and lizard's tail (*Saururus cernuus*) are common. Deeper sloughs may contain floating and submerged aquatic plants such as American white waterlily (*Nymphaea odorata*), big floatingheart (*Nymphoides aquatica*), yellow pondlily (*Nuphar advena*), frog's bit (*Limnobium spongia*), duckweeds (*Lemna* spp.), and bladderworts (*Utricularia* spp.). In south Florida, submerged plants and algae (including cyanobacteria, known as periphyton, found in more alkaline waters) can form mats in sloughs that contribute food and oxygen.¹⁴⁸ South Florida pond apple sloughs are ideal, moist, warm habitats for rare and endangered tropical epiphytes. Pond apple branches are often densely covered with such epiphytes as orchids, bromeliads, ferns, and peperomias. Some epiphytic orchids, including several rarely found elsewhere in Florida, may be common in this habitat, especially dingy flowered star orchid (*Epidendrum anceps*), clamshell orchid (*Encyclia cochleata* var. *triandra*), stiff flower star orchid (*Epidendrum rigidum*), and night-scented orchid (*Epidendrum nocturnum*).³¹²

Sloughs occur in irregular linear arrangements within strand swamp, floodplain swamp, basin swamp, glades marsh, or slough marsh communities, often forming an intricate mosaic of wetland communities. In strand swamps and

glades marsh, sloughs are often aligned with the lowest part of troughs in the underlying limestone bedrock. Within floodplain swamps sloughs occur as overflow channels within backswamps off the main river. In basin swamps, they may occur as slow moving to stagnant drains. These channels are formed by flowing water during floods and periods of heavy rainfall. While they may be common features within a swamp, sloughs are usually not described separately from the swamp vegetation. The soils in a slough are peat, unless consumed by catastrophic fires that may occur during droughts.

Characteristic Set of Species: pond apple (in south Florida), Carolina ash, alligator flag, American white waterlily

Rare Species: Many rare epiphytic plants depend on slough for its constant humidity afforded by the long hydroperiod. These include ribbon orchid (*Campylocentrum pachyrrhizum*), powdery catopsis (*Catopsis berteroniana*), nodding catopsis (*Catopsis nutans*), ghost orchid (*Dendrophylax lindenii*), Acuna's epidendrum (*Epidendrum acunae*), night-scented orchid, pendant epidendrum (*Epidendrum strobiliferum*), hanging clubmoss (*Huperzia dichotoma*), delicate ionopsis (*Ionopsis utricularioides*), tiny orchid (*Lepanthopsis melanantha*), hidden orchid (*Maxillaria crassifolia*), cypress peperomia (*Peperomia glabella*), blunt-leaved peperomia (*Peperomia obtusifolia*), frost-flower orchid (*Pleurothallis gelida*), clamshell orchid, and dwarf butterfly orchid (*Prosthechea pygmaea*).

Many rare animals that occur in swamps and marshes are also typical of sloughs. American alligators (*Alligator mississippiensis*) are particularly dependent on sloughs to maintain healthy populations. These animals require open water areas in the larger marsh and swamp systems for breeding, feeding, and, for juveniles, escape paths.¹²⁷

Range: Sloughs are found throughout Florida and the Southeastern coastal plain as features of swamps and marshes. In south Florida, sloughs are larger and more distinctive communities.

Natural Processes: Sloughs may be formed by floodplain processes associated with meandering riverbeds in North and Central Florida that create variation in topography within the floodplain. The water in these sloughs is slow moving, and sloughs may dry completely during droughts.

In South Florida, some sloughs have formed from the burning of underlying peat layers in strand swamps and glades marsh during droughts. These depressions then fill with water when the site is once again flooded. As such, these can be shifting communities, with old sloughs eventually filling in with peat while new ones are created by peat fires. Coastalplain willow is a common colonizer when fires have consumed soils in the Everglades.¹⁴⁸ Alligators further create heterogeneity in sloughs by wallowing and digging in the peat substrate, excavating "gator holes" which may then provide a refuge for fish during droughts.^{73,313}

Despite the vulnerability of some South Florida sloughs to fire, the high humidity and long hydroperiod of sites dominated by pond apple provide frost and fire protection. These factors, in turn, allow for the proliferation of large populations of tropical epiphytes, including many endangered species.¹³ Some of these sloughs may never experience fire, as evidenced by peat core samples dating back 6,000 years at a site in the Fakahatchee Strand Preserve State Park.³¹²

Community Variations: Variation in the community structure of sloughs is mainly attributable to climate, fire, and substrate differences across the state. Due to the abundance of rare plants, a variant is recognized and described below.

Variant: POND APPLE SLOUGH – Found exclusively in South Florida, these are canopied sloughs dominated by pond apple or Carolina ash, often with abundant epiphytes.

Associated Communities: Slough occurs in swamp (strand, floodplain, or basin) or marsh, and often closely resembles these communities. The distinction between slough and blackwater stream is obscure, with no absolute characters distinguishing the two types. Sloughs are relatively shallow, often with floating or emergent vegetation throughout. They are inundated with slow-moving or nearly stagnant water, except during periods of extreme drought when they may dry out entirely. Blackwater streams, by contrast, have constantly moving water and are rarely covered in vegetation.

Management Considerations: Sloughs are extremely vulnerable to hydrologic disturbances and must have a reliable water source to persist. In pond apple sloughs, the maintenance of a natural hydrology is important to sustain epiphyte diversity. The mosaic of habitats formed by sloughs, marshes, and strand swamps in South Florida

is critical for wildlife, especially wading birds that rely on an abundance of aquatic prey.¹¹³ In sloughs that have been overly drained due to water management practices, bird populations have decreased following a decline in invertebrates, fishes, frogs, and turtles.³⁰¹ Maintaining deep water in sloughs is also necessary for alligator populations.⁷³

Watershed disturbance from the creation of canals and roads can cause ponding in some areas, and unnatural drought conditions in others. This can result in increased soil oxidation and fire frequency.³⁰¹ Canals also provide a portal through which exotic fish, amphibian, and snail species may invade natural slough habitats.¹¹¹ Floating and submerged invasive aquatic plants such as water-lettuce (*Pistia stratiotes*), water hyacinth (*Eichhornia crassipes*), and hydrilla (*Hydrilla verticillata*), can also encroach from canals. Other exotic plant species, mainly melaleuca (*Melaleuca quinquenervia*), are occasionally found in slough, but seem to prefer ecotones between slough and glades marsh. Emergent plant growth may be negatively impacted by continual airboat use that forms trails and may break up mats of vegetation in sloughs.⁹⁷ Poaching of epiphytes is also an ongoing threat along pond apple sloughs.³¹²

Exemplary Sites: Fakahatchee Strand Preserve State Park (Collier County), Corkscrew Swamp Sanctuary (Collier County), Big Cypress National Preserve (Collier, Monroe, and Miami-Dade counties), Everglades National Park (Miami-Dade, Monroe, and Collier counties), Rock Bluff Scenic Area in Ochlockonee River floodplain in Apalachicola National Forest (Leon County)

Global and State Rank: G3/S3

Crosswalk and Synonyms: The term slough is often used in the literature to refer to any broad shallow channel regardless of the dominant vegetation, particularly in the flatlands of the central and southern peninsula. This classification restricts slough to deep water marsh or open water. Other communities that occupy broad shallow channels in this region include slough marsh, glades marsh, and strand swamp.

Kuchler	113/Southern Floodplain Forest
Davis	7/Cypress Swamp Forests
SCS	17/Cypress Swamp
	21/Swamp Hardwoods
Myers and Ewel	Freshwater Swamp Forests - sloughs and strands
SAF	101/Baldcypress
FLUCCS	621/Cypress

Other synonyms: flag pond, gator hole

FRESHWATER FORESTED WETLANDS – floodplains or depressions dominated by hydrophytic trees

CYPRESS/TUPELO – dominated entirely by cypress or tupelo, or these species important in the canopy; long hydroperiod



Three Lakes Wildlife Management Area (Osceola County)

Photo by Caitlin Elam

Dome Swamp

Description: Dome swamp is an isolated, forested, depression wetland occurring within a fire-maintained community such as mesic flatwoods. These swamps are generally small, but may also be large and shallow. The characteristic dome shape is created by smaller trees that grow in the shallower waters of the outer edge, while taller trees grow in the deeper water in the interior of the swamp. Pond cypress (*Taxodium ascendens*) often dominates, but swamp tupelo (*Nyssa sylvatica* var. *biflora*), may also form pure stands or occur as a co-dominant. Other canopy or subcanopy species include red maple (*Acer rubrum*), dahoon (*Ilex cassine*), swamp bay (*Persea palustris*), slash pine (*Pinus elliottii*), sweetbay (*Magnolia virginiana*), loblolly bay (*Gordonia lasianthus*), and, in South Florida, coco plum (*Chrysobalanus icaco*) and pond apple (*Annona glabra*). Shrubs are typically sparse to moderate, but often are absent in dome swamps with a high fire frequency or dense in swamps where fire has long been absent. Shrubs common in dome swamps include Virginia willow (*Itea virginica*), fetterbush (*Lyonia lucida*), common buttonbush (*Cephalanthus occidentalis*), coastalplain willow (*Salix caroliniana*), wax myrtle (*Myrica cerifera*), titi (*Cyrilla racemiflora*), and St. John's wort (*Hypericum* spp.). Herbaceous species can be dense or absent and include a wide variety of ferns, graminoids, and herbs including Virginia chain fern (*Woodwardia virginica*), royal fern (*Osmunda regalis* var. *spectabilis*), cinnamon fern (*Osmunda cinnamomea*), toothed midsorus fern (*Blechnum serrulatum*), maidencane (*Panicum hemitomon*), sawgrass (*Cladium jamaicense*), various species of beaksedge (*Rhynchospora* spp.), lizard's tail (*Saururus cernuus*), Carolina redroot (*Lachnanthes caroliniana*), taperleaf waterhorehound (*Lycopus rubellus*), false nettle (*Boehmeria cylindrica*), and knotweeds (*Polygonum* spp.). Sphagnum moss (*Sphagnum* spp.) often occurs in patches where the soil is saturated but not flooded.²⁸⁰ Vines such as eastern poison ivy (*Toxicodendron radicans*), white twinevine (*Sarcostemma clausum*), laurel greenbrier (*Smilax laurifolia*), epiphytes such as Spanish moss (*Tillandsia usneoides*), several species of wild pine (*Tillandsia* spp.), and orchids can be common in dome swamps. The center of the dome swamp contains the largest cypress trees and

the understory can be open with deeper water and floating and emergent species such as alligatorflag (*Thalia geniculata*), big floatingheart (*Nymphoides aquatica*), floating water spangles (*Salvinia minima*), duckweeds (*Lemna*, *Spirodela*, and/or *Landoltia*), and bulltongue arrowhead (*Sagittaria lancifolia*).

Dome swamps are most often found on flat terraces, where they develop when the overlying sand has slumped into a depression in the underlying limestone, creating a rounded depression connected to a shallow water table. In uplands with clay subsoils, dome swamps may occupy depressions over a perched water table. Soils in dome swamps are variable⁷⁰ but are most often composed of a layer of peat, which may be thin or absent at the periphery, becoming thicker toward the center of the dome.²⁸⁰ This peat layer is generally underlain with acidic sands or marl and then limestone or a clay lens. In South Florida, dome swamps also occur on peat directly overlying limestone.¹⁰⁵ Common soil types include Bladen, Coxville, and Bayboro.

Characteristic Set of Species: pond cypress, swamp tupelo

Rare Species: Dome swamps can host a suite of rare species, including pondspice (*Litsea aestivalis*), panhandle spiderlily (*Hymenocallis henryae*), and small-flowered meadowbeauty (*Rhexia parviflora*) in North Florida, and many-flowered catopsis (*Catopsis floribunda*) in South Florida. Dome swamps provide important habitat for many wildlife species,⁵⁰ including several rare animals. They provide critical breeding habitat for flatwoods salamanders (*Ambystoma cingulatum* and *Ambystoma bishopi*) and are important roosting sites for wading birds such as white ibis (*Eudocimus albus*) and wood stork (*Mycteria americana*).

Range: Dome swamps are most common in Central Florida but occur throughout the state, except in the Florida Keys. Similar cypress swamps in shallow depressions also occur throughout the southeastern coastal plain.⁵⁰

Natural Processes: Dome swamps are often formed when poor surface drainage causes water to move downward and dissolve the limestone bedrock. These depressions then fill in with peat or marl.⁹⁸ Dome swamps derive much of their water through surficial runoff from surrounding uplands.¹²⁹ Water levels in dome swamps naturally fluctuate with seasonal rainfall changes.¹⁶⁷ They may also be connected directly to the aquifer, where groundwater influences the hydrological regime, especially during periods of drought.¹⁶⁷ Dome swamps can function as reservoirs that recharge the aquifer.^{50,167} The normal hydroperiod for dome swamps is 180 to 270 days per year,⁵⁰ with water being deepest, and remaining longest, near the center of the dome creating a larger buildup of peat there. Ewel¹⁰⁶ suggests the most likely reason for the domed profile, where trees grow faster in the center of the dome swamp¹⁰⁸ is due to deeper peat and lower competition from other species.

Dome swamps experience a wide range of water level variation.^{42,222} Prolonged dry periods as well as prolonged wet periods can have a significant effect on cypress regeneration. Although adult cypress trees are tolerant of extended inundation, their seeds cannot germinate under water and cypress seedlings may not survive if submerged.^{222,422}

Fire is essential for maintaining the structure and the species composition of a dome swamp community.¹⁰⁷ Without periodic fires cypress may become less dominant as hardwood or bay canopy species increase and peat accumulates. Cypress have fairly thick, fire-resistant bark and are tolerant of light surface fires, but catastrophic fires burning into the peat can kill cypress trees, especially when fire has long been absent. The consumption of muck fuels from such a catastrophic wildfire can lower the ground surface and transform a dome swamp into a pond, wet prairie, or shrub bog. Fire frequency is generally greatest at the periphery of the dome and least in the interior, where long hydroperiods and deeper peat, and/or water, maintain high moisture levels.²²² The normal fire cycle might be as short as three to five years along the outer edge and as long as 100 to 150 years towards the center.¹³⁰ The domed profile of these swamps may be partly attributable to this frequent, peripheral fire regime. Fire in a long-unburned dome swamp may result in higher cypress mortality in the center of the dome where fire burns through a deeper layer of accumulated peat and kills the cypress roots.¹⁰⁷ Emergent marshes can develop in the center of such dome swamps.

Topographic microsites can be important areas for tree, shrub, and herbaceous seedling recruitment in dome swamps.¹⁸² Raised mats of root fiber and peat form hummocks at the bases of trees and shrubs, on old tree stumps, or among cypress knees, often creating microsites for more diverse and mesic species to establish above the water surface.²⁸⁰

Community Variations: Dome swamps are classically small (relative to other swamp types) and circular or elliptical in shape but can occur in any size or shape on the landscape, especially if the swamp is shallow. Dome swamps can completely surround, or appear as fringes, on the edge of basin or depression marshes. Some dome swamps have marsh vegetation or a small pond in their center, creating a “doughnut” appearance when viewed from above. Although most dome swamps are isolated on the landscape they can also be loosely connected to one another by wet prairie or depression marsh. They also may be present as a series of swamps connected together forming a shallow drainageway where water flows only during periods of heavy rain.

Variation in species composition is partly attributable to geographic distribution. Dome swamps in South Florida have a higher component of tropical species but the dominant species (i.e., pond cypress, swamp tupelo) are mostly temperate. Dome swamps generally have an epiphytic component throughout their range, with the highest density and diversity occurring in South Florida.²⁹⁷ Dome swamps within the Everglades basin occur in a matrix of marl prairie or glades marsh and form where peat accumulates in limestone depressions or rises, and are locally referred to as “cypress domes” and “cypress heads,” respectively.³⁰⁵ These dome swamps often consist of a canopy of cypress over an understory of baygall vegetation.³⁰³ Myrtle-leaved holly (*Ilex cassine* var. *myrtifolia*) may dominate shallow dome swamps in upland pine, sandhill, or scrub communities in North Florida.

Two common variants of dome swamp occur within Florida.

Variants: GUM POND – depressions dominated by swamp tupelo instead of cypress and found primarily in the Florida Panhandle, commonly occurring within upland pine. These swamps are underlain by a clay lens, have a longer hydroperiod and lower fire frequency than cypress-dominated dome swamps.¹⁰⁵

STRINGER SWAMP – narrow linear swamps dominated by pond cypress occurring within a pyrogenic community along an intermittent stream that only flows during times of heavy rainfall. Stringer swamps often burn with the adjoining uplands.

Associated Communities: Dome swamps only occur within a suite of pyrogenic matrix communities: mesic flatwoods, dry prairie, glades marsh, upland pine, wet flatwoods, and sandhill. They are often encircled by wet prairie or depression marsh. These dense and diverse herbaceous communities serve as a transition from the swamp to the adjacent upland community and can help carry fire into the swamp.

The species composition of dome swamps overlaps that of strand swamp, basin swamp, baygall, and floodplain swamp. Distinguishing features of dome swamps include their isolation (within the landscape) and relatively shallow nature. Dome swamps generally have fewer canopy species than other swamp types in Florida due to their more frequent fire regime and smaller size. Dome swamps can be distinguished from baygall by the dominance of deciduous species (i.e., cypress) rather than evergreen bay species.²⁷⁹ Fire-excluded dome swamps, and especially those where cypress has been logged out, may succeed to baygall as evergreen bay species shade out the ground layer and peat accumulates.²⁸⁰ Dome swamps have an isolated landscape position as opposed to floodplain swamps which occur along perennial streams. Distinguishing between basin, strand, and dome swamps is complicated and requires thorough ground and aerial investigation. Dome swamps are always found within fire-maintained communities and are generally, although not always, smaller, have a greater fire frequency, less peat accumulation, and lower species diversity than basin or strand swamps.

Management Considerations: Dome swamps often suffer from anthropogenic alterations or influences such as regional hydrological modifications,³⁴² logging, nutrient enrichment, pollution from agricultural runoff, and invasive exotic species invasion.^{129,417} Conversion of the adjacent uplands to pasture, development, or agriculture impedes natural fire and alters the hydrology of dome swamps that are left unconverted.²¹³ The hydroperiod also may be substantially shortened through ditching, or conversely increased by impoundment. It is important to maintain natural hydroperiods and natural (both seasonal and long term) fluctuations in water level in dome swamps. Extended hydroperiods can limit tree growth and prevent reproduction. Shortened hydroperiods can permit the invasion of mesophytic species, which can change the character of the understory and eventually allow hardwoods to replace cypress. Regional lowering of the water table can cause drastic effects (i.e., cypress mortality) in dome swamps, including colonization by herbaceous marsh or upland species.¹²³

Since fire is important in the ecology of dome swamps, it should be allowed to burn into dome swamps from the adjacent uplands and extinguish naturally. The practice of putting firebreaks around dome swamps has been used in

Florida to prevent fire from entering dome swamps, mostly in an effort to control peat fires. This practice negatively affects the structure and function of the dome swamp by altering drainage from adjoining uplands,²⁶⁷ degrading the wet prairie buffer, and impeding fire. Within the dome swamp, a heavy shrub layer resulting from fire suppression impedes wildlife movement between the swamp and uplands, and increases the likelihood of catastrophic wildfire. Additionally, the natural upland buffers around dome swamps are important for many dome swamp inhabitants such as turtles and salamanders, who use the buffer zones for specific stages of their life cycle.⁴⁴ Firebreaks should not be created around dome swamps and should be restored where present in the landscape.²⁶⁷

Dome swamps have long been used for their timber resources. In fact, most cypress trees in the southeast were harvested in the late nineteenth and early twentieth centuries.²⁹ Unlike most pine plantations, cypress harvested in Florida generally is cut from natural stands and few areas are ever replanted. Although cypress trees are capable of regenerating, or resprouting from cut stumps, cypress regeneration in most dome swamps is from seed. It is therefore important that at least a few seed trees be left in place for canopy regeneration. Cypress seeds are water-dispersed and are infrequently moved from one depression to another. The short-lived seeds will not germinate in standing water and seedling plants are intolerant of prolonged inundation. Young cypress trees are also vulnerable to fire, especially in logged dome swamps that are undergoing canopy regeneration.¹⁰⁶ If cypress saplings and seedlings are destroyed by fire, or if cypress seed trees are removed, bay species, coastalplain willow, and swamp tupelo are likely to invade the swamp.^{106,147}

Dome swamps are sometimes used as treatment areas for secondarily treated wastewater.⁵⁰ This causes increased nutrients, organic matter, and minerals to flow into the dome swamp, which can have negative effects such as an increased cover of duckweed, decreased oxygen in the water, and declines in amphibian populations. Dome swamps treated with sewage can have higher water levels, litter production, and wood production.⁴²

Invasive exotic plant species can be a problem in dome swamps through competition for light and nutrients. Species of particular concern include melaleuca (*Melaleuca quinquenervia*), both species of climbing fern (*Lygodium japonicum* and *L. microphyllum*), and Chinese tallow (*Sapium sebiferum*).

Exemplary Sites: Eglin Air Force Base (Walton, Okaloosa, and Santa Rosa counties), Three Lakes Wildlife Management Area (Osceola County), Everglades National Park (Miami-Dade and Monroe counties), Big Cypress National Preserve (Monroe County)

Global and State Rank: G4/S4

Crosswalk and Synonyms:

Kuchler	113/Southern Floodplain Forest
	112/Southern Mixed Forest
Davis	7/Cypress Swamp Forests
SCS	17/Cypress Swamp
Myers and Ewel	Freshwater Swamp Forests - depression or basin wetlands
SAF	85/Slash Pine - Hardwood
	100/Pondcypress
	103/Water Tupelo - Swamp Tupelo
FLUCCS	613/Gum Swamps
	616/Inland Ponds and Sloughs
	621/Cypress

Other synonyms: cypress dome³⁰⁵ or pond; cypress head^{280,303,305,422}; gum pond; cypress gall; pine barrens pond; cypress doughnut⁴²²; cypress ponds⁴³⁶



Eglin Air Force Base (Okaloosa County)

Photo by Don Herring



Goethe State Forest (Levy County)

Photo by Paul Russo

Basin Swamp

Description: Basin swamp is a basin wetland vegetated with hydrophytic trees and shrubs that can withstand an extended hydroperiod. Basin swamps are highly variable in size, shape, and species composition. While mixed species canopies are common, the dominant trees are pond cypress (*Taxodium ascendens*) and swamp tupelo (*Nyssa sylvatica* var. *biflora*). Other typical canopy and subcanopy trees include slash pine (*Pinus elliotii*), red maple (*Acer rubrum*), dahoon (*Ilex cassine*), swamp bay (*Persea palustris*), sweetbay (*Magnolia virginiana*), loblolly bay (*Gordonia lasianthus*), swamp laurel oak (*Quercus laurifolia*), sweetgum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), green ash (*Fraxinus pennsylvanica*), American hornbeam (*Carpinus caroliniana*), and American elm (*Ulmus americana*). Depending on the hydrology and fire history, shrubs may be found throughout a basin swamp or they may be concentrated around the perimeter. Common species include Virginia willow (*Itea virginica*), swamp dogwood (*Cornus foemina*), swamp doghobble (*Leucothoe racemosa*), coastal sweetpepperbush (*Clethra alnifolia*), myrtle dahoon (*Ilex cassine* var. *myrtifolia*), fetterbush (*Lyonia lucida*), wax myrtle (*Myrica cerifera*), titi (*Cyrilla racemiflora*), black titi (*Cliftonia monophylla*), and common buttonbush (*Cephalanthus occidentalis*). The herbaceous layer is also variable and includes a wide array of species including maidencane (*Panicum hemitomon*), Virginia chain fern (*Woodwardia virginica*), arrowheads (*Sagittaria* spp.), lizard's tail (*Saururus cernuus*), false nettle (*Boehmeria cylindrica*), beaksedges (*Rhynchospora* spp.), bladderworts (*Utricularia* spp.), and royal fern (*Osmunda regalis* var. *spectabilis*). Sphagnum moss (*Sphagnum* spp.) often occurs in patches where the soil is saturated but not flooded.²⁸⁰ Vines may be present, particularly coral greenbrier (*Smilax walteri*), laurel greenbrier (*Smilax laurifolia*), and eastern poison ivy (*Toxicodendron radicans*). Epiphytic species such as resurrection fern (*Pleopeltis polypodioides* var. *michauxiana*), Spanish moss (*Tillandsia usneoides*), and Bartram's air-plant (*Tillandsia bartramii*) are common, especially in older, more mature examples of basin swamp.

This natural community typically occurs in any type of large landscape depression such as old lake beds or river basins, or ancient coastal swales and lagoons that existed during higher sea levels. Basin swamps exist around lakes

and are sometimes headwater sources for major rivers, such as the Suwannee. Soils are generally acidic, nutrient-poor peats often overlying a clay lens or other impervious layer.

Characteristic Set of Species: pond cypress, swamp tupelo

Rare Species: An epiphytic fern, swamp plume polypody (*Pecluma ptilodon*), thrives in basin swamps throughout the peninsula. Basin swamp provides important foraging and nesting grounds for several rare animals including blackbanded sunfish (*Enneacanthus chaetodon*), frosted flatwoods salamander (*Ambystoma cingulatum*), carpenter frog (*Rana virgatipes*), many-lined salamander (*Stereochilus marginatus*), spotted turtle (*Clemmys guttata*), swallow-tailed kite (*Elanoides forficatus*), wood stork (*Mycteria americana*), southeastern weasel (*Mustela frenata olivacea*), and Florida long-tailed weasel (*Mustela frenata peninsulae*).

Range: Basin swamps occur throughout the Florida Panhandle and peninsula south to the Lake Okeechobee area; they are mostly replaced in South Florida by strand swamp. Similar cypress swamps also occur in large basins throughout the southeastern coastal plain.⁵⁰

Natural Processes: The primary source of water in basin swamps is local rainfall, with additional input from runoff and seepage from the surrounding uplands. A clay lens or other impervious layer often causes a perched water table above that of the adjacent uplands.²⁸⁰ Basin swamps hold standing water for most of the year. Basin swamps are generally still water swamps but can flow during periods of high water. These swamps may contain streams and sloughs that drain the swamp, especially during periods of high rainfall.

Fire intervals are variable and depend on such factors as dominant vegetation, fire exposure, and drought. The interior of basin swamps may go without fire for decades or even centuries while the exposed outer edges can be more susceptible to frequent fire. Basin swamps that are situated within the matrix of a pyrogenic community, such as mesic flatwoods, will likely burn more frequently than basin swamps positioned within a matrix of mesic or hydric hammock. Without fire, bays and hardwoods increase in density and peat accumulates more rapidly. Cypress and pines are tolerant of light surface fires, but muck fires burning into the peat can kill the trees, lower the ground surface, and transform a swamp into a pond, lake, marsh, or shrub bog.

Topographic microsites can be important areas for tree, shrub, and herbaceous seedling recruitment in basin swamps.¹⁸² Raised mats of root fiber and peat form hummocks at the bases of trees and shrubs, on old tree stumps, or among cypress knees, and often create microsites for mesic species to establish above the water surface.^{105,280}

Community Variations: Basin swamps are generally large but can occur as small inclusions within non-pyrogenic communities such as hydric hammock. The structure of a basin swamp is variable, depending largely on fire and hydrological history. A mature basin swamp is similar in structure to an old-growth forest with varying tree size classes represented.⁴¹⁷ Although pond cypress dominates the canopy of most basin swamps, hardwood trees including red maple, green ash, and swamp laurel oak also may be present. Higher woody plant and herbaceous species diversity is expected around the perimeter of the swamp where the soil is more aerated; fewer species are able to tolerate the longer hydroperiod and more anaerobic conditions of the interior.¹⁰⁵ Shrub diversity and density are typically higher around the edges of a basin swamp, particularly in fire excluded examples of this community.

Basin swamps can be encircled by wet prairie or depression marsh especially where they occur within a pyrogenic upland matrix community such as mesic flatwoods. These dense and diverse herbaceous communities serve as a transition from the swamp to the adjacent upland community and can help carry fire into the swamp.

In the northern peninsula, basin swamps can be found within a complicated environment of hydric hammock and mesic hammock or, as in the Okefenokee Swamp, Pinhook Swamp, and San Pedro Bay, can form a complex matrix with basin marsh and shrub bog. The fire exposure for basin swamps is quite different in each of these situations. Basin swamps that occur in and around hydric and mesic hammock have a low exposure to fire while basin swamps associated with basin marsh and shrub bog likely burn much more frequently.

Associated Communities: Basin swamps can be surrounded by various upland communities and can also form complex mosaics with other wetland communities. The species composition of basin swamps overlaps with other swamp communities in Florida, including floodplain swamp, dome swamp, strand swamp, and baygall.

Smaller basin swamps may be difficult to distinguish from large dome swamps as both are cypress-dominated communities that occupy isolated depressions in the landscape. Basin swamps are generally, although not always,

larger swamps with a more irregular shape and a higher species richness, lower fire frequency, and deeper peat accumulation than dome swamps. Additionally, basin swamps can be, but are not always, surrounded by pyrogenic communities, whereas dome swamps are always surrounded by a pyrogenic community.

Basin swamp often intergrades with floodplain swamp, especially when they exist near, or within, the floodplain of a river, creek, or lake. Basin swamps are generally isolated and dominated by pond cypress, while floodplain swamps occur along rivers and creeks and are dominated by bald cypress (*Taxodium distichum*). Both swamp communities may occur around lakes that are part of, or connected to, a river floodplain. In general, lakes occurring as wider parts of a river are bordered by floodplain swamps, while lakes not closely associated with a river and not receiving input from flowing water are bordered by basin swamps.

A roughly linear outline and cypress-dominated canopy are common to basin swamps and strand swamps; however these two community types have different origins. Basin swamps usually develop in basins such as old lakes or former coast-parallel lagoons that were present during times of higher sea level. Strand swamps occupy troughs aligned with bedrock lows in a gently sloping limestone plain. In South Florida, roughly south of Lake Okeechobee, strand swamp more or less replaces basin swamp.

Hydric hammock may occur in close proximity to basin swamp but this hammock community is distinguished by dominance of oaks rather than cypress. Similarly, baygall has a dominant cover of evergreen bay species as opposed to a canopy of pond cypress or swamp tupelo, although cypress logging activity can create confusion where it substantially changes the canopy composition.

Management Considerations: Basin swamps can suffer from anthropogenic alterations such as regional hydrological modifications, logging, nutrient enrichment, pollution from agricultural runoff, and invasive exotic species invasion.^{129,417} Conversion of the adjacent uplands to pasture, development, or agriculture impedes natural fire and alters hydrologic inputs to basin swamps that are left unconverted.²¹³

Some basin swamps in Florida have been drained through ditching or have been impounded to alter water levels. It is important to maintain natural hydroperiods and natural (both seasonal and long term) fluctuations in water level in basin swamps. Extended hydroperiods can limit tree growth and prevent reproduction. Shortened hydroperiods can permit the invasion of mesophytic species, allow for increases in shrubs and hardwoods, and can increase fire potential.¹⁰⁵

Basin swamps have long been used for their timber resources. Most cypress trees in the southeast were harvested in the late nineteenth and early twentieth centuries.²⁹ Unlike most pine plantations, cypress harvested in Florida generally is cut from natural stands and few areas are ever replanted. Although cypress trees are capable of regenerating, or resprouting from cut stumps, cypress regeneration is usually from seed. It is therefore important that at least a few seed trees be left in place for canopy regeneration. Cypress seeds are water-dispersed and they are infrequently moved from one area to another. The short-lived seeds will not germinate in standing water and seedlings are intolerant of prolonged inundation.¹⁰⁵ Young cypress trees are also vulnerable to fire, especially in logged swamps that are undergoing canopy regeneration (Ewel 1995). If cypress saplings and seedlings are destroyed by fire, or if cypress seed trees are removed, coastalplain willow, swamp tupelo, or bay species are likely to dominate the swamp.^{106,147}

Silvicultural operations, particularly those including “bedding,” have altered many basin swamps throughout Florida. This forestry practice creates rows of mounded soil upon which pine seedlings (typically slash pine) are planted. The root zone of the young trees is raised above any standing water that may be present in troughs between the bedded rows. This practice alters the hydrology and structure of the swamp.

Invasive exotic plant species can be a problem in basin swamps through competition for light and nutrients. Species of particular concern include both species of climbing fern (*Lygodium japonicum* and *L. microphyllum*) and Chinese tallow (*Sapium sebiferum*).

Exemplary Sites: Goethe State Forest (Levy County), Lake Panasofkee (SWFWMD property, Sumter County), Osceola National Forest (Baker County), John M. Bethea State Forest (Baker County)

Global and State Rank: G4/S3

Crosswalk and Synonyms:

Kuchler	113/Southern Floodplain Forest
Davis	7/Cypress Swamp Forests
	8/Swamp forests, mostly of hardwoods
SCS	17/Cypress Swamp
Myers and Ewel	Freshwater Swamp Forests - depression or basin wetlands
SAF	85/Slash Pine - Hardwood
	100/Pondcypress
	103/Water Tupelo - Swamp Tupelo
FLUCCS	613/Gum Swamps
	616/Inland Ponds and Sloughs
	621/Cypress

Other synonyms: gum swamp; bog swamp⁴³⁶; cypress forest⁴³⁶



Corkscrew Swamp Sanctuary (Collier County)

Photo by Gary Knight

Strand Swamp

Description: Strand swamp is a shallow, forested, usually elongated depression or channel situated in a trough within a flat limestone plain, and dominated primarily by bald cypress (*Taxodium distichum*). Smaller strand swamps and shallow edges may instead contain pond cypress (*T. ascendens*). Small, young cypress trees at the outer edge of strand swamps grade into large old ones in the deeper interior, giving a strand a distinctly rounded cross-sectional profile.⁹⁷ The variable woody understory contains a mixture of temperate and tropical elements, mainly red maple (*Acer rubrum*), pond apple (*Annona glabra*), swamp laurel oak (*Quercus laurifolia*), cabbage palm (*Sabal palmetto*), strangler fig (*Ficus aurea*), swamp bay (*Persea palustris*), sweetbay (*Magnolia virginiana*), coastalplain willow (*Salix caroliniana*), wax myrtle (*Myrica cerifera*), myrsine (*Rapanea punctata*), and common buttonbush (*Cephalanthus occidentalis*). In the Fakahatchee Strand, Florida royal palm (*Roystonea regia*) may also be present in the subcanopy. Herbs include string lily (*Crinum americanum*), giant leather fern (*Acrostichum danaeifolium*), toothed midsorus fern (*Blechnum serrulatum*), royal fern (*Osmunda regalis* var. *spectabilis*), sawgrass (*Cladium jamaicense*), and waterhyssops (*Bacopa* spp). Vines such as eastern poison ivy (*Toxicodendron radicans*) and white twinevine (*Sarcostemma clausum*) may be common. The warm, humid climate in strand swamp make it ideal habitat for epiphytic orchids and bromeliads. While the greatest diversity of these epiphytes may be found along the deeper sloughs, several are common throughout the swamp. These include a variety of air-plants (*Tillandsia* spp.), particularly common wild-pine (*Tillandsia fasciculata*), which is often abundant.

Strand swamp soils are peat and sand over limestone. Swamps with larger cypress and a more diverse understory are on deep peat that acts as a wick to draw moisture from groundwater up into the root zone during droughts.⁹⁷ Swamp edges, however, often have little organic matter over deep sand. The normal hydroperiod ranges from 100-300 days.⁹⁶ Water levels rise with increasing rainfall around June and then decrease to their lowest levels during winter and early spring.⁹⁷ Water is deepest and remains longest near the center.

Characteristic Set of Species: cypress, pond apple, strangler fig

Rare Species: Rare plants in strand swamps include many epiphytic species restricted in Florida to the southern peninsula. These include American bird's nest fern (*Asplenium serratum*), narrow-leaved strap fern (*Campyloneurum angustifolium*), tailed strap fern (*C. costatum*), many-flowered catopsis (*Catopsis floribunda*),

cowhorn orchid (*Cyrtopodium punctatum*), Fakahatchee guzmania (*Guzmania monostachia*), hand fern (*Ophioglossum palmatum*), fuzzy-wuzzy air-plant (*Tillandsia pruinosa*), entire-winged bristle fern (*Trichomanes holopterum*), and leafy vanilla (*Vanilla phaeantha*).

Strand swamp provides important foraging and nesting habitat for several rare animals including American alligator (*Alligator mississippiensis*), short-tailed hawk (*Buteo brachyurus*), swallow-tailed kite (*Elanoides forficatus*), mangrove fox squirrel (*Sciurus niger avicennia*), American alligator (*Alligator mississippiensis*), Florida panther (*Puma concolor coryi*), Florida black bear (*Ursus americanus floridanus*), southern mink (*Neovison vison*, southern Florida population). Many wading birds depend on the mosaic of habitats found in strands for feeding and nesting, especially wood storks (*Mycteria americana*).

Range: Strand swamps are restricted to South Florida, and probably do not occur north of Lake Okeechobee. They are mainly in Collier County where the Fakahatchee Strand and Corkscrew Swamp are perhaps the finest examples.

Natural Processes: Fire occurs rarely in strand swamps, with the largest trees on the deepest peat towards the center of the strand burning least frequently. However, fires from surrounding pine-dominated communities can frequently burn into the outer edges of strand swamps. Duever et al.⁹⁷ report that cypress trees along these edges are typically both smaller and younger than those toward the interior, resulting from greater fire frequency along the edge that often kills adult cypress already stunted by poor sandy soils. In addition to having a shorter stature, strand edges are often a monospecific stand of cypress, owing to the vulnerability of the typical understory components to fire.^{96,424} In this way, occasional fire contributes to the maintenance of a cypress dominated community; without fire, hardwood invasion and peat accumulation create a mixed hardwood and cypress swamp, and under certain conditions the strand may convert to hydric hammock.³¹⁹ Cypress is very tolerant of light surface fires, but muck fires burning into the peat can kill the trees and lower the ground surface, transforming a strand swamp into a slough. Where severe fires have killed cypress, coastalplain willow commonly establishes as a thicket.

Community Variations: In undisturbed strand swamps, higher plant diversity is partly attributable to topographical variations, such as depressions caused by peat fires, high spots on old stumps, and irregularities caused by unequal solution of the underlying limestone, that allow species of varying flood tolerance to become established.^{96,232}

Associated Communities: Strand swamps are similar to other swamps in Florida that have a primarily cypress dominated canopy. Both basin and dome swamps, however, occur in relatively closed depressions with little water flow except during heavy rainfall. While many basin swamps north of Lake Okeechobee are roughly linear in outline, these usually occupy basins of former lagoons parallel to the coast that formed during times of high sea level, rather than troughs aligned with bedrock lows in a very gently sloping limestone plain. Floodplain swamp is a similar community that also has flowing water. However, the flat landscape of South Florida, with its very slight elevation gradient, prevents the typical downcutting of flowing streams found elsewhere in the state. Thus floodplain swamps occur along streams and rivers, as opposed to strand swamps, which have an irregular network of lower sloughs. Due to climate differences, strand swamps have a more tropical understory than most floodplain swamps, which tend to be found further north. Dome swamps occur within the same range as strand swamps where solution sinkholes fill with peat. With additional subsidence in the limestone substrate, these domes can grow together, forming an irregular strand.⁹⁷ Hydric hammocks often occur on slightly higher ground in strand swamps. These areas have drier soils and are oak dominated rather than cypress dominated.

Management Considerations: Cypress wood is important to the forest products industry in Florida. Its natural resistance to rot makes it useful for many outdoor applications, including siding, outdoor furniture, fence posts, and garden mulch. Most strands were heavily disturbed by cypress logging in the early 20th century but many have recovered well, and there are a few small stands that are thought to be virgin, including within the Corkscrew Swamp Sanctuary. However, clearcutting of cypress for mulch is still practiced.⁴¹⁴ Although stands generally regenerate from resprouting stumps and fast growing seedlings, logging of cypress may lead to a shift in canopy dominance, with hardwoods normally restricted to the subcanopy replacing the cypress that was removed.⁹⁷ Logged swamps may be more vulnerable to destructive fires and the subsequent establishment of coastalplain willow thickets.⁶ Soil compaction from machinery used for logging can also inhibit cypress regeneration.²⁹

Conversion of surrounding lands to pasture, citrus groves, and developments that interfere with the natural fire and hydrological regimes can be highly detrimental to strand swamps. Roads and old logging trams running perpendicular to water flow can impede water, causing unnatural ponding on the upstream side and droughty

conditions on the downstream side.^{97,414} These effects are usually localized and may be partially ameliorated by bridge construction that distributes flow more evenly.

Restoration efforts in strand swamp should focus on landscape level management that re-establishes natural hydrology and maintains high quality surrounding uplands. Any clearcutting operation should leave a cypress seed source adjacent to the cleared area for regeneration to occur. Cypress seedlings require light and cannot withstand either severe flooding or fire.^{244,414} In order to maintain a natural ecotone between strand swamp and surrounding communities, fires should be allowed to extinguish naturally in the edge of the swamp when possible.

Exotic pest plants that show the greatest potential for disrupting strand swamp communities include old world climbing fern (*Lygodium microphyllum*), Java plum (*Syzygium cumini*), and Peruvian primrosewillow (*Ludwigia peruviana*). Brazilian pepper (*Schinus terebinthifolius*) and melaleuca (*Melaleuca quinquenervia*) can also invade artificially drained sites and drier edges. These species have the potential to crowd out native plants and form large monocultures. Old world climbing fern can cover trees and create a ladder for fires to burn into the canopy.¹¹⁴

Exemplary Sites: Fakahatchee Strand Preserve State Park (Collier County), Corkscrew Swamp Sanctuary (Collier and Lee counties)

Global and State Rank: G2/S2

Crosswalk and Synonyms:

Kuchler	113/Southern Floodplain Forest
Davis	7/Cypress Swamp Forests
SCS	17/Cypress Swamp
Myers and Ewel	Freshwater Swamp forests - sloughs and strands
SAF	101/Baldcypress
FLUCCS	621/Cypress



Torrey State Park (Liberty County)

Photo by Gary Knight

Floodplain Swamp

Description: Floodplain swamp is a closed-canopy forest of hydrophytic trees occurring on frequently or permanently flooded hydric soils adjacent to stream and river channels and in depressions and oxbows within floodplains. Trees are often buttressed, and the understory and groundcover are sparse. The canopy is sometimes a pure stand of bald cypress (*Taxodium distichum*), but more commonly bald cypress shares dominance with one or more of the following tupelo species: water tupelo (*Nyssa aquatica*), swamp tupelo (*N. sylvatica* var. *biflora*), or ogeechee tupelo (*N. ogeche*). The “knees” arising from the root systems of both cypress and tupelo are common features in floodplain swamp. Other canopy trees capable of withstanding frequent inundation may be present but rarely dominant, including water hickory (*Carya aquatica*), overcup oak (*Quercus lyrata*), red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), and swamp laurel oak (*Q. laurifolia*). Pond cypress (*T. ascendens*) is sometimes present in backswamps and depressions of the more hydrologically isolated areas of the floodplain. Floodplain swamp can often occur within a complex mixture of communities including alluvial forest, bottomland forest, and baygall. This produces a variable assemblage of canopy and subcanopy species, with less flood tolerant trees and shrubs found on small hummocks and ridges within the swamp. Shrubs and smaller trees such as Carolina ash (*Fraxinus caroliniana*), planer tree (*Planera aquatica*), black willow (*Salix nigra*), titi (*Cyrilla racemiflora*), Virginia willow (*Itea virginica*), common buttonbush (*Cephalanthus occidentalis*), cabbage palm (*Sabal palmetto*), and dahoon (*Ilex cassine*) may be present. A groundcover of flood tolerant ferns and herbs are found in some floodplain swamps, including lizard’s tail (*Saururus cernuus*), false nettle (*Boehmeria cylindrica*), creeping primrosewillow (*Ludwigia repens*), savannah panicum (*Phanopyrum gymnocarpon*), royal fern (*Osmunda regalis* var. *spectabilis*), dotted smartweed (*Polygonum punctatum*), climbing aster (*Symphyotrichum carolinianum*), and string lily (*Crinum americanum*). Swamps with stagnant water typically have a mixture of floating aquatics such as duckweeds (*Lemna* spp.) and Florida mudmidget (*Wolffiella gladiata*). Eastern poison ivy (*Toxicodendron radicans*) is a frequent vine. This species list is developed in part from Leitman et al.²³⁵ and Darst et al.⁷⁶

Floodplain swamp is located within floodplains of any permanently moving stream or river. It ranges from narrow strips of cypress along primary and secondary streams to expansive stands along large rivers to tidally influenced freshwater swamps near river mouths. Often, floodplain swamps immediately border the stream or river channel. In

many cases, however, floodplain swamps are isolated from the main channel by riverbank levees and restricted to oxbows, overflow channels, old stream beds, and expansive flats commonly called backswamps. Soils are variable mixtures of alluvial and organic materials, sometimes with layers of sand in the subsoil. Inundation is seasonal and usually prolonged, restricting the growth of most shrubs and herbs and leaving most of the ground surface open or thinly mantled with leaf litter.

Characteristic Set of Species: bald cypress, pond cypress, water tupelo, swamp tupelo, ogeechee tupelo

Rare Species: Rare plants found in floodplain swamp include serviceberry holly (*Ilex amelanchier*), Curtiss' loosestrife (*Lythrum curtissii*), Mexican tear-thumb (*Polygonum meisnerianum* var. *beyrichianum*), pinkroot (*Spigelia loganioides*), Florida willow (*Salix floridana*), and Washington hawthorn (*Crataegus phaenopyrum*). Rare animal species include blackbanded sunfish (*Enneacanthus chaetodon*), lowland topminnow (*Fundulus blairae*), cypress minnow (*Hybognathus hayi*), eastern mudminnow (*Umbra pygmaea*), one-toed amphiuma (*Amphiuma pholeter*), American alligator (*Alligator mississippiensis*), spotted turtle (*Clemmys guttata*), South Florida rainbow snake (*Farancia erythrogramma seminola*), Mississippi green water snake (*Nerodia cyclopion*), Barbour's map turtle (*Graptemys barbouri*), limpkin (*Aramus guarana*), swallow-tailed kite (*Elanoides forficatus*), wood stork (*Mycteria americana*), yellow-crowned night-heron (*Nyctanassa violacea*), black-crowned night-heron (*Nycticorax nycticorax*), Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), big brown bat (*Eptesicus fuscus*), southeastern bat (*Myotis austroriparius*), gray bat (*Myotis grisescens*), northern long-eared myotis (*Myotis septentrionalis*), southeastern weasel (*Mustela frenata olivacea*), Florida long-tailed weasel (*Mustela frenata peninsulae*), and Florida black bear (*Ursus americanus floridanus*).

Range: Floodplain swamp is distributed throughout Florida along river systems and is also widespread in the Southeastern Coastal Plain. South of Lake Okeechobee, however, strand swamp generally replaces floodplain swamp.

Natural Processes: Floodplain swamp along channels may be regularly inundated by flowing aerobic water. However, backswamps are flooded with stagnant water for extensive periods of time, resulting in highly anaerobic conditions. The lack of available oxygen inhibits breakdown of leaf litter and leads to considerable peat accumulation. Anaerobic conditions may contribute to increased nutrient release from sediments through bacterial processes.⁴³⁸ During dry summer months when evapotranspiration rates increase, surface water may be entirely lacking.⁶²

Floods redistribute detrital accumulations to other portions of the floodplain or into the main river channel. This rich organic debris is essential to the functional integrity of downriver ecosystems such as estuaries, providing a vital source of nutrients. Floodplain swamp may also act as a nutrient sink or transformer depending on local conditions, making these wetlands particularly valuable in disposal of partially treated wastewater.⁶²

The topography of alluvial forest and floodplain swamp, particularly in larger alluvial river systems, is a result of a seasonal flooding pattern which builds levees and point bars, creates scour channels and depressions, and introduces flowing water into backswamps. Old channels and levees left behind by the changing meander of the river itself become part of the complex mosaic.⁴³⁷ The oxbows and backswamps created by meander processes are important breeding grounds for fish when high water connects them to the river.⁶²

In floodplain swamps located within tidal influence, flooding patterns, tidal range, and storm events are major driving factors. These swamps are subject to daily freshwater inundation associated with tidal fluctuations.⁸¹ Periodic events such as storms and hurricanes may push saltwater into the normally freshwater swamp. Low river flows during droughts also lead to more saltwater intrusion.⁸⁹ High river flood stages in the southeastern U.S. usually correspond with low tides in winter and spring, while low river flow occurs at roughly the same time as seasonal high tides in summer and fall. This means that swamps potentially receive more saltwater stress during the growing season, rather than during dormancy when the effects would be minimized.⁸⁹

Floodplain swamp is usually too wet to support fire; however, large cypress trees are somewhat fire-resistant, and thus infrequent fires during very dry conditions may contribute to cypress dominance.⁶² Fires may greatly damage the understory.⁴³⁷

Community Variations: Due to the complex nature of dynamic riverine systems, floodplain swamps are variable in canopy dominance and understory composition depending on their placement in the landscape. Larger rivers with

broad floodplains have many features such as levees and oxbows created by a high energy riverine system, and floodplain swamp differs in composition throughout these features. Edges of stream channels that are inundated with flowing water nearly year-round are usually dominated by large bald cypress with tall “knees.” Large backswamps and depression swamps in floodplains are usually a mixture of bald cypress, water tupelo, and/or swamp tupelo, sometimes with less flood-tolerant species present but not dominant in the canopy. Pond cypress is more common in depressional swamps located in peninsular river floodplains. Water tupelo and ogeechee tupelo are mainly limited to northern and Panhandle Florida swamps. Atlantic white cedar (*Chamaecyparis thyoides*) may be present with swamp tupelo and baygall species in some floodplain swamps of the Panhandle and central peninsula.

One commonly occurring variant of floodplain swamp is recognized.

Variant: FRESHWATER TIDAL SWAMP – As a river approaches the coast, increasing stresses from daily tidal-driven inundation and occasional saltwater intrusion gradually influence vegetation structure. At the lower end of this gradient, cypress becomes much less dominant, replaced by stunted tupelo, pumpkin ash, and sweetbay. The landward extent of this community is difficult to determine but it is roughly defined as occurring between the head of the tide, where the bottom of the stream channel is higher than the mean tide range, and the point of tide reversal, where water flow is always downstream, even during high tide.⁸¹

Associated Communities: Floodplain swamp is often associated with and grades into alluvial forest, bottomland forest, hydric hammock, and occasionally baygall. Floodplain swamp is often found in a mosaic with bottomland forest and alluvial forest where the ridge and swale topography of the floodplain creates a mixture of habitats including low depressions that hold water most of the year. Oxbows that are permanently flooded with an open treeless center are generally considered to be river floodplain lakes.

Narrow creeks often have either baygall or bottomland forest occurring between a narrow zone of floodplain swamp and adjacent uplands. In both cases, swamps can usually be distinguished by the dominance of cypress and/or tupelo.

The species composition of floodplain swamp is similar to that of dome swamp, basin swamp, and strand swamp. Dome swamp and basin swamp are generally isolated communities within uplands with pond cypress dominant rather than bald cypress. Both basin swamp and floodplain swamp may occur around lakes that are part of or connected to a river floodplain such as the St. John's. In general, lakes occurring as wider portions of the river are bordered by floodplain swamp, while those that are not closely associated with the river and thus not receiving input from flowing water are bordered by basin swamp.

Strand swamp is similar to floodplain swamp, being a linear community that generally has intermittent moving water. In the flat topography of the southern peninsula, slow moving sloughs with associated strand swamps tend to replace the floodplain systems that occur in central and northern Florida. There is some intergradation between sloughs that contain moving water for most of the year and streams that occasionally dry up during droughts, and therefore these swamps may not be easily distinguished.

Management Considerations: Floodplain swamp communities provide important wildlife habitat, contribute to flood attenuation, and help protect the overall water quality of streams and rivers. Artificial water impoundments on rivers can severely limit the effects of seasonal flooding that maintain the health of these systems, including the stabilization of deposits and flushing of detritus.⁴³⁷ Alteration of the hydroperiod by impoundments or river diversions and the conversion of floodplain communities to forestry or agriculture uses have devastating consequences to river and bay systems. The natural hydroperiods of swamps promote their high productivity, and drainage of these systems may greatly reduce biomass.⁶²

Near the mouth of a river, channel dredging has the effect of lowering the stream bottom in relation to the tide, thereby pushing the head of the tide further upstream and magnifying saltwater intrusion into the surrounding wetlands.⁸¹ During storms, dredged channels and canals can provide a direct conduit for saltwater during storms.⁸⁹

Vegetation composition change due to drying conditions in the floodplain can be detected first in swamps even if the remainder of the floodplain is virtually unchanged.⁷⁵ A net increase in flooding or permanent water may also have an adverse affect on cypress and tupelo growth, as these species require some dry periods in order for seedlings to attain the size necessary to withstand flooding.⁶²

Virtually all cypress/tupelo stands are second growth, having been intensively logged by the first half of the 20th century. The damage caused by the removal of millions of trees as well as the physical methods used for extraction is still evident today. Logging generally favors the dominance of tupelo, which can vigorously re-sprout after cutting.³⁶⁵ Cypress has been re-introduced through planting in both natural and plantation conditions, with subsequent thinning resulting in larger diameter trees.⁶² Several invasive exotic plants have encroached into floodplain swamp including Japanese climbing fern (*Lygodium japonicum*), old world climbing fern (*Lygodium microphyllum*), alligator weed (*Alternanthera philoxeroides*), water hyacinth (*Eichhornia crassipes*), wetland nightshade (*Solanum tampicense*), Caesar's weed (*Urena lobata*), cat's claw vine (*Macfadyena unguis-cati*), and wild taro (*Colocasia esculenta*).

Exemplary Sites: Escambia River, Apalachicola River, Choctawhatchee River, Suwannee River, Holmes Creek, Oklawaha River, Withlacoochee River, and most other rivers and streams in Florida

Global and State Rank: G4/S4

Crosswalk and Synonyms:

Kuchler	113/Southern Floodplain Forest
Davis	7/Cypress Swamp Forests
	8/Swamp Forests, mostly of Hardwoods
SCS	17/Cypress Swamp
	21/Swamp Hardwoods
Myers and Ewel	Freshwater Swamp Forests - floodplain forests
SAF	101/Baldcypress
	102/Baldcypress - Tupelo
	103/Water Tupelo - Swamp Tupelo
	104/Sweetbay - Swamp Tupelo - Redbay
FLUCCS	613/Gum Swamp
	615/Stream and Lake Swamps
	621/Cypress
	624/Cypress - Pine - Cabbage Palm

Other synonyms: river swamp, bottomland hardwoods, seasonally flooded basins or flats, oak-gum-cypress, cypress-tupelo, NWTC Zones II-III, tidewater swamp, river mouth swamp, sweetbay-swamp, tupelo-redbay; slough, backswamp, and oxbow features of floodplains treated in Wharton⁴³⁷ and others



Near the Florida River, Apalachicola Water Management Area (Liberty County)

Photo by Ann F. Johnson



Cross Florida Greenway (Putnam County)

Photo by Brenda Herring

HARDWOOD – dominated by a mix of hydrophytic hardwood trees; cypress or tupelo may be occasional or infrequent in the canopy; short hydroperiod



Little Big Econ State Forest (Seminole County)

Photo by Kimberly Gullede

Baygall

Description: Baygall is an evergreen forested wetland of bay species situated at the base of a slope or in a depression. Loblolly bay (*Gordonia lasianthus*), sweetbay (*Magnolia virginiana*), and/or swamp bay (*Persea palustris*) form an open to dense tree canopy and are also dominant in the understory along with fetterbush (*Lyonia lucida*), large gallberry (*Ilex coriacea*), dahoon (*I. cassine*), myrtle dahoon (*I. cassine* var. *myrtifolia*), titi (*Cyrilla racemiflora*), black titi (*Cliftonia monophylla*), wax myrtle (*Myrica cerifera*), coastal doghobble (*Leucothoe axillaris*), swamp doghobble (*L. racemosa*), red maple (*Acer rubrum*), Florida anisetree (*Illicium floridanum*), coco plum (*Chrysobalanus icaco*), and/or Virginia willow (*Itea virginica*). Composition of the understory varies regionally; coco plum is restricted to South Florida, Florida anisetree to the central and western Panhandle. Black titi is a dominant component of baygall in the Florida Panhandle, but uncommon in other areas. Loblolly pine (*Pinus taeda*), slash pine (*P. elliottii*), and/or pond pine (*P. serotina*) are often found in the canopy, as well as sweetgum (*Liquidambar styraciflua*), and in the Panhandle, Atlantic white cedar (*Chamaecyparis thyoides*). Wetter baygalls may also contain swamp tupelo (*Nyssa sylvatica* var. *biflora*) and/or pond cypress (*Taxodium ascendens*). The canopy and understory do not generally form distinct strata but may appear as a dense, tall thicket.⁵⁷ Vines, especially laurel greenbrier (*Smilax laurifolia*), coral greenbrier (*S. walteri*), and muscadine (*Vitis rotundifolia*), may be abundant and contribute to the often impenetrable nature of the understory. Herbs are absent or few, and typically consist of ferns such as cinnamon fern (*Osmunda cinnamomea*), netted chain fern (*Woodwardia areolata*), and Virginia chain fern (*W. virginica*). Sphagnum mosses (*Sphagnum* spp.) are common.

Baygall typically develops on wet soils at the bases of slopes, edges of floodplains, in depressions, and in stagnant drainages. The soils are generally composed of peat with an acidic pH (3.5 - 4.5). Seepage from uplands, rainfall, and/or capillary action from adjacent wetlands maintains a saturated peat substrate.⁹⁵ While baygalls are not

generally influenced by flowing water, they are often drained by small blackwater streams. Within the slough and glades marsh communities of the Everglades in South Florida, baygall may develop on elevated islands of peat (often called “bayheads”). Although most baygalls are small in acreage, some form large, mature forests, often called “bay swamps.”

Characteristic Set of Species: loblolly bay, sweetbay, swamp bay

Rare Species: Baygall forests are important habitat for Florida black bear (*Ursus americanus floridanus*) and provide cover for their dens. South Florida bayheads are critical for supporting wading bird rookeries.

Range: Baygall occurs throughout mainland Florida and much of the southeastern coastal plain. The largest examples occur near the Georgia border in the Pinhook Swamp area south of Okefenokee Swamp.

Natural Processes: Deep peat soils and seepage from uplands or adjacent wetlands work to maintain a constantly saturated but rarely flooded environment. Constant damp conditions limit decomposition of organic material, which in turn keeps available nutrient levels low.²³² In deep swamps dominated by cypress and swamp tupelo, baygall can eventually develop. Leaf litter accumulation raises the soil level and creates a shallower depression, allowing bay species that require a shorter hydroperiod to become established. As the broad-leaved species proliferate, the shade-intolerant cypress and swamp tupelo seedlings are inhibited, shifting vegetation and soil conditions to favor broadleaf species that can germinate and grow in low light.²⁴⁴

The dominant baygall species are fire-intolerant, and a mature canopy indicates the lack of destructive fire for many years.⁵⁷ Although the saturated soils and humid conditions within baygalls typically inhibit fire, droughts may create conditions that allow them to burn catastrophically. These fires not only destroy the canopy, but also may ignite the deep peat layers that can smolder for weeks, or even months. This occurs perhaps only a few times each century in the deepest baygalls.

Where the peat layer is destroyed, the lower soil level may collect open water that can be re-colonized by marsh or cypress/tupelo swamp vegetation. If the root systems are not killed, bay species will readily re-sprout and form a shrub thicket.⁵⁷ Peat areas with more frequent fires develop shrub bog vegetation rather than baygall.²⁵³ Thus, certain vegetation types (baygall, basin swamp, shrub bog, and open water) in the Okefenokee Swamp have been described as a “moving mosaic” of vegetation determined by fire history and hydrology.²⁴⁴ In South Florida bayheads, severe fires that consume the peat can convert a bay-dominated forest to a lower thicket of coastalplain willow (*Salix caroliniana*).⁴²⁴

Community Variations: Several pine species can withstand hydric soil conditions (loblolly pine, pond pine, slash pine), and the occurrence of these pines in baygall is apparently part of the natural variation. Many baygall species common in the northern peninsula and Panhandle reach their southern limits in the central peninsula (titi, black titi, coastal doghobble, and swamp doghobble). In the western Panhandle, Atlantic white cedar may be found in baygall which grades into bottomland forest along blackwater and seepage streams in the region.

The following variants are defined for two common situations.

<u>Variants:</u>	BAY SWAMP – A large basin with deep peat soils and a well-developed baygall forest such as those found in Pinhook Swamp.
	SOUTH FLORIDA BAYHEAD – Occurs on tree islands in the Everglades. These are on small elevated sites of Gandy peat, a woody peat that is more resistant to decay under aerobic conditions. ²⁴³ These communities may or may not be underlain by a limestone bedrock high. The open or closed canopy and shrub layers are dominated by swamp bay, sweetbay, dahoon, coastalplain willow, and/or coco plum, and the understory consists of ferns (on higher sites) or marsh species. ^{243,303} Portions of more elevated, drier sites may support hammock vegetation.

Associated Communities: The dominance of evergreen bay trees rather than a mixture of deciduous and other evergreen species can be used to distinguish baygall from other forested wetlands. Baygall may be quite similar to bottomland forest, sometimes forming a transition between the floodplain where the bottomland forest occurs and the adjacent uplands. Cypress/tupelo swamps are similar to baygalls (bay swamp variant), and there are many instances of intermediate stages between these communities caused primarily by fire and/or logging history. Many

swamps may have a baygall understory, but retain a cypress or tupelo canopy. In general, cypress/tupelo swamps experience greater water fluctuation and maximum water depth than do baygalls.^{279,436} Hydric hammocks are dominated by evergreen oaks and cabbage palms rather than bays.

Shrub bogs lack a closed canopy of bay trees. Baygall that has burned recently may be shrubby, but will have a large component of re-sprouting bay trees and burned tree stumps. Overgrown wet or mesic flatwoods may contain a sizable amount of evergreen bay species, particularly along ecotones between swamps and uplands. In addition, many baygalls can have a significant number of canopy pines, making these communities difficult to distinguish. The dominance of flatwoods species in the understory, such as saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), coastalplain staggerbush (*Lyonia fruticosa*), and shiny blueberry (*Vaccinium myrsinites*), as well as a nearly continuous pine overstory, can indicate a recent development of baygall vegetation in historic flatwoods communities.

Management Considerations: As with other wetlands, baygall communities are best managed with a landscape level focus on maintaining high quality adjacent natural uplands and upland-wetland ecotones. When possible, fires from adjacent communities should be allowed to extinguish naturally at the edges of the baygall to prevent encroachment of bay species into other communities and to maintain open, grassy wetland/upland ecotones. The maintenance or restoration of natural hydrology is critical to wetland communities. Artificial drainage of baygalls creates an opportunity for catastrophic peat fires.

Invasive exotic plants are a concern in all natural communities of Florida. Old world climbing fern (*Lygodium microphyllum*) has been documented in baygall communities, and poses a current threat to tree islands in Loxahatchee Slough in the northern Everglades.²⁴²

Historically, many areas that were a mosaic of flatwoods, wet prairies, bay swamps, and shrub bogs were converted to pine plantation, and these communities may be difficult to distinguish after such disturbance. Baygalls have been cleared in order to grow horticultural plants in the mucky soil, and many areas, including bayheads in the Everglades have also been altered by drainage manipulation.⁴¹⁸ These activities may expose the normally saturated peat soils to air, speeding decomposition. Baygalls have also been damaged or eliminated by peat mining.

Timber harvest and fire exclusion can encourage the replacement of other natural community types by baygall. For example, examination of historic aerial photography suggests that logging of cypress swamps led to a shift in vegetation to baygall.²⁴⁴ Medium-depth depressions with evidence of pond cypress logging in north Florida show a pattern of increased loblolly bay and swamp tupelo dominance.⁵¹ Baygall may also be generated by the removal of pine trees in wet flatwoods; shading from the remaining shrub layer may inhibit pine regeneration but does not limit bay species growth. This process is further promoted by fire exclusion.²⁴⁴

Swamp bay, a major component of baygall, is susceptible to Laurel Wilt Disease, which is caused by a fungus spread by an exotic wood-boring ambrosia beetle (*Xyleborus glabratus*). As of 2009, the infestation had spread to 20 counties in north Florida.⁴¹¹ There is no known means of treating diseased trees or controlling the spread of the disease, although root-flare injections of propiconazole has recently shown promise to provide temporary protection of individual trees.²⁶⁰ Wood or mulch from areas with infected trees should not be transported to avoid creating new centers of infection.

Exemplary Sites: Blackwater River State Forest (Santa Rosa and Okaloosa counties), Lake Talquin State Forest (Gadsden and Leon counties), Osceola National Forest (Columbia and Baker counties), Avon Park Air Force Range (Highlands and Polk counties), and Everglades National Park (Dade and Monroe counties)

Global and State Rank: G4/S4

Crosswalk and Synonyms:

Kuchler	112/Southern Mixed Forest
Davis	2/Pine Flatwoods
	8/Swamp Forests, mostly of Hardwoods
SCS	12/Wetland Hardwood Hammocks
Myers and Ewel	Freshwater Swamp Forests - titi swamps, bayheads
SAF	85/Slash Pine - Hardwood
	104/Sweetbay-Swamp Tupelo-Redbay
FLUCCS	611/Bay Swamps

Other synonyms: seepage swamp, sandhill bog



Big Bend Wildlife Management Area (Taylor County)

Photo by Ann F. Johnson

Hydric Hammock

Description: Hydric hammock is an evergreen hardwood and/or palm forest with a variable understory typically dominated by palms and ferns occurring on moist soils, often with limestone very near the surface. While species composition varies, the community generally has a closed canopy of oaks and palms, an open understory, and a sparse to a moderate groundcover of grasses and ferns. The canopy is dominated by swamp laurel oak (*Quercus laurifolia*) and/or live oak (*Q. virginiana*) with varying amounts of cabbage palm (*Sabal palmetto*), American elm (*Ulmus americana*), sweetbay (*Magnolia virginiana*), red cedar (*Juniperus virginiana*), red maple (*Acer rubrum*), sugarberry (*Celtis laevigata*), sweetgum (*Liquidambar styraciflua*), and water oak (*Q. nigra*). Cabbage palm is a common to dominant component of hydric hammock throughout most of Florida. Loblolly pine (*Pinus taeda*) may be frequent in some areas, but slash pine (*Pinus elliottii*) is less frequently encountered. In addition to saplings of canopy species, the understory may contain a number of small trees and shrubs. American hornbeam (*Carpinus caroliniana*) is often frequent, and various other woody species may be present including swamp dogwood (*Cornus foemina*), small-leaf viburnum (*Viburnum obovatum*), common persimmon (*Diospyros virginiana*), swamp bay (*Persea palustris*), wax myrtle (*Myrica cerifera*), dwarf palmetto (*Sabal minor*), American beautyberry (*Callicarpa americana*), and needle palm (*Rhapidophyllum hystrix*). Vines may be frequent and diverse; common species are eastern poison ivy (*Toxicodendron radicans*), peppervine (*Ampelopsis arborea*), rattan vine (*Berchemia scandens*), trumpet creeper (*Campsis radicans*), climbing hydrangea (*Decumaria barbara*), yellow jessamine (*Gelsemium sempervirens*), greenbriers (*Smilax* spp.), summer grape (*Vitis aestivalis*), and muscadine (*Vitis rotundifolia*). Herb cover, when present includes mostly graminoids and ferns with the following species commonly encountered: sedges (*Carex* spp.), woodoats (*Chasmanthium* spp.), smooth elephantsfoot (*Elephantopus nudatus*), Carolina

scalystem (*Elytraria caroliniensis*), woodsgrass (*Oplismenus hirtellus*), maiden ferns (*Thelypteris* spp.), cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis* var. *spectabilis*), toothed midsorus fern (*Blechnum serrulatum*), netted chain fern (*Woodwardia areolata*), and Virginia chain fern (*Woodwardia virginica*). Epiphytes such as golden polypody (*Phlebodium aureum*), air-plants (*Tillandsia* spp.), and shoestring fern (*Vittaria lineata*) increase in frequency to the south along with other more subtropical shrubs such as myrsine (*Rapanea punctata*), and wild coffee (*Psychotria nervosa*; species list developed in part from Vince et al.⁴²³).

Species composition is mainly influenced by flooding patterns. In saturated and frequently flooded environments, hydrophytic trees such as swamp tupelo (*Nyssa sylvatica* var. *biflora*) become more abundant. Frequency and depth of inundation have a pronounced effect on oak canopy composition as well, with saturated soils supporting more swamp laurel oak, and areas of infrequent flooding supporting more live oak.⁴²³ Increased salinity is a factor often limiting certain species. Rises in terrain as well as ecotones to mesic hammock and upland hardwood forest induce a greater cover of upland species, specifically southern magnolia (*Magnolia grandiflora*), pignut hickory (*Carya glabra*), and saw palmetto (*Serenoa repens*).

Hydric hammock occurs on low, flat, wet sites where limestone may be near the surface and soil moisture is kept high mainly by rainfall accumulation on poorly drained soils. Periodic flooding from rivers, seepage, and spring discharge may also contribute to hydric conditions.⁴²³ Soils are variable, usually somewhat acidic to slightly alkaline with little organic matter, and in all cases, alkaline materials are available in the substrate.⁴²³ In the extensive Gulf Hammock region shallow loamy soils (Waccasassa series) formed by marine sediments overlie a layer of Oligocene limestone near the surface that frequently outcrops.^{157,409} Deeper soils over limestone (Aripeka series) and deep sands with calcium carbonate nodules and shell fragments underlie many hammocks in peninsular Florida.⁴⁰⁹ These substrates are conducive for the growth of calciphiles characteristic of hydric hammock (red cedar, rattan vine, etc.). Hydric hammock is inundated only for short periods following heavy rains. The normal hydroperiod is seldom over 60 days per year. Fire may be rare or occasional depending on several factors including how often the surrounding community burns and hammock size.

Characteristic Set of Species: swamp laurel oak, live oak, cabbage palm, red cedar

Rare Species: Rare plants occurring in hydric hammock include auricled spleenwort (*Asplenium erosum*), Chapman's sedge (*Carex chapmanii*), hay scented fern (*Dennstaedtia bipinnata*), Tampa vervain (*Glandularia tampensis*), Florida hasteola (*Hasteola robertorum*), star anise (*Illicium parviflorum*), hand fern (*Ophioglossum palmatum*), plume polypody (*Pecluma plumula*), terrestrial peperomia (*Peperomia humilis*), pinewoods dainties (*Phyllanthus liebmannianus* ssp. *platylepis*), and pinkroot (*Spigelia loganioides*). Hydric hammock is important habitat and foraging grounds for an array of rare animals including Gulf hammock dwarf siren (*Pseudobranchius striatus lustricolus*), spotted turtle (*Clemmys guttata*), eastern indigo snake (*Drymarchon couperi*), limpkin (*Aramus guarauna*), short-tailed hawk (*Buteo brachyurus*), swallow-tailed kite (*Elanoides forficatus*), yellow-crowned night-heron (*Nyctanassa violacea*), black-crowned night-heron (*Nycticorax nycticorax*), Sherman's short-tailed shrew (*Blarina carolinensis shermani*), Homosassa shrew (*Sorex longirostris eionis*), Southeastern bat (*Myotis austroriparius*), Florida black bear (*Ursus americanus floridanus*), Florida long-tailed weasel (*Mustela frenata peninsulae*), and Gulf salt marsh mink (*Neovison vison halilimnetes*).

Range: Hydric hammock is restricted to Florida and coastal Georgia.⁴²³ It mainly occurs in the Florida peninsula north of the Everglades and is most extensive between Pasco and Wakulla counties, with only small occurrences further west immediately adjacent to salt marshes. Hydric hammock is less widespread on the east coast, but may be found on the St. John's River floodplain and just inland of salt marshes along the northeastern coast. Many other small hydric hammocks are scattered throughout the state, particularly along spring runs. The range of inland hammocks extends to approximately Alachua County.

Natural Processes: Fire is not considered an important component of hydric hammock dynamics; however, they do burn occasionally. Cabbage palms are fire tolerant and intense fires favor this species. Live oak can survive low intensity fires, but red cedar is highly susceptible to fire. Flooding duration and frequency are primary factors in species composition. While most hydric hammock trees are at least somewhat adapted to flooding, the ranges of tolerance vary according to timing and depth of inundation.⁴²³

Community Variations: Along the Gulf coast where hammock and flatwoods vegetation grades into salt marshes, salinity levels allow the persistence of only a subset of the hydric hammock vegetation, particularly cabbage palm, live oak, and red cedar. These coastal hydric hammocks extend west along the Florida Panhandle at least to the

Apalachicola basin and may be mixed stands of palms, oaks and loblolly pines.³²⁸ Small stands of hammock that are surrounded by marsh or prairie are known as prairie hammocks, and are common along the St. John's River. Isolated stands of Atlantic white cedar (*Chamaecyparis thyoides*) are known to occur in at least a few hydric hammocks in Central Florida.

Two commonly occurring variants of hydric hammock are recognized here.

- Variants:
- COASTAL HYDRIC HAMMOCK – Strips of hammock immediately bordering salt marsh or other coastal communities. Species composition is limited by salinity to mostly cabbage palm, live oak, and red cedar.
- PRAIRIE HYDRIC HAMMOCK – Isolated pods of trees occurring within a larger matrix of pyrogenic vegetation, usually floodplain marsh. Dominant trees are cabbage palm, live oak, and red cedar with an open sparse understory. Prairie hammock burns more frequently and is often completely dominated by cabbage palm. Also see Mesic Hammock in this guide for description of prairie mesic hammock.

Associated Communities: Hydric hammock often grades into, or may be difficult to differentiate from, mesic hammock, bottomland forest, alluvial forest, swamps, and baygall. Hydric hammock may be distinguished from mesic hammock by its species composition that is dependent on occasional flooding.³⁶⁷ Both are typically oak-dominated. However, since mesic hammock is less saturated and does not flood frequently, it supports a higher frequency of southern magnolia and pignut hickory, and often has a shrub layer of saw palmetto.

Alluvial forest, influenced primarily by periodic flooding from rivers, tends to have a greater abundance of trees characteristic of riverine habitats, particularly water hickory (*Carya aquatica*) and overcup oak (*Quercus lyrata*), although the transition may be gradual where hydric hammock and alluvial forest occur in the same floodplain.⁴³⁸ Hydric hammock may occur finely intermixed with either basin or floodplain swamp. Although cypress and tupelo may be present in hydric hammock, they are not dominant trees.

Perhaps the most difficult distinction to draw is between hydric hammock and bottomland forest, a community usually found in broad floodplains or along primary streams. Both have a similar species composition and may be found in the same general situations, but bottomland forest generally lacks the cabbage palm and red cedar components found in most hydric hammocks. Baygall is maintained by continual seepage from surrounding uplands and is dominated by bay species – loblolly bay (*Gordonia lasianthus*), sweetbay, and red bay (*Persea borbonia*) – rather than an oak/cedar/cabbage palm assemblage. Soils are more acid with a higher organic matter than the slightly acidic to neutral soils of hydric hammock.

Management Considerations: Preservation of good quality hydric hammock is important for a variety of reasons. In addition to the aesthetic qualities of the community that promote outdoor tourism, these hammocks provide valuable habitat for game animals that rely on the large production of oak mast. The canopy and forest floor of hydric hammocks act to reduce soil erosion. During heavy rains, sheet flow is slowed across the forested floor of a hammock, allowing greater absorption into the soil. Hammocks adjacent to salt marshes function to protect inland areas from damaging hurricane winds.^{367,438}

Selective logging of the natural canopy trees such as live oak and red cedar has been a continual disturbance to hydric hammock, and although forest structure may have been impacted by these activities, species composition does not seem to have been greatly altered.³⁶⁷ A greater threat has come from the conversion of hydric hammock into pine plantation. Soil damage caused by site preparation and logging is particularly detrimental in hydric hammock, forming ruts and canals that increase surface water runoff and, consequentially, soil erosion. Once planted, the time required to return to a natural stand depends on the intensity of the site preparation prior to planting. Crowded thickets of weedy shrubs and vines generally dominate clearcut hammocks for many years; however, with the removal of the planted pine canopy, hammock trees may re-establish a natural stand by re-seeding or resprouting from remaining trees.³⁶⁷

Projected rises in sea level over the next century threaten coastal hydric hammock. While adult cabbage palms may persist for years following increased saltwater flooding, regeneration of stands eventually halts and palm forests are replaced by salt marsh.⁴⁴⁰

Effective conservation management of hydric hammock primarily consists of maintaining natural hydrology and controlling exotic plant invasion. Ditching and water control structures should be avoided and existing ones should be removed or filled. Any activity that requires the use of heavy machinery should be limited to dry periods when the soil is not saturated, thereby reducing rutting which can cause unnatural water channelization.

Exotic plants and animals pose significant problems in hydric hammock. This community may be the most preferred habitat of feral hogs (*Sus scrofa*).³⁶⁷ Control of this species is not only important in order to reduce competition with native wildlife, but also to minimize soil disturbance which decreases diversity of native ground cover within hydric hammock. Soil disturbance and canopy openings allow the spread of exotic invasive plants, particularly Brazilian pepper (*Schinus terebinthifolius*), skunk vine (*Paederia foetida*), camphor tree (*Cinnamomum camphora*), Japanese climbing fern (*Lygodium japonicum*), old world climbing fern (*L. microphyllum*), white-flowered wandering jew (*Tradescantia fluminensis*), sword fern (*Nephrolepis cordifolia*), Caesar's weed (*Urena lobata*), and cogon grass (*Imperata cylindrica*). Once established these species require costly efforts for control or removal.

Exemplary Sites: Waccasassa Bay Preserve State Park (Levy County), Chassahowitska Wildlife Management Area (Hernando County), Lower Hillsborough River Flood Detention Area (Hillsborough County), St. Marks National Wildlife Refuge (Jefferson County), Triple N Ranch Wildlife Management Area (Osceola County), Highlands Hammock State Park (Highlands County), Bulow Creek State Park (Volusia County)

Global and State Rank: G4/S4

Crosswalk and Synonyms:

Kuchler	113/Southern Floodplain Forest
Davis	8/Swamp Forests
	12/Hardwood Forests
SCS	12/Wetland Hardwood Hammocks
	13/Cabbage Palm Hammocks
Myers and Ewel	Hydric hammocks
SAF	73/Southern Red Cedar
	74/Cabbage Palmetto
FLUCCS	617/Mixed Wetland Hardwoods

Other synonyms: wet hammock, Gulf Hammock



Big Shoals State Forest (Hamilton County)

Photo by Dan Hipes

Bottomland Forest

Description: Bottomland forest is a deciduous, or mixed deciduous/evergreen, closed-canopy forest on terraces and levees within riverine floodplains and in shallow depressions. Found in situations intermediate between swamps (which are flooded most of the time) and uplands, the canopy may be quite diverse with both deciduous and evergreen hydrophytic to mesophytic trees. Dominant species include sweetgum (*Liquidambar styraciflua*), spruce pine (*Pinus glabra*), loblolly pine (*Pinus taeda*), sweetbay (*Magnolia virginiana*), swamp laurel oak (*Quercus laurifolia*), water oak (*Q. nigra*), live oak (*Q. virginiana*), swamp chestnut oak (*Q. michauxii*), and sugarberry (*Celtis laevigata*). More flood tolerant species that are often present include American elm (*Ulmus americana*) and red maple (*Acer rubrum*), as well as occasional swamp tupelo (*Nyssa sylvatica* var. *biflora*) and bald cypress (*Taxodium distichum*). Evergreen bay species such as loblolly bay (*Gordonia lasianthus*), and sweetbay are often mixed in the canopy and understory in acidic or seepage systems. Smaller trees and shrubs often include American hornbeam (*Carpinus caroliniana*), swamp dogwood (*Cornus foemina*), possumhaw (*Ilex decidua*), dahoon (*I. cassine*), dwarf palmetto (*Sabal minor*), swamp bay (*Persea palustris*), wax myrtle (*Myrica cerifera*), and highbush blueberry (*Vaccinium corymbosum*). The understory is either dense shrubs with little ground cover, or open, with few shrubs and a groundcover of ferns, herbs, and grasses. In the drier forests of this type, American holly (*Ilex opaca*), Gulf Sebastian bush (*Sebastiania fruticosa*), and sparkleberry (*Vaccinium arboreum*) may be frequent. Ground cover is also variable in composition and abundance, often with species overlap between herbs suited to either mesic or hydric conditions. Characteristic species include witchgrasses (*Dichanthelium* spp.), slender woodoats (*Chasmanthium laxum*), and sedges (*Carex* spp.). Species lists are based in part on Leitman et al.²³⁵, Light and Darst²³⁹, and Darst and Light⁷⁵.

Situations where bottomland forest occurs include several distinct ecological settings in Florida: along rivers and tributaries, on higher terraces and levees in floodplains, and in somewhat isolated depressions that do not flood frequently. Bottomland forests along smaller streams are prone to periodic flooding attributable to localized rainfall that increases seepage and runoff from surrounding uplands. In floodplains along larger rivers and tributaries, bottomland forests on higher terraces, ridges, and levees are subject to short seasonal floods due to either high relief or quickly drained sandy soils or both. Soils are a mixture of sand, clay, and organic materials. The water table in

these forests is high in blackwater or spring-fed floodplains and relatively low in alluvial floodplains (during dry periods). Inundation occurs only during higher floods, regardless of the stream type.

Characteristic Set of Species: water oak, sweetgum, swamp laurel oak, red maple, loblolly pine, spruce pine

Rare Species: Rare plants found in bottomland forest include sweet-shrub (*Calycanthus floridus*), ciliate-leaf tickseed (*Coreopsis integrifolia*), Indian cucumber-root (*Medeola virginiana*), little club-spur orchid (*Platanthera clavellata*), and buckthorn (*Sideroxylon lycioides*).

Rare animals that may be found in bottomland forest include Apalachicola dusky salamander (*Desmognathus apalachicola*), four-toed salamander (*Hemidactylium scutatum*), copperhead (*Agkistrodon contortrix*), Mississippi green water snake (*Nerodia cyclopion*), yellow-crowned night-heron (*Nyctanassa violacea*), black-crowned night-heron (*Nycticorax nycticorax*), Louisiana waterthrush (*Seiurus motacilla*), Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), big brown bat (*Eptesicus fuscus*), southeastern bat (*Myotis austroriparius*), gray bat (*Myotis grisescens*), northern long-eared myotis (*Myotis septentrionalis*), southeastern weasel (*Mustela frenata olivacea*), Florida long-tailed weasel (*Mustela frenata peninsulae*), and Florida black bear (*Ursus americanus floridanus*).

Range: Bottomland forest is found throughout Florida, associated mostly with blackwater and alluvial floodplains. Where limestone is near the surface, particularly along spring-run streams, hydric hammocks often replace bottomland forest.

Natural Processes: The complex topography formed by alluvial rivers and some larger blackwater rivers such as the Suwannee River creates a mixture of bottomland forest and more frequently flooded alluvial forest and floodplain swamp. Bottomland forest vegetation may be found not only on higher terraces within the floodplain, but also on natural levees and ridges. Levees are formed during high floods when water from the main channel overtops the banks. As flood waters are slowed by the process of spreading across the floodplain surface, sand and other heavy sediments are the first to be deposited along these ridges, and thus levees are gradually built upward.⁴³⁷ Along oxbows that have become isolated from the main channel, levees persist as high ridges. In some cases, these levees and ridges may be quite dry and support upland communities such as mesic or xeric hammock.

Bottomland forest, while not as prone to prolonged growing season inundations as alluvial forest, is nevertheless influenced by high water tables and peak seasonal flooding as well as irregular high flood events.⁷⁶ Variations in seedling establishment are often caused not only by flooding regimes, but also by windthrows and treefall gaps that allow for the establishment of shade intolerant species.³⁶⁵

Organic debris from bottomland forests is an important nutrient source for downstream ecosystems. Although annual floods do not always inundate bottomland forest, large scale patterns of high water pulses occurring every 5-7 years along the Apalachicola River are critical in providing nutrients flushed from higher terraces of the floodplain into the Apalachicola Bay and are correlated with a significant increase in commercial fish abundance in the bay.⁴³⁷ Fire is not a significant factor in bottomland forest, and is primarily limited to individual trees affected by lightning strikes.²³⁵

Community Variations: Differences in hydrologic conditions across bottomland forests (high vs. low water table, deep vs. shallow flood depths) lead to highly variable mixtures of species that fluctuate across different floodplains as well as within the same system. Bottomland forests along small blackwater streams and rivers may immediately border the stream or form a transition between floodplain swamp and the surrounding uplands. Narrow bottomland forests flanking small seepage streams often contain a large percentage of evergreen bay or oak species.

Larger blackwater rivers and alluvial rivers may have bottomland forest occurring in broad terraces, or on higher ridges and levees. High levees bordering the main river channel are often characterized by a dominance of sweetgum, live oak, and water oak, with understory and groundcover species that are adapted to infrequent or short duration floods such as American holly and Gulf Sebastian bush. They may also contain less flood tolerant trees such as loblolly pine and spruce pine, with the specific composition in each case determined by elevation in the floodplain.

Bottomland forest occurring along some blackwater and seepage streams in the western Panhandle are particularly exceptional, being a mixture of various hardwood species, Atlantic white cedar (*Chamaecyparis thyoides*), tuliptree (*Liriodendron tulipifera*), and bay species occurring on low, sandy deposits not introduced by the river. These

forests are not subject to the higher amounts of deposition occurring along alluvial or semi-alluvial streams⁵⁷; although the shifting river may rapidly move sand along meander loops and periodically overflow its banks.⁴³⁸ Atlantic white cedar trees of the western Panhandle are tolerant of this acidic, disturbance-prone habitat.⁶²

Associated Communities: Although bottomland forest may flood and even contain occasional tupelo and cypress trees, it is not dominated by these species, as is floodplain swamp. The transition to upland communities is often gradual with much species overlap due to the large range of hydrologic conditions that many bottomland forest species may tolerate; however, upland species such as pignut hickory (*Carya glabra*) and southern magnolia (*Magnolia grandiflora*) are not common in bottomland forest.

Hydric hammock often closely resembles bottomland forest, but the dominance of evergreen oaks and cabbage palm rather than a generalized mix of hydrophytic and mesophytic trees distinguish hydric hammock. Baygall communities are found in areas of high seepage and are dominated by bay species with other hydrophytic trees of secondary importance in the canopy. Bottomland forest and alluvial forest often occur intermixed within a floodplain. In general, bottomland forest is a drier community than alluvial forest, although this distinction may be difficult to draw, particularly when bottomland forest grades into floodplain swamp. Regardless of the mix of hydrophytic trees in various bottomland forests, water hickory, overcup oak, and/or green ash, the set of species characteristic of alluvial forest, are generally not important elements in the canopy.

Management Considerations: Nearly all bottomland forests have suffered from timbering operations, which frequently leave long-lasting scars from soil disturbance. In addition to clearcutting, some bottomland forests have been converted to pine plantations, usually with severe effects on species composition and leaving exposed topsoil that would normally have been bound by tree roots.⁴³⁸ Clearcutting of bottomland forest in the Panhandle often leads to a second growth canopy dominated by loblolly pine and sweetgum.⁵⁷ Sweetgum is often favored by disturbance due to its ability to sprout following damage to the tree.³⁶⁵

Bottomland forest is generally unsuitable for development due to its location on substrates that occasionally are flooded or saturated. Construction that makes use of landfill, such as some road crossings, may be highly detrimental to bottomland forest by effectively acting as dams, backing up floodwater and increasing sedimentation upstream of the landfill.⁴³⁸

Large mammals such as Florida black bears often rely on long corridors of wetlands, and the development of land in these floodplains leads to population isolation and corresponding negative impacts, including increased highway collisions.³⁶⁵ Beaver dams along streams may kill bottomland forest canopies and lead to the development of open marshes by raising local water levels.⁵⁷ Similarly, man-made structures such as dikes which do not allow for adequate drainage of bottomland forest also cause considerable damage to forest canopies which are not adapted to long periods of inundation.⁴³⁸ Invasive exotic plants, particularly Japanese climbing fern (*Lygodium japonicum*), Chinese privet (*Ligustrum sinense*), Chinese tallow (*Sapium sebiferum*), and white-flowered wandering jew (*Tradescantia fluminensis*), may form dense stands in bottomland forest, particularly where the community borders development.

Exemplary Sites: Blackwater River State Forest (Santa Rosa and Okaloosa counties), Lake Talquin State Forest (Leon County), San Felasco Preserve State Park (Alachua County), Jennings State Forest (Clay County), Myakka River State Park (Sarasota County)

Global and State Rank: G4/S3

Crosswalk and Synonyms:

Kuchler	113/Southern Floodplain Forest
Davis	8/Swamp Forests, mostly of Hardwoods
SCS	20/Bottomland Hardwoods
Myers and Ewel	Freshwater Swamp Forests - floodplain forests
SAF	82/Loblolly Pine - Hardwood
	88/Willow Oak - Water Oak - Diamondleaf Oak
	91/Swamp Chestnut Oak - Cherrybark Oak
	92/Sweetgum - Willow Oak
	97/Atlantic White Cedar
FLUCCS	615/Stream and Lake Swamps (Bottomland)
	617/Mixed Wetland Hardwoods
	623/Atlantic White Cedar
	630/Wetland Forested Mixed

Other synonyms: high bottomland forest⁷⁵; blackwater branch or creek swamp, in part⁴³⁶; bottomland; river bottom; stream bottom; white cedar swamp; NWTC Zones IV-V; levees; terraces; lowland hardwood forest



Atlantic white cedar-dominated bottomland forest along river, Blackwater River State Forest (Santa Rosa County)

Photo by Paul Russo



Apalachicola River Water Management Area (Liberty County)

Photo by Ann F. Johnson

Alluvial Forest

Description: Alluvial forest is a hardwood forest found in river floodplains on low levees, ridges and terraces that are slightly elevated above floodplain swamp and are regularly flooded for a portion of the growing season. The physical environment is greatly influenced by ongoing disturbances created by a fluctuating river bed which is both eroding and depositing substrates.³⁶⁵ Primary trees found include overcup oak (*Quercus lyrata*), swamp laurel oak (*Q. laurifolia*), water hickory (*Carya aquatica*), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), water locust (*Gleditsia aquatica*), river birch (*Betula nigra*), and red maple (*Acer rubrum*). A great diversity of less flood-tolerant hardwoods or swamp species such as cypress (*Taxodium* spp.) and tupelo (*Nyssa* spp.) may also be present, but not dominant elements. Shrubs, small trees, and vines are usually sparse or moderate in abundance with green hawthorn (*Crataegus viridis*), swamp dogwood (*Cornus foemina*), eastern swampprivet (*Forestiera acuminata*), dwarf palmetto (*Sabal minor*), coastalplain willow (*Salix caroliniana*), black willow (*S. nigra*), American hornbeam (*Carpinus caroliniana*), *Hypericum* spp., possumhaw (*Ilex decidua*), and laurel greenbrier (*Smilax laurifolia*) common. Groundcover is variable in abundance with false nettle (*Boehmeria cylindrica*), butterweed (*Packera glabella*), netted chain fern (*Woodwardia areolata*), redbud panicum (*Panicum rigidulum*), and big carpetgrass (*Axonopus furcatus*) among the herbs most commonly encountered (species lists developed in part from Leitman et al.²³⁵; Darst⁷⁵; and Darst⁷⁶). The ability of both adult plants and seedlings to withstand specific flooding regimes throughout the “ridge and swale” topography of the floodplain often creates a mix of mesophytic and hydrophytic tree species.

Alluvial forest occurs in river floodplains and occupies low levees along channels, expansive flats located behind levees, low ridges alternating with swamps, and successional point bars. It is usually intermixed with lower areas of floodplain swamp and higher areas of bottomland forest, baygall, or upland hardwood forest. This forest develops along tertiary or higher order streams where deposition of alluvium becomes a significant factor in floodplain development (rather than simply erosional forces). Soils are variable mixtures of sand and alluvial sediments that have been deposited by the current drainage system and are often distinctly layered. Alluvial forest occupies an

elevation within the broader floodplain that is inundated seasonally from river bank overflow for one to four months of the year during the growing season.⁷⁶

Characteristic Set of Species: water hickory, overcup oak, swamp laurel oak, green ash, American elm, water locust, river birch

Rare Species: Examples of rare plants found in alluvial forest include variable-leaved indian-plantain (*Arnoglossum diversifolium*), Canada honeysuckle (*Cryptotaenia canadensis*), and Thorne's buckthorn (*Sideroxylon thornei*). Animal diversity is high, particularly in drier portions of the alluvial forest where forage is plentiful.³⁶⁵ The long list of rare animals found (or historically found) in alluvial forest includes one-toed amphiuma (*Amphiuma pholeter*), American alligator (*Alligator mississippiensis*), Mississippi green water snake (*Nerodia cyclopion*), Barbour's map turtle (*Graptemys barbouri*), ivory-billed woodpecker (*Campephilus principalis*), swallow-tailed kite (*Elanoides forficatus*), yellow-crowned night-heron (*Nyctanassa violacea*), black-crowned night-heron (*Nycticorax nycticorax*), hairy woodpecker (*Picoides villosus*), Louisiana waterthrush (*Seiurus motacilla*), Bachman's warbler (*Vermivora bachmanii*), Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), big brown bat (*Eptesicus fuscus*), southeastern bat (*Myotis austroriparius*), gray bat (*M. grisescens*), northern long-eared myotis (*M. septentrionalis*), southeastern weasel (*Mustela frenata olivacea*), Florida long-tailed weasel (*M. frenata peninsulae*), and Florida black bear (*Ursus americanus floridanus*).

Range: Alluvial forest is most widespread in the Florida Panhandle where alluvial rivers, particularly the Apalachicola, create broad floodplains. Blackwater river systems may also contain alluvial forest; however, the deficiency of suspended inorganic alluvium and shorter flood duration is not as conducive to their development. In the peninsula south of the Suwannee River, alluvial forest is usually restricted to small areas around oxbows and riverbanks where deposition occurs on the inside curve of meander loops or in narrow strips bordering floodplain swamps. In these peninsular forests, overbank flooding does not contribute significant deposition to the remainder of the floodplain surface, and the majority of these systems are usually either hammocks or bottomland forest with shorter flood durations accompanying periods of heavy rainfall in the late summer and early fall. Alluvial forest is not found south of Lake Okeechobee where broad strand swamp systems replace the floodplains found further north.

Natural Processes: Hydroperiod is the primary physical feature of alluvial forest, which is inundated by flood waters nearly every year for at least a portion of the growing season. This factor is critical to species composition, since many trees that can withstand frequent flooding are nonetheless sensitive to prolonged growing season inundation. Although flooding may be extensive, alluvial forest usually does not contain standing water during the dry season.

Seasonal inundation serves to flush the forest floor of leaf litter as accumulated organic material on the forest floor is picked up and redistributed in the floodplain or is washed downriver to provide a critical source of minerals and nutrients for downstream ecosystems, in particular estuarine systems. These floods also replenish soil minerals through deposition on the floodplain.⁴³⁷ The unique topography of alluvial forest and floodplain swamp is a result of the seasonal flooding pattern which not only builds levees and point bars, but also creates scour channels and depressions. The changing meander of the river itself leaves behind old channels and levees that become part of the complex mosaic.⁴³⁷ The formation of high levees along rivers may have a significant impact on alluvial forest and swamp located further from the river, as these levees block flow between the main channel and the rest of the floodplain, leading to ponding of floodwaters and an increase in anaerobic soil conditions.²³⁵

The advancement of alluvial forest onto point bars follows a successional pattern with pioneer, shade-intolerant species such as black willow and river birch initially stabilizing the soil and then gradually giving way to less disturbance tolerant species such as overcup oak. This pattern results in point bars with vegetation that is progressively younger toward the river channel.

Fire is very infrequent, often restricted to individual trees.²³⁵ Stands that burn during drought conditions sustain heavy damage to the understory.⁴³⁷ In addition to flooding regimes, variation in seedling establishment may be caused by individual tree death which creates canopy gaps necessary for the establishment of certain shade intolerant seedlings such as river birch.³⁶⁵

Community Variations: Alluvial forest is heavily influenced by seasonal river flooding. Each floodplain contains its own unique set of physical and chemical environments that lead to multiple species assemblages both across different floodplains and at different points within the same floodplain. The overcup oak/water hickory forests are

the best examples of this community; however, other variations such as point bar thickets are common. Overcup oak and river birch are entirely absent from the narrower floodplains of the peninsula, reaching their southern limit just south of the Suwannee River. Peninsular alluvial forest usually contains a variable mixture of water hickory, water locust, American elm, swamp laurel oak, and/or green ash. Since peninsular rivers usually exhibit a stronger fall flooding pattern, these forests could only marginally be considered alluvial forest rather than bottomland forest.

Associated Communities: Alluvial forest is often positioned between high riverbank levees and the lower floodplain swamp. It may also occur as a terrace uphill from the floodplain swamp or immediately adjacent to rivers on aggrading point bars where recent deposition favors species particular to these conditions, particularly willows and river birch. Although many of the characteristic species of alluvial forest may be common in floodplain swamp, cypress and/or tupelo are dominant in these swamps because of the longer hydroperiod. Bottomland forest often occupies slightly higher terraces, ridges, and levees in the floodplain and usually does not receive annual springtime flooding, whether due to higher elevation or differences in stream type. These forests sometimes have loblolly pine (*Pinus taeda*) and generally lack water hickory, overcup oak, and/or green ash as dominants. Baygall is dominated by evergreen bay species and lacks the diverse assemblage of deciduous trees found in alluvial forest. Both bottomland forest and baygall can line the courses of primary and secondary streams. The downstream transition to a broader floodplain where seasonal flooding shapes the course of the river (conditions conducive to the development of alluvial forest) is gradual. Hydric hammocks share many species of hydrophytic plants but are generally dominated by a mix of evergreen oaks, cabbage palm (*Sabal palmetto*), and red cedar (*Juniperus virginiana*).

Management Considerations: Alluvial forest must be managed as part of the whole of a riverine system. These communities provide important wildlife habitat and contribute to the overall water quality of streams and rivers. The maintenance of natural hydrologic regimes is critical to the health of forested floodplains and to the downstream systems with which they are connected. Species composition and the functional relationships throughout a river system are negatively impacted by hydrological alterations such as artificial impoundments, river diversion projects, pesticide use, forest clearcutting, or intensive agriculture. Upstream dam construction may severely limit the effects of seasonal flooding that maintain the health of these systems, including the stabilization of deposits and flushing of detritus.⁴³⁷ Channelization of rivers also leads to a reduction of sedimentation in the floodplain by contributing to increased runoff.¹⁸⁵ These artificial channels may also increase flooding downstream, decrease the filtering effects of floodplains, and amplify erosion because of the lack of stabilizing root masses.⁴³⁸

Exemplary Sites: Torreya State Park (Apalachicola River; Liberty County), Apalachicola Water Management Area (Florida River; Liberty County), Gum Landing in Choctawhatchee River Water Management Area (Washington County), Log Landing and Wannee Conservation Areas (Suwannee River; Dixie and Gilchrist counties)

Global and State Rank: G4/S3

Crosswalk and Synonyms:

Kuchler	113/Southern Floodplain Forest
Davis	8/Swamp Forests, mostly of Hardwoods
SCS	20/Bottomland Hardwoods
Myers and Ewel	Freshwater Swamp Forests - floodplain forests
SAF	61/River Birch - Sycamore
	95/Black Willow
	96/Overcup oak - Water Hickory
FLUCCS	615/Stream and Lake Swamps (Bottomland)
	617/Mixed Wetland Hardwoods
	630/Wetland Forested Mixed

Other synonyms: bottomland hardwoods, seasonally flooded basins of flats, oak-gum-cypress, elm-ash-cottonwoods, NWTC Zones III-IV, second bottom, levees, point bars, terraces, river terrace, river ridge, mixed bottomland hardwood



Typical “ridge and swale” topography resulting from an aggrading point bar on the Ochlockonee River, Lake Talquin State Forest (Leon County)

Photo by Ann Johnson

MARINE and ESTUARINE VEGETATED WETLANDS – intertidal or supratidal zone dominated by herbaceous or woody halophytic vascular plants; salinity greater than 0.5 ppt



St. Marks National Wildlife Refuge (Wakulla County)

Photo by Amy Jenkins

Salt Marsh

Description: 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. The width of the intertidal zone depends on the slope of the shore and the tidal range. Salt marsh may have distinct zones of vegetation, each dominated by a single species of grass or rush. Saltmarsh cordgrass (*Spartina alterniflora*) dominates the seaward edge and borders of tidal creeks, areas most frequently inundated by the tides. Needle rush (*Juncus roemerianus*) dominates higher, less frequently flooded areas.¹⁰⁴ Other characteristic species include Carolina sea lavender (*Limonium carolinianum*), perennial saltmarsh aster (*Symphyotrichum tenuifolium*), wand loosestrife (*Lythrum lineare*), marsh fimbry (*Fimbristylis spadicea*), and shoreline seapurslane (*Sesuvium portulacastrum*). 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, including needle rush, sawgrass (*Cladium jamaicense*), saltmeadow cordgrass (*Spartina patens*), Gulf cordgrass (*Spartina spartinae*), and sand cordgrass (*Spartina bakeri*), among others. A border of salt-tolerant shrubs, such as groundsel tree (*Baccharis halimifolia*), saltwater falsewillow (*Baccharis angustifolia*), marshelder (*Iva frutescens*), and christmasberry (*Lycium carolinianum*), often marks the transition to upland vegetation or low berms along the seaward marsh edge.⁵⁹

Salt marsh soils range from deep mucks with high clay and organic content in the deeper portions to silts and fine sands in higher areas. The organic soils have a high salinity, neutral reaction, and high sulfur content; soil properties of salt flats on higher portions of the marsh are little studied.⁶⁸

Characteristic Set of Species: saltmarsh cordgrass, needle rush, saltgrass, saltwort, perennial glasswort, seaside oxeeye, saltmeadow cordgrass, marsh elder, christmasberry

Rare Species: Three rare plants are found in salt marshes: Godfrey's spiderlily (*Hymenocallis godfreyi*), endemic to Wakulla County, golden leather fern (*Acrostichum aureum*) in South Florida, and beaked spikerush (*Eleocharis rostellata*) along brackish shores in the Florida Panhandle.

A large number of rare animals are found in salt marshes. The saltmarsh topminnow (*Fundulus jenkinsi*) is found in tidal channels in western Panhandle and ranges west to Texas. The Atlantic salt marsh snake (*Nerodia clarkii taeniata*) is endemic to Volusia County and its close relative, the Gulf coast salt marsh snake (*N. c. clarkii*), ranges from the vicinity of Cedar Key westward to Texas. The American crocodile (*Crocodylus acutus*) utilizes salt marsh as well as mangrove swamp at the south end of the Florida peninsula, in the Florida Keys, and on islands in Florida Bay.

Several bird species nest in salt marshes and are dependent on them for their entire life cycle. These include three seaside sparrows: MacGillivray's (*Ammodramus maritimus macgillivrayi*) in Nassau and Duval counties; Scott's (*A. m. peninsulae*) along the Gulf coast from Pinellas to Franklin County, and Louisiana (*A. m. fisheri*), ranging from Santa Rosa County west to Texas. Two marsh wrens also breed in salt marshes in Florida, preferring the taller vegetation along tidal creeks: Worthington's marsh wren (*Cistothorus palustris griseus*), which ranges from South Carolina to northeast Florida, and Marian's marsh wren (*C. p. marianae*), which occurs in the Big Bend area from Pasco to Franklin County, with a disjunct population in upper Escambia Bay, Santa Rosa County. The Florida clapper rail (*Rallus longirostris scottii*), utilizes salt marshes from Pensacola south to Cape Sable and north on the Atlantic coast to Jupiter. The black rail (*Laterallus jamaicensis*) winters in northern Florida where it utilizes upper marsh habitat. Among wading birds, the reddish egret (*Egretta rufescens*), tricolored heron (*Egretta tricolor*), and roseate spoonbill (*Platalea ajaja*) favor coastal flats and marshes. Other wading birds that frequent coastal marshes include white ibis (*Eudocimus albus*), little blue heron (*Egretta caerulea*), and, in South Florida, great white heron (*Ardea herodias occidentalis*).

Several rare mammals utilize the infrequently flooded upper marsh habitat, especially areas with saltgrass (*Distichlis spicata*). The common rice rat (*Oryzomys palustris*), which is found in salt marshes throughout the southeast, has two rare varieties in Florida: the Sanibel Island rice rat (*O. p. pop. 2*) and the key rice rat (*O. p. pop. 3*). The salt marsh vole (*Microtus pennsylvanicus dukecampbelli*) is known only from salt marshes in the vicinity of Cedar Key, Levy County. Several subspecies of mink utilize salt marshes in Florida: southern mink (*Neovison vison pop.1*), found in the Everglades region, Gulf salt marsh mink (*N. v. halilimnetes*), found in the Big Bend from Franklin to Pasco County, and Atlantic salt marsh mink (*N. v. lutensis*), found in Nassau, Duval, and St Johns counties. The Lower Keys rabbit (*Sylvilagus palustris hefneri*) is found on higher elevations within salt marshes from Big Pine to Boca Chica Key.

Rare invertebrates include three species of tiger beetle: the elusive tiger beetle (*Cicindela striga*), endemic to both east and west Florida salt marshes, the Florida big-headed tiger beetle (*Tetracha floridana*), found along the Gulf coast of Florida, and the saltmarsh tiger beetle (*Cicindela severa*), found along the Gulf coast of Florida and ranging west to Texas.

Range: Salt marshes cover roughly 170,000 hectares in Florida²⁸¹ and occur along the coast throughout the state, except for the high wave energy shorelines of Palm Beach, Broward, and northern Dade counties. The greatest acreage of salt marsh is concentrated in four areas: three with very gentle seaward slopes (the Big Bend from Wakulla to Pasco counties, the southwest coast inland from the extensive mangrove fringe in Collier, Monroe, and Dade counties, and the Indian River Lagoon from Volusia to Martin counties) and one with a high tidal range (northeast Florida at the mouths of the St Johns and Nassau Rivers). Outside Florida, salt marshes dominated by saltmarsh cordgrass and needle rush are found from Delaware to Texas.

Natural Processes: Flooding frequency and soil salinity are the two major environmental factors that influence salt marsh vegetation.²⁸¹ 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.¹⁰⁴ 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 some of the most biologically productive natural communities known. 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. Commercial marine species that

spend all or part of their life cycle in tidal creeks include mullet (*Mugil* spp.), spot (*Leiostomus xanthurus*), blue crabs (*Callinectes sapindus*), oysters (*Crassostrea virginica*), and shrimp (*Penaeus* spp.). The smaller minnows and juvenile fish in tidal creeks provide food for many recreationally important, predatory fish, such as tarpon (*Megalops atlanticus*), snook (*Centropomus undecimalis*), red drum (*Sciaenops ocellatus*), and spotted seatrout (*Cynoscion nebulosus*).²⁸¹

While there are no data on natural fire frequency in salt marshes, fires probably occurred sporadically, either by spreading from nearby uplands or from lightning strikes in the marsh itself. Needle rush re-sprouts vigorously after fire but, if burned on an annual basis, declines and is replaced by upland species.⁵⁹ Seaside sparrows can quickly re-colonize following small-scale fires; however catastrophic fires may kill even adult birds.³³¹ Natural barriers such as tidal creeks and salt barrens would probably have limited the area burned in each fire, allowing unburned marsh to serve as a refuge for species dependent on marsh habitat.

Community Variations: Although the two dominant marsh plants, salt marsh cordgrass and needle rush, range throughout Florida, the extent of the zone occupied by each varies with physical conditions.²²¹ On the Gulf coast, with a low tidal range of 0.6 to 0.9 meters (2 to 3 feet) and gentle seaward slope, most of the marsh is above mean high water level and is dominated by needle rush, with saltmarsh cordgrass often forming only a fringe along the seaward edge of the marsh and along tidal creeks. On the northeast coast with a tidal range of 1.4 to 1.8 meters (5 to 6 feet), most of the marsh at the river mouths is below mean high water and is dominated by saltmarsh cordgrass, with needle rush confined to a fringe on the landward margin. Away from the river mouths, however, tidal flushing is reduced, and needle rush makes up most of the marsh area. The Indian River Lagoon has a small tidal range and its marshes are mostly above mean high water. Before impoundment, they had a high marsh flora typical of salt flats (saltgrass, perennial glasswort, etc.), with needle rush forming a fringe at the landward edge.²⁸¹

Most salt marsh species range throughout Florida, but a few are confined to South Florida. Species in South Florida marshes that are rare or absent in North Florida marshes include golden leather fern, tree seaside oxeye (*Borrchia arborescens*), hurricanegrass (*Fimbristylis cymosa*), narrowleaf yellowtops (*Flaveria linearis*), and seaside heliotrope (*Heliotropium curassavicum*).

From Brevard and Pinellas counties southward, mangrove swamps (*Rhizophora mangle*, *Avicennia germinans*, and *Laguncularia racemosa*) dominate the seaward portion of the tidal zone (below mean high water) with salt marsh confined to the upper marsh zone where it is usually dominated by needle rush. Salt marsh cordgrass, if present, occurs as a fringe bordering the mangroves.^{176,281} Salt marsh in the Keys is dominated by Gulf cordgrass.³⁴⁵

The following variant is defined for salt marsh.

Variant: SALT FLAT – Slightly higher areas within the marsh, flooded only by storm tides or extreme high tides and isolated from freshwater influx from the surrounding uplands, become very saline and desiccated due to evaporation. These areas are dominated by species that can tolerate high salinities, consisting of either succulents, such as saltwort (*Batis maritima*), perennial glasswort (*Sarcocornia ambigua*), annual glasswort (*Salicornia bigelovii*), and bushy seaside oxeye (*Borrchia frutescens*), or short grasses, such as saltgrass (*Distichlis spicata*), seashore paspalum (*Paspalum vaginatum*), and shoregrass (*Monanthochloe littoralis*). An extreme form of these higher areas may become too saline and desiccated to support much plant cover. Vegetation is limited to a very sparse and stunted cover of succulents and/or shoregrasses with much bare ground. Such areas appear on aerial photographs as white patches within the marsh.⁵⁹

Associated Communities: Salt marsh grades into floodplain marsh as one travels up rivers and is distinguished from floodplain marsh by the dominance of needle rush or saltmarsh cordgrass rather than freshwater species, such as sawgrass. The higher portions of salt marsh adjacent to beach dune may include some dune species such as beach cordgrass, seashore paspalum, and seashore dropseed but can be distinguished from the dune by a lack of sea oats (*Uniola paniculata*), bitter panicgrass (*Panicum amarum*), and Gulf bluestem (*Schizachyrium maritimum*). Salt marsh is distinguished from coastal berm by the absence of the upland shrub species such as joewood (*Jacquinia keyensis*), Florida Keys blackbead (*Pithecellobium keyense*), and others. In its early developmental stages, coastal interdunal swale may be subject to periodic inundation by salt water and share some species with salt marsh, such as seashore paspalum and marsh fimbry, but as the dunes around it build up and it is cut off from the sea, the swale

becomes dominated by freshwater species, such as hairawn muhly (*Muhlenbergia capillaris*).¹⁹¹ Salt marsh is distinguished from mangrove swamp by the predominance of herbaceous, rather than woody, species.

Management Considerations: Currently about 65 percent of the total area of salt marsh in the state is protected on conservation lands and aquatic preserves. Although large expanses of salt marsh remain in natural condition along the coasts of the Big Bend, northeast Florida, and the Everglades, many marshes closer to population centers have been destroyed by bulkheading and filling, or impacted by ditching and impoundment for mosquito control. The state originally held title to all salt marshes as sovereign submerged lands but sale to private owners was encouraged prior to the 1960s before the value of marshes to marine life was recognized.^{152,348} Close to half the area of salt marsh fringing Charlotte Harbor and Tampa Bay was lost to development between 1950 and 1980. Along with loss of marshes came loss of adjacent seagrass beds, due in part to the increased turbidity of the water caused by the reduction in sediment filtration that the marsh once provided.¹⁵¹

Many salt marshes along the east coast south of Jacksonville were ditched and/or impounded for mosquito control in the 1940s, denying female salt marsh mosquitoes (*Aedes taeniorhynchus*, *A. sollicitans*) the damp mud surface they require for egg laying. Salt marsh plants, however, cannot tolerate permanent flooding and die when the marsh is impounded. Most of the publicly-owned marshes in Brevard and Volusia counties have since been re-opened to tidal flushing. Some of these areas have re-established to salt marsh, but others have lost too much sediment for marsh plants to re-colonize.³¹⁵

Pesticides sprayed on marshes to control mosquitoes adversely affect the marsh food chain. Changes in the east coast marshes resulting from these various mosquito control measures contributed to the extinction of the dusky seaside sparrow (*Ammodramus maritimus nigrescens*) on Merritt Island and the reduction in range of MacGillivray's seaside sparrow south of the St. Johns River.³³¹ Salt marshes in the Everglades and Big Bend region have not been as heavily impacted, but human population growth is increasing north of Tampa and on the northeast coast, and pressure for marinas, coastal development, and mosquito control will follow.¹⁵¹

Prescribed burns have traditionally been used in salt marshes to provide tender shoots as food for geese and other wildlife and to decrease the possibility of wildfires. Fire should be used with caution in marshes so as not to cause destructive peat fires or adversely affect rare bird or other species dependent on the marsh habitat for nesting and foraging.²⁹⁶

Sea level rise is already affecting salt marsh distribution in at least one portion of Florida. Along the broad, flat Big Bend coast, sea level rise has led to the invasion of marsh grasses into the lower parts of the hammock islands that dot these marshes. These islands are dominated by sand live oak (*Quercus geminata*), slash pine (*Pinus elliottii*), red cedar (*Juniperus virginiana*), and cabbage palm (*Sabal palmetto*). The presence of former islands is marked by groups of trunks of dead cabbage palms (the most salt tolerant of the upland trees) standing in the middle of what is now salt marsh.⁴⁴⁰

Exemplary Sites: St. Marks National Wildlife Refuge, Big Bend Wildlife Management Area, Lower Suwannee National Wildlife Refuge, Nassau River - St. Johns River Marshes Aquatic Preserve, Everglades National Park, Florida Keys Wildlife and Environmental Area (Lower Sugarloaf Key)

Global and State Ranks: G4/S4

Crosswalk and Synonyms:

Davis	9/Coastal marsh
SCS	18/Salt Marsh
Myers and Ewel	Salt Marshes
FLUCCS	642/Saltwater Marshes

Other synonyms: tidal marsh¹²⁶; saltmarsh; coastal wetlands; tidal wetlands; saltern



Timucuan Ecological and Historic Preserve (Duval County; salt marsh cordgrass in foreground)

Photo by Gary Schultz



Florida Keys Wildlife and Environmental Area (Monroe County)

Photo by Amy Jenkins

Mangrove Swamp

Description: Mangrove swamp is 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*). 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.²⁹⁸ 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.²⁹⁹

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). Mangrove swamps often exist with no understory, although shrubs such as seaside oxeye (*Borrchia 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.

Mangrove swamp occurs in flat coastal areas along saline or brackish portions of rivers, the edges of low-energy estuaries,⁴⁴⁴ and the seaward fringes of salt marshes and rockland hammocks. Soils are generally anaerobic and are saturated with brackish water at all times, becoming inundated during high tides. Mangrove 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.²⁹⁹ In older

mangrove swamps containing red mangroves, a layer of peat can build up from decaying plant material (mostly red and black mangrove roots), covering the soil.²⁹⁹

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

Rare Species: Rare plants occurring within mangrove 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. Mangrove 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 (*Platalea ajaja*), 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 mangrove swamp include mangrove long-horned beetle (*Heterachthes sablensis*), tropical buckeye butterfly (*Junonia evarete*), and mangrove root crab (*Goniopsis cruentata*).

Range: Within the United States, mangrove swamps are common along the Gulf of Mexico coastline, in the tropical latitudes (south of Latitude 27) of Florida and Texas.²⁹⁹ 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 mangrove swamp, most of which occurs in the southern peninsula.²⁹⁸ Nearly two-thirds of the mangrove swamp in Florida occurs within Everglades National Park.³⁰³ Mangrove swamps in Florida occur along both coasts where they are buffered by barrier island formations. Mangrove 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 less 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.^{298,446} 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.²⁵⁷ Scattered, populations exist northward from the Keys along the Atlantic coastline to Merritt Island and to Hernando County on the west coast.²⁸⁸

Natural Processes: 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 have adapted to saltwater environments by either excluding or excreting salt from plant tissues.²⁹⁸ These specializations allow 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.⁵⁵ 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.²⁹⁸

Water fluctuations, both fresh- and saltwater, 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.²⁹⁸ 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.²⁹⁸ Waves along high energy coastlines discourage mangrove establishment and reduce anaerobic sediment accumulation, in which mangroves thrive.²⁹⁸

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.²⁹⁸ 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.²⁹⁸ 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, mangrove swamps are generally among the most productive forests in the world.²⁹⁸

In addition to providing habitat for many rare species (listed above), mangrove 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.^{172,398} Mangrove swamps and isolated mangrove islands also provide important roosting and nesting areas for substantial populations of wading birds and shorebirds.

Though mangrove swamps help protect other inland communities by absorbing the brunt of tropical storms and hurricanes and by preventing coastal erosion,^{9,397} these storm events and periodic freezing temperatures have an influence on the stature of mangrove species and generally drive succession within mangrove swamps.^{303,378} Often when canopy damage is incurred following a storm event, new mangrove propagules regenerate in their place.³⁷⁸ However, there are examples in Everglades National Park where, after catastrophic storm events, mangrove swamp areas do not always regenerate to their historical state. Following the catastrophic damage caused by Hurricane Donna in 1960, areas of former mangrove swamp remained for decades as mud flats.³⁷⁸ 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. Mangrove swamps are especially vulnerable to climate change impacts such as rising sea levels and the increasing intensity and frequency of tropical weather systems.⁸⁸

Community Variations: Lugo and Snedaker²⁵² recognized several variations of mangrove 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) mangrove 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.

Salt flats or barrens can form within mangrove 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.²⁹⁸

One common variant of mangrove swamp occurs within Florida.

Variant: BUTTONWOOD FOREST – Forests dominated by buttonwood often exist in upper tidal areas, especially where mangrove 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*). Extensive well-developed buttonwood forests are common along Florida Bay.

Associated Communities: Mangrove swamps are closely associated with, and often grade into, seagrass beds, unconsolidated substrate, salt 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 mangrove swamps. Extensive areas of mangrove swamp in South Florida, most notably along the southwest coast, exist in close association with salt marsh community.²⁹⁹ Salt marshes can occur intermixed with mangrove swamp³⁰³ and are often found along the inland boundary of mangrove swamps. While they are dominated by graminoids, salt 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 mangrove 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 mangrove swamp by its extensive exposed limestone. Tropical hardwood species occupy coastal berm, rockland hammock, and shell mound, communities which may be surrounded by mangrove 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 mangrove swamp such as joewood (*Jacquinia keyensis*) and pride-of-big-pine (*Strumpfia maritima*). Mangrove swamps do not develop in freshwater systems where mangrove species are easily outcompeted by other woody plants.²⁹⁸

Management Considerations: Mangrove 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 mangrove swamps are old mosquito ditches that drain water from a swamp and alter its hydrology. Mangroves may perish if their root systems are permanently flooded or covered with fill dirt for an extended period of time, depriving the roots of adequate oxygen.²⁹⁸ 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.³⁹⁹ 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 mangrove swamp areas and the invasion by non-mangrove and non-native species. Mangrove 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 mangrove swamp community function is difficult and considerable time is required before faunal species reestablish themselves.⁹ Restoring tidal flow and natural hydrology to mangrove swamps can include dike removal and/or reconnecting the swamp to tidal flow via culverts. The best management practices include preventing further destruction of existing mangrove swamps and maintaining a natural flow of fresh and salt water into these areas.

Exemplary 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



Florida Keys Wildlife and Environmental Area (Monroe County)

Photo by Amy Jenkins

Keys Tidal Rock Barren

Description: Keys tidal rock barren is a flat rockland in the supratidal zone with much exposed and eroded limestone and a sparse cover of stunted halophytic herbs and shrubs. The limestone has a white color, in contrast to the grey or black color of the limestone exposed in lower tidal zones,³⁸⁹ and it is inundated by salt water only during the extreme equinoctial high tides.³⁴⁵ The amount of exposed rock varies from practically zero to over fifty percent of the area. Patches of low, salt-tolerant herbaceous species include seaside oxeye (*Borrchia frutescens* and *B. arborescens*), perennial glasswort (*Sarcocornia perennis*), saltwort (*Batis maritima*), shoregrass (*Monanthochloe littoralis*), saltgrass (*Distichlis spicata*), seashore dropseed (*Sporobolus virginicus*), and marsh fimbry (*Fimbristylis spadicea*). Buttonwood (*Conocarpus erectus*) is the dominant woody plant. It varies from stunted, sprawling, multi-stemmed shrubs to tree size. Other typical woody species are red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), and christmasberry (*Lycium carolinianum*). At the transition to upland vegetation, buttonwood may be joined by a variety of shrubs and stunted trees of inland woody species, including saffron plum (*Sideroxylon celastrinum*), wild cotton (*Gossypium hirsutum*), Florida Keys blackbead (*Pithecellobium keyense*), bay cedar (*Suriana maritima*), white indigoberry (*Randia aculeata*), wild dilly (*Manilkara jaimiqui*), poisonwood (*Metopium toxiferum*), joewood (*Jacquinia keyensis*), Florida mayten (*Maytenus phyllanthoides*), and barbed-wire cactus (*Acanthocereus tetragonus*).

Characteristic Set of Species: buttonwood, christmasberry, perennial glasswort, saltwort, seashore dropseed, shoregrass

Rare Species: Rare plants on Keys tidal rock barren include joewood (*Jacquinia keyensis*) and Florida semaphore cactus (*Opuntia corallicola*).

Range: Keys tidal rock barren is confined to the Florida Keys on limestone bedrock along shores facing both Florida Bay and the Straits of Florida.

Natural Processes: Keys tidal rock barren occurs above the daily tidal range, but is subject to flooding by seawater during extreme tides and storm events. Salt spray from coastal winds, as well as shallow soils, may limit height growth of woody plants. Aside from bare rock substrate, discontinuous patches of thin marl soils may be present. Depressions with deeper peat and mud soils support mangrove swamp and salt marsh communities, dominated respectively by mangroves or Gulf cordgrass (*Spartina spartinae*).³⁴⁵ Fires are rare to non-existent in this community.

Community Variations: Salt-tolerant grasses (e.g., seashore dropseed, shoregrass, saltgrass) tend to form the dominant herbaceous component in the supratidal portions of this community in the Lower Keys, whereas succulent halophytes (e.g., saltwort, shoreline perennial glasswort, seaside oxeye) are more prevalent in the Upper Keys. Ross et al.³⁴⁵ attribute this difference to differences in salinity, with the less permeable Miami oolite keeping the Lower Keys rock barrens less saline than rock barrens on the more permeable Key Largo limestone of the Upper Keys.

Associated Communities: At its seaward edge, Keys tidal rock barren borders regularly inundated mangrove swamp. Areas with greater than 50 percent cover of red and black mangroves, either normal height or dwarfed, are considered mangrove swamp; areas with less than 50 percent cover of mangroves are Keys tidal rock barren. Keys tidal rock barren may also border salt marsh dominated by Gulf cordgrass, usually found growing on mud in depressions in the upper tidal zone.³⁴⁵ At its upper inland limit, Keys tidal rock barren often borders the thorn scrub variant of rockland hammock, which, though it may have buttonwood, is mainly dominated by non-halophytic woody species such as blolly (*Guapira discolor*), Florida Keys blackbead (*Pithecellobium keyense*), bayleaf capertree (*Capparis flexuosa*), poisonwood (*Metopium toxiferum*), and brittle thatch palm (*Thrinax morrisii*). In other situations Keys tidal rock barren may grade directly into rockland hammock communities with a well-developed forest structure, or into pine rockland.

Management Considerations: Ditches cut into the limestone rock for mosquito control are now prevalent in this community, as well as in the salt marsh and mangrove swamp communities. These may have had the effect of smoothing out the salinity variations in this supratidal zone by draining off salt water after storms and allowing salt water to penetrate further inland on normal tides; such ditching should be avoided, or at least kept to a minimum, in the future.

Exemplary Sites: Florida Keys Wildlife and Environmental Area, especially coastal areas of Sugarloaf Key south of US 1 (Monroe County), Dagny Johnson Key Largo Hammock Botanical State Park (Monroe County), Curry Hammock State Park (Monroe County), Lignumvitae Key Botanical State Park (Monroe County)

Global and State Rank: G3/S3?

Crosswalk and Synonyms: The community formerly known as “coastal rock barren” has been split into an upland community called “Keys cactus barren” and a tidally influenced community called “Keys tidal rock barren.”

Kuchler	105/mangrove
Davis	9/mangrove swamp forests and coastal marshes
SCS	14/ tropical hammocks
	19/mangrove
Myers and Ewel	south Florida rockland
SAF	106/mangrove
FLUCCS	642/saltwater marshes
	651/tidal flats
Whitney	beach dune systems-coastal rock barren

Other synonyms: exposed rocky platform-white zone³⁸⁹; succulent supratidal scrub and graminoid supratidal scrub³⁴⁵; coastal rock barren¹²⁶

LACUSTRINE — Non-flowing wetlands of natural depressions lacking persistent emergent vegetation except around the perimeter.

**Lacustrine communities are unchanged from the 1990 Guide*

Clastic Upland Lake

Description: Clastic Upland Lakes are shallow to relatively deep, irregular- shaped depressions or basins occurring in uplands on clay substrates. They are lentic water bodies with surface inflows but often without significant outflows. Water is generally dissipated through evaporation and transpiration, but it may also disappear, especially during prolonged droughts, through sinks that connect with the aquifer.

Vegetation varies substantially in Clastic Upland Lakes. Some portions of the water's edge may be dominated by hydrophytic shrubs, such as common buttonbush (*Cephalanthus occidentalis*), Virginia willow (*Itea virginica*), wax myrtle (*Myrica cerifera*), St. John's wort (*Hypericum* spp.), Peruvian primrosewillow (*Ludwigia peruviana*), elderberry (*Sambucus nigra* ssp. *canadensis*), sweet pepperbush (*Clethra alnifolia*), black titi (*Cliftonia monophylla*), eastern swampprivet (*Forestiera acuminata*), Carolina ash (*Fraxinus caroliniana*), American witchhazel (*Hamamelis virginiana*), large gallberry (*Ilex coriacea*), and swamp doghobble (*Leucothoe racemosa*). Other shorelines may be vegetated with sedges (*Cyperus* spp.), grasses (Poaceae), and rushes (*Juncus* spp.); or they may be dominated by hydrophytic trees, such as bald cypress (*Taxodium distichum*), water hickory (*Carya aquatica*), water oak (*Quercus nigra*), laurel oak (*Quercus hemisphaerica*), planer tree (*Planera aquatica*), sweetbay (*Magnolia virginiana*), red bay (*Persea borbonia*), sweetgum (*Liquidambar styraciflua*), water locust (*Gleditsia aquatica*), red maple (*Acer rubrum*), loblolly bay (*Gordonia lasianthus*), and blackgum (*Nyssa sylvatica*). Shallow water zones of Clastic Upland Lakes are generally densely vegetated by concentric bands of emergents, floating, and submersed aquatics, including pickerelweed (*Pontederia cordata*), arrowheads (*Sagittaria* spp.), yellow waterlily (*Nymphaea mexicana*), American lotus (*Nelumbo lutea*), pondlilies (*Nuphar* spp.), white waterlily (*Nymphaea odorata*), coontail (*Ceratophyllum demersum*), water milfoil (*Myriophyllum* spp.), bladderworts (*Utricularia* spp.), Carolina fanwort (*Cabomba caroliniana*), and pondweed (*Potamogeton* spp.).

Typical animals include Florida gar (*Lepisosteus platyrhincus*), bowfin (*Amia calva*), threadfin shad (*Dorosoma petenense*), chain pickerel (*Esox niger*), golden shiner (*Notemigonus crysoleucas*), ironcolor shiner (*Notropis chalybaeus*), redeye chub (*Notropis harperi*), yellow bullhead (*Ameiurus natalis*), brown bullhead (*Ameiurus nebulosus*), pirate perch (*Aphredoderus sayanus*), golden topminnow (*Fundulus chrysotus*), lined topminnow (*Fundulus lineolatus*), pygmy killifish (*Leptolucania ommata*), western mosquitofish (*Gambusia affinis*), least killifish (*Heterandria formosa*), brook silverside (*Labidesthes sicculus*), flier (*Centrarchus macropterus*), Okefenokee pygmy sunfish (*Elassoma okefenokee*), bluespotted sunfish (*Enneacanthus gloriosus*), warmouth (*Lepomis gulosus*), bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), swamp darter (*Etheostoma fusiforme*), two-toed amphiuma (*Amphiuma means*), eastern newt (*Notophthalmus viridescens*), sirens (*Siren* spp), southern cricket frog (*Acris gryllus*), bullfrog (*Rana catesbeiana*), pig frog (*Rana grylio*), southern leopard frog (*Rana sphenoccephala*), American alligator (*Alligator mississippiensis*), common snapping turtle (*Chelydra serpentina*), Florida cooter (*Pseudemys floridana*), yellow-bellied slider (*Trachemys scripta scripta*), eastern mud turtle (*Kinosternon subrubrum*), common musk turtle (*Sternotherus odoratus*), Florida softshell turtle (*Apalone floridana*), mud snake (*Farancia abacura*), Mississippi green water snake (*Nerodia cyclopion*), banded water snake (*Nerodia fasciata*), common garter snake (*Thamnophis sirtalis*), cottonmouth (*Agkistrodon piscivorus*), great blue heron (*Ardea herodias*), great egret (*Ardea alba*), snowy egret (*Egretta thula*), little blue heron (*Egretta caerulea*), green heron (*Butorides virescens*), white ibis (*Eudocimus albus*), wood stork (*Mycteria americana*), belted kingfisher (*Megaceryle alcyon*), beaver (*Castor canadensis*), and North American river otter (*Lutra canadensis*).

Clastic Upland Lakes generally have clay and organic substrates. Their water is characteristically clear to colored, circumneutral to slightly acidic, and soft with a low mineral content (particularly sodium, chloride, and sulfate). Clastic Upland Lakes may be oligo-mesotrophic, with relatively low nutrient levels, to eutrophic, with very high nutrient levels, depending upon their geologic age and nutrient supplements from the surrounding uplands.

Clastic Upland Lakes are important breeding areas for many terrestrial and semi-aquatic amphibians. They are frequently very important feeding and nesting areas for many wading birds, ducks, reptiles, and fish. Clastic Upland Lakes are vulnerable to hydrological manipulations which permanently lower the water levels and hasten

successional processes, and those which prevent periodic dry-downs and hasten eutrophication. They are also vulnerable to various activities in the surrounding uplands. Land clearing and timber harvests on the adjacent uplands generally increase sedimentation rates and, therefore, successional processes. Residential, agricultural, and industrial development within a lake's drainage basin generally increases pollution levels and accelerates eutrophication, which could be extremely detrimental to fish and other aquatic organisms. Human-related manipulations and activities within the drainage basin must be adequately controlled to avoid detrimental repercussions to these important communities.

Global and State Ranks: G3/S2

Crosswalk and Synonyms: clay-bottomed lake, silt-bottomed lake, fluctuating or disappearing lake, deep water lake, limesink

Coastal Dune Lake

Description: Coastal Dune Lakes are shallow irregularly shaped or elliptic depressions occurring in coastal communities. They are generally permanent water bodies, although water levels may fluctuate substantially. They are typically lentic water bodies without significant surface inflows or outflows. Instead, water is largely derived from lateral ground water seepage through the surrounding well-drained coastal sands. Storms occasionally provide large inputs of salt water and salinities vary dramatically over the long term.

Vegetation may be largely restricted to a narrow band along the shore, composed of hydrophytic grasses and herbs or a dense shrub thicket, depending on fire frequency and/or water fluctuations. Shallow, gradually sloping shorelines may have much broader bands of emergent vegetation with submersed aquatic plants occasionally dominating much of the surface. Typical plants include rushes (*Juncus* spp.), sedges (*Cyperus* spp.), manyflower marshpennywort (*Hydrocotyle umbellata*), cattails (*Typha* spp.), sawgrass (*Cladium jamaicense*), waterlilies (*Nymphaea* spp.), watershield (*Brasenia schreberi*), royal fern (*Osmunda regalis* var. *spectabilis*), camphorweed (*Pluchea* spp.), marshelder (*Iva frutescens*), groundsel tree (*Baccharis halimifolia*), and black willow (*Salix nigra*). Typical animals include western mosquitofish (*Gambusia affinis*), sailfin molly (*Poecilia latipinna*), American alligator (*Alligator mississippiensis*), eastern mud turtle (*Kinosternon subrubrum*), saltmarsh snake (*Nerodia clarkii* spp.), little blue heron (*Egretta caerulea*), American coot (*Fulica americana*), and North American river otter (*Lutra canadensis*).

The substrate of Coastal Dune Lakes is primarily composed of sands with organic deposits increasing with water depth. Coastal Dune Lakes characteristically have slightly acidic, hard water with high mineral content, predominately sodium and chloride. Salinity levels often vary greatly, depending on local rainfall and storms. They are generally oligotrophic with low nutrient levels.

Coastal Dune Lakes develop from various coastal processes. They most commonly begin as a tidally influenced basin or lagoon that becomes closed by sand filling its inlet. Once isolated from the direct effects of tides, the water may become hypersaline, as salt water intrusion occurs readily through the sandy substrates, and the surface water evaporates rapidly. With further isolation from subsurface and overwash saltwater intrusion, the water gradually becomes less saline, but still varies considerably with local weather conditions.

Coastal Dune Lakes are very unusual coastal features, being relatively short-lived and likely to disappear rapidly. They are important breeding areas for many insects that form the base of numerous food chains. They may also be important watering holes for many mammals and birds inhabiting the surrounding xeric and coastal communities. Wading birds and ducks may also use these lakes as feeding and resting areas.

Coastal Dune Lakes are extremely vulnerable to hydrological manipulations. Excessive withdrawals of ground water could lower local water tables or increase salt water intrusion and, thus, induce successional responses in the lake basin. Groundwater pollution, especially from misapplications of chemicals on the surrounding coastal communities, could significantly alter the nutrient balance and produce devastating effects on the fauna and flora.

Global and State Ranks: G2/S1

Crosswalk and Synonyms: lagoon, sand-bottomed lake, silt-bottomed lake, oligotrophic lake, coastal lake

Coastal Rockland Lake

Description: Coastal Rockland Lakes are "bare bottom" lacustrine systems of diminutive size with severely limited numbers and range (primarily confined to Monroe County). Lithophytic algae may occur sparsely on the limestone substrate that may be one of two types. In the Upper Keys from the northeast to approximately Big Pine Key, Miami limestone is prevalent, while west of this point a geologic shift to oolite occurs. The significance of this shift is not well known. Also characteristic of this community type are highly variable salinity ranges caused by saltwater intrusion and storm surges introducing saltwater into the system. The water is generally alkaline due to the limestone substrate and has a high mineral content.

Although this Natural Community is generally sparsely vegetated, it is critical in supporting an assortment of animals in the Keys. Typical animals associated with these communities include Florida Keys sheepshead minnow (*Cyprinodon cf. variegatus*) and Florida Keys sailfin molly (*Poecilia cf. latipinna*). The rare Key deer (*Odocoileus virginianus clavium*) and other terrestrial fauna are thought to be dependent on Coastal Rockland Lakes for drinking water. Coastal Rockland Lakes are generally surrounded by Mangrove Swamp, Pine Rockland, or Rockland Hammock, depending on the proximity to the shoreline and the elevation of the surrounding ground.

Management of these systems requires protection of the essential fresh groundwater lens that floats above the denser saline groundwater. Protection of the surrounding vegetated communities is also desirable to maintain the association between the terrestrial and avian fauna dependent on Coastal Rockland Lakes.

The primary threat to Coastal Rockland Lakes is development. Even limited use of the groundwater in the vicinity of this natural community may lead to elimination of the freshwater lens. Although less common than residential and commercial development in the Keys, rock mining activities occur in close proximity to Coastal Rockland Lakes and can destroy an entire cluster in a very limited time. The estimated number of Coastal Rockland Lakes thought to occur in Florida is very deceptive in that they are often clustered and the range is extremely limited. Therefore, detrimental activities at one location could eliminate as much as 10 to 20 percent of the total number of Coastal Rockland Lakes.

Global and State Ranks: G2/S1

Crosswalk and Synonyms:

Flatwoods/Prairie Lake and Marsh Lake

Description: The distinctions between these communities, and from Depression Marsh, are often quite subtle, because of their successional interrelationships. Depression Marsh is characterized as a shallow, generally round or elliptical depression vegetated with concentric bands of hydrophytic herbaceous plants. Depending upon the depth and slope of the depression, an open water zone with or without floating plants may occur at the center. The open water zone is considered to be a Marsh Lake if it is small in comparison to the surrounding marsh. Otherwise, the system is considered to be a Flatwoods Lake or a Prairie Lake, depending upon the surrounding community.

Both Flatwoods Lake and Prairie Lake are surrounded by either a sparse, Wet Prairie-like zone or a dense ring of saw palmetto (*Serenoa repens*) and other shrubs. Typical plants include spikerush (*Eleocharis* spp.), yellow-eyed grasses (*Xyris* spp.), St. John's wort (*Hypericum* spp.), chain fern (*Woodwardia* spp.), coastalplain willow (*Salix caroliniana*), maidencane (*Panicum hemitomon*), wax myrtle (*Myrica cerifera*), creeping primrosewillow (*Ludwigia repens*), big floatingheart (*Nymphoides aquatica*), common buttonbush (*Cephalanthus occidentalis*), alligatorflag (*Thalia geniculata*), pickerelweed (*Pontederia cordata*), arrowheads (*Sagittaria* spp.), bladderworts (*Utricularia* spp.), bottlebrush threeawn (*Aristida spiciformis*), toothache grass (*Ctenium aromaticum*), white-top sedge (*Rhynchospora latifolia*), bulrushes (*Scirpus* spp.), sawgrass (*Cladium jamaicense*), and yellow nutgrass (*Cyperus esculentus*). Many animals utilize marshes primarily for feeding and breeding areas but spend most of their time in other habitats. Other animals are more dependent on marshes, spending most of their time within them. Typical animals include two-toed amphiuma (*Amphiuma means*), lesser siren (*Siren intermedia*), greater siren (*Siren lacertina*), southern cricket frog (*Acris gryllus*), green treefrog (*Hyla cinerea*), bullfrog (*Rana catesbeiana*), pig frog (*Rana grylio*), southern leopard frog (*Rana sphenoccephala*), American alligator (*Alligator mississippiensis*), eastern mud snake (*Farancia abacura*), banded water snake (*Nerodia fasciata*), Mississippi green water snake (*Nerodia*

cyclopion), striped crayfish snake (*Regina alleni*), black swamp snake (*Seminatrix pygaea*), American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), great blue heron (*Ardea herodias*), great egret (*Ardea alba*), snowy egret (*Egretta thula*), little blue heron (*Egretta caerulea*), tricolored heron (*Egretta tricolor*), green heron (*Butorides virescens*), black-crowned night-heron (*Nycticorax nycticorax*), white ibis (*Eudocimus albus*), glossy ibis (*Plegadis falcinellus*), bald eagle (*Haliaeetus leucocephalus*), northern harrier (*Circus cyaneus*), king rail (*Rallus elegans*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), limpkin (*Aramus guarauna*), marsh wren (*Cistothorus palustris*), common yellowthroat (*Geothlypis trichas*), red-winged blackbird (*Agelaius phoeniceus*), boat-tailed grackle (*Quiscalus major*), and round-tailed muskrat (*Neofiber alleni*).

The depressions in which these communities develop are typically formed by one of two geological processes: (1) solution holes form in the underlying limestone, causing surface sands to slump into a circular depression; or (2) during higher sea levels, offshore currents, waves, and winds scoured depressions that became seasonally or permanently inundated after the seas regressed. Soils in these depressions generally consist of acidic sands with some peat and occasionally a clay lens.

Water is derived mostly from runoff from the immediately surrounding uplands. These NC's function as aquifer recharge areas by acting as reservoirs which release groundwater when adjacent water tables drop during drought periods. Water generally remains throughout the year in a Flatwoods/Prairie Lake or a Marsh Lake, although water levels may fluctuate substantially.

Global and State Ranks: Flatwoods/Prairie Lake - G4/S3
Marsh Lake - G4/S4

Crosswalk and Synonyms: Flatwoods pond, ephemeral pond, grass pond, St. John's wort pond, freshwater lake, pineland depression, swale, prairie pond

River Floodplain Lake and Swamp Lake

Description: Swamp Lakes and River Floodplain Lakes are shallow open water zones, with or without floating and submerged aquatic plants that are surrounded by Basin Swamp or Floodplain Swamp. They are generally permanent water bodies, although water levels often fluctuate substantially and they may become completely dry during extreme droughts. They are typically lentic water bodies occurring in confined basins or depressions. However, during floods or following heavy rains, they may exhibit decidedly lotic characteristics, flowing with the flood water or overflowing their banks into lower topographic areas. Some may even exhibit a slow perennial sheet flow, but water movement is generally so slow that lentic conditions prevail.

Except for the fringe of hydrophytic trees, shrubs and scattered emergents, plants may be absent altogether, or they may almost completely cover the water surface. When present, typical plants include white waterlily (*Nymphaea odorata*), yellow waterlily (*Nymphaea mexicana*), American lotus (*Nelumbo lutea*), pondlilies (*Nuphar* spp.), duckweed (*Lemna* spp.), watermeal (*Wolffia* spp.), mudmidget (*Wolffiella* spp.), water spangles (*Salvinia minima*), watershield (*Brasenia schreberi*), frog's bit (*Limnobium spongia*), waterhyssop (*Bacopa* spp.), marshpennywort (*Hydrocotyle* spp.), coontail (*Ceratophyllum demersum*), water milfoil (*Myriophyllum* spp.), bladderwort (*Utricularia* spp.), stream bogmoss (*Mayaca fluviatilis*), and Carolina fanwort (*Cabomba caroliniana*). Several exotic plants may also occur, including water-lettuce (*Pistia stratiotes*), water hyacinth (*Eichhornia crassipes*), water spangles, alligator weed (*Alternanthera philoxeroides*), water spinach (*Ipomoea aquatica*), parrot feather water milfoil (*Myriophyllum aquaticum*), watersprite (*Ceratopteris thalictroides*), hydrilla (*Hydrilla verticillata*), and Canadian waterweed (*Elodea canadensis*). Scattered emergent plants such as lizard's tail (*Saururus cernuus*), pickerelweed (*Pontederia cordata*), slender spikerush (*Eleocharis* spp.) and goldenclub (*Orontium aquaticum*) may also occur, but the community will more appropriately be called Depression Marsh or Floodplain Marsh if emergents dominate the water body.

Typical animals include Florida gar (*Lepisosteus platyrhincus*), bowfin (*Amia calva*), redfin pickerel (*Esox americanus americanus*), golden shiner (*Notemigonus crysoleucas*), taillight shiner (*Notropis maculatus*), lake chubsucker (*Erimyzon sucetta*), brown bullhead (*Ameiurus nebulosus*), tadpole madtom (*Noturus gyrinus*), pirate perch (*Aphredoderus sayanus*), golden topminnow (*Fundulus chrysotus*), pygmy killifish (*Leptolucania ommata*), western mosquitofish (*Gambusia affinis*), flier (*Centrarchus macropterus*), spot (*Leiostomus xanthurus*), bluegill

(*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), swamp darter (*Etheostoma fusiforme*), mole salamander (*Ambystoma talpoideum*), two-toed amphiuma (*Amphiuma means*), Alabama waterdog (*Necturus alabamensis*), sirens (*Siren* spp.), southern cricket frog (*Acris gryllus*), bullfrog (*Rana catesbeiana*), pig frog (*Rana grylio*), river frog (*Rana heckscheri*), southern leopard frog (*Rana sphenoccephala*), American alligator (*Alligator mississippiensis*), common snapping turtle (*Chelydra serpentina*), Florida cooter (*Pseudemys floridana*), yellow-bellied slider (*Trachemys scripta scripta*), eastern mud turtle (*Kinosternon subrubrum*), common musk turtle (*Sternotherus odoratus*), Florida softshell turtle (*Apalone floridana*), mud snake (*Farancia abacura*), plainbelly watersnake (*Nerodia erythrogaster*), banded water snake (*Nerodia fasciata*), brown water snake (*Nerodia taxispilota*), cottonmouth (*Agkistrodon piscivorus*), great blue heron (*Ardea herodias*), great egret (*Ardea alba*), snowy egret (*Egretta thula*), little blue heron (*Egretta caerulea*), green heron (*Butorides virescens*), white ibis (*Eudocimus albus*), wood stork (*Mycteria americana*), belted kingfisher (*Megaceryle alcyon*), beaver (*Castor canadensis*), and North American river otter (*Lutra canadensis*).

The substrates of Swamp Lakes and River Floodplain Lakes are variable and may be composed primarily of peats, sands, alluvial clays, or any combination of these. Swamp Lakes characteristically have highly colored, acidic, soft water with moderate mineral content, while River Floodplain Lakes characteristically have colored, alkaline or slightly acidic, hard or moderately hard water with high mineral content (sulfate, chloride, calcium, magnesium). Both types are generally mesotrophic to eutrophic (i.e., have moderate to high nutrient levels and primary productivity), although they sometimes exhibit partial oligotrophic characteristics, with low nutrient levels and primary productivity, because their darkly stained, acidic waters and surrounding tree canopy limit their productivity.

Swamp Lakes may have originated from one or more of the following geological processes: (1) solution of the underlying limestone and subsequent collapse of the surface to form a depression; (2) lowering of sea levels to isolate ancient coastal features, such as lagoons or dune swales; or (3) isolation of ancient river systems within relatively confined basins. River Floodplain Lakes generally originate along former stream channels as oxbows that have been isolated when new channels cut across a meander loop in the river, or along erosion scours formed by the tremendous forces of floodstage waters. They may also have been influenced by some of the processes that developed Swamp Lakes, or be the result of "nature's engineer", the beaver (*Castor canadensis*).

Swamp Lakes and River Floodplain Lakes are important breeding areas for many terrestrial and semi-aquatic amphibians. They are frequently very important feeding areas for many wading birds, ducks, and reptiles. They are also important nursery grounds and habitats for several species of fish. Swamp Lakes and Floodplain Lakes are extremely vulnerable to hydrological manipulations which lower the water levels and hasten successional processes. They are also vulnerable to land clearing and timber harvest operations within the surrounding swamps or adjacent uplands. Upland activities generally increase sedimentation, while activities within the swamp may increase insolation levels, alter nutrient levels and, in the case of Floodplain Lakes, increase the effects of flood scouring.

Global and State Ranks: River Floodplain Lake - G4/S2
Swamp Lake - G4/S3

Crosswalk and Synonyms: cypress pond, gum pond, oxbow lake, backwater, blackwater lake or pond

Sandhill Upland Lake

Description: Sandhill Upland Lakes are shallow rounded solution depressions occurring in sandy upland communities. They are generally permanent water bodies, although water levels may fluctuate substantially, sometimes becoming completely dry during extreme droughts. They are typically lentic water bodies without significant surface inflows or outflows. Instead, water may be largely derived from lateral ground water seepage through the surrounding well-drained uplands and/or from artesian sources via connections with the underlying limestone aquifer.

Vegetation may be largely restricted to a narrow band along the shore, composed of hydrophytic grasses and herbs or a dense shrub thicket, depending on fire frequency and water fluctuations. Shallow, gradually sloping shorelines may have much broader bands of emergent vegetation with submerged aquatic plants occasionally dominating much of the water column; floating plants sometimes cover much of the surface. Typical plants include panic grasses

(*Panicum* spp.), rushes (*Juncus* spp.), bladderwort (*Utricularia* spp.), waterlily (*Nymphaea* spp.), sawgrass (*Cladium jamaicense*), pickerelweed (*Pontederia cordata*), white waterlily (*Nymphaea odorata*), watershield (*Brasenia schreberi*), St. John's worts (*Hypericum* spp.), arrowheads (*Sagittaria* spp.), beakrushes (*Rhynchospora* spp.), yellow-eyed grass (*Xyris* spp.), hatpins (*Eriocaulon* spp.), meadowbeauty (*Rhexia* spp.), sundews (*Drosera* spp.), and spikerush (*Eleocharis* spp.).

The substrate of Sandhill Upland Lakes is primarily composed of sands with organic deposits increasing with water depth. Sandhill Upland Lakes characteristically have clear, circumneutral to slightly acidic, moderately soft water with varying mineral content. They may be ultra-oligotrophic, with extremely low nutrient levels, seldom becoming eutrophic unless artificially fertilized by human-related activities.

Sandhill Upland Lakes are frequently extremely important breeding areas for terrestrial amphibians, including the threatened gopher frog (*Rana capito*), as well as many unusual or endemic insects. They are also important watering holes for many mammals and birds inhabiting the surrounding xeric communities. Wading birds and ducks may also use these lakes as feeding areas.

Sandhill Upland Lakes are extremely vulnerable to hydrological manipulations. Excessive municipal, industrial, or agricultural withdrawals of ground water could lower regional water tables and, thus, induce successional responses in the lake basin. Groundwater pollution, especially from misapplications of chemicals on the surrounding well-drained uplands, could significantly alter the nutrient balance and produce devastating effects on the fauna and flora. Furthermore, because they frequently have direct or indirect connections with the aquifer, Sandhill Upland Lakes often function as aquifer recharge areas and, thus, should be diligently protected from chemical pollution. Invasion by exotic species is also an important concern in Sandhill Upland Lake communities.

Global and State Ranks: G3/S2

Crosswalk and Synonyms: sand-bottomed lake, silt-bottomed lake, oligotrophic lake, sandhill lake

Sinkhole Lake

Description: Sinkhole Lakes occur typically in deep, funnel-shaped depressions in a limestone base. Although the depression is relatively permanent, water levels may fluctuate dramatically. These lakes are characterized by clear, alkaline, hard water with high mineral content, including calcium, bicarbonate, and magnesium. Although they occur in most physiographic regions, the major occurrences of this NC in the U.S. are in Florida, where they are moderately widespread in the karst regions. They provide habitat for many species also found in accompanying subterranean NCs. The vegetation in some Sinkhole Lakes may be conspicuously absent or limited to a narrow fringe of emergents at the edge of the water. Other Sinkhole Lakes are completely covered by floating plants. When they occur, typical plants include American cupscale (*Sacciolepis striata*), stream bogmoss (*Mayaca fluviatilis*), smartweed (*Polygonum* spp.), rushes (*Juncus* spp.), cattails (*Typha* spp.), bladderwort (*Utricularia* spp.), duckweed (*Lemna* spp.), watermeal (*Wolffia* spp.), Carolina mosquito fern (*Azolla caroliniana*), and water spangles (*Salvinia minima*). Typical animals include crayfish, isopods, amphipods, pirate perch (*Aphredoderus sayanus*), redeye chub (*Notropis harperi*), yellow bullhead (*Ameiurus natalis*), and eastern mud turtle (*Kinosternon subrubrum*).

Sinkhole Lakes are considered endangered in Florida. They are threatened by erosion which causes destruction of surrounding vegetation and to pollution and other threats to the aquifers with which they are connected.

Global and State Ranks: G3/S3

Crosswalk and Synonyms:

RIVERINE - Natural, flowing waters from their source to the downstream limits of tidal influence, and bounded by channel banks.

**Riverine communities are unchanged from the 1990 Guide*

Alluvial Stream

Description: Alluvial Streams are perennial or intermittent seasonal watercourses originating in high uplands that are primarily composed of sandy clays and clayey-silty sands. Because clay is a substantial component of these soils, surface runoff generally predominates over subsurface drainage. Thus, Alluvial Stream waters are typically turbid due to a high content of suspended particulates, including clays, silts, and sands, as well as detritus and other organic debris. Water temperatures may fluctuate substantially and are generally correlated with seasonal fluctuations in air temperature. Similarly, other water quality parameters vary substantially and generally fluctuate with seasonal rainfall patterns.

The most important characteristics of Alluvial Streams are the large range of flow rates and sediment loads encountered. Thus, water depth fluctuates substantially and is generally separated into two distinct stages, a normal or low flow stage and a flood or high flow stage. During the normal low flow stage the water is confined within the stream banks, while during flood stage the water overflows the banks and inundates the adjacent floodplain communities. Flood stages generally occur once or twice each year during winter or early spring and occasionally in summer.

Several important phenomena occur during floodstage. The flood waters transport detritus, minerals and nutrients from the surrounding uplands to the floodplain communities and beyond. This flushing action removes biological waste materials and simultaneously renourishes the floodplain communities. Most important, however, it provides a pulse of nutrient-rich water to the estuarine communities which occur where the stream empties into the sea. As the water spreads and moves more slowly over the broad floodplain communities, the heavy load of sediments, which was suspended by water currents, begins to settle. The heaviest sediments settle rapidly where the stream overflows its banks, causing a natural levee to develop. The flood waters are a controlling factor in the reproductive cycles of many aquatic and semi-aquatic organisms. The onset of flooding, or its subsequent regressions, stimulates some animals to breed and lay eggs, or it may induce the hatching of eggs and the development of larvae. The flood stage waters expand the feeding grounds and habitat of fish and other aquatic organisms that normally inhabit the main stream. The flood waters function as a primary dispersal mechanism for many organisms, transporting seeds and small animals to distant locations where they otherwise would probably not reach.

Very few rooted plants occur within the main channel of Alluvial Streams, largely because the high natural turbidity reduces available light for photosynthesis. Waterlilies (*Nymphaea* spp.), pondlilies (*Nuphar* spp.) and other floating-leaved plants occasionally occur along quiet stretches, while pickerelweed (*Pontederia cordata*), cattails (*Typha* spp.), and other emergents may fringe the banks. Willows (*Salix* spp.), cottonwood (*Populus* spp.), river birch (*Betula nigra*), silver maple (*Acer saccharinum*), and other trees typically occur along the banks and natural levees. Typical animals include American eel (*Anguilla rostrata*), gizzard shad (*Dorosoma cepedianum*), speckled chub (*Macrhybopsis aestivalis*), madtom (*Noturus* spp), pirate perch (*Aphredoderus sayanus*), striped bass (*Morone saxatilis*), redbreast sunfish (*Lepomis auritus*), warmouth (*Lepomis gulosus*), bluegill (*Lepomis macrochirus*), crappie (*Pomoxis* spp.), darters (*Ammocrypta*, *Crystallaria*, *Etheostoma*, and *Percina* spp.), Alabama waterdog (*Necturus alabamensis*), river frog (*Rana heckscheri*), American alligator (*Alligator mississippiensis*), common snapping turtle (*Chelydra serpentina*), alligator snapping turtle (*Macrochelys temminckii*), Florida cooter (*Pseudemys floridana*), river cooter (*Pseudemys concinna*), eastern mud turtle (*Kinosternon subrubrum*), common musk turtle (*Sternotherus odoratus*), brown water snake (*Nerodia taxispilota*), belted kingfisher (*Megaceryle alcyon*), Louisiana waterthrush (*Parkesia motacilla*), beaver (*Castor canadensis*), and North American river otter (*Lutra canadensis*).

Alluvial Streams are sparsely distributed in Florida, being primarily restricted to the northern panhandle. Nearly all have been degraded to some degree by disturbances within their watersheds. More serious damage can occur through physical alterations of their main channels, such as dredging, filling or damming. Damming poses the most serious threat, because it disrupts the natural flood cycle, traps upstream nutrients, and can lead to permanent loss of the floodplains due to longterm flooding of areas upstream of the dam. The adjacent floodplain communities are an essential and interrelated component of a viable Alluvial Stream community.

Global and State Ranks: G4/S2

Crosswalk and Synonyms: alluvial river, slow flowing river, deep river, muddy stream

Blackwater Stream

Description: Blackwater Streams are perennial or intermittent seasonal watercourses originating deep in sandy lowlands where extensive wetlands with organic soils function as reservoirs, collecting rainfall and discharging it slowly to the stream. The tea-colored waters of Blackwater Streams are laden with tannins, particulates, and dissolved organic matter and iron derived from drainage through swamps and marshes. They generally are acidic (pH = 4.0 - 6.0), but may become circumneutral or slightly alkaline during low-flow stages when influenced by alkaline groundwater. Water temperatures may fluctuate substantially and are generally correlated with seasonal fluctuations in air temperature. The dark-colored water reduces light penetration and, thus, inhibits photosynthesis and the growth of submerged aquatic plants. Emergent and floating aquatic vegetation may occur along shallower and slower moving sections, but their presence is often reduced because of typically steep banks and considerable seasonal fluctuations in water level. Typical plants include goldenclub (*Orontium aquaticum*), smartweed (*Polygonum* spp.), sedges (*Cyperus* spp.), and grasses (Poaceae). Typical animals include longnose gar (*Lepisosteus osseus*), gizzard shad (*Dorosoma cepedianum*), threadfin shad (*Dorosoma petenense*), redbfin pickerel (*Esox americanus americanus*), chain pickerel (*Esox niger*), ironcolor shiner (*Notropis chalybaeus*), Bannerfin shiner (*Cyprinella leedsi*), weed shiner (*Notropis texanus*), blacktail shiner (*Cyprinella venusta*), lake chubsucker (*Erimyzon sucetta*), channel catfish (*Ictalurus punctatus*), banded topminnow (*Fundulus cingulatus*), pygmy killifish (*Leptolucania ommata*), western mosquitofish (*Gambusia affinis*), mud sunfish (*Acantharchus pomotis*), flier (*Centrarchus macropterus*), Everglades pygmy sunfish (*Elassoma evergladei*), banded sunfish (*Enneacanthus obesus*), redbreast sunfish (*Lepomis auritus*), dollar sunfish (*Lepomis marginatus*), redear sunfish (*Lepomis microlophus*), spotted sunfish (*Lepomis punctatus*), black crappie (*Pomoxis nigromaculatus*), darters (*Ammocrypta*, *Crystallaria*, *Etheostoma*, and *Percina* spp.), Alabama waterdog (*Necturus alabamensis*), river frog (*Rana heckscheri*), American alligator (*Alligator mississippiensis*), common snapping turtle (*Chelydra serpentina*), alligator snapping turtle (*Macrochelys temminckii*), river cooter (*Pseudemys concinna*), Florida cooter (*Pseudemys floridana*), peninsula cooter (*Pseudemys peninsularis*), common musk turtle (*Sternotherus odoratus*), spiny softshell (*Apalone spinifera*), plainbelly watersnake (*Nerodia erythrogaster*), Florida watersnake (*Nerodia fasciata pictiventris*), beaver (*Castor canadensis*), and North American river otter (*Lutra canadensis*).

Blackwater Streams have sandy bottoms overlain by organics and frequently underlain by limestone. Limestone outcrops may also occur. Blackwater Streams generally lack the continuous extensive floodplains and natural levees of Alluvial Streams. Instead, they typically have high, steep banks alternating with Floodplain Swamps. High banks confine water movement except during major floods. The absence of significant quantities of suspended sediments reduces their ability to construct natural levees.

Blackwater Streams are the most widely distributed and numerous Riverine systems in the southeast Coastal Plain. Very few, however, have escaped major disturbances and alteration. Clearcutting adjacent forested lands is one of the more devastating alterations for this community. Additionally, the limited buffering capacity of Blackwater Streams intensifies the detrimental impacts of agricultural and industrial effluents.

Global and State Ranks: G4/S2

Crosswalk and Synonyms: blackwater river, blackwater creek

Seepage Stream

Description: Seepage Streams are perennial or intermittent seasonal water courses originating from shallow ground waters that have percolated through deep, sandy, upland soils. Seepage Streams typically have clear to lightly colored water maintained at fairly constant temperatures of around 70°F, and are relatively short, shallow, and narrow. Although a stream may be classified as a Seepage Stream along its entire length, they also form the

headwaters of many Alluvial and Blackwater Streams. After large sediment loads are picked up or after drainage through extensive swamps, water clarity is diminished and the stream is then classified as Alluvial or Blackwater.

Because they are generally sheltered by a dense overstory of broad-leaved hardwoods which block out most sunlight, Seepage Streams most often have depauperate aquatic floras. Filamentous green algae occur sporadically within the stream, while mosses, ferns and liverworts may grow in clumps at the water's edge. In the lower, broader reaches where insolation levels are sometimes greater, narrow bands of pondlily (*Nuphar* spp.), goldenclub (*Orontium aquaticum*), spikerush (*Eleocharis* spp.) and pondweed (*Potamogeton* spp.) may occur along the shorelines, and tapegrass (*Vallisneria americana*) and pondweed may grow in the streambed. Typical animals include sailfin shiner (*Pteronotrops hypselopterus*), creek chub (*Semotilus atromaculatus*), speckled madtom (*Noturus leptacanthus*), brown darter (*Etheostoma edwini*), blackbanded darter (*Percina nigrofasciata*), Alabama waterdog (*Necturus alabamensis*), southern dusky salamander (*Desmognathus auriculatus*), southern two-lined salamander (*Eurycea cirrigera*), mud salamander (*Pseudotriton montanus*), southern red salamander (*Pseudotriton ruber vioscai*), green frog (*Rana clamitans*), common snapping turtle (*Chelydra serpentina*), loggerhead musk turtle (*Sternotherus minor*), and rainbow snake (*Farancia erythrogramma*), plainbelly watersnake (*Nerodia erythrogaster*), Florida watersnake (*Nerodia fasciata pictiventris*).

Percolation through deep soils slows the release of rainwater, filters the water, and buffers temperature extremes. Thus, Seepage Streams often exhibit perennial, slow flow rates of clear, cool, unpolluted water. Seepage Streams generally have sandy bottoms, although clays, gravel and limestone may be prevalent along stretches where formations composed of these sediments are exposed. Additionally, deep organic deposits may accumulate near stream bends and in other low areas where the leaf litter is not washed away by currents.

Seepage Streams are generally confined to portions of the state where topographic relief is pronounced, especially in northern Florida. They are often associated with Seepage Slope and Slope Forest near their head waters, and Bottomland Forest, Alluvial Forest and Floodplain Swamp near their mouths. Seepage Streams are readily distinguished from other Florida stream communities by their small magnitude, lack of a deep aquifer water source, and the absence of extensive swamp lowlands surrounding their head waters.

A unique type of Seepage Stream, the steephead stream, develops by a rather unusual geologic process. Rainfall percolates through the deep sandy soils capping the surrounding uplands until it encounters impermeable clays or other non-porous sediments. Water then travels laterally until reaching the surface and producing a seepage area along a slope or a spring. The seepage waters begin to erode the hill's base and cause the overburden to slump. Thus, the steephead stream valley is largely a product of seepage erosion which begins primarily at the bottoms of valleys instead of at their tops. Consequently, the gradient of steephead streams is generally much lower than that of other upland streams in similar topography, because the head of a steephead stream is already near the bottom of a valley.

Seepage Streams may be threatened by various activities. Applications of fertilizers or biocides on the surrounding uplands, or dumping of hazardous wastes and other refuse within the drainage basin could pollute the shallow ground waters that feed the Seepage Streams. Deforestation of the surrounding slopes could increase surface erosion and cause excessive sedimentation of the stream valley, as well as increase insolation levels and cause the stream to become overgrown with shrubs or emergent herbaceous species. Impounding the stream would destroy much of the lotic habitat and restrict the upstream movements of aquatic animals. Because they are unique natural features of limited distribution within the state, Seepage Streams should be diligently protected from significant disturbances.

Global and State Ranks: G3/S2

Crosswalk and Synonyms: steephead stream, clear brook, swift brook, hammock stream

Spring-run Stream

Description: Spring-run Streams are perennial water courses that derive most, if not all, of their water from artesian openings in the underground aquifer. Waters issuing from the aquifer are generally clear, circumneutral to slightly alkaline (pH=7.0-8.2), and perennially cool (66-75°F). These conditions saturate the water with important minerals,

allow light to penetrate deeply, and reduce the limiting effects of environmental fluctuations, all of which are conducive for plant growth. Thus, Spring-run Streams are among the most productive aquatic habitats. Typical plants include tapegrass (*Vallisneria americana*), annual wild rice (*Zizania aquatica*), giant cutgrass (*Zizaniopsis miliacea*), arrowheads (*Sagittaria* spp.), southern naiads (*Najas quadalupensis*), pondweed (*Potamogeton* spp.), and chara (*Chara* spp.). Typical animals include mollusks, stoneflies, mayflies, caddisflies, simuliids, chironomids, American alligator (*Alligator mississippiensis*), alligator snapping turtle (*Macrochelys temminckii*), Suwannee cooter (*Pseudemys concinna suwanniensis*), loggerhead musk turtle (*Sternotherus minor*), rainbow snake (*Farancia erythrogramma*), plainbelly watersnake (*Nerodia erythrogaster*), Florida watersnake (*Nerodia fasciata pictiventris*), and many fishes.

Spring-run Streams generally have sand bottoms or exposed limestone along their central channel. Calcareous silts may form thick deposits in quiet shallow zones, while leaf drift and other debris collect around fallen trees and quiet basins. The latter, along with limestone outcrops and rock debris, form important aquatic habitats for many small aquatic organisms. When undisturbed, submerged aquatic vegetation clothes most of the spring-run stream bottom and provides shelter and an abundant food source for the extensive web of life.

The water emanating from the aquifer is generally clear because of the filtering and absorbing actions of the soils and aquifer limestones through which the water percolates and flows. When the water is deep, it may appear bluish because of light-refraction characteristics that are similar to those which cause the sky to be blue on clear days. If the water sources for the aquifer are substantially influenced by nearby swamps or flatwoods, the spring-run may temporarily become stained with tannins and other dissolved organics during or following periods of heavy rains. When extensive underground cavities connect the spring caverns with nearby sinks and swallow holes, the spring-run may become turbid with suspended particulates during and following heavy rains and floods. Conversely during periods of low rainfall, the aquifer can become supersaturated with calcium, carbonates, and other ions. These chemicals readily precipitate when the water reaches the surface, causing the spring head or boil to appear milky. Human activities affect flow rates by withdrawing water from the aquifer through deep wells. When withdrawal is substantial within the recharge area, spring flow is reduced or, in some cases, ceases entirely. Normal flow rates may return when excessive withdrawals are eliminated.

People can also substantially affect the quality of spring waters. Agricultural, residential, and industrial pollutants may readily leach through soils, especially when they are improperly applied or disposed. If polluted groundwater infiltrates the deep aquifer feeding a Spring-run Stream, recovery may not be possible. Applications of herbicides to control aquatic plant growth are also detrimental, because their use often induces eutrophication of the stream.

Other human-related impacts to Spring-run Streams include the destruction of aquatic vegetation by overuse or misuse, and the introduction and proliferation of exotic plants and animals. Both of these impacts may be very difficult to control. Overuse is likely to increase because of the limited number of publicly-owned springs and the desires of an increasing population to enjoy their clean, cool, aesthetic qualities and unique recreational opportunities. Exotic species are often severely detrimental to native species, and they may also disrupt recreational activities. A delicate balance between recreation and preservation must be sought.

Global and State Ranks: G2/S2

Crosswalk and Synonyms: calcareous stream, spring, or creek

MARINE and ESTUARINE

**Marine and Estuarine communities are unchanged from the 1990 Guide, with the exception of Salt Marsh and Mangrove Swamp (formerly Tidal Marsh and Tidal Swamp) which are now classified under "Marine and Estuarine Vegetated Wetlands"*

General Information

Marine Natural Communities and Estuarine Natural Communities occur along coastlines and include subtidal, intertidal, and supratidal zones. The distinction between Marine and Estuarine Natural Communities is often subtle. Estuarine Communities may temporarily exhibit freshwater conditions during periods of heavy rainfall or upland runoff or marine conditions when rainfall and upland runoff are low. Generally, however, estuarine areas are those areas within which seawater is significantly diluted with freshwater inflow from the land, while marine areas are those areas without significant freshwater inflow. The primary criterion for separation is the salinity level of the water, which often varies with local and temporal climatic conditions. In general, freshwater communities have salinity levels below 0.5 parts per thousand (ppt), Estuarine Natural Communities have salinity levels between 0.5 and 30 ppt, and Marine Natural Communities have salinity levels between 30 and 37 ppt. Differences in species compositions may exist between otherwise similar Marine and Estuarine Natural Communities, because of differences in salinity tolerance or other physical or biological factors.

Both Marine Natural Communities and Estuarine Natural Communities of Florida may be separated into Mineral Based, Faunal Based and Floral Based Communities. Mineral Based Communities include Consolidated Substrate and Unconsolidated Substrate communities which occur in subtidal, intertidal and supratidal zones. Faunal-based Communities include Octocoral Bed, Sponge Bed, Coral Reef, Mollusk Reef and Worm Reef Communities which occur in subtidal zones (Worm Reefs also occur in intertidal zones). Floral-based Communities include Algal Bed, Seagrass Bed, Tidal Marsh† and Tidal Swamp† Communities which occur in intertidal and supratidal zones (Seagrass Beds are subtidal only). Composite Substrate Communities include components of various other Marine and Estuarine Natural Communities in quantities too sparse to be classified as those communities. Composite Substrate Natural Communities occur in subtidal, intertidal and supratidal zones.

†These communities have been removed from this category (see * above)

MINERAL BASED

Consolidated Substrate

Description: Marine and Estuarine Consolidated Substrates are Mineral Based Natural Communities generally characterized as expansive, relatively open areas of subtidal, intertidal, and supratidal zones which lack dense populations of sessile plant and animal species. Consolidated Substrates are solidified rock or shell conglomerates and include coquina, limerock or relic reef materials. These communities may be sparsely inhabited by sessile, planktonic, epifaunal, and pelagic plants and animals but house few infaunal organisms (i.e., animals living within the substrate).

The three kinds of Consolidated Substrate Communities occurring in Florida are of limited distribution. Coquina, which is a limestone composed of broken shells, corals and other organic debris, occurs primarily along the east coast, in marine areas in the vicinity of St. Johns and Flagler Counties.

Limerock substrates occur as outcrops of bedded sedimentary deposits consisting primarily of calcium carbonate. This Consolidated Substrate is more widespread than coquina substrate and can be found in a patchy distribution under both marine and estuarine conditions from north Florida to the lower-most keys in Monroe County. Relic reefs, the skeletal remains of formerly living reefs, are more limited in distribution than limerock outcrops but more common than coquina substrate.

Consolidated Substrates are important in that they form the foundation for the development of other Marine and Estuarine Natural communities when conditions become appropriate. Consolidated Substrate Communities are easily destroyed through siltation or placement of fill, and deliberate removal by actions such as blasting or nondeliberate destruction by forces such as vehicular traffic.

Another type of disturbance involves the accumulation of toxic levels of heavy metals, oils, and pesticides in Consolidated Substrates. Significant amounts of these components in the sediments will kill the infauna, thereby eliminating a food source for certain fishes, birds and other organisms. A film of pollutants engulfing Consolidated Substrates can render these areas unsuitable for colonization by marine and estuarine flora and fauna. Such problems occur in some of the major port cities, in areas where there is heavy industrial development, and along major shipping channels where oil spills are likely to occur.

Global and State Ranks: G3/S3

Crosswalk and Synonyms: hard bottom, rock bottom, limerock bottom, coquina bottom, relic reef

Unconsolidated Substrate

Description: Marine and Estuarine Unconsolidated Substrates are Mineral Based Natural Communities generally 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 coralgall, marl, mud, mud/sand, sand or shell. This community may support a large population of infaunal organisms as well as a variety of transient planktonic and pelagic organisms [e.g., tube worms, sand dollar (*Clypeasteroida*), mollusks, isopods, amphipods, burrowing shrimp (*Thalassinidea*), and an assortment of crabs].

In general, Marine and Estuarine Unconsolidated Substrate Communities are the most widespread communities in the world. However, Unconsolidated Substrates vary greatly throughout Florida, based on surrounding parent material. 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., coralgall, marl and shell substrates). Marl and coralgall substrates are primarily restricted to the southern portion of the state. The remaining four kinds of Unconsolidated Substrate, mud, mud/sand, sand, and shell, are found throughout the coastal areas of Florida. While these areas may seem relatively barren, the densities of infaunal organisms in subtidal zones can reach the tens of thousands per meter square, making these areas important feeding grounds for many bottom feeding fish, such as red drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*), spot (*Leiostomus xanthurus*), and sheepshead (*Archosargus probatocephalus*). The intertidal and supratidal zones are extremely important feeding grounds for many shorebirds and invertebrates.

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 Beach Dunes, Salt Marshes, Mangrove Swamps, Seagrass Beds, Coral Reefs, Mollusk Reefs, Worm Reefs, Octocoral Beds, Sponge Beds, and Algal Beds.

Unconsolidated Substrate Communities which are composed chiefly of sand (e.g., sand beaches) are the most important recreational areas in Florida, attracting millions of residents and tourists annually. This community is resilient and may recover from recreational disturbances. However, this community is vulnerable to compaction associated with vehicular traffic on beaches and disturbances from dredging activities and low dissolved oxygen levels, all of which can cause infaunal organisms to be destroyed or to migrate out of the area. Generally these areas are easily recolonized either by the same organisms or a series of organisms which eventually results in the community returning to its original state once the disturbance has ceased. In extreme examples, such as significant alterations of elevation, there is potential for serious long-term impacts from this type of disturbance.

Another type of disturbance involves the accumulation of toxic levels of heavy metals, oils, and pesticides within Unconsolidated Substrates. Significant amounts of these compounds in the sediments will kill the infaunal organisms, thereby eliminating a food source for certain fishes, birds, and other organisms. Such problems occur in some of the major port cities, in areas where there is heavy industrial development, and along major shipping channels where oil spills are likely to occur.

Global and State Ranks: G5/S5

Crosswalk and Synonyms: beach, shore, sand bottom, shell bottom, sand bar, mud flat, tidal flat, soft bottom, coralgall substrate, marl, gravel, pebble, calcareous clay

FAUNAL BASED

Coral Reef

Description: Marine and Estuarine Coral Reefs are Faunal Based Natural Communities generally characterized as expansive conglomerates of hard, sessile, limestone-building coral occurring in warm subtidal waters. Coral Reefs are formed from a diverse assemblage of carbonate precipitating organisms of the phylum Cnidaria (Coelenterata). Two classes of Cnidaria are the principal reef builders. Hydrozoa, the class which includes coral, are important fast growing, colonial reef builders that are capable of withstanding temperate water temperatures. Fire coral (*Millepora alcicornis*) are distributed as far north in Florida as Tarpon Springs in the Gulf of Mexico and at least to Cape Kennedy in the Atlantic Ocean. The second class of reef building Cnidarians are the Anthozoa. This class is divided into two subclasses, the Octocorallia [e.g., soft coral, sea fans (Gorgonacea) and sea feathers (*Pseudopterogorgia* sp.)] and the Zoantharia [e.g., true stony coral (Scleractinia), and colonial anemones]. The Octocorallia represent the group of organisms comprising Octocoral Bed communities. The Scleractinians, or true stony coral, are the primary hermatypic or reef building coral that belong in this subclass. Examples of the reef building, true stony coral, are: elkhorn coral (*Acropora palmata*), staghorn coral (*Acropora* spp.), mountainous star coral (*Montastraea faveolata*), massive starlet coral (*Siderastrea siderea*), great star coral (*Montastraea cavernosa*), sheet coral (*Agaricia lamarcki*), ivory tree coral (*Oculina* sp.), large grooved brain coral (*Colpophyllia natans*), grooved brain coral (*Diploria labyrinthiformis*), and pillar coral (*Dendrogyra cylindrus*). As many as thirty-four species of coral have been reported on individual Coral Reefs in the Florida Keys.

Coral Reefs can be classified into at least four kinds including: shallow and deep water barrier reefs and shallow and deep water patch reefs. Patch reef communities are roughly dome shaped with a topographic relief of 5 to 10 feet. Patch reefs vary considerably in dimension, depending on the size and number of coral colonies comprising the reef. A patch reef may be as small as a single large grooved brain coral head with its associated biota, or as large as several acres. Common builders of patch reefs include mountainous star coral, large grooved brain coral, massive starlet coral, great star coral, symmetrical brain coral (*Diploria strigosa*), grooved brain coral and fire coral. Associated flora and fauna vary greatly between shallow water and deep water patch reefs.

A common feature associated with patch reefs is the "halo" effect. A zone of barren solid substrate, sand, or rubble is formed as a result of grazing by various species of fishes and invertebrates. The organisms exit at night from the refuge of the coral heads to forage on the attached algae and sea grasses, thus leaving a "halo" of barren, exposed substrate surrounding the patch reef. The halo is easy to spot from the surface, which aides in locating patch reef habitat. An important function of halos on solidified substrates is that reef-expansion is made possible because coral recruitment can take place only on hard (consolidated) substrates.

Major barrier reef communities form the expansive, living structures oriented parallel to the shoreline and serving as natural, protective breakwaters. Barrier reefs may form as shallow-water reefs or deep-water reefs at the edge of the shelf, providing light penetration is adequate. Barrier reefs are important in absorbing wave energy as a primary line of protection for the shoreline allowing formation of low energy communities such as Mangrove Swamps in areas that would be inhospitable otherwise. Distinctive features of the barrier reef are the presence of staghorn and elkhorn corals, coral zonation by depth, and spur and groove formations oriented seaward. A generalized bank reef can be subdivided into various biological zones including fore reef, back reef/rubble zone and spur and groove zone. This zonation is determined by water depth, degree of light penetration, and wave energy.

A major barrier reef builder is elkhorn coral. This fast growing species forms the structural framework for the reef while supplying the necessary habitat for reef oriented organisms. Other major reef builders in this type of reef habitat are: knobby brain coral (*Diploria clivosa*), mountainous star coral, symmetrical brain coral, large grooved brain coral, lettuce coral (*Agaricia agaricites*), and pillar coral. However, reef coral species and associated flora and fauna vary greatly between shallow-water and deep-water barrier reefs.

Factors affecting the distribution of Coral Reefs include temperature, light penetration (turbidity), salinity, water currents and availability of suitable substrates. Most corals are very sensitive to cold temperatures, being largely restricted to seas that average above 21°C (70°F). Additionally, the water must be quite clear, since the symbiotic algae living within the corals are generally restricted to water depths of less than 50 meters (164 feet). Most Coral Reefs occur in marine waters with salinities between 30 and 37 ppt. Exposure to freshwater kills most species of corals within 30 minutes. Water currents transport essential nutrients and remove biological waste materials, silts

and sands which could smother the reef. A hard substrate is necessary for completion of development of the planktonic larvae of coral.

Coral Reefs are among the most diverse and productive environments in the world. Coral Reefs provide shelter and food for a myriad of reef fishes and marine invertebrates. Gross production of calcium carbonate is between 100 and 500 tons per acre per year on actively growing reefs. Fragmented coral are often the primary source for creating and nourishing the beaches of nearby islands. These qualities, combined with their structural complexity, biological richness, and aesthetic appeal make Coral Reefs an extremely valuable resource wherever they occur.

Coral Reefs are biologically and structurally sensitive systems. They are slow growing, requiring decades to fully develop. Thus, structural damage caused by boat groundings, anchors, and other physical impacts may require decades to fully recover. Coral Reefs in Florida are at the northern extent of their range. As such, they are vulnerable to decreases in water temperature. High water temperatures also affect corals adversely. Sedimentation and turbid water restrict coral growth and, when significant, smother and kill Coral Reefs. Thus, dredge and fill operations or upland developments which increase the amount of suspended sediments in runoff water impact coral reefs. Pollutants may trigger planktonic algal blooms, reduce oxygen levels, or otherwise upset the delicate balance of the reef ecosystem, thereby damaging the Coral Reef community. Over-fishing, coral collecting, and other recreational activities may also create chronic problems in this community and should be periodically assessed.

Global and State Ranks: G2/S1

Crosswalk and Synonyms: deep-water barrier reef, deep-water patch reef, shallow-water barrier reef, shallow-water patch reef, live bottom community, hard bottom community, transitional reef, Hawk Channel reef, bank reef

Mollusk Reef

Description: Marine and Estuarine Mollusk Reefs are Faunal Based Natural Communities typically characterized as expansive concentrations of sessile mollusks occurring in intertidal and subtidal zones to a depth of 40 feet. In Florida, the most developed Mollusk Reefs are generally restricted to estuarine areas and are dominated by the American oyster. Less common are Mollusk Reefs dominated by mussels and others dominated by Vermetid worm shells. Numerous other sessile and benthic invertebrates live among, attached to, or within the collage of mollusk shells. Most common are burrowing sponge (Hadromerida), anemones, mussels, clams, oyster drill (*Urosalpinx* sp.), lightning whelk (*Busycon contrarium*), polychaetes, oyster leech (*Stylochus* sp.), barnacles, blue crab (*Callinectes sapidus*), mud crab (Xanthidae), stone crab (*Menippe mercenaria*), pea crab (Pinnotheridae), amphipods, and starfish (Asteroidea). Several fish also frequently occur near or feed among Mollusk Reefs, including cownose ray (*Rhinoptera bonasus*), gulf menhaden (*Brevoortia patronus*), gafftopsail catfish (*Bagre marinus*), pinfish (*Lagodon rhomboides*), spotted seatrout (*Cynoscion nebulosus*), spot (*Leiostomus xanthurus*), black drum (*Pogonias cromis*), and striped mullet (*Mugil cephalus*). Mollusk Reefs that are exposed during low tides are frequented by a multitude of shorebirds, wading birds, raccoons (*Procyon lotor*), and other vertebrates.

Reef-building mollusks require a hard (consolidated) substrate on which the planktonic larvae (i.e., spat) settle and complete development. The spat dies if it settles on soft (unconsolidated) substrates, such as mud, sand or grass. Hard substrates include rocks, limestone, wood and other mollusk shells. Hard substrates are often limited in Estuarine Natural Communities because of the large amounts of silt, sands and muds that are deposited around river mouths. Once established, however, Mollusk Reefs can generally persist and often expand by building upon themselves.

The most common kind of Mollusk Reef, oyster mollusk reefs, occur in water salinities from just above fresh water to just below full strength sea water, but develop most frequently in estuarine water with salinities between 15 and 30 ppt. Their absence in marine water is largely attributed to the many predators, parasites, and diseases of oysters that occur in higher salinities. Prolonged exposure to low salinities (less than 2 ppt.) is also known to be responsible for massive mortality of oyster reefs. Thus, significant increases or decreases in salinity levels through natural or unnatural alterations of freshwater inflow can be detrimental to oyster Mollusk Reef communities.

Mollusk Reefs occupy a unique position among estuarine invertebrates and have been an important human food source since prehistoric times. They present a dynamic community of estuarine ecology, forming refugia, nursery

grounds, and feeding areas for a myriad of other estuarine organisms.

The major threats to mollusk reefs continue to be pollution and substrate degradation due, in large part, to upland development. Mollusks are filter feeders, filtering up to 100 gallons of water a day. In addition to filtering food, they also filter and accumulate toxins from polluted waters. Sources of these pollutants can be from considerably distant areas, but are often more damaging when nearby. Substrate degradation occurs when silts, sludge and dredge spoils cover and bury the Mollusk Reefs. Declining oyster and other Mollusk Reef populations can be expected in coastal waters that are being dredged or are receiving chemicals mixed with rainwater flowing off the land, or from drainage of untreated residential or industrial sewage systems.

Global and State Ranks: G3/S3

Crosswalk and Synonyms: oyster bar, oyster reef, oyster bed, oyster rock, oyster grounds, mussel reef, worm shell reef, Vermetid reef

Octocoral Bed

Description: Marine and Estuarine Octocoral Beds are soft Faunal Based Natural Communities characterized as large populations of sessile invertebrates of the Class Anthozoa, Subclass Octocorallia, Orders Gorgonacea and Pennatulacea. The dominant animal species are soft corals such as gorgonians, sea fans (Gorgonacea), sea feathers and sea plumes (*Pseudopterogorgia* spp.), sea fingers (*Briareum asbetinum*), sea pansies (*Renilla* spp.), sea rods (*Plexaura* spp.), and sea whips (*Leptogorgia* spp.). This community is confined to the subtidal zone since the sessile organisms are highly susceptible to desiccation. Other sessile animals typically occurring in association with these soft corals are sea anemones (Actiniaria). An assortment of non-sessile benthic and pelagic invertebrates and vertebrates [e.g., sponges, mollusks, tube worms, burrowing shrimp (Thalassinidea), crabs, isopods, amphipods, sand dollars (Clypeasteroidea), and fishes] are associated with Octocoral Beds. Specific species of interest living on or among the soft corals include the flamingo tongue snail (*Cyphoma gibbosa*) and the giant basket starfish (*Astrophyton muricatum*). Sessile and drift algae can also be found scattered throughout Octocoral Beds.

Octocoral Beds require hard bottom (consolidated) substrate (i.e., coquina, limerock, relic reefs) on which to anchor. Hard bottom substrate occurs sparsely throughout Florida in marine and estuarine areas; however, soft corals prefer the warmer waters of the southern portion of the state, severely limiting the distribution.

Octocoral Beds may grade into other marine and estuarine hard bottom subtidal, intertidal, and supratidal communities (i.e., Consolidated Substrate, Sponge Bed, Coral Reef, Mollusk Reef, Worm Reef, lithophytic Algal Bed) as well as soft bottom communities (i.e., Unconsolidated Substrate, sammophytic Algal Bed, Seagrass Bed, Salt Marsh, Mangrove Swamp).

Management considerations should include locating all true Octocoral Beds within the state, thought to be more prevalent off the Southeast coast, and providing protection for them from external degradation. Primary threats to Octocoral Beds include siltation from beach "renourishment" or "restoration" projects, anchor damage by nautical craft, trawling by commercial fishermen, collecting for tourist-oriented trade, and water pollution, particularly oil spills.

Global and State Ranks: G2/S1

Crosswalk and Synonyms: gorgonians, sea fans, sea feathers, sea fingers, sea pansies, sea plumes, sea rods, sea whips, soft corals

Sponge Bed

Description: Marine and Estuarine Sponge Beds are soft Faunal Based Natural Communities characterized as dense populations of sessile invertebrates of the phylum Porifera, Class Demospongiae. The dominant animal species are sponges such as branching candle sponge (*Verongia longissima*), Florida loggerhead sponge (*Spheciospongia vesparium*) and sheepswool sponge (*Hippiospongia lachne*). Although concentrations of living

sponges can occur in marine and estuarine intertidal zones, Sponge Beds are confined primarily to subtidal zones. Other sessile animals typically occurring in association with these sponges are stony corals (Scleractinia), sea anemones (Actiniaria), mollusks, tube worms, isopods, amphipods, burrowing shrimp (Thalassinidea), crabs, sand dollars (Clypeasteroidea), and fishes. Sessile and drift algae can also be found scattered throughout Sponge Beds.

Sponge Beds require hard bottom (consolidated) substrate (i.e., coquina, limerock, relic reefs) on which to anchor. Hard bottom substrate occurs sparsely throughout Florida in marine and estuarine areas; however, sponges prefer the warmer waters of the southern portion of the state, significantly limiting the distribution severely.

Sponge Beds may grade into other marine and estuarine hard bottom subtidal, intertidal and supratidal communities (i.e., Consolidated Substrate, Sponge Bed, Coral Reef, Mollusk Reef, Worm Reef, lithophytic Algal Bed) as well as soft bottom communities (i.e., Unconsolidated Substrate, ammophytic Algal Bed, Seagrass Bed, Salt Marsh, Mangrove Swamp).

Management considerations should include locating all true Sponge Beds within the state, thought to be more prevalent off the SW coast, and providing protection for them from external degradation. Primary threats to Sponge Beds include siltation from beach "renourishment" or "restoration" projects, anchor damage by nautical craft, trawling by commercial fishermen, collecting for tourist-oriented trade, and water pollution, particularly oil spills.

Global and State Ranks: G2/S2

Crosswalk and Synonyms: branching candle sponge, Florida loggerhead sponge, sheepswool sponge

Worm Reef

Description: Worm Reefs are Faunal Based Natural Communities characterized by large colonial conglomerates of rigid Sabellariid worm tubes of the species *Phragmatopoma lapidosa*. These shallow water "reefs" are generally found in the lower reaches of the intertidal zone or upper reaches of the subtidal zone. Sabellariid reefs provide shelter for a diverse assortment of small benthic vertebrate and invertebrate organisms, particularly since the surrounding habitat is generally bare substrate (e.g., Consolidated Substrate or Unconsolidated Substrate). Therefore, the mere presence of Worm Reefs greatly increases the faunal diversity of a given area.

Of all the Marine and Estuarine Natural Communities, Worm Reefs are probably the least well known. Worm Reefs are known from several locations along the southern coast of the state.

A Worm Reef can be surrounded by and grade into virtually any of the remaining Marine and Estuarine Natural Communities but is more likely to grade into an expanse of Unconsolidated Substrate. Information regarding effective management of Worm Reefs is lacking. However, excessive turbidity and siltation are probably significant factors in the decline of Worm Reefs. A beach renourishment project in West Palm Beach threatens one of the few remaining productive Worm Reef sites, located in one to three meters of water near the shore.

Global and State Ranks: G1/S1

Crosswalk and Synonyms: Sabellariid Reef

FLORAL BASED

Algal Bed

Description: Marine and Estuarine Algal Beds are Floral Based Natural Communities characterized as large populations of nondrift macro or micro algae. The dominant plant species include star algae (*Anadyomene stellata*), *Argardhiella*, *Avrainvella*, *Batophora*, *Bryopsis*, *Calothrix*, *Caulerpa*, *Chondria*, *Cladophora*, *Dictyota*, *Digenia*, *Gracilaria*, *Halimeda*, *Laurencia*, *Oscillatoria*, shaving brush (*Penicillus capitatus*), *Rhypocephalus*, and *Sargassum*. This community may occur in subtidal, intertidal, and supratidal zones on soft and hard bottom substrates. Vascular plants (e.g., seagrasses) may occur in Algal Beds associated with soft bottoms. Sessile animals

associated with Algal Beds will vary based on bottom type. For Algal Beds associated with hard bottom substrate (lithophytic), faunal populations will be similar to populations associated with Octocoral Beds and Sponge Beds. Those associated with soft bottom substrate (psammophytic) may have similar benthic and pelagic species in addition to infauna species. Recent research has shown that Algal Beds provide critical habitat for juvenile spiny lobsters (*Panulirus argus*), a species of great commercial importance.

Lithophytic Algal Beds are thought to be less widespread within Florida than psammophytic Algal Beds. The precise distribution of both kinds is not known; however, the distribution is thought to be less than for Marine and Estuarine Seagrass Beds.

Marine and Estuarine Algal Beds may grade into Seagrass Beds, Salt Marsh, Mangrove Swamp, or many of the other Marine or Estuarine Natural Communities. Supratidal Algal Beds such as periphyton beds (e.g., blue-green algal mats) may grade into various coastal Palustrine and Terrestrial Natural Communities.

Distribution information for Algal Beds is lacking. The location of major beds must be determined before this Natural Community can be managed adequately. Existing state dredge and fill laws provide specific protection for Marine and Estuarine Seagrass Beds but not for Algal Beds. The correction of this deficiency could prove to be the most effective management tool available.

The primary threat to Marine and Estuarine Algal Beds are dredging and filling activities which physically remove or bury the beds. Other damage occurs from increased turbidity in the water column which reduces available light; pollution, particularly from oil spills; and damage from boats.

Global and State Ranks: G3/S2

Crosswalk and Synonyms: algal mats, periphyton mats

Seagrass Bed

Description: Marine and Estuarine Seagrass Beds are Floral Based Natural Communities typically characterized as expansive stands of vascular plants. This community occurs in subtidal (rarely intertidal) zones, in clear, coastal waters where wave energy is moderate. Seagrasses are not true grasses (Poaceae). The three most common species of seagrasses in Florida are turtlegrass (*Thalassia testudinum*), manateegrass (*Syringodium filiforme*), and shoalweed (*Halodule wrightii*). Nearly pure stands of any one of these species can occur, but mixed stands are also common. Species of *Halophila* may be intermingled with the other seagrasses, but species of this genus are considerably less common than turtlegrass, manateegrass and shoalweed (*Halodule wrightii*). Wigeongrass (*Ruppia maritima*) can also be found occurring with the previously listed seagrasses although they occur primarily under high salinities while wigeongrass occurs in areas of lower salinity.

Attached to the seagrass leaf blades are numerous species of epiphytic algae and invertebrates. Together, seagrasses and their epiphytes serve as important food sources for manatees, marine turtles, and many fish, including spotted seatrout (*Cynoscion nebulosus*), spot (*Leiostomus xanthurus*), sheepshead (*Archosargus probatocephalus*), and red drum (*Sciaenops ocellatus*). The dense seagrasses also serve as shelter or nursery grounds for many invertebrates and fish, including marine snails, clams, scallops, polychaete worms, blue crab (*Callinectes sapidus*), starfish (Asteroidea), sea urchins (Echinoidea), tarpon (*Megalops atlanticus*), bonefish (*Albula vulpes*), seahorses (*Hippocampus* spp.), Florida pompano (*Trachinotus carolinus*), permit (*Trachinotus falcatus*), striped mullet (*Mugil cephalus*), great barracuda (*Sphyrna barracuda*), and long-horned cowfish (*Lactoria cornuta*).

Marine and Estuarine Seagrass Beds occur most frequently on Unconsolidated Substrates of marl, muck or sand, although they may also occur on other Unconsolidated Substrates. The dense blanket of leaf blades reduces the wave-energy on the bottom and promotes settling of suspended particulates. The settled particles become stabilized by the dense roots and rhizomes of the seagrasses. Thus, Marine and Estuarine Seagrass Beds are generally areas of soil accumulation.

Other factors affecting the establishment and growth of Seagrass Beds include water temperature, salinity, wave-energy, tidal activity, and available light. Generally, seagrasses are found in waters with temperatures ranging from between 20° and 30°C (68°-86°F). Seagrasses occur most frequently in areas with moderate current velocities, as

opposed to either low or high velocities. Although Marine and Estuarine Seagrass Beds are most commonly submerged in shallow subtidal zones, they may be exposed for brief periods of time during extreme low tides.

One of the more important factors influencing seagrass communities is the amount of solar radiation reaching the leaf blades. In general, the water must be fairly clear because turbidity blocks essential light necessary for photosynthesis. The rapid growth rate of seagrass under optimum conditions rivals that of most intensive agricultural practices, without energy input from man.

Marine and Estuarine Seagrass Beds are often associated with and grade into Unconsolidated Substrate, Coral Reefs, Mangrove Swamps, and Salt Marshes, but may also be associated with any other Marine and Estuarine Natural Community.

Marine and Estuarine Seagrass Beds are extremely vulnerable to human impacts. Many have been destroyed through dredging and filling activities or have been damaged by sewage outfalls and industrial wastes. In these instances, the Seagrass Beds are either physically destroyed, or succumb as a result of decreased solar radiation resulting from increased water turbidity.

Seagrass Beds are also highly vulnerable to oil spills. Low concentrations of oil are known to greatly reduce the ability of seagrasses to photosynthesize. Extreme high temperatures also have adverse impacts on Seagrass Beds. The area surrounding power plant outfalls, where water temperatures may exceed 35°C (95°F), has been found to be lethal to seagrasses. Marine and Estuarine Seagrass Beds are susceptible to long term scarring cuts from boat propellers, anchors and trawls. Such gouges may require many years to become revegetated. When protected from disturbances, seagrasses have the ability to regenerate and recolonize areas. Additionally, some successful replantings of Seagrass Beds have been conducted. However, the best management is to preserve and protect Marine and Estuarine Seagrass Beds in their natural state.

Global and State Ranks: G2/S2

Crosswalk and Synonyms: seagrass meadows, grass beds, grass flats

COMPOSITE SUBSTRATE

Composite Substrate

Description: Marine and Estuarine Composite Substrates consist of a combination of Natural Communities such as "beds" of algae and seagrasses or areas with small patches of consolidated and unconsolidated bottom with or without sessile floral and faunal populations.

Composite Substrates may be dominated by any combination of marine and estuarine sessile flora or fauna, or mineral substrate type. Typical combinations of plants, animals and substrates representing Composite Substrates include soft and stony corals (Scleractinia) with sponges on a hard bottom such as a limerock outcrop; psammophytic algae and seagrasses scattered over a sand bottom; and patch reefs throughout a coralgal bottom. Any of the remaining Marine and Estuarine Natural Communities can grade into Composite Substrate communities.

Although Composite Substrates can occur in any marine or estuarine area in Florida, some combinations are common while others are extremely rare. Combinations of Consolidated and Unconsolidated Substrate components offer the greatest opportunity for diversity, and should be high priority areas for protection. Management requirements are negligible providing the composite community is adequately protected.

Protection efforts will vary slightly based on components of the Composite Substrate community. Generally, degradation of physical and chemical water quality parameters should be prevented, as well as mechanical disturbance from anchoring, dredging, trawling and similar activities.

Global and State Ranks: G3/S3

Crosswalk and Synonyms:

SUBTERRANEAN – Occur below ground surface.

**Subterranean communities are unchanged from the 1990 Guide*

Aquatic and Terrestrial Cave

Description: Aquatic and Terrestrial Caves are characterized as cavities below the surface of the ground in karst areas of the state. A cave system may contain portions classified as Terrestrial Caves and portions classified as Aquatic Caves. The latter vary from shallow pools highly susceptible to disturbance, to more stable, totally submerged systems. Because all caves initially develop under aquatic conditions, Terrestrial Caves can be considered essentially dry Aquatic Caves. The limestone aquifers that underlie the entire state of Florida could be considered vast Aquatic Cave communities. Troglobites (also called phreatobites) are organisms specially evolved to survive in deep cave habitats. The occasional observation of various species of troglobites in deep water wells from several regions in the state suggests that this community could be widespread. However, the dependence of troglobites on detrital inputs and other nutrients imported from the surface generally limits the distribution of well developed Aquatic Cave communities to karst areas with surface connections.

The area around cave entrances may be densely vegetated with species from the surrounding Natural Community. Within the cave, however, illumination levels and, thereby, vegetation densities drop rapidly with increased distance from the entrance. Within the limits of light penetration, called the twilight zone, species of algae, mosses, liverworts, and an occasional fern or herbaceous plant may grow. Beyond the twilight zone, plants are generally absent or limited to a few inconspicuous species of fungi that grow on guano or other organic debris. Thus, Subterranean Natural Communities differ from most other Natural Communities in that living plants are not dominant elements.

Animals inhabiting Subterranean Natural Communities are generally divided into three groups according to their cave adaptations: troglloxenes, trogllophiles, and troglobites. Troglloxenes spend much of their time in caves, but they must periodically return to the surface to feed or breed. Eastern woodrats (*Neotoma floridana*), harvestmen (*Opiliones*), cave crickets (Raphidophoridae), some salamanders, and many species of bats are typical examples of troglloxenes. Trogllophiles may regularly live in caves, but their conspecifics also inhabit surface communities with moist microhabitats. Crickets, fish and salamanders are typical examples of trogllophiles. Troglobites are obligatory cave dwellers with special adaptations for living in complete darkness. Cave crayfish (*Cambarus* spp., *Procambarus* spp., *Troglocambarus* spp.), Georgia blind salamander (*Haideotriton wallacei*), cave amphipods (*Crangonyx* sp.), and cave isopods (*Caecidotea* sp.) are typical troglobites in Florida's Aquatic Caves; some cave spiders (Araneae) and cave springtails (*Collembola*) are typical troglobites in some Terrestrial Caves of north Florida. Even though they never leave their cave environments, troglobites and trogllophiles depend on outside energy sources, such as detritus that washes in through sinkholes and other cave entrances. Fecal materials derived from troglloxenes which feed outside the cave are also important nutrients for troglobites. Without these energy subsidies, the troglobitic elements could not exist.

Two geologic processes are predominantly responsible for the development of caves: phreatic and vadose. Phreatic processes occur below the aquifer's surface where ground water is confined and subjected to hydrostatic pressure. Vadose processes occur at the top of or above the aquifer, where air enters the passageways and water flows freely under the influence of gravity. In both processes, the dissolution and corrosion of limestone play active roles in enlarging cave passageways. These forces differ primarily in the slopes of the passageways which result. Phreatic passageways are generally circular or elliptic, while vadose passageways are more triangular with the broad base of the triangle at the bottom. All limestone caves begin development under phreatic conditions in the aquifer. As water tables drop, vadose conditions eventually replace phreatic conditions. If the water table then rises, another reversal of processes occurs. Because water tables have fluctuated substantially with fluctuating sea levels during the Pleistocene and other geologic epochs, most caves in Florida exhibit both phreatic and vadose characteristics.

Since limestone caves initially develop in the aquifer, they are frequently associated with aquifer-related surface features. Thus, a Spring Run Stream issues from an Aquatic Cave, while Sinkhole Lakes and occasionally Blackwater Streams lead into Aquatic Caves. Similarly, Terrestrial Caves may occur at the bottoms of dry sinkholes or be associated with ancient springs, swallow holes or Aquatic Caves that have since been exposed by lower water tables. Typically, Terrestrial Caves may also exhibit aquatic conditions during periods of heavy rainfall, or vice versa during droughts. Additionally, Terrestrial Caves may harbor relatively permanent pools or lakes that are

formed in natural depressions in the floor of the cave from the buildup of rimstone, or where the aquifer inundates the lower cavities. Thus, Terrestrial and Aquatic Caves often occur together.

Cave waters are generally clear, with deep water appearing bluish. The water may become stained brown from tannins leached from decaying plant matter nearby and carried in with rainwater. The water may also become milky white if fine limestone mud from the bottom of the Aquatic Cave is suspended in the water column following disturbance. A bottom substrate of organic silts can also muddy the water with suspended particles. Waters are generally circumneutral to alkaline with a high mineral content (particularly calcium bicarbonate and magnesium) and with constant temperature. Flowing water within Aquatic Caves generally has a lower pH, is often undersaturated with respect to carbonates, and has a relatively richer fauna. Contrastingly, pools that are fed by seepage or dripping water are generally characterized by a high pH, high concentration of dissolved carbonates, low content of organic matter suitable for food, and a sparse fauna. Cave water characteristics may also vary seasonally because of fluvial inputs from interconnected surface streams, or because of detrital pulses and other surface inputs during periods of substantial aquifer recharge. In general, however, Aquatic Caves are very stable environments with relatively constant physical and chemical characteristics.

Terrestrial Caves also are very stable environments, having relatively constant temperatures and humidities. Within the cave, however, these factors may vary with location. For example, the twilight zone (nearest to the light source) is generally warmer and experiences more temperature and humidity fluctuations than does the middle zone, a dark zone that is subject to air circulation due to "cave breathing" phenomena. The deep zone, when it occurs, is the most stable zone of a Terrestrial Cave, because the air in it is essentially static. Terrestrial Cave faunas often partition their distributions according to these zones, with troglonenes being more common in the twilight and middle zones, and troglobites being more common in the deep zone.

Subterranean Natural Communities are extremely fragile. Their faunas are adapted to very stable environments and have a limited ability to survive even minor environmental perturbations. Terrestrial Caves are threatened by disturbances of spelunkers. The mere entry into a bat roosting, maternity, or hibernation cave is often sufficient to cause abandonment by bats, thereby causing a major reduction in an important energy source for the remainder of the cave ecosystem.

Alterations in or around cave entrances will often upset detrital input levels and may also induce significant changes in air circulation patterns and the cave microclimate. Aquatic Caves are threatened by pollution of ground and surface waters from agricultural, industrial, and residential sources, as well as by disturbances from divers. The unique troglobitic species generally have very low population levels and can be severely impacted by overcollection or by changes in nutrient input levels that result from surface manipulations or hydrological alterations. Thus, special precautions and management procedures must be invoked to protect these unique, fragile communities from deleterious activities.

Global and State Ranks: G3/S2

Crosswalk and Synonyms: cave, cavern grotto, chamber, chimney, sink, swallow hole, spring rise

REFERENCES

1. Abrahamson, W.G. 1991. South Florida slash pine mortality in seasonal ponds. *Florida Scientist* 54:80-83.
2. Abrahamson, W.G. and D.C. Hartnett. 1990. Pine flatwoods and dry prairies. 103-149 in Myers, R.L. and J.J. Ewel. *Ecosystems of Florida*. University of Central Florida Press, Orlando.
3. Abrahamson, W.G., A.F. Johnson, J.N. Layne, and P.A. Peroni. 1984. Vegetation of the Archbold Biological Station, Florida: an example of the southern Lake Wales Ridge. *Florida Scientist* 47:209-250.
4. Alexander, T.R. 1953. Plant succession on Key Largo, Florida, involving *Pinus caribaea* and *Quercus virginiana*. *Florida Academy of Sciences Quarterly Journal* 16:133-138.
5. Alexander, T.R. 1958. High hammock vegetation of the southern Florida mainland. *Quarterly Journal Florida Academy of Sciences* 21:293-298.
6. Alexander, T.R. and A.G. Crook. 1973. Recent and long-term vegetation changes and patterns in South Florida. Appendix G, Part 1. South Florida Ecological Study. University of Miami, Coral Gables, Florida.
7. Alexander, T.R. and A.G. Crook. 1984. Recent vegetational changes in southern Florida. 99-210 in Gleason, P.J. *Environments of South Florida: Present and Past II*. Miami Geological Society, Coral Gables.
8. Almquist, D. Invertebrate Zoologist, Florida Natural Areas Inventory. Personal Communication. 2007
9. Alongi, D.M. 2002. Present state and future of the world's mangrove forests. *Environmental Conservation* 29:331-349.
10. Anderson, L.C. and R. Kral. 2008. *Xyris panacea* (Xyridaceae) - a new yellow-eyed grass from the Florida panhandle. *Journal of the Botanical Research Institute of Texas* 2:1-5.
11. Armentano, T.V., J.P. Sah, M.S. Ross, D.T. Jones, H.C. Cooley, and C.S. Smith. 2006. Rapid responses of vegetation to hydrological changes in Taylor Slough, Everglades National Park, Florida, USA. *Hydrobiologia* 569:293-309.
12. Austin, D.F., G.B. Iverson, and C.E. Nauman. 1979. A tropical fern grotto in Broward County, Florida. *American Fern Journal* 14-16.
13. Austin, D.F., J.L. Jones, and B.C. Bennett. 1990. Endangered plants of Fakahatchee Strand State Preserve. *Rhodora* 92:27-35.
14. Austin, D.F., J.L. Jones, and B.C. Bennett. 1990. Vascular plants of the Fakahatchee Strand. *Florida Scientist* 53:85-88.
15. Avery, G. 1982. Unpublished field reports. F82AVE02-F82AVE11. Florida Natural Areas Inventory, Tallahassee, Florida.
16. Bacchus, S.T. 1991. Identification and review procedure for cutthroat seeps, a special habitat. Report to the Central Florida Regional Planning Council 36. Report prepared by Applied Environmental Services for the Central Florida Regional Planning Council.
17. Bacchus, S.T. 1995. Groundwater levels are critical to the success of prescribed burns. 117-133 in Cerulean, S.I. and R.T. Engstrom. *Fire in Wetlands: A Management Perspective*. Proceedings of the Tall Timbers Fire Ecology Conference, No. 19. Tall Timbers Research Station, Tallahassee, Florida.
18. Baskin, J.M. and C.C. Baskin. 1999. Cedar glades of the southeastern United States. 206-219 in Anderson, R.C., J.S. Fralish, and J.M. Baskin. *Savannas, Barrens, and Rock Outcrop Plant Communities of North America*. Cambridge University Press, Cambridge.
19. Batista, W.B. and W.J. Platt. 1997. An old-growth definition for southern mixed hardwood forests. General Technical Report SRS-9. United States Department of Agriculture, Forest Service. Southern Research Station, Asheville, North Carolina.
20. Beard, J.S. 1944. Climax vegetation in tropical America. *Ecology* 25:127-158.
21. Beever, J.W., III and K.A. Dryden. 1991. The hydric pine flatwoods of southwest Florida, a community profile. Unpublished report.FGFWFC Florida Fish and Wildlife Conservation Commission, Southwest Florida Field Office, Punta Gorda, Florida.
22. Bellis, V.J. 1995. Ecology of maritime forests of the southern Atlantic coast: a community profile. United States Department of the Interior, National Biological Service, Washington, D.C.
23. Bennetts, R.E., M.W. Collopy, and J.A. Rodgers, Jr. 1994. The snail kite in the Florida Everglades: a food specialist in a changing environment. 507-532 in Davis, S.M. and J.C. Ogden. *Everglades: The Ecosystem and its Restoration*. St. Lucie Press, Delray Beach.
24. Bodle, M.J., A.P. Ferriter, and D.D. Thayer. 1994. The biology, distribution, and ecological consequences of *Melaleuca quinquenervia* in the Everglades. 341-355 in Davis, S.M. and J.C. Ogden. *Everglades: The Ecosystem and its Restoration*. St. Lucie Press, Delray Beach.
25. Boyce, S.G. 1954. The salt spray community. *Ecological Monographs* 24:29-67.
26. Bradley, K. and G. Gann. 1999. The pine rockland forests of southern Florida. *The Palmetto* 19:12-19.
27. Bradley, K.A. Botanist, Institute for Regional Conservation. Personal Communication. 2004
28. Bradley, K.A. and G.D. Gann. 1999. Status summaries of 12 rockland plant taxa in southern Florida. Institute for Regional Conservation. Report submitted to United States Fish and Wildlife Service, Vero Beach, Florida.

29. Brandt, K. and K.C. Ewel. 1989. Ecology and management of cypress swamps: a review. Florida Cooperative Extension Service, Gainesville, Florida.
30. Bratton, S.P. 1993. Survivorship of evergreen hardwoods after wildfire in maritime forest, Cumberland Island National Seashore, Georgia. *Castanea* 58:34-44.
31. Breininger, D.R. and G.M. Carter. 2003. Territory quality transitions and source-sink dynamics in a Florida scrub-jay population. *Ecological Applications* 13:516-529.
32. Breininger, D.R., B.W. Duncan, and N.J. Dominy. 2002. Relationships between fire frequency and vegetation type in pine flatwoods of east-central Florida, USA. *Natural Areas Journal* 22:186-193.
33. Breininger, D.R. and P.A. Schmalzer. 1990. Effect of fire and disturbance on plants and animals in oak/palmetto scrub. *American Midland Naturalist* 123:64-74.
34. Bridges, E.L. 1998. Vegetation mapping and natural community types of Kissimmee Prairie State Preserve. Kissimmee Prairie State Preserve unit management plan. Florida Department of Environmental Protection.
35. Bridges, E.L. 2006. Historical accounts of vegetation in the Kissimmee River dry prairie landscape. 43-62 in Noss, R.F. *Land of Fire and Water: The Florida Dry Prairie Ecosystem*. Proceedings of the Florida Dry Prairie Conference. Painter, DeLeon Springs.
36. Bridges, E.L. 2006. Landscape ecology of the Florida dry prairie landscape in the Kissimmee River region. 14-42 in Noss, R.F. *Land of Fire and Water: The Florida Dry Prairie Ecosystem*. Proceedings of the Florida Dry Prairie Conference. Painter, DeLeon Springs.
37. Bridges, E.L. and S.L. Orzell. 1986. Distribution patterns of the non-endemic flora of Middle Tennessee limestone glades. *Association of Southeastern Biologists Bulletin* 33:155-166.
38. Bridges, E.L. and S.L. Orzell. 1989. Longleaf pine communities of the West Gulf Coastal Plain. *Natural Areas Journal* 9:246-263.
39. Bridges, E.L., S.L. Orzell, and L.C. Anderson. 1989. *Carex microdonta* Torr. & Hook. (Cyperaceae) new to Florida. *Sida* 13:379-381.
40. Brooks, H.K. 1981. Guide to the physiographic divisions of Florida. 8-5M-82. Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences, University of Florida, Gainesville, Florida.
41. Browder, J.A., P.J. Gleason, and D.R. Swift. 1994. Periphyton in the Everglades: spatial variation, environmental correlates, and ecological implications. 379-418 in Davis, S.M. and J.C. Ogden. *Everglades: The Ecosystem and its Restoration*. St. Lucie Press, Delray Beach.
42. Brown, S. 1981. A comparison of the structure, primary productivity, and transpiration of cypress ecosystems in Florida. *Ecological Monographs* 51:403-427.
43. Buckner, J.L. and J.L. Landers. 1979. Fire and disking effects on herbaceous food plants and seed supplies. *Journal of Wildlife Management* 43:807-811.
44. Burke, V.J. and J.W. Gibbons. 1995. Terrestrial buffer zones and wetland conservation: a case study of freshwater turtles in a Carolina bay. *Conservation Biology* 1365-1369.
45. Burks, K.C. 1992. A critical floristic study of Lake Miccosukee and environs. Thesis, Florida State University, Tallahassee.
46. Burks, K.C. 1997. Vegetation monitoring, Savanna Research Natural Area, Apalachicola National Forest, final report, part 2: species richness. U.S. Forest Service, Bristol, FL.
47. Carlson, P.C., G.W. Tanner, J.M. Wood, and S.R. Humphrey. 1993. Fire in key deer habitat improves browse, prevents succession, and preserves endemic herbs. *The Journal of Wildlife Management* 914-928.
48. Carr, S.C. 2007. Floristic and environmental variation of pyrogenic pinelands in the Southeastern Coastal Plain: Description, classification, and restoration. Dissertation, University of Florida, Gainesville.
49. Carrington, M.E. and J.E. Keeley. 1999. Comparison of post-fire seedling establishment between scrub communities in mediterranean and non-mediterranean climate ecosystems. *Journal of Ecology* 87:1025-1036.
50. Casey, W.P. and K.C. Ewel. 1998. Soil redox potential in small pondcypress swamps after harvesting. *Forest Ecology and Management* 112:281-287.
51. Casey, W.P. and K.C. Ewel. 2006. Patterns of succession in forested depressional wetlands in north Florida. *Wetlands* 26:147-160.
52. Cavender-Bares, J., K. Kitajima, and F.A. Bazzaz. 2004. Multiple trait associations in relation to habitat differentiation among 17 Floridian oak species. *Ecological Monographs* 74:635-662.
53. Christensen, N.L., R.B. Burchell, A. Liggett, and E.L. Simms. 1981. The structure and development of pocosin vegetation. 43-61 in Richardson, C.J. *Pocosin Wetlands*. Hutchinson Ross Publishing Co., Hutchinson.
54. Christman, S.P. and W.S. Judd. 1990. Notes on plants endemic to Florida scrub. *Florida Scientist* 53:52-73.
55. 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.
56. Clewell, A.F. 1980. Vegetation of Leon County. 386-440 in *The Leon County Bicentennial Report*. Florida Department of State, Tallahassee, Florida.
57. Clewell, A.F. 1986. Natural setting and vegetation of the Florida Panhandle - An account of the environments and plant communities of northern Florida west of the Suwannee River. Report No. COESAM/PDEI-86/001. United States Army Corps of Engineers, Mobile District, Alabama.

58. Clewell, A.F. 1989. Botanical inventory of the Choctawhatchee River valley, Florida. Report to the Northwest Florida Water Management District, Havana, Florida.
59. Clewell, A.F. 1997. Vegetation. 77-109 in Coultas, C.L. and Y.P. Hsieh. Ecology and Management of Tidal Marshes: A Model from the Gulf of Mexico. St. Lucie Press, Delray Beach.
60. Cole, D.P. 1975. Vegetational analysis of selected coastal Indian shell mounds in Florida. Thesis, University of South Florida, Tampa.
61. Conner, R.N. and D.C. Rudolph. 1989. Red-cockaded woodpecker colony status and trends on the Angelina, Davy Crockett, and Sabine National Forests. Forest Service Research Paper SO-250. United States Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, Louisiana.
62. Conner, W.H. and M.A. Buford. 1998. Southern deepwater swamps. 261-287 in Messina, M.G. and W.H. Conner. Southern Forested Wetlands: Ecology and Management. Lewis Publishers/CRC Press, Boca Raton.
63. Cooley, G.R. 1955. The vegetation of Sanibel Island, Lee County, Florida. *Rhodora* 57:269-289.
64. Cooper, R.W. 1973. Fire and sand pine. Southern Forest Fire Laboratory, Southeast Forest Experiment Station, Macon, Georgia.
65. Correll, D.S. and H.B. Correll. 1982. Flora of the Bahama Archipelago. J. Cramer, Vaduz.
66. Coultas, C.L. 1977. Soils of Apalachicola National Forest wetlands .1. Titi swamps and savannahs. *Soil and Crop Science Society of Florida Proceedings* 36:72-77.
67. Coultas, C.L. 1983. Examination of soils associated with four small "limestone glade communities" surrounded by forest in the hills of western Gadsden County. *Florida Natural Areas Inventory*, Tallahassee.
68. Coultas, C.L. 1997. Soils. 53-75 in Coultas, C.L. and Y.P. Hsieh. Ecology and Management of Tidal Marshes: A Model from the Gulf of Mexico. St. Lucie Press, Delray Beach.
69. Coultas, C.L., A.F. Clewell, and E.M. Taylor. 1979. Aberrant toposequence of soils through a titi swamp. *Soil Science Society of America Journal* 43:377-383.
70. Coultas, C.L. and M.J. Duever. 1984. Soils of cypress swamps. 51-59 in Ewel, K.C. and H.T. Odum. *Cypress Swamps*. University of Florida Press, Gainesville.
71. Cox, A.C., D.R. Gordon, J.L. Slapcinsky, and G.S. Seamon. 2004. Understory restoration in longleaf pine sandhills. *Natural Areas Journal* 24:4-14.
72. Cox, J. 1988. The influence of forest size on transient and resident bird species occupying maritime hammocks of northeastern Florida. *Florida Field Naturalist* 16:25-34.
73. Craighead, F.C. 1968. The role of the alligator in shaping plant communities and maintaining wildlife in the southern Everglades. *Florida Naturalist* 21:2-7, 68-74, 94.
74. Craighead, F.C. 1971. *The Trees of South Florida*. University of Miami Press, Coral Gables.
75. Darst, M.R. and H.M. Light. 2008. Drier forest composition associated with hydrologic change in the Apalachicola River floodplain, Florida. Scientific Investigations Report 2008-5062. United States Geological Survey, Reston, Virginia. Available at: <http://pubs.usgs.gov/sir/2008/5062/>
76. Darst, M.R., H.M. Light, and L.P. Lewis. 2002. Ground-cover vegetation in wetland forests of the lower Suwannee River floodplain, Florida, and potential impacts of flow reductions. Water-Resources Investigations Report 02-4027. United States Geological Survey, Tallahassee, Florida.
77. Daubenmire, R. 1990. The *Magnolia grandiflora-Quercus virginiana* forest of Florida. *American Midland Naturalist* 123:331-347.
78. Davis, J.H., Jr. 1942. The ecology of the vegetation and topography of the sand keys of Florida. Papers from the Tortugas Laboratory 33 (6) of the Carnegie Institution of Washington .
79. Davis, J.H., Jr. 1943. The natural features of southern Florida, especially the vegetation, and the Everglades. Geological Bulletin No. 25. Florida Geological Survey, Tallahassee, Florida.
80. Davis, S.M., L.H. Gunderson, W.A. Park, J.R. Richardson, and J.E. Mattson. 1994. Landscape dimension, composition, and function in a changing Everglades ecosystem. 419-458 in Davis, S.M. and J.C. Ogden. *Everglades: The Ecosystem and its Restoration*. St. Lucie Press, Delray Beach.
81. Day, R.H., T.M. Williams, and C.M. Swarzenski. 2007. Hydrology of tidal freshwater forested wetlands of the southeastern United States. 29-63 in Conner, W.H., T.W. Doyle, and K.W. Krauss. *Ecology of Tidal Freshwater Forested Wetlands of the Southeastern United States*. Springer Netherlands.
82. Delcourt, H.R. 1976. Presettlement vegetation of the North of Red River Land District, Louisiana. *Castanea* 41:122-139.
83. Delcourt, H.R. and P.A. Delcourt. 1977. Presettlement magnolia-beech climax of the Gulf Coastal Plain: quantitative evidence from the Apalachicola River Bluffs, North-Central Florida. *Ecology* 58:1085-1093.
84. Deyrup, M. 1989. Arthropods endemic to Florida scrub. *Florida Scientist* 52:254-270.
85. Deyrup, M. Entomologist, Archbold Biological Station, Lake Placid, Florida. Personal Communication. 2007
86. Donoghue, J.F. and W.F. Tanner. 1992. Quaternary terraces and shorelines of the panhandle Florida region. 233-241 in Wehmiller, J.F. and C.H. Fletcher. *Quaternary coasts of the United States: marine and lacustrine systems*, SEPM Special Publication No. 48. Society for Sedimentary Geology, Tulsa, OK.

87. Doren, R.F., D.R. Richardson, and R.E. Roberts. 1987. Prescribed burning of the sand pine scrub community: Yamato Scrub, a test case. *Florida Scientist* 50:184-192.
88. Doyle, T.W., G.F. Girod, and M.A. Books. 2003. Modeling mangrove forest migration along the southwest coast of Florida under climate change. 211-222 in Ning, Z.H., R.E. Turner, T. Doyle, and K. Abdollahi. 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.
89. Doyle, T.W., C.P. O'Neil, M.P.V. Melder, A.S. From, and M.M. Palta. 2007. Tidal freshwater swamps of the southeastern United States: effects of land use, hurricanes, sea-level rise, and climate change. 1-28 in Conner, W.H., T.W. Doyle, and K.W. Krauss. *Ecology of Tidal Freshwater Forested Wetlands of the Southeastern United States*. Springer Netherlands.
90. Drew, R.D. and N.S. Schomer. 1984. Ecological characterization of the Caloosahatchee River/Big Cypress watershed. FWS/OBS-82/58-2. United States Fish and Wildlife Service, Office of Biological Services, Washington, D.C.
91. Drewa, P.B., W.J. Platt, and E.B. Moser. 2002. Community structure along elevation gradients in headwater regions of longleaf pine savannas. *Plant Ecology* 160:61-78.
92. Drewa, P.B., W.J. Platt, and E.B. Moser. 2002. Fire effects on resprouting of shrubs in headwaters of southeastern longleaf pine savannas. *Ecology* 83:755-767.
93. Duever, L.C. 1984. Natural communities of Florida's rocklands. *Palmetto* 4:8-11.
94. Duever, L.C. President, Conway Conservation, Micanopy, FL. Personal Communication. 2008
95. Duever, L.C., J.F. Meeder, and M.J. Duever. 1982. Ecological portion, Florida peninsula natural region theme study. Report to the National Park Service. Ecosystem Research Unit, National Audubon Society, Naples, Florida.
96. Duever, M.J. 1984. Environmental factors controlling plant communities of the Big Cypress Swamp. 127-137 in Gleason, P.J. *Environments of South Florida: Present and Past II*. Miami Geological Society, Coral Gables.
97. Duever, M.J., J.E. Carlson, J.F. Meeder, L.C. Duever, L.H. Gunderson, L.A. Riopelle, T.R. Alexander, R.L. Myers, and D.P. Spangler. 1986. *The Big Cypress National Preserve*. National Audubon Society, New York.
98. Duever, M.J., J.F. Meeder, and L.C. Duever. 1984. Ecosystems of the Big Cypress Swamp. 294-303 in Ewel, K.C. and H.T. Odum. *Cypress Swamps*. University of Florida Press, Gainesville.
99. Duffee, E.M., W.J. Allen, and H.C. Ammons. 1979. Soil survey of Jackson County, Florida. United States Department of Agriculture, Soil Conservation Service in cooperation with the University of Florida Institute of Food and Agricultural Sciences, Agricultural Experiment Stations, Soil Science Department, Gainesville, Florida.
100. Duncan, R.S., C.B. Anderson, H.N. Sellers, and E.E. Robbins. 2008. The effect of fire reintroduction on endemic and rare plants of a Southeastern glade ecosystem. *Restoration Ecology* 16:39-49.
101. Dunn, W.J. 1982. Plant communities and vascular flora of San Felasco Hammock, Alachua County, Florida. Thesis, University of Florida, Gainesville.
102. Dwyer, N. 1990. Nesting ecology and nest-site selection of Florida sandhill cranes. Thesis, University of Florida, Gainesville, Florida.
103. Echols, S.L., Jr. 2007. Vascular flora of remnant blackland prairies and associated vegetation of Georgia. Masters Thesis, University of Georgia, Athens.
104. Eleuterius, L.N. and C.K. Eleuterius. 1979. Tide levels and salt-marsh zonation. *Bulletin of Marine Science* 29:394-400.
105. Ewel, K.C. 1990. Swamps. 281-323 in Myers, R.L. and J.J. Ewel. *Ecosystems of Florida*. University of Central Florida Press, Orlando.
106. Ewel, K.C. 1995. Fire in cypress swamps in the southeastern United States. 111-116 in Cerulean, S.I. and R.T. Engstrom. *Fire in Wetlands: A Management Perspective*. Proceedings of the Tall Timbers Fire Ecology Conference, No. 19. Tall Timbers Research Station, Tallahassee, Florida.
107. Ewel, K.C. and W.J. Mitsch. 1978. The effect of fire on species composition in cypress dome ecosystems. *Florida Scientist* 41:25-30.
108. Ewel, K.C. and L.P. Wickenheiser. 1988. Effect of swamp size on growth rates of cypress (*Taxodium distichum*) trees. *American Midland Naturalist* 120:362-370.
109. Florida Department of Environmental Protection FDEP. 2004. Florida Forever five year plan. Florida Department of Environmental Protection, Office of State Lands, Tallahassee, Florida.
110. Fernald, E.A., E.D. Purdum, J.R. Anderson, Jr., and P.A. Krafft, editors. 1998. *Water Resources Atlas of Florida*. Institute of Science and Public Affairs, Florida State University, Tallahassee.
111. Ferriter, A., B. Doren, C. Goodyear, D. Thayer, J. Burch, L. Toth, M. Bodle, J. Lane, D. Schmitz, and P. Pratt. 2006. The status of nonindigenous species in the South Florida environment. South Florida Environmental Report 9-1. Available at: <http://iswgflla.org/files/South%20Fla%20report%20Chap%209.pdf>
112. Fitzpatrick, J.W., G.E. Woolfenden, and M.T. Kopeny. 1991. Ecology and development-related habitat requirements of the Florida scrub jay (*Aphelocoma coerulescens coerulescens*). Nongame Wildlife Program Technical Report 8. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.
113. Fleming, D.M., W.F. Wolff, and D.L. DeAngelis. 1994. Importance of landscape heterogeneity to wood storks in Florida Everglades. *Environmental Management* 18:743-757.

114. FLEPPC. 2007. Florida Exotic Pest Plant Council. Florida Exotic Pest Plant Council. URL: <http://www.fleppc.org/>
115. Flohrschutz, E.W. 1978. Dwarf cypress in the Big Cypress Swamp of southwestern Florida. Thesis, University of Florida, Gainesville.
116. Flora of North America Editorial Committee. 2007. Flora of North America North of Mexico. New York and Oxford.
117. Florida Natural Areas Inventory FNAI. 2004. Natural community descriptions to accompany a vegetation map of Three Lakes Wildlife Management Area. Unpublished report to the Florida Fish and Wildlife Conservation Commission. Florida Natural Areas Inventory, Tallahassee, Florida.
118. Florida Natural Areas Inventory FNAI. 2005. Historic natural communities at Okaloacoochee Slough State Forest. Unpublished report to the Florida Department of Agriculture and Consumer Services, Division of Forestry. Florida Natural Areas Inventory, Tallahassee, Florida.
119. Florida Natural Areas Inventory FNAI. 2005. Natural community descriptions to accompany a vegetation map of Florida Keys Wildlife and Environmental Area. Unpublished report to the Florida Fish and Wildlife Conservation Commission. Florida Natural Areas Inventory, Tallahassee, Florida.
120. Florida Natural Areas Inventory FNAI. 2006. Historic natural communities at Blackwater River State Forest. Unpublished report to the Florida Division of Forestry. Florida Natural Areas Inventory, Tallahassee, Florida.
121. Florida Natural Areas Inventory FNAI. 2006. Natural community descriptions to accompany a vegetation map of Flying Eagle Ranch. Unpublished report to Southwest Florida Water Management District. Florida Natural Areas Inventory, Tallahassee, Florida.
122. Florida Natural Areas Inventory FNAI. 2006. Natural community descriptions to accompany a vegetation map of Salt Lake Wildlife Management Area. Unpublished report to the Florida Fish and Wildlife Conservation Commission. Florida Natural Areas Inventory, Tallahassee, Florida.
123. Florida Natural Areas Inventory FNAI. 2006. Natural community descriptions to accompany a vegetation map of Upper Hillsborough. Unpublished report to the Southwest Florida Water Management District. Florida Natural Areas Inventory, Tallahassee, Florida.
124. Florida Natural Areas Inventory FNAI. 2007. Current and historical natural communities at Ralph E. Simmons State Forest. Unpublished report to the Florida Division of Forestry. Florida Natural Areas Inventory, Tallahassee, Florida.
125. Florida Natural Areas Inventory FNAI and E.J. Chicardi. 1993. A natural areas inventory of Marion County, Florida. Florida Natural Areas Inventory, Tallahassee, Florida.
126. Florida Natural Areas Inventory and Florida Department of Natural Resources FNAI and FDNR. 1990. Guide to the natural communities of Florida. Florida Natural Areas Inventory and Florida Department of Natural Resources, Tallahassee, Florida. Available at: http://www.fnai.org/PDF/Natural_Communities_Guide.pdf
127. Fogarty, M.J. 1984. The ecology of the Everglades alligator. 211-218 in Gleason, P.J. Environments of South Florida: Present and Past II. Miami Geological Society, Coral Gables.
128. Folkerts, G.W. 1982. The Gulf-Coast pitcher plant bogs. *American Scientist* 70:260-267.
129. Fowlkes, M.D., J.L. Michael, T.L. Crisman, and J.P. Prenger. 2003. Effects of the herbicide Imazapyr on benthic macroinvertebrates in a logged pond cypress dome. *Environmental Toxicology and Chemistry* 22:900-907.
130. Frost, C.C. 1995. Presettlement fire regimes in southeastern marshes, peatlands, and swamps. 39-60 in Cerulean, S.I. and R.T. Engstrom. *Fire in Wetlands: A Management Perspective*. Proceedings of the Tall Timbers Fire Ecology Conference, No. 19. Tall Timbers Research Station, Tallahassee, Florida.
131. Frost, C.C. 1998. Presettlement fire frequency regimes of the United States: a first approximation. 70-81 in Pruden, T.L. and L.A. Brennan. *Fire in Ecosystem Management: Shifting the Paradigm from Suppression to Prescription*. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, Florida.
132. Gaddy, L.L. 1982. The floristics of three South Carolina pine savannas. *Castanea* 47:393-402.
133. Gann, G.D., K.A. Bradley, and S.W. Woodmansee. 2009. Floristic Inventory of South Florida Database. Institute for Regional Conservation. URL: <http://regionalconservation.org/ircs/database/database.asp>
134. Garren, K.H. 1943. Effects of fire on vegetation of the southeastern United States. *Botanical Review* 9:617-654.
135. Gibson, D.J. and E.S. Menges. 1994. Population structure and spatial pattern in the dioecious shrub *Ceratiola ericoides*. *Journal of Vegetation Science* 5:337-346.
136. Gilbert, K.M., J.D. Tobe, R.W. Cantrell, M.E. Sweeley, and J.R. Cooper. 1995. The Florida Wetlands Delineation Manual. Florida Department of Environmental Protection, Florida Department of Environmental Regulation (in cooperation with the Florida Water Management Districts), Tallahassee, Florida.
137. Girardon, D.L. and E.F. Lowe. 1986. The effects of off-road vehicle traffic on vegetation of the floodplain of the Upper St. Johns River. Technical Publication SJ 87-6. St. Johns River Water Management District, Department of Water Resources, Palatka, Florida.
138. Gleason, P.J. and P. Stone. 1994. Age, origin, and landscape evolution of the Everglades peatland. 149-198 in Davis, S.M. and J.C. Ogden. *Everglades: The Ecosystem and its Restoration*. St. Lucie Press, Delray Beach.

139. Glitzenstein, J.S., W.J. Platt, and D.R. Streng. 1995. Effects of fire regime and habitat on tree dynamics in north Florida longleaf pine savannas. *Ecological Monographs* 65:441-476.
140. Glitzenstein, J.S., D.R. Streng, and D.D. Wade. 2003. Fire frequency effects on longleaf pine (*Pinus palustris*, P. Miller) vegetation in South Carolina and northeast Florida, USA. *Natural Areas Journal* 23:22-37.
141. Goodrick, R.L. and J.F. Milleson. 1974. Studies of floodplain vegetation and water level fluctuation in the Kissimmee River Valley. Technical Publication 74-2. South Florida Water Management District, West Palm Beach, Florida.
142. Gordon, D.R. and K.J. Rice. 1998. Patterns of differentiation in wiregrass (*Aristida beyrichiana*): implications for restoration efforts. *Restoration Ecology* 6:166-174.
143. Greenberg, C.H. 2003. Vegetation recovery and stand structure following a prescribed stand-replacement burn in sand pine scrub. *Natural Areas Journal* 23:141-151.
144. Grelen, H.E. 1980. Longleaf pine-slash pine. 52-53 in Eyre, F.H. *Forest Cover Types of the United States and Canada*. Society of American Foresters, Washington.
145. Greller, A.M. 1980. Correlation of some climate statistics with distribution of broadleaved forest zones in Florida, USA. *Bulletin of the Torrey Botanical Club* 107:189-219.
146. Guerin, D.N. 1993. Oak dome clonal structure and fire ecology in a Florida longleaf pine dominated community. *Bulletin of the Torrey Botanical Club* 120:107-114.
147. Gunderson, L.H. 1984. Regeneration of cypress in logged and burned strands at Corkscrew Swamp Sanctuary, Florida. 349-357 in Ewel, K.C. and H.T. Odum. *Cypress Swamps*. University Press of Florida, Gainesville.
148. Gunderson, L.H. and W.F. Loftus. 1993. The Everglades. 199-255 in Martin, W.H., S.G. Boyce, and A.C. Echternacht. *Biodiversity of the Southeastern United States: Lowland Terrestrial Communities*. John Wiley and Sons, Inc., New York.
149. Gunderson, L.H. and L.L. Loope. 1982. An inventory of the plant communities within the Deep Lake Strand area, Big Cypress National Preserve. South Florida Research Center T-666. Everglades National Park, Homestead, Florida.
150. Gunderson, L.H. and J.R. Snyder. 1994. Fire patterns in the southern Everglades. 291-305 in Davis, S.M. and J.C. Ogden. *Everglades: The Ecosystem and its Restoration*. St. Lucie Press, Delray Beach.
151. Haddad, K.D. and E.A. Joyce, Jr. 1997. Management. 309-329 in Coultas, C.L. and Y.P. Hsieh. *Ecology and Management of Tidal Marshes: A Model from the Gulf of Mexico*. St. Lucie Press, Delray Beach.
152. Hamann, R. and J. Tucker. 1997. Legal protection. 277-308 in Coultas, C.L. and Y.P. Hsieh. *Ecology and Management of Tidal Marshes: A Model from the Gulf of Mexico*. St. Lucie Press, Delray Beach.
153. Harcombe, P.A., J.S. Glitzenstein, R.G. Knox, S.L. Orzell, and E.L. Bridges. 1993. Vegetation of the longleaf pine region of the West Gulf Coastal Plain. 83-104 in Hermann, S.M., K. Ross, and K. Gainey. *The Longleaf Pine Ecosystem: Ecology, Restoration and Management*. Proceedings of the Tall Timbers Fire Ecology Conference, 18. Tall Timbers Research, Inc., Tallahassee, Florida.
154. Hardin, J.W. 1954. The vegetation pattern around a Florida sinkhole. *Contributions to Science* 2:6-17.
155. Harper, R.M. 1905. 'Hammock,' 'hommock' or 'hummock'? *Science* 22:400-402.
156. Harper, R.M. 1911. The relation of climax vegetation to islands and peninsulas. *Bulletin of the Torrey Botanical Club* 38:515-525.
157. Harper, R.M. 1914. Geography and vegetation of northern Florida. 172-451 in 6th Annual Report. Florida Geological Survey, Tallahassee, Florida.
158. Harper, R.M. 1915. Vegetation types. 135-188 in Sellards, E.H., R.M. Harper, E.N. Mooney, W.J. Gunter, and E. Gunter. *Natural resources survey of an area in central Florida*. 7th Annual Report of the Florida Geological Survey, Tallahassee, Florida.
159. Harper, R.M. 1916. The fern grottoes of Citrus County, Florida. *American Fern Journal* 68-81.
160. Harper, R.M. 1921. Geography of central Florida. 13th Annual Report. Florida Geological Survey, Tallahassee, Florida.
161. Harper, R.M. 1927. Natural resources of southern Florida. 27-206 in 18th Annual Report. Florida Geological Survey, Tallahassee, Florida.
162. Harper, R.M. 1943. Forests of Alabama. Alabama geological survey monograph 10:1-230.
163. Harshberger, J.W. 1914. The vegetation of south Florida south of 27 degrees 30 minutes north, exclusive of the Florida Keys. *Transactions of the Wagner Free Institute of Science of Philadelphia* 7:51-189.
164. Hawkes, C.V. and V.R. Flechtner. 2002. Biological soil crusts in a xeric Florida shrubland: composition, abundance, and spatial heterogeneity of crusts with different disturbance histories. *Microbial Ecology* 43:1-12.
165. Hawkes, C.V. and E.S. Menges. 1996. The relationship between open space and fire for species in a xeric Florida shrubland. *Bulletin of the Torrey Botanical Club* 123:81-92.
166. Hay-Smith, L. and G.W. Tanner. 1999. Restoring longleaf pine sandhill communities with an herbicide. Publication Document WEC-131. University of Florida, Department of Wildlife Ecology and Conservation, Institute of Food and Agricultural Sciences, Gainesville, Florida.
167. Heimburg, K. 1984. Hydrology of north-central Florida cypress domes.

168. Hermann, S.M. 1995. Status and management of Florida's carnivorous plant communities. Nongame Wildlife Program project no. GFC-84-033. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.
169. Herndon, A. and D. Taylor. 1986. Response of a *Muhlenbergia* prairie to repeated burning: changes in above-ground biomass. South Florida Research Center Report# SFRC-86/05. Everglades National Park, Homestead, Florida.
170. Herring, B.J. and W.S. Judd. 1995. A floristic study of Ichetucknee Springs State Park, Suwannee and Columbia Counties, Florida. *Castanea* 60:318-369.
171. Hess, C. 2007. Historical landscape of Apalachicola National Forest. Lecture presented at Florida State University.
172. 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.
173. Heyward, F. 1939. The relation of fire to stand composition of longleaf pine forests. *Ecology* 20:287-304.
174. Hilmon, J.B. 1964. Plants of the Caloosa Experimental Range. Forest Service Research Paper SE-12. Southeastern Forest Experiment Station, Asheville, North Carolina.
175. Hilsenbeck, C.E., R.H. Hofstetter, and T.R. Alexander. 1979. Preliminary synopsis of major plant communities in the east Everglades area: vegetation map supplement. Unpublished Report Department of Biology, University of Miami, Miami, Florida.
176. Hine, A.C. and D.F. Belknap. 1986. Recent geological history and modern sedimentary processes of the Pasco, Hernando, and Citrus County coastline, west central Florida. Florida Sea Grant Report 79. Florida Sea Grant College, Gainesville, Florida.
177. Holder, G.L., M.K. Johnson, and J.L. Baker. 1980. Cattle grazing and management of dusky seaside sparrow habitat. *Wildlife Society Bulletin* 8:105-109.
178. Hubbell, T.H., A.M. Laessle, and J.C. Dickinson. 1956. The Flint-Chattahoochee-Apalachicola region and its environments. *Bulletin of the Florida State Museum* 1:1-72.
179. Huck, R.B. 1987. Plant communities along an edaphic continuum in a central Florida watershed. *Florida Scientist* 50:111-128.
180. Huck, R.B., A.F. Johnson, A.J. Parker, K.C. Parker, W.J. Platt, and D.B. Ward. 1996. Management of natural communities of Choctawhatchee sand pine [*Pinus clausa* (Englem.) Sarg. var. *immuginata* Ward] in the Florida Panhandle. 89-91 in Resource Management Notes, Vol. 8 No. 4. Florida Park Service, Florida Department of Environmental Protection, Tallahassee, Florida.
181. Huckle, H.F., H.D. Dollar, and R.F. Pendleton. 1974. Soil survey of Brevard County, Florida. United States Department of Agriculture, Soil Conservation Service in cooperation with the University of Florida Institute of Food and Agricultural Sciences, Agricultural Experiment Stations, Soil Science Department, Gainesville, Florida.
182. Huenneke, L.F. and R.R. Sharitz. 1986. Microsite abundance and distribution of woody seedlings in a South Carolina cypress-tupelo swamp. *American Midland Naturalist* 115:328-335.
183. Huffman, J.M. 2006. Historical fire regimes in southeastern pine savannahs. Dissertation, Louisiana State University and Agricultural and Mechanical College, Baton Rouge.
184. Huffman, J.M. and S.W. Blanchard. 1991. Changes in woody vegetation in Florida dry prairie and wetlands during a period of fire exclusion and after dry-growing-season fire. 75-83 in Nodvin, S.C. and T.A. Waldrop. Fire and the environment: ecological and cultural perspectives. Forest Service General Technical Report SE-69. Southeastern Forest Experiment Station, Asheville, North Carolina.
185. Hupp, C.R. 2000. Hydrology, geomorphology and vegetation of Coastal Plain rivers in the south-eastern USA. *Hydrological Processes* 14:2991-3010.
186. Jackson, D.R. and E.G. Miltrey. 1989. The fauna of gopher tortoise burrows. 86-98 in Diemer, J.E., D.R. Jackson, J.L. Landers, J.N. Lane, and D.A. Wood. Gopher Tortoise Relocation Symposium Proceedings, Nongame Wildlife Program Technical Report #5. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.
187. Jacqmain, E.I., R.H. Jones, and R.J. Mitchell. 1999. Influences of frequent cool-season burning across a soil moisture gradient on oak community structure in longleaf pine ecosystems. *American Midland Naturalist* 141:85-100.
188. James, C.W. 1961. Endemism in Florida. *Brittonia* 13:225-244.
189. Johnson, A.F. 1982. Some demographic characteristics of the Florida rosemary, *Ceratiola ericoides* Michx. *American Midland Naturalist* 108:170-174.
190. Johnson, A.F. 1994. Coastal impacts on non-indigenous species. in Schmitz, D.C. and T.C. Brown. An assessment of invasive non-indigenous species in Florida's public lands. Florida Department of Environmental Protection, Tallahassee, Florida.
191. Johnson, A.F. 1997. Rates of vegetation succession on a coastal dune system in northwest Florida. *Journal of Coastal Research* 13:373-384.
192. Johnson, A.F. and W.G. Abrahamson. 1982. *Quercus inopina*: a species to be recognized from south-central Florida. *Bulletin of the Torrey Botanical Club* 109:392-395.
193. Johnson, A.F. and W.G. Abrahamson. 2002. Stem turnover in the rhizomatous scrub oak, *Quercus inopina*, from south-central Florida. *The American Midland Naturalist* 147:237-246.
194. Johnson, A.F. and M.G. Barbour. 1990. Dunes and maritime forest. 429-480 in Myers, R.L. and J.J. Ewel. Ecosystems of Florida. University of Central Florida Press, Orlando.

195. Johnson, A.F. and D. Hipes. 1997. A survey of gopher tortoises and high quality seepage slopes at Backwater River State Forest: an FNAI ecological inventory. Unpublished report to the Florida Department of Environmental Protection. Florida Natural Areas Inventory, Tallahassee, Florida.
196. Johnson, A.F., H.E. Horne, and C.E. Kindell. 2000. Status of rare plant and lichen species and natural communities on Eglin Air Force Base, Santa Rosa Island, Florida. Unpublished report to Eglin Air Force Base. Florida Natural Areas Inventory, Tallahassee, Florida.
197. Johnson, A.F. and J.W. Muller. 1992. An assessment of Florida's remaining coastal upland natural communities: southwest Florida. Unpublished report submitted to the Florida Department of Environmental Protection. Florida Natural Areas Inventory, Tallahassee, Florida.
198. Johnson, A.F. and J.W. Muller. 1993. An assessment of Florida's remaining coastal upland natural communities: final summary report. Unpublished report submitted to the Florida Department of Environmental Protection. Florida Natural Areas Inventory, Tallahassee, Florida.
199. Johnson, A.F. and J.W. Muller. 1993. An assessment of Florida's remaining coastal upland natural communities: northeast Florida. Unpublished report submitted to the Florida Department of Environmental Protection. Florida Natural Areas Inventory, Tallahassee, Florida.
200. Johnson, A.F., J.W. Muller, and K.A. Bettinger. 1992. An assessment of Florida's remaining coastal upland natural communities: panhandle. Unpublished report submitted to the Florida Department of Environmental Protection. Florida Natural Areas Inventory, Tallahassee, Florida.
201. Johnson, A.F., J.W. Muller, and K.A. Bettinger. 1992. An assessment of Florida's remaining coastal upland natural communities: southeast Florida. Unpublished report submitted to the Florida Department of Environmental Protection. Florida Natural Areas Inventory, Tallahassee, Florida.
202. Johnson, A.S., H.O. Hillestad, S.F. Shanholtzer, and G.F. Shanholtzer. 1974. An ecological survey of the coastal region of Georgia. National Park Service Scientific Monograph Series No. 3. United States Government Printing Office, Washington, D.C.
203. Johnson, E.D. 2001. Pitcherplants and their habitats in the Florida State Park system: resource conditions, trends, and management needs. Resource Management Evaluation. Division of Recreation and Parks, Florida Department of Environmental Protection, Tallahassee.
204. Johnstone, J., P. Russo, and C. Kindell. 2004. Historic vegetation of Mallory Swamp. Unpublished report to the Suwannee River Water Management District. Florida Natural Areas Inventory, Tallahassee, Florida.
205. Jordan, J. 1994. After melaleuca tree removal: no money and little time. 154 in Schmitz, D.C. and T.C. Brown. An assessment of invasive non-indigenous species in Florida's public lands. Florida Department of Environmental Protection, Tallahassee, Florida.
206. Kautz, R.S. 1998. Land use and land cover trends in Florida 1936-1995. Florida Scientist 61:171-187.
207. Keppner, E. Biologist, Panama City, FL. Personal Communication. 2008
208. Kindell, C.E. 1997. Historic distribution of wet savannas in Tate's Hell State Forest. Report to the United States Fish and Wildlife Service and Northwest Florida Water Management District. Florida Natural Areas Inventory, Tallahassee, Florida.
209. Kindell, C.E., B.J. Herring, C. Nordman, J. Jensen, A.R. Schotz, and L.G. Chafin. 1997. Natural community survey of Eglin Air Force Base, 1993-1996: Final Report. Florida Natural Areas Inventory, Tallahassee, Florida Natural Areas Inventory, Tallahassee, Florida.
210. Kindell, C.E., A.A. Winn, and T.E. Miller. 1996. The effects of surrounding vegetation and transplant age on the detection of local adaptation in the perennial grass *Aristida stricta*. Journal of Ecology 84:745-754.
211. Kirkman, L.K., K.L. Coffey, R.J. Mitchell, and E.B. Moser. 2004. Ground cover recovery patterns and life-history traits: implications for restoration obstacles and opportunities in a species-rich savanna. Journal of Ecology 92:409-421.
212. Kirkman, L.K., P.C. Goebel, M.B. Drew, and B.J. Palik. 2000. Depressional wetland vegetation types: a question of plant community development. Wetlands 20:373-385.
213. Kirkman, L.K., S.W. Golladay, L. Laclaire, and R. Sutter. 1999. Biodiversity in southeastern, seasonally ponded, isolated wetlands: management and policy perspectives for research and conservation. Journal of the North American Benthological Society 18:553-562.
214. Kirkman, L.K., R.J. Mitchell, R.C. Helton, and M.B. Drew. 2001. Productivity and species richness across an environmental gradient in a fire-dependent ecosystem. American Journal of Botany 88:2119-2128.
215. Knight, G.R. 1986. A floristic study of Three Rivers State Recreation Area and Apalachee Game Management Area, Jackson County, Florida. Thesis, Florida State University, Tallahassee.
216. Kologiski, R.L. 1977. The phytosociology of the Green Swamp, North Carolina. Technical Bulletin 250. North Carolina Agricultural Experiment Station, Raleigh, North Carolina.
217. Kruer, C.R. 1992. An assessment of Florida's remaining coastal upland natural communities: Florida Keys. Unpublished report submitted to the Florida Department of Environmental Protection. Florida Natural Areas Inventory, Tallahassee, Florida.
218. Kuchler, A.W. 1964. Potential natural vegetation of the conterminous United States: manual to accompany the map. 36. American Geographical Society, New York.
219. Kurz, H. 1942. Florida dunes and scrub, vegetation and geology. Florida Geological Survey Bulletin 23:1-154.
220. Kurz, H. 1944. Secondary forest succession in the Tallahassee Red Hills. Proceedings of the Florida Academy of Science 7:59-100.

221. Kurz, H. and K. Wagner. 1957. Tidal marshes of the Gulf and Atlantic coasts of north Florida and Charleston, South Carolina. *Florida State University Studies* 24:1-168.
222. Kurz, H. and K.A. Wagner. 1953. Factors in cypress dome development. *Ecology* 34:157-164.
223. Kushlan, J.A. 1990. Freshwater marshes. 324-363 in Myers, R.L. and J.J. Ewel. *Ecosystems of Florida*. University of Central Florida Press, Orlando.
224. Kwit, C., M.W. Schwartz, W.J. Platt, and J.P. Geaghan. 1998. The distribution of tree species in steepheads of the Apalachicola River Bluffs, Florida. *Journal of the Torrey Botanical Society* 125:309-318.
225. LaClaire, L.V. 1995. Vegetation of selected upland temporary ponds in north and north-central Florida. *Bulletin Florida Museum of Natural History* 38:69-96.
226. LaClaire, L.V. and R. Franz. 1991. Importance of isolated wetlands in upland landscapes. 9-15 in Kelly, M. *The Role of Aquatic Plants in Florida's Lakes and Rivers*. Proceedings of the second annual meeting of the Florida Lake Management Society. Florida Lake Management Society, Orlando, Florida.
227. Laessle, A.M. 1942. The plant communities of the Welaka area with special reference to correlations between soils and vegetational succession. *Biological Sciences Series Vol. 4 No. 1*. University of Florida Publication, Gainesville, Florida.
228. Laessle, A.M. 1958. The origin and successional relationship of sandhill vegetation and sand-pine scrub. *Ecological Monographs* 28:361-387.
229. Laessle, A.M. and C.H. Wharton. 1959. Northern extensions in the recorded ranges of plants on Seahorse Key and associated Keys, Levy County, Florida. *Quarterly Journal Florida Academy of Sciences* 22:105-113.
230. Lakela, O. 1964. Fewer Florida rarities: changing flora of Pineola Grotto, Citrus County. *Sida* 1:299-305.
231. Landers, J.L. 1991. Disturbance influences on pine traits in the southeastern United States. 39-60 in *High intensity fire in wildlands: management challenges and opportunities*. Proceedings of the Tall Timbers Fire Ecology Conference, No. 17. Tall Timbers Research Station, Tallahassee, Florida.
232. Larson, R. 1995. *Swamp Song: A Natural History of Florida's Swamps*. University Press of Florida, Gainesville.
233. Lee, M.A.B., K.L. Snyder, P. Valentine-Darby, S.J. Miller, and K.J. Ponzio. 2005. Dormant season prescribed fire as a management tool for the control of *Salix caroliniana* Michx. in a floodplain marsh. *Wetlands Ecology and Management* 13:479-487.
234. Legare, M., H. Hill, R. Farinetti, and F.T. Cole. 1998. Marsh bird response during two prescribed fires at the St. Johns National Wildlife Refuge, Brevard County, Florida. 114 in Pruden, T.L. and L.A. Brennan. *Fire in Ecosystem Management: Shifting the Paradigm from Suppression to Prescription*. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, Florida.
235. Leitman, H.M., J.E. Sohm, and M.A. Franklin. 1982. Wetland hydrology and tree distribution of the Apalachicola River flood plain, Florida. 2196-A. United States Geological Survey Water Supply, Alexandria.
236. Lemon, P.C. 1949. Successional responses of herbs in the longleaf-slash pine forest after fire. *Ecology* 30:135-145.
237. Leonard, S.W. and W.W. Baker. 1982. Biological survey of the Apalachicola Ravines biotic region of Florida. Report to the Florida state office of The Nature Conservancy and to the Florida Natural Areas Inventory, Tallahassee, Florida.
238. Lewis, C.E. 1970. Responses to chopping and rock phosphate on south Florida ranges. *Journal of Range Management* 23:276-282.
239. Light, H.M. and M.R. Darst. 1993. Hydrology, vegetation, and soils of four north Florida river flood plains with an evaluation of state and federal wetland determinations. *Water Resources Investigation Report 93-4033*. United States Geological Survey, Tallahassee, Florida.
240. Light, S.S. and J.W. Dineen. 1994. Water control in the Everglades: a historical perspective. 47-84 in Davis, S.M. and J.C. Ogden. *Everglades: The Ecosystem and its Restoration*. St. Lucie Press, Delray Beach.
241. Lippincott, C.L. 1997. Ecological consequences of *Imperata cylindrica* (cogongrass) invasion in Florida sandhill. Dissertation, University of Florida, Gainesville.
242. Lockhart, C. *Lygodium* specialist, Florida Natural Areas Inventory. Personal Communication. 2008
243. Lodge, T.E. 2005. *The Everglades Handbook: Understanding the Ecosystem*. CRC Press, Boca Raton.
244. Loftin, C.S. 1998. Assessing pattern and processes of landscape change in Okefenokee Swamp, Georgia. Dissertation, University of Florida, Gainesville.
245. Loope, L., M. Duever, A. Herndon, J. Snyder, and D. Jansen. 1994. Hurricane impact on uplands and freshwater swamp forest. *Bioscience* 44:238-246.
246. Loope, L.L., D.W. Black, S. Black, and G.N. Avery. 1979. Distribution and abundance of flora in limestone rockland pine forests of southeastern Florida. South Florida Research Center, Everglades National Park, Homestead, Florida.
247. Loope, L.L. and V.L. Dunevitz. 1981. Impact of fire exclusion and invasion of *Schinus terebinthifolius* on limestone rockland pine forests of southeastern Florida. Report T-645. South Florida Research Center, Everglades National Park, Homestead, Florida.
248. Lopanski, M.J., J.P. Evans, and R.E. Shaw. 1988. An assessment of maritime forest resources on the North Carolina coast. 108. A final report submitted to the North Carolina Department of Natural Resources and Community Development, Division of Coastal Management, Raleigh, North Carolina.
249. Loveless, C.M. 1959. A study of the vegetation in the Florida Everglades. *Ecology* 40:1-9.

250. Lowe, E.F. 1986. The relationship between hydrology and vegetational pattern within the floodplain marsh of a subtropical, Florida lake. *Florida Scientist* 49:213-233.
251. Lowery, L. Ocala National Forest. Personal Communication. 2007
252. Lugo, A.E. and S.C. Snedaker. 1974. The ecology of mangroves. *Annual Review of Ecological Systems* 5:39-64.
253. Lynch, J.M. and W.W. Baker. 1988. Natural areas inventory of the St. Marys River, Georgia-Florida. The Nature Conservancy Southeast Region, Chapel Hill, North Carolina.
254. MacRoberts, B.R. and M.H. MacRoberts. 1995. Vascular flora of two calcareous prairie remnants on the Kisatchie National Forest, Louisiana. *Phytologia* 78:18-27.
255. MacRoberts, B.R. and M.H. MacRoberts. 1996. The floristics of calcareous prairies on the Kisatchie National Forest, Louisiana. *Phytologia* 81:35-43.
256. MacRoberts, M.H. and B.R. MacRoberts. 2001. Bog communities of west Gulf Coastal Plain: a profile. Bog Research papers in Botany and Ecology No.1. Bog Research, Shreveport, LA.
257. Madison, M. and J. Waldberg. 2009. The Knowledge of Bonsai Forums. URL: http://www.knowledgeofbonsai.org/species_specific/buttonwood.php
258. Main, K.N. and E.S. Menges. 1997. Archbold Biological Station fire management plan. 97-1 Land Management Publication. Archbold Biological Station, Lake Placid, Florida.
259. Main, M.B. and M.J. Barry. 2002. Influence of season of fire on flowering of wet prairie grasses in South Florida, USA. *Wetlands* 22:430-434.
260. Mayfield, A.E., III, E.L. Barnard, J.A. Smith, S.C. Bernick, J.M. Eickwort, and T.J. Dreaden. 2008. The effect of propiconazole on laurel wilt disease development in redbay trees and on the pathogen *in vitro*. *Arboriculture & Urban Forestry* 35:317-324.
261. McCollum, S.H., O.E. Cruz, L.T. Stem, W.H. Wittstruck, R.D. Ford, and F.C. Watts. 1978. Soil survey of Palm Beach County area, Florida. United States Department of Agriculture, Soil Conservation Service in cooperation with the University of Florida Institute of Food and Agricultural Sciences, Agricultural Experiment Stations, Soil Science Department, Gainesville, Florida.
262. McCollum, S.H. and R.F. Pendleton. 1971. Soil survey of Okeechobee County, Florida. United States Department of Agriculture, Soil Conservation Service in cooperation with the University of Florida Institute of Food and Agricultural Sciences, Agricultural Experiment Stations, Soil Science Department, Gainesville, Florida.
263. McCormick, P.V. and M.B. O'Dell. 1996. Quantifying periphyton responses to phosphorus in the Florida Everglades: A synoptic-experimental approach. *Journal of the North American Benthological Society* 15:450-468.
264. McPherson, B.F. and H.J. McCoy. 1974. Physiographic map of the Okaloacoochee Slough in Collier County, Florida. United States Geological Survey Open-File Report FL-74022.
265. Means, D.B. and C.J. Longden. 1976. Aspects of the biology and zoogeography of the pine barrens treefrog (*Hyla andersonii*) in northern Florida. *Herpetologica* 32:117-130.
266. Means, H. Geologist with the Florida Geological Survey, Tallahassee. Personal Communication. 2007
267. Means, R. 2008. Management strategies for Florida's ephemeral ponds and pond breeding amphibians. FWC Agreement Number 05039. Coastal Plains Institute, Tallahassee, Florida. Available at: <http://www.coastalplains.org/pdf/Final%20Report%202008.pdf>
268. Menges, E.S. 2007. Integrating demography and fire management: an example from the Florida scrub. *Australian Journal of Botany* 55:261-272.
269. Menges, E.S. and M.A. Deyrup. 2001. Postfire survival in south Florida slash pine: interacting effects of fire intensity, fire season, vegetation, burn size, and bark beetles. *International Journal of Wildland Fire* 10:53-63.
270. Menges, E.S. and N. Kohfeldt. 1995. Life history strategies of Florida scrub plants in relation to fire. *Bulletin of the Torrey Botanical Club* 122:282-297.
271. Menges, E.S., C.W. Weekley, S.I. Hamze, and R.L. Pickert. 2007. Soil preferences for federally-listed plants on the Lake Wales Ridge in Highlands County, Florida. *Florida Scientist* 70:24-39.
272. Meyer, K.D. 1997. Migrant and resident bird populations during spring and fall in coastal oak scrub and maritime hammock natural communities at Cape Canaveral Air Station. Florida Natural Areas Inventory, Tallahassee, Florida.
273. Miller, S.J., K.J. Ponzio, M.A. Lee, L.W. Keenan, and S.R. Miller. 1998. The use of fire in wetland preservation and restoration: are there risks? 127-139 in Pruden, T.L. and L.A. Brennan. *Fire in Ecosystem Management: Shifting the Paradigm from Suppression to Prescription*. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, Florida.
274. Minno, M.C., S.J. Miller, and K.J. Ponzio. 2001. Assessing the potential occurrence of rare, threatened and endangered species in the upper St. Johns River Basin. Technical Publication SJ2001-3. St. Johns River Water Management District, Palatka, Florida.
275. Mitchell, R.S. 1963. Phytogeography and floristic survey of a relic area in the Marianna Lowlands, Florida. *The American Midland Naturalist* 69:328-366.
276. Mize, R., R.E. Evans, B.R. MacRoberts, M.H. MacRoberts, and D.C. Rudolph. 2005. Restoration of pitcher plant bogs in eastern Texas, USA. *Natural Areas Journal* 25:197-201.

277. Moler, P.E. and R. Franz. 1987. Wildlife values of small, isolated wetlands in the southeastern coastal plain. 234-241 in Odum, R.R., K.A. Riddleberger, and J.C. Ozier. Proceedings of the third Southeastern Nongame and Endangered Wildlife Symposium. Georgia Department of Natural Resources, Atlanta, Georgia.
278. Monk, C.D. 1960. A preliminary study on the relationships between the vegetation of a mesic hammock community and a sandhill community. Quarterly Journal of the Florida Academy of Science 23:1-12.
279. Monk, C.D. 1966. An ecological study of hardwood swamps in north-central Florida. Ecology 47:649-654.
280. Monk, C.D. and T.W. Brown. 1965. Ecological consideration of cypress heads in northcentral Florida. American Midland Naturalist 74:126-140.
281. Montague, C.L. and R.G. Wiegert. 1990. Salt marshes. 481-516 in Myers, R.L. and J.J. Ewel. Ecosystems of Florida. University of Central Florida Press, Orlando.
282. Moore, W.E. 1955. Geology of Jackson County. Florida: Florida Geological Survey Bulletin 37:1-101.
283. Myers, R.L. 1990. Scrub and high pine. 150-193 in Myers, R.L. and J.J. Ewel. Ecosystems of Florida. University of Central Florida Press, Orlando.
284. Myers, R.L. and S. Boettcher. 1987. Flowering response of cutthroat grass (*Panicum abscissum*) following fire. Bulletin of the Ecological Society of America 68:375.
285. Myers, R.L. and D.L. White. 1987. Landscape history and changes in sandhill vegetation in north-central and south-central Florida. Bulletin of the Torrey Botanical Club 114:21-32.
286. NatureServe. 2008. NatureServe Explorer website. <http://www.natureserve.org/explorer/>. URL: <http://www.natureserve.org/explorer/>
287. NatureServe. 2009. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. <http://www.natureserve.org/explorer/>. URL: <http://www.natureserve.org/explorer/>
288. Nelson, G. 1996. The Shrubs and Woody Vines of Florida: A Reference and Field Guide. Pineapple Press Inc, Sarasota.
289. NeSmith, C. Zoologist, Florida Natural Areas Inventory, Tallahassee, Florida. Personal Communication. 2008
290. Newman, S., J.B. Grace, and J.W. Koebel. 1996. Effects of nutrients and hydroperiod on *Typha*, *Cladium*, and *Eleocharis*: Implications for Everglades restoration. Ecological Applications 6:774-783.
291. Noe, G.B., D.L. Childers, and R.D. Jones. 2001. Phosphorus biogeochemistry and the impact of phosphorus enrichment: Why is the Everglades so unique? Ecosystems 4:603-624.
292. Norman, E.M. 1976. An analysis of the vegetation at Turtle Mound. Florida Scientist 39:19-31.
293. Norman, E.M. and S.S. Hawley. 1995. An analysis of the vegetation at Turtle Mound, Volusia County, Florida: twenty years later. Florida Scientist 58:258-269.
294. Norquist, H.C. 1984. A comparative study of the soils and vegetation of savannas in Mississippi. Thesis, Mississippi State University,
295. Noss, R.F., E.T. LaRoe, III, and J.M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. Biological Report 28. United States Department of Interior, National Biological Service, Washington, D.C.
296. Nyman, J.A. and R.H. Chabreck. 1995. Fire in coastal marshes: history and recent concerns. 134-141 in Cerulean, S.I. and R.T. Engstrom. Fire in Wetlands: A Management Perspective. Proceedings of the Tall Timbers Fire Ecology Conference, No. 19. Tall Timbers Research Station, Tallahassee, Florida.
297. Oberbauer, S.F., K. von Kleist, K.R.T. Whelan, and S. Koptur. 1996. Effects of Hurricane Andrew on epiphyte communities within cypress domes of Everglades National Park. Ecology 77:964-967.
298. Odum, W.E. and C.C. McIvor. 1990. Mangroves. 517-548 in Myers, R.L. and J.J. Ewel. Ecosystems of Florida. University of Central Florida Press, Orlando.
299. 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.
300. Ogden, J.C. 1994. A comparison of wading bird nesting colony dynamics (1931-1946 and 1974-1989) as an indication of ecosystem conditions in the southern Everglades. 533-570 in Davis, S.M. and J.C. Ogden. Everglades: The Ecosystem and its Restoration. St. Lucie Press, Delray Beach.
301. Ogden, J.C. 2005. Everglades ridge and slough conceptual ecological model. Wetlands 25:810-820.
302. Olmsted, I.C. and T.V. Armentano. 1997. Vegetation of Shark Slough, Everglades National Park. South Florida Natural Resources Center Report 97-001. National Park Service, Homestead, Florida.
303. Olmsted, I.C. and L.L. Loope. 1984. Plant communities of Everglades National Park. 167-184 in Gleason, P.J. Environments of South Florida: Present and Past II. Miami Geological Society, Coral Gables.
304. Olmsted, I.C., L.L. Loope, and C.E. Hilsenbeck. 1980. Tropical hardwood hammocks of the interior of Everglades National Park and Big Cypress National Preserve. Report T-604. South Florida Research Center, Everglades National Park, Homestead, Florida.
305. Olmsted, I.C., L.L. Loope, and R.E. Rintz. 1980. A survey and baseline analysis of aspects of the vegetation of Taylor Slough, Everglades National Park. Report T-586. South Florida Research Center, Everglades National Park, Homestead, Florida.

306. Orzell, S.L. and E.L. Bridges. 2006. Floristic composition and species richness of subtropical seasonally wet *Muhlenbergia sericea* prairies in portions of central and south Florida. 136-175 in Noss, R.F. Land of Fire and Water: The Florida Dry Prairie Ecosystem. Proceedings of the Florida Dry Prairie Conference. Painter, DeLeon Springs.
307. Orzell, S.L. and E.L. Bridges. 2006. Species composition and environmental characteristics of Florida dry prairies from the Kissimmee River region of south-central Florida. 100-135 in Noss, R.F. Land of Fire and Water: The Florida Dry Prairie Ecosystem. Proceedings of the Florida Dry Prairie Conference. Painter, DeLeon Springs.
308. Ostertag, R. and E.S. Menges. 1994. Patterns of reproductive effort with time since last fire in Florida scrub plants. *Journal of Vegetation Science* 5:303-310.
309. Ostertag, T.E. and K.M. Robertson. 2006. A comparison of native versus old-field vegetation in upland pinelands managed with frequent fire, South Georgia, USA. Masters, R.E. and K.E.M. Galley. Fire in grassland and shrubland ecosystems. Tall Timbers Fire Ecology Conference Proceedings, No. 23. Tall Timbers Research Station, Tallahassee, Florida.
310. Outcalt, K.W. 1997. An old-growth definition for sand pine forests. General Technical Report SRS-012. United States Department of Agriculture Forest Service, Southern Research Station, Asheville, North Carolina.
311. Outcalt, K.W. 1997. An old-growth definition for tropical and subtropical forests in Florida. General Technical Report SRS-013. United States Department of Agriculture Forest Service, Southern Research Station, Asheville, North Carolina.
312. Owen, M. Biologist, Fakahatchee Strand State Preserve. Personal Communication. 2008
313. Palmer, M.L. and F.J. Mazzotti. 2004. Structure of Everglades alligator holes. *Wetlands* 24:115-122.
314. Parker, K.C., J.L. Hamrick, A.J. Parker, and J.D. Nason. 2001. Fine-scale genetic structure in *Pinus clausa* (Pinaceae) populations: effects of disturbance history. *Heredity* 87:99-113.
315. Parkinson, R.W., R.R. DeLaune, C.T. Hutcherson, and J. Stewart. 2006. Tuning surface water management and wetland restoration programs with historic sediment accumulation rates: Merritt Island National Wildlife Refuge, East-Central Florida, USA. *Journal of Coastal Research* 22:1268-1277.
316. Patton, J.E. and W.S. Judd. 1986. Vascular flora of Paynes Prairie Basin and Alachua Sink Hammock, Alachua County, Florida. *Castanea* 51:88-110.
317. Pauly, G.B., O. Piskurek, and H.B. Shaffer. 2007. Phylogeographic concordance in the southeastern United States: the flatwoods salamander, *Ambystoma cingulatum*, as a test case. *Molecular Ecology* 16:415-429.
318. Peet, R.K. and D.J. Allard. 1993. Longleaf pine vegetation of the southern Atlantic and eastern Gulf Coast regions: a preliminary classification. 45-82 in Hermann, S.M. The Longleaf Pine Ecosystem: Ecology, Restoration and Management. Proceedings of the Tall Timbers Fire Ecology Conference, No. 23. Tall Timbers Research Station, Tallahassee, Florida.
319. Penfound, W.T. 1952. Southern swamps and marshes. *Botanical Review* 18:413-446.
320. Peroni, P.A. and W.G. Abrahamson. 1986. Succession in Florida sandridge vegetation: a retrospective study. *Florida Scientist* 49:176-190.
321. Perrin, L.S., M.J. Allen, L.A. Rowse, F. Montalbano, III, K.J. Foote, and M.W. Olinde. 1982. A report on fish and wildlife studies in the Kissimmee River Basin and recommendations for restoration. Florida Game and Fresh Water Fish Commission, Office of Biological Services, Okeechobee, Florida.
322. Phillips, W.S. 1940. A tropical hammock on the Miami (Florida) limestone. *Ecology* 21:166-175.
323. Pilkey, O.H., Jr., D.C. Sharma, H.R. Wanless, L.J. Doyle, O.H. Pilkey, Sr., W.J. Neal, and B.L. Gruver. 1984. Living with the East Florida Shore. Duke University Press, Durham.
324. Platt, W.J. 1999. Southeastern pine savannas. 23-51 in Anderson, R.C., J.S. Fralish, and J.M. Baskin. Savannas, Barrens, and Rock Outcrop Plant Communities of North America. Cambridge University Press, Cambridge.
325. Platt, W.J., R.F. Doren, and T.V. Armentano. 2000. Effects of Hurricane Andrew on stands of slash pine (*Pinus elliottii* var. *densa*) in the everglades region of south Florida (USA). *Plant Ecology* 146:43-60.
326. Platt, W.J., G.W. Evans, and M.M. Davis. 1988. Effects of fire season on flowering of forbs and shrubs in longleaf pine forests. *Oecologia* 76:353-363.
327. Platt, W.J., J.M. Huffman, and M.G. Slocum. 2006. Fire regimes and trees in Florida dry prairie landscapes. 3-13 in Noss, R.F. Land of Fire and Water: The Florida Dry Prairie Ecosystem. Proceedings of the Florida Dry Prairie Conference. Painter, DeLeon Springs.
328. Platt, W.J. and M.W. Schwartz. 1990. Temperate hardwood forests. 194-229 in Myers, R.L. and J.J. Ewel. Ecosystems of Florida. University of Central Florida Press, Orlando.
329. Porter, C.L., Jr. 1967. Composition and productivity of a subtropical prairie. *Ecology* 48:937-942.
330. Possley, J. and J. Maschinski. 2006. Competitive effects of the invasive grass *Rhynchelytrum repens* (Willd.) CE Hubb. on pine rockland vegetation. *Natural Areas Journal* 26:391-395.
331. Post, W. and J.S. Greenlaw. 1994. Seaside Sparrow. 1-28 in Poole, A. and F. Gill. Birds of North America. American Ornithologists Union, Washington, DC.

332. Pranty, B. and J.W. Tucker, Jr. 2006. Ecology and management of the Florida Grasshopper Sparrow. 188-200 in Noss, R.F. Land of Fire and Water: The Florida Dry Prairie Ecosystem. Proceedings of the Florida Dry Prairie Conference. Painter, DeLeon Springs.
333. Provencher, L., K.E.M. Galley, B.J. Herring, J.P. Sheehan, N.M. McAdoo, S.J. Gobris, A.R. McAdoo, A.R. Litt, G.W. Gordon, G.W. Tanner, L.A. Brennan, and J.L. Hardesty. 1999. Effects of hardwood reduction on trees and community similarity and sand pine harvest on groundcover vegetation in longleaf pine sandhills at Eglin Air Force Base. Science Division, The Nature Conservancy, Gainesville, Florida.
334. Provencher, L., A.R. Litt, K.E.M. Galley, D.R. Gordon, G.W. Tanner, L.A. Brennan, N.M. Gobris, S.J. McAdoo, J.P. McAdoo, and B.J. Herring. 2001. Restoration of fire-suppressed longleaf pine sandhills at Eglin Air Force Base, Florida. Final report to the Natural Resources Management Division, Eglin Air Force Base. The Nature Conservancy, Gainesville, Florida.
335. Provencher, L., A.R. Litt, and D.R. Gordon. 2003. Predictors of species richness in northwest Florida longleaf pine sandhills. Conservation Biology 17:1660-1671.
336. Quarterman, E. 1950. Major plant communities of Tennessee Cedar Glades. Ecology 31:234-254.
337. Quarterman, E., M.P. Burbank, and D.J. Shure. 1993. Rock outcrop communities: limestone, sandstone, and granite. 35-86 in Martin, W.H., S.G. Boyce, and A.C. Echternacht. Biodiversity of the Southeastern United States: Upland Terrestrial Communities. John Wiley and Sons, Inc., New York.
338. Richardson, C.J., M.L. Matthews, and S.A. Anderson. 1981. Pocosin Wetlands: An Integrated Analysis of Coastal Plain Freshwater Bogs in North Carolina. Hutchinson Ross Publishing Company, Hutchinson.
339. Robbins, L.E. and R.L. Myers. 1992. Seasonal effects of prescribed burning in Florida: a review. Miscellaneous Publication No. 8. Tall Timbers Research Station, Tallahassee, Florida.
340. Robertson, K. Fire Ecology Research Scientist, Tall Timbers Research Station. Personal Communication. 2007
341. Robertson, W.B., Jr. 1953. A survey of the effects of fire in Everglades National Park. United States Department of the Interior, National Park Service, Homestead, Florida.
342. Rochow, T.F. 1985. Hydrologic and vegetational changes resulting from underground pumping at the Cypress Creek Well Field, Pasco County, Florida. Florida Scientist 48:65-80.
343. Ross, M.S., J.F. Meeder, J.P. Sah, P.L. Ruiz, and G.J. Telesnicki. 2000. The southeast saline Everglades revisited: 50 years of coastal vegetation change. Journal of Vegetation Science 11:101-112.
344. Ross, M.S., S. Mitchell-Bruker, J.P. Sah, S. Stothoff, P.L. Ruiz, D.L. Reed, K. Jayachandran, and C.L. Coultas. 2006. Interaction of hydrology and nutrient limitation in the ridge and slough landscape of the southern Everglades. Hydrobiologia 569:37-59.
345. Ross, M.S., J.J. O'Brien, and L.J. Flynn. 1992. Ecological site classification of Florida Keys terrestrial habitats. Biotropica 24:488-502.
346. Ross, M.S., J.J. O'Brien, and L.d.S. Sternberg. 1994. Sea-level rise and the reduction in pine forests in the Florida Keys. Ecological Applications 4:144-156.
347. Rothmel, R.C. 1983. How to predict the spread and intensity of forest and range fires. General Technical Report INT-143. United States Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.
348. Rudloe, J. 1972. Northwest Florida: a last frontier. Underwater Naturalist 6:8-15.
349. Rummell, R.S. 1957. Beef cattle production and range practices in south Florida. Journal of Range Management 10:71-78.
350. Rupert, F.R. 1990. Geology of Gadsden County, Florida. Florida Geological Survey, Tallahassee Florida.
351. Rutchey, K., T.N. Schall, R.F. Doren, A. Atkinson, M.S. Ross, D.T. Jones, M. Madden, L. Vilcheck, K.A. Bradley, J.R. Snyder, J.N. Burch, T. Pernas, B. Witcher, M. Pyne, R. White, T.J. Smith, III, J. Sadie, C.S. Smith, M.E. Patterson, and G.D. Gann. 2006. Vegetation classification for south Florida natural areas. Open-File Report 2006-1240. United States Department of the Interior, United States Geological Survey, Reston, Virginia.
352. Rymal, D.F. and G.W. Folkerts. 1982. Insects associated with pitcher plants (*Sarracenia*: Sarraceniaceae), and their relationship to pitcher plant conservation: a review. Journal of the Alabama Academy of Science 53:131-151.
353. Sauer, J.D. 1967. Geographic reconnaissance of seashore vegetation along the Mexican Gulf Coast. Louisiana State University Coastal Studies Series No.21 DTIC Research Report AD0665777.
354. Schafale, M.P. and P.A. Harcombe. 1983. Presettlement vegetation of Hardin County, Texas. American Midland Naturalist 109:355-366.
355. Schmalzer, P.A. 2003. Growth and recovery of oak-saw palmetto scrub through ten years after fire. Natural Areas Journal 23:5-13.
356. Schmalzer, P.A. and F.W. Adrian. 2001. Scrub restoration on Kennedy Space Center/Merritt Island National Wildlife Refuge, 1992-2000. 17-20 in Zattau, D.P. Proceedings of the Florida Scrub Symposium 2001. United States Fish and Wildlife Service, Jacksonville, Florida.

357. Schmalzer, P.A. and C.R. Hinkle. 1987. Effects of fire on composition, biomass, and nutrients in oak scrub vegetation on John F. Kennedy Space Center, Florida. Technical Memorandum 100305. NASA, Kennedy Space Center.
358. Schotz, A. 2005. A checklist of vascular flora in the Black Belt Prairies of Alabama. Alabama Natural Heritage Program, Montgomery, Alabama.
359. Schwartz, M.W. 1988. Species diversity patterns in woody flora on three North American peninsulas. *Journal of Biogeography* 15:759-774.
360. Schwartz, M.W. 1994. Natural distribution and abundance of forest species and communities in northern Florida. *Ecology* 75:687-705.
361. Schwartz, M.W. and S.M. Hermann. 1993. The continuing population decline of *Torreya taxifolia* Arn. *Bulletin of the Torrey Botanical Club* 120:275-286.
362. Soil Conservation Service SCS. 1989. 26 ecological communities of Florida. United States Department of Agriculture.
363. Sekerak, C.M. and J.K. Hinchey. 2001. The evolution of Ocala National Forest's current sand pine scrub management program. 21-24 in Zatta, D.P. *Proceedings of the Florida Scrub Symposium 2001*. United States Fish and Wildlife Service, Jacksonville, Florida.
364. Sharitz, R.R. and J.W. Gibbons. 1982. The ecology of southeastern shrub bogs (pocosins) and Carolina bays: a community profile. FWS/OBS-82/04. United States Fish and Wildlife Service, Division of Biological Services, Washington, D.C.
365. Sharitz, R.R. and W.J. Mitsch. 1993. Southern floodplain forests. 311-372 in Martin, W.H., S.G. Boyce, and A.C. Echternacht. *Biodiversity of the Southeastern United States: Lowland Terrestrial Communities*. John Wiley and Sons, Inc., New York.
366. Simons, R.W. 1990. Terrestrial and freshwater habitats. 99-157 in Wolfe, S.H. *An ecological characterization of the Florida Springs Coast: Pithlachascotee to Waccasassa Rivers*. Biological Report 90(21). United States Fish and Wildlife Service, Washington, DC.
367. Simons, R.W., S.W. Vince, and S.R. Humphrey. 1989. *Hydric hammocks: a guide to management*. 85 (7.26 Supplement). United States Fish and Wildlife Service, Washington, DC.
368. Sinclair, W.C. and J.W. Stewart. 1985. Sinkhole type, development, and distribution in Florida. Map Series No. 110. Florida Department of Natural Resources, Bureau of Geology, Tallahassee, Florida.
369. Skeen, J.N., P.D. Doerr, and D.H. Van Lear. 1993. Oak-hickory-pine forests. 1-33 in Martin, W.H., S.G. Boyce, and A.C. Echternacht. *Biodiversity of the Southeastern United States: Upland Terrestrial Communities*. John Wiley & Sons, New York.
370. Skelley, P. Collections Manager, Florida Department of Agriculture and Consumer Services - Florida State Collection of Arthropods. Personal Communication. 2009
371. Small, J.K. 1920. Of grottoes and ancient dunes, a record of exploration in Florida in December 1918. *Journal of the New York Botanical Garden* 21:25-54.
372. Small, J.K. 1921. Old trails and new discoveries: a record of exploration in Florida in the spring of 1919. *Journal of the New York Botanical Garden* 22:25-40; 49-64.
373. Small, J.K. 1922. The botanical fountain of youth: a record of exploration in Florida in April 1920. *Journal of the New York Botanical Garden* 23:117-133; 139-154.
374. Small, J.K. 1923. Green deserts and dead gardens: a record of exploration in the spring of 1921. *Journal of the New York Botanical Garden* 24:193-247.
375. Small, J.K. 1927. Among floral aborigines: a record of exploration in Florida in the winter of 1922. *Journal of the New York Botanical Garden* 28:1-40.
376. Small, J.K. 1928. Botanical fields, historic and prehistoric: a record of exploration in Southeastern Coastal Plain in the spring of 1923. *Journal of the New York Botanical Garden* 29:149-209; 223-235.
377. Small, J.K. 1929. *From Eden to Sahara: Florida's Tragedy*. Privately printed by author (re-printed in 2004 by Seminole Soil and Water Conservation District), Sanford.
378. Smith, T.J., III, M.B. Robblee, H.R. Wanless, and T.W. Doyle. 1994. Mangroves, hurricanes, and lightning strikes. *Bioscience* 44:256.
379. Snyder, G.H. and J.M. Davidson. 1994. Everglades agriculture: past, present, and future. 85-115 in Davis, S.M. and J.C. Ogden. *Everglades: The Ecosystem and its Restoration*. St. Lucie Press, Delray Beach.
380. Snyder, J.R. 1991. Fire regimes in subtropical south Florida. 303-319 in *High Intensity Fire in Wildlands: Management Challenges and Options*. *Proceedings of the Tall Timbers Fire Ecology Conference*, No. 17. Tall Timbers Research Station, Tallahassee, Florida.
381. Snyder, J.R., A. Herndon, and W.B. Robertson, Jr. 1990. South Florida rockland. 230-280 in Myers, R.L. and J.J. Ewel. *Ecosystems of Florida*. University of Central Florida Press, Orlando.
382. Sorrie, B.A. 1997. Alabama and Mississippi seepage bog survey. Final report to the Alabama Natural Heritage Program and United States Fish and Wildlife Service, Montgomery, Alabama.
383. Sparks, J.C., R.E. Masters, D.M. Engle, M.W. Palmer, and G.A. Bukenhofer. 1998. Effects of late growing-season and late dormant-season prescribed fire on herbaceous vegetation in restored pine-grassland communities. *Journal of Vegetation Science* 9:133-142.

384. Sparling, J.H. 1968. Biological flora of the British Isles: *Schoenus nigricans* L. (*Chaetospora nigricans* Kunth). Journal of Ecology 56:883-899.
385. Stallins, J.A. and J. Griggs. 2004. Influence of historic upland silviculture on the composition of ravine forests along the Apalachicola River, Florida, USA. Natural Areas Journal 24:242-250.
386. Stalter, R. and D. Kincaid. 2004. The vascular flora of five Florida shell middens. Journal of the Torrey Botanical Society 93-103.
387. Stalter, R. and E.E. Lamont. 1997. Flora of North Carolina's Outer Banks, Ocracoke Island to Virginia. Journal of the Torrey Botanical Society 124:71-88.
388. Stein, B.A., L.S. Kutner, and J.S. Adams, editors. 2000. Precious Heritage: The Status of Biodiversity in the United States. Oxford University Press, USA, New York.
389. Stephenson, T.A. and A. Stephenson. 1950. Life between tide-marks in North America. I. The Florida Keys. Journal of Ecology 38:354-402.
390. Streng, D.R., J.S. Glitzenstein, and W.J. Platt. 1993. Evaluating effects of season of burn in longleaf pine forests: a critical literature review and some results from an ongoing long-term study. 227-264 in Hermann, S.M. Proceedings of the Tall Timbers Fire Ecology Conference, No. 18. Tall Timbers Research Station, Tallahassee, Florida.
391. Swilling, R.W., Jr., M.C. Wooten, M.R. Holler, and W.J. Lynn. 1998. Population dynamics of Alabama beach mice (*Peromyscus polionotus ammobates*) following Hurricane Opal. American Midland Naturalist 140:287-298.
392. Sykes, P.W., Jr. 1984. The range of the snail kite and its history in Florida. Bulletin of the Florida State Museum Biological Science 29:211-264.
393. Tall Timbers Research Station. 2007. Unpublished research. Tall Timbers Research Station, Tallahassee, FL.
394. Tan, B.H. and W.S. Judd. 1995. A floristic inventory of O'Leno State Park and northeast River Rise State Preserve, Alachua and Columbia Counties, Florida. Castanea 60:141-165.
395. Tanner, G.W., W.S. Terry, and L.L. Yarlett. 1982. Vegetation dynamics of three freshwater marshes within the Kissimmee River Valley. Final Report submitted to Coordinating Council on the Restoration of the Kissimmee River Valley and Taylor Creek-Nubbin Slough, Tallahassee, Florida. School of Forest Resources and Conservation, University of Florida, Gainesville, Florida.
396. Taylor, D.L. 1983. Fire management and the Cape Sable seaside sparrow. 147-152 in Quay, T., J. Funderburg, D. Lee, E. Potter, and C. Robbins. The Seaside Sparrow, its Biology and Management. North Carolina State Museum of Natural History, Raleigh.
397. Teas, H.J. 1977. Ecology and restoration of mangrove shorelines in Florida. Environmental Conservation 4:51-58.
398. 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.
399. The Florida Senate. 2009. The Florida Senate website. URL: <http://www.flsenate.gov/Welcome/index.cfm?CFID=120927317&CFTOKEN=16710813>
400. Thomas, B.P., L. Law, and D.L. Stankey. 1979. Soil survey of Marion County, Florida. United States Department of Agriculture, Soil Conservation Service in cooperation with the University of Florida Institute of Food and Agricultural Sciences, Agricultural Experiment Stations, Soil Science Department, Gainesville, Florida.
401. Thomas, B.P., H.H. Weeks, and M.W. Hazen, Jr. 1961. Soil Survey of Gadsden County, Florida. United States Department of Agriculture, Soil Conservation Service in cooperation with the University of Florida Institute of Food and Agricultural Sciences, Agricultural Experiment Stations, Soil Science Department, Gainesville, Florida.
402. Thompson, S.M. 1977. Vascular plant communities and environmental parameters under tidal influence on the Wakulla and St. Marks Rivers, Florida. Thesis, Florida State University, Tallahassee.
403. Thompson, W. Central region conservation director, The Nature Conservancy, Florida Chapter. Personal Communication. 2006
404. Tipping, P.W., M.R. Martin, K.R. Nimmo, R.M. Pierce, M.D. Smart, E. White, P.T. Madeira, and T.D. Center. 2009. Invasion of a West Everglades wetland by *Melaleuca quinquenervia* countered by classical biological control. Biological Control 48:73-78.
405. Toth, L.A. 1993. The ecological basis of the Kissimmee River restoration plan. Florida Scientist 56:25-51.
406. Toth, L.A., S.L. Melvin, D.A. Arrington, and J. Chamberlain. 1998. Hydrologic manipulations of the channelized Kissimmee River - implications for restoration. Bioscience 48:757-764.
407. Turner, W.R., D.S. Wilcove, and H.M. Swain. 2006. State of the scrub: conservation progress, management responsibilities, and land acquisition priorities for imperiled species of Florida's Lake Wales Ridge. Archbold Biological Station, Lake Placid, Florida.
408. URS Corporation Southern, Institute for Regional Conservation, and Muller and Associates, Inc. 2007. Miami-Dade County environmentally endangered lands program management plan, part II: management of specific habitat types. Chapter 1: The pine rockland habitat. Miami-Dade County, Miami, Florida.
409. United States Department of Agriculture USDA. 2007. Official soil series descriptions. Natural Resources Conservation Service. URL: <http://www.soils.usda.gov/technical/classification/osd/index.html>
410. United States Forest Service USFS. 1984. Soils and vegetation of Apalachicola National Forest. United States Forest Service, Tallahassee, Florida.

411. United States Forest Service USFS. 2009. Laurel Wilt. United States Department of Agriculture. URL: <http://www.fs.fed.us/r8/foresthealth/laurelwilt/index.shtml>
412. United States Fish and Wildlife Service USFWS. 1999. Dry prairie. South Florida multi-species recovery plan - Ecological communities. United States Fish and Wildlife Service. URL: <http://www.fws.gov/verobeach/images/pdfLibrary/dry%20prairie.pdf>
413. United States Fish and Wildlife Service USFWS. 1999. Florida scrub (including scrubby flatwoods and scrubby high pine). South Florida multi-species recovery plan - Ecological communities. U.S.Fish and Wildlife Service. URL: <http://www.fws.gov/verobeach/images/pdfLibrary/Florida%20scrub.pdf>
414. United States Fish and Wildlife Service USFWS. 1999. Flowing water swamp. South Florida multi-species recovery plan - Ecological communities. United States Fish and Wildlife Service. URL: <http://www.fws.gov/verobeach/images/pdfLibrary/flowing%20water%20swamps.pdf>
415. United States Fish and Wildlife Service USFWS. 1999. Freshwater marshes and wet prairies. South Florida multi-species recovery plan - Ecological communities. United States Fish and Wildlife Service. URL: <http://www.fws.gov/verobeach/images/pdfLibrary/marshes%20wet%20prairies.pdf>
416. United States Fish and Wildlife Service USFWS. 1999. Mesic temperate hammock. South Florida multi-species recovery plan - Ecological communities. United States Fish and Wildlife Service. URL: <http://www.fws.gov/southeast/vbpdfs/commun/mth.pdf>
417. United States Fish and Wildlife Service USFWS. 1999. Pond swamps. South Florida multi-species recovery plan - Ecological communities. United States Fish and Wildlife Service.
418. United States Fish and Wildlife Service USFWS. 1999. Seepage swamps. South Florida multi-species recovery plan - Ecological communities. U.S.Fish and Wildlife Service. URL: <http://www.fws.gov/verobeach/images/pdfLibrary/marshes%20wet%20prairies.pdf>
419. Van Loan, A.N., J.R. Meeker, and M.C. Minno. 2002. Cogon grass. 353-364 in Van Driesche, R., S. Lyon, B. Blossey, M. Hoddle, and R. Reardon. Biological control of invasive plants in the eastern United States. Publication FHTET-2002-04. United States Department of Agriculture Forest Service.
420. Varner, J.M., D.R. Gordon, F.E. Putz, and J.K. Hiers. 2005. Restoring fire to long-unburned *Pinus palustris* ecosystems: novel fire effects and consequences for long-unburned ecosystems. Restoration Ecology 13:536-544.
421. Verdi, R.J., S.A. Tomlinson, and R.L. Marella. 2006. The drought of 1998-2002: impacts on Florida's hydrology and landscape. United States Geological Survey Circular 1295.
422. Vernon, R.O. 1947. Cypress domes. Science 105:97-99.
423. Vince, S.W., S.R. Humphrey, and R.W. Simons. 1989. The ecology of hydric hammocks: a community profile. 85(7.26). Biological Report. United States Fish and Wildlife Service, Washington, DC.
424. Wade, D., J. Ewel, and R. Hofstetter. 1980. Fire in South Florida ecosystems. Forest Service General Technical Report SE-17. Southeastern Forest Experiment Station, Asheville, North Carolina.
425. Wade, D. and R.W. Johansen. 1986. Effect of fire on southern pine: observations and recommendations. General Technical Report SE-41. U.S. Forest Service Southeastern Forest Experiment Station, Asheville, N.C.
426. Walker, J. and R.K. Peet. 1983. Composition and species diversity of pine-wiregrass savannas of the Green Swamp, North Carolina. Vegetatio 55:163-179.
427. Walters, T.W., D.S. Decker-Walters, and D.R. Gordon. 1994. Restoration considerations for wiregrass (*Aristida stricta*): allozymic diversity of populations. Conservation Biology 8:581-585.
428. Ward, D.B. and A.K. Gholson. 1987. The hidden abundance of *Lepuropetalon spathulatum* (Saxifragaceae) and its first reported occurrence in Florida. Castanea 52:59-67.
429. Ware, S., C. Frost, and P.D. Doerr. 1993. Southern mixed hardwood forest: the former longleaf pine forest. 447-493 in Martin, W.H., S.G. Boyce, and A.C. Echternacht. Biodiversity of the Southeastern United States: Upland Terrestrial Communities. John Wiley and Sons, Inc., New York.
430. Watts, F.C. 1997. Soil survey of the city of Jacksonville, Duval County. United States Department of Agriculture, Natural Resources Conservation Service in cooperation with University of Florida Institute of Food and Agricultural Sciences, Agricultural Experiment Stations, Soil Science Department, Gainesville, Florida.
431. Webb, D.S. 1990. Historical biogeography. 70-100 in Myers, R.L. and J.J. Ewel. Ecosystems of Florida. University of Central Florida Press, Orlando.
432. Weeks, H.H., A.G. Hyde, A. Roberts, D. Lewis, and C.R. Peters. 1980. Soil survey of Santa Rosa County, Florida. United States Department of Agriculture, Soil Conservation Service in cooperation with the University of Florida Institute of Food and Agricultural Sciences, Agricultural Experiment Stations, Soil Science Department, Gainesville, Florida.
433. Welch, J.R., K.V. Miller, W.E. Palmer, and T.B. Harrington. 2004. Response of understory vegetation important to the northern bobwhite following imazapyr and mechanical treatments. Wildlife Society Bulletin 32:1071-1076.
434. Werner, D. 1975. The biology of the Cape Sable seaside sparrow. United States Fish and Wildlife Service, Everglades National Park, Homestead, Florida.
435. Wetzel, P.R., A.G. van der Valk, and L.A. Toth. 2001. Restoration of wetland vegetation on the Kissimmee River floodplain: Potential role of seed banks. Wetlands 21:189-198.

436. Wharton, C.H. 1978. The Natural Environments of Georgia. Geologic and Water Resources Division and Resource Planning Section, Office of Planning and Research, Georgia Department of Natural Resources, Atlanta.
437. Wharton, C.H., W.M. Kitchens, E.C. Pendleton, and T.W. Sipe. 1982. The ecology of bottomland hardwood swamps of the southeast: a community profile. FWS/OBS-81/37. United States Fish and Wildlife Service, Biological Service Program, Washington, D.C.
438. Wharton, C.H., H.T. Odum, K. Ewel, M. Duever, A. Lugo, R. Boyt, J. Bartholomew, E. DeBellevue, S. Brown, M. Brown, and L. Duever. 1977. Forested wetlands of Florida - Their management and use. Final Report to Florida Division of State Planning, DSP-BCP-19-77. Center for Wetlands, University of Florida, Gainesville, Florida.
439. Whitney, E., D.B. Means, and A. Rudloe. 2004. Priceless Florida: Natural Ecosystems and Native Species. Pineapple Press, Sarasota.
440. Williams, K., K.C. Ewel, R.P. Stumpf, F.E. Putz, and T.W. Workman. 1999. Sea-level rise and coastal forest retreat on the west coast of Florida, USA. *Ecology* 80:2045-2063.
441. Winchester, B.H., J.S. Bays, J.C. Higman, and R.L. Knight. 1985. Physiography and vegetation zonation of shallow emergent marshes in southwestern Florida. *Wetlands* 5:99-118.
442. Winsberg, M.D. 1992. Weather and climate. 40-57 in Fernald, E.A., E.D. Purdum, J.R. Anderson, Jr., and P.A. Krafft. Atlas of Florida. University Press of Florida, Gainesville.
443. Woolfenden, G.E. and J.W. Fitzpatrick. 1992. Florida scrub jay (*Aphelocoma coerulescens*). 1-28 in Poole, A.F. and F.B. Gill. The Birds of North America No. 228. The Academy of Natural Sciences of Philadelphia and the American Ornithologists' Union, Washington, D.C., Philadelphia.
444. Wunderlin, R.P. and B.F. Hansen. 2000. Flora of Florida. Volume I. Pteridophytes and Gymnosperms. University Press of Florida, Gainesville.
445. Young, C.C. and E.S. Menges. 1999. Postfire gap-phase regeneration in scrubby flatwoods on the Lake Wales Ridge. *Florida Scientist* 62:1-12.
446. 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.

APPENDIX 1. CROSSWALK

1990 to 2010 Crosswalk

<i>1990 NC Guide Name</i>	<i>2010 NC Guide Name</i>	<i>Explanation for Major Changes</i>
Basin Marsh	Basin Marsh	
Basin Swamp	Basin Swamp	
Baygall	Baygall	
Beach Dune	Beach Dune	
Bog	Shrub Bog	The concept of "bog" was restricted to shrubby species and the name changed to reflect this.
Bottomland Forest	Bottomland Forest	
Coastal Berm	Coastal Berm	
Coastal Grassland	Coastal Grassland	
Coastal Interdunal Swale	Coastal Interdunal Swale	
Coastal Rock Barren	Keys Cactus Barren Keys Tidal Rock Barren	The "coastal rock barren" community was split into an upland "Keys cactus barren" community and an intertidal "Keys tidal rock barren" community.
Coastal Strand	Coastal Strand	
Depression Marsh	Depression Marsh	
Dome Swamp	Dome Swamp	
Dry Prairie	Dry Prairie	
Floodplain Forest	Alluvial Forest	The name has been changed to "alluvial forest" to emphasize the role of active floodplain dynamics in the structure and composition of the community.
Floodplain Marsh	Floodplain Marsh	
Floodplain Swamp	Floodplain Swamp	
Freshwater Tidal Swamp	Floodplain Swamp (Freshwater Tidal Swamp)	Freshwater tidal swamp is recognized in the 2009 update as a variant of floodplain swamp.
Hydric Hammock	Hydric Hammock	
Maritime Hammock	Maritime Hammock	
Marl Prairie	Marl Prairie	
Mesic Flatwoods	Mesic Flatwoods	
Mesic Hammock	Mesic Hammock	
Pine Rockland	Pine Rockland	
Prairie Hammock	Mesic Hammock (Prairie Mesic Hammock) Hydric Hammock (Prairie Hydric Hammock)	Small isolated hammocks are recognized as variants of either mesic or hydric hammock based on their hydrology and vegetation.
Rockland Hammock	Rockland Hammock	
Sandhill	Sandhill	
Scrub	Scrub	
Scrubby Flatwoods	Scrubby Flatwoods	
Seepage Slope	Wet Prairie Seepage Slope	Seepage slope was re-defined as an herbaceous community within high pine and scrub communities. Some communities previously referred to as seepage slope may now fall under wet prairie if they are in a pine flatwoods system. The shrubby type of seepage slope (not due to fire suppression) would now be called shrub bog.

<i>1990 NC Guide Name</i>	<i>2010 NC Guide Name</i>	<i>Explanation for Major Changes</i>
Shell Mound	Shell Mound	
Sinkhole	Sinkhole Limestone Outcrop	Exposed limestone is now classified as "limestone outcrop." This community often occurs within sinkholes.
Slope Forest	Slope Forest Upland Hardwood Forest	Geographically restricted to the upper Apalachicola River bluffs and ravines. Areas that were classified as slope forest outside of this range, under the 1990 Guide, should now be classified as upland hardwood forest.
Slough	Slough	
Strand Swamp	Strand Swamp	Geographically restricted to south Florida.
Swale	Glades Marsh Slough Marsh	Two marsh categories are recognized in place of the 1990 "swale" community. Marshes with a substrate of peat or peat/marl directly overlying limestone in the Everglades and Big Cypress region are "glades marsh." Drainageway marshes on peat overlying sand substrates in flat topography are "slough marsh."
Tidal Marsh	Salt Marsh	The common term "salt marsh" was chosen to avoid potential confusion.
Tidal Swamp	Mangrove Swamp Keys Tidal Rock Barren	The common term "mangrove swamp" was chosen to avoid potential confusion.
Upland Glade	Upland Glade	
Upland Hardwood Forest	Upland Hardwood Forest	
Upland Mixed Forest	Upland Mixed Woodland Upland Hardwood Forest	Upland mixed forest is no longer included as a community in the 2009 update. Much of what was classified as upland mixed forest under the 1990 Guide will now be classified as upland hardwood forest (Dry upland hardwood forest variant), successional hardwood forest (a new altered landcover type recognized in this update), or the new upland mixed woodland community.
Upland Pine Forest	Upland Pine Upland Mixed Woodland	The name has been changed to upland pine so as not to imply a closed canopy. Upland mixed woodland is a new community that encompasses the ecotone between upland pine and upland hardwood forest.
Wet Flatwoods	Wet Flatwoods	
Wet Prairie	Wet Prairie	
Xeric Hammock	Xeric Hammock	

2010 to 1990 Crosswalk

<i>2010 NC Guide Name</i>	<i>1990 NC Guide Name</i>	<i>Explanation for Major Changes</i>
Alluvial Forest	Floodplain Forest Bottomland Forest (misapplied)	The name has been changed to "alluvial forest" to emphasize the role of active floodplain dynamics in the structure and composition of the community.
Basin Marsh	Basin Marsh	
Basin Swamp	Basin Swamp	
Baygall	Baygall	
Beach Dune	Beach Dune	
Bottomland Forest	Bottomland Forest Floodplain Forest (misapplied)	
Coastal Berm	Coastal Berm	
Coastal Grassland	Coastal Grassland	
Coastal Interdunal Swale	Coastal Interdunal Swale	
Coastal Strand	Coastal Strand	
Depression Marsh	Depression Marsh	
Dome Swamp	Dome Swamp	
Dry Prairie	Dry Prairie	
Floodplain Marsh	Floodplain Marsh	
Floodplain Swamp	Floodplain Swamp Freshwater Tidal Swamp	Freshwater tidal swamp is recognized in the 2009 update as a variant of floodplain swamp.
Glades Marsh	Swale	Two marsh categories are recognized in place of the 1990 "swale" community. Marshes with a substrate of peat or peat/marl directly overlying limestone in the Everglades and Big Cypress region are "glades marsh." Drainageway marshes on peat overlying sand substrates in flat topography are "slough marsh."
Hydric Hammock	Hydric Hammock Prairie Hammock (in part)	Small isolated hammocks are recognized as variants of either mesic or hydric hammock based on their hydrology and vegetation.
Keys Cactus Barren	Coastal Rock Barren	The "coastal rock barren" community was split into an upland "Keys cactus barren" community and an intertidal "Keys tidal rock barren" community.
Keys Tidal Rock Barren	Coastal Rock Barren	The "coastal rock barren" community was split into an upland "Keys cactus barren" community and an intertidal "Keys tidal rock barren" community.
Limestone Outcrop	Sinkhole (in part)	New community consisting of unique species assemblages occurring on exposed limestone. Often occurs within sinkholes.
Maritime Hammock	Maritime Hammock	
Marl Prairie	Marl Prairie	
Mesic Flatwoods	Mesic Flatwoods	
Mesic Hammock	Mesic Hammock Prairie Hammock (in part)	Small isolated hammocks are recognized as variants of either mesic or hydric hammock based on their hydrology and vegetation.
Pine Rockland	Pine Rockland	
Rockland Hammock	Rockland Hammock	
Sandhill	Sandhill	
Scrub	Scrub	
Scrubby Flatwoods	Scrubby Flatwoods	

<i>2010 NC Guide Name</i>	<i>1990 NC Guide Name</i>	<i>Explanation for Major Changes</i>
Seepage Slope	Seepage Slope	
Shell Mound	Shell Mound	
Shrub Bog	Bog Baygall	The concept of "bog" was restricted to shrubby species and the name changed to reflect this.
Sinkhole	Sinkhole	
Slope Forest	Slope Forest	Geographically restricted to the upper Apalachicola River bluffs and ravines. Areas that were classified as slope forest outside of this range, under the 1990 Guide, should now be classified as upland hardwood forest.
Slough	Slough	
Slough Marsh	Swale	Two marsh categories are recognized in place of the 1990 "swale" community. Marshes with a substrate of peat or peat/marl directly overlying limestone in the Everglades and Big Cypress region are "glades marsh." Drainageway marshes on peat overlying sand substrates in flat topography are "slough marsh."
Strand Swamp	Strand Swamp	
Salt Marsh	Tidal Marsh	
Mangrove Swamp	Tidal Swamp	
Upland Glade	Upland Glade	
Upland Hardwood Forest	Upland Hardwood Forest Slope Forest Upland Mixed Forest	Upland mixed forest is no longer included as a community in the 2009 update. Much of what was classified as upland mixed forest under the 1990 Guide will now be classified as upland hardwood forest (Dry upland hardwood forest variant), successional hardwood forest (a new altered landcover type recognized in this update), or the new upland mixed woodland community.
Upland Mixed Woodland	Upland Hardwood Forest Upland Mixed Forest Upland Pine Forest	Upland mixed woodland is a new community often found in the ecotone between upland pine and upland hardwood forest. It was formerly encompassed in the descriptions of the three communities listed but differs from any of them in having an open, mixed pine-hardwood canopy and non-wiregrass understory.
Upland Pine	Upland Pine Forest	The name has been changed to upland pine so as not to imply a closed canopy.
Wet Flatwoods	Wet Flatwoods	
Wet Prairie	Seepage Slope Wet Prairie Bog	Seepage slope was re-defined as an herbaceous community within high pine and scrub communities. Some communities previously referred to as seepage slope may now fall under wet prairie if they are in a pine flatwoods system. The shrubby type of seepage slope (not due to fire suppression) would now be called shrub bog.
Xeric Hammock	Xeric Hammock	

APPENDIX 2. ALTERED LANDCOVER TYPES

FNAI recognizes that not all habitats and landscapes in Florida are in natural condition. Some have been completely converted from their historic natural community (e.g., agriculture, pasture) while others have been severely altered by human impacts such as fire suppression or silvicultural activities. These altered habitats do not fit into FNAI's Natural Community Classification. For these reasons FNAI recognizes the following altered landcover types to describe the most common non-natural habitats observed on conservation lands in Florida.

Abandoned field – Old fields, early successional areas formerly in agriculture. These areas are often dominated by weedy native (e.g., *Rubus* spp., *Myrica cerifera*) and non-native species (e.g., *Indigofera hirsuta*).

Abandoned pasture – Improved pastures without recent activity (grazing, mowing, burning) to maintain the community as a pasture. Generally designated when weedy cover from woody species (*Rubus* spp., *Myrica cerifera*, etc) is greater than 20 percent.

Agriculture – Row crops, citrus groves, and sod fields that are currently being maintained to grow products for human or domesticated animal use.

Canal/ditch – Artificial drainageway

Clearcut pine plantation – Areas of pine plantation that have undergone clearcutting of the pine canopy but have not yet been replanted with pine trees. These areas are often dominated by weedy native and non-native species. Natural communities that have been clearcut but not further altered should be classified as the natural community.

Clearing – Dove fields, wildlife food plots, clearing of unknown origin, etc.

Developed – Mines, check stations, ORV use areas, parking lots, buildings, maintained lawns (as part of recreational, business, or residential areas), campgrounds, recreational, industrial, and residential areas

Invasive exotic monoculture – Stand of invasive exotic plant species that have eliminated the native vegetation, or nearly so

Impoundment/artificial pond – Stream or watershed impoundment, water retention ponds, cattle ponds, and borrow pits

Pasture - improved – Dominated by planted non-native or domesticated native forage species and evidence of current or recent pasture activity and/or cultural treatments (mowing, grazing, burning, fertilizing; Agro-Ecology Grazing Issues Working Group 2009). Improved pastures have been cleared of their native vegetation. Most improved pastures in Florida are planted with bahiagrass (*Paspalum notatum*) and to a lesser extent with Bermudagrass (*Cynodon dactylon*) or pangolagrass (*Digitaria eriantha*). Weedy native species are often common in improved pastures in Florida and include dogfennel (*Eupatorium capillifolium*), many species of flatsedge (*Cyperus* spp.), carpetgrasses (*Axonopus* spp.), crabgrasses (*Digitaria* spp.), and rustweed (*Polypremum procumbens*) among many others. Lawns or turf areas that are being maintained by mowing for human/recreational-use should be classified as developed (see above).

Pasture - semi-improved – Dominated by a mix of planted non-native or domesticated native forage species and native groundcover, due to an incomplete conversion to pasture, not regeneration. Semi-improved pastures have been cleared of a significant percentage of their native vegetation and planted in non-native or domesticated native forage species, but still retain scattered patches of native vegetation with natural species composition and structure (most often small areas of mesic flatwoods) among the pastured areas. The planted areas are usually dominated by bahiagrass (*Paspalum notatum*) and can resemble improved pastures. Seeding of bahiagrass can also occur within areas of native groundcover. This category should apply regardless of recent pasture maintenance.

Pine plantation – Areas altered by silvicultural activities. These include lands where either 1) planted pines are having or will have an ongoing detrimental effect on native groundcover, 2) the history of planted pines has damaged ground cover to the point where further restoration beyond thinning and burning is required, and/or 3) the method of planting (e.g. bedding) has severely impacted groundcover. Pine plantations in Florida are often dominated by even-aged loblolly, sand, or slash pine (*Pinus taeda*, *P. clausa*, or *P. elliottii*, respectively). Dense pine plantations typically have sparse to absent herbaceous vegetation as a result of shading or a cover of deep pine needle duff. These plantations may be very shrubby or vine-dominated or open at ground level. The groundcover in

most cases has been severely impacted by mechanical site preparation, such as roller chopping and bedding. However, while perennial grasses such as wiregrass (*Aristida stricta* var. *beyrichiana*) may be greatly reduced, many components of the native groundcover persist even though the relative abundance is altered. Groundcover can be partially restored by thinning and/or frequent burning, although some planting of perennial grasses such as wiregrass may be required. With activities such as thinning and burning, plantations with intact native groundcover can be restored to the former natural community.

Road – Paved or unpaved

Spoil area – Area where dredge or spoil material is deposited, may be re-colonized by plants

Successional hardwood forest – Closed-canopied forest dominated by fast growing hardwoods such as laurel oak (*Quercus hemisphaerica*), water oak (*Quercus nigra*), and/or sweetgum (*Liquidambar styraciflua*), often with remnant pines. These forests are either invaded natural habitat (i.e., mesic flatwoods, sandhill, upland pine, upland mixed woodland) due to lengthy fire-suppression or old fields that have succeeded to forest. The subcanopy and shrub layers of these forests are often dense and dominated by smaller individuals of the canopy species. Successional hardwood forests can contain remnant species of the former natural community such as turkey oak (*Quercus laevis*), saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), and infrequently wiregrass (*Aristida stricta* var. *beyrichiana*). Additionally, species such as beautyberry (*Callicarpa americana*), muscadine (*Vitis rotundifolia*), and sparkleberry (*Vaccinium arboreum*) are common. Restoration of these forests includes mechanical tree removal and reintroduction of fire. Where characteristic herbaceous species (e.g., wiregrass) have been lost, reintroduction via seed or plants may be necessary to restore natural species composition and community function.

Utility corridor – Electric, gas, telephone right-of-ways

References:

Agro-Ecology Grazing Issues Working Group. 2009. Florida Land Terms. The Florida Center for Environmental Studies. Florida Atlantic University. URL: www.ces.fau.edu/agro/dl/Florida_Land_Terms%20.pdf