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SNAIL KITE NESTING ECOLOGY IN FLORIDA

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Abstract.—The nesting ecology of the Snail Kite (*Rostrhamus sociabilis plumbeus*) was studied in Florida primarily from 1968 to 1978. Kites nested only in flooded freshwater marshes with water depths of 12–115 cm beneath nests. Nests were located in five vegetation cover types with sawgrass, wet prairie (includes cattails), and willow stands being the most commonly used habitats. Most nests were built in willows. Males selected all nest sites and did most of the nest construction. Nest construction took 4–18 days. Mean structural dimensions for nests were: width 41.6 cm (N=94), depth 22.7 cm (N=92), cup diameter 15.7 cm (N=84), and cup depth 6.1 cm (N=84). Mean height above water was 1.6 m and above ground 2.1 m (N=99). Thirty-two species of plants were identified as nesting materials with coastal-plain willow (*Salix caroliniana*) and wax myrtle (*Myrica cerifera*) the most frequently used materials. Generally the lining of the nest was of green plant parts.

Nesting tenacity from year to year was variable. Most kites nested in loose colonies frequently in association with Anhingas (*Anhinga anhinga*), five species of herons, Common Moorhen (*Gallinula chloropus*), and three species of passerines. Kites defended a small territory in the vicinity of the nest; females were the most frequent and more aggressive defenders. The incidence of predation was inversely correlated with the distance of the nests from source of predation at upland habitats. Management recommendations to establish breeding units of no less than 80 ha and 500 m in width are suggested to avoid the problem of reproductive sinks.

Although many Snail Kite (*Rostrhamus sociabilis plumbeus*) nests have been found in Florida since the first nest was discovered in 1870 (Baird et al. 1874), the nesting ecology has been characterized only in rather general terms (Baird et al. 1874, Maynard 1881, 1896, Bendire 1892, Nicholson 1926, Howell 1932, Bent 1937, Stieglitz and Thompson

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1967). I describe in this paper: nesting habitats, substrates, and heights; depths of marsh flooding; nest building, construction time, measurements, and materials; nest site tenacity; nesting associates; nest defense; the problem of reproductive sinks (Gates and Gysel 1978, Wiens and Rotenberry 1981); and management recommendations.

METHODS

I studied the breeding biology of the Snail Kite in Florida (Sykes 1979, 1987) primarily from 1968 to 1978, with some additional work through 1980. Major study areas (see Sykes 1979, 1983a, 1983b, 1984, 1985) were the freshwater marshes in three impoundments (St. Johns, Cloud Lake, and Strazzulla reservoirs) in the historic headwaters of the St. Johns River (Indian River and St. Lucie counties), the northern sector of the Savannas at Ft. Pierce (St. Lucie County), the west side of Lake Okeechobee (Glades and Hendry counties), the Everglades (Loxahatchee National Wildlife Refuge [N.W.R.], Palm Beach County; Conservation Area 2A [CA2A], Palm Beach and Broward counties; and Conservation Area 3A [CA3A], Broward and Dade counties). Searches were made at 15 additional localities. Supplemental information was obtained from egg data slips at 25 museum collections (Sykes 1984). Data from 600+ kite nests (1870–1980) were used in this paper, but for any category the sample size was smaller because information available often was limited.

Known nesting areas were surveyed annually each year, and periodic observations were made at active nests. Nests measurements were made in the field to the nearest centimeter. Nest widths were measured across the top from one rim edge to the opposite edge at the widest point. Nest depths were taken from the plane of the rim to the bottom of the structure. Sticks protruding beyond the bulk of a nest were excluded from these measurements. The diameter of the cup was measured across the usually circular nest bowl. The cup depth was measured at the center of the bowl from the horizontal plane of the rim to the bottom. Nest heights were measured from the plane of the nest rim to the ground and water surfaces. Water depths were taken as close to a point directly under the nest as possible during egg laying or early incubation.

Spacing between nests (N=71) was estimated (83%), determined on aerial photographs (14%), or measured (3%). Intact nests were inspected in the field and construction materials identified. Three nests were collected, two from Loxahatchee N.W.R. and one from Lake Okeechobee. These nests were placed in large plastic bags and carefully moved to the laboratory, air dried for at least 10 days in an air-conditioned room, and weighed to the nearest gram with a triple-beam balance. Each nest was taken apart, each item identified, and the length and greatest diameter of representative pieces measured.

The scientific names of plants are listed in the Appendix and follow Long and Lakela (1971). Terms for freshwater plant communities used have been well described (Harshberger 1914, Davis 1943, Parker et al. 1955, Sincock 1958, Loveless 1959, Tebeau 1968, 1971, Gleason 1974, Pesnell and Brown 1977, Sykes 1983).

RESULTS AND DISCUSSION

Nesting sites.—Snail Kites generally inhabitated large inland freshwater marshes (Table 1) where the vegetation was of low physiographic profile. Nesting habitats used by kites (N=386 nests) were similar to the surrounding plant community: sawgrass 35.5% (Fig. 1), wet prairie (in-

Table 1. Snail Kite nests at six wetland regions in Florida.[1]

Year[2]	Headwaters St. Johns River	Lake Okeechobee	Loxahatchee N.W.R.	CA2A	CA2B	CA3A	Total
	Number of nests						
			Everglades				
1968		1		12			13
1969				13			13
1970		2	11	4	1	1	19
1972	1	5					6
1973	6	28					34
1974	4	23	8				35
1975	1	25	3				29
1976		23	1			17	41
1977		26				5	31
1978		20				65	85
Total nests	12	153	23	29	1	88	306

[1]Includes renesting attempts.
[2]No nesting observed during 1971 spring drought.

cludes cattail stands) 35.0%, willow stands 23.6%, aquatic slough 5.7% (see Loveless (1959) for description of these four communities), and riparian 0.2%. Kites tended not to nest on tree islands except where the trees had been killed by fire, the organic substrate burned away, and the island usually invaded by willows or cattails. Such habitat was classed as willow stand or wet prairie for purposes of this study. The first four habitats listed above and tree islands are the principal plant communities of freshwater marshes in peninsular Florida (Harshberger 1914, Davis 1943, Sincock 1958, Loveless 1959). The only known nesting in riparian habitat was one at Wakulla Springs (Howell 1932).

Willow stands were used for nesting sites with a greater frequency than other components of the marsh communities. Willow stands provided potential nesting substrates and more shelter from sun, wind, and rain than the other plant communities. Sawgrass and cattail stands in wet prairies seldom exceeded 2.4 m in height (3 m maximum), and most were 1.8 m or less; willows generally were 5 m or less in height. Thus, most nesting took place in habitats of low stature with an open distant horizon. For further description of kite habitats in Florida refer to Sykes (1983a, 1983b, 1985).

All kite nests were built over water; no nest construction was started in a dry marsh. However, six nests were initially built over shallow water ($\leq$ 20 cm), and as the man-manipulated water levels were subsequently lowered 0.9 m in 28 days, the nests were left with no water under them. Nests in these situations always failed, usually as a result of predation (100%) (Sykes 1987).

Figure 1. Female Snail Kite at nest containing small young (head of one nestling visible in front of adult) in dead cypress in sawgrass habitat.

Water depths beneath nests (N=139, excluding above 6 nests which were considered atypical) ranged from 12 to 115 cm ($\bar{x}$=52.0, SE=1.8). Relationship of wet conditions and timing of nesting was discussed by Sykes (1987). To reduce disturbance, water depths were not monitored continually for individual active nests. There was no significant difference between water depths beneath nests containing eggs on the headwaters of the St. Johns, at Lake Okeechobee, or in the Everglades (F=0.62; df=2,58; N=61). Distribution of nests (N=139) according to water depths peaked between 51–60 cm and was slightly skewed toward lower water depths (Fig. 2). In flooded marshes, no significant difference (t=1.21, P>0.10) in water depths (12–115 cm) was found between successful (N=54) and unsuccessful (N=53) nests. Flooding tends to reduce predation in kite nesting areas by restricting movements and numbers of terrestrial predators (pers. obs.).

Nesting substrates.—Of fifteen species of plants used by kites as nesting substrates (Table 2), the most frequently used were coastal-plain willow (44.9%), cattail (16.6%), and wax myrtle (12.8%). These plants are ubiquitous in kite habitats in Florida, but comprise less than 10% of the total vegetative cover (Sincock 1958, Loveless 1959, Pesnell and Brown 1977, pers. obs.). The kites showed a definite preference for woody-stemmed plants (77%), but there were regional differences (Everglades 98%, St. Johns 81%, Lake Okeechobee 49%). Woody plants afford much stronger support for nests than do non-woody species (Sykes and Chandler 1974). Nests were usually supported by a single species of plant (96.6%), but may be supported by more than one species (3.4%).

Most nest supports were either completely or partly living plants (90%); however, dead plants also were used, primarily dahoon holly and wax myrtle (Table 2). Some of the wax myrtles used by kites for nest supports were killed by fire or prolonged flooding (33%). In the late 1960's, high water levels killed all the dahoon hollies and most other species of woody plants in the eastern sector of CA2A used by kites. Dead hollies were the most abundant, widespread, and suitable substrate in that area used by kites during 1968–1970. No difference in nesting success of nests placed in live versus dead substrates occurred during 1968–1970 (χ^2=0.25, P>0.5, df=1, N=33 nests).

Nest site selection and nest construction.—All nest site selection (N=60) and almost all nest construction (95%; 1000+ observations) were accomplished by males. Females assisted in structural maintenance of the nest following completion of the initial construction. Nest construction (N=13 nests) required 4–18 days ($\bar{x}$=11.2, SE=1.2), but for 15 additional nests, construction was interrupted for several days to several

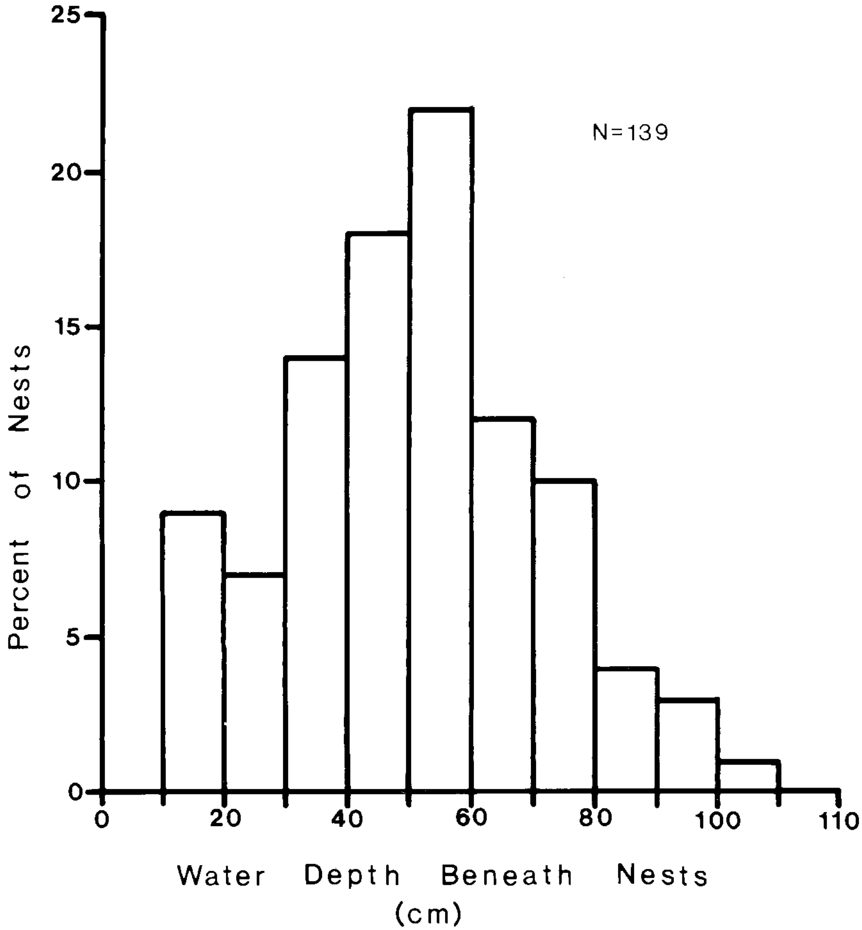

Figure 2. Distribution of Snail Kite nests by marsh water depth.

weeks, then resumed. The reason for the interruptions was unknown, but could possibly have been the male's failure to secure a mate when he first began construction.

Nest mensuration.—Nest width ranged from 25–58 cm ($\bar{x}$=41.6, SE=0.7, N=94), with nest depth of 8–44 cm ($\bar{x}$=22.7, SE=0.7, N=92). The diameter of the cup ranged from 7–20 cm ($\bar{x}$=15.7, SE=0.3, N=84), with the cup depth of 2–11 cm ($\bar{x}$=6.1, SE=0.2, N=84). The height of nests above water during the egg-laying or early incubation period ranged from 0.4–3.7 m ($\bar{x}$=1.6, SE=0.06, N=99) and above ground surface was 0.9–4.2 m ($\bar{x}$=2.1, SE=0.06, N=99). The highest nest on record was estimated to be 9.1 m above the water in a cypress near Wakulla Springs in May 1929 (Howell 1932).

Nest materials.—Snail Kite nests were usually large, bulky, loosely woven structures composed mostly of dry sticks, often with a few dry inflorescences of sawgrass or pieces of dry vines. Kites collected larger nesting materials by breaking off the tips of small dead branches with their feet, while the bill was used to detach small dead twigs and carry materials to the nest. Thirty-two species of plants were identified in kite nests and 18 species occurred in 1% or more of the nests (Table 3). Coastal-plain willow and wax myrtle were the most frequently used construction materials in the main structure; these two species and maidencane were used to line most nest cups. The sticks ranged in length from 10–92 cm ($\bar{x}$=35.3, SD=18.1, N=30) with large-end diameters of 2–21 mm ($\bar{x}$=5.8, SD=4.8, N=30). Pieces of sawgrass ranged in length from 10–43 cm ($\bar{x}$=30.9, SD=13.9, N=7) with large-end diameters of 1–5 mm ($\bar{x}$=3, SD=1.3, N=7).

The nest cup was lined with finer mostly green materials. This green material consisted of twigs with green leaves, grass stalks with roots and leaves, sawgrass blades, and other living pieces of plants. Kites continued to add green material to the nest into the nestling period. The nest greenery may help regulate humidity, influence temperatures during incubation and brooding of newly hatched young, or aid in controlling nest parasites.

Twenty-two species of plants were used in construction of the three nests I collected (Table 4). In as much as material was usually taken to the nest one piece at a time, the 803 pieces in the larger nest represented a considerable expenditure of time and energy.

Nest site tenacity.—Generally, kites built a new nest for each nesting attempt, but the new nest was often located in the vicinity of a previous nest. Five nests were built on the exact site of the previous year's nests, but I did not know if these were the same birds. In each case, a new structure was either built on top of the remains of the previous nest or a new nest was built in its place if the old nest had fallen. Kites also may move large distances between nestings as in the case of a female I uniquely color banded as a nestling at Loxahatchee N.W.R. in 1970. She nested at Lake Okeechobee in 1973 and at Loxahatchee N.W.R. in 1974 (ca. 125 km distance; Sykes 1979). I have similar movement data on three other uniquely marked female birds, involving the St. Johns, Lake Okeechobee, Loxahatchee N.W.R., and CA3A regions.

Table 2. Nesting substrates used by Snail Kites in Florida.

	Number of nests[1]						Percent	
Substrate[2]	Headwaters St. Johns	Lake Okeechobee	Everglades region	Other[3]	Total	Percent	Living	Dead
Cypress	7		13	1	21	3.5	86	14
Cattail		99	3		102	17.2	91	9
Reed		5			5	0.8	100	–
Bulrush		11			11	1.8	100	–
Sawgrass	13		4		17	2.9	100	–
Coastal-plain willow		75	195	6	276	46.4	99	1
Wax myrtle	45		32	2	79	13.3	67	33
Scrub oak			1		1	0.2	100	–
Sweet bay			1		1	0.2	100	–
Pond apple	2		13	1	16	2.7	100	–
Cocoplum			4		4	0.7	100	–
Brazilian pepper			1		1	0.2	100	–
Dahoon holly			15		15	2.5	7	93
Punk-tree		32	9		41	6.9	95	5
Buttonbush		2	2		4	0.7	100	–
Total	67	224	293	10	594	100.0[4]	—	–

[1]Data from 1870–1980 (this study N=486; other sources N=108).
[2]One species of plant supported the nest structure.
[3]Includes Lee and Wakulla counties and the Savannas.
[4]An additional 3.5% of the nests (N=21) occurred in multiple substrates (i.e., more than one species of plant supported the nest structure).

Intra- and interspecific nesting associations.—Although Snail Kites nest in loose colonies or as solitary pairs (Bendire 1892, Nicholson 1926, Howell 1932), I found loose colonial nesting was the most common situation (78%, N=406 nests). My usage of the term colonial nesting generally follows that given by Thomson (1964) with the addition that it include two or more active nests, no one of which is greater than 300 m from any other. With my data there appeared to be a natural break around the 300 m distance. The spacing between nests in loose colonies ranged from 6 to 287 m ($\bar{x}$=84, SE=9.7, N=71). During this study both solitary and colonial nesting were found throughout the kite's range in Florida. Loose colonial nesting by kites, a gregarious species, may involve availability of nesting substrates in proximity to food resources.

Kites often nest near Anhingas (*Anhinga anhinga*) and herons (Howell 1932, Stieglitz and Thompson 1967). I found the following eleven species of birds nesting in close association ($\leq$ 15 m) with kites: Anhinga, Great Blue Heron (*Ardea herodias*), Great Egret (*Casmerodius albus*), Snowy Egret (*Egretta thula*), Little Blue Heron (*E. caerulea*), Tricolored Heron (*E. tricolor*), Green-backed Heron (*Butorides striatus*), Common Moorhen (*Gallinula chloropus*), Common Yellowthroat (*Geothlypis trichas*), Red-winged Blackbird (*Agelaius phoeniceus*), and Boat-tailed Grackle (*Quiscalus major*). Only colonial nesting kites had Anhingas and herons nesting near them. The Green-backed Heron nested on occasion (N=5) in the same tree or bush with the kite. In such cases, the heron nest was always below the kite nest. The close nesting associations between these two species also was described in South America (Haverschmidt 1970). The association of kites and other colonial nesting birds may be due to the distribution of suitable woody vegetation for nesting substrates or a deterrent to some predation. The Common Yellowthroat and the two species of blackbirds often nested close to solitary nesting kites.

Nesting territorality.—Snail Kites actively defended a rather small nesting territory, usually within 4 m or less of the nest, but sometimes up to 30 m or more. Intraspecific conflict at nest sites was infrequent, whereas interspecific conflict was commonplace. On occasion, females were observed driving off males that were not their mates. Both sexes were observed "dive bombing" Anhingas perched near their nests, a behavior also reported by Stieglitz and Thompson (1967) at Loxahatchee N.W.R. Turkey Vultures (*Cathartes aura*) flying within 20–30 m of a kite nest were frequently harassed and driven off. Aggressive encounters also occurred between kites and Black-crowned Night-Herons (*Nycticorax nycticorax*), Ospreys (*Pandion haliaetus*), Red-shouldered Hawks (*Buteo lineatus*), and Limpkins (*Aramus guarauna*). In nesting territorial defense (N=88), the female was the more aggressive (active pursuit and vocalizations) of the pair (80%).

Human approach to an active nest elicited several responses. Usually, kites flushed from their nest or perch and one or both members of the pair circled low (≤ 12 m) above the nest site giving alarm calls. A few females feigned an attack to the head and shoulder region of the intruder with talons extended while giving alarm calls. At other times the birds flew off, returned a short time later and circled the nest site, then disappeared from view.

Nest predation.—The principal cause of nesting failure was predation (44%, N=36 nests; Sykes 1987). The Everglades rat snake (*Elaphe obsoleta rossalleni*) was responsible for 17% of the total predation losses and it is suspected that this reptile also had a large part in the 58% predation loss not traceable to a specific predator (Sykes 1987).

Table 3. Materials used by Snail Kites for nest construction in Florida.

	Percent nests[1]	
Nesting material	Main structure (N=406 nests)	Lining of cup (N=194 nests)
Cypress	3	1
Cattail	20	6
Reed	1	
Maidencane	7	23
Sawgrass	7	8
Spanish moss		2
Bromelaid sp.		1
Pickerelweed		5
Coastal-plain willow	66	44
Wax myrtle	18	20
Smartweed	2	1
Dahoon holly	2	
Punk-tree	9	9
Primrose-willow	4	
White vine	1	2
Groundsel	1	
Hemp vine		3
Dog-fennel	1	
Other	7[2]	22[3]
Fragments[4]	100	100

[1]More than one species may be used in nest construction, thus sum of the columns does not equal 100%.

[2]Includes the following species (<1%): slough grass, broom-sedge, bulrush, pickerelweed, greenbrier, Australian pine, water hemp, pond apple, red bay, Brazilian pepper, muscadine grape, morning glory, buttonbush, hemp vine, and unidentified vines and grasses.

[3]Includes the following species (<1%): bulrush, Australian pine, dahoon holly, primrose-willow, morning glory, and unidentified vines.

[4]Pieces (<1 cm) not identified.

I estimated that 83% of nest failures at Loxahatchee N.W.R. in 1970 were attributable to predation at nests located less than 180 m from upland habitats. The data showed a sharp change in incidence of predation between 150 and 160 m from the uplands (Mann-Whitney U test, $U=2.40$, $P=0.05$). Initially, predation at kite nests at Loxahatchee N.W.R. and CA2A were presumed to be similar; however, 11 nests were lost to predation on the refuge (1970, 1974–1975) compared to none in CA2A (1968–1970). The critical distance between incidences of predation and no predation was 98–220 m from uplands for the two areas (Mann-Whitney U test, 95% confidence interval).

The incidence of predation was inversely correlated with nest distance from upland habitats. Included in these upland habitats were large man-

Table 4. Composition and dry weights of three Snail Kite nests in Florida.

Construction material	Number of pieces					
	Nest number					
	1	Percent	2	Percent	3	Percent
Cattail					6	2
Reed					3	1
Slough grass					48	17
Maidencane					17	6
Bulrush					9	3
Sawgrass	48	6	44	7		
Pickerelweed					2	1
Greenbrier			6	1		
Coastal-plain willow	160	20	281	42	153	55
Wax myrtle	93	11	49	7		
Brazilian pepper			4	1		
Muscadine grape			13	2		
Punk-tree	239	30	39	6		
Primrose-willow	39	5	51	7		
Vine spp.	184	23	122	18	27	10
Morning glory			7	1		
Groundsel			12	2		
Dog-fennel					5	2
Other[1]	11	1	2	T[2]	1	T[2]
Unidentified	29	4	36	5	5	2
Total pieces	803	—	666	—	276	—
Total species	10	—	13	—	11	—
Weight (g)	1964	—	1533	—	662	—

[1]Includes the following species, each less than 1%: maidencane, broom-sedge, Australian pine, and smartweed.

[2]T = < 0.3%.

made levees and low dikes, which were located on the perimeter of wetlands or transected the marshes. These structures provided terrestrial predators with access to habitats that otherwise would have been more difficult for them to reach. The numbers and species of predators in marshes used by kites were greatest near uplands (pers. obs.). As long as kites nest within 200 m or less of dikes, levees, or uplands, such nesting sites will act as reproductive sinks (Gates and Gysel 1978, Wiens and Rotenberry 1981) for kites in Florida.

Recommendations.—Areas managed for Snail Kites in Florida should be as large as possible but not less than 80 ha, with a width of no less than 500 m, and flooded to a depth of at least 0.5 m throughout the breeding season. By establishing an appropriate minimum size for managed units, which as proposed included a large buffer zone surrounding a core "safe" nesting area, the problem of reproductive sinks may be avoided or at least greatly reduced. Managers of these selected "islands" of habitat also should strive for a mix of the most important communities as previously described (Sykes 1983).

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APPENDIX

Alphabetical list of English, scientific, and family names of plants used in text.[1]

English name	Scientific name	Family name
Australian pine	*Casuarina equisetifolia*	Casuarinaceae
Beak rush	*Rhyncospora corniculata*	Cyperaceae
Brazilian pepper	*Schinus terebinthifolius*	Anacardiaceae
Broom-sedge	*Andropogon virginicus*	Poaceae
Bulrush	*Scirpus californicus*	Cyperaceae
Buttonbush	*Cephalanthus occidentalis*	Rubiaceae
Cattail	*Typha angustifolia, T. domingensis*	Typhaceae
Coastal-plain willow	*Salix caroliniana*	Salicaceae
Cocoplum	*Chrysobalanus icaco*	Chrysobalanaceae
Cypress	*Taxodium distichum, T. ascendens*	Taxodiaceae
Dahoon holly	*Ilex cassine*	Aquifoliaceae
Dog-fennel	*Eupatorium* sp.	Asteraceae
Greenbrier	*Smilax* spp.	Smilacaceae
Groundsel	*Baccharis* spp.	Asteraceae
Hemp vine	*Mikania scandens*	Asteraceae
Maidencane	*Panicum hemitomon*	Poaceae
Muscadine grape	*Vitis rotundifolia*	Vitaceae
Morning glory	*Ipomoea* sp.	Convolvulaceae
Pickerelweed	*Pontederia lanceolata*	Pontederiaceae
Pond apple	*Annona glabra*	Annonaceae
Primrose-willow	*Ludwigia peruviana*	Onagraceae
Punk-tree	*Melaleuca quinquenervia*	Myrtaceae
Red bay	*Persea borbonia*	Lauraceae
Reed	*Phragmites australis*	Poaceae
Sawgrass	*Cladium jamaicensis*	Cyperaceae
Scrub oak	*Quercus chapmanii*	Fagaceae
Slough grass	*Paspalidium paludivagum*	Poaceae
Smartweed	*Polygonum* spp.	Polygonaceae
Spanish moss	*Tillandsia usneoides*	Bromeliaceae
Spike rush	*Eleocharis cellulosa, E. elongata*	Cyperaceae
Tracy's beak rush	*Rhyncospora tracyi*	Cyperaceae
Water hemp	*Amaranthus* sp.	Amaranthaceae
Wax myrtle	*Myrica cerifera*	Myricaceae
White vine	*Sarcostemma clausa*	Asclepiadaceae
White water-lily	*Nymphaea odorata*	Nymphaeceae

[1]Scientific and family names follow Long and Lakela (1971).