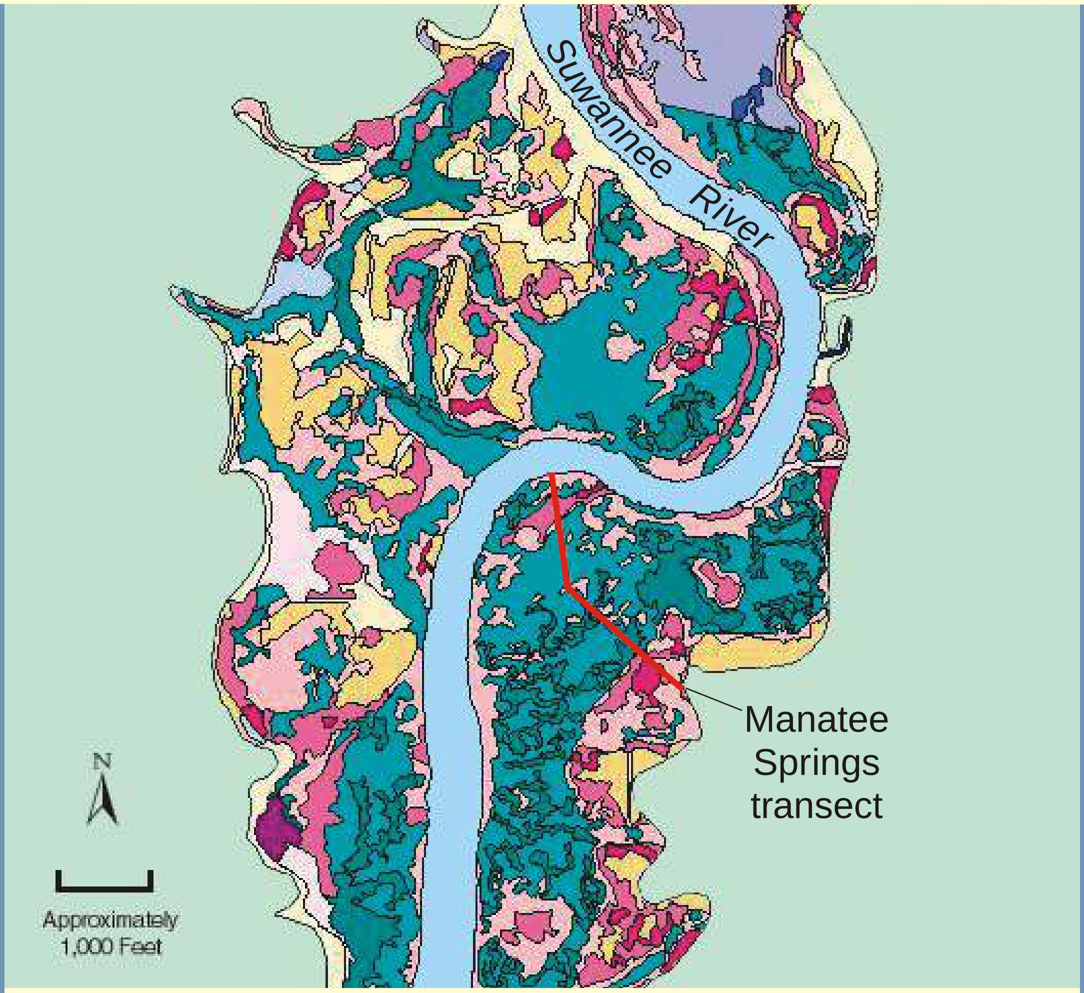
Forest Types in the Lower Suwannee River Floodplain, Florida — A Report and Interactive Map

Water-Resources Investigations Report 03-4008



U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with the
Suwannee River Water Management District

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By Melanie R. Darst, Helen M. Light, Lori J. Lewis, *and* A. Alejandro Sepúlveda

U.S. GEOLOGICAL SURVEY
Water Resources Investigations Report 03-4008

Prepared in cooperation with the
SUWANNEE RIVER WATER MANAGEMENT DISTRICT

Tallahassee, Florida
2003

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Conversion Factors and Unit Abbreviations

Multiply	By	To obtain
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.28	foot (ft)
kilometer (km)	0.62	mile (mi)
river kilometers (rkm)	0.62	river miles
square meter (m^2)	10.76	square foot (ft^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
hectare (ha)	2.471	acre
hectare (ha)	0.003861	square mile (mi^2)
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
degree Celsius (°C)	1.8 (+ 32 °)	degree Fahrenheit (°F)

In this report, horizontal coordinate information is referenced to the North American Datum of 1929 (NGVD of 1929).

Acronyms and Abbreviations

DOQ	Digital Orthophoto Quadrangles
GIS	Geographic Information System
LSNWR	Lower Suwannee National Wildlife Refuge
PLGR	Precise Lightweight Global Positioning System Receiver
SRWMD	Suwannee River Water Management District
USGS	U.S. Geological Survey
blh	bottomland hardwoods
dbh	diameter at breast height
rba	relative basal area
sw	swamps
ham	hammocks
up	upland

LIST OF SCIENTIFIC NAMES USED WITH COMMON NAME EQUIVALENTS

[Plant nomenclature used in this report follows that by Godfrey and Wooten (1979, 1981) unless otherwise indicated. For species with only one variety present in the study area, variety names have been omitted in the body of the report]

Scientific name	Common name
Betula nigra L	river birch
Cladium jamaicense Crantz	sawgrass
Fraxinus profunda (Bush) Bush	pumpkin ash
Hydrocotyle verticillata Thunb.	whorled marsh pennywort
Liquidambar styraciflua L.	sweetgum
Magnolia virginiana L.	sweetbay
Nyssa aquatica L.	water tupelo
Nyssa biflora (Walt.) Walt.[1]	swamp gum
Panicum rigidulum Bosc ex Nees[2] var. *pubescens* (Vasey) Lelong	panic grass
Persea palustris (Raf.) Sarg.	swamp red bay
Pilea pumila (L.) A. Gray	clearweed
Pinus taeda L.	loblolly pine
Planera aquatica J. F. Gmel.	planer-tree
Quercus geminata Small	sand live oak
Quercus hemisphaerica Bartr. Ex Willd.	laurel oak
Quercus laurifolia Michx.	swamp laurel oak
Quercus lyrata Walt.	overcup oak
Quercus virginiana Mill.	live oak
Rumex verticillatus L.	swamp dock
Sabal palmetto Lodd. ex J. S. Shult. & J. H. Shult.	cabbage palm
Sagittaria lancifolia L.	arrowhead
Taxodium distichum (L.) L. C. Rich.	bald cypress
Zizaniopsis miliacea (Michx.) Döll. & Asch.	southern wild rice

[1] Clewell (1985)
[2] Lelong (1984)

Forest Types in the Lower Suwannee River Floodplain, Florida—A Report and Interactive Map

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Abstract

A map of forest types in the lower Suwannee River floodplain, Florida, was created during a study conducted from 1996 to 2000 by the U.S. Geological Survey in cooperation with the Suwannee River Water Management District. The map is presented with this report on a compact disc with interactive viewing software. The forest map can be used by scientists for ecological studies in the floodplain based on land cover types and by landowners and management personnel making land use decisions.

The study area is the 10-year floodplain of the lower Suwannee River from its confluence with the Santa Fe River to the lower limit of forests near the Gulf of Mexico. The floodplain is divided into three reaches: riverine (non-tidal), upper tidal, and lower tidal, due to changes in hydrology, vegetation, and soils with proximity to the coast.

The 10-year floodplain covers about 21,170 hectares; nearly 88 percent of this area (18,580 hectares) is mapped as 14 major forest types. Approximately 29 percent (5,319 hectares) of these forests have been altered by agriculture or development. About 75 percent of the area of major forest types (13,994 hectares) is wetland forests and about 25 percent (4,586 hectares) is upland forests. Tidal wetland forests (8,955 hectares) cover a much greater area than riverine wetland forests (5,039 hectares).

Oak/pine upland forests are present in the riverine and upper tidal reaches of the floodplain on elevations that are inundated only briefly during the highest floods. High bottomland hardwoods are present on the higher levees, ridges, and flats of the riverine reach where soils are usually sandy. Low bottomland hardwood forests are present in the riverine reach on swamp margins and low levees and flats that are flooded continuously for several weeks or longer every 1 to 3 years. Riverine swamps are present in the lowest and wettest areas of the non-tidal floodplain that are either inundated or saturated most of the time.

Upper tidal bottomland hardwood forests are present on sandy soils on high flats and in transitional areas between upland forests and swamps. Upper tidal mixed forests are found on low levees or between swamps and higher forest types. Upper tidal swamps are present at elevations below median monthly high stage and usually have surface soils that are permanently saturated mucks.

Lower tidal hammocks are found on higher elevations that do not receive regular tidal inundation but have a high water table and are briefly inundated by storm surges several times a decade. Lower tidal mixed forests include swamps with numerous small hummocks or less common larger hummocks. Lower tidal swamps are found on deep muck soils that are below the elevation of the median daily or monthly high stage.

Seven additional land cover types (2,590 hectares) are mapped. Water in the main channel of the lower Suwannee River (1,767 hectares) was mapped separately from open water in the floodplain (239 hectares). Other land cover types are: seepage slopes (70 hectares), isolated forested wetlands (19 hectares), marshes upstream of the tree line (505 hectares), beds of emergent aquatic vegetation (21 hectares), and floodplain glades (46 hectares).

INTRODUCTION

River floodplains provide storage and filtration of surface water, diverse habitats for plants and animals, corridors for the movement of animals and dissemination of plants, and a supply of nutrients to estuarine environments. Floodplain functions and their contribution to ecological integrity have been described by many authors, and the need for protection is generally acknowledged by the scientific community (Greeson and others, eds., 1979; Brinson and others, 1981; Clark and Benforado, eds., 1981; Wharton and others, 1982; Gosselink and others, 1990; Lugo and others, eds., 1990; Mitsch and Gosselink, 1993; Davis and others, 1996; Messina and Conner, eds., 1998).

Wetlands protection is an important goal of water management in the Suwannee River basin. Florida law directs water management districts to use best available information to establish minimum flows and levels for watercourses in their districts. A series of studies was undertaken by the U.S. Geological Survey (USGS), in cooperation with the Suwannee River Water Management District (SRWMD), to describe the water resources and ecology of the lower Suwannee River. In one of those studies, Light and others (2002) described the hydrology, vegetation, and soils of the forested floodplain of the lower Suwannee River and potential impacts of flow reductions. A map of the lower Suwannee River floodplain created during that study is described and presented with this report.

Purpose and Scope

The objective of this report is to describe and present a map of forest types in the lower Suwannee River floodplain, Florida. The study area is the floodplain of the lower Suwannee River from its confluence with the Santa Fe River to the downstream limit of forests near the Gulf of Mexico (fig. 1). Mapping began in 1997 and continued through 2000.

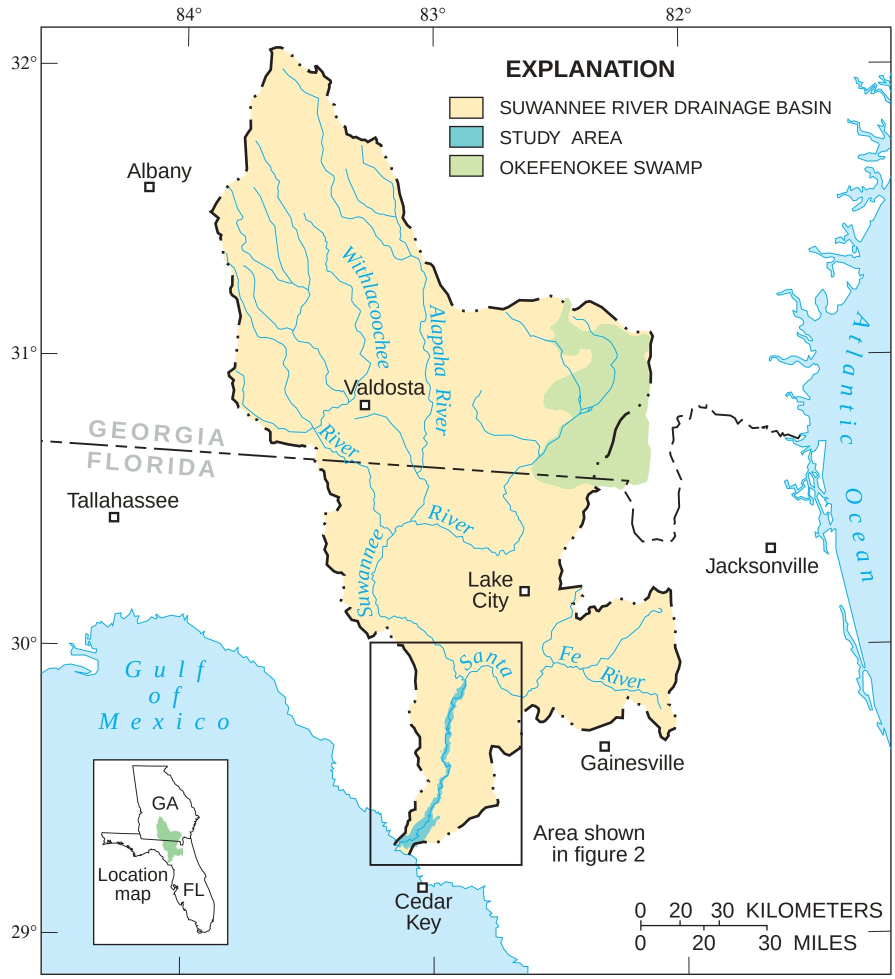
Acknowledgments

The authors are grateful to Rob Mattson and John Good, SRWMD, and S. Jack Alhadeff and Jonathan Musser, USGS, for review of this report and map. The authors also appreciate the assistance of the following USGS staff with report production: John D. Guthrie for computer programming; Teresa Embry for technical and editorial reviews; Ron Spencer for graphics; and Pat Mixson for layout.

Extensive fieldwork was needed to accomplish the mapping project. Access to study sites and logistical support from landowners was received from Ken Litzenberger, Lower Suwannee National Wildlife Refuge (LSNWR); Paul Perras, Manatee Springs State Park; Greg Galpin, Georgia-Pacific Corporation; Jeff King, Andrews Wildlife Management Area; Robert Heeke, SRWMD; and John R. Falkenburry, private landowner. Many people contributed hundreds of hours of invaluable assistance with field work, including the verification of mapped forest types: Lani Webster, Angus Gholson, Duncan Johnson, Jill Pittman, Donald Foose, Venu Oddiraju, Robert Tighe, volunteers; Henry Sansing, Russ Langford, Kenny McCain, Kendall Smith, LSNWR; Kathy Burks, Florida Department of Environmental Protection; Dennis Hardin and Penny Isom, Florida Division of Forest Management; Kip Runyon, Florida Fish and Wildlife Conservation Commission; Rob Mattson, John Good, Christine Sutter, Eric Lewis, Kelly Chancey, and Susie Hetrick, SRWMD; Gary Mahon, and Ed Oaksford, USGS.

Setting

The Suwannee River flows from its headwaters in the Okefenokee Swamp to the Gulf of Mexico (fig. 1). The drainage basin covers approximately 25,770 square kilometers (km^2) of the Gulf Coastal Plain in central southern Georgia and central northern Florida (Berndt and others, 1996). The lower Suwannee River refers to that portion of the river from its confluence with the Santa Fe River to the mouth of the river at the Gulf of Mexico. The lower Suwannee River flows through the Gulf Coastal Lowlands physiographic region (Puri and Vernon, 1964). Stream characteristics in the lower Suwannee River show a combination of blackwater and spring-fed influences, with some alluvial features in the floodplain. Limestone



Base from U.S. Geological Survey digital data, 1972
Albers Equal-Area Conic Projection,
Standard parallels 29°30′ and 45°30′, central meridian -83°00′

Figure 1. Drainage basin of the Suwannee River in Florida and Georgia (from Light and others, 2002).

is at or near land surface in the lower Suwannee River basin. Solution features, such as sinkholes, sinkhole lakes, springs, and submerged caves, are common in the basin. Surface-water streams in the non-tidal portion of the river are fed predominantly by springs rather than from surface runoff (Crane, 1986). Tidal creeks are present in the floodplain of the tidal portion of the river and increase in number and extent with proximity to the Gulf of Mexico.

The warm, temperate climate of the lower Suwannee River floodplain is characterized by long, humid summers and mild, dry winters. Average annual precipitation (1961-90) at Cross City is 146 centimeters (cm) (Owenby and Ezell, 1992). Average summer air temperature (June, July, and August) is 26.4 degrees Celsius (°C), and average winter air temperature (December, January, and February) is 12.1 °C at Cross City based on the period 1961 to 1990 (Owenby and Ezell, 1992). The growing season (50 percent probability freeze-free period) varies from 259 days at the upstream end of the study area to 283 days near the mouth of the river (Bradley, 1975). Annual flood peaks occur more often in the growing season than in the dormant season.

METHODS

Floodplain Boundaries and River Kilometers

The floodplain boundary in the non-tidal and upper tidal reaches of the lower Suwannee River is the 10-year floodplain digitized by the SRWMD from data collected by the U.S. Army Corps of Engineers. The floodplain boundary in the lower tidal reach was determined by connecting the downstream limit of the 10-year floodplain boundary to the drainage basin boundary near the mouth, usually along roads or other obvious drainage divide features. The lower limit of the study area, near the mouth of the river, is the tree line, an east-west line across the lower tidal floodplain with primarily forests on the upstream side and marshes on the downstream side (fig. 2). River kilometers (rkm) indicate stream distances starting with rkm 0 at the mouth of the river at latitude 29°17’19.2” and longitude 83°9’51.8”.

Study Sites

Three types of study sites were used to collect data for map creation and verification. Transects were established for intensive collection of quantitative vegetation data used to interpret aerial signatures and define forest types. Verification plots were used to collect quantitative vegetation data to verify the forest map and describe forest types. Observation sites were used to obtain non-quantitative vegetation data to verify mapping signatures. Locations of all transects and verification plots are shown in figure 2.

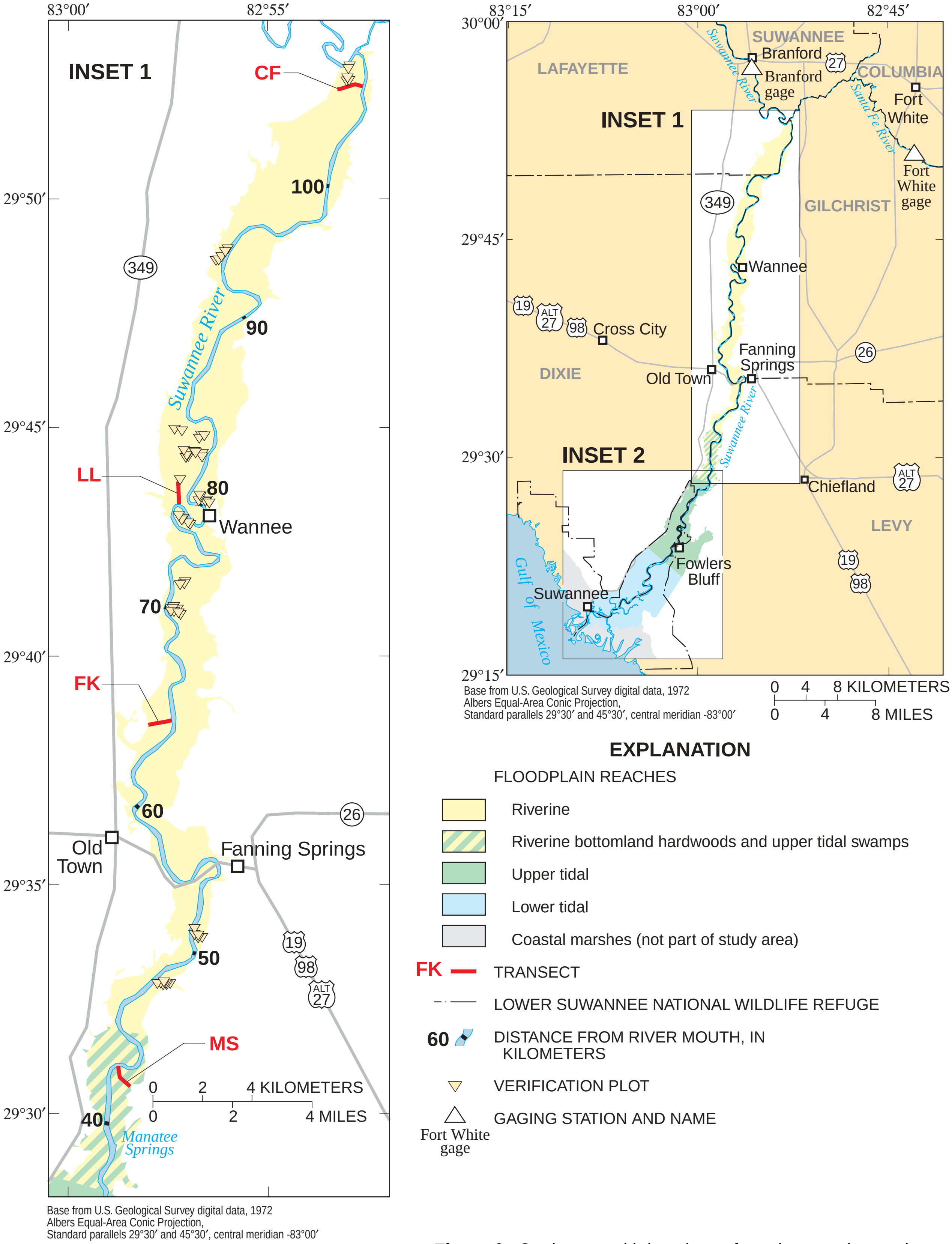
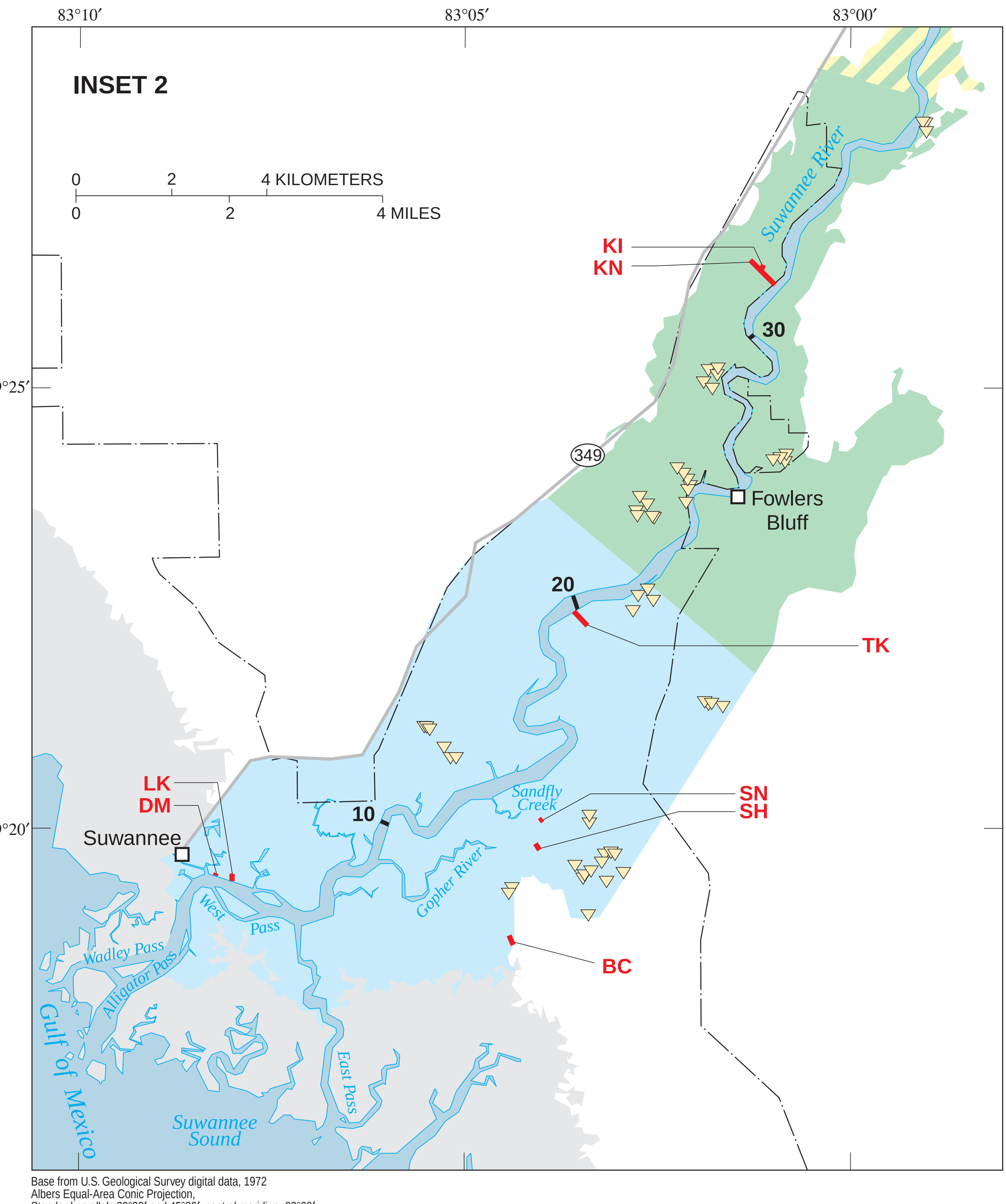


Figure 2. Study area with locations of reaches, gaging stations, and study sites in the floodplain of the lower Suwannee River, Florida (modified from Light and others, 2002).



Base from U.S. Geological Survey digital data, 1972
Albers Equal-Area Conic Projection,
Standard parallels 29°30′ and 45°30′, central meridian -83°00′

Figure 2. Study area with locations of reaches, gaging stations, and study sites in the floodplain of the lower Suwannee River, Florida (modified from Light and others, 2002). (Continued)

Transects

Establishment of transects -- Color-infrared photographs (scale 1:40,000), taken in the winter of 1994 by the National Aerial Photography Program, were used with maps of public lands to determine the location of transects. Transect locations were selected based on the need to adequately sample all major forest types within each reach at accessible sites where permanent transects could be established. Forest types were frequently differentiated in zones parallel to the river; therefore, most transects were located perpendicular to the river to sample vegetation growing in the center and in transitional areas at the edges of each forest type zone. Two transects were located in a homogeneous forest type for the purpose of sampling that specific type. Location, length, and compass bearings of transects were predetermined on aerial photographs and then located on the ground using a Precise Lightweight Global Positioning System Receiver (PLGR) with an approximate 4- to 6-meter (m) horizontal accuracy in real-time. Position coordinates at most transects were obtained on several field visits.

Twelve belt transects totaling about 4,600 m in length and 33,000 square meters (m^2) in area were established in the lower Suwannee River floodplain (fig. 2) (table 1). Details on the location of each transect are presented in Lewis and others (2002). Transects were visited many times throughout the data collection period.

Vegetation sampling -- Canopy plants were identified to species and measured for diameter at breast height (dbh) on belt transects 5-13 m in width. Canopy plants included all woody plants with a stem diameter of 10 cm or more measured at breast height and with a height of 3 m or taller. Swollen bases of trees were measured for dbh above the swelling. Trees with multiple trunks were

Table 1. Location and sampling area of transects and verification plots in the lower Suwannee River floodplain, Florida (modified from Light and others, 2002)

[rkm, river kilometers; m, meter; m^2, square meters; blh, bottomland hardwoods; sw, swamps]

Reach	Transect name or number of verification plots	Abbreviated transect name	Location, in rkm	Length of transect, in m	Canopy plants: Area sampled, in m^2	Canopy plants: Number of plants sampled
Riverine	Confluence	**CF**	104.3	441.0	4,400	293
	Log Landing	**LL**	77.6	921.2	4,606	189
	Falkenburry	**FK**	64.4	362.6	2,570	233
	Manatee Springs (blh)	**MS**	42.5	414.1[1]	3,330	145
	58 verification plots		47.9 - 106.7		27,965	1,440
Upper Tidal	Manatee Springs (sw)	**MS**	42.5	594.9[1]	4,189	392
	Keen	**KN**	31.2	734.1	3,709	329
	Keen Island	**KI**	31.2	100.0	1,000	21
	24 verification plots		23.0 - 36.5		9,824	771
Lower Tidal	Turkey Island	**TK**	19.8	411.9	2,056	201
	Sandfly North	**SN**	13	88.3	1,148	110
	Sandfly Hammock	**SH**	12.6	151.0	1,510	102
	Barnett Creek	**BC**	11.3	215.6	2,126	235
	Lock	**LK**	5.1	145.5	1,455	184
	Demory	**DM**	4.8	53.2	532	86
	29 verification plots		11.7 - 21.4		11,600	1,170
			Subtotal for transects	4,633.4	32,631	2,520
			Subtotal for verification plots	--	49,388	3,381
			Total	**3,624.4**	**82,019**	**5,901**

[1]The total length of the Manatee Springs transect is 1,009 meters.

considered canopy trees if any single trunk had a dbh of 10 cm or more. Trunks of all multiple-trunked canopy trees were individually measured for dbh; basal areas for these trees were the sum of the basal areas of individual trunks. Subcanopy and ground-cover vegetation were also sampled and the results are presented in Light and others (2002) and Darst and others (2002), respectively. Only canopy plants were used to determine forest type. Relative basal area, the percentage of basal area of a species in a forest type or sampling area, was used to determine and compare forest composition. Relative basal area is calculated by dividing the total basal area of one species (in square meters) by the total basal area of all species in that forest type or sampling area.

Plant nomenclature used in this report follows that by Godfrey and Wooten (1979, 1981) unless otherwise indicated. Common names of all species mentioned are listed in the front of this report. For species with only one variety present in the study area, variety names have been omitted in the body of the report, but are included in the plant list in the front of the report.

Verification Plots

A total of 111 verification plots with a combined area of over 49,000 m^2 were established in the lower Suwannee River floodplain (table 1). Coordinates for the centers of verification plots were obtained from Geographic Information System (GIS) aerial photographic images and then located in the field using the PLGR. Areas selected for verification had to be large enough to allow a possible field error of about 10-15 m in locating the center coordinates due to variation in the accuracy of the PLGR under forest cover. Some verification plots were located by pacing from known starting points. The centers of the plots were marked, and then circular plots were established using flagging and meter tapes. Plots with recent tree falls or obvious alteration (like roadbeds) were not used. Verification plots usually had a radius of 10 m in swamps and 13 m in uplands or bottomland hardwoods. Most verification plots were visited only once during the data collection period. Canopy plants were identified to species and measured using methods for transect sampling. Nine verification plots were used for basic data collection and interpretation of aerial signatures. The polygons containing these nine plots were mapped by forest type determined from field data. Mapped forest types of polygons containing the 102 plots used in map verification were not changed regardless of actual forest composition.

Observation Sites

About 150 observation sites were used for additional verification of forest type mapping signatures on aerial photography. Observation sites were identified on GIS aerial photographic images and then located in the field using the PLGR. At most observation sites, dominant tree species were recorded. Locations of observation sites are not shown on figure 2. Most observation sites were visited once, either during reconnaissance at the beginning of the study or later during forest map verification.

Reach Boundaries

Floodplain reaches are divisions of the floodplain in which hydrologic conditions and vegetation are relatively similar (Light and others, 2002). Three reaches (riverine, upper tidal, and lower tidal) were defined based on the presence or absence of selected canopy species with distributions reflecting tidal influence, flood depths, and duration of inundation, and on changes in hydrology and soils with proximity to the coast. The floodplain from rkm 37 to 45.2 (containing Manatee Springs and the MS transect) has riverine forest types on the higher elevations of the floodplain and upper tidal forest types on the lower elevations (fig 2).

Reach divisions were initially established using data from transects, then modified using results from verification plots. Divisions were placed halfway between the most downstream occurrence of a forest at a study site meeting the criteria of one reach and the most upstream occurrence of a forest meeting the criteria of the next downstream reach.

Mapping Aerial Signatures

Figure 3 is a flow chart showing the methods used to produce the forest map and define forest types. Digital orthophoto quadrangles (DOQ), developed from color-infrared photographs taken in 1994, scanned with 1 meter per pixel resolution, and rectified by USGS, were used as the basis for the floodplain map. The DOQ’s were transformed into grids and color values were enhanced with ARC-INFO programs and display options.

Transects were mapped in GIS by color signatures. Relative basal area was calculated and the canopy composition of segments of transects with similar signatures was analyzed. Minimum areas of

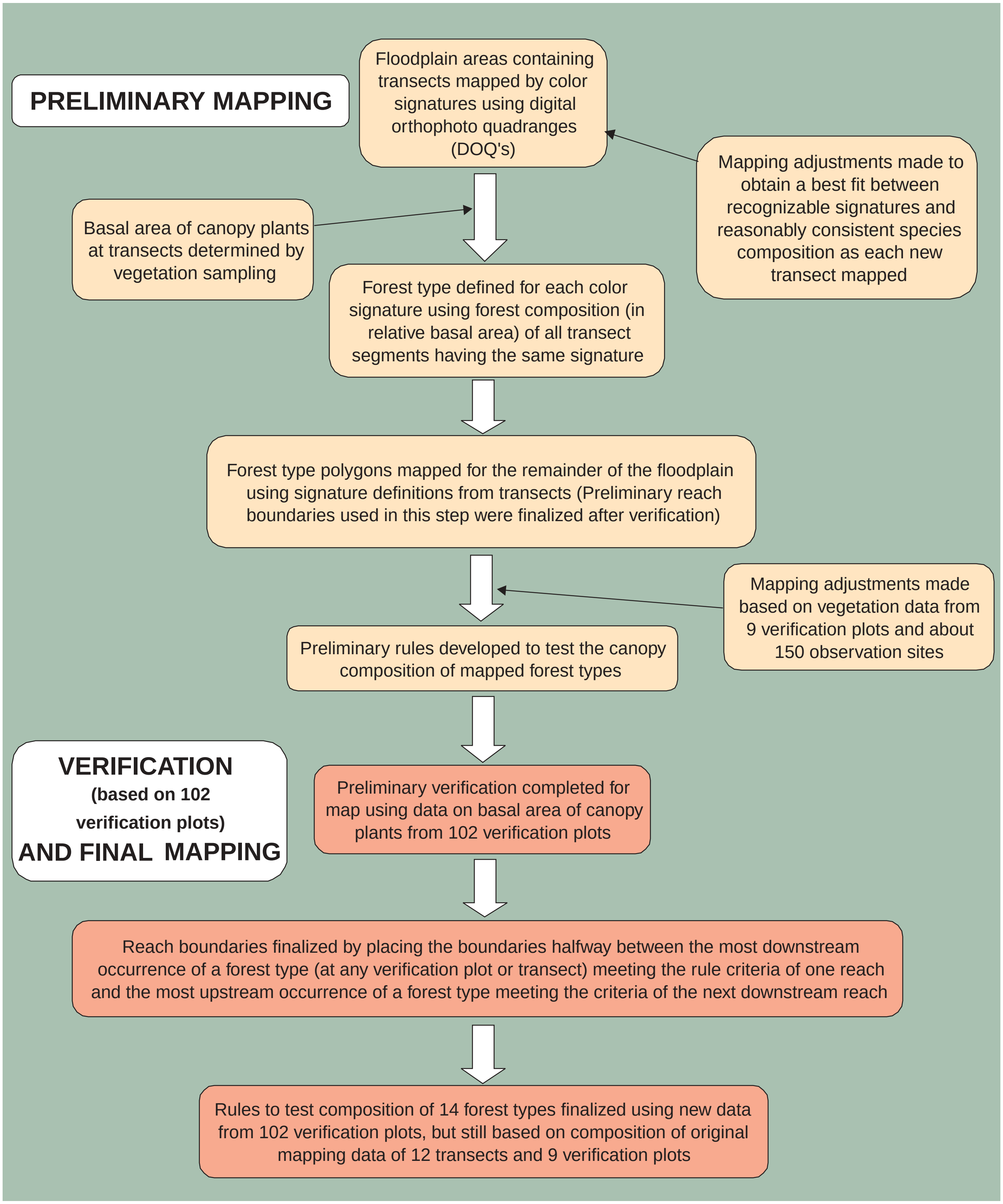


Figure 3. Methods for mapping and defining forest types in the lower Suwannee River floodplain (modified from Light and others, 2000) .

314 m² for swamp types and 500 m² for uplands and bottomland hardwood forests were used for analyzing forest type composition. If insufficient area of a forest type was present at one transect, the data from that forest type were combined with data from the nearest transect with the same forest type, to calculate species composition. Adjustments in mapping were made to get a best fit between recognizable signatures and forest composition. Aerial signatures at transects and nine verification sites were then used as a basis for mapping and labeling polygons in the rest of the floodplain on the map (fig. 4).

Map Verification, Completion, and Conversion to Interactive Format

Rules for determining reaches and forest types (table 2) were developed from the composition of mapped forest types on transects and nine verification plots that were

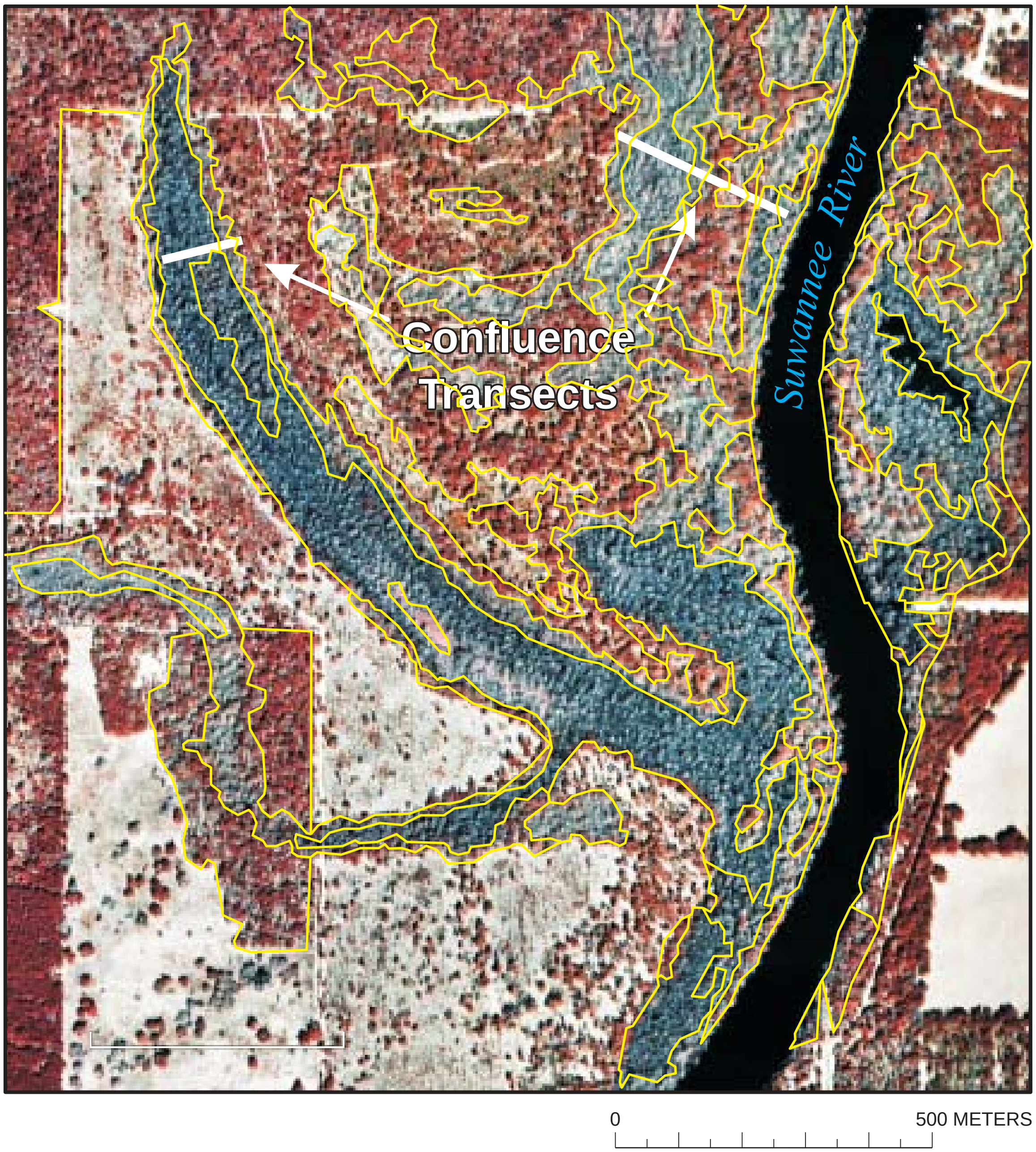


Figure 4. Mapping of the floodplain of the lower Suwannee River, Florida, was based on aerial signatures at transects and other study sites.

Table 2. Rules for testing mapped forest types at verification plots in the floodplain of the lower Suwannee River, Florida (from Light and others, 2002)

[All percentages are based on relative basal area (rba). The rba of a category is equal to the sum of the rbas of all species in that category. sw, swamp; blh, bottomland hardwood; ham, hammock; up, upland; >=, greater than or equal to; >, greater than; <=, less than or equal to; <, less than; %, percent]

Categories of species used in forest type determinations:

Category		Species
sw		*Cephalanthus occidentalis*
sw		*Fraxinus caroliniana*
sw		*Fraxinus profunda*
sw		*Nyssa aquatica*
sw		*Nyssa biflora* [2]
sw		*Planera aquatica*
sw		*Taxodium ascendens*
sw		*Taxodium distichum*
blh	low	*Acer rubrum*
blh	low	*Betula nigra*
blh	low	*Carya aquatica*
blh	low	*Cornus foemina*
blh	low	*Crataegus viridis*
blh	low	*Forestiera acuminata*
blh	low	*Gleditsia aquatica*
blh	low	*Quercus laurifolia*
blh	low	*Quercus lyrata*
blh	low	*Ulmus americana*
blh	low	*Ulmus crassifolia*
blh	low	*Vitis cinerea*
blh	high	*Carpinus caroliniana*
blh	high	*Celtis laevigata*
blh	high	*Crataegus flava*
blh	high	*Crataegus marshallii*
blh	high	*Diospyros virginiana*
blh	high	*Ilex decidua*
blh	high	*Ilex opaca*
blh	high	*Liquidambar styraciflua*
blh	high	*Nyssa biflora* [1]
blh	high	*Pinus glabra*
blh	high	*Quercus michauxii*
blh	high	*Quercus nigra*
blh	high	*Quercus virginiana*
ham		*Ilex cassine*
ham		*Juniperus silicicola*
ham		*Myrica cerifera*
ham		*Persea palustris*
ham		*Pinus elliottii* [2]
ham		*Pinus taeda* [2]
ham		*Sabal palmetto*
ham		*Viburnum obovatum*
up		*Carya glabra*
up		*Lyonia ferruginea*
up		*Magnolia grandifolia*
up		*Nyssa sylvatica*
up		*Persea borbonia*
up		*Pinus elliottii* [1]
up		*Pinus taeda* [1]
up		*Quercus austrina*
up		*Quercus chapmanii*
up		*Quercus geminata*
up		*Quercus hemispherica*
up		*Quercus myrtifolia*
up		*Symplocos tinctoria*
up		*Ulmus alata*
up		*Vaccinium arboreum*

[1] In riverine reach.

[2] In tidal reaches.

Determination of reach:

1) IF *Sabal palmetto* >= 60%, THEN reach is **lower tidal**.
1) IF *Sabal palmetto* < 60%, THEN
2) IF *Magnolia virginiana* > 0% OR IF *Juniperus silicicola* > 0%, THEN reach is **lower tidal**.
2) OR IF *Magnolia virginiana* = 0% AND *Juniperus silicicola* = 0%, THEN
3) IF sw (including *Nyssa biflora*) >= 40%, THEN
4) IF *Nyssa biflora* + *Fraxinus profunda* >= 1%, THEN
5) IF *Nyssa aquatica* >= 5%, THEN reach is **upper tidal**.
5) OR IF *Nyssa aquatica* < 5%, THEN
6) IF *Fraxinus profunda* + *Nyssa biflora* >= 40%, THEN reach is **lower tidal**.
6) OR IF *Fraxinus profunda* + *Nyssa biflora* < 40%, THEN reach is **upper tidal**.
4) OR IF *Nyssa biflora* + *Fraxinus profunda* < 1%, THEN
5) IF *Sabal palmetto* >= 2% THEN reach is **upper tidal**.
5) OR IF *Sabal palmetto* < 2% THEN reach is riverine.
3) OR IF sw (including *Nyssa biflora*) < 40%, THEN
4) IF *Sabal palmetto* >= 2%. THEN reach is **upper tidal**.
4) OR IF *Sabal palmetto* < 2%, THEN
5) IF *Fraxinus profunda* >= 1%, THEN reach is **upper tidal**.
5) OR IF *Fraxinus profunda* < 1%, THEN reach is **riverine**.

Determination of forest type:

Riverine reach forest types:

1) IF sw > 50% THEN,
2) IF *Planera aquatica* >= 50%, THEN forest type is **Rsw2**.
2) OR IF *Planera aquatica* < 50% THEN,
3) IF blh < 15%, THEN forest type is **Rsw1**.
3) OR IF blh >= 15% THEN forest type is **Rsw2**.
1) OR IF sw <= 50% THEN,
2) IF blh > 50% THEN,
3) IF sw >= 1%, THEN forest type is **Rblh1**,
3) OR IF sw < 1% THEN,
4) IF high blh + up < 85%, THEN forest type is **Rblh2**,
4) OR IF high blh + up >= 85%, THEN forest type is **Rblh3**.
2) OR IF blh <= 50%, THEN forest type is **oak/pine**.

Upper tidal reach forest types:

1) IF sw >= 85%, THEN forest type is **UTsw1**.
1) OR IF sw < 85% THEN,
2) IF sw >= 60%, THEN forest type is **UTsw2**.
2) OR IF sw < 60% THEN,
3) IF up <= 50% THEN,
4) IF ham + blh < 75%, THEN forest type is **UTmix**.
4) OR IF ham + blh >= 75%, THEN forest type is **UTblh**.
3) OR IF up > 50%, THEN forest type is **oak/pine**.

Lower tidal reach forest types:

1) IF sw > 70% THEN,
2) IF *Fraxinus profunda* + *Nyssa biflora* >= 60% THEN,
3) IF ham < 10% AND *Magnolia virginiana* < 6%, THEN forest type is **LTsw1**.
3) OR IF ham >= 10% OR *Magnolia virginiana* >= 6%, THEN forest type is **LTsw2**.
2) OR IF *Fraxinus profunda* + *Nyssa biflora* < 60% THEN,
3) IF *Fraxinus profunda* >= 20% THEN,
4) IF ham < 10% AND *Magnolia virginiana* < 6% AND blh < 15%, THEN forest type is **LTsw1**.
4) OR IF ham >= 10% OR *Magnolia virginiana* >= 6% OR blh >= 15%, THEN forest type is **LTsw2**.
3) OR IF *Fraxinus profunda* < 20%, THEN forest type is **LTsw2**.
1) OR IF sw <= 70% THEN,
2) IF up < 50% THEN,
3) IF ham + blh < 75%, THEN forest type is **LTmix**,
3) OR IF ham = blh >= 75%, THEN forest type is **LTham,**
2) OR IF up >= 50%, THEN forest type is **oak/pine**.

Table 3. Mapping accuracy based on tests of forest type rules at verification plots in the floodplain of the lower Suwannee River, Florida (modified from Light and others, 2002)

[Rblh, riverine bottomland hardwood forests; Rsw, riverine swamp; UTblh, upper tidal bottomland hardwood forests; UTmix, upper tidal mixed; UTsw, upper tidal swamp; LTham, lower tidal hammock; LT mix, lower tidal mixed; LTsw, lower tidal swamp]

Specific forest types					
Forest type name	Number of polygons mapped	Verification plots			
		Total number sampled	Number correctly mapped	Percent correctly mapped	Forest types of incorrectly mapped plots
oak/pine	506	7	5	71	Rblh2, Rblh3
Rblh3	474	10	6	60	Rblh2, oak/pine (3)
Rblh2	491	11	10	91	Rblh1
Rblh1	654	11	9	82	Rsw2, Rblh2
Rsw2	306	7	4	57	Rsw1 (2), Rblh1
Rsw1	182	5	4	80	Rsw2
UTblh	202	6	5	83	oak/pine
UTmix	225	5	2	40	UTsw2 (2), UTblh
UTsw2	317	7	4	57	Rsw1, UTsw1, LTsw1
UTsw1	208	4	4	100	none
LTham	204	6	5	83	oak/pine
LTmix	353	7	5	71	UTblh, LTsw2
LTsw2	444	8	5	63	UTsw1, UTblh, LTsw1
LTsw1	417	8	4	50	UTsw1, UTsw2 (2), LTsw2
TOTAL	4,983	102	72	**71**	

used to interpret aerial signatures. The forest types of the polygons containing the nine verification plots were mapped by actual forest composition. The forest types (other than reach) of polygons containing the other 102 verification plots were not changed, regardless of actual composition.

Seventy-one percent of 102 verification plots had a canopy composition that qualified as the mapped type (table 3), using the rules developed from transects. Incorrectly mapped sites were slightly more likely to be wetter forest types than mapped types. All verification sites falling within a reach that did not meet rule criteria for that reach were considered wrongly classified. On 8 of 102 plots (8 percent), the actual forest type was a forest type of a different river reach.

Other aerial signatures were verified in the field at observation sites. Altered upland and wetland forests were mapped using a combination of aerial signatures and topography based on USGS quadrangle maps. Altered wetland forests could not be assigned to specific forest types, but were separated into altered bottomland hardwood forests (riverine and upper tidal reaches), hammocks (lower tidal reach), and swamp forests (all reaches).

Mapping was completed for the entire study area and the total area of each forest type was calculated from the polygon coverage. Final composition of forest types was based on data from transects and verification plots. Absolute and relative basal areas and densities for all canopy plants and forest types are presented in Light and others (2002). The areas of altered bottomland hardwood and swamp forests were divided between major forest types based on the proportion of each forest type present in the floodplain reach.

The GIS map was developed as a project using ArcExplorer software, and annotations were added to polygon label names and land cover types (including major forest types). ArcExplorer software and instructions are available on the Internet at http:\\www.esri.com. The interactive map and software for viewing were written on a compact disc along with several related coverages and this report.

FLOODPLAIN HYDROLOGY, TOPOGRAPHIC FEATURES, AND SOILS

The hydrology of the river and the topographic features, hydrologic conditions, and soil characteristics of the forested floodplain of the lower Suwannee River are discussed in detail in Light and others (2002). A brief summary of these topics is presented in the following sections because of their importance in determining the distribution of floodplain forests.

Hydrology of the River

The Suwannee River is the second largest river in Florida in terms of mean discharge. Median flow in the upstream part of the study area, based on combined flow of the Suwannee River at Branford and the Santa Fe River near Fort White from 1933-99 (fig. 2), was approximately 181 cubic meters per second (m^3/s) (6,480 cubic feet per second). At the upper end of the riverine reach, river stages are unaffected by tides and have a typical annual range of 4.1 m. Tides affect river stages at low and medium flows in the upper tidal reach, and at all flows in the lower tidal reach. Median tidal range at the mouth of the Suwannee River is about 1 m. In the lower part of the lower tidal reach, stages during storm surges are higher than river flood stages; however, duration of storm surges is usually less than 24 hours.

Floodplain Topography and Hydrology

Land-surface elevations and topographic relief in the floodplain decrease with proximity to the Gulf. Elevations range from 4.1 to 7.3 m above sea level at the most upstream riverine transect and range from 0.3 to 1.3 m above sea level at lower tidal transects. Elevations associated with a variety of statistics describing long-term hydrologic conditions in the river channel are shown on cross sections in figure 15 of Light and others (2002). Natural riverbank levees are prominent features on the riverine transects including the MS transect. Levees range from 1 to 3 m high and 15 to 80 m wide. Most levees and high ridges are vegetated with high bottomland hardwood (blh) forests. These areas are partially submerged during a 2-year flood, and totally submerged during a 5-year flood. Riverbank levees are very low or nonexistent on tidal transects below MS. The highest elevations on tidal transects are in blh forests, hammocks, and on the tops of the higher hummocks. These higher elevations are submerged by large floods and, in the lower tidal reach, by storm surges. Some lower tidal forests have a distinct hummock-mud floor microtopography that supports hammock species on the hummocks and swamp species on the mud floor.

Depressions on riverine transects are vegetated with swamps. Water levels in riverine swamps are sometimes higher than water levels in the river channel, but standing water disappears during severe droughts. From the MS transect downstream to the Gulf, the influence of river flooding on river stage gradually decreases, whereas the influence of tides and storm surges on river stage gradually increases. Tidal creeks, flowing in and out with daily tides, are usually located in the riverward half of tidal transects. The swamps near the upland are isolated from regular tidal inundation.

Floodplain Soils

Soils in all riverine forests except the deeper swamps are predominantly mineral (sand, loam, or clay) and are dry during low-flow periods. Soils in some riverine swamps and upper and lower tidal forests are predominantly organic on the surface, with organic or mineral subsurface textures. Surface soils in tidal swamps, lower tidal mixed forests, and some riverine swamps are continuously saturated. Electrical conductivity of surface soils in the downstream part of the lower tidal reach is high enough to exclude some tree species that are intolerant of salinity.

MAJOR FOREST TYPES

The 10-year floodplain covers about 21,170 hectares; nearly 88 percent of this area (18,580 hectares) is mapped as upland and wetland forest types (fig. 5). About 75 percent of the area of forest types is wetland forests (13,994 ha) and about 25 percent is upland forests

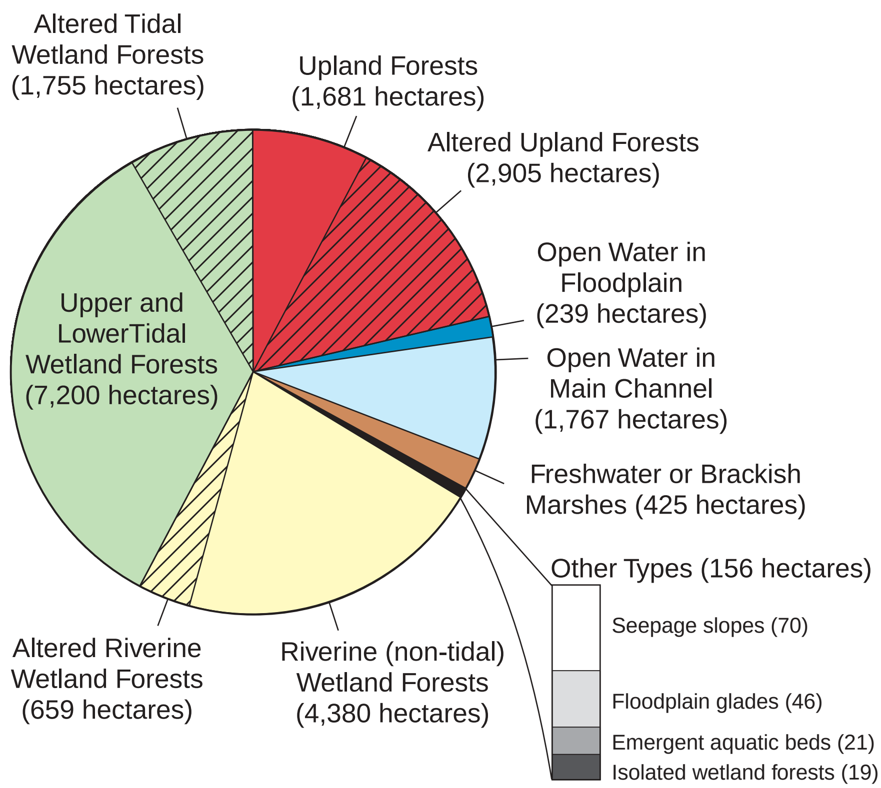


Figure 5. Area of land cover types in the 10-year floodplain and main channel of the lower Suwannee River, Florida. Numbers in parentheses indicate area, in hectares. Total area is about 21,170 hectares.

(4,586 ha). Tidal wetland forests (8,955 ha) cover a much greater area than riverine wetland forests (5,039 ha). The percentage of wetland forests that would be classified as jurisdictional wetlands according to criteria in State and Federal wetland regulations is not known. Most of the wetlands in the floodplain would be classified as palustrine using the classification system developed by the U.S. Fish and Wildlife Service (Cowardin and others, 1979). Approximately 5,320 ha (about 29 percent of 18,580 ha) of upland and wetland forests have been altered by agriculture or development.

The basic characteristics of major forest types with regard to hydrologic conditions, soil textures, and dominant canopy trees are summarized in table 4. Area of each wetland forest type is shown on figure 6. Composition of canopy and subcanopy vegetation is presented in greater detail in Light and others (2002). Composition of ground cover vegetation in wetland forest types is presented in Darst and others (2002).

Oak/pine Uplands

Oak/pine upland forests are present in the riverine and upper tidal reaches of the 10-yr floodplain on the highest elevations. Most of these forests are inundated briefly during the highest floods. Many tree species present in upland forests cannot survive more than brief periods of inundation. *Quercus hemisphaerica*, *Pinus taeda*, and *Quercus geminata* are the dominant canopy species in oak/pine upland forests. Some upland verification sites were oak scrub forests where *Quercus geminata* was the most dominant tree. Oak/pine upland forests have been altered to a much greater extent (63 percent) than wetland forests (17 percent).

Table 4. Summary of hydrologic conditions, soil textures, and dominant canopy species of forest types in the 10-year floodplain of the lower Suwannee River, Florida (modified from Light and others, 2002)

[Rbh, riverine bottomland hardwood forests: Rsw, riverine swamp; UTblh, upper tidal bottomland hardwood forests; UTmix, upper tidal mixed; UTsw, upper tidal swamp; LTham, lower tidal hammock; LTmix, lower tidal mixed; LTsw, lower tidal swamp]

Forest type	Typical hydrologic conditions	Primary soil texture in root zone	Dominant canopy species
Oak/pine	Flooded average of every 10 years; soils dry quickly after floods recede	Sand	*Quercus hemisphaerica* *Pinus taeda* *Quercus geminata*
Rblh3 **Rblh2**	Flooded average of every 3 years, sometimes for durations of 1-2 months or more; soils dry quickly after floods recede	Sand	*Quercus virginiana* *Liquidambar styraciflua* *Quercus laurifolia*
Rblh1	Flooded average of 2 months every year; soils remain saturated another month	Sand, loam, clay	*Quercus laurifolia* *Taxodium distichum* *Quercus lyrata* *Betula nigra* *Liquidambar styraciflua*
Rsw2 **Rsw1**	Flooded 4-7 months every year; soils remain saturated another 5 months	Clay, muck	*Taxodium distichum* *Planera aquatica*
UTblh	Flooded 1 to 2 months every 2 years; soils dry quickly after floods recede	Sand	*Quercus laurifolia* *Sabal palmetto*
UTmix	Flooded 2 to 3 months every year; soils dry quickly in some areas and remain continuously saturated in others	Loam, muck, sand	*Taxodium distichum* *Fraxinus profunda* *Quercus laurifolia*
UTsw2 **UTsw1**	Flooded monthly by high tides or high river flows; most soils continuously saturated	Muck	*Nyssa aquatica* *Taxodium distichum* *Fraxinus profunda*
LTham	Flooded every 1-2 years by either storm surge or high river flows; high water table; surface soils on higher elevations dry quickly and soils are continuously saturated in low areas	Muck, sand	*Sabal palmetto* *Pinus taeda*
LTmix	Flooded daily or several times a month by high tides, except in isolated areas; soils continuously saturated except for hummock tops, which have conditions similar to hammocks.	Muck	*Fraxinus profunda* *Nyssa biflora* *Magnolia virginiana*
LTsw2 **LTsw1**		Muck	*Nyssa biflora* *Fraxinus profunda* *Taxodium distichum*

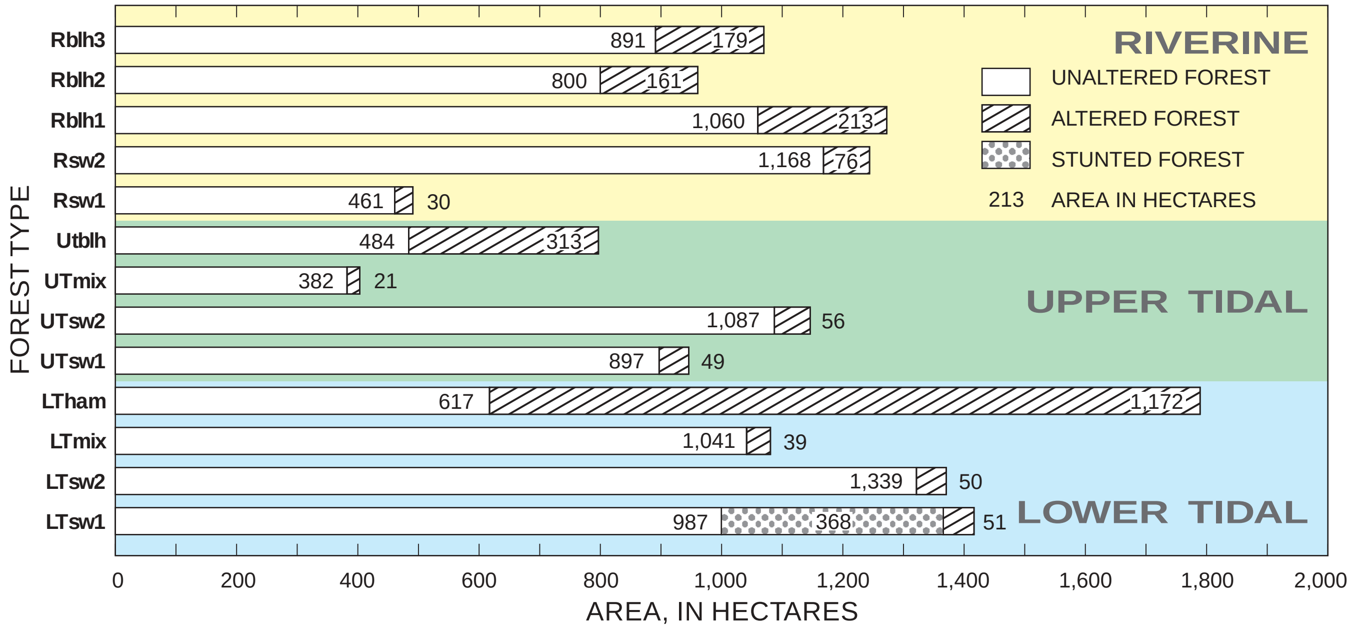


Figure 6. Area of major wetland forest types in the floodplain of the lower Suwannee River, Florida (modified from Light and others, 2002).

Riverine Wetland Forests

High bottomland hardwoods (Rblh3 and Rblh2) are present primarily on the higher levees, ridges, and flats where soils are usually sandy (fig. 7). *Quercus virginiana* is the dominant canopy species in Rblh3 forests. *Quercus laurifolia*, *Quercus virginiana*, and *Liquidambar styraciflua* are dominant in the canopy of Rblh2 forests.

Low bottomland hardwood forests (Rblh1) (fig. 8) are present on slopes around swamps, on low levees, ridges, and flats, and in higher elevation depressions that are flooded continuously for several weeks or longer every 1 to 3 years and contain plant species adapted to periodic inundation and saturation. Rblh1 forests have a significant proportion of swamp tree species in the canopy that distinguish them from high bottomland hardwood forests in which swamp trees are usually absent. Dominance in the

Figure 7. Large *Quercus virginiana* and *Quercus laurifolia* trees dominate the canopy of a high bottomland hardwood forest in the riverine reach of the floodplain of the lower Suwannee River, Florida.

Rblh1 forest canopy is shared between *Quercus laurifolia*, *Taxodium distichum*, *Quercus lyrata*, *Betula nigra*, and *Liquidambar styraciflua*.

Riverine swamps (Rsw2, Rsw1) are present in the lowest and wettest areas of the floodplain (fig. 9) that are either inundated or saturated most of the time. Swamps contain plant species that have special adaptations for survival in anoxic soils. *Taxodium distichum* is dominant in the canopy of Rsw1; whereas, *Taxodium distichum* and *Planera aquatica* share dominance in Rsw2. Bottomland hardwood species are a minor component in the canopy of Rsw1, and a significant component in the canopy of Rsw2.

Upper Tidal Wetland Forests

Upper tidal bottomland hardwood forests (UTblh) are present on sandy soils on high flats and in transitional areas between upland forests and swamps (fig. 10). UTblh forests are dominated by *Quercus laurifolia* and *Sabal palmetto*. While the canopy composition of UTblh is similar to some hydric hammocks, flooding is deeper, approximately 1 m during the 5-year 1-day flood.

Upper tidal mixed forests (UTmix) are found on low levees or are present as transitional areas between swamps and higher forest types. A mixed forest (UTmix, LTmix) is a tidal forest type dominated by both swamp and bottomland hardwood or hammock tree species. Dominance in the UTmix canopy is shared by *Taxodium distichum*, *Fraxinus profunda*, and *Quercus laurifolia*.

Upper tidal swamps (UTsw2, UTsw1) are present at elevations below median monthly high stage and usually have surface soils that are permanently saturated mucks (fig. 11). *Nyssa aquatica* and *Taxodium distichum* are dominant in the canopy of UTsw1. These two species share dominance with *Fraxinus profunda* in UTsw2. Bottomland hardwood trees are more important in the canopy of UTsw2 than in UTsw1.

Figure 8. The flared base of *Ulmus americana* growing in a low bottomland hardwood forest in the riverine reach of the floodplain of the lower Suwannee River, Florida.

Figure 9. *Taxodium distichum* trees growing in a dense stand in a riverine swamp in the floodplain of the lower Suwannee River, Florida (from Light and others, 2002).

Figure 10. Bottomland hardwood trees such as *Quercus laurifolia* (in right foreground) are the dominant canopy species in the most elevated wetlands of the upper tidal reach of the lower Suwannee River, Florida (modified from Light and others, 2002).

Figure 11. The bases of trunks of *Nyssa aquatica* are usually swollen in upper tidal swamps in the floodplain of the lower Suwannee River, Florida.

Lower Tidal Wetland Forests

Figure 12. *Sabal palmetto* is the dominant canopy species in lower tidal hammocks in the floodplain of the lower Suwannee River, Florida. Cabbage palms become increasingly numerous in hammocks with proximity to the Gulf of Mexico.

Lower tidal hammocks (LTham) (fig. 12) in the lower Suwannee River floodplain are part of the Gulf Coastal Hammocks as described by Vince and others (1989). Hydric hammocks are a unique wetland forest type, rare outside Florida, that support a characteristic mixed hardwood forest with evergreen and semi-evergreen trees. LTham is by far the most altered wetland forest type (66 percent) (fig. 6). LTham forests are found on higher elevations that do not receive regular tidal inundation or frequent river flooding, but have a high water table and are briefly inundated by storm surges several times a decade. LTham forests are dominated by *Sabal palmetto* and *Pinus taeda*.

Lower tidal mixed forests (LTmix) include swamps with numerous small hummocks or less common large hummocks, and transitional areas between swamps and hammocks. *Fraxinus profunda*, *Nyssa biflora* and *Magnolia virginiana* are dominant canopy species in LTmix. Lower tidal mixed forests and swamps (LTmix, LTsw2, LTsw1) are found on deep muck soils that are below the elevation of the median daily or monthly high stage. *Fraxinus profunda*, *Taxodium distichum*, and *Nyssa biflora* are the most important canopy species in LTsw2 and LTsw1 forests (fig. 13). Stunted stands of *Fraxinus profunda* (fig. 14) are an important variant of LTsw1 forests, comprising 27 percent of the total area of LTsw1 forest (fig. 6). Stunted swamps sometimes have scattered individuals or sparse overstories of slightly taller *Taxodium distichum* trees.

Figure 13. A dense stand of canopy trees in a lower tidal swamp in the floodplain of the lower Suwannee River, Florida. Lower tidal swamps were dominated by *Nyssa biflora, Fraxinus profunda,* and *Taxodium distichum.*

Figure 14. A stunted stand of *Fraxinus profunda* trees growing along East Pass near the tree line in the lower Suwannee River floodplain, Florida. Trees in this stand are less than 6 meters tall (from Light and others, 2002).

OTHER LAND COVER TYPES

The map of the 10-year floodplain includes seven land cover types in addition to the major forest types (fig.5). Two open water land cover types are mapped; the main channel of the lower Suwannee River (1,767 ha) (fig. 15) and open water in the floodplain (239 ha). Most areas of open water in the non-tidal floodplain are ponds in swamps (fig. 16). In tidal reaches, open water in the floodplain is usually found in tidal creeks.

Two minor forest types mapped separately are seepage slopes and isolated forested wetlands. Seepage slopes (70 ha) are usually located between upland forests and the wetlands adjacent to the main channel. One seepage slope was sampled at a verification plot in the upper tidal reach. Although the ground was saturated, the vegetation was typical of areas with shallow flood depths. The presence of species such as *Pinus taeda*, *Persea palustris*, and *Pilea pumila*, indicated that the elevation of this site was probably above the average elevations of upper tidal mixed forests and swamps (Darst and others, 2002). Small areas of isolated forested wetlands (19 ha) were separated from the wetlands adjacent to the river and were not sampled. Their forest composition may be more typical of non-riverine wetlands such as cypress domes, shallow sinkholes, and gum swamps (Myers and Ewel, eds., 1991).

Figure 15. The main channel of the lower Suwannee River, Florida, covers 1,767 hectares of the total area mapped (21,170 hectares).

Figure 16. An open water pond in the floodplain of the riverine reach of the lower Suwannee River, Florida.

Figure 17. Marshes, including this freshwater marsh near Gopher River, cover 425 hectares of land upstream of the tree line in the floodplain of the lower Suwannee River, Florida.

Figure 18. Floodplain glades are non-forested areas in the lower Suwannee River floodplain, Florida, that usually have a thick ground cover of grasses and sedges.

Nearly all marshes upstream of the tree line (425 ha) are found in the lower tidal reach (fig. 17). Marshes are predominantly freshwater and are dominated by *Cladium jamaicense*, *Zizaniopsis miliacea*, and other herbaceous sedges and grasses. Clewell and others (1999) describe tidal marshes upstream and downstream of the tree line in the lower Suwannee River. Small beds of emergent aquatic vegetation (21 ha) are visible on the aerial photographs, which were taken in the winter. These beds differ from the larger beds of emergent vegetation present in the main channel in the warmer months of the year, which were not usually visible on the aerial photographs. Winter emergent vegetation is most often found in small tidal streams within marshes. Emergent plants such as *Sagittaria lancifolia*, *Rumex verticillatus*, and *Hydrocotyle verticillata* grow in floating mats or are rooted in the shallow edges of streams.

Floodplain glades are non-forested areas (46 ha) (fig. 18) that were encountered principally in the riverine reach of the floodplain. Floodplain glades are elevated above the wetlands adjacent to the river and are usually oval in shape. The mean area of the 54 mapped glades was less than 1 ha (0.9 ha). These areas were seen at several observation sites, including one shown in figure 18 that was located on the eastern side (left bank) of the floodplain at rkm 48.0. At this site, the ground cover was dominated by *Panicum rigidulum*.

USES OF THE FOREST MAP

The forest map can be used by scientists for ecological studies in the floodplain based on land cover types and in comparative studies with other floodplains. Landowners and management personnel can use the map to develop property descriptions and land use decisions, but on-site verification of specific forest types may be desirable on some sites considering that verification of the map indicated that 71 percent of the polygons mapped as major forest types are correctly labeled. The mapping of seepage slopes and floodplain glades will facilitate research on these unusual land cover types.

SUMMARY

A map of forest types in the lower Suwannee River floodplain, Florida, was created during a study conducted from 1996 to 2000 by the U.S. Geological Survey in cooperation with the Suwannee River Water Management District. The map is presented with this report on a compact disc with interactive viewing software. The study area was the 10-year floodplain of the lower Suwannee River from its confluence with the Santa Fe River to the lower limit of forests near the Gulf of Mexico. The floodplain was divided into three reaches, riverine (non-tidal), upper tidal, and lower tidal, due to changes in hydrology, vegetation, and soils with proximity to the coast.

Digital orthophoto quadrangles, developed from color-infrared aerial photographs, were used as the basis for the floodplain map. Canopy composition for different aerial signatures was determined from the relative basal area of canopy tree species on transects and at nine verification sites. The floodplain map accuracy was evaluated using 102 verification plots. Seventy-one percent (71 percent) of verification plots had a canopy composition that qualified as the mapped forest type.

River stages in the riverine reach of the Suwannee River are unaffected by tides. The influence of river flooding on river stage gradually decreases with proximity to the Gulf, and the influence of tides and storm surges on river stage gradually increases. Tides affect river stages at low and medium flows in the upper tidal reach, and at all flows in the lower tidal reach. In the lower part of the lower tidal reach, stages during storm surges are higher than river flood stages. Land-surface elevations and topographic relief in the floodplain decrease with proximity to the Gulf. Soils in all riverine wetland forests but the wettest swamps are mineral and dry during low-flow periods. Most surface soils in the deepest riverine swamps, upper and lower tidal swamps, and lower tidal mixed forests are continuously saturated mucks.

Major forest types in the lower Suwannee River floodplain cover 18,580 ha. Approximately 29 percent of the area of floodplain forests has been altered by agriculture or development. About 75 percent of the area of major forest types is wetland forests (13,994 ha) and about 25 percent is upland forests (4,586 ha). Tidal wetlands cover a much greater area than riverine wetlands.

Oak/pine upland forests are inundated briefly during the highest floods. Many tree species present in oak/pine forests cannot survive more than brief periods of inundation. High bottomland hardwoods are present on the higher levees, ridges, and flats where soils are usually sandy. Low bottomland hardwood forests are present on slopes around swamps, low levees, flats, and higher elevation depressions that are flooded continuously for several weeks or longer every 1 to 3 years. Most canopy species in low bottomland hardwoods are adapted to periodic inundation and saturation. Riverine swamps are present in the lowest and wettest areas of the reach that are either inundated or saturated most of the time.

Upper tidal bottomland hardwood forests are present on sandy soils on high flats and in areas between upland forests and swamps. Upper tidal mixed forests are found on low levees or in transitional areas between swamps and higher forest types. Upper tidal swamps are present at elevations below median monthly high stage and usually have surface soils that are permanently saturated mucks.

Lower tidal hammocks in the lower Suwannee River floodplain are found on elevations that do not receive regular tidal inundation or frequent river flooding, but have a high water table and are briefly inundated by storm surges several times a decade. Lower tidal mixed forests include swamps with numerous small hummocks or less common large hummocks. Lower tidal mixed and swamp forests are found on deep muck soils that are below the elevation of the median daily or monthly high stage. Stunted stands of *Fraxinus profunda* are an important variant of lower tidal swamps.

The floodplain contains seven land cover types covering about 2,590 ha in addition to the major forest types. Water in the main channel of the lower Suwannee River was mapped separately from open water in the floodplain. Seep-

age slopes usually have saturated soils that support species tolerant of shallow flooding. Isolated forested wetlands were separated from the wetlands adjacent to the river. Freshwater marshes and beds of emergent aquatic vegetation are present upstream of the tree line in the lower tidal reach. Floodplain glades are non-forested areas found primarily in the riverine reach of the floodplain.

The forest map can be used by scientists for ecological studies in the floodplain based on land cover types and by landowners and management personnel making land use decisions. The mapping of seepage slopes and floodplain glades will facilitate research on these unusual land cover types.

REFERENCES

Berndt, M.P., Oaksford, E.T., Darst, M.R., and Marella, R.L., 1996, Environmental setting and factors that affect water quality in the Georgia-Florida Coastal Plain study unit: U.S. Geological Survey Water-Resources Investigations Report 95-4268, 45 p.

Bradley, J.T., 1975, Freeze probabilities in Florida: Agricultural Experiment Stations, Institute of Food and Agricultural Sciences, University of Florida: Bulletin 777 (technical), 22 p.

Brinson, M.M., Swift, B.L., Plantico, R.C., and Barclay, 1981, Riparian ecosystems: Their ecology and status: U.S. Fish and Wildlife Service, FWS/OBS-81/17, 154 p.

Clark, J.R., and Benforado, J., eds., 1981, Wetlands of bottomland hardwood forests— Proceedings of a workshop on bottomland hardwood forest wetlands of the southeastern United States, Lake Lanier, Georgia, June 1-5, 1980: Elsevier, Developments in Agricultural and Managed-Forest Ecology, v. 11, p. 335-357.

Clewell, A.F., Beaman, R.S., Coultas, C.L., and Lasley, M.E., 1999, Suwannee River tidal marsh vegetation and its response to external variables and endogenous community processes: Live Oak, Fla., Suwannee River Water Management District, 118 p., plus 15 appendices, variously paged.

Clewell, A.F., 1985, Guide to the vascular plants of the Florida Panhandle: Tallahassee, Florida State University Press, 605 p.

Cowardin, L.M., Carter, Virginia, Golet, F.C., and LaRoe, E.T., 1979, Classification of wetlands and deepwater habitats of the United States: U.S. Fish and Wildlife Service FWS/OBS-79/31, 103 p.

Crane, J.J., 1986, An investigation of the geology, hydrogeology, and hydrochemistry of the lower Suwannee River basin: Tallahassee, Florida Geological Survey Report of Investigation 96, 110 p.

Darst, M.R., Light, H.M., and Lewis, L.P., 2002, Ground-cover vegetation in wetland forests of the lower Suwannee River floodplain, Florida, and potential impacts of flow reductions: U.S. Geological Survey Water-Resources Investigations Report 02-4027, 46 p.

Davis, M.M., Mitchell, W.A., Wakeley, J.S., Fischenich, J.C., and Craft, M.M., 1996, Environmental value of riparian vegetation: U.S. Army Corps of Engineers, Technical Report EL-96-16, 147 p., plus appendixes.

Godfrey, R.K., and Wooten, J.W., 1979, Aquatic and wetland plants of southeastern United States (Monocotyledons): Athens, The University of Georgia Press, 712 p.

———1981, Aquatic and wetland plants of southeastern United States (Dicotyledons): Athens, The University of Georgia Press, 933 p.

Gosselink, J.G., Lee, L.C., and Muir, T.A., eds., 1990, Ecological processes and cumulative impacts: Chelsea, Mich., Lewis Publishers, 708 p.

Greeson, P.E., Clark, J.R., and Clark, J.E., eds., 1979, Wetland functions and values: The state of our understanding--Proceedings of the national symposium on wetlands, Lake Buena Vista, Florida, November 1978: Minneapolis, American Water Resources Association, Technical Publication Series TPS79-2, 674 p.

Lelong, M.G., 1984, New combinations for *Panicum* subgenus *Panicum* and subgenus *Dichanthelium* (*Poaceae*) of the Southeastern United States: Brittonia, v. 36, no. 3, p. 262-273.

Lewis, L.J., Lights, H.M., and Darst, M.R., 2002, Location and description of ecological study sites in floodplain forests of the lower Suwannee River, Florida: U.S. Geological Survey Open-File Report 01-410 , 84 p.

Light, H.M., Darst, M.R., Lewis, L.J., and Howell, D.A., 2002, Hydrology, vegetation, and soils of riverine and tidal floodplain forests of the lower Suwannee River, Florida and potential impacts of flow reductions: U.S. Geological Survey Professional Paper 1656-A, 124 p.

Lugo, A.E., Brinson, M., and Brown, S., eds., 1990, Ecosystems of the world--Forested Wetlands: Elsevier, v.15, 527 p.

Messina M.G., and Conner, W.H., eds., 1998, Southern forested wetlands—Ecology and management: New York, Louis Publishers, 616 p.

Mitsch, W.J., and Gosselink, J.G., 1993, Wetlands (2d ed.): New York, Van Nostrand Reinhold, 722 p.

Mueller-Dombois, Dieter, and Ellenberg, Heinz, 1974, Aims and methods of vegetation ecology: New York, John Wiley and Sons, 547 p.

Myers, R.L., and Ewel, J.J., eds., 1991, Ecosystems of Florida: Orlando, University of Central Florida Press, 765 p.

Owenby, J.R., and Ezell, D.S., 1992, Monthly station normals of temperature, precipitation, and heating and cooling degree days 1961-90: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, North Carolina: Climatography of the United States No. 81, 26 p.

Puri, H.S., and Vernon, R.O., 1964, Summary of the geology of Florida and a guidebook to the classic exposures (revised): Tallahassee, Florida Geological Survey, Special Publication no. 5, 312 p.

Vince, S.W., Humphrey, S.R., Simons, R.W., 1989, The ecology of hydric hammocks: A community profile: Washington, D.C., U.S. Fish and Wildlife Service, National Wetlands Research Center, Biological Report 85(7.26), 81 p.

Wharton, C.H., Kitchens, W.M., and