VEGETATION APPENDIX

Characterization of Woody Wetland Vegetation Communities along Gum Slough

Executive Summary

The purpose of this study was to characterize relationships among vegetation, soils, and elevations in wetlands along Gum Slough, in Sumter County, Florida, and assist the Southwest Florida Water Management District (District) in establishing minimum flows and levels (MFLs) for the river. Vegetation classes, plant species importance, soil characteristics, and elevations were characterized along 8 transects within the upper reaches of Gum Slough. The study corridor extended 1.6 miles downstream from Transect PHABSIM1 and the slough flows 3.5 miles farther downstream to its confluence with the Withlacoochee River.

Vegetation. The permanent ground water flows and clear water of the spring-fed Gum Slough differentiate it from streams and rivers dominated by surface water flows. Unlike many coastal springs rivers, such as the Homosassa and Crystal rivers, Gum Slough has a well-developed floodplain characterized by extensive seasonally and sometimes semipermanently inundated swamps. The floodplain vegetation associated with Gum Slough is similar to vegetation described for parts of the Withlacoochee River floodplain (SWFWMD 1997).

Differences in vegetation classes along Gum Slough study corridor were measured using importance values (IVs) that were calculated using tree species density and basal area and subsequently provided a relative measure of species dominance (no units). Differences in species and species importance were significant between the 6 vegetation classes identified along Gum Slough (Wilcoxon Signed Rank test, $p < 0.01$).

Six vegetation classes were characterized as wetland classes and a single upland class was identified. The six wetland classes could be differentiated based on dominance of cypress, (*Taxodium distichum*), sweetgum (*Liquidambar styraciflua*), swamp bay (*Persea palustris*), ironwood (*Carpinus caroliniana*), laurel oak (*Quercus laurifolia*), and water oak (*Q. nigra*).

Swamps. These 2 vegetation classes occurred on muck soils and were characterized by obligate and facultative wetland species. Cypress swamp had a total of 12 species and IVs for obligate wetland species totaled 127.5 (out of the total possible 300). Dominant species (IV> 50) were cypress (IV = 65.2), followed by sweetgum (IV=49.2) and laurel oak (IV=41.5). Bay swamp included only six species and IVs for obligate wetland species totaled 108.5. Dominant species were: sweetgum (IV=69.4), swamp bay (IV=57.9), red maple (IV=54.7), and American elm (IV=51.3).

Hammocks. Like the swamp classes, hammocks included primarily obligate and facultative wetland species, including cypress. Obligate and facultative wetland species totaled more than 275 of a total 300 possible. Hammock vegetation classes included:

- Maple hardwood hammock (14 species). Dominant species: swamp bay (IV=63.8), dahoon holly (IV=40.8), and red maple (IV=27.7).

- Ironwood hardwood hammock (10 species). Dominant species: ironwood (IV=70.4), laurel oak (IV=45.1), sweetgum (IV=35.3), swamp bay (IV=31.3), and cypress (IV=30.1).

Laurel oak hammock (8 species). Dominated by laurel oak (IV=100.8) and swamp bay (IV=56.7).

Water oak / sweetgum hammock (9 species). Dominant species: water oak (IV=149.2).

Laurel oak / pine upland. The single upland class included 12 species. Dominant species: loblolly pine (IV=87.5) and laurel oak (IV=68.7).

Elevations and Soils. Elevations ranged from 41.3 (cypress swamp) to 46.6 (laurel oak / pine upland) feet NAVD among vegetation classes. Median and mean elevations by vegetation class, however, varied much less. Mean elevations for the wetland classes ranged from 1.0 to 1.8 feet above channel bottom in the ironwood hardwood and water oak / sweetgum hammocks, to 4.6 feet above channel bottom in the laurel oak / pine upland. Median elevations of hydric soils were lower when compared with nonhydric soils and overlap was negligible, in spite of variation in elevations along the Gum Slough channel. Median elevations of hydric soils ranged from 40.4 feet NAVD (water oak / sweetgum hammock) to 42.8 feet NAVD (maple hardwood hammock) and nonhydric soils elevations ranged from 42.7 (ironwood hardwood hammock) to 45.3 (water oak / sweetgum hammock) feet NAVD.

Discriminant Function Analysis (DFA). DFA was successful in differentiating among vegetation classes based on measures of elevation, distance from river channel, and soil parameters along the Gum Slough transects. Elevation (r^2 = 0.56), soils (r^2 = 0.54), relative elevation (r^2 = 0.62), and distance from river channel (r^2 = 0.30) were significantly correlated with vegetation class. Correct classifications ranged from 0 percent (ironwood hardwood hammock) to 80 percent (bay swamp) and 83.3 percent (laurel oak / pine upland). Misclassifications generally occurred between adjacent vegetation classes. For example, cypress swamp overlapped with bay swamp and, in turn, bay swamp overlapped with maple hardwood hammock. There was very little overlap between the upland class and the wetland classes. Overlap among wetland classes was frequent and merging similar classes, e.g. cypress swamp and bay swamp into a single "swamp" class, and merging the remaining wetland classes into a single "hammock" class increased the "success" of the classifications in a second DFA. However, correlations between vegetation classes and environmental parameters did not improve.

Wetted Perimeter. Wetland classes consistently coincided with the steep portion of wetted perimeter curves for each of the Gum Slough transects and corresponded to a greater wetted perimeter. The upland class corresponded to the portion of the curves that indicates a steeper elevation gradient (and less wetted perimeter). These results are consistent with the larger reductions in wetted perimeter (habitat) in wetlands that can result from relatively small changes in water level along Gum Slough.

Results of this study indicate that the cypress and bay swamps and the maple hardwood hammock along Gum Slough occurred at lower elevations along individual transects, had a greater frequency of muck soils with a soil index greater than 2 (muck and saturated), exhibited species dominance by obligate wetland species, and had IVs for obligate and facultative wetland species >100.

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Purpose

The statutory directive for minimum flows and levels (MFLs) included in the Water Resources Act was enacted by the Florida Legislature in 1972. Section 373.042 F.S. of the Act directs each water management district to establish MFLs for surface water bodies, watercourses, and aquifers within their respective jurisdictions. Under the statute, the minimum flow for a given watercourse is defined as the limit at which further withdrawals would be "significantly harmful" to the water resources or ecology of the area. In addition, the determination of MFLs must be based on the "best available" information.

The purpose of this study was to characterize relationships among vegetation, soils, and elevation in wetlands along a portion of Gum Slough (refer to Figure below). Given the assumption that vegetation is a good and easily measured integrator of environmental and historical site conditions, vegetation, soils, and elevation data will be used to support the Southwest Florida Water Management District (District) in establishing MFLs for Gum Slough.

Instream flows are important to maintaining a functional river or stream system, fish and wildlife habitat, recreation, navigation, and consumptive uses such as irrigation and domestic water supply. MFLs are intended to guide water resource and water supply development to ensure water resource sustainability for people and the natural environment. They will also be used to assist in making water use and other permitting decisions. In summary, MFLs are being established to:

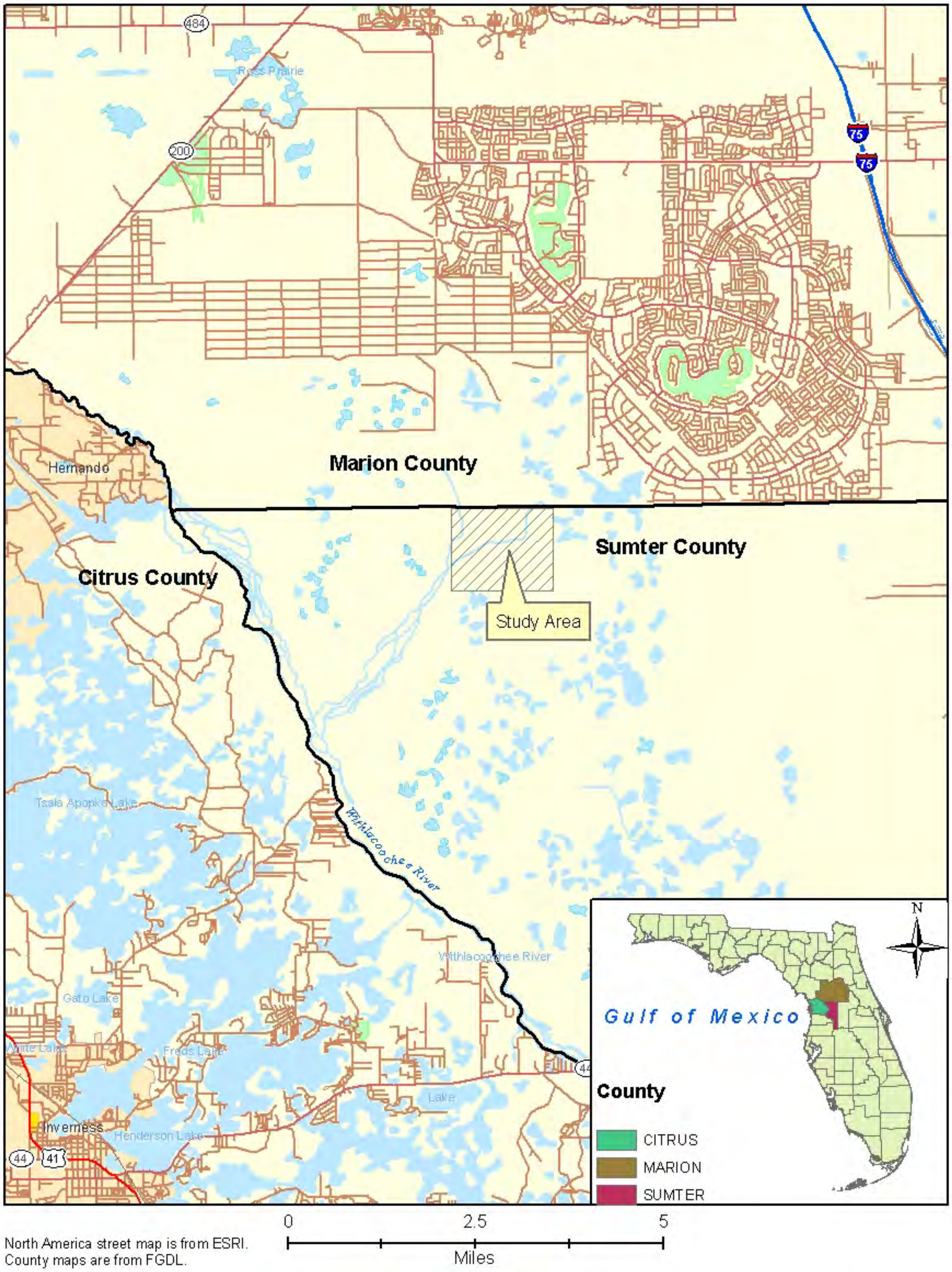
- Address Florida Statute 373.042(1)(a)&(b)
- Protect water resources and ecology
- Determine water availability

The District Governing Board has the final authority to set MFLs within its jurisdiction, using several guidelines provided by the state (and listed below).

- Using the best information available
- When appropriate, setting MFLs to reflect seasonal variations
- Considering the protection of non-consumptive uses of water (e.g. recreation)

This report presents the relationships among vegetation and physical factors, such as elevation and soils that characterize the Gum Slough study area and may be used in establishing MFLs for vegetation communities.

Location of the Gum Slough Study Area in Sumter County, Florida



North America street map is from ESRI.
County maps are from FGDL.

1.0 Background

Gum Slough drainage basin includes 32,672 acres of the 1,638,646 acre Withlacoochee River watershed (Figure 1-1). The Withlacoochee River watershed encompasses an area that extends about 65 miles south of Gum Springs near the cities of Lake Alfred and Haines City in Polk County and approximately 38 miles north of Gum Springs near the town of Raleigh.

Gum Springs are located approximately 70 miles north-northwest of Tampa, 22 miles east of Crystal River, and 10 miles southwest of Ocala off SR 484. Gum Slough flows southwest from the springs to its confluence with the Withlacoochee River approximately 6 miles northeast of the city of Inverness. The Withlacoochee River flows northwest from that point for approximately 14 miles to the city of Dunnellon where it turns west and flows about 18 miles to the Gulf of Mexico. Gum Slough and Gum Springs were designated as Outstanding Florida Waters in 1989 when the Withlacoochee River acquired this designation. The Gum Slough addressed in this study should not be confused with Gum Slough that flows under Interstate 75 at about 9 miles north of U.S. Highway 98.

Champion and Starks (2001) list 7 seven springs in the Gum Slough Springs Group: Wilson Head Spring, Alligator Spring, Gum Spring Main, and Gum Slough 1, 2, 3, and 4. However, Wilson Head Spring begins about 5 miles downstream of the confluence of Gum Slough with the Withlacoochee River and is not described here. The Florida Department of Environmental Protection (FDEP 2009) lists all but one of the Gum Springs as second magnitude springs (discharges water at a rate of 10 to 100 cubic feet per second, cfs). The closest first magnitude springs to Gum Springs are Rainbow Springs, 16 miles northwest of Gum Spring Main, and Silver Springs, 20 miles to the northeast.

The 6 springs associated with Gum Slough are mapped in Figure 1-2 and briefly described below in order of upstream to downstream. The first 3 springs are considered part of the headwaters of Gum Slough (Champion and Starks 2001).

Alligator Spring. Alligator Spring (also known as Gum Spring 01A) is located on private property in forested wetlands at the uppermost reach of Gum Slough on the Marion-Sumter County line. Alligator Spring is a third magnitude spring (discharges 1 to 10 cfs) and the spring pool is about 50 feet in diameter. The edge of the vent is about 6 feet below the surface and has a depth of 20.5 feet below the surface of the water (Rosenau 1977). The spring was named for a large alligator that was seen lying on the bottom of the pool every time the spring was sampled (Champion and Starks 2001).

Gum Slough 1. Gum Slough 1 is located on private property about 580 feet southwest of Alligator Spring in forested wetlands. Its pool is about 40 feet in diameter. The vent is about three feet below the surface and is about 15 feet in diameter with a maximum depth of about 10 feet (Rosenau 1977). The spring flows west about 200 feet into Gum Spring Main.

Gum Spring Main. Gum Spring Main is located on private property approximately 300 feet southwest of Gum Slough 1. The pool is approximately 80 feet in diameter. The top edge of the vent is about five feet below the surface and has a diameter of about 25 feet and a depth of 13 feet (Rosenau 1977). The water from this spring flows north-northeast about 200 feet where it joins the flow from Gum Slough 1 and flows northwest.

Gum Slough 2. Gum Slough 2 is located 4,000 feet downstream of Gum Spring Main. There is no pool but often a slight boil is visible at the surface. The vent is in the bed of Gum Slough and has a diameter of about 30 feet and a maximum depth of 17 feet (Rosenau 1977). This spring is known locally as "Blue Hole" (Champion and Starks 2001).

Gum Slough 3. Gum Slough 3 is located about 170 feet downstream of Gum Slough 2. Its vent is in the bed of Gum Slough and is about 20 feet in diameter and 15 feet in depth (Rosenau 1977).

Gum Slough 4. Gum Slough 4 is located about 1,000 feet downstream of 3. The vent is about 30 feet in diameter with a depth of about 15 feet (Rosenau 1977).

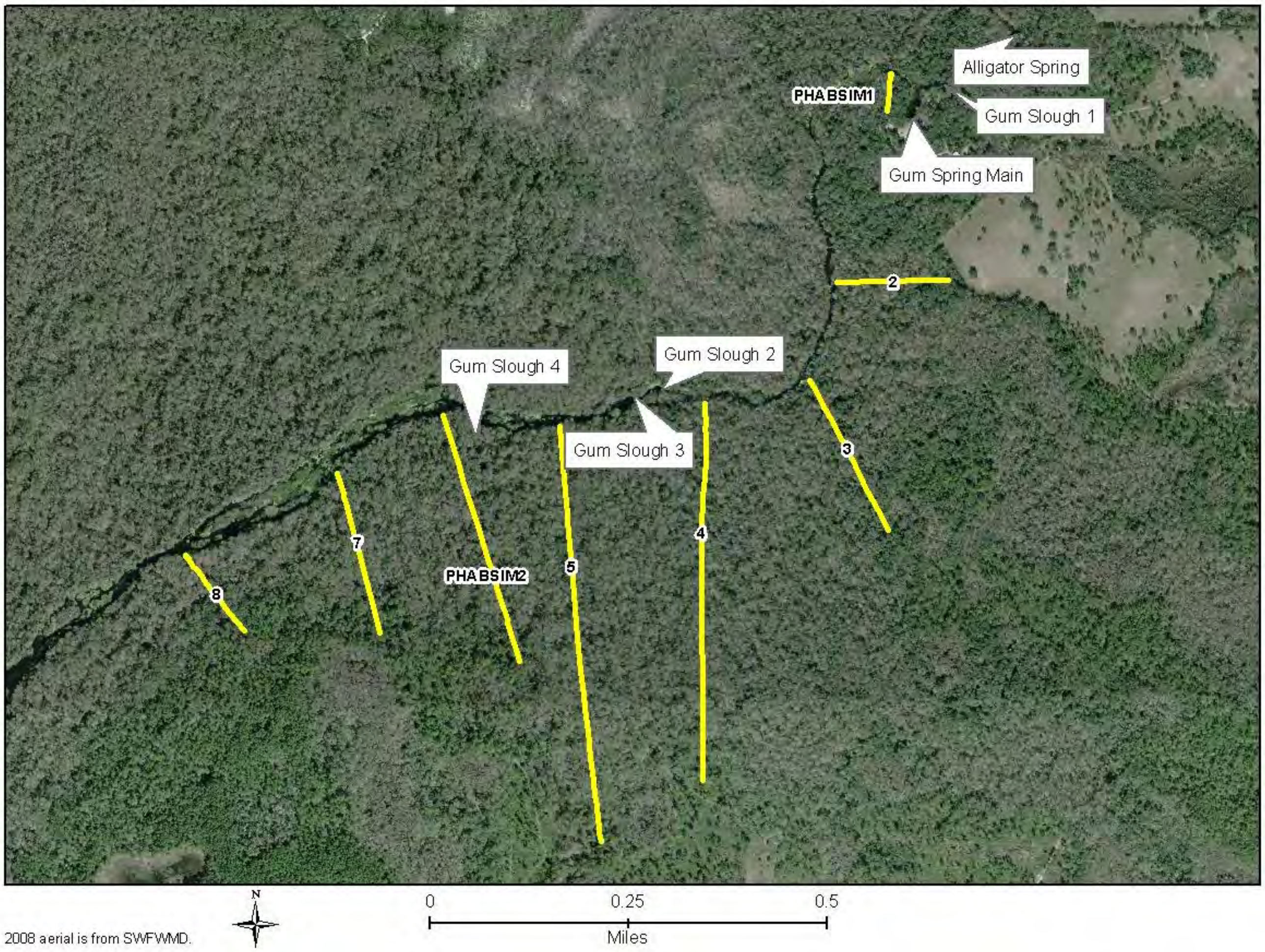
The springs are surrounded by the Marion Oaks subdivision and are not accessible to the public. Gum Springs Main is surrounded by private land and is used privately for swimming. Most of the study area is part of the Half Moon Wildlife Management Area (HMWMA). HMWMA is the largest single acquisition of the 11,500-acre Conservation and Recreation Lands (CARL) project (as yet incomplete). The primary objectives of the purchase are to preserve the water quality of the Withlacoochee River, Gum Slough, and their proximal tributaries; and collaterally to establish a wildlife management area (Florida Fish and Wildlife Conservation Commission (FFWCC) 2001).

The remainder of the study area, especially the northeast portion, is primarily improved pasture and agricultural land and Marion Oaks residential area is located just outside the northeast side of the Gum Slough basin. Only about 12 percent of the watershed is developed, primarily as residential housing (Trommer et al. 2009). The watershed includes ecosystems ranging from forested river floodplain, cypress domes, pine flatwoods, and sandhills in the Green Swamp, to extensive lake systems and marshes in the middle watershed, to salt marshes and an estuary at the mouth of the river. Agricultural land use is primarily improved pasture, and lime rock mining is the largest industrial land use in the watershed. Major towns include Brooksville, Bushnell, Dade City, Dunnellon, Inverness, and Ridge Manor. There are currently no urban developments in the Gum Slough basin or along the Withlacoochee River.

Figure 1-1
Gum Slough Drainage Basin

2008 aerial and drainage basin map are from SWFWMD.

Figure 1-2
Location of Gum Slough Springs and Study Transects



1.1 Physiography, Stratigraphy, and the Floridan Aquifer

Gum Slough and Gum Springs are in the Tsala Apopka Plain physiographic region, which is a lower and flatter part of the Western Valley in the Central or Mid-Peninsular Zone. The study area is located between the Brooksville Ridge to the west and the Sumter Upland to the east. Gum Slough drainage basin is in the Tsala Apopka Plain, the Western Valley, and the Sumter Upland. The Tsala Apopka Plain is a flat, poorly-drained region with elevations ranging from 35 to 75 feet NGVD (Armstrong et al 2003). The region includes a series of lakes and wetlands that are hydrologically connected to the Withlacoochee River. The lakes include Tsala Apopka Lake, Lake Panasoffkee, and Lake Holathlikaha. The Western Valley is a poorly drained erosion basin with many karst features (Armstrong et al 2003).

Surface sediments and near surface sediments in Sumter County consist of quartz sand, clay, peat, limestone, and dolomite and the stratigraphic units range from middle Eocene (40 to 45 billion years ago) to Holocene (10,000 years ago to present) in age. The Gum Slough study area is in the Eocene Series within the Tertiary System and consists of 3 layers, or formations. The deepest layer is the Oldsmar Limestone, which ranges in depth in Sumter County from approximately 1,000 to 1,500 feet below mean sea level (MSL) and has a thickness of 600 to 800 feet. This formation is composed primarily of dolomite and limestone with minor components of gypsum and anhydrite (Campbell 1989).

The Oldsmar Limestone layer is beneath the Avon Park Formation, which may consist of either limestone or dolomite. Generally the upper 30 to 70 feet of the formation consists of limestone that is underlain by either dolostone or dolomitic limestone. The depth of the Avon Park Formation ranges from approximately 15 feet above MSL to approximately 80 feet below MSL. Its thickness ranges from approximately 1,100 to 1,400 feet. This formation is overlain by the Ocala Group (Campbell 1989). The Ocala Group is divided into 3 formations: the Inglis, Williston, and Crystal River Formations. The study area is located in the Williston Formation. The limestone of this formation forms the bedrock of the Tsala Apopka Plain of the study area (Campbell 1989).

The Floridan aquifer in Sumter County is composed of rocks from the Avon Park and Ocala Group limestone formations. The Avon Park limestone yields moderate to large quantities of water. The Ocala limestone contains many solution cavities and is considered one of the most productive formations in the Floridan. The upper part of the aquifer is more productive than the lower part (Anderson and Laughlin 1982).

Elevations to the north, east, and south of Gum Slough range from 70 feet NGVD approximately a mile north of the study area in the Western Valley (in Marion County), to 115 feet 3 miles northeast (Marion County) and east (Sumter County) of the study area in the Sumter Uplands physiographic region, to 70 feet approximately 1.5 miles south of the study area in the Western Valley. The elevations in the study area decline from approximately 45 feet at the headsprings to less than 40 feet (but above 35 feet) downstream toward the Withlacoochee River.

1.2 Hydrogeology

Gum Springs is one of several springs contributing to base flow in the Withlacoochee River. Other springs include Dobes Hole Spring, Riverdale Spring, Nichols Spring, Wilson Head Spring, and Blue Spring. Gum Slough Springs' discharge into the Withlacoochee River averaged about 88 cfs, or about 18.5 percent of the average river flow at the USGS gage at Holder), just upstream of the influence of Lake Rousseau and approximately 5 miles downstream of the confluence of Gum Slough with the Withlacoochee River. Gum Slough enters the Withlacoochee River along its lower reaches, where flows in the Withlacoochee River are primarily from springs and groundwater seepage from the Upper Floridan aquifer. Groundwater discharges along most of the Withlacoochee River increase downstream at greater rates than can be explained by tributaries or springflow contributions. Groundwater originates from shallower (younger) rocks in the upper reaches of the river and from deeper (older) rocks in the lower reaches of the river.

Streamflow along the lower Withlacoochee River is influenced primarily by direct runoff and input from tributaries during wet periods, while during dry periods, groundwater from the underlying Upper Floridan aquifer contributes substantially to flows. Farther upstream, beyond the influence of springs discharges, confinement between surficial deposits and the Upper Floridan aquifer is greater in the Green Swamp area than in areas farther downstream in the watershed. The Withlacoochee River may receive groundwater inflow from the east and lose water to the underlying aquifer to the west in this area during dry conditions.

Water chemistry changes along the Withlacoochee River also reflect the change from surface to ground water influences. Ionic composition of the river is the same as groundwater (predominately calcium bicarbonate) along the lower river reaches, reflecting groundwater influence, especially during low flow conditions. Water in the Withlacoochee River is slightly acidic in the headwater area in the Green Swamp, indicative of surface-water contributions. Water chemistry is more variable during high flow conditions because of dilution by surface water runoff. The variability in constituent concentrations is greater in the upper reach of the river than in the middle and lower reaches because of the greater influence of surface runoff.

Trommer et al. (2009) also concluded that the slope of the relationship of cumulative daily mean streamflow (cfs) over time (for the 1970–2000 period) indicated a trend toward lower streamflow coincident with the wetter pre- and drier post-1970 rainfall cycles related to the Atlantic Multidecadal Oscillation (AMO). The slope for the 2000–2006 period is steeper than the slope for the 1970–2000 period, indicating a trend toward higher streamflow. Previous studies have examined rainfall and streamflow in Florida rivers in relation to the AMO, and also found them to be directly correlated.

1.3 Hydrology

Discharge volumes and water levels are measured along Gum Slough at the U.S. Geological Survey (USGS) gage 02312764 located approximately 2,400 feet downstream of Gum Slough 4 and about 180 feet downstream of Transect 8 (Figure 1-2 or 1-5). Discharge data (November 2003 through mid-August 2009) and gage height data (November 2003 through October 2009) are available. The USGS notes that "flow may be affected at times by backwater from the Withlacoochee River." Rainfall is measured at the USGS collection site 02313200 at the Withlacoochee River in Dunnellon, about 15 miles northwest of the Gum Slough gage. Rainfall data used in these analyses are for the period November 2003 through September 2009. The discharge, gage height, and rainfall data are from the U.S. Geological Survey (http://waterdata.usgs.gov/nwis).

The average daily discharge was 97 cfs with a low of 35 cfs in May 2009 and a high of 247 cfs in October 2004 (for the period November 2003 – August 2009). For the period November 2003 – October 2009 the average daily gage height (in feet) was 9.21 with a low of 8.27 in May 2009 and a high of 10.51 in October 2004. The average daily discharge and average gage height are graphed by month in Figure 1-3. The total monthly rainfall data for the same period are graphed in Figure 1-4.

In April 2002, Gum Spring was barely flowing and the slough was less than 1 foot deep. Similarly, most Florida springs were reportedly at historic low water levels in 2002. Gum Spring lost 1.3 cfs in May 2004, but gained 9.0 and 18 cfs in April 2005 and April 2006, respectively. Inflow from Gum Slough Springs averages about 88 cfs, or about 18.5 percent of the average river flow at the Holder station on the Withlacoochee River (Trommer et al. 2009). Greater than 40 percent of the total flow in the Withlacoochee upstream of the influence of Lake Rousseau was attributed to groundwater seepage. About 30 percent of the flows were attributed to tributary flow and spring flow accounted for a little less than 30 percent of total river flow.

The median of the monthly values for cumulative rainfall, average daily discharge, and average daily gage height, and the differences between the monthly values for discharge and gage height and the medians for the period of record (POR) are listed in Table 1-1. Total monthly rainfall in the region peaks in June and water discharge and gage height exceed median values in August during the latter part of the wet season.

Figure 1-3
Average Daily Discharge from the Gum Springs Group and Average Daily Gage Height on Gum Slough

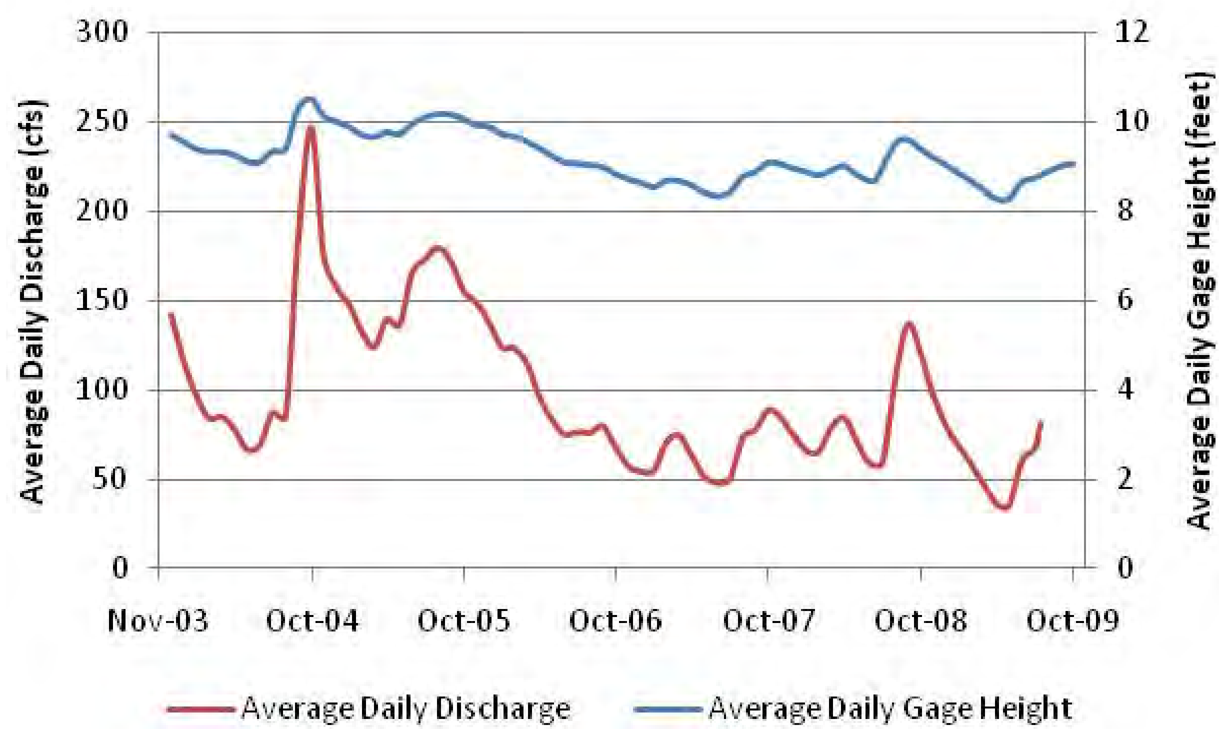


Figure 1-4
Total Monthly Rainfall at Dunnellon, Florida

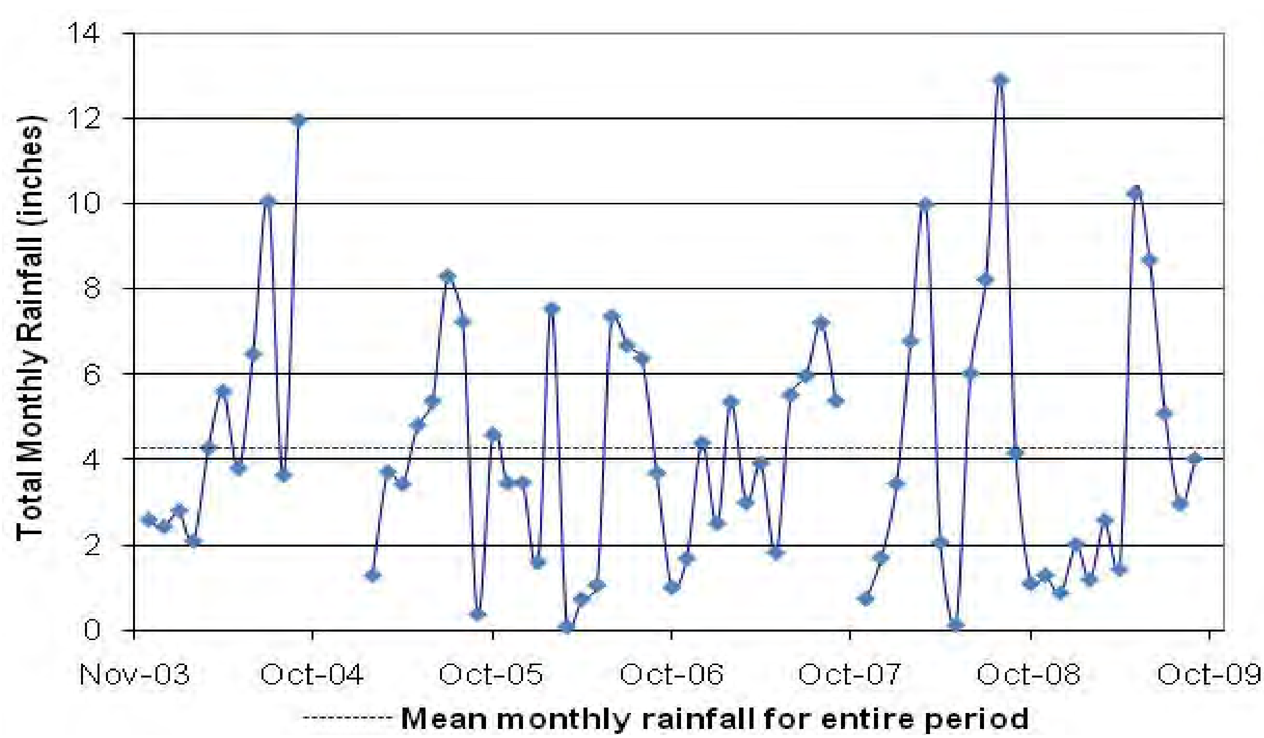


Table 1-1
Monthly Values for Median Cumulative Rainfall, Median Daily Discharge, and Median Gage Height*

Month	Median Cumulative Rainfall for Month (inches)	Median Average Daily Discharge for Month (cfs)	Discharge Above or Below Median of POR (cfs)*	Median Average Daily Gage Height for Month (feet)	Difference between Monthly Median Gage Height and Median for POR
January	2.49	82	0	9.14	0.05
February	3.70	77	-5	9.07	-0.02
March	3.34	82	0	9.12	0.03
April	2.73	81	-1	9.14	0.05
May	2.79	68	-14	8.96	-0.13
June	6.23	64	-18	8.88	-0.21
July	7.43	72	-10	8.91	-0.18
August	6.77	83	1	9.22	0.13
September	4.07	137	55	9.31	0.22
October	1.08	120	38	9.24	0.15
November	1.67	119	37	9.46	0.37
December	2.41	97	15	9.29	0.20

*November 30, 2003 through October 31, 2009

1.4 Soils

Soils along the study transects, as designated and described by National Resources Conservation Service maps (NRCS) (1988), are listed in Table 1-2 and mapped in Figure 1-5. More than 70 percent of the study area is characterized by hydric soils and sampling transects intercept upland soils only at their landward extents.

Soils in the Gum Slough study area are primarily frequently flooded, hydric Malabar fine sands (67.6 percent) and all 8 transects intercept Malabar fine sands along most of their length. This soil series is very deep, poorly to very poorly drained, and very permeable in the upper horizons. Malabar fine sands were formed on thick beds of sandy and loamy marine sediments. The water table is less than 10 inches below land surface for 2 to 6 months of the year, resulting in seasonally flooded conditions and these soils are typically associated with sloughs and shallow depressions. Native vegetation on Malabar sands typically consists of scattered slash pine (*Pinus elliottii*), cypress (*Taxodium* sp.), wax myrtle (*Myrica cerifera*), cabbage palm (*Sabal palmetto*), and maidencane (*Panicum hemitomon*).

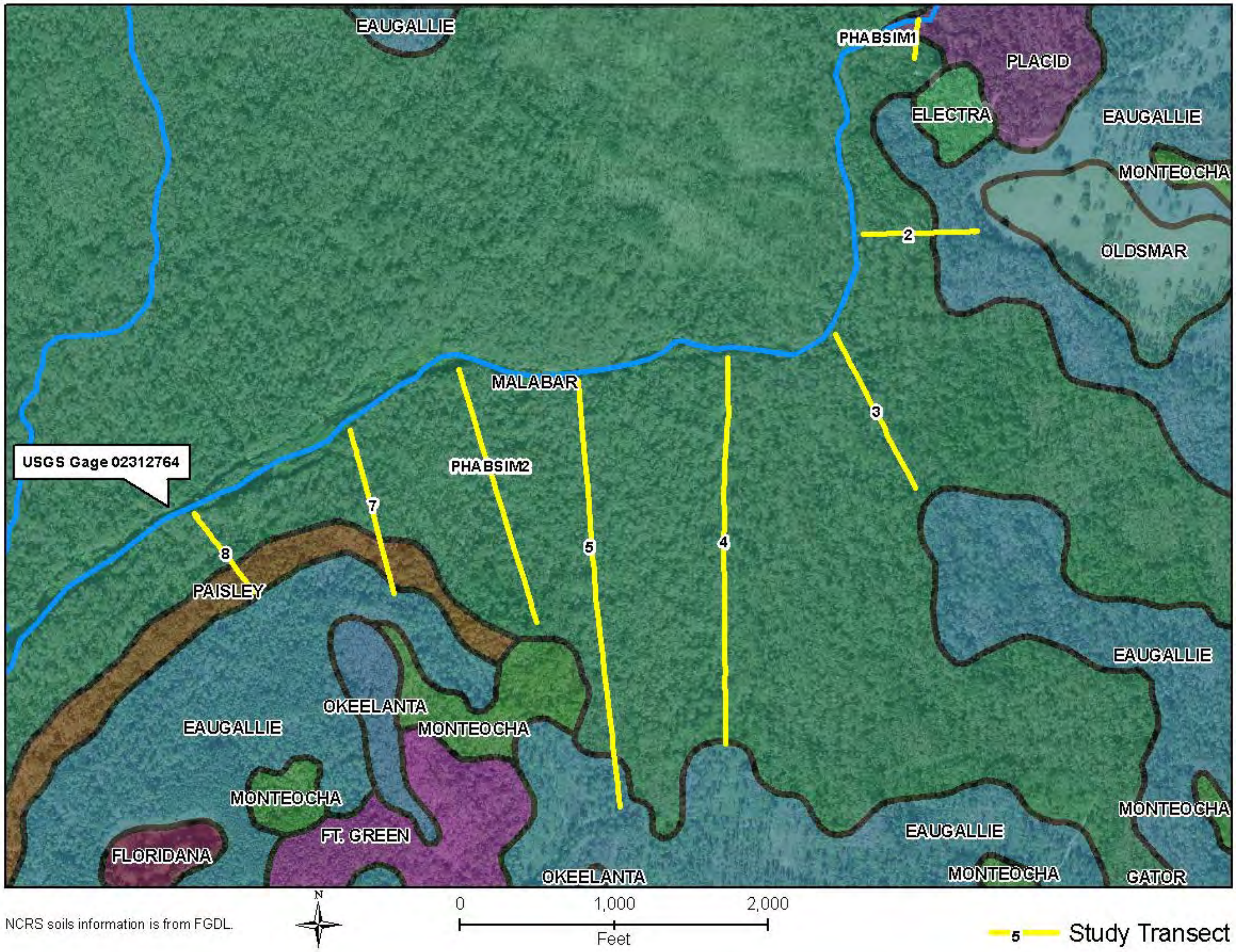
Okeelanta mucks and the Monteocha and Placid fine sands make up about 5 percent of the soils in the study area. Trees commonly found in these soils include cypress, tupelo (*Nyssa* sp.), red maple (*Acer rubrum*), and sweetbay magnolia (*Magnolia virginiana*). The water table is typically above land surface for 6 to 10 months and vegetation may range from freshwater marshes and ponds to forested swamps. Similarly, Placid fine sands are depressional wetlands characterized by a water table that is above land surface for 6 to 9 months. Transect PHABSIM1 intercepts hydric Placid fine sands. The landward portions of Transects 7 and 8 intercept nonhydric Paisley fine sands that are characterized by a water table less than 10 inches below land surface for 2 to 6 months during the year. The landward portions of Transects 2 and 5 are in nonhydric Eaugallie fine sands typically characterized by flatwoods. Paisley and

Eugallie both commonly support slash pine, loblolly pine (*Pinus taeda*), and live oak (*Quercus virginiana*).

Table 1-2
Percent Cover of Soil Series in Gum Slough Study Area

Soil Series	Acres	Percent of total	Drainage	Water Table	NRCS Soil Designation
Malabar fine sand, frequently flooded	642.2	67.6	Poorly	Within 10” for 2-6 months	Hydric
Eaugallie fine sand, bouldery subsurface	191.4	20.2	Poorly	Within 6-18” for 1-4 months	Nonhydric
Ft. Green fine sand, bouldery subsurface	24.4	2.6	Poorly	Within 6-18” for 1-4 months	Nonhydric
Monteocha fine sand, depressional	19.6	2.1	Very poorly	Within 10” for $\geq$6 months	Hydric
Paisley fine sand, bouldery subsurface	19.0	2.0	Poorly	Within 10” for 2-6 months	Nonhydric
Placid fine sand, depressional	17.7	1.9	Very poorly	Within 0-6” for > 2 months	Hydric
Oldsmar fine sand, bouldery subsurface	13.9	1.5	Poorly	Within 18” for 1-3 months	Nonhydric
Okeelanta muck	9.5	1.0	Very poorly	Within 10” for 6-12 months	Hydric
Three soil series, each < 1% of the study area	11.7	1.3			
Total	949.4	100.0			

Figure 1-5
Transect Locations and Soils Series in Gum Slough Study Area



1.5 Climate and Precipitation

Sumter County and the Gum Slough watershed have a humid subtropical climate. The average daily temperature is approximately 71°F (22°C). The warmest months are May through September with an average temperature of 79°F. The average temperature during October through April is 66°F (www.worldclimate.com).

Rainfall in Sumter County is a function of frontal, convective, and tropical cyclonic systems. Most of the rainfall is associated with summer convective storms. The average total rainfall for June through September is 29.2 inches with an average of 7.3 inches per month. For the drier months October through May the total rainfall averages 18.9 inches with an average of 2.4 inches per month. The average annual total is 52.1 inches (43 complete years between 1936 and 1995 www.worldclimate.com).

1.6 Vegetation

Wetland vegetation along Gum Slough is generally characterized by seasonally and semipermanently flooded hardwood hammocks that include tree species such as water oak (*Quercus nigra*), red maple *(Acer rubrum*), ironwood (*Carpinus caroliniana*), sweetgum (*Liquidambar styraciflua*), and tupelo (*Nyssa sylvatica* var. *biflora*). Cypress and bay swamps are a smaller component of the forested wetlands and typically occur along the edges of the slough primarily along the mid-reaches of the slough. Farther landward, uplands are characterized by upland species such as loblolly, slash pine and saw palmettos.

2.0 Sampling Methods

An underlying assumption of vegetation classification is that vegetation is the best and most easily measured integrator of environmental and historic site conditions. Sampling methods for this study were designed to provide data needed to characterize the wetlands and associated vegetation and soils along Gum Slough. The methods used in transect selection, data collection, and data analyses are described in the following sections.

2.1 Transect Selection

Eight sampling transects were established along Gum Slough study corridor, perpendicular to the river channel, as requested by the District. The first step in assigning transect locations was a thorough review of potential criteria on which to base the selections. The data used to examine potential criteria for selecting transects are listed below.

- Vegetation communities based on National Wetlands Inventory (NWI) vegetation classification.
- U.S. Department of Agriculture/NCRS soils classifications and Hydric Soils Groups.
- USGS elevation/topography.
- USGS water level gage locations.
- Aerial photography.
- Land use, e.g. historical alterations and/or development.

NWI classifications were compared with available aerial photography, soils maps, and field observations. NWI classes were consistent with aerial photography in the study area, and priority communities were identified in which sampling efforts would be focused. NWI data were subsequently used for mapping and selecting transects. Numbers of acres and corresponding percent of NWI classes in the Gum Slough study area are listed in Table 2-1 and described in Table 2-2. A diagram of the distinguishing features of the NWI palustrine vegetation classes is presented in Figure 2-1.

The study transects and associated NWI vegetation classes are mapped in Figure 2-2. Transects were numbered in order from upstream to downstream. Two transects, PHABSIM1 and PHABSIM2 were transects for the District's instream studies. For this study, the 2 instream transects and 6 additional transects were monitored.

An analysis of the NWI vegetation classes was used as the basis on which to allocate 6 of the 8 transects among vegetation communities along the Gum Slough (the District selected the instream transects). NWI classes were quantified based on the distance each class occupied along a transect. The percent of each NWI vegetation class present along the 8 sampling transects is listed in Table 2-3. Potential transects were assigned in areas characterized by native vegetation. The vegetation classes identified for this study were named based on woody species dominance and generally corresponded with NWI vegetation classes.

NWI mapping indicated mixed deciduous (P_FO6) along all transects and the more specific class broad-leaved deciduous on two of the three transects farthest downstream. NWI classified both of these palustrine forested systems as seasonally flooded. No needle-leaved (e.g. cypress) forested classes were identified using the NWI data, although cypress can be a component of the mixed deciduous P_FO6 class.

Table 2-1
Percent Cover of NWI Classes in the Gum Slough Study Area

NWI Classification	Description	Acres	Percent of Total	
			Including Upland	Excluding Upland
U	Upland	197.5	20.8	0.0
PFO6C	Palustrine Forested Deciduous Seasonally Flooded	515.3	54.3	68.5
PFO1C	Palustrine Forested Broad-leaved Deciduous Seasonally Flooded	77.3	8.1	10.3
PFO6F	Palustrine Forested Deciduous Semipermanently Flooded	67.0	7.1	8.9
PFO2F	Palustrine Forested Needle-leaved Deciduous Semipermanently Flooded	48.7	5.1	6.5
R2UBH	Riverine Lower Perennial Unconsolidated Bottom Permanently Flooded	15.9	1.7	2.1
R2AB4H	Riverine Lower Perennial Aquatic Bed Floating Vascular Permanently Flooded	10.3	1.1	1.4
4 additional classes	Palustrine classes each making up < one percent of the area	17.5	1.8	2.3
Total		949.5	100.0	100.0

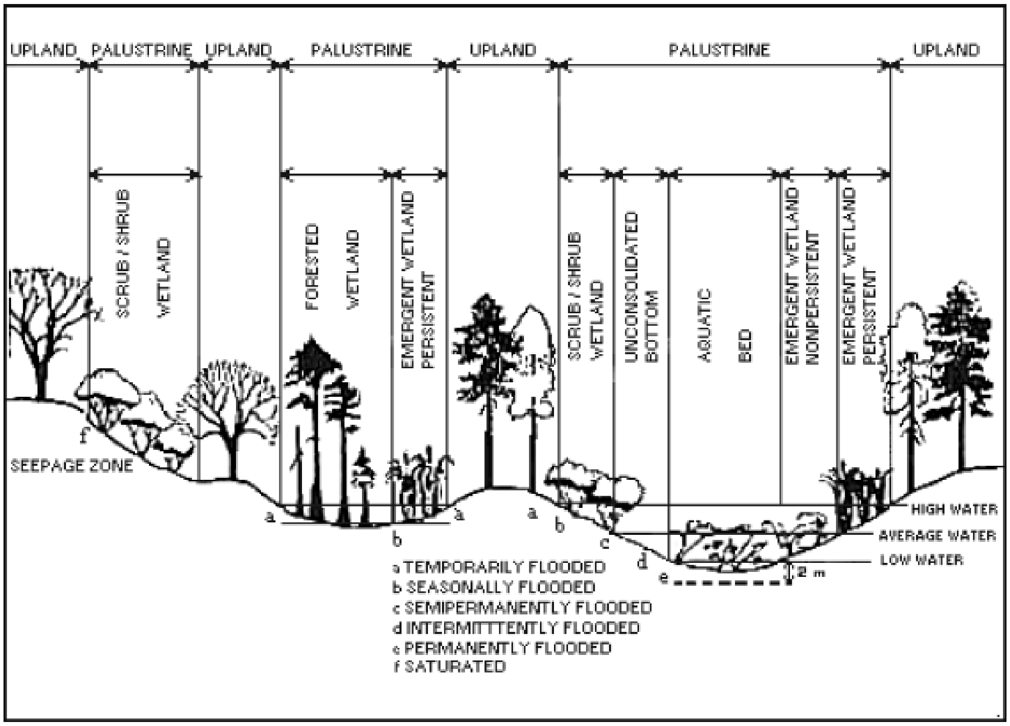
Table 2-2
Descriptions of NWI Classifications in the Gum Slough Study Area*

NWI Class	Description	
P_ **Palustrine**	Nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and same wetlands in tidal areas with ocean-derived salinity < 0.5 ‰. Includes wetlands lacking such vegetation, but with (1) area < 20 acres; (2) no active wave-formed or bedrock shoreline features; (3) deepest water depth < 2 m at low water; and (4) salinity less than 0.5 ‰.	
P_FO **Palustrine** **Forested**	Woody vegetation 20 feet tall or taller. Species include both broad and needle -leaved deciduous and evergreen categories.	
	_1 **Broad-leaved** **Deciduous**	Typical trees include red maple, American elm, and black gum.
	_2 **Needle-leaved** **Deciduous**	Typical species in Florida is the bald cypress.
	_4 **Needle-leaved** **Evergreen**	Typical species include cedars and pond pine.
	_6 **Deciduous**	May include a mix of broad-leaved and needle-leaved deciduous trees such as oaks, popash, and maples, cypress.
	_7 **Evergreen**	May include a mix of broad-leaved or needle-leaved evergreen trees. Broad-leaved evergreens include red, loblolly, and sweet bays.
P_EM **Palustrine** **Emergent**	Usually dominated by perennial plants that are present for most of the growing season in most years. Characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens.	
	_1 **Persistent**	Dominated by species that normally remain standing at least until the beginning of the next growing season. Includes: grasses, bulrushes, sedges, cattails, and smartweeds.
P_AB **Palustrine** **Aquatic Bed**	Dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years.	
	_3 **Rooted Vascular**	Rooted vascular aquatic plants occur at all depths within the photic zone. Includes pondweeds, wild celery, and some plants with floating leaves such as water lilies.
R_2 **Riverine** **Lower** **Perennial**	A Riverine system contains all wetlands and deepwater habitats contained within a channel except wetlands dominated by trees, shrubs, persistent emergents and habitats with water containing ocean-derived salts in excess of 0.5 ppt. In a Lower Perennial subsystem the gradient is low and velocity is slow. There is no tidal influence and some water flows throughout the year.	
	_UB **Unconsolidated** **Bottom**	Includes deepwater habitats with at least 25% cover of particles smaller than stones; less than 30% vegetation cover.
	_AB4 **Aquatic Bed** **Floating Vascular**	Dominated by plants that float freely in the water or on its surface. Includes duckweed, water lettuce, and water ferns.
Hydrologic Modifiers for Classes and Subclasses		
A	Temporarily Flooded	
C	Seasonally Flooded	
F	Semipermanently Flooded	
H	Permanently Flooded	

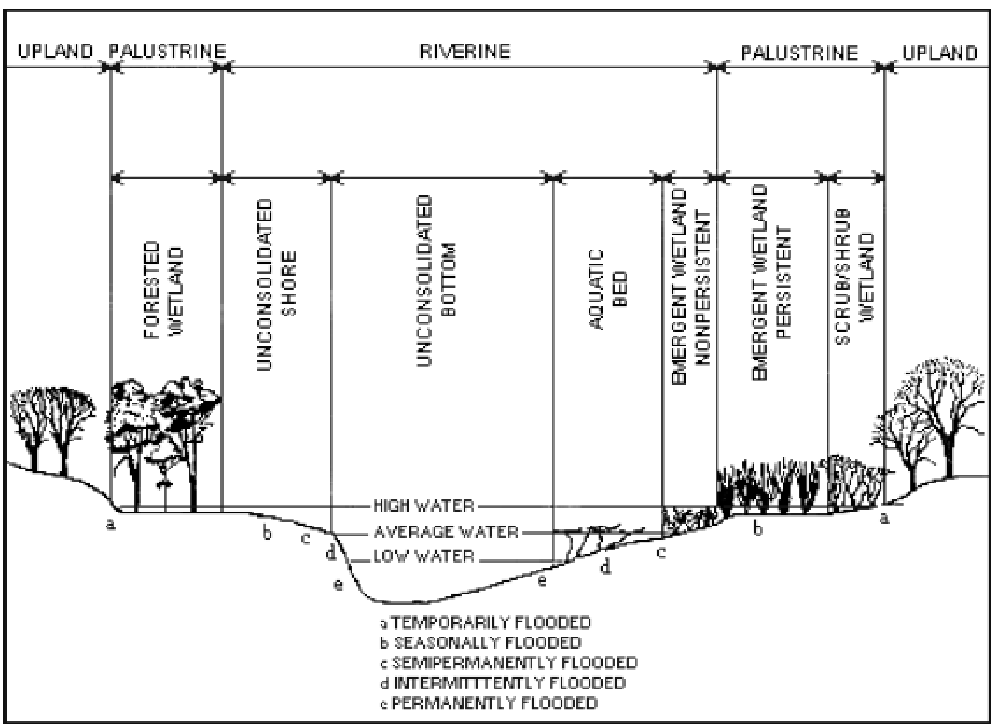
*After Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/ resource/ 1998/ classwet/classwet.htm (Version 04DEC98).

Figure 2-1
Features and Examples of Habitats in the Palustrine and Riverine Systems*

Palustrine



Riverine



*After Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/ resource/ 1998/ classwet/classwet.htm (Version 04DEC98).

Figure 2-2
Transect Locations and NWI Classifications in the Gum Slough Study Area

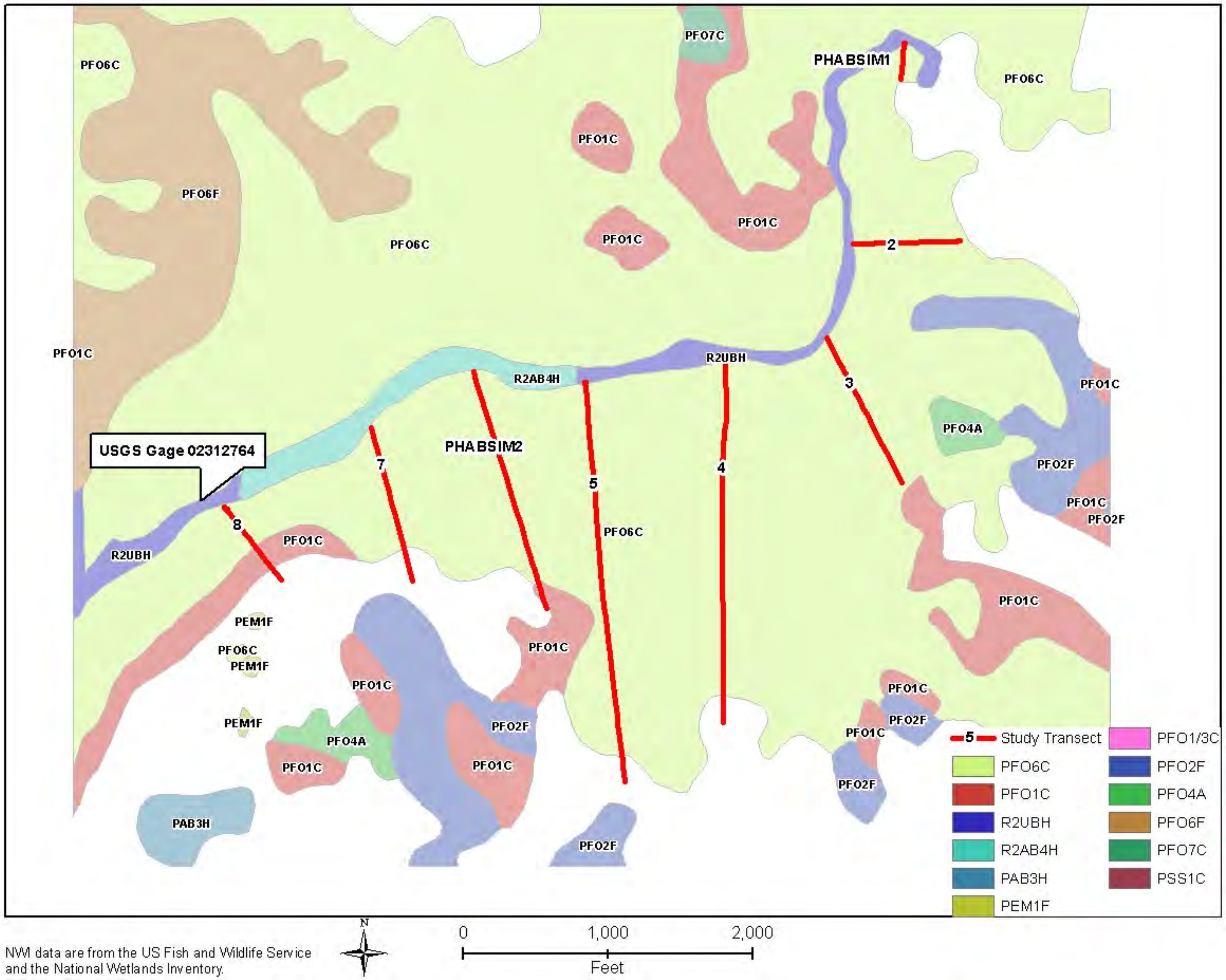


Table 2-3
Percent Cover of NWI Classification* along each Transect

Transect	P_FO1C	P_FO6C	Upland	Total
PHABSIM1		100		100
2		100		100
3		100		100
4		93	7	100
5		94	6	100
PHABSIM2	10	88	2	100
7		79	21	100
8	30	55	15	100

*Excludes Riverine classes. Shading indicates absence of a class.

2.2 Elevation Surveys and Distance to Channel

The landward extent of the sampling transects coincided with the uplands identified by NWI, as well as the extent of hydric soils identified by NRCS. Transects were subsequently assigned to include the area within the NWI wetlands on the south and east sides of the slough channel. Elevations were surveyed at the edge of water, at the transect sampling points, at changes in vegetation community, and where changes in elevation were conspicuous. Distances from the edge of the channel were recorded as reference points for pairing elevation data with vegetation and soils data. Beginning and ending points for each change in plant community were recorded to evaluate the potential influence of distance from channel on vegetation communities. Transects were limited to the south side of Gum Slough due to property access. Elevation data were plotted against distances along transects.

Hydrologic indicators of buttressing, lichen lines, moss lines, and stain lines on trees were also recorded if observed along transects. If a hydrological indicator was located, its elevation was surveyed and included in the elevation data.

2.3 Vegetation Characterization

Vegetation transects were located based on NWI wetlands mapping data (previously mapped in Figure 2-2). Vegetation along the 8 transects was identified primarily as indeterminate deciduous tree species indicating a mix of broad-leaved and needle-leaved deciduous species (maple, popash, oak, pines, cypress). Two of the downstream transects (PHABSIM2 and Transect 8) were identified as intersecting small amounts of broad-leaved deciduous trees (maple, elm (*Ulmus* sp.), tupelo. Both of these NWI classifications were described as seasonally flooded.

The study area was composed predominantly of seasonally flooded forested wetlands (62 percent) classified as deciduous (mixed and broad-leaved) by NWI (Table 2-1). Twelve percent of the study area was classified as semipermanently flooded mixed deciduous and needle-leaved deciduous trees. Approximately 3 percent of the corridor was classified as riverine, and approximately 21 percent of the study area was classified as upland. Four palustrine wetland vegetation classes made up the remaining 2 percent of the study area. These NWI vegetation classes individually made up no more than 1 percent (each) of the study area and totaled about 18 acres. Palustrine wetland classes included needle-leaved evergreen, temporarily flooded; aquatic bed, rooted vascular; mixed evergreen, seasonally flooded; and persistent emergent vegetation, semipermanently flooded. None of these classes were designated by NWI along sampling transects.

While these NWI classes were adequate for identifying general vegetation classes for sampling purposes, they were considered too broad for the level of community characterizations in this study. Boundaries between communities were identified in the field using a combination of indicators, including, but not limited to the following:

- General community type (e.g. wetland to upland)
- Species cover (e.g. cypress to oak, obligate wetlands to facultative wetlands)
- Elevation (e.g. scarp presence)
- Soils (e.g. hydric or nonhydric)

Vegetation classes were further differentiated as part of this study using data from transects and subsequently identifying and quantifying species along individual transects. A general method of vegetation class nomenclature was developed based on species importance. Vegetation classes were named based on dominant tree species apparent during sampling and species dominance, or importance, was used to further refine classes using importance values (IVs) of tree species, an index that combines relative density (100), relative frequency (100), and relative basal area (100) of tree species and has a total value of 300.

Sampling plots were located randomly in each vegetation class along transects and the point-centered-quarter (PCQ) sampling method (Mueller-Dombois and Ellenberg 1974) was used to measure density, basal area, frequency, and IVs of the vegetation. A minimum of three plots was sampled from each vegetation class. Density, basal area, and frequency were calculated for each tree species, by transect and vegetation class, and subsequently used to calculate IV. Density, basal area, and relative dominance values were calculated for each tree species, by transect and vegetation class:

- Density/ acre = 43,560 feet/(average measured distance, in feet)^2
- Basal area = basal area of individual trees (in^2)
- Dominance = (relative density) (basal area, in^2)
- Frequency = number of plots in which individual species occurred
- IV = relative density + relative frequency + relative basal area

2.4. Soils Characterization

The U.S. Army Corps of Engineers (USACE) *Wetlands Delineation Manual* defines a hydric soil as one that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part. Under saturated or flooded conditions that are anaerobic for part of the growing season, soil profiles usually acquire unique characteristics that can be relied upon as positive indicators of hydric conditions. Most organic soils (histosols) are hydric, and the extent of decomposition of organic plant materials can be used to classify these soils as muck (highly decomposed remains of plants and other organisms), peaty muck, mucky peat, and peat (partially decomposed remains of plants and other organisms).

Soils along Gum Slough are generally alfisols and ultisols and were predominantly sandy with varying degrees of permeability (described earlier in Section 2.0). The hydrologic soils group (HSG) classifications for the soils along Gum Slough indicate poorly drained soils with a relatively high water table and high runoff due to saturated or inundated conditions. Soils are mineral, rather than organic, and consist primarily of sand, silt, and/or clay sized particles of minerals or rock fragments rather than being dominated by organic materials. Wetland conditions associated with mineral soils typically have:

- Histic epipedon (organic surface horizon).
- Hydrogen sulfide odor and other sulfidic material.
- Aquic conditions (oxygen-deficient soil saturation).
- Soil series on hydric soil lists.
- Redoximorphic features such as gleyed soil matrix color, low chroma matrix color with or without bright mottling and segregated iron and manganese concretions.

Evidence in soil profiles can also indicate flooding in soils that may not be hydric. Importantly, hydric soils are used in characterizing wetlands, not river channels in which organics are washed downstream. For example, flooded river banks that have a high sand content and occur at elevations high enough that flooding is infrequent generally have nonhydric soils, but show signs of flooding such as thin strata of gravel, sand, silt, or clay deposited by flood waters. Other evidence of flooding includes cypress buttressing, moss collars, lichen lines, and water stains.

Soil cores were extracted with a soil probe and were examined for each sampling point along each transect. The presence of hydric or flooding indicators, as well as saturation and/or inundation conditions were evaluated and recorded. The soil profile was examined to a minimum depth of 12 inches. Soils were evaluated and recorded: a numeric code of “0” was recorded if a characteristic was absent, and a “1” was recorded if the characteristic was present. Soils data were subsequently paired with vegetation and elevation data for analysis.

Once soils data were compiled, hydric indicators were assigned a composite soil index for each core sampled. As noted previously, some soils have evidence of flooding, e.g. sandy and steep river banks, although the soils may not show indications of hydric conditions. Consequently, soils with no evidence of wetland indicators (uplands) were given a soils index of zero. In contrast, saturated hydric soils received a maximum value of three. Soils indices were assigned as described below.

0 = soil showed no evidence of flooding or hydric conditions
1 = soil was hydric with muck
2 = soil was hydric and saturated
3 = soil was hydric and saturated and inundated

2.5 Data Analysis

Elevation, soils, and vegetation data were compared among and between vegetation classes identified in the river corridor. Statistical analyses were performed using SAS statistical software (Cary, NC 1998). Hydrologic flow analyses were performed by the District and used to characterize inundation conditions based on median elevations of vegetation classes and were not part of the present study.

2.5.1 Elevations and Wetted Perimeter

Ground elevation data (feet NAVD) were used to compare vegetation, soils, and distance from channel among transects. Normalized (relative) elevations were calculated as the difference between the transect elevations and the river bottom to account for variation due to downstream-upstream elevation gradients.

Wetted perimeter was calculated for vegetation classes in the study corridor to evaluate the potential change in inundated habitat that may be anticipated due to changes in river stage. The wetted perimeter for a vegetation class is the linear distance inundated along a transect below a particular elevation or water level (river stage). Consequently, as distance from the river channel increases, the total wetted perimeter also increases, but can vary among vegetation classes. Wetted perimeter changes, relative to changes in elevation, were compared using the Kruskal Wallis test, a nonparametric analog to a one-way analysis of variance (ANOVA).

2.5.2 Vegetation and Soils

Relationships between vegetation classes and corresponding environmental parameters were examined for this study to ascertain whether there were differences in:

- Species composition and dominance between or among vegetation classes
- Elevation, soils, and distance from channel between or among vegetation classes

Plant species IVs were calculated for woody species in vegetation classes along sampling transects. Due to small sample size (N = 8 transects, N = 7 vegetation classes) and non-normal data distributions, nonparametric statistics were applied to comparisons of species dominance between vegetation classes. The Kruskal Wallis test was used to measure the difference (or lack of difference) in species dominance among vegetation classes. The Wilcoxon Signed Rank test (a nonparametric analog to the paired-t test) was used to evaluate differences in species importance (or "dominance") between individual communities. For example, differences in species dominance between willow marsh and hardwood swamp vegetation classes.

The sample size for comparisons of elevation and soils among vegetation classes was relatively large and a parametric discriminant function analysis (DFA) was used to quantify the contribution of elevation, soils, and distance from river channel in defining vegetation classes, based on relationships between environmental variables and species composition and dominance along sampling transects. A "successful" DFA is one that results in correct pairing of vegetation types and environmental parameters into vegetation classes. P-values indicate the significance of a relationship, e.g. the ability to predict a vegetation class using elevation, while r^2 values indicate the amount of variation in vegetation classes accounted for by each variable.

3.0 Results and Discussion

Vegetation communities along the Gum Slough study corridor were differentiated based on species densities, frequencies, and basal areas, as measured by IVs. The relationships among vegetation classes and environmental variables in the study corridor were subsequently evaluated using discriminant function analysis (DFA). Elevations, soils, and distance to channel were significant in characterizing environmental conditions of vegetation classes along the slough. While differences between the 7 vegetation communities were significant based on species IV, relationships were not as distinct when environmental parameters were used to distinguish between the same communities. Overlap was more frequent between wetland classes than between wetland classes and the upland class due to greater similarity in elevation, soils, and/or distance to river channel among wetland classes. Assigning broader vegetation classes (greater variation in species IVs) resulted in more pronounced differences in vegetation classes based on physical factors. These relationships are described in the following sections.

Photographs were taken along the study transects and are included in Appendix A.

3.1 Elevations

There was an overall increase in elevations along the channel of Gum Slough from downstream to upstream. Increases ranged from as much as 3.5 feet (from downstream-most transect to Transect 4) to as little as 1 foot (from downstream-most transect to PHABSIM1, the most upstream transect). Median transect elevations transects consistently increased from Transect 8, the downstream-most transect (40.6 feet NAVD) to PHABSIM1, the upstream-most transect (43.3 feet NAVD).

Elevation increases along transects were greater than increases along the channel. The floodplain, or extent of wetlands, was broadest along Transects 4 (2,494 feet) and 5 (2,762 feet) in the mid-reaches of Gum Slough and elevation changes were greatest along these same transects (Figures 3-2 through 3-9). Transects 3, PHABSIM2, and 7 ranged from 1,091 to 1,709 feet in length, and Transects PHABSIM1 and 2 (most upstream reaches) and 8 (most downstream) ranged from 246 to 739 feet in length. The wettest vegetation communities (bay and cypress swamps) occurred at only Transects 4, 5, and 7.

Elevation changes along transects were evaluated using relative elevations (elevations above, or normalized to, the channel bottom) and ranged from channel bottom (0 feet) to 3.0 feet at Transect 4 to a change of 7.1 feet at PHABSIM1. Elevations and distances along the 8 transects are listed in Table 3-1 and graphed in Figure 3-1. The elevation profile, associated vegetation communities, and locations of hydric soils along the transects are graphed in Figures 3-2 through 3-9.

Table 3-1
Elevation and Distance along the Gum Slough Transects

Transect		Transect Distance (feet)*	Transect Maximum Elevation (NAVD)*	Channel Elevation (NAVD)	Maximum Elevation Change	Median Elevation (NAVD)*	Median Relative Elevation	N*
Downstream ⇩	**PHABSIM1**	246	44.5	36.2	8.3	43.3	7.1	6
	2	739	44.8	38.6	6.2	43.1	4.5	13
	3	1,173	43.8	38.6	5.2	42.3	3.8	23
	4	2,494	47.8	38.7	9.1	41.9	3.0	35
	5	2,762	45.2	35.8	9.4	41.7	6.0	27
	PHABSIM2	1,709	44.9	38.1	6.8	41.5	3.4	20
	7	1,091	45.6	37.6	8.0	41.5	4.0	12
	8	636	46.4	35.2	11.2	40.6	5.6	15

*excludes the channel

Figure 3-1
Channel Bottom, Maximum, and Median Elevations along Gum Slough Transects

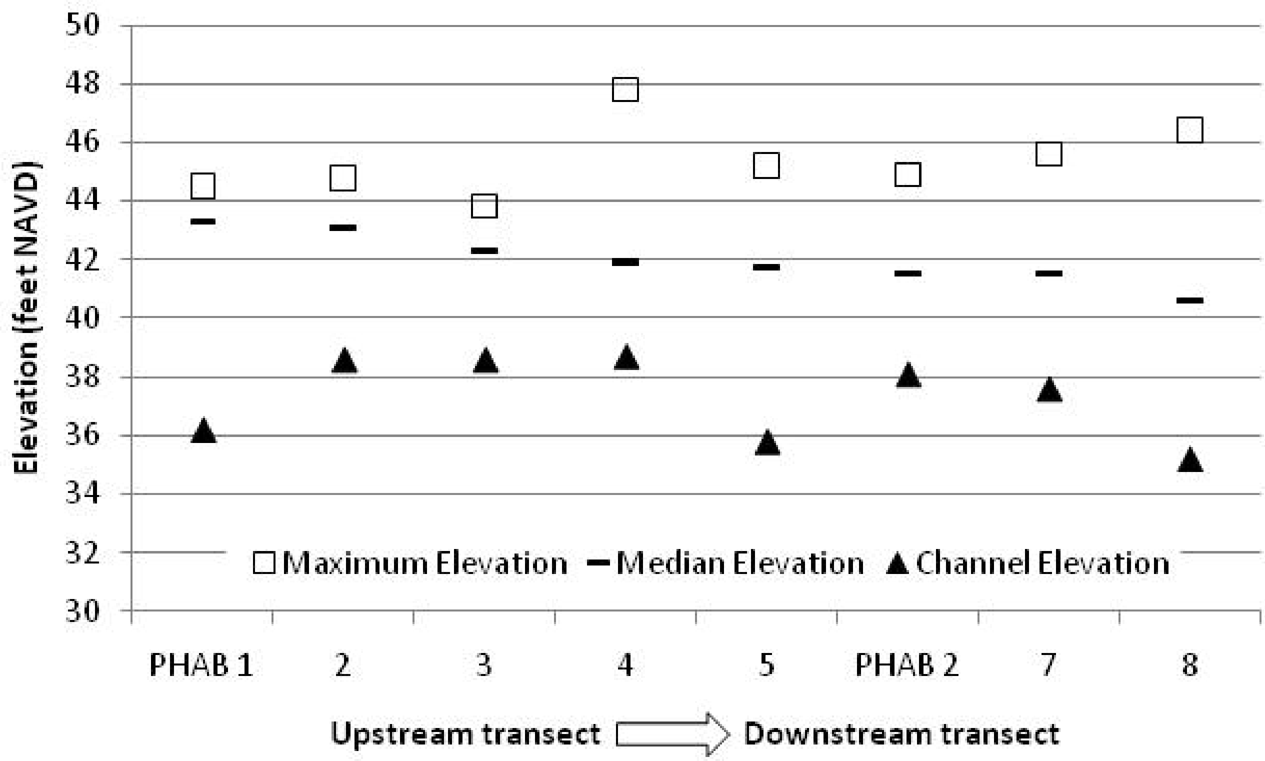


Figure 3-2
Elevation, Vegetation, and Hydric Soil Profile along Transect PHABSIM1

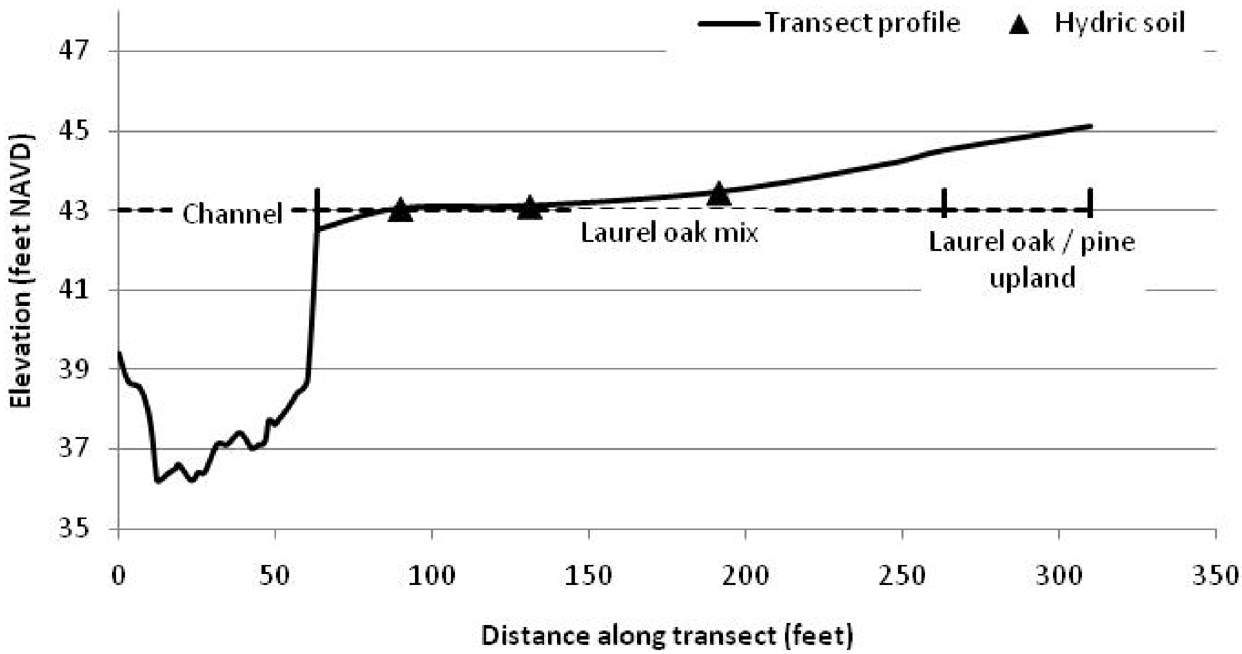


Figure 3-3
Elevation, Vegetation, and Hydric Soil Profile along Transect 2

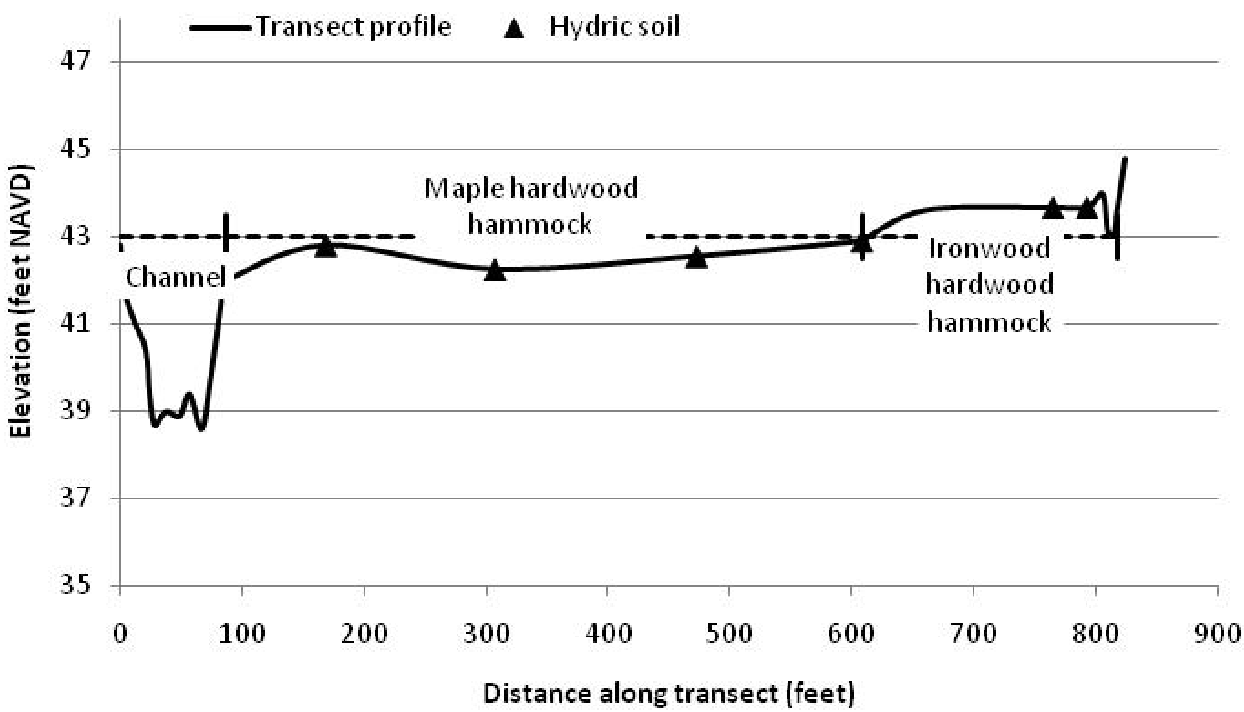


Figure 3-4
Elevation, Vegetation, and Hydric Soil Profile along Transect 3

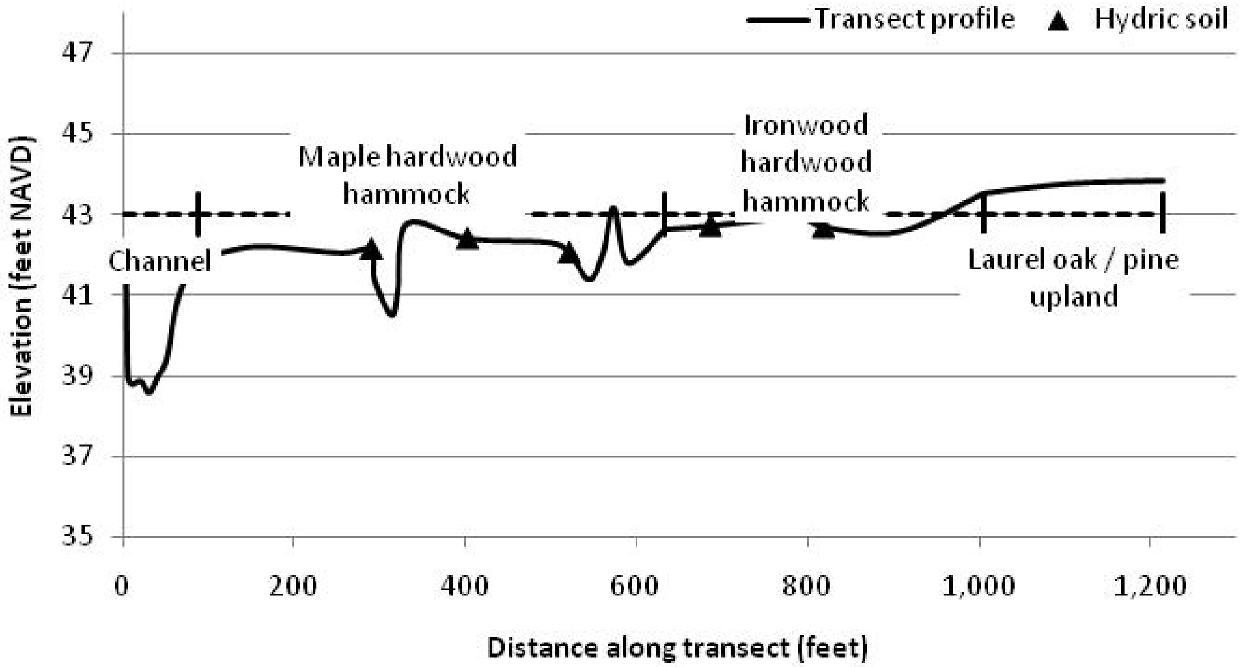


Figure 3-5
Elevation, Vegetation, and Hydric Soil Profile along Transect 4

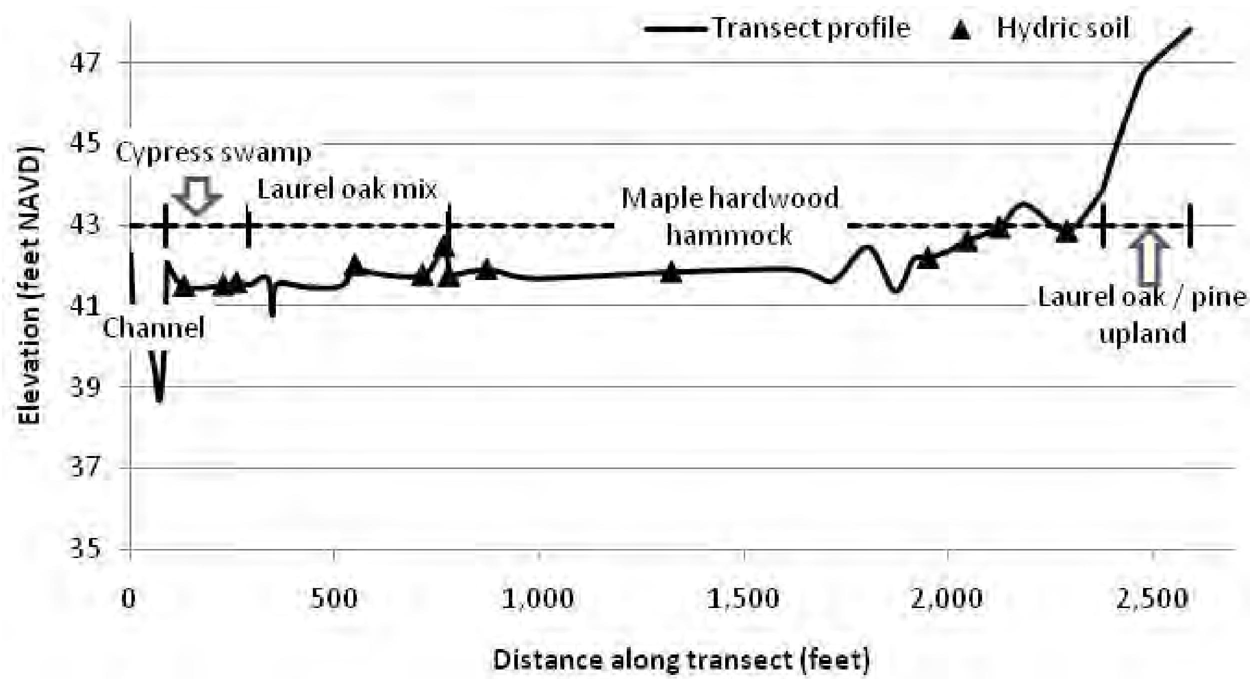


Figure 3-6
Elevation, Vegetation, and Hydric Soil Profile along Transect 5

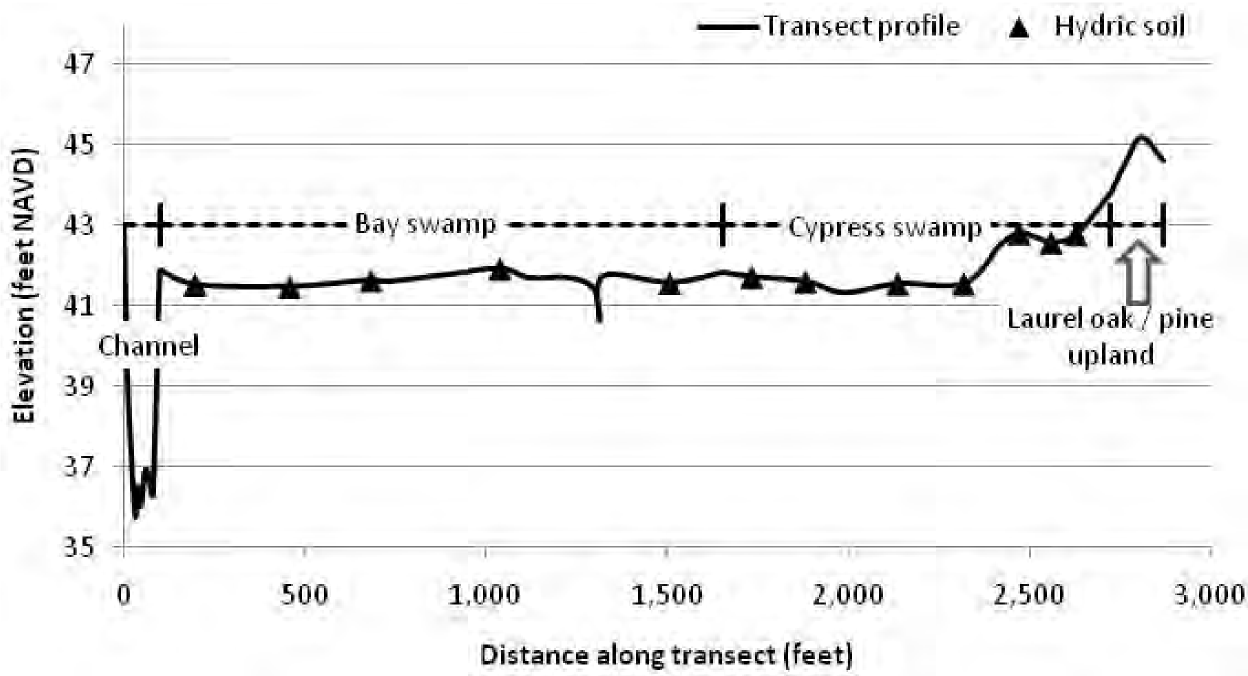


Figure 3-7
Elevation, Vegetation, and Hydric Soil Profile along Transect PHABSIM2

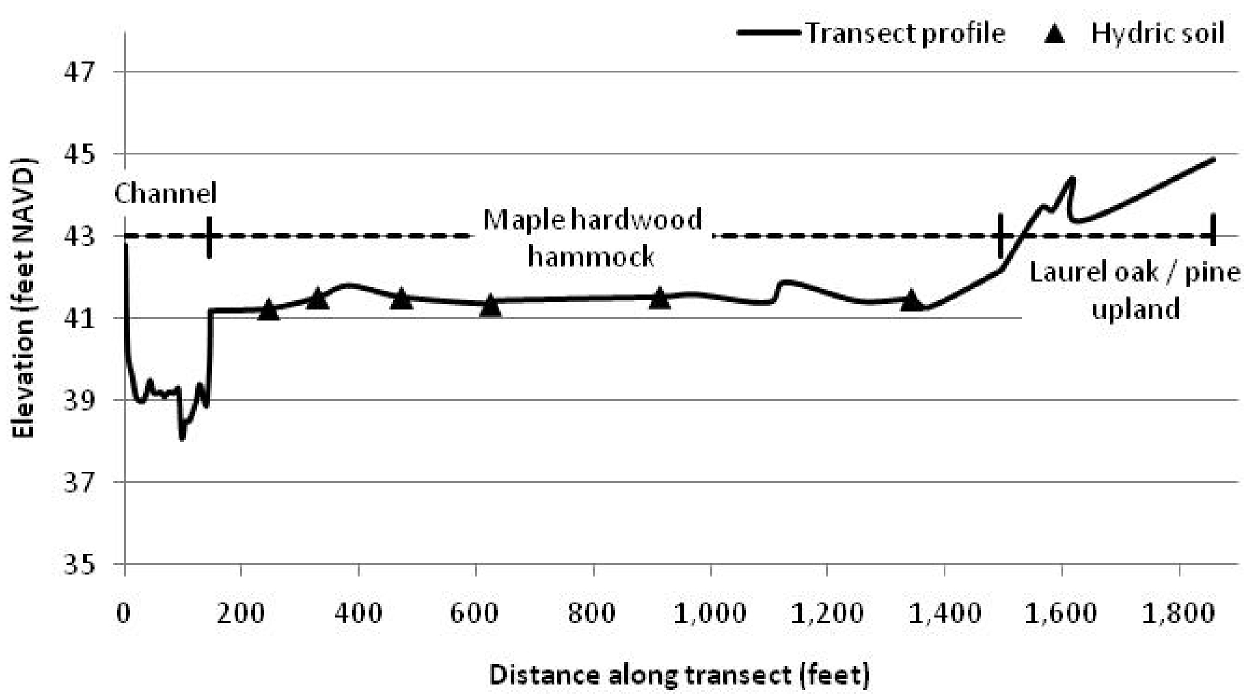


Figure 3-8
Elevation, Vegetation, and Hydric Soil Profile along Transect 7

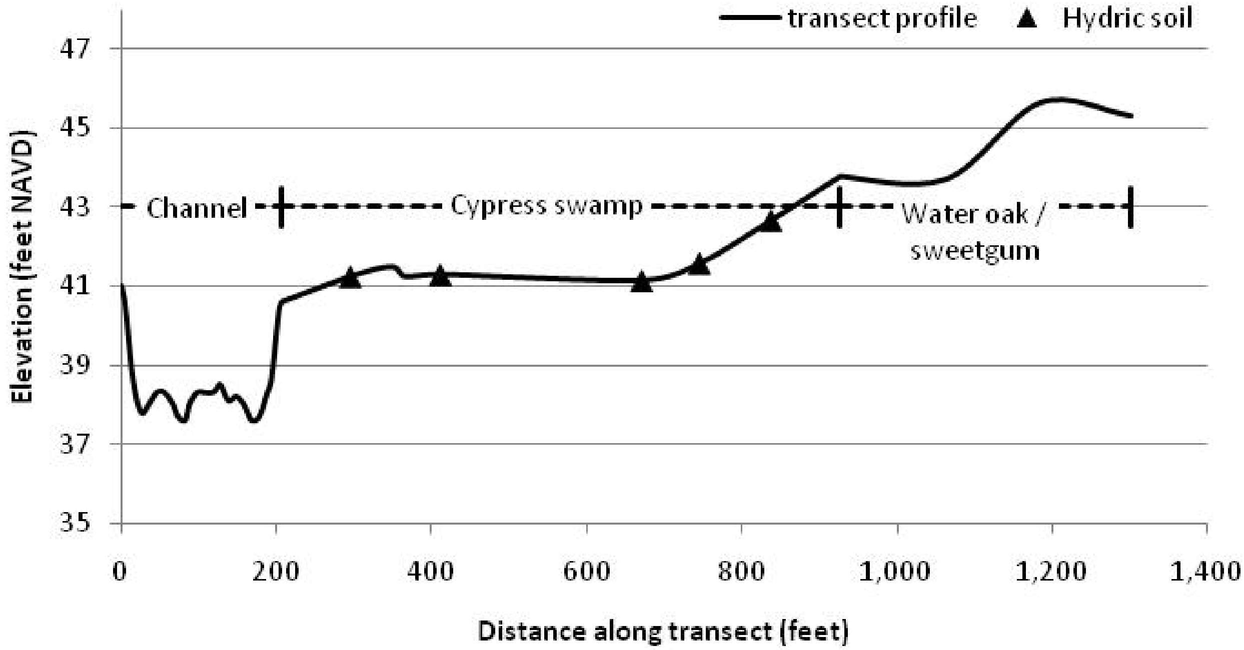
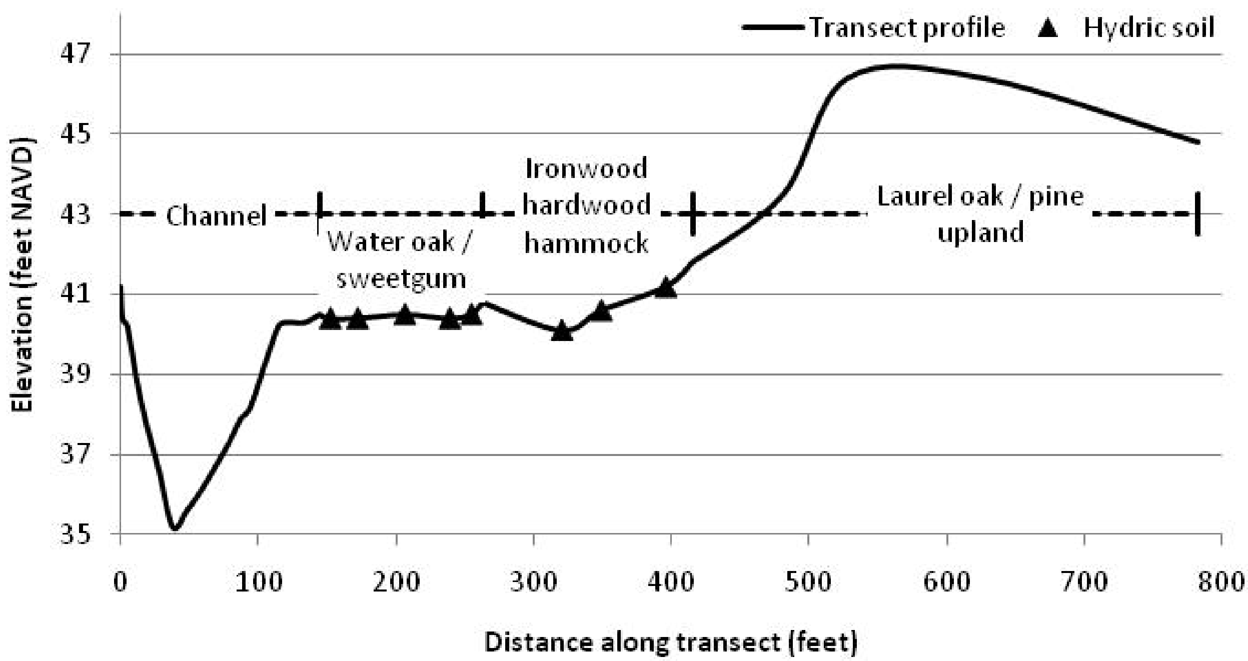


Figure 3-9
Elevation, Vegetation, and Hydric Soil Profile along Transect 8



3.2 Soils

Alfisols and ultisols form the central ridge where the Gum Slough study corridor is located, although spodosols, or flatwoods soils are the dominant soil order throughout Florida. Alfisols and ultisols are gently sloping and well drained sandy soils with loamy subsoils layered over phosphatic limestone (Fernald 1981). Natural systems associated with these soils are generally mixed hardwood forests (Myers and Ewel 1990). Sand, limestone, and clay (NRCS 1988) components dominate these soils rather than organic materials. In spite of the relative absence of peat soils in alfisols and ultisols, there are adequate organic peat deposits to support horticultural peat mining in the Holocene deposits east of Oxfort and southwest of Tarrytown in Sumter County (NRCS 1988).

FAC Chapter 62-340.550 (*Delineation of the Landward Extent of Wetlands and Surface Waters*) indicates that inundation for at least 7 consecutive days or saturation for at least 20 consecutive days annually constitutes long term hydrologic conditions necessary for the maintenance of hydric soils. Thus, the inundation period necessary for hydric soil conditions is shorter than the two to three weeks required to exclude upland vegetation.

Hydric soils were found along all 8 study transects (Table 3-2 and Figure 3-10) and all hydric soils were also characterized by the presence of muck. Soils were examined for other hydric indicators such as organic bodies, oxidized rhizospheres, and stripped matrix, but no other indicators were noted. Elevations of hydric soils ranged from 40.5 to 43.1 feet NAVD and consistently increased from downstream Transect 8 to upstream Transect PHABSIM1.

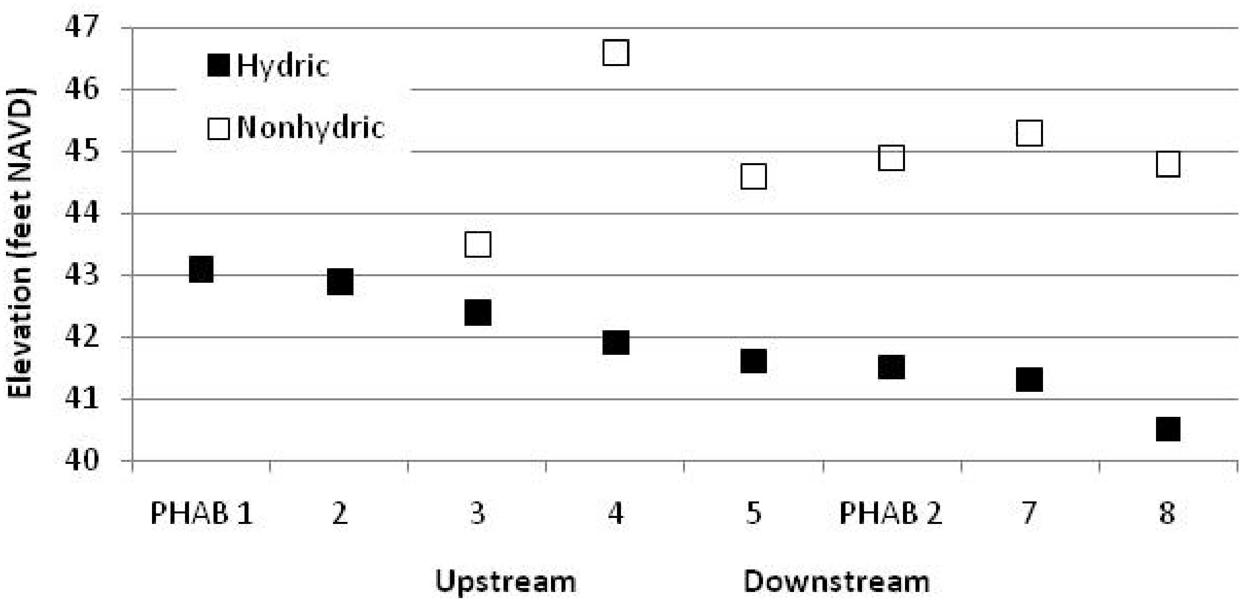
Median elevations of nonhydric soils were consistently greater than hydric soils and ranged from 43.5 feet NAVD at Transect 3 to 46.6 feet NAVD at Transect 4. Differences in median elevations between hydric and nonhydric soils ranged from nearly 5 feet at Transect 4 to just over 1 foot higher at Transect 3. With the exception of Transect 4, differences between hydric and nonhydric soils elevations increased downstream. Median elevations of hydric soils were lower when compared with nonhydric soils (Wilcoxon Signed Rank test, $p < 0.01$).

Table 3-2
Median Elevations (feet NAVD) of Hydric and Nonhydric Soils along Gum Slough Study Transects

Transect		Hydric* (N)	Nonhydric (N)
Upstream ⇩ Downstream	PHABSIM1	43.1 (3)	
	2	42.9 (6)	
	3	42.4 (5)	43.5 (1)
	4	41.9 (13)	46.6 (3)
	5	41.6 (12)	44.6 (3)
	PHABSIM2	41.5 (6)	44.9 (3)
	7	41.3 (5)	45.3 (3)
	8	40.5 (8)	44.8 (3)

*All hydric soils included presence of muck.

Figure 3-10
Median Elevations of Hydric and Nonhydric Soils along Gum Slough Transects



3.3 Vegetation Relationships

Differences in vegetation classes in the Gum Slough study area were significant based on importance values (IVs) that were calculated using tree species density, basal area, and frequency, and provide a relative measure of species dominance (no units). DFA results indicated that differences in vegetation classes that are conspicuous based on species characteristics may be based on physical environmental parameters.

3.4 Vegetation Classes

Nomenclature. Vegetation classes identified for this study were consistent with, although more specific than, the NWI vegetation classes initially used to map vegetation along transects. The NWI classification system does not specifically address cabbage palm, while authors such as Myers and Ewel (1990) recognize its importance in Florida systems.

The species-specific designations used in this study were retained so that they could be easily combined into a more general context or class. While the NWI classes were too general for defining species-specific community classes, the NWI flooding component may be useful in addressing MFLs. Forested wetlands along the river are generally consistent with seasonally or flooded conditions. The cypress and bay swamps that are semipermanently flooded were mapped by NWI in the study area, although these particular areas were not intercepted by study transects.

Wetland status. The wetland status of the tree species encountered during sampling is important to discussions comparing the vegetation classes. The FDEP wetland status designations of OBL, FACW, FAC, and not listed, are defined below. A few species found during sampling were not listed by FDEP, so the status according to the National Wetlands Inventory (NWI) was used.

- OBL – Obligate Wetland – species occurs almost always in wetlands
- FACW – Facultative Wetland – usually occur in wetlands
- FAC – Facultative – equally likely to occur in wetlands or non-wetlands
- Not listed – not provided an indicator status by FDEP

Class Comparisons. Differences between vegetation classes along the Gum Slough study transects were significant (Wilcoxon Signed Rank test, $p < 0.01$) based on IVs and provided a relative measure of species dominance (no units) (Tables 3-2 and 3-3). For example, species IVs were consistently different between the cypress swamp and the bay swamp, as well as between these two classes and any of the 5 remaining vegetation classes. IVs of individual species for each of these vegetation classes are summarized in Table 3-4 and graphed in Figure 3-11. It should be noted that only species sampled along transects are included.

Six vegetation classes were characterized as wetland classes, including bay swamp and cypress swamps and 4 “hammocks.” A single upland class was identified. The wetland classes included obligate and facultative wetland tree species, including bald cypress (*Taxodium distichum*), dahoon holly (*Ilex cassine*), swamp bay (*Persea palustris*), sweet bay magnolia (*Magnolia virginiana*) tupelo (*Nyssa sylvatica*), red maple (*Acer rubrum)*, and ironwood (*Carpinus caroliniana*). The six wetland classes could be differentiated based on dominance of cypress, sweetgum (*Liquidambar styraciflua*), swamp bay, ironwood, laurel oak (*Quercus laurifolia*), and water oak (*Q. nigra*). IVs subtotaled by obligate, facultative, and other wetland status for each vegetation class are listed in Table 3-3.

The vegetation classes were named according to the conspicuous canopy species observed along the transects during sampling (species IVs were calculated after sampling). In the bay swamp and maple hardwood hammock classes the highest IV values were not swamp bay or red maple, but sweetgum and swamp bay, respectively. This is likely due to the random nature of PCQ sampling and different dispersion patterns of different species.

Swamps. The swamp vegetation classes were characterized by a large component of obligate and facultative wetland species, for which IVs totaled 294 out of total 300 possible. Swamp species differ from other species in their extreme flood tolerance. For example, cypress trees can tolerate up to 3 meters of water for periods of time and can typically tolerate 1 meter of inundation for more than 10 years, while 30 days of inundation will kill seeds (Harms et al. 1980; Souther and Shaffer 2000; Mattson and Krummrich 1995; DuBarry 1963; Loucks and Keen 1973). Cypress, tupelo, and ash are the most tolerant of inundation and can tolerate up to a meter of inundation for up to 10 years.

- Cypress swamp. Twelve species total. IVs for obligate wetland species totaled 127.5 (out of the total possible 300) and included cypress, swamp bay, and tupelo. Dominant species (IV> 50) included cypress (IV = 65.2), followed by sweetgum (IV=49.2) and laurel oak (IV=41.5). Minor (10< IV < 50) components: swamp bay, red maple (*Acer rubrum*), tupelo, and American elm (*Ulmus americana*). Very small (IV< 10) components: pignut hickory (*Carya glabra*), buttonbush (*Cephalanthus occidentalis*), popash (*Fraxinus caroliniana*), and ironwood.

- Bay Swamp. Six species total. IVs for obligate wetland species totaled 100.8. Dominant species: sweetgum (IV=69.4), swamp bay (IV=57.9), red maple (IV=54.7), and American elm (IV=51.3). Minor components: dahoon holly and laurel oak. No species with IV<10.

Hammocks. These vegetation classes, like the swamp classes, were characterized by large obligate and facultative wetland species components, including cypress. However, many of these species, while tolerant of temporary flooding, may be less tolerant of prolonged flooding. Obligate and facultative wetland species totaled more than 275 of a total 300 possible.

- Maple hardwood hammock (14 species). Dominant components: swamp bay (IV=63.8). Minor components: dahoon holly (IV=40.8), American elm (IV=36.5), laurel oak (IV=33.7), red maple (IV=27.7), tupelo (IV=23.2), popash (IV=15.0), and sweet bay magnolia (IV=10.9). Small components: buttonbush, cypress, hackberry (*Celtis laevigata*), sweetgum, and water oak.

- Ironwood hardwood hammock (10 species). Dominant component: ironwood (IV=70.4), laurel oak (IV=45.1), sweetgum (IV=35.3), swamp bay (IV=31.3), cypress (IV=30.1), American elm (IV=37.3), tupelo (IV=19.2), and dahoon holly (IV=10.5). Small component: red maple.

- Laurel oak hammock (8 species) was dominated by laurel oak (IV=100.8) and swamp bay (IV=56.7). Minor components included cypress (IV=29.0), red maple (IV=26.3), American elm (IV=37.3), dahoon holly (IV=26.0), popash (IV=12.7), and hackberry (IV=11.2). No minor components.

- Water oak / sweetgum hammock (9 species). Dominant components: water oak (IV=149.2). Smaller components: buttonbush (IV=20.3), swamp bay (IV=19.7), red bay (*Persea borbonia*, IV=13.4), ironwood (IV=22.4), loblolly pine (*Pinus taeda*, IV=13.0), and pignut hickory (IV=10.1). No minor components. Obligate wetland species IVs totaled only 40.

Laurel oak / pine upland. The single upland class included 12 species. Dominants: loblolly pine (IV=87.5) and laurel oak (IV=68.7). Lesser components: hackberry, sweetgum, water oak, wax myrtle. Minor components: sweet bay, southern magnolia (*Magnolia grandiflora*), cabbage palm (*Sabal palmetto*), pignut hickory, and live oak. IVs for obligate (zero) and facultative wetland species totaled 174.1.

Species Importance. Species IVs comparisons (Table 3-4) indicated a shift in importance from cypress, maple, swamp bay, and ironwood in wetlands to laurel oak and loblolly pine in transition vegetation classes. Laurel oak, which occurred in all six vegetation classes, had the largest overall IV (349) when compared with all other species. Hackberry followed with the second highest IV (221), primarily a result of the presence of only one other species (southern magnolia) in the vegetation class. No other species had an IV greater than 200, i.e., no other vegetation class had a single species making up such a large component.

Obligate wetland species IVs ranged from 265.1 (swamp bay) to 120.3 (holly) and the remaining obligate wetland species had IVs less than 100. In comparison, laurel oak (facultative wetland species) had the greatest overall IV (313.7) and occurred in all vegetation classes except the water oak / sweetgum class: No other species had a total IV>300. Water oak had the largest IV in a single vegetation class (IV=149), indicating it was the single largest component in any class. Swamp bay (obligate wetland species) occurred in all 6 wetland classes and had an IV=265.1, followed by sweetgum and American elm, both with IVs > 200. Remaining IVs ranged from 7.9 (live oak) to 184.0 (water oak). Overall trends in species dominance and diversity are summarized below.

- Four species, swamp bay, sweetgum, laurel oak, and American elm, made up 49 percent of the total IVs (by species) among all classes and each of the individual species had IVs greater than 200.

- Another five species, cypress, dahoon holly, ironwood, red maple, and loblolly pine, totaled 39 percent of the species IVs, each with an IV greater than 100.

- The remaining 12 percent of the IVs was accounted for by the 12 remaining species, nearly evenly split among obligate and facultative wetland species and non-wetland species.

Table 3-3
Importance Values for Tree Species in Vegetation Classes along the Gum Slough Transects

Wetland Status[2]	Species	Vegetation Class[1]							
		Cypress Swamp	Bay Swamp	Maple Hardwood Hammock	Laurel Oak Mix Hammock	Ironwood Hardwood Hammock	Water Oak/ Sweetgum Hammock	Laurel Oak/ Pine Upland	Total IV
OBL	*Cephalanthus occidentalis*	3.9	0	3.3	0	0	20.3	0	27.6
OBL	*Fraxinus caroliniana*	4.4	0	15.0	12.7	0	0	0	32.1
OBL	*Ilex cassine*	0	43.0	40.8	26.0	10.5	0	0	120.3
OBL	*Magnolia virginiana*	0	0	10.9	0	0	0	0	10.9
OBL	*Nyssa sylvatica* var. *biflora*	18.2	0	23.2	0	19.2	0	0	60.7
OBL	*Persea palustris*	35.8	57.9	63.8	56.7	31.3	19.7	0	265.1
OBL	*Taxodium distichum*	65.2	0	5.7	29.0	30.1	0	0	130.1
FACW[3]	*Persea borbonia*	0	0	0	0	0	13.4	0	13.4
FACW	*Acer rubrum*	25.8	54.7	27.7	26.3	7.6	0	0	142.0
FACW	*Carpinus caroliniana*	7.9	0	19.5	0	70.4	22.4	23.2	143.6
FACW	*Celtis laevigata*	0	0	6.0	11.2	0	0	0	17.2
FACW	*Gordonia lasianthus*	4.0	0	0	0	0	0	5.7	9.7
FACW	*Liquidambar styraciflua*	49.2	69.4	7.3	0	35.3	39.4	42.3	242.9
FACW	*Quercus laurifolia*	41.5	23.8	33.7	100.8	45.1	0	68.7	313.7
FACW	*Quercus nigra*	0	0	6.3	0	0	149.2	28.5	184.0
FACW	*Ulmus americana*	38.5	51.3	36.5	37.3	29.6	12.4	5.7	211.2
FAC[3]	*Magnolia grandiflora*	0	0	0	0	0	0	7.0	7.0
FAC[3]	*Pinus taeda*	0	0	0	0	0	13.0	87.5	100.6
FAC	*Myrica cerifera*	0	0	0	0	0	0	11.0	11.0
FAC	*Sabal palmetto*	0	0	0	0	20.8	0	7.0	27.8
FAC[3]	*Carya glabra*	5.7	0	0	0	0	10.1	5.5	21.3
FACU[3]	*Quercus virginiana*	0	0	0	0	0	0	7.9	7.9

[1] Vegetation class columns total 300. [2] Wetland status according to FDEP unless noted otherwise. [3] Wetland status according to NWI.

Figure 3-11
Importance Values for Tree Species in Vegetation Classes along the Gum Slough Transects

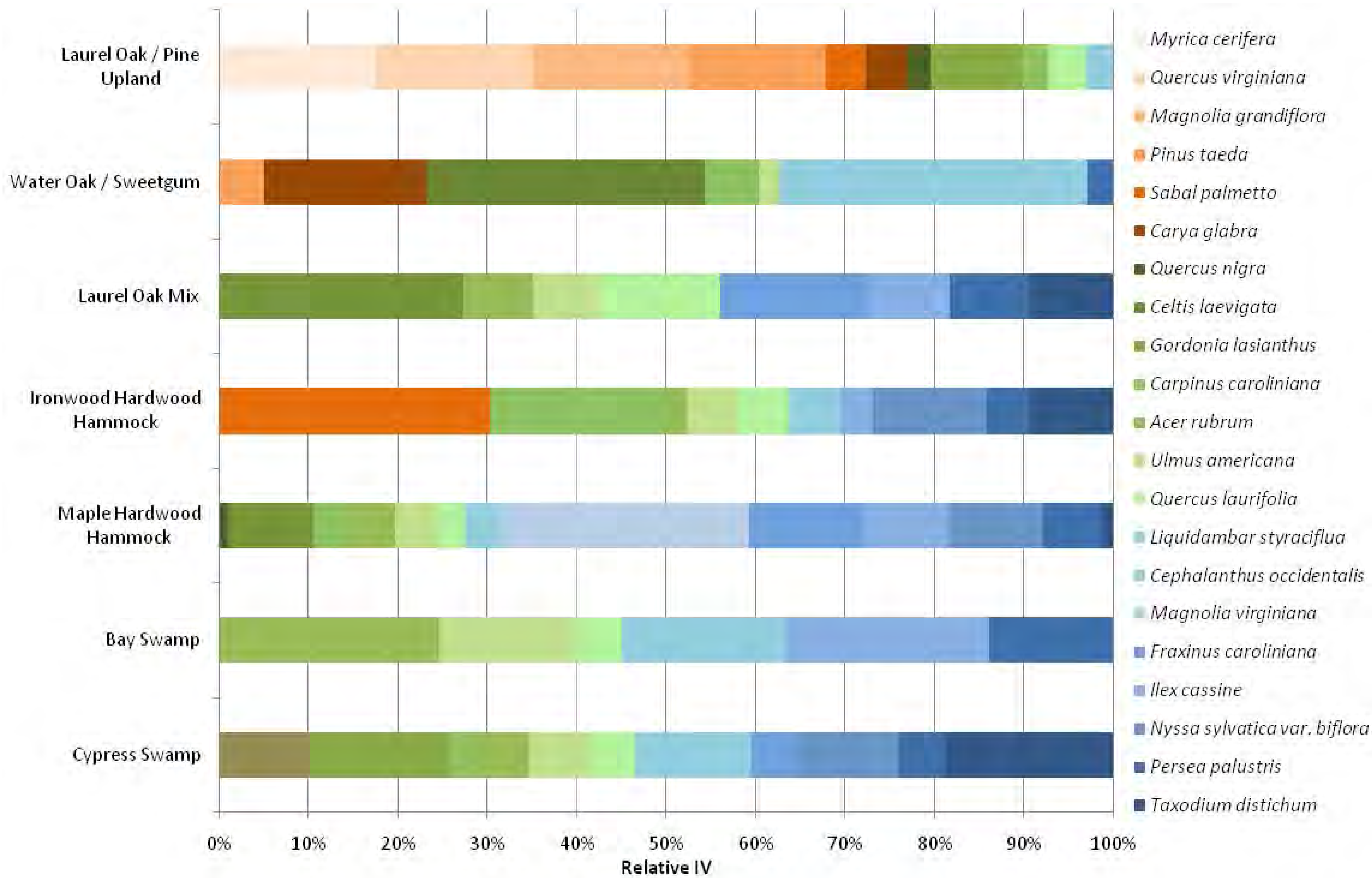


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Table 3-4
Importance Values for Tree Species in Vegetation Classes by Wetland Status

Wetland Status	Vegetation Class						
	Cypress Swamp	Bay Swamp	Maple Hardwood Hammock	Laurel Oak Mix Hammock	Ironwood Hardwood Hammock	Water Oak / Sweetgum Hammock	Laurel Oak / Pine Upland
OBL	127.5	100.8	162.9	124.4	91.1	40.0	0.0
FACW	166.8	199.2	137.1	175.6	188.0	236.8	174.1
OBL + FACW	294.3	300.0	300.0	300.0	279.2	276.9	174.1
Other (FAC or unlisted)	5.7	0.0	0.0	0.0	20.8	23.1	125.9

These vegetation classes were used in further analyses and, for organizational purposes, are presented in general order from those nearest the channel (cypress swamp and bay swamp) to those farthest from the channel (laurel oak/pine mix).

Density and Basal Area. Species IVs for each vegetation class totaled 300, as described earlier, and provide a means of comparison among species. However, total basal area and density were also calculated for each vegetation class (Table 3-5) and species (Table 3-6) to provide a means of comparison between vegetation classes and among species.

Comparisons of tree basal areas and densities can indicate whether a population is more mature (smaller numbers of larger trees) or in transition in response to a disturbance or change of some sort (increased numbers of smaller trees). A developed tree canopy will shade out new seedlings and inhibit invasion by other species or individuals, which may have an opportunity only when a gap is created by the loss of an older tree and an opening in the canopy. A disturbance that produces a gap in the canopy provides the light necessary for the expansion of new species and individuals. Reduced or loss of stream flows due to rainfall patterns or local ground water withdrawals can also alter vegetation growth and distribution patterns.

Basal area and densities varied among vegetation classes in the Gum Slough study area. Overall, highest densities by species occurred for species with smallest basal areas and vice versa – there were generally many smaller trees or fewer larger trees. For example, laurel oak had the largest total basal area (33,742 in^2) when compared with all other species and was about double that of the second largest basal area, exhibited by loblolly pine (16,873 in^2). However, the density of laurel oak averaged 219 trees/acre, about half that of red bay (444 trees/acre), which had a basal area of 5,580 in^2.

- The highest average densities (400 – 445 trees/acre) and corresponding smallest basal areas per tree (24.5 and 25.6) occurred in the maple hardwood hammock and water oak / sweetgum classes.

- The lowest density and corresponding largest trees occurred in the laurel oak / pine upland, which had an average basal area of 175.3 in^2/tree, indicating an older and more established tree stand when compared with the other classes. The second largest trees occurred in the cypress swamp, at about half the basal area of the upland (86.2 in^2/tree).

- The average tree density for all species was 319 trees/ acre and the average basal area for all species was 69.2 in^2/tree.

Cabbage palms were not a large component of any of the vegetation classes along Gum Slough, likely a result of greater depth and duration of seasonal flooding. All the cabbage palms measured were approximately 11 inches in diameter (like all palms, have no bark, or secondary phloem, and do not grow in diameter as they grow in height). Therefore, basal area can be considered a constant among cabbage palms and differences in IV among cabbage palms in vegetation classes can be attributed to density alone. Cabbage palm occurred in the ironwood hardwood hammock and the laurel oak / pine upland and had the third lowest overall IV (IV=27.8) of all 23 species.

Table 3-5
Basal Area and Density in Vegetation Classes along the Gum Slough Transects

Vegetation Class	Density (trees/acres)	Basal Area (in^2/acre)	Basal Area / Tree
Cypress swamp	286	24,669	86.2
Red bay swamp	323	10,730	33.2
Maple hardwood hammock	445	11,414	25.6
Laurel oak mix hammock	299	19,525	65.3
Ironwood hardwood hammock	287	21,358	74.4
Water oak / sweetgum hammock	400	9,823	24.5
Laurel oak / pine upland	190	33,307	175.3

Table 3-6
Basal Area and Density of Tree Species

Wetland Status	Species	Total Basal Area (in^2)	Density (trees/acre)
OBL	*Cephalanthus occidentalis*	100	44
OBL	*Fraxinus caroliniana*	980	41
OBL	*Ilex cassine*	2,524	178
OBL	*Magnolia virginiana*	864	6
OBL	*Nyssa sylvatica* var. *biflora*	7,410	29
OBL	*Persea palustris*	362	17
OBL	*Taxodium distichum*	14,000	102
FACW	*Persea borbonia*	5,580	444
FACW	*Acer rubrum*	7,464	124
FACW	*Carpinus caroliniana*	3,970	201
FACW	*Celtis laevigata*	505	24
FACW	*Gordonia lasianthus*	142	9
FACW	*Liquidambar styraciflua*	10,684	272
FACW	*Quercus laurifolia*	33,742	219
FACW	*Quercus nigra*	12,270	185
FACW	*Ulmus americana*	9,266	214
FAC	*Magnolia grandiflora*	524	4
FAC	*Pinus taeda*	16,873	58
FAC	*Myrica cerifera*	71	8
FAC	*Sabal palmetto*	2,146	20
FAC	*Carya glabra*	529	26
FACU	*Quercus virginiana*	819	4

Percent Occurrence along Transects. Based on NWI data along transects (previous Table 2-3), vegetation along most transects was mixed deciduous and broad leaved deciduous seasonally flooded, however, needle-leaved deciduous (i.e. bald cypress) occurred in 4 of the 6 vegetation classes and along 6 of the 8 transects. Similar to other spring runs, the wetland vegetation is well developed along Gum Slough, likely a result of regular seasonal inundation due to more constant spring flows and fewer drought periods. The percent of each vegetation class measured along each of the transects is shown in Table 3-7.

The vegetation classes described in NWI for the study area were general enough that vegetation classes identified along the 8 transects fell into the designated NWI class (PFO6_C, described earlier). NWI did not specifically call out cypress swamp although cypress swamp occurred along Transects 4, 5, and 7. The remaining vegetation classes frequently included large components of broad-leaved deciduous and evergreen species such as swamp bay, sweetgum, American elm, and oaks, all of which are consistent with the NWI descriptions. The data collected in this study, therefore, appear to represent more specific subsets of the more general NWI vegetation classes.

Table 3-7
Percent Composition of Vegetation Class along the Gum Slough Transects*

Transect		Cypress swamp	Bay swamp	Maple hardwood hammock	Laurel oak mix hammock	Ironwood hardwood hammock	Water oak /sweetgum hammock	Laurel oak / pine upland
Downstream ⇩	PHABSIM1				81			19
	2			71		28		1
	3			48		33		19
	4	8		64	19			9
	5	39	56					5
	PHABSIM2			79				21
	7	66					34	
	8					24	18	58

*Shaded cells indicate absence of vegetation class.

3.4.1 Elevations and Vegetation Classes

Changes in vegetation associated with elevation were more conspicuous along individual transects due to the steeper elevation changes along transects when compared with the change in elevation along the river channel. Swamp classes (cypress and bay) were similar in elevation to each other and to the 4 hammock vegetation classes, although the variation in elevation along the river channel seemed to obscure any upstream-downstream elevation pattern among vegetation classes. Median elevations among wetland vegetation classes (Table 3-8, Figure 3-12) only ranged from 41.3 to 42.6 feet NAVD for the swamp classes and 40.8 to 44.5 feet for the 4 hammock vegetation classes. Elevations in the upland class ranged from 43.7 to 46.6 feet NAVD.

Median relative elevations along transects (Table 3-9, Figure 3-13) ranged from 2.8 to 6.4 feet above the channel bottom for the swamp vegetation classes and 3.0 to 7.1 feet above the channel bottom for the hammock vegetation classes. For the upland class, the elevations ranged from 5.2 to 9.6 feet above the channel bottom along transects where the upland class was included.

The swamp and hammock vegetation classes occurred at very similar elevations along individual transects and decreased in elevation along the downstream transects when compared with the upstream transects. The laurel oak / pine upland vegetation class consistently occurred at higher elevations and differences between the upland and wetland vegetation classes appeared greater at downstream transects when compared with upstream transects. The water oak / sweetgum hammock vegetation class on Transect 7 and the upland class on Transect 4 seemed to be the only vegetation classes that occurred at much different (higher) elevations than other vegetation classes. Similarly, median relative elevations (Figure 3-13) indicate lower elevations among swamps when compared with hammocks and among hammocks when compared with the upland class.

Table 3-8
Median Elevation (NAVD) of Vegetation Classes along the Gum Slough Transects*

Transect		Cypress swamp	Bay swamp	Maple hardwood hammock	Laurel oak mix hammock	Ironwood hardwood hammock	Water oak/ sweetgum hammock	Laurel oak/ pine upland
Downstream ⇩	PHABSIM1				43.3			
	2			42.6		43.6		44.1
	3			42.1		42.7		43.8
	4	41.5		42.2	41.7			46.6
	5	42.2	41.7					44.6
	PHABSIM2			41.5				43.7
	7	41.3					44.5	
	8					40.8	40.5	44.8

*Shaded cells indicate absence of vegetation class.

Figure 3-12
Median Elevation (NAVD) of Vegetation Classes along the Gum Slough Transects

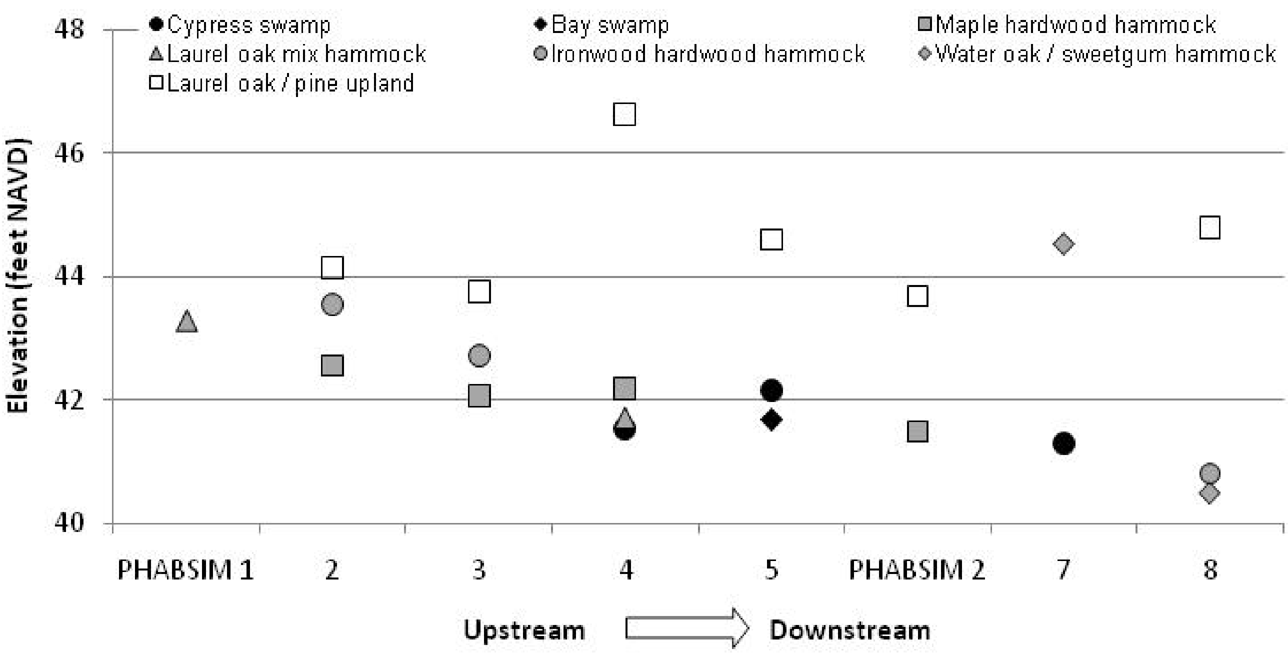
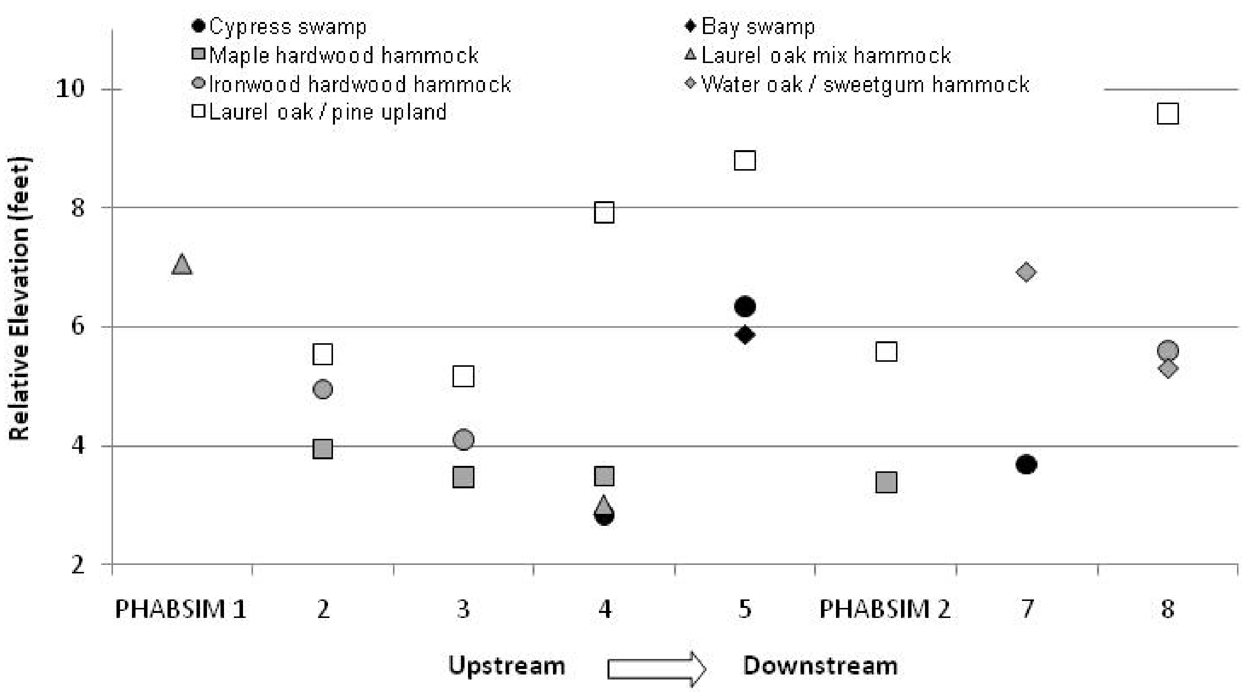


Table 3-9
Median Relative Elevation (feet above channel bottom) of Vegetation Classes along the Gum Slough Transects

Transect		Cypress swamp	Bay swamp	Maple hardwood hammock	Laurel oak mix hammock	Ironwood hardwood hammock	Water oak/ sweetgum hammock	Laurel oak / pine upland
Downstream ⇩	PHABSIM1				7.1			
	2			4.0		5.0		5.5
	3			3.5		4.1		5.2
	4	2.8		3.5	3.0			7.9
	5	6.4	5.9					8.8
	PHABSIM2			3.4				5.6
	7	3.7					6.9	
	8					5.6	5.3	9.6

*Shaded cells indicate absence of vegetation class.

Figure 3-13
Median Relative Elevation (feet above channel bottom) of Vegetation Classes along the Gum Slough Transects



3.4.2 Soils, Distance to Channel, and Vegetation Classes

Hydric and muck soils were found along all 8 study transects. Hydric and muck soils characterized the 6 wetland vegetation classes. Median elevations of hydric soils were lower when compared with nonhydric soils (Table 3-10) in all vegetation classes (and along all transects, as described in section 3.2). Only hydric soils were found in the cypress swamp, bay swamp, laurel oak mix hammock, and maple hardwood hammock. Nonhydric soils were observed in the ironwood hardwood hammock (in 1 of 9 points sampled), the water oak / sweetgum hammock (in 3 of 8 points sampled), and in the laurel oak / pine upland (in all 12 points sampled).

Median elevations of hydric soils were lower when compared with nonhydric soils (Table 3-8 and Table 3-11). There were 3 points at which the median elevation of the hydric soils was higher than the median elevation of the vegetation class, but at only 1 point (the laurel oak mix hammock along Transect 4) was the difference greater than one-tenth of a foot.

Inconsistencies in vegetation-elevation relationships are likely due to the broad environmental tolerance of wetland species. Upland species can out-compete wetland species within the upland species' range of tolerance, but have a narrower range of environmental tolerance that limits them to uplands. The broad environmental range of wetland and transition vegetation when compared with upland species results in greater overlap of wetland and transition species across elevation and soils gradients.

Table 3-10
Median Elevations (feet NAVD) of Hydric and Nonhydric Soils by Vegetation Class*

Vegetation Class	Median Elevation (feet NAVD)	
	Hydric (N)	Nonhydric (N)
Cypress swamp	41.6 (15)	
Bay swamp	41.6 (5)	
Maple hardwood hammock	42.1 (19)	
Laurel oak mix hammock	42.8 (6)	
Ironwood hardwood hammock	42.7 (8)	42.7 (1)
Water oak / sweetgum hammock	40.4 (5)	45.3 (3)
Laurel oak / pine upland		44.9 (12)

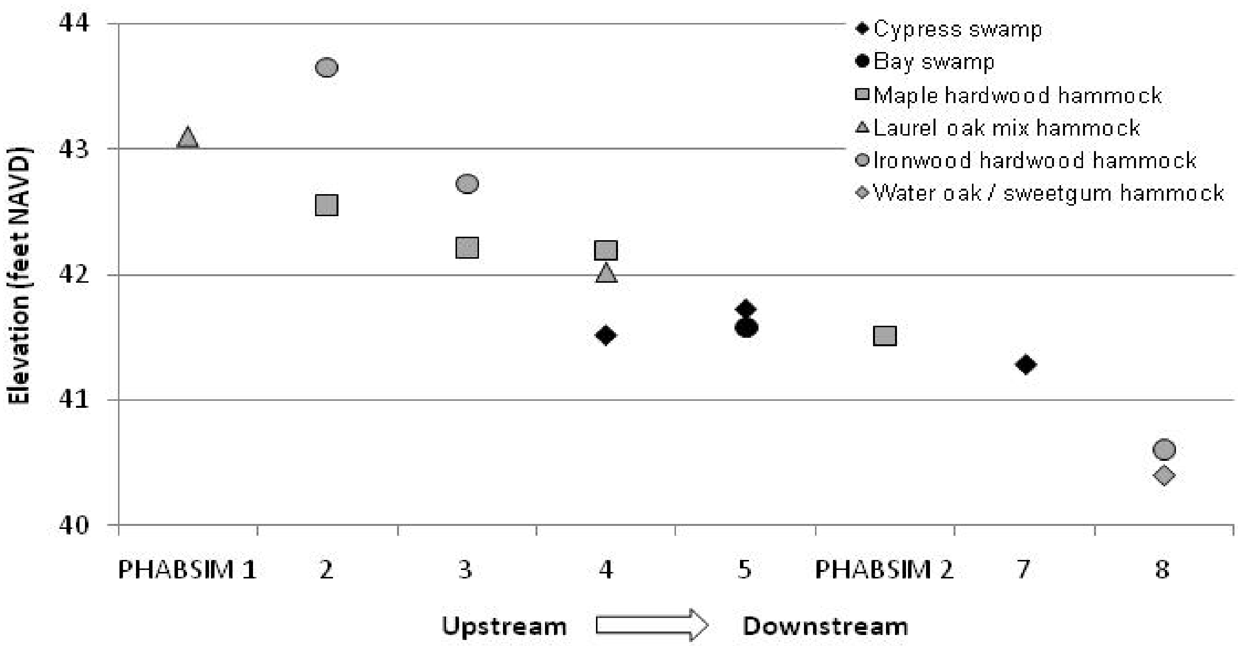
*Shading indicates absence of condition.

Table 3-11
Median Elevations (feet NAVD) of Hydric Soils by Vegetation Class along the Gum Slough Transects*

Transect		Cypress swamp	Bay swamp	Maple hardwood hammock	Laurel oak mix hammock	Ironwood hardwood hammock	Water oak/ sweetgum hammock	Laurel oak /pine upland
Downstream ⇩	PHABSIM 1				43.1			
	2			42.6		43.7		
	3			42.2		42.7		
	4	41.5		42.2	42.0			
	5	41.7	41.6					
	PHABSIM 2			41.5				
	7	41.3						
	8					40.6	40.4	

*Shading indicates absence of vegetation class. Diagonal hatching indicates absence of hydric soils.

Figure 3-14
Median Elevations (feet NAVD) of Hydric Soils by Vegetation Class along the Gum Slough Transects



Distance to river channel may provide a proxy for combinations of elevation, wave energy, soils, and vegetation if distance coincides with these other variables. Average distances of vegetation classes from the Gum Slough channel ranged from 310.5 feet for the laurel oak / water oak hammock to 1,739.4 feet for the laurel oak / pine upland. While the cypress swamp was adjacent to the slough along Transects 4 and 7, it was over 1,500 feet from the slough channel on Transect 5, and the mean distance to cypress swamp was 1,123.8 feet. Variation in mean distances of vegetation classes from the slough channel was high for all classes and ranged from 243.4 feet for the ironwood hardwood hammock to 974.6 for the cypress swamp, compared with mean distances that ranged from 310.5 (laurel oak mix) to 1,739.4 feet (laurel oak / pine upland). Frequently the swamps are located more closely to the channel and hammocks occur more landward, followed by upland vegetation classes, as a result of a gradual increase in elevation landward of the channel. This pattern was not apparent along Gum Slough and likely reflects large differences in the extent of wetlands (overall length of transects from channel to upland) between transects as well as overlap in environmental parameters among the wetland vegetation classes.

Table 3-12
Mean Distances of Vegetation Classes from Gum Slough Channel

Vegetation Class	Mean Distance	Standard Deviation	N
Cypress swamp	1,123.8	974.6	67
Red bay swamp	740.0	461.1	28
Maple hardwood hammock	825.5	707.3	106
Laurel oak mix hammock	310.5	240.2	34
Ironwood hardwood hammock	546.2	243.4	45
Water oak / sweetgum hammock	483.4	456.7	28
Laurel oak / pine upland	1,739.4	846.7	60

3.4.3 Discriminant Function Analysis (DFA)

DFA was used to examine relationships among vegetation classes and environmental variables along the Gum Slough study transects. Elevations, soils, and distance to channel accounted for a significant amount of variation among vegetation classes.

Correlation Results. The contributions of elevation, distance from river channel, and hydric soils index were significant in separating vegetation classes (Wilks' Lambda = 0.16; $p < 0.0001$) (Table 3-13). Vegetation classes were distinct in terms of species composition and IV, and environmental variables were significant in accounting for differences between vegetation classes. Elevations, relative elevations along transects, distance from channel, and hydric soil index were significant in separating vegetation classes from each other, although overlap in environmental parameters between vegetation classes was frequent. Elevation ($r^2 = 0.56$), soils ($r^2 = 0.54$), and relative elevation ($r^2 = 0.62$) were more strongly correlated with vegetation class than distance from river channel ($r^2 = 0.30$).

Classifications and Misclassifications. The two swamp vegetation classes were classified correctly 46.7 percent of the time for cypress swamp and 80.0 percent of the time for bay swamp. Hammock classes were classified correctly from 0 percent (ironwood hardwood hammock) to 50.0 percent (laurel oak mix hammock). The laurel oak / pine upland was classified correctly 83.3 percent of the time. Overlap among classes was greatest among classes that were sampled less frequently, had greater variability in species, or occurred along more transects. Overlap was greatest with "adjacent" classes, e.g. cypress swamp was misclassified as another wetland class rather than an upland class.

Row totals (the "to" classes) in Table 3-13 indicate the percent of the time (and number of times) a vegetation class was classified correctly and incorrectly. For example, cypress swamp was identified in the field on 15 occasions (100 percent) and was classified as cypress swamp based on environmental measures on 7 of those occasions (46.7 percent correct classifications). Cypress swamp was incorrectly classified as bay swamp on 5 occasions (33.3 percent incorrect classifications) and as water oak / sweetgum (6.7 percent incorrect classifications). In contrast, maple hardwood hammock was correctly classified as correctly as maple hardwood hammock only 31.6 percent of the time (in 6 out of a total of 19 cases). Ironwood hardwood hammock was never classified correctly.

Column totals in Table 3-13 (the "from" classes) represent the total number of times a group of measurements recorded in the field was classified as a target community (column heading) in the DFA analysis. Using the cypress swamp example again, the total number of observations classified as cypress swamp was 13 (17.5 percent) based on field measurements alone. While cypress swamp was correctly classified 46.7 percent of the time (7 times), maple hardwood hammock was also classified (incorrectly) as cypress swamp (column heading) 26.3 percent of the time (in 5 of the 19 times it was encountered), and bay swamp was classified (incorrectly) as cypress swamp once (in 1 of the 5 times it was encountered).

Vegetation classes were distinct in terms of species composition and IV, and environmental variables were significant in accounting for differences between vegetation classes. Elevations, relative elevations along transects, distance from channel, and hydric soil index were significant in separating vegetation classes from each other, although overlap in environmental parameters between vegetation classes was frequent.

Correlations between environmental variables and vegetation class ranged from 30 to 62 percent. Percent correct classifications (outlined in bold in Table 3-13) are graphed in Figure 3-15. In general, misclassifications generally occurred with adjacent vegetation classes. For example, cypress swamp overlapped with bay swamp and, in turn, bay swamp overlapped with maple hardwood hammock. There was very little overlap between the upland class and the wetland classes.

Table 3-13
DFA Results for Vegetation Classifications

Vegetation Class	Cypress swamp	Bay swamp	Maple hardwood hammock	Laurel oak mix hammock	Ironwood hardwood hammock	Water oak/ sweetgum	Laurel oak/ pine upland	Total
Cypress swamp	46.7 (7)	33.3 (5)			13.3 (2)	6.7 (1)		100 (15)
Bay swamp	20.0 (1)	80.0 (4)						100 (5)
Maple hardwood hammock	26.3 (5)	21.0 (4)	31.6 (6)	15.8 (3)		5.3 (1)		100 (19)
Laurel oak mix hammock				50.0 (3)	50.0 (3)			100 (6)

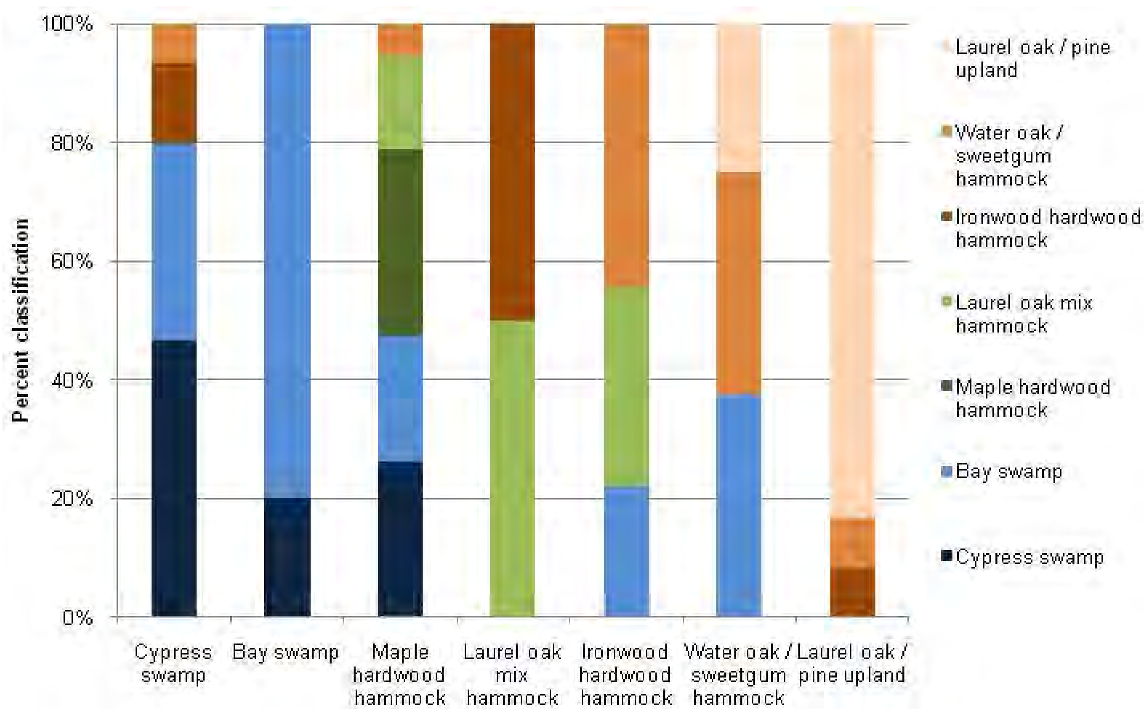
Ironwood hardwood hammock		22.2 (2)		33.3 (5)		44.4 (4)		100 (9)
Water oak/ sweetgum hammock		37.5 (3)				37.5 (3)	25.0 (2)	100 (8)
Laurel oak/ pine upland					8.3 (1)	8.3 (1)	83.3 (10)	100 (12)
Total	17.6 (13)	24.3 (18)	8.1 (6)	12.2 (9)	8.1 (6)	13.5 (10)	16.2 (12)	100 (74)

Wilks' Lambda = 0.161255; F = 6.43; DF = 24; p < 0.0001

Variable	**R-square**	**F Value**	**Pr>F**
Elevation (NAVD)	0.56	14.24	<0.0001
Relative Elevation (feet)	0.62	18.48	<0.0001
Soils	0.54	13.01	<0.0001
Distance	0.30	4.81	0.0004

Number in parentheses indicates N.

Figure 3-15
Percent Correct Classifications of Vegetation Classes



Species differences between vegetation classes were significant, as described earlier. However, DFA analysis indicates that differences between vegetation classes are less conspicuous based on environmental parameters and, therefore, overlap among vegetation classes is actually greater across environmental gradients. Consequently, merging similar classes, e.g. cypress swamp and bay swamp into a single “swamp” class, and merging the remaining wetland classes into a single “hammock” class for a second DFA resulted in a larger number of successful classifications (Table 3-14). Swamp was correctly classified as swamp in nearly 77 percent of the cases (30 of 39 occurrences). Hammock and uplands classes were correctly classified 56.5 and 91.7 percent of the time, respectively.

While grouping vegetation into broader classes resulted in more successful correlations among vegetation classes, correlations between these vegetation classes and corresponding environmental measures were negligible. Correlations between vegetation classes and elevation, relative elevation, soils, and distance from channel were 0.55, 0.61, 0.51, and 0.28, respectively, and varied by no more than 0.03 percent for any single parameter.

Misclassifications in a DFA occur when a vegetation class is not successfully paired with corresponding environmental parameters and subsequently overlaps with other vegetation classes in regards to soil index, relative elevation, and distance from channel. Overlapping vegetation classes can indicate shared, or similar, habitat based on measured parameters (McNeely 1987). The overlap itself gives no indication of the resource preferences of overlapping species, although it does indicate the habitat being used (Colwell and Futuyama 1971), as well as the similar resource requirements of most plants (Goldberg and Werner 1983).

The mean values for elevation (NAVD), relative elevation, soils index, and distance from channel associated with each vegetation class through the DFA are listed in Table 3-15. The swamp vegetation classes frequently corresponded to lower relative elevations, higher soils index values, and shorter distances to the river channel than the transition and upland vegetation classes.

Table 3-14
DFA Results for Vegetation Classifications by Merged Communities

Vegetation Class	Swamp	Hammock	Upland	Total
Swamp	76.9 (30)	23.1 (9)		100 (39)
Hammock	30.4 (7)	56.5 (13)	13.0 (3)	100 (23)
Upland		8.3 (1)	91.7 (11)	100 (12)
Total	50.0 (37)	31.1 (23)	18.9 (14)	100 (74)
Wilks’ Lambda = 0.2747; F = 15.44; DF = 8; p < 0.0001				
Variable		**R-square**	**F Value**	**Pr>F**
Elevation (NAVD)		0.55	43.34	<0.0001
Relative Elevation (feet)		0.61	55.51	<0.0001
Soils		0.51	37.35	<0.0001
Distance		0.28	13.50	<0.0001

Number in parentheses indicates N.

Table 3-15
Mean Values of Parameters Used in DFA for Vegetation Classes

Parameter	Cypress swamp	Bay swamp	Maple hardwood hammock	Laurel oak mix hammock	Ironwood hardwood hammock	Water oak / sweetgum hammock	Laurel oak / pine upland
Elevation (NAVD)	41.8	41.6	42.1	42.6	42.3	42.1	45.2
Relative elevation (feet)	1.2	1.0	1.0	1.0	1.5	1.8	4.6
Soils	2.4	3.0	2.2	1.7	1.4	1.5	0.0
Distance (feet)	1154.0	675.9	848.9	330.8	531.5	403.7	1791.0

3.4.4 Wetted Perimeter

A general increase in cumulative wetted perimeter (inundated habitat) coincident with a shift in vegetation classes was apparent along the Gum Slough transects. The sigmoid-shaped curve generally associated with corresponding changes in habitat and elevation was apparent along most of the 8 transects. Wetland classes consistently aligned with the steeper portion of the curves and corresponded to a more gradual elevation change (slope) and greater wetted perimeter. The two swamp classes have the largest wetted perimeters at the lower elevations, reflecting smaller changes in elevation across longer distances and the large change in inundated wetlands that can occur as a result of a relatively small change in water level in these wetlands. The upland class exhibited the highest median elevation, but lower wetted perimeter when compared with the swamps, indicating less habitat inundation at its median elevation.

The wetted perimeters of vegetation classes along the Gum Slough transects are listed in Table 3-16 and indicate the linear distance inundated along a transect at a particular elevation or water level (river stage) in the river channel. The mean cumulative wetted perimeter for each vegetation class is graphed against the median elevation of the vegetation class in Figure 3-16. Wetted perimeters and corresponding elevations for vegetation classes along the 8 Gum Slough transects are graphed in Figures 3-17 through 3-24. The total wetted perimeter increases as elevation increases and varies among vegetation classes. For example, if river stage was level with the median elevation of the cypress swamp vegetation class at Transect 5, 2,344 linear feet of habitat would be inundated below that median elevation (Table 3-16). Similarly, at a river stage equal to the median elevation of the bay swamp vegetation class along the same Transect 5, 1,856 linear feet of habitat would be inundated.

Wetted perimeter changes, relative to changes in elevation, were compared using the Kruskal Wallis test, a nonparametric analog to a one-way analysis of variance (ANOVA).

Table 3-16
Cumulative Wetted Perimeter (linear feet), by Vegetation Class along Gum Slough Transects*

Transect		Cypress swamp	Bay swamp	Maple hardwood hammock	Laurel oak mix hammock	Ironwood hardwood hammock	Water oak / sweetgum hammock	Laurel oak / pine upland
Downstream ⇩	PHABSIM1				194			
	2			392		674		820
	3			299		784		1,216
	4	495		1,810	923			2,625
	5	2,344	1,856					2,825
	PHABSIM2			1,234				1,768
	7	620					1,181	
	8					350	313	639

*Shaded cells indicate absence of vegetation class.

Figure 3-16
Mean Wetted Perimeter and Median Elevations Associated with Vegetation Classes

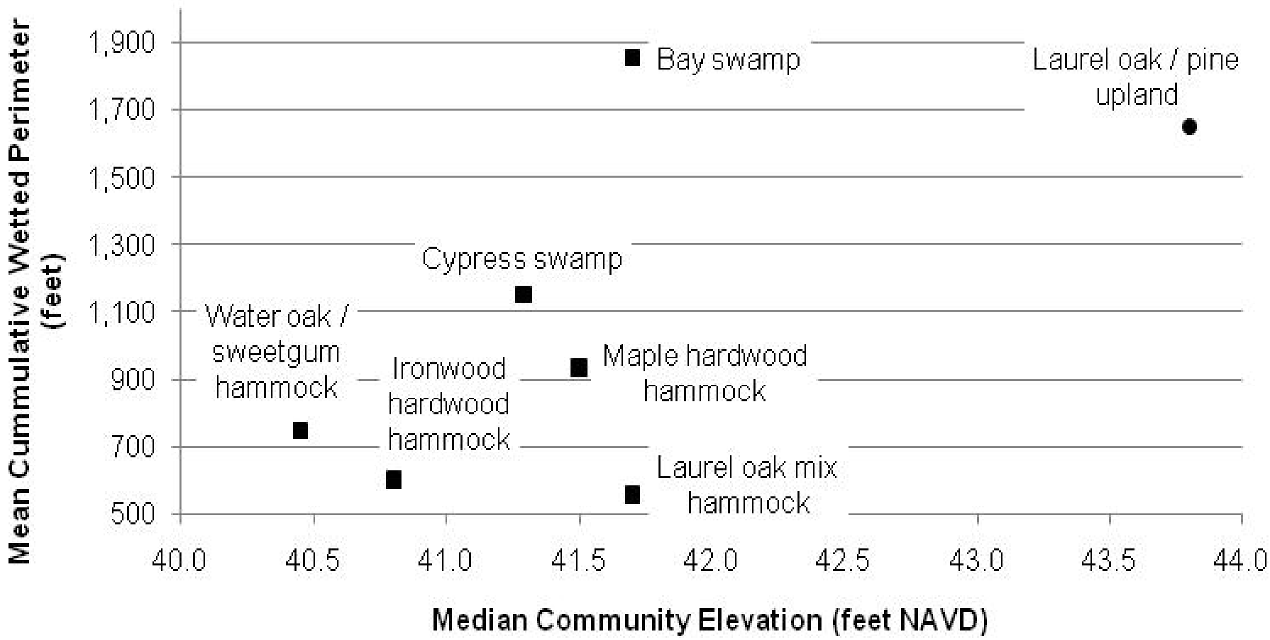


Figure 3-17
Wetted Perimeter and Median Vegetation Class Elevations along Transect PHABSIM1

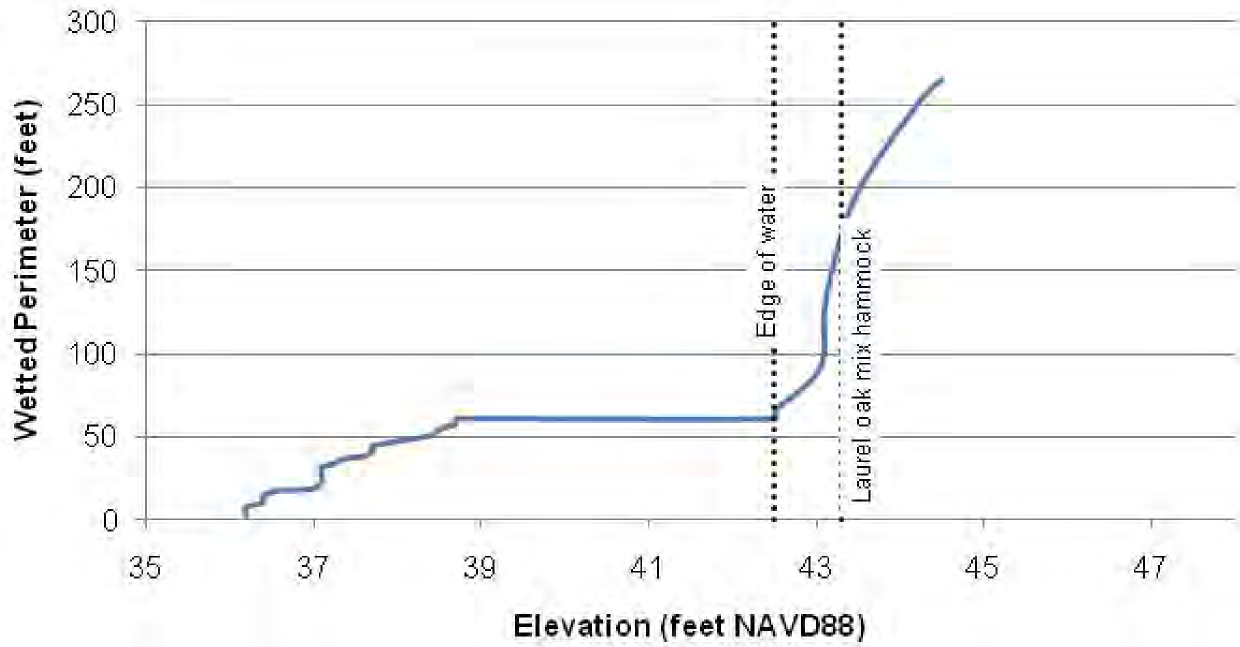


Figure 3-18
Wetted Perimeter and Median Vegetation Class Elevations along Transect 2

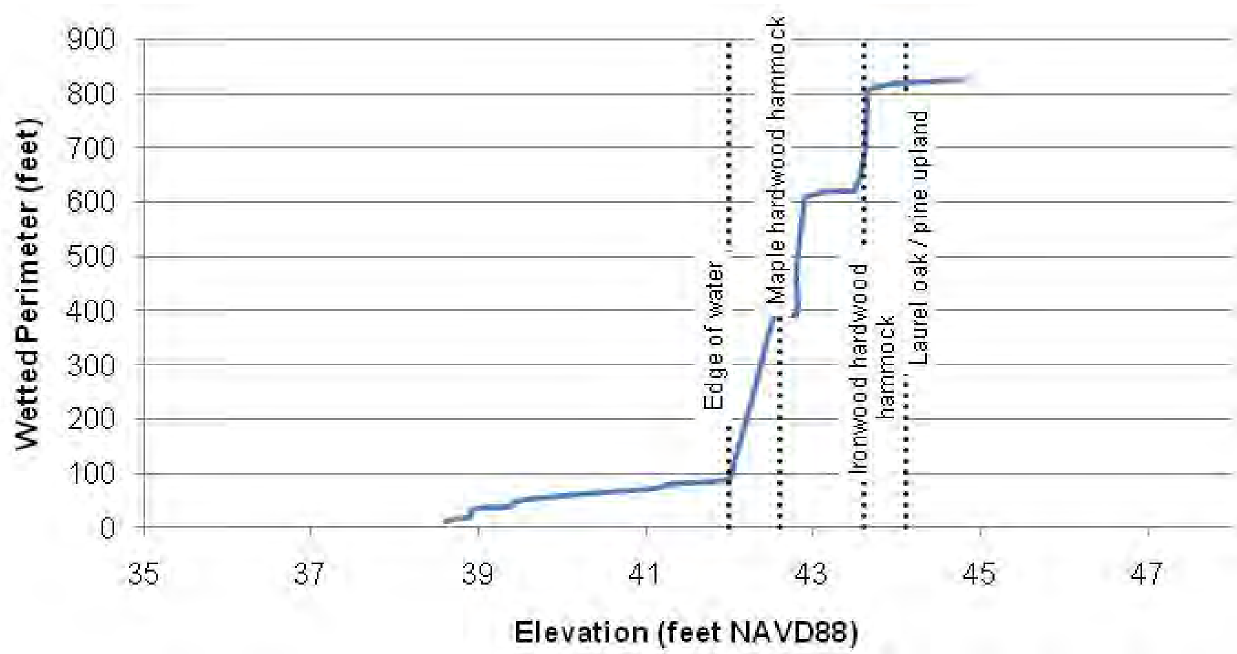


Figure 3-19
Wetted Perimeter and Median Vegetation Class Elevations along Transect 3

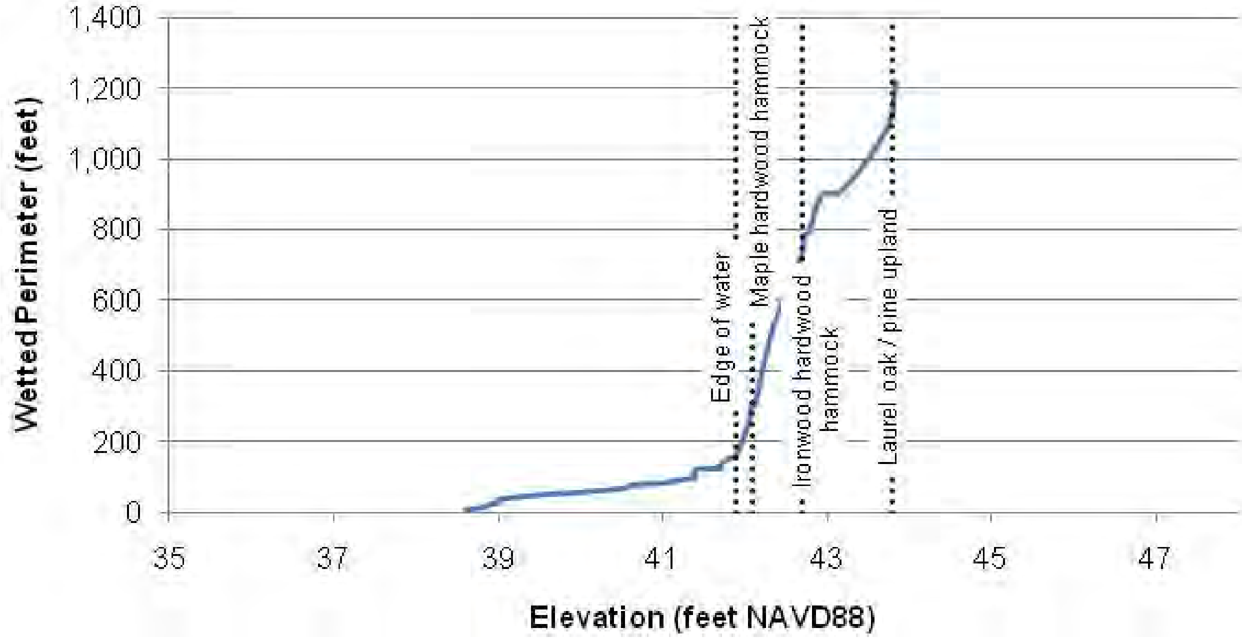


Figure 3-20
Wetted Perimeter and Median Vegetation Class Elevations along Transect 4

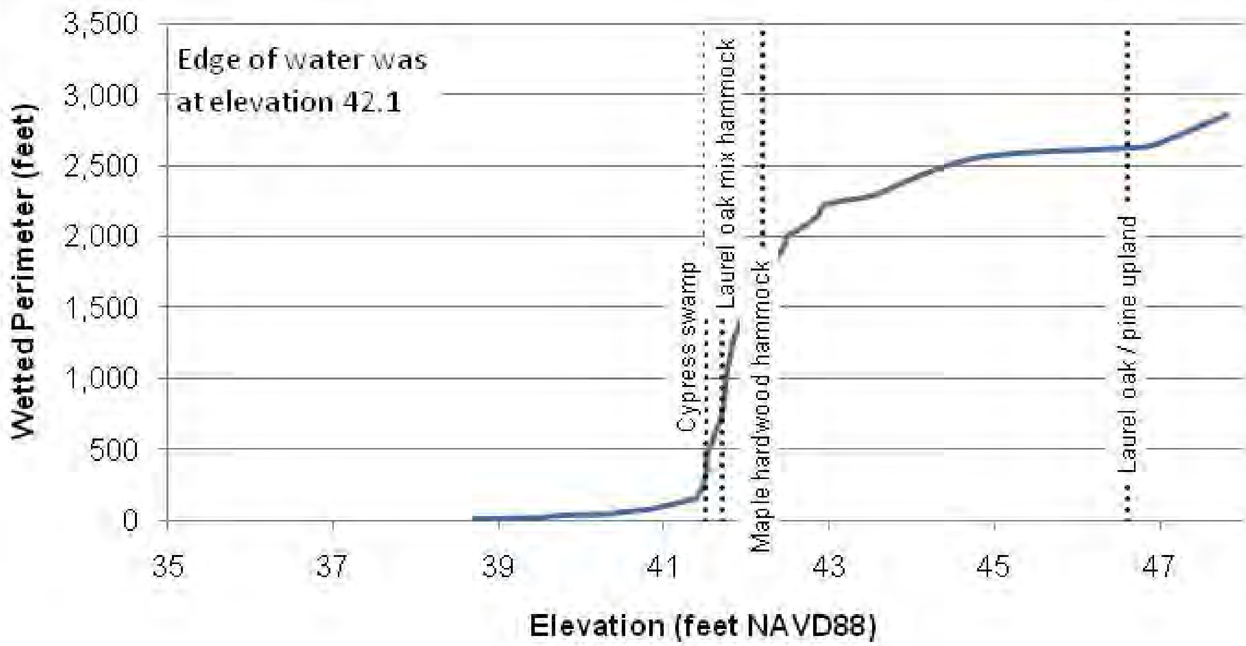


Figure 3-21
Wetted Perimeter and Median Vegetation Class Elevations along Transect 5

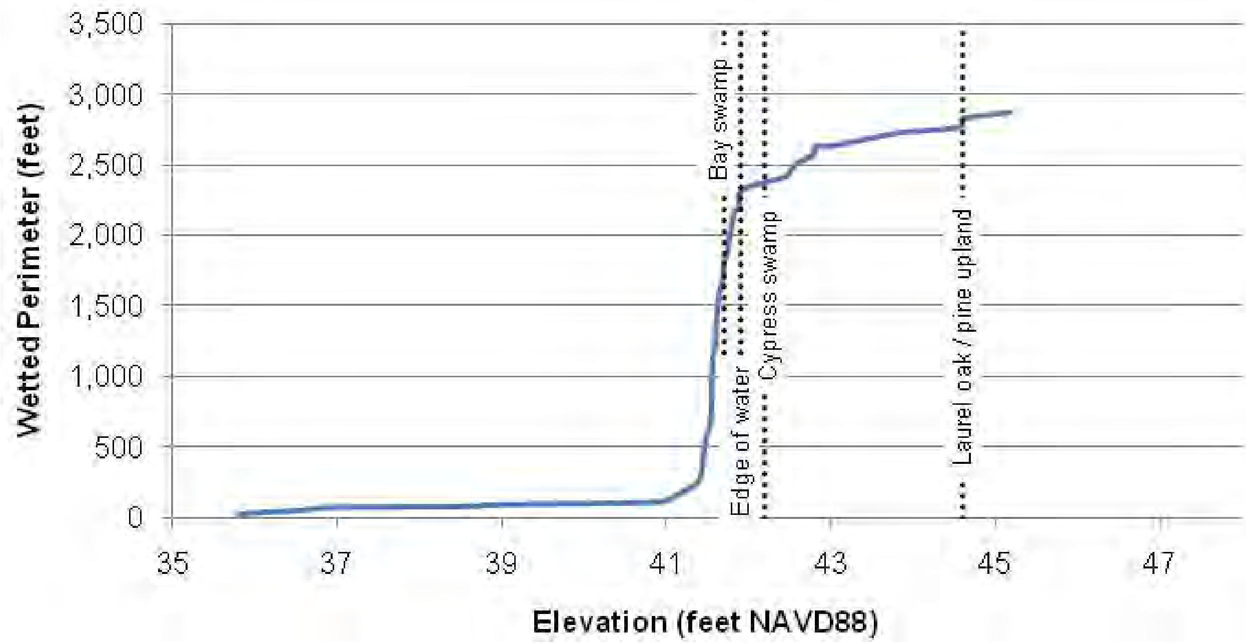


Figure 3-22
Wetted Perimeter and Median Vegetation Class Elevations along Transect PHABSIM2

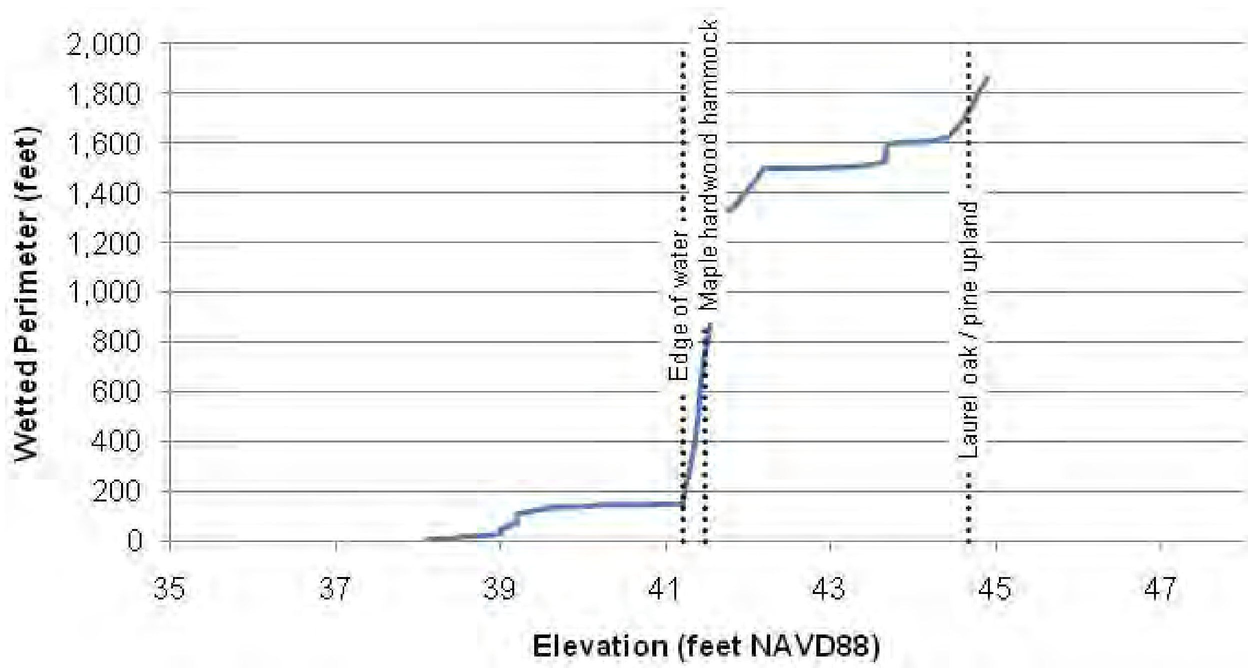


Figure 3-23
Wetted Perimeter and Median Vegetation Class Elevations along Transect 7

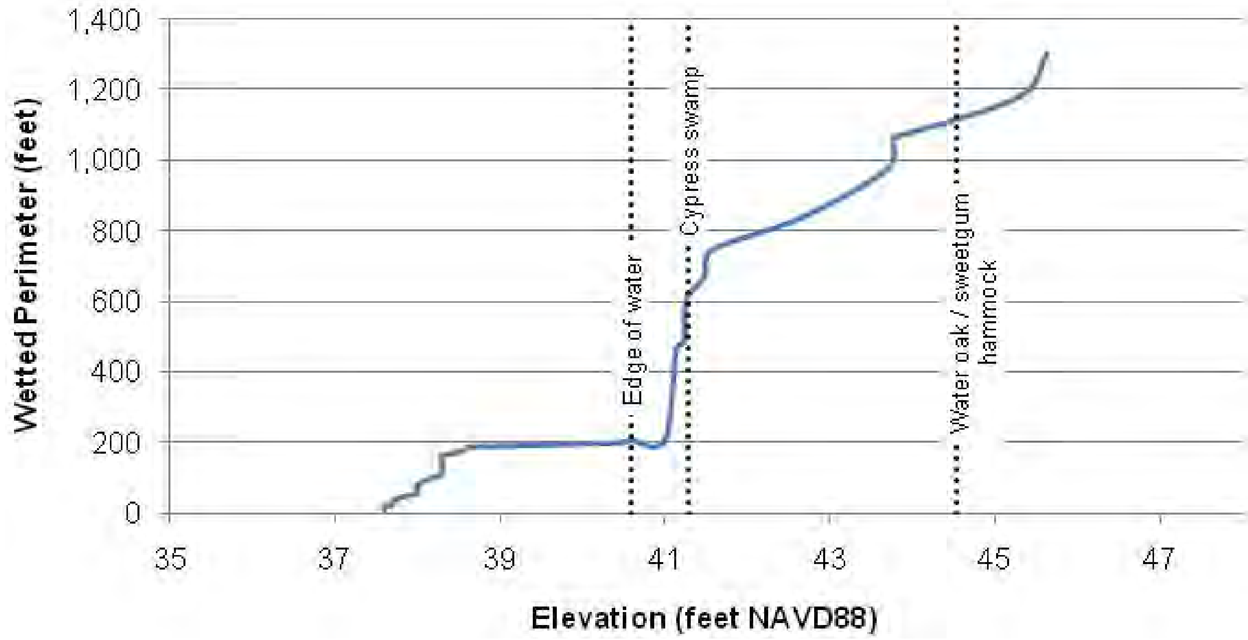
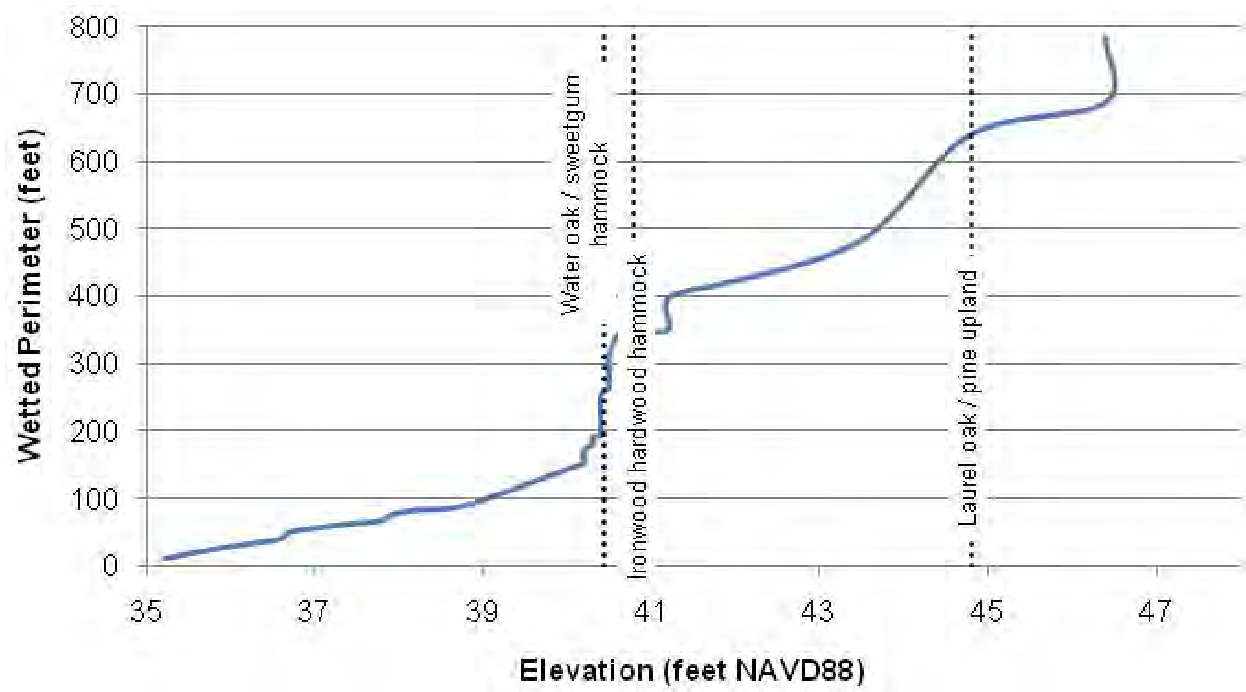


Figure 3-24
Wetted Perimeter and Median Vegetation Class Elevations along Transect 8



3.5 Relationship of Vegetation with Environmental Variables

Relationships among river stage, flow, and elevations were developed by the District for Gum Slough and are not presented here. However, it is appropriate to address hydrologic conditions such as saturation and inundation that are critical to the development of hydric soils and associated wetland vegetation.

Hydrology. Saturation and/or inundation are critical to the maintenance of wetlands vegetation in floodplains, although overbank flooding is not necessary (Cowardin *et al*. 1979, Reid and Wood 1976), and ground water can strongly influence the extent of wetlands (Light *et al.* 2002). Wetland trees are relatively fast-growing and in five years can generally grow to a height at which it is tolerant of inundation. For example, cypress trees can exceed one meter tall in one to two years (Harms 1973). Cabbage palms are unusual in that they require an initial establishment phase of 30 to 60 years during which they have no above-ground trunk (McPherson and Williams 1996) and flood events at 25 year intervals or more probably restrict the regeneration of cabbage palm. Once established, they are susceptible to only rising sea level, hurricanes, and fires. Under existing conditions, the tree communities along Gum Slough are not anticipated to change in composition or structure.

Competition. Wetland species occur in wetlands because they are tolerant of saturated and anoxic conditions that preclude upland species. Several studies have indicated that environmental gradients are more important in determining species distributions under physiological stressful conditions (e.g. flooding), while competition may be more important under relatively benign conditions (Latham *et al.* 1994, Grace and Wetzel 1981, others). The basal area and densities of cypress trees along Gum Slough suggest that this is a well-established stand of vegetation. There was no indication of recent invasion of wetlands by upland species along the study corridor.

Disturbance. Invasive and nonnative species such as Brazilian pepper (*Schinus terebinthifolius*) and paragrass have a competitive advantage under disturbed conditions. Disturbances can occur as fire, flooding, animal activity, etc. and provide an opening into which a species that may not otherwise survive can become established due to the absence of other species. Mature native trees can continue to shade out many invasive species until the native trees die and create openings into which invasive species expand. No nonnative species such as Brazilian pepper, punk trees (*Melaleuca quinquenervia),* Chinese tallow *(Sapium sebiferum),* or camphor tree *(Cinnamomum camphora),* were observed along any of the study transects. Nor were any signs of serious invasion by nonnative and invasive species observed.

Inundation Periods in Southeastern Wetlands. The flood tolerant forested floodplain and associated muck soils along Gum Slough are a result of the permanent (although seasonally variable) flows. The wetland vegetation classes along the river are subject to seasonal rise and fall in the water table in addition to surface water runoff. The wetlands along Gum Slough are more typical of those along the Withlacoochee River and are not typical of the more karst-dominated rivers of the Florida Springs Coast, such as the Rainbow, Crystal, and Homosassa rivers.

Spring-fed rivers differ from blackwater streams and other streams and rivers dominated by surface water in that flows are permanent and the water has greater clarity. Consequently, vegetation studies of many of the Springs Coast rivers focus on instream vegetation and water quality rather than wetland vegetation. Instream vegetation is absent along narrower reaches of Gum Slough where the tree canopy is well developed and the channel is shaded.

Alterations in the historical inundation patterns in the upper reaches of Gum Slough have not been documented. The vegetation along the study corridor appears consistent with species of temporarily and seasonally flooded hardwood hammocks described for the southeastern U.S. (Table 3-17) with the exception of reaches along the slough that are characterized by cypress swamp and appear to be seasonally or semipermanently flooded.

The banks along Gum Slough are generally characterized by narrow, seasonally and/or semipermanently flooded swamps along the river edges that include species such as cypress and tupelo. Cypress is an obligate wetland species, tolerant of up to three meters of inundation for more than 10 years, and more tolerant of wetland conditions than the other species documented as part of this study. However, cypress trees are not limited to the river edge where the water table is closer to the land surface and inundation is more persistent. Where the floodplain is broad, cypress swamp occurred landward of hardwood, or bay swamps. Cypress cannot germinate under flooded conditions and do not grow quickly enough to successfully compete with other wetland tolerant species where flooding is less persistent. In addition, fire following logging or drainage (historically common in the watershed) can destroy seeds and roots and favor replacement by willows and then mixed hardwoods (Myers and Ewel 1990).

Climate. Large-scale climatic events may also influence long term stream flows and should be considered when establishing MFLs for Gum Slough. For example, seasonal and long term flow pattern differences between north Florida rivers (Suwannee River, Apalachicola River, Withlacoochee River) and south Florida rivers (Alafia River, Peace River, Myakka River) appear to coincide with the Atlantic multi-decadal oscillation (AMO) events (Basso and Schultz 2003). These events affect ocean temperature and rainfall patterns that ultimately influence regional ground water flows, stream flows, floodplain inundation, and vegetation patterns. In the Peace River watershed, wet periods correspond to higher wet season flows, but not dry season flows. Stream flow and rainfall data recorded since the 1900s indicate flow declines in the Peace River even when these rainfall patterns are accounted for. Flows in Gum Slough are also influenced by ground water withdrawals for agriculture and potable use.

Table 3-17
Typical Hydrology, Soils, and Species Composition in Floodplain Communities in the Southeastern U.S.

Vegetation Community[1]	Hydrology [2,3,4]	Soils[1,2]	Dominant Trees[1]
Cypress, palm/ cypress, and hardwood swamps, semipermanently flooded	Inundated avg. 7 mo./yr. [2] Flooded 4-7 mo./yr. Saturated 9 mo.[3,4] Min. 14-day flood/2 yr. at 1m. Range of 5-10 mo./yr. [5]	Hydric-clay, muck, loam	Cypress dominant in lower swamp, mixed in higher swamp.
Wet hardwood hammock, seasonally flooded	Flooded avg. of 2 mo./year. Saturated 3 mo. [2,3,4] Min. 14-day flood/2 yr.	Hydric-loam, sand, clay	Cypress, hickory, ash, water oak, maple
Dry hardwood hammock, temporarily flooded	Flooded up to 1 month of growing season [3,4] Minimum 14-day flood/5 yr.	Hydric/ nonhydric	Maple, elm, ash, gum, oak.

[1]Peace and Myakka Rivers (PBS&J 2002). [2]Light *et al.* 2002). [3]Wharton *et al.* 1982. [4]Cowardin *et al.* 1979. [5] Coultas and Deuver 1984.

4.0 Conclusions

Forested wetlands in the Gum Slough study area included six distinct vegetation classes based on tree species diversity and IV. Soils, elevations, and distances from river channel were significantly related to vegetation classes and correlations ranged from 31.6 to 80.4 percent among wetland vegetation classes. Cypress and bay swamp consistently occurred at lower elevations in combination with hydric and muck soils and greater wet perimeter when compared with the upland vegetation class, as did the “hammock” vegetation classes. Based on the results of this study, the cypress and bay swamp and the hardwood hammock were the only vegetation classes that may be considered characterized by semi-permanent or permanent inundation and may provide a criterion on which to establish MFLs for vegetation communities along Gum Slough. The remaining wetland vegetation classes (ironwood hardwood hammock, laurel oak mix, and water oak / sweetgum hammock) are likely seasonally flooded. MFLs that rely on fish passage will address freshwater needs in the shallow portions of the river corridor.

Vegetation. Differences in vegetation classes were significant based on importance values (IVs). Six vegetation classes were characterized as wetland classes, including swamp bay and cypress swamps and 4 “hammocks”. A single upland class was identified. The wetland classes included obligate and facultative wetland tree species, including cypress (*Taxodiuim distichum*), holly (*Ilex cassine*), swamp bay (*Persea palustris*), sweet bay magnolia (*Magnolia virginiana*) tupelo (*Nyssa sylvatica*), red maple (*Acer rubrum)*, and ironwood (*Carpinus caroliniana*). The six wetland classes could be differentiated based on dominance of cypress, sweetgum (*Liquidambar styraciflua*), swamp bay, ironwood , laurel oak (*Quercus laurifolia*), and water oak (*Q. nigra*).

Species IVs comparisons indicated a shift in importance from cypress, maple, swamp bay, and ironwood in wetlands to laurel oak and loblolly pine in transition vegetation classes. Laurel oak, which occurred in all six vegetation classes, had the largest overall IV (349) when compared with all other species. Hackberry followed with the second highest IV (221), primarily a result of the presence of only one other species (southern magnolia) in the vegetation class. No other species had an IV greater than 200, i.e., no other vegetation class had a single species making up such a large component.

Four species, swamp bay, sweetgum, laurel oak, and American elm, made up 49 percent of the total IVs (by species) among all classes and each of the individual species had IVs greater than 200. Another four species, cypress, holly, ironwood, maple, and loblolly pine, totaled 39 percent of the species IVs. The remaining 12 percent of the IVs was accounted for by the 12 remaining species.

Elevations and Soils. Elevations in vegetation classes ranged from 41.3 (cypress swamp) to 46.6 (laurel oak / pine upland) feet NAVD along transects. Median and mean elevations by vegetation class, however, varied much less among vegetation classes and along individual transects. Mean elevations for the cypress swamp, bay swamp, maple hardwood hammock, and laurel oak mix hammock ranged from 1.0 to 1.2 feet. Mean elevations ranged from 1.5 to 1.8 feet above channel bottom in the ironwood hardwood and water oak / sweetgum hammocks, and 4.6 feet above channel bottom in the laurel oak / pine upland.

Median elevations of hydric soils were lower when compared with nonhydric soils and overlap was negligible, in spite of variation in elevations along the channel. Elevations of hydric soils ranged from 40.4 feet NAVD (water oak / sweetgum hammock) to 42.8 feet NAVD (maple hardwood hammock) and nonhydric soils elevations ranged from 42.7 (ironwood hardwood hammock) to 45.3 (water oak / sweetgum hammock) feet NAVD.

Discriminant Function Analysis (DFA). DFA was successful in differentiating among vegetation classes based on measures of elevation, distance from river channel, and soil parameters along the Gum Slough transects. Elevations, relative elevations along transects, distance from channel, and hydric soil index were significant in separating vegetation classes from each other, although overlap in environmental parameters between vegetation classes was frequent. Elevation (r^2 = 0.56), soils (r^2 = 0.54), and relative elevation (r^2 = 0.62) were more strongly correlated with vegetation class than distance from river channel (r^2 = 0.30).

The cypress swamp vegetation class was classified correctly 46.7 percent of the time and bay swamp 80.0 percent of the time. Hammock classes were classified correctly from 0 percent (ironwood hardwood hammock) to 50.0 percent (laurel oak mix hammock). The laurel oak / pine upland was classified correctly 83.3 percent of the time. In general, misclassifications generally occurred with adjacent vegetation classes. For example, cypress swamp overlapped with bay swamp and, in turn, bay swamp overlapped with maple hardwood hammock. There was very little overlap between the upland class and the wetland classes.

Overlap among classes indicated that differences between vegetation classes were less conspicuous based on environmental parameters. Merging similar classes, e.g. cypress swamp and bay swamp into a single “swamp” class, and merging the remaining wetland classes into a single “hammock” class increased the “success” of the classifications, although correlations between these vegetation classes and environmental parameters were no better when the classes were merged into fewer classes.

Wetted Perimeter. Wetland classes consistently aligned with the steep portion of wetted perimeter curves for each of the Gum Slough transects and corresponded to a more gradual slope and greater wetted perimeter. The upland class corresponded to the portion of the curves that indicates a steeper elevation gradient (and less wetted perimeter). However, differences between wetland These results are consistent with the larger reductions in wetted perimeter (habitat) in wetlands that can result from relatively small changes in water level along Gum Slough.

5.0 Relevant Literature

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Appendix A
Photographs of the Gum Slough Transects

Transect PHABSIM1

Transect 2

Transect 3

Transect 4

Transect 5

Transect PHABSIM2

Transect 7

Transect 8