Appendix IV
Floodplain Biology Technical Memo

Digitial Files under Separate Submittal
Appendix A - CAPS
Appendix B - MiniTab
Appendix C - Spreadsheet Explorations
Appendix D - GIS Community Map Shapefiles

CONCEPTUAL FLOODPLAIN COMMUNITY MODEL

1.0 INTRODUCTION

The purpose of this assessment was to develop a conceptual model of the floodplain communities in the Middle Suwannee River (MSR), covering a study area 50 miles long within the 10-year floodplain extending from the confluence of the Withlacoochee and Suwannee Rivers downstream to the USGS gage near Wilcox (**Figures 1 and 2**). The approach was process-based, seeking to define community types based on differences in their species composition along a hydrologic gradient. This is important because this work product will ultimately assist in the formulation of minimum flows and levels (MFL) intended to protect water resource values related to floodplain communities. Therefore, the conceptual model provides descriptions for vegetative assemblages associated with site-specific threshold differences in water levels.

Figure 1 - MSR Study Area

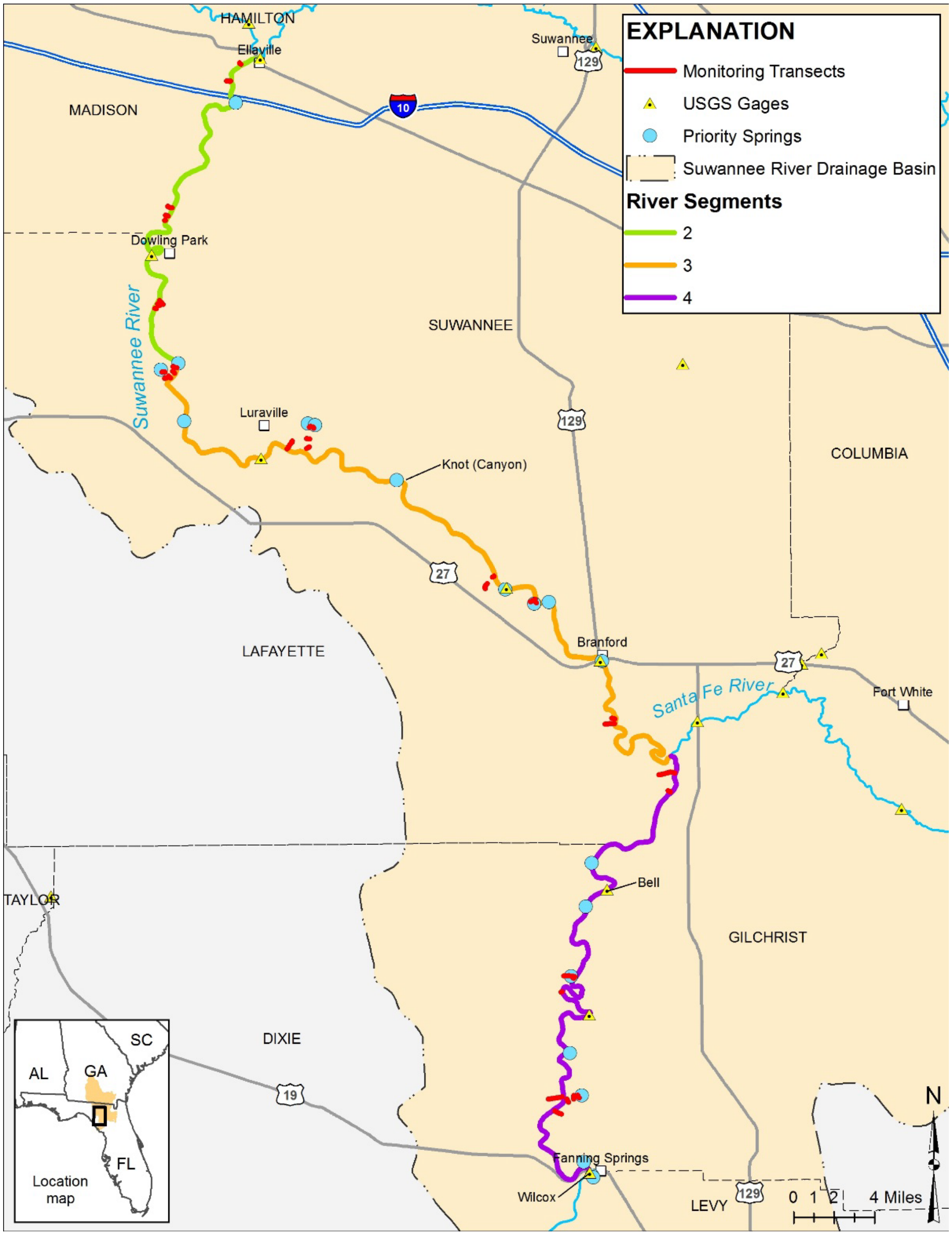

Figure 2 - MSR Study Area Detail

The study area is wonderfully complex. It covers three limnological river segments differing in their artesian spring discharge and associated water quality and flow volumes (Hornsby et al., 2000). It crosses three bedrock shoals affecting the lower water surface profiles of the river, two of which frame a 4 mile long part of the river where it is so deeply incised that it functions more like a canyon than a floodplain. The downstream end of the canyon occurs near river-mile 90, and that location is referred to as the 'knot' in this report (**Figure 1**). Some of the water surface profiles of interest exhibit a notable change in slope along the river at the knot. The valley also contains two major fluvial geomorphic divisions affecting floodplain width and fluvial processes, divided near the Santa Fe River confluence. Further, the floodplain topography is gradually dynamic. Its forests develop on shifting ground, adding a time component to the corridor's biological complexity. While this is true of many large rivers, the MSR floodplain's genesis stems not only from standard fluvial forces and associated sedimentation (alluvial) processes, but also from the fact the river valley is a karst terrain. The interactions between these two dynamic controls on geomorphology (alluvial and geological) create a wide range of elevations within the floodplain that drive much of its habitat heterogeneity.

The substantial elevation gradients sustained by this system occur in an area where continental and peninsular zoogeographical regions meet, thus allowing for a rather full expression of the potential richness of the species composition within the riparian corridor. Not surprisingly, comparative studies indicate the MSR has a high amount of plant species diversity for a Florida riparian corridor. Extensive conservation acquisitions have been made along the corridor by the SRWMD, often in collaboration with state agencies and local governments. The conceptual model provides a description of the floodplain communities including their vegetation, geomorphology, soils, and hydrology. The study sifts through the complexity to identify communities with significantly different sensitivities to water levels as a partial basis for establishing MFL's protective of floodplain water resource values.

1.1 Methods and Community Screening Outcomes

The MSR's floodplain was examined using a combination of literature review, aerial images, a LiDAR-derived 5-foot digital elevation model (DEM), original field studies, ground surveys, a HEC-RAS hydraulic simulation model, multi-decadal daily river discharge records, available monitoring well data in the Floridan aquifer, available water quality data, and statistical analysis of the field study data and long-term discharge records. The field study provided quantitative data regarding plant species composition and distribution at 100 plots along the MSR, a rather characteristic year's worth of water level data collected in 17 shallow monitoring wells and 14 stage gages distributed throughout the floodplain, characterization of the alluvial and geologic surfaces in the floodplain, and 98 shallow borings used to describe the soil layers.

The evaluation of these resources was structured by first exploring selected data using multivariate statistics for ordination. Ordination is the process of numerically ordering and subsequently classifying groups along a potential environmental gradient. Most multivariate ordination methods are exploratory, and are more useful in generating hypothesis than confirming them. The ordination efforts provided potential groups, the utility of which was subsequently tested by comparing differences among groups for hydrologic variables not used in the ordination. These differences were tested using one-way analysis of variance (ANOVA) statistics. In each case the data was determined to meet the assumptions of ANOVA for normal distribution and equitable scatter of residuals. If it had not met these assumptions the data would have been transformed to meet them and failing a successful transformation, non-parametric statistics would have been used in lieu of ANOVA. Further, the data was tested for equality of variances to select the appropriate post-hoc pairwise comparisons of groups. Tukey's post-hoc test was applied to equal variance samples and Games-Howell's test to those with unequal variances. Statistical significance was defined as alpha less than 0.05. ANOVA was conducted using Minitab 17.1.0 software. Some regressions were also run in either Minitab and in Microsoft Excel 2013 for this analysis.

Three ordination techniques were used. The first, referred to as Field Classification, determined group membership based on qualitative differences of plant communities along 34 transects observed during a series of field reconnaissance visits made from April 24-30, 2013. These visits were conducted simultaneously by at least 3 experts each day with collective experience understanding the plant species of the region, wetland hydrology, soil science, and fluvial geomorphology. The experts included two PhD's, a Professional Engineer, and three certified Professional Wetland Scientists. Potential communities were determined based on perceived breaks in topography and soil differences observed at or near relatively abrupt changes in plant species composition and forest structure. Breaks were identified and flagged for further study based on consensus among the experts in the field (**Figure 3**). In effect this was a qualitative charrette method of ordination and classification.

Figure 3 - Field-Determined Community Break

The break locations and elevations along each transect were subsequently surveyed by a Professional Surveyor and Mapper, thus allowing for the derivation of quantitative variables related to elevation and water depths relative to river and aquifer levels. As mentioned, the shallow monitoring wells and stage gages equipped with continuous recorders provided a 12 month period of record for water levels in the floodplain that was useful for determining actual water levels in nearby wetlands during that period of record. A stratified random sample of 100 vegetation plots was also established at locations along the reconnaissance transects and quantitative measures of vegetation and soil strata were made in each plot. The field methods are described in detail in Amec Foster Wheeler (2015).

The quantitative vegetation data was used in the second ordination and classification technique, Two-Way Indicator Species Analysis (TWINSPAN). TWINSPAN is a divisive clustering technique which enables exploration of group membership based on species composition and their relative importance or abundance measures within a sample. TWINSPAN was run separately for canopy and understory data. Canopy relative importance values were based on the average of the relative fraction of basal area by species for each plot and the relative abundance of the total trunk count by species within each plot. Understory importance values were the relative fraction of the total understory cover by species for each plot. TWINSPAN provides output in tabular form, diagrams, and division lists that enable one to view the ordination of the plots and species on a matrix, determine which species-abundance combinations were most influential in the ordination and clustering results, and visualize the clusters in a dendrogram. Interpretation of the TWINSPAN results was enhanced by also ordinating the species data using Nonmetric Multidimensional Scaling (NMDS). NMDS provides a visual clustering of the multidimensional data into two dimensions, placing the most similar sites closest together in a biplot graph. TWINSPAN and NMDS were run in Community Analysis Package 5.3.3.472 (CAP 5) software. Groups assigned in accordance with interpreting the results from TWINSPAN and NMDS are referred to as the Species Classification. TWINSPAN and NMDS input data and selected output are provided in digital **Appendix A**.

Hierarchical Cluster Analysis (HCA) provided the basis for the third and final approach to ordination and classification. HCA was run in Minitab on standardized variables so each had equal weight in the analysis, using Ward's linkage method and the Euclidean distance measure. This combination represents a customary approach for applications assessing environmental data. HCA is an agglomerative classification method assigning groups based on the similarity of their data into branches of a dendrogram. HCA was used to cluster plots by a single multivariate assessment of three variables for each plot. This is referred to as the Hydrometric Classification because the three variables are suspected to be influenced by plot hydrology, but are not direct measures of hydrology. These variables include the percent of the total canopy cover (uppermost stratum) with combined Florida Department of Environmental Protection (FDEP) wetland plant index assignments of facultative wet (FACW) and obligate (OBL)[1]. This variable, labeled as %FACW+ represents an index of what percentage of the uppermost vegetative stratum consists of species that tend to occur in wetlands. The second variable is the depth to hydric soil indicators encountered in the soil cores. This measure indicates the prevailing or routinely achieved maximum saturated water levels in the soil, thus incorporating soil indicators of plot wetness. The third variable was the total percent groundcover measured in each plot. The premise for including percent groundcover rests on a concept that areas with very high sustained water depths or routine wide fluctuations in water levels are less likely to support high densities of low-lying species. Minitab files are provided in digital **Appendix B**.

The approach entailed separately using each classification method to explore multiple potential groupings in apparent community types. The multivariate classification methods were used to generate hypotheses concerning the group membership of plots. These hypothesis were then tested using a parametric statistic on data not used in the hypothesis generation statistics. The test used, Analysis of Variance (ANOVA), determines if statistically significant differences occur among group means. If ANOVA indicates significance, then the means are compared for each pair of groups using post-hoc tests to determine which groups are not similar to each other. The apparent groups were reduced if post-hoc ANOVA tests failed to detect pairwise differences between them in the preliminary assignments. The idea was to start with overly refined groupings (too many groups) and then agglomerate them until ANOVA indicated statistically-significant differences in their mean bankfull depth for all pairwise comparisons. In other words, seek a classification where all groups are different from each other. If the preliminary groups had all split cleanly, they would have been further parsed until clean separation was not achieved, accepting

[1] As listed in Chapter 62-340 in the Florida Administrative Code.

the last clean partition as the correct one. This did not occur though. In all three classifications we achieved an overly split grouping on the first pass, with the next logical grouping achieving clean pairwise separations on the second attempt.

The variable used for the ANOVA hypothesis testing of group membership was mean plot depth above the bankfull flow profile. Mean plot depth was calculated by subtracting the bankfull profile elevation at a transect from the average elevation of the survey points made in each vegetation plot occurring on the same transect. Subtracting the bankfull elevation from plot elevation provides a depth measure that is corrected for the roughly 30 foot vertical decline in valley elevation as one moves downstream, and it avoids the significant amount of noise related to depth calculations referencing stream bed or other ground elevations. **Figure 4** depicts a HEC-RAS water surface profile (WS-PF-15) close to the bankfull stage and the stream bed ground elevation for the study area. The streambed routinely fluctuates more than 10 vertical feet over short longitudinal distances.

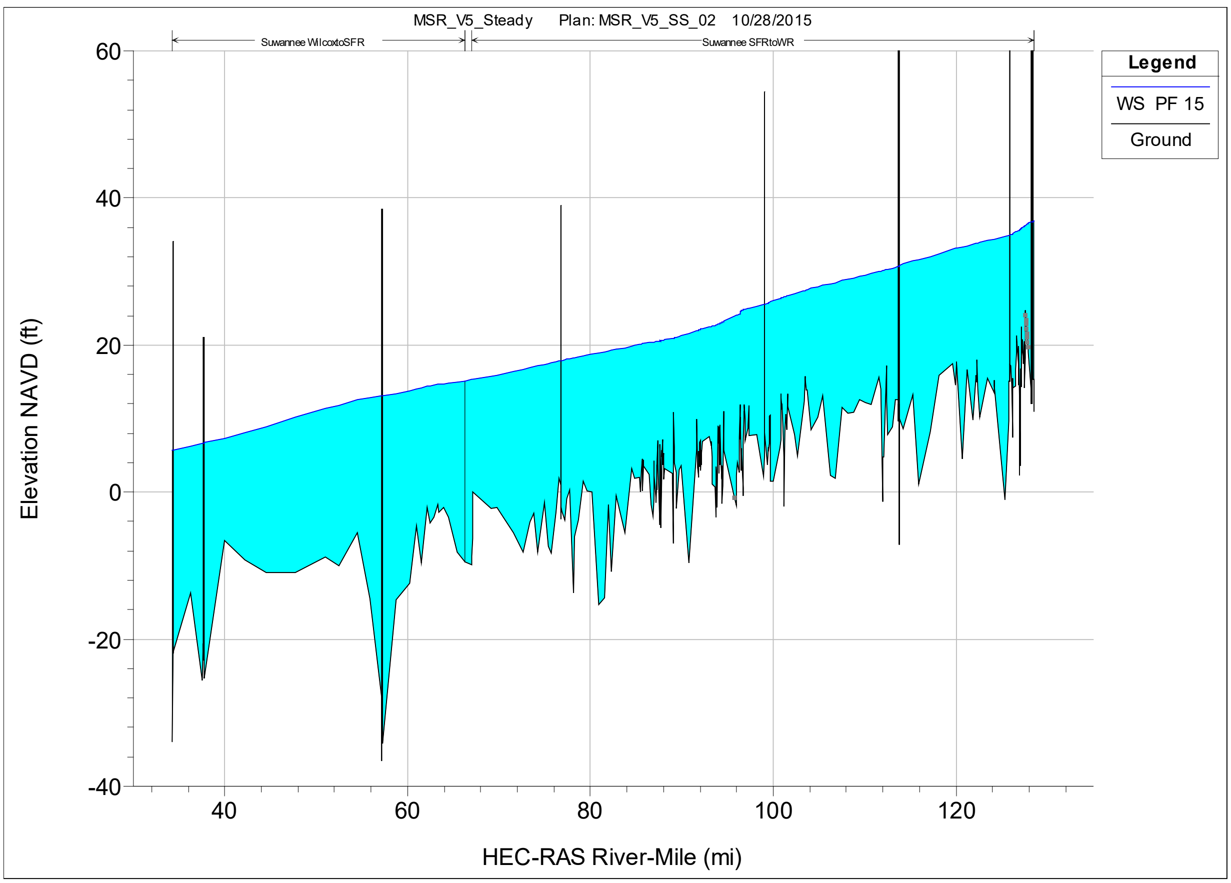

Figure 4 - Bankfull Flow Profile and Streambed Elevation

Bankfull stage was defined based on the average elevation of the scour line and convex inflection field indicators described in Amec Foster Wheeler (2015) (**Figure 5**). Bankfull stage was egressed versus HEC-RAS river-mile[2] so it could be estimated for any location along the study area. Bankfull stage is an important floodplain metric itself and is described in some more detail later.

Figure 5 - Bankfull Stage Indicators

Each of the three classification approaches generated three community categories clearly sorting along a hydrologic gradient (associated spreadsheets provided in digital **Appendix C**). This enabled a straightforward method for assigning final group membership for each plot based on a comparison of how the three methods individually classified the plot into comparatively dry, intermediate, and wet communities. Majority rules were applied based on having at least two methods agree on a wet, intermediate, or dry grouping. If a plot did not classify similarly on at least 2 of the 3 methods, it was classified at the intermediate level. One site was rejected from further assessment because it was very narrow, did not encompass any trees and was therefore missing canopy data. Of the remaining 99 sites, 54 were classified identically by all three methods, 42 by a two-method majority, and 3 based solely on the intermediate value.

ANOVA was then re-run on the 'depth above bankfull' variable for the plots based on their majority group membership to confirm the validity of the final grouping. The final grouping was statistically significant for all pairwise comparisons, so it was then used to develop regressions of maximum

[2] HEC-RAS is a hydraulic modeling code maintained by the U.S. Army Corps of Engineers. The cross-sections used in that model are inventoried and sequenced based on the linear distance along the river moving in an upstream direction. Amec Foster Wheeler adopted the HEC-RAS river-mile designations used by ECT (2014) for our study area to provide a consistent and convenient frame of reference.

surveyed plot elevation for the two lowest wetland communities (Deep Swamp and Bottomland Swamp) versus their respective locations according to river-mile. The driest Upper Surface in the floodplain was mapped from the upper Bottomland Swamp boundary to the limits of the 10-year floodplain. The lowest wetland community (Deep Swamp) required a lower limit to be mapped. This was set using the woody plant limits surveyed along the river channel margins as part of the bankfull stage and spring run assessments (Amec Foster Wheeler 2015). Elevations below that 'treeline' were categorized as Open Water. Thus the primary mapped community types from wettest to driest include Open Water, Deep Swamp, Bottomland Swamp, and Upper Surface. As will be discussed later, the Upper Surface was further divided into two geomorphic units (an Upper Terrace community and Upper Active community).

To support mapping, the upper elevations surveyed for plots of the same community type on the same transect were averaged to avoid potential pseudo-replication in the regression versus river-mile[3]. The scatter pattern of the data was then examined for potential inflections along the profile and piecewise regressions were fit at the inflection(s) as deemed appropriate. The scatter suggested an inflection near river-mile 90 for most of the profiles. That inflection occurs within a major geomorphic anomaly in the river valley where it rapidly descends between two bedrock shoals between river-miles 96 and 88. The anomaly presents itself as a deeply entrenched river valley, virtually lacking an alluvially active floodplain and effectively functioning as a canyon. The canyon is downstream of where Peacock Springs discharges to the river, and runs from roughly river-mile 94 to 90.

No inflection was apparent for the Deep Swamp community (**Figure 6**), so a simple linear regression was fit. The scatter implied an inflection at river-mile 90 for the Bottomland Swamp community (**Figure 7**) and a piecewise regression was fit using a knot at river-mile 90.[4] The Open Water surface was the most complex, with an apparent knot at river-mile 90 and a constant elevation set downstream of river-mile 39.5 where the system is more greatly influenced by tide (**Figure 8**). The resulting elevations in feet NAVD (EL) versus HEC-RAS river-mile (RM) were calculated using the following equations:

<u>Deep Swamp</u>
EL = -5.39 + 0.3274*RM
n = 11 and r^2 = 98.3%

<u>Bottomland Swamp</u>
Upstream of RM 90, EL = -11.19 + 0.4365*RM
Downstream of RM 90, EL = -3.99 + 0.3565*RM
n = 18 and r^2 = 97.9%

---

[3] Plot locations were selected in a stratified random manner as described in Amec Foster Wheeler (2015). This means they can be treated as independent samples for most analyses. However, the plots were also organized along transects whereby each transect represents a single position along the river. Therefore, plots of the same community on a single transect constitute redundant samples versus river-mile. To avoid pseudo-replication among samples versus river-mile, the values of redundant plots along a given transect were simply averaged and used as a single data point for that community at that river-mile location. The effect of pseudo-replication would have placed an unintended weight on the transect locations where redundant community plots occurred.

[4] A knot is simply the location where an inflection point is assigned in a piecewise regression. It is the location where the two adjacent equations provide an identical result.

Open Water
Upstream of RM 90, EL = -12.232 + 0.3243*RM
Between RM 39.5 and 90, EL = -10.54 + 0.3055*RM
Downstream of RM 39.5, EL = 1.53
n = 15 and r^2 = 96.9% (from RM 39.5 upstream)

A linear model with an interaction term representing the piecewise effects was developed for each regression to determine if piecewise regression made a statistically significant improvement versus simple linear regression. In all cases the overall model was statistically significant ($p < 0.0001$), but the piecewise approach did not appear to add a statistically significant interaction. However, a good physical rationale exists for the piecewise approach and it was retained because it did not harm the overall model significance or fit (r^2).

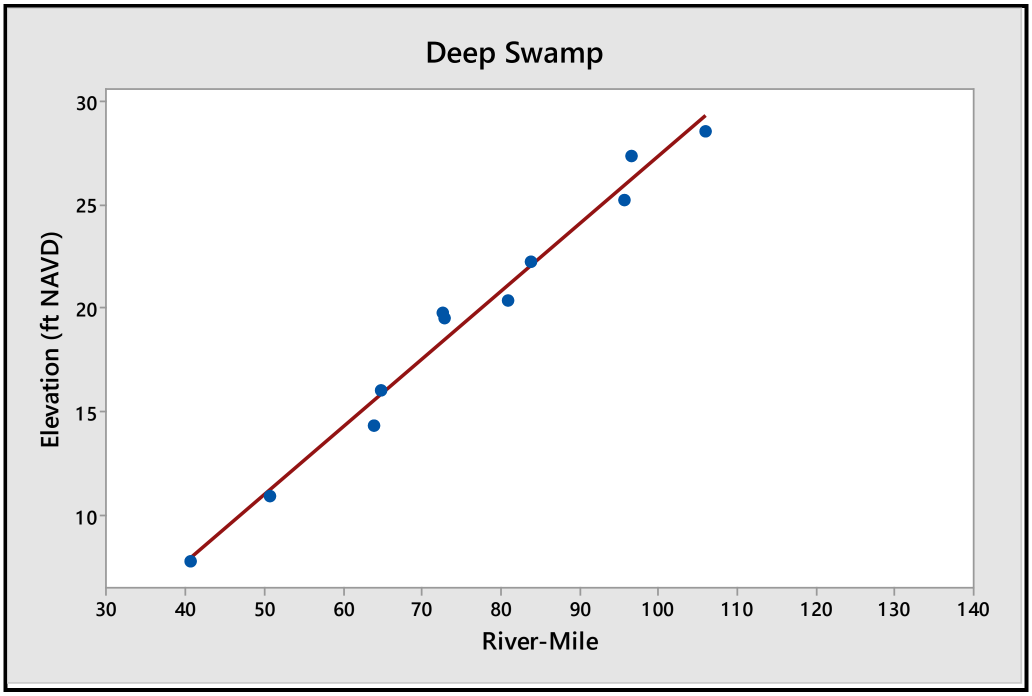

Figure 6 - Deep Swamp Elevation versus River-Mile

The regression lines were used to create and intersect a declining surface with the LiDAR DEM ground elevations in ESRI ArcGIS. The regressed surfaces are akin to the fluid elevation that, on average, fills each of the two wetland types to their vertical and horizontal limits along the valley profile. Subtracting the regressed surface from the ground elevations results in a mapped surface of that community type. The mapped community was compared to that assigned to each plot location and was found to be in 82% agreement. This result is at least as good as typical wetland mappings using georeferenced aerial photography and selected ground-truthing. However, the 82% level of concordance is based on an assessment of the plots that were used to generate the model. A random ground sample of community type versus that mapped would provide a less biased estimate of the model’s accuracy.

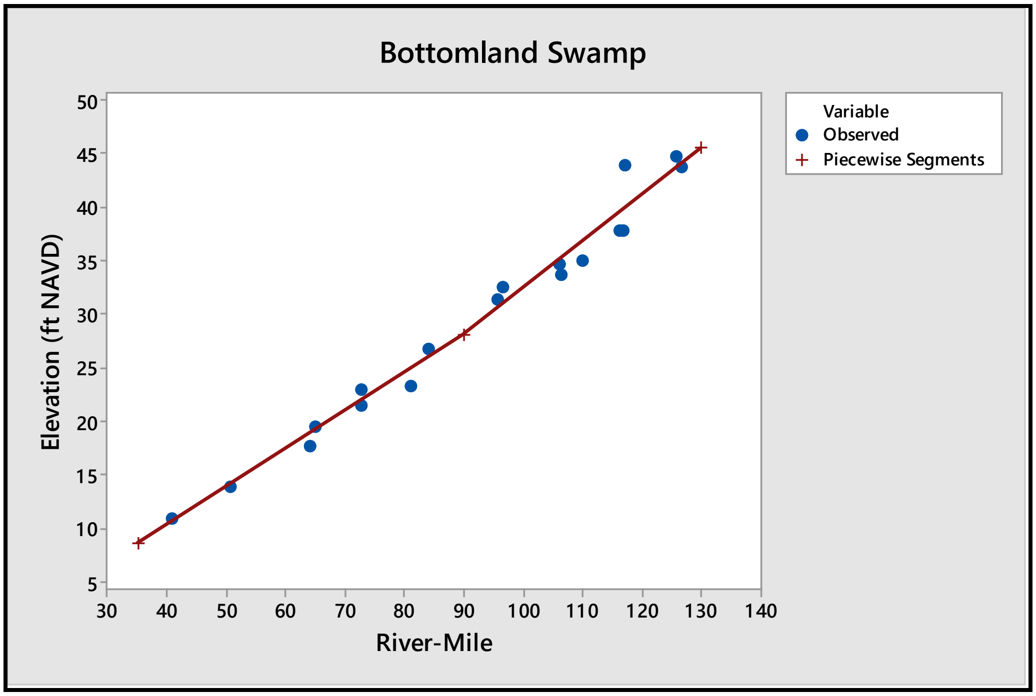

Figure 7 - Bottomland Swamp Elevation versus River-Mile

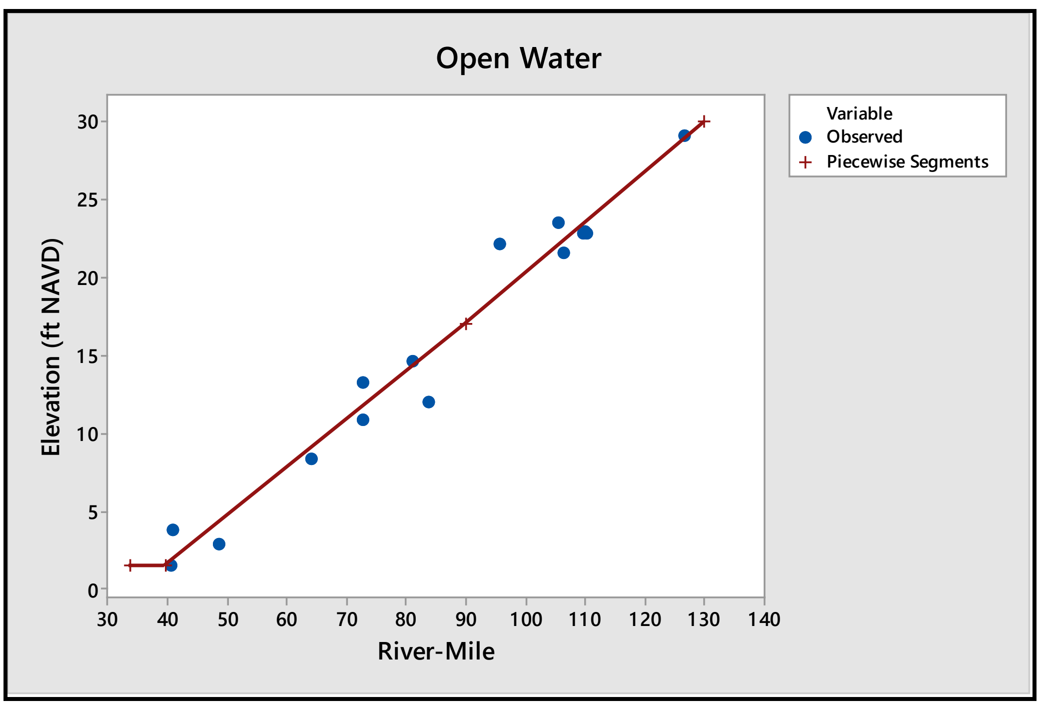

Figure 8 - Open Water Elevation versus River-Mile

In addition to the community assessments, two fluvial geomorphic profiles were linearly regressed against river-mile; bankfull stage and alluvial ridge crests. Bankfull stage occurs at or near a hydraulic break where stream channel carving processes begin to give way to floodplain building. Bankfull stage thus provides a process-oriented way to characterize the boundary between the river channel and floodplain. The bankfull profile was identified by fitting a piecewise regression through the average of the two most reliable field indicators of bankfull stage (**Figure 9**). The field indicators were the rooted scour line and the upper convex inflection along the bank which tended to straddle the prevailing floodplain surface elevations behind the alluvial ridge along each transect. The piecewise linear regression of the bankfull profile generally corresponded to the HEC-RAS river profile of the 20% exceedance discharge for the study area, which is well within the normal range of bankfull flow of large Florida rivers and perennial streams, which average 24% exceedance (Kiefer et al. 2015). The bankfull profile represents the part of the flow regime that does the most overall work to maintain the open channel. It can also contribute sediment to the lowest parts of the floodplain with river access.

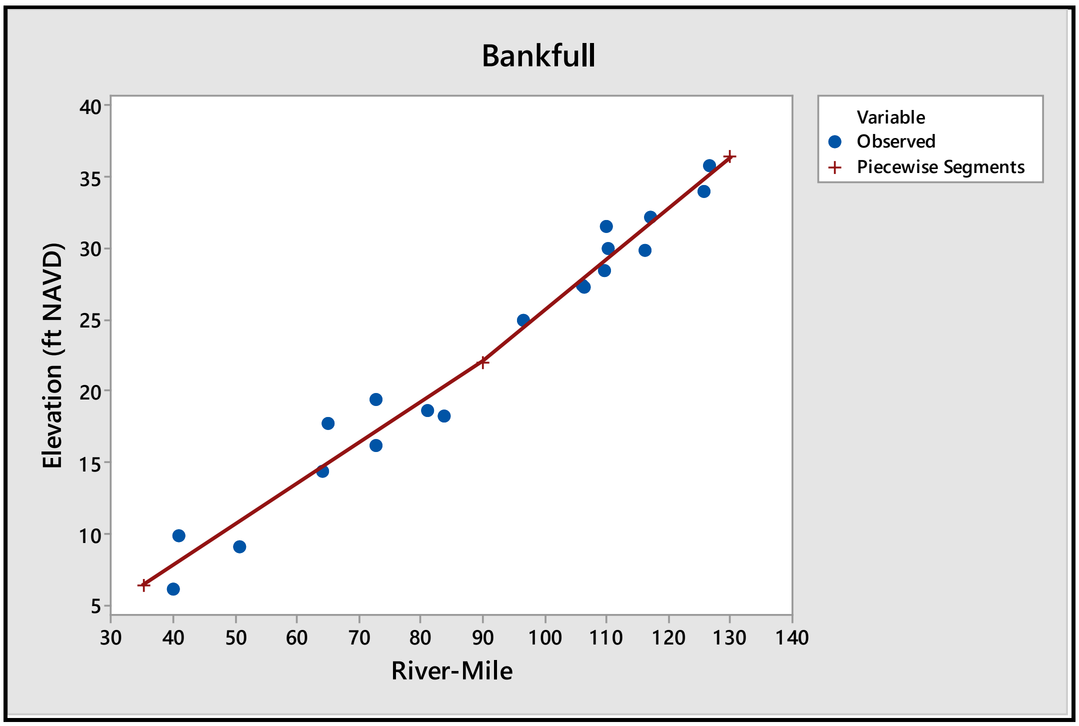

Figure 9 - Bottomland Swamp Elevation versus River-Mile

The alluvial ridge represents an upper surface that is actively maintained by sporadic floods, generally occurring at close to a five year return interval on the lower Suwannee River (Light et al. 2002). In fact, an approximately 5-year flood occurred during our field study and it crested the alluvial ridge in many places, depositing a veneer of fresh sand on it. The alluvial ridges in the study area are typically formed by sand depositing close to the river margins as flood waters rise. It is the first place the river can drop the heavier sediments it is carrying during a flood, and most alluvial rivers have such ridges. Alluvial ridge elevations are highly variable and the ridge sometimes pinches down to lower crest elevations around bends and as it approaches natural breaches near floodplain swale inlets. Therefore ridge elevation data was selected only from surveyed locations deemed to be representative of the local ridge crest. Local low areas near breaches and pinch-down areas were excluded. The alluvial ridge crest profile was defined by fitting a piecewise regression of the elevations of the selected sample areas versus the HEC-RAS river mile designations (**Figure 10**). The profile falls between the 2% and 5% HEC-RAS exceedance profiles downstream of Luraville. This is within the range of floodplain-forming flows estimated for Florida perennial blackwater streams, with a mean exceedance of 2% (Kiefer et al. 2015). The alluvial ridge is crested for an even shorter period upstream of Luraville, with discharge exceedances ranging between 1% and 2%.

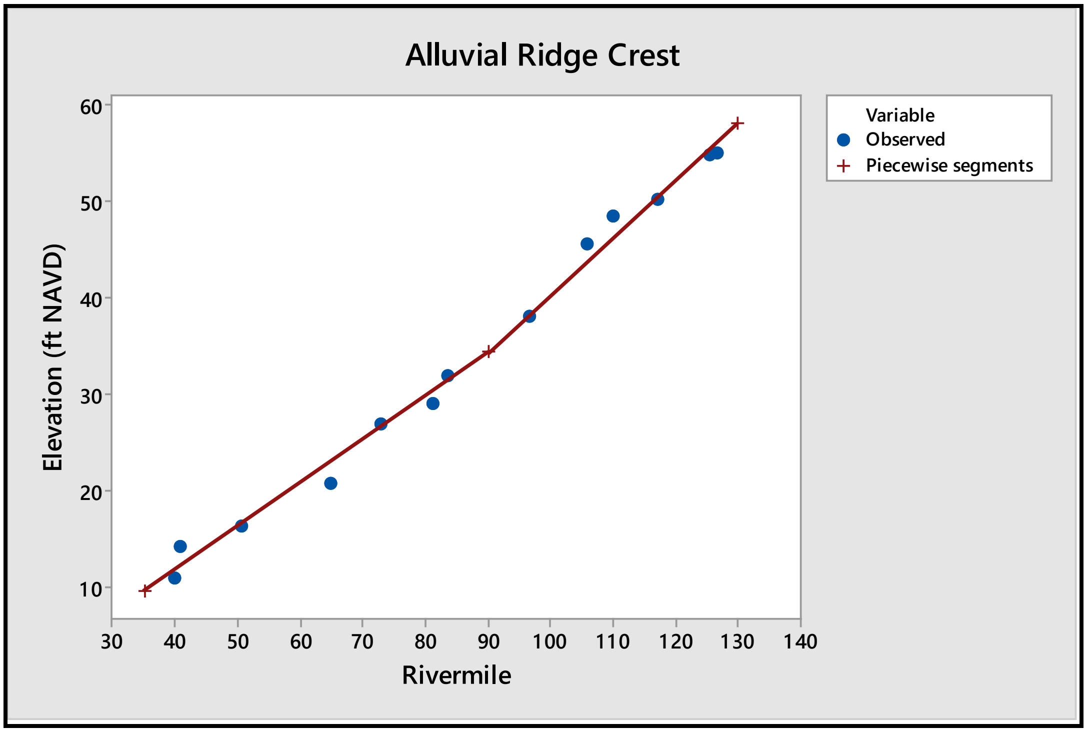

Figure 10 - Alluvial Ridge Crest Elevation versus River-Mile

The equations used to develop the fluvial geomorphic profiles are:

<u>Bankfull Stage</u>
Upstream of RM 90, EL = -10.354 + 0.3600*RM
Downstream of RM 90, EL = -3.55 + 0.2844*RM
n = 19 and r^2 = 97.4%

<u>Alluvial Ridge Crest</u>
Upstream of RM 90, EL = -19.153 + 0.5940*RM
Downstream of RM 90, EL = -6.22 + 0.4503*RM
n = 13 and r^2 = 99.3%

The bankfull and alluvial ridge crest regressions models were statistically significant ($p < 0.0001$). The interaction term did not add statistically significant value to the bankfull regression. However, a good physical rationale exists for the piecewise approach and it was retained because it did not harm the overall model significance or fit (r^2). The interaction term was statistically significant for the alluvial ridge crest ($p = 0.039$), lending an additional reason to use the piecewise regression for it as well.

The Upper Surface community was mapped up to the reported limits of the 10-year floodplain, which provides a good visual fit to where the river's valley bottom ends and its adjacent valley hillslopes transition into the palustrine landscape. In other words, the 10-year floodplain approximates the external limits of the riparian corridor. FDEP (2010) mapped about 30% of Upper Surface community with altered land uses including pine plantations, improved pasture, low density residential areas, hay fields, and electric power transmission lines, among others. This amount of alteration is much greater than that of the bottomland swamp (5%) and deep swamp (2%) communities, suggesting decreased land use conversions associated with increased flood frequency and depth. This implies some level of flow-dependency for the elimination of native habitat in the floodplain. In other words, the flow regime affects land use.

Further, the Upper Surface community can be divided into areas above and below the alluvial ridge crest elevation. This crest elevation represents a water level that is exceeded approximately once every 5 to 10 years. The Upper Surface below the alluvial ridge elevation floods every 2 to 5 years. This division is potentially important for two reasons. First, it occurs near the 5-year return interval Light et al. (2002) reported as being the upper threshold for wetland community sustainability, and second it represents an upper elevation at which a threshold of major alluvial work (sandy ridge building) occurs. Because the lower of these two divisions of the Upper Community floods more frequently, the river is doing more re-working of that surface over time. In other words, it is likely to be more alluvially active. The portion of the upper surface at or below the alluvial ridge elevation is hereafter referred to as the 'active' surface because it more routinely floods at an elevation with the potential to conduct alluvial work. This part of the Upper Surface community is hereafter referred to as the Upper Active community. Land at higher elevations are not only flooded less frequently, their floodwaters have been substantially depleted of sand, most of which has been deposited on or near the alluvial ridge. This combination of reduced events and sediment depletion means less work is conducted on the uppermost surface.

Upper river valley surfaces with limited potential for routine alluvial work are often referred to as 'terraces'.Therefore this community is referred to as the Upper Terrace. Given the lower flood frequency, perhaps it is not surprising that land use conversion based on FDEP (2010) maps occurred on 38% of the Upper Terrace, almost double that of the 21% conversion of the Upper Active community. The most dominant land use conversion, pine plantation, would seemingly be a more risky venture if planted in areas that flood less than once every 5 years. **Figure 11** shows a rather illustrative example of an Upper Surface community where a landowner on the east side of the riparian corridor cleared almost exactly along the Terrace versus Active boundary, preserving the native cover of the Upper Active area and planting pines on the Upper Terrace.

From a native community perspective, however, it does not appear that the Upper Active and Terrace communities are distinguishable based on the results of exploratory ordination analyses. The Upper community is therefore best viewed as one plant community divided into two geomorphic surfaces. Ordination analyses resulted in a testable hypothesis that three kinds of floodplain communities occur within the MSR's riparian corridor, differing in their relative elevations and hydrologic associations. This was first tested using the aforementioned 'elevation above bankfull' metric in ANOVA. All pairwise comparisons exhibited statistically significant differences. These elevation differences averaged 0.9, 5.9, and 11.1 feet for the low, intermediate, and high communities.

Further testing utilized transect topographic surveys and 12 months of daily water level data from the monitoring wells installed for this project. This data was used to assign the annual hydroperiod for each vegetation plot near a monitoring well (n=64 plots). The hydroperiod is simply the percent of time the wetland was inundated at or above its outer edge during the 12 month period of record.

The mean hydroperiods of all three communities were statistically significantly different based on the ANOVA results. The low, intermediate, and high communities had average hydroperiods of 25%, 14%, and 5% respectively.

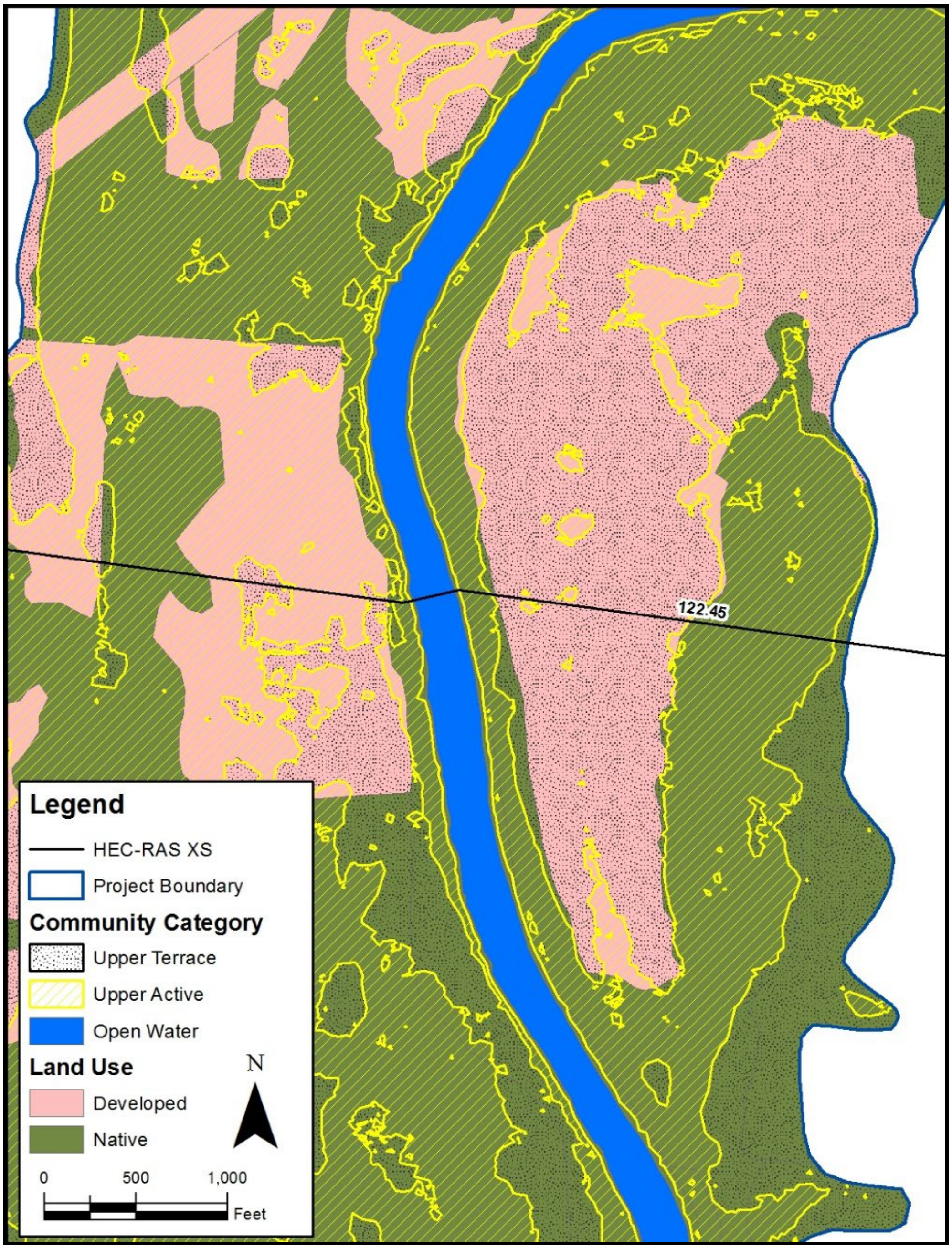

Figure 11 - Land Use Comparison for the Two Upper Surfaces

The final test utilized a general linear model to holistically evaluate the statistical significance of the surface slopes and, if applicable, the constants for three linear regressions representing the mean elevations versus river-mile for three categorical variables (the Upper Active (alluvial ridge crest), Bottomland Swamp, and Deep Swamp communities). **Figure 12** provides a graphical representation of the model being tested. The overall model was statistically significant (p<0.0001). Statistically significant contributors to the model included river-mile (P<0.0001) and all three pairwise comparisons of the regression slope coefficients. Because the slopes differed, further comparisons of the regression constants are largely irrelevant. The general linear model confirmed statistically significant differences among the elevations of all three of these community types in association with river-mile, further supporting the hypothesis that they are distinct entities. In summary, they differed in their average elevation above bankfull stage, their hydroperiod during a nominally 5-year flood, and the slopes of their profiles along the river.

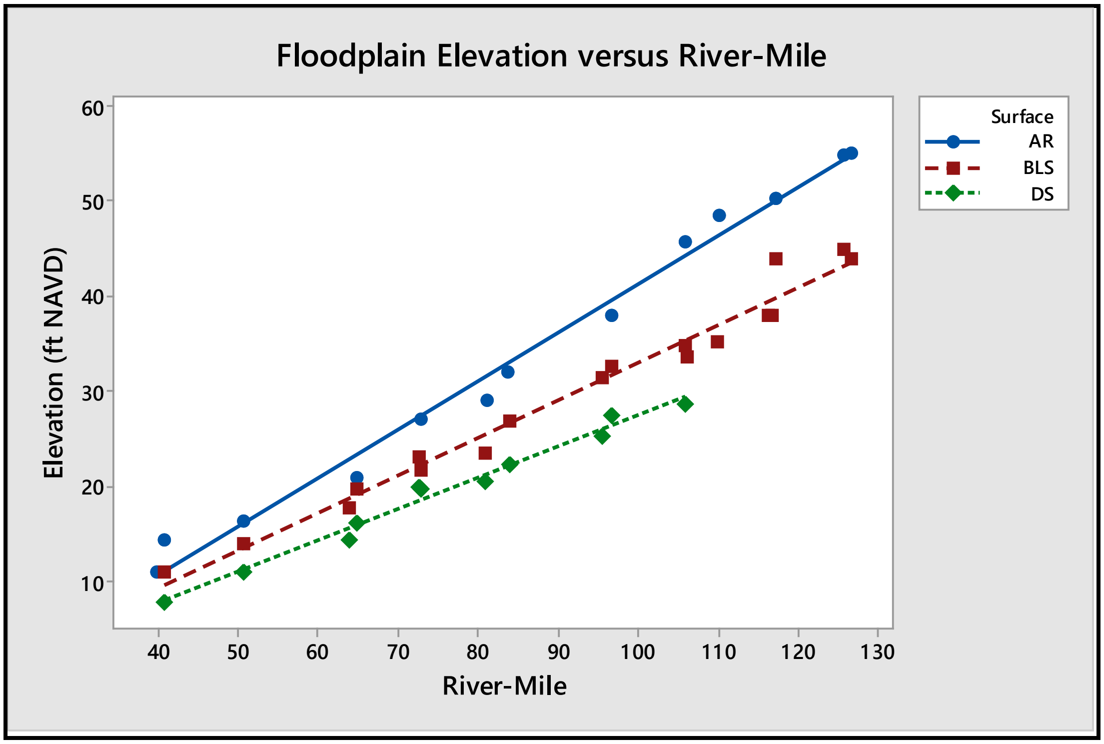

Figure 12 - General Regression Model for Three Surfaces

2.0 COMMUNITY DESCRIPTIONS

2.1 Geomorphic Setting

The Deep Swamps (DS), Bottomland Swamps (BLS), and the Upper Surfaces (UP) clearly exhibit differences in species composition along a hydrologic gradient. In other words, the communities are at least partially sorted by the variable sensitivity of their plant species to the depth, duration and frequency of water levels. There is overlap in species composition, but each community achieves distinguishing thresholds of certain kinds of indicator taxa. The communities also differ in their coarse associations with particular soil textures and geomorphic surfaces, both of which are structured themselves by fluvial forces, groundwater flow, and sediment transport.

The surfaces occupied by these communities range from a couple of feet below bankfull stage to more than 10 feet above it. This wide range of elevations depends on an array of active geomorphic processes that form the physical template upon which the plant communities depend. Thus it is important to understand and protect the geomorphic and related sediment transport processes from significant harm to sustain the natural distribution and function of the floodplain communities. The MSR delivers large, relatively routine flood pulses that not only variably wet these surfaces over time, but build the floodplain and alter its topography. The main floodplain surface consists of a broad valley flat (BVF) that is being rather inexorably re-worked by fluvial and karst processes. In many Florida river systems the BVF is the dominant floodplain surface, but the geological and alluvial processes in the MSR often severely dissect the BVF rendering it as a series of islands within many areas of the floodplain (see **Figures 13** through **18** for examples).

One of the main floodplain building processes occurs as the river channel migrates across its valley over many years, leaving series of low ridges and swales in its wake called lateral accretions (LAR, LAS) (**Figure 13**). The river also deposits comparatively thick amounts of sand along its shoreline, forming some of the highest ground in the floodplain on alluvial ridges (AR) located right along the deep open river channel's margins (**Figure 13**). AR's comprise one form of vertical accretion in the floodplain.

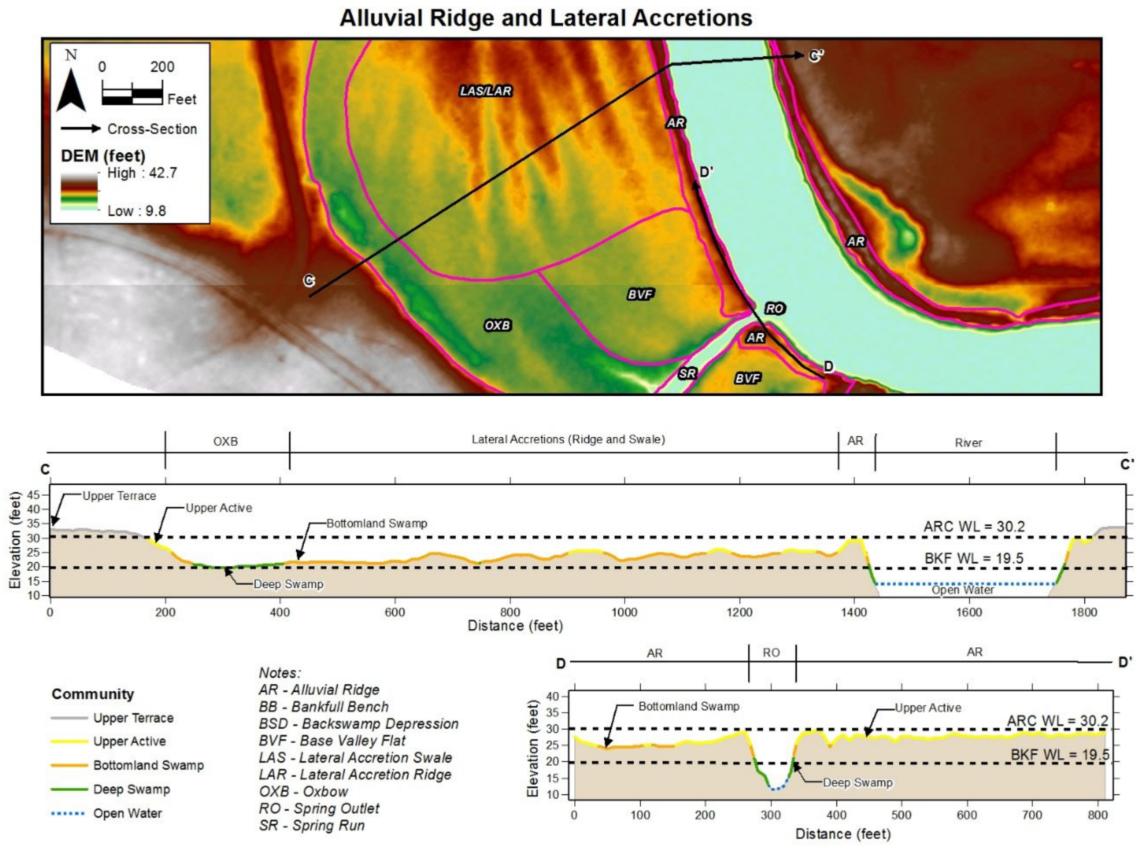

Figure 13 - Alluvial Ridge and Lateral Accretion Topography and Communities

Some of the wetlands in the floodplain follow suddenly abandoned river courses, called oxbows, which are subsequently, gradually, and partially filled by fine sediments over time (**Figure 14**). This sedimentation in the wake of channel abandonment is another kind of vertical accretion.

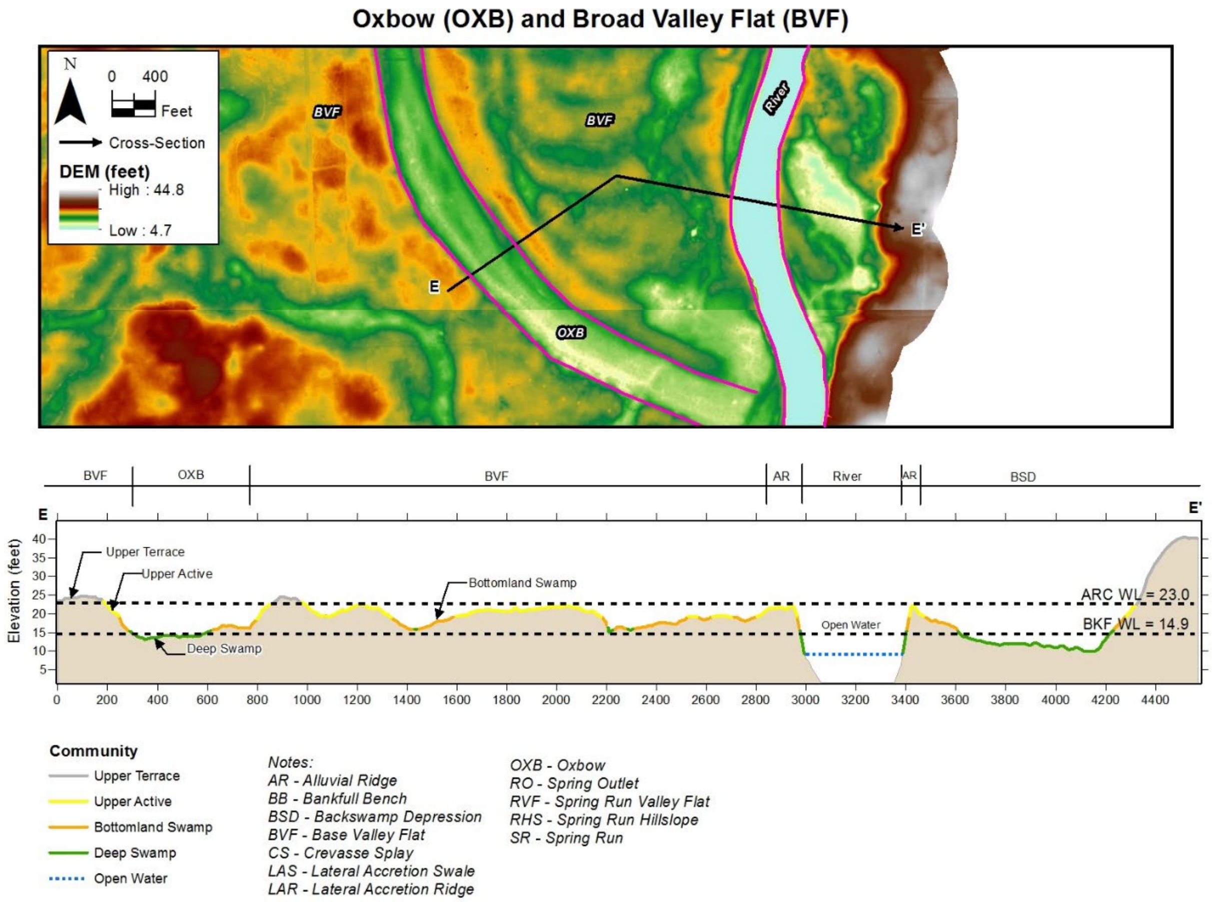

Figure 14 - Oxbow and Broad Valley Flat Topography and Communities

Although comparatively uncommon, some sand bars persist along portions of the channel forming benches submerged by bankfull discharges (**Figure 15**). These persistent 'bankfull benches' are colonized by water-loving tree and shrub taxa. Narrow bands of trees also occur below bankfull stage along portions of the river channel margins. These fringe forests provide shade and submerged structure in shallow water that are likely to provide habitat benefits for aquatic fauna not occurring elsewhere in the system, except along spring runs.

Bankfull Bench

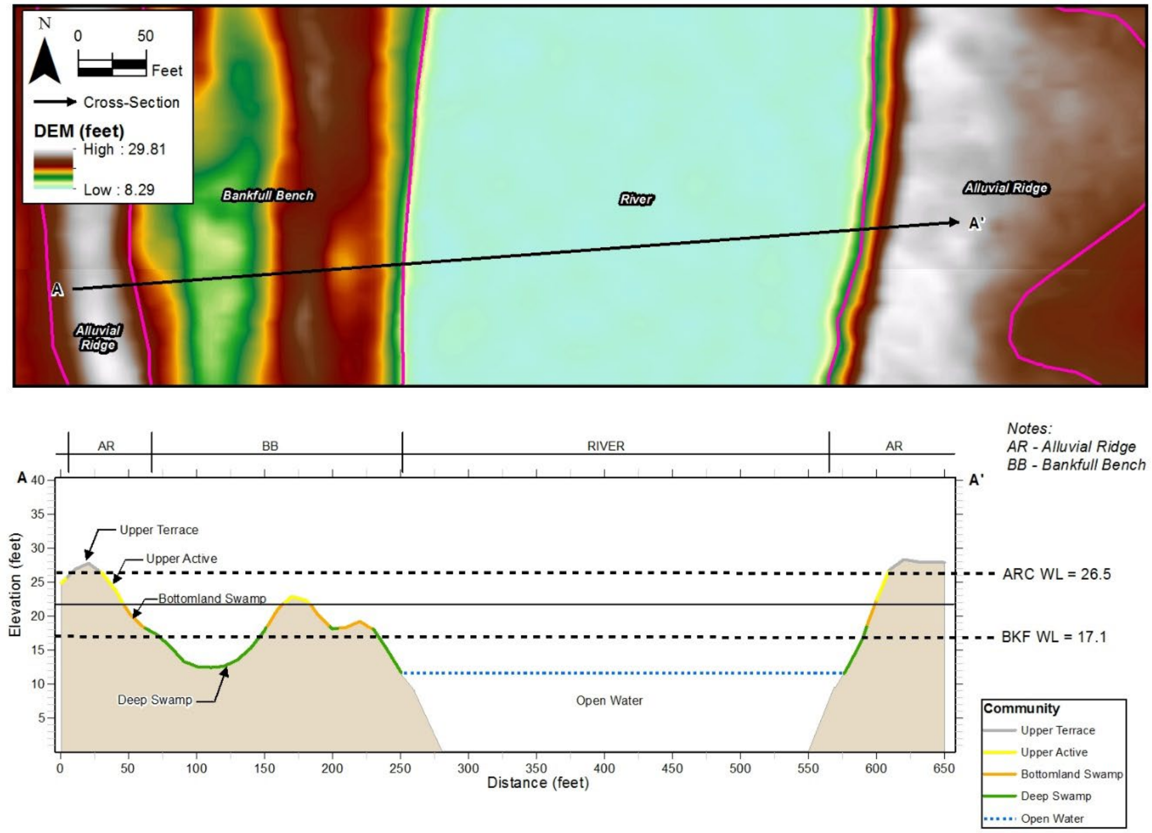

Figure 15 - Bankfull Bench Topography and Communities

Thin layers of silt and clay are frequently deposited on the BVF and in the broader swamps and swales located in the floodplain beyond the alluvial ridge, gradually changing their elevations. This sedimentation is another mechanism of vertical accretion that builds and maintains the floodplain. In some places the river occasionally breaks through its alluvial ridge, rather catastrophically eroding its sandy material to form small deltas fanning out into the adjacent swamps. These deltas are referred to as 'crevasse splays' (**Figure 16**). This process is normally associated with major alluvial rivers in the mid-western and western United States, but is an uncommon floodplain building process for Florida rivers.

Most lateral and vertical accretions are gradualistic processes, with incremental work being done to build and maintain the floodplain every year to once every few years. River channel abandonments leading to oxbow formation and new crevasse splays are likely to be more sporadic (or nominally 'catastrophic'), perhaps occurring once every decade or less. Collectively, these factors represent the means by which the river builds and maintains the floodplain with a variety of fluvial and alluvial processes that variably scour and deposit sediments. Most of these floodplain re-working activities occur between bankfull and alluvial ridge crest elevations. But these alluvial processes are not the whole story because the MSR valley occupies a karst terrain.

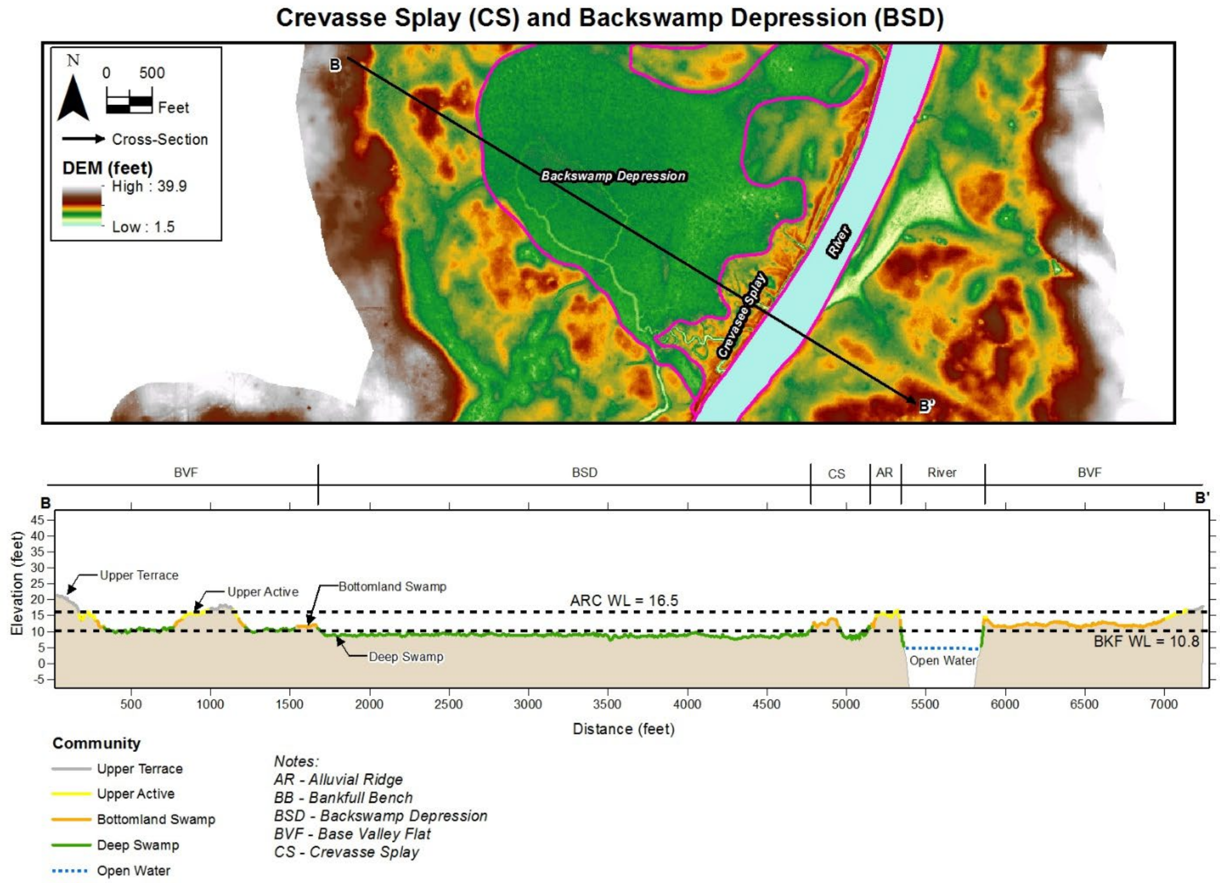

Figure 16 - Broad Surface Depression and Crevasse Splay Topography and Communities

For example, the river routinely accesses its floodplain through perennial openings in the alluvial ridge maintained by karst hydrogeology. These breaches in the AR are typically maintained by copious groundwater discharge emanating from the larger springs found scattered within the floodplain (**Figure 13**). It seems possible that crevasse splays would be more common without these permanent openings, which effectively function like pressure relief valves for the ridge by allowing water exchanges to occur at much lower elevations than the ridge crests. This is just one way that karst features modify the alluvial floodplain processes and appurtenant surfaces. These permanently flowing ridge openings seem likely to promote predictable and useful foci for fish passage between the river and floodplain habitats.

Some of the artesian springs such as Allan's Millpond, Otter Springs, and Peacock-Bonnet Springs form long runs within the floodplain, dissecting the river deposits at depths sometimes greater than 10 feet, thus creating rather permanent topographic relief and hydrologic gradients that would not otherwise occur at those locations. Each of these runs creates a stream valley within the main river valley. These valleys-within-a-valley create three unique surface types; a spring run (SR), a spring run valley flat (RVF), and a spring run hillslope (RHS) (**Figure 17**).

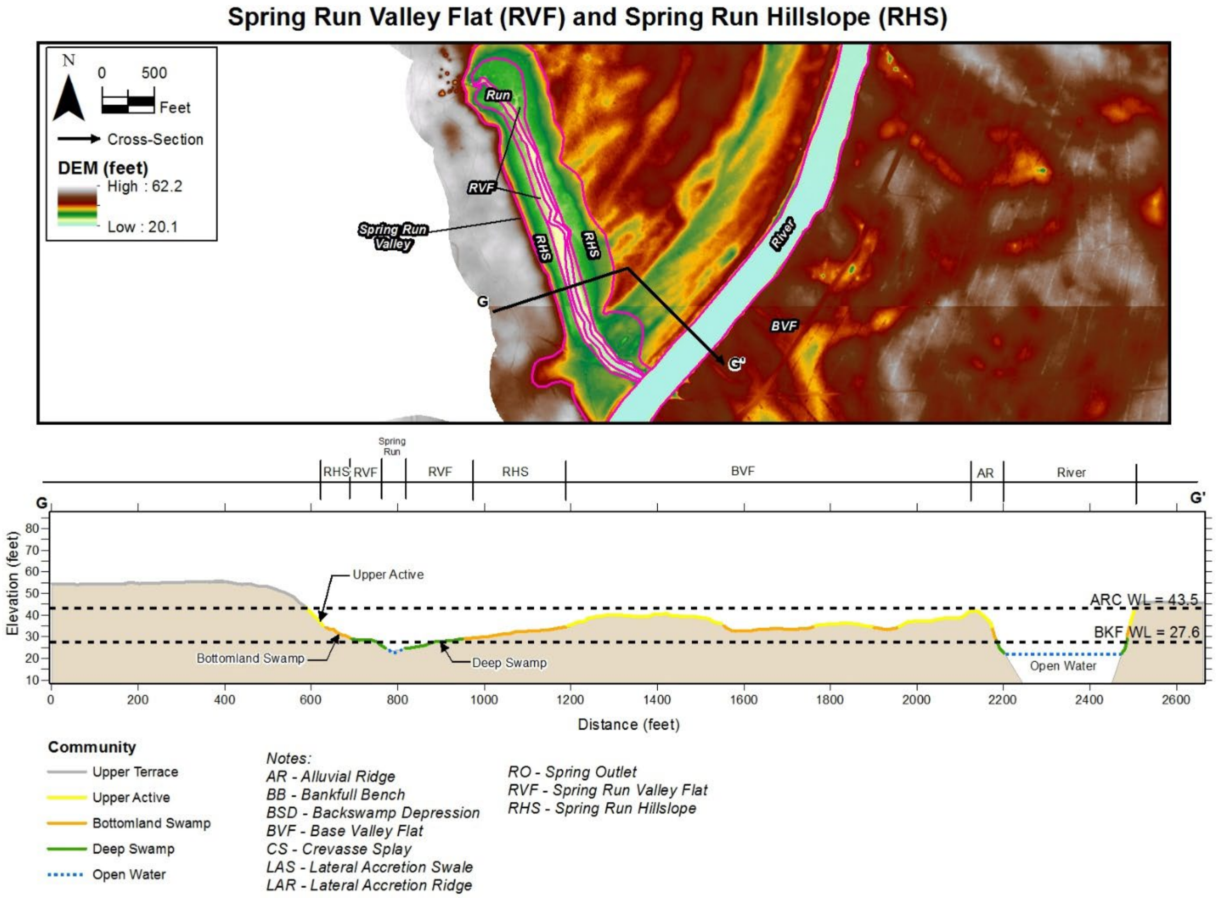

Figure 17 - Spring Run Surface Topography and Communities

In the upper reach of the MSR, other wetlands follow very linear and comparatively narrow depressions pocked with series of shallow clay-filled circular depressions indicating a karst lineament below (**Figure 18**). Thus some of the study area's wetlands occupy karst lineament swales (KLS). Some of the lineaments also have occasional karst window depressions (KWD) nearby, suggesting that while most of the solution features are mantled with alluvium from the river, others may be active at rates that are greater than the sedimentation rates in the floodplain.

In the lower reaches of the MSR valley, most of the largest and deepest wetlands occupy broad, rather polygonal-shaped depressions that are more suggestive of solution subsidence than fluvial processes. In fact it is along a couple of these backswamp depressions (BSD) that the crevasse splays have formed, perhaps because their dissolution has reduced elevations beyond what could support the adjacent natural levees (**Figure 16**). Groundwater upwellings called 'boils' were observed in the largest BSD traversed during the field study, adding further credence to the concept that such features are associated with a karst plain at least as much as they are with a floodplain.

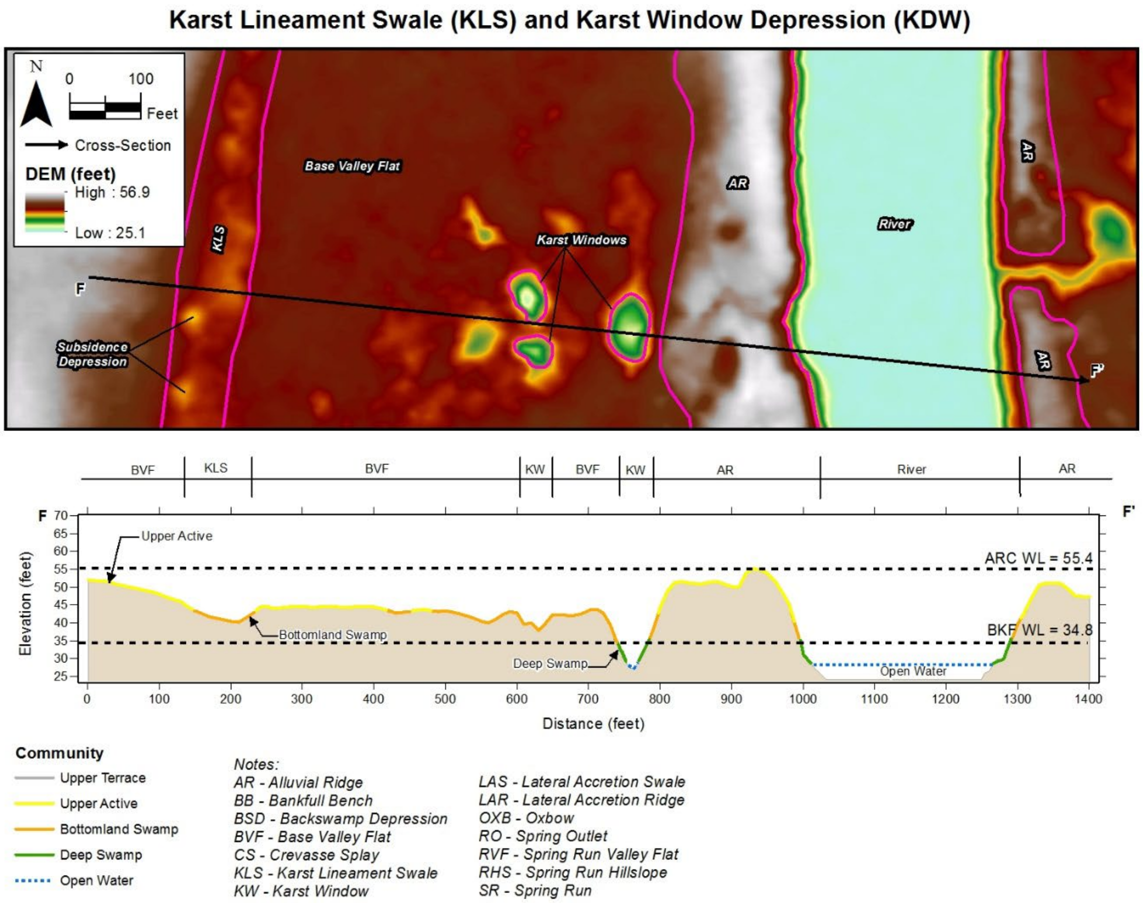

Figure 18 - Karst Lineaments and Window Topography and Communities

Even as the river variably builds and partially dissects its floodplain, the underlying karst hydrogeology further dissects and subsides it. These processes interact to result in a very rough topography, which is slowly dynamic. It is upon this shifting and complex ground that the riparian forests form. The result is a wonderfully complex patchwork of plant assemblages distributed somewhat chaotically among the three major community types. For these reasons, we attempted to characterize and describe the communities based not only on their species composition along a hydrologic gradient, but to also include information regarding their alluvial and karst surface associations and soil textures, as well as any apparent patterns or differences in forest structure. Forest structure is described based on the occurrence and density of leaf cover at three vertical strata including the bigger trees forming the canopy layer, smaller trees and woody shrubs forming an understory layer, and lower-lying plants forming the groundcover layer. Aspects of forest structure can vary with canopy maturity and species succession associated with the time between pulsed disturbances such as long-lasting floods or sediment transport episodes. Given all this background information, we can now describe the plant communities not only based on their vegetation but also in association with their physical environment.

2.2 Deep Swamps

Deep Swamps typically have a nearly closed canopy stratum, often with very large and mature trees, with low amounts of understory cover (average of 38% total cover) and the lowest amount of groundcover (average of 46% total cover) among the three community types (**Figure 19**). The moderate shrub and low groundcover levels likely are associated with the deep depths and longer hydroperiods achieved in these wetlands, which stress and increase mortality of short statured vegetation by completely submerging it for weeks at a time.

Figure 19a - Deep Swamp Forests
(a) Bald cypress along a spring run

Figure 19b - Deep Swamp Forests
(b) Pop-ash in floodplain depression

Forest composition is generally dominated by cypress trees, with some large patches alternatively or collectively dominated by overcup oak, planer tree, popash and water locust (**Table 1**). Some of the canopy species are also common understory components in these forests including popash, planer tree, and water locust (**Table 2**). The understory is not always simply a younger version of the canopy. It is not uncommon to have one of these three species dominating the canopy while one or two of the others form most of the understory. This suggests a rather dynamic forest condition with patches of particular species likely to move around the floodplain over time. Swamp privet and buttonbush also occur in patchy abundance, and some areas take on an appearance of a swamp privet thicket. Some of the shrubs occupy hummocks, which are microtopograhical features at higher elevation than the base of the swamp.

Table 1 - Deep Swamp Canopy Species

Scientific Name	Common Name	FDEP Index	Relative Frequency	Relative Basal Area	Relative Density	Importance Value	Cumulative Importance
Taxodium distichum	bald cypress	OBL	27.68%	62.04%	17.82%	35.85%	0.358
Planera aquatica	planer tree	OBL	16.71%	12.94%	13.86%	14.50%	0.504
Fraxinus caroliniana	Carolina ash	OBL	17.75%	2.71%	11.88%	10.78%	0.611
Gleditsia aquatica	water locust	OBL	6.53%	2.73%	8.91%	6.06%	0.672
Quercus laurifolia	laurel oak	FACW	3.13%	3.79%	6.93%	4.62%	0.718
Betula nigra	river birch	OBL	7.57%	1.85%	2.97%	4.13%	0.759
Quercus lyrata	overcup oak	OBL	3.39%	3.46%	4.95%	3.94%	0.799
Carya aquatica	water hickory	OBL	2.61%	2.17%	6.93%	3.90%	0.838
Fraxinus pennsylvanica	green ash	OBL	4.44%	2.70%	1.98%	3.04%	0.868
Acer rubrum	red maple	FACW	1.83%	1.88%	3.96%	2.56%	0.894
Ulmus crassifolia	cedar elm	FACW	1.57%	0.75%	2.97%	1.76%	0.911
Ulmus americana	American elm	FACW	1.57%	0.54%	2.97%	1.69%	0.928
Liquidambar styraciflua	sweetgum	FACW	1.04%	0.90%	2.97%	1.64%	0.945
Forestiera acuminata	swamp privet	FACW	1.57%	0.30%	2.97%	1.61%	0.961
Cephalanthus occidentalis	buttonbush	OBL	1.04%	0.12%	2.97%	1.38%	0.975
Quercus virginiana	live oak	UPL	0.26%	0.86%	0.99%	0.70%	0.982
Celtis occidentalis	hackberry	UPL	0.52%	0.15%	0.99%	0.55%	0.987
Crataegus aestivalis	mayhaw	OBL	0.26%	0.04%	0.99%	0.43%	0.991
Diospyros virginiana	common persimmon	FAC	0.26%	0.04%	0.99%	0.43%	0.996
Cornus foemina	swamp dogwood	FACW	0.26%	0.03%	0.99%	0.43%	1.000
TOTAL			100.00%	100.00%	100.00%	100.00%	

Soil layers are most often thick accumulations of fines (silt and clay); complex deposits of sand, clay and loam occurring in the upper 18 inches; or deposits of fines over sand. The emphasis is on fine inorganic sediments (**Figure 20**). In fact, only one site of 20 was on a thick sand layer without fines. Only two of the 98 soil cores from the monitored plots in the entire study area had muck layers. These were thin, and both were found in deep swamps. The virtual absence of muck is notable for a major Florida river. It indicates that soil building processes are mostly physical rather than biological for this system, consistent with its major fluvial forces and wide ranging water fluctuations.

Table 2 - Deep Swamp Understory Species

Scientific Name	Common Name	FDEP Index	Relative Cover	Relative Density	Importance Value	Cumulative Importance
Forestiera acuminata	swamp privet	OBL	39.52%	9.09%	24.31%	0.243
Fraxinus caroliniana	Carolina ash	OBL	26.39%	15.45%	20.92%	0.452
Planera aquatica	planer tree	OBL	12.47%	9.09%	10.78%	0.560
Cephalanthus occidentalis	buttonbush	OBL	5.04%	14.55%	9.79%	0.658
Gleditsia aquatica	water locust	OBL	2.52%	7.27%	4.90%	0.707
Cornus foemina	swamp dogwood	FACW	2.25%	4.55%	3.40%	0.741
Fraxinus pennsylvanica	green ash	OBL	3.98%	0.91%	2.44%	0.765
Taxodium distichum	bald cypress	OBL	0.80%	3.64%	2.22%	0.788
Bumelia reclianta	Florida bully	OBL	0.66%	3.64%	2.15%	0.809
Betula nigra	river birch	OBL	0.53%	3.64%	2.08%	0.830
Quercus lyrata	overcup oak	OBL	0.53%	3.64%	2.08%	0.851
Sabal minor	dwarf palmetto	FACW	0.53%	3.64%	2.08%	0.872
Ulmus americana	American elm	FACW	0.40%	2.73%	1.56%	0.887
Acer rubrum	red maple	FACW	0.80%	1.82%	1.31%	0.900
Crataegus viridis	green haw	FACW	0.66%	1.82%	1.24%	0.913
Carpinus caroliniana	musclewood	FACW	0.53%	1.82%	1.17%	0.924
Cyrilla racemiflora	swamp titi	FAC	0.27%	1.82%	1.04%	0.935
Ilex decidua	swamp holly	FACW	0.27%	1.82%	1.04%	0.945
Quercus laurifolia	laurel oak	FACW	0.27%	1.82%	1.04%	0.956
Vitis rotundifolia	musadine grape vine	VINE	0.66%	0.91%	0.79%	0.964
Acer saccharinum	silver maple	OBL	0.13%	0.91%	0.52%	0.969
Berchemia scandens	jackswitch	UPL	0.13%	0.91%	0.52%	0.974
Carya aquatica	water hickory	OBL	0.13%	0.91%	0.52%	0.979
Diospyros virginiana	common persimmon	FAC	0.13%	0.91%	0.52%	0.984
Hypericum sp.	St. Johns wort	FACW	0.13%	0.91%	0.52%	0.990
Liquidambar styraciflua	sweetgum	FACW	0.13%	0.91%	0.52%	0.995
Sebastiania sp.	sebastian bush	UPL	0.13%	0.91%	0.52%	1.000
TOTAL			100.00%	100.00%	100.00%	

Figure 20 - Deep Swamp Soil Core
(Silt over Stiff Clay)

Geomorphic surfaces include the low lying areas of the floodplain and channel margins that can be found on the valley flat and lower hillslopes of spring runs, oxbow depressions, polygonal depressions, swales of lateral accretions, karst lineaments, and bankfull benches (see cross-sections on **Figures 13, 14, 15, 16, 17,** and **18** for typical examples). Eleven of the 20 occurrences of these swamps in our sample were found on karst surfaces, highlighting the importance of hydrogeologic processes on these communities in the MSR.

Canopy cover among Deep Swamp plots averaged 98% FACW+OBL, indicating a rather ubiquitous wetland jurisdictional status of this community. Soils are hydric, with hydric indicators typically found within the upper inch of the soil profile. The deepest hydric indicator among the plots in this community was encountered only 2 inches below the ground surface.

The greatest concentrations of these swamps occur in the lower half of the MSR, with the most expansive areas found downstream of the confluence with the Santa Fe River where the floodplain is almost twice as wide as it is upstream (**Figure 21**). These communities frequently associate with karst features such as spring runs and subsidence depressions. **Figure 22** illustrates such an example where the only Deep Swamp in the area occurs along a spring run.

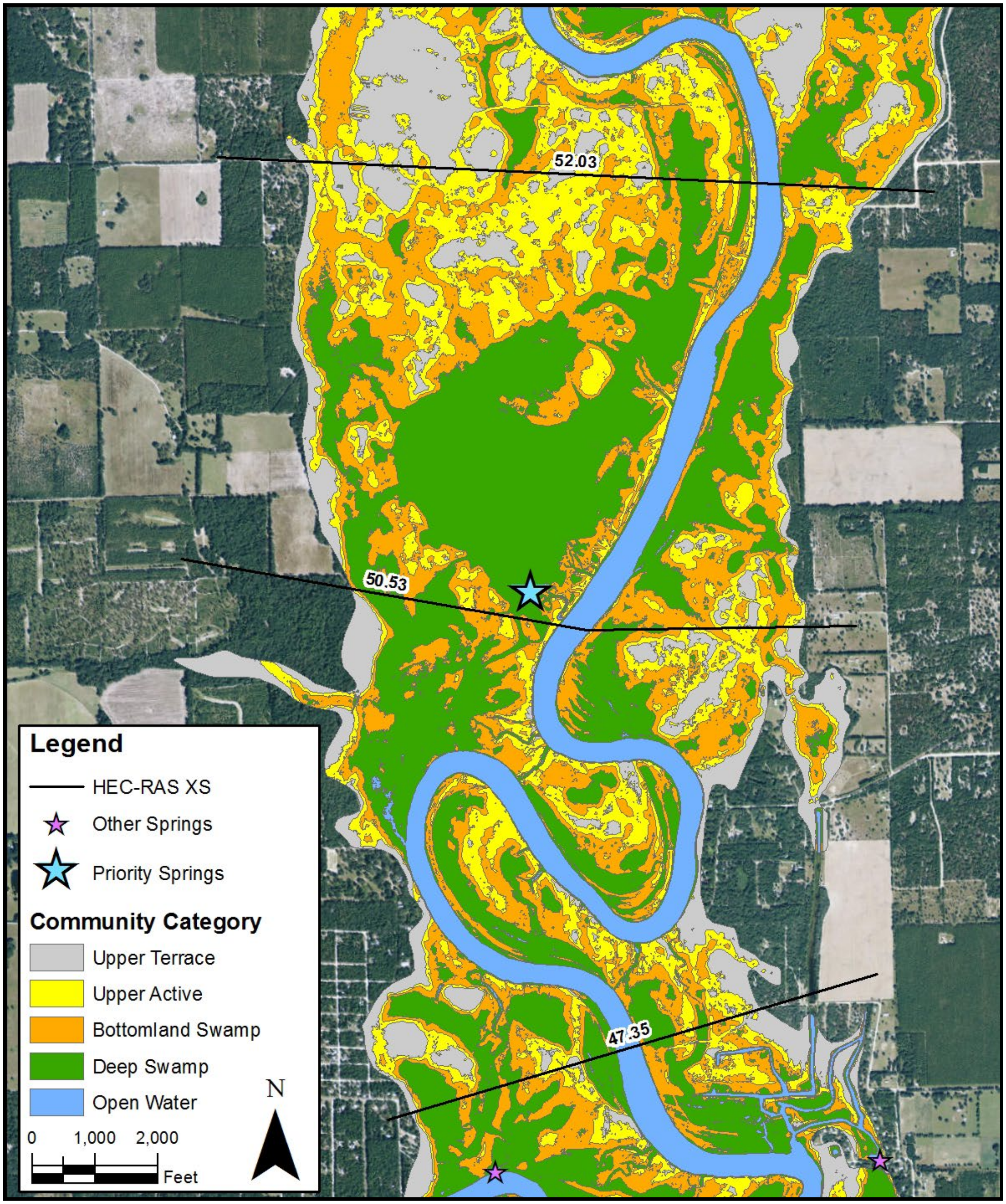

Figure 21 - Middle Suwannee Floodplain Communities Downstream of the Santa Fe River

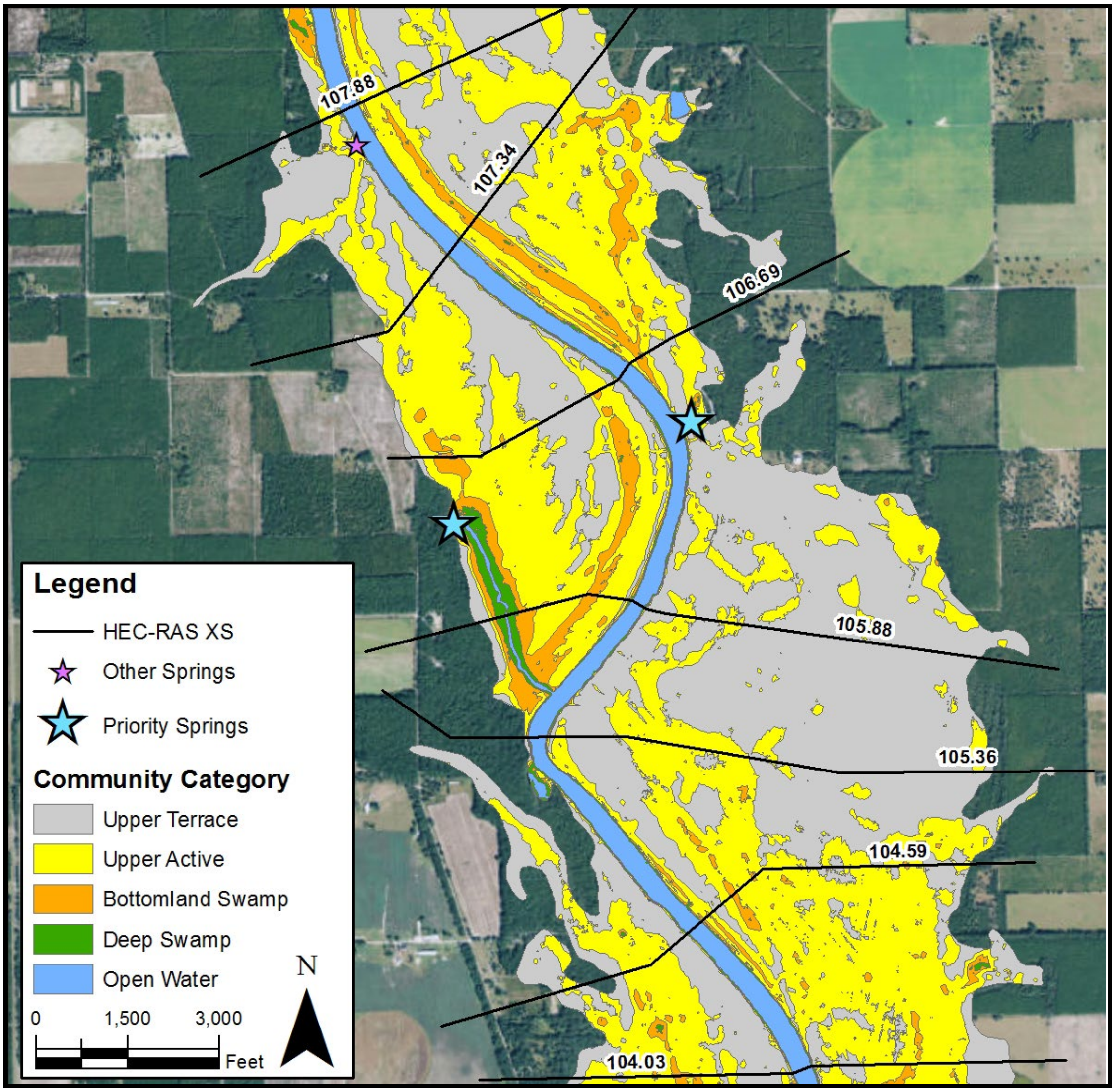

Figure 22 - Middle Suwannee Floodplain Communities Upstream of the Knot with a Spring Run

2.3 Bottomland Swamps

Bottomland Swamps typically have a nearly closed canopy stratum, often dominated by fast growing and comparatively short-lived tree species with low amounts of understory cover (average 31% total cover) and relatively dense groundcover (average 93% total cover) among the three community types. The moderate shrub and high groundcover levels likely are associated with the shallower depths and shorter durations of flooding experienced by these communities versus the deep swamps.

Forest composition is diverse, dominated by hardwood species in most areas although some places have pines and cypress. Four main groupings of species tend to comprise the canopy in large patches. These include live oak galleries often fringing deep swamps; patches dominated by various combinations of ironwood, red maple and sweetgum; and broad areas dominated by either laurel oak, water hickory or river birch (**Figure 23, Table 3**).

Figure 23a - Bottomland Swamp Forests
(a) River birch bordering a deep swamp

Figure 23b - Bottomland Swamp Forests
(b) Laurel oaks and dwarf palm on broad valley flat

Figure 23c - Bottomland Swamp Forests
(c) Mixed species on an alluvial accretion swale

Understory is more diverse than that of the deep swamps, with shorter statured and shrubby species such as Florida bully, titi, parsley hawthorn, cedar elm, possumhaw, mayhaw, swamp dogwood, and bluestem palm (**Table 4**). The bluestem palm is a dwarf tree with seeds distributed by flood waters. Some of the most common understory plants are also canopy species including sweetgum, red maple, ironwood, American elm, and laurel oak. About 40% of the plots had wetter assemblages of understory plants than that of the canopy, while only 9% were drier. For example some of the mature live oak galleries had cypress and bluestem palm understories. This shift occurred beyond what a chi-square test deemed attributable to chance, suggesting that the forest composition at a given location is patchy and successional in complex ways not strictly governed by parentage from the overstory.

Table 3 - Bottomland Swamp Canopy Species

Scientific Name	Common Name	FDEP Index	Relative Frequency	Relative Basal Area	Relative Density	Importance Value	Cumulative Importance
Quercus laurifolia	laurel oak	FACW	18.78%	30.85%	13.75%	21.13%	0.211
Quercus virginiana	live oak	UPL	3.38%	22.29%	5.83%	10.50%	0.316
Acer rubrum	red maple	FACW	12.35%	6.88%	10.83%	10.02%	0.417
Liquidambar styraciflua	sweetgum	FACW	9.14%	7.64%	9.17%	8.65%	0.503
Carpinus caroliniana	musclewood	FACW	13.54%	3.17%	8.75%	8.49%	0.588
Betula nigra	river birch	OBL	10.32%	3.60%	6.25%	6.72%	0.655
Ulmus americana	American elm	FACW	6.60%	3.03%	8.33%	5.99%	0.715
Carya aquatica	water hickory	OBL	4.74%	6.58%	5.83%	5.72%	0.772
Taxodium distichum	bald cypress	OBL	3.89%	4.53%	4.58%	4.34%	0.816
Quercus nigra	water oak	FACW	3.89%	2.59%	3.33%	3.27%	0.848
Celtis occidentalis	hackberry	UPL	2.71%	1.14%	3.33%	2.39%	0.872
Diospyros virginiana	common persimmon	FAC	1.86%	0.49%	4.17%	2.17%	0.894
Crataegus aestivalis	mayhaw	OBL	2.20%	0.52%	3.75%	2.16%	0.916
Ulmus crassifolia	cedar elm	FACW	1.35%	1.60%	2.08%	1.68%	0.932
Pinus taeda	loblolly pine	UPL	0.68%	1.52%	1.67%	1.29%	0.945
Nyssa sylvatica	black tupelo	OBL	1.35%	0.62%	1.67%	1.21%	0.957
Quercus lyrata	overcup oak	OBL	0.85%	0.92%	1.67%	1.14%	0.969
Crataegus viridis	green haw	FACW	0.34%	0.11%	0.83%	0.43%	0.973
Quercus geminata	sand live oak	UPL	0.51%	0.15%	0.42%	0.36%	0.977
Acer barbatum	Florida maple	UPL	0.17%	0.47%	0.42%	0.35%	0.980
Pinus glabra	spruce pine	FACW	0.17%	0.47%	0.42%	0.35%	0.984
Quercus michauxii	swamp chesnut oak	FACW	0.17%	0.44%	0.42%	0.34%	0.987
Nyssa aquatica	water tupelo	OBL	0.17%	0.13%	0.42%	0.24%	0.989
Acer floridanum	southern sugar maple	UPL	0.17%	0.08%	0.42%	0.22%	0.992
Celtis laevigata	sugarberry	FACW	0.17%	0.06%	0.42%	0.21%	0.994
Morus rubra	red mulberry	FAC	0.17%	0.05%	0.42%	0.21%	0.996
Vitis rotundifolia	muscadine grape vine	VINE	0.17%	0.03%	0.42%	0.20%	0.998
Planera aquatica	planer tree	OBL	0.17%	0.02%	0.42%	0.20%	1.000
TOTAL			100.00%	100.00%	100.00%	100.00%	

Table 4 - Bottomland Swamp Understory Species

Scientific Name	Common Name	FDEP Index	Relative Cover	Relative Density	Importance Value	Cumulative Importance
Carpinus caroliniana	musclewood	FACW	15.20%	5.74%	10.47%	0.105
Ulmus americana	American elm	FACW	7.67%	6.34%	7.01%	0.175
Acer rubrum	red maple	FACW	6.62%	6.34%	6.48%	0.240
Quercus laurifolia	laurel oak	FACW	6.21%	5.44%	5.82%	0.298
Ilex decidua	swamp holly	FACW	5.30%	6.34%	5.82%	0.356
Liquidambar styraciflua	sweetgum	FACW	3.84%	3.63%	3.73%	0.393
Fraxinus caroliniana	Carolina ash	OBL	3.97%	3.32%	3.65%	0.430
Sabal minor	dwarf palmetto	FACW	2.79%	4.23%	3.51%	0.465
Crataegus viridis	green haw	FACW	4.46%	1.81%	3.14%	0.496
Betula nigra	river birch	OBL	3.49%	2.72%	3.10%	0.527
Cyrilla racemiflora	swamp titi	FAC	4.18%	1.81%	3.00%	0.557
Diospyros virginiana	common persimmon	FAC	1.46%	4.53%	3.00%	0.587
Bumelia reclinata	Florida bully	FAC	1.12%	4.83%	2.97%	0.617
Crataegus aestivalis	mayhaw	OBL	2.79%	3.02%	2.91%	0.646
Vaccinium elliottii	high bush blueberry	FAC	2.09%	3.32%	2.71%	0.673
Cornus foemina	swamp dogwood	FACW	1.81%	3.02%	2.42%	0.697
Taxodium distichum	bald cypress	OBL	1.81%	3.02%	2.42%	0.722
Crataegus marshallii	parsley haw	FACW	2.30%	2.42%	2.36%	0.745
Vaccinium arboreum	sparkleberry	UPL	2.93%	1.51%	2.22%	0.767
Cephalanthus occidentalis	buttonbush	OBL	1.95%	2.42%	2.18%	0.789
Serenoa repens	saw palmetto	UPL	2.79%	1.51%	2.15%	0.811
Vitis rotundifolia	musadine grape vine	VINE	1.05%	2.72%	1.88%	0.830
Carya aquatica	water hickory	OBL	1.60%	2.11%	1.86%	0.848
Hypericum hypericoides	St. Andrews cross	FAC	2.51%	0.60%	1.56%	0.864
Celtis occidentalis	hackberry	UPL	1.32%	1.51%	1.42%	0.878
Ulmus crassifolia	cedar elm	FACW	1.53%	1.21%	1.37%	0.892
Quercus lyrata	overcup oak	OBL	0.84%	1.81%	1.32%	0.905
Quercus nigra	water oak	FACW	0.70%	1.81%	1.26%	0.917
Sebastiania sp.	Sebastian bush	UPL	1.05%	1.21%	1.13%	0.929
Viburnum obovatum	Walter's viburnum	FACW	0.77%	1.21%	0.99%	0.939
Ilex opaca	American holly	FAC	0.35%	1.21%	0.78%	0.946
Planera aquatica	planer tree	OBL	0.42%	0.91%	0.66%	0.953
Quercus geminata	sand live oak	UPL	0.84%	0.30%	0.57%	0.959
Vaccinium stamineum	deer berry	UPL	0.42%	0.60%	0.51%	0.964
Forestiera acuminata	swamp privet	OBL	0.35%	0.60%	0.48%	0.969
Carya glabra	pignut hickory	UPL	0.21%	0.60%	0.41%	0.973
Nyssa sylvatica	black tupelo	OBL	0.14%	0.60%	0.37%	0.976
Quercus virginiana	live oak	UPL	0.14%	0.60%	0.37%	0.980
Sabal palmetto	cabbage palm	FAC	0.14%	0.60%	0.37%	0.984
Symplocos tinctoria	common sweetleaf	UPL	0.35%	0.30%	0.33%	0.987
Baptisia lecontei	pineland wild indigo	UPL	0.07%	0.30%	0.19%	0.989
Callicarpa americana	American beauty berry	UPL	0.07%	0.30%	0.19%	0.991
Hamamelis virginiana	witch hazel	UPL	0.07%	0.30%	0.19%	0.993
Ilex vomitoria	yaupon holly	FAC	0.07%	0.30%	0.19%	0.994
Morus rubra	mulberry	FAC	0.07%	0.30%	0.19%	0.996
Pinus taeda	loblolly pine	UPL	0.07%	0.30%	0.19%	0.998
Vitis cinerea	Winter Grape	VINE	0.07%	0.30%	0.19%	1.000
TOTAL			100.00%	100.00%	100.00%	

Soil layers can be any of the textural sequences observed in the study area, except muck. This includes sand; sand over fines; fines over sand; complex layers of sands, loam and/or fines; and silt and clay (**Figure 24**).

Geomorphic surfaces include the intermediate elevations of the floodplain on undulating surfaces and along the margins of deep swamps. They occur along deep swamp margins at the upper hillslopes along spring runs, oxbow depressions, and polygonal depressions. They also occur within somewhat linear areas including shallow swales and lower ridges of lateral accretions, karst lineaments, and oxbow bottoms. Some are found on the lower lying alluvial ridges as well. See cross-sections on **Figures 13, 14, 15, 16, 17, and 18** for typical examples.

Figure 24 - Bottomland Swamp Soil Core
(Sand, over Loam, over Clay)

Canopy cover averages 89% FACW+OBL, indicating a rather ubiquitous wetland jurisdictional status of this community. Soils are typically hydric, with hydric indicators found within the upper 2 inches of the soil profile on average. The deepest indicator among the plots in this community was encountered at 7 inches, barely out of the 6 inch depth required for wetland jurisdiction. Because this is a transitional community between the deep swamps and upper surfaces, some patches may classify as uplands, but the vast majority are clearly wetlands. As such, these communities are distributed virtually throughout the MSR, but are seldom the dominant community along the river valley (**Figures 21, 22, 25** and **26**).

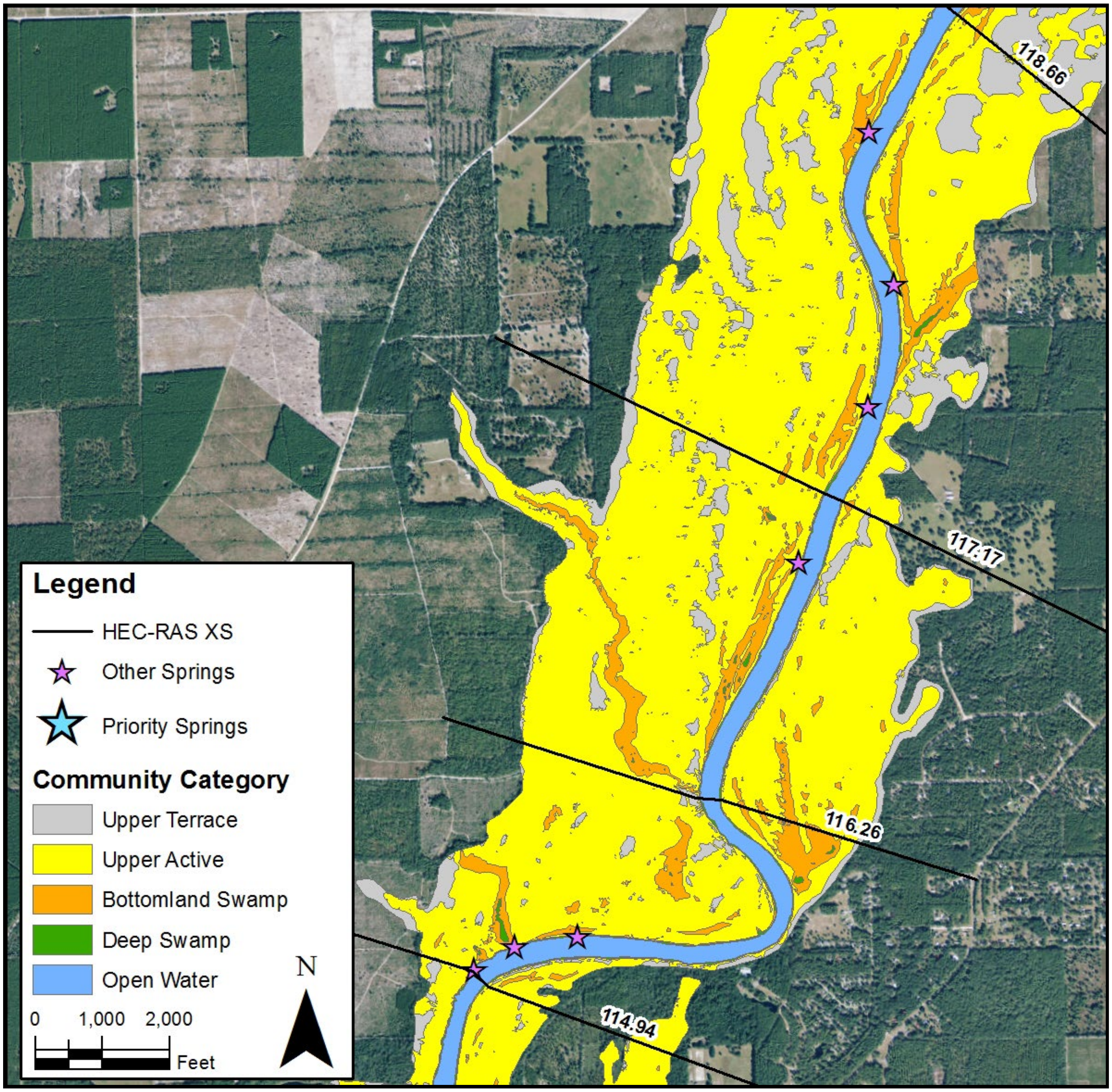

Figure 25 - Middle Suwannee Floodplain Upstream of the Knot Dominated by Upper Active Community

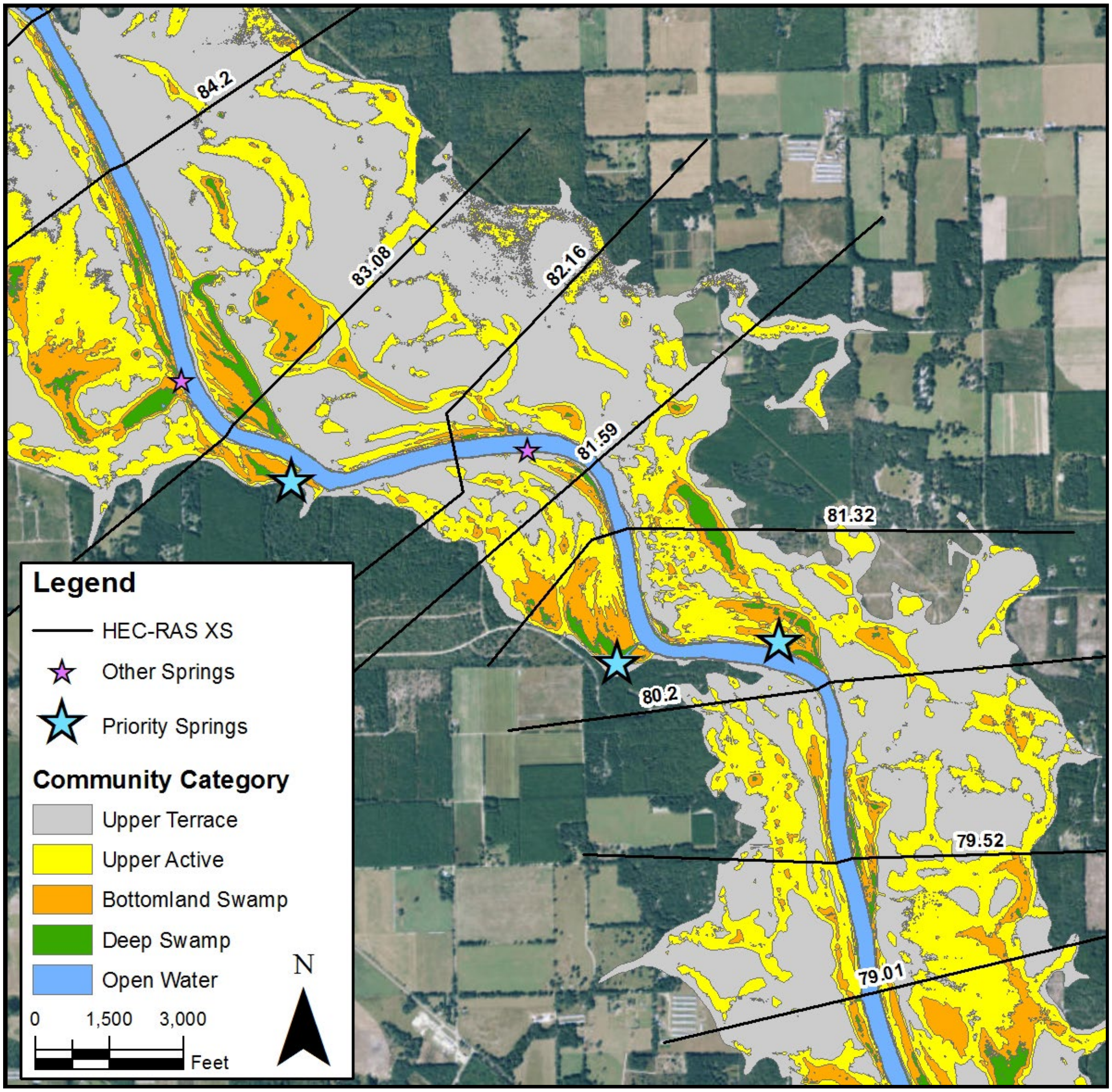

Figure 26 - Middle Suwannee Floodplain Downstream of the Knot Dominated by Upper Terrace Community

2.4 Upper Surfaces

The Upper Surface community typically has a nearly closed canopy stratum, with comparatively dense understory (average 77% total cover) and groundcover (average 80% total cover) among the three community types. The high shrub and high groundcover levels likely are associated with the shallower depths and shorter durations of flooding experienced by these communities versus the other communities.

Forest composition is diverse, dominated by hardwood species in most areas although some places have pines. Four main groupings of species tend to dominate the canopy in large patches. These include mature live oak hammocks; broad areas dominated by fast growing water oaks with blackgum; mesic hammocks without a clear dominance of species but often including some combination of American holly, pignut hickory, juniper, cabbage palm or sweetleaf; and patches dominated by either red maple and/or sweetgum (**Figure 27, Table 5**).

The understory is more diverse than that of the other communities and many of these forests resemble thickets. Three main groupings of understory assemblages are most common including a mesic hammock group consisting of about 20 hardwood shrub and tree species; palmetto thickets; and a short-statured oak species and ericaceous shrub grouping (**Table 6**). Statistically significant differences in the wetness preferences of the canopy versus the understory were reversed from that found in the bottomland swamp community. About 28% of the Upper Surface plots had a wetter canopy than understory composition, while only 16% of the plots in this community exhibited a drier canopy than understory. Once again there is some indication that forest layers are not merely a shorter statured reflection of one another.

Figure 27a - Upper Surface Forests
(a) Live oaks on broad valley flat

Figure 27b - Upper Surface Forests
(b) Mesic hammock with palmettos on valley hillslope

Figure 27c - Upper Surface Forests
(c) Hardwood thicket on alluvial ridge

Table 5 - Upper Surface Canopy Species

Scientific Name	Common Name	FDEP Index	Relative Frequency	Relative Basal Area	Relative Density	Importance Value	Cumulative Importance
Quercus virginiana	live oak	UPL	19.20%	41.39%	14.00%	24.86%	0.249
Quercus nigra	water oak	FACW	18.62%	13.82%	15.33%	15.93%	0.408
Liquidambar styraciflua	sweetgum	FACW	9.74%	6.73%	9.33%	8.60%	0.494
Acer rubrum	red maple	FACW	11.46%	4.18%	9.33%	8.32%	0.577
Quercus laurifolia	laurel oak	FACW	5.44%	9.10%	7.33%	7.29%	0.650
Nyssa sylvatica	black tupelo	OBL	6.30%	5.25%	10.00%	7.18%	0.722
Pinus taeda	loblolly pine	UPL	2.87%	6.86%	5.33%	5.02%	0.772
Carpinus caroliniana	musclewood	FACW	7.74%	1.89%	5.33%	4.99%	0.822
Carya glabra	pignut hickory	UPL	4.58%	4.00%	4.00%	4.20%	0.864
Ilex opaca	American holly	FAC	4.30%	1.28%	4.67%	3.41%	0.898
Diospyros virginiana	common persimmon	FAC	2.29%	0.48%	4.00%	2.26%	0.921
Juniperus virginiana	red cedar	UPL	2.58%	1.90%	2.00%	2.16%	0.942
Ulmus americana	American elm	FACW	0.86%	0.41%	1.33%	0.87%	0.951
Vaccinium arboreum	sparkleberry	UPL	0.57%	0.45%	1.33%	0.79%	0.959
Pinus glabra	spruce pine	FACW	0.57%	0.76%	0.67%	0.67%	0.965
Betula nigra	river birch	OBL	0.57%	0.16%	0.67%	0.47%	0.970
Quercus michauxii	swamp chesnut oak	FACW	0.29%	0.38%	0.67%	0.44%	0.975
Taxodium distichum	bald cypress	OBL	0.29%	0.37%	0.67%	0.44%	0.979
Sabal palmetto	cabbage palm	FAC	0.29%	0.23%	0.67%	0.39%	0.983
Ostrya virginiana	American hophornbeam	UPL	0.29%	0.13%	0.67%	0.36%	0.987
Quercus stellata	post oak	UPL	0.29%	0.12%	0.67%	0.36%	0.990
Symplocos tinctoria	common sweetleaf	UPL	0.29%	0.04%	0.67%	0.33%	0.993
Halesia carolina	Carolina silverbell	UPL	0.29%	0.03%	0.67%	0.33%	0.997
Vitis rotundifolia	muscadine grape vine	VINE	0.29%	0.03%	0.67%	0.33%	1.000
TOTAL			100.00%	100.00%	100.00%	100.00%	

Table 6 - Upper Surface Understory Species

Scientific Name	Common Name	FDEP Index	Relative Cover	Relative Density	Importance Value	Cumulative Importance
Serenoa repens	saw palmetto	UPL	42.37%	7.05%	24.71%	0.247
Vaccinium arboreum	sparkleberry	UPL	8.31%	9.06%	8.68%	0.334
Ilex decidua	swamp holly	FACW	8.02%	6.38%	7.20%	0.406
Quercus nigra	water oak	FACW	4.92%	6.04%	5.48%	0.461
Vaccinium elliottii	high bush blueberry	FAC	3.06%	6.04%	4.55%	0.506
Cyrilla racemiflora	swamp titi	FAC	5.99%	2.35%	4.17%	0.548
Ilex opaca	American holly	FAC	3.43%	4.03%	3.73%	0.585
Acer rubrum	red maple	FACW	2.32%	4.70%	3.51%	0.620
Liquidambar styraciflua	sweetgum	FACW	1.07%	5.03%	3.05%	0.651
Vaccinium stamineum	deer berry	UPL	1.69%	4.03%	2.86%	0.679
Diospyros virginiana	common persimmon	FAC	1.49%	4.03%	2.76%	0.707
Carpinus caroliniana	musclewood	FACW	3.80%	1.34%	2.57%	0.733
Symplocos tinctoria	common sweetleaf	UPL	3.27%	1.68%	2.47%	0.757
Sebastiania sp.	Sebastian bush	UPL	1.24%	3.36%	2.30%	0.780
Quercus laurifolia	laurel oak	FACW	0.70%	3.69%	2.20%	0.802
Nyssa sylvatica	black tupelo	OBL	0.62%	2.35%	1.48%	0.817
Sabal minor	dwarf palmetto	FACW	0.58%	2.35%	1.46%	0.832
Vitis rotundifolia	musadine grape vine	VINE	0.37%	2.01%	1.19%	0.844
Viburnum obovatum	Walter's viburnum	FACW	0.58%	1.34%	0.96%	0.853
Osmanthus americanus	wild olive	UPL	0.79%	1.01%	0.90%	0.862
Ulmus americana	American elm	FACW	0.29%	1.34%	0.82%	0.871
Cornus foemina	swamp dogwood	FACW	0.17%	1.34%	0.75%	0.878
Quercus virginiana	live oak	UPL	0.17%	1.34%	0.75%	0.886
Sabal palmetto	cabbage palm	FAC	0.17%	1.34%	0.75%	0.893
Halesia sp.	silverbell	UPL	0.29%	1.01%	0.65%	0.900
Carya glabra	pignut hickory	UPL	0.25%	1.01%	0.63%	0.906
Bumelia reclinata	Florida bully	FAC	0.17%	1.01%	0.59%	0.912
Chionanthus virginicus	white fringetree	UPL	0.62%	0.34%	0.48%	0.917
Rhododendron sp.	wild azalea	UPL	0.62%	0.34%	0.48%	0.921
Callicarpa americana	American beauty berry	FACW	0.17%	0.67%	0.42%	0.926
Persea borbonia	redbay	UPL	0.12%	0.67%	0.40%	0.929
Quercus michauxii	swamp chesnut oak	FACW	0.12%	0.67%	0.40%	0.933
Carya aquatica	water hickory	OBL	0.08%	0.67%	0.38%	0.937
Celtis occidentalis	hackberry	UPL	0.08%	0.67%	0.38%	0.941
Cephalanthus occidentalis	buttonbush	OBL	0.08%	0.67%	0.38%	0.945
Crataegus crus-galli	cockspur haw	UPL	0.08%	0.67%	0.38%	0.949
Fraxinus caroliniana	Carolina ash	OBL	0.08%	0.67%	0.38%	0.952
Morus rubra	mulberry	FAC	0.08%	0.67%	0.38%	0.956
Halesia carolina	Carolina silverbell	UPL	0.41%	0.34%	0.37%	0.960
Betula nigra	river birch	OBL	0.21%	0.34%	0.27%	0.963
Ilex ambigua	Carolina holly	UPL	0.21%	0.34%	0.27%	0.965
Juniperus virginiana	Red Cedar	UPL	0.12%	0.34%	0.23%	0.968
Quercus lyrata	overcup oak	OBL	0.12%	0.34%	0.23%	0.970
Acer saccharinum	silver maple	OBL	0.04%	0.34%	0.19%	0.972
Asimina angustifolia	slimleaf pawpaw	UPL	0.04%	0.34%	0.19%	0.974
Baptisia lecontei	pineland wild indigo	UPL	0.04%	0.34%	0.19%	0.976
Bignonia capreolata	crossvine	VINE	0.04%	0.34%	0.19%	0.977
Cercis canadensis	eastern redbud	UPL	0.04%	0.34%	0.19%	0.979
Cocculus carolinus	Carolina coralbead	UPL	0.04%	0.34%	0.19%	0.981
Crataegus marshallii	parsley haw	FACW	0.04%	0.34%	0.19%	0.983
Gleditsia aquatica	water locust	OBL	0.04%	0.34%	0.19%	0.985
Hypericum hypericoides	St. Andrews cross	FAC	0.04%	0.34%	0.19%	0.987
Ilex vomitoria	yaupon holly	FAC	0.04%	0.34%	0.19%	0.989
Leucothoe racemosa	swamp doghobble	FACW	0.04%	0.34%	0.19%	0.991
Magnolia grandiflora	southern magnolia	UPL	0.04%	0.34%	0.19%	0.992
Pinus glabra	spruce pine	FACW	0.04%	0.34%	0.19%	0.994
Prunus caroliniana	cherry laurel	UPL	0.04%	0.34%	0.19%	0.996
Quercus shumardii	shumard oak	UPL	0.04%	0.34%	0.19%	0.998
Ulmus alata	winged elm	FACW	0.04%	0.34%	0.19%	1.000
TOTAL			100.00%	100.00%	100.00%	

This community strongly associates with thick sandy soils (72% of the plots sampled) (**Figure 28**). The exceptions occurred on sand over fines, fines over sand, and mixed loam/sand/or fines layers. This community did not occur on thick pure silt or clay layers or muck. These assemblages are found on the best drained soils occurring on the floodplain's highest elevations.

Figure 28 - Upper Surface Soil Core (Sand)

Geomorphic surfaces include the broad valley flat, which could be viewed as the parent surface of the floodplain which is otherwise dissected by a variety of lower lying surfaces. In many Florida rivers, the analogous surface is much lower lying and wetter. Alluvial ridges and the ridges of lateral accretions are other characteristic and common surfaces for this community. It also occurs along the main valley hillslope where it is transitioning from the floodplain into the adjacent palustrine longleaf pine forests and other non-riparian communities. See cross-sections on **Figures 13, 14, 15, 16, 17,** and **18** for typical examples.

Canopy cover averages 59% FACW+OBL, well below the regulatory wetland threshold of 80%. Hydric soil indicators averaged 16 inches below the land surface among the plots in this community, which is well below the upper 6 inches necessary to classify the soil as hydric for most indicators. The maximum depth of hydric indicators was found at 54 inches for this community. Because this is a transitional community often adjacent to the bottomland swamps, some of the plots are jurisdictional wetlands but most would not be claimed solely based on their hydric soil conditions and species wetness indices.

These communities are distributed at appropriate elevations throughout the MSR floodplain, and are the most expansive type found in roughly the upper two-thirds of the study area upstream of the Santa Fe River. The usual pattern is for these communities to form large 'islands' between the various types of lower-lying fluvial and karst dissections of the floodplain (**Figures 21, 22, 25,** and **26**). The community is reduced in relative importance downstream of the Santa Fe River where deep swamps are more dominant.

As discussed earlier, the portions of this community located throughout the floodplain at elevations above that of the alluvial ridge crest appear to have more intense anthropogenic land use patterns and the portions below that boundary are more likely to be alluvially active. For these reasons the Upper Surface community has been subdivided and mapped as an Upper Terrace above the AR crest elevation and as an Upper Active community below it. In general, the Upper Active community tends to dominate in the upper half of the study area (**Figure 25**), while the Upper Terrace community is more extensive in the lower half (**Figure 26**), perhaps because flood levels and sand availability are greater closer to the Withlacoochee River.

The community maps for the entire study area are available as ESRI GIS Shapefiles in digital **Appendix D**.

2.5 Sustaining Processes

MFL focuses upon sustaining threshold effects of river and spring flows and their interactions with the ground surface to create the water level regimes each of the three communities rely upon. The forest complexity not only relies upon seasonal and long term flow patterns from the river, but also from the Floridan aquifer. This suggests prevention of significant harm to these extensive wildlife habitats requires consideration of river discharge and aquifer levels. Further, the riverine and groundwater flow patterns do not merely interact with a static landscape, they literally build it and re-shape it over time via sediment transport, erosion, and deposition. These land-forming processes sustain the tremendous vertical relief driving the hydrologic gradient of the communities. The fact that some of this relief gradually and episodically shifts position allows for a successional dynamic that would not otherwise occur. These shifts are likely to facilitate a large degree of the habitat heterogeneity, differences in forest structure, and patch dynamics found within each community type. For these reasons the threshold effects of flowing water and aquifer levels must be placed in two contexts; geomorphic effects that create the complex topographic template upon which the habitat structure develops, and the hydroecological gradient that sorts the forest into distinguishable community types.

That conceptualization of the sustaining processes to prevent significant harm to floodplain communities is expected to contribute to the following water resource values;

- Fish and wildlife habitats and fish passage
- Detrital transfer
- Freshwater storage and supply
- Aesthetic and scenic attributes
- Pollutant filtration and adsorption
- Sediment transport
- Water quality

Aquifer levels (actually, the potentiometric surface of the Floridan aquifer) provide the head driving groundwater flow to the land surface or river channel. The volume of groundwater discharge and the rates of rise and fall of these levels also can affect land subsidence through dissolution and sinkhole formation. These processes have natural levels and the floodplain communities have developed under their influence. In fact, the deep swamps are strongly associated with karst features. This does not seem to be a mere coincidence, as six Upper Floridan Aquifer monitoring wells with at least a decade of data nearest the floodplain (within 2.5 miles it) provide evidence that the aquifer's potentiometric surface is routinely higher than the deep swamp elevations.

These aquifer levels alone could sustain deep swamp hydroperiods of 16% to 30% in the downstream half of the study area where subterranean access to the floodplain exists (**Table 7**). Such access is essentially a given because the aquifer is unconfined in the river valley. The estimated potentiometric hydroperiods are enough to maintain wetland conditions even without riverine contributions[5]. The upstream portion of the study area, which generally lacks large expressions of deep swamps, only had a 5% exceedance of the deep swamp ground elevations by the potentiometric surface, which is not enough to sustain wetlands by itself (**Table 7**). Thus the geographic pattern of aquifer levels and deep swamp occurrence suggests a prominent role for groundwater flow in maintaining such swamps. The Floridan aquifer also could contribute to the wetness of the bottomland swamps ranging from theoretical hydroperiods of less than 2% and as high as 14%, contributions that would generally not be enough to support wetland conditions independently of other water sources.

Table 7 - Upper Floridan Aquifer Head Exceedance Values near the MSR Floodplain

			Community Elevation (ft NAVD)		%Exceedance	
Well	**Closest Transect**	**River-Mile**	**Deep Swamp**	**Bottomland Swamp**	**Deep Swamp**	**Bottomland Swamp**
S011232006 Falmouth	Wii15	125.6	--	43.6	--	5%
S031105006 Advent Village	Wii5	116.3	36.0	43.0	5%	2%
S051334013 Troy_TYA_UFA	Wi34	83.9	21.1	25.2	25%	7%
S061301007 Little River	Wi30	80.8	19.2	22.0	16%	9%
S06143006 Carrol Hall	Wi10	72.6	18.1	20.5	21%	14%
S091420001 Clifton Mikel	X-26	50.5	8.3	12.5	30%	7%

The river flow layers much deeper water levels with long-lasting flood pulses above and beyond those potentially contributed by aquifer exchanges. Although these flood pulses occur frequently, they do not happen every year and sometimes fail to occur for periods of up to a few years. As an example, the circa 5-year flood that occurred during 2014 placed water in the floodplain for 2-3 months, at peak depths of over 10 feet above the deep swamp land surfaces (**Figure 29**). This flood also deposited readily observable thin layers of silt and clay in the swamps and sand on the alluvial ridges (generally a veneer to a few inches) (**Figures 30** and **31**). Further, it added to a crevasse splay, driving up to a couple of feet of sand into the adjacent deep swamp (**Figure 32**).

[5] The forest structure and size of the wetlands would almost assuredly differ without the river flow, however.

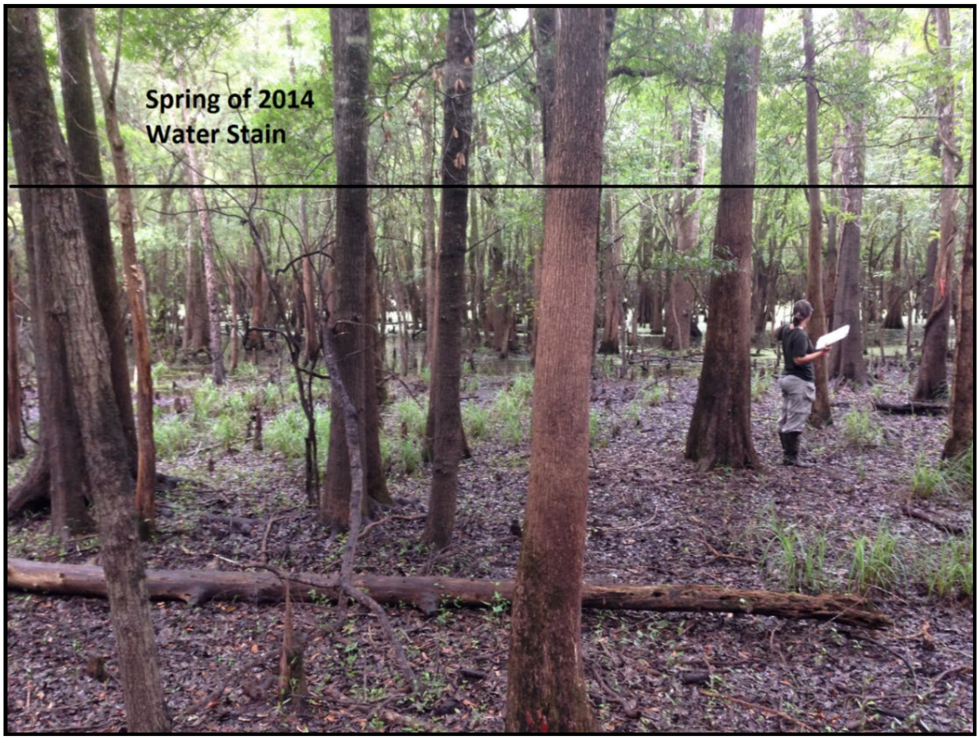

Figure 29 - Water Stain Line from 2014 Wet Season Flood-Pulse

Figure 30 - Fresh Sand Deposit on Alluvial Ridge from 2014 Wet-Season Flood-Pulse

Figure 31 - Fresh Silt Deposit on Lateral Accretion Swale from 2014 Wet-Season Flood-Pulse

Figure 32 - Crevasse Splay Expansion into Deep Swamp from 2014 Wet-Season Flood-Pulse

An examination of nearly seven-decades[6] of gap-filled daily flow records at the Ellaville, Luraville, Branford and Bell gages provides insight regarding the magnitude, duration and frequencies of the flow events sustaining the wetland communities and their riparian surfaces in the floodplain. Amec Foster Wheeler used regressions of surface elevation versus river mile, described previously, to assign elevations at each gage location. These elevations were then associated with river discharge in cubic feet per second for each gage using stage-flow relationships modeled in the HEC-RAS steady-state runs (ECT 2014).[7]

A threshold event that exceeds the wetland surface elevation for a period of at least 14 days was selected in accordance with suggestions by a USGS team that intensively studied Suwannee River wetlands in the lower quarter of the MSR (Light et al. 2002). It is deemed long enough to kill sensitive tree and shrub seedlings and small saplings when waters overtop them, thus structuring the forest composition.

For consistency, a minimum 14-day duration was also used to define threshold events driving the formation of alluvial surfaces (bankfull flow and floods cresting the alluvial ridge). This duration provides a reasonable amount of time for scour to affect soil and root masses, and also for the deposition of fine soil particles in quiescent areas of the floodplain. For example, Kiefer et al. (2015) determined that bankfull events lasted an average of 2 to 34 days for wadable Florida streams (with a central tendency of around 6 days for most of the 8 streams examined). Events flooding the entire alluvially active floodplain lasted 2 to 14 days, on average, for streams in the same study. Based on Stokes Law calculations, a 14 day spell is also long enough to allow coarse silts to settle completely over quiescent depths of 1.7 feet[8], thus allowing some vertical accretion to occur in the floodplain.

Five critical surfaces were examined, in increasing order of elevation;

- Bankfull stage
- Deep swamp upper boundary
- Bottomland swamp upper boundary
- Alluvial ridge crest-line
- 10-year floodplain boundary (as upper surface outer boundary)

The bankfull stage and alluvial ridge crest evaluations bracket the lower and upper limits of routine floodplain building processes, thus assuring riverine surface altering effects are maintained. The remaining three surfaces represent the upper bounds of each of the floodplain community types. Stages corresponding to those surfaces range collectively from 12.5 to 56.6 feet NAVD between Bell and Ellaville (**Table 8**). The elevation difference between the bankfull stage and alluvial ridge crest declines in a downstream direction. It is 21 feet at Ellaville and only 7 feet at Bell. A similar longitudinal trend occurs regarding the difference between the upper elevations of the Deep Swamp and Bottomland Swamp communities (8.1 feet at Ellaville and 3.2 feet at Bell).

[6] WY1933 – WY2000. This is the baseline period of record

[7] Steady flow run MSR_V5_SS_02 was used.

[8] 1.7 feet is the 14-day settling depth of coarse silt particles in the water column. The settled sediment generally consists of a thin veneer after the flood recedes.

Table 8 - Upper Water Surface Elevations of Floodplain Communities from Ellaville to Bell

Gage	River-Mile	Stage (ft NAVD)			
		BKF	DS	BLS	AR
Ellaville	127.5	35.5	36.4	44.5	56.6
Luraville	98.1	25.0	26.7	31.6	39.1
Branford	76.1	18.1	19.5	23.1	28.0
Bell	56.5	12.5	13.1	16.2	19.2

Bankfull discharge and deep swamp discharges are somewhat similar with the deep swamp flows being rather consistently about 1,000 cfs greater (**Table 9**). Both of these discharges increase downstream, with bankfull flow ranging from 8,300 to 12,700 cfs from Ellaville to Bell (a 50% increase). This downstream pattern implies that while many of these flood events originate from the large watershed upstream of the study area, the river also picks up flow from local interbasin areas, the Santa Fe River, and groundwater discharge. This pickup allows the deep swamps to maintain a very similar hydraulic slope to that of bankfull discharge, despite the fact that the floodplain can accommodate larger flow volumes in a downstream direction.

Table 9 - Discharge Necessary to Cover Floodplain Surfaces from Ellaville to Bell

Gage	River-Mile	Discharge (cfs)				
		BKF	DS	BLS	AR	10-yr
Ellaville	127.5	8,282	9,028	17,776	34.623	40,941
Luraville	98.1	9,039	10,961	16,963	28,650	36,088
Branford	76.1	10,553	12,259	17,149	24,996	34,300
Bell	56.5	12,696	13,536	18,775	25,780	38,203

Conversely, the bottomland swamp, alluvial ridge, and 10-year floodplain flows do not significantly increase in a downstream direction, suggesting that they are associated with comparatively large upstream rainfall events that provide good continuity of discharge through the study area. This occurs because the rainfall associated with the largest floods tends to occur in the upper parts of the watershed, creating events so large that they are known to retard and even reverse flow into spring vents and also embay the Santa Fe River corridor, retarding and even reversing its flow at times.

The bottomland swamp discharge remains relatively constant in a downstream direction, ranging from a low of 16,900 cfs at Luraville to a high of 18,800 cfs at Bell (**Table 9**). Notably, the bottomland swamp profile is not the same as the bankfull slope. The bottomland profile occurs about nine feet above bankfull at Ellaville and only three feet above it at Bell. Given the small increase in corresponding downstream discharge, to the point that it is almost constant, this effect is best explained by the fact that the floodplain is less confining to the discharge downstream because it is wider there.

The 10-year discharge was greater at the Ellaville gage (39,000+ cfs) than the three downstream gages which ranged from 33,000 to 35,400 cfs. This implies the middle Suwannee River's floodplain attenuates the high combined discharges of major floods from the Withlacoochee and upper Suwannee Rivers.

The alluvial ridge discharge decreases downstream from 35,000 cfs at Ellaville to 25,000 cfs at Branford, remaining rather constant thereafter (**Table 9**). This pattern is largely a reflection of the fact that the ridge is maintained at decreasing elevations relative to bankfull stage in the downstream direction, perhaps because the sand load is being depleted as the flood wave progresses along the river thus limiting the potential upper limit of the downstream ridge height. It also may be associated with the apparent trend that the peak discharges of large combined flood pulses from the Withlacoochee and Upper Suwannee Rivers are higher than those downstream, thus generating a comparatively high upper hydraulic limit for ridge construction near Ellaville.

The percent exceedances of the critical discharges were examined for each gage using their gap-filled records. Bankfull and deep swamp exceedances were similar, ranged from 15% to 24%, with no longitudinal trend (**Table 10**). Bottomland swamp exceedances were less, ranging from 6% to 8% with no trend. The alluvial ridge was exceeded 0.5% to 3% of the time. The 10-year floodplain was exceeded during less than 1% of the record.

Table 10 - Percent Discharge Exceedance for Floodplain Surfaces from Ellaville to Bell

Gage	River-Mile	Percent Exceedance				
		BKF	DS	BLS	AR	10-yr
Ellaville	127.5	24.0%	21.0%	6.2%	0.5%	0.2%
Luraville	98.1	22.0%	17.0%	6.9%	1.2%	0.4%
Branford	76.1	19.0%	15.0%	6.8%	1.9%	0.4%
Bell	56.5	20.0%	18.0%	8.1%	2.8%	0.5%

A partial duration series relating discharge to its average annual reoccurrence interval (ARI) was derived by plotting the data at its Weibull positions and only counting events based on a series requiring at least a 7-day peak-to-peak timing separation and a software default target number of floods 3 times the number of years in the record. This means that intervals could be calculated at least as low as 1/3 of a year. This distribution was calculated using the River Analysis Package (RAP v. 3.0.7).

Bankfull discharge occurred on average about once every year or two (0.9 to 1.8 years), and deep swamp occurrences were similar to bankfull (0.9 to 1.9 years) (**Table 11**). Bottomland swamps flooded slightly less frequently (1.9 to 3.0 years). The alluvial ridge flooded every 4.7 to 7.8 years, exhibiting a downstream trend of greater overtopping (e.g. lower ARI at Bell than Ellaville). It was the only return interval that exhibited a potentially substantial longitudinal trend. By definition the 10-year flood averaged a 10-year ARI.

Table 11 - Average Annual Return Interval for Floodplain Surfaces from Ellaville to Bell

Gage	River-Mile	Average Annual Return Interval (years)				
		BKF	DS	BLS	AR	10-yr
Ellaville	127.5	0.89	0.93	1.89	7.85	10.0
Luraville	98.1	1.04	1.18	2.03	6.32	10.0
Branford	76.1	1.05	1.21	2.02	4.90	10.0
Bell	56.5	1.76	1.91	3.01	4.65	10.0

A spells analysis was also conducted using the RAP software for a daily average flow record covering WY1933 through WY2000. A spell is a critical event that, based on USGS recommendations for floodplain vegetation, lasts at least 14 days at or above the critical discharge for each surface of interest. As with the partial duration series calculations, a 7-day peak-to-peak event separation was required. The software calculates the mean duration of the spells, the mean period between them; the maximum time recorded between spells, and the mean peak daily discharge occurring among the spells. Bankfull and deep swamp spells exceeding 14 days actually last much longer than the minimum event threshold, ranging from 52 to 62 days on average (**Table 12**). Bottomland swamp spells lasted 35 to 41 days, alluvial ridge spells 16 to 39 days, and 10-year spells 16 to 25 days. These means suggest that the necessary spells are derived from large flood pulses that, on average, greatly outlast the structuring event duration reported by the USGS. Comparison of **Tables 9** and **13** shows that the average peak flow values of these qualifying events are generally 1.5 to 2 times greater than the minimum discharge necessary to fully wet each surface of interest as well, bolstering the concept that the naturally available flood pulses have historically been more than ample to sustain the species composition of the existing vegetation communities.

Table 12 - Average Spell Duration for Floodplain Surfaces from Ellaville to Bell

Sound	River-Mile	Average Spell Duration (days)				
		BKF	DS	BLS	AR	10-yr
Ellaville	127.5	58	55	35	16	16
Luraville	98.1	62	53	38	25	18
Branford	76.1	59	52	38	30	18
Bell	56.5	61	59	41	39	25

Table 13 - Peak Daily Discharge During Spells that Cover Floodplain Surfaces from Ellaville to Bell

Gage	River-Mile	Mean Peak Daily Flow During Spell (cfs)				
		BKF	DS	BLS	AR	10-yr
Ellaville	127.5	20,892	21,752	32,760	57,929	74,000
Luraville	98.1	20,141	21,734	28,287	44,733	61,790
Branford	76.1	20,729	22,251	27,469	37,481	56,350
Bell	56.5	22,984	24,084	29,356	39,660	58,935

The average period between spells was 6 to 8 months for bankfull events, 7 to 10 months for deep swamps, 15 to 19 months for bottomland swamps, 39 to 100 months for the alluvial ridge, and 199 to 215 months for the 10-year floodplain (**Table 14**). As might be expected, the period of time between critical events expands with increased elevation.

Table 14 - Average Period between Spells for Floodplain Surfaces from Ellaville to Bell

Gage	River-Mile	Average Period Between Spells (months)				
		BKF	DS	BLS	AR	10-yr
Ellaville	127.5	6.5	7.0	18.8	99.9	215.0
Luraville	98.1	7.5	8.9	17.8	59.5	214.9
Branford	76.1	8.4	10.0	17.8	39.2	198.7
Bell	56.5	8.0	9.0	15.6	40.6	198.7

Although the MSR has rather routine flood pulses during the spring, significant temporal variability can occur. The record's longest period of time between spells was about 4.2, 4.7, 10.0, 14.0, and 25.0 years for the bankfull, deep swamp, bottomland swamp, alluvial ridge, and 10-year events respectively (**Table 15**). This variability likely allows for some complex responses of different vegetative strata over time. Upland vegetation taking more than 5 years to mature to the point of being able to tolerate deep flooding would have had almost no time during the last 80 years to become established let alone persist in deep swamps, but could gain some footholds in the bottomland swamps; and this is exactly what seems to have occurred. None of the spells metrics exhibited a longitudinal trend, except perhaps for the period of time between bottomland swamps and alluvial ridge spells which decreased downstream.

Table 15 - Longest Period between Spells for Floodplain Surfaces from Ellaville to Bell (1933 - 2014)

Gage	River-Mile	Longest Period Between Spells (years)				
		BKF	DS	BLS	AR	10-yr
Ellaville	127.5	3.4	3.4	10.0	14.0	25.0
Luraville	98.1	3.4	4.2	9.9	14.0	25.0
Branford	76.1	4.2	4.7	9.9	10.9	25.0
Bell	56.5	4.2	4.2	5.4	10.9	25.0

3.0 SUMMARY

The MSR floodplain supports a diverse riparian corridor with three main kinds of plant communities. Although they have some species overlap, each community is dominated by taxa that sort along a hydrologic gradient. The canopy species that were comparatively most important in the Deep Swamps are all obligate wetland taxa (**Figure 33)**. Those most important in the Bottomland Swamp community ranged from upland to obligate wetland categories, but most were facultative wetland species (FACW), suggesting drier conditions than those found in the Deep Swamp. The majority of most important species in the Upper Surface community were facultative (FAC) to upland (UPL) taxa, indicating drier conditions than that of the Bottomland Swamps.

Similar trends occurred in the understory **(Figure 34**). All but one of the species with their greatest relative importance in the Deep Swamps were obligate wetland taxa (OBL). Half of the taxa found mostly in Bottomland Swamps were facultative wetland species (FACW). Most of the species with their greatest importance values in the Upland Surface community were facultative (FAC) and upland (UPL) taxa.

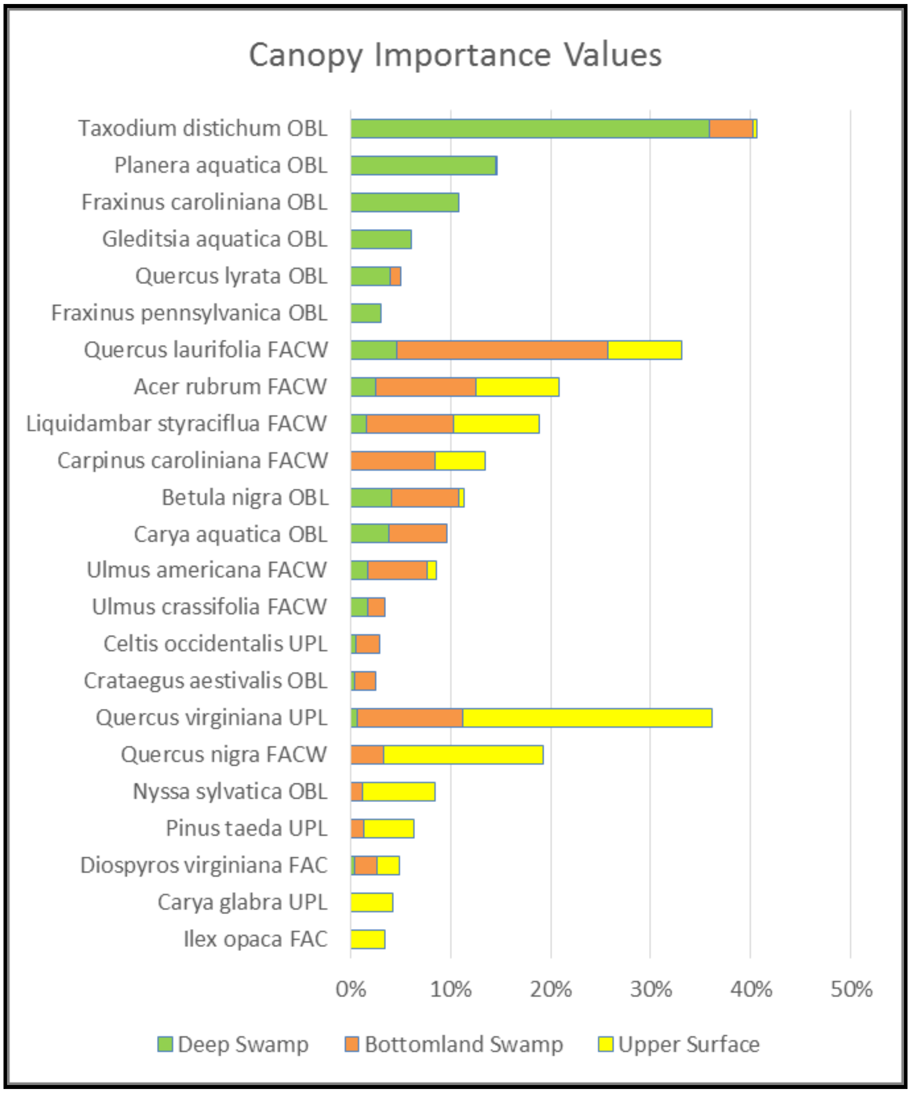

Figure 33 - Common Canopy Species Importance Values by Community[9]

[9] 'Common species' were assigned by ranking the importance values by taxon for each community and only including those species that contributed to the upper 90% of cumulative importance for at least one of the community types. This simply eliminates clutter from the graph by excluding less common species that would be unlikely to register at a discernable scale.

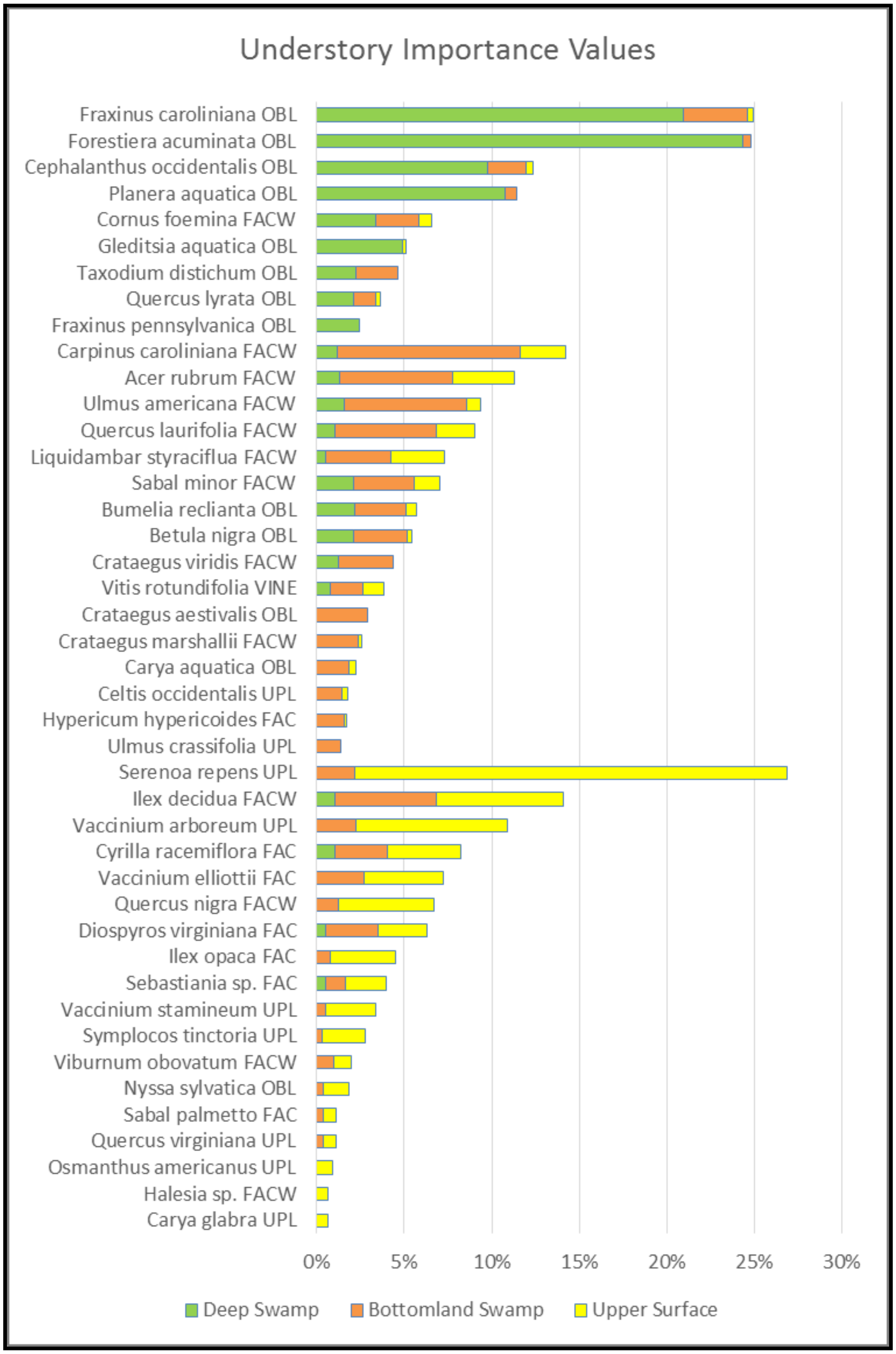

Figure 34 - Common Understory Species Importance Values by Community

The community gradient is associated with water level patterns affected by karst and riverine geomorphic processes that alter the elevations of the floodplain surface over time, as well as the aquifer and river water levels themselves. For these reasons, it is recommended to explore setting MFLs to protect floodplain communities from significant harm by assessing the effects of withdrawals on three community types (deep swamp, bottomland swamp, and upper surface) and two geomorphic profiles (bankfull stage and crest of the alluvial ridge). The lower limit of the floodplain is defined as the upper limit of open water, adding another profile of interest. Thus, a total of six floodplain surfaces are to be explored for MFL purposes.

4.0 REFERENCES

Amec Foster Wheeler, Inc. 2015. Middle Suwannee River Floodplain and Spring Run Data Collection Summarization Report. SRWMD. Live Oak, FL. 251 p.

Environmental Consulting & Technology, Inc. 2014. HEC-RAS Modeling of Middle Suwannee River Phase B. Technical Report – Final. SRWMD. Live Oak, FL. 144 p.

Florida Department of Environmental Protection. 2010. Land Use

Hornsby, D, R. A. Mattson, and T. Mirti. 2000. Surface Water Quality and Biology. 1999 Annual Report. Suwannee River Water Management District Technical Report WR00-04. 148 pp.

Kiefer, J.H., Mossa, J., Nowak, K.B., Wise, W.R., Portier, K.M., and T.L. Crisman. 2015. Peninsular Florida Stream Systems: Guidance for Their Classification and Restoration. Final Report. Pub. No. 03-154-253. FIPR Institute. Bartow, FL. 696 p.

Light, H.M., Darst, M.R., Lewis, L.J. and D.A. Howell. 2002. Hydrology, Vegetation, and Soils of Riverine and Tidal Floodplain Forests of the Lower Suwannee River, Florida, and Potential Impacts of Flow Reductions. SRWMD. Live Oak, FL.