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VEGETATION SURVEY OF FOUR MILE CREEK WETLANDS (U)

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Figure 1-1. Sampled Areas Along Four Mile Creek.

Figure 1-2. Vegetation Sampling Areas in Relation to Contamination Levels.
 Dark circles are proportional to surface water conductivity.
 (Modified from Haselow et al., 1990)

2.2 SRS Plant Communities

The range of forest variation from deep swamps to dry upland hardwood forests in the southeastern coastal plain can be divided into four categories for the purpose of review: Upland Hardwood Forests, Mesic Hardwood Forests, Bottomland Hardwood Forests, and Swamps (Whipple et al., 1981). The major controlling environmental factors in these forest types are the depth and duration of flooding on the wetter sites and the amount of soil moisture on the sites that do not flood. However, within each forest type, additional variation is controlled by soil characteristics, pH, nutrient availability, siltation, and disturbance (Monk, 1965a,b; Gemborys, 1974; Golden, 1976, 1979). Therefore, it may be expected that each of these forest communities is variable and that many of them will intergrade.

2.2.1 Basic Physiographic Types

Basic physiographic forest types will be described next, followed by descriptions of particular communities delimited by previous studies at SRS. This discussion is modified from Whipple et al. (1981).

2.2.1.1 Upland Hardwood Forest

Upland Hardwood Forests are found on dry upper and midslopes and ridge tops. Many such habitats now are dominated by pine forests, either because fires have excluded the more sensitive hardwoods or because of the planting of pines. If fires are excluded, however, succession appears to be towards an oak and hickory forest which can be divided into several subtypes. This type of forest is largely excluded from this study, but it forms the border around much of the Four Mile Creek wetlands.

2.2.1.2 Mesic Hardwood Forest

The forests of mesic sites that are seldom, if ever, flooded or burned have been variously described as southern mixed hardwood forest (Quarterman and Kever, 1962; Monk, 1965a; Ware, 1970), magnolia-beech forest (Gano, 1917; Pessin, 1933; Braun, 1950; Delcourt and Delcourt, 1977), magnolia-holly forest (Veno, 1976), and magnolia-holly-beech forest (Delcourt and Delcourt, 1974), among others. The different designations are related to the geographic regions of the southeast and the precise range of sites included by different authors. In addition, since very few examples of primeval forest remain on these sites, various authors have interpreted the end point of successional sequences differently. Delcourt and Delcourt (1977) feel that southern mesic forests that were once dominated by two species (beech and magnolia) have been so frequently disturbed by human activity that they are now returning to a forest dominated by an assemblage of between five and nine species. The Mesic Hardwood Forest represents a transition from seasonally flooded Bottomland Hardwood Forest to dry Upland Hardwood Forest. However, it can exist only on sites which are also protected from fires. This situation can occur on the steep slopes of ravines, on islands surrounded by wetter Swamp or Bottomland Hardwood Forest, and, perhaps, on terrain that has long been divided into cultivated lots which act as fire breaks (Delcourt and Delcourt, 1977). When fire has been recurrent on this type of site, the Mesic Hardwood Forest will be absent and pine forests will extend along the moisture gradient to the border of the

Bottomland Hardwood Forest (Oosting, 1942; Braun, 1950; Quarterman and Keever, 1962; Johnson, 1977).

As Quarterman and Keever's (1962) name "southern mixed hardwood forest" implies, a large number of species are found in this forest type. These include Fagus grandifolia, Magnolia grandiflora, Quercus laurifolia, Q. alba, Q. nigra, Q. falcata, Liquidambar styraciflua, Nyssa sylvatica, Ilex opaca, Liriodendron tulipifera, Carya cordiformis, Acer rubrum, and Carpinus caroliniana (Akerman, 1925; Harper, 1943; Braun, 1950; Quarterman and Keever, 1962; Golley et al., 1965; Monk, 1965a, Ware, 1970).

2.2.1.3 Bottomland Hardwood Forest

Bottomland Hardwood Forests occur on sites where flooding is of limited depth and primarily restricted to the late winter and early spring when the plants are dormant (Braun, 1950; Penfound, 1952; Putnam et al., 1960). Numerous tree species are found in this forest type: Liquidambar styraciflua, Nyssa sylvatica, Populus heterophylla, Ulmus americana, Platanus occidentalis, Celtis laevigata, Acer rubrum, and several species of Quercus (Chittenden, 1905; Braun, 1950; Penfound, 1952; Putnam et al., 1960; Lindsey et al., 1961; Bell, 1974). Variation within this forest type has been poorly described but is primarily related to duration of flooding into the growing season, successional recovery from disturbance, and time since the land was created by river deposition (Chittenden, 1905; Telford, 1926; Putnam et al., 1960; Bell, 1974; Huffman, 1974). Species typical of the Bottomland Hardwood Forest are prevented from occurring in more hydric habitats by the intolerance of both the mature trees and their seedlings to flooding in the growing season, although most are not affected by flooding while dormant. At the same time, these species are often prevented from occurring on upland sites by frequent fires.

2.2.1.4 Swamp Forest

Floodplain forests that are inundated most or all of the year comprise the true swamps, which are characterized by Taxodium distichum and Nyssa aquatica (Hall and Penfound, 1943; Braun, 1950; Penfound, 1952). Variation within the swamp is controlled by the depth and duration of flooding.

2.2.2 SRS Community Types

In a study by Whipple et al. (1981), seven community types were delimited based on ordination of samples taken along Upper Three Runs Creek. The name given each community type is a combination of the names of two typical species in that community. The first name is usually that of one of the important canopy dominants while the second name may belong to one of the lesser tree species or sometimes to a dominant in the sapling layer. The names given the forest communities here are not diagnostic in themselves: the species often occur in several communities and may be missing in one or two stands of a community. In the latter case, the stand has been included with that community because of its overall similarity to the other stands. The forest communities delimited, in approximate order from the driest to those most deeply flooded, are:

- (1) Cara tomentosa-Quercus alba

- (2) Nyssa sylvatica-Persea borbonia
- (3) Nyssa sylvatica-Acer rubrum
- (4) Quercus nigra-Carpinus caroliniana
- (5) Quercus laurifolia-Ilex decidua
- (6) Nyssa aquatica-Fraxinus pennsylvanica
- (7) Taxodium distichum-Nyssa aquatica

A key to these communities is provided in Whipple et al. (1981). A brief description of these basic community types follows.

- (1) Carya tomentosa-Quercus alba community: This forest community is the driest one that was sampled. It is easily differentiated from other communities by the presence of C. tomentosa, Q. alba, Cornus florida, and Vaccinium spp. This community occurs primarily near the dry tops of slopes.
- (2) Nyssa sylvatica-Persea borbonia community: This forest community is best characterized by P. borbonia, Q. nigra, Vitis rotundifolia, and Rubus spp. and by the absence or low numbers of Q. laurifolia, which is found more frequently in combination with Nyssa sylvatica in the next community. Stands of this community are restricted to sites which are mesic but which do not flood or do so for only short periods. They are found in protected coves and ravines, and on the lower to middle parts of steep slopes. They also occur in the floodplain of Upper Three Runs Creek on elevated sites that seldom flood. This community has a fairly closed canopy and is usually dominated by a mixture of Liquidambar styraciflua, Nyssa sylvatica, Acer rubrum, and Magnolia virginiana. Liriodendron tulipifera and Fagus grandifolia are seldom dominant species but are largely restricted to stands of this type. The sapling layer is dominated by Persea borbonia, Ilex opaca, A. rubrum, N. sylvatica, Carpinus caroliniana, and M. virginiana. The understory of this community is variable with fairly high cover.
- (3) Nyssa sylvatica-Acer rubrum community: This forest community is best characterized by the presence of Q. laurifolia, Carpinus caroliniana, Ilex opaca, and Saururus cernuus, and by the absence of, or very low numbers of Persea borbonia and large Q. nigra individuals. This community is usually found on flat, moist sites on low floodplains that are regularly but not permanently flooded.
- (4) Quercus nigra-Carpinus caroliniana community: This community is characterized by the presence of Q. nigra, C. caroliniana, Q. laurifolia, Liquidambar styraciflua, Ulmus alata, and by the absence of Ilex opaca stems > 10 cm diameter breast height and of Persea borbonia. Stands of this type are typically found only on islands and levees within or immediately adjacent to the large Savannah River swamp.
- (5) Quercus laurifolia-Ilex decidua community: Stands of this forest community are distinguished from the previous community by the greater abundance of Fraxinus

pennsylvanica, the more widespread occurrence of Platanus occidentalis and by the absence or very low densities of Ilex opaca, Carpinus caroliniana, and Nyssa sylvatica. Although not restricted to this community, Celtis laevigata and Ulmus americana reach their greatest abundances here. This type was only found on low levees within and surrounding the large swampy areas adjacent to the Savannah River.

- (6) Nyssa aquatica-Fraxinus pennsylvanica community: This community is characterized by a canopy of N. aquatica and Taxodium distichum mixed with several other species, e.g., F. pennsylvanica, Acer rubrum, and Liquidambar styraciflua. The presence of F. pennsylvanica indicates a strong relationship to the drier Quercus laurifolia-Ilex decidua community but it differs by the higher densities of N. aquatica and T. distichum and by the absence or near absence of Celtis laevigata, Toxicodendron radicans, and Arundinaria gigantea.
- (7) Taxodium distichum-Nyssa aquatica community: Stands of this community are characterized by a canopy composed completely or nearly completely of T. distichum and N. aquatica and by the absence of Liquidambar styraciflua. A sapling layer is moderately well developed in many stands and is dominated by one or more of the following: Fraxinus caroliniana, T. distichum, and F. pennsylvanica.

3.0 MATERIALS AND METHODS FOR FIELD WORK

3.1 Field Methods

Quadrats were established in wetlands along Four Mile Creek by Dames and Moore, Inc. field crews during July and August, 1990 to determine vegetation composition and characteristics. Each site was surveyed to ensure that the plot would characterize the wetland areas. After selection of the site for each sample plot, a brief characterization of the area was made in the field journal or on the ground cover data sheet. The plot was then established in a rectangular shape of 20 m x 25 m, with all azimuths being recorded on field data sheets. Modifications of the plot shape were necessary in some cases to ensure that the sampling area remained within the floodplain or below the seepage basin; however, the 500 m² sampling area size was retained (e.g., a 10 m x 50 m plot might be established).

In opposing corners of each plot, 1 m² and 25 m² plots were established for characterization of the ground cover and shrub/understory layers, respectively (Figure 3)

The materials used for marking each site consisted of a section of PVC pipe (approximately 5 ft long) which was painted with pink florescent spray paint or flagged with pink flagging. The PVC pipe was driven into the ground in each corner of the plot, with exposed pipe extending at least 1.0 m above the ground. The plot was also staked with a 2 ft section of metal rebar to ensure that each site was permanently marked. All sites were then tagged with an aluminum tag to identify the plot number.

Figure 3-1. Plot Layout for Sampling

One 500 m² plot was used to characterize the overstory (tree) vegetation. To meet the criteria for overstory vegetation, woody plants had to be greater than 61.0 cm in height and greater than or equal to 10.0 cm diameter at breast height (dbh). Diameter at breast height quantifies the diameter of a tree at the standard height of 1.5 meters. The measurement of dbh is used to determine basal area to establish overstory vegetation dominance. All trees which met the above requirements and were located within the plot boundaries, or partially within, were measured and identified to species.

Two 5 x 5 m plots were established in opposing corners within the 20 m x 25 m plot for sampling the shrub layer and understory vegetation. The criterion for understory vegetation was all woody plants greater than 61.0 cm in height and greater than or equal to 2.5 cm dbh and less than 10.0 cm dbh. The shrub stratum contains all woody plants and vines greater than 61.0 cm in height vertically or climbing and less than 2.5 cm dbh (while this criterion is used to define the stratum, actual field measurements of diameter were taken 5.0 cm above the ground on the largest stem). A tree caliper was used to measure the diameter of the vegetation, which was recorded in inches as the standard unit of measurement on the data sheets and converted to centimeters during data analyses.

Two 1 m² plots were sampled in opposing corners of the 20 m x 25 m quadrat, nested within the 5 m shrub/understory plots, to examine the ground cover vegetation. Ground cover vegetation consists of all woody plants less than 61.0 cm in height and all herbaceous plants of any height. All plant species which met the criterion for ground cover vegetation within the 1 m plots were assigned a numerical value indicative of percent cover for that plot. The following table (from Radford et al., 1974) shows cover values.

Cover 0*	-	Cover less than 1 %
Cover 1	-	Cover 1% to 5%
Cover 2	-	Cover 5% to 12.5% to 25%
Cover 4	-	Cover 25% to 50%
Cover 5	-	Cover 50% to 100%

* Cover 0 was used instead of the + for individuals that have a cover less than 1%.

Two specimens of each species documented within each plot were collected when first observed. Both specimens were pressed and then dried in a herbarium dryer. One specimen was identified, labeled, and mounted for archiving. The second specimen will remain in the Dames & Moore Herbarium for future reference. In addition, a species list of all the vascular flora occurring within the 20 m x 25 m plots was compiled to show species that may not have fallen into the nested subplots (Appendix A). Species were identified according to Godfrey et al. (1981a,b) and Radford et al. (1978, 1987).

Tree height was measured using a clinometer to ascertain the average overstory height. Three readings were taken at each plot, then averaged to determine the approximate tree height.

3.2 Analytical Methods

3.2.1 Overstory, Understory, And Shrub Layer Vegetation

Quantitative data were collected from each of the individual quadrat locations for the overstory, understory, and shrub layer strata. The type of data collected for each of these strata was identical and consisted of the individual species identification and the diameter (in inches) measured at breast height for trees in the field. From these data, the following information was derived based on Phillips (1959):

$$\text{Total Density (plants/plot)} = \frac{\text{Number of plants}}{\text{Number of plots sampled}}$$

Total density refers to the number of individuals per plot recorded by species, which is a direct measure of the individual species abundance within the sampling area. For a particular stratum, all plots are a standard size, so comparisons on a per plot basis are equivalent to comparisons on a per unit area basis.

$$\text{Relative Density} = \frac{\text{Number of individuals per species} \times 100}{\text{Number of individuals of all species}}$$

Relative density is derived from the total density just described and is a representation of the percentage of the individuals which consist of an individual species.

$$\text{Total Frequency} = \frac{\text{Number of plots in which the species occurs}}{\text{Number of plots sampled}}$$

Total frequency is the number of times an individual species is recorded from within a given number of quadrats or transects. Commonly the term "frequency of occurrence" is used for this concept. Conceptually, frequency can be considered a measure of abundance and is related in concept to density. However, frequency gives no indication of the cover or biomass of individual plant species within a given measurement area.

$$\text{Relative Frequency} = \frac{\text{Frequency of individual species} \times 100}{\text{Sum of frequencies of all species}}$$

The relative frequency measurement is a directly measured value that is converted to a percentage which is normalized for the individual study area.

$$\text{Total Dominance} = \frac{\text{Total basal area of one species}}{\text{Number of plots}}$$

Total dominance is commonly measured by cover or by basal area. For this study, basal area was selected as the measure of dominance that would provide the most useful data concerning the structural characteristics of the individual vegetation stands surveyed. The total dominance is the collected individual basal area values per tree from within an individual species. Basal area is expressed in cm² for this program. From a plant ecology perspective, the total dominance value is a measure of the success or the "influence" that a given tree species has when compared to other species from within the same measured area. Frequently, important tree species are evaluated on the basis of their dominance characteristics.

$$\text{Relative Dominance} = \frac{\text{Total basal area of one species} \times 100}{\text{Total basal area of all species}}$$

In a manner similar to that noted for relative density and relative frequency, relative dominance is the absolute dominance term expressed as a percentage. The relative dominance percentage indicates the portion of the entire sampling population that consists (in terms of basal area) of the different species that are measured within the transect or quadrat.

$$\text{Importance Value (I.V.)} = \text{Relative Density (\%)} + \text{Relative Frequency (\%)} + \text{Relative Dominance (\%)}$$

The importance value (I.V.) is useful for the evaluation of site vegetation because it combines the three principal measures of the vegetation taken from each of the study sites, namely the density, frequency, and dominance of the plant species. The I.V. uses the relative values (the percentages) obtained for each of the three measurement parameters and results in a numerical value that can range from 0 to 300 depending on the individual site and the mix of species observed. Generally, the higher the I.V. for the individual species, the greater the influence which the species exerts on the study site based on the competition for available nutrients, water, and sunlight. In addition, the I.V. is an indication of the success of the individual species within a specific study site relative to all other species.

In addition to the above numerical results tabulated for the SRS site data, several other statistical measures were determined from the data to provide further insight into the dynamics of the species interactions. The two measures are species richness and species diversity. These concepts are briefly described as follows:

$$\text{Species Richness} = \frac{S-1}{\text{Log } (N)}$$

where: S = Total number of taxa in all sampling units, and
N = Total number of individuals.

This index of species richness was originally proposed by Margalef (1968), and has been extensively used by botanists since. The richness index will vary with sample size, and assumes a functional relationship between S and N. In essence, the richness index is a "species-area" relationship and commonly can be plotted as an approximately straight line if the relationship used is the number of species recorded against the logarithm of the area.

$$\text{Species Diversity} = 1 - \frac{\sum [n_i(n_i-1)]}{N(N-1)}$$

where: n_i = number of individuals in taxa i, and
N = total of all individuals

This is Simpson's diversity index (1949) which represents the probability of picking two organisms at random that belong to different taxa. This index, the complement of Simpson's original measure, ranges from 0.0 (low diversity) to almost 1.0.

3.2.2 Ground Cover Vegetation

Quantitative data were collected from each of the individual transect locations for the ground cover stratum. The data collected for the ground cover stratum were obtained using the microplot-quadrat method (using 1 m² plots). Individual ground cover species were identified from the microplots and an indication of the relative cover was made using the Braun-Blanquet method. (Phillips, 1959). Using this method, individual plant species occupying a percentage of the microplot are recorded on the field sheets showing their percent cover as a Braun-Blanquet cover abundance value ranging from 1 to 5. The following indices were computed.

$$\text{Total Frequency} = \frac{\text{Number of plots at which the species occurs}}{\text{Number of plots sampled}}$$

Vegetation frequency is the number of times that an individual species is recorded from within a given number of individual sampling points. Total frequency is the actual number of points at which a species is found to occur for a given number of sample points. Thus, the total frequency is an absolute value derived directly from the field data sheets.

$$\text{Relative Frequency} = \frac{\text{Frequency of individual species} \times 100}{\text{Sum of frequencies of all species}}$$

The relative frequency measurement is the total frequency value converted to a percentage that is normalized for the individual study area.

$$\text{Total Dominance (Cover)} = \frac{\text{Cover (in \%)} \text{ for each species}}{\text{Number of plots}}$$

Plant dominance is frequently measured by cover. The total dominance (cover) is the collected individual cover values per species, divided by the number of plots sampled. Cover was computed as the midpoint cover value for each cover class.

$$\text{Relative Dominance (Cover)} = \frac{\text{Dominance of the species} \times 100}{\text{Sum of dominances of all species}}$$

The relative dominance (cover) term is expressed as a percentage. The relative dominance percentage indicates the portion of the entire sampling population that consists (based solely on cover) of the different species within the microplot sampling area.

$$\text{Importance Value (I.V.)} = \text{Relative Frequency (\%)} + \text{Relative Dominance (\%)}$$

The importance value (I.V.) concept as applied to the ground cover vegetation is based on two plant measures: frequency (occurrence) and dominance (cover). The I.V. uses the relative values (percentages) obtained for both measurement parameters and results in a numerical value that can range from 0 to 200, depending on the individual site.

For the ground cover stratum, it is necessary to modify the richness and diversity calculations. Because individuals were not counted but only presence and cover, the variable N in the richness calculation can not be number of individuals. Instead, it is calculated as the number

of species x plot occurrences. For example, if five species each occurred on each of seven plots, then $N = 5 \times 7$. This still somewhat overestimates richness because most species on a given plot are represented by many individuals. For diversity, $n = \% \text{ cover of species } i$ and $N = \text{total } \% \text{ cover over all species and plots}$. With these substitutions, the same formulas are used as before.

4.0 RESULTS AND DISCUSSION

This section provides summary descriptive data for the sites sampled. Detailed data by species are provided in Dames & Moore (1990). Following this section, these sample areas are compared and examined for indicators of stress. Note that in the FC and HB areas sampling was confined to intact forest surrounding tree kill zones. The zones of tree kill are discrete and obvious, particularly at FC area where almost no vegetation is left in the wettest spots and all trees in the seeps are dead. At HB area some vegetation recovery is evident, with willows, cattails, and various shrubs and grasses being prominent. The stands described provide a basis for inferring what the kill zone communities looked like before disturbance and what they could look like after recovery. Area locations are shown in Figures 1-1 and 1-2. Summary data are provided in Tables 4-1 through 4-8.

4.1 HC Area

HC area is a control area for comparison to the sampling areas. The area was chosen as a control because of the apparent absence of impact from SRS operations; however, nature has subjected the area to impacts in the form of extensive beaver construction downstream.

The beaver dams have restricted water flow, which may alter the vegetative composition within each stratum. Also, the construction of Youman Road (C-6) has restricted the flow of surface water, thereby causing some ponding of water upstream of the road crossing.

HC area begins west of Road F at a fork in Four Mile Creek, then extends west along the creek, for approximately 2 miles, to the intersection with Road 4 and Four Mile Creek. This section of the creek is within the Aiken Plateau subregion of the Upper Coastal Plain province and ranges in elevation from 210 ft to 240 ft.

Eight sampling plots were established and analyzed within HC area. Old House Road, Seven Springs Road, and Road E-1 were used for access to the sampling sites.

Sixty species were documented during sampling of the HC area. Analysis of the species area curve (Dames & Moore, 1990) indicates that sampling was sufficient to characterize the species diversity of the area after the completion of sample plot 4.

4.1.1 Overstory Stratum

Eight plots were sampled in the HC study area. The 106 individuals representing 15 species gave a diversity value of 0.88, which characterizes the area as being highly diverse. Richness was 6.91. Average canopy height was 58 ft. The dominant species, based on I.V., was yellow poplar (Liriodendron tulipifera) (I.V. 58.72). Following yellow poplar were swamp white oak (Quercus bicolor) (57.25) and sweetgum (Liquidambar styraciflua) (43.0).

Table 4-1. Overstory Basal Area Summary

	Basal Area (cm ² /500m ²)					
	DB	FA	FB	FC	HB	HC
<i>Acer rubrum</i>	625	335	735	961	2139	283
<i>Acer saccharum</i> var. <i>leucoderme</i>						216
<i>Betula nigra</i>	109					
<i>Carpinus caroliniana</i>			366			21
<i>Carya cordiformis</i>				1225		
<i>Cornus florida</i>				128		16
<i>Gordonia lasianthus</i>						82
<i>Ilex decidua</i>					27	
<i>Ilex opaca</i>	141	48	25	30	181	145
<i>Liquidambar styraciflua</i>	429	243	102	794	2050	642
<i>Liriodendron tulipifera</i>	2153	2147	1503		1190	1306
<i>Magnolia virginica</i>	453	1217	488	667	179	166
<i>Myrica cerifera</i>	10					
<i>Nyssa sylvatica</i>	1429	12504	17251	3539	6449	692
<i>Persea borbonia</i>					113	
<i>Pinus taeda</i>		1321	397		431	
<i>Quercus alba</i>						221
<i>Quercus bicolor</i>			50			1689
<i>Quercus lyrata</i>				227		51
<i>Quercus nigra</i>				1533	27	84
<i>Salix nigra</i>	330					

Table 4-2. Overstory Density Summary

	Density (trees/500m ²)					
	DB	FA	FB	FC	HB	HC
<i>Acer rubrum</i>	1.75	1.20	2.00	1.33	6.67	1.13
<i>Acer saccharum</i> var. <i>leucoderme</i>						0.75
<i>Betula nigra</i>	0.50		0.20			
<i>Carpinus caroliniana</i>				3.33		0.13
<i>Carya cordiformis</i>						0.13
<i>Cornus florida</i>				1.33		
<i>Gordonia lasianthus</i>						0.50
<i>Ilex decidua</i>					0.33	
<i>Ilex opaca</i>	0.88	0.40	0.40	0.33	1.33	0.75
<i>Liquidambar styraciflua</i>	0.38		0.60	3.00	3.33	2.13
<i>Liriodendron tulipifera</i>	3.13	2.00	1.00		2.67	3.00
<i>Magnolia virginica</i>	0.88	2.40	2.00	1.00	1.00	1.38
<i>Myrica cerifera</i>	0.13					
<i>Nyssa sylvatica</i>	2.5	12.8	15.00	6.33	9.00	0.38
<i>Persea borbonia</i>					0.67	
<i>Pinus taeda</i>		0.40	0.20		0.67	
<i>Quercus alba</i>						1.00
<i>Quercus bicolor</i>			0.20			0.75
<i>Quercus lyrata</i>				0.33		0.13
<i>Quercus nigra</i>				2.00	0.33	0.75
<i>Salix nigra</i>	1.50					

Table 4-3. Understory Basal Area Summary

	Basal Area (cm ² /500m ²)					
	DB	FA	FB	FC	HB	HC
<i>Acer rubrum</i>	667	69	79	739	544	415
<i>Alnus serrulata</i>	880	3		20		96
<i>Aralia spinosa</i>	6					
<i>Carpinus caroliniana</i>						350
<i>Carya cordiformis</i>				128		
<i>Cornus florida</i>				23		
<i>Cornus stricta</i>	67					
<i>Gordonia lasianthus</i>						43
<i>Ilex opaca</i>	200	427	210	130	713	506
<i>Itea virginica</i>			5			8
<i>Liquidambar styraciflua</i>	25	212	149	333.8	106	518
<i>Liriodendron tulipifera</i>	120				269	196
<i>Magnolia virginica</i>	240	236	29	105	20	862
<i>Nyssa sylvatica</i>	165		91	97		
<i>Persea borbonia</i>		12	57		224	643
<i>Quercus alba</i>					38	8
<i>Quercus bicolor</i>						78
<i>Quercus lyrata</i>						127
<i>Quercus nigra</i>						222
<i>Salix nigra</i>	123					
<i>Smilax laurifolia</i>			2			
<i>Styrex americana</i>	147					
<i>Ulmus alata</i>						65
<i>Vaccinium corymbosum</i>						15
<i>Vitis rotundifolia</i>		12				
<i>Viburnum rufidulum</i>	8	6	4			

Table 4-4. Understory Density Summary

	Density (trees/500m ²)					
	DB	FA	FB	FC	HB	HC
<i>Acer rubrum</i>	23.8	14.0	8.0	43.4	10.0	16.2
<i>Alnus serrulata</i>	93.8	2.0		3.4		11.2
<i>Aralia spinosa</i>	1.2					
<i>Carpinus caroliniana</i>						17.6
<i>Carya cordiformis</i>				10.0		
<i>Cornus florida</i>				10.0		
<i>Cornus stricta</i>	7.6					
<i>Gordonia lasianthus</i>						5.0
<i>Ilex opaca</i>	13.8	18.0	20.0	16.6	30.0	28.8
<i>Itea virginica</i>			14.0			1.2
<i>Liquidambar styraciflua</i>	5.0	26.0	40.0	10.0	3.4	15.0
<i>Liriodendron tulipifera</i>	5.0				6.6	5.0
<i>Magnolia virginica</i>	6.2	20.0	16.0	10.0	6.6	32.6
<i>Nyssa sylvatica</i>	8.8		2.0	3.4		
<i>Persea borbonia</i>		2.0	8.0		23.4	20.0
<i>Quercus alba</i>					3.4	1.2
<i>Quercus bicolor</i>						1.2
<i>Quercus lyrata</i>						2.6
<i>Quercus nigra</i>						8.8
<i>Salix nigra</i>	2.6					
<i>Smilax laurifolia</i>			2.0			5.0
<i>Styrex americana</i>	22.6					
<i>Ulmus alata</i>						2.6
<i>Vaccinium corymbosum</i>						2.6
<i>Vitis rotundifolia</i>		2.0				
<i>Viburnum rufidulum</i>	1.2	20.0	2.0			

Table 4-5. Shrub Basal Area Summary

	Basal Area (cm ² /25m ²)					
	DB	FA	FB	FC	HB	HC
<i>Acer rubrum</i>	1.68	4.06	6.84	1.22		1.76
<i>Alnus serrulata</i>	9.44	1.14		1.81		2.34
<i>Aralia spinosa</i>	0.22					
<i>Betula nigra</i>	0.14					
<i>Carex amphibola</i>	0.03					0.05
<i>Carya cordiformis</i>				0.70		
<i>Cornus florida</i>				0.48		
<i>Cornus stricta</i>	0.74					
<i>Gordonia lasianthus</i>						0.22
<i>Ilex decidua</i>					0.14	
<i>Ilex glauca</i>	0.03					
<i>Ilex opaca</i>	0.73	1.78	9.69	0.17	6.74	1.36
<i>Itea virginica</i>	0.79	0.07	0.13	0.65		1.25
<i>Leucothoe axillaris</i>	6.65					
<i>Ligustrum sinensis</i>					0.08	
<i>Liquidambar styraciflua</i>	0.37	4.78	0.86	1.42		0.42
<i>Liriodendron tulipifera</i>		0.07				0.01
<i>Lyonia lucida</i>	0.06				2.32	1.01
<i>Magnolia virginica</i>	3.66	8.85	19.07	1.22	1.29	2.06
<i>Morus rubra</i>		0.01		0.08		
<i>Myrica cerifera</i>	0.43	1.20		0.22		0.01
<i>Myrica heterophylla</i>		1.20				
<i>Nyssa sylvatica</i>	0.67					
<i>Osmunda cinnamomea</i>		0.25				
<i>Persea borbonia</i>	0.16	1.52	5.17	0.13	15.08	0.64
<i>Pinus taeda</i>		0.02				
<i>Quercus alba</i>			7.32	0.18		
<i>Quercus bicolor</i>			0.08			
<i>Quercus nigra</i>				0.25	0.05	0.48

Table 4-5. Shrub Basal Area Summary (contd)

	Basal Area (cm ² /25m ²)					
	DB	FA	FB	FC	HB	HC
<i>Rhus</i> sp.						0.02
<i>Sambucus canadensis</i>						
<i>Smilax laurifolia</i>		0.05		1.06		0.09
<i>Toxicodendron radicans</i>		0.02			0.20	
<i>Ulmus alata</i>			0.13	0.08		
<i>Vaccinium</i> sp.		0.10			1.50	
<i>Viburnum dentatum</i>		1.09	0.13			
<i>Viburnum nudum</i>	1.68	0.33		3.02		
<i>Viburnum prunifolium</i>					0.05	
<i>Viburnum rufidulum</i>		4.31	2.86	1.13	0.08	0.05
<i>Vitis cinerea</i>		0.05				
<i>Vitis rotundifolia</i>		1.10		0.14	0.77	0.45

Table 4-6. Shrub Density Summary

	Density (stems/25m ²)					
	DB	FA	FB	FC	HB	HC
<i>Acer rubrum</i>	1.0	0.20	0.30	0.33		0.81
<i>Alnus serrulata</i>	6.44	0.30		1.67		1.44
<i>Aralia spinosa</i>	0.31					
<i>Betula nigra</i>	0.19					
<i>Carex amphibola</i>	0.13					0.06
<i>Carya cordiformis</i>				0.83		
<i>Cornus florida</i>				0.83		
<i>Cornus stricta</i>	0.44					
<i>Gordonia lasianthus</i>						0.13
<i>Ilex decidua</i>					0.17	
<i>Ilex glauca</i>	0.06					
<i>Ilex opaca</i>	0.44	0.90	0.50	0.33	1.50	0.75
<i>Itea virginica</i>	2.5	0.30	0.80	2.17		0.75
<i>Leucothoe axillaris</i>	0.13					
<i>Ligustrum sinensis</i>					0.17	
<i>Liquidambar styraciflua</i>	0.25	1.90	0.10	2.17		0.37
<i>Liriodendron tulipifera</i>		0.30				0.06
<i>Lyonia lucida</i>	0.13				2.67	1.31
<i>Magnolia virginica</i>	2.19	0.90	0.90	1.50	0.83	0.88
<i>Morus rubra</i>		0.20		0.17		
<i>Myrica cerifera</i>	0.88			0.67		
<i>Myrica heterophylla</i>		0.70				0.06
<i>Nyssa sylvatica</i>	0.44					
<i>Osmonda cinnamomea</i>		1.20				
<i>Persea borbonia</i>	0.25	1.00	0.20	0.67	7.67	1.0
<i>Pinus taeda</i>		0.10				
<i>Querus alba</i>			0.10	0.67		
<i>Quercus bicolor</i>			0.10			
<i>Quercus nigra</i>				0.83	0.17	0.69

Table 4-6. Shrub Density Summary (contd)

	Density (stems/25m ²)					
	DB	FA	FB	FC	HB	HC
<i>Rhus</i> sp.						0.06
<i>Sambucus canadensis</i>	0.25					
<i>Smilax laurifolia</i>		0.10		1.50		0.13
<i>Toxicodendron radicans</i>		0.10			0.50	
<i>Ulmus alata</i>			0.10	0.17		
<i>Vaccinium</i> sp.		0.10			0.67	
<i>Viburnum dentatum</i>			0.20			
<i>Viburnum nudum</i>	3.88	0.20		5.67		
<i>Viburnum prunifolium</i>					0.17	
<i>Viburnum rufidulum</i>	0.38	4.30	4.40	1.67	0.33	0.13
<i>Vitis cinerea</i>		0.30				
<i>Vitis rotundifolia</i>		0.40		0.17	1.33	0.19

Table 4-7. Summary Presence Data For Ground Cover

	DB	FA	FB	FC	HB	HC
<i>Acer rubrum</i>	X	X	X	X	X	X
<i>Alternanthera philoxeroides</i>						X
<i>Alnus serrulata</i>	X			X		
<i>Antennaria caroliniana</i>	X			X		X
<i>Aristolochia</i> sp.		X				
<i>Arundinaria gigantea</i>	X	X	X			
<i>Arundinaria tecta</i>			X			X
<i>Asplenium platyneuron</i>		X				
<i>Athyrium asplenioides</i>	X	X		X		
<i>Betula nigra</i>	X					X
<i>Bidens frondosa</i>	X					
<i>Bidens vulgata</i>		X				
<i>Boehemeria cylindrica</i>	X			X		
<i>Brassica</i> sp.		X				
<i>Carex digitalis</i>						X
<i>Carex</i> sp.	X	X	X			
<i>Cephalanthus occidentalis</i>				X		
<i>Chasmanthium sessiflorum</i>				X		
<i>Cheilanthes tomentosa</i>						X
<i>Cicuta maculata</i>	X					
<i>Cladium jamaicense</i>			X			
<i>Cyperus</i> sp.	X			X		X
<i>Decumaria barbara</i>	X	X	X	X	X	
<i>Diospyros virginiana</i>						X
<i>Dotter</i>						X
<i>Egeria</i> sp.		X				
<i>Eleocharis</i> sp.		X				X
<i>Elephantopus tomentosa</i>				X		
<i>Eupatorium</i> sp.						X
<i>Festuca</i> sp.		X				
<i>Galium</i> sp.	X				X	X

Table 4-7. Summary Presence Data For Ground Cover (contd)

	DB	FA	FB	FC	HB	HC
<i>Galium tinctorum</i>	X			X		
<i>Gelsemium sempervirens</i>	X		X			
<i>Glyceria</i>			X			
<i>Grass sp.</i>	X			X	X	X
<i>Hexastylis arifolia</i>						X
<i>Hypericum mutilum</i>	X					
<i>Hypericum sp.</i>	X					X
<i>Hydrocotyle verticillata</i>	X					
<i>Ilex decidua</i>					X	
<i>Ilex opaca</i>	X	X			X	X
<i>Impatiens capensis</i>	X			X	X	
<i>Impatiens pallida</i>		X			X	
<i>Itea virginica</i>	X	X	X	X		
<i>Juncus effusus</i>	X					X
<i>Leersia sp.</i>	X					
<i>Leersia virginia</i>	X					
<i>Leucothoe axillaris</i>	X					
<i>Liquidambar styraciflua</i>	X	X	X			
<i>Liriodendron tulipifera</i>		X	X			
<i>Lobelia cardinalis</i>	X					
<i>Lonicera japonica</i>	X		X			X
<i>Ludwigia sp.</i>	X					
<i>Luostria sp.</i>						X
<i>Luzula sp.</i>	X		X			
<i>Lionia lucida</i>	X				X	X
<i>Magnolia virginica</i>			X	X		
<i>Mikania scandens</i>	X					
<i>Mitchella repens</i>		X	X	X	X	
<i>Murdania keisak</i>	X					
<i>Myrica cerifera</i>	X				X	
<i>Nymphaea odorata</i>						X

Table 4-7. Summary Presence Data For Ground Cover (contd)

	DB	FA	FB	FC	HB	HC
<i>Osmunda cinnamonea</i>			X		X	X
<i>Osmunda regales</i>		X			X	
<i>Parthenocissus quinquefolia</i>	X	X	X			
<i>Pavican</i> sp.	X					X
<i>Peltandra virginica</i>	X					
<i>Persea borbonia</i>			X		X	
<i>Pinus taeda</i>		X		X		
<i>Poa autumnalis</i>						X
<i>Polygonum hydropiperoides</i>						X
<i>Polygonum punctatum</i>	X					
<i>Polygonum sagittatum</i>	X					
<i>Polygala rugelii</i>						X
<i>Quercus bicolor</i>			X			
<i>Quercus lyrata</i>			X			
<i>Quercus nigra</i>		X		X		
<i>Rhus</i> sp.				X		
<i>Rubus</i> sp.	X	X		X		X
<i>Saururus cernuus</i>				X		X
<i>Sagittaria latifolia</i>	X			X		X
<i>Salix nigra</i>						X
<i>Scirpus</i> sp.						X
<i>Scirpus cyperanus</i>		X				
<i>Smilax glauca</i>		X	X	X		
<i>Smilax laurifolia</i>			X	X		
<i>Smilax rotundifolia</i>	X	X		X		X
<i>Toxicodendron radicans</i>		X	X	X	X	X
<i>Thelypteris noveboracensis</i>						X
<i>Tradescantia</i> sp.				X		
<i>Tridenum</i> sp.	X					
<i>Triadenum walteri</i>	X					
<i>Typha latifolia</i>	X					

Table 4-7. Summary Presence Data For Ground Cover (contd)

	DB	FA	FB	FC	HB	HC
Vaccinium sp.		X				
Vaccinium vacillens						X
Viburnum nudum	X		X			
Viburnum rufidulum		X				
Vitis rotundifolia			X		X	X
Vitis sp.						X
Viola sp	X	X	X		X	X
Woodwardia areolata	X	X	X	X	X	
Xyris sp.						X

Table 4-8. Richness and Diversity Values

	DB	FA	FB	FC	HB	HC
Richness						
Overstory	4.06	3.52	3.93	4.56	4.76	6.91
Understory	5.04	4.08	5.13	4.65	5.59	9.49
Shrub	7.81	9.23	5.80	8.02	6.50	10.4
Groundcover	23.90	17.10	27.82	17.48	11.01	21.48
Diversity						
Overstory	0.84	0.54	0.50	0.82	0.79	0.88
Understory	0.72	0.83	0.81	0.80	0.82	0.92
Shrub	0.86	0.88	0.66	0.89	0.75	0.92
Groundcover	0.89	0.91	0.92	0.89	0.62	0.83

The relative density for yellow poplar was 22.6. Sweetgum was the most frequently occurring species (relative frequency of 15.8%) with six individuals being measured within the area. Red maple (Acer rubrum) and sweet bay (Magnolia virginiana) frequently occurred within HC area.

4.1.2 Understory Stratum

In the HC sampling area, 16 subplots were sampled for understory vegetation. The area has a highly diverse understory flora with a diversity of 0.91. Richness was 9.49. A total of 163 individuals were measured with 22 different species represented. The number of species reflects the transition and intergradation of community types encountered within the area.

Sweet bay had the highest I.V. (46.6) for the sampling area. Other species with high I.V.'s included American holly (Ilex opaca) (36.91), red bay (Persea borbonia) (33.97), red maple (28.77), and sweetgum (27.10).

Three species had a relative frequency of 11.67%: 7 individuals each of American holly, sweet bay, and red maple occurred within the sampling subplots. Sweet bay had the highest relative dominance (18.98%) while the species with the greatest relative densities were sweet bay (15.95%) and American holly (14.11%).

4.1.3 Shrub Layer Stratum

The shrub layer stratum in HC area was highly diverse with a value of 0.92. Richness was 10.4. Twenty-three species occurred within the 16 subplots that were sampled. The dominant species, based on the I.V., was tag alder (Alnus serrulata) with a value of 38.79. Other species with I.V.'s of significance included: sweet bay (31.35); red maple (30.43); fetterbush (Lyonia lucida) (30.37); American holly (27.12); and red bay (24.74).

Four species had a relative frequency of 10.53%. American holly, Lyonia, red maple, and red bay each had six individuals occurring within the HC shrub layer sampling stratum. Tag alder had a relative dominance of 15.74% and the greatest relative density (14.2%) for the stratum.

4.1.4 Ground Cover Stratum

Sixteen microplots were sampled for ground cover. Forty-two distinct species were recorded. Diversity was 0.83 and richness was 21.48. The species with the highest relative dominance was fetterbush (37.88%). Following fetterbush in relative dominance was woolgrass (Scirpus sp.) (10.49%) and giant bamboo (Arundinaria gigantea) (7.90%). The remainder of the ground cover vegetation had relative dominance values of less than 5%. The species possessing the greatest relative frequency of occurrence was fetterbush with a value of 9.88%. Except for netted chain-fern (6.17%), each of the remaining ground cover species had relative frequency values lower than 5%.

The species with the overall highest I.V. for the HC ground cover was fetterbush (47.74), followed by woolgrass (15.42) and giant bamboo (12.39).

4.2 HB Area

This area was sampled to test for impacts from the H-Area seepage basins. It was only possible to sample stands closest to the creek, which means they are farthest from potential contamination (Figure 1-2). The trees in wetlands closest to the basins have all been killed by outcropping groundwater.

HB area begins at the intersection of Road C and Four Mile Creek and extends east to Road 4. This stretch of Four Mile Creek is located within the Aiken Plateau subregion of the Upper Coastal Plain province and ranges in elevation from 200 ft to 210 ft throughout the 1-mile-long sampling area. There is extensive ponding in this area due to beaver dams below the confluence of Four Mile Creek and an unnamed tributary entering from the north. Three sampling plots were established and sampled within HB area.

Thirty two plant species were documented within HB area. Although the species area curve for the area was not satisfied (i.e., did not level off), sampling was completed after the third plot because the remaining area was inaccessible due to water.

4.2.1 Overstory Stratum

Three subplots were sampled within HB area for overstory vegetation. Seventy-eight individuals were measured within the overstory with 11 species in this stratum. HB area consists of a highly diverse assemblage of vegetation. The diversity for the overstory stratum is 0.79, with a richness of 4.76. Average canopy height was 95 ft.

Based on I.V.'s obtained for HB overstory, the species with the highest value was black gum (Nyssa sylvatica) (100.4). Next, in descending order of importance, were red maple (Acer rubrum) (57.23), sweetgum (Liquidambar styraciflua) (43.0), and yellow poplar (Liriodendron tulipifera) (34.5).

Black gum had both the greatest relative density (34.6%) and relative dominance (50.85%). There were four species with relative frequencies of 15.00% (black gum, red maple, yellow poplar, sweetgum), with each having three specimens occurring within the subplots.

4.2.2 Understory Stratum

Twenty-seven individuals representing 9 species were sampled within the six HB area understory subplots. The diversity for this sampling area was high at 0.82. Richness was 5.59. American holly (Ilex opaca) had four individuals measured within the subplots for a relative density of 33.3%.

American holly was the most frequently occurring species with a relative frequency value of 23.5%. Red maple followed with a value of 17.65%. The dominant species according to the I.V. were American holly (89.85), red maple (53.9), and yellow poplar (31.6).

4.2.3 Shrub Layer Stratum

The measured shrub layer of the HB area was a highly diverse (diversity of 0.74) assemblage of vegetation. Richness was 6.5. The 100 measured specimens represented 14 species. The

species with the highest I.V. for the six subplots was red bay (Persea borbonia) with a value of 121.12. Other dominant species, based on I.V., included American holly (51.17) and fetterbush (Lyonia lucida) (31.55). The remaining 11 species possessed I.V.'s of less than 20 and were not considered to be dominant components of the HB area shrub layer stratum.

The most frequently occurring species was red bay with a relative frequency of 22.2% and relative density of 46.0%. The American holly had a relative dominance value of 23.65%.

4.2.4 Ground Cover Stratum

The HB sampling area included ground cover stratum data from six microplots and resulted in records for 18 distinct species. Diversity was 0.62 and richness was 11.01. The most dominant herbaceous stratum species in this sampling area was fetterbush with a dominance of 59.24%. The netted chain-fern (Woodwardia areolata) was second in dominance with 13.74%, followed by partridge berry (Mitchella repens) with 5.33% relative dominance. Netted chain-fern was the most frequent species with a relative frequency of 17.14%. The other ground cover species with frequent occurrences included partridge berry and fetterbush (11.43%) and American holly (8.57%).

The species that had the highest I.V. for the sampled area was fetterbush, with an I.V. of 70.67. This species was followed by netted chain-fern (30.9), partridge berry (16.76), and American holly (10.58)

4.3 FA Area

Five sampling plots were established within FA area. This location is the first delineated seepage area southwest of Road C-4 on Four Mile Creek. Forty-six species were identified within the sampling plots of FA area. The species area curve indicates that additional samples were needed; however, due to spatial constraints, no further sampling could be accomplished.

4.3.1 Overstory Stratum

Five subplots were analyzed in detail within the overstory stratum. Ninety-seven individual trees were measured, representing a total of seven distinct species. The FA overstory vegetation was moderately diverse in composition with a diversity index of 0.54. Richness was 3.52. Average canopy height was 69 ft. The species with the highest I.V. was black gum (Nyssa sylvatica) (162.48). Next, in descending order of I.V., were sweet bay (Magnolia virginica) (42.52), yellow poplar (Liriodendron tulipifera) (38.15), and red maple (Acer rubrum) (23.86).

The species with the greatest average plot basal area was black gum (12504 cm²/500m²). The species that possessed the greatest relative density within the sampling area was black gum with a relative density of 65.98%.

Black gum also had the highest relative frequency of overstory trees within the sampled area with 64 trees, for a relative frequency of 26.3%.

4.3.2 Understory Stratum

The understory vegetation for the FA sampling area included eight species measured from the 10 subplots accounting for a total of 52 individuals. Diversity was 0.83 and richness 4.08. The species with the highest I.V.'s included American holly (Ilex opaca) (82.75), sweetgum (Liquidambar styraciflua) (72.8), sweet bay (60.75), and red maple (37.9). The understory species that was most numerous was sweetgum with 13 individuals. Sweetgum had the highest relative frequency for the sampling area with 26.09% of the entire stand comprised by this species. In addition, the relative density of this species was also greatest within the measured subplots with a relative density of 25%. By contrast the species with the largest basal area for the stand was American holly which comprised 43.7% of the entire basal area measured for all of the subplots. This large value accounts for American holly having the highest I.V.

4.3.3 Shrub Layer Stratum

The measured shrub layer of the FA sampling area was a highly diverse assemblage of vegetation. This stratum included 147 measured individuals representing 21 species for a diversity value of 0.88. Richness was 9.23. The species with the highest I.V. for the 10 subplot sampling area was rusty blackhaw (Viburnum rufidulum) with an I.V. of 56.25. Other dominant species included sweet bay (45.6), sweetgum (39.25), and American holly (24.9). The remaining 16 species each possessed I.V.'s of less than 20 and were not considered to be dominant components of this stratum.

The species with the highest relative density for the shrub sampling layer in the FA area was rusty blackhaw which accounted for 29.25% of the relative density of the entire stand. Sweet bay had the highest relative dominance, with 28.6%. The highest relative frequency (of occurrence) in the shrub layer was shared by rusty blackhaw and American holly, both possessing relative frequencies of 13.09%.

4.3.4 Ground Cover Stratum

The ground cover stratum of the FA sampling area was sampled at 10 subplot locations. Diversity was 0.91 and richness was 17.10. Within the FA area, 32 distinct species were recorded. The most dominant of the ground cover vegetation was rusty blackhaw (Viburnum rufidulum) with a relative dominance of 17.69%. Giant bamboo (Arundinaria gigantea) followed, with a relative dominance of 13.78%. Netted chain-fern was the most frequently occurring species with a relative frequency of 10.77%, followed by rusty blackhaw with a relative frequency of 9.23%. Based on I.V., rusty blackhaw (26.92), giant bamboo (20.39), netted chain-fern (16.52), were the dominant components of the ground cover vegetation stratum.

4.4 FB Area

FB area is situated to the west of (downstream), and adjacent to, FA area. Five plots were sampled, with 46 species surveyed within this area. Although the species area curve shows sufficient sampling with the completion of the second plot, five plots were sampled.

4.4.1 Overstory Stratum

The FB area was sampled in the same manner as described previously for the FA area. Within the FB sampling area, the overstory vegetation was analyzed in the field from five subplot locations. In the overstory tree stratum, 108 individual trees of nine distinct species were measured giving a moderate diversity of 0.5. Richness was 3.93. Average canopy height was 65 ft. The overstory tree species possessing the highest I.V. for this sampling area was black gum (Nyssa sylvatica) (174.68). The other dominant tree species included yellow poplar (Liriodendron tulipifera) (25.23), red maple (Acer rubrum) (30.95), and sweet bay (Magnolia virginica) (25.73). The species with the highest relative density was black gum (relative density 69.44%). Black gum also was the species with the highest relative dominance (78.74%). Black gum had the highest relative frequency with 22.73%. All other species had relative frequencies lower than 20%.

The overstory species with the highest average individual tree basal area was loblolly pine (Pinus taeda) with an average value of 1,986.5 cm² per tree. The loblolly pine was closely followed in average basal area by the southern shagbark hickory (Carya carolinac-septentrionalis) with a value of 1,829.2 cm² per tree. By far, the species with the largest total basal area was black gum with 13580 cm²/500 m².

4.4.2 Understory Stratum

The FB area understory stratum consisted of 57 individuals from the ten subplots measured. Ten species were recorded from the understory stratum, giving a diversity of 0.81. Richness was 5.13. The understory species possessing the highest I.V. was American holly (Ilex opaca) (75.08). Next in importance were sweetgum (Liquidambar styraciflua) (70.97), red maple (35.62), sweet bay (34.6), and red bay (Persea borbonia) (28.18). The understory species with the highest relative density was sweetgum with a value of 35.09%. American holly had the highest relative dominance with 33.54%. American holly was the most numerous species encountered and resulted in the highest relative frequency at 24.0%.

4.4.3 Shrub Layer Stratum

The shrub layer stratum for FB area had 24 species representing the 79 individuals that were measured, giving a diversity of 0.66. Richness was 5.80. Ten subplots were analyzed for this area. The dominant species was sweet bay with a relative dominance of 35.71%. American holly followed with a relative dominance of 18.14%, then white oak (Quercus alba) with 13.7%.

The most frequently occurring species in the shrub layer stratum were sweet bay, with a relative frequency of 25.0% (nine occurrences), American holly (12.5%), red maple (12.5%), and three others with a relative frequency of 8.3%. The highest I.V. was calculated for sweet bay, with a value of 72.1. Other species included rusty blackhaw (69.38), American holly (36.97), and red maple (29.10).

4.4.4 Ground Cover Stratum

Ten subplots were measured within the FB sampling area. The sampling points included measurements of 28 distinct species. Diversity was 0.89 and richness was 27.41. The species with the highest individual relative dominance was giant bamboo (Arundinaria gigantea) with a 14.74% dominance. This was followed in dominance by Virginia willow (Itea virginica) with a dominance of 13.42%. Netted chain-fern (Woodwardia areolata) was third with a dominance of 8.36%. The most frequently occurring species was the netted chain-fern with a relative frequency of 13.73%. Climbing hydrangea (Decumaria barbara), was second in relative frequency at 7.84%.

The species with the highest I.V.'s included giant bamboo (30.44), netted chain-fern (22.09), climbing hydrangea (14.70), Virginia willow (19.31), and cinnamon fern (Osmunda cinnamomea) (11.93).

4.5 FC Area

FC area is located approximately 300 ft to the east of Road C-4. Three plots were sampled in this area.

The species area curve, with 40 plant species encountered, indicates insufficient sampling of FC area. Although the curve shows more sampling was needed, there were spatial constraints which prevented the addition of more sample plots.

4.5.1 Overstory Stratum

Nine different species representing 57 individuals were measured in the three FC area overstory plots. The diversity for this sampling area was 0.80, with black gum (Nyssa sylvatica) having the highest I.V. (93.6). Richness was 4.56. Average canopy height was 57 ft. Black gum also had the greatest frequency (relative frequency of 21.4) with three individuals occurring within the overstory stratum sampling plots. Three species with two individuals each were measured within FC area: water oak (Quercus nigra), red maple (Acer rubrum), and sweetgum (Liquidambar styraciflua).

The species that possessed the greatest relative density within the sampling area was black gum with a relative density of 33.3%. Black gum had a relative dominance of 38.8%, followed by water oak (16.8%), red maple (10.5%), and sweet bay (Magnolia virginica) (7.3%).

4.5.2 Understory Stratum

The FC understory stratum was moderately diverse with a value of 0.79. Richness was 4.65. Within the six subplots, there were a total of 32 individuals representing eight species. Red maple had the greatest basal area with a relative dominance of 46.88%. The highest relative density was red maple with 40.6%.

The I.V. for red maple was 114.78. Three other species, sweetgum (39.64), bitternut hickory (Carya cordiformis 35.63), and American holly (Ilex opaca 32.9), had I.V.'s over 30 in the FC understory stratum.

4.5.3 Shrub Layer Stratum

The shrub layer vegetation stratum for FC area was sampled with six subplots. Twenty-eight different species were documented and 132 individual specimens were measured and recorded. The area was highly diverse with a value of 0.89. Richness was 8.02. This shrub layer stratum was typical of all shrub layer units within the F-Area sampling sites.

Possumhaw (Viburnum nudum) had the greatest I.V. (54.58), with red maple, tag alder (Alnus serrulata), and sweetgum following. Possumhaw had the highest relative density, with a value of 25.76%, and was the dominant (in terms of relative dominance) with a value of 21.68%.

Possumhaw was also the most frequently occurring species within the shrub layer stratum.

4.5.4 Ground Cover Stratum

Six subplots were sampled within FC area for ground cover vegetation. The stratum had 29 distinct species. Diversity was 0.89 and richness was 28.38. The most dominant ground cover species recorded from this area was netted chain-fern (Woodwardia areolata) with a relative dominance of 25.88%. This was followed by giant bamboo (Arundinaria gigantea) (17.29%), ox-eye daisy (Chrysanthemum segetum) (7.05%), and partridge berry (4.71%).

The most frequently occurring species within the stand were red maple, giant bamboo, and netted chain-fern, with relative frequencies of 7.5% each.

Netted chain-fern had the highest I.V. of the ground cover species, with an I.V. of 33.38. Following netted chain-fern were giant bamboo (24.79), daisy (12.85), red maple (11.03), and partridge berry (Mitchella repens) (9.71).

4.6 DB Area

DB area begins north of the junction of Four Mile Creek and Road 3, extending to approximately 500 feet above Road A-6. This section of Four Mile Creek is situated within the Brandywine Terrace subregion of the Pleistocene Coastal Terraces. There is little elevation change in the DB area.

Eight sampling plots were established and sampled, with 64 species being documented. The species area curve is incomplete, which may possibly be attributed to a change in the community type being sampled.

4.6.1 Overstory Stratum

Eight subplots were sampled in DB area for overstory vegetation. Ninety-three individual trees, comprised of nine different species, were measured giving a diversity of 0.83 and a richness of 4.06. Average canopy height was 66 ft. The species with the highest I.V. was yellow poplar (Liriodendron tulipifera) (I.V. 84.79). The following species were determined to have high I.V.'s: black gum (Nyssa sylvatica) (66.67), red maple (Acer rubrum) (41.05), sweet bay (Magnolia virginica) (30.51), and black willow (Salix nigra) (28.72).

Yellow poplar had the highest relative density within the sampling area at 26.8%. Yellow poplar, along with black gum, had the greatest relative frequency of overstory trees at 20%.

4.6.2 Understory Stratum

Sixteen subplots were sampled for understory vegetation in DB area. The species with the highest I.V.'s included tag alder (Alnus serrulata) (101.65), red maple (60.1), sweet bay (25.29), and black gum (20.47). The highest relative frequency for the understory vegetation was red maple (22.58%), which had 19 individuals within the study area.

The DB area understory represents an extremely diverse stratum. One hundred fifty-three individuals were measured, representing 12 different species, yielding a diversity of 0.72 and a richness of 5.04. In terms of relative density, tag alder was the highest at 49.02% followed by red maple at 12.42%.

Relative dominance was the greatest for tag alder due to its large total basal area coverage (33.28%).

4.6.3 Shrub Layer Stratum

The shrub layer stratum for DB area was highly diverse; it included 20 individual species with a total occurrence of 68 specimens, yielding a diversity value of 0.85 and a richness of 7.81. The I.V.'s for the dominants are tag alder (70.77), possumhaw (Viburnum nudum) (34.18), and Virginia willow (Itea virginica) (30.22). Itea had the highest relative frequency with a value of 16.13 and was closely followed by red maple and tag alder, both having values of 12.9. Tag alder accounted for 28.2% of the relative density for the sampling area as a whole.

4.6.4 Ground Cover Stratum

The DB sample area included 28 individual ground cover stratum plots with 58 distinct species observed. Diversity was 0.89 and richness was 23.90. Three of the ground cover species rated high for relative dominance: touch-me-not (Impatiens capensis) (27.58%), tear-thumb (Polygonum sagittatum) (11.82%), and Murdannia (Murdannia keisak) (10.24%). Three species had high relative frequencies: touch-me-not (12.0%), Murdannia (6.0%) and tear-thumb (Polygonum sagittatum) (5.33%).

The following species possessed notable I.V.'s: touch-me-not (39.58), tear-thumb (Polygonum sagittatum) (17.15), Murdannia (16.24), netted chain-fern (10.32), cutgrass (Leersia sp.) (8.37), false nettle (Boehemeria cylindrica) (7.01), red maple (7.18), an unidentified grass species (6.26), and Lycopus (Lycopus sp.) (5.85).

5.0 SITE COMPARISONS

All of the stands sampled could be classified (Whipple et al., 1981) as bottomland hardwood forest based on overstory and understory dominant species (Tables 4-1 through 4-4). Areas FC and FB could be classified as Nyssa sylvatica - Acer rubrum communities and all the rest as the slightly drier Nyssa sylvatica - Persea borbonia type. These two types are quite similar. The ground cover is highly diverse and variable (Table 4-8). No threatened or endangered plant species were found on any site.

Figure 5-1. Cluster Analysis of overstory attributes. (a) Clustering based on dominant species basal areas per 500 m²: Magnolia virginica, Acer rubrum, Nyssa sylvatica, Liquidambar styraciflua, Ilex opaca, and Liriodendron tulipifera. (b) Clustering based on average basal area, diversity, and number of stems per plot.

To compare the different sites, cluster analysis was performed on stand attributes using the SYSTAT computer code. Because the age of overstory trees predates any likely environmental impact, overstory attributes were used for an initial clustering. Using mean plot basal area, tree diversity, and mean number of tree stems per plot, the clustering in Figure 5-1 was obtained. Stands DB and HC are the most similar, due largely to very low and almost identical mean basal areas. Stands FC and HB cluster next with these two. Stands FB and FA cluster together due to large mean basal areas and low diversities. These two stands are strongly dominated by *Nyssa sylvatica*. These results were not affected by the linkage method used. To test this result, these same stands were clustered based on mean plot basal area for dominant species. Species that made up the bulk of the basal area were used: *Magnolia virginica*, *Acer rubrum*, *Nyssa sylvatica*, *Liquidambar styraciflua*, *Ilex opaca*, and *Liriodendron tulipifera*. Results (Figure 5-1) are qualitatively the same as when based on aggregate stand attributes.

Data for the shrub and herbaceous layers were examined for any effects. Only dominant species were used in the analysis, based on the six to eight species with the greatest dominance. Shrub and herbaceous layer cluster analyses were not similar to each other nor to the overstory. Shrub results based on aggregate attributes were very different from those based on species basal areas. Results were very sensitive to which species were included and to the linkage method used. The two most contaminated plots (FA and FC) did not tend to cluster together nor did they tend (singly or together) to be outliers from the other sites, nor did potentially impacted HB. Thus there was no evidence based on species composition of the shrub and herb layers for inferring a contamination effect. It is possible, however, that the high species diversity and plot to plot variability prevents any differences due to contamination from being detected using cluster analysis.

If there were any effects of contamination on the overstory, it might show up in the mean basal area per plot. Contamination since the early 1970's could have caused reduced growth. However, the stands near or in contaminated zones (FA and FC) have the highest mean total (overstory plus understory) basal areas (21893 and 23068 cm²/500 m² vs. 8334, 9730, 10240 and 15059 for DB, FB, HC and HB, respectively). Potentially impacted HB has average basal area. Thus, site quality and stand history factors (e.g., circumstances of stand establishment) are far more important in determining gross stand structure as measured by mature trees than is any effect of soil contamination.

The total average herbaceous cover per plot from FC area (the most contaminated) was 42%, which is much lower than the other sites (65%, 76%, 77%, 84%, and 74% from DB, FB, FA, HC, and HB, respectively). For the shrub layer, the total average basal area per plot is lower in FC area (14 cm²/plot) than in any other area (32, 53, 31, and 29 cm²/plot from DB, FB, FA, and HC, respectively) except for HB (15 cm²/plot) which is also a potentially impacted area. These trends could be due to overstory basal area effects, however, in FC area.

For the overstory, species richnesses (Table 4-8) for FB (3.93) and FA (3.52) but not FC (4.56) were lower than those for DB, HB, and HC (4.06, 4.76, and 6.91 respectively). The same trend can be seen for overstory diversity; FB (0.50) and FA (0.54) but not FC (0.82) are lower than DB, HB, and HC (0.84, 0.79, and 0.88, respectively). No understory

differences in diversity or richness were evident. For the shrub layer all sites showed high diversity except FB (0.66 vs 0.86, 0.89, 0.87, 0.75, and 0.92 for DB, FC, FA, HC, and HB, respectively). The same trend exists for species richness. These results are likely due to the fact that the FA overstory is very dense and probably suppresses the understory. FB is farthest of the F sites from the seepage basins and experienced only low levels of contamination. Thus the differences in diversity and richness in FA and FB overstory and shrub strata do not seem to result from contamination.

For the ground cover layer, however, species richness was much lower in HB (11.01) and somewhat lower in FA and FC (17.10 and 17.48) compared to the unimpacted DB, FB, and HC sites (23.90, 27.82, and 21.48, respectively). Ground cover diversity was only reduced in HB area (0.62 vs 0.89, 0.91, 0.92, 0.89, and 0.83 for DB, FA, FB, FC, and HC, respectively). It is likely that these trends are ecologically significant, except possibly for the FA richness value.

In conclusion, the sampled areas are all broadly similar and highly diverse. Cluster analysis does not reveal any pattern related to the pattern of contamination. Average ground cover stratum cover and shrub layer basal area are significantly lower in FC area and shrub basal area is lower in HB area. Some diversity and richness effects are evident in FC and HB areas and perhaps in FA area, although high tree basal area in FA and FC areas complicates interpretation. Otherwise no effects due to contamination are detectable with the type of data collected.

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APPENDIX I - VASCULAR FLORA OF SRS

PTERIDOPHYTA

Blechnaceae	Woodwardia areolata - Netted chain-fern
Osmundaceae	Osmunda cinnamomea - Cinnamon fern Osmunda regales - Royal fern
Polypodiaceae	Athyrium asplenoides - Southern lady fern Thelypteris noveboracensis - New York Fern
Aspleniaceae	Asplenium platyneuron - Ebony spleen wort
Pteridaceae	Cheilanthes tomentosa - Woolly lipped fern Pteridium aquilinum - Bracken fern

GYMNOSPERMAE

	Pinus echinata - Shortleaf pine
	Pinus elliottii - Slashpine
Pinaceae	Pinus palustris - Longleaf pine Pinus taeda - Loblolly pine
Taxodiaceae	Taxodium distichum - Bald cypress

ANGIOSPERMAE

DICOTYLEDONEAE:

Aceraceae	Acer negundo - Box elder Acer rubrum - Red maple Acer saccharum floridanum var. - Southern sugar maple Acer saccharum var. leucoderme - Chalk maple
Amaranthaceae	Alternanthera philoxeroides - Alligator weed
Anacardiaceae	Rhus copallina - Winged sumac Rhus glabra - Smooth sumac Toxicodendron radicans - Poison ivy Toxicodendron vernix - Poison sumac
Apiaceae	Cicuta maculata - Water hemlock Hydrocotyle ranunculoides - Floating pennywort Hydrocotyle verticillata - Whorled pennywort
Apocynaceae	Vinca sp. - Periwinkle
Aquifoliaceae	Ilex glauca - Inkberry

APPENDIX I (contd)

	<i>Ilex opaca</i> – American holly
	<i>Ilex verticillata</i> – Winter holly
	<i>Ilex vomitoria</i> – Yaupon
Araliaceae	<i>Aralia spinosa</i> – Hercules club
Aristolochiaceae	<i>Aristolochia</i> sp. – Birthwort
	<i>Hexastylis arifolia</i> – Wild ginger
Balsaminaceae	<i>Impatiens capensis</i> – Jewelweed
Betulaceae	<i>Alnus serrulata</i> – Tag alder
Bignoniaceae	<i>Bignonia capreolata</i> – Crossvine
Brassicaceae	<i>Nasturtium officinale</i> – Watercress
	<i>Nasturtium</i> sp. –
Campanulaceae	<i>Lobelia cardinalis</i> – Cardinal flower
	<i>Sphenoclea zeylandica</i> –
Caprifoliaceae	<i>Lonicera japonica</i> – Japanese honeysuckle
	<i>Sambucus canadensis</i> – Elderberry
	<i>Viburnum dentatum</i>
	<i>Viburnum nudum</i> – Possumhaw
	<i>Viburnum prunifolium</i> – Black haw
	<i>Viburnum rufidulum</i> – Bluehaw
	<i>Viburnum</i> sp.
Caryophyllaceae	<i>Paronychia riparia</i> –
Celastraceae	<i>Euonymus americanus</i> – Strawberry bush
Chenopodiaceae	<i>Chenopodium ambrosioides</i> – Mexican tea
Compositae	<i>Antennaria caroliniana</i> – Pussy-toes
	<i>Aster</i> sp.
	<i>Aster vimineus</i> var. <i>subdumosus</i>
	<i>Baccharis halimifolia</i>
	<i>Bidens discoidea</i>
	<i>Bidens frondosa</i> – Beggar ticks
	<i>Bidens</i> sp. – Beggar ticks
	<i>Bidens vulgata</i> –
	<i>Chrysanthemum segetum</i> – Daisy

APPENDIX I (contd)

	<i>Eclipta alba</i>
	<i>Elephantopus tomentosus</i> – Elephant's foot
	<i>Erigeron canadensis</i> – Horseweed
	<i>Eupatorium capillifolium</i> – Dogfennel
	<i>Eupatorium perfoliatum</i> – Boneset
	<i>Eupatorium rugosum</i>
	<i>Eupatorium</i> sp.
	<i>Latuca canadensis</i> –
	<i>Latuca</i> sp.
	<i>Mikania scandens</i> – Climbing hempweed
	<i>Pluchea camphorata</i> – Marsh fleabane
	<i>Solidago gigantea</i> – Goldenrod
	<i>Solidago</i> sp.
Commelinaceae	<i>Tradescantia</i> sp. – Spiderwort
Convolvulaceae	<i>Cuscuta</i> sp. – Dodder
	<i>Cornus amomum</i> – Dogwood
Cornaceae	<i>Cornus florida</i> – Flowering dogwood
	<i>Cornus stricta</i> – Swamp dogwood
Ebenaceae	<i>Diospyros virginiana</i> – Persimmon
Ericaceae	<i>Leucothoe axillaris</i> – Leucothoe
	<i>Lyonia lucida</i> – Fetter-bush
	<i>Oxydendrum arboreum</i> – Sourwood
	<i>Rhododendron</i> sp. – Rhododendron
	<i>Rhododendron viscosum</i> – Swamp honeysuckle
	<i>Vaccinium corymbosum</i> – Blueberry
	<i>Vaccinium arboreum</i> – Sparkleberry
	<i>Vaccinium</i> sp.
	<i>Vaccinium vacillans</i>
Euphorbiaceae	<i>Tragia urens</i>
Fabaceae	<i>Aeschynomene evenia</i>
	<i>Centrosema virginianum</i> – Butterfly pea
	<i>Clitoria mariana</i> – Butterfly pea

APPENDIX I (contd)

	<i>Prunus angustifolia</i> – Chickasaw plum
	<i>Prunus serotina</i> var <i>virens</i> – Black cheery
	<i>Rubus</i> sp. – Blackberry
	<i>Sorbus arbutifolia</i> – Red chokeberry
	<i>Sorbus melanocarpa</i> – Black chokeberry
	<i>Sorbus</i> sp. – Chokeberry
Rubiaceae	<i>Cephalanthus occidentalis</i> – Buttonbush
	<i>Diodia</i> sp.
	<i>Galium circaezans</i> – Bedstraw
	<i>Galium obtusum</i> – Bedstraw
	<i>Galium</i> sp. – Bedstraw
	<i>Galium tinctorium</i> – Bedstraw
	<i>Mitchella repens</i> – Partridge berry
	<i>Oldenlandia uniflora</i> –
Salicaceae	<i>Salix nigra</i> – Black willow
Saururaceae	<i>Itea virginica</i> – Virginia willow
	<i>Saururus cernuus</i> – Lizard's tail
Saxifragaceae	<i>Decumaria barbara</i> – Climbing hydrangea
Scrophulariaceae	<i>Agalinis purpurea</i>
	<i>Lindernia</i> sp.
	<i>Mimulus alatus</i>
	<i>Mimulus ringens</i>
Styracaceae	<i>Styrax americana</i> – Storax
Theaceae	<i>Gordonia lasianthus</i> – Loblolly bay
Ulmaceae	<i>Celtis laevigata</i> – Hackberry
	<i>Planera aquatica</i> – Planer-tree
	<i>Ulmus alata</i> – Winged elm
	<i>Ulmus americana</i> – American elm
Urticaceae	<i>Boehemeria cylindrica</i> – False nettle
	<i>Pilea pumila</i> – Clearweed
Verbenaceae	<i>Callicarpa americana</i> – Beauty-berry
Violaceae	<i>Viola</i> sp. – Violet

APPENDIX I (contd)

	Decodon verticillatus – Water willow
Magnoliaceae	Liriodendron tulipifera – Yellow poplar
	Magnolia virginica – Sweet bay
Malvaceae	Hibiscus militaris – Halberd-leaved marshmallow
	Hibiscus moscheuto – Rose mallow
Moraceae	Morus rubra – Red mulberry
Myricaceae	Myrica cerifera – Wax myrtle
	Myrica heterophylla – Bayberry
Nymphacaceae	Nymphaea odorata – Water lily
Nyssaceae	Nyssa aquatica – Watergum
	Nyssa sylvatica – Black gum
Oleaceae	Fraxinus pennsylvanica – Green ash
	Fraxinus sp. – Ash
Onagraceae	Ludwigia alternifolia – Seedbox
	Ludwigia decurrens
	Ludwigia glandulosa – Seedbox
	Ludwigia leptocarpa – Seedbox
	Ludwigia linearis – Seedbox
	Ludwigia palustris – Seedbox
	Ludwigia sp.
Orchidaceae	Habenaria repens – Water-spider orchid
Oxalidaceae	Oxalis sp. – Wood sorrel
Polygalaceae	Polygala rugelii – Yellow milkwort
Polygonaceae	Polygonum hydropiper – Knotweed
	Polygonum hydropiperoides – Knotweed
	Polygonum punctatum – Dotted smartweed
	Polygonum sagittatum – Tearthumb
	Polygonum setaceum – Knotweed
	Polygonum sp. – Knotweed
Primulaceae	Lysimachia sp. –
Rhamnaceae	Berchemia scandens
Rosaceae	Crataegus sp. – Hawthorne

APPENDIX I (contd)

	Desmodium tortuosum – Beggars lice
	Lespedeza cuneata – Sericea
	Lespedeza sp. – Sericea
	Wisteria frutescens – Wisteria
Fagaceae	Carpinus caroliniana – Iron wood
	Quercus alba – White oak
	Quercus bicolor – Swamp white oak
	Quercus laurifolia – Laurel oak
	Quercus lyrata – Overcup oak
	Quercus marilandica – Black jack oak
	Quercus michauxii – Swamp chestnut oak
	Quercus nigra – Water oak
	Quercus phellos – Willow oak
	Quercus sp. – Oak
	Quercus stellata – Post oak
	Quercus stellata var margarettae – Scrubby post oak var MA
Gentianaceae	Obolaria virginica – Pennywort
	Sabatia sp.
	Sabatia stellaris
Hamamelidaceae	Liquidambar styraciflua – Sweetgum
Hydrophyllaceae	Hydrolea quadrivalvis –
Hypericaceae	Hypericum mutilum – St. John's wort
	Hypericum sp. – St. John's wort
	Triadenum sp.
	Triadenum walteri
Juglandaceae	Carya sp. – Hickory
Lamiaceae	Lycopus rubellus
	Lycopus sp.
Lauraceae	Persea borbonia – Red bay
	Sassafras albidum – Sassafras
Loganiaceae	Gelsemium sempervirens –
Lythraceae	Ammannia coccinea – Toothcups

APPENDIX I (contd)

Vitaceae	Parthenocissus quinquefolia – Virginia creeper Amphelopsis arborea – Peppervine Vitis cinerea – Pigeon grape Vitis rotundifolia – Muscadine
	MONOCOTYLEDONEAE:
Alismataceae	Sagittaria latifolia – Arrowleaf Sagittaria montevidensis – Giant arrowleaf Sagittaria sp.
Araceae	Peltandra virginica – Duck potato
Arecaceae	Sabal minor – Palmetto Serenoa repens – Saw palmetto
Bromeliaceae	Tillandsia usneoides – Spanish moss
Commelinaceae	Murdania keisak – Marsh dew flower
Cyperaceae	Carex amphibola – Sedge Carex digitalis Carex folliculata Carex janiesii Carex jorii Carex radiata Carex sp. Cyperis albomarginatus Cyperis sp. Cyperus strigosus Dulichium arundinaceum Eleocharis sp. – Spikerush Rhynchospora sp. Rhynchospora corniculata – Beakrush Cyperus cyperinus – Woolgrass Scirpus sp.
Dioscoreaceae	Dioscorea villosa – Wild yam
Hydrocharitaceae	Elodea sp. – Water weed
Juncaceae	Juncus coriaceus

APPENDIX I (contd)

	<i>Juncus effusus</i> – Rush
	<i>Juncus</i> sp. – Rush
Liliaceae	<i>Smilax glauca</i> – Catbriar
	<i>Smilax laurifolia</i> – Bamboo catbriar
	<i>Smilax rotundifolia</i> – Roundleaf catbriar
	<i>Smilax</i> sp. – Catbriar
Ophioglossaceae	<i>Botrychium biternatum</i> – Southern grape fern
	<i>Botrychium dissectum</i> – Common grape fern
	<i>Botrychium</i> sp. – Grape fern
Orchidaceae	<i>Habenaria</i> sp.
Osmundaceae	<i>Osmunda cinnamomea</i> – Cinnamon fern
Poaceae	<i>Andropogon</i> sp. – Bedstraw
	<i>Andropogon virginicus</i> – Broom sedge
	<i>Arundinaria gigantea</i> – Giant bamboo
	<i>Echinochola colonum</i> – Bog button
	<i>Echinochola crusgalli</i> – Barnyard grass
	<i>Echinochola</i> sp.
	<i>Phyllostachys aurea</i> – Cane
	<i>Chasmanthium sessiflorum</i>
	<i>Cynodon dactylon</i>
	<i>Digitaria sanguinalis</i> – Crab grass
	<i>Glyceria</i> sp. – Manna grass
	<i>Festuca</i> sp. – Fescu
	<i>Leersia</i> sp. – Cutgrass
	<i>Leersia oryzoides</i> – Cutgrass
	<i>Leersia virginia</i> – Cutgrass
	<i>Paspalum floridianum</i> – Paspalum
	<i>Panicum</i> sp.
	<i>Panicum verrucosum</i>
	<i>Paspalum urvillei</i> – Paspalum
	<i>Poa autumnalis</i>
	<i>Setaria</i> sp.

APPENDIX I (contd)

	<i>Trisetum pensylvanicum</i>
Polypodiaceae	<i>Polypodium polypodioides</i> – Resurrection fern
Salviniaceae	<i>Azolla caroliniana</i> – Mosquito fern
Typhaceae	<i>Typha latifolia</i> – Cattail
Xyridaceae	<i>Xyris</i> sp. – Yellow eyed grass

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