
Atlantic White Cedar Wetlands

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Vegetation Patterns in Six Bogs and Adjacent Forested Wetlands on the Inner Coastal Plain of Maryland

James C. Hull and Dennis F. Whigham

Abstract. Phytosociological comparisons were made between one of the last remaining natural bogs and forested wetlands containing Atlantic white cedar (*Chamaecyparis thyoides*) on the Maryland western shore and five nearby wetlands. Each of the five sites contained a bog that had developed as a result of human alteration of the original forested wetland. Comparisons were made using indices of similarity, polar ordination, and cluster analysis of data obtained by sampling transects in the bogs and forested wetlands.

In general, the bogs and forested wetlands had similar woody species, but the herbaceous flora was different. The bog that was the greatest distance from the natural white cedar bog was floristically more distinct than were the closer bogs. All of the bogs will probably succeed to forested wetlands, but there is no evidence that Atlantic white cedar will invade the five anthropogenically created bogs even though the habitat conditions appear to be suitable.

Key words: Atlantic white cedar, bog, cluster analysis, floristic similarity, forested wetland, Maryland, polar ordination

Introduction

Atlantic white cedar [*Chamaecyparis thyoides* L. BSP.] in Maryland, Delaware, and Virginia is almost totally restricted to wetlands on the Outer Coastal Plain, an area known as the Delmarva Peninsula. The only exception is an area on the Western Shore of Chesapeake Bay near Annapolis, Maryland where one or two stands and scattered individuals are still extant (Sipple and Klockner 1980; 1984).

Except for a study by Beaven and Oosting (1939), most information on Atlantic white cedar wetlands in the Delmarva region is qualitative (Fleming 1978; Maryland Department of State Planning 1975;

McCormick and Somes 1982; Sipple 1977a; 1977b; 1977c; 1978; Smith 1938; Stalter 1981). The Atlantic white cedar site on the Western Shore has been floristically evaluated along with several other nearby bogs (Sipple and Klockner 1980; 1984). In this paper we report results of a quantitative comparison of vegetation in the Western Shore Atlantic white cedar wetland with vegetation in five other wetlands in the same area. Forested wetlands and bogs occur at all of the sites, but the Atlantic white cedar site (Cypress Creek) is the only one with a natural bog. At the other sites, bogs are of recent origin and have all developed in areas altered by man's activities.

Our working hypothesis was that the forested wetlands would contain many shared species while the bogs would have fewer species in common because they are small, isolated, and have undergone succession for relatively brief periods of time. In addition, we expected that similarity of the herbaceous communities between bog and forested wetlands would be low because of the uniqueness of the open, freshwater habitats. Conversely, we expected that the woody communities would be very similar between bogs and wetland forests due to the long successional nature of the habitats and the proximity of propagules. We also wanted to determine how much convergence in species composition had and would likely occur between the five anthropogenically created bogs and the natural bog. The project also included a study of nutrient concentrations in vegetation and substrates (Whigham and Richardson in press) and a study to determine how the forested wetlands and bogs modified surface and/or subsurface water (Whigham 1981; this volume).

Location and Characterization of Study Sites

The sites are all located near Annapolis in Anne Arundel County (Fig. 1). Additional information on site locations, sizes of bog and forested wetland habitats, substrate types, and how the wetlands would be categorized in the new U.S. Fish and Wildlife classification system are given in Table 1. A brief characterization of each site follows:

Angel's Bog (Site 1, Fig. 1) is located along the southern shore of a man-made impoundment known as Fresh Pond. The 2.21 ha bog is bordered on the landward side by a very narrow band of forested wetland vegetation that has an abrupt transition to the upland forest. Abrupt transitions between wetlands and upland forests occur at all of the sites. Fresh Pond first appeared on the 1915 Geologic Map of Anne Arundel County and the bog portion was first shown on the 1979 revision of the 1954 U.S. Geologic Survey Quadrangle map.

The North Grays Creek wetland (Site 2, Fig. 1) consists of a relatively large forested wetland (6.01 ha) and smaller bog (1.31 ha) and open water areas. Bog vegetation has developed between the open water portion and

the adjoining forested wetland. The relatively large open water area reflects the young age of the pond, which did not appear on any of the U.S. Geologic Survey Quadrangle Maps before 1975.

South Grays Creek bog (Site 3, Fig. 1) was not found on any of the quadrangle maps but it is probably older than the North Grays Creek bog because most of the impounded area has been colonized by bog vegetation that is dominated by shrubs and small trees. Only a very small open water area persists near the earthen dam. Herbaceous macrophytes are restricted to the small open water area near the earthen dam and a narrow band between it and the shrub zone.

Eagle Hill (Site 4, Fig. 1) is the only site where the bog portion is larger (0.35 ha) than the forested wetland (0.28 ha). Bog vegetation has developed behind an earthen dam where there is still a small ephemeral open water area dominated by floating-leaved and submersed macrophytes. Most of the original impoundment is, however, now dominated by bog vegetation that is almost completely surrounded by a distinct shrub zone dominated by *Chamaedaphne calyculata*. Eagle Hill was not shown on the 1915 Geologic Map of Anne Arundel County but was present on the 1949 Quadrangle Map. Smith (1938) compared vegetation of this site, then known as "Glenburnie Bog" with vegetation of abandoned mill ponds on the Maryland Eastern Shore.

Cypress Creek (Site 5, Fig. 1), as noted earlier, is the only site not altered by man's activities. The site is surrounded by upland forest except for one portion which is contiguous with a freshwater tidal wetland of the type described by McCormick and Somes (1982). The small bog (0.14 ha) is located near the center of the site and is almost entirely surrounded by a forested wetland. Atlantic white cedar occurs in both the bog and forested wetland (Sipple and Klockner 1980; 1984).

The bog portion of the Round Bay site (Site 6, Fig. 1) is small (0.54 ha) compared to the size of the forested wetland (Table 1). Bog vegetation colonized the site following the 1939 removal of a portion of the forested wetland to create a power line right-of-way. In 1954, a gas pipeline was also routed through the right-of-way area. The right-of-way has been managed by periodic removal of shrubs and small trees. The bog would undoubtedly be converted to a forested wetland if right-of-way management ceased.

Methods

After preliminary reconnaissance of each site, we decided to sample vegetation along transects. Three criteria were used to determine the number of transects and their placement. A minimum of six transects was used per site: three to sample bog vegetation and three to sample the forested wetland. Second, the transects were positioned perpendicular to the direction of drainage. Third, the three transects within each area were arbitrarily positioned at the lower end (downstream), middle, and

upper end (upstream) of each vegetated zone. Contiguous 5 X 2 meter quadrats were marked along each transect, and percent cover was recorded for all woody species rooted in or overhanging the quadrat. A minimum of 15 quadrats was sampled in the bog and forested wetland at each site. At Cypress Creek, Eagle Hill, and Round Bay the bog portions of the sites were small or narrow, and it was necessary to use more than three transects to obtain enough samples. Alternatively, the bog at North Grays was comparatively wide, and we only sampled alternate quadrats along the three transects. We sampled 168 quadrats in bogs and 94 in forested wetlands. There were 31 quadrats at Angel's Bog. The forested wetland at that site was not sampled as it formed a narrow and discontinuous band around the bog. Nineteen bog quadrats and 17 forested wetland quadrats were sampled at Cypress Creek. The number of bog quadrats sampled at Eagle Hill, North Grays, Round Bay, and South Grays were 17, 50, 25, and 26, respectively. For the same sites, 16, 17, 25, and 19 quadrats were sampled in the forested wetlands.

The quadrats used to sample woody species were also used to sample herbaceous vegetation. Each quadrat was divided into 10 plots that were each 0.5 X 2 meters. One of the 10 plots was randomly selected from each of 50 randomly selected quadrats at each site. Twenty-five of the plots were in bog areas and 25 in forested wetland areas. In instances where there were fewer than 25 quadrats per vegetation type in a site, additional plots were randomly located and sampled. Percent cover estimates were made for all herbaceous species in the plots. Nomenclature follows National List of Scientific Plant Names (USDA, SCS 1982). Scientific names and common names are provided in Appendix 1.

Data Analysis

Species presence data were used to calculate frequency and relative frequency. Percent cover estimates were used to calculate cover and relative cover. Relative frequency and relative cover were then used to calculate importance values (I.V.) for each species in the bog and forest wetland habitats at each site. Computational procedures followed those described in Mueller-Dombois and Ellenberg (1974). Importance values were then analyzed using Bray and Curtis polar ordination (Mueller-Dombois and Ellenberg 1974) and cluster analysis (Dixon et al. 1981). Shannon-Weiner diversity (H') and Simpson dominance index (C) were also calculated from the importance value data, and H' and C were used to calculate evenness as $J = H' / H_{max}$ where $H_{max} = \log S$; S is the number of species (Whittaker 1975). We made further comparisons by calculating Gleason's modification of Jaccard's community coefficient for all combinations of sites. The coefficient is based on the summed

importance values of all species common to two sites compared to the summed importance values of all species in the two sites (Mueller-Dombois and Ellenberg 1974).

Results

Approximately 140 woody and herbaceous taxa were sampled at the six sites. We believe that our sample design was adequate, although certainly not all taxa were sampled. For comparison, Sipple and Klockner (1980) visited Cypress Creek bog biweekly for more than 7 months and collected 72 species of vascular plants compared to 54 that were recorded in our quadrats. A total of 52 herbaceous species was recorded in the six bogs (Table 2). Thirty-two species were sampled at Cypress Creek, followed by Angel's (25), South Grays (15), Round Bay (14), North Grays (12), and Eagle Hill (12). Only *Sphagnum* spp. and *Triadenum virginicum* were present in all bogs although *Drosera intermedia*, *Juncus abortivus*, *Nymphaea odorata*, *Rhynchospora alba*, and *Utricularia fibrosa* occurred in five bogs. *Arundinaria gigantea*, *D. intermedia*, *Drosera rotundifolia*, and *Platanthera ciliaris* are rare species in the region. *Sarracenia purpurea* and *Drosera filiformis* were recorded at one site each, but Sipple and Klockner (1984) suggested that both species were recently introduced.

Sphagnum spp. had comparatively high importance values at all bog sites, except at North Grays where *Triadenum virginicum* (I.V.=35.62), *J. abortivus* (I.V.=40.67), *N. odorata* (I.V.=34.62), and *Rhynchospora alba* (I.V.=40.98) were dominant species (Table 2). At Cypress Creek, only *Cladium mariscoides* (I.V.=23.16), *N. odorata* (I.V.=20.29), and *Sphagnum* spp. (I.V.=26.06) were clearly dominant. *Juncus abortivus* (I.V.=33.09) and *R. alba* (I.V.=43.97) were the only species other than *Sphagnum* spp. (I.V.=49.80) to have high importance values at Eagle Hill. Only *T. virginicum* (I.V.=20.04) and *Sphagnum* spp. (I.V.=56.68) had importance values greater than 20 at Angel's Bog. The Round Bay bog was dominated by *Carex lurida* (I.V.=57.85) and *Sphagnum* spp. (I.V.=75.52). Similarly, only one species (*Arundinaria gigantea*, I.V.=35.91) besides *Sphagnum* spp. (I.V.=48.35) had a high importance value at South Grays.

Only 20 herbaceous species were recorded in the forested wetland quadrats (Table 3). *Osmunda cinnamomea* and *Sphagnum* spp. had importance values greater than 20 at all sites. *Osmunda cinnamomea* was clearly the dominant species at both North Grays (I.V.=155.89) and Cypress Creek (I.V.=113.31). *Osmunda regalis* (I.V.=42.34) and *Sphagnum* spp. (I.V.=21.23) also had high importance values at Eagle Hill. Dominance at South Grays and Eagle Hill was shared by *A. gigantea*, *O. cinnamomea*, and *Sphagnum* spp. (Table 3). Round Bay

had the highest number of herbaceous species, but only *Sphagnum* spp. and two other species (*Carex lurida*, I.V.=35.90 and *O. cinnamomea*, I.V.=21.74) had importance values greater than 20.

Herb species diversity (S and H', Table 4) was higher in the bogs, except at Round Bay where the bog and forested wetland areas had almost the same number of species. Angel's Bog had the highest H' diversity of any bog site (Table 4). Simpson's Index was highest and evenness the lowest in the forested wetlands, with the exception of Round Bay, indicating that these habitats were dominated by fewer species and that the dominant species had high importance values.

The number of woody species in the bogs (Table 5) was nearly as high as the number of herbaceous species. Round Bay had 27 species of woody plants followed by Angel's Bog (25), North Grays (22), South Grays (19), Cypress Creek (18), and Eagle Hill (17). Nine species were present at all of the bog sites (Table 5).

The number of woody species in the forested wetlands was similar to the number recorded in the bogs (Table 6). Eleven species were sampled at all sites, and all but three were also present in the bog areas at each site. The overstory vegetation at all sites was characterized by the dominance of *Acer rubrum*, *Magnolia virginiana* and *Nyssa sylvatica*. The understory was typically quite diverse, but *Amelanchier canadensis*, *Clethra alnifolia*, *Leucothoe racemosa*, *Rhododendron viscosum*, *Smilax rotundifolia*, and *Vaccinium corymbosum* had high importance values at one or more of the sites.

Indices of diversity, evenness, and dominance for woody vegetation were similar at all sites. Evenness values were high and dominance values low (Table 7) and similar to the values calculated for herbaceous species at the same sites (Table 4). Species richness (S) and Shannon-Weiner (H') diversity for the woody species were higher than those for the herbaceous species in the forested wetlands.

The relationship between the bogs and forested wetlands at the six sites is shown in Figure 2 for herbaceous species and Figure 3 for woody species. Polar ordinations divided the sites into three groupings based on importance values of herbaceous species. All bog sites, except Round Bay, were positioned in the lower left portion of the ordination. A second group was composed of the forested wetland sites, with the exception of Round Bay. The bog and forested areas of Round Bay formed a third cluster. The relationships for the herbaceous species were verified by the cluster analysis (Fig. 4). In Figure 4, sites with the closest relationships are linked with horizontal lines near the bottom of the plot while those that are least related are linked nearer the top of the diagram. Similar to the pattern seen in Figure 2, both Round Bay sites were the first to be clustered. Other pairings were similar to those shown in the ordination. The wetland forests at Eagle Hill and South Grays were more closely

related, as were Cypress Creek and North Grays. With the exception of Round Bay, the bog and wetland forest sites were all linked together in the cluster analysis before the two habitat types were joined.

Ordination and cluster analysis of the woody species produced a slightly different result. All of the forested wetlands, except for Cypress Creek, were tightly grouped in the ordination (Fig. 3). The Cypress Creek location was undoubtedly placed in an outlying position for both bog and forested wetland habitats due to the presence of Atlantic white cedar. The remaining bog sites were not as tightly clustered as were the forested wetlands. The two sites positioned closest to the forested wetland group (North Grays and Angel's Bog) were the bog sites clustered earliest to the forested wetland sites in the cluster analysis (Fig. 5). The cluster analysis also demonstrates the close relationship between the forested wetland sites since those sites were linked before all but two of the bog sites.

The mean community coefficients for herbaceous species (Table 8), 62% for bogs and 68% for forested wetlands, were not significantly different. Hence, the generalization that the between site similarity of the flora of the bogs is less than that of the forested wetlands is not universally supported. Table 8, however, demonstrates that the variance between sites is more pronounced for the bogs than for the forested wetlands. Community coefficients for Round Bay are clearly lower than those for the other sites. When this site is excluded, the mean community coefficient of the bog sites increases to 73% compared to 62%. This suggests that the herbaceous bog flora is rather similar in the sites that are physically the closest (Sites 1-5 in Fig. 1) and dissimilar to that furthest removed (Site 6, Fig. 1). Site differences were not as distinct when the herbaceous communities of the forested wetlands are compared (Table 8). The mean community coefficient between Sites 1-5 (Fig. 1) was 75% compared to the mean of 68% for all sites combined. The mean coefficient between Sites 1-5 and Round Bay was 61%.

Community coefficients were higher when woody species were compared in the bogs and forested wetlands (Table 9). The patterns, however, were similar to those described for the herbaceous species. Sites 1-4 had a mean woody plant community coefficient of 94% between bogs and 95% between forested wetlands. When compared to Sites 1-4, the mean community coefficient for Cypress Creek was 62% for the bogs and 91% for the forested wetlands. The difference in woody vegetation between Cypress Creek and the other sites is undoubtedly due to the high importance values of Atlantic white cedar in both types of habitats. When Round Bay bog and forested wetland were compared to Sites 1-4, the mean coefficients were 74% and 85%, respectively. The bog portions of Round Bay and Cypress Creek were less similar (74%) than were the forested wetlands (89%).

Discussion

These Western Shore forested wetlands are floristically similar to other sites in the Chesapeake Bay region (Beaven and Oosting 1939; Fleming 1978; McCormick and Somes 1982). Most of the same species also occur in Atlantic white cedar wetlands in North Carolina (Richardson 1981), Virginia (Dabel and Day 1977), New Jersey (Ehrenfeld and Gulick 1981), and Rhode Island (Lowry 1984). Atlantic white cedar wetlands in Maine (Eastman 1977) contain species more typical of northern bogs while subtropical species are more common in Florida (Clewett and Ward this volume).

The Western Shore wetlands provide an opportunity to compare the floras of anthropogenically created bogs with the floras of adjoining forested wetlands. The presence of the Cypress Creek wetland provides an additional opportunity to compare the flora of a natural bog and forested wetland which contains Atlantic white cedar with the flora of developing bogs, as well as other natural forested wetlands.

We hypothesized that the bogs would not share as many herbaceous species as would the forested wetlands. Ordination (Fig. 2) and cluster analysis (Fig. 4) of the importance value data did not support the hypothesis. In Figure 2, the bog and forested wetland sites are distinct from each other but the scatter of points within the two groups is about the same. Round Bay bog and forested wetland form a third distinct grouping. The same groupings were also found when the data were subjected to cluster analysis (Fig. 4). In the cluster analysis, however, all of the bog sites clustered before the forested wetland sites, suggesting that there was greater similarity between bog sites.

Results of the community coefficient computations are shown in Table 8 for herbaceous species and Table 9 for woody species. The analysis of community coefficients supports our hypothesis of the difference between bog herbaceous communities but with the refinement that physical isolation is an important factor in determining similarity. Differences based upon distance suggest that the rate of species colonization may be limiting community similarities. By virtue of its age, the Cypress Creek bog has probably been the main source of propagules for colonization of the five man-made bogs. Sites 1-4 (Fig. 1) are in the Severn River watershed. They are physically close to each other; the high community coefficients suggest that bog species have had about equal probabilities of colonizing those sites. Between 72 and 83% of the herbaceous taxa at these sites are shared with the Cypress Creek bog. Round Bay bog is in the Magothy River watershed and is apparently the most isolated. It had the lowest community coefficients with Sites 1-4 and with Cypress Creek, and it shared only 50% of its taxa with Cypress Creek. Herbaceous communities of the Cypress Creek and Round Bay forested wetlands are less similar to the other sites than those sites are to

each other, but the differences are not as large as those demonstrated for the bog flora.

An alternative explanation for the pattern of community coefficients for herbaceous vegetation is a substantial difference in site characteristics. Round Bay bog has no open, standing water. The open water provides habitat required by some species (e.g., *Nymphaea odorata* and *Utricularia fibrosa*), and the shallow edges of the open water provide habitat required by other species (e.g., *Drosera intermedia* and *Triadenum virginicum*). In addition, open water attracts waterfowl which may bring in propagules from other habitats. Therefore, in addition to physical separation, Round Bay may lack suitable habitats for some species and not be attractive to some propagule disseminating birds. Differences between Round Bay bog and the other sites may be due to the fact that the bog is actively managed to eliminate woody species that have the potential of growing into tree-sized individuals.

We had also hypothesized that there would be low similarity between herbaceous communities in the bogs and adjacent forested wetlands. The proportion of species that occurred in one of those two habitats at each site, and the sum of their importance values are presented in Table 10. A high proportion of the herbaceous species and a substantial total of the importance values were restricted to the bog habitat. For example, 81.3% of the species found in the Cypress Creek bog were not found in the Cypress Creek forested wetland. Those species had a combined importance value of 140.1 out of a possible 200. Conversely, only 25% of the herbs in the forested wetland were restricted to that habitat, and those species had a combined importance value of 15.2 out of 200. This habitat pattern was similar for all sites, except for Round Bay where the forested wetland had the greatest number of herbaceous species and most of those same species were also sampled in the bog habitat.

Among woody species, only *Chamaedaphne calyculata*, *Decodon verticillatus*, and *Vaccinium macrocarpon* were restricted to bogs, and they had high importance values. There is no evidence that *C. calyculata* occurs on the Delmarva Peninsula; these bog sites may represent its southern most stations on the Coastal Plain. In addition to *Chamaecyparis thyoides* and *C. calyculata*, *V. macrocarpon* is also uncommon on the Coastal Plain (Sipple and Klockner 1984). Few woody species were restricted to the forested wetlands (Table 10). This supports our hypothesis that there would be a high similarity of the woody communities between the bog and the adjacent forested wetlands.

The herbaceous vegetation at North Grays, South Grays, Eagle Hill, Cypress Creek, and Angel's bogs reflects the presence of standing water with no overhead canopy. Species requiring open water conditions (*Drosera intermedia*, *Juncus abortivus*, *Triadenum virginicum*, *Nymphaea odorata*, *Rhynchospora alba*, and *Utricularia fibrosa*) had an

average importance value of 87.1 at those sites. Round Bay, which does not have any open water areas, had only *T. virginicum*. This difference probably contributed to the separation of Round Bay bog from the other bog sites in the ordination. While *T. virginicum* and *Sphagnum* spp. are present at all sites, the importance of *Sphagnum* spp. varies and probably reflects the presence, absence, and/or abundance of other species, especially *Vaccinium macrocarpon*, which are dependent upon the presence of *Sphagnum* spp. *Arundinaria gigantea* and *Woodwardia areolata* are uncommon in the region; Sipple and Klockner (1984) have suggested that they are worthy of conservation considerations.

The successional status of the bog sites is evidenced by the high degree of similarity of the woody bog communities to those of the adjacent forested wetlands (Table 10). These bogs will likely succeed, although at different rates, to forested wetlands in a pattern described by Buell and Cain (1943) and Little (1979). As this occurs, the differences between woody bog communities (Figs. 3 and 5) will decrease and converge toward a more uniform vegetation. Sipple and Klockner (1984) suggested that the more open portion of Cypress Creek, referred to as a savanna, is the only one that might not progress toward a forested wetland. They suggested that the bog portion of the Cypress Creek site will be invaded slowly because of the well developed bog vegetation and the fact that the growth of Atlantic white cedar may be retarded in the bog area due to the presence of standing water. They suggested, however, that management of the site would ultimately be required. Within the forested wetland portion of Cypress Creek, Atlantic white cedar is overtopped by deciduous or semi-deciduous species (e.g., *Magnolia virginiana*), and it would appear that Atlantic white cedar might ultimately be eliminated. The successional process will probably occur more slowly at Eagle Hill where the bog vegetation is well developed and where there is little evidence of invasion by species from the forested area.

If species associations can be used to predict the potential distribution of Atlantic white cedar, the habitats examined in Anne Arundel County appear to be suitable for potential invasion. This is especially true for Eagle Hill where the bog is very well developed and the open area appears to be large enough to support the establishment of Atlantic white cedar seedlings. However, little is known about the effective dispersal of the species and its requirements for successful establishment in the Inner Coastal Plain. Numerous seedlings are present in the Cypress Creek bog, but the factors involved in regeneration are unknown. From the information available (Sipple and Klockner 1984), it would appear that the species range in Maryland is shrinking. We can only speculate on the causes, but sea level rise is probably an important factor. The only remaining stands of Atlantic white cedar on the Western Shore are small and all of the sites are surrounded by steep slopes. As sea

level rises, the small wetlands would gradually become brackish, and Atlantic white cedar would be eliminated.

Further studies of the current and potential distribution of the species are needed. Physiological investigation of mineral nutrition requirements, salt tolerance, photosynthetic responses, tolerance to flooding, and seedling establishment requirements promise to be fruitful. At minimum, efforts should be made to preserve the Cypress Creek site. Recent development adjacent to that site has eliminated another wetland that contained Atlantic white cedar.

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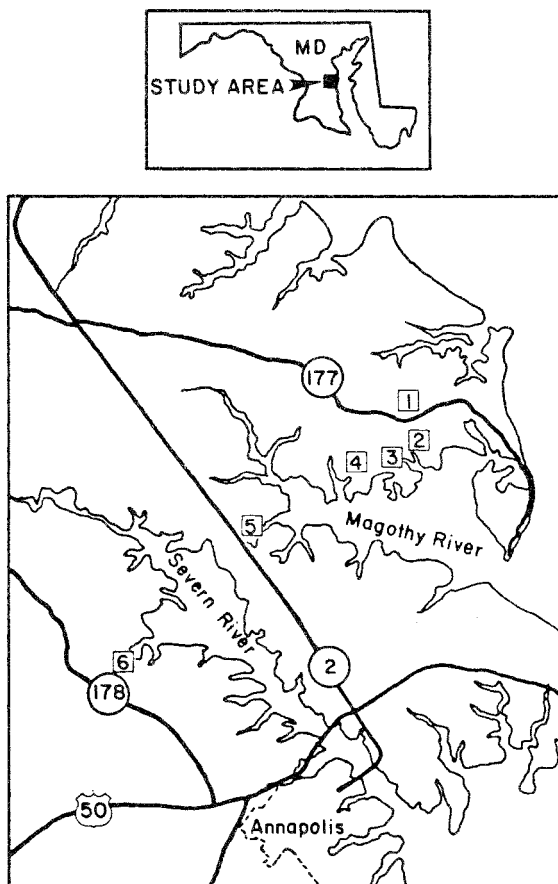


Figure 1. Generalized map of six study sites in Anne Arundel County, Maryland. Site names are: Angel's Bog (1), North Grays Creek (2), South Grays Creek (3), Eagle Hill (4), Cypress Creek (5), and Round Bay (6).

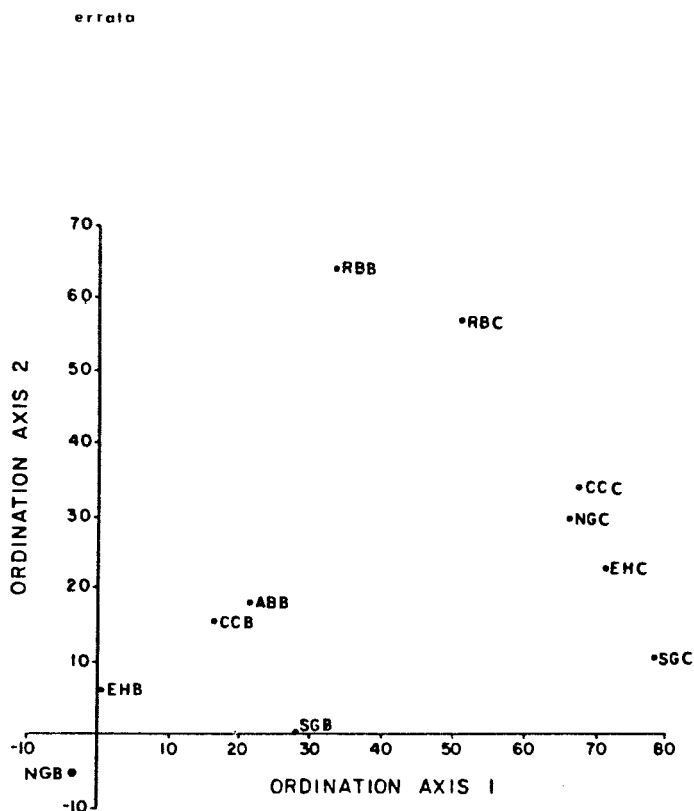


Figure 2. Polar ordination of herbaceous vegetation at six bogs and five forested wetlands sites. Abbreviations for sites are followed by a C for forested wetlands and a B for bog. Site abbreviations are AB—Angel's Bog, NG—North Grays, SG—South Grays, EH—Eagle Hill, RB—Round Bay, and CC—Cypress Creek.

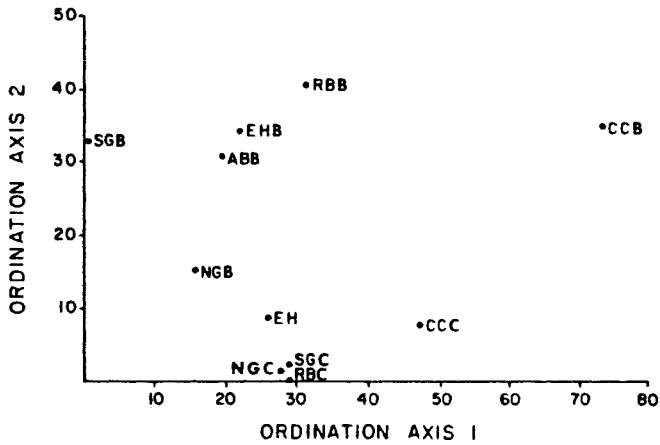


Figure 3. Polar ordination of woody vegetation for the six bog and five forested wetland sites. Abbreviations for the sites are as in the Figure 2 caption.

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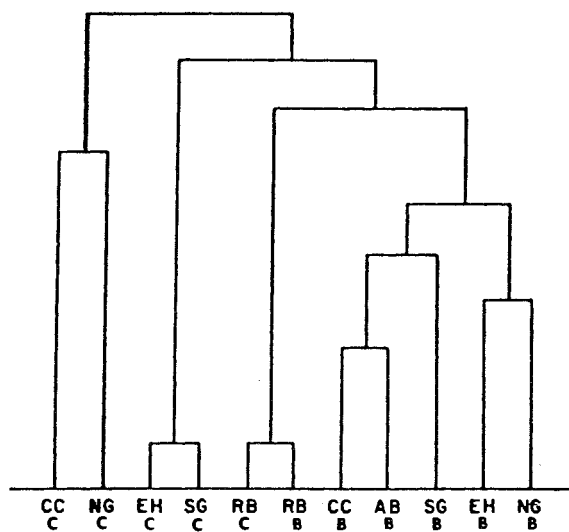


Figure 4. Cluster analysis of herbaceous vegetation for the six bog and forested wetland sites. Abbreviations for sites are as in the Figure 2 caption.

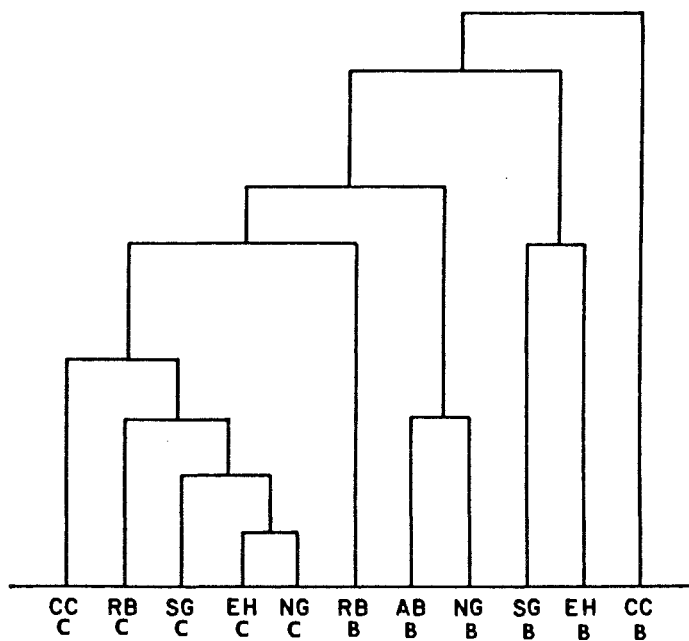


Figure 5. Cluster analysis of woody vegetation for the six bog and five forested wetland sites. Abbreviations for the sites are as in Figure 2 caption.

Table 1.
Wetland classification, area, location and underlying soil substrate for the six sites.

Site	Palustrine Classification ¹		Area (ha) ²		Location	Soil Series ³
	Bog	Forested Wetland	Bog	Control		
Angel's Bog	Emergent, Aquatic, Scrub-shrub	----	2.21	----	39°06'N 76°28'W	Fallsington sandy loam
Cypress Creek	Emergent, Scrub-shrub	Forest	0.14	0.30	39°04'N 76°32'W	Sassafras sandy loam
Eagle Hill	Aquatic, Emergent	Forest	0.35	0.28	39°05'N 76°29'W	Collington sandy loam
North Grays Creek	Aquatic, Emergent Scrub-shrub	Forest	1.31	6.01	39°06'N 76°28'W	Bibb silt loam
Round Bay	Emergent, Scrub-shrub	Forest	0.54	>25.00	39°02'N 76°35'W	Mixed alluvial
South Grays Creek	Aquatic, Emergent, Scrub-shrub	Forest	0.81	1.89	39°05'N 76°28'W	Bibb silt loam

1 Classification follows Cowardin et al. (1979)

2 Data from tracings of Maryland wetlands maps

3 Data from Kirby and Matthews (1973)

Table 2.
Importance values (maximum = 200) for herbaceous species in the six bogs.

Species	Site					
	North Grays	South Grays	Round Bay	Angel's Bog	Eagle Hill	Cypres Creek
<u>Andropogon virginicus</u>			1.43	2.24		1.67
<u>Arundinaria gigantea</u>		35.91			4.02	
<u>Aster dumosus</u>						7.78
<u>Boehmeria cylindrica</u>				10.31		
<u>Carex sp.1</u>			1.43			1.39
<u>Carex sp.2</u>		5.38		8.99		3.99
<u>Carex lurida</u>			57.85			
<u>Cladium mariscoides</u>				1.12		23.16
<u>Cuscuta sp.</u>	6.85	3.17		12.31		0.48
<u>Cyperus sp.</u>				5.62		1.90
<u>Drosera filiformis</u>						0.55
<u>Drosera intermedia</u>	8.80	13.03		2.24	14.73	4.73
<u>Drosera rotundifolia</u>				1.12		
<u>Dulichium arundinaceum</u>	14.21	10.07		8.28		
<u>Eleocharis sp.</u>	1.01				5.87	0.78
<u>Eriocaulon sp.</u>						0.55
<u>Galium tinctorium</u>				3.32		4.33
<u>Hydrocotyle sp.</u>						0.51
<u>Juncus sp.1</u>					18.36	
<u>Juncus sp.2</u>			1.83			
<u>Juncus abortivus</u>	40.67	12.35		4.37	33.09	6.06
<u>Juncus canadensis</u>				1.08	1.75	
<u>Juncus effusus</u>			1.83			10.49
<u>Leersia oryzoides</u>				1.08		
<u>Nymphaea odorata</u>	34.62	1.93		6.83	14.47	20.29
<u>Oenothera fruticosa</u>						6.57
<u>Onoclea sensibilis</u>				1.49		
<u>Osmunda cinnamomea</u>	2.47			2.97		3.40
<u>Osmunda regalis</u>						14.58
<u>var. spectabilis</u>						
<u>Oxypolis rigidior</u>						2.60
<u>Panicum verrucosum</u>		10.77	15.96	1.17		10.93
<u>Panicum virgatum</u>			1.43			3.62
<u>Peltandra virginica</u>						0.55
<u>Phragmites australis</u>						0.48
<u>Platanthera ciliaris</u>						1.67
<u>Pogonia ophioglossoides</u>						5.63
<u>Polygonum sagittatum</u>				4.47		
<u>Rhexia virginica</u>		5.98				
<u>Rhynchospora alba</u>	40.98	16.24		17.33	43.97	19.38
<u>Rhynchospora</u>			4.30			
<u>chalarocephala</u>						

Table 2.
(Cont'd) Importance values (maximum = 200) for herbaceous species in the six bogs.

Species	Site					
	North Grays	South Grays	Round Bay	Angel's Bog	Eagle Hill	Cypress Creek
<u>Sagittaria sp.</u>			3.30			
<u>Sarracenia purpurea</u>			1.63			
<u>Sparganium sp.</u>		3.87				
<u>Sphagnum sp.</u>	6.27	48.35	75.52	58.68	49.80	26.06
<u>Thelypteris</u>				14.34		0.62
<u>thelypteroides</u>						
<u>Triadenum virginicum</u>	35.62	17.29	12.59	20.04	3.31	9.25
<u>Typha angustifolia</u>						0.55
<u>Unknown grass</u>				4.89		
<u>Utricularia fibrosa</u>	7.53	11.87		2.72	7.26	4.47
<u>Woodwardia areolata</u>			2.90			
<u>Woodwardia virginica</u>			17.99			
<u>Xyris ambigua</u>	0.98	3.80		3.05	3.37	

Table 3.

Importance values (maximum = 200) for herbaceous species in forested wetlands at five sites.

Species	Site				
	North Grays	South Grays	Round Bay	Eagle Hill	Cypress Creek
<u>Arundinaria gigantea</u>		79.24		82.22	
<u>Aster dumosus</u>					2.19
<u>Bartonia paniculata</u>			2.97		
<u>Carex sp.</u>			3.03		
<u>Carex lurida</u>			35.90		
<u>Cuscuta sp.</u>	4.78	2.46	14.05		
<u>Cyperus sp.</u>		3.52	10.54		
<u>Impatiens pallida</u>					4.74
<u>Lycopodium obscurum</u>			5.30		
<u>Medeola virginiana</u>	4.67			3.88	
<u>Mitchella repens</u>			1.57	14.96	
<u>Oenothera fruticosa</u>					2.24
<u>Osmunda cinnamomea</u>	155.89	58.92	21.74	26.43	113.36
<u>Osmunda regalis</u>					42.34
<u>var. spectabilis</u>					
<u>Sphagnum spp.</u>	34.67	39.62	63.47	62.70	21.23
<u>Symplocarpus foetidus</u>		16.24	7.62		
<u>Thelypteris simulata</u>			17.08		
<u>Typha angustifolia</u>					3.48
<u>Woodwardia areolata</u>			9.74	9.80	10.43
<u>Woodwardia virginica</u>			6.99		

Table 4.
Diversity and related indices for herbaceous species in the bogs and forested wetland.

	Site					
	North Grays	South Grays	Round Bay	Angel's Bog	Eagle Hill	Cypress Creek
Species Diversity (S)						
Bog	12	15	14	25	12	32
Forest	4	6	13	--	6	8
Diversity (H')						
Bog	2.04	2.36	1.76	2.60	2.06	2.20
Forest	0.67	1.38	2.11	----	1.41	1.30
Evenness (J')						
Bog	0.82	0.87	0.67	0.81	0.83	0.64
Forest	0.48	0.77	0.82	----	0.79	0.63
Dominance (C)						
Bog	0.16	0.12	0.25	0.12	0.16	0.07
Forest	0.64	0.29	0.17	----	0.29	0.38

Table 5.
Importance values (maximum = 200) for woody species in the six bogs.

Species	Site					
	North Grays	South Grays	Round Bay	Angel's Bog	Eagle Hill	Cypress Creek
<u>Acer rubrum</u>	31.28	22.61	24.10	41.08	42.97	30.23
<u>Amelanchier canadensis</u>	4.62	0.93	6.74	9.62	6.02	3.96
<u>Aronia arbutifolia</u>			7.87			6.38
<u>Carya cordiformis</u>		0.67				
<u>Chamaecyparis thyoides</u>						58.69
<u>Chamaedaphne calyculata</u>	8.63	56.27		22.60	64.93	
<u>Clethra alnifolia</u>	24.56	33.64	20.29	23.16	5.98	5.03
<u>Decodon verticillatus</u>	41.75	25.37	3.68	46.66	2.69	3.13
<u>Diospyros virginiana</u>				0.60		
<u>Gaylussacia frondosa</u>	7.09	0.56	0.48	0.92	3.70	
<u>Ilex laevigata</u>	2.01	0.56	0.88		1.64	1.61
<u>Ilex opaca</u>	3.05			0.80		
<u>Itea virginica</u>	2.88	1.41		0.50		
<u>Kalmia angustifolia</u>	0.89	1.52			2.53	
<u>Leucothoe racemosa</u>	6.32	8.16	2.71	1.44	5.01	
<u>Liquidambar styraciflua</u>		2.21	11.02	2.20		3.00
<u>Ludwigia alternifolia</u>				2.07		
<u>Lyonia ligustrina</u>		0.48				
<u>Magnolia virginiana</u>	28.20	4.50	10.63	6.50	13.73	3.97
<u>Myrica pensylvanica</u>			0.48	0.87		15.54
<u>Nyssa sylvatica</u>	6.42	5.14	8.58	13.88	5.14	4.14
<u>Pinus rigida</u>	4.78	7.64	0.46	1.72	7.13	22.93
<u>Pinus virginiana</u>			2.07			
<u>Quercus falcata</u>	0.36		1.10			
<u>Quercus palustris</u>			0.44			
<u>Quercus prinus</u>	5.11					
<u>Quercus rubra</u>			0.48			
<u>Rhododendron viscosum</u>	9.45	9.84	10.35	0.81	6.86	6.72
<u>Rosa palustris</u>						3.13
<u>Rubus hispida</u>			11.31			
<u>Rubus sp.</u>				0.44		
<u>Salix nigra</u>			0.44	1.00		
<u>Sassafras albidum</u>	0.52				1.30	
<u>Smilax rotundifolia</u>	0.33		0.52	1.24	1.26	4.72
<u>Toxicodendron radicans</u>				0.80		11.87
<u>Toxicodendron vernix</u>			3.37			
<u>Vaccinium angustifolium</u>	0.69	6.40	7.04	0.41		
<u>Vaccinium corymbosum</u>	10.56	16.08	19.87	9.55	13.26	1.17
<u>Vaccinium macrocarpon</u>			42.32	10.74	15.85	13.78
<u>Vaccinium vacillans</u>	0.51			0.40		
<u>Toxicodendron radicans</u>				0.80		11.87
<u>Toxicodendron vernix</u>			3.37			
<u>Viburnum dentatum</u>			1.80			
<u>Viburnum nudum</u>			0.98			

Table 6.
Importance values (maximum = 200) for woody species and vines in the five forested wetlands.

Species	Site				
	North Grays	South Grays	Round Bay	Eagle Hill	Cypress Creek
<u>Acer rubrum</u>	30.50	41.63	18.30	27.99	38.17
<u>Alnus serrulata</u>			2.48		
<u>Amelanchier canadensis</u>	2.64	7.94	5.84	10.68	6.43
<u>Aronia arbutifolia</u>			11.27		1.65
<u>Chamaecyparis thyoides</u>					7.01
<u>Clethra alnifolia</u>	16.56	17.32	18.15	17.96	10.72
<u>Decodon verticillatus</u>					1.61
<u>Fagus grandifolia</u>			2.26		
<u>Gaylussacia frondosa</u>	5.74	2.35	0.62	0.89	0.55
<u>Ilex laevigata</u>	4.44	7.21	1.57	4.39	6.06
<u>Ilex opaca</u>	8.98		3.84	4.88	14.65
<u>Itea virginica</u>	5.82	0.99			0.57
<u>Kalmia angustifolia</u>		1.36			
<u>Kalmia latifolia</u>		1.45		1.95	
<u>Leucothoe racemosa</u>	10.22	15.00	3.35	9.85	2.24
<u>Liquidambar styraciflua</u>			7.33		1.06
<u>Magnolia virginiana</u>	34.30	44.49	26.62	39.16	21.88
<u>Myrica pensylvanica</u>			1.89		3.92
<u>Nyssa sylvatica</u>	22.44	16.41	18.19	14.91	27.57
<u>Parthenocissus quinquefolia</u>				0.88	0.53
<u>Pinus rigida</u>	7.21	3.96	0.29	19.97	21.17
<u>Pinus virginiana</u>			1.61		
<u>Quercus alba</u>	0.79		0.30	1.05	
<u>Quercus falcata</u>					0.55
<u>Quercus palustris</u>			4.86		
<u>Quercus prinus</u>	1.59				3.05
<u>Quercus rubra</u>			0.30		0.89
<u>Rhododendron viscosum</u>	16.66	23.31	32.05	13.73	5.62
<u>Rosa palustris</u>					0.54
<u>Rubus hispidus</u>			4.72		
<u>Salix nigra</u>			1.61		
<u>Sassafras albidum</u>				1.76	1.58
<u>Smilax herbacea</u>		0.77	0.30		
<u>Smilax rotundifolia</u>	9.34	4.19	2.37	8.56	2.35
<u>Toxicodendron radicans</u>					1.75
<u>Toxicodendron vernix</u>			0.45		
<u>Vaccinium angustifolium</u>			0.88		
<u>Vaccinium corymbosum</u>	12.76	10.12	14.30	19.27	11.28
<u>Vaccinium macrocarpon</u>			0.31		0.55
<u>Viburnum dentatum</u>			5.25		
<u>Viburnum nudum</u>		1.40	8.77	2.10	1.08

Table 7.
Diversity and related indices for woody species and vines in the bogs and forested wetlands.

	Site					
	North Grays	South Grays	Round Bay	Angel's Bog	Eagle Hill	Cypress Creek
Species Diversity (S)						
Bog	22	19	27	25	17	18
Forest	16	17	30	--	18	28
Diversity (H')						
Bog	2.46	2.24	2.64	2.32	2.18	2.35
Forest	2.38	2.29	2.99	----	2.46	2.66
Evenness (J')						
Bog	0.80	0.76	0.80	0.72	0.77	0.81
Forest	0.86	0.81	0.89	----	0.85	0.80
Dominance (C)						
Bog	0.12	0.15	0.10	0.14	0.18	0.14
Forest	0.09	0.13	0.08	----	0.10	0.10

TABLE 8.

Community coefficients for herbaceous species in all combinations of study sites. All values to the right of the X's are for bog habitats. All values to the left of the X's are for forested wetland habitats. NS indicates that the forested wetland was not sampled at Angel's Bog. All community coefficients were rounded to the nearest whole number.

SITE	NORTH GRAYS	SOUTH GRAYS	ROUND BAY	ANGEL'S BOG	EAGLE HILL	CYPRESS CREEK
NORTH GRAYS	X	84	33	85	88	70
SOUTH GRAYS	74	X	45	75	84	62
ROUND BAY	74	60	X	47	35	43
ANGEL'S BOG	NS	NS	NS	X	39	77
EAGLE HILL	72	91	50	NS	X	66
CYPRESS CREEK	81	58	60	NS	61	X

TABLE 9.

Community coefficients for woody tree and shrub species in all combinations of study sites. All values to the right of the X's are for bog habitats. All values to the left of the X's are for forested wetland habitats. NS indicates that the forested wetland was not sampled at Angel's Bog. All community coefficients are rounded to the nearest whole number.

SITE	NORTH GRAYS	SOUTH GRAYS	ROUND BAY	ANGEL'S BOG	EAGLE HILL	CYPRESS CREEK
NORTH GRAYS	X	97	74	93	93	63
SOUTH GRAYS	93	X	67	95	92	54
ROUND BAY	80	87	X	85	71	74
ANGEL'S BOG	NS	NS	NS	X	96	75
EAGLE HILL	94	97	88	NS	X	56
CYPRESS CREEK	92	89	89	NS	94	X

Table 10.
Comparison of similarities between herbaceous and woody species (including vines) at each site. The data are a measure of how much species are restricted to either bog or forested wetland habitats at each site. Importance values (IV) are sums of importance values for those species that occurred in only one habitat at each site.

	Site									
	North Grays		South Grays		Round Bay		Eagle Hill		Cypress Creek	
	%	IV	%	IV	%	IV	%	IV	%	IV
Herbaceous										
Bog	75.0	184	80.0	113	64.3	44	83.3	146	81.3	140
Forest	25.0	5	50.0	79	61.5	67	66.7	55	25.0	15
Woody										
Bog	31.8	51	31.6	87	7.4	5	23.5	86	0	0
Forest	6.3	1	23.5	8	16.7	9	27.8	11	35.7	25

Appendix 1.

Scientific and common names for woody and herbaceous species. Nomenclature follows National list of scientific plant names (USDA, SCS 1982).

Scientific Name	Common Name
I. Woody Species and Vines	
<u>Acer rubrum</u>	Red Maple
<u>Alnus serrulata</u>	Common alder
<u>Amelanchier canadensis</u>	Serviceberry
<u>Aronia arbutifolia</u>	Red Chokeberry
<u>Carya cordiformis</u>	Pignut Hickory
<u>Chamaecyparis thyoides</u>	White Cedar
<u>Chamaedaphne calyculata</u>	Leatherleaf
<u>Clethra alnifolia</u>	Beech
<u>Decodon verticillatus</u>	Water-willow
<u>Diospyros virginiana</u>	Common Persimmon
<u>Fagus grandifolia</u>	Beech
<u>Gaylussacia frondosa</u>	Dangleberry
<u>Ilex laevigata</u>	Smooth Winterberry
<u>Ilex opaca</u>	American Holly
<u>Itea virginica</u>	Tassel-white
<u>Kalmia angustifolia</u>	Lambkill
<u>Kalmia latifolia</u>	Mountain Laurel
<u>Leucothoe racemosa</u>	Fetter-bush
<u>Liquidambar styraciflua</u>	Sweet Gum
<u>Ludwigia alternifolia</u>	Seedbox
<u>Lyonia ligustrina</u>	Maleberry
<u>Magnolia virginiana</u>	Small Magnolia
<u>Myrica pensylvanica</u>	Bayberry
<u>Nyssa sylvatica</u>	Black Gum
<u>Parthenocissus quinquefolia</u>	Virginia Creeper
<u>Pinus rigida</u>	Pitch Pine
<u>Pinus virginiana</u>	Virginia Pine
<u>Quercus alba</u>	White Oak
<u>Quercus falcata</u>	Spanish Oak
<u>Quercus palustris</u>	Pin Oak
<u>Quercus prinus</u>	Chestnut Oak
<u>Quercus rubra</u>	Red Oak
<u>Rhododendron viscosum</u>	Swamp-Honeysuckle
<u>Rosa palustris</u>	Marsh Rose
<u>Rubus hispidus</u>	Bramble
<u>Rubus sp.</u>	Bramble
<u>Salix nigra</u>	Black Willow
<u>Sassafras albidum</u>	Sassafras
<u>Smilax herbacea</u>	Carrión-flower
<u>Smilax rotundifolia</u>	Common Greenbrier
<u>Toxicodendron radicans</u>	Poison Ivy
<u>Toxicodendron vernix</u>	Poison Elder
<u>Vaccinium angustifolium</u>	Low Sweet Blueberry
<u>Vaccinium corymbosum</u>	Highbush Blueberry

Vaccinium macrocarpon
Vaccinium vacillans
Viburnum dentatum
Viburnum nudum

Large Cranberry
 Low Blueberry
 Southern Arrow-Wood
 Possum Viburnum

II. Herbaceous species

Andropogon virginicus
Arundinaria gigantea

Broom-Sedge
 Switch-Cane

Aster dumosus
Bartonia paniculata
Boehmeria cylindrica
Carex sp. 1
Carex sp. 2
Carex lurida
Cladium mariscoides
Cuscuta sp.
Cyperus sp.
Drosera filiformis
Drosera intermedia
Drosera rotundifolia
Dulichium arundinaceum
Eleocharis sp.
Eriocaulon sp.
Galium tinctorium
Hydrocotyle sp.
Impatiens pallida
Juncus sp. 1
Juncus sp. 2
Juncus abortivus
Juncus canadensis
Juncus effusus
Leersia oryzoides
Lycopodium obscurum
Medeola virginiana
Mitchella repens
Nymphaea odorata
Oenothera fruticosa
Onoclea sensibilis
Osmunda cinnamomea
Osmunda regalis
var. spectabilis
Oxyopsis rigidior
Panicum verrucosum
Panicum virgatum
Peltandra virginica
Phragmites australis
Platanthera ciliaris
Pogonia ophioglossoides
Polygonum sagittatum
Rhexia virginica
Rhynchospora alba
Rhynchospora chalarocephala

Aster
 Screw-Stem
 Bog-Hemp
 Sedge
 Sedge
 Pseudo-Cypereae
 Twig-Rush
 Dodder
 Galingale
 Dew-Thread
 Sundew
 Round-Leaved Sundew
 Three-Way Sedge
 Spike-Rush
 Spike-Rush
 Bedstraw
 Water-Pennywort
 Pale Touch-Me-Not
 Rush
 Rush
 Rush
 Rush
 Soft Rush
 Rice-Cutgrass
 Tree Club Moss
 Indian Cucumber-Root
 Partridge-Berry
 Fragrant Water Lily
 Sundrop
 Sensitive Fern
 Cinnamon-Fern
 Royal Fern
 Cowbone
 Panic-Grass
 Switchgrass
 Arrow-Arum
 Reed
 Yellow Fringed Orchis
 Pogonia
 Arrow-Leaved Tearthumb
 Deerflower
 Beak-Rush
 Beak-Rush

<u>Sagittaria sp.</u>	Arrowhead
<u>Sarracenia purpurea</u>	Sidesaddle-Flower
<u>Sparganium sp.</u>	Bur-Reed
<u>Sphagnum spp.</u>	Sphagnum
<u>Symplocarpus foetidus</u>	Skunk-Cabbage
<u>Thelypteris simulata</u>	Shield-Fern
<u>Thelypteris thelypteroides</u>	Meadow-Fern
<u>Triadenum virginicum</u>	Marsh St. John's-Wort
<u>Typha angustifolia</u>	Narrow-Leaved Cattail
<u>Unknown grass</u>	
<u>Utricularia fibrosa</u>	Bladderwort
<u>Woodwardia areolata</u>	Netted Chain-Fern
<u>Woodwardia virginica</u>	Virginian Chain-Fern
<u>Xyris ambigua</u>	Yellow-Eyed Grass