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Plant Communities and Floristic Features of Sinkhole Ponds and Seepage Wetlands in Southeastern Augusta County, Virginia

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INTRODUCTION

Distinctive wetlands in the Big Levels - Maple Flats region of Augusta County, Virginia, have received considerable attention from botanists and ecologists during the past 60 years. Situated on deep, alluvial fan deposits overlying carbonate rocks along the western base of the Blue Ridge Mountains, these wetlands include natural depressions or sinkhole ponds formed through processes of karstic collapse and sedimentation, as well as seepage wetlands developed along streams draining the area. Freer (1933), Carr (1937, 1938, 1939, 1940a, 1940b), Rawlinson & Carr (1937), and Harvill (1972, 1973a, 1975) have noted the occurrence of Coastal Plain plants and disjunct northern plants in some of the ponds and seepages. Work in the Big Levels - Maple Flats region wetlands by the Virginia Department of Conservation and Recreation's Division of Natural Heritage (DCR-DNH) over the past decade has focused on inventory of rare taxa (Van Alstine & Ludwig, 1991; Van Alstine et al., 1992; Longbottom & Van Alstine, 1995; Van Alstine, 1996). In addition, a preliminary classification of plant communities in Shenandoah Valley sinkhole ponds, including some of those in the Big Levels - Maple Flats region, was prepared by Van Alstine & Rawinski (1992).

In this paper, we focus on two objectives to more fully characterize the vegetation of the Big Levels - Maple Flats region: 1) development of a provisional classification of the plant communities in undisturbed ponds and seepages; and 2) a phytogeographic analysis of all vascular plant taxa reported from these wetlands.

STUDY AREA

For the purposes of this study, the Big Levels - Maple Flats region is broadly defined to include the entire flank and toe of the Blue Ridge, from the Big Levels ridgeline on the south to the edge of alluvial fan deposits on the north (Fig. 1). This region is located in southeastern Augusta County, generally south of Stuarts Draft, east of Steeles Tavern, and west of Sherando. Topographically, it is characterized by broad, gentle mountain tops, steep rocky slopes and boulderfields, and gently sloping to nearly level terrain where the foot-slopes meet the Shenandoah Valley floor. Bedrock of the mountain slopes is mostly Cambrian-age quartzite of the Antietam Formation (Werner, 1966). Fan deposits of three different ages and consisting of cobble to boulder-sized gravels extend for approximately three miles from the lower mountain slopes to near the South River (Whittecar & Duffy, 1992). These alluvial deposits overlie dolomites and limestones of the Cambrian Shady and Elbrook formations. Both residual and alluvial soils of the area are strongly acidic and infertile. Subxeric to xeric conditions and oligotrophic oak-pine forest vegetation prevail over much of the landscape. However, more mesophytic forests and forested wetlands influenced by groundwater seepage occur along streams draining the Big Level flanks and mantle of foot-slope fans. One of the best known seepages, Magnolia Swamp (Carr, 1939), is situated near the outermost edge of fan deposits, approximately 8 km WSW of Stuarts Draft.

Local solution of underlying carbonate formations and reworking of surficial material by streams have resulted in the development of numerous natural ponds in the fan deposits around the foot of Big Levels (Rawinski et al., 1996). These ponds vary in size from less than 0.1 ha to over 1.0 ha. Pollen profiles from bottom sediments in two ponds demonstrate the continuous existence of pond habitats in this area over the past 15,000 years, as well as major shifts of local climate and vegetation during this period (Craig, 1969). Ponds that are particularly well

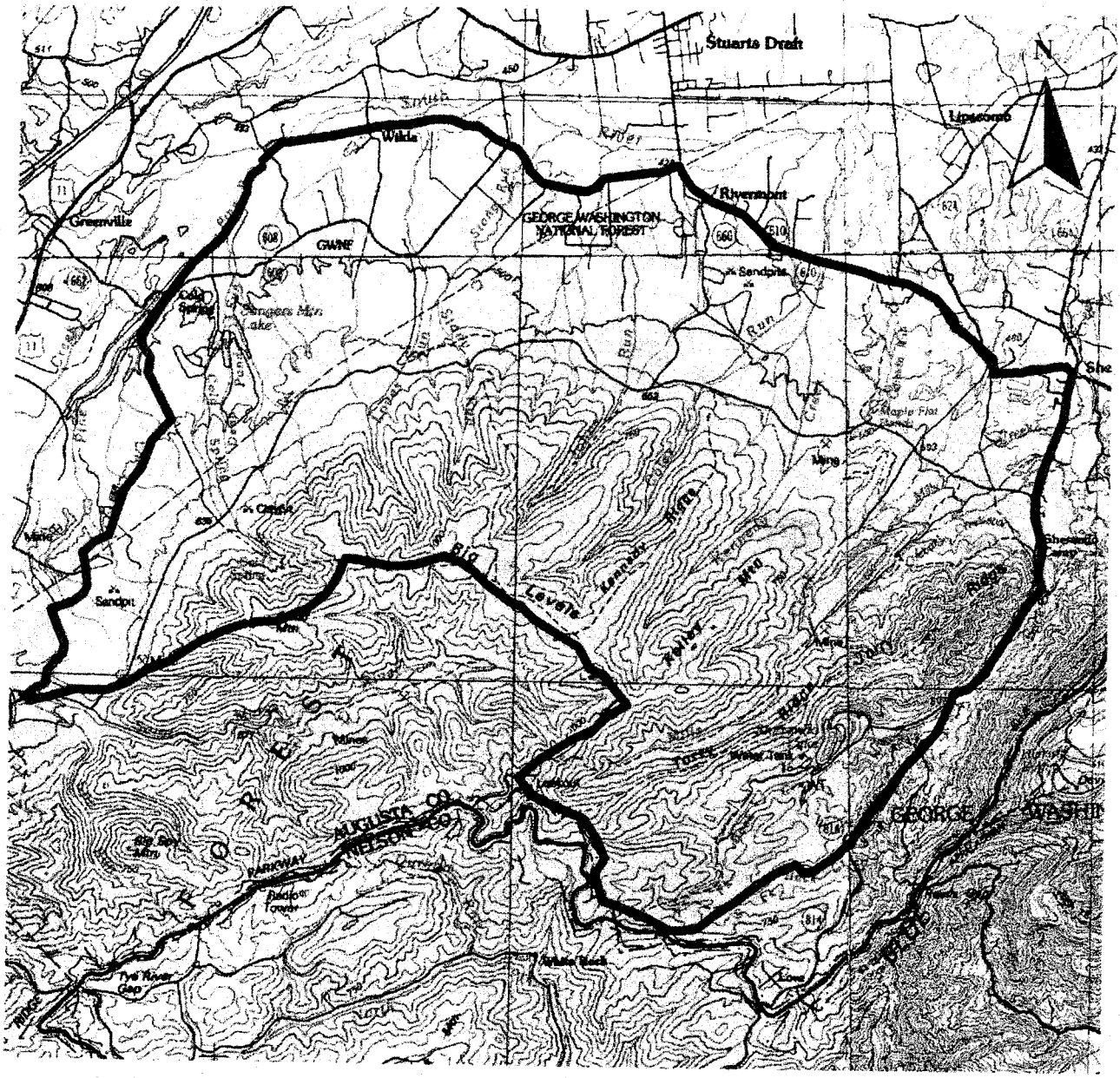

Fig. 1. Location of the Big Levels - Maple Flats region study area in Augusta County, Virginia.

known botanically include Deep Pond, Kennedy Mountain Meadow, Oak Pond, Quarles Pond, Spring Pond (Hack Pond), and the Twin Ponds (North and South) (Freer, 1933; Rawlinson & Carr, 1937; Craig, 1969; Harvill, 1973; Mohlenbrock, 1990; Knox, 1997).

The Big Levels - Maple Flats region study area is part of a larger depositional landscape that stretches along the western base of the Blue Ridge for approximately 90 km, from the Rockbridge/Augusta county line north to the southernmost part of Page County. Sinkhole ponds and seepage wetlands scattered throughout this larger area are refugia for many rare species and contribute significantly to the biological diversity of the region (Woodward & Hoffman, 1991).

MATERIALS AND METHODS

Floristic presence/absence data collected by DCR-DNH biologists and cooperators from 78 relatively undisturbed wetland vegetation stands provided the basis for a provisional classification of plant communities. These data represent 24 seepage wetland and 29 pond stands in the Big Levels - Maple Flats region, as well as 25 additional pond stands located elsewhere in Augusta and Rockingham Counties in ecologically similar landscapes. It was essential to include stands from outside the study area in order to make the pond classification as robust and regionally representative as possible.

Much of the available data consisted of species lists recorded from individual wetlands during the period 1990-1998. A few stands were quantitatively sampled using the releve method of plot sampling (sensu Peet et al., 1998) with 100 m^2 quadrats; these data were converted to presence/absence for consistency across the entire data set. Multiple visits were made to many of the ponds, and hydrologic conditions, soil composition, and other environmental factors were subjectively evaluated in the field during these visits. A-horizon soil samples were collected from 13 ponds, and the chemical analysis of these samples and six others collected by J.S. Knox was reported in Knox (1997). Hydrologic regime descriptors follow Cowardin et al. (1979). However, field observations indicate that the hydroperiods of many ponds are irregular and unpredictable, making definitive placement in Cowardin's hydrologic regimes difficult in some cases (Buhlmann et al., 1999) .

The limited scope of data made community analysis and interpretation somewhat problematic. Pond vegetation in the study area is complex and varies with distinct, often concentric hydrological zonation. Since species lists frequently reflect heterogeneous, within-pond composition and environments, a modified Braun-Blanquet tabular analysis (Westhoff & van der Maarel, 1973) was employed to identify groups of species that tend to co-occur under similar environmental conditions. Compositional relationships among these stands were further examined, and community type groupings validated, using Detrended Correspondence Analysis (DCA; Hill, 1979) implemented in the software program PC-ORD (version 3.18, McCune & Mefford, 1997). Traditional Braun-Blanquet tabular methods were used to define compositionally similar units in the seepage wetlands. The major units of the classification are treated simply as "community types," which are defined as units with similar floristic composition, physiognomy, and environmental relationships. In a few cases, community subtypes or variants are defined. Types and subtypes are named using up to five species with high constancy and diagnostic value. Community names reflect stand structure, with the taller species listed first. Nominal species in the same stratum are separated by a dash (-) while those in different strata are separated by a slash (/).

Because much of the supporting data was not collected from areas of standard size, was not quantitative, and did not include environmental measurements, compositional units defined in this study must be considered provisional. More intensive and rigorous sampling of these wetlands is needed to fully circumscribe these communities and their hierarchical relationships.

Phytogeographic analysis of the flora of the Big Levels - Maple Flats region is based on floristic data from 33 ponds and 24 seepage wetlands located within the study area. These data consist mostly of taxa collected or identified in the field by DCR-DNH biologists and cooperators. Data from older herbarium records and literature sources were also included for a few sites; therefore, not all of the listed taxa are currently known to be extant. Nomenclature follows Kartesz (1994). Species were sorted into geographic distribution groups using standard botanical manuals (Fernald, 1950; Radford et al., 1968; Gleason & Cronquist, 1991) and the Biota of North America Project species distribution maps available on the Internet (BONAP, 1998). Using these sources, along with atlases of the Virginia flora (Harvill et al., 1992) and West Virginia flora (West Virginia Nongame and Natural Heritage Program, 1997), we also evaluated whether each taxon's Augusta County occurrence represents an outlier from its continuous range. In addition to significantly disjunct taxa, outliers included some taxa which occur regularly east of the mountains in the Piedmont Plateau but are absent to rare on or west of the Blue Ridge. The percentage of the total Big Levels - Maple Flats region wetland flora attributable to each of nine geographic distributional groups, as well as the total number of outliers in all groups, was calculated. The same calculations were performed using the area's pond flora (exclud

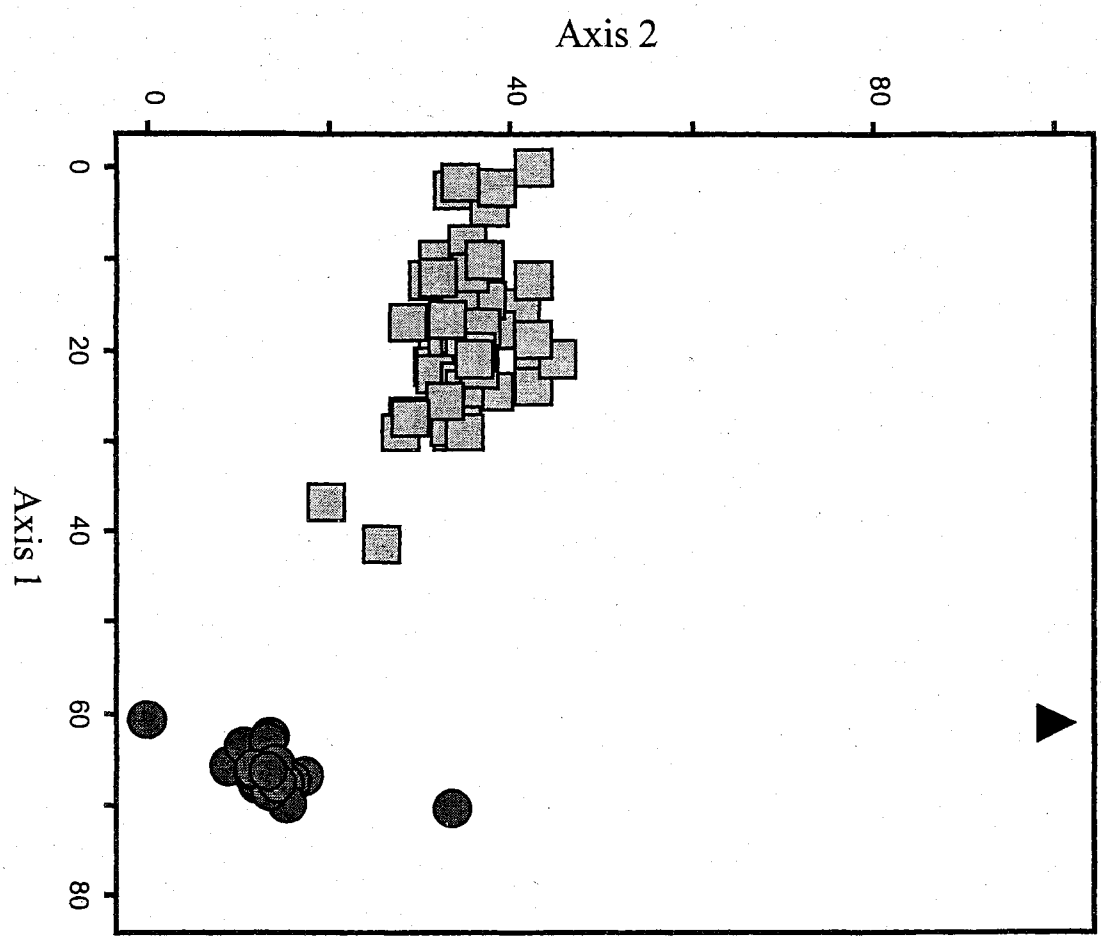

Fig. 2. Scatterplot diagram for DCA ordination showing the distribution of 78 relatively undisturbed wetlands on the first and second compositional axes. Wetland types: ▲ - calcareous fen; ● - forested swamp; ■ - sinkhole pond.

ing seepage wetlands) and using the group of taxa considered globally or state rare by DCR-DNH (Belden, 1998).

RESULTS AND DISCUSSION

Community Classification

Nine plant community types, one community subtype, and five variants were classified using tabular analysis and Detrended Correspondence Analysis of vegetation data. Distribution of all 78 stands on the first and second axes of a DCA ordination (Fig. 2) shows three compositional groupings: pond vegetation, indicated by squares; forested seepage wetlands, indicated by circles; and a single stand of fen-like shrub vegetation, indicated by a triangle.

Classification of pond vegetation is shown in Table 1, with the characteristic species of each community type enclosed by boxes. One subtype and two variants are nested within the community type boxes. Major boxes overlap where heterogeneous (e.g., zoned) vegetation and environments were recorded at sites; thus, some individual samples (ponds) contain more than one community type. A majority of ponds (indicated by the uppermost box) are wholly or partly occupied by a seasonally flooded zone with mineral soils that are exposed for a significant portion of the growing season. These environments support open woodland or herbaceous vegetation of the *Quercus palustris* / *Panicum rigidulum* var. *rigidulum* - *Panicum verrucosum* - *Eleocharis acicularis* community (type 1). Some ponds in this group also have a zone of deeper and more prolonged flooding supporting a *Cephalanthus occidentalis* / *Proserpinaca palustris* - *Polygonum hydropiperoides* community (type 2). The latter type also occupies marginal zones of five ponds characterized by a semipermanently flooded hydrologic regime, organic soils, and vegetation classified as a

Cephalanthus occidentalis / *Dulichium arundinaceum* community (type 3). Five ponds approach permanently flooded status and support a *Cephalanthus occidentalis* / *Torreyochloa pallida* community (type 4). Spring Pond, with a constant water level maintained by groundwater inputs, contained two unique compositional units (types 5 and 6). Another unique unit, characterized by nearly monospecific stands of *Carex barrattii* (type 7), was documented in an unusual seasonally flooded basin with organic soils.

When the compositional relationships of ponds were examined using DCA, comparable groupings are evident in an ordination diagram (Fig. 3). The two stands from Spring Pond performed as extreme outliers and distorted the initial scatterplot diagram. These were omitted from the final DCA analysis to better elucidate the relationships among the remaining stands. The group represented by triangles contains seasonally flooded ponds supporting community type 1 or both community types 1 and 2. The group represented by circles contains semipermanently flooded ponds supporting community type 3 or both community types 2 and 3. The group represented by squares are permanently flooded ponds supporting community type 4. The singular pond supporting community type 7 is represented by a diamond.

Classification of seepage wetlands is shown in Table 2. Vegetation and environments of the sample sites in this group are relatively homogeneous, and the units

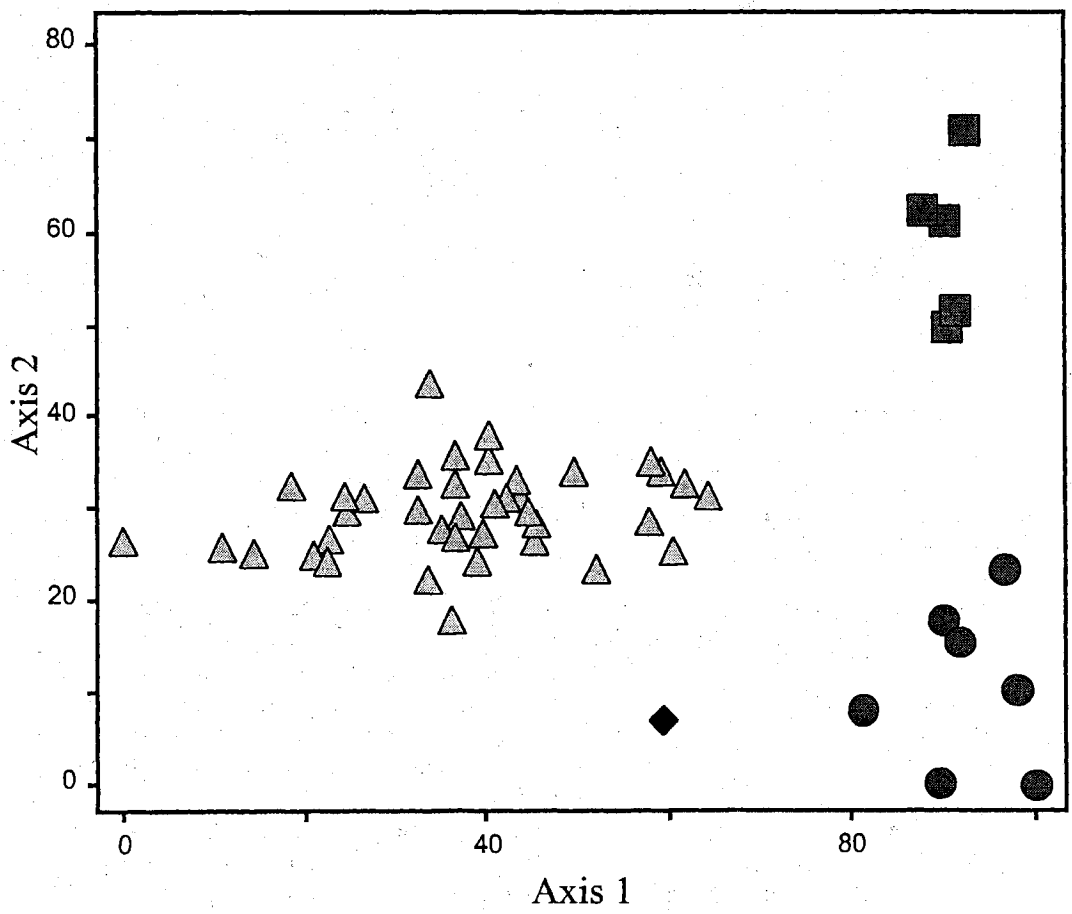

Fig. 3. Scatterplot diagram for DCA ordination showing the distribution of 52 relatively undisturbed ponds on the first and second compositional axes. Pond / community types: ▲ - wholly or partly seasonally flooded with mineral soil (ponds with community type 1 or both types 1 and 2); ● - semipermanently flooded with organic soil (ponds with community type 3 or both types 2 and 3); ■ - permanently flooded (community type 4); ◆ - seasonally flooded with organic soil (community type 7).

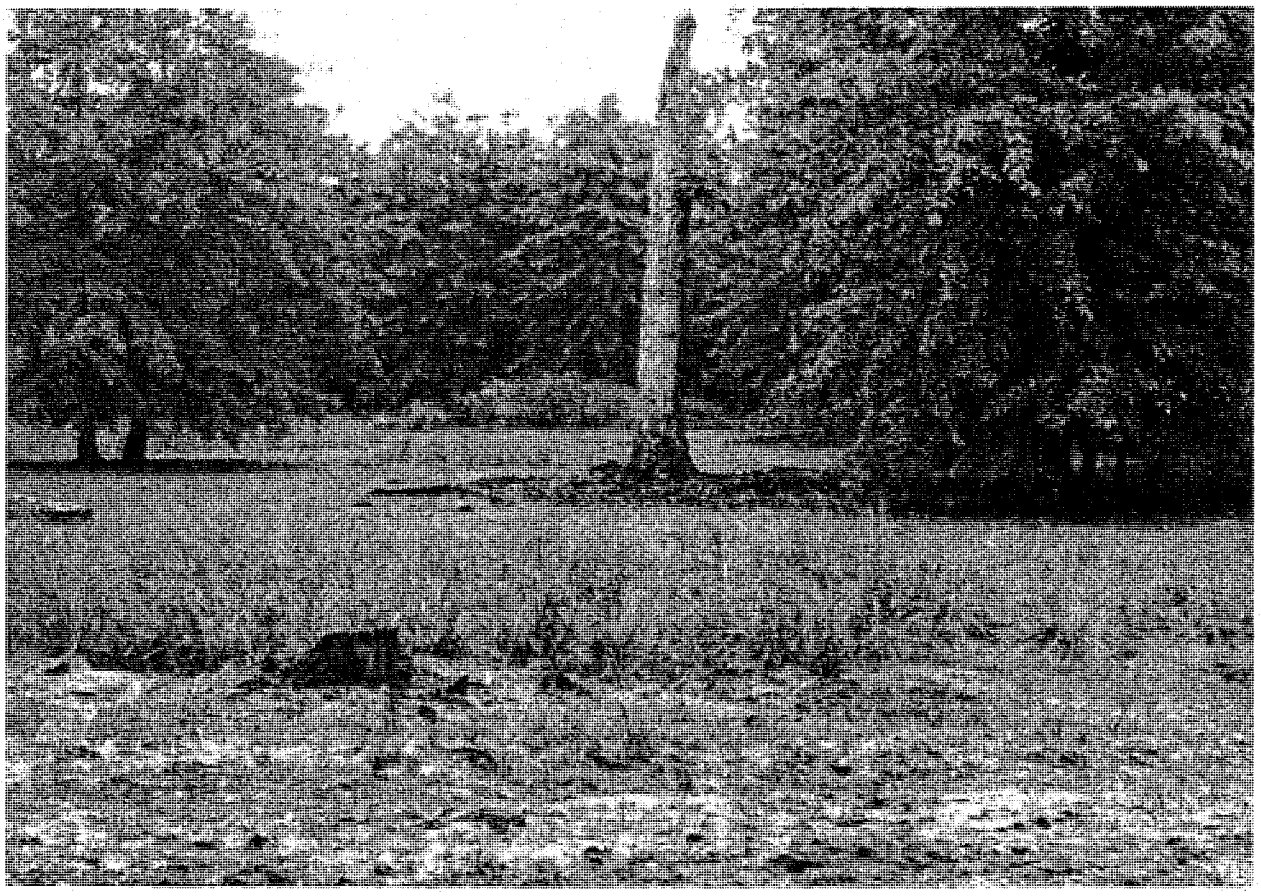

Fig. 4. Exsiccated, seasonally flooded pond supporting the *Quercus palustris / Panicum rigidulum* var. *rigidulum - Panicum verrucosum - Eleocharis acicularis* community (type 1; pin oak / tall flat panic grass - warty panic grass - least spikerush). Photo: Nancy E. Van Alstine.

represented by overlapping boxes have a hierarchical relationship. The single stand of calcareous shrub fen vegetation (type 9), represented by the box in the bottom right portion of the table, is floristically unique with the exception of one species. The remaining 23 stands, represented by the large box at the top of the table, contain forested seepage swamps classified as an *Acer rubrum - Nyssa sylvatica - Pinus rigida / Ilex verticillata / Osmunda cinnamomea* community (type 8). The three boxes in the middle of the table are overlapped by the large box above and show small groups of species largely confined to lower elevations (8a), middle elevations (8b), and the acidic portion of Magnolia Swamp (8c), respectively. These nested groups appear to represent relatively minor variants in a single, compositionally consistent unit with a large group of more or less constant, characteristic species.

Description of Community Types

All nine community types are found within the Big Levels - Maple Flats study area:

1. *Quercus palustris / Panicum rigidulum* var. *rigidulum - Panicum verrucosum - Eleocharis acicularis* community (pin oak / tall flat panic grass - warty panic grass - least spikerush)

Documented at 39 sites, this is the most prevalent plant community of the Shenandoah Valley sinkhole ponds in Augusta and Rockingham Counties. It is well represented in the study area at Kennedy Mountain Meadow, Twin Ponds (North and South), Oak Pond, and other sites. Physiognomy of these communities varies from open woodland with scattered individuals or groves

of *Quercus palustris*, to entirely herbaceous with trees confined to a marginal zone. The establishment and persistence of tree reproduction in these stands is episodic and probably associated with prolonged droughts. Shrubs are sparse or absent and the herbaceous flora is dominated by annual and perennial species adapted to seasonally flooded mineral soils. Soil chemistry at 19 sites is characterized by low pH (mean = 4.5), high levels of Al and As, and low levels of B, Ca, K, Mg, and P. Low pH in combination with high Al may impair the assimilation of macronutrients by plants (Knox, 1997). These data suggest that soil chemistry, in combination with hydrologic conditions, may produce unusual edaphic stresses that strongly influence community composition in these ponds. No comparable or similar vegetation is listed in The National Vegetation Classification (Anderson et al., 1998) or described for the southeastern United States by Weakley et al. (1998). Consequently, this community type is not only considered globally rare, but appears to be endemic to these Shenandoah Valley habitats. The distinctive *Salix humilis* var. *tristis* / *Schizachyrium scoparium* - *Sorghastrum nutans* community subtype (Dwarf Prairie Willow / Little Bluestem - Indian Grass) has affinities to prairie vegetation and is known from a single, intermittently flooded pond in the Maple Flats complex.

2. *Cephalanthus occidentalis* / *Proserpinaca palustris* - *Polygonum hydropiperoides* community (buttonbush / common mermaid-weed - mild water pepper)

Documented at 21 sites, this community occupies pond zones of relatively deep and/or long seasonal flooding and usually occurs in association with the

Fig. 5. Semipermanently flooded pond at Horseshoe Swamp, Maple Flats complex, supporting the *Cephalanthus occidentalis* / *Dulichium arundinaceum* community (type 3; buttonbush /three-way sedge). Photo: Gary P. Fleming.

previous type, or with the semipermanently flooded *Cephalanthus occidentalis* / *Dulichium arundinaceum* type below. Physiognomic expressions of this and other types with *Cephalanthus occidentalis* are quite variable, often comprising patch mosaics of shrubs and herbaceous openings. This community appears to be quite limited in the study area; small occurrences are located at several ponds, including Twin Pond North. It has some affinities to Coastal Plain vegetation types, but lacks many characteristic austral species.

3. *Cephalanthus occidentalis* / *Dulichium arundinaceum* community (buttonbush - three-way sedge)

This community type was documented at eight semipermanently flooded sites. Within the study area, excellent examples occur at Green Pond (Big Levels), Quarles Pond, Horseshoe Swamp (3 km W Sherando), and Hatton's Pond (4 km SW Stuarts Draft). Habitats are generally characterized by organic soils and retain surface water continuously in most years. The two nominal species occur in variable proportions, and at several sites *Cephalanthus occidentalis* is limited to marginal zones. Several other forbs and graminoids, including *Carex aquatilis* (water sedge), *Glyceria canadensis* (Canada mannagrass), *Glyceria obtusa* (coastal mannagrass), *Nuphar lutea* ssp. *advena* (spatterdock), *Scirpus ancistrochaetus* (northeastern bulrush; not documented within the study area), and *Scirpus torreyi* (Torrey's bulrush), are locally prominent. Stands dominated by *Carex aquatilis* and by *Scirpus torreyi* are classified as variants. The prevalence of *Carex aquatilis* at Green Pond on the Big Levels ridge crest may be related to a local weathering of Antietam quartzite that has exposed the less acidic Shady Formation (Werner, 1966; Wieboldt et al., 1998). Floristically and ecologically similar *Cephalanthus* - *Dulichium* ponds have been documented by DCR-DNH ecologists from several ridge crest depression ponds in the Virginia mountains. Coastal Plain ponds containing the two nominal species have also been documented, but their overall floristic composition is quite different from those of the mountain region (Rawinski, 1997).

4. *Cephalanthus occidentalis* / *Torreyochloa pallida* community (buttonbush - pale mannagrass)

This unit is a poorly known community type that occupies all or part of five ponds in the Big Levels - Maple Flats region. Stands are floristically depauperate and contain a high proportion of floating or submersed aquatic species. Dominants include the two nominal species, *Decodon verticillatus* (swamp loosestrife), *Eleocharis smallii* (creeping spikerush), *Glyceria acutiflora* (sharp-scaled mannagrass), *Potamogeton* spp. (pondweeds), *Proserpinaca palustris* (common mermaidweed), and *Utricularia* spp. (bladderworts). The habitats supporting this vegetation are permanently flooded, or nearly so. The relationships between this type and similar vegetation documented from the Virginia Coastal Plain (Rawinski, 1997) need further evaluation.

5. *Orontium aquaticum* - *Scirpus subterminalis* community (golden club - water bulrush)

This is an aquatic community dominated by *Orontium aquaticum* and also containing *Brasenia schreberi* (watershield), *Eleocharis robbinsii* (Robbins spikerush), *Eriocaulon aquaticum* (seven-angled pipewort), *Panicum hemitomon* (maidencane), *Scirpus subterminalis* (water bulrush), and *Woodwardia virginica* (Virginia chain fern). Hydrologic conditions supporting this type in the study area are unique to Spring Pond, a cold, permanently flooded pond with water levels constantly replenished by groundwater inputs. Very similar vegetation has been documented in oligotrophic, spring-fed, Coastal Plain millponds and beaver ponds in Delaware and eastern Virginia (Fleming & Van Alstine, 1994; J.C. Ludwig, pers. comm.). Consequently, the type's occurrence in the Big Levels - Maple Flats region perhaps could be considered a Coastal Plain "disjunct," reflecting the similar disjunct status of many of its component species and unusual edaphic conditions.

6. *Vaccinium macrocarpon* - *Pogonia ophioglossoides* community (large cranberry - rose pogonia)

This unit is a distinctive, ecotonal community occupying groundwater-saturated, locally floating peat and sphagnum mats along the south shoreline of Spring Pond. *Vaccinium macrocarpon* dominates in dense colonies. The bog-loving species *Calopogon tuberosus* (tuberous grass-pink), *Drosera rotundifolia* (round-leaved sundew), *Dulichium arundinaceum* (three-way sedge), *Eriophorum virginicum* (cotton-grass), *Juncus canadensis* (Canada rush), *Pogonia ophioglossoides*, *Triadenum virginicum* (marsh St. John's-wort), and *Xyris torta* (twisted yellow-eyed grass) occur as associates.

7. *Carex barrattii* community (Barratt's sedge)

This unit is confined to the drier, seasonally flooded portion of Horseshoe Swamp, which has an unusually deep, organic soil for this type of wetland. The community is dominated by nearly monospecific swards of the state-rare sedge *Carex barrattii*, with scattered associates

of *Bartonia paniculata* (twining bartonia), *Bartonia virginica* (yellow screwstem), *Spiraea tomentosa* (hardhack steeplebush), and *Triadenum virginicum*. One of the Shenandoah Valley's most pronounced Coastal Plain disjuncts, *Carex barrattii* is primarily found in the Coastal Plain from Connecticut to Virginia and formerly North Carolina, but has been documented at other disjunct inland sites with Coastal Plain affinities: Coffee County, Tennessee; Henderson County in the mountains of southwest North Carolina (where now extirpated); Pickens County in the mountains of South Carolina; and the mountains of Alabama and Georgia (Hill & Horn, 1997; Weakley, 1998).

8. *Acer rubrum - Nyssa sylvatica - Pinus rigida / Ilex verticillata / Osmunda cinnamomea* community (red maple - blackgum - pitch pine / winterberry / cinnamon fern)

This wetland forest occupies groundwater-saturated flats and low slopes along streams draining the study area. Outstanding examples occur along Canada Run, Kennedy Creek, Mills Creek, and Orebank Creek. These communities, commonly known as "seepage swamps," are most extensively developed in the area's gentler, lower elevation topography and have a variable canopy of *Acer rubrum*, *Nyssa sylvatica*, *Pinus rigida*, and *Liriodendron tulipifera* (tulip-poplar). A diversity of shade-tolerant shrubs, herbaceous acidiphiles, and mats of *Sphagnum* mosses are prevalent in the lower strata. Three variants with small groups of characteristic species are recognized (Table 2) and appear to be correlated with an elevational / topographic gradient. One of the most interesting variants occurs at Magnolia Swamp and features a notably disjunct population of the coastal plain tree *Magnolia virginiana* (sweetbay; Carr, 1939). This community type has many floristic affinities with saturated forests occurring in seepage- influenced wetlands of the inner Coastal Plain. The rare and beautiful plant *Helonias bullata* (swamp-pink) is locally abundant in seepage swamps of both geographic regions.

9. Calcareous Shrub Fen community (not formally named)

The unit is represented by a single stand of shrubby vegetation occupying a portion of Magnolia Swamp. This site is located at the extreme northern edge of alluvial fan deposits and is partly influenced by underlying carbonate rocks (Carr, 1939). This community, which intergrades with the adjacent, acidic seepage swamp, is dominated by the shrubs *Aronia arbutifolia* (red chokeberry) and *Rosa palustris* (swamp rose), with herbaceous openings containing the study area's only calcium-demanding plants. Among the pronounced calciphiles found here are *Carex conoidea* (field sedge), *Filipendula rubra* (queen-of-the-prairie), *Juncus brachycephalus* (small-headed rush), *Lysimachia quadriflora* (smooth loosestrife), *Parnassia grandifolia* (large-leaved grass-of-parnassus), *Pedicularis lanceolata* (swamp lousewort), and *Veronica scutellata* (marsh speedwell). This is a somewhat enigmatic community type, the interpretation of which is made difficult by co-occurring calciphiles and acidiphiles. More intensive study of within-site environmental dynamics and the floristic relationships of this stand to similar shrublands elsewhere will be required before the community can be formally classified.

Floristics and Phytogeography

A total of 274 vascular plant taxa, representing nine geographic distribution groups, was documented from wetlands of the Big Levels - Maple Flats study area (Table 3; Appendix A). The geographic groups are Widespread, Northern, Southeastern, Coastal Plain, Appalachian, Midwestern, Coastal Plain / Appalachian, Endemic, and Exotic. The distributional status of ten taxa is unknown due to uncertain taxonomic dispositions. It is important to note that phytogeographic assessments are based on distributions in eastern North America rather than rangewide or worldwide distributions.

Widespread taxa include those generally distributed in the eastern United States or eastern North America. The Northern group is comprised of taxa generally found in northeastern North America, northern North America, or circumboreally. These taxa typically extend south in the Appalachians or other highland regions, but do not reach the lower elevations of the southeastern United States. The Southeastern taxa occur commonly on the Atlantic and Gulf Coastal Plains but also extend more or less commonly into other provinces. They typically do not occur much farther north than Massachusetts, southern New York, Ohio, and Indiana, except sometimes along the Atlantic coast.

The more restricted taxa of the Coastal Plain group have distributions concentrated on the Atlantic and Gulf Coastal Plains, or just the Atlantic Coastal Plain. These plants are usually disjunct at scattered inland stations with Coastal Plain-like habitats and floristics, e.g., the Great Lakes region of northern Indiana and Michigan, and the Cumberland Plateau of central Tennessee (Peattie, 1922; Harvill, 1992). The Appalachian group consists of plants with distributions primarily in the Appalachian or southern Appalachian Mountains. Taxa of the Midwestern group have distributions centered west of the Appalachians in the northern part of the midwestern United States. With the exception of *Quercus palustris* (pin oak),

Fig. 6. Permanently flooded, spring-fed wetland at Spring Pond, Maple Flats complex, supporting the *Orontium aquaticum* - *Scirpus subterminalis* community (type 5; golden club - water bulrush). Photo: Gary P. Fleming.

a characteristic tree of glacially-leveled claypan wetlands in the midwest, plants of the Midwestern group reach their eastern range limits in the western or central Virginia uplands and are typically associated with prairies or prairie-like habitats in the main part of their range. The Coastal Plain / Appalachian category is represented by a single taxon, *Helonias bullata* (swamp-pink), whose range-wide distribution is fairly equally divided between the two geographic areas. Taxa restricted either to Virginia or to the Shenandoah Valley are included in the Endemic group.

Although Widespread taxa are most abundant in the overall wetland flora, significant numbers of Northern, Coastal Plain, and Southeastern taxa occur, along with a small number of interesting Midwestern plants and Virginia endemics (Table 3). Two long-range northern disjuncts, *Carex aquatilis* (water sedge) and *Cyperus dentatus* (toothed flatsedge), are documented in Virginia only from the Big Levels - Maple Flats study area. Several others, including *Arethusa bulbosa* (dragon's mouth), *Carex lasiocarpa* var. *americana* (slender sedge), and *Scirpus torreyi* (Torrey's bulrush), are known from only one or a few other sites in Virginia. The globally rare species *Echinodorus parvulus* (dwarf burhead) and the state rarities *Carex barrattii* (Barratt's sedge), *Eleocharis melanocarpa* (black-fruited spikerush), *Eleocharis robbinsii* (Robbins spikerush), *Lachnanthes caroliana* (redroot), *Panicum hemitomon* (maidencane), and *Utricularia fibrosa* (fibrous bladderwort) are particularly notable members of the Coastal Plain group. Only a small number of taxa have Midwestern affinities but two of these, *Filipendula rubra* (queen-of-the-prairie) and *Lysimachia quadriflora* (smooth loosestrife), are state rarities. *Helenium virginicum* (Virginia sneezeweed) and *Isoetes virginica* (Virginia quillwort) are endemic to Virginia. The former is endemic to seasonally flooded

sinkhole ponds in Augusta and Rockingham Counties, and is currently considered to be extant at 25 sites (Blake, 1936; Knox, 1995; Van Alstine, 1996; U.S. Fish and Wildlife Service, 1998). The type locality of *Isoetes virginica* is located within the Big Levels - Maple Flats study area, but the taxon is also documented from upland depression ponds of the southern Virginia Piedmont (Brunton et al., 1996; DCR-DNH, unpublished data).

The distributional status of the sinkhole pond flora alone was also analyzed (Table 3). The relative

Fig. 7. Forested seepage wetlands characterized by the *Acer rubrum - Nyssa sylvatica - Pinus rigida / Ilex verticillata / Osmunda cinnamomea* community (type 8; red maple - blackgum - pitch pine / winterberry / cinnamon fern) are common along streams draining the Big Levels - Maple Flats region. Photo: Gary P. Fleming.

importance of the four distributional groups containing the majority of the taxa found in the overall wetland flora remain the same for the pond flora. Slight shifts in group percentages result from an increase of Coastal Plain taxa, decreases of Northern and Midwestern taxa, and the loss of all taxa with a distinctly Appalachian distribution.

Taxa considered to be outliers from their continuous ranges constitute a significant percentage (20.4%) of the Big Levels - Maple Flats wetland flora (Appendix A). This percentage increased to 28.8% when the pond flora alone was evaluated. No one geographic distribution group predominated, and outliers were included in the Coastal Plain (18), Northern (15 taxa), Southeastern (13), Widespread (9), and Coastal Plain / Appalachian (1) groups.

Thirty-four taxa, or 12% of the wetland flora of the Big Levels - Maple Flats study area, are considered to be rare in Virginia by DCR-DNH (Table 3; Belden, 1998). Nearly half are of northern distribution, with Coastal Plain taxa comprising a smaller but significant percentage. Most (76%) of these rarities are associated with sinkhole ponds rather than seepage wetlands. Two species, *Lachnanthes caroliana* and *Lysimachia radicans*, are considered historical members of Virginia's flora due to long periods without documentation. Three species, *Helenium virginicum*, *Helonias bullata*, and *Echinodorus parvulus* are ranked as globally rare by The Nature Conservancy and network of Natural Heritage programs. Both *Helenium virginicum* and *Helonias bullata* are listed as threatened under the Federal Endangered Species Act and are state listed as endangered under the Virginia Endangered Plant and Insect Act.

Phytogeographic Discussion

The paleoecological work of Craig (1969) indicates that boreal-like forests and wetlands were prevalent in the early Holocene landscape of the study area. Pollen profiles show that *Picea*, *Pinus*, and *Abies* were abundant until approximately 9,500 years BP, when vegetation began to shift toward a *Quercus-Tsuga* assemblage perhaps resembling contemporary "northern hardwoods." A *Quercus-Pinus* assemblage, composed of the pollen of many species now occurring in the Big Levels - Maple Flats region, marks the upper parts of the profiles (Craig, 1969). The pollen record clearly suggests a warming post-glacial climate accompanied by major, if gradual, shifts in regional vegetation types. Although many genera present early in the record are no longer extant in the region, it seems reasonable to assume that at least some of the northern or boreal disjuncts presently occurring in the Big Levels - Maple Flats region are Pleistocene or early Holocene relicts that have persisted here in unusual wetland microhabitats.

The concentration of Coastal Plain disjuncts in the area is harder to explain. Harvill (1973b, 1992) has advanced the hypothesis that, in the mid-latitudes of the southeastern states, these taxa migrated inland when the boreal forest collapsed about 10,000 years BP but while the climate was still oceanic. When the climate turned continental about 8,000 to 9,000 years BP, or later during xerothermic intervals, most of the populations were extirpated from the interior, leaving relict colonies in localized, favorable habitats. These include certain wetland-laden areas of the Cumberland Plateau (particularly Coffee County, Tennessee), wetlands of the Blue Ridge escarpment of southwestern North Carolina (particularly Henderson County), and dunes and wetlands of the Great Lakes region in southwestern Michigan, northwestern Indiana, and northwestern Wisconsin -- all of which harbor notable occurrences of Coastal Plain species (Peattie, 1922; McLaughlin, 1932; Svenson, 1941; Kral, 1973; Harvill, 1984; Harvill, 1992; Weakley & Schafale, 1994).

The vegetational and phytogeographic history underlying contemporary distribution patterns is a fascinating subject that lies well beyond the scope of our objectives to more fully describe the present-day wetland vegetation and flora. Our analyses clearly demonstrate that the Big Levels - Maple Flats region supports a diversity of wetland habitats and community types, some of them globally rare or even endemic to this region. Botanical literature on the Big Levels - Maple Flats region has somewhat overemphasized the Coastal Plain element and underemphasized the northern element in relation to their actual numerical importance in this flora. More importantly, an objective enumeration of the flora reveals a remarkably high number of outlier taxa and rare species with several phytogeographic alliances. Although both Coastal Plain and northern elements are significant contributors to the region's biodiversity, it is the overall assemblage of geographically diverse outliers and unusual plant communities that makes these wetlands so biologically important and worthy of conservation.

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Table 1. Provisional classification of plant communities in 54 undisturbed sinkhole pond wetlands using floristic presence / absence data. Characteristic species of each community type are denoted by the boxes. Overlapping boxes indicate community and environmental zonation within ponds. An additional 80 inconstant and/or transgressive taxa were omitted from the table.

SITE:	P8	P17	P21	P24	P31	P36	P37	P44	P56	P61	P12	P13	P15	P28	P29	P1	P40	P41	P3	P5	P22	P23	P65	P66
1. QUERCUS PALUSTRIS / PANICUM RIGIDULUM VAR. RIGIDULUM - PANICUM VERRUCOSUM - ELEOCHARIS ACICULARIS Community - Open woodland/herbaceous vegetation																								
Quercus palustris	X	X					X			X	X	X	X			X	X						X	X
Panicum rigidulum var. rigidulum	X	X		X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Panicum verrucosum		X		X	X	X			X	X			X	X	X	X	X	X					X	X
Eleocharis acicularis		X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Acer rubrum	X			X	X	X		X			X	X	X	X		X			X	X		X		
Nyssa sylvatica		X	X	X	X			X		X	X		X	X	X	X			X	X	X	X		X
Pinus rigida			X		X								X		X			X			X	X		
Agrostis perennans	X		X	X		X	X	X		X	X	X	X		X	X				X		X		X
Dichanthelium acuminatum	X		X			X	X	X			X	X	X	X	X	X				X	X	X		X
Diospyros virginiana	X	X						X	X			X			X	X			X	X	X	X		X
Hypericum boreale			X	X			X			X			X			X	X	X	X	X	X	X	X	
Helenium virginicum	X			X	X										X					X				
Panicum philadelphicum							X					X				X				X	X	X	X	
Bidens frondosa								X			X	X	X											
Smilax rotundifolia	X	X			X			X	X		X	X	X			X	X		X	X	X			X
Viola lanceolata	X	X	X	X	X			X		X	X	X	X		X	X	X	X	X	X	X	X		X
Erechtites hieraciifolia			X							X	X	X			X	X	X	X		X				
Aster dumosus	X		X				X	X		X	X				X						X	X		
Fimbristylis autumnalis						X			X	X						X	X		X			X		
Vaccinium corymbosum/fuscatum		X			X					X			X	X					X	X	X	X	X	X
Rhexia mariana / virginica						X		X		X					X						X	X		X
Community Subtype:	**Salix humilis var. tristis / Schizachyrium scoparium - Sorghastrum nutans** - Intermittently flooded shrubland / herbaceous vegetation with prairie affinities.																							
Salix humilis var. tristis																								
Schizachyrium scoparium																								
Sorghastrum nutans																								
Baptisia tinctoria																								
Polygala nuttallii																								
Pteridium aquilinum v. lat.																								
2. CEPHALANTHUS OCCIDENTALIS / PROSERPINACA PALUSTRIS - POLYGONUM HYDROPIPEROIDES Community - Shrubland or herbaceous vegetation of seasonally flooded to																								
Cephalanthus occidentalis																			X	X	X	X		
Proserpinaca palustris														X		X		X						
Polygonum hydropiperoides											X	X				X	X							
Juncus canadensis																								
Eleocharis melanocarpa																								
Eleocharis smallii															X									
Glyceria acutiflora																								
Leersia oryzoides																								
Polygonum amphibium																								
Scirpus cyperinus													X											
Bidens discoidea																								
Woodwardia virginica																								
3. CEPHALANTHUS OCCIDENTALIS / DULICHIUM ARUNDINACEUM Community; Variants dominated by Carex aquatilis and Scirpus torreyi are indicated by the internal boxes -																								
Dulichium arundinaceum																								
Nuphar luteum																								
Scirpus ancistrochaetus																								
Triadenum virginicum																								
Utricularia sp.																								
Eleocharis robbinsii																								
Scirpus torreyi																								
Carex aquatilis																								
Glyceria canadensis																								
Potamogeton pulcher											X													
Utricularia gibba																								
Eleocharis quadrangulata																								
Glyceria obtusa																								
4. CEPHALANTHUS OCCIDENTALIS / TORREYOCHLOA PALLIDA Community - Semipermanently to permanently flooded shrubland and herbaceous vegetation with many floating/aquatic spp.																								
Torreyochloa pallida																								
Decodon verticillatus																								
Potamogeton sp.																								
Potamogeton oakesianus																								
Utricularia radiata																								
5. ORONTIUM AQUATICUM - SCIRPUS SUBTERMINALIS Community - Floating/aquatic herbaceous vegetation documented only from the permanently flooded portions of Spring Pond.																								
Orontium aquaticum																								
Scirpus subterminalis																								
Panicum hemitomon																								
Brasenia schreberi																								
Eriocaulon aquaticum							X																	
6. VACCINIUM MACROCARPON - POGONIA OPHIOGLOSSOIDES Community - Ecotonal shrubland and herbaceous vegetation of floating sphagnous peat mat along edge of Spring Pond																								
Vaccinium macrocarpon																								
Pogonia ophioglossoides																								
Calopogon tuberosus																								
Cuscuta compacta																								
Drosera rotundifolia																								
Eriophorum virginicum																								
Xyris torta																								
7. CAREX BARRATTII Community - Nearly monospecific, seasonally flooded herbaceous vegetation dominated by the nominal species; documented from Horseshoe Swamp																								
Carex barrattii																								
Bartonia paniculata																								
Bartonia virginica																								
Spiraea tomentosa																								

Table 1. Continued.

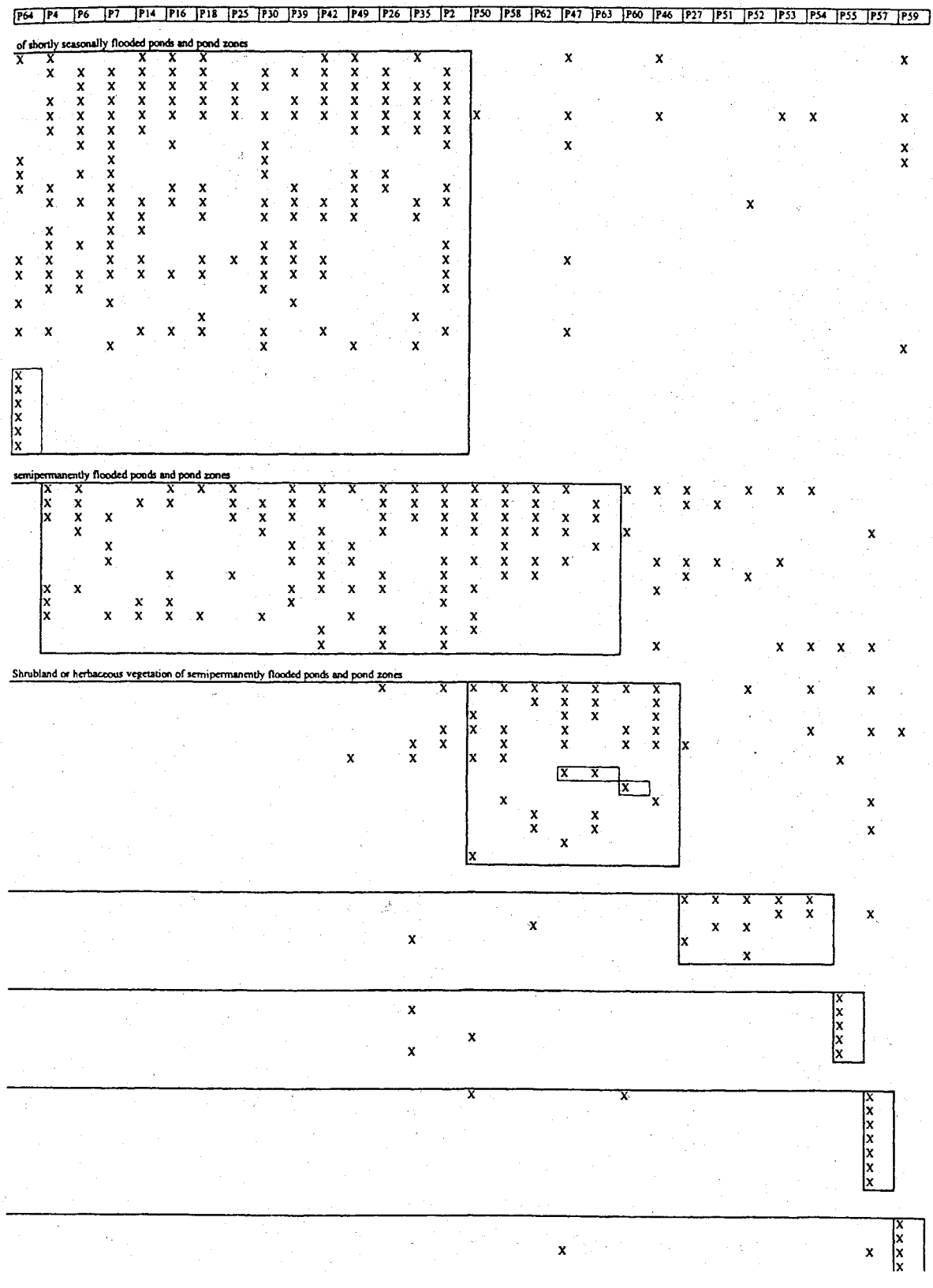

Table 2. Provisional classification of plant communities in 24 seepage wetlands using floristic presence/absence data Characteristic species of each community type and three hierarchically nested variants of one are denoted by the boxes An additional 60 inconstant and/or transgressive taxa were omitted from the table.

SITE:	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S16	S14	S15	S17	S18	S19	S20	S21	S22	S23	S24	S2	S1
8. ACER RUBRUM - NYSSA SYLVATICA - PINUS RIGIDA / ILEX VERTICILLATA / OSMUNDA CINNAMOMEA Community																								
Forest vegetation of groundwater-saturated stream bottoms in acidic alluvial and colluvial soils; low to middle elevations																								
Acer rubrum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Nyssa sylvatica	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X		X	
Pinus rigida	X	X	X		X	X		X	X	X	X	X		X	X	X	X	X					X	
Ilex verticillata		X	X		X	X	X		X	X	X	X	X	X	X			X	X	X	X	X	X	
Osmunda cinnamomea		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Liriodendron tulipifera	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	
Kalmia latifolia	X	X	X			X		X	X	X	X	X	X	X	X	X		X	X	X	X	X		
Alnus serrulata	X	X					X		X	X	X	X		X	X			X			X		X	X
Viburnum nudum var. cassinoides	X	X			X	X			X	X	X	X	X	X	X	X	X	X	X	X	X		X	
Viburnum dentatum	X	X	X	X	X	X	X		X	X	X		X						X	X	X		X	
Menziesia pilosa		X	X	X				X	X			X	X	X	X	X	X	X	X	X	X			
Chionanthus virginicus	X	X			X				X	X		X						X	X	X				
Smilax sp.	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X			X			
Rubus hispidus	X			X	X	X		X	X		X			X			X		X	X	X	X	X	
Carex gynandra		X	X	X				X	X			X		X			X				X	X	X	
Helonias bullata	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Thelypteris noveboracensis	X	X	X	X		X			X			X	X	X	X			X	X	X	X	X		
Medeola virginiana	X	X	X	X	X	X	X	X	X		X	X	X			X	X				X	X	X	
Lycopodium obscurum	X		X				X	X	X	X	X				X		X	X	X	X				
Osmunda regalis var. spectabilis		X	X	X		X			X		X	X			X		X	X	X	X	X	X	X	
Parnassia asarifolia	X		X	X	X	X		X		X		X			X			X	X	X	X			
Viola cucullata		X		X	X	X	X					X					X				X	X	X	
Sphagnum spp.	X		X	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X	
8a. Characteristic species of low elevation variant:																								
Amianthium muscitoxicum	X		X		X					X														
Brachyelytrum erectum		X	X		X				X		X										X			
Carex debilis	X	X	X							X		X												
Carex folliculata			X	X																				
Carex intumescens		X	X				X				X											X		
Cypripedium acaule			X			X		X		X		X												
Gaylussacia frondosa	X			X																			X	
Lindera benzoin		X	X	X		X	X				X						X						X	
Platanthera ciliaris				X		X				X		X												
Platanthera clavellata	X	X	X	X	X	X		X			X		X					X					X	
Uvularia sessilifolia	X	X	X		X	X			X	X	X											X		
Viburnum nudum var. nudum					X		X																	
Viola primulifolia	X		X	X							X	X											X	
8b. Characteristic species of middle elevation variant:																								
Aster acuminatus												X	X	X	X			X	X	X				
Betula lenta						X						X	X	X				X			X	X		
Magnolia acuminata		X							X	X					X				X	X	X			
Pinus strobus														X				X	X	X				
Rhododendron catawbiense								X		X		X	X			X		X			X	X		
Rhododendron viscosum																	X	X	X	X		X	X	
8c. Characteristic species of "Magnolia Swamp" variant:																								
Magnolia virginiana																							X	
Arethusa bulbosa																							X	
Dulichium arundinaceum																							X	
Juncus effusus																							X	
Parthenocissus quinquefolia																							X	
Triadenum virginicum																							X	
Woodwardia areolata																							X	

Table 2. Continued. Provisional classification of plant communities in 24 seepage wetlands using floristic presence/absence data. Characteristic species of each community type and three hierarchially nested variants of one are denoted by the boxes. An additional 60 inconstant and/or transgressive taxa were omitted from the table.

SITE:	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S16	S14	S15	S17	S18	S19	S20	S21	S22	S23	S24	S2	S1
9. CALCAREOUS FEN Community (not formally named)																								
Saturated shrubland vegetation in stream bottom seepage zone; calcareous soil and/or groundwater ; known in this region only from Magnolia Swamp, in part																								
Alisma subcordatum																								X
Aronia arbutifolia																						X		X
Caltha palustris																								X
Campanula aparinoides																								X
Cardamine bulbosa																								X
Carex buxbaumii																								X
Carex conoidea																								X
Carex lurida																								X
Carex stricta		X																						X
Cornus amomum																								X
Eleocharis tenuis																								X
Filipendula rubra																								X
Hydrocotyle americana																								X
Iris versicolor																								X
Juncus brachycephalus																								X
Lysimachia quadriflora																								X
Lysimachia terrestris																								X
Parnassia grandifolia																								X
Pedicularis lanceolata																								X
Peltandra virginica																								X
Physocarpus opulifolius																								X
Ranunculus hispidus var. caricetorum																								X
Rosa palustris																								X
Sagittaria rigida																								X
Selaginella apoda																								X
Senecio aureus																								X
Veronica scutellata																								X

Table 3. Phytogeographical summary of the vascular plant taxa in wetlands of the Big Levels - Maple Flats region. Rare taxa are those designated as such by DCR-DNH (Belden, 1998).

DISTRIBU-TIONAL GROUP	NO. OF TAXA -ALL WETLANDS	% OF TOTAL FLORA	NO. OF POND TAXA	% OF TOTAL POND TAXA	NO. OF RARE TAXA	% OF TOTAL RARE TAXA
Widely Distributed	133	48.54	82	52.56	3	8.82
Northern	53	19.34	25	16.03	16	47.06
Southeastern	39	14.23	21	13.46	2	5.88
Coastal Plain	20	7.30	17	10.90	8	23.53
Appalachian	8	2.91	0	0	0	0
Midwestern	4	1.46	1	0.64	2	5.88
Exotic	4	1.46	1	0.64	-	-
Coastal Plain /Appalachian	1	0.36	0	0	1	2.94
Endemic	2	0.73	2	1.28	2	5.88
Unknown	10	3.65	7	4.49	-	-
Totals	274	100.00	156	100.00	34	100.00

Appendix A. Floristics of the wetlands of the Big Levels - Maple Flats region, Augusta County, Virginia. Distributional Status: W= Widespread; N= Northern; SE = Southeastern; CP = Coastal Plain; A= Appalachian; MW = Midwestern; CP/A = Coastal Plain /Appalachian; E = Endemic to Virginia; EX= Exotic; and U = Unknown. Note: Some pond taxa may also be in seepages. See text for explanation of Outlier category and Belden (1998) for explanation of Rarity Status codes.

Taxon	Distributional Status	Pond Taxa	Outlier	Rarity Status
PTERIDOPHYTA				
ASPLENIACEAE				
Asplenium platyneuron (L.) B.S.P.	W	X		
BLECHNACEAE				
Woodwardia areolata (L.) T. Moore	SE		X	
Woodwardia virginica (L.)Sm.	W	X	X	
DENNSTAEDTIACEAE				
Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underwood *ex* Heller	W	X		
DRYOPTERIDACEAE				
Dryopteris cristata (L.) Gray	N			
ISOETACEAE				
Isoetes virginica N. E. Pfeiffer	E	X		G1Q / S1?
LYCOPODIACEAE				
Huperzia lucidula (Michx.) Trevisan	N			
Lycopodiella inundata (L.) Holub	N	X	X	G5 / S1
Lycopodium clavatum L.	N			
Lycopodium obscurum L.	W			
OSMUNDACEAE				
Osmunda cinnamomea L. var. *cinnamomea*	W	X		
Osmunda regalis L. var. *spectabilis* (Willd.) Gray	W			
SELAGINELLACEAE				
Selaginella apoda (L.) Spring	SE			
THELYPTERIDACEAE				
Thelypteris noveboracensis (L.) Nieuwl.	W			
Thelypteris palustris var. *pubescens* (Lawson) Fern.	W			
SPERMOPHYTA: GYMNOSPERMAE				
PINACEAE				
Pinus rigida P. Mill.	N	X		
Pinus strobus L.	N	X		
Tsuga canadensis (L.) Carr.	N			
SPERMOPHYTA: ANGIOSPERMAE				
Monocotyledoneae				
ALISMATACEAE				
Alisma subcordatum Raf.	W			
Echinodorus parvulus Engelm.	CP	X	X	G3 / S1
Sagittaria rigida Pursh	N			G5 / S1
ARACEAE				
Arisaema triphyllum (L.) Schott	W	X		
Orontium aquaticum L.	CP	X		
Peltandra virginica (L.) Schott	W			
Symplocarpus foetidus (L.) Salisb. *ex* Nutt.	N			

Taxon	Distributional Status	Pond Taxa	Outlier	Rarity Status
CYPERACEAE				
Carex aquatilis Wahlenb.	N	X	X	G5 / S1
Carex barrattii Schwein. & Torr.	CP	X	X	G4 / S2
Carex buxbaumii Wahlenb.	N	X		G5 / S2
Carex conoidea Schkuhr *ex* Willd.	N			G4 / S1S2
Carex debilis Michx.	SE			
Carex echinata Murr. ssp. *echinata*	N	X		
Carex folliculata L.	N	X		
Carex gynandra Schwein.	N			
Carex intumescens Rudge	W			
Carex lasiocarpa Ehrh. var. *americana* Fern.	N	X	X	G5 / S1
Carex leptalea Wahlenb.	W			
Carex longii Mackenzie	W		X	
Carex lupulina Muhl. *ex* Willd.	W	X		
Carex lurida Wahlenb.	W			
Carex mitchelliana M.A. Curtis	SE	X	X	
Carex stricta Lam.	W	X		
Carex tribuloides Wahlenb.	W	X		
Cyperus dentatus Torr.	N	X	X	G4 / S1
Dulichium arundinaceum (L.) Britt.	W	X		
Eleocharis acicularis (L.) Roemer & J.A. Schultes	W	X		
Eleocharis melanocarpa Torr.	CP	X	X	G4 / S2
Eleocharis robbinsii Oakes	CP	X	X	G4G5 / S1
Eleocharis smallii Britt.	N	X		
Eleocharis tenuis (Willd.) J.A. Schultes	W			
Eriophorum virginicum L.	N	X		
Fimbristylis autumnalis (L.) Roemer & J.A. Schultes	W	X		
Rhynchospora capitellata (Michx.) Vahl	W	X		
Rhynchospora gracilenta Gray	CP	X	X	
Scirpus cyperinus (L.) Kunth	W	X		
Scirpus subterminalis Torr.	N	X	X	G4G5 / S1S2
Scirpus torreyi Olney	N	X	X	G5? / S1
Scleria muehlenbergii Steud.	SE		X	
ERIOCAULACEAE				
Eriocaulon aquaticum (Hill) Druce	N	X	X	G5 / S1
HAEMODORACEAE				
Lachnanthes caroliana (Lam.) Dandy	CP	X	X	G4 / SH
IRIDACEAE				
Iris versicolor L.	N			
Iris virginica L.	W			
JUNCACEAE				
Juncus acuminatus Michx.	W	X		
Juncus brachycephalus (Engelm.) Buch.	N		X	G5 / S2
Juncus canadensis J. Gay *ex* Laharpe	W	X		
Juncus debilis Gray	CP	X	X	
Juncus dichotomus Ell.	SE	X		
Juncus effusus L.	W	X		
Juncus scirpoides Lam.	SE	X		
Juncus tenuis Willd.	W	X		

Taxon	Distributional Status	Pond Taxa	Outlier	Rarity Status
LEMNACEAE				
Lemna sp.	U	X		
LILIACEAE				
Aletris farinosa L.	W			
Amianthium muscitoxicum (Walt.) Gray	W			
Chamaelirium luteum (L.) Gray	SE			
Clintonia umbellulata (Michx.) Morong	A			
Helonias bullata L.	CP/A		X	G3 /S2S3 / LT / LE
Lilium canadense ssp. *editorum* (Fern.) Wherry	A			
Lilium superbum L.	SE			
Maianthemum canadense Desf.	N			
Medeola virginiana L.	W			
Melanthium parviflorum (Michx.) S. Wats.	A			
Uvularia puberula Michx. var. *puberula*	A			
Uvularia sessilifolia L.	W			
ORCHIDACEAE				
Arethusa bulbosa L.	N	X	X	G4 / S1
Calopogon tuberosus (L.) B.S.P.	W	X		G5T? /S2
Malaxis unifolia Michx.	W	X		
Platanthera ciliaris (L.) Lindl.	W			
Platanthera clavellata (Michx.) Luer	W	X		
Platanthera lacera (Michx.) G. Don	W			
Pogonia ophioglossoides (L.) Ker-Gawl.	W	X		
POACEAE				
Agrostis perennans (Walt.) Tuckerman	W	X		
Andropogon virginicus L.	W	X		
Aristida dichotoma Michx.	W	X		
Brachyelytrum erectum (Schreb. ex Spreng.) Beauv.	W			
Calamagrostis coarctata (Torr.) Eat.	SE			
Cinna arundinacea L.	W			
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark	W	X		
Dichanthelium longiligulatum/spretum	U	X		
Dichanthelium sp.	U	X		
Digitaria filiformis (L.) Koel.	W	X		
Glyceria acutiflora Torr.	N	X		
Glyceria canadensis (Michx.) Trin.	N	X		
Glyceria melicaria (Michx.) F.T. Hubbard	A			
Glyceria obtusa (Muhl.) Trin.	CP	X	X	
Glyceria septentrionalis A.S. Hitchc.	W	X		
Glyceria striata (Lam.) A.S. Hitchc.	W			
Leersia oryzoides (L.) Sw.	W	X		
Panicum hemitomon J.A. Schultes	CP	X	X	G5? / S2
Panicum philadelphicum Bernh. *ex* Trin.	W	X		
Panicum rigidulum Bosc *ex* Nees var. *pubescens* (Vasey) Lelong	SE	X	X	
Panicum rigidulum Bosc *ex* Nees var. *rigidulum*	W	X		
Panicum verrucosum Muhl.	SE	X	X	

Taxon	Distributional Status	Pond Taxa	Outlier	Rarity Status
Panicum virgatum L. var. *virgatum* (incl. var. *cubense*)	W	X		
Paspalum laeve Michx.	SE	X		
Schizachyrium scoparium (Michx.) Nash	W	X		
Sorghastrum nutans (L.) Nash	W	X		
Torreyochloa pallida (Torr.) Church	N	X	X	
POTAMOGETONACEAE				
Potamogeton oakesianus J.W. Robbins	N	X	X	G4 / S2
Potamogeton sp.	U	X		
SMILACACEAE				
Smilax glauca Walt.	SE	X		
Smilax herbacea L.	W	X		
Smilax rotundifolia L.	W	X		
SPARGANIACEAE				
Sparganium eurycarpum Engelm. *ex* Gray	N		X	
Sparganium sp.	U			
XYRIDACEAE				
Xyris torta Sm.	W	X	X	
Dicotyledoneae				
ACERACEAE				
Acer rubrum L.	W	X		
APIACEAE				
Hydrocotyle americana L.	N			
Oxypolis rigidior (L.) Raf.	W			
APOCYNACEAE				
Apocynum cannabinum L.	W	X		
AQUIFOLIACEAE				
Ilex verticillata (L.) Gray	W	X		
ARALIACEAE				
Aralia nudicaulis L.	N			
ASCLEPIADACEAE				
Asclepias incarnata L.	W			
ASTERACEAE				
Aster acuminatus Michx.	N			
Aster dumosus L.	W	X		
Aster umbellatus P. Mill.	N			
Bidens cernua L.	W	X		
Bidens discoidea (Torr. & Gray) Britt.	W	X	X	
Bidens frondosa L.	W	X		
Boltonia asteroides (L.) L. Her. var. *asteroides*	CP	X	X	
Erechtites hieraciifolia (L.) Raf. *ex* DC.	W	X		
Eupatorium fistulosum Barratt	W			
Eupatorium pilosum Walt.	SE	X		
Eupatorium rotundifolium var. *ovatum*	SE	X		
Euthamia tenuifolia (Pursh) Nutt. var. *tenuifolia*	CP	X	X	
Helenium autumnale L.	W			
Helenium virginicum Blake	E	X		G2 /S2 / LT / LE
Rudbeckia fulgida var. *spathulata* (Michx.) Perdue	SE			
Senecio aureus L.	W			

Taxon	Distributional Status	Pond Taxa	Outlier	Rarity Status
BALSAMINACEAE				
Impatiens capensis Meerb.	W			
BETULACEAE				
Alnus serrulata (Ait.)Willd.	W			
Betula lenta L.	A			
BORAGINACEAE				
Myosotis laxa Lehm.	W			
BRASSICACEAE				
Cardamine bulbosa (Schreb. *ex* Muhl.) B.S.P.	W			
CABOMBACEAE				
Brasenia schreberi J.F. Gmel.	W	X		
CAMPANULACEAE				
Campanula aparinoides Pursh	W			
Lobelia cardinalis L.	W	X		
Lobelia siphilitica L.	W			
CAPRIFOLIACEAE				
Lonicera japonica Thunb.	EX			
Viburnum dentatum L.	W	X		
Viburnum nudum L. var. *cassinioides* (L.) Torr. & Gray	N			
Viburnum nudum L. var. *nudum*	SE		X	
CLUSIACEAE				
Hypericum boreale (Britt.) Bickn.	N	X		G5 / S2
Hypericum canadense L.	W			
Hypericum densiflorum Pursh	SE	X		
Hypericum gentianoides (L.) B.S.P.	W	X		
Hypericum gymnanthum Engelm. & Gray	SE	X	X	
Hypericum punctatum Lam.	W	X		
Triadenum virginicum (L.) Raf.	W	X	X	
Triadenum walteri (J.G. Gmel.) Gleason	SE	X	X	
CORNACEAE				
Cornus amomum P. Mill.	W	X		
CUSCUTACEAE				
Cuscuta compacta Juss. *ex* Choisy	W	X	X	
Cuscuta gronovii Willd. *ex* J.A. Schultes	W			
Cuscuta pentagona Engelm. var. *pentagona*	W	X		
Cuscuta polygonorum Engelm.	W	X	X	G5 / S2?
DROSERACEAE				
Drosera rotundifolia L.	N	X		
EBENACEAE				
Diospyros virginiana L.	SE	X		
ERICACEAE				
Gaultheria procumbens L.	N			
Gaylussacia baccata (Wangenh.) K. Koch	W	X		
Gaylussacia dumosa Torr. & Gray var. *bigeloviana* Fern.	CP	X	X	
Gaylussacia frondosa (L.) Torr. & Gray *ex* Torr.	CP		X	
Kalmia latifolia L.	W	X		
Lyonia ligustrina (L.) DC. var. *ligustrina*	SE	X		
Menziesia pilosa (Michx. *ex* Lam.) Juss. *ex* Pers.	A			

Taxon	Distributional Status	Pond Taxa	Outlier	Rarity Status
Rhododendron catawbiense Michx.	A			
Rhododendron periclymenoides (Michx.) Shinners	SE			
Rhododendron viscosum (L.) Torr.	SE			
Vaccinium corymbosum L.	W	X		
Vaccinium fuscatum Ait.	SE		X	
Vaccinium macrocarpon Ait.	N	X	X	G4 / S2
FABACEAE				
Apios americana Medik.	W			
Baptisia tinctoria (L.) R.Br. *ex* Ait. f.	W	X		
FAGACEAE				
Quercus alba L.	W			
Quercus palustris Muenchh.	MW	X		
GENTIANACEAE				
Bartonia paniculata (Michx.) Muhl.	SE	X	X	
Bartonia virginica (L.) B.S.P.	W	X		
Sabatia campanulata (L.) Torr.	SE	X	X	G5 / S2
HALORAGACEAE				
Proserpinaca palustris L.	W	X		
HAMAMELIDACEAE				
Hamamelis virginiana L.	W			
LAMIACEAE				
Lycopus sp.	U	X		
Mentha X *piperita* L	EX			
Mentha spicata L.	EX			
Pycnanthemum muticum (Michx.) Pers.	W			
Scutellaria integrifolia L.	SE	X		
Stachys hyssopifolia Michx.	CP	X	X	
Trichostema dichotomum L.	W	X		
LAURACEAE				
Lindera benzoin (L.) Blume	W			
LENTIBULARIACEAE				
Utricularia fibrosa Walt.	CP	X	X	G4G5 / S1
Utricularia geminiscapa Benj.	N	X	X	
Utricularia gibba L.	W	X		
Utricularia radiata Small	CP	X	X	
Utricularia subulata L.	SE	X	X	
Utricularia sp.	U	X		
LINACEAE				
Linum virginianum L.	W			
LYTHRACEAE				
Decodon verticillatus (L.) Ell.	W	X	X	
Rotala ramosior (L.) Koehne	W	X		
MAGNOLIACEAE				
Liriodendron tulipifera L.	W	X		
Magnolia acuminata (L.) L.	SE			
Magnolia virginiana L.	CP		X	
MALVACEAE				
Hibiscus moscheutos L. ssp. *moscheutos*	W	X		
MELASTOMATACEAE				
Rhexia mariana L. var. *mariana*	SE	X	X	

Taxon	Distributional Status	Pond Taxa	Outlier	Rarity Status
Rhexia virginica L.	W	X		
NYSSACEAE				
Nyssa sylvatica Marsh.	W	X		
NYMPHAEACEAE				
Nuphar lutea (L.) Sm. ssp. *advena* (Ait.) Kartesz & Gandhi	W	X		
OLEACEAE				
Chionanthus virginicus L.	SE			
ONAGRACEAE				
Ludwigia palustris (L.) Ell.	W	X		
Oenothera fruticosa L.	W			
POLYGALACEAE				
Polygala cruciata L.	W		X	
Polygala nuttallii Torr. & Gray	CP			
Polygala sanguinea L.	W			
POLYGONACEAE				
Polygonum hydropiper L.	EX	X		
Polygonum hydropiperoides Michx.	W	X		
Polygonum punctatum Ell.	W			
Polygonum sagittatum L.	W			
PRIMULACEAE				
Lysimachia ciliata L.	W	X		
Lysimachia hybrida Michx.	W	X		G5 / S2
Lysimachia quadriflora Sims	MW			G5? / S1
Lysimachia quadrifolia L.	W	X		
Lysimachia radicans Hook.	CP	X	X	G4G5 / SH
Lysimachia terrestris (L.) B.S.P.	N	X		
Trientalis borealis Raf. ssp. *borealis*	N			
RANUNCULACEAE				
Aconitum uncinatum L.	SE			
Caltha palustris L. var. *palustris*	N			
Ranunculus hispidus var. *caricetorum* (Greene) T. Duncan	N			
Thalictrum pubescens Pursh	W			
Trautvetteria caroliniensis (Walt.) Vail var. *caroliniensis*	SE			
ROSACEAE				
Amelanchier sp.	U			
Aronia arbutifolia (L.) Pers.	W	X		
Aronia melanocarpa (Michx.) Ell.	W			
Filipendula rubra (Hill) B.L. Robins.	MW			G4G5 / S2
Physocarpus opulifolius (L.) Maxim	N			
Rosa palustris Marsh.	W	X		
Rubus allegheniensis Porter	N			
Rubus hispidus L.	N			
Spiraea tomentosa L.	W	X		
RUBIACEAE				
Cephalanthus occidentalis L.	W	X		
Diodia teres Walt.	W	X		
Galium asprellum Michx.	N			

Taxon	Distributional Status	Pond Taxa	Outlier	Rarity Status
Galium tinctorium (L.) Scop.	W	X		
Galium sp.	U	X		
Mitchella repens L.	W			
SALICACEAE				
Salix humilis var. *tristis* (Ait.) Griggs	W	X		
SAXIFRAGACEAE				
Parnassia asarifolia Vent.	SE			
Parnassia grandifolia DC.	SE			G3G4 / S2
Saxifraga pensylvanica L.	N			
SCROPHULARIACEAE				
Agalinis purpurea (L.) Pennell	W			
Agalinis sp.	U			
Chelone glabra L.	W			
Mimulus ringens L.	W			
Pedicularis lanceolata Michx.	MW			
Veronica scutellata L.	N			G5 / S1
VIOLACEAE				
Viola cucullata Ait.	N			
Viola lanceolata L. ssp. *lanceolata*	N	X	X	
Viola primulifolia L.	SE	X		
VISCACEAE				
Phoradendron leucarpum (Raf.) Reveal & M.C. Johnston	SE	X		
VITACEAE				
Parthenocissus quinquefolia (L.) Planch. var. *quinquefolia*	W	X		