VASCULAR FLORA OF THE 
UPPER ETOWAH RIVER WATERSHED, GEORGIA

by

LISA MARIE KRUSE

(Under the Direction of DAVID E. GIANNASI)

ABSTRACT

The Etowah River Basin in North Georgia is a biologically diverse Southern Appalachian River system, threatened by regional population growth. This is a two-part botanical study in the Upper Etowah watershed. The primary component is a survey of vascular flora. Habitats include riparian zones, lowland forest, tributary drainages, bluffs, and uplands. A total of 662 taxa were inventoried, and seventeen reference communities were described and mapped. Small streams, remote public land, and forested private land are important for plant conservation in this watershed. In the second component, cumulative plant species richness was sampled across six floodplain sites to estimate optimal widths for riparian buffer zones. To include 90% of floodplain species in a buffer, 60-75% of the floodplain width must be protected, depending on the stream size. Soil moisture influences species richness, and is dependent on upland water sources. An optimal buffer would protect hydrologic connections between floodplains and uplands.

INDEX WORDS: Etowah River, Southeastern United States, floristic inventory, riparian buffer zone, floodplain plant species, plant habitat conservation
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LISA MARIE KRUSE

Major Professor:  David Giannasi
Committee:  Jim Affolter
             Rebecca Sharitz

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
December 2003
DEDICATION

I dedicate this thesis to those that have inspired and sustained me:

The plants of Georgia, in their intricacies and beauty

My family

My husband Scott

With love
ACKNOWLEDGEMENTS

Without the help of others, I could never have completed this work.

I would like to gratefully acknowledge my major advisor, Dr. Giannasi, for his strong support throughout and for granting me the time needed to complete these studies. My committee has been essential: Dr. Rebecca Sharitz provided extensive advice on the second chapter of this work, and Dr. Jim Affolter has been a strong link for me to the Georgia Plant Conservation Alliance, which provided incentive for me to design this particular study.

Tom Patrick, State Botanist for the Georgia Natural Heritage Program, has been an inspiration to me. He has generously given his time for field trips to the survey area, plant identification, and general advice; I have benefited greatly from his extensive knowledge.

At the University of Georgia, Dr. Chris Peterson of the Plant Biology Department has assisted graciously with equipment loans, software availability, and suggestions for data analysis. Dr. Lynne Seymour of the statistics department has advised me on regression analysis for the second chapter. The Department of Statistics Consulting Office has provided an excellent report on the initial analysis of the second chapter data: thanks are due to Jin-Hong Park, Jan Vollmer, and Dr. Jaxk Reeves.

Managers of the Dawson Forest have made this project flow smoothly by providing information and access; I would especially like to acknowledge Nathan McClure of the Georgia Forestry Commission and Kent Kammermeyer of the Department of Natural Resources.

The Garden Club of America, The Garden Club of Georgia, and The Georgia Museum of Natural History are dedicated to botanical field work and plant conservation, and have provided funding that made this study possible. The Plant Biology Department has also generously given financial support for my work.

I cannot close without thanking the multitude of individuals in the University of Georgia community who have given me direction, hope, and happiness throughout my time here. Thanks to all!
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The native ecosystems of the Southeast currently face a fundamental irony. As for many other regions, the Southeast has undergone a long history of resource abuse. Principally, it has been in the form of wanton agricultural practices and timber harvest that lasted roughly 200 years after European colonization (Martin and Boyce 1993). This resulted, for example, in decimation of the original forests of the southern Piedmont (Braun 1950). Yet, particular facets of the Southeastern economy have allowed areas of important biodiversity to recover and persist. European colonization patterns resulted in a regional economy that was dependent on agriculture; three cycles of agricultural depression resulting from war, insect damage, and erosion entrenched much of the Southeast in poverty, and thus relaxed development pressure in the region (Brender 1974, Martin and Boyce 1993). This led to substantial periodic re-growth of Southeastern forests (Brender 1974), but simultaneously engendered a strong political will to encourage industry growth by whatever means possible. New development has focused on conversion of forested and agricultural land to water impoundments, highways, and subdivisions that tend to reduce habitat diversity for animals and plants (Martin and Boyce 1993).

These two historical forces—one which has allowed the quiet survival of localized Southeastern ecosystems, the other which would rapidly degrade them—are now in conflict. Contemporary species inventories have demonstrated centers of floral endemism throughout the Southeast, including the Southern Appalachians, Atlantic Coastal Plain, and the Appalachee River Basin (Estil 2000). More recent is the evolving awareness of southeastern river systems, especially those of the Southern Appalachians, as world-ranking hotspots for aquatic faunal diversity (Burkhead et al. 1997, Estil 2000). Yet, the recent boom of the southern business economy has brought people and development to the region at unprecedented rates. Because of the ancient nature of Southeastern landscapes (Pittillo et al. 1998) they lack wide expanses of rugged, inaccessible terrain (Martin and Boyce 1993). Thus protected areas in the Southeast tend to be relatively small (Franklin 1993), and exist in a matrix of privately owned lands.
Therefore, with the ongoing description of Southeastern biodiversity, is its concomitant destruction by urbanization. A prime example of a landscape facing such a crossroads is the Etowah River Basin. A part of the headwaters of the Mobile River drainage, the Etowah flows south from the boundary of the Blue Ridge, then in a westerly direction across the Georgia Piedmont into the Ridge and Valley province (Burkhead et al. 1997), where it meets the Oostanaula River to form the Coosa (Fig. 1.1). Recent work has established the high diversity of aquatic fauna of the Etowah Basin (Burkhead et al. 1997, Freeman and Wenger 2000). Four species of fish are endemic to the Basin, including two species that have yet to be described (Burkhead et al. 1997).

Although regional variation exists in urbanization rates, it is proceeding dramatically in the Etowah River watershed. This is by virtue of its proximity to the North Atlanta Metro region. Atlanta’s sprawling growth has been quantified by the United States Census of 2000. The Atlanta Metropolitan Statistical Area, defined by urban population size and commuting patterns, increased from 20 to 28 counties between 1990 and 2000 (U.S. Census Bureau 2003). Eight of these counties include some part of the Etowah Basin. Damage to the aquatic ecosystem has already been confirmed; Burkhead et al. (1997) estimated that there are more imperiled species of aquatic fauna in the Etowah River than in any other Southeastern river of comparable size. Causes of this imperilment are, in general, attributed to habitat loss and fragmentation throughout the Coosa River system (Burkhead et al. 1997). The status of the flora of the Etowah Basin is not as well-understood; important centers for floral diversity in the watershed have not yet been established (T. Patrick, pers. com.).

Despite rapid development, there is opportunity to apply conservation science and land use planning in the Etowah Watershed. A survey of 1,809 watershed residents showed an awareness of the relationship of development to the declining quality of the river, apprehensiveness about drinking water quality, and a desire to preserve greenspace and aquatic biodiversity (A.L. Burruss Institute 2003). County governments of the watershed are responding to these grassroots demands, as well as to requirements of the Endangered Species Act, in an effort to create a more sustainable, multi-county
development plan (Etowah Regional Aquatic Habitat Conservation Plan 2003). Concurrently, scientists of the University of Georgia Institute of Ecology are developing a prioritization system for selecting tracts of land for conservation and restoration (B. Freeman and S. Wenger, pers. com.). Fundamental to this process is the ongoing inventory of biological data and physical conditions in the Etowah Basin (Burkhead et al 1997).

Thus, this Masters thesis represents a portion of the efforts to document and publicize the biodiversity of the Etowah Basin. Society’s ultimate reliance on this biodiversity is as yet unknown. Since great rewards, both economic and aesthetic, have already been reaped from this watershed, possible future uses cannot be underestimated nor fully imagined. This botanical survey provides important data that must be compiled for wise planning of land-use allocation as the watershed develops, to provide long-term protection for Georgia’s floral and faunal heritage.
CHAPTER 1: FLORISTIC INVENTORY OF RIVER CORRIDORS IN THE

UPPER ETOWAH RIVER WATERSHED

Introduction

The Upper Etowah River Watershed

The main stem of the Upper Etowah River is approximately 70 river miles in length, with a drainage area of 1,588 km$^2$ (987 square miles). Its headwaters are within the Chattahoochee National Forest of Lumpkin County, Georgia (elevation 2590 ft.), and flow south off of the Tennessee Valley Divide that is formed by the southern boundary of the Blue Ridge. After leaving National Forest, the river continues towards the southwest into the Piedmont Uplands, which are mainly private agricultural land. In southwest Dawson County, it is joined by the Amicalola River, a major tributary flowing off of the Blue Ridge, at which point the Upper Etowah becomes a sixth-order river. It remains so until it ends at Lake Allatoona, a large reservoir, from which flows the lower section of the Etowah (Fig 1.1).

Within the Upper Etowah watershed three areas were prioritized for floristic inventory: the headwaters in the Chattahoochee National Forest, selected public and private forested land along the main channel, and the Dawson Forest Wildlife Management Areas surrounding the Amicalola River (Fig. 1.2). These river reaches were chosen for the following reasons:

1. All are within Dawson and Lumpkin Counties. These counties are of high priority for inventory, as they are under-represented in collections of the University of Georgia Herbarium (D. Giannasi, pers. com.).

2. They are high priority reaches for conservation and restoration of aquatic habitat, as determined by Freeman and Wenger (2000). Each has populations of endemic fish species and high aquatic habitat quality indices, such as low road crossing density and few point sources of pollution. The
endemic species associated with the study area are the Etowah darter (*Etheostoma etowahae*), known from the Etowah headwaters and the mainstem in Dawson Forest; an undescribed darter species (*E. sp. cf. E. brevirostrum*), known only from the headwaters to just downstream of Campbell Mountain in Lumpkin County; and a second undescribed darter known only in the Amicalola, from its headwaters to State Hwy. 53 in Dawson County (Freeman and Wenger 2000). Vegetation data associated with these reaches will give additional factors by which to further select land for conservation.

3. Each has large tracts of forested land. Special interest habitats and species are most probably located in relatively intact areas. Finding such sites is an important goal of the Georgia Department of Natural Resources, which is also in need of inventory of State-owned lands (T. Patrick, pers. com.). Private land is included in the survey, but is exceptional as most private land is difficult to access and is generally homogenized by intensive agriculture.

*Influences on the Upper Etowah vegetation: Evolutionary history*

As products of the ancient Appalachian mountain chain, which was at its peak height between 325 and 250 million years ago (Ma) (Pittillo et al. 1998), the southern Blue Ridge and the Piedmont both have a long vegetation history. The plant species composition of the Southeastern highlands has evolved since the inception of the angiosperms (approximately 120 Ma) without major geologic disturbances (Cain 1943). This, in combination with historic climatic cycles, has resulted in high species diversity (Martin and Boyce 1993), which is now maintained throughout the region because of variation in elevation, topographic relief, geology, and microclimate (Martin and Boyce 1993).
Figure 1.2 Location and names of study sites along the Etowah and Amicalola Rivers in Dawson and Lumpkin Counties. DF WMA= Dawson Forest Wildlife Management Area.
In the Blue Ridge, two aspects of the modern vegetation are often cited as important evidence for the ancient nature of the flora. First, many of the extant genera now have disjunct distributions in southeastern Asia and southeastern North America, with fossil records indicating they were once widespread (Little 1970, Pittillo et al. 1998). Nine of these are tree genera (Little 1970), seven of which are present in the Upper Etowah study area (Carya, Chionanthus, Halesia, Hamamelis, Liriodendron, Sassafras, and Stewartia). Such genera were established in the region by the early Tertiary period (60 Ma), when the lowlands were occupied by warm temperate and humid-subtropical floras, and many are tropical in their modern distributions (Braun 1950, Cain 1943).

Second, the past 40,000 years have been dominated by periods of glaciation, during which trees of typically northern distributions migrated to the Southern Appalachians (Delcourt and Delcourt 1981). High elevation areas have enabled some of these species, such as Picea rubens and Abies fraseri, to persist during the modern inter-glacial period (Pittillo et al. 1998) although these do not enter into the Upper Etowah watershed. It is hypothesized that during glacial periods, the more tropical species persisted by southward migration (Pittillo et al. 1998) and in lowlands of major river valleys of the southeast (Delcourt and Delcourt 1981). During the peak of the most recent glaciation (the Late Wisconsinan Continental Glaciation; 18,000 yr. B.P.), the southern Blue Ridge was likely in northern hardwood-conifer forest, and the Georgia Piedmont in a mixed forest of oak, hickory, and southern pines (Delcourt and Delcourt 1981).

As the Upper Etowah flows along the transition zone from the southern Blue Ridge to the Piedmont Uplands, flora from both regions are likely to be present. Species known to be specific to southeastern mountain environments are well-documented, such as those of mixed-mesophytic cove forests and high elevation ridgetops (Braun 1950, Wharton 1978). Location of sites rich in mountain species will be an important result of this study, as they likely represent sheltered habitats that have maintained high levels of native species diversity. Analysis of the flora for Piedmont specific species is more difficult. This is due to the fragmented nature of the modern Piedmont flora (Wharton 1978). Only localized patches of reference plant communities remain, resulting in a description of Piedmont
environments that is based on variable lists with a few key species, rather than overarching patterns (as exemplified in Wharton 1978). Also, the Georgia Piedmont flora overlaps greatly with that of the Georgia Mountains; Wharton (1978) estimates that there are only 15 taxa which may be restricted to the Piedmont in Georgia, while there are about 150 species unique to the Mountains.

Currently, documentation of the Upper Etowah flora is not sufficient to know how much of the composition is represented by species specific to the Mountains, or to the Georgia Piedmont. Inventories of disparate areas have been performed (e.g. Tatum et al. 1998, WRD 2003), but have not addressed this question.

**Influences on the Upper Etowah vegetation: Soils**

Between the Southern Blue Ridge and the Georgia Piedmont, the soils are distinctly different. Wharton (1978) classifies the soils of the highest ridges in Dawson and Lumpkin Counties as the Edneyville-Porters-Ashe Association, and lower slopes in the Hayesville-Fannin-Edneyville Association or the Tallapoosa-Musella Association. These soils tend to be loam or fine sandy loam at the surface, with clay loam subsoils (USDA 1972). In contrast, typical Piedmont soils are shallow sandy-loams at the surface with deep, red clay or clay-loam subsoils; these are the Cecil, Madison, and Lloyd soil series (Wharton 1978). However, one trait soils of both regions have in common is that they are generally acidic with low fertility (USDA 1972, Wharton 1978).

Soils of the survey area are characteristic of the Georgia Blue Ridge soils, rather than those of the Piedmont. Generally, the slope and ridgetop soils belong to the Tallapoosa-Musella Association (USDA 1972), except on the highest slopes in the survey area where the Edneyville-Porters-Ashe Association is dominant (USDA 1972). The most frequently occurring soil series are the Tallapoosa, Hayesville, and Tusquitee series (Table 1). All are strongly acid. Tallapoosa and Hayesville soils have gneiss, schists or quartzites as parent materials (USDA 1972), which tend to be rich in alluminum and sillica (Wharton 1978). Tusquitee loam, however, is colluvial in origin, and occurs at toe-slopes or on river floodplains (USDA 1972).
Stream floodplains along the study sites have soils of the Cartecay-Toccoa-Congaree association (USDA 1972), which is more typical of Mountain rivers than those of the Piedmont (Wharton 1978). On small streams, Cartecay and Toccoa soils are most common (USDA 1972). On study sites along main river channels, Buncombe soils are occasionally found. This soil has high sand content and very low water holding capacity (USDA 1972). Other alluvial soil series in the study area are Congaree, Starr, and Masada soils (Table 1). Small tributaries and stream origins in the study area are often within flat ravines encircled by steep slopes; soils of these tributaries are generally colluvial and of the Hiwasee or Starr series (Table 1).

*Influences on the Upper Etowah vegetation: Modern climate*

In general, Lumpkin and Dawson counties have a climate of mild summers, cold winters and relatively constant year-round precipitation (USDA 1972). Maximum summer temperatures exceed 95°F fewer than one out of three days; in the winter, minimum temperatures below 0°F are rare (USDA 1972). The variation in elevation and topography, however, causes notable local variation in temperature and precipitation across the study area. For example, in southern Dawson County, the temperature falls below freezing about 65 days each winter, while in higher elevation areas freezing temperatures occur for 100 or more days each year (USDA 1972).

Despite local variation, average monthly precipitation values for Dawsonville (Dawson Co.) in the Piedmont and for Dahlonega, (Lumpkin Co.) in the Blue Ridge, are similar (Fig. 1.3). Dahlonega receives slightly more rain; the yearly average from 1930-2002 for this city was 62.5 inches, while the yearly average for Dawsonville from 1948-2002 was 59.7 inches (SERCC 2003). Temperature in Dahlonega ranges from an average minimum of 30.1°F in January to an average maximum of 86.9°F in July (Fig. 1.3). Historical temperature data are not available for Dawsonville (SERCC 2003). Data from surrounding municipalities indicate that temperatures would follow the trend of Dahlonega, although slightly warmer (GAENM 2003, SERCC 2003).
Table 1.1 Characteristics of soils across the study area. Data from USDA 1972.

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Acidity</th>
<th>Fertility</th>
<th>Drainage</th>
<th>Parent Material</th>
<th>Surface Texture</th>
<th>Location</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartecay Complex</td>
<td>Med.</td>
<td>Low</td>
<td>Mod. Well</td>
<td>Alluvial</td>
<td>Loamy sand, silt loam</td>
<td>Narrow floodplains</td>
<td>AHT, EHF, FSR, HCT, RCR, WCT</td>
</tr>
<tr>
<td>Toccoa</td>
<td>Med.</td>
<td>Low</td>
<td>Well</td>
<td>Alluvial</td>
<td>Loamy sand, loam</td>
<td>Stream floodplain</td>
<td>AHT, CW, EHF, PLT, RAM, RRT</td>
</tr>
<tr>
<td>Buncombe Med. to Strong</td>
<td>Low</td>
<td>Excessively Well</td>
<td>Alluvial</td>
<td>Loamy sand</td>
<td>River floodplain</td>
<td>AFT, EA, HCT, PLT, RCR</td>
<td></td>
</tr>
<tr>
<td>Masada, Eroded Strong</td>
<td>Strong</td>
<td>Low</td>
<td>Well</td>
<td>Alluvial</td>
<td>Fine sandy loam</td>
<td>Stream terraces</td>
<td>PLT, RCR</td>
</tr>
<tr>
<td>Congaree and Starr Med. to Strong</td>
<td>Low/Med.</td>
<td>Well</td>
<td>Alluvial</td>
<td>Silt loam</td>
<td>Floodplain</td>
<td>AFT, WCT</td>
<td></td>
</tr>
<tr>
<td>Edneyville and Porters Strong</td>
<td>Low</td>
<td>Well</td>
<td>Gneiss, Schist (Biotite)</td>
<td>Loam, clay-loam</td>
<td>High ridgetops</td>
<td>AFT, CMT, EHF, CMT</td>
<td></td>
</tr>
<tr>
<td>Ashe and Edneyville Strong to V. Strong</td>
<td>Low</td>
<td>Excessively Well</td>
<td>Gneiss, Schist (Biotite)</td>
<td>Fine sandy loam</td>
<td>Steep slopes</td>
<td>AHT</td>
<td></td>
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<tr>
<td>Starr Strong</td>
<td>Low/Med.</td>
<td>Well</td>
<td>Alluvial/ Colluvial</td>
<td>Fine sandy loam</td>
<td>Stream terraces, depressions</td>
<td>EHF</td>
<td></td>
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<tr>
<td>Wickham Strong</td>
<td>Low</td>
<td>Well</td>
<td>Gneiss, Schist, Granite</td>
<td>Fine sandy loam</td>
<td>Uplands, toeslopes</td>
<td>EHF, WCT</td>
<td></td>
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<tr>
<td>Hiwassee Strong</td>
<td>Low/Med.</td>
<td>Well</td>
<td>Alluvial/ Colluvial</td>
<td>Loam, clay-loam</td>
<td>Stream terraces, drainage heads</td>
<td>AFT, EHF</td>
<td></td>
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<tr>
<td>Tallapoosa Strong to V. Strong</td>
<td>Low</td>
<td>Well to Excessively Well</td>
<td>Gneiss, Schist, Quartzite</td>
<td>Sandy loam, loam</td>
<td>Slopes</td>
<td>AFT, CMT, CW, DCS, ERR, HCT, PLT, RAM, RCR, RRT</td>
<td></td>
</tr>
</tbody>
</table>
Table 1.1 continued. Characteristics of soils across the study area. Data from USDA 1972.

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Acidity</th>
<th>Fertility</th>
<th>Drainage</th>
<th>Parent Material</th>
<th>Surface Texture</th>
<th>Location</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tusquitee</td>
<td>Strong</td>
<td>Low/Med.</td>
<td>Well</td>
<td>Colluvial: Gneiss, Schist, Granite</td>
<td>Loam, stony-loam</td>
<td>Slope bases, floodplains, mtn. coves</td>
<td>AHT, CW, ERR, FSR, WCT</td>
</tr>
<tr>
<td>Hayesville</td>
<td>Strong</td>
<td>Low</td>
<td>Well</td>
<td>Gneiss</td>
<td>Sandy loam, clay-loam</td>
<td>Slopes, ridgetops</td>
<td>AHT, CMT, DCS, ERR, FSR, HCT, RCR, WCT, RRT</td>
</tr>
<tr>
<td>Rabun</td>
<td>Med. to Strong</td>
<td>Low/Med.</td>
<td>Well</td>
<td>Gneiss, Schist, Diorite</td>
<td>Loam</td>
<td>Slopes, ridgetops</td>
<td>RRT</td>
</tr>
<tr>
<td>Musella</td>
<td>Strong</td>
<td>Low</td>
<td>Well</td>
<td>Gneiss, Schist,</td>
<td>Cobbly Loam</td>
<td>Uplands</td>
<td>RRT</td>
</tr>
<tr>
<td>Fannin</td>
<td>Strong</td>
<td>Low</td>
<td>Well</td>
<td>Gneiss, Schist (Mica)</td>
<td>Fine sandy loam</td>
<td>Gentle slopes, ridgetops</td>
<td>AFT, PLT, RAM</td>
</tr>
</tbody>
</table>
During the survey period, Georgia was in a period of prolonged drought, a trend that had begun in the late 1990’s. Rainfall deficit, relative to the normal average for 1961-1990, ranged between 4 and 18 inches for the study area (GAENM 2003), and temperatures tended to reach higher maximums than normal (Table 1.2).

Table 1.2 Precipitation and temperature anomalies over the time period of the survey, based on deviations from the normal average calculated for 1961-1990. Deviations from normal encompass the approximate range for the survey area as a whole. Most notable are the negative quantities of precipitation. Data were obtained from maps published online by the Georgia Automated Environmental Monitoring Network (2003).

<table>
<thead>
<tr>
<th>Years</th>
<th>Normal Average</th>
<th>1961-1990</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total precipitation (in.)</td>
<td>58.0</td>
<td>-18.0</td>
<td>-8.5</td>
<td>-4.0</td>
<td>-7.0</td>
</tr>
<tr>
<td>Mean yearly max temp. (°F)</td>
<td>68.0 to 69.0</td>
<td>0 to +.8</td>
<td>+.4</td>
<td>+1.2</td>
<td>+1.6</td>
</tr>
<tr>
<td>Mean yearly min temp. (°F)</td>
<td>46.5</td>
<td>-1.0 to -2.0</td>
<td>0</td>
<td>+1.0</td>
<td></td>
</tr>
</tbody>
</table>

Influences on the Upper Etowah vegetation: Land use history

Contrary to popular belief, it has been well-established that aboriginal peoples of the Southeastern United States caused significant, large-scale impacts on the land (Brender 1974, Denevan 1992, Doolittle 1992). Solid archeological evidence exists for human culture in the region 12,000 years ago (Delacourt and Delcourt 1993). Pre-colonial cultures influenced the vegetation in multiple ways—by the
introduction of new species, especially maize, for agriculture; by selection of preferential species as food and timber sources; and by burning forests to maintain open land for hunting and agriculture (Doolittle 1992, Delcourt and Delcourt 1993). At the time of the arrival of the Spanish in the 16th century, Native American culture in the Southeastern United States was at its peak, such that there were centralized, agricultural communities surrounding powerful, competitive chiefdoms (Delcourt and Delcourt 1993). This is known as the Mississippian Period (Delcourt and Delcourt 1993). Land development in this period followed major river corridors through the landscape, as this land had the richest and most tillable soils for agriculture (Brender 1974, Delcourt and Delcourt 1993). Remains of a socially complex Mississippian settlement exist at the Etowah Indian Mounds, a large archeological site downstream from the Allatoona Reservoir (Burkhead et al. 1997, Delcourt and Delcourt 1993).

With an estimated 3.8 million North American inhabitants at the time of initial European exploration, population density was such that Old World diseases introduced by cross-cultural meetings rapidly reached epidemic status (Denevan 1992). Estimates of aboriginal population decrease due to disease range from 80% for the Central Mississippi Valley (Delcourt and Delcourt 1993), to 92% for North America as a whole (Denevan 1992). Afterwards, as European migration was initially slow, the Southeastern landscape entered into nearly 200 years of forest regeneration in the absence of wide-spread human manipulation (Delcourt and Delcourt 1997, Denevan 1992). Yet, by the early 1700’s, European impacts were accelerating (Martin and Boyce 1993). Initial disturbances of the flora and fauna were for slash-and-burn style agriculture, livestock grazing, hunting, and for trade in novel New-World species (Martin and Boyce 1993). During expansion of the British colonies, agriculture and timber harvest became the dominant industries of the South and remained so after formation of the United States. The effects of opportunistic resource use and increasingly efficient extraction technologies, exacerbated by lack of understanding of finite resources, were such that by 1920 millions of hectares of forest had been cleared, even in wetlands and moutainous terrain (Martin and Boyce 1993). Erosion of all orginal topsoil had occurred on 47% of uplands in the southern Piedmont (Brender 1974). An additional consequence of American economic development was a dramatic increase in the rate of exotic species introductions.
(Martin and Boyce 1993). In the Eastern United States, one of the most destructive was the importation of the Chestnut Blight fungus, *Endothia parasitica*, from China to New York in 1904 (Keever 1953). American Chestnut, which once comprised over 40% of Appalachian forests (Keever 1953), had no natural immunity from the fungus and was eliminated from the entire Eastern forest canopy (Braun 1950).

Economic stagnation in the Southeast in the early 1900’s, combined with a growing awareness of declining Southeastern biota, incited a philosophical shift towards “resource cultivation,” in which resource stability is a primary goal (Martin and Boyce 1993). During the 1930’s the practice of long-term land management developed, concurrent with the science of ecology (Martin and Boyce 1993). In addition, the eroded soils of the Southeast were often too poor for productive row cropping, and pine plantations became a dominant industry (Brender 1974, Martin and Boyce 1993). Both trends contributed to regeneration of forest in the region, initiated on abandoned farmlands. The most dramatic increase in forest cover occurred after World War II; from 1950 to 1960 land area in timberlands rose by about 2 million ha (Martin and Boyce 1993).

In the 1960’s, land conversion to urban uses began to rise. Nearly 6 million hectares of Southeastern forest were lost to urbanization between 1960 and 1990 (Martin and Boyce 1993). Due to the rapidity and randomness of its spread, urbanization has become a serious threat to Southeastern ecosystems (Burkhead et al. 1997, Martin and Boyce 1993). Effects of urbanization include increase in ambient temperature, habitat fragmentation, siltation and pollution of streams, increase of invasive exotic species, and loss of habitat for both aquatic and terrestrial animals (Burkhead et al. 1997).

Nonetheless, with overall changes in economy, some change in attitude towards land use has occurred. In a society which no longer depends directly on the land for survival, more emphasis has been placed on conservation of its natural character, both for future uses and for the sake of the land itself (Martin and Boyce 1993). For example, “Best Management Practices” (BMP’s) have been legislated through the Clean Water Act for the timber industry. These dictate cutting practices so as to protect stream quality and important wildlife habitat (USFS 1988). Such practices are often extended to areas of urban and residential development, as in the Georgia Erosion and Sedimentation Control Act (OCGA 12-
These components of modern society generate support for studies of the remaining biota, and may enable its long-term survival (Martin and Boyce 1993).

Influences on the Upper Etowah vegetation: Local land ownership and management

Sites within the study area of the Upper Etowah watershed have varied ownership histories, but all fall within four general categories: land of the Chattahoochee National Forest, Toccoa Ranger District; land of the Dawson Forest Wildlife Management Area, managed either by the Georgia Department of Natural Resources (DNR) or the Georgia Forestry Commission (GFC); and privately owned land.

The study sites along the Etowah headwaters downstream to Campbell Mountain fall within the Chattahoochee National Forest. Land of these sites was acquired by the Forest Service in the 1930’s; it was purchased either from timber companies such as the Roland Lumber Company, or from small farmers (D. Vaughters, USFS, pers. com.). The Forest Service conducts periodic timber harvests on this land, and manages areas along streams to protect stream water quality and aquatic habitat (D. Vaughters, USFS, pers. com.). Just south of the headwaters ravine, within the National Forest, is Army Ranger Camp Merrill. This is a 600 acre military base, which houses an Army Ranger Training Brigade. One-quarter mile of the Etowah river flows through the base, and the army also uses the contiguous National Forest for teaching mountaineering, patrolling, and ambush techniques (Camp Merrill Headquarters, pers. com.). The presence of the Army is strong along the Etowah headwaters; heavy trail use is evident in the forest, waste products of the residential base are stored in a local sewage lagoon, and the cacophony from helicopters and war-games is common.

All other public land of the survey area is within tracts of the Dawson Forest Wildlife Management Area. The southernmost tract is called the Atlanta tract, and its management history is separate from other Dawson Forest land. It was purchased by the Federal government from a Dawson County land-owner in 1956, as approximately 10,000 acres of old-field succession and small woodlots (McClure 2003). Previous uses were for small-scale farming, timber harvest, and livestock grazing (N. McClure, pers. com.). A military research laboratory was operated on the site until 1971, and currently
there are 3 acres with restricted access due to small quantities of residual radioactive contamination, which are continuously monitored (McClure 2003).

Upon decommissioning of the military facility, the City of Atlanta purchased this tract to reserve land for an anticipated second metropolitan airport, and contracted the GFC to manage the forest in 1975 (McClure 2003). Until this point the tract had suffered from overall lack of maintenance (McClure 2003). After several years of adjusting management strategies and of forest research, the Atlanta tract is now managed for low-intensity use. Management goals include soil and water conservation; timber harvest; wildlife enhancement; protection of riparian areas and steep slopes; and recreation, with horsetrails, hiking, and hunting (McClure 2003). Future use of the forest has yet to be specified. Alternative options to airport construction are under serious consideration, especially as the Atlanta tract has become established as a popular, forested recreation area (McClure 2003).

Other sections of the Dawson Forest are the Amicalola Tract (6,577 acres), Wildcat Creek Tract (4,856 acres), and Burnt Mountain Tract (2,609 acres). These tracts preserve forest within the Amicalola River watershed, from its headwater streams in the northwest corner of Dawson County nearly to its confluence with the Etowah. These areas were purchased by the DNR on separate occasions and are managed by the Wildlife Resources Division (WRD). Both the Wildcat Creek and Burnt Mountain tracts were purchased within the past decade.

Prior to state purchase, agriculture within these tracts was limited to small-scale farming and livestock grazing, due to their rugged physiography and thin rocky soils (WRD 2003). However, the majority of the acreage was extensively cleared for timber in the 1950’s (WRD 2003). The forest has been left to naturally regenerate, resulting mostly in pine-hardwood forest with stands of 40-50 years in age (WRD 2003).

Much of the land in these tracts is relatively inaccessible to the general public, has rugged terrain with few marked trails, and lies more distant from the Atlanta Metro region than the Atlanta Tract. These traits have allowed sections of these forests to remain more wild in character than the Atlanta Tract; most notable are parts of the Wildcat Creek and Burnt Mountain Tracts (WRD 2003). The Wildlife Resources
Division has recognized these qualities, and long-term management planning directs the maintenance of wildlife, healthy forest, and protection of non-game animals and plants over both timber harvest and recreation (WRD 2003). Current land management strategies allow timber harvest with the long-term goals of reducing acres of pine forest, maintaining wildlife openings without plantings of invasive exotics, and limiting recreation to lower-impact activities such as hiking, hunting, fishing, and boating (WRD 2003).

Finally, two sites of the study area are on private land. These are exceptional areas along the Etowah River mainstem, maintained in un-managed forest by their owner. Mr. George David, of Dawsonville, inherited partial ownership to these properties from his uncle, William Roscoe Tucker. Tucker was a land speculator and chairman of the Republican party in Georgia under President Eisenhower (G. David, pers. com.). He purchased the land during the early 1950’s, in hopes of gaining wealth from gold and timber (G. David, pers. com.).

In North Georgia near Dahlonega and Dawsonville, gold mining had significant impacts on the land. For example, earthen ditches up to 30 miles long were used to change the course of streams and wash gold from sill, and entire hillslopes were destroyed in search of gold (G. David, pers. com.). Some of these operations occurred along the Etowah, and on the land now owned by Mr. David. Since the mid 1960’s this land has remained undeveloped. Mr. David, although not the sole owner, is working to preserve this land in forest for perpetuity (G. David, pers. com.).

Materials and Methods

Reconnaissance of the Upper Etowah watershed, and some specimen collection, was carried out in the autumn and winter of 2000-2001. I selected 18 sites (Fig. 1.2), with a total area of 633 ha. In Dawson County, there are 12 sites comprising 465 ha, and the remaining sites in Lumpkin County total 138 ha (Table 1.3). Most sites are in the Chattahoochee National Forest and Dawson Forest Wildlife Management Area, and two are on private land. Most include a reach of the Etowah or Amicalola mainstem and, to maximize habitat diversity, follow a small feeder tributary ravine into the uplands.
Large stretches of the Etowah River downstream of the Chattahoochee National Forest are in private ownership. Initially, I assessed several tracts of private land, but most were either agriculture or pasture land with little or no secondary growth. Therefore, survey of these areas was not worthwhile.

The species inventory was conducted throughout the growing seasons (approximately April-October) of 2001 and 2002, with some collections in the Spring of 2003. Two or three-day trips were made to the study area every 1.5 to 2 weeks. Not all sites were visited each trip, nor were all sites visited with equal frequency; sufficient overlap of species composition among sites instead allowed me to concentrate on the sites with unique habitats or higher habitat diversity. Also, not all sites were visited both years. Certain sites (AFT, ACT, JBR and RCR) were such that one season was sufficient for thorough exploration. Others were added in the second season to expand the total area explored (AHT, CMT, and sections of WCT).

Specimens were collected in duplicate. For each specimen, location, habitat, surrounding plant community composition, and forest type were noted. Species identifications were made on-site, or at the University of Georgia Herbarium. Vouchers are preserved at the University of Georgia Herbarium, Athens, GA.

**Results**

*Species statistics*

In the 633 ha study area of the Upper Etowah River watershed, 649 species, plus 12 varieties and one hybrid have been inventoried, for a total of 662 vascular plant taxa. These taxa represent 123 families and 366 genera, yielding a ratio of 1.8 species per genus. Non-native species represent 8.6% of the flora, with 57 taxa. Fifty-seven county records have been documented, as determined by specimens in the University of Georgia Herbarium. Eight records are for Lumpkin County, 34 for Dawson, and 15 records represent both counties. The number of taxa inventoried is 20.8% of the number of taxa listed in the Georgia Plant List (Jones and Coile 1985). This demonstrates the richness of the flora within this watershed, a relatively small area of the state, and emphasizes the need for continued exploration.
<table>
<thead>
<tr>
<th>Site Name</th>
<th>Site Code</th>
<th>County</th>
<th>Property</th>
<th>Area (ha)</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Elevation Min. (ft.)</th>
<th>Elevation Max.(ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amicalola Headwaters Tributary</td>
<td>AHT</td>
<td>Dawson</td>
<td>DF WMA</td>
<td>56.6</td>
<td>34° 33'</td>
<td>84° 19'</td>
<td>1840</td>
<td>2490</td>
</tr>
<tr>
<td>Eagle Ridge Road</td>
<td>ERR</td>
<td>Dawson</td>
<td>DF WMA</td>
<td>60.1</td>
<td>34° 31'</td>
<td>84° 19'</td>
<td>1900</td>
<td>2500</td>
</tr>
<tr>
<td>Wildcat Creek</td>
<td>WCT</td>
<td>Dawson</td>
<td>DF WMA Wildcat Cr.</td>
<td>203.4</td>
<td>34° 29'-31'</td>
<td>84° 17'</td>
<td>1520</td>
<td>2230</td>
</tr>
<tr>
<td>Amicalola Church Trib.</td>
<td>ACT</td>
<td>Dawson</td>
<td>DF WMA</td>
<td>27.5</td>
<td>34° 29'</td>
<td>84° 14'</td>
<td>1370</td>
<td>1510</td>
</tr>
<tr>
<td>Rock Cellar Road</td>
<td>RCR</td>
<td>Dawson</td>
<td>DF WMA</td>
<td>41.0</td>
<td>34° 29'</td>
<td>84° 13'</td>
<td>1340</td>
<td>1550</td>
</tr>
<tr>
<td>Holly Creek Tributary</td>
<td>HCT</td>
<td>Dawson</td>
<td>DF WMA</td>
<td>22.4</td>
<td>34° 26'</td>
<td>84° 12'</td>
<td>1250</td>
<td>1410</td>
</tr>
<tr>
<td>Dawson Check Station</td>
<td>DCS</td>
<td>Dawson</td>
<td>DF WMA</td>
<td>28.2</td>
<td>34° 24'</td>
<td>84° 12'</td>
<td>1060</td>
<td>1360</td>
</tr>
<tr>
<td>Amicalola Field Road Tributary</td>
<td>AFT</td>
<td>Dawson</td>
<td>DF WMA Atlanta</td>
<td>63.8</td>
<td>34° 22'</td>
<td>84° 11'</td>
<td>1000</td>
<td>1310</td>
</tr>
<tr>
<td>Power Line Tributary</td>
<td>PLT</td>
<td>Dawson</td>
<td>DF WMA Atlanta</td>
<td>74.1</td>
<td>34° 22'</td>
<td>84° 10'-11'</td>
<td>1000</td>
<td>1250</td>
</tr>
<tr>
<td>Etowah-Amicalola Confluence</td>
<td>EA</td>
<td>Dawson</td>
<td>DF WMA Atlanta</td>
<td>8.6</td>
<td>34° 22'</td>
<td>84° 12'</td>
<td>1000</td>
<td>1090</td>
</tr>
<tr>
<td>Ram Road Tributary</td>
<td>RAM</td>
<td>Dawson</td>
<td>DF WMA Atlanta</td>
<td>25.7</td>
<td>34° 21'</td>
<td>84° 11'</td>
<td>1000</td>
<td>1240</td>
</tr>
<tr>
<td>Reactor Rd. Tributary</td>
<td>RRT</td>
<td>Dawson</td>
<td>DF WMA Atlanta</td>
<td>18.4</td>
<td>34° 21'</td>
<td>84° 10'</td>
<td>1000</td>
<td>1200</td>
</tr>
<tr>
<td>Dawson</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total area</td>
<td></td>
<td></td>
<td></td>
<td>494.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Etowah Headwater Flats</td>
<td>EHF</td>
<td>Lumpkin</td>
<td>National Forest</td>
<td>54.5</td>
<td>34° 38'</td>
<td>84° 06'</td>
<td>1830</td>
<td>2075</td>
</tr>
<tr>
<td>Camp Wahsega</td>
<td>CW</td>
<td>Lumpkin</td>
<td>National Forest</td>
<td>26.0</td>
<td>34° 36'</td>
<td>84° 06'</td>
<td>1500</td>
<td>1790</td>
</tr>
<tr>
<td>Forest Service Rd. Tributary</td>
<td>FSR</td>
<td>Lumpkin</td>
<td>National Forest</td>
<td>20.5</td>
<td>34° 36'</td>
<td>84° 05'</td>
<td>1470</td>
<td>1720</td>
</tr>
<tr>
<td>Campbell Mountain</td>
<td>CMT</td>
<td>Lumpkin</td>
<td>National Forest</td>
<td>29.4</td>
<td>34° 34'</td>
<td>84° 05'</td>
<td>1400</td>
<td>2050</td>
</tr>
<tr>
<td>James Bridge Road</td>
<td>JBR</td>
<td>Lumpkin</td>
<td>Private</td>
<td>7.9</td>
<td>34° 33'</td>
<td>84° 04'</td>
<td>1340</td>
<td>1360</td>
</tr>
<tr>
<td>Castleberry Bridge Rd.</td>
<td>CBR</td>
<td>Lumpkin</td>
<td>Private</td>
<td>40.4</td>
<td>34° 28'</td>
<td>84° 02'</td>
<td>1160</td>
<td>1300</td>
</tr>
<tr>
<td>Lumpkin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total area</td>
<td></td>
<td></td>
<td></td>
<td>138.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>633.0</td>
<td></td>
</tr>
</tbody>
</table>
The four families with the greatest representation (Table 1.4) are as follows: Asteraceae (89 species), Poaceae (57 species), Cyperaceae (49 species), and Fabaceae s.l. (38 species). Three other families are notably well-represented—Ericaceae, Lamiaceae, and Rosaceae; each comprises approximately 3% of the total flora. This distribution of species among families is as expected for Georgia; it follows closely with analogous percentages calculated for the state (Table 1.4), using the checklist of Jones and Coile (1985).

In order to examine how the familial composition of the Upper Etowah flora compares to that of flora of similar physiographic regions, I calculated percent representation of the dominant families in five other floristic inventories from Georgia and the Carolinas. Averages are reported for three upland studies in the Mountain province (Milstead 1997, Moore 2002, Murrell and Wofford 1987), two in the Piedmont (Cruse 1997, Howel 1991), and two river-corridor studies (DuMond 1970, Seward 1993) in the Blue Ridge Escarpment and in the Piedmont (Table 1.4). Familial distribution of taxa is similar across all study types. However, river-corridor studies tend to have a higher percentage of species in the family Cyperaceae. This study is similar to Mountain flora in its percentage of Fabaceae, intermediate to Mountain and Piedmont flora in its percentage of Poaceae, and has fewer species in Asteraceae than for any other geographical category.

Table 1.4 Distribution of plant taxa among major families, for floras within Mountain and Piedmont provinces, and river corridors of both provinces, within Georgia and the Carolinas. Averages were calculated for floras within the same geographic category. Data for the entire state of Georgia are presented for comparison. Data sources for each flora are listed.

<table>
<thead>
<tr>
<th>Province of Survey</th>
<th>Asteraceae</th>
<th>Poaceae</th>
<th>Cyperaceae</th>
<th>Fabaceae s.l.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Etowah River Corridors</td>
<td>13.5</td>
<td>8.7</td>
<td>7.4</td>
<td>5.8</td>
</tr>
<tr>
<td>State of Georgia (Jones and Coile 1985)</td>
<td>12.1</td>
<td>10.0</td>
<td>7.6</td>
<td>5.8</td>
</tr>
<tr>
<td>Mountain (Milstead 1997, Moore 2002, Murrell and Wofford 1987)</td>
<td>15.8</td>
<td>7.5</td>
<td>4.3</td>
<td>5.4</td>
</tr>
<tr>
<td>Piedmont (Cruse 1996, Howel 1991)</td>
<td>14.5</td>
<td>10.4</td>
<td>4.4</td>
<td>7.4</td>
</tr>
<tr>
<td>River Corridors, Mtn.-Piedmont (DuMond 1970, Seward 1993)</td>
<td>14.4</td>
<td>9.5</td>
<td>6.9</td>
<td>6.0</td>
</tr>
</tbody>
</table>
Unusual species

No Federally listed species have been found in the study area. However, six state listed species occur (GNHPa 2003), and numerous species with documented need for monitoring (GNHPb 2003, GNHPc 2003) have been located (Table 1.5). Of the species on the Georgia Watch List (Table 1.5), both Carex debilis and Carex prasina were common in the study area.

Also noteworthy are three species which are not generally found in the physiographic region of the study area. Golden Club (Orontium aquaticum), is relatively common in the Coastal Plain, but extremely rare in the mountains (Jones and Coile 1988). It occurs as a population of fewer than 10 individuals along rocky shoals of the Amicalola River, between two narrow promontories south of State Hwy 53 (site DCS, Appendix B). Red Buckeye (Aesculus pavia) is most common in the lower Piedmont and Coastal Plain (Jones and Coile 1988). In the study area it has been found in two locations with Georgia Buckeye (A. sylvatica) and with hybrids of these two Buckeye species, on slopes and colluvial flats near to the Etowah-Amicalola confluence (sites RAM and EA, Appendix B). Finally, the rush Juncus vallidus previously has been documented from South Georgia and the Piedmont (Jones and Coile 1988), but a small population has been located in a gravelly sand-bar alongside the Etowah near its headwaters (site CW, Appendix B).

Other native species have distributions that include the study area, but occur rarely in the inventory. The sedge Carex swanii has no documented populations in the University of Georgia Herbarium, but is known from the Eastern United States. In this study it is found at three locations, and at each only one or two individuals could be sighted. Further review of the status of this sedge may be merited. Two aquatic species, Eel-grass (Vallisneria americana) and Riverweed (Podostemum ceratophyllum), grow at only one location, in a rocky-bottomed reach of the Etowah near the Amicalola confluence (site RAM). Certain species are found only once, with very small populations. These are Figwort (Scrophularia marilandica), Piedmont Meadow-rue (Thalictrum macrostylum), Southern Adders Tongue (Ophioglossum vulgatum var. pychostichum), and Wild Ginger (Asarum canadense). Others—
Carex frankii, American bladdernut (Staphylea trifolia), Featherbells (Stenanthium gramineum), Hairy Lip-fern (Cheilanthes lanosa), Mealy Colic-root (Aletris farinosa), Mock-orange (Philadelphus inodorus), Pennywort (Obolaria virginica), Purple Cliff-break (Pellaea atropurpurea), and Wild Comfrey (Cynoglossum virginianum) — are each limited to one site with small populations or scattered individuals. Finally, Autumn Coral-root (Corallorhiza odontorhiza), Ditch Stonecrop (Penthorum sedoides), Spider-lily (Hymenocallis caroliniana), Showy Orchid (Galearis spectabilis), and Trillium rugelii have each been found at two to three locations throughout the study area, but in small populations of one to several individuals. Locations of these species in the study area are shown in Appendix B.

<table>
<thead>
<tr>
<th>List Title</th>
<th>Species</th>
<th>Rating/State Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protected Plants of Georgia</strong> (GNHPa 2003)</td>
<td>Carex manhartii</td>
<td>Threated</td>
</tr>
<tr>
<td></td>
<td>Cypripedium acaule</td>
<td>Unusual</td>
</tr>
<tr>
<td></td>
<td>Cypripedium pubescens var. pubescens</td>
<td>Unusual</td>
</tr>
<tr>
<td></td>
<td>Schisandra glabra</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Waldsteinia lobata</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Xerophyllum asphodeloides</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Georgia Plants of Special Concern</strong> (GNHPb 2003)</td>
<td>Carex platyphylla</td>
<td>S1</td>
</tr>
<tr>
<td></td>
<td>Carex torta</td>
<td>S1</td>
</tr>
<tr>
<td></td>
<td>Juncus gymnocarpus</td>
<td>S2/S3</td>
</tr>
<tr>
<td></td>
<td>Panax quinquefolius</td>
<td>S3</td>
</tr>
<tr>
<td></td>
<td>Panax trifolius</td>
<td>S1</td>
</tr>
<tr>
<td></td>
<td>Spiranthus ovalis var. erostellata</td>
<td>S2/S3</td>
</tr>
<tr>
<td></td>
<td>Stachys latidens</td>
<td>S2</td>
</tr>
<tr>
<td><strong>Georgia Watch List</strong> (further documentation needed) (GNHPc 2003)</td>
<td>Boykinia aconitifolia</td>
<td>S3</td>
</tr>
<tr>
<td></td>
<td>Cardamine flagellifera</td>
<td>S3</td>
</tr>
<tr>
<td></td>
<td>Carex austrocaroliniana</td>
<td>S3</td>
</tr>
<tr>
<td></td>
<td>Carex communis var. amplisquama</td>
<td>S3</td>
</tr>
<tr>
<td></td>
<td>Carex debilis</td>
<td>SU</td>
</tr>
<tr>
<td></td>
<td>Carex prasina</td>
<td>S3</td>
</tr>
<tr>
<td></td>
<td>Carex radiata</td>
<td>S3</td>
</tr>
<tr>
<td></td>
<td>Carex ruthii</td>
<td>S2/S3</td>
</tr>
<tr>
<td></td>
<td>Stewartia ovata</td>
<td>S3</td>
</tr>
<tr>
<td></td>
<td>Viola conspersa</td>
<td>S3</td>
</tr>
</tbody>
</table>
Species specific to the Georgia Mountains or Piedmont

Several tree species whose Georgia distributions are limited to the Mountains have been found. Three of these, Mountain Camellia (*Stewartia ovata*), Mountain Magnolia (*Magnolia fraseri*), and Sweet Pepperbush (*Clethra acuminata*) are endemic to the Southern Appalachians (Little 1970), and they are rare within the study area. Common throughout is White Pine (*Pinus strobus*), and absent only at the most southern sites (Altanta Tract, DF) is Canadian Hemlock (*Tsuga canadensis*). Both are near the lowest latitudes of their extensive northern ranges (Little 1970). Mountain understory trees are restricted to northern sites. They are Sweet Birch (*Betula lenta*) and Alternate-leaf Dogwood (*Cornus alternifolia*), which grow on mesic slopes; Buffalo-nut (*Pyrularia pubera*), which is common on floodplains; and Black Locust (*Robinia pseudoacacia*), which is occasional in uplands.

The herbaceous community on mesic north-facing slopes has representatives of mixed-mesophytic cove forests of the Blue Ridge (Braun 1950, Wharton 1978). These are Appalachian Bunchflower (*Veratrum parviflorum*), Blue Cohosh (*Caulophyllum thalictroides*), Mandarin (*Disporum lanuginosum*), *Trillium vaseyi*, and Wood-nettle (*Laportea canadensis*). They are generally rare within the study area. Other mountain species, not restricted to north-facing slopes, are Big-leaf Aster (*Aster macrophyllus*), Pennsylania Sedge (*Carex pensylvanica*), and Spikenard (*Aralia racemosa*). However, there are several species considered indicative of various Mountain habitats not present in the study area (Wharton 1978), especially in the tree community. Examples are Mountain Maple and Striped Maple (*Acer spicatum* and *A. pensylvanicum*), Pitch and Table Mountain Pines (*Pinus rigida* and *P. pungens*), Yellow Birch (*Betula alleghaniensis*), and Yellow Buckeye (*Aesculus flava*).

Species documented for the Georgia Piedmont have extensive overlap with those of the Mountains (Wharton 1978). Among numerous examples are trees common to the Upper Etowah such as Oaks (Northern Red, Post, Scarlet, and White Oak), Hickories, Tulip Poplar, Blackgum, Sourwood,
Beech, and Basswood. In this study, what is most notable is that many trees important in Piedmont forests are absent in the Upper Etowah. On north-facing slopes, Wharton (1978) lists Big-leaf and Umbrella Magnolia (*Magnolia macrophylla* and *M. tripetala*) as key Piedmont species; these are not found in the study area. Piedmont Oaks such as Swamp Chestnut Oak, Oglethorpe Oak, Willow Oak and Water Oak (*Quercus michauxii*, *Q. oglethorpesis*, *Q. phellos*, and *Q. nigra*) are not present, and Southern Red Oak (*Q. falcata*) is not common. Bottomland species of the Piedmont such as Elms (*Ulmus* spp.) and Cottonwoods (*Populus* sp.) are not found, while another, Black Willow (*Salix nigra*), is present only on floodplains of the Etowah mainstem in Dawson County.

*Plant community types*

**Overview**

In order to generalize similarities and differences among study sites, and to facilitate location of specific plant communities, I have made compositional comparisons among all study sites and classified the plant habitats which occur throughout. This classification scheme is based heavily on those of Wharton (1978) and Braun (1950). Many of the defined habitat types exist throughout the study area, but several are unique to specific sites (Table 1.6). Habitats have been categorized according to both moisture regime and plant communities (Table 1.6). Hydric habitats, as employed by Wharton (1978), are directly associated with wetlands, streams and rivers, although they are not consistently wet areas. Plant community definitions for hydric habitats are driven by the shrub and herbaceous species composition. All other habitats occur along a moisture gradient from mesic to sub-xeric; these communities are defined by the canopy composition. The locations of large-scale communities are mapped onto the study site areas (Appendix B). Smaller-scale community types are strongly determined by topography, and their locations can be extrapolated from these maps.
### Table 1.6 Plant community types for study sites in the Upper Etowah watershed, with coded names and descriptions. Classifications are based heavily on Braun (1950) and Wharton (1978). Habitats are classified according to moisture regime (H = hydric, M1 = mesic, M2 = sub-mesic, X2 = sub-xeric, X = xeric) and plant community composition. An * next to a study site code indicates that the habitat there has undergone recent human disturbance.

<table>
<thead>
<tr>
<th>Habitat Code</th>
<th>Description</th>
<th>Study sites where present</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-CS</td>
<td>Cobbly and sandy, islands and beaches on rivers</td>
<td>CBR, CW, DCS, EHF, WCT</td>
</tr>
<tr>
<td>H-RS</td>
<td>River shoals, rock channel margins and islands</td>
<td>CBR, DCS</td>
</tr>
<tr>
<td>H-SRB</td>
<td>Steep river banks, sandy loam or silt alluvial soil</td>
<td>ACT, AFT, CBR, EA, FSR, HCT, JBR, RAM, RRT</td>
</tr>
<tr>
<td>H-DS</td>
<td>Depressional and seepage wetlands</td>
<td>ACT, AHT, CBR, EHF, ERR, HCT, PLT, RAM, RRT, WCT</td>
</tr>
<tr>
<td>H-BP</td>
<td>Beaver pond</td>
<td>WCT</td>
</tr>
<tr>
<td>M1-WTR</td>
<td>Mesic wide tributary ravine</td>
<td>ACT, AFT, AHT, EHF, ERR, HCT, PLT, RAM, RCR, RRT, WCT</td>
</tr>
<tr>
<td>M1-FRT</td>
<td>Mesic flat river terrace and floodplain</td>
<td>CBR, DCS, EA, FSR, HCT, JBR, PLT, RAM, AFT*, PLT*, RRT*</td>
</tr>
<tr>
<td>M1-OHE</td>
<td>Mesic Oak-Hemlock forest, Ericaceous understory</td>
<td>CMT, CW, EHF, ERR, FSR, HCT, JBR, WCT</td>
</tr>
<tr>
<td>M1-HW</td>
<td>Hardwood forests, steep north-facing toe-slopes</td>
<td>AHT, ERR, PLT, WCT</td>
</tr>
<tr>
<td>M1-OPH</td>
<td>Mesic Oak-Pine-Hickory forest</td>
<td>ACT, AFT, AHT, CBR, CMT, DCS, EHF, ERR, PLT, RAM, RCR, RRT</td>
</tr>
<tr>
<td>M2-OPH</td>
<td>Sub-mesic Oak-Pine-Hickory forest</td>
<td>AHT, CMT, CW, EHF, ERR, FSR, HCT, PLT, WCT</td>
</tr>
<tr>
<td>M1-RB</td>
<td>Mesic rocky bluffs and cliffs over rivers</td>
<td>DCS</td>
</tr>
<tr>
<td>M2-PE</td>
<td>Sub-mesic Pine forest, Ericaceous understory</td>
<td>CBR</td>
</tr>
<tr>
<td>M2-EEB</td>
<td>Sub-mesic Evergreen-Ericaceous bluff</td>
<td>DCS</td>
</tr>
<tr>
<td>X2-OPH</td>
<td>Sub-xeric Oak-Pine-Hickory forest</td>
<td>AFT, PLT, RAM</td>
</tr>
<tr>
<td>X-RB</td>
<td>Xeric exposed rocky river bluffs</td>
<td>CBR, RRT</td>
</tr>
<tr>
<td>FP</td>
<td>Wildlife feed plots</td>
<td>AFT, EHF, RRT</td>
</tr>
</tbody>
</table>

#### General trends

Habitats with the highest species richness are floodplains and terraces of high order rivers. Several factors probably contribute to this effect. I noted that river terraces often have wide canopy openings or areas of recent disturbance. Ruderal species, both native and exotic, are prevalent here, but they are often found with substantial populations of plants that generally require stable habitats. River terraces also seem to be a convergence area for slope and wetland communities. The second richest
habitats are flat ravines of low order streams, which contain many micro-environmental gradients—from mesic to saturated habitats, from rocky to silty-dark soils. In this survey, approximately half of all plants of special concern are found in such stream ravines. Also, certain north-facing slopes are high in species diversity and quality.

The highest number of invasive species occurs along wildlife feed plots, and at sites near to roads and jeep trails. Feed plots contain some of the most notorious invasive exotics: Japanese Honeysuckle, Privet, and Autumn Olive (*Elaeagnus umbellata*), which spread out into the forest from the feed plot in all directions. River terraces also have higher numbers of exotic species, but they are not abundant unless the above disturbances are also present.

Although not always high in diversity, river shoals, gravel sand bars, and rocky river bluffs have some of the more unique communities of the study area. Plants in these habitats often have highly localized distributions.

The lowest species diversity generally occurs in closed-canopy, upland forests that are sub-mesic to sub-xeric. However, mesic ravine forests with a canopy composed mostly of Hemlock and Pine, and with an understory of Mountain Laurel and Rhododendron, also have a very sparse herbaceous layer.

**Plant community descriptions**

**H-CS:** Hydric habitat, cobbly and sandy deposits forming islands and beaches along rivers. Typically, this community occurs along mid-order river sites and has no canopy trees. There are occasional Sycamore (*Platanus occidentalis*), Alder (*Alnus serrulata*), Mountain Laurel (*Kalmia latifolia*), Blackgum (*Nyssa sylvatica*), and *Rhododendron* species growing from bed-rock crevices on the channel margins above, which sometimes create shady micro-habitats.

The dominant plants are graminoids, such as Rice Cut-grass (*Leersia oryzoides*), Witch-grasses (especially *Dichanthelium clandestinum* and *D. dichotomum*), sedges (especially *Carex lurida*, *Cyperus strigosus*, *Rhyncospora* spp., and *Scirpus polyphyllus*), and rushes (mainly *Juncus acuminatus*, *J. effusus*, and *J. coriaceous*). Also common are the forbs *Ludwigia alternifolia*, *Ludwigia decurrens*, *Polygonum*...
sagittatum, and Mimulus alatus. Occasional are Meadow Beauty (Rhexia virginica), Wapato (Sagittaria latifolia), Linum striatum, and aquatics such as Marsh Seedbox (Ludwigia palustris) and Hedge-hyssop (Gratiola virginiana). Rare to this study, but notable from this habitat are Twisted Sedge (Carex torta), a Georgia Plant of Special Concern (DNR 2003); Bur-reed (Sparganium americanum); and the sedge Carex frankii.

**H-RS:** Hydric habitat, river shoals, rock channel margins and islands. This habitat occurs along mid-order river sites and is subject to heavy flooding. There are few canopy trees, but woody plants dominate this harsh environment. These are typically Winterberry (Ilex verticillata), Alder (Alnus serrulata), Silky Dogwood (Cornus amomum), Mountain Laurel (Kalmia latifolia), Virginia Willow (Itea virginica), Male-berry (Lyonia ligustrina), Sycamore (Platanus occidentalis), and Rhododendron species. Forbs that are common in this community are Touch-me-not (Impatiens capensis), Joe-pye-weed (Eupatorium fistulosum), False Nettle (Boehmeria cylindrica), Tickseed Sunflowers (Bidens spp.), and Carolina Bugbane (Trautvetteria carolinensis). Unusual plants found only in this habitat are Golden Club (Orontium aquaticum), a plant with a Coastal Plain distribution in Georgia; and Brook Saxifrage (Boykinia aconitifolia), listed as rare or uncommon in Georgia (DNR 2003).

**H-SRB:** Hydric habitat, steep river banks with alluvial soil of sandy loam or silt. These communities are higher above the river channel than those of rock margins, and are subject to moisture extremes. They are above the water table during dry seasons, and the soil texture allows rapid draining of precipitation, often leaving the surface soil dry. These steep banks occur on rivers of higher order (4-6th) in the study area.

Dominant canopy trees are River Birch (Betula nigra), Ironwood (Carpinus caroliniana), and Sycamore (Platanus occidentalis). Frequently these exist with no others, although Hackberry (Celtis occidentalis) and Tulip Poplar (Liriodendron tulipifera) are occasional. Sub-canopy woody species are Silverbell (Halesia carolina) and Mountain Dog-hobble (Leucothoë fontanesiana), and occasional Mountain Azalea (Rhododendron canescens), Serviceberry (Amelanchier arborea), Devil’s Walking-stick (Aralia spinosa), and Crab-apple (Malus angustifolia).
Graminoids are abundant. River Cane (*Arundinaria gigantea*) is the most common, followed by River Oats (*Chasmanthium latifolium*), Witch-grasses (*Dichanthelium clandestinum*, *D. dichotomum*, *D. laxiflorum*, and *D. commutatum*), *Chasmanthium sessiliflorum*, and sedges such as *Carex amphibola*, *C. laxiflora*, and *C. blanda*.

Outside the canopy edge on the banks, forbs and herbs are diverse: Joe-pye-weed (*Eupatorium fistulosum*), Cone-flower (*Rudbeckia laciniata*), Ironweed (*Vernonia gigantea*), False Nettle (*Boehmeria cylindrica*), and Button-bush (*Cephalanthus occidentalis*) are common. In shadier micro-sites grow *Aster sagittifolius* and *Solidago caesia*. Vines are also dominant, such as Poison Ivy (*Toxicodendron radicans*), Man-root (*Ipomoea pandurata*), and Muscadine (*Vitis rotundifolia*).

Although Privet (*Ligustrum sinense*) and Japanese Honeysuckle (*Lonicera japonica*), are present on these river banks, exotic species have not formed a dominant part of this community in the study area. They are more abundant on river floodplains and terraces.

**H-DS:** Hydric habitat, depressional and seepage wetlands. These habitats occur in specific locations: in drainages at the emergence stream origins; at the bases of toe-slopes on stream and river floodplains; and where small streams diverge into braided channels across wide colluvial flats. Generally, the surface is shallowly inundated or saturated year-round. Soils are either sandy and gravelly, or are dark silts with high organic matter content.

The canopy species are varied, but generally are composed of mesic-site species noted below for the wide tributary ravine habitats. However, there is typically a definitive shrub layer at the wetland margins, and the herbaceous layer is distinctive. The shrub species are Winterberry (*Ilex verticillata*), Possumhaw (*Viburnum nudum*), and occasionally American Holly (*Ilex opaca*). *Rhododendron maximum* occurs at wetlands at the base of steep slopes. Ferns are among the most eye-catching indicators of these wetlands; most common are Cinnamon Fern (*Osmunda cinnamomea*), Royal Fern (*Osmunda regalis*), and Chain Fern (*Woodwardia aureolata*). Graminoids are important: Rushes (*Juncus effusus* and *J. marginatus*), White-grass (*Leersia virginica*), Fowl Manna-grass (*Glyceria striata*), and the sedges *Carex leptalea* and *Carex atlantica* are typical. Certain violets such as *Viola primulifolia*, *Viola blanda*, and
Viola sororia are components. Water Horehound (Lycopus virginicus), Jack-in-the-Pulpit (Arisaema triphyllum), Small Green Wood-orchid (Platanthera clavellata), Roughleaf Goldenrod (Solidago patula), Coneflower (Rudbeckia laciniata) and Green Arum (Peltandra virginica) are distinctive representatives of this community at nearly every site. Finally, occasional members are Grass of Parnassus (Parnassia asarifolia), White Turtlehead (Chelone glabra), Monkey-flower (Mimulus alatus), Water Hemlock (Cicuta maculata), Rich-weed (Collinsonia canadensis), Honewort (Cryptotaenia canadensis), and Cardinal-flower (Lobelia cardinalis).

**H-BP:** Hydric habitat, beaver pond. One beaver pond was located; it nearly fills the southern half of the wide colluvial valley of a Wildcat Creek tributary. The plant community at the pond margins is representative of communities found along sand bars and gravelly river margins, and in sunny seepage wetlands.

**M1-WTR:** Mesic habitats, wide tributary ravines. These occur along low-order streams, and correspond to the mixed Pine-Hardwood colluvial forests defined by Wharton (1978). Topography of these areas is such that there is a wide flat stream ravine, which resembles a floodplain, but the soil originates from spills from surrounding steep slopes. Wharton (1978) states that the vegetation of these sites resembles that of adjacent moist slopes, due to lack of alluvial wetlands. Although this does frequently occur along small streams in this study area, I often found that braided stream channels, depressional areas, and shallow-groundwater seeps provide wetland habitat in the stream flats. These support a herbaceous community that is strikingly different from that of the slope, and is as described above for depressional wetlands and seeps.

The canopy described by Wharton (1978) for this environment, fits remarkably well with the colluvial forests in the study area. Dominant trees are White Oak (Quercus alba) and Tulip Poplar (Liriodendron tulipifera). In addition to trees listed by Wharton (1978), Basswood (Tilia americana) is abundant at more northern sites with this habitat. Pines are occasional. Other common trees are Sweetgum (Liquidambar styraciflua), Ash (Fraxinus pensylvanica and F. americana), Beech (Fagus americana) and Mockernut Hickory (Carya tomentosa). The sub-canopy consists mainly of Ironwood
(Carpinus caroliniana), Spicebush (Lindera benzoin), Silverbell (Halesia carolina) and, at northern sites, Buffalo-nut (Pyrularia pubera).

This habitat is extremely significant; seven of 12 sites inventoried with wide tributary ravine had plants of special concern. Interestingly, the sites with special concern herbaceous plants are also indicated by changes in their tree and shrub communities. In addition to the species listed above, sensitive sites to the north of the study area have Cucumber Tree (Magnolia acuminata) and Sweet Birch (Betula lenta) in the canopy. Most of the sensitive sites throughout the study have Buckeye (Aesculus spp.) in the understory. Notable species found in this habitat are Blue-Ridge Bittercress (Cardamine flagellifera), the sedges Carex austrocaroliniana, C. debilis, C. manhartii, C. prasina, and C. ruthii, Virginia Pennywort (Obolaria virginica), Showy Orchis (Galearis spectabilis), American and Dwarf Ginseng (Panax quinquefolius and P. trifolius), Star-vine (Schisandra glabra), October Ladies-tresses (Spiranthes ovalis), Mountain Camellia (Stewartia ovata), Ill-scented Wakerobin (Trillium rugelii), and Piedmont Barren Strawberry (Waldsteinia lobata).

Herbaceous vegetation covers the forest floor at these mesic sites. At virtually every wide tributary ravine, aggressive vines are dominant to abundant. These are Climbing Hydrangea (Decumaria barbara), Virginia Creeper (Parthenocissus quinquefolia), Hog Peanut (Amphicarpa bracteata), and Poison Ivy (Toxicodendron radicans). The exotic species Japanese Honeysuckle (Lonicera japonica) and Microstegium vimineum are nearly ubiquitous, but rarely dominant. Yellow-root (Xanthorrhiza simplicissima) is abundant at stream margins, typically with Foam-flower (Tiarella cordifolia), Wood Rush (Luzula spp.) and Starved-aster (Aster lateriflorus). New York Fern (Thelypteris noveboracensis) is the dominant groundcover. Numerous sedges and grasses are significant, both within the shallow stream channels, and on the colluvial flats. More sensitive plants are also an important part of this community, such as Mayapple (Podophyllum peltatum), Jack-in-the-Pulpit (Arisaema triphyllum), Trout-lily (Erythronium umbilicatum), Mountain Goldenrod (Solidago curtissii), Liverleaf (Hepatica spp.), Trillium
species, White Clintonia (*Clintonia umbellulata*), Star Chickweed (*Stellaria pubera*), and Wood-aster (*Aster divaricatus*).

The tributary channels are shallow and slow-flowing, such that they also support a diverse plant community, especially along gravelly and sandy margins. Found here are Showy Gentian (*Gentiana decora*), Small Green Wood-orchid (*Platanthera clavellata*), and White Turtlehead (*Chelone glabra*). Graminoids are abundant: various sedges (*Carex atlantica, C. cumberlandensis, C. intumescens, C. laxiflora, C. lurida*, and *C. mitchelliana* are typical), Leafy Bulrush (*Scirpus polyphyllus*), Virginia Cut-grass (*Leersia virginica*), Bearded Shorthusk (*Brachyelytrum erectum*), and Sweet Woodreed (*Cinna arundinacea*) are most common.

**M1-FRT:** Mesic habitat, flat river terrace. These are wide flat floodplains, where the survey area is contiguous with higher order rivers (4-6th) that flood at least occasionally. The furthest upstream of the study sites to have this type of habitat are near Camp Wasegah on the Etowah, and at the confluence of the Amicalola with the Little Amicalola River. The largest trees of the survey tend to occur in these terraces. However, other floodplain terraces are recently disturbed and clogged with secondary growth.

These are the most species rich areas of the survey. The canopy reflects this diversity. It is generally composed of mesic site hardwoods; Tulip Poplar (*Liriodendron tulipifera*) and White Oak (*Quercus alba*) are dominant in the canopy. Sweet Gum (*Liquidambar styraciflua*), Ash (*Fraxinus* spp), River Birch (*Betula nigra*), Hickories (*Carya* spp.), and Red Oak (*Quercus rubra*) are also abundant, and Basswood (*Tilia americana*) is occasional. Pines are frequent, including *Pinus strobus, Pinus taeda*, and *Pinus virginiana*. Red Mulberry (*Morus rubra*) and Hackberry (*Celtis occidentalis*) are present at the southern most river terraces; *Tsuga canadensis* is occasional at all others. However, drier site trees such as Sand Hickory (*Carya pallida*), Scarlett Oak (*Quercus coccinea*), and Redbud (*Cercis canadensis*) occur sporadically as well.

The subcanopy is typically composed of Ironwood (*Carpinus caroliniana*), Flowering Dogwood (*Cornus florida*), and Silverbell (*Halesia carolina*). Other species are site-dependent: Georgia Buckeye (*Aesculus sylvatica*), Sourwood (*Oxydendrum arboreum*), Spicebush (*Lindera benzoin*), Witch-hazel
(Hamamelis virginiana), Black Cherry (Prunus serotina), and Hop-hornbeam (Ostrya virginiana). Large stands of Paw-paw (Asimina triloba) are frequent.

The herbaceous layer is especially varied, so only broad generalizations will be made about its composition. Although graminoids are abundant, they represent only about 15% of the total species found at these sites, as determined by transect sampling (Chapter 3). River Cane (Arundinaria gigantea), Short-husk (Brachyelytrum erectum), Bluegrasses (Poa spp.), Chasmanthium species, and sedges (Carex spp.) are the graminoid taxa with greatest representation. Most diverse are the forbs, with about 40% of the species. They are characterized by an abundance of Asteraceous plants, especially Crownbeards (Verbesina spp.), Thoroughworts (Eupatorium spp.), and various Asters. Vines are also abundant, and in secondary growth areas form dense mats of nearly impassible vegetation. Moonseed (Mensispermum canadense), overall rare in this survey, was a dominant vine at the Etowah-Amicalola confluence.

Pteridophytes, however, are a very small component, in terms of both species richness (about 5% of total species) and abundance.

Ruderal, weedy species are common in this habitat. Natives include Bedstraw (Galium aparine), Ragweed (Ambrosia artemesiifolia), and Littleleaf Buttercup (Ranunculus abortivus). The exotics Japanese Honeysuckle (Lonicera japonica) and Microstegium vimineum are at nearly every floodplain site, while other occasional examples are Tear-thumb (Polygonum cespitosum), Silktree (Albizia julibrissin), Wart-removing Herb (Murdannia keisak), Tall Fescue (Lolium arundinaceum), and Ale-hoof (Glechoma hederacea). This is the one habitat where Kudzu (Pueraria montana) was found, covering large localized areas of floodplain terrace below Castleberry Bridge and at the north side of the Etowah-Amicalola confluence. Interestingly, Chinese Privet (Ligustrum sinense) is only a dominant presence when the river terraces abut roads, jeep trails, and feed plots. Elsewhere, it is infrequent to rare.

Despite the abundance of weeds, several floodplain terraces also support notable species. Most outstanding was the west-facing terrace below the promontories of the DCS site (Appendix B). Important plants found here are Starvine (Schisandra glabra), Piedmont Barren Strawberry (Waldsteinia lobata), and Carolina Spiderlily (Hymenocallis caroliniana).
**M1-OHE:** Mesic habitat, Oak-Hemlock forest with Ericaceous understory. This habitat is closely aligned with the Broadleaf Deciduous-Hemlock forest of Wharton (1978). These habitats occur solely along stream ravines and rivers, near the toe of steep slopes. Soils are generally rocky, frequently with bedrock exposed at the surface. Canopy trees are Chestnut, Red, and Black Oaks (*Quercus prinus, Q. rubra, Q. velutina*), Hemlock (*Tsuga canadensis*), and White Pine (*Pinus strobus*). In richer sites, such as certain ravines near Wildcat Creek, Basswood (*Tilia americana*), Tulip Poplar (*Liriodendron tulipifera*), Mountain Magnolia (*Magnolia fraseri*), and Cucumber Tree (*Magnolia acuminata*) occur. The sub-canopy is generally composed of Sourwood (*Oxydendrum arboreum*), Red Maple (*Acer rubrum*), and Flowering Dogwood (*Cornus florida*). The shrub layer is dominated entirely by *Rhododendron maximum* on the toe-slopes, and *Kalmia latifolia* above. This canopy creates a characteristic soil organic layer, termed mor humus by Braun (1950). Only a few species can grow in these conditions (Braun 1950), such as Pipsissewa (*Chimaphila maculata*), Partridge-berry (*Mitchella repens*), Indian Cucumber-root (*Medeola virginiana*), Rattlesnake Plantain (*Goodyera pubescens*), and Galax (*Galax urceolata*)—all typical of this habitat in the study area.

**M1-HW:** Mesic habitat, hardwood forests at the base of steep slopes of northern aspect. These are species rich plant communities, with strong mountain affinities in the composition. Not all northern slopes support such communities. Instead, they are localized to select slopes in oak-hickory-pine forests. Their lush character is striking, as sunlight filters through a high, deciduous canopy onto the understory. Shrubs are sparse—Mountain Laurel thickets rarely infiltrate—which adds to the open nature of this forest.

Canopy components, in general order of abundance, are Tulip Poplar (*Liriodendron tulipifera*), Basswood (*Tilia americana*), Cucumber Tree (*Magnolia acuminata*), Red Oak (*Quercus rubra*), Chestnut Oak (*Quercus prinus*), Sweetgum (*Liquidambar styraciflua*), American Beech (*Fagus grandifolia*), Red Maple (*Acer rubrum*), Mockernut Hickory (*Carya tomentosa*), and Red Hickory (*Carya ovalis*). In the sub-canopy are generally Flowering Dogwood (*Cornus florida*), Sweet Birch (*Betula lenta*), Witch-hazel (*Hamamelis virginiana*), Georgia Buckeye (*Aesculus sylvatica*), and occasionally Hop-hornbeam (*Ostrya*).
virginiana). At northern sites, shrubs that are especially noted for being mountain species occur: Alternate-leaf Dogwood (*Cornus alternifolia*) and Maple-leaf Viburnum (*Viburnum acerifolium*).

The herbaceous layer is rich, but not overgrown as would be in a recent canopy opening. Examples of important species are the Christmas and Maidenhair ferns (*Polystichum acrostichoides* and *Adiantum pedatum*); Doll’s-eye (*Actaea pachypoda*), Foam-flower (*Tiarella cordifolia*), Black Snakerooot (*Sanicula odora*), Liverleaf (*Hepatica* spp.), Wild Ginger (*Asarum canadense*), Virginia Creeper (*Parthenocissus quinquefolia*), Mandarin lily (*Disporum lanuginosum*), Appalachian Bunchflower (*Veratrum parviflorum*), White Clintonia (*Clintonia umbellulata*), and Sweet Wake-robin (*Trillium vaseyi*). The delicate sedge *Carex pensylvanica* often forms soft carpets where the soil is shallow or rocky. At the Amicalola headwaters is the only population in the study area of Blue Cohosh (*Caulophyllum thalictroides*), a mountain species. Also, small populations of American Ginseng (*Panax quinquefolius*) are frequent. It is found only on these slopes or rich ravines below.

**M1-OPH:** Mesic habitat, Oak-Pine-Hickory forest. This is the most typical slope forest of the study sites. In general, it is composed of oaks and other hardwoods, but shows variation with elevation and aspect (Braun 1950). Throughout, pines are occasional, often in large stands due to recent disturbance (Wharton 1978). White Pine (*Pinus strobus*) is the most common pine in this forest type. On lower slopes, White Oak (*Quercus alba*) and Tulip Poplar (*Liriodendron tulipifera*) are the most important trees, with occasional Sweetgum (*Liquidambar styriciflua*), Hickories (*Carya* spp.), Blackgum (*Nyssa sylvatica*), Red Oak (*Querus rubra*), Ash (*Fraxinus* spp.), and American Beech (*Fagus grandifolia*). With elevation, American Beech and Tulip Poplar decrease, and Oak species increase in abundance.

The herbaceous layer is often lush, and a great variety of species occur here—although their occurrence is patchy. Often, the forest floor is merely dominated by vines such as Virginia Creeper and Muscadine (*Parthenocissus quinquefolia* and *Vitis rotundifolia*), with forbs flowering only in canopy openings. Composites such as Sunflowers (*Helianthus* spp.), Aster species, and Black-eyed Susan (*Rudbeckia hirta*) are common. The legumes Tick-trefoil (*Desmodium* spp.) and Lespedeza species are
also typical. Frequent are Christmas fern (*Polystichum acrostichoides*), Heart-leaf (*Hexastylis arifolia*), False Soloman’s Seal (*Maianthemum racemosum*), Bloodroot (*Sanguinaria canadensis*), Wood-sorrel (*Oxalis* spp.), Meadow Parsnip (*Thaspium* spp.), Northern dewberry (*Rubus flagellaris*), and Violets (especially *Viola sororia* and *Viola hastata*). The exotic species *Vinca minor* and *Prunella vulgaris* are occasional. Finally, one state-listed plant was located in this habitat, which is *Cypripedium pubescens* var. *pubescens*, the Greater Yellow Ladies-slipper.

**M2-OPH:** Sub-mesic habitat, Oak-Pine-Hickory forest. This is the second-most common forest type in the study area. It occurs on upper slopes, shoulders and wide ridges. This forest is dominated by a variety of oaks, with Black Oak (*Quercus velutina*), Chestnut Oak (*Q. prinus*), White Oak (*Q. alba*), and Scarlett Oak (*Q. coccinea*) all distributed relatively equally. They are associated with frequent Pines (*Pinus strobus, P. taeda, P. virginiana*) and Hickories (*Carya tomentosa, C. ovata, and C. pallida* are the most common). Tulip Poplar (*Liriodendron tulipifera*) is only occasional to rare, and American Beech (*Fagus grandifolia*) does not occur.

This forest type falls into 3 separate categories. In addition to the general type described above, occasionally these sub-mesic forests are dominated by only Chestnut Oak, or by Pines. The Chestnut Oak-type corresponds to the Chestnut Oak Ridge forest described by Wharton (1978) and occurs occasionally at slope shoulders, where soil is thin and rocky. Blueberries (*Vaccinium* spp.) and Mountain Laurel (*Kalmia latifolia*) are the dominant shrub layer. The Pine-type tends to occur on lower southern or western facing slopes, and is frequently recently harvested forest.

In the study area, the sub-canopy in these forests is generally composed of Sourwood (*Oxydendrum arborum*), Red Maple (*Acer rubrum*), and Flowering Dogwood (*Cornus florida*), with occasional Blackgum (*Nyssa sylvatica*), Sassafras (*Sassafras albidum*), American Holly (*Ilex opaca*), and Black Locust (*Robinia pseudoacacia*). American Chestnut (*Castanea dentata*) sprouts are often present. At a few sites, Redbud (*Cercis Canadensis*) is prominent, which indicates local habitats with soils of lower acidity (Wharton 1978). Often, the shrub layer is composed entirely of Ericaceous shrubs: Mountain Laurel (*Kalmia latifolia*), Blueberry (*Vaccinium* spp.), Huckleberry (*Gaylussacia* spp.), and
Mountain Azalea (*Rhododendron canescens*) are all common. The herbaceous layer is sparse and of low diversity. Most frequently encountered are: graminoids such as Spear-grass (*Piptochaetium avenaceum*), Black-edge sedge (*Carex nigromarginata*), Witch-grass (*Dichanthelium* spp.) and Oat-grass (*Danthonia* spp.); composites such as Tickseed (*Coreopsis major*), Robin’s Plantain (*Erigeron pulchellus*), Rattlesnake-weed (*Hieracium venosum*), and Goldenrod (*Solidago* spp.); Pipsissewa (*Chimaphila maculata*) and Muscadine (*Vitis rotundifolia*). One state-listed plant seen in this forest type is the Pink Ladies-slipper, *Cypripedium acaule*.

**X2-OPH:** Sub-xeric habitat, Oak-Pine-Hickory forest. Drier site forests in this survey are confined to ridgetops. The forest is open and trees are widely spaced. Post Oak (*Quercus stellata*) and Southern Red Oak (*Q. falcata*) are dry-site indicators (Braun 1950, Wharton 1978) and are both found here. These forests are not defined as fully xeric, because of the absence of certain xeric-site species, such as Blackjack Oak (Wharton 1978), and because of the continued occurrence of White Pine on these ridgetops. Other common canopy trees are Scarlett, Black, and White Oaks (*Quercus coccinea*, *Q. velutina*, and *Q. alba*), and Hickories (*Carya ovalis*, *C. glabra*, *C. tomentosa*, and *C. pallida*). In the sub-canopy are Flowering Dogwood (*Cornus florida*), Sourwood (*Oxydendrum arboreum*), and Sparkleberry (*Vaccinium arboreum*). Mountain Laurel (*Kalmia latifolia*) often forms thickets at the crest of these ridgetops.

Populating these habitats is a unique herbaceous community, relative to the mesic communities. Illustrative examples are Rattlesnake-master (*Eryngium yuccifolium*), Pencil-flower (*Stylosanthes biflora*), Little Blue-stem Grass (*Schizachyrium scoparium*), Kidney-leaf Rosinweed (*Silphium compositum*), Ragged Goldenrod (*Solidago petiolaris*), the Lespedezas, *Lespedeza procumbens* and *L. repens*, Blue-eyed Grass (*Sisyrinchium* spp.), and Sensitive Brier (*Mimosa microphylla*). There is significant overlap between these communities and those on sandy river banks on high order rivers.

**M1-PE:** Mesic habitat, Pine forest with an Ericaceous understory. This habitat is unique to one location in the study area. It is a narrow ridgetop-bluff over the Etowah, near the crossroads of Auraria (latitude 34° 28'') with steep rocky slopes. The forest is composed almost entirely of White Pine (*Pinus*...
strobus). The pine are well over 100 years old (T. Patrick, pers. com.), and widely spaced over an understory of Mountain Laurel (Kalmia latifolia). On the lower slopes, the community transitions to the Oak-Pine-Hemlock (M1-OHE) forest, with Oaks, Hickories, Hemlock, and Mountain Magnolia joining the canopy.

M2-EHB: Sub-mesic habitat, evergreen heath bluff. Another highly localized community, this habitat is represented in the study area by the forest along the edges of promontories of the DCS site. These communities are loosely described by Wharton (1978) as occurring on steep, often north facing bluffs and slopes above rivers, with rocky or thin soil.

The canopy is Oak-Hickory. The oaks tend to be drier site trees. Also important are Virginia and White Pines (Pinus virginiana and P. strobus), Sand Hickory (Carya pallida), and Blackgum (Nyssa sylvatica). In the subcanopy are Red Maple (Acer rubrum), Sourwood (Oxydendrum arborem), Sassafras (Sassafras albidum), and American Chestnut (Castanea dentata).

These forests support a dense shrub-layer of Mountain Laurel (Kalmia latifolia) at the crest of the slope, often accompanied by Rhododendron maximum. The conditions at the edges of these precarious bluffs are favorable for the State-listed species Eastern Turkey Beard, Xerophyllum asphodeloides. On the narrow promontory tips above the Amicalola (latitude 34° 24’) grow two populations of this plant, with numbers totaling over 100. These populations were known prior to this inventory. On the southern promontory, the relatively linear population extends down onto the river terrace, a habit which is unusual for this species (T. Patrick, pers. com). When growing beneath the Mountain Laurel, Turkey Beard persists in a vegetative state, occasionally budding from rhizomes. In canopy openings, it regularly flowers and sets seed.

M1-RB: Mesic habitat, rocky bluffs and cliffs over rivers. This habitat is the intermediately wet cliff and gorge wall environment as classified by Wharton (1978). No spray-cliff type communities have been located in the study area, which would require a more abundant water source than has been observed.
The best examples of this community occur along the Amicalola at latitude 34° 24', as it winds through a region of unique geology, with steep gorges, shoals, and hair-pin turns. Well-explored in this study are the sheltered cliffs at the DCS site (Appendix B). Here, there is sufficient moisture to support large Hemlock (*Tsuga canadensis*), White Pine (*Pinus strobus*), and also Hop-hornbeam (*Ostrya virginiana*), Sweet Birch (*Betula lenta*), and Basswood (*Tilia americana*) on the slightly less-steep slopes. On one sheltered north-facing cliff is a substantial population of Littleflower Alum-root (*Heuchera parviflora*). Moss-covered boulders support Bird’s Nest Fern (*Asplenium trichomanes*) in their crevices. Both are important indicator species for this habitat (Wharton 1978). The narrow ledges are abundantly covered with the sedge *Carex pensylvanica*, Poison Ivy (*Toxicodendron radicans*), Wild Hydrangea (*Hydrangea arborescens*), Soloman’s Seal (*Polygonatum biflorum*), Wood-aster (*Aster divaricatus*), Marginal Wood-fern (*Dryopteris marginalis*), and Maple-leaf Viburnum (*Viburnum acerifolium*). Turk’s Cap Lily (*Lilium superbum*) has been observed on these ledges as well.

**X-RB:** Xeric habitat, exposed rocky river bluffs. These outcrops, with shallow or no soil, frequently rise directly over the Etowah channel as it meanders out of the Mountain province. They are described Wharton (1978) as an environment typical of the Piedmont province in Georgia, and several species key to that classification are encountered on xeric bluffs in this study area: Yucca (*Yucca flaccidifolia*), American Alum-root (*Heuchera americana*), Oat-grass (*Danthonia spp*), and Hairy Lip-fern (*Cheilanthes lanosa*). The latter occurs nowhere else in the study. Shrubs listed by Wharton (1978) for these bluffs include Winged Sumac (*Rhus copallinum*) and Sparkleberry (*Vaccinium arboreum*); these two occur here. However, Wharton (1978) highlights a tree community which bears little resemblance to that occurring in the study area, including Red Cedar, Blackjack Oak, and Hop-hornbeam. Instead, the trees found growing on ledges of these bluffs are Virginia Pine (*Pinus virginiana*), Shortleaf Pine (*P. echinata*), Scarlett Oak (*Quercus coccinea*), Service Berry (*Amelanchier arborea*), Crab-apple (*Malus angustifolia*), and White Ash (*Fraxinus americana*).

Other species which are typical on the bluffs of the study area are Whorled Milkweed (*Asclepias verticillata*), Sampson’s Snakeroot (*Orbexilum pedunculatum*), Early Saxifrage (*Saxifraga virginiensis*),
Pinewood (*Hypericum gentianoides*), Shrubby St. Johns-wort (*Hypericum prolificum*), and Man-root (*Ipomoea pandurata*). Grasses cover any open space on ledges, among lichens and mosses. Often, dense vines cover the rocks.

Cliff-brake fern (*Pellaea atropurpurea*) grows on a bluff in the southernmost tract of Dawson Forest, and, as it favors basic soils (Wharton 1978), may indicate a localized patch of atypical parent material.

**FP:** Wildlife feed plots, planted at the periphery with Autumn Olive (*Elaeagnus umbellata*) and Japanese Honeysuckle (*Lonicera japonica*), and at the interior with various grasses and legumes. There are no canopy trees. These disturbed sites have a high concentration of invasive exotic species.

**Discussion**

This inventory has provided a clear picture of the plant community types that occur along corridors of the Upper Etowah and Amicalola Rivers. It is likely that these communities are well-representative of those that would be found throughout the watershed as a whole. This is because the study area includes a wide range in latitude, and the survey sites include diverse habitats—from riparian areas of high and low order streams, to drainages, slopes, and higher elevation ridgetops. Therefore, assessment of overall patterns in the flora, and of conservation needs, can be made.

Further study of the flora of this watershed would benefit from inclusion of additional tracts of private land. Of particular interest would be pockets of forest in riparian zones or on north-facing slopes. These could indicate what components of sensitive plant communities, if any, are able to survive in more fragmented forest, and subsequently enable their documentation. Certain landowners may be willing to work for the protection of remnant native flora on private lands.

Also useful would be to continue the survey on more remote high-elevation slopes and ridges of the Upper Etowah Watershed. These are beyond the scope of the current study, but additional rare species and plant community types would likely be found in such areas.
Physiographic affinities of the flora

The flora of the Upper Etowah River most resembles plant communities of the Georgia Mountains. This is not unexpected, as key Piedmont soils are not present, and the character of the landscape reflects the Blue Ridge. The terrain is rocky and steep, with bouldery rivers that have relatively narrow floodplains—these traits correspond to the Mountain River environment characterized by Wharton (1978). Many characteristic Mountain species are present, and some such as White Pine and Canadian Hemlock occur throughout most of the study area. Also, species important in Piedmont environments are missing from the Upper Etowah flora.

However, the fact that this watershed is along the transitional zone into the Piedmont Uplands is apparent. Many Mountain species only occur at the northern sites. Also notable is that north-facing coves found here do not support the true mixed-mesophytic forest (sensu Braun 1950) that would be expected in the Blue Ridge. Ridgetops are also missing classic mountain species, such as Pitch and Table Mountain Pines, and elevations are not high enough to generate gnarled Oak ridge forests and heath balds (Wharton 1978).

Because the Piedmont flora has suffered repeated periods of extensive disturbance in Georgia there is no definitive suite of Piedmont species (Wharton 1978, Braun 1950). This, in addition to the overlap between the floras of the Upper Piedmont and Mountains in Georgia, prevents calculation of the exact percentage of Mountain and Piedmont species in this survey.

Conservation priorities for the flora of the Upper Etowah watershed

Stream origins and low order streams

Shallow groundwater seeps, at slope bases and stream origins, are oases of primary productivity in upland forests, which otherwise often have sparse vegetation. First and second order streams provide a great diversity of wet and mesic habitat types over a small area. Together, these habitats have among the highest plant species richness of all habitats in the study area. Sites of stream origins had two plants of special concern, Spiranthes ovalis and Carex praolina. Along small streams, 15 of the 22 special concern
These habitats are likely at high risk during land development. In general, low order streams and their associated wetlands receive less emphasis in protective regulations than do higher order rivers (Brinson 1993). Most stream buffer regulations are not developed in the field, but rather based on standardized models that are applied to streams shown on topographical maps (Wenger 2000). As many primary streams have intermittent flow, they do not appear on 1:24,000 scale topographical maps and escape protection altogether. During urban development, primary streams are frequently piped belowground, as their inconspicuous size makes it politically feasible to obtain variances to wetland regulations. Yet, this survey indicates that such streams are equally as important for plant species diversity as riparian areas of larger rivers in this region. Sedimentation and erosion will likely have dramatic impacts on the physical structure of these small habitats. These tributaries, and the small seepage wetlands that accompany them, cannot be overlooked in development or conservation planning.

**Public land—remote areas and managed areas**

The best examples of intact Mountain plant communities exist within the most remote areas of the Dawson Forest WMA. Examples of these are the north-facing slopes along the Amicalola Headwaters Tributary, the ravine below Eagle Ridge Road off of State Hwy 136, and along Wildcat Creek just west of the confluence with the Amicalola River. Also unique are the Ericaceous bluffs, river shoals, and rocky floodplain along the Amicalola south of State Hwy 53 (site DCS). In these locations the forest has recently been under low-intensity management, with relatively low recreational traffic. These are important habitats; none equal is found over the entire survey area. Fortunately, under the 50 year management plan for these tracts of forest, they are slated for protection and will not likely be harvested for timber (WMD 2003). Their documentation in this survey will also contribute to their protection, by providing detail for land management planning.

The Atlanta Tract and sections of the Amicalola tract have had more intensive historical uses, and areas of both are highly used for recreation. The Atlanta Tract also has locations where management for
timber harvest is emphasized. Plant communities in these areas reflect this disturbance, yet maintenance of riparian and bottomland forest has allowed for pockets of high floristic diversity and rare species to be preserved. For example, along slopes of the Ram Road tributary in the Atlanta Tract, exist species such as *Schisandra glabra*, *Panax quinquefolius*, *Trillium rugelii*, *Sanguinaria canadensis*, *Cypripedium acaule*, and *Aesculus pavia*, three of which are state listed (GNHP 2003a).

One challenge for managing public forests will be to balance human uses of the surrounding land with protection of forest health. For example, residential construction is occurring along ridgetops above the most remote sections of the Dawson Forest WMA. Critical locations are the Big Canoe Resort above Wildcat Creek, and a subdivision above the north-facing slopes of the Eagle Ridge Road study ravine. These sensitive habitats could be affected by the erosion and increased recreational traffic that accompany residential development. Protection of these last relics of intact plant communities that exist along the Amicalola River and its tributaries should be made a priority. This study recommends that forest managers and development planners initiate open lines of communication to address this and similar issues that will arise during development planning around public lands of the Upper Etowah watershed. New types of conservation tools should be given consideration for these areas, such as the designation of lands contiguous to public property as buffer zones, where development is regulated to minimize impacts on the forest (Franklin 1993).

**Private land**

Finally, of equal importance is the network of private lands that remain forested in the Upper Etowah watershed. The tract at Castleberry Bridge Road is a prime example of private land with high quality, diverse habitat and great beauty. Its current long-time owner has made it a priority to maintain the land undisturbed, while property upstream has been built in resort-style homes adjacent to the river channel. Since tracts of land such as the Castleberry Bridge Road site are rare in the matrix of agriculture along the Etowah mainstem, the integrity of those that remain is of vital importance. However, public acquisition of private land is not always feasible. Thus legal incentives for conservation, plus effective public education about their use, will likely be essential for protection of private land in the Etowah
watershed (Burkhead 1997). Governments of Etowah watershed counties are currently addressing their manner of development, and as such they now have opportunities to provide support for conservation-minded landowners (L. Fowler, pers. com.). Remnant forests on private land would benefit greatly if such mechanisms are successfully implemented.

**Summary and Conclusions**

In this survey of 633 ha along major river corridors of the Upper Etowah watershed, 667 plant taxa have been inventoried. The diversity of habitats encountered, from mesic to xeric, indicates that the collection method has been successful. Additional work that would be useful to this survey would include tracts of private land and remote high-elevation slopes.

Many habitats have been noted that are unique and merit protection. However, I feel that certain areas should be emphasized for plant conservation. These are stream origins and primary streams, remote tracts of the Dawson Forest WMA, and private land with intact forest.

This survey has also described reference plant communities and their locations in the Upper Etowah watershed. These data can now be used to supplement data on the quality of aquatic habitats in determining the highest priority lands for conservation, and to serve as baseline information for local restoration projects.
CHAPTER 2: PLANT SPECIES RICHNESS IN POTENTIAL RIPARIAN BUFFER ZONES

OF THE UPPER ETOWAH RIVER WATERSHED

Introduction

The Etowah River Basin, in its current state, provides tourism, recreation, and drinking water to counties within its boundaries, and its headwaters remain one of Georgia's most intact river systems (Quinn 2003). However, urban development threatens Etowah ecosystems, which contain twelve Federally listed aquatic animal species (Quinn 2003). At this time, both local efforts and federal legislation are inciting the counties of the Basin to examine how to balance economic growth with ecosystem protection (ERHCP 2003, Quinn 2003). Timely data is needed on how to most effectively meet this goal (Burkhead et al. 1997). One legal tool used in conservation is the riparian buffer zone. This paper focuses on the design of forested riparian buffer zones for conservation of plant communities.

A riparian ecosystem is the transition zone between aquatic and terrestrial ecosystems across time and space (Gregory et al. 1991). Due to periodic, uneven disturbance from both upland and fluvial sources (Gregory et al. 1991), riparian zones provide highly heterogeneous habitats (Decocq 2002, Naimen et al. 1993, Nilsson et al. 1989, Tabacchi et al. 1998, Williams et al. 1999). Riparian plant communities thus tend to be more species rich than those of uplands, as micro-variations in habitat support plants from hydric to hillslope communities (Decocq 2002, Tabacchi et al. 1998). Herbaceous communities in floodplains have also been shown to vary over short distances with changes in micro-topography and light levels (Menges and Waller 1983, Williams 1999). Preserving riparian plant communities is thus an efficient way to capture a wide range of species (Naimen et al. 1993, Spackman and Hughes 1995).
A riparian buffer zone is a corridor of land along a water body that is protected from development. Benefits of riparian buffer zones are well-documented, especially in their capacity to function as sinks for polluting sediments and nutrients from adjacent uplands that would otherwise enter the stream channel with precipitation (Lowrance 1998). If a buffer zone is protected as forest, it can also have the capacity to improve aquatic and terrestrial habitats for a region's fauna and flora (Lowrance 1998, Tabacchi et al. 1998). Since the 1990's, successful quantification of these multiple benefits has made it politically feasible to legislate or encourage forested buffer zones (Lowrance 1998). In Georgia, state law mandates that all perennial streams have a buffer that extends 25 feet (7.6 m) out from the stream channel, and for specially designated trout streams the requirement is 50 feet (15.2 m) (Georgia Erosion and Sedimentation Control Act, OCGA 12-7-1).

Since buffer zones limit economic activity, an important emphasis of their study is to determine how wide riparian buffers must be to enable their protective functions (Lowrance 1998, Spackman and Hughes 1992, Sparovek et al. 2002, Wenger 1999). Optimal buffer zone width will differ with various management goals (Wenger 1999). Most studies address effectiveness of different buffer widths in control of non-point source pollution, especially of nitrogen runoff (Lowrance 1998). Riparian zone functioning, and hence buffer effectiveness, changes with vegetation type (Boutin et al. 2003, Gregory et al. 1991, Lowrance 1998), soil characteristics and topography (Dukes et al. 2002, Sparovek et al. 2002). Nonetheless, broad recommendations are possible (Wenger 1999). On the short-term, a buffer zone of 15 feet can prevent sediment flow and erosion of the stream channel (Wenger 1999). However, for long-term retention of sediments and sediment-borne pollutants such as phosphorus and herbicides, a buffer of 100 feet (30.5 m) in width is recommended (Wenger 1999). Also, careful timber management within the buffer can enhance long-term uptake of polluting nutrients by plants and soil microbes (Lowrance 1998).

For protection of terrestrial ecosystems, wider buffers are necessary than for protection of water quality alone (Wenger 1999). Most studies focusing on the value of terrestrial habitats in riparian buffers have examined bird communities (Wenger 1999). Riparian corridors have been shown to be preferentially used by birds over adjacent clear-cuts (Machtans et al. 1996). The number of interior-forest
Studies that examine plant species conservation in buffer zones of differing widths are few, and show great variation in results (Sparovek et al. 2002, Wenger 1999). In Québec, Canada, riparian buffers averaging from 3.1-19.2 m in width in an agricultural matrix were found to be a reservoir for native plant species and had few noxious weeds (Boutin et al. 2003). Forested buffers had greater species richness, and greater percent native species, than did non-forested buffers (Boutin et al. 2003). Along the Ardour River in France, invasive species richness was not correlated with the width of forest in riparian areas (Tabacchi and Tabacchi 2001). In a study of riparian plant communities in intact forest in Vermont, Spackman and Hughes (1995) could not make a standardized recommendation for buffer width due to high variation among sites. They found that a buffer width of 10 to 30 meters (33 to 98 ft.) would be required to contain 90% of the streamside plant species that were present before disturbance (Spackman and Hughes 1995).

Therefore, this study has been designed to examine plant species richness in potential riparian buffer zones of different widths in the Upper Etowah watershed. The objectives are: 1. To quantify species richness in floodplains of sites along large and small streams; 2. To determine what percent of the total species would be contained within buffer zones of increasing widths; 3. To determine if variation among sites, stream order, or distance from the stream influence plant species richness; and 4. To look for patterns in the environmental variables of soil moisture and canopy species richness, and assess whether these variables also influence species richness.
Materials and Methods

Sampling

Species richness was sampled on six floodplain sites in the Upper Etowah watershed. The sites are within the transition zone from the Blue Ridge Mountains to the Piedmont Uplands in North-central Georgia (Fig. 2.1). Topography along the streams is generally of high relief. All sites are within intact forest, in either Dawson Forest State Wildlife Management Areas or the Chattahoochee National Forest, Toccoa Ranger District. Three sites were designated along 2nd order streams—these are small stream sites. The three remaining sites were established along the Etowah main stem where it is a river of either 5th or 6th order. These are designated as large stream sites.

Each site is 100-m in length parallel to the stream channel. The entire area of each site is a flat river terrace with a distinctive boundary at the base of the slope that descends from the upland. For this study, the floodplain is defined as this area of flat river terrace from the high water mark on the stream bank, to the upland slope base. Within each site, six transects have been established that run across the floodplain width, 20 meters apart (Fig. 2.2). The floodplain width varies within and among sites (Table 2.1). Six circular sampling plots, 1.5-m in diameter, are evenly spaced along each transect and represent an increasing percentage of the total floodplain width. Percentages are used in order to standardize plot positions among different transects. Therefore, the first plot at the river channel is a sample of the species that occur at 0% of the total floodplain width, the second plot represents 20% of the width, and this pattern progresses until 100% of the floodplain has been captured. The outside edges of the first and last plots are aligned with the edge of the high water mark and the slope base, respectively. Transect ends and sampling plots are marked for repeat sampling. Each transect end is marked with a metal stake and each sampling plot center is marked with a field flag. During sampling, the plots are delineated with strings that are 1.5-m in length, placed on the ground and centered across the plots.
Figure 2.1 Location and names of sampling sites along the Etowah and Amicalola Rivers in Dawson and Lumpkin Counties. DF WMA = Dawson Forest Wildlife Management Area.
Every plant species within or above each plot has been identified and recorded. Sampling was performed twice over two-week periods—one in late spring (early May) and one in late summer (mid-August)—to facilitate identification of all species present. Percent canopy cover was calculated in late spring using a spherical densiometer. Percent soil moisture was measured in late summer using a Hydrosense™ soil moisture reader (Spectrum Technologies, Inc.), with 8-in. long probes. When the probes could not penetrate their full length due rocks at the surface, 4-in. probes were substituted. Soil moisture was measured at least two days after any rainfall for all sites. Three moisture readings were taken per plot, and the plot average was calculated for use in data analysis.
Data Analysis

For each site, total species richness was calculated. Then, all plots at proportionally equivalent distances from the high water mark were grouped, to obtain a list of species for each position. The number of new species added with increasing distance from the stream was tallied, and then converted to the percentage of total species that would be included within each increment of increasing buffer width. Species were then grouped into vegetation types of forbs, graminoids, trees/shrubs, vines, and pteridophytes. The above calculations were then performed for each vegetation type separately.

Regression analysis was conducted to analyze the relationship between plot species richness and the following variables: site, stream order (small or large), percent canopy cover, percent soil moisture, relative plot position on the floodplain, and absolute plot distance from the stream channel (Park and Vollmer 2003). Because the response variable of species richness is a count, these data are most likely to be Poisson rather than normally distributed. Therefore, the above questions were examined in the context of the Generalized Linear Model (GLiM), because under this model the only assumption about the data is that they are independent. Using the GLiM procedure in SAS, a Poisson regression was performed on the data to examine goodness of fit to the Poisson distribution, and the contribution of the listed variables to plot species richness.

Initial analysis demonstrated that the data were overdispersed relative to the Poisson distribution (Table 2.2)—the distribution variance was greater than the mean, while under the Poisson distribution the variance is equal to the mean (Park and Vollmer 2003). Therefore, other models were examined for goodness of fit to the data: the negative binomial distribution, which scales the data to adjust for overdispersion; the fixed-effects model; and mixed effects models. The latter two models are the more conservative because they assume that the data are normally distributed; this is a reasonable initial assumption because the mean plot species richness is relatively high (Park and Vollmer 2003). Mixed-effects models differ from fixed-effects models in that they can test for random effects that occur due to variations among sites and to spatial auto-correlation among plots. All models were first analyzed in their most complex form with all variables and interaction terms, and were systematically reduced to models
where all effects were significant at $\alpha=.05$ (Park and Vollmer 2003). Maximum likelihood statistics were used to determine the best fitting models, but the best fitting models tend to be the most complex. Therefore, the ultimate criteria used were AIC and BIC scores, which are also maximum likelihood statistics but include a penalty for models with a higher number of variables (Park and Vollmer 2003).

Table 2.2 Criteria for assessing goodness of fit for Poisson and Negative binomial models. A ratio of either Deviance or Pearson statistics to degrees of freedom that is greater than one indicates that the data are overdispersed relative to the model. Therefore, the negative binomial model is a better fit to the data.

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<th>Model</th>
<th>Response variable</th>
<th>Degrees of freedom (DF)</th>
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<th>Deviance/DF</th>
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<th>Pearson/DF</th>
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<td>Poisson</td>
<td>Plot richness</td>
<td>211</td>
<td>374.5</td>
<td>1.8</td>
<td>355.2</td>
<td>1.7</td>
</tr>
<tr>
<td>Negative binomial</td>
<td>Plot richness</td>
<td>211</td>
<td>229.6</td>
<td>1.1</td>
<td>212.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>

During examination of plant communities at increasing distances from the high water mark, both field observations and species counts indicated that quantifiable differences might exist in community composition at the slope base, relative to other locations in the floodplain. To test for this, ordination of plots was performed for each site separately, using non-metric multi-dimensional scaling (NMDS) with the PC-ORD software package. Graphs of these ordinations were examined to see if the plots at the slope base grouped apart from the others.

**Results**

*Patterns in species richness*

The total number of species per site ranged from 92 to 156 (Fig. 2.3). Floodplains of large streams had significantly higher species richness than those of small streams, with a mean of 142 species for large stream sites and of 102 species for small stream sites. (T-test, assuming unequal variances, $p = .02$). Site species richness shows no correlation with mean transect length, indicating that there is no relationship between site area and species richness (Pearson correlation coefficient = -.073).
Plot species richness showed no linear relationship with relative plot position on the floodplain nor with absolute distance from the high water mark (Pearson correlation coefficients = -.06, -.07, and respectively, with p >.2). Plot species richness had a strong negative correlation with soil moisture (Pearson correlation coefficient = -.42, p <.001) and a slight positive correlation with canopy cover (Pearson correlation coefficient =.15, p =.03).

The distribution of plot species richness was best estimated by the negative binomial distribution (Table 2.3), with four effects included in the model. The effects that have important influence on species richness are stream order (large or small), log-transformed soil moisture, canopy cover, and an interaction effect of log soil moisture by stream order. Percent soil moisture was log transformed for regression analysis because its distribution was skewed to the left and because it was significantly correlated with plot species richness (Park and Vollmer 2003). The model is:

$$\log(\mu_{sp}) = 4.2 - .54(\text{stream size}) - .25(\log\text{soil}) - .01(\text{canopy}) + .38(\text{stream size*logsoil})$$

Where $\mu_{sp}$ = mean plot species richness, and stream size is either 0 (small) or 1 (large). All coefficients in the model are significantly different from zero (Table 2.4). The model shows that the variables of stream size and the interaction term have the greatest effect on species richness. Canopy cover has a small effect.
The interaction term indicates that soil moisture affects species richness differently on small and large stream floodplains. Neither the absolute or relative distance of the plot from the high water mark are important to the model; they have no significant effect on plot species richness. Hence, the location of the plot does not contribute to the variation of species richness across the floodplain.

Since the effect of site is not an important factor in the best fitting model, and sites on similar size streams show similar patterns in species richness, all further results are grouped according to stream size, rather than presented for each individual site. However, in the regression analysis the effect of site did have some relationship to species richness, because in mixed-effects models random variation due to site was a significant factor (Park and Vollmer 2003).

**Table 2.3** Maximum likelihood AIC and BIC scores for models used in regression analysis. Lower scores reflect a better fit to the data. ¹Random effects due to variation among sites. ²Random effects due to variation among sites and to spatial autocorrelation among plots that is assumed to be the same at all sites. ³Random effects due to spatial autocorrelation among plots that varies with site.

<table>
<thead>
<tr>
<th>Model name</th>
<th>Maximum Likelihood Statistic</th>
<th>AIC Score</th>
<th>BIC score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poisson</td>
<td>167.8</td>
<td>184.7</td>
<td></td>
</tr>
<tr>
<td>Negative binomial</td>
<td>92.2</td>
<td>112.4</td>
<td></td>
</tr>
<tr>
<td>Fixed effects</td>
<td>450.6</td>
<td>470.8</td>
<td></td>
</tr>
<tr>
<td>Mixed effects</td>
<td>450.6</td>
<td>449.3</td>
<td></td>
</tr>
<tr>
<td>Mixed effects²</td>
<td>452.3</td>
<td>450.8</td>
<td></td>
</tr>
<tr>
<td>Mixed effects³</td>
<td>447.4</td>
<td>443.8</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2.4** P-values for variables of the Negative binomial model.

<table>
<thead>
<tr>
<th>Response variable</th>
<th>Effect</th>
<th>Degrees of freedom</th>
<th>Chi-square</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot richness</td>
<td>Stream size</td>
<td>1</td>
<td>15.74</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Log of soil</td>
<td>1</td>
<td>4.83</td>
<td>.028</td>
</tr>
<tr>
<td></td>
<td>moisture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canopy cover</td>
<td>1</td>
<td>4.73</td>
<td>.030</td>
</tr>
<tr>
<td></td>
<td>Log soil*</td>
<td>1</td>
<td>39.68</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>stream size</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Species richness within increasing floodplain widths

Figure 2.4 shows the percent of total species richness sampled within increasing floodplain widths. For a hypothetical buffer zone, the percent of floodplain to be protected can be used to extrapolate the percent of riparian species that would be included within that buffer zone. For example, if a riparian buffer were to be established that protected half of the floodplain, it would include approximately 88% of the total species in the small stream sites, and approximately 81% of the species in the large stream sites (Fig. 2.4). This corresponds to a buffer width that averages from 18-23 m (60-75 ft.) for small stream floodplains, and from 16-36 m (52-120 ft.) for large stream floodplains. To include 90% of the total species, at least 60% of the floodplain would have to be protected along small streams (25 m on average, or 81 ft.), and 75% of the floodplain along large streams (36 m on average, or 117 ft.). These estimates do not account for any edge effects that would occur after disturbance outside of the buffer zone.

A high percentage of species occur in plots at the high water mark—an average of 65% and of 42% along small and large streams, respectively. However, new species are encountered across the entire floodplain width. The rate of increase slows towards the middle of the floodplain, but rises again near the slope base. This is different from an expected species-area curve within a homogeneous habitat, where rate of change levels off to zero (Hopkins 1957), and indicates that differences in the floodplain plant community exist near the slope base.
Figure 2.4 Change in percent of total species richness within increasing floodplain width, averaged for large and small stream sites with standard error bars.

Plant community composition

Floodplains of large and small stream sites had similar distributions of vegetation types (Fig. 2.5). Forbs constituted the greatest number of species, followed by trees and shrubs. Graminoids had a relatively low representation when compared to these first two groups, with numbers closer to those of vine species. Pteridophytes had the lowest species richness.

When examining changes in species richness across the floodplain, there is no apparent difference in pattern among the different vegetation types (Fig. 2.6).

Figure 2.5 Floodplain community composition based on vegetation types. Values are averaged for large and small stream sites, with standard error bars.
Exotic species did not comprise a large part of the plant communities. A total of only seven exotic species were found for all study sites combined (Tables 2.4 and 2.5). Small stream floodplains were nearly devoid of exotic species, except for *Lonicera japonica* (Japanese honeysuckle) which was sampled at one small stream site, and *Microstegium vimineum* (Japanese Rain-grass) which was sampled on two small stream sites. These two species occur in high plot frequencies on large stream sites. The remaining five exotic species occur only on large stream sites in low frequency.
Table 2.5  Plot frequencies of exotic species for all sites. Frequencies for the most abundant exotic species, *Lonicera japonica* and *Microstegium vimineum*, are also listed.

<table>
<thead>
<tr>
<th>Site</th>
<th>Stream size</th>
<th>All exotics</th>
<th><em>Lonicera japonica</em></th>
<th><em>Microstegium vimineum</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>EHF</td>
<td>small</td>
<td>.25</td>
<td>.00</td>
<td>.25</td>
</tr>
<tr>
<td>ERR</td>
<td>small</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>WC</td>
<td>small</td>
<td>.19</td>
<td>.11</td>
<td>.11</td>
</tr>
<tr>
<td>EA</td>
<td>large</td>
<td>.94</td>
<td>.86</td>
<td>.69</td>
</tr>
<tr>
<td>RAM</td>
<td>large</td>
<td>.83</td>
<td>.56</td>
<td>.69</td>
</tr>
<tr>
<td>RRT</td>
<td>large</td>
<td>.81</td>
<td>.72</td>
<td>.17</td>
</tr>
<tr>
<td>All small stream</td>
<td></td>
<td>.15</td>
<td>.04</td>
<td>.12</td>
</tr>
<tr>
<td>All large stream</td>
<td></td>
<td>.86</td>
<td>.75</td>
<td>.52</td>
</tr>
</tbody>
</table>

Table 2.6  Plot frequencies for the least abundant exotic species sampled. These species occur only on large stream sites.

<table>
<thead>
<tr>
<th>Exotic species</th>
<th>Site</th>
<th>Plot frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cardamine hirsuta</em></td>
<td>RAM</td>
<td>.11</td>
</tr>
<tr>
<td><em>Dioscorea batatas</em></td>
<td>EA</td>
<td>.11</td>
</tr>
<tr>
<td><em>Glechoma hederacea</em></td>
<td>EA</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td>RAM</td>
<td>.06</td>
</tr>
<tr>
<td><em>Ligustrum sinense</em></td>
<td>RRT</td>
<td>.03</td>
</tr>
<tr>
<td><em>Stellaria media</em></td>
<td>EA</td>
<td>.42</td>
</tr>
<tr>
<td></td>
<td>RAM</td>
<td>.03</td>
</tr>
</tbody>
</table>

Frequencies of *L. japonica* and *M. vimineum* do not show any pattern relative to plot position on the floodplain for either large or small stream sites (Fig. 2.7). Other exotic species occurred in numbers that were too small to analyze changes in frequency with distance from the high water mark.
Figure 2.7 Average changes in the frequencies of the two most abundant exotic species, *Lonicera japonica* and *Microstegium vimineum*, with increasing distance from the high water mark. Both species are present on all large stream sites. *Lonicera japonica* is present on one small stream site, and *Microstegium vimineum* is present on two large stream sites.

Patterns in soil moisture and canopy cover

Relative plot position on the floodplain correlated with soil moisture (Pearson correlation coefficient = .32, p<.001), but absolute distance from the high water mark had no relationship to soil moisture (Pearson correlation coefficient = .10, p=.2). This provides evidence that that the location of a microhabitat relative to the stream channel and slope base, may be more important in determining local environmental conditions than the absolute distance of a microhabitat from the high water mark. Standardizing the plot positions relative to the high water mark is thus a valid design for sampling riparian plant communities. There was no correlation between canopy cover and either measure of distance.

Large stream floodplains tend to be drier than small stream floodplains, but the dominant pattern in soil moisture across the floodplain is the same for all streams but one (Figs. 2.8 and 2.9). Soil at the high water mark is drier than at the slope base. The increase in soil moisture across the floodplain at small stream sites is dramatic. This trend is explained by field observations. The stream banks where the high water mark occurs are often steep, and are separated from the water level during normal flows. The soil there is sandy and often excessively well-drained, especially along higher order streams in this
region. Across the floodplain, there are notable dips in the topography and the soil increases in organic matter and clay content. At the slope base are frequently depressions that hold precipitation, or shallow groundwater seeps. At most sites, these depressions had standing water or were saturated throughout the sampling period. Notably fewer plant species grew in saturated plots, and tended to be different species than those on higher elevation plots.

Canopy cover was greater on small stream floodplains than large stream floodplains (Fig. 2.10). As indicated by the correlation coefficient above, there is no evident pattern in canopy cover across the floodplain.

**Figure 2.8** Changes in percent soil moisture across small stream floodplains, averaged across transects.

**Figure 2.9** Changes in percent soil moisture across large stream floodplains, averaged across transects.
Patterns in soil moisture near the slope base could partially explain the appearance of new species there. In addition, a particularly rich plant community was often observed on the hillslope above the floodplain. The transition zone between hillslope and floodplain communities was generally not distinct; hillslope species occurred onto the floodplain. This effect could also contribute to the addition of new species at the slope base. If a different plant community is indeed occurring, graphs of plot ordinations will demonstrate grouping of the slope base plots apart from the others.

Ordination graphs resulted in mixed evidence for transitional plant communities at the slope base. For small stream sites, only one site (ERR) demonstrates distinct species composition of the plots at the slope base, with an $R^2$ value of .735 for the axes shown in the ordination graph (Fig. 2.11). Another small stream site (EHF) shows slight grouping of four of the slope base plots ($R^2 = .591$), while the third (WC) shows no pattern in plot species composition ($R^2 = .655$). For large stream sites, again there is one site (EA) that has a distinct plant community at the slope base ($R^2 = .439$). Plots at this site also show a fairly smooth transition in species composition across the floodplain. The remaining two large stream sites show either separation (RAM) or grouping (RRT) of some plots at the slope base, which indicates plant
community differences at the slope base for some transects. Ordination plots at the large stream sites also demonstrate that plots at the high water mark have a clear difference in species composition from other plots. This is likely due to the very sandy soil and sharp break in the canopy that occurs at the high water mark along the high order rivers.

**Discussion**

This study has strong implications for riparian buffer zone planning. For one, patterns in plant species richness are significantly different between floodplains of high and low order streams. When determining how wide a riparian buffer should be in order to capture a representative sample of the plant community, high and low order streams should be surveyed separately. Since regression analysis shows some variation in richness due to variation among sites, it may be advisable to survey species richness in potential riparian buffer zones on a site to site basis if resources are available. Nonetheless, stream size is the more important factor in estimating plant species richness. Adequate riparian buffer planning for plant species conservation may be able to be developed based on stream order for streams in this geographical region.

Other studies have found differences in plant species richness among different stream orders. Nilsson et al. (1989) sampled plants on river banks from the headwaters to the lower reaches of two rivers in Sweden. They found that native species richness was highest along the middle river reaches. Planty-Tabacchi et al. (1996) found a similar pattern in floodplain species richness along the Ardour river in France. These effects have been attributed to the intermediate-disturbance hypothesis, suggesting that mid-reaches of rivers undergo disturbance in the flow regime at a frequency that encourages higher habitat heterogeneity (Nilsson et al. 1989, Tabacchi et al. 1998, Tabacchi and Tabacchi 2001). However, indirect measures of disturbance along these rivers indicated the presence of complex environmental gradients without one dominant effect on plant species richness (Nilsson et al. 1989).
Figure 2.11 Ordination of plots, based on species composition, for each site. The proportion of variation in species composition that is explained by the ordination axes ($R^2$) is indicated on each graph. The plot position on the floodplain is indicated by the graph symbol. A transitional community at the slope base is most evident at sites ERR and EA, where these plots (labeled 100) cluster together or apart from plots at other floodplain positions.
In the Upper Etowah watershed, 5th and 6th order stream floodplains have higher plant species richness than 2nd order stream floodplains. Relative to larger rivers such as the Mississippi, which is a 10th order river (Brinson 1993), the large streams in this study can be considered as mid-order streams. However, measures of environmental variables on these sites do not indicate that the large stream floodplains have greater habitat heterogeneity than the small stream floodplains. Under current land use conditions in the study area, small streams have greater freedom for lateral movement, which is evidenced by frequent side channels and depressions along small streams in the study area. This, in combination with the wide range in percent soil moisture seen on small stream sites, implies that low order stream floodplains can have high habitat heterogeneity as well as larger stream floodplains.

Ruderal species and weedy exotic species have been shown to increase with distance downstream along rivers (Nilsson et al. 1989, Tabacchi and Tabacchi 2001). Exotic species richness has been shown to correlate with habitat heterogeneity, natural disturbance, and warming of climate from upstream to downstream, but human impact on the surrounding landscape is also implicated in their increase (Nilsson et al. 1989, Tabacchi and Tabacchi 2001). In this study, exotic species richness was greater on large stream sites, but exotics were never a large component of the sampled communities. In addition, community composition among all sites was similar. This is in contrast to species composition along the Ardour River, where exotics comprised approximately 23% of total species richness and community composition changed with distance downstream (Tabacchi and Tabacchi 2001).

Thus between large and small stream floodplains of this study, differences in species richness are not likely due to differences in habitat heterogeneity nor in abundance of exotic species. One possibility is that differences in surrounding land use and topography have contributed to changes in species richness. Upland areas surrounding all study sites have been used for resource extraction (WRD 2003, McClure 2003, D. Vaughters pers. com.), but steeper topography of the small stream sites has prevented their use for intensive agriculture and kept them relatively isolated (WRD 2003). The three large stream sites are within one tract of public forest and have been managed similarly. During the past century, this forest has undergone a wide range of human uses—for agriculture, government research, recreation, and
timber harvest (McClure 2003). This array of land uses likely introduced propagules, habitat changes, and greater opportunity for invasion by new, if not necessarily exotic, plant species.

A second implication of this study is that, for flat floodplains along streams of this geographical region, it has estimated the percent of the plant community that can be captured within buffer zones of different widths. The buffer zone widths found to capture 90% of the plant species are greater than recommended by Spackman and Hughes (1995) for preserving an equivalent percentage of plant species along 3rd order streams in Vermont.

More importantly, this study documents that plant communities are not static across the floodplain. New species are found across the entire floodplain, and there is evidence that a transition between toe-slope and floodplain communities occurs near the upland slope base. In general, this result is not new; patchiness in riparian plant communities is well documented (Decocq 2002, Gregory et al. 1991, Naimen et al. 1993, Nilsson et al. 1989, Tabacchi et al. 1998, Williams et al. 1999). However, in the context of riparian buffer design it is important to know that the floodplain species composition tends to be unique at the slope base and also at the high water mark, as demonstrated by the rate of increase in species across the floodplain and by ordination analysis. Also important are field observations of rich communities, often with sensitive species, occurring on the hillslope above the floodplain. When conservation of plant biodiversity is a goal of riparian buffer design, all of these areas should be protected.

Beyond setting aside space for these plant communities, their conservation depends on the presence of appropriate habitats and the processes which form these habitats, such as groundwater movement, stream migration, and flooding regime (Tabacchi et al. 1998). In this study, soil moisture influences plant species richness, and likely contributes to changes in community composition across the floodplain (Menges and Waller 1983). Changes in canopy cover are only slightly correlated with species richness, and do not seem to influence community composition across the floodplain. These results echo those of Williams et al. (1999) who found that ground-layer species richness in riparian forests was influenced by quantity of flooding but not by canopy cover.
In general, shallow groundwater is important to the maintenance of soil moisture for riparian species when precipitation levels are low (Tabacchi et al. 1998). During the sampling season, a drought year, the moisture in depressional areas on the floodplains did not originate from the river channel—the river water level was below the floodplain. Thus it was likely that storage of overland run-off or shallow groundwater seeps contributed to increases in soil moisture near the upland slope base. This demonstrates a clear hydrological connection of the riparian zone to the slope and upland ridge that define the profile of the stream drainage. The structure of this connection, in terms of variables such as slope, soil type and texture, influences the source and the rate of upland water supply to the riparian zone (Winter 1998). When uplands that are contiguous to wetlands are modified, by actions such as road construction, surface water storage or vegetation alteration, this hydrologic system can be impacted (Winter 1998).

Therefore, to maintain riparian plant habitat integrity, the recommended buffer zone would not be of a defined numerical width. Instead, it would include the entire topographical profile from the ridge-top of the adjacent hillslope to the margin of the river channel. Such an area would be easily delineated from topographical maps or aerial photographs. Economic and land-use constraints may not allow for a protected buffer zone of this extent to be implemented along most streams. However, where plant biodiversity protection is a goal, surveys can easily indicate which riparian plant communities merit greater protection than others. Application of this study may be most feasible in areas where the management infrastructure is established to value natural resources, such as in designation of parks, greenways, and state-owned lands.
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APENDIX A

Annotated list of the vascular flora of the Upper Etowah River watershed. Species are arranged by division, following USDA (2002), and alphabetically by family, genus and species. Familial concepts follow USDA (2002), except for families of the Liliales which follow Weakley (2000). Nomenclature for the genus *Aster* s.l. is taken from Weakley (2000), all other nomenclature follows USDA (2002). Non-native species are indicated by an * following the name of the taxon and its author. D= Dawson County record and L= Lumpkin County record, based on specimens accessioned in the University of Georgia Herbarium, Athens, GA. Lastly, the habitat codes are listed for where each plant was found within the study area. A key to the codes is given at the end of the list. Habitats marked with the † symbol are recently or severely disturbed. Although subjective, the number of habitat codes for a species gives a picture of its overall abundance and range among the study sites.

**LYCOPODIOPHYTA**

**LYCOPODIACEAE**

*Diphasiastrum digitatum* (Dill. ex A. Braun) Holoub
M1-WTR, M1-FRT, M2-OPH

*Huperzia lucidula* (Michx.) Trevisan D M1-WTR

*Lycopodium obscurum* L. D L M1-FRT

**DENNSTAEDTIACEAE**

*Pteridium aquilinum* (L.) Kuhn. M2-OPH, X2-OPH

**DRYOPTERIDACEAE**

*Onoclea sensibilis* L. H-DS, M1-FRT

**ASPLENIACEAE**

*Asplenium platyneuron* (L.) B.S.P. M1-FRT, M1-OHE, M1-OPH, M2-OPH, M1-RB, M2-PE, M2-EHB, X-RB

*Asplenium trichomanes* L. ssp. *trichomanes* M1-RB

**BLECHNACEAE**

*Woodwardia aureolata* (L.) T. Moore H-DS

**DENNSTAEDTIACEAE**

*Pteridium aquilinum* (L.) Kuhn. M2-OPH, X2-OPH

**DRYOPTERIDACEAE**

*Onoclea sensibilis* L. H-DS, M1-FRT

*Dryopteris marginalis* (L.) Gray M1-RB, M2-EHB

*Onoclea sensibilis* L. H-DS, M1-FRT

*Polystichum acrostichoides* (Michx.) Schott M1-WTR, M1-FRT, M1-OPH, M2-OPH, M2-PE

**OPHIOGLOSSACEAE**

*Botrychium biternatum* (Sav.) Underwood H-DS, M1-WTR, M1-FRT
Botrychium virginianum (L.) Sw. M1-WTR, M1-FRT
Ophioglossum vulgatum L. var. pycnostichum Fern. D M1-WTR

**OSMUNDACEAE**
Osmunda cinnamomea L. H-DS, M1-WTR
Osmunda regalis L. H-DS, M1-WTR

**POLYPODIACEAE**
Pleopeltis polypodioides (L.) Andrews & Windham M2-RB
Polypodium virginianum L. M2-RB

**PTERIDACEAE**
Adiantum pedatum L. M1-WTR, M1-HW, M1-OPH
Cheilanthes lanosa (Michx.) D.C. Eaton X-RB
Pellaea atropurpurea (L.) Link. D X-RB

**THELYPTERIDACEAE**
Phegopteris hexagonoptera (Michx.) Fée M1-WTR, M1-HW
Thelypteris noveboracensis (L.) Nieuwl. M1-WTR, M1-FRT

**CONIFEROPHYTA**

**PINACEAE**
Pinus strobus L. M1-WTR, M1-FRT, M1-OHE, M1-OPH, M2-OPH, M1-RB, M2-PE, M2-EHB
Pinus taeda L. M1-FRT, M1-OPH, M2-OPH
Pinus virginiana P. Mill. M1-WTR, M1-FRT, M1-OPH, M2-OPH, M2-EHB, X2-OPH, X-RB
Tsuga canadensis (L.) Carr. M1-WTR, M1-FRT, M1-OHE, M1-RB, M2-PE

**MAGNOLIOPHYTA**

**LILIOPSIDA**

**AGAVACEAE**
Yucca flaccida Haworth X-RB

**ALISMATACEAE**
Sagittaria latifolia Willd. var. latifolia L H-CS, H-RS

**ALLIACEAE**
Allium canadense L. var. canadense M1-WTR, M1-FRT

**AMARYLLIDACEAE**
Hymenocallis caroliniana (L.) Herbert D MI-FRT, MI-OPH

**ARACEAE**
Arisaema dracontium (L.) Schott H-DS, M1-FRT
Arisaema triphyllum (L.) Schott H-DS, M1-WTR, M1-FRT

**CHIONOGRAPHIDACEAE**
Chamaelirium luteum (L.) Gray M1-OHE, M1-OPH

**COLCHICACEAE**
Uvularia perfoliata L. M1-WTR, M1-HW, M1-OPH

**COMMELINACEAE**
Commelina communis L. * M1-WTR, M1-FRT
Commelina virginica L. M1-FRT
Murdannia keisak (Hassk.) Hand.-Mazz.* H-CS, M1-FRT

**CONVALLARIACEAE**
Maianthemum racemosum Desf. M1-WTR, M1-FRT, M1-OPH, M1-RB
Polygonatum biflorum (Walt.) Ell. M1-WTR, M1-FRT, M1-HW, M1-RB, X-RB

**CYPERACEAE**
Bulbostylis capillaris (L.) Kunth ex. C.B. Clarke X2-RB
Carex abscondita Mack. D L M1-WTR, M1-FRT, M1-OPH
Carex amphibola Steud. H-SRB, M1-FRT
Carex atlantica Bailey H-DS, M1-WTR, M1-FRT
Carex atlantica Bailey ssp. capillacea (Bailey) Reznicek M1-WTR
Carex austrocaroliniana Bailey D M1-WTR, M1-HW, M1-OPH
Carex blanda Dewey D L H-SRB, M1-WTR, M1-FRT, M1-HW, M1-OPH
Carex comminis Bailey var. amplisquama (F.J. Hermann) J. Rettig M1-FRT
Carex crebriflora Weig. H-SRB, M1-WTR, M1-FRT, M1-OPH
Carex crinita Lam. var. crinita L H-SRB, H-DS, M1-WTR, M1-FRT
Carex cumberlandensis Naczi, Kral, & Bryson D L M1-WTR, M1-FRT
Carex debilis Michx. var. debilis H-DS, M1-WTR, M1-FRT
Carex debilis Michx. var. rudgei Bailey M1-WTR, M1-FRT
Carex frankii Kunth. D H-RS
Carex gracilescens Steud. L M1-WTR
Carex gynandra Schwein. D L H-DS, H-BP, M1-WTR
Carex intumesens Rudge H-DS, H-BP, M1-WTR, M1-FRT
Carex laxiculmis Schwein. M1-FRT
Carex laxiflora Lam. var. laxiflora H-DS, M1-WTR, M1-FRT, M1-RB
Carex leptalea Wahl. H-DS
Carex lucorum Willd. ex Link var. austrolucorum J. Rettig D L M1-WTR
Carex lurida Wahlenb. H-DS, H-BP, M1-WTR
Carex manhartii Bryson D M1-WTR
Carex mitchelliana M.A. Curtis D H-DS, M1-WTR
Carex nigromarginata Schweinitz. M2-OPH
Carex pensylvanica Lam. D L M1-WTR, M1-FRT, M1-HW, M1-OPH
Carex platyphylla Carey D L M1-WTR
Carex prasina Wahl. D H-DS, M1-WTR
Carex radiata (Wahl.) Small D M1-FRT
Carex retroflexa Muhl. ex Willd H-SRB, M1-FRT
Carex rufii Mack. D L H-DS
Carex scabrata Schwein. H-CS
Carex striatula Michx. H-SRB, M1-FRT
Carex styloflexa Buckley H-RS, H-SRB, M1-WTR, M1-FRT
Carex swanii (Fern.) Mack. D L M1-FRT
Carex torta Boott ex Tuckerman H-CS, H-RS
Carex tribuloides Wahlenb. H-CS, M1-FRT
Carex virens Muhl. ex Willd. D M1-WTR, M1-FRT
Carex vulpinoidea Michx. H-CS
Cyperus flavescens L. H-CS
Cyperus strigosus L. H-CS, H-RS, H-BP
Eleocharis obtusa (Willd.) J.A. Schultes H-DS, H-BP
Fimbristylis autumnalis (L.) R. & S. H-CS
Kyllinga pumila Michx. L H-CS
Rhynchospora capitellata (Michx.) Vahl. H-CS, H-RS, M1-FRT
Rhynchospora glomerata (L.) Vahl. var. glomerata H-CS, H-RS, M1-FRT
Schoenoplectus purshianus (Fern.) M.T. Strong H-CS, H-DS, H-BP
Scirpus eperinum (L.) Kunth H-CS
Scleria oligantha Michx. M1-OPH
DIOSCOREACEAE
Dioscorea oppositifolia L.* L M1-FRT†
Dioscorea quaternata J.F. Gmel. M1-WTR, M1-FRT, M1-OPH
Dioscorea villosa L. var. villosa M1-WTR, M1-FRT, M1-OPH
HYDROCHARITACEAE
Vallisneria americana Michx.  D AQUATIC

HYPOXIDACEAE
Hypoxis hirsuta (L.) Coville  M1-WTR, M1-OPH, M2-OPH

IRIDACEAE
Iris cristata Ait.  M1-WTR, M1-FRT, M1-OPH
Iris verna L. var. smalliana Fern. ex M.E. Edwards  D M1-FRT
Sisyrinchium angustifolium P. Mill.  M1-FRT, M2-OPH
Sisyrinchium atlanticum Bickn.  M1-FRT, M2-OPH
Sisyrinchium nashii Bickn.  M1-WTR, M2-OPH

JUNCACEAE
Juncus coriaceus Mack.  H-CS, H-BP
Juncus debilis Gray  H-CS, H-DS, H-BP
Juncus gymnocarpus Coville  H-CS
Juncus tenuis Willd.  H-DS, M1-WTR, M1-FRT
Juncus validus Coville var. validus  L H-CS
Luzula acuminata Raf. var. acuminata  M1-WTR, M1-FRT
Luzula acuminata Raf. var. carolinae (S. Wats) Fern.  M1-WTR
Luzula echinata (Small) F.J. Herm.  M1-WTR, M1-FRT, M1-OPH

LILIACEAE
Clintonia umbellulata (Michx.) Morong.  M1-WTR, M1-HW
Disporum lanuginosum (Michx.) Nicholson  M1-HW
Erythronium umbilicatum Parks & Hardin  M1-WTR
Lilium superbum L.  H-RS, M2-OPH, M1-RB
Medeola virginiana L.  M1-WTR, M1-OHE, M1-HW

MELANTHIACEAE
Amianthium muscitoxicum (Walt.) Gray  M1-WTR
Stenanthium gramineum (Ker-Gawl.) Morong var. micranthum Fern.  M1-OPH
Veratrum parviflorum Michx.  M1-HW, M1-OPH
Xerophyllum asphodeloides (L.) Nutt.  M2-EHB, M1-FRT

NARTHECIACEAE
Aletris farinosa L.  M1-WTR, M2-OPH

ORCHIDACEAE
Corallorhiza odontorhiza (Willd.) Nutt.  L M1-OPH
Cypripedium acaule Ait.  D M1-OHE, M2-OPH, X2-OPH
Cypripedium pubescens Willd. var. pubescens  D L M1-OPH
Galearis spectabilis (L.) Raf.  M1-WTR
Goodyera pubescens (Willd.) R.Br. ex Ait. f.  M1-WTR, M1-OHE, M1-OPH
Platanthera ciliaris (L.) Lindl.  M1-WTR, M2-OPH
Platanthera clavellata (Michx.) Luer.  H-DS
Spiranthes ovalis Lindl. var. erostellata Catling  D M1-WTR
Tipularia discolor (Pursh.) Nutt. M1-WTR, M1-FRT, M1-OPH, M2-OPH

POACEAE
Agrostis hyemalis (Walt.) B.S.P.  M2-OPH
Agrostis perennis (Walt.) Tuckerm.  H-CS, M1-WTR
Andropogon gerardi Vitman.  M2-OPH
Andropogon virginicus L.  M1-OPH†, M2-OPH, X2-OPH, X-RB
Anthraxon hispidus (Thunb.) Makino*  H-CS
Aristida purpurascens Poiret. var. virginicus  X-RB
Arundinaria gigantea (Walt.) Muhl.  H-SRB, M1-WTR, M1-FRT, M1-OPH
Brachyelytrum erectum (Schreb. ex. Spreng.) Beauv. H-SRB, M1-WTR, M1-FRT
Chasmanthium latifolium (Michx.) Yates  H-SRB, M1-FRT
Chasmanthium laxum (L.) Yates  H-SRB, M1-WTR, M1-FRT, M1-OPH, M2-OPH
Chasmanthium sessiliflorum (Poir.) Yates  H-SRB, M1-FRT, M1-OPH
Cinna arundinacea L.  H-DS, M1-WTR
Dactylis glomerata L.*  M1-FRT
Danthonia compressa Austin ex Peck  M1-FRT
Danthonia sericea Nutt.  X-RB
Danthonia spicata (L.) Beauvois ex Roemer & J.A. Schultes  M1-FRT, M2-OPH, X-RB
Dichanthelium boscii (Poir.) Gould & Clark  M1-WTR, M1-FRT
Dichanthelium clandestinum (L.) Gould  H-CS, M1-FRT
Dichanthelium commutatum (Schultes) Gould  H-SRB, M1-WTR, M1-FRT, M1-HW, M1-OPH, M2-OPH, X2-OPH
Dichanthelium dichotomum (L.) Gould  H-CS, H-SRB, M1-WTR, M1-FRT, M1-OPH, M2-OPH
Dichanthelium laxiflorum (Lam.) Gould  H-SRB, M1-FRT
Dichanthelium ravenelii (Scribn. & Merr.) Gould  X-RB
Dichanthelium sphaerocarpon (Ell.) Gould var. sphaerocarpon  X-RB
Dichanthelium sphaerocarpon (Ell.) Gould var. isophyllum (Scribn.) Gould & C.A. Clark  H-RS, M1-FRT, M2-OPH
Dichanthelium villosissimum (Nash) Freck var. villosissimum  X-RB
Digitaria ischaemum (Schreber) Schreber ex Muhl.* var. ischaemum  M1-FRT†
Digitaria sanguinalis (L.) Scopoli*  FP
Echinochloa crus-galli (L.) Beauv.  H-CS, M1-FRT
Eleusine indica (L.) Gaertn.*  M1-FRT
Elymus virginicus L.  H-SRB, M1-FRT
Festuca subverticillata (Pers.) Alexeev  M1-FRT
Glyceria striata (Lam.) A.S. Hitchcock var. striata  H-CS, H-DS
Holcus lanatus L.*  M1-FRT
Leersia oryzoides (L.) Swartz  H-CS
Leersia virginica Willd.  H-DS, M1-WTR
Lolium arundinaceum (Schreb.) S.J. Darbyshire* H-CS, M1-WTR, M1-FRT†
Danthonia compressa Austin ex Peck  M1-FRT
Danthonia sericea Nutt.  X-RB
Danthonia spicata (L.) Beauvois ex Roemer & J.A. Schultes  M1-FRT, M2-OPH, X-RB
Dichanthelium boscii (Poir.) Gould & Clark  M1-WTR, M1-FRT
Dichanthelium clandestinum (L.) Gould  H-CS, M1-FRT
Dichanthelium commutatum (Schultes) Gould  H-SRB, M1-WTR, M1-FRT, M1-HW, M1-OPH, M2-OPH, X2-OPH
Dichanthelium dichotomum (L.) Gould  H-CS, H-SRB, M1-WTR, M1-FRT, M1-OPH, M2-OPH
Dichanthelium laxiflorum (Lam.) Gould  H-SRB, M1-FRT
Dichanthelium ravenelii (Scribn. & Merr.) Gould  X-RB
Dichanthelium sphaerocarpon (Ell.) Gould var. sphaerocarpon  X-RB
Dichanthelium sphaerocarpon (Ell.) Gould var. isophyllum (Scribn.) Gould & C.A. Clark  H-RS, M1-FRT, M2-OPH
Dichanthelium villosissimum (Nash) Freck var. villosissimum  X-RB
Digitaria ischaemum (Schreber) Schreber ex Muhl.* var. ischaemum  M1-FRT†
Digitaria sanguinalis (L.) Scopoli*  FP
Echinochloa crus-galli (L.) Beauv.  H-CS, M1-FRT
Eleusine indica (L.) Gaertn.*  M1-FRT
Elymus virginicus L.  H-SRB, M1-FRT
Festuca subverticillata (Pers.) Alexeev  M1-FRT
Glyceria striata (Lam.) A.S. Hitchcock var. striata  H-CS, H-DS
Holcus lanatus L.*  M1-FRT
Leersia oryzoides (L.) Swartz  H-CS
Leersia virginica Willd.  H-DS, M1-WTR
Lolium arundinaceum (Schreb.) S.J. Darbyshire* H-CS, M1-WTR, M1-FRT†
Danthonia compressa Austin ex Peck  M1-FRT
Danthonia sericea Nutt.  X-RB
Danthonia spicata (L.) Beauvois ex Roemer & J.A. Schultes  M1-FRT, M2-OPH, X-RB
Dichanthelium boscii (Poir.) Gould & Clark  M1-WTR, M1-FRT
Dichanthelium clandestinum (L.) Gould  H-CS, M1-FRT
Dichanthelium commutatum (Schultes) Gould  H-SRB, M1-WTR, M1-FRT, M1-HW, M1-OPH, M2-OPH, X2-OPH
Dichanthelium dichotomum (L.) Gould  H-CS, H-SRB, M1-WTR, M1-FRT, M1-OPH, M2-OPH
Dichanthelium laxiflorum (Lam.) Gould  H-SRB, M1-FRT
Dichanthelium ravenelii (Scribn. & Merr.) Gould  X-RB
Dichanthelium sphaerocarpon (Ell.) Gould var. sphaerocarpon  X-RB
Dichanthelium sphaerocarpon (Ell.) Gould var. isophyllum (Scribn.) Gould & C.A. Clark  H-RS, M1-FRT, M2-OPH
Dichanthelium villosissimum (Nash) Freck var. villosissimum  X-RB
Digitaria ischaemum (Schreber) Schreber ex Muhl.* var. ischaemum  M1-FRT†
Digitaria sanguinalis (L.) Scopoli*  FP
Echinochloa crus-galli (L.) Beauv.  H-CS, M1-FRT
Eleusine indica (L.) Gaertn.*  M1-FRT
Elymus virginicus L.  H-SRB, M1-FRT
Festuca subverticillata (Pers.) Alexeev  M1-FRT
Glyceria striata (Lam.) A.S. Hitchcock var. striata  H-CS, H-DS
Holcus lanatus L.*  M1-FRT
Leersia oryzoides (L.) Swartz  H-CS
Leersia virginica Willd.  H-DS, M1-WTR
Lolium arundinaceum (Schreb.) S.J. Darbyshire* H-CS, M1-WTR, M1-FRT†
Melica mutica Walt.  M1-FRT, M1-OPH
Microstegium vimineum (Trin.) A. Camus*  M1-WTR, M1-FRT
Miscanthus sinensis Anderss.*  M2-OPH†
Muhlenbergia schreberi J.F. Gmel.  H-RS, M1-FRT
Muhlenbergia sylvatica Torr. ex Gray  M1-FRT
Muhlenbergia tenuiflora (Willd.) B.S.P. var. variabilis (Scribn.) Pohl  M1-WTR
Panicum anceps Michx. var. anceps  H-CS, M1-FRT
Paspalum setaceum Michx.  FP†
Piptochaetium avenaceum (L.) Parodi  M1-FRT, M2-OPH, X-RB
Poa autumnalis Muhl. ex Ell.  M1-WTR, M1-FRT, M1-HW
Poa cuspidata Nutt.  M1-FRT
Poa pratensis L.  M1-WTR†
Poa sylvestris Gray  M1-FRT
Saccharum alopecuroidum (L.) Nutt.  M1-FRT, M2-OPH
Saccharum brevibarbe (Michx.) Pers. var. contortum (Ell.) R. Webster  M2-OPH
Schizachyrium scoparium (Michx.) Nash. var. scoparium  H-RS, M2-OPH, X-RB
Setaria geniculata (Lam.) Beauvois*  FP
Sorghum halepense (L.) Pers.*  FP
Sphenopholis nitida (Biehler) Scribn.  M1-FRT
Sphenopholis obtusata (Michx.) Scribn.  M2-OPH†
Sphenopholis pensylvanica (L.) A.S. Hitchcock
   H-DS, M1-WTR
Tridens flavus (L.) A.S. Hitchcock   H-CS, M1-FRT, FP†
SMILACACEAE
Smilax bona-nox L.   M1-WTR, M1-FRT, M1-OHE, M1-OPH, M2-OPH
Smilax glauca Walt.   M1-WTR, M1-FRT, M1-OHE, M1-OPH, M2-OPH
Smilax hugeri (Small) JBS Norton ex Pennell   D M1-WTR
Smilax laurifolia L.   M1-FRT
Smilax rotundifolia L.   M1-WTR, M1-FRT, M1-OHE, M1-OPH, M2-OPH
Smilax tammoides L.   M1-WTR, M1-FRT
SPARGANIACEAE
Sparganium americanum Nutt.   H-CS, H-BP
TRILLIACEAE
Trillium catesbaei Ell.   M1-WTR, M1-OHE, M1-OPH, M2-OPH
Trillium cuneatum Raf.   M1-FRT, M1-OPH
Trillium rugelii Rendle   D M1-WTR, M1-FRT
Trillium vaseyi Harbison   M1-HW
MAGNOLIOPSIDA
ACANTHACEAE
Ruellia caroliniensis (J.F. Gmel.) Steud.   H-SRB, M1-FRT, M1-OPH
ACERACEAE
Acer leucoderme Small   M1-OPH
Acer negundo L. var. negundo   M1-WTR
Acer rubrum L.   M1-WTR, M1-FRT, M1-OHE, M1-HW, M1-OPH, M2-OPH, M2-EHB
ANACARDIACEAE
Rhus copallinum L.   X-RB
Rhus glabra L.   H-SRB, M2-OPH
Toxicodendron radicans (L.) Kuntze. ssp. radicans   H-SRB, M1-WTR, M1-FRT, M1-OPH, M2-OPH, M1-RB, M2-PE, X-RB
ANNONACEAE
Asimina parviflora (Michx.) Dunal   H-SRB, M1-WTR, M1-FRT, M1-OPH, M2-EHB
Asimina triloba (L.) Dunal   M1-FRT
APIACEAE
Angelica venenosa (Greenway) Fern.   M2-OPH
Cicuta maculata L.   H-RS, H-DS, M1-WTR
Ligusticum canadense (L.) Britt. H-SRB, M1-WTR, M1-FRT, M1-OPH
Daucus carota L.*   M2-OPH
Eryngium yuccifolium Michx.   X2-OPH
Ligusticum canadense (L.) Britt.   M1-WTR, M1-OPH
Oxypolis rigidior (L.) Raf.   H-DS, M1-WTR
Sanicula canadensis L. var. canadensis   M1-WTR, M1-FRT, M1-OPH
Sanicula odorata (Raf.) K.M. Pryer & L.R. Phillippe M1-WTR, M1-HW
Sanicula smallii Bickn.   M1-WTR, M1-OHE, M1-OPH
Thaspium barbinode (Michx.) Nutt.   M1-OPH
Thaspium trifoliatum (L.) A. Gray   M1-OPH
Thaspium trifoliatum (L.) A. Gray var. aureum Britt. M1-OPH
Zizia trifoliata (Michx.) Fern.   M1-OPH
APOCYNACEAE
Amsonia tabernaemontana Walt. var.
   tabernaemontana   M1-FRT
Amsonia tabernaemontana Walt. var. salicifolia (Pursh) Woodson M1-FRT
Vinca minor L.*   M1-OPH
AQUIFOLIACEAE
Ilex ambigua (Michx.) Torr. var. ambigua   M1-OPH
Ilex montana Torr. & A. Gray ex. A. Gray   M1-OPH
Ilex opaca Ait. M1-WTR, M1-FRT, M1-OPH, M2-OPH
Ilex verticillata (L.) A. Gray H-DS

**ARALIACEAE**

Aralia racemosa L. M1-OHE, M1-HW, M1-OPH
Aralia spinosa L. H-SRB, M1-FRT, M2-OPH
Panax quinquefolius L. M1-WTR, M1-HW
Panax trifolius L. M1-WTR

**ARISTOLOCHIACEAE**

Aristolochia serpentaria L. H-SRB, M1-FRT, M1-OPH, M1-RB
Asarum canadense L. M1-HW
Hexastylis arifolia (Michx.) Small M1-OHE, M1-OPH, M2-OPH
Hexastylis heterophylla (Ashe.) Small M1-RB
Hexastylis shuttleworthii (Britten & Baker) Small M1-WTR, M1-OHE, M1-OPH

**ASCLEPIADACEAE**

Asclepias tuberosa L. M2-OPH
Asclepias variegata L. M1-FRT, M1-OPH, X2-OPH
Asclepias verticillata L. X-RB
Matelea carolinensis (Jacq.) Woodson M1-FRT

**ASTERACEAE**

Ageratina altissima (L.) King & H.E. Robins var. altissima M1-WTR, M1-FRT, M1-HW, M1-OPH
Ambrosia artemesiiifolia L. M1-FRT, FP
Antennaria plantaginifolia (L.) Richardson var. plantaginifolia M2-OPH, X2-OPH
Arnoglossum atriplicifolium (L.) H.E. Robins M1-WTR, M1-FRT, M1-OPH
Aster cordifolius L. M1-FRT
Aster divaricatus L. var. divaricatus M1-WTR, M1-FRT, M1-HW, M1-OPH, M1-RB
Aster dumosus L. H-CS, H-SRB, M2-OPH, X2-OPH
Aster lateriflorus (L.) Britt. M1-WTR, M1-FRT
Aster macrophyllus L. M1-OPH
Aster patens Ait. var. patens M1-WTR, M1-OPH

Aster pilosus Willd. var. pilosus H-BP, M1-WTR
Aster puniceus L. H-CS, H-DS, M1-FRT
Aster retroflexus Lindl. ex D.C. M1-WTR, M1-HW, M1-OPH, M2-OPH
Aster sagittifolius Wedem. ex Willd. H-RS, H-SRB, M1-FRT, M1-OPH, M1-RB
Aster surculosus Michx. M2-OPH
Aster undulatus L. M1-OHE, M1-OPH, M2-OPH
Bidens aristosa (Michx.) Britt.* D H-CS, M1-FRT
Bidens bipinnata L. M1-FRT
Bidens frondosa L. M1-FRT
Panax quinquefolius L. M1-WTR
Panax trifolius L. M1-WTR
Aster surculosis Michx. M2-OPH

Cichorium intybus L.* D M1-OPH†

Cirsium altissimum (L.) Hill M2-OPH†
Cirsium vulgare (Savi) Ten.* M1-OHE
Conoclinum coelestinum (L.) D.C. M1-FRT
Conyza canadensis (L.) Cronq. var. canadensis M1-FRT†, FP
Conyza canadensis (L.) Cronq. var. pusilla (Nutt.) Cronq. M1-FRT

Coreopsis auriculata L. M1-WTR
Coreopsis major Walt. M1-OPH, M2-OPH
Coreopsis tripteris L. M1-FRT
Doellingeria infirma (Michx.) E. Greene M1-WTR, M1-OPH
Elephantopus carolinianus Raeuschel M1-WTR, M1-FRT
Elephantopus tomentosus L. M1-WTR, M1-FRT, M2-OPH

Erigeron annuus (L.) Pers. M1-FRT, M2-OPH
Erigeron pulchellus Michx. M2-OPH
Erigeron strigosus Muhl. ex Willd. var. strigosus M1-FRT, M2-OPH

Doellingeria infirma (Michx.) E. Greene M1-WTR, M1-OPH
Eupatorium album L. var. album  M2-OPH
Eupatorium capillifolium (Lam.) Small  M1-FRT, FP
Eupatorium fistulosum Barratt  H-RS, H-SRB, H-BP, M2-OPH†
Eupatorium hyssopifolium L.  M1-OPH
Eupatorium perfoliatum L.  H-CS
Eupatorium purpureum L.  M1-WTR, M1-FRT, M1-OPH
Eupatorium rotundifolium L. var. ovatum (Bigel.) Torr.  M2-OPH
Eupatorium serotinum Michx.  H-CS, M2-OPH, FP
Gamochaeta purpurea (L.) Cabrera  H-CS
Helianthus atrorubens L.  M2-OPH
Helianthus decapetalus L.  D L M1-WTR, M1-OPH
Helianthus hirsutus Raf.  M1-FRT, M1-OPH
Helianthus microcephalus Torr. & A. Gray  M1-WTR, M1-OPH, M2-OPH
Helianthus resinosus Small  H-SRB, M1-WTR, M1-FRT, M1-OPH
Hieracium gronovii L.  M2-OPH
Hieracium venosum L.  M2-OPH, X2-OPH
Ionactis linearifolia (L.) greene  X2-OPH
Lactuca canadensis L.  M2-OPH†
Lactuca floridana (L.) Gaertn.  M1-WTR, M1-FRT
Leucanthemum vulgare Lam.*  M2-OPH
Liatris graminifolia Willd.  M2-OPH, X2-OPH
Packera anonyama (Wood) W.A. Weber & A. Löve  M2-OPH†
Packera aurea (L.) A.&D. Löve  H-CS, H-DS, M1-WTR
Pityopsis aspera (Shuttlw. ex Small) Small  M2-OPH
Pityopsis graminifolia (Shuttlw. ex Small) Small var. graminifolia  M2-OPH
Pityopsis graminifolia (Michx.) Nutt. var. latifolia  (Fern.) Semple & Bowers  M2-OPH
Polyinna uvedalila L.  M1-WTR
Prenanthes altissima L.  L M1-WTR, M1-FRT, M1-OPH
Prenanthes trifoliolata (Cass.) Fern.  D M1-WTR
Pseudognaphalium obtusifolium (L.) Hillard & Burlt. ssp. obtusifolium  M2-OPH†
Rudbeckia hirta L.  M1-WTR, M1-OPH
Rudbeckia laciniata L.  H-CS, H-SRB, M1-WTR
Sericocarpus asteroides (L.) B.S.P.  M1-OPH, M2-OPH
Silphium asteriscus L. var. laevicaule D.C.  H-SRB, M1-WTR, M1-FRT, M2-OPH
Silphium compositum Michx.  X2-OPH
Solidago arguta Ait. var. caroliniana Gray  M1-WTR, M1-FRT, M2-OPH, X2-OPH, X-RB
Solidago arguta Ait. var. arguta  X2-OPH
Solidago caesia L.  H-SRB, M1-WTR, M1-FRT, M1-OPH
Solidago canadensis L. var. scabra (Torr. & Gray) M1-OPH†
Solidago curtisii Torr. & Gray  M1-WTR, M1-HW
Solidago erecta Pursh.  M1-FRT, M2-OPH, X2-OPH
Solidago gigantea Ait. var. gigantea  M2-OPH
Solidago nemoralis Ait. var. haleana Fern.  M2-OPH, X2-OPH, X-RB
Solidago odorata Ait. var. odorata  M1-FRT, M1-OPH, M2-OPH
Solidago patula Muhl. ex Willd. var. patula  H-DS
Solidago petiolaris Ait.  M2-OPH, X2-OPH, X-RB
Solidago rugosa Mill. var. rugosa  H-RS, M1-FRT, M2-OPH
Solidago speciosa Nutt.  D M1-OPH
Verbesina alternifolia (L.) Britt. ex Kearney  H-SRB, M1-FRT
Verbesina occidentalis (L.) Walt.  H-SRB, M1-FRT
Verbesina virginica L. var. virginica  M1-FRT†
Vernonia gigantea (Walt.) Trel. ssp. gigantea  
H-SRB, M1-FRT
Youngia japonica (L.) D.C.*  H-CS†

BALSAMINACEAE

BERBERIDACEAE
Caulophyllum thalictroides (L.) Michx.  D M1-HW
Podophyllum peltatum L.  M1-WTR, M1-FRT

BETULACEAE
Betula lenta L.  M1-WTR, M1-HW
Betula nigra L.  H-SRB, M1-WTR, M1-FRT
Carpinus caroliniana Walt.  H-SRB, M1-WTR, M1-FRT
Corylus americana Walt.  M1-FRT, M2-OPH, X2-OPH
Corylus cornuta Marsh. var. cornuta  D M1-HW
Ostrya virginiana (P. Mill) K. Koch  M1-WTR, M1-FRT, M1-HW

BIGNONIACEAE
Bignonia capreolata L.  H-SRB, M1-WTR, M1-FRT, M1-OPH
Campsis radicans (L.) Seem. ex Bureau  H-SRB, M1-WTR, M1-FRT, M1-OPH
Catalpa bignoniioides Walt.*  M1-FRT

BORAGINACEAE
Cynoglossum virginianum L. M1-WTR, M1-HW
Myosotis macrosperma Engelm.  M1-FRT

BRASSICACEAE
Arabis canadensis L.  M1-FRT
Brassica rapa L. var. rapa*  M1-FRT†
Cardamine angustata O.E. Schulz  H-SRB, M1WTR, M1-FRT
Cardamine diphylla (Michx.) Wood.  M1-WTR, M1-FRT

CARYOPHYLLACEAE
Cardamine flagellifera O.E. Schulz var. flagellifera  
D M1-WTR
Cardamine flagellifera O.E. Schulz var. hugeri  L M1-WTR
Cardamine hirsuta L.*  M1-FRT

Buddlejaceae
Polyprenum procumbens L.*  H-CS

Calycanthaceae
Calycanthus floridus L.  M1-FRT, M1-OPH, M2-OPH

Campanulaceae
Campanula divaricata Michx.  M2-OPH, M1-RB

Betula lenta L.  H-RS, H-DS, M1-WTR
Betula nigra L.  H-DS, M1-WTR
Lobelia inflata L.  M1-FRT, M1-OHE, M2-OPH, X2-OPH
Lobelia puberula Michx.  M1-WTR, M1-FRT, M1-OPH
Lobelia spicata Lam.  M2-OPH
Triodanis perfoliata (L.) Newl.  M1-FRT, M2-OPH

CAPRIFOLIACEAE
Lonicera japonica Thunb.*  H-CS, H-SRB, M1-WTR, M-FRT, M1-OPH, M2-OPH, X-RB
Sambucus nigra L. ssp. canadensis (L.) R. Bolli  
H-RS, H-DS, H-BP, M1-WTR

Viburnum acerifolium L.  M1-WTR, M1-HW, M1-OPH
Viburnum cassinoides L.  M2-OPH
Viburnum nudum L.  H-DS, M1-WTR
Viburnum prunifolium L.  M1-WTR, M1-FTR, M1-OPH

Cerasium fontanum Baumg. ssp. vulgare* Greuter & Burdet  M1-FTR
Cerasium glomeratum Thuill.*  M1-FTR
Cerastium nutans Raf. M1-FTR
Dianthus armeria L.* M1-FTR, H-CS†
Silene stellata (L.) Ait. f. M1-FTR, M1-OPH, M2-OPH
Silene virginica L. H-SRB, M1-RB
Stellaria media (L.) Villars* H-SRB, M1-WTR, M1-FRT, M1-OPH
Stellaria pubera Michx. M1-WTR, M1-HW, M1-OPH
CELASTRACEAE
Celastrus orbiculatus Thunb.* D M1-RB†
Euonymus americana L. M1-WTR, M1-FRT
CHENOPODIACEAE
Chenopodium ambrosioides L.* D L M1-FRT
CLETHRACEAE
Clethra acuminata Michx. M2-PE
CLUSIACEAE
Hypericum gentianoides (L.) Britt. X2-RB
Hypericum hypericoides (L.) Crantz ssp.
hypericoides M1-FRT, M1-OPH, M2-OPH
Hypericum hypericoides (L.) Crantz ssp. multicaule
(Michx. ex Willd.) Robson M1-FRT, M1-OPH, M2-OPH
Hypericum prolificum L. X2-RB
Hypericum pseudomaculatum Bush M1-OPH, M2-OPH, X2-OPH
Hypericum punctatum Lam. M1-OPH, M2-OPH, X2-OPH
CONVOLVULACEAE
Ipomoea pandurata (L.) G.F.W. Mey. H-SRB, M1-FRT, X-RB
CORNACEAE
Cornus alternifolia L. f. M1-HW
Cornus amomum P. Mill. H-RS, M1-WTR
Cornus florida L. M1-WTR, M1-FRT, M1-OHE, M1-HW, M1-OPH, M2-OPH, M2-EHB
CRASSULACEAE
Penthorum sedoides L. H-CS, H-DS
Sedum ternatum Michx. M1-FRT, M1-OPH
CUSCUTACEAE
Cuscuta compacta Juss. ex Choisy M1-WTR, M1-FRT
DIAPENSIACEAE
Galax urceolata (Poir.) Brummit M1-OHE, M2-PE, M2-EHB
EBENACEAE
Diospyros virginiana L. H-RS, M1-OPH
ELAEAGNACEAE
Elaeagnus umbellata Thunb. var. parviflora* (Royle) Schneid. FP†
ERICACEAE
Chimaphila maculata (L.) Pursh M1-OHE, M2-OPH
Epigaea repens L. M1-OHE
Gaylussacia baccata (Wangenh.) K. Koch M1-WTR, M1-OPH, M2-OPH
Gaylussacia ursina (M.A. Curtis) Torr. & Gray ex Gray M2-OPH
Kalmia latifolia L. H-RS, M1-FRT, M1-OHE, M1-OPH, M1-RB, M2-PE, M2-EHB
Leucothoe fontanesiana (Steud.) Sleumer H-SRB, M1-FRT
Lyonia ligustrina (L.) D.C. H-RS, M1-FRT
Monotropa hypopithys L. M1-WTR, M1-OPH
Monotropa uniflora L. M1-WTR, M1-OPH
Oxydendrum arboreum (L.) D.C. M1-WTR, M1-FRT, M1-OHE, M1-OPH, M2-OPH, M2-PE, M2-EHB
Rhododendron arborescens (Pursh) Torr. H-CS, M1-WTR
Rhododendron calendulaceum (Michx.) Torr. M1-WTR, M1-0PH
Rhododendron canescens (Michx.) Sweet M1-SRB, M1-FRT, M1-OPH, M2-OPH
Rhododendron maximum L.   H-RS, M1-WTR, M1-FRT, M1-OHE
Vaccinium arborescens Marsh. M1-FRT, M2-OPH, M2-EHB, X2-OPH, X-RB
Vaccinium corymbosum L.   M1-WTR, M1-FRT, M1-OPH, M2-OPH
Vaccinium pallidum Ait. M2-OPH, X2-OPH, X-RB
Vaccinium stamineum L. M1-OPH, M2-OPH

EUPHORBIACEAE
Acalypha graciens A. Gray X-RB
Acalypha virginica L. FP
Chamaesyce nutans (Lag.) Small X-RB
Euphorbia pubentissima Michx. M1-WTR, M1-OHE, M1-OPH, M2-OPH

FABACEAE
Albizia julibrissin Durazz.* M1-FRT
Amphicarpaea bracteata (L.) Fern. var. bracteata M1-WTR, M1-FRT
Amphicarpaea bracteata (L.) Fern. var. comosa M1-WTR
Apis americana Medik. H-CS, M1-FRT
Baptisia tinctoria (L.) R. Brown ex Ait. f. M2-OPH
Chamaecrista fasciculata (Michx.) Greene M1-FRT†, X-RB
Chamaecrista nictitans (L.) Moench. M1-FRT†
Clitoria mariana L. M1-FRT, M1-OPH, M2-OPH
Crotalaria sagittalis L. M1-FRT†
Desmodium glabellum (Michx.) D.C. M1-OPH, M2-OPH
Desmodium glutinosum (Muhl. ex Willd.) Wood M1-OPH, M2-OPH
Desmodium marilandicum (L.) D.C. M1-OPH, M2-OPH
Desmodium nudiflorum (L.) D.C. M1-WTR, M1-FRT, M1-OPH, M2-OPH
Desmodium paniculatum (L.) D.C. M1-FRT, M1-OPH, M2-OPH

Desmodium perplexum Schub. M1-FRT, M1-OPH, M2-OPH
Desmodium rotundifolium D.C. M1-FRT, M1-OHE, M1-RB
Galactia volubilis (L.) Britt. H-CS, M1-FRT
Kummerowia stipulacea (Maxim.) Makino* FP†
Kummerowia striata (Thunb.) Schindl.* M2-OPH†
Lespedeza bicolor Turcz.* M1-WTR, FP
Lespedeza cuneata (Dum.-Cours.) G. Don* M1-FRT, FP
Lespedeza hirta (L.) Hornemann M2-OPH
Lespedeza procumbens Michx. M1-FRT, X2-OPH
Lespedeza repens (L.) W. Barton M1-FRT, X2-OPH
Lespedeza violacea (L.) Pers. M1-FRT, M2-OPH, X-RB

Orbexilum pedunculatum (P. Mill) Rydb. var. pedunculatum M1-FRT, X-RB
Pueraria montana (Lour.) Merr. var. lobata (Willd.) Maesen & S. Almeida* M1-FRT
Robinia hispida L. X2-OPH
Robinia pseudo-acacia L. M1-OPH, M2-OPH
Senna marilandica (L.) Link M1-WTR
Stylosanthes biflora (L.) B.S.P. X2-OPH, X-RB
Tephrosia spicata (Walt.) Torr. & Gray M2-OPH
Tephrosia virginiana (L.) Pers. X2-0PH, X-RB
Trifolium pratense L. M1-FRT†
Trifolium repens L. M1-FRT
Vicia caroliniana Walt. M1-FRT, M2-OPH

FAGACEAE
Castanea dentata (Marsh.) Borkh. M1-WTR, M1-OPH
Castanea pumila (L.) P. Miller M1-FRT, M2-OPH
Fagus grandifolia Ehrhart M1-FRT, M1-HW, M1-OPH
Quercus alba L. M1-WTR, M1-FRT, M1-OHE, M1-HW, M1-OPH, M2-OPH
Quercus cocinea Muenchh. M1-OPH, M2-OPH, X2-OPH
Quercus prinus L. M1-FRT, M1-OHE, M1-HW, M1-OPH, M2-OPH
Quercus rubra L. M1-WTR, M1-FRT, M1-OPH, M2-OPH
Quercus stellata Wangenh. X2-OPH
Quercus velutina Lam. M1-OPH, M2-OPH

JUGLANDACEAE
Carya glabra (P. Mill.) Sweet M1-FRT, M1-OPH, M2-OPH
Carya ovalis (Wanenh.) Sarg. M1-OPH, M2-OPH
Carya pallida (Ashe) Engl. & Graebn. M1-FRT, M2-OPH, M2-EHB, X2-OPH
Carya tomentosa (Poir.) Nutt. M1-WTR, M1-FRT, M1-OPH, M2-OPH, X2-OPH
Juglans nigra L. M1-FRT

LAMIACEAE
Collinsonia canadensis L. H-DS, M1-WTR, M1-OPH
Gentiana decora Pollard H-DS, M1-WTR
Obolaria virginica L. M1-WTR
Sabatia angularis (L.) Pursh. M1-OPH
Cunila origanoides (L.) Britt. M1-FRT, M1-RB

GROSSULARIACEAE
Geranium maculatum L. M1-WTR, M1-FRT, M1-HW, M1-OPH

HAMAMELIDACEAE
Hamamelis virginiana L. H-RS, M1-WTR, M1-OHE, M1-HW, M1-OPH
Liquidambar styraciflua L. M1-WTR, M1-FRT, M1-OPH

HIPPOCASTANACEAE
Aesculus parviflora M1-WTR, M1-OPH
Aesculus sylvatica (Spach) Scheele M1-WTR, M1-OPH
Aesculus X mutabilis Bartr. [A. sylvatica X A. pavia]
D M1-WTR, M1-FRT, M1-HW, M1-OPH

HYDRANGEACEAE
Deutzia scabra Thunb.* D M1-OPH†
Hydrangea arborescens L. M1-WTR, M1-FRT, M1-OPH, M1-RB
Philadelphus inodorus L. M1-OPH

JUGLANDACEAE
Carya glabra (P. Mill.) Sweet M1-FRT, M1-OPH, M2-OPH
Carya ovalis (Wanenh.) Sarg. M1-OPH, M2-OPH
Carya pallida (Ashe) Engl. & Graebn. M1-FRT, M2-OPH, M2-EHB, X2-OPH
Carya tomentosa (Poir.) Nutt. M1-WTR, M1-FRT, M1-OPH, M2-OPH, X2-OPH
Juglans nigra L. M1-FRT

LAMIACEAE
Collinsonia canadensis L. H-DS, M1-WTR, M1-OPH
Gentiana decora Pollard H-DS, M1-WTR
Obolaria virginica L. M1-WTR
Trichostema dichotomum L.  M1-FRT†

**LAURACEAE**
Lindera benzoin (L.) Blume  M1-WTR, M1-FRT
Sassafras albidum (Nutt.) Nees  M2-OPH, X2-OPH

**LINACEAE**
Linum striatum  H-CS, H-BP

**MAGNOLIACEAE**
Liriodendron tulipifera L.  M1-WTR, M1-FRT, M1-HW, M1-OPH, M2-OPH
Magnolia acuminata  M1-WTR, M1-HW
Magnolia fraseri  M1-OHE, M1-OPH

**MALVACEAE**
Sida rhombifolia L.  M1-FRT†

**MELASTOMATACEAE**
Rhexia mariana  H-CS
Rhexia virginica  H-CS, M1-FRT

**MENISPERMACEAE**
Menispernum canadense  H-SRB, M1-FRT

**MOLLUGINACEAE**
Mollugo verticillata L.*  H-CS

**MORACEAE**
Morus rubra  M1-FRT

**NYSSACEAE**
Nyssa sylvatica  H-RS, M1-FRT, M1-OPH, M2-OPH, M2-EHB

**OLEACEAE**
Chionanthus virginicus L.  M1-OHE
Fraxinus americana L.  M1-WTR, M1-FRT, M1-OPH, X-RB
Fraxinus pennsylvanica Marsh.  M1-WTR, M1-FRT, M1-OPH
Ligustrum sinense Lour.*  M1-WTR†, M1-FRT, FP

**ONAGRACEAE**
Ludwigia alternifolia  H-CS, H-SRB, H-DS, H-BP, M1-FRT
Ludwigia decurrens  H-CS
Ludwigia palustris (L.) Ell.  H-CS

Oenothera biennis L.  M1-FRT†

**OROBANCHACEAE**
Epifagus virginiana (L.) Barton  M1-WTR

**OXALIDACEAE**
Oxalis grandis  M1-FRT, M1-OPH
Oxalis stricta L.  M1-WTR, M1-FRT, M1-OPH
Oxalis violacea L.  M1-WTR, M1-FRT, M1-OPH

**PAPAVERACEAE**
Sanguinaria canadensis  M1-OPH
Passiflora incarnata  FP
Passiflora lutea  M1-WTR, M1-OPH

**PHRYMACEAE**
Phryma leptostachya  M1-HW

**PHYTOLACCACEAE**
Phytolacca americana L.  H-SRB, M1-FRT

**PLANTAGINACEAE**
Plantago aristata Michx.*  M2-OPH†
Plantago lanceolata L.*  FP
Plantago rugelii Dene.*  H-CS, M1-FRT
Plantago virginica L.  M1-FRT

**PLATANACEAE**
Platanus occidentalis L.  H-SRB, M1-FRT

**PODOCOTEMACEAE**
Podostemum ceratophyllum Michx.  AQUATIC

**POLEMONIACEAE**
Phlox amonea Sims.  M2-OPH
Phlox carolina L. ssp. carolina  M1-FRT, M1-OPH
Phlox maculata (L.) ssp. pyramidales (J.E. Smith)
Wherry D M1-OPH, M2-OPH
Phlox stolonifera Sims  H-SRB

**POLYGALACEAE**
Polygala polygama  M1-OPH, M2-OPH, X-RB

**POLYGONACEAE**
Polygonum caespitosum Blume var. longisetum*
(DeBruyn) A.N. Steward  H-CS, H-RS, H-DS, M1-FRT
Polygonum lapathifolium L.     FP
Polygonum punctatum Ell.     H-SRB, H-DS
Polygonum sagittatum L.     H-CS, H-DS
Polygonum setaceum Baldw. ex Ell.     H-RS, M1-WTR
Polygonum virginianum L.     H-SRB, M1-WTR, M1-FRT
Polygonum punctatum Ell.     H-SRB, H-DS
Polygonum setaceum Baldw. ex Ell.     H-RS, M1-WTR
Polygonum virginianum L.     H-SRB, M1-WTR, M1-FRT

Rumex obtusifolius L.*     H-CS

**PRIMULACEAE**

Lysimachia ciliata L.     H-SRB, M1-FRT
Lysimachia quadrifolia L.     M1-FRT, M1-OPH, M2-OPH

**RANUNCULACEAE**

Actaea pachypoda Ell.     M1-WTR, M1-HW
Anemone lancerifolia Pursh.     M1-WTR, M1-FRT
Anemone quinquefolia L. var. quinquefolia M1-WTR, M1-HW
Cimicifuga racemosa (L.) Nutt.     M1-WTR, M1-OPH
Clematis virginiana L.     H-DS, M1-WTR, M1-FRT, M1-OPH, M2-OPH
Hepatica acutiloba D.C.     M1-WTR, M1-HW
Hepatica americana (D.C.) Ker.     M1-WTR, M1-HW, M1-OPH
Ranunculus abortivus L.     H-DS, M1-WTR
Ranunculus recurvatus Poir. var. recurvatus M1-FRT
Thalictrum clavatum D.C.     H-DS, M1-WTR
Thalictrum macrostylum Small & Heller M1-FRT
Thalictrum pubescens Pursh.     D     H-SRB, M1-FRT
Thalictrum thalictroides (L.) Eames & Boivin M1-WTR, M1-FRT, M1-HW, M1-OPH
Trautvetteria carolinensis (Walt.) Vail     H-RS
Xanthorhiza simplicissima Marsh.     H-CS, M1-WTR

**RHAMNACEAE**

Ceanothus americanus L.     M2-OPH

**ROSACEAE**

Agrimonia parviflora Ait.     M1-OPH
Agrimonia pubescens Wallr.     M1-WTR, M1-FRT

Agrimonia rostellata Wallr.     H-DS, M1-WTR
Amelanchier arborea (Michaux f.) Fernald     H-SRB, M1-FRT, M1-OPH, M2-OPH, X-RB
Crataegus prunoida (Wendl.) K. Koch     X2-OPH
Fragaria virginiana Duchesne     M1-FRT, X-RB
Geum canadense Jacq.     M1-FRT
Malus angustifolia (Ait.) Michx.     H-SRB, X2-OPH, X-RB
Porteranthus trifoliatus (L.) Britt.     X2-OPH
Potentilla canadensis L. var. canadensis M1-WTR, M1-FRT, M1-OPH
Potentilla simplex Michx.     M1-WTR
Prunus americana Marsh.     H-SRB, M1-FRT
Prunus serotina Ehrh. var. serotina M1-WTR, M1-FRT, M1-OPH
Rosa multiflora Thunb. ex Murray*     D     FP
Rubus argutus Link     M1-WTR, M1-FRT, M1-OPH†
Rubus flagellaris Wild.     D     M1-FRT
Rubus occidentalis L.     M1-WTR
Waldsteinia fragarioides (Michx.) Tratt. ssp. doniana (Tratt.) Teppner M1-WTR, M1-OPH
Waldsteinia lobata (Baldw.) Torr. & Gray M1-WTR, M1-FRT, M1-HW

**RUBIACEAE**

Cephalanthus occidentalis L.     H-SRB
Diodia teres Walt.     H-SRB, M1-FRT, M2-OPH†
Diodia virginiana L.     M1-FRT
Galium aparine L.     M1-FRT
Galium circaezans Michx. var. circaezans M1-WTR
Galium circaezans Michx. var. hypomalacum Fern.     M1-OPH
Galium pilosum Ait. var. pilosum M1-FRT†, FP
Galium triflorum (Michx.)     M1-WTR
Houstonia caerulea L.     H-CS, M1-WTR
Houstonia longifolia Gaertn.     M2-OPH
Houstonia purpurea L. var. purpurea  M1-WTR, M1-OHE, M1-OPH
Mitchella repens L.  M1-FRT, M1-OHE

SALICACEAE
Salix nigra Marsh.  M1-FRT, FP

SANTALACEAE
Pyrularia pubera Michx.  M1-WTR, M1-FRT

SAXIFRAGACEAE
Boykinia aconitifolia Nutt.  H-RS
Decumaria barbara L.  H-SRB, M1-WTR, M1-FRT
Heuchera americana L.  M1-HW, M1-RB, X-RB
Heuchera parviflora Bartl.  D M1-RB
Parnassia asarifolia Vent.  H-DS, M1-WTR
Saxifraga virginica Michx.  M1-RB, X-RB
Tiarella cordifolia L.  H-SRB, H-DS, M1-WTR, M1-FRT, M1-HW, M1-OPH

SCHISANDRACEAE
Schisandra glabra (Bicknell) Rehder  D M1-WTR, M1-FRT

SCROPHULARIACEAE
Agalinus decemloba (Greene) Pennell  M2-OPH
Aureolaria flava (L.) Farwell var. flava  M1-RB
Aureolaria laevigata (Raf.) Raf.  M2-EHB
Aureolaria pectinata (Nutt.) Pennell  X2-OPH
Aureolaria virginica (L.) Pennell.  M1-FRT
Chelone glabra L.  H-DS, M1-WTR
Gratiola virginiana L.  L H-CS, H-DS
Linaria canadensis (L.) Dumont  X-RB
Lindernia dubia (L.) Pennell  H-CS
Melampyrum lineare Desr.  M1-WTR, M1-OPH
Mimulus alatus Ait.  H-CS, H-DS
Pedicularis canadensis L.  M1-WTR
Scrophularia marilandica L.  L M1-FRT
Verbascum thapsus L.*  M2-OPH†
Veronica arvensis L.*  M1-FRT†

SOLANACEAE
Solanum carolinense L.  M1-WTR†, M1-FRT

STAPHYLEACEAE
Staphylea trifolia L.  D M1-FRT

STYRACACEAE
Halesia carolina L.  H-SRB, M1-WTR, M1-FRT, M1-HW, M1-OPH
Styrax americanus Lam.  H-RS

SYMPLOCACEAE
Symlocos tinctoria (L.) L'Hér.  M1-FRT, M2-OPH

THEACEAE
Stewartia ovata (Cav.) Weatherby  M1-WTR, M1-FRT

TILIACEAE
Tilia americana L.  M1-WTR, M1-FRT, M1-HW, M1-OPH

ULMACEAE
Celtis occidentalis L.  M1-FRT
Ulmus alata Michx.  M1-FRT

URTICACEAE
Boehmeria cylindrica (L.) Swartz  H-CS, H-RS, H-BP, M1-WTR, M1-FRT
Laportea canadensis (L.) Weddell  M1-WTR, M1-HW
Pilea pumila (L.) Gray  H-DS, M1-WTR

VALERIANELLACEAE
Valerianella radiata (L.) Dufr.  M1-FRT

VERBENACEAE
Verbena brasiliensis Vellozo*  FP†
Verbena urticifolia L.  H-SRB, M1-FRT, M1-OPH†

VIOLACEAE
Viola blanda Willd.  H-CS, H-DS, M1-WTR, M1-OHE, M1-HW, M1-OPH
Viola conspersa Reichenb.  M1-WTR, M1-FRT
Viola hastata Michx.  M1-WTR, M1-FRT, M1-OHE, M1-OPH, M2-OPH
Viola palmata L. var. palmata  M1-WTR, M1-FRT, M1-HW
Viola pedata L.  M2-OPH
Viola primulifolia L.   H-DS, M1-WTR
Viola pubescens Ait. var. pubescens  M1-WTR
Viola rostrata Pursh.  M1-WTR, M1-HW
Viola rotundifolia Michx.  H-CS, M1-WTR
Viola sororia Willd.  H-DS, M1-WTR, M1-FRT, M1-OPH

VITACEAE

Parthenocissus quinquefolia (L.) Planch.  H-SRB, M1-WTR, M1-FRT, M1-HW, M1-OPH, M2-OPH, M1-RB, M2-PE

Vitis aestivalis Michx. var. bicolor Deam  D  M2-OPH

Vitis cinerea (Engelm.) Millard var. baileyana
(Munson) Comeaux  M1-OPH

Vitis labrusca L.  M1-OPH

Vitis rotundifolia Michx.  H-SRB, M1-WTR, M1-FRT, M1-OPH, M2-OPH, X-RB

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Key to habitat codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-CS</td>
<td>Sandy islands and beaches on rivers</td>
</tr>
<tr>
<td>H-RS</td>
<td>River shoals, rock channel margins</td>
</tr>
<tr>
<td>H-SRB</td>
<td>Steep river banks, sandy loam or silt</td>
</tr>
<tr>
<td>H-DS</td>
<td>Depressional and seepage wetlands</td>
</tr>
<tr>
<td>H-BP</td>
<td>Beaver pond</td>
</tr>
<tr>
<td>M1-WTR</td>
<td>Mesic wide tributary ravine</td>
</tr>
<tr>
<td>M1-FRT</td>
<td>Mesic flat river terrace</td>
</tr>
<tr>
<td>M1-OHE</td>
<td>Mesic Oak-Hemlock forest, Ericaceous understory</td>
</tr>
<tr>
<td>M1-HW</td>
<td>Hardwood cove forests</td>
</tr>
<tr>
<td>M1-OPH</td>
<td>Mesic Oak-Pine-Hickory forest</td>
</tr>
<tr>
<td>M2-OPH</td>
<td>Sub-mesic Oak-Pine-Hickory forest</td>
</tr>
<tr>
<td>M1-RB</td>
<td>Mesic rocky bluffs and cliffs</td>
</tr>
<tr>
<td>M2-PE</td>
<td>Pine forest, Ericaceous understory</td>
</tr>
<tr>
<td>M2-EHB</td>
<td>Sub-mesic Evergreen-Ericaceous bluff</td>
</tr>
<tr>
<td>X2-OPH</td>
<td>Sub-xeric Oak-Pine-Hickory forest</td>
</tr>
<tr>
<td>X-RB</td>
<td>Xeric rocky river bluffs</td>
</tr>
<tr>
<td>FP</td>
<td>Wildlife feed plots</td>
</tr>
</tbody>
</table>
APPENDIX B

Topographical maps of study sites in the Upper Etowah River watershed. The location of the study sites within the watershed is shown in Figure 1.2. On each map, large-scale plant communities, species of special concern, and species rare to the study area are shown.
Figure B.1 Amicalola Headwaters Trib site (AHT) with unusual species and select habitat locations. △ = Species listed by GA Natural Heritage Program. ○ = Species rare to study area. 1-Cardamine flagellifera; 2-Carex prasina; 3-Panax quinquefolius; 4-Caulophyllum thalictroides; 5-Clintonia umbellulata; 6-Cornus alternifolia; 7-Trillium vaseyi; 8-Veratrum parviflorum. Habitat types: M1-HW= mesic hardwood; M1-OPH= mesic oak-pine-hickory; M2-OPH= sub-mesic oak-pine-hickory.
Figure B.3 Wildcat Creek site (WCT) with unusual species and select habitat locations.

$\Delta$ = Species listed by the GA Natural Heritage Program. ○ = Species rare to study area. 1-Cypripedium acaule; 2-Panax quinquefolius; 3-Stachys latidens; 4-Carex swanii; 5-Philadelphus inodorus; 6-Sparganium americanum.

Habitat types: H-BP = beaver pond; M1-HW = mesic hardwoods; M1-OHE = mesic oak-hemlock-ericaceous; M1-OPH = mesic oak-pine-hickory; M2-OPH = sub-mesic oak-pine-hickory; X2-OPH = sub-xeric oak-pine-hickory.
Figure B.4 Amicalola Church Rd. (ACT) and Rock Cellar Rd. (RCR) sites, with select habitat locations. No unusual species occur at these sites. Habitat types: H-SRB= sandy river bank; H-DS= depressional seeps; M1-OPH= mesic oak-pine-hickory; M2-OPH= sub-mesic oak-pine-hickory.
Figure B.5 Holly Creek Tributary site (HCT) with unusual species and select habitat locations. △ Species listed by the GA Natural Heritage Program. ○ Species rare to study area. 1. Panax trifolius; 2. Arnica montana; 3. Vaccinium angustifolium. Habitat types: H.D.S=depressional seeps; M1-OHE=mesic oak-hemlock-ericeeous; M2-OPH=mesic oak-pine-hickory.
Figure B.6  Dawson Check Station site (DCS) with unusual species and select habitat locations. △ = Species listed by the GA Natural Heritage Program. ○ = Species rare to study area. 1-Boykinia aconitifolia; 2-Carex torta; 3-Schisandra glabra; 4-Stewartia ovata; 5-Waldsteinia lobata; 6-Xerophyllum asphodeloides; 7-Carex frankii; 8-Hoechera parviflora; 9-Hymenocalis caroliniana; 10-Orontium aquaticum. Habitat types: M1-OPH = mesic oak-pine-hickory; M2-OPH = sub-mesic oak-pine-hickory; M1-RB = mesic river bluffs; M2-EEB = mesic evergreen heath bluff; 🌾 = rocky shoals and sand bars.
Figure B.8. Power Line Tributary site (PLT) with unusual species and select habitat locations. △ = Species listed by the GA Natural Heritage Program. ○ = Species rare to study area. 1-Carex ruthii; 2-Cypripedium pubescens var. pubescens; 3-Panax quinquefolius; 4-Spiranthes ovalis; 5-Aletris farinosa; 6-Asarum canadense; 7-Cynoglossum virginianum; 8-Galearhis spectabilis; 9-Hymenocallis caroliniana; 10-Staphylea trifolia; 11-Stenanthium gramineum. Habitat types: M1-FRT= flat river terrace; degraded; M1-HW= mesic hardwood; M1-OPH= mesic oak-pine-hickory; M2-OPH= sub-mesic oak-pine-hickory; X2-OPH= sub-xeric oak-pine hickory.
Figure B.10 Ram Rd. site (RAM) with unusual species and select habitat locations. △ = Species listed by the GA Natural Heritage Program. ○ = Species rare to study area. 1-Carex radiata; 2-Cypripedium acaule; 3-Panax quinquefolius; 4-Schisandra glabra; 5-Viola conspersa; 6-Aesculus pavia; 7-Amianthium muscitoxicum; 8-Galearis spectabilis; 9-Obolaria virginica; 10-Podostemum ceratophyllum; 11-Trillium rugelii; 12-Vallisneria americana. Habitat types: H-SRB= sandy river bank; H-DS= depressional seeps; M1-OPH= mesic oak-pine-hickory; M2-OPH= sub-mesic oak-pine-hickory; X2-OPH= sub-xeric oak-pine-hickory.
Figure B.13  Camp Wahsega site (CW) with unusual species and select habitat locations. △ = Species listed by the GA Natural Heritage Program. ○ = Species rare to study area. 1-Carex platyphylla; 2-Carex scabrata; 3-Juncus gymnocarpus; 4-Stewartia ovata; 5-Juncus validus; 6-Scrophularia marilandica. Habitat types: M1-OHE= mesic oak-hemlock-Ericaceous; M1-OPH= mesic oak-pine-hickory.
Figure B.14  Forest Service Road site (FSR) with unusual species and select habitat locations. △ = Species listed by the GA Natural Heritage Program. 1-Carex platyphylla. Habitats types: M1-OHE= mesic oak-hemlock-Ericaceous; M1-OPH= mesic oak-pine-hickory.
Figure B.15 Campbell Mountain site (CMT) with unusual species and select habitat locations. △ = Species listed by the GA Natural Heritage Program. 1-Stewartia ovata. Habitat types: M1-OHE= mesic oak-hemlock-Ericaceous; M1-OPH= mesic oak-pine-hickory; M2-OPH= sub-mesic oak-pine-hickory.
Figure B.17 Castleberry Bridge Road site (CBR) with unusual species and select habitat locations. △ = Species listed by the GA Natural Heritage Program. ○ = Species rare to study area. 1- *Stachys latidens*; 2- *Carex swanii*; 3- *Cheilanthes lanosa*; 4- *Penthorum sedoides*; 5- *Sparganium americanum*; 6- *Veratum parviflorum*. Habitat types: H-DS = depressional seeps; M1-FRT* = flat river terrace, degraded; M1-OHE = mesic oak-hemlock-Ericaceous; M1-OPH = mesic oak-pine-hickory; M2-OPH = sub-mesic oak-pine-hickory; M1-PE = mesic pine-Ericaceous; X-RB = xeric river bluff; ⚪ = rocky shoals and sand bars.