Flora of Riverscour Communities of Tennessee's Caney Fork River

Mason Brock

Flora of Riverscour Communities of Tennessee's Caney Fork River

A Thesis

Presented to Dr. Dwayne Estes

Dr. Rebecca Johansen

and Dr. Jefferson Lebkuecher

In Partial Fulfillment of the Requirements for

Master's Degree in Biology from Austin Peay State University

Mason Brock

December 2017

December 2017

To the College of Graduate Studies:

We are submitting a thesis written by Mason Brock entitled "Flora and Vegetation of Riverscour Communities of Tennessee's Caney Fork River." We have examined the final copy of this thesis for form and content. We recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science in Biology.

Dwayne Estes, Committee Advisor

Rebecca Johansen, Committee Member

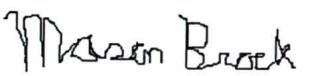
Jefferson Lebkuecher, Committee Member

Accepted for the Graduate and Research Council

Dean, College of Graduate Studies

Statement of Permission to Use

In presenting this thesis in partial fulfillment of the requirements for the Master of Science in Biology at Austin Peay State University, I hereby release this work into the public domain. All rights to this work have been waived worldwide under copyright law, including all related and neighboring rights, to the extent allowed by law. Anyone can copy, modify, distribute and perform the work, even for commercial purposes, all without asking permission.



Mason Brock December 4, 2017

Table of Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER I- INTRODUCTION

Overview of Floristics as a Science

This paper presents a study documenting the flora of the Caney Fork River in Middle Tennessee. A "flora" is the process of collecting plant material in the field, determining its identity, and processing it so that it can be stored in an herbarium. A scientist conducting a flora is asking a simple question: "Which plants grow here?" Answering this question involves the science of taxonomy, and biogeography. Floristic inventories remain the core basis for our ability to identify, and in effect conserve, the plants species that grow within a given area (Heywood 2001).

Although the question that a scientist conducting a flora seeks to answer may seem simple, it has tremendous scientific value. The audience for floristic studies has increasingly changed over the past few decades from fellow taxonomists to including the general public as well (Heywood 2001). Governments and conservation organizations have turned to taxonomists to inform crucial conservation decisions. Knowledge of taxonomy and species distribution has become the "backbone" that informs conservation policy decisions. There are also cross-disciplinary uses. For example, floras form the baseline data that can later be used for studies in community ecology (Pearman 2006, Peet et al. 1998). The physical specimens themselves are also used as baseline data for taxonomic and genetic studies (Heywood 2001).

One of the often unstated underlying assumption that is present in both scientific literature and in the discourse around environmental policy, is the idea that our natural areas have been thoroughly surveyed and catalogued. The idea that floristic surveys in the Southeast are incomplete that there are large, possibly significantly so, gaps in our understanding is rarely acknowledged. Recent discoveries, however, have shown there is a significant portion of the

Southeastern flora that remains undocumented. One of the best examples demonstrating this is the discovery of remarkable undescribed diversity during the 1990's in Bibb County, Alabama. In a single region of dolomite barrens, eight endemic taxa were discovered and described within a seven year period. (Allison and Stevens 2001). While not every region in the Southeast possesses the potential for such discoveries, the existence of such an area in a well-populated state just outside of Alabama's largest city should give those who operate with the assumption of completeness pause. From 1970 to 2010, an average 4.8 new species a year were described from the Southeastern United States (A. Weakley and D. Estes, unpublished data). While this trend could obviously not continue indefinitely, the rate does not appear to be in decline. Worldwide, the yearly rate of new species descriptions has remained constant from 1970 to 2011 (Bebber et al. 2013). However, the attitude in both mainstream science and policy is an assumption of botanical completeness (Ertter 2000). Due to this, there appears to be dwindling interest in the science of taxonomy and floristics from its late 20th century heyday.

Part of the problem of lack of interest may derive from the institutional structure of academia. A study from the Academy of Natural Sciences found a mismatch between productivity in taxonomy, including specimen collection and curation, and career success in academia. They highlighted that much of the work of systematics doesn't fit into the "traditional peer-reviewed-publication formula" (Drew 2011). In addition to this, much of this disinterest can be attributed to the rise in molecular systematics, which has diverted funding and prestige from traditional taxonomy and floristics (Heywood 2001).

Our modern situation presents a paradox: We have an increase in urgency of need for floristic surveys due to environmental destruction and climatic change, which is simultaneously coexisting with declining institutional interest in support of the science of taxonomy. Botanists

stand as members of a dwindling tribe against the oncoming tides of ecological destruction and societal indifference. It is a goal of this flora to play at least a small part in adding to the collective knowledge, and allow us to make more informed decisions in questions of both science and policy.

Overview of Riverscour Communities

A riverscour community is a type of linear riparian community that is kept in an open state due to hindrance of woody plant growth from intense flooding. This community is found along the banks of high-gradient rivers, which often experience high-velocity flash floods followed by long periods without inundation. They can be found over many types of underlying bedrock, including sandstone, limestone, dolomite, and various metamorphic geologies. Typical riverscour communities grade from drier, sandy substrate higher on the banks to more hydric boulder and cobble along the river channel (NatureServe 2015). While the surface of these cobble riverscour bars is often unstable, they show little change in location or shape over long periods of time, suggesting that the cobble bar itself is a stable scoured community (Wolfe et al. 2007). With decreasing disturbance away from the river channel, riverscour communities intergrade into more typical riparian woodland community. Less well-documented forms of riverscour are associated with sheer bedrock and sand deposits.

Influence from fire is also found in areas where the river is shallowly entrenched, with gentle slopes leading to areas of prairies and savanna. In forested areas, riverscour acts as an "island" for heliophytic species in otherwise shaded surrounding communities. In contrast, riverscour found in areas of grassland communities is differentiated from the upland vegetation by being maintained by flood events as well as fire.

Riverscour communities are characterized by their more open conditions compared to typical riparian forests. The community structure can vary from woodland, shrubland, grassland, to nearly bare bedrock. They can arise in any region that has bedrock near the surface and a high gradient river, and are found scattered throughout North America (Cartwright and Wolfe 2016). In the Southeast, riverscour is known from the Interior Low Plateau, the Cumberland Plateau, the Ridge and Valley, the Blue Ridge, and the Piedmont (Cartwright and Wolfe 2016). The Cumberland Plateau region is the most well documented area with riverscour communities, and it is known to harbor the highest number of endemic plant species. It is characterized by grasses typical of prairie communities such as *Andropogon gerardii* and *Sorghastrum nutans*, and is most often found on cobble to boulder sized substrate. Some other regions of riverscour are well-documented, such as the Potomac River in Virginia. It has been scientifically investigated since an early date, and continues to be an area of research (Steury et al. 2008). Other regions of riverscour, such as the Interior Low Plateaus, have had no comprehensive floras conducted on them to date, and remain poorly known.

Riverscour communities are not important only for the plants that live on them. Open, rocky riparian zones, which include riverscour communities, serve many ecological functions (Gregory et al. 1991). For example, streams with open riparian canopies have been shown to support higher concentrations of herbivore aquatic invertebrates (Hawkins and Sedell 1981). In addition, the increased prey availability in areas of open riparian canopies also results in greater abundance of predator fish (Tschaplinski and Hartman 1983).

Due to their unusual disturbance regime, riverscour communities are distinct from the more typical forests or grasslands surrounding them, which are found away from flood zones of the river. The ecological distinctiveness of riverscour, along with the geographic isolation of

different river watersheds in which they occur, has contributed to species diversification resulting in many endemic species in these habitats. In Tennessee, ten species have been identified as strict riverscour endemics. These are: *Eurybia saxicastelli*, *Conradina verticillata*, *Marshallia grandiflora*, *Pityopsis ruthii*, *Sagittaria secundifolia*, *Solidago arenicola*, *Solidago racemosa*, *Spiraea virginiana*, *Sporobolus arcuatus*, and *Vitis rupestris*. Of these, four out of ten are endemic entirely to the Cumberland Plateau. In addition, there are more Cumberland Plateau endemics known from the Black Warrior River drainage in Alabama that are not found in Tennessee, such as *Coreopsis pulchra* and an undescribed species of *Amsonia*.

Importance of Study

Recent floristic surveys of riverscour areas have continued to find new rare plants for their respective watersheds, suggesting there is still merit in continuing research in riverscour areas (Anderson 2017, Bailey and Coe 2001, Mausert-Mooney in prep, Rodgers 2016, Schmalzer 1989). Previous surveys of the Caney Fork conducted by the Tennessee Natural Heritage Program found numerous state-listed taxa, suggesting the need for further exploration (Tennessee Natural Heritage Program pers. comm.). Other than this, the Caney Fork has been very sparingly surveyed, with no comprehensive floras previously produced. In addition, the Caney Fork harbors the only known remnant of riverscour on the Eastern Highland Rim of Tennessee at Rock Island State Park. Initial surveys of Rock Island by Dr. Dwayne Estes (pers. comm. 2012) indicated a large expanse of limestone riverscour existed at the park, with indicators of undocumented high quality habitat.

The limestone riverscour of the Interior Low Plateau has been particularly poorly documented, with no comprehensive floras having been conducted on any riverscour community

in this region. This region once harbored an endemic species (*Orbexilum stipulatum*) at the large limestone riverscour of the Falls of the Ohio, which has experienced significant habitat destruction (Baskin and Baskin 1986). The Interior Low Plateau riverscour is generally uncharacterized, with the closest corresponding community as described by NatureServe being "Cumberland Riverscour", which does not extend into the region of the Interior Low Plateau (NatureServe 2015). There are likely significant differences in the floristic composition of the Interior Low Plateau riverscour, compared to the Cumberland Plateau riverscour system. The Caney Fork, which crosses both physiographic regions, is an ideal river to use to investigate this distinction.

By collecting and documenting the species of the Caney Fork watershed, this study will expand our understanding of riverscour systems of the Southeast. The information gathered during this flora can be used to inform questions of taxonomy, biogeography, and conservation. This study will serve as baseline documentation of the flora of the Caney Fork, is the first full floristic inventory of an Interior Low Plateau riverscour community.

Previous Studies of Limestone Riverscour

While the existence of riverscour in Middle Tennessee is well documented, previous studies have focused almost entirely on the Cumberland Plateau region. The Interior Low Plateau and Cumberland Escarpment, in contrast, remained largely unexplored. Very little is known about limestone riverscour due to dam construction, and the deliberate destruction of river bedrock for shipping purposes. In particular, the construction of Wolf Creek Dam on the Cumberland River in the 1940s inundated many areas of riverscour in southeast Kentucky before

they were ever explored by botanists, as seen on maps that predate the construction of the dam (U.S. Army Corps of Engineers 1930). The most extensive sections of limestone riverscour were at the base of the Cumberland Escarpment, where early eyewitness accounts described extensive areas of flat limestone "shoals" or "reefs" lining the banks of the Cumberland River. These undoubtedly harbored riverscour communities, as evidenced by the small remnants of this community found in the non-inundated sections Buck Creek and the Little South Fork. (Campbell 2016).

Even less is known about riverscour of the Eastern Highland Rim. Since the Eastern Highland Rim is downstream of the Cumberland Plateau, the Cumberland River in this section was channelized very rapidly for shipping purposes. Exposed bedrock areas were detonated, and boulder bars were excavated, destroying potential riverscour habitats before they were ever surveyed. Excavations of the Caney Fork for shipping began as early as the year 1830 (U.S. Army Corps of Engineers 1890). These shipping channels extended up until just below Rock Island, at a place called Frank's Ferry. Based on the few surviving remnants and early descriptions remaining, it is likely that Eastern Highland Rim riverscour was of a bedrock-based nature, and less widespread that of the Cumberland Escarpment.

The best remaining example, Rock Island on the Caney Fork, attracted the attention of botanists in the mid-20th century. Collections from Dr. Jesse Shaver show that he ventured into the areas riverscour glades at Rock Island in the 1940s (APSC Herbarium), as did other botanists in the latter 20th century. Collections from Buck Creek and the Little South Fork in Kentucky indicate surviving examples of Cumberland Escarpment riverscour (Campbell 2016). However, they remain poorly documented.

Previous Studies of the Cumberland Plateau Riverscour

The Cumberland Plateau has received significant scientific attention in modern times for its widespread riverscour communities. While botanists had collected in these communities since at least the late 1800s when *Conradina verticillata* was first noted by Dr. Augustin Gattinger, riverscour communities had not received complete floristic analysis until the late 20th century. Surveys of riverscour habitat did not begin in the Cumberland Plateau until the 1970s. The "Devil's Breakfast Table" of Daddy's Creek was one of the first areas to receive floristic attention, by collectors such as Dr. Robert Kral and Dr. Hal DeSelm. It was from this location that the riverscour endemic *Sporobolus arcuatus* was first described to science (Rogers 1970). It was also during this time that Max Medley and Dr. Eugene Wofford first explored the Big South Fork of the Cumberland River, resulting in many new records for the state of Kentucky (Medley and Wofford 1980). In 1985, a complete flora of the Obed River Gorge that included extensive riverscour areas was produced, which documented the first population of *Sporobolus junceus* known to Tennessee (Schmalzer 1989). Another riverscour endemic, *Eurybia saxicastelli*, would be described in at the end of the decade (Campbell and Medley 1989). In the 1990s, interest in Cumberland Plateau riverscour would shift towards Alabama. In 1992, C.C. Dickson conducted a flora of the remarkable Little River in Alabama, the first riverscour flora outside of the Mississippi River drainage (Dickson 1992). In 1995, D. Spaulding conducted a flora of Lake Guntersville State Park in Marshall County Alabama, which included riverscour along small tributaries of the Tennessee River (Spaulding 1995). In 1999, Brain Keener conducted the flora of Blount County Alabama, which included riverscour areas along the Locust Fork (Keener 1999).

The first decade of the 2000's saw continued interest in Cumberland Plateau riverscour surveys. In 2001, a flora that focused on the riparian zones of the Clear Fork and New River was published (Bailey and Coe 2001). In Alabama, after conducting a flora of Blount County that included riverscour, Dr. Brian Keener would go on to describe the endemic *Solidago arenicola* in 2003 (Keener and Kral 2003). A flora of Fall Creek Falls State Park was conducted in 2004 that included riverscour along Cane Creek, a tributary to the Caney Fork (Fleming and Woffford 2004). In the current decade, the 2010's, the first Cumberland Plateau riverscour in Georgia was documented, in a flora on Lookout Mountain (Prater 2015). In 2016, a complete flora of Daddy's Creek was completed, which was the tributary that initially spurred interest in riverscour in the 1970's (Rodgers 2016). The Locust Fork of Alabama would also be revisited for a floristic survey focusing exclusively on the riparian zones (Anderson 2017). In addition, a complete survey of the riparian areas of the Big South Fork is has recently been completed. (Mausert-Mooney in prep).

Objectives

1) Conduct a floristic inventory of the riverscour areas of the upper Caney Fork, and provide comparisons to other riverscour floras.

2) Provide locations for taxa that are of conservation concern or new to the state of Tennessee.

3) Conduct a biogeographical analysis of the flora of the Caney Fork, and compare this to other riverscour floras.

4) Describe the riverscour communities of the Caney Fork.

CHAPTER II- STUDY AREA OVERVIEW

Location and Boundaries of the Study Area

The Caney Fork is a medium-sized river located in Middle Tennessee. The headwaters of the Caney Fork are located on the Cumberland Plateau, in the area around Crossville in Cumberland County and White Counties at approximately 579m (1900 ft.) elevation. At this point the river has a sinuous gradient, and has extensive sandstone bedrock outcrops. This section is around 31km long. The Caney Fork begins to drop in elevation significantly once it reaches the area of Todd Town on the Cumberland/White County border. Here, it flows southwest where it drains the western escarpment of the Cumberland Plateau, in White and Van Buren Counties. Through this section, the river drops around 207m (680 feet) and becomes a boulder-filled narrow gorge. This section is around 11km long. During summer months, the Caney Fork in this section exhibits subsurface flow except during periods of high rainfall. At the confluence of Bee Creek, the Caney Fork reemerges in an area known as Scott's Gulf. This area has significant karst formation. From here, the Caney Fork maintains a westward course, where it has its first significant cobble bar development. This section is around 11km long. At the bottom of the escarpment, at around 250m (820 ft.) elevation, the river enters the Eastern Highland Rim where it first develops a large floodplain. Soon after this point, it quickly becomes inundated by the tailwaters of Great Falls Dam. The significant tributaries of Cane Creek, Calfkiller River, Rocky River, and the Collins River converge with the Caney Fork through this section. This section is around 35km long, and the average river elevation is around 244m (800 ft). Below Great Falls Dam, at Rock Island State Park in Warren and White Counties, the river begins to cut down into the Outer Nashville Basin and turns to the north. It then flows through the escarpment region that transitions from the Eastern Highland Rim to the Outer Nashville

Basin in Dekalb County. Nearly as soon as it drops off the Eastern Highland Rim it becomes inundated again, this time by the tailwaters of Center Hill Dam. This section is around 90km long. The final section of the Caney Fork emerges from the dissected escarpment into the rolling to hilly Outer Nashville Basin of Smith County, where there is a significant non-inundated stretch below Center Hill Dam. This section of river maintains a sinuous source with numerous bends and shear limestone cliffs before emptying into Cumberland River. This section is around 41km long. The Caney Fork is the largest tributary to the Cumberland River. A map of the river's course, showing the primary collecting sites and area of inundation is provided (Figure 1).

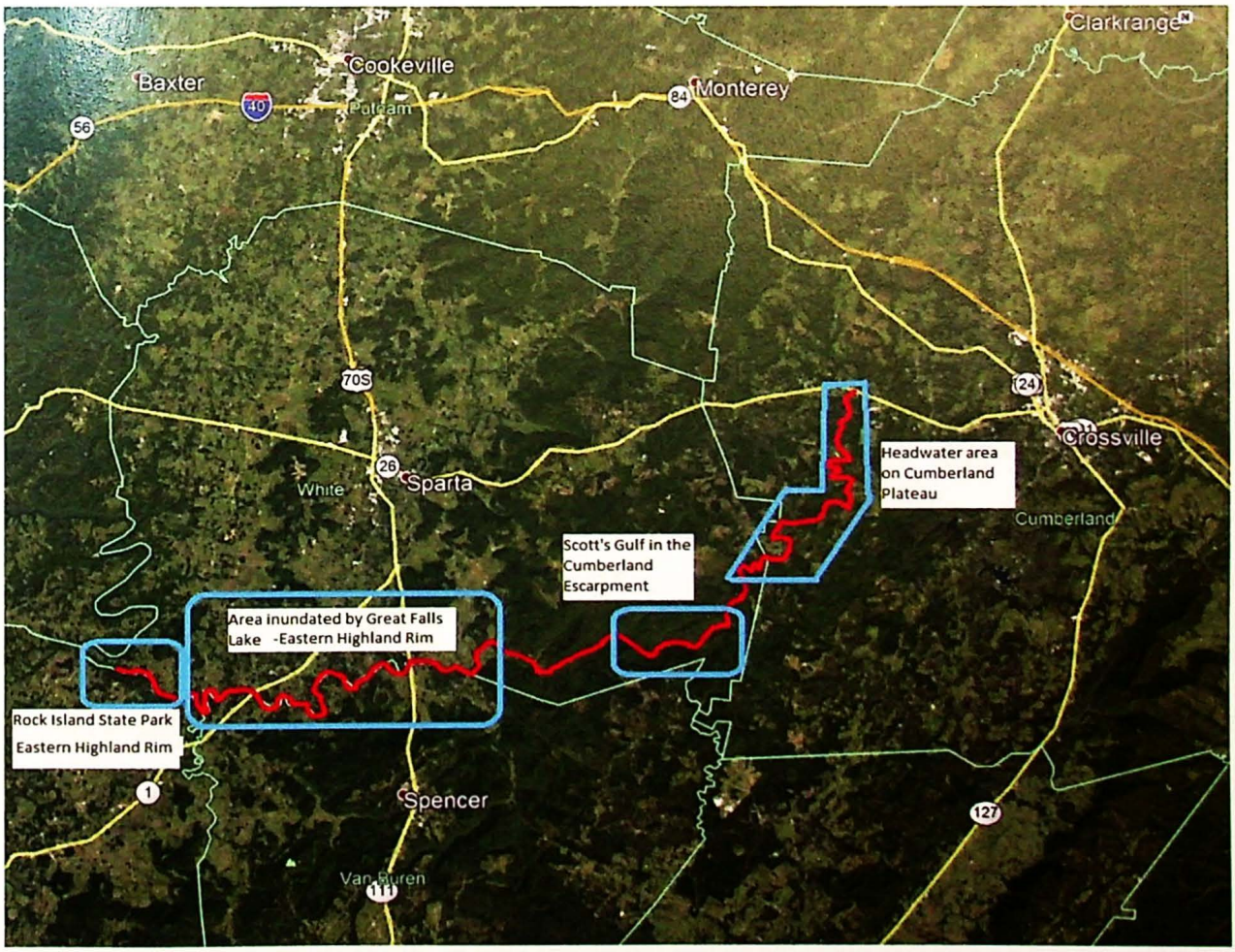


Figure 1. Major collection sites of the Caney Fork watershed in Middle Tennessee, including the area of lake inundation.

For the scope of this thesis, three major sections of river were surveyed, each which harbors riverscour habitats. The first section is located the farthest upstream at the Hwy 70 crossing west of Crossville in Cumberland County. The second section surveyed was located around and below Scott's Gulf, at the confluence of Bee Creek. The third section is located the farthest downstream, and is the stretch immediately downstream of Great Falls Dam to Blue Hole Island at Rock Island State Park, Warren County. Although small areas of riverscour also exists below Center Hill Dam in the Outer Nashville Basin, these are outside of the scope of this study.

Along the three sections of river surveyed, the specific sections samples were delineated by observing for signs of scouring flood events, such as sand deposits or a thin, battered canopy. This line corresponds to the normal high-water mark of most floods but exceptional flooding sometimes inundates areas above this line, though the flooding frequency and intensity are not great enough to exert a controlling influence over the plant community. As such, these rarely flooded higher sections support mostly closed-canopy forest. Therefore, the zone from the river channel to this edge of the scour zone were included in the survey area. In the headwaters of the Caney Fork, this boundary was quite narrow, and it included only plants growing nearly directly on the interface between the river and the surrounding forest. Farther downstream, due to larger flood events coupled with a more developed floodplain, the survey boundary was increased to include a broader riparian woodland along the banks of the Caney Fork.

Geology of the Upper Caney Fork

The Highland Rim and Cumberland Plateau sections of the Caney Fork, which are the sections that comprise the study area for this flora, pass through six distinct geological formations. The uppermost Cumberland Plateau section, from the headwaters west of Crossville to the mouth of Laurel Creek, consist of Pennsylvanian age conglomeritic sandstone of the Crab Orchard Mountains group. The Sewanee Conglomerate is the only formation preserved in this area (U.S. Geological Service 2016). A distinguishing characteristic of this formation is the presence of large amount of quartz pebbles and quartz sand (Stearns 1954). The riverscour in this section is narrow, and consists primarily of sandy riparian woodlands and meadows.

Below this Crab Orchard Mountains group is a small formation called the Gizzard Group. This formation is simply defined as any formation directly below the Sewanee Conglomerate and above the Pennington formation, which results in it having considerable variation in lithology (Stearns 1954). In the Caney Fork, it largely consists of horizontal sheets of sandstone and conglomerate. It begins around the region of Clifty Falls, and ends in the vicinity of Todd Town (U.S. Geological Service 2016). Despite this formation's small size, the unusual flat bedrock exposures of bedrock in this formation results in it being one of the most botanically significant features of the Caney Fork river.

Descending into the Cumberland Plateau Escarpment at the head of Scott's Gulf begins the Mississippian-age Pennington formation. This formation consists of soft, easily erodible siltstone and shales. Almost all outcrops of the Pennington formation are covered by sandstone talus (Stearns 1954). In the region of the Pennington formation south of Todd Town, the Caney Fork has largely already descended into the underground caverns of the Bangor Limestone,

which comprise the next geologic formation below. The Bangor Limestone marks the edge of the Cumberland Plateau escarpment, and is notable for its extensive cave systems (McCallie 1904). Below the Bangor Limestone is a thin geologic layer called the Hartsville Sandstone which is undifferentiated on geological maps of the Caney Fork area (U.S. Geological Service 2016). These combined formations comprise the remote, often submerged, region of the Caney Fork upstream of Scott's Gulf.

Below this is one of the most prominent geologic formations of the Caney Fork, the Monteagle Limestone. It forms the entire lower section of the Cumberland Escarpment. On the Caney Fork, this geologic formation is found from the mouth of Bee Creek at Scott's Gulf, to Dry Branch at the base of the Cumberland Escarpment. The Monteagle Limestone is very porous and many caves have been found in this region (Gunn 2003).

At the start of the Eastern Highland Rim, the Caney Fork meets the St. Louis Limestone, which consists primarily of limestone with chert nodules (U.S. Geological Service 2016). This Mississippian formation comprises much of the Eastern Highland Rim. In this region, the Caney Fork is almost entirely inundated by Great Falls Lake, except for at the eastern edge near the town of Dodson.

The last geologic unit at the downstream end of the study area is the Ft. Payne formation. This Mississippian formation consists primarily of calcareous and dolomitic chert (U.S. Geological Service 2016). It this formation that is well exposed in the area of Rock Island, and forms the riverscour communities found in the Great Falls area.

Soils of the Upper Caney Fork

The soils of the upper Caney Fork area are highly diverse. This is due partially to the study area comprising three ecoregions, and the Caney Fork passing through numerous geologic formations. In summary, the Caney Fork is comprised mostly of sands, loams, and cobble in the Cumberland Plateau, and transitions into silts, loams, and cobble in the Eastern Highland Rim.

The headwaters in Cumberland County begin in the Bethesda-Mine pits complex, Ealy Loam, Jefferson-Varilla-Shelocta complex, Lily Loam, Ramsey Loam, and the Ramsey-Rock outcrop complex (Soil Survey Staff 2016).

Below the headwaters, as the Caney Fork enters the Cumberland Escarpment in White County, it crosses through the Bouldin very cobbly fine sandy loam, the Caneyville-Rock outcrop-Standingstone complex, Nella cobbly loam, the Ramsey-Rock outcrop complex, Staser silt loam, the Talbott-Rock outcrop complex, the Varilla-Beetree-Muse complex, and the Welchland cobbly loam (Soil Survey Staff 2016).

At the base of the escarpment, where the Caney Fork enters the Eastern Highland Rim, the soil composition changes significantly. The Caney Fork passes through the following soil complexes here: the Algood gravelly silt loam, Allen loam, the Caneyville-Rock outcrop-Standingstone complex, Christian cherty silt loam, Etowah silt loam, Hamblen silt loam, Taft silt loam, the Talbott-Rock outcrop complex, Talbott silty clay loam, Sequatchie loam, Staser silt loam, and the Waynesboro clay and loam (Soil Survey Staff 2016).

In the lower reaches of this study, in the vicinity of Rock Island, a separate soil survey is mapped for Warren County. In this region, the Caney Fork passes through the following soil

series: Baxter cherty silt loam, Cobbly alluvial land, Jefferson cobbly sandy loam, Rockland bedrock, and Sengtown gravelly silt loam (Soil Survey Staff 2016).

Hydrology

The nearest water gauge on the Caney Fork is located in Smith County, downstream of the study area. Long-term hydrologic data for the middle and upper Caney Fork is not available. Figure 2 shows the discharge over the available period from January 2011 to March 2017.

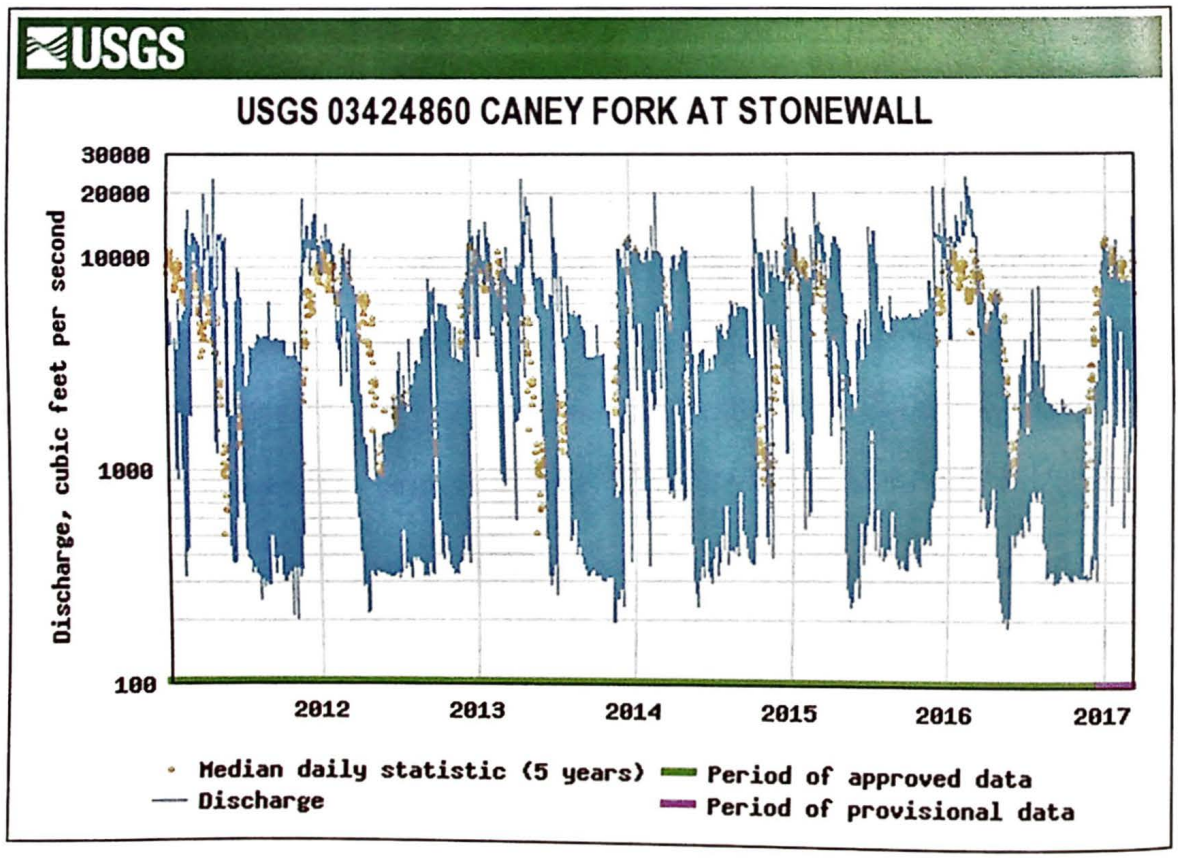


Figure 2. Rates of river discharge at the Smith County gauge of the Caney Fork River, from 2011-2017.

River flow is generally higher in the winter and spring, and lower in the summer and fall. Peak discharge is just over 20,000 cubic feet per second, and it drops to 200 cubic feet per second during drought conditions (U.S. Department of Agriculture Natural Resources Conservation Service 2017). In the nearby Daddy's Creek headwaters, which are near the headwaters of the Caney Fork, peak flows are known to reach around 9,000 cubic feet per second (Rodgers 2016). Extreme flows have been reported from nearby areas. In 2010, for example, a streamflow velocity of 150,000 cfs was reported on the nearby Obed River (USDA WR 2017). This is powerful enough to remove tree growth, and shape boulder and cobble bars.

Climate

Climate data is provided from two weather stations, at the Crossville Memorial Airport, in Cumberland County (located at N 35.95°, -85.08°), and another on the Eastern Highland Rim in Warren County at McMinnville (located at 35.69°, -85.81°). For both regions, March is the month with the highest amount of precipitation and October is the month with the lowest. Also, for both regions July is the warmest month and January is the coldest (Southern Regional Climate Center 2017).

On the Cumberland Plateau, according to data spanning from 1954 to 2016, the average maximum temperature is 18.6°C, and the average minimum temperature is 7.3°C. Average annual precipitation is 141.1 cm, with 36.1 cm of snowfall (Southern Regional Climate Center 2017).

On the Eastern Highland Rim, according to data spanning from 1891 to 2916, the average maximum temperature is 21.4°C, and the average minimum temperature is 8.8°C. Average

annual precipitation is 132.7 cm, with 20.1 cm of snowfall (Southern Regional Climate Center 2017).

Pleistocene Paleoecology of the Caney Fork Watershed

The period of most relevance to the flora, due to the presence of most modern plant genera during this time, begins in the Quaternary Period. The Quaternary Period is defined as the period from about 2.588 million years ago to the present, and is characterized by repeating cycles of gradual global cooling followed by spikes of rapid global warming. This cooling/warming cycle had a profound effect on the North American continent in the form of gradual glacial advance followed by rapid glacial retreat (Denton et al. 2010). It is difficult to accurately determine how many glacial cycles occurred during the Quaternary, since each new glaciation event largely destroyed evidence of the previous glacial period, but evidence from ice cores have shown in the past 740,000 years there have been eight glacial cycles, and these cycles seem to operate roughly on a 100,000 year timeline (Augustin et al. 2004). The last glacial period ended approximately12,000 years ago, and we are currently a few thousand years into what is presumed to be another long interglacial warm period. The Quaternary Period is divided into two epochs, the Pleistocene and Holocene, with the Pleistocene representing the time period before 11,700 years before present, and the Holocene representing the time after. The beginning of the Holocene corresponds with the most recent interglacial cycle (Walker et al. 2009).

The change in species composition over this time period can be examined by analyzing the pollen cores of stable ponds in the region. In Middle Tennessee, we have only a single site where the change in plant composition from the last glacial maximum has been documented. The pollen from Anderson Pond, a forested sinkhole swamp in the Eastern Highland Rim of White

County, Tennessee, provides a data set documenting tree composition change in the region (Liu et al. 2013). It shows that as of ~25,000 years ago, the area was dominated by *Pinus*, *Picea*, and *Abies*, with low amounts of angiosperm genera such as *Fraxinus* and *Quercus*. Starting around 15,000 years ago there was a gradual decline in gymnosperm pollen and a rise in woody angiosperms, with the most recent reliable dating (from around 13,000 years ago) showing a dominance of *Ostrya* and *Quercus*. This is evidence for a change from a colder environment with boreal elements at the height of glaciation, to a warmer, perhaps fire-dominated landscape. The persistence of temperate broadleaf trees at the height of glaciation is not surprising; there is prior molecular evidence for the persistence of populations of temperate trees within a few hundred kilometers of the glacial boundary (McLachlan et al. 2005), resulting in a "no-analogue" mixed community.

The animals that had the largest impact on Middle Tennessee's communities were the megafauna, best exemplified by mammals such as mammoths and mastodons. While no direct studies have investigated how megafauna (and the loss thereof) impacted the Middle Tennessee landscape, we can infer the impact they would have had from studies of megafauna in other areas. In particular, Proboscidea are considered "ecosystem engineers" that modify their landscape through grazing, resulting in the maintenance of grassland in what would otherwise be a forested community (Haynes 2012). A recent study has shown a correlation between the extinction of mammoths and the rapid transition in the arctic from grassland to *Betula* forest, suggesting that mammoths helped maintain a grassland ecosystem through their grazing (Doughty et al. 2010).

Human Ecological History of Middle Tennessee

The post-glacial landscape of Middle Tennessee has been most recently shaped by the influence of humans. The first evidence of Paleoindians in Tennessee dates to around 12,050 years ago, who subsisted off of hunting and gathering (Deter-Wolf et al. 2011).The first evidence of Native Americans clearing land for agricultural use has been documented from around 1,800 BC (Smith and Yarnell 2009). It is difficult to surmise the extent that Native American agriculture impacted the landscape, since so no written records were kept of this time period. However, the Native American impact on the natural communities is thought to be very significant. The arrival of human in North America is believed to be the primary trigger of the Holocene extinction event. While there is certainly a level of background extinction that took place, a majority of the scientific community believes that the Holocene extinction of North America was primarily driven by the arrival and subsequent population increases of humans, with climate change playing a smaller role (Lyons et al 2004). Roughly 35 mammals became extinct around the time humans arrived on the North American continent (Faith and Surovell 2009). While it is difficult to pinpoint the exact cause, a combination of overhunting, disease, and habitat destruction are thought to be the primary drivers of extinction. An analysis of various regions around the globe that have faced megafaunal extinction has shown that there is little correlation between extinction and climatic history, and a strong correlation between extinction and the arrival of humans (Burney and Flannery 2005).

Large-scale anthropogenic changes to the landscape did not take place in Middle Tennessee until the early 1800's, with the colonization of Native American lands by European-American migrants. The changes to the natural communities were abrupt, with the extirpation of

bison in Tennessee by the 1820s (Noss 2013), along with a decrease in regular burning due to fire suppression (Stambaugh et al 2016). Both of these factors contributed to the replacement grassland communities in Middle Tennessee with forest communities. Today the active mesophication of the landscape continues, with many forests having the older *Quercus-Carya* cohort that arose during the initial transition from grassland being replaced by fire-intolerant *Acer* and *Fagus* (Nowacki and Abrams 2008).

After the industrial revolution brought about the capability of large-scale agriculture, wholly anthropogenic landscapes began to outnumber natural communities, particularly in the flat surfaces of the Eastern Highland Rim and Cumberland Plateau. In addition, the 20th century brought about the era of dam construction in Tennessee. Large sections of the Caney Fork were impounded by Great Falls Dam in 1917, and by Center Hill Dam in 1948, resulting in a nearly complete loss of riparian communities in the Eastern Highland Rim and Outer Nashville Basin sections.

Natural Vegetation of the Caney Fork River Watershed

Due to the early widespread destruction and alteration of natural communities in Middle Tennessee, there remains many gaps in our scientific and historical knowledge of what comprises the natural vegetation of this region. The understanding that dominated most of the 20th century is best characterized by Braun's (1950) highly influential publication of the forest communities of the eastern United States. She described the Cumberland Plateau surface as oak-hickory-pine (*Quercus-Carya-Pinus*) forest, and described the ravines as mixed mesophytic forest. Mixed mesophytic forest is a highly diverse community, dominated by species such as *Acer saccharum, Fagus grandifolia, Liriodendron tulipfera, Quercus rubra,*and *Tilia americana.*

The Highland Rim was classified as "Western mesophytic", which was characterized by lower canopy diversity and more dominance by oak and hickory (Braun 1950). Notably, her descriptions only include forested communities, presumably due to her reliance on the now-discredited "climax community" hypothesis which is based on climatic equilibrium (Dyer 2006). We now know that the grassland communities of eastern North America are not "successional,"- but are the stable, natural expression of a communities maintained by non-climatic stresses such as fire and grazing (Noss 2013). These can shape a community just as much, if not more, than climate (Dyer 2006). In addition, Braun's understanding was hampered by her reliance on personal observations of what are now understood to have been highly altered communities, and her lack of a thorough analysis of early pioneer literature, which was largely unavailable for review until the digital age.

The more modern approach views the natural communities of Eastern North America as a mosaic of grassland, savanna, and forest communities, dominating the landscape in a patchwork based on local variations in topography. This viewpoint is best summarized in the recent work *Forgotten Grasslands of the South,* which emphasizes how fire, drought, and herbivory led to the evolution and maintenance of natural grassland communities throughout much of the Southeast over the past several million years (Noss 2013).

The communities of the Eastern Highland Rim and Cumberland Plateau follow similar patterns in their physiognomy, but differ in their species composition based on their differences in geology. River and creek bottoms contain isolated riverscour communities, surrounded by more widespread riparian forest communities which are often dominated by *Platanus occidentalis*, *Acer rubrum*, and *Betula nigra* (NatureServe 2015). Waterways that are bordered by steep slopes or cliffs contain a diverse mixed mesophytic forest community, which is

characterized by trees such as *Acer saccharum, Fagus grandifolia, Liriodendron tulipifera,* and *Tilia americana* (NatureServe 2015). This community is protected from both regular fire and floods. The most widespread topography in the region are the gentle slopes which naturally would have contained pine and oak woodland/savanna, and had a moderate historical fire frequency. Drier ridgetops and the edge of escarpments are often dominated by *Pinus virginiana,* and historically, *Castanea dentata*. The open plateau surfaces of both the Cumberland Plateau and the Eastern Highland Rim would have contained natural grassland communities, thought to be dominated by species such as *Andropogon gerardii, Schizachyrium scoparium,* and *Sorghastrum nutans* (NatureServe 2015). More localized natural communities in this region include limestone and sandstone glades and cliffs, calcareous seepage fens, acidic streamhead seepage bogs, and sinkhole ponds (NatureServe 2015).

For the Cumberland Plateau and Highland Rim, the existence of historical widespread natural grassland communities can be inferred from a variety of sources. Many areas of grassland in this region contain highly conservative, or even endemic, taxa that could not represent a recent ecological phenomenon. These few representative examples are not located on geological or topographical aberrations on the landscape, but represent the remnants of what was once the typical vegetation for the region, being found in locations inadvertently protected from the changes brought by fire suppression. The abundance of conservatism and endemism in the grassland communities, and the paucity of conservatism and endemism in the forested communities that now occupy these areas, points to the antiquity of the former community, and the novelty of the latter.

In addition to the information that can be gleaned from looking at modern remnants, there is good historical documentation of the grasslands of Middle Tennessee. These accounts, while

sparse in number, are unanimous in their descriptions of grassland and savanna in flat upland areas. Early pioneer accounts describe the Cumberland Plateau surface as "a plain almost void of trees, and covered entirely in grass" in 1796, and a "vast upland prairie covered with a most luxuriant growth of native grasses, pastured over as far as the eye can see" in 1785 (Bailey and Herschel 1856, J.G.M. Ramsey 1853). A 1779 account of the Eastern Highland Rim which describes the landscape from Wayne County, Kentucky to the Caney Fork, says that "All the country [...] was covered in high grass, which seemed inexhaustible" (Haywood 1823).

Today, the flat surfaces of the Eastern Highland Rim and Cumberland Plateau are almost entirely in either agriculture or forest, with grassland remnants largely restricted to areas of disturbance such as roadsides and powerline cuts. This is due to a combination of fire suppression, agriculture and development, and the absence of tree-removing megafauna (Estes et al. 2016).These last remnants are further under threat from the modern increase in herbicide use and road-widening projects.

There are, however, some exceptions to this widespread habitat destruction in the Caney Fork watershed. There are high quality pine savanna remnants being maintained at the Bridgestone/Firestone Wildlife Management Area in the Cumberland Plateau. In addition, one of the most intact natural communities in the Caney Fork watershed are the forests of the mesic gorges of the Cumberland Escarpment and Eastern Highland Rim escarpment. These forests are neither fire dependent nor suitable for agriculture or development, so they are of high quality and are widespread.

CHAPTER III – METHODS

Floristic Inventory

Twenty-seven collecting trips were made to the Caney Fork between August 2012 and October 2015. An attempt was made to sample the Caney Fork at as many locations as possible. The collections were primarily concentrated within a mile of road crossings and other access points. The Caney Fork is a dangerous river to float in the area of study, and no attempt to do so was made. Collecting locations were identified using the maps of Google Earth, Bing.com, and information from previously collected herbarium specimens. Sites that were determined to have high floristic diversity based upon initial collections were given greater attention than depauperate areas.

For all specimens, the locality, habitat, and date of collection was recorded. These specimens were then pressed and dried for preservation. After drying, the specimens were mounted on standard herbarium sheets with labels. Specimens were collected in duplicate and triplicate when possible.

The coordinates for each specimen was inferred from the online mapping system Acme Mapper. The coordinates on the specimens are accurate to at least three decimal places. In rare cases the exact coordinates could not be determined, and for these specimens a general description of the location is provided.

Plants were identified using the following keys: The Flora of the Southern and Mid-Atlantic States by Weakley (2015 version), Guide to the Vascular Plants of Tennessee by Chester et. al., and The Flora of North America by the Flora of North America Editorial Committee. In addition, Dr. Estes assisted with some difficult identifications. Nomenclature and nativity follows Weakley, 2015. The Biota of North America Program (BONAP.org) was used to

determine if a specimen was a new county record. Voucher specimens were deposited at the Austin Peay State University Herbarium (APSC) and duplicates will be sent to the Botanical Research Institute of Texas (BRIT).

Biogeographical Analysis

The Biota of North America Program (BONAP.org) was also used determine the biogeographic affinities of the species collected. A species was determined to be "extraneous" if it was within a three-county border of the edge of its range, and a species was determined to be "intraneous" if it was within more than three counties from the edge of its range. Species were determined to be "endemic" if they had a range of less than ten counties. Examples of the BONAP maps that were used are provided to give a visualization of the methodology (Figure 3).

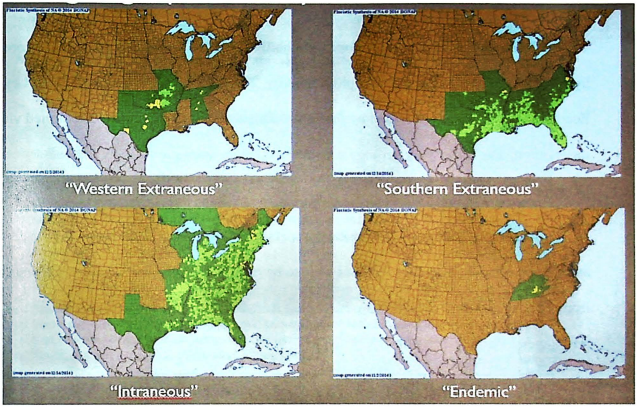


Figure 3. Examples of range maps fitting the criteria of "western extraneous", "southern extraneous", "intraneous", and "endemic". Maps are provided by Kartesz, 2015.

A Sorenson's Similarity Index was used to compare the Cumberland Plateau section of the Caney Fork to the nearby riverscour floras of the Big South Fork in Kentucky and Tennessee, the Locust Fork in Alabama, and Clear Creek and Daddy's Creek of Tennessee. The Sorenson's Similarity Index is defined as "2C/(A/B)", with "A" and "B" representing the total number of species in each flora, and "C" representing their total number of shared species between the two floras.

Community Classification

Communities of the Caney Fork were outlined using a four-factor approach: Ecoregion, hydrology, geology, and vegetation physiognomy. The ecoregions are based on of the Level IV Ecoregion maps that are provided by the EPA, while the other factors were determined via field observation. The underlying geology was informed from maps provided by the Tennessee Division of Geology.

The determination of "characteristic species" of each community is based on a general assessment of how likely these species were to be present in a given community, and excluded from other communities. This was not conducted in any quantitative way, but was instead based on a general visual observation.

Purely anthropogenic communities are not included in this study. It is likely that every community has some level of human disturbance, and distinguishing "anthropogenic" from "non-anthropogenic" here would be an unhelpful dichotomy. Photographs were taken of many of the communities. These photographs attempt to show the community at its most characteristic form.

Ranking Species Rarity

Species of conservation concern were listed as part of this study. A standard ranking of global rarity is provided by NatureServe, a non-governmental organization that provides conservation-related information. These ranks are defined by the following table supplied by the NatureServe website (Table 1).

Table 1. NatureServe global conservation rank descriptions (NatureServe 2015).

Global Rank Definitions	
Global Rank	**Definition**
GX	**Presumed Extinct** (species)/**Eliminated** (ecological communities and systems) — Species not located despite intensive searches and virtually no likelihood of rediscovery. Ecological community or system eliminated throughout its range, with no restoration potential.
GH	**Possibly Extinct** (species)/ **Eliminated** (ecological communities and systems) — Known from only historical occurrences but still some hope of rediscovery. There is evidence that the species may be extinct or the ecosystem may be eliminated throughout its range, but not enough to state this with certainty.
G1	**Critically Imperiled**—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
G2	**Imperiled**—At high risk of extinction or elimination due to very restricted range, very few populations, steep declines, or other factors.
G3	**Vulnerable**—At moderate risk of extinction or elimination due to a restricted range, relatively few populations, recent and widespread declines, or other factors.
G4	**Apparently Secure**—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
G5	**Secure**—Common; widespread and abundant.

Ranking Species Conservatism

The species collected during this study were given a coefficient of conservatism rank based on a list created by Dr. Dwayne Estes (pers. comm. 2016). The ranking goes from zero to ten, with ten meaning a species is the most conservative in its habitat preferences, and zero

meaning a species is the least conservative. An average conservatism rank for entire project area was determined, as well as separate averages for the Interior Low Plateau and Cumberland Plateau sections.

CHAPTER IV – RESULTS

Floristic Summary

This study documented 107 families, 282 genera, and 415 species from the Caney Fork. A total of 170 species were found in the Interior Low Plateau section, and a total of 310 species were found in the Cumberland Plateau section. Of the species documented, dicots comprised 71%, monocots 24%, and primitive vascular plants 6% of the total. Table 1 provides a summary of this information, comparing the distribution of higher-level plant classifications between ecoregions.

The family with the most species in this study was Asteraceae (56 taxa), which accounted for 13.4% of the flora. This was followed by Poaceae (44 taxa) and Cyperaceae (25 taxa). The genus with the most species in this study was *Carex*, with 10 species collected.

The component of the flora that are trees and shrubs consisted of 87 species (21.0%). Woody vines compromised 18 species (4.3%). There were 35 (8.4%) taxa that are considered non-native. A total of 174 taxa are considered county records, as determined from the University of Tennessee Plant Database (Appendix).

Since independent surveys were conducted of both the Cumberland Plateau and Interior Low Plateau sections of the Caney Fork, the total number of specimens collected exceeds the total number of species found. An overlap of 64 taxa were found to be present in both ecoregions. This represents a 15% overlap of all the species found.

Table 2. Summary of vascular flora of the riverscour communities of the Caney Fork				
Location	**Primitive Vascular Plants**	**Monocots**	**Dicots**	**Total**
Rock Island (Interior Low Plateau)	9 (5%)	34 (20%)	127 (75%)	170
Upper Caney Fork (Cumberland Plateau)	16 (5%)	75 (24%)	219 (71%)	310
Total	23 (6%)	99 (24%)	293 (71%)	415

Taxa of Conservation Concern

A total of fourteen taxa were found during this study that are listed by the Tennessee Natural Heritage Program as being of conservation concern (Table 3). Five are considered "Special concern", the lowest rank. These are *Amsonia salicifolia, Ceratophyllum echinatum, Cornus obliqua, Drosera intermedia,* and *Solidago arenicola*. Eight are considered "Threatened", a moderate rank. These are *Conradina verticillata, Dalea candida, Drosera brevifolia, Potamogeton amplifolius, Potamogeton tennesseensis, Rhynchospora chalarocephala, Sporobolus arcuatus,* and *Utricularia subulata*. One species, *Vitis rupestris*, was found that is considered "Endangered", the most imperiled rank at the state level. One species, *Conradina verticillata,* was found that is federally listed as "Threatened" under the Endangered Species Act, as determined by the United States Environmental Protection Agency. This ranking is given to taxa that are determined to likely become endangered in the foreseeable future.

Table 3. State-listed rare species

Taxon	State Listing	Federal Listing	NatureServe Rank
Amsonia tabernaemontana var. gattingeri	Special concern	-	G4
Ceratophyllum echinatum	Special concern	-	G4
Conradina verticillata	Threatened	Threatened	G3
Cornus obliqua	Special concern	-	G5
Dalea candida	Threatened	-	G5
Drosera brevifolia	Threatened	-	G5
Drosera intermedia	Special concern	-	G5
Potamogeton amplifolius	Threatened	-	G5
Potamogeton tennesseensis	Threatened	-	G2
Rhynchospora chalarocephala	Threatened	-	G5
Solidago arenicola	Special concern	-	G2
Sporobolus arcuatus	Threatened	-	G2
Utricularia subulata	Threatened	-	G5
Vitis rupestris	Endangered	-	G3

Exotic Species

A total of 35 species were collected that are determined to be exotic as determined by the Flora of the Southern and Mid-Atlantic States (Weakley, 2015). This represents 8% of the total flora. Of these, 17 are considered invasive by the Tennessee Invasive Plant Council (Table 4). Of these, 9 are considered a "Severe Threat", meaning that they spread readily into native plant communities. There are 6 species determined to be a "Significant Threat", meaning that they do not spread as easily into native plant communities. There are 2 species determined to be "Lesser Threat", meaning that they only spread into disturbed areas.

The ranking of these species does not correspond well with their particular threat to the Caney Fork riverscour communities. Of these, *Albizia julibrissin, Elaeagnus umbellata,* and

Lespedeza cuneata are the invasive species most abundant on riverscour communities of the Caney Fork. Others, such as *Celastrus orbiculatus*, *Maclura pomifera*, *Mentha x piperata* are exceedingly local and likely to remain so, due to lack of suitable habitat.

Table 4. Invasive species of the Caney Fork

Taxon	State Listing
Albizia julibrissin	Severe Threat
Celastrus orbiculatus	Severe Threat
Elaeagnus umbellata	Severe Threat
Ligustrum sinense	Severe Threat
Lespedeza cuneata	Severe Threat
Lonicera japonica	Severe Threat
Microstegium vimineum	Severe Threat
Peuraria montana	Severe Threat
Rosa multiflora	Severe Threat
Arthraxon hispidus	Significant Threat
Maclura pomifera	Significant Threat
Mentha x *piperata*	Significant Threat
Murdannia keisak	Significant Threat
Persicaria longiseta	Significant Threat
Spiraea japonica	Significant Threat
Clematis terniflora	Lesser Threat
Euonymus fortunei	Lesser Threat

County Records

A total of 163 species were found during this study that are determined to be a new county record in the county from which they were collected (Table 5). The county with the greatest number of new county records is White County, with 92 new records collected. For Warren County, 62 new records were collected. For Cumberland County, which has had extensive prior floristic work, only 17 new records were collected.

Table 5. New county records found during this study

Taxon	Cumberland	Warren	White
Acalypha virginiana			x
Acer pensylvanicum			x
Acer saccahrinum		x	
Agalinis fasciculata			x
Albizia julibrissin		x	
Allium canadense	x		
Ambrosia trifida			x
Amorpha nitens		x	
Ampelopsis cordata		x	x
Andropogon gerardii			x
Andropogon ternarius			x
Andropogon virginicus		x	
Angelica venenosa			x
Antennaria parlinii	x		
Apocynum cannabium			x
Apocynum sibiricum		x	x
Aronia prunifolia			x
Asclepias syriaca		x	
Asclepias tuberosa		x	
Athraxon hispidus		x	
Baptisia australis		x	
Baptisia tinctoria			x
Berchemia scandens			x
Bidens frondosa		x	
Boykinia aconitifolia			x
Calystegia sylvatica		x	
Carex albicans	x		
Carex amphibola			x
Carex umbellata	x		
Catalpa speciosa		x	
Celtis tenuifloia		x	
Cephalanthus occidentalis		x	
Cerastium glomeratum		x	
Ceratophyllum echinatum	x		
Chamaecrista nictitans			x

Chasmanthium latifolium		x	
Chelone glabra		x	
Clematis terniflora			x
Clinopodium glabellum		x	
Cocculus carolinus		x	
Coleateania longifolia			x
Comandra umbellata			x
Commelina virginica		x	
Coreopsis lanceolata			x
Coreopsis major			x
Coreopsis triperis			x
Cornus obliqua		x	
Crataegus intricata			x
Crataegus macrosperma			x
Cuscuta cuspidata		x	
Cyperus flavescens		x	
Cyperus odoratus		x	
Cystopteris bulbifera		x	
Daucus carota			x
Deutzia scabra			x
Digitaria cilliaris	x		
Diodia teres			x
Diospyros virginiana	x	x	
Drosera brevifolia	x		x
Elaeagnus umbellata		x	
Elymus villosus			x
Epigea repens			x
Equisetum laevigatum			x
Eragrostis capillaris		x	
Euonymus fortunei			x
Euphorbia maculata			
Euphorbia nutans			x
Euphorbia pubentissima			x
Eurybia surculosa			x
Fraxinus americana			x
Gleditsia triacanthos			x
Helianthus atrorubens			x
Hypericum prolificum			x
Impatiens capensis		x	
Ipomoea coccinea		x	
Ipomoea pandurata			x

Isoetes engelmanii			x
Juglans nigra		x	
Juncus dudleyi		x	
Juniperus virginiana		x	x
Justicia americana		x	
Lespedeza cuneata			x
Leucospora multifida		x	
Ligusticum canadense			x
Ligustrum sinense			x
Liquidambar styraciflua		x	x
Lobelia siphilitica		x	
Maclura pomifera		x	
Mandreda virginica			x
Melilotus albus			x
Micranthes virginiensis		x	
Microstegium vimineum		x	
Mimosa microphylla			x
Muhlenbergia sobolifera	x		
Murdannia keisak			x
Muscadinia rotundifolia		x	
Nyssa biflora	x		
Oenothera fillipes			x
Oenothera tetragona	x		
Oxalis dillenii			x
Packera anonyma			x
Packera aurea		x	
Panicum philadelphicum ssp. *lithophilum*	x		
Penstemon calycosus		x	
Perilla frutescens	x		
Persicaria longiseta		x	
Peuraria montana		x	
Phlox glaberrima			x
Phyla lanceolata		x	
Pilea pumila	x		
Pityopsis aspera			x
Platanus occidentalis			x
Poa annua		x	
Podostemum ceratophyllum			x
Potentilla simplex			x

Prunus americana			x
Prunus mexicana			x
Prunus serotina			x
Quercus alba			x
Quercus montana			x
Ranunculus carolinianus			x
Rhododendron arborescens			x
Rhododendron maximum			x
Rorippa palustris			x
Rubus flagellaris			x
Rudbeckia laciniata		x	x
Rumex verticillatus			x
Sagittaria australis			x
Salix caroliniana		x	
Saururus parviflorus		x	
Schizachyrium scoparium			x
Schoenoplectiella purshiana			x
Schoenoplectus pungens			x
Scirpus atrovirens		x	
Scirpus pendulus			x
Sedum pulchellum		x	
Smliax glauca			x
Solanum carolinense			x
Solidago altissima		x	
Solidago arenicola			x
Soliago arguta			x
Solidago odorata			x
Solidago rigida		x	
Sorghastrum nutans		x	
Sporobolus arcuatus			x
Sporobolus clandestinus	x		
Symphyotrichum dumosum			x
Symphyotrichum oblongifolium		x	
Symphyotrichum patens			x
Tephrosia virginiana			x
Thallictrum revolutum			x
Toxicodendron radicans	x	x	
Trautvettaria caroliensis		x	x
Trifolium repens	x		
Tsuga canadense			x

Typha angustifolia		x	
Utricularia subulata			x
Vaccinium arboreum			x
Veronicastrum virginicum			x
Viburnum alabamense			x
Vitis rupestris		x	x
Vitis vulpina		x	
Yucca flaccida			x

Biogeographic Analysis

The results of the biogeographical analysis can be seen in Table 6. The Caney Fork is dominated by intraneous taxa, which comprise 62% of the total flora. Southern extraneous taxa comprise 11%, northern extraneous are 10%, eastern extraneous are 6%, and western extraneous are 4% of the total flora. Endemic species comprised 2% of the flora. Exotic species, which were not included in the biogeographical analysis, comprise 8% of the flora

.

Table 6. Biogeographic affinities of taxa on the Caney Fork

	Endemic	Exotic	Northern Extraneous	Southern Extraneous	Western Extraneous	Eastern Extraneous	Intraneous
Rock Island (Interior Low Plateau)	1 (1%)	20 (12%)	12 (7%)	10 (6%)	18 (11%)	5 (3%)	108 (64%)
Cumberland Plateau	6 (2%)	18 (6%)	30 (10%)	39 (13%)	3 (1%)	23 (7%)	201 (65%)
Overall	7 (2%)	35 (8%)	40 (10%)	47 (11%)	18 (4%)	26 (6%)	257 (62%)

Conservatism Ranking

The average coefficient of conservatism for the Caney Fork project area was 5.21 on a scale from 0 to 10. The Interior Low Plateau section area had an average conservative coefficient of 4.49, and the Cumberland Plateau section had an average conservatism coefficient of 5.52.

Similarity to Other Riverscour Floras

The Cumberland Plateau section of the Caney Fork was compared to other riverscour floras using the Sorenson's similarity index (Table 7). This index ranges from 0 to 1, with a higher number indicating greater floristic similarity. It was found that the Caney Fork riverscour was most similar to Daddy's Creek, Tennessee, and least similar to the Locust Fork, Alabama.

Table 7. Sorenson's similarity index values for the Cumberland Plateau section of the Caney Fork compared to nearby riverscour floras.

Riverscour flora	Sorenson's similarity value	Total taxa collected
Big South Fork River, KY and TN (Mausert-Mooney in prep.)	0.49	416
Clear Fork, TN (Bailey and Coe 2001)	0.45	585
Daddy's Creek, TN (Rodgers 2016)	0.60	421
Locust Fork, AL (Anderson 2017)	0.41	467

Rare Taxa and Taxa New to the State

The 21 taxa that are considered either rare or new to the state are discussed below. Details are given of their locality, habitat, taxonomic status, and other observations, where notable.

Amsonia tabernaemontana* var. *gattingeri

TN-Special Concern

Collected in Warren and White County

This species was collected from two localities, both within the boundaries of Rock Island State Park. This species' typical habitat is brushy edges along seasonally inundated limestone outcrops. This is the same habitat as *Salix caroliniana,* and they are often mixed together making field recognition difficult. The two populations are small. One population was on a large island by the "Blue Hole" at N 35.81593 W -85.64147, and the other on an outcrop by the main falls at Rock Island. It is likely this species was once much more widespread in the Interior Plateau section of the Caney Fork, prior to inundation. This species is known from the Ozark Mountains, the Edward's Plateau of Texas, and the Interior Low Plateaus (Weakley 2015).

Apocynum sibiricum

TN- New to state

Collected in Warren and White County

This taxa is notoriously difficult to distinguish from the similar *Apocynum cannabinum*, and it has been treated both as a variety and a complete synonym by various authors. The identity of the specimens on the Caney Fork is highly uncertain. It is unclear if this species has been

widely overlooked in the state, or if it is truly rare for Tennessee. It is moderately common at Rock Island on the Caney Fork. This species is widespread in northern North America, ranging from British Columbia to Virginia (Weakley 2015).

Ceratophyllum echinatum

TN- Special Concern

Collected in Cumberland County

On the Caney Fork, this species is found in shallow areas of sandstone bedrock often in clear, fast moving water. It is restricted to the headwater areas of the Caney Fork, above Clifty Falls. It can become locally abundant in ideal habitat. The existence of this species in the Caney Fork is surprising, given that *C. echinatum* is typically found in ponds, lakes, and swamps (Les 1997). It appears clearly distinct from *C. demersum,* which is the taxa typically seen in riparian areas of Tennessee. Further investigation into its identity is warranted.

Clematis aff. viorna

TN-Undescribed species

Collected from White county

This undescribed species is under review by Dr. Dwayne Estes. It is a member of the *C. viorna* complex, and is restricted to outcrops in the Cumberland Plateau, Interior Low Plateau and Ridge and Valley. The only population found so far on the Caney Fork is on a fairly high limestone outcrop at Rock Island. Another population is known from Cumberland County along Daddy's Creek. This taxon is expected to be found in the Cumberland Plateau section of the Caney Fork, although no populations were found during this study.

Conradina verticillata

US-Threatened

TN-Threatened

Collected in Cumberland and White County

This species is endemic to the Cumberland Plateau, and is known to occur along the Caney Fork in open sandy areas. Three populations were observed during this study: a single individual at Scott's Gulf, scattered individuals below Clifty Falls, and a large population south of Todd Town consisting of many individuals on both sides of the river. This species is known from many localities along the Caney Fork, too numerous to mention in detail (Tennessee Natural Heritage Program pers. comm.). A mysterious record of *Conradina verticillata* was found at the BRIT herbarium, describing a large population downstream of Scott's Gulf that was apparently 100s of yards away from the riverbank, collected in the mid-20th century. In addition, the locality at Clifty Falls is described by the Tennessee Natural Heritage Program as "not typical" and consists of "sandy, shrubby woods with scattered grasses". Despite this, the population is described as "very healthy" with 83 clumps recorded (pers. comm. 2016). This site is located on a relatively gradual slope leading down to the Caney Fork, and has a mixture of species more typically associated with upland prairies as well as riverscour species. The flourishing of *Conradina verticillata* on these high, rarely-flooded sandy areas and the very low populations found in typical riverscour communities suggests that this species may be only facultative to open areas maintained strictly by flooding.

Cornus obliqua

TN-Special concern

Collected from Warren County

This is a widespread northern species, with Tennessee representing the continuous southern end of its natural distribution. It is locally common at Rock Island, found mixed with *Cornus amomum* over the bedrock limestone riverscour. Earlier collections from Rock Island from the 1960s were misidentified as *Cornus amomum*. It seems reasonable that this species has been overlooked in the state of Tennessee, and it should be sought out in any riparian areas over limestone. This species is known to have intermediates with *C. amomum*, the result of hybridization or perhaps incomplete speciation (Murrell and Poindexter 2016).

Dalea candida

TN-Threatened

Collected from Warren and White County

This species was already known from Rock Island from before this study was conducted. Large populations were observed on sloping barren-like riverscour growing with *Baptisia australis*, *Ratibida pinnata*, *Manfreda virginica*, and at one site *Phyllanthopsis phyllanthoides*. Two locations were found at Rock Island, N 35.80636 W -85.63315, and N 35.80490 W -85.62811. This species is widespread in central North America west of Tennessee, often found in areas of prairie.

Drosera brevifolia

TN-Threatened

Collected from Cumberland and White County

Two populations consisting of dozens of plants were found on seeping sandstone riverscour outcrops. This is the first time this species has been documented for the Cumberland Plateau region. This species is more typically found in areas of the Southeastern Coastal Plain (Kartesz 2015). The two populations are around 400m from each other. The downstream population was perched above, but not mixed with, with *Drosera intermedia* and *Utricularia subulata*. More populations of this inconspicuous species likely occur on the Cumberland Plateau in similar habitats; one of the sites on the Caney Fork was visited four times for this study before *Drosera brevifolia* was spotted.

Drosera intermedia

TN-Special concern

Collected from White County

This species was found only at one location on the Caney Fork, and in low numbers. It is a sunny, horizontal sandstone bedrock seep located south of Todd Town at N 35.87673 W -85.22448. The entire population consisted of only 20-30 plants, which co-occur with *Utricularia subulata*. Very little of this habitat exists, and it is not expected for more populations to be found along the Caney Fork. This species primarily inhabits coastal areas, and is found sparingly in wet acidic habitats of the Cumberland Plateau and Interior Low Plateau (Kartesz 2015).

Equisetum laevigatum

TN-new to state

Collected from White County

A population of what appears to be this species is present at Rock Island State Park. If it is correctly identified, this represents the first documentation from the state of Tennessee. A moderately large population was found in a limestone riverscour pool growing with *Saururus cernuus.* It is an extremely widespread taxon, found in the west from Canada to Mexico, east into much of the Ohio River valley of the Midwest (Kartesz 2015). Its presence at Rock Island seems reasonable given the number of western disjuncts found in the area. However, species identification within this genus is difficult, and further verification is needed.

Panicum philadelphicum* var. *lithophilum

TN-New to state

Collected from Cumberland County

A small population of this taxon was found growing on conglomerate outcrops directly above Clifty Falls. This variety is known to be endemic to granitic outcrops of the Piedmont and Blue Ridge (Weakley 2015). The distinction this taxon is questioned (Zuloaga and Morrone 1996). If the population is not var. *lithophilum,* then it appears to be *P. gattingeri,* which is considered a calciphile and would not be expected to be found on sandstone conglomerate. The presence of a few other taxa that exist only on both the outcrops on the Cumberland Plateau and the Piedmont suggests that it would not be unreasonable for this to be var. *lithophilum*, although a much more thorough investigation is needed.

Phyllanthopsis phyllanthoides

TN- New to state

Collected from White County

This rare shrub is found in abundance in certain areas of Rock Island State Park. It is a largely Ozarkian species, with populations disjunct into Texas and Alabama (Kartesz 2015). The collection of this species represents the first documentation of *Phyllanthopsis phyllanthoides* in Tennessee. At Rock Island it is found on limestone riverscour, often in higher, more sloping and barrens-like habitat. It is possible that this somewhat obscure shrub could exist elsewhere in Tennessee, as it doesn't necessarily require a limestone riverscour habitat and is found on sandstone cobble in Alabama (Anderson 2017).

Pityopsis adenolepis

TN-New to state

Collected from Cumberland and White County

Collections of what appears to be this species were made from high sandy riverscour. This species is typically found in the Southeastern United States, and Tennessee is just northwest of its known range (Kartesz 2015). This collection presents a taxonomic difficulty. Collections of this taxon on the Caney Fork (and nearby collections on Daddy's Creek) resemble *P. adenolepis* in many respects, in having narrow leaves and stipulate glandular peduncles and phyllaries. However, the heads are fewer in number than one would expect for *P. adenolepis* (less than ten heads per plant). This may represent an undescribed taxon endemic to sandstone riverscour, or is perhaps disjunct *P. adenolepis* showing a morphological response to a riverscour habitat. It is moderately common in high sand riverscour along the Caney Fork.

Potamogeton amplifolius

TN-Threatened

Collected from Cumberland County

This aquatic species is local on the Caney Fork, being restricted to the shallow sandstone bedrock in the vicinity of the Taylor Chapel crossing. In this area it is common, and co-occurs with the much rarer *P. tennessensis*. It is likely that more populations exist in the headwater areas of the Caney Fork. This aquatic species is common throughout much of the northeastern United States, and becomes rare further south (Kartesz 2015).

Potamogeton tennesseensis

TN- Threatened

Collected from Cumberland County

This species is very rare on the Caney Fork. Two populations were found in shallow, swift water over sandstone bedrock. The larger population is at the Hwy 70 road crossing, where to co-occurs with *Ceratophyllum echinatum* and historically, *Schoenoplectiella subterminalis*. A small population (less than 0.5m sq.) was documented upstream of the Taylor Chapel road crossing. It is likely more populations exist in the difficult to access stretch between these two crossings. This globally rare species is only known from high quality Appalachian rivers and streams (NatureServe 2015).

Rhynchospora chalarocephala

TN- Threatened

Collected from Warren and White County

A large population of this species was found growing around the limestone pools and seeps at Rock Island State Park. This coastal plain taxon was previously only known in

Tennessee from the wet prairies of the Eastern Highland Rim, and a recent discovery on Daddy's Creek on the Cumberland Plateau (Rodgers 2016). The discovery of this species at Rock Island was surprising, since there are few species with coastal plain affinities known from that area. In addition, this species is typically known from acidic substrates, so its presence on limestone is unusual (Kral 2002). This species is superficially similar to *Rhynchospora capitellata*, and it has likely been overlooked in Tennessee.

Solidago arenicola

TN- Special concern

Collected from White County

This poorly understood species was described recently from the Locust Fork in Alabama (Keener 2003). Further field research has revealed many localities in the Cumberland Plateau, where it can often be locally abundant. A large population exists along the Caney Fork, particularly on the extensive sandstone cobble of Scott's Gulf. The identity of the taxon on the Caney Fork is not entirely certain. It is unlike type material of *S. arenicola* in that it has phyllaries that are 4-7 mm long (as opposed to 7-12 mm), but it is unlike *S. racemosa* in that it has pubescent achenes (as opposed to glabrous). In addition, there do not appear to be glands present on the phyllaries of either dried or live plants. Similar taxonomic problems exist for the other populations that have been called *Solidago arenicola* in Tennessee (Floden 2012). The Caney Fork material may represent an undescribed species. Recent work on *Solidago* Subsection *Humiles* (which includes *S. arenicola*) indicates that the group readily undergoes speciation into novel habitats based on polyploidization (Peirson et al. 2013). It is possible that each watershed containing populations of what we call "*S. arenicola*" in fact arose from an independent speciation event, and exhibits recognizable morphological characters identifying it as such.

Sporobolus arcuatus

TN- Threatened

Collected from White and Cumberland County

This grass was found sparingly at two nearby sites in the Cumberland Plateau section of the Caney Fork. The larger population, at N 35.87885 W 85.22050, was found growing in cracks on a large exposed sheet of sandstone bedrock. The smaller population, consisting of only ~5 individuals was on a smaller bedrock outcrop at N 35.87970 W 85.22397. A large historical population existed below Clift Falls, but it could not be relocated during this study (Tennessee Natural Heritage Program pers. comm.). This globally uncommon species is restricted to riverscour habitats. It has an unusual and widely separated bimodal distribution, being found only in the Ouachita Mountains and the Cumberland Plateau (Kartesz 2015). It is likely that more populations of this inconspicuous grass will be found on the Caney Fork.

Symphyotrichum pilosum* var. *pringlei

TN- New to state

Collected from Warren County

A large population of this taxa was found growing in the riverscour glades at Rock Island. A previous collection of this taxon from Rock Island found in the Hollister Herbarium (HTTU) had been identified only to genus. An additional historical collection of this taxa was discovered from a limestone riverbank near Clarksville, Tennessee. This variety has previously been reported from Tennessee by Sharp et al (1960) and Cronquist (1980), although no specimens have been cited. It was not mapped for Tennessee by Weakley (2015). It is primarily a northern taxon, often found on calcareous outcrops, shores, alvars, and fens (Chmielewski and Semple 2001).

Utricularia subulata

TN- Threatened

Collected from White County

This species was found only at one location on the Caney Fork. It is a very small population on sunny, horizontal sandstone bedrock seep located south of Todd Town at N 35.87673 W -85.22448. The entire population consisted of only ~10 plants, which co-occur with *Drosera intermedia*. This species is primarily found on the Southeastern Coastal Plain, although populations were previously known from the Cumberland Plateau of Tennessee (Kartesz 2015). Very little of this habitat exists on the Caney Fork, and it is not expected for more populations to be found. It likely represents a small facultative population that colonized this unusual microhabitat from the larger, more sustainable populations that existed in the acidic bogs that were formerly widespread on the plateau surface.

Vitis rupestris

TN- Endangered

Collected from Warren and White County

This species was found at two locations on the Caney Fork. There is a small population at Rock Island at N35.80860, W-85.63408, and a single individual at Scott's Gulf at N 35.83015, W-85.27659. It appears to be a colonizer after disturbance in riverscour communities. The population at Rock Island is growing on a boulder-filled bank with many young trees and shrubs, and the Scott's Gulf population in on a sandy washout on a riverscour bar that has successional species not typical of stable riverscour communities. The Scott's Gulf population represents only the second collection for the Cumberland Plateau in Tennessee, the first being a recently discovered population on the Big South Fork by Chris Maussert-Mooney (growing on a

disturbed boulder bank by the O & W Bridge Crossing). This globally uncommon species is restricted to riverscour communities (Moore and Wen 2016). It has experienced significant decline due to habitat destruction in the form of removal of rocky shoals from waterways, channelization, and impoundments. Due to its superficial similarity to other *Vitis,* it is likely that more populations of *Vitis rupestris* exist on the Caney Fork than were discovered during this survey, and it should be searched for in other areas on the Cumberland Plateau as well.

Rare Taxa Not Documented During This Study

The following rare species have previously been collected from the Caney Fork, but were not found during this study. Locality information was provided by the Tennessee Natural Heritage Program.

Ceanothus herbaceus – This western species is only known on the Caney Fork from a 1947 collection from "sand along river along Caney Fork near Webb's Camp below Great Falls Dam" (Verified in herbaria at VDB, TENN). Although unknown throughout the rest of the state, this species has been found in similar riverscour habitats on the Rockcastle River and Little South Fork in Kentucky. The habitat in which this species was collected was almost certainly destroyed by the construction of Center Hill Dam in 1948, which occurred the very next year after the collection. This species seems to have a preference for more calcareous riverscour (co-occurring with *Vitis rupestris* in its Kentucky localities). Therefore, the place most likely for re-discovery on the Caney Fork would be the remote areas of the lower Cumberland Escarpment.

Danthonia epilis- This globally uncommon grass is known from seepage areas around rock outcrops. In 1980, it was collected on the Caney Fork downsteam of the Taylor Chapel Bridge,

growing on a wet sandstone outcrop (specimen at TENN). This locality was not accessed during the course of this study. This species is somewhat inconspicuous, and it is likely that populations were overlooked during sampling.

Juglans cinerea- This species has experienced tremendous population declines due to a Butternut Canker, a fungus. This disease, thought to be an exotic introduction, has particularly decimated *Juglans cinerea* in the southern part of its range (Ostry and Woeste 2008). Occasional individuals of *Juglans cinerea* can still be found in Tennessee, particularly along rich, mesic streambanks. A single individual was documented on the Caney Fork in 2005 (Tennessee Natural Heritage Program pers. comm.). No herbarium specimens were located for this study.

Juncus brachycephalus- This rush was documented at Rock Island in 1966, growing in "lime outcrops in wet crevices" below Great Falls Dam (specimens at TENN). This habitat is largely still intact, and it is likely that this inconspicuous species was simply overlooked during this study. *Juncus brachycephalus* is a northern species known primarily from calcareous meadows, a habitat found in abundance at Rock Island.

Schoenoplectus subterminalis – This aquatic plant was collected on the Caney Fork in 1985 at the Highway 70 bridge crossing (specimen at TENN). This represents the only known documentation of this species in the state of Tennessee. *Schoenoplectus subterminalis* is primarily found in the northeastern and western United States, although there are scattered populations in the southeast (Kartesz 2015). The Highway 70 bridge crossing is an area of peculiar aquatic diversity, with lush beds of *Ceratophyllum echinatum* and *Potamogeton tennesseensis*. This site is at the furthest upstream boundary of the study area, where they Caney Fork begins to turn into little more than a stream. While *Schoenoplectus subterminalis* was not

found during this study, it is likely that highly inconspicuous species still exists on the Caney Fork.

Spiraea virginiana - A single population of this federally threatened species is known on the Caney Fork. It was observed in 2007 on a boulder bar downstream of Old Cabin Branch, (the exact locality is not included in this report, for the purpose of data confidentiality). This extremely remote section of the Caney Fork was not accessed during the course of this study. It is likely that there are other populations of this shrub in the escarpment section. In vegetative condition, it is somewhat non-descript and easily mistaken for *Ilex verticillata* or *Itea virginiana*, which are abundant on the Caney Fork. This is easily the species of greatest conservation concern in the Caney Fork watershed; it is believed that there are less than 30 distinct genotypes of this taxa in current existence (NatureServe 2015). No herbarium specimens were located for this study.

Ecological Communities

A total of 16 distinct ecological communities were documented along the Caney Fork (Table 8). They are organized based on the Level III ecoregion in which they are located. These communities were determined from field observation, as described in the Methods section. Photographs are provided for some communities showing their most characteristic form.

Table 8. Ecological Communities of the Caney Fork riverscour zone

Ecological Community Name	Ecoregion
1. Limestone riverscour glade	Interior Low Plateau
2. Limestone boulder shrub riverscour	Interior Low Plateau
3. Limestone grassland riverscour	Interior Low Plateau
4. Limestone riverscour seep	Interior Low Plateau
5. Limestone riverscour pool	Interior Low Plateau
6. Calcareous riparian woodland	Interior Low Plateau
7. Sandstone cobble riverscour grassland	Cumberland Plateau
8. Sandstone shrub riverscour	Cumberland Plateau
9. Sand prairie riverscour	Cumberland Plateau
10. Sandy riparian woodland	Cumberland Plateau
11. Acidic seep riverscour	Cumberland Plateau
12. Sandstone outcrop riverscour	Cumberland Plateau
13. Wet riparian sandstone banks	Cumberland Plateau
14. Sandstone backwater pool	Cumberland Plateau
15. Riverbank meadow	Cumberland Plateau
16. Riverine aquatic beds	Cumberland Plateau

1. Interior Low Plateau: Limestone riverscour glade (Figure 4)

Figure 4. Limestone riverscour glade at Rock Island State Park, with *Sedum pulchellum*, Warren County, Tennessee (by Kelly Anderson).

Description: This community is found abundantly on the broad sheets of bedrock around Rock Island State Park. It is characterized by thin soil and a xerohydric hydrology typical of limestone glades in upland habitats. Because of its xerohydric nature, this community has a mixture of both rock outcrop species and wetland species. From historical maps that predate the damming of the Caney Fork, it seems unlikely that this community was much more widespread beyond the "falls" area of Rock Island, where bedrock was close to the surface. This community is extremely rare in the Interior Low Plateau, with most historically known examples being destroyed to accommodate shipping.

Characteristic species: *Dalea candida, Clinopodium glabellum, Hypericum interior, Sedum pulchellum, Symphyotrichum pilosum* var. *pringlei*

2. Interior Low Plateau: Limestone boulder shrub riverscour (Figure 5)

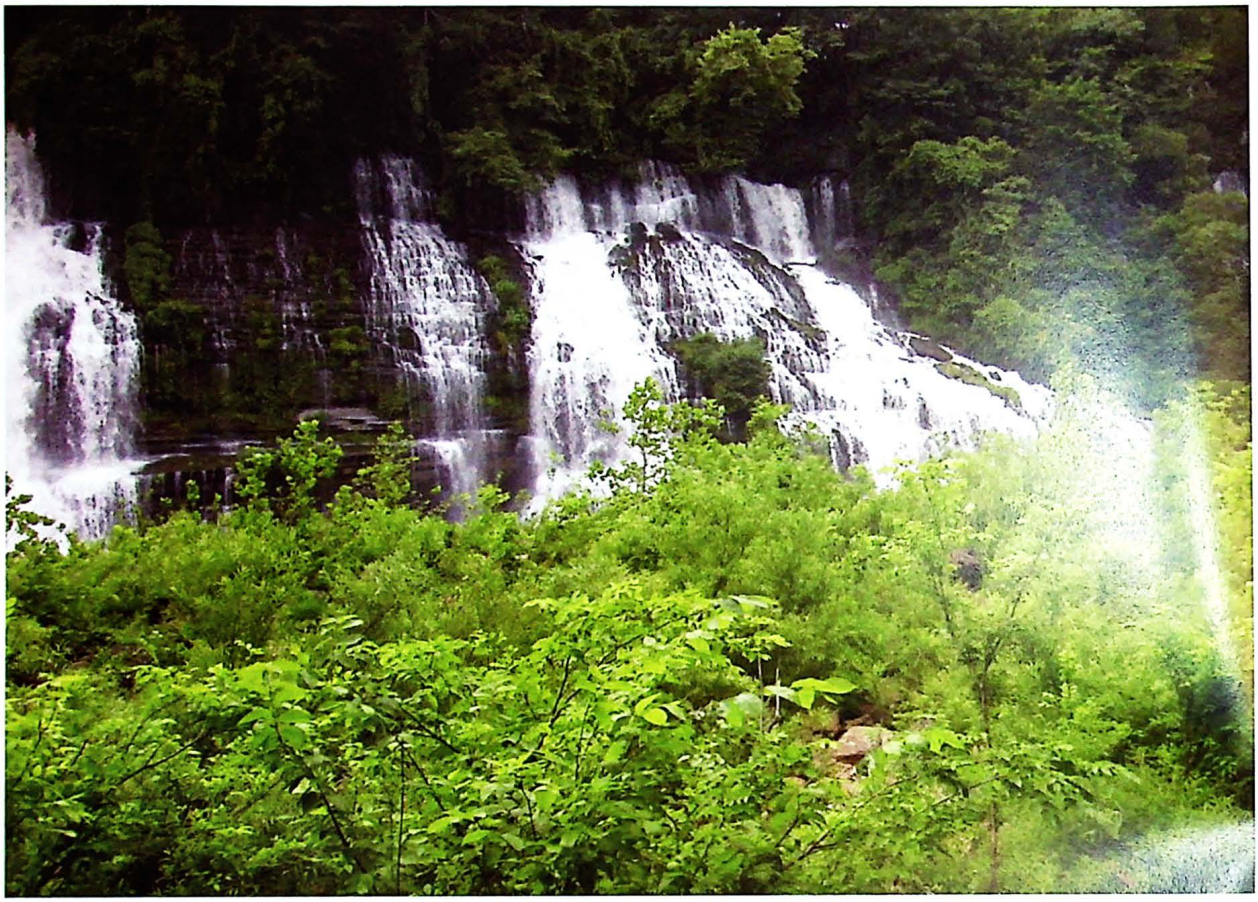


Figure 5. Limestone boulder riverscour shrub community at Rock Island State Park, across from Twin Falls, White County, Tennessee.

Description: This community is found on boulder bars that are stable enough to allow low woody vegetation to take hold. Forbs and grasses are generally uncommon, while shrubs and vines dominate. This community has little soil development. It is found in a few locations at Rock Island State Park, and may have been more widespread before dam construction.

Characteristic species: *Ampelopsis cordata, Phyllanthopsis phyllanthoides, Salix caroliniana, Ulmus americana*

3. Interior Low Plateau: Limestone grassland riverscour (Figure 6)

Figure 6. Limestone grassland riverscour at Rock Island State Park, Warren County, Tennessee (by Dwayne Estes.)

Description: This community is characterized by a tall prairie grass component and general lack of shrubs. It is found in areas of fissures in limestone, which results in linear strips of soil development. It is restricted to a single area in Rock Island, along the shelves east of the hydro plant. It is unlikely that this community was much more widespread along the Caney Fork prior to damming. The abundance of conservative species (such as *Baptisia australis*) indicate that despite the close proximity to the hydro plants, this is a natural ecological community.

Characteristic species: *Andropogon gerardii, Baptisia australis, Panicum virgatum, Schizachyrium scoparium, Sorghastrum nutans*

4. Interior Low Plateau: Limestone riverscour seep

Description: This small community is found on the margins of the river channel, where water seeps over bedrock limestone. It is dominated by shrubs and herbaceous vegetation, often with a large moss component. It is rare on the Caney Fork, only being found in the vicinity of Rock Island State Park. Much of this community on the SW side of the park is at least partially anthropogenic, and the result of elevated water from Great Fall Lake seeping through the narrow ridge. The presence of conservative species and karst geology indicate that this community is at least partially non-anthropogenic. It is unclear how widespread this community was on the Caney Fork before dam construction.

Characteristic species: *Cornus obliqua, Hypericum interior, Mitreola petiolata, Trautvetteria caroliniensis*

5. Interior Low Plateau: Limestone riverscour pool (Figure 7)

Figure 7. Limestone riverscour pool community at Rock Island State Park, Warren County, Tennessee.

Description: This community is found in a very small area on the Caney Fork, in the vicinity of Rock Island State Park. It is characterized by standing, shallow water pools with a limestone bedrock bottom. Emergent wetland plants are found along the margins and shallow areas. These pools appear to be fed by seeps, although they could also accumulate water through rain and flooding. This differs from the limestone glade community by being dominated entirely by wetland plants, and by being permanently inundated.

Characteristic species: *Alnus serrulata, Justicia americana, Rhynchospora chalarochephala*

6. Interior Low Plateau: Calcareous riparian woodland

Description: This community is characterized by large, flood-battered trees and a thick herbaceous layer. This community often has large boulder that help facilitate tree growth, although it can also exist in more elevated areas that receive less flooding than the limestone shrub riverscour community. This community lacks unusual grassland and outcrop species, and is instead dominated by more typical riparian woodland species found throughout the southeast. Due to the damming of the Caney Fork, this community is now found primarily in the vicinity of Rock Island State Park, although it also still remains in the tailwaters of Great Falls Lake near the base of the Cumberland Escarpment. It was undoubtedly the dominant community along the Eastern Highland Rim section of the Caney Fork before dam construction.

Characteristic species: *Acer saccharinum, Apios americana, Chasmanthium latifolium, Toxicodendron radicans*

7. Cumberland Plateau: Sandstone cobble riverscour grassland (Figure 8)

Figure 8. Sandstone cobble riverscour grassland at Scott's Gulf, Caney Fork, White County, Tennessee.

Description: This community is characterized by its cobble-sized sandstone substrate and open, prairie-like vegetation. It is dominated by conservative perennial heliophytic grasses, forbs, and shrubs. It is maintained by regular flooding events that prevent tree growth. This is the characteristic Cumberland Plateau "cobble bar" that is the habitat of many rare and endemic species, and because of this it has received significant botanical study where it is found on the Cumberland Plateau. On the Caney Fork, this community only exists in the Cumberland Plateau escarpment area, where the river is high-gradient and cutting down the edge of the plateau. Though the primary substrate is sandstone cobble, it is underlain by limestone bedrock which

allows for a mixture of acidophiles and calciphiles. This community is occasional along the Caney Fork from below Scott's Gulf to the base of the escarpment.

Characteristic species: *Andropogon gerardii, Heterotheca camporum, Ionactis linariifolia, Solidago arenicola*

8. Cumberland Plateau: Sandstone shrub riverscour (Figure 9)

Figure 9. Sandstone cobble shrub riverscour on the Caney Fork, at Frazer Chapel, White County, Tennessee.

Description: This community is characterized by its sandstone cobble-size substrate and dominance of woody shrubs. Some trees and prairie grasses may be present. This community is

transitional between riverscour grasslands and the riparian woodlands, and is likely maintained by an intermediate level of disturbance. This community has relatively low diversity, lacking both the prairie heliophytes of riverscour grasslands and the rich herbaceous understory of riparian woodlands, although it does contain the federally threatened *Spiraea virginiana*. This community is more common along the Caney Fork than the open grassland riverscour, and is one of the most widespread communities found.

Characteristic species: *Alnus serrulata, Cornus amomum, Hypericum prolificum, Physocarpus opulifolius, Viburnum alabamense*

9. Cumberland Plateau: Sand prairie riverscour (Figure 10)

Figure 10. Sand prairie riverscour on the Caney Fork, at Clifty Bridge, Cumberland County, Tennessee.

Description: This rare community is characterized its substrate of sand and its open habitat. It is positioned higher on the banks of the Caney Fork than the sandstone cobble riverscour communities, and it only receives irregular flooding. It contains many heliophytic species, and lacks riparian species. These openings were likely maintained by fires that burned down gentles slope of the Cumberland Plateau surface. It is unclear if this community was always rare due to the generally deep incision of the Caney Fork River, or if it has declined due to fire suppression. It is one of the few communities on the Caney Fork that appears to be in ecological decline, from both over-use for recreation and continued fire suppression.

Characteristic species: *Pityopsis aspera, Conradina verticillata, Gaylussacia baccata, Pseudognaphalium obtusifolium, Sporobolus clandestinus*

10. Cumberland Plateau: Sandy riparian woodland

Description: This community is characterized by its sandy substrate and large tree growth. It is found on high banks and only receives irregular flooding. It sometimes be shrubby, but it usually has a well-developed herbaceous layer, with conservative species typically seen in forest settings. It is lacking the heliophytes seen in more open communities. This community is common along the Caney Fork, and may be even more widespread than would naturally occur. These same high-sand communities would become sand-barren riverscour if they underwent regular burning.

Characteristic species: *Betula nigra, Nyssa biflora, Ranunculus carolinianus, Viburnum cassinoides*

11. Cumberland Plateau: Acidic seep riverscour (Figure 11)

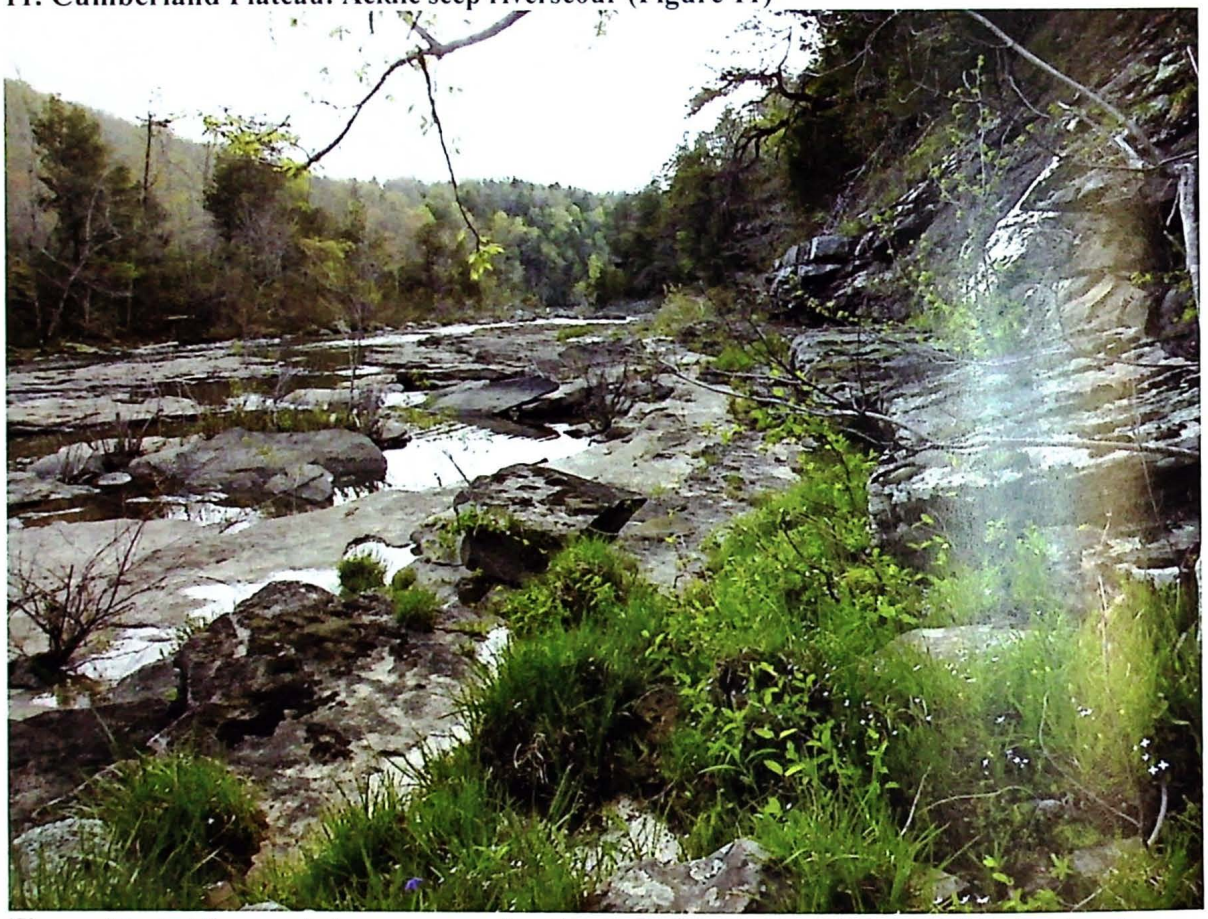


Figure 11. Acidic speed riverscour on the Caney Fork near Todd Town, Cumberland County, Tennessee.

Description: This community is characterized by consistent seepage sandstone over bedrock or boulders. It is a rare community on the Caney Fork, and is usually found in small patches around the source of the seep, although at one site on the Caney Fork it forms a large complex interspersed in bedrock outcrop communities. This community only appears in Gizzard Group sandstone formation, and is spotty even within that stretch. These seeps harbor some of the rarest species on the Caney Fork, and represent a previously undescribed community. There appears to be some differentiation in seeps that are one sloping boulders and bedrock vs. seeps on flat open bedrock, with the former having *Drosera brevifolia* and the latter having *Drosera*

intermedia. These seeps can be recognized at a distance by their abundance of *Sphagnum* moss.

Characteristic species: *Drosera brevifolia, Drosera intermedia, Hypericum crux-andre, Hypoxis hirsuta, Lobelia nuttallii, Xyris torta*

12. Cumberland Plateau: Sandstone outcrop riverscour (Figure 12)

Figure 12. Extensive sandstone outcrop riverscour on the Caney Fork, Cumberland County, Tennessee.

Description: This community is characterized by its open beds of exposed sandstone and conglomerate along the banks of the river. It receives intense enough flooding that soil development is very low, and tree growth almost absent. This community is moderately common

in the upper sections of the Caney Fork, and becomes less common in the escarpment section of the plateau where the intensely sloping boulderfields make soil development almost impossible. This community is comprised of a sparsely vegetated layer of heliophytic grasses and forbs, and is closely associated with the previously community, acidic seep riverscour.

Characteristic species: *Danthonia compressa, Liatris microcephala, Rhynchospora globularis, Sporobolus arcuatus*

13. Cumberland Plateau: Wet riparian sandstone banks (Figure 13)

Figure 13. Wet riparian sandstone banks along the Caney Fork, Cumberland County, Tennessee.

Description: This community is characterized by being a thin strip of exposed bedrock along the banks of the river, often having little soil development or tree growth. It differs from the previous community by being dominated by wetland plants. Although it may be fed by seepage, it is often shaded and lacks the sphagnum component of the acidic seep riverscour community. This community is common along the banks of the Caney Fork, particularly in the upper sections with more extensive bedrock. It is low diversity and dominated by wet-mesic species.

Characteristic species: *Boykinia aconitifolia, Houstonia caerula, Osmunda regalis, Trauvetteria caroliniensis, Xanthorhiza simplicissima, Viola cucullata*

14. Cumberland Plateau: Sandstone backwater pool

Description: This community is characterized by its shallow, standing water over a sandstone bedrock substrate. During high water flow it is connected to the main river channel, but by late summer it becomes disconnected and stagnant. The characteristic species of the backwater pool don't grow until this time of year when a muddy bottom substrate has developed, and thus this is when the community is most readily visible. This community is very rare along the Caney Fork, and is only found in the upper sections of the plateau, where sandstone bedrock is common. This community is not known to harbor conservative species, perhaps due to its ephemeral nature.

Characteristic species: *Alisma subcordatum, Potemogeton diversifolius, Sagittaria australis Scirpus pendulus*

15. Cumberland Plateau: Riverbank meadow

Description: This community is characterized by being wet-mesic and dominated by grasses and forbs. It has tall, thick vegetation lacking prairie species typical of other riverscour communities. This community is only found in in the headwaters of the Caney Fork on the flat plateau surface, where there is no gorge development. It was only observed at one location of the Caney Fork, although it likely exists elsewhere in the headwaters area. This community differs from other wetland communities along the Caney Fork by being treeless, with deep soil development, and is fed by floodwater instead of seepage. It is likely that this in its natural state, this community is associated with beaver activity, and therefore may have declined considerably over the past 200 years.

Characteristic species: *Bidens frondosa, Impatiens capensis*, *Leerzia oryzoides, Persicaria punctata, Schoenoplectus tabernaemontani, Sparganium americanum*

16. Cumberland Plateau: Riverine aquatic beds (Figure 14)

Figure 14. Diverse aquatic beds along the Caney Fork, at Highway 7 crossing, Cumberland County, Tennessee.

Description: This community is characterized by its submerged aquatic flora. It is usually found over sandstone bedrock, often is swiftly flowing water. This community is restricted to the upper regions of the Caney Fork on the plateau surface, due to its requirement for shallow water. Light must be able to penetrate to the bottom of the river bed during normal flow conditions for this community to exist. This community is widespread in the upper regions of the Caney Fork, but is spotty and greatly varying in species composition for reasons that are unclear. The Caney Fork has an unusually rich aquatic flora for a Cumberland Plateau system, with four state-listed rare aquatic plants having been documented.

Characteristic species: *Ceratophyllum echinatum, Potamogeton amplifolius, Potamogeton tennesseensis, Sparganium americanum*

CHAPTER V- DISCUSSION

Floristic Similarity to Other Riverscour Floras

This study was conducted in conjunction with three other studies of Cumberland Plateau riverscour (Anderson 2017, Mausert-Mooney in prep, Rodgers 2016). These, along with the 2001 study of the Clear Fork (Bailey and Coe 2001), can be used to make fine-level comparisons of the differences along watersheds. Of these, the Cumberland Plateau portion of the Caney Fork River showed the highest floristic similarity with Daddy's Creek of the Tennessee River watershed (SSI=0.60), and the lowest with the Locust Fork of Alabama (SSI=0.41).

The similarity to Daddy's Creek is likely explained by the fact that the headwaters of the Caney Fork and Daddy's Creek abut each other geographically in Cumberland County, Tennessee. This closeness and the similar climatic and geological conditions have allowed for much species overlap. Daddy's Creek shares five globally uncommon species with the Caney Fork (*Conradina verticillata, Potamogeton tennesseensis*, *Solidago arenicola, Spiraea virginiana*, and *Sporobolus arcuatus*) which is more than any other Cumberland Plateau riverscour system that has been studied to date. In upper reaches, streamhead capture could have allowed species from one watershed to migrate to another. However, some unusual species such as *Marshallia grandiflora* and *Sabatia campanulata* do not fit this pattern, and are found only in Daddy's Creek. One explanation for this could be the difference in watershed (Cumberland River vs. Tennessee River) between the two systems, which creates a geographic barrier. Geographic barriers in Tennessee have been previously examined in *Paysonia*, a flood-dispersed genus that has resulted in allopatric speciation into individual watersheds in the Interior Low Plateau (Rollins 1955). It is possible that differences in the Cumberland Plateau section of the Caney

Fork and Daddy's creek could be the result of low dispersal potential, in taxa that are not able to cross over into a nearby watershed, due to the Caney Fork and Daddy's creek being deeply entrenched in gorges.

It was suspected that the Caney Fork would have been the most similar to the Big South Fork, since they are both part of the Cumberland River watershed, and plants growing in riparian areas are known to disperse via flood events (Hayashi et al. 2012) This was not the case, however, and the floristic similarity with the Big South Fork was only moderate (SSI=0.49). This may be because the Big South Fork, despite being in the same primary watershed as the Caney Fork, is located about 40km farther away than Daddy's Creek. In addition, the Big South Fork has more exposed areas of Monteagle and Pennington limestone at the base of the Cumberland Escarpment (Mausert-Mooney in prep), a geologic formation that is largely inundated in the Caney Fork. The transition from the Big South Fork watershed to the Obed-Emory River watershed has been identified as a significant biogeographic break. It is in this region that watersheds which have a higher species richness of northern plants transition to having a higher species richness of southern plants (Blyveis 2011). Four globally uncommon species were identified as occurring on both the Big South Fork and the Caney Fork. They are: *Conradina verticillata, Spiraea virginiana, Sporobolus arcuatus,* and *Vitis ruprestis*.

The dissimilarity between the Caney Fork and the Locust Fork was expected, and is likely explained by a number of factors. The Locust Fork drains into the Mobile River watershed, which in turn drains into the Gulf of Mexico. In addition, it is located approximately 225km to the south, resulting in warmer climatic conditions, and an average 7.8 cm more annual rainfall (Anderson 2017). The Locust Fork has a particularly high percentage of coastal plain taxa documented from that system (Anderson 2017). This may be because of the Locust Fork's

location at the southern end of the Cumberland Plateau, close to the Southeastern Coastal Plain. It has been hypothesized that species from coastal pine savannas were able to migrate north through this route, onto the Cumberland Plateau at the close of the Pleistocene (Harvill 1984). The only globally uncommon (G3 or lower) species shared between the Locust Fork and the Caney Fork are *Sporobolus arcuatus* and *Solidago arenicola*, and as discussed in the species profile in Chapter IV, there appears to be significant morphological differences in the Caney Fork population of *Solidago arenicola*.

Species Richness Compared to Other Riverscour Floras

In terms of total number of taxa present, the Caney Fork appears to be the most depauperate of the comparable riverscour systems. A total of 415 taxa were documented on the Caney Fork, only a single taxon less than the 416 documented on the next-lowest system, the Big South Fork. However, the Caney Fork total includes species found both on the Cumberland Plateau section and the highly anomalous Interior Plateau section. When the species found only in the Interior Plateau are excluded, the Caney Fork total drops down to only 310 taxa.

There are a number of possible explanations for this. Unlike the Big South Fork and Daddy's Creek, the Caney Fork has relatively few areas of the sandstone cobble riverscour grassland community. The sandstone cobble riverscour grassland community harbors a large amount of the diversity and endemism in areas of the Cumberland Plateau. While the community is present on the Caney Fork, it is generally sparse and poorly developed compared to its extent on the Big South Fork and Daddy's Creek.

Of the riverscour systems compared, the Locust Fork has the greatest species richness, totaling to 467 taxa. Although there is a general phenomenon of species richness increasing along a gradient towards the equator (Hillebrand 2004), the Caney Fork and the Locust Fork are separated by only ~1.8° longitudinally, which has an extremely minimal effect on richness (Kerkhoff 2014). Such a large increase in richness over a relatively short distance needs further explanation. The greater richness in Alabama can perhaps best be attributed to its greater climatic stability during periods of glaciation. Recent evidence suggests that much of the deeper Southeast had essentially no floristic displacement by northern taxa during the Pleistocene (Noss et al. 2014). This climatic stability has allowed for greater speciation and endemism in the lower parts of the Southeast. The Caney Fork, in contrast, experienced more severe floristic changes during periods of glaciation (Liu et al. 2013), which likely extirpated taxa that were unable to migrate southward.

There is also the possibility that the relatively low number species on the Caney Fork may simply be an artifact of variance in collecting methods. Due to its extensive underground section, much of the Caney Fork is impossible to kayak except during high flood events. Based on aerial photography, it appears this area of the Caney Fork has a depauperate riverscour flora compared to the more regularly-flowing section, and consists largely of unvegetated boulders. In contrast, nearly all of the Big South Fork and the Locust Fork are accessible by kayak during the growing season, and have year-round water flow, which create the conditions for a richer riverscour flora.

Rare Species in Riverscour Communities

Riverscour communities are known to have globally rare and endemic taxa. Table 9 shows a list of the 28 known globally rare (G1-G3 or T1-T3) taxa occurring in association with Cumberland Plateau and Interior Plateau riverscour systems. The processes that shape the distribution of individual riverscour taxa among watersheds are influenced by a variety of factors. While some rare species are found in almost all river systems that contain riverscour communities (such as *Spiraea virginiana*), other species are restricted to riverscour communities in distinct watersheds (an example being *Eurybia saxicastelli*).

The presence or absence of a species in a given watershed is often based the availability of specialized habitats. For example, the Caney Fork contains extensive areas of acidic seep riverscour, and so it contains seep specialists such as *Drosera brevifolia* and *Utricularia subulata* which have not been found in systems without acidic seeps. River systems that contain large sand bars such as the Obed and the Locust Fork provide habitat for open sand specialists such as *Polygonum americanum*, which has not been found on the Caney Fork. It is likely that species that require highly specialized small-scale communities are merely facultative on riverscour habitat, and their presence in a river system is indicative of larger (perhaps historical) populations in nearby upland areas. In contrast, species that are strictly endemic to riverscour such as *Solidago arenicola* and *Sporobolus arcuatus* are not restricted to specialized small-scale riverscour habitats, and able to support larger self-sustaining populations.

Of the globally rare species on the Caney Fork, five are held in common with three or more riverscour systems with published floras (Table 9). These are *Conradina verticillata, Potemogeton tennesseensis, Solidago arenicola, Spiraea virginiana,* and *Sporobolus arcuatus*. These species appear to be regularly found sandstone-based riverscour systems, and are not

highly restricted by watershed. Two globally rare taxa, *Amsonia tabernaemontana* var. *gattingeri* and *Clinopodium glabellum*, are unique to the Caney Fork out of the surveyed systems. These taxa are endemic to limestone, which is rare or absent on most of the other surveyed riverscour systems. On the Caney Fork, these taxa are found at Rock Island State Park, which is an area of extensive limestone riverscour. The remaining globally rare species of the Caney Fork, *Vitis rupestris*, is found in common only with the Big South Fork out of the systems surveyed. This somewhat enigmatic species is has been found in both sandstone and limestone riverscour, and generally in very low numbers. Its presence in a community is difficult to predict, although it appears to colonize areas that have been disturbed, such as areas of bridge crossings or tree uprooting.

Table 9. Globally rare taxa (G1-G3 or T1-T3) found on riverscour systems with published floras. The sources are as follows: Big South Fork (Shaw and Wofford 2003; Mausert-Mooney in prep.), Cahaba River (Allison and Stevens 2001), Clear Fork/New River (Goodson 2000; Bailey and Coe 2001), Emory/Obed system (Schmalzer 1989; Estes and Fleming 2008), Little River (Dickson 1992), and the Locust Fork (Keener 1999; Anderson 2017). Global rankings are provided by NatureServe Explorer (NatureServe 2015).

Taxon	Caney Fork	Big South Fork, KY/TN	Cahaba River, AL	Clear Fork/New River, TN	Emory/Obed system, TN	Daddy's Creek, TN	Little River, AL	Locust Fork, AL	Global Ranking
Amsonia tabernaemontana var. *gattingeri*	X								G5T3
Aureolaria patula								X	G3
Berberis canadensis					X	X			G3
Bigelowia nuttallii							X	X	G3G4
Clinopodium glabellum	X								G3
Conradina verticillata	X	X		X	X	X			G3
Coreopsis pulchra							X	X	G2
Diervilla rivularis							X	X	G3
Eurybia saxicastelli		X							G1G2
Fothergilla major		X						X	G3
Harperella nodosa							X		G2
Hymenocallis coronaria			X					X	G2
Jamesianthus alabemensis			X						G3
Marshallia grandiflora		X		X	X	X			G2
Marshallia mohrii			X					X	G3
Parnassia grandifolia			X						G3
Phlox pulchra			X						G2G3
Potamogeton tennesseensis	X				X	X			G2G3
Rhynchospora thornei			X						G3
Sagittaria secundifolia						X	X		G1
Sarracenia oreophila							X		G2
Solidago arenicola	X				X	X		X	G2G3
Solidago racemosa		X		X					G5T3
Spiraea virginiana	X	X		X	X	X			G2
Sporobolus arcuatus	X	X		X	X	X		X	G2G3
Tridens chapmanii					X			X	G5T3
Xyris tennesseensis			X						G2
Vitis rupestris	X	X							G3

Biogeographic Affinities of Caney Fork Riverscour

The biogeographic affinities of the flora of the Caney Fork has been examined by assigning each species a "primary range" as it relates to a cardinal direction. The results of the cardinal direction biogeographic analysis shows the highest percentage of taxa (62%) having an intraneous distribution. These are widespread taxa that comprise the majority of the species found in the study. Of the species that shows affinity to a cardinal direction, species showing a southern (11%) and northern (10%) distribution are more abundant than species showing an eastern (6%) or western (4%) distribution.

Other riverscour floras, such as on the Obed River (Schmalzer et al. 1985), Daddy's Creek (Rodgers 2016), Clear Fork (Goodson and Bailey 2001), Little River Canyon (Dickson 1992), and Big South Fork (Mausert-Mooney, in prep.), all show the same pattern of a greater percentage of taxa having northern and southern affinity over eastern and western. Of these floras, the range of percent for each cardinal direction are: northern 3.61%-6.36%; southern 5.59%-7.37%; eastern 0.41%-0.96%; western 0%-0.24% (Rogers 2016). The Caney Fork, with its high percent of southern (11%) and northern (10%) taxa, shows this same pattern to an even more pronounced extent. The reason for this north/south affinity in riverscour communities in this region is still unknown, however previous researches have also noticed this trend and speculated on its cause. Much of the habitat in the Cumberland Plateau and Eastern Highland Rim surface contains flat, sandy, marshy and historically fire-maintained conditions that are very similar to habitat found in the Southeastern Coastal Plain. One of the earliest papers to remark on this phenomenon hypothesized that species of Southeastern Coastal Plain habitats are relictual of

a once larger range, and the end of the Pleistocene resulted in a greater dissection of much of the interior Southeast, which isolated these southern taxa (Braun 1955). The existence of northern taxa in the Cumberland Plateau has been hypothesized as refugia following the retreat of glaciation, being isolated in the cool, narrow gorges that provide a suitable microhabitat (Sherman 1958). A recent analysis from Prater (2015) emphasizes the complexity of the biogeographic question, noting that there is growing evidence that many temperate taxa remained geographically stable during glaciation. He suggests that the current distribution of temperate taxa is likely not based solely on re-colonization after glacial retreat.

The scarcity of species with eastern affinities can likely be explained by the Appalachian Mountains which create a physical barrier for migration of species that are found on the Atlantic Coastal Plain and Piedmont (Gugger et al. 2008). Despite the similarity of these habitats to those found on the Cumberland Plateau (in being sandy and fire maintained), an eastern biogeographic affinity for taxa was consistently low among these riverscour floras.

The scarcity of species with western affinity is more difficult to explain, but is perhaps related to the prevalence of limestone and dolomite throughout much of the region west of the Caney Fork, including the Ozark Mountains and the Interior Plateau (Kiver and Harris 1999, Unklesbay and Vinyard 1992). These rocks are calcareous, and most studies of riverscour communities have focused on those with acidic sandstone substrates on the Cumberland Plateau. Species which have evolved in high pH regions farther west likely cannot survive in the low pH conditions found in most riverscour. The Caney Fork has unusually high level of western extraneous taxa (4%) compared to the other riverscour floras for the Cumberland Plateau ($\leq$0.5%). This is likely explained by the Caney Fork containing the only significant stretches of

limestone riverscour amongst the riverscour floras that have been conducted to date, which is a bedrock found in more abundance farther west in the Interior Plateau and Ozark Mountains.

Comparison of Ecological Communities

Sixteen separate ecological communities have been identified along the Caney Fork as part of this study. Of these, most are well known communities that have been documented by prior researchers. However, some communities appear to be undocumented prior to this study.

Well-known riverscour communities include the calcareous riparian woodland and sandy riparian woodland. These have been classified by NatureServe as "South-Central Interior Small Stream and Riparian", and includes woodlands and shrublands over both sand and limestone (NatureServe 2015). Sandy riparian woodlands are common, and have been documented in Georgia (Edwards et al. 2013), on Daddy's Creek in Tennessee (Rodgers 2016), and on the Locust Fork in Alabama (Anderson 2017). Calcareous riparian woodlands are less extensively documented in the Interior Low Plateau region, but have been noted to occur in the Bluegrass of Kentucky (Campbell 2012). This community is likely under-reported in the state of Tennessee.

Many of the communities identified along the Caney Fork have also been found on other Cumberland Plateau systems. Sandstone cobble riverscour grassland is well documented, and is known from Big South Fork (Shaw and Wofford 2003; Mausert-Mooney in prep.), Clear Fork (Bailey and Coe 2001), Obed River (Estes and Fleming 2008), Daddy's Creek (Rodgers 2016), and the Locust Fork (Anderson 2017). In addition, sandstone shrub riverscour, acidic seep riverscour, sandstone outcrop riverscour, wet riparian sandstone banks, and riverine aquatic beds have all been reported on the nearby Daddy's Creek (Rodgers 2017), under different

nomenclature. Along the Locust Fork, sandstone shrub riverscour, acidic seep riverscour, sandstone outcrop riverscour, and wet riparian sandstone banks have all been reported under different nomenclature (Anderson 2017). These communities underlain by sandstone and sand should be expected along any major river system in the Cumberland Plateau area.

Two communities found on the Cumberland Plateau of the Caney Fork have not been identified by previous researchers. One, the sandstone backwater pool, is a very minor component along the Caney Fork. This community was identified only from a few small sites, which were sparsely vegetated. It is possible this community exists on other Cumberland Plateau systems and has gone unrecognized. The other novel community is the riverbank meadow. This community was observed only in the uppermost headwaters of the Caney Fork. This open, grassy community on alluvial soil is likely associated with beaver activity. Elsewhere on the Cumberland Plateau, well-developed examples of this community exist along Meadow Branch in Catoosa Wildlife Management Area (Devin Rodgers pers comm. 2016).

Six distinct limestone-based riverscour communities were identified on the Caney Fork. Open limestone riverscour communities were essentially undocumented in the Interior Low Plateau, prior to this study. No previous researchers have identified the limestone riverscour glade, limestone boulder shrub riverscour, limestone grassland riverscour, limestone riverscour seep, or limestone riverscour pool communities in the state of Tennessee. These newly described communities are likely very rare in the Interior Low Plateau, with the Caney Fork harboring the largest and most intact remaining examples. This community should be sought out on other rivers that flow through limestone areas, such as the Little South Fork in Kentucky.

Conservation

The Caney Fork is part of the larger Cumberland River system, which is one of the most biologically diverse rivers in North America, which together with the Tennessee River, contain the highest levels of freshwater diversity in North America (Abell et al. 2000). However, the Caney Fork has experienced significant ecological changes over the past two centuries. The most ecologically damaging modification has likely been the creation of two reservoirs, through the construction of Great Falls Dam in 1917 and Center Hill Dam in 1948. Due to the lack of biological surveys that predate the dams, it is difficult to quantify exactly how much biodiversity has been lost, although evidence points to the damage being extensive, particularly in aquatic obligates such as fish and freshwater mussels. Dams have also been directly implicated with loss of freshwater fish diversity (Liermann et al. 2012). In addition, out of the harbored 93 species of freshwater mussels the Cumberland River historically harbored, 11 (~12%) are now believed to be globally extinct, any more have been extirpated from the system (Gordon and Layzer 1989).

There is no botanical record of the riparian zones of the Caney Fork that were inundated before 1917, and the records that predate 1948 are exceedingly sparse. However, the presence of extensive riverscour in the few areas that are non-inundated (such as Rock Island State Park) suggests that much riverscour habitat was destroyed by their construction. Dams also have significant impacts downstream. Water stored at the base of a reservoir is colder and has less dissolved oxygen than is natural for a system, and its release can be damaging to downstream aquatic communities (Neel 1963).

Practically speaking, there is little that can be done in regards to alleviating the damage caused by these dams outside of their removal. However, the protection and popularity of Rock

Island State Park perhaps ensures that no attempt will be made to further raise the water levels of the downstream Center Hill Dam.

Upstream of the tailwaters of Great Fall Reservoir, the prevalence of riverscour communities increases significantly. In this area, large sections of the banks of the Caney Fork are publically owned in Bridgestone Firestone Wildlife Management Area and the Virgin Falls State Natural Area. Wildlife Management Areas are properties owned by the state and set aside for hunting and recreation. This designation protects the property from commercial development, as long as the land remains publically owned. In addition, the rugged terrain of the Caney Fork in this section reduces the likelihood of future urbanization.

While legal protection may prevent development, the invasive species remain a problem in riverscour areas. Fortunately, the Caney Fork remains free of the invasion of *Hydrilla verticillata* that has carpeted some sections of the nearby Daddy's Creek (Rodgers 2016). However, many of the terrestrial invasive species that are typical for the region are found along the Caney Fork. The two most prevalent invasive species appear to be *Lespedeza cuneata* and *Elaeagnus umbellata*. In particular, the extremely rare sand barren community (which harbors a large population of the federally threatened *Conradina verticillata*) is under imminent threat of being overrun with *Elaeagnus* bushes. The degradation of this community is also aggravated by the extensive use of off-road vehicles in this location. With the combination of fragile sandy soils, destructive human use, and invasive species, it is likely that the sand barren habitat will soon be destroyed at this location.

The largest threat for the Caney Fork that is appearing in the imminent future, is perhaps the expansion and continued urbanization of the city of Crossville. According to the U.S. census, the population of Cumberland County now stands at 58,655 people, which is nearly triple from

what it was in 1970 (U.S. Census Bureau 2016). Crossville is in the farthest headwaters of the Caney Fork, an area that once consisted of bogs, beaver meadows, and wet prairie. These habitats have declined considerably (Neel 1914, DeSelm 1992). The transformation of these headwater areas into water retention ponds also threatens the Caney Fork with the possible introduction of *Hydrilla*, along with other invasive species, as has happened at Daddy's Creek. In addition, the continued urbanization of Crossville threatens all the downstream areas with possible industrial and residential pollutants.

Future Research Needs

It is likely that further collection efforts could add to the total number of species known on the Caney Fork. In particular, the high spring water levels that are typical for the Caney Fork made it unfruitful to survey extensively for spring ephemeral species. While they are unlikely to be high in richness, more extensive spring collecting would likely add a minor amount to the total number of taxa.

There are sections of the Caney Fork that were not surveyed as part of this study, which have the possibility of yielding interesting species and communities if they are accessed. This includes the area from the mouth of Dark Hollow Branch (35.82404°, -85.30038°) to the Road 2190 bridge (35.82418°, -85.39376°). This area is in the transition from the Cumberland Escarpment to the Eastern Highland Rim, and may contain calciphile species, such as was found downstream at Frazier Chapel. Also, the section of the Caney Fork in the vicinity of the mouth of Laurel Creek (35.89825°, -85.20368° to 35.91057°, -85.18537°) is in need of exploration. Aerial photographs of this region show what appears to be a sandstone bedrock glade located at

35.90299°, -85.18732° that was not accessed due to its remoteness and location surrounded by private land.

Literature Cited

Abell, R.A., D. Olson, E. Dinerstein, P. Hurley, J. Diggs, W. Eichbaum, S. Walters, W. Wettengel, T. Allnutt, C. Loucks, P. Hedao. 2000. Freshwater ecoregions of North America: a conservation assessment. Washington, DC, USA: Island Press.

Allison, J. and T. Stevens. 2001. Vascular flora of Ketona Dolomite outcrops in Bibb County, Alabama. Castanea 66:154-205.

Anderson, K.A. 2017. Floristics and biogeography of riverscour communities on the Locust Fork of the Black Warrior River, Blount County, Alabama. M.S. thesis, Austin Peay State University.

Augustin, L., C. Barbante, P. Barnes, J.M. Barnola, M. Bigler, E. Castellano, O. Cattani, J. Chappellaz, D. Dahl-Jensen, B. Delmonte, G. Dreyfus, G. Durand, S. Falourd, H. Fischer, J. Flückiger, M. Hansson, P. Huybrechts, G. Jugie, S.J. Johnsen, M. Zucchelli. 2004. Eight glacial cycles from an Antarctic ice core. Nature 429:623–628.

Bailey, C. and F. Coe. 2001. The vascular flora of the riparian zones of the Clear Fork River and the New River in the Big South Fork National River and Recreation Area (BSFNRRA). Castanea 66:252–274.

Baily, F. and J.F. Herschel. 1856. Journal of a tour in unsettled parts of North America: In 1796 & 1797. Baily Brothers, London, United Kingdom.

Baskin, J. and C. Baskin. 1986. Geographical origin of the specimens of *Orbexilum stipulatum* (T. & G.) Rydb. (Psoralea stipulata T. & G.). Castanea 51:207-210.

Bebber, D., J. Wood, C. Barker, and R. Scotland. 2014. Author inflation masks global capacity for species discovery in flowering plants. New Phytologist 201:700-706.

Blyveis, E.R. 2011. The vascular flora of the Tennessee River Gorge, Hamilton and Marion Counties, Tennessee. M.S. thesis, Univeristy of Tennessee, Chattanooga.

Braun, E.L. 1955. The phytogeography of unglaciated eastern United States and its interpretation. Botanical Review 21:297-375.

Burney, D.A. and T.F. Flannery. 2005. Fifty millennia of catastrophic extinctions after human contact. Trends in Ecology and Evolution 20:395–401.

Campbell, J. 2012. Riparian vegetation of the Central Bluegrass Region. Available at: http://bluegrasswoodland.com/uploads/Riparian_Bluegrass.pdf (Accessed December 2017)

Campbell, J. 2016. The atlas of vascular plants in Kentucky (Microsoft Access Database).

Campbell, J. and M. Medley. 1989. *Aster saxicastelli* (Asteraceae) a new species from the Rockcastle River bars in southeastern Kentucky. Sida 13:277-284.

Cartwright, J.M. and W.J. Wolfe. 2016. Insular ecosytems of the southeastern United States: A regional synthesis to support biodiversity conservation in a changing climate. U.S. geological survey professional paper 1828.

Chmielewski, J.G., and J.C. Semple. 2001. The biology of Canadian weeds. 114. *Symphyotrichum pilosum* (Willd.) Nesom (*Aster pilosus* Willd.). Canadian Journal of Plant Science 81:851-865.

Denton, G.H., R.F. Anderson, J.R. Toggweiler, R.L. Edwards, J.M. Schaefer, and A.E. Putnam. 2010. The last glacial termination. Science 328:1652–1656.

DeSelm, H.R. 1992. Flora and vegetation of the barrens of the Cumberland Plateau of Tennessee. p. 27-65. In: Snyder, D.H. (ed.). Proceedings of the contributed paper session, Fourth annual symposium on the natural history of lower Tennessee and Cumberland River Valleys. The Center for Field Biology of Land Between the Lakes, Austin Peay State University, Clarksville, Tennessee.

Deter-Wolf, A., J. Tune, and J. Broster. 2011. Excavations and dating of Late Pleistocene and Paleoindian deposits at the Coats-Hines Site, Williamson County, Tennessee. Tennessee Archaeology 5:142-156.

Dickson, C.C. 1992. A vascular and non-vascular flora of Little River on Lookout Mountain in northeast Alabama. M.S. thesis, Jacksonville State University.

Doughty, C.E., A. Wolf, and C.B. Field. 2010. Biophysical feedbacks between the Pleistocene megafauna extinction and climate: The first human-induced global warming? Geophysical Research Letters 37.

Drew, L. 2011. Are we losing the science of taxonomy? BioScience 61:942-946.

Dyer, J. 2006. Revisiting the deciduous forests of eastern North America. BioScience 56:341-352.

Edwards, L., J. Ambrose, and L. Kirkman. 2013. The natural communities of Georgia. University of Georgia Press.

Ertter, B. 2000. Floristic surprises in North America north of Mexico. Annals of the Missouri Botanical Garden. 87:81-109.

Estes, D., M. Brock, M. Homoya, A. Datillo, and S. Fleming. 2016. A guide to grasslands of the mid-south. Working draft of guide and maps of May 2016. Published by the Natural Resources Conservation Service, Tennessee Valley Authority, Austin Peay State University, and the Botanical Research Institute of Texas.

Faith, J.T., and T.A. Surovell. 2009. Synchronous extinction of North America's pleistocene mammals. Proceedings of the National Academy of Sciences 106:20641–20645.

Fleming, C.A. and B.E. Wofford. 2004. The vascular flora of Fall Creek Falls State Park, Van Buren and Bledsoe Counties, Tennessee. Castanea 69:164-184.

Floden, A. 2012. Notes on two rare *Solidago* (Asteraceae) in Tennessee: *S. arenicola* and *S. simplex*. Phytoneuron 2012-63:1-4.

Goodson, B.E. 2000. The vascular flora of the Clear Fork and New River Gorges of the Big South Fork National River and Recreation Area. Master's thesis, Tennessee Technological University.

Gordon, M. and J. Layzer. 1989. Mussels (Bivalvia: Unionoidea) of the Cumberland River. U.S. Fish and Wildlife Service Biological Report 89.

Gregory, S., F. Swanson, W. McKee, and K. Cummins. 1991. An ecosystem perspective of riparian zones. Bioscience 42:540-551.

Gugger, P., J. McLachlan, P. Manos, and J. Clark. 2008. Inferring long-distance dispersal and topographic barriers during post-glacial colonization from the genetic structure of red maple (*Acer rubrum* L.) in New England. Journal of Biogeography 35:1665-1673

Gunn, John. 2003. The encyclopedia of caves and karst science. Routledge. pg. 144.

Harvill, A.M. 1984. On the history of coastal plain species on the Cumberland Plateau and Highland Rim. SIDA, Contributions to Botany 10:290-294

Hawkins, C., and J. Sedell. 1981. Longitudinal and seasonal changes in functional organization of macroinvertebrate communities in four Oregon streams. Ecology 62:387-397.

Hayashi, H., Y. Shimatani, K. Shigematsu, J. Nishihiro, S. Ikematsu, Y. Kawahuchi. 2012. A study of seed dispersal by flood flow in an artificially restored floodplain. Landscape and Ecological Engineering 8:129-143

Haynes, G. 2012. Elephants (and extinct relatives) as earth-movers and ecosystem engineers. Geomorphology 157-158:99-107.

Haywood, J. 1823. The civil and political history of the state of Tennessee: from its earliest settlement up to the year 1796; including the boundaries of the state. Knoxville, Tennessee.

Heywood, V. 2001. Floristics and monography: an uncertain future. Taxon 50:361-380.

Hillebrand, H. 2004. On the generality of the latitudinal diversity gradient. The American Naturalist 163:192–211.

Kartesz, J.T., The Biota of North America Program (BONAP). 2015. Taxonomic Data Center. (http://www.bonap.net/tdc). Chapel Hill, N.C. [maps generated from Kartesz, J.T. 2015.

Floristic synthesis of North America, Version 1.0. Biota of North America Program (BONAP). (in press)].

Keener, B.R. 1999. Vascular flora of Blount County, Alabama. M.S. thesis, University of Alabama, Tuscaloosa.

Keener, B.R. and R. Kral. 2003. A new species of *Solidago* (Asteraceae:Astereae) from north central Alabama. Sida 20:1589-1593.

Kerkhoff, A., P. Moriarty, and M. Weiser, Michael. 2014. The latitudinal species richness gradient in New World woody angiosperms is consistent with the tropical conservatism hypothesis. Proceedings of the National Academy of Sciences of the United States of America:111.

Kiver, E., and D. Harris. 1999. Geology of U.S. parklands. John Wiley and Sons, Inc.

Kral, R. 2002. *Rhynchospora*. In: Flora of North America. New York and Oxford. Vol. 23.

Les, D.H. 1997. Ceratophyllaceae. In: Flora of North America. New York and Oxford. Vol. 3.

Liermann, C., C. Nilsson, J. Robertson, and R. Ng. 2012. Implications of dam obstruction for global freshwater fish diversity. Bioscience 62:539-548

Liu, Y., J.J. Anderson, J.W. Williams, and S.T. Jackson. 2013. Vegetation history in central Kentucky and Tennessee (USA) during the last glacial and deglacial periods. Quaternary Research 79:189-198.

Lyons, S., F. Smith, J. Brown. 2004. Of mice, mastodons and men: human-mediated extinctions on four continents. Evolutionary Ecology Research 6:339–358

Mausert-Mooney, C. In prep. Floristic inventory of the scour zones of the Big South Fork River, Tennessee and Kentucky. M.S. thesis, Austin Peay State University.

McCallie, S.W. 1904. A preliminary report of the coal deposits of Georgia. Page 19.

McLachlan, J.S., J.S. Clark, and P.S. Manos. 2005. Molecular indicators of tree migration capacity under rapid climate change. Ecology 86:2088–2098.

Medley, M., and B. Wofford. 1980. *Thuja occidentalis* L. and other noteworthy collections from the Big South Fork of the Cumberland River in McCreary County, Kentucky. Castanea. 45:213–215.

Moore, M.O., and J. Wen. 2016 Vitaceae. In: Flora of North America. New York and Oxford. Vol. 12.

Murrell, Z., and D. Poindexter. 2016. Cornaceae. In: Flora of North America. New York and Oxford. Vol. 12.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: October 21, 2016).

Neel J.K. 1963. Impact of reservoirs, chapter 21. In: Limnology in North America (ed D. G. Frey) pp. 575–593. The University of Wisconsin Press, Madison.

Neel, L.R. 1914. Natural meadows of the Cumberland Plateau. Transactions of the Tennessee Academy Science 2:35-37.

Noss, R. 2013. Forgotten grasslands of the south. Island Press.

Noss, R., W. Platt, B. Sorrie, A. Weakley, D. Means, J. Costanza, and R. Peet. 2014. How global biodiversity hotspots may go unrecognized: lessons from the North American Coastal Plain. Diversity and Distributions 21:236-244.

Nowacki, G., and M. Abrams. 2008. The demise of fire and "mesophication" of forests in the eastern United States. BioScience 58:123-138.

Ostry, M., and K. Woeste. 2004. Spread of butternut canker in North America, host range, evidence of resistance within butternut populations and conservation genetics, in black walnut in a new century, proceedings of the 6th Walnut Council research symposium.

Pearman, M., M. Penskar, E. Schools, and H. Enander. 2006. Identifying potential indicators of conservation value ussing Natural Heritage occurrence data. Ecological Applications 16:186-201.

Peet, R., T.R. Wentworth, P. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262-274.

Peirson, J.A., C. Dick, A. Reznicek. 2013. Phylogeography and polyploid evolution of North American goldenrods (*Solidago* subs. *Humiles,* Asteraceae). Journal of Biogeography 40:1887-1898.

Prater, R.A. 2015. The vascular flora of the Lula Lake Land Trust on Lookout Mountain in Walker County, Georgia and a biogeographical analysis of the coastal plain element on the Cumberland Plateau. M.S. thesis, University of Tennessee, Chattanooga.

Ramsey, J.G.M. 1853. The annals of Tennessee to the end of the eighteenth century. Walker and Jones, Charleston, South Carolina.

Rodgers, D. 2016. Vascular flora and vegetation of the Cumberland Plateau sandstone riverscour communities in Daddy's Creek Gorge, Cumberland and Morgan Counties, TN. M.S. thesis, Austin Peay State University.

Rogers, K. 1970. A new species of *Calamovilfa* (Gramineae) from North America. Rhodora 72:72–79.

Rollins, R.C. 1955. The auriculate-leaved species of *Lesquerella* (Cruciferae). Rhodora 57:241–264.

Schmalzer, P. 1989. Vegetation and flora of the Obed River gorge system, Cumberland Plateau, Tennessee. Journal of the Tennessee Academy of Science 64:161–168.

Shaw, J. and B.E. Wofford. 2003. Woody plants of Big South Fork National River and Recreation Area, Tennessee and Kentucky and floristic comparison of selected Southern Appalachian woody floras. Castanea 68:119-134.

Sherman, H.L. 1958. The vegetation and floristics of five gorges of the Cumberland Plateau. M.S. thesis, University of Tennessee, Knoxville. [http://trace.tennessee.edu/utk_gradthes/2492, accessed 12 July 2017].

Smith, B. and R. Yarnell. 2009. Initial formation of an indigenous crop complex in eastern North America. Proceedings of the National Academy of Sciences 106:6561–6566

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. [http://websoilsurvey.nrcs.usda.gov/, accessed 28 Jan 2017].

Southern Regional Climate Center. 2017. Historical Climate Summaries- New Version. [http://www.sercc.com/coopsummaries, accessed 26 Feb 2017].

Spaulding, D.D. 1995. The vascular flora of Lake Guntersville State Park, Marshall County, Alabama. M.S. thesis, Jacksonville State University.

Stambaugh, M., R. Guyette, J. Marschall, D. Dey. 2016. Scale dependence of oak woodland historical fire intervals: contrasting the barrens of Tennessee and Cross Timbers of Oklahoma, USA. Fire Ecology 12:65-84.

Stearns, R.G. 1954. Bulletin 60: the Cumberland Plateau overthrust and geology of the Crab Orchard Mountains area, Tennessee. State of Tennessee Department of Conservation: Division of Geology. Nashville, Tennessee.

Steury, B., G. Fleming, and M. Strong. 2008. An emendation of the vascular flora of Great Falls Park, Fairfax County, Virginia. Castanea 73:123-149.

Tschaplinki, R., and G. Hartman. 1983. Winter distribution of winter juvenile coho salmon (*Onchorhynchus kisuch*) before and after the logging of Carnation Creek, British Columbia, and some implications for overwinter survival. Canadian Journal of Fisheries and Aquatic Sciences 40:452-461.

Unklesbay, A., and J. Vineyard. 1992. Missouri geology — three billion years of volcanoes, seas, sediments, and erosion. University of Missouri Press.

U.S. Army Corps of Engineers. Analytical and topical index to the reports of the chief and engineers and the officers of the Corps of Engineers, United States Army, upon Works and Surveys from River and Harbor Improvement. Pages 1866-1879.

U.S. Army Corps of Engineers. 1890. Annual report to the secretary. Page 2149.

U.S. Army Corps of Engineers. 1930. Cumberland River survey.

U.S. Census Bureau. 2016. Population and housing unit estimates. [https://www.census.gov/programs-surveys/popest/data/tables.2016.html, accessed 3 Aug 2017].

U. S. Department of Agriculture Natural Resources Conservation Service (USDA WR). 2017. Water Data. Available at nwis.waterdata.usgs.gov. Accessed March 2017.

U.S. Geological Service. 2016. Mineral resources on-line spatial data, Tennessee.

Walker, M., S. Johnsen, S.O. Rasmussen, T. Popp, J-P Steffensen, P. Gibbard, W. Hoek, J. Lowe, J. Andrews, S. Bjo, L.C. Swynar, K. Hughen, P. Kershaw, B. Kromer, T. Litt, D.J. Lowe, T. Nakagawa, R. Newnham, J. Schwander. 2009. Formal definition and dating of the GSSP (Global Stratotype Section and Point) for the base of the Holocene using the Greenland NGRIP ice core, and selected auxiliary records. Journal of Quaternary Science 24:3-17.

Weakley, A. 2015. Flora of the Southern and Mid-Atlantic states. Working draft of 21 May 2015. University of North Carolina Herbarium, Chapel Hill.

[http://www.herbarium.unc.edu/FloraArchives/WeakleyFlora_2015-05-29.pdf, accessed 2 Jun 2015]

Wolfe, W.J., K.C. Fitch, and D.E. Ladd. 2007. Alluvial bars of the Obed Wild and Scenic River, Tennessee. U.S. Geological Survey Scientific Investigations Map 2007-2972. United States Geological Survey, Washington, D.C.

Zuloaga, F.O. and O. Morrone. 1996. Revisión de las especies Americanas de *Panicum* subgenera *Panicum* sección *Panicum* (Poaceae: Panicoideae: Paniceae). Annals of the Missouri Botanical Garden 83:200-280.