THE VASCULAR FLORA OF THE BARE ZONE OF THE COPPER HILL BASIN, POLK COUNTY, TENNESSEE AND FANNIN COUNTY GEORGIA

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A Thesis Submitted to the Faculty of the University of
Tennessee at Chattanooga in Partial
Fulfillment of the Requirements of the Degree
of Master of Science: Environmental Science

The University of Tennessee at Chattanooga
Chattanooga, Tennessee

May 2020

ABSTRACT

A vascular plant inventory of The Bare Zone of the Copper Hill Basin, Polk County, Tennessee and Fannin County, Georgia was conducted during the growing seasons of 2017 through 2019. The site encompasses 3215 ha in the Blue Ridge ecoregion. A total of 444 species and lesser taxa from 113 families were documented during this survey. There were five rare species (*Chelone obliqua* ssp. *erwinae, Clematis vinacea*, *Eriophorum virginicum*, *Lilium philadelphicum*, and *Lobelia amoena*), documented in the Basin. There were 107 non-native species found at the site. A total of 17 ecological systems containing 25 associations were delineated during this study. A comparison of six other Blue Ridge floras show the Copper Hill Basin is most like those that have a history of disturbance, such as the Vascular Flora of Steele Creek. A phytogeographical analysis showed the Bare Zone differs from these floras by having more of a southern affinity.

ACKNOWLEDGMENTS

I would like to thank Dr. Joey Shaw for the exceptional education I have received while at the University of Tennessee at Chattanooga. His guidance and patience have given me every available opportunity to succeed and grow as a Tennessee botanist. I would like to thank Dr. J Hill Craddock for his optimism and advice in the thesis writing process and Dr. Stylianos Chatzimanolis for his guidance and patience in this process. I want to thank Jack Muncy from the Tennessee Valley Authority for introducing me to the Copper Hill Basin and the staff at the Ducktown Mining Museum for their constant support and ability to answer questions regarding mining in the region. I would also like to thank Zach Irick, a friend and mentor in the field of southeastern taxonomy and Gary Morton who mentored me in the genus *Solidago*. I would like to thank Caleb Powell for every countless effort that allowed me to collect and organize data in this project. I would like to thank Grace Sarabia for her tireless efforts with editing, figure creation, and overall support. I would like to thank Erica Rylander and Courtney Alley for the late-night editing, conversing about this project and their constant support. I want to recognize the faculty and fellow students in the Department of Biology, Geology, and Environmental Science that have supported me. I would like to thank the many friends and colleagues who have helped me conduct field research through plant collections and learning opportunities. I would like to thank the Department of Biology, Geology, and Environmental Science for their financial support in travel and aid for this project. Finally, I would like to thank the Veteran's Affairs Office and Folded Flag Foundation who have financially supported me through my master's education.

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LIST OF ABBREVIATIONS

TNIPC, Tennessee Invasive Plant Council

SERNEC, Southeastern Regional Network of Expertise and Collections

TDEC, Tennessee Department of Environment and Conservation

NOAA, National Oceanic and Atmospheric Administration

USDA, United States Department of Agriculture

BONAP, Biota of North America Program

OCR, Optical Character Recognition

m, Meters

Km, Kilometers

ha, Hectares

C, Coefficient of Conservatism

MYA, Million Years Ago

BYA, Billion Years Ago

CHB, Copper Hill Basin

BFG, Big Frog Mountain

GM, Grassy Mountain

SB, Sandy Bottom

RFT, Rocky Fork Tract

SC, Steele Creek

NRG, New River Gorge

INTRODUCTION

The Copper Hill Basin, located in the far southeastern corner of Tennessee in Polk County and northwestern Georgia in Fannin County, is infamous for the extreme environmental degradation that it sustained from 1848 until 1980. For over 130 years, copper mining practices that included the clearing of forests for wood and the open smelting of copper extirpated all plant life and ecologically destroyed an area of 3215 ha (7907 acres). This area ultimately became known as the Bare Zone and was barren, nearly 100% devoid of vegetation for much of the last 100 years. Jack Muncy, a Senior Land Specialist with the Tennessee Valley Authority (TVA from here on) was tasked in the early 1980's with much of the revegetation efforts that took place at the Copper Hill Bare Zone. He would go on to describe the site as a man-made biological desert (Muncy, 1986). Ecologist E. W. Teale described the site as a moonscape (Fig. 1).

Figure 1 Copper Hill Basin, circa 1951-1954 showing the area nearly devoid of vegetation. Photo taken by John Fraser Hart.

Contributing to the inability of vegetation to reestablish in the area was the total erosion of the subsoil (Fig. 2), the soil layer underneath the topsoil (Edwards, 1942), which was estimated to exceed 574,000 m^3 annually (Rothacher, 1954). The only vegetation having been cited as surviving this event were greenbriar (*Smilax* sp.), a peach orchard, local home gardens (McGill, 1916) and “sedge grass” (*Andropogon virginicus*, or broom sedge) that would be found in deep, man-made gullies (Wood, 1942). Today, the area is largely green (with a few exceptions) due in part to the efforts of Jack Muncy, the TVA, the Citizen Conservation Corps, the U.S Forest Service, and the people who live in the Copper Hill Basin.

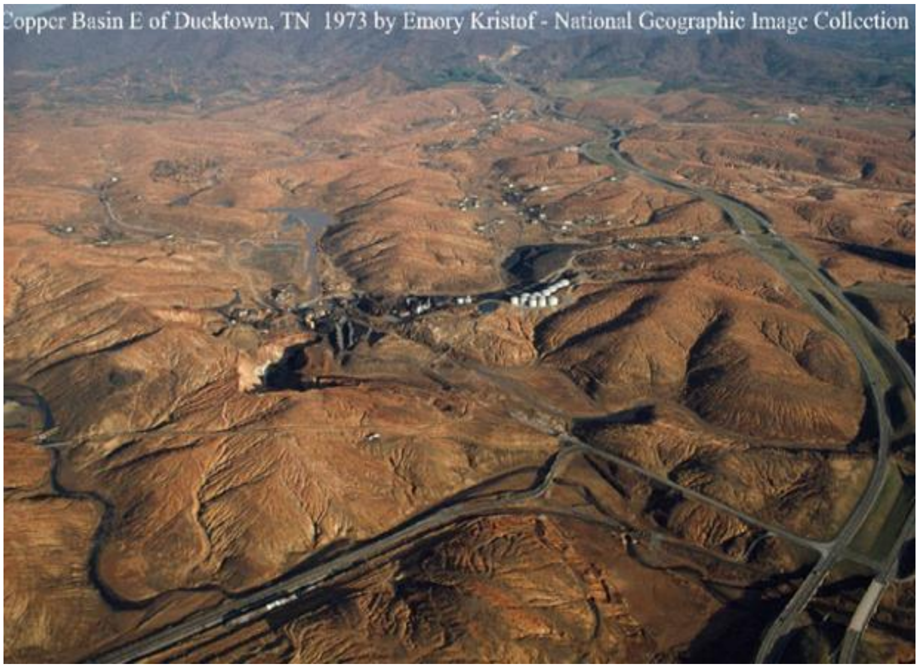

Figure 2 Aerial overview of US Highway 64 at the Copper Hill Basin in 1973, Photo taken by Emory Kristoff.

Since the late 1970’s, over 10 million trees were planted and approximately 4.7 million US dollars spent on reclamation (Thames, 1997). The Copper Hill Basin remains as one of the largest collective mine remediation areas found in the United States (EPA, 2020). It was one of three human made objects to be seen from space during the Apollo 11 Space Mission (Fig. 3). Since reclamation, the area has become revegetated.

Figure 3 Landsat 1 image taken on October 23rd, 1974. Seen in the center of the image is the white, barren “moonscape” that is the Copper Hill Basin.

Mining devastation, however, is not unique to the Copper Hill Basin. Around the world (Hentschel et al., 2002; Salomons, 1995; Swenson et al., 2011) mining entities have harmed regions and habitats using destructive mining practices. In fact, several researchers have investigated the process of how to revegetate these sites, how the change in flora after destructive mining happens, and how these habitats can change after the loss of vegetation. Hadocova and Prach (2003) looked at coal mining sites in the Czech Republic to understand the difference between spontaneous vegetation (natural revegetation) and practiced revegetation techniques on habitat reclamation. When observing sites from 0 to 45 years in age, the authors found that although practiced revegetation tended to perform better initially, as time progressed, sites that had been left alone and allowed to go through spontaneous vegetation had both higher species richness and the flora tended to look more like that of the surrounding region. This result is primarily from the suite of plants planted in these reclamation sites, 12 of 27 were nonnative, and competition between *Calamagrostis epigeous*, a common invader of these sites, and other species found in these areas. *Calamagrostis epigeios* is notable in that it is the most aggressive species in these reclamation sites, and it's spread is more limited in spontaneously vegetated sites compared to areas that were restored using practiced revegetation techniques.

Although Czech site was like the Copper Hill Basin because it had gone through destructive mining practices that removed vegetation, there is one key difference that demonstrated the devastation at the Copper Hill Basin. Because coal mining can alter the substrates (Mishra et al., 2008), it is much more akin to physical destruction at this site. In the Copper Hill Basin, the soil was both removed, leaving only subsoil, and altered by both acid rain and sulfur poisoning. The soil in the Copper Hill Basin had become much more acidic (Byers, 1929, Berry, 1979), and toxic (Nwadialo, 1982) than the rest of the region, which made spontaneous vegetation impossible until large-scale practiced revegetation efforts, including mycorrhizae & nutrient additives were put in place.

In another coal mine in Rock Castle Kentucky, researchers observed five reclaimed surface coal mining sites across 2.5 ha to compare the species richness 12 years after a revegetation plan was enforced (Thompson & Wade, 1991). Each site had been mined for 15-23 years and was then planted with a common suite of species used regionally for reclamation (including species used at the Copper Hill Basin, such as: *Robinia pseudoacacia*, *Kummerowia striata*; both Fabaceae). A floristic checklist and habitat analysis of each site was conducted to compare the planted species assemblage with the total flora that existed at the sites. Thompson & Wade (1991) found that many of the planted species were non-native, not all of the species that were planted remained in the sites by the time the observations were made, and diversity had increased after the 12-year period.

Similarly, to the Copper Hill Basin, this area was in the Southeastern United States. Additionally, much of the pre- and post-mining flora may have been similar to that of the Copper Hill Basin given their proximity (350 km) to one another and their shared physiographic ecoregion (Blue Ridge ecoregion and Appalachian/Cumberland Plateau). Similar to Hadocova and Prach (2003), what really distinguishes these two sites is coal mining versus copper mining. The Rock Castle, Kentucky site was physically altered by mining, but within 12 years since mining had ended (35 years since the start of mining), those areas were reclaimed by vegetation. The Copper Hill Basin in comparison had little vegetation development before 1980, 132 years since mining began (Quinn, 1990).

When comparing similar levels of devastation, the Olkusz ore-bearing region of south Poland bears a resemblance to the Copper Hill Basin (Szarek-Łukaszewska, 2010). The area's soils were poisoned by lead, zinc, and sulfur from the opening-cast smelting of heavy metal rich ore. The aftermath left the area's soils extremely toxic. Following the cessation of mining operations in the 1980's, research was conducted to understand the grasslands that had since returned to the area by recording the species assemblages found in 28 sites across the 4800 ha region.

This site represents the most direct similarity to the Copper Hill Basin. At least a century of harmful mining and smelting practices, similar if not worse toxicity due to a combination of sulfur, lead, and zinc soil contamination, and a return of vegetation. Where the two sites differ were in the use of select sites and revegetation because not all the 4800 ha region was grassland; some of it has been reforested. Additionally, the devastation that had taken place there was almost solely based on the chemical alteration of the soil substrate. Removal of vegetation, the destruction of the surrounding ecosystems, and the erosion of soil did not play a factor in the land history. A combination of both physical and chemical destruction truly made the Copper Hill Basin's destruction unique.

Each of these studies used botanical collections to support the research (Hadocova & Prach, 2003, Szarek-Łukaszewska, 2010; Thompson & Wade, 1991). Botanical collections or specimens are voucher records that ensure the research is repeatable (Culley, 2013). These specimens were taken from the field, pressed, mounted, and labeled to indicate their location, population, size, date of collection, phenology, elevation and other general characteristics about the organism (Prater, 2015; Fleming, 2006). Some estimates for total plant (including algae and fungi) collections worldwide show there to be 350 million specimens in over 3400 herbaria (Nelson et al., 2015). These specimens may be utilized in an ever increasing variety of ways as technology allows for their uses to be expanded (Culley, 2013).

Recently, there has been a push to begin digitizing these specimens, taking them from natural history collections to the online data portals like the Symbiota, iDigBio, and regional consortium like the Southeastern Regional Network of Expertise and Collections (SERNEC) (Barkwell & Murrell, 2012). With this information easy to access, areas like the Copper Hill Basin may be explored using plant specimens that illuminate the areas botanical history.

Goals and Objectives

While the floristic composition and plant communities are well known from the Southern Appalachians (Boyd & Preusser, 2016; Gattinger, 1903; Klahs, 2014; Levy & Donaldson, 2018; Malter, 1977; Moore & Giannassi, 2002; NatureServe, 2020; Poindexter, 2008; Rohrer, 1983;

Stiles & Howel, 1998; Suiter & Evans, 1999; Thomas, 1966) and even Polk County, Tennessee (Murrell & Wofford, 1987; Wyrick, 1996), a comprehensive floristic study of the Copper Hill Basin has never been conducted. This study seeks to (1) document the current vascular plant floristic composition of the Copper Hill Basin Bare Zone, especially to document the plant species that have returned to the area, (2) document the plant communities using Naturserve's Ecological Systems Classification dataset (Natureserve, 2020) to determine what communities have returned to the area, (3) determine the geographical affinity of the flora of the Bare Zone of the Copper Hill Basin using a floristic comparisons database by Huskins (2010), Blyveis (2012), and Prater (2015), and (4) compare the results of the current flora of the Copper Hill Basin Bare Zone to online historical digital herbarium collections of the southern Blue Ridge, Polk County, and Copper Hill Basin.

Study Area Description

Geologic History

The Blue Ridge, the mountain chain that is the namesake for the ecoregion, is composed of primarily metamorphosed rock, partially metamorphosed rock, and sedimentary rock. Formation of the Blue Ridge began 480-460 MYA with the Taconic orogeny that pushed the Taconic island chain tectonic plate and North American tectonic plate together, which began the formation of Pangea (USGS, 2009). Formation of the Blue Ridge would last until 280-260 MYA when the continental African and North American plates completed their separation, leaving the chain of mountains where it is today. Many volcanic events occurred in the Ordovician, Devonian, Mississippian, and Permian Periods (480 MYA to 250MYA), deposited shale and minor carbonates over 1 BYA to 1.2 BYA rocks that were there prior to the geologic formation

(USGS, 2009). Since its creation, the Blue Ridge has slowly eroded, the elevation decreasing over time and depositing sediment in the surrounding area (Cook et al., 1980). The Blue Ridge comprises 76% of Polk County and is made up of some of the highest metamorphosed rock found in that province. As part of the Precambrian age rocks that form the Ocoee supergroup, the metamorphosed, metasedimentary rock that underlays the Copper Hill Basin is said to be the core of the Blue Ridge (Ross, 1935).

Copper Hill Formation

The Copper Hill Basin was formed through a combination of exterior elements and fault lines that created the low elevation and rolling hills found within the area. The Copper Hill Basin is surrounded by the Frog Mountains to the west (Big and Little), Stansbury Mountain to the north, and White Mountain to the east. The Ocoee/Toccoa River makes up the southern border of the basin. The average elevation of the Basin ranges from 480 m to 540 m, while the surrounding mountains reach heights of 1250 m. Copper Hill Basin is classified as being an intermontane erosional depression (Mathews & Harden, 1999). These types of depressions can be formed through several means, including common processes like weathering from streams (Ocoee/Toccoa) or being located along a fault line, both of which make up the geography of the Copper Hill Basin. The metasedimentary rock of the Copper Hill Basin is more easily eroded than the surrounding higher elevation mountains, which most likely lead to some of the erosion in the basin, making it have a lower elevation.

Copper containing layers at Copper Hill Basin are thought to have formed from hydrothermal replacement in the Devonian Period which was then brought to the surface during mountain building events taking place during the Blue Ridge formation (Emmons & Laney, 1910). The main copper containing layer can be broken into three separate layers. The uppermost layer would have been worn by surface exposure and erosion, containing iron oxide and only trace amounts of copper. The layer immediately underneath would have been the most copper rich, called the gossan layer (Quinn, 1993). Finally, a third layer composed of sulfates and less copper than the gossan layer would have rounded out the surface copper veins.

Soil

Soils for the area are composed primarily of typic hapludults and kanhapludults of the Evard-Hayesville loam complex, with occasional udorthents along drainage ways (Mathews & Harden, 1999). Typic hapludults are loamy soils composed of clay sized particles and ultimately having a medium to deep average depth (Soil Survey Staff, 2017). The typic kanhapludults of the Evard-Hayesville loam complex are composed of loamy-sized particles, a deep average depth, a high level of acidity and are often indicative of closed or forest habitats (Soil Survey Staff, 2017). The primary acidity of the soil is particularly high in the Copper Hill Basin being composed of hapludult types, degradation of the environment adding to that soil property.

Climate

A National Oceanic and Atmospheric Administration (NOAA) weather station was in use from 1981-2010 within the boundary of the Copper Hill Basin Bare Zone, at 34.99389°, -84.37583°, near the border of Tennessee and Georgia. The average annual temperature was 13.6°C, with the lowest monthly average occurring in January at 3.2°C and the highest monthly average occurring in July at 24°C (NOAA, 2020). Precipitation was not recorded at this station. Average precipitation for Copperhill, a township within the Copper Hill Basin, was 143.2 cm, several cm above the 132.1 cm average (NOAA, 2020), the highest average monthly precipitation occurs in March with 14.5 cm and the lowest average monthly precipitation with 8.1 cm (NOAA, 2020). Historical precipitation for the site has been estimated to be between 125 cm (Rothacher, 1954) and 145 cm (Muncy, 1986), which falls in the previously stated range of values from NOAA. Light snowfall may occur, but snow is not known to accumulate at the site (NOAA, 2020).

Historical Land Use

The Copper Hill Basin was historically occupied by Native American, Cherokee (Bartram, 1791). Several reports indicate that the land was a hunting ground, predominantly burned in the spring and fall to open the understory (Quinn, 1993; Mathews & Harden, 1999). Pressure to remove Native Americans was high from the early 1800's following the gold rush (Emmons & Laney, 1926), but it was the Indian Removal Act of 1830 that primarily removed the Cherokee Native Americans from the area (Anderson, 1992). White settlement into the basin was primarily due to gold having been found 10 years prior in Dahlonega, Georgia, 105 km south of the Copper Hill Basin (Mathews & Harden, 1999). Settlement of this site continued into the early 1840's, but it was the surprising find of Copper in 1843 by a prospector named Mr. Lemmons in what was colloquially known as "Chief Duck's Town" (Emmons & Laney, 1926) that spurred mining in the region. It was not until April of 1847 when A.J. Weaver identified copper ore, and prospectors began to mine the area (Emmons & Laney, 1926). From there, initial mining of the copper ore rapidly proceeded, with the first initial copper smelting having been put in place by 1854 (Mathews & Harden, 1999).

The primary process that was used to smelt the copper ore found at the Copper Hill Basin is called open pit smelting. This process involved laying chords of wood on top of copper ore and heating the ore for months at a time, liberating impurities from the ore (Fig. 4).

The treated ore was then transported to a copper smelter outside of the basin and used in goods and industry (until a smelter was built in Copper Hill in 1858). It was estimated that the Union Consolidated Mining Company used 30,000 cords (108,600 m^3) of wood annually from 1854 to 1878 (Barclay, 1946) to drive smelting. Raw wood utilization as the primary fuel source lasted until 1858, when the use of charcoal lessened the use of raw wood (Barclay, 1946).

Copper Smelting would continue until the Civil War (1861), when northern funds that supported the mining efforts ended. It would then be impacted again with the Union takeover of the primary railway through Cleveland, Tennessee in 1863 (Barclay, 1946). From 1866-1878 the mines functioned at a slower pace, eventually halting from a lack of wood in the surrounding region (Foehner, 1980). During that time, 12140 ha (30000 acres) were estimated to have been clear cut (Barclay, 1946) for copper ore smelters in the region. Growth of the forest following the end of copper mining and smelting was reported from 1879-1890 (Smallshaw, 1938), until copper mining continued in 1890.

Following the second iteration of mining, the population of the Copper Hill Basin boomed to 7,660 in 1906. It was during this time the area would become even more degraded because of increased population and an increase in mining. Smelting the ore had become more efficient by 1906 (Tennessee Copper Company, 1908), but overall more harmful to the region because more copper was being processed than ever before (Foehner, 1980). With the onset of increased smelting, several initial legal cases came out of the region, sparking discourse on what the copper companies were liable for when it came to the destruction of the land. By 1911, 235 lawsuits had been laid on the copper companies, which caught the attention of the U.S. Supreme Court (Barclay, 1973).

Figure 4 Mining operations at the McPherson Roast Yard in 1916. Note the lack of vegetation on the ground in both the foreground and background. Photo obtained from the historical collections of the University of Tennessee at Chattanooga Library.

The state of Georgia sued the copper companies in the landmark environmental law case Georgia v. Tennessee Copper Co., 206 U.S. Georgia sought the U.S. Supreme court in what was happening downwind of the Copper Hill Basin in Georgia, the destruction of property and farmland affecting Georgians in the region. Georgia would win the case, holding an injunction against the copper companies, but allowing the companies to continue under the premise that practices would change (Mercier & Crawford, 1978). This case made the companies stop the destructive open smelting process that had destroyed much of the local environment and was having impacts regionally. One remedy was to build large smokestacks to disperse the fumes of the smelting process over a larger area, therefore minimizing the localized damage, and by converting much of the harmful SO2 gas into agriculture grade sulfuric acid. It was by 1909 that the sulfuric acid production out-produced the copper production and became a viable source of income for these companies (Emmons & Laney, 1910). Following this, copper production would decline until its eventual end in 1973.

As early as 1910, the Bare Zone of the Copper Hill Basin was formed (Fig. 5). McGill in 1916 described the first zonation of the Bare Zone as comprising 30 km^2 (3000 ha) and a Grassy Zone as having gone as far out to the tops of Stansbury and Little Frog mountains and 3.2 km into Georgia (McGill, 1916). A map created by Hursh in 1948 delineated these zones and was consistent with McGill's image of the area (Hursh, 1948) (Fig. 6).

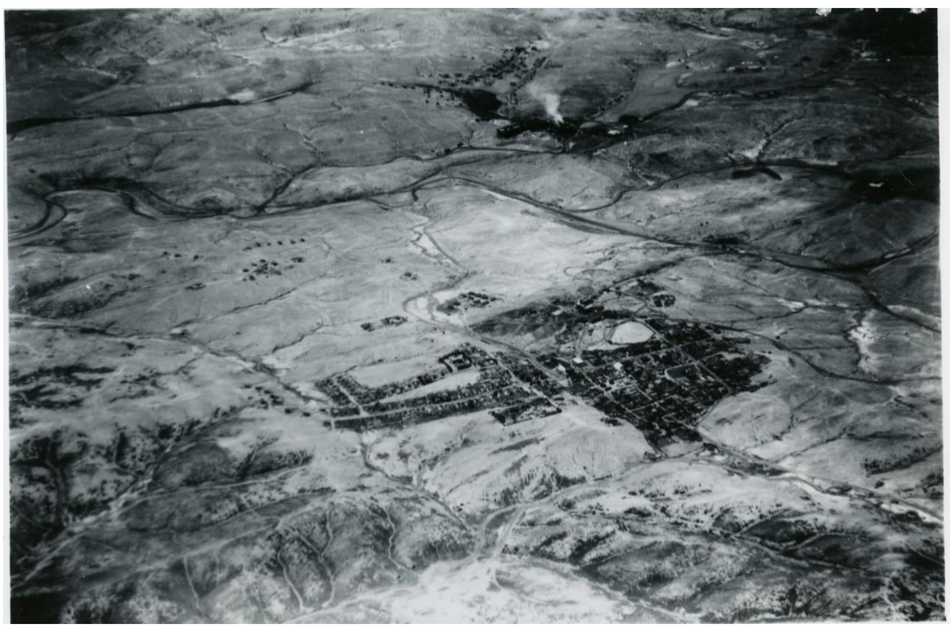

Figure 5 An aerial image of the Copper Hill Basin taken in the late 1920s shows the town of Copper Hill and the exposed landscape that made up much of the Copper Hill Basin. Photo obtained from the historical collections of the University of Tennessee at Chattanooga Library.

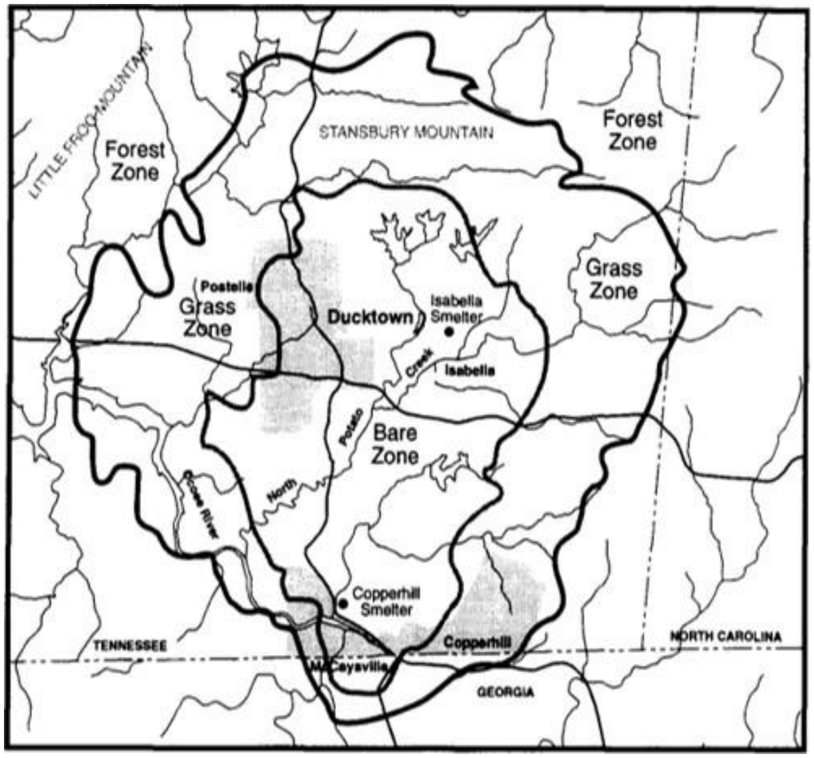

Figure 6 Vegetational zones found in the Copper Hill Basin, Hursh 1948 which shows the boundaries of the Forest, Grassy, and Bare Zones in relation to Georgia, North Carolina, and Tennessee.

Erosion was the main point of contention for the region following the switch to sulfuric acid production. It has been estimated that 0.58 m of topsoil was lost annually from the region because of the combination of vegetation removal and the Blue Ridge's high annual rainfall (Rothacher, 1954). This left the area lacking in topsoil, with little remaining subsoil layers to support vegetation. Additionally, eroded soil and heavy metals from mining and smelting operations were flowing into the Ocoee River, forming visible islands downstream of the Copper Hill Basin (Fig. 7).

Figure 7 A portion of the Ocoee River with visible islands (two to three in the middle of the image, they look like beaches) of eroded sediment from the Copper Hill Basin.

Contemporaneously, dams were built along the Ocoee River in 1910 and 1912 by the Tennessee Electric Power Company (Matthews & Harden, 1999). The Tennessee Electric Power Company took a vested interest in the potential revegetation of the Copper Hill Basin, but it was not until the Tennessee Valley Authority purchased the dams in 1939, and the creation of the Civilian Conservation Corps (CCC) in 1933 that large scale changes would begin taking place in the barren landscape.

Remediation for the Copper Hill Basin began in 1930's with the creation of the CCC camp in the basin (1941), the U.S. Forest Service and TVA, along with schools and people in the community coming together to plant trees. This first revegetation attempts progressed with indiscriminate planting through the region of trees better suited to surviving along the Grassy Zone and the margin of the Bare Zone (Table 1). From 1930-1949, over 2.8 million trees were planted in the region, primarily *Pinus taeda* and *P. virginiana* with scattered *Robinia* *pseudoacacia* (Allen, 1950), with little success in the interior as trees that survived longer than 10 years were often dwarfed and incapable of reproducing (USDA, 1978). Practiced plantings showed little results until the usage of nutrient tablets starting in 1969 and of mycorrhizal fungal associates in the 1970's (Berry, 1979).

Table 1 A detailed list of the known vegetation planted in the Copper Hill Basin, their common names, the year they were planted, and the reference to that planting.

Planted Species	**Common Name**	**Approximate Year**	**Source**
Pinus taeda	Loblolly pine	1939	Allen, 1950
Pinus echinata	Short leaf pine	1939	Allen, 1950
Pinus virginiana	Virginia pine	1939	Allen, 1950
Pinus rigida	Table mountain pine	1939	Allen, 1950
Robinia pseudoacacia	Black locust	1939	Allen, 1950
Pinus resinosa	Red pine	1941	Allen, 1950
Lespedeza cuneata	Sericea lespedeza	1941	Allen, 1950
Kummerowia striata	Japanese clover	1942	Wood, 1942
Eragrostis curvula	Weeping love grass	1947	Cummings, 1947
Panicum virgatum	Switchgrass	1947	Cummings, 1947
Pueraria montana	Kudzu	1950s	Muncy, 1986
Fallopia japonica	Japanese knot-weed	1950s	Muncy, 1986

Through the 1900's there were many scientific efforts focused on trying to revegetate the Copper Hill Basin (Allen, 1950; Berry 1979; 1982, 1985; Berry & Marx, 1976; Cummings, 1947; EMPE, 1988; Foehner, 1980; Maher, 1973; Matthews, 1995; Muncy, 1986, 1991; Thames, 1997; TVA, 1945; USDA, 1978). Of the studies conducted at the Copper Hill Basin, they were focused on vegetation plots and their viability (Allen, 1950), hydrological studies looking at the streams of the Copper Hill Basin and the surrounding area (TVA, 1945), the use of fertilizer in aiding of vegetational growth (USDA, 1978), and as mentioned earlier, the use of fungal associates in the soil.

In addition to new planting techniques, many species were planted in the region to see if any could survive the harsh conditions of the Copper Hill Basin (Matthews & Harden, 1999). One of the most pivotal studies was done on several species of pines that would be native to the region. This included *Pinus rigida*, *Pinus echinata*, *Pinus virginiana*, and *Pinus taeda*. Interestingly, *Pinus rigida* had the best survival of the four, but *Pinus virginiana* and *Pinus taeda* were ultimately selected because of their fast growth and relative ability to survive in the region (Allen, 1950).

Following the onset of new planting techniques, a revitalized interest would take place in the Bare Zone of the Copper Hill Basin. Muncy estimated that in 1985, 46.5 km^2 remained barren within the Copper Hill Basin, primarily focused on the interior of the site. A suite of hand plantings of trees, dustings of the fungus *Pisolithus tinctorius,* a fungus known to participate in mycorrhizal associations with many plant species and has a notable high tolerance to heavy metal toxicity (Tam, 1995), and the use of nutrient tablets, were key to increasing the likelihood of success of plantings in the Copper Hill Basin. In 1991, Muncy reported that much of the barren area was at least partially vegetated (Muncy, 1991).

Materials and Methods

Floristic Analysis

The 3215 ha Bare Zone of the Copperhill Basin lies between latitudes 34.981° W and 35.059° W and longitudes 84.339° N and 84.406° N in southeastern Polk County, Tennessee. At the outset of this study, an initial tour of the site was given by Jack Muncy, a Tennessee Valley Authority employee responsible for much of the revegetation efforts at the Copper Hill Basin.

Vascular plant species and lesser taxa were documented between Spring 2017 and Fall 2019 over the course of 60 collection trips. Plant specimens were made using standard protocols, such as clipping woody taxa for specimen collection, making collections above roots for rarer taxa, and whole plant collections were made for smaller, common herbaceous taxa. Specimen collection was aided using CollNotes, a phone application that records GPS coordinates, locality, habitat, relative abundance, flowering stage, associated taxa, and elevation and stores these specimen collection notes in a .csv file (Powell et al., 2019). Specimens were identified using the *Guide to the Vascular Flora of Tennessee* (Tennessee Flora Committee, 2015) and Weakley (in preparation). Difficult taxa were compared to physical specimens in the University of Tennessee at Chattanooga Herbarium (UCHT) and the SERNEC data portal. Nomenclature followed the *Guide to the Vascular Flora of Tennessee* (Tennessee Flora Committee, 2015) or Weakley (in preparation) as well as a comparative floristic database developed from previous floristic workers in the Shaw lab (Huskins & Shaw, 2010, Blyveis & Shaw, 2012, Prater & Shaw, 2015).

Phytogeographical Analysis

The comparative floristic database developed by earlier workers in the Shaw lab at the University of Tennessee at Chattanooga, Huskins (2010), Blyveis (2012), and Prater (2015), was one source used to standardize the nomenclature of taxa found within the Bare Zone of the Copper Hill Basin and aid in the creation of the floristic, introduced, and rare taxa lists. Additionally, this dataset was used to compare the distribution of plant taxa collected at the site to other floras found within the Blue Ridge ecoregion. The dataset itself contained plant records of 26 floristic studies in the states Alabama, Georgia, Kentucky, North Carolina, Tennessee, and West Virginia from the Eastern Highland Rim ecoregion to the Blue Ridge ecoregion. Taxonomy was standardized using *Guide to the Vascular Flora of Tennessee* (2015), Weakley Flora (in preparation), and the USDA NRCS Plants Database (USDA, 2006, Huskins & Shaw, 2010, Prater & Shaw, 2015). Introduced and rare species designations follow the USDA Plant Database (USDA, 2006) and Tennessee Department of Environment and Conservation's Natural Heritage Program Designations (Tennessee Natural Heritage Program, 2016). Phytogeographical affinity was determined by Blyveis (Blyveis & Shaw, 2012) using the USDA PLANTS Database (USDA, 2006). This parameter was applied to the taxa found at the Bare Zone of the Copper Hill Basin to indicate the approximate center of their distributional spread and to describe the geographic affinity of the Basin. Blyveis identified five centers of distributional spread (central, eastern, northern, southern, western) that focused on the eastern United States (Blyveis & Shaw, 2012). Species that had widespread geographic distributions in the southeastern United States were classified as central. Additionally, Species that had much of their range in the northern united states but extended to the south were classified as northern, species that had a southern range that narrowed to the north were classified as southern, species that had a geographic range to the west but diminished eastward were classified as western, and species that had a geographic range in the east and narrowed to the west were classified as eastern. Following this analysis, six floras were added to the database for the Blue Ridge ecoregion, making the total number of floras in the database to 32 (Boyd, 2016; Levy, 2018; Murrell, 1987; Moore, 2002; 1998, Suiter, 1993; Thomas, 1966).

Land Cover Analysis

Geospatial Information Systems were used to recreate a historic map and perform land cover analyses using the Natureserve Ecological Classifications dataset. Prior to physical collections, a GIS map of the Bare Zone of the Copper Hill Basin was created using the figure by Hursh in 1948 (Fig. 4). Using the georeference tool in ArcPro (Esri, 2020) the image was given a spatial identity turning physical features found in the image that persist today, like Highways 64 and 68 and the Ocoee River, into reference points for the image. Then the outline of the area was drawn over the image, selected and used to create a polygon of the Copper Hill Basin Bare Zone. The area for the newly formed polygon was calculated in hectares using the calculate geometry tool.

Finally, an analysis of public vs. private land was performed to adjust the size of the Basin. Collections made on private property are considered trespassing and hinders the repeatability of specimen collections made in the Basin. All the area in the Basin was deemed private excluding roads, parks, and areas where landowners allowed for collection records to be made. A corrected plant collection area of the Copper Hill Basin Bare Zone was created using collection sites made at the Copper Hill Basin. Both the original size from the historic recreation of the Copper Hill Basin Bare Zone and the plant collection corrected area was used in further analyses.

Following the creation of the Copper Hill Basin Bare Zone map, a habitat analysis of the site was performed using Natureserve's Ecological Classifications data included on a Gap analysis project (GAP) layer by the U.S Geological Society (USGS, 2011). Natureserve's Ecological Classifications is a raster layer that represents ecological systems, a type of land cover analysis created by Natureserve, that is specific to region and habitat type. Different values represented by pixels found in the raster layer correspond with each habitat type found across the United States. Using the extract by mask tool, the raster was reduced to the outline of the Copper Hill Basin Bare Zone polygon. Then, points were disseminated by converting the raster into a series of complex polygons using the raster to feature layer tool so that each value that had represented a pixel now represents a habitat polygon found in the Bare Zone. The area in hectares was calculated for each polygon class using the calculate geometry tool and compared to one another by converting each value to a percentage in Microsoft Excel.

Each polygon representing a Natureserve Ecological System was used to determine the possible vegetation associations that would fall under each system. Natureserve Vegetation Classification associations are often determined by survey plots created in the field, however given the size of the Copper Hill Basin, creating these survey plots would have been out of the scope of this project. Instead species associations were determined ex situ using GAP analysis and plant specimen collections at the Copper Hill Basin. All possible representative associations that are related to the Natureserve Ecological System and corresponded with species documented in the field were utilized to describe the present habitats currently found in the Copper Hill Basin Bare Zone.

Digital Herbarium Specimens of the Region

Online, historical herbarium records were assessed to better understand species that were present prior to landscape degradation, during land degradation, and post revegetation. These historical herbarium specimen records were obtained from the SERNEC data portal. However, more complex data queries were necessary as most digitized herbarium specimen records available from the SERNEC portal are only minimally transcribed to include “skeletal data” such as scientific name and the state and county collected. Two levels of queries were performed. First, an analysis of the herbarium specimens of the southern Blue Ridge was generated for all the counties in the Blue Ridge ecoregion below the Tennessee and North Carolina state lines (exclusive of Polk County, Tennessee, because that was the focus of another analysis). Because most data were only to the level of county, and many counties of this ecoregion have portions both within and outside of the region, only counties that had 50% or greater of their total area within the southern Blue Ridge were selected. This analysis resulted in 32 counties across Tennessee, North Carolina, and Georgia. Collection of records for the southern Blue Ridge were queried on February 4th, 2020. (Appendix A). The second dataset was compiled from specimens collected within Polk County, Tennessee, because those records might contain direct references to the Copper Hill Basin. Fannin County, Georgia was omitted from the county level search because it only makes up 2% of the total area of the Bare Zone. But, Fannin County, Georgia was included in the southern Blue Ridge analysis. The query of specimen records for Polk County was made on February 4th, 2020.

A final analysis was then performed on the Polk County records to create a dataset of records only found in or near the Copper Hill Basin. An optical character recognition (OCR) script, written in the Python programming language, was utilized to determine which specimens from Polk County directly reference portions of the Copper Hill Basin. This script was created by Caleb Powell (M.S. candidate, University of Tennessee at Chattanooga) and can be found on GitHub (Link: https://github.com/CapPow/ocrFilter). The script selects the bottom right portion of every imaged plant specimen, approximately where the label is located. That portion of the specimen image was then converted to grayscale four times, each with different threshold parameters, using OpenCV. Those grayscale threshold images were then sent to a Python implementation of Tesseract, which is a tool that was used to convert images to text. The OCR results were then queried for select specific terms that would either be associated to the Copper Hill Basin (copper, duck, ducktown, copperhill, bog, ellis, potato) and terms that would not be associated to the Copper Hill Basin as they would represent specimens collected from other studies within Polk County (murrell, hiwassee, frog, wyrick, gee). Records were then selected and distinguished as being 5 km or farther away, 5 to 2 km away, less than 2 km or being within the Copper Hill Basin to identify records of specimens that were collected far away from the Copper Hill Basin, nearby the Copper Hill Basin, and surrounding or within the Copper Hill Basin.

Floristic Comparisons

In order to measure qualitative data collected at the Bare Zone of the Copper Hill Basin, both Jaccard’s Index of Similarity and Sorenson’s Coefficient were considered because they are often used in ecology to compare the similarities between multiple datasets (Magurran, 1988). Sorensen's Coefficient however gives greater weight to shared features found between the datasets than Jaccard’s Index of Similarity. Due to the proximity of the Bare Zone to the southern Blue Ridge, Polk County, historical Copper Hill Basin records, and other floras found within the region, Jaccard's is a more reasonable statistic for this study.

Jaccard's Index is represented by the formula $S_J = a/(a + b + c)$, where S_J is the Jaccard's similarity, a is the number of features shared by (in common) between the two datasets, b is the number of features unique to the first dataset, c is the number of features unique to the second dataset. A value between 0-1 will be produced, datasets that share a higher similarity have a larger value and less similar datasets having a lower value.

A floristic quality assessment was utilized to compare the quality of the recorded flora of the Copper Hill Basin Bare Zone to the other Blue Ridge floras in the database. Coefficients of conservation (C), the values used to determine floristic quality (Matthews, 2003), were added to the dataset for each taxon found in the comparative database. C values range from zero to ten and are an estimate of the fidelity of a species to a plant community that characterized the region prior to European settlement (Rothrock & Homoya, 2005). Species with values closer to zero tend to be more advantageous of non-natural habitats and species with higher values are dependent on natural, higher quality sites. Average C value was calculated for the Basin and six other Blue Ridge floras input into the comparative database by Huskins (2010), Blyveis (2012) and Prater (2015).

Finally, the flora of the Bare Zone and other Blue Ridge floras found in the comparative database were plotted to generate a species-area curve. Both the historic size and actual collections area were used to compare the results between the areas. Excel was used to perform a nonlinear regression which generated values for the equation $S=cA^z$ (Preston, 1962; Wade and Thompson, 1991) where S is the number of species recorded in that flora, c is a constant which represents the number of species predicted per hectare, A is the area (in ha) that was survey in a flora, and z is a constant derived from the regression and slope. Using the comparative plant list of Blue Ridge floras, the regression analysis provides values specific to the region which can be used to predict species numbers based on area as well as allow comparisons of species richness between floras (Huskins, 2010; Prater, 2015). An additional species area curve was created using only native species found in the Blue Ridge Floras and the Copper Hill Basin flora.

Results

Floristic Summary

A total of 444 species and lesser taxa were documented from the Bare Zone of the Copper Hill Basin (Appendix B). A total of 889 specimens were documented across 196 collection sites (Fig. 8). Specimens will be deposited to the University of Tennessee at Chattanooga Herbarium (UCHT) and a second set will be sent to Austin Peay State University Herbarium (APSU). Additional sets will be contributed to the exchange program at UCHT. The documented flora of the Bare Zone represents 444 species and lesser taxa in 259 genera in 113 families (Table 2). There were 107 non-native species, which compose 24% of the flora (Table 2). There were 41 county records (Appendix B) to Polk County found at the Copper Hill Basin Bare Zone.

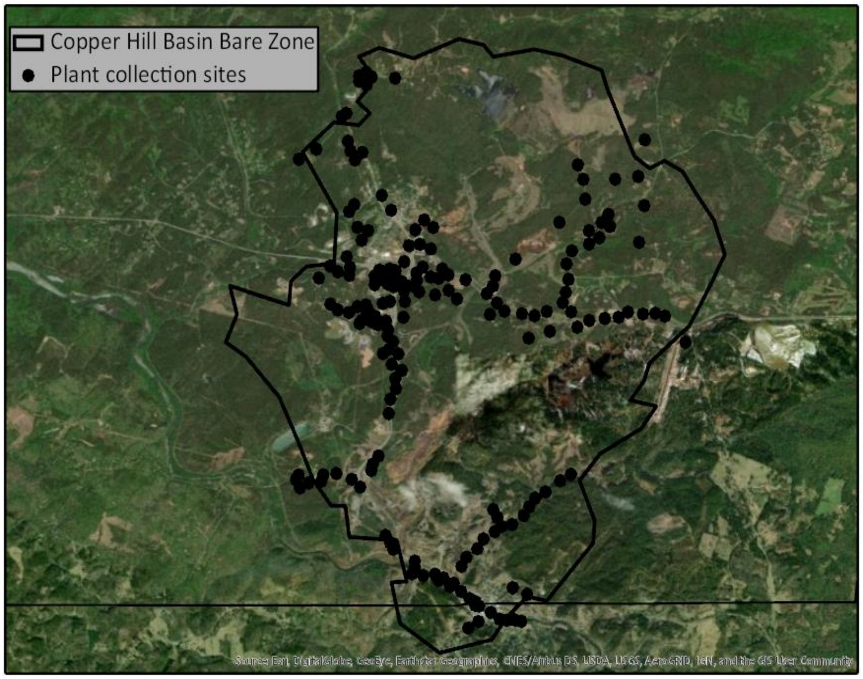

Figure 8 Collection sites in the Copper Hill Basin Bare Zone.

Table 2 Floristic Summary of The Bare Zone of the Copper Hill Basin, Polk County, Tennessee and Fannin County, Georgia.

Groups	**Family**	**Genera**	**Total Species**	**Native**	**Non-native**	**Species Composition of each group**
Ferns & Fern allies	14	22	24	24	0	5.41
Gymnosperms	2	3	6	6	0	1.35
Monocots	20	63	109	86	18	24.55
Dicots	77	171	305	237	89	68.69
Total	**113**	**259**	**444**	**337**	**107**	**100**

Rare Species

Five species documented in the Copper Hill Basin Bare Zone were considered rare. The Endangered Species Act allows the U.S. Fish and Wildlife Service to declare species as ecologically valuable or vulnerable with designations of Endangered or Threatened. Natureserve has created a ranking system for species, where they are ranked from S1 to S5, S1 representing endangered species, to S5 which represents common species and G1 to G5, G1 representing globally rare species, to G5 which represents globally common species. Given the land use history, rare species would be of interest to the flora of the Copper Hill Basin. The rare species documented in this study were: *Chelone obliqua* ssp. *erwinae*, *Clematis vinacea*, *Eriophorum virginicum*, *Lilium philadelphicum*, and *Lobelia amoena*. Their designations are listed in Table 3, below.

Table 3 Rare Species documented at the Copper Hill Basin Bare Zone and their State and Global Rank.

Species	**Rank (State, Global)**
Chelone obliqua ssp. *erwinae*	SNR, G4T2T4Q
Clematis vinacea	S2, G2
Eriophorum virginicum	S1S2, G5
Lilium philadelphicum	S1, G5
Lobelia amoena	S1S2, G4?

Introduced Species

Introduced species account for 107 of the 444 species and lesser taxa documented at the Copper Hill Basin, which comprises 24% of the total flora. The Tennessee Invasive Plant Council (TNIPC) has two defined categories for introduced species: Established Threats and Emerging Threats. Established threats are species that have been seen in at least 10 counties in Tennessee and are difficult to remove using current invasive species removal techniques. There were 22 Established Threat species documented in this project. Emerging Threats are differentiated as being relatively new threats to the state and have been verified in less than 10 counties in Tennessee. There were three Emerging Threat species documented in this project. The remaining introduced species are not presently ranked by TNIPC. There were 82 introduced species not included in TNIPC's ranking system found at the Copper Hill Basin (Appendix C).

Phytogeographical Analysis

In the comparative database compiled by Huskins (2010), Blyveis (2012), and Prater (2015) Phytogeographical affinity was applied to the species collected at the Bare Zone of the Copper Hill Basin. Only 337 taxa of the Bare Zone had distribution designations, the remainder not having designations because of their non-native status. Surprisingly, the Copper Hill Basin Bare Zone has a primarily southern and eastern affinity. Taxa distribution data can be seen in Table 4.

Table 4 Summary of the distribution of plant taxa collected at the Bare Zone of the Copper Hill Basin.

Distribution	Taxa	Percentage
Central	296	87.8
Eastern	2	0.6
Northern	12	3.6
Southern	25	7.4
Western	2	0.6
Total	**337**	**100**

Land Cover Analysis

Recreation of the Hursh 1948 map created Figure 8. The total area of the historic recreation of the Bare Zone is 3215 ha. Using data collection sites available for public lands, a total area of 1386 ha was calculated in Figure 9.

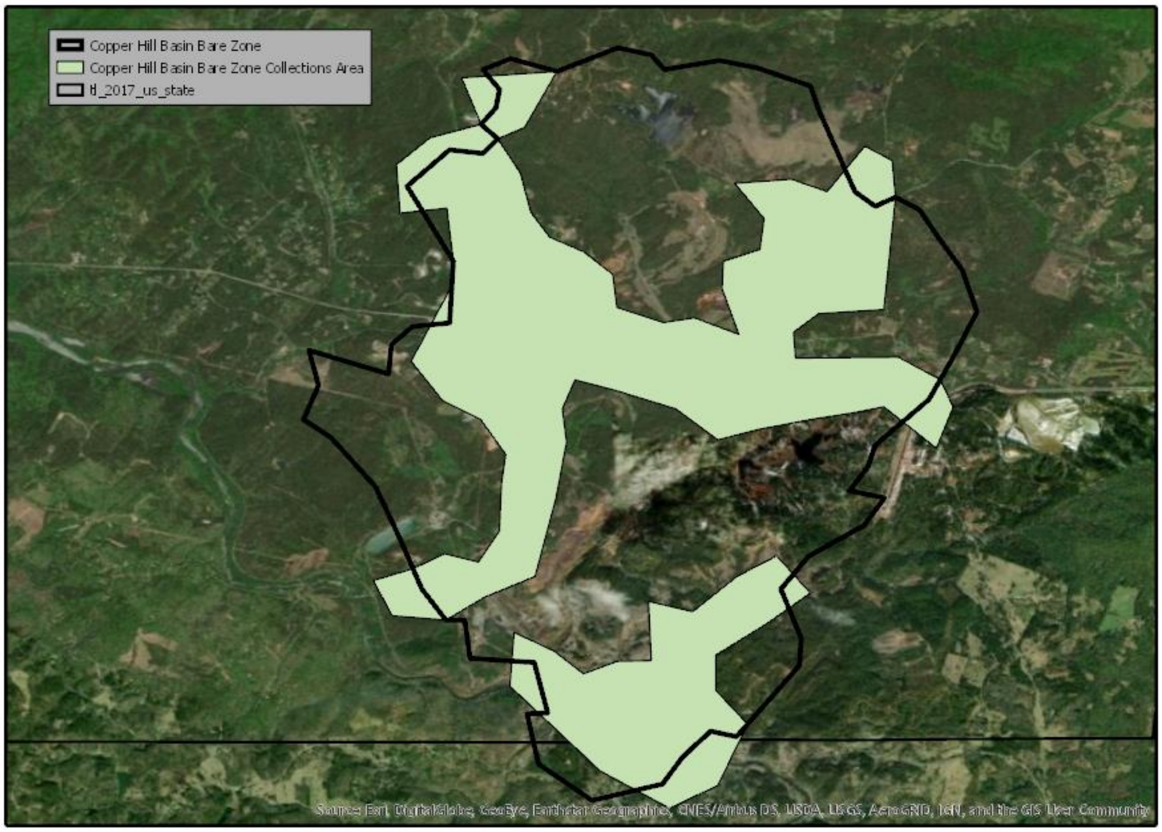

Figure 9 Area of the Copper Hill Basin Bare Zone collection areas.

Ecological Systems within the Copper Hill Basin

There were 17 different ecological systems recognized in the Copper Hill Basin (Appendix D). Eleven of the 17 ecological systems were considered anthropogenic, successional, or open water habitats for which Natureserve does not provide species associations because these systems can vary by location. The remaining six ecological systems had an estimated 27 associations among them.

The Copper Hill Basin was primarily composed of ecological systems that were anthropogenic, successional, or open water. In total, 11 ecological systems made up 92.6% of the Copper Hill Basin. The highest percent area ecological system was the Evergreen Plantation or Managed Pine with 1378 ha or 46.3% of the total area. This ecological system was noted by Natureserve as having evenly spaced, similar age class evergreen dominated forests. Following Evergreen Plantation or Managed Pine was the Pasture/Hay ecological system. Pasture/Hay was described as an area planted with vegetation for livestock grazing. This system made up 13.6% of the basin. Following that in order of highest percent is Developed/Open Space, then Harvest Forest, then Developed, Low, Medium, High intensity, then Quarries, Mines, Gravel Pits, and Oil Wells, then Developed, Low intensity, then Introduced Upland Vegetation, then Cultivated Cropland, then Open Water, then Disturbed/Successional, and Undifferentiated Barren Land. Size and percentage of the Bare Zone of the Copper Hill Basin can be seen in Table 5.

Table 5 Natureserve Ecological Systems with their corresponding area in ha and percentage found in the Bare Zone of the Copper Hill Basin.

Ecological System	**Area (in ha)**	**Percentage**
Evergreen plantation or Managed Pine	1378	46.3
Pasture/Hay	406	13.6
Developed/Open Space	259	8.7
Harvest Forest	200	6.7
Developed (Low, Medium, High Intensity)	191	6.4
Quarries, Mines, Gravel Pits, and Oil Wells	162	5.3
Introduced upland Vegetation	55	1.8
Cultivated Cropland	48	1.6
Open Water	35	1.2
Disturbed/Successional	16	0.6
Undifferentiated Barren Land	12	0.4
Total	**2762**	**92.6**

The remainder of the systems contained associations based on the plant diversity found in those systems. Of the six systems that have associations, there were approximately 25 associations among them (Appendix D). These systems take up a total of 7.8% of the Bare Zone of the Copper Hill Basin. They are as follows in order of the amount of area they inhabit: Southern and Central Appalachian Oak Forest, Appalachian Hemlock-Hardwood Forest, Southern Appalachian Low Mountain Pine Forest, Southern and Central Appalachian Cove

Forest, South-Central Interior Large Floodplain, and South-Central Interior Small Stream and Riparian. Their areas and percentages they inhabit are listed in Table 6.

Table 6 Natureserve Ecological Systems that has associations with their corresponding size in ha and the percentage of that size found in the Bare Zone of the Copper Hill Basin.

System	Area (in ha)	Percentage
Appalachian Hemlock-Hardwood Forest	76	2.5
Southern and Central Appalachian Oak Forest	65	2.1
Southern Appalachian Low Mountain Pine Forest	49	1.5
Southern and Central Appalachian Cove Forest	28	0.8
South-Central Interior Small Stream and Riparian	9	0.3
South-Central Interior Large Floodplain	3	0.1
Total	**230**	**7.3**

Digital Herbaria Specimens of the Region

Using the SERNEC data portal to query plant specimens for the southern Blue Ridge and Polk County, Tennessee produced two datasets. Querying the 32 counties across the southern Blue Ridge, a total of 107880 specimen records of vascular plants were revealed as having been from the region. Of those, there were an estimated 4281 species or lesser taxa (but a fair portion of these likely represent synonyms and no analysis was performed to synonymize that data set). The query of Polk County, Tennessee, revealed 10200 vascular plant specimen records, representing 1604 taxa. Figure 10 shows the number of specimen records from each county of the Blue Ridge that were returned by the query. Polk County ranks ninth out of the 32 counties in the southern Blue Ridge. Figure 11 illustrates the number of species returned for each county. Polk County ranks fifth out of the 32 counties found in the southern Blue Ridge.

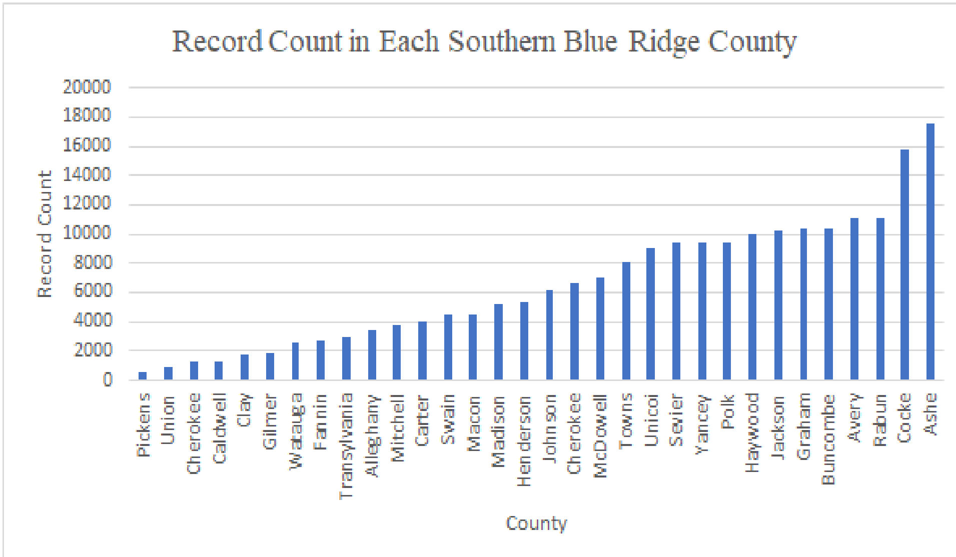

Figure 10 A bar chart showing the number of specimen records per county of the southern Blue Ridge found on SERNEC in February of 2020.

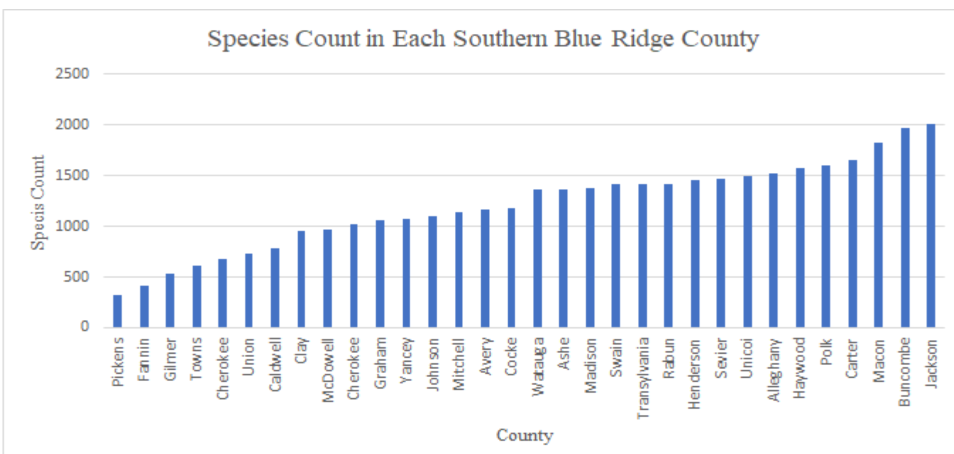

Figure 11 A bar chart showing the number of plant taxa found in the southern Blue Ridge on SERNEC in February of 2020 for the southern Blue Ridge.

Using OCR on the specimen records from Polk County, Tennessee produced a total of 332 records that referenced the Copper Hill Basin ranging from 1897 to 2019. Of those records, 120 were approximately five km or farther away from the Copper Hill Basin with an average collection date of 4/15/1967, 45 records were recorded as being 5 km to 2 km away from the Copper Hill Basin with an average collection date of 3/22/1972, 67 records were recorded as being less than 2 km away from the copper Hill Basin with an average collection date of 2/15/1974, and 100 records were found one km or less to the Copper Hill Basin with an average collection date of 12/5/1978.

Table 7 Specimen Records that reference the Copper Hill Basin with distance and average date of collection.

Distance Category	**Records available**	**Average Date of Collection**
Within Copper Hill Basin	100	12/5/1978
>2 km	67	2/15/1974
2 km to 5 km	45	3/22/1972
<5 km	120	4/15/1967
Total	**332**	**-**

Jaccard's Index of Similarity

The datasets used for the Jaccard's Index of Similarity were the SERNEC queries of the taxa found in the southern Blue Ridge, Polk County, the taxa of the OCR results for specimens collected 1 km or less to the Copper Hill Basin, and the taxa found in the flora of the Bare Zone of the Copper Hill Basin. The Flora of the Bare Zone of the Copper Hill Basin was compared to each of these sets resulting in a similarity of 0.11 when compared to the southern Blue Ridge, 0.23 when compared to Polk County, and 0.12 when the species found within the Copper Hill Basin on SERNEC were compared to the flora of the Bare Zone of the Copper Hill Basin.

Species Area Curve

Six floras were added to the comparative database by Huskins (2010), Blyveis (2012), and Prater (2015). Those floras were input into a species area curve with the Copper Hill Basin Bare Zone. This analysis was performed to determine how the Copper Hill Basin Bare Zone compared to other floras in the region that were done in natural areas. The actual collections area was also added to compare the two calculated areas for the basin. Area for the comparison ranged from 10 to 10166 ha and species richness ranged from 221 to 909 (Fig. 11). The species area curve of the dataset generated the formula $y=143.2x^{0.177}$. A r^2 value of 0.79 corresponded with these seven floras.

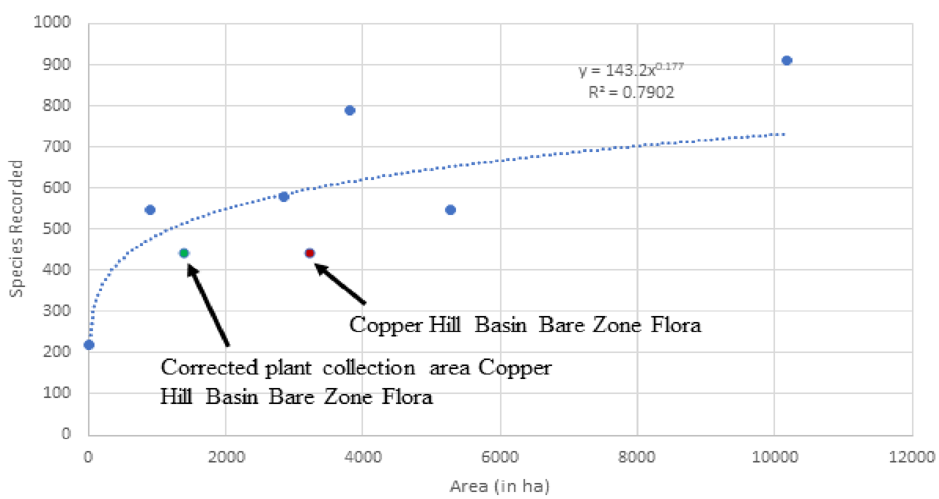

Figure 12 Species Area Curve for floras added to the Blue Ridge and The Copper Hill Basin Bare Zone.

When the same analysis was performed with species that were not introduced, the species area curve of the dataset generated the formula $y=128.26x^{0.1647}$. A r^2 value of 0.71 corresponded with these seven floras (Fig. 13).

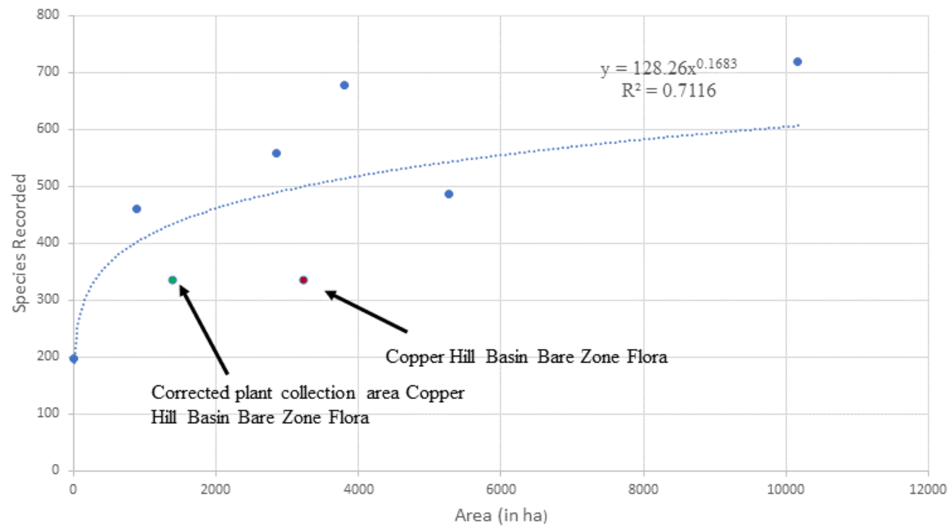

Figure 13 Species Area Curve for floras added to the Blue Ridge and The Copper Hill Basin Bare Zone using only native species.

Floristic Quality Assessment

A floristic quality assessment was performed on the floras added to the comparative database Huskins (2010), Blyveis (2012), and Prater (2015). The total values of the comparison can be seen below in table 8. Average C values range from 3.58 to 5.32 which indicates overall quality of the flora based on the species collected.

Table 8 Floristic quality assessment results for floras added to the comparative database (CHB is Copper Hill Basin, BFG is Big Frog Mountain, GM is Grassy Mountain, SB is Sandy Bottom, RFT is Rocky Fork Tract, SC is Steele Creek, and NRG is New River Gorge).

Flora	**CHB**	**BFG**	**GM**	**SB**	**RFT**	**SC**	**NRG**
# of species with C values	386	397	471	181	586	508	416
Sum of C values	1380.4	2112.4	2167.7	844.8	2508.5	1959.4	1702.8
Average	3.58	5.32	4.60	4.67	4.28	3.86	4.09

Discussion

Complete Floristic History of the Copper Hill Basin

An evaluation of the floristic significance of the revegetation of the Copper Hill Basin requires a reconstruction of the historic flora from the specimen collections and historical references to Copper Hill Basin. This dataset includes historical references to the plant species of Tennessee that have been seen in the region (Gattinger, 1903) and records made from the region that are available on SERNEC.

In the past, tracking down each record that was made in the Copper Hill Basin would have been difficult for botanists because herbaria are sorted by species not date or location and accessing those resources may have proved challenging. With the onset of the digitization of herbaria records, accessing these records have been easier than ever. When conducting this study, over 100000 herbaria records were accessed to create a list of the 4281 taxa found in the southern Blue Ridge. Polk County, Tennessee was then queried and contained over 10000 plant records, a body of work supplemented by the three prior floristic studies done in the county. Compared to other counties found in the southern Blue Ridge, Polk is fifth in species diversity and seventh in overall records (Fig. 11 & Fig. 12). Since 1837, botanists have made specimen collections in the region. That is almost 200 years of botanical data to pull from, in what was a historically difficult region to collect in.

Post Native American settlement began in the Copper Hill Basin in the 1830s. The earliest collection from the Copper Hill Basin is cited as 1897, although there were historical records known prior to this date (Gattinger, 1903; Oakes, 1932; Chester, 2009). Often cited as Tennessee's first botanist, Dr. Augustin Gattinger arrived at the basin in 1858 who was hired on as a surgeon for a copper company 20 years after mining began in the basin. During this time, it is known that he made several botanical collections in the region that would have been earlier than 1897 (Oakes, 1932), but they were lost fleeing confederate sympathizers from the Copper Hill Basin. It would take him 30 years before he would return to the basin and make another plant collection.

The first documented specimen from the Copper Hill Basin is *Magnolia tripetala*, which was collected by Gattinger on August 27th, 1897. This species was not found in the region, probably extirpated during the mining practices. There are no other records made in the Copper Hill Basin until 1920. Between 1897 and 1920, Gattinger would release his *Flora of Tennessee and Philosophy of Botany* in 1903 detailing 26 species that he had seen in the region (Appendix E). In it he describes several species that have no records in the state of Tennessee, like C*oreopsis rosea*, *Lindernia monticola*, and *Scutellaria galericulata*.

It was not until the 1940s that specimens were recorded as being in the Copper Hill Basin. There are several reasons for this. First, the region was barren, and may have had a lack of vegetation to collect. Secondly, the University of Tennessee herbarium burned down in 1934 (Chester, 2009) taking Gattinger's original herbarium and 30000 - 50000 other specimens with it

(Tennessee Flora Committee, 2015), including any specimens that may have pertained to the Copper Hill Basin. There were three specimens collected in the 1940's. Those specimens include *Croton glandulosus* in 1940, *Nabalus serpentarius*, *Coreopsis major*, and *Hieracium gronovii* in 1946. Only *Coreopsis major* was documented in this study. These specimens represent records from Ken Rogers (1940 specimen) and E.S. Ford and N.H. Russell (1946 specimens).

Following this, there were no records in the Copper Hill Basin in the 1950s. However, the records to the region grew rapidly in the 1960s with 56 records found within the Copper Hill Basin. 38 of those records are found in the Copper Hill Basin Bare Zone flora today. Notable species found in the 1960's but not documented in the Basin flora include *Lilium superbum* and *Cornus amomum*.

In the 1970s there were two specimen collections made in the Copper Hill Basin. *Desmodium perplexum* and *Rhexia virginica* were both collected in 1976 by Wofford, Odenwelder, and Pearmen. *Rhexia virginica* was collected at the Bare Zone of the Copper Hill Basin. This decade represents records made prior to major revegetation efforts made by TVA.

In the 1980s, there were 10 specimen collections made in the Bare Zone. Of those specimens, records of *Eriophorum virginicus* and *Vaccinium macrocarpon* (both state threatened) were found just north of the Bare Zone. These specimens represent observations made in the William L. Davenport Refuge, one of the southernmost cranberry bogs in Tennessee. During this time, the first flora of Polk County also took place at Big Frog Mountain by Zach Murrell. In this study, Murrell found 479 plant species and 13 endangered and/or threatened, none of which are seen at the Copper Hill Basin but is near the Copper Hill Basin (12 km). Murrell also talks about the effect of the proximity to the basin, how sulfur fumes may have affected vegetation found in the area when air was stagnant (Forest Service, 1982).

In the 1990s, there were 15 specimen collections made in the Copper Hill Basin. Of those specimens, the only species that was not seen in the Flora of the Bare Zone of the Copper Hill Basin were *Vaccinium corymbosum*, which was seen immediately outside of the Bare Zone in the William L. Davenport Refuge. This species is interesting because it is a southern Blue Ridge endemic (Natureserve, 2020) and a special concern species in Tennessee. Additionally, a flora was conducted in Northern Polk County. The flora of the Gee Creek Wilderness was done in 1996 by Wyrick and resulted in the documentation of 387 species and 10 endangered, threatened, or special concern species. This flora differs from Murrell in that the author makes no mention of potential damage from the Copper Hill Basin, primarily because it is on the opposite end of the county.

In the 2000s, there were four specimen collections made in the Copper Hill Basin. Two of these were specimens of *Vaccinium macrocarpon* made immediately outside of the Bare Zone and the other two were *Vicia villosa*, a common non-native species.

In the 2010s, there were 13 total specimen collections made in the Copper Hill Basin. All these specimens have been represented in the flora of the Copper Hill Basin, including *Carex atlantica* ssp. *capillacea*, a relatively new species to the county.

Floristic Results and Summary

The results for the similarity analysis for the Southern Blue Ridge and Polk County, 0.11 and 0.23 respectively, show that there is an 11% similarity between the flora of the Bare Zone of the Copper Hill Basin and a 23% similarity between the Bare Zone and Polk County, Tennessee. Although these values seem low, it is primarily due to the overall size of the datasets being compared. The flora of the Bare Zone is composed of 444 taxa, the southern Blue Ridge is comprised of 4217 taxa, and Polk County is composed of 1607 taxa. These results can be understood as this: the Bare Zone flora represents a fourth of the species in Polk County, the Bare Zone flora represents a tenth of the species found in the southern Blue Ridge. When comparing the historical Copper Hill Basin records to the flora of the Bare Zone of the Copper Hill Basin records, the results show that there is a 12% similarity between the Bare Zone and the historical Copper Hill Basin records. Essentially an eighth of the species found at the Bare Zone are records that were historically documented in the Copper Hill Basin.

The Bare Zone of the Copper Hill Basin flora was then compared to Blue Ridge floras added to the comparative dataset by Huskins (2010), Blyveis (2012), and Prater (2015). Overall, this flora is most similar to Steely Creek flora, having the Jaccard's similarity value of .33 meaning that the two floras are 33% similar. The rest of the floras entered the dataset range from Jaccard's similarity values of .31 to .14 (Table 9).

Table 9 Floras added to the comparative database (CHB is Copper Hill Basin, BFG is Big Frog Mountain, GM is Grassy Mountain, SB is Sandy Bottom, RFT is Rocky Fork Tract, SC is Steele Creek, and NRG is New River Gorge), their taxa counts, the number of taxa that are shared between that flora and the Bare Zone of the Copper Hill Basin flora, and the Jaccard's similarity index number for each flora to the Bare Zone of the Copper Hill Basin.

Flora	**CHB**	**BFG**	**GM**	**SB**	**RFT**	**SC**	**NRG**
Species and Lesser taxa	444	579	548	221	791	547	909
Taxa in common	-	150	190	91	220	200	148
Jaccard's	-	0.21	0.31	0.19	0.28	0.33	0.14

Compared to the other floras used in conducting the species area curves, the flora of the Copper Hill Basin Bare Zone fell under the line Figure 12 showing that for its size, the species diversity is less than the other floras included in the analysis. The distance from the line is more dramatic when comparing only native species collected at the Copper Hill Basin to the other floras in the analysis. Comparing the two areas of the Copper Hill Basin Bare Zone, the size per area of the actual collected area seems to be closer to the line for both species area curves. Compared to other species area curve analyses performed using the comparative database utilized in this project, Huskins (2010) found a r^2 value of 0.78 using Cumberland plateau floras in Tennessee and a Prater (2015) found an r^2 value of 0.82 for the entire Cumberland Plateau in Alabama, Kentucky, and Tennessee. Compared to the species area curves in this project, the analyses have a similar fit to the line.

The floristic quality assessment results showed that the Copper Hill Basin had the lowest average C value when compared to the six other floras included in the analysis. The flora that had the second lowest C value average was the flora of the Steele Creek, which also had the highest Jaccard's similarity value to the Basin flora. The flora with the highest C value is the flora of Big Frog Mountain. Big Frog Mountain is also the closest flora conducted to the Copper Hill Basin.

Rare Species

There were five species that have been documented in the flora of the Bare zone of the Copper Hill Basin that are listed as S1, S2 or is a state record species. One of these species, *Chelone obliqua* ssp*. erwinae,* is a state record to Tennessee and Georgia. *Lilium philadelphicum* is a county record to Polk County, Tennessee. The other three records are known from the county but have yet to have been seen in the Basin prior to this research.

Chelone obliqua ssp. *erwinae*, is a species with relatively few collections in a small range between southwest North Carolina and northwest South Carolina (Weakley, in preparation).

Naturserve cites the species as having been falsely identified from Kentucky, and having a range in North Carolina and South Carolina, counties are not recorded. According to Weakley (2015), it is often found alongside streambanks and swamp forests. It is a hexaploid variant of the traditional members in the *Chelone obliqua* complex, the others are tetraploid. There are currently four specimens available on SERNEC, all in Transylvania County, North Carolina. A county map shows the relative proximity, 210 km, between the collection site in the Copper Hill Basin to that of Transylvania County (Fig. 14).

An issue arose when trying to determine the identification of this species following the initial documentation of it on the Georgia side of the Toccoa River. The primary taxonomic key used for determining species during this project was the *Guide to the Vascular Flora of Tennessee* (Tennessee Flora Committee, 2015) and this species had yet to be included in that key. When referring to Weakley's flora (In Preparation), a secondary reference used for harder/more difficult groups, there was some confusion when determining this record between *Chelone glabra* and *C. obliqua* ssp. *erwinae* due to variation in the color of the corolla. *Chelone glabra's* corolla color can range from white to pink to red with various mixes of color, while *C. obliqua* ssp. *erwinae* corolla is primarily red. Records collected at the site in following seasons have displayed a majority of red corolla colored individuals with some individuals displaying partial red and white corollas. Given the difference in color, other vegetative characters were used (primarily leaf characteristics) to determine the species.

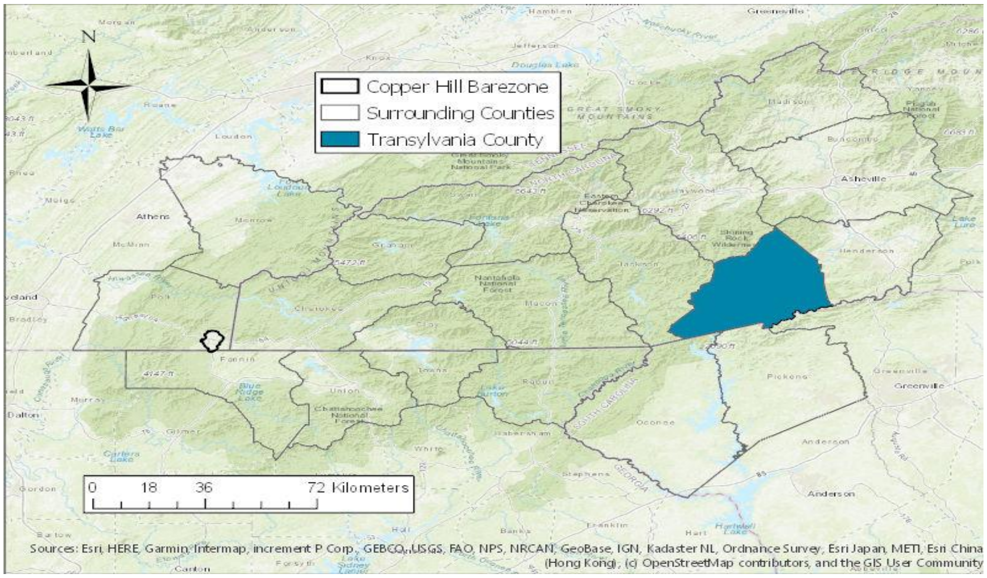

Figure 14 Location of Transylvania County, North Carolina, where *Chelone obliqua* ssp. *erwinae* was seen from SERNEC information in relation to the Copper Hill Basin.

Lilium philadelphicum is ranked as an S1 (Natureserve), Endangered (TDEC), and a G5 (Natureserve). This species has been seen in four counties (Claiborne, Grundy, Hamilton, Sequatchie) (USDA, 2020), and the *Guide to the Vascular Flora of Tennessee* (Tennessee Flora Committee, 2015) cites the description as being found in “meadows”. A record of *Lilium philadelphicum* was made in the final collecting season in early Fall of 2019 with Nate Parrish. Although the specimen was collected during fruit, the determination was made using the Weakley flora (In Preparation), specimens available at UCHT from Tennessee, and specimens available on the SERNEC portal. Its inclusion in the flora of the Bare Zone of the Copper Hill Basin aids in demonstrating how effective revegetation has taken place at the basin.

Clematis vinacea was described in 2013 to Polk and Fannin Counties by Dr. Aaron Floden (Missouri Botanical Garden, St. Louis, MO) along the Ocoee and Toccoa Rivers. Floden described the species and corresponding habitat as being *Clematis crispa*, without the frilled edges, and along drier, rockier habitats than *Clematis crispa* would normally be found (Floden, 2013). It was not initially found in the Copper Hill Basin by Floden. Specimen records made at the Copper Hill Basin were found on the road to the London Mill historical mine. The conditions were ruderal, dry, sparsely vegetated, but several large bushes of *Clematis vinacea* were seen along the path, approximately 20 individuals. Specimens collected by Floden and the author can be seen to demonstrate their proximity within Polk County, Tennessee (Fig.15). This species has not been observed at any other sites in the Cooper Hill Basin, but given the habitat, it was possible that the species could have been seen during the last hundred years since this area was once bare. There are no records on SERNEC from Polk county that identify any members of the *Clematis* genus as having been found in the area historically. It is also possible that due to increasing habitat availability that *Clematis vinacea* has recently dispersed into the area from the Ocoee River, which has portions in the Copper Hill Basin, but not the same portions where the species was described from.

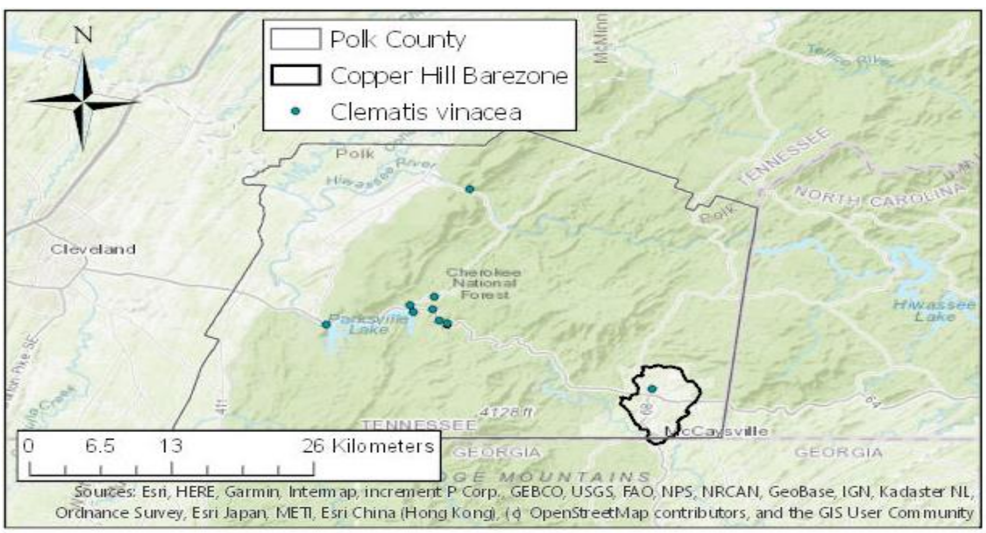

Figure 15 Locations of specimens of *Clematis vinacea* found on SERNEC in Polk County, Tennessee.

Introduced Species

In comparison to the other floras collected in the comparative database created by Huskins (Huskins & Shaw, 2010), and expanded on by Blyveis (Blyveis & Shaw, 2012) and then Prater (Prater & Shaw, 2015), the average non-native species composition of those three floras were 14.7%, which is less than the 23% of non-native species that make up the flora of the Bare Zone of the Copper Hill Basin. When compared to other floristic projects that have been done in Polk County, the non-native species percentage is 4.2% (Murrell & Wofford, 1987), and 2.0% (Wyrick, 1996). This large percentage of non-native species found at the Bare Zone of the Copper Hill Basin is because of the devastation that occurred in the area. In most mining sites, pioneer species will often inhabit the region before larger, heartier species move in due to disturbance alone (Lake & Leishmann, 2004). Given the large scale disturbance that has resulted in the loss of much of the vegetation at the Copper Hill Basin, introductions from exotic species seem appropriate.

Phytogeographical Analysis

A total of six floras of the Blue Ridge ecoregion were added into the comparative database compiled by Huskins (2010), Blyveis (2012), and Prater (2015). Compared to the rest of the floras seen below (New River Gorge, Big Frog Mountain, Grassy Mountain, Steele Creek, Rocky Fork Tract, and Sandy Bottom), all floras have a northern or eastern affinity, followed by a southern or western affinity. This trend differs when compared to the Copper Hill Basin, as there is a higher southern affinity, species that range south of the eastern United States, than northern or eastern. For the other floras, these distributional spreads verify what most botanists have believed for a long time, that there is a northern and eastern affinity to much of the Blue

Ridge Ecoregion species because of their increased elevation and increased dormancy from winter (Murrell & Wofford, 1987). In relation to the Bare Zone, these floras display different distributions because they all represent floras of natural or protected areas (Murrell & Wofford, 1987, Suiter & Evans, 1999), the amount of anthropogenic influence and devastation at the Bare Zone having effected the species present and the overall distribution of the area.

Table 10 A list of the floras added to the comparative database (CHB is Copper Hill Basin, BFG is Big Frog Mountain, GM is Grassy Mountain, SB is Sandy Bottom, RFT is Rocky Fork Tract, SC is Steele Creek, and NRG is New River Gorge), size in ha, Central, Northern, Eastern, Southern, Western affinities, invasive species, and totals.

Study site (area)	**CHB 3215 ha**	**BFG 2842 ha**	**GM 5269 ha**	**SB 10 ha**	**RFT 3800 ha**	**SC 892 ha**	**NRG 10166 ha**
State	TN	TN	GA	NC	TN	TN	WV
Central	87.8%	82.4%	80.8%	90.0%	81.8%	88.8%	82.4%
Northern	0.6%	14.9%	11.3%	7.2%	11.5%	7.0%	14.9%
Eastern	3.6%	0.0%	0.4%	0.0%	1.5%	0.0%	1.8%
Southern	7.4%	2.7%	8%	2.7%	5.3%	4.2%	0.0%
Western	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Introduced	107	22	61	25	113	86	190
Total	**444**	**579**	**548**	**221**	**791**	**547**	**909**

Ecological Systems within the Copper Hill Basin

Southern and Central Appalachian Oak Forest & Southern and Central Appalachian Oak Forest -Xeric

The largest natural ecological system found in the Copper Hill Basin was the Southern and Central Appalachian Oak Forest with 92.3 ha or 3.1% of the total basin. This system occurs primarily in dry to mesic forests, on open and exposed topography at lower to mid elevations in the Blue Ridge and Ridge and Valley. It forms most of the forest at the Copper Hill Basin. As the Pine Plantation system becomes more developed around streams and their margins, this system mixes with the introduction of hardwood species. Although these forests are typically dominated by oaks, and other species such as *Pinus strobus* and *Fraxinus americana*, the basin is much more inclined to have *Pinus taeda* because of the plantings surrounding the area. Understory species include *Ilex opaca*, *Oxydendrum arboreum*, and *Sassafras albidum*. Typical shrub species include *Kalmia latifolia* and various *Vaccinium* spp.

There was one association listed for this system that was found in the Copper Hill Basin Bare Zone. The *Sassafras albidum* - *Quercus* spp. Ruderal Forest consists of deciduous forests dominated by *Sassafras albidum*. Most occurrences developed through catastrophic disturbance such as fire and/or partial clear-cuts. These upland forests are found in patches along exposed slopes. Forests are primarily below 915 m elevation and are usually associated with acidic slopes that are heavily disturbed.

Natureserve rare species for this association include *Panax quinquefolius, Pycnanthemum beadlei, Silene ovata.* From the Copper Hill Basin, the most interesting documented species from this habitat include *Lilium philadelphicum*, a species found on the margin of the system towards the northern border of the site.

A common theme for this system is the presence of disturbance. Natureserve often cites disturbance from fire or from the physical removal of vegetation, which is indicative of the overall habitat of the Bare Zone of the Copper Hill Basin. This being one the largest systems found in the basin indicates that as more and more woody species are introduced into the area, some of the habitats would form into a similar assemblage as the one described above.

Appalachian Hemlock-Hardwood Forest

This ecological system is the second largest natural system found at the Copper Hill Basin Bare Zone with a total of 76 ha comprising 2.6 percent of the total site. Northern hardwoods such as *Acer saccharum*, *Betula alleghaniensis*, and *Fagus grandifolia* are characteristic, either forming a deciduous canopy or mixed with *Tsuga canadensis*. Other common and sometimes dominant trees include *Quercus rubra*, *Liriodendron tulipifera*, *Prunus serotina*, *Acer rubrum*, and *Betula lenta*. It is typically associated with being found in the Southern Appalachians.

There are six identified associations occurring in the Appalachian hemlock - Hardwood Forest system at the Copper Hill Basin Bare Zone. Of the six associations the *Rhododendron maximum* Montane Ruderal Thicket represents much of this ecological system. This association is dominated by *Rhododendron maximum, Leucothoe fontanesiana*, and *Oxydendrum arboreum* along stream sides with other ericaceous members making up the understory. This association typically forms through degradation and will eventually succeed into being more forested as other ericaceous members become more dominant.

Rare species to the community described by Natureserve include *Buckleya distichophylla*, *Tsuga caroliniana* neither of which are seen at the Copper Hill Basin. Uncommon species to the basin found in this habitat include *Hamamelis virginiana* and *Cypripedium acaule*.

Southern Appalachian Low Mountain Pine Forest

This ecological system is the third largest found at the Copper Hill Basin, making up 49 ha, comprising 1.6 percent of the total area of the site. This ecological system consists of *Pinus* *echinata* and *Pinus virginiana* dominated forests in lower elevations of the Southern Appalachians and adjacent Piedmont and Cumberland Plateau, extending into the Interior Low Plateau of Indiana, Kentucky and Tennessee. Examples can occur on a variety of topographic and landscape positions, including ridgetops, upper and midslopes, as well as lower elevations (generally below 700 m) in the Southern Appalachians such as mountain valleys.

There are three associations that fit in the Southern Appalachian Low Mountain Pine Forest system at the Copper Hill Basin. Two predominant associations are seen more frequently than the other. They include the *Pinus virginiana* Ruderal Forest and *Pinus strobus* / *Kalmia latifolia* - (*Vaccinium stamineum, Gaylussacia ursina*) Forest. The *Pinus virginiana* Ruderal Forest was selected because it occurs in areas where canopy removal has created dry, open conditions and bare mineral soil, allowing for the establishment of *Pinus virginiana*. In this case, much of the *Pinus virginiana* was planted in mass during the reforestation of the Copper Hill Basin Bare Zone. The *Pinus strobus* / *Kalmia latifolia* - (*Vaccinium stamineum, Gaylussacia ursina*) Forest was determined to be at the site because it includes stands some stands of *Pinus strobus* and the understory is dominated by *Kalmia latifolia* and *Vaccinium stamineum* throughout. This community occurs at lower elevations (below 900 m) in the Southern Blue Ridge region of the Southern Appalachians on upper slopes and ridgetops protected by higher landforms. This is one of the more conservative sites found at the Bare Zone of the Copper Hill Basin, *Pinus strobus* not having been planted in the region due to its susceptibility to sulfur toxicity (Allen, 1950)

Rare species denoted by Natureserve include *Arabis serotina*, *Desmodium ochroleucum*, and *Packera millefolium*, none of which are seen at the Bare Zone of the Copper Hill Basin.

Southern and Central Appalachian Cove Forest

This ecological system is the fourth largest found at the Copper Hill Basin, making up 28 ha and comprising 0.9 percent of the total area of the site. This system consists of mesophytic hardwood or hemlock-hardwood forests of sheltered topographic positions in the Southern Blue Ridge and central Appalachian Mountains. Found here, are acidic and "rich" coves that may be distinguished by individual plant communities based on perceived differences in soil fertility and species richness. Characteristic species in the canopy include *Aesculus flava*, *Acer saccharum*, *Fraxinus americana*, *Tilia americana*, *Carya cordiformis*, *Liriodendron tulipifera*, *Halesia tetraptera*, *Tsuga canadensis*, *Fagus grandifolia*, *Magnolia acuminata*, and *Magnolia fraseri*. There are four possible associations that occur within this system at the Bare Zone of the Copper Hill Basin. Of those four, two are likely to be seen more than the others. Both the *Liriodendron tulipifera* - *Pinus strobus* - *Tsuga canadensis* - *Quercus rubra* / *Polystichum acrostichoides* Forest and the *Pinus strobus* - *Tsuga canadensis* / *Rhododendron maximum* - (*Leucothoe fontanesiana*) Forest occupy the Southern Blue Ridge and central Appalachian Mountains. Their presence in the Bare Zone can be seen near the eastern interior of the site and are often found in areas that are surrounded by the Evergreen Plantation or Managed Pine system. This area is often associated with *Leucothoe fontanesiana,* a dominant shrub along streams that is found in most portions of more conserved areas in the Copper Hill Basin.

Rare species often found in this system include *Cardamine clematitis*, *Panax quinquefolius*, and *Scutellaria pseudoserrata*, all of which have been seen in the county but are not found at the Bare Zone of The Copper Hill Basin.

South-Central Interior Large Floodplain

This ecological system is the fifth largest found at the Copper Hill Basin, making up 9 ha and comprising 0.3 percent of the total area of the site. This system consists of the floodplains around streams and rivers found within the Copper Hill Basin. Common dominant tree species include *Salix nigra*, *Juglans nigra* and *Platanus occidentalis* and understory composition is mixed but may contain *Cephalanthus occidentalis* and *Arundinaria gigantea*, and members in the genus *Carex* ssp..

There are three associations found in this system. The primary association found in the Bare Zone of the Copper Hill Basin is the *Salix nigra* - (*Platanus occidentalis*, *Populus deltoides*) Southern Floodplain Forest. This association is primarily composed of *Salix nigra*, and has been seen along Burra-Burra Creek and North Potato Creek. Other associated species that have been seen in this association include *Liquidambar styraciflua* and *Cephalanthus occidentalis*.

The rare species seen at this site include *Lysimachia fraseri*, *Potamogeton tennesseensis,* and *Sagittaria secundifolia*, none of which were documented at the Bare Zone of the Copper Hill Bare Zone. However, *Chelone obliqua ssp. erwinae* was documented around a floodplain forest on the Ocoee River and *Eriophorum virginicum* was observed along in the floodplain of a small stream on the Northern edge of the Copper Hill Basin Bare Zone.

South-Central Interior Small Stream and Riparian

This ecological system is the sixth largest found at the Copper Hill Basin, making up 3 ha and comprising 0.1 percent of the total area of the site. This system is common in the southern

Blue Ridge and examples occur along small streams and floodplains with low to moderately high gradients. There may be little to moderate floodplain development. Typical tree species found in this system may include *Platanus occidentalis*, *Acer rubrum*, *Betula nigra*, *Liquidambar styraciflua*, and *Quercus* spp..

There are seven associations for this system found at the Copper Hill Basin Bare Zone. Of those seven associations, the most prevalent association would be the *Salix nigra* Shrubland. This association represents vegetation dominated by scrubby forms of *Salix nigra* (and *Salix caroliniana*) across the southeastern and northeastern United States, and possibly into Canada. Much of this association can be seen west and east of *Salix nigra* - (*Platanus occidentalis*, *Populus deltoides*) Southern Floodplain Forest that follows North Potato Creek.

Rare species seen in this system include *Pityopsis ruthii* and *Lysimachia fraseri* both of which have been seen in the county. Interesting specimens made in the flora of the Bare Zone of the Copper Hill Basin that can be seen in this system include *Xyris torta* and *Utricularia gibba*.

Conclusion

The Bare Zone of the Copper Hill Basin was reforested after being devoid of plant life as recently as the 1970's (Muncy, 1986). In the Bare Zone, there are a total of 444 species or lesser taxa, which given its size is lower than expected (Prater, 2015). Although almost a fourth (23%) of the flora is non-native plant species, there are five rare species collected at the site. Although most of the habitat found in the Bare Zone is still anthropogenically influenced, more than 7% of the area has developed into noticeably distinct ecosystems. The flora of the Bare Zone has even begun to resemble the surrounding region, counties, and published floras of the region that have been done prior. It is likely that as time progresses, the flora will change and resemble that of the area that surrounds it.

Following the conclusion of this study, other opportunities for research in the area should be considered. An additional flora after several decades should be conducted to see if the flora has changed over the years. Annual plots could be made in habitats within the Copper Hill Basin to see how they succeed and evolve as time progresses. Other baseline research for fauna could be conducted overtime to see how the increase in vegetation is influencing species migrations into the area.

Having grown as a botanist while conducting the first flora since the reintroduction of vascular plants to the Copper Hill Basin, I am excited for what the future holds for the area.

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APPENDIX A

SERNEC RESULTS FOR EACH SOUTHERN BLUE RIDGE COUNTY

State	County	Record Count	Species Count	Percent Area in Blue Ridge
Georgia	Pickens	538	317	99.8672
	Union	2707	735	100
	Towns	1891	618	100
	Rabun	8091	1420	99.992
	Cherokee	1200	674	56.0442
	Fannin	882	408	100
	Gilmer	1227	534	100
	Caldwell	1685	789	58.1149
North Carolina	Madison	6974	1374	100
	Alleghany	6678	1526	100
	Watauga	10352	1358	100
	Swain	9419	1415	100
	Avery	6134	1171	100
	Graham	3729	1056	100
	Haywood	11057	1570	100
	Jackson	15794	2008	100
	Cherokee	2621	1019	100
	Macon	17569	1817	100
	Mitchell	5193	1137	100
	Yancey	4441	1071	100
	McDowell	2894	963	85.0275
	Buncombe	11080	1962	100
	Henderson	5365	1456	100
	Ashe	9363	1359	100
	Transylvania	9011	1417	100
	Clay	3418	955	100
Tennessee	Carter	9970	1655	77.7959
	Unicoi	9441	1490	95.9566
	Cocke	4031	1172	53.438
	Johnson	4526	1099	100
	Sevier	10399	1470	64.492
	Polk	10200	1604	76.4984

APPENDIX B

FLORISTIC CHECKLIST OF THE BARE ZONE OF THE COPPER HILL BASIN

Key to Relative Abundance Abbreviations (Murrell and Wofford 1987)

* - Introduced species
** - Rare Species
ǂ - New Polk County Record

ChB Flora

EQUISETOPHYTA

EQUISETACEAE
Equisetum arvense L.
Equisetum hyemale L. ssp. *affine* (Engelm.) Calder & Roy L. Taylor

LYCOPODIOPHYTA

LYCOPODIACEAE
Dendrolycopodium hickeyi (W.H.Wagner, Beitel & R.C.Moran) A.Haines
Diphasiastrum digitatum (Dill. ex A. Braun) Holub
Huperzia lucidula (Michx.) Trevis.

PTERIDOPHYTA

ASPLENIACEAE
Asplenium platyneuron (L.) Britton, Stearns & Poggenb.
Asplenium resiliens Kunze
BLECHNACEAE
Woodwardia areolata (L.) T. Moore
DENNSTAEDTIACEAE
Dennstaedtia punctilobula (Michx.) T. Moore
DRYOPTERIDACEAE
Dryopteris marginalis (L.) A. Gray
Polystichum acrostichoides (Michx.) Schott
LYGODIACEAE
Lygodium palmatum (Bernh.) Sw.
ONOCLEACEAE
Onoclea sensibilis L.
OPHIOGLOSSACEAE
Botrypus virginianus (L.) Holub
Sceptridium biternatum (Sav.) Lyon

OSMUNDACEAE

Osmundastrum cinnamomea L.

Osmunda regalis L.

POLYPODIACEAE

Pleopeltis polypodioides (L.) Andrews & Windham ssp. *polypoioides*

PTERIDACEAE

Adiantum pedatum L.

Pellaea atropurpurea (L.) Link

SALVINIACEAE

Azolla caroliniana Willd.

WOODSIACEAE

Athyrium filix-femina (L.) Roth

Cystopteris bulbifera (L.) Bernh.

Cystopteris protrusa (Weath.) Blasdell

CONIFEROPHYTA

CUPRESSACEAE

Juniperus virginiana L.

PINACEAE

Pinus rigida Mill.

Pinus strobus L.

Pinus taeda L.

Pinus virginiana Mill.

Tsuga canadensis (L.) Carriére

MAGNOLIOPHYTA - LILIOPSIDA

AGAVACEAE

Yucca filamentosa L.

ALISMATACEAE

Sagittaria australis (J.G. Sm.) Small

ALLIACEAE

Allium canadense L.

Allium cernuum Roth

Nothoscordum bivalve (L.) Britton

AMARYLLIDACEAE

ǂ**Narcissus pseudonarcissus* L.

ARACEAE

Arisaema triphyllum (L.) Schott

ASPARAGACEAE
**Asparagus officinalis* L.
COMMELINACEAE
Tradescantia subaspera Ker Gawl.
CYPERACEAE
Carex albolutescens Schwein.
Carex amphibola Steud.
Carex atlantica L.H. Bailey ssp.*capillacea* (Bailey) Reznicek
Carex aureolensis Steud.
Carex cherokeensis Schwein.
Carex crinita Lam. var. *brevicrinis* Fernald
Carex frankii Kunth
Carex gigantea Rudge
ǂ*Carex gravida* Bailey var. *Luneliana*
Carex grayi Carey
Carex gynandra Schwein.
Carex hirsutella Mack.
Carex intumescens Rudge
ǂ*Carex louisianica* Bailey
Carex lurida Wahlenb.
Carex swanii (Fernald) Mack.
Carex texensis (Torr.) L.H. Bailey
Cyperus esculentus L.
Cyperus odoratus L.
Cyperus strigosus L.
Dulichium arundinaceum (L.) Britton
Eleocharis engelmannii Steud.
Eleocharis obtusa (Willd.) Schult.
Rhynchospora capitellata (Michx.) Vahl
Rhynchospora glomerata (L.) Vahl
Schoenoplectus tabernaemontani (C.C. Gmel.) Palla
Scirpus atrovirens Willd.
Scleria triglomerata Michx.
DIOSCOREACEAE
Dioscorea villosa L.
HYDROCHARITACEAE
Najas guadalupensis (Spreng.) Magnus
HYPOXIDACEAE
Hypoxis hirsuta (L.) Coville
IRIDACEAE

Iris cristata Aiton
Sisyrinchium albidum Raf.
Sisyrinchium angustifolium Mill.
JUNCACEAE
Juncus acuminatus Michx.
Juncus biflorus Elliot
Juncus coriaceus Mack.
ǂ*Juncus dichotomus* Elliott
Juncus diffusissimus Buckley
Juncus effusus L.
Juncus marginatus Rostk.
ǂ*Juncus secundus* P. Beauv. ex Poir.
Luzula bulbosa (Alph. Wood) Smyth & Smyth
LILIACEAE
ǂ***Lillium philadelphicum* L.
ORCHIDACEAE
Aplectrum hyemale (Muhl. ex Willd.) Torr.
Calopogon tuberosus (L.)B.S.P.
Cypripedium acuale Aiton
Goodyera pubescens (Willd.) R. Br.
Platanthera flava (L.) Lindl. var. *Flava*
Spiranthes lacera (Raf.) Raf. var. *Lacera*
Spiranthes vernalis Engelm. & A. Gray
Tipularia discolor (Pursh) Nutt.
POACEAE
ǂ**Aira caryophyllacea* L.
Andropogon gerardii Vitman
Andropogon glomeratus (Walter) Britton, Sterns & Poggenb.
Andropogon virginicus L.
**Anthoxanthum odoratum* L.
Arundinaria gigantea (Walter) Muhl.
**Bromus inermis* Leyss.
**Bromus japonicus* Thunb.
ǂ*Calamagrostis cinnoides (Muhl.) W.P.C. Barton*
Chasmanthium latifolium (Michx.) Yates
Chasmanthium laxum (Poir.) Yates
Cinna arundinacea L.
**Dactylis glomerata* L.
Danthonia sericea Nutt.
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark ssp. *Acuminatum*

Dichanthelium boscii (Poir.) Gould & C.A. Clark
Dichanthelium clandestinum (L.) Gould
Dichanthelium commutatum (Schult.) Gould ssp. *Commutatum*
Dichanthelium ovale (Elliot) Gould & C.A. Clark ssp. *villosissimum* (Nash) Freckmann & Lelong
Dichanthelium scoparium (Lam.) Gould
Eragrostis capillaris (L.) Nees
**Eragrostis curvula* (Schrad.) Nees
ǂ*Glyceria melicaria* (Michx.) F.T. Hubbard
Glyceria striata (Lam.) Hitchc.
**Holcus lanatus* L.
ǂ**Hordeum vulgare* L.
Leersia oryzoides (L.) Sw.
**Lolium multiflorum* Lam.
**Lolium perenne* L.
Melica mutica Walter
**Microstegium vimineum* (Trin.) A. Camus
Panicum anceps Michx. ssp. *Anceps*
**Phleum pratense* L.
**Poa annua* L.
Poa autumnalis Muhl. ex Elliot
**Poa pratensis* L.
Schizachyrium scoparium (Michx.) Nash var. *Scoparium*
Setaria parviflora (Poir.) Kerguélen
**Setaria pumila* (Poir.) Roem. & Schult.
**Sorghum halepense* (L.) Pers.
Tridens flavus (L.) Hitchc.
POTAMOGETONACEAE
Potamogeton nodosus Poir.
SMILACACEAE
Smilax bona-nox L.
Smilax glauca Walter
Smilax rotundifolia L.
SPARGANIACEAE
Sparganium americanum Nutt.
TYPHACEAE
ǂ*Typha angustifolia L.*
Typha latifolia L.

MAGNOLIOPHYTA - MAGNOLIOPSIDA

ACANTHACEAE
Ruellia caroliniensis (J.F. Gmel.) Steud.
Ruellia humilis Nutt.
ADOXACEAE
Sambucus canadensis L.
ALTINGIACEAE
Liquidamber styraciflua L.
AMARANTHACEAE
ǂ*Amaranthus spinosus* L.
ANACARDIACEAE
Rhus copallinum L.
Rhus glabra L.
Toxicodendron radicans (L.) Kuntze
APIACEAE
**Daucus carota* L.
Oxypolis rigidior (L.) Raf.
Thaspium barbinode (Michx.) Nutt.
APOCYNACEAE
Asclepias incarnata L. ssp. I*ncarnata*
Asclepias tuberosa L. ssp. *Tuberosa*
**Vinca major* L.
**Vinca minor* L.
AQUIFOLIACEAE
Ilex opaca Aiton
ARALIACEAE
Aralia spinosa L.
**Hedera helix* L.
ASTERACEAE
Achillea millefolium L. var. *occidentalis* DC.
Ambrosia trifida L.
Antenaria solitaria Rydb.
Bidens aristosa (Michx.) Britt.
ǂ*Bidens tripartita* L.
ǂ**Carduus nutans* L.
ǂ**Centaurea stoebe* L. ssp. m*icranthos* (Gugler) Hayek
**Cichorium intybus* L.
ǂ**Cirsium arvense* (L.) Scop.
Cirsium discolor (Muhl. ex Willd.) Spreng.
Cirsium horridulum Michx.

Conoclinium coelestinum (L.) DC.
ǂ*Coreopsis grandiflora* Hogg ex Sweet
Coreopsis major Walter
Elephantopus carolinianus Raeusch.
Erigeron annuus (L.) Pers.
Erigeron philadelphicus L.
Erigeron pulchellus Michx.
Erigeron strigosus Muhl. ex Willd. var. *Strigosus*
Eupatorium perfoliatum L.
ǂ*Eupatorium x pinnatifidum* Ell.
Eupatorium serotinum Michx.
Euerybia surculosa (Michx.) G.L. Nesom
Gamochaeta argyrinea G.L. Nesom
Gamochaeta purpurea (L.) Cabrera
Helenium autumnale L.
Helianthus angustifolius L.
Helianthus atrorubens L.
Heliopsis helianthoides (L.) Sweet
ǂ*Heterotheca camporum* (Greene) Shinners *var. glandulissima* Semple
Hieracium paniculatum L.
ǂ*Iva annua* L.
ǂ*Krigia caespitosa* (Raf.) K.L. Chambers
Krigia dandelion (L.) Nutt.
Lactuca biennis (Moench) Fernald
**Leucanthemum vulgare* Lam.
Liatris microcephala (Small) K. Schum.
ǂ*Nabalus asper* (Michx.) Trr. & A. Gray
Packera anonyma (Alph. Wood) W.A. Weber & A. Löve
Packera glabella (Poir.) C. Jeffrey
Packera obovata (Muhl. ex Willd.) W.A. Weber & A. Löve
Pityopsis graminifolia (Michx.) Nutt. var. *graminifolia*
Pluchea camphorata (L.) DC.
Pseudognaphalium obtusifolium (L.) Hillard & B.L. Burtt
Rudbeckia hirta L. var. *hirta*
Solidago altissima L. ssp. *Altissima*
Solidago erecta Pursh
Solidago gigantea Aiton
ǂ*Solidago juncea* Aiton
Solidago odora Aiton
Solidago puberula Nutt.

Solidago rugosa Mill. ssp. *rugosa* var. *Rugosa*
**Sonchus asper* (L.) Hill
Symphyotrichum dumosum (L.) G.L. Nesom
Symphyotrichum laeve (L.) A. Löve & D. Löve var. *Laeve*
**Symphyotrichum oblongifolium* (Nutt.) G.L.Nesom
**Taraxacum officinale* F.H. Wigg.
Verbesina alternifolia (L.) Britton ex Kearney
Verbesina occidentalis (L.) Walter
Vernonia gigantea (Walter) Trel.
Vernonia noveboracensis (L.) Michx.
**Xanthium strumarium* L.
ǂ**Youngia japonica* (L.) DC.
BALSAMINACEAE
Impatiens capensis Meerb.
BERBERIDACEAE
**Nandina domestica* Thunb.
ǂ**Mahonia bealei* (Fortune) Carrière
BETULACEAE
ǂ**Alnus glutinosa* (L.) Gaertn.
Alnus serrulata (Aiton) Willd.
Betula nigra L.
BIGNONIACEAE
Bignonia capreolata L.
Campsis radicans (L.) Seem. ex Bureau
BORAGINACEAE
**Buglossoides arvensis* (L.) I.M. Johnston
BRASSICACEAE
Boechera laevigata (Muhl. ex Willd.) Al-Shehbaz
**Brassica rapa* L.
**Capsella bursa-pastoris* (L.) Medik.
Cardamine bulbosa (Schreb. Ex Muhl.) Britton, Sterns & Poggenb.
**Cardamine hirsuta* L.
ǂ*Dentaria laciniata* Muhl. ex Willd.
Lepidium virginicum L.
**Microthlaspi perfoliatum* (L.)F.K.Mey.
CALYCANTHACEAE
Calycanthus floridus L. var. *Floridus*
CAMPANULACEAE
Campanula americana L.
***Lobelia amoena* Michx.

Lobelia cardinalis L.
Lobelia inflata L.
Lobelia puberula Michx.
Lobelia siphilitica L.
Triodanis perfoliata (L.) Nieuwl. var. *Perfoliata*
CANNABACEAE
Celtis laevigata Willd.
CAPRIFOLIACEAE
**Lonicera japonica* Thunb.
ǂ**Lonicera maackii* (Rupr.) Herder
Symphoricarpos orbiculatus Moench
CARYOPHYLACEAE
**Cerastium brachypetalum* Pers.
**Cerastium glomeratum* Thuill.
ǂ**Holosteum umbellatum* L. .
Silene virginica L. var. *Virginica*
**Stellaria media* (L.) Vill.
Stellaria pubera Michx.
CELASTRACEAE
**Euonymus alatus* (Thunb.) Siebold
**Euonymus hederaceus* Champ. & Benth.
CONVOLVULACEAE
Cuscuta pentagona Engelm.
**Ipomoea coccinea* L.
**Ipomoea hederacea* Jacq.
**Ipomoea purpurea* (L.) Roth
CORNACEAE
Cornus florida L.
EBENACEAE
Diospyros virginiana L.
ELAEAGNACEAE
**Elaeagnus pungens* Thunb.
**Elaeagnus umbellata* Thunb. var. *parviflora* (Wall. ex Royle) C.K. Schneid.
ERICACEAE
Chimaphila maculata (L.) Pursh
Epigaea repens L.
Kalmia latifolia L.
Leucothoe fontanesiana (Steud.) Sleumer
Oxydendrum arboreum (L.) DC.
Rhododendron maximum L.

Vaccinium arboreum Marsh.
Vaccinium corymbosum L.
Vaccinium pallidum Aiton
Vaccinium stamineum L.
EUPHORBIACEAE
Euphorbia dentata Michx.
Euphorbia maculata (L.) Small
FABACEAE
**Albizia julibrissin* Durazz.
Apios americana Medik.
Cercis canadensis L.
Chamaecrista fasciculata (Michx.) Greene
Clitoria mariana L.
ǂ*Desmodium ciliare* (Muhl. ex Willd.) DC.
Desmodium rotundifolium DC.
Gleditsia triacanthos L.
**Kummerowia stipulacea* (Maxim.) Makino
**Lathyrus latifolius* L.
**Lespedeza bicolor* Turcz.
ǂ*Lespedeza capitata* Michx.
**Lespedeza cuneata* (Dum. Cours.) G. Don
Lespedeza hirta (L.) Hornem.
ǂ*Lotus corniculatus* L.
**Medicago orbicularis* (L.) Bartal.
**Melilotus alba* Medik.
**Melilotus officinalis* (L.) Lam.
**Pueraria montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen & S. Almeida
Robinia hispida L.
Robinia pseudoacacia L.
**Securigera varia* (L.) Lassen
Tephrosia spicata (Walt.) Torr. & A. Gray
**Trifolium arvense* L.
**T. hybridum* L.
**T. pratense* L.
**T. repens* L.
Vicia caroliniana Walter
**Vicia sativa* L. ssp. *Sativa*
**Vicia villosa* Roth ssp. *villosa*
**Wisteria floribunda* (Willd.) DC.
FAGACEAE

Fagus grandifolia Ehrh.

ǂ**Quercus acutissima* Carruthers

Quercus alba L.

Quercus falcata Michx.

Quercus marilandica Münchh.

Quercus nigra L.

Quercus rubra L.

Quercus stellata Wangenh.

GENTIANACEAE

Sabatia angularis (L.) Pursh

GERANIACEAE

Geranium carolinianum L.

Geranium maculatum L.

HAMAMELIDACEAE

Hamamelis virginiana L.

HYDRANGEACEAE

Hydrangea cinerea Small

Philadelphus hirsutus Nutt.

HYPERICACEAE

Hypericum crux-andreae (L.) Crantz

Hypericum gentianoides (L.) Britton, Sterns & Poggenb.

Hypericum mutilum L.

Hypericum punctatum Lam.

ITEACEAE

Itea virginica L.

JUGLANDACEAE

C. ovata (Mill.) K. Koch

Juglans nigra L.

LAMIACEAE

ǂ**Calamintha nepeta* (L.) Savi

ǂ**Glechoma hederacea* L.

**Lamium amplexicaule* L.

**Lamium purpureum* L.

Lycopus virginicus L.

**Nepeta cataria* (L.) Britton

**Perilla frutescens* (L.) Britton

Prunella vulgaris L.

Pycnanthemum loomisii Nutt.

Pycnanthemum muticum (Michx.) Pers.

Pycnanthemum tenuifolium Schrad.

Salvia lyrata L.
ǂ*Satureja vulgaris* (L.) Fritsch
Scutellaria incana Biehler var. *punctata* (Chapm.) C. Mohr
Scutellaria integrifolia L.
Scutellaria lateriflora L.
Scutellaria parvula Michx. var. *Parvula*
LAURACEAE
Lindera benzoin (L.) Blume
Sassafras albidum (Nutt.) Nees
LENTIBULARIACEAE
ǂ*Utricularia gibba* L.
LOGANIACEAE
Spigelia marilandica (L.) L.
MAGNOLIACEAE
Liriodendron tulipifera L.
Magnollia grandiflora L.
MELASTOMATACEAE
Rhexia mariana L. var. *Mariana*
Rhexia virginica L.
MONTIACEAE
Claytonia virginica L.
MORACEAE
**Morus alba* L.
MYRSINACEAE
Lysimachia lanceolata Walter
Lysimachia quadrifolia L.
NYSSACEAE
Nyssa sylvatica Marsh. var. *Sylvatica*
OLEACEAE
**Ligustrum sinense* Lour.
ONAGRACEAE
Ludwigia palustris (L.) Elliot
Oenothera biennis L.
Oenothera fruticosa L. ssp. *fruticosa*
**Oenothera speciosa* Nutt.
OROBANCHACEAE
Agalinis purpurea (L.) Pennell
Agalinis tenuifolia (Vahl) Raf.
OXALIDACEAE
Oxalis stricta L.

Oxalis violacea L.
PASSIFLORACEAE
Passiflora incarnata L.
Passiflora lutea L.
PAULOWNIACEAE
**Paulownia tomentosa* (Thunb.) Siebold & Zucc. ex Steud.
PENTHORACEAE
ǂ*Penthorum sedoides* L.
PHRYMACEAE
Mimulus ringens L.
PHYTOLACCACEAE
Phytolacca americana L.
PLANTAGINACEAE
ǂ***Chelone obliqua* L. *ssp. erwinae* Pennell & Wherry
Nuttallanthus canadensis (L.) D.L. Sutton
Plantago aristata Michx.
**Plantago lanceolata* L.
**Veronica anagallis-aquatica* L
**Veronica arvensis* L.
**Veronica hederifolia* L.
**Veronica officinalis* L.
PLATANACEAE
Platanus occidentalis L.
POLYGALACEAE
Polygala curtissii A. Gray
Polygala sanguinea L.
POLYGONACEAE
**Fallopia japonica* (Houtt.) Ronse Decr.
Persicaria glabra (Willd.) M. Gomez
**Polygonum cespitosum* Blume, nom. Inq.
**Rumex acetosella* L.
**Rumex crispus* L.
PORTULACACEAE
**Portulaca oleracea* L.
RANUNCULACEAE
**Clematis terniflora* DC.
***Clematis vinacea* Floden
Clematis virginiana L.
Ranunculus abortivus L.
**Ranunculus ficaria* L.

**Ranunculus sardous* Crantz
Thalictrum revolutum DC.
Thalictrum thalictroides (L.) Eames & B. Boivin
ROSACEAE
Amelanchier arborea (Michx. f.) Fernald
Aronia arbutifolia (L.) Pers.
Aronia melanocarpa (Michx.) Ell.
**Duchesnea indica* (Andrews) Focke
Geum canadense Jacq.
Potentilla simplex Michx. var. *Simplex*
Prunus serotina Ehrh.
ǂ**Pyrus calleryana* Decne.
Rosa carolina L. var. *Carolina*
**Rosa multiflora* Thunb. ex. Murr.
Rosa palustris Marsh.
Rubus argutus Link
**Rubus bifrons* Vest ex Tratt.
Rubus flagellaris Willd.
ǂ*Spiraea tomentosa* L.
RUBIACEAE
Cephalanthus occidentalis L.
Galium circaezans Michx.
Houstonia canadensis Willd. ex Roem. & Schult.
Mitchella repens L.
**Sherardia arvensis* L.
SALICACEAE
**Populus alba* L.
***Populus balsamifera* L.
Salix caroliniana Michx.
Salix nigra Marsh.
SAPINDACEAE
Acer negundo L.
Acer rubrum L.
Acer saccharum Marsh. var. *saccharum*
SAXIFRAGACEAE
**Saxifraga tridactylites*
SCROPHULARIACEAE
**V*erbascum *thapsus* L.
SIMAROUBACEAE
**Ailanthus altissima* (Mill) Swingle

SOLANACEAE

*Datura stramonium L.

Solanum carolinense L.

ULMACEAE

Ulmus alata Michx.

Ulmus rubra Muhl.

URTICACEAE

Boehmeria cylindrica (L.) Sw.

VALERIANACEAE

**Valerianella locusta* (L.) Lat.

Valerianella radiata (L.) Dufr.

VIOLACEAE

**Viola arvensis* Murray

Viola bicolor Pursh

Viola blanda Willd.

Viola sororia Willd. var. *Sororia*

VITACEAE

Ampelopsis cordata Michx.

Parthenocissus quinquefolia (L.) Planch.

Vitis cinerea (Engelm.) Engelm. ex Millard var. *baileyana* (Munson) Comeaux

APPENDIX C

INVASIVE SPECIES LIST AND TNIPC STATUS

Species list	TNIPC Status
**Ailanthus altissima (Mill) Swingle*	Established
**Aira caryophyllacea L.*	Introduced
**Albizia julibrissin Durazz.*	Established
**Alnus glutinosa (L.) Gaertn.*	Introduced
**Anthoxanthum odoratum L.*	Introduced
**Asparagus officinalis L.*	Introduced
**Bromus inermis Leyss.*	Established
**Bromus japonicus Thunb.*	Introduced
**Brassica rapa L.*	Introduced
**Buglossoides arvensis (L.) I.M. Johnston*	Introduced
**Cichorum arvense (L.)Scop.*	Introduced
**Cerastium glomeratum Thuill.*	Introduced
**Cardamine hirsuta L.*	Introduced
**Carduus nutans L.*	Introduced
**Centaurea stoebe L. ssp. micranthos (Gugler) Hayek*	Established
**Clematis terniflora DC.*	Established
**Calamintha nepeta (L.) Savi*	Introduced
**Capsella bursa-pastoris (L.) Medik.*	Introduced
**Cerastium brachypetalum Pers.*	Introduced
**Cichorium intybus L.*	Introduced
**Dactylis glomerata L.*	Introduced
**Datura stramonium L.*	Introduced
**Daucus carota L.*	Introduced
**Dianthus armeria L.*	Introduced
**Duchesnea indica (Andrews) Focke*	Introduced
**Eragrostis curvula (Schrad.) Nees*	Introduced
**Eunymus hederaceus Champ. & Benth.*	Introduced
**Elaeagnus umbellata Thunb. var. parviflora (Wall. ex Royle) C.K. Schneid.*	Established
**Elaeagnus pungens Thunb.*	Introduced
**Euonymus alatus (Thunb.) Siebold*	Established

**Fallopia japonica (Houtt.) Ronse Decr.*	Established
**Glechoma hederacea L.*	Introduced
**Holcus vulgare L.*	Introduced
**Hedera helix L.*	Introduced
**Holcus lanatus L.*	Introduced
**Holosteum umbellatum L.*	Introduced
**Iva hederacea Jacq.*	Introduced
**Ipomoea purpurea (L.) Roth*	Introduced
**Ipomoea coccinea L.*	Introduced
**Kummerowia stipulacea (Maxim.) Makino*	Introduced
**Lespedeza bicolor Turcz.*	Established
**Lespedeza cuneata (Dum. Cours.) G. Don*	Established
**Lonicera japonica Thunb.*	Established
**Lathyrus latifolius L.*	Introduced
**Lonicera maackii (Rupr.) Herder*	Established
**Lollium perenne L.*	Introduced
**Lamium purpureum L.*	Introduced
**Ligustrum sinense Lour.*	Introduced
**Lamium amplexicaule L.*	Introduced
**Leucanthemum vulgare Lam.*	Introduced
**Loliummultiflorum Lam.*	Introduced
**Mahonia bealei (Fortune) Carrière*	Emerging
**Medicago orbicularis (L.) Bartal.*	Introduced
**Melilotus alba Medik.*	Introduced
**Melilotus officinalis (L.) Lam.*	Introduced
**Microstegium vimineum (Trin.) A. Camus*	Established
**Microthlaspi perfoliatum (L.)F.K.Mey.*	Introduced
**Morus alba L.*	Introduced
**Najas minor All.*	Introduced
**Narcissus pseudonarcissus L.*	Introduced
**Nandina domestica Thunb.*	Emerging
**Nepeta cataria (L.) Britton*	Introduced
**Oenothera speciosa Nutt.*	Introduced

**Poa annua L.*	Introduced
**Polygonum cespitosum Blume, nom. inq.*	Introduced
**Plantago lanceolata L.*	Introduced
**Poa pratensis L.*	Introduced
**Paulownia tomentosa (Thunb.) Siebold & Zucc. ex Steud.*	Established
**Perilla frutescens (L.) Britton*	Established
**Phleum pratense L.*	Introduced
**Populus alba L.*	Introduced
**Portulaca oleracea L.*	Introduced
**Pueraria montana (Lour.) Merr. var. lobata (Willd.) Maesen & S. Almeida*	Established
**Pyrus calleryana Decne.*	Established
**Rubus bifrons Vest ex Tratt.*	Introduced
**Rumex crispus L.*	Introduced
**Ranunculus ficaria L.*	Emerging
**Rosa multiflora Thunb. ex. Murr.*	Established
**Ranunculus sardous Crantz*	Introduced
**Rumex acetosella L.*	Introduced
**Silene coronaria (L.) Clarirv.*	Introduced
**Sorghum halepense (L.) Pers.*	Established
**Stellaria media (L.) Vill.*	Introduced
**Symphyotrichum oblongifolium (Nutt.) G.L.Nesom*	Introduced
**Setaria pumila (Poir.) Roem. & Schult.*	Introduced
**Securigera varia (L.) Lassen*	Introduced
**Sherardia arvensis L.*	Introduced
**Sonchus asper (L.) Hill*	Introduced
**Trifolium hybridum L.*	Introduced
**Trifolium pratense L.*	Introduced
**Trifolium repens L.*	Introduced
**Taraxacum officinale F.H. Wigg.*	Introduced
**Trifolium arvense L.*	Introduced
**V. hederifolia L.*	Introduced
**Vinca minor L.*	Established
**Veronica officinalis L.*	Introduced
**Viccia sativa L. ssp. Sativa*	Introduced

**Verbascum thapsus L.*	Introduced
**Viccia villosa Roth ssp. Villosa*	Introduced
**Valerianella locusta (L.) Lat.*	Introduced
**Veronica anagallis-aquatica L*	Introduced
**Veronica arvensis L.*	Introduced
**Vinca major L.*	Established
**Viola arvensis Murray*	Introduced
**Wisteria floribunda (Willd.) DC.*	Established
**Xanthium strumarium L.*	Introduced
**Youngia japonica (L.) DC.*	Introduced

APPENDIX D

NATURESERVE SYSTEMS AND THE ASSOCIATIONS FOUND IN THE BARE ZONE OF THE COPPER HILL BASIN

System	Association
Southern and Central Appalachian Oak Forest	*Sassafras albidum* - *Quercus* spp. Ruderal Forest
Appalachian Hemlock-Hardwood Forest	*Rhododendron maximum* Montane Ruderal Thicket
	Tsuga canadensis - *Fagus grandifolia* - *Acer saccharum* / (*Hamamelis virginiana*, *Kalmia latifolia*) Forest
	Tsuga canadensis - *Fagus grandifolia* - *Quercus rubra* Forest,
	Quercus rubra - *Acer saccharum* - *Liriodendron tulipifera* Forest
	Tsuga canadensis - *Acer saccharum* - *Fagus grandifolia* / *Dryopteris intermedia* Forest
	Quercus rubra - *Tsuga canadensis* - *Liriodendron tulipifera* / *Hamamelis virginiana* Forest
Southern Appalachian Low Mountain Pine Forest	*Pinus virginiana* Ruderal Forest
	Pinus strobus / *Kalmia latifolia* - (*Vaccinium stamineum*, *Gaylussacia ursina*) Forest
	Pinus virginiana - *Pinus* (*rigida*, *echinata*) - (*Quercus montana*) / *Vaccinium pallidum* Forest
Southern and Central Appalachian Cove Forest	*Liriodendron tulipifera* - *Pinus strobus* - *Tsuga canadensis* - *Quercus rubra* / *Polystichum acrostichoides* Forest
	Pinus strobus - *Tsuga canadensis* / *Rhododendron maximum* - *(Leucothoe fontanesiana*) Forest
	Tsuga canadensis / *Rhododendron maximum* - (*Clethra acuminata*, *Leucothoe fontanesiana*) Forest
	Liriodendron tulipifera / (*Cercis canadensis*) / (*Lindera benzoin*) Ruderal Forest,
South-Central Interior Large Floodplain	*Platanus occidentalis* - *Acer saccharinum* - *Juglans nigra* - *Ulmus rubra* Floodplain Forest,

	Liquidambar styraciflua - *Liriodendron tulipifera* - (*Platanus occidentalis*) / *Halesia tetraptera* / *Amphicarpaea bracteata* Floodplain Forest
	Salix nigra - (*Platanus occidentalis, Populus deltoides*) Southern Floodplain Forest
South-Central Interior Small Stream and Riparian	*Carex crinita* - *Osmunda spp.* / *Sphagnum spp.* Acidic Herbaceous Seep
	Betula nigra - *Platanus occidentalis* Floodplain Forest
	Platanus occidentalis - *Betula nigra* - *Salix* (*caroliniana, nigra*) Floodplain Forest
	Salix nigra Wet Shrubland
	Quercus (*alba*, *coccinea*, *falcata*, *velutina*) / *Kalmia latifolia* Forest
	Liquidambar styraciflua - *Liriodendron tulipifera* / *Lindera benzoin* / *Arisaema triphyllum* Floodplain Forest
	Salix nigra - *Platanus occidentalis* Floodplain Forest
	Platanus occidentalis - *Liriodendron tulipifera* - (*Betula alleghaniensis*) / *Alnus serrulata* - *Leucothoe fontanesiana* Floodplain Forest

APPENDIX E

NOTED SPECIES OF THE COPPER HILL BASIN IN *FLORA OF TENNESSEE AND PHILOSOPHY OF BOTANY*

Taxon	Description	Current taxon
Gentiana quinquefolia	Hills around the copper Mines	*Gentiana quinquefolia*
Typha angustifolia	Apparently rare. Ducktown, Polk county, near Kingston Springs. In Ponds and ditches.	*Typha angustifolia*
Panicularia pallida	Edge of a millpond in Ducktown.	*Torreyochloa pallida*
Carex plantaginea	Ducktown, E. Tenn. Waters of Holston River.	*Carex plantaginea*
Lilium canadense	Yellow lily. Moist woodlands. Paradise Ridge. Mountains about Ducktown, E. Tenn.	*Lilium canadense*
Trillium cernuum	Lookout Mt., Ducktown.	*Trillium cernuum*
Cypripedium reginae	Ducktown	*Cypripedium reginae*
Tipularia unifolia	Vicinity of Ducktown,	*Tipularia discolor*
Paronychia dichotoma	Mts. of E. Tenn., near Ducktown	*Paronychia canadensis*
Caltha palustris	Boggy mountain meadows	*Caltha palustris*
Anemone cylindrica	Alleghenies, near Ducktown	*Anemone cylindrica*
Thalictrum coriaceum	Mts. of E. Tenn. Ducktown.	*Thalictrum coriaceum*
Malapoena geniculata	East of Ducktown	*Unknown*
Rubus alleghaniensis	Mountains around Ducktown	*Rubus alleghaniensis*

Potentilla fruticosa	Near Ducktown	*Potentilla fruticosa*
Baptisia alba	Mts. of E. Tenn. Ducktown.	*Baptisia alba*
Gaylussacia ursina	A few miles southeast of Ducktown	*Gaylussacia ursina*
Symplocos tinctoria	Near Ducktown	*Symplocos tinctoria*
Phlox reptans	Ducktown	*Unknown*
Hydrophyllum virginicum	Ducktown	*Hydrophyllum virginicum*
Scutellaria galericulata	Ducktown	*Scutellaria galericulata*
Ilysanthes refracta	Ducktown	*Lindernia monticola*
Sitilias caroliniana	Ducktown Road	*Pyrrhopappus carolinianus*
Chrysogonum virginianum	Ducktown	*Chrysogonum virginianum*
Coreopsis rosea	In a swamp in Ducktown	*Coreopsis rosea*
Senecio balsamitae	Ducktown	*Packera paupercula var. balsamitae*

VITA

John Shelton was born on October 17th, 1994 in Raleigh, North Carolina. He would move around from North Carolina, to Fairbanks, Alaska, Fort Campbell, Kentucky, Hanau, Hessen, Germany, Fairbanks, Alaska, before graduating in Lacey, Washington in 2013. He and his family would move to Clarksville, Tennessee where he would attend Austin Peay State University, receiving his B.A. in Biology in 2016. John then applied to the University of Tennessee at Chattanooga and was accepted into the environmental science program. With his Master's behind him, John is living in Knoxville, Tennessee, with his fiancé Grace Sarabia, and their two cats, Oliver and Sylvia Mae.