THE VASCULAR FLORA AND VEGETATION CLASSIFICATION OF THE CHEATHAM WILDLIFE MANAGEMENT AREA, CHEATHAM COUNTY, TENNESSEE

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THE VASCULAR FLORA AND VEGETATION CLASSIFICATION OF THE CHEATHAM WILDLIFE MANAGEMENT AREA, CHEATHAM COUNTY, TENNESSEE

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Master of Science

Clea F. Klagstad

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TO THE COLLEGE OF GRADUATE STUDIES:

We are submitting a thesis written by Clea Klagstad entitled "The Vascular Flora and Vegetation Classification of the Cheatham Wildlife Management Area, Cheatham County, Tennessee." We have examined the final copy of this thesis for form and content. We recommend that it be accepted in partial fulfillment of the requirements for the Masters in Science.

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TABLE OF CONTENTS

DEDICATION

I dedicate this work to my loving parents, Lenore and Harold Klagstad, for their unconditional guidance throughout this project. They kept me grounded and motivated in the whirlwind that often surrounds worthwhile endeavors as scholastics. Without their devoted input, none of this would have been possible.

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ABSTRACT

CLEA FRANCES KLAGSTAD. The Vascular Flora and Vegetation Classification of the Cheatham Wildlife Management Area (CWMA), Cheatham County, Tennessee (under the direction of DR. DWAYNE ESTES).

The Cheatham Wildlife Management Area (CWMA) comprises 8,422 ha in Cheatham County, Tennessee and is owned and managed by the Tennessee Wildlife Resources Agency (TWRA). It is the second largest public land unit on the Western Highland Rim and is located in the south-central part of the county ca. 64 km west of Nashville. A total of 31 collection trips from August 2010 to May 2012 yielded an inventory of 419 species representing 102 families and 287 genera. In addition, 121 county records were documented, as well as seven species with a state or federal listing, including *Aristida ramosissimus*, *Cornus obliqua*, *Helianthus eggertii, Hydrastis canadensis, Juglans cinerea,* and *Packera plattensis,* and *Panax quinquefolius.* Numerous additional rare species have been discovered within close proximity of the refuge. Fifteen percent of the flora is introduced, of which the most problematic are *Elaeagnus umbellata* and *Lespedeza cuneata*. Analyses were performed using BONAP's Floristic Synthesis of North America software (Kartesz, 2011) to understand range extensions and phytogeographic affinities. Vegetation types were classified using NatureServe (2007) and the South Eastern Gap Analysis Project (SEGAP; USGS, 2011) data to prepare a map of the vegetation types. Noteworthy systems included the Western Highland Rim Prairie and Barrens, Central Interior Highlands and Appalachian Sinkhole and Depression Pond, South-Central Interior/Upper Coastal Plain Flatwoods, Interior Low Plateau Seepage Fens, South Central Interior Large Floodplain, and Southern Appalachian Low-Elevation Pine communities. Conclusions from the study may be used by TWRA as baseline data for further research and management decisions.

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

LIST OF ABBREVIATIONS

NATURAL COMMUNITIES

SCISS/R ....South-Central Interior Small Stream/Riparian

ILPSF .. ..Interior Low Plateau Seepage Fen

SCIMF South-Central Interior Mesophytic Forest

SILPDM...........Southern Interior Low Plateau Dry-Mesic Oak

SALEP South Appalachian Low-Elevation Pine

CICCT. ....Central Interior Calcareous Cliff and Talus

SCILF . ...South-Central Interior Large Floodplain

SCI/UCPF ....South-Central Interior/Upper Coastal Plain Flatwoods

CIHASDP ....Central Interior Highlands and Appalachian Sinkhole and Depression Pond

ANTHROPOGENIC COMMUNITIES

WHRPB ....Western Highland Rim Prairie and Barrens.

PL..........Power line or right of way

P ....Pipeline or Transmission line right of way

AP ....Artificial Pond

F ....Field

PP..........Pine Plantation

CC ....Clear-cut

CF..........Crop field (wheat or corn)

FP..........Food plot

RS ....Roadside

Relative Abundances (Gunn and Chester, 2003)

I ....Infrequent. Not always in stated community types and usually in small numbers

O ....Occasional. Often stated in community types but rarely in large numbers

F ....Frequent. Usually encountered but not always in large numbers

LA ....Locally Abundant. Known from few locales with large numbers in each

A ....Abundant. Expected in the type, usually in large numbers

R..........Rare. Known from few locales, generally with small populations

Conservation Status (TDEC, 2008)

S1 ....Tennessee State Rank 1

S2 ......Tennessee State Rank 2

S3 ....Tennessee State Rank 3

S4 ....Tennessee State Rank 4

S2/S3....Ranked between S2 and S3

S3/S4....Ranked between S3 and S4

LT.......Federally Listed Threatened

E ....Endangered Species (Tennessee)

T ....Threatened species

SC.......Special Concern

CE ......Commercially Exploited

Localities and Organizations

APSU ....Austin Peay State University

CWMA...........Cheatham Wildlife Management Area

TENN ....Herbarium of the University of Tennessee

TWRA............Tennessee Wildlife Management Area

USGS ....United States Geological Survey

OTHER

BONAP ....Biota of North America Project

GIS ....Geographic Information System

GPS ....Global Positioning System receiver

SEGAP...........South Eastern Gap Analysis Project

CHAPTER I

INTRODUCTION

Floristics as a whole is understudied and continues to lose presence and funding in the scientific discipline. This is largely because of "the perception that the vascular plant flora of North America has been fully explored and cataloged," even though the rate of species discovery in the past two decades has increased by one-fourth (Ertter, 2000). Between 1880 and 1993, the number of known plant species more than doubled in California alone. Alongside botanists such as Marcus E. Jones, the perception of the 19th century has become the "dogma" for the 20th century, in that North America has been fully explored, with "nothing left to do," and that any further species discoveries [are] simply ego-gratification rather than real science (Ertter, 2000). It is estimated that 5% of North America's flora remains undiscovered, and that these discoveries are not always far from our backyards. More than seven new species records were found no more than 40 kilometers away from civilization, a statistic given by one study alone (Ertter, 2000). These often pose interesting biogeographic questions, while some expand our understanding of known ranges and/or invasive species distributions for a particular area.

Ertter (2000) noted that a common and recurring assumption of floristics was that observation-based studies like floristic inventories are not "intrinsically scientific" (Ertter, 2000). This particular assumption limits the amount of hiring and funding of researchers capable of performing large inventories. Many agencies that purportedly support biodiversity reject studies pertaining to taxonomy. The college and university infrastructure hinders such research because "the value of new species descriptions...seems low relative to other publications that could be generated (Cotterill, 1994)."

Another limiting factor to the field of scientific discovery is that there are researchers with the expertise to acknowledge new species. With the exception of apprenticeships and other avenues of relaying information to new students, the knowledge of experienced systematists is insufficiently transferred solely through literature, especially in the absence of field experience. Decaying collections, cost of newer literature sources, incorrect identifications, poor database management, inadequacies of biological curricula, and overall lack of communication are in part due to the fact that the benefits of preserving biology "rarely extend beyond [our] immediate neighborhoods" (Cotterill, 1994). There are few university-level taxonomists, emeriti plant systematists, museum systematists, government agency biologists, and amateur enthusiasts left to study the field of floristics (Ertter, 2000).

Our floristic heritage remains unexplored largely because "it's a big job!" (Ertter, 2000). Most professional floristic studies take upwards of five years to perform fully, depending on the size and scope of the study. Without them, though, "we risk losing a significant percentage of our floristic heritage out of sheer ignorance of its existence, not just in the tropics but in our own backyards" (Ertter, 2000). Crucial management decisions are based on such floristic inventories, so it is imperative that companies and land managers are given the most comprehensive information available. The information within any floristic inventory is important for environmental consultants, engineers, silviculturists, farmers, lawyers, municipal planners, landscape architects, and customs officials, to name a few (Palmer, 1995). Documented declines in species richness due to timber harvesting, grazing by deer and wildlife populations, as well as clear cutting for various anthropogenic needs augmented the necessity of creating site-specific floras and noting shifts in species assemblages over time (McEwan *et al.*, 2005; Palmer *et al.*, 1995).

Last, floristic inventories lay the groundwork for molecular studies, including information about difficult genera and hybridizing species. It is the work of a taxonomist to recognize problematic complexes, after which molecular and research may be completed. Even though "taxonomic resources, especially biological collections, are of international worth," taxonomists, environmentalists, and biologists remain largely uninformed or unconcerned (Cotterill, 1994). Clearly, the work of the taxonomist is far from over and shockingly underrepresented in research today.

Vegetation History of the Western Highland Rim

The history of the vegetation on the Western Highland Rim in the Quaternary Period (1.6 million years – present) encompassed the Pleistocene and Holocene epochs. Forms of the alpine tundra at high elevations were present in the southeastern United States at the last glacial maximum, expressed by ground conditions which included low percentages of tree pollen, abundant Cyperaceous species, and other herbaceous plants (Graham, 1999). Glaciers stopped just above the Western Highland Rim in Kentucky and Indiana, therefore the land unit known as Tennessee today was never glaciated. While the description of the vegetation at that time is speculative, higher elevations were most likely covered by "spruce parkland," and lower elevations by coniferous and boreal forests (Graham, 1999). Not only were these forests dominant, they expanded and contracted, and appeared and disappeared several times, which provided evidence of repeated glaciations in the Northern reaches of North America. In the late-glacial periods *Pinus banksiana* began to disappear, as deciduous species gained dominance within the landscape. Following these glaciations was a particularly warm epoch known as the Hypsithermal Period, where *Quercus* and *Carya* gained dominance, most likely migrating north from the Coastal Plain as temperatures increased. As *Castanea* (Chestnut species) began to migrate north, oak-chestnut forests began to dominate the landscape (Graham, 1999).

Floristic Inventories

Lucy Braun (1950), one of the first well-known botanists of North America, described the Western Highland Rim as part of the Western Mesophytic Forest, a transition area between the Mixed Mesophytic Forest Region of the mountains to the east and the Oak-Hickory Forest Region to the west. She noted that there was "a scattering of shade tolerant mesophytes within *Quercus* communities," indicating seral, or successive forest conditions. This zone without characteristic dominants was largely determined by variations in local climate, topography, and soils, which determined the vegetation features. The Western Highland Rim was therefore a truly transitional area.

Küchler (1964) recognized the potential natural vegetation versus the existing vegetation of North America as the composition of plant communities pre- and post-settlement, respectively. He categorized the vegetation of North America based on "phytocenoses," (areas where plants share common site qualities), based on floristic inventories that were published at that time throughout the United States. Dominant species were used to classify and map vegetation types, noting any transition zones or areas of co-dominant species. Küchler noted that because vegetation in the southeastern United States tended to merge gradually, it was termed the "weakest part of an otherwise fine map." Vegetation of the Western Highland Rim region in Tennessee was included in Küchler's Oak Hickory Forest description. This area consisted of medium to tall forests of broadleaf deciduous and needle leaf evergreen trees, including hickories, pines, oaks, chestnuts, tulip-trees, and dogwoods.

The deep history of southwestern Tennessee influenced the vegetation of the Western Highland Rim as well (Chester, 1995). For instance, Mesozoic vegetation, tropical species, migration across land bridges, boreal elements, and anthropogenic activities as humans arrived, impacted species assemblages within the area. In fact, Chester (1995) deemed the Western Highland Rim a "botanical crossroads that receives elements from many migratory pathways," from Tennessee and bordering states. The floristic richness of the Western Highland Rim is a result of soils, slope aspect, temperature, precipitation, and drainage systems, to name a few. Within the past 65 million years, several regions within Tennessee were once under marine water, save a few areas like the Western Highland Rim. The fact that glacial ice never coated the area is another cause of floristic richness. These factors explain why species distributions were elevated to the Western Highland Rim, though much of the extant diversity has been degraded by anthropogenic activity (Chester, 1995). Extant forest types within the province include mixed mesophytic, mixed hardwoods, oak and oak-hickory pine, cedar, bottomland hardwoods, and swamp forests, with a minor element of upland swamps, karst fens, cedar glades, barrens, and prairie relicts (Chester, 1995).

Vegetation Classification Systems

Smalley (1991) proposed a flexible vegetation classification system for the Interior Low Plateau based on 'landforms' and 'associations.' He noted that soils, solar radiation, and elevation were determined by landform and topographic position. He also noted that vegetation closely follows these landform characteristics, and that "once land types are defined and mapped, existing forest type and inventory information can be merged with the land types" (Smalley, 1991). Using the Western Highland Rim as a pilot study area, Smalley established a subjective, but adaptable classification scheme for vegetation analyses, particularly those of a larger scope.

Griffith (1997) developed the Ecoregion classification of extant forests, based on the biological, physical, and chemical habitats characteristic of regional reference sites that served as the standard for comparison. The use of these Ecoregions is still widespread today. NatureServe (Cromer *et al.*, 2003) described them as "regional landscapes or relatively large areas of land and water defined by similar geology, landforms, climates, and ecological processes." They are important to vegetation classification in that they delineate major assemblages of ecological communities and environmental processes, which provide its users with diverse functionality. All Ecoregions were measured by length, width, area, and percentage of the state in which they occur. For instance, the Western Highland Rim is denoted, 'region (71f)' and covers

15,206 square kilometers (5,871 miles), which makes up 13.9% of the state (Griffith *et al.*, 1997). About 0.8 kilometers (0.5 miles) away from the lowermost extent of the Western Highland Rim is 'region 71h,' the Outer Central Basin, which makes up 10.5% of the state, covering 11,432 square kilometers (4,414 square miles) (Griffith *et al.*, 1997). In addition to biotic and abiotic factors, these measurements

Grossman *et al.* (1998) in the North Carolina Vegetation Survey (NCVS) documented vegetation types of the United States by dividing vegetation into several hierarchical classes. The most inclusive level, the physiognomic 'system level,' was broken into several classes, subclasses, groups, and formations (Figure 1).

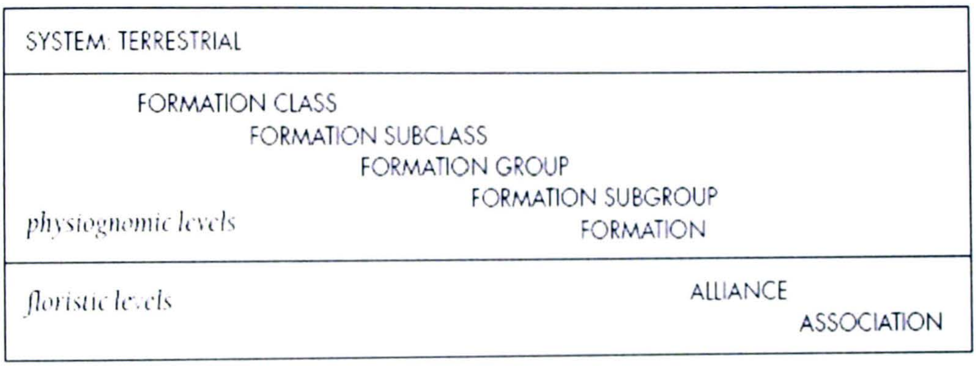


FIGURE 1. The Grossman *et al.* (1998) method used to document vegetation in the NCVS survey, from the System to Association level.

These systems were defined as, "unified by similar ecological processes (e.g. fire, riverine flooding), substrates, (e.g., shallow soils, serpentine parent material), and/or environmental gradients (e.g. local climate, hydrologically-defined patterns in coastal zones)" (Grossman *et al.*, 1998). The floristic association was the least inclusive unit of the system (Figure 1) (Grossman *et al.*, 1998). Associations were named according to the names of dominant and diagnostic species. If two species occurred in the same stratum (physiognomic or floristic level), they were separated by a hyphen, where those of different strata were separated with a slash. Uppermost occurring species of the stratum were listed first, followed by those in the lower strata. This decreasing hierarchy reflected the dominance of the species within each association. The lowest possible number of names was used in the nomenclature (Grossman *et al.*, 1998).

Jennings *et al.* (2009) also characterized the associations within the United States. Associations are defined based on spatial and temporal data obtained by field botanists and ecologists. They were comprised of 4 defined characteristics, (1) uniform physiognomy and structure, (2) uniform habitat, (3) definite floristic composition, and (4) recurring distribution on a landscape (NatureServe, 2009). When determining associations, it is necessary to have an understanding of the natural patterns of vegetation, as there is variability within them across geography with respect to species profiles, physiognomy, habitat, and abiotic factors (Jennings *et al.*, 2009).

NatureServe (Cromer *et al.*, 2003; NatureServe 2006 and 2010) is one of the most widely used classification systems in the southeastern United States. Based on ecological plot data, NatureServe aims to assess vegetation at a regional scale to document baseline data and trends in regional biodiversity. This method first divides vegetation into ecological systems, which include all natural and semi-natural terrestrial or aquatic systems in an area (NatureServe, 2010). They represent "recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding" (NatureServe, 2010). These easily mapped systems are further divided into associations. According to NatureServe (Cromer *et al.*, 2003), an ecological association is a plant community type that co-occurs with landscapes of similar ecological processes, substrates, and/or environmental gradients. They are chosen based on 'Diagnostic Classifiers,' which are simply grouped multiple environmental factors.

The term, "type" was used to describe a vegetation classification unit by means of 'association' or 'alliance' as described by Grossman *et al.* (1998) and other previous studies. NatureServe (Cromer *et al.*, 2003) described broad scale ecological "pattern types" as falling into one of four general categories differentiated by spatial categories (Figure 2).

Patch Type	Definition
Matrix	Ecological Systems that form extensive and contiguous cover, occur on the most extensive landforms, and typically have wide ecological tolerances. Disturbance patches typically occupy a relatively small percentage (e.g. < 5%) of the total occurrence. In undisturbed conditions, typical occurrences range in size from 2,000 to 10,000s ha.
Large Patch	Ecological Systems that form large areas of interrupted cover and typically have narrower ranges of ecological tolerances than matrix types. Individual disturbance events tend to occupy patches that can encompass a large proportion of the overall occurrence (e.g. > 20%). Given common disturbance dynamics, these types may tend to shift somewhat in location within large landscapes over time spans of several hundred years. In undisturbed conditions, typical occurrences range from 50-2,000 ha.
Small patch	Ecological Systems that form small, discrete areas of vegetation cover typically limited in distribution by localized environmental features. In undisturbed conditions, typical occurrences range from 1-50 ha.
Linear	Ecological Systems that occur as linear strips. They are often ecotonal between terrestrial and aquatic ecosystems. In undisturbed conditions, typical occurrences range in linear distance from 0.5 to 100 km

FIGURE 2. Four spatial categories of ecological system patterns within a landscape from NatureServe (Cromer *et al.*, 2003).

The nomenclature of the NatureServe (Cromer *et al.*, 2003) system was based on three main components, (1) the vegetation physiognomy, (2) composition, and/or (3) environmental setting, and named accordingly. For example, the name, "Central Appalachian Limestone Glade and Woodland" is comprised of several descriptors for a particular ecological system. The 'Central Appalachian' descriptor provides climate and abiotic background, the 'glade and woodland' marks the composition of that area, and third, the environmental setting is described by the 'limestone' notation.

Mapping

Clatterbuck (1991) expanded eight community types found within a small area of the CWMA to the remainder of the refuge. By taking 30 samples per community type, they obtained an 85-90% level of precision. The map was given to TWRA to document resource conditions (Clatterbuck, 1991).

A more technological approach to vegetation analysis used to classify the vegetation in the Southeast was SEGAP data, which stands for the Southeastern Gap Analysis Project (USGS, 2011). This is another systems classification that can be applied at a national scale. SEGAP analysis is a type of remote sensing, in addition to a "phase modifier," which is a well refined system based on phenological or structural variation for mapping purposes. This device captures orthoimages, which is a remotely sensed image where displacement of features caused by sensor orientation or terrain relief is removed (North Carolina Center for Geographic Information and Analysis, 2011). Teams flew above the desired study area in Cessna 210 Centurion aircrafts, with a window mounted sensor array, which was modified from a dual Hi-8 video camera to contain a digital still camera as well as a digital video camera" (USGS, 2011). The resulting data was downloaded in the form of several grouped polygons separated by habitat type, which were based on differing spectral signatures.

Objectives

The need for botanical inventories and community typing is imperative for stabilizing wildlife diversity and understanding the natural environment. We hope that the TWRA better recognizes the plant species and communities in the CWMA on which the ecosystem and most importantly the wildlife, thrives. "If valid relationships between plant communities and landscape units can be found, TWRA can use the units as a faster, cheaper method to define and map habitat for many wildlife species" (TWRA, 2007). The objectives of this research aimed to fulfill those goals by:

(1) Characterizing the vascular flora of the CWMA to provide an assessment of biological resources by which baseline data may guide subsequent studies. We hypothesize that due to anthropogenic degradation within the CWMA, the area is not reflective of a botanical crossroads as described by Chester (1995);

(2) Providing broad characterizations of the CWMA vegetation classes. We hypothesize that by using a combined approach of Smalley (1991) and NatureServe (2007), accurate descriptions of the vegetation of the CWMA can be made;

(3) Mapping these vegetation classes to provide TWRA employees with a readily useable, updated habitat map. We hypothesize that we can use GIS and field observation to make a map of the CWMA and use it to test the relative utility of SEGAP (USGS, 2011) data.

CHAPTER II

STUDY AREA

Location and Size

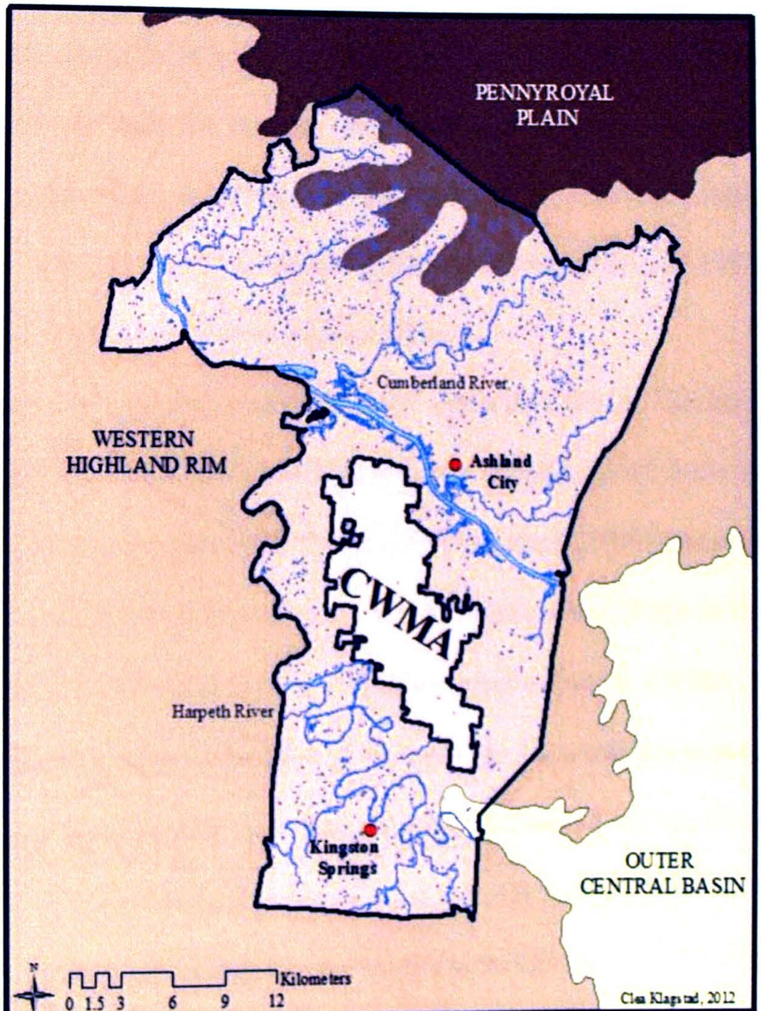


FIGURE 3. The location of the study site within Cheatham County, Tennessee lies mostly on the Western Highland Rim, in close proximity to the Outer Central Basin and Pennyroyal Plain physiographic provinces. Ashland City and Kingston Springs lie northeast and southwest, respectively.

The CWMA comprises 8,421.5 hectares in Cheatham County, Tennessee, and lies approximately 64 kilometers (40 miles) west of Nashville, Tennessee (Figure 3). It is the second largest public land unit under Land Between the Lakes. Cheatham County is situated in three physiographic provinces, mostly the Western Highland Rim and small portions of the Pennyroyal Plain and Outer Central Basin. The Cumberland River bisects the county, and located farther south is the Harpeth River near Kingston Springs (Figure 3). The CWMA, the study site, is located at latitude 36.199337° and longitude 87.090907° (center point). It is mapped on the Ashland City, Lillamay, Kingston Springs, and Pleasant View topographic quadrants (USGS 1987, 1983, 1984, and 1997). The entire study site lies on the Western Highland Rim.

Several studies documented biodiversity within the CWMA. This included a dragonfly study (ABTI, 2010), herpetological survey (Hopkins, 2012 draft), and a checklist of aquatic angiosperms (Wallen, 1974). Clatterbuck (1990) assessed the effects of disturbance via timber cutting for charcoal production on the CWMA in 1990. Clatterbuck (1996) distinguished eight community types within the CWMA. He followed Smalley (1980) to initiate stratification of the landscape. He tested this system using validation, or ground-truthing. He differentiated (1) Northern Red Oak, (2) Sycamore-Sweetgum, (3) Black Oak-Hickory, (4) Chestnut Oak, (5) Scarlet Oak, (6) Post Oak, (7) American Beech, and (8) Yellow-Poplar forests. He studied a 462-ha plot, and collected data in terms of vegetation strata. Finally, he recorded importance values and used factor analysis, clustering procedures, and canonical discrimination to designate community types.

The TWRA, TVA, and the United States Forest Service, currently manage over 60,703 hectares (150,000 acres) of land and continue to evaluate land classification systems as part of a long-term wildlife-forest management program (Hughes, 1987). Some additional field research by botanists has been conducted (USDA & NRCS, 2008; E.W. Chester, pers. comm.), though an extensive floristic inventory remains incomplete.

Geology

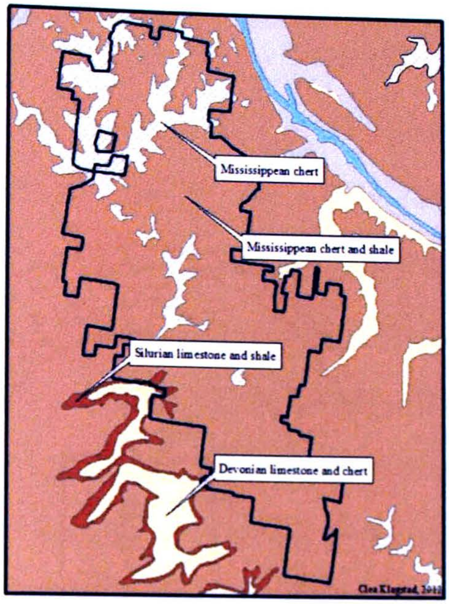


FIGURE 4. The four main geologic components of the CWMA.

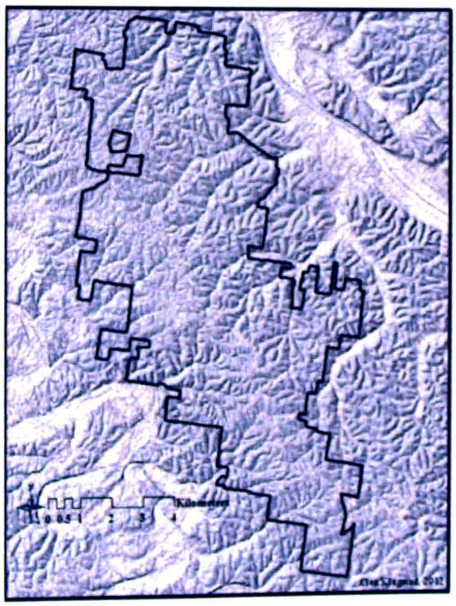


FIGURE 5. The dissected nature of the Western Highland Rim, most notably around streams and tributaries. There is less dissection toward Outer Central Basin on the bottom right.

Mississippian-aged chert and limestone characterizes much of the geological formations in the area, and Silurian and Devonian formations occurred nearer the Harpeth River (Figure 4). The Highland Rim expanded nearly 32,763 km^2 (12,650 mi^2) and rose from 400 to 1,000 feet above mean sea level, with local relief from 300-500 feet (DeSelm, 1959). The area was characterized from gently rolling hills to more dissected, rough topography bordering the Outer Central Basin (Griffith *et al.* 1997; Figure 5).

The CWMA was somewhat characteristic of the Outer Central Basin nearer the southern end, due to its proximity. Rising 500 to 1200 feet in elevation, remnants of the dissected rim extended into this fertile area (DeSelm, 1959). Coined the "dimple of the Universe," it was characterized by Paleozoic rock strata and an abundance of karst formations (Law, 1961), underlain by Ordovician limestone bedrock (Griffith, 1974). The Highland Rim once expanded over the entire Central Basin province until uplift of the Nashville Dome occurred. This arch caused erosion of Ordovician limestone, forming the deep Basin present today. Upon uplift, the Cumberland, Elk, and Duck rivers were drained (Law, 1961).

The ages of formations within Cheatham County include the Devonian, Fort Payne, St. Louis Limestone and Warsaw Limestone, Ordovician units, alluvial deposits, and Silurian Formations. The Devonian Formation was characterized by north and south facies variations (USGS, 2010). This particular formation included the Pegram, Camden, Harriman, and Ross, which varied in thickness due to pre-Chattanooga and/or pre-Cretaceous warping and erosion (USGS, 2010). This Formation covered about 1.2% of the County. The Fort Payne and St. Louis and Warsaw Limestone were of Mississippian age. The Fort Payne Formation was calcareous, dolomitic, and crinoidal, with a minor shale counterpart. It was generally 200 feet thick and covers 55% of the County. The St. Louis and Warsaw Limestone were created from residuum of nodules and blocks in sandy clay, and are about 50-60 feet thick. This Formation covered about 36% of the County (USGS, 2010). The Ordovician units included the Richmond, Maysville, Eden, and Nashville Group, which were composed of limestone, including argillaceous, dolomitic, sandy, gray, crystalline, and laminated. These units covered less than 1% of the area. Alluvial deposits, which covered about 4.1% of the area, were dated to the Quaternary period, and mainly comprised of sand, silt, clay, and gravel, up to about 100 feet thick. Last, the Silurian Formation included the Decatur Limestone, the Brownsport and Wayne Group, and the Brassfield Limestone. These were generally thick-bedded limestone and covered 2.9% of the County.

Soils

Cheatham County spanned a transitional zone with respect to soil temperatures, both mesic and thermic (USDA, 2002). Mesic soils were particularly useful for corn production and thermic for cotton. Soil orders included alfisols, entisols, inceptisols, mollisols, and ultisols. Subgroups within the County included typic paleudults and aeric fluvaquents (Dr. Goode, pers. comm.). Most soils families included some type of fine-silty or fine-loamy classes, which comprised several series, including Melvin and Newark (USDA, 2002). In general, there were about five soil units that dominated Cheatham County, two of which occurred in the CWMA. The Hawthorne-Sulphura-Sengtown unit was excessively drained and weathered to gravelly subsoil and soft bedrock. The parent material of this unit was siltstone, clayey residuum of limestone, and shale (USDA, 2002). This unit comprised about 55% of the County, near the central and southern areas. The Byler-Nolin-Armour-Arrington unit occurred on nearly level to rolling, somewhat well drained soils that formed in alluvium. In the CWMA, this was found along the Harpeth River and its major tributaries (USDA, 2002). This soil type was underlain by siltstone and limestone and comprised about 7% of the County. Well suited for agriculture and trees, this soil risked ruts (USDA, 2002).

Climate

Tennessee is known as the "US in miniature" due to its temperate season without extremes (Law, 1961). Cheatham County receives about 51 inches of rain per year, with 60% sunshine. Thunderstorms are recorded about 54 days of the year (USDA, 2002). The average temperature in Cheatham County is about of 38°F, with a mean low of 27 °F (USDA, 2002). January produces the coldest days, the lowest recorded at -18°F on January 17th, 1982, while July is generally the hottest, with the highest recorded temperature reaching 107°F on July 17th, 1980. The growing season is between April and September (USDA, 2002).

On the Highland Rim, there are 185-205 freeze-free days, with an annual precipitation of about 50-56 inches (Griffith, 1974). In the Outer Central Basin, there are 190-210 freeze-free days, and the annual precipitation is 48-54 inches (Griffith, 1974). Northeast and southwest winds average 13 kilometers (8 miles) per hour (Law, 1961).

Nearest to the CWMA are two weather stations, namely in Charlotte and Kingston Springs. Charlotte does not have climate normals posted (as of 3/25/12), so Kingston Springs was used instead (Table 1). The CWMA experiences the lowest temperatures in January at 1.4°C (34.6°F; SRCC, 2012) and the highest in July at 25.03 °C (77.1°F; SRCC, 2012). The lowest precipitation month is January (4.02 cm; SRCC, 2012) and the highest occurs in March (5.39cm; SRCC, 2012).

TABLE 1. Mean temperature and precipitation of the Kingston Springs Weather Station, Cheatham County, Tennessee (elevation 517 feet). Located at -87.12° longitude and 36.10° latitude, these averages were taken from 1971-2010 (U.S. National Oceanic and Atmospheric Administration, obtained from Southern Regional Climate Center, 2012).

KINGSTON SPRINGS WEATHER STATION		
Temperature and Precipitation Normals for 1971-2000		
Month	Temperature (°C)	Precipitation (cm)
January	1.44	4.02
February	3.69	4.37
March	8.75	5.39
April	13.4	4.27
May	18.17	5.37
June	22.78	4.28
July	25.03	4.03
August	24.21	3.27
September	20.56	4.03
October	14.06	3.4
November	8.56	4.78
December	3.67	5.06

Human History

The Amerindians existed in the Southeastern United States in the Late Holocene, as confirmed by pollen from corn within the area (Graham, 1999). The fist Native

Americans who travelled throughout the Tennessee area were big game hunters of the Paleo-Indian society as early as 15,000 – 8,000 BCE. Adult males led these tribes and hunted the American Mastodon (*Mammut americanum*) as their primary source of food. Ancient bison, peccary, paleo-llama, saber-tooth tiger, giant sloths, and beavers existed on the landscape then as well. As the Mastodon died in the Ice Age, so did the Paleo-Indians ("The First Tennesseans," 2012).

About 5,000 to 10,000 years ago, the climate warmed, Archaic peoples became largely sedentary, relying on deer, small mammals, fish, and vegetation, including walnut, butternut, hazelnut, acorn, and hickory and nutshells for sustenance. Honey locust, persimmon, grape, wild bean, bedstraw, and blackberry, to name a few, were local native plant food sources as well (Law and Shea, 1995).

About 1,000 to 5,000 years ago, Archaic and Early Woodland Indians drastically changed the landscapes, planting more "weedy" species, high in starches and oily seeds. Garden plots were cleared and maintained by tilling, sowing, and burning (Law and Shea, 1995). In this period, Indians genetically altered plants through deliberate selection of species. Intentional plantings of pine, red cedar, cane, iron-wood, tulip popular, and hop-hornbeam occurred as well (Law and Shea, 1995). Tennessee State Archaeologist Michael C. Moore (pers. comm.) mentioned that "only two prehistoric archaeological sites (40CH38, 40CH131) have been recorded within the project area. Both sites date to the Archaic period, roughly 3000 to 8000 years ago. This low site total was due to the lack of comprehensive archaeological surveys of the area rather than an actual absence of sites" (Michael C. Moore, pers. comm.).

Between 950 and 1,250 years ago, "socio-political systems, extensive mound complexes, and elaborate symbolism" marked the Mississippian Period" (Law and Shea, 1995). The people at this time experienced a population increase, perhaps due to food availability and timber for housing. Forest edge communities increased, giving rise to more early-successional species and deer habitat (Law and Shea, 1995).

In 1541, Desoto arrived and settled (Law, 1961). The Shawnees migrated away from the area under Cherokee pressure by 1714 (Williams, 1973). Annual burning by Native Americans was apparently practiced throughout the area (Chester *et al.*, 1998) along the Northwestern Highland Rim. Settlers to Middle Tennessee arrived in 1780 when Adam Binkley reached Sycamore Creek near where Ashland City is today (USDA, 2002). The county was thereafter visited by a steady influx of settlers, and continues to grow. As a result of Chickasaw Treaties of 1770-1791 and 1805-1806, white settlement increased on the Western Highland Rim (Williams, 1930). As migration of these cultures increased around North America, more invasive species were planted (Law and Shea, 1995).

Land Use

Middle and western Tennessee was once known for the extensive iron industry, which flourished during the 19th century. One ton of charcoal per one ton of iron was necessary to run these operations, which was fueled by large timber reserves. As a result, massive amounts of forest acreage were cleared for charcoal production (Clatterbuck, 1990). "A manufacturing plant near Nashville, Tennessee purchased chestnut wood in quantity and extracted tannin from it… whether green, affected with blight, or dead and lying on the forest floor…" (Clatterbuck, 1990). White oak and hickories were mostly harvested, where as black-jack oaks were not cut, likely because white oak and hickory made the "best and hottest burning charcoal for forging iron" (Clatterbuck, 1990).

As the iron industry declined, cutover areas were burned annually in order to impede the growth of woody vegetation for livestock grazing purposes and to control snake and tick populations. During this time, cattle and hogs grazed the land until fence laws were passed (Clatterbuck, 1990). Since, Cheatham County has been extensively farmed, with wheat primarily on the Pennyroyal Plain, corn and hogs to the southwest, and dark tobacco to the southeast.

More than half of the forests throughout the county have been significantly degraded throughout the past several decades, resulting in a loss of about 11 million tons of silt (Law, 1961). Clatterbuck (1990) noted that most forests of the CWMA were at least 2-aged, because of charcoal burning for iron forging. In addition to clear cutting, "periodic burning and associated grazing promoted advanced regeneration and establishment of oaks and hickories" (Clatterbuck, 1990). Further altering the landscape to encourage wildlife activity, the TWRA plants *Elaeagnus* around the CWMA. Pine plantations are also present for commercial purposes.

Not until the 1940's was the CWMA finally protected from intense livestock grazing, with the exception of deer populations. Since then, anthropogenic disturbances were limited to hunting and timber production. The State of Tennessee obtained land for the CWMA in 1938 (Clatterbuck, 1990). The Game and Fish Commission officially named the CWMA in 1949 in order to preserve white-tailed deer populations, as they were in swift decline due to unmanaged hunting activity. In 1974, the Commission re-established as the Tennessee Wildlife Resources Agency (TWRA), which currently owns and manages the land today (TWRA, 2007). Recreational activities on the CWMA include archery and shooting ranges, as well as hunting seasons for white-tailed deer, turkey, groundhog, grouse, quail, dove, raccoon, opossum, and rabbit.

Natural Disturbances

Tornados represent a prevalent natural disturbance to the CWMA. They pose the greatest threat to Tennessee (with respect to natural disasters), as the United States was deemed "by far suffering the most" tornado damage in the world (Peterson, 2000). Tennessee experiences the highest frequency of tornadoes between March and April, where the most damaging effecter to the vegetation was catastrophic wind. The severity of forest damage depended on tree age and size, where the oldest, tallest trees were most susceptible to damage. In addition, mortality of tree species, size structure, and species composition are affected by tornado activity (Peterson, 2000). Between 1953 and 2004, the average number of tornados per year in Tennessee was 15, four of which were violent (NOAA, 2001). Though the CWMA has not been struck recently, windy weather from surrounding downbursts affects the vegetation. Snapped and uprooted stands provide light gaps for early-successional species, a common sight within the CWMA.

Fire may have been a part of the natural disturbance within the Tennessee landscape, though little data exists to support this claim. Chester *et al.* (1998) noted that "fire was a major factor in maintaining oak dominance in eastern United States before

European settlement." Delcourt and Delcourt (1998) studied three sites around East Tennessee in order to document charcoal particles in pollen cores, which indicated the use of fire by prehistoric Native Americans. At Cliff Palace Pond, Kentucky, near the Cumberland Plateau, they noted an increase in charcoal production. At Tuskegee Pond, Tennessee and Horse Cove Bog, North Carolina along the Blue Ridge Mountains, an increase in charcoal particles was noted as well. Delcourt and Delcourt (1998) explained that because lightning strikes occurred infrequently and usually during large downpours, they were ineffective in igniting large tracts of forest. Whether or not fire was a widespread natural disturbance within the CWMA or Western Highland Rim area prior to anthropogenic settlement is unknown.

CHAPTER III

RESEARCH PLAN AND METHODS

Floristic Inventory

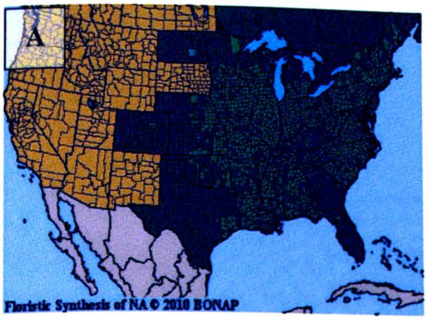
Thirty-one trips were made to the CWMA between August 2010 and May 2012. An attempt to cover the entire CWMA was made in order to document as many plant species as possible. Due to the size of the area and the time limits of the study, field visits were designed to capture diversity in both habitat and floristic composition; therefore not all areas were assessed more than once. To ensure that the most diverse areas of the CMWA were sampled, a combination of aerial, topographic, soils, and GIS maps were examined. Each soil type was visited at least once to ensure that a representative flora was documented, because soils are closely related to landforms and topography (Smalley, 1991).

An attempt was made to document each collection with a GPS location. Where habitat differences were obvious (mesic stream bank to an upland ridge, for example), a GPS point was taken, and that area was given a subjective habitat type name. From all sites, plants were collected, placed in a marked bag, and subsequently pressed and identified. Plants were collected ethically in that specimens were uprooted only when found in healthy populations. A photo voucher was taken when only one individual representing a new species to the collection was found.

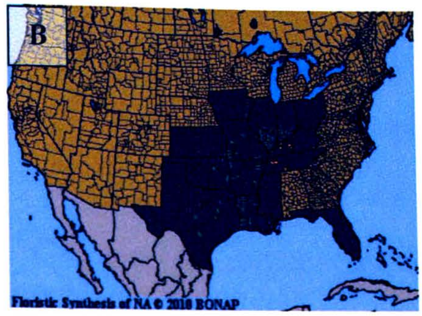
Standard manuals, including Cronquist (1981), Gleason (1963), Jones (2005), Radford *et al.* (1968), Small (1933), Tennessee Flora Committee (2012, draft), Wofford and Chester (2002), and Weakley (2007 and 2011) were used for species identification. In addition, Drs. Chester and Estes assisted with grass, sedge, and vegetative specimen identifications. Nomenclature followed the USDA Plant Database (USDA and NRCS, 2008) for nativity, growth habit, and intraspecific rank. The UTK Online Herbarium Database (TENN, 2011) was used to check and obtain county and state record statuses. Annotated voucher specimens were accessioned into the Austin Peay State University Herbarium (APSC) with duplicates forwarded to the University of Tennessee at Knoxville (TENN), the Missouri Botanical Garden (MO), and the University of Tennessee at Chattanooga (UCHT).

To document range extensions and biogeographic patterns, BONAP's Floristic Synthesis of North America software was used (Kartesz, 2011). Species were assigned to a category, " intraneous," or "extraneous" with respect to their distribution from Tennessee, following Norton and Estes (2009) (Figure 6), which was adapted from DeSelm *et al.* (1997). Intraneous species followed a distribution in or around the study area. A species was said to be extraneously distributed if it occurred outside of the study area to the north, south, east, or west (Figure 7) (DeSelm *et al.*, 1997). For example, *Aesculus pavia* (Figure 7) exhibits a southern range within the southeastern United States. The study area (red dot) marks the northern limit of its range, within that southeastern distribution. The species is said to be, "extraneous north" of its more southern populations.

INTRANEOUS **EXTRANEOUS**



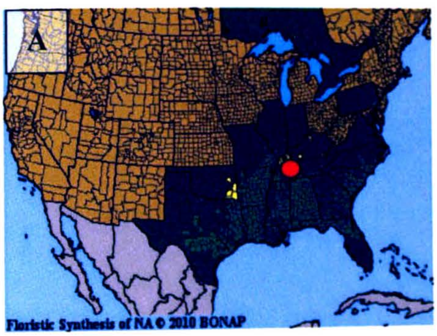
Acalypha rhomboidea



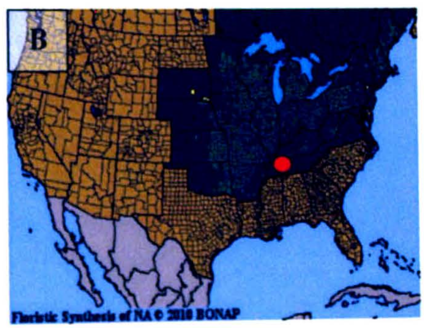
Aristida ramosissima

FIGURE 6. Examples of intraneous or extraneous distributions of species within the study area. *Acalypha rhomboidea* (A) is intraneous because most of the distribution occurs or is centered on Tennessee. *Aristida ramosissima* (B) is extraneous because its distribution occurs in a direction outside of the study area.

NORTH **SOUTH**

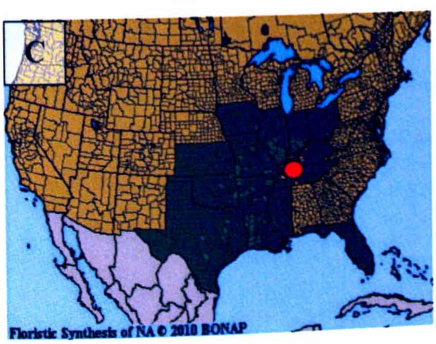


Aesculus pavia

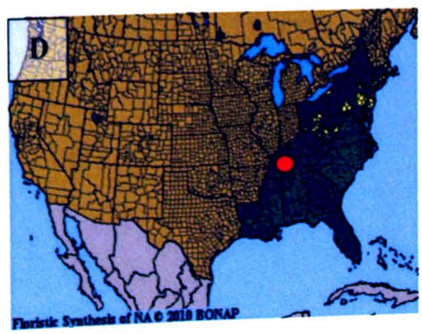


Cornus obliqua

EAST **WEST**



Aristida ramosissima



Ageratina aromatica

FIGURE 7. Examples of extraneous north (A), south (B), east (C), and west (D) of four species distributions from the study area (red dot).

Vegetation Classification

Areas of the CWMA were subjectively visited based on (1) soils maps, (2) unique landform qualities, including steep contours, riparian, and stream habitats, (3) frequency of site types within the refuge, (3) known sites with high biodiversity (Chester and Hopkins, pers. comm.), and/or (4) accessibility (residential areas where strict security was enforced were not visited). Each habitat type was documented via a GPS point, photography, and any necessary floristic information (canopy, shrub, and herb species).

Natural communities were described based on distribution, physical characteristics such as geology and soils, and vegetation. Community variation was described and threats to these natural communities were also listed. Anthropogenic communities were merely described, as they were much less complex than natural community types and occur non-specifically to any particular geologies and soils. The location of all habitat types was mapped for management and forestry purposes (Figure 9).

All habitat types were identified to the System level except one, the Southern Interior Dry Mesic Oak Forest. This System was identified further, to two distinct Associations, (1) the *Quercus rubra* – (*Acer saccharum*, *Quercus alba*) Forest and (2) the *Quercus falcata* – *Quercus* (*coccinea*, *stellata*) / *Vaccinium* (*pallidum*, *stamineum*) Forest (NatureServe, 2007).

Mapping

CWMA maps were constructed in ArcGIS software version 9.3.1 and 10. Polygon shapefiles and layers were digitized, downloaded from Internet sources, or provided by several individuals. Collected base layers included ortho-imagery, soils, geology, elevation, topographic maps, and boundaries (state, county, and CWMA). Because vegetation mapping requires the integration of multiple sets of information, particularly interpreting signatures from remotely sensed data (USGS, 2011), Southeast Gap Analysis Project (SEGAP) layers were compared against observed vegetation.

Using aerial photography as a guide, shapefiles were first divided into natural versus anthropogenic classes. Anthropogenic classes such as fields and clear-cuts were easily discernible from surrounding vegetation. Two methods were used to map natural communities, because of the difficulty discerning them. Drastic changes in slope and aspect, hydrology, and elevation were deemed barriers to a community type and thereby used to discriminate grading vegetation types. Slope and aspect were calculated in order to identify north-, south-, east-, and west-facing slopes, which primarily distinguished mesic from dry assemblages. These calculations also helped clarify the percent slope within the CWMA.

Polygon shapefiles were created to represent a specific stand or patch of a vegetation type, which was mapped qualitatively using 1) natural barriers (physical locations) that totally or almost completely prevented ecological processes and species interactions, and/or 2) systems between these elements that were partially restricted from interaction, following NatureServe (Cromer *et al.*, 2003). They were recognized based on large shifts of abiotic factors (hydrology, slope, and aspect) and species assemblages.

The percentage and acreage of each community type within the refuge was calculated in order to understand the distribution and size of each. Because some habitat types overlapped during the mapping process, in addition to the fact that buffers were created for stream, roadside, and pipeline habitats, more acreage was recorded than was present within the CWMA.

CHAPTER IV

RESULTS

Floristic Summary

This study documented 102 families, 289 genera, and 419 species and lesser taxa from the CWMA (Table 2).

TABLE 2. Summary of the vascular flora of the CWMA.

			Species and Lesser Taxa		
	Families	Genera	Native	Introduced	Total
Lycophytes	1	1	1	0	1
Pteridophytes	6	6	7	0	7
Gymnosperms	2	3	2	1	3
Angiosperms					
Monocots	18	55	76	18	94
Dicots	75	224	271	43	314
Total	102	289	354	64	419

The largest family was Asteraceae (58 taxa), followed by Poaceae (39 taxa), Fabacaceae (32 taxa), and Cyperaceae (22 taxa). These families accounted for about 36.0% of the flora. Other large families included Rosaceae (14 taxa), Scrophulariaceae (12 taxa), Liliaceae, Rubiaceae (9 each), Ranunculaceae, and Euphorbiaceae (8 each). The largest genus was *Carex* (16 taxa), followed by *Dichanthelium*, *Lespedeza*, and *Viola* (6 each).

The woody component of the flora was comprised of 106 taxa (25.3%). There were 40 trees, 43 shrub/subshrubs, and 23 vines. In addition, there were 247 herbs/forbs and 70 graminoids. About 64 (15.3%) non-native taxa were documented. A total of 121 (28.9%) county records were found (Appendix C). *Monotropa uniflora* was photo-vouchered as it was only seen from a single area throughout the duration of the study. The contribution of this study as compared to others was listed (Table 3; Appendix A).

Rare, Threatened, and Endangered Taxa

Aristida ramosissima (S-curve threeawn) was found on one roadside within the CWMA. It was listed endangered in Tennessee. It has no global rank (Table 4, Appendix A; TDEC, 2009). Found on a dry grassy roadside adjacent to a pipe-line right of way, the population was quite small. Characteristics of this species include culms between 20 and 60 cm. The inflorescences are paniculate-racemose, from about 5 to 12 cm long and 2 to 4 cm wide. Distinctive central awns of its inflorescences are between 12 and 25 mm, with a semicircular, prominent bend. This grass typically grows in open, dry sterile ground, primarily in fallow fields and roadsides (Allred, 1984). It is also known from clay barrens, where sites are ephemerally wet from clay fragipans, but dry quickly in the summer (Homoya, 1994).

Cornus obliqua (Silky dogwood) was reported twice from Tennessee, and its discovery in the CWMA marked its third record. *Cornus obliqua* was found in one area within the CMWA, a cobble bar in protected, mesic woods. Because this species was recently found in the state of Tennessee, it has no listed status (Table 4, Appendix A). This species is a small tree or shrub that occurs mainly north and west of Tennessee, from

Kentucky to Quebec, and west to Nebraska (Weakley, 2011). It reaches almost every state along the eastern coast of the United States. This species generally flowers late as a wide, open perennial shrub that can grow around 2.48 m (8 and 10 feet) tall. Terminally clustered cream-white flowers appear in June, which mature to blue-black drupes and are particularly useful to native bee species. The twigs are grayish to purple-red. Silky dogwood prefers shade to part shade in moist, circumneutral soils (Lady Bird Wildflower Center, 2012).

Helianthus eggertii (Eggert's sunflower) is an erect, glabrous herb with distinctive blue glaucous stems and leaf undersides. The leaves are all cauline, sessile, and opposite with one prominent nerve. There are generally about 1-5 heads per plant, comprised of hemispheric involucres with lanceolate phyllaries. The paleae are entire or toothed and the ray florets range from 10-18 mm. The disc florets are 70 mm and longer, with yellow lobes and dark anthers. This species flowers late in the summer and fall, and thrives in open barrens and oak-hickory woodlands. Although it is now in the process of being removed from the federal list, it is still of conservation concern (FNA, 2006). This species is threatened in Tennessee, with an S3 rank and a global rank of G3 (Table 4, Appendix A; TDEC, 2009). It was discovered in two areas within the CWMA. A population of about 100 individuals was found along a dry roadside, adjacent to dry woods. Another healthy population of nearly 20 adults was discovered on a stream bank in Dry Branch. Upon a second visit to this site, these plants had been grazed, most likely by deer within the refuge.

Hydrastis canadensis (Goldenseal) is an herb characterized by rhizomes with tough fibrous roots and erect, unbranched, and pubescent stems. The basal leaves are often deciduous where cauline leaves persist. The leaf blades are about 3-10cm wide at anthesis with serrate margins. The stamens of the flowers are strongly exserted, white, and showy, with 1-carpellate, distinct pistils that give rise to dark red aggregates. This species flowers in the spring and early summer in rich, undisturbed mesic deciduous forests, often on limestone soil (FNA, 1997). Beginning with the Native Americans, this herb was used medicinally for treating cancer, whooping cough, diarrhea, liver issues, earaches, fevers, pneumonia, tuberculosis, chapped lips, and dyspepsia, as well as to improve appetite and to treat inflammation (D. E. Moerman, 1986; cross reference from FNA, 1997). This herb was discovered in one area within the refuge on a stream bank, in protected mesic woods. It was listed as a species of special concern in Tennessee, with a state rank of S3 due to commercial exploitation, and a global rank of G4 (Table 4, Appendix A; TDEC, 2009).

Juglans cinerea (White walnut or Butternut) was discovered in Dry Branch, one on a cobble bar within the creek and another against a cherty, north-facing slope. This tree grows to about 20-30 m with light gray to brown bark. The pith of this species is distinctly dark brown, and the buds flattened. The leaves are comprised of about 7-17 ovate to lanceolate leaflets with serrate margins and acuminate apices. The fruits are distinctive as well, measuring 4-8cm, and ellipsoid to cylindric, with dense capitate-glandular hairs and longitudinal ridges (Weakley, 2010). This species flowers between April and June in rich woods or dry slopes. It is of conservation concern due to the butternut canker (*Sirococcus clavigigenti-juglandacearum*), which prevents root-sprout in seedlings (Schlarbaum *et al.*, 1997). This species is listed as threatened in Tennessee (Table 4, Appendix A; TDEC, 2009).

Panax quinquefolius (Ginseng) ranges from Québec and west to Minnesota and South Dakota. This species is known from the mountains of Georgia, North Carolina, South Carolina, Virginia, and West Virginia. Ginseng grows in the Piedmont are of Delaware, Georgia, North Carolina, South Carolina, and Virginia, as well as the Coastal Plain regions of Delaware, Georgia, North Carolina, and Virginia (Weakley, 2010). This plant has 3-5 leaflets with petiolules between 0.7 and 2.5 cm long. The larger leaflets are between 6 to 15 cm long, 3.5 cm wide, and about 2 times as long as wide. The leaf apices are acuminate, and the plant produces bright red berries (Weakley, 2010). This herb was also discovered along the stream banks of the CWMA. It is of special concern in Tennessee, with a state rank of S3/S4 due to commercial exploitation and has a global rank of G3G4 (Table 4, Appendix A; TDEC, 2009).

Senecio plattensis (Prairie groundsel) is known from two counties within the state of Tennessee, Montgomery and Knox. This species is rhizomatous and sometimes stoloniferous, with petiolate, narrowly-elliptic basal leaves. The cauline leaves become gradually reduced with subentire to irregularly dissections. There are about 13-21 green-tipped phyllaries, 8-10 ray florets, and over 60 disc florets (FNA, 2003). This was discovered on a dry, cherty cliff adjacent to a stream near Dry Branch. It was listed special concern in Tennessee due to extirpation, with a state rank of S and a global rank of G5 (Table 4, Appendix A; TDEC, 2009).

Noteworthy Collections

Asarum acuminata (Canadian wildginger), known currently as *Asarum canadense* is under scrutiny (Estes, unpublished data). The complex was split into three species according to sepal length. The species found within the CWMA was the long-sepal type, found quite commonly among moist stream banks.

*Populus grandidentata (*Big-tooth aspen) was discovered along a forested roadside within the CMWA. This is a successional species that regenerates after fire by "suckering from living rootstocks" (FNA, 2010). It thrives in dry to moist upland woods and flowers in the spring. It reaches its Southern-most distribution in North Carolina and Tennessee.

Viola lanceolata (Bog white violet) was discovered in the depressional wetland within the CWMA. This erect, perennial forb prefers open, moist wet areas such as bogs, meadows, stream banks, and in sandy soils. It exhibits a primarily eastern range, but is disjunct to California, Oregon, Washington, and British Columbia. This species is not present in the entire mid-west region of the United States and Canada (USDA, 2002).

Viola rostrata (Longspur violet) was quite common within the stream banks of the CWMA, especially near Dry Branch. This species prefers moist, deciduous forests, primarily in wetter areas such as stream banks. It has a primarily eastern distribution within the United States and Canada (USDA, 2002).

Non-native Taxa

Ailanthus altissima (Tree of heaven) originated in eastern China and was first introduced from Europe into the United States in 1784. Also known as Ailanthus, Chinese sumac, stinking sumac, paradise-tree, and copal-tree, this deciduous species grows up to 25 m (80 feet) with long, pinnately compound leaves. It flowers from April to June, and exhibits extraordinarily rapid growth, forming "thickets and dense stands"

(Miller, 2003). It reproduces prolifically by wind- and water-dispersal and is both shade- and flood-intolerant. This inhabited several roadsides and dry forested areas within the CWMA.

Albizia julibrissin (Silky acacia), a deciduous, leguminous tree, grows 3-15 m (10 to 50 feet) with feathery, alternate, and bipinnately compound leaves and showy pink blossoms. The tree flowers from May to June (-November), on dry-to-wet sites. This species persists in the shade and forms colonies from root sprouts through which it fixes nitrogen. This traditional ornamental was introduced to North America from Asia in 1745 (Miller, 2003). This species inhabited most roadsides habitats within the study area, and was present in several drier forests, including an older growth ridge.

Elaeagnus umbellata (Autumn olive) grows anywhere from 1-6 m (3-20 feet), with scattered, thorny branches. Distinctive silvery scales exist below the branches, and red berries occur in the fall. This species prefers drier sites and tends to be rather shade tolerant. In the 1830's, it was introduced from China and Japan for wildlife habitat, strip mine reclamation, and shelterbelts (Miller, 2003). This species was common along roadsides at the entrance to the CWMA, as it was planted for wildlife food and cover (Hopkins, pers. comm.).

Lespedeza cuneata and *sericea* (Lespedeza) were introduced from Japan sometime in the 1800's. These plants are typically perennials, with ascending to upright leguminous branches, growing to 2 m (6 feet) in height. Depending on the species, these typically flower in the fall around October in forested openings, dry woodlands, moist savannas, fields, power line and pipeline right-of-ways, and in cities. They typically form dense stands, spreading slowly from plantings, and remain viable for decades. They fix nitrogen and are often planted to promote quail or for soil stabilization (Miller, 2003). Within the CWMA, these species were found within food plots, fields, power- and pipe-line right-of-ways, and along roadsides.

Ligustrum sinense (Chinese privet) was introduced from China in the mid-1800s as an ornamental. It is a semi-evergreen, thicket-forming shrub that grows to 9 m (30 feet) with multiple stems per plant. The branches typically arch, with opposite leaves, which persist into the winter. This species flowers from April to June, and becomes incredibly invasive quickly, particularly in bottom-land forests and fencerows. Deer are known to browse these sprouts (Miller, 2003). This species was found in several dry woodland and forest habitat types as well as along roadsides of the CWMA.

Lonicera japonica (Japanese honeysuckle) was found in almost every habitat type within the refuge. This semi-evergreen to evergreen woody vine climbs or trails to 24m (80 feet), with long, woody rhizomes that sprout frequently. These have distinctive opposite, broadly ovate leaves, and flower in April or August. Miller (2003) described *L. japonica* as the most commonly occurring invasive plant, which overwhelms and replaces native flora in a wide range of sites. This very persistent species was introduced from Japan in the early 1800's for deer food plots and erosion control (Miller, 2003).

Microstegium vimineum (Japanese grass, Mary's grass, or basketgrass) is a short, annual grass (to 3 feet) with flat leaf blades and off-center veins. The stems arch or ascend, covered by overlapping sheaths with hairless nodes and internodes that tend to be green or purple. This species flowers from August to October with a thin, spikelike raceme. Japanese grass is highly invasive and flourishes on floodplains and stream banks due to its flood-tolerance. It was introduced from tropical Asia and first identified from

Knoxville, Tennessee in 1919. Though it is planted as ground cover, it provides little food for wildlife (Miller, 2003). Within the CWMA, this species invaded much of the stream habitat within the area.

Nandina domestica (Sacred bamboo) is an evergreen, erect shrub that grows to 2.5 m (8 feet). It has multiple bushy stems that resemble bamboo and flower in white-pinkish flowers with bright red berries in May to July. *Nandina* occurs under forest canopies and near forest edges. It is a shade tolerant plant that colonizes by root sprout and spreads by animal-dispersed seeds. In the early 1800's, this plant was introduced here from eastern Asia and India (Miller, 2003). Within the CWMA, it was documented in one location, a home site.

Paulownia tomentosa (Princess tree or Empresstree), grows up to 18 m (60 feet) in height, and exposes heart-shaped leaves and showy, pale-violet flowers in early spring and fruits in the summer. These trees are common around old homes, roadsides, riparian areas, and forest margins. They spread by wind- and water-dispersed seeds. *P. tomentosa* is particularly capable of invading habitat that is recently burned, harvested, or otherwise disturbed. Introduced from East Asia in the 1800's, this plant was widely planted and grown in scattered plantations for speculative high-value wood exports to Japan (Miller, 2003). This species was found along several roadsides of the CWMA.

Pueraria montana (Kudzu) is a deciduous, climbing, mat-forming, trailing liana (woody vine) that can grow to 30 m (100 feet) in height. The three leaflets and large, bright purple flowers are unmistakable. Kudzu flowers between June and September and produces long, flattened legume pods nearer wintertime. This species is highly invasive, as it spreads by the nodes from its roots as well as by wind, water, or animal dispersal

(Miller, 2003). It was introduced from China in the early 1900's for erosion control, livestock feed, and folk art. Kudzu existed along the perimeter of the CWMA, but was not present elsewhere.

Rosa multiflora (Multiflora rose) is an erect, climbing or arching shrub that grows to about 3 m (10 feet) in height. It is armed with straight or recurved thorns and pinnately compound leaves. Between April and June it flowers with a single white, showy flower with five petals and many yellow anthers. These plants form small to large clumps and often infest forests. It is widely planted and colonizes roadsides quickly by prolifically sprouting stems and roots, as well as animal-dispersed seeds. Multiflora rose was introduced from Asia as an ornamental and as a habitat promoter for wildlife (Miller, 2003). This species was found primarily on roadsides and forest edges within the CWMA.

Phytogeographic Analysis

Phytogeographic affinities were analyzed using BONAP's Synthesis (Kartesz, 2011) for the native, non-native, and total species composition. Results indicated that 203 of the native species (48.4%) exhibited a central distribution. Those exhibiting a northern distribution comprised 9.8% (41 taxa), eastern was 6.2% (26 taxa), southern was 18.1% (76 taxa), and western was 2.9% (12 taxa) (Table 4; Appendix a) (Figure 8). When the non-native taxa were added to the analysis, 45 taxa (10.7%) exhibited a central distribution. Those exhibiting a northern distribution comprised 1.7% (7 taxa), eastern was 0.5% (2 taxa), southern was 1.2% (5 taxa), and western was 0.5% (2 taxa) (Table 5; Appendix A).

When totaled, 59.2% (248 taxa) of the flora originated from a central distribution, 11.5% (48 taxa) from a northern, 6.7% (28 taxa) from an eastern, 19.3% (81 taxa) from a southern, and 3.3% (14 taxa) from a western distribution (Figure 8). The phytogeographic implications of this analysis were mapped (Figure 10; Appendix A)

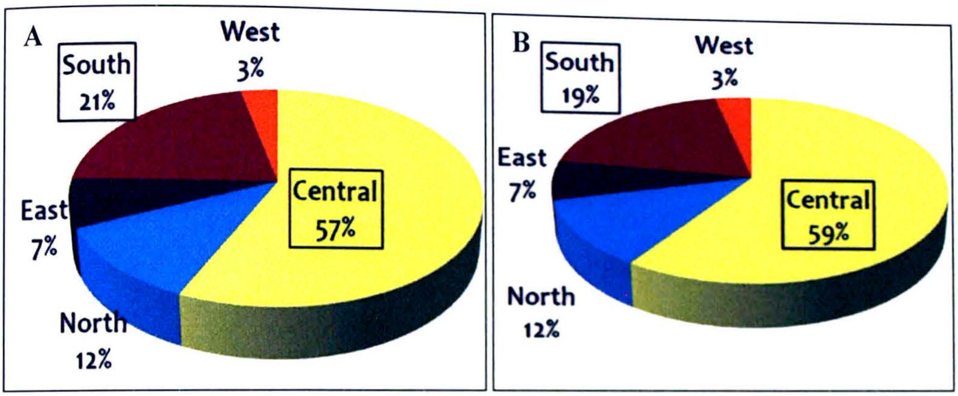


FIGURE 8. Affinities of native taxa (A) and the affinities of the flora when non-native taxa were added (B). The box highlights the shift in taxa affinity when non-native taxa were included.

Vegetation Classification

Thirteen vegetation classes were discovered and mapped within the refuge (Table 5; Figure 10). The nine natural communities were listed first, followed by the four anthropogenic types. The distribution, geology, soil type, community variation, and threat level of these communities were listed.

TABLE 5. Community types within the CWMA, including nine natural and four anthropogenic communities.

List of Community Types within the CWMA	
Abbreviations	**Natural Communities**
CIACT	Central Interior Calcareous Cliff and Talus
CIHASDP	Central Interior Highlands and Appalachian Sinkhole and Depression Pond
ILPSF	Interior Low Plateau Seepage Fen
SALEP	South Appalachian Low-Elevation Pine
SCILF	South-Central Interior Large Floodplain
SILPDM	Southern Interior Low Plateau Dry-Mesic Oak
SCIMF	South-Central Interior Mesophytic Forest
SCISS/R	South-Central Interior Small Stream/Riparian
SCI/UCPF	South-Central Interior/Upper Coastal Plain Flatwoods
Abbreviations	**Anthropogenic Communities**
WHRPB	Western Highland Rim Prairie and Barrens.
AP	Artificial Pond
F	Field and other clearings (Food plot, Pine Plantation, Residential, Clear-cuts)
RS	Roadside

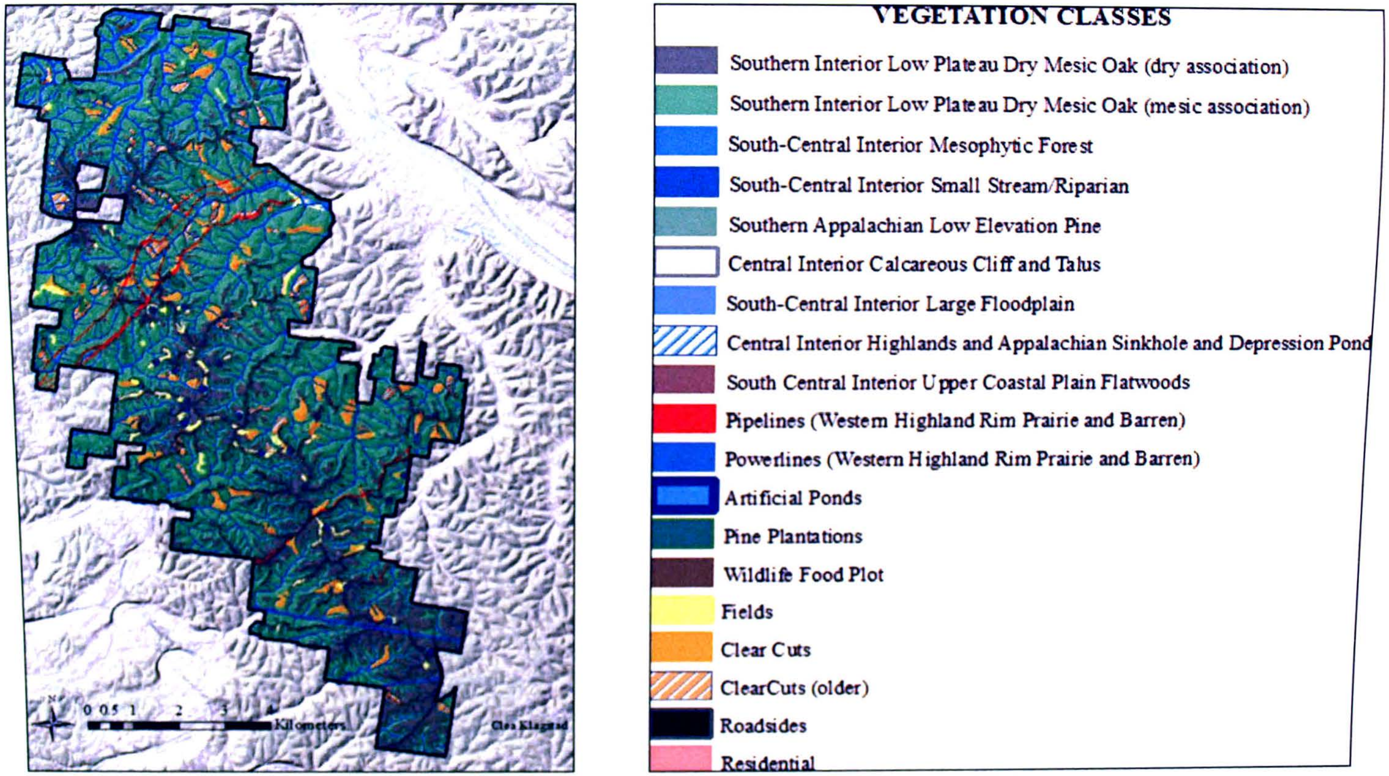


FIGURE 10. The 13 habitat types mapped within the CWMA. Though some categories were lumped together, this map shows the distribution of each separate class.

NATURAL COMMUNITIES

1. South-Central Interior Small Stream/Riparian (SCISS/R)

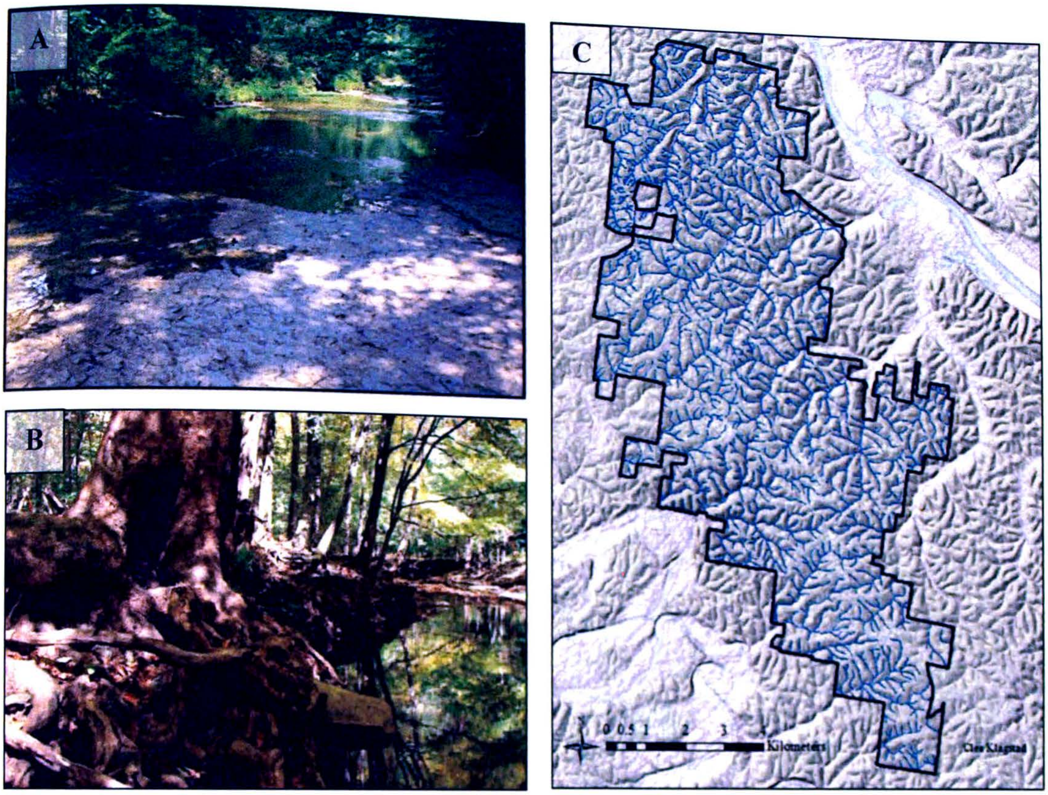


Figure 11. Streams within the CWMA were underlain by limestone bedrock (A) or soil and gravel (B). This habitat distribution was mapped with a 20-foot buffer (C).

Distribution: These streams were frequently underlain by bedrock, though some were comprised of soil and gravel (Figure 11 A, B). Covering 510 hectares of the CWMA, streams comprised about 5% of the refuge. These were linear community types (Figure 11 C).

Physical Characterization: Geology varied across the CWMA, as these were some of the most widespread community types of the area.

Soil Type: The most commonly occurring soil type under-laying stream communities was En soil, though various types occurred within these areas. HsF soil types constituted several streams habitats as well.

Vegetation Description: Vegetation in these areas consisted of delicate herbs, mostly in the spring and throughout the fall. Within the streams, *Justicia americana* (American water willow) was common. *Cornus obliqua* (silky dogwood), a listed species in Tennessee was discovered from a cobble bar within this habitat type.

Community Variation: Streams varied with respect to light availability, topography, elevation, aspect, size, and flow. In some areas, power- and pipe-line right-of-ways interrupted the stream causing a shift in species assemblage, to more weedy, shade intolerant species.

Threats: Invasive species, including *Ailanthus altissima*, *Pawlonia tomentosa*, *Lonicera japonica*, and *Microstegium vineum* patches threatened these communities.

2. Interior Low Plateau Seepage Fen (ILPSF)

Figure 12. Seeps characteristic of every visited stream (A). TWRA employee, Terry Hopkins stood for scale at one of the larger seeps within the area (B).

Distribution: Seeps were found in small patches, within every visited stream of the CWMA (Figure 12 A, B). Because these were difficult to map and predict based on aerial or topographic maps, this community type was not mapped, and percentages were not calculated.

Physical Characterization: The geology in these areas mostly followed that in the South-Central Interior Small Stream/Riparian communities. Most seep communities within the CWMA were found on sloping, north-facing topography.

Soil Type: The soils in these areas were similar to the South-Central Interior Small Stream/Riparian zones. Many of these areas were present solely on moist limestone bedrock, while others existed on moist, well-drained soil.

Vegetation Description: Three of the seven rare species from the CWMA occurred in these habitats, including *Hydrastis canadensis* (Goldenseal) *Juglans cinerea* (White walnut), and *Panax quinquefolius* (Ginseng). The most striking of the flora was documented here, including, *Mitella diphylla* (Miterwort), *Trillium* spp. (Wake robins), and *Hymenocalis americana* (Spider lilly).

Community Variation: Variation depended on the bedrock, substrate, and proximity to forests, roadsides, or logged areas. For example, some plant species are better adapted to attach to soil substrates rather than rock. Canopy openings in these areas may cause the seep to dry out considerably, as compared to other seep types.

Threats: Erosion from logging on upland ridges above where these seeps occurred threatened these areas.

3. South-Central Interior Mesophytic Forest (SCIMF)

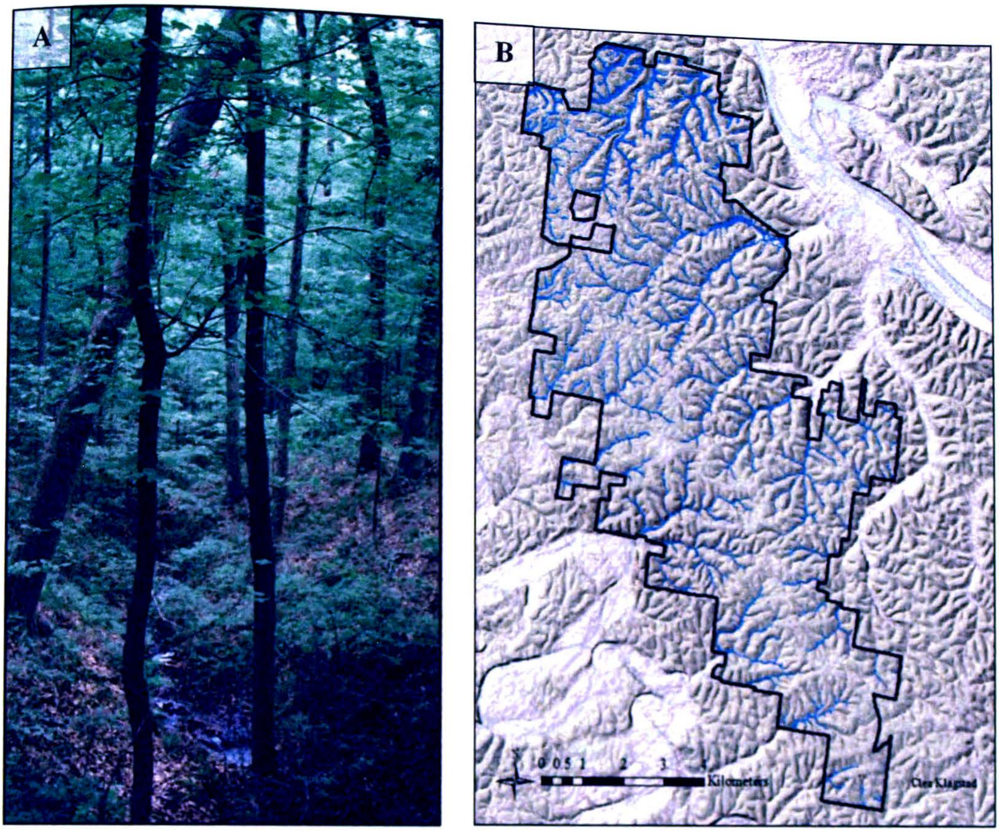


FIGURE 13. Example of the mesic forests within the CWMA (A). The springs that feed these streams can be seen (A). This community was abundant throughout the refuge (B).

Distribution: This community type occurred on stream banks, north- and east- facing slopes, and lower south- and west-facing slopes of the CWMA, in small patches, in protected, moist sites (Figure 13 A). It covered 940 hectares, which comprised about 10% of the CWMA (Figure 13 B).

Physical Characterization: Various springs and streams supplied these areas with water. These forests did not follow any unique geological patterns, as they were found throughout the management area.

Soil Type: This community existed throughout the CWMA, so several soils were characteristic of the sites, including En, HaD, HsF, SgC2, MtB2, and MtC2.

Vegetation Description: Delicate herbaceous plants coated forest floors in the spring, followed by an understory of Asteraceous species in the fall. These habitats remained very moist earlier in the year and retained moisture as long as the adjacent streams maintained flow. The canopy of these areas was comprised of large *Fagus grandifolia* individuals, *Acer saccharum*, *Oxydendron arboreum*, *Amelanchier*, *Carya* spp., *Fraxinus* spp., *Staphylea trifolia*, *Carpinus,* and *Prunus* spp.

Community Variation: Light gaps generally created habitats preferred by non-native species, including *Pawlonia tomentosa*, *Ailanthus altissima,* and *Microstegium vimineum* which were discovered in several stands of this forest type. Depending on the size and flow of streams present in these areas, light availability, and anthropogenic disturbance, species assemblages differed.

Threats: Erosion from logging, grazing, and invasive species threatened the species of these areas.

4. Southern Interior Low Plateau Dry-Mesic Oak (SILPDM)

Association: *Quercus rubra* – (*Acer saccharum*, *Quercus alba*) Forest

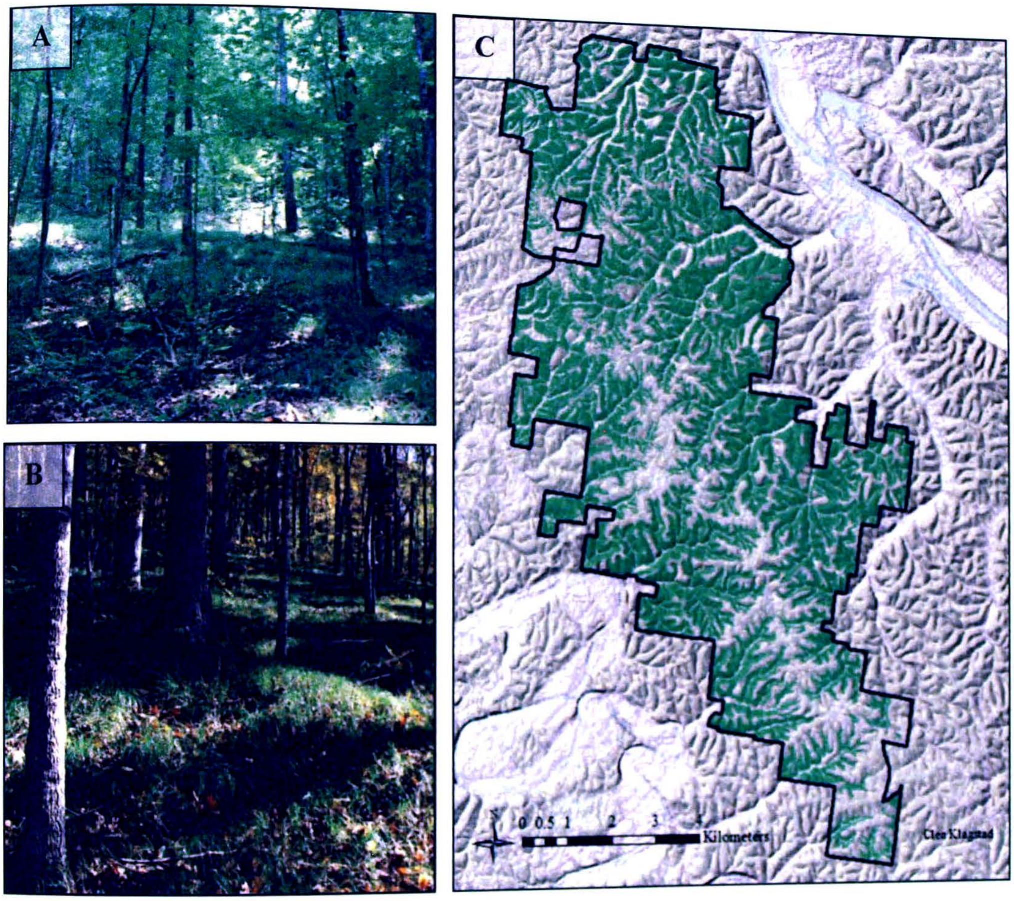


Figure 14. This association was typically found at lower elevations on south facing slopes (A). *Carex picta* and mesic canopy species were dominants of the community type (B). This association was mapped separately (C).

Association: *Quercus falcata – Quercus* (*coccinea, stellata*) / *Vaccinium* (*V. pallidum, V. stamineum*) Forest

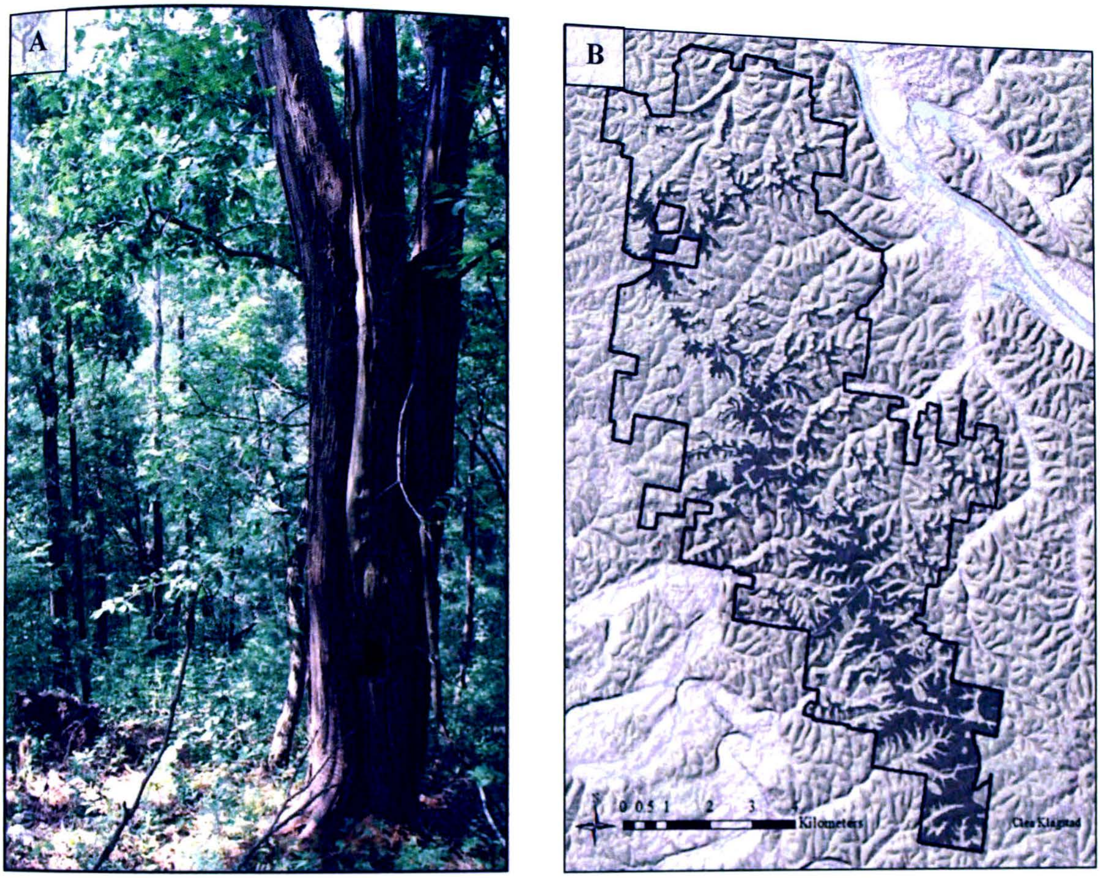


Figure 15. Large red cedars and drier canopy species dominated this upland association (A). It was mapped at a higher elevation (B).

Distribution: This matrix community type was present in two dominant associations. In total, this system covered 82% of the refuge. The more common association of this Interior Low Plateau Dry-Mesic Oak Forest System was the *Quercus rubra* – (*Acer saccharum, Quercus alba*) Forest (Figure 14 A, B), which covered about 4,539 hectares of the area, about 53% of the CWMA (Figure 14 C). These systems were generally found lower in elevation, on south- and west-facing slopes. This was the most abundant habitat type, as it constituted the largest percentage within the area. The second association of this system was the *Quercus falcata – Quercus* (*coccinea, stellata*) / *Vaccinium* (*pallidum, stamineum*) Forest (Figure 15 A). These areas covered about 2,061 hectares of the CWMA, or 29%, and were generally found higher in elevation (about 213 m, or 700 feet) (Figure 15 B).

Physical Characterization: These communities typically followed no geological pattern, as they were found throughout the area.

Soil Type: All soils were representative of this system as this community was widespread, but those visited included HaD, HsF, SgC2, MtB2, and MtC2 soils.

Vegetation Description: Lower on these slopes, there was a heavy grass and sedge understory, typically dominated by *Carex picta*, a mixture of xeric *Quercus* and *Carya* taxa, as well as more mesic species, like *Acer saccharum* and *Fagus grandifolia*. As elevation increased, the *Quercus falcata – Quercus* (*coccinea, stellata*) / *Vaccinium* (*pallidum, stamineum*) Association was more prominent. These forests were considerably drier, giving way to a dense understory of acidic-loving species and a canopy of xeric oaks and hickories. One of the largest tree species within the sites visited was found at the top of one of these slopes, a *Liriodendron tulipifera* (Tulip poplar) with a DBH (diameter at breast-height) of 44 inches.

Community Variation: The above photo (Figure 14 A) captured a calcareous woodland, dominated primarily by calciphiles like *Quercus mulhenbergia* (Chinquapin oak), and

Juniperus virginiana. Acidic woodlands existed in these communities as well, which were also comprised of beeches and sugar maples, but differed with respect to an acidic understory of *Vaccinium* (blueberry) and *Ilex* (holly) species.

Threats: Logging threatens these slopes, with the exception of the Beech trees. On more upland tracks, these forests were extensively logged prior to this visit in the fall of 2011.

5. South Appalachian Low-Elevation Pine (SALEP)

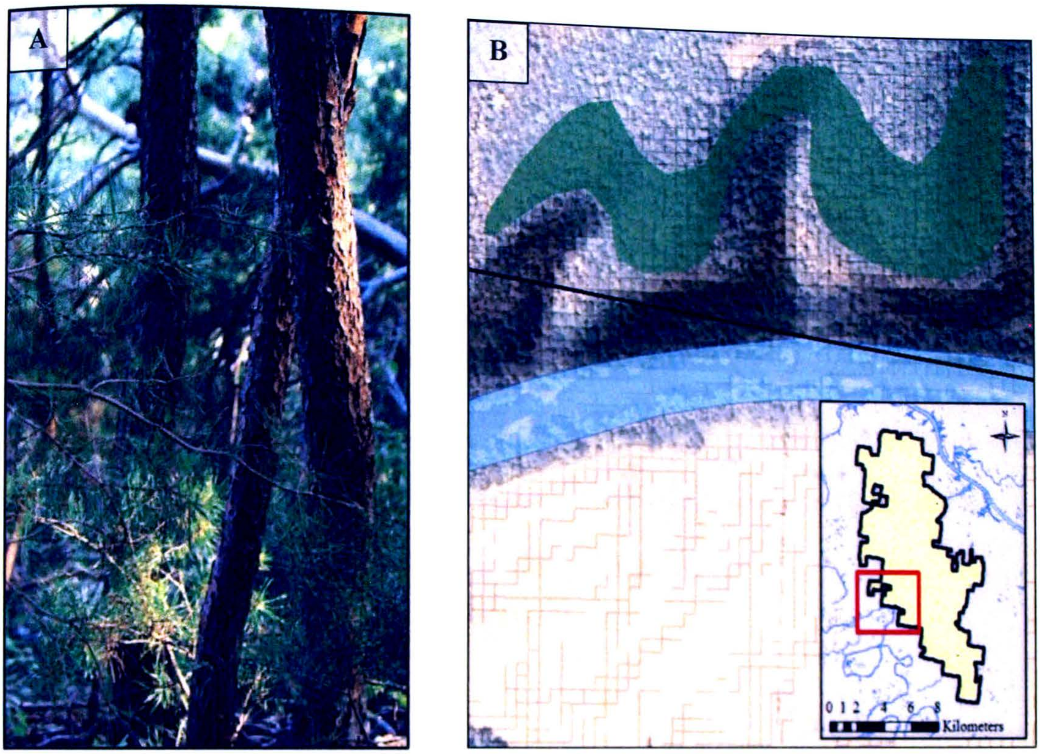


Figure 16. Several red cedars and pines occupy the canopy in this community type (A). This community exists in only one place on the CWMA (B).

Distribution: This system was a very small patch community (Figure 16 A) restricted to one location on the CWMA above the Harpeth River (Figure 16 B). It resided at an elevation of 797 feet. This habitat type covered about four hectares of the refuge, which makes up less than 1% of all communities.

Physical Characterization: The geology of this forest was all Mississippian chert and shale. The top of the ridge overlooking the Harpeth River was especially dry, but springs existed to the left and right, down slope.

Soil Type: Soils here were mostly present as HsF types with small HaD and SgC2 counterparts.

Vegetation Description: This community was dominated by very xeric species. The DBH of several canopy species was recorded to reveal *Quercus velutina* at 24 inches, a *Quercus alba* at 17, and several large *Juniperus virginiana* individuals, at 18, 13, and 12 inches. Last, a large *Pinus virginiana* had a DBH of 24 inches.

Community Variation: None.

Threats: Clatterbuck (1990) mentioned that this area was selectively logged rather than clear-cut, so some of the species on this particular ridge may be quite old. Selective logging still threatens the area today.

6. Central Interior Calcareous Cliff and Talus (CICCT)

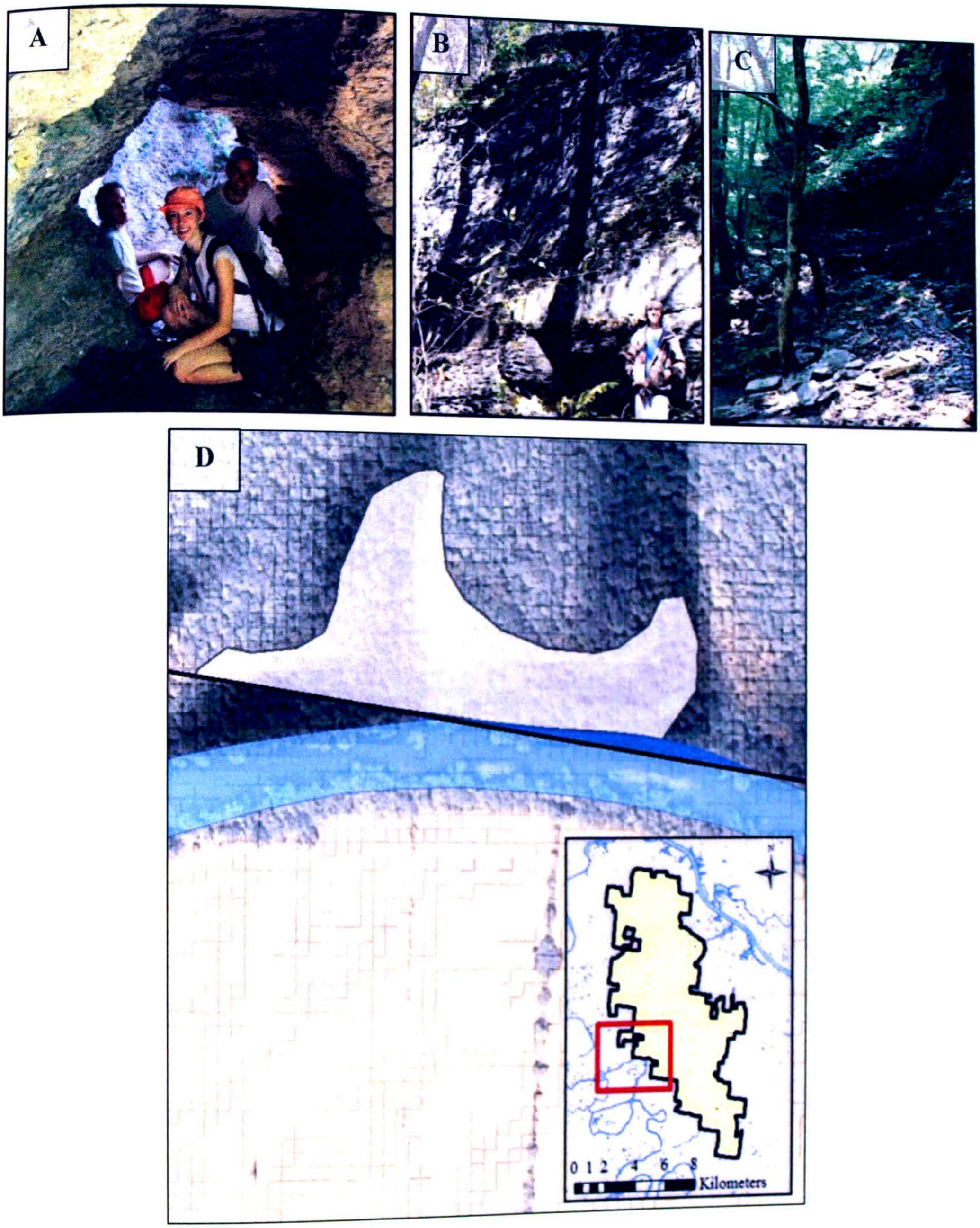


FIGURE 17. The talus slope (A, with Seth McCormick, Mark Hoger, and I) leads to the cliff community under the Harpeth River. Other cliff communities occur along streams within the refuge, from solid, boulder-like cliffs (B, Stephen Smith), to cherty, brittle communities (C). These communities were mapped from one location on the refuge (D).

Distribution: There was one unique community type upslope from the Harpeth River, directly underneath the South Appalachian Low-Elevation Pine forest type (Figure 17 A, B, C, D). The other communities of this type occur within the South-Central Interior Mesophytic Forests (Figure 13) as large, stream-side cliff communities. The only community mapped was the type that occurred below the Harpeth River (Figure 17 D), as those within stream communities were difficult to relocate from aerial photography. The talus slope above the Harpeth River comprised about three hectares of the CWMA, which was less than 1% of the total land cover. Both the stream calcareous cliffs and that below the Harpeth were small patch communities.

Physical Characterization: For the Harpeth site, the dominant geology type was Mississippian chert and shale. The talus slope leading to this cliff rose about 50 feet in elevation. Where these communities occurred along streams, geology and soil type varied, creating either very solid cliff faces (Figure 17 B) or cherty, loose communities (Figure 17 C), like that above the Harpeth River.

Soil Type: The soil type of the Harpeth talus slope was Rc, and those found along stream banks varied (see types for South-Central Interior Mesophytic Forest communities).

Vegetation Description: The vegetation along these communities was weedy in the summer. The Harpeth River cliff and talus system was dominated by native *Impatiens capensis* and *I. pallida*. *Fraxinus pensylvanica* was also found on the talus slope. One of the rare species from the CWMA was recorded from the cliff communities occurring as larger boulders among streams, *Packera plattensis*.

Community Variation: Cliffs existed both over the Harpeth River and among the streams within the CWMA. Species assemblages differed with respect to forest cover, proximity to water, and sun exposure.

Threats: Invasive species, namely *Lonicera japonica* (Japanese honeysuckle) (Figure 17 C, hanging from cliff face).

7. South-Central Interior Large Floodplain (SCILF)

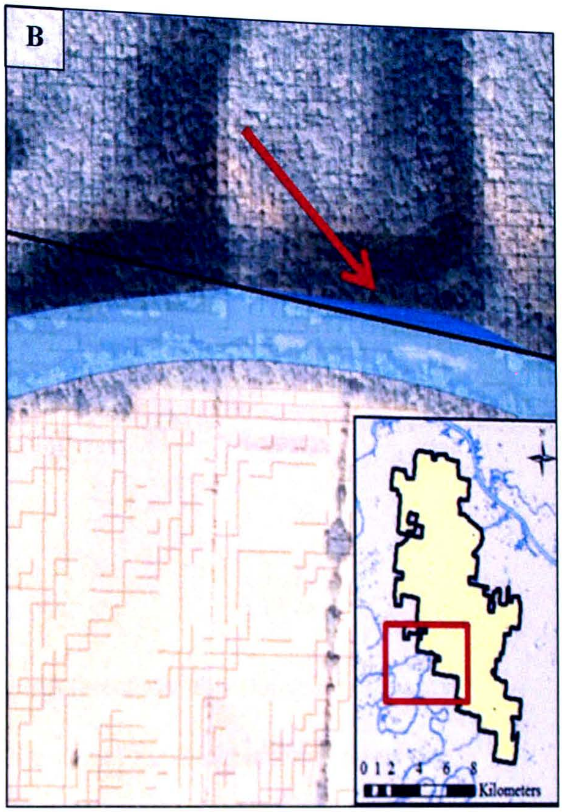


Figure 18. View overlooking the Harpeth River from the CWMA property (A) and the distribution of the SCILF community within the CWMA (B).

Distribution: There was only one community of this type found, the small portion of Harpeth River Floodplain that touched the CWMA in one area (Figure 18 A). This was defined as a small patch community that comprised about 0.2 hectares of the refuge, comprising less than 1% of the area of the CWMA (Figure 18 B).

Physical Characterization: This occurred at 462 feet in elevation on both Devonian chert and limestone, and Silurian limestone and shale, one of the only areas where these geologies occur.

Soil Type: The soil type along the Harpeth River was W.

Vegetation Description: The vegetation on the banks of the River was mostly weedy species, including *Mimulus* (monkey flower), *Campsis radicans* (trumpet creeper), *Chenopodium album* (lambsquarters), and *Hibiscus moscheutos* (crimson-eyed rose mallow).

Community Variation: None.

Threats: Agriculture practices and invasive species threatened this floodplain. Cows were standing directly in the water adjacent to the area of the floodplain that meets the CWMA property. In addition, almost the entire bluff/cliff surface was covered by invasive species.

8. South-Central Interior/Upper Coastal Plain Flatwoods (SCI/UCPF)

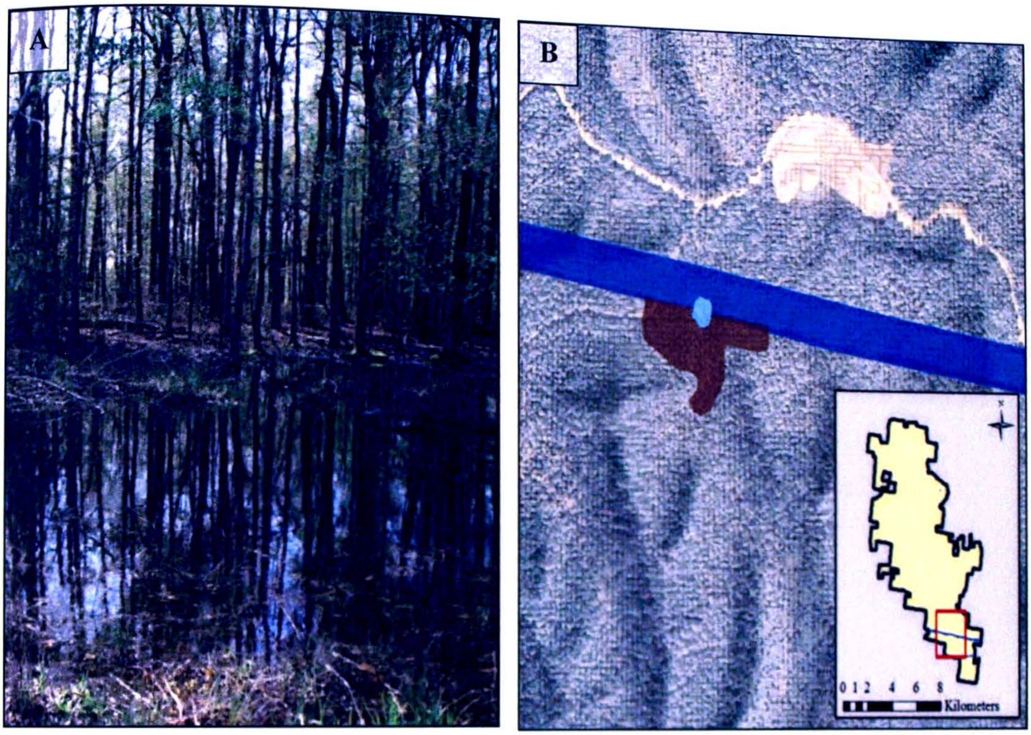


FIGURE 19. Flatwoods directly behind a depressional wetland (A). Mapped in brown (B) in only one place within the CWMA.

Distribution: Only one flatwoods area was found on the CWMA during this study. It occurred adjacent to a power line right of way, in which a depressional wetland was discovered (Figure 19 A). This community type covered two ha of the CWMA, which was less than 1% (Figure 19 B). This was therefore considered a small patch community.

Physical Characterization: The geology underlying this forest was Mississippian chert.

Soil Type: These woods occurred on HsF soils, and possibly extending into SgC2 types.

Vegetation Description: The vegetation of this forest was not markedly different from that of the Southern Interior Low Plateau Dry Mesic Oak Forest. Closer to the wetland community, a thick fragipan and lack of slope introduced several wetland species (see CIHASDP description below).

Community Variation: The frequency of mowing influenced this community, where repeated mowing promoted more prairie-like vegetation, and less allowed forested areas to overtake power line right-of-ways.

Threats: Clear-cutting and logging were the largest threats to this community type.

FIGURE 20. Spring flora and hydrology of the CIHASPD community (A). Note the moss growing up the trunks of these trees and darker soils (B). These are indicators of wetland conditions (mapped in light blue in Figure 19).

FIGURE 21. Summer flora and hydrology (A). Perhaps not as obvious in this photo are water marks on the trees. Notice that even in the summer, moss is present beneath the tree trunks, indicating wetland status (B) (mapped in light blue FIGURE 18).

Distribution: This plant community was found in a nearly flat South-Central Interior/Upper Coastal Plain Flatwoods habitat. It protruded into a power line right-of-way and had xerohydric characteristics (Figure 20 A, B; Figure 21 A, B). This wetland was the smallest community type within the CWMA, covering only 0.16 hectares, which is less than 1% of the total area (Figure 19 B). This was a small patch community.

Physical Characterization: The geology did not differ from the surrounding area, as it was underlain by Mississippian aged chert and shale.

Soil Type: This type occurred on SgC2 soils, which rarely supports wetlands (Goode, pers. comm.).

Vegetation Description: This particular wetland was comprised of about 80% facultative wetland- or obligate-wetland species. *Viola lanceolata* (bog white violet) was discovered here, as well as *Scirpus cyperinus* (woolgrass), *Rhexia virginica* (handsome Harry), *Dioidia virginiana* (Virginia buttonweed), *Dichanthelium sphaerocarpon* (roundseed panicgrass), *Carex vulpinoidea* (fox sedge), *Eleocharis tenuis* (slender spikerush), and *Juncus effusus* (common rush), to name a few.

Community Variation: None.

Threats: Invasive species and grazing. Several populations of *Eliocharis* had been eaten, presumably by deer within this wetland. In addition, the field adjacent to this wetland was populated with invasive species.

ANTHROPOGENIC COMMUNITIES

10. Western Highland Rim Prairie and Barrens (WHRPB)

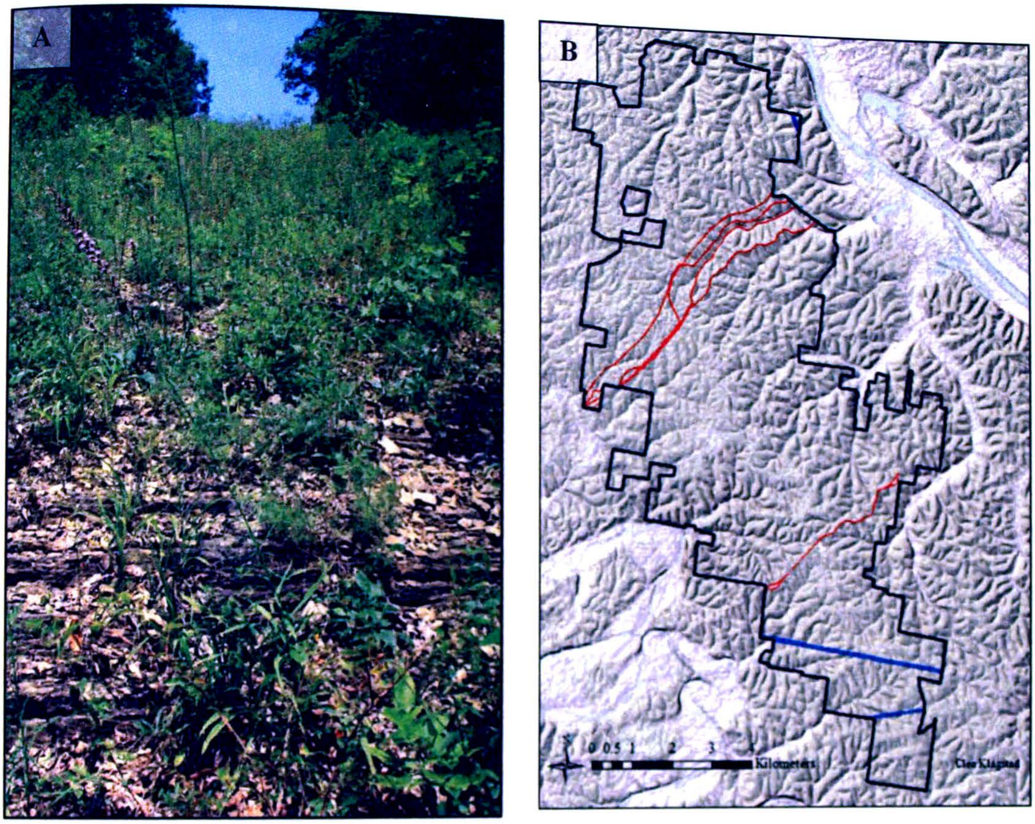


Figure 22. Sloping pipeline right-of-way with vegetation typical of a barren (A). Distribution occurs in anthropogenically created power- and pipe-lines (B).

Distribution: This community was documented from power line and pipeline right-of-ways, especially those with sloping topographies that were maintained by mowing (Figure 22 A). Some of these areas acted as refugia for species that were not able to outcompete woodland species due to lack of available sunlight (Estes, pers. comm.). This anthropogenic habitat type was therefore often composed of prairie and barren-like vegetation. This made up almost 0.01% of the CMWA, covering about 74 hectares

(Figure 22 B). Because they were found in power and pipelines, all examples of this community were linear.

Physical Characterization: Mississippian clay, mud, and chert comprised these areas. Barrens tended to be sloping, with large amounts of sun and bedrock exposure.

Soil Type: HsF and MtC2 soil types were characteristic of this vegetation community.

Vegetation Description: *Liatris spicata* (blazing star), *Verbascum thlapsi* (mullen), several grasses, and a few Asteraceous species dominated these areas in the summer. It was very dry along these glades, and temperatures were unusually warm.

Community Variation: The degree to which these areas sloped, proximity to water, and the time since they were last cut led to variation in the species assemblages observed among these communities. Power line outings that sloped into a stream area tended to support canopies.

Stability: These areas were maintained by frequent mowing so as to clear the power- and pipe line right-of-ways.

11. Artificial Ponds (AP)

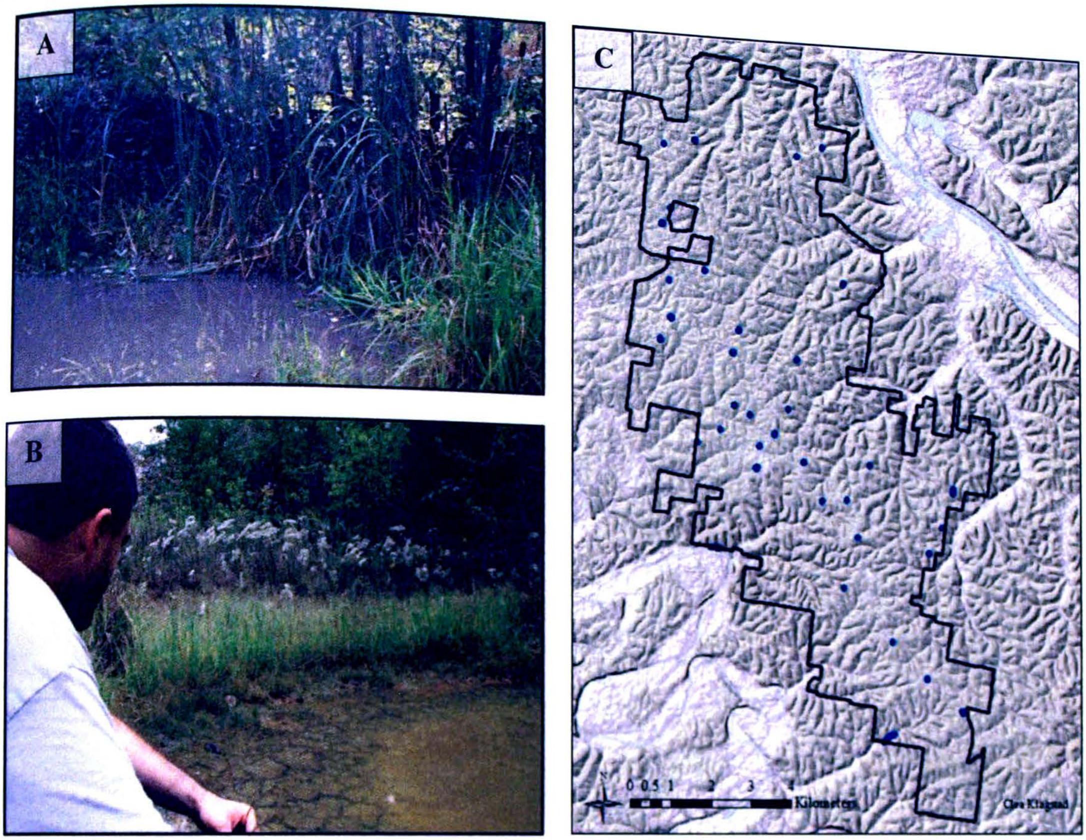


FIGURE 23. Result of a bulldozer dig (A). Dr. Dwayne Estes overlooks a small artificial pond next to *Panicum* species (B). Several ponds were scattered throughout the CWMA, most coinciding with food plots or fields (C).

Aquatic species of the flora were described from the artificial ponds in the CWMA, including *Typha latifolia* (cat-tail) and *Scirpus* (bull-rush) (Figure 23 A, B). Depending on the placement of the ponds, vegetation may differ, from more weedy, open field habitats, to forested, more natural species. These areas may have provided mating sites for some rare frogs, including Fowler's toad, which is believed to exist around the area, though has not yet been found (Hopkins, 2012 draft). Scattered throughout the CWMA, these habitat types contributed about two hectares of the total area, which was much less than 1% of the CWMA (Figure 23 C). These varied in size from 1 m to upwards of 30 m (100 ft) in size.

12. Fields and Other Clearings (F)

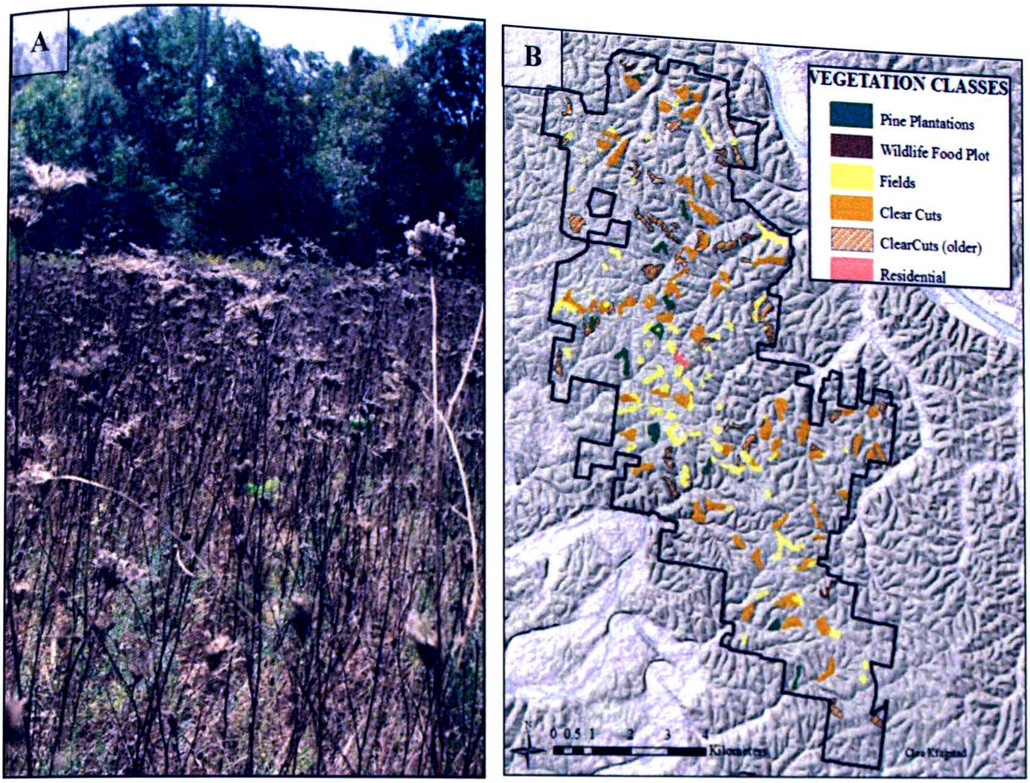


FIGURE 24. This particular wildlife food plot is dominated by weedy, Queen Anne's Lace (*Daucus carrota*) (A). Pine plantations were mapped in green, food plots in brown, fields in yellow, clear-cuts in orange, and residential areas in pink. These were frequent across the refuge (B).

Because there was no real floristic difference between food plots, pine plantations, fields, residential areas, and clear-cuts, these habitats were lumped into the "Fields" community type. Food plots and fields were typically planted with *Daucus carrota* (carrot), *Hordeum vulgare* (common barley), wheat, and corn (Figure 24 A and B). The total amount of these fields on the refuge was less than 1% (Appendix C).

13. Roadsides (RS)

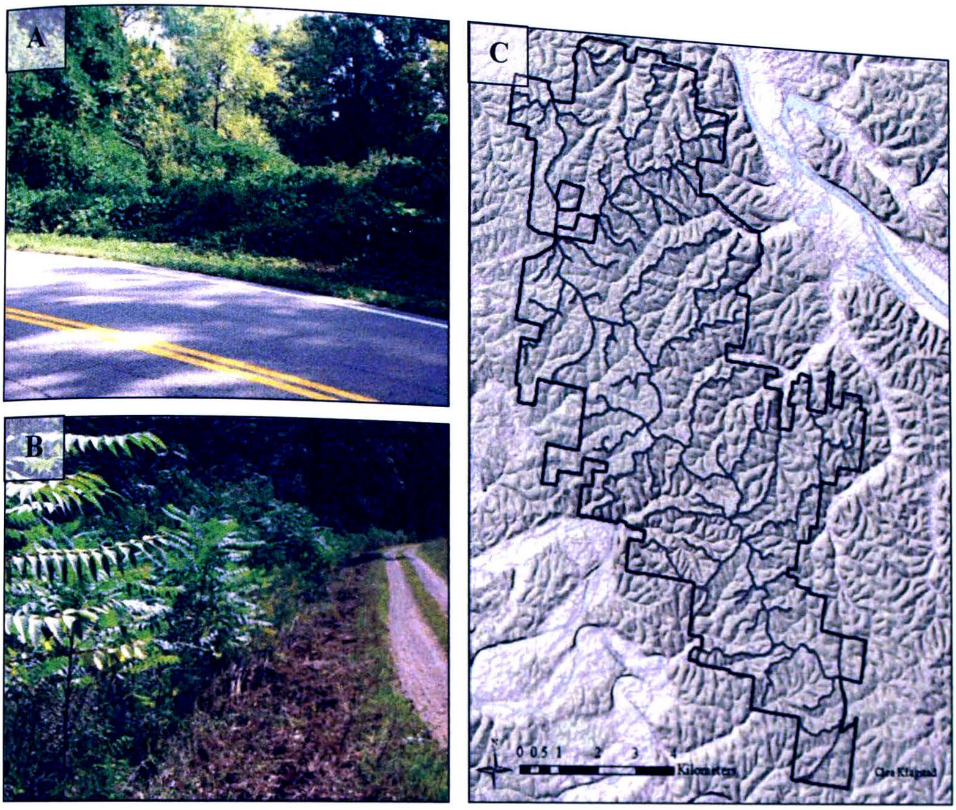


FIGURE 25. Roadsides on the CWMA house a variety of species, from weedy Kudzu (A) and Tree of Heaven (B) to the rare *Aristida ramosissima*. This community type was mapped using a 20-foot buffer (C).

Along roadsides, many wildflower mixes were planted, particularly towards the entrance to the CWMA (Hopkins, pers. comm.), and weedy species were documented (Figure 25 A, B). *Linum usitatissimum* (common flax), several *Festuca* spp. (fescue), *Lespedeza* spp. (lespedeza), *Lathyrus latifolius* (perennial pea), *Lobelia puberula* (downy lobelia), and *Conoclinium coelestinum* (blue mistflower), were reported from here as well. In addition, a population of *Helianthus eggertii* was discovered here, as well as *Aristida ramosissimus* (s-curve three-awn), a listed species that had not been collected in about 80 years. Roadsides covered about 154 hectares within the CWMA, which comprised less that 1% of the area (Figure 25 C).

Mapping

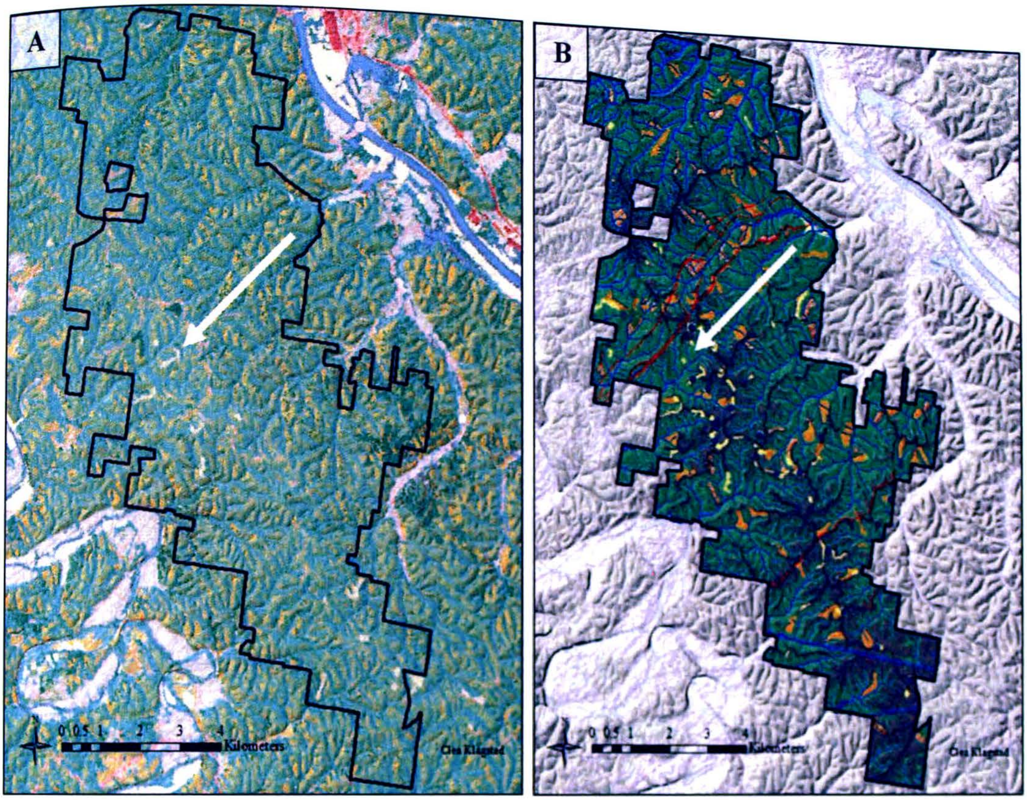


FIGURE 26. Comparison of SEGAP (USGS, 2011) (A) data with that of this study (B). The arrow on the SEGAP map points to "Cliff and Talus," where as our arrow points out a "field." There are several differences like this between the map created with remote sensing and ours.

The study area was comprised of 8,421.5 total ha. However, the resulting map totaled 9,050 ha, a difference of 628 ha (Table 6, Appendix A). Without buffers, the total cover was 8,539.912, which is only 118.4 ha larger than the total land coverage (Table 6, Appendix A).

There were several noted discrepancies between the SEGAP and the observed vegetation classes. SEGAP captured 71 community types within and around the CWMA.

Of the ten natural communities we discovered using the Smalley (1991) methodology, six were shared by the SEGAP analysis (Figure 26).

In addition, SEGAP (USGS, 2011) confused several spectral signatures that we found easily distinguishable from aerial photography. SEGAP (USGS, 2011) most likely confused the presence of *Juniperus virginiana* (red cedar) with pine plantations (Figure 26). SEGAP (USGS, 2011) also used a "developed open space" category in addition to the intensity of a particular developed space (low, medium, and high) for ruderal communities. We found that this was not as descriptive as defining the *type* of open space. For example, on the CWMA, food plots vs. power- and pipeline communities contained considerably different species assemblages, the former comprised of far weedier species than the latter, which generally supported prairie vegetation. Cliff and talus was often confused for fields or cobble bars in mesic woods by SEGAP analyses. Some power- and pipelines were missed altogether.

This study found that Southern Appalachian Low-Elevation Pine Forest existed in one place within the refuge. It was composed of an evergreen-dry oak canopy with acidic shrubs in the understory, including blueberry and other fire-suppressed species. SEGAP described this area, however, as a Southern Appalachian Montane Pine Forest and Woodland, which is known from the Blue Ridge and other high elevation systems, and to have elements of eastern forests such as *Tsuga caroliniana* and *Rhododendron catawbiense*. This was a clear misinterpretation of spectral signature, as these eastern species are found nowhere along the Western Highland Rim.

CHAPTER V

DISCUSSION

Floristic Inventory

The results of this flora, when compared to other floristic inventories, differed with respect to taxa abundance. Gunn and Chester (2003) sampled the Tennessee National Wildlife Refuge's Duck River Unit in Humphreys County, Tennessee (10,817 ha) and reported 718 taxa (Table 3, Appendix A). Stack (1982) discovered 715 taxa from a proportionally small area (325 ha). Estes and Walck (2005) discovered 627 species from a 62.5 ha area (Table 3, Appendix A). From a 69,000 ha area, Gunn and Chester (1993) found about 1,289 taxa (Table 3, Appendix A). TDA and TDEC (2003) studied a 3,000 ha area and discovered about 340 species (Table 3, Appendix A).The observed 419 species in the 8,422.5 ha (20,000 acres) CWMA is most likely an underrepresentation the floristic diversity within the CWMA and broader Western Highland Rim physiographic province. The addition of an extensive mapping element to this study decreased the amount of time and intensity of the floristic sampling.

Rare and Invasive Taxa

Several rare, threatened, or endangered species that existed in close proximity to the CWMA were not recovered during this study, including *Apios priceana*, *Carex davidii* and *C. hirtifolia*, *Cimicifuga rubifolia*, *Diervilla lonicera*, *Lilium michagenense*, *Lonicera dioica*, *Phlox bifida*, and *Physaria globosa*. It is possible that these species were overlooked, or that there is no suitable habitat within the CWMA. Because over 10% (2,000 acres) of the CWMA has been anthropogenically degraded within the past couple of hundreds of years (Figure 26, Appendix A) in the form of pine plantations, clear-cuts, logging, agriculture, and invasive species promotion, it is possible that the species no longer exist within the landscape. Several studies support our finding in that anthropogenic effects caused a marked decrease in species richness and diversity (Findlay and Houlahan, 1997; Knops et al., 1999; Lyons and Schwartz, 2001). Further study into the current flora and potential natural vegetation of the area is needed to better understand this phenomenon.

Vegetation Classification

The community types within the CMWA were found to be highly characteristic of the Western Highland Rim when compared to the literature (Braun, 1950; Küchler, 1964; Cranfill, 1991; Clatterbuck 1996; Chester, 1995; Estes and Walck, 2005; NatureServe, 2007). The species that comprise each community type are listed by relative abundance. Natural communities were discussed in detail, as multiple studies documented vegetation from similar areas. Anthropogenic communities provided some added richness, but were not discussed, as few studies detail the vegetation of these areas, providing no context for our results. One exception was the anthropogenic WHRBP community, as this housed more natural vegetation that was present in several other studies.

South-Central Interior Small Stream/Riparian (SCISSR)

NatureServe (2007) described this habitat type as a linear community comprised of a "mosaic of forests, woodlands, shrublands, and herbaceous communities." They noted that tree species included *Platanus occidentalis, Acer rubrum var. trilobum, Betula nigra, Liquidambar styraciflua,* and *Quercus* spp. Shrubs and herbaceous species varied in richness across these systems. Characteristic herbs and shrubs included *Hypericum densiflorum, Salix* spp., *Alnus* spp., *Carex* spp., and *Osmunda* spp. Species richness ain these areas was affected by flooding and seed propagule dispersal, and varied depending on stream size, topography, and presence of invasive exotics, to name a few (NatureServe, 2007).

Within the CWMA SCISSR systems, the above species were collected, with the exception of *Hypericum densiflorum* and *Alnus* spp. *Hypericum punctatum* was found instead. Streams in the CWMA supported a large amount of herbaceous diversity, including *Carex amphibola, C. blanda, C. cumberlandensis, C. leptonervia,* and *C. superata*, to name a few. *Osmunda cinnamomea* was found adjacent to *Arisaema triphyllum* ssp. *triphyllum*. *Asarum acuminatum, Sedum pulchellum,* and *Selaginella apoda* were also found from these areas. In agreement with NatureServe (2007), species assemblages of SCISSR communities differed within the CWMA depending on light availability, substrate, stream size, and topography. Overall, the CWMA streams were highly comparable to NatureServe (2007) descriptions.

Interior Low Plateau Seepage Fen (ICPSF)

NatureServe (2007) recognized this community as the most frequent in the Western Highland Rim of Tennessee occurring mostly within Lewis, Cheatham, and Williamson counties. They are small patch communities dominated by herbaceous plants, including: *Carex* spp., *Parnassia grandifolia, Juncus brachycephalus, J. effusus, J. coriaceous, Rudbeckia fulgida* var. *umbrosa, Cardamine bulbosa, Impatiens capensis, Lobelia puberula, L. cardinalis, Oxypolis rigidor, Phlox glaberrima*, *Rhynchospora* spp., *Alnus serrulata, Salix humilis* and *S. caroliniana, Cornus amomum*, and *Acer rubrum*. *Xyris tennesseensis* was also known from this system, occurring over 50% of the time. Characteristic topography included slopes, bluff bases, rock ledges, and terraces of streams and rivers. Stands in southern Ohio were distinguished based on a lack of *Parnassia* (NatureServe, 2007). Estes and Walck (2005) identified these areas as "calcareous seeps" from the Western Highland Rim in southeastern Tennessee. These sites were often dominated by *Impatiens, Parnassia, Alnus, Chelone, Cuscuta, Juncus, Oxypolis, Phlox,* and *Rudbeckia* species.

The ILPSFs within the CWMA differed when compared to the literature. Several genera were similar, but differed with respect to species assemblages. Some taxa were simply absent from this community type, including *Parnassia* and *Xyris* species, though special field trips were made in an attempt to document their presence. *Salix caroliniana, Cornus amomum, Acer rubrum,* several *Juncus* spp. including *J. anthelatus*, and *coriaceous*, were found within these communities in the CWMA, in addition to *Lobelia inflata, L. puberula,* and *L. silphitica*. Large clumps of *Impatiens capensis* often dominated these areas as well, one result which was largely supported by the literature

(NatureServe, 2007; Estes and Walck, 2005). The ICPSF communities in the CWMA most likely differed from the literature in that most were dominated strictly by limestone bedrock. Additional research as to other possible affecters is needed.

South-Central Interior Mesophytic Forest (SCIMF)

This forest association was recognized by NatureServe (2007), who characterized it as an unglaciated, vegetated, tree-dominated, closed tree deciduous canopy forest. It is most extensive forest type in the Cumberland, Allegheny plateaus, and Interior Low Plateau (NatureServe, 2007; Braun, 1950). The species that dominated this community type included *Acer saccharum, Fagus grandifolia, Liriodendron tulipifera, Quercus rubra, Tilia americana, Tsuga canadensis* and *Juglans nigra*. Cranfill (1991) recognized these forests as simply, "Mesophytic Forests," in his flora of Hardin County, Kentucky on the Western Highland Rim. These occurred on lower slopes and were generally comprised of *Acer saccharum* and *Fagus grandfolia* in the canopy, and several herbaceous understory species. Cranfill (1991) documented *Acer nigrum, Carya tomentosa, Juglans cinerea, J. nigra, Fraxinus americana, Liriodendron tulipifera, Morus rubra, Prunus serotina, Quercus* and *Ulmus* spp., *Asimina triloba, Carpinus caroliniana, Cornus florida, Dirca paulustris, Hamamelis virginiana, Hydrangea arobrescens, Lindera benzoin,* and *Ostrya virginiana* as part of this community type as well.

Estes and Walck (2005) referred to this community as "ravine forests" of the southwestern Highland Rim, which were dominated by a much denser understory of herbaceous species. These areas were correlated with moisture availability, and included species such as *Acer saccharum, Liriodendron tulipifera, Asimina triloba, Carpinus caroliniana, Hamamelis virginiana, Hydrangea cinerea, Lindera benzoin,* and *Staphylea trifolia* (Estes and Walck, 2005). Jones (1983) coined these areas "mesic hardwood" forests along the Western Highland Rim of Tennessee, which were dominated by *Fagus grandifolia*. The understory included *Ostrya virginiana, Hydrangea arborescens, Viburnum rufidulum, Cercis canadensis, Ceanothus americanus,* and *Staphylea trifolia.*

The communities represented in the CWMA were also highly diverse in protected landscape positions. Our species profile was nearly identical to that of NatureServe (2007) with the exception of *Tilia americana* and *Tsuga candensis* (Appendix C). These species ranges do not exceed East Tennessee, and were therefore not encountered within the CWMA. The species listed from Cranfill's (1991) flora as well as those documented from Estes and Walck (2005) were identical to those found within the CWMA. The richness of the herb layer in the CWMA varied with light availability, stream proximity, stream size, and logging history. Older forests tended to have much more diverse understories than recently logged sites. In older stands, *Spigellia marylandica, Echinacea purpurea, Iris cristata, Hymenocallis caroliniana, Staphylea trifolia,* and *Viola rostrata* were present. Overall, this community type was supported by the literature.

Southern Interior Low Plateau Dry-Mesic Oak Forest (SILPDM)

This community is the most widely supported type on the Western Highland Rim by literature sources (Braun, 1950; Küchler, 1964; Jones, 1983; Chester, 1996; Clatterbuck, 1996; Estes, 2005; NatureServe, 2007). NatureServe (2007) describes this community as a vegetated, tree-dominated, closed deciduous canopy matrix, comprised of all upland hardwood forests except the mesic hardwood forests (which were placed in the SCIMF system). They mentioned that soil type and slope created the largest differences in floristic expression, specifically those forests found on northerly to easterly aspects, versus drier slopes on southerly to westerly aspects and those on ridges (NatureServe, 2007). Canopy closure in this community varies from closed to open, and frequent fire may be a maintaining factor (NatureServe, 2007). A number of different *Quercus* spp. typically dominated these areas in addition to several *Carya* spp. In drier areas, *Quercus prinus* dominated the landscape, associated with *Q. stellata, Q. marilandica, Q. coccinea. Quercus alba, Q. rubra,* or *Q. falcata* dominated sub-mesic slopes. Typical understory species included *Cornus florida, Cercis canadensis, Oxydendrum arboreum, Vaccinium pallidum* and *V. arboreum, Kalmis latifolia, Viburnum acerifolium, Styrax americanus, Schizachyrium scoparium, Danthonia spicata, Desmodium,* and *Helianthus* species.

This community type led Braun (1950) to describe the Western Highland Rim as part of a transition area between the Mixed Mesophytic Forest Region of the eastern mountains and the Oak-Hickory Forest Regions of the west. In addition, Küchler (1964) recognized this community type in his "oak hickory forest" description. He defined this area as consisting of medium to tall forests of broadleaf deciduous and needle leaf evergreen trees, including hickories, pines, oaks, chestnuts, tulip-trees, and dogwoods.

Chester (1995) noted that the more mesic slopes along the Western Highland Rim housed *Acer saccharum, Fagus grandifolia, Liriodendron tulipifera, Quercus alba, Aesculus* spp., *Tilia americana,* and *Magnolia* spp. The "composition varies with aspect and elevation" such that *Fagus grandifolia, Acer sacchrum, Fraxinus americana, Prunus* *serotina*, and *Lirodendron tulipifera* dominated mesic sites and ravines, where upper slopes were comprised of much drier species, including dry oak-hickory forests (Chester, 1995).

Clatterbuck (1996) also discovered an association between *Carex* spp., *Fagus grandifolia*, and *Acer saccharum*. In his construction of community types within the CWMA based on factor and cluster analyses, he found that understory vegetation of a 482-ha sample plot did not correspond with canopy structure, except in this case. He noted *Carex* spp., *Vaccinium*, and *Smilax* in these understories. Though he did not separate these communities into mesic and drier counterparts, these results were consistent with the communities we observed.

Jones (1983), studied the Western Highland Rim in Hardin County, Tennessee, and referred to it as "oak hickory forest." Common canopy species included *Quercus alba, Q. stellata, Q. falcata, Q. borealis, Carya tomentosa, C. glabra, Prunus serotina, Nyssa sylvatica,* and *Liquidambar syraciflua*, with an understory of *Cornus florida, Rhododendron canescens, Vaccinium arboreum, Viburnum acerifolium, Sassafras albidum, Rhus copallina,* and *Kalmia latifolia*, to name a few. He subdivided this Oak Hickory Forest with respect to topographic position, in particular, uplands, old field successional stage areas, and blufftops, according to species assemblages.

Estes and Walck (2005) studied Rattlesnake Falls, located in southwestern Maury County, Tennessee. The canopy of these "oak-hickory forests" was dominated by *Quercus alba, Q. coccinea, Q. prinus, Q. stellata,* and *Q. velutina*, as well as *Carya alba, C. glabra, Quercus marilandica* and *Pinus* species on ridgetops. Shrub layers consisted of *Amelanchier arborea*, *Nyssa sylvatica,* and *Smilax* species.

In the CWMA, this was the most abundant community type. While many of these areas were recovering from logging, some of the oldest forests on the refuge were found in these communities as well, illustrated by the presence of massive *Fagus grandifolia* and *Acer saccharum* trees. Found on northerly and easterly slopes, as well as on lower southerly and westerly slopes, this system occurred between 60-200 m (200 and 700 ft) in elevation. It was dominated in the spring by painted sedge (*Carex picta*) with a canopy of *Fagus grandifolia*, *Quercus* spp., *Carya* spp., and *Oxydendron arboreum*.

For the vegetation classification within the CWMA, two prominent associations were differentiated in this system based solely on slope aspect and elevation. This split was supported by Jones (1983), Chester (1995), and Cranfill (1991). The first association was more mesic, and found lower in elevation. It was deemed the *Quercus rubra* – (*Acer saccharum*, *Quercus alba*) Forest (NatureServe, 2007), which was dominated by *Fagus grandifolia, Quercus rubra* and *Q. alba. Carex picta*, *Danthonia serecia* and *Desmodium glutinosum* in the understory.

A second drier association, the *Quercus falcata* – *Quercus* (*coccinea*, *stellata*) / *Vaccinium* (*pallidum*, *stamineum*) Forest occurred higher in elevation, upwards of 200 m (700 ft). This community was dominated by *Q. falcata* and *stellata*. The understory contained *Juniperus virginiana*, *Vaccinium arboreum*, *V. stamineum*, *Rhamnus caroliniana*, *Sassafras albidum*, *Rhus* spp., *Smilax rotundifolia*, *S. glauca*, *S. tamnoides*, *Cornus florida*, *Cercis candensis*, *Viburnum rufidulum*, *Chasmanthium latiflorum*, and several *Dichanthelium* species. Cranfill (1991) supported this drier association as the, "mixed oak forest," that occurred on ridgetops, south facing slopes, and in shallow ravines. These assemblages clearly agreed with those found in the CMWA.

South Appalachian Low-Elevation Pine Forest (SALEP)

NatureServe (2007) describes this large patch community as a forest and woodland atop acidic soil with a closed evergreen canopy of shortleaf and Virginia pine toward the southern Appalachians and adjacent Piedmont and Cumberland Plateau. Toward the Interior Low Plateau, this community is found on ridgetops, mid- and upper-slopes, generally below 700 m (2300 ft). It was noted that low intensity to severe fire maintained the species assemblages within this community types (NatureServe, 2007). Dominant species known to occur in this community type include *Pinus echinata, P. virginiana, P. rigida, Quercus falcata, Q. prinus, Q. coccinea, Carya glabra,* and *Acer rubrum,* with an understory of *Vaccinium pallidum, Gaylussacia baccata,* and other acid-tolerant species. *Pityopsis graminifolia, Tephrosia virginiana, Schizachyrium scoparium,* and *Danthonia* spp. were also known from these systems (NatureServe, 2007).

While many trees were selectively logged for iron production, specifically within this habitat type on the CWMA (Clatterbuck, 1990), this area most likely represented a climax community. In the CWMA our system closely matched that of NatureServe (2007) in that *Pinus virginiana*, *Juniperus virginiana*, *Quercus velutina*, and *Q. stellata* individuals dominated the community. Several species of *Vaccinium* were present in the understory, in addition to a thick *Smilax* component. *Danthonia serecia* was seen here, as well as *Chasmanthium laxiflorum* and many *Galium* spp. It is clear that this community as described by NatureServe (2007) exists within the CWMA.

Central Interior Calcareous Cliff and Talus (CICCT)

NatureServe (2007) characterized this community as a small patch, unvegetated upland area, primarily of the Interior Highlands, that varies based on soil type and moisture availability. Dominants include *Thuja occidentalis*, *Andropogon gerardii*, *Acontinum noveboracense*, *Adiantum capillus-veneris*, *Adoxa moschatellina*, *Aquilegia canadensis*, *Dichanthelium depauperatum*, *Heuchera americanum*, *Heuchera* spp., *Hydrangea arborescens*, *Impatiens pallida*, *Toxicodendron radicans*, and *Woodsia obtusa.* Estes and Walck (2005), in a study of the Western Highland Rim of southwestern Tennessee, characterized the vegetation of "bluffs and rock outcrops," as containing *Hypericum* spp., *Philadelphus hirsutus*, *Aquilegia canadensis*, *Asclepias verticillata*, and *Heuchera villosa* var. *macrorhiza*, to name a few.

The CICCT existed in two landform types within the CWMA. First, this system was found directly beneath the SALEP forest and above the Harpeth River floodplain. From the floodplain, a large, rocky talus slope led to an almost vertical cliff of brittle shale. Few species existed on the talus slope, except a population of *Impatiens capensis* and *I. pallida*, which agree with the Estes and Walck (2005) description. The second landform type of this system represented within the CWMA was found in stream communities in the form of large boulders, with nearly vertical calcareous faces. These were largely supported by the results of Estes and Walck (2005) with respect to the presence of the genus, *Heuchera* spp., *Aquilegia canadensis*, and *Hydrangea arborescens.* In addition, several weedy species, most notably *Lonicera japonica* were documented from these communities. Overall, these communities differed from literature sources. More intensive surveying, mostly in the spring months is recommended to clarify this community type.

South-Central Interior Large Floodplain (SCILF)

NatureServe (2007) recognized this system as a linear community vegetated by herbaceous species. Flood regimes and soil type determine the floristic expressions. Characteristic dominants include *Acer saccharinum, Platanus occidentalis, Liquidambar styraciflua, Quercus* spp., *Carex* spp., *Cephalanthus occidentalis, Arundinaria gigantea. Salix* and *Populus* species were known toward the westernmost limit of the community type. Cranfill (1991) also noticed this community in the North-Central Highland Rim in Kentucky, and described this as a riparian forest was dominated by *Acer saccharinum, Betula nigra, Fraxinus pennsylvanica, Platanus occidentalis,* and species of *Carex, Hibiscus laevis,* and *Ilex decidua*, to name a few.

The SCILF community within the CWMA was consistent with previous descriptions (NatureServe, 2007; Cranfill, 1991). For example, characteristic dominants included *Acer saccharinum, Platanus occidentalis, Liquidambar styraciflua, Quercus alba,* and *Q. rubra* along the banks of the Harpeth River. In addition, there were several herbs that were not described as part of the SCILF that dominated these areas, including *Mimulus alatus, Cynanchum laeve, Calystegia silvatica* ssp. *fraterniflora,* and *Hibiscus moscheutos*. This community type occurred in close proximity to a cow pasture and agricultural field. The nutrient content of the river may have fluctuated from its natural state, which can potentially affect vegetation, though further study is necessary. These anthropogenic influences may have affected our results.

South-Central Interior / Upper Coastal Plain Flatwoods (SCI/UCPF)

This large patch community type was described by NatureServe (2007) as a vegetated upland or wetland type with a forested or woodland canopy of broad-leaved deciduous trees. This system is dominated by, xerohydric flatwoods, and is found in the Interior Low Plateau on elevated ridges of areas with well-developed hardpans. NatureServe (2007) noted that the associations are poorly known and described, and that more work is necessary to clarify which types exist. They describe *Quercus stellata, Q. alba, Carya ovata, Cragaegus imbricaria, Ilex decidua, Ulmus alata, Schizachyrium scoparium, Sorhastrum nutans, Andropogon* spp., *Manfreda virginica, Croton willdenowii, Danthonia spicata, Porteranthus stipulatus, Pycnanthemum tenuifolium*, and *Taxodium distichum* from this community. They noted that local herb dominance of depressional wetland species includes *Juncus* and *Carex* spp., because wetlands and sinkholes are typically juxtaposed to this community type.

The main similarity between the NatureServe (2007) description and the observed SCI/UCPF was the flat topography, well-developed hardpan in the soil, xerohydric nature, and proximity to a depressional wetland. The percent cover of this particular habitat type was so small that there were hardly characteristic dominants other than *Nyssa sylvatica*. The understory of this community type was found around the edge of the CIHASDP (below). This included *J. effusus, Carex vulpinoidea, Eleocharis tenuifolia, Viola lanceolata*, and several *Dichanthelium* spp. *Croton monanthogynus* which were discovered in a field adjacent to this area. Should the CWMA allow the flatwoods to develop fully, there may be more characteristic vegetation in this community as described by NatureServe (2007).

Central Interior Highlands and Appalachian Sinkhole and Depression Pond (CIHASDP)

NatureServe (2007) described this community as co-occurring with the SCI/UCPF (see above). They are typically small patch communities of vegetated, wetland species that are partially isolated in forests and woodlands. Soils are very poorly drained, and standing surface water is present for much of the year (NatureServe, 2007). Their geology originates in karst collapse features in the form of sinkholes or sagponds (mostly in Georgia and Alabama). *Quercus* spp., *Platanus occidentalis, Fraxinus pennsylvanica, Acer saccharinum, Nyssa* spp., *Liquidambar syraciflua,* and *Cephalanthus occidentalis* are known from these areas. *Nyssa sylvatica* is known generally from the Cumberland Plateau.

Cranfill (1991) found a similar community type in the North-Central Highland Rim in Kentucky, known as Sinkhole Swamp forest. He noted that Sinkhole swamps were abundant on the Highland Rim in Kentucky and Middle Tennessee, and were comprised of *Carex*, *Cephalanthus*, *Decodon*, and *Hibiscus*. The U.S. Army Corps of Engineers (2011) noted that depression wetlands were the most abundant wetland community throughout the Eastern Mountains and Piedmont Region. Due to the karst topography of the Western Highland Rim, these wetlands occur where limestone bedrock was subjected to dissolution, weakening, or collapse (U.S. Army Corps of Engineers, 2011). There are also several scattered sinkholes existing within the region where downward movement of water is restricted. Wetlands are then formed when filled with sediment from the surrounding area (Wolfe, 1996, cross-reference). Fracture zones in the underlying bedrock are known to encourage wetland growth as well (Heath 1984 cross-reference).

The vegetation found within the CMWA CIHASDP was comprised of several *Carex* and *Juncus* spp. (see description for the SCI/UCPF above). The assemblage noted by Cranfill (1991) was not represented in this particular wetland of the CWMA. Instead, *Rhexia virgnicia* was abundant, which reflected the community described by NatureServe (2007), in addition to topography and proximity to flatwoods. Interestingly, *Nyssa sylvatica* dominated the canopy within this wetland, which was typical of the Cumberland Plateau (NatureServe, 2007). This wetland also matched the description given by the U.S. Army Corps of Engineers (2011) in that about 80% of the species from this area had a facultative- or obligate-wetland status. Because this area was different from a typical Sengtown soil (Goode, pers. comm.) the USDA should consider placing a depression or sink symbol over this area.

Anthropogenic Communities

Western Highland Rim Prairie and Barrens (WHRPB)

NatureServe (2007) described this system based on natural barrens and prairies. It is a vegetated upland community dominated by herbaceous species and graminoids. It is maintained by fire on uplands in western Tennessee, and is most extensive in southern LBL. Stands within woodland communities were dominated by *Quercus marilandica, Q. prinus,* and/or *Quercus stellata* with an understory of *Schizachyrium scoparium, Andropogon* spp., *Dichanthelium dichotomum* var. *dichotomum, Symphiotrichum dumosum, Seriocarpus linifolius, Coreopsis major, Eupatorium hyssopifolium, Eupatorium rotundifolium, Helianthus angustifolius, Liatris microcephala, L. spicata,* *Packer anonyma, Solidago juncea, S. odora, Chamaecrista fasciculata, C. nictitans, Stylosanthes biflora, Lobelia puberula, Dioidia teres, Potentilla simplex, Aristida longispica, Calamogrostic coarctata, Sorghastrum nutans, Pteridium aquilinum*, and *Smilax glauca.*

Cranfill (1991), in a study of Hardin County, Kentucky, noted that the vegetation found within pipeline and power line right-of-ways had prairie and barren characteristics. While barrens no longer exist in broad expanses, remnant patches can be found sporadically on karst areas along steep to moderate slopes. Vegetation is often comprised of *Andropogon, Sorghastrum, Aristida, Panicum, Agave, Allium, Symphyotrichum, Liatris* spp., and *Thalictrum revolutum* (Cranfill, 1991). Estes and Walck (2005) also discovered that the floristic elements of old, distrubance-maintained fields were barren-like in composition, and noted that *Andropogon, Dichanthelium, Panicum, Tridens, Desmodium, Helianthus, Lespedeza, Solidago,* and *Symphyotrichum* spp commonly occurred in these areas.

The WHRPB communities discovered within the CWMA were non-natural in that they were maintained by mowing rather than fire, and existed largely in pipeline and power line right-of-ways, as noted by Cranfill (1991) and Estes and Walck (2005). Often times these linear communities were sloping. The vegetation of sloping versus non-sloping topography differed such that areas of steeper slopes housed more characteristic vegetation of prairies and barrens, where less sloping areas were generally weedy. Several *Andropogon* and *Dichanthelium* spp. were documented, including *Adropogon gerardii* and *Dichanthelium acuminatum* var. *fasciculatum*, *D. acuminatum* var. *acuminatum*, and *D. dichotomum*. *Coreopsis major, Eupatorium hyssopifolium, E.*

rotundifolium, Helianthus annuus, H. maximiliani, Liatrus spicata, Solidago odora, Chamaecrista fasciculata, Lobelia puberula, Smilax glauca, and *Thalictrum revolutum.* Based on species profiles, slope, and maintained disturbance, the CWMA does in fact house WHRPB vegetation that is similar to those barrens and prairies previously described (NatureServe 2007; Cranfill, 1991).

Floristic and Vegetation Affinities of the CWMA

The floristic and vegetation communities of the Western Highland Rim were deemed a botanical crossroads by Chester (1995) due to the number of conduits that influenced the vegetation from surrounding areas. The Tennessee river has provided a significant Appalachian element, the Cumberland River has contributed its flora from the Cumberland Plateau, prairie elements have influenced the flora from the north and west, and Coastal Plain elements from the south and southwest (Chester, 1995).

The phytogeographic affinities of the flora analyzed with BONAP's Floristic Synthesis Program (Kartesz, 2011) suggested the CWMA is reflective of this botanical crossroads. It was influenced from the west by a xeric, oak hickory flora and a more mesophytic region to the east. Mixed mesophytic, mixed hardwoods, oak, and oak-hickory themes were observed over the course of this study, in addition to pine, cedar, barren and prairie relicts, and several other minor community types, like that described by Chester (1995), although there is little baseline data to compare these results. If the CWMA was not a true crossroads, the contributions from northern, eastern, southern, western, and central areas would comprise far less a percentage to the flora than calculated (Figure 9).

Many origins of diversity that comprised the modern flora of the Western Highland Rim and therefore the CWMA, helped explain this phenomenon (Chester, 1995) (Figure 9). (1) A portion of the vegetation from the Western Highland Rim evolved from older, Mesozoic vegetation, including maples, birch, walnut, oak, cottonwood, and willow, most of which were found over the course of this study. (2) Persimmon and pawpaw connected the present vegetation to that of the Eocene and Early Oligocene, as climates favored tropical species. (3) Migration of species over land bridges was also a factor in creating Western Highland Rim vegetation, which were well-documented as "Arcto-Tertiary Geoflora" (Chester, 1995). Species characteristic of this "Geoflora" included yellow-wood, sweetshrub, sycamore, oak, maple, walnut, and elm, which were collected during the study. In addition, (4) the Pleistocene Period introduced many boreal elements, including northern disjuncts. Last, (5) anthropogenic activity caused significant modifications to the Western Highland Rim, specifically the Cheatham Wildlife Management Area (Chester, 1995). In fact, over 800 ha (2,000 acres has been anthropogenically degraded (Figure 26, Appendix A).

Vegetation Mapping

Although vegetation is a most readily observable feature of the landscape, it remains difficult to map quickly with currently available technology. Because many of the landscapes within the southeastern United States are complex, it is extremely difficult to differentiate communities through SEGAP data (USGS, 2011) alone. The strongest vegetation classification method discovered through the course of this study was ground-truthing, as suggested by Smalley (1991), Grossman *et al.* (1998), and NatureServe (Cromer *et al.*, 2003).

This study showed that by using frequently observed vegetation types in a physiographic province as a guide, the remaining area may be mapped based on the landforms, soil type, elevation, and other abiotic factors. Little difference in species assemblages existed over similar hydrological and elevation gradients. For example, the vegetation occurring in one mesic forest near a stream was similar at almost every other stream visited within the CWMA. These ecological similarities noted at almost every community type made the Western Highland Rim a particularly good candidate for detailed GIS mapping.

NatureServe (Cromer *et al.*, 2003) mentioned that the development of the North Carolina Vegetation Survey is incomplete (Cromer *et al.*, 2003). Results of this study offer a temporary solution to this technological problem. Ground-truthing, in addition to 'hand-drawn' GIS mapping, based on known vegetation patterns within a landscape, provided a more accurate depiction of Western Highland Rim vegetation. The authors of this study do not wish to undermine SEGAP remote sensing data (USGS, 2011), as it is an incredibly useful tool by which vegetation may be classified on large scales. Rather, when mapping at a medium to large scale, some form of ground-truthing and 'hand-drawn' GIS maps are imperative to understand landscape patterns for effective and accurate vegetation classification.

Study Limitations

Most differences between the CWMA vegetation and previously described Western Highland Rim vegetation were largely due to study duration, sampling effort, and study area size. Because of time limitations, the number of species collected was smaller than expected. Sampling methodology also differed in previous studies, specifically with respect to plot use. Clatterbuck (1996), for example, found 8 forest types within the CWMA based in 462-ha area (1,142 acres) based on plot data and multivariate statistical analyses. Last, the sample size of this study comprised the entire 8,421.5 ha area, which was larger than most other areas studied on the Western Highland Rim (Table 3, Appendix A). The amount of time it took to map this system also affected the floristic inventory collection attempts. Further study into the floristic inventory of this area is therefore recommended.

CHAPTER VI

CONCLUSIONS

Four main conclusions were drawn from this research:

(1) The CWMA is a botanical crossroads that received elements through many migratory pathways, which supports the work of Chester (1995);

(2) The utility of the "No More Plots" method (Smalley, 1991) paired with NatureServe (2007) nomenclature and species profiles from past studies sufficiently described the vegetation classes within the Western Highland Rim;

(3) By observing landforms and species compositions, an accurate map of vegetation classes within the Western Highland Rim can be created. Further study is necessary to test this method on other physiographic provinces, areas of more than one physiographic province per study site, and other areas within the United States and around the world;

(4) The floristic inventory of the CWMA will serve as baseline data for subsequent ecological, entomological, herpetofaunal, and other studies focused on Western Highland Rim vegetation.

CHAPTER VII

MANAGEMENT NOTES

Invasive Species Management

The authors suspect that rare plant diversity within the CWMA is low due to the large amount of logging and grazing that occurs in the area. The addition of planted, non-native species will continue to decrease the floristic diversity within the refuge, which may become expensive to restore. The TWRA may therefore want to consider eradication efforts of the many exotic plant species within the refuge. There are alternatives to planting these species that are equally hearty and prolific with respect to wildlife food and habitat (Table 8, Appendix A). The encountered invasive species within the area were listed and assigned a subjective threat level based on frequency and percent cover (Table 8, Appendix A).

Fire

The TWRA may also want to consider fire as a means of promoting leguminous diversity so that its wildlife has more natural areas in which to graze. It is possible that some of the vegetation trends found within the CWMA were similar to those documented by Franklin *et al.* (1993) at LBL. Decreasing natural disturbances such as fire drastically altered the communities within large forested tracts. For example, suppression of woodland fires gave rise to mesophytic counterparts, namely beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*) (Franklin *et al.*, 1993; Chester *et al.*, 1998), a familiar sight within the forests on the CWMA.

In addition Franklin *et al.* (1993) noted two successional trends occurring at LBL. First, seral (successive) species such as *Pinus echinata* succeeded into xeric *Quercus* spp. stands. Second, *Quercus* spp. succeeded into mesophytic forests, as a result of decreasing disturbance. The succession of *Q. alba* communities dominates xeric-mesic and mesic sites at LBL, and mesophytic communities are dominated by *A. saccharum* and *F. grandifolia* (Franklin *et al.* 1993). These trends were documented in almost every forested stand within the CWMA, which suggests that fire suppression has altered the landscape.

Franklin *et al.* (2003) studied vegetation responses to fire. They noted that disturbance maintains *Quercus* dominance. Implementing management techniques, such as cutting and fire, were suggested to attain maximum biodiversity in natural systems and sustainable use of public lands (Franklin *et al.*, 2003). In addition, the invasion of *A. saccharum* in old-growth forests has become a primary management concern (Franklin *et al.*, 1993) at LBL in Kentucky and Tennessee. The suppression of fire is believed to cause this situation. Shade intolerant species have flourished without fire regimes, and are rapidly deteriorating the natural vegetation structure. Franklin *et al.* (1993) also noted that these habitats returned to pre-burn conditions about 5-15 years after a fire.

Delcourt and Delcourt (1998) studied the influence of prehistoric human-set fires in the Southern Appalachians by analyzing tree cores, fossilized pollen, and charcoal. They noted that, at least in eastern Tennessee, increased charcoal in pollen cores suggested prehistoric human-set fires. In addition, NatureServe (Cromer *et al.*, 2003) described several variations of community types that occur throughout Tennessee in the absence of fire. Under the Allegheny-Cumberland Dry Oak Forest and Woodland System were several associations that housed vegetation similar to that of the CWMA. This included a *Quercus alba* and *Q. alba*, *Carya*, *Cornus*, *Vaccinium*, *Cercis*, *Juniperus*, *Chasmanthium sessiliflorum*, and *Carex* assemblage that depended on fire to maintain the community. About 12 communities within Tennessee and surrounding areas were also dependent on fire at some point, according to NatureServe (2006). Several of these communities were found within the CWMA, for example the South-Central Interior/Upper Coastal Plain Flatwoods and Southern Appalachian Low-Elevation Pine Forest. Another example was the Western Highland Rim Barren and Prairie element that existed in the pipe- and power-lines within the CWMA. Because these were anthropogenically created future studies are recommended for these communities.

To support the historical presence of fire in the CWMA, countless stands of vegetation were encountered that may be capable of producing volatile, flammable chemicals that often promote fire were discovered in the CWMA, including *Carex picta*, *Vaccinium* spp., *Chasmanthium sessiliflorum*, and several drier *Quercus* spp. (NatureServe, 2006). While this is not enough evidence to establish that fire was once a part of the natural history within the CWMA, it may help return the area to its potential natural state, at least in older forested stands. We therefore suggest the implementation of fire and cutting in the sense of Franklin *et al.* (2003) as a means of invasive species management.

Preservation of Older Growth Stands

The CWMA is the second largest public land unit within the southeastern United States. Because it represents a botanical crossroads it may contain a unique flora, unlike any in the United States. Therefore, the author strongly recommends that TWRA conserves areas so that they may grow to their potential natural vegetation as noted by Küchler (1964). Several stands, most notably those with forests with exceptionally large individual trees and open understories are currently developing the characteristics of older growth forests and should therefore be secluded from timber harvest, selective logging, and wildlife activity (Table 9; Figure 29). Continued care for the found wetland, more pristine habitats such as streams and climax communities is also recommended.

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APPENDIX A

Tables and Figures Pertaining to the Study

TABLE 3. *The relative contribution from studies of the Western Highland Rim.*

Study Area	Area (ha)	Families	Genera	Species	Non-Native Taxa
Barrens on the Southwestern Pennyroyal Plain (Chester *et al.*, 1997)	1-40	70	302	342	31
Rattlesnake Falls (Estes and Walck, 2005)	62.5	107	348	627	81
Lower Bear Creek Watershed (Stack, 1982)	324	108	377	715	NA
Bear Creek Natural Area (Carpenter and Chester, 1987)	325	111	388	733	123
Cedars of Lebanon State Forest (TDA and TDC, 2003)	3,232	NA	NA	340	30
Duck River Unit (Gunn and Chester, 2003)	10,817	125	408	718	120
Updated Checklist of LBL (Chester, 1993)	69,000	139	591	1,289	307
Contribution from the CWMA (Klagstad, 2012)	**21,000**	**102**	**289**	**419**	**64**

TABLE 4. Rare plants of the CWMA (Crabtree, 2008).

CWMA RARE SPECIES							
Scientific Name	**Common Name**	**State Status**	**Reason**	**Federal Status**	**State (S) Rank**	**Global (G) Rank**	**Habitat**
Aristida ramosissimus	S-curved threeawn	Endangered	Possibly extirpated	None	E	NA	Dry roadside near fiel
Cornus obliqua	Silky dogwood	*State record	NA	NA	New	NA	Rich stream banks
Helianthus eggertii	Eggert's sunflower	Threatened	NA	None	S3	G3	Dry roadsides and glad
Hydrastis canadensis	Goldenseal	Special Concern	Commercially exploited	NA	S3	G4	Rich stream banks
Juglans cinerea	White walnut	Threatened	Fungus	NA	NA	NA	Rich stream banks
Panax quinquefolius	Ginseng	Special Concern	Commercially exploited	None	S3S4	G3G4	Rich stream banks
Packera plattensis	Prairie groundsel	Special Concern	Extirpated	None	SH	G5	Open riverbanks & glades

TABLE 5. Phytogeographic analysis of the native and non-native taxa within the CWMA.

Affinity	Number of Native Taxa	Percentage of Native Taxa	Number of Non-native Taxa	Percentage of Non-Native Taxa	Total Number	**Total Percentage**
Central	203	48.4	45	10.7	248	**59.2**
Northern	41	9.8	7	1.7	48	**11.5**
Eastern	26	6.2	2	0.5	28	**6.7**
Southern	76	18.1	5	1.2	81	**19.3**
Western	12	2.9	2	0.5	14	**3.3**

TABLE 6. List of total percentage of each community type within the CWMA, with and without buffers.

Abbreviations	Community Name	Ha of CWMA	% in CWMA (total/Ha)	Without Buffers
CIACT	Central Interior Acidic Cliff and Talus	3.04542	0.003652	3.04542
CIHASDP	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	0.16947	0.000187	0.16947
ILPSF	Interior Low Plateau Seepage Fen	NA		NA
SALEP	South Appalachian Low-Elevation Pine	3.95648	0.00432	3.95648
SCILF	South-Central Interior Large Floodplain	0.21433	0.000237	0.21433
SILPDM	Southern Interior Low Plateau Dry-Mesic Oak (2 associations)	--		--
	Quercus rubra – (*Acer saccharum*, *Quercus alba*) Forest	4539.42045	50.16000	4539.42045
	Quercus falcata – *Quercus* (*coccinea*, *stellata*) / *Vaccinium* Forest	2061.56243	22.77999	2061.56243
SCIMF	South-Central Interior Mesophytic Forest	939.36321	10.37984	939.36321
SCISS/R	South-Central Interior Small Stream/Riparian	509.966068	5.63505	0
SCI/UCPF	South-Central Interior/Upper Coastal Plain Flatwoods	2.12156	0.002344	2.12156
WHRPB	Western Highland Rim Prairie and Barrens.	--		--
	Pipelines	73.95379	0.081718	73.95379
	Power lines	0.13707	0.0001546	0.13707
AP	Artificial Pond	2.02208	0.0022344	2.02208
F	Field, Crop Field	107.78092	1.190965	107.78092
	Food plot	11.53424	0.127452	11.53424
	Pine Plantations	45.4886	0.502643	45.4886
	Clear-cut	342.73495	3.787177	342.73495
	Older clear cuts	247.66309	2.736645	247.66309
	Residential	5.149500	0.0056901	5.149500
RS	Roadside	153.59463	1.697201	153.59463
TOTAL		9,049.880158	99.0975	8,539.912

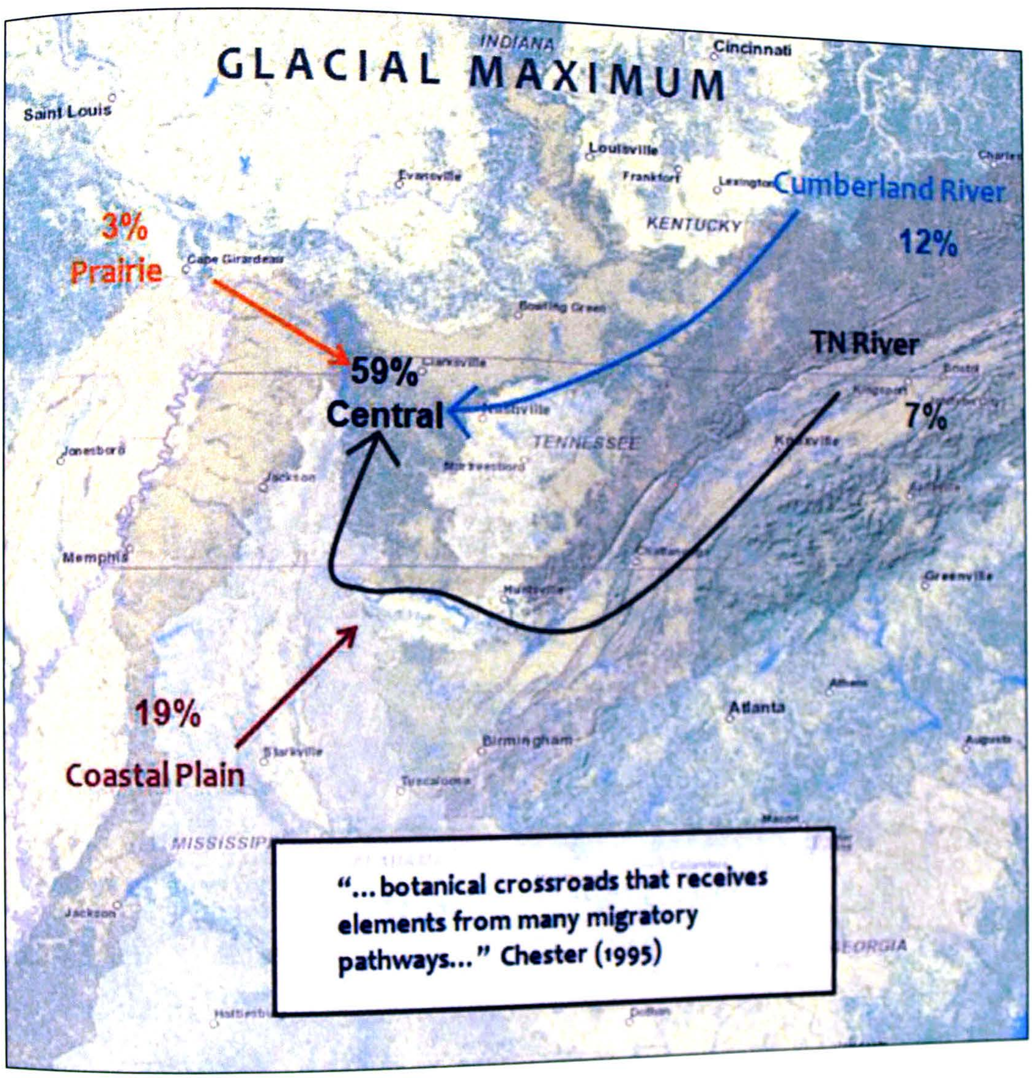

FIGURE 9. Analysis of the CWMA flora floristic affinities, in context of the "botanical crossroads" of the Western Highland Rim.

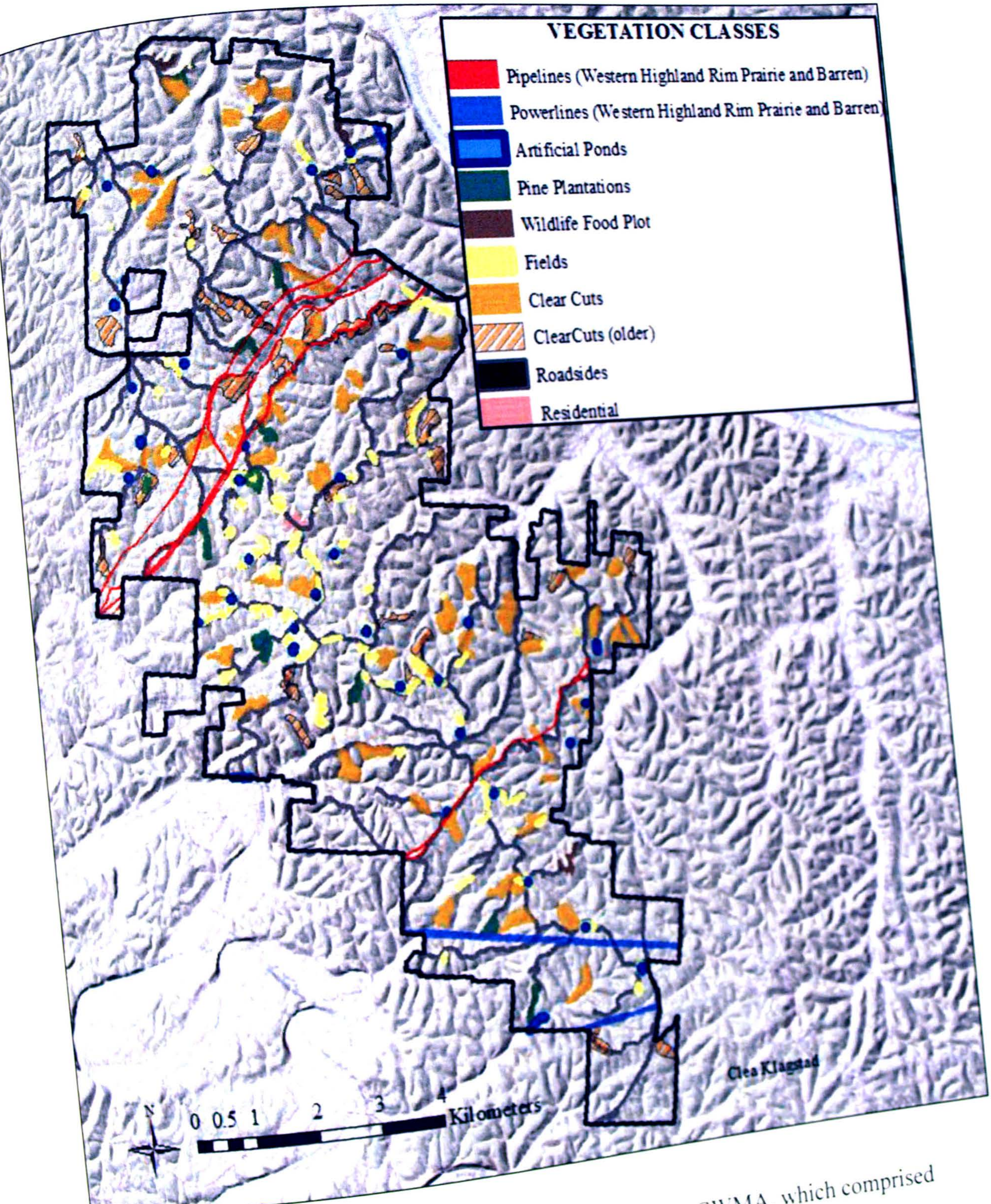

FIGURE 27. All anthropogenically disturbed areas within the CWMA, which comprised about 809 ha (2,000 acres).

TABLE 7. A comparison of the habitat types described this study and USGS (2011).

COMPARISON OF VEGETATION CLASSIFICATION METHODS	
Communities found from Klagstad and Estes (2012)	**SEGAP**
South-Central Interior Small Stream/Riparian	Yes
Interior Low Plateau Seepage Fen	*No
South-Central Interior Mesophytic Forest	Yes
Southern Interior Low Plateau Dry-Mesic Oak	Yes
Central Interior Acidic Cliff and Talus	Yes
South Appalachian Low-Elevation Pine	*No
South-Central Interior Large Floodplain	Yes
Central Interior Highlands and Appalachian Sinkhole and Depression Pond	*No
South-Central Interior/Upper Coastal Plain Flatwoods	Yes
Western Highland Rim Barren and Prairies.	*No

APPENDIX B

Tables and Figures Pertaining to Management Notes

TABLE 8. Alternatives to invasive species using native plants or eradication techniques.

NATIVE ALTERNATIVES TO INVASIVE SPECIES				
Invasive Species	**Location**	**Treat Level**	**Alternatives**	**Wildlife Advantag**
Elaeagnus umbellata. Autumn olive.	Throughout.	Severe	Bayberry (*Myrica pensylvanica*)	Birds
			Winterberry (*Ilex verticillata*)	Birds
			Fothergilla (*Fothergilla gardenii*)	NA
			Chokeberry (*Aronia arbutifolia*)	Birds
Lespedeza bicolor and *cuneata* Lespedeza.	Throughout.	Severe	Roundhead lespedeza (*L. capitata*)	Deer, some bi
			Hairy lespedeza (*L. hirta*)	Deer, some bir
			Trailing lespedeza (*L. procumbens*)	Deer, some bir
			Creeping lespedeza (*L. repens*)	Deer, some bir
			Tall lespedeza (*L. stuevei*)	Deer, some bir
			Violet lespedeza (*L. violacea*)	Deer, some bird
			Slender lespedeza (*L. virginica*)	Deer, some birds
Ligustrum sinense. Privet.	Throughout.	Severe	Arrowwood (*Viburnum dentatum*)	Birds
			Buttonbush (*Cephalanthus occidentalis*)	NA
			Spicebush (*Lindera benzoin* var. *benzoin*)	Birds, mammals
			Witch hazel (*Hamamelis vernalis*)	NA
Microstegium vineum. Browntop.	Throughout, in less disturbed stream banks.	Severe	Eradicate	NA
Ailanthus altissima. Tree of heaven	Along most roadsides.	Moderate	Eradicate	NA
Albizia julibrissin. Silky acacia.	Along roadsides.	Moderate	Eradicate	NA
Paulownia tomentosa. Princess tree.	Along roadsides.	Moderate	Eradicate	NA
Pueraria montana var. lobata. Kudzu.	Found along the perimeter.	Moderate	Eradicate	NA
Rosa multiflora. Multiflora rose.	Most roadsides.	Moderate	Eradicate	NA
Nandina domestica. Sacred bamboo.	Found at home site.	Light	Eradicate	NA

TABLE 9. List of the 10 most pristine areas that we recommend setting aside so as to allow the forests to develop old-growth characteristics. We recommend no logging, grazing, or recreational activity be allowed in these sites.

Community type or Name	Latitude	Longitude
1. Big Bluff Creek	36.2603417	-87.111203
2. Older Growth Forest	36.232733	-87.105723
3. Entirety of Brush Creek	36.234473	-87.088633
4. Intact Mesic Forest	36.205876	-87.124499
5. Dunn Hollow	36.197341	-87.089668
6. Low Elevation Pine Forest	36.178844	-87.113213
7. Dry Creek	36.191025	-87.062785
8. Gardling Hollow	36.176722	-87.096757
9. Harpeth Access	36.171387	-87.10568
10. Temporary Wetland	36.143906	-87.061364

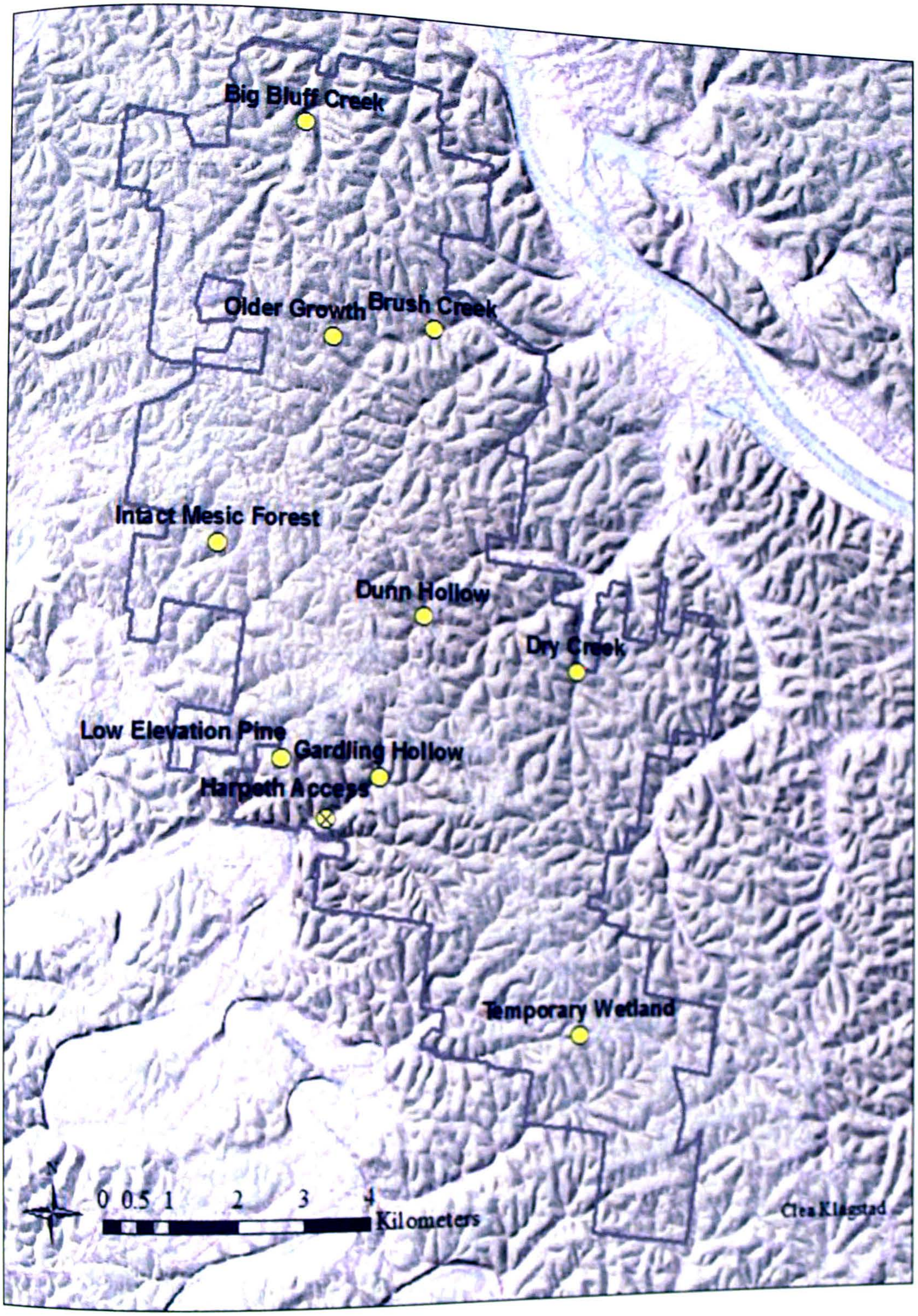

FIGURE 28. Map of older growth stands within the area that we recommend setting aside for preservation.

APPENDIX C

The Species Checklist

General Guidelines

The checklist is divided into Pteridophyta (fern and fern allies), Gymnospermae (non-flowering seed plants), and Angiospermae (flowering plants), and further divided into the Monocotyledonae and Dicotyledonae. Families, genera, and species are arranged alphabetically. The abundance is described according to Gunn and Chester (2003), where infrequent (not always in stated community types and usually in small numbers); occasional (often in stated community types but rarely in large numbers); frequent (usually encountered in the community types but not always in large numbers), abundant (expected in the type, usually in large numbers), rare (known from few locales, generally with small populations), locally abundant (known from few locales with large numbers in each) (Table 10). A single asterisk precedes introduced taxa, and two asterisks precede rare taxa. County records are marked with a plus sign. Vegetation classes and relative abundance were indicated (APPENDIX C).

Table 10. Abundance meanings for the vascular inventory of the CWMA (Gunn and Chester, 2003).

Density	Description
Infrequent	Not always in stated community types and usually in small numbers
Occasional	Often stated in community types but rarely in large numbers
Frequent	Usually encountered in the community types but not always in large numbers
Abundant	Expected in the type, usually in large numbers
Rare	Known from few locales, generally with small populations
Locally abundant	Known from few locales with large numbers in each.

Lycophyta

Selaginellaceae

Selaginella apoda (L.) Spring. SCIMF/ILPSF. Infrequent.

Pteridophyta

Aspleniaceae

Asplenium platyneuron (L.) Britton, Sterns, & Poggenb. WHRPB. Frequent.

Dryopteridaceae

Deparia acrostichoides (Sw.) M. Kato. SCIMF/ILPSF. Frequent.
Diplazium pycnocarpon (Spreng.) Broun. SCIMF/ILPSF. Freuqent.

Equisetaceae

Equisetum arvense L. SCIMF/ILPSF. Frequent.

Osmundaceae

Osmunda cinnamomea L. SCIMF/ILPSF. Infrequent.

Polypodiaceae

Pleopeltis polypodioides (L.) Andrews & Windham ssp. *michauxiana* (Weath.) Andrews & Windham. SCIMF/ILPSF. Frequent.

Pteridaceae

Aidiantum pedatum L. SILPDM. Frequent.

Spermatophyta: Gymnospermae

Cupressaceae

**Cunninghamia lanceolata* (Lamb.) Hook. Home site. Infrequent.
Juniperus virginiana L. SCIMF/ILPSF. Occasional.

Pinaceae

Pinus taeda L. SCIMF. Infrequent.

Spermatophyta: Angiospermae I.
Monocots

Agavaceae

Manfreda virginica (L.) Salisb. ex Rose. SCIMF/ILPSF. Infrequent.

Alismataceae

Alisma subcordatum Raf. AP. Infrequent.

Araceae

Arisaema triphyllum L. Schott ssp. *triphyllum*. SCIMF/ILPSF. Infrequent.

Aristilochiaceae

Asarum acuminatum L. SCIMF/ILPSF. Frequent.

Crassulaceae

Sedum pulchellum Michx. SCIMF/ILPSF. Frequent.

Cypraceae

Carex albicans Willd. ex Spreng. SILPDM. Infrequent.
Carex amphibola Steud. SCIMF/SCISSR. Occasional.
Carex blanda Dewey. SCIMF/SCISSR. Frequent.
Carex cumberlandensis Naczi, Kral, and Bryson. SCIMF/SCISSR. Frequent.
Carex communis L.H. Bailey. SCIMF/ILPSF. Frequent.
Carex communis LH Bailey. var. *communis*. SCIMF/SCISSR. Frequent.
Carex digitalis Willd. var. *macropoda* Fernald. SILPDM. Frequent.
+*Carex mesochorea* Mack. SCIMF/SCISSR. Frequent.
Carex nigromarginata Schwein. SCIMF/SCISSR. Infrequent.
Carex hirsutella Mack. RS. Abundant.
+*Carex kraliana* Naczi & Bryson. SCIMF/SCISSR. Occasional.
+*Carex leptonervia* (Fernald) Fernald. SCIMF/SCISSR. Occasional.
Carex picta Steud. SCIMF/ILPSF. Frequent.
Carex rosea Schkuhr ex Willd. SCIMF/ILPSF. Occasional.
Carex superata Naczi, Reznicek, & B.A. Ford. (Fernald) Fernald. SCIMF/SCISSR. Frequent.
Carex vulpinoidea Michx. CIHASDP. Frequent.
+*Cyperus odoratus* L. CIACT. Frequent.
Cyperus lacastriensis L. SCIMF/SCISSR. Infrequent.
Eleocharis tenuis Torr. CIHASDP. Frequent.
Fimbristylis autumnalis (L.) Roem & Schult. SCIMF. Infrequent.
Scirpus cyperinus (L.) Kunth. CIHASDP. SCIMF/ILPSF. Frequent.
Scleria Olignatha Michx. SILPDM. Frequent.

Discoreaceae

Discorea villosa L. SCIMF/ILPSF. Frequent.

Iridaceae

Iris cristata Aiton. SCIMF/ILPSF. Frequent
Sisyrinchium albidum EP Bicknell. SCIMF/ILPSF. Infrequent.

Juncaceae

Juncus acuminatus Michx. WHRPB. Frequent.
Juncus anthelatus (Wiegand) RE Brooks. SCIMF/ILPSF. Frequent.
Juncus coriaceous Mack. SCIMF/ILPSFSCISS/R. Frequent.
Juncus effusus L. SCIMF/ILPSF/CIHASDP. Frequent.
Luzula echinata (Small) FJ Herm. ILPSF/SCIMF. Frequent.
Luzula multiflora (Ehrh.) Lej. Home site. Infrequent.

Liliaceae

Allium cernuum Roth. SCIMF/ILPSF. Frequent.
**Allium vineale* L. RS. Frequent.
Erythronium americanum Ker Gawl. SCIMF. Frequent.
**Hemerocallis fulva* (L.) L. RS. Frequent.
Hymenocallis caroliniana (L.) Herbern. SCIMF/ILPSF.
Polygonatum biflorum (Walter) Elliott. SCIMF. Frequent
Trillium cuneatum L. SCIMF/ILPSF. Frequent
Trillium flexipes Raf. SCIMF/ILPSF. Frequent.
Uvularia grandiflora L. SCIMF/ILPSF. Frequent.

Menispermeaceae

Menispermum canadense L. SCIMF/ILPSF. Occasional.

Monotropaceae

Monotropa uniflora L. SILPDM. Infrequent. (Photo voucher).

Orchidaceae

Tipularia discolor (Pursh) Nutt. SCIMF/ILPSF. Frequent.

Passifloraceae

Passiflora lutea L. SCIMF/ILPSF. Infrequent.

Poaceae

Andropogon gerardii Vitman. RS. Abundant.
+***Aristida ramosissima* Engelm. ex A. Gray. RS. Frequent.
**Arthraxon hispidus* (Thunb.) Makino. SCIMF. Frequent.
**Bromus japonicus* L. RS. Frequent. Introduced.
Bromus pubescens Muhl. ex. Willd. SCIMF/ILPSF. Frequent.
Chasmanthium latifolium (Michx.) Yates. SCIMF, SILPDM, RS. Frequent.
Danthonia sericea (Shear) Hitchc. SCIMF, SILPDM, CIHASDP. Infrequent.
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *acuminatum*. WHRPB, FP. Infrequent
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *fasciculatum* (Torr) Freckmann.
WHRPBF. Infrequent.
Dichanthelium commutatum (Schult.) Gould. CIHASDP. Frequent.
Dichanthelium dichotomum (L.) Gould. WHRPB, RS. Infrequent.
Dichanthelium laxifloraum (Lam.) Gould. SILPDM. Frequent.

Dichanthelium sphaerocarpon (Elliott) Gould. CIHASDP. Frequent.
**Digitaria ischamum* (Schreb.) Schreb. ex Muhl. RS. Frequent
Echinochloa muricata (P. Beauv.) Fernald var. *muricata*. AP. Infrequent.
**Eleusine indica* (L.) Gaertn. RS. Frequent.
Elymus hystrix L. SCIMF/ILPSF. Frequent.
+*Elymus riparius* Wiegand. CIACT. Infrequent.
Elymus virginicus L. var. *virginicus* RS. Infrequent.
**Hordeum vulgare* L. RS. Frequent.
**Lolium perenne* L. RS. Frequent
Melica mutica Walter. SCIMF/ILPSF. Frequent.
**Microstegium vimineum* (Trin.) A. Camus. SCIMF/ILPSF. Abundant.
Muhlenbergia sylvatica (Torr.) Torr. ex A. Gray. SCIMF/ILPSF. Frequent.
+*Panicum dichotomiflorum* Michx. SCIMF. Infrequent.
Panicum flexile (Gattinger) Scribn. RS. Frequent.
+*Panicum rigidulum* Bosc ex. Nees. SCIMF. Infrequent.
**Paspalum dilatatum* Poir. RS. Frequent.
+*Paspalum laeve* Michx. CIHASDP. Infrequent.
**Phleum pratense* L. RS. Frequent.
Poa autumnalis Muhl. ex Elliott. SCIMF. Infrequent.
Poa sylvestris A. Gray. SCIMF/ILPSF. Frequent.
+**Schedonorus phoenix* (Scop.) Holub. SCIMF/ILPSF. Frequent.
**Setaria faberi* Herrn. RS. Frequent.
+*Setaria parviflora* (Poir.) Kerguélen. RS. Frequent.
**Setaria pumila* (Poir.) Roem. & Schult. RS. Frequent.
**Sorghum halpense* (L.) Pers. SCIMF. Frequent.
Sphenopholis obtusata (Michx.) Scribn. var. *major*. SCIMF. Frequent.
**Vulpia bromoides* (L.) Gray. FP. Infrequent.

Potamogetonaceae

Potamogeton diversifolius Raf. RS. Infrequent.

Smilacaceae

Smilax bona-nox L. RS. Frequent.
Smilax glauca Walter. SCIMF, SILPDM, WHRPB. Frequent.
Smilax rotundifolia L. SILPDM. Frequent.
Smilax tamnoides L. SCIMF/ILPSF, SILPDM. Infrequent.

Typhaceae

**Typha angustifolia* L. AP. Infrequent.

SPERMATOPHYTA: ANGIOSPERMAE II. Dicots

Acanthaceae

Justicia americana (L.) Vahl. SCISS/R. Frequent.
(*Ruellia caroliniensis* (J.F. Gmel.) Steud. RS. Frequent.
Ruellia strepens L. RS. Frequent.

Anacardiaceae

Rhus aromatica Aiton. RS. Frequent
Rhus copallinum L. RS. Frequent.
Rhus glabra L. RS. Infrequent.
Toxicodendron radicans (L.) Kuntze. SCIMF, SILPDM, CICCT. Abundant.

Annoneaceae

Asimina triloba (L.) Dunal. RS. Occasional.

Apiaceae

Chaerophyllum procumbens (L.) Crantz. SILPDM. Frequent.
Cryptotaenia canadensis (L.) D.C. SCIMF/ILPSF. Infrequent.
Erigenia bulbosa (Michx.) Nutt. SCIMF/ILPSF. Infrequent.
Osmorhiza claytonii (Michx.) C.B. Clarke. CIACT. Infrequent.
Zizia aurea (L.) WDJ Koch. SCIMF/ILPSF. Frequent.

Aquifoliaceae

Arisaema triphyllum (L.) Schott ssp. triphyllum.
Ilex opaca Aiton. F. Infrequent.

Araliaceae

Aralia spinosa L. SCIMF. Frequent.
***Panax quinquefolius* L. SCIMF/ILFSF. Rare.

Asclepiadaceae

Asclepias quadrifolia Jacq. F. Infrequent.
Asclepias variegata. L. RS. Frequent.
Asclepias tuberosa. L. ssp. *tuberosa.* RS. Frequent.
Cynanchum laeve (Michx.) Pers. SCILF. Infrequent.

Asteraceae

**Achillea millefolium* L. RS. Frequent.
Ageratina aromatica (L.) Spach. RS. Frequent.
Ambrosia artemisiifolia L. SILPDM. Frequent.
Antennaria plantaginifolia (L.) Richardson. SCIMF ILPSF. Frequent.
Antennaria solitaria Rydb. SILPDM. Infrequent.
Bidens tripartita (Michx.) Britton. SILPDM. Frequent.
**Cichorium intybus* L. RS. Infrequent.
**Cirsium muticum* Michx. SCIMF ILPSF. Infrequent.
Conoclinium coelestinum (L.) DC. RS. Infrequent.
Conyza canadensis (L.) Cronquist. RS. Frequent.
Coreopsis major Walter WHRPB. Frequent.
Coreopsis pubescens Elliott SCIMF ILPSF. Frequent.
Coreopsis tinctoria Nutt. RS. Frequent.
Coreopsis tripteris L. RS. Frequent.
**Daucus carota* L. RS. Frequent.
Echinacea purpurea (L.) Moench. F. Frequent.
Elephantopus carolinianus Raeusch. AP. Frequent.
Erechtites hieraciifolia (L.) Raf. ex DC. F. Frequent.
Erigeron philadelphicus L. F. Frequent.

Erigeron strigosus Muhl. ex Willd. var. *strigosus*. FP. Infrequent.
Eupatoriadelphus fistulosus (Barratt) King and H. Rob. SCIMF/ILPSF. Frequent.
Eupatorium capillifolium (Lam.) Small. WHRPB. Frequent.
Eupatorium hyssopifolium L. SCIMF/ILPSF. Frequent.
Eupatorium purpureum L. SCIMF. Frequent.
Eupatorium rotundifolium L. var. *ovatum*. (Begelow) Torr. RS. Frequent.
Eurybia hemispherica (Alexander) GL Nesom. RS. Frequent.
Helenium amarum (Raf.) H. Rock. RS. Frequent.
Helenium autumnale L. SCILF. Frequent.
Helianthus annuus L. WHRPB, RS. Frequent.
***Helianthus eggertii* Small. WHRPB, SCIMF/ILPSF, RS. Rare.
Helianthus maximiliani. Schrad. WHRPB, RS. Infrequent.
Krigia biflora (Walter) SF Blake. SILPDM. Frequent.
Lactuca canadensis L. RS. Infrequent.
**Leucanthemum vulgare* Lam. RS. Frequent.
Liatris spicata L. var. *spicata* Willd. SILPDM. Frequent.
+***Packera plattensis*. (Nutt.) W.A. Weber & A. Love. SCIMF/ILPSF. Infrequent.
Parthenium integrifolium var. *integrifolium*. WHRPB. Infrequent.
Polymnia canadensis L. CIACT. Frequent.
Pseudognaphalium obtusifolium (L.) Hilliard & BL Burtt. F. Frequent.
Ratibia pinnata (Vent.) Barnhart. RS. Infrequent.
Rudbeckia fulgida Aiton. var. *fulgida*. SCIMF/ILPSF. Frequent.
Rudbeckia fulgida Aiton. var. *paulustris*. SCIMF/ILPSF. Frequent.
Rudbeckia laciniata L. SCIMF/ILPSF. Frequent.
Rudbeckia subtomentosa Pursh. RS. Frequent.
Senecio glabellus (Poir.) C. Jeffrey. Home site. Infrequent.
Sericocarpus linifolius (L.) Britton, Sterns, & Poggenb. SILPDM. Infrequent.
Silphium astericus. L. var. *astericus*. RS. Frequent.
Smallanthus uvedalius (L.) Mack. ex Small. SCIMF/ILPSF. Frequent.
Solidago caesia L. SCIMF/ILPSF. Occasional.
Solidago odora Aiton. WHRPB, RS. Frequent.
Solidaog rugosa Mill. ssp. *aspera* (Aiton) Cronquist. RS. Frequent.
Solidago patula Muhl. ex Willd. SCIMF/ILPSF. Infrequent.
Solidago flexicaulis L. SCIMF/ILPSF. Frequent.
Symphyotrichum cordifolium (Lindl.) GL Nesom. SCIMF/ILPSF. Infrequent.
Symphyotrichum pilosum (Willd) GL Nesom. RS. Occasional.
**Taraxacum officinale* FH Wigg. Home site. Abundant.
Verbesina virginiana L. SILPDM. Frequent.
Vernonia gigantea (Walter) Trel. RS. Frequent.

Balsaminaceae

Impatiens capensis Meerb. SCIMF/ILPSF. Frequent.
Impatiens pallida Nutt. CICCT. Frequent.

Berberidaceae

Podophyllum peltatum L. SCIMF/ILPSF. Frequent.

Betulaceae

Carpinus caroliniana Walter. SCIMF/ILPSF. Frequent.
Ostrya virginiana (Mill.) K. Koch. SILPDM. Frequent.

Bignoniaceae

Bignonia capreolata L. RS. Frequent
Campsis radicans (L.) Seem. Ex. Bureau. SCILF. Frequent.

Boraginaceae

Cynoglossum virginianum L. SILPDM. Infrequent.
Mertensia virginica (L.) Pers. ex Link. SCIMF/ILPSF. Frequent.

Brassicaceae

**Alliaria petiolata* (M. Bieb.) Cavara & Grande. SCIMF/ILPSF. Frequent.
Arabis laevigata (Muhl. ex Willd.) Poir var. *laevigata*. SCIMF/ILPSF. Frequent.
Cardamine concatenata (Michx.) Sw. SCIMF/ILPSF. Frequent.
Cardamine diphylla (Mich.) Alph. Wood. SCIMF/ILPSF. Frequent.

Buxaceae

Pachysandra procumbens SCIMF/ILPSF. Frequent.

Campanulaceae

Campanula americana (L.) Small. SCIMF/ILPSF. Frequent.
Lobelia inflata (L.) SCIMF/ILPSF. Frequent.
Lobelia siphiltica L. SCIMF/ILPSF. Occasional.
Lobelia puberula Michx. RS, WHRPB, and SCIMF/ILPSF. Frequent.
Triodanis perfoliata Nieuwl. var. *perfoliata* RS. Infrequent.

Caprifoliaceae

**Lonicera maackii* (Rupr.) Heder. RS. Frequent.
**Lonicera japonica* Thunb. SCIMF/ILPSF. Infrequent
Sambucus canadensis (L.) R. Bolli. Home site. Infrequent.
Sambucus nigra L. ssp. *canadensis* (L.) R. Bolli. SCIMF. Frequent.
Symphoricarpos orbiculatus Moench SILPDM. Frequent.
Viburnum rufidulum Raf. SILPDM, RS. Frequent.

Caryophyllaceae

**Dianthus armeria* L. RS. Frequent.
Silene virginica L. var. *virginica* SCIMF/ILPSF. Frequent.
Stellaria pubera (L.) Vill. SCIMF/ILPSF. Frequent.

Celastraceae

Euonymus americanus L. SCIMF/ILPSF. Occasional.

Chenopodiaceae

**Chenopodium album* L. var. album. CIACT. Frequent.

Clusiaceae

Hypericum prolificum L. RS. Frequent.
Hypericum virgatum Lam. SILPDM. Infrequent.
Hypericum punctatum Lam. SCIMF/ILPSF. Frequent.

Commelinaceae

Tradescantia virginica L. SCIMF/ILPSF. Frequent.
Calystegia silvatica (Kit.) Griseb. ssp. *fraterniflora* (Mack. & Bush) Brummitt. SCILF. Frequent.

Cornaceae

Cornus ammomum Mill. SCIMF/ILPSF. Infrequent
Cornus drummondii CA Mey. CIACT. Infrequent.
Cornus florida L. RS. Frequent.
***Cornus obliqua* Raf. SCIMF/ILPSF. Rare.

Ebenaceae

Diospyros virginiana L. CIHASDP. Infrequent.
**Elaeagnus umbellata* Thunb. RS. Infrequent

Ericaceae

Kalmia latifolia L. SCIMF/ILPSF. Infrequent.
Oxydendrum arboreum (L.) DC. CIHASDP. Frequent.
Rhododendron alabamense Rehder. SCIMF/ILPSF. Infrequent.
Vaccinium arboreum Marsh. SILPDM. Frequent.
Vaccinium stamineum L. SILPDM. Infrequent.

Euphorbiaceae

Acalypha gracilens A. Gray. SILPDM. Frequent
Acalypha rhomboidea Raf. SILPDM. Frequent.
Chamaesyce nutans (Lag.) Small. RS. Freqent.
Croton monothogynus Michx. Field next to the CIHACT, RS. Frequent.
Euphorbia corollata L. var. *corollata*. SCIMF/ILPSF. Frequent.
**Euphorbia corollata* L. var. *zinnifolia*. RS. Infrequent.
Euphorbia commutata Engelm. ex A. Gray. SCIMF/ILPSF. Frequent.
Euphorbia prostrata (L.) Small. RS. Frequent.

Fabaceae

**Albizia julibrissin* Durazz RS. Frequent.
Amphicarpaea bracteata (L.) Fernald. SCIMF/ILPSF. Frequent
Cercis canadensis L. SCIMF/ILPSF. Frequent.
Chamaecrista fasciculata (Michx.) Green. WHRPB, RS. Frequent.
Clitoria mariana L. CIHASDP. Frequent.
Desmanthus illinoensis (Michx.) MacMill. ex Bl. Rob. & Fernald. RS. Frequent.
Desmodium glutinosum (Muhl. ex Willd.) Alph. Wood. SCIMF/ILPSF. Frequent.
Desmodium nudiflorum (L.) DC. SILPDM. Frequent.
Galactia volubilis (L.) Britton. RS. Frequent.
Gleditsia tricanthos L. SCIMF. Frequent.
**Kummerowia striata* (Thunb.) Schindl. RS. Infrequent.
**Lathyrus latifolius* L. RS. Frequent.
**Lespedeza bicolor* Turcz. F. Frequent.
**Lespedeza cuneata* (Dum. Course.) G. Don. Rs. Frequent.
Lespedeza hirta (L.) Hornem. WHRPB. Frequent.
Lespedeza procumbens Michx. RS. Frequent
Lespedeza violacea (L.) Pers. F. Frequent.
Lespedeza repens (L.) W. Bartram. WHRPB. Frequent.
**Melilotus officinalis* (L.) Lam. RS. Frequent.

Orbexilum pendunculatum (Mill.) Rydb. var. *psoralioides* (Walter) Isely. RS. Frequent.
**Pueraria montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen & S. Almeida. RS. Frequent.
Robinia pseudoacacia L. RS. Infrequent.
Securigera varia (L.) Lassen. FP. Infrequent.
Senna obtusifolia (L.) Irwin and Barneby. RS. Frequent.
Tephrosia virginiana (L.) Pers. WHRPB. Frequent.
Thermopsis villosa (Walter) Fernald & BG Shub. FP/RS. Infrequent.
**Trifolium campestre* Schreb. RS. Frequent.
**Trifolium incarnatum* L. RS. Frequent.
**Trifolium pratense* L. RS. Frequent.
Vicia caroliniana Walter. SCIMF/ILPSF. Infrequent.
**Vicia sativa* L. ssp. *nigra* (L.) Ehrh. FP. Infrequent
**Vicia villosa* Roth ssp. *villosa* Roth. FP. Infrequent.

Fagaceae

Fagus grandifolia Ehrh. SCIMF/ILPSF. Frequent.
Quercus alba L. SCIMF/ILPSF. Frequent.
Quercus rubra L. SILPDM. Frequent
Quercus stellata Wangenh. RS. Infrequent.
**Quercus acutissima* Carruthers. Home site. Infrequent.

Gentianaceae

Gentiana villosa L. RS. Infrequent.
Obolaria virginica L. SCIMF/ILPSF. Infrequent
Sabatia angularis (L.) Pursh. RS. Frequent.

Geraniaceae

Geranium maculatum L. SCIMF/ILPSF. Frequent

Hammamelidaceae

Hamamelis virginiana L. RS. Frequent.
Liquidambar styraciflua L. SCIMF/ILPSF. Frequent

Hippocastanaceae

Aesculus pavia L. SCIMF/ILPSF. Infrequent

Hydrangeaceae

Hydrangea cinerea Small. CICCT. ILPSF. Frequent
Philadelphus hirsutus Nutt. SILPDM. Frequent

Hydrophyllaceae

Phacelia bipinnatifida Michx. SCIMF. Frequent.

Juglandaceae

Carya glabra (Mill.) Sweet. SCIMF/ILPSF. Frequent.
Carya tomentosa Nutt. SILPDM. Frequent
***Juglans cinerea* L. SCIMF/ILPSF. Rare.
Juglans nigra L. SILPDM. Infrequent.

Lamiaceae

Blephilia ciliata (L.) Benth. SCIMF/ILPSF. Infrequent.
**Lamium purpureum* L. SCIMF/ILPSF. Frequent
Monarda bradburiana Beck. SILPDM. Infrequent.
Monarda citriodora Cerv. ex Lag. RS. Frequent.
Monarda fistulosa L. RS. Occasional.
**Mosla dianthera* (Buch.-Ham. ex Roxb.) Maxim. RS. Frequent.
**Perilla frutescens* (L.) Britton. RS. Frequent.
Prunella vulgaris L. WHRPB. Frequent.
Pycnanthemum loomisii Nutt. F. Frequent.
Pycnanthemum tenuifolium Schrad. F. Frequent.
Salvia lyrata L. SILPDM. Frequent.
Scutellaria incana Biehler var. *incana*. F. Frequent.
Trichostema dichotomum L. WHRPB. Infrequent.

Lauraceae

Lindera benzoin (L.) Blume. SCIMF/ILPSF. Frequent.
Sassafras albidum (Nutt.) Nees. SILPDM. Infrequent.

Linaceae

Linum medium (Planch.) Britton var. *texanum* (Planch.) Fernald. WHRPB. Frequent.
**Linum usitatissimum* L. RS. Infrequent.

Loganiaceae

Spigelia marilandica (L.) L. SCIMF/ILPSF. Infrequent.

Magnoliaceae

Liriodendron tulipifera L. SILPDM. Frequent.

Malvaceae

Hibiscus moscheutos L. SCILF. Frequent.
Sida spinosa L. RS. Frequent.

Melastomataceae

Rhexia virginica L. CIHASDP. Infrequent.

Moraceae

Morus rubra L. SCIMF/ILPSF. Occasional.

Oleaceae

Fraxinus americana L. SILPDM. Frequent.
Fraxinus pennsylvanica Marsh. CIACT. Infrequent.
Fraxinus quadrangulata Michx. SCIMF/ILPSF. Infrequent.
**Ligustrum sinense* Lour. RS. Infrequent.

Onagraceae

Lamiaceae

Blephilia ciliata (L.) Benth. SCIMF/ILPSF. Infrequent.
**Lamium purpureum* L. SCIMF/ILPSF. Frequent
Monarda bradburiana Beck. SILPDM. Infrequent.
Monarda citriodora Cerv. ex Lag. RS. Frequent.
Monarda fistulosa L. RS. Occasional.
**Mosla dianthera* (Buch.-Ham. ex Roxb.) Maxim. RS. Frequent.
**Perilla frutescens* (L.) Britton. RS. Frequent.
Prunella vulgaris L. WHRPB. Frequent.
Pycnanthemum loomisii Nutt. F. Frequent.
Pycnanthemum tenuifolium Schrad. F. Frequent.
Salvia lyrata L. SILPDM. Frequent.
Scutellaria incana Biehler var. *incana*. F. Frequent.
Trichostema dichotomum L. WHRPB. Infrequent.

Lauraceae

Lindera benzoin (L.) Blume. SCIMF/ILPSF. Frequent.
Sassafras albidum (Nutt.) Nees. SILPDM. Infrequent.

Linaceae

Linum medium (Planch.) Britton var. *texanum* (Planch.) Fernald. WHRPB. Frequent.
**Linum usitatissimum* L. RS. Infrequent.

Loganiaceae

Spigelia marilandica (L.) L. SCIMF/ILPSF. Infrequent.

Magnoliaceae

Liriodendron tulipifera L. SILPDM. Frequent.

Malvaceae

Hibiscus moscheutos L. SCILF. Frequent.
Sida spinosa L. RS. Frequent.

Melastomataceae

Rhexia virginica L. CIHASDP. Infrequent.

Moraceae

Morus rubra L. SCIMF/ILPSF. Occasional

Oleaceae

Fraxinus americana L. SILPDM. Frequent.
Fraxinus pennsylvanica Marsh. CIACT. Infrequent.
Fraxinus quadrangulata Michx. SCIMF/ILPSF. Infrequent.
**Ligustrum sinense* Lour. RS. Infrequent.

Onagraceae

Ludwigia palustris (L.) Elliott. SCIMF. Frequent.
Oenothera biennis L. RS. Frequent.

Orobanchaceae

Epifagus virginiana (L.) W. Bartram. SCIMF/ILPSF. Infrequent.

Oxalidaceae

Oxalis violaceae L. SCIMF/ILPSF. Frequent.

Papaveraceae

Sanguinaria canadensis L. SCIMF/ILPSF. Frequent.

Phytolaccaceae

Phytolacca americana L. RS. Infrequent.

Plantaginaceae

Plantago aristata Michx. RS. Frequent.
**Plantago lanceolata* L. SCIMF/ILPSF. Infrequent.
Plantago virginica L. RS. Frequent.
Plantago rugelii Decne. SCIMF/ILPSF. Frequent.

Platanaceae

Platanus occidentalis L. SILPDM. Frequent.

Polemoniaceae

Polemonium reptans L. var. villosum EL Braun. SCIMF/ILPSF. Infrequent

Polygalaceae

Polygala senega L. SCIMF/ILPSF. Frequent

Polygonaceae

**Polygonum cespitosum* Blume var. *longisetum* (Bruijn) AN Steward. SCIMF/ILPSF. Abundant.
**Rumex acetosella* L. CIHASDP. Infrequent.

Portulaceae

Claytonia virginica L. SCIMF/ILPSF. Frequent.

Primulaceae

Dodecatheon meadia L. SCIMF/ILPSF. Frequent.
Lysimachia quadrifolia L. WHRPB. Frequent.
Samolus valerandi L. ssp. *parviflorus* (Raf.) Hulten. SCIMF/ILPSF. Frequent.

Pyrolaceae

Chimaphila maculata (L.) Pursh. SILPDM. Frequent.

Ranunculaceae

Aquilegia canadensis L. SCIMF/ILPSF. Frequent.
Cimicifuga racemosa L. var. *racemosa* Nutt. SCIMF/ILPSF.
Clematis virginiana L. ILPSF. Frequent.
Hepatica acutiloba Schreb. var. *acuta* (Pursh) Steyerm. SCIMF/ILPSF. Infrequent.
***Hydrastis candensis* L. SCIMF/ILPSF. Rare.
Ranunculus hispidus Michx. var. *hispidus* Michx. SILPDM. Infrequent.
**Ranunculus sardous* Crantz. RS. Frequent.
Thalictrum revolutum DC. WHRPB. Infrequent.
Trautvetteria caroliniensis (Walter) Vail. SCIMF/ILPSF. Infrequent.

Rhamnaceae

Ceanothus americanus L. RS. Infrequent.
Rhamnus caroliniana (Walter) A. Gray. SCIMF/ILPSF. Frequent

Rosaceae

Agrimonia rostellata Wallr. SCIMF/ILPSF. Frequent.
Amelanchier arborea (Michx. f.) Fernald. RS. Infrequent.
**Chaenomeles speciosa* (Sweet) Nakai. F. Infrequent
Cretaegus calpodendron (Ehrh.) Medik. SCIMF/ILPSF. Frequent.
Cretaegus crus-galli L. RS. Frequent.
Geum canadense Jacq. SCIMF/ILPSF. Frequent
Geum vernum (Raf.) Torr. & A. Gray SCIMF/ILPSF. Frequent.
**Hibiscus syriacus* L. Frequent.
**Potentilla recta* L. RS. Infrequent.
Potentilla simplex L. RS. Infrequent.
+*Prunus mexicana* S. Watson. SCIMF Infrequent.
**Prunus persica* (L.) Batsch. SCIMF/ILPSF. Infrequent.
**Pyrus calleryana* Decne. RS. Infrequent.
Rosa carolina L. ssp. carolina. RS. Frequent.
Rubus hispidus L. FP. Infrequent.

Rubiaceae

Cephalanthus occidentalis L. SCIMF/ILPSF. Occasional.
Diodia virginica L. CIHASDP. Freqent.
Diodia teres Water. F. Infrqeuent.
Galium circaezans Michx. SCIMF. Occasional.
Galium aparine L. SILPDM. Frequent.
Galium pilosum Aiton. RS. Frequent.
Houstonia caerulea L. SILPDM. Infrequent.
Houstonia purpurea L. SCIMF/ILPSF. Infrequent.
Mitchella repens L. SCIMF/ILPSF. Infrequent.

Salicaceae

Populus deltoides Bartram ex Marsh. RS. Frequent.
Populus grandidentata Michx. RS. Infrequent.
Salix caroliniana Michx. SCIMFL/ILPSF. Infrequent.
Salix nigra Marsh. RS. Infrequent.

Sapindaceae

Acer barbatum Michx. SCIMF. Infrequent.
Acer negundo L. CIACT. Infrequent.
Acer saccharainum L. SCILF. Infrequent.
Acer saccharum Marsh. SCIMFL/ILPSF. Frequent.
Acer rubrum L. var. *trilobum* Torr. & Gray ex. K. Koch. RS. Frequent.

Saxifragaceae

Heuchera americana L. SCIMF/ILPSF. Frequent.
Mitell diphylla L. SCIMF/ILPSF. Infrequent.
Penthorum sedoides L. SCIMF/ILPSF. Frequent.

Schrophulariaceae

Agalinis purpurea (L.) Pennell. RS. Infrequent.
Agalinis tenuifolia (Vahl) Raf. F. Frequent.
Aureolaria flava (L.) Farw. var. *macrantha* Pennell. SILPDM . Frequent.
*Aureolaria virginica (*L.) Pennell. SILPDM. Infrequent.
Chelone glabra L. SCIMF/ILPSF. Infrequent.
Mimulus alata Aiton. SCIMF. Frequent.
**Paulownia tomentosa* (Thunb.) Siebold & Zucc. ex. Steud. RS. Infrequent.
Pedicularis canadensis L. SCIMF/ILPSF. Infrequent.
Penstemon calycosus Small. RS. Infrequent.
Physostegia virginiana (L.) Benth. Ssp. praemorsa (Shinners) Cantino. SCIMF/ILPSF. Frequent.
Scrophularia marilandica. L. SCIMF/ILPSF. Frequent.
**Verbascum thapsus* L. SILPDM. Frequent.

Simbaroubaceae

**Ailanthus altissima* (Mill.) Swingle SILPDM. Abundant.

Solanaceae

Physalis heterophylla Nees. SCIMF/ILPSF. Frequent.
Solanum carolinense L. RS. Frequent.
**Solanum lycopersicum* L. F. Frequent
Solanum ptycanthum Dunal. SCIMF/ILPSF. Occasional.

Staphyleaceae

Staphylea trifolia L. SILPDM. Infrequent.

Thymelaceae

Dirca palustris L. SCIMF/ILPSF. Infrequent.

Ulmaceae

Celtis occidentalis cf. *tenuifolia* L. CIACT. Frequent.
Ulmus alata. Michx. RS. Frequent.
Ulmus rubra. Muhl. SCIMF/ILPSF. Infrequent.

Urticaceae

Pilea pumila (L.) A. Gray. SCIMF/ILPSF. Occasional.

Valerianaceae

Valerianella umbilicata (Sull.) Alph. Wood. WHRPB. Frequent.

Verbenaceae

Phryma leptostachya L. SCIMF/ILPSF. Frequent.
Verbena simplex Lehm. RS. Frequent.

Violaceae

Hybanthus concolor (TF Forst.) Spreng. SCIMF/ILPSF. Frequent.
Viola cucullata Aiton. SCIMF/ILPSF. Frequent.
Viola lanceolata L. CIHASDP. Infrequent.
Viola rotundifolia Michx. SCIMF. Frequent.
Viola sororia Willd. SCIMF/ILPSF. Frequent.
Viola striata Aiton. SCIMF/ILPSF. Infrequent.
Viola bicolor Push. SCIMF/ILPSF. Infrequent

Vitaceae

Vitis aestivalis Michx. var. aestivalis. RS. Frequent.
Vitis labrusca L. SCIMF/ILPSF. Infrequent.

VITA

Clea Klagstad was born to Harold and Lenore Klagstad in Lafayette, Indiana, in February of 1988, shortly after which she moved to Mequon, Wisconsin. She then moved to Chattanooga, Tennessee in 1996, where she later attended Notre Dame High School in Chattanooga. There she was involved in several theatrical activities and represented her classmates as senior class president. She completed her first two years of college at Middle Tennessee State University, where she discovered her interests in the field of Biology. Clea then transferred to the University of Tennessee at Chattanooga to further her education in Ecology and Evolution. Her interest in botany was discovered there and further nurtured at Austin Peay State University through a graduate research assistantship in floristics.

Throughout this study, Clea's interests in community ecology and classification were realized. She graduated on May 4th, 2012, and accepted a job with the Natural Heritage Program in Helena, Montana, as a Wetland Ecologist/Botanist for the summer and a Photo Interpreter working with GIS in the fall and winter. She hopes to gain valuable experience before venturing further into the work world or applying to a PhD program. She hopes to build upon her knowledge of botany and Geographic Information Systems so that she may help preserve and protect the environments that most need it.

Institutional Review Board Approval Letter Paper

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