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A Study Of Forest Herbs And Land Use History In Southern Appalachia: A Mixed Methods Approach

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Abstract

The majority of botanical biodiversity in broadleaf temperate forest ecosystems is found in the herbaceous layer. Because many herbaceous species are highly sensitive to environmental changes and take longer to populate areas than other plant layers, they are useful indicators of both anthropogenic and natural forest disturbance. Most forests in Western North Carolina have been farmed or cleared within the past 100 years and the biodiversity of herbs can provide insight into past land use practices. Farming and clearcutting have been shown to have long-lasting impacts on the biodiversity of the herbaceous layer in secondary forests. Previous land use history and the current composition of the herbaceous layer were investigated at Christmount Christian Assembly (CCA) in Black Mountain, North Carolina. Botanical field sampling was conducted in two plots within the vicinity of an abandoned mid-nineteenth century homestead, located in a rich cove forest at CCA, to provide insight into the biodiversity of the extant herbaceous layer and to determine which herbaceous plants should be included in an interpretive guide for CCA. Plots were comparable in elevation, slope, and aspect. Results showed a 45% herbaceous plant similarity between plots. The most abundant plants were wood nettle (*Laportea canadensis* (L.) Wedd.), violet (*Viola* spp. L.), and sedum (*Sedum ternatum* Michx.), all typical of a rich cove forest. Five herbaceous species were selected for representation in an illustrated, interpretive guide that was created with the intent of eliciting ecological curiosity and place-based critical thinking in CCA visitors.

1. Introduction

1.1. Herbaceous Plants and Anthropogenic Disturbance

The herbaceous plant layer constitutes a mere 1% of plant biomass in forests yet is integral to ecosystem function, forest composition, and biodiversity.[1] Herbaceous species are intimately linked with canopy species and play a significant role in mediating forest health and controlling nutrient cycling. Conservative estimates infer that the herbaceous layer encompasses at least 80% of the species richness in temperate forests.[1] Species-rich herb layers are indicative of species-rich overstories. The herbaceous layer is also the most sensitive layer to disturbance and is thus a valuable indicator of past land use and overall forest health. There are variations in the definition of the herbaceous layer, but herein the herb layer is defined as vascular forest species that typically can not grow taller than 1m, excluding woody plants such as tree seedlings.

The majority of land in North America has been altered for human use, and 85% of forests in North America are <100 years old.[1,2] Secondary forests are habitats that have regrown after previous clearcutting or agricultural practices were abandoned and can be distinguished from primary forests. Forest disturbances, both natural and anthropogenic, have immediate and long-term consequences for forest ecosystems, particularly the herbaceous layer. Many herbaceous forest plants are sensitive to disturbance and are slow colonizing species with low fertility rates and seeds with limited dispersal and range.[1] Duffy and Meier found the herb layer had reduced genetic diversity in secondary forests compared to unaltered reference stands.[3]

Clearcutting and farming have had different short-term and long-term impacts on the herb layer. The short-term effects of anthropogenic timber removal on the herb layer are disputed. Comparing old growth and secondary growth forests, Duffy and Meier found that species richness of the herb layer was severely reduced after clearcut logging and hypothesized that full recovery of the herb layer to pre-disturbance levels of biodiversity would take a minimum of 200 years, or it may not ever fully recover.[3] Using a different study design, Gilliam found that after clearcutting, the herb layer was able to fully regenerate to pre-disturbance levels after only 10 to 20 years.[1] Earlier studies found that slow-colonizing herbs were less abundant in logged stands >50 years of age compared to the primary stands.[1,3]

Conventional farming practices remove, alter, and reduce the complexity of substrate, which may permanently change the composition of forests.[4] In secondary forests that were previously farmed, the biodiversity of the herb layer is reduced and the spatial distribution of populations becomes more homogenized.[3,4,5] Because herbaceous species have evolved to colonize pits and mounds created by fallen canopy trees, reduced substrate complexity removes vital habitat.[2] Furthermore, herbs that have few seeds or large seeds, and herbs that rely on seed dispersal by ants are particularly negatively impacted since these species require specific ecological conditions and more time than other herbaceous plants to recolonize.[3] Additionally, changes in nutrient availability and other soil characteristics such as bulk density due to previous farming have lasting effects on herb layer regeneration and impact herbaceous taxa differently.[3,4]

1.2 Objective

The objective of this study was to examine the interaction between herbaceous plants and previous land use history within a forested landscape from ecological, historical, artistic frameworks. This research was developed and conducted using a mixed methods approach from an intentionally interdisciplinary and anti-colonial framework. From May to August 2021 previous land use and the diversity of the herbaceous layer were studied at Christmount Christian Assembly (CCA) in Black Mountain, NC. The land use history of CCA and the greater Swannanoa Valley was researched in several archives. Plot sampling of herbaceous plants was conducted in a forested area with clear evidence of historic anthropogenic disturbance. An illustrated interpretive guide of selected herbaceous plants found at CCA was created with the intention of promoting ecological curiosity in visitors and to raise awareness of the complex history of the interaction between people, plants and land use in the Southern Appalachian region.

2. Methods

2.1. Study Site

Christmount Christian Assembly is located in Black Mountain, NC, (35.59729°, -82.30632°), within the greater Swannanoa Valley. The property owned by CCA covers an area of 2.51 km^2 within the French Broad Watershed and includes the headwaters of Lakey Creek. Since 2010, approximately 1.62 km^2 of CCA's property (1 km^2 of which is the riparian area for the French Broad basin) is held in a conservation easement with the North Carolina Clean Water Management Trust Fund and overseen by the Southern Appalachian Highlands Conservancy (SAHC).

The botanical portion of this study is organized around the framework of natural community types [6,7] as defined by the National Heritage Program (NHP) in order to situate the herbaceous layer within the broader context of regional-scale ecological patterns. This framework is also useful for cataloging biodiversity and identifying ecosystem responses to natural disturbance regimes. The forested portion of CCA consists primarily of three natural community types: Rich Cove Forest (RCF): Montane Intermediate Subtype (RCF), Acidic Cove Forest (ACF): Typic Subtype, Montane Oak- Hickory Forest (MOH): Acidic Subtype. A small portion of the property consists of the Pine Oak Heath Forest community type (POH): High Elevation Subtype.[2,6]

CCA has several recreation and lodging facilities, a small residential neighborhood, multiple small garden plots, and outdoor chapels. The majority of development has occurred within the valley and lower elevations. Most of the property (1.62 km^2) is deciduous secondary forest that was previously clearcut for timber, and sections of the property were used for agriculture. The forested portion of the property currently hosts a lightly trafficked network of hiking trails.

2.2. Archival Research

From May through July 2021, archival research was conducted at the University of North Carolina Asheville Special Collections, Pack Memorial Library Special Collections, Western North Carolina Historical Association at the Smith-McDowell House, Swannanoa Valley Museum, and the archives and library at CCA. The goal of the archival research was to build a better understanding of land use history at CCA and the greater Swannanoa Valley. Informal interviews with key informants were also conducted at CCA during this period; these included walking tours of the historical areas and trail system.

2.3. Field Sampling

Plot-based sampling was used to document herbaceous species occurrence and gather quantitative data on plant abundance to evaluate biodiversity of the extant flora.[1,8] Several areas were considered for sampling within the forested property of CCA; all were sites with evidence of abandoned homesites and agricultural usage, little evidence of contemporary disturbance, and proximity to the trail system. Geographic Information Systems (GIS) maps of CCA were created using ArcMap 10.6 to assist with plot selection. A slope map of the terrain provided a clarified view of anthropogenic land modifications, and a digital elevation model (DEM) provided accurate elevation data.

In June- July 2021, one abandoned mid- nineteenth century homesite along the Blue Ridge Trail in the forested property of CCA was selected. The center of the homesite had clear evidence of human disturbance, including artificial terracing, a standing stacked-stone chimney, apple trees, some hosta (*Hosta* spp., an herbaceous ornamental perennial plant that was introduced from Europe to North America in the 1830s),[9,10] and forsythia (*Forsythia* spp., an ornamental shrub, introduced from Eurasia to eastern North America in 1918)[11] Within the vicinity of the homesite, a primary plant sampling location (Site 1) was chosen because it was flat enough to have been suitable for farming and had minimal evidence of contemporary natural or anthropogenic disturbance. A secondary sampling location (Site 2) was chosen based on its proximity to the primary location, and its comparable slope, aspect, and elevation. Both sites were located in rich cove forests (RCF), which have the most biodiverse herb layer of the community types represented at CCA and occur frequently within the property.[2] One 10m x 15m plot was situated within each site. Within each plot, 15 0.25-m^2 quadrats were set at random points. Herbaceous taxa rooted within each quadrat were identified to species when possible. For each site, the data were used to calculate taxonomic richness, mean density and frequency of each taxon, and the Shannon Index of Diversity. Sorensen's Coefficient of Community Similarity was calculated to compare the two plots. Frequency was calculated as the percentage of quadrats within each plot that contained each taxon. Abundance of each taxon was calculated by summing the total number of individuals within each quadrat within each plot. Density was calculated for each taxon by summing the total number of individuals within each plot and dividing by the number of quadrats per plot.

2.4. Interpretive Guide of Herbaceous Plants

Five herbaceous species were selected for representation in an interpretive guide and illustrated by hand. Their Cherokee names, scientific names, ecological relationships, and environmental needs were researched and collated into short "plant biographies" for the interpretive guide, which will be made available to visitors at CCA.

3. Results

3.1. Post-colonial Land Use History at CCA and in the Greater Swannanoa Valley

Prior to the beginning of the American Revolutionary War in 1775, the Swannanoa Valley was hunting grounds for the Cherokee and Shawano people.[12,13] By the mid-1760s, 75% of Cherokee territory had been lost through treaties including the area that is now called Black Mountain, North Carolina.[14] The French and Indian War from 1754-1783 prompted colonists to settle in the Swannanoa Valley,[12] and from 1784-1879 a series of land grants allowed European immigrants (Scots-Irish, English, and German) to build subsistence farms in Swannanoa Valley.[13] Due to the affordable price of 25-50 cents an acre, farmers were able to cultivate land until it was nutritionally depleted and then move on to new, fertile, arable land.[12] The town of Grey Eagle (later named Black Mountain) was sparsely populated with farmsteads,[13] but the arrival of the railroad in 1880 incentivized further settling.

Architect Rafael Guastavino y Moreno began purchasing valley and mountain-side acreage in Black Mountain, NC in 1894, accumulating a total of 1088 acres by 1901.[15,16] He chose the location because of its access to the railroad, inexpensive labor, and lumber. Some tracts purchased by Guastavino were likely pre-existing farmsteads owned by settlers. These tracts had probably already been cleared of trees, making the location ideal for further development and agricultural use. In 1895 Guastavino built a house, locally known as the "Spanish Castle"[16], a brick kiln, and several outbuildings on the estate that he named Rhododendron.[16] He greatly modified the land by building roads, digging clay pits, rerouting stream channels, and cultivating cornfields and a vineyard among other crops.[16] Agricultural, timber, and livestock products were sold under the name Rhododendron Farms.[15] Guastavino died in 1908, leaving the estate to his wife Francesca Guastavino. After her death, 543 acres of the estate were sold to the Southeastern Christian Assembly in 1947. In 1953, the property was renamed Christmount and converted into a Christian conference and retreat center.

A timber deed (Reg. book 615 page 359) found in the archive at CCA gave permission to J.A. Dougherty and A.P. Perley of the Black Mountain Lumber Company to clear 1078 acres of all "marketable timber". The deed stipulated that, for a five-year period starting in 1946, any logging roads and sawmills could be built. Marketable timber included any tree greater than 10 inches in diameter, locust trees (*Robinia* spp.) of any size and American chestnut trees (*Castanea dentata* (Marshall) Borkh.) of any size, standing or fallen. A correspondence found in the CCA archive confirmed that the clearcutting occurred from 1947-1949 on all acreage owned by Christmount except the ridgeline, which would not have been "economically feasible" to log at that time. This correspondence also recommended establishing white pine (*Pinus strobus* L.) for later harvest in the cleared area, although no evidence of a planted pine stand was encountered during this study. Other anthropogenic disturbances that have impacted forest composition at CCA include the loss of the American Chestnut due to a fungal blight introduced in the 1930s and the decline of hemlocks (*Tsuga* spp.) due to the non-native hemlock woolly adelgid (*Adelges tsugae* (Annand, 1928)) (HWA) that was introduced to the Southern Appalachians in 2010 (Fig. 1).

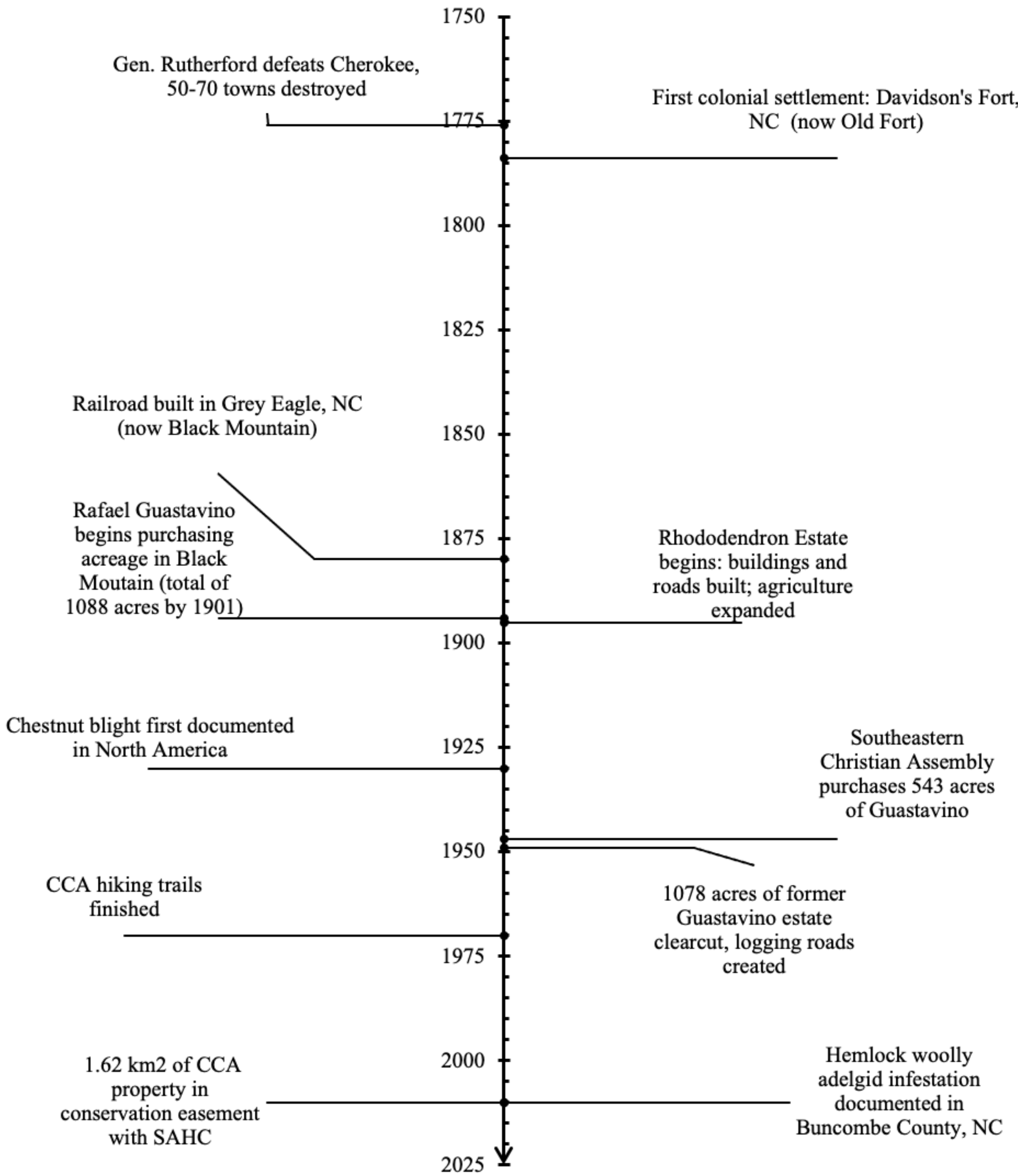

Figure 1. Post-colonial land use history timeline at CCA

3.2. Results Of Botanical Sampling

Site 1 (elev. 2965 ft.) had a slope ranging from 7% to 18% grade and a west to southwest facing aspect. Canopy trees included tulip poplar (*Liriodendron tulipifera* L.), buckeye (*Aesculus flava* Sol.) and black locust (*Robinia pseudoacacia* L.) snags, all characteristic of RCF communities. Understory trees and woody plants included white hickory (*Carya alba* (L.) Nutt., witch hazel (*Hamamelis virginiana* L.), white ash (*Fraxinus americana* L.), northern red oak (*Quercus rubra* L.), musclewood (*Carpinus caroliniana* Walter.), and greenbriar (*Smilax* spp.).

Site 2 (elev. 2880 ft.) had a slope ranging from 10% to 18% and a west to southwest facing aspect. Canopy trees included tulip poplar, and American basswood (*Tilia americana*), white hickory and black locust snags. The understory included witch hazel, white ash, northern red oak, red maple (*Acer rubrum* L.) and black cherry (*Prunus serotina* Ehrh.).

In Site 1, violets (*Viola* spp.) and wood nettle (*Laportea canadensis* (L.) Wedd.) were the most frequent taxa, occurring more consistently in each quadrat than other species. Taxa with intermediate frequency included sedum (*Sedum ternatum* Michx.), sweet cicely (*Osmorhiza claytonii* (Michx.) C.B. Clarke), and Small's black snakeroot (*Sanicula smallii* E.P. Bicknell). In Site 2, sedum and Small's black snakeroot occurred most frequently, while wood nettle, violets and hog peanut (*Amphicarpaea bracteata* L.) had intermediate frequency. Several taxa had very low frequency in one or both plots. Results are shown in Fig. 1 (only plants with frequencies > 13% in one or both plots are included).

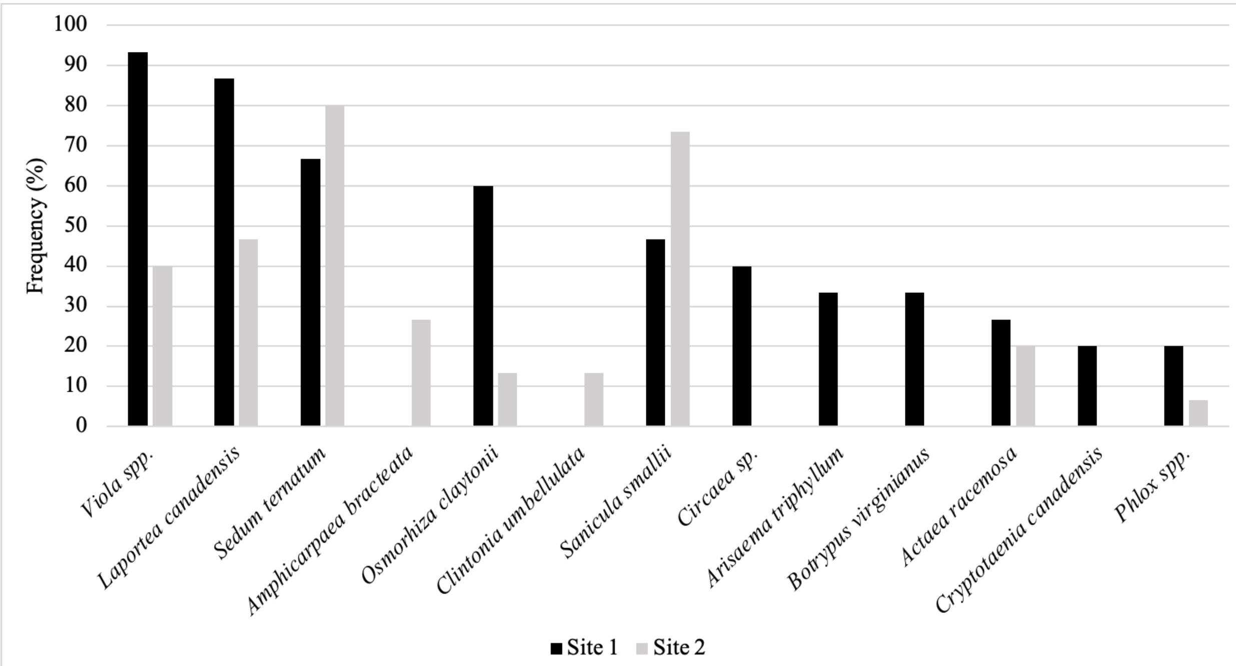

Figure 1. Frequency of herbaceous plant taxa in Site 1 compared to Site 2. Plants included have frequencies > 13% in one or both plots.

Sedum had the highest mean density of any taxa in both plots, but occurred at a much higher mean density in Site 2. Violets were fairly numerous in Site 1, while Small's black snakeroot was found in similar densities to violets in Site 2 (Fig. 2).

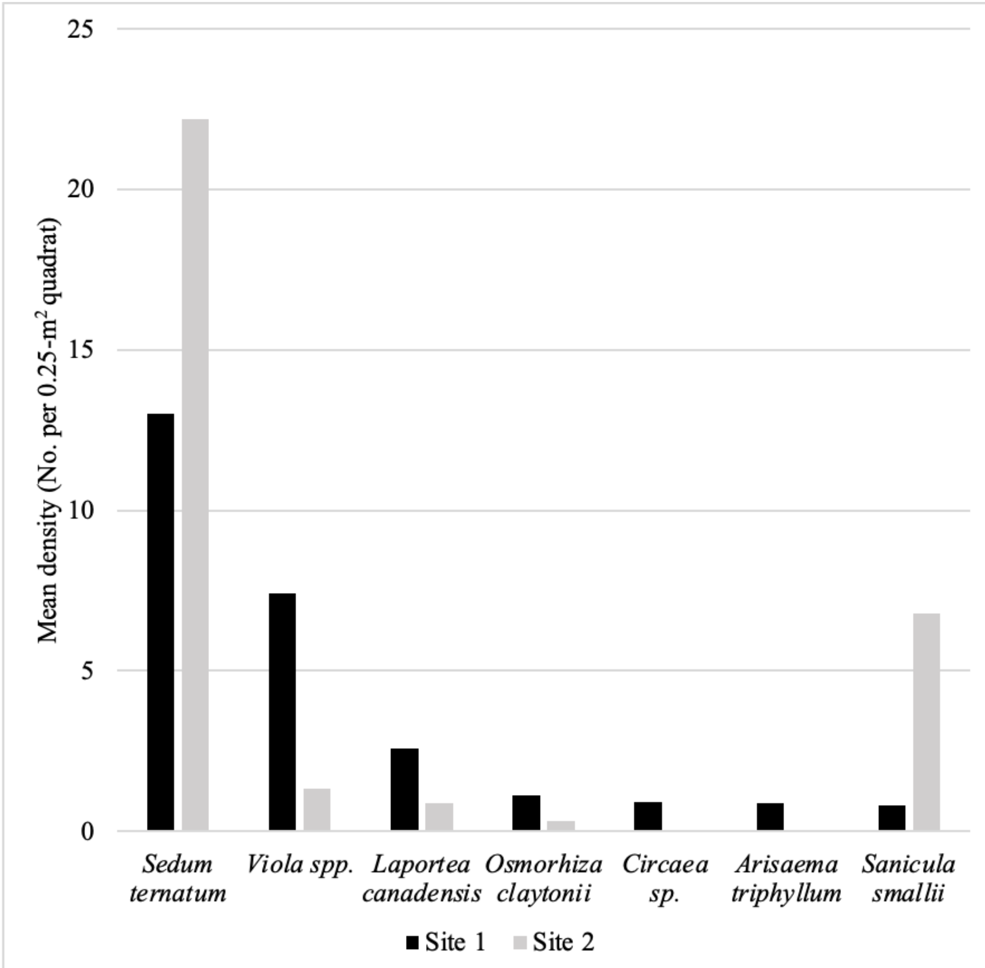

Figure 2. Mean densities of the most abundant herbaceous taxa in Sites 1 and 2.

Site 1 had a higher taxonomic richness than Site 2, and a higher diversity index. The herbaceous communities in the two plots were roughly 45% similar in taxonomic composition (Table 1).

Table 1. Botanical Characteristics and Diversity in Sites 1 and 2

	Site 1	Site 2
Taxonomic richness	36	22
Shannon Diversity Index	2.31	1.37
Sorensen Coefficient	0.45	

3.3. Plant Selection for the Botanical Interpretive Guide

The herbaceous species selected for the interpretive guide had one or more of the following characteristics: abundant in the sampling plots, visually striking features in the spring and summer, and/or occurrence along accessible and popular trails at CCA. Plants were also prioritized if they were characteristic of natural communities other than RCFs on CCA property, [6,7] and if the plant genus was represented in prior botanical and land use history studies conducted in WNC. Plants chosen included three species found during botanical sampling: wood nettle, black cohosh (*Actaea racemosa* L.) and bloodroot (*Sanguinaria canadensis* L.), along with striped wintergreen (*Chimaphila maculata* L.), and rattlesnake plantain (*Goodyera pubescens* (Willd.) R.Br.).

4. Discussion

4.1. Herbaceous Flora at CCA

Despite clearcutting completed in 1949 and an earlier history of farming, the secondary forests at CCA are exceptionally biodiverse with few invasive and non-native species and minimal current human impact.[2] In a recent floristic inventory at CCA, Boyd et al. found that only 4.5% of all plants surveyed were non-native. Consistent with Boyd's findings, no invasive plants were documented in Sites 1 or 2. These observations may indicate that the CCA clearcutting may not have been as impactful or destructive to ecosystem function as clearcutting has been in other forested areas in the Southern Appalachians where invasive plant species are more rampant. However, without sufficient documentation of plant communities prior to farming or clearcutting at CCA these claims cannot be substantiated.

The results of the botanical sampling provided a glimpse into the biodiversity of the regenerating forests of CCA. Both plots supported diverse taxa. Site 1 had 22 taxa and Site 2 had 36 taxa (40% more than Site 1). Sedum had high frequency and density in both plots. Violets were also quite frequent in both plots but were less dense than Sedum in Site 2. Both species are small, low-growing plants. In comparison, wood nettle, a larger and taller herbaceous plant, occurred frequently in both plots but had low density. The differences in density, frequency and taxonomic richness of herbaceous species between two sites so close in proximity illustrate the natural variability across forested landscapes in the region.

4.2. Anthropogenic Disturbance at CCA

Legacies of past land alteration were observed within the vicinity of both plots and throughout CCA. During sampling, introduced European cultivars such as forsythia and hosta were encountered and were interpreted as further evidence of prior human land use. The presence of dead and dying black locust trees around the abandoned homesite and throughout CCA were one of the most important indicators of secondary succession.[17] Black locust is characteristic of early succession and requires full sun to thrive. After disturbance (such as clearcutting) creates a gap in the canopy, pioneer species such as black locust colonize the sunlit area. Black locusts have a relatively short lifespan of 70-100 years and their snags provided clues as to when the forest had last been cleared.[17] The age at death of black locusts at CCA was estimated at 50-70 years, corresponding with timber deed evidence of clearcutting from 1947-1949.

Larger scale anthropogenic disturbances occurring throughout eastern North America have greatly impacted forested ecosystems throughout the Southern Appalachians and can be observed at CCA. In the 1930's the dominant canopy tree, American chestnut (*Castanea dentata* (Marshall) Borkh.), was decimated by an introduced fungal blight (*Cryphonectria parasitica* (Murrill) M.E. Barr). During the survey at CCA, young American chestnut seedlings were observed that had not yet succumbed to the blight.

Throughout WNC, in response to openings in the canopy, the distribution of the understory shrub Rhododendron (*Rhododendron maximum* L.) expanded, altering soil pH, preventing hardwood tree establishment and reducing herbaceous species richness.[18] Rhododendron was well established in both RCF and ACF communities at CCA, and minimal herbaceous growth was observed below or in close vicinity to the rhododendron.

An invasive pest, the hemlock woolly adelgid (*Adelges tsugae* (Annand, 1928)) (HWA), was introduced in North America in the 1950s. This insect kills hemlock trees (*Tsuga* spp.), a riparian species important to ecosystem function. The HWA infestation is especially rampant in the Southern Appalachians due to warmer climates than farther north in the HWA range.[19] Several hemlock snags and fallen hemlock logs were encountered in the RCFs of CCA. Short term impacts of hemlock mortality include changes to aquatic ecosystem composition, increase in hardwood tree growth and Rhododendron expansion. Long term impacts of the HWA are not yet known.[20]

4.3. Legacies of Farming in Soil Profiles

In forests, 4% of net primary productivity (NPP) is produced by the herbaceous layer. Herbaceous plants have shorter life cycles than woody species and contribute up to 16% of fresh plant biomass to the forest litter layer, providing nutrients for the entire ecosystem. The rapid decomposition rate of herbaceous plant litter provides a major source of available nitrogen (N), phosphorous (P), potassium (K^+) and magnesium (Mg^{2+}) in forests.[1] However, in anthropogenically disturbed forests, the role of the herb layer in NPP and nutrient recycling may be notably altered.

Fraterrigo found that herbs in previously farmed secondary forests had more biomass than those in previously clearcut stands or the reference primary forest stands, likely from excess P in soil. Increased biomass did not necessarily indicate more robust herb species populations. The study also found that certain herbs benefitted from soil P increase while others did not.[4] Environmental factors such as soil nutrient availability and spatial heterogeneity distinguish previously farmed stands from previously clearcut stands.

Soil chemistry plays an important role in the composition and regeneration of herbaceous plants.[1,4] Conducting soil research at CCA, such as collecting data on soil P levels, would provide valuable long-term data about impact of previous farming practices on secondary forests and increase the accuracy of mapping previously farmed areas.

4.4. Interpretive Guide to Herbaceous Plants at CCA

The interpretive guide was created for visitors as an intentionally interdisciplinary introduction to the forested landscape of CCA. It combined hand-illustrated depictions, ecological facts and life history traits of five herbaceous plants. In addition to the scientific and common names, the Cherokee names and translations of each plant name were included. The primary researcher and CCA felt it important to acknowledge that the guide was developed from a non-indigenous perspective, and therefore historic cultural uses of the plants were intentionally omitted. Instead, a resource list of diverse authorship was included in the guide relating to the subjects of regional ethnobotany, Cherokee and African American Appalachian medicinal practices, decolonization of conservation and other place-based subjects. The guide was created to elicit curiosity about the botanical biodiversity present at Christmount while also encouraging visitors to consider their personal and ancestral relationships with the natural world.

Two representative illustrations depict black cohosh (*Actaea racemosa*; Fig. 3) and bloodroot (*Sanguinaria canadensis*; Fig. 4).

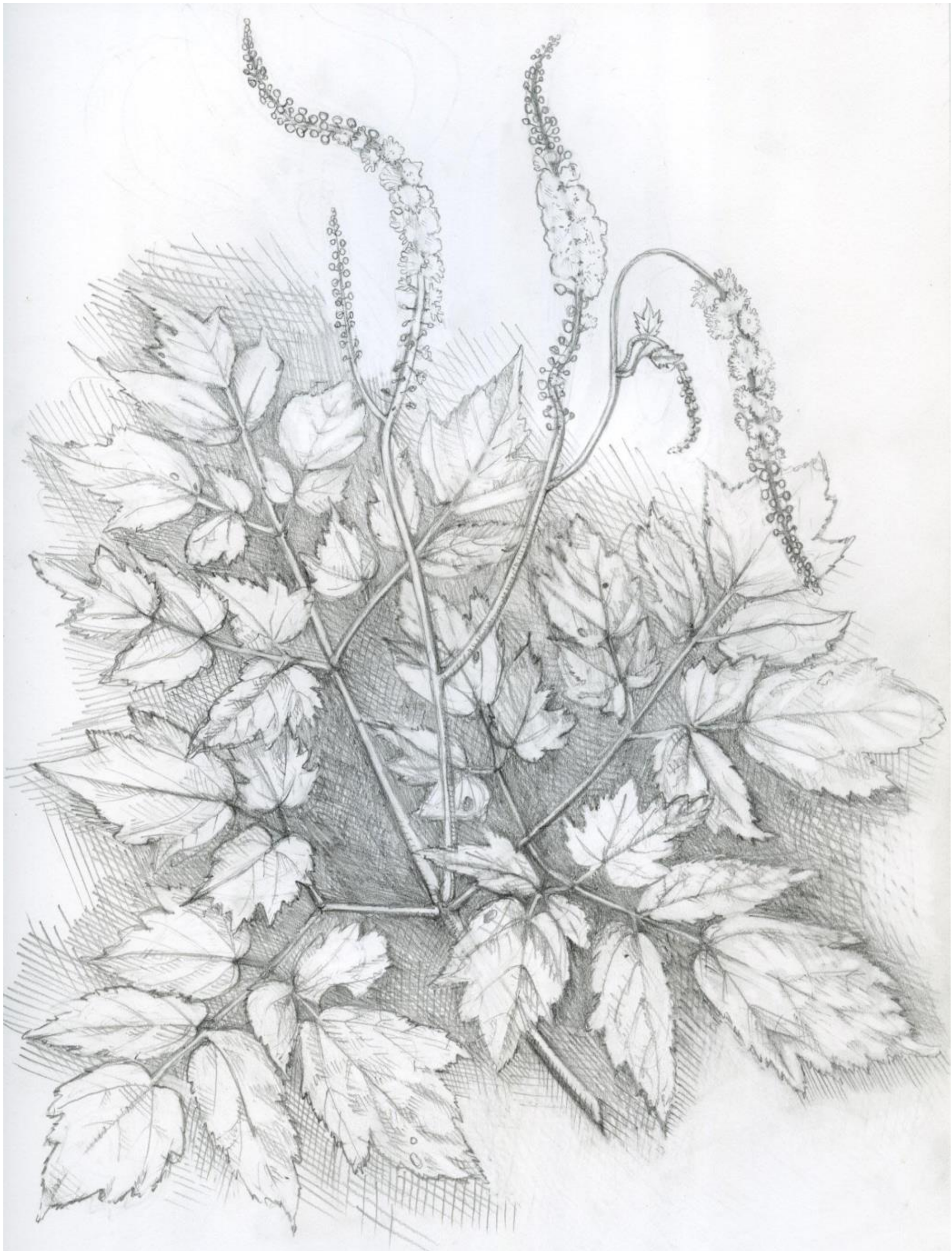

Figure 3. Illustration of black cohosh (*Actaea racemosa*) for CCA interpretive guide

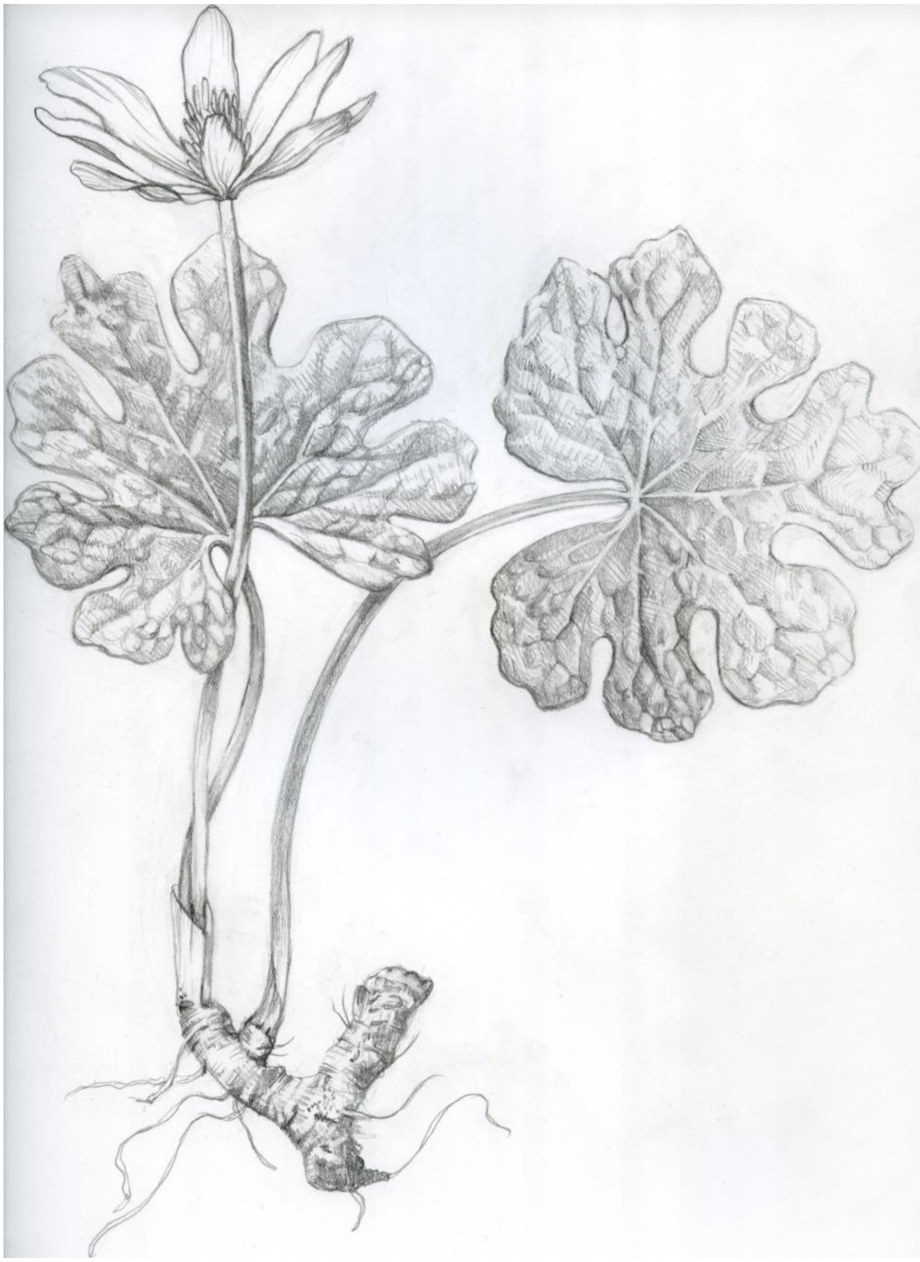

Figure 4. Illustration of bloodroot (*Sanguinaria canadensis*) for CCA interpretive guide

Black cohosh was selected for representation in the guide because it occurred frequently and in abundance throughout the RCFs of CCA and because of its distinctive blooms. The illustration is meant to depict the leaflet shape and orientation on the petiole, and the flower in bloom to assist visitors with identification in the field (Fig. 3). Bloodroot was selected for representation in the guide because it was commonly sighted along trails at CCA and has easily identifiable leaves. The bloodroot illustration was intended to depict the shape and structure of the leaves, flowers and rhizome to help visitors identify bloodroot at CCA (Fig. 4).

5. Conclusion

The results of this study show that the secondary forests of CCA are complex, patchy and varied ecosystems. Results of the botanical sampling revealed a high level of difference in herbaceous plant communities within two sites in close proximity. Archival research at CCA showed that throughout history, CCA's forested property has been modified, farmed and cleared. While no distinct link was found between declines in herbaceous biodiversity and farming or clearcutting at CCA, the impacts of anthropogenic disturbance on the landscape were documented. The interpretive guide was created to introduce visitors to several interconnected topics: the ecological importance of selected herbaceous plants, the implications of past and current anthropogenic disturbance in the forested landscape, and an exploration of personal and ancestral relationships to place.

6. Acknowledgements

Efforts have been made to address institutional colonialism in this project. The primary researcher is a white, upper-middle class, North American, cis-gender female, among other intersectional identities. Therefore, the research has been designed and conducted from a specific, non-native perspective. The researcher felt that transparency about identity provided valuable information about project motive and contextual bias.

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