HISTORY OF BOTANICAL COLLECTORS AT GRANDFATHER MOUNTAIN, NC DURING THE 19TH CENTURY AND AN ANALYSIS OF THE FLORA OF THE BOONE FORK HEADWATERS WITHIN GRANDFATHER MOUNTAIN STATE PARK, NC

A Thesis
by
ETHAN LUKE HUGHES

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Department of Biology

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Abstract

History of botanical collectors at Grandfather Mountain,
NC during the 19th century and an analysis of the flora of the Boone Fork headwaters within Grandfather Mountain State Park, NC

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The Southern Appalachian Mountains have been an active region of botanical exploration for over 250 years. The high mountain peaks of western North Carolina, in particular, have attracted interest due to their resemblance of forest communities in New England and Canada and to their high species diversity. From the middle of the 19th century, Grandfather Mountain has been a destination for famous botanists conducting research in the region. Some of these botanists noted the floristic similarities of the high elevation Southern Appalachian Mountains to communities in the Northern Appalachian Mountains. The intent of this study was to identify the important botanists visiting Grandfather Mountain during the 19th century. Botanists were identified through literature searches, herbarium databases and personal communications. Collections from Grandfather Mountain were accessed through the Southeast Regional Network of Expertise and Collections (SERNEC) database and total specimens were recorded for each collector. Four collectors were selected for this analysis. These four scientists who played an important role in the history of taxonomic and botanical work on Grandfather

Mountain and the Southern Appalachians, Asa Gray, Rev. Moses Ashley Curtis, John K. Small and Amos A. Heller, all contributed to our knowledge of Grandfather Mountain and the species residing there today.

Two river drainages originate on the slopes of Grandfather Mountain: the Watauga and Catawba River watersheds. The Boone Fork headwaters originate on the northeastern slope of Calloway Peak within Grandfather Mountain State Park and represent an area of high natural quality significance. The Boone Fork headwaters drain into the Catawba River watershed and represent an area within Grandfather Mountain State Park for which there is little plant species or natural community data. The second portion of my thesis work focused on the vascular flora, natural communities, and a preliminary list of epipetric mosses collected from dry boulders and rock outcrops within the Boone Fork headwaters. Field research revealed 262 vascular plant species, 19 epipetric mosses, and 18 distinct natural communities. Twenty-four vascular plant species found during field surveys were categorized as state listed or federally listed and three identifications represent new county records. The vascular flora was represented by 76 plant families, ten of which made up over 48% of the species within the BFH.

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I greatly appreciate the help and guidance of Dr. Murrell during my time at Appalachian State University. He helped explain the biology program, the grad school process, and was in communication with me about potential projects before I arrived at App State. Throughout my thesis he provided important insights to processes in grad school and plant taxonomy and ecology. He has been a good friend through this process. I especially thank Dr. Madritch for his help with statistical analysis and review of my thesis. Dr. Davison has been instrumental in helping me to understand the exiting field of bryology and I am very thankful for his help with all of my bryophyte questions. I was very fortunate to have a number of undergraduate students who were very excited about botanical field research and trying to increase their knowledge of the flora of the Southern Appalachian Mountains. Those who helped me during the 2019 field season include Jace Besold, Brandon Turlington, Rachel Milkereit, and Vanessa Gremler.

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Bruce Shinn grant and this was very helpful for travel to and from the field site during the 2019 growing season. The Appalachian State University Office of Student Research and the Graduate Student Government Association provided funding throughout my master's work and this enabled me to acquire essential equipment and present my research at various conferences. The most important support I received during my thesis work was the constant support of my family and friends. My family was always interested in what I was doing and what I had "found" and it was great to have friends in the biology grad program to encourage one another through the process of grad school.

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Foreword

The following information contained in Chapters 1 and 2 of this thesis have been formatted to meet the guidelines of the journal Castanea and will be submitted as two manuscripts.

Introduction

Grandfather Mountain (GM), in the Blue Ridge Mountains of North Carolina, represents one of the most biodiverse sites in the southeastern United States and in 1992 was designated as a UNESCO biosphere reserve. The mountain harbors over 17 unique natural communities and more than 70 species that are considered rare in North Carolina or federally listed through the USFWS. Plant species occur here that are more common in the mountains of New England and the boreal forests of Canada, mainly due to the high elevations and similar climate. The disjunct distribution of these plant taxa was observed in the early 1800s by one of the most famous botanists in North American history, Asa Gray; however, Asa Gray was not the only famous botanist to visit GM. A rich history of botanical collectors passed through the mountains of NC, from the 17th century down to our contemporary time describing new plant species and making critical observations on plant biogeography. A portion of my thesis research investigated the botanical collectors at GM during the 19th century and what contributions they made to the field of botany and plant ecology. The four collectors that contributed the most to furthering our knowledge of the flora of GM and the Southern Appalachian Mountains during the 19th century were Asa Gray, Reverend Moses Ashley Curtis, Arthur A. Heller, and John K. Small. Each of these men played a vital role in the description of GM's flora and natural communities.

The second portion of my thesis research investigated the vascular flora, epipetric mosses, and natural communities of the Boone Fork headwaters (BFH) within Grandfather Mountain State Park (GMSP). The area was specifically targeted after meeting with state park managers due to the lack of knowledge about the community types and plant species within this roughly 1000-acre portion of the state park. Only two trails exist within this area of the park and much of the terrain is very steep, rugged, and difficult to access. I spent a portion of the 2018

growing season and all of the 2019 growing season collecting and documenting the vascular flora, epipetric mosses and natural communities of the BFH. The work was especially important as many rare plants are known from the ridgeline at GMSP, but the BFH likely harbors other rare plant species that may not currently be documented within the state park boundaries.

A subset of the work was focused on a preliminary list of epipetric mosses from the dry portions of boulders and rock outcrops within the BFH due to the high number of boulders within many of the forest stands, ridgelines, and slopes. Mosses are not typically sampled during floristic inventories and many of the bryophyte records for GMSP are over 30 years old and need more current documentation, making this part of my research of particular value to the scientific community. The last part of my thesis work within the BFH was to document the natural communities of the study area. Floristic inventories will often anecdotally list natural communities within their study site but do not perform plot-based sampling to accurately and quantitatively sample the natural communities. I inventoried the natural communities of the BFH through plot sampling, following the Carolina Vegetation Survey method developed by Peet et. al (1998). The historical portion of my thesis will provide an important backdrop to the rich botanical history of GM, an icon of biodiversity in the southeastern United States. The inventory of the vascular flora, epipetric mosses, and natural communities of the BFH will also provide critical natural resource information to park managers and update taxonomic records of species within the state park.

Chapter 1
History of botanical collectors at Grandfather Mountain, NC during the 19th century

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Abstract: The Southern Appalachian Mountains have been an active region of botanical exploration for over 250 years. The high mountain peaks of western North Carolina, in particular, have attracted interest due to their resemblance of forest communities in New England and Canada and to their high species diversity. From the middle of the 19th century, Grandfather Mountain (GM) has been a destination for famous botanists conducting research in the region. Some of these botanists noted the floristic similarities of the high elevation Southern Appalachian Mountains to communities in the Northern Appalachian Mountains. The intent of this study was to identify the important botanists visiting GM during the 19th century. Botanists were identified through literature searches, herbarium databases and personal communications. Collections from GM were accessed through the Southeast Regional Network of Expertise and Collections (SERNEC) database and total specimens were recorded for each collector. Four collectors were selected for this analysis. These four scientists who played an important role in the history of taxonomic and botanical work on GM and the Southern Appalachians, Asa Gray, Rev. Moses Ashley Curtis, John K. Small and Amos A. Heller, all contributed to our knowledge of GM and the species residing there today.

Key words: *Aconitum*, flora, *Saxifraga*, Southern Appalachian, type

Introduction

Botanical exploration in North America by European collectors began in the 1500s, continued steadily through the 1600s, and then declined after 1700 (Reveal 2004). During the 1700s, botanical discoveries were made by intrepid botanists such as Mark Catesby, John and William Bartram, John Fraser, Thomas Walter and André Michaux, who continued the exploration of the vast lands of America and its botanical treasures (Middleton 1925, Hume 1943). Mark Catesby stimulated interest in botany and zoology with his exceptional representations of plants and animals through sketches and watercolor paintings found in his work, *The natural history of Carolina, Florida, and the Bahama Islands* (Catesby and the Royal Society 1729).

A prolific plant collector, John Bartram, established a personal garden on the grounds of his estate south of Philadelphia and sent many of his plant collections to England, where his discoveries were studied by Peter Collinson (Middleton 1925, Hume 1943). Bartram's son, William, followed in the footsteps of his father and became a learned naturalist. The descriptive power with which William Bartram wrote in his *Travels* elucidates vivid imagery of the American southeast and the plants and animals of which Bartram wrote. Bartram relates seeing the ground dove described by Catesby in the area of Savanna, Georgia:

> Catesby's ground doves are also here in abundance: they are remarkably beautiful, about the size of a sparrow, and their soft and plaintive cooing perfectly enchanting. How chaste the dove! 'never known to violate the conjugal contract.' She flees the seats of envy and strife, and seeks the retired paths of peace (Bartram 1791).

From his home near Charleston, South Carolina, Thomas Walter pursued botanical exploration in the adjacent areas of the Carolinas and even collected with another famous

botanist John Fraser (Rembert 1980). Thomas Walter's greatest contribution to the botanical endeavors of the American southeast was his famous *Flora Caroliniana* (Walter 1788). Of the plant species described in *Flora Caroliniana*, 88 species first named and described by Walter are still taxonomically valid today (Rembert 1980). A contemporary of Walter, André Michaux, came to North America as the King's botanist and collected thousands of plants and plant seeds, which he then sent back to France (Reveal 2004). Michaux was one of the first botanists who collected extensively in the Southern Appalachian Mountains and even traveled to GM. He proclaimed that GM was "the most elevated of all those which form the chain of the Alleghenies [sic] and Appalachians (Johnson 2016)."

These 18th century botanists helped pave the way for continued botanical endeavors in the southeast of North America. In the early part of the 19th century, one of the more famous botanists of the period, John Lyon, was exploring the Southern Appalachian Mountains (Ewan and Ewan 1963). Silas McDowell recorded in his journal account on September 2, 1814, that he traveled with John Lyon to Roan Mountain and GM, Yellow Mountain and the Linville "Ravine" (Dunbar 1964). Their travels involved the study of plants and the geology of the mountains of North Carolina and Tennessee (Dunbar 1964). On Lyon's second trip to Roan Mountain, one of the most unique and floristically diverse mountains in North Carolina, he describes the "weather fine, enjoyed a most extensive and curious prospect…got down safe from Rhoan with a valuable collection (Ewan and Ewan 1963)." Lyon advanced our knowledge on the flora of the Southern Appalachian Mountains to a large extent (Ewan and Ewan 1963). William J. Hooker described the herbarium and garden collection of Lyon as being of great use to Frederick Pursh in the description of new species from herbarium specimens of Lyon (Ewan and Ewan 1963). In praise

of John Lyon, Henry Muhlenberg described him “as an indefatigable collector of mountain plants (Ewan 1952).”

Thomas Nuttall was an important naturalist of the early 1800s who contributed greatly to our knowledge of plants in North America (Nuttall 1818). Nuttall received funding from the American Philosophical Society and raised additional monies from sales of seeds and plants to contemporaries (Cutright 1969). His important trips to Virginia, the Carolinas, and Georgia for collection and description of various taxa occurred in the years 1815-1817 (Cutright 1969).

A man of considerable botanical acumen, and a contemporary of Nuttall living in North Carolina at the time, was the Reverend Moses Ashley Curtis (Wood 1885). Curtis was born in Massachusetts and in the year 1830 he arrived in Wilmington, North Carolina as a tutor in the family of Governor Dudley (Wood 1885). He had many daily duties as a minister and tutor, but any spare time was devoted entirely to the study of the local flora (Wood 1885). In spite of having limited time for botanical forays, in the space of two growing seasons he had amassed a collection of 1,031 plant species, half the number of species described in Stephen Elliott’s *Botany of South Carolina and Georgia* (Wood 1885). During his study of the flora around Wilmington, Curtis maintained a regular correspondence with renowned botanist John Torrey (Petersen 1988). Curtis was more than capable of identifying previously published taxa, but would solicit help from Torrey on identifications of more difficult and possibly undescribed taxa (Petersen 1988).

Before returning to Massachusetts in 1833 to continue his education, he began work on the *Enumeration of Plants Growing Spontaneously Around Wilmington, North Carolina,* which was published in 1834 (Wood 1885). Curtis returned to North Carolina in 1834, and in the summer of 1839 departed on a floristic expedition to the mountains of North Carolina to follow

in the footsteps of André Michaux (Wood 1885). He continued his communication with John Torrey and Asa Gray and had a list of plant species he hoped to collect in his expedition to the mountains, including *Carex fraseri* Andrews (Petersen 1988). Curtis departed on June 8, 1839 for the mountain region, where he visited Table Rock, Grandfather, and Roan Mountain, the Black and Balsam Mountains, the Cowee Mountains and the Little Tennessee River (Petersen 1988). Curtis was one of the most important botanists of this period contributing to our knowledge of the Southern Appalachians and the flora of GM (Wood 1885, Petersen 1988).

After receiving many specimens from Curtis during Curtis' botanical foray in 1839, Asa Gray became interested in exploring western North Carolina for himself (Petersen 1988). Gray communicated with Curtis in 1841 regarding his intentions of plant collecting in the North Carolina Mountains, for which Curtis provided long and detailed information of the area to Gray (Petersen 1988). On July 9, 1841, Gray ascended GM and noted species of particular interest: *Carex fraseri* Andrews , *Geum radiatum* Michx., *Pycnanthemum montanum* Michx., *Saxifraga careyana* A. Gray, *Conioselinum chinenese* (L.) Britton, Sterns, & Poggenb., and *Aconitum reclinatum* A. Gray (Gray 1889a). Gray described GM as " the highest as well as the most rugged and savage mountain we had yet attempted (Gray 1889a, Johnson 2016)." Gray found other taxa of interest along the slopes of GM and described the forests of the summit as having "the most perfect resemblance to the dark and somber forests of the northern parts of New York and Vermont…the vegetation is essentially Canadian (Gray 1889a)."

Almost 75 years later, John W. Harshberger described the plant ecology of the mountains of western North Carolina, noting the similar vegetation zones of the high elevations forests to those of the northeastern United States (Harshberger 1903). Many northern plant species occur in the high elevation forests and vegetation communities of the Southern Appalachian Mountains,

such as *Sibbaldia retusa* (O.F. Müll.) T. Erikss., *Oxalis montana* Raf., *Paronychia argyrocoma* (Michx.) Nutt., and other unique or rare plant species (Harshberger 1903).

Harshberger (1903) spoke of three forest zones, or floras, that composed the Southern Appalachian Mountains: the Upper Austral (Carolinian) zone, the Alleghenian (Transition) flora, and the Hudsonian flora of the highest elevations above 1830m. In 1913, Cooper observed the similarities of the boreal forest of Isle Royale on Lake Superior to the high elevation spruce-fir forests of the Southern Appalachians (Cooper 1913). Roughly 40 years later, comparisons were made to the overall similarities of the spruce-fir forests of the Northern and Southern Appalachian Mountains, pertaining to their floristic composition (Oosting and Billings 1951). The similar floristic and community structure of the Northern and Southern Appalachians Mountains has spawned continued research seeking to understand the underlying mechanisms of how and why these communities are so alike despite their geographic separation (Oosting and Billings 1951, Wiser 1998).

GM fits this biogeographical comparison; however, there are several characteristics that make GM unique in the Appalachian Mountains. It is one of few Appalachian mountain peaks that has a large vertical rise from its base (4800’ in the case of GM) (Johnson 2016). An elevational gradient of this magnitude, provides for a large number of potential plant community types that may occur in close proximity, due to the elevational rise and climatic factors affecting the vegetation (Harshberger 1903). GM is very rugged in its appearance, with many rock outcrops at the summit and on the slopes of the mountain, providing habitat for rare plant species associated with the outcrops (Wiser 1994, 1998, Wiser et al. 1996). These characteristics are the likely reasons why GM has been a treasured destination of botanical enthusiasts for centuries.

The collections made from GM, in the period of the early 1800s to the early 1900s, provide details into the early botanical explorations of this peak. It is the purpose of this study to investigate the plant collectors of this period, the herbarium vouchers collected from GM, and how their collections contributed to our knowledge of the flora and ecology of GM. We will focus on four important collectors of this period: Asa Gray, Rev. Moses Ashley Curtis, John K. Small, and Amos A. Heller. A brief overview of the collectors will be done, number of type specimens from GM will be reported, rare plant species records will be reported, and finally we will discuss the importance of the collector's findings to the knowledge of GM and its unique flora.

Methods

To better understand the four botanists and their collections at GM, we employed a variety of research techniques. The pertinent literature was examined through various online databases, mainly the Appalachian State University library database. Through this effective tool, we searched peer-reviewed journals describing the collectors, their expeditions to GM, and the herbarium vouchers they collected. Additionally, we were able to use the Southeast Regional Network of Expertise and Collections (SERNEC Data Portal 2018) database in order to search for herbarium records of plant species occurring on GM and their associated collectors. SERNEC allowed us to search for specimens collected on GM from our suite of collectors. Subsequently, we then could identify important collections, such as type specimens and rare plant specimens, collected on GM.

Plant names will be given as they occurred on the original herbarium sheet. The currently accepted taxonomic names will be displayed in a table at the end of the manuscript following Weakley (2015). Authority will be given following *Authors of Plant Names* (Brummitt and

Powell 1992). Rare plant herbarium records will be listed without specific site info due to the sensitivity of their populations. State rankings for rare plants are cited from Nature Serve Explorer Comprehensive Species Reports (NatureServe 2019).

Results

A total of 140 herbarium sheets compose the collections made by Gray, Curtis, Small, and Heller during roughly 52 years of collections at GM (SERNEC Data Portal 2018). Curtis has only one specimen collected and described by him, at this time, attributed to GM. A possible explanation is that he often sent material he deemed to be new species to other more competent botanists (Petersen 1988). Gray, Small, and Heller had 12, 79, and 48 herbarium sheets attributed to GM, respectively (SERNEC Data Portal 2018). Of the 140 herbarium specimens collected by Gray, Curtis, Small, and Heller, seven specimens are representative of type material and 14 specimens represent plant species currently listed as vulnerable, imperiled or critically imperiled in North Carolina (Table 1.) The contributions of Asa Gray, Rev. Moses A. Curtis, John K. Small, and Amos A. Heller provide us with insights into some of the flora at GM during the 19th century.

Rev. Moses Ashley Curtis can be credited with re-invigorating botanical exploration in the Southern Appalachians close to the middle part of the 19th century (Petersen 1988). By the year 1835, he had published his *Enumeration of Plants Growing Spontaneously Around Wilmington, North Carolina* and was anxious to explore the high country to the west of Wilmington (Wood 1885, Petersen 1988). Curtis set out for the mountains of North Carolina in the year 1839 (Petersen 1988). His expedition would later prove to be of great benefit to collectors such as Gray (Petersen 1988).

Curtis provided a detailed account of his wanderings across the mountains of North Carolina, but spoke very little of GM, except to advise Gray that he believed the flora of GM was richer and more interesting than the Black Mountains (Petersen 1988). He did collect one specimen (Fig 1.) on GM that proved to be a new species: *Solidago curtisii* Torr. & A. Gray (SERNEC Data Portal 2018). The information Curtis provided to Gray greatly aided Gray's trip to North Carolina in 1841 (Petersen 1988). Gray praised Curtis by saying, "No living botanist, however, is so well acquainted with the vegetation of the southern Allegheny Mountains…as Rev. Mr. M. A. Curtis (Gray 1889a)." Curtis' collection of *Solidago curtisii* Torr. & A. Gray is housed at the New York Botanical Garden herbarium (SERNEC Data Portal 2018).

Described by some as the "greatest American botanist", Asa Gray's importance to American botany cannot be understated (1810.-Asa Gray.-1885). He co-authored the monumental publication *A Flora of North America* with fellow botanist John Torrey (Torrey and Gray 1838). In the late 1830s, Gray began communication with Rev. Moses Ashley Curtis and planned a collecting trip to the Southern Appalachians in the immediate future (Petersen 1988). In 1841, Gray traveled to the mountains of North Carolina (Petersen 1988). He corresponded with Curtis in hopes of determining where he should go during his expedition (Petersen 1988). Curtis obliged readily and provided a plethora of information to Gray, of which he later credited Curtis for his successful foray into the North Carolina Mountains (Petersen 1988).

Gray documented his travels to the mountains of North Carolina in the publication: *Notes of a Botanical Excursion to the Mountains of North Carolina* (Gray 1889a). The meticulous description of their journey and the plants Gray collected provide us with exciting insights into the botanists' discoveries (Gray 1889a). He and his party ascended GM on July 9, 1841, and found several species Gray desired (Gray 1889a). The first plant which provided much

excitement was *Carex fraseriana* Ker Gawl. (Fig. 2) on a ridge several hundred feet above the Watauga River (Gray 1889a). Gray also commented on the "new Saxifrage" (*Saxifraga careyana*) appearing at GM that they had previously collected on Mount Jefferson in Ashe County, NC (Gray 1889a). As they proceeded up the mountain, they met with two other taxa of great interest: *Conioselinum chinense* (L.) Britton, Sterns, & Poggenb. and a new *Aconitum*, that Gray would later describe as *Aconitum reclinatum* A. Gray (Gray 1889a). Gray made two more collections near the summit of GM; *Solidago glomerata* Michx. and *Geum geniculatum* Michx., the latter of which is found only in a few counties of Tennessee and North Carolina (Gray 1889a).

Asa Gray's total collections at GM included two collections of *Solidago glomerata* Michx., two collections of *Solidago spithamaea* M. A. Curtis, one collection of *Solidago lancifolia* (Torr. & A. Gray) Chapm., four specimens of *Saxifraga careyana* A. Gray, one specimen of *Saxifraga caroliniana* A. Gray, one specimen of *Luzula acuminata var. carolinae* (S. Watson) Fernald, and a single specimen of *Carex fraseriana* Ker Gawl. (SERNEC Data Portal 2018). Three of the specimens collected by Gray at GM were type specimens: *Saxifraga caroliniana* A. Gray (Fig. 3), *Saxifraga careyana* A. Gray, and *Luzula acuminata var. carolinae* (S. Watson) Fernald (SERNEC Data Portal 2018).

One of the foremost botanists of the early 20th century, especially in the flora of the southeastern United States, was John K. Small (Core 1938). He later became the first curator of museums at the esteemed New York Botanical Garden, but his first introduction to the flora of the southeast was a botanical foray to the mountains of North Carolina with fellow botanist Amos A. Heller (Small and Heller 1892, Core 1938). Small described their trip to various sites in

the mountains of North Carolina, and provided details of the day they summited GM (Small and Heller 1892).

He speaks in rather comical tones of their hike up GM: “quite the task for our unseasoned limbs” (Small and Heller 1892). Even with this supposed “difficulty”, they reached the summit by midday, observing several plant species along the way, such as, *Cardamine clematitis* Shuttlw. ex S. Watson (Small and Heller 1892). Small noted several plant species occurring on the summit of GM (Small and Heller 1892). He described a number of plants blooming in the vicinity of the spring on GM, which Gray mentioned in his account of 1842 (Gray 1889a, Small and Heller 1892). Small collected at least 79 plant specimens on GM for which we have records and two of them were rare species: *Rhododendron vaseyi* A. Gray and *Zigadenus leimanthoides* A. Gray (SERNEC Data Portal 2018). The vast majority of Small’s vascular herbarium specimens are graminoids, many of which are common species, with the remainder of specimens representing trees, shrubs and herbaceous species (SERNEC Data Portal 2018). Small also collected a large number of bryophyte specimens at GM during the summer of 1891 (Small and Heller 1892). In the appendix of *The Flora of Western North Carolina and Contiguous Territory*, he lists all the mosses collected during their trip, of which 124 specimens were collected at GM (Small and Heller 1892, Consortium of North American Bryophyte Herbaria 2019). The 124 specimens represented vouchers for ~38 species of moss occurring on GM (Small and Heller 1892).

The collecting trip of Small and Heller in 1891 would prove to be a springboard for Small, focusing on the flora of the southeast, particularly that of Florida (Core 1938). For the next 40 years, he spent countless collecting trips in the southeastern United States gathering plant

specimens and preparing his monumental work: *A Manual of the Southeastern Flora*, the last edition published in 1933 (Core 1938).

Amos A. Heller was another important botanist of the late 19th to early 20th century and appeared in the high country of North Carolina in the year 1890 (Heller 1891, Santiago-Valentín 2005). Heller headed for the mountains of North Carolina onboard a train from Lenoir, North Carolina to Blowing Rock (Heller 1891). It was the 17th of July and his excitement is palpable as he rode into the mountains for the first time and noted "Grandfather towers above all the rest like a huge sentinel (Heller 1891)."

On the 22nd of July, Heller departed for GM collecting specimens along the way (Heller 1891). He was quick to note the arduous task of climbing GM, but was rewarded shortly with the discovery of a population of *Goodyera repens* (Linnaeus) R. Brown (Heller 1891). Heller noted, "About half way up is what may be termed the moss belt, for the ground, trunks of trees, logs and rocks, are covered with a thick cushion of moss, and growing in it was *Oxalis Acetosella* L., with its pretty pink-veined petals" (Heller 1891, Weakley 2015). Heller noted the same spring Asa Gray reported in his travels to GM nearly 50 years prior, and it was below this spring that Heller collected an important and rare plant species Gray had described on his trip to North Carolina in 1841: *Aconitum reclinatum* A. Gray (Gray 1889a, Heller 1891). Other plants he described on his hike were *Chelone lyonii* Pursh, *Diphylleia cymosa* Michx., and more common species to the area (Heller 1891).

Heller would return to GM the same year on August 22nd and collect, among others, *Geum geniculatum* Michx. (Heller 1891). In the summer of 1891 he would visit GM again with John K. Small for another expedition into the mountains of North Carolina (Small and Heller 1892). Heller's plant collections on GM number 48 total specimens (SERNEC Data Portal

2018). Of these collections, one specimen was determined to be a new species (Fig. 4): *Aster chlorolepis* Burgess (Weakley 2015, SERNEC Data Portal 2018). Amos A. Heller went on to study mainly in the western United States, where he was a prolific collector and describer of new plant species (Heller 1895, 1897). He also was one of the foremost authorities on *Lupinus* taxa in the western U. S., where he regularly published on new material and taxonomic revisions (Heller and Kennedy 1909).

The information collected from each of these botanists at GM provided some of the first glimpses into the similarities of the Southern and Northern Appalachian Mountain floras. Gray comments in writing to William J. Hooker that there were many northern species present at Mount Jefferson in Ashe County, NC, which they did not have room (in the paper) to enumerate on (Gray 1889b). Gray noted the occurrence of *Potentilla tridentata* (*Sibbaldia retusa* (O.F.Müll.) T.Erikss.) and *Carex conoidea* Willd. on Bluff Mountain, *Lycopodium selago* (*Huperzia appressa* (Desv.) Á.Löve & D.Löve) on Phoenix Mountain, *Paronychia argyrocoma* Nutt. on the "highest and most exposed peaks", and *Woodsia ilvensis* (L.) R.Br. (presumably in Amphibolite Macrosite Area?) in their collections (Gray 1889b). All of these taxa occurring in the Northern Appalachian Mountains (Kartesz 2015).

John K. Small relates several northern species occurring at GM in the summer of 1891, such as, *Clintonia borealis* Raf., *Carex canescens* var. *alpicola* (*Carex brunnescens* subsp. *sphaerostachya* (Tük.) Kük.), *Goodyera repens* R.Br., and *Platanthera orbiculata* Lindl. (Small and Heller 1892). Heller described some plant taxa from his first trip to the mountains of North Carolina in 1890 that are known to occur in the Northern Appalachians (Heller 1891). Plant taxa he described from Blowing Rock were *Potentilla tridentata* (*Sibbaldia retusa* (O.F.Müll.) T.Erikss.) and *Paronychia argyrocoma* Nutt. (Heller 1891). He proceeded on to GM and

described northern species *Oxalis acetosella* (*Oxalis montana* Raf.) and *Streptopus roseus* (*Streptopus lanceolatus* (Ait.) Reveal var. lanceolatus) (Heller 1891).

The collections made by these four botanists during a 52 year period began to demonstrate the associated floras of the high-elevation forests of the Southern and Northern Appalachian Mountains (Gray 1889b, Heller 1891, Small and Heller 1892, Harshberger 1903, Oosting and Billings 1951, Petersen 1988). We are indebted to the persistence of each of these men in their determination to uncover the botanical treasures of the Southern Appalachian Mountains, particularly those contained on the slopes and summit of GM.

Table 1. Table representing the collections of Asa Gray, Rev. Moses A. Curtis, John K. Small and Amos A. Heller from Grandfather Mountain. Only type material and rare plant species are shown in the table with plant status based on Nature Serve Comprehensive species reports. *The *Angelica curtisii* Michx. specimen does have label info attributed to Grandfather Mountain and was collected by M. A. Curtis; however, we could not be fully certain of its type locality.

Taxon	**Current Name**	**Authority**	**A. Gray**	**M. A. Curtis**	**J. K. Small**	**A. A. Heller**	**Herbarium (Code)**	**Specimen Type**	**Plant Status**
Saxifraga careyana	*Micranthes careyana*	Small	Coll.				NY	Isotype	G3S3
Smilax rotundifolia var. crenulata	*Smilax rotundifolia*	L.			Coll.		NY	Syntype	G5S5
Picea australis	*Picea rubens*	Sarg.			Coll.		NY	Holotype	G5S3
Saxifraga caroliniana	*Micranthes caroliniana*	Small	Coll.				NY	Lectotype	G3S3
Solidago curtisii	*Solidago curtisii*	Torr. & A. Gray		Coll.		Coll.	NY	Holotype	G4G5S3?
Aster chlorolepis	*Eurybia chlorolepis*	(Burgess) G. L. Nesom				Coll.	NY	Holotype	G4S3
Solidago glomerata	*Solidago glomerata*	Michx.	Coll.			Coll.	F:Botany, NY, BRU		G3S3
Solidago spithamaea	*Solidago spithamaea*	M. A. Curtis ex A. Gray	Coll.				NY		G2S2
Carex fraserianus	*Carex fraseriana*	Ker Gawl.	Coll.				NCU		G4S3
Abies fraseri	*Abies fraseri*	(Pursh) Poir.			Coll.		CM, NY		G2S2
Carex brunnescens ssp. sphaerostachya	*Carex brunnescens ssp. sphaerostachya*	Boeckeler (Tuck.) Kük.			Coll.	Coll.	MO, NY		G5S3
Oxalis acetosella	*Oxalis montana*	Raf.				Coll.	PH		G5S3
Cacalia reniformis	*Arnoglossum reniforme*	(Hook.) H. Rob.				Coll.	PH		G4S3
Geum geniculatum	*Geum geniculatum*	Michx.				Coll.	NY		G2S1S2
Rhododendron vaseyi	*Rhododendron vaseyi*	A. Gray			Coll.	Coll.	NY, MO		G3S3
Robinia hispida var. fertilis	*Robinia hispida var. fertilis*	(Ashe) R. T. Clausen				Coll.	NCU		G4T1QS1

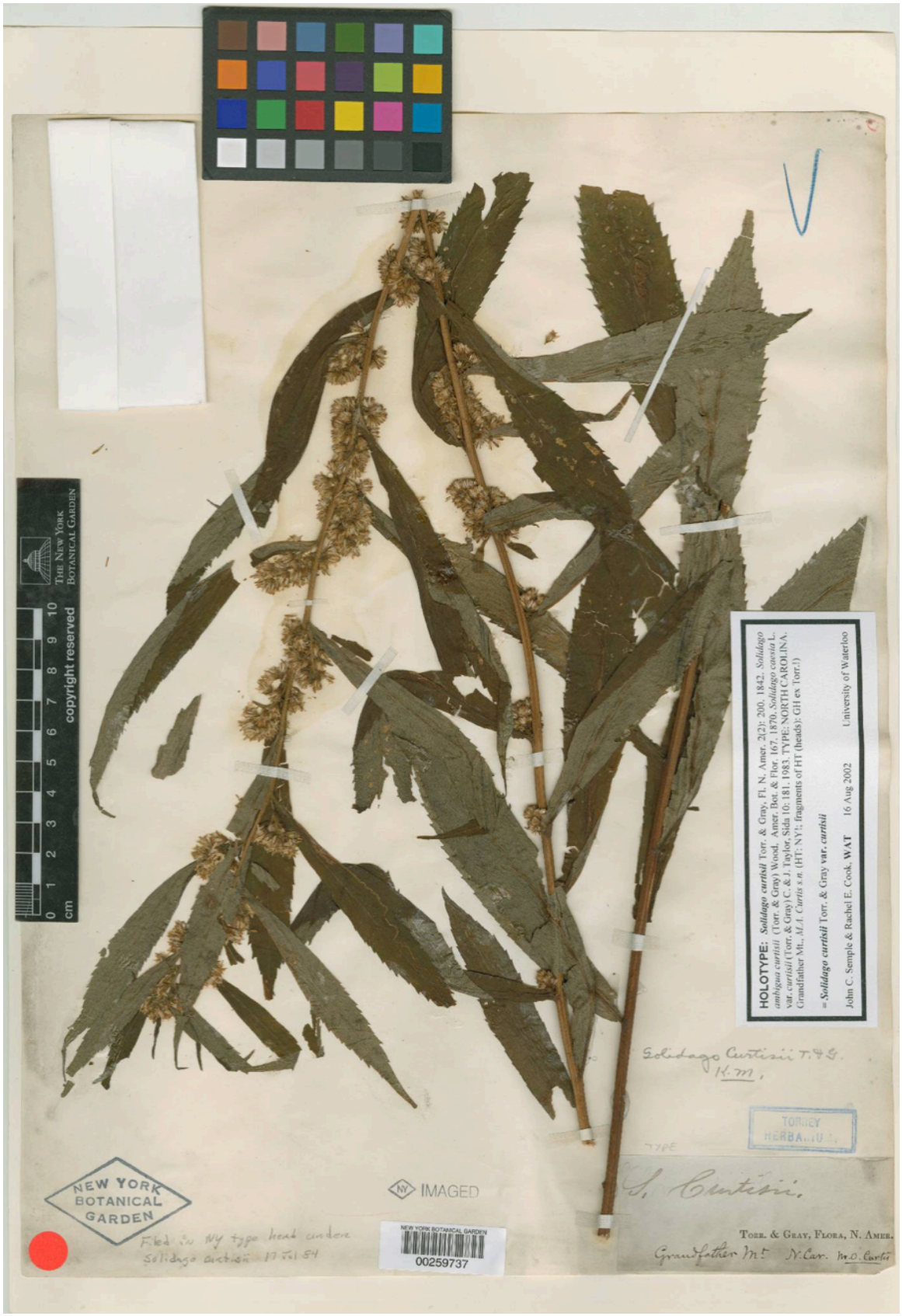
Pycnanthemum montanum	*Pycnanthemum montanum*	Michx.				Coll.	NCU		G4S3
Leiophyllum buxifolium	*Kalmia buxifolia*	(Bergius) Gift, Kron, & P. F. Stevens				Coll.	NCU		G4S3
Zigadenus leimanthoides	*Stenanthium leimanthoides*	(A. Gray) Zomlefer & Judd			Coll.	Coll.	FLAS, NCU		G4QS1
**Angelica curtisii*	*Angelica triquinata*	Michx.		Coll.			NY	Type	G4S4

Figure 1. Herbarium specimen of *Solidago curtisii* Torr. & A. Gray collected at Grandfather Mountain by Rev. Moses A. Curtis (1839?). The specimen is housed at the New York Botanical Garden herbarium.

Figure 2. Herbarium specimen of *Carex fraseriana* Ker Gawl. collected by Asa Gray on Grandfather Mountain in July of 1841. The specimen is housed at the University of North Carolina at Chapel Hill herbarium.

Figure 3. Herbarium specimen of *Saxifraga caroliniana* A. Gray collected at Grandfather Mountain by Asa Gray in 1841. The specimen is housed at the New York Botanical Garden herbarium.

Figure 4. Herbarium specimen of *Aster chlorolepis* (Burgess) G. L. Nesom collected at Grandfather Mountain by Amos A. Heller on August 25, 1893. The specimen is housed at the New York Botanical Garden herbarium.


HOLOTYPE: Solidago curtisii Torr. & Gray, Fl. N. Amer. 2(2): 200. 1842. Solidago ambigua curtisii (Torr. & Gray) Wood. Amer. Bot. & Flor. 167. 1870. Solidago caesia L. var. curtisii (Torr. & Gray) C. & J. Taylor, Sida 10: 181. 1983. TYPE: NORTH CAROLINA. Grandfather Mt., M.A. Curtis s.n. (HT: NY!; fragments of HT (heads): GH ex Torr.)
= Solidago curtisii Torr. & Gray var. curtisii
John C. Semple & Rachel E. Cook, WAT 16 Aug 2002 University of Waterloo
Solidago Curtisii T. & G.
H. m.
TORREY HERBARIUM
TYPE
S. Curtisii.
Torr. & Gray, Flora, N. Amer.
Grandfather Mt. N. Car. M.O. Curtis
NEW YORK BOTANICAL GARDEN
Filed in NY type head cuttings Solidago curtisii 17 Jul 84
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THE NEW YORK BOTANICAL GARDEN
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NCU
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University of North Carolina at Chapel Hill
UNIVERSITY OF NORTH CAROLINA HERBARIUM NCU
578436
24ColorCard
JESUP HERBARIUM GIFT TO NCU 2002 DARTMOUTH COLLEGE
University of North Carolina Herbarium (NCU)
Cymophyllus fraserianus (Ker-Gawler) Kartesz & Gandhi
Annot. Lisa Giencke 17 March 2005
Avery County, N. Caroline
Cymophyllus fraseri (Andr.) Mackenz.
JESUP HERBARIUM
HERBARIUM OF DARTMOUTH COLLEGE
Name,
Locality,
Collected by
Carex Fraseriana
In Carolinæ Septentrionalis,
legerunt A. Gray et J. Carey, Julio 1841.
UNIVERSITY OF NORTH CAROLINA HERBARIUM
NCU00053276


TORREY HERBARIUM.
cm 0 1 2 3 4 5 6 7 8 9 10
copyright reserved
THE NEW YORK BOTANICAL GARDEN
North Carolina State University
SAXIFRAGA CAROLINIANA Gray
R. M. Weber December, 1981
THE UNIVERSITY OF TENNESSEE
Saxifraga caroliniana Gray
LOIS P. LORD 2 August 19 58
COLUMBIA COLLEGE
HERBARIUM,
NEW YORK
LECTOTYPE
= S. Grayana Britton.
= Micranthes Grayana (Britton) Small
M. Caroliniana (A. Gray) Small.
Examined for NORTH AMERICAN FLORA
HERBARIUM OF COLUMBIA COLLEGE, NEW YORK.
Saxifraga Caroliniana A. Gray
A. Gray & J. Carey - July, 1841
Grandfather Mt., N. C.
NEW YORK BOTANICAL GARDEN
00186171
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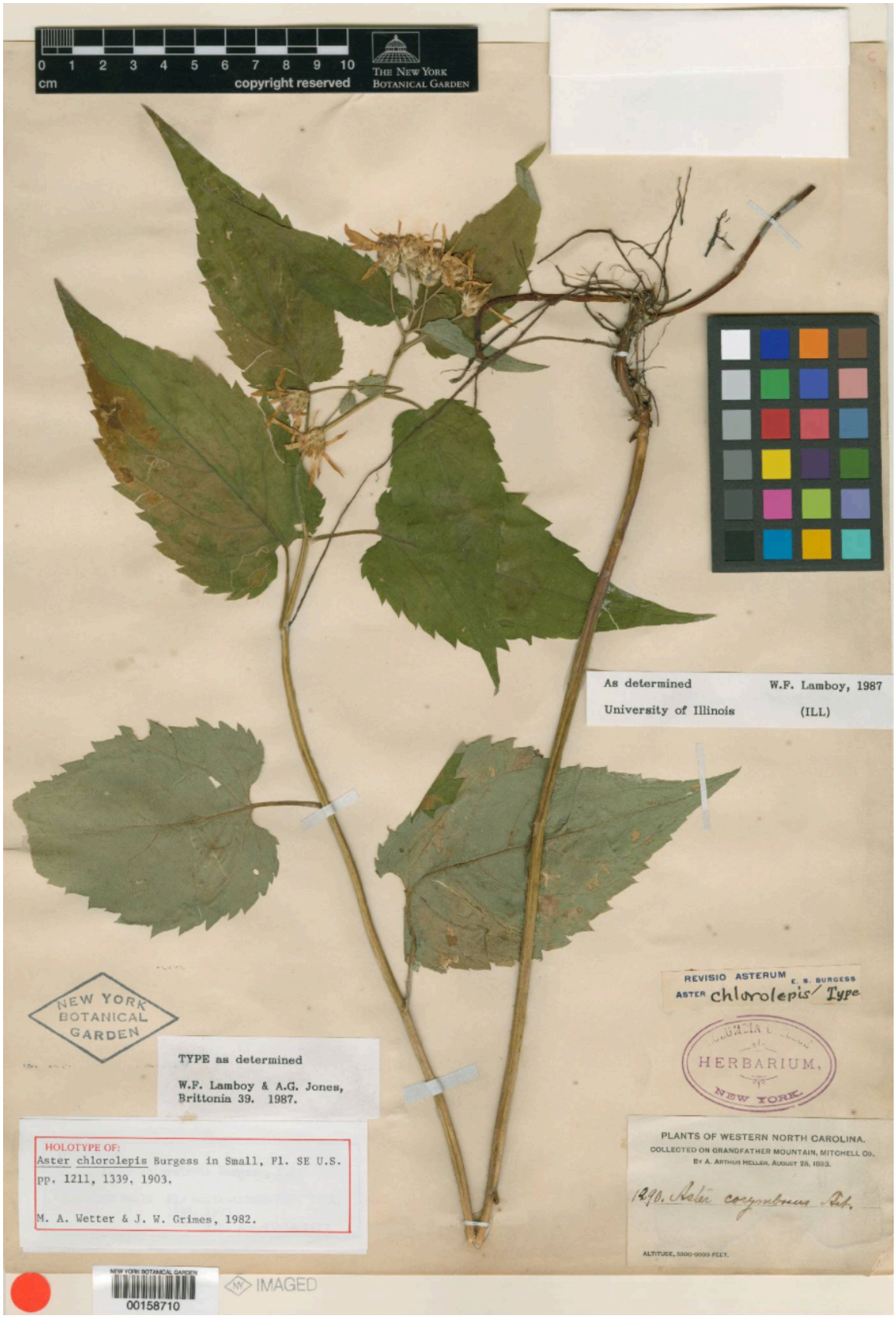
NEW YORK BOTANICAL GARDEN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copyright reserved
THE NEW YORK BOTANICAL GARDEN
As determined W.F. Lamboy, 1987
University of Illinois (ILL)
REVISIO ASTERUM E. S. BURGESS
ASTER chlorolepis Type
NEW YORK BOTANICAL GARDEN
HERBARIUM
NEW YORK
TYPE as determined
W.F. Lamboy & A.G. Jones,
Brittonia 39. 1987.
HOLOTYPE OF:
Aster chlorolepis Burgess in Small, Fl. SE U.S.
pp. 1211, 1339, 1903.
M. A. Wetter & J. W. Grimes, 1982.
PLANTS OF WESTERN NORTH CAROLINA.
COLLECTED ON GRANDFATHER MOUNTAIN, MITCHELL Co.
BY A. ARTHUR HELLER, AUGUST 26, 1903.
1290. Solidago corymbosa Pursh.
ALTITUDE, 5500-6000 FEET.
NEW YORK BOTANICAL GARDEN
00158710
IMAGED

Bridge

A critical component of any botanical analysis is the historical details of the study site and any important information, such as past collection history, land use, and disturbance regimes. If collections have been made within the study area in the past, it is imperative to understand who collected and what vascular plant species they encountered during their respective botanical forays. This information will help to inform the collector about what they might expect within the area and prepare them more thoroughly for field identification of taxa, decreasing the amount of time spent in the laboratory identifying collected specimens. With this in mind, the author had a better idea of what taxa Asa Gray, Rev. Moses Ashley Curtis, Arthur A. Heller, and John K. Small encountered while visiting GM and prepared accordingly for sampling within the BFH of GMSP. The vascular plant and moss information mined from the history of the four collectors discussed above provided me with a solid botanical foundation for fieldwork. The floristic inventory and vegetation sampling composing the second part of my thesis work will be discussed thoroughly in the subsequent chapter, documenting the vascular plant species, epipetric mosses, and natural communities found within the BFH of GMSP.

Chapter 2
An analysis on the flora of the Boone Fork headwaters within Grandfather Mountain State Park, NC

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Boone, NC 28608

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Abstract: Grandfather Mountain (GM) is a site of exceptional biological diversity in the Southern Appalachian Mountains of western North Carolina. Long known for its unique assemblage of natural communities and rare and endemic species, GM has been a site of scientific research for many years. Grandfather Mountain produces headwater streams for two river drainages: the Watauga and Catawba River watersheds. The Boone Fork headwaters (BFH) originate on the northeastern slope of Calloway Peak within Grandfather Mountain State Park (GMSP) and represent an area of high natural quality significance. The BFH drain into the Catawba River watershed and represent an area within GMSP for which there is little plant species or natural community data. My project investigated the flora of the BFH and described all vascular plant species, a preliminary list of epipetric mosses on dry portions of boulders and rock outcrops, and the natural communities occurring within the roughly 1000-acre study site. Field research revealed 262 vascular plant species, 19 epipetric mosses, and 18 distinct natural communities. Twenty-four vascular plant species found during field surveys were categorized as state-listed or federally listed and three identifications represent new county records. The vascular flora was represented by 76 plant families, ten of which made up over 48% of the species within the BFH.

Keywords: *Arabidopsis*, community, epipetric, *Prunus*, rare

Introduction

Grandfather Mountain (GM) is a site of exceptional biological diversity in the Southern Appalachian Mountains of western North Carolina. Long known for its unique assemblage of natural communities and rare and endemic species, GM has been a focal point of scientific research for many years. Grandfather Mountain produces headwater streams for two river drainages: the Watauga and the Catawba River watersheds. The BFH originate on the northeastern slope of Calloway Peak within GMSP and represent an area of high natural quality significance. The BFH drain into the Catawba River watershed and represent an area within GMSP for which there is little plant species or natural community data. My research effort involved an investigation of the flora of the BFH and a description of all the vascular plant species and epipetric mosses occurring within the roughly 1000-acre study site. I also described the natural communities of the BFH following the Carolina Vegetation Survey method devised by Peet et al. (1998). The data generated will provide critical insight for management of sensitive rare plant populations and natural communities within GMSP.

Physiography

Grandfather Mountain occurs in the northwestern portion of North Carolina and is one of the highest mountains within the region. It is included within the boundaries of three different counties: Avery, Caldwell and Watauga. MacRae Peak, Attic Window Peak and Calloway Peak compose GM as a whole, the tallest being Calloway Peak at roughly 1812 meters. Grandfather Mountain is one of the main attractions for the High Country of North Carolina and is a short distance from the larger towns in the area including Boone, Blowing Rock, Banner Elk, and Beech Mountain. It is bounded to the west by Flattop Mountain, Hanging Rock and Sugar Mountain, to the south by Beacon Heights and Grandmother Mountain, to the east by the Blue

Ridge Escarpment and to the north by Bench Mountain and Ash Bearpen Knob. Several headwater streams originate on the slopes of GM, including the Boone Fork and Wilson Creek, and these drain into the Watauga and Catawba River watersheds respectively.

Grandfather Mountain is entirely a montane site from the borders of the Blue Ridge Parkway to the east, Highway 221 to the south, Highway 105 to the west and the state park boundary to the north. The lowest elevation at Grandfather within these aforementioned bounds begins around 1213m and rises to the highest elevation of 1812m on Calloway Peak. Grandfather Mountain falls within the Blue Ridge Physiographic Province which is nested within the larger Southern Appalachian section of the Oak-Chestnut Forest Region (Fenneman 1938, Braun 1950); however, it is noted that this is now a misnomer, since the American Chestnut was decimated by the chestnut blight and typically now persists mainly as root sprouts, small to large shrubs or very rarely tree size specimens (Hepting 1974). The topography of Grandfather is very rugged with many vertical cliff faces and rock outcrops that, coupled with the high elevation, promotes the growth of floristic elements more common in New England and Canada (Gray 1889b, Harshberger 1903, Johnson 2016). Similar mountains and ranges within North Carolina that share this same physiognomy include the Black Mountains, the Great Smoky Mountains and the Roan Mountain Massif. Some of the higher mountains surrounding Grandfather include Beech Mountain (1663m), Hanging Rock (1582m), Rocky Knob (1211m), Flat Top Mountain (1362) and Grandmother Mountain (1408m).

Grandfather Mountain State Park was established in 2009 by the North Carolina state park service after purchasing the land from the Morton family. Trails were developed in the 70s and 80s mainly through the extensive work of Randy Johnson and others (Johnson 2016). A concerted effort was given from several different groups in acquiring the property for the

conservation of one of the most unique sites in the Southern Appalachian Mountains, including The Conservation Fund, Nature Conservancy, and The Blue Ridge Conservancy (Johnson 2016). The park is composed of many unique natural communities and rare species occurring within the 2456-acre state park with elevations spanning from ~1188-1824m.

Climate

The temperate climate of GM is characterized by cold winters and mild summers with precipitation occurring throughout the year (Trewartha and Horn 1980). A weather station has been recording climatic data beside the "mile-high bridge" on GM since August 1955 and the following data are based on averages for the period from 1955-2012. The average maximum temperature is 12.11°C with the highest average maximum temperature occurring in July (20.94°C). The average minimum temperature is 3.83°C with the lowest average minimum temperature occurring in January (-6.78°C). The average annual precipitation occurring on Grandfather is 157.73cm with the highest amount of precipitation in the months of June and September (15.85cm). The average annual snowfall for GM is 134.62cm with the highest amount of snowfall occurring in January (36.83cm). According to data on "freeze-free" probabilities, there is a 70% chance that atop GM the temperature will not drop below 0.278°C for 143 days of the year.

Geology

In western North Carolina, the Blue Ridge physiographic province is largely composed of gneiss, schist, migmatite, and granitic rock which are the products of metamorphism and plutonism dating back roughly one billion years (Bryant and Reed 1970). Within this zone, the Blue Ridge thrust sheet occupies a large portion of western North Carolina and consists mainly of schist, gneiss and amphibolite formed largely by the forces of metamorphism of sedimentary

and volcanic rocks 1 – 1.1 BYA (Bryant and Reed 1970, Adams and Su 1996). The Grandfather Mountain Window is an area of younger rock exposed through the Blue Ridge thrust sheet ~ 72 kilometers long by 32 kilometers wide and includes three distinct geologic zones: the Grandfather Mountain formation, the Table Rock thrust sheet and the Basement Rock (Bryant and Reed 1970). In the Grandfather Mountain Window (GMW) the oldest rocks, dating to the Precambrian Age, are layered migmatitic gneiss, metamorphosed diorite and gabbro (Bryant and Reed 1970).

The Grandfather Mountain Formation overlays these older rocks in the northwestern portion of the GMW and is primarily composed of arkose, siltstone, feldspathic conglomerate and shale with interbedding of metarhyolite and metabasalt dating back to the late Precambrian Age, ~ 800-900 MYA (Bryant and Reed 1970, Schwab 1977). The arkose and sub-arkose units within the GMW account for roughly 40% of the Grandfather Mountain Formation and are composed of two distinct rock types: 1) gray, green or tan conglomerate a few centimeters to several meters thick in discontinuous layers or beds and 2) sandstone from several meters to tens of meters thick in continuous beds (Bryant and Reed 1970, Schwab 1977). Siltstone units are interbedded with the arkose units of the Grandfather Mountain Formation and make up roughly 35% of the total area (Schwab 1977). This unit is dominated primarily by greenish-gray laminated siltstone and to a lesser extent local abundance of phyllite, sandy marble, slate, sandstone and shale (Bryant and Reed 1970, Schwab 1977). The final and least abundant rock component of the Grandfather Mountain Formation are the volcanic rocks, metabasalt and metarhyolite, occurring as discontinuous lenses and beds and composing roughly 5% of the formation (Schwab 1977).

Rocks from the Cambrian Age compose the majority of the Table Rock thrust sheet, which occupies the southwestern corner of the GMW (Schwab 1977). The Chilhowee Group of rocks forms the largest component of the Table Rock thrust sheet and consists of quartzite, feldspathic quartzite and phyllite (Bryant and Reed 1970, Schwab 1977). There are three units within the Chilhowee Group: 1) the upper quartzite 2) the lower quartzite and 3) the phyllite unit (Schwab 1977). The upper quartzite unit is composed of medium to fine-grained white to greenish-gray or bluish-gray quartzite and feldspathic quartzite, ranging from ~ 396 to 762 meters thick (Bryant and Reed 1970, Schwab 1977). The lower quartzite unit ranges in thickness from ~ 224 – 670 meters and is primarily composed of quartzite, feldspathic quartzite and interbedded green sericite phyllite. Some other additions to this unit are quartz-pebble conglomerates occurring near the base of the sequence and angular clasts of feldspar, which are abundant in some beds (Bryant and Reed 1970, Schwab 1977). The main features separating the upper quartzite unit from the lower quartzite unit are the better sorting, gray rather than green phyllites and lack of pebble beds in the upper quartzite unit (Bryant and Reed 1970, Schwab 1977). The final unit within the Chilhowee Group is the phyllite unit consisting of dark phyllite with interbedding of fine-grained gray or white quartzite. The phyllite is finely laminated with a dark blue color and has folia of fine-grained sericite and granoblastic quartz in thin lenses (Bryant and Reed 1970, Schwab 1977). The Shady Dolomite is the second component of the Table Rock thrust sheet and is composed of fine-grained white, light-gray or buff-gray crystalline dolomite, which is generally mottled or thin-bedded to ribboned (Bryant and Reed 1970, Schwab 1977).

The final unit of the GMW is the Basement Rock, which is primarily composed of the Wilson Creek Gneiss, the Blowing Rock Gneiss and the Brown Mountain Granite (Bryant and

Reed 1970, Schwab 1977). The Wilson Creek Gneiss (WCG) is composed of nonlayered plutonic rock ranging from diorite to granite and averaging quartz monzonite; however, the WCG can be difficult to distinguish from the non-bedded arkose of the Grandfather Mountain Formation due to both being pervasively sheared and the lack of bedding in the arkose (Bryant and Reed 1970). One of the distinguishing features that helps to separate the WCG from the arkose of the Grandfather Mountain Formation is the white quartz-plagioclase-potassic feldspar pegmatites of the WCG, which are lacking in the arkose (Bryant and Reed 1970). The Blowing Rock Gneiss (BRG) is composed of coarse-grained strongly foliated mafic rock, occurring with dikes and small bodies of pegmatite and light-colored granite rock (Bryant and Reed 1970). Scattered throughout the BRG are small inclusions of mafic rock consisting of biotite quartz, hornblende-biotite schist, biotite schist, amphibolite, diorite gneiss and epidote-plagioclase-biotite schist (Bryant and Reed 1970, Schwab 1977). The final component of the Basement Rock is the Brown Mountain Granite, which is characteristically coarse-grained, light-colored and homogenous with small zones of medium-gray phyllonite, small quartz segregation lenses and veinlets and quartz-perthite pegmatite occurring in small bodies (Bryant and Reed 1970).

Soils

The majority of soil types within the BFH of GMSP are classified as Ultisols. Many of the soil associations have very steep slopes and a minor to large component of rock fragments either in the soil layer or as boulders on the soil surface. All soil associations are weathered from felsic to mafic, igneous or high-grade metamorphic rock. Six soil series are found within the study site: Balsam, Burton, Clingman, Craggey, Cullasaja and Unaka-Porters (Soil Survey Staff 2019).

The first soil association is classified as Balsam very cobbly loam (BaE), windswept, 30 to 50% slopes and has an extreme number of boulders. This soil association occurs mainly in the western half of the field site at the headwaters of the Boone Fork making up a large portion of the soil area. This soil type is found primarily at higher elevations (~1219-1768m) and occupies drainageways, benches and colluvial fans. The soil is well-drained, loamy with abundant rock fragments, very high organic material, acidic and subject to very high severity erosion. Due to the high elevation occurrence of this soil type it is highly susceptible to extreme freezing, rime ice, high winds and heavy rainfall and a short growing season. Throughout the soil area there are seeps and springs and the soil content has at least 33% or higher amount of rock fragments in the soil profile.

The Burton-Craggey-Rock outcrop complex (BuD) is composed of windswept, 15 to 30% slopes with bedrock and rock outcrop made up of hard, unweathered fractured amphibolite. This soil association is found in the southeastern and northeastern portion of the study area and composes a small portion of the total soil area. The soil type occurs at high elevations typically along ridgelines where they occupy the summits and shoulders of the mountains. It has a moderately deep to shallow soil profile and is moderately to excessively drained, loamy, acidic, very high organic material and is susceptible to severe erosion. Like the Balsam soil association, the BuD experiences extreme freezing and rime ice, high winds, heavy rainfall and a short growing season. A second classification within the Burton-Craggey-Rock outcrop complex is BuF; the main difference from BuD being the 30 to 95% slopes associated with BuF. All previous details accorded to BuD are the same in BuF. The BuF soil association occurs in the central, southeastern and northeastern portion of the study area composing nearly 15% of the soil area.

The Clingman-Craggey-Rock outcrop complex (CmF) is associated with windswept, 15 to 95% slopes that have an extreme number of boulders and typically occupy slopes and ridges on the summits and shoulders of mountains. This soil association occupies the major ridgelines in the study area, specifically, the northeastern ridgeline leading from Calloway Peak to the Bench Huckleberry Patch and east for portions of the ridgeline leading down to the Blue Ridge Parkway. Parent material consists of arkose and amphibolite and the soils are shallow to very shallow, organic to loamy, acidic and highly susceptible to severe erosion. The CmF is also subject to the same environmental conditions as the BuD, BuF and BaE.

The next soil association is the Cullasaja very cobbly loam (CtD) soil with 15 to 30% slopes and an extreme number of boulders. This soil type occurs at a lower elevation (~518-1280m) within colluvial fans, drainageways and benches and has a loamy texture with abundant rock fragments. It is well-drained, very high in organic material, acidic and subject to severe erosion. Similar to the BaE soil association is has scattered seeps and springs and rock fragments in >35% of the soil profile. A second classification within the Cullasaja very cobbly loam is the CtE, the only difference being 30 to 50% slopes in CtE. All other parameters mentioned regarding CtD are the same for CtE.

The final soil association found within the BFH of GMSP is the Unaka-Porters complex, which consists of 30 to 50% slopes and very rocky soils, typically associated with intermediate (~975-1341m) mountains and hills occupying the ridges and slopes. The soil is well-drained, loamy, very high in organic material, acidic, has severe erosion potential and amphibolite bedrock.

Land Use History

For the vast majority of Grandfather Mountain's modern history, the mountain was undisturbed, excepting small game trails and natural phenomenon, such as windstorms, heavy snowfalls, and rainstorms. It was not until the early part of the 20th century that eyes began to look upward at the virgin timber cloaking the mountain and consider the profits of a logging operation. The history of systematic logging began in the late 1800s with Walter Waightstill Lenoir, the owner of GM and much of the land surrounding it (Johnson 2016). Lenoir was a decorated Civil War veteran who had lost one of his legs in battle and after the war was intent on selling the majority of his land holdings. He was known to regularly patrol his land on Grandfather, sometimes walking upwards of ten miles a day on his wooden leg, making sure his timber was not poached by locals (Johnson 2016). Lenoir found his man in Samuel T. Kelsey, who offered to purchase Grandfather and over 8000 acres in Linville and its proximity. However, Kelsey was not the only one viewing the land around Grandfather as an ideal place to attract tourism and generate revenue. The MacRaes' were wealthy railroad builders from Scotland who had settled in Wilmington and continued to amass a fortune in the railroad business. William MacRae's son Donald was not content to stay in the lowlands and turned his gaze to the mountains of western North Carolina and in 1888 his son Hugh MacRae met with Kelsey about the land holdings in Linville and on Grandfather (Johnson 2016).

The MacRae family formed the Linville Improvement Company and Hugh MacRae was the president. His founding idea was to make "Linville a place of beauty and a popular resort for health and pleasure for the best class of cultivated people" (Johnson 2016). At this point in time Linville was not connected to Blowing Rock via road so they set out to build a stagecoach road connecting the two towns opening up the area to tourism. On this road-building operation, two

men met whose families would be intricately entangled in the future of GM and its fabled story (Johnson 2016). Alexander MacRae was not of the same lineage as the railroad MacRaes from Wilmington and his family had settled near the base of Grandfather before the arrival of Donald and his son Hugh. Alexander was part of the Linville Improvement Company's road crew and found a hard-working young man in Joe Hartley, who went on to become legend in the history of Grandfather. Hartley was raised on the Watauga River near Shull's Mill and knew the mountains very well. Alexander and his family settled on the southern slopes of Grandfather and the area still bears his name, MacRae Meadows (Johnson 2016). He was renowned for his excellent skill in bagpipe music and Margaret Morley, writer of *The Carolina Mountains*, described his playing, "Mr. MacRae has not forgotten how to play on the bagpipes those ancient airs that have so stirred the blood of his race" (Johnson 2016). The road between Linville and Blowing Rock was completed in 1891 and was deemed by state engineers an "excellent [*road*] for summer travel through one of the most beautiful and interesting portions of the mountain region" (Johnson 2016).

After the completion of the road, known as Yonahlossee ("Bear Trail" or "Passing Bear" in Cherokee), Alexander MacRae worked for years on the road delivering mail between Linville and Blowing Rock (Johnson 2016). With the road now open to tourism, the Linville Improvement Company invested in building the Eseeola Inn at Linville, a beautiful hotel attracting prominent individuals from across the United States. The area surrounding Linville and Blowing Rock, by the 1920s, was rapidly becoming a popular destination for tourism and by 1919 the railroad had reached Linville and Blowing Rock providing the critical infrastructure necessary for timber harvesting in the High Country (Johnson 2016). However, it would be a number of years before Grandfather itself was heavily timbered.

The first spot that attracted the attention of the owner of the world's then largest timber company, William McClellan Ritter, was an area to the southeast of Grandfather known as The Globe to locals (Johnson 2016). Ritter owned the Linville River Railroad, which linked forests near Pineola to Tennessee and he also used the Carolina & North-West Railway (C&NW) which gave him access to some of his timber holdings at the foot of Grandfather on the eastern side. This settled perfectly into his plans of logging the High Country. The owner of the C&NW railway, William Barber, had another smaller railroad (Caldwell & Northern) that extended towards Grandfather (Johnson 2016). Ritter and Barber joined in business and connected their railways on the lower slopes of the eastern side of Grandfather at a small town known as Edgemont. By 1906 the logging operation had begun with the use of narrow-gauge trains providing access to timber in the difficult terrain and by 1914 much of the area surrounding Edgemont had been cut over. One traveler in 1913 describing the cut-over Wilson Creek Gorge said, "the only thing marring the attractive beauty of the mountains and gorge are the denuded mountainsides devastated by fire" (Johnson 2016).

Ritter would sell his Linville River Railroad line to the East Tennessee & Western North Carolina (ET&WNC) railroad, which would expand rail to Linville and eventually reach the town of Boone by 1919. William Whiting was another important player in the exploitation of Grandfather Mountain's timber resources and in the year 1913 he would purchase the timber rights on the northern slopes of Grandfather, including the valley where the headwaters of the Boone Fork originated (Johnson 2016). Whiting was building a lumber mill at Shull's Mill just north of Grandfather and targeted the pristine high elevation cove of the Boone Fork described by Joe Hartley as "the great north woods." Whiting and his men laid rail up through the Boone Fork valley all the way to a location known as Storyteller's Rock and thus one of the "best

boundaries of timber in Carolina" was swept away by the onslaught of logging (Johnson 2016). The Linville Improvement Company was getting underway with logging around Linville but wanted to follow the regulations of the Bureau of Forestry and asked for guidance on how to log in order to minimize degradation of the land. The Linville Improvement Company placed George Tate Davis as their timber warden meticulously detailing a day's work and marking timber for harvest or retention (Johnson 2016).

The Linville Improvement Company was now run by Nelson MacRae, who took over from his father Hugh in the year 1920, however, finances were low, and the locals were suffering. The LIC had produced a new tourist opportunity on Grandfather where cars could drive to a rocky outcrop, known as Observation Point, above MacRae Meadows and take in the spectacular view (Johnson 2016). In 1930, Nelson and the board of LIC voted to sell "all of the spruce and balsam timber eight inches in diameter and up at the stump, on the upper slopes of Grandfather Mountain" to Will Smith from Canton, who owned the massive Champion Fibre Mill and was responsible for the logging devastation of Roan Mountain. Railways would not be developed on Grandfather, instead Smith would use "board roads" capable of truck transportation along the slopes of Grandfather for harvesting the mountains bounty of timber. Major board roads were known to occur above Grandfather's profile face, below MacRae Meadows and even one passing not far below Shanty Spring (Johnson 2016). By the late 1930s, the board roads were being removed and the majority of the timber was harvested on the southern slopes of Grandfather.

It was not long after the cessation of logging that forest fires ravaged the cut-over lands, particularly a fire in the Boone Fork, which then fire marshal Joe Hartley described as "burned in the turf for 30 days (Johnson 2016)." It is significant to note that because of the topography of

Grandfather and its demanding nature a number of trees across the mountain were left mainly because it was impossible to safely fell them, or they were distorted and twisted because of the fierce storms that often assault the high slopes. In Teddy Roosevelt's 1902 report on the Southern Appalachian Mountains he describes how some merchantable timber would avoid the saw due to its inaccessibility or scattered distribution, almost prophetically speaking of Grandfather (Johnson 2016). A scientific article published in the literature in the 1980s assessed the spruce-fir forests of the Southern Appalachian Mountains and found that plots above 1524m on GM had varying average ages for trees (55, 81, 217yrs) suggesting that not all trees on Grandfather were harvested in the early 1900s.

One of the last and likely more important disturbances in Grandfather's fabled history was the building of the mile-high swinging bridge and the associated road and visitor shop. A road had been built to Observation Point just above MacRae Meadows and was the main attraction to Grandfather into the mid 20th century, however, Joe Hartley and Hugh Morton were considering extending the road higher to Convention Table Rock (Johnson 2016). This was eventually completed by dynamiting much of the roadway and then developing a parking lot and visitor/gift shop where tourists could learn more about the mountain. In 1953, the mile-high swinging bridge was opened and ever since has provided intrigue to visitors and those wanting to experience Grandfather's unique history and ecosystems.

Methods

Plant collections were made in the Fall of 2018 and during the growing season of 2019, for a total of 49 field days (47 in 2019). Topographic maps, aerial imagery, soil, and natural heritage program data reports were used to target specific areas of the study site for specimen collection. In the early spring of 2019, visits were made to the BFH for collection of early spring

ephemerals and information about natural communities throughout the site where collections could be made during the growing season. After acquiring a more intimate knowledge of the site, specific locations were targeted where species diversity was high, and the majority of the collections were made. GPS location data were collected for all specimens, including rare species that were not collected, and a number of other metrics were recorded, such as elevation, aspect, family and associated species. Specimens were collected in the field using a portable press and then transported back to the herbarium at the end of the field day where they were placed in an herbarium press and put in a dryer for 24-48hrs. After specimens had dried for an appropriate time period, they were transferred to a cooler for another 24hrs and then they subsequently were mounted onto herbarium paper, labeled, and accessioned into the herbarium.

Taxonomic nomenclature for all final identifications for vascular plant species followed Weakley (2015). A number of other taxonomic resources were used during the field season and included: The Flora of Virginia (2012), Manual of the Vascular Flora of the Carolinas (1965), The Flora of West Virginia (1978), and Guide to the Vascular Plants of the Blue Ridge (1989). A duplicate collection was made during the sampling period and collections will be housed at the Appalachian State University Herbarium (BOON) and the University of North Carolina at Chapel Hill Herbarium (UNC). Specimens were digitized after mounting, labeling and accessioning into the herbarium and will be uploaded to the Southeast Regional Network of Expertise and Collections (SERNEC) online database.

Epipetric mosses were mainly collected during the late winter and early spring of 2019. The sampling was not exhaustive and was a subset of the main thesis work and therefore is representative of a preliminary list. The term epipetric is not often used in the field of bryology and therefore I will explain the meaning of this term for my study. For this preliminary list of

epipetric mosses in the BFH, epipetric refers to those species of moss that have their rhizoids directly attached to the surface of boulders or rock outcrops. In essence, these species are tightly adherent to the rock surface. I focused on the dry portions of boulders, roughly desk-sized to the size of small houses, and the dry portions of rock outcrops of any size within the study area. Epipetric mosses, in the sense of this study, occur in many other habitats throughout the BFH, however, these habitats (e.g. seeps, streams) were not sampled. Specimens were sought with sporophytes, however, if material was not available a gametophytic portion of the moss was still collected in hopes of an identification. Mosses were collected into paper bags, transferred to the herbarium, and identified mainly in the lab using Crum and Anderson (1983) and nomenclature followed the Flora of North America (Vol. 27, 28). Other resources used mainly in the field to help narrow the range of choices before final identification in the lab included Mosses, Liverworts, and Hornworts: A Field Guide to the Common Bryophytes of the Northeast (2016), and Common Mosses of the Northeast and Appalachians (2013).

From May – August 2019 sampling was conducted to determine the natural communities of the BFH. Sampling methodology followed the Carolina Vegetation Survey protocol developed by Peet et al. (1998). A preliminary assessment of the natural communities was obtained by looking at aerial imagery, soil data, topographic maps, natural heritage program data reports, and other metrics to determine where distinctive natural communities existed in the study area. Natural communities were also identified by noting potential sampling sites while collecting herbarium vouchers during the growing season. After a potential sampling site was identified, a GPS point was taken in order to return and collect community data. Plots were selected subjectively based on the homogeneity of the vegetation within a certain natural community. Plots cannot typically be randomized when describing vegetation due to the problem of

randomly generated points occurring in transition zones between two communities where the intermediate zone of vegetation is described, and subsequently there is failure to describe either of the communities represented. Therefore, each plot was subjectively chosen, deemed to be representative of the natural community and had homogenous vegetation across the plot, helping to reduce variability of species from adjacent natural communities.

Plots ranged in size from $100m^2$ – $1000m^2$ (Fig. 1). Most of the plots sampled were $1000m^2$ plots and provided the typical plot size for sampling using the Carolina Vegetation Survey method (Peet et al. 1998). Plots with a smaller size resulted because of the smaller nature of the natural community being sampled and could not be any larger due to encroachment on adjacent vegetation types resulting in inaccurate description. Seepages were typically sampled using a 20x5m plot with a rectangular shape and four corners sampled per plot. This plot dimension was due to the shape of many forest seepages and was the most accurate way to setup and describe these vegetation types. Any plot > $400m^2$ had four intensive modules (10x10) sampled within the plot. Intensive modules have two corners sampled using a nested sampling method and percent cover values recorded for all species within the module. Residual modules were in plots > $600m^2$. Within these modules, I only documented species that were new to the plot and had not previously been recorded. These new species were assigned a cover value for the entire plot. DBH were recorded for all tree species > breast height within both intensive and residual modules.

Similarity comparisons of the flora of the BFH to other floras in the High Country and in western North Carolina were obtained through the Sørenson's Similarity Index (SSI). The index is based on presence/absence data and compares species data from different floras to determine the percent similarity of the sites being analyzed. Comparisons were made with various peaks in

the High Country (e.g. Bluff Mountain), Tennessee (e.g. Rocky Fork Tract), and locations in western North Carolina (e.g. The Black & Balsam Mtns.). The SSI was also used to determine the percent similarity of vegetation plots within the BFH. Non-metric multi-dimensional scaling (NMDS) and hierarchical cluster analysis were performed to determine the similarity of natural communities within the BFH. All statistical analyses were performed in RStudio Version 1.1.456 (2009-2018).

Results

Vascular Flora. Field collections (Fig. 2) accounted for 262 taxa representing 76 families. Within the 76 families, 172 genera were documented with 14 species in the Pteridophyta, five species in the Pinophyta, five species in the Lycopodiophyta, and 238 species in the Magnoliophyta. Due to the protected nature of the site and its absence from large scale disturbance for almost a century, only one exotic taxon was found in the study: *Malus pumila* Mill. The flora consists of 167 herbaceous species (64%), 62 woody species (24%), 31 graminoids (12%), and only 2 vine species (1%). The 14 most abundant plant families made up ~56% of the flora and consisted of 144 sp. found in the following families (Table 1): Asteraceae (21), Cyperaceae (17), Ericaceae (16), Ranunculaceae (15), Poaceae (14), Rosaceae (12), Liliaceae (8), Violaceae (8), Apiaceae (7), Lamiaceae (6), Orchidaceae (7), Orobonchaceae (5), Rubiaceae (5), and Saxifragaceae (5). The most diverse genera were *Carex* (17), *Viola* (8), *Solidago* (7), *Rhododendron* (5), and *Acer* (4).

A number of taxa found within the study site (Fig. 3) are tracked by the North Carolina Heritage Program (NCNHP) and are listed as threatened, vulnerable or endangered (Table 2.). Six species are considered significantly rare throughout North Carolina: *Aconitum reclinatum*, *Cardamine clematitis*, *Carex roanensis*, *Dendrolycopodium hickeyi*, *Geum geniculatum*, and

Rhododendron vaseyi. Three additional taxa are considered threatened or endangered in North Carolina: *Houstonia montana*, *Lilium grayi*, and *Platanthera grandiflora*. Fifteen species are on the NCNHP's watch list: *Abies fraseri*, *Arabidopsis lyrata ssp. lyrata*, *Carex bromoides ssp. montana*, *Carex fraseriana*, *Carex misera*, *Cinna latifolia*, *Gentiana clausa*, *Huperzia appressa*, *Hypericum mitchellianum*, *Micranthes careyana*, *Populus grandidentata*, *Prunus virginiana var. virginiana*, *Rudbeckia laciniata var. humilis*, and *Solidago puberula*.

According to the NCNHP's rare plant list (2018), records for *Arabidopsis lyrata ssp. lyrata* in Watauga county are considered uncertain because of lack of survey data on known populations in the last 20-40 years. However, the species was found in flower on a mafic rock outcrop in association with a large population of *Houstonia montana* growing on a high ridgeline just northeast of Calloway Peak. The NCNHP also lists *Cinna latifolia* on the plant species watchlist as poorly known in NC and records for Watauga county are considered uncertain due to the lack of recent survey data and verification of previously known occurrences in the last 20-40 years. The Southeast Regional Network of Expertise and Collections (SERNEC) online herbarium database only shows two collections from Watauga county: one collection from Tom Daggy (UNCC_24281) in 1961 on the Daniel Boone Scout Trail at ~1676m and another collection from George S. Ramseur (NCU00171124) in 1957 just below the summit of Calloway Peak on the western slope. The two specimen records represent the most recent specimen data for *Cinna latifolia* in Watauga county on the SERNEC database. During field collections in the BFH, the species was documented again from several community types. It can be found along the Daniel Boone Scout Trail in Red Spruce / Northern Hardwood Forest (Herb Type) communities in likely the same area that Tom Daggy recorded the species almost 60 years ago. Two other communities in which it was identified were Beech Gaps along the ridgeline northeast

of Calloway Peak and in Southern Appalachian Boulderfield Forest (Currant & Rockcap Fern Type). Populations discovered in the BFH of *Cinna latifolia* typically consisted of single individuals or small groups of scattered individuals (5-10).

Another species that represents a new record for GMSP is *Prunus virginiana var. virginiana*. A clonal shrub often associated with riparian zones and streambanks, but found on steep, seepy slopes with high boulder content in the BFH. The first population of the species was discovered in mid-May. The population was roughly 225m^2 and only a small portion was in flower, which may have been due to a treefall gap providing more sunlight to the flowering portion. A number of other *Prunus virginiana var. virginiana* populations were documented (none in flower/fruit) in the latter part of the sampling season and occurred on steep, seepy slopes with high boulder content in Northern Hardwood Forest community types. The species is relatively uncommon in the BFH but is known to occur just west of Grandfather Mtn. on Hanging Rock (NCU00065165) in Northern Red Oak Forest over metabasalt (SERNEC Data Portal 2018).

Epipetric Mosses. Nineteen epipetric mosses were discovered within the BFH and represent 12 distinct families (Table 3.). The three most common families were Anomodontaceae, Hypnaceae, and Grimmiaceae. All species collected are classified as true epipetrics, meaning that their rhizoids directly grip the rock unlike other species that appear to be epipetric but are actually growing on thin soil pockets overlaying the rock substrate (e.g. *Dicranum scoparium*). One species collected, *Andraea rothii*, is more associated with temporary seepages and creeks rather than forest boulders and rock outcrops, however, it can be abundant on rock outcrops where seepage periodically flows across the rock substrate. On forest boulders in the understory of the BFH, five species were regularly the most abundant and prolific mosses: *Grimmia pilifera*, *Ulota*

hutchinsiae, *Schistidium apocarpum*, *Hedwigia ciliata*, and *Dicranum fulvum*. Three species, *Anomodon attenuatus*, *A. rostratus*, and *Haplohymenium triste* are most often associated with tree bark as a substrate, however, all three were found on boulders within the study site, the most unusual of which was *Haplohymenium triste*. Moss occurrence on the underside of rock overhangs was low and may be due to the steepness of the rock, moisture input, or the porosity and microtexture of the rock surface (anecdotal observation). It is likely that a number of these factors are working in concert decreasing the abundance of moss species in these unique habitats. Another important facet of epipetric mosses is the ability to trap soil particles from sheet flows or wind-blown soil particles facilitating soil development and forwarding the successional trajectory toward larger terrestrial mosses and vascular plant species.

Natural Communities. Vegetation sampling within the BFH of GMSP revealed 18 distinct natural communities (Fig. 3), including four additional communities that were identified but not sampled due to time constraints and issues with accessibility and three communities that did not match well with currently described communities (Table 4). Blue Ridge Hemlock – Northern Hardwood Forest, Southern Appalachian Northern Hardwood Forest (Rich Type), Red Spruce – Northern Hardwood Forest (Herb Type), and High-Elevation Red Oak Forest (Tall Herb Type) were the most abundant natural communities within the BFH. The five most species diverse natural communities sampled were the Southern Appalachian High-Elevation Red Oak Forest (Deciduous Shrub Type) with 89 identified species, Southern Appalachian Northern Hardwood Forest (Rich Type) with 80 and 76 identified species respectively, Southern Appalachian Rich Cove Forest (Montane Calcareous Type) with 76 identified species, and Southern Appalachian Northern Hardwood Forest with 73 identified species. The most species poor community

sampled was the *Picea rubens / (Rhododendron maximum, R. catawbiense) / Bazzania trilobata* Forest type with only 14 identified species.

All vascular plant species were identified, following Weakley (2015), within the vegetation plots and a limited number of nonvascular plant species were identified if they contributed a high percent cover to the plot's flora. Below are descriptions of all the natural communities identified within the BFH mainly following the descriptions found in the NatureServe Explorer database, which corresponds to the USNVC (NatureServe 2019). I also provide additional information about observations made during the course of sampling that pertain to the floristic assemblage of the natural community described.

Southern Appalachian Northern Hardwood Forest (Typic Type) (G3G4) – A broadly delineated association encompassing northern hardwood forests above 1220m in the Southern Blue Ridge and the Ridge and Valley province of NC, VA, and TN. This community can occur on a wide variety of slopes and aspects, however, within the BFH it was mainly found on northeast and east-facing slopes. The canopy is most often dominated by mixtures of *Betula alleghaniensis* and *Fagus grandifolia*, sometimes with minor occurrence of *Aesculus flava*, *Prunus serotina*, and *Quercus rubra*. Acer saccharum can be codominant in the canopy in the northern part of the communities' range. Small trees found within the community include *Acer pennsylvanicum*, *Acer spicatum*, *Amelanchier laevis*, and *Ilex montana*. The shrub layer may be depauperate or moderately developed and contains *Viburnum lantanoides*, *Sambucus racemosa*, *Hydrangea arborescens*, and *Rubus canadensis*. The herbaceous layer can be quite variable and may contain a number of species, including *Stellaria pubera*, *Eurybia chlorolepis*, *Ageratina altissima var. roanensis*, *Carex pennsylvanica*, *Arisaema triphyllum*, *Dryopteris intermedia*, *Solidago curtisii*, and *Athyrium asplenioides*. Some rare taxa reported for this community type

include *Solidago glomerata*, *Cardamine clematitis*, *Hypericum mitchellianum*, *Rhododendron vaseyi*, *Carex misera*, and *Abies fraseri*.

The plot sampled within the BFH was strongly dominated by *Betula alleghaniensis* in the canopy, with minor components of *Tilia heterophylla*, *Aesculus flava*, and *Fraxinus americana*. The subcanopy layer had high abundance of *Acer spicatum* and *A. pennsylvanicum*. The shrub layer was poorly developed and consisted of scattered individuals of *Hydrangea arborescens*, *Cornus alternifolia*, and *Rhododendron maximum*. The herbaceous layer was mildly diverse and had a large number of boulders throughout the plot. Herbaceous species contributing higher percent cover included *Dryopteris intermedia*, *Eurybia chlorolepis*, and *Solidago flaccidifolia* with minor contributions of *Solidago glomerata*, *Arisaema triphyllum*, *Oclemena acuminata*, *Solidago flexicaulis*, *Viola blanda*, *Huperzia lucidula*, *Maianthemum racemosum*, *Solidago curtisii*, *Cardamine concatenata*, *Osmorhiza claytonii*, and *Streptopus lanceolatus var. lanceolatus*. One bryophyte, *Thuidium delicatulum*, contributed a large percent cover to the herbaceous layer, mainly scrambling and completely covering boulders on the surface of the ground. Other bryophyte taxa of minor importance included *Loeskeobryum brevirostre*, *Schistidium apocarpum*, *Hypnum imponens*, *Dicranum fulvum*, and *Ulota hutchinsiae*.

Southern Appalachian Mountain Laurel Bald (G2G3) – This community type occurs on ridgelines and steep, rocky slopes at intermediate elevations (1220-1524m) in GA, NC, VA, and TN. It is typically dominated by evergreen shrubs, but in some occurrences deciduous shrubs can be codominant. Very dense thickets are formed 1-4m tall and are most often dominated by *Kalmia latifolia* and *Rhododendron catawbiense*, however, *Gaylussacia baccata*, *Kalmia buxifolia*, *Pieris floribunda*, *Vaccinium corymbosum*, and *Rhododendron carolinianum* can dominate in some occurrences. Other minor shrub constituents include *Aronia melanocarpa*,

Clethra acuminata, *Eubotrys recurva*, and *Viburnum cassinoides*. Openings occur between the shrub layers and provide habitat for herbaceous species, lichens, and some bryophyte taxa along with bare rock. Herbaceous species commonly found in this community type contain *Gaultheria procumbens*, *Galax urceolata*, *Melampyrum lineare var. latifolium*, *Pteridium latiusculum var. latiusculum*, and *Goodyera pubescens*. A number of tree species may occur in this community as stunted individuals including *Acer rubrum*, *Amelanchier laevis*, *Nyssa sylvatica*, and *Picea rubens*. A number of rare taxa may be encountered in this community and include *Abies fraseri*, *Glyceria nubigena*, *Hypericum buckleyi*, and *Liatris helleri*.

The vegetation plot sampled within the BFH represents a stand on the Bench Huckleberry Patch where this community is dominant atop the ridgeline. Shrub species with the highest percent cover include *Kalmia latifolia*, *Kalmia buxifolia*, *Rhododendron catawbiense*, *Gaylussacia baccata* and a minor component of *Lyonia ligustrina var. ligustrina*, *Aronia melanocarpa* and *Eubotrys recurva*. The subshrub *Gaultheria procumbens* is abundant underneath the canopy shrubs and common herbaceous species found within the plot include *Galax urceolata*, *Pteridium latiusculum var. latiusculum*, *Melampyrum lineare var. latifolium*, *Amianthium muscitoxicum*, *Uvularia pubera*, *Iris verna var. smalliana*, *Coreopsis major var. major*, *Maianthemum canadense*, *Goodyera pubescens*, *Platanthera ciliaris* and *Smilax rotundifolia*. Stunted tree species in this plot were composed of *Acer rubrum*, *Picea rubens*, *Amelanchier laevis*, *Tsuga canadensis*, *Sassafras albidum*, and *Sorbus americana*. This is the only documented community in the BFH where the rare *Dendrolycopodium hickeyi* occurs with some abundance, growing rhizomatously underneath the deciduous shrub layer and open patches adjacent to bare rock. Other uncommon or rare species in this community are *Solidago puberula* and *Aronia prunifolia*. Nonvascular taxa can be quite common and include the lichen species

Cetraria islandica, *Cladonia rangiferina*, *Lasallia papulosa*, *Umbilicaria caroliniana*, and *Platismatia tuckermanii*. Some bryophyte species found within this community can include *Pleurozium schreberi*, *Thuidium delicatulum*, *Hylocomium splendens*, and *Leucobryum glaucum*.

Betula alleghaniensis – Acer rubrum / Hamamelis virginiana – (Ilex montana) / Dryopteris intermedia – (Carex pennsylvanica) **Forest (Poor Fit)** – This vegetation plot represents a community type with poor classification fit to currently described communities, therefore, I have designated the above name indicating the dominant plant species in the tree, shrub, and herb layers respectively. The tree canopy is mainly composed of the dominant species *Betula alleghaniensis* and *Acer rubrum*, with minor constituents *Acer saccharum*, *Quercus rubra*, *Picea rubens*, *Sorbus americana*, and *Prunus pennsylvanica*. The shrub layer is mainly deciduous species, such as *Hamamelis virginiana*, *Ilex montana*, *Clethra acuminata*, *Rhododendron vaseyi*, *Acer pennsylvanicum*, and *Crataegus macrosperma* with a scattered evergreen component of *Rhododendron catawbiense* and *R. maximum*. The herbaceous layer had a strong abundance of *Dryopteris intermedia* and *Carex pennsylvanica* with lesser amounts of *Athyrium asplenioides*, *Eurybia chlorolepis*, *Smilax herbacea*, *Dennstaedtia punctiloba*, *Amianthium muscitoxicum*, *Maianthemum canadense*, *Carex intumescens var. fernaldii*, and *Erythronium umbilicatum var. umbilicatum*. Lichen species identified within the plot include *Cetrelia chicitae*, *Umbilicaria mammulata*, *Cladonia furcata*, and *Lasallia papulosa*. A number of bryophyte taxa were found in the plot: *Hedwigia ciliata*, *Thuidium delicatulum*, *Dicranum fulvum*, *Ulota hutchinsiae*, and *Anomodon attenuatus*. *Lilium grayi* may be found within this community where there is intermittent seepage flowing down braided channels developed from rainstorms.

High-Elevation Red Oak Forest (Tall Herb Type) (G2) – A community occurring in most of the major mountain ranges of the Southern Appalachian Mountains usually above 1400m on

ridgecrests and at the heads of coves on steep, rocky soil in NC and TN. The forests within this community type are closed to somewhat open and are strongly dominated by *Quercus rubra* in the canopy with only minor amounts of *Acer rubrum*, *Crataegus punctata*, *Betula alleghaniensis*, and *Picea rubens*. The shrub layer is usually absent or only minimally developed and composed of *Hamamelis virginiana*, *Acer pennsylvanicum*, *Rhododendron calendulaceum*, and *Ilex montana*. Herbaceous species are abundant, and the ground layer can be dominated by *Carex pennsylvanica* and *Ageratina altissima var. roanensis* with associated species *Parathelypteris noveboracensis*, *Dennstaedtia punctiloba*, *Eurybia chlorolepis*, *Oclemena acuminata*, and *Laportea canadensis*. Some rare species encountered within this community type are *Carex roanensis*, *Coreopsis latifolia*, *Gentiana austromontana*, *Rhododendron vaseyi*, and *Silene ovata*.

Two plots sampled within the BFH were classifies as this community type and both expressed strong dominance of *Quercus rubra* in the canopy with associated tree species *Betula alleghaniensis*, *Acer rubrum*, *A. saccharum*, and subcanopy *Magnolia acuminata*, *Aesculus flava*, and minor *Robinia pseudoacacia*. The shrub stratum was minorly developed and included *Acer pennsylvanicum*, *Ilex montana*, *Ribes cynosbati*, *Ostrya virginiana*, and root sprouts of *Fagus grandifolia*. In both plots, the herbaceous layer is well-developed and high percent cover of *Carex pennsylvanica*, *Anemone quinquefolia*, *Solidago flaccidifolia*, *Ageratina altissima var. roanensis*, and minor presence of *Stellaria pubera*, *Viola hastata*, *Arisaema triphyllum*, *Solidago flexicaulis*, *Tradescantia subaspera*, *Carex laxiflora*, *Agrostis perennans*, *Athyrium asplenioides*, and *Dennstaedtia punctiloba*. A number of lichen and bryophyte species were identified in the two plots and include *Thuidium delicatulum*, *Sciuro-hypnum plumosum*, *Hedwigia ciliata*, *Dicranum fulvum*, *Brotherella recurvans*, *Schistidium apocarpum*, *Grimmia pilifera*, *Lasallia papulosa*, *Umbilicaria mammulata*, *Cetrelia chicitae*, and *Anomodon attenuatus*. *Lilium grayi*

can sometimes be found within this community along small seepages and intermittent creeks. Another uncommon (for GMSP) species found within this community type is *Carya cordiformis*, a tree species seen only several times in the survey of the BFH.

Red Spruce – Northern Hardwood Forest (Herb Type) (G2) – A community type occurring in the transitional zone between Spruce-Fir Forest and Northern Hardwood Forest in the Southern Blue Ridge Mountains at 1400-1555m in NC and TN. The community typically occurs on steep slopes or protected ridges with shallow, rocky soils co-dominated by *Picea rubens* and deciduous species, such as *Betula alleghaniensis*, *Aesculus flava*, *Fagus grandifolia*, and *Abies fraseri*. The shrub layer is usually absent or only minimally developed and includes *Viburnum lantanoides*, *Amelanchier laevis*, and *Acer pennsylvanicum*. The herbaceous layer can be strongly dominated by *Dryopteris campyloptera*, *Dryopteris intermedia*, *Athyrium asplenioides*, *Carex pennsylvanica*, *Oclemena acuminata*, and *Maianthemum canadense*. Rare species found within this community type include *Solidago glomerata*, *Hypericum graveolens*, *Carex ruthii*, and *Abies fraseri*.

Vegetation sampling within the BFH revealed two plots classified as this community type. In both plots, the canopy had strong representation of *Picea rubens* and *Betula alleghaniensis* with moderate percent cover of *Abies fraseri* and *Sorbus americana*. The shrub layer is virtually non-existent except for minor representation of *Viburnum lantanoides*, *Acer spicatum*, *Vaccinium erythrocarpum*, and *Rubus canadensis*. The herbaceous layer for both plots is strongly dominated by *Dryopteris campyloptera* and *Athyrium asplenioides*. Other herbaceous species found within the plots include *Maianthemum canadense*, *Huperzia lucidula*, *Oxalis montana*, *Streptopus lanceolatus var. lanceolatus*, *Carex intumescens var. fernaldii*, *Oclemena acuminata*, *Eurybia chlorolepis*, *Trillium erectum*, *Carex flexuosa*, and *Veratrum parviflorum*.

Some bryophyte taxa found within this community are *Rhytidiadelphus triquetrus*, *Thuidium delicatulum*, *Hylocomium splendens*, *Loeskeobryum brevirostre*, and potentially the liverwort *Bazzania trilobata*. Rare or uncommon species occurring within this community type include *Abies fraseri* and *Cardamine clematitis*, the latter seeming to prefer disturbance (anecdotal observation) afforded by high flows within intermittent creeks crossing through this community type.

Fraser Fir Forest (Deciduous Shrub Type) (G1) – An uncommon community type in the Southern Appalachian Mountains of NC, VA, and TN occurring in island-like stands above 1830m typically on shallow, steep, rocky soils with braided seepages. *Abies fraseri* is the dominant tree species in the canopy with standing snags of *A. fraseri* and abundant recruitment in treefall gaps. The shrub stratum may be absent to moderately developed and mainly consists of *Vaccinium erythrocarpum*, *Sambucus racemosa var. pubens*, *Viburnum lantanoides*, and *Rubus alleghaniensis*. Herbaceous species with high representation in this community include *Oxalis montana*, *Dryopteris campyloptera*, and *Athyrium felix-femina* with a minor component of *Oclemena acuminata*, *Eurybia chlorolepis*, *Clintonia borealis*, *Solidago glomerata*, *Viola pallens*, *Chelone lyonii*, and *Ageratina altissima var. roanensis*. Bryophyte taxa commonly found within this community type include *Ptilium crista-castrensis*, *Hylocomium splendens*, and *Rhytidiadelphus triquetrus*. Rare species encountered within this community are composed of *Abies fraseri*, *Glyceria nubigena*, *Cardamine clematitis*, *Solidago glomerata*, and *Stachys clingmanii*.

One plot was identified as this community type within the BFH occurring at roughly 1760m and dominated by *Abies fraseri* with minor cover of *Betula alleghaniensis*, *Sorbus americana*, and *Picea rubens*. The shrub layer is minorly developed and composed of *Viburnum*

lantanoides, *Acer spicatum*, *Vaccinium erythrocarpum*, and *Sambucus racemosa var. pubens*. The herb layer is sparse and includes *Oxalis montana*, *Clintonia borealis*, *Dryopteris campyloptera*, *Streptopus lanceolatus var. lanceolatus*, *Trillium undulatum*, *Oclemena acuminata*, *Chelone lyonii*, *Carex brunnescens ssp. sphaerostachya*, and *C. intumescens var. fernaldii*. The bryophyte stratum is well developed and represented by *Thuidium delicatulum*, *Hylocomium splendens*, *Loeskeobryum brevirostre*, *Rhytidiadelphus triquetrus*, and *Ptilium crista-castrensis*. The 1000m^2 plot had over 200 stems of *Abies fraseri*.

Southern Appalachian High-Elevation Red Oak Forest (Evergreen Shrub Type) (G4) – Occurring in most of the major mountain ranges of the Southern Appalachian Mountains, this community is found on ridges and mid to upper slopes from 1070-1676m with southern to southeastern exposures in GA, TN, NC, and VA. The canopy is dominated by *Quercus rubra* and may have a minor component of *Acer rubrum*, *Abies fraseri*, and *Aesculus flava*. The shrub layer is mainly composed of abundant evergreen species, such as *Rhododendron maximum*, *R. catawbiense* and *Kalmia latifolia* with minor inclusions of *Eubotrys recurva* and *Rhododendron vaseyi*. Due to the dense evergreen shrub layer, the herbaceous stratum is depauperate and composed of *Galax urceolata*, *Solidago curtisii*, *Dennstaedtia punctiloba*, *Conopholis americana*, *Clintonia umbellulata*, and *Parathelypteris noveboracensis*. Rare species that may be encountered within this community type include *Abies fraseri*, *Hypericum buckleyi*, *Nabalus roanensis*, *Rhododendron vaseyi*, and *Tsuga caroliniana*.

One plot within the BFH was identified as this community type and exhibited strong dominance by *Quercus rubra* in the canopy with minor association of *Fagus grandifolia*, *Betula lenta*, *Magnolia acuminata*, and *Picea rubens*. The shrub layer was strongly dominated by *Rhododendron maximum* with minor abundance of *Hamamelis virginiana*, *Amelanchier laevis*,

Acer pennsylvanicum, *Vaccinium corymbosum*, and *Viburnum lantanoides*. The herbaceous stratum was poorly developed and composed of *Viola rotundifolia*, *V. hastata*, *Medeola virginiana*, *Conopholis americana*, *Dennstaedtia punctiloba*, *Maianthemum racemosum*, *Gentiana clausa*, *Polygonatum biflorum*, *Houstonia serpyllifolia*, and *Luzula echinata*. A few bryophyte taxa occurred in the plot: *Polytrichum commune*, *Dicranum fulvum*, *Hypnum imponens*, and *Thuidium delicatulum*.

Rich Montane Seep (Cove Type) (G3) – This community type occurs at medium to high elevations in the southern Blue Ridge Mountains of GA, NC, TN, VA, and possibly SC. It is the more common seep of the Southern Appalachian Mountains and is typically shaded by overhanging tree species. Abundant herbaceous taxa in the seep include *Diphylleia cymosa*, *Micranthes micranthidifolia*, and *Laportea canadensis* with varying amounts of *Cardamine clematitis*, *Chelone glabra*, *C. lyonii*, *Houstonia serpyllifolia*, *Viola cucullata*, *Lilium grayi*, *Oxypolis rigidior*, *Trautvetteria caroliniensis*, *Thalictrum clavatum*, and *Boykinia aconitifolia*. Overhanging tree species bordering this community may include *Tilia americana var. heterophylla*, *Fraxinus americana*, *Acer saccharum*, *Aesculus flava*, and *Liriodendron tulipifera*.

This community is well represented in the BFH mainly occurring on south to southeast-facing slopes with considerable variability in the dominant taxa. Herbaceous species with high percent cover include *Diphylleia cymosa*, *Eurybia chlorolepis*, *Ageratina altissima var. roanensis*, *Collinsonia canadensis*, *Solidago flaccidifolia*, and *Chelone glabra*. Herbaceous species with minor abundance include *Thalictrum clavatum*, *Viola cucullata*, *Boechera laevigata*, *Rudbeckia laciniata var. humilis*, *Deparia acrostichoides*, *Galium triflorum*, *Monarda didyma*, *Bromus pubescens*, *Carex laxiflora*, *Prosartes lanuginosa*, *Thaspium barbinode*, and *Ranunculus recurvatus*. Tree species shading this community from adjacent uplands were

composed of *Acer saccharum*, *Quercus rubra*, *Prunus serotina*, *Betula alleghaniensis*, and *Carya cordiformis*. The rare species *Lilium grayi* often occurs in this seepage community. *While sampling this plot on July 5, 2019 the author observed an Eastern Fox Squirrel (*Sciurus niger vulpinus*?) scrambling up a Bitternut Hickory. A subsequent discussion with the head ranger at GMSP revealed that he had only seen Eastern Fox Squirrels a few times near the road leading to the mile-high bridge in the GM Preserve in 11 years. This observation may therefore represent a new record for the park and possible expansion of Eastern Fox Squirrel into GMSP.

Carex bromoides ssp. montana – Rudbeckia laciniata var. humilis – Monarda didyma – Ageratina altissima var. roanensis **Herbaceous Seep (Poor Fit)** – This community type was encountered as a somewhat large seepage nested within Northern Hardwood Forest and does not fit well with any currently described seepage communities, therefore, the author has given it a name. This site represents the only location within the BFH where *Carex bromoides ssp. montana* occurs as a strong dominant. The upper portion of the seepage has a mild slope and is strongly dominated by caespitose clumps of *Carex bromoides ssp. montana*. Other herbaceous species found within the community are *Diphylleia cymosa*, *Ageratina altissima var. roanensis*, *Monarda didyma*, *Rudbeckia laciniata var. humilis*, *Micranthes micranthidifolia*, *Elymus hystrix var. hystrix*, *Platanthera grandiflora*, *Chelone glabra*, *C. lyonii*, *Oxpolis rigidior*, *Lilium grayi*, *Viola cucullata*, and *Arisaema triphyllum*. This is a permanent seepage supporting a number of rare taxa, such as *Lilium grayi*, *Platanthera grandiflora*, and *Carex bromoides ssp. montana*.

Carex scabrata – Rudbeckia laciniata var. humilis – Diphylleia cymosa **Herbaceous Seep (Poor Fit)** – This community is characterized by abundant *Carex scabrata* and has no currently described community for NC, however, there is a seepage described from West Virginia (*Carex scabrata – Viola cucullata* / *Plagiomnium ciliare* Seepage Meadow) that is somewhat similar to

the vegetation sampled in the BFH. Herbaceous species typically encountered within this community type include *Carex scabrata*, *Rudbeckia laciniata var. humilis*, *Diphylleia cymosa*, *Monarda didyma*, *Collinsonia canadensis*, *Thalictrum clavatum*, *Oxypolis rigidior*, *Trautvetteria caroliniensis*, *Viola cucullata*, *Platanthera grandiflora*, *Houstonia serpyllifolia*, and *Symphyotrichum puniceum*. Overhanging tree species included *Tilia americana var. heterophylla*, *Quercus rubra*, *Acer rubrum*, and *Aesculus flava*.

Southern Appalachian Northern Hardwood Forest (Rich Type) (G3) – A community type occurring in deep, rocky soils of sheltered coves and protected landforms 1070-1525m in the Southern and Central Appalachian Mountains of GA, NC, TN, VA, and WV. The canopy is composed of typical "northern hardwood" species, such as *Aesculus flava*, *Fagus grandifolia*, *Acer saccharum*, and *Betula alleghaniensis* with minor abundance of *Fraxinus americana*, *Tilia americana var. heterophylla*, and *Quercus rubra*. The shrub layer is usually minimally developed with scattered individuals of *Acer pennsylvanicum*, *A. spicatum*, and *Amelanchier laevis*. The herbaceous stratum is well developed and can be quite diverse with abundance of *Caulophyllum thalictroides*, *Actaea podocarpa*, *A. racemosa*, *Collinsonia canadensis*, *Ageratina altissima var. roanensis*, *Laportea canadensis*, *Dryopteris intermedia*, and *Campanula americana*. Rare species encountered within this community type include *Aconitum reclinatum*, *Coreopsis latifolia*, *Carex ruthii*, *Gentiana austromontana*, *Nabalus roanensis*, and *Stachys clingmanii*.

Three plots sampled within the BFH were identified as this community type and occurred on east, south, and southeast-facing slopes ranging from ~1275-1430m. Plots had canopy dominance of *Acer saccharum*, *Aesculus flava*, *Fagus grandifolia*, *Fraxinus americana*, and *Betula alleghaniensis* with one plot exhibiting strong dominance of *Tilia americana var.*

heterophylla. The shrub stratum is mildly developed and mainly composed of deciduous species, such as *Acer pennsylvanicum*, *Hamamelis virginiana*, *Hydrangea arborescens*, *Viburnum lantanoides*, *Sambucus racemosa var. pubens*, and *Ribes cynosbati*. Herbaceous species are diverse and carpet much of the understory with very little bare ground exposed. Common species within this layer include *Solidago curtisii*, *Sanicula smallii*, *Carex pennsylvanica*, *Laportea canadensis*, *Caulophyllum thalictroides*, *Zizia trifoliata*, *Collinsonia canadensis*, *Uvularia grandiflora*, *Prosartes lanuginosa*, *Arnoglossum reniforme*, *Osmorhiza claytonii*, *Hydrophyllum canadense*, *Festuca paradoxa*, *Deparia acrostichoides*, *Cystopteris protrusa*, *Carex laxiflora*, and *Bromus pubescens*. Uncommon or rare species found within this community type where intermittent creeks or seepages occur are *Lilium grayi* and *Geum geniculatum*. One of the plots sampled also represents the only population of a *Stachys sp*. found within the BFH. The author was never able to identify the taxon due to persistent grazing of vegetative stems, however, GPS coordinates were obtained.

Southern Appalachian Beech Gap (G1) – A community of forest vegetation with short-statured *Fagus grandifolia* on concave slopes, gaps, flat ridgetops or slopes of all aspects at an elevation of 1370m or greater. The core range of the community is found in the Southern Appalachian Mountains of NC and TN at high elevations on both mesic and dry sites. The canopy has a strong dominance of *Fagus grandifolia* with minor amounts of *Aesculus flava* and *Betula alleghaniensis*. The shrub stratum is usually absent or only minorly developed and contains *Ribes spp*., *Cornus alternifolia*, *Viburnum lantanoides*, *Crataegus punctata*, and *Rubus canadensis*. The herbaceous layer is strongly dominated by graminoids and often approaches 100% cover. The most common species occurring in this layer are *Carex pennsylvanica, C. intumescens var. fernaldii, C. flexuosa, C. brunnescens ssp. sphaerostachya, Ageratina altissima*

var. roanensis, Anemone quinquefolia, Dryopteris campyloptera, Athyrium asplenioides, Oxalis montana, Poa alsodes, Parathelypteris noveboracensis, Nabalus altissima, and *Stellaria pubera*. Rare plant species encountered within this community are *Abies fraseri, Erythronium umbilicatum ssp. monostolum, Hypericum mitchellianum, Solidago glomerata, Geum geniculatum*, and *Lilium grayi*.

One plot sampled within the BFH was identified as this community type and occurs on the ridgeline northeast of Calloway Peak. *Fagus grandifolia* was the dominant canopy species approaching 6-7m tall with some portions of the plot composed of mainly *F. grandifolia* root sprouts. The tall shrub layer was composed of minor amounts of *Acer spicatum, Prunus serotina, Acer pennsylvanicum*, and *Viburnum lantanoides*. The low shrub layer contained *Ribes glandulosum*, which was dominant in some portions of the plot. Herbaceous cover was very high and included abundant *Carex pennsylvanica, C. flexuosa, C. intumescens var. fernaldii, C. aestivalis, C. brunnescens ssp. sphaerostachya, Smilax hispida, Dryopteris campyloptera, Athyrium asplenioides, Maianthemum canadense, Oclemena acuminata, Fallopia cilinodis, Luzula acuminata, Clintonia borealis, Trillium undulatum*, and *Streptopus lanceolatus var. lanceolatus*. Rare species that may occur in this community are *Cinna latifolia* and *Carex brunnescens ssp. sphaerostachya*. The plot classified as Southern Appalachian Beech Gap within the BFH had a woodland structure with scattered *Fagus grandifolia* and some dead snags allowing much sunlight to reach the herbaceous layer. There are several other locations along the ridgeline leading northeast from Calloway Peak that appear to have been Beech Gap communities in the past but are now exhibiting total loss of *F. grandifolia* with abundant *Rubus canadensis*. Other locations have a more closed forest structure with a lush graminoid layer and

abundant *F. grandifolia* and other deciduous hardwoods, such as *Betula alleghaniensis* and *Acer saccharum*.

Southern Appalachian Boulderfield Forest (Currant & Rockcap Fern Type) (G2G3) – This community type occurs at high elevations (1370-1615m) in the Southern Appalachian Mountains on cool, rocky, humid, steep northwest to northeast-facing slopes, middle to upper concave slopes or saddles between ridges in WV, VA, NC, and TN. The community occurs on fairly large boulders (0.25-1m) with high cover throughout the plot. The dominant canopy species is *Betula alleghaniensis* usually stunted due to the difficult growing conditions, with minor canopy species *Aesculus flava, Picea rubens, Prunus pennsylvanica, Sorbus americana*, and *Acer spicatum*. Shrub species may include *Acer pennsylvanicum, Diervilla sessifolia, Hydrangea arborescens, Rubus canadensis, Ribes glandulosum, Ribes rotundifolium, Lonicera canadensis, Sambucus racemosa var. pubens*, and *Vaccinium erythrocarpum*. Species common in the herbaceous layer are *Oclemena acuminata, Eurybia chlorolepis, Clintonia borealis, Dryopteris marginalis, D. campyloptera, Cardamine clematitis, Aconitum reclinatum, Claytonia caroliniana*, and *Carex aestivalis*. Intermittent seepages often flow through this community and species common to these microhabitats are *Chelone lyonii, Circaea alpina ssp. alpina, Impatiens pallida, Monarda didyma*, and *Rudbeckia laciniata*. The rare species *Aconitum reclinatum, Geum geniculatum, Stachys clingmanii, Cardamine clematitis, Lilium grayi*, and *Solidago glomerata*.

A small plot (200m^2) within the BFH was identified as this community type and was strongly dominated by *Betula alleghaniensis* with minor percent cover of *Abies fraseri* and *Aesculus flava*. The small tree layer had abundant *Acer spicatum* and the shrub layer was dominated by *Ribes glandulosum* with minor *Sambucus racemosa var. pubens*, *Viburnum lantanoides*, and *Rhododendron maximum*. Large boulders occur within the herbaceous layer and

are covered by mosses (e.g. *Thuidium delicatulum*) providing substrate for *Clintonia borealis, Tiarella cordifolia, Eurybia chlorolepis, Laportea canadensis, Dryopteris intermedia, Oxalis montana, Oclemena acuminata, Impatiens pallida, Huperzia lucidula, Polypodium appalachianum*, and *Streptopus lanceolatus var. lanceolatus*. Two rare species found within this plot were *Cinna latifolia* and *Prunus virginiana var. virginiana*, one of several occurrences representing the first record of *P. virginiana var. virginiana* within GMSP.

Southern Appalachian High-Elevation Red Oak Forest (Deciduous Shrub Type) (G4) – A community occurring across most of the major mountain ranges in the Southern Appalachian Mountains of WV, VA, TN, NC, and GA on broad ridges and mid to upper slopes positions between 1070-1525m with mostly southeastern to southern aspect. *Quercus rubra* dominates the canopy with at least 75% cover and deciduous shrub species, such as *Rhododendron calendulaceum, Vaccinium simulatum, V. erythrocarpum, Ilex montana, Lyonia ligustrina var. ligustrina, Corylus cornuta*, and *Rubus canadensis*. The herbaceous layer is quite diverse and includes *Ageratina altissima var. roanensis, Clintonia umbellulata, Collinsonia canadensis, Dennstaedtia punctiloba, Athyrium asplenioides, Conopholis americana, Laportea canadensis, Oclemena acuminata, Solidago curtisii*, and *Silene stellata*. Rare plant species that may occur within this community type are *Carex roanensis, Silene ovata, Chelone cuthbertii, Coreopsis latifolia, Delphinium exaltatum, Hypericum mitchellianum*, and *Robinia viscosa var. hartwegii*.

One plot within the BFH was classified as this community type and was the most species diverse plot in the BFH with 89 vascular plant species in 800m^2. *Quercus rubra* dominated the canopy with minor abundance of *Acer saccharum* and *Betula alleghaniensis*. The shrub layer is composed of *Acer pennsylvanicum, Vaccinium corymbosum, Ilex montana, Rhododendron calendulaceum, Castanea dentata, Amelanchier laevis*, and *Hydrangea arborescens*. Abundant

herbaceous species included *Parathelypteris noveboracensis, Carex pennsylvanica*, and *Eurybia chlorolepis* with minor components of *Solidago curtisii, Houstonia purpurea, Pedicularis canadensis, Polygonatum biflorum, Zizia trifoliata, Smilax herbacea, Anemone quinquefolia, Danthonia spicata, Brachyelytrum erectum, Dichanthelium latifolium, Amianthium muscitoxicum, Lysimachia quadrifolia, Carex communis, C. flexuosa, Conopholis americana, Heuchera villosa var. villosa, Campanula divaricata*, and *Trautvetteria caroliniensis*.

***Picea rubens / (Rhododendron maximum, R. catawbiense) / Bazzania trilobata* Forest (Poor Fit) –** One plot was identified as this community type within the BFH occurring at 1703m. The canopy was strongly dominated by *Picea rubens* with living and dead snags of *Abies fraseri* scattered throughout the canopy layer. The shrub stratum had abundant coverage of *Rhododendron catawbiense* and *R. maximum*, with minor amounts of *Vaccinium corymbosum, Sorbus americana, Rhododendron pilosum* and *Amelanchier laevis*. The herbaceous layer was absent, however, nonvascular taxa (e.g. *Bazzania trilobata*) was quite dominant and forming almost a complete monoculture on the forest floor.

Southern Appalachian Rich Cove Forest (Montane Calcareous Type) (G3G4) – This community type includes forests in middle to low (610-1400m) sheltered coves and protected slopes usually associated with rich soils and mafic geology found in TN, NC, and VA. The canopy is dominated by various combinations of *Acer saccharum, Aesculus flava, Fraxinus americana, Halesia tetraptera*, and *Tilia americana var. heterophylla* with minor association of *Carya cordiformis* and *Quercus rubra*. The shrub stratum is typically absent, and the herbaceous layer is lush and rich, often including a number of calciphiles, such as *Asarum canadense, Carex plantaginea, Carex fraserianus, Cystopteris protrusa, Deparia acrostichoides, Hydrophyllum canadense, Prosartes lanuginosa, Solidago flexicaulis*, and *Viola canadensis*. Sometimes this

forest can have local herbaceous dominance by *Laportea canadensis, Viola canadensis, Dryopteris intermedia, Actaea podocarpa*, and *Caulophyllum thalictroides*. A defining characteristic of this community type is the lack of *Betula alleghaniensis* and *Fagus grandifolia* in the canopy as dominant species and the abundance of base-loving herbaceous species in the understory layer.

One plot sampled within the BFH was classified as this community type and occurred at ~1397m. The canopy had a strong dominance of *Fraxinus americana, Acer saccharum, Aesculus flava*, and *Prunus serotina* with minor amounts of *Quercus rubra, Betula alleghaniensis, Robinia pseudoacacia, Tilia americana var. heterophylla,* and *Fagus grandifolia*. A minor shrub stratum was developed over the very rocky soils with *Acer spicatum, Ribes cynosbati, Acer pennsylvanicum*, and *Sambucus racemosa var. pubens*. The herbaceous layer was well developed and composed of the abundant species *Laportea canadensis, Solidago flexicaulis, Osmorhiza claytonii, Hydrophyllum canadense, Ageratina altissima var. roanensis, Festuca paradoxa*, and *Caulophyllum thalictroides* with minor amounts of *Rudbeckia laciniata var. humilis, Dryopteris intermedia, Eurybia chlorolepis, Cystopteris protrusa, Prosartes lanuginosa, Viola canadensis, Boechera laevigata, Actaea racemosa, A. podocarpa, Maianthemum racemosum, Trillium erectum, Deparia acrostichoides, Monarda clinopodia*, and *Polystichum acrostichoides*. This plot had a large number of boulders on the surface of the soil and has a number of intermittent stream channels cutting through the plot.

Rich Montane Seep (High Elevation Type) (G3) – This community type is characterized by forb-dominated wetlands at high elevations (>1200m) in the Southern Blue Ridge Mountains of VA, TN, NC, SC, and GA. The herbaceous wetlands lack *Sphagnum sp*. and are typically open without shading from a forest canopy. Species that are usually dominant in these communities

include *Impatiens pallida, Monarda didyma*, and *Rudbeckia laciniata var. digitata* with minor amounts of *Cardamine clematitis, Carex flexuosa, Chelone lyonii, Conioselinum chinense, Geum geniculatum, Houstonia serpyllifolia, Lilium grayi, Solidago patula, Thalictrum clavatum, Trautvetteria caroliniensis, Veratrum viride*, and *Viola cucullata*. Rare species sometimes found in this community are *Aconitum reclinatum, Geum geniculatum, Cardamine clematitis, Carex bromoides ssp. montana*, and *Lilium grayi*.

One plot was designated as this community type, however, there was some uncertainty of its classification and it may actually be Rich Montane Seep (Cove Type). Herbaceous species with high cover values included *Eurybia chlorolepis, Solidago flexicaulis, Rudbeckia laciniata var. ?, Ageratina altissima var. roanensis, Laportea canadensis, Symphyotrichum cordifolium, Monarda didyma, Thalictrum clavatum, Diphylleia cymosa, Micranthes micranthidifolia*, and *Chelone lyonii* with a minor component of *Micranthes careyana, Hydrophyllum canadense, Bromus pubescens, Osmorhiza claytonii, Galium triflorum, Thaspium barbinode, Viola canadensis, Sanicula smallii, Allium tricoccum, Lilium grayi, Actaea podocarpa, Arnoglossum reniforme*, and *Elymus hystrix*. The seepage was primarily open and did not seem to be caused by a treefall gap as the middle of the seepage had no evidence of old stumps or turned up root balls.

High-Elevation Granitic Dome (High Peak Lichen Type) (G2) – An imperiled community type known to occur at Roan Mountain and GM on typically dry, steeply sloping exfoliation domes. The association, as defined, covers vertical cliffs and sometimes more gently sloping large rock outcrops, which have extremely few vascular plants and are commonly dry. In the Southern Appalachian Mountains, these communities typically occur due to few or no suitable crevices in the outcrop geometry and lack of seepage, which can support vascular species. The umbilicate lichens *Lasallia papulosa* and *L. caroliniana* dominate this community, with the

majority of occurrences having no vascular species. This community type is commonly encountered on rock outcrops occurring on the ridgeline leading northeast from Calloway Peak. From field observations, it seems each outcrop can vary from almost complete dominance of *L. papulosa* and minor amounts of *L. caroliniana* or vice versa. On large outcrops, the community can have small inclusions of soil where rare species, such as *Paronychia argyrocoma* and *Solidago puberula* occur with the common moss *Polytrichum piliferum*. Sometimes this community is adjacent to mafic outcrops that include *Houstonia montana*, *Arabidopsis lyrata ssp. lyrata, Aquilegia canadensis*, and *Heuchera villosa var. villosa*.

Southern Appalachian High-Elevation Rocky Summit (High Peak Type) (G1) – A very rare community in the Southern Appalachian Mountains of NC and TN typically occurring over 1980m on vegetated outcrops of highly-fractured felsic to mafic bedrock. Fissures in the rock outcrop develop soil pockets and provide habitat for *Carex misera, Abies fraseri, Rhododendron pilosum, R. catawbiense, Heuchera villosa, Hydatica petiolaris, Oclemena acuminata, Solidago glomerata,* and *Sorbus americana*. A study in the Southern Appalachian Mountains investigated Appalachian trail vegetation in an 1134 plot analysis and found two plots identified as this vegetation type on Mount Buckley in TN. The most constant species in both plots included *Carex misera, Abies fraseri, Clintonia borealis, Carex brunnescens ssp. sphaerostachya, Rhododendron pilosum, Oxalis montana, Oclemena acuminata, Athyrium asplenioides*, and *Hydatica petiolaris*. There is one location within the BFH where this community type may occur, even though it is well below the supposed elevational gradient for this community. It is on a large, sloping rock outcrop with soil pockets including *Abies fraseri, Rhododendron catawbiense, Hydatica petiolaris, Carex misera, C. aestivalis, Solidago glomerata*, and *Oclemena acuminata*. At the base of the outcrop there are seepage communities with nearly

constant seepage and *Sphagnum sp*. transitioning from a sloping seep to a nearly vertical "splash zone cliff."

Blue Ridge Hemlock – Northern Hardwood Forest (G3) – This vegetation type occurs on steep north-facing slopes and slopes and flats along and above streams in the Southern Appalachian Mountains of NC, TN, VA, and WV. The protected nature of this community contributes to low solar exposure with rocky soils, talus slopes, and heavy litter layers. The community type typically occurs between 320-1350m, although it is suspected to extend upwards in elevation to 1524m. The mixed canopy can be open to closed with strong dominance of *Betula alleghaniensis* and *Tsuga canadensis* and minor cover from *Acer rubrum, Betula lenta, Tilia americana var. heterophylla, Magnolia acuminata, Picea rubens, Quercus rubra*, and *Prunus serotina*. The tall shrub stratum is usually around two meters tall and forms monospecific stands (50-100% coverage) of *Rhododendron maximum* with minor inclusions of *Acer pennsylvanicum, Amelanchier laevis, Hamamelis virginiana, Ilex montana*, and *Vaccinium erythrocarpum*. The ground layer is almost devoid of vascular plants and has scattered occurrence of bryophytes with some species including *Dryopteris intermedia, Oclemena acuminata, Polystichum acrostichoides,* and *Viola rotundifolia*. The diminutive orchid, *Listera smallii*, may also occur in this community type.

There is a relatively unbroken occurrence of this community type on the north-facing slopes below Flat Rock overlook on the Daniel Boone Scout Trail. *Betula alleghaniensis* is dominant in the canopy with the canopy associates *Acer rubrum, Quercus rubra, Magnolia fraseri, Prunus serotina,* and minor *Tsuga canadensis*. The shrub layer is an almost impenetrable stand of *Rhododendron maximum*, with minor occurrences of *R. catawbiense, Clethra acuminata, Amelanchier laevis* and *Acer pennsylvanicum*. The herb layer is virtually non-

existent, however *Dryopteris intermedia, Viola rotundifolia, Oclemena acuminata*, and some graminoids may occur in this stratum. The community is rocky and very steep with intermittent creeks and seepages scattered throughout.

Montane Cliff (Common Rocktripe Type) (G4) – This community type occurs on relatively moist, shaded acidic rock outcrops typically with northern aspects. *Umbilicaria mammulata* strongly dominates the rock surface, with very few vascular plant species in the herbaceous or shrub layer. Adjacent canopy species may overhang the community and provide shade for a certain portion of the day. *Dryopteris intermedia* and *Polypodium appalachianum* may occur as minor associates. Some occasional bryophytes that can occur in this community are *Andraea rothii, Leucobryum albidum*, and *Rhabdoweisia crispata*. There are a number of occurrences of this community type in the BFH with variable size, but all are dominated by *Umbilicaria mammulata*.

Floristic Similarity. When vascular plant sampling was completed within the BFH, it was possible to compare the flora of the BFH with other completed floras, primarily in the Southern and Central Appalachian Mountains (Table 5). The Sørensen Index, or Sørensen's similarity coefficient, was used to determine the percent of floristic similarity between sites and was calculated through a presence/absence matrix in R with the package CommEcol and the function dis.chao(). Ten floras were included in the analysis with four from the Amphibolite Mountain Macrosite (AMM) in northwestern NC, Tater Hill Preserve (NC), the Black & Craggy Mountains (NC), Fernow Experimental Forest (WV), Hanging Rock (NC), Rocky Fork Tract (TN), and the Roan Mountain Massif (TN/NC). Floras within the AMM were expected to have lower floristic similarity to the BFH due mainly to the amphibolite bedrock, which through weathering produces soils with a more basic pH, provides a larger amount of calcium,

magnesium, aluminum, and iron ions, and allows for development of unique and diverse natural communities. Hanging Rock's flora was expected to have the highest similarity with the BFH because of its proximity to GM and many of the same natural communities shared between the two sites.

The results corroborated my predictions about the AMM and its floristic relationship to the BFH with three of the four AMM floras having an average similarity of 44%, indicating a poor overlap in the vascular plant species between sites. The low similarity is likely due to the aforementioned amphibolite bedrock, the number of plant species collected at the three AMM locations, and the size of the sample area. The BFH was ~404ha and contains only minor inclusions of amphibolite with the majority of the site containing natural communities and species with a more widespread distribution across the Southern Appalachian Mountains. Bluff Mtn. (1287ha) and Phoenix Mtn. (767ha) have larger sample areas and contain many species that are uncommon in NC and occur in specific natural community types that are also rare in NC (e.g. Southern Appalachian Ultramafic Seep). Three Top Mtn., also within the AMM, had a higher similarity to the BFH (56.8%), likely due to the smaller amount of species found at both sites with a larger amount of species overlap between sites. The Hanging Rock flora had the highest similarity to the BFH (59.5%), likely attributed to the very close association of the two mountains and the overlapping community types found at both locations. The rock type underlying Hanging Rock is composed mainly of foliated greenstone and greenschist, with minor inclusions of arkose on the crests and upper slopes of Peak Mtn. and siltstone found on the lower slopes of Hanging Rock near the Watauga River Valley (Rohrer 1983), which is in contrast to the strong dominance of sericitic metamorphosed arkose and arkosic quartzite found predominantly within the BFH.

The Sørensen Index was also used to assess the floristic similarity of the natural community plots sampled within the BFH. Plots were classified based on dominant taxa within the canopy, subcanopy, shrub, herb and nonvascular layers (Fig. 3). High similarity values between 20 different plots ranged from 64-78% overlap in vascular and some nonvascular taxa. Plots 4, 6, and 17 all had high similarity (6-4 65%; 6-17 66%) to one another and were classified as High Elevation Red Oak Forest (Tall Herb Type) and Southern Appalachian High Elevation Red Oak Forest (Deciduous Shrub Type). Three plots (12,13,15) were classified as Southern Appalachian Northern Hardwood Forest (Rich Type) and had high vegetation overlap between plots (12-13 77%; 13-15 66%). Plots 5, 7, and 18 were all very similar floristically to one another (5-18 76%; 7-18 70%) and contained two community types: Red Spruce – Northern Hardwood Forest (Herb Type) and Fraser Fir Forest (Deciduous Shrub Type). Seepage plots (e.g. 10,11) tended to have similarities ranging between 66-71%. An NMDS (Fig. 4) was performed on the vegetation plots to determine similarity amongst community types and their relationship to one another. Hierarchical cluster analysis (HCA) was also performed in order to display a simpler visualization of the data for the natural community plots (Fig. 5). Both NMDS and HCA were performed within RStudio utilizing a number of packages and functions.

Discussion

The floristic survey within the BFH revealed a number of new and updated county records for vascular plant species and two natural communities which may represent undescribed community types for NC. Meeting with the park staff gave us critical information about the relatively unexplored BFH and provided the opportunity to sample and inventory this portion of the state park. We now understand that *Dendrolycopodium hickeyi, Populus grandidentata, Prunus virginiana var. virginiana*, and *Solidago puberula* all occur within the BFH and represent

Watauga County records according to the NC Natural Heritage Program 2018 rare plant list. *Arabidopsis lyrata ssp. lyrata* and *Cinna latifolia* were also identified within the BFH and represent important updated elemental occurrence records for the NCNHP. In the 2018 rare plant list, published by the NCNHP, both species are considered uncertain for Watauga County due to poor information about the species (for Watauga Cty.) over the last 20-40 years. We have confirmed that both species occur within the state park and Watauga County, at least within the BFH study area.

The unique and rare vascular plant taxa identified within the BFH were not the only interesting data to be gathered during the study period. Two natural communities sampled within the BFH appear to represent unique vegetation types within NC and are proposed as new community types in the Southern Appalachian Mountains. Final recognition of these community types as unique will require more intimate study across the region to determine if they merit recognition (Michael Schafale pers. comm.). The first community is a permanent seepage dominated by *Carex bromoides ssp. montana* with similar associated species to the recognized Rich Montane Seep community of the Southern Appalachian Mountains. The second community is the most depauperate community type sampled within the BFH and is typified by a canopy layer dominated by *Picea rubens*, a minor, low percent cover shrub layer, and a nonvascular ground layer dominated by *Bazzania trilobata*. The potentially new community types and vascular plant records will be discussed in detail in the following paragraphs.

Many of the vascular plants and epipetric mosses collected during this study are common within the BFH and the Southern Appalachian Mountains, however, there are a small portion of vascular plants identified with a limited distribution in North Carolina. Two species that were of particular interest were *Prunus virginiana var. virginiana* and *Dendrolycopodium hickeyi*. Both

species are widespread and abundant mainly to the north and west of North Carolina, but within NC are listed as S2 and S2? respectively. *Prunus virginiana var. virginiana* (Chokecherry) occurs within the BFH primarily in high-elevation northern hardwood forests and in boulderfield forests on steep slopes. These community types usually have a high number of boulders on the surface of the ground and sometimes have braided stream/seepage areas. Chokecherry seems to be associated with seepage or moist soils within these boulder-covered community types. All of the occurrences within the BFH were spreading clonally except for one location adjacent to a treefall gap where individual ramets were blooming. Due to the large amount of high-elevation forest communities in the mountains of NC, Chokecherry may be more common than currently known and overlooked in its forest habitat. The species can be determined relatively easily when in bloom or fruit but because of the largely clonal nature in the mountains of NC it can be more difficult to identify.

Dendrolycopodium hickeyi (Hickey's Clubmoss) was also identified within the BFH and was relatively common in appropriate habitats. It was most common in shrub bald communities where it spreads rhizomatously beneath deciduous shrubs and along the edge of rock outcrops in soil pockets. It may be overlooked in appropriate habitats due to its very similar appearance to *D. obscurum* and sometimes being passed over as a "Lycopodium". This species has ample habitat across the mountains of NC at high elevations as deciduous shrub balds occur quite commonly in the various mountain ranges of NC. The species may be more common than is currently known due to confusion with *D. obscurum* and difficult access to appropriate habitats at high elevations. Another rare species occurring within the BFH is *Cardamine clematitis*, a member of the Brassicaceae. The species can be found in appropriate habitats of the high-elevation forest and seep communities (e.g. Red Spruce – Northern Hardwood Forest (Herb Type)) within the BFH.

It is interesting to note that John K. Small and Arthur A. Heller documented this plant occurring with regularity "in and alongside the trail" leading to the summit of Calloway Peak (Small and Heller 1892). The author also discovered the species alongside the Daniel Boone Scout Trail and in intermittent stream/seepage channels at high elevations. Based on anecdotal evidence the species seems to prefer habitats with a regular disturbance regime. All individuals found occurred on the edge of trails or in stream/seepage channels where high flow events can typically occur multiple times during the year. It may be that this species uses the disturbance events to distribute its seeds and therefore migrate short distances within the appropriate habitat.

In the natural community sampling within the BFH, two natural communities did not fit well with current classifications and may represent new community types or state records of community types. One of the community types is a seepage (Fig. 6) dominated by *Carex bromoides ssp. montana*, an uncommon species in NC. This community is a constant seepage with associated species *Rudbeckia laciniata var. humilis, Monarda didyma, Ageratina altissima var. roanensis, Elymus hystrix, Micranthes micranthidifolia, Chelone glabra, C. lyonii*, and *Platanthera grandiflora*. Even though the dominant graminoid is uniquely different from other seepage communities within the BFH, all seepage plots (9,10,11,21) group closely in ordination (Fig. 4) and have floristic similarity between plots ranging from 66-71%. The Rich Montane Seep community type is highly variable across its range and it is likely that this plot represents a variation of that community with *Carex bromoides ssp. montana* as a dominant (Michael Schafale pers. comm.).

The second community type (Fig. 7) which may represent a new vegetation type or state record is a Red Spruce Forest on the upper portion of the Daniel Boone Scout Trail. The canopy is strongly dominated by *Picea rubens* with minor amounts of *Abies fraseri* and the shrub canopy

has low percent cover of mainly evergreen and some deciduous shrubs, including *Rhododendron catawbiense, R. maximum, Vaccinium corymbosum*, and *Sorbus americana*. The herbaceous layer is almost entirely absent, and the nonvascular layer is dominated by sometimes continuous carpets of *Bazzania trilobata*. A community type currently described from West Virginia closely mirrors the species occurring in this community on Grandfather and is classified as Red Spruce Forest (Central Appalachian Upland Type). Ordination (Fig. 4) revealed this plot is different from all other plots, even plots occurring in high-elevation habitats with similar floristic elements within the BFH. Low similarity between spruce-fir plots, such as Fraser Fir Forest (Deciduous Shrub Type), is likely due to the depauperate nature of this forest type and the lack of herbaceous species in the ground layer contributing to its low species richness. There are very few examples of this community in NC and it is likely that this stand represents a successional stage following disturbance (e.g. logging) and is not a permanent community type (Michael Schafale pers. comm.).

One observation made between different northern hardwood forest stands within GMSP are a number of herbaceous species and their presence/absence in similar forest stands within the park. On the northwest side of the park, the Profile Trail passes through several impressive northern hardwood forest stands with a number of herbaceous species that do not occur in similar forest stands of the BFH. For example, *Asarum canadense, Phacelia fimbriata, Mitella diphylla, Anemone virginiana, A. acutiloba, A. americana*, and *Boykinia aconitifolia* occur in northern hardwood forest stands along the Profile Trail with similar vegetation to the BFH. However, these species are notably absent from the BFH. Almost all of these species are associated with circumneutral soils which occur sporadically across GM where amphibolite, metadiabase, and dolomitic bedrock occur in minor inclusions (Fig. 8). Plant species often associated with

circumneutral soils do occur in the BFH, and include species such as *Solidago flexicaulis, Aconitum reclinatum, Collinsonia canadensis, Platanthera orbiculata,* and *Scrophularia marilandica*. The presence of these and other species in northern hardwood forest stands of the BFH would suggest that specific areas within the stands have inclusions of more circumneutral soil even though there are no mapped units of amphibolite within the BFH. Most of these forest stands with circumneutral-loving species occur along creeks or intermittent seepages where alluvium has been deposited from mafic rocks for millennia and likely contributes to the inclusion of these plant species within the BFH. On the northwest side of GM, along the Profile Trail there are mapped inclusions of dolomite, metadiabase, and amphibole porphyroclasts likely contributing to the presence of the aforementioned species not found in the BFH. It is possible some of the herbaceous species occurring along the Profile Trail were historically found in the BFH but may have been eliminated by disturbance. In the late 1930s, there was a major fire that occurred in the BFH that burned for 30 days and likely eliminated many herbaceous species due to the extended exposure of the seedbank to fire (Johnson 2016). It is possible this event contributed to the elimination of some taxa from the BFH, however, it is likely the underlying bedrock is the major component for their absence in the BFH.

On the high-elevation rock outcrop communities within the BFH, a common plant species in the Southern Appalachian Mountains at high elevations, *Sibbaldia retusa* (O.F. Müll.) T. Erikss., is notably absent or was overlooked by the author. The species occurs with regularity in the high mountains south of Asheville along the Blue Ridge Parkway where large rock outcrops and grassy balds (e.g. Black Balsam Mtn.) are more common (pers. obs.). The species was collected just south of GM at Beacon Heights in 1977 (WCUH0028626) and just west in 1961 on Hanging Rock (NCU00065171) at elevations of 1311m and undocumented for the

Hanging Rock collection (SERNEC Data Portal 2018). Therefore, it seems strange that this species was not located during the 2019 field season, especially along the ridgeline from Calloway Peak to the Bench Huckleberry Patch, where abundant large outcroppings are located. The species should be surveyed for in appropriate habitats of the BFH during the 2020 field season to make sure it was not overlooked during the initial 2019 collecting season.

Cinna latifolia (Trevis. ex Goepp.) Griseb. is an uncommon species of grass found within the BFH and high-elevation forests in the Southern Appalachian Mountains of NC. The species is certainly uncommon within the BFH drainage and was observed within the transition zone between northern hardwood forest and spruce-fir forest and within beech gaps and boulderfield forests at high elevations. It is more widely distributed to the north and west of the Southern Appalachian Mountains and may warrant variety, subspecies, or specific rank in the four different regions in which it grows (Fig. 9). A study was performed on the taxonomy of *Cinna* L. in the early 90s and the authors determined there were four species of *Cinna* L. in North America (Brandenburg et al. 1991). They state that *C. latifolia* is the most variable of the four taxa listed but still treat it as a single species based off of spikelet characteristics (Brandenburg et al. 1991). It would seem a study investigating the genetic differences between the Southern Appalachian Mountain, New England, Great Lakes, and upper mid-western populations may provide a finer scale of differentiation between these populations that appear to be separated geographically.

A number of vascular plant species were not collected during the fieldwork for this project and are listed below (Table 6.). *Osmorhiza longistylis* (Torrey) A.P. de Candolle, *Symphyotrichum lowrieanum* (Porter) G.L. Nesom, *Boechera canadensis* (L.) Al-Shehbaz, *Stellaria corei* Shinners, *Circaea alpina* L. *ssp. alpina*, *Thalictrum coriaceum* (Britton) Small, *Vaccinium simulatum* Small, and *Micranthes caroliniana* (A. Gray) Small could be represented

within the BFH but were not identified due to taxonomic confusion/misidentification of closely related taxa. *Solidago arguta* Aiton *var. caroliniana* A. Gray and *Symphyotrichum prenanthoides* (Muhlenberg ex Willdenow) G.L. Nesom were not encountered during this survey and may be absent due to the lack of more open habitats (e.g. wet meadows, grassy balds), which seem to be more suitable for these species. *Symphyotrichum retroflexum* (Lindley ex A.P. de Candolle) G.L. Nesom is found ~15mi north of the BFH along the Blue Ridge Parkway but is absent from the BFH potentially due to the higher elevation and the more shaded habitats occurring within the BFH. The author has observed this species in forest communities within the mountains of SC at elevations of ~762-914m. Three species of *Dryopteris* Adanson were identified during the floristic inventory and hybrids are likely present especially where *D. intermedia* overlaps with *D. campyloptera* along the transitional zone from northern hardwood forest to spruce-fir forest. *Goodyera repens* (L.) R. Brown is known to occur on GM and may have been overlooked while collecting within spruce-fir forest communities of the BFH. *Danthonia compressa* Austin ex Peck may occur within the BFH but is likely absent due to the small number of open habitats (e.g. grassy balds, rock outcrops) that typically support this species.

The epipetric mosses identified during this study are well represented throughout the BFH, with a suite of five species occurring with regularity on boulders in the understory of mainly northern hardwood forest communities. The five most common species found on boulders were *Schistidium apocarpum, Grimmia pilifera, Ulota hutchinsiae, Hedwigia ciliata,* and *Dicranum fulvum*. These species are quite common and sometimes all are represented on one boulder often with the associated lichens *Umbilicaria mammulata, Cetrelia chicitae*, and *Sticta beauvoisii*. It is worth noting that many of the rock outcrops and boulders in full sunlight had very few epipetric mosses and were mainly dominated by lichen taxa, such as *Rhizocarpon sp.,*

Umbilicaria caroliniana, and other crustose lichens (Fig. 10). Moss taxa were represented within the confines of these outcrops but were mainly terrestrial species that took advantage of soil pockets in rock crevices (e.g. *Polytrichum piliferum*). Certainly, mosses have the physiological mechanisms in place to tolerate extreme environments, but it may be that the environmental constraints on moss taxa at high elevations within the BFH are outside the physiological tolerance levels for most epipetric moss taxa. The survey for epipetric mosses during my floristic inventory was a subset of my main thesis work and a more detailed study focusing on bryophyte taxa at GMSP should be proposed and enacted in the future in order to document the diverse bryophyte flora within the confines of the state park.

Conclusion

The floristic inventory of the BFH has revealed a number of interesting details pertaining to the flora and vegetation of this portion of the state park. Several new taxonomic records for the state park and Watauga County have been identified (e.g. *Prunus virginiana var. virginiana*). The new taxonomic records will provide accurate locality data for the 24 vascular plant species that are currently tracked by the NCNHP and facilitate a more intimate knowledge of this lesser explored portion of the state park. The vegetation sampling performed within the BFH revealed 18 distinct natural communities, two of which are proposed as new undescribed community types in the Southern Appalachian Mountains. Park managers and staff will have full access to the detailed information set forth within this thesis and will be better equipped to appropriately manage the natural resources found throughout GMSP. The work completed within the BFH in no way represents the summation of floristic work within the study area. However, it does provide a strong foundation for continued sampling, not only within the BFH, but particularly those areas of the park that are more remote and distanced from community trails and human

traffic. These locations should be targeted for future research assessing bryophyte and lichen diversity within the state park and searching for more cryptic taxa that may have remained hidden due to unique microclimatic habitats or lack of intensive surveys.

Table 1. The most species rich plant families within the Boone Fork Headwaters of GMSP.

Family	# of Sp./family
Asteraceae	21
Ericaceae	18
Cyperaceae	17
Ranunculaceae	15
Poaceae	14
Rosaceae	11
Violaceae	8
Liliaceae	8
Apiaceae	7
Orchidaceae	7

Table 2. A list of all vulnerable, threatened, endangered, and watchlist vascular plant species, according to the NCNHP (2018), occurring within the BFH of GMSP.

Species Name	Common Name	Family	NCNHP Ranking*
Abies fraseri	Fraser Fir	Pinaceae	W5 S2G2
Aconitum reclinatum	Trailing Wolfsbane	Ranunculaceae	SR-T S3G3
Arabidopsis lyrata ssp. lyrata	Lyre-leaf Rockcress	Brassicaceae	W1 S2G5
Aronia prunifolia	Purple Chokeberry	Rosaceae	W1 S2 GNA
Cardamine clematitis	Mountain Bittercress	Brassicaceae	SR-T S2S3G3
Carex bromoides subsp. montana	Blue Ridge Brome Sedge	Cyperaceae	W7 S3?G5T3?
Carex fraseriana	Fraser's Sedge	Cyperaceae	W1 S3G4
Carex misera	Wretched Sedge	Cyperaceae	W1 S3G3
Carex roanensis	Roan Mountain Sedge	Cyperaceae	SR-T S2G2G3
Cinna latifolia	Drooping Woodreed	Poaceae	W7 S1S2G5
Dendrolycopodium hickeyi	Hickey's Tree-clubmoss	Lycopodiaceae	SR-P S2?G5
Gentiana clausa	Meadow Bottle Gentian	Gentianaceae	W7 S3?G5
Geum geniculatum	Bent Avens	Rosaceae	SC-V S1S2G2
Houstonia montana	Roan Mountain Bluet	Rubiaceae	EE S2G5T2
Huperzia apressa	Appalachian Firmoss	Huperziaceae	W1 S3G5
Hypericum mitchellianum	Mitchell's St. John's-wort	Hypericaceae	W1 S2S3G3
Lilium grayi	Gray's Lily	Liliaceae	T S1S2G1G2
Micranthes careyana	Carey Saxifrage	Saxifragaceae	W1 S3G3
Platanthera grandiflora	Large Purple Fringed Orchid	Orchidaceae	T S2G5
Populus grandidentata	Bigtooth Aspen	Salicaceae	W7 S2G5
Prunus virginiana var. virginiana	Choke Cherry	Rosaceae	W7 S2G5T5

Rhododendron vaseyi	Pinkshell Azalea	Ericaceae	SR-L S3G3
Rudbeckia laciniata var. humilis	Cutleaf Coneflower	Asteraceae	W7 S2?G5T3?
Solidago puberula	Downy Goldenrod	Asteraceae	W7 S2G5T4T5

*See appendix for NCNHP ranking codes

Table 3. List of epipetric mosses found occupying dry boulders and rock outcrops within the BFH of GMSP.

Epipetric Mosses	**Family**
Andraea rothii Web. & Mohr	Andreaeaceae
Anomodon attenuatus (Hedw.) Hüb.	Anomodontaceae
Anomodon rostratus (Hedw.) Schimp.	Anomodontaceae
Dicranum fulvum Hook.	Dicranaceae
Fissidens dubius P. Beauv.	Fissidentaceae
Grimmia pilifera P. Beauv.	Grimmiaceae
Gymnostomum aeruginosum Smith	Pottiaceae
Haplohymenium triste (Ces.) Kindb.	Anomodontaceae
Hedwigia ciliata (Hedw.) P. Beauv.	Hedwigiaceae
Herzogiella striatella (Brid.) Iwats.	Hypnaceae
Hypnum imponens Hedw.	Hypnaceae
Hypnum pallescens (Hedw.) P. Beauv.	Hypnaceae
Plagiothecium laetum Schimp.	Plagiotheciaceae
Ptychomitrium incurvum (Schwägr.) Spruce	Ptychomitriaceae
Pylaisiadelpha tenuirostris (Bruch & Schimp.) W. R. Buck	Sematophyllaceae
Schistidium apocarpum (Hedw.) Bruch & Schimp.	Grimmiaceae
Taxiphyllum deplanatum (Bruch & Schimp. ex Sull.) Fleisch.	Hypnaceae
Thuidium delicatulum (Hedw.) Schimp.	Thuidiaceae
Ulota hutchinsiae (Sm.) Hammar	Orthotrichaceae

Table 4. The natural communities of the BFH within GMSP.

NVC Unique Identifier*	**Natural Communities of Grandfather Mountain**	**# Sp./Plot**	**Area (m2)**
CEGL007285 (1) +	Southern Appalachian Northern Hardwood Forest	73	1000
CEGL003814 (2)	Southern Appalachian Mountain Laurel Bald	50	600
Poor Fit (3)	*Betula alleghaniensis – Acer rubrum / Hamamelis virginiana - (Ilex montana) / Dryopteris intermedia - (Carex pennsylvanica)* Forest	66	1000
CEGL007298 (4)	High-Elevation Red Oak Forest (Tall Herb Type)	72	1000
CEGL006256 (5)	Red Spruce - Northern Hardwood Forest (Herb Type)	53	1000
CEGL007298 (6)	High Elevation Red Oak Forest (Herb Type)	52	600
CEGL006049 (7)	Fraser Fir Forest (Deciduous Shrub Type)	30	1000

CEGL007299 (8)	Southern Appalachian High-Elevation Red Oak Forest (Evergreen Shrub Type)	42	1000
CEGL004296 (9)	Rich Montane Seep (Cove Type)	52	100
Poor Fit (10)	*Carex bromoides ssp. montana – Rudbeckia laciniata var. humilis – Monarda didyma – Ageratina altissima var. roanensis* Seep	43	100
Poor Fit (11)	*Carex scabrata – Rudbeckia laciniata var. humilis – Diphylleia cymosa Seep*	32	100
CEGL004973 (12)	Southern Appalachian Northern Hardwood Forest (Rich Type)	80	1000
CEGL004973 (13)	Southern Appalachian Northern Hardwood Forest (Rich Type)	76	1000
CEGL006130 (14)	Southern Appalachian Beech Gap	45	600
CEGL004973 (15)	Southern Appalachian Northern Hardwood Forest (Rich Type)	67	600
CEGL006124 (16)	Southern Appalachian Boulderfield Forest (Currant & Rockcap Fern Type)	32	200
CEGL007300 (17)	Southern Appalachian High-Elevation Red Oak Forest (Deciduous Shrub Type)	89	800
CEGL006256 (18)	Red Spruce - Northern Hardwood Forest (Herb Type)	36	1000
Poor Fit (19)	*Picea rubens / (Rhododendron maximum, R. catawbiense) / Bazzania trilobata* Forest	14	600
CEGL007695 (20)	Southern Appalachian Rich Cove Forest (Montane Calcareous Type)	76	1000
CEGL004293 (21)	Rich Montane Seep (High Elevation Type)	46	100
CEGL004386	High-Elevation Granitic Dome (High Peak Lichen Type) †	NA	NA
CEGL004277	Southern Appalachian High-Elevation Rocky Summit (High Peak Type) †	NA	NA
CEGL007861	Blue Ridge Hemlock - Northern Hardwood Forest †	NA	NA
CEGL004387	Montane Cliff (Common Rocktripe Type) †	NA	NA

* Codes correspond to the United States National Vegetation Classification (USNVC) system
† These communities were not sampled due to time and safety constraints
+ Numbers in parentheses correspond to numbered sites in NMDS and Hierarchical Cluster Analysis

Table 5. Sørensen similarity coefficient calculated for 11 different floras conducted within the Southern and Central Appalachian Mountains of WV, TN, and NC.

Site	**State**	**Area (ha)**	**Species #**	**Sorensen Index**
Mount Jefferson (AMM)	NC	368	695	**41.0%**
Three Top Mtn. (AMM)	NC	866	316	**56.8%**
Bluff Mtn. (AMM)	NC	1287	693	**44.0%**
Phoenix Mtn. (AMM)	NC	767	426	**48.2%**
Tater Hill	NC	63	321	**49.8%**
GMSP - Boone Fork	NC	404	263	**100.0%**
Black/Craggy Mtns.	NC	35000	972	**38.5%**
Fernow Exp. Forest	WV	1861	461	**45.3%**
Hanging Rock	NC	?	355	**59.5%**

Rocky Fork Tract	TN	3800	749	**43.2%**
Roan Mtn. Massif	TN/NC	?	852?	**43.8%**

Table 6. A list of vascular plant taxa that were not collected within the BFH but may be present and were overlooked during the 2019 growing season.

Taxa
Osmorhiza longistylis (Torrey) A.P. de Candolle
Solidago arguta Aiton *var. caroliniana* A. Gray
Symphyotrichum lowrieanum (Porter) G.L. Nesom
S. prenanthoides (Muhlenberg ex Willdenow) G.L. Nesom
S. retroflexum (Lindley ex A.P. de Candolle) G.L. Nesom
Boechera canadensis (L.) Al-Shehbaz
Stellaria corei Shinners
Dryopteris Adanson hybrids
Vaccinium simulatum Small
Circaea alpina L. *ssp. alpina*
Goodyera repens (L.) R. Brown
Danthonia compressa Austin ex Peck
Thalictrum coriaceum (Britton) Small
Micranthes caroliniana (A. Gray) Small

Figure 1. Carolina Vegetation Survey plot description for vegetation sampling developed by Peet et al. 1998.

Figure 2. Vascular plant collections within the BFH of GMSP.

Figure 3. Natural community plot locations and rare plant taxa found within the BFH of GMSP.

Figure 4. NMDS on natural community plots within the BFH of GMSP.

Figure 5. Hierarchical cluster analysis analyzing natural community plot data within the BFH of GMSP.

Figure 6. The single occurrence of a vegetation plot within a seepage dominated by *Carex bromoides ssp. montana*. The prominent green caespitose clumps are *C. bromoides ssp. montana*.

Figure 7. High-elevation Red Spruce Forest sampled within the BFH with a nonvascular ground layer dominated by *Bazzania trilobata*.

Figure 8. Geologic map of the Linville Quadrangle representing bedrock from North Carolina and Tennessee. The red square highlights the various bedrock types associated with GM.

Figure 9. Range of *Cinna latifolia* (Trevis. ex Goepp.) Griseb. within the United States. *Light green color = common; yellow color = rare; orange color = extirpated

Figure 10. Example of high-elevation rock outcrop on ridgeline within the BFH of GMSP. *Rhizocarpon* and *Umbilicaria* lichen species are evident in this photo.

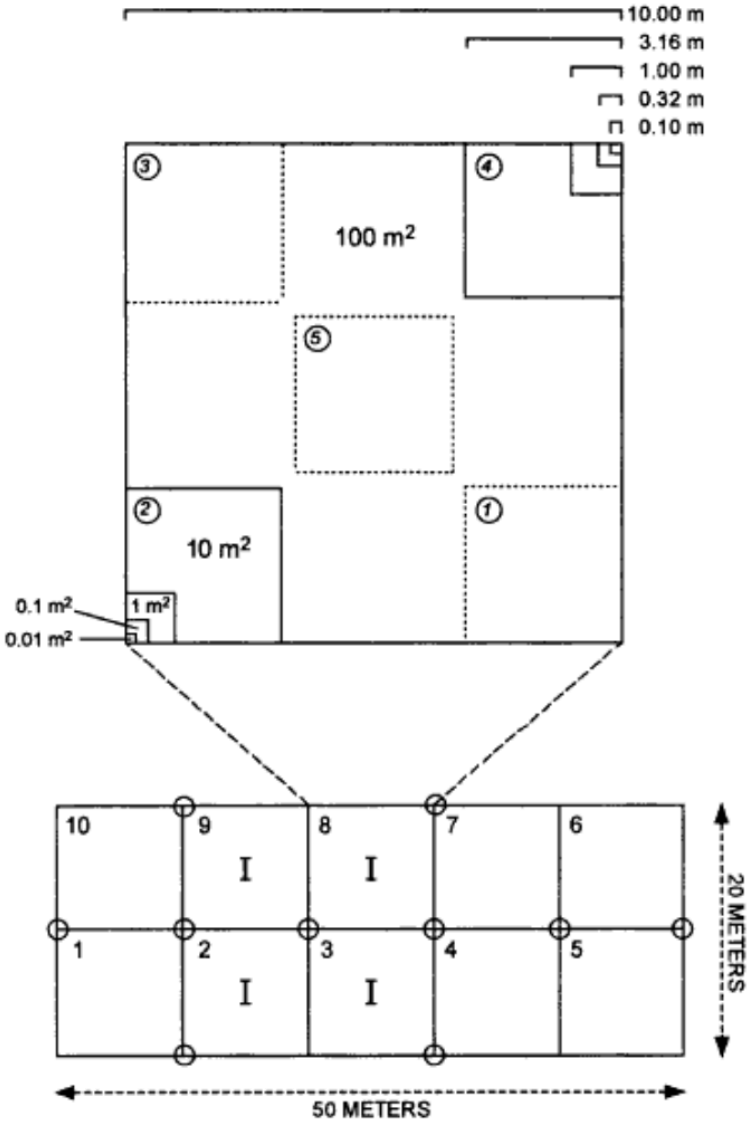
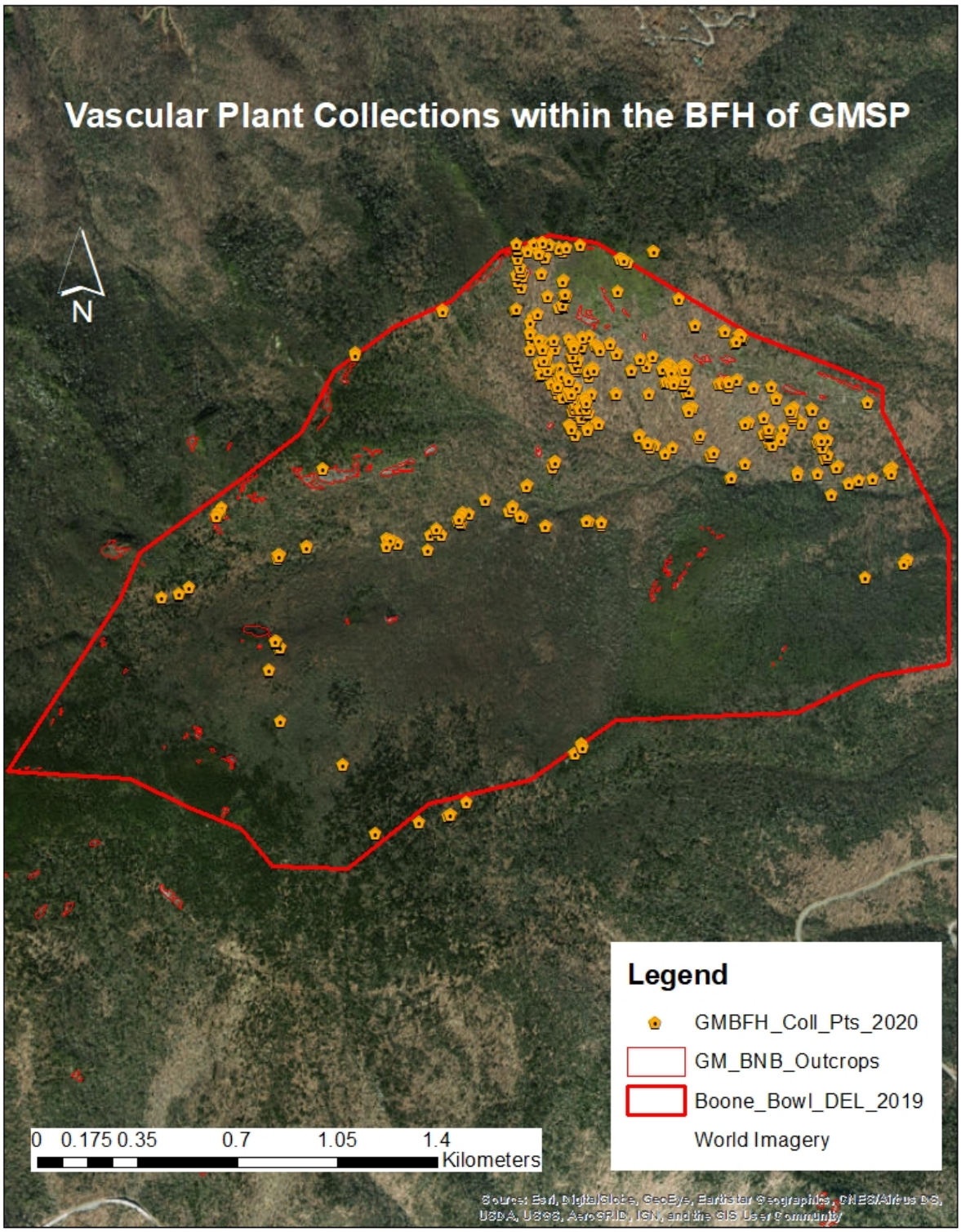
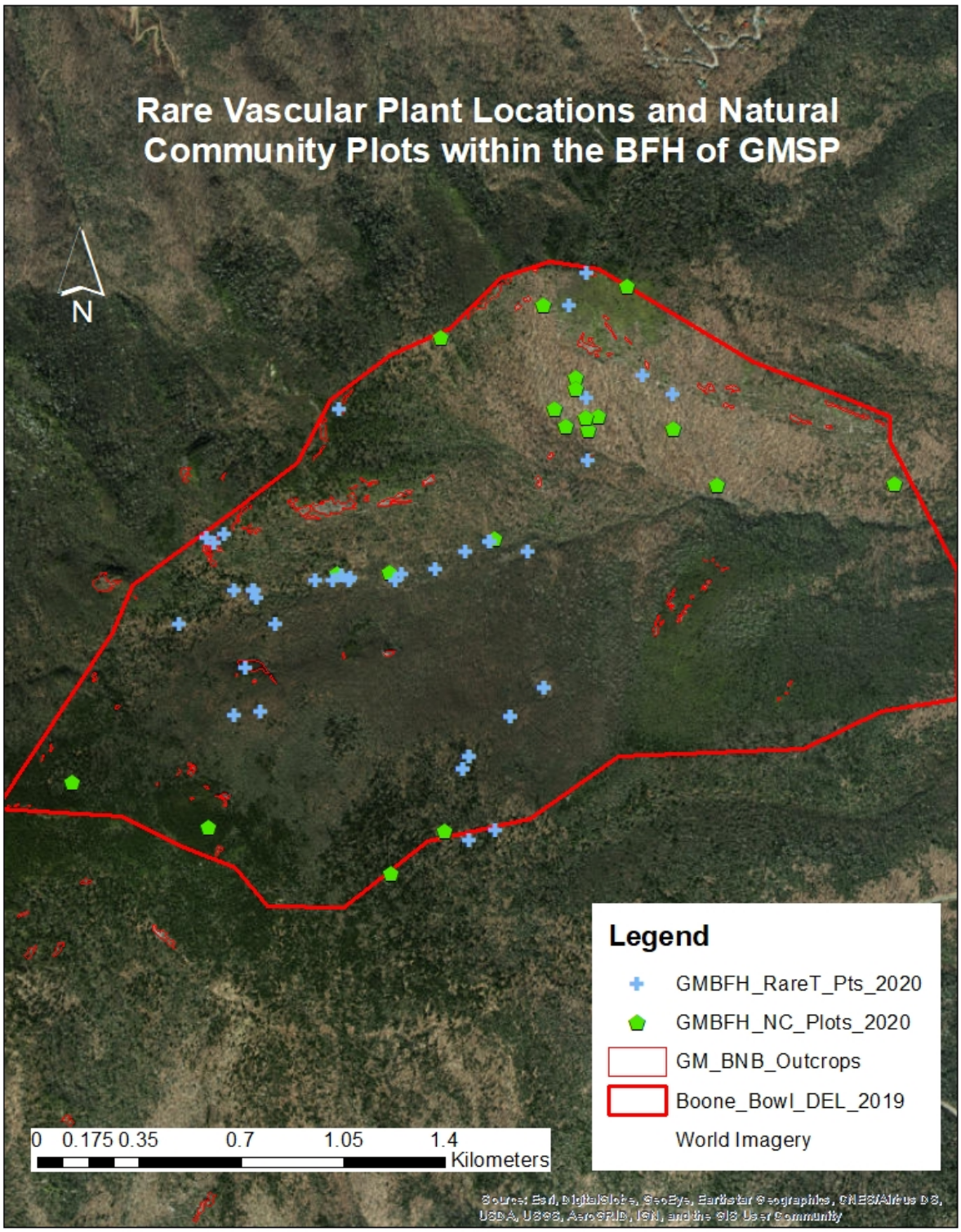
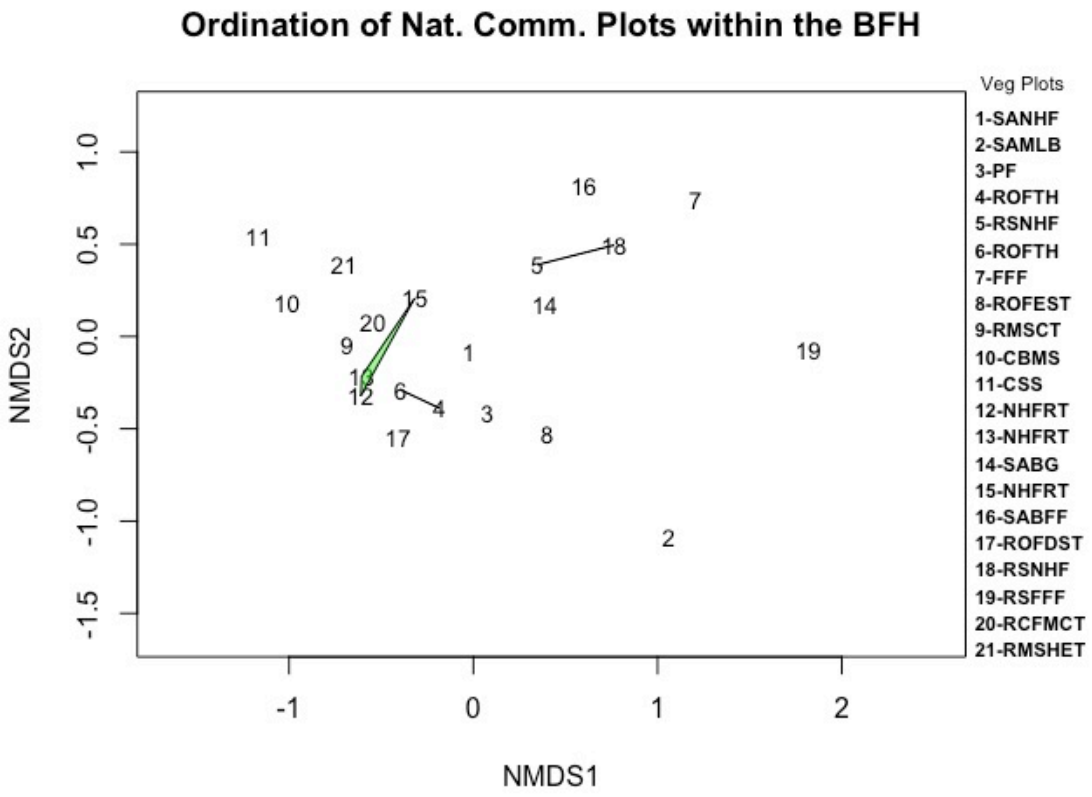
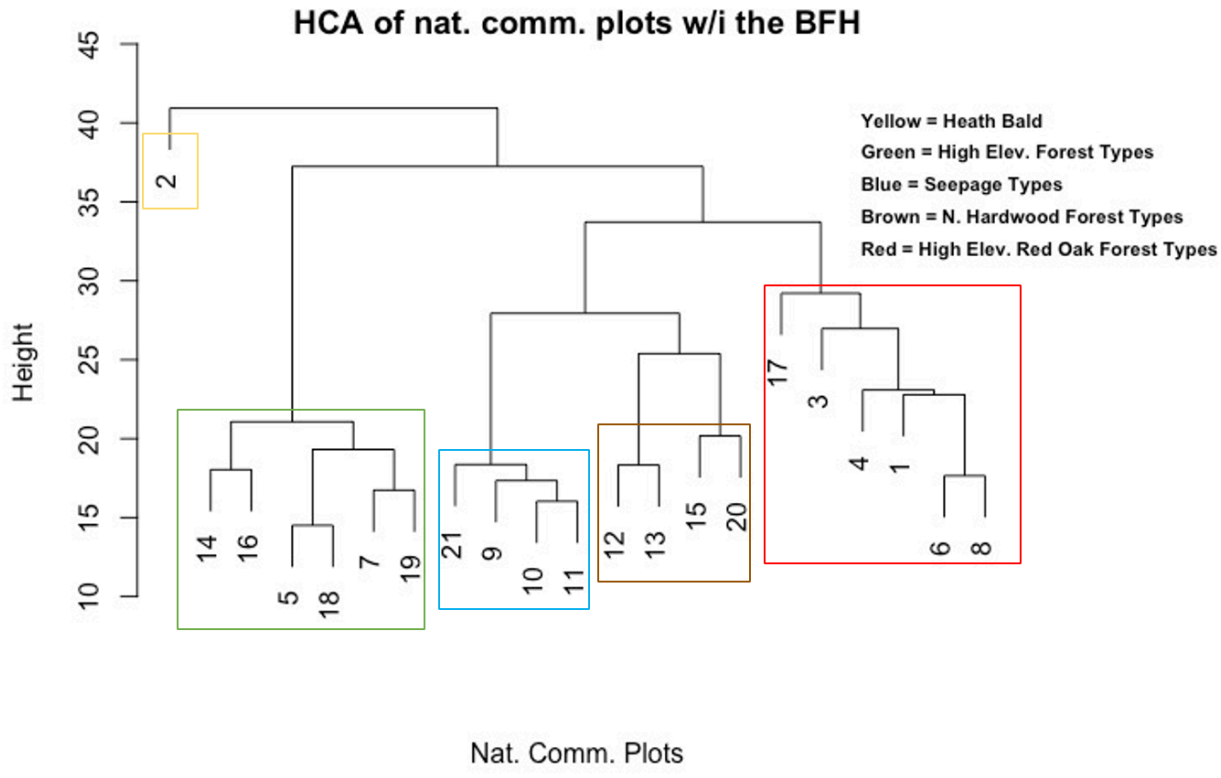


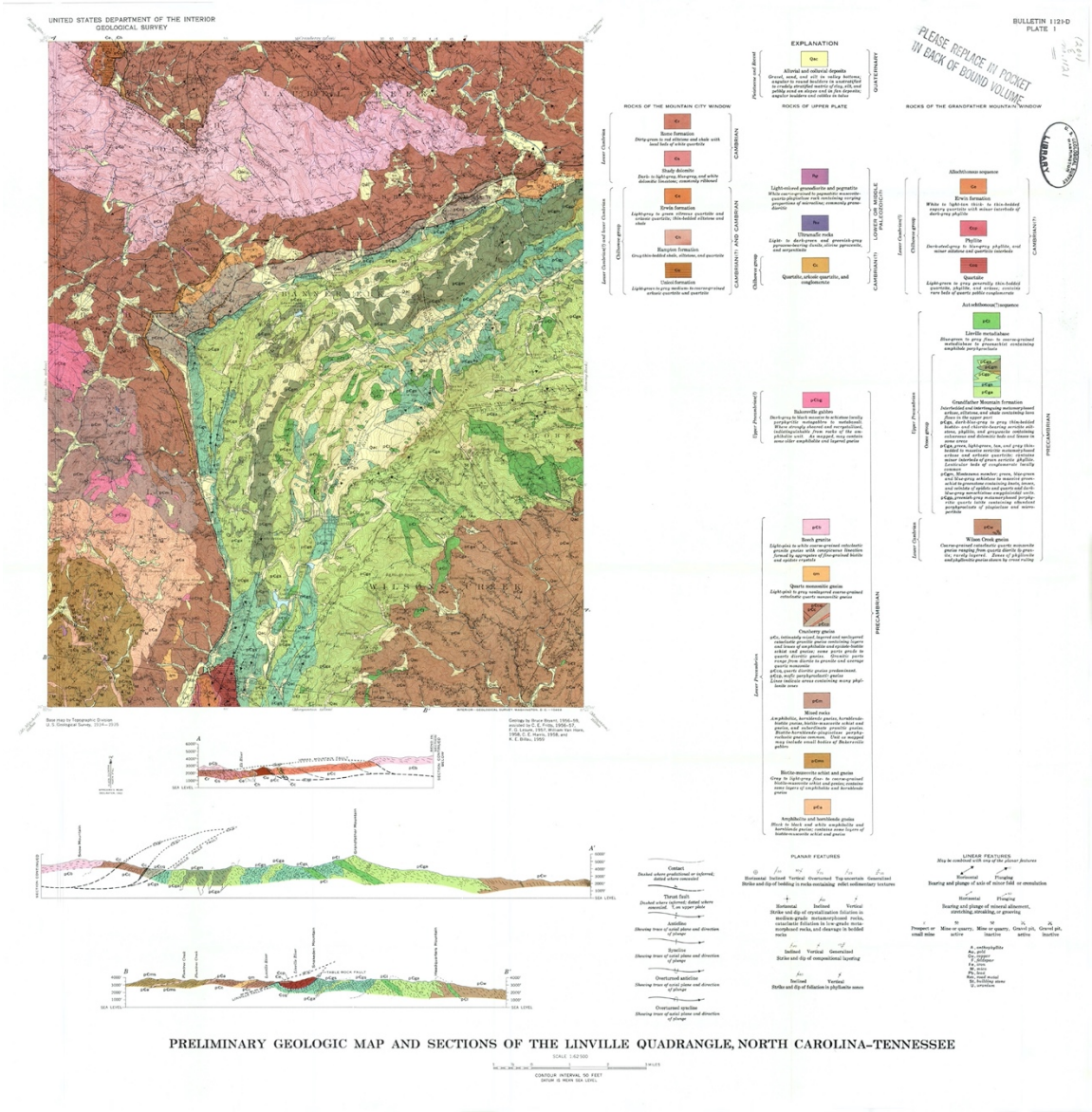
Figure 1. Typical layout of an intensive module, and a set of 10 modules as a 0.1 ha plot. Modules are numbered counter-clockwise. The five standard locations in a module for nested quadrats are indicated, although in the standard 0.1 ha configuration only two nests are recorded (solid lines rather than dashed) in each of the four intensive modules. Typically, these intensive modules are 2, 3, 8 and 9 as intensive modules (marked I), with nested quadrats in the eight corners indicated. The remaining six modules are recorded as an aggregate. Corners within a module are numbered clockwise, starting along the centerline and moving initially along the centerline in the direction that the modules are numbered, as indicated for module eight. Typically a 50 m tape is placed along the centerline and two 20 m tapes cross the main tape along the outside edges of the four focal modules. Permanent metal stakes (circles in the 0.1 ha configuration) are located at the 10 locations where a tape touches the corner of a module.


Vascular Plant Collections within the BFH of GMSP
N
0 0.175 0.35 0.7 1.05 1.4
Kilometers
Legend
GMBFH_Coll_Pts_2020
GM_BNB_Outcrops
Boone_Bowl_DEL_2019
World Imagery
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

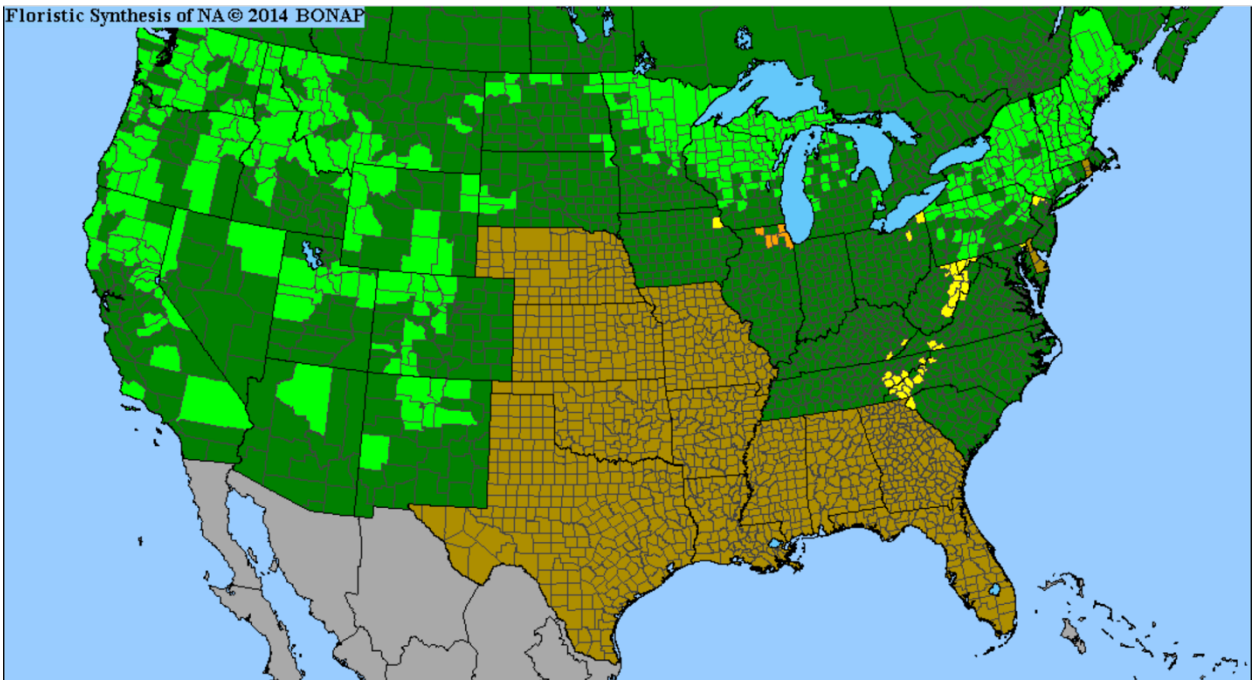

Rare Vascular Plant Locations and Natural Community Plots within the BFH of GMSP
N
0 0.175 0.35 0.7 1.05 1.4
Kilometers
Legend
GMBFH_RareT_Pts_2020
GMBFH_NC_Plots_2020
GM_BNB_Outcrops
Boone_Bowl_DEL_2019
World Imagery
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

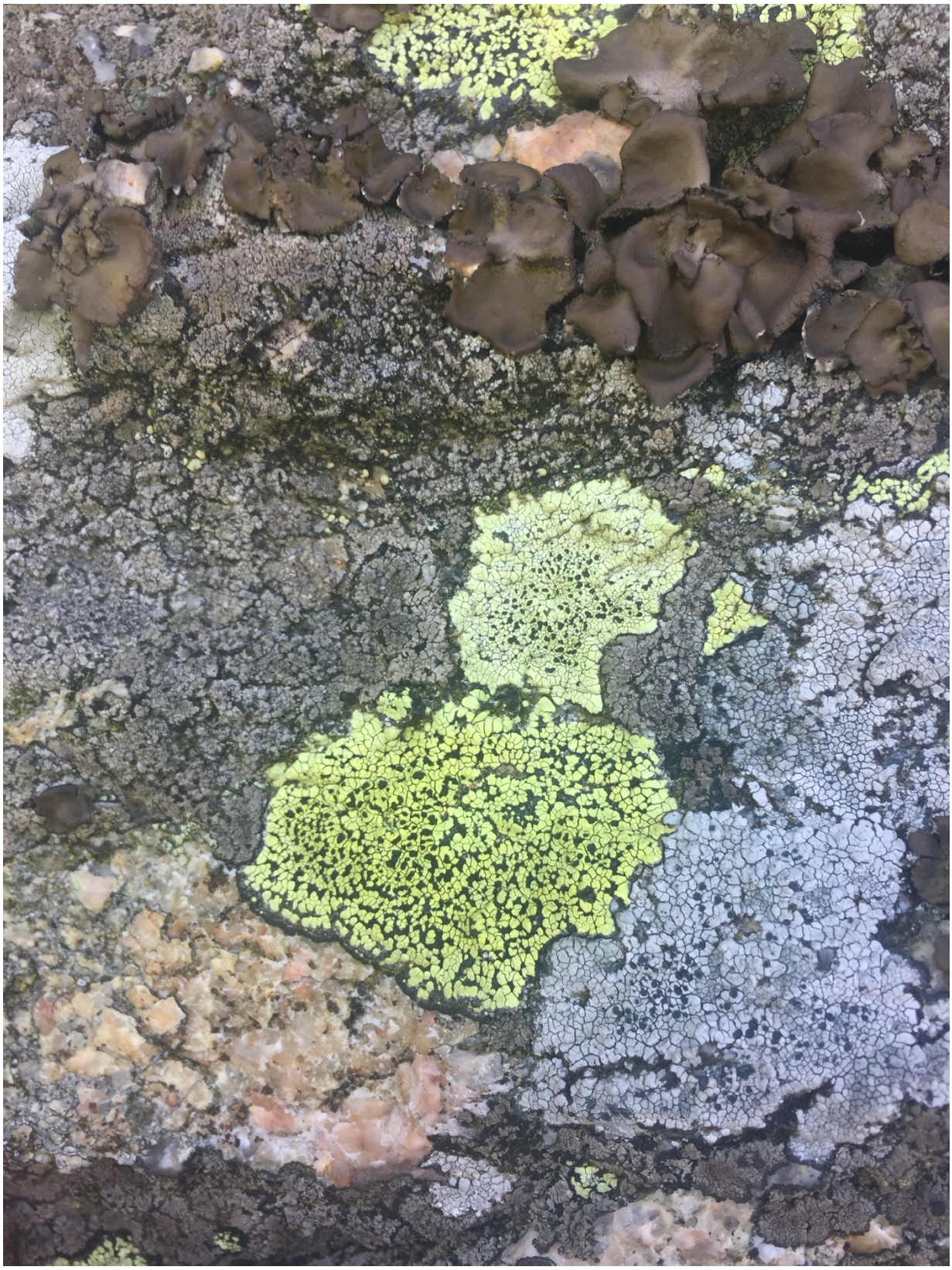

Ordination of Nat. Comm. Plots within the BFH
Veg Plots
1-SANHF
2-SAMLB
3-PF
4-ROFTH
5-RSNHF
6-ROFTH
7-FFF
8-ROFEST
9-RMSCT
10-CBMS
11-CSS
12-NHFRT
13-NHFRT
14-SABG
15-NHFRT
16-SABFF
17-ROFDST
18-RSNHF
19-RSFFF
20-RCFMCT
21-RMSHET
NMDS1
NMDS2
-1
0
1
2
-1.5
-1.0
-0.5
0.0
0.5
1.0


HCA of nat. comm. plots w/i the BFH
Yellow = Heath Bald
Green = High Elev. Forest Types
Blue = Seepage Types
Brown = N. Hardwood Forest Types
Red = High Elev. Red Oak Forest Types
Height
10
15
20
25
30
35
40
45
2
14
16
5
18
7
19
21
9
10
11
12
13
15
20
17
3
4
1
6
8
Nat. Comm. Plots



PRELIMINARY GEOLOGIC MAP AND SECTIONS OF THE LINVILLE QUADRANGLE, NORTH CAROLINA–TENNESSEE


Floristic Synthesis of NA © 2014 BONAP



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French : to which, are added observations on the air, soil, and waters : with remarks upon agriculture, grain, pulse, roots, &c. : to the whole, is prefixed a new and correct map of the countries treated of. Printed at the expence of the author, and sold by W. Innys and R. Manby, at the West End of St. Paul's, by Mr. Hauksbee, at the Royal Society House, and by the author, at Mr. Bacon's in Hoxton, London.

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Appendix A
Annotated List of vascular plant species from the BFH within GMSP

The subsequent table is a list of all vascular plant species collected during the floristic inventory of the BFH within GMSP. The table is arranged alphabetically by family representing four phyla: Magnoliophyta, Lycopodiophyta, Pinophyta, and Pteridophyta. The ranking column indicates which species are listed, either federal or state, and codes may be referenced in Appendix B. Abundance ranks were determined through observations in the field and were determined subjectively. *Asclepias exaltata, Chimaphila maculata, Prunus serotina, Oxydendron arboreum, Liriodendron tulipifera, Stachys sp.,* and *Dichanthelium clandestinum* were not collected due to no reproductive material or inability to find voucher material from tree species poorly represented in the understory (e.g. saplings). Final taxonomic status was determined by Weakley (2015). It was decided in this floristic inventory not to collect orchid species, therefore, the species were documented when found but no voucher specimens were collected. All species are native taxa except *Malus pumila* Mill.

Vascular flora of the BFH within GMSP.

Species Name	Authority	Family	Phylum	Ranking	Coll. #	Abundance
Sambucus racemosa var. pubens	(Michx.) Koehne	Adoxaceae	Magnoliophyta		GM141, 142	Uncommon
Viburnum cassinoides	L.	Adoxaceae	Magnoliophyta		GM326, 327	Common
Viburnum lantanoides	Michx.	Adoxaceae	Magnoliophyta		GM084, 087	Common
Allium tricoccum	Aiton	Alliaceae	Magnoliophyta		GM354, 355	Common
Angelica triquinata	Michx.	Apiaceae	Magnoliophyta		GM477, 478	Uncommon
Cryptotaenia canadensis	(L.) DC.	Apiaceae	Magnoliophyta		GM293, 294	Uncommon
Osmorhiza claytonii	(Michx.) C. B. Clarke	Apiaceae	Magnoliophyta		GM184, 185	Common
Oxypolis rigidior	(L.) Raf.	Apiaceae	Magnoliophyta		GM441, 442	Common
Sanicula smallii	E. P. Bicknell	Apiaceae	Magnoliophyta		GM162, 163	Common
Thaspium barbinode	(Michx.) Nutt.	Apiaceae	Magnoliophyta		GM193, 194	Common
Zizia trifoliata	(Michx.) Fernald	Apiaceae	Magnoliophyta		GM130, 131	Common

Asclepias exaltata	L.	Apocynaceae	Magnoliophyta		**GM500 (NO COLL.)**	Rare
Ilex montana	Torr. & A. Gray ex A. Gray	Aquifoliaceae	Magnoliophyta		GM242, 243	Common
Arisaema quinatum	(Buckley) Schott	Araceae	Magnoliophyta		GM209	Uncommon ?
Arisaema triphyllum	(L.) Schott	Araceae	Magnoliophyta		GM114, 126	Common
Aralia nudicaulis	L.	Araliaceae	Magnoliophyta		GM253, 254	Uncommon
Isotrema macrophyllum	(Lam.) C.F. Reed	Aristolochiaceae	Magnoliophyta		GM210, 211	Common
Asplenium montanum	Willd.	Aspleniaceae	Pteridophyta		GM043, 524	Uncommon
Ageratina altissima var. altissima	(L.) R. M. King & H. Rob.	Asteraceae	Magnoliophyta		GM003	Common?
Ageratina altissima var. roanensis	(Small) Clewell & Wooton	Asteraceae	Magnoliophyta		GM479, 480	Common
Arnoglossum reniforme	(Hook.) H. Rob.	Asteraceae	Magnoliophyta		GM399, 400	Uncommon
Coreopsis major var. major	Walter	Asteraceae	Magnoliophyta		GM397, 398	Uncommon
Eurybia chlorolepis	(Burgess) G.L. Nesom	Asteraceae	Magnoliophyta		GM413, 414	Common
Eutrochium fistulosum	(Barratt) E. E. Lamont	Asteraceae	Magnoliophyta		GM411, 412	Common
Helianthus decapetalus	L.	Asteraceae	Magnoliophyta		GM423, 424	Uncommon
Hieracium paniculatum	L.	Asteraceae	Magnoliophyta		GM460, 461	Uncommon
Nabalus altissimus	(L.) Hook.	Asteraceae	Magnoliophyta		GM007	Uncommon
Nabalus serpentarius	(Pursh) Hook.	Asteraceae	Magnoliophyta		GM509, 510	Common
Oclemena acuminata	(Michx.) Greene	Asteraceae	Magnoliophyta		GM437, 438	Common
Rudbeckia laciniata var. ?	L.	Asteraceae	Magnoliophyta	W7 S2?G5T3?	GM387, 388	Common
Solidago curtisii	Torr. & A. Gray	Asteraceae	Magnoliophyta		GM515, 516	Common
Solidago flaccidifolia	Small	Asteraceae	Magnoliophyta		GM505, 506	Common
Solidago flexicaulis	L.	Asteraceae	Magnoliophyta		GM519, 520	Common
Solidago flexicaulis x flaccidifolia?		Asteraceae	Magnoliophyta		GM527, 528	Rare?
Solidago glomerata	Michx.	Asteraceae	Magnoliophyta		GM481, 486	Common
Solidago puberula	Nutt.	Asteraceae	Magnoliophyta	W7 S2G5T4T 5	GM525, 526	Rare
Solidago roanensis	Porter	Asteraceae	Magnoliophyta		GM447, 448	Uncommon
Symphyotrichum cordifolium	(L.) G. L. Nesom	Asteraceae	Magnoliophyta		GM513, 514	Common
Symphyotrichum puniceum var. puniceum	(L.) Á Löve & D. Löve	Asteraceae	Magnoliophyta		GM529, 530	Rare
Athyrium asplenioides	(Michx.) A.A. Eaton	Athyriaceae	Pteridophyta		GM462, 463	Common
Deparia acrostichoides	(Sw.) M. Kato	Athyriaceae	Pteridophyta		GM443, 444	Uncommon
Impatiens pallida	Nutt.	Balsaminaceae	Magnoliophyta		GM368, 369	Common
Diphylleia cymosa	Michx.	Berberidaceae	Magnoliophyta		GM112, 113	Common

Podophyllum peltatum	L.	Berberidaceae	Magnoliophyta		GM106, 107	Common
Betula alleghaniensis	Britton	Betulaceae	Magnoliophyta		GM228, 229	Common
Betula lenta	L.	Betulaceae	Magnoliophyta		GM451, 452	Common
Ostrya virginiana	(Mill.) K. Koch	Betulaceae	Magnoliophyta		GM466, 467	Uncommon
Arabidopsis lyrata ssp. lyrata	(L.) O'Kane & Al-Shehbaz	Brassicaceae	Magnoliophyta	W1 S2G5	NO COLL.	Rare
Boechera laevigata	(Muhl. ex Willd.) Al-Shehbaz	Brassicaceae	Magnoliophyta		GM090, 104	Common
Cardamine clematitis	Shuttlew. ex S. Watson	Brassicaceae	Magnoliophyta	SR-T S2S3G3	**GM168 (NO COLL.)**	Rare
Cardamine concatenata	(Michx.) O. Schwarz	Brassicaceae	Magnoliophyta		GM059, 068	Common
Campanula americana	L.	Campanulaceae	Magnoliophyta		GM392, 393	Uncommon
Campanula divaricata	Michx.	Campanulaceae	Magnoliophyta		GM458, 459	Common
Lobelia puberula	Michx.	Campanulaceae	Magnoliophyta		GM457	Uncommon
Paronychia argyrocoma	(Michx.) Nutt.	Caryophyllaceae	Magnoliophyta		**NO COLL.**	Rare*
Silene stellata	(L.) W. T. Aiton	Caryophyllaceae	Magnoliophyta		GM425, 426	Uncommon
Silene virginica var. virginica	L.	Caryophyllaceae	Magnoliophyta		GM284, 285	Uncommon
Stellaria pubera	Michx.	Caryophyllaceae	Magnoliophyta		GM072, 092	Common
Clethra acuminata	Michx.	Clethraceae	Magnoliophyta		GM415, 416	Common
Uvularia grandiflora	Sm.	Colchicaceae	Magnoliophyta		GM101, 105	Uncommon
Uvularia puberula	Michx.	Colchicaceae	Magnoliophyta		GM310, 311	Uncommon
Tradescantia subaspera	Ker Gawl.	Commelinaceae	Magnoliophyta		GM282, 283	Common
Cuscuta compacta	Juss. ex Choisy	Convolulaceae	Magnoliophyta		GM401, 402	Common
Cornus alternifolia	L. f.	Cornaceae	Magnoliophyta		GM238, 239	Uncommon
Sedum ternatum	Michx.	Crassulaceae	Magnoliophyta		GM212, 213	Uncommon
Carex aestivalis	M.A. Curtis ex A. Gray	Cyperaceae	Magnoliophyta		GM019, 251	Common
Carex atlantica	L. H. Bailey	Cyperaceae	Magnoliophyta		GM236, 237	Uncommon
Carex bromoides subsp. montana	Naczi	Cyperaceae	Magnoliophyta	W7 S3?G5T3?	GM207, 208	Uncommon
Carex brunnescens var. sphaerostachya	(Pers.) Poir. ssp. (Tuck.) Kük.	Cyperaceae	Magnoliophyta		GM044, 218	Uncommon ?
Carex communis	L.H. Bailey	Cyperaceae	Magnoliophyta		GM123, 124	Common
Carex digitalis var. digitalis	Willd.	Cyperaceae	Magnoliophyta		GM351, 352	Uncommon
Carex flexuosa	Muhl. ex Willd.	Cyperaceae	Magnoliophyta		GM181, 182	Common
Carex fraseriana	Ker-Gawler	Cyperaceae	Magnoliophyta	W1 S3G4	**NO COLL.**	Rare
Carex gynandra	Schwein.	Cyperaceae	Magnoliophyta		GM286, 287	Uncommon
Carex intumescens var. fernaldii	L.H. Bailey	Cyperaceae	Magnoliophyta		GM045, 521	Uncommon
Carex laxiflora	Lam.	Cyperaceae	Magnoliophyta		GM259, 260	Common

Carex misera	Buckley	Cyperaceae	Magnoliophyta	W1 S3G3	GM405, 406	Rare
Carex pennsylvanica	Torr., sensu auct.	Cyperaceae	Magnoliophyta		GM137, 138	Common
Carex roanensis	F. J. Herm.	Cyperaceae	Magnoliophyta	SR-T S2G2G3	GM455, 456	Rare
Carex rosea	Schkuhr ex Willd.	Cyperaceae	Magnoliophyta		GM183, 250	Common
Carex scabrata	Schwein.	Cyperaceae	Magnoliophyta		GM234, 235	Uncommon
Carex umbellata	Schkuhr ex Willd.	Cyperaceae	Magnoliophyta		GM154, 155	Common
Cystopteris protrusa	(Weath.) Blasdell	Cystopteridaceae	Pteridophyta		GM291, 292	Uncommon
Dennstaedtia punctiloba	(Poir.) J. Sm.	Dennstaedtiaceae	Pteridophyta		GM419, 420	Common
Pteridium latiusculum var. latiusculum	(Desv.) Hieron ex Fries	Dennstaedtiaceae	Pteridophyta		GM468, 469	Uncommon
Galax urceolata	(Poir.) Brummitt	Diapensiaceae	Magnoliophyta		GM272, 273	Common
Dioscorea villosa	L.	Dioscoreaceae	Magnoliophyta		GM244, 245	Uncommon
Dryopteris campyloptera	Clarkson	Dryopteridaceae	Pteridophyta		GM372, 373	Common
Dryopteris intermedia	(Muhl. ex Willd.) A. Gray	Dryopteridaceae	Pteridophyta		GM427, 428	Common
Dryopteris marginalis	(L.) A. Gray	Dryopteridaceae	Pteridophyta		GM498, 499	Rare
Polystichum acrostichoides	(Michx.) Schott	Dryopteridaceae	Pteridophyta		GM464, 465	Common
Chimaphila maculata	(L.) Pursh	Ericaceae	Magnoliophyta		**GM531 (NO COLL.)**	Rare
Epigaea repens	L.	Ericaceae	Magnoliophyta		GM061	Uncommon
Eubotrys recurvus	(Buckley) Britton	Ericaceae	Magnoliophyta		GM171, 172	Common
Gaultheria procumbens	L.	Ericaceae	Magnoliophyta		GM473, 474	Common
Gaylussacia baccata	(Wangenh.) K. Koch	Ericaceae	Magnoliophyta		GM150, 151	Common
Kalmia buxifolia		Ericaceae	Magnoliophyta			Uncommon
Kalmia latifolia	L.	Ericaceae	Magnoliophyta		GM255, 256	Common
Lyonia ligustrina var. ligustrina	(L.) DC.	Ericaceae	Magnoliophyta		GM328, 329	Common
Oxydendrum arboreum	(L.) DC.	Ericaceae	Magnoliophyta		**GM496 (NO COLL.)**	Rare
Monotropa uniflora	L.	Ericaceae	Magnoliophyta		GM376, 377	Common
Rhododendron calendulaceum	(Michx.) Torr.	Ericaceae	Magnoliophyta		GM280, 281	Common
Rhododendron catawbiense	Michx.	Ericaceae	Magnoliophyta		GM216, 217	Common
Rhododendron maximum	L.	Ericaceae	Magnoliophyta		GM364, 365	Common
Rhododendron pilosum	(Michx.) Craven	Ericaceae	Magnoliophyta		GM173, 174	Common
Rhododendron vaseyi	A. Gray	Ericaceae	Magnoliophyta	SR-L S3G3	GM115, 116	Common
Vaccinium altomontanum	Ashe	Ericaceae	Magnoliophyta		GM156, 274	Uncommon ?
Vaccinium corymbosum	L.	Ericaceae	Magnoliophyta		GM169, 170	Common
Vaccinium erythrocarpum	Michx.	Ericaceae	Magnoliophyta		GM197, 198	Common

Amphicarpaea bracteata	(L.) Fernald	Fabaceae	Magnoliophyta		GM507, 508	Uncommon
Robinia pseudoacacia	L.	Fabaceae	Magnoliophyta		GM265, 266	Common
Castanea dentata	(Marshall) Borkh.	Fagaceae	Magnoliophyta		GM318, 319	Common
Fagus grandifolia var. grandifolia	Ehrh.	Fagaceae	Magnoliophyta		GM011, 534	Common
Quercus montana	Willd.	Fagaceae	Magnoliophyta		GM475, 476	Uncommon
Quercus rubra	L.	Fagaceae	Magnoliophyta		GM350, 353	Common
Dicentra canadensis	(Goldie) Walp.	Fumariaceae	Magnoliophyta		GM082, 100	Common
Dicentra cucullaria	(L.) Bernh.	Fumariaceae	Magnoliophyta		GM083, 099	Common
Gentiana clausa	Raf.	Gentianaceae	Magnoliophyta	W7 S3?G5	GM517, 518	Uncommon
Ribes cynosbati	L.	Grossulariaceae	Magnoliophyta		GM097, 098	Common
Ribes glandulosum	Grauer	Grossulariaceae	Magnoliophyta		GM139, 140	Rare?
Ribes rotundifolium	Michx.	Grossulariaceae	Magnoliophyta		GM133, 303	Uncommon
Hamamelis virginiana	L.	Hamamelidaceae	Magnoliophyta		GM522, 523	Common
Huperzia apressa	(Desv.) A.& D. Love	Huperziaceae	Lycopodiophyta	W1 S3G5	**NO COLL.**	Rare
Huperzia lucidula	(Michx.) Trevis.	Huperziaceae	Lycopodiophyta		GM001, 050	Common
Hydrangea arborescens	L.	Hydrangeaceae	Magnoliophyta		GM324, 325	Common
Hydrophyllum canadense	L.	Hydrophyllaceae	Magnoliophyta		GM289, 290	Common
Hydrophyllum virginianum var. atranthum	(L.) (Alexander) Constance	Hydrophyllaceae	Magnoliophyta		GM305, 306	Uncommon
Hypericum mitchellianum	Rydb.	Hypericaceae	Magnoliophyta	W1 S2S3G3	**NO COLL.**	Rare
Iris cristata	Aiton	Iridaceae	Magnoliophyta		GM166, 167	Common
Iris verna var. smalliana	Fernald ex M.E. Edwards	Iridaceae	Magnoliophyta		GM159, 160	Common
Carya cordiformis	(Wangenh.) K. Koch	Judglandaceae	Magnoliophyta		GM449, 450	Rare
Luzula acuminata var. ?	Raf.	Juncaceae	Magnoliophyta		GM066, 085	Common
Luzula echinata	(Small) F. J. Herm.	Juncaceae	Magnoliophyta		GM058	Common
Blephilia hirsuta	(Pursh) Benth.	Lamiaceae	Magnoliophyta		GM386, 395	Uncommon
Collinsonia canadensis	L.	Lamiaceae	Magnoliophyta		GM429, 430	Common
Lycopus virginicus	L.	Lamiaceae	Magnoliophyta		GM511, 512	Uncommon
Monarda clinopodia	L.	Lamiaceae	Magnoliophyta		GM389, 390	Uncommon
Monarda didyma	L.	Lamiaceae	Magnoliophyta		GM384, 385	Common
Stachys sp.		Lamiaceae	Magnoliophyta		**NO COLL.**	Uncommon
Sassafras albidum	(Nutt.) Nees	Lauraceae	Magnoliophyta		GM152, 153	Common
Clintonia borealis	(Aiton) Raf.	Liliaceae	Magnoliophyta		GM220, 221	Common
Clintonia umbellulata	(Michx.) Morong	Liliaceae	Magnoliophyta		GM189, 199	Common

Erythronium umbilicatum var. umbilicatum	Parks & Hardin	Liliaceae	Magnoliophyta		GM057, 075	Common
Lilium grayi	S. Watson	Liliaceae	Magnoliophyta	T S1S2G1G2	**NO COLL.**	Rare*
Lilium superbum	L.	Liliaceae	Magnoliophyta		GM431, 432	Uncommon
Medeola virginiana	L.	Liliaceae	Magnoliophyta		GM334, 335	Uncommon
Prosartes lanuginosa	(Michx.) D. Don	Liliaceae	Magnoliophyta			Common
Streptopus lanceolatus var. lanceolatus	(Aiton) Reveal	Liliaceae	Magnoliophyta		GM220-A, 221-B	Common
Dendrolycopodium hickeyi	(W. H. Wagner, Beitel & R. C. Moran) A. Haines	Lycopodiaceae	Lycopodiophyta	SR-P S2?G5	GM046, 047	Rare
Dendrolycopodium obscurum	(L.) A. Haines	Lycopodiaceae	Lycopodiophyta		GM039, 048	Common
Diphasiastrum digitatum	(Dill.) Holub	Lycopodiaceae	Lycopodiophyta		GM535, 536	Common
Liriodendron tulipifera	L.	Magnoliaceae	Magnoliophyta		**GM497 (NO COLL.)**	Rare
Magnolia acuminata	(L.) L.	Magnoliaceae	Magnoliophyta		GM214, 215	Common
Magnolia fraseri	Walter	Magnoliaceae	Magnoliophyta		GM200, 201	Common
Tilia americana var. heterophylla	(L.) (Vent.) Loudon	Malvaceae	Magnoliophyta		GM445, 446	Common
Amianthium muscitoxicum	(Walter) A.Gray	Melanthiaceae	Magnoliophyta		GM316, 317	Common
Veratrum parviflorum	Michx.	Melanthiaceae	Magnoliophyta		GM403, 404	Common
Veratrum viride	Aiton	Melanthiaceae	Magnoliophyta		GM301, 302	Common
Claytonia caroliniana	Michx.	Montiaceae	Magnoliophyta		GM049, 051	Common
Nyssa sylvatica	Marshall	Nyssaceae	Magnoliophyta		GM312, 313	Uncommon
Fraxinus americana	L.	Oleaceae	Magnoliophyta		GM439, 440	Common
Circaea canadensis	(L.) Hill	Onagraceae	Magnoliophyta		GM378, 379	Rare
Sceptridium dissectum	(Spreng.) Lyon	Ophioglossaceae	Pteridophyta		GM288, 307	Uncommon
Aplectrum hyemale		Orchidaceae	Magnoliophyta		**NO COLL.**	Uncommon
Cypripedium acaule	Aiton	Orchidaceae	Magnoliophyta		**GM271 (NO COLL.)**	Rare
Goodyera pubescens	(Willd.) R. Br.	Orchidaceae	Magnoliophyta		**GM493 (NO COLL.)**	Uncommon
Listera smallii	Wiegand	Orchidaceae	Magnoliophyta		**NO COLL.**	Uncommon
Platanthera ciliaris	(L.) Lindl.	Orchidaceae	Magnoliophyta		**NO COLL.**	Rare
Platanthera grandiflora	(Bigelow) Lindl.	Orchidaceae	Magnoliophyta	T S2G5	**NO COLL.**	Uncommon *
Platanthera orbiculata	(Pursh) Lindl.	Orchidaceae	Magnoliophyta		**NO COLL.**	Rare
Conopholis americana	(L.) Wallr.	Orobonchaceae	Magnoliophyta		GM119, 120	Common
Epifagus virginianus	(L.) Barton	Orobonchaceae	Magnoliophyta		GM489, 490	Common
Melampyrum lineare var. latifolium	Desr. Bart.	Orobonchaceae	Magnoliophyta		GM360, 361	Uncommon

Pedicularis canadensis	L.	Orobonchaceae	Magnoliophyta		GM232, 233	Uncommon
Osmundastrum cinnamomeum	(L.) C. Presl	Osmundaceae	Magnoliophyta		GM257, 258	Uncommon
Oxalis montana	Raf.	Oxalidaceae	Magnoliophyta		GM299, 300	Common
Abies fraseri	(Pursh) Poir.	Pinaceae	Pinophyta	W5 S2G2	**NO COLL.**	Common
Picea rubens	Sarg.	Pinaceae	Pinophyta		GM030	Common
Pinus pungens	Lamb.	Pinaceae	Pinophyta		GM037	Rare
Pinus strobus	L.	Pinaceae	Pinophyta		GM470, 471	Rare
Tsuga canadensis	(L.) Carrière	Pinaceae	Pinophyta		GM024, 034	Uncommon
Chelone glabra	L.	Plantaginaceae	Magnoliophyta		GM503, 504	Common
Chelone lyonii	Pursh	Plantaginaceae	Magnoliophyta		GM409, 410	Uncommon
Agrostis perennans	(Walter) Tuck.	Poaceae	Magnoliophyta		GM374, 375	Common
Avenella flexuosa	(L.) Drejer	Poaceae	Magnoliophyta		GM345, 346	Uncommon
Brachyelytrum erectum	P. Beauv.	Poaceae	Magnoliophyta		GM314, 315	Common
Bromus pubescens	Muhl. ex Willd.	Poaceae	Magnoliophyta		GM320, 321	Common
Cinna latifolia	(Trevis. ex Goepp.) Griseb.	Poaceae	Magnoliophyta	W7 S1S2G5	**NO COLL.**	Rare
Danthonia sericea	Nutt.	Poaceae	Magnoliophyta		GM308, 309	Uncommon
Danthonia spicata	(L.) P. Beauv. ex Roem. & Schult.	Poaceae	Magnoliophyta		GM347, 348	Common
Dichanthelium clandestinum	(L.) Gould	Poaceae	Magnoliophyta		**GM537 (NO COLL.)**	Rare
Dichanthelium latifolium	(L.) Harvill	Poaceae	Magnoliophyta		GM358, 359	Common
Elymus hystrix var. hystrix	L.	Poaceae	Magnoliophyta		GM338, 339	Uncommon
Festuca paradoxa	Desv.	Poaceae	Magnoliophyta		GM322, 323	Common
Muhlenbergia tenuiflora	(Willd.) Britton, Sterns & Poggenb.	Poaceae	Magnoliophyta		GM417, 418	Common
Poa alsodes	A. Gray	Poaceae	Magnoliophyta		GM175, 176	Common
Poa cuspidata	Nutt.	Poaceae	Magnoliophyta		GM060, 081	Common
Fallopia cilinodis	(Michx.) Holub	Polygonaceae	Magnoliophyta		GM332, 333	Rare
Polypodium appalachianum	Haufler & Windham	Polypodiaceae	Pteridophyta		GM036, 079	Common
Polypodium virginianum	L.	Polypodiaceae	Pteridophyta		GM027	Uncommon
Lysimachia quadrifolia	L.	Primulaceae	Magnoliophyta		GM362, 363	Common
Aconitum reclinatum	A.Gray	Ranunculaceae	Magnoliophyta	SR-T S3G3	**NO COLL.**	Rare
Aconitum uncinatum	L.	Ranunculaceae	Magnoliophyta		GM491, 492	Uncommon
Actaea pachypoda	Elliott	Ranunculaceae	Magnoliophyta		GM434, 501	Uncommon
Actaea podocarpa	DC.	Ranunculaceae	Magnoliophyta		GM501, 502	Uncommon
Actaea racemosa	L.	Ranunculaceae	Magnoliophyta		GM394, 396	Common
Anemone quinquefolia	L.	Ranunculaceae	Magnoliophyta		GM054, 071	Common

Aquilegia canadensis	L.	Ranunculaceae	Magnoliophyta		GM482, 483	Uncommon
Caulophyllum thalictroides	(L.) Michx.	Ranunculaceae	Magnoliophyta		GM012, 125	Common
Clematis virginiana	L.	Ranunculaceae	Magnoliophyta		GM494, 495	Uncommon
Ranunculus abortivus	L.	Ranunculaceae	Magnoliophyta		GM164, 165	Uncommon
Ranunculus recurvatus var. recurvatus	Poir.	Ranunculaceae	Magnoliophyta		GM110, 111	Common
Thalictrum clavatum	DC.	Ranunculaceae	Magnoliophyta		GM195, 196	Common
Thalictrum pubescens	Pursh	Ranunculaceae	Magnoliophyta		GM366, 367	Uncommon
Thalictrum revolutum	DC.	Ranunculaceae	Magnoliophyta		GM191, 192	Uncommon
Trautvetteria caroliniensis	Britton ex A. Murr. & Vail	Ranunculaceae	Magnoliophyta		GM263, 264	Common
Amelanchier laevis	Wiegand	Rosaceae	Magnoliophyta		GM157, 158	Common
Aronia melanocarpa	(Michx.) Elliott	Rosaceae	Magnoliophyta		GM380, 381	Common
Aronia prunifolia	(Marsh.) Rehder	Rosaceae	Magnoliophyta		GM148, 149	Rare
Crataegus macrosperma	Ashe	Rosaceae	Magnoliophyta		GM144, 145	Uncommon
Geum geniculatum	Michx.	Rosaceae	Magnoliophyta	SC-V S1S2G2	**NO COLL.**	Rare*
Malus pumila	Mill.	Rosaceae	Magnoliophyta		GM435, 436	Rare
Prunus pennsylvanica	L. f.	Rosaceae	Magnoliophyta		GM134, 135	Common
Prunus serotina	Ehrh.	Rosaceae	Magnoliophyta		**NO COLL.**	Common
Prunus virginiana var. virginiana	L.	Rosaceae	Magnoliophyta	W7 S2G5T5	GM203, 204	Rare
Rubus canadensis	L.	Rosaceae	Magnoliophyta		GM230, 231	Common
Sibbaldia retusa?	(O.F. Müll.) T. Erikss.	Rosaceae	Magnoliophyta		**NO COLL.**	Rare?
Sorbus americana	Marshall	Rosaceae	Magnoliophyta		GM330, 331	Common
Galium triflorum	Michx.	Rubiaceae	Magnoliophyta		GM336, 337	Common
Houstonia montana	Small	Rubiaceae	Magnoliophyta	EE S2G5T2	NO COLL.	Rare*
Houstonia purpurea	L.	Rubiaceae	Magnoliophyta		GM261, 262	Common
Houstonia serpyllifolia	Michx.	Rubiaceae	Magnoliophyta		GM055, 070	Common
Mitchella repens	L.	Rubiaceae	Magnoliophyta		GM343, 344	Uncommon
Maianthemum canadense	Desf.	Ruscaceae	Magnoliophyta		GM179, 180	Common
Maianthemum racemosum ssp. racemosum	(L.) Link	Ruscaceae	Magnoliophyta		GM205, 206	Common
Polygonatum biflorum	(Walter) Elliott	Ruscaceae	Magnoliophyta		GM121, 122	Common
Populus grandidentata	Michx.	Salicaceae	Magnoliophyta	W7 S2G5	GM295, 296	Rare
Salix sericea	Marshall	Salicaceae	Magnoliophyta		GM453, 454	Rare
Acer pennsylvanicum	Du Roi	Sapindaceae	Magnoliophyta		GM117, 118	Common
Acer rubrum	L.	Sapindaceae	Magnoliophyta		GM062	Common

Acer saccharum	Marshall	Sapindaceae	Magnoliophyta		GM356, 357	Common
Acer spicatum	Lam.	Sapindaceae	Magnoliophyta		GM226, 227	Common
Aesculus flava	Aiton	Sapindaceae	Magnoliophyta		GM146, 147	Common
Heuchera villosa var. villosa	Michx.	Saxifragaceae	Magnoliophyta		GM382, 383	Common
Hydatica petiolaris	(Raf.) Small	Saxifragaceae	Magnoliophyta		GM248, 249	Common
Micranthes careyana	(A. Gray) Small	Saxifragaceae	Magnoliophyta	W1 S3G3	GM103, 127	Common
Micranthes micranthidifolia	(Haw.) Small	Saxifragaceae	Magnoliophyta		GM108, 109	Common
Tiarella cordifolia	L.	Saxifragaceae	Magnoliophyta		GM177, 178	Uncommon
Scrophularia marilandica	L.	Scrophulariaceae	Magnoliophyta		GM391	Rare
Smilax herbacea	L.	Smilacaceae	Magnoliophyta		GM246, 247	Common
Smilax hispida	Muhl. ex Torr.	Smilacaceae	Magnoliophyta		GM340, 341	Common
Smilax rotundifolia	L.	Smilacaceae	Magnoliophyta		GM240, 241	Common
Parathelypteris noveboracensis	(L.) Ching	Thelypteridaceae	Pteridophyta		GM421, 422	Common
Trillium erectum	L.	Trilliaceae	Magnoliophyta		GM073, 102	Common
Trillium undulatum	Willd.	Trilliaceae	Magnoliophyta		GM143, 161	Common
Laportea canadensis	(L.) Wedd.	Urticaceae	Magnoliophyta		GM370, 371	Common
Pilea pumila	(L.) A. Gray	Urticaceae	Magnoliophyta		GM487, 488	Common
Viola blanda	Willd.	Violaceae	Magnoliophyta		GM074, 091	Common
Viola canadensis var. canadensis	L.	Violaceae	Magnoliophyta		GM080, 096	Common
Viola cucullata	Aiton	Violaceae	Magnoliophyta		GM128, 129	Common?
Viola eriocarpa	Schwein.	Violaceae	Magnoliophyta		GM065, 078	Uncommon
Viola hastata	Michx.	Violaceae	Magnoliophyta		GM056, 077	Common
Viola pallens	(Banks ex Ging.) Brainerd	Violaceae	Magnoliophyta		GM222, 223	Common
Viola rotundifolia	Michx.	Violaceae	Magnoliophyta		GM053, 069	Common
Viola sororia	Willd.	Violaceae	Magnoliophyta		GM076, 093	Common

Appendix B
North Carolina Natural Heritage Program (2018) and Global ranking codes

N.C. STATUS – PLANTS

N.C. STATUS CODE	STATUS	DEFINITION
E	Endangered	Any native or once-native species of higher taxon of plant whose continued existence as a viable component of the state's flora is determined to be in jeopardy or any species of plant determined to be an Endangered species pursuant to the Endangered Species Act. (GS19B-106:202.12.)
T	Threatened	Any native or once-native resident species of plant which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, or one that is designated as a Threatened species pursuant to the Endangered Species Act. (GS19B-106:202.12.)
SC-V	Special Concern-Vulnerable	Any species or higher taxon of plant which is likely to become a threatened species within the foreseeable future. (NCAC 02 NCAC 48F .0401.)
SC-H	Special Concern-Historical	Any species or higher taxon of plant that occurred in North Carolina at one time, but for which all known populations are currently considered to be either historical or extirpated. (NCAC 02 NCAC 48F .0401)
SR	Significantly Rare	This is a NCNHP designation. Any species which has not been listed by the NCPCP as an Endangered, Threatened, or Special Concern species, but which exists in the state (or recently occurred in the state) in small numbers (generally fewer than 100 statewide populations) and has been determined by the NCNHP to need monitoring. Significantly Rare species include species of historical occurrence with some likelihood of rediscovery in the state and species substantially reduced in numbers by habitat destruction, direct exploitation, or disease. Species considered extirpated in the state, with little likelihood of rediscovery, are given no N.C. status

N.C. STATUS CODE	STATUS	DEFINITION
		listed by the NCWRC or NCPCP as E, T, or SC).
SR-L	Significantly Rare-Limited	The range of the species is **limited** to North Carolina and adjacent states (endemic or near endemic). These are species that may have 20-50 populations in North Carolina, but fewer than 100 populations range-wide. The preponderance of their distribution is in North Carolina and their fate depends largely on conservation here.
SR-T	Significantly Rare-Throughout	The species is rare **throughout** its range (fewer than 100 populations total).
SR-D	Significantly Rare-Disjunct	The species is **disjunct** to North Carolina from a main range in a different part of the country or world.
SR-P	Significantly Rare-Peripheral	The species is at the **periphery** of its range in North Carolina. These species are generally more common somewhere else in their ranges, occurring in North Carolina peripherally to their main ranges, mostly in habitats that are unusual in North Carolina.
SR-O	Significantly Rare-Other	The range of the species is sporadic or cannot be described by the other Significantly Rare categories.
WL	Watch List	This is an NCNHP designation for any other species believed to be rare and of conservation concern in the state but not warranting active monitoring at this time.

U.S. STATUS – PLANTS

U.S. STATUS CODE	STATUS	DEFINITION
E	Endangered	A taxon that is in danger of extinction throughout all or a significant portion of its range (Public Law 93-205 87 Stat. 884).
T	Threatened	A taxon that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (Public Law 93-205 87 Stat. 884).
C	Candidate	Taxa for which the USFWS has on file enough substantial information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened. Proposed rules have not yet been issued because this action is precluded at present by other listing activity. Development and publication of proposed rules on these taxa are anticipated. The USFWS encourages state and other federal agencies as well as other affected parties to give consideration to these taxa in environmental planning [Federal Register, 5 December 1996 Volume 61(235):64481]. Taxa formerly considered "Category 1" are now considered "Candidate."

N.C. RANK – PLANTS

N.C. RANK	NUMBER OF EXTANT POPULATIONS	DESIGNATION	DESCRIPTION
S1	1-5	Critically Imperiled	Critically imperiled due to extreme rarity or some factor(s) making it especially vulnerable to extirpation (local extinction) from the state. Typically 5 or fewer occurrences or very few remaining individuals (<1,000).
S2	6-20	Imperiled	Imperiled due to rarity or some factor(s) making it very vulnerable to extirpation from the state. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000).
S3	21-100	Vulnerable	Vulnerable to extinction either because rare or uncommon, found only in a restricted range (even if abundant at some locations), or due to other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences or between 3,000 to 10,000 individuals.
S4	101-1,000	Apparently Secure	Apparently secure and widespread, usually with more than 100 occurrences and more than 10,000 individuals.

N.C. RANK	NUMBER OF EXTANT POPULATIONS	DESIGNATION	DESCRIPTION
S5	1,001+	Secure	Common, widespread, and abundant. Essentially ineradicable under present conditions. Typically with considerably more than 100 occurrences and more than 10,000 individuals.
SH	0?	Historical	Of historical occurrence, with some expectation that it may be rediscovered. Its presence may not have been verified in the past 20 years. Upon verification of an extant occurrence, SH-ranked elements would typically receive an S1 rank. Note: an element is not automatically assigned an SH (or SX) rank if it has not been verified in the past 20 years; some effort must have been made to locate or relocate occurrences.
SX	0	Presumed Extirpated	Believed to be extirpated. Has not been located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
SU	Unknown	Unrankable	Currently unrankable due to lack of information or substantially conflicting information about status or trends. More information is needed.
SNR	Unknown	Not Ranked	Statewide rank not yet assessed.
SNA	N/A	Not Applicable	A conservation rank is not applicable because the element is not a suitable target for conservation for one of these reasons: • Hybrid – an interspecific hybrid without conservation value; • Exotic Origin – not native to North Carolina; • Accidental/Nonregular – outside usual range and not regularly found in North Carolina; • Not Confidently Present – never documented as present in NC; • Synonym – the taxon is not recognized by the NCNHP.
S_?	---	Uncertain	Denotes inexact or uncertain numeric rank.

GLOBAL STATUS - PLANTS

GLOBAL RANK	NUMBER OF EXTANT POPULATIONS	DESIGNATION	DESCRIPTION
G1	1-5	Critically Imperiled	Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically five or fewer occurrences or very few remaining individuals (<1,000) or acres (<2,000) or linear miles (<10).
G2	6-20	Imperiled	Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000) or acres (2,000 to 10,000) or linear miles (10 to 50).
G3	21-100	Vulnerable	Vulnerable globally either because very rare throughout its range, found only in a restricted range (even if abundant at some locations), or other factors making it vulnerable to extinction. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals.
G4	101-1,000	Apparently Secure	Uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery) and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern. Typically more than 100 occurrences and more than 10,000
G5	1,001+	Secure	Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals.
GH	0?	Historical	Known only from historical occurrences, but with some expectation that it may be rediscovered. May still be extant; further searching is needed.
GX	0	Presumed Extinct	Believed to be extinct throughout its range (e.g., passenger pigeon) with virtually no likelihood that it will be rediscovered. Not located despite intensive searches of historical sites and other appropriate habitat.
GU	Unknown	Unrankable	Currently unrankable due to lack of information or due to substantially conflicting information about status or trends; need more information.
GNR	Unknown	Not Ranked	Global rank not yet assessed.
G_T_	---	Subspecies or Variety Rank	The rank of a taxonomic subspecies or variety. As an example, G4T1 would apply to a subspecies of a species with an overall rank of G4, but the subspecies warranting a rank of G1.
G_?	---	Uncertain	Denotes inexact or uncertain numeric rank.

GLOBAL RANK	NUMBER OF EXTANT POPULATIONS	DESIGNATION	DESCRIPTION
G_Q	---	Questionable Taxonomy	Taxonomic classification that may reduce conservation priority. Distinctiveness of this entity as a taxon at the current level is questionable. Resolution of this uncertainty may result in change from a species to a subspecies or inclusion of this taxon in another taxon, with the resulting element having a lower-priority conservation status rank.

North Carolina Plant Watch List

CATEGORY	DESIGNATION	DESCRIPTION
W1	Rare but Relatively Secure	Species whose status in N.C. is relatively well known and appear to be relatively secure at this time. While still notably rare, these species do not currently require site-specific monitoring and so are not on the Rare List. Many of these species were formerly on the Rare List; they are retained in this category because they require a lower level of continued monitoring to ensure their long-term security.
W2	Rare but Questionable Taxonomy	Species including taxa of dubious validity and taxa under study and potentially to be named. If further study reveals that these are valid taxa, they would warrant addition to the Rare List. This category has been used for named and unnamed taxa that currently appear to have some significant chance of being proven valid.
W3	Rare but Questionable Documentation	Species that have been reported from N.C. without adequate documentation. These species should be listed at a higher level when their reported occurrence in N.C. is verified. This category includes sight records, old and vague reports for which no documentation has appeared, and, in a few cases, more recent literature reports for which we have not yet received documentation.
W4	Rare but Possibly Not Native	Species known to occur in N.C. that current data suggest are not native to N.C. but whose native occurrence is plausible. Some of

		these species were previously listed at a higher level, but field investigations suggest that all known N.C. occurrences are introductions.
W5	Rare because of Severe Decline to Population or Habitat	Species that have declined sharply in N.C. but do not appear yet to warrant site-specific monitoring. Most species in this category have undergone declines of more than 50% (in many cases more than 90%) from their pre-Columbian status. Reasons for decline include exotic pests or pathogens, massive modification of the landscape, suppression of natural fires, and failure of reproduction. Because many of these species were once abundant or even dominant in parts of N.C., they may still be fairly common or frequently encountered, despite the strong decline. If current trends continue, however, many of these species will be threatened with extirpation in all or a major part of their ranges in N.C.
W6	Regionally Rare	Species that are rare in one region of North Carolina while being uncommon to abundant within another region. These regional rarities, generally within-state disjuncts, are significant for protection of genetic variation and long-term viability of species. **W6 plants are listed immediately following the Watch List in this volume**.
W7	Poorly Known in NC	Species with inadequate information about their distribution and rarity in N.C. These are generally species not previously listed as rare in N.C. but which appear to be so based on herbarium or museum records and field experience of NCNHP staff, consultants, and cooperating scientists. Further information is needed to determine the true status of these species in N.C.

Vita

Ethan Luke Hughes was born in Travelers Rest, South Carolina on June 8, 1990 to Michael A. and Ann R. Hughes. He graduated from Hampton Park Christian School in 2008 and enrolled in Spartanburg Community College in August of 2008, where he received his A.S. degree in Horticulture in 2010. In the fall of 2010, he transferred to Clemson University, where he received his B.S. in Horticulture and a minor in Wildlife & Fisheries Biology in 2013. The next five years he spent working in the plant ecology and botany fields for the private sector, state, and federal government around the U.S. In August of 2018, he began his graduate career at Appalachian State University in the Biology program and received his degree in the spring of 2020. He currently resides in Tallahassee, Florida where he is employed as a botanist with the Florida Natural Areas Inventory.