

BIODIVERSITY SURVEY OF THE WHITE PINES NATURE PRESERVE, CHATHAM COUNTY, NC

NORTH CAROLINA BIODIVERSITY PROJECT, 2024



Hall, S. (ed.); Agüero, B.; Amoroso, J.; Backstrom, P.; Bockhahn, B.; Corey, E.; Cotter, V.; Cubeta, M.; Feldman, T.; Gatens, L.; George, D.; Goodwin, M.; Hollinger, J.; Howard, T.; LeGrand, H.; Levenson, H.K.; Niznik, J.; Perlmutter, G.; Petranka, J.; Petranka, J.; Pippen, J.; Shields, M.; Sorrie, B.; Tingley, C.; Vilgalys, R.

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In addition to our members, a number of volunteers joined us in the field or otherwise provided records used in our report. These include Pat Coin, Mark Basinger, Jimmy Randolph, Carol Anne McCormick, Mark Peifer, Merry Conlin, Scott Pohlman, Rich Teper, Stephen Dunn, Larry Chen, Sarah Toner, Ren Rooney, and Jena Ostendorf. Charley Eiseman provided help with the identification of leaf-mining insects.

Bird records were shared with eBird and butterfly records with the Carolinas Butterfly Monitoring Program of PollardBase. In addition to the records collected directly in this survey, we made use of the large amount of data from the White Pines Preserve available through GBIF (GBIF.org (16 August 2025) GBIF Occurrence Download <https://doi.org/10.15468/dl.7ycs9x>),

Finally, we would like to acknowledge our debt to the surveys conducted by Ed Swab and Marj Boyer in the 1980s, shortly after the preserve was acquired by the Triangle Land Conservancy. The data they collected played a key role in estimating the viability of a number of species, particularly vascular plants.

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INTRODUCTION

The [White Pines Nature Preserve](#) has intrigued naturalists and biologists for over 100 years, with its stand of White Pines and other northern or montane species that are seemingly far out-of-place in the eastern Piedmont. Because of these features and its scenic values, the White Pines was the first natural area acquired by the [Triangle Land Conservancy](#), right at the beginning of the local land trust movement. With its miles of trails running along the Deep and Rocky Rivers and winding up and down the ravines and ridges that dominate this promontory, the White Pines Preserve is now one of the most popular sites for outdoor recreation in the region.

Natural areas that have managed to preserve high levels of species and ecological diversity over the past several decades are especially important targets for conservation efforts. Having withstood the tests of time, they are among the most likely sites to keep their biodiversity features into the future. Given the increasing pace of extirpation, such sites will play a major role not only in maintaining the biodiversity within their own boundaries but also as sources for the recovery of losses in more distant areas. Now more than ever, conservation aimed at well-connected, resilient networks of natural areas is a major priority (see Lawler et al., 2015 and Anderson et al., 2023).

The White Pines Nature Preserve fits every one of these criteria. Most notably, it has served as a refuge for a number of northern and montane species – e.g., White Pines, Catawba Rhododendrons, and Red-backed Salamanders – probably since the end of the Ice Age ten thousand years ago. The survival of those species is undoubtedly due to the cool, moist microclimates offered by the preserve's steep bluffs and ravines. Those same topographic features were also probably responsible for the survival and recovery of these species following the massive logging event that took place in the early 1900s.

For other species, it is the location of the preserve within an area that retained or recovered its forest cover that is important. Particularly important is its location at the confluence of the Rocky and the Deep Rivers and close to the confluence of the Deep and Haw -- the major headwaters of the Cape Fear River system. As such, it occupies a key location along a system of natural areas stretching from the southern Coastal Plain to the north-central Piedmont, with overland connections open for some species to river basins still further to the north. Any loss of species within the White Pines Preserve itself can be reversed through immigration along these movement corridors. Conversely, emigration out from the preserve can help reverse losses elsewhere.

Combined, these features all indicate the importance of this preserve, both for its current levels of biodiversity but also for its role as an anchor in a larger system of natural areas. As such, the White Pines Preserve needs to be recognized as a keystone site for the state's native biodiversity.

The North Carolina Biodiversity Project has as its core mission gathering widespread support for the preservation of the state's native species and ecosystems, making biodiversity information as freely and easily available as possible. We accomplish this goal partly through our websites focused on an extensive array of taxonomic groups and more recently through our involvement in comprehensive, year-long surveys of sites that are regionally important as centers of biodiversity. In addition to original field work, the NCBP websites compile historic and current data from publications and collections. The websites provide a resource for land managers and offer the opportunity to monitor and evaluate the ecological integrity of sites over time.

We began this survey, with the permission of the Triangle Land Conservancy, in May 2024 and completed the field work for this project in May 2025. This report includes the results not only of our own survey efforts but also compiles information obtained through other citizen-science-based projects, notably iNaturalist, eBird, and GBIF. The results present an in-depth picture of the importance of the White Pines Preserve in maintaining the state's biodiversity, with the hope of increasing the public's appreciation of the need for its continued conservation.

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FEATURES OF THE WHITE PINES NATURE PRESERVE

LOCATION AND EXTENT

The White Pines Nature Preserve is a 285-acre stand of mature hardwoods intermixed with White Pines located along the southern edge of Chatham County at the confluence of the Rocky and Deep Rivers. As shown in Figure 1, it is accessed off of US 15-501, 10 miles south of Pittsboro or 12 miles north of Sanford. The preserve is owned by the Triangle Land Conservancy and managed to protect its unique combination of species and habitats. The preserve also has a well-developed set of trails that are open year-round for hiking. For general information on the preserve, as a well as a map of its trail system, see <https://triangleland.org/explore/nature-preserves/white-pines-nature-preserve>.

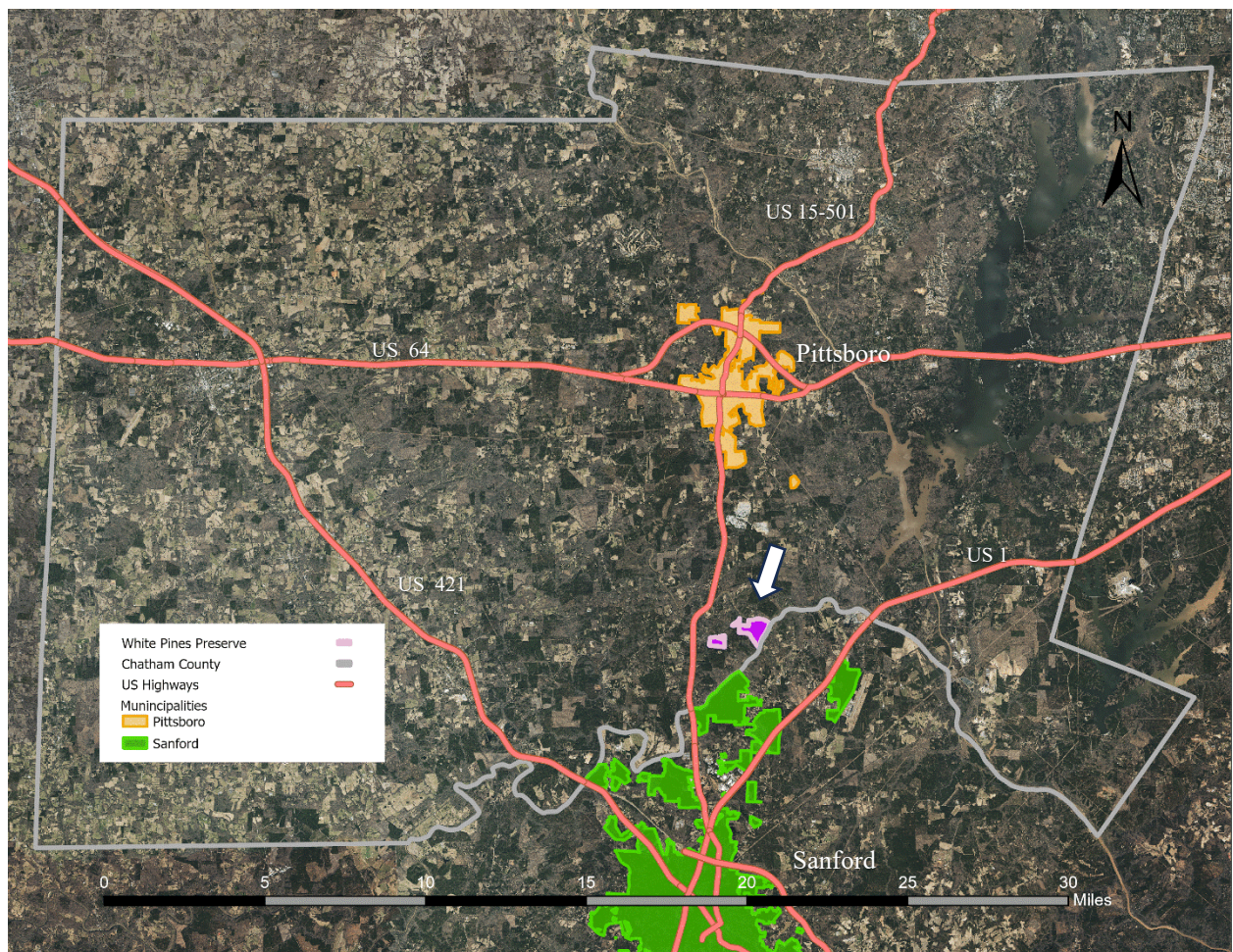


FIGURE 1. LOCATION OF THE PRESERVE

An excellent description of the geography, land use history, environment, vegetation and early protection efforts of the White Pines Preserve is given in Ed Swab's 1990 M.S. thesis, which is available online from the NCSU Library (see References below). The description of the plant communities and the list of plant species compiled by Ed is especially impressive and provides a

baseline – as he intended – for surveys such as the one currently being conducted by the North Carolina Biodiversity Project. He also provided a very thorough list of the birds, mammals, herps, butterflies, and other animals he encountered while surveying the preserve, which also serves as a baseline for current comparisons. Some of the information on geology, soils and past land use has changed, however, as is updated in the sections below.

Topography, Geology, Waters, and Soils

The geological features of the preserve were recently described in detail by Bradley et al. (2022). The site is located on a fairly high promontory, a triangle of uplands surrounded on two sides by rivers: the Rocky River on the north and the Deep River on the east and southeast. The high elevation at this location is due to uplift events that may have occurred as recently as the last period of glaciation, possibly the result of bulges in the crust resulting from the great weight of the Laurentide Ice Sheet pressing down on the earth (see discussion in Bradley et al.). In any case, this uplift resulted in recent, strong erosion creating the steep cliffs and deep ravines that are hallmark features of the White Pines promontory. As discussed below, the cool, moist microclimates associated with these features are believed to explain the disjunct presence of the White Pines, along with a number of other plants and animals found at this site whose main range in North Carolina is in the Southern Appalachians.

Geologically, the promontory is underlain primarily by felsic igneous rock formations, primarily metamorphosed dacitic lavas and tuffs. Flow-banded dacitic boulders – reflecting their formation from pyroclastic ash flows – are common features of the uplands within the preserve (see Figure 2). Additionally, a recently discovered inclusion of Triassic sedimentary rock is located in the eastern part of the preserve, extending from the ridge top down to the Deep River floodplain (see Bradley et al., 2020). This inclusion consists of conglomerates of the Pekin Formation and are dark reddish brown, in contrast to the light-colored felsic rocks found over most of the preserve.



Although this formation is often associated with border faults, no diabase or other mafic rock formations – often associated with faults bordering the Triassic Basin – have been found within the preserve.

Some of the rock outcrops along the Rocky River extend all the way to the river's edge and the riverbed itself is extremely rocky in some places, forming rock gardens and extensive riffles – the Rocky River is very aptly named. In some areas, however, sediments have formed low floodplain terraces. These are somewhat restricted along the Rocky River but are continuous and much wider along the Deep River, particularly towards the southern end of the preserve. A levee has also been built up along most of the shoreline along the Deep, with a floodway located behind it that contains seasonal to relatively permanent floodplain pools, some quite large.

Soils mapped by the NRCS Soil Web Soil Survey are shown in Figure 3 and are listed in Table 1. The largest soil units mapped for the preserve include Badin-Nanford Complex, Nanford-Badin Complex, Goldston-Badin Complex, and Cid-Lignum Complex (USDA Web Soil Survey, accessed 2024). All of these, along with smaller components, are acidic and support dry-to-mesic stands of upland hardwoods. The sediments along the rivers include Riverview Silt Loam, bordering the shorelines of both rivers, and a wider band of Chewacla in the area behind the levee along the Deep River. In strong contrast to the upland soils, these sedimentary soils are nutrient-rich and much higher in pH.

FIGURE 3. SOIL TYPES WITHIN THE PRESERVE

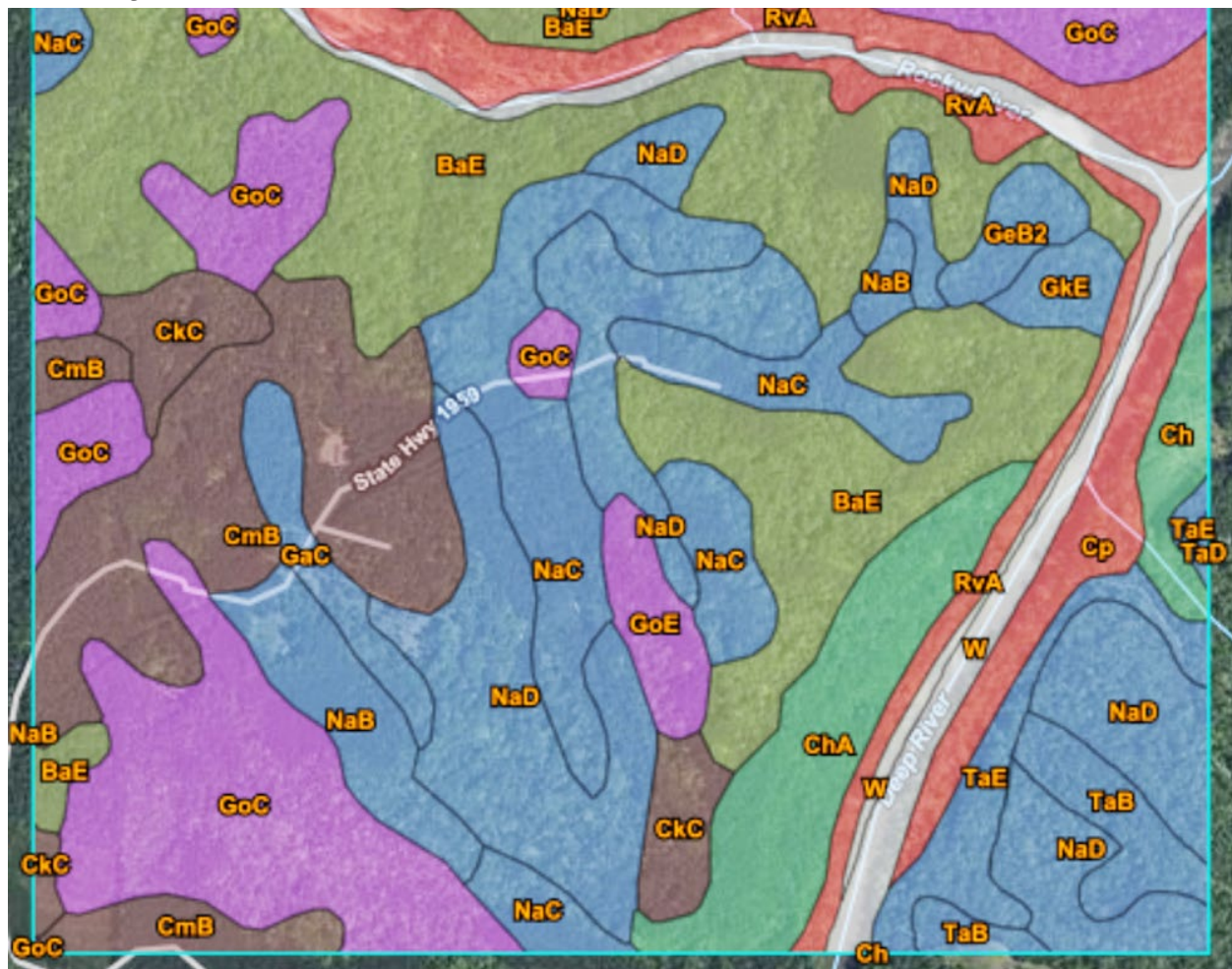


TABLE 1. SOIL TYPES WITHIN THE PRESERVE

USDA United States Department of Agriculture		Web Soil Survey		Natural Resources Conservation Service	
Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
BaE	Badin-Nanford complex, 15 to 30 percent slopes	Badin (50%)	F136XY830NC — Acidic upland forest, depth restriction, dry-moist	133.8	21.30%
		Nanford (30%)	F136XY820GA — Acidic upland forest, moist		
ChA	Chewacla and Wehadkee soils, 0 to 2 percent slopes, frequently flooded	Chewacla (55%)	F136XY610GA — Flood plain forest, wet	29.6	4.70%
		Wehadkee, undrained (30%)	F136XY600NC — Flood plain forest, very wet		
		Wehadkee, drained (10%)	F136XY600NC — Flood plain forest, very wet		
		Congaree (5%)			
CkC	Cid silt loam, 6 to 10 percent slopes	Cid (70%)	F136XY815NC — Acidic upland woodland, depth restriction, seasonally wet and dry	15.9	2.50%
CmB	Cid-Lignum complex, 2 to 6 percent slopes	Cid (50%)	F136XY815NC — Acidic upland woodland, depth restriction, seasonally wet and dry	61.1	9.70%
		Lignum (20%)	F136XY810SC — Acidic upland forest, seasonally wet		
		Wehadkee, undrained (2%)			
GaC	Georgeville silt loam, 6 to 10 percent slopes	Georgeville (90%)	F136XY820GA — Acidic upland forest, moist	9	1.40%
		Tarrus (10%)			
GeB2	Georgeville silty clay loam, 2 to 6 percent slopes, moderately eroded	Georgeville, moderately eroded (8%)	F136XY820GA — Acidic upland forest, moist	6.1	1.00%
		Tarrus, moderately eroded (8%)			
		Lignum (4%)			
GkE	Georgeville-Badin complex, 15 to 30 percent slopes	Georgeville (54%)	F136XY820GA — Acidic upland forest, moist	5.2	0.80%
		Badin (26%)	F136XY830NC — Acidic upland forest, depth restriction, dry-moist		
GoC	Goldston-Badin complex, 2 to 15 percent slopes	Goldston (55%)	F136XY880GA — Acidic high hills and isolated ridges, depth restriction, dry	81	12.90%
		Badin (30%)	F136XY830NC — Acidic upland forest, depth restriction, dry-moist		
GoE	Goldston-Badin complex, 15 to 35 percent slopes	Goldston (55%)	F136XY880GA — Acidic high hills and isolated ridges, depth restriction, dry	8.3	1.30%
		Badin (30%)	F136XY830NC — Acidic upland forest, depth restriction, dry-moist		
		Tarrus (5%)			
NaB	Nanford-Badin complex, 2 to 6 percent slopes	Nanford (36%)	F136XY820GA — Acidic upland forest, moist	16.9	2.70%
		Badin (33%)	F136XY830NC — Acidic upland forest, depth restriction, dry-moist		
NaC	Nanford-Badin complex, 6 to 10 percent slopes	Nanford (50%)	F136XY820GA — Acidic upland forest, moist	56.1	8.90%
		Badin (30%)	F136XY830NC — Acidic upland forest, depth restriction, dry-moist		
NaD	Nanford-Badin complex, 10 to 15 percent slopes	Nanford (40%)	F136XY820GA — Acidic upland forest, moist	61.7	9.80%
		Badin (35%)	F136XY830NC — Acidic upland forest, depth restriction, dry-moist		
RvA	Riverview silt loam, 0 to 3 percent slopes, frequently	Riverview (85%)	F136XY620GA — Flood plain forest, moist	38.7	6.20%
		Wehadkee, undrained (1%)			
W	Water	Water (100%)		15.9	2.50%

Unlike the acidic soils of the uplands, which have developed in place from the underlying felsic rock formations, the alluvial soils along the rivers include materials that have weathered from mafic rock formations upstream, including extensive areas of basalt along the upper reach of the Rocky River and an extensive sill of diabase located upstream along the Deep. Some of these sediments appear to have been deposited by floods along the lower slopes, which gives them a richer character in terms of their vegetation than the soils that have developed in place.

Land Use History

The region surrounding the preserve is rural and still relatively remote from intensively developed areas, a factor that appears to be important in explaining its high biodiversity: the air is relatively clean, the sky is dark at night, and what noise that exists comes almost entirely from its birds, frogs, and insects. Of critical importance, none of the roads within the preserve appear to have ever been paved; vehicular traffic, consequently, is less lethal to wildlife than it is in more developed areas. The remoteness of this area – with access limited in the past to the north and south by the two rivers -- seems to be well-summarized by the cable bridge across the Rocky River that served to allow children access, via a long foot trail (now called the Schoolkids Trail), to the New Zion School, a one teacher schoolhouse in the Gorgas Community located on the north side of the river (Pollard, 2005). This school was built in 1918 and continued to be used until 1946 (USDI, 1985). The cable bridge itself shows up in an aerial photo taken in 1938 and the remains of the cable are still visible today where the Schoolkids Trail comes down to the Rocky River.



FIGURE 4. 1938 AERIAL PHOTO OF THE STUDY AREA

The land within the preserve appears to have been only lightly used for agriculture. The 1938 aerial photo of the area shows just a single farmstead within the area now contained within the preserve (Figure 4). Additionally, about ten other fields existed at that time, including several – some large – located within the floodplains of the Rocky and Deep Rivers. Only one farm pond large enough to show up on the 1938 photo was located in a large field that extended along what is now the southern border of the preserve.

The field and buildings at the farmstead are still visible in a 1955 aerial photo but appear to be much reduced in a 1966 photo (Chatham County Soil and Water Conservation District). The large field with the farm pond located along the southern edge of the preserve was also apparently still kept open in the 1960s but had succeeded to pine forest by the 1970s, along with most of the other fields that were present earlier. Two new farm ponds and clearings surrounding them show up for the first time in the 1950s, located along the upland portion of the Schoolkids Trail. These appear to be associated with the construction of a cabin, chicken house, and barn in this area, with the barn currently still standing. A cluster of buildings is also located near the trailhead, close to the area now used for parking at the preserve.

Even in the 1938 photo, most of the area within the current preserve appears to be forested, including pine stands as well as hardwood. Timber harvesting was historically important within the Deep River Valley (Costa, 2001), and Coker and Totten (1932) reported that approximately 35,000 ft of White Pines had been cut from both the Chatham promontory as well as from the area across the Deep River in Lee County. At least some of the young pine stands that show up on the 1938 aerial photograph may represent stands that were regenerating from that episode, although probably through growth of Loblolly Pines rather than the original White Pines.

Biodiversity Features

Currently, the upland portions of the preserve are covered with fairly mature stands of oak-hickory forest or mesic mixed hardwood forest. Some stands are still undergoing succession, with loblolly or short-leaf pines still dominating the canopy. Shrub layers composed of blueberries, huckleberries, and other acidophilic species are well developed on many of the ridges.

The White Pines, whose presence distinguishes this site, were apparently first noted in 1884 by J.A. Holmes, the first state geologist in North Carolina, who described them as not otherwise having been recorded east of the mountains (Swab, 1990). This assessment was repeated in 1932 by W.C. Coker, the first chair of the botany department at UNC, and H.R. Totten, a graduate student of Coker's and later a professor in the UNC botany department. They recorded finding a specimen that was 3 ft in diameter, along with plentiful smaller trees and numerous seedlings, indicating the presence of a healthy, reproducing population. They also noted the biogeographic resemblance of this population to a similarly isolated stand of Eastern Hemlocks located in Wake County along a similarly steep, north-facing bluff.

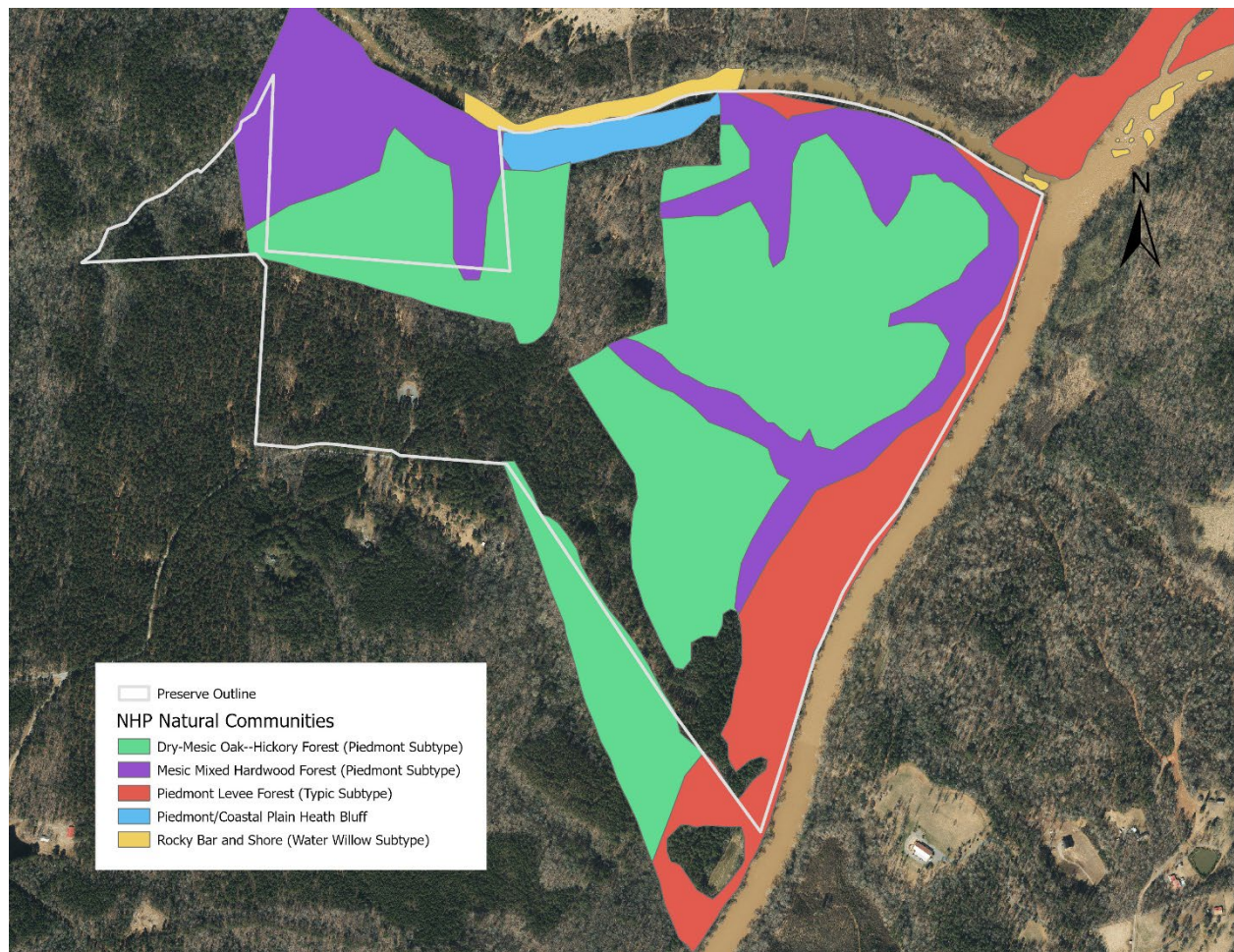
Swab presented an excellent summary of the hypotheses explaining the disjunct presence of montane species at the eastern edge of the Piedmont, with the evidence favoring their status as relicts from a past Pleistocene distribution, when cool, moist environmental conditions existed over the entire area that is now North Carolina. In addition to the White Pines, other montane disjuncts/Pleistocene relicts found at the White Pines Preserve or on adjoining lands include Catawba Rhododendron (*Rhododendron catawbiense*), Witch Alder (*Fothergilla major*), and Dutchman's Breeches (*Dicentra cucullaria*). In 1988, Steve Hall added Red-backed Salamanders (*Plethodon cinereus*), to the White Pines List, the first animal species documented at this site that appears to have a similar relictual distribution in the eastern Piedmont of North Carolina (see Sather and Hall, 1988 and Hall and Boyer, 1992). Several more have subsequently been added, including a number discovered during the current NCBP inventory. Still others include two species of fungi that are obligate symbionts of White Pine: *Suillus americanus* and *S. pictus*, whose presence at the White Pines Preserve was studied by Betsy Randall (1983).

The presence of these species at this particular site has long been connected to the very steep, north-facing, rocky bluffs that are located along the Rocky River within the preserve and along similar slopes on the Lee County side of the Deep River. These very steep bluffs, in fact, may have also preserved these species during the episode of heavy timbering of White Pines that occurred around 1911 (Coker and Totten, 1932), due to their general inaccessibility.

As Swab pointed out, however, White Pines can be found at many sites within the preserve well away from the steep bluffs, including at sites near the upper slopes of the ravines where seedlings are commonly seen. This may indicate that the steep bluffs serve as a major sanctuary for the disjunct montane species during particular hot and dry climatic conditions, but that they can also spread out during intervening cooler and wetter conditions, which also helps improve their odds of surviving localized, catastrophic conditions other than those related to weather and climate.

The high topographic diversity, microclimate diversity, and soil diversity of this site are some of the most important factors explaining the high level of biodiversity present at this site. As noted by Swab, the White Pines Preserve “is probably the only existing location where white pine, longleaf pine, shortleaf pine, and loblolly pine can be seen growing naturally within sight of one another.” The Natural Heritage Program has identified five Natural Community Element Occurrences at this site: Piedmont/Coastal Plain Heath Bluff, Dry-Mesic Oak--Hickory Forest (Piedmont Subtype), Mesic Mixed Hardwood Forest (Piedmont Subtype), Piedmont Levee Forest (Typic Subtype), and Rocky Bar and Shore (Water Willow Subtype).

FIGURE 5. NATURAL COMMUNITIES OF THE WHITE PINES PRESERVE



As a Natural Heritage Natural Area, the White Pines Preserve itself is rated as having Very High Significance and the adjoining CPF/Rocky River Subbasin Aquatic Habitat is rated as Exceptional by the NC Natural Heritage Program.

Conservation History

Following the discovery of the population of White Pines and other montane disjuncts at the confluence of the Rocky and Deep Rivers, this area has been subject to innumerable site visits and more detailed surveys by botanists from many of the state's universities and colleges. Animal surveys were also conducted at this site in 1988-89 by both Swab and by Steve Hall and Marj Boyer in a survey of the natural areas of Chatham County commissioned by the Triangle Land Conservancy (Hall and Boyer, 1992). Based on these surveys, the White Pines area has long been considered a prime target for biodiversity conservation and in 1987, a tract within the White Pines area became the first land purchase project of the Triangle Land Conservancy (see <https://triangleland.org/about/history>). Several other tracts were subsequently added, and the total area now stands at 285 acres with several of the adjoining tracts voluntarily protected as Registered State Natural Areas. The preserve itself became the 11th State Nature Preserve, dedicating the use of the property for the preservation of its natural features.

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NCBP APPROACH TO BIODIVERSITY SURVEYS

The North Carolina Biodiversity Project uses what we term an extended bioblitz approach to conducting biodiversity surveys. The bioblitz approach itself is a fairly recent development, focusing survey efforts on a single site of high diversity and/or conservation significance. Experts on multiple taxonomic groups are given free-reign within a concentrated time period – usually 24 hours – to document as many species within their specialty as possible. All such surveys are conducted within the same time period. Our approach matches all of these features except that our surveys are extended over an entire year. Although each taxonomic group is allocated the same funding for field work, each one selects the most appropriate times to conduct their surveys within the course of the year, splitting their efforts, where needed, into multiple visits to the site.

The different taxonomic groups included in these surveys correspond in our case to the different websites we set up to document the biodiversity of North Carolina. Each of these groups has a core of experts who have had a long history of working with their particular taxa and are knowledgeable not only with the identification of the full range of species in their particular subject group but also where and how to find them in the field. They are also masters of record-keeping, in most cases compiling species records into databases that serve to permanently document the biodiversity of the state. We now have websites that include representatives of all of the major groups of eukaryotes, from protists (represented by slime molds), to fungi (represented by Lichens), to non-vascular and vascular plants, to several groups of insects and other invertebrate animals, to all classes of vertebrates. Except for fish and tardigrades, all of these groups have been targeted in our extended bioblitz surveys.

The data compiled in these databases are used to monitor the status of the state's biodiversity. For particular sites, they provide a basis for assessing their biological integrity, i.e., how well they have retained their native species and natural ecological relationships through time. Those that have a high degree of integrity are those that are most likely to retain it into the future and are particularly important core areas for conserving biodiversity over the surrounding region, particularly where dispersal corridors are also maintained that provide interconnections throughout these regions.

SPECIES OF SPECIAL SIGNIFICANCE

As in Natural Heritage Program inventories, we give attention to species that are determined to be Significantly Rare by NHP, i.e., that are declining across their geographic range in North Carolina due to loss or decline of their populations. Their presence within a site is a particularly good indicator of ecological integrity, i.e., that the site has been able to maintain its historic complement of species and ecological processes that have been widely lost elsewhere across the state. The same is true for species such as White Pines, Red-backed Salamanders, and Catawba Rhododendrons, all of which are still common in the Southern Appalachians but still have highly disjunct populations elsewhere, such as at the White Pines Preserve in the far eastern Piedmont. The presence of these species is not only of scientific interest – revealing distributions that once included the entire state in the distant past – but again show that the site has maintained its biological integrity, in this case over a period of 10,000 years.

BIOTIC PERSISTENCE ANALYSIS

In addition to assessing the conservation significance of individual species, we assess the needs of groups of species using a measure termed the Biotic Persistence Index as described in the Habitats of North Carolina Website (Hall and Howard, 2026, Ch. 7). This measures how well a particular preserve or site has maintained its species composition through time and is likely to continue to do so. As such, it reflects the intactness of the ecological systems present at a given place, with the more complete, the higher the value for conservation. It is, therefore, of particular value in assessing the importance of individual sites, such as the White Pines Preserve.

This method first estimates the probability of survival of each species belonging to a particular group; in our approach, we use the coming ten years as our estimation interval. Based on the density, distribution, degree of threat, and ability to recover from catastrophic events, we assign each species a viability rank, following criteria similar to those used for occurrence ranking by the Natural Heritage Program. We go one step further, assigning probabilities of survival to each of these ranks. For example, we assign a probability of 0.9 to an A-level (Excellent) occurrence, 0.6 to a C-level (Fair) and 0.5 to an E-level, where we do not have enough information to judge whether it is likely to survive or perish. Species that are believed to have become extirpated from the site are given a value of 0 and those that are completely secure are given a value of 1 (see Appendix S for the criteria we use in estimating these values).

Mathematically, the sum of all of these probabilities gives the number of species in a particular group that are expected to survive over the coming estimation interval. If that number is divided by the total number of extant species, the resulting Viability Index, expressed as a percentage, gives the proportion of these species that are expected to survive.

If, on the other hand, the sum of the species' survival probabilities is divided by the total number of species believed to have once existed there – the baseline group – this produces what we term the Biotic Persistence Index (BPI), i.e., the proportion of species that have persisted since the time when that group was once intact¹. Although this measure requires more information than the Viability Index, it is for that very reason the more useful measure of biotic survival. For a given taxonomic or ecologically-defined group, a site that has a high value of BPI represents a better conservation investment – one that is more likely to continue to persist – than a site where that group has a lower value. Unlike the Viability Index, which can be used to compare only the same biotic groups across different sites, the BPI can be compared across different biotic groups as well, providing a more general measure of persistence.

In this project, we use this analysis mainly for groups where both good baseline information exists – i.e., where past species composition can be estimated – and where multiple samples are taken over both time and space. These include mainly animal groups for which transect surveys were made, including butterflies, breeding birds, orthoptera, amphibians, reptiles, and mammals².

¹ Note that the missing species can be considered to contribute zero values in the sum of survival probabilities in this analysis.

² Moths are a special case. While there are enough quantitative data available to assess probabilities of species' survival, baseline data are largely unavailable – particularly for micro-moths -- from past regional surveys. That

We also use this approach in analysis of multi-taxa groups showing high fidelity to particular habitats, following the classification developed in NCBP's Habitats of North Carolina website. This provides a more direct focus on the ecological structure of the preserve and how well it is holding up under the immense changes to the environment that are currently taking place. As with the taxonomic groups, the BPI plays an important role in this analysis.

TAXONOMIC COVERAGE

In evaluating the ecological integrity of a given site, the greater the number of taxonomic groups that are included, the greater the information that is provided on the functional integrity of the site. The following list describes the functional roles in the ecosystem that each of our surveyed taxa represent.

- Vascular Plants – primary producers (autotrophs), mutualists with mycorrhizal fungi
- Bryophytes – primary producers
- Lichens – primary producers, tree commensals, and air quality indicators
- Lepidoptera – primary consumers (herbivores) and a few detritivores (feeding on litter and fungi); pollinators
- Orthoptera – primary consumers, some secondary consumers and detritivores
- Long-horned Beetles – primary consumers and detritivores
- Tiger Beetles and Fireflies – secondary consumers (insectivores)
- Odonata – secondary consumers, both aquatic and terrestrial
- Spiders – secondary consumers
- Harvestmen – secondary consumers and detritivores
- Centipedes -- secondary consumers
- Amphibians – secondary consumers (insectivores and carnivores)
- Reptiles – secondary consumers
- Birds – secondary consumers (a few detritivores)
- Mammals – primary, secondary, and higher level consumers; some omnivores and detritivores
- Millipedes -- detritivores
- Fungi – primary and secondary consumers; important decomposers and mutualists with vascular plants and a few insect species
- Myxomycetes -- detritivores

Myxomycetes (Slime molds) -- ingest primarily bacteria along with yeasts, spores, hyphae and occasionally whole fungal bodies. Although our taxonomic coverage is still incomplete – we hope to keep adding websites as we are joined by experts on new taxonomic groups – the ecological coverage we already have allows us to assess the integrity of the entire ecosystem present within our focal survey site. In particular, we are able to determine the biological persistence within

factor plus the sheer volume of species observed in the survey made other methods of analysis more suitable. However, moths – especially including the micro-moths – possess a large number of habitat specialists and those play an important role in our persistence analysis of particular habitats.

particular taxonomic/functional groups and to look for correlations across these groups. In the New Hope Bottomlands survey, for example, we found a potentially strong relationship between what appears to be a massive decline in Lepidopteran species and a similarly strong decline in the Neotropical migrant songbirds of the study area. An understanding of the conservation needs of the entire ecosystem needs exactly this sort of cross-taxonomic/functional group analysis, a major goal of the NCBP surveys.

SURVEY SCHEDULE

Field work for the current project was conducted between May 1, 2024, and May 1, 2025. As described above, the schedule followed by each taxonomic group varied, along with their method of study. These details are described in the Taxonomic Summaries that follow.

VASCULAR PLANTS

Bruce A. Sorrie

PREVIOUS BOTANICAL WORK

White Pines Nature Preserve (WPNP) was set aside by the Triangle Land Conservancy in 1987. Prior to that date, a small number of botanists had visited portions of the site during the course of studies on the Deep River (Beard publications 1958, 1959) or general botanical collecting (L.J. Dorr & J. Niese specimens in 1977, R.M. Downs specimens in 1973, M.L. May specimens in 1977, A.E. Radford specimens in 1962, S. Rowland specimens in 1973, H.R. Totten specimens in 1921). Totten's specimens of White Pine, collected on 25 July 1921, are the oldest herbarium specimens known from WPNP.

Since the creation of the preserve, several other botanists have continued to make plant collections (P.S. Manos specimens in 2020, C.A. McCormick & M. Peifer specimens in 2020-22, B.A. Sorrie specimens in 2024-25). Others took photos with digital cameras and shared images via the internet, notably Jimmy Randolph and McCormick & Peifer. With the advent of digital photography with cellphones, the number of people making images of plants on the preserve has grown exponentially. Many of these observations have been reported at websites such as iNaturalist.

Most notable was the botanical survey conducted by Ed Swab of NC State University, who collected extensively in the mid- to late 1980s and produced an annotated list of 478 species and infraspecific taxa (Swab 1990). His was the first attempt to document the complete flora of WPNP and is the baseline with which the 2024-25 survey was compared.

THE 2024-25 BOTANICAL SURVEY

Objectives

The primary objective of the 2024-25 survey was to document as complete a list of vascular plants on the 285 acres of WPNP as time allowed. This list would then be compared to the list compiled by Swab (1990), and the following questions addressed:

- Which species continue to occur on the preserve.
- Which species have been lost.
- Does the small population size of a native species suggest it may not persist.
- Do any state or federally rare species occur.
- Have any plant communities (habitats) been lost or significantly degraded.
- Which non-native species can be considered invasive or a threat to native species.

Methodology

My methodology was straightforward. First, information on general ecology and habitats of WPNP was gathered from Hall & Boyer (1992); a list of vascular plants documented from WPNP was extracted from Swab (1990); data on rare species was obtained from North Carolina Natural Heritage Program (2024). With this background I was able to plan a rough schedule of areas to visit on the preserve.

In the field, I walked the length of every trail at least once and at different times of the growing season, in order to maximize species detection. I walked off trail frequently, so as to cover small or localized habitats or rare species locations. These included rich mesic ravines, floodplain forests, rocky ledges, two man-made ponds, and the one-pole powerline. The map of the preserve, showing topographical contours and trails, was critical to field research.

Specimens were collected for species "new" to the preserve (they may have been there all along but overlooked) and deposited at the herbarium at UNC-Chapel Hill or at NC State. In some cases, such as small population size, no specimens were collected but digital photos were taken. Specimens were identified using Radford, Ahles, and Bell (1968) and Weakley et al. (2024).

Results

COMPOSITION OF THE FLORA

As of 1 January 2025, there are 617 species of vascular plants recorded from White Pines Nature Preserve (see Appendix A). Table 1 gives a breakdown of the species by native vs. alien status, and also whether current (verified during 2024-25) vs. historical (not recorded in 2024-25). Note: For simplicity, I treat as separate "species" each variety or subspecies (the vast majority have only one taxon found on WPNP).

Table 1.

Native Species Current	365 (59% of total flora)
Native Species Historical	170 (28%)
Native Species Total	535 (87%)
Alien Species Current	50 (8%)
Alien Species Historical	32 (5%)
Alien Species Total	82 (13%)
Total Flora of WPNP	617 (100%)

As Table 1 documents, the great majority (87%) of vascular plants that occur on WPNP are native and naturally occurring, as opposed to only 13% of non-native plants. This is likely due to the heavily forested nature of WPNP, which resists immigration by alien species. It is well documented that most alien species occur in open or lightly shaded environments. Such habitats occupy relatively small areas on WPNP and consist of a narrow powerline, very narrow roadsides, two small parking lots, and a former dwelling site. Additionally, alien plants also tend to favor areas of disturbed soil, whereas most of WPNP has not been disturbed for decades except for making and maintaining trails and parking lots and mowing the powerline.

Reasons for why 28% of the native flora has apparently been "lost" are complex. First, a short inventory such as the one conducted in 2024-25 is unlikely to detect a high percentage. A single observer in a one-year timespan is unlikely to detect as many plants as dozens of observers over decades. Second, a short inventory timespan also means that an observer cannot make as many repeat visits to species-rich areas as one would like and therefore is likely to miss some species. Third, some species may not have flowered in 2024-25 and thus may have been difficult to detect. For example, the late spring-mid summer drought, followed abruptly by the late summer-mid fall rainy period (including hurricane events) may have adversely affected the growth and flowering of some plants. Fourth, some plants may actually no longer be present on WPNP. This is the most difficult group to document with certainty -- how can one be certain that a species is completely gone from a site? Especially if suitable habitat remains.

The vascular flora of White Pines Nature Preserve contains 129 families, 264 genera, and 617 species. By comparison, the much larger Raven Rock State Park (4810 ac/1924 ha) in nearby Harnett County supports 723 species (NC State Parks 2024). Weymouth Woods State Nature Preserve in nearby Moore County, three times larger at 363 ha and entirely in the Coastal Plain, supports 626 species (Sorrie et al. 2006).

Table 2 displays the 11 largest families, according to number of species (native and alien species combined). In well-inventoried sites throughout the Southeastern United States, the top four families are the Poaceae, Asteraceae, Cyperaceae, and Fabaceae, although not necessarily in that order (Sorrie, unpublished data). The high number of grasses may at first seem unusual for a mostly forested environment, but WPNP harbors many alien and native grass species in the narrow powerline and the parking lots. Native grasses were mostly found in mesic forests, floodplain forests, forest openings, and on rocky ledges.

Table 2

Poaceae	80 species	Apiaceae	16
Asteraceae	60	Lamiaceae	16
Cyperaceae	39	Fagaceae	15
Fabaceae	23	Rosaceae	15
Ericaceae	19	Ranunculaceae	14
		Rubiaceae	14

Table 3 displays the largest genera, according to number of species (native and alien species combined). In well-inventoried sites throughout the Southeastern United States, the genus *Carex* typically ranks first (Sorrie, unpublished data). Note that the genus *Quercus*, the oaks, ranks second and *Galium* fourth; testament to the relatively high diversity of forest communities and soil types within the preserve. *Juncus*, the rushes, normally ranks higher in Southeastern floras, but WPNP supports few permanent wetlands that rushes favor.

Table 3

Carex	29	Viola	9
Quercus	14	Galium	8
Dichanthelium	11	Hypericum	6
		Juncus	6

RARE SPECIES

White Pines Nature Preserve supports four state or globally rare vascular plant species. Table 4 lists them and their ranks and current status. None are federally listed. Three species are given a state rank of S3 and a global rank of G3, indicating that North Carolina harbors the majority of the occurrences of *Fothergilla major*, *Monotropsis odorata*, and *Phacelia covillei*.

Tridens chapmanii is rarer in North Carolina than the other three species (fewer documented populations) and is ranked S1S2 but was not verified during the 2024-25 survey. It was apparently collected by Swab in the 1980s, but specimens of this species at NC State herbarium have not been uploaded to SERNEC for viewing. In NC, Chapman's Redtop occurs in the Coastal Plain and adjacent lower Piedmont.

Fothergilla major was discovered and collected by Ed Swab on 4-25-1988 on the north slope just below the Newton farmhouse. This remains the sole specimen record of this species at WPNP, though there is a sight record from 2012. On 10-17-2024 a healthy population was vouchered from lower ledges on Camp land, adjacent to WPNP. Thus, it is highly likely that Large Witch-alder is extant on WPNP. In NC, Large Witch-alder occurs in the Piedmont and low Mountains from Harnett and Wake counties westward.

Monotropsis odorata was discovered and photographed in ordinary woods along the entrance road just west of the main parking lot by Jimmy Randolph in 2024. The population is small and may not be viable in the future. However, there is suitable habitat elsewhere on the preserve, such that additional populations are to be expected. In NC, Sweet Pinesap occurs in the Piedmont and Mountains from Wake and Person counties westward.

Phacelia covillei is another recent discovery at WPNP, first detected in 2020 on ledges near Rocky River. In 2024 the population numbered in the thousands and specimens were taken. This population is very healthy and will be viable in the future. In NC, Coville's Phacelia occurs in a narrow band from Caswell and Vance counties south to Moore and Cumberland counties.

Table 4

Species	NC status	NC rank	Global rank	Current?
<i>Fothergilla major</i>	SR-T	S3	G3	Yes
<i>Monotropsis odorata</i>	SR-O	S3	G3	Yes
<i>Phacelia covillei</i>	SR-T	S3	G3	Yes
<i>Tridens chapmanii</i>	SC-V	S1S2	G3	No

A fifth rare species, the federally endangered *Harperella nodosa* (Harperella, state endangered, S1, G2), is known from a gravel bar in Deep River a very short distance downstream from Rocky River. The population may or may not be extant and is highly dependent on specific water levels for effective growth and reproduction. Alas, I made no attempt to survey it in 2024.

In addition to the four species listed as Significantly Rare by the Natural Heritage Program, there are four that they treat as Watch List Species. This category includes plants that were formerly on the NC Rare list, but which have been found to be too numerous to warrant continued listing (W-RS). It also includes plants that have a questionable taxonomic status and that require more study (W-QT). Finally, it also includes plants whose distribution and rarity status in NC are poorly known (W-PK).

Corallorhiza odontorhiza (Autumn Coralroot) is a W1 species whose populations are typically small and hard to detect in leaf litter, due to the brownish color and small size of the plant. It inhabits mesic to dryish forests and woodlands, In NC, Autumn Coralroot occurs scattered throughout the Mountains and Piedmont, rare in the Coastal Plain.

Dirca palustris (Leatherwood) is a W1 species that also occurs in small numbers. Its inconspicuous flowers open in the spring, but throughout the year it may be identified by its pliable twigs that do not split when bent sharply. It inhabits rich mesic hardwood forests at the base of steep slopes and/or at upper margins of floodplains. In NC, it occurs scattered throughout the Mountains and Piedmont, eastward to Person, Wake, and Moore counties.

Magnolia acuminata* var. *subcordata (Piedmont Cucumber Magnolia) is a W7 species about which little is known. Populations tend to be small and far apart from each other, even in the southeastern corner of the Piedmont where it is known from six adjacent counties. It differs from normal Cucumber Magnolia (var. *acuminata*) in its pubescent twigs of the year (vs. glabrous) and yellow petals (vs. greenish or yellow-green). At WPNP it is known from only two adult trees plus several seedlings.

Scutellaria ovata* ssp. *bracteata (Bracted Heartleaf Skullcap) is a W7 plant that is known from a single but large population near the mouth of the northwestern ravine of the Schoolkids Trail. It was first discovered and photographed by Julie Tuttle in 2020; additional photos and specimens by Becky Dill and me in 2024. It inhabits rich mesic hardwood forests, often on lower slopes. In NC, it occurs scattered in the lower Piedmont from Union, Randolph, and Caswell counties eastward to Martin County.

ALIEN INVASIVES

With some 82 alien (non-native) species recorded for WPNP, there are bound to be some which are problematic; that is, aggressive species which outcompete native species. In doing so, they reduce the population size of native species, while also restricting habitat space available and usurping nutrients. Here I discuss several species which require management right now, as well as a few which are likely to require management in the near future.

It has been estimated that more than 5,000 non-native species have been introduced into the U.S., deliberately or otherwise, and that they cause \$137 billion annually to control or manage (Pimental et al. 2000).

Elaeagnus umbellata (Autumn Olive). As of 2024, this shrub is far and away the most widespread and troublesome plant on WPNP and can be rightly be termed an invasive alien. It occurs as individuals or small groups nearly throughout the preserve, save for the steep, north-facing rocky slopes. It is seldom out of sight on slopes and hilltops, in a variety of forest types.

Bright red berries are attractive to birds, which spread seeds widely as they move about. Gould (2023) gives Autumn Olive a rank of 1 for NC, indicating the highest invasiveness potential. ***Ligustrum sinense*** (Chinese Privet). Also ranked 1 for NC by Gould (2023), this shrub now occupies thousands of acres of floodplain forests in NC to the near exclusion of native shrubs and herbs (LeGrand, Sorrie, and Howard 2024). At WPNP the infestation is not yet severe, as floodplain forests bordering the Deep and Rocky rivers are mostly open in the shrub layer. Plants vary from short (less than 3 feet) to tall (exceeding 7 feet). Birds spread seeds from the dull blue berries. Now would be a good time to initiate control measures, before the infestation becomes dire.

Youngia japonica (Asiatic Hawksbeard). This species has rapidly expanded its distribution on WPNP, following the first report in 2017. It now occurs along several trails, most notably lower portion of Deep Bluffs Trail. Its lightweight seeds are attached to fluffy hairs, which allow seeds to "parachute" long distances, even in light breezes. Although first collected in NC in 1958, Asiatic Hawksbeard spread slowly until the 1990s when it moved explosively across the state. Gould (2023) gives it an invasiveness rank of 1. Management may be difficult, due to continual influx of seeds from elsewhere.

Microstegium vimineum (Japanese Stiltgrass). Just about everyone who spends time outdoors knows this highly invasive grass, especially on brownwater river floodplains where it can cover the ground to the near exclusion of native species. No surprise, its invasiveness rank is 1. At WPNP, it also occurs as a patch dominant at former homesites (e.g., Newton place), mesic to moist disturbed areas near trails, in the powerline, and even covers more than an acre on mesic uplands southwest of Shiner's Way Trail. Frey & Schmit (2015) reported successful suppression of *Microstegium* in MD with the herbicide Sethoxydim.

Ailanthus altissima (Tree-of-Heaven). This alien has slowly expanded its distribution in NC, following escape from cultivation in the 1940s; now it occurs in 58 Mountain and Piedmont counties but is rare in the Coastal Plain. Gould (2023) assigned it an invasiveness rank of 1, due in part to its ability to invade natural forests. At WPNP, I found only a handful of saplings on Shiner's Way Trail in 2024, but I expect this aggressive species to become more widespread. Now is an excellent time to eradicate it while numbers are very low.

Paulownia tomentosa (Princess Tree, Empress Tree). Much the same story as *Ailanthus*: currently known from a handful of trees on the preserve. Ranked 1. Now is an excellent time to eradicate it while numbers are very low.

Pyrus calleryana (Bradford Pear). With its abundant white flowers, this tree has for decades been a popular yard ornament in NC. However, only in the past 20-30 years has it escaped cultivation and spread to disturbed and semi-natural habitats, where it has earned an invasiveness rank of 1. This tree has yet to be recorded from WPNP, but it will happen soon, and folks should uproot any they find before there is an infestation.

NATIVE SPECIES NOT LIKELY TO PERSIST

As Table 1 indicates, 170 species or 28% of the total flora of 617 species has not been recorded during the current inventory of White Pines Nature Preserve. That is a large percentage. The reasons why 28% of the native flora has apparently been "lost" are complex; several are given in the text below Table 1. Moreover, this percentage increases to 36% if we compare the 170 "lost" species to the 478 originally documented by Swab in 1990. Note that I place the word "lost" in quotes. It is my considered biological opinion that the actual percentage of species that no longer

occur is much lower. Plants, once they germinate, grow, and reproduce in a favorable environment tend to remain there for their entire life span and that of their offspring. Population numbers may wax and wane over time, but the population itself persists. Only severe drought, flood events, or other natural phenomena may cause a local population to become extirpated. And of course, human activities may also cause extirpations, but at conservation lands such as WPNP, such adverse human actions are minimal. Even then, however, seeds remain in the soil and may be viable for decades, if not longer. Thus, our belief that most of the "lost" species at WPNP still occur there--we simply have not yet found them.

Despite the above argument, however, there are several reasons why some kinds of plants documented by Swab (1990) are not likely to persist. I will enumerate them below and provide examples.

1. Waifs. These are plants that, although native, prefer disturbed habitats such as roadsides, forest openings (natural treefalls, logging events), powerlines, etc. Their seeds have the ability to travel large distances via air currents, attached to tire treads, etc.

Sabatia angularis (Common Rose-pink) - collected once in 1988 in grassy driveway leading to the Camp cottage.

2. Annual plants. These are species that depend on production of viable seeds each growing season in order for the population to persist to the next year.

Senega (Polygala) incarnata (Pink Milkwort) - side of entrance road; *Samolus parviflorus* (Seaside Brookweed, Water Pimpernel) - single collection in 1988 from streamhead seepage at head of a ravine.

3. Forest maturation. Since becoming a nature preserve, the forest at WPNP has become taller and with a denser canopy. Logging/tree removal only occurs after hurricanes and where downed trees cross trails. The slow maturation of the forest has reduced light available to the ground and shrub layers, and roadsides have all become +/- shaded.

Myriopteris lanosa (Hairy Lipfern) - may not persist due to shading of ledges; *Silene virginica* (Fire Pink) - shading of ledges; *Asclepias amplexicaulis* (Wavy-leaved Milkweed) - collected once near "Newton's shed"; *Lobelia spicata* (Palespike Lobelia) - woods edges; *Lyonia mariana* (Staggerbush) - roadside; *Tephrosia virginiana* (Goat's-rue) - roadside.

4. Dynamic river shores. The Deep and Rocky rivers overflow their banks on a +/- annual basis; sometimes more than annual in cases of high rainfall events that are a result of global warming. Severe flooding events can cause small populations of plants to disappear. Droughts produce the opposite, when water shrinks to a trickle and exposes broad sandy margins where seeds can germinate. Such plants tend to be naturally weedy and take advantage of short windows of favorable habitat.

Physostegia virginiana (Obedient-plant); *Penthorum sedoides* (Ditch Stonecrop).

5. Dynamic pond margins. Similarly, the margins of the two small ponds at WPNP yield changing plant cover, depending on water levels. Excessively long inundations or droughts may cause plant populations to become extirpated.

Eragrostis refracta (Coastal Lovegrass); *Agalinis purpurea* (Purple False-foxglove).

6. Deer browse. It is well documented that White-tailed Deer browse orchids, lilies, trilliums, and other monocots in addition to shrub and tree twigs.

Trillium catesbyi (Catesby's Trillium); *Lilium caroliniana* (Carolina Lily); *Galearis spectabilis* (Showy Orchis).

Plant Communities

This section provides basic information about some of the most important communities of plants. The majority treated here are natural assemblages of plants; two are human created. These communities are important because they harbor high numbers of species or because they harbor rare or unusual species. Other plant communities that occur at WPNP are not treated here. There has not been a published account of the plant communities of WPNP, and the following is intended only to be a beginning.

Each community description begins with a short paragraph, followed by lists of plants in the canopy, shrub layer, and herb layer. Plants are listed alphabetically and do not represent a dominance sequence; however, all species are prominent visually in the field.

Floodplain Forest of Deep River. The elongate floodplain forest fronting the Deep River may be the largest natural community at WPNP. It is mature, or nearly mature, with tall trees exceeding 100 feet in height and some exceeding 3 feet dbh. The understory and shrub layer is mostly open, the herb layer dominated by graminoids. There are several seasonally inundated channels or depressions.

Canopy Layer: *Acer floridanum*, *Carya cordiformis*, *Celtis laevigata*, *Fraxinus pennsylvanica*, *Juglans nigra*, *Pinus taeda*, *Platanus occidentalis*, *Quercus michauxii*, *Ulmus americana*.

Vines: *Campsis radicans* - one of them is 8" dbh; *Vitis baileyana*.

Shrub Layer: *Arundinaria gigantea*, *Asimina triloba*, *Ligustrum sinense*, *Lindera benzoin*, *Symphoricarpos orbiculatus*.

Herb Layer: *Carex amphibola*, *C. debilis*, *C. grayi*, *C. intumescens*, *C. squarrosa*, *C. tribuloides*, *Chasmanthium latifolium*, *Claytonia virginica*, *Galium obtusum* var. *filifolium*, *Microstegium vimineum*, *Viola eriocarpa*, *V. sororia*, *Zephyranthes atamasco*.

Floodplain Forest of Rocky River. Two semi-circular, flat areas face the Rocky River at bases of steep slopes. Canopy trees are not as large as those of the Deep River forest, and there are no seasonally inundated pools or depressions.

Canopy Layer: *Acer negundo*, *Celtis laevigata*, *Juglans nigra*

Shrub Layer: *Asimina triloba*, *Lindera benzoin*, *Sambucus canadensis*, *Smallanthus uvedalia*.

Herb Layer: *Arisaema triphyllum* (2 varieties), *Asarum reflexum*, *Carex amphibola*, *C. rosea*, *Chasmanthium latifolium*, *Cinna arundinacea*, *Circaea canadensis*, *Corydalis flavula*, *Elymus macgregorii*, *Glechoma hederacea*, *Microstegium vimineum*, *Nemophila*

aphylla, *Osmorhiza longistylis*, *Saururus cernuus*, *Scutellaria ovata* var. *bracteata*, *Stellaria media*, *Symphyotrichum lateriflorum*.

Mountain Laurel Ledges. The northern edge of White Pines Preserve, facing Rocky River and extending onto Camp land, consists of very steep rocky slopes and ledges about 160 feet high. This rugged topography supports two state-rare plant species (*Fothergilla major*, *Phacelia covillei*) as well as a number of plants not found elsewhere on WPNP.

Canopy Layer: *Acer rubrum*, *Oxydendrum arboreum*, *Pinus strobus*, *P. taeda*, *Quercus alba*, *Q. montana*

Shrub Layer: *Fothergilla major* (local), *Hamamelis virginiana*, *Kalmia latifolia*, *Rhododendron catawbiense*, *Styrax grandifolius*, *Viburnum acerifolium*.

Herb Layer: *Dryopteris marginalis*, *Hepatica americana*, *Phacelia covillei* (local dominant), *Nemophila aphylla*, *Solidago arguta* var. *arguta*, *Waldsteinia doniana*.

Artificial Ponds. Two small human-dug ponds occur in what formerly was a moist to wet streamhead. One is adjacent to the western portion of Schoolkids Trail; the other lies 20 feet lower downslope.

Canopy Layer on shores: *Salix nigra* - scattered.

Shrub Layer on shores: *Ludwigia decurrens* - local, *Rosa multiflora* - local.

Herb Layer on shores: *Boehmeria cylindrica*, *Carex lurida*, *Cinna arundinacea*, *Diodia virginiana*, *Hypericum mutilum*, *Juncus acuminatus*, *J. effusus*, *Leersia oryzoides*, *Ludwigia palustris*, *Lycopus virginicus*, *Persicaria punctata*, *Pluchea camphorata*.

Open Water: Lemnaceae species.

Powerline. A one-pole powerline runs from the junction of the entrance road and the short road to the Shiner's Way Trailhead parking lot, eastward across the White Pines Trail parking lot, downslope, then northward, passing by the lower pond, then on up to the crest of the slope and crosses Rocky Bluff Trail. This powerline traverses several slopes and hollows, thus providing variable soil moisture regimes. The open-to-sun aspect (no canopy trees) supports many non-native plants, as well as native species that prefer openings or disturbances. Due to the forested nature of WPNP, the powerline harbors many species not found elsewhere and has been a source of many species new to the preserve.

Shrub Layer: *Diospyros virginiana*, *Elaeagnus umbellata*, *Erianthus coarctatus*, *Verbesina alternifolia*, *V. occidentalis*

Herb Layer: *Andropogon virginicus*, *Danthonia sericea*, *Danthonia spicata*, *Dichanthelium commutatum*, *D. laxiflorum*, *D. scoparium*, *Erigeron strigosus*, *Eupatorium hyssopifolium*, *Euphorbia corollata*, *Hypericum lloydii*, *Lespedeza cuneata*, *L. procumbens*, *Microstegium vimineum*, *Oenothera fruticosa*, *Oxalis stricta*, *Penstemon laevigatus*, *Plantago rugelii*, *Rhexia mariana*, *Scirpus georgianus*, *Scleria oligantha*, *Scutellaria integrifolia*, *Solanum carolinense*, *Thyrsanthella difformis*, *Tragia urticifolia*, *Tridens flavus*.

Mesic Slopes and Ravines. Between the numerous drier ridges at WPNP there are mesic to moist slopes and ravines. During rainfall events these act as conduits to drain runoff water down to the lowlands and, ultimately, to the Rocky and Deep Rivers. On WPNP, all are intermittent creeks; none are permanent. A few of Swab's specimen labels note the presence of seepages within ravines, but I did not encounter any in the 2024 inventory.

Due to the downward movement of water into and through these troughs, soils have collected higher levels of minerals and nutrients than surrounding hilltops and ridges. This accumulation process is very slow, on the timescale of millennia. But the results are obvious to botanists and ecologists: in every layer of the forest there are species which do not (or seldom) occur in the upland communities, and vice versa. They are among the most species-rich communities on the preserve, notably the herb layer.

Canopy Layer: *Acer floridanum*, *Carya ovata*, *C. tomentosa*, *Fagus grandifolia*, *Fraxinus americana*, *Liriodendron tulipifera*, *Pinus strobus*, *Quercus alba*, *Q. rubra*,

Shrub Layer: *Aesculus sylvatica*, *Asimina triloba*, *Elaeagnus umbellata*, *Styrax grandifolius*

Herb Layer: *Anemone lancifolia*, *Arisaema triphyllum*, *Botrypus virginiana*, *Carex cephalophora*, *C. digitalis* var. *macropoda*, *C. kraliana*, *C. planispicata*, *Dichanthelium boscii*, *D. dichotomum*, *Hepatica americana*, *Iris cristata*, *Maianthemum racemosum*, *Nabalus altissimus*, *Nemophila aphylla*, *Osmorhiza longistylis*, *Phegopteris hexagonoptera*, *Podophyllum peltatum*, *Polystichum acrostichoides*, *Ranunculus abortivus*, *Sanguinaria canadensis*, *Solidago caesia*, *Stellaria pubera*, *Thalictrum thalictroides*, *Tiarella cordifolia*, *Tipularia discolor*, *Viola palmata*, *Zephyranthes atamasco*.

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BRYOPHYTES

Blanka Aguero & Jame Amoroso

BIOLOGY AND CHARACTERISTICS

Bryophytes are a group of land plants that reproduce by spores. The bryophyte life cycle is characterized by alternation of generations; its haploid stage is the dominant stage (green photosynthesizing gametophytes, consisting of leafy or thallose stems producing gametes), whereas its diploid stage develops after fertilization, forming a sporophyte, consisting of seta and capsule, that is attached to, and dependent on, the gametophyte. Bryophytes are non-vascular plants, which means that they do not form xylem and phloem in vascular bundles. They also do not form lignin, and that limits their body size. They lack an active mechanism of keeping water in their bodies, and that limits their growing environment. Bryophytes don't have roots. Each bryophyte cell is capable of regenerating into a new plant in favorable conditions, and vegetative reproduction by gametophyte fragmentation and/or by forming asexual propagules is frequent.

Bryophytes include members of three plant divisions: Bryophyta (mosses), Marchantiophyta (liverworts), and Anthocerotophyta (hornworts). All three groups were surveyed. They consist of some 20,000 species worldwide, around 2,000 species in North America, and about 700 taxa in North Carolina.

Species names follow the nomenclature used at <https://www.bryonames.org/>, a resource using the Tropicos database to provide a comprehensive list of accepted bryophyte names (Brinda & Atwood 2025).

SURVEY EFFORTS

The broad vicinity of Durham, NC, has been well surveyed in the past because of the proximity to Duke University, where bryology has thrived since 1930s. NSF-sponsored efforts to digitize natural history collections during the past decade resulted in the creation of the Consortium of Bryophyte Herbaria (CBH), and CBH website (www.bryophyteportal.org).

To start this survey, the CBH website was searched for records from White Pines Preserve and 149 moss specimens collected by Robert Meyer on twelve visits in spring and Fall of 1976 were found. These collections formed the initial checklist. Other records were from the general area but were not considered due to insufficient locality information ("6 mi S of Pittsboro"). An initial survey was conducted on 4/22/2024 but observations were not georeferenced. Bryophytes were surveyed during five days between 3/14 – 4/27/2025. Surveys were conducted in early springtime before tree canopy leaf-out to capture species with an ephemeral life strategy. Also moss populations that are not covered by vascular vegetation are easier to discover. Surveys focused on areas around River Trail (3/14), Gilbert Yager Trail and the ravine to the north of the Gilbert Yager (3/21), School Kids Trail and floodplains of both rivers (3/26), upper part of Shiner's Way trail, River Trail and floodplains (4/16), and lower part of Shiner's Way trail and large outcrop on Rocky River (4/27). Collection locations are depicted in Figure 1.

Sampling involved searching for species growing on all available substrates (soil, rocks, bark of living trees, as well as rotting wood in a variety of moisture and light exposure conditions). Species which were identifiable by using a hand-held 20x magnifying lens without microscopic examination were noted on recording cards in the field. However, most bryophyte species require dissection of plants, and observation of gametophytic and/or sporophytic character under 10-400x magnification of a compound light microscope. For this purpose, small collections were made in brown paper bags, air dried, and stored for further examination. Plant identifications using microscopes were conducted in Duke University Herbarium, where vouchers for this study are stored.

All sampling was done by Blanka Aguero and Jame Amoroso.

SUMMARY OF THE BRYOPHYTE SPECIES RECORDED DURING THE PROJECT

In total, 121 species of Bryophytes were identified during the survey: one hornwort, 36 liverworts, and 84 mosses (see Appendix B). Sixty-two moss species were reported by Robert Meyer 49 years ago. Twenty-one additional species are presented here. Five species reported from the 1976 survey were not relocated in 2025.

Seven species found during the 2025 survey with a NCNHP status are listed in Table 1. Distribution of all these species is poorly known.

Taxon name	Specimens	Observations	State status	State rank	Global rank
<i>Fissidens fontanus</i>	1	0	W-PK	S2?	G5
<i>Helodium paludosum</i>	1	0	W-PK	S2?	G3G5
<i>Hygroamblystegium humile</i>	2	0	W-PK	S2?	G5T5
<i>Monocryphaea ravenelii</i>	6	0	W-PK	S2?	G3?
<i>Pelekium pygmaeum</i>	3	0	SR-O	S1?	G4G5
<i>Sciuro-hypnum plumosum</i>	4	1	W-PK	S2?	G5
<i>Weissia muhlenbergiana</i>	2	0	W-PK	S2?	G5

Table 1: List of taxa with a NC state status according to Walker, Amoroso & East 2024.

Conservation Rank codes follow NatureServe methodology: S for subnational units, such as state boundaries, G for Global distribution. The lower the number, the rarer the taxon is with a status of 1 designating critical imperilment, 2 is imperiled, 3-vulnerable, 4 - apparently secure, 5 – Secure. NC Natural Heritage Program status definitions for SR-O and W-PK:

Significantly Rare-Other (SR-O) - the range of the species is sporadic or cannot be described by the other Significantly Rare categories.

W-PK is a NCNHP conservation status category for taxa with inadequate information about their distribution and rarity in NC (Walker, Amoroso & East 2024).

Fissidens fontanus is a genus of aquatic plants growing on rocks and roots submerged in slow to fast moving rivers and streams. It grows submerged in clear to weakly polluted running water in rivers, and its presence has been used as an indication of water quality and pollution levels.

Helodium paludosum is a species of wooded swamps, marshes, and wet meadows. One small colony was discovered on the disturbed edge of hardwood forest below the old homestead, in a seep. This species was also recently collected in Duke Forest on wet ground under power lines, and in Chatham Co. by a pond on grounds of Shakori Hills farm. It was not detected in the New Hope Creek survey in 2023 where it was expected.

Hygroamblystegium humile (syn. *Amblystegium kochii*, *A. trichopodium*) is also a species of swamps. The species is not well understood in North America, and consequently undercollected. It is probably not uncommon in suitable habitats, but those are rarely surveyed. Both sites at the preserve are man-made habitats (on moist soil among gravel of parking lot, where water collects, and on muck on bank of pond and over wood in pond along yellow trail). It was collected at Crowders Mountain SP last spring, and in a small periodically flooded hardwood swamp in rural Bertie Co. in 2018. It's likely not an endangered species.

Monocryphaea ravenelii is perhaps the most exciting discovery at the preserve. It was collected in White Pines preserve three times by Meyer in 1976, and his specimens were revised by the world-wide monographer of the family. It is nearly identical to a common species, *Cryphaea glomerata*. *Monocryphaea* wasn't collected during the first three visits. It prompted a thorough herbarium study of existing material, and a dedicated search just for this moss. Luckily, after 5 hours of examining every *Cryphaea* encountered, the species was located on Florida Maple in the white pine area along blue trail below its junction with White Pines (red) trail. It was found to be more common in the floodplain on young Florida Maples, always in shade under dense canopy. The species was also discovered in the Korstian division of Duke Forest in June, on *Carpinus*, in the floodplain of New Hope Creek. There are only 36 known specimens of this moss which is endemic to the Southeastern US (bryophyte portal records, GBIF). These are first known collections in NC since Meyer 1976. The newest US record was collected in Texas in 1992 (GBIF).

Pelekiium pygmaeum is a very small moss that is easily overlooked. It is scattered in the mountains of NC (B. Smucker, pers. comm.). In White Pines, it was collected on small stone on steep slope above stream at the lower end of ravine E of blue trail leading to canoe launch. It was recently collected in the piedmont area of South Carolina (Kings Mountain SP, in 2024) in similar microhabitat (on stone in small ravine with permanent stream surrounded by hardwood forest).

Sciuro-hypnum plumosum grows on stones and rocks in streams. It is likely under-collected in our area. It was found in two ravines (stream E of blue trail leading to canoe launch, and at the end of Shinner's Path).

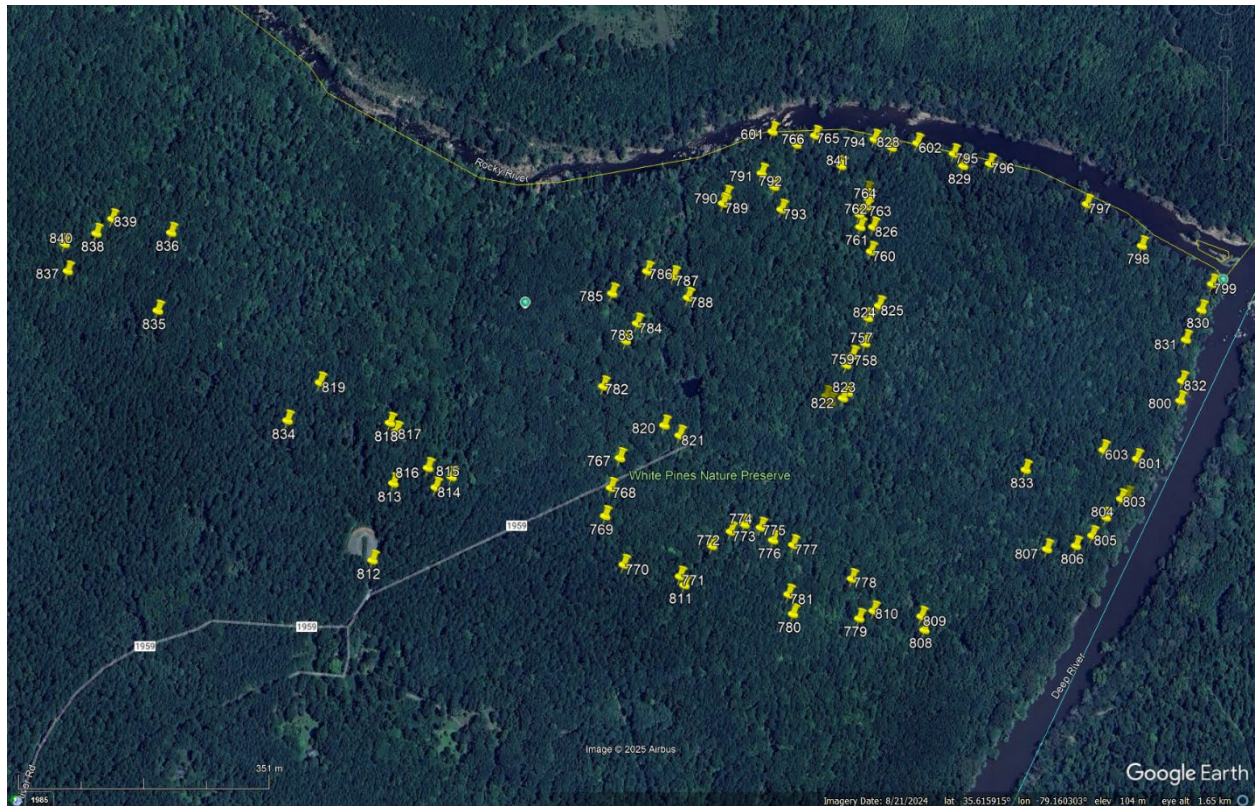
Weissia muhlenbergiana is a moss growing on soil in lawns, meadows, pastures, and among grass on roadsides. It is small, with immersed capsules that are hidden among leaves and discovered only in dissecting scope under close examination. For this reason, it is frequently overlooked. It grew hidden among other mosses on stone along the yellow trail in the disturbed seepy area under the old homestead, and among gravel of the Shiner's Way Trail parking lot.

One additional moss is worth highlighting, *Platylomela lescurii*. It was collected in three ravines. It is abundant at the end of Shiner's Way Trail and in the ravine E of blue trail leading to the

canoe launch, but only a small patch was found in the ravine to the N of the Gilbert Yager trail, at confluence of streams near broken manmade structure. This moss is found in streams and on dripping rocks in the mountains, and only rarely in the piedmont. Its presence is comparable to presence of *Pinus strobus* in the preserve.

Five species were not located after the 1976 survey. Four of them were likely overlooked in the field. *Enthostodon serratus* (syn. *Funaria serrata*) is a Southeastern moss also known from Mexico and east Asia, growing on soil in disturbed places, often near streams or ditches (Crum and Anderson 1981). It is state-listed in W-PK category as SH.

Figure 1. Map of bryophyte collection sites in the White Pines Preserve.



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Monocryphaea ravenelii from site 823.



Platylomela lescurii from site 838.



Detail of *Platylomela lescurii* from site 838.



Pelekium pygmeum from site 761 (width of the image is 2.1cm).



Thelia hirtella from site 770.



Phaeoceros carolinianus (hornwort) from site 785.



Atrichum angustatum, male plants forming splash cups, from site 820. This is the most common moss species in the preserve.



LICHENS (LICHENIZED FUNGI)

Gary Perlmutter and Jason Hollinger

BIOLOGY AND CHARACTERISTICS

Lichens are symbiotic organisms composed of a fungus (mycobiont), an alga or cyanobacterium (photobiont) plus other organisms including bacterial communities and other fungi. Based on this symbiosis with the mycobiont forming the structure (thallus) of the lichen, lichens follow the classification of the mycobiont and thus are considered lichenized fungi. Lichens grow on any stable substrate and come in a variety of growth forms with the three primary ones being crustose (crust-like), foliose (leaf-like) and fruticose (bushy or otherwise three-dimensional).

Often included in lichen surveys are lichenicolous and allied fungi. Lichenicolous fungi are those fungal parasites and commensals that grow on lichen thalli and thus are collected with lichens. Allied fungi are nonlichenized fungi that are often confused with lichens and collected in lichen surveys; many are in families with lichens and represent species that have lost the lichenized lifestyle within a given family or genus.

Ecologically, lichens function as primary producers, wherein the photobiont produces carbohydrates through photosynthesis, some of which are transferred to the mycobiont to build the lichen thallus structure. Lichens grow throughout the forest habitat, from the floor up to the canopy on any stable environmental surface, including soil, rock, wood of logs and stumps, bark of exposed roots, trunks, branches and twigs, pinecones, and evergreen leaves.

The few allied and lichenicolous fungi recorded in TLC's White Pines Nature Preserve (hereafter WHPI) receive their nutrition from airborne detritus (*Lichenothelia* sp.) or the host substrate, whether that is a tree as a saprobe (e.g., *Arthonia* *quintaria*) or a lichen as a lichenicolous fungus (e.g., *Sclerococcum inquilinum*) (Fig. 1).

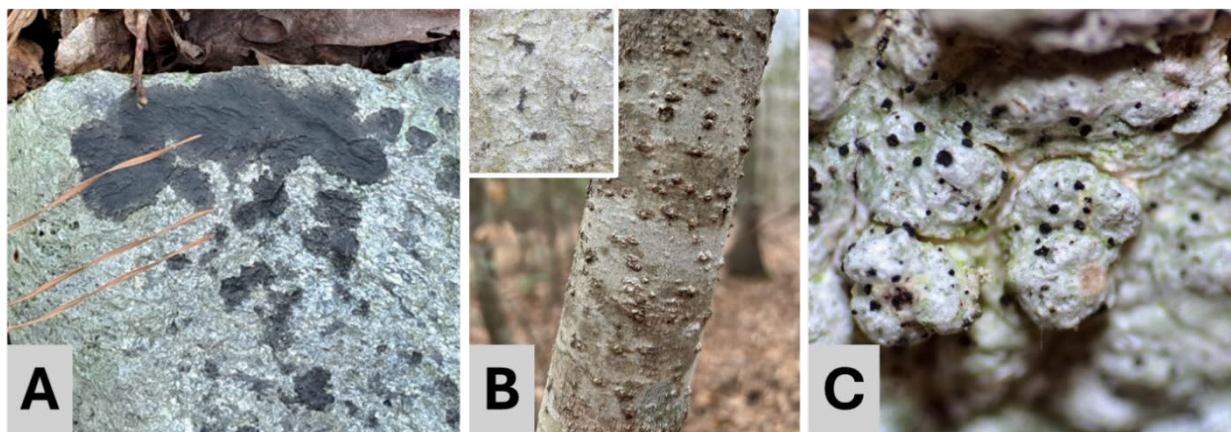


FIGURE 6. EXAMPLE ALLIED AND LICHENICOLOUS FUNGI FOUND IN WHITE PINES NATURE PRESERVE. A. *LICHENOTHELIA* SP. (ROCK-INHABITING ALLIED FUNGUS). B. *ARTHONIA* SP. (SAPROPHYTIC ALLIED FUNGUS); INSET SHOWS CLOSEUP OF THALLUS WITH ELONGATED FRUITING BODIES. C. *SCLEROCOCCUM INQUILINUM* (LICHENICOLOUS FUNGUS ON A WART LICHEN, *PERTUSARIA*).

SURVEY EFFORT

Six forays to observe and collect lichens were made during this one-year survey, from April 2024 through March 2025, covering all trails of the preserve (Fig. 2). A total of 30 field-hours were tallied and 64 hours were spent on specimen processing and identification work. Collected specimens were deposited in the University of North Carolina – Chapel Hill Herbarium (NCU) and the personal herbarium of Jason Hollinger (hb. Hollinger). Specimen/observation records were entered both in the NCBP website for transfer to the WP project website, as well as the Consortium of Lichen Herbaria (CLH) website (www.lichenportal.org) wherein a companion lichen checklist was developed. Observers participating in one or more of the forays were Gary B. Perlmutter, Jason P. Hollinger, Blanka Arguelo and Meriel Goodwin among other NCBP members whom we joined with in the field.

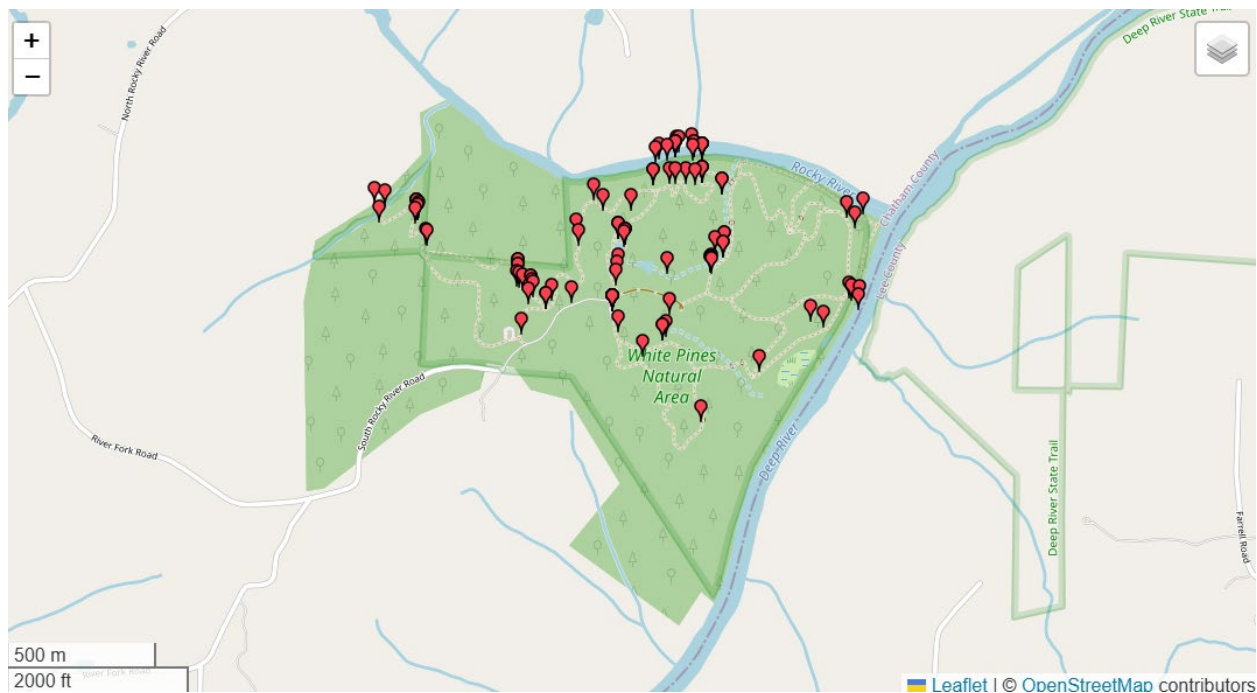


Figure 2. Map of lichen collection sites in the White Pines Nature Preserve.

SUMMARY OF SURVEY RESULTS

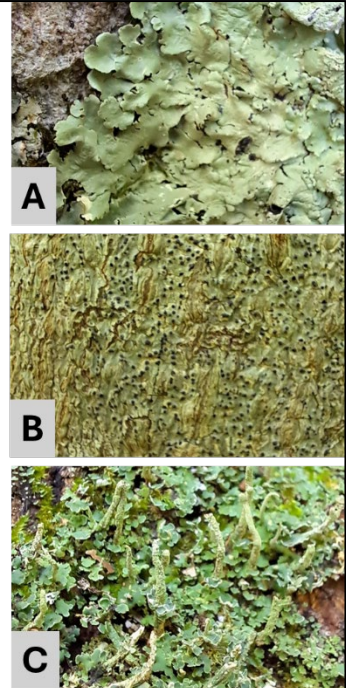
A total of 127 lichen species plus four lichenicolous fungi and four allied fungi from 153 vouchered specimens were documented for WHPI (for the full annotated list see Appendix C). No historical records were found from the preserve area, indicating the current lichen survey is the first of its kind. Among species documented are 67 new Chatham County records, raising the county lichen list to 203 recorded species (Perlmutter et al. 2025).

Forest Lichen Diversity

Much of WHPI is covered in mixed deciduous forest of various subtypes from oak-hickory forests in the uplands, mesic mixed forests along slopes, and bottomland forests on the floodplains bordering the Rocky and Deep rivers, all with scattered conifers including the White Pine (*Pinus strobus*) for which the preserve is named. Most of the WHPI lichen diversity (110 species) are recorded from forest habitats including clearing edges. Lichens were found throughout the forest from the forest floor on rocks, soil, downed logs and tree bases up the stems and trunks of shrubs, woody vines and trees and into the canopy (Box 1). Overall, lichen species were evenly distributed within the forest profile, with 41 taxa (36%) on the floor at 0-0.5 m above ground, 35 taxa (31%) at the mid-bole level at 0.5-2 m above ground and 36 taxa (32%) in the canopy as represented by fallen branches. These totals are exclusively forest lichens with those from the Rocky River removed; river lichens are treated below.

Box 1 Example Forest Lichens

- A. *Flavoparmelia caperata* (Common Greenshield Lichen), found on larger branches of the canopy.
- B. *Pyrenula pseudobufonia* (Eastern Pox Lichen), found on smooth-barked trunks at midbole level.
- C. *Cladonia ochrochlora* (Smooth-footed Powderhorn Lichen), found on logs and tree bases of the forest floor.



Freshwater Lichen Communities: Zonation along the Rocky River

Along the northern border of the White Pines Nature Preserve is the Rocky River, which is so named for the numerous large rocks lining the banks and rising above the water in the channel (Figs. 3, 4). The lichens on these rocks were sampled and their heights above base water level were measured during the June and December 2024 visits to see if discernible vertical zoned communities were present as found in similar rocky river habitats in Chatham and surrounding counties of the Piedmont (Perlmutter & LaGreca 2024). A description of the Rocky River lichens at White Pines is here presented.

A total of 20 lichen taxa were found on rocks of the Rocky River including three taxa of lichenicolous fungi infecting some of these lichens. Lichen taxa were found at rock heights in agreement with the three zoned communities described by Perlmutter & LaGreca (2024), here expressed as cm above the base water level, visited at least 3 days after a rain event. See Boxes 2 and 3 for representative lichen species per river zone community.

Box 2
River Channel Lichens

Riparian Zone (> 100 cm above water)

Lecanora oreinoides

Rinodina moziana

Squamulea subsoluta (A)

Xanthoparmelia conspersa

Xeric Fluvial Zone (30 – 100 cm above water)

Dermatocarpon arenosaxi

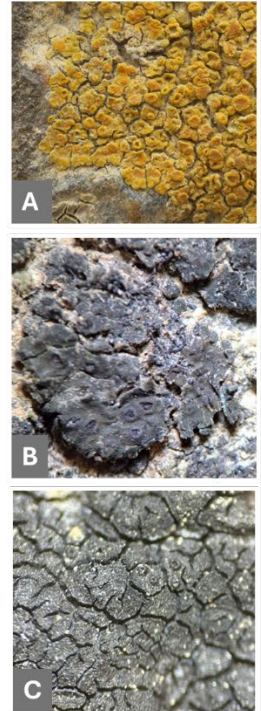
D. luridum

Peltula euploca (B)

Rinodina fimbriata

Mesic Fluvial Zone (0- 30 cm above water)

Collembopsideium angermannicum (C)



Box 3
Riverbank Lichens

Riparian Zone (> 100 cm above water)

Pertusaria plittiana

Phlyctis petraea (A)

Porpidia albocaerulescens

Xeric Fluvial Zone (30 – 100 cm above water)

Collema subflaccidum (B)

Dermatocarpon luridum

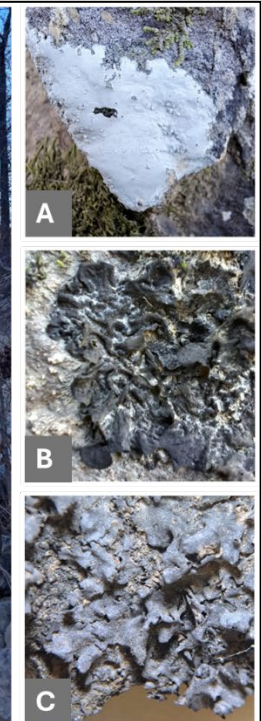
Halecania sp.

Pseudosagedia cestrensis

Mesic Fluvial Zone (0- 30 cm above water)

Bilimbia fuscoviridescens

Leptogium cyanescens (river form) (C)



Noteworthy Lichen Species

The lichen survey in the White Pines Nature Preserve yielded 65 Chatham County records plus some possibly undescribed species. More details on selected noteworthy species are as follows.

Buellia mamillana (Fig. 3A, B) is a crustose lichen found on rocks in the upland oak-hickory forests along the Rocky Ridge Trail. An interesting feature of this lichen is that it produces chemicals that fluoresce in UV light.

***Endococcus* sp.** (3C) this lichenicolous fungus is found growing on the semi-aquatic lichen *Rinodina fimbriata* on channel rocks of the Rocky River, with its fruiting bodies immersed in the fruiting bodies of its host. This species appears to be undescribed.

Flakea papillata (Fig. 4A) is an interesting lichen composed of minute, thin, “flaky” branches and having an unusual, specialized habitat preference. It is primarily found in dark recesses of rocky grottos near water, such as the habitat where we found it in WHPI along Schoolkids Trail by the Rocky River.

***Halecania* sp.** (Fig. 4B) is a crustose river lichen that appears to be closely related to the undescribed *H. rheophila*, which is pending publication. It is currently under study at the University of Kansas Herbarium (KANU) and may represent another undescribed species in the genus.

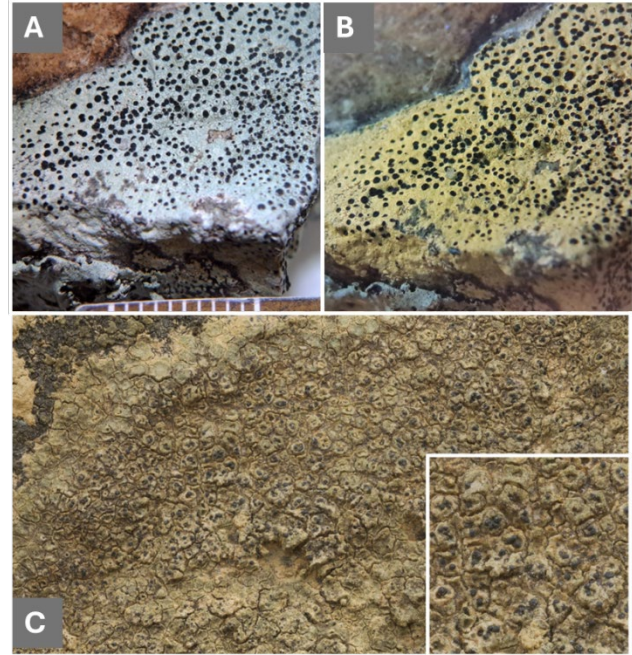


FIGURE 3. NOTEWORTHY SPECIES FROM WHITE PINES NATURE PRESERVE. A, B. *BUELLIA MACULATA* IN NATURAL AND UV LIGHT, RESPECTIVELY. C. RIVER LICHEN *RINODINA FIMBRIATA* INFECTED WITH *ENDOCOCCUS* SP. INSET SHOWS INFECTED APOTHECIA OF THE HOST WITH FOREIGN PERITHECIA OF THE LICHENICOLOUS FUNGUS.

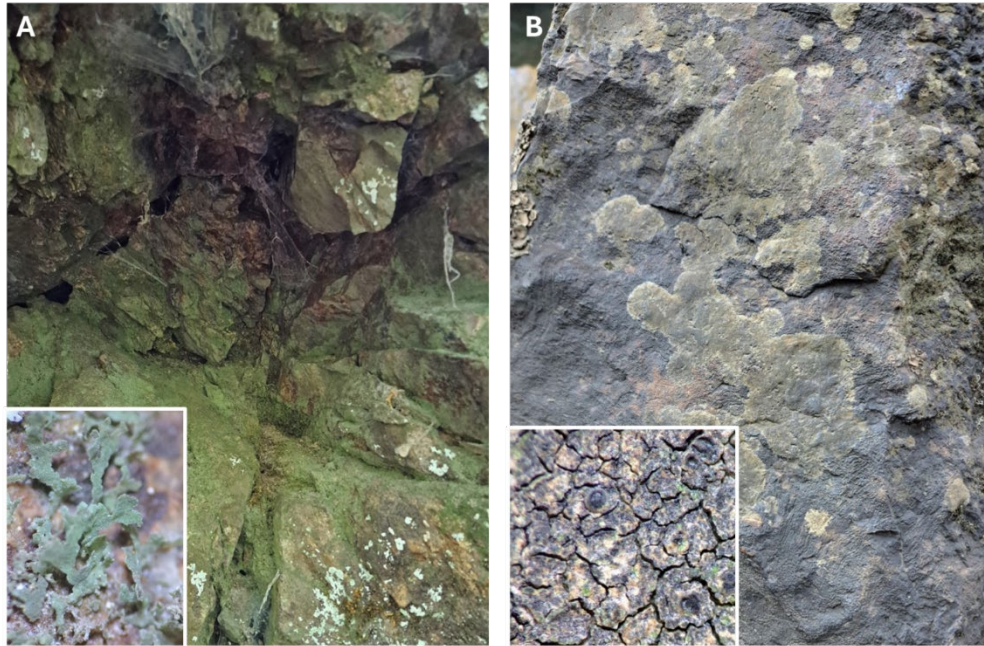


FIGURE 4. NOTEWORTHY SPECIES FROM WHITE PINES NATURE PRESERVE. A. FLAKEA PAPILLATA LINING THE ROCKS OF A SHADED GROTTTO NEAR THE ROCKY RIVER. B. HALECANIA SP. ON EXPOSED ROCKS ALONG THE LOWER BANKS OF THE ROCKY RIVER. INSETS SHOW DETAILS OF THE LICHEN THALLI.

Parmotrema hypoleucinum and *P. hypotropum* (Fig. 5). These two ruffle lichen species are common elements of the canopy. They are morphologically very similar to one another and thus difficult to distinguish in the field, both being pale bluish green, with erect lobes harboring marginal soredia and blotchy white undersides. Specimens were collected during the TLC-led bioblitz at the preserve in August 2025 and taken to NCU for identification and processing. Distinguishing features include a network of white maculae (faint, minute whitish spots) on the lobe tips of *P. hypoleucinum* which are lacking in *P. hypotropum*, and chemistry differences revealed by differing spot test results (K+ yellow in *P. hypoleucinum* and K+ red in *P. hypotropum*). Both species are new to the preserve with *P. hypoleucinum* being a new Chatham County record.

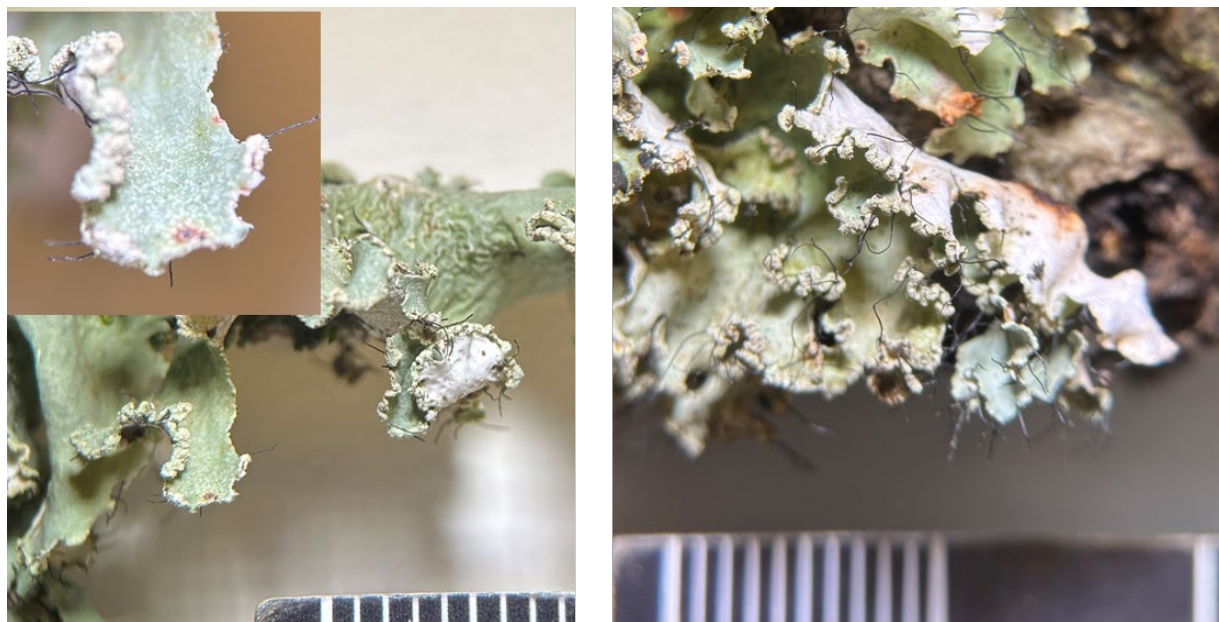


FIGURE 5. THE MORPHOLOGICAL SPECIES PAIR *PARMOTREMA HYPOLEUCINUM* “WHITE BELLY RUFFLE LICHEN” (LEFT) AND *P. HYPOTROPUM* “POWDERED RUFFLE LICHEN” (RIGHT) COLLECTED AT WHITE PINES. THE INSET TO *P. HYPOLEUCINUM* SHOWS THE WHITE MACULAE ON LOBE TIP THAT DISTINGUISHES IT FROM *P. HYPOTROPUM*.

OVERALL QUALITY OF LICHEN BIODIVERSITY; COMPARISON WITH NEW HOPE CREEK SURVEY

The WHPI lichen biota was compared with that of NCBP’s previous biodiversity survey along the New Hope Creek corridor (NEHO) in Durham and Orange counties (Hall et al. 2022). WHPI shared 69 species with NEHO. There was a combined total of 160 species for both areas and a similarity rating of 43%. WHPI has a richer lichen biota, likely due to the higher diversity of habitats including multiple kinds of forest (floodplain, mesic mixed, and upland) and rocky habitats (upland, bluff, grotto and river).

The overall lichen species richness of the White Pines preserve suggests a healthy environment. Found among the typical Piedmont species are a few old-growth indicators and mountain disjuncts as well as both pollution-sensitive and tolerant species.

Sporodophoron americanum is an uncommon crustose lichen that grows primarily in the deep bark furrows of old oaks and therefore is typically strongly associated with old growth forests. It was first described from Great Smoky Mountains National Park by Lendemer et al. (2013, as *Tylophoron americanum*), and has an Appalachian-Ozark distribution with a few scattered occurrences in the Piedmont. In North Carolina, *S. americanum* is known almost exclusively from the southern Appalachians with an additional disjunct population in William B. Umstead State Park in Wake County.

The crustose species *Lepraria cryophila*, *Leprocaulon nicholsiae* and *Lecanora saxigena* are all previously known from North Carolina exclusively in the mountains (Lendemer 2013, Lendemer & Harris 2014, Tripp & Lendemer 2019). *Leparia cryophila* and *Leprocaulon nicholsiae* are both leprose (i.e., dust lichens) that grow in cold, dark, humid rock overhangs, such as those near the river in WHPI, supporting the hypothesis that these protected microhabitats harbor relict populations of mountain and northern species once more common in the Piedmont. *Lecanora saxigena* grows on a wider variety of siliceous rocks in forested habitats. It was only recently separated from the widespread, common, bark-dwelling *Lecanora cinereofusca*, which is also present at WHPI (Lendemer & Harris 2014). Historical collections of *L. cinereofusca* from the Piedmont should be checked for misidentified *L. saxigena* specimens.

In addition to the above old-growth indicator and mountain disjunct species are disturbance or pollution-tolerant lichens that are also found in urban areas and near roadways. Nitrophilous (i.e., preferring environments high in nitrogen pollution) species *Candelaria concolor*, as well as pollution-tolerant species (*Phycia millegrana*, *Pyxine subcinerea*, *Punctelia rudecta*), reported from urban parks in the Raleigh area (Perlmutter 2010), were also found in the preserve, nearly all from fallen branches and twigs, representing the more exposed habitats of the canopy. These species were most prevalent on fallen branches facing the open air of the Rocky River. Forest interior species found to be pollution-tolerant (*Cladonia ravenelii*, *Pseudosagedia cestrensis*) from highway-adjacent transects (Perlmutter et al. 2017) were also found on trunks in the study area. *Cladonia ravenelii* was found on pine trunks along the Ridge Trail near the first parking lot; *P. cestrensis* was found on hardwoods throughout the survey area and in agreement with other surveys, where it was found to be abundant.

The cyanolichen component of WHPI was 11 species or 8% of the total lichen biota, over twice that of NEHO. A contributing factor to the low cyanolichen diversity at NEHO was likely the close proximity to human development, whereas the cyanolichen diversity at WHPI was higher likely due to its relative remoteness, higher diversity of habitats, and the Rocky River where semi-aquatic cyanolichen species were found growing on the river rocks.

CONSERVATION CONCERNS

Conservation concerns for lichens relate to species rarity and population trends. Determined lichenized, lichenicolous and allied species found in WHPI were cross-referenced against IUCN Red List (<https://www.iucnredlist.org/>), NatureServe Explorer (<https://explorer.natureserve.org/>) and the 2024 North Carolina Rare Plant List (Walker & East 2024) for any listed as of conservation concern. The IUCN Red List has one species, Carolina Moon Lichen (*Sticta carolinensis*), listed as Vulnerable (Lendemer 2020). This is a cyanolichen found with *Scytinium lichinoides* on mossy rocky bluffs above the Rocky River; incidentally both species were also found in the New Hope Creek corridor in a similar habitat.

The NatureServe Explorer review found 124 of the 136 species assessed but most of them were not ranked at the global or state level (GNR and SNR, respectively). Most of those that were ranked were either as Secure (G5 or S5) or Apparently Secure (G4 or S4). Two species were ranked Vulnerable globally (G3): *Cladonia ravenelii* and *Phaeographis inusta*; neither of which were assessed at the state level. And three species were found ranked as Vulnerable in North Carolina:

Arthonia quintaria (S3), *Flakea papillata* (S3), and *Sporodophoron americanum* (S3), all of which have the caveat that their distributions may be incomplete. Only one species is on the 2024 North Carolina Rare Plant List: *Sporodophoron americanum*, which is categorized as W-PK, meaning poorly known in North Carolina (Walker & East 2024). Overall, WHPI has a few species that are of potential conservation concern, but more distribution information from surveys is needed.

An alternative way of assessing rarity is by county occurrences through specimen records on the NCBP and CNALH websites. Species county occurrences can be directly expressed as a percentage of North Carolina's 100 counties. We classified species with 10 or fewer counties as rare and 5 or fewer counties (up to 5%) as significantly rare. Using this method, 22 species were found to be rare, including 5 significantly rare species (*Bilimbia fuscoviridis*, *Collemopsidium angermannicum*, *Peltula euploca*, *Rinodina pachysperma*, *Verrucaria hydrella*, see notes below).

Applying this method to the listed Vulnerable species above, we found most to be rather widespread in North Carolina:

- *Arthonia quintaria* (GNR, S3?) is recorded from 30 counties
- *Cladonia ravenelii* (G3, not NC assessed) is recorded from 28 counties
- *Flakea papillata* (G4, S3?) is recorded from 13 counties
- *Phaeographis inusta* (G3, not NC assessed) is recorded from 24 counties
- *Sticta carolinensis* (IUCN Red List Vulnerable; GNR, S4) is recorded from 18 counties
- *Sporodophoron americanum* (GNR, S3S4) is recorded from 7 counties

Following are brief discussions of the five significantly rare species.

- *Bilimbia fuscoviridis* – This is an asexually reproducing, crustose species usually associated with water in eastern North America. It was only recently reported for North America (Curtis et al. 2023). It is likely more common than the sparse number of existing records for North Carolina indicate. At WHPI it was found on riverbank rocks.
- *Collemopsidium angermannicum* – This is a blackish, semi-aquatic crustose species found on river channel rocks in the lower Mesic Fluvial zoned community. It has a seemingly widespread distribution, found in few localities in Europe and North America, and is therefore likely overlooked (Nordin 2002) due to its habitat and nondescript appearance as a black stain.
- *Peltula euploca* – This is a globally widespread, normally sorediate, peltate-squamulose cyanolichen species which appears to be very rare in North Carolina, apparently restricted to exposed river channel rocks in the Piedmont. The species is variable in morphology (Marques et al. 2013) and the river forms found at White Pines and other river localities in North Carolina are distinct in having sunken apothecia and largely lacking soredia, adaptations to its semi-aquatic lifestyle (Thüs and Schultz 2009).
- *Rinodina pachysperma* – This is a tiny, crustose canopy species typically found on twigs. Sheard (2010) has observed that it may be in decline throughout its range in eastern North America. It is very similar to *R. maculans*, differing primarily in spore size and shape. *Rinodina maculans* is a common coastal species, whereas *R. pachysperma* is typically found farther north,
- *Sticta carolinensis* – This foliose cyanolichen is found throughout southeastern North America from the Ozarks to the coastal plain of the Carolinas, however it is typically

associated with high-quality habitats with low levels of disturbance, mostly in the southern Appalachians and the Dare Regional Biodiversity Hotspot (Lendemer et al. 2016, Lendemer 2020). It was found on rocks near streams and rivers at WHPI.

- *Verrucaria hydrela* – This is a semi-aquatic crustose species with scattered occurrences throughout the world (e.g., Breuss 2007). At WHPI it was found on shaded rocks in a small forested stream.

Several of the significantly rare species are semi-aquatic lichens, found in stream and riverine habitats that are rarely surveyed for lichens in North America, and thus represent species that are more likely overlooked. The canopy species *Rinodina pachysperma* could be more prevalent as historical specimens could easily have been misidentified as the similar species *R. maculans*, found in 17 counties of the state.

These results also show that lichens as a taxonomic group are largely understudied from a conservation standpoint, and work is urgently needed to assess conservation concern of lichen species. The high level of lichen diversity and presence of rare lichens are a testament to the conservation value of the White Pines Nature Preserve with its diverse set of habitats and the importance of preserving them.

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FUNGI (NON-LICHENIZED)

Steve Hall, Rytas Vilgalys, Van Cotter, and Marc Cubeta

When you walk along the forest paths at the White Pines Preserve, you are surrounded as much by fungi as by the trees, birds, insects, and other species that are far more conspicuous to our senses. The very foundation of the forest lies underground beneath your feet in the vast network of fungal hyphae (filament-like structures) involved in an ancient form of mutualistic symbiosis with all of the trees overhead. Without this network the forest itself would not exist. The same is true for the enormous number of single-celled fungi, the yeasts, which also play major roles in nutrient cycling.

The fungi, like animals, are heterotrophic, meaning they obtain energy and materials from other organisms rather than producing it directly from inorganic sources, as do plants. In the mycorrhizal network, sugars produced by the plants through photosynthesis are shared with their fungal symbionts, which, in turn, help the plants uptake of water and nutrients from the soil. In other cases, fungi act as pathogens, infecting and feeding on other organisms, including plants, animals, or other fungi. By feeding on dead organisms, they are one of the prime decomposers in all ecosystems they occupy, recycling the nutrients and energy stored in deceased bodies – plants or animals -- back to the foundations of the ecosystem.

Much of the activities in which fungi are involved only occasionally attract our attention. We become aware of their presence mainly through observation of their fruiting bodies – e.g., mushrooms – which serve to disperse their spores. As in the flowers and fruits produced by plants, these structures are involved in multiple modes of dispersal, from wind currents to animals that feed on the mushrooms and disperse their spores by transporting them in their digestive system and subsequently depositing them in their scats. Animal species that play an important role in this regard include the numerous fungus beetles, flies, and even moths that specialize in feeding on mushrooms. More generalized feeders that make important contributions to fungal dispersal include snails and slugs, camel crickets, box turtles, shrews, mice, and squirrels. The mammals, in particular, are especially important for digging up and eating the fruiting bodies of hypogeous – underground fruiting – fungi, including truffles, all of which produce scents that are attractive to these animals.

In all these respects, plants, animals, and fungi play extremely important, interacting roles in supporting ecosystem diversity and stability. Any survey of the biodiversity of a particular site, therefore, needs to cast as wide a net as possible with regard to these taxa. Unfortunately, in this regard, the NCBP currently lacks a fungi taxonomic group, and this taxon was not surveyed by our members during the White Pines inventory. However, a number of surveys have been conducted in the past, with specimens deposited in collections at Duke and NC State University. We wish to acknowledge the lists of species collected at the White Pines Preserve contributed by Rytas Vilgalys, Van Cotter, and Marc Cubeta. These records are included in the MyCoPortal website.

SUMMARY OF HISTORIC RECORDS

A total of 134 species of fungi have been collected at the White Pines Preserve (see Appendix D for a complete list). These are summarized by family and ecological roles, where known, in the following table.

Table 1. Ecological Roles

Class	Order	Family	# of Species	# of Mycorrhizal Species	# of Saprobic Species	# of Parasitic Species
Agaricomycetes	Agaricales	Agaricaceae	2		2	
Agaricomycetes	Agaricales	Amanitaceae	6	6		
Agaricomycetes	Agaricales	Clavariaceae	3		3	
Agaricomycetes	Agaricales	Cortinariaceae	1	1		
Agaricomycetes	Agaricales	Gomphaceae	4	4		
Agaricomycetes	Agaricales	Hygrophoraceae	3	1	2	
Agaricomycetes	Agaricales	Marasmiaceae	12		2	
Agaricomycetes	Agaricales	Mycenaceae	2		2	
Agaricomycetes	Agaricales	Omphalotaceae	1		1	
Agaricomycetes	Agaricales	Pleurotaceae	1		1	
Agaricomycetes	Agaricales	Psathyrellaceae	1		1	
Agaricomycetes	Agaricales	Schizophyllaceae	1		1	
Agaricomycetes	Agaricales	Strophariaceae	1	1		
Agaricomycetes	Agaricales	Tricholomataceae	1		1	
Agaricomycetes	Agaricales	Typhulaceae	1		1	
Agaricomycetes	Auriculariales	Auriculariaceae	1			
Agaricomycetes	Auriculariales	Dacrymycetaceae	1		1	
Agaricomycetes	Boletales	Boletaceae	6	6		
Agaricomycetes	Boletales	Calostomataceae	2	2		
Agaricomycetes	Boletales	Suillaceae	4	4		
Agaricomycetes	Cantharellales	Cantharellaceae	1	1		
Agaricomycetes	Cantharellales	Hydnaceae	1	1		
Agaricomycetes	Gomphales	Gomphaceae	1	1		
Agaricomycetes	Hymenochaetales	Hymenochaetaceae	3	1	1	1
Agaricomycetes	Phallales	Phallaceae	1		1	
Agaricomycetes	Polyporales	Fomitopsidaceae	1			1
Agaricomycetes	Polyporales	Ganodermataceae	1			1
Agaricomycetes	Polyporales	Phanerochaetaceae	1			1
Agaricomycetes	Polyporales	Polyporaceae	6		5	1

Class	Order	Family	# of Species	# of Mycorrhizal Species	# of Saprobic Species	# of Parasitic Species
Agaricomycetes	Russulales	Russulaceae	7	6	1	
Agaricomycetes	Russulales	Stereaceae	2		2	
Dothideomycetes	Hysteriales	Hysteriaceae	1		1	
Dothideomycetes	Pleosporales	Anteagloniaceae	1			1
Dothideomycetes	Pleosporales	Sporomiaceae	1		1	
Leotiomyces	Erysiphales	Erysiphaceae	2			2
Leotiomyces	Helotiales	Helotiaceae	1			1
Leotiomyces	Leotiales	Leotiaceae	1		1	
Sordariomycetes	Diaporthales	Valsaceae	1			1
Distinct Counts and Totals	4	15	38	87	35	31
						10

40% of these species are involved in mycorrhizal relationships with tree species, including both hardwoods and pines. An additional 36% are saprobic, being involved in the decomposition primarily of woody plants. 12% are parasitic on plant species (note that these records are mostly for macro-fungi, with many more micro-fungi involved in parasitic relationships, both with plants, animals, and other fungi). Additionally, four species are hypogeous and are either known or suspected to be obligately involved in zoochoric relationships with small mammals.

NOTEWORTHY SPECIES

Although a number of the lichenized species of fungi are now listed as Significantly Rare by the NC Natural Heritage Program, a similar list has not yet been created for the non-lichenized species. Several species recorded at the White Pines Preserve, however, appear to be rare in the state.

Also noteworthy are species that may be common in the mountains, but which appear to be regionally rare, particularly where they appear to represent relicts from a long past distribution. Two such species were recorded by Betsy Randall (1983) who found two species at the White Pines Preserve that are believed to be obligately associated with Eastern White Pine. These are now known as *Suillus weaverae* (previously lumped under the European name *S. granulatus* or *S. granulatus* ssp. *snellii*), and *Suillus spraguei* (= *S. pictus*). These species continue to be found within the preserve, including the two in the photographs below that were collected in 2015 by Van Cotter.



FIGURE 7. *SUILLUS WEAVERAE*



FIGURE 8 *SUILLUS SPRAGUEI*

SLIME MOLDS

Meriel Goodwin

MYXOMYCETE BIOLOGY AND CHARACTERISTICS:

Myxomycetes, also called the Plasmodial Slime Molds, are organisms with a complex life cycle which begins with single celled amoebflagellates hatched from spores. These at some point join together to produce a multinucleated unicellular mass of free-living protoplasm, often visible to the naked eye (Fig. 1), which travels over or through substrates such as soil or decaying wood, and feeds on bacteria, algae, yeasts, fungal spores and other organic matter. Under the right conditions this plasmodium transforms into fixed sporocarps, frequently only millimeters in diameter and resembling tiny fungal fruiting bodies (Fig. 2). These reproductive structures mature and release airborne spores that eventually split open to produce new, mobile amoeba which begin the cycle again. It is the fruiting body stage which is used for species identification.

With their mix of animal and fugal characters, myxomycetes have been the subject of mystery and taxonomic speculation since the first recorded observation in the 17th century. Earlier classed with the fungi, they are now normally placed in Kingdom Protista, Phylum Amoebozoa. There are currently 68 genera and more than 1050 morphological species, 460 of which appear in the Eastern United States. 196 myxomycete taxa have been recorded in over two centuries of observations in North Carolina.

As a very ancient organism, myxomycetes are found worldwide in all terrestrial habitats, but are particularly abundant in temperate forests. They are therefore ideal to include in a survey of the White Pines Nature Preserve.

SURVEY EFFORT:

For the North Carolina Biodiversity Project White Pines survey, a total of nine myxomycete collecting forays were made to the Preserve between May and August 2024: May 22, May 24, May 30, May 31, June 4, June 16, August 6, August 17, August 24. The collector was primarily Meriel Torrey Goodwin, accompanied on several occasions by Steve Hall, Gary Perlmutter and David George. The dates were chosen as particularly propitious for myxomycete fruitings, as they came after light rains at the height of the major summer collecting season. The organism is ephemeral - some say even capricious - appearing most frequently after alternate wet and dry periods, with sunlight and some warmth, but not too much. Mid June through early August 2024 were both very hot and very dry, and were thus omitted from the sampling.

All the marked White Pines trails were explored, with the most myxo productive areas being the covered woodlands lower down than the rocky bluffs (too dry for fruitings) but higher than the river fronts (usually too wet).

SUMMARY OF MYXOMYCETE SPECIES OBSERVED:

A total of 32 myxo species were noted, with 94 observations recorded. This latter number is an undercount, however, as 4 common taxa (*Arcyria cinerea* (Fig. 3) *Hematrachia calyculata* (Fig. 4) *Cribraria cancellata* (Fig. 5) and *Ceratiomyxa fruticulosa* (Fig. 6) were ubiquitous, seen in abundance multiple times per foray and subsequently not noted individually. A full list of myxomycete species collected with the number of observations, is given in Appendix E.

The other 28 observations represent mainly a cross section of typical North Carolina Piedmont myxomycetes. However, 7 interesting taxa are uncommon, with 6 or fewer collections ever listed in MyCoPortal for the entire state.

The most exciting find is a taxon completely new to our North Carolina Myxomycetes Checklist: *Cribraria argillacea* (Fig. 7). Other rare species are:

Stemonitis pallida (5 previous observations)

Comatrachia pulchella (4 previous observations)

Physarum melleum (4 previous observations)

Cribraria languescens (3 previous observations)

Cribraria oregana (1 observation, for the 2021-2022 NC Biodiversity New Hope Creek Survey)

Stemonitopsis hyperopta (1 previous observation)

The presence of these more unusual taxa might be a reflection of the undisturbed nature of the Preserve. Some myxomycetes are thought to be uncommon because of restricted microhabitat requirements which human activity can disrupt.

The great majority of the White Pines Preserve collections were found on myxos' favorite habitat, decaying wood on the ground: logs, twigs, branches, fallen tree trunks (preferably decorticated). Exceptions to this context are noted in the full species list.

Amongst the taxons it is also worth noting the relatively high number of *Cribraria*, unsurprising in the White Pines Preserve given the preference of that genus for fallen trunks of gymnosperms. Conversely, there was a relative paucity of some common myxos known to favor angiosperms, including *Physarum globuliferum* and *Physarum album*.

In sum, the White Pines Nature Preserve presented in the summer of 2024 a mature and well-rounded environment for North Carolina Piedmont myxomycetes. They flourished in the excellent conditions, manifesting a wide spectrum of species and large numbers of extensive fruitings.

Furthermore, the high conservation quality of the area allowed some of the rarer myxomycetes in North Carolina to make an appearance, much to the delight of the collector and to the benefit of the North Carolina Botanical Garden Herbarium Myxomycete Collection where the specimens will be deposited.



Fig. 1 Myxomycete plasmodium



Fig. 2 *Arcyria denudata*



Fig. 3 *Arcyria cinerea*



Fig.4. *Hemitrichia calyculata*



Fig. 5 *Cribraria cancellata*



Fig. 6 *Ceratiomyxa fruticulosa*



Fig. 7 *Cribraria argillacea*



Figure 8. *Physarum melleum*

Myriapods (Millipedes and Centipedes)

Carol Tingley

BIOLOGY AND CHARACTERISTICS

There is an astounding diversity of animals in the soil, leaf litter, and woody debris of deciduous forests. The diversity and numbers of leaf litter inhabitants are good indicators of the quality of the soil and the diversity of microhabitats on a site. In addition, the leaf litter fauna, along with fungi, bacteria and other microorganisms, are key to nutrient cycling in the forest. Nutrients and minerals taken up by tree roots are stored in the leaves. When the leaves fall, they are broken down and decomposed by the soil and leaf litter organisms, returning the nutrients to the soil.

The leaf litter has layers from the dry surface leaves of this year's autumn, to the soft, moist, partially decomposed leaves from prior years, to the fully decomposed rich organic layer underneath. The larger burrowing animals help mix these layers by carrying the newer material down, and creating air spaces and pathways for smaller animals, fungi and microorganisms.



Myriapods are important components of leaf litter communities. Millipedes are largely detritivores and play an important role in leaf litter decomposition. For example, the American giant millipede (*Narceus americanus*) is common and conspicuous in southeastern forests. This large millipede grinds leaf matter into smaller bits and partially decomposes the material in its gut, making the bits more accessible to fungi and smaller animals. There may be thousands of these millipedes in an acre, and it is estimated that cumulatively, they can contribute two tons per acre per year of nutrient-rich millipede manure to the forest soil (Coville, F.V., 1913). A European study found carbon cycling was accelerated by 38.1% when detritivores converted leaf litter into feces (Joly, F-X et al, 2020).

Centipedes are fast-moving predators and play a role in the complex food webs of the soil and leaf litter communities. As in any natural community, predator-prey interactions can be complex, and changes in predator populations can affect ecosystem processes. A study that experimentally removed centipedes and other predators from the leaf litter community found that a 50% reduction in the densities of predators was associated with a 50% reduction in decomposition rates in dry forests. (Melguizo-Ruiz,N., et al, 2020). The effect was not noticeable in wet forests.

METHODS

Myriapods were surveyed on seven dates in 2024 and 2025, representing February, March, April, July and September. These included samples taken in three primary habitats: the steep north-facing slopes along the Rocky River, the general mesic slopes and ravines in other parts of the property, and the floodplains of the Rocky and Deep Rivers. The north-facing slope was sampled more frequently than the other two.

Sampling involved searching in downed logs and debris on the forest floor, sifting leaf litter by hand, and processing leaf litter samples in Berlese funnels. A night survey was conducted with a UV flashlight, which will cause some species to fluoresce.

RESULTS

Table 1 shows the species of millipedes and centipedes recorded in each of the three primary habitats.

	North-facing Slope	Mesic Slope	Floodplain
DIPLOPODA (Millipedes)			
Slug Millipedes (Polyzoniida)			
<i>Petaserpes strictus</i>	X		
Feather Millipedes (Platydesmida)			
<i>Andrognathus corticarius</i>	X		
Snake Millipedes (Julida)			
<i>Ophiulus pilosus</i>	X	X	X
Iron Millipedes (Spirobolida)			
<i>Narceus americanus</i>	X	X	X
Ornate Millipedes (Spirostreptida)			
<i>Cambala annulata</i>	X		X
Sausage Millipedes (Chordeumatida)			
<i>Cleidogona sp</i>	X		
Crested Millipedes (Callipodida)			
<i>Abacion magnum</i>	X		
Flat-backed Millipedes (Polydesmida)			
<i>Apheloria virginensis</i>		X	X
<i>Chaetaspis sp</i>	X	X	
<i>Oxidus gracilis</i>	X		X
CHILOPODA (Centipedes)			
Soil Centipedes (Geophilomorpha)			
<i>Strigamia branneri</i>	X		
Stone Centipedes (Lithobiomorpha)			
<i>Arenobius manegitus</i>	X	X	
<i>Nadabius pullus</i>			X
<i>Neolithobius latzelii</i>			X
<i>Paitobius zinus</i>	X		X
<i>Pampibius paitius</i>	X		
<i>Sozibius carolinus</i>	X		
<i>Sozibius proridens</i>		X	X
Bark Centipedes (Scolopendromorpha)			
<i>Cryptops leucopodus</i>	X		
<i>Hemiscolopendra marginata</i>		X	
<i>Scolopocryptops nigridius</i>			X
<i>Theatops posticus</i>			X

These species represent a good diversity relative to the sampling effort. For the most part, these are species that would be expected in good natural habitat in the North Carolina Piedmont. Two non-native species were recorded. *Ophiulus pilosus* was found in all three habitats, and *Oxidus gracilis* was found most commonly in the floodplains, but also on the north-facing slope. Both of these species are common almost everywhere in North Carolina.



Two unusual species of centipedes were recorded. *Pampibius paitius* was described as a localized endemic from the Appalachian mountain region of Tennessee, North Carolina and Virginia by Richard Hoffman in 1995. Since then, it has been found as far north as southeastern Ohio and as far east as Orange County NC (Pers. Comm. Derek Hennen), but is still seldom encountered and is considered rare.



Originally described from Duke Forest, *Sozibius carolinus* has also been found in Virginia but appears to be quite rare and localized. There are no observations on BugGuide, iNaturalist or GBIF. This species was found at White Pines in February, April and July, all on the north-facing slope, and so it seems to be a healthy population.

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SPIDERS

Brian Bockhahn

METHODS

Visits were made in each season and included both day and night work. Survey methods include sweep net, beat sheet, leaf litter sifting, vacuum, daytime visual surveys on foot and by water, nighttime visual surveys with head lamp and UV lights.

RESULTS

A total of 115 species were tallied during a one-year inventory at White Pines Preserve (see Appendix F). A handful of Ice Age relicts, and a wonderful composition of piedmont/mountain and coastal plain species were found! Several habitat specialists are reported, including some having restricted range near portions of the fall line/upper coastal plain; these species, though unranked, could warrant state rankings of “Significantly Rare.”

Noteworthy Species

Mountain relicts include *Anahita punctulata* and *Maevia* new species B. Uncommon finds include the diminutive *Agyneta parva*, *Origantes rostratus*, *Blestia sarcocoon* and *Ero leonina*. Habitat specialists include the Sandhills *Habronattus carolinensis*; rock outcrop specialist *Dolichognatha pentagona*; Fall line/upper coastal plain *Tutelina* n sp 2. Coastal plain species creeping up into the piedmont include *Chrysso albomaculata* and *Rhomphea projiciens*; Piedmont riverine specialist *Pardosa lapidicina*.



Family Summaries

EUCTENIZIDAE: The sole Mygalomorph found was *Myrmekeiaphila foliata*, a waferlid trapdoor spider. A colony was found on a mossy embankment along the trail, similar to other upland piedmont riverine habitats such as the Eno River and Falls Lake.

FIGURE 9 MYRMEKIAPHILA FOLIATA

AGELENIDAE: Funnel web spiders were abundant in all habitats, including not only *Barronopsis texana* and *Agelenopsis naevia* —species associated with human structures—but also the deeper woodland *Agelenopsis* species *kastoni* and *utahana*, indicating a healthy, long protected forested habitat.

ANYPHAENIDAE: These ghost spiders were abundant and represent a nice comparison of several statewide species more common in the upper piedmont: *Anyphaena pectorosa*, *Hibana gracilis*, *Wulfila saltabundus* and their sister species more commonly found in the coastal plain: *A. fraterna*, *H. velox*, and *W. albens*.

ARANEIDAE: The 26 species of orb-weavers detected indicated a diverse and healthy mix of habitats, with enough food sources for web usage low or high in the canopy. While the majority of species were statewide and common, there were some species more commonly found in coastal plain habitats.

CHEIRACANTHIIDAE: Two species from this family were detected, including the common statewide *Cheiracanthium inclusum* and the more riverine/water loving *Strotarchus piscatorious*.

CLUBIONIDAE: Only one species was identified, the common statewide *Elaver excepta*, most commonly found around human habitations. Other members of the *Clubionia* are likely present, but difficult to identify to species.

CORINNIDAE: Two ant-mimic spiders were observed, the common statewide *Castianeira longipalpus*, and a less common species found typically in the upper piedmont and foothills, *C. cingulata*.

CTENIDAE: Several of the sole native species of this family, *Anahita punctulata*, were detected on Mesic slopes around rock outcrops. This species is more common in the foothills of the state and represents a relict species for this locale.



FIGURE 10 ANAHITA PUNCTULATA

DOLOMEDIDAE: Fishing spiders were abundant on tree trunks both close to and far from the river's edge. Three common statewide species were present, including the tree dwelling *Dolomedes albineus* and *tenebrosus*. *D. triton* was present on water surface of ponds and in slack parts of the river. *D. vitattus* was also detected, despite its being more common in the piedmont and mountains.

DICTYNIDAE: The statewide-abundant *Nopalityna sublata* was present with several detections.

GNAPHOSIDAE: Only one species of ground spider was detected, *Herpyllus ecclesiasticus*, a common species statewide. Other members of the family may not be present due to lack of leaf litter along the river's edge.

LATHYIDAE: This tiny mesh web weaver was represented with one species, *Scotolathys maculina* suggesting that there is hope for the health of the leaf litter on this site.

LINYPHIIDAE: Dwarf and sheetweb spiders were surprisingly low in numbers and diversity with only 7 species detected. *Agyneta parva* and *Origantes rostratus* generally occur along the fall line in the state and represent surprisingly good finds. The tiny *Blestia sarcocuon* has only been found twice in the state, and only where thorough searching has occurred.



FIGURE 11 BLESTIA SARCOCUON



FIGURE 13 AGYNETA PARVA



FIGURE 12 ORIGANTES ROSTRATUS

LYCOSIDAE: The wolf spiders are some of the most common spiders in the state, yet only 7 species were detected. Both species of the tree trunk dwelling *Gladicosa* were present in good numbers along the interior portions of the preserve. Both species of forest dwelling *Tigrosa* were detected in interior portions, with *T. georgicola* present throughout and the burrowing *T. aspersa* present in the higher portions of the preserve. Only one species of *Rabidosa* was found, the statewide common *rabida*; it is surprising that other species of the piedmont and coast were not found³. *Pardosa milvina* was abundant along the river's edge and other wet areas. The rock outcrops in the center of the river had populations of *P. lapidicina*, the "stone" spider which only occurs in piedmont streams with rocky outcrops and riffles. *Pardosa* species have several strategies to survive the frequent inundation of rivers, including submersion tolerance, refugia, finding air bubbles, and having migration abilities enhanced with their ability to move rapidly across the surface of the water.



FIGURE 14 PARDOSA LAPIDICINA

MIMETIDAE: Two species of the forest-dwelling pirate spiders were detected, the statewide-common *Mimetus puritanus*, and the minute *Ero leonina*, which has only been found a few times in the state.



FIGURE 15 ERO LEONINA

³ A record for *Rabidosa punctulata* was submitted to iNaturalist by David George

OXYOPIDAE: Two species of lynx spiders were found, including the piedmont and mountain *Oxyopes scalaris* and *O. aglossus*, the latter being more common on the fall line and upper coastal plain. The super abundant *Peucitia viridans* was *not* detected; it normally occurs in disturbed areas and secondary growth.

PISAUROIDAE: Two species of nursery-web Spiders were recorded with numerous *Pisaurina mira* and *P. dubia*. Two other species of *Pisaurina* more common in the southern coastal plain were not detected. They normally occur on smaller and wetter drainages with steady flow and not on major rivers.

PHILODROMIDAE: Surprisingly, only one species of this diverse group was detected, the statewide *Philodromus marxi*. This location may be at the convergent epicenter of several other species in this genus, none of which occur at this “island” site.

PHRUROLITHIDAE: Three species of these leaf litter dwelling spiders were found, all of which represent species that occur in the center part of the state in the upper piedmont above the fall line.

SEGESTRIIDAE: The sole member of the family in NC, *Ariadna bicolor* was detected. This tube dwelling spider has a wide distribution but is not often encountered unless intentionally looked for as they build their tubular silk retreats in deep furrows of hardwood bark in dry forests.

SALTICIDAE: Ten species of jumping spiders were detected, showing off the diversity of the family as many members of this genus are habitat specialists. *Habronattus carolinensis*, having only a few records in the state was found, as were two species of undescribed spiders, including “*Maevia* species B,” which occurs in the State at elevations of 700-3300 feet. This detection represents the lowest elevation and furthest southeast in the state, certainly an ice age relict. The other non-described species found is the tiny “*Tutelina* n. sp. 2,” which appears to occur along the fall line in the upper piedmont of the state.



FIGURE 17 HABRONATTUS CAROLINENSIS



FIGURE 16 MAEVIA N SP B



FIGURE 18 TUTELINA N SP 2

TETRAGNATHIDAE: Four species were detected, each of which have their own habitat preferences. *Tetragnatha elongata* was abundant around the water, *T. viridis* on green vegetation in forest undergrowth, *T. caudata* in old fields, and *Dolochognatha pentagona*—an uncommon species that has only a few records for the state—was detected in the rock outcrop.



FIGURE 19 DOLOCHOGNATHA PENTAGONA

THERIDIIDAE: Twelve species of cobweb spiders were found, including both *Latrodectus mactans* and *variolus*—the Southern and Northern Black Widows—the ranges of which overlap in our state. *Chrysso albomaculata* is a small, colorful cobweb weaver of river floodplains in the upper coastal plain...but only in the southern part of the state. The tiny *Phoroncidia americana* was found representing just a handful of records for the state. *Rhomphea projiciens*, sometimes

called the “lizard spider,” ranges from the coast, up the rivers, and into the upper piedmont headlands.



FIGURE 21 CHRYSO ALBOMACULATA



FIGURE 20 PHORONCIDIA AMERICANA



FIGURE 22 RHOMPHEA PROJICIENS

THERIDIOSOMATIDAE: *Theridiosomma gemmosum*, our only species from this family, was found in good numbers at night. This species has a wide range occurring in dry forests, but due to its small size, it is not often encountered.

THOMISIDAE: Six species of crab spiders were detected including two of the flower dwelling species, three of the bark mimic species and *Tmarus angulatus*, being more common on saplings and low brush.

ULOBORIDAE: This is the only family in the western hemisphere known to possess no venom glands. A single species, the feather-legged orbweaver *Uloborus glomosus* was found in forest understory in significant numbers. While not closely related to true orb weavers, this species does build small, often horizontal, orb webs.

ODONATES

John Petranka, Mark Shields, and Harry LeGrand

BIOLOGY AND CHARACTERISTICS

The order Odonata consists of two suborders: Anisoptera (dragonflies) and Zygoptera (damselflies). The Dragonflies and Damselflies of North Carolina website ((LeGrand, H., et al., 2025); hereafter referred to as the NC Odonates website), lists 189 species in North Carolina (136 dragonflies and 53 damselflies), and 115 species in Chatham County (79 dragonflies and 36 damselflies).

All odonates share an amphibious life cycle consisting of three stages: 1) predacious flying adults; 2) eggs, which typically are deposited directly in water (exophytic oviposition), but which in some taxa are inserted into plants (endophytic oviposition); and, 3) predacious aquatic nymphs. Whether a species is present at a given site is mainly determined by the nymph's habitat requirements. Habitat requirements vary from species to species, but include essentially all North Carolina freshwater habitats. Within a habitat, species may have additional requirements, such as riverine dragonfly nymphs requiring stony versus sandy or silty streambeds, or, for certain damselflies, whether floating or emergent vegetation necessary for endophytic oviposition is present.

METHODS

We surveyed the White Pines Nature Preserve (i.e., 'the Preserve' or 'White Pines') by direct searches during six planned visits made in April and June of 2024, and March, April, and June of 2025. In addition, nine members of the North Carolina Biodiversity Project ([NCBP](#)) documented incidental encounters on various dates while conducting surveys of other taxa, see Table 1.

The planned visits were made on sunny days when odonates would be more active. Five surveys were made during mornings until around mid-day, and one was made from mid-day into the late afternoon. Surveys typically lasted for three to four hours, but some were shortened if skies became too cloudy or temperatures were too low for significant odonate activity.

A typical survey would begin at a parking area and proceed along one of the trails leading to the Rocky River (e.g., Schoolkids, River, or White Pines Trails). We then followed the River Trail to its confluence with the Deep River and continued along the Deep River for a short distance before returning to the parking area. We also searched along powerline corridors, parking areas and other open sunny areas, and visited the two former farm ponds located near the second parking area. We would have liked to survey the rocky shoals that border steep north-facing bluffs along the Rocky River, but we found access too limited.

RESULTS AND DISCUSSION

During the odonate survey period (March 1, 2024 to June 30, 2025) we (John Petranka, Mark Shields, Harry LeGrand and other NCBP biologists) documented 28 species of odonates (19 dragonflies and 9 damselflies) -- see Appendix H. Twenty-six species were found during planned visits, and two more, American Rubyspot (*Hetaerina americana*) and Spine-crowned Clubtail (*Hylogomphus abbreviatus*) were among the 12 species documented from incidental encounters. Ten of the 28 species are new occurrences for White Pines, and Duckweed Firetail (*Telebasis byersi*) is also the first record for Chatham County.

In addition to data from the physical searches, we queried iNaturalist, BugGuide, and Odonata Central (see references) for observations made during the survey period. iNaturalist returned 17 records, but all were species that had been found during the survey. No records, either during or prior to the survey, were returned from the BugGuide and Odonata Central searches.

As a rough gauge of the survey's completeness, we searched the NC Odonates and iNaturalist databases for odonate observations made prior to the survey. The NC Odonates search returned 45 records that included 22 species, five of which were not found during the survey: Carolina Saddlebags (*Tramea carolina*), Common Green Darner (*Anax junius*), Slaty Skimmer (*Libellula incesta*), Swamp Darner (*Epiaeschna heros*), and Umber Shadowdragon (*Neurocordulia obsoleta*). The iNaturalist search returned seven species among which only Ebony Jewelwing (*Calopteryx maculata*) was not seen during the survey. Each of these six species is widely distributed in North Carolina and commonly encountered (except for Umber Shadowdragon, see below). As there are recent records from White Pines for each of them, they were probably present during the survey but just not encountered.

Umber Shadowdragon has been found in 57 counties in the state but is rarely seen because of its crepuscular daily flight period and its habit of hanging nearly motionless in streamside forests when resting. Therefore, assessing its abundance (or for that matter, its mere presence) at any site is difficult. Despite that, the NC Odonates database does have a 2018 record for an adult from White Pines. There are also 13 records from the Dragonfly Riffles, with dates ranging from 1965 to 2002. It is thus reasonable to assume that Umber Shadowdragon was present at the Preserve during the survey but not found due to its secretive habits. (See the Summary for an alternative approach to documenting Shadowdragons).

Summarizing, we documented 28 odonate species during the NCBP White Pines Survey, ten of which had not previously been reported, including one that was a new county record. Database searches for odonate records prior to the survey yielded six additional species, bringing the documented odonate fauna of White Pines to 34 species, three of which are ranked at some level of conservation concern (Table 2).

Noteworthy Species

The status of the three species at the Preserve that have a state rarity rank of S3 (rare or uncommon in North Carolina) or S3S4 (between rare or uncommon, and apparently secure) are discussed here.

SEPTIMA'S CLUBTAIL (GOMPHURUS SEPTIMA) S3 G3 SR Septima's Clubtail was originally collected in the late 1930's by Septima Smith (and others) from the Warrior River, Alabama. It was described as a distinct species in 1956, and by the Spring of 1957 Duncan Cuyler (Donnelly, 2010) had collected the first North Carolina specimens from the Eno and Haw Rivers. The earliest known collection from the Rocky River is from May of 1965 at the US 15-501 bridge. The portion of the Rocky River in the vicinity of the bridge is now protected as part of the Rocky River Dragonfly Riffles Natural Area (Conlin, M.R., 2025) where over the past six decades an additional 29 Septima's Clubtail occurrences have been documented.



The population at White Pines appears to be stable. Searches of the NC Odonates and iNaturalist websites produced nine records documenting 34 individuals between 2015 and 2025, and Septima's is one of the most commonly encountered dragonflies at the Preserve from April to early May. It also appears to be doing well in North Carolina as a whole, as its known range now includes 20 counties. As a result, its state ranking has been moved from S2 (imperiled because of rarity) to S3 (rare or uncommon). It is still very rare in neighboring states, with just two known localities each in South Carolina (conservation status not rated), and Virginia

(S1, critically imperiled).

SPINE-CROWNED CLUBTAIL (HYLOGOMPHUS ABBREVIATUS) S3S4 G4, W Spine-crowned Clubtail is a riverine species with an early Spring flight period similar to that of Septima's Clubtail. Two teneral (day 1 adults) have been found at White Pines, both during the first week of April (2021 and 2024). More sightings are needed to assess its status at the Preserve, but the presence of tenerals confirms that there is a breeding population. It also bodes well that there have been 13 records of Spine-crowned Clubtail from the Dragonfly Riffles since 1969, indicating that there is a long-standing population not far upstream from which adults might disperse to White Pines.



Duckweed Firetail (*Telebasis byersi*) S3S4 G5 As its name implies, Duckweed Firetail is associated with still waters containing duckweed species, where it is usually found perched atop the floating mats. On June 13, 2024 Shields and Petranka observed five individuals at the smaller pond, which is matted with duckweed around its periphery. Duckweed Firetail has long been considered to be a Coastal Plain species in North Carolina, but in recent years sightings from several counties (Wake, Durham, Orange, Anson, and now, Chatham) indicate that its range is expanding into the Piedmont. Duckweed Firetail can be considered to be vulnerable at the Preserve since it has only been seen in small numbers and its continued occurrence depends on the presence of duckweed.



Summary. We documented 28 odonate species during the survey, ten of which had not previously been reported from White Pines (including a first record for Chatham County). Those, plus six more species recorded prior to the survey, bring the Preserve's odonates list to 34 species.

The survey covered species whose flight period is from April through June fairly well, but surveys during late Summer into Fall would likely have increased the species total. Also, we were unlikely to encounter adults of secretive species like Shadowdragons by using direct searches. A more fruitful approach might be to search for nymph exuviae (exoskeletons) that are still clinging to tree trunks and other vertical surfaces after adult emergence. Using that method, we might be able to document not only Umber Shadowdragon, but also the rare (S2? G4) Cinnamon Shadowdragon (*Neurocordulia virginiensis*), which was known to be present at the Dragonfly Riffles as recently as 2000. Encouragingly, exuviae collection was used in 2022 to document both Umber and Cinnamon Shadowdragons from the Haw River at Bynum (LeGrand, H., et al., 2025).

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ORTHOPTERA

Steve Hall

The grasshoppers, crickets, katydids and their relatives are some of the most widely recognized insects by the general public. They are characterized by the jumping hind legs, which are large



Brown Winter Grasshopper
Photo by Steve Hall

even in burrowing species such as mole crickets. They are also the most familiar and diverse group of singing insects. They include some of our larger species of arthropods and are among the most important groups of herbivores. While none are aquatic, several are important marsh and shoreline species and the rest are found in essentially all of our terrestrial habitats. Grasshoppers are particularly important in grasslands and other open, herbaceous habitats. Katydids are similarly important in forests and shrublands, while crickets can be found from ground level of most terrestrial habitats to the tree-tops of both coniferous and hardwood forests.

In all these habitats, orthoptera represent not only a key group of primary consumers but a major prey source for many groups of secondary consumers, ranging from many groups of predatory or parasitic insects and other invertebrates, to frogs, lizards, and insectivorous mammals. They are a particularly important food for birds, especially species inhabiting grasslands and early successional habitats.

Given their ecological importance, as well as their ease of study -- using both direct search, trapping methods, and auditory recording -- orthoptera are one of the main groups we include in our extended bioblitzes of particularly important sites for biodiversity conservation.

SURVEY COVERAGE

Observers: Steve Hall (principal investigator). Other records come from Jeff Niznik, Pat Coin, Mark Basinger, and particularly David George, all of whom were involved in nocturnal sampling aimed primarily at moths but that also produced some orthopteran records. Others who took part in the transect surveys were Parker Backstrom, Bruce Sorrie, Mark Peifer, Carol Tingley, Tom Howard, and Savannah Hall.

Survey Trips: Orthopterans were recorded on 27 dates during the survey, from 5/3/2024 to 11/5/2024 (specific observation dates are shown in the records displayed in Appendix I).

Survey Locations: Most observations were made along the same transect used to sample butterflies and breeding birds, with many of the orthopteran observations made incidental to those surveys. This route was also used specifically to survey singing orthopterans. All of the records

made along this transect were made during the day but orthopterans were also recorded on several occasions at night, mostly incidental to the sheet/UV light sampling used in the moth survey.

METHODS

Grasshoppers were surveyed primarily using direct visual search, usually involving flushing individuals from hiding by walking through their habitats. Five of these species were found only using this method. One other -- *Hippiscus ocelote* -- was observed at a moth sheet at night despite the fact that this species is normally active only during the day. This species was also found in a riparian forest although it is strongly associated with pastures and other open grasslands. It was, therefor, highly likely to have been a dispersing individual, not one actually resident where it was found.

In contrast to the grasshoppers, only three non-singing members of the Ensifera (the sub-order including nearly all non-grasshopper members of the Orthoptera) were found using visual search: two species of camel crickets and the one species of leaf-rollers, all three of which are wingless and therefor lacking the main sound producing structures of this suborder. They are also nocturnal and were observed during the moth sampling sessions.

Although a few crickets and katydids were found through visual search of their habitats, the vast majority – 117 records -- were obtained using acoustic recording while walking the same transect used in the butterfly and breeding bird surveys. Most of these records were made using a parabolic microphone (Wildtronics Pro Mono) and a Zoom H4n Pro digital recorder. On a few occasions, recordings were also made using the Sony ICD-UX570 voice recorder used primarily for taking field notes. Analysis of the songs was done using Raven Lite 2.0, a free program produced by the Cornell Laboratory of Ornithology. Songs were identified through comparisons to recordings on the Singing Insects of North America website, the Macaulay Library website, the Songs of Insects website, and various published articles that describe the pulse rate, pitch, and other diagnostic variables that can be detected through spectrographic analysis.

RESULTS

A total of 48 species of orthopterans were observed during the study, as tallied in the following table:

Family	Number of Species
Suborder Caelifera	
Acrididae (Grasshoppers)	7
Suborder Ensifera	
Gryllacrididae (Leaf Rollers)	1
Gryllidae (Crickets)	24
Rhaphidophoridae (Camel Crickets)	3
Tettigoniidae (Katydids)	14
Total	49

The total number of species represents only 34% of the orthoptera recorded for the Piedmont overall. It is comparable, however, to both the 45 species that were recorded in our previous survey of the New Hope Creek Bottomlands in Durham County and to the 49 recorded at the Mason Farm Biological Reserve, another Piedmont site that has been well-studied for orthopterans and where similar survey methods have been used. While we would expect a few more species to be added⁴, we feel that our sample is fairly representative of this site.



Scudder's Short-winged Locust.
Photo by David George

Grasshoppers

Only seven species of grasshoppers were recorded in this survey. This group is mainly associated with open grasslands or other rich herbaceous sites, which were limited in extent within the study area. Two of the species, *Amblytropidia mysteca* and *Melanoplus scudderi*, were found in the remnants of the early successional vegetation located near the old homesite above the Schoolkids Trail and a third species, *Arphia sulphurea*, was regularly seen in the opening at the parking area used for the canoe launch.

The rest were recorded in the semi-open patches of herbaceous vegetation located along the River Trail in the Rocky and Deep River floodplains. One of these species, *Hippiscus ocelote*, was found at night at a moth sheet and probably represented a dispersing individual from the pasturelands located on the north side of the Rocky. The most common of these species, *Metaleptea brevicornis*, is particularly associated with marshlands and was abundant in the area adjoining an extensive marsh of *Zizaniopsis miliacea* (Southern Wild-rice) growing out in the Rocky River near its confluence with the Deep River. The other two species -- *Chortophaga viridifasciata* and *Dichromorpha viridis* -- are found in nearly any open herbaceous area in the state and were observed on multiple occasions in open patches located near the river shorelines.

Missing from the survey are several species associated with open woodlands that have been recorded in the ridges and ravines in the Uwharrie Mountain region, located forty miles to the west of the study area (see the Orthoptera of North Carolina website). Three of these species are flightless members of the genus *Melanoplus*, all of which have only small, highly localized populations and are rare in the state generally. Their absence from the White Pines is therefore not surprising. *Spharagemon bolli*, however, is a strong-flying, widespread species that should be expected to occur in the upland habitats of the White Pines Preserve and should continue to be looked for there. Another species likely to turn up within the preserve is *Melanoplus punctulatus*, one of our few arboreal species of grasshopper. This species is widespread in the state but is usually only found at ground level in the fall, when cold weather and/or storms knock individuals out of the canopy.

⁴ Ten orthopteran records are included in GBIF, which compiles information from both museum collections and citizen science observations from iNaturalist. All of those for the White Pines Preserve, however, are from our study.

None of the species found during the inventory are currently of any conservation concern, and with the potential exception of the flightless species of *Melanoplus* mentioned above, none are likely to be found with more survey effort.

Katydids



More katydid species than the grasshoppers are associated with forested habitats and consequently are better represented in the survey. These include canopy-dwelling species, such as *Pterophylla camellifolia*, *Microcentrum retinerve*, and *Orchelimum minor*, as well as the forest-floor-dwelling *Atlanticus pachymerus* and *A. americanus*. Most of the others are shrub-inhabiting species and were found primarily in the riparian areas or near the pond along the Schoolkids Trail. Two species, *Conocephalus brevipennis* and *C. fasciatus*, like the grasshoppers, are associated with open herbaceous habitat and were found only in the disturbed areas near the old homesite.

A few additional species are likely to turn up with more survey effort, including *Hubbellia marginifera*, which is particularly associated with pines, and *Montezumina modesta* and *Microcentrum rhombifolium*, two other species associated with hardwood forests. Several shrubland species, particularly in the genus *Scudderia*, are

also likely to turn up.

None of the species either found within the Preserve or that remain to be discovered are currently considered to be of any conservation concern. One species, *Atlanticus monticola*, however, appears to be at least regionally rare in the Piedmont and may represent a Pleistocene relict – the few other populations that have been recorded in this region have been found on shaded, north-facing slopes.

Crickets

By far the most diverse and abundant group of orthopterans in the study area are the members of the Gryllidae, which occupy forested as well as open, herbaceous habitats and include both ground-dwelling species as well as those associated with the shrub, understory, and canopy levels of forests and woodlands. Although usually small, secretive, and generally inconspicuous visually, they are dominant members of insect choruses and are particularly prominent within the auditory range of most humans (unlike several of the katydids). They are, in fact, one of the easiest groups of animals to census, with many of their species best identified based on the species-specific characteristics of the male songs.

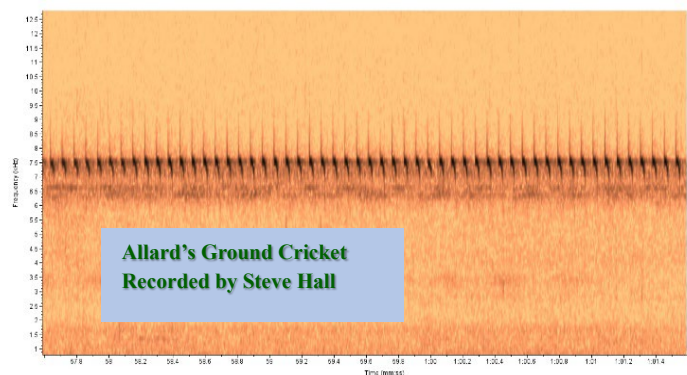
Field Crickets (subfamily Gryllinae), the group most familiar to the public, were represented by three species in the survey, including the Southern Wood Cricket (*Gryllus fultoni*), whose songs

consist of the classic “chirp-chirp-chirp” associated with crickets. Less familiar are the Eastern Striped Cricket (*Miogryllus verticalis*) and the Japanese Burrowing Cricket (*Velarifictorus micado*), an introduced species that is now one of our most common and widespread species. Because of its secretive behavior and the fact that it is not an important crop pest, the Japanese Burrowing Cricket receives virtually no notice from the public, which is far more alarmed by Kudzu, a far-less ubiquitous exotic. The damage it does is probably confined to displacing our native field and ground crickets, with which it probably closely competes for food and space. Given the importance of our native species in those groups – although scarcely appreciated – it may be having a far greater ecological impact than some of the more widely recognized invasive species.



Ground Crickets (subfamily Neomobiinae) are a much more diverse group, represented by sixteen species in North Carolina, eight of which were recorded in our survey. Although most of the species we found are associated with woodland or wetland habitats, possibly the most interesting with respect to our survey is Allard’s Ground Cricket (*Allonemobius allardi*), a grassland species. This is a well-known species in the North, but in North Carolina it is confirmed only in the mountains (populations previously identified in the Piedmont have been largely split between two

sibling species). If true, then its occurrence at the White Pines Preserve may represent a montane disjunct, similar to the White Pines, Catawba Rhododendrons, Red-backed Salamanders and other species that are believed to represent Pleistocene relicts at this site. Although one of the places where we recorded it was in the old-field vegetation associated with the old homesite along the Schoolkids Trail, the other was on a forested ridge where the River Trail comes up from the Deep River. More study, both at the White Pines Preserve and elsewhere in the Piedmont will be needed to confirm both its status and local habitat associations.



Another group of eleven species, belonging to three subfamilies, are associated with shrubs and understory trees. Most of these are widespread across the Piedmont or over most of the state, but one species, Thomas’s Trig (*Anaxipha thomasi*), again appears to be especially interesting with respect our particular study. This species is strongly associated with pines, including White Pines, and its range is mainly located in the Blue Ridge and the Ridge and Valley Provinces (Walker and Funk, 2014). In North Carolina, we have recorded it in pine habitats in Orange and Iredell Counties, where its songs closely match those described in the literature. At the White Pines

Preserve, we recorded what appears to be this species primarily on the steep slope above the Rocky River where White Pines are particularly prominent. The songs at this site – although similar in pulse rate and pitch to those typical of the species elsewhere – were consistently broken into discrete segments rather than the prolonged, unbroken trills normally produced by this species (see examples on the Orthoptera of North Carolina website). Whether the population at the White Pines Preserve represents another disjunct, relict species, or an undescribed species remains to be determined.

The fourth group of crickets represented in our survey are the Tree Crickets (subfamily Oecanthinae). Despite their common name, only a couple of species in this group reside up in the canopy, neither of which were recorded in our study. Instead, most are found in shrubs or understory trees or even out in open fields with abundant tall forbs. Only two species were recorded, the Narrow-Winged Tree Cricket (*Oecanthus niveus*), a tree-dwelling species, and Broad-Winged Tree Cricket (*Oecanthus latipennis*), a primarily vine- and shrub-dwelling species. Other species are very likely to be present but may have been missed since this group sings almost entirely after dark, when we made few recording trips. One species that would be particularly good to find is the Pine Tree Cricket (*Oecanthus pini*), which is strongly associated with pine species, including White Pine in the mountains.

Camel Crickets and Leaf Rollers

Members of two families of completely wingless (and song-less) orthopterans were recorded by direct searches made at night. The Carolina Leaf-Roller (*Camptonotus carolinensis*), the sole member of the Gryllacrididae in North Carolina, was observed shedding its exoskeleton beneath a leaf on one occasion. This species is widespread in the Eastern Deciduous Forest, and constructs shelters by tying together a roll of leaves using the silk it produces, a unique ability among our species of orthopterans.

Three species of camel crickets, belonging to the family Rhaphidophoridae, were more frequently observed. One species, the Greenhouse Camel Cricket (*Tachycines asynamorus*) is the second exotic orthopteran found in the preserve. Unlike the Japanese Burrowing Cricket, however, it is much more closely associated with human habitations, including cellars and crawl spaces in addition to greenhouses. It has now, however, also been found at several sites located well away from human settlements, as at the White Pines Preserve, but fortunately still in very low numbers, particularly compared to *Velarifictorus*.

Much more interesting from the standpoint of native biodiversity was the discovery of two species of native camel crickets (genus *Ceuthophilus*). One species, apparently the less common, was *Ceuthophilus uhleri*, a species known primarily from the mountains but found as far east as Iredell County in North Carolina (Orthoptera of North Carolina website). Based on what is known of its distribution so far, this could be another disjunct species at the White Pines Preserve.

Possibly even more disjunct, however, may be the Spotted Camel Cricket (*Ceuthophilus maculatus*), a widespread, common species in the North but not previously recorded south of Washington along the Atlantic Slope. This species, however, belongs to a relatively poorly surveyed group, in both North Carolina and elsewhere. As with some of our other discoveries,

more needs to be learned about its overall distribution before its status can be completely determined.



Other Orthopteran Families

Several other small families of orthopterans exist here in North Carolina, including the Mole Crickets (Gryllotalpidae), Sand Crickets (Tridactylidae), and Grouse Locusts (Tetrigidae). None were recorded during our survey, but all are likely to

be present within the Preserve. Mole Crickets have a very distinctive song and should be listened for in wetland habitats, including the floodplains of the two rivers and around the edges of the upland ponds. The other two families are found predominantly along shorelines and other wetland areas (some occur in drier habitats), but are small, well-camouflaged, and do not sing.

CONSERVATION SIGNIFICANCE OF THE ORTHOPTERA

The members of the orthoptera, like all other insects and terrestrial arthropods in North Carolina, are given no protection under the state's Endangered and Threatened Wildlife act. They may, however, be recognized as having priority for protection by the state's Natural Heritage Program, which can (potentially at least) designate any species as in need of conservation. Several orthopterans are already on the NHP list of Significantly Rare Species, although none that have been documented at the White Pines Preserve. As described above, however, at least one species – *Ceuthophilus maculatus* – may qualify for Critically Imperiled (S1) status, and the same may be true of the species we have tentatively identified as *Anaxipha thomasi* if it turns out to be an undescribed and possibly highly restricted species. *Neonemobius variegatus* – one individual of which was recorded along the Rocky River within the preserve -- also appears to be uncommon to rare.

Biotic Persistence Analysis

Beyond just singling out the most imperiled species for particular conservation attention, we are interested in knowing how well the orthoptera as a group are faring within the preserve. If, as we have described previously, orthopterans as a group play an important role in the food web within

an ecosystem, then the viability of both the common as well as the rare species needs to be evaluated. This is done through use of Biotic Persistence Analysis, as described in the Methods chapter.

The orthoptera fauna of the White Pines Preserve appears to have been completely unstudied prior to our survey and we cannot use previous survey records to determine the number of species that existed at this site in the past. Instead, we use the set of species associated with the habitats recorded at the preserve to estimate the original complement of species. We further restrict that list to just those species that have been recorded since 1950 in the four eastern Piedmont counties of Chatham, Orange, Durham, and Wake, as documented in the Orthoptera of North Carolina Website.

The table below shows these calculations for the forested habitats at both the White Pines Preserve and the New Hope Bottomlands that were surveyed by the NCBP in 2021-22. In both cases, closed-canopy forests covered most of their extent. These stands consist of hardwoods with some old pine plantations also included. At the White Pines Preserve, White Pines are mixed in with most of the hardwood stands.

Table 1. Calculation of Biotic Persistence Index, Forested Habitats

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
General Dry-Mesic Hardwood Forests		
<i>Gryllus fultoni</i>	0.80	0.65
<i>Microcentrum retinerve</i>	0.80	0.65
<i>Oecanthus niveus</i>	0.55	
<i>Hapithus agitator</i>	0.65	0.65
<i>Orocharis luteolira</i>	0.65	0.80
<i>Atlantius americanus</i>	0.65	
<i>Atlantius pachymerus</i>	0.80	
<i>Oecanthus exclamationis</i>		
<i>Pterophylla camellifolia</i>	0.85	0.85
<i>Camptonotus carolinensis</i>	0.65	
<i>Cyrtoxipha columbiana</i>	0.85	0.55
<i>Allonemobius tinnulus</i>	0.65	0.80
<i>Montezumina modesta</i>		
<i>Cycloptilum trigonipalpus</i>	0.65	
<i>Orocharis saltator</i>	0.65	0.80
Count = 15	Sum = 9.20	Sum = 5.75
	BPI = 61%	BPI = 38%

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
General Mesic Hardwood Forests		
Allonemobius maculatus	0.80	0.65
Atlanticus monticola	0.65	
Ceuthophilus maculatus	0.80	
Ceuthophilus uhleri	0.65	
Eunemobius confusus	0.85	0.55
Count = 5	3.75	1.20
	75%	24%
General Wet-Mesic Forests		
Eunemobius carolinus	0.80	0.85
Tettigidea acuta		0.65
Count = 2	Sum = 0.80	Sum = 1.50
	BPI = 40%	BPI = 75%
All Hardwood Forests		
22	13.75	8.45
	63%	38%
General Pine Forests		
Oecanthus pini		
Anaxipha thomasi	0.85	0.55
Melanoplus punctulatus		
Hubbellia marginifera		
Orchelimum minor	0.65	0.80
Count = 5	Sum = 1.50	Sum = 1.35
	BPI = 30%	BPI = 27%
All Forested Habitats		
Total = 27	Sum = 15.25	Sum = 9.80
	BPI = 56%	BPI = 36%

Compared to the White Pines Preserve, the orthopteran species associated with forested habitats along New Hope Creek is much reduced, with the BPI for the entire set of forest habitats is only 70% of the value for the White Pines Preserve. In the case of this taxonomic group, the amount of upland versus lowland forests may be responsible for these observed differences: the species missing from this preserve are primarily those associated with dry-to-mesic stands of hardwoods; the few species associated with wet-mesic forests – i.e., floodplain forests – appear to be doing fairly well. Unlike the White Pines Preserve, where upland forests cover a much larger expanse, nearly all of the habitats in the New Hope Bottomlands are located within a frequently inundated

floodplain. While some species associated with mesic slopes hang on in the lower slopes just above the flood zone, nearly all of the mesic and drier habitats that once adjoined the floodplain have now been developed.

When species associated with shrubby or herbaceous wetlands are considered, the two preserves are reversed in terms of their importance, as shown in Table 2.

Table 2. Calculation of Biotic Persistence Index, Open to Semi-open Wetlands

Scientific Name	OPS	
	White Pines	New Hope Bottomlands/ Hollow Rock
Wet Herbaceous Vegetation		
Allonemobius fultoni		0.65
Orchelimum pulchellum		0.65
Tettigidea lateralis		0.65
Neocurtilla hexadactyla		0.65
Anaxipha exigua	0.65	0.65
Metaleptea brevicornis	0.85	0.85
Orchelimum agile		
Anaxipha tinnulenta	0.65	0.85
Paroxya clavuligera		0.55
Paroxya atlantica		
Anaxipha vernalis	0.85	0.80
Neonemobius cubensis		0.55
Leptysma marginicollis		
Count = 13	Sum = 3.00	Sum = 6.85
	BPI = 23%	BPI = 53%
Shorelines		
Eunemobius melodius	0.85	0.55
Tetrix arenosa		0.55
Paratettix cucullatus		0.55
Neonemobius variegatus	0.80	0.65
Count = 4	Sum = 1.65	Sum = 2.30
	BPI = 41%	BPI = 58%
All Wetland Habitats		
Total = 17	Sum = 4.65	Sum = 9.15
	BPI = 27%	BPI = 54%

Conversely, almost no open wetlands exist at the White Pines Preserve, but they are extensive at the New Hope Bottomlands, due both to a wide powerline that runs down the length of the floodplain and to the numerous open floodways and sloughs that exist in the flat terrain characteristic of the Triassic Basin in which the entire New Hope Bottomlands preserve is located.

While neither site has extensive areas of old field and other successional habitats, the powerlines that cut through the forests provide at least some areas that are suitable for species that require open, dry-mesic expanses dominated by herbs and shrubs. As shown in Table 3, the BPI values are the same for both sites with respect to these habitats:

Table 3. Calculation of Biotic Persistence Index, Old Field and Mixed Habitats

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
Successional Fields		
Allonemobius allardi	0.80	
Allonemobius griseus funeralis		0.55
Allonemobius socius		0.85
Allonemobius walkeri		0.85
Amblycorypha carinata	0.55	
Amblycorypha oblongifolia	0.65	
Arphia sulphurea	0.60	
Arphia xanthoptera		
Chortophaga viridifasciata	0.60	
Conocephalus brevipennis	0.55	0.65
Conocephalus fasciatus	0.55	0.80
Conocephalus strictus		
Dichromorpha viridis	0.60	0.80
Dissosteira carolina		
Gryllus rubens		0.85
Hippiscus ocelote		
Melanoplus bivittatus		
Melanoplus differentialis		0.55
Melanoplus femurrubrum		
Melanoplus scudderi	0.55	0.65
Neoconocephalus retusus	0.55	0.55
Oecanthus latipennis	0.55	
Oecanthus quadripunctatus		
Orchelimum erythrocephalum		
Orchelimum vulgare	0.65	0.65
Pyrgocorypha uncinata	0.55	
Scudderia cuneata	0.55	0.65
Scudderia furcata		0.55
Scudderia texensis		
Syrbula admirabilis		0.55

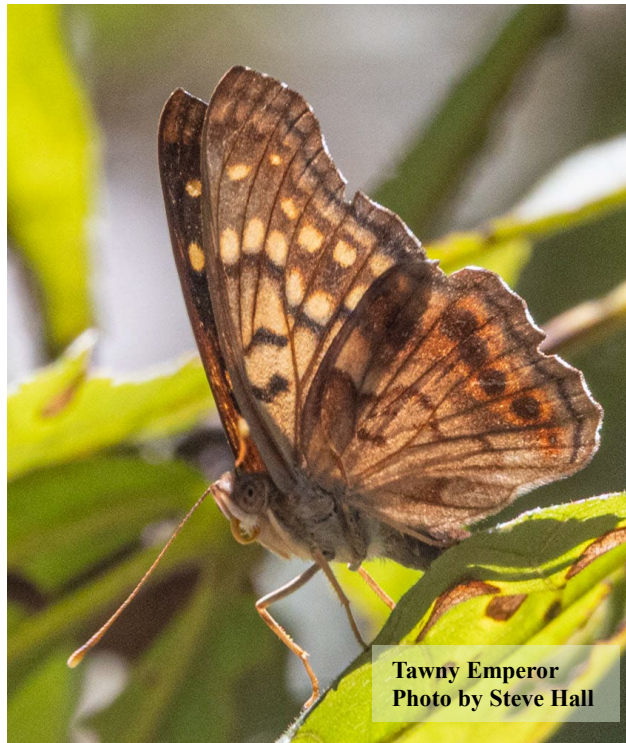
Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
General Forests and Fields		
Amblycorypha longinicta		
Anaxipha tinnulacita	0.85	0.65
Cycloptilum slossoni		
Microcentrum rhombifolium		
Myrmecophilus pergandei		
Neoconocephalus triops	0.80	
Neoxabea bipunctata		
Phyllopalpus pulchellus	0.85	0.85
Schistocerca americana		
Count = 39	Sum = 10.80	Sum = 11.00
	BPI = 28%	BPI = 28%

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BUTTERFLIES

Steve Hall and Parker Backstrom



Butterflies, with few rivals, are our most familiar group of insects and include many of our largest and showiest species. They are also among the few groups of insects that are appreciated in a positive way by humans: not only are their bright colors and shimmering patterns beautiful to human eyes, but they are well recognized as “beneficial” (to us) for their conspicuous role as pollinators. As a group, they have been studied for centuries and there is now a large number of field guides devoted specifically to this taxon, second only to those for birds. One of the latest of these is the *Butterflies of North Carolina, South Carolina, Virginia, and Georgia* (LeGrand, Pippen, Carter, and Howard, 2024), two of whose authors – LeGrand and Pippen -- are members of the NCBP⁵.

Butterflies share many of the same ecological traits as moths, the much larger group of the

lepidoptera of which they are mainly just a small, day-flying subset. This entire group is of key importance in terrestrial ecosystems as primary consumers – herbivores – transferring the materials and energy produced by plant species on up to the higher levels of the food web. Without this very large and diverse group, feeding on the entire range of native plant species, many, if not all, terrestrial ecosystems would collapse.

Unfortunately, this group is now also known for their massive declines across the world. Although only a very few butterflies count as crop pests – e.g., the Cabbage Butterfly -- they nonetheless share the same fate as the moths that pose significant threats to our food supply: they are highly vulnerable to the same pesticides used to control moth populations. In their occupation of open herbaceous habitats, often adjoining cultivated fields, they are vulnerable to pesticide drift. Herbicides used to combat “weeds” such as milkweed, are affecting not only Monarchs but a large number of other butterflies. Many of their native habitats are being converted and fragmented, including through suppression of the wildfires that are necessary to keep savannas, sandhills, and many other habitats open and herb-dominated. For many butterflies, the loss of successional fields due to agricultural intensification plays a key role in their decline. And the many impacts of global climate change are just beginning to be felt.

The existence of this multitude of threats, as well as the wide support for their conservation, makes butterflies flagship species for insect conservation and for biodiversity conservation more

⁵ Harry and Tom Howard were founders of the Butterflies of North Carolina website, now also joined by Jeff Pippen.

generally, i.e., going beyond the traditional concerns focused on vertebrate animals and vascular plants. In addition, butterflies are some of the most easily surveyed groups of insects due to their flashy, diurnal behavior. These factors combined make them one of the main groups we include in our extended bioblitzes of particularly important sites for biodiversity conservation.

SURVEY METHODS AND COVERAGE

Observers: Steve Hall and Parker Backstrom were the principal investigators for the transect surveys that formed the core of this study. Others that joined us on the transects include Holly Weston, Bruce Sorrie, Mark Peifer, Pat Coin, and Savannah Hall. David George, Jeff Niznik, and Pat Coin additionally submitted several records to iNaturalist based on observations made during the course of our overall inventory.

Survey Trips: Transects were conducted on 13 dates in 2024, from May 3 to September 22. Other records obtained during the NCBP survey were made on an additional 12 dates. Apart from the records that were made during our study, we also include in our analysis a number of records from other sources and covering previous years back to 2016. 31 were obtained from the Global Biodiversity Information Facility (GBIF.org (16 August 2025) GBIF Occurrence Download <https://doi.org/10.15468/dl.7ycs9x>), some of which were originally submitted to iNaturalist or eButterfly. Only those records meeting Research Grade criteria are accepted by GBIF and were consequently used in this study. 40 more records were obtained from the Butterflies of North Carolina website, which compiles records obtained from several different butterfly groups in the state.

Survey Locations: Fifty butterfly observations were made along a fixed route that served as our principal transect, shown in Figure 1. This runs along the Schoolkids Trail from its trailhead at the Preserve's main parking area down to its intersection with the River Trail near the canoe launching site. From there, it follows the River Trail down to the confluence of the Rocky and Deep Rivers and then along the Deep River floodplain to where it turns uphill and intersects the White Pines Trail and from there along the White Pines Trail back to the parking area. The transect is 1.7 miles long and runs through or adjoins most of the habitats present in the Preserve, from upland pine and hardwood communities, down and up along deep mesic ravines, and along the main floodplains of the area. The upland portion of the Schoolkids Trail also passes through some of the only open, successional habitats in the preserve -- including pond edge -- as well as following the eastern edge of the steep rocky bluff that supports many of the montane disjuncts for which the Preserve is so widely known; White Pines themselves are present along the entire length of the transects.

METHODS

Butterflies were surveyed entirely using direct visual search. The transect survey followed the Pollard monitoring protocol, with the data compiled by the [Carolinas Butterfly Monitoring Program](#). These surveys involve walking along the route at a steady pace, counting all individual butterflies -- identified to species -- within a 5m distance of the observer (for details, see <https://www.jeffpippen.com/butterflies/carolinasbmp/carbmp-protocols.htm>).

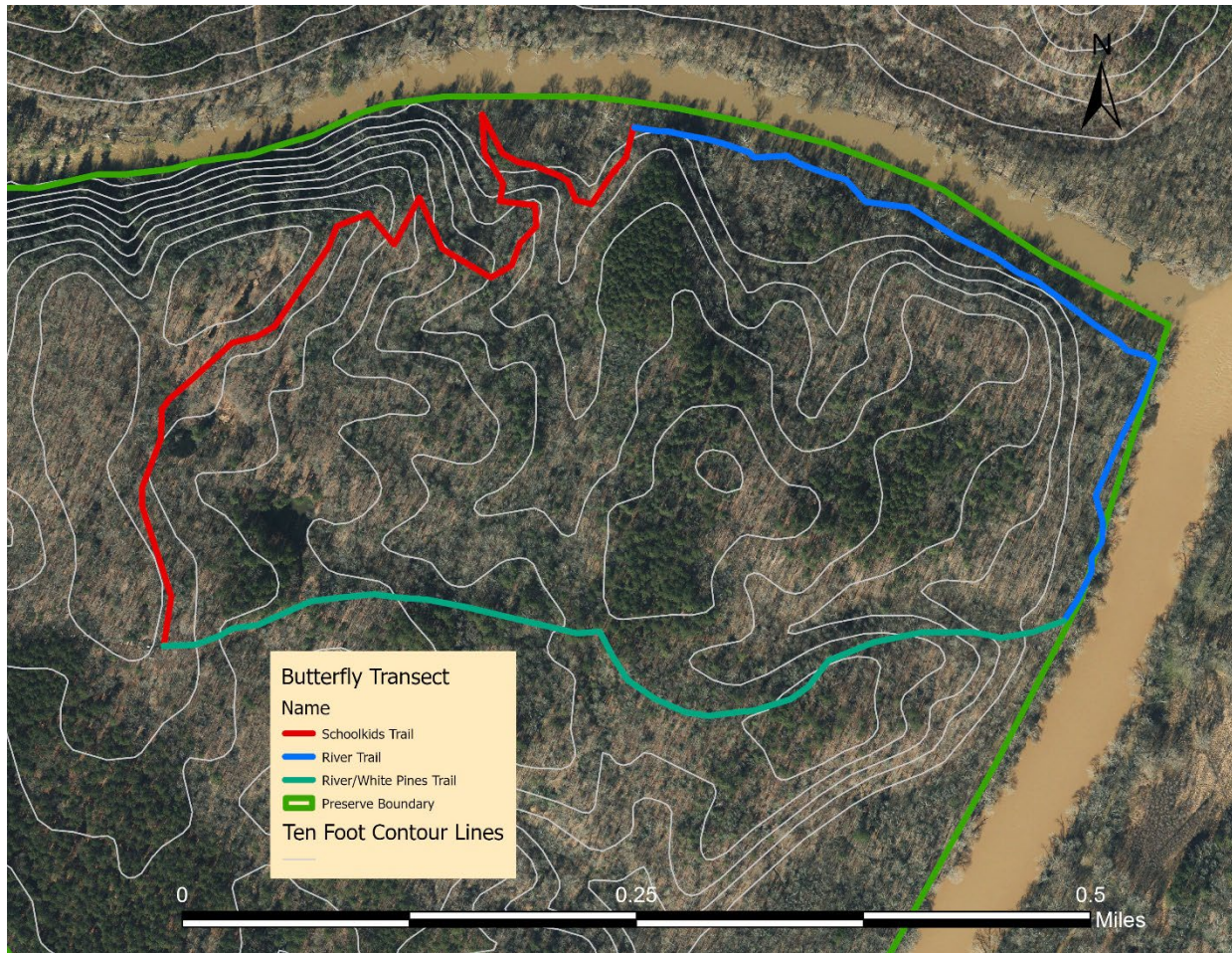


FIGURE 23. BUTTERFLY TRANSECT

RESULTS

A total of thirty species of butterflies has been observed at the White Pines Preserve, including twenty-five recorded in our survey and five additional species reported in GBIF. The number of species per family, based on all records is given in the following table; those observed in our survey are included in parentheses.

Table 1. Species Summary

Family	Number of Species (in 2024)
Superfamily Papilionoidea	
Papilionidae	5 (5)
Pieridae	2 (2)
Lycaenidae	8 (3)
Nymphalidae	13 (10)

Family	Number of Species (in 2024)
Superfamily Hesperoidea	
Hesperiidae	4 (3)
Total	32 (23)

The total number is low compared to the 44 species that are listed as Common in the Piedmont by the Butterflies of North Carolina website. Most likely, this reflects the fact that most of the White Pines Preserve is forested, with only a few small areas of the open, sunny, and herb-dominated habitats favored by butterflies.

Transect Surveys

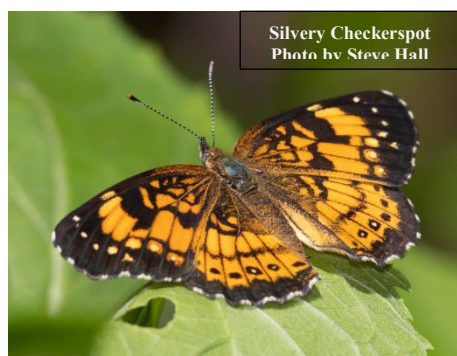
Transect counts were made on 13 different occasions, with the results shown in the following table:

Table 2. Summary Of Transect Samples

Date	Number of Species*	Number of Individuals
05/03	3	4
05/12	7	10
05/21	2	5
05/25	2	2
06/08	2	3
06/15	3	6
06/22	2	4
06/29	5	10
07/21	3	4
08/04	2	9
08/22	6	18
09/10	7	11
09/22	6	7

* Includes some individuals identified only to genus

Species that are associated primarily with open fields were observed mainly within the remnant openings located around the old homesite along the upper portion of Schoolkids Trail, as well as at a powerline that crosses the trail close to the homesite. Cloudless Sulphur, Silvery Checkerspot, Pearl Crescents, Eastern Tailed Blues, and Zabulon Skippers, were all observed in this area. Additionally, a Black Swallowtail and Gray Hairstreak were recorded in open areas at the canoe launch parking area along the White Pines Trail.



Species associated with riparian habitats were all found down in the floodplains of the Rocky and Deep Rivers where the transect follows the lower portion of the River Trail. Species found in this area include American Snout, Tawny Emperor, and Hackberry Emperor, all of whose larvae feed on the Sugar Berries (*Celtis laevigata*) growing in this area and were observed on several occasions in this part of the



transect. One Eastern Comma, whose larvae feed on nettles and elms, was also found along this portion of the transect. Earlier in the spring – before the transect surveys began – a few Zebra Swallowtails, a Pawpaw-feeding species, were also observed in these floodplains.



Species more typical of upland forests were observed along the portions of the transect running along the ridges. These include the Red-spotted Purple, Gemmed Satyr and Little Wood Satyr, both of which were observed on only a few occasions and as single individuals. Other species found in both uplands and lowlands as well as the few open habitats within the preserve include Tiger Swallowtail, Summer Azure, and the most common species observed along the transect, the Carolina Satyr.



With the exception of the Carolina Satyr, most of the species were observed only occasionally and in small numbers. The following table summarizes the quantitative results of the transect surveys.

Table 3. Number of Observations

Species	Number of Dates	Number of Individuals
Papilionidae		
Black Swallowtail	1	1
Eastern Tiger Swallowtail	4	4
Spicebush Swallowtail	1	1

Species	Number of Dates	Number of Individuals
Pieridae		
Cloudless Sulphur	1	1
Lycaenidae		
Gray Hairstreak	1	1
Summer Azure	7	9
Nymphalidae		
American Snout	1	1
Eastern Comma	1	1
Pearl Crescent	3	5
Silvery Checkerspot	2	2
Red-spotted Purple	2	2
Carolina Satyr	13	33
Little Wood-Satyr	1	1
Gemmed Satyr	3	4
Hackberry Emperor	5	7
Tawny Emperor	2	5
Hesperiidae		
Zabulon Skipper	3	4

CONSERVATION SIGNIFICANCE

None of the species recorded at the White Pines Preserve are considered to be of even moderate conservation significance by the Natural Heritage Program: 27 species are state ranked as S5 and three as S4. At the regional level, the Butterflies of North Carolina website considers two species to be rare to uncommon in Piedmont: Henry's Elfin (recorded in 2017) and the White-M Hairstreak (recorded in 2021).

Biotic Persistence Analysis

As we did for the orthoptera, we use as a baseline the set of species that have been recorded since 1950 in the four-county region of Chatham, Orange, Durham, and Wake Counties and again divided the species into habitat groups based on the assignments used in the Habitats of North Carolina. Estimates of species' probabilities of survival over the next ten-year period in this case incorporate information compiled from both GBIF and the Butterflies of North Carolina Website for the period prior to the current survey. These data are included in Appendix J.

The following tables calculate the BPI for each of the habitat groups and again compares the results obtained in this survey to that obtained in our previous survey conducted at the New Hope Bottomlands.

Table 4. Calculation of Biotic Persistence Index, Forested Habitats

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
I. Hardwood Forests, Ridges and Slopes		
Upland Hardwood Forests		
Battus philenor	0.80	
Parrhasius m-album	0.65	
Satyrium calanus		
Satyrium favonius		
Megisto cymela	0.65	0.80
Heraclides crespontes		
Limenitis arthemis astyanax	0.65	
Nymphalis antiopa		0.65
Pterourus glaucus	0.90	0.85
General Forests		
Asterocampa celtis	0.85	0.80
Asterocampa clyton	0.65	0.10
Atlides halesus	0.10	
Celastrina ladon		
Cyllopsis gemma	0.80	0.65
Erynnis horatius		0.10
Erynnis juvenalis	0.85	0.85
Libytheana carinenta	0.65	0.80
Hermeuptychia sosybius	0.90	0.85
Telegonus cellus		
Count = 19	Sum = 8.45	Sum = 6.45
	BPI = 44%	BPI = 34%

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
II. Hardwood Forests, Bottomlands		
Wet-Mesic Forests		
Amblyscirtes hegona		
Anthocharis midea	0.9	0.85
Eurytides marcellus	0.65	0.9
Feniseca tarquinius	0.55	
Lethe anhedon		

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
Polygonia comma	0.65	0.85
Polygonia interrogationis	0.65	0.8
Vanessa atalanta	0.65	0.65
Wet Hardwood Forests		
Poanes yehl		
Lethe appalachia		0.9
Amblyscirtes aesculapius		
Amblyscirtes carolina		
Lethe creola		
Lethe portlandia		
Count = 14	Sum = 4.05	Sum = 4.95
	BPI = 29%	BPI = 35%

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
III. Pine Forests		
General Pine Forests		
Callophrys niphon		

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
IV. Combined Forested Habitats		
Count = 34	Sum = 12.50	Sum = 11.40
	BPI = 37%	BPI = 34%

As was true for the orthoptera, butterfly species associated with upland forests have a higher Biotic Persistence Index at the White Pines Preserve than at the New Hope/Hollow Rock preserves. This again is likely due to the more extensive and intact upland habitats at the White Pines Preserve. Conversely, the situation is reversed for bottomland forests, with the more extensive habitats along New Hope Creek having the greater persistence of its associated butterflies.

Compared to the orthoptera, a larger number of butterfly species are associated with open fields and shrublands than with forests. As with the orthoptera, however, the BPI values for these habitats are much lower than for the forests due to the much smaller extent of these habitats at

both the White Pines and New Hope preserves, although larger for the New Hope tracts where open habitats are somewhat more extensive.

Table 5. Calculation of Biotic Persistence Index, Open Habitats

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
V. General Open Herblands		
Successional Fields		
Abaeis nicippe		0.1
Anatrytone logan		
Argynnis cybele		0.65
Atrytonopsis hianna		
Burnsius communis		0.65
Cercyonis pegala	0.55	0.1
Colias eurytheme		
Colias philodice		
Cupido comyntas	0.8	0.8
Euptoieta claudia		
Hesperia leonardus		
Hesperia metea		
Hylephila phyleus		0.65
Junonia coenia		0.65
Lerodea eufala		
Nastra lherminier		
Panoquina ocola		
Papilio polyxenes	0.6	0.65
Phoebis sennae	0.55	0.65
Pholisora catullus		
Phyciodes tharos	0.8	0.9
Polites origenes		
Polites themistocles		
Pontia protodice		
Pyrisitia lisa		0.1
Staphylus hayhurstii		
Strymon melinus	0.65	
Vanessa virginiensis		0.8
Wet-Mesic Fields and Edges		
Chlosyne nycteis	0.65	0.8
Lon zabulon	0.8	0.8

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
Polites egeremet		
Polites otho		
Vernia verna		0.65
Leguminous Forb- and Shrublands		
Epargyreus clarus	0.1	0.65
Erynnis baptisiae		
Thorybes bathyllus		
Thorybes pylades		
Dry-Xeric Barrens and Glades		
Amblyscirtes vialis		
Erynnis zarucco	0.10	
Polites vibex		
Erynnis brizo		
Thorybes confusus		
Thorybes lycaides		
Count = 43	Sum = 5.60	Sum = 9.60
	BPI = 13%	BPI = 22%

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
V. Dry-Mesic Shrublands		
General Shrublands and Thickets		
Erynnis martialis		
Satyrus titus		
Callophrys henrici	0.1	
Heath Thickets		
Callophrys augustinus		
Cedar Thickets		
Callophrys gryneus		
Count = 5	Sum = 0.1	Sum = 0
	2%	0%
VI. Combined Open Herblands and Shrublands		
Count = 48	Sum = 5.70	Sum = 9.60
	BPI = 12%	BPI = 20%

For wetland habitats, the number of species is again smaller for both sites, but with higher BPI values for the New Hope Bottomlands:

Scientific Name	Occurrence Probability of Survival	
	White Pines	New Hope Bottomlands/ Hollow Rock
VIII. Wet-Hydric Shrublands and Edges		
Shoreline Thickets		
<i>Limenitis archippus</i>		0.65
IX. Wet-Hydric Herblands		
General Mires		
<i>Ancyloxypha numitor</i>	0.1	0.65
<i>Euphyes dion</i>		
<i>Euphyes vestris</i>		0.65
Count = 4	Sum = 0.1	Sum = 1.95
	BPI = 3%	BPI = 49%

These results demonstrate the importance of the type and extent of habitats in explaining the differences between the two sites in terms of their species composition and, consequently, on the ability of the sites to retain both their species and their ecological interactions.

That insects are not a monolithic group when it comes to their vulnerabilities and consequent conservation needs is shown in the following table, comparing BPI values for butterflies to those for orthoptera, considering both habitat type and the two preserves we investigated.

Table 7. Comparison of BPI Values for Butterflies and Orthoptera

Taxon	Forests		Fields and Shrublands		Wetlands	
	WP	NHB/HR	WP	NHB/HR	WP	NHB/HR
Orthoptera	63%	38%	28%	28%	27%	54%
Butterflies	37%	34%	12%	20%	3%	49%

Although both of these taxonomic groups are primarily herbivorous, or omnivorous in the case of many crickets, butterflies and lepidoptera more generally are more specific in their choice of host plants. Such specificity makes them more subject to co-extinction events: factors that affect their host plants may have devastating impacts to species that are highly dependent upon them (Sánchez-Bayo and Wyckhuys, 2019). Conversely, polyphagous herbivores and omnivores are far less vulnerable.

In order to counter local extirpation events, butterflies and other lepidoptera rely on strong dispersal abilities and rapid population growth; if populations survive anywhere in the area surrounding a site of local, but temporary environmental change affecting the host plants, these insects can quickly regain lost territory. On the other hand, that makes them particularly vulnerable to the effects of habitat fragmentation, one of whose effects is to increase the distances

between habitat patches, making dispersal more-and-more hazardous. In the case of butterflies, the need to fly over human altered habitats runs the risk of bringing individuals into contact with the pesticides used to control crop pests, which include a large number of lepidopteran species.

While there are a few orthopteran species that are highly migratory, at least periodically, many of the species that occur in our area are highly sedentary, including a significant number that have lost their ability to fly. This life-style is possible due both to the wide range of food sources they can utilize and also to their ability to survive environmental disturbances on-site rather than relying on spared refugia. For many of the species that dwell on the ground or in low vegetation, eggs are laid underground and due to their ability to remain dormant for several seasons or even years, provide the same sort of survival abilities that plants have to cope with fire and other short-term disturbances.

Although based on their greater reliance on dispersal, we would expect butterflies to be strongly affected by the intensive development of the lands adjoining the New Hope Bottomlands and Hollow Rock Preserves compared to the far less disturbed landscape at the White Pines Preserve, those effects may simply be outweighed by the differences in habitat types and distributions between the two preserves. In the case of moths – which include the vast majority of lepidopteran species – the effects of intense urbanization on dispersing individuals may be far greater as, in fact, is indicated in the survey results for that group.

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- Hall, S., Sullivan, J. and Schweitzer, D., 1999. Assessment of risk to non-target macromoths after Btk application to Asian gypsy moth in the Cape Fear region of North Carolina. USDA Forest Service, Morgantown West Virginia. FHTET-98-16, 95pp.

MOTHS

David George, Jeff Niznik

Moths, insects of the order Lepidoptera, are among the most diverse forms of life on our planet, with more than 160,000 described species worldwide. Of these, around 11,000 can be found in North America.⁶ North Carolina is particularly rich in moth species diversity due to its great diversity of habitats and plants. Our rapidly growing state checklist currently includes over 3,100 moth species.⁷ Among Lepidoptera, the butterflies receive relatively more attention, though moths are far more diverse⁸ in form and in their life histories, and arguably of greater ecological importance. This lack of attention is due in part to the fact that most moths are active only at night (though there are many exceptions), while butterflies are active during the day and highly visible.

Like butterflies, moths are important pollinators of a wide range of plants, but this is of less importance than the keystone role moths play in terrestrial ecosystems as primary consumers, converting plant biomass to a form usable by secondary consumers. In a typical woodland habitat, moth caterpillars are the largest consumers of plant material. Many animals feed on moths⁹, including birds, bats and other mammals, and predatory insects. Neotropical migratory songbirds are entirely dependent on caterpillars to feed their young. And caterpillars in staggering numbers are required to support a healthy bird population.¹⁰

Moth larvae primarily eat plants,¹¹ and moths and plants have co-evolved over millions of years, with plants developing a variety of chemical and physical defenses against caterpillars, which in turn find ways to overcome these defenses. This ecological arms race has shaped the forms and life strategies of both groups. Because plants are well protected, moths tend to specialize in eating certain types of plants, and most moth species eat plants from only one or a few families. There are many exceptions however, including monophagous or stenophagous species, as well as highly polyphagous species that will eat nearly anything.¹²

Moths are broadly split into the micromoths and the macromoths, categories based on evolutionary history and taxonomy, with micromoths being the more “primitive” group. While useful for general classification, this can be a misleading distinction for a general audience, with numerous examples of “micros” that are quite large, dwarfing the smaller “macros” on the sheet.

⁶ Smithsonian Institution. Moths (Information Sheet Number 169). (accessed 9-27-25).
<https://www.si.edu/spotlight/buginfo/moths>

⁷ 3151, as of September 2025.

⁸ Moths are at least 18 times more diverse in North Carolina, with the state’s current butterfly checklist numbering only 177 species.

⁹ While caterpillars are at greater risk of predation, adult moths are also preyed upon by animals such as bats and birds. Another major threat to larval moths are parasitoids (usually wasps or flies), whose larvae consume the caterpillar from within.

¹⁰ In The Living Landscape, Doug Tallamy estimated that it might take 10,000 caterpillars to fledge a single nest of Carolina Chickadees, with parents bringing up to 500 caterpillars a day.

¹¹ There are numerous exceptions, including species that feed on fungi, algae, or organic detritus.

¹² Monophagous refers to an insect species that eats only a single species of plant. Stenophagous species are not quite as picky, typically eating plants of the same genus (or closely related genera). Polyphagous species eat a wide range of plants.

Until recent decades, the vast majority of study focused on the macromoths, in large part because they are generally easier to collect and identify. Modern technology, including high-resolution macro photography, microscopic dissection, and DNA barcoding, have made possible great advances in the study of micromoths. New micromoth species are continuously being discovered and described.

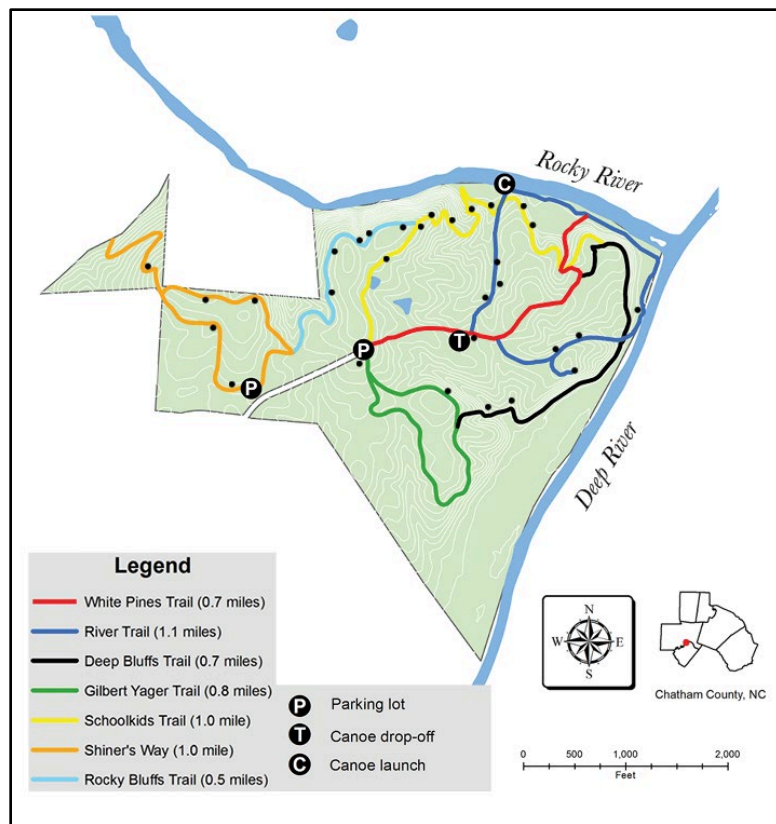
There is also great diversity in the life histories of moths. Larvae often feed on leaves, but range from impressively large caterpillars consuming many leaves, to tiny “leaf-mining” caterpillars that spend their lives inside of a single leaf. Other moths may feed on fungi, lichens, tree algae, dead leaves, or other organic detritus. Because moths exploit nearly every ecological niche and are such an important foundation of the food web, they are excellent indicators of the health of an ecosystem.

Note on species ranks: The Moths of North Carolina website assigns numerical ranks for the conservation status of species found in the state. The most secure species are S5, while the most imperiled are S1. The North Carolina Natural Heritage Program has assigned ranks to a limited number of species, and for these species we list the NHP rank. For species not listed by the NHP, the ranks are shown in brackets, indicating that these are suggested ranks based on our current knowledge. In many cases, our knowledge is too limited to accurately assess conservation status (indicated by a rank of [SU]). For species where there is uncertainty about the rank, we show ranges in the form of S1S2 (for a species that might be either S1 or S2).

SURVEY COVERAGE

Observers: The moth survey was conducted by David George and Jeff Niznik. Also making significant contributions were Tracy Feldman (leaf-mining moths), Jim Petranka (specimen dissection and identification), Rich Teper (trapping, equipment, and specimen mounting), and Stephen Dunn (photographic records and equipment). Others who participated in the moth survey effort include Mark Basinger, Larry Chen, Patrick Coin, Kaitlyn Elliott, Steve Hall, Tom Howard, Carol Tingley, and Sarah Toner.

Survey Trips: Moth sampling was conducted on 20 nighttime survey visits, from April 1, 2024 to April 5, 2025. A full list of survey dates and species counts is available in Appendix K, Table 1.



Survey Locations: Much of the preserve was sampled, including 4 of the 5 natural communities¹³ identified by the NC NHP. Most heavily sampled were the heath bluff above the Rocky River (Rocky Bluffs Trail), the rich mesic slopes around the preserve (Schoolkids, River, Gilbert Yager, and other trails), and the Rocky River floodplain (River Trail). The locations of individual sheets and traps are shown with black dots on the trail map.

METHODS

Moths are mostly nocturnal, and the majority of the survey effort was conducted at night. Moths and many other night-flying insects are attracted to lights, particularly those at certain wavelengths. The primary mode of observation during the survey involved using portable, battery-powered ultraviolet (UV) lights to attract moths to sheets that had been tied between trees. The moths attracted to the lights would land on the sheet, where they could be photographed and collected (if needed for identification). On each visit we set up between two to five sheets at different locations. On four trips, bucket traps¹⁴ were also used to collect specimens.

Moth populations vary greatly over the course of the year, usually reaching a peak in the Piedmont between May and August. Different species may be active (as adults) during a single part of the year, or have multiple generations that span seasons. The species observed in April are

¹³ Dry-Mesic Oak-Hickory Forest (Piedmont subtype), Mesic Mixed Hardwood Forest (Piedmont subtype), Piedmont Levee Forest (Typic subtype), and Piedmont/Coastal Plain Heath Bluff. The Rocky Bar and Shore natural community was not included in the moth survey.

¹⁴ Bucket traps have long been the standard for moth sampling, and have both advantages and disadvantages. Their primary advantage is that they allow for precise quantitative sampling. They also allow for detailed examination of specimens. The biggest downside is that they kill moths, along with a variety of non-target insects. Moths caught in traps are often not in good condition, and this is a particular problem with micromoths. In spite of the disadvantages, we determined it was necessary to do limited trapping in order to make direct quantitative comparisons with previous survey data.

usually quite different from those seen in September. Survey efforts were conducted throughout the year¹⁵ in order to assess the full species diversity.

David, Jeff, and others used cameras with macro lenses to photograph moths on the sheets. Images were then edited and organized, and the subjects identified to species (when possible¹⁶), with the help of Jim Petranka and Steve Hall. All records were entered into the Moths of NC database, and are accessible to the public on the website. In addition to the moths collected in bucket traps on four dates, a small selection of moths were collected from the sheets. On two trips, bait was used to attract moths to trees.¹⁷ While the primary focus was on adult moths, larval searches were also made during the survey trips. In addition to David and Jeff's survey efforts, Tracy Feldman visited White Pines to survey leaf-mining insects, which include a large number of moth species.¹⁸

RESULTS

Species Diversity

A total of 804 species¹⁹ were recorded at the preserve during the year-long survey. This included 283 new records for Chatham County, two new state records, and 17 species that had not previously been documented in the Piedmont. Taxonomic diversity included species from 49 families and 475 genera. Of the recorded species, 411 were micromoths and 384 macromoths. A breakdown of records by family is available in Appendix K, Table 2. The full species list can be found in Appendix K, Table 5, which includes the number of dates observed and total counts for each species.

Because no previous moth survey work had been done at White Pines, we cannot make a direct comparison with historic data from the site. The NCBP's New Hope Bottomlands survey was conducted over a year-long period and in a similar format, so offers the most direct comparison, though its location in an urban area and lower diversity of habitats make it significantly different

¹⁵ With the exception of the winter months. While relatively few moths are active during the winter, there are a number of exceptions that can only be seen at this time of year. Due to these early flight dates, these species would not have been observed during the survey.

¹⁶ Many moths cannot be reliably identified from a photograph. In some cases, these species can be determined by a close, detailed inspection, or by good images of specific body elements (such as hindwing pattern or antennal structure). More often, dissection of a specimen is required. Moths that are indistinguishable in external appearance usually have marked differences in their internal structures. Of primary importance in moth identification are the internal genitalia, which are usually quite distinct between species. Specimens of particular interest were sent to Jim Petranka, who carried out the dissections and in many cases was able to determine the species by comparing the genitalia with reference images from literature (as well as the many contributed by Bo Sullivan, accessible on the Moths of NC website).

¹⁷ Bait consisting of rotting fruit and fermented alcohol was painted on the trunks of trees. Certain species of moths can at times be attracted in large numbers with this technique.

¹⁸ The counts for the leaf-mining species are included in the moth totals, but these species are not discussed in this section. See the Leaf-mining insect section.

¹⁹ This number does not include 82 distinct specimens which could be determined to genus but not species level. In many cases, these are probably species not included in the total, and this is certainly the case for those in genera for which there were no species-level records.

from White Pines. Two other site locations, Mason Farm Biological Reserve in Orange County and the Jordan Game Lands in Chatham County, also have high-quality habitats, and were the subject of independent survey efforts by David George and Jeff Niznik over the years preceding the White Pines survey. While both sites are also quite different from White Pines in terms of habitats, they offer the most direct comparison in terms of how the survey work was conducted.²⁰ Roughly the same number of survey trips were made to each site (with the exception of Mason Farm).

Site	Trips	Species ²¹
Jordan Game Lands	18	412
Mason Farm Biological Reserve	11	389
New Hope Bottomlands	18	323
White Pines Nature Preserve	20	804

The total species diversity observed at White Pines was far greater than seen at any of the other Piedmont sites. This diversity included nearly every family, as seen in the table below:

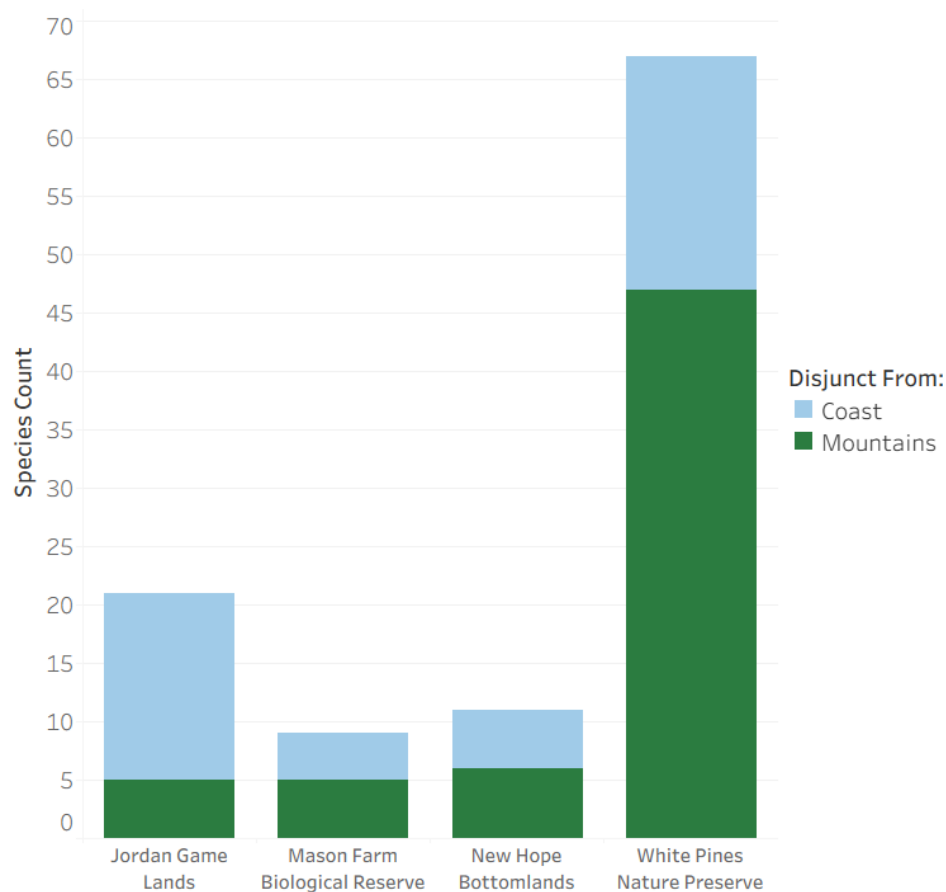
Superfamily	White Pines	New Hope	Mason Farm	Jordan Lake
Adeloidea	3	4	2	0
Bombycoidea	24	3	12	14
Copromorphoidea	1	0	0	0
Cossoidea	2	0	0	1
Drepanoidea	3	0	1	0
Eriocranoidea	1	1	0	1
Gelechioidea	78	36	43	40
Geometroidea	97	31	39	56
Gracillarioidea	44	32	11	4
Incurvarioidea	1	0	1	0
Mimallonoidea	1	0	0	0
Nepticuloidea	13	11	3	2
Noctuoidea	260	93	147	139
Pterophoroidea	1	0	0	2
Pyraloidea	123	53	70	78
Sesioidea	1	0	0	0
Tineoidea	29	11	17	18

²⁰ The New Hope Bottomlands moth survey was conducted by Steve Hall and relied primarily on trapping. Tracy Feldman also surveyed leaf-mining moths at the bottomlands.

²¹ Leaf-miner surveys were not conducted at Mason Farm or the Jordan Game Lands, which could add dozens of species to the totals for these sites. During the New Hope Bottomlands survey, the focus was on macromoths, and not as many of the micromoths may have been counted.

Superfamily	White Pines	New Hope	Mason Farm	Jordan Lake
Tischerioidea	2	5	0	2
Tortricoidea	93	36	34	41
Urodoidea	1	0	0	1
Yponomeutoidea	6	3	1	6
Zygaenoidea	20	3	9	7
Other	0	1	1	0
TOTAL	804	323	389	412

Of the species observed at White Pines, 67 are not ones that would be expected in this part of the state.²² Most (47) were species that are found primarily in the mountains in North Carolina, including three species that had not previously been recorded outside the mountains. But there were also 20 species with a primarily coastal distribution, four of which had not been documented outside the Coastal Plain. This number is considerably greater than seen in our previous surveys in the region.

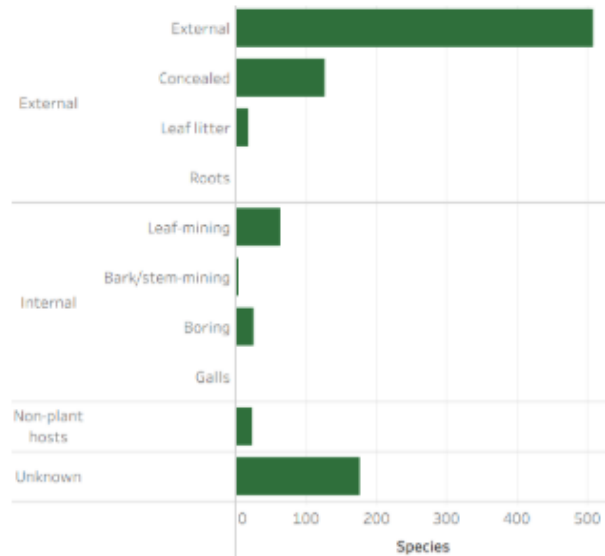


²² These are species where nearly all of the previous records in North Carolina had been either from the coast or the mountains.

Life Histories and Hosts

The species observed at White Pines were diverse in terms of their life histories. Nearly two-thirds are external feeders on plant tissues. Of these, 127 are concealed feeders, rolling up, folding, or tying together leaves, or constructing some other form of feeding shelter. There were at least 19 species that feed on dead leaves in the leaf litter. Another 3 percent do not feed on living plants, with hosts including fungi, lichens, algae, and organic detritus. Almost 12 percent of the recorded species are internal plant feeders, primarily leaf-miners and borers. There is still a great deal to learn about moth-host plant relationships, and the larval ecology is undocumented for nearly a quarter of the recorded species. During the survey, larvae (or evidence of larval feeding in the case of internal feeders) were observed for 95 species.²³

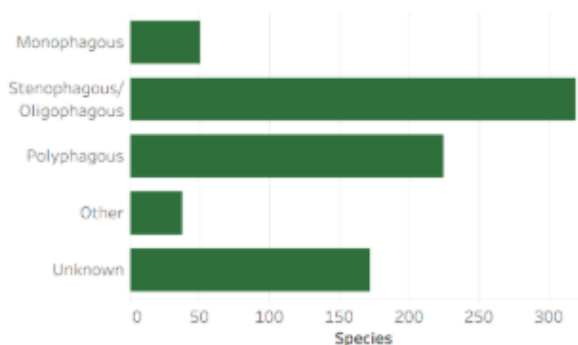
Feeding Style	Species	Percent
External	508	63.84%
- Concealed	127	15.80%
- Leaf litter	19	2.36%
- Roots	1	0.12%
Internal	95	11.82%
- Leaf-mining	64	7.96%
- Bark/stem-mining	4	0.50%
- Boring	25	3.11%
- Galls	2	0.25%
Non-plant hosts	24	2.99%
Unknown	177	22.01%



The great diversity of plants at White Pines is certainly a key part of the moth diversity at the preserve, and the species recorded have a wide range of host plant preferences. The majority of the species (370) with known hosts rely on only one or a few genera of plants. Of these, 51 species are monophagous, feeding only on a single plant species. There were also a significant number (224) of polyphagous species. While most of the species are herbivores, there are also 38 that do not feed on living plants, including detritivores and fungivores. For nearly a quarter (172) of the species recorded at the preserve, the larval hosts are unknown.

²³ These species are marked on the species list in Appendix K, Table 5. They include leaf-mining moths recorded by Tracy Feldman.

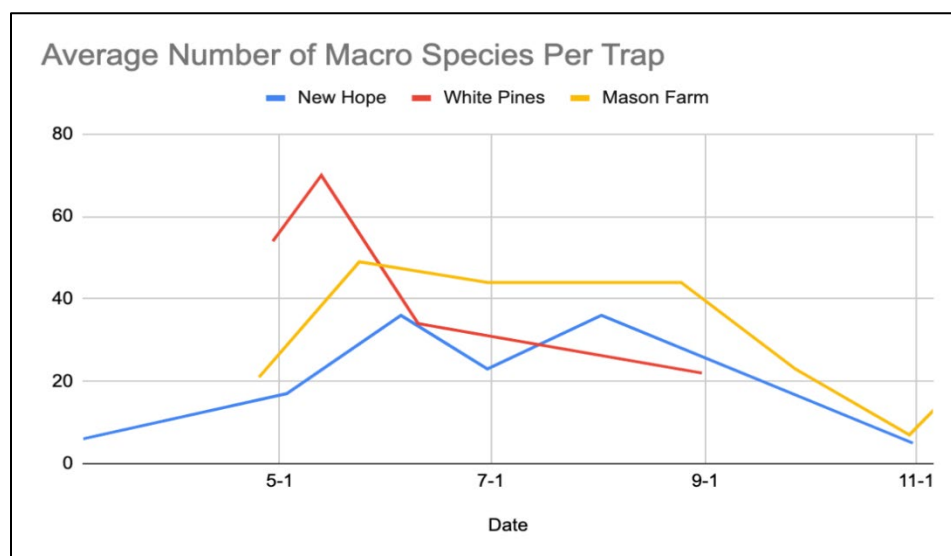
Host Specificity	Species	Percent
Monophagous	51	6.34%
Stenophagous/Oligophagous	319	39.68%
Polyphagous	224	27.86%
Other (detritus, fungi, etc.)	38	4.73%
Unknown	172	21.39%
TOTAL	804	



For the 51 monophagous species there are 24 different host plants, among the most significant of which are American Witch-hazel (*Hamamelis virginiana*, 7 species) and American Sycamore (*Platanus occidentalis*, 6 species). Of particular significance were two host plants that are not typically found in the Piedmont. Eastern White Pine (*Pinus strobus*) is host to two of the monophagous species, and American Basswood (*Tilia americana*) is host to three of the monophagous species. A full list of hosts for the monophagous species is available in Appendix K, Table 4.

Sampling Data Analysis

While sheet sampling was the focus of the survey efforts, traps were also used on four visits to White Pines. For logistical reasons, only the first two of these dates represent a full night's worth of trapping.²⁴ The numbers in the traps compare favorably to survey data from the New Hope Bottomlands and Mason Farm Biological Reserve.²⁵

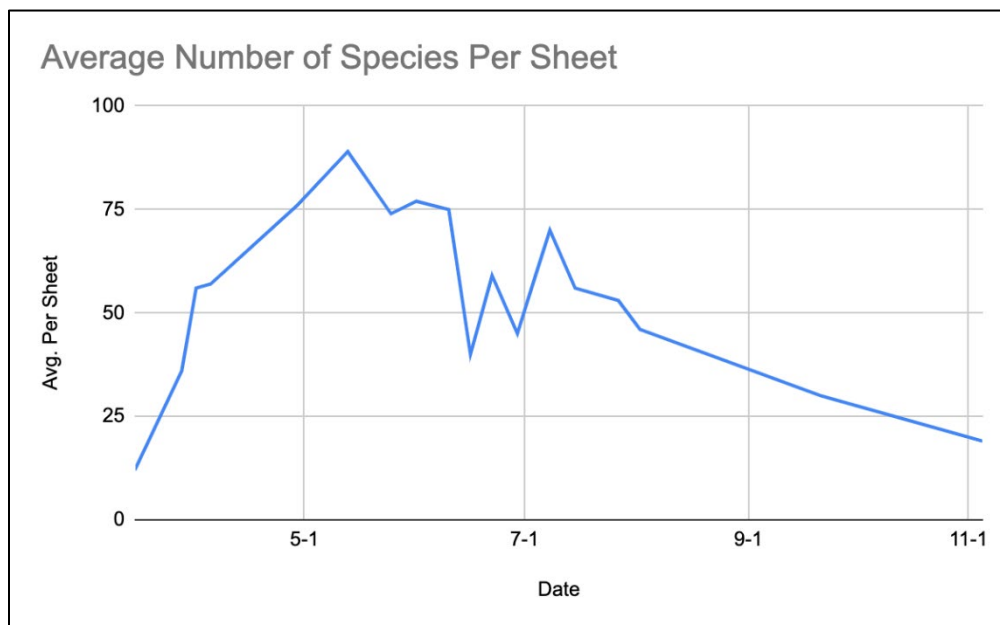


²⁴ On the third date, the trap was taken in due to an approaching storm. On the fourth date, we decided to leave early due to unseasonably cool temperatures.

²⁵ Steve Hall sampled with bucket traps at Mason Farm in Orange County from 2005 to 2007. Because the New Hope and Mason Farm surveys focused on macromoths, we use only the total species of macros here for comparison.

The peak of 70 macro-moth species in the trap at White Pines on May 13, 2024 was considerably greater than the highest counts for New Hope (36) or Mason Farm (49). Totals for the last two dates are lower than expected, though as previously mentioned they do not represent a full night worth of trapping. Still, they are comparable to the numbers seen during the New Hope survey. Many factors, particularly weather and moon phase, can affect trap counts, so there is a degree of natural variability that can only be compensated for with repeated trapping at the same sites. While more trapping data from White Pines (and the other sites) is needed for a true comparison, the high species counts from the first two traps do seem to indicate significantly greater diversity than seen at the other two sites.

The phenology observed during the White Pines survey followed an expected pattern, with peak diversity and abundance occurring during a spring “flush” period. Numbers remained high throughout the summer, with a typical dip in early summer followed by a second peak and then a steady decline in the late summer and fall. This is illustrated in a graph showing the average number of species observed per sheet on our trips over the course of the survey.

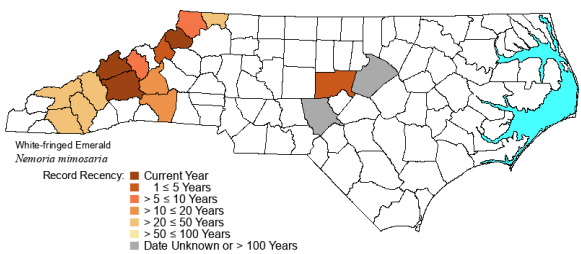


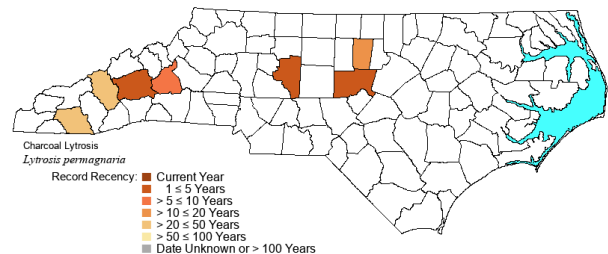
Significant Species

Among the 804 species recorded at White Pines were many of conservation interest, either due to their rarity in the state or being found outside of their typical range. The following is a partial list of significant species, grouped by family. There were many more species of interest recorded, as can be seen in Appendix K, Table 3.

Geometridae

Diversity was particularly high among the geometer moths, whose larvae are the familiar “inchworms,” with 97 species recorded at White Pines.

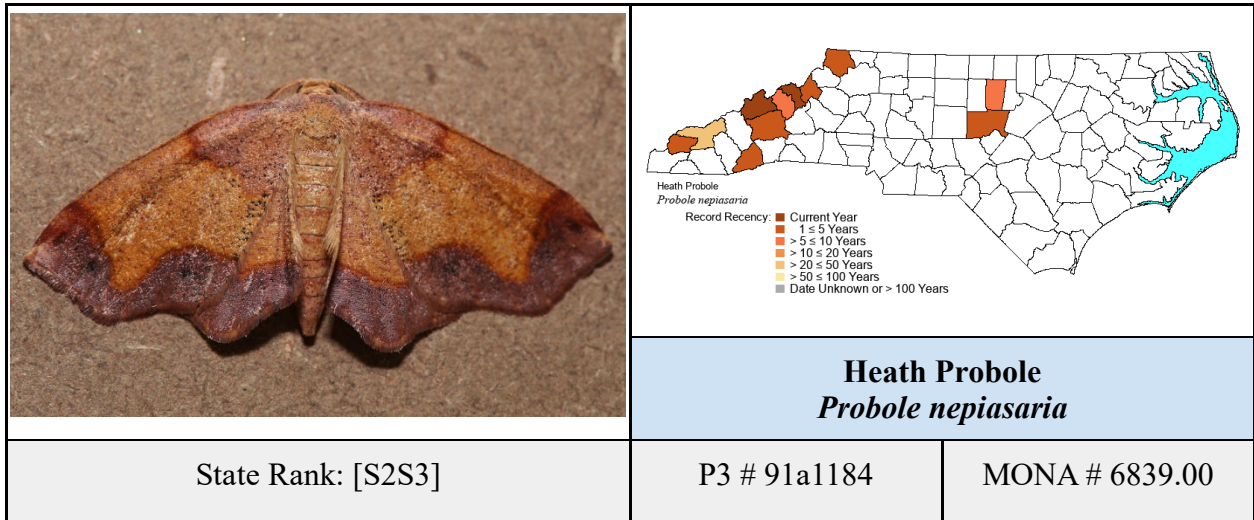
	 White-fringed Emerald <i>Nemoria mimosaria</i> Record Recency: ■ Current Year ■ 1 ≤ 5 Years ■ > 5 ≤ 10 Years ■ > 10 ≤ 20 Years ■ > 20 ≤ 50 Years ■ > 50 ≤ 100 Years ■ Date Unknown or > 100 Years	
State Rank: [S3S4]	P3 # 91a0636	MONA # 7048.00
<u>Larval Hosts:</u> Reportedly feeds on a wide variety of hardwood trees and shrubs, as well as conifers.²⁶ We do not have any feeding records in North Carolina.		
<u>Comments:</u> Almost exclusively a mountain species in North Carolina, this was the first record in the Piedmont since at least 1938.²⁷ Nearly all of our records come from stands of mesic, montane forests. This species is potentially vulnerable to the effects of climate change, particularly in the Piedmont.		

	 Charcoal Lytrosis <i>Lytrosis permagnaria</i> Record Recency: ■ Current Year ■ 1 ≤ 5 Years ■ > 5 ≤ 10 Years ■ > 10 ≤ 20 Years ■ > 20 ≤ 50 Years ■ > 50 ≤ 100 Years ■ Date Unknown or > 100 Years	
State Rank: S2S3	P3 # 91a1203	MONA # 6723.00
<u>Larval Hosts:</u> Larval hosts have apparently not been documented.		
<u>Comments:</u> A rare species in North Carolina, with only three Piedmont site records. This record is apparently the farthest east the species has been recorded. <i>Lytrosis permagnaria</i>		

²⁶ Wagner et al., 2001

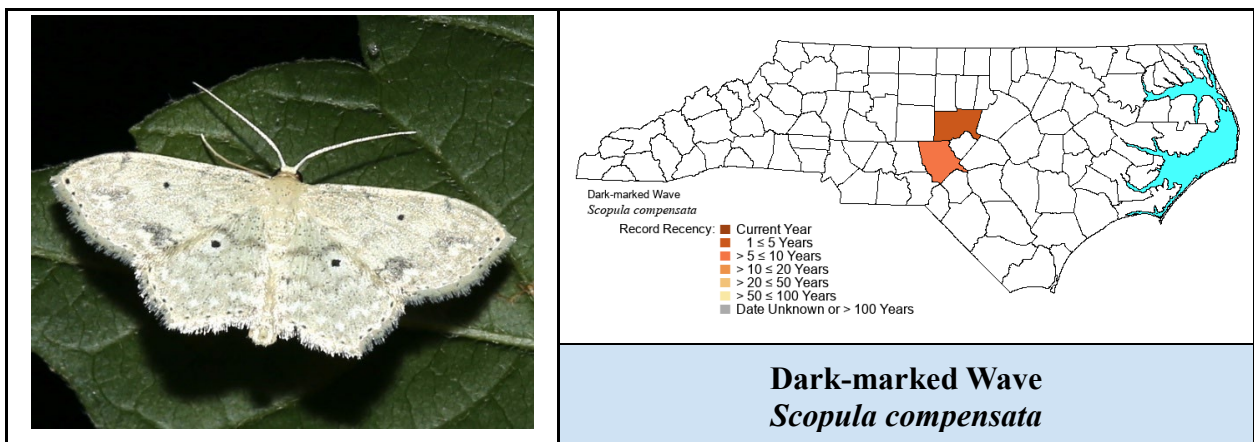
²⁷ Brimley, 1938

occurs in highly localized populations, but is associated with habitats that occur more widely in our state. The reasons for this sparsity are unknown. Until larvae are found feeding in the wild, the ecological relationships of this species remain obscure.



Larval Hosts: Larvae feed on heaths, including azaleas (*Rhododendron*) and Mountain Laurel (*Kalmia*).²⁸

Comments: It is unclear whether *Probole nepiasaria* represents a distinct species from *P. amicara*, but in North Carolina there are morphological and biogeographical differences that suggest they should be treated as at least distinct types. *P. nepiasaria* has only been recorded at two sites in the Piedmont, including White Pines. Piedmont populations apparently occur as disjuncts associated with heath thickets growing on steep north-facing slopes.

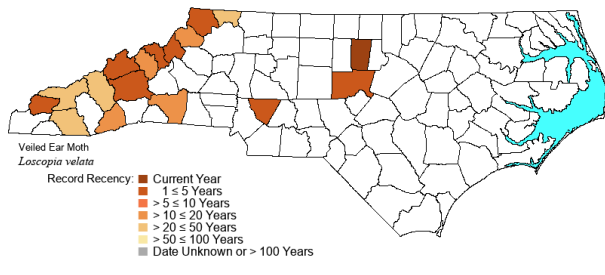


²⁸ Wagner et al., 2001

State Rank: [S1S2]	P3 # 91a0097	MONA # 7152.00
<u>Larval Hosts:</u> The hosts are apparently undocumented.		
<u>Comments:</u> <i>Scopula compensata</i> is a southern species that seems to be in the process of establishing populations in North Carolina. We currently only have two site records in the state, at White Pines and a site in the Sandhills (Moore County). Climate change may play a role in its spread in NC, but it is currently very rare in the state.		

Noctuidae

The Noctuidae were also well represented at the preserve, with 103 species recorded.

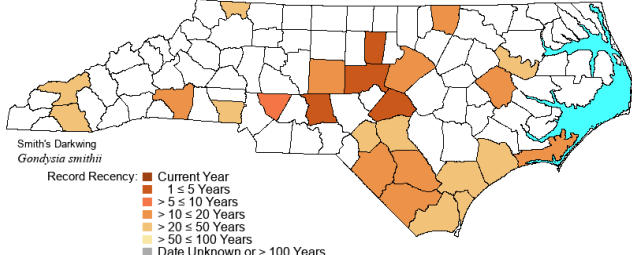
		
	Veiled Ear Moth <i>Loscopia velata</i>	
State Rank: [S3S4]	P3 # 932358	MONA # 9454.00
<u>Larval Hosts:</u> Larvae feed on grasses, ²⁹ and have been recorded on a <i>Juncus</i> species in North Carolina.		
<u>Comments:</u> While relatively common in the North Carolina mountains, we only have a few records for the species from the Piedmont. Most of our records come from cove forests and high elevation forests. More study is needed of the Piedmont populations, which may represent the southeastern extreme of its range.		

²⁹ Wagner et al., 2011

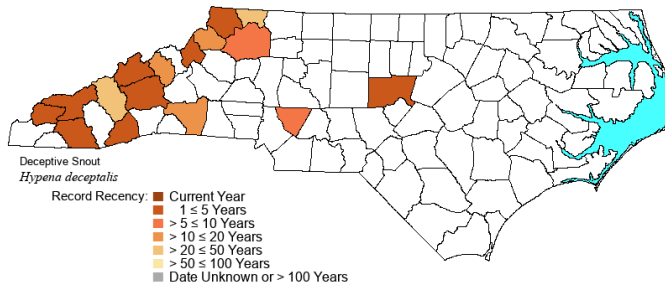
		
	Orange-banded Tripudia <i>Tripudia flavofasciata</i>	
State Rank: SU [S2S3]	P3 # 931268	MONA # 9009.00
<u>Larval Hosts:</u> The host plants are apparently undocumented.		
<u>Comments:</u> A rare species throughout its range, <i>T. flavofasciata</i> seemed to be restricted to alluvial forests in the Coastal Plain before it was discovered in the Piedmont at White Pines.		

Erebidae

Erebidae was the most diverse family of moths at White Pines, with 118 species recorded during the survey.

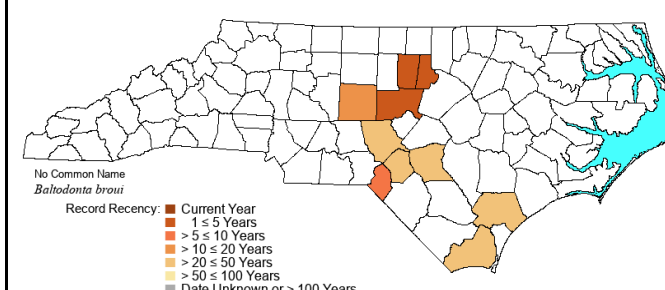
		
	Smith's Darkwing <i>Gondysia smithii</i>	
State Rank: [S3S4]	P3 # 930959	MONA # 8726.00
<u>Larval Hosts:</u> Larvae feed on snowbell (<i>Styrax</i>) species.		
<u>Comments:</u> Although quite rare over much of the Piedmont, this species is locally common at White Pines, particularly along the cool, moist slopes. During the survey, larvae were reared from Bigleaf Snowbell (<i>Styrax grandifolius</i>), a species associated with mesic hardwoods. This		

was the first confirmed host recorded for the species. Identification of the specimen required dissection, which was performed by Jim Petranka.

	 Deceptive Snout <i>Hypena deceptalis</i> Record Recency: ■ Current Year ■ 1 ≤ 5 Years ■ 5 ≤ 10 Years ■ 10 ≤ 20 Years ■ 20 ≤ 50 Years ■ 50 ≤ 100 Years ■ Date Unknown or > 100 Years	
State Rank: [S4S5]	P3 # 930567	MONA # 8446.00
<u>Larval Hosts:</u> Feeds on American Basswood (<i>Tilia americana</i>),³⁰ which is rare in the eastern Piedmont, restricted to rich, mesic forest slopes at scattered sites.		
<u>Comments:</u> This is our first record for the species from the eastern Piedmont. It may represent a disjunct population from its typical range in the mountains.		

Notodontidae

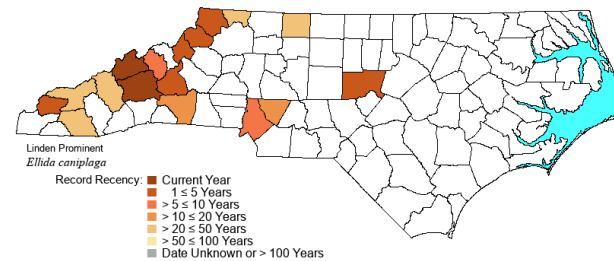
The prominent moths were well represented, with 28 species recorded during the survey.

	 No Common Name <i>Baltodonta broui</i> Record Recency: ■ Current Year ■ 1 ≤ 5 Years ■ 5 ≤ 10 Years ■ 10 ≤ 20 Years ■ 20 ≤ 50 Years ■ 50 ≤ 100 Years ■ Date Unknown or > 100 Years	
State Rank: S2S3	P3 # 930063.5	MONA # 7971.10

³⁰ Wagner et al., 2011

Larval Hosts: Larvae feed on snowbell (*Styrax*) species. Previously, it was known only from American Snowbell (*S. americanus*), but Jeff Niznik collected and reared larvae from Bigleaf Snowbell (*S. grandifolius*) during the White Pines survey.

Comments: Primarily a blackwater habitat specialist of the Coastal Plain, it is typically found along small streamhead bottomlands or beaver ponds. It is a rare species in the state, particularly in the Piedmont, and its host plants are relatively uncommon. Because of its host plant and habitat specializations, it should be considered a species of conservation concern.



Linden Prominent
Ellida caniplaga

State Rank: [S3S4]

P3 # 930051

MONA # 7930.00

Larval Hosts: Larvae feed exclusively on American Basswood (*Tilia americana*),³¹ which is rare in the eastern Piedmont.

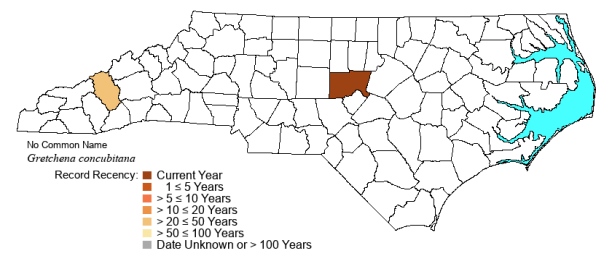
Comments: A host plant specialist, it is relatively common in the mountains but quite rare in the Piedmont, apparently restricted to a few high quality mesic habitats where Basswood can be found. This was the first record from the eastern Piedmont. Due to the host plant specialization and rarity in this part of the state, the White Pines population should be considered of conservation concern.

³¹ Wagner, 2005

Tortricidae

93 Tortricidae species were recorded during the survey.

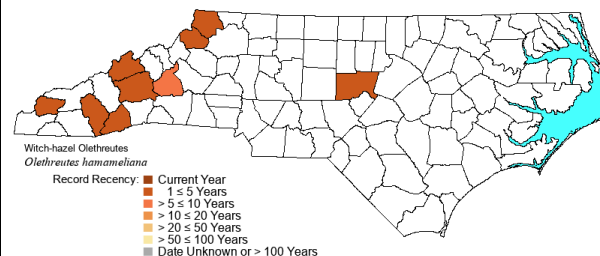
	 No Common Name <i>Cagiva cephalanthana</i> Record Recency: ■ Current Year ■ 1 ≤ 5 Years ■ 6 ≤ 10 Years ■ 11 ≤ 20 Years ■ 21 ≤ 50 Years ■ 51 ≤ 100 Years ■ Date Unknown or > 100 Years <i>Cagiva cephalanthana</i>	
State Rank: [SU]	P3 # 51a0178.1	MONA # 3818.00
<u>Larval Hosts:</u> The host plants are apparently undocumented.		
<u>Comments:</u> The first state record for this species. A rare species with few records anywhere in its range, little is known about its lifecycle or habitats. The White Pines population could represent a significant disjunct, but more needs to be learned about its presence in North Carolina before its conservation status can be assessed.³²		

	 No Common Name <i>Gretchena concubitana</i> Record Recency: ■ Current Year ■ 1 ≤ 5 Years ■ 6 ≤ 10 Years ■ 11 ≤ 20 Years ■ 21 ≤ 50 Years ■ 51 ≤ 100 Years ■ Date Unknown or > 100 Years <i>Gretchena concubitana</i>	
State Rank: [S1S3]	P3 # 51a1168	MONA # 3260.00

³² The Moth Photographers Group distribution map shows records in the Midwest from Texas north into Indiana, as well as New England and southern Florida. There are no records shown for the Southeastern states.
<https://mothphotographersgroup.msstate.edu/species.php?hodges=3260.00>

Larval Hosts: Reportedly feeds on hickory,³³ but this needs confirmation.

Comments: Only the second site record in North Carolina, and the first in the Piedmont. Apparently quite rare in the state, but probably undersampled due to its early flight date. More study is needed to determine the habitats and host plants used in NC.



Witch-hazel Olethreutes
Olethreutes hamameliana

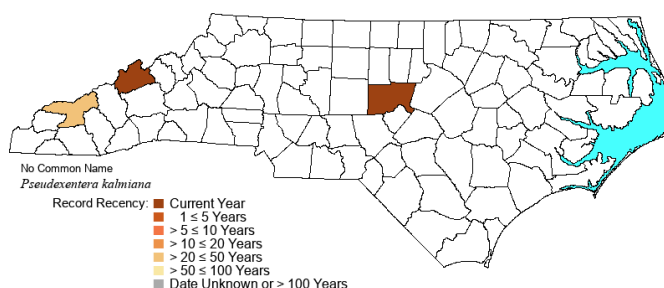
State Rank: [S2S4]

P3 # 51a0572

MONA # 2804.00

Larval Hosts: Larvae reportedly feed exclusively on American Witch-hazel (*Hamamelis virginiana*).³⁴

Comments: An uncommon species in North Carolina, it had not previously been documented in the Piedmont. In the mountains, it can be locally common in mesic forests and forest openings and edges where Witch-hazel is present.



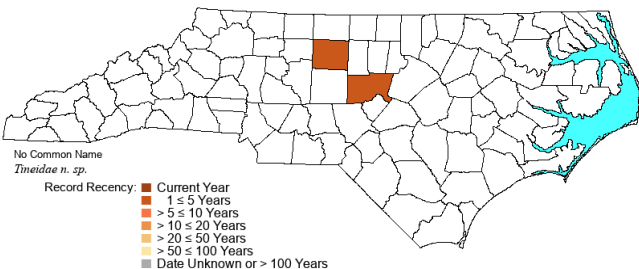
Pseudexentera kalmiana

³³ Heinrich, 1923

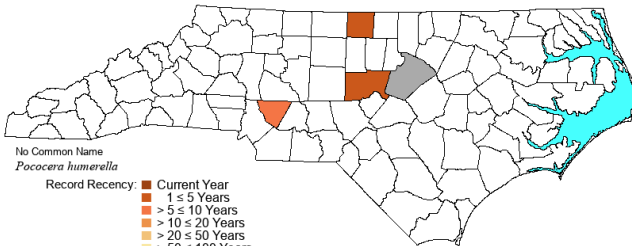
³⁴ MacKay, 1959

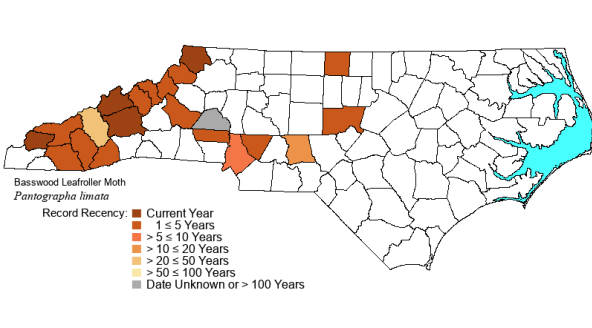
State Rank: [S1S3]	P3 # 51a1160	MONA # 3255.00
<u>Larval Hosts:</u> Larvae reportedly feed on <i>Kalmia</i> species. ³⁵		
<u>Comments:</u> Apparently a very rare species in North Carolina, this was only the second state record and the first in the Piedmont. The NC populations seem to represent a major disjunct from populations in the Great Lakes region and New England. Identification of the species requires dissection, which was carried out by Jim Petranka. More information is needed about the habitats used in NC and the rarity of the species in our region.		

Other Micromoths

		
	Tineidae new species	
State Rank: [SU]	P3 # 300223.86n	MONA # 434.96
<u>Larval Hosts:</u> The hosts and life history of the species are unknown. Most Tineidae species do not feed on living plants, but consume fungi, lichens, or organic detritus.		
<u>Comments:</u> An undescribed species (which has yet to even be assigned a genus), there are few records and little is known about its habitats or life history. This was the first state record for the species.		

³⁵ Ferguson, 1975

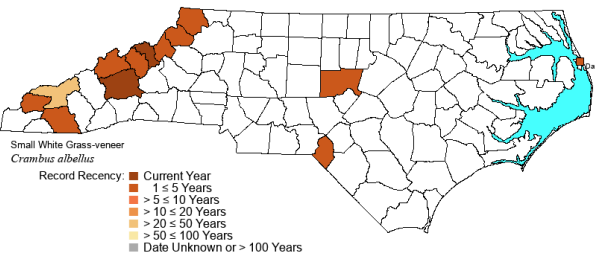
	 No Common Name <i>Pococera humerella</i> Record Recency ■ Current Year ■ 1 ≤ 5 Years ■ 5 ≤ 10 Years ■ 10 ≤ 20 Years ■ 20 ≤ 50 Years ■ 50 ≤ 100 Years ■ Date Unknown or > 100 Years	
<i>Pococera humerella</i>		
State Rank: [S1S2]	P3 # 80a0662	MONA # 5617.00
<u>Larval Hosts:</u> Host plants have apparently not been documented. Members of the genus feed on a wide range of plants.		
<u>Comments:</u> Formerly considered a historical species in North Carolina, it was not observed in the state between 1938 and 2020. We only have a few modern records for <i>P. humerella</i> , which seems to be very rare in the Southeast. More research is needed into the habitats and host plants used in our state.		

	 Basswood Leafroller Moth <i>Pantographa limata</i> Record Recency: ■ Current Year ■ 1 ≤ 5 Years ■ > 5 ≤ 10 Years ■ > 10 ≤ 20 Years ■ > 20 ≤ 50 Years ■ > 50 ≤ 100 Years ■ Date Unknown or > 100 Years	
Basswood Leafroller Moth <i>Pantographa limata</i>		
State Rank: [S4S5]	P3 # 80a0936	MONA # 5241.00
<u>Larval Hosts:</u> Larvae feed on American Basswood (<i>Tilia americana</i>).³⁶ Basswood is relatively common in the mountains, but is rare in the eastern Piedmont and absent from much of the Coastal Plain.³⁷ While Basswood is considered secure in the state, local populations in the Piedmont and Coastal Plain may be vulnerable to the effects of climate change.		

³⁶ Forbes, 1923

³⁷ Vascular Plants of North Carolina website: https://auth1.dpr.ncparks.gov/flora/species_account.php?id=2742

Comments: While locally common in the mountains and foothills, *Pantographa limitata* is rare in the Piedmont, limited to a small number of rich mesic forest sites where Basswood can be found. This was the farthest east the species has been documented in NC. Given that the range of Basswood in the state extends east all the way to the southern coast, the existence of the host plant does not seem to be the only factor determining the range of *P. limitata*.

	 Small White Grass-veneer <i>Crambus albellus</i> Record Recency: ■ Current Year ■ 1 ≤ 5 Years ■ > 5 ≤ 10 Years ■ > 10 ≤ 20 Years ■ > 20 ≤ 50 Years ■ > 50 ≤ 100 Years ■ Date Unknown or > 100 Years	
Small White Grass-veneer <i>Crambus albellus</i>		
State Rank: [S3S4]	P3 # 80a1571	MONA # 5361.00
<u>Larval Hosts:</u> The hosts of this species are apparently undocumented, but are thought to be grasses based on the food preferences of other members of the genus.		
<u>Comments:</u> This was the first Piedmont record for this species, which is restricted primarily to the mountains in North Carolina (though we also now have two records from the Coastal Plain). More research is needed into its habitat preferences and host plants.		

DISCUSSION

White Pines Nature Preserve appears to have very high moth diversity, particularly relative to other Piedmont sites. Data from traps and sheets support our personal impressions from the survey, with moths in greater abundance than we are used to seeing in this part of the state. This moth diversity is made possible by the great diversity of habitats and host plants at the preserve. The other survey sites used in the data comparison are primarily bottomland habitat, so would be expected to be inhabited by fewer species, and this was certainly the case, with hundreds more species recorded at White Pines than at the other sites.

In addition to the diversity of habitats and plants, the high moth diversity at White Pines is likely due to its relative remoteness from urban development, which has overtaken most of the eastern Piedmont. Particularly noticeable is the relative lack of light pollution, with night skies at the preserve considerably darker than can be seen in most of the Triangle area.³⁸ The old, towering trees also form a dense canopy, blocking sky glow and moonlight and allowing lights used for the

³⁸ The urban area to the north of the preserve centered around the cities of Raleigh, Durham, and Chapel Hill.

survey to stand out and attract more moths. Light pollution is one of the factors indicated in global declines in moth populations, and probably has a significant impact at the New Hope Bottomlands and other sites adjacent to urban development. Other factors negatively impacting moth populations, including the use of pesticides, introduction of invasive species, and air and water pollution seem to be having less impact at White Pines than in most of the Piedmont. One of the suspected factors in the low diversity seen at the New Hope Bottomlands were changes in flooding patterns resulting from urban land use and climate change. Increases in flood frequency or intensity may also be a concern at White Pines for species inhabiting the floodplains along the Rocky and Deep Rivers.

Because no prior moth survey work had been done at White Pines, we do not have a clear picture of the state of the moth populations at the preserve. Currently they seem quite healthy, particularly compared to the other survey sites, both in terms of species diversity and quantity. But we do not know if these populations are relatively stable or are in decline, as they are at the New Hope Bottomlands and much of the rest of the world. To accurately assess population trends, follow-up sampling is needed over the coming years.

The high diversity of moth species at the preserve is dependent on the continued existence of the unique microhabitats and plant communities at the preserve, particularly along the steep bluffs and cool mesic slopes that serve as an isolated refuge for species usually not found outside the mountains in North Carolina. Climate change can be expected to have a major impact on these habitats, and ultimately may lead to the loss of these disjunct moth populations. The health of the moth populations will also depend on the preserve's continued isolation from the negative impacts of human development.

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LEAF MINERS

Tracy S. Feldman, freelance ecologist

INTRODUCTION

Leaf or stem miners are insects that burrow (during their larval stages) into leaf or stem tissues of the plants they eat. Beetles in two families, sawflies in at least one family, flies in many families, and moths in many families can be leaf- or stem-miners. They tend to be very small (a few millimeters long) even as adults. A few are miners only in their earlier stages, and exit the mines to feed externally or in tied leaves as older larvae. Leaf and stem miners may pupate in soil, leaf-litter, or in their leaf mines, depending on the species and taxonomic group. Also, they tend to be more specialized in their host (food plant) preferences, feeding on a single species, one genus, or one family. A few are more generalized in their feeding habits.

During four visits in summer 2024, I set out to catalog leaf-mining insects at White Pines Nature Preserve. Leaf-mining insects tend to be under-reported and under-studied, so there are many unknown species, or species with unknown host plants. By focusing on plants with mines, I could potentially find out both host information and leaf-miner identities. As with other herbivores, many leaf-mining insects are relatively specialized to a family or genus of plant hosts. Thus, the large number of plant species may harbor large numbers of leaf mining insects. In addition, I set up 11 “permanent” leaf-miner monitoring plots in which I measured diversity and abundance of leaf-mining insects in a more quantitative way.

METHODS

I visited White Pines on 21 June 2024, 25 July 2024, and 29 August 2024. I walked the School Kids Trail and a few other trails. For the general search, I encountered leaves with mines, I inspected them for signs of living leaf-mining insects. I photographed representative mines of all species I encountered. If I found living insects that were unknown, I put mined leaves in 15-dram plastic snap-cap vials with pieces of damp paper towels in the bottom. If no insects were present, I placed mined leaves in number 1 coin envelopes, folding them if necessary, then pressing the leaves. I identified host plants to species.

I photographed all mined leaf samples and, when insect identities were not known or were unclear, I posted photographs on iNaturalist or on bugguide.net to confirm identities (where possible) with Charley Eiseman. I sent him live specimens to help him confirm their identities.

For the leaf-miner monitoring plots, I set up eleven 10-meter radius plots at arbitrarily determined locations chosen to maximize habitat diversity along the trails, thus hopefully capturing diversity of leaf-mining insects there. In each monitoring plot, I intensively searched vegetation for leaf mines for 30 minutes to assess diversity of leaf miners. For as many species as possible, I counted leaf miners of individual species on 100 host plant leaves, to measure abundance of those miners within the plots.

RESULTS AND DISCUSSION

I found 88 species of leaf-mining insects overall, across sampling dates: 2 beetle species (in two families), at least 21 fly species (in one family), 1 sawfly species, and at least 64 moth species (in 9 families). Thirty-two of the 87 species were not identified to species—of these, six are new species that have not yet been described. I counted the other 26 unknowns as separate species because their morphologies were different and/or their host plants were different than other miners in that genus—some could be narrowed down to a few (or just two) species, but the identities could not be determined without rearing adults. Miners were found on 54 plant hosts.

From the eleven leaf-miner monitoring points, I found an average of 14 species per plot. A species sampling curve calculated from the data show that the number of species is not quite leveling off, suggesting that additional sampling would recover additional species (see Figure 1).

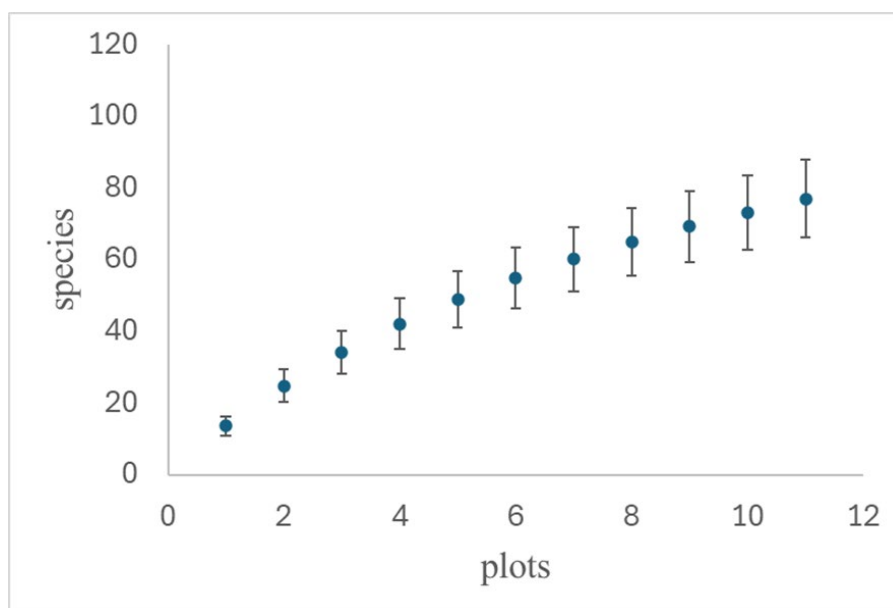


Figure 1. Species sampling curve for White Pines Nature Preserve 2024

There were approximately 0.21 miners per square meter (or one per 5 square meters). The most abundant miners included *Cerodontha dorsalis* (a fly) on *Dichantheium*, a *Phyllonorycter* species (a moth) on *Acer floridanum*, a *Cameraria* species (a moth) on *Quercus*, and *Liriomyza arctii* (a fly) on *Verbesina*.

Table 1. For each taxonomic group, numbers of species found at White Pines in 2024

Order	Family	Number of Species	Potential new species
Coleoptera	Buprestidae	1	
Coleoptera	Curculionidae	1	

Order	Family	Number of Species	Potential new species
Diptera	Agromyzidae	21	
Hymenoptera	Tenthredinidae	1	
Lepidoptera	Bucculatricidae	4	1 (<i>Bucculatrix</i> on <i>Ulmus</i>)
Lepidoptera	Cosmopterigidae	1	
Lepidoptera	Elachista	2	1 (<i>Elachista</i> on <i>Chasmanthium</i>)
Lepidoptera	Gracillariidae	34	1 (<i>Cameraria</i> with central frass on <i>Quercus alba</i>)
Lepidoptera	Heliodinidae	1	
Lepidoptera	Heliozelidae	3	1 (<i>Antispila</i> on <i>Parthenocissus</i>)
Lepidoptera	Momphidae	1	1 (<i>Mompha</i> on <i>Galium</i>)
Lepidoptera	Nepticulidae	12	
Lepidoptera	Tischeriidae	3	
Lepidoptera	Tortricidae	3	1 (<i>Rhopobota</i> on <i>Ilex opaca</i>)
Totals		88	11

My iNaturalist entries for White Pines:

https://www.inaturalist.org/observations?nelat=35.61502608029149&nelng=-79.16030669999999&swlat=35.61232811970849&swlng=-79.1644275&user_id=tracysfeldman&verifiable=any

BEES

Hannah Levenson

Bees are a subgroup (Anthophila) of the stinging wasps (Aculeata), almost the only members of which have become primarily vegetarian rather than preying on other insects. As a group, they arose in the Cretaceous, evolving in concert with the flowering plants that appeared just shortly before. Of all the groups of insects involved in pollination – one of the most important forms of mutualism in almost all terrestrial ecosystems – they have undergone the most changes, specifically related to their gathering and transporting pollen. The bees themselves are working primarily to feed their pollinivorous young but accomplish a significant amount of cross-pollination in the process.

This key ecological relationship is becoming increasingly threatened, however. Not only are honeybees – an old world species – undergoing well-publicized crises, but the much larger group of native bees that play key roles in pollinating our native plant species are also disappearing but almost unnoticed. Given the high degree of ecological importance of this group, they must be included in any comprehensive survey of the biodiversity present in an area devoted to the protection of our native species and ecological processes.

SURVEY METHODS AND COVERAGE

Observers: bee surveys were conducted in 2024 by Hannah Levenson (lead investigator), Ren Rooney, and Jena Ostendorf. Additionally, two historic records based on specimens in the Insect Museum at NCSU are included that we obtained from the Global Biodiversity Information Facility (GBIF.org (16 August 2025) GBIF Occurrence Download <https://doi.org/10.15468/dl.7ycs9x>).

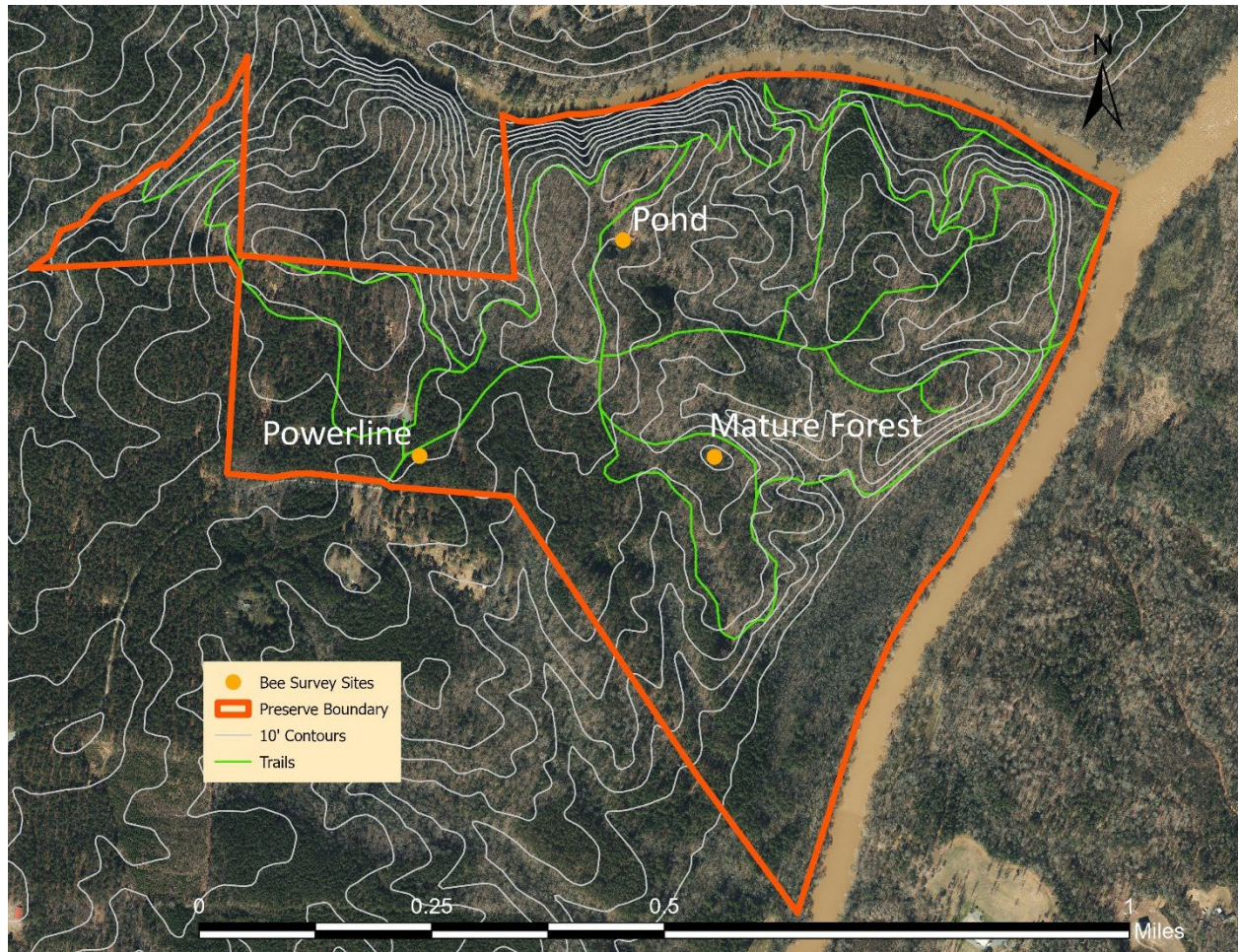
Survey Methods: Two sampling methods were used: bee bowls and hand netting. Sampling using bee bowls involves the use of small cups painted yellow, blue, or white. These are placed on the ground (unobstructed by vegetation) and filled with soapy water. The cups are left for 24 hours and act as a passive sampling tool, capturing insects that are normally attracted to the bright colors of flowers. Bee bowls were placed in three sites to sample different habitat types: open meadow area in the power line right-of-way, closed canopy forest, and nearby a small pond.

Hand netting, as it sounds, involves direct capture of individual bees. The protocol used in this survey involved 1 - 2 people walking around the preserve with hand nets looking for actively blooming flowers and visiting bees. Once a bee is found visiting a flower it is captured with the net and transferred to an individual vial for marking and identification. The plant the bee was collected from was also noted on the vial.

Sampling Schedule and Locations: Both sampling methods were used four times across the active season: April, June, August, September. In April, the three colors of bee bowls were combined into one sample for each of the three sites. In August, a miscommunication between the researcher and the volunteer led to bee bowls being collected by color, rather than by site. Thus, for August,

there is no site information to associate with the collected insects. In June and September, bee bowls were kept separate by color and site.

The three sites chosen for sampling are shown on the following map:



Both the Powerline and Pond sites are somewhat open and support early successional vegetation, with wetland plants additionally present around the small farm pond. The Mature Forest site is located on a dry ridgetop that has a closed canopy consisting of both hardwoods and pines.

RESULTS

Six species of bees were recorded during the survey, with one species added from the GBIF compilation. The number of records obtained for each of these species during the NCBP survey is given in the table below, with an additional record from the NCSU Insect Museum included in parenthesis.

All but two of the records from the current survey were obtained using direct capture. The bee bowls, however, collected a total of 190 other species, including a large number of pollinators. These are listed in Appendix L. Given these results, the apparent scarcity of bees at this site appears to be real rather than a result of sampling intensity. A main reason, as was true for both butterflies and grasshoppers, is the general lack of flower-rich habitats over most of the preserve.

Conservation Significance None of the bee species observed at the White Pines Preserve is considered Significantly Rare by the Natural Heritage Program. All have been recorded at various locations across the state and none are known to have a high degree of habitat or host plant specificity.

Family	Species	Number of Records
Anthophoridae	<i>Anthophora abrupta</i>	(1 historic)
Apidae	<i>Bombus impatiens</i>	8
Ápidae	<i>Ceratina dupla</i>	1
Halictidae	<i>Lasioglossum unidentified species</i>	2
Megachilidae	<i>Hoplitis spoliata</i>	1
Megachilidae	<i>Osmia atriventris</i>	1

AMPHIBIANS

Steve Hall

Frogs are among our most familiar species, although most people would probably be surprised to learn that the thirty-one species we have in North Carolina is among the highest counts in the country. Salamanders are less well-known -- often confused with lizards -- and it is probably even more amazing that our 81 species represent one of the most diverse assemblages in the world. Although the White Pines Preserve has only a fraction of these numbers -- just eight species of frogs and four of salamanders -- one of these species, the Red-backed Salamander, is one of the hallmark species of the preserve, standing alongside the White Pines, Catawba Rhododendrons, and several other species that have survived in isolation at this site since the retreat of the cool climatic conditions they require at the end of the Ice Age.

Ecologically, amphibians play important roles as secondary consumers, particularly as insectivores: true frogs in shoreline habitats, brook salamanders in small streams, toads and salamanders in the leaf litter/woody debris of forest floors, and treefrogs in the shrub, understory, and canopy layers of forests. In those habitats, they are among the most abundant small vertebrates and consequently are themselves important prey items for other vertebrates higher up the food web.

Amphibians in general are among the most threatened groups of vertebrates, especially frogs, many species of which are becoming rare or imperiled across the world due to the spread of a Chytrid fungus. Salamanders are also vulnerable to several amphibian diseases, and the largest family of these species, the Plethodontidae, is particularly vulnerable to both the effects of climate change as well as clear-cutting, wood-chipping, and other impacts to the mesic hardwood forests they inhabit. As non-flying, fairly slow-moving species, all amphibians are vulnerable to the effects of habitat fragmentation, including the construction of roads through their habitats. They are also vulnerable to many environmental toxins due to the highly permeable skins of the majority of their species. The aquatic larvae of many of their species are particularly susceptible and are further vulnerable to changes in the flood regime as well as the impacts of sedimentation resulting from construction projects.

Monitoring the status of amphibian populations is thus critical to assessing the overall integrity and quality of the ecosystems to which they belong. Consequently, they are key targets of the multi-taxa biodiversity surveys conducted by the NCBP.

SURVEY METHODS AND COVERAGE

Observers: Records were provided by several members of the NCBP incidental to their surveys of other taxonomic groups. Main contributors include Steve Hall, David George, and Jeff Niznik. A few additional records from the study area have been entered by other observers into the iNaturalist online database. These record, in turn, have been compiled by the Global Biodiversity Information Facility, of which we have made extensive use (GBIF.org (16 August 2025) GBIF Occurrence Download <https://doi.org/10.15468/dl.7y9s9x>).

Survey Methods: As is true for the orthoptera and birds, frogs can be surveyed by both direct visual search and acoustic recording -- frogs are vocally prominent during the breeding season, which includes mid-winter for some species and stretches until August for others. The majority of our records for this group were made using this method, with recording equipment used in a couple of cases where the choruses were particularly large and involved multiple species. Frogs and especially toads were also noted visually, usually during the course of conducting transects for other taxa or at night in the vicinity of moth sheets.

Salamanders were also occasionally encountered during surveys for other groups but most records involved directly searching under logs. That method unavoidably involves some disturbance to habitats and we used it primarily to do site checks for Red-backed Salamanders, with other species often discovered in the process. No attempt was made to survey for aquatic species.

RESULTS

Sixteen species of amphibians have been recorded at the White Pines Nature Preserve, with fourteen documented during the NCBP survey. The number of records compiled for each of these species is given in the table below, with additional records from other sources are included in parenthesis. Historic records are also included from Swab (1990), and Hall and Boyer (1989).

Order	Family	Species	Number of Records
Anura	Bufonidae	<i>Anaxyrus americanus</i>	2 (1 historic)
Anura	Bufonidae	<i>Anaxyrus fowleri</i>	9 (5 from GBIF, 1 historic)
Anura	Hylidae	<i>Acris crepitans</i>	11 (2 historic)
Anura	Hylidae	<i>Hyla chrysoscelis</i>	5 (2 historic)
Anura	Hylidae	<i>Hyla cinerea</i>	3
Anura	Hylidae	<i>Pseudacris crucifer</i>	(1 historic)
Anura	Hylidae	<i>Pseudacris feriarum</i>	1 (1 historic)
Anura	Ranidae	<i>Lithobates catesbeianus</i>	2 (2 from GBIF, 1 historic)
Anura	Ranidae	<i>Lithobates clamitans</i>	7 (1 historic)
Anura	Ranidae	<i>Lithobates palustris</i>	(1 from GBIF)
Anura	Ranidae	<i>Lithobates sphenoccephalus</i>	(1 historic)
Caudata	Ambystomatidae	<i>Ambystoma maculatum</i>	(1 historic)
Caudata	Ambystomatidae	<i>Ambystoma opacum</i>	1 (1 historic)
Caudata	Plethodontidae	<i>Eurycea cirrigera</i>	3
Caudata	Plethodontidae	<i>Plethodon cinereus</i>	3 (1 historic)
Caudata	Plethodontidae	<i>Plethodon cylindraceus</i>	1 (1 historic)
Caudata	Salamandridae	<i>Notophthalmus viridescens</i>	(1 from GBIF, 1 historic)

Conservation Significance: None of these species, either currently documented or historic, is listed as having any conservation concern by the North Carolina Natural Heritage Program. All are state listed as S5 (Secure).

Noteworthy Species As mentioned previously, the Red-backed Salamander (*Plethodon cinereus*) has regional significance as a montane disjunct, similar in status to the White Pines at this site. This species is relatively common in the northern Blue Ridge but in the eastern Piedmont, it occurs primarily as small, isolated populations associated with steep, north-facing bluffs, usually in association with a number of plant species that are also disjunct from the mountains. As has been proposed for the plants (e.g., Swab, 1990), these disjuncts may have been widespread across the state during the Pleistocene but became isolated – as relicts from that distribution – following the retreat of cool climatic conditions at the end of the Pleistocene.



One other noteworthy species is the Green Treefrog (*Hyla cinerea*). Although all other species recorded during this survey were documented in biological surveys of the newly created White Pines Preserve conducted in the 1980s (Hall and Boyer, 1989; Swab, 1990), the Green Treefrog probably colonized the site fairly recently as part of a major westward expansion of its range from the Coastal Plain, possibly following the re-creation of beaver pond habitats that has been taking place since the 1980s. This species now appears to be well-established in association with the Southern Wild Rice (*Zizaniopsis miliacea*) marsh growing in the Rocky River just upstream from its confluence with the Deep River.



Viability Assessments

Two of the species known only from single, historic records – Spring Peeper and Southern Leopard Frog – are likely residents within the preserve, at least in low numbers, but are left out of the viability analysis due to a lack of confirmed current occurrences. The two species of Ambystomas are also left out, even though the Marbled Salamander has one current record. These species require fish-free pools for their larval development, which have not been documented within the preserve and without which, a residential occurrence cannot be defined.

All other species recorded during the survey appear to have viable occurrences within the preserve. None of them show any evidence of a decline or increase in any known threat. All of these, consequently, are assigned viability ranks higher than E. Five of these species were seen as single individuals on either just a few occasions or were restricted to just a small area within the preserve (e.g., the farm ponds). These are assigned a viability rank of BC, spanning Good to Fair, corresponding to an intermediate probability of survival of 0.65.

The remaining five species were observed on multiple occasions, either during the course of the NCBP survey or over a multiple year period. They were also observed at several locations within the preserve and exhibited evidence of successful reproduction, with both juveniles and adults being present. Three of these species, including the Red-backed Salamander, were assigned viability ranks of AB – Excellent to Good viability – equivalent to a 0.80 probability of survival. Two species – Eastern Cricket Frog and Fowler’s Toad -- had very large populations of both breeding adults and immatures and were observed at several locations throughout the preserve. These were assigned a viability rank of A – Excellent viability – equivalent to a probability of survival of 0.90. No species was regarded as completely secure, however, i.e., having a 1.0 probability of surviving over the next ten years.

Biotic Persistence Analysis

Records compiled for Chatham, Orange, and Durham Counties in the Amphibians of North Carolina website provide a baseline for the species that we expect to occur within the preserve, excluding a few, such as Southern Toad, that are rare within this region. As in our analysis of other taxonomic groups, we compare the results for the White Pines Preserve to those obtained in our previous survey of the New Hope Creek Bottomlands/Hollow Rock Park preserves. Only those species that occur in both Durham and Chatham Counties were included in this comparison. Dwarf Waterdog, a species that is entirely aquatic, was left out of this analysis, although it was recently re-confirmed to exist in Duke Forest just upstream from the Hollow Rock study site.

Table 2. Biotic Persistence Analysis, Frogs and Toads

Scientific Name	White Pines Preserve		New Hope/Hollow Rock Preserves	
	OVR	OPS	OVR	OPS
Frogs and Toads				
<i>Acris crepitans</i>	A	0.90	F	0.10
<i>Anaxyrus americanus</i>	BC	0.65	BC	0.65
<i>Anaxyrus fowleri</i>	A	0.90	BC	0.65
<i>Gastrophryne carolinensis</i>			BC	0.65
<i>Hyla chrysoscelis</i>	AB	0.80	A	0.90
<i>Hyla cinerea</i>	AB	0.80	A	0.90
<i>Hyla squirella</i>				
<i>Lithobates catesbeianus</i>	BC	0.65	CE	0.55
<i>Lithobates clamitans</i>	BC	0.65	AB	0.80
<i>Lithobates palustris</i>	BC	0.65		
<i>Lithobates sphenoccephalus</i>			AB	0.80
<i>Pseudacris crucifer</i>			AB	0.80
<i>Pseudacris feriarum</i>	BC	0.65	A	0.90
<i>Scaphiopus holbrookii</i>				

Scientific Name	White Pines Preserve		New Hope/Hollow Rock Preserves	
	OVR	OPS	OVR	OPS
Count = 14		Sum = 6.65		Sum = 7.70
		BPI = 48%		BPI = 55%

The two species that were missed in both surveys, Squirrel Treefrog and Eastern Spadefoot Toad, are primarily found in the Coastal Plain that have only scattered populations in the eastern Piedmont. Most of the others missed at one or the other site are relatively common and widespread in this region and are likely to be found with greater survey effort. The slight advantage the New Hope Bottomlands apparently has, however, may be explained by its greater number and type of wetland and shoreline habitats.

On the other hand, the difference in viability in the case of the Eastern Cricket Frog (*Acris crepitans*) seems to be very real. This species is easily detected by its song, which is given day or night, and is usually both abundant and ubiquitous wherever there are any natural bodies of water – streams, rivers, marshes, or small pools; at the White Pines Preserve they were observed well away from water along trails running through the uplands. Its essential absence from the New Hope Bottomlands³⁹ is therefore puzzling, but possibly the result of herbicide spraying along the powerline that bisects that preserve.

Table 6. Biotic Persistence Analysis, Salamanders

Scientific Name	White Pines Preserve		New Hope/Hollow Rock Preserves	
	OVR	OPS	OVR	OPS
Salamanders				
Ambystoma maculatum			F	0.10
Ambystoma opacum	CE	0.55	BC	0.65
Eurycea chamberlaini				
Eurycea cirrigera	BC	0.65	BC	0.65
Eurycea guttolineata				
Hemidactylium scutatum			F	0.10
Notophthalmus viridescens	BC	0.65		
Plethodon cinereus	AB	0.80		
Plethodon cylindraceus	BC	0.65	F	0.10
Pseudotriton ruber				
Count = 10		Sum = 3.30		Sum = 1.60
		BPI = 33%		BPI = 16%

³⁹ Cricket Frogs were heard once along the Loop Trail in the year before the survey began and have recently been heard at the beaver pond at the Hollow Rock Park. They were not heard or seen, however, during the survey period, including along the frequently visited Loop Trail.

One of the species missing from both sites, Chamberlain's Dwarf Salamander (*E. chamberlaini*), is again primarily a Coastal Plain species with relatively few and scattered populations in the eastern Piedmont. The other three are more widely distributed in this area and several may turn up with more survey effort, particularly the Three-lined Salamander (*E. guttolineata*) and Red Salamander (*P. ruber*).

Red-backed Salamanders (*P. cinereus*), on the other hand, are found in this region in association with steep, north-facing bluffs or deep ravines. These are prominent features at the White Pines Preserve but are missing from both the New Hope Bottomlands and Hollow Rock Park. Even though a population of this species occurs further upstream in Duke Forest, they are unlikely to be found along the east- and west-facing slopes bordering the New Hope survey sites.

Both Four-toed Salamanders (*H. scutatum*) and Spotted Salamanders (*A. maculatum*) are similarly restricted to particular terrain features: isolated, fish-free pools and/or seeps in the case of the Four-toed Salamanders. These features are now rare to missing in both of survey areas. Although pools in the upper terraces of the New Hope floodplain once supported populations of these species, increased flooding due to development of the adjoining areas now allows more access to these pools by fish, likely having eliminated these two species from the New Hope project area. If so, then those losses, along with the elimination of populations of the Cricket Frogs, can be considered to represent secondary impacts related to urbanization of the area surrounding the New Hope sites.

REFERENCES

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REPTILES

Steve Hall

The term “Reptile” referring to a taxonomic Class has become somewhat muddled due to questions as to whether birds belong or not, representing the last surviving lineage of dinosaurs, or whether warm-blooded, feathered dinosaurs themselves still belong to this class. However, the term still applies to lizards, snakes, turtles, and alligators in the classic sense, as scaly-skinned, cold-blooded, amniotic-egg laying vertebrates, all descended from four-legged, terrestrial ancestors.

Although the three groups included in the White Pines survey -- snakes, lizards, and turtles -- are all familiar species, they elicit widely varying responses among humans: snakes are generally among the most feared group of animals, whereas turtles are usually perceived as among the most harmless -- snapping turtles excepted -- with lizards falling somewhere in between⁴⁰.

With the exception of some of the turtles, several of which feed on plant species, the majority of our reptile species are carnivores. The smaller species of snakes and lizards feed primarily on insects and other small invertebrate animals, and the larger species on other vertebrates, including amphibians, other reptiles, birds, and mammals. They, in turn, are the prey of mammalian carnivores and raptorial bird species. As such, they are an important link in the food web of nearly all terrestrial and freshwater ecosystems, only cold regions excepted.

SURVEY METHODS AND COVERAGE

Observers: Records were provided by several members of the NCBP incidental to their surveys of other taxonomic groups. Main contributors include Steve Hall, David George, and John Petranka. Additional records from the study area have been entered by other observers into the iNaturalist online database. These records, in turn, have been compiled by the Global Biodiversity Information Facility, of which we have made extensive use (GBIF.org (16 August 2025) GBIF Occurrence Download <https://doi.org/10.15468/dl.7ycs9x>).

Survey Methods All of our records come from direct, visual searches made during the day. Only a limited amount of log and rock rolling were done to avoid habitat damage. Instead, we set out cover boards at a couple of locations, although we did not have any success in finding species making use of the shelter they offer.

⁴⁰ The relationship between lizards and snakes -- long recognized to be closely related -- is under review. Instead of representing separate, sister lineages, snakes now appear to have branched off from just one particular branch of an already evolved complex of lizard families.

RESULTS

Twenty-two species of reptiles have been recorded at the White Pines Nature Preserve, with twelve documented during the NCBP survey and four others with current records obtained from GBIF. Six are represented by historic records only, dating back over thirty years.

Group	Family	Species	Number of Records
Turtles	Emydidae	<i>Pseudemys concinna</i>	6 (2 from GBIF, 1 historic)
Turtles	Emydidae	<i>Trachemys scripta</i>	4
Turtles	Emydidae	<i>Terrapene carolina</i>	3 (1 historic)
Turtles	Kinosternidae	<i>Sternotherus odoratus</i>	(1 from GBIF, 1 historic)
Turtles	Kinosternidae	<i>Kinosternon subrubrum</i>	1
Turtles	Chelydridae	<i>Chelydra serpentina</i>	1
Lizards	Anolidae	<i>Anolis carolinensis</i>	1 (1 from GBIF, 1 historic)
Lizards	Phrynosomatidae	<i>Sceloporus undulatus</i>	3 (1 historic)
Lizards	Scincidae	<i>Scincella lateralis</i>	(1 historic)
Lizards	Scincidae	<i>Plestiodon fasciatus</i>	(1 from GBIF)
Lizards	Scincidae	<i>Plestiodon laticeps</i>	2 (1 historic)
Lizards	Scincidae	<i>Plestiodon</i> (unidentified species)	3
Snakes	Colubridae	<i>Carphophis amoenus</i>	1 (2 from GBIF, 1 historic)
Snakes	Colubridae	<i>Coluber constrictor</i>	1 (1 from GBIF)
Snakes	Colubridae	<i>Diadophis punctatus</i>	(1 from GBIF, 1 historic)
Snakes	Colubridae	<i>Heterodon platirhinos</i>	(1 historic)
Snakes	Colubridae	<i>Nerodia erythrogaster</i>	(1 from GBIF)
Snakes	Colubridae	<i>Nerodia sipedon</i>	2
Snakes	Colubridae	<i>Opheodrys aestivus</i>	(1 historic)
Snakes	Colubridae	<i>Pantherophis alleghaniensis-quadrivittatus</i>	3 (3 from GBIF)
Snakes	Colubridae	<i>Storeria dekayi</i>	(1 historic)
Snakes	Colubridae	<i>Virginia striatula</i>	(1 historic)
Snakes	Colubridae	<i>Virginia valeriae</i>	(1 historic)

Conservation Significance

Only one species, Smooth Earthsnake (*Virginia valeriae*), has a minimal level of conservation concern, being state-ranked as S3 by the Natural Heritage Program. The rest are ranked as either S4S5 or S5, and are considered essentially secure from being extirpated from the state.

Noteworthy Species

One of the animal species most often spotted by visitors to the White Pines Preserve is the River Cooter (*Pseudemys concinna*). Large basking congregations of this turtle can be observed out on rocks and logs in the Deep River on most sunny days from March through November. Although primarily aquatic, they are tied to land for nesting, with the protected shorelines within the preserve supplying a critical resource for this population. Some protection from disturbance is also afforded by the preserve for their offshore basking sites.



Whereas records for River Cooters at the White Pines Preserve go back to the 1980s, one other large aquatic turtle, the Yellow-bellied Slider, was first added to the list of reptiles for this preserve by the NCBP survey. This species prefers slower-moving, mucky-bottomed, and well-vegetated waters and at the White Pines Preserve, it has been spotted so far along the lower reach of the Rocky River, close to the marsh of Southern Wild Rice.



Viability Assessment

All of the species with records from the preserve occur in hardwood forests or the shorelines of rivers and streams that adjoin them. They also normally occupy relatively permanent home ranges, where reproduction as well as foraging and sheltering typically take place. Consequently, they are all likely to have residential occurrences within the preserve. Except for species for which only historic records exist – i.e., that have not been observed in over thirty years – all are considered more likely than not to survive over at least the next ten-year period, and thus have Viability Ranks greater than E. These scores are listed in the Table 2 below that calculates the Biotic Persistence of these species within the preserve.

All species with only 1 to 3 recent records are ones we consider to be more easily overlooked, and we consequently give them more the benefit of the doubt: these are assigned a Range Rank of BC, with possibly very good viability to possibly only fair.

Only a few species appear to be relatively common, with four or more recent observations. We assigned Occurrence Ranks of AB to both Black Rat Snakes (*Pantheropsis alleghaniensis*) and Yellow-Bellied Sliders (*Trachemys scripta*) on this basis. We gave, however, a rank of SA – secure to excellent viability -- to River Cooters (*Pseudemys concinna*), due to their high frequency of observation, both within and between years; their long history of observations at this preserve (dating back at least to the 1980s); their apparently large local population; and finally, to their extensive occurrence within the Cape Fear River basin below the Jordan and Randleman Dams.

Biotic Persistence Analysis

Records compiled for Chatham, Orange, and Durham Counties in the Reptiles of North Carolina website provide a baseline for the species that we expect to occur within the preserve. The tables that follow are divided by both habitat and taxonomic group.

Species	White Pines		New Hope-Hollow Rock	
	OVR	OPS	OVR	OPS
Lizards				
Plestiodon fasciatus	BC	0.65	BC	0.65
Plestiodon inexpectatus				
Plestiodon laticeps	BC	0.65	BC	0.65
Sceloporus undulatus	BC	0.65	BC	0.65
Scincella lateralis	F	0.10		
Subtotal, n = 5		Sum = 2.05		Sum = 1.95
		BPI = 41%		BPI = 39%
Snakes				
Agkistrodon contortrix			BC	0.65
Carphophis amoenus	BC	0.65		
Crotalus horridus				
Diadophis punctatus	F	0.10	BC	0.65
Pantherophis alleghaniensis-quadrivittatus	BC	0.65	AB	0.80
Storeria occipitomaculata			BC	0.65
Tantilla coronata				
Virginia striatula	F	0.10		
Virginia valeriae	F	0.10		
Subtotal, n = 9		Sum = 1.60		Sum = 2.75
		BPI = 18%		BPI = 31%
Turtles				
Terrapene carolina	C	0.40	A	0.90
Grand Total, n = 15		Sum = 4.05		Sum = 5.60
		BPI = 27%		BPI = 37%

Despite more species overall having been recorded at the White Pines Preserve – 10 vs. 8 – the New Hope-Hollow Rock study area had 10% more of the original species complement expected to persist than the White Pines Preserve. This is partly due to four of the species historically recorded at the White Pines Preserve could not be found. Additionally, both Eastern Box Turtles and Black Ratsnakes both had higher viability occurrences at New Hope-Hollow Rock, somewhat contrary to our expectations based on the greater likelihood of adverse interactions with humans in areas with higher human populations. For the ratsnakes in particular, we also expected to see more decline in the New Hope-Hollow Rock area due to the loss of nesting birds – a major prey item of that species – within those sites.

The failure to find several of the smaller, more secretive snake species could also indicate declines in habitat suitability at both sites, but may also reflect a lack of intensive surveys for these species. Particularly at the White Pines Preserve, we limited the habitat disturbance due to log rolling and searching under bark and other debris, relying on cover boards instead. However, that method did not produce the results we had hoped for.

One other species that was missed in the surveys at both sites was the Ground Skink (*Scincella lateralis*). Although a secretive species, it is relatively easy to detect by the rustling sounds it makes when it moves through the leaf litter. In the past at least, this species was one of the most abundant species of vertebrates inhabiting the leaf-litter layer of various types of forests across the state. Increased flooding in the New Hope Bottomlands might provide an explanation for its absence at that site, but not at the White Pines Preserve, where upland forests predominate. One possible cause at that site is the proliferation of the Asian Needle Ant (*Brachyponera chinensis*)⁴¹. This species invades native forest habitats in our area and directly attacks the small arthropods in the leaf litter and fallen logs that are the main prey of Ground Skinks. They also feed on vertebrate carrion and may attack the eggs of ground nesting herps.

The persistence analysis of mixed forest and open habitats shows a similar pattern.

Table 3. Mixed Habitats

Species	White Pines		New Hope-Hollow Rock	
	OVR	OPS	OVR	OPS
Lizards				
Anolis carolinensis	BC	0.65	BC	0.65
Aspidoscelis sexlineatus				
Ophisaurus attenuatus				
Subtotal, n = 3		Sum = 0.65		Sum = 0.65
		BPI = 22%		BPI = 22%
Snakes				
Cemophora coccinea				
Coluber constrictor	BC	0.65	F	0.10
Heterodon platirhinos	F	0.10		

⁴¹ See section on Exotic Species in the Discussion chapter of this report

Species	White Pines		New Hope-Hollow Rock	
	OVR	OPS	OVR	OPS
Lampropeltis getula				
Lampropeltis rhombomaculata				
Opheodrys aestivus	F	0.10	BC	0.65
Pantherophis guttatus				
Storeria dekayi	F	0.10	BC	0.65
Thamnophis sirtalis			BC	0.65
Subtotal, n = 9		Sum = 0.95		Sum = 2.05
		BPI = 11%		BPI = 23%
Grand Total, n = 12		Sum = 1.60		Sum = 2.70
		BPI = 13%		BPI = 23%

As expected, based on the low amount of open habitat at the two study sites, the persistence values for this group of habitats is less than those for the forest-inhabiting species. Species that depend mainly on fields and barrens, e.g., Six-lined Racerunner (*Aspidoscelis sexlineatus*) and Slender Glasslizard (*Ophisaurus attenuatus*), are completely absent, as are species more strongly associated with sandhill habitats, e.g., Common Scarletsnake (*Cemophora coccinea*) and Red Cornsnake (*Pantherophis guttatus*).

Of greater conservation concern is the status of species more typical of Piedmont habitats, particularly the larger, diurnal, surface-active snakes such as Eastern Hog-nosed Snake (*Heterodon platirhinos*), Eastern Kingsnake (*Lampropeltis getula*), North American Racer (*Coluber constrictor*), and Common Gartersnake (*Thamnophis sirtalis*). These harmless species, along with the poisonous Copperhead (*Agkistrodon contortrix*), are often killed on sight by humans who do not distinguish between snake species. Consequently, they are declining in areas adjoining dense human settlement and are persecuted even in otherwise protected natural areas. Considering just this group of five species (leaving out the nocturnal Copperhead), the Biotic Persistence Index for the White Pines Preserve is 0.28 compared to 0.30 for the New Hope-Hollow Rock study area. In both studies, only two of these species was recorded in each of these areas. Although contrary to our expectations that the White Pines Preserve would have a much stronger value, these results serve to emphasize the concern over these species, whose decline even in protected areas needs far more investigation.

The last group of species are semi-aquatic, including those associated with wetlands, ponds, or general shorelines.

Table 4. Wet-Hydric Habitats

Species	White Pines		New Hope-Hollow Rock	
	OVR	OPS	OVR	OPS
Snakes				
Nerodia erythrogaster	BC	0.65	BC	0.65
Nerodia sipedon	BC	0.65	BC	0.65

Species	White Pines		New Hope-Hollow Rock	
	OVR	OPS	OVR	OPS
Regina septemvittata				
Thamnophis saurita				
Subtotal, n = 4		Sum = 1.30		Sum = 1.30
		BPI = 33%		BPI = 33%
Turtles				
Chelydra serpentina	BC	0.65	F	0.10
Chrysemys picta				
Clemmys guttata				
Kinosternon subrubrum	BC	0.65		
Pseudemys concinna	SA	0.95	C	0.40
Sternotherus odoratus	BC	0.65	F	0.10
Trachemys scripta scripta	AB	0.80	BC	0.65
Subtotal, n = 7		Sum = 3.70		Sum = 1.25
		BPI = 53%		BPI = 18%
Grand Total, n = 11		Sum = 2.10		Sum = 1.95
		BPI = 19%		BPI = 18%

BREEDING BIRDS

Steve Hall, Harry LeGrand, and Parker Backstrom

We generally consider birds to be a positive feature of our natural environment. With their bright colors, complex polyphonic songs, and conspicuous diurnal behaviors, birds are our most popular group of wildlife, with a multitude and constantly growing number of field guides covering all aspects of their identification and life histories. Backyard bird feeders are among the most important connections that people still have with the natural world, reminding us that it still exists and is still of value to us. Ecologically, birds play an important role in the food web as secondary consumers, i.e., most species are predators, feeding on other animals. The majority of birds feed on insects, a fact that further endears them to humans. On the other hand, relatively few feed on crops or otherwise compete with us for resources.

Given the wide popularity of this group, it is especially alarming when we learn that bird populations are in decline. The massive destruction of bird populations by market hunters and particularly the use of bird feathers by the fashion industry, fueled the development of some of the first conservation groups in the early 20th Century, and the modern conservation movement traces its origin in the massive bird declines due to pesticide use, brought to the public's knowledge in the 1960s with Rachel Carson's publication of *Silent Spring*. Although the conservation movement she sparked led to the banning of DDT and successfully brought back many species from the brink of destruction, concerns about the fate of birds have recently re-emerged with the realization that bird populations are now plummeting around the globe, along with nearly all other taxa. Once again, concerns about birds – more than any other group of species – is driving our concerns about the fate of the biosphere; their declining numbers are something that you can see in your own backyards or on strolls through your favorite natural areas.

Because of these long-standing concerns about the health of bird populations, they are among the group of animals that have been most consistently and methodologically surveyed. Particularly during the breeding season, birds can be recorded acoustically as well as visually, making breeding bird surveys a major monitoring tool for tracking the state of the natural world. Breeding populations, moreover, are a critical focus for conservation, especially at the local level, where efforts to maintain population levels can be particularly effective. For all these reasons, breeding bird surveys are an important staple in our multi-taxa, extended bioblitzes of key natural areas, and have influenced our approach to the survey of several other animal groups, including butterflies, orthoptera, and odonates.

SURVEY METHODS AND COVERAGE

Observers: Principal investigators for the breeding bird surveys were Steve Hall, Parker Backstrom, and Harry Legrand. Records were also provided by other members of the NCBP incidental to their surveys of other taxonomic groups. Many additional records from the study area have been entered by other observers into the eBird or iNaturalist online databases. These record, in turn, have been compiled by the Global Biodiversity Information Facility, of which we have made extensive use (GBIF.org (16 August 2025) GBIF Occurrence Download <https://doi.org/10.15468/dl.7ycs9x>).

Transect Surveys: our primary data comes from transect surveys that follow the same route as used for the butterfly surveys (see the map and description of the route provided under Butterflies). Individuals were counted where they were observed – usually based on the territorial songs given by the males -- within 20 meters of the trail, providing an estimate of density⁴². Other individuals heard beyond this area were also noted but not counted individually. As shown in the following table, transects were conducted at frequent intervals through the main breeding period, from late May to the end of June.

Visit Date	Observers	Number of Species
2024-05-21	Steve Hall	32
2024-05-28	Steve Hall	33
2024-06-04	Steve Hall and Harry LeGrand	34
2024-06-08	Steve Hall and Parker Backstrom	23
2024-06-11	Steve Hall	28
2024-06-15	Parker Backstrom	22
2024-06-22	Parker Backstrom	25
2024-06-29	Parker Backstrom	26

RESULTS

A total of 46 species were recorded in the transect surveys and records from an additional 23 species in the GBIF database were recorded in the months of June or July over the past ten years, of which 15 were possibly present as breeding species. These records are listed in Appendix P.

Conservation Significance: Only two species listed as conservation concern by the Natural Heritage Program – Bald Eagle and Eastern Whip-poor-will – were observed during the survey period. The eagles, however, were seen only occasionally flying over the rivers with no evidence of nesting in the immediate area. The status of the Whip-poor-will is also uncertain, since they were only heard on one occasion during one of the several moth surveys that were conducted (as nocturnal species, they were not detected during our diurnal transects).

Among the less common nesting species in this region was Black-and-White Warbler, which were observed on several occasions during the main nesting period. This species belongs to the group known as neotropical migrants, which spend the winter south of the United States and migrate up to our region in the spring in order to nest. These species are of significant conservation concern, showing strong declines over most of their breeding range (Rosenberg et al., 2019), including locally here in North Carolina as documented in our previous survey of the New Hope Bottomlands (NCBP, 2022). A total of 19 of them were recorded in our transect surveys, including the following, that are either rare or declining in the area of Chatham, Durham, and Orange

⁴² We did not plot the locations of individual territories, unlike the method employed in breeding bird surveys conducted at the New Hope Bottomlands in 2024 and at the Hollow Rock Nature Park in 2025.

Counties (Wiley et al., 2023): Ruby-throated Hummingbird, Red-eyed Vireo, Wood Thrush, American Redstart, and Scarlet Tanager.

Viability Analysis

As listed in Appendix P, the viability of breeding birds within the preserve is based both on the 544 records collected in our survey along with an additional set of 1547 records obtained for the White Pines Preserve from the Global Biodiversity Information Facility (GBIF)⁴³. Only species believed to be at least potentially nesting within the preserve are included in this analysis. Species, such as Bald Eagles, Canada Geese, and Great Blue Herons that appear to be occasional visitors to the preserve but where no evidence exists for their nesting there are not assigned a viability rank.

Viability estimates were based on five different criteria:

- Recency of observation, as indicated by the latest year of observation
- Number of different years of observation
- Number of different dates of observation during the breeding period, May 15 to July 15
- Number of different locations within the preserve where the species was observed
- Number of individuals observed

Twenty-two species were assigned ranks of A or AB, having Excellent to Good viabilities within the preserve. An additional nine were assigned a rank of BC, the default value given to species believed to be breeding residents within the preserve. Six species that were likely nesting species in the past but for which no current records exist were assigned a rank of F (Failed to Find). This last group includes mainly species whose habitat is only marginally present within the preserve, such as Blue Grosbeak, a species of early successional habitats.

Similar viability estimates were made for the New Hope Bottomlands and Hollow Rock preserves, as used Biotic Persistence Analysis below. However, in their case we combined data collected in the 2024 NCBP survey of those areas with the results of two more detailed territorial mapping studies conducted in collaboration with the New Hope Bird Alliance (Hall et al., 2024; Bai et al., 2025). In both of those surveys, the results were compared to territorial densities observed at the Mason Farm Biological Preserve in the 1980s (Wiley et al., 1980-89), a benchmark for what we believe were the normal conditions in this area prior to its recent wave of urbanization.

Biotic Persistence Analysis

The viability scores just described, translated into occurrence probabilities of survival (OPS), form the basis for Biotic Persistence Analysis, which is presented in the table below. Again, we made use of a list of species that have been observed nesting within the eastern Piedmont, in this case, the three-county area of Chatham, Orange, and Durham Counties according to the list

⁴³ GBIF.org (29 December 2025) GBIF Occurrence Download <https://doi.org/10.15468/dl.qnxs4z>

prepared by for the Mini-Breeding Bird Surveys initiated in this area by Haven Wiley (see <https://minibbs.us/>). As in the previous taxa where this analysis was done, we grouped the species by habitat, following the designations given in the Habitats of North Carolina Website. We further subdivided these groups according to the residency status of the species, also calculating the BPI for migrants (= summer residents) separately from permanent residents.

Table 1 presents the analysis for species that inhabit forests of various kinds and that rarely, if ever, venture out into open habitats, at least during the breeding period. The Viability Ranks for the migratory species were consistently much higher for the White Pines Preserve compared to the other two preserves, even though the extent and quality of the vegetation overall appear to be similar. Thirteen migratory species were, in fact, completely missed at one or both of two preserves along New Hope Creek, strongly contrasting with the White Pines Preserve, where only five migrants were missed during the breeding period survey⁴⁴.

Table 1. Biotic Persistence, Forest Species

Species	n	White Pines Preserve		New Hope Bottomlands		Hollow Rock Nature Park	
		Sum of OPS	BPI	Sum of OPS	BPI	Sum of OPS	BPI
General Forests							
Migrants							
<i>Antrostomus carolinensis</i>							
<i>Antrostomus vociferus</i>							
<i>Buteo platypterus</i>							
<i>Coccyzus americanus</i>		0.90		0.65		0.65	
<i>Contopus virens</i>		0.85		0.55		0.65	
<i>Empidonax virescens</i>		0.80		0.65		0.70	
<i>Geothlypis formosa</i>							
<i>Hylocichla mustelina</i>		0.65					
<i>Mniotilta varia</i>		0.65					
<i>Myiarchus crinitus</i>		0.80		0.65		0.90	
<i>Piranga olivacea</i>		0.90				0.65	
<i>Piranga rubra</i>		0.90		0.80		0.90	
<i>Polioptila caerulea</i>		0.60		0.65		0.90	
<i>Protonotaria citrea</i>		0.80		0.80			
<i>Seiurus aurocapilla</i>		0.80					
<i>Setophaga americana</i>		0.90		0.90		0.95	
<i>Setophaga citrina</i>		0.90					
<i>Setophaga dominica</i>		0.90		0.65		0.80	
<i>Setophaga ruticilla</i>		0.80					
<i>Vireo flavifrons</i>		0.90					

⁴⁴ Whip-poor-wills were heard once early-on during the survey and both Broad-winged Hawks and Blue-headed Vireos were heard at the beginning of the breeding period but not later.

Species	n	White Pines Preserve		New Hope Bottomlands		Hollow Rock Nature Park	
		Sum of OPS	BPI	Sum of OPS	BPI	Sum of OPS	BPI
<i>Vireo olivaceus</i>		0.65		0.60		0.70	
<i>Vireo solitarius</i>							
Migrants Total	22	13.70	62%	6.90	31%	7.80	35%
Residents							
<i>Baeolophus bicolor</i>		0.90		0.95		0.95	
<i>Buteo lineatus</i>		0.90		0.90		0.80	
<i>Cyanocitta cristata</i>		0.65		0.65		0.80	
<i>Dryobates pubescens</i>		0.65		0.70		0.90	
<i>Dryocopus pileatus</i>		0.80		0.80		0.80	
<i>Leuconotopicus villosus</i>		0.65		0.65			
<i>Megascops asio</i>							
<i>Melanerpes carolinus</i>		0.80		0.90		0.65	
<i>Melanerpes erythrocephalus</i>						0.65	
<i>Poecile carolinensis</i>		0.90		0.95		0.95	
<i>Setophaga pinus</i>		0.80		0.80		0.90	
<i>Sitta carolinensis</i>		0.65		0.80		0.90	
<i>Sitta pusilla</i>				0.65		0.65	
<i>Strix varia</i>		0.65		0.65		0.65	
Residents Total	14	8.35	60%	9.40	67%	9.60	69%
General Forests Total	36	22.5	61%	16.30	45%	17.40	48%

Although these results seem to indicate that habitat quality is higher at the White Pines Preserve, the opposite view appears to be true for permanent residents: the BPI values are higher for both of the two New Hope sites. This pattern is consistent with the results of the territorial density calculations conducted for the New Hope Bottomlands (Hall et al., 2024) and for the Hollow Rock Park (Bai et al., 2025), where reductions in territorial density were observed primarily among the neotropical migrants but increases in the densities for permanent residents. One possible conclusion reached in these studies was that the permanent residents were somehow taking advantage of the reduction of the migrant populations, increasing in number and taking over space formerly occupied by the migratory species.

Table 2 presents the analysis for Mixed Forest and Open Habitats. Species in this group make use of forests, early successional habitats, or disturbed areas, including residential neighborhoods. In some cases, they require trees for nesting – often located near the edge of a forest -- but forage more widely beyond the tree cover. Others can nest both within forests and outside, where they make use of copses, brushy thickets, or residential shrubbery. A number of these species have accustomed to the use of bird feeders and are now typical backyard birds.

Table 2. Biotic Persistence, Mixed Wooded and Open Habitats

Species	n	White Pines Preserve		New Hope Bottomlands		Hollow Rock Nature Park	
		Sum of OPS	BPI	Sum of OPS	BPI	Sum of OPS	BPI
Migrants							
Archilochus colubris		0.55		0.55		0.55	
Icterus galbula							
Icterus spurius							
Setophaga discolor							
Spizella passerina		0.10		0.55		0.80	
Tyrannus							
Vireo gilvus							
Migrants Total	7	0.55	8%	1.10	16%	1.35	19%
Residents							
Accipiter cooperii							
Accipiter striatus							
Bombcilla cedrorum							
Bubo virginianus							
Buteo jamaicensis							
Cardinalis cardinalis		0.90		0.95		0.95	
Cathartes aura							
Colaptes auratus							
Colinus virginianus							
Coragyps atratus							
Corvus brachyrhynchos		0.65		0.60		0.55	
Corvus ossifragus				0.55		0.55	
Dumetella carolinensis							
Geothlypis trichas		0.65		0.65			
Meleagris gallopavo							
Mimus polyglottos				0.55			
Pipilo erythrophthalmus		0.10		0.50		0.65	
Quiscalus quiscula							
Sialia sialis		0.10		0.65		0.55	
Spinus tristis		0.65		0.90		0.90	
Thryothorus ludovicianus		0.90		0.95		0.95	
Toxostoma rufum				0.55			
Troglodytes aedon							
Turdus migratorius		0.65				0.90	
Vireo griseus		0.80		0.80		0.85	

Species	n	White Pines Preserve		New Hope Bottomlands		Hollow Rock Nature Park	
		Sum of OPS	BPI	Sum of OPS	BPI	Sum of OPS	BPI
<i>Zenaidura macroura</i>		0.80		0.70		0.70	
Residents Total	26	5.35	21%	8.35	32%	7.55	29%
Mixed Forest and Open Habitats Total	33	5.9	18%	9.45	29%	8.90	27%

In this group of habitats, the two preserves along New Hope Creek have higher BPI scores than the White Pines Preserve, with even the few migrants showing this pattern. For this group, there is more habitat available, at least for the most human-tolerant species, in the New Hope preserves, provided by the adjoining suburban areas. Cardinals, Carolina Wrens, Bluebirds, Mockingbirds, Brown Thrashers, Towhees, Robins, and the two crow species all had higher viability scores where adjoining suburban areas were present.

One large group of missing species from all three sites are obligate “edge” species, which nest or roost in forests – often along their outer margins – but forage out in open habitats. These include several raptorial species, such as Red-tailed Hawks, but also ground-foraging species such as American Robins or Wild Turkeys. For these species, the lack of extensive open fields adjacent to any of these preserves is likely the explanation for their absence, although Red-tailed Hawks have been observed foraging over the powerline that runs through the New Hope Bottomlands. The generally lower BPI scores for this group of habitats compared to the forest group appears to be due largely to this cause.

The same lack of large open fields adjacent to these three preserves also explains the poor persistence values for species associated with open, herbaceous fields, as summarized in Table 3.

Table 3. Biotic Persistence, Old Fields, Grasslands, and Barrens

Species	n	White Pines Preserve		New Hope Bottomlands		Hollow Rock Nature Park	
		Sum of OPS	BPI	Sum of OPS	BPI	Sum of OPS	BPI
Migrants							
<i>Ammodramus savannarum</i>							
<i>Chordeiles minor</i>							
<i>Hirundo rustica</i>							
<i>Icteria virens</i>							
<i>Passerina caerulea</i>		0.10					
<i>Passerina cyanea</i>		0.80		0.65		0.65	
<i>Petrochelidon pyrrhonota</i>							
<i>Progne subis</i>							
<i>Spiza americana</i>							
Migrants Total	9	0.8	9%	0.65	7%	0.65	7%

Species	n	White Pines Preserve		New Hope Bottomlands		Hollow Rock Nature Park	
		Sum of OPS	BPI	Sum of OPS	BPI	Sum of OPS	BPI
Residents							
Charadrius vociferus							
Lanius ludovicianus							
Melospiza melodia				0.55			
Spizella pusilla							
Sturnella magna							
Residents Total	5		0%	0.55	11%		0%
Fields, Grasslands, and Barrens Total	14	0.8	6%	1.20	9%	0.65	5%

In this group, Indigo Buntings were the only one of the four migrants that was observed, all within the powerline rights-of-way or along the edges of these preserves. Song Sparrows, a resident species, were observed along a disturbed edge located between a large expanse of mowed grass and other artificially landscaped vegetation and the edge of the floodplain.

Table 4 groups together the species that are associated with streams, ponds and lakes, marshes, and the shorelines that adjoin them.

Table 4. Biotic Persistence, Wet-Hydric Habitats

Species	n	White Pines Preserve		New Hope Bottomlands		Hollow Rock Nature Park	
		Sum of OPS	BPI	Sum of OPS	BPI	Sum of OPS	BPI
Wet-Hydric Habitats							
Migrants							
Butorides virescens				0.55		0.55	
Empidonax traillii							
Nyctanassa violacea				0.65			
Pandion haliaetus							
Parkesia motacilla		0.80				0.65	
Setophaga petechia							
Stelgidopteryx serripennis							
Tachycineta bicolor							
Migrants Total	8	0.80	10%	1.20	15%	1.20	15%
Residents							
Agelaius phoeniceus							
Aix sponsa		0.80					
Anas platyrhynchos				0.60			
Ardea herodias				0.55			
Branta canadensis							

Species	n	White Pines Preserve		New Hope Bottomlands		Hollow Rock Nature Park	
		Sum of OPS	BPI	Sum of OPS	BPI	Sum of OPS	BPI
<i>Haliaeetus leucocephalus</i>							
<i>Megaceryle alcyon</i>				0.50			
<i>Phalacrocorax auritus</i>							
<i>Plegadis falcinellus</i>							
<i>Sayornis phoebe</i>		0.01		0.55			
Residents Total	10	0.8	8%	2.20	22%		0%
Wet-Hydric Habitats Total	18	1.6	9%	3.40	19%	1.20	7%

Unlike the open, terrestrial fields considered above, these wetland habitats are all important components of the three preserves. Except for Red-winged Blackbirds, whose cattail marshes are not present on any of the three preserves, the species were present representing the remaining wet-hydric habitats, although in most cases, fairly sparsely. Breeding activity in general is more difficult to observe in this group, with only the two passerines – Louisiana Waterthrush and Eastern Phoebe – defending territories using male song. In several cases, evidence indicates that the species at least forage in the wetlands within these preserves but do not necessarily nest there. The Yellow-crowned Night Heron, for instance has been seen several times within the breeding season at the New Hope Bottomlands, but where the nesting colony appears to be located at another bottomland site a few miles away.

As indicated by the Biotic Persistence Index values, the New Hope Bottomlands offer the greatest support for this range of habitats, reflecting the number of oxbows and floodways at that site, along with its high frequency of overbank flooding. Cattail marshes would probably also be present if it were not for the spraying of herbicides to suppress vegetation growing under the powerline that bisects this preserve (see NCBP, 2022). One noteworthy migrant, the Louisiana Waterthrush, however, follow the same pattern for other forest-interior, neotropical passerines, having its best population at the White Pines Preserve.

One final group is considered in Table 5, although their unifying feature is the lack of their natural habitats, i.e., those that they evolved within and which possess both natural controls on their populations, as well as other species that are well-adapted to their presence. Although not a natural group, a Biotic Persistence Index can be used to assess how well they are thriving within a given site, with a high value considered to represent a threat to native species and their habitats.

Table 5. Biotic Persistence, Species with Non-native Habitats

Species	n	White Pines Preserve		New Hope Bottomlands		Hollow Rock Nature Park	
		Sum of OPS	BPI	Sum of OPS	BPI	Sum of OPS	BPI
Non-native Habitats							
Migrants							
<i>Chaetura pelagica</i>							

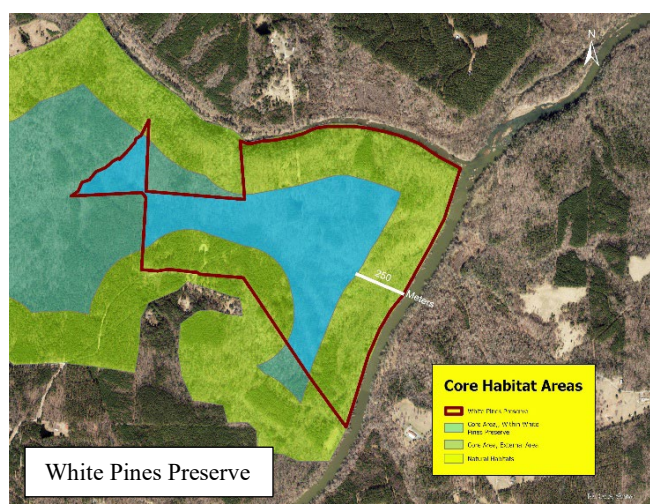
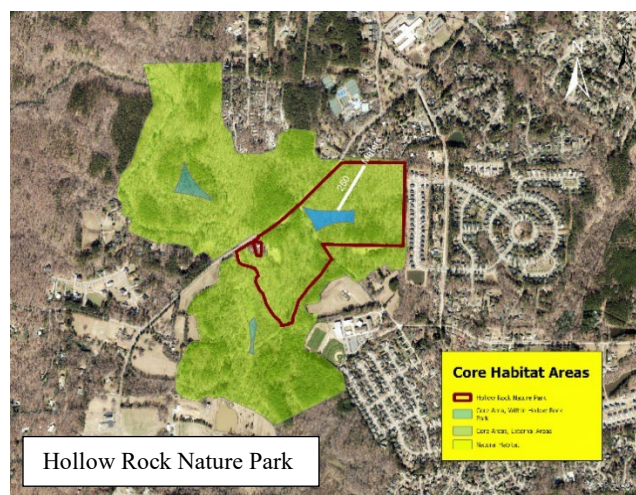
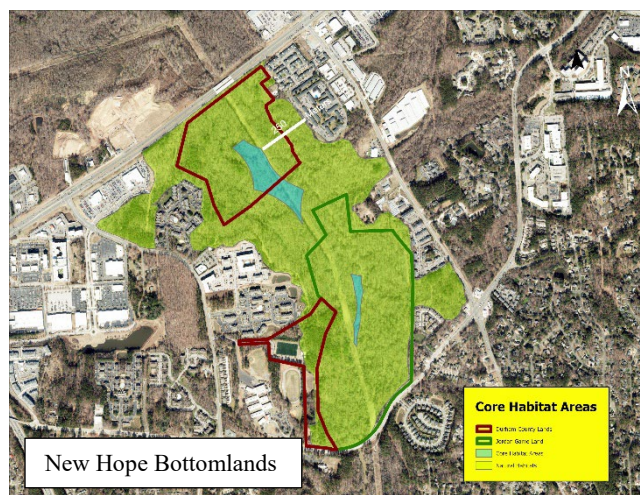
Species	n	White Pines Preserve		New Hope Bottomlands		Hollow Rock Nature Park	
		Sum of OPS	BPI	Sum of OPS	BPI	Sum of OPS	BPI
Migrants Total	1		0%		0%		0%
Residents							
Columba livia							
Haemorhous mexicanus				0.65		0.65	
Molothrus ater		0.60		0.65		0.70	
Passer domesticus							
Sturnus vulgaris							
Residents Total	5	0.60	12%	1.30	26%	1.35	27%
Non-native Habitats Total	6	0.60	10%	1.30	22%	1.35	23%

In our area, these species are associated with open areas, including residential neighborhoods. They were observed mainly along the edges of the preserves, particularly in the two preserves along New Hope Creek, where urban areas encroach closely. Brown-headed Cowbirds, however, are common in farmlands, where they can invade adjoining forests for purposes of nest parasitism. This is true for even the White Pines Preserve, which occurs in a primarily forested region, although with apparently enough fields to provide foraging areas for the adults.

Altogether, the findings described above are consistent with the results obtained from over forty years of breeding bird surveys conducted in the Eastern Deciduous Forest biome. Whereas the diversity and abundance of species show an increase in edge habitats, particularly among those with wide habitat tolerances, the opposite is true for specialist forest interior species, particularly those that migrate into an area for nesting but depart during the winter (see for example, Robbins, 1979, Whitcomb et al., 1979, and Noss, 1981). Since those initial studies, the cumulative effect of these trends has resulted in massive changes in avian abundance across eastern North America. Rosenberg et al. (2019) reported a –17.4% change in abundance in the forest birds of this region, with migratory species experiencing a –28.3% change in abundance, but permanent residents having instead a modest increase of 5.3%.

The effects of habitat fragmentation on forest interior, migrant bird species have been linked to the distance that edge effects penetrate into the interior of a stand or, conversely, to the amount of interior habitat that exists within the stand beyond the reach of the edge effects. The edge effect distance, in turn, depends on the nature of the edge, with “hard” edges, where a natural stand is located next to a heavily human developed area, having a much greater penetration than where “soft” edges exist, where the stand is bordered by less heavily converted old fields, pastures, or lightly managed silvicultural plantations. In explaining the differences found between the White Pines Preserve and the two conservation lands located along New Hope Creek, both effects appear to play important roles.

As shown in the maps below – all shown at the same scale -- hard edges completely surround the New Hope Bottomlands and adjoin the Hollow Rock Nature Park in an arc around the northeast to southeast. In contrast, only soft edges surround the White Pines Preserve.



The areas shown in blue on these maps estimate the amount of forest interior habitat that exists within each preserve, based on estimates recently made in a review by Akresh et al. (2024) that nesting success declines inward from an edge up to 250 meters⁴⁵. The White Pines Preserve contains 124 acres (50 ha) of core habitat, with a larger expanse extending on private lands located to the west. The two core areas located within the New Hope Bottomlands, in contrast, have a combined area of 13 acres (5 ha) and the tract at Hollow Rock Park is only 4 acres (2 ha) in extent. For species requiring forest interior habitat, the White Pines Preserve has by far the greatest amount of the three preserves.

Although our findings are consistent with those of other studies that identify edge effects as key factors affecting survival of forest-interior, migratory bird species, the majority of those studies

⁴⁵ Although recognizing that edges have variable impacts depending on the nature of the adjoining areas, this study combined all types in their analysis, with 250 meters representing a general estimate. In our analysis, we drew lines dividing forested areas from those include areas with multiple buildings, extensive cultivated fields, or major roads. Isolated houses with small areas of disturbed vegetation were ignored and in the case of the Hollow Rock Park, we ignored the presence of the edges along Erwin and Pickett Roads. For the White Pines Preserve, we included the two rivers as major edges even though there are extensive areas of natural habitats located on the sides opposite from the preserve.

focus on the direct impacts of edge effects on the birds themselves. Predation, nest parasitism, and differences in how habitat influences foraging efficiency have all been major foci. Cowbirds – an important nest parasite – do, in fact, appear to be more numerous in the habitats along New Hope Creek than at the White Pines Preserve. However, our multi-taxa surveys point to another critical factor: food availability. Insects are the main food of forest-inhabiting bird species, with lepidoptera – moths and butterflies -- the most important group used by both adults and nestlings (Holmes and Schultz, 1988; Kennedy, 2019; Tallamy and Shriver, 2021). This is especially true for species that migrate thousands of miles from their wintering grounds to their breeding grounds and need to quickly replenish their own reserves before meeting the heavy demands of their nestlings. In the past, their main arrival period in May in their North American nesting grounds coincided with the peak period for caterpillar abundance (see Tallamy and Shriver, 2021).

It seems no coincidence, therefore, that we found a major deficit in macro-moth abundance and diversity in our survey of the New Hope Bottomlands, as well as a deficit in breeding bird BPI, compared to more normal levels of moth diversity in the White Pines Survey (see section on Moths) and a much higher level of breeding bird BPI. The likely edge effects may be more important for the moth fauna and only indirectly for the neotropical migrants. Particularly for moths, the light pollution from the closely adjoining residential and commercial areas may be a major factor explaining population reductions along New Hope Creek. Other factors, however, may also play a role, including exposure to pesticides applied in areas outside the preserve.

The factors affecting both breeding bird and moth diversity can be divided into those that operate on a continental level – e.g., the effects of climate change or loss of the wintering habitats used by neotropical migrants – and those that operate more locally – e.g., the effects of noise pollution on the ability of birds to communicate. The three preserves compared in the persistence analysis presented above are all located in the same region, the same climate zone, the same biome. They are also all located the same distance from the wintering grounds of migratory species and along the migratory corridors. The striking differences particularly in the migratory species between the White Pines Preserve and the two located along New Hope Creek therefore need to be explained on the basis of local factors. That by itself is an important conclusion in that it indicates that local conservation actions can play a key role in protecting our native biodiversity, not that combating the global factors does not have its own urgency. For the White Pines Preserve, protecting the rural setting that it now enjoys should be given special urgency, now that sewer and water lines have been extended from Pittsboro to Sanford, potentially opening up the entire southern portion of Chatham County to the same intensive development now taking place in the northern end.

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MAMMALS

Steve Hall, Ed Corey, Lisa Gatens, and Harry LeGrand

This is the taxonomic group that includes humans, and as such includes animals that we can easily recognize as fellow species. Consequently, we take great interest in their decline and potential loss, which along with birds, makes their protection within preserves such as the White Pines an important concern.

With a few exceptions, however, mammals are secretive and hard to observe. Many are also nocturnal, remaining hidden within burrows, dens, or tree cavities during the day. For these reasons, the majority are far less familiar to the general public, with people not even aware of how many species occur in their own yards, let alone large tracts of forest or other habitats. Compared to the other vertebrate groups, which all have a large number of observations at the White Pines Preserve recorded in iNaturalist or eBird, only two mammal records currently exist, for Eastern Cottontail and White-tailed Deer.

Despite their obscurity, mammals play several critical ecological roles in any natural area. Along with hawks and owls, mammalian carnivores are at the top of the food web, exerting what has been termed top-down control of prey species, maintaining stable populations of both those species and the plants and smaller animals that those species themselves control. Where those controls are lost, as in the case of White-tailed Deer following the eradication of wolves and mountain lions (as well as reductions in hunting by humans), the over-browsing that resulted has had massive impacts on native ecosystems.

Mammals such as Gray Squirrels, White-footed Mice, and other rodents play key roles as primary consumers and as prey species but another critical role is often overlooked: the dispersers of seeds of many species of plants and of the spores of mushrooms and other fungi, including those that play massively important ecosystem roles as the mycorrhizal mutualists of forest trees.

SURVEY METHODS AND COVERAGE

Observers: Records were provided by several members of the NCBP incidental to their surveys of other taxonomic groups. Main contributors include Steve Hall and David George. Three bat records were provided by Ed Corey and two additional records were obtained from the iNaturalist online database (compiled by the Global Biodiversity Information Facility, of which we have made extensive use (GBIF.org (16 August 2025) GBIF Occurrence Download <https://doi.org/10.15468/dl.7ycs9x>). A number of historic records were obtained from the natural heritage inventory conducted by Hall and Boyer (1989) and the thesis research done at the preserve by Ed Swab (1990).

Survey Methods Mammals were only casually surveyed during our inventory. Records include observations of the animals themselves as well as of their tracks and other sign. Records of coyotes howling at night were made on several occasions by observers conducting sheet surveys of moths. Bats were recorded using Wildlife Acoustics Song Meter Mini Bat 2s and analyzed with Kaleidoscope Pro acoustic software. Effective surveys for insectivores and mice require trapping,

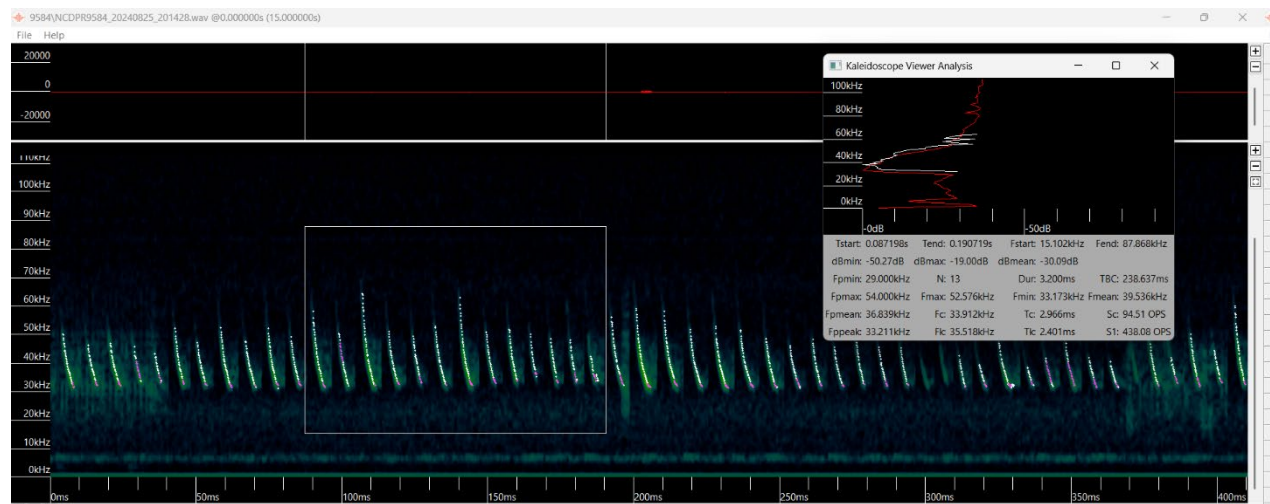
which we did not do in this survey. Consequently, these groups are significantly under-represented in our results.

RESULTS

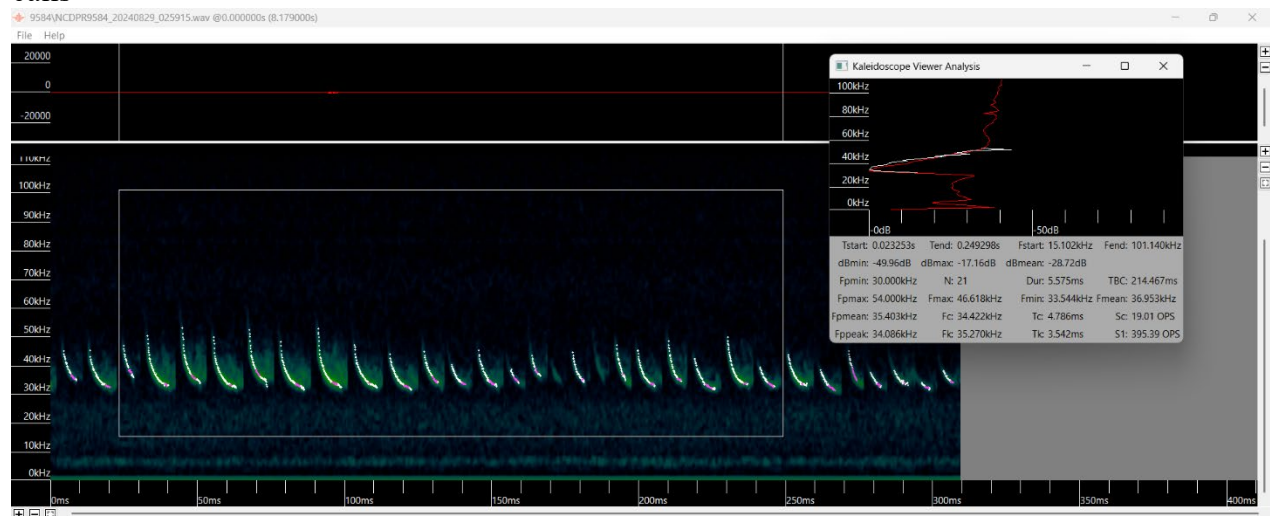
Fourteen species of mammals have been recorded at the White Pines Nature Preserve. Four are known only from historic records dating back to the late 1980s. Four others, on the other hand, were added by this survey, including coyotes and the three bats.

Bat Recordings

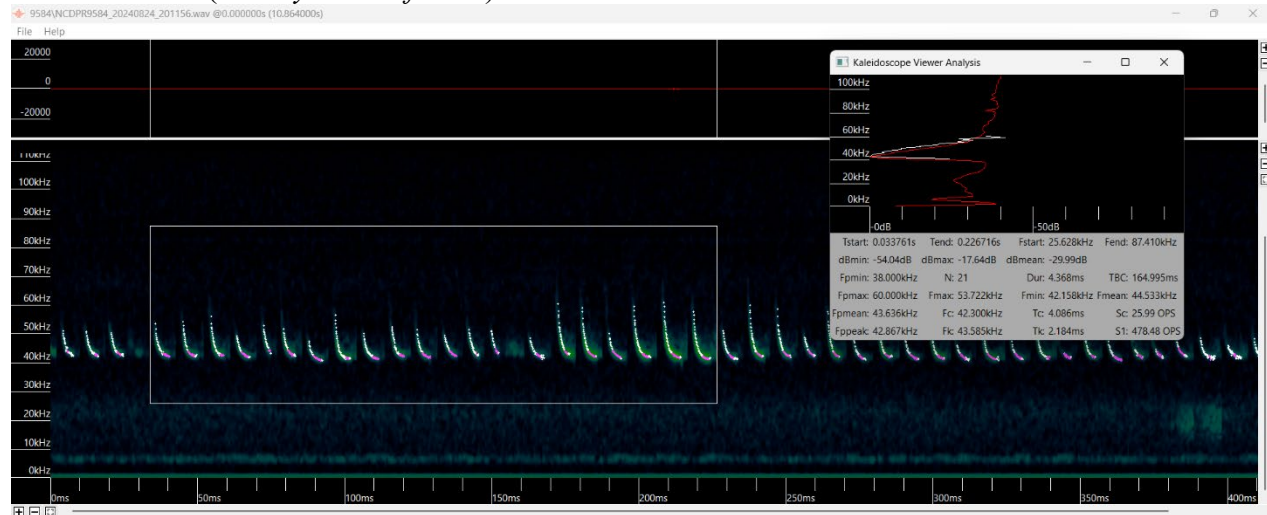
Big Brown Bat (*Eptesicus fuscus*)



Eastern Red/Seminole Bat (*Lasiurus borealis*/*L. seminolus*) – Unable to ID to species based on calls



Tricolored Bat (*Perimyotis subflavus*)



Records Summary

The number of records obtained for mammal species both during the NCBP survey and from other sources is given in the table below.

Table 1. Mammal Records

Order	Scientific Name	NCBP Records	Other Records
Eulipotyphla	Scalopus aquaticus (Eastern Mole)	9	Hall and Boyer (1989), Swab (1990)
Chiroptera	Eptesicus fuscus (Big Brown Bat)	1	
Chiroptera	Lasiurus borealis-seminolus (Unid. Bat)	1	
Chiroptera	Perimyotis subflavus (Tricolored Bat)	1	
Lagomorpha	Sylvilagus floridanus (Eastern Cottontail)	2	Swab (1990), GBIF/iNaturalist
Rodentia	Castor canadensis (American Beaver)	3	Hall and Boyer (1989), Swab (1990)
Rodentia	Glaucomys volans (Southern Flying Squirrel)	1	
Rodentia	Peromyscus leucopus (White-footed Mouse)		Hall and Boyer (1989)
Rodentia	Sciurus carolinensis (Eastern Gray Squirrel)	3	
Rodentia	Tamias striatus (Eastern Chipmunk)		Hall and Boyer (1989), Swab (1990)
Carnivora	Canis latrans (Coyote)	3	
Carnivora	Mephitis mephitis (Striped Skunk)		Swab (1990)
Carnivora	Procyon lotor (Common Raccoon)	1	Swab (1990)
Carnivora	Urocyon cinereoargenteus (Gray Fox)		Hall and Boyer (1989)
Artiodactyla	Odocoileus virginianus (White-tailed Deer)	2	Hall and Boyer (1989), Swab (1990), iNaturalist

Conservation Significance

Tricolored Bat (*Perimyotis subflavus*) is state-listed as Endangered and is also proposed for that status at the federal level. It is endangered due to its hibernation in caves, where it has been highly

susceptible to the White-nose Syndrome, a fungal disease that has killed millions of bats in the eastern United States. In the summer, however, this species roosts and breeds in forest canopies, which it may do at the White Pines Preserve, based on at least one record obtained in our survey.

None of the other species of mammals recorded in the preserve are considered to be of any significant conservation concern. All are listed as S5 by the Natural Heritage Program, indicating that they are secure within the state.

Only one species, coyote (*Canis latrans*), was added by this survey to the list of mammal species recorded within the preserve. This canid was originally native to the western United States but has been moving into the East over the past several decades. It may be in the process of occupying at least part of the ecological niche once occupied by wolves (Red or Gray) as one of the top carnivores in the state. To the extent that it helps control the population of White-Tailed Deer or Raccoons, it may become a beneficial species, although it also is adept at making use of developed areas, where it is far from welcome by the human inhabitants.

Viability Estimates

Two of the species known only from historic records, the Eastern Chipmunk (*Tamias striatus*) and Striped Skunk (*Mephitis mephitis*), are on southeastern edge of their range in the state in this area and their extirpation from the site seems possible. The Gray Fox (*Urocyon cinereoargenteus*) may also be declining due to the arrival of coyotes, and GBIF shows no records for this species within a 20 km radius of the preserve. These three species are therefore all treated as historic but given a viability rank of F (Failed to Find). That rank was also given to the White-footed Mouse (*Peromyscus leucopus*), which is undoubtedly present but simply not sampled.

All of the remaining species have multiple records, and are given minimal ranks of BC, reflecting both their likely security within the preserve itself and their likely landscape-level occurrences in this region. Based on the high frequency of observing the tunnels of Eastern Moles, especially in the floodplain but also in the uplands, that species is estimated to have a viability of straight A. Beaver sign was also frequently observed and that species was given a viability rank of AB. The same rank was also assigned to Eastern Gray Squirrels, Northern Raccoons, and White-tailed Deer.

Biotic Persistence Analysis

Records for 39 species compiled for Chatham, Orange, and Durham Counties in the Mammals of North Carolina website provide a baseline for the species that we expect to have historically occurred within the preserve. As in other taxa for which this analysis was done, we divide the species into habitat-based groups. Recent arrivals, including Coyotes and Nine-banded Armadillos, are not considered, at least as belonging to habitats native to this region.

Table 1. Forests

Species	n	White Pines		New Hope Bottomland & Hollow Rock	
		OPS	BPI	OPS	BPI
Glaucomys volans (Southern Flying Squirrel)		0.65		0.65	
Lasionycteris noctivagans (Silver-haired Bat)					
Lasiurus borealis-seminolus (Red Bat or Seminole Bat)		0.65			
Lasiurus cinereus (Hoary Bat)					
Peromyscus leucopus (White-footed Mouse)		0.10			
Sciurus carolinensis (Eastern Gray Squirrel)		0.80		0.90	
Sciurus niger (Fox Squirrel)					
Tamias striatus (Eastern Chipmunk)		0.10		0.10	
Total	8	2.30	29%	1.65	21%

Table 2. Mixed Forests and Open Habitats

Species	n	White Pines		New Hope Bottomland & Hollow Rock	
		OPS	BPI	OPS	BPI
Blarina brevicauda (Northern Short-tailed Shrew)					
Blarina carolinensis (Southern Short-tailed Shrew)					
Didelphis virginiana (Virginia Opossum)				0.90	
Eptesicus fuscus (Big Brown Bat)		0.65			
Lynx rufus (Bobcat)				0.65	
Marmota monax (Woodchuck)				0.10	
Mephitis mephitis (Striped Skunk)		0.10			
Microtus pinetorum (Woodland Vole)					
Mustela frenata (Long-tailed Weasel)					
Myotis lucifugus (Little Brown Bat)					
Nycticeius humeralis (Evening Bat)					
Ochrotomys nuttalli (Golden Mouse)				0.65	
Odocoileus virginianus (White-tailed Deer)		0.80		0.90	
Perimyotis subflavus (Tricolored Bat)		0.65			
Procyon lotor (Common Raccoon)		0.65		0.90	
Scalopus aquaticus (Eastern Mole)		0.90		0.90	
Sorex longirostris (Long-tailed Shrew)					
Sylvilagus floridanus (Eastern Cottontail)		0.70		0.90	
Tadarida brasiliensis (Free-tailed Bat)					
Urocyon cinereoargenteus (Gray Fox)		0.10		0.10	
Ursus americanus (Black Bear)					
Total	21	4.55	22%	6.00	29%

Table 3. Open Herblands and Shrublands

Species	n	White Pines		New Hope Bottomland & Hollow Rock	
		OPS	BPI	OPS	BPI
<i>Cryptotis parva</i> (North American Least Shrew)					
<i>Microtus pennsylvanicus</i> (Meadow Vole)					
<i>Reithrodontomys humulis</i> (Eastern Harvest Mouse)					
<i>Sigmodon hispidus</i> (Hispid Cotton Rat)				0.65	
<i>Zapus hudsonius</i> (Meadow Jumping Mouse)					
Total	5	0.00	0%	0.65	13%

Table 4. Wetlands and Shorelines

Species	n	White Pines		New Hope Bottomland & Hollow Rock	
		OPS	BPI	OPS	BPI
<i>Castor canadensis</i> (Beaver)		0.80		0.90	
<i>Lontra canadensis</i> (River Otter)				0.90	
<i>Neovison vison</i> (Mink)				0.80	
<i>Ondatra zibethicus</i> (Muskrat)				0.90	
<i>Sylvilagus palustris</i> (Marsh Rabbit)					
Total	5	0.80	16%	3.50	70%

Apart from the General Forests group, where the use of bat detection equipment resulted in records for three species at the White Pines Preserve not observed at the other sites, the Biotic Persistence values were all higher for the New Hope Bottomlands/Hollow Rock study area. Those results, however, reflect the greater opportunity for detecting the larger species through their tracks, with the New Hope project area having much more extensive areas of mud than the White Pines Preserve. In addition to more comprehensive sampling for bats, we recommend the use of camera traps, environmental acoustic recorders, tracking boxes, and possibly environmental DNA sampling to provide a more comprehensive survey for this group of species.

Several questions that could be answered with these data include:

- Are coyotes causing any reduction in the deer herd, restoring a control on their populations that was lost with the extirpation of wolves and mountain lions and to a reduction in hunting intensity that has taken place over the last century?
- Are coyotes causing any reduction in raccoon populations and, if so, will that help reduce nest predation of reptiles, both adults and their eggs? A corollary question is whether raccoon populations are, in fact, larger than they were historically and whether they are actually responsible for a decline in reptile and amphibian populations?

- Are populations of bats and insectivores significantly higher at the White Pines Preserve than they are in the New Hope Bottomlands/Hollow Rock Park, as expected by the much higher moth diversity and abundance present at this site? That appears likely for the bird fauna, but no data currently exists for these other groups.
- Are the populations of rodents in good shape? These species play a key role in dispersing seeds of many species of plants as well as mushroom spores, and are therefore critical for restoring forests following major catastrophes, such as fires or wind storms. Given the expectation that those events are likely to increase with climate change, a healthy rodent population will be more necessary than ever before.

EXOTIC SPECIES

Steve Hall

Although many of the factors affecting the persistence of species are beyond our scope to investigate, multi-taxa, site-focused biotic inventories such as the one we conducted at the White Pines Preserve are highly effective in recording the presence of exotic species, just as they are for native species, using the same survey methods. The following table lists the number of exotic species we found in selected survey groups along with the percentage they represent of the total number of species in that group.

Taxon	White Pines Preserve				New Hope Bottomlands/Hollow Rock Park			
	Exotics	Natives	Total	Exotics Percent of Total	Exotics	Natives	Total	Exotics Percent of Total
Vascular Plants	82	535	617	13%	63	380	443	14%
Orthoptera	2	46	48	4%	1	44	45	2%
Butterflies	0	30	30	0%	1	36	39	3%
Moths	12	792	804	1%	7	428	435	2%
Amphibians	0	16	16	0%	0	17	17	0%
Reptiles	0	22	22	0%	0	13	13	0%
Breeding Birds	2	53	55	4%	1	81	82	1%
Mammals	1	14	15	7%	3	16	19	16%
Totals	99	1508	1607	6%	76	1015	1093	7%

Despite the greater degree of development in the areas adjoining the New Hope Bottomlands and Hollow Rock Park, there were actually fewer exotic species in that area compared to the White Pines Preserve, although the percentages of the total number of species included in these taxa was nearly the same. In both cases, however, the exotics were concentrated in disturbed areas, such as the powerlines that run through each of the sites or, in the case of the White Pines Preserve, the areas cleared for parking and around an old abandoned homesite. Far fewer – but some of the most significant in their impacts – occur in the mature stands of forest that cover most of these two areas. The differences in total numbers of species between these areas is likely due to the much higher topographic and microclimatic diversity of the White Pines Preserve, not in this case due to less within-park disturbances.

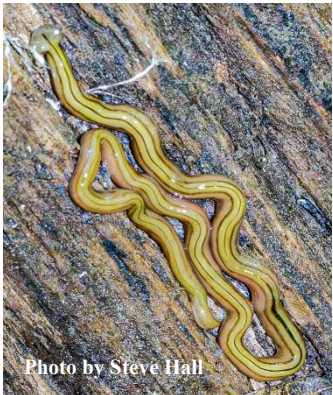
In terms of the impacts of the exotic species, however, that can depend more on the severity of the effects of the individual species than on their overall number. Particularly important with regard to conservation are the exotics that are capable of invading natural areas, including those located well away from disturbances. By far the most severe impacts currently taking place in forests across the eastern United States are those of the Emerald Ash Borer, a very small species of beetle against which none of our native ash species has resistance to the feeding of its larvae on their cambium layers. Hundreds of thousands of trees have now died as a result, with no end in sight.

At the New Hope Bottomlands and Hollow Rock, dead ash snags are common, with entire groves destroyed, opening up the canopy and allowing colonization by Japanese Stilt Grass, Chinese Privet, and other exotic species. At the White Pines Preserve, however, ash species are far less common, probably due to the more acidic soils that prevail at this site. The damage by the beetle is far less conspicuous at that site, with none of the large openings created by the die-off of Green Ash at the New Hope sites.

The individual species of exotic vascular plants are fairly well-known and there are ongoing efforts at both the White Pines Preserve and the New Hope Bottomlands/Hollow Rock Park to control them, mainly by mechanical clearance and the careful application of herbicides. Seven species of particular concern are discussed by Sorrie in the section of this report on the Vascular Plants. Here, we focus on exotics found in the current survey that belong to taxa other than the vascular plants or vertebrates. Although some of these are scarcely known to the public, they have the potential to create major impacts to native ecosystems.

Terrestrial Flatworms

- *Diversibipalium multilineatum* (Multi-lined Hammerhead Worm). This species and other related flatworms are primarily tropical species that are now becoming widespread around the world via potting soils used in greenhouses. Although once found mainly around greenhouses or landscaped yards, this species was quite common at the White Pines Preserve, both in the ravines and especially in the floodplains – hundreds were seen along the Rocky River after a heavy rain (D. George, pers. obs.). Almost nothing is known about its impacts to native ecosystems, but they prey on earthworms, slugs, snails, and other soil invertebrates. At the White Pines Preserve, any chance of finding the rare, Pleistocene relict Black Mantleslug may now be gone. They are also highly toxic and there consequently could be some impacts to the salamanders, small snakes, insectivores, and birds that consume worms and mollusks as major parts of their diet. There are no known effective control methods for this species (see Bertone et al., 2020).

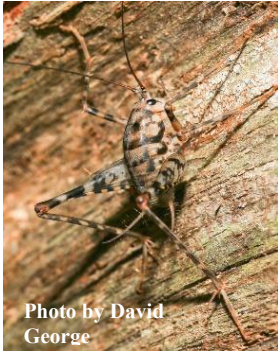


Millipedes

- *Oxidus gracilis* (Greenhouse Millipede). This is another species that appears to have been introduced via greenhouses. It is now commonly found around houses in suburban areas where it can have major outbreaks. At the White Pines Preserve, however, it now occurs in natural habitats – primarily floodplains – far from any greenhouse or human habitation. Like the hammerhead worm, it is chemically protected and has few, if any, predators in the exotic areas it now occupies. Although apparently unstudied, the impacts to the native ecosystem are likely to be mainly to native millipedes and soil detritivores with which it competes for food and space.
- *Ophiulus pilosus* (no common name). This is another small millipede introduced apparently from Europe. Although it has also been considered mainly synanthropic (living

close to humans), it was also found to be common in the preserve and even more widely distributed than *O. gracilis*, occurring in the uplands as well as the bottomlands. Again, nothing is apparently known about its potential for impacts to native ecosystems and there are no recommendations for its control.

Crickets



- *Tachycines asymamorus* (Greenhouse Camel Cricket). As the common name implies, this is yet another species that has been widely introduced via greenhouses, but is now quite common in basements throughout North Carolina. Although again thought to be mainly synanthropic, populations have now been found in natural areas far from any human development. This species was observed mainly in the ravines and floodplains in the White Pines Preserve, where it may compete with the native species of camel crickets, including the Spotted Camel Cricket, possibly the rarest of the preserve's Pleistocene relicts.



- *Velarifictorus micado* (Japanese Burrowing Cricket). First detected in this country in 1959, it has now spread over much of eastern North America (Bowles, 2018). This is another species that has long been considered to be synanthropic but has successfully invaded natural habitats, including hardwood forests, sandhills, and coastal dune grasslands. In many of these areas it is now the most abundant species of cricket. At the White Pines Preserve, we recorded these crickets from the

ridgetops to the floodplains. Although not considered a pest species, at least with regard to human interests, it is likely to be having a severe impact on our native field and ground crickets as well as other members of the litter fauna.

MOTHS

Family	Species	Larval hosts
Tineidae	<i>Scardia amurensis</i> (no common name)	bracket fungi
Peleopodidae	<i>Autosticha kyotensis</i> (Kyoto Moth)	the only documented hosts are exotic
Oecophoridae	<i>Promalactis suzukiella</i> (Suzuki's Promalactis)	rotten logs
Plutellidae	<i>Plutella xylostella</i> (Diamondback Moth)	mainly Brassicaceae, including crop species and other exotics
Yponomeutidae	<i>Atteva aurea</i> (Ailanthus Webworm Moth)	Tree of Heaven
Tortricidae	<i>Notocelia rosaecolana</i> (Doubleday's Notocelia)	Roses, including Multiflora Rose
Crambidae	<i>Ecpyrrhorrhoe puralis</i> (no common name)	Princess-tree
Crambidae	<i>Diaphania costata</i> (Orange-shouldered Sherbet Moth)	Periwinkle and Bluestar
Crambidae	<i>Euchromius ocella</i> (no common name)	Corn and sorghum
Pyralidae	<i>Galleria mellonella</i> (Greater Wax Moth)	Beeswax

Family	Species	Larval hosts
Pyralidae	<i>Ephestia kuehniella</i> (Mediterranean Flour Moth)	widely polyphagous, primarily on crop species
Noctuidae	<i>Noctua pronuba</i> (Large Yellow Underwing)	widely polyphagous on herbaceous plants

Out of the 804 species of moths that were documented in the survey, only these 12 species are exotic. Two feed solely on exotic species of plants and can be therefore considered beneficial. The same is true for the Greater Wax Moth, which feeds on the combs of the exotic Honey Bee, an introduced species that has adverse impacts on native bees. The rest are unlikely to have any significant impact to the native vegetation of the preserve, although *Noctua pronuba*, whose range is still expanding in North America, is considered a garden pest in parts of Europe and could potentially develop as a problem in the herb-rich bottomlands of the preserve. The tolerance of its larvae for flooding, however, appears to be unknown.

Wasps and Ants

- *Brachyponera chinensis* (Asian Needle Ant). This is a small and secretive species that probably arrived in North America from East Asia nearly a century ago (Nelder et al., 2006). As a primarily forest-inhabiting species, it probably would have remained completely obscure except that its powerful sting has drawn significant human attention. At the White Pines Preserve, David George reports having been stung at nearly every one of the sites where sheet-sampling for moths was done. Aside from its public health concerns, it may have profound ecological impacts. Not only is it a significant predator on termites and other species in the forest floor decomposer community, but it attacks other species of ants, some of which play important roles as seed dispersers or as controls on other species of insects (see Guénard and Dunn. 2010). Our failure to observe Ground Skinks could also be due to the presence of this ant. This species is probably too widespread now for any effective treatment other than by finding its native control agents, propagating them, and releasing them into the environment provided they themselves do not cause any harm to native species.
- *Vespa crabro* (European Hornet). This is another species that was introduced into North America over a century ago. Although individuals of this species are very large and conspicuous, their nests are typically made inside tree cavities where they often go undetected, unlike the much more obvious nests of our native Bald-faced Hornets, which are constructed hanging from branches. If it has any significant ecological impact, it may be in its usurpation of cavities that would otherwise be used by a variety of native species, including Southern Flying Squirrels, Cope's Gray Treefrogs, and a number of cavity-nesting birds.

Other Exotic Species

Several other exotic species were recorded incidentally to our main survey interests. David George provided the following observations:

Taxon	Species
Crustacea	<i>Armadillidium nasatum</i> (Nosy Pill Woodlouse)
Insecta	<i>Tenodera sinensis</i> (Chinese Mantis)
Insecta	<i>Japananus hyalinus</i> (Japanese Maple Leafhopper)
Insecta	<i>Orientus ishidae</i> (Japanese Leafhopper)
Taxon	Species
Insecta	<i>Halyomorpha halys</i> (Brown Marmorated Stink Bug)
Insecta	<i>Cyrtopistomus castaneus</i> (Asiatic Oak Weevil)
Insecta	<i>Exomala orientalis</i> (Oriental Beetle)
Insecta	<i>Harmonia axyridis</i> (Asian Lady Beetle)

Of these species, the Asiatic Oak Weevil appears to represent the greatest threat to the forested ecosystems in the White Pines Preserve. Adults feed on the foliage of both red and black oak species and the larvae feed on the roots (Baker, 2024). The Japanese Maple Leafhopper also feeds on our native species of maples, although possibly with little damage (Baker, 2019). The other plant-feeding species in this group – Japanese Leafhopper, Brown Marmorated Stink Bug, and Oriental Beetle – are not primarily forest species and probably have more marginal impacts within the preserve, if any. The non-plant-feeding species -- Nosy Pill Woodlouse, Chinese Mantis, and Asian Lady Beetle – are likely to have an effect through competing with native species rather than by targeted feeding.

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HABITATS

Steve Hall

In addition to the taxonomic groups covered previously, we investigated ecologically-defined assemblages, using the multi-species approach developed in the Habitats of North Carolina Website (Hall and Howard, 2026). Each habitat in that classification is based on a particular set of species that shows a high degree of fidelity to a unique set of environmental factors, both biotic and abiotic. Each species – of any taxonomic group – belongs to just one such habitat, and the presence of any of these species, where they are actually resident, determines the presence of that habitat. In the survey of the White Pines Preserve, we identified 67 such habitats where at least three of their species were recorded in the preserve. Collectively, these habitats cover a total of 831 species in 22 higher-order taxonomic groups (see Appendix R).

As in several of the individual taxonomic groups we surveyed, we use persistence analysis to determine how well the habitats within the preserve have held onto their biota over time, using here the species identified as belonging to particular habitats as the basis for comparison. The following table gives the results of this analysis for twenty of the forest habitats present within the preserve.

Habitat	Number of Species	Number of WP Species	Sum of OPS	Proportion of Persistent Species	BPI	QM-BPI
General Maple Forests	16	12	9.85	75%	62%	68%
General Hardwood Forests	144	99	70.20	69%	49%	59%
General Wet Hardwood Forests	23	15	10.00	65%	43%	54%
White Pine Forests	11	7	4.60	64%	42%	53%
General Oak-Hickory Forests	121	72	52.75	60%	44%	52%
General Forests	61	37	25.00	61%	41%	51%
General Pine Forests and Woodlands	57	32	23.05	56%	40%	48%
General Mesic Hardwood Forests	42	24	15.40	57%	37%	47%
General Elm Forests	12	6	4.05	50%	34%	42%
Rich Wet Hardwood Forests	38	18	12.60	47%	33%	40%
General Cool, Mesic Cliffs, Bluffs, and Coves	14	6	3.15	43%	23%	33%
General Wet-Mesic Hardwood Forests	80	29	19.85	36%	25%	31%
Basswood Forests	12	4	3.15	33%	26%	30%
General Wet-Hydric Forests	28	10	6.35	36%	23%	29%
Rich Wet-Mesic Hardwood Forests	156	55	35.75	35%	23%	29%
Rich Dry-Mesic Hardwood Forests	35	10	6.50	29%	19%	24%
General Ash Forests	15	4	3.00	27%	20%	23%
General Dry-Mesic Hardwood Forests	19	5	3.55	26%	19%	23%
General Dry-Xeric Hardwood Forests	43	9	6.05	21%	14%	18%
Total	927	454	314.85	49%	34%	41%

In addition to the Biotic Persistence Index (BPI) that we used previously for the taxonomic groups, we add here a quality-modified version (QM-BPI) that is especially suitable for analysis of habitat-based groups (see Hall and Howard, 2026, Chapter VII). Although the habitat quality for individual species plays a role in determining their probability of surviving over a particular time period, the QM-BPI makes use of a measure that is available only after all species belonging to a particular habitat at a site have been identified as extant; the intactness of that group is a reflection of the habitat quality at that site. This value is the Proportion of Persisting Species (PPS) -- the number of species that have been found in a given survey to the total number expected based on their membership in the habitat as it exists across the state. Unlike the BPI, this value uses solely presence-absence data, with a value of 1 assigned to extant species and 0 to those that were not found. The higher this proportion, the more intact the habitat is, with more of its ecological relationships inferred to be still functioning.

Interpreted in terms of the individual species' chances of survival, however, a value of 1 implies complete security over the coming time period, which the BPI assigns only under rare circumstances. The methods used in species' assessments in the BPI are more realistic in this regard⁴⁶. The QM-BPI itself represents a compromise between these two measures, taking the average of the BPI and the PPS.

At the level of the entire habitat, the quality of information provided by the PPS has a strong effect on the outcome. At the level of the individual species, this has the effect of re-assigning the probability of survival to the midpoint between the originally estimated value and that of complete security, i.e., the value of 1. In that sense, it represents a re-evaluation of the chance of a species surviving based on the information provided specifically by the PPS. Species that already have a high estimated probability of survival are less affected in this regard, the midpoint values being relatively close to the original value. Species that have low original estimates, on the other hand, are most greatly affected, i.e., benefiting the most from the additional information regarding habitat quality.

The use of the QM-BPI is particularly useful for surveys where presence-absence is recorded, but little or no information regarding abundance, frequency of observation, distribution across the area, degree of threat at that site, or other information is used to assess individual species occurrences used in the calculation of BPI. In the current survey of the White Pines Preserve, that is true for several of the taxonomic groups, all of which benefit from the addition of the general habitat quality estimated by the PPS value. For that reason, we give more weight to the QM-BPI than to the BPI itself, at least at the level of the analysis of entire habitats. As in the case of the BPI, the scores for the species provided by the QM-BPI represent predictions of how likely the species is to survive through the coming time period, and the overall value of the QM-BPI predicts the proportion of the original group of species believed to have existed at the site that will survive through that period. As predictions, both can be tested to see which one provides the better estimates through time.

Based on QM-BPI, more than half of the twenty habitats listed in the table are likely to retain at least 40% of their original complement of species, with six retaining 50% or more. The highest

⁴⁶ Including the use of 0.1 probabilities of survival for species regarded as Failed to Find, i.e., historically present but not found in a particular survey.

value – close to 70% -- belongs to the General Maple Forests habitat, whose species are typically abundant anywhere in the state where maple species occur, including the ubiquitous Red Maple. The other habitats in this group are also widespread and possess species that are highly generalized in terms of their habitat requirements. Three of these habitats -- General Hardwood Forests, General Oak-Hickory Forests, and General Forests – have over 50 species identified as their characteristic members and hence are particularly important in their contribution to the biodiversity and ecological functioning of the preserve.

More generally, the magnitude of persistence appears to be strongly related to the amount of the habitat that is present within the preserve. Apart from the Rich Wet Hardwood Forests, which have fairly high QM-BPI score of 40%, owing to the rich alluvial soils along the two river floodplains, upland habitats whose species require nutrient-rich, relatively high pH soils are less well represented than the more generalized habitats. The Basswood Forests, General Ash Forests, Rich Wet-Mesic Hardwood Forests, and Rich Dry-Mesic Hardwood Forests collectively have a QM-BPI score of only 28%. This is most likely due to the absence of mafic rock formations within the preserve, although why American Basswood – a species associated with rich uplands – is present at all is difficult to explain.

Also poorly represented are the dry extreme of habitats. The two habitats with the poorest representation are the General Dry-Mesic Hardwood Forests and the General Dry-Xeric Hardwood Forests, whose combined QM-BPI score is only 19%. The more strictly mesic forests are much better represented, with the General Mesic Hardwood Forests alone having a QM-BPI value of 47%. This reflects the importance of both the ravines and steep north- and east-facing bluffs above the rivers in accounting for the rich biodiversity of this preserve. Several habitats that are particularly relevant in this regard are treated individually in the following sections.

WHITE PINE FORESTS

Forests with a substantial amount of Eastern White Pines (*Pinus strobus*) represent a habitat that supports eleven determining species over the state as a whole. These include the White Pines themselves along with a number of insect herbivores that feed primarily or exclusively on White Pines. Several species of mushrooms are also included that have obligate mycorrhizal associations with White Pines (see the account in the Habitats of North Carolina website for a more detailed description).

While a common habitat in the Blue Ridge and even more widespread further north, the occurrence of White Pine forests at the far eastern edge of the Piedmont, with only a single other relict population in this area on the Uwharrie River, is a striking feature. Even more so is its QM-BPI value of 54%: not only have the White Pines and their mutualistic fungi survived at this site, presumably for 10,000 years, but so have two of its specialist herbivores. Not only has this survey added these two species to what was previously known to exist at this site, but also an entire trophic level for this particular habitat.

The following table shows the estimation of the viability ranks and probabilities of survival of these species at this particular site.

Occurrence Probabilities of Survival (OPS), White Pine Forest

Species	# Dates	# Stations	# Individuals	Viability Rank	OPS
Vascular Plants					
<i>Pinus strobus</i> (Eastern White Pine)	Many	Many	>100	A	0.90
Fungi					
<i>Suillus americanus</i>				F	0.10
<i>Suillus spraguei</i>				BC	0.65
<i>Suillus weaverae</i>				BC	0.65
Moths					
<i>Argyrotaenia pinatubana</i> (Pine Tube Moth)	6	14	7	AB	0.80
<i>Eufidonia convergaria</i> (Pine Powder Moth)				(unrec.)	0
<i>Macaria bisignata</i> (Red-headed Inchworm Moth)	6	7	7	AB	0.80
<i>Macaria minorata</i> (Minor Angle)				(unrec.)	0
<i>Macaria pinistrobata</i> (White Pine Angle)				(unrec.)	0
<i>Marmara fasciella</i> (White Pine Barkminer Moth)	5	5	5	AB	0.80
<i>Zale duplicata</i> (Pine False Looper Moth)				(unrec.)	0

Calculation of BPI and QM-BPI

$$\sum OPS = 4.6$$

$$PSS = 7/11 = 64\%$$

$$BPI = 4.6/11 = 42\%$$

$$QM-BPI = (64 + 42) / 2 = 53\%$$

To put these values into perspective, we can compare them to a set of state parks where records exist in the NRID database for members of this habitat. One very thoroughly surveyed private tract is also included. The persistence estimates for these sites are as follows:

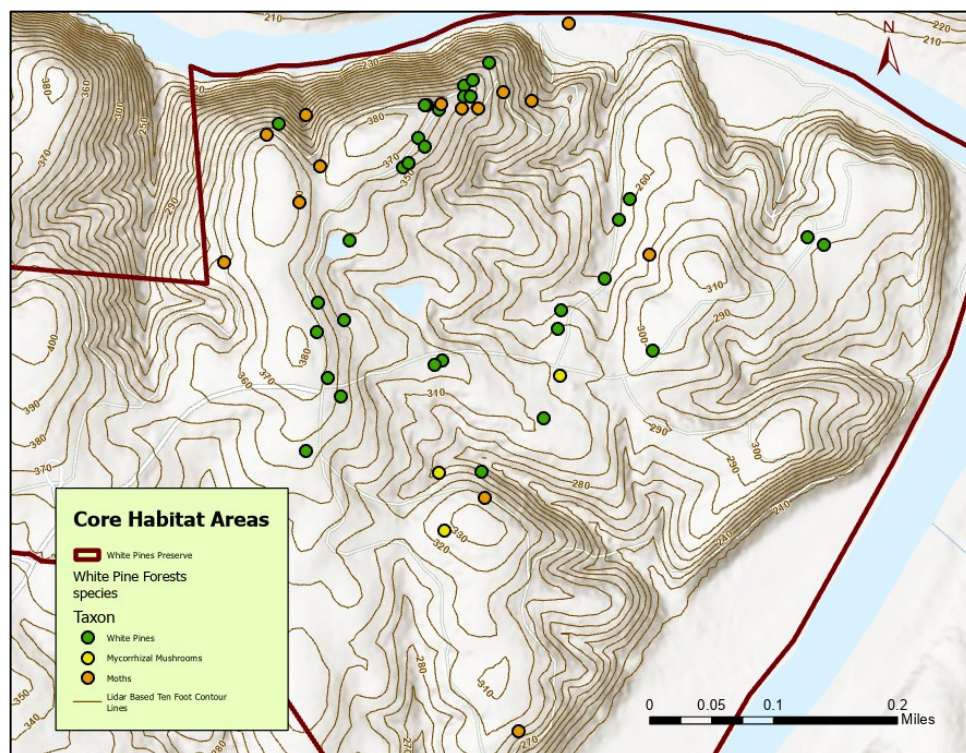
Preserve	Number of Obs. Species	PSS	BPI	QM-BPI
Mars Hill (Private Tract)	8	73%	55%	64%
Gorges State Park*	8	73%	47%	60%
White Pines Preserve*	7	64%	42%	53%
New River State Park*	5	45%	27%	36%
Stone Mountain State Park	4	36%	25%	31%
Lake James State Park	4	36%	23%	30%
South Mountains State Park	4	36%	20%	28%
Mount Jefferson State Nat. Area*	3	27%	13%	20%
Elk Knob State Park	2	18%	11%	14%
Pilot Mountain State Park	2	18%	10%	14%

Preserve	Number of Obs. Species	PSS	BPI	QM-BPI
Hanging Rock State Park*	2	18%	8%	13%

The values for the White Pines Preserve appear to compare very favorably to those for this set of preserves, but the thoroughness of the surveys conducted at these sites needs to be taken into account. Although the state parks generally have been well surveyed for certain taxa, particularly vertebrates and vascular plants, in the case of this habitat, those groups include only the White Pine itself, with all of its other species belonging to other, less-well surveyed groups. Only the Gorges State Park has an ongoing survey for moths, although several others, indicated by asterisks, were surveyed for this taxonomic group but over twenty years ago, with a consequent decline in their occurrence viability estimates (see Hall and Howard, 2026, Ch. VI, for an explanation of the decay function used to adjust the OPS values). Surveys for fungi have been similarly incomplete, but with at least one of the *Suillus* species associated with White Pines recorded in seven of the state parks used for these comparisons. Although upward adjustments are likely to be made to most of these preserves once more current and thorough surveys are conducted, we expect the value we obtained for the White Pines Preserve to remain at least comparable and especially significant given its isolation from the major range of this habitat in North Carolina.

The following map shows the distribution of this habitat within the White Pines Preserve, where records for each of its species indicates the presence of this habitat.

Apart from the fact that most of these records are located next to trails – many of them were obtained from iNaturalist observations – the map indicates that this habitat has a fairly wide distribution within the preserve, but with some degree of concentration in the several ravines that



penetrate this area, as well as along the steep north- and east-facing bluffs. These are the topographic features that most likely explain the survival of this cool, mesic habitat that prevailed across most of the state during the Pleistocene but which has largely retreated to higher elevations here in the South since the end of the Ice Age. At lower elevations, particularly towards the hotter climate found in the Coastal Plain, only small remnants managed to survive in areas that are cooler and moister than the habitats adapted to the warmer and often drier microclimates that have replaced them. These same pockets also support other species that are relicts from the Pleistocene but that do not have as close an association with White Pines, as do members of the habitat just considered. These are described in the next two sections.

GENERAL COOL, MESIC CLIFFS, BLUFFS, AND COVES

This is a somewhat more generalized habitat than the White Pine Forest, but one that is similarly restricted to cool, moist conditions, and particularly those that are highly shaded in the Piedmont. It again includes species such as Catawba Rhododendrons, Sweet Pinesaps, and Red-backed Salamanders that are common and widespread in the cove forests of the Blue Ridge but also have disjunct occurrences well into the eastern Piedmont. The White Pines and their associated species can themselves be considered a sub-habitat of this larger assemblage. Well-known examples are found at Oconeechee Mountain, Eno River State Park, Hemlock Bluffs, New Hope Creek Slopes, Morgan Creek Bluffs, and Raven Rock State Park (see Hardin and Cooper, 1967 for a list of the vascular plants that have disjunct and apparent relict distributions in the North Carolina Piedmont).

Estimates for viability at the White Pines Preserve for the 15 species belonging to this habitat are given in the following table:

Two species, Catawba Rhododendron and Red-backed Salamander, have numerous records from within the preserve as well as some that date back to 1989, when Steve Hall and Marj Boyer conducted one of the first biodiversity surveys at this site. Although these species appear to be at

Species	# of Dates	# Stations	# Individuals	Viability Rank	OPS
Vascular Plants					
<i>Asplenium bradleyi</i> (Bradley's Spleenwort)				(unrec.)	
<i>Asplenium montanum</i> (Mountain Spleenwort)				(unrec.)	
<i>Aralia nudicaulis</i> (Wild Sarsaparilla)				(unrec.)	
<i>Galax urceolata</i> (Galax)				(unrec.)	
<i>Monotropsis odorata</i> (Sweet Pinesap)		1		BC	0.65
<i>Fothergilla major</i> (Large Witch-alder)				F	0.10
<i>Hydrangea arborescens</i> (Smooth Hydrangea)				F	0.10
<i>Rhododendron catawbiense</i> (Catawba Rhododendron)		1	>10	AB	0.80
<i>Rhododendron maximum</i> (Rosebay Rhododendron)				(unrec.)	
<i>Rhododendron minus</i> (Piedmont Rhododendron)				(unrec.)	
Moths					
<i>Olethreutes ferriferana</i> (Hydrangea Leaf-tier Moth)				(unrec.)	
Orthoptera					
<i>Atlantius monticola</i> (Least Shieldback)	1	3	3	BC	0.65
<i>Ceuthophilus maculatus</i> (Spotted Camel Cricket)	4	4	>15	AB	0.80
<i>Ceuthophilus uhleri</i> (Uhler's Camel Cricket)	2	2	>5	BC	0.65
Salamanders					
<i>Plethodon cinereus</i> (Eastern Red-backed Salamander)		>5	>10	AB	0.80

some risk due to climate change, we estimate that they currently have an AB viability score (OPS = 0.8) over at least the next ten years. Three other species discovered at this site in 2024, Spotted Camel Cricket, Uhler's Camel Cricket, and Sweet Pinesap, are assigned viability scores of BC (OPS = 0.65). Two species-- Witch Alder and Smooth Hydrangea – are historically known to have occurred within the preserve but were not relocated in our survey⁴⁷. Given the difficulty in searching the steep bluffs, however, we treat them as Failed-to-Find rather than historic, giving them at least minimal representation (PS = 0.1) in this analysis.

Calculation of BPI and QM-BPI

$$\sum OPS = 4.55$$

$$PSS = 8/15 = 53\%$$

$$BPI = 4.55 / 15 = 30\%$$

$$QM-BPI = (53 + 30) / 2 = 42\%$$

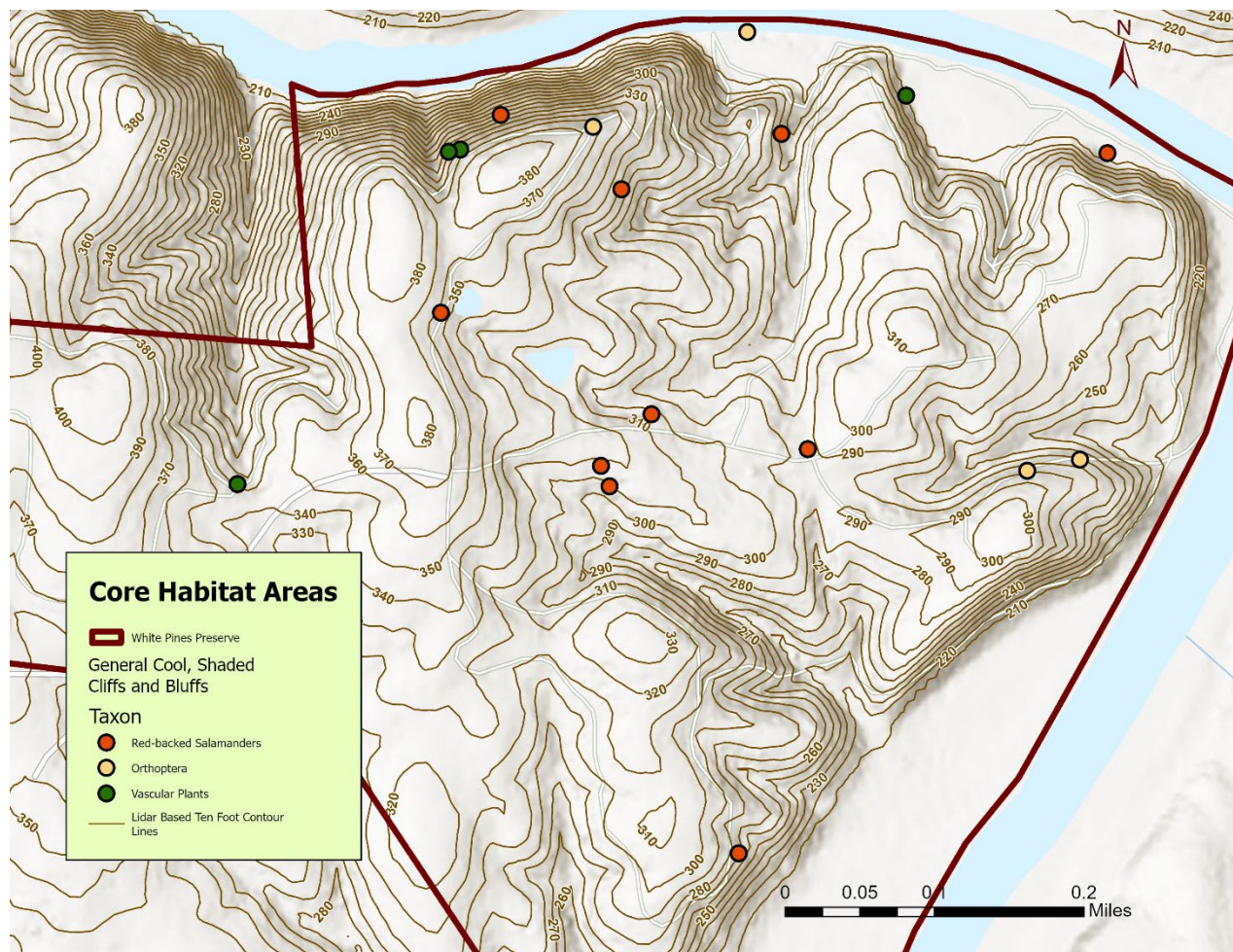
Although the persistence estimates are lower than they were for the White Pines Forest, the comparison of those from the current survey to the values obtained from a set of state parks, based on NRID data, indicates that the results of our survey again compare favorably.

The White Pines Preserve, in fact, has the highest number of species belonging to this habitat of any of the parks included in this analysis, as shown in the following table.

Preserve	Number of Obs. Species	PSS	BPI	QM-BPI
Chimney Rock State Park	7	47	39	43
White Pines TLC Preserve	8	53	30	42
Grandfather Mountain State Park	7	47	36	41
Occoneechee Mountain State Natural Area	7	47	34	41
Pilot Mountain State Park	7	47	32	39
Hanging Rock State Park	6	40	35	38
Gorges State Park	6	40	38	34
Elk Knob State Park	6	40	22	31
Stone Mountain State Park	5	33	23	28
Mount Jefferson State Natural Area	5	33	17	25
William B. Umstead State Park	4	27	18	22
South Mountains State Park	4	27	15	21
Raven Rock State Park	4	27	15	21
Mount Mitchell State Park	3	20	15	18
Yellow Mountain State Natural Area	3	20	14	17
Pisgah View State Natural Area	3	20	14	17
Crowders Mountain State Park	3	20	12	16
Merchants Millpond State Park	2	13	12	13
Bullhead Mountain State Natural Area	2	13	11	12
Eno River State Park	2	13	10	12

⁴⁷ A population of Witch-alder was observed during the survey period on a neighboring tract supporting the same habitat.

This may again be due to differences in sampling intensity, particularly with regard to the orthopteran species belonging to this habitat. As with the White Pines Forest, the biotic integrity of this preserve is actually quite impressive, considering that this site has possibly been isolated from the main part of its range over the past 10,000 years. If so – and that can be tested by genetic analysis – it appears to have held on to at least half of the species that were likely to have been originally present. That includes the population of Spotted Camel Crickets, a species which has not been recorded before either in North Carolina or, in fact, anywhere south of Maryland. The following map shows the locations where determining species of this habitat have been recorded within the preserve. The steep, north-facing slopes along the Rocky River represent the core area for this habitat, with several species occurring nowhere else in the preserve. As was true for the White Pine Forests, however, records for a few species – particularly the Red-backed Salamander – extend over a larger portion of the preserve, particularly within some of the mesic ravines.



MONTANE FOREST DISJUNCTS IN THE EASTERN PIEDMONT

In addition to the White Pines, Catawba Rhododendrons, and Red-backed Salamanders, several species in the two habitats described above appear to represent relicts from the time

approximately 10,000 years ago when the main part of their range extended well to the east of its current center in the Blue Ridge. A number of other plant species with similar disjunct ranges were identified by Hardin and Cooper (1967). Those that are forest inhabitants and have at least one population in the eastern Piedmont⁴⁸ are listed in the table below. Additionally, we have added a number of other species from other taxonomic groups that show similar distributions in North Carolina. Together these species represent a biogeographically- and habitat-based group that can be used for comparative purposes, similar to what we have described for habitat-based groups.

Scientific Name	Viability Rank	OPS
Vascular Plants		
<i>Acer saccharum</i> *		
<i>Aconitum uncinatum</i> *		
<i>Actaea pachypoda</i> *		
<i>Aralia nudicaulis</i> *		
<i>Aralia racemosa</i> *		
<i>Asplenium bradleyi</i>		
<i>Asplenium montanum</i> *		
<i>Asplenium rhizophyllum</i> *	F	0.10
<i>Buchneria americana</i> *		
<i>Carex gracillima</i> *		
<i>Carex torta</i> *		
<i>Caulophyllum thalictroides</i> *		
<i>Cornus alternifolia</i> *		
<i>Delphinium exaltatum</i> *		
<i>Delphinium tricorne</i> *		
<i>Deparia acrostichoides</i> *		
<i>Dicentra cucullaria</i> *	AB	0.80
<i>Diplaziopsis pycnocarpa</i> *		
<i>Dryopteris cristata</i> *		
<i>Dryopteris goldieana</i> *		
<i>Enemion biternatum</i> *	AB	0.80
<i>Galax urceolata</i>		
<i>Hydrophyllum canadense</i> *		
<i>Lathyrus venosus</i> *		
<i>Melanthium hybridum</i> *		
<i>Monotropsis odorata</i> *	BC	0.65
<i>Nanopanax trifolius</i> *		
<i>Osmorhiza claytoni</i> *		

⁴⁸ Only those that have been recorded in the eastern Piedmont – found in the Roanoke, Tar, Neuse, and Cape Fear basins – are included in our list.

Scientific Name	Viability Rank	OPS
<i>Panax quinquefolius</i> *		
<i>Pinus strobus</i> *	AB	0.80
<i>Rhododendron catawbiense</i> *	BC	0.65
<i>Stewartia ovata</i> *		
<i>Symplocarpus foetidus</i> *		
<i>Tsuga canadensis</i> *		
Bryophytes		
<i>Platylomella lescurii</i>	BC	0.65
Fungi		
<i>Suillus americanus</i>	AB	0.80
<i>Suillus spraguei</i>	AB	0.80
<i>Suillus weaverae</i>	F	0.10
Lichens		
<i>Lecanora saxigena</i>	BC	0.65
<i>Lepraria cryophila</i>	BC	0.65
<i>Leprocaulon nicholsiae</i>	BC	0.65
<i>Sporodophoron americanum</i>	BC	0.65
Spiders		
<i>Anahita punctulata</i>	BC	0.65
<i>Maevia undescribed species B</i>	BC	0.65
<i>Pampibius paitius</i>	BC	0.65
Orthoptera		
<i>Allonemobius allardi</i>	BC	0.65
<i>Atlanticus monticola</i>	BC	0.65
<i>Ceuthophilus maculatus</i>	BC	0.65
<i>Ceuthophilus uhleri</i>	BC	0.65
Butterflies		
<i>Callophrys augustinus</i>		
Moths		
<i>Argyrotaenia pinatubana</i>	AB	0.80
<i>Crambus albellus</i>	BC	0.65
<i>Ellida caniplaga</i>	B	0.70
<i>Gretchena concubitana</i>	AB	0.80
<i>Hypena deceptalis</i>	AB	0.80
<i>Loscopia velata</i>	BC	0.65
<i>Macaria bisignata</i>	AB	0.80
<i>Metarranthis amyrisaria</i>	B	0.70
<i>Nemoria mimosaria</i>	B	0.70
<i>Olethreutes hamameliana</i>	AB	0.80
<i>Pantographa limata</i>	A?	0.85

Scientific Name	Viability Rank	OPS
<i>Probole nepiasaria</i>	AB	0.80
<i>Pseudexentera kalmiana</i>	BC	0.65
Beetles		
<i>Monochamus notatus</i>	AB	0.80
Gastropods		
<i>Pallifera hemphili</i>	F	0.10
Salamanders		
<i>Plethodon cinereus</i>	AB	0.80

* Identified as montane disjuncts by Hardin and Cooper (1967)

$$\sum OPS = 24.47$$

$$PSS = 37/66 = 0.56$$

$$BPI = 24.47/66 = 37\%$$

$$QM-BPI = (56 + 37)/2 = 46\%$$

The persistence of between 37% and 46% of these species at the White Pines Preserve over the past 10,000 years when they have otherwise vanished over most of the Piedmont seems remarkable. The magnitude of this persistence, however, is largely due to our identification of 28 species as belonging to this group. Based instead on just the vascular plants, the BPI drops to just 11% and QM-BPI to 14%. The main difference here, is that many more plant species have been identified as disjuncts, a large number of which are absent from the White Pines Preserve, whereas all the species we added belong to groups where this analysis has not been done, or at least with the same degree of thoroughness. There is at least the potential that many species that might qualify for disjunct status do not, in fact, occur at the White Pines Preserve.

It is also difficult to compare these persistence values to other preserves that have not received as much survey attention for the taxa to which these newly recognized disjuncts belong. BPI values for Raven Rock State Park, Eno River State Park, and Oconeechee State Natural Area – all of which are known to possess Pleistocene relict plants – are only 8%, 3%, and 6% respectively. On the positive side, our identification of 28 possible Pleistocene Relicts provides a new set of targets for survey efforts. If, as we are emphasizing here, the persistence of species over 10,000 years in isolation from their main range is an important indicator of conservation value of a particular preserve, we hope this information will drive renewed survey efforts not only towards these state parks, but to all of the other sites that also shelter these relict species.

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DISCUSSION

TAXONOMIC SUMMARY

As reviewed in the taxonomic sections, the White Pines Preserve has received a lot of attention by field biologists over the years. Botanists have visited the site since the 1920s, with a vast amount of work done by Swab in the 1980s, who documented 562 species. Dragonflies have also been sampled in the Rocky River since the 1960s, bryophytes since the 1970s, fungi, butterflies, and terrestrial vertebrates since the 1980s. Despite all of this work, however, we were still able to add to the lists for all of these groups except for butterflies and for fungi, which we did not actively survey. Due to the more extensive set of taxa that we included in our survey, we added 1,122 species not previously reported, including 127 lichens, 22 myriapods, 115 spiders, 48 orthopterans, 6 bees and 804 moths.

Among these species, we documented or re-confirmed the presence of six species currently tracked as Significantly Rare (SR) by the NC Natural Heritage Program:

Species	State Rank	NHP Status
<i>Fothergilla major</i> (Large Witch-alder)	S3	SR
<i>Monotropsis odorata</i> (Sweet Pinesap)	S3	SR
<i>Phacelia covillei</i> (Buttercup Phacelia)	S3	SR
<i>Pelekium pygmaeum</i> (Pygmy Cyрто-hypnum Moss)	S1?	SR
<i>Gomphurus septima</i> (Septima's Clubtail)	S3	SR
<i>Lytrosis permagnaria</i> (A Geometrid Moth)	S2S3	SR

Although none of these species are legally protected as state Endangered, Threatened, or Special Concern, Significantly Rare (SR) species as designated by the Natural Heritage Program are used in assessing the conservation significance of particular natural areas. For a Piedmont site with otherwise common types of habitat, the White Pines Preserve has a fairly high number of SR species. Three other Piedmont preserves with similar habitats have either the same number or fewer: Raven Rock State Park also has six, Oconeechee Mountain State Natural Area has two, and the Eno River/Cates Ford Slopes and Uplands have four (NC Natural Heritage Program, 2025).

In addition to these species officially listed as Significantly Rare, a large number of species were identified as new to the state or to the region but have yet to be ranked. Others, such as the White Pines themselves (*Pinus strobus*), are considered only regionally rare (the species itself is common in the western part of the state and is ranked as S5). While this designation can be considered an additional factor in considering priorities for conservation actions, species that are regionally rare are given a much lower value compared to the SR species that are rare across the entire state.

MEASUREMENT OF BIOTIC PERSISTENCE

Federal and state-listed species are given a high priority for conservation mainly since they are believed to be on the brink of extirpation or complete extinction, but they also have significance as indicators of what has been termed biotic integrity: the capability of a site to maintain its species and their ecological relationships through time. If a site has managed to hold on to the populations of species that have disappeared or strongly declined elsewhere, the site itself is likely to do the same for its biota more generally. The greater the number of such species present within a preserve, the greater its overall integrity.

We agree that consideration of ecological integrity should be a major concern for conservation efforts, but a focus on just the rarest, most imperiled species overlooks the information provided both by species that have already become extirpated from a particular site, as well as by species that might be common elsewhere in the state but that are highly imperiled locally. That is exactly what the BPI measures at a given site.

Relict Occurrences

The significance of biotic persistence is no better shown than by the populations of White Pines and other species that have presumably survived at this site since the end of the Pleistocene 10,000 years ago. Although these species may be common in the Blue Ridge and of essentially no importance to conservation at the state level, their survival at the site of the White Pines Preserve for ten thousand years within a small site located hundreds of miles from the current heart of their range is striking testimony of their ability to cope with immense changes in its environment. While more research is needed to confirm the status of these species as actual relicts – possibly through measurement of the genetic divergence from populations in the Blue Ridge or by finding residual traces of their DNA (aka “Ancient DNA”) in soil samples taken down to the strata where they are intermixed with those of ground sloths – we are interested here more in the persistence of entire groups of species, or equivalently, their habitats. They would still be of interest even if all of them turned out to be much more recent arrivals, having colonized this site by dispersal – either natural or man-aided – from the core of their current range in the mountains. Just how did that come about?

That five symbionts of the White Pines have been documented at this site by itself suggests the existence of both the abiotic as well as biotic factors that are quite unusual in the context of the eastern Piedmont. Even more remarkable is the apparent persistence of 33 species that occur alongside White Pines in the Blue Ridge but that have little or no dependence on the White Pines themselves. That they nonetheless co-occur with the pines within our study area we believe strongly supports the persistence of the entire habitat to which they belong and which seems far less likely to have been assembled recently by independent dispersal than by persistence on site, even for the remarkable period of 10,000 years, most spent in long isolation from the rest of their range.

This diversity as reflected in the high BPI value for the Pleistocene relicts at the White Pines Preserve is one of the major highlights of our survey. Taken at face-value, no other site in the eastern Piedmont rivals the total of 33 relict species documented at this site, indicating that this

site has had a superlative history of maintaining the species associated with their otherwise highly restricted habitats in this region. As such, this site should be a major target for studies that both confirm the relict status of its species but also determine what features of this site help explain their extremely high level of biotic persistence.

As we noted previously, however, other sites within the region known to support Pleistocene relicts have not been as intensively sampled for relict species other than vascular plants. Twenty-eight of the species we include in this category were, in fact, not suspected to have relict status in this region prior to our survey. In the case of the Spotted Camel Cricket (*Ceuthophilus maculatus*), the species itself had not been recorded south of New Jersey before our discovery of the population at the White Pines Preserve. Equally unexpected – and not documented in our survey – is the Black Mantleslug (*Pallifera hemphili*), a species associated with Spruce-fir Forests in our mountains but discovered in 1975 by J. Clamp in a Rhododendron thicket in a small ravine just north of the Rocky River opposite the White Pines Preserve (NCSM 84448 - North Carolina Museum of Natural Sciences Mollusk Collection; see account in GBIF record 1438672185).

Clearly there is a lot left to be learned about the distribution and status of potential Pleistocene relicts in North Carolina. If 28 new species to this group have been found at just one site in the state, it seems highly likely that surveys conducted at similar sites will add a great many more. Although our total of 33 species produced a BPI of 37%, there is at least the possibility that other sites could have even higher values. In any case, until more such sites are surveyed, comparisons of BPI values between sites do not hold much meaning.

Once we have a more complete picture, however, differences between sites in terms of their persistence may help determine which features of both the abiotic and biotic factors of their habitats have allowed such extreme persistence. As reviewed by Hampe and Jump (2011), relicts “have probably been exposed to stronger and longer-lasting climate-related selection than their conspecifics from the main distribution range. Nevertheless, they have not gone extinct. This particular combination renders climate relicts as instructive models and natural laboratories for investigating how populations will react (and potentially adapt) to ongoing climatic changes.” Given the potential insights we can gain into our current environmental crisis, identification of exemplary sites for detailed studies, such as the White Pines Preserve, justifies the amount of effort it requires.

Between Site Comparisons

Aside from the exceptional cases of persistence just discussed, the normal use for measurements of biotic integrity or persistence is to gauge current declines or losses due to recent or ongoing causes, particularly those suspected to be due to human activities. One of our main goals in the survey of the White Pines Preserve was, in fact, to investigate how well a site that is relatively remote from urbanization compares to sites such as the New Hope Open Space Preserve in Durham County that are now closely enveloped by residential and commercial development. One basic question we hoped to answer was whether the decline in neotropical migrant, forest-interior-nesting birds that we observed in the New Hope Creek survey was due to remote causes, such as the impacts to their wintering habitat, to causes centered in North America, such as massive loss of habitats, or to global causes, such as climate change. In all of these cases, even a preserve

located in a rural, relatively undeveloped area in North Carolina should show similar levels of decline.

Alternatively, local causes related to the close proximity to development could be the main cause, in which case, a site located well away from developed areas should be much more intact, i.e., should have a much higher value of BPI for this particular group of species. If so, then local conservation actions have a chance of success, whereas only global actions would be effective if remote or global factors are primarily to blame.

As described previously in the section on Breeding Birds and repeated in the following table, the BPI for the neotropical, forest-interior nesting birds at the White Pines Preserve is nearly twice as high as obtained for the New Hope Creek preserves. This is at least consistent with the hypothesis that factors related to the local intensity of human-related impacts play a major role affecting the persistence of this group.

Biotic Persistence of Forest Interior Species

Taxon	Baseline Number of Species	White Pines		New Hope Creek	
		Sum of OPS	BPI	Sum of OPS	BPI
Orthoptera	15	9.20	61%	5.75	38%
Butterflies	14	4.05	29%	4.95	35%
Amphibians	11	4.75	43%	4.85	44%
Reptiles	15	4.05	27%	5.60	37%
Migrant Breeding Birds	22	13.70	62%	7.35	33%
Resident Birds	14	8.35	60%	9.50	68%
Mammals	8	2.20	28%	1.65	21%
Total	99	45.65	46%	39.65	40%

This analysis also pin-points the fact that among bird species at least, it is the migratory species that show the greatest difference between the two sites, with a BPI difference of 29 percentage points in favor of the White Pines Preserve. In sharp contrast, the year-round resident bird species – in this case also those that nest in forest interiors – show the opposite pattern, with the populations at the New Hope preserves showing the higher level of persistence. In this case, however, it may be the decline of migrants at those sites may be responsible, freeing the resident species from competition for food and nesting sites. If that is the reason, then the same local factors are responsible, although indirect and more positive in their effects on the resident species.

The other taxonomic groups we analyzed using the Biotic Persistence Index show a much more mixed set of between-site comparisons. The only other taxonomic group that shows a much higher BPI value for the White Pines Preserve and for the New Hope Preserves is the orthoptera, but in their case, the difference appears to be related to the much larger proportion of upland habitats at the White Pines Preserve, which the majority of forest species of crickets and katydids prefer over the bottomlands that are much more prominent in the New Hope preserves. For the

other groups, both habitat differences and sampling factors are likely to be responsible for the differences observed between the sites.

One additional taxonomic group, however, shows a level of difference between the White Pines Preserve and the New Hope preserves that appears to be as extreme as that shown by the neotropical migrant, forest interior bird species and, in fact, may account for those findings. In a comparison of the diversity and abundance of the macro-moths recorded in the New Hope survey to surveys conducted by the Natural Heritage Program at several similar rich bottomland preserves, the New Hope Bottomlands had a strikingly large deficit across the entire year, across all the families in this group, and across all host-plant types, from canopy-foliage feeders to those feeding on detritus in the leaf litter. Particularly relevant for the bird species, the macro-moths – consisting as the name implies of the families containing the larger species of moths – form the most important food for both adults and especially the nestlings of forest-interior, neotropical migrant birds (Holmes and Schultz, 1988; Talamy and Shriver, 2021). Where populations of their prey species suffer declines, there are correlated declines in the bird populations.

As discussed by George and Niznik in their section of this report on moth species, the overall diversity of this group appears to be exceptionally high at the White Pines Preserve compared not only to the results of the New Hope survey but also to other sites in the Piedmont where methods and sampling intensity were similar. Those findings, however, refer to the samples obtained over all habitats found in these preserves. In the case of the New Hope survey, however, all samples for this group were taken for floodplain habitats, there being essentially no natural upland habitats left in the adjoining areas.

In order to narrow the comparison of the White Pines Preserve to the New Hope Bottomlands, the following table presents the results of biotic persistence analysis solely for habitats that present in the floodplains of the two areas. The baseline set of species in this analysis are based on the habitat descriptions included in the Habitats of North Carolina website. Note that both micro- and macro-moths were sampled in our surveys of these areas and both are included in this analysis.

Comparison of Biotic Persistence Index Values for the Moths of Floodplain Habitats

Habitat	Number of Expected Species	White Pines Preserve			New Hope Creek		
		Observed Species	Sum of OPS	BPI	Observed Species	Sum of OPS	BPI
General Ash Forests	14	4	3.05	22%	1	0.8	6%
General Elm Forests	9	4	2.65	29%	1	0.65	7%
General Forests	19	11	8.85	47%	8	6.05	32%
General Hardwood Forests	96	63	46.75	49%	29	19.4	20%
General Maple Forests	15	9	7.40	49%	4	2.75	18%
General Oak-Hickory Forests	111	61	44.80	40%	30	19.95	18%
General Pine Forests and Woodlands	41	23	16.10	39%	2	1.3	3%
General Wet Hardwood Forests	11	8	5.35	49%	2	1.35	12%

Habitat	Number of Expected Species	White Pines Preserve			New Hope Creek		
		Observed Species	Sum of OPS	BPI	Observed Species	Sum of OPS	BPI
General Wet-Hydric Forests	4	2	1.30	33%	3	2	50%
General Wet-Mesic Hardwood Forests	50	28	20.30	41%	15	9.95	20%
Rich Wet Hardwood Forests	49	10	7.40	15%	2	1.3	3%
Rich Wet-Mesic Hardwood Forests	43	15	10.30	24%	8	5.35	12%
Totals	462	238	174.25	38%	105	70.85	15%

With the sole exception of the General Wet-Hydric Forests, which contains only four species, the BPI values for this group of habitats are much higher for the White Pines Preserve compared to those for the New Hope Bottomlands. Despite the fact that these habitats are much more extensive and consist of even older stands of forest along New Hope Creek than at the White Pines Preserve, the total BPI for this group of habitats and species is only 40% of that for the White Pines Preserve.

Although both moths and birds are suffering global declines in diversity and abundance, these results are consistent with the action of local factors. For the bird species, there could be direct impacts of urbanization on the populations in the New Hope Bottomlands, including increased predation levels, noise impacts, and loss of populations in the surrounding areas. There is also likely, however, to be a major effect due to the decrease in food availability due to whatever factors are affecting the moth populations. Those include light pollution; pesticide drift from agricultural areas; pollutant-laden run-off from urbanizing areas; increased flooding associated with greater areas of impervious surface; and the impacts of exotic invasive species. Except for the impacts of agriculture, these factors are all likely to be much greater in the New Hope Bottomlands – now almost completely surrounded by urban development – than they are in the still heavily forested, rural area where the White Pines Preserve is located. For neither site do widespread effects such as increased temperature, drought, flooding or other storm damage explain the difference between the sites, although they may also be affecting each of these sites and are expected to only increase in their impacts on all species and ecosystems.

More detailed, focused investigations will be needed to determine both the likely causes for the current status of the biodiversity at these preserves as well as to refine the predictions for their ongoing change.

THE IMPORTANCE OF BIOMONITORING

In a recent review of ecological integrity, Rohwer and Marris (2021) argue that “ecosystems are simply too dynamic in space and time, their complex interconnections, including coevolved relationships, ultimately fleeting at the geological scale” to be “the kinds of things that have integrity.” Our findings with regard to the Pleistocene relicts, however, argue that habitats can, in fact, maintain their species and at least some of their ecological interactions over periods of thousands of years, even after their main habitat has shifted far out of reach. Over much shorter periods, such as the thirty years over which we believe the decline in breeding bird populations

took place in the New Hope Bottomlands, detection of those changes as well as their relative absence from the White Pines Preserve, has important implications for conservation. Unless “ecological integrity” is viewed as an all-or-nothing property (with persistence perhaps a less loaded term), its measurement -- as a variable property -- is critical for conservation actions.

Under that interpretation, one important outcome of the current survey is to re-set the biotic baselines of the preserve for future comparisons. The predictions we have made using the Biotic Persistence Index cover the ten year period following the completion of our study. At the very least, repeated surveys of the same biotic groups can determine whether the rates of persistence we predict hold true or are, alternatively, overly pessimistic or optimistic. Such information is crucially important in order to adjust our predictions about the rate of biotic change and for the urgency of conservation efforts needed to combat the most negative changes.

Aside from keeping informed about the ongoing changes to the environment, information about which species, habitats, and preserves are declining the fastest can help direct conservation efforts to where they are needed the most. Equally important, if not more so, biomonitoring can be used to assess the beneficial effects of particular conservation efforts: the BPI should increase where the actions have a positive effect on survival of both species and their habitats. The more species within a given habitat that are positively affected, the greater the positive result as measured by BPI.

Biological surveys can themselves be considered as key conservation actions. Any action intended to benefit species or their habitats can be effective only if supported by detailed, up-to-date information on their distribution and status. One easy way to boost the BPI scores for a given site is to look more intensively for the species that were failed to find in previous surveys. This includes species that were actually overlooked but still present, as well as species that have returned to the site following an absence or that were artificially restored to the site.

BPI scores can also be raised by more accurately estimating the survival of individual species whose viability estimates were low due to a lack of information regarding their density, frequency of observation, distribution over the preserve, and evidence of reproduction and maturation. This includes a very large number of species that were recorded only once or whose status within the preserve was only scored as “present.”

THE CONSERVATION VALUE OF THE WHITE PINES PRESERVE

The North Carolina Natural Heritage Program currently rates the White Pines Natural Area⁴⁹ as Very High, the second highest value they assign. This rank is based partly on the NHP Element Species that are documented at this site, although their current file for this site has not yet registered three Element Species that were documented in the course of our survey: *Pelekium pygmaeum* (Pygmy Cyrto-hypnum Moss), *Lytrosis permagnaria* (A Geometrid Moth), and *Monotropsis odorata* (Sweet Pinesap). Also left out is *Gomphurus septima* (Septima's Clubtail), a dragonfly the has long been observed within this site but that is included in the adjoining Rocky

⁴⁹ Note that the White Pines Natural Area includes areas adjacent to the TLC preserve, to the north and east across the rivers. The aquatic habitats located in between, however, are not included.

River Dragonfly Riffles. As an amphibious species – adults can be found perched onshore – we include it in the list of Element Species for the preserve. With these adjustments, the state ranks and viability ranks assigned to these elements by the Natural Heritage Program are listed below, along with our estimates of the survival probabilities of their occurrences (OPS values) at the White Pines Preserve.

NHP Element Species	State Rank	Viability Rank	Occurrence Probability of Survival
Harperella nodosa (Harperella)	S1	F	0.10
Peleikum pygmaeum (Pygmy Cyrto-hypnum Moss)	S1?	BC	0.65
Carex jamesii (James's Sedge)	S2	B	0.70
Enemion biternatum (Eastern Isopyrum)	S2S3	AB	0.80
Lyctosis permagnaria (A Geometrid Moth)	S2S3	BC	0.65
Fothergilla major (Large Witch-alder)	S3	BC	0.65
Gomphurus septima (Septima's Clubtail)	S3	AB	0.80
Monotropis odorata (Sweet Pinesap)	S3	BC	0.65
Panax quinquefolius (Ginseng)	S3	D?	0.35
Phacelia covillei (Buttercup Phacelia)	S3	AB	0.80
Number of Species =10			Sum of OPS = 6.15
			Viability Index = 62%

Additionally, the Natural Heritage Program treats Natural Communities as Elements, and the table below lists the types identified for the White Pines Natural Area, along with their state ranks and viability estimates.

NHP Element Communities	State Rank	Viability Rank	Occurrence Probability of Survival
Floodplain Pool	S2	1A , 1C ⁵⁰	0.96
Piedmont/Coastal Plain Heath Bluff	S3	A	0.99
Basic Mesic Forest (Piedmont Subtype)	S3S4	A	0.90
Piedmont Levee Forest (Typic Subtype)	S3S4	B	0.70
Mesic Mixed Hardwood Forest (Piedmont Subtype)	S4	1AB, 1E	0.90
Dry-Mesic Oak--Hickory Forest (Piedmont Subtype)	S4	B	0.70
Rocky Bar and Shore (Water Willow Subtype)	S4	A?	0.85
Number of Species = 7			Sum of OPS = 6.00
			Viability Index = 86%

⁵⁰ Where more than one occurrence exists for a given element, the overall probability that the element itself will survive uses the following formula: Combined OPS = $1 - \prod (1 - PS_i)$. Assuming that the survival of the occurrences are independent of one another, this equation gives the complement – the probability of survival of at least one occurrence -- of the probability that all of the separate occurrences become extirpated during the coming time period.

Although not used in the NHP rating system for natural areas, we estimate that both the Element Species and Element Communities have a high probability of survival as groups over the next ten years. For the Element Species in particular (*Harparella* excepted), this indicates that the preserve has been effective in maintaining its ecological integrity, offering a good refuge for species that are generally in decline across the state. The same conclusion applies to the Natural Communities, although most of the elements in that group are considered generally secure across the state, as implied by the state ranks of S3S4 or S4 (i.e., of no conservation concern).

In contrast, our analysis of the habitats (as defined by the NCBP) indicate a lower level of security. For the 19 forest habitats analyzed in our study (see section on Habitats), the corresponding Viability Index – taking only extant species into consideration -- is 69% (see the section on the NCBP Approach to Biodiversity Surveys for more information). While we still consider that to be a fairly high value, it is far less than the 86% obtained for the group of Natural Communities. When the species that were missed in the survey but expected to have once occurred in this area are included, the resulting BPI value is just 34%. Even the value of QM-BPI, which corrects to some extent for the extensive use of presence-absence assessments for some of the taxa documented in the survey, is still only 41%.

At least one of the habitats we included in our analysis -- the General Ash Forests, is in fact highly imperiled due to the ravages of the introduced Emerald Ash Borer, with no preserve in the entire state immune to its impacts. Several other habitats are only marginally present within the preserve, especially upland habitats associated either with rich, relatively high pH soils or with dry-xeric micro-climates. In general, our analysis of habitats includes a much wider range of species than are included in the evaluation of natural communities, which is based almost entirely on vascular plants. If we then take the 41% QM-BPI score as a meaningful measure of persistence, then there has been a significant amount of species attrition since at least the time when European colonists started altering the natural landscape. With however, the 69% viability index for the remaining species indicating a high chance of persistence, the preserve appears capable of providing significant value as a biodiversity refuge going forward, although with improvements still possible to make.

For one group of species, those that we have identified as likely Pleistocene relicts, a BPI score of even 37% seems spectacular, considering the time span for the persistence involved. Currently, this value far surpasses any other site in the eastern Piedmont, although we expect that to change once more thorough surveys are conducted, aided by the information collected in this survey. Although this group of species normally has only a minor role in assessing preserves for biodiversity conservation, understanding how this group has managed to survive a massive change in climate, habitat, and biodiversity has a very high degree of relevance today, when we are entering into another such drastic period of change (see Hampe and Petit, 2005; Hampe and Jump, 2011, and Woolbright et al., 2014). The White Pines Preserve, in fact, may turn out to be a prime center for research on the ability of species, habitats, and ecosystems to persist in the face of environmental change in general.

Several of the taxonomic groups also stand out as having high values of BPI, especially the forest-interior, neotropical migrant breeding birds and the forest-interior orthoptera. These and other

groups whose BPI scores compared favorably to those obtained in the survey of the New Hope Bottomlands are considered in the following section.

THE WHITE PINES PRESERVE WITHIN THE LARGER CONSERVATION LANDSCAPE

The location of the White Pines Preserve in an area that has remained very rural up to now appears to have played an important role in safeguarding several groups of species. These include both the moths and their major predators, the forest-interior, neotropical migrant breeding birds, as indicated in our comparison of the results of the White Pines Survey and the one we previously conducted along New Hope Creek in Durham County.

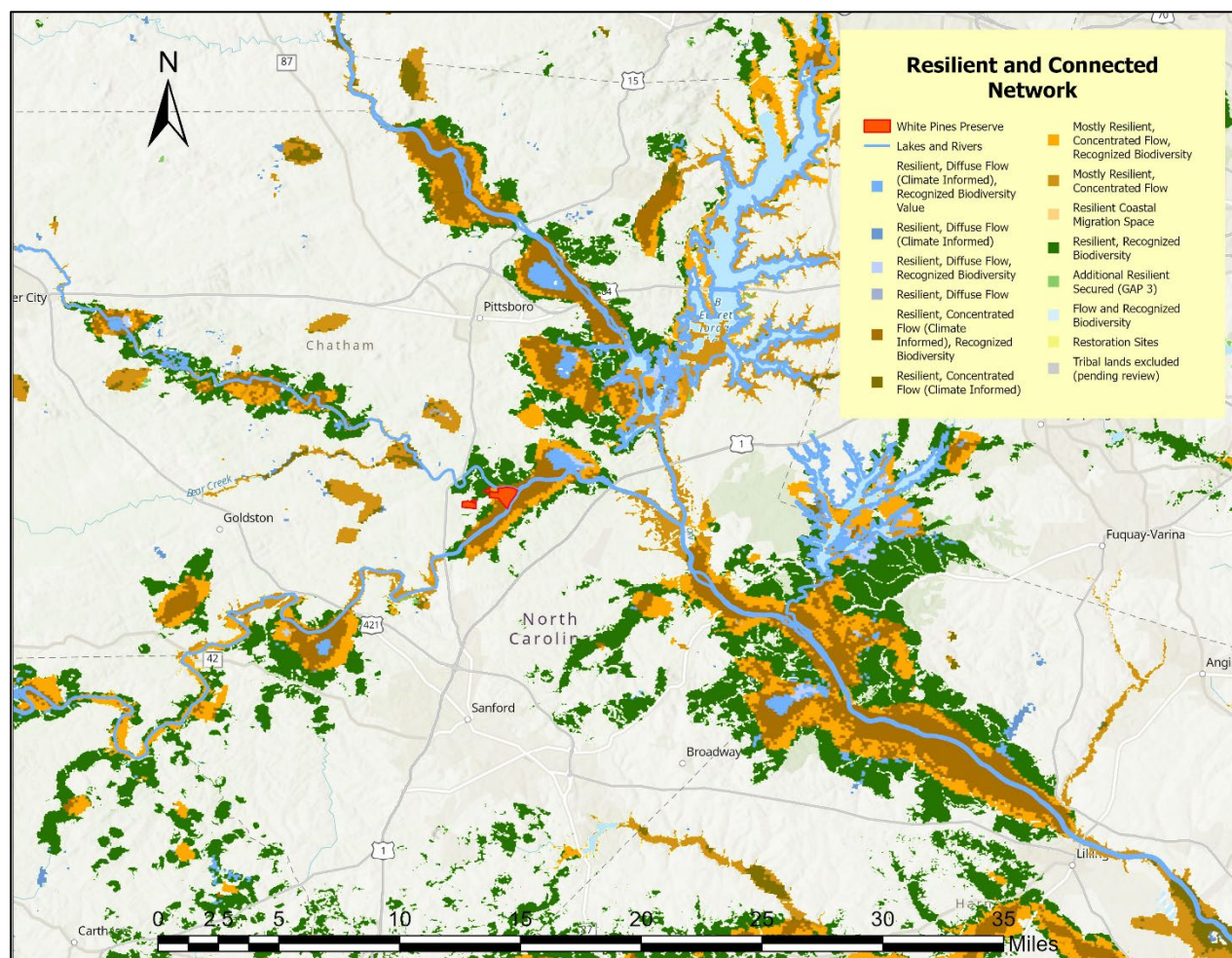
In the discussion of breeding bird populations, we presented a map showing the extent of core forest interior habitat, i.e., the area located beyond the reach of edge impacts originating at the boundary between the forest and the closest non-forested habitats. Based on the 250 m distance found by Akresh et al. (2024) for increased nest losses in from an edge, the White Pines Preserve had 50 hectares of core habitat, or more than 10 times the amount present in either the New Hope Bottomlands or the Hollow Rock Park. The core area within the White Pines Preserve, moreover extends well outside the preserve onto adjacent privately owned lands. Given the well-documented sensitivity of nesting birds – particularly forest interior, neotropical migrants – to edge effects, this difference alone could account for at least part of the difference in viability observed between the White Pines Preserve and the New Hope Creek preserves.

Moths are also a group for which edge effects can play a big role in terms of viability. In their case, it is the effects of artificial lighting at night that appear to have the biggest impact. Nocturnally flying insects use the stars and moon to steer a straight course, an important factor in their dispersal behavior. Artificial lights disrupt this ability, trapping individuals within a narrow zone around the light source, including during the following day when they are normally dormant. This makes them highly vulnerable to predation, let alone preventing them from foraging, mate finding, egg-laying sites, or effective dispersal. In moth surveys conducted over two decades by the North Carolina Natural Heritage Program, sites with the highest diversity of species and the greatest abundance of individuals were found in areas furthest away from developed areas and where the natural habitats were the most extensive (S. Hall, pers. obs.). The White Pines Preserve fits that pattern very well.

While the preserve contains an extensive amount of core, forest-interior habitat, it is imbedded in an extensive area of rural lands, most of which is still forested, although including some very large tracts of pine plantations. For the forest-interior species inhabiting the White Pines Preserve, they are therefore connected to a much larger landscape. That by itself means their population sizes are much larger than just the portion that exists within the preserve, and although that portion may contain some of the best remaining quality of their habitats, the extensiveness of their populations over the wider region contributes to their viability: any localized losses can be recovered due to the “rescue effect” of immigration back in from areas that were less affected by a particular extirpation event. Such connectivity has long been shown to be of high importance in maintaining breeding bird populations, and our surveys of moths in disturbance-prone habitats have demonstrated their reliance on large, well-connected landscapes to maintain their populations. In such areas, at least some portions of their population survive in any given

extirpating event, followed by rapid dispersal back into the lost areas coupled with high levels of fecundity at those sites. In terms of their survival strategies, they are just as much “landscape species” as black bears, bobcats, or other species whose individuals occupy very large home ranges.

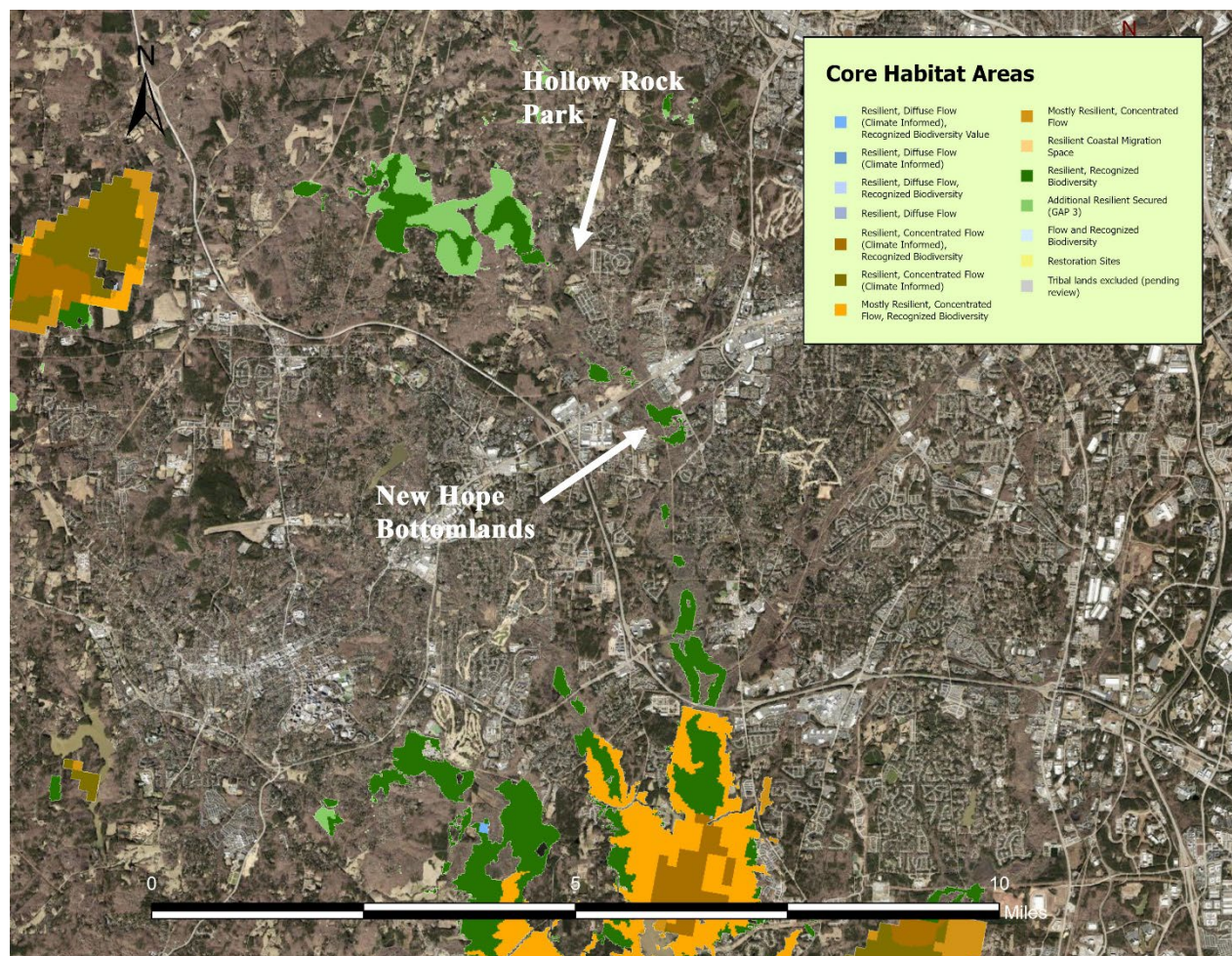
Further enhancing the value of the surrounding landscape in maintaining a high level of species diversity within the White Pines Preserve is the fact that it is connected to several other large tracts of high quality habitat. This is illustrated in the following map taken from a nationwide



mapping effort by the Nature Conservancy to identify core areas of high biodiversity that are well-connected to other such areas by means of intact dispersal-ways. As shown, the White Pines Preserve is located within a larger biodiversity hot-spot and sits near the center of an extensive network of such sites, several of which – but not all -- are managed for conservation (see Lombard et al., 2021).

Contrast this concentration with the results presented for the New Hope Creek study area, as shown in the figure below⁵¹.

⁵¹ Note the difference in scale – the view shown in the map for the New Hope Creek area is greatly magnified compared to the one above shown for the White Pines Preserve and its landscape context.



Although this map should look somewhat more filled in once the new Durham County Natural Heritage Inventory is completed – perhaps giving recognition to the Hollow Rock Park, which currently does not even show up on this map – comparing the maps for these two survey areas helps explain the difference in viability for at least some of the groups of conservation concern studied in our two surveys. Based on the presence of highly imperiled species – reflected in their global and state ranks, the Natural Heritage Program currently ranks the New Hope Bottomlands as Exceptional in terms of the quality of its biodiversity, the highest such value and one step above that given to the White Pines Preserve. In terms of biotic viability, however, this comparison strongly favors the latter. We strongly believe that both aspects need to be taken into consideration in deciding priorities for conservation action.

CONSERVATION RECOMMENDATIONS

Despite its generally high viability scores, the future status of several of the most distinctive species of the White Pines Preserve is uncertain. This is particularly the case for its populations of Pleistocene relicts: they are among the most likely early casualties of the increased temperatures and droughts associated with climate change. Protection of as much as possible of the steep north-facing slopes – probably the last refuge for these species during the worst conditions – is the

highest priority, but the extensive mesic ravines also play a role in supporting their populations and also need to be protected as much as possible.

Increased likelihood of wildfires is another aspect of climate change that needs to be considered in conservation plans. Prescribed burns conducted along the ridges will help reduce this risk, as well as restore the more open habitats needed by the xerophilic species that still survive.

For the majority of the forest-interior species, protection of wide-enough buffers is critical if the impacts of urbanization, such as now exist along New Hope Creek, are to be avoided. Maintaining dark night skies should be a major goal. So should minimizing any runoff from developed areas into the reserve. This includes any drainage from detention ponds, which at New Hope Creek have introduced pollution, sediments, and exotic wetland species into the otherwise protected preserves in that area.

Ideally, land use planning should be used to keep any development to a low level in the area surrounding the White Pines Preserve, ideally maintaining its rural state. This is likely to be a critical issue, given the spread of development into the southern part of Chatham County, now that it has been facilitated by the extension of sewer and water lines along US 15-501 from Pittsboro to Sanford.

Given the combined effects of development and climate change, the best hope for conserving even some of the most common species and habitats in our area will require implementing the sort of landscape level conservation scheme promoted by the Resilient and Connected Network of natural areas envisioned by the Nature Conservancy. This will require the combined efforts of multiple agencies, private conservation groups, and the citizens of Chatham and Lee Counties.

In order to guide any of these efforts and to determine which management practices work and which do not, ongoing biomonitoring, such as described in this survey, is a critical need. In addition to experts on various aspects of biodiversity, the involvement of the public – as described below – is essential if there is any hope for success.

THE IMPORTANCE OF PUBLIC SUPPORT

This survey was accomplished entirely through the efforts of volunteers. No outside funding was used and support for transportation and equipment costs was provided by the NCBP itself from funds donated to the organization. The product of our work – information on the status of the biodiversity of this key preserve – is also made available to the public free of charge, including through means of a website that we have created specifically for this project.

All of this is in keeping with the mission of the North Carolina Biodiversity Project, which is to make information on the biodiversity of North Carolina as widely and freely available to the public as possible. We have done this mainly through our websites, which compile as much information as possible on the state's native species, habitats, and ecosystems. These are again supported mainly through voluntary efforts on the part of our members, although we do want to credit the state's Division of Parks and Recreation, who as a partner organization has donated the server space for our websites and also provides IT support.

We do this work partly to share our discoveries with others that share our enthusiasm for natural history. But we also do it for what might be seen as an altruistic purpose: volunteering our time and expertise to help conserve the natural world. However, we view that work as benefiting the entire planet -- its human occupants and ourselves included -- as well all other life on earth. By sharing information on biodiversity, and particularly its viability, we hope to encourage others to take a similarly “altruistic” approach to safeguarding nature.

This partnership is one we hope can be extended to conducting field surveys aimed at documenting both the presence of individual species, as is now increasingly done through websites such as iNaturalist, eBird, and BugGuide, but also in obtaining information that can be used in viability assessments, such described in this study. Although the current survey shows that a lot can be accomplished through the efforts of a small group of dedicated scientist-citizens, the amount of effort needed – and that needs to be sustained through time – requires a much greater commitment by the public, but again through recognition of their own self-interests.

This can be done through linking together the different interest groups that are working mainly separately on climate change, water resources and disaster relief, pollution abatement, and other interests related to alleviating the stresses on the planet due to human activities. The government also needs to play a role, listening to all of these concerns and taking direct action that is beyond the ability of small, private interest groups. Above all, we need to re-find the faith we once had in science and what it reveals about the consequences of our actions on the planet.

Sanctuaries such as the White Pines Preserve that welcome visits by the public are particularly critical for supporting interest in conservation. These are the places that people visit for the pure enjoyment of the natural world. Consequently, these are places where people can see the need to actively support their individual preservation and ideally the wider world beyond the limits of these sites. We hope to continue our surveys of these key resources and to welcome greater participation by other conservation groups, academic departments, government agencies, and particularly interested members of the public.

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