Inventory of Recently Identified Old-Growth Forest
Leopold's Preserve, Prince William County, Virginia

Abigail Marino
Conservation Field Technician
B.S. in Wildlife Conservation (Minor: Forestry)
Virginia Tech College of Natural Resources and Environment
Leopold's Preserve

Supervisor: Nick Davis
Land Stewardship Manager

Originally written August 2025. Edited and expanded in July 2026.

Abstract

Leopold's Preserve in Prince William County, Virginia, contains two recently recognized old-growth forest tracts, totaling 127.2 acres. This study established a baseline inventory to support long-term monitoring and conservation. Eight permanent quarter-acre plots were surveyed to document forest composition, structure, and regeneration. Across two surveyed acres, 31,616 trees representing 46 species were inventoried, including mature trees, saplings, and seedlings. Invasive plant species, emerald ash borer impacts, snags, and regeneration differences between forest tracts were also documented. These findings provide baseline data for future monitoring and adaptive management.

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Introduction

Leopold’s Preserve Background:

Leopold’s Preserve is a beautiful 386-acre nature preserve located in Prince William County, Virginia. It is privately owned and managed by the White House Farm Foundation. The preserve has seven miles of hiking trails, diverse habitats, historic sites, scenic overlooks, and educational signage. With a history spanning over 10,000 years, the land showcases evidence of Indigenous use, timber harvesting, agricultural development, and the lives of enslaved and freed African American communities (Pinto, 2019).

By the early 2000s, the 500 acres now known as Leopold’s Preserve were all planned for residential development. However, local Prince William County developer Scott Plein recognized the importance of conserving natural space. At that time, he was unaware of an old-growth forest within Leopold’s boundaries, but he knew there was something special about the land. He chose to implement cluster housing and protect the remaining 386 acres. His example shows the importance of researching land and considering ecological significance before building. This is now more important than ever with the rise of data centers and mass urbanization. Without Scott Plein’s decision, this vital habitat would have been lost forever. Today, Leopold’s Preserve is protected through a conservation easement in partnership with the Northern Virginia Conservation Trust. It continues to support native wildlife, educate the public, and safeguard important cultural history.

Project Description:

Leopold’s Preserve was recently recognized for containing two distinct tracts of old-growth forest: a 58.9-acre oak-hickory forest on North Fork Hill and a 68.3-acre oak-hickory forest in Pinkard Woods, totaling 127.2 acres. This project established a baseline inventory of the tracts by identifying and measuring mature trees (DBH greater than 5 inches), saplings (DBH less than 5 inches and height greater than 4.5 feet), and seedlings (DBH less than 5 inches and height less than 4.5 feet). DBH, or diameter at breast height, is a standard forestry measurement. This data provides insight into forest composition and supports long-term monitoring of growth rates, regeneration, mortality, and invasive species. The inventory also reinforces the importance of preserving rare natural spaces in a rapidly developing region of Northern Virginia.

Old-Growth Forest Significance:

Old-growth forests are ecologically mature woodlands that have developed over long periods with negligible human disturbance. They represent the final stage of natural forest succession. They are characterized by large living and dead trees, snags, multilayered canopies, diverse understories, undisturbed soils, and little or no recent logging, agriculture, or fire (White et al., 1994).

Old-growth forests support biodiversity by providing numerous niches that certain species depend on for survival and completion of their life cycles. For example, cool temperatures, fallen logs, hollow trunks, moisture, and canopy gaps support mosses, lichens, amphibians, and cavity-nesting birds (Carbon, 2022). Despite their importance, these forests are increasingly rare, especially in the eastern United States. Less than 1% of precolonial old-growth forest remains in the eastern United States, and less than 5% remains in the West, largely due to commercial logging and land conversion during the 19th and 20th centuries (Why Old-Growth 2024). Recent studies show that eastern old-growth forests can store 35-40% more aboveground and soil carbon than logged or secondary forests (DellaSala et al., 2022). Protecting mature and old-growth forests is essential for maintaining biodiversity and ecological stability during a critical era of climate change and land-use transformation.

Old-growth forests also provide vital ecosystem services and function as carbon sinks. Although older trees may absorb carbon more slowly than younger trees, they continue to remove carbon dioxide from the atmosphere and store greater amounts of carbon overall. Logging these forests can release 40-65% of their stored carbon into the atmosphere (Conservation, 2022). In addition to sequestering more carbon and nitrogen than younger forests, old-growth forests purify air and water, prevent erosion, reduce flooding, and build topsoil (Why Old-Growth 2024; Old-Growth, 2025).

This knowledge contributes to the national effort to protect mature and old-growth forests. In 2022, President Biden signed Executive Order 14072, which required the Departments of Agriculture and the Interior to define and inventory all mature and old-growth forests on federal lands, publicly release the inventory within one year, and develop policies for forest protection, management, and wildfire risk reduction (Biden, 2022). Although Leopold's Preserve is privately owned, protecting its old-growth forests is equally important. Long-term conservation depends on public awareness and policies that safeguard these forests. At the state and local levels, conservation easements and partnerships with land trusts or nonprofit organizations, such as Bull Run Mountains Conservancy, can provide additional layers of protection.

Methods

Site Selection:

Before establishing the plots, historical aerial photographs were reviewed to identify the areas within the old-growth forest that have been forested the longest and were, therefore, the most mature sections. The aerial maps date back to 1937 and are supplemented by a drawn map from 1908. Eight random points were selected in these mature sections, with four in the Pinkard Woods section and four in the North Fork Hill section. Each plot covers a quarter acre (55.32 meters by 18.28 meters). In the field, the corners of each plot were marked using the Avenza Maps app, and their GPS coordinates were recorded and later mapped in Google Earth Pro.

Figure 1a shows the 1937 aerial photograph of the Pinkard Woods section. In this image, it is clear where the forest has developed the longest. One plot was placed in the upper-left forested section, one in the lower-left, and two in the upper-right. Figure 1b and 1c show the same area in 2000 and 2015.

Figure 1a. Aerial imagery from 1937 showing the perimeter of the Pinkard Woods tract of old-growth forest and the sections that were forested at the time.

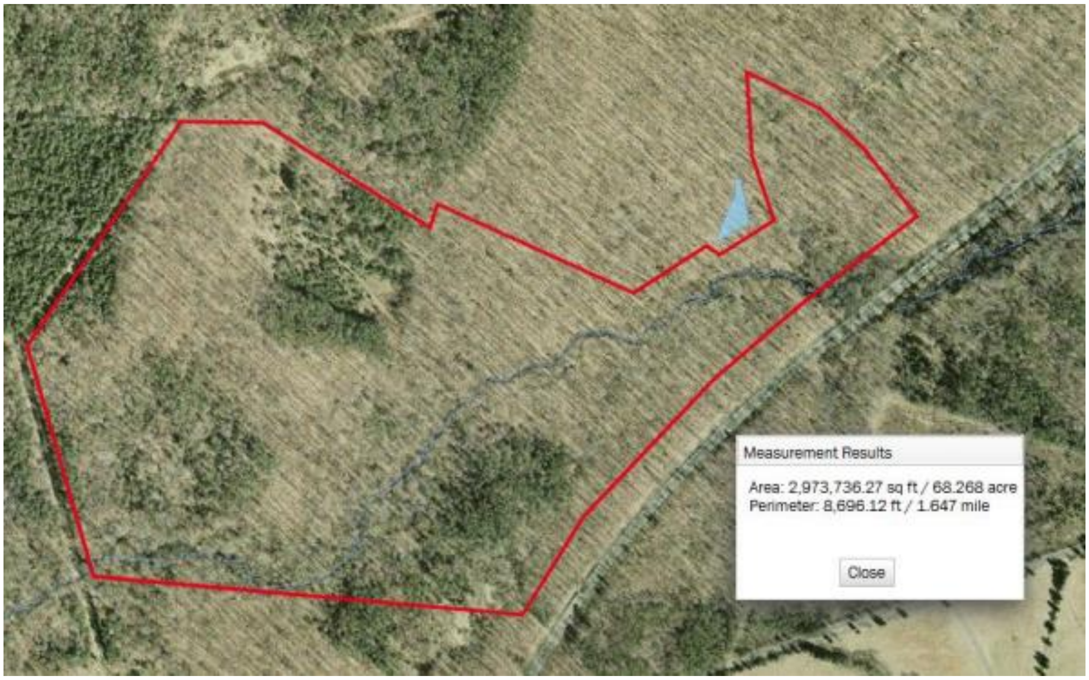

Figure 1b. Aerial imagery from 2000 showing the perimeter of the Pinkard Woods tract of old-growth forest and the sections that were forested at the time.

Figure 1c. Aerial imagery from 2015 showing the perimeter of the Pinkard Woods tract of old-growth forest and the sections that were forested at the time, overlaid with Leopold's Preserve trail map.

Figure 2a shows the 1937 aerial photograph of the North Fork Hill section. For this tract, three plots were placed in the lower forested section, and one was placed in the upper-left section. Figures 2b and 2c show the same area in 1987 and 2015.

Figure 2a. Aerial imagery from 1937 showing the perimeter of the North Fork Hill tract of old-growth forest and the sections that were forested at the time.

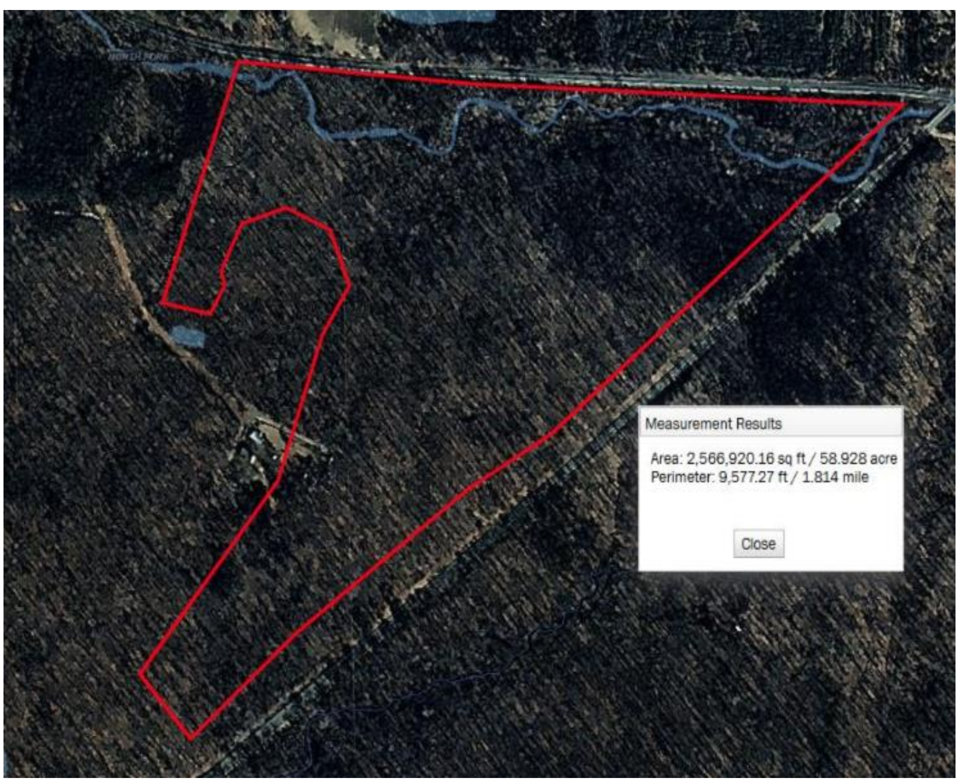

Figure 2b. Aerial imagery from 1987 showing the perimeter of the North Fork Hill tract of the old-growth forest and the sections that were forested at the time.

Figure 2c. Aerial imagery from 2015 showing the perimeter of the North Fork Hill tract of the old-growth forest and the sections that were forested at the time, overlaid with Leopold's Preserve trail map.

Tools and Technology:

Many tools and resources were implemented to establish and inventory each plot. The items were selected for their usability and durability in long-term monitoring. From the initial site selection using historical imagery to the final data entry in Excel and Google Earth Pro, each tool played a critical role in documenting the forest's composition.

Table 1. Tools used during the survey and their purpose.

Tool/Technology	**Purpose**
Historical aerial imagery	To identify the oldest section of OGF before entering the field
Avenza Maps app	To mark plot corners and save GPS coordinates in the field
Flagging tape, metal/wood posts, and mallet	To temporarily mark plot corners during setup
Compass	To accurately create plots and determine if trees were in or out of the range
300-foot tape measure	To measure plot dimensions and the height of notable mature trees
1.5-inch PVC pipes and spray paint	To permanently mark plot corners and increase plot boundary visibility
Tree tags, hammer, and aluminum nails	To label/number each tree in each plot
Calipers	To confirm that tagged trees were more than 5 inches DBH
DBH tape	To accurately measure the diameter at breast height of each mature tree
Tangent height gauge	To measure the heights of notable mature trees outside the plots
Laser hypsometer	To measure height of all mature trees and some saplings within plot boundaries
Data sheets and pen	To manually record data in the field
iPad with Excel	To digitally record and organize data
Google Earth Pro	To map plot locations after fieldwork

Plot Layout:

As noted above, eight quarter-acre plots measuring 55.32 meters by 18.28 meters were established across the 127.2-acre old-growth forest. Trees within each plot were tagged in a snaking pattern. Figure 3 shows an example plot: the survey began at corner A, proceeded along the 55.32-meter side to corner B, then returned through the center toward corner D, and finally turned back to corner C. This method ensured that all trees were systematically recorded as the team passed them and could be easily relocated. All tags were placed on the same side of each tree, facing the AD side of the plot. Trees at least halfway within the plot boundaries were included, while those more than halfway outside the boundaries were excluded. For trees with multiple trunks, DBH was recorded for the largest trunk. Additional trunks were noted in the comments but were excluded from calculations and graphs.

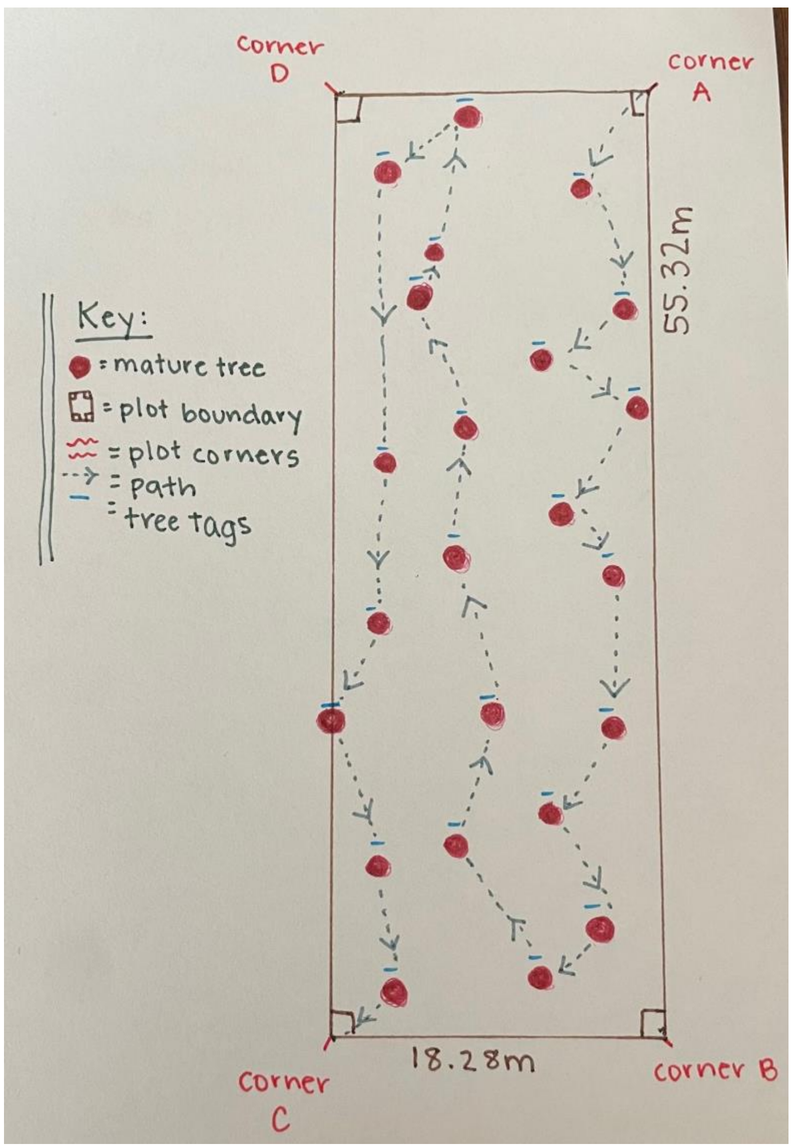

Figure 3. Example of tree tagging method.

Pinkard Woods Plot Overview:

Table 2 describes the coordinates and orientation of each Pinkard Woods plot. Figure 4 shows these plots overlaid on the aerial map, with 4a-d focusing on each plot individually.

Plot 1 was near a power line and the Villages of Piedmont housing development, in a relatively dry area of the forest (Figure 4a). This plot contained many mature hickory trees (*Carya* spp.), blackhaw saplings (*Viburnum prunifolium*), red maple (*Acer rubrum*) seedlings, and abundant blueberry shrubs (*Vaccinium* spp.). It also had many eastern red cedars (*Juniperus virginiana*), Virginia pines (*Pinus virginiana*), and American hollies (*Ilex opac*a) near the power line. An interesting non-woody plant in this plot was bracken fern (*Pteridium aquilinum*).

Plot 2 was divided by an ephemeral stream (Figure 4b). The AD side was much wetter than the BC side and supported many American hornbeams (*Carpinus caroliniana*) and northern spicebush (*Lindera benzoin*). On the BC side, numerous white oak (*Quercus alba*) trees were present, with the tallest measuring 103.3 feet. This plot also contained a few arrowwood viburnums (*Viburnum dentatum*). The understory included roundleaf greenbrier (*Smilax rotundifolia*), mayapple (*Podophyllum peltatum*), jack-in-the-pulpit (*Arisaema triphyllum*), Solomon's seal (*Polygonatum biflorum*), dewberry (*Rubus* spp.), false nettle (*Boehmeria cylindrica*), grapevine (*Vitis* spp.), lowbush blueberry (*Vaccinium pallidum*), and the invasive wavyleaf basketgrass (*Oplismenus undulatifolius*), Japanese stiltgrass (*Microstegium vimineum*), and Japanese barberry (*Berberis thunbergii*).

Plot 3 featured a moist stream with banks rising on either side (Figure 4c). Here, we observed Canadian moonseed (*Menispermum canadense*), a distinctive native vine. Other vegetation included poison ivy (*Toxicodendron radicans*), wild yam (*Dioscorea villosa*), licorice bedstraw (*Galium circaezans*), false nettle, American burnweed (*Erechtites hieraciifolius*), jack-in-the-pulpit, Virginia creeper (*Parthenocissus quinquefolia*), and hog peanut (*Amphicarpaea bracteata*). The plot also contained an abundance of the invasive Japanese stiltgrass.

Plot 4 crossed the Leopold's Loop trail (Figure 4d). The BC side was wetter and contained more boxelders (*Acer negundo*), whereas the drier AD side had many flowering dogwoods (*Cornus florida*) and eastern redbuds (*Cercis canadensis*). The plot also featured arrowwood viburnums, coralberry (*Symphoricarpos orbiculatus*), and several hickory seedlings, some of which may have been misidentified because hickory species are similar at their earliest stage. Other vegetation included bottlebrush grass (*Elymus hystrix*), Virginia creeper, dewberry, wild yam, licorice bedstraw, Carolina wild petunia (*Ruellia caroliniensis*), and Bosc's panicgrass (*Dichanthelium boscii*). Invasive species included multiflora rose (*Rosa multiflora*) and Japanese honeysuckle (*Lonicera japonica*).

Table 2. Pinkard Woods plot data.

Plot 1	**Plot 2**	**Plot 3**	**Plot 4**
Corner A: 38.8080087, -77.665273	Corner A: 38.804626, -77.664136	Corner A: 38.805942, -77.660983	Corner A: 38.807337, -77.657279
A→B 240°, 181.5'	A→B 80°, 60'	A→B 260°, 181.5'	A→B 220°, 181.5'
B→C 150°, 60'	B→C 170°, 181.5'	B→C 170°, 60'	B→C 310°, 60'
C→D 60°, 181.5'	C→D 260°, 60'	C→D 80°, 181.5'	C→D 40°, 181.5'
D→A 330°, 60'	D→A 350°, 181.5'	D→A 350°, 60'	D→A 130°, 60'

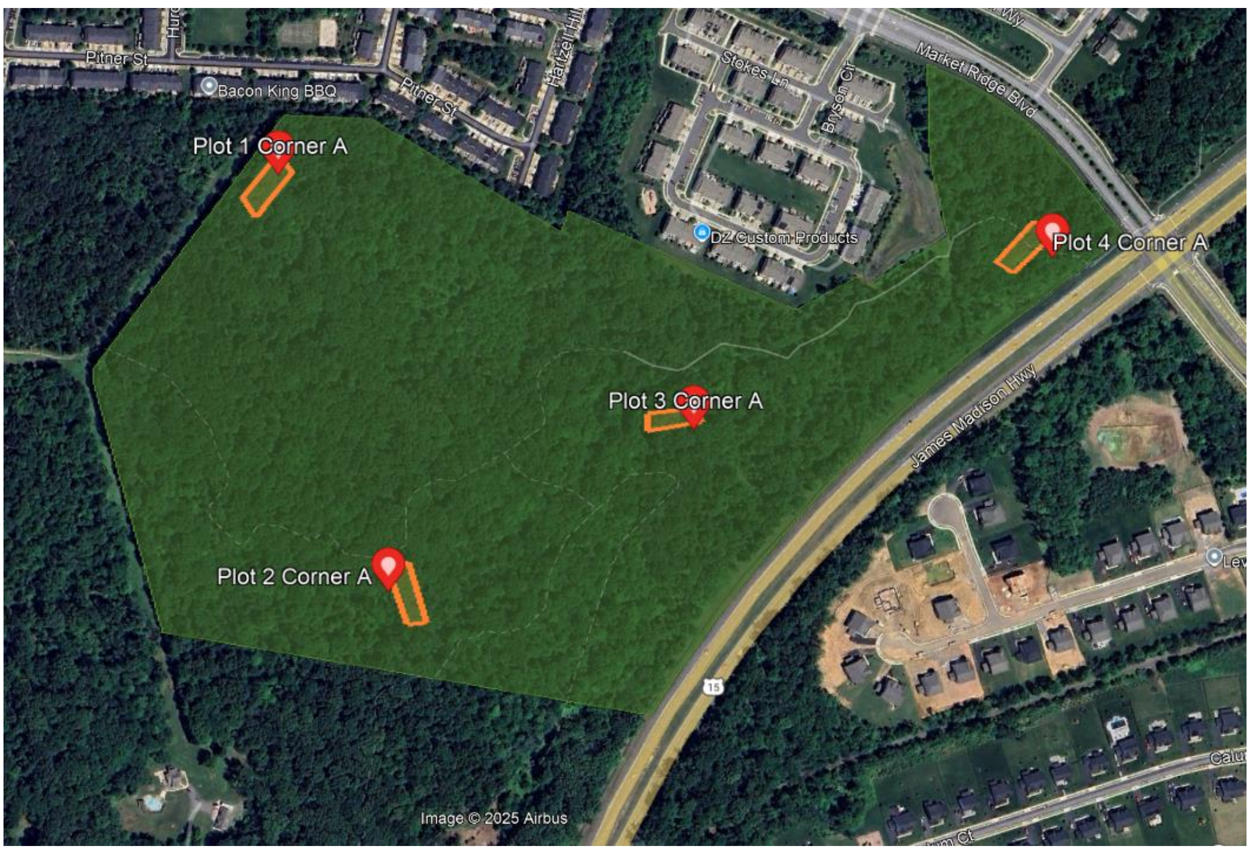

Figure 4. Google Earth Pro imagery of the four plots in the Pinkard Woods section of old-growth forest.

Figure 4a. Close-up of Plot 1, showing the power line and VOP I townhomes.

Figure 4b. Close-up of Plot 2, showing the trail on either side.

Figure 4c. Close-up of Plot 3, showing the trail on either side.

Figure 4d. Close-up of Plot 4, showing the trail running through the middle of the plot, James Madison Highway (Hwy 15) to the southeast, and Market Ridge Boulevard to the northeast.

North Fork Hill Plot Overview:

Table 3 presents the coordinates and layout information for the North Fork Hill plots. Figure 5 shows the plots on the aerial map, and Figures 5a–5d highlight the individual plots.

Plot 5 was located on a relatively dry site, with a mature canopy dominated by tulip poplars (*Liriodendron tulipifera*), mockernut hickories (*Carya tomentosa*), and white oaks (Figure 5a). The understory contained highbush blueberry (*Vaccinium corymbosum*), early lowbush blueberry (*Vaccinium angustifolium*), deerberry (*Vaccinium stamineum*), Solomon's seal, grape fern (*Botrychium* spp.), Virginia creeper, roundleaf greenbrier, and partridgeberry. The invasive oriental bittersweet (*Celastrus orbiculatus*) was also present.

After completion of the survey, a large pin oak (*Quercus palustris*) fell within the plot, bending two mature trees (numbers 237 and 245), uprooting tree 246, and damaging tree 262. The tag on tree 262 had to be relocated above the DBH mark, and several seedlings within the plot were also crushed.

Plot 6 was on a hill, with the CD end sloping down towards a stream (Figure 5b). The canopy was dominated by mature white oaks, mockernut hickories, and a few mature scarlet oaks (*Quercus coccinea*). The understory included northern spicebush, coralberry, tall grasses, poison ivy, Virginia creeper, common cinquefoil (*Potentilla simplex*), Solomon's seal, licorice bedstraw, jack-in-the-pulpit, wild comfrey (*Cynoglossum virginianum*), and dewberry. Invasive Japanese stiltgrass and Japanese barberry were also present throughout the plot.

Plot 7 was characterized by an extremely dense understory (Figure 5c). The canopy consisted primarily of mature scarlet oaks, tulip poplars, white oaks, and mockernut hickories. There were many American hornbeam and pawpaw (*Asimina triloba*) saplings. In addition to these trees, the plot contained northern spicebush, blueberry, Virginia creeper, licorice bedstraw, mayapple, New York fern (*Parathelypteris noveboracensis*), poison ivy, roundleaf greenbrier, wild yam, false Solomon's seal (*Maianthemum racemosum*), eastern hay-scented fern (*Dennstaedtia punctilobula*), and naked-flowered tick-trefoil (*Hylodesmum nudiflorum*). Invasive species included wineberry (*Rubus phoenicolasius*), Japanese barberry, and multiflora rose.

Plot 8 was located adjacent to a stream and had the most diverse understory vegetation of any plot (Figure 5d). The canopy was dominated by mature mockernut hickories, pignut hickories (*Carya glabra*), white oaks, and several northern red oaks (*Quercus rubra*). This plot also contained the only mature ash tree observed across all eight plots that retained any living foliage, with a single surviving branch. This was a green ash (*Fraxinus pennsylvanica*). The understory featured blackberry, Christmas fern (*Polystichum acrostichoides*), Appalachian gooseberry (*Ribes rotundifolium*), LeConte’s violet (*Viola leucocarpa*), yellow stargrass (*Hypoxis hirsuta*), deertongue (*Dichanthelium clandestinum*), Solomon’s seal, roundleaf greenbrier, black snakeroot (*Sanicula canadensis*), American plantain (*Plantago rugelii*), muscadine (*Vitis rotundifolia*), false nettle, lowbush blueberry, hooked buttercup (*Ranunculus recurvatus*), Schreber’s wood aster (*Eurybia schreberi*), dwarf St. John’s wort (*Hypericum mutilum*), poison ivy, hog peanut, sensitive fern (*Onoclea sensibilis*), golden Alexanders (*Zizia aurea*), bottlebrush grass, mayapple, hairy skullcap (*Scutellaria elliptica*), fringed loosestrife (*Lysimachia ciliata*), Virginia creeper, and woodrushes (*Luzula* spp.). Invasive species present included multiflora rose, five-leaf akebia (*Akebia quinata*), and Japanese stiltgrass.

It is important to note that, as part of the ongoing management of this woodland, all invasive species will be eradicated.

Table 3. North Fork Hill plot data.

Plot 5	**Plot 6**	**Plot 7**	**Plot 8**
Corner A: 38.809136, -77.654690	Corner A: 38.811397, -77.651317	Corner A: 38.810885, -77.653198	Corner A: 38.813422, -77.655501
A→B 120°, 60'	A→B 150°, 60'	A→B 30°, 181.5'	A→B 0°, 60'
B→C 30°, 181.5'	B→C 60°, 181.5'	B→C 300°, 60'	B→C 90°, 181.5'
C→D 300°, 60'	C→D 330°, 60'	C→D 210°, 181.5'	C→D 180°, 60'
D→A 210°, 181.5'	D→A 240°, 181.5'	D→A 120°, 60'	D→A 270°, 181.5'

Figure 5. Google Earth Pro imagery of the four plots in the North Fork Hill section of old-growth forest.

Figure 5a. Close-up of Plot 5, showing the trail and VOP II homes to the northwest and James Madison Highway (Hwy 15) to the southeast.

Figure 5b. Close-up of Plot 6, showing James Madison Highway (Hwy 15) to the southeast.

Figure 5c. Close-up of Plot 7, showing the trail to the east, James Madison Highway (Hwy 15) to the southeast, and VOP II homes to the west.

Figure 5d. Close-up of Plot 8, showing the trail to the south of the plot and the North Fork Broad Run to the north

Data Collection:

The data was collected in a three-step process, starting with mature trees, then saplings, and finally seedlings. All mature trees (above 5 inches DBH) were tagged from 101 to 360. (Note: Trees 228–234 were outside the plots but within the OGF boundary and therefore were not used in any numerical or graphical analyses.) For each tagged tree, the plot, tag number, Latin code, species, status, DBH (in inches), height (in feet), crown class, live crown ratio, mortality code, and any necessary comments were recorded (Figure 6). All tree heights were measured in 2026 using a laser hypsometer. Tree status, crown class, live crown ratio, and mortality were recorded using the standard data codes listed in Table 4 (Tree Data n.d.). Live crown ratio was estimated from the extent of the crown along the trunk and the percentage of the trunk covered by leafy branches. Live crown ratio, crown class, and tree status may be partially subject to observer interpretation. Each row in the Excel sheet was color-coded by tree status. In the Figure 6 example, all trees are healthy, so the rows are green. Throughout the sheet, unhealthy trees were marked in yellow, sick trees in orange, and dead trees in red.

A	B	C	D	E	F	G	H	I	J	K	L	
Plot	Tag Number	Maturity	CODE	Species	Status	Count	DBH (in)	Height (ft)	Crown Class	Live Crown Ratio	Mortality	Comments
1	101	Mature	CATO6	mockernut hickory	Healthy	1	10	67.2	Codominant	50		
1	102	Mature	CAGL8	pignut hickory	Healthy	1	11	77.1	Dominant	50		
1	103	Mature	CATO6	mockernut hickory	Healthy	1	11	68.8	Codominant	60		
1	104	Mature	CATO6	mockernut hickory	Healthy	1	12	82	Codominant	60		
1	105	Mature	CAGL8	pignut hickory	Healthy	1	11	52.4	Dominant	50		
1	106	Mature	NYSY	blackgum	Healthy	1	10	75.4	Intermediate	70		
1	107	Mature	CATO6	mockernut hickory	Healthy	1	15	106.6	Dominant	50		
1	108	Mature	CATO6	mockernut hickory	Healthy	1	5	34.4	Intermediate	80		
1	109	Mature	QUFA	southern red oak	Healthy	1	10	80.5	Codominant	60		

Figure 6. Data collection sheet for mature trees in Excel.

Table 4. Tree survey data codes (Tree Data n.d.)

Table 4a. Tree status codes and descriptions

Tree Status Code	Description
H	Healthy tree with very little biotic or abiotic damage
U	Unhealthy tree with some biotic or abiotic damage, and this damage will reduce growth. It appears the tree will fully recover from this damage
S	Sick tree with extensive biotic or abiotic damage and this damage will ultimately cause death within the next 5-10 years
D	Dead tree or snag with no living tissue visible

Table 4b. Crown class codes and descriptions

Crown Class Code	Description
O	Open-grown, or the tree is not near any other tree
E	Emergent, or the crown is totally above the canopy of the stand
D	Dominant, or the crown receives light from at least 3–4 directions
C	Codominant, or the crown receives light from at least 1–2 directions
I	Intermediate, or the crown only receives light from the top
S	Suppressed, or the crown is entirely shaded and underneath the stand canopy

Table 4c. Mortality codes and descriptions

Mortality Code	Description
F	Fire caused
I	Insect caused
D	Disease caused
A	Abiotic (flooding, erosion)
H	Harvest caused
U	Unable to determine
X	Did not assess

Table 4d. Live crown ratio codes and descriptions

Live Crown Ratio Code	Description
0	Zero
0.5	>0–1 percent
3	>1–5 percent
10	>5–15 percent
20	>15–25 percent
30	>25–35 percent
40	>35–45 percent
50	>45–55 percent
60	>55–65 percent
70	>65–75 percent
80	>75–85 percent
90	>85–95 percent
98	>95–100 percent

For seedlings and saplings, simplified data was collected. Saplings were defined as trees with a DBH under 5 inches and a height over 4.5 feet. For each sapling, the tree code, species, status, count, height, and comments were recorded. Seedlings were defined as trees with a DBH under 5 inches and a height under 4.5 feet. For seedlings, only tree code, species, status, and count were recorded. There were significantly more saplings in the North Fork Hill section because deer were absent near Highway 15, necessitating a different survey method. In Pinkard Woods, the survey team counted each seedling within the plot in approximately 10-foot-by-10-foot blocks. In North Fork Hill, a 60-foot-by-15-foot rectangle was mapped within each plot. Every seedling was counted in 15-foot-by-5-foot blocks, and the total was then extrapolated across the quarter-acre. The mortality codes from Table 4c were used for both seedlings and saplings. The Excel data sheets for saplings and seedlings are shown in Figures 7 and 8, respectively.

C	D	E	F	G	H	I	J	K	L	
Maturity	**CODE**	**Species**	**Status**	**Count**	**DBH (in)**	**Height (ft)**	**Crown Class**	**Live Crown Ratio**	**Mortality**	**Comments**
Sapling	CACA18	American hornbeam (ironwood)	Unhealthy	1		4.5				Leaf scale
Sapling	CACA18	American hornbeam (ironwood)	Sick	1		4.5				
Sapling	CACA18	American hornbeam (ironwood)	Dead	1		4.5				
Sapling	FRAXI	ash	Healthy	1		4.5				
Sapling	PRSE2	black cherry	Healthy	1		4.5				
Sapling	QUVE	black oak	Healthy	1		4.5				
Sapling	NYSY	blackgum	Healthy	1		4.5				
Sapling	VIPR	blackhaw	Healthy	1		4.5				
Sapling	CATO6	mockernut hickory	Sick	1		4.5				

Figure 7. Data collection sheet for saplings in Excel.

C	D	E	F	G
Maturity	**CODE**	**Species**	**Status**	**Count**
Seedling	JUVI	eastern redcedar	Healthy	47
Seedling	NYSY	blackgum	Healthy	46
Seedling	CAOV3	red hickory	Healthy	45
Seedling	QUPH	willow oak	Healthy	36
Seedling	ASTR	pawpaw	Healthy	33
Seedling	CARYA	hybrid hickory	Healthy	29
Seedling	BELE	sweet birch	Healthy	25
Seedling	HAVA	common witch-hazel	Healthy	15
Seedling	ACNE2	boxelder	Healthy	13
Seedling	CEOC	common hackberry	Healthy	13
Seedling	FRPE	green ash	Unhealthy	11

Figure 8. Data collection sheet for seedlings in Excel.

Results

Species Composition and Diversity:

Across the 2 acres surveyed, 31,616 trees were recorded. This includes 253 mature trees, 1,565 saplings, and 29,798 seedlings. The number of mature trees and saplings was fairly consistent across both tracts; however, the number of seedlings differed greatly. In the four Pinkard Woods plots, there were a total of 3,771 seedlings, while in the four North Fork Hill plots, there were 26,027. As mentioned, we believe that this is due to the heavy deer pressure in the Pinkard Woods section. Extrapolated to the 127.2 acres, we estimate that there are 2,010,778 trees in the entire old-growth forest, which can be divided into 16,091 mature trees, 99,534 saplings, and 1,895,153 seedlings (Figure 9). This relies on the assumption that the sample plots are representative of the entire old-growth forest.

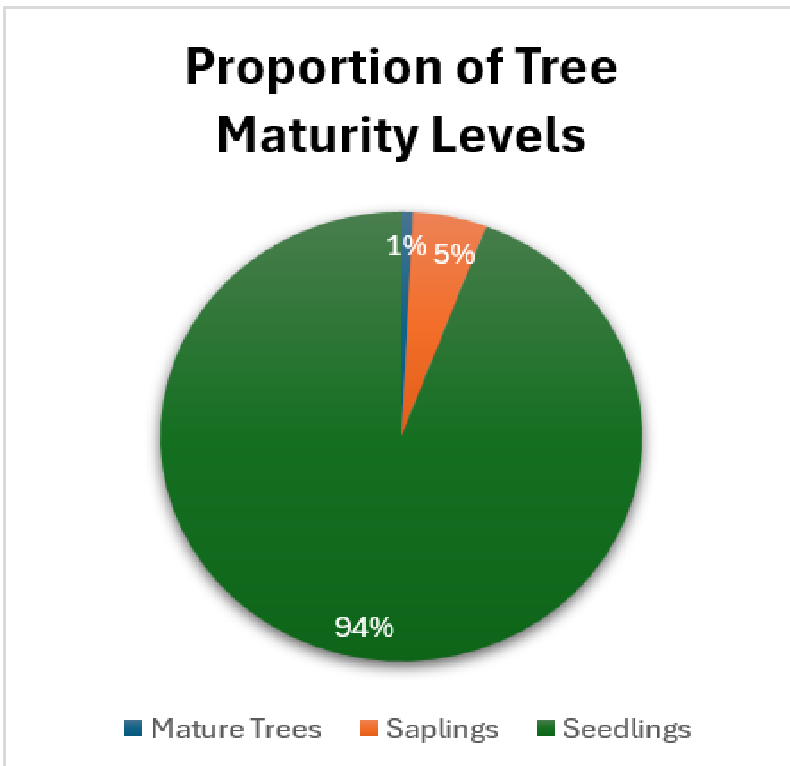

Figure 9. Proportion of mature trees, saplings, and seedlings in the old-growth forest.

Throughout the survey, 46 unique tree species were observed. American beech (*Fagus grandifolia*) and quaking aspen (*Populus tremuloides*) were also observed outside the plots, indicating that species richness within the old-growth forest exceeds what the study documented. Table 5 lists each tree species, its scientific name, and the number of individuals observed across the eight plots. These unextrapolated counts include mature trees, saplings, and seedlings. Unidentified trees were removed from the list, and ash trees identified only to the genus level were not counted as a separate species.

Table 5. Unique tree species across all plots from most abundant to least (count NOT extrapolated).

Common Name	Scientific Name	Qty.
Green ash	*Fraxinus pennsylvanica*	7,278
White oak	*Quercus alba*	4,108
American hornbeam	*Carpinus caroliniana*	2,797
Maple-leaf viburnum	*Viburnum acerifolium*	2,490
Red maple	*Acer rubrum*	1,897
White ash	*Fraxinus americana*	1,612
Mockernut hickory	*Carya tomentosa*	1,510
Pignut hickory	*Carya glabra*	1,471
Flowering dogwood	*Cornus florida*	1,336
Eastern redbud	*Cercis canadensis*	1,070
Eastern red cedar	*Juniperus virginiana*	753
Northern red oak	*Quercus rubra*	609
Blackgum	*Nyssa sylvatica*	608
Arrowwood	*Viburnum dentatum*	595
Black cherry	*Prunus serotina*	570
Ash spp.	*Fraxinus spp.*	567
Red hickory	*Carya ovalis*	560
Blackhaw	*Viburnum prunifolium*	448
Pawpaw	*Asimina triloba*	424
Sweet birch	*Betula lenta*	320
Slippery elm	*Ulmus rubra*	210
Common witch-hazel	*Hamamelis virginiana*	183
Bitternut hickory	*Carya cordiformis*	154
Virginia pine	*Pinus virginiana*	109
Southern red oak	*Quercus falcata*	95
Black oak	*Quercus velutina*	85
Willow oak	*Quercus phellos*	85
Downy Serviceberry	*Amelanchier arborea*	79
River birch	*Betula nigra*	61
Tulip poplar	*Liriodendron tulipifera*	55
Hybrid hickory	*Carya spp.*	30
Siberian elm	*Ulmus pumila*	26
Boxelder	*Acer negundo*	18

Common hackberry	*Celtis occidentalis*	17
Sassafras	*Sassafras albidum*	12
Scarlet oak	*Quercus coccinea*	7
Fringetree	*Chionanthus virginicus*	7
Shagbark hickory	*Carya ovata*	5
American holly	*Ilex opaca*	5
Swamp white oak	*Quercus bicolor*	4
American elm	*Ulmus americana*	3
Pin oak	*Quercus palustris*	2
Black walnut	*Juglans nigra*	1
Hawthorn	*Crataegus spp.*	1
Sweet cherry	*Prunus avium*	1
Honey locust	*Gleditsia triacanthos*	1

Canopy Structure:

Among mature trees, oaks and hickories were the most common, at 32% and 28% of the canopy, respectively (Figure 10). Then, red maples accounted for 11% of the canopy, followed by tulip poplars at 10%. There were also a significant number of trees from the dogwood, ash, and elm families. The “Other” category includes species from the birch, pine, hemp, and walnut families. In total, 23 unique tree species were identified in the mature canopy. Most mature trees were classified as codominant, with suppressed trees being the second most common crown class. Dominant and intermediate trees occurred in equal proportions (Figure 11).

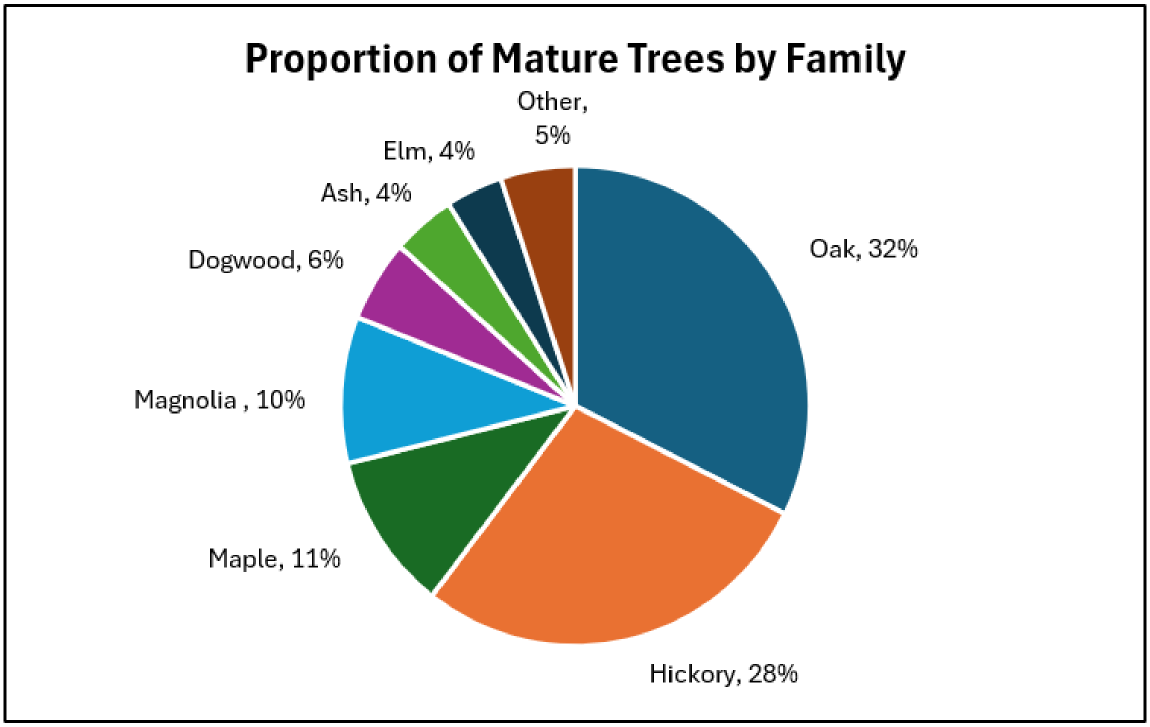

Figure 10. Proportion of mature trees by family across the eight plots.

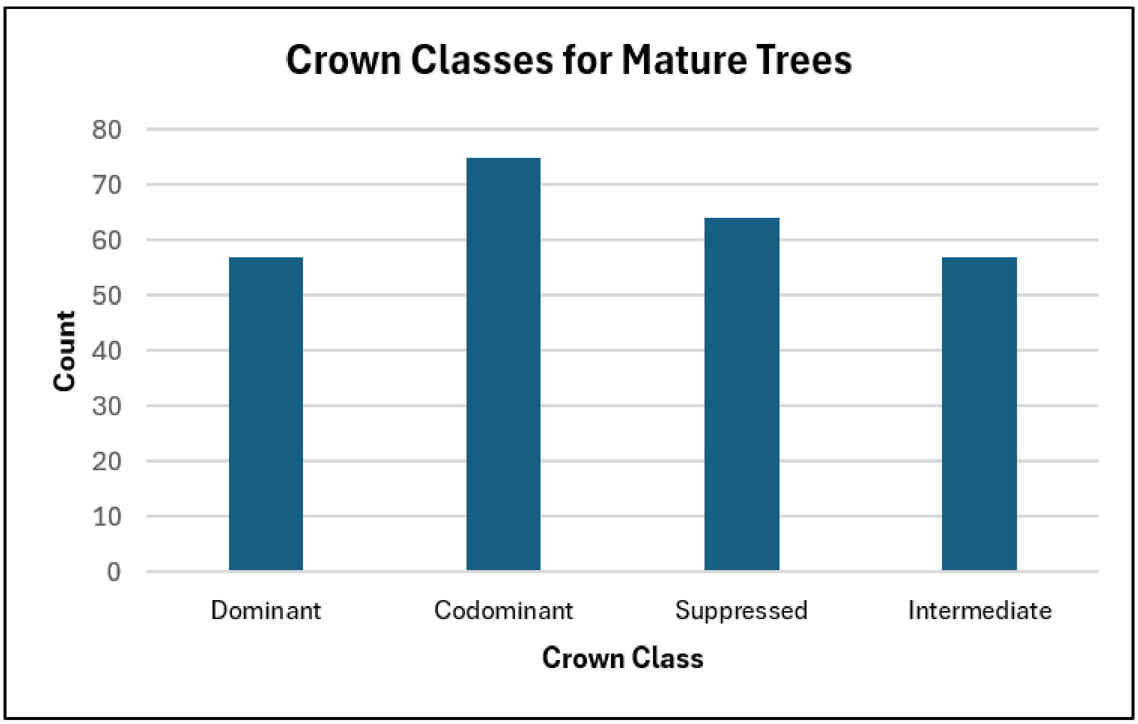

Figure 11. Crown classes for the mature trees across the eight plots.

The sapling layer was dominated by the birch family (36%), primarily American hornbeam (Figure 12). Hickories (12%) and oaks (11%) were the next most common groups. Next, viburnums accounted for 11%, followed by ashes (10%) and legumes (6%), most of which were eastern redbuds. The remaining 14% consisted of 13 additional families, including tupelo, maple, dogwood, custard-apple, magnolia, elm, cherry, and more. A total of 36 unique tree species were recorded in the sapling layer.

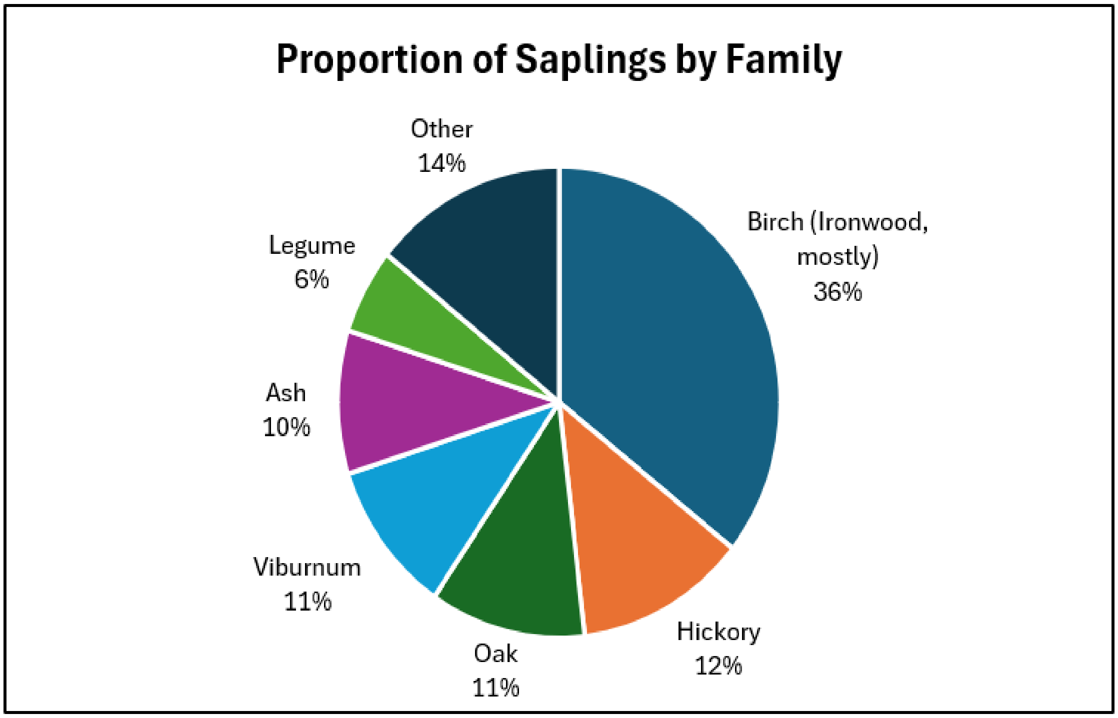

Figure 12. Proportion of saplings by family across the eight plots.

Finally, the seedling layer was dominated by ash species (31%), followed by oaks (16%), hickories (12%), viburnums (11%), birches (9%), again mostly American hornbeam, maples (6%), and dogwoods (4%) (Figure 13). In total, 40 unique tree species were identified in the seedling layer.

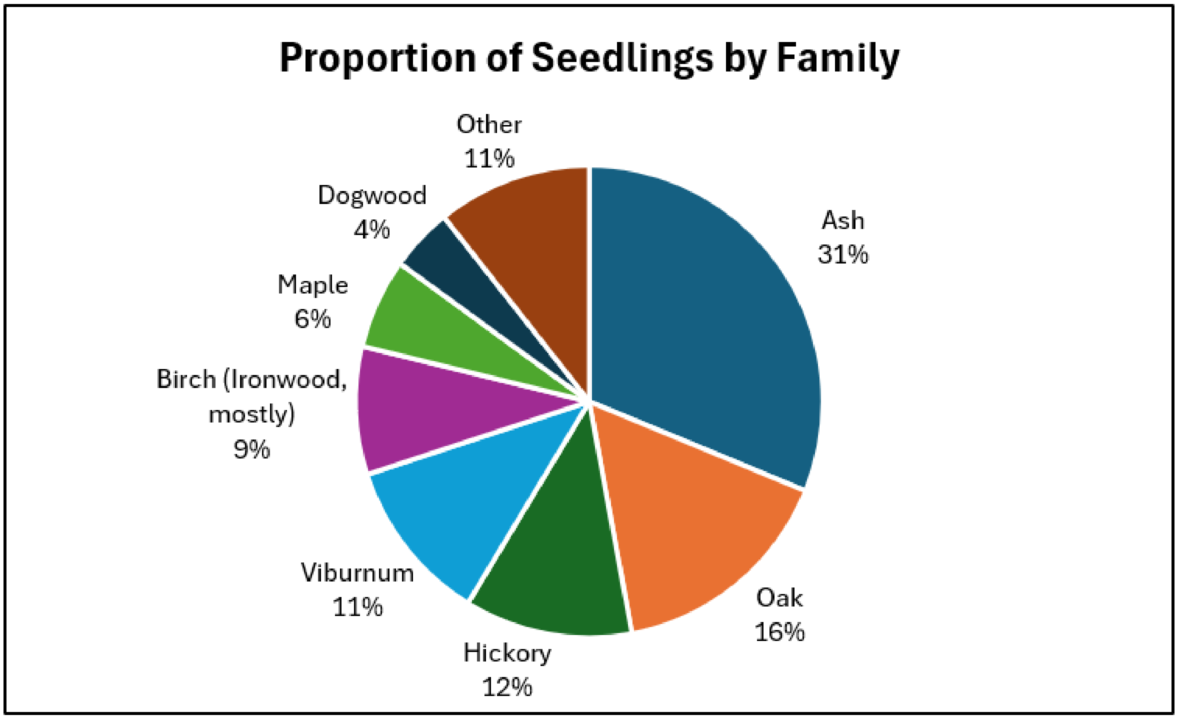

Figure 13. Proportion of seedlings by family across the eight plots.

Overall, oak and hickory trees dominate the canopy and are abundant across all layers of the forest (Figure 14). Ash, viburnum, and birch species are especially abundant in the understory, with American hornbeam making up most of the birch family. Although ash is common in the sapling and seedling layers, it is unlikely that many individuals will reach maturity because of the emerald ash borer (*Agrilus planipennis*), or EAB. Of the 11 mature ash trees observed, all but one have died. The one partially surviving ash tree has a single surviving branch and will likely die soon. Most of the maples in the understory are red maples, which are more likely to grow taller than many other understory species and even reach the canopy. The American hornbeams, viburnums, dogwoods, and eastern redbuds, on the other hand, do better in the shade of the understory layer and don't grow as tall. This shows how the diversity within the forest adds to its structural complexity.

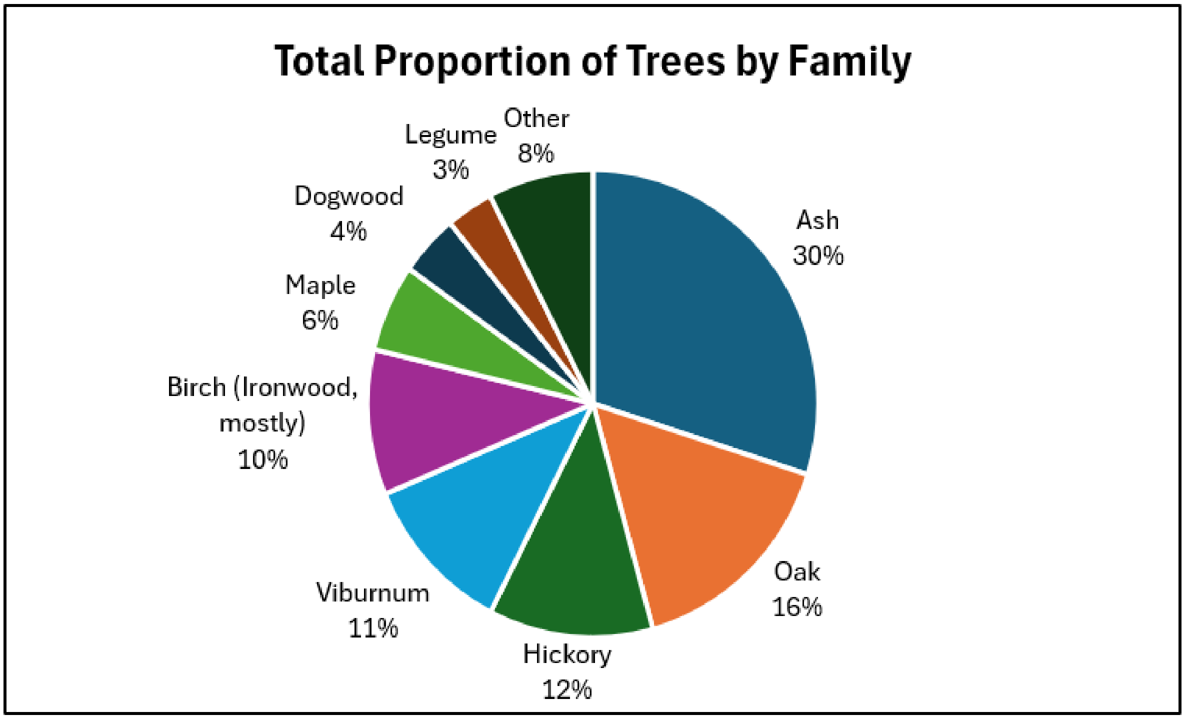

Figure 14. Overall proportion of trees by family across the eight plots.

Tree Size Distribution:

The majority of the trees measured across the eight plots were between 0 and 16 feet tall, and the count decreased exponentially with increasing heights (Figure 15). This is known as a reverse-J distribution and is common in an uneven-aged forest. A similar pattern was observed in the DBH of mature trees, as shown in Figure 16.

The tallest trees across the eight plots were primarily oaks. The tallest individual was a 129.6-foot scarlet oak with a DBH of 30.3 inches. Other notable large trees within the plots included a 123-foot scarlet oak with a DBH of 32.7 inches, a 122.3-foot white oak with a DBH of 27 inches, and a 119.3-foot white oak with a DBH of 16.5 inches. Some tulip poplars were also more than 115 feet tall. The average height of mature trees was 63.56 feet.

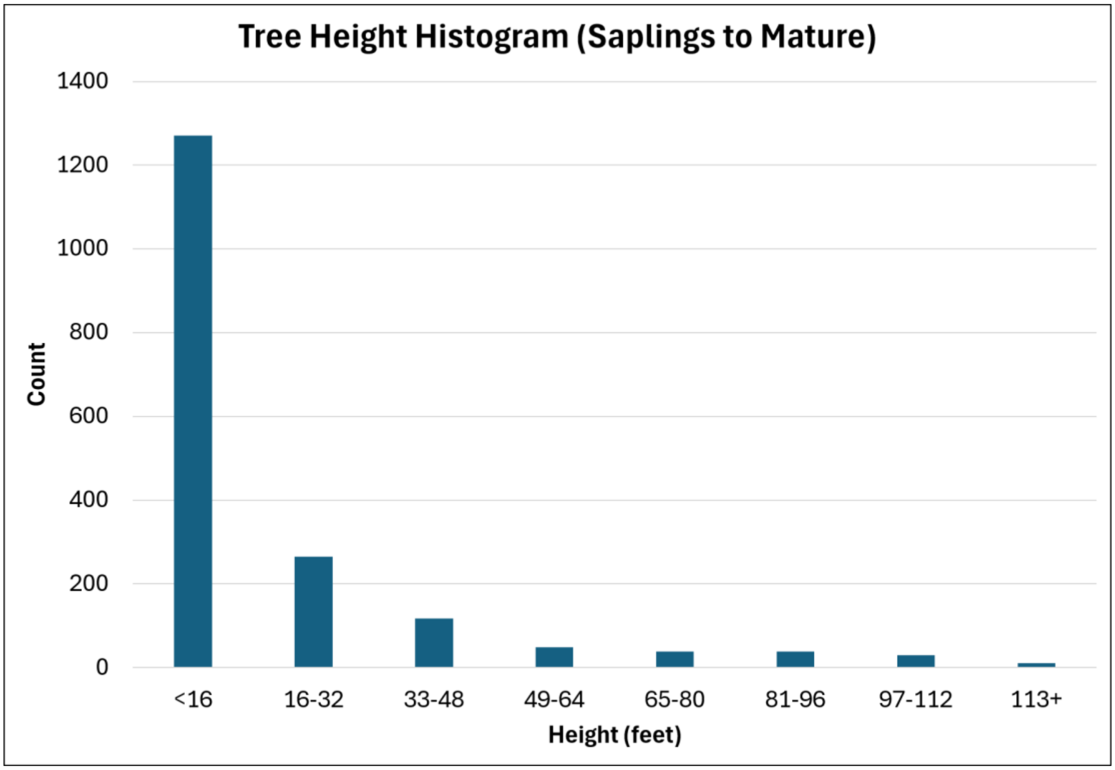

Figure 15. Histogram of tree heights for all saplings and mature trees, following a reverse-J distribution.

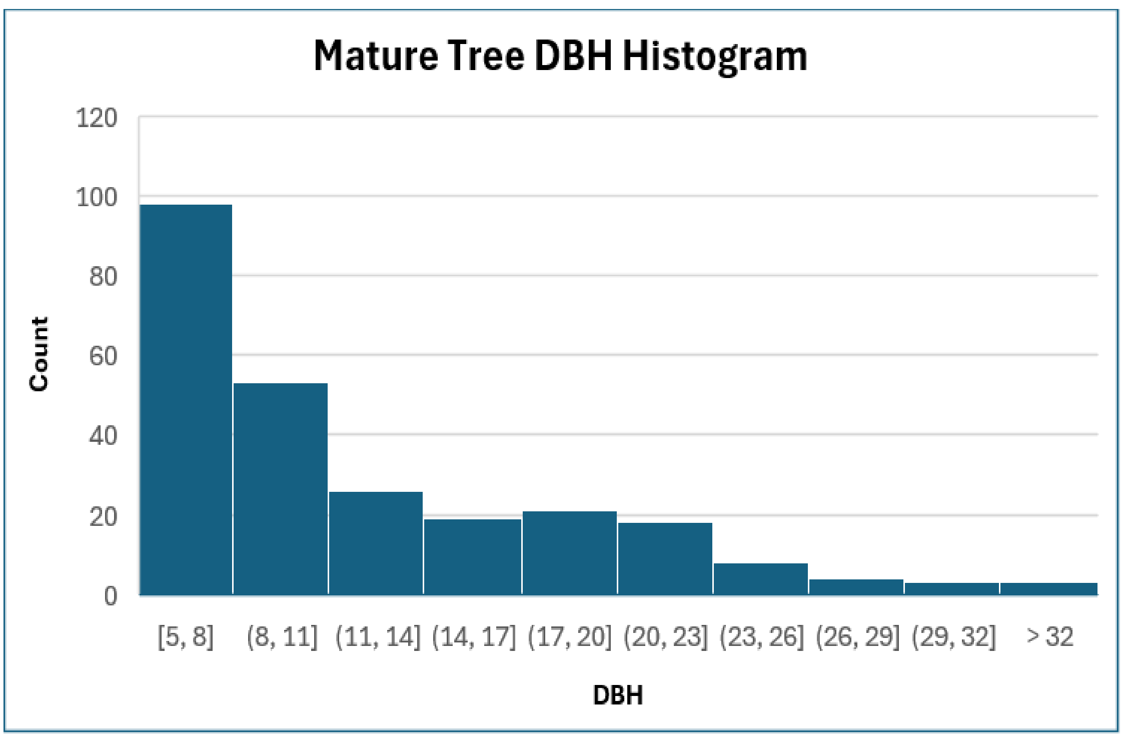

Figure 16. Histogram of DBH for mature trees, following a reverse-J distribution.

The live crown ratio for mature trees followed a generally standard distribution, with a slight left-skew (Figure 17). Most mature trees had live crown ratios between 50% and 60%. All dead trees have a live crown ratio of 0%, so there is a larger number of trees in the [0,10] bin.

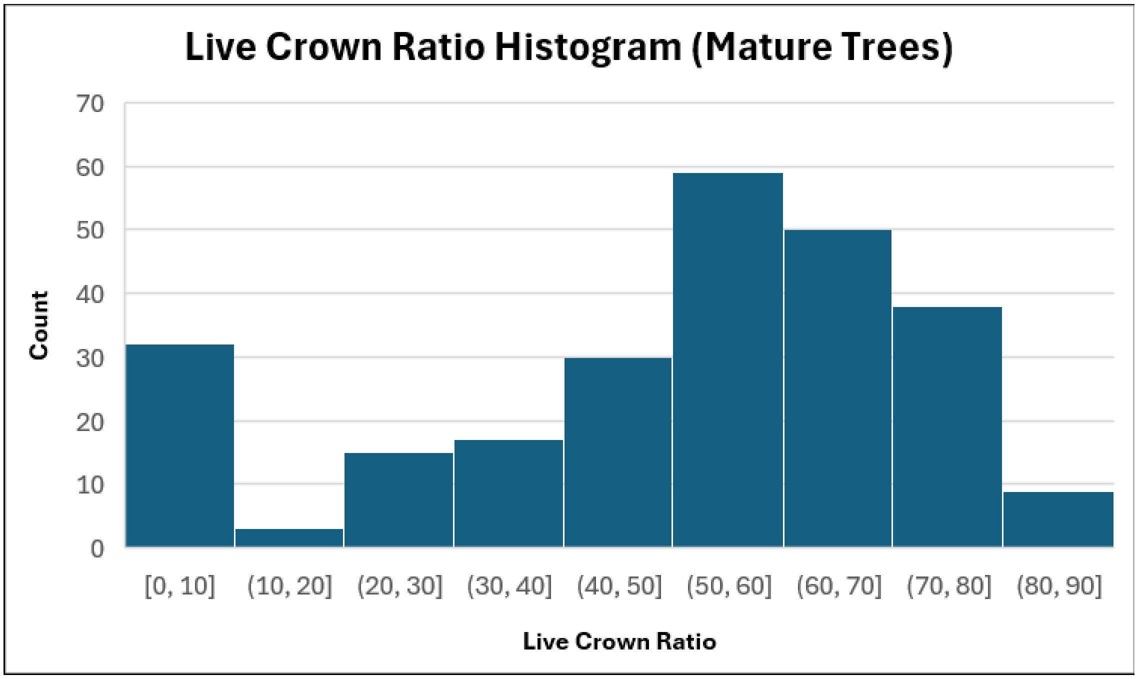

Figure 17. Left-skewed histogram of the live crown ratios for mature trees.
Note: All dead trees have a live crown ratio of 0, and therefore the [0,10] bin is fuller.

Notable Observations:

Several invasive species were identified, underscoring the need for ongoing monitoring and management to protect this valuable ecosystem and encourage stewardship.

There were 28 standing dead trees, known as snags, across the eight plots. This gives us an estimate of 1,781 snags throughout the old-growth forest. These habitats are essential for cavity-nesting birds, small mammals, and insects, and they play a vital role in long-term carbon storage and nutrient cycling (Carbon, 2022). The snags were mostly oak and ash trees, with a few cedars, elms, and pines. Of the 11 mature ash (*Fraxinus* spp.) trees recorded, 10 were dead due to the EAB, while the one partially living green ash had a single living branch.

Notable Trees Seen From Trail (Outside of Plots):

Table 6 lists some of the interesting trees within the old-growth forest boundaries that were not included in our survey because they were outside the plot boundaries. This illustrates the extent of species richness and the size of trees within the forest. The tree status codes are provided in Table 4a; for simplicity, all trees are healthy. The quaking aspen is located right on the forest border. Again, this data is not included in any of our graphs or numerical data, as those trees did not fall within our plot boundaries.

Table 6. Notable trees seen from the trail (within old-growth forest, outside of plots).

Tag Number	Species	Status	DBH (in)	Height (ft)	Comments
228	Willow oak	H	28.5	99	
229	White oak	H	30	80	
230	White oak	H	38.5	121	
231	Tulip poplar	H	20.5, 13.5, 18.5, & 19	98	4-stem, logged, sprout-origin
232	American beech	H	12	X	Common for eastern old-growth forests
233	Quaking aspen	H	15	101	Unusual non-native
234	Tulip poplar	H	34	131	

Discussion

Implications:

Based on the research, this is a diverse and relatively healthy example of an old-growth forest. The large presence of oaks and hickories across all three life stages, the high species count, and the abundant wildlife resources are typical of an eastern deciduous forest (Eastern Deciduous Forest 2024). This is supported by the presence of 46 unique species in just 2 acres of this forest, the habitat provided by snags and canopy layers, and the abundance of seedlings and saplings. Old-growth forests retain more carbon and nitrogen than younger stands, store more biomass, and buffer temperature extremes, making their protection extremely important (Why Old-Growth 2024; Mezei et al., 2022).

Invasive Species:

As mentioned, wavyleaf basketgrass, Japanese stiltgrass, Japanese barberry, multiflora rose, oriental bittersweet, wineberry, Japanese honeysuckle, and five-leaf akebia were found within the plots, raising concerns about the forest's health. These species can outcompete native plants, altering the forest's overall composition. It is important to continue monitoring and removing these invasive species to help preserve the native forest. Additionally, the presence of the EAB is evident. All 11 mature standing ash trees were affected by this insect, with 10 completely killed and 1 barely surviving. There are many ash seedlings and saplings in these plots, but it is unlikely they will reach maturity.

Forest Future:

Oaks, hickories, red maples, and tulip poplars currently dominate the forest canopy. The sapling layer is composed primarily of American hornbeams, hickories, oaks, viburnums, ash trees, and eastern redbuds. Shade-tolerant species such as American hornbeams, viburnums, and eastern redbuds are likely to remain in the understory, while hickories and oaks are expected to continue growing into the canopy. Ash trees are susceptible to EAB and therefore will likely die before they can take over the canopy.

The seedling layer is also dominated by ashes, oaks, hickories, viburnums, and red maples, so the current composition is likely to remain. However, the abundance of red maples might affect the forest's future. Red maple trees are shade-tolerant and grow quickly, allowing them to dominate the understory rapidly and sometimes outcompeting oaks when there are no fires or other disturbances (Walters et al.). It is important to monitor these changes over time.

Comparison of Other Old-Growth Forests:

This old-growth forest is similar to others in the region. Oak and hickory trees commonly dominate the canopy, with many maples, ashes, and hornbeams in the understory (Mesic 2025).

High species diversity and a reverse-J distribution across height and DBH classes are also typical of stands that have not been recently disturbed (McGee et al., 1999).

Limitations and Field Challenges

Several fieldwork challenges should be addressed in future surveys. Identifying certain seedlings, including black oak, northern red oak, and several hickory species, proved difficult, and the dense understory sometimes complicated plot layout. The team addressed the latter problem by flagging trees along the compass bearing between posts and taking backsights throughout the study. As discussed above, the sample size and random plot selection resulted in the omission of some species known to occur in the old-growth forest. The data therefore provide a general estimate of forest composition rather than a complete inventory of every species or tree type. GPS tools such as Avenza can also provide slightly inaccurate coordinates because of multipath interference, canopy cover, poor signal strength, and adverse weather. Finally, invasive species can complicate assessments of natural forest structure.

Suggestions for Future Research:

Future research could expand on this study in many ways. For example, it would be interesting to age some of the trees using an increment borer to gather more accurate dendrochronological data or to test soil properties such as pH and organic matter content. It may also be valuable to conduct general wildlife surveys. These could involve setting up trail cameras and bat detectors, conducting herpetofauna and small-mammal surveys, or conducting bird point counts within the old-growth forest. Additionally, the entire survey could be compared with surveys of non-old-growth sections of the property. Establishing more plots would also improve the current study's accuracy. By adding four new plots in 2026, we discovered 16 additional tree species within the boundaries. Most importantly, long-term monitoring of the existing plots is necessary to track growth rates, regeneration, mortality, and the spread of invasive species.

Conclusion

This study surveyed a 2-acre section of the 127.2-acre old-growth forest at Leopold's Preserve in Prince William County, Virginia. The goal was to document forest composition and structure, identify species within the old-growth boundaries, and establish a baseline for future studies and management practices. Data were collected on mature trees (>5 inches DBH), tagged saplings (<5 inches DBH and >4.5 feet tall), and seedlings (<5 inches DBH and <4.5 feet tall). The entire 127.2-acre forest comprises approximately 2,010,778 trees, including an estimated 16,091 mature trees, 99,534 saplings, and 1,895,153 seedlings.

Acknowledgements

I am incredibly grateful for all the help I received in completing this project. I would like to sincerely thank my research supervisor, **Nick Davis**, Land Stewardship Manager at Leopold's Preserve, for giving me the opportunity to conduct research and for his guidance throughout this project. His perspective, honesty, care, and motivation have inspired me. It was a great privilege to work and learn under his supervision.

I am extremely thankful to the Leopold's Preserve volunteers, whose support and contributions helped make this project successful. It is truly inspiring to see so many people who are passionate about our natural world, and I am honored to have worked with them.

I would like to recognize the volunteers from each survey year who contributed the most hours.

2025: 6 volunteer events (July 9 - July 28) for a total of 56.5 hours from eight volunteers.

Mike Dow, *Vice President, Bull Run Mountains Conservancy (Partner organization)*

Nora Waide, *Forest Resources and Environmental Conservation, Virginia Tech CNRE*

Matthew Frost, *Assistant Director, Bull Run Mountains Conservancy (Partner organization)*

Kheya Siripurapu, *Environmental Science & Systems Engineering, University of Virginia*

Ariel Stater, *Dedicated volunteer and former intern at Leopold's Preserve*

2026: 14 volunteer events (May 14 - July 1) for a total of 115 hours from nine volunteers.

Mike Dow, *Vice President, Bull Run Mountains Conservancy (Partner organization)*

Paul Guay, *VWL Citizen Scientist and Virginia Master Naturalist (Shenandoah Chapter)*

Kaimy Oehlberg, *Virginia Master Naturalist (Banshee-Reeks Chapter)*

Emily Tuszynaska, *George Mason English, Composition, and Creative Writing Professor*

Valerie Huelsman, *Environmental Educator and Natural Resources Specialist*

Additional volunteers: Arul Siripurapu, Natalie Buford, Nasrolan Pooyan, Pouran Azari, Lucky Foster, Joshua Mecham, and Andrew Mecham

Lastly, I would like to give a special thanks to **Scott Plein** for providing vital resources, funding, and unwavering dedication to conserving Leopold's Preserve. Without his efforts, this old-growth forest would not exist.

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