The North Woods of Greenbelt, Maryland: A mature forest with 140-year-old trees

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The North Woods is a 190-acre forest in the city of Greenbelt in Prince George's County, Maryland. The purpose of the present report is to establish that at least parts of the North Woods are mature second-growth. This oak forest is somewhat unusual in Maryland's coastal plain for the following reasons:

- The oldest trees are 140 years old, although it is unclear if any patches of the forest are that old too
- The North Woods contains several habitats in close proximity
- The North Woods is part of the Greenbelt National Historic Landmark

The present report is loosely modeled after site reports posted to the website of the Native Tree Society during the past 15 years (See References). Those reports provided site history and ecological overview, and their purpose was to evaluate whether a site was old growth or mature second growth. Except where noted in the text, the data in the present report were collected by the author between 2017 and 2019. Supporting information is provided in the data file and tree-location map that accompany this report on the author's web page: https://mason.gmu.edu/~okelley/forest .

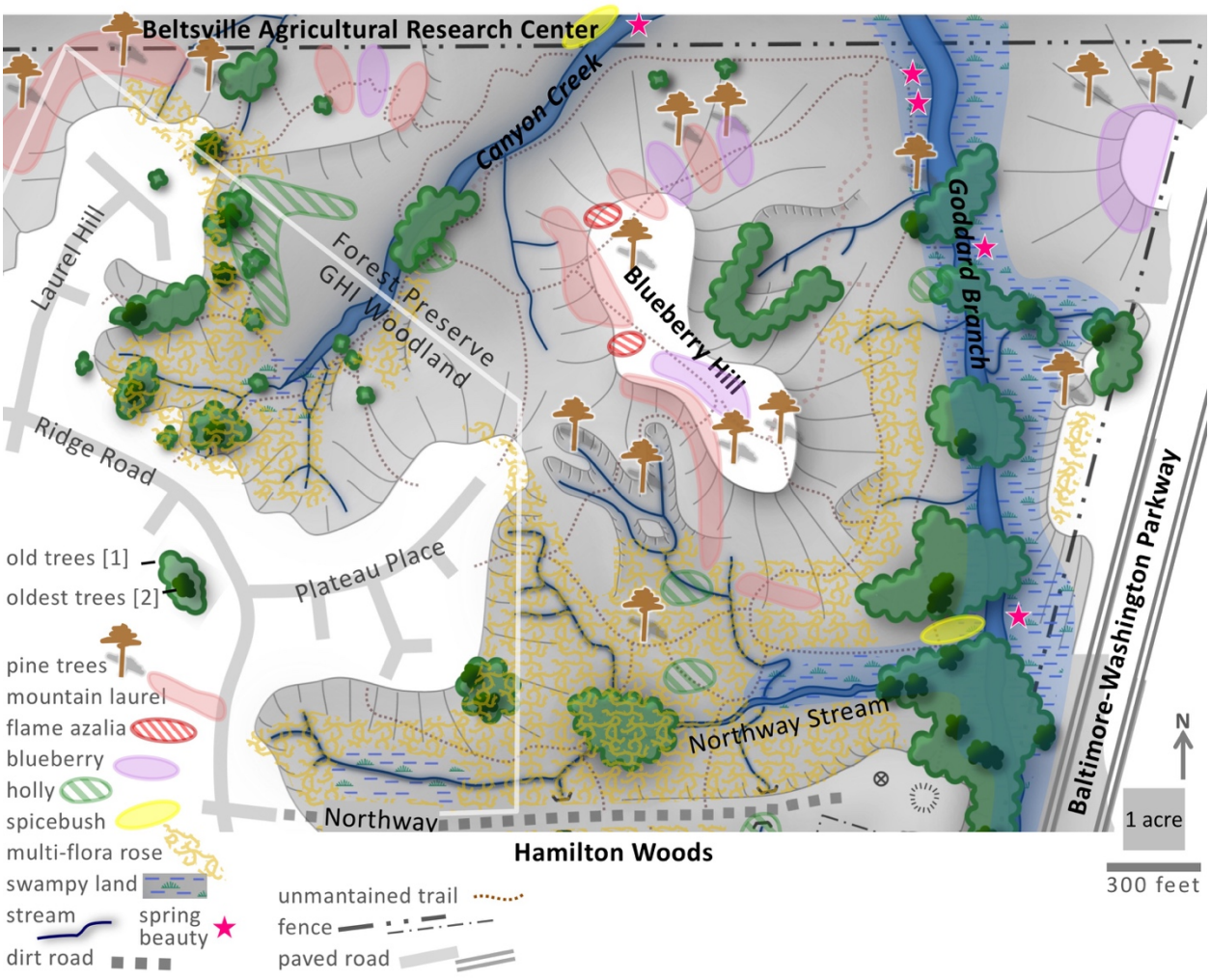
1. Site Description

The Greenbelt North Woods is a contributing element to the Greenbelt National Historic Landmark located in northern Prince George's County, Maryland. On February 2, 1997, the landmark was added to the National Registry of Historic Places because it represents a New Deal experiment in which the federal government bought thousands of acres of forest and field and built what was intended to be an ideal suburb for families of modest income during the Great Depression. The landmark includes the 190-acre North Woods and the adjacent Hamilton Woods because these two forests were part of the town's original "belt of green." The New Deal planers intended that the belt of green would surround the residential core of Greenbelt in perpetuity.

The North Woods is the focus of this study (rather than the Hamilton Woods) because the North Woods contains a broader range of forest-interior habitats. The North Woods contains floodplain forest, upland-oak forest, and heath forest at the top of a hill. In the schematic map below, the floodplain is indicated by blue-dotted lines along Goddard Branch. An area of heath

forest is indicated by the pine, laurel, and blueberry at the summit of Blueberry Hill. Most of the rest of the forest can be loosely described as "upland oak."

To the south of the North Woods lies the Hamilton Woods, and to the north lies several hundred acres of forest in the USDA's Beltsville Agricultural Research Center. Along the eastern border of the North Woods is the National Park Service's Baltimore Washington Parkway and the wooded campus of NASA Goddard Space Flight Center. The western border of the North Woods is traced by the New Deal era townhomes built by the federal government in 1941. On the schematic map below, the "old tree" bubbles represent trees whose trunks are at least 30 inches in diameter at chest height. The smaller, "oldest tree" bubbles indicate an oak or maple with a ≥36-inch-diameter trunk or a tulip poplar with a ≥42-inch-diameter trunk.



Map 1. Schematic map of terrain and habitats in the Greenbelt North Woods. The city of Greenbelt owns 141 acres of forest-preserve land in the North Woods. Greenbelt Homes, Inc., (GHI) owns 49 acres of forest within of the North Woods.

The Greenbelt North Woods is located in Maryland's coastal plain. It contains two small streams (Goddard Branch and Canyon Creek) that, beyond the edge of the property, flow into Beaverdam Creek then Indian Creek, the Anacostia River, the Potomac River, and finally, the Chesapeake Bay. Within the Greenbelt North Woods, there is approximately a 100-foot elevation difference between the floodplain along Goddard Branch and the flat, dry, 195-foot-elevation summit of Blueberry Hill at the center of the tract.

The USDA web-soil survey states that the soil type in the Greenbelt North Woods is Russett-Christiana complex at high elevations, Christian-Downer complex at mid-elevations, and frequently flooded Zekiah and Issue soils in the Goddard Branch floodplain and along Canyon Creek (https://websoilsurvey.nrcs.usda.gov).

2. Site History

Before the arrival of Europeans, Native Americans established work sites along the Indian Creek floodplain, a few miles west of the Greenbelt North Woods. These Native American sites were active between 8,000 BC and 1,000 BC (Berger 1991). Native Americans may have visited the Greenbelt North Woods more recently than 1,000 BC if a few lithic points that Greenbelt residents have found are a guide.

Between 1703 and 1761, surveyors divided the Greenbelt area into parcels. Many of the original surveys listed a tree at the first corner of the property line, which suggests what species were particular large and noteworthy in the 1700s. Local historian Alan Virta has examined the original land surveys in the vicinity of the Greenbelt North Woods, and Table 1 shows the first corner trees that he found. In some cases, one tree was the first corner of more than one parcel.

Table 1. "First corner" trees in 1703–1767 property surveys in the vicinity of the Greenbelt North Woods

Kind of tree	Number of parcels with this kind of tree at their first corner
white oak	16
Spanish oak [a]	5
black oak	3
red oak [b]	2
poplar [c]	3

[a] An alternative name for southern red oak

[b] Red oak is the name of a group of species that includes including northern red oak, southern red oak, and scarlet oak

[c] "Poplar" most likely refers to tulip poplar (Liriodendron tulipifera), one of the most common tree species in Maryland and Virginia

Table 1 shows that white oak was by far the most common pre-settlement first-corner species in the Greenbelt North Woods. Today, there are still a good number of outstanding, large, white oaks in the North Woods, but today they are out-numbered by tulip poplar, scarlet oak, and red maple. Tulip poplar and red maple are more easily harmed by brush fires than is white oak. Ecologists have documented that these fire-sensitive species have become more common in U.S. East Coast after forest fire was effectively suppressed since the early 1900s (Nowacki and Abrams 2008).

It is unclear how many decades separate the 1703–1767 land surveys and the start of farming by European settlers in what is today the Greenbelt North Woods. According to historian Alan Virta, the first evidence of farming here is the federal government's 1798 special tax assessment that listed the buildings on the farm of Elisha and Isabella Woods. Their farm included the present-day Blueberry Hill and land to the south.

The possibility cannot be ruled out that small patches of forest may have escaped clear-cutting throughout the farming era that roughly spanned the late 1700s to the late 1800s. In 1850 and 1860, the U.S. Agricultural Census showed that the present-day Greenbelt North Woods fell within one of three family farms, all of which were partially forested and partially cleared for field and pasture. These three farms were the 300 acres called "Poplar Thicket" that Jacob Riddle owned in 1850, the 175 acres called "Green Spring" that Sarah Boteler owned in 1860, and the 146 acres called "Parcel Enlarged" that George L. Clark owned in 1860.

In contrast to the 1850 and 1860 Agricultural Censuses, the 1870 Agricultural Census does not list any farms on what is today the North Woods. The apparent cessation of farming might be explained a decline of farming in the area following the Civil War or by local farmers refusing to participate in the 1870 census. The former explanation seems most likely because, in 1913, Maryland state forester Fred Besley published the first survey of Prince George's County forests, and his survey listed all of the present-day Greenbelt North Woods as either culled hardwood or culled pine-hardwood. If trees throughout the North Woods had time to grow up and then be selectively logged prior to 1913, then field and pasture must have been abandoned and begun reverting to forest at least a few decades earlier than 1913.

Since 1952, the Greenbelt North Woods' western-most 49 acres have been owned by Greenbelt's housing cooperative. The cooperative adopted its present-day name in 1957: Greenbelt Homes, Inc. (GHI). Known as the GHI Woodlands, these 49 acres and other GHI-owned forest in Greenbelt have been under a conservation-management agreement with the state of Maryland since 1972. In the 1980s and 1990s, GHI selectively logged some of its 49 acres in the North Woods because the Maryland Department of Natural Resources (DNR) forester who wrote the conservation-and-management plan for this land required that GHI remove some of the

old, disfigured, diseased, and other trees. In 1990 and 1992, DNR foresters claimed that this sort of logging was necessary to improve forest health. There is a body of opinion that foresters sometimes recommend logging in the name of improving forest health when natural processes alone would have sufficed (Leverett 2007; Puettmann et al. 2009).

The Greenbelt North Woods' eastern-most 141 acres have been entirely owned by the city of Greenbelt since 1990 and the great majority of these acres have experienced no logging since at least 1935. The minor exceptions are a handful of acres along the forest boundary: an acre cleared for an astronomical observatory at the southeast boundary and a few acres cleared at the eastern boundary associated with construction of a Parkway interchange for NASA Goddard.

Foresters have collected a limited amount of ecological information about Greenbelt's North Woods. The 49 acres owned by Greenbelt Homes, Inc., has been evaluated by DNR foresters in 1990, 1992, 1998, and 2013 as part of the process of writing management-and-conservation plans for these 49 acres. The 141 acres of the North Woods owned by the city of Greenbelt was evaluated by a DNR forester in 2013 and by a city-hired consultant in 2016 (A. Morton Thomas Associates, draft Forest Health Assessment).

3. Estimating Tree Age

Various official surveys of the Greenbelt North Woods give inconsistent estimates of the age of the forest, ranging from 40 to 140 years. In 1998, DNR foresters Miller and Masse estimated an age of 118 years for the North Woods between Laurel Hill Road and Plateau Place, which would equate to 139 years in 2019. Similarly, Miller and Masse described the North Woods between Plateau Place and Northway Road as 112 years old in 1998. In contrast, DNR foresters Stupak and Long estimated that these two tracts were only 40–70 and 40–60 years old, respectively, in 2013.

To narrow down the age of the North Wood's oldest trees, the author has measured two variables more exhaustively than was done in the various DNR reports over the years. The first variable is trunk diameter. Between 2017 and 2019, the author attempted to locate all living single-trunked trees in the North Woods that had a trunk diameter at chest height of at least 30 inches (measured girth ÷ π). The data file and tree-location map on the author's web page document the individual trees that the author found (https://mason.gmu.edu/~okelley/forest). This data is summarized in Table 2 below, using 2-inch trunk-diameter classes. The minimum diameter in each class is stated in the table's header.

Table 2. Population of large-girth trees in the Greenbelt North Woods in 2-inch diameter classes

Tree type	Tree count in 2-inch diameter class, girth ÷ π (inches)										Max. diameter
	30	32	34	36	38	40	42	44	46	48	
tulip poplar	18	15	17	9	7	5	4	3	2	1	49.7"
scarlet oak	6	4	1	1	1				1		46.8"
red maple	7	4	2	1	1		2				43.9"
white oak	5	5	5	3	2						39.2"
willow oak	2	1	4								35.3"
southern red oak	3	1	1								35.0"
sweetgum	3	3	2								34.7"
black oak	1	1									32.5"
chestnut oak		1									32.4"
hickory	1										30.6"
										Average:	38.0"

The second variable that the author estimated is the relationship between tree age and trunk diameter among the large-girth trees of the Greenbelt North Woods. Table 3 provides three kinds of age-diameter estimates. One data point comes from the stump of a large red oak that was recently cut down (for unknown reasons) in the GHI portion of the North Woods. Another data source is the cores that the author extracted with an increment borer from recently windfallen large-girth trees during 2017 to 2019. The last data source is the hypothetical diameter of a 140-year-old tree based on the site index and the formulas of Teck and Hilt (1991). The data file that supplements the present report includes a compilation of site index values for the Greenbelt North Woods based on DNR site reports of the Greenbelt North Woods and the USDA soil database.

Table 3 suggests that a 30-to-38-inch-diameter oak might be 140 years old in the interior of the North Woods. A 41-to-45-inch tulip poplar and a 26-to-31-inch red maple might also be 140-years old in the interior of the Greenbelt North Woods. In contrast, a tree growing in the middle of a clearing or at the edge of the forest may reach these trunk diameters at a much younger age because it faces less competition for light, water, and nutrients. The sample size in Table 3 is very small, but the author knows of no alternative data set for the Greenbelt North Woods.

Table 3. Empirical relationship between trunk diameter and tree age

Data type	Measured or assumed quantities	Diameter that would be achieved after 140 years at this growth rate
	tulip poplar	
Core from windfallen tree	74 rings, 21.6" diameter	40.9"
Core from windfallen tree	62 rings, 19.9" diameter	44.9"
Hypothetical canopy tree [a]	site index = 100 ft	45"
	red oak [b]	
Chain-sawn stump [c]	142 rings, 30" diameter	29.6"
Core from windfallen tree	133 rings, 29.6" diameter	31.2"
Core from windfallen tree in clearing [d]	96 rings, 33.4" diameter	47.2"
Hypothetical canopy scarlet oak [a]	site index = 66–75 ft	32.9–35.7"
	white oak	
Chain-sawn stump [e]	140 rings, 38" diameter	38"
Hypothetical canopy tree [a]	site index = 67–70 ft	30.0–30.7"
	red maple	
Core from trunk that snapped 20 feet above ground in clearing [d]	140 rings, 30.6" diameter	30.6"
Core from windfallen tree	97 rings, 20.5" diameter	29.6"
Core from windfallen tree	88 rings, 18.45" diameter	29.4"
Hypothetical canopy tree [a]	site index = 60 ft	26"
	pine	
Core from windfallen loblolly pine	128 rings, 22" diameter	24.1"
Core from windfallen Virginia pine	119 rings, 20" diameter	23.5"
Hypothetical canopy loblolly pine [a]	site index = 90 ft	39.4"
Hypothetical canopy Virginia pine [a]	site index = 70 ft	24.5"

[a] Using the formula of Teck and Hilt (1990)

[b] An oak of unknown species in the red-oak group, i.e., not white oak

[c] Recently chain sawn stump in the GHI Woodlands near 8G Plateau Place

[d] This red maple and scarlet oak are 20 feet from each other in the middle of a 0.6-acre clearing within the floodplain, west of Goddard Branch and south of Northway stream

[e] In a forest on the northeast shore of Greenbelt Lake, a mile from the North Woods

Table 3 includes two trees within the North Woods that have actually achieved a 140-year age based on a count of their trunk's growth rings. The North Woods contains other examples of these species with even larger-diameter trunks growing under similar conditions (Table 2), which suggests that some of these trees might also have achieved a 140-year age. To get a rough sense of how rare 140-year-old trees are, consider that the U.S. Forest Service reports that 3% of forested acres in Maryland are over 120 years old and only 0.3% of acres are over 140 years old (Forest Service 2017, Table MD-6).

4. Rucker Girth Index Suggests a Mature Forest

Having located all trees in the Greenbelt North Woods with ≥30-inch-diameter trunks at chest height, one has a good start for constructing several iterations of the Rucker Girth Index, a metric developed by the Native Tree Society in 2003 to evaluate sites for mature second growth or old growth. After the first iteration in the Greenbelt North Woods, the sample of ≥30-inch trees must be supplemented by some trees of lesser girth, a population that the author has only incompletely surveyed. To calculate the second iteration of the girth index, the 10 trees that were used to calculate the first iteration are removed from the sample before selecting 10 trees of different species with the widest trunks.

Table 4. Three iterations of the Rucker Girth Index for the Greenbelt North Woods with values expressed as diameter at chest height (measured girth ÷ π in inches)

	1st Iteration	2nd Iteration	3rd Iteration
1	49.7" tulip poplar	47.1" tulip poplar	45.8" tulip poplar
2	46.8" scarlet oak	42.0" red maple	37.6" white oak
3	43.9" red maple	38.8" scarlet oak	37.2" red maple
4	39.2" white oak	38.8" white oak	36.9" scarlet oak
5	35.3" willow oak	35.3" willow oak	33.1" sweetgum
6	35.0" southern red oak	34.4 sweetgum	33.1" willow oak
7	34.7" sweetgum	33.4 southern red oak	30.9" southern red oak
8	32.5" black oak	30.6" black oak	25.4" loblolly pine
9	32.4" chestnut oak	27.0" loblolly pine	25.1" Virginia pine
10	30.6" hickory	25.5" sycamore	21.0" sycamore
	38.0" average	35.3" average	32.6" average

One can compare the Rucker Girth Index for the Greenbelt North Woods with that of other mature second-growth forests and old-growth forests in the mid-Atlantic states. These girth-index values are available in site reports on the website of the Native Tree Society, as listed in the reference section of the present report. To make rough generalizations based on a few sites, famous eastern U.S. old-growth forests tend to have girth indices in the vicinity of 50" diameter (e.g., Cook Forest, Pennsylvania), while the girth indices of mature second-growth forests are little more than 40" diameter even for large tracts with particularly good growing conditions (e.g., Patuxent River floodplain within the Patuxent Wildlife Research Center, Maryland). Small tracts of woods that are borderline old growth (selectively logged but not clear cut) may have girth indices under 40" diameter (e.g., Belt Woods in Prince George's County, Maryland). Table 5 makes these comparisons.

In Table 5, shaded cells indicate trees that are smaller than the tree of corresponding rank in the Greenbelt North Woods' first-iteration girth index. For example, trees of rank #5 to #10 in

the Belt Woods old-growth forest are smaller than those rank #5 to #10 in Greenbelt's North Woods. One way to explain these data would be to speculate both that Belt Woods is older than the Greenbelt North Woods and also that Belt Woods experienced some logging that removed certain species and reduced the species diversity of large-girth trees. Another contributing factor may be that the Belt Woods survey of Blozan and Copiz (2010) focused on finding the tallest trees, not finding trees with the greatest girth.

Table 5. Girth indices for several forests, expressed as diameter at chest height (measured girth ÷ π in inches)

Cook Forest, PA	Patuxent Wildlife Research Center, MD	Belt Woods, Prince George's County, MD	Greenbelt North Woods, Greenbelt, MD
78.6" sycamore	78.0" sycamore	62.9" tulip poplar	49.7" tulip poplar
63.8" northern red oak	57.3" tulip poplar	57.6" northern red oak	46.8" scarlet oak
50.8" white oak	52.2" swamp chestnut oak	50.6" white oak	43.9" red maple
50.5" white pine	44.6" pin oak	48.5" black oak	39.2" white oak
50.5" hemlock	41.4" green ash	29.8" mockernut hickory	35.3" willow oak
49.7" black cherry	40.7" white ash	29.3" pale hickory	35.0" southern red oak
44.2" cucumber tree	40.1" overcup oak	25.7" blackgum	34.7" sweetgum
39.8" beech	39.8" beech	24.2" sweetgum	32.5" black oak
38.5" basswood	14.6" ironwood	22.7" black walnut	32.4" chestnut oak
38.5" red maple	13.4" Virginia pine	22.2" sycamore	30.6" hickory
RGI = 50.48" (diameter)	RGI = 42.21" (diameter)	RGI = 37.4" (diameter)	RGI = 38.0" (diameter)
1,300 acres of old growth, "some of the finest examples of old-growth forest in the eastern U.S." A National Natural Landmark. Numerous trees 225–450 years old. July 2003, compiled by Colby Rucker.	1,360 acres mature second growth in Patuxent River floodplain. Patches may contain ≥150 year old trees. Floodplain located in central portion of research center, which is not open to the public. Fall 2010, Darian Copiz.	43 acre "south woods" is a National Natural Landmark with oldest trees ≥200 years old. Within 625-acres of MD conservation land. Selectively logged. Access by permit for scientific study. 26 Jan. 2010, Will Blozan. Colby Rucker survey in Oct. 2001 lacked girth.	190 acres of mature second growth forest, with oldest trees ≥140 years old. No logging on most of land since at least 1935. Includes several habitats: floodplain, seeps, vernal pools, upland oak forest, and dry "pine barren" habitat on hilltop. 2017–2019, Owen Kelley.

5. An Uneven-aged, Naturally Thinning Forest

One characteristic of a mature forest is that the trees are unevenly aged, i.e., not all falling in a 10–20 year range of ages. Although not definitive, one technique that may be used to estimate whether a forest is mature is to create a histogram of diameter at chest height for plots within the forest under study. The author measured the girth of all trees ≥4 inches in diameter in four square plots each 111 feet on a side (1/3.5 of an acre each). These four plots were selected in widely scattered locations in the North Woods. The location of these four plots is shown on the tree-location map that accompanies this report.

Table 5 shows the diameter distribution in these four plots. Plot (a) is in the Goddard Branch floodplain, and plot (d) is in a cove on the east side of Blueberry Hill. Plot (b) is an upland-oak forest where Greenbelt Homes, Inc., (GHI) performed some culling in 1994. That same year, GHI also girdled some trees in Plot (b) to increase wildlife habitats. The girdled trees were still visible in 1998 (DNR 1998), but are no longer visible in 2019. Plot (c) is upland-oak forest with a heavy presence of two invasive species: English ivy on the ground and on some tree trunks and a dense thicket of multiflora rose.

Table 6. Living-tree count and basal area in four plots in the Greenbelt North Woods, each 111×111 feet

	Tree count in 2-inch diameter class, girth ÷ π (inches)																		Tree /	ft^2 /
Site	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	acre[a]	acre[a]
(a) Floodplain	20	12	5	1	2	1			2		1				1			1	165	137
(b) Culled	9	10	4	4					3	4	1	1	1						130	136
(c) Upland	3	5	2	2	1	2	3	1	1					1	1	1			81	124
(d) Cove forest	6	6	3	2	1	1	1		2	1	1		1	1				1	95	131

[a] The number of living tree per acre and the living-tree basal area per acre is calculated by multiplying the observed value on each 111×111 ft plot by a factor of 3.5. Basal area is measured here in square feet of trunk cross-sectional area at chest height per acre for all living trees with ≥4-inch-diameter trunks at chest height.

As stated in Table 5, the four square plots in the North Woods each have a living-tree basal area of 124–137 ft^2/acre with 81–165 living trees per acres in 2019. These values are typical for a oak forest in the Eastern U.S. that has not been logged and that is experiencing natural thinning as it matures. In other words, the stocking is approximately 100% relative to other natural oak forests. From the individual tree data used to compile Table 5, one can calculate the stocking percent relative to various reference forest types. Using the formulas of Johnson et al. (2002, pg. 242) the four plots in Table 5 are 96%–105% stocked relative to typical mid-western oak forests. Relative to tulip-poplar forests of the Allegany Plateau, the four plots in Table 5 are only 40%–51% stocked. Compared with oak forests, tulip-poplar forests reach approximately double the basal area before self-thinning limits further increases in basal area. Tulip poplars contribute between 16% to 95% of the basal area in these four plots of the Greenbelt North Woods, so it is unclear which kind of reference forest is the most appropriate for estimating the stocking level in the Greenbelt North Woods.

The Greenbelt North Woods' living-tree basal area and trees per acre also fall within the range given for old-growth oak forests of the eastern U.S. (White and White, 1996, pg. 185; Johnson et al. 2002, pg. 406). It is known that mature second-growth forests may reach the basal area and the tree count per acre of an old-growth forest long before the second-growth forest takes on other old-growth characteristics.

DNR forester Steve Stadelman expressed alarm that the western 49 acres of the North Woods had a living-tree basal area of 90 to 105 ft^2/acre in 1992. To reduce the perceived danger that the forest might become unhealthy due to over-stocking in the future, Stadelman proposed, in 1992, a draft management plan that called for Greenbelt Homes, Inc. (GHI) to log the forest down to a basal area of 70 ft^2/acre. While the plan proposed in 1992 was never adopted, GHI did selectively log a portion of the western 49 acres of the North Woods during the 1990s. This logging occurred in 1994 according to the DNR's 1998 report. It is unclear why Stadelman thought that the forest would become dangerously overstocked if no logging occurred because it is a basic tenant of silviculture that "natural" forests, i.e. forests that are not logged, will self-thin to avoid becoming grossly overstocked (Johnson et al. 2002, Chap. 6).

DNR foresters Stacy Miller and Richard Masse found the North Woods between Laurel Hill Road and Plateau Place had a 140 ft^2/acre basal area and 176 trees per acre in 1998. Rather than being alarmed about possible overstocking, Miller and Masse labeled this stocking as only 80% of "ideal." Miller and Masse's values are similar to those that the author found in 2019 in roughly the same part of the North Woods: plots (b) and (c). It is unclear what reference forest Miller and Masse were using in 1998 to determine percent stocking of 80% between Laurel Hill and Plateau, especially in light of the fact that they also claimed that the 148 ft^2/acre basal area and 250 trees per acre between Plateau and Northway Road represented 108% of ideal stocking.

So far, only living trees have been considered, but the number of standing dead trees and the amount of deadwood on the ground are also measures of a forest's maturity. Compared with young forests, mature forests tend to have more dead trees still standing and more fallen wood in various stages of decomposition. The author estimated the volume of large pieces of fallen deadwood (≥4 inch diameter) in the four plots in Table 5. In three of these four plots, fallen deadwood occurred at a rate of 174–418 ft^3/acre. These values are fairly typical for Maryland's forests. Maryland DNR estimates that forests in Maryland with a living-tree basal area of ≥120 ft^2/acre typically have a total of 220–300 ft^3/acre of fallen and standing deadwood (DNR 2008, pg. 40). In contrast, plot (a) in the Goddard Branch floodplain had a higher amount of fallen deadwood, equivalent to 976 ft^3/acre. A value this high is in the range found in old-growth oak forests (Johnson et al. 2002, pg. 406).

There were 12 standing dead trees total in the four sampled plots in Table 5 that together cover 1.1 acres. Eight of these standing dead trees had a diameter at chest height of ≥11.8" (30 cm). These are fairly typical values for Maryland's forests, which average 14.2 standing dead trees per acre (DNR 2008, pg. 37).

The four plots in Table 5 also had among them a total of 4 pit-and-mound pairs. A pit-and-mound pair is the remnant of a tree's root ball and the adjacent hole created when the tree blew down and the root ball was pulled from the ground.

The cove forest sampled by the author (plot d), has one "living stump," which is a stump that is being sustained by the root systems of adjacent, living trees. The stump is old enough for bark to have grown up and over the circumference of the stump. The stump has numerous 1-foot-tall shoots in April 2019 that clearly identify the species as tulip poplar. The stump is located a few feet from the largest tulip poplar tree in plot (d). Wohlleben (2015, Chap. 1) brought to the public's attention the fact that a tree stump may be kept alive for many years if the roots of neighboring trees connect to it and supply it with nourishment. (See also Wikipedia.org, "living stump.")

It is unclear if the Greenbelt North Woods is a 140-year-old forest, but at least a few trees in it are 140 years old and several patches of it appear to be mature. There is nothing in the historical record to rule out the possibility that at least a portion of the forest is 140 years old. Numerous characteristics of the North Woods indicate a mature forest, including the trunk-diameter distribution observed in four plots, the Rucker Girth index for the entire North Woods, the amount of deadwood, pit-and-mound topography, and the presence of shade-tolerant species (see Appendix).

Appendix: Plant Species in the North Woods

This appendix provides a partial list of plants, lichen, fungi, and slime molds that the author has observed in the Greenbelt North Woods during 2017 to 2019. The list includes native and non-native species growing in the forest interior. This list includes a number of shade-tolerant species, as well as species that prefer full sun. Herbaceous species that are found only at the forest edge are not included in this list. Additional species have been observed in the North Woods by the members of the Greenbelt Biota club, but are not included on this list because the author has not himself found specimens. Information about the club can be found on their Facebook page: https://www.facebook.com/groups/325927877605844 .

Tree

Acer negundo	box elder
Acer rubrum	red maple
Ailanthus altissima	tree of heaven (non-native)
Carpinus caroliniana	ironwood
Carya tomentosa	mockernut hickory
Castanea pumila	chinquapin
Cercis canadensis	redbud
Cornus florida	dogwood
Fagus grandifolia	beech
Ilex opaca	holly
Liquidambar styraciflua	sweetgum

Liriodendron tulipifera	tulip poplar
Nyssa sylvatica	blackgum or tupelo
Pinus rigida	pitch pine
Pinus strobus	white pine
Pinus taeda	loblolly pine
Pinus virginiana	Virginia pine
Platanus occidentalis	sycamore
Pyrus calleryana	callery pear (non-native)
Quercus alba	white oak
Quercus coccinea	scarlet oak
Quercus falcata	southern red oak
Quercus marilandica	blackjack oak
Quercus montana	chestnut oak
Quercus phellos	willow oak
Quercus velutina	black oak
Robinia pseudoacacia	black locust

Bush

Aralia spinosa	devil's walking stick
Berberis thunbergii	barberry
Euonymus alatus	burning bush
Euonymus americana	strawberry bush
Forsythia sp.	forsythia
Kalmia latifolia	mountain laurel
Lindera benzoin	spicebush
Lonicera maackii	amur honeysuckle
Rhododendron periclymenoides	pinkster azalea
Sassafras albidum	sassafras
Vaccinium angustifolium and corymbosum	blueberry, low/ high
Viburnum acerfolium	maple-leaved viburnum
Viburnum dentatum	arrowwood
Viburnum prunifolim	blackhaw viburnum

Vine-like habit (woody or herbaceous)

Celastrus orbiculatus	bittersweet (non-native)
Desmodium nudiflorum	naked-flowered tick trefoil
Dioscorea villosa	wild yam
Euonymus fortunei	wintercreeper
Galium aparine	cleavers

Hedera helix	English ivy (non-native)
Lonicera japonica	Japanese honeysuckle (non-native)
Medeola virginiana	Indian cucumber
Parthenocissus quinquefolia	Virginia creeper
Polygonum perfoliatum	mile-a-minute (non-native)
Rosa multiflora	multiflora rose (non-native)
Rubus phoenicalasius	wineberry
Rubus spp.	blackberry, dewberry, wineberry
Smilax glauca	cat greenbrier
Smilax rotundifloria	common greenbrier
Toxicodendron radicans	poison ivy
Vinca minor	periwinkle (non-native)
Vitis sp.	grape
Wisteria sinensis	Chinese wisteria (non-native)

Fern

Botrypus virginianus	rattlesnake fern
Dennstaedtia punctilobula	hay-scanted fern
Onoclea sensibilis	sensitive fern
Osmundastrum cinnamomeum	cinnamon fern
Polystichum acrostichoides	Christmas fern
Thelypteris noveboracensis	New York fern

Moss

Atrichum sp.	star-burst moss
Brachythecium sp.	foxtail moss
Leucobryum sp.	pincushion moss
Plagiomnium sp.	tooth moss
Thuidium sp.	fern moss

Other herbaceous Plants

Alliaria petiolata	garlic mustard (non-native)
Allium vineale	onion grass
Aralia nudicaulis	wild sarsaparilla
Arisaema triphyllum	jack-in-the-pulpit
Cardamine hirsuta	hairy bittercress (non-native)
Carex sp.	sedge
Claytonia virginica	spring beauty
Cypripedium acaule	pink lady's slippers

Diphasiastrum digitatum	fan clubmoss
Duchesnea indica	mock strawberry
Ficaria verna	lesser celandine (non-native)
Geum canadense	white avens
Geranium molle	dove's-foot cranes-bill
Glechoma hederacea	creeping Charlie (non-native)
Goodyera pubescens	rattlesnake plantain
Huperzia lucidula	shining clubmoss
Lycopodium obscurum	princess pine (a clubmoss)
Maianthemum racemosum	false Solomon’s seal
Microstegium vimineum	Japanese stiltgrass (non-native)
Mitchella repens	partridge berry
Monotropa uniflora	Indian pipe
Ornithogalum umbellatum	star-of-Bethlehem
Persicaria virginiana	lance corporal
Plantanthera clavellata	small green wood orchid
Podophyllum peltatum	mayapple
Polygonatum biflorum	smooth Solomon’s seal
Symplocarpus foetidus	skunk cabbage
Symphyotrichum racemosum	small white aster
Thalictrum dioicum	early meadow rue
Tipularia discolor	crane-fly orchid
Viola papilionacea	wild violet

Lichen

Candelaria or Xanthoria sp.	candle flame / starburst lichen
Candelariella sp.	goldspeck lichen
Cladonia coniocraea	common powderhorn lichen
Flavoparmelia sp.	greenshield lichen
Graphis scripta	common script lichen
Lepraria sp.	dust lichen
Parmotrema sp.	ruffle lichen
Physcia sp.	rosette lichen
Phlyctis argena	whitewash lichen

Fungus

Clavaria fragilis	lady fingers
Cratelelius fallux	black trumpet mushroom
Hericium erinaceus	lion's mane mushroom
Hygrophorus sp.	waxy cap mushroom

Irpex lacteus	milk-white toothed polypore
Mycena sp.	bonnet mushroom
Pseudocolous fusiformis	stinky squid mushroom
Russula sp.	russula mushroom
Schizophyllum commune	split gill fungus
Trametes versicolor	turkey tail
Trichaptum biforme	violet tooth mushroom

Slime mold

Ceratiomyxa sp.	coral slime slime mold
Exidia glandulosa	black jelly roll slime mold
Exidia recisa	amber jelly roll slime mold
Fuligo septica	dog vomit slime mold
Lycogala sp.	wolf's milk slime mold
Tremella mesenterica	witches butter slime mold

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