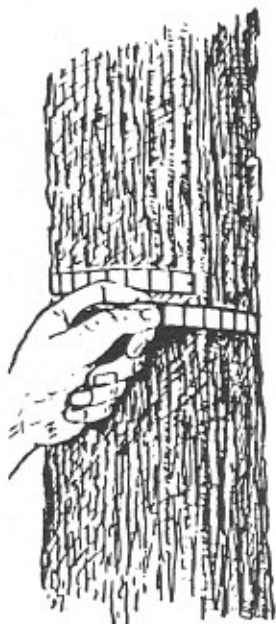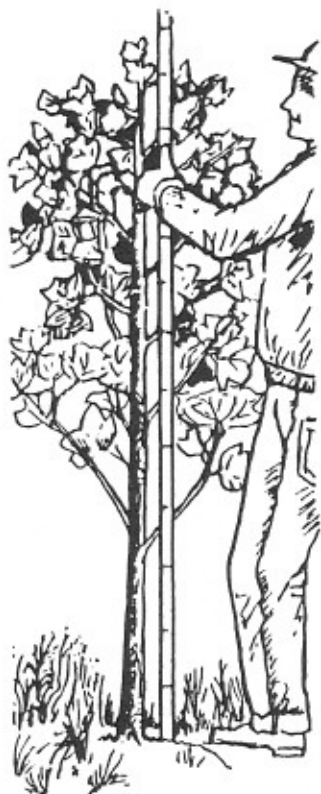# A STUDY OF DIAMETER GROWTH IN BLACK WALNUT STANDS

By
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Virginia
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A STUDY OF DIAMETER GROWTH IN BLACK WALNUT STANDS

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Introduction

A growth study was initiated in 1970 to monitor diameter growth in black walnut stands growing on what appeared to be good sites for black walnut. Between 1970 and 1980, studies were installed in 32 stands, 26 naturally seeded and 6 planted, ranging in age from 7 to 69 years. Age was estimated from ring counts. These stands are scattered over the piedmont and mountain areas of the state (Figure 1). Most stands were large enough to select 30 potential crop trees to measure. Stocking in these 32 stands ranged from widely scattered trees in an almost open-grown condition to dense stands where crowns were crowded and restricted. A few stands were thinned at the time we initiated the study and a few others were thinned later, but most stands were never thinned. All stands were measured annually for the first 5 years or so to establish a pattern of diameter growth, and then were measured less frequently in subsequent years.

In addition, between 1967 and 1974 we installed 57 black walnut planting studies, also scattered over the piedmont and mountain areas of the state. We measured height growth on these plots for a number of years[1]. When the trees got large enough on 15 of these studies, generally the studies that had grown the fastest, we began to measure DBH (Figure 1).
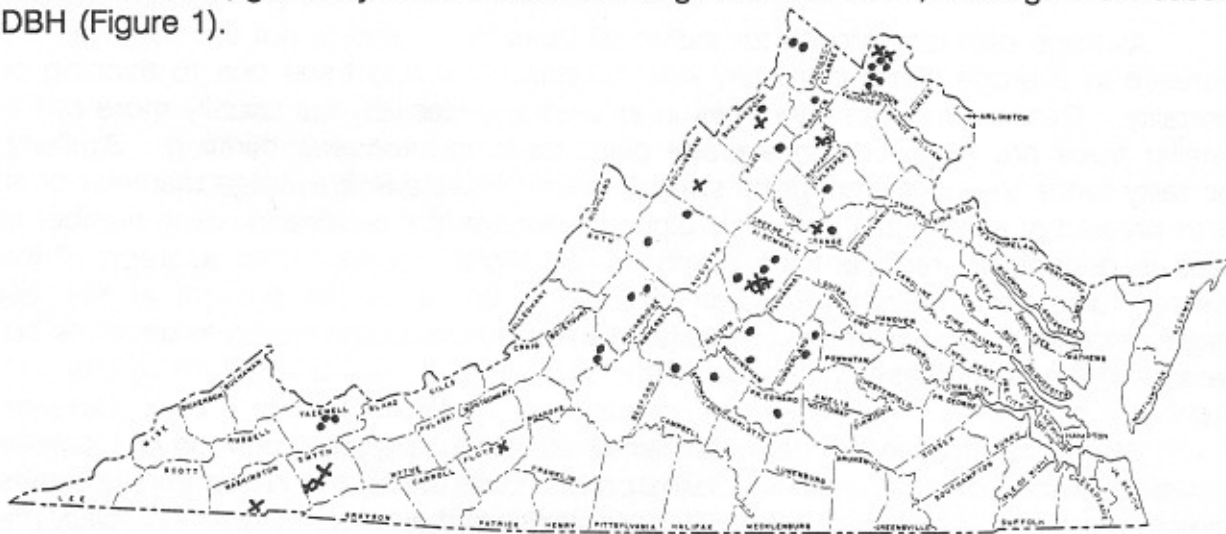

Figure 1. Location of 47 plots. "●"s identify the 32 growth study plots and "x"s the 15 planting study plots.

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[1] See Occasional Report 57, Black Walnut-Planting, Cultural Treatment, and Early Growth

Most of these plots were planted at a spacing of 6.6 by 6.6 feet, so we started thinning them early and most have been thinned several times. Consequently, the data from these 15 plots should give us a good estimate of potential diameter growth for the first 20 to 25 years in well managed walnut plantations on good sites in Virginia.

Procedure

In the stands already established (that we didn't plant ourselves), we tried to scatter the 30 potential crop trees selected for measurement throughout the stand. A DBH mark was sawn lightly in the bark so we would measure DBH at the same point each year. The trees were numbered, and we also obtained bearings and distances from tree to tree. Most of the trees selected for measurement were dominant or co-dominant at the time the studies were installed, but we deliberately picked some intermediate trees on many plots so we could compare the growth of dominant, co-dominant, and intermediate trees.

In the plots we planted ourselves, we measured the DBH of every tree. We started measuring these plots at young ages, often by age 6, before stratification into crown classes had occurred. Consequently, the trees on these plots were never classified by crown class.

Results

Average diameter growth for individual trees in a stand is not the same as the increase in average stand diameter, when a stand is losing trees due to thinning or mortality. Thinning may remove trees in all diameter classes, but usually more of the smaller trees are removed, so average diameter is greater after thinning. Similarly, mortality tends to occur among the smaller trees. Therefore, if average diameter of all trees present at each measurement is plotted over age (for a stand in which number of trees is periodically reduced) the graph will be slightly steeper than a graph of the average diameter at each measurement of only the trees still present at the last measurement. The data we present is for diameter growth of surviving trees, trees still present at the final measurement.

We wanted to use the data from all 47 stands to suggest the trend of diameter growth over the length of a rotation. One problem with doing this is that young stands contain more trees per acre (i.e. have denser stocking) than older stands, especially the stands we planted ourselves, even though they were thinned frequently. Ideally, we would use average diameter growth of only the trees that would be expected to still be present at rotation age. Using just dominant trees would be one approach, but the trees on the plots we planted ourselves were not classified by crown class. The strategy we decided on was to use the average diameter growth of the 10 largest trees, at the final

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measurement, on each plot. The plots we planted ourselves started out with from 40 to 240 seedlings, so using the largest 10 means selecting anywhere from 1 in 4 to 1 in 24. The older stands we did not plant ourselves started out mostly with 30 trees, and so we selected 1 in 3 from these generally older stands.

Another problem with combining the data is that we know the exact age of the plots we planted ourselves, but estimated the ages of the other 32 plots from ring counts. On most of these 32 plots, we were able to cut 1 or 2 trees, remove cross sections, plane them smooth, and count growth rings. Then we made the assumption that the other trees on the plot were the same age, which may or may not have been true, even though the stands "appeared" to be even-aged.

The data for the 10 largest trees per plot is plotted separately for the 15 plots we planted ourselves (Figure 2-A) and the 32 other plots on which we estimated age (Figure 2-B). Figure 2-C combines data for all 47 plots. The two sets of data seem to merge smoothly, suggesting, we hope, the expected diameter growth on good walnut sites in Virginia, for the better dominant trees in a stand.

For the 32 stands we did not plant, the 10 largest trees per stand usually did not include all the dominant trees, and a similar plotting of all dominant trees has the same overall shape (Figure 3-A), but the individual stand graphs are slightly lower (average DBH is less) because most plots had more than 10 dominant trees. Average diameter growth is considerably slower for co-dominant trees (Figure 3-B) and slower still for intermediate trees (Figure 3-C). At 80 years, which may be a reasonable rotation age, average DBH interpreted from the four graphs is approximately:

    10 largest - 20 inches
    All dominants - 18 inches
    Co-dominants - 14 inches
    Intermediates - 11 inches

There is considerable variation in average DBH in all of these graphs. In Figure 2C, at age 50, for example, average DBH varies from 11.2 to 18.3 inches. There are several reasons for this variation, but variation in site quality is the most important. Variation in stand density is probably responsible for some of the variation also. For 17 of the 32 plots, we tallied basal area with a 10-factor prism around each sample tree, at the time the plots were installed. We would expect a negative correlation between diameter growth and basal area, i.e., the greater the basal area of competing trees, the slower the growth. Looking at just dominant trees, however, these correlations were negative for only 9 of the 17 plots and positive for the other 8, suggesting that for dominant trees, stand density was not an important factor.
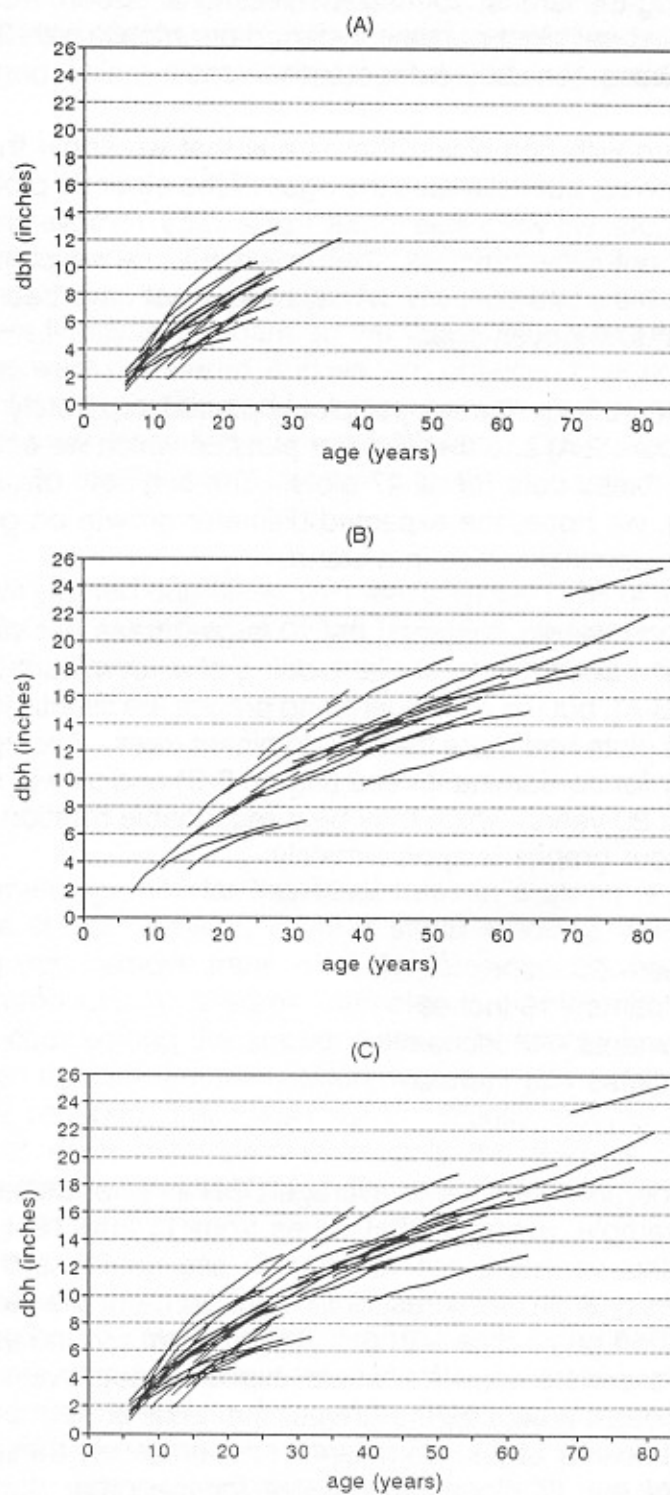
Figure 2. Average DBH plotted over age for the 10 largest trees on the 15 plots we planted ourselves (A), the 32 plots for which we estimated age (B), and all 47 plots combined (C).
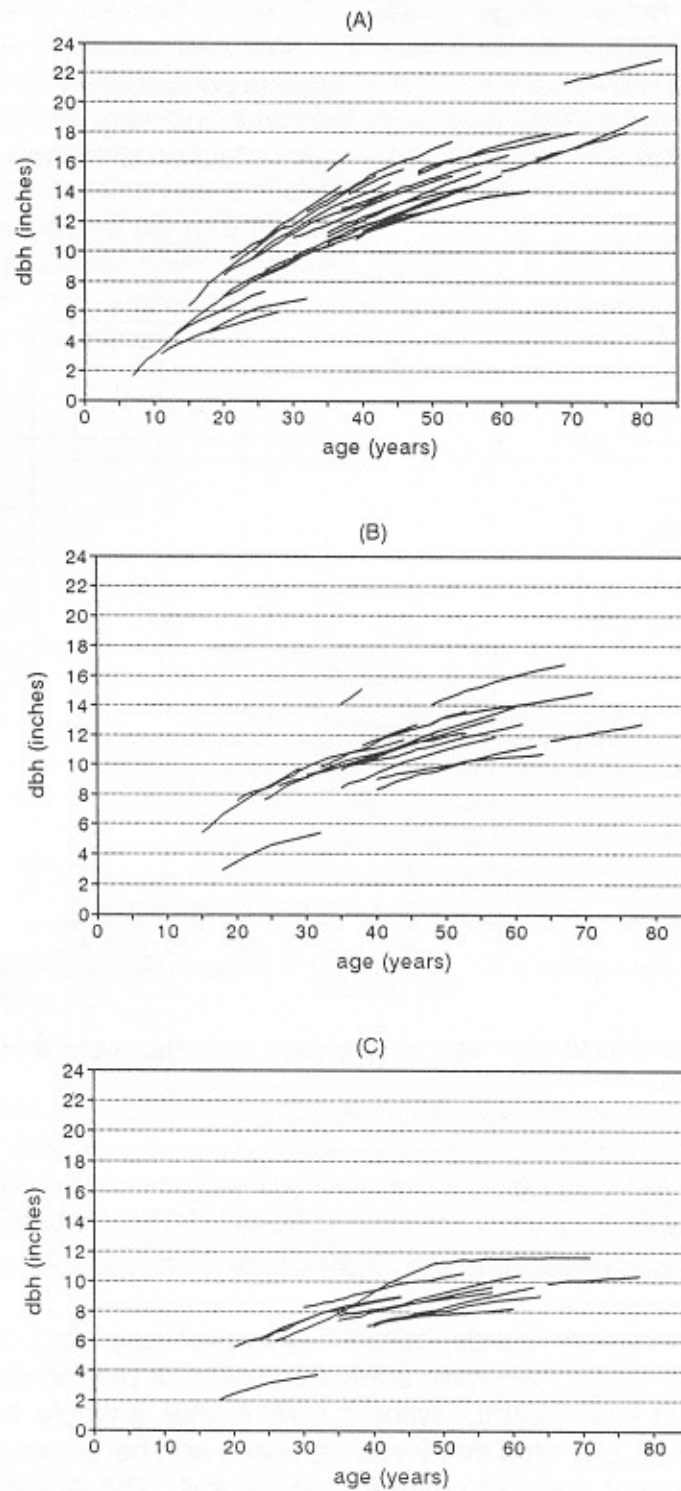
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Figure 3. Average DBH plotted over age for all dominant (A), codominant (B), and intermediate (C) trees on the 32 plots for which we estimated age.

Five of the 35 older stands were thinned after we had been measuring them for 6 years or more. They ranged in age from 26 to 47 when thinned. Diameter growth of the remaining trees did not increase (Figure 4). We had expected to see an increase because the thinnings were heavy enough to provide considerably more room around the crowns of the trees left. This seems to reinforce the suggestion in the preceding paragraph that stand density did not have a major effect on diameter growth of dominant trees.
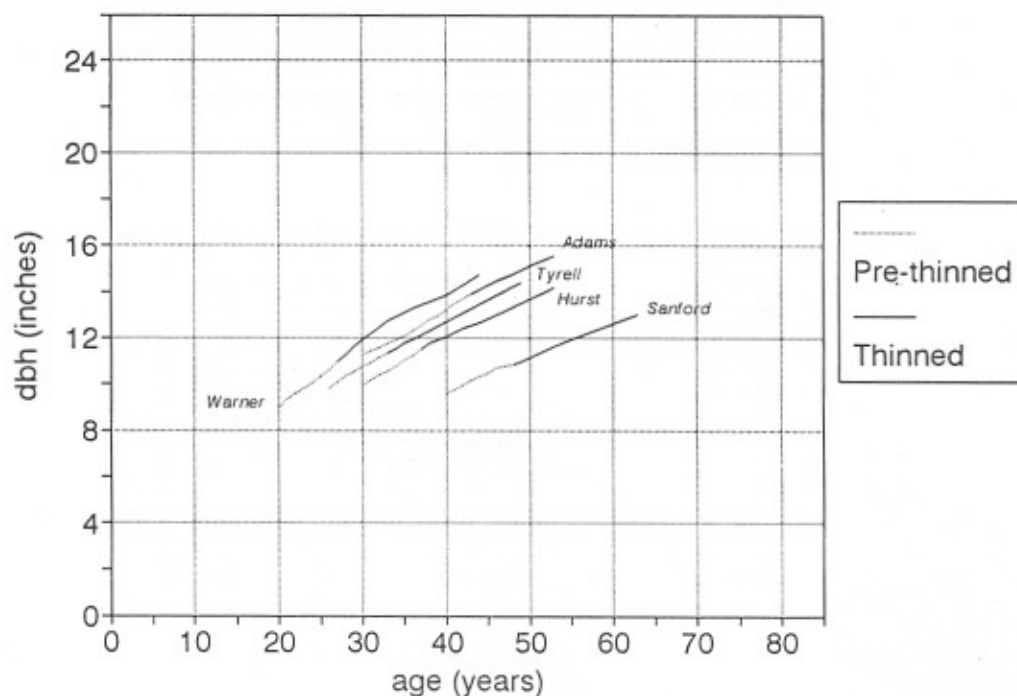
Figure 4. Average DBH plotted over age for 5 growth plots that were thinned 6 years or more following plot installation.

Errors in estimating stand age may also be responsible for some of the variation in average DBH. Of the three possible causes, however, variation in site index is by far the most important. Black walnut is extremely sensitive to variations in site quality.

Considerable sediment was deposited in several of the plots located on flood plains over the course of the study. We have a few trees on one plot on which the sawn DBH marks are now only at knee height. Without DBH marks, it would be easy to miss this soil buildup. Even for plots visited every year, grasses and herbaceous plants invade the "new soil" so rapidly that it is easy to miss the added soil. The lack of "root flare" can be a clue. There has not been any obvious effect from the added soil on tree vigor and growth.

The growth trends for several of the plots suggest that site quality has not been constant over the life of the stand. For example, the Gale Richmond plot is on the flood plain of the Calfpasture River, and growth rate has increased over the 23 years we have been measuring the plot (figure 5). There has been at least one major flood during this period and flood debris in the stand when we installed the plot indicates there was at least one earlier flood. Floods could have altered and re-altered drainage on the plot to adversely affect and later improve soil drainage. Another example is the Hartman plot located in a well-maintained pasture (Figure 5). Diameter growth rate has increased on this plot also over the 21 years we have been measuring it. Excessive trampling by cattle sometimes reduces "site quality" and growth rate, but an increase in fertilizer applied could have the opposite effect.
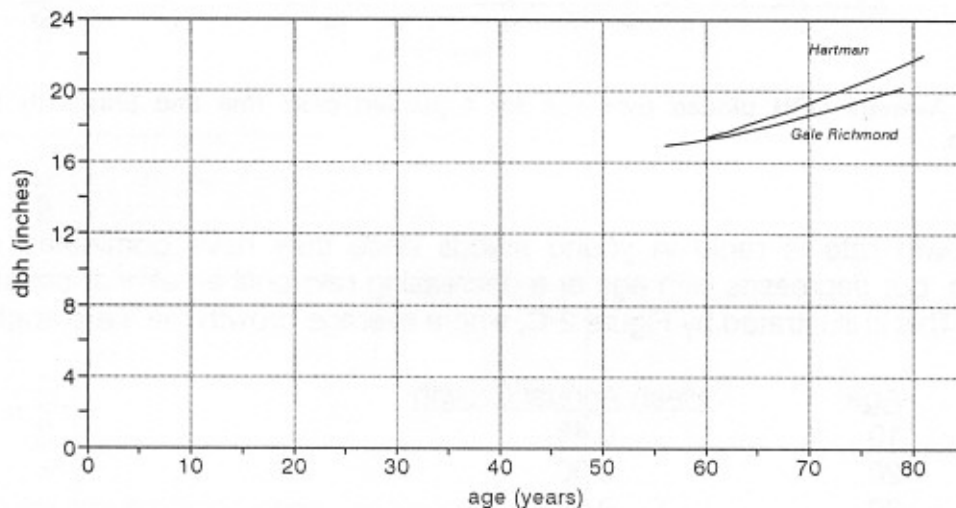
Figure 5. Average DBH plotted over age for 2 growth plots on which growth rate increased over the period of measurement.

Unusually heavy competing vegetation in the early years, when young walnut trees are struggling to dominate and capture the site, can, for a while, cause slower growth than the site is capable of. Several of the 15 plots we planted ourselves provide examples of this (Figure 6). The competition on these plots was not from overtopping hardwoods, but from low competition due to grass, weeds, blackberry, and Japanese honeysuckle.
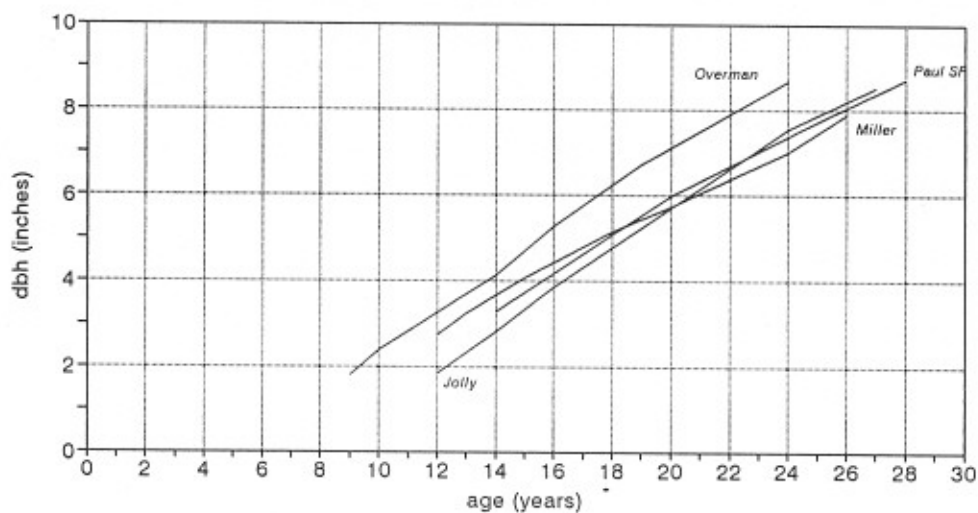
Figure 6. Average DBH plotted over age for 4 planted plots that had unusually heavy early competition.

Growth rate is rapid in young stands once they have dominated competing vegetation, but decreases with age at a decreasing rate until an almost constant rate is reached. This is illustrated by Figure 2-C, where average growth rates are approximately:

Age	Mean Annual Growth
10	0.45
20	0.30
30	0.25
40	0.22
50	0.20
60	0.19
70	0.18

APPENDIX   Plot Data Summaries

Plot	Ages Start	End	Ten Largest DBH Start	End	MAI	Dominant Trees DBH N Start	End	MAI	Codominant Trees DBH N Start	End	MAI	Intermediate Trees DBH N Start	End	MAI
Carter Block 2	6	27	1.43	9.26	0.37									
Carter Block 3	6	27	1.31	7.33	0.29									
Carter Block 4	6	21	0.98	4.78	0.25									
Nelson	6	22	2.07	8.53	0.40									
Richardson	6	21	2.33	7.20	0.32									
Rouse #1	6	26	2.32	9.72	0.37									
Lagather	6	26	1.63	9.55	0.40									
Rouse #2	7	26	2.16	9.31	0.38									
Carter (1969)	8	25	2.36	6.35	0.23									
National Humane #1	8	25	3.80	10.43	0.39									
National Humane #2	8	28	3.14	13.02	0.49									
Overman	9	24	1.81	8.67	0.46									
Art Jolly	12	27	1.85	8.53	0.45									
Miller	12	26	2.75	7.89	0.37									
Paul State Forest	14	28	3.28	8.71	0.39									

Plot	Ages Start	End	Ten Largest DBH Start	End	MAI	Dominant Trees DBH N	Start	End	MAI	Codominant Trees DBH N	Start	End	MAI	Intermediate Trees DBH N	Start	End	MAI
White Hall	7	26	1.77	9.07	0.38	22	1.63	7.34	0.30								
Mike Lee	8	24	2.79	10.45	0.48												
J. W. Hurst #3	11	28	3.56	6.82	0.19	16	3.11	5.95	0.17								
Coles	13	31	4.85	10.56	0.32	25	4.44	9.56	0.28								
R. S. Burruss	15	29	6.59	12.40	0.42	11	6.40	11.75	0.38	9	5.44	9.78	0.31				
Charles Smith	15	37	5.10	12.26	0.33												
Flippen	18	32	4.58	7.01	0.17	10	4.67	6.87	0.16	10	2.91	5.44	0.18	6	2.03	3.73	0.12
J. W. Hurst #2	20	36	7.36	10.74	0.21	11	7.06	10.51	0.22								
John Warner	20	44	8.98	14.74	0.24	14	8.45	13.92	0.23	6	7.57	11.67	0.17	1	5.60	9.00	0.14
Cumberland State Fore	21	42				8	9.53	15.10	0.27								
Lowry	24	44	9.02	13.86	0.24	5	9.50	14.64	0.26	15	7.59	11.27	0.18	5	6.22	9.02	0.14
E. T. Willis	25	37	11.44	15.74	0.36	15	10.55	14.36	0.32								
Tyrrel	26	49	9.81	14.43	0.20	13	8.77	12.63	0.17	4	8.55	12.30	0.16	1	6.00	11.30	0.23
Grace Adams #1	30	53	11.26	15.53	0.19	12	10.94	15.08	0.18	4	9.32	12.12	0.12	1	8.30	10.60	0.10
J. W. Hurst #1	30	53	9.97	14.21	0.18	12	9.69	13.87	0.18								
Grace Adams #2	32	53	13.43	18.85	0.26	19	12.67	17.38	0.22	2	9.85	13.65	0.18				
George Breeden #1	35	38	15.39	16.46	0.36	7	15.39	16.54	0.38	7	14.10	15.13	0.34				
Catoctin Church	35	55	11.93	15.25	0.17	14	11.26	14.31	0.15								
R. R. Wall #1	35	57	10.50	15.00	0.20	11	10.58	14.54	0.18	11	8.44	11.87	0.16	4	7.38	9.65	0.10
R. R. Wall #2	35	57	11.38	15.96	0.21	9	10.99	15.38	0.20	14	9.68	13.11	0.16	7	7.69	9.30	0.07
Huntington Harris	37	61	13.12	17.06	0.16	12	12.86	16.46	0.15	10	9.97	12.76	0.12	4	7.82	10.45	0.11
George Breeden #2	38	46	12.74	14.29	0.19	5	13.88	15.50	0.20	6	11.33	12.73	0.18				
Edgehill Farm	39	60	12.60	17.60	0.24	20	10.80	15.11	0.21	7	10.21	13.91	0.18	2	7.05	8.20	0.05
Sanford	40	63	9.58	13.03	0.15	4	11.40	14.02	0.11	8	8.34	11.32	0.13	6	7.08	9.65	0.11
Dofflemyer #1	40	64	11.86	14.95	0.13	19	11.31	14.11	0.12	5	9.04	10.72	0.07	4	7.22	9.08	0.08
J. E. Carr	48	71	15.24	17.62	0.10	4	15.40	18.05	0.12	20	12.84	14.94	0.09	2	11.15	11.65	0.02
Jimmie Howie	48	67	15.84	19.62	0.20	18	15.19	17.93	0.14	6	14.08	16.80	0.14				
Hostetter	53	74	17.10	22.27	0.25	15	15.83	20.41	0.22	14	13.43	17.39	0.19	1	11.00	14.30	0.16
Gale Richmond	56	79	16.91	20.20	0.14	8	16.02	19.32	0.14	13	13.52	16.75	0.14	3	9.40	13.27	0.17
Hartman	60	81	17.40	21.99	0.22	25	15.40	19.19	0.18								
W. W. Everett	65	78	17.33	19.40	0.16	15	16.30	18.10	0.14	9	11.63	12.76	0.09	6	9.92	10.38	0.04
Harmon	69	83	23.37	25.44	0.15	23	21.39	22.97	0.11								