Some Elementary Notes on Stem Analyses of White Oak.

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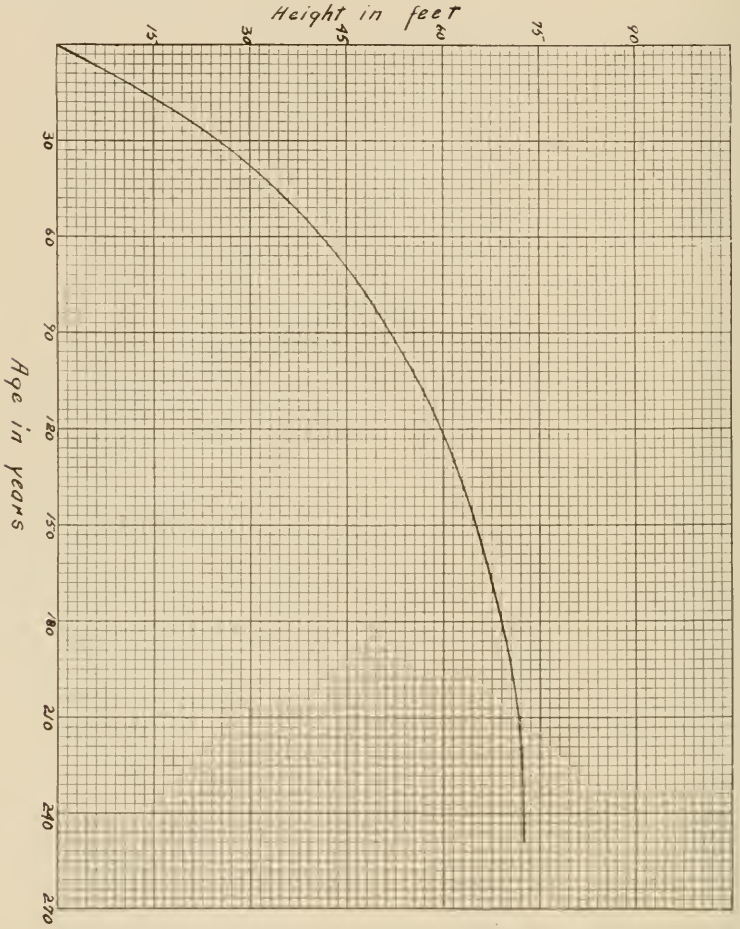
In the fall of 1915 I had the opportunity to gather some facts concerning the growth of White Oak (Quercus alba). The opportunity was in the form of a small logging operation which took place in a woodlot of mature White Oak belonging to Mr. George Justice, in Tippecanoe county, Indiana, about seven miles north of Lafayette. The woodlot is located on rolling to flat land only a short distance from the Wabash river. The soil is typical of that region, being a sandy loam underlain with gravel. The cutting was not a large one, only covering about thirty trees, but the majority of the trees were old and fully mature, so that a good idea of the life history and growth of White Oak on similar situations in Indiana could be gained by a study of their stems.

Complete stem analyses of the trees were taken. These included the following measurements on each bole; the diameter at the stump, together with the distance from the center to each tenth ring, counting from the outside in, and similar measurements at each of the other crosscuts on the tree, thus getting the diameter of each section at any decade throughout the life of the tree. The diameter at breast height, i.e., four and one-half feet from the ground, was taken in each case. The following height measurements were also included; height of stump, length of each section above the stump, length of tip above the last section, and the length and width of crown. Careful record was kept of the number of rings in decades at each section since by these are determined the various periods of growth.

From this data was worked out the mean annual volume growth of the average tree of the stand for the entire period of its life. The method outlined by Mlodjianski, as modified by Graves, was followed. This requires the construction of a height growth table showing the average time required for the trees to grow from the ground to the various crosscuts. The accompanying curve drawn from plotting height in feet against age in years shows how such a table was obtained. This height table is given as a part of table three.

The next step is the determination of the average stump height. By averaging the heights of the stumps of the entire plot, this height was determined as one and one-half feet.



Curve based on age and total height of White Oak (Quercus alba), showing time required to grow to any specified height. Based on measurement of thirty trees.

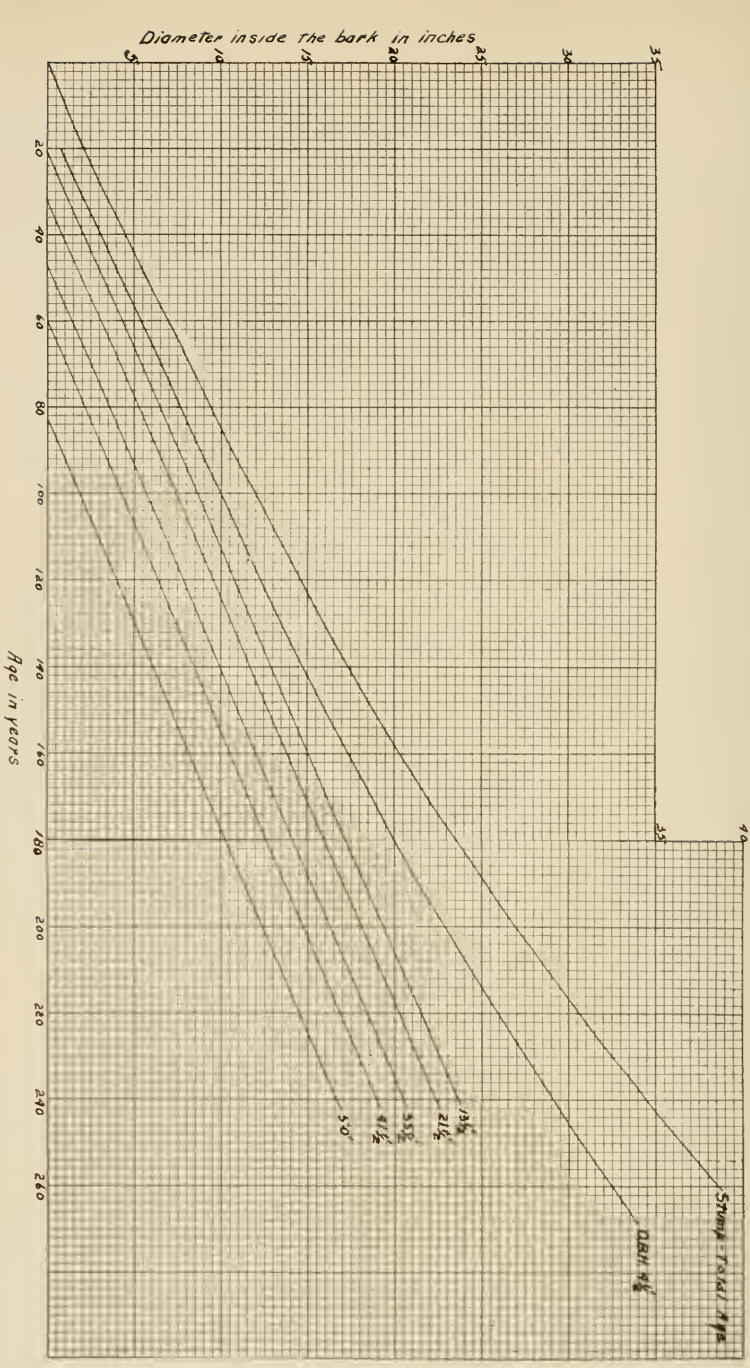
A curve based on diameter and age at the stump was then drawn, to show the average diameter growth at the stump for each decade. This curve smoothed out any irregularities in growth at the stump for the entire number

of trees measured. A similar curve was drawn for each of the other crosscuts above the stump. It has already been noted that the average stump height was one and one-half feet. Therefore the curve for the top of the first twelve-foot log represents the diameter growth at a point thirteen and one-half feet above the ground. The same is, of course, true for the other curves as well.

These curves were then all transferred to one sheet in such a manner that the growth at the respective crosscuts was shown on the basis of total age, i.e., each curve begins as many years to the right of the intersection of the two axes as it took the tree to grow to the height of the crosscut in question. These points are determined from the height growth table.

These curves represent the diameter growth at their respective distances above the ground, on the basis of total age (age at the ground), and not on the basis of the age at the respective crosscuts. We are able to get from this series of curves, for any age, the average total height and the dimensions of the trees inside the bark at various points along the bole.

A diameter breast height curve was also constructed in the following manner. On the same sheet with the stump curve a second curve was drawn, letting the ordinate represent diameter breast height values instead of diameter inside the bark at the stump. Since there were but a small number of trees, all of uniformly large diameter, it was impossible, as yet, to continue this curve into the early age of the trees. But when the curves for the other points on the bole were also transferred thus to a single sheet, the diameter breast height height curve was prolonged by a process of interpolation to the younger ages of the trees.



Series of curves based on age at the ground and diameters at various cross cuts, showing time required for the tree to grow from the ground to any specified diameter at various points up the bole. Based on the measurement of thirty White Oak trees.

From this series of curves Table No. 1 was taken. The cubic contents (Table 2) of the average tree at ten year periods throughout its life, was computed according to the Schiffel formula, which is (.16B + .66b)h = V, in which B represents the area of cross section at breast height, b represents the area of cross section at mid-height, h represents the total height of the tree, and V represents the volume.

TABLE I.—Diameters at various points along the bole for every decade throughout the life of the tree; white oak.

Height of Section Above Ground, in Feet.	Age in Years.												
	10	20	30	40	50	60	70	80	90	100	110	120	130
	Diameter inside the bark, in inches.												
(Stump) 1½	1.0	2.2	3.3	4.5	5.8	6.9	8.2	9.5	10.7	12.0	13.2	14.5	15.9
D.B.H. 4½	....	1.0	2.0	3.2	4.3	5.4	6.5	7.5	8.6	9.8	10.9	12.2	13.4
13½	....	....	1.0	2.2	3.4	4.3	5.3	6.5	7.5	8.6	9.8	10.7	11.8
21½	....	....	....	.9	2.0	3.0	4.2	5.3	6.3	7.4	8.5	9.6	10.6
35½	....	....	....	....	.4	1.4	2.5	3.4	4.6	5.7	6.7	7.8	8.9
41½	....	....	....	....	....	....	1.1	2.2	3.3	4.3	5.3	6.4	7.5
50	....	....	....	....	....	....	....	....	....	1.8	2.8	3.9	5.0

TABLE I—Continued.

Height of Section Above Ground, in Feet.	Age in Years.										
	140	150	160	170	180	190	200	210	220	230	240
	Diameter inside the bark, in inches.										
(Stump) 1½	17.4	18.8	20.3	22.0	23.8	25.4	27.2	29.0	30.7	32.7	35.0
D.B.H. 4½	14.6	16.0	17.4	18.7	20.2	21.5	23.0	24.5	26.0	27.6	29.3
13½	13.0	14.0	15.2	16.3	17.4	18.4	19.4	20.5	21.5	22.6	23.6
21½	11.7	12.8	13.9	15.0	16.0	17.1	18.2	19.3	20.3	21.4	22.6
35½	10.0	11.0	12.2	13.2	14.2	15.3	16.3	17.4	18.4	19.5	20.5
41½	8.5	9.6	10.6	11.6	12.7	13.7	14.8	15.8	16.9	17.9	19.0
50	6.0	7.2	8.3	9.3	10.3	11.4	12.4	13.4	14.5	15.6	16.6

TABLE II.—Total height and *cubic volume of white oak for each decade of the life of the tree.

Age, Years.	Height, Feet.	Volume, Cu. Ft.	Age, Years.	Height, Feet.	Volume, Cu. Ft.
10	10.0	.003	130	61.6	29.691
20	18.2	.054	140	63.2	36.846
30	25.5	.178	150	65.0	45.330
40	31.8	.668	160	66.5	54.397
50	37.4	1.159	170	67.9	63.962
60	41.8	2.590	180	69.0	75.348
70	45.6	4.332	190	70.0	87.220
80	49.2	6.494	200	71.0	100.678
90	52.1	9.482	210	71.8	115.885
100	54.8	13.481	220	72.4	128.076
110	57.2	20.821	230	72.8	146.037
120	59.4	23.522	240	73.0	156.658

*Volumes computed according to Schiffel: V = (.16B .66b)h, where,
V = Volume.
B = Basal area of cross section at breast height.
b = Area of cross section at middle height.
h = Total height of tree.

TABLE III.—Volume in board feet of Merchantable stem for even decades.

Age, Years.	Volume, B. M.	Age, Years.	Volume, B. M.	Age, Years.	Volume, B. M.
70	10	130	170	190	535
80	15	140	225	200	630
90	40	150	275	210	725
100	65	160	335	220	830
110	100	170	405	230	955
120	140	180	460	240	1,095

It must be remembered that these figures are based on trees growing under an entire absence of management. Proper management should easily materially increase the rate of growth shown here. Even among these trees there were many that were above the average rate here given. A curve drawn for the maximum growth in diameter at the stump showed the following comparison:

Age at Stump.	Average D. I. B.	Maximum D. I. B.	Age at Stump.	Average D. I. B.	Maximum D. I. B.
20	2.5	3.0	140	18.0	21.5
40	5.0	5.8	160	21.0	25.0
60	7.0	8.0	180	24.4	28.8
80	10.0	11.9	200	28.0	32.5
100	12.4	15.0	220	31.4	36.4
120	15.0	18.2	240	35.2	40.6

It will be noticed that there is a difference of approximately 20 per cent. in diameter for any given age, between the average maximum growth and the average growth. Allowing for a proportionate increase throughout the stem, this would give a maximum volume for table three as follows:

Age Years.	Volume B. M. (Maximum).	Age Years.	Volume B. M. (Maximum).	Age Years.	Volume B. M. (Maximum).
70	12	130	205	190	642
80	18	140	270	200	756
90	48	150	330	210	870
100	78	160	402	220	996
110	120	170	486	230	1,146
120	168	180	552	240	1,314

This 20 per cent. increase could hardly be regarded as reliable, however, when applied to later life of the tree. Artificial plantations both at home and abroad show that it is not at all out of proportion with what may be expected during the early life of well managed plantations.

A study of the crowns of this plot showed the average width of crown to be forty feet. This would allow in a fully stocked stand, about forty mature trees to the acre. During the extremely early years of the stand, an acre would bear upwards of one thousand trees. *Mr. Earl Frothingham, Forest Assistant in the Forest Service, shows that from observed plots an acre is able to support seven hundred and twenty-four oak trees to the age of forty-

*Second Growth Hardwoods in Connecticut. Bulletin 96, U. S. Forest Service by Earl H. Frothingham, Forest Assistant.

five. Our analyses show that the trees in the present study did not attain a diameter breast height of six inches until they were seventy years of age. If we allow approximately one-half of the seven hundred and twenty-four, or three hundred and fifty, to remain at the age of seventy, and reduce this number by a series of intermediate acceleration thinnings, to the final forty at the age of one hundred and fifty, we get the following result:

Number Trees Per Acre.	Age, Years.	Number Feet B. M.	Number Trees Per Acre.	Age, Years.	Number Feet B. M.
	70	3,500		*Thinning.*	
350	80	5,250		160	13,400
	90	14,000		170	16,200
				180	18,400
	Thinning.			190	21,400
	100	11,375	40	200	25,200
175	110	17,500		210	29,000
	120	24,500		220	33,200
				230	38,200
	Thinning.			240	43,800
	130	14,450			
85	140	19,125			
	150	23,375			

While the problem of reforestation with oak is somewhat more difficult than that connected with coniferous plantations, nevertheless these figures look interesting, to say the least. It is true that there is little material that is actually merchantable that can be looked for under one hundred years. There are many poor plots of land, however, on nearly every farm in Indiana which at present detract from the value of the whole property. If these plots were planted with even so slow growing a tree as the white oak the result would be an increase in the value of the entire property many years before the trees themselves actually attained merchantable size.