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CROWN DEVELOPMENT AND BASAL AREA GROWTH OF RED OAK AND WHITE ASH

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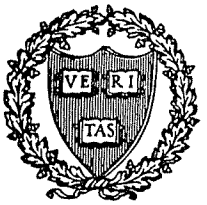

HARVARD FOREST
PETERSHAM, MASSACHUSETTS

CROWN DEVELOPMENT AND BASAL AREA GROWTH OF RED OAK AND WHITE ASH

IN MANY silvicultural operations, such as crown thinning and reproduction cuttings done according to the selection method, the question often arises, how much space is to be allotted the individual tree in order for it to maintain a profitable growth rate. In other words, the crown size is considered in relation to its production of satisfactory diameter growth.

Several research workers have found that the relationship between crown dimensions and linear increment in diameter is not very satisfactory. It was hoped that a better relationship could be obtained between the different crown dimensions and the tree volume by substituting the diameter increment for the basal area growth.

The purpose of this study is to determine for red oak and white ash in New England the relationship between the crown dimensions and the growth in the basal area.

Earlier Studies

As long as crown thinning has been practiced, considerations have been given to the development of the individual tree. It is generally assumed that a tree with a large crown has a faster diameter growth than a tree of the same species with a smaller crown. Several authors have tried to determine the relationship between crown dimensions and diameter growth. Heck [3] found that "in the present stage of our forestry knowledge, it is not possible to obtain a dependable correlation between the diameter of the crown and the width of the annual rings."

Busse [2] stated that his graphs "show that tree crown and diameter growth are related only a little to each other." By plotting diameter increment over length, diameter, and surface of the crown for a large number of trees, he found only slight correlation. He contended that "good crowns by no means signify good diameter growth." Busse, however, found a good correlation between dry weight of needles of spruce and yearly stem volume increment.

Macon [6] found that no physical dimension or characteristic can be employed to express quantitative diameter growth. He stated that a combination of crown and site characteristics, however, can be used to estimate, within practical limits, the diameter growth rate of white pine.

Any study in which the relationship is investigated between crown development and diameter growth will always meet difficulties when it comes to measuring the crown dimensions. Trees grown in forest stands will usually have crowns in which the lower branches show asymmetrical development. In other words, the lower limit of the crown is not well defined. Furthermore, Stålfelt [9] showed that in stands of Norway spruce, where the light intensity has been changed through thinnings or natural elimination of other trees, the lower branches adjust themselves differently according to their previous exposure. It has also been pointed out by Løvengreen [5] that in deep-crowned Norway spruce the diameter growth of the lower branches is extremely small. He judges that these branches do not add to the total volume of the tree. Bavngaard [1] advanced the theory that the branches in a shaded position may even act negatively as far as the diameter growth of the tree is concerned, or work as parasites during the years prior to the time when they die from lack of light. Ladefoged [4] stated "that if the tree received plenty of water and minerals, it must be assumed that the suppressed branches add to the growth. Their importance will, however, be very slight. If the supply of water and minerals during certain times is limited, it must be expected that the suppressed branches will retard the growth of the tree, because the amount of water and minerals these branches use could be used to better advantage by more economically working branches."

Methods of Collecting Data

The measurements on which this study is based were taken on 128 crop trees of red oak (*Quercus borealis* var. *maxima*) ranging in d.b.h. from 3.0 to 22.5 inches, and 101 white ash (*Fraxinus americana*) with diameter from 3.0 to 18.5 inches in even-aged, second-growth, hardwood stands in the transition region between northern hardwood types and oak types in New England. The sample trees had considerable variation in crown development. The crown percentages of the red oak ranged from 26.0 to 74.2, while those of the white ash ranged from 33.3 to 78.2. All the trees were growing on about the same site. Each of the sample trees was measured for total height, crown length, crown diameter, d.b.h., and growth on the d.b.h. during the last 10 years. The first two measurements were taken with an Abney level. The crown length was measured from the top of the tree down to where the crown diameter was largest. In that way the heavily shaded lower branches were disregarded, as these may have a lower productivity than the rest of the crown and therefore have a disturbing influence on the relationship between crown development and diameter growth. The crown diameter was determined as the average of two diameters measured with a tape at right angles to each other on the horizontal projection of the crown.

Analyses of Data

The first analyses were made following the method used by Heck [3], Busse [2], and Macon [6], namely, by plotting diameter growth over crown diameter and over crown length. For red oak no valid correlation indices were obtained; while for white ash a correlation index of .482 was found for the relationship between crown length and diameter growth, and .488 for crown diameter and diameter growth. These results are no more satisfactory than the ratios obtained by the above-mentioned authors. The reason for this is that the same width of annual ring represents more volume on a tree of large diameter than on a tree of small diameter.

It was realized that a better relationship might be found between crown dimensions and volume growth.

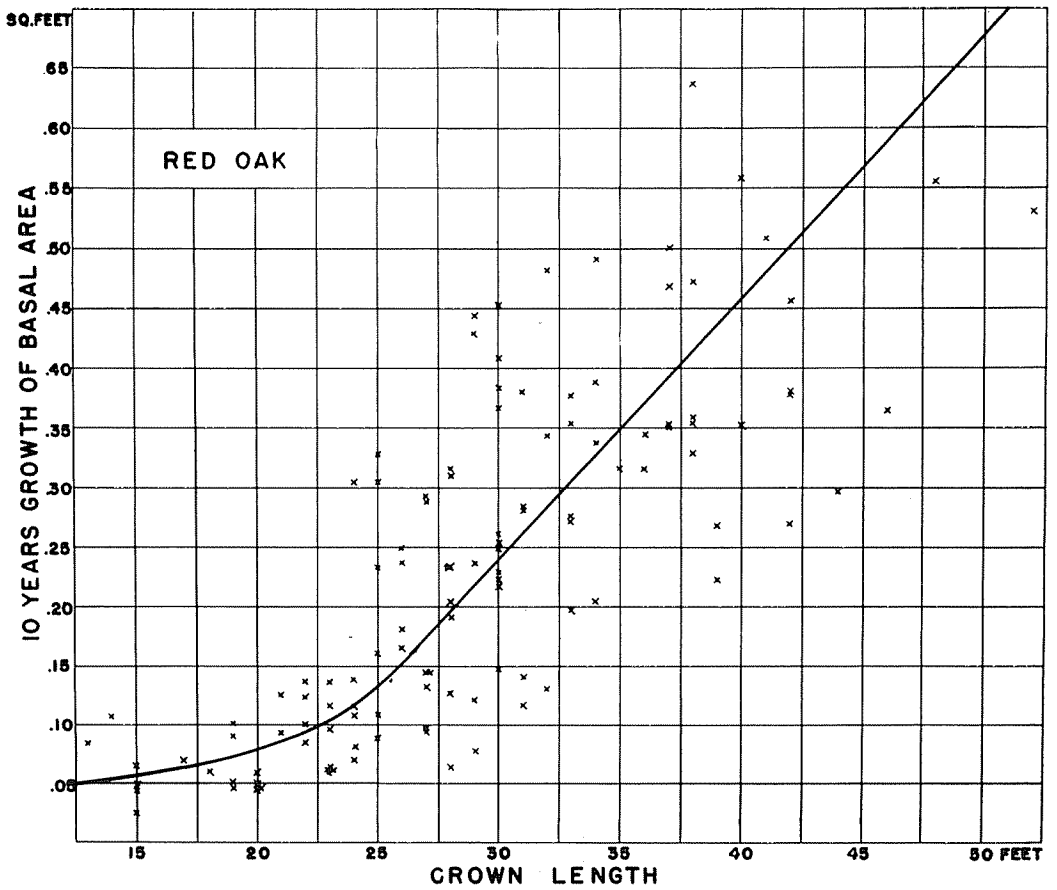

FIGURE 1a. Relationship between 10 years growth of basal areas and crown length for red oak.

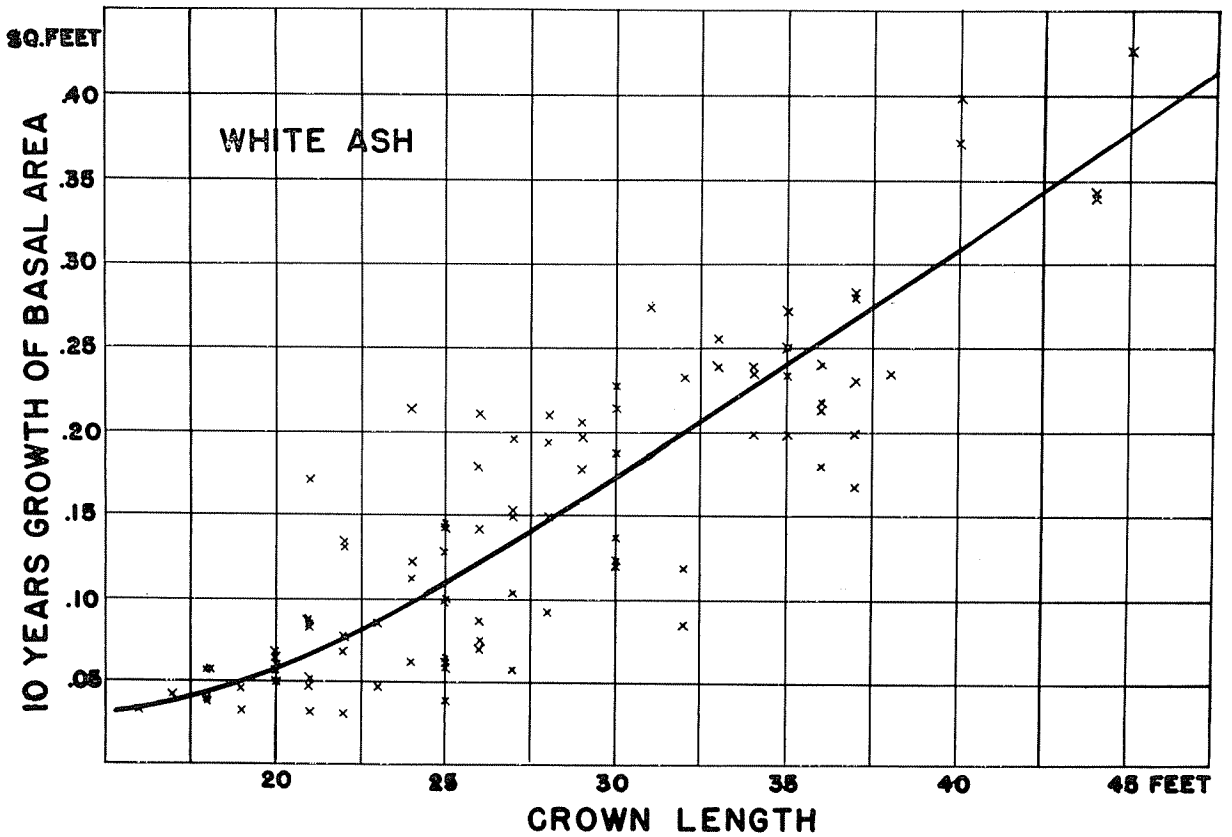

FIGURE 1b. Relationship between 10 years growth of basal area and crown length for white ash.

However, since volume growth is difficult to measure, basal area growth was adopted as the next best measure. Figures 1a and 1b show the relationship between basal area growth during the last 10 years, expressed in square feet, and crown length for red oak and white ash. The correlation indices for these two curves are .740 and .850 respectively. The red oak curve shows a considerably steeper rise than the white ash curve, which means that, for the same crown length, red oak has a greater basal area growth than white ash.

Figures 2a and 2b show the relationship between basal area growth during the last 10 years and crown diameter of red oak and white ash. The correlation indices for these relationships are .927 and .867 respectively. Crown diameter is a better indicator of basal area growth than crown length, as will be seen by comparing the correlation indices for the two sets of curves. Figures 2a and 2b show that, with the same crown diameter, white ash has a slightly greater basal area growth than red oak. This means that, with the same basal area growth, white ash has a longer but slightly narrower crown than red oak. This finding corroborates the statement by Patton [8] that "red oak is space demanding, while white ash is crowd enduring." However, if white ash is given the proper space for crown development, so that a large crown diameter can be developed while a deep crown is maintained, it will readily respond and produce as much or more basal area growth than red oak. The general conception that forest-grown white ash is a relatively slow growing tree is due only to the fact that this species seldom is given opportunity to develop its crown properly.

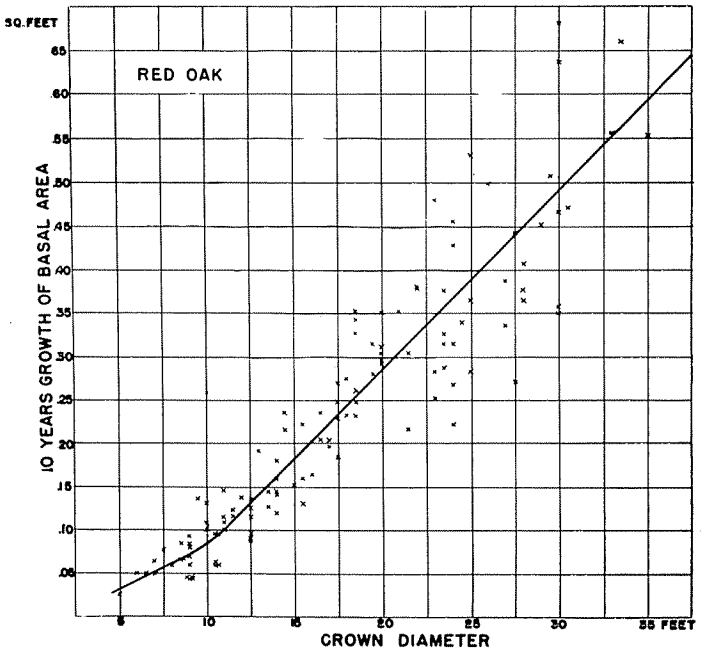

FIGURE 2a. Relationship between 10 years growth of basal area and crown diameter for red oak.

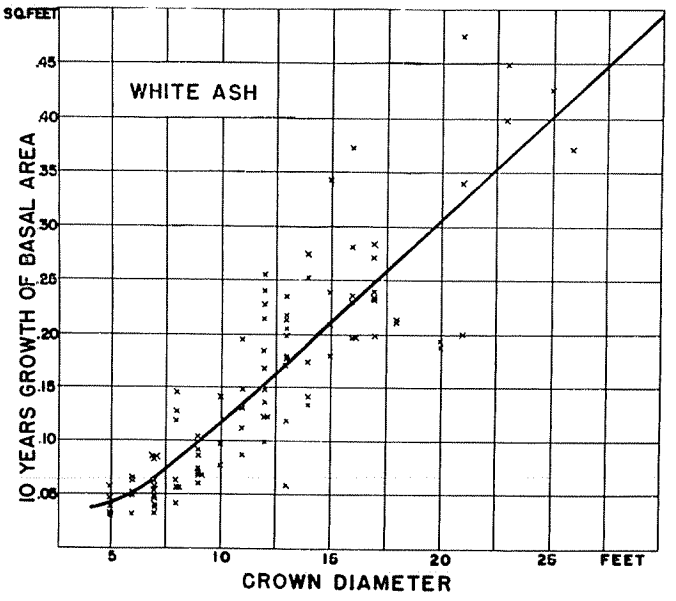

FIGURE 2b. Relationship between 10 years growth of basal area and crown diameter for white ash.

In order to find a better relationship between crown dimensions and basal area growth, crown surface was used. The crown surface of the sample trees was determined as a paraboloid. The formula for the surface of this body was determined as

$$A = \frac{\pi r}{6h^2}\left[(4h^2 + r^2)^{3/2} - r^3\right]$$

where r is equal to half crown diameter and h is equal to crown length.

Figures 3a and 3b show the relationship for red oak and white ash between basal area growth during the last 10 years and crown surface expressed in square feet. The correlation indices are .962 and .899 respectively. It will be seen that this relationship both for red oak and white ash is closer both to the relationship between basal area growth and crown length and to that of basal area and crown diameter. This agrees with the investigations of Heck [3] and Møller [7], who have shown that the growth of a tree is largely dependent upon the area of leaf surface. Certain discrepancies will enter into the relationship between crown surface and basal area growth, as the thickness of the layer of leaves varies in different parts of the crown. In the upper part of the crown the shell of leaves is thicker and consists of many layers, while in the lower part of the crown the shell is very thin. It can therefore be expected that the correlation between crown surface and basal area growth will not be as close as it might have been if the weight of the leaves had been used instead of the crown surface. However, crown surface gives a rather satisfactory relationship with basal area growth.

From Figures 3a and 3b it will be seen that for red oak and white ash trees with the same crown surface, the basal area growth is about the same. If white ash is

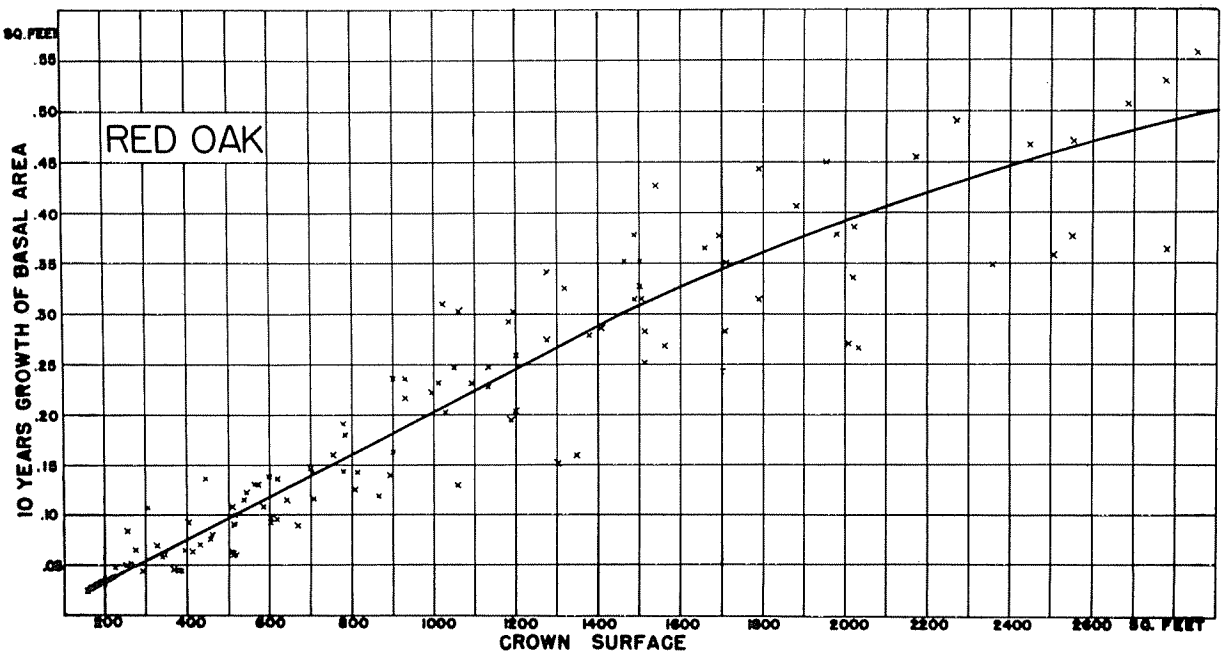

FIGURE 3a. Relationship between 10 years growth of basal area and crown surface for red oak.

given proper space through thinnings, therefore, it should be able to produce as fast growth as red oak.

Figures 4a and 4b show the relationship between crown length and crown diameter for red oak and white ash. The correlation indices for the relationship of the two species are .754 and .764 respectively. They show that these species have definite crown forms which, however, react differently as the trees grow larger. The curve for red oak shows that as the trees grow larger, the crown diameter becomes greater in proportion to the crown length; while the white ash maintains the same ratio between crown diameter and crown length throughout its development. This again bears out Patton's [8] statement that red oak will expand its crown, crowding out less "tolerant" trees, while white ash, being "intolerant," will be kept in check by more tolerant neighbors.

As a practical application of this study, Figures 5a and 5b have been constructed. These figures show for red oak and white ash the last 10 years' growth in d.b.h. for trees of different diameters and d.b.h. After the

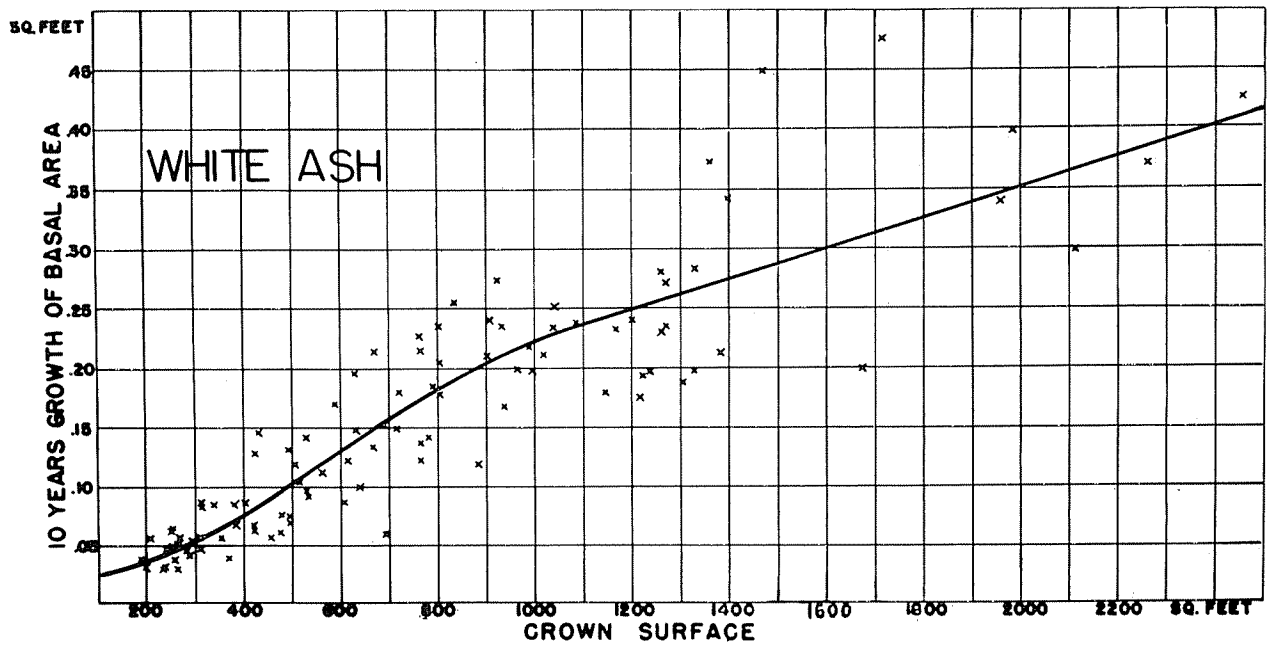

FIGURE 3b. Relationship between 10 years growth of basal area and crown surface for white ash.

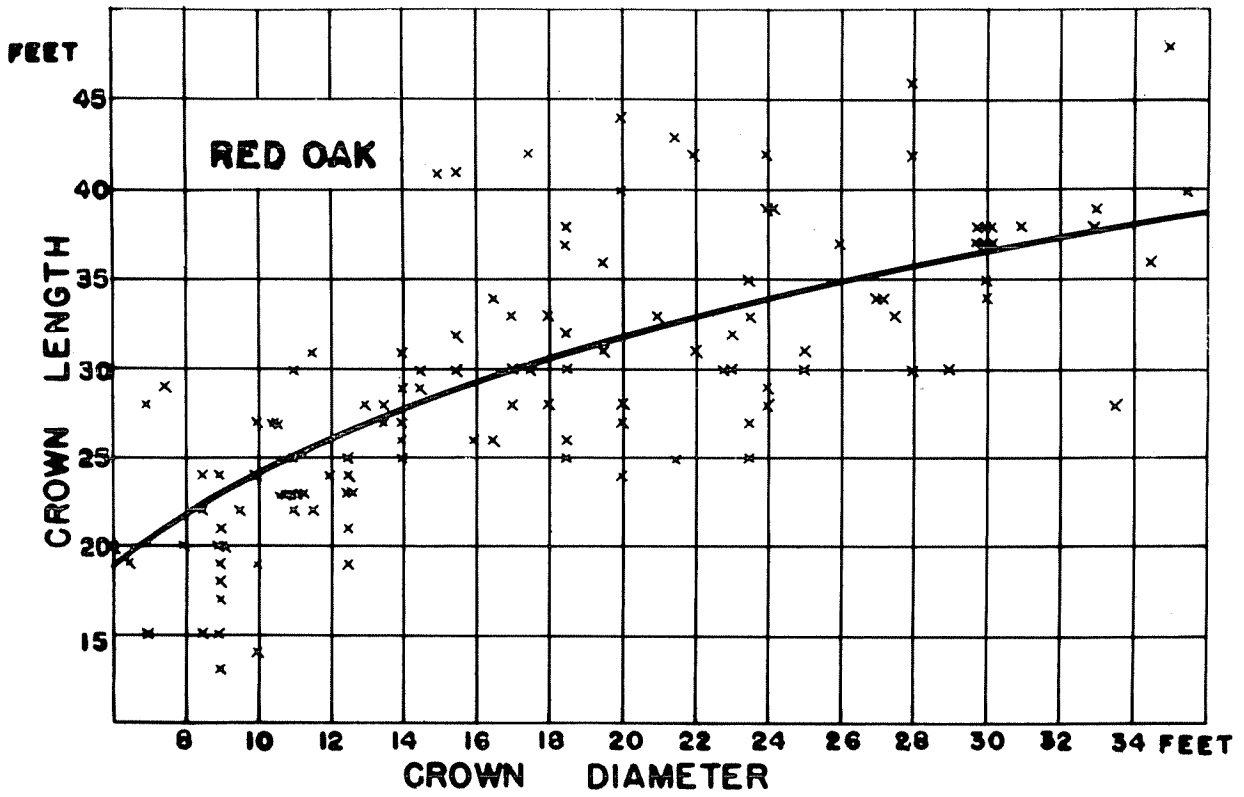

FIGURE 4a. Relationship between crown length and crown diameter for red oak.

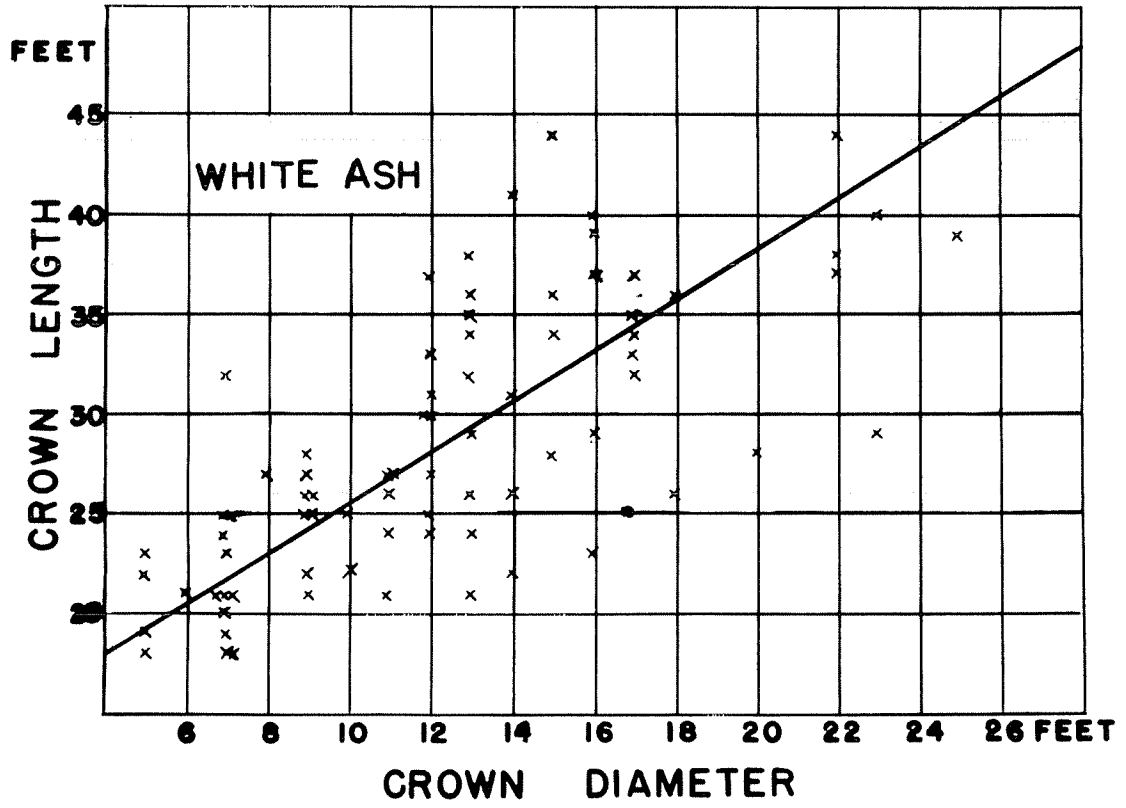

FIGURE 4b. Relationship between crown length and crown diameter for white ash.

crown diameter of the tree has been estimated, a line is drawn vertically from this point on the abscissa axis until it reaches the line which corresponds to the d.b.h. of the tree. A horizontal line is drawn to the left, and the growth is read from the ordinate axis. The curves are applicable for the transition zone between the northern hardwood types and the oak types in New England. For other sections, correction factors can be made. For the forester who marks a forest stand for crown thinning, it is of value to be able to know from the crown size of the individual tree how fast it is growing without using an increment borer in each case. After having used these curves for some time, the forester will be more crown conscious, and will be able better to determine when a tree has reached maturity and is not producing enough growth.

Summary

Instead of using linear diameter growth, it has been found that for red oak and white ash in New England a highly significant relationship exists between basal area growth during the last 10 years and various crown dimensions. Crown length, crown diameter, and crown surface all give very satisfactory results. This knowledge is used to construct charts which can be used in the field with crown diameter and d.b.h. as entries from which the last 10 years d.b.h. growth can be found.

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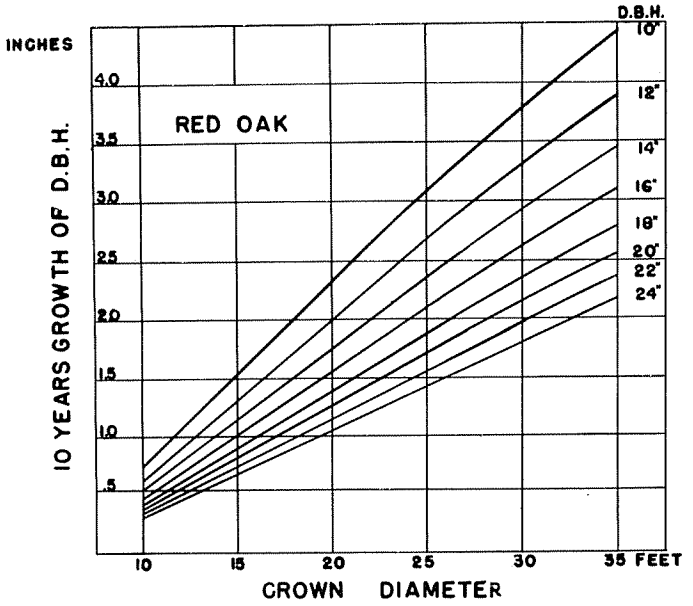

FIGURE 5a. Chart showing 10 years d.b.h. growth for different crown diameters and d.b.h. for red oak.

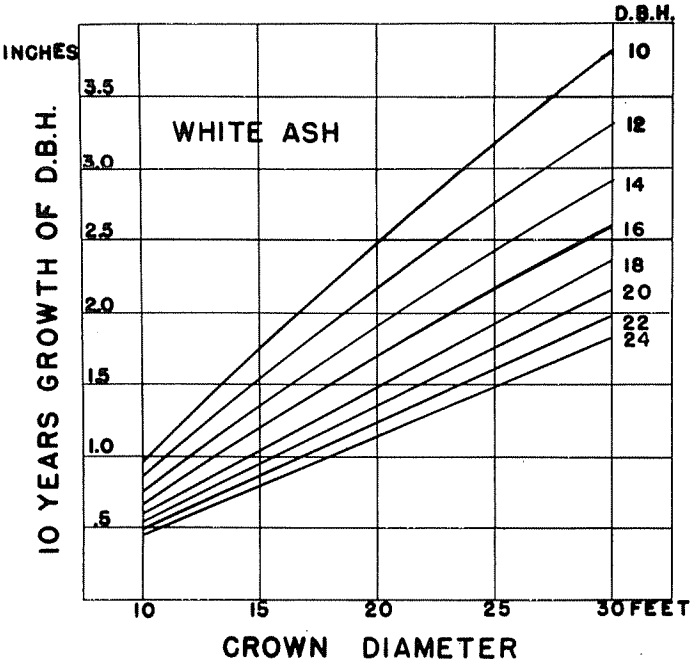

FIGURE 5b. Chart showing 10 years d.b.h. growth for different crown diameters and d.b.h. for white ash.