TREES AND THEIR TYPICAL AGES AND GROWTH RATES [1]

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INTRODUCTION

Our attention is captured by the unusual, the biggest, and the oldest of anything -- particularly trees. These are the individuals we photograph and write about. Thus, people including foresters are given to believe that trees live forever or at least a thousand years or more. Bristlecone pine and California redwoods do live for thousands of years but the life span of typical trees is much shorter. Several years ago, I was disappointed to note that fewer than three of the trees planted by Thomas Jefferson on the University of Virginia Campus and fewer than 10 of the trees he planted at Montecello are still alive and that there were no old trees (other than mullberries) at Williamsburg, Virginia.

How long do trees typically live and how rapidly do they grow? The following is a summary of data that may answer these questions.

DATA FROM FORESTS

Foresters tabulate the numbers of trees, their ages, and sizes for typical stands of many species. A review of these yield table data shows that Darwin's laws of geometric ratio of the increase and survival of the fittest hold. Competition in the young forest stand is intense with tens of thousands of seedlings per acre struggling to survive and dominate the main canopy. A typical hardwood forest will contain 25,000 or more stems per acre at year l; 10,000 stems per acre at year 5; 1,500 stems per acre at year 20 and fewer than 200 stems per acre at year 100. Thus, less than one tree per hundred will live a hundred years. Visits to virgin forests like those in the Olympic National Park in Washington reveal a similar pattern of mortality. Only the rarest trees in the park may be 1900 years old. The typical maximum age of trees in this virgin forest is between 200 and 600 years old and these trees are confined to narrow bands along the streams., Most of the dominant trees of this forest are less than 250 years old and are, as with typical forests, the product of a self-thinning process that elim-

[1] Metro. Tree Impr. Alliance (METRIA) Proc. 1:l - l2,l978.

inated the vast majority of trees before they were 20 years old,

The situation is no different in the Joyce Kilmer Memorial Forest in the Southern Applachians. The big trees there are confined to a few sheltered coves that occupy fewer than 100 of the 3,000 acres in the forest. New trees die there every year and there is more dead wood on the ground than in the main canopy. The highest number of growth rings I have ever counted among the many trees that have fallen across the trails is 320. The size an age of the trees decreases rapidly as one leaves the moist streams and sheltered coves and goes upslope to where fires and wind play an active role in addition to the normal processes of competition. The oldest trees on the ridgetops are much twisted and penetrated by rots that developed after historic fires. The average maximum age of trees on the ridge tops is between 100 and 220 years. Again the typical tree in this virgin forest dies before it has lived 20 years.

Rates of growth are highly variable in a crowded forest, and size bears little relationship to age. Trees growing without corn etition commonly attain diameters of 30 inches (76.2 cm.P) or more by age 50 years while the same trees would attain diameters of only 3 inches (7.62 cm.) when growing in a crowded forest. Rates of growth vary radically with the depth of the soil and availability of moisture and oxygen for a given site. The size a tree achieves at a given age is made even more unpredictable when these environmental variables are combined with the variable effects of crowding. Knowledge of the tremendous variation involved makes foresters fall into embarassed silence when'challenged with the question "how old is that tree?"

DATA FROM SINGLE TREES

Competition, fires, wind, insects, rot,and other agents, but particularly competition of other trees combine to make life harsh and short for most trees of the forest. Is the life expectancy of a tree in a park,protected by man, and free of competition any longer?

Some people chase after fire engines and ambulances. I chase after loggers and tree specialists, rights-of-way clearers and construction firms to measure the stumps and count their growth rings. When possible, I like to arrive ahead of time and measure and record the condition of the trees before they are felled. Years of semilegible notes in sweaty pocket diaries reveal that undisturbed trees grown in the open areas of farm yards, house lots, parks, or cemeteries achieve an average maximum age between 40 to 70 years before they succumb to some rot, insect, disease, ice storm, wrenching wind or lightning bolt. When spacing between trees is between 25 and 30 feet or more diameter growth is usually 3/4 in. to 1 in. (2 to 3 cm.) or more per year for the first thirty years. Yard trees often attain diameters greater than 20 inches before they are thirty years old. Heights to the lowest limb of such trees are usually 12 to 20 ft. (3.66 to 6.10 meters) or less, and the total heights achieved by such trees are commonly between 50 to 70 ft. (15.24 to 21.34 meters). Such spreading "old homesite" trees are the "wolf" trees of most of our eastern forests and reflect a land use history of agriculture and land abandonment.

The rapid diameter growth of these early years continues as long as competition from surrounding trees is kept to a minimun and as long as construction workers and other diggers and burriers of tree roots are restrained. After the 20th to 30th year, diameter growth slows gradually but trees 70 to 80 years of age still commonly maintain annual diameter increments of 3/8 in.(8mm) or more per year. A typical ard tree 40 to 70 years of age will have a diameter of 3 to 4 ft. (0.914 to 1.22 meters). Rapid growth rates and large tree sizes are not just confined to trees in southern latitudes or mild climates. The larger trees in the cemeteries of Maine and in the Royal Botanic Gardens of Edinburgh, Scotland are over 45 inches in diameter and 90 to 115 feet (114.3 cm. DBH and 27.4 to 35.0 m. height) tall even though they are less than 75 years old.

I have done my stump-sitting and ring-counting act from southern Florida to Northern Maine, from Los Angeles to the Olympic Penninsula of Washington, and from London to Inverness, Scotland. The results are amazingly homogenous. Wherever there is sufficient space for root growth, and water is in reasonable supply, and competition between trees is kept to a minimum, and man is reasonably restrained, the average maximum age of tree stumps is less than 70 years and the average diameter is between 3 and 4 ft. (0.914 to 1.22 meters). In urban situations, the vast majority of the stumps I examine posses fewer than 30 growth rings. Indeed, the majority of trees I examine in the pun planting holes (4 x 4 ft. and less 1.22 x 1.22 meters) that line our city streets are less than 15 years old.

The key take-home lessons from several hundred stump-sitting and ring-counting episodes are:

1. The average maximum age of open grown tree in the U.S. and the British Isles is much less than 40 to 70 years of age. Most city and forest trees are less than 20 years of age.

When water, roots space, and other resources are in good supply, tree growth is extremely rapid so that trees thirty years of age often attain diameters of 20 or more inches (50.8 cm.).

3. Growth in diameter and size is much slower in crowded forests than it is in yards.

4. Trees that are large are common, trees or stands of trees older than 120 to 150 years are indeed uncommon.

DATA FROM LANDSCAPE PLANTINGS

Random measurements of single trees only yield data on the average maximum age of trees. More precise data on average ages of single trees can be obtained by measuring the diameters of trees in multiple-tree plantings of known age and relating the frequency distribution of tree diameters to the diameter vs. age relationship of the largest and oldest trees present. Usually, I have been fortunate in locating a fresh stump so that the use of increment borers has not been required to obtain a diameter vs.age relationship. Figures 1 through 5 represent the results of two such studies. The horsechestnut planting at the Queen's palace at Hampton Court was planned by Sir Christopher Wrenn in 1699. Multiple rows of trees were set out extending some 4 miles from the formal entrance to the Palace. The spacing between the trees is 44 feet or 120 trees per mile. These colonnades of trees served as "rides" where the Queen and her court could ride horseback and where grand parades and receptions could be organized. The average diameter of the stump represented in figure 1 was actually 61 in. including the buttress roots but the effective diameter to where the growth rings were indistorted was 50.5 inches. The diameter-at-breast-height curve was estimated from measurements of 20 trees at both stump height and breast height. When the effects of root buttresses were discounted there appeared to be very little taper for the larger horsechestnut trees and the diameter at breast height of the tree represented by the stump was estimated to be 49 inches. As indicated in figure 2, a total of 84 trees were measured and one half of the trees or 42 were less than 16.5 inches DBH. Reference to the diameter vs. age curve based on measurements of the stump indicates that the age of one-half of the trees in the 276-year-old planting conceived by Sir Christopher Wrenn was less than 26 years. If one assumes more optimistically that the half-life of a tree in this planting is 30 years and that mortality patterns are approximately described with a negative exponential function, one comes to the conclusion that the average tree in the Queen's ride has been replaced 9.5 times in the 276 years before my measurements were made in 1976. Further extension of these assumptions indicated that fewer than 0.1% of the trees in the original planting are still alive. Patient replanting by the Queen's gardener has yielded a long ride of trees which still maintains the solid visual impact intended by the architect. Only the deliberate observer who looks across the row is aware of the irregular size and survival of Her Majesty's horsechestnuts.

I have made similar observations of the rides planned by van Brugh for the Dutchess of Marlboro at Blenheim in 1719 and conclude that the elms in this planting had a half-life of less than 26 years before the depredations of the Dutch elm disease.

Sometimes it is possible to make estimates even when there are no stumps available and when use of increment borers would result in jail sentences. The 1920 planting of elm trees in front of the Lincoln Memorial in Washington, D. C. extended along the mall to the Capitol. A frequency distribution of diameters indicated that a maximum of 30% fo the original trees were still alive in 1975. Again calculations based on an assumed negative exponential mortality pattern indicate that the average half-life of a tree in this planting is not more than 31 years.

Some trees are shorter-lived than others. The Japanese cherry trees in the planting that surrounds the Jefferson Memorial area and extends out Haines Point in Washington, D. C. are an example. Mr. Roland Jefferson of the National Arboretum kindly made a beautifully polished cross section from one of the Japanese cherry trees killed by hurricane Agnes in 1973. The first of the trees included in this beautiful planting were set out in 1912. A few of the original trees are still alive and present a picturesque array of twists, warbles, hollows, and rots. Even the newer replacement trees in this famous planting seem to be prone to one sort of plague or another. The ring counts and diameter measurements from the sample tree are summarized in figure 4, and a cumulative frequency distribution for 70 trees in the vicinity of the original planting site (figures) indicated that the average diameter of one-half of the trees was less than 5.2 inches (13 cm.). The data indicate that the average cherry tree in the vicinity of the Jefferson Memorial lives only 16,j years.

The American landscape architect Olmsted planted many rides of trees. Many of the plantings like the one at

Franklin Park in Boston involved eln trees which have succumbed to the Dutch Elm Disease. An exception is the Mall planting in Central Park which was sprayed regularly until 1975. The half-life of this planting has been 35 ± 5 years. One of the more successful rides planned by Olmsted was for Cornelius Vanderbilt in 1897 on the Biltmore Estate near Asheville, N. C. Yellow poplar, (Lirodendron tulipifera L.) was the species selected and the trees have been provided with excellent care and growing space. After 89 years, only 16 of the original 52 trees in the planting have died and the calculated half-life of the planting is a remarkable 152 years.

Such longevity is an exception among the many rides and plantations that I have measured and it is more realistic to conclude that the half-life of a typical landscape planting is less than 30 years when conditions are favorable and less than 15 to 20 years along city streets. The intended design life of many buildings is 50 years or more. Architects will need more data like these for various species if the landscape plantings are to continue to enhance the beauty and comfort of our structures after beyond the first 20 to 30 years. A regular program of replacement should be planned; particularly in locations where the space for roots is small or where soil compaction from pedestrians and salt from roads and other insults will further shorten the normally short life of a tree.

CAPTIONS FOR ILLUSTRATIONS

Figure 1. Diameter vs. age relationship for a 184-year-old horsechestnut inThe landscape planting at the Hampton Court Palace near London. This planting was conceived by Sir Christopher Wrenn and established in 1699. The trees in this famous planting have died and been replaced several times. Reference to Figure 2 indicates that one-half of the trees in this planting are less than 16.5 inches (41.9 cm.) DBH and estimations using the above graph indicate that one-half of the trees in this planting are replacedevery 26 years.

Figure 2. Cumulative number of trees vs. diameter for a sample population of 84 horsechestnut trees in the planting at the Royal Palace at Hampton Court. One-half of the trees in this planting are less than 16.5 inches 41.9 cm,). See Firgure 1.

Figure 3 Hypothetical percent survival vs. time for the horsechestnut planting at Hampton Court. See Figures land 2. Assumed is a negative decay function in which one-half of the population dies every 30 years. The assumed 30-year half-life is more optimistic than the 26-year half-life indicated by Figures 1 and 2. Calculations based on these assumptions indicate the average tree in this planting has bee replaced 9.5 times since 1699 and that less than 0.1% of the trees from the original population are likely to be alive today.

Figure 4. Diameter vs. age relationship for a Japanese cherry tree planted near the Jefferson Memorial in 1912 and which was killed by hurricane Agnes in 1973. Reference to Figure 5 indicated that one-half the trees in this planting are less than 16 years of age.

Figure 5 Cumulative number of trees vs. diameter relationship for the 1912 planting of Japanese cherry trees in Washington, D. C. One half of the trees in this planting are less than 5.5 inches (13 cm.) in diameter.

FIGURE 1

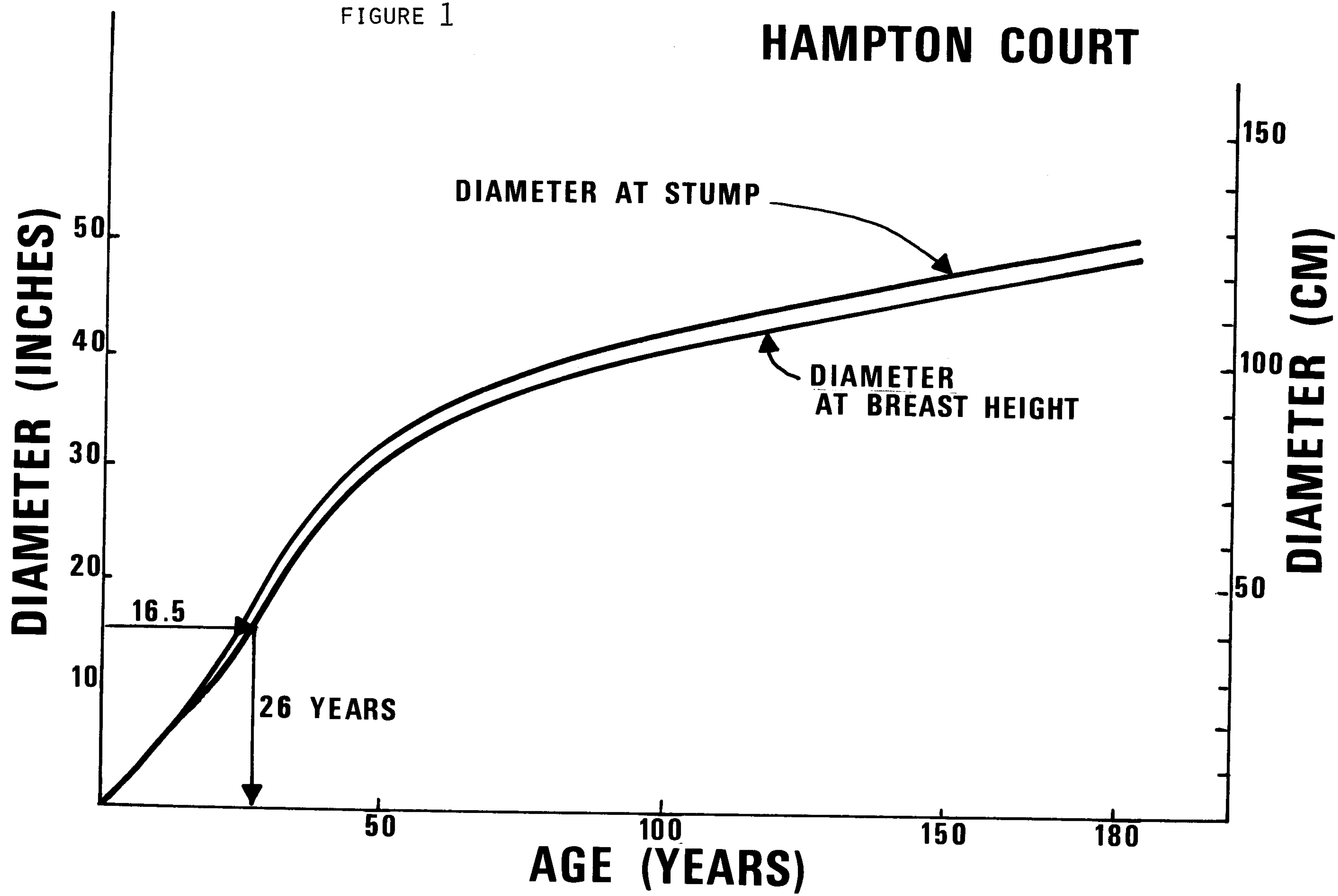

HAMPTON COURT
DIAMETER AT STUMP
DIAMETER
AT BREAST HEIGHT
16.5
26 YEARS
DIAMETER (INCHES)
10
20
30
40
50
DIAMETER (CM)
50
100
150
AGE (YEARS)
50
100
150
180

FIGURE 2

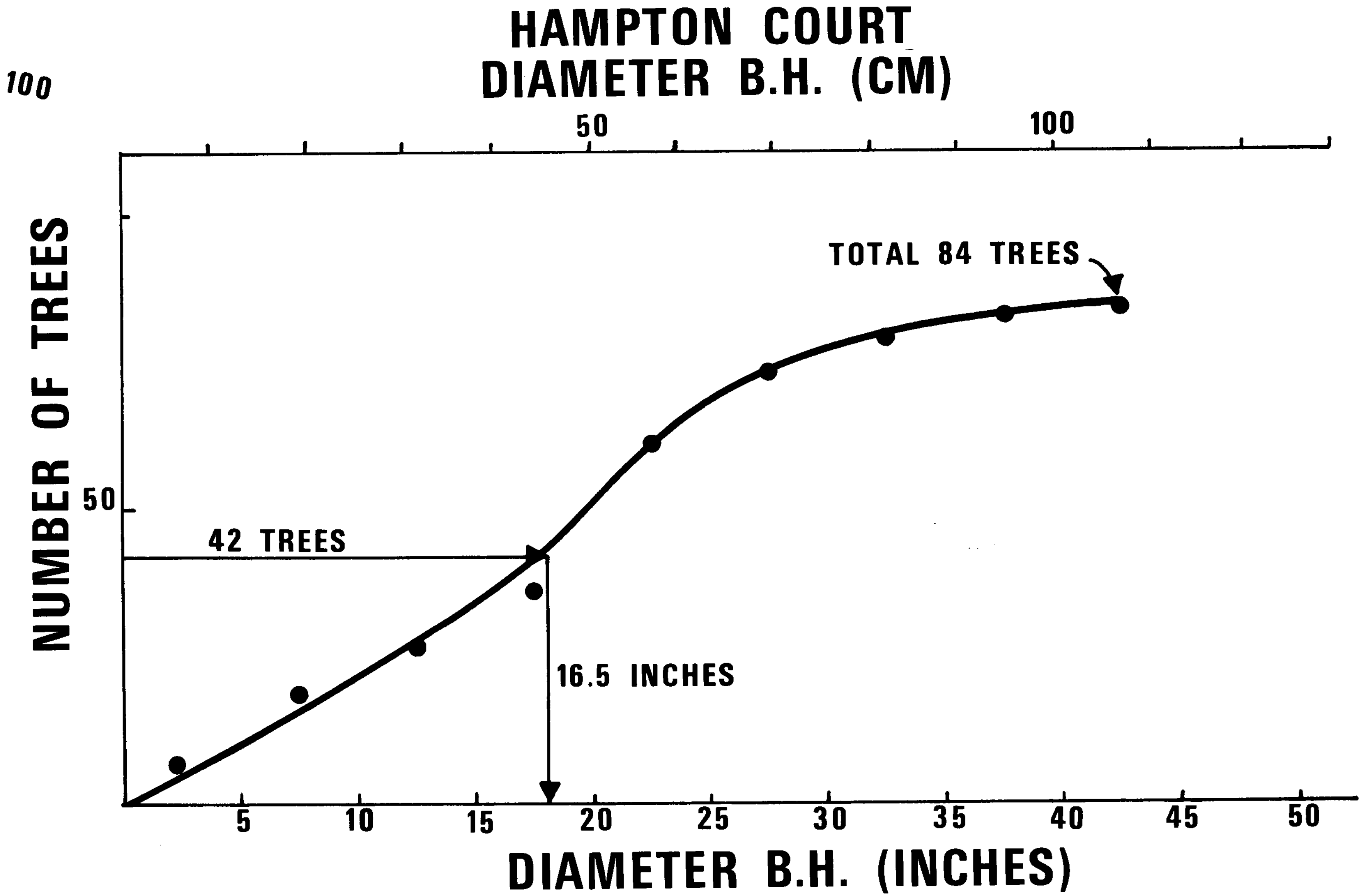

HAMPTON COURT
DIAMETER B.H. (CM)
50
100
100
NUMBER OF TREES
50
TOTAL 84 TREES
42 TREES
16.5 INCHES
5
10
15
20
25
30
35
40
45
50
DIAMETER B.H. (INCHES)

FIGURE 3

TIME VS. % SURVIVAL FOR HAMPTON COURT TREES

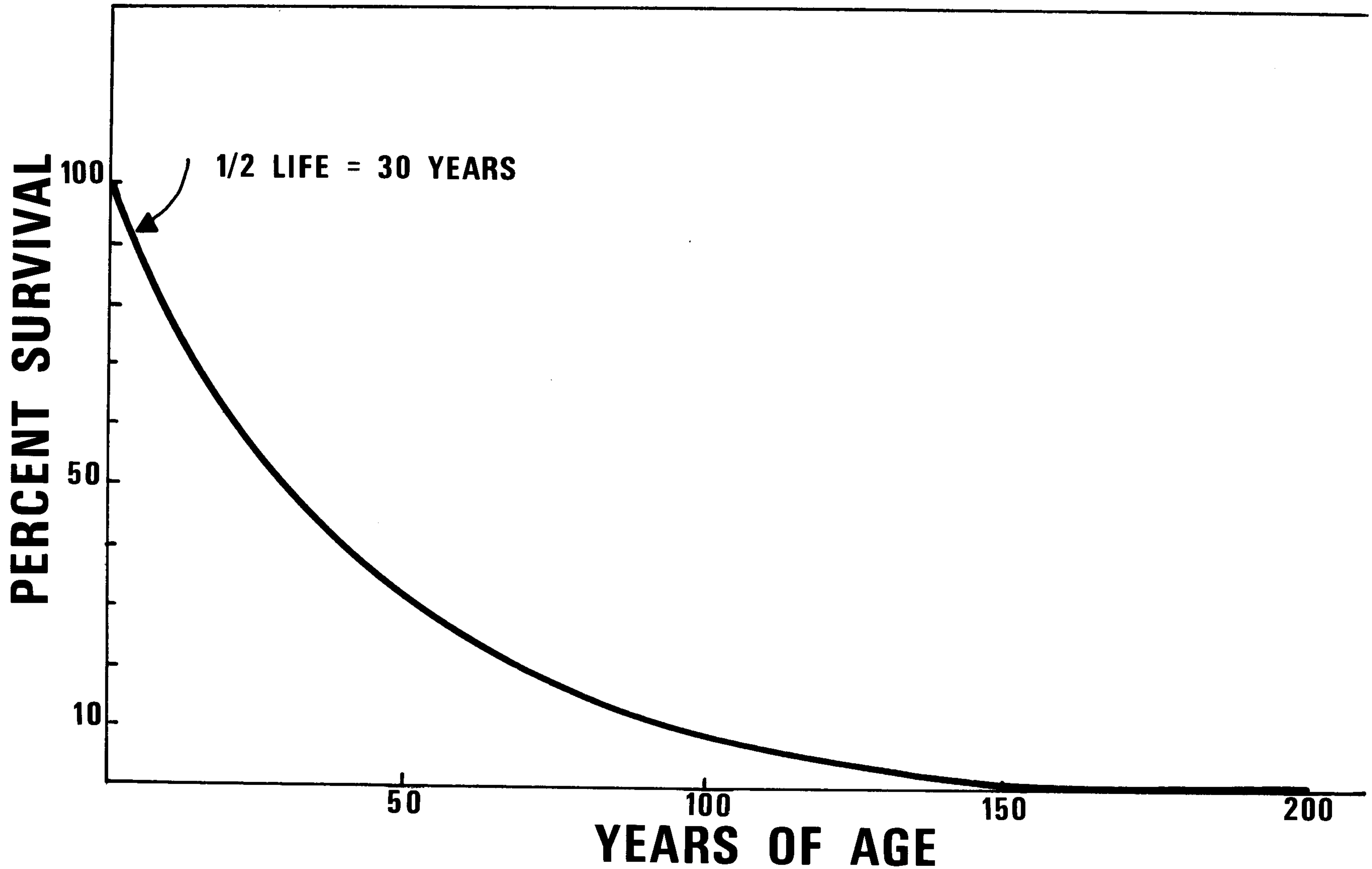


FIGURE 4

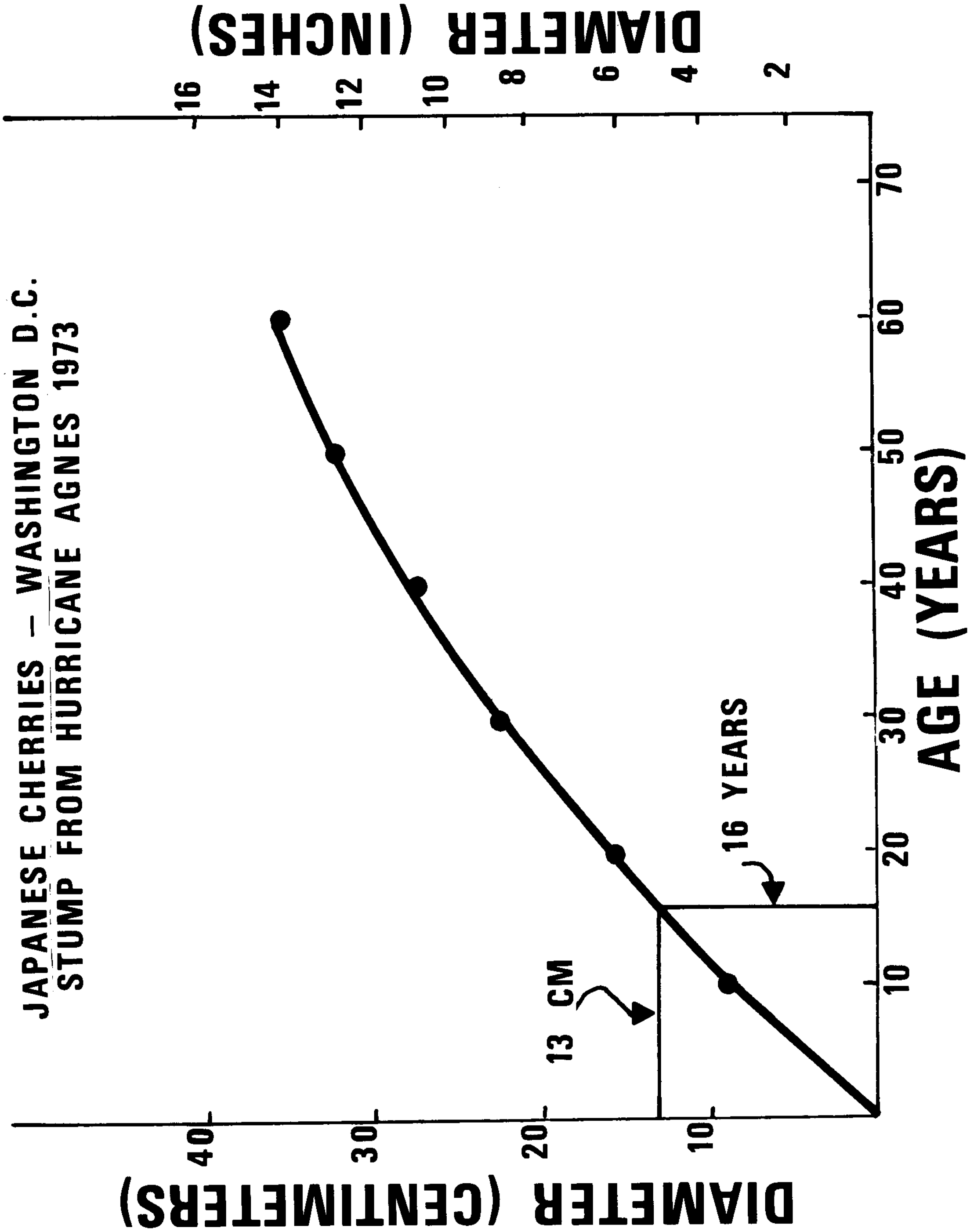
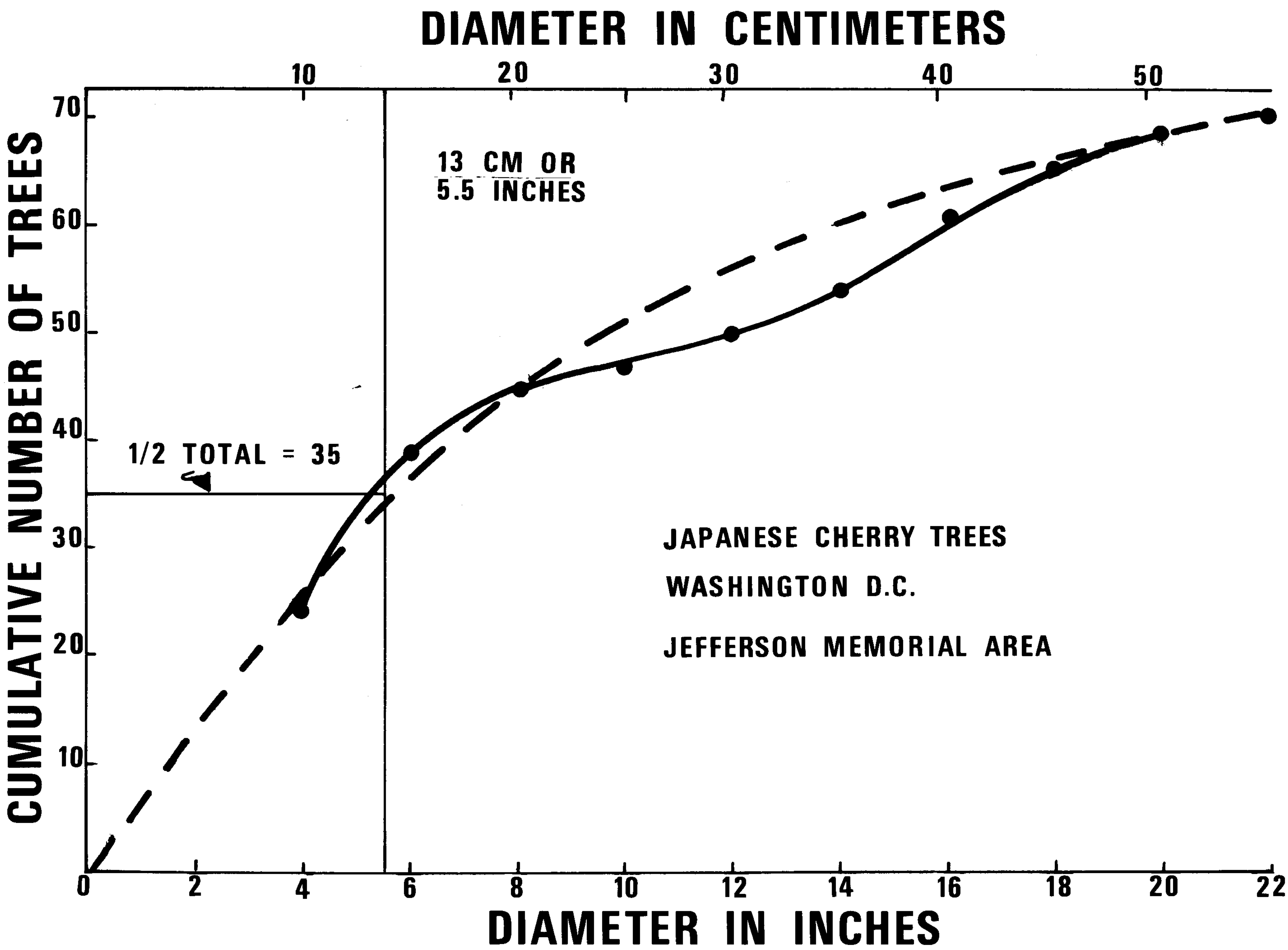

JAPANESE CHERRIES — WASHINGTON D.C.
STUMP FROM HURRICANE AGNES 1973
DIAMETER (INCHES)
2
4
6
8
10
12
14
16
DIAMETER (CENTIMETERS)
10
20
30
40
AGE (YEARS)
10
20
30
40
50
60
70
13 CM
16 YEARS

FIGURE 5


DIAMETER IN CENTIMETERS
10
20
30
40
50
70
60
50
40
30
20
10
CUMULATIVE NUMBER OF TREES
13 CM OR
5.5 INCHES
1/2 TOTAL = 35
JAPANESE CHERRY TREES
WASHINGTON D.C.
JEFFERSON MEMORIAL AREA
0
2
4
6
8
10
12
14
16
18
20
22
DIAMETER IN INCHES