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SITE INDEX curves for black white scarlet and chestnut oaks in the Central States

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Site Index Curves For Black, White, Scarlet, And Chestnut Oaks In The Central States

Willard H. Carmean

The site index method is the most widely accepted means for estimating site quality in the United States. However, proper application of this method of site evaluation requires suitable trees for the required height and age measurements. Also needed are accurate site index curves suitable to the tree species and to the area where site is being estimated (Carmean 1970).

Satisfactory site index measurements can be taken only from older dominant and codominant trees that have been free-growing and uninjured throughout their lives. Such trees are most commonly found in older, even-aged, fully stocked stands that have not been disturbed by past cutting, heavy grazing, or repeated burning. In the Central States extensive areas of even-aged upland oak stands now occupy areas originally clearcut for charcoal, mine props, and railroad ties. Dominant and codominant trees in such stands are very well suited for site index measurements.

But errors in site index estimation still may occur if site index curves do not accurately portray the variable patterns of tree height growth that may exist within a particular forest region (Carmean 1970). For the Central States the only site index curves for upland oaks are harmonized curves presumed to be applicable to all species of upland oak (Schnur 1937). However, upland oaks in the Central States have an extremely wide range and grow on lands having great differences in soil, topography, climate, and site quality. Presently we do not know if these older harmonized curves accurately describe the patterns of tree height growth found in this large and variable region. Nor do we know if these general curves are suitable for all species of upland oak found in our mixed oak forests.

Our studies are based on stem analysis measurements for four species of upland oaks growing on a wide range of site in the unglaciated portions of southeastern Ohio, eastern Kentucky, southern Indiana, southern Illinois, and southern Missouri. Results show that each of these four species of oak have different patterns of height growth; also we have found polymorphic height growth patterns for different levels of site quality. Refined site index curves are presented for black, white, scarlet, and chestnut oaks growing in the Central States.

THE DATA

Stem analyses were made on a total of 559 dominant and codominant oaks growing on 204 1/5-acre plots (table 1). A wide range of site index was observed for each of four species of

Table 1.—Number of plots and trees used in constructing site index curves from stem analyses of four species of upland oaks in the Central States[1]

Species	State					Totals
	Ohio	Kentucky	Indiana	Illinois	Missouri	
	- - - - - Total number of plots 2/ - - - - -					
Black oak	9(27)	7(30)	16(36)	3(10)	85(197)	120(300)
White oak	8(26)	5(25)	17(37)	4(12)	7(12)	41(112)
Scarlet oak	5(20)	8(34)	--	1(2)	11(32)	25(88)
Chestnut oak	13(43)	4(15)	1(1)	--	--	18(59)
Totals	35(116)	24(104)	34(74)	8(24)	103(24)	204(559)

1/ Trees in Kentucky, Indiana, Illinois, and many of the Missouri trees were sectioned as a part of a hardwood decay study conducted by the Northeastern Forest Experiment Station. Data for the remainder of the Missouri trees were furnished by Robert A. McQuilkin, North Central Forest Experiment Station. A portion of the statistical computations was accomplished using cooperative funds from the Kentucky Conservation Department.

2/ Numbers in parentheses are the number of trees sectioned.

oaks, and stand ages ranged from 33 to 129 years of age. All plots were in even-aged, well stocked stands apparently undisturbed by past cutting, grazing, or severe burning. From one to six dominant and codominant trees of each species were felled and sectioned on each plot. Each tree was sectioned at 1.0 foot, 4.5 feet, and at 4-foot intervals thereafter up to the growing tip of the tree. Total tree height was recorded and annual rings were field counted at each of the section points.

ANALYSIS AND RESULTS

Procedures followed in the compilation and analysis of data generally are those recommended by Curtis (1964). Details of the procedures we followed are described elsewhere.[1] Briefly, height-age curves for individual trees were combined into average species curves for each plot. Then adjustments were made for bias resulting from section points falling below terminal buds, and for bias due to an association between stand age and site quality. Next, estimated tree height at 1 year of age, and at successive 5-year intervals was read from the adjusted plot height-age curves for each plot. Data for each species were then stratified into 10-foot site index classes based upon tree height at 50 years observed from the average plot height-age curves.

A large number of equations were tested to determine which was best suited to the actual data. Several equations adequately expressed the variable height growth patterns characteristic of different species of oak growing on a wide range of sites. However, a nonlinear growth curve fitted the data best at all age classes. The equation we used is:

$$H = b_1(1-e^{-b_2 age})^{b_3}$$

where H = tree height at any age

b_1 = coefficient expressing asymptotic tree height, (i.e., estimated ultimate tree height)

b_2 = coefficient determining rate of tree height growth

b_3 = coefficient determining initial pattern of height growth

e = base of natural logarithm $\cong$ 2.718.

[1] *Willard H. Carmean. Site index curves for upland oaks in the Central States. (Unpublished manuscript)*

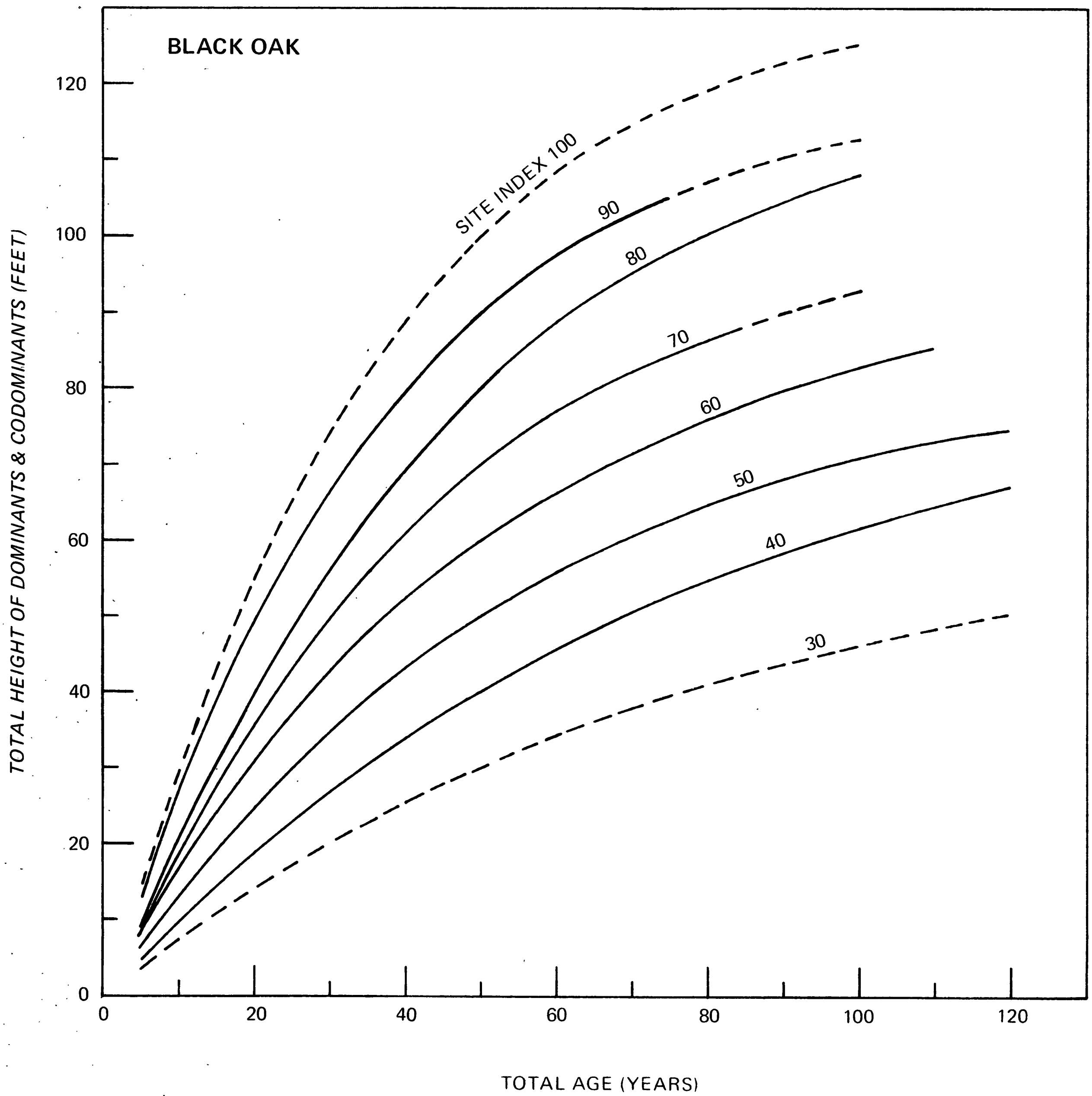

Figure 1.—Site index curves for black oak in the Central States. These curves are based on stem analyses of 300 dominant and codominant black oaks growing on 120 plots located in the unglaciated portions of southeastern Ohio, eastern Kentucky, southern Indiana, southern Illinois, and southern Missouri.

Extra copies of site-index charts are available upon request.

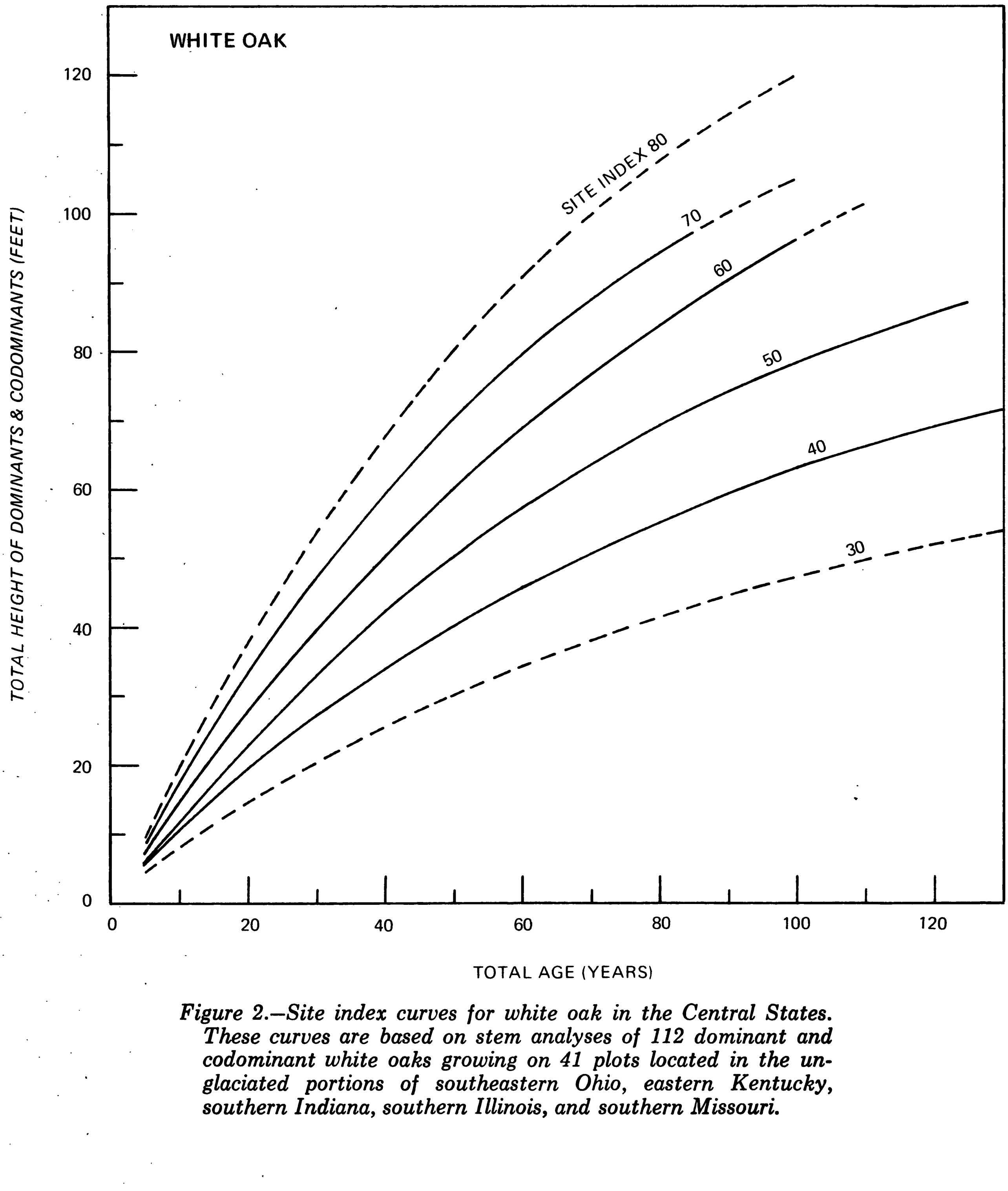

Figure 2.—Site index curves for white oak in the Central States. These curves are based on stem analyses of 112 dominant and codominant white oaks growing on 41 plots located in the unglaciated portions of southeastern Ohio, eastern Kentucky, southern Indiana, southern Illinois, and southern Missouri.

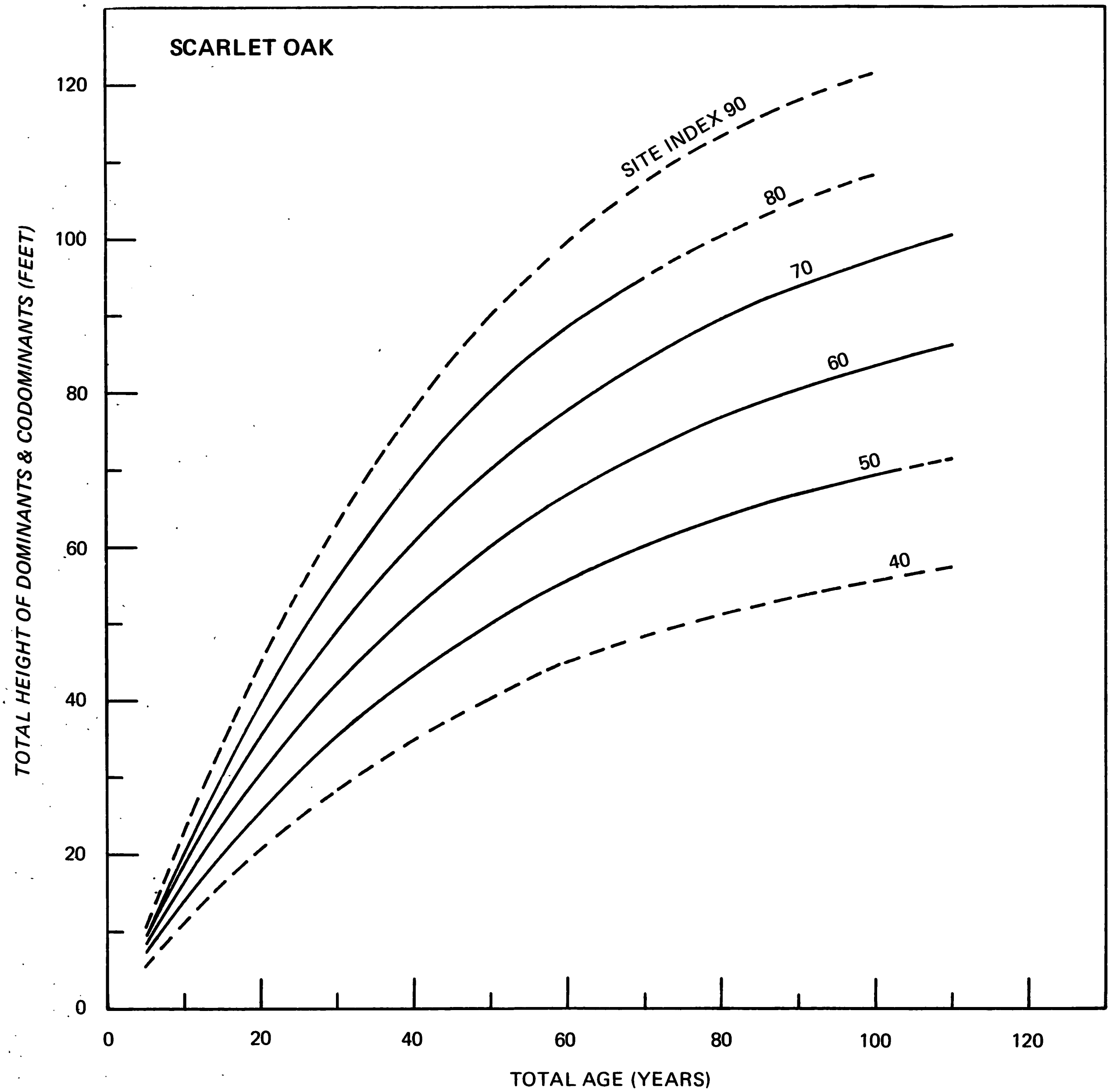

Figure 3.—Site index curves for scarlet oak in the Central States. These curves are based on stem analyses of 88 dominant and codominant scarlet oaks growing on 25 plots located in the unglaciated portions of southeastern Ohio, eastern Kentucky, southern Illinois, and southern Missouri.

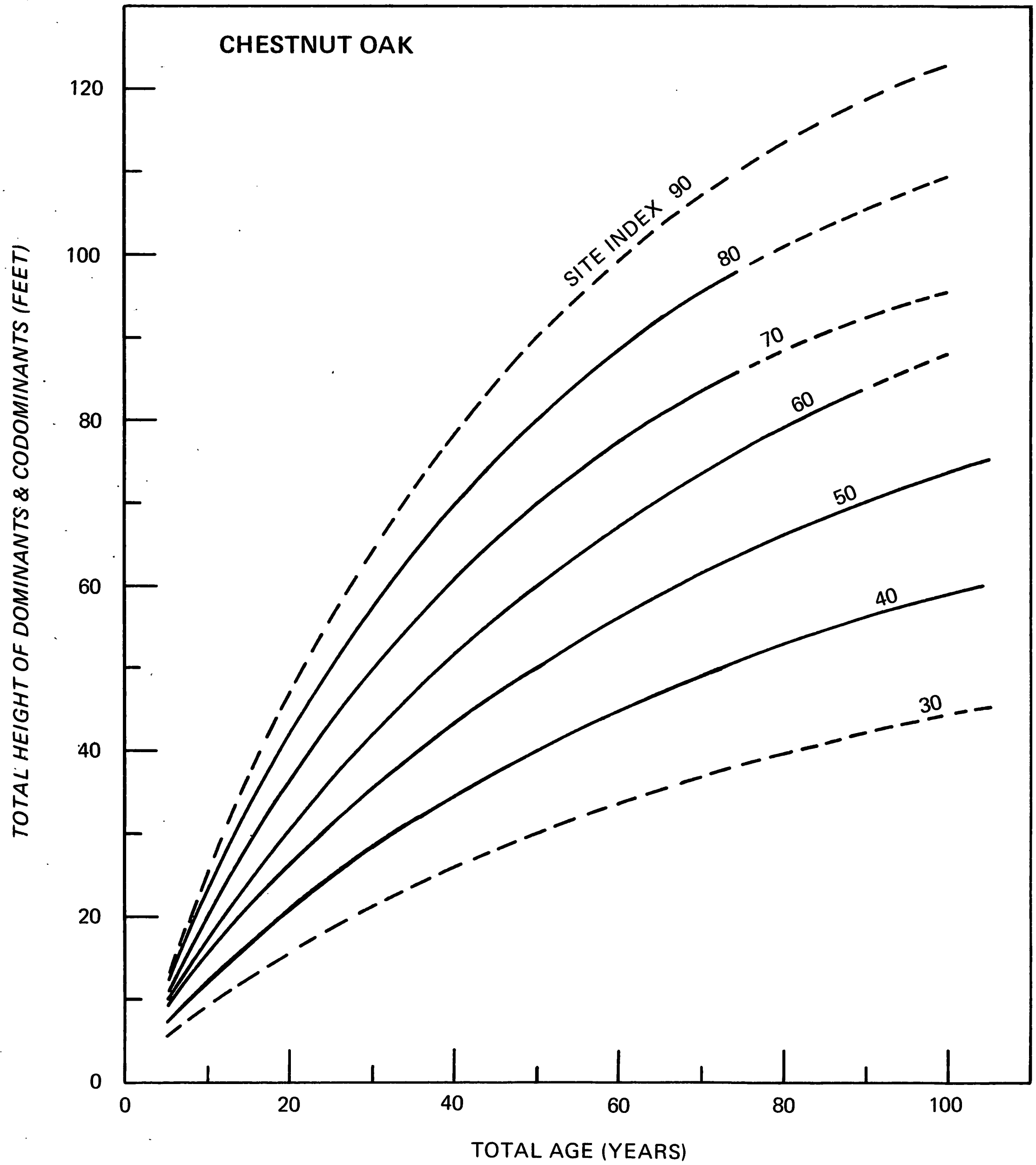

Figure 4.—Site index curves for chestnut oak in the Central States. These curves are based on stem analyses of 59 dominant and codominant chestnut oaks growing on 18 plots located in the unglaciated portions of southeastern Ohio, eastern Kentucky, and southern Indiana.

This growth equation was used to compute average height growth equations for black and white oak by 10-foot site index classes. Broader site index classes were used to compute equations for scarlet and chestnut oak because fewer data were available for these species. Each of the resulting equations was computed from data restricted to narrow site index classes, hence these equations are independent of each other and are not influenced by height growth patterns characteristic of other site index classes. The many height growth equations computed for black, white, scarlet, and chestnut oaks are given elsewhere.[1]

Examination of the various regression coefficients and the resulting height-growth curves showed that significant differences in pattern of height growth existed among the various oak species. Also for each species of oak significant polymorphic height growth patterns were observed for different levels of site quality. However, early height growth was found to be almost linear for all species rather than sigmoid as is characteristic for many tree seedlings. No consistent differences in height growth patterns were associated with the different States where data were collected.

The height growth equations computed from this study were used to construct separate site index curves for black, white, scarlet, and chestnut oaks (figs. 1 through 4). The broken lines show where site curves were extended using the height growth equations, or where curves for very good or very poor sites were computed based on equations for adjacent site classes. Consistent tree growth patterns were observed within plots and within site classes but no consistent growth patterns were associated with different States. Thus we consider these site index curves to be at least applicable throughout the unglaciated portions of the Central States.

DISCUSSION

One important finding is that the pattern of height growth differs among the various species of upland oaks. Our stem analyses reveal that white oak has a decidedly different height growth pattern from that of black and scarlet oak; chestnut oak has a growth pattern intermediate between white oak and that of black and scarlet oak. We have found that white oak has relatively slow height growth in early years in contrast to the more rapid early height growth of black and scarlet oak. However, after 50 or 60 years black and scarlet oak slow in growth while white oak maintains a relatively rapid rate of height growth past 100 years of age. Until 60 or 70 years white oak may be shorter than black or scarlet oak, but in later years white oak surpasses the other oaks and by 100 years will be the tallest oak in the stand. For example, if black and white oak are both 70 feet tall at 50 years (site index 70) then white oak will be about 13 feet taller than black oak at 100 years (figs. 1 and 2).

Another finding is that polymorphic height growth patterns occur on different sites. Trees on very good sites have a very rapid surge of early height growth in contrast to trees on poorer sites which have much slower early height growth. After 20 or 30 years the rapid growth on good sites is expended. Trees then slow in growth and by 60 or 70 years annual height growth on all sites is rather similar.

The third finding is that height growth does not slow as much as predicted by the conventional harmonized site index curves for upland oaks (Schnur 1937). Our curves and the conventional curves are fairly similar until about 60 years of age – especially on medium sites. However, at about 60 years the conventional curves show a more pronounced slowing in height growth than our species curves. Differences between our curves and the standard curves are particularly pronounced for white oak which maintains a relatively rapid rate of height growth past 100 years. These differences mean that site index will be overestimated if the conventional site index curves are used in older oak stands for estimating site index (Carmean 1971).

Our site curves also are different from the harmonized site index curves for upland oaks in the southeast (Olson 1959), and for red oak in the Lake States (Gevorkiantz 1957). Olson's curves show even more pronounced slowing in height growth in older ages than do the conventional site index curves. In contrast, the Gevorkiantz curves do not display as much slowing in height growth as do the Schnur and Olson site index curves. The Gevorkiantz curves for red oak are decidedly different from our white oak curves (fig. 2), but they do have a height growth pattern very close to the pattern of our black oak site index curves (fig. 1).

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