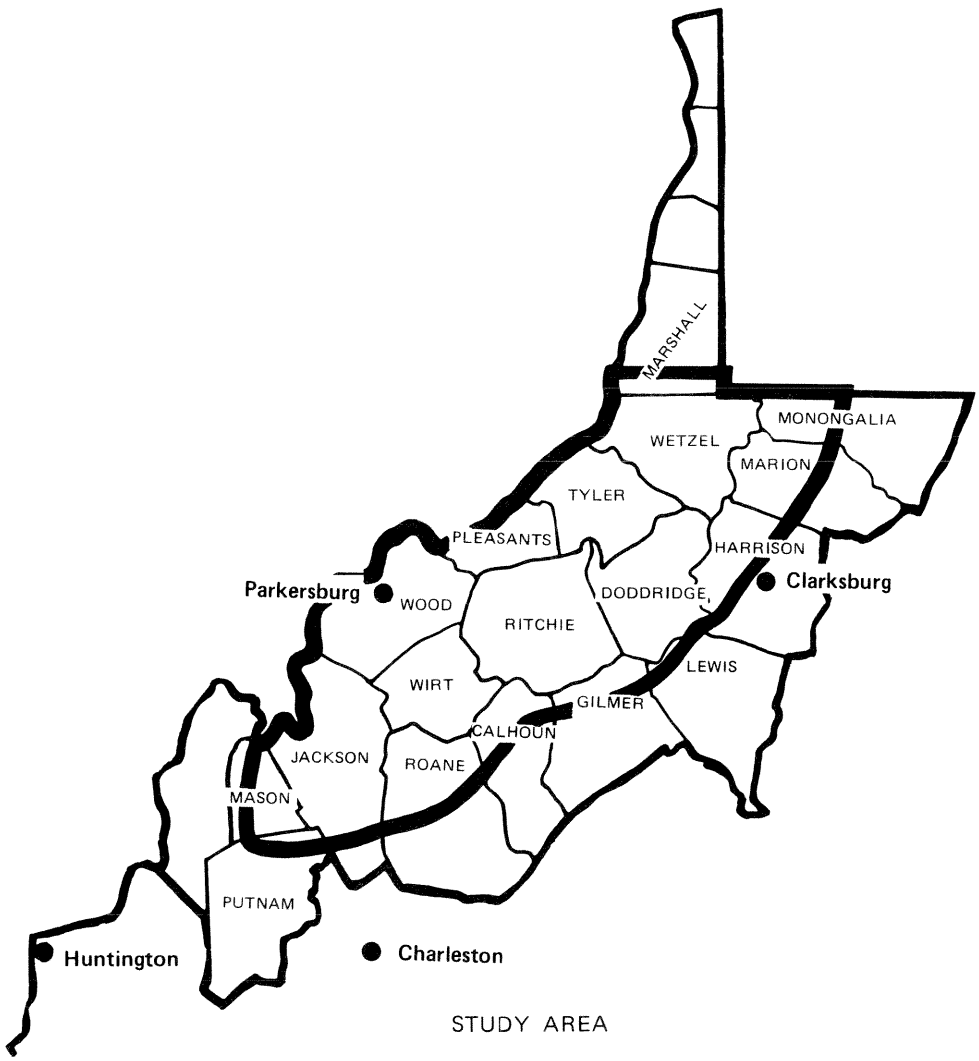
ODC 541 176.1 561.1

by Neil Lamson

Site Index Prediction Tables for Oak in NORTHWESTERN WEST VIRGINIA



FOREST SERVICE RESEARCH PAPER NE-462
1980

FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
NORTHEASTERN FOREST EXPERIMENT STATION
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MANUSCRIPT RECEIVED FOR PUBLICATION 3 MARCH 1980

Abstract

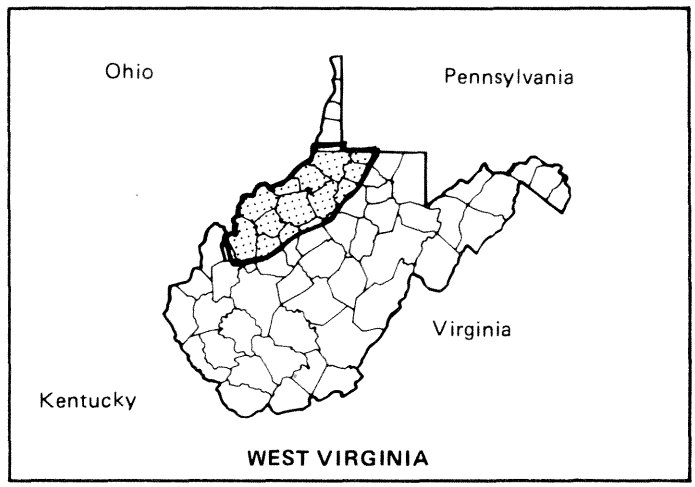
Prediction tables for even-aged stands of white, chestnut, northern red, scarlet, and black oaks can be used to estimate the site index of forest land in 13 counties of northwestern West Virginia. The half-width of the 95 percent confidence interval of the predicted site index is included; it can be used to determine the number of sample trees necessary to attain given levels of precision, or to determine the precision of a site index prediction for different numbers of sample trees.

BACKGROUND

SITE INDEX, the height of dominant and codominant trees at age 50, is the most commonly used indicator of forest site productivity in eastern hardwoods. Height growth curves, commonly referred to as site index curves, show the height growth patterns of trees on various sites. These curves are usually developed by taking height measurements of trees over a range of ages or by stem analysis techniques (Curtis et al. 1974).

Site index prediction tables presented in this paper were developed by first determining the age of sample trees at 4-foot intervals along the stem. These data were used to determine the height of the trees at various ages. Then, by methods similar to Curtis's (1964), linear regressions were calculated for ages 10 to 80 by 5-year intervals. Site index is better predicted from known tree heights and ages with this type of site-index prediction table than by height/growth curves because the estimated variable, site index, is the dependent variable in the calculations (Curtis et al. 1974).

Figure 1.—The region studied includes about 3 million acres of forest land in northwestern West Virginia. Region boundaries are delineated by uniform climate, topographic configuration, and the geologic formation from which the dominant soils have formed.



TREE SELECTION AND DATA COLLECTION

Study trees were selected in Wetzel, Monongalia, Marion, Doddridge, Harrison, Tyler, Pleasants, Ritchie, Wood, Wirt, Calhoun, Roane, and Jackson counties in northwestern West Virginia (Fig. 1). Eighty-one trees were measured on 27 plots that were established in even-aged stands 50 to 105 years old. Stands were selected over the range of site qualities in the area (Table 1). Only straight, codominant or dominant trees with no outward signs of suppression or fire, insect, or disease damage were selected. Age at 4.5 feet was determined from increment cores. Study tree ages ranged from 53 to 107 years.

Table 1.—Number of plots sampled and trees sectioned[a] by site index class

Species	Site index class				Total number of trees sectioned
	46-55	56-65	66-75	76-85	
Chestnut oak	2 (6)	1 (2)	1 (2)	—	10
White oak	2 (4)	3 (8)	4 (11)	1 (3)	26
Scarlet oak	—	2 (5)	2 (6)	—	11
Red oak	—	1 (3)	5 (11)	2 (4)	18
Black oak	1 (3)	—	4 (11)	1 (2)	16
Total number of trees sectioned	(13)	(18)	(41)	(9)	81

[a]Numbers in parentheses are the number of trees sectioned; 2 (6) refers to 6 trees on 2 plots.

If the tree's age was within 10 years of the estimated stand age, it was felled and sectioned at 4-foot intervals. Age was determined at each sectioning point.

DATA ANALYSIS

The height above ground of each sampling point was corrected for inherent bias (McQuilkin 1974, Carmean 1971). Although the ring counts gave the age at a specific height, the total height of the tree at that age would be slightly greater because the cut probably was made somewhere in the middle of the height growth for that year. So half the average annual height growth of the tree at that age was added to the height of the sectioning point to obtain total tree height. Total tree height over age was plotted for each sample tree. Trees that showed signs of early suppression or top breakage (irregular height growth) were discarded. The total height at 5-year intervals was determined from the height-over-age graphs. These data were used in all subsequent calculations.

The data were stratified by species. A linear regression, SI = a + b (ht), was calculated for each 5-year age class and each species. Comparisons of the curves showed that chestnut (*Quercus prinus* L.) and white oaks (*Q. alba* L.) were not significantly different, nor were northern red (*Q. rubra* L.), black, (*Q. velutina* Lam.), and scarlet oaks (*Q. coccinea* Muenchh.). Thus, the data were combined into two species groups—red oaks and white oaks—and the 5-year regression equations were recalculated. These equations were used to construct the site index prediction tables (Tables 2 and 3).

The half-width of the 95 percent confidence interval of each site index equation was calculated with the formula

$$HW = \pm t\,(s)$$

in which t is the value of the t distribution at the .975 probability level with degrees of freedom (number of trees minus 2) and s is the standard error of the stand site index.

The standard error of the stand site index was calculated as the square root of the variance, V, of the stand site index which was calculated with formula 6 from McQuilkin and Rogers (1978).

$$V = S_{SI \cdot H^2} \left[\frac{1}{k} + \frac{1}{n} + \frac{(\bar{h}_A - \bar{H}_A)^2}{\sum_{i=1}^{n} (H_{Ai} - \bar{H}_A)^2} \right] + b^2 \frac{V(h_A)}{k} .$$

where

$S_{SI \cdot H^2}$ = mean square error term of the regression

k = number of future sample trees

Table 2.—Site index estimates for northern red, scarlet, and black oaks

Stand age (years)	Height (feet)																
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
20	51	56	60	64	68	72	76	81	85								
25		50	54	58	62	66	70	74	78	82							
30			48	52	56	61	65	69	73	77	82						
35				45	50	54	59	63	67	72	76	81					
40						48	52	57	62	66	71	75	80				
45							46	51	55	60	65	70	75	80			
50								45	50	55	60	65	70	75	80		
55									46	51	55	60	65	70	75	80	
60										47	52	56	61	66	71	76	81
65											48	53	58	63	68	73	78
70												50	55	60	65	69	74

Table 3.—Site index estimates for white and chestnut oaks

Stand age (years)	Height (feet)															
	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
20	44	51	58	65	72	79	86									
25	37	43	50	57	63	70	76	83								
30			43	50	56	62	68	75	81	87						
35				42	48	54	61	67	73	79	85					
40					42	48	54	60	66	72	78	84	90			
45						43	49	54	60	65	71	77	82			
50						40	45	50	55	60	65	70	75	80	85	
55							42	47	51	56	60	65	69	74	79	83
60							40	44	48	52	57	61	65	69	73	77
65							39	43	46	50	54	58	61	65	69	73
70								41	45	48	52	55	59	62	66	69

n = number of sample trees used to calculate the regression

b = regression coefficient

$V(h_A)$ = within-plot variance of the future sample tree heights

h_A = mean height of k future sample trees at age A

H_{Ai} = height at age A of the i^{th} tree (i = 1 to n)

$\overline{H}_A$ = mean height of age A of all n trees used in the regressions.

The half-width of the 95 percent confidence intervals for stands from 10 to 80 years old when the number of sample trees ranges from 5 to 25 are presented in Table 4.

The within-plot variance of the future sample tree heights was assumed to be the same as the within-plot variance of the sample tree heights used to calculate the regression. In practice, the variance of the future sample tree heights will be less than the value used in these calculations because a single even-aged stand will have less height variation than trees selected over a wide range of site qualities. Therefore, the half-widths of the 95 percent confidence intervals presented in Table 4 are wider than those that normally would be encountered when using these tables to estimate the site index of an individual stand.

Table 4.—Half-width of the 95 percent confidence interval of the predicted site index when the number of sample trees ranges from 5 to 25 trees

Stand age	Half-width of confidence interval (± feet) when number of sample trees is				
	5	10	15	20	25
	NORTHERN RED, SCARLET, AND BLACK OAKS				
20	6.2	4.8	4.2	3.8	3.6
25	6.1	4.7	4.1	3.7	3.5
30	5.6	4.4	3.9	3.6	3.4
35	4.9	4.0	3.6	3.3	3.1
40	4.0	3.4	3.1	2.9	2.7
45	3.9	3.5	3.2	3.0	2.9
50	3.3	3.1	2.9	2.7	2.6
55	3.2	2.9	2.7	2.5	2.4
60	3.6	2.6	2.3	2.0	1.9
65	4.1	3.1	2.7	2.5	2.4
70	5.1	4.0	3.5	3.3	3.1
	WHITE AND CHESTNUT OAKS				
20	7.6	5.9	5.1	4.7	4.4
25	6.8	5.2	4.6	4.2	3.9
30	5.9	4.7	4.1	3.8	3.5
35	4.9	4.0	3.6	3.4	3.2
40	4.3	3.7	3.4	3.1	3.0
45	3.9	3.5	3.3	3.1	2.9
50	3.4	3.2	3.0	2.8	2.7
55	3.8	2.7	2.2	2.0	1.8
60	3.7	2.7	2.3	2.0	1.9
65	3.9	2.9	2.5	2.3	2.2
70	4.8	3.7	3.2	3.0	2.8

HOW TO USE THE SITE INDEX PREDICTION TABLES

1. Delineate the stand to obtain relatively uniform site and tree age.

2. Determine the stand age by boring several trees and use Table 5 to determine the number of sample trees needed. For example, 10 sample trees would be needed to predict the site index with a 95 percent confidence interval of 8 feet in a 35-year-old red oak stand. Trees used for age determination that are within 10 years of the average stand age can be used for site index determination in step 4; therefore straight, undamaged, dominant or codominant trees should be selected.

3. Randomly select sample trees. Use only straight, undamaged, dominant or codominant trees with no signs of past height-growth depression. Forks and crooks are good indications that the top may have been broken, reducing total height of the tree.

4. For each sample tree:
   a. Determine the age at breast height and add 2 years to get total age. If the total age of the sample tree differs by 10 years from stand age, do not use the tree, but find a sample tree that is within 10 years of the stand age. To reduce the number of trees bored, trees bored in step 2 that are within the 10-year limit can be used.
   b. Measure the total height. On larger trees, at least two measurements should be averaged to estimate total height because it is difficult to see the tops of large trees.
   c. Use Table 2 or 3 to determine the estimated site index. For example, the estimated site index for a 35-year-old, 40-foot-tall red oak tree is 59 feet (Table 2).

5. Average the estimated site indexes from the sample trees to determine the average site index of the stand.

DISCUSSION

To use these site index prediction tables, it is essential that at least the recommended number of sample trees be measured. For example, from Table 4 for a 20-year-old white oak stand, 15 sample trees are needed to estimate the site index so that the half-width of the confidence interval is 5.1 feet. In other words, if the average site index of the sample trees was 67 feet, one would be 95 percent confident that the true site index is between 61.9 and 72.1 feet. If, for example, only 5 trees had been sampled, the half-width of the confidence interval would have been ±7.6 feet.

These site index tables were developed from data on trees in even-aged stands, and should be used only in even-aged stands.

Height growth curves constructed from site index prediction tables cannot be compared to height growth curves constructed from stem analysis data (Carmean 1971) or from plot observations over a range of stand ages (Schnur 1937). However, tree age and height data can be used to predict site index from both site index prediction tables and height growth curves. In this sense, site index predictions are comparable between Tables 2 and 3, Carmean's (1971) height growth curves, and Schnur's (1937) height growth curves. Comparisons showed that for trees 50 to 70 years old, these site index prediction tables gave estimates of site index up to 5 feet higher than estimates from either Carmean's or Schnur's height growth curves. For ages 30 to 50 years, these site index estimation tables gave estimates up to 3 feet lower than did Carmean's or Schnur's height growth curves. Since these differences are not large enough to change the 10-foot site index class of a plot, Schnur's (1937) yield tables can be used with these site index estimation tables.

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