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PRELIMINARY SITE INDEX CURVES FOR NOBLE FIR FROM STEM ANALYSIS DATA

by

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Abstract

Preliminary polymorphic site index curves were developed using stem analysis data from 54 plot locations in Oregon and Washington. Site index reference age is 100 years at breast height, *and* total height is measured from average ground level. *A family of 11 curves was obtained from four polymorphic curves by interpolation and proportional methods. The curves were extended from 250 to 350 years of age to provide site index values for these older age classes.*

The curves were based on tallest dominants only; therefore, the tallest dominant should be used when estimating the site index of a particular area. Curves based on additional stem analyses of noble fir will be produced in the future.

INTRODUCTION

Cooperative stem analysis studies were undertaken by the U.S. Forest Service and Oregon State University in June 1965 to obtain information for managing the upper-slope forest complex. The studies were especially aimed at collection of growth data for old-growth noble fir. However, similar data were also collected for species associated with noble fir and will be used in comparative growth studies.

The usual upper-slope forest stand is an uneven-aged mixed coniferous type. To obtain an estimate of site in this forest type, noble fir (*Abies procera* Rehd.) was selected for study because it is an intolerant species and is usually free from suppression effects. Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) is perhaps as intolerant of shade as noble fir, but it does not occur as frequently in the upper-slope, mixed-conifer type.

Noble fir trees were felled at 54 locations from McKenzie Pass in the Central Oregon Cascades to Mount Rainier in the Washington Cascades. Location lists of timber stands containing noble fir were compiled from information provided by National Forest personnel, loggers, and research workers. Study areas were selected from the lists to provide a complete range from best to poorest growing conditions as evidenced by height in relation to age, soil, slope and exposure factors, and composition and frequency of understory vegetation. We relied strongly on preliminary site quality and plant association relationships explained by Franklin (1966) for recognition of site differential.

A single, tallest dominant noble fir was felled and sectioned at each plot location.[1/] Previous exploratory work (Herman 1967) showed that, with minor exceptions, the tallest dominant tree had been the tallest throughout the life of the stand.

ANAMORPHIC VERSUS POLYMORPHIC SITE INDEX CURVES

Various methods of classifying sites have been used, such as indicator plants, volume, and soil condition, but the most common measure of site quality is site index, the height of a specified stand component at a given age (Spurr 1952). In the past, many site index curves have been anamorphic, that is, proportional curves based on one master curve. A weakness of anamorphic curves is that they have the same shape for high and low sites (Smith, Ker, and Heger 1960). Bull (1931) found in red pine that the period of maximum height growth varied with site class. Low sites exhibited their period of maximum height growth at an older age than the high sites did.

Polymorphic curves are curves that are not proportional to each other (Bull 1931). Since polymorphic site curves do not have the same shape or trend for each site classification (Spurr 1964), stem analysis data must be used in the construction of such curves.

1/ Each plot was approximately one-fourth acre.

ANALYSIS METHOD

For each tree sectioned, the height of each section above breast height was plotted over total number of years the tree required to attain that section height. The points were connected with a smoothed curve. Heights were then read from the curves at 10-year intervals of total breast-height age. These heights and ages were the data used in the subsequent analysis. Heights for ages over 250 years were eliminated from further analysis because the older age classes were inadequately represented. In addition, site curves can be distorted if the older trees differ in average site index from the younger trees (Curtis 1964).

A frequency distribution of sample tree heights at 100 years of age was made to determine their range. Heights ranged from 50 to 150 feet, with most of the trees in the 80- to 120-foot class. Data were sorted into four height/age groups on the basis of site indices, and a separate curve was fitted to each group.

STEPWISE REGRESSION

Two general equations were used to analyze the four groups of data. These models are:

1. $\log_{10}$ (Height) = a + b (Age^K)

   where

   K are selected values from -2.00 to -0.10

2. Age^2/Height = a + b (Age) + c(Age^2) (Prodan 1968)

By means of a stepwide regression computer program, two curves based on the above two models were fitted to each data group. Graphical comparisons indicated that Model 2 provided the better fit. The equations for the four major site groupings are as follows:

<u>Group A</u>

$$(\text{Age})^2/\text{HT} = 13.64781 + 0.19937\,(\text{Age}) + 0.00416\,(\text{Age})^2$$

<u>Group B</u>

$$(\text{Age})^2/\text{HT} = 10.11508 + 0.40115\,(\text{Age}) + 0.00426\,(\text{Age})^2$$

<u>Group C</u>

$$(\text{Age})^2/\text{HT} = 19.10187 + 0.50996\,(\text{Age}) + 0.00490\,(\text{Age})^2$$

<u>Group D</u>

$$(\text{Age})^2/\text{HT} = 12.68825 + 1.05408\,(\text{Age}) + 0.00501\,(\text{Age})^2$$

The four equations were solved for heights at 10-year intervals of age (the four curves are shown in fig. 1). Note that the axes are graduated for *height above breast height and age at breast height.* Breast height was selected as a base not only because it is more convenient to use, but also because it provides a set of curves little influenced by early stand history (Husch 1956).

Table 1 gives root residual mean square and multiple correlation coefficients for each of the site group equations.

A graphical test for polymorphism indicated the site index curves were polymorphic. Previous investigation of scatter diagrams for the individual site groups indicated that polymorphism might exist. The graphical test on the four major curves confirmed this fact.

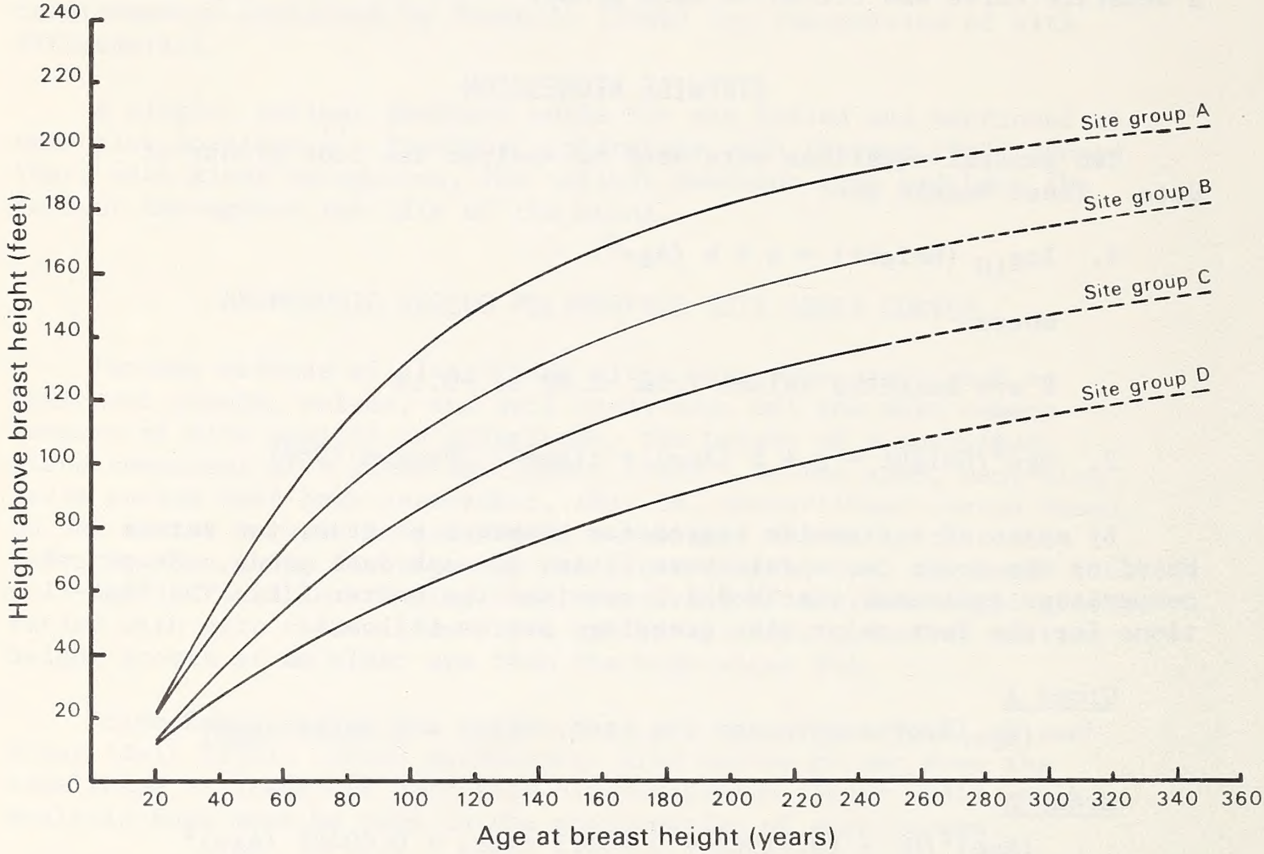

Figure 1.--Curves fitted to group data.

Table 1.--*Root residual mean square and multiple correlation coefficient for each site group equation*[1/]

Site group	Root residual mean square[2/]	Multiple correlation coefficient
A	13.27	0.989
B	11.46	.994
C	20.53	.986
D	40.86	.972

[1/] Values refer to $(Age)^2$/Height.

[2/] Standard deviation from regression line.

FAMILY OF SITE INDEX CURVES

A family of 10-foot index curves at the standard age of 100 was constructed from the four polymorphic curves. An adjustment of 4.5 feet was made to the family of curves to obtain total height since the four major curves were based on height above breast height. Two proportional curves, a 45.5-foot and a 55.5-foot, were obtained from the Site D master curve. Likewise, the 135.5-foot and 145.5-foot curves were proportional curves obtained from the Site A master curve. The 4.5-foot adjustment was added to each of these curves to obtain total height. Thus, the curves became 50, 60, 140, and 150 feet, respectively, at the standard age of 100 years.

The construction of the other curves, 70, 80, 90, 100, 110, 120, and 130, was not as simple. Since each curve in question lies between two major curves, a problem arose as to which major curve should influence the minor curve. A reasonable approach to the problem is to have both major curves influence the 10-foot interval curves that lie between them. The method used is as follows:

1. Calculate the height interval between the two major curves of interest at 10-year intervals.

2. At the index age, calculate the height interval between the curve that is to be constructed and the lower major site curve. In this case, the curves to be constructed are 65.5, 75.5, 85.5, 95.5, 105.5, 115.5, and 125.5.

3. Divide the height interval obtained in step 2 by the height interval between the two major curves at the index age.

4. Multiply each interval obtained in step 1 by the value obtained in step 3. This gives a value for each 10 years of age.

5. Add each 10-year age value obtained in step 4 to the height of the lower major site curve at corresponding age.

6. Add the 4.5-foot adjustment to provide curves of total height.

Table 2 presents in detail average total height of tallest dominant trees by age and site index. The 10-foot noble fir site index curves are shown in (fig. 2).

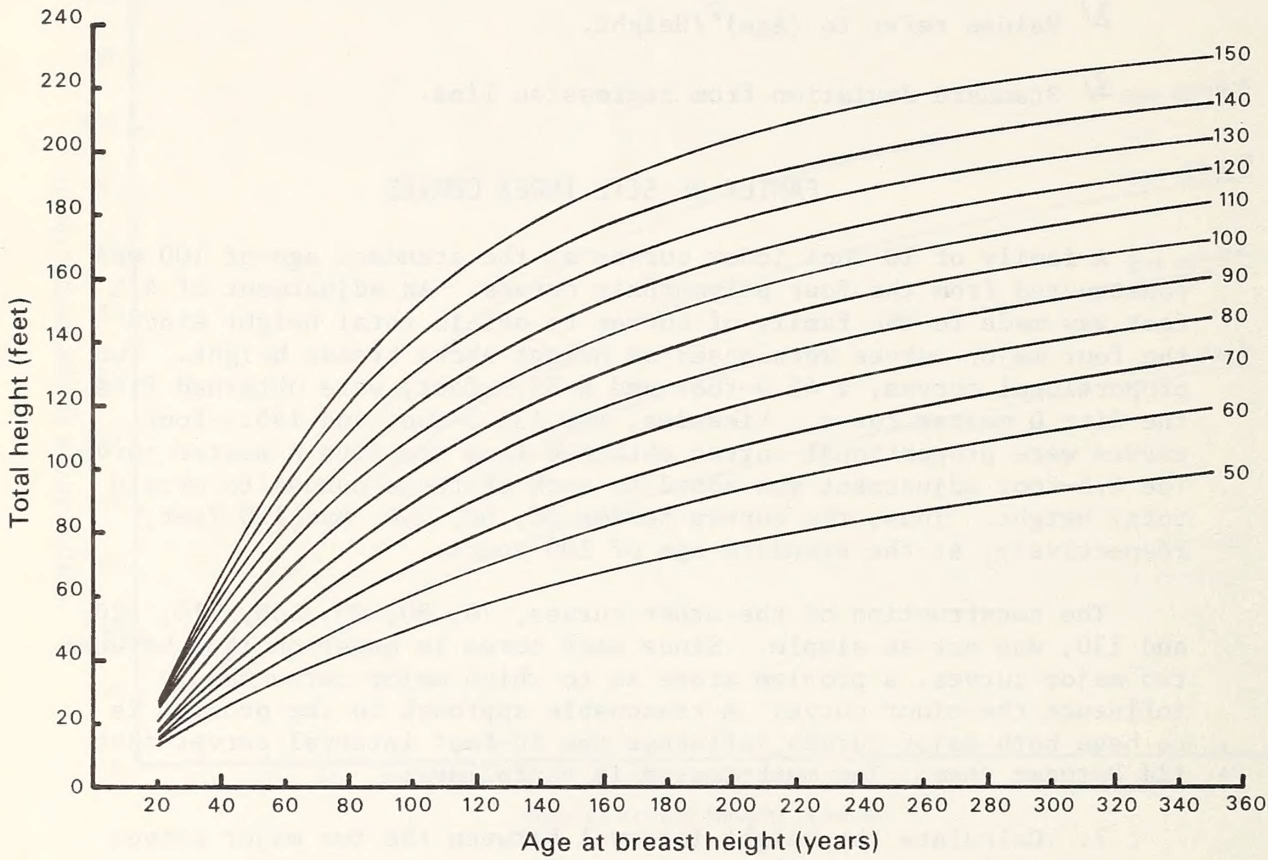

Figure 2.--Family of site index curves for noble fir.

Table 2.--*Average total height of tallest dominant trees by breast-height age and site index*[1/]

Age in years	Site Class IV Site Index-- 50	60	Site Class III Site Index-- 70	80	90	Site Class II Site Index-- 100	110	120	Site Class I Site Index-- 130	140	150
						Feet					
20	13	15	16	17	18	21	24	25	25	26	27
30	19	22	24	26	28	33	38	40	42	44	47
40	24	28	32	35	39	45	52	56	59	62	66
50	29	34	40	44	50	57	64	70	74	79	85
60	34	40	47	53	59	67	75	82	88	95	102
70	38	46	53	60	68	77	86	93	101	109	116
80	42	51	59	68	76	85	95	103	112	120	129
90	46	56	65	74	83	93	103	112	122	131	140
100	50	60	70	80	90	100	110	120	130	140	150
110	53	64	75	85	96	106	117	127	137	148	159
120	57	68	79	91	102	112	123	133	144	155	166
130	60	72	84	95	107	117	128	139	150	161	173
140	63	75	88	99	111	122	133	144	155	167	179
150	65	79	91	103	116	126	137	149	160	172	184
160	68	82	95	107	119	131	142	153	164	176	189
170	70	85	98	111	123	134	145	157	168	180	193
180	72	87	101	114	126	138	149	160	172	184	197
190	75	90	104	117	130	141	152	164	175	187	200
200	77	93	107	120	132	144	155	167	178	190	203
210	79	95	109	122	135	147	158	169	181	192	206
220	81	97	112	125	138	149	161	172	183	195	209
230	82	99	114	127	140	152	163	174	185	197	211
240	84	102	116	129	142	154	166	177	188	199	214
250	86	104	118	131	144	156	168	179	190	201	216
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260	87	105	120	133	146	158	170	181	191	203	218
270	89	107	122	135	148	160	172	183	193	205	220
280	90	109	124	137	150	162	174	184	195	206	221
290	92	111	126	139	152	163	175	186	196	208	223
300	93	112	128	140	153	165	177	188	198	209	224
310	94	114	129	142	155	167	179	189	199	211	226
320	95	115	131	143	156	168	180	190	200	212	227
330	96	117	132	145	157	169	181	192	202	213	228
340	98	118	134	146	159	171	183	193	203	214	229
350	99	119	135	148	160	172	184	194	204	215	230

[1/] Values below the dashed line were obtained by extrapolation of curves.

The 10-foot curves were checked by comparing them graphically with dissected trees not used in the analysis. The checking consisted of estimating the site index of a dissected tree at two ages in its development. The first age was 80 years, and the second age was 220 years or greater. The two estimates of site were always quite close to one another, which indicated the 10-foot site curves were reasonably shaped.

SUMMARY

The polymorphic site index curves should provide reliable estimates of site index for noble fir found between McKenzie Pass in Oregon and the White River drainage north of Mount Rainier in Washington.

In using the site curves or site index table, use total height of the tallest dominant or dominants since the curves are based on the tallest dominant noble fir within one-fourth acre. According to Dahms (1966), tallest trees in the stand give the best estimate of site. In estimating site index, *breast height age and total tree height above average ground level* should be used.

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