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Using Height/Diameter Curves to Estimate Site Index in Old-Growth Western Larch Stands[1]

by

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Site index, the height of dominant trees at a subjectively chosen base age, is the conventional descriptor of the potential productivity of a site. The taller a tree is at a given age, the better a site is considered to be. Because height and volume are positively correlated, the site index reflects both the height growth of a tree and, indirectly, potential volume growth of a stand. Possible sources of error in estimating site index include age determination (Husch 1956, Ferree et al., 1958, Mader 1963) and unrepresentative height growth. Height growth may be reduced in very dense or very open stands, and the pattern of height growth within a stand may vary if the trees are not all the same age (Carmean 1975, McQuilken 1975).

Height/diameter curves have been proposed as an alternative method of estimating site index (Meyer 1940, McLintock and Bickford 1957, Stout and Shumway 1982). Diameter can be measured more quickly and easily than age. A height/diameter predictor could save time and reduce the error in site index estimation caused by errors in age determination. It might also reduce errors caused by suppressed juvenile growth or reduced height growth in an overstocked stand. The height/diameter relationship has been proposed as a site index for stands of uneven age or mixed species.

This study tested the hypothesis that the height/diameter relationship of western larch trees varies with site quality and thus can be used to estimate site index.

Methods

Height/diameter data were obtained from three sources. The U.S. Forest Service Intermountain Experiment Station provided access to data collected by Cummings in the 1930s. Some of the data came from the Forest Service's Forest Product Laboratory's Western Wood Density Survey. Additional data were collected in the field. Fieldwork for the latter was done in the fall of 1981 on the Lolo National Forest. Height and diameter were measured in pure and mixed western larch stands, and site index was measured in each stand with Brickell's (1970) formula and height and age measurements of several dominant trees. The three sources combined contributed data on 1,369 trees. Ages were not available for every tree, but the

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Table 1
Models Tested In This Study

1. $H = a + bD - cD^2$
2. $H = a + b \log D$
3. $H = a + b(1/D)$
4. $\log H = a + b \log D$
5. $H = 4.5 + S(1-e^{-bD})$

*6. $H = 4.5 + S(1-e^{-bD})^m$

* Selected Model

information collected included trees up to 300 years old. Heights ranged up to 200 feet and diameters up to 45 inches. Site index ranged from 28 to 80 feet at 50 years.

Several height/diameter equations were fitted to the data by site class with least squares regression in order to select an equation that provided an adequate fit over the range of the data (Table 1). Examination of the residuals and comparison of the magnitude of standard errors of regression provided criteria for selection of a model (Reinhardt 1982).

Site classes were comprised of 10-foot site index intervals. Site class 1 included trees with a site index of 70 or above, site class 2 included trees with a site index between 60 and 70, and so on. Site class 5 included all trees with a site index less than 40. The height/diameter curves for the five site classes were compared to determine whether the height/diameter relationship varies with site quality.

Results

There was a marked difference in height/diameter curves between sites for large trees, with trees on a good site reaching greater heights at a given diameter than trees on a poor site (Figure 1). However, the curves could not be distinguished for small trees. It is possible that variations in stocking in younger stands mask the influence of site on the height/diameter relationship.

Not only were trees on a good site taller at a given diameter than trees on a poor site, but the pattern of growth was different. Initially, all the height/diameter curves were steep, indicating that small trees have a proportionally large increase in height with respect to diameter. After a time, the curves leveled off. This leveling occurred at a smaller diameter on poor sites than on good sites. Relative height growth decreased, while diameter growth continued.

Recommendations

These curves may be used to estimate site index in the same way that height/age site curves are used. Measured heights and diameters can be compared to the curves or Table 2 to find the site index. Because the curves did not separate appreciably before trees reached a 20-inch diameter, this method will be useful only in stands of trees with diameters of 20 inches or larger, such as those found in old-growth timber. The number of trees necessary for determination of the stand's site index depends on the height/diameter variability within the stand. Five to fifteen trees should be adequate for most purposes. Additional measurements can be taken for the desired level of precision.

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Figure 1
Height/Diameter Site Curves for Western Larch

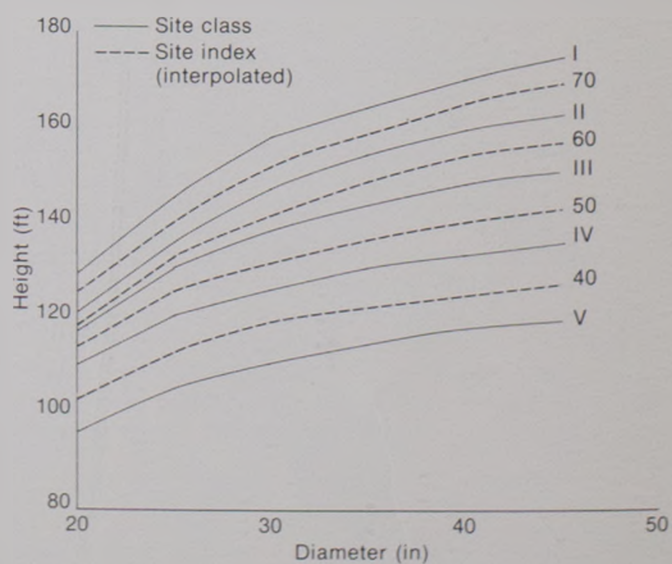

Table 2
Heights of Trees by Diameter and Site Class

Site Index

DBH	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74
20	98	101	104	106	109	111	112	114	116	117	118	119	120	120	121	122	123	125	127	128
21	100	103	105	108	111	113	115	116	118	120	121	122	122	123	124	125	127	128	130	131
22	102	104	107	110	113	115	117	118	120	122	123	124	125	126	127	128	130	131	133	135
23	103	106	109	112	115	117	119	121	122	124	126	127	128	129	130	131	133	134	136	138
24	105	108	111	114	117	119	121	123	125	127	128	129	130	131	133	134	136	137	139	141
25	107	110	113	116	119	121	123	125	127	129	131	132	133	134	135	137	139	141	142	144
26	108	111	114	117	120	122	124	126	129	131	132	134	135	136	138	139	141	143	145	146
27	109	112	115	118	121	124	126	128	130	132	134	135	137	138	140	141	143	145	147	149
28	110	113	116	119	122	125	127	129	131	134	136	137	139	140	142	144	145	147	149	151
29	111	114	117	120	123	126	128	131	133	135	137	139	141	142	144	146	148	149	151	153
30	112	115	118	121	124	127	130	132	134	137	139	141	143	144	146	148	150	152	153	155
31	112	116	119	122	125	128	131	133	135	138	140	142	144	146	148	149	151	153	155	157
32	113	116	120	123	126	129	131	134	136	139	141	143	145	147	149	151	153	155	156	158
33	114	117	120	124	127	130	132	135	137	140	142	144	146	148	150	152	154	156	158	160
34	115	118	121	124	128	131	133	136	138	141	143	145	147	149	152	154	156	158	160	161
35	116	119	122	125	128	131	134	137	139	142	144	146	149	151	153	155	157	159	161	163
36	116	119	123	126	129	132	135	137	140	143	145	147	150	152	154	156	158	160	162	164
37	116	120	123	126	130	133	135	138	141	143	146	148	151	153	155	157	159	161	163	165
38	117	120	124	127	130	133	136	139	141	144	147	149	152	154	156	159	161	163	165	167
39	117	121	124	127	131	134	137	139	142	145	148	150	153	155	158	160	162	164	166	168
40	118	121	125	128	131	134	137	140	143	146	148	151	154	156	159	161	163	165	167	169
41	118	122	125	128	132	135	138	141	143	146	149	152	154	157	159	162	164	166	168	170
42	119	122	125	129	132	135	138	141	144	147	150	152	155	157	160	162	164	166	169	171
43	119	122	126	129	133	136	139	142	144	147	150	153	155	158	161	163	165	167	169	171
44	119	123	126	130	133	136	139	142	145	148	151	153	156	159	161	164	166	168	170	172
45	120	123	127	130	133	137	140	143	146	149	151	154	157	159	162	164	166	169	171	173

Tree Height

The above heights are derived from the following equations with intermediate values produced by interpolation

Site class 1: $H = 4.5 + 178(1-e^{-076D})^{1\ 4556}$

Site class 2: $H = 4.5 + 167(1-e^{-076D})^{1\ 4368}$

Site class 3: $H = 4.5 + 151(1-e^{-076D})^{1\ 1455}$

Site class 4: $H = 4.5 + 135(1-e^{-076D})^{9671}$

Site class 5: $H = 4.5 + 117(1-e^{-076D})^{9416}$

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