PACIFIC SOUTHWEST
Forest and Range
Experiment Station

FOREST SERVICE
U.S.DEPARTMENT OF AGRICULTURE
P.O. BOX 245, BERKELEY, CALIFORNIA 94701

SITE INDEX CURVES for unmanaged stands of CALIFORNIA BLACK OAK

Robert F. Powers

USDA Forest Service
Research Note PSW-262
1972

Abstract: California black oak *(Quercus kelloggii* Newb.*)* is a potentially valuable species of wide distribution in California and southern Oregon. Site index curves related to slope aspect and to the site index of a close associate–ponderosa pine have been developed, and are reported for the first time in this Note. The curves should be useful in estimating the growth potential of California black oak in even-aged unmanaged stands of the Sierra Nevada and southern Cascade Range between 39° and 41° north latitude.

Oxford: 176.1 *Quercus kelloggii:* 54–015: 181.65.
Retrieval Terms: Quercus kelloggii; growth potential; economic potential; site index; site classification; California.

California black oak *(Quercus kelloggii* Newb.*)*,a member of the *Erythrobalanus* subgenus of red and black oaks, is widely distributed in California and southern Oregon.[1] Although the species is now considered of limited commercial value, it compares favorably in grade recovery with its more valuable eastern cousins.[2] The merchantable sawtimber volume of black oak is only a small fraction of California's total timber resource, but considering the value of eastern red and black oak, its economic potential is good.

Site classification indices have been developed for several California broadleaves,[3] but until now, no index existed for California black oak. Because black oak grows in close association with ponderosa pine *(Pinus ponderosa* Laws.*)*, sites favorable for one species often seem favorable for the other.[4] The wide distribution and potential value of black oak prompted this study. Site index curves related to slope aspect and to site index for ponderosa pine were developed. They are reported for the first time in this Note.

SAMPLING

Sixty-seven even-aged black oak stands were examined at elevations ranging from 1,000 to 5,000 feet in six California counties: Shasta, Tehama, Butte, Yuba, Nevada, and Placer. All stands were of sprout origin, apparently resulting from past fires or fuel wood cuttings *(fig. 1)*. Most stands were mosaics of distinct groups reflecting differences in age-class or site-quality. Groups free of any evidence of past suppression or damage provided 104 sample plots for the study.

In selecting sample trees, I assumed that the tallest sprouts in multiple-stemmed clones were comparable in height with single-stemmed sprouts of the same age.[5] Therefore, I limited my sampling to the single

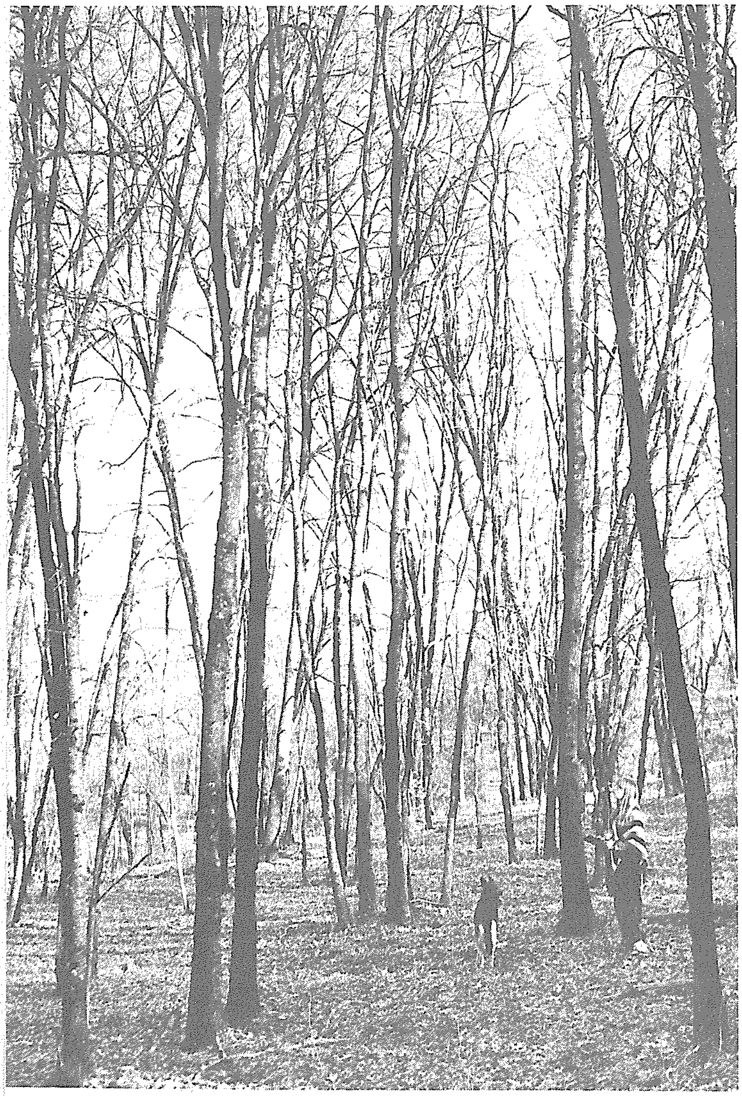

Figure 1—*A stand of California black oak in which the dominant trees average 62 feet in height at 50 years.*

tallest tree in any given clone. Sample trees were free of forking for the first 18 feet of bole. Trees with heavy infection of mistletoe *(Phoradendron flavescens* [Pursh]Nutt.*)* were avoided. Black oak is highly phototropic, and stems often angle outward from the center of clones toward canopy openings. And since leaning trees pose a problem in height measurement, sampling was restricted to trees leaning less than 20°. Trees with excessive sweep or crook were not sampled.

An average of five dominant black oaks were measured on each sample plot. Total height, breast-height age from increment borings, and slope angle and aspect were recorded for each tree. Ponderosa pine grew in small groups or as scattered individuals on or near 82 of the 104 sample plots. Height and age data were collected from the dominant pines when they were present.

ANALYSIS

Stem sectioning techniques did not seem practical for this study. Most pure oak stands grow at relatively low elevations on privately-owned lands. The destructive sampling involved in tree sectioning would require individual contracts with many land owners. And the tendency of the species in unmanaged stands to produce forking in the upper bole would further complicate stem analyses.

The problem of curve distortion from site-age imbalance was minimized by stratifying all sample plots associated with ponderosa pine into five pine site index classes. Conifer and broadleaf site indices often are correlated highly if silvical tolerances of the species overlap.[6] Assuming that a correlation existed between pine and oak site quality[4], stratifying oak plot data into narrow ponderosa pine site index bands provided homogeneous strata for separate regressions involving oak height and age. Regression coefficients derived from each site stratum were then analyzed for the change in oak growth rate with respect to site quality.

Heights and ages of sample trees were averaged for each oak plot and grouped into five pine site index classes. Site index for ponderosa pine was defined as the height of dominant trees at 50 years, breast-height age. Results from another study[7] favored the use of curves by Dunning and Reineke[8] for trees younger than 50 years old and those by Arvanitis, *et al.*[9] for trees older. Graphs of the mean values linearly related black oak height to the square root of age. Least-square regression equations were developed for each pine site stratum in the inverse form:

$$\sqrt{A} = a + bH$$

in which

A	=	mean breast-height age of dominant black oak in years
H	=	mean total height of dominant black oak in feet
a and b	=	least squares coefficients.

Statictics for each stratum are shown in *table 1*.

The mean site index of black oak in each pine site stratum was determined by solving each equation for height at index age 50. A plot of the reciprocals of slope coefficients over height at index age suggested that some curvilinearity may exist in the rate change in b with respect to site. But because of the limited

Table 1—*Regression data of form $\sqrt{A} = a + bH$ for California black oak plot data stratified by ponderosa pine site index classes*

Site index class (feet)	Intercept (a)	Slope (b)	Standard deviation	Correlation coefficient (r)	Basis: no. of plots
60 - 69	0.442	0.158	0.418	0.99	11
70 - 79	1.888	.117	1.070	.75	19
80 - 89	2.267	.093	.712	.75	18
90 - 99	2.080	.088	.682	.91	25
100 -115	2.174	.089	.525	.94	9

number of observations, I analyzed the growth rate of black oak as a linear function of site (correlation coefficient [r]= 0.96). Using this equation:

$$\frac{1}{b} = -6.413 + 0.322\ S_{50}$$

in which S_{50} = site index of black oak at 50 years index age.

Substituting values and solving for S_{50} defines site index as:

$$S_{50} = \frac{H + 6.413\ (\sqrt{A} - \sqrt{50})}{1 + 0.322\ (\sqrt{A} - \sqrt{50})}$$

To study the effect of aspect on site index, I grouped 79 oak plots on slopes ranging between 5° and 35° into 22.5° azimuth classes. Site index was determined by equation for each plot and averaged for each azimuth class.

To test the site index correlation of black oak with ponderosa pine, I averaged the 82 paired oak and pine site indices by 5-foot pine site index classes. The 11 mean values between site index 60 and 115 were analyzed by regression.

RESULTS

Discussion

Rapid early growth is characteristic of California black oak. Ground-line borings reveal that dominant sprouts usually reach breast height in two growing seasons. But although one plot had dominant sprouts averaging 22 feet tall at 9 years (breast-height age), indications are that such high rates of growth are not sustained. Early growth is strongly controlled by the parent stump root system.[10] Therefore, such growth does not indicate true site potential until sprout clones have reached a later stage of development. For this reason the curves in *fig. 2* begin at 20 years.

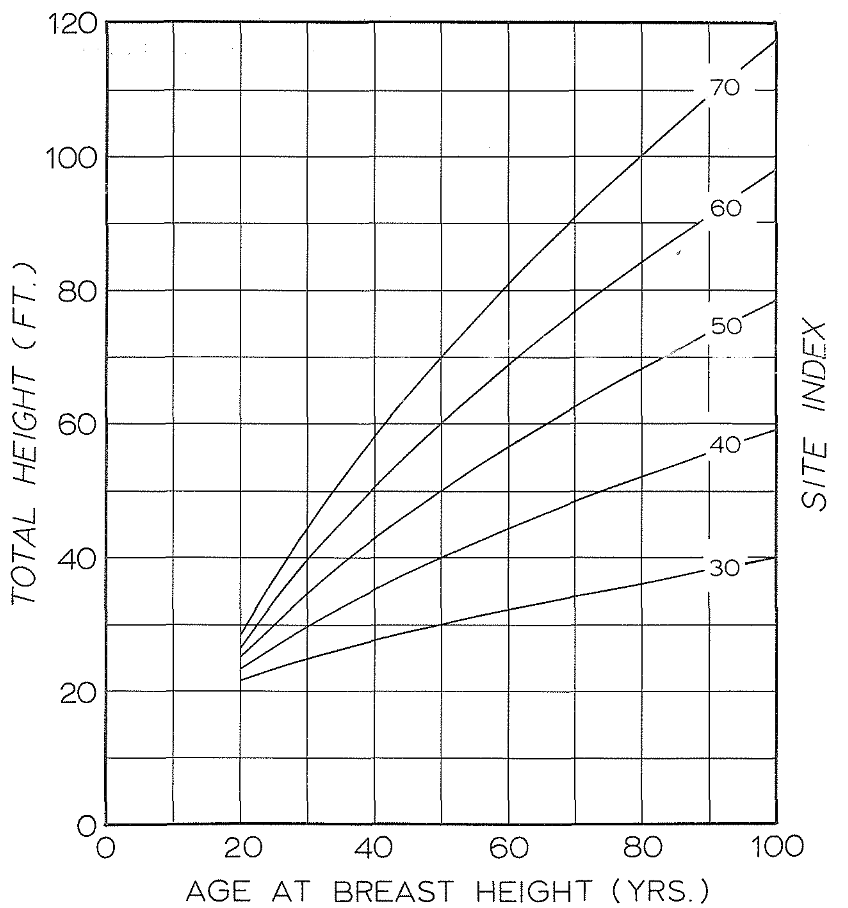

Figure 2—*Site index curves for unmanaged stands of California black oak.*

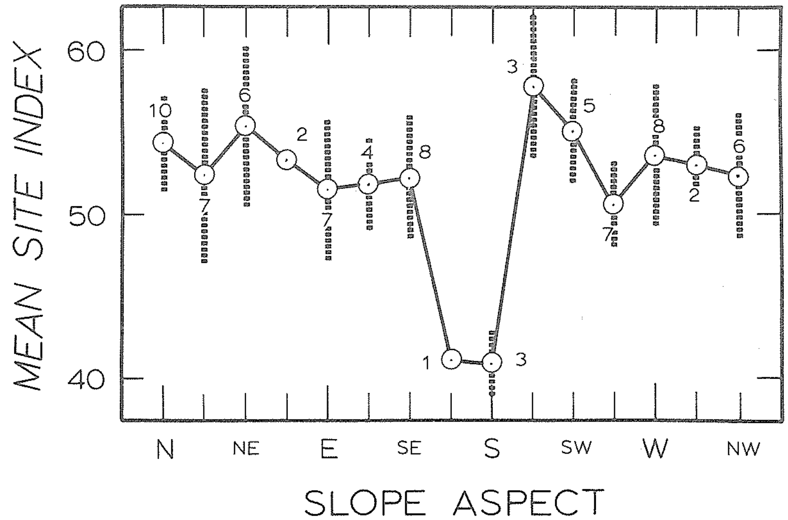

Figure 3—*Effect of slope aspect on site index of California black oak. The number of sample plots is shown in each aspect class. Vertical bars show one standard error of the plot means. NNW aspects were not sampled.*

Except on south-facing slopes, aspect had little effect on site index of black oak *(fig. 3)*. Soil moisture and profile development are probably limiting factors on southerly aspects, though latitude and altitude may modify these effects.[1]

Site index of black oak may be estimated from the site index of ponderosa pine by the equation:

$$S_{oak} = -78.66 + 67.18 \log_{10} S_{pine}$$

in which

S_{oak} = site index of black oak at index age 50

S_{pine} = site index of ponderosa pine at index age 50.

As site index of ponderosa pine improves, site index of black oak increases at a lessening rate and then appears to level off at pine site indices above 100. Although the regression of site class means indicates a consistent and significant trend ($r = 0.84$), variation within the 11 means limits the usefulness of one species in predicting the growth potential of the other *(fig. 4)*. This variation may result from (a) lack of suitable ponderosa pine site trees on the black oak plots, or (b) dissimilar silvical requirements for the two species.

Application

In using the curves in *figure 2*. . .

1. Select at least five well-formed dominant trees from representative portions of the stand. Avoid selecting more than one tree per clone, as over-sampling a single genotype can bias stand site estimates.

2. Measure total height of each tree. Curving oak crowns promote measurement error, so stand far enough from each tree to be certain of the highest point.

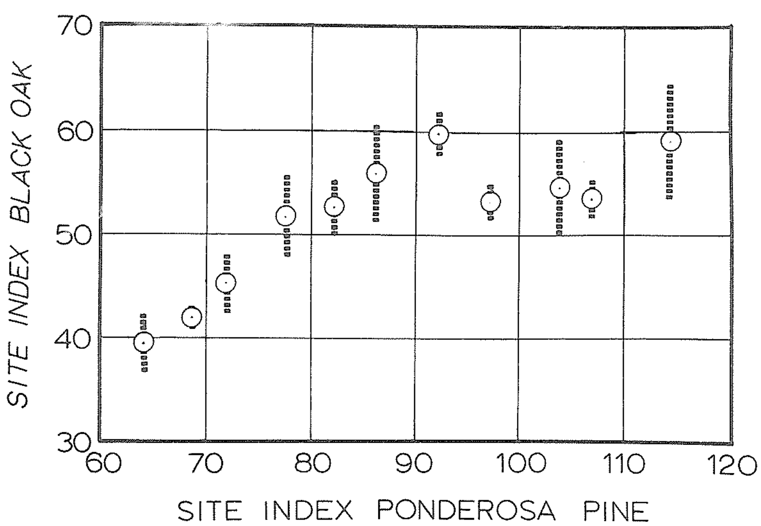

Figure 4—*Site index relationship of black oak to ponderosa pine at index age 50 years. Vertical bars show one standard error of the plot means.*

3. Determine the breast-height age of each tree. Rings are counted easily on radially-shaved cores by using 5X magnification. Increment borers will dull quickly on this species and should be sharpened frequently.

4. Determine the site index of each tree independently and average the indices to estimate the stand site index.

Site curves developed from this study should be useful in estimating the growth potential of California black oak in even-aged unmanaged stands of the Sierra Nevada and southern Cascades between 39° and 41° north latitude. These curves can be refined and extended if future economic prospects favor intensive management of the species.

NOTES

[1]McDonald, Philip M. *Silvical characteristics of California black oak (Quercus kelloggii Newb.).* USDA Forest Serv. Res. Paper PSW-53. Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 20 p., illus. 1969.

[2]Malcolm, F. B. *California black oak–a utilization study.* U.S. Forest Serv. Forest Prod. Lab. Rep. 2237. 17 p. 1962.

[3]Porter, Dennis R., and Harry V. Wiant,Jr. *Site index equations for tanoak, Pacific madrone, and red alder in the redwood region of Humboldt County.* J. Forestry 63(4): 286-287. 1965.

[4]Edwards, Milton B. *California black oak–its management and economic possibilities.* J. Forestry 55(7): 506-510. 1957.

[5]Trimble, G. R., Jr. *Multiple stems and single stems of red oak give same site index.* J. Forestry 66(3): 198. 1968.

[6]Foster, Ralph W. *Relation between site indexes of eastern white pine and red maple.* Forest Sci. 5(3): 279-291. 1959.

[7]Powers, Robert F. *Estimating site index of ponderosa pine in northern California . . .standard curves, soil series, stem analysis.* (MS. in preparation.)

[8]Dunning, Duncan, and L. H. Reineke. *Preliminary yield tables for second-growth stands in the California pine region.* U.S. Dep. Agr. Tech. Bull. 354. 23 p., illus. 1933.

[9]Arvanitis, L. G., J. Lindquist, and M. Palley. *Site index curves for even-aged young-growth ponderosa pine of the westside Sierra Nevada.* Calif. Forestry & Forest Prod. 35. 8 p., illus. 1964.

[10]Roy, D. F. *Hardwood sprout measurements in northwestern California.* U.S. Forest Serv. Calif. Forest & Range Exp. Sta. Forest Res. Note 95. 6 p., illus. 1955.

The Author

ROBERT F. POWERS is doing research on the silviculture of the Sierra Nevada conifer types project, with headquarters at Redding, California. He joined the Station's staff in 1966, after earning a B.S. degree in forestry at Humboldt State College.

The Forest Service of the U.S. Department of Agriculture

. . . Conducts forest and range research at more than 75 locations from Puerto Rico to Alaska and Hawaii.

. . . Participates with all State forestry agencies in cooperative programs to protect and improve the Nation's 395 million acres of State, local, and private forest lands.

. . . Manages and protects the 187-million-acre National Forest System for sustained yield of its many products and services.

The Pacific Southwest Forest and Range Experiment Station

represents the research branch of the Forest Service in California and Hawaii.

☆ U. S. GOVERNMENT PRINTING OFFICE 794–235/4205