

IMPLICATIONS OF SITE QUALITY FOR EASTSIDE
PONDEROSA PINE

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ABSTRACT

Proper use of a site index system, combined with reasonable stocking levels and good estimates of growth rates, is necessary for sound management of ponderosa pine (Pinus ponderosa Dougl. ex Laws.) on the east side of the Cascade Range or the Sierra Nevada. Various site index systems and their uses are discussed. Stocking levels designed to prevent serious problems with mountain pine beetle are given, and tentative equations for growth rates based on site index, age at breast height, and stocking levels are presented.

INTRODUCTION

Estimates of the ability of a given area of land to produce wood are fundamental to the practice of forestry. Volume production is closely related to height growth, and the most common method of rating site quality is the use of a site index system that provides comparison of attained heights at a standard reference age. Determination of site index by the various methods is often incorrect because the methods are not well understood. We believe the proper use of the site index system outlined by Barrett (1978), combined with reasonable stocking levels and estimates of growth rates, can provide a sound basis for management of even-aged ponderosa pine on the east side of the Cascade Range and the Sierra Nevada.

SITE INDEX SYSTEMS

Site index is the height of some specified component of the stand at some defined age. Heights used in various site index systems include heights of the dominants, average heights

of the dominants and codominants, average heights of a specified number of largest diameter trees per unit area, height of the single tallest tree on one-fifth acre, and the height equivalent to the quadratic mean diameter of the dominants and codominants. The reference age (usually 50 or 100 years) can be the total age or age at breast height of the stand or the trees measured for height. In practice, it is extremely important to determine the site index exactly as directed in the publication describing the curves. For example, Meyer (1961) recommends constructing a height over diameter curve for the stand, computing the average diameter of the dominant and codominant trees from a stand tally, and reading from the height curve the height corresponding to this average diameter. This height, along with the average total age of the dominant and codominant trees, is then used to read the site index from Meyer's set of curves. This detailed procedure is seldom followed in the field by users of Meyer's system. Barrett's (1978) system uses the measured height of the tallest tree on a 1/5-acre plot, and the average measured age at breast height of the three tallest trees on the plot. This height and age are then used with a figure or a formula from his publication. Barrett's procedure is simpler than Meyer's, but in the field users commonly underestimate the site index unless the plots are carefully selected. Underestimation of site index results from failure to appreciate the influence of stand density on height growth. Plots must be selected from areas where density levels have not decreased height growth in the past. This plot selection, described by Barrett, is essential in most current stands that have not been continually managed since their inception.

Differences exist between height growth curves and site index curves (Curtis et al. 1974). Height growth curves describe total height as a function of site index and age. Height growth curves are used in the construction of managed yield tables to predict the course of height growth with time for a known site index. Site index curves describe site index as a function of height and age. Use of height growth curves to determine site indexes can result in serious errors at ages much lower or higher than the index age (fig. 1).

SITE INDEX, STOCKABILITY, AND STOCKING LEVEL

Site index values are often used in combination with ages to define yields that sites are capable of producing at "full stocking" where there is a near maximum number of trees per unit area. Stockability, however, varies from place to place in areas with the same site index. Two concepts are important to recognize in dealing with site index and stockability. First, pine stands develop in such a way that they are not fully stocked at all times. Second, maintenance of full stocking for any length of time reduces the growth of salable stems and is an invitation to disastrous outbreaks of mountain pine beetles. Therefore, the ability of site index to predict yields associated with full stocking levels is not nearly as important as the ability of site index, in combination with managed levels of stocking, to predict growth and yield.

For reasons not fully understood, susceptibility to damaging levels of mountain pine beetle is somehow related to stocking levels within broad ranges of site quality as defined by site index. Therefore, two sets of stocking level curves have been developed for the eastside pine type (Barrett 1979). One set (fig. 2) applies to site indexes of 90 feet or better, and the other set is used for site indexes of 80 feet or lower (fig. 3). The stocking level curves have been developed from experience, and the upper limit of stocking is set to avoid problems with mountain pine beetle. At the lower site indexes, carrying fewer trees for a given quadratic mean diameter is recommended to avert beetle outbreaks.

SITE INDEX, STOCKING LEVELS, AND GROWTH

Development of equations to predict growth rates as a function of site index, age and stocking requires quantification of stocking levels. Donald DeMars (Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, personal communication) has computed the number of trees per acre (N) as a function of the quadratic mean diameter (diameter of the tree average basal area) (Dg) for the normal or fully stocked stands sampled by Meyer (1961). A least square fit by Meyer's data is

$$\ln N = 9.9657 - 1.7654 \ln Dg; \quad (1)$$

where the symbol \ln refers to natural logarithms. We describe stocking levels as fractions of normality. The fraction of normality for a stand or a plot is the actual number of trees per acre divided by the number of trees per acre a "normal" stand would have at the same quadratic mean diameter (equation 1).

We used data from control plots of fertilizer studies in thinned stands, levels of growing stock studies, and some other studies where basal area and volume growth had been carefully assessed to determine periodic annual growth as a function of site index (Barrett 1979), stand age at breast height, and fraction of normality. Data from 75 plots were used. Five of these plots were 0.1 acre in size, 17 were 0.2 acre, and the remainder were at least 0.4 acre. All plots had buffer strips of at least 33 feet. The plots were located in at least five different plant communities on pumice, ash, and residual soils in central and eastern Oregon. Breast high ages ranged from 29 to 106 years, site index values from 57 to 121 feet, and stocking levels from 0.13 to 1.0 normal.

We found periodic annual basal area increments (PABI) and periodic annual volume increments (PAVI) over 5-year periods to be related to site index (S), age at breast height at the start of a 5-year period (A), and the fraction of normality (N1/N) at the start of the 5-year period. N1 is the number of trees per acre, and N is the number of trees per acre in a fully stocked stand at the same quadratic mean diameter.

Stepwise regression techniques with natural

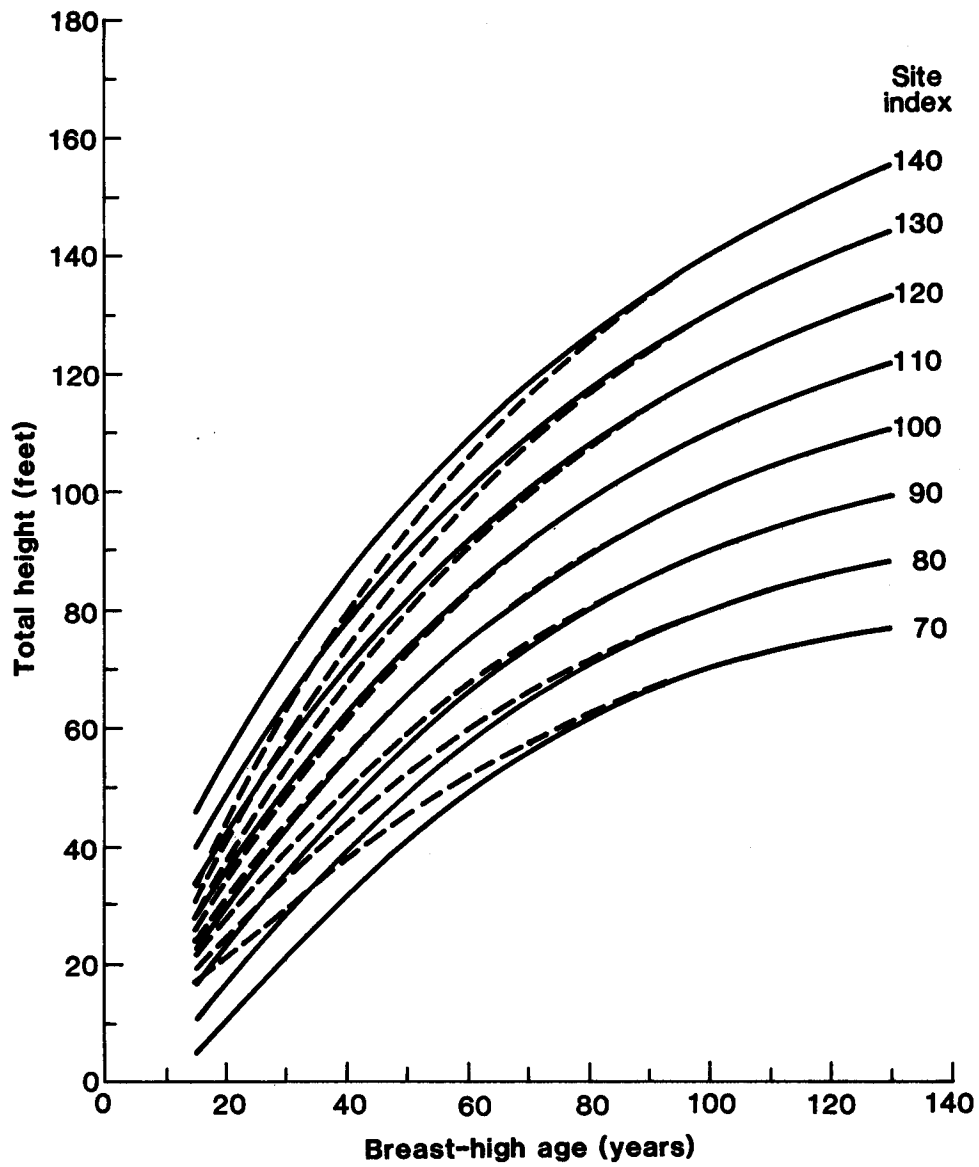


Figure 1.--Site index (solid lines) and height growth curves (dashed lines) for even-aged managed stands of ponderosa pine in the Pacific Northwest.

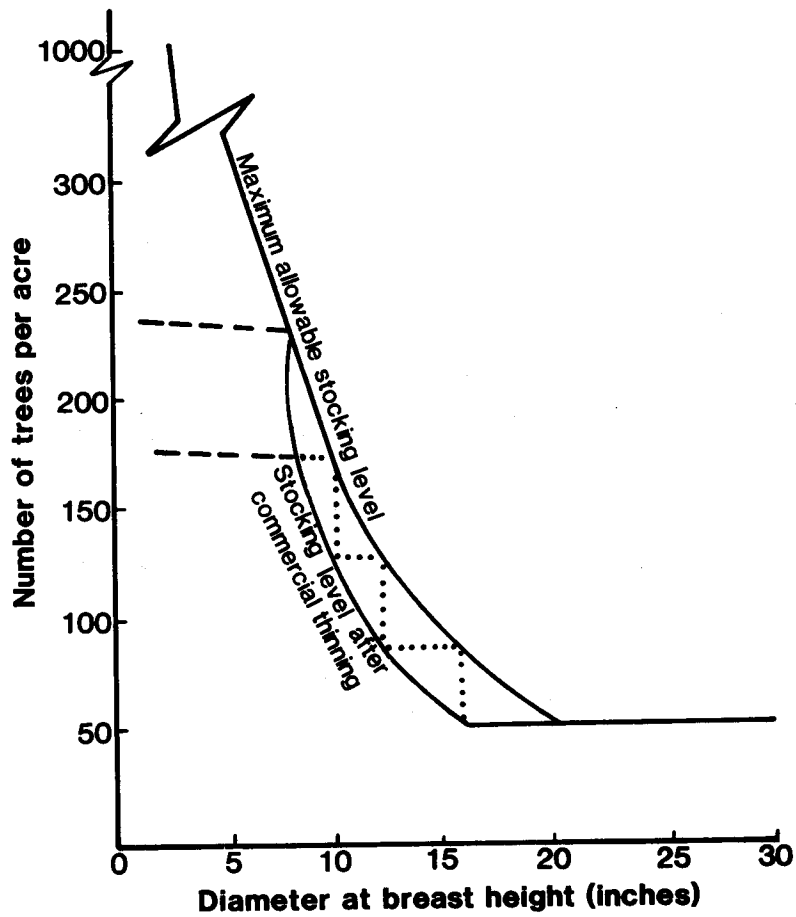


Figure 2.--Stocking level curves for ponderosa pine where site index is 90 feet or better (Barrett 1978). Precommercial thinnings to 180 and 240 trees per acre are represented. Slopes of dashed lines show assumed rates of mortality. The dotted lines depict growth and commercial thinnings.

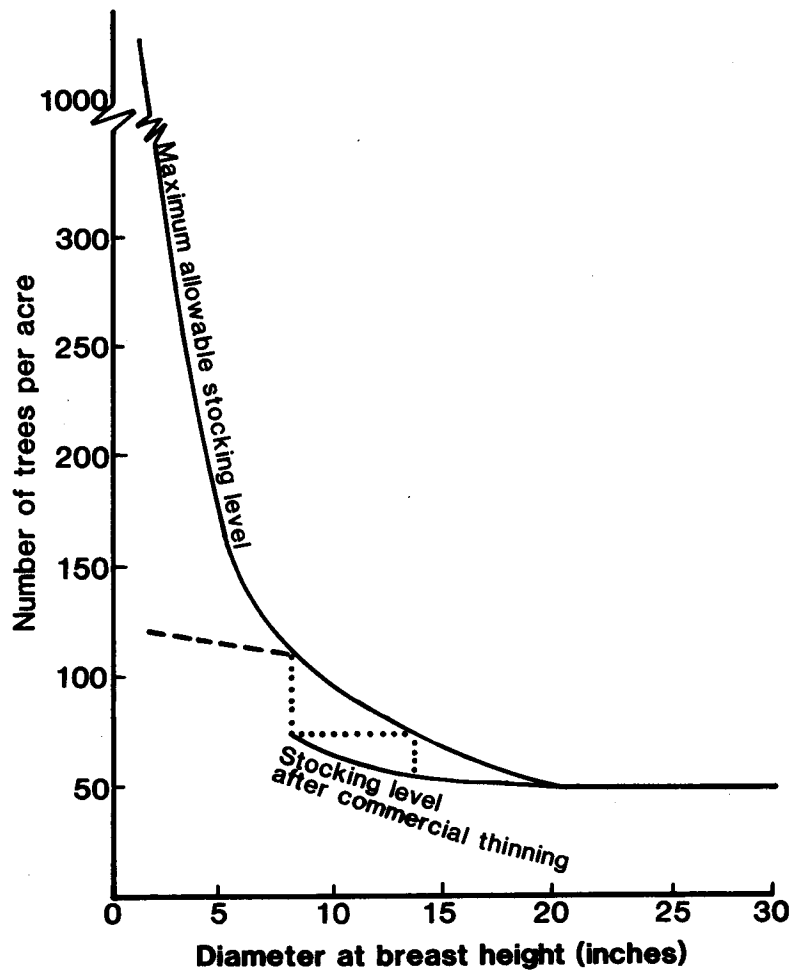


Figure 3.--Stocking level curves for ponderosa pine where site index is 80 feet or lower (Barrett 1978). A pre-commercial thinning to 120 trees per acre is shown. The slope of the dashed line represents an assumed mortality rate after precommercial thinning. The dotted lines depict growth and commercial thinnings.

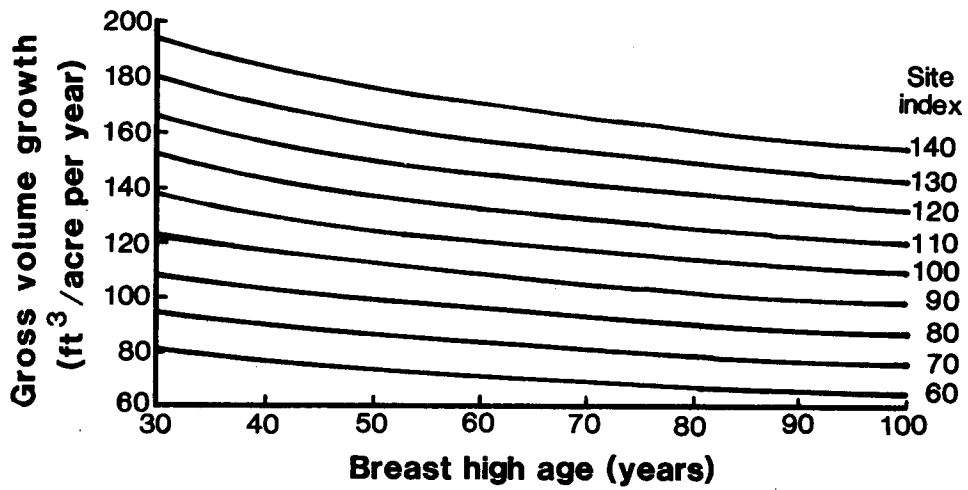
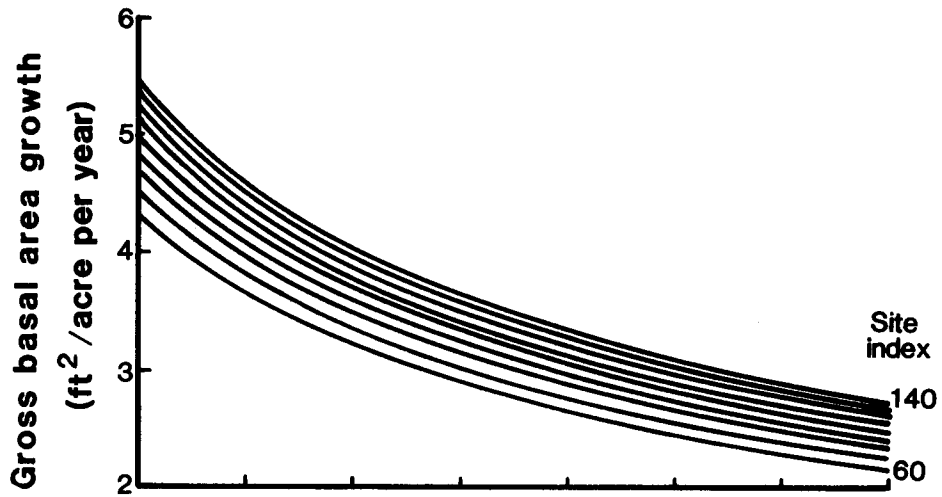


Figure 4.--Gross periodic annual increments (PAI) at full stocking.

logs of the variables produced:

$$\ln \text{PABI} = 2.3104 + 0.3776 \ln (N1/N) - 0.5787 \\ \ln A + 0.2731 \ln S, \quad (2)$$

and

$$\ln \text{PAVI} = 0.8746 + 0.5993 \ln (N1/N) - 0.1952 \\ \ln A + 1.02359 \ln S. \quad (3)$$

The correlation coefficient, R^2 , is 0.66 for both equations; the standard error is 0.18 for equation (2) and 0.29 for equation (3). These equations are gross periodic annual increments (fig. 4). Either mortality did not occur or trees that died during the period were considered live for calculation of volume and basal area at the end of the period. The low R^2 values indicate other sources of variation in these gross periodic annual increments besides those described by the independent variables; for example, the 5-year period was not the same for all 75 plots and growing conditions varied by period. Also, the amount and nature of the competitive understory vegetation varied greatly over the five areas where the plots are located.

Equations (2) and (3), which are being tested with independent data, do describe growth in terms of variables that can be measured or controlled. These or similar equations (see Oliver, this publication) or better ones that will come with more work should provide the basis for predictions of future growth of even-aged stands.

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