Silvicultural Factors Affecting Sawlog Quality of Loblolly Pine

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Abstract. A series of 47 uncut, ¼-acre plots of insect- and disease-free even-aged pure loblolly pine in Georgia, South Carolina, and Virginia were selected for use in assessing the effects of age, site index, and density on sawlog quality. Plot ages ranged from 25 to 93 years, site indices from 52 to 104 feet, and stand densities from 102 to 179 square feet of basal area per acre of stems 0.6 d.b.h. and larger. The index of sawlog quality was "K"/MBF where "K" equals the number of overgrown knots, plus the sum of diameters of sound exposed knots, plus twice the sum of diameters of unsound knots. The best fit of 2 stepwise regression analysis resulted in the following equation: Log "K"-count/MBF = 3.313940 − .013522(Age) − .000185 (Age × Site) Approximately 89 percent of the variation about the mean was accounted for by this expression.

TIMBER QUALITY appraisals of southern pine are complicated by the variety of end products that may be produced from a single stand. The problem is simplified—if not solved—when a single product group, such as yard lumber, is used as a reference base for log or tree quality.

Past efforts in the field of timber quality appraisals have produced the Interim Log Grades for Southern Pine.[1] These grades are simple to use and have given reasonable results in stratifying logs into value classes. Although they were originally designed for grading individual logs, they have been successfully used in making appraisals of standing timber either by direct application of the log grades or by using them as a basis for tree grades. Log grades and tree grades are time-consuming and difficult to apply to standing timber. Each graded tree must be carefully inspected and the values of the individual trees accumulated to arrive at an estimate of the value of the entire stand. While this procedure will give an estimate of the present value, another disadvantage of tree grading is that it cannot be readily adapted for estimating the future value of a stand.

For some time we have had techniques for estimating or predicting stand volumes that do not require tree-by-tree measurements. With yield tables based upon age, site, and stand density we can estimate or predict stand volumes. To the extent that sawlog quality is correlated with these variables, we may be able to bypass log and tree grades and make a direct estimate of stand quality. Obviously a quality estimate based upon a few stand parameters will not be as accurate as an estimate based upon a tree-by-tree examination. The stand estimate may have two advantages, the lower accuracy per plot could be offset by the lower cost of the estimate and the method can be used for predicting changes in quality with time.

This approach is not new, for all of us instinctively classify any stand we see. It is not difficult to accept the idea that a well stocked, mature stand on a good site will have sawtimber of higher quality, as well as higher volumes, than an understocked young stand growing on a poor site. The problem is to settle on a quantitative measure of timber quality and to find stand attributes that will serve as reasonably accurate predictors of stand quality. One of the early efforts to measure the effect of stand conditions on the quality of white pine was hampered by the absence of a measure of timber quality.[2] In a recently completed study of Douglas-fir, Grah investigated the effects of stand density on knot size and log quality but did not sample a range of ages or sites.[3]

The most comprehensive work to date has been by Hopkins in Louisiana.[4] He found that the quality of loblolly pine was related to age and to the presence of subdominant hardwoods. Although he tested stand density and site index, neither proved to be significantly related to pine quality in his analysis.

The present study was prompted by the experience gained in the development of the Interim Log Grades for Southern Pine and the success of our long-term growth studies in loblolly pine. During the development of the log grades, it was obvious that the value yield per unit outturn of yard lumber depends largely on log diameter and the aggregate size and number of knots present. In the growth studies it was equally obvious that tree size and stand volume or growth can be estimated using age, site, and stand density. It was a relatively simple matter to select an index of sawlog quality and relate it to these three variables.

Methods and Results

A series of 47 uncut, ¼-acre plots of insect- and disease-free, even-aged, pure loblolly pine covering a wide range in age, site index, and stand density were selected in the lower Piedmont of Georgia, the low country of South Carolina, and Tidewater Virginia[5] in 1949-1950.

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[1]U. S. Forest Service. Interim log grades for southern pine (based on unit value of yard lumber outturn). A cooperative publication by the Southern and Southeastern Forest Expt. Stations, Region 8, and the Forest Products Laboratory. 18 pp. 1953.

[2]Tarbox, E. E., and P. M. Reed. Quality and growth of white pine as influenced by density, site, and associated species. Harvard Forest Bul. 7. 46 pp. 1924.

[3]Grah, Rudolf F. Relationship between tree spacing, knot size, and log quality in young Douglas-fir stands. Jour. Forestry 59:270-272. 1961.

[4]Hopkins, William C. Relation of stand characteristics to quality of loblolly pine. La. State Univ. Bul. 517 27 pp 1958.

[5]Plots were located on the Westvaco Experimental Forest, maintained by the West Virginia Pulp and Paper Company near Georgetown, S. C., and on the Camp Experimental Forest, maintained in Surry County, Va., by the U. S. Forest Service in cooperation with the Union Bag-Camp Paper Corporation. Plots were also located on the Hitchiti Experimental Forest near Macon, Ga., and the Santee Experimental Forest near Charleston, S. C.

By 1959-1960, plot ages ranged from 25 to 93, site indices from 52 to 104, and stand densities from 102 to 179 square feet of basal area per acre of stems 0.6 inch d.b.h. and larger. Unfortunately, no data were available for stands with densities of less than 102 square feet of basal area—the stands where density might have the greatest effect on the number and size of limbs and knots. Board-foot volumes (International ¼-inch rule) were calculated for all pine stems 9.6 inches d.b.h. and larger.

Following the 1960 growing season, all knots in the entire 16-foot butt log of all sawtimber trees were classified as overgrown, sound, or unsound and a "K"-count per tree and per plot was calculated.

"K" equals the number of overgrown knots, plus the sum of diameters of sound exposed knots, plus twice the sum of diameters of unsound knots. Knot diameters were to be the nearest whole inch at the point of trimming.

Overgrown knots are defined as any invisible branch or stub buried beneath the log surface but indicated by a surface bump or disturbance of bark pattern. A sound knot is any visible branch, stub, or socket which contains neither advanced decay extending to the log heart nor any hole larger than one-quarter of an inch penetrating more than 2 inches. An unsound knot is any visible branch, stub, or socket not conforming to definition of a sound knot.

"K"-count per plot was divided by total board-foot volume (International ¼-inch rule) to obtain a "K"-count/MBF and to establish an equal base among plots.

The relationship of "K"-count/MBF to age, site index, and total basal area per acre was obtained by a stepwise regression analysis of the variates using the model form:

$\text{Log } Y = b_0 + b_1A + b_2D + b_3S + b_4AD + b_5AS + b_6SD$ (1) where

Y = "K"-count/MBF

A = stand age

D = stand density expressed as total basal area per acre of stems 0.6 inch d.b.h. and larger

S = site index

The best fit from this screening indicated significance of the age term and the age-site interaction (Table 1). The resulting equation can be expressed as:

Log "K"-count/MBF = 3.313940−.013522 (Age − .000185 (Age × Site) (2)

The results are shown graphically in Figure 1. Approximately 89 percent of the variation about the mean was accounted for by this expression.

TABLE 1.—ANALYSIS OF VARIANCE FOR EQUATION (2)

Source	D. F.	Sums of squares	Mean square	F
Age × site	1	88.851	88.851	323.09**
Age	1	4.834	4.834	17.578**
Age × stand density	1	.647	.647	2.353
Stand density	1	.380	.380	1.382
Site	1	.036	.036	
Site × stand density	1	.023	.023	
Error	40	10.955	.275	
Total	46			

**Indicates significance at 1 percent level.

Discussion

The general effect of age on timber quality has long been known—for many people the term "old growth" is synonymous with high quality. The interim log grades for southern pine recognize log size, a factor highly correlated with age as a criterion for quality. The results of this study are in agreement with Hopkins' finding that age was the most significant stand characteristic correlated with loblolly pine quality.

The age-site interaction in this analysis merely indicates that the differences in "K"-count/MBF among site classes may be greater at young ages than at older ones. For example, between site index 50 and 100 there is a difference in "K"-count/MBF of 228 units at age 25, but the difference at age 90 is only 16 units. This relationship is not difficult to explain. Although the differences in volume per acre may increase with age, the "K"-count will continue to diminish on all sites as the knots are overlaid with a shell of clear wood. The "K"-count cannot be less than zero, so the differences among sites do become smaller with age. This effect of the age-site interaction on "K"-count/MBF cannot be extrapolated to quality per se, where the more rapid growth on the better sites may maintain the differences in quality among sites.

"K"-count/MBF was also significantly related to site index in a

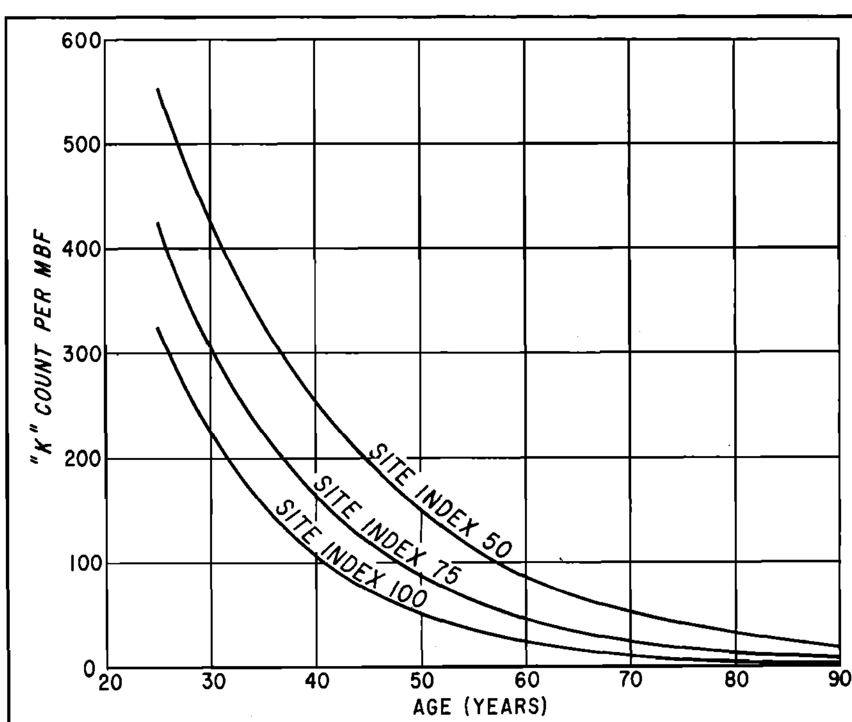

FIG. 1.—The relation of "K"-count/MBF to age and site index in uncut stands of loblolly pine.

simple correlation analysis of the two variates, although the simple correlation only accounted for 10.3 percent of the variation about the mean. The important point in both analyses is the indication that there are real and measurable differences in timber quality due to site.

The lack of a correlation with stand density was not unexpected with these data. None of the plots had a total basal area below 102 square feet of basal area per acre. This value is apparently above the threshold where stand density might be expected to have an effect on knot size and distribution. Had data been available from stands with lower basal areas, it seems likely that density would have affected quality.

One of the obvious defects of this study is the estimate of timber quality based upon data from only the butt log. Although it is recognized that each 16-foot log of loblolly pine is usually one grade lower than the log below it, some bias was introduced because there is less volume above the butt log on poor sites than on good sites. The high proportion of volume in the butt log on all sites, however, should mitigate against a serious influence from the lack of a quality measurement of upper logs.

Timber quality as indicated by "K"-count within the ¼-acre plots and its standard deviation were quite uniform. The standard deviation of "K"-count/tree was above 10.0 in only one plot out of 47 ($\bar{x} = 31.0$), and standard deviations of "K"-count/tree of less than 5.0 were not uncommon.

TABLE 2.—COMPARISON OF "K"-COUNT IN YOUNG AND OLD STANDS ON HIGH AND LOW SITES AT PRESENT AND WITH THE REMOVAL OF 40 SQUARE FEET BASAL AREA PER ACRE BY THINNING FROM BELOW

Stand conditions	Age	Site	Present "K"-count/MBF	"K"-count/MBF after thinning
Young, high-site	34	97	180	149
Young, low-site	32	60	492	492
Old, high-site	89	86	5	4
Old, low-site	66	57	64	60

The uniform "K"-count/tree within plots leads us to the conclusion that thinning from below is not likely to have a profound effect on timber quality as expressed by knot count, especially in older stands. The increase in timber quality will be largely from increased volume growth of the residual stand rather than a marked drop in "K"-count/tree attributable to thinning. Progressively reducing stands by 40 square feet of basal area per acre from the smallest diameter classes upward indicates the changes in quality that might be expected by thinning from below. The four plots in Table 2 represent young and old stands on poor and good sites.

The uniformity and relative lack of knots in older stands does not leave much opportunity to upgrade stands by thinning from below. In young stands much of the material removed by thinnings is of pulpwood size, and thus does not directly affect the quality of the crop trees. The upgrading of young stands should be correlated with the number of cutting cycles, a rather small upgrading resulting from any single thinning. This change should be uniform throughout the residual stand and should be predictable. Some promise exists, therefore, for developing stand grades in managed southern pine and studies designed to test this hypothesis are planned.

Obviously, the correlation of timber quality of forest stands as expressed by "K"-count on standing trees is but a first step in the development of a predicting mechanism for loblolly pine stand quality. It is clearly recognized that the quality criterion used here, "K"-count/MBF, is merely an indicator and not a measure of timber quality. Stand quality in terms of lumber grade yield must be related to stand characteristics before such a system could be developed. Despite the many limitations of this study, the fact that nearly 90 percent of the variation in "K"-count/MBF was accounted for by the stand characteristics of age and site—and the intriguing possibilities of a stand quality grading system that is relatively simple, cheap, and meets the requirements of both the timber buyer and seller—makes this approach worthy of further exploration.

Correction

In the article "Soviet Forestry and the 'New Biology'" Volume 63, No. 1, pp 12-19, January 1963 *Journal of Forestry* there occurs a typographical error that changes the author's meaning. On page 14, left column, 5th line from the bottom: "a logical discourse" should read "alogical discourse."