Provisional
GRADE SPECIFICATIONS
For Hardwood Growing-Stock Trees

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GRADE SPECIFICATIONS ARE NEEDED NOW

THE YOUNG TREES that we see growing in our forests today are the trees that we must rely upon to supply our timber needs 25 years from now. We see plenty of these young trees. The question is: How well can we foretell what their quality will be when they mature?

High quality in hardwood trees is measured by the proportion of clear, sound wood that they contain. We can assume that only a portion of the young trees will grow into high-quality sawtimber trees. These will be needed for veneer logs, sawlogs, bourbon staves, handle bolts, and other products that require high-grade material. Those trees that do not grow into grade-1

trees will be used for crossties, pulpwood, and other products for which defect-free wood is not required.

The problem today is to identify those young trees that can be grown to provide the high-quality mature trees of the future. To do this, we need a set of technically sound and readily understandable and applicable specifications that forest managers can use to single out young trees according to their potential for yielding grade-1, grade-2, and grade-3 sawlogs at maturity.

To this end we have evolved a set of provisional grade specifications for hardwood growing-stock trees. Please note that these specifications are only tentative. They must be evaluated by examining the performance of graded trees for many years. As our experience increases, we can refine and modify the grade specifications. Meanwhile, tentative as they are, they provide a tool that we can use.

THE OPPORTUNITY

Today there is a shortage of the large, clear logs needed for fine veneer and high-grade lumber. This shortage is especially acute for select oaks, yellow birch, sugar maple, white ash, black cherry, black walnut, sweet-gum, and yellow-poplar. The supply of big trees from the original old-growth forests is nearly exhausted.

Our big opportunity is to make the best use of the small trees. Our hardwood timber, though smaller, is growing faster than it is being cut. Sixty percent of all forest growing stock of desirable commercial species is in small trees, 7 to 15 inches in diameter breast high (*10*).

Many of these young trees will die as insects, disease, fire, and competition exact their toll. Yet there are enough to provide the basic growing stock for millions of grade-1 hardwood trees. Our opportunity is to select and then to promote the young trees that have this potential.

Meanwhile we already know a lot about the growth of hardwood trees, the identification of defects from their indicators,

and the conformation of logs needed to satisfy the specifications of the Forest Service hardwood sawlog grades. We can compute the volume of lumber from logs and trees by lumber grade.

THE GRADE SPECIFICATIONS

Our grade specifications for growing-stock trees are correlated with the Forest Service grade specifications for hardwood sawlogs (table 1). Our specifications describe three basic grades for trees: growing-stock grade 1, growing-stock grade 2 and growing-stock grade 3. The grades are assigned according to the probability of a tree yielding a grade-1, grade-2, or grade-3 butt log when it reaches 16 inches d.b.h. A tree 16 inches d.b.h. is the smallest tree that will yield a 16-foot grade-1 butt log. We define our tree grades as follows:

- A grade-1 growing-stock tree has an 80-percent probability or better of yielding a grade-1 butt log 12, 14, or 16 feet long.
- A grade-2 growing-stock tree has less than an 80-percent probability of yielding a grade-1 butt log, but a 50-percent chance or better of yielding a grade-2 butt log.
- A grade-3 growing-stock tree has less than a 50-percent

Table 1.—Provisional grade specifications for hardwood growing-stock trees

Growing-stock grades	Grading factors						
	D.b.h.	Crown class	Length of butt log	Scaling deductions	Sweep, maximum	Lean, maximum	Surface defect indicators
	Inches		*Feet*		*Inches*	*Degrees*	*Number*
1	7-15	Dominants and codominants	12, 14, 16	Only sweep admitted	4	4	4
2	7-15	Dominants and codominants	12, 14, 16	Only sweep admitted	6	6	5-17
3	7-15	Dominants and codominants	12, 14, 16	Only sweep admitted	8	8	18-30

probability of yielding a grade-2 butt log, but a 50-percent chance or better of yielding a grade-3 butt log.

Trees are graded according to those factors that will limit the value of lumber products. The grading factors we used are as follows:

D.b.h. (Diameter Breast High)

A growing-stock tree is 7 to 15 inches d.b.h. The upper limit was set at 15 inches because trees 16 inches and larger can yield a grade-1 butt log, and tree grades can be applied to them (*8*). The lower limit of 7 inches d.b.h. was set for two reasons. First, the heart center (*7*) permitted in the smallest allowable grade-1 log has formed by the time the tree reaches 7 inches d.b.h. Second, the number of suppressed buds and epicormic branches decreases rapidly just before the tree reaches this diameter (*1*).

Crown Class

The opportunity for improving tree quality is greater with dominant and codominant trees than with those in the lower crown classes. Only dominant and codominant trees qualify for growing-stock grade 1 and grade 2. Grade 3 admits all crown classes.

Length of Butt Log

Characteristics of the lower 12-, 14-, or 16-foot log are used in the grading specifications. The butt log of hardwoods has the best potential for producing grade-1 logs in the shortest time (*1*). The butt log reaches grade-1 diameter requirements faster than upper logs because hardwood tree stems taper upward, and added diameter is essential to the increase in volume of clear wood. Second logs can qualify for grade 1 only when they reach 16 inches in scaling diameter. Grade-1 second logs demand trees of 22 inches d.b.h. or more. The growing-stock grade is assigned to each tree for the 12-, 14-, or 16-foot butt log according to its potential to yield a grade-1, grade-2, or grade-3 log.

Scaling Deductions

Growing-stock trees are chosen without any defects that will cause a reduction in gross log scale — except sweep. Trees with seams, cracks, splits, rot, and other features that indicate possible decay will not be considered. If admitted, these defects might well increase in time, and the percent deduction in the mature logs could exceed the total scaling deduction allowed in the Standard Hardwood Sawlog Grades.

Sweep

Sweep in a log causes a deduction from gross log scale when it exceeds the taper measurement for a given log. Growing-stock grade-1 trees are allowed to have up to 4 inches of sweep in the butt 12-, 14-, or 16-foot log; grade-2 trees are allowed up to 6 inches, and grade-3 trees are allowed up to 8 inches. These limits are slightly too large for grade-1 and grade-2 logs of the minimum 13-inch scaling diameter, but for logs 14 inches and larger they will fall well within the restrictions contained in the Standard Hardwood Sawlog Grades. Methods for computing log scale deductions for sweep are set forth in *A Guide to Hardwood Log Grading* (7).

Lean

Grade-1 growing-stock trees are allowed to have up to 4 degrees of lean ; grade-2 trees are allowed up to 6 degrees; and grade-3 trees are allowed up to 8 degrees. The effect of lean in a tree is not included in the Standard Hardwood Sawlog Grades as a degrading factor, yet the tension wood nearly always associated with leaning trees may reduce the utility of the wood for some uses. Trees that have less than 4 degrees of lean usually have little tension wood; however, those with 8 degrees of lean or more will have enough to affect the utility of the lumber (*2*, *9*). Thus the permissible lean for grade-1, grade-2, and grade-3 immature trees is limited to 4, 6, and 8 degrees, respectively.

Surface Defect Indicators

Surface features such as knots, birdpeck, insect signs, epicormic branches, adventitious bud clusters, and limbs indicate

log defects (*5*). And on trees 7 to 15 inches d.b.h. these defects will limit the length of clear cuttings in lumber sawed from most merchantable sawlogs. However, exceptions occur. For example, in black cherry, adventitious bud clusters and light bark distortions are admitted in the cuttings. This is done because the indicated small knots (1/8 inch), pith ray flecks, and gum spots are admitted in the designated clear cuttings as defined in the official lumber grading rules of the National Hardwood Lumber Association (*6*).

The presence of most defects in merchantable logs usually is signified by bark distortions and other surface indicators. But bark grows, so indicators lose their usefulness progressively; and in time the indicators may become buried under normal bark growth. It is not always possible to predict the loss of an indicator, the entrance or emergence of a grub, the growth of a new branch, or the feeding of a sapsucker. Changes in the number and location of defect indicators cannot be predicted. Thus, an element of chance is inherent in any system designed to predict future log grades for growing trees. Because of this element of chance, probabilities (table 2) are used to segregate trees for growing-stock grades rather than clear cuttings as for the sawlog grades.

From the Standard Hardwood Sawlog Grade Specifications, it is possible to count the number of defects that limit clear cuttings on the three best faces of the log (*3*) and to determine the probability of a given number of defects limiting these clear cuttings in relation to specified lengths. While developing these specifications (*11*), we found that logs could be grouped reliably according to similar lumber grade yields by combining the minimum length and the number of clear cuttings with the percentage of log length required in clear cuttings and applying this to the three best log faces. The same combining process is used to determine the grade of a board in grading hardwood lumber (*6*).

If we find one defect on one face of an otherwise clear grade-1 log, we cannot lower the log grade from 1 to 2. So, for

logs having 0 or 1 defect indicator and no other degrading features, the probability that these logs will qualify for grade 1 is 100 percent. However, two indicators can be so located that the log grade is 2 instead of 1. The probability that two defect indicators will have just the right position to place the log in grade 2 is less than 1 percent, and the probability is about 99

Table 2.—Probability of the butt 12-, 14-, or 16-foot log with various numbers of defects occurring in one of three standard sawlog grades and the relationship to growing-stock grades.[1]

Number of defects	Standard sawlog grade			Growing-stock grade
	1	2	3	
	Percent	*Percent*	*Percent*	
0	100.0	—	—	
1	100.0	—	—	
2	99.0	—	—	1
3	89.4	10.6	—	
4	80.7	19.3	—	
5	69.7	30.3	—	
6	58.9	41.1	—	
7	44.9	55.1	—	
8	30.2	69.8	—	
9	22.3	77.2	0.5	
10	17.9	81.0	1.1	
11	12.7	82.8	4.5	2
12	9.3	82.7	8.0	
13	6.5	79.5	14.0	
14	3.9	74.2	21.9	
15	1.3	69.7	29.0	
16	—	63.0	37.0	
17	—	55.5	44.5	
18	—	47.5	52.5	
19	—	40.0	60.0	
20	—	32.0	68.0	
21	—	25.0	75.0	
22	—	20.0	80.0	
23	—	14.0	86.0	3
24	—	9.0	91.0	
25	—	5.0	95.0	
26	—	1.0	99.0	
27	—	.5	99.5	
28	—	—	100.0	

[1] Table adapted from Boyce and Schroeder (*3*).

percent that an otherwise perfect log with two indicators will qualify for grade 1 (table 2).

If the two indicators are on the same face, they cancel out because three clear faces remain. If they are on different faces, only one affects log grade, and a choice remains for selecting the three best faces. The chance that both will occur in the same horizontal plane in the tree stem is very slim. Probabilities for 0 to 28 defect indicators were determined for 1,109 logs (3). These probabilities are shown in table 2.

As the number of indicators increases, the probability that a log will qualify for grade 1 decreases. Between 4 and 8 indicators, the addition of one more reduces the probability that the log will qualify for grade 1 by 10 to 15 percent. These numbers constitute the range of most rapid decrease for grade 1 and the most rapid increase for grade 2. These probabilities are determined from the log-grade specifications and not from differences among species. Changes in the log-grade specifications will alter these probabilities.

Grade-1 growing-stock trees have 80 percent probability or better of producing grade-1 butt sawlogs at maturity. Table 2 reveals that grade-1 growing-stock trees can have up to four surface indicators of defect limiting clear cuttings on the butt log when the tree is 16 inches d.b.h. Likewise, grade-2 growing-stock trees can have 5 to 17 indicators, and grade-3 trees can have 18 or more indicators.

SOME PRACTICAL APPLICATIONS

Hardwood sawlogs have a range of values extending all the way from that of the poorest grade-3 log up to that of the largest and best grade-1 log. For yellow birch this spread could make a difference of $240 per thousand board feet at present lumber prices. The yields of No. 1 common and better grades of hardwood lumber produce most of the value of hardwood sawlogs. The Standard Hardwood Sawlog Grades segregrate woods-run sawlogs into the three grades based on the

proportions of No. 1 common and better lumber present. Actually the log grades are best depicted as three bands with a small amount of overlapping at the boundaries between grade 1 and grade 2 and between grade 2 and grade 3 (*11*).

The accompanying yield tables are expressed in terms of percentage of each of the standard hardwood lumber grades (*6*) for each scaling diameter in each of the three sawlog grades. The growing-stock grades are also best depicted by the band concept, with a certain amount of overlapping at the two inner boundaries. Expected lumber grade yields now calculated for the growing-stock grades may be somewhat lower because each tree is graded on the probability that it will produce the same mature grade of log as now assigned to it. These expected yields can be computed by multiplying the probability numbers in table 2 by the appropriate percentage figures taken from the lumber grade yield tales (*11*).

The ranges of expected lumber grade yields for several common hardwoods at 16 inches d.b.h. are shown in table 3. These are minimum figures because they are based on the allowable scaling diameter, 13 inches, for grade -1 logs. Larger logs will produce higher yields because diameter is the most important factor that affects hardwood sawlog grades. And in a group of

Tables 3.—The ranges of expected yields of Number 1 common and better lumber from butt logs of growing-stock trees when 16 inches d.b.h. for some species.

Species	Growing-stock grades		
	1	2	3
	Percent	*Percent*	*Percent*
Yellow-poplar	51-49	44-23	20-18
* Black oak	61-55	51-21	20-13
Red oak (upland)	58-54	51-24	21-9
White oak (upland)	55-51	48-23	20-9
Hard maple	60-55	52-25	23-14
Yellow birch	57-53	50-25	23-10
Sap gum	64-60	58-35	32-22

grade-1 logs, including logs with small, medium, and large scaling diameters, average yields of the better lumber grades will be higher because the yields from larger logs will raise the average for the smaller ones. Any examination of lumber grade yields, including those in table 3, demonstrates vividly the advantage that grade-1 growing-stock trees have over growing-stock trees of grades 2 and 3.

Growing-stock grades provide an effective means for using timber-stand-improvement operations for growing more grade-1 sawlogs. Obviously, grade 1 and grade 2 offer good opportunities to use timber-stand-improvement practices effectively and to return a profit on the investment. Let us consider a few likely applications of the growing-stock grades.

Say that a forest manager wants to increase the diameter growth of trees in an immature hardwood stand. He is willing to invest only in trees with an 80 percent probability or better of yielding a grade-1 sawlog upon reaching 16 inches d.b.h. He instructs his workers to choose for culture only dominant and codominant trees 7 to 15 inches d.b.h. with potential 12-, 14-, or 16-foot butt logs. These trees must show no evidence of defect that may cause a reduction in gross log scale; they must show no more than 4 inches of actual sweep, no more than 4 degrees of lean, and no more than four surface indicators of defects that would limit clear cuttings. With some training and practice most workers can readily apply these relatively simple specifications, and the forest manager will not have to use his time to select the trees or to give constant supervision.

Say that the forest manager decides to invest in trees with a 50 percent or higher probability of producing grade-1 logs at maturity. He merely changes his instructions to include trees with five and six surface defect indicators (table 2). In doing this, he is selecting some grade-2 growing-stock trees along with his grade-1 trees. Thus, table 2 provides the manager with flexibility in selecting the quality of young trees to suit his goals; and at the same time he can maintain the desired stand density.

Say that our forest manager has a surplus of grade-2 trees,

and he wants to prune those that can be changed to grade-1 trees with a minimum investment. Which trees shall he prune? Obviously, he should prune only those trees by which he can substantially increase the probability of their yielding a grade-1 sawlog upon reaching 16 inches d.b.h. Probability figures from table 2 show that the greatest improvement in log quality occurs when the number of log-defect surface indicators is reduced from eight to four. In this range the elimination of a single log defect increases by 10 to 15 percent the probability that the trees will yield grade-1 butt logs.

Thus, pruning efforts should be limited to growing-stock trees that qualify for grade 1 except that they have five to eight branches. New branches may form after the first pruning. But, if only one less branch forms than those originally present, a substantial gain is made in the probability of growing grade-1 logs. With an expectation of increasing the probability of grade-1 log yield by 10 to 15 percent by eliminating a single log defect, the forest manager can justify repeated pruning of selected trees. Pruning of a tree that has only a grade-2 butt log potential should be done only rarely.

A forest manager could also rate a group of young hardwood stands according to their expected yield of grade 1, grade 2, and grade 3 logs when the trees reach 16 inches d.b.h.

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