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Guidelines For Grading Hardwood Logs

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INTRODUCTION TO USFS GRADING RULES

Almost all sawmills purchase logs based on both log volume and log quality. Processing high quality, large logs costs less per board foot of lumber produced, and yields a larger percentage of high grade lumber, than does processing smaller or lower quality logs. Higher grade lumber with lower costs means higher returns; thus, a mill can afford to pay more per board foot of volume for larger and/or higher quality logs than for smaller or lower quality logs.

The log grades presented here were developed nearly 50 years ago by the USDA Forest Service (USFS). The three log grades in the USFS grading system are No.1, No.2 and No.3 - sometimes called F1, F2 and F3, with "F" standing for factory. Most logs will fall into one of these three grades. Two additional "qualities" are also often encountered: a higher grade called "veneer" and a lower grade, "cull." Neither is included in the USFS factory log grading system nor are they discussed here.

The USFS factory log grades - No. 1, No.2 and No.3 - are quite close to the individualized, independently developed, log grades used in many mills in Wisconsin and throughout the East and South. USFS grades, however, offer several distinct advantages to the sawmill:

1. The grades separate logs of the same size by at least 20% in value.

2. The grades allow easy estimation of lumber volume yield by NHLA grade, based upon log size and USFS grade.

3. With price information, value yields for different log sizes and USFS grades are easily computable.

4. The USFS grades provide a basis for a mill to compare its yields from different sizes and grades of logs to actual industry standards.

This paper further explains the potential benefits which can be realized using the USFS hardwood grading rules. The rules are described and illustrated, and grading procedures are explained in detail, including the definitions and treatment of log defects.

IMPORTANCE OF USFS GRADING RULES

The primary intent of developing the USFS grades was to provide at least a 20% value separation between logs of equal size but different grades. This value separation allows the buyer a certain confidence in knowing what to pay for logs. In other words, the buyer knows that a No.1 log is at least 20% more valuable than a No.2 log, which is at least 20% more valuable than a No.3 log.

The value separation arises because different grades of logs produce different grades of lumber. For example, consider a red oak log 16 inches in diameter and 16 feet long (Table 1). Regardless of its grade, the log will produce roughly the same total volume of lumber. However, the volume of lumber in each grade, and therefore the total value of lumber produced, will vary with the log grade.

Note: Another useful rule of thumb available with USFS log grades is that No.1 logs will yield 60% or more of No.1C and Better lumber; No.2 logs will yield 40 to 60% of No.1 C and Better; and No.3 logs will yield less than 40%. (Lumber grades referred to are standard National Hardwood Lumber Association grades.)

Table 1. The average grade and value of lumber produced from 16-inch diameter, 16-foot long red oak logs of three different grades.

Log Grade	Lumber Produced					Value
	FAS & Sel	No.1C	No.2C	No.3C	Total	
	bd ft					\$
1	90	45	34	13	182	173
2	40	64	44	29	177	140
3	12	44	53	56	165	103

Based on \$1225/MBF for FAS and Sel, \$875 for No.1C, \$550 for No.2C, and \$360 for No.3C

Another major benefit of using USFS log grades, and one which is especially valuable with today's small profit margins and high log costs, is the ability to quickly and accurately estimate the volume and value of lumber a log will yield based on its USFS log grade. Following the development of the log grades, formulas were developed to predict lumber production based on the new grading system. Thousands of logs were graded and sawn into lumber, with their lumber tallied by NHLA grades. A simple computer program for personal computers incorporates these data, so that with inputs of small-end diameter, log length, grade, percent defect, and current lumber prices, you can generate accurate estimates for each log of the volume of lumber in each grade and the corresponding value of this lumber (Table 2).

In addition, if both small- and large-end diameters are provided, the cubic foot volume of the logs is calculated. The program, called "LOG," is available at no cost from the author (send a blank, 3-1/4", formatted, DOS disk).

With expected lumber value in hand, we know that the maximum price we can pay for any log is its expected lumber value minus its sawmill production costs. Production costs include energy, labor, equipment depreciation, profit, marketing, taxes, inventory and any other sawmill costs. If we pay the calculated maximum log purchase price, we will achieve the profit level we set in our cost/profit equation. (The cost/profit equation for sawmills is covered in detail in Forestry Facts #70, "Ideas for Increasing Sawmill Profitability.")

Another potential advantage of the USFS grading system is that a mill can compare its lumber yields to industry standards. You can, for example, measure and grade 50 typical logs according to USFS rules and calculate their expected volume yield for each lumber grade. Then, saw the logs and grade and tally their actual yield. The computer model which predicts volume yield is based on average industry yield values. To attain the industry standard, a mill's actual lumber recovery should be at the expected yield. Actual yields below predicted indicate a potential problem in the mill. Although this "check" need not be used for every load of logs purchased, its use from time to time can help fine tune sawmill profitability and efficiency.

GRADING HARDWOOD LOGS

Mastering the USFS log grading system is not difficult, and close adherence to the following guidelines will ensure that grading is accurate.

The key to accurate grading is determining which externally visible bark anomalies, or "defect indicators," are signs of underlying defects and which can be ignored. Note that grading defects are often NOT related to scaling defects. Scaling defects are those defects that reduce the volume of sound wood; grading defects, on the other hand, take away from the appearance or limit the usefulness of the wood.

Clear Cutting Area

The log grading system is based on clear areas called cuttings. To begin grading, the log is divided into four equal sections or faces. Each face is one quarter of the circumference, extending the full length of the log. The faces do not overlap each other; hence, the four faces completely cover the log's exterior surface. The faces can be rotated into the most advantageous position. Usually this means that the faces are rotated into a position that concentrates as many defects as possible into one face. This "worst face" is not considered in grading. Likewise, the best and second best faces are not considered, other than to assure that they are of equal or better quality than the third best face. It is the third best face that is used to establish the grade. (However, often all faces must be inspected to establish which face is actually the third best grading face.)

Log				Lumber Produced				
Grade	Diameter	Length	Volume	FAS & Sel	No.1C	No.2C	No.3C	Value
	in	ft	cu ft		bd ft			\$
1	17	12	20	80	39	27	11	150
2	14	12	14	20	33	28	20	76
2	15	12	16	25	40	31	20	90
2	12	12	11	12	20	23	17	51
3	14	10	10	4	18	27	30	47
3	12	10	9	2	11	20	25	32

The grade of a face is based on the clear areas, or clear cuttings, of the face. A clear cutting is an area that is the full width of the face (that is, one quarter of the log's circumference) and as long as possible without including any defect indicators. The grading rules establish minimum lengths of clear cuttings for each log grade, and maximum number of cuttings permitted on a face (Table 3).

Each log grade requires the cuttings to occupy a minimum percentage of the scaled length (Table 3).

(Note: The entire log length can be used for the cuttings, even though the scaling length may be shorter.) The proportions for various log lengths are calculated in Table 4. As a short cut, remember this: For a No.1 log, "*log length (in feet) times two*" gives the inches that can be lost while maintaining 5/6 of the yield; for a No.2 log, "*length times four*" equals the allowable loss (in inches) to maintain 2/3 yield.

The USFS clear culling requirements for a No.1 face are quite similar to the rules for clear cuttings in FAS lumber grades—minimum length of 7 feet for a clear cutting and clear cuttings occupying 10/12 (or 5/6) of the surface area. Therefore, a No.1 face can be expected to produce FAS (or perhaps Select or FAS-1 face) lumber when sawing begins on this face. For a No.2 face, the rules for clear cuttings are similar to No.1 Common lumber rules - 3-foot minimum length and clear cuttings occupying 8/12 (or 2/3); therefore, a No.2 face will likely initially produce No. 1 Common lumber. Finally, a No.3 face has rules similar to No.2 Common lumber - 2-foot minimum length and clear areas occupying 6/12 of the surface; No.3 faces will produce No.2 Common lumber initially.

Log Grades								
Grading Factors	1			2			3	
Position in Tree	Butt	Any		Any			Any	
Scaling diameter, inches	13-15	16-19	20+	11+ ¹	12+			8
Log scaling length, feet	10+			10+	8-9	10-11	12+	8+
Clear cutting requirements								
Minimum length	7	5	3	3	3	3	3	2
Maximum number in a face	2	2	2	2	2	2	3	No limit
Minimum proportion of log length required in clear cuttings	5/6			2/3	3/4	2/3	2/3	1/2
Maximum sweep & crook								
For logs with less than ¼ of end in sound defects	15%			30%			50%	
For logs with more than ¼ of end in sound defects	10%			20%			35%	
Max, scaling deduction	40% ²			50% ³			50%	
¹ A 10-inch diameter log can be No.2 if it meets all the other requirements for No.1. ² A No.1 log with 41 to 60% scaling deduction is No.2. ³ A No.2 log with 51 to 60% scaling deduction in No.3.								

Log		Proportion			
Length (ft)	5/6	3/4	2/3	1/2	
8	-	6' 0"	-	4' 0"	
9	-	6' 9"	-	4' 6"	
10	8' 4"	7' 6"	6' 8"	5' 0"	
11	9' 2"	8' 3"	7' 4"	5' 6"	
12	10' 0"	9' 0"	8' 0"	6' 0"	
13	10' 10"	9' 9"	8' 8"	6' 6"	
14	11' 8"	10' 6"	9' 4"	7' 0"	
15	12' 6"	11' 3"	10' 0"	7' 6"	
16	13' 4"	12' 0"	10' 8"	8' 0"	
Omitted proportions are not used in USFS grading rules.					

Defects and Clear Areas

Defects, as indicated by bark anomalies or indicators, cannot be included in clear areas. The following guidelines for identifying defects or their indicators are standard:

- A distortion of the bark clearly indicating an overgrown knot is a defect.
- A slight distortion of the bark that is believed to indicate a defect that extends into the wood for a depth of 15% or more of the log diameter is graded as a defect.
- A small distortion of the bark, not clearly an overgrown knot, is not a defect in 15-inch or larger logs.
- Grub holes or other insect holes are defects, with the following exceptions:
 - Logs 16 to 19 inches in diam., disregard every 6th hole
 - Logs 20 to 23 inches, disregard every 5th hole
 - Logs 24 to 27 inches, every 4th hole
 - Logs 28 inches and over, every 3rd hole
- Bird peck is ignored in grade 3 logs. Fresh bird peck (the hole is open and not occluded) is ignored in all grades. Bird peck is a defect in Grade 1 and 2 logs when there are more than four pecks per square foot.
- Bumps are a defect if their height is greater than 1/12 their length (i.e. height to length ratios (H:L) are greater than 1:12). Low bumps have a H:L of 1:12 to 1:6; medium bumps, 1:6 to 1:3; high bumps, 1:3 or greater. Clear cuttings can include 1/4 of the length of a low bump on each end, or 1/8 of a medium bump.
- An adventitious branch 3/8 inch or less in diameter is a defect in logs under 14 inches in diameter. On larger logs, only every other adventitious branch is considered a defect. For soft hardwoods, adventitious branches are not a defect in Grade 3 logs.
- Straight seams, frost cracks, and splits are ignored if they are on the line dividing two faces. Surface seams, cracks and splits are ignored if their depth is less than 15% of the log diameter. Deep seams, not included in the above cases, are defects as follows: If full length, they are a defect. If not, one-third of the length can be included in a

clear cutting (but not at the end of a log); if not showing at the end, one-fourth of each end of the seam can be included in a clear cutting.

- Spiral seams, spiral frost cracks, and spiral splits deeper than 15% of the log diameter are defects.

End Defects

End defects are disregarded if they are in the heart center, the central 40% of the log diameter. The remainder of the log end is divided into two concentric, ring-shaped areas, each of a thickness equal to 15% of the log diameter, called the inner and outer quality zones (Figure 1). Disregard rot, heart check and ring shake that extend into only one quality zone and are within one quadrant. If the defect extends into both outer and inner quality zones, consider it as a defect as follows: If the defect extends full length, it is a full length defect; if it extends partially along a log, one third of the defect (at the end where the defects tapers out) can be included in a clear cutting.

- Holes, bird peck, bark pockets, grub holes, and gum spots are ignored in grade 3 logs. In grade 1 and 2 logs, when the affected area extends more than half the width of a quality zone, and is also present in three quadrants at one end, or two quadrants on both ends, lower the log grade one grade.
- Stain is ignored in grade 3 logs. In grade 1 and 2 logs, stain, including stain in the heart center, is only a defect if the stained area has an effective diameter greater than one-half of the log diameter.

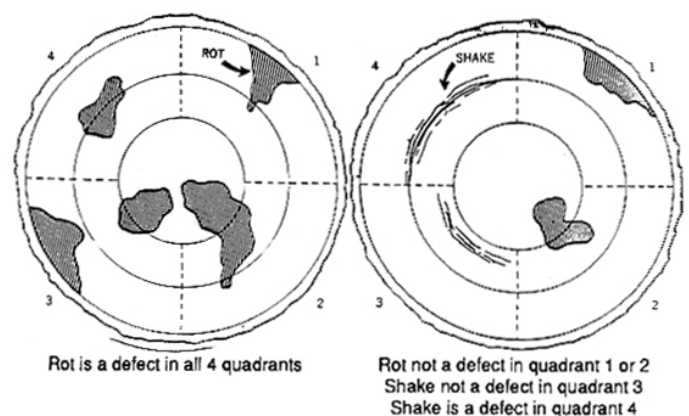


Figure 1. Example evaluation of rot and shake.

Other Considerations

Total allowable sweep and crook are limited according to the rules in Table 3. To assist in calculation of sweep and crook deductions, consult Table 5. There are also allowable total scaling deduction limits, including sweep and crook, permitted (Table 3).

Log Grading Procedures

There are four steps to determining log grade:

1. Measure the average small-end diameter, inside the bark. For oval shapes, average two diameter measurements taken at tight angles to each other - the same procedure as in log scaling. Estimate the diameter of abnormal shapes or sizes.

Measure the log length; any fractional footage is dropped, not rounded up or down. That is, a 12' 10" length is recorded as 12 feet.

2. Establish the location of the four faces, and choose the third best face. (Note: Occasionally, several faces may have to be graded (as in Step 3) to determine which face is the third best.)

3. "Grade" the third best face based on the log size and the clearcutting requirements (Table 3).

4. Adjust the grade determined in Step 3, as necessary, for end defects, excessive sweep and crook, or large scaling deductions (Tables 3 & 5).

Table 5. Sweep and crook deductions, in percent.

Amount of sweep, in.		Scaling diameter							
Log length, ft.		8	10	12	14	16	18	20	22
8,9,10	14,15,16								
-	3	12	10	8	7	6	6	5	5
3	4	25	20	17	14	12	11	10	9
4	5	38	30	25	21	19	17	15	14
5	6	50	40	33	29	25	22	20	18
6	7	62	50	42	36	31	28	25	23
7	8		60	50	43	38	33	30	27
8	9			58	50	44	39	35	32
9	10			67	57	50	44	40	36
10	11				64	56	50	45	41
11	12					62	56	50	45
11,12,13		19	15	12	11	9	8	8	7
3		31	25	21	18	16	14	12	11
4		44	35	29	25	22	19	18	16
5		56	45	38	32	28	25	22	20
6			55	46	39	34	31	28	25
7			65	54	46	41	36	32	30
8				62	54	47	42	38	34
9					61	53	47	42	39
10						59	53	48	43
11						66	58	52	48
12									

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USFS Hardwood Log Grading Rules

A supplement to "Guidelines for Grading Hardwood Logs," Forestry Facts No. 74,
by E.M. Wengert and D.A. Meyer, University of Wisconsin-Madison, Department of Forestry.



CUT OUT ALONG DOTTED LINES, THEN FOLD ALONG SHADED LINES.

Grading Factors	Log Grades		
	1	2	3
Position in Tree	Butt Any	Any	Any
Scaling diameter, inches	13-15 16-19 20+	11+ ¹ 12+	8+
Log scaling length, feet	10+	10+ 8-9 10-11 12+	8+
Clear cutting requirements			
Minimum length	7	3	3
Maximum number in a face	2	2	3
Minimum proportion of log length required in clear cuttings	5/6	2/3	2/3
Maximum sweep & crook			
For logs with less than 1/4 of end in sound defects	15%	30%	50%
For logs with more than 1/4 of end in sound defects	10%	20%	35%
Max. scaling deduction	40% ²	50% ³	50%

¹A 10-inch diameter log can be No.2 if it meets all the other requirements for No.1.

²A No.1 log with 41 to 60% scaling deduction is No.2.

³A No.2 log with 51 to 60% scaling deduction is No.3.

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	1	2	3
Position in Tree	Butt Any	Any	Any
Scaling diameter, inches	13-15 16-19 20+	11+ ¹ 12+	8+
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