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Forest Landowner's Guide to Field Grading Hardwood Trees

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Many forest landowners own hardwood stands and are not aware of the great differences in quality and value between individual trees within these stands. Tree (or log) grade, among other factors, is essential in determining the quality and economic value of hardwood trees. The objective of this fact sheet will be to explain the tree grading process in a simple, straightforward manner.

Why Is Tree Grade Important?

Because grading is the method for estimating the wood quality a particular tree may produce, it provides information for establishing a tree's monetary value. If a landowner is interested in timber production, maintaining higher grade trees is important. The reason for this principle is simple: high-grade trees contain much more economic value than low-grade trees. If a forest landowner is interested in economic return, tree grade is as important as tree volume in determining the rate of return for a hardwood stand.

What Is a Tree Grade?

Tree grade is a measure used to express a tree's wood quality. Grade is determined using the amount of clear wood (defect-free stem length) within the butt-log portion of a tree (Figure 1). The butt-log of a tree is the lowest 16-foot section above the stump height (approximately 1.5 feet). Though the upper-logs may be graded at a sawmill, the butt-log is generally the portion used to establish a standing tree's grade because this portion contains the majority of a tree's economic value. Therefore, this fact sheet will refer to tree grade and butt-log grade interchangeably.

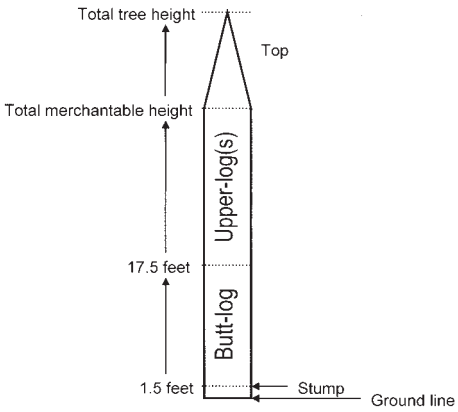

Figure 1. Log locations within the main stem of a tree.

Because grade is the determining factor in establishing the type of sawtimber product (or products) a tree may produce, grades are typically applied to sawlog-size trees (diameter > 12 inches).

Field Grades

Three field grades are used to rank the quality of tree logs: F1, F2 and F3. An F1 tree grade represents stems capable of producing large amounts of high-quality wood products. This means that F1 grade trees will produce a large proportion of wood that can be used for furniture, flooring, dimension lumber and other high-value wood products.

An F2 tree grade represents stems capable of producing some high-value wood products but not enough to be ranked as a grade F1.

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An F3 tree grade represents stems containing a small proportion of high-value wood products. F3 grade stems will often be used for pallet or container material.

If a sawtimber-size hardwood tree does not contain enough quality to make grade F3, it is classified as "no grade" and will either be used as pulpwood, tie-logs, other products or be determined "non-merchantable" (or cull).

Components of Tree Grade

Tree Size

One of the most important aspects of tree grading is the size or diameter at breast height (DBH = diameter of tree at 4.5 feet above ground) of a tree. First, there are differing minimum DBH sizes required for a tree log to be considered an F1, F2 or F3 grade. For example, a tree must have a DBH of at least 16 inches to be a candidate for a grade F1, at least 13 inches for grade F2 or at least 10 inches for grade F3.

Also based on DBH, there are varying lengths of clear wood (defect-free sections) required to make a specific tree grade. For example, a tree with a DBH of 20 inches must have two clear sections of wood that are each a minimum of 5 feet in length to be a grade F1. However, a 16-inch DBH tree would need two clear sections that are a minimum of 7 feet in length. Essentially, smaller diameter trees require longer lengths of clear wood to make a grade.

Scaling Diameter

Scaling diameter (SD) is another important measure used in tree grading. The SD can be defined as the diameter (inside bark) at the small (or top) end of a tree log. It is used to determine how much wood can be extracted from a log. Because it is difficult to obtain this measurement from standing trees, an assumption is applied that the SD is equal to 80 percent of a tree's DBH (Table 1). Therefore, a tree with a 20-inch DBH would have a 16-inch SD ($20 \times 0.80 = 16$). The 80 percent figure refers to a tree's "form class," which expresses the ratio between DBH and SD. Most sawtimber-size hardwood trees have a form class near 80 percent.

Table 1. Estimated Scaling Diameter for Form Class 80 Trees

DBH (inches)	SD (inches)
12	10
14	11
16	13
18	14
20	16
22	18
24	19
26	21
28	22
30	24

Grading Faces

Establishing grading faces is another key component in determining tree grade. Typically four equal sections are established by dividing the butt-log vertically (Figure 2). The first face is established by placing as many defects as possible into one grading face. This grading face becomes the "worst face" because it contains the highest proportion of tree

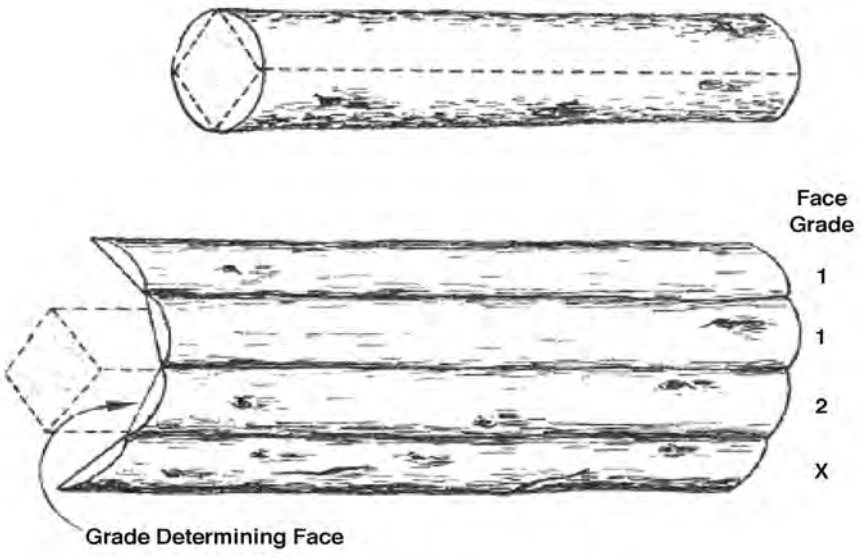


Figure 2. Establishing 4 grading faces on the butt-log. *Source: Rast and others, USDA Forest Service, 1973.*

defects and the least amount of clear wood. The remaining three grading faces are established by vertically dividing the remainder of the butt-log into three equal sections. It is important to note that the second worst grading face of the butt-log will be used to determine a tree's grade.

Tree Defects

Being able to identify tree defects is essential in accurately establishing a tree grade. These defects can include knots, epicormic branching, decay, fractures and/or crook and sweep. Tree defects directly affect tree grade in that they reduce the length of defect-free stem sections in the butt-log.

Knots – Knots are probably the most common defect found on hardwood logs. Knots are simply the remnants of old limbs (Figure 3). As a forest stand develops, some of the lower limbs of trees are shaded and eventually die and fall off. The point on the trunk where the limb prunes itself establishes a knot. All knots are counted as defects, because they affect the wood all the way to the core (or pith) of the stem.

Figure 3. Example of a knot.

Epicormic Branches – Hardwood trees contain dormant buds all along their trunks. Given the right conditions (light, stress and others), these buds are triggered to sprout a new limb on the trunk of a tree called an "epicormic branch" (Figure 4). Timber buyers will usually not grade a tree very high if it contains epicormic branching. However, epicormic branching is often not as severe as it appears. In most cases, the majority of epicormic branches occur above the butt-log of a tree (remember the butt-log contains most of the economic value). Also, epicormic branches must be 3/8 inch in diameter or larger to be considered a defect. On trees with a scaling diameter under 14 inches, every epicormic branch (> 3/8 inch) is considered a defect. On trees with a scaling diameter 14 inches or larger, count every other epicormic branch (> 3/8 inch) as a defect.

Figure 4. Example of epicormic branching.

Stress Fractures – Stress fractures may include frost cracks, seams or splits. The major determination that must be made with a stress fracture is whether or not it is on the surface only or extends into the interior of the trunk. For stress fractures that extend into the interior of the trunk, measure the length affected to be counted as a defect.

Assumptions for Decay, Crook and Sweep – *In standard log grading, crook, sweep and decay are handled by one of two methods: (1) use a series of formulas derived by the USDA Forest Service based on the length and severity of the defect or (2) simply reduce the length of the log so that it does not include the portion with the defect (remembering a log must be at least 12 feet in length). To keep things less complicated, this fact sheet will only demonstrate the formula for sweep (which is straightforward). Crook and decay will be handled by reducing the log length to exclude the defect.*

Decay – Decay or rot may be caused by several factors, but it is always viewed as a defect. Decay may be initiated by fire damage (Figure 5), insects, disease, mechanical damage and/or others. In standing trees, it may be difficult to determine the area of the trunk affected by decay because only the

Figure 5. Example of decay.

exterior damage can be viewed. When establishing the length of the trunk affected by decay, a measure of the length of the exterior decay and an estimate of the length of interior decay should be determined. This portion of the log should be excluded, if possible, and the resulting shorter log is then graded.

Sweep and Crook – Sweep and crook refer to different types of curvature in the butt-log of a tree. Sweep is simply a log that is curved from its base to the top. Figuring sweep can be difficult, but it is easier to calculate with a little background knowledge. The number needed in log grading is the sweep percentage. This percentage is easily calculated by dividing the inches of actual sweep by the diameter at breast height. The inches of actual sweep are determined by imagining a straight trunk and measuring the difference between a straight trunk and the actual trunk (Figure 6).

Crook is similar to sweep except that a portion of the log is straight and turns at one end (Figure 7). As noted earlier, this fact sheet assumes the crooked portion is not included and the resulting shorter log is graded. If greater than 4 feet of the log length is affected by a significant crook, the log is probably not gradable and should be considered a pulp, tie or cull log.

Clear Cuttings

Clear cuttings are sections of clear wood or defect-free stem in a grading face (Figure 8). These sections are used to establish the grade of a particular face. Clear cuttings involve two primary characteristics: (1) the number of cuttings present and (2) the length of each cutting. This information is used in Table 2 to establish a tree grade.

Cumulative Length of Clear Cuttings

The cumulative (total) length of the clear cuttings is the final and most important component necessary to establish tree grade. The cumulative length is simply the sum of the lengths of the clear cuttings within a single grade face. There are different requirements for this measurement based on grade (F1, F2 or F3), log length (12, 14 or 16) and diameter. Determining cumulative length of clear cuttings is described in more detail in the next section.

Determining a Tree Grade

Step 1 – Establish the Butt-Log

Establishing the butt-log portion of a tree is a simple process. First determine the stump height. For most trees, this will be within 1.5 feet from the

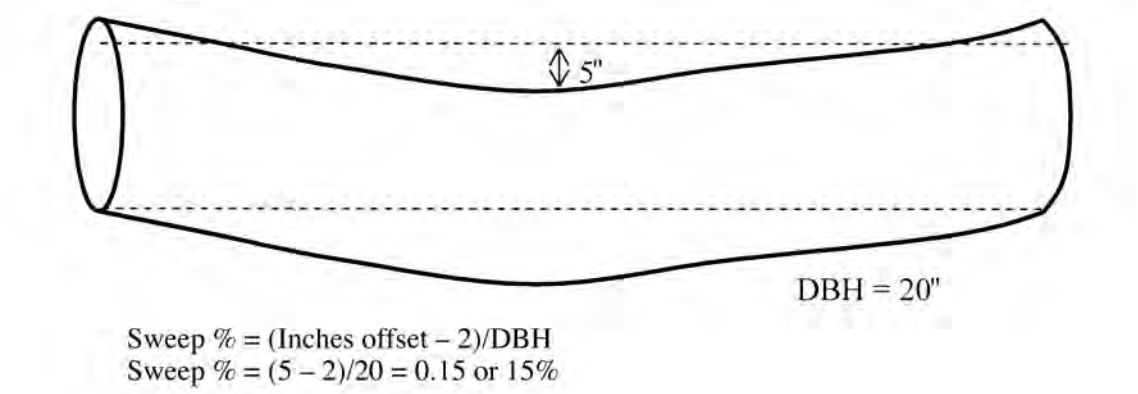


Figure 6. Example of sweep in the butt-log of a tree.

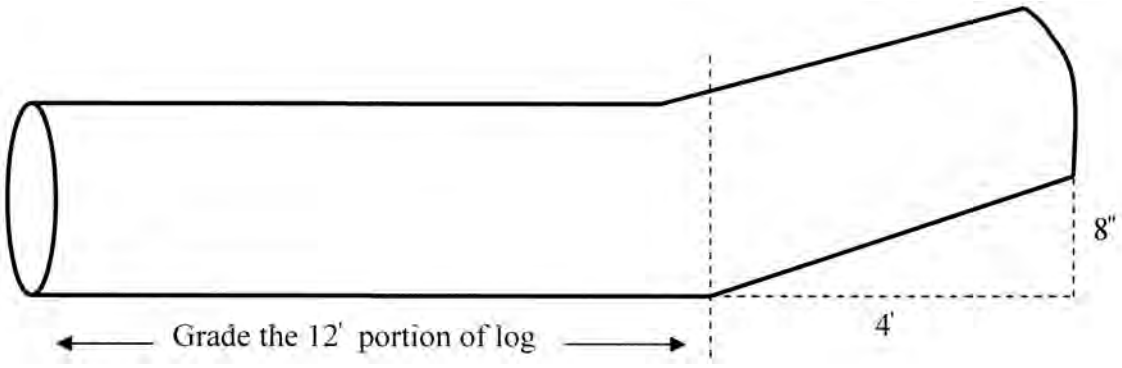


Figure 7. Example of crook in the butt-log of a tree.

ground. Exceptions may occur if a tree has a large amount of swell at the base or if a split trunk is present. For trees with normal taper, simply measure or estimate 17.5 feet from the ground to establish the butt-log (Figure 1). If a tree contains swell or a split trunk, the butt-log will be the first 16 feet above the defect. For grading purposes, it is recommended that the larger of the two split stems is graded.

Step 2 – Determine Scaling Diameter

As described earlier, scaling diameter (SD) is the inside bark diameter of a tree at the top of a log (or small end). For standing trees, this measure must be estimated using a form class.

A. Measure the tree's diameter at breast height (DBH = diameter at 4.5 feet above ground).
   a. Either use a diameter stick, diameter tape or an estimate of diameter.
B. Multiply the DBH times the form class (80%) or use Table 1.

Example: DBH = 20 inches
SD = 20 × 0.80 = 16 inches

16 inches would be the scaling diameter used in Table 2.

Step 3 – Establish Four Grading Faces

A. Find the vertical quarter section of the butt-log containing the most defects.
   a. This quarter section is the worst grading face.
B. Establish remaining three grading faces (Figure 2).
   a. Remember grading faces must be equal size and will differ depending on tree size.

Step 4 – Determine Number and Length of Clear Cuttings on Each Face

A. After establishing the worst grading face (fourth face) and the remaining three grading faces, determine the number of clear sections and their respective lengths.
   a. The worksheet in Example 1 can help with these measurements.

In Example 1, marks are placed on the worksheet that represent defect locations. The clear wood sections are established as areas between defects. Grade face 3 has defects located at 4, 9 and 13 feet above the stump. This grading face contains four sections of clear wood. Section 1 is 3 feet in length, section 2 is 4 feet in length, section 3 is 3 feet in length and section 4 is 3 feet in length.

Step 5 – Determine Second Worst Face (Grade of Second Worst Face Is Tree Grade)

Using a worksheet similar to Example 1 and inputting that information into Table 2, grade and rank the grading faces. Table 2 incorporates all of the measurements to determine the grade of a particular grading face.

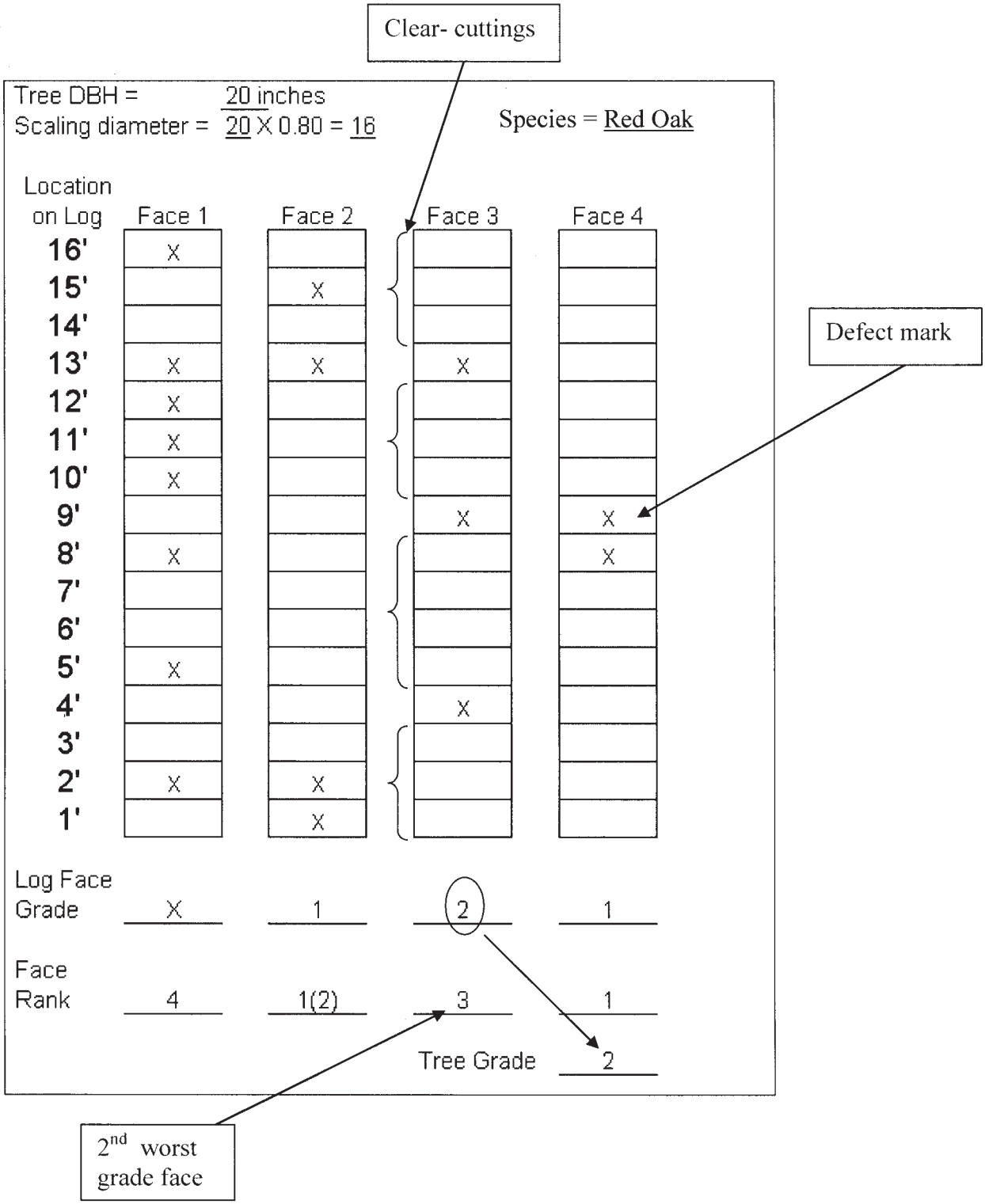
In Example 1, face 3 was ranked as the second worst face, meaning that this would be a grade F2 tree and would have the economic value of a grade F2 red oak. Face 3 contains four clear sections of wood, with lengths of 3, 4, 3 and 3 feet, respectively. This information is used in Table 2 to determine the face grade. In order to make a grade F2, face 3 (SD = 16 inches) must contain 8 total feet of clear wood in a 12-foot section (9.3 feet in a 14-foot section

Table 2. Standard Butt-Log Grades for Hardwood Sawtimber Using the Best 12-, 14- or a 16-Foot Grading Section

Grading Factors		Log Grades				
		Tree Grade 1			Tree Grade 2	Tree Grade 3
Length of grading zone, *feet*		Butt 16			Butt 16	Butt 16
DBH minimum, *inches*		16+			13+	10+
Scaling diameter, *inches*		13	16	20+	12+	8+
Clear cuttings	Minimum length, *feet*	7	5	3	3	2
	Maximum number	2	2	2	3	No-limit
Minimum cumulative length of clear cuttings (12-foot section), *feet*		10	10	10	8	6
Minimum cumulative length of clear cuttings (14-foot section), *feet*		11.7	11.7	11.7	9.3	7
Minimum cumulative length of clear cuttings (16-foot section), *feet*		13.3	13.3	13.3	10.7	8
Maximum sweep and crook allowance		15%			30%	50%

Adapted from USDA Forest Service standard grades for factory lumber logs from Rast et al. (1973).

Example 1. An Example Worksheet for Grading and Ranking Each of the Four Grading Faces



or 10.7 feet in a 16-foot section). The 8 total feet can be accumulated using a maximum of three clear cuttings that are at least 3 feet in length. The first 12 feet in face 3 contain a 3-, 4- and 3-foot section, which totals 10 feet in length. Therefore, this face 3 is at least a grade F2. In order to make grade F1, this face would require two or less clear wood sections at least 5 feet in length that total 10 cumulative feet for a 12-foot section (11.7 feet for a 14-foot section or 13.3 feet for a 16-foot section). Because of these requirements, face 3 could not be a grade F1 and is, therefore, a grade F2. When working with Table 2, always start at grade F3 and work up to the highest grade a face will make.

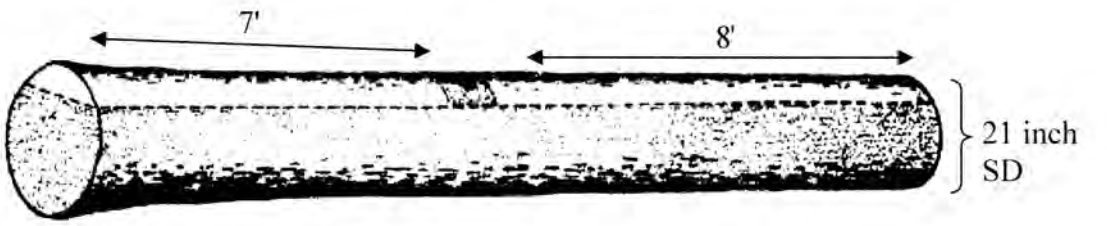


Figure 8. Example of an F1 grade, 16-foot butt-log. *Adapted from Rast and others, USDA Forest Service, 1973.*

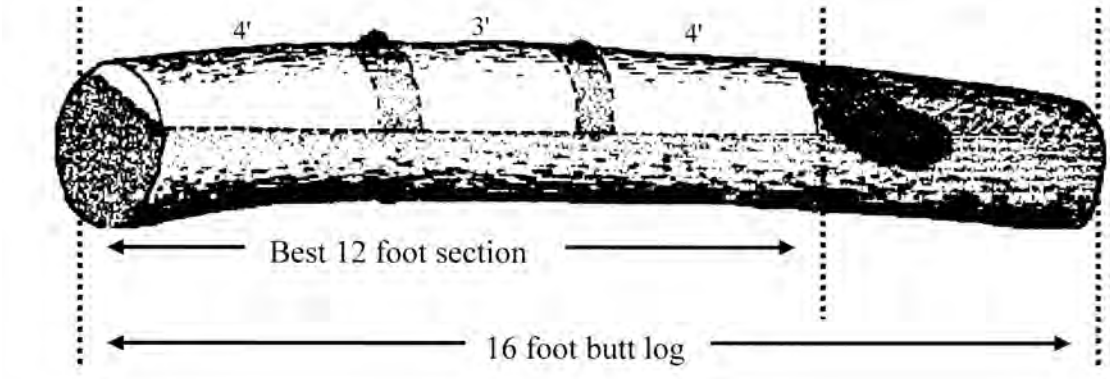


Figure 9. An example of an F2 grade butt-log. *Adapted from Rast and others, USDA Forest Service, 1973.*

F1 Grade Example

Figure 8 demonstrates the traits of an F1 grade 16-foot section of a butt-log. Assume the DBH is 26 inches. The SD would be 26 × 0.80 = 20.8 or 21 inches. Also assume the grading section in Figure 8 represents the second worst face. This face contains two clear sections of wood that are 8 and 7 feet long, respectively. In Table 2, a tree with these dimensions would need 8 total feet of clear wood in as many 2-foot or longer sections that are present to be an F3 grade. So, the tree is at least a grade F3. To make an F2 grade, the tree would need 10.7 total feet of clear wood in three or less sections that are at least 3 feet in length. So, the face is at least an F2 grade. To make an F1 grade, the face would need 13.3 total feet in two or less sections that are at least 3 feet long. Since this face meets these requirements and it is the second worst face, the tree is an F1 grade tree. This example demonstrates that the size of a tree greatly affects its ability to be an F1 grade. A very important consideration for large diameter trees is that if they are old trees (> 80 years), they may be hollow in the center, which would degrade and devalue the tree.

F2 Grade Example

Figure 9 demonstrates the traits of an F2 grade 12-foot section of a butt-log. The DBH is 16 inches. The SD would be 16 × 0.80 = 12.8 or 13 inches. Assume the grading face in Figure 9 represents the second worst face. This face contains three clear sections of wood that are 3, 4 and 3 feet long, respectively. In Table 2, a tree with these dimensions would need 6 total feet of clear wood in as many 2-foot or longer sections that are present to be an F3 grade. So, the tree is at least a grade F3. To make an F2 grade, the tree would need 8 total feet of clear wood in three or less sections that are at least 3 feet in length. So, the face is at least an F2 grade. To make an F1 grade, the face would need 10 total feet in two or less sections that are at least 7 feet long. Since this face does not meet these requirements, it cannot be a grade F1. Therefore, it is an F2 grade tree.

F3 Grade Example

Figure 10 demonstrates the traits of an F3 grade 12-foot section of a butt-log. The DBH is 12 inches. The SD would be 12 × 0.80 = 10.6 or 11 inches. Assume the grading face in Figure 10 represents the second worst face. This face contains two clear sections of wood that are 5 and 3 feet long, respectively. In Table 2, a tree with these dimensions would need 6 total feet of clear wood in as many 2-foot or longer sections that are present to be an F3 grade. So, the tree is at least a grade F3. This tree contains enough clear wood to make grade F2. However, it does not meet the minimum diameter requirements (neither the DBH nor SD). Therefore, it is a grade F3.

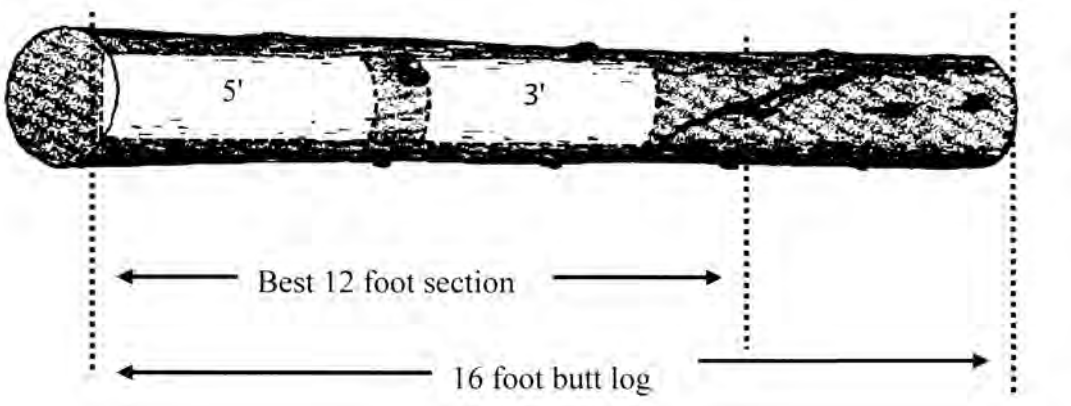


Figure 10. An example of an F3 grade butt-log. *Adapted from Rast and others, USDA Forest Service, 1973.*

Summary

Determining standing tree grade can be an important tool in hardwood management. Tree grade can be used when determining a stand's economic value. Also, tree grade can be important when preparing to conduct a thinning. The idea during thinning should be to remove the lower grade trees and manage the higher grade trees. Furthermore, tree grade is an integral part of evaluating the management potential of hardwood stands (see FSA5012, *Evaluating the Management Potential of Upland Hardwood Stands* at www.uaex.edu).

There are many factors involved in determining a tree grade. The key is to learn each aspect of tree grade and then attempt to bring them together to determine tree grade. The ultimate goal of this fact sheet is not to make professional foresters out of landowners but to provide landowners with some background knowledge that will allow them to make better management decisions and help protect them when marketing hardwood timber.

Additional Reference

Rast, D. E., D. L. Senderman and G. L. Gammon. 1973. *A Guide to Hardwood Log Grading*. USDA Forest Service General Technical Report, NE-1. 31 pages.

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