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Hardwood Log and Tree Quality

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All farm crops have some unit of measure associated with their market value. In the case of logs and lumber, the unit of measure is board feet—or more often, thousands of board feet (MBF). Most agricultural products are also judged by some quality scale or grading system. The grading criteria for hardwood lumber in Ohio are based on National Hardwood Lumber Association (NHLA) rules, which are universal throughout the United States and Canada.

There are, however, no set standards for grading hardwood logs and trees. The hardwood market is a value-driven sector, thus local market conditions can play a significant role in a log's ultimate class and grade designation. Also, a mill's available technology can significantly impact the amount of high-grade lumber produced from a single log. All contribute to the lack of an accepted grading standard. Even though the United States Forest Service has published a comprehensive rule for log grading, there are many other simplified versions in everyday use.

Most sawmills use some form of log grading to determine the price paid for logs delivered to the mill. The translation of these log grades into tree grades by the timber buyer can be somewhat imprecise. Judgments concerning tree quality during the timber cruising and bidding process are usually estimates rather than measurements. This fact sheet describes some of the basic concepts regarding the United States Forest Service's log and tree grading specifications.

Figure 1. Hardwood logs being unloaded at the Glatfelter merchandising yard in Piketon, Ohio.

Log Classes

Hardwood logs can be merchandised into four log-use classes. **Veneer** logs are of the highest quality and are segregated at the logging site or log yard for shipment to the veneer plant.

Factory logs will be sawn into hardwood lumber and are the subject of this fact sheet. They are divided into three grades: F1, F2, and F3. The United States Forest Service's log grading rule closely follows the NHLA standards for lumber grading. These standards are based on **cuttings**, the number of obtainable clear pieces in a board. Any defects present and the percent deducted from the log for the defects are also considered. An outline of the grading standards for factory-class hardwood logs can be found in Table 1 at the end of this document.

Low-quality logs are sorted into two classes: **construction** or **local-use**. Construction-class logs are manufactured into ties, timbers, and other structural products where strength is considered but appearance is not of principal concern. These logs can be graded depending on the end use but are often grouped into a single grade. Local-use logs are the lowest class for producing pallets, blocking, and other products where standards are not specified. Grades within this class are rarely applied.

NHLA Lumber Grades and Log Grading

Grades for hardwood lumber are assigned based on the size of the board and the appearance of its poorest face. The premise behind this being hardwood lumber will be further processed into smaller pieces for manufacturing value-added, secondary forest products such as flooring and furniture. **First and Seconds**, or **FAS**, is the highest grade. FAS boards must be at least 6 inches wide and 8–16 feet long, with 5/6 (83.3%) of the poorest face clear of defects. The select grades of lumber must be at least 3 inches wide and 4–16 feet long. Boards graded **#1 Common** must have 2/3 (66.7%) of the poorest face clear, and **#2 Common** lumber must be 1/2 (50%) clear. Lastly, **#3 Common** need only have 1/3 (33.3%) of its poorest face clear.

The United States Forest Service over a 40-year period measured thousands of factory-class hardwood logs from many species. They then evaluated the lumber obtained from the logs to create their grading rule. The following estimations can be made from these standards.

- At least 60% of the lumber sawn from an F1 log will grade #1 Common or better.
- Between 40–60% of the lumber sawn from an F2 log will grade #1 Common or better.
- Less than 40% of the lumber sawn from an F3 log will grade #1 Common or better.

Log Size

Minimum size requirements must be adhered to in log grading to meet the standards of the higher lumber grades. Diameter is measured *inside the bark* at the top end of the log. This is also called the **scaling end**. Setting this minimum assumes larger diameter logs will be able to meet the needed conditions for obtaining wide and defect-free lumber of the highest grade.

Log quality also increases with length, up to 16 feet. Logs longer than 16 feet will usually be cut into shorter lengths. The usual practice is to purchase logs in 2-foot increments, starting at 8 feet for grades F2 or F3. A 10-foot minimum length is required for F1 logs. Species in great demand and high-quality logs are sometimes bought in increments of 1 foot. All logs must have a few extra inches of **trimming allowance**, normally 4–6 inches, in addition to the nominal length in feet. This is so rough-cut boards can be squared to the desired length at the mill.

The position of the log in the tree is very important as well. The United States Forest Service's log grading rule classifies logs as either **butts** *or* **uppers**. The butt log is harvested from the base of the tree above a 1-foot stump and is typically the largest and often best log obtainable. It normally yields the highest percentage of clear wood. Logs from the upper stem are acceptable so long as they meet the minimum size requirements for each grade.

Smaller diameter logs are generally of poorer quality. Juvenile trees have many branches that are necessary for growth but form knots in the wood. These branches die and fall off as the tree grows. Larger trees have many layers of new, clear wood grown over this knotty heart center. Sawmills realize their greatest returns from furniture-grade boards sawn from these outermost sections of the log. Boards and timbers from the heart center are often of lower quality and are sold as rail ties or pallet lumber.

Straightness and Taper

Any deviation from straightness takes away from quality. Crooked logs cause cross grain in the lumber, which reduces quality and significantly lowers the board foot yield. Slight sweep in one direction can be tolerated. Curvature in two directions automatically makes it a low-quality log. Excessive taper reduces both yield and quality by contributing to cross grain in the lumber. The sawyer may minimize this by changing the log's position on the carriage, but this takes time and increases production costs. On average, taper results in a decrease of approximately 2 inches in diameter from the bottom to the top end of a 16-foot log.

The Grading Face

Log graders visualize the surface of the log divided into four quarters as it may be sawn. These faces will be chosen so that knots and other defects are most numerous on one face. That is, the other three faces will have fewer defects and result in higher quality lumber. The poorest face is eliminated from evaluation, and the log grade is then determined based upon the least of the three remaining faces. Figure 2 provides an example of determining the grading face of a hardwood log.

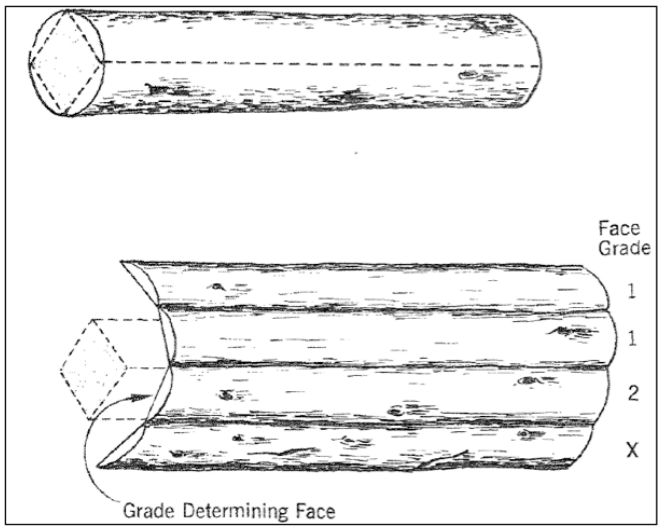

Figure 2. The grading face is the third-best quarter of the log (from Rast, Sonderman, and Gammon 1973).

Clear Cuttings

Lumber graders look for clear cuttings between the defects on a sawn board's poorest face. The highest quality boards are those that yield the greatest surface area clear in the fewest number of cuttings. So it is with the United States Forest Service log grading rule. The grading face is judged according to the percentage of length free of defects *across the entire width* of the face. A top-grade log must have 5/6 (83.3%) of the grading face clear in one or two cuttings. This is identical to meeting the NHLA standards for FAS lumber. Knots are the most common defect separating the grading face into clear cuttings. Bumps on the log surface indicate submerged knots and are also considered "stoppers." An F3 log, though, only requires half of its grading face to be clear. This can be met by identifying as many as three cuttings.

End Defects

Estimating the number and severity of defects contained inside a log is difficult. Defects that are visible on the ends may be a clue to what is inside. Ohio forest fires create wounds near the base of older trees, opening the way for insect attack and later decay. The hooves of livestock grazing wooded farmland can inflict similar damage. The tree may continue to grow new wood around the perimeter while the decay advances inside. The larvae of wood-boring insects inflict damage not acceptable in furniture grade lumber. **Shakes** are separations between the annual rings often caused by high winds in standing timber. Boards or timbers containing shake are of little value. Evidence of various stains may also be seen on the ends of logs. The United States Forest Service's log grading rule provides particular instructions for evaluating specific end defects.

Log buyers are cautious when dealing with end defects. The log end is divided into four quarters when end defects are found, matching those determined from obtaining the grading face. Imperfections entirely within the heart center, the inner 40% of the diameter, are disregarded for grading defects. The log end is then evaluated on the outer 60% of its diameter inside the bark, termed the **quality zone**. The quality zone is further divided into an inner and outer half. An affected area must be present in both the inner- and outer-quality zones to be considered a defect. Scaling deductions can be made for blemishes not meeting this condition.

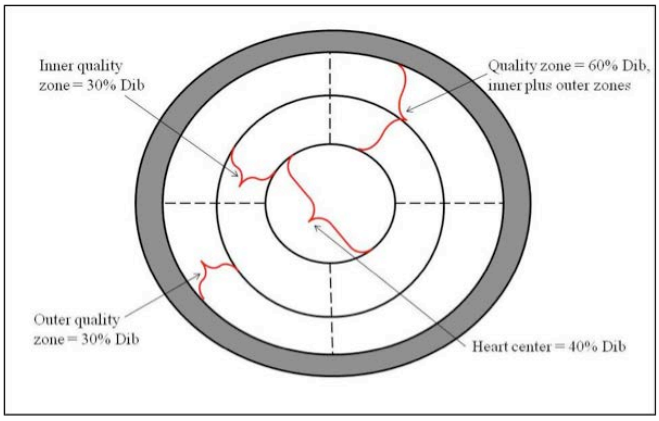

Figure 3. The quality zones of a log end [Dib = diameter inside the bark] (from Rast, Sonderman, and Gammon 1973).

Using Tree Grades

The majority of a tree's value is contained in the butt log. Therefore, the grade of a hardwood tree for factory lumber is normally considered to be equal to the grade of its butt log. Because the tree is standing and the butt log is near the ground, the defects are easy to see. Grade 1 is the highest, followed by Grades 2 and 3. An overview of the United States Forest Service's hardwood tree grading specifications can be found in Table 2.

Tree grade is determined on the best 12-foot section of the 16-foot butt log above a 1-foot stump height and takes into account three characteristics: size, clear cuttings, and cull deductions. The length of the clear cutting(s) is determined on the grading face. Size is based on diameter at breast height (DBH) *outside the bark*, measured 4.5 feet above the ground, and the estimated diameter *inside the bark* at the top of the grading section, either 12, 14, or 16 feet above the stump. The amount of volume deducted for sweep, crook, and rot are combined and calculated as a percent.

The grading section's top end diameter inside the bark is predicted according to a particular **form class**. Form class describes the straightness of trees in a stand, and this measure is independent of species. It is the ratio of stem diameter inside the bark at the top of a 16-foot log (actually measured at a height of 17 feet, 4 inches from the ground to account for stump height and trim allowance) and the DBH outside the bark.

A form class of 78, which is commonly assumed for most tree species in Ohio, means the diameter inside the bark at the top end of a 16-foot butt log would be 78% of the tree's DBH outside the bark. Figure 4 provides an example of estimating top end diameter by applying a form class of 78 to a 16-foot butt log. A relationship applicable to tree grading can also be established between DBH and diameters inside the bark at heights of 12 and 14 feet once a particular form class has been determined for a stand.

Equations estimating dry lumber-grade yields for each tree grade have been developed for a number of species including white oak, northern red oak, black cherry, red and sugar maples, and yellow-poplar. Dry lumber volumes by NHLA grade can be predicted in standing timber by applying the tree grades. A value for the expected amount of lumber can then be approximated based on the current dry lumber prices for an area. These volumes and values provide a basis for sustainable forest management and fair business practices. Top-grade trees of red oak, white oak, and walnut may become veneer quality when they are large enough. Leaning trees, crooked trees, and small, overtopped trees can be designated for removal in a timber stand improvement harvesting operation. The woodland owner who understands the basic ideas of log and tree grading is better able to select trees to manage for the future.

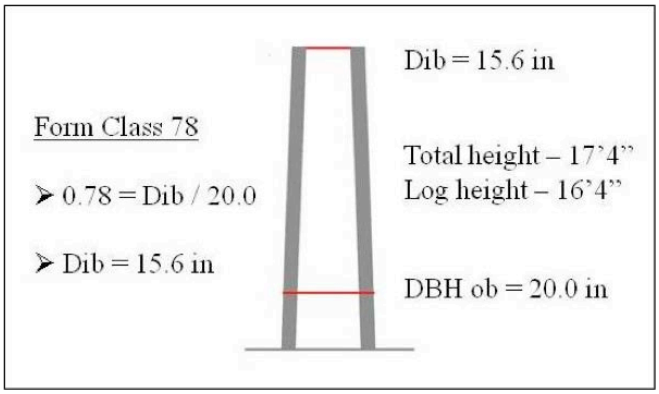

Figure 4. Correctly applying form class provides reliable estimates when actual measurements would be difficult to make (Dib = diameter inside the bark; DBH ob = diameter at breast height outside the bark).

More Information

A Guide to Hardwood Log Grading by Rast, Sonderman, and Gammon (1973) and *Hardwood Tree Grades for Factory Lumber* by Hanks (1976) are two comprehensive instruction booklets from the United States Forest Service; these publications provide detailed information regarding log and tree grading specifications. If you would like to study grading systems further, you may search Ohio State University Extension's Forest Operations and Products website at **www.ohiowood.osu.edu** for these publications as well as contact information for The Ohio State University School of Environment and Natural Resources.

Acknowledgment

This fact sheet is a revision of an earlier edition by Robert D. Touse, OSU Extension Forester, and has been peer reviewed.

Table 1. A summary of the standards for grading factory class hardwood logs (from Rast, Sonderman, and Gammon 1973).

Grading Factors		Log Grades							
		F1			F2				F3
Position in tree		Butts Only	Butts and Uppers		Butts and Uppers				Butts and Uppers
Scaling diameter, inches		13-15	16-19	20+	11+	12+			8+
Length without trim, feet		10+			10+	8-9	10-11	12+	8+
Required clear cuttings on the grading face	Min. length, feet	7	5	3	3	3	3	3	2
	Max. number	2	2	2	2	2	2	3	No Limit
	Min. proportion of log length required in clear cutting	83.3%	83.3%	83.3%	66.7%	75%	66.7%	66.7%	50%
Maximum sweep and crook allowance	For logs with less than ¼ end in sound defects	15%			30%				50%
	For logs with more than ¼ end in sound defects	10%			20%				35%
Maximum scaling deduction		40%			50%				50%
End defect: Specific instructions must be followed for end defects.									

Table 2. A summary of the hardwood tree grades for factory lumber (from Hanks 1976).						
Grade Factors	Tree Grade 1			Tree Grade 2		Tree Grade 3
Length of grading zone, feet	Butt 16			Butt 16		Butt 16
Length of grading section, feet	Best 12			Best 12		Best 12
Minimum DBH, inches	16			13		10
Minimum diameter inside bark at top of grading section	13	16	20	11	12	8
Clear cuttings on the grading face						
Minimum length, feet	7	5	3	3	3	2
Maximum number of clear cuttings	2			2	3	No Limit
Minimum yield in face length	83.3%			66.7%		50%
Maximum cull deduction (%) within the grading section, including crook and sweep but excluding shake	9%			9%		50%