Hardwood Log Grading in the United States—Part II: United States Forest Service Log Grades and the Hardwood Industry

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Abstract

The major effort to develop hardwood log grades was undertaken by the US Department of Agriculture Forest Service (USDAFS) during the 1940s through the 1960s. While the USDAFS officially adopted the grading system for their own use in 1952, it has never taken hold in the hardwood lumber industry. This article discusses the variety of reasons that have most likely contributed to this failure of adoption of the USDAFS system by the industry, ranging from ease of use, to individual log grades covering wide ranges of log characteristics/quality, and to overlapping grades for a given set of log attributes, among others. Finally, the authors suggest developing a hardwood log grading system that embraces the de facto industry system of scaling diameter and clear faces.

Hassler et al. (2019) documented the development of hardwood log grading in the United States. The major development period for hardwood log grades took place between 1940 and 1966, with the US Department of Agriculture Forest Service (USDAFS) the dominant player in this effort. The final refinement of the log grades occurred in 1966 (Vaughan et al. 1966), with the last major milestone occurring with the publication of ''USFS Hardwood Grade Yields for Factory Sawlogs'' in 1980 (Hanks et al. 1980). With the work of Yaussy and his coauthors during the late 1980s in developing statistical models for predicting the lumber grade yields from Hanks et al. (1980; Yaussy and Brisbin 1983; Howard and Yaussy 1986; Yaussy 1986, 1987, 1989), this marked the end of developmental work on the USDAFS log grades.

Although several competitors surfaced during this time period, none had the necessary staying power, and none are in use today. One reason for this may be that the USDAFS, in 1952, officially adopted the grades to serve as the organization's official hardwood log grades. The USDAFS Hardwood Log Grading System has seen the most application in USDAFS Forest Inventory Analysis (FIA) and in research, both with the USDA Forest Service and universities. It is still being taught at most, if not all, workshops on hardwood log grading in the United States.

However, from a hardwood industry perspective, there has never been a broad acceptance of the USDAFS Hardwood Log Grades. The purpose of this article is to provide a perspective on the reasons why the hardwood industry has never adopted the USDAFS system and to suggest that a new system that more closely aligns with hardwood industry needs to be considered.

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Hardwood Industry Perspective

The Appalachian Hardwood Center (AHC) at West Virginia University (WVU), in 2005, embarked on a research/hardwood industry assistance program to aid hardwood sawmills in better understanding their log grades, lumber grade yields, and pricing of hardwood logs. In the course of conducting over 50 mill studies at over 20 mills in six states, they determined that none of these mills were using the USDAFS hardwood log grades. Additionally, through various activities with a range of hardwood mills in the eastern United States, including an informal review of publicly available log specifications, none of those mills were using USDAFS grades.

In a 2010 survey profiling various aspects of hardwood sawmills in the Appalachian region, respondents were asked about their log grading system (Hassler 2010). None of the respondents indicated that they were using the USDAFS system.

An unpublished USDAFS report (Rast and Baumgras 1997) confirms the lack of use of the USDAFS hardwood log grades. The purpose of the study was to visit mills to determine how they were grading logs. Results from 24 mills showed three categories of grading practices:

- Grade by diameter and a grading system (usually clear faces): 13 mills.
- Grade by clear faces only or by clear faces and price: four mills. These mills were not using diameter to establish price/grade.
- Grade only by price or only buy standing timber: seven mills. The report indicates that even though they were assigning a price to each log, they were mentally grading each one by size, number of defects/clear faces, or just how the log looked in general.

A similar outcome occurred for the eight concentration yards that were sampled:

- Grading system based on diameter and clear faces (or percentage of the log or clear face): five yards.
- Grade based on clear faces only: one yard.
- Grade only by price, although some unstated grading evaluation was obviously occurring: two yards.

The report also indicates that it was difficult to summarize the collected data, since no two mills were similar in the way they graded logs.

An obvious conclusion is that the development work on hardwood log grading and the ensuing research work using the USDAFS grades have not adequately addressed the needs of the hardwood industry. One can speculate about reasons for this, including difficulty in using the USDAFS system and determining whether it can effectively quantify the relationship between log quality and lumber grade yields for hardwood industry purposes.

In response, hardwood sawmills have independently arrived at a de facto system of log grading that is based primarily on scaling diameter and number of clear faces (zero to four clear faces) with a variety of nuances developed on a mill-by-mill basis to fine tune the grades. These nuances include admitting or excluding certain log lengths, end conditions, and position in tree, among others. The problem with the de facto industry system is that the actual grade designations vary from mill to mill, even with number of clear faces and scaling diameter as the basis, so that comparisons between mill grades and prices are difficult and in some cases impossible.

USDAFS System versus Industry De Facto System: Ease of Use

The USDAFS system (Table 1) can require an assessment of all four faces of a log, which requires turning the log if the three visible faces are not all the same grade. The de facto industry system allows for grading ''as it lays,'' with the assumption that the bottom face is either clear or not. There is no question that turning the log to view all faces is superior and favors the USDAFS system, although it is significantly more labor intensive from the mill point of view.

In order to make the grade decisions the USDAFS rules require grading of each face, where distance between defects must be determined as a proportion of total length. In this process, the grader must make the grading decision with a combination rule that includes scaling diameter, log length, minimum length of clear cuttings, the maximum number of clear cuttings allowed, and the minimum proportion of log length required in clear cuttings. The second worst face becomes the grading face. Then, an assessment is made for crook and sweep and for a complicated set of end defects to finally arrive at the final grade.

In the de facto industry method, clear faces are determined, and sweep and crook defects (as well as interior defects such as holes, rot, etc.) are accounted for in adjusting scaling diameter or log length via a rule of thumb, and finally end conditions are recognized to qualitatively determine if a grade or scale adjustment is needed. Since speed of grading is often an issue at mills, the de facto system is certainly a faster method for arriving at a grade. The question here is whether speed should trump more effective assessment of grade. If the assessment actually provides a strong correlation between log quality and lumber grade yields, then the answer is yes, without question. However, this is where the USDAFS system falls short from an industry perspective, because experience has shown the industry that the USDAFS grades are not an accurate reflection of expected lumber grade yields when compared with the de facto system.

USDAFS System versus Industry De Facto System: Lumber Grade Yields

There are several aspects of the USDAFS log grading system (Table 1) one can point to that fall short of ensuring log grades accurately reflect lumber grade yields. First, it is a well-established fact that a log with a clear surface will yield more clear lumber than a log that is not clear. It is also true that a smaller diameter clear log will yield less clear lumber than a larger diameter clear log, because the larger log has a thicker layer of knot-free wood. As log diameter increases the evidence of knots diminishes. In very small, four clear face logs, the clear lumber is often slabbed off in the process of squaring up the log. So, the point is that log size certainly affects sawn lumber quality.

The first issue with the lumber grade yields, reported in Hanks et al. (1980) and used during the development of the USDAFS grades, is that they are air-dry lumber yields. For sawmills producing, grading, and selling green lumber, air-dry lumber yields are not as valuable, from an informational

Table 1.—Official US Department of Agriculture Forest Service hardwood log grades for standard lumber. Reproduced based on report developed by Vaughan et al. (1966).

Grading factors	F1			F2				F3
Position in tree	Butts only	Butts and uppers		Butts and uppers				Butts and uppers
Diameter, scaling, minimum (inches)	13–15[a]	16–19	20+	11[b]		12+		8+
Length, minimum (feet)		10+		10+	8–9	10–11	12+	8+
Clear cuttings[c] on each three best faces								
Length, minimum (feet)	7	5	3	3	3	3	3	2
Number on face (maximum)	2	2	2	2	2	2	3	No limit
Fraction of log length required in clear cuttings[d]		5/6		2/3	3/4	2/3	2/3	1/2
Sweep and crook allowance (maximum) in percent gross volume								
For logs with <1/4 of end in sound defects (%)		15			30			50
For logs with >1/4 of end in sound defects (%)		10			20			35
Total scaling deduction including sweep and crook (%)		30[e]			50[f]			50
End defects				see instructions				

[a] Ash and basswood butts can be 12 inches if otherwise meeting requirements for small No. 1s.
[b] Ten-inch logs of all species can be No. 2 if otherwise meeting requirements for small No. 1s.
[c] A clear cutting is a portion of a face free of defects, extending the width of the face.
[d] See table 46 in Vaughan et al. (1966).
[e] Otherwise No. 1 logs with 41 to 60 percent deductions can be No. 2.
[f] Otherwise No. 2 logs with 51 to 60 percent deductions can be No. 3.

perspective, as green lumber yields when scaling and grading hardwood logs. Green lumber yields in combination with third-party published pricing reports are an important tool for hardwood sawmills in deciding the best value-added approach for their green lumber. Additionally, the air-dry lumber yields must necessarily reflect drying degradation, which does not accurately reflect the green yields. It also introduces another level of variation, since different mills will have different levels of performance in their air-drying operations. Finally, the availability of conversion factors for estimating green lumber yields from air-dry grade yields (Gammon 1971) can alleviate this problem but must inevitably introduce another level of variability in green lumber yields.

Since the goal of any mill is to maximize the production of higher-grade lumber (Selects & Better lumber grades), it is important to take into account how log size is going to affect lumber quality. Hanks et al. (1980) provide lumber grade yields for a variety of species over a range of diameters. Table 2 shows the northern red oak results for Factory Grade 1 sawlogs (where butt logs can be 13 to 15 inches scaling diameter and butts and uppers can be 16 to 19 inches and 20+ inches, with required clear cuttings varying by diameter). The key here is to note that, beginning with 17-inch logs, the Selects & Better and Common & Better yields take a significant jump, as one would expect, showing better yields with increasing diameter. These yields stay fairly consistent from about 17 inches through 25 inches, where sample sizes begin to have an effect. Thus, is it reasonable to lump the smaller diameter logs, with lower Selects & Better yields, into the highest USDAFS grade—Factory Grade 1?

A mill can easily justify paying a higher price for larger clear logs than for smaller clear logs, thereby requiring a different grade. Aggregating the large and small clear logs into the same grade or placing logs that yield substantially different lumber grade yields in the same grade can place the mill at risk. If log receipts are weighted toward smaller logs (with poorer Selects & Better yields) then it may be difficult to generate sufficient revenue to justify the established log price. Placing logs in grades that accurately reflect expected lumber grade yields will serve to price logs appropriately and as a result will encourage suppliers to be more effective in how they process their logs, ensuring they receive maximum value for their product. It is also likely that this effect is even more pronounced if Factory Grade 1 specifications were discriminating among logs, which leads to the next problem with the USDAFS grades.

Consider the specifications for USDAFS Factory Grade 1 sawlogs for a 16-inch log:

- Any 16-inch log that is clear (i.e., four clear faces) will fit the Grade 1 definition.
- Any 16-inch log with three clear faces will fit the Grade 1 criteria.
- Consider a 16-inch log with two clear faces. The grading face of that log is the higher-graded face of the two nonclear faces. If that face has 5/6 of its length clear, then it fits a Grade 1 definition.
- Continuing the progression, it is possible that a 16-inch log with one clear face or no clear faces could have the grading face meet the 5/6 requirement, by having a maximum of two clear cuttings with a minimum of 5 feet in length.

While they may or may not be common occurrences, these latter two situations are certainly possible. Is it reasonable, then, to lump all these 16-inch logs into the same classification? The net result is that logs of wide ranging quality can meet a USDAFS Factory Grade 1 specification. What isn't as likely is that all these logs are going to produce lumber grade yields that are similar. In practice, this would be unacceptable to hardwood lumber producers.

The only logs that are effectively excluded from Factory Grade 1 are all logs 8 feet in length, butt logs with diameters 12 inches and smaller, and upper logs 15 inches in diameter and less. The possibility of overlapping grades is best illustrated by casting the USDAFS log grades in the context of a typical de facto industry hardwood log grading system.

Table 2.—Air-dry lumber grade yields for US Department of Agriculture Forest Service Factory Grade 1 northern red oak logs (Hanks et al. 1980).

Log diameter (inches)	No. of logs	NHLA lumber grade yield (%)[a]				Selects & Better yield (%)	Com & Better yield (%)
		FAS	F1F	Selects	1 Com		
13	15	18.5	16.5	5.1	21.4	40.1	61.5
14	26	24.7	15.0	3.3	27.7	43.0	70.7
15	26	25.2	15.0	3.5	24.5	43.7	68.2
16	43	24.7	12.6	3.3	27.4	40.6	68.0
17	42	32.1	14.8	3.7	26.1	50.6	76.7
18	38	28.7	16.1	2.5	27.3	47.3	74.6
19	44	37.9	13.3	2.8	23.6	54.0	77.6
20	35	33.8	15.0	1.7	28.6	50.5	79.1
21	29	30.9	13.6	1.4	33.0	45.9	78.9
22	36	33.0	16.4	1.7	25.2	51.1	76.3
23	26	34.6	15.4	3.2	26.4	53.2	79.6
24	20	30.9	13.6	3.5	31.7	48.0	79.7
25	15	40.7	12.3	4.0	26.4	57.0	83.4
26	12	25.8	10.5	4.2	38.0	40.5	78.5
27	3	24.1	9.6	7.9	40.5	41.6	82.1
28	5	40.1	12.4	1.4	30.8	53.9	84.7
29	3	26.9	18.9	0.0	38.4	45.8	84.2
30	1	22.9	9.3	7.5	50.3	39.7	90.0
31	1	56.1	11.2	5.0	20.1	72.3	92.4

[a] NHLA = National Hardwood Lumber Association.

Table 3 illustrates a typical de facto hardwood industry log grading system of scaling diameter and clear faces.

The question then, is how does the USDAFS system classify logs within this framework? That is, in which cells of the table could a Factory Grade 1 sawlog qualify? Using USDAFS specification ''FS1'' (indicating both butts and uppers qualify) or ''FS1B'' (indicating butt logs only qualify), Table 4 indicates where USDAFS Factory Grade 1 could potentially be classified (it also assumes that only logs 10 feet and greater are being classified). From an industry perspective, it is unacceptable for a system to potentially classify logs of a single grade into a majority of the cells in the grading matrix, particularly when it is the highest grade classification.

Of additional concern is the potential overlapping of USDAFS grades in individual cells within this grading matrix. For instance, a 16-inch log with two clear sides could also qualify as a Factory Grade 2 sawlog, if the clear cuttings fall below 5/6 of the log length. This applies to several other combinations of scaling diameter and clear sides as well.

More specifically, it would be instructive to compare the Factory Grade 1 logs to Factory Grade 3 logs for potential overlap in the Scaling Diameter/Clear Sides grading framework. Table 5 indicates where Factory Grade 3 sawlogs could be potentially classified (where ''FS3'' indicates that both butts and uppers qualify), assuming for direct comparison that only 10-foot and longer logs are considered. Obviously, depending on the layout of the defects present on a log, it could be classified as either a Grade 1 or a Grade 3 in 15 different cells of the grading matrix (i.e., 13 inches and up, and zero, one, and two clear faces). So, for instance, a two clear-sided log, 16 inches in diameter, depending on the placement of the defect(s) on the two nonclear sides could be classified as either a Factory Grade 1 or Factory Grade 3 sawlog. It is clearly unacceptable from an industry perspective to have a single cell of the grading matrix containing potentially two USDAFS grades classified as part of that cell. Extending the argument, a two clear-sided log, 16 inches in diameter, could also potentially be classified as a Factory Grade 2

Table 3.—A typical de facto baseline hardwood log grading system in use by hardwood sawmills.

Scaling diameter (inches)	Clear sides				
	Four	Three	Two	One	None
≥17					
16					
15					
14					
13					
12					
11					
≤10					

Table 4.—Classification possibilities of US Department of Agriculture Forest Service Factory Grade 1 logs into the de facto hardwood log grading system used by hardwood sawmills (only logs 10 feet and longer are considered).

Scaling diameter (inches)	Clear sides[a]				
	Four	Three	Two	One	None
≥17	FS1	FS1	FS1	FS1	FS1
16	FS1	FS1	FS1	FS1	FS1
15	FS1B	FS1B	FS1B	FS1B	FS1B
14	FS1B	FS1B	FS1B	FS1B	FS1B
13	FS1B	FS1B	FS1B	FS1B	FS1B
12	—	—	—	—	—
11	—	—	—	—	—
≤10	—	—	—	—	—

[a] FS1 = both butt logs and upper logs qualify; FSB1 = only butt logs qualify.

Table 5.—*Classification possibilities of US Department of Agriculture Forest Service Factory Grade 3 logs in the de facto hardwood sawmill grading system (only logs 10 feet and longer are considered).*

Scaling diameter (inches)	Clear sides[a]				
	Four	Three	Two	One	None
≥17	—	—	FS3	FS3	FS3
16	—	—	FS3	FS3	FS3
15	—	—	FS3	FS3	FS3
14	—	—	FS3	FS3	FS3
13	—	—	FS3	FS3	FS3
12	—	—	FS3	FS3	FS3
11	—	—	FS3	FS3	FS3
≤10	—	—	FS3	FS3	FS3

[a] FS3 = both butt logs and upper logs qualify.

sawlog, meaning that a single cell of the grading matrix could contain each of the USDAFS log grades.

From a mill owner's perspective, the built-in variability of the USDAFS log grading system does not allow for sufficient levels of confidence for a mill to generate consistent lumber grade yields from any sample of factory grade sawlogs. If the owner cannot be confident about lumber grade yields within a grade, then that owner cannot be confident in establishing log prices as end-product markets fluctuate and/or raw material changes occur. And herein lies a logical reason why mills have not seen fit to adopt the USDAFS hardwood log grading system. The manifestation of these issues can be observed in the Hanks et al. (1980) lumber grade yields. By way of example, take the Hanks et al. (1980) lumber grade yield results for white oak Factory Grade 1 sawlogs (Table 6). In this instance, the expected finding of lower Selects & Better yields for smaller diameters is not evident. In fact, there is no consistent trend in those yields—they simply fluctuate throughout the range. One explanation stems from the inclusion in Grade 1 logs of a range of log characteristics that serves to dilute Selects & Better lumber yields over the entire grade. It also seems unreasonable that the highest grade log would have Selects & Better yields as low as the 30 to 40 percent range. Of course, sample sizes in many of these cases are small enough to be causing some problems as well.

USDAFS System versus De Facto System: Other Considerations

Consider how the de facto industry system and the USDAFS system compare in their respective use of the entire surface of the log. The de facto system provides for equal weighting of each face in the determination of log grade. The USDAFS system, on the other hand, treats each of the four faces equally only when determining the grading face (i.e., second worst face). Once the grading face is established, the grade of the log is determined only on 1/4 of the available surface data. The question, then, is whether this provides a better representation of the expected lumber grade yields than the de facto system. Based on the discussion thus far, it is hard to argue that the USDAFS system is superior to the de facto alternative, by effectively minimizing the information contained in 3/4 of the log surface.

Further, the USDAFS system is based, in large part, on the concept of clear-cutting rules as established in the National Hardwood Lumber Association (NHLA) hardwood lumber grades (NHLA 2014). It is important to remember that lumber grading is essentially a documentation of the results from a lumber manufacturing operation, and the lumber grading system has been established to use the poorer face of the board to establish the grade. Log grading is different, in that the assignment of a log grade is an attempt to estimate the lumber grade yields that a log can produce, prior to manufacturing, in order to establish log prices and thereby the economic performance of the mill. In this sense, log grading becomes perhaps the most important decision a mill can make and at least on a par with the primary breakdown process at the mill headrig. Lumber grade yields are a direct function of the defects or lack thereof on each face of the log and how the log is positioned for sawing in the context of the visible defects. The USDAFS system, by using only the information on a single

Table 6.—*Air-dry lumber grade yields for US Department of Agriculture Forest Service Factory Grade 1 white oak logs (Hanks et al. 1980).*

Log diameter (inches)	No. of logs	NHLA lumber grade yield (%)[a]				Selects & Better yield (%)	Com & Better yield (%)
		FAS	F1F	Selects	1 Com		
13	13	13.0	13.3	3.4	30.2	29.7	59.9
14	10	21.3	16.9	5.6	21.9	43.8	65.7
15	23	15.3	11.9	3.3	25.2	30.5	55.7
16	21	22.4	13.5	3.5	28.3	39.4	67.7
17	11	18.8	10.7	7.1	22.2	36.6	58.8
18	13	13.7	8.5	2.8	21.8	25.0	46.8
19	16	15.4	9.2	3.3	36.5	27.9	64.4
20	10	20.2	13.5	4.2	25.5	37.9	63.4
21	10	16.8	15.1	5.8	28.2	37.7	65.9
22	9	14.2	19.4	3.2	40.3	36.8	77.1
23	8	17.0	9.0	4.6	29.0	30.6	59.6
24	8	13.1	16.6	0.9	41.1	30.6	71.7
26	2	19.0	11.4	3.1	35.1	33.5	68.6
27	1	22.7	2.3	3.1	57.7	28.1	85.8
28	1	7.3	29.0	0.0	43.6	36.3	79.9
29	1	39.4	7.2	7.8	36.0	54.4	90.4

[a] NHLA = National Hardwood Lumber Association.

face, is inconsistent in producing estimates of lumber grade yields.

Also, either by design or by chance, the USDAFS system seems to be maximizing the yield of No. 1 Common lumber rather than Selects & Better lumber. This would be expected, since logs of poorer quality are included in the USDAFS Factory Grade 1 classification. Conversely, mills are generally seeking to maximize Selects & Better yields from their log grades. This makes perfect economic sense because of the price differential between 1 Common lumber and Selects & Better lumber. Depending on species and market conditions the differential can be as little as 20 to 25 percent and more than 100 percent. So, it would be logical for mills to gravitate to a system that more accurately classifies logs according to Selects & Better yields.

Furthermore, a system with only three grades does not provide the ability to set reasonable minimum Selects & Better yields and pay accordingly for those logs. For example, a five log grade system based on the number of clear faces allows for more reasonable incremental Selects & Better yields between grades, which can more effectively minimize variation within and between grades, as recommended by the National Log Grading Committee (Newport et al. 1959). The de facto industry system lends itself to the application of five separate grades that are focused and limited to specific cells of the table, and the specification for one grade does not overlap with those of another grade. Table 7 illustrates how a new system *might* be constructed with five grades. Of course, one would want to use lumber grade yield data to specify which cells of the grading matrix will fit a certain grade. For instance, a 13-inch log with two clear sides may, based on empirical evidence, actually fit better into Grade 2 rather than Grade 1, because of lumber grade yields.

Clearly, the Prime grade in Table 7 provides the mill with a very focused and well-defined classification that is not diluted by the inclusion of a much wider range of possible log quality as represented by the USDAFS Factory Grade 1 specification. Also, the combination of broad specifications for USDAFS Factory Grade 1 log with sample size of the Hanks et al. (1980) data could have a significant impact in practice, in direct opposition to the recommendations of the National Log Grading Committee (Newport et al. 1959). That is, as mill log receipts vary among log sizes over time, the mill could expect increasing variation in lumber yields and thereby instability in gross and net revenue. Yet, as sample size increases for the well-defined, focused Prime grade, the expectation is that variation would decrease, in line with the recommendations of the National Log Grading Committee (Newport et al. 1959).

Another critically favorable attribute of a log grading system is the ability to classify logs according to the parameters set forth (e.g., Selects & Better yields) regardless of species. That is, for example, the Selects & Better yields qualifying a log into the highest grade should be the same or at least similar across all species. Table 8 illustrates the Selects & Better yields for USDAFS Factory Grade 1 sawlogs over six major hardwood species, as reported by Hanks et al. (1980). Clearly, the Factory Grade 1 designation produces a wide range of results for Selects & Better yields across species, with yellow-poplar on the low end and black cherry on the high end with a range of outcomes between those extremes. It is not clear whether this effect is due to natural differences between species or due to the USDAFS log grading system. In fact, it is not possible to judge the former effect in light of the possible classifications of a log of specific diameter and clear sides within the USDAFS system, as detailed earlier.

Table 7.—A possible hardwood log grading system based on the de facto log grades currently in use by hardwood sawmills.

Scaling diameter (inches)	Clear sides[a]				
	Four	Three	Two	One	None
≥17	P	S	1	2	3
16	S	S	1	2	3
15	S	S	1	2	3
14	1	1	1	2	3
13	1	1	1	2	3
12	2	2	2	2	3
11	2	2	2	2	3
≤10	3	3	3	3	3

[a] P = Prime Grade; S = Select Grade; 1 = No. 1 grade; 2 = No. 2 grade; 3 = No. 3 grade.

A similar outcome is evident in USDAFS Factory Grade 2 sawlogs, as illustrated in Table 9. Again, for any given diameter the range of Selects & Better yields is wide, with black cherry generally on the high end and yellow-poplar generally on the low end. The results are similar for USDAFS Factory Grade 3 sawlogs, although the range of results is less pronounced, because of the smaller likelihood of producing Selects & Better lumber.

Summary and Discussion

The National Log Grading Committee's Working Group Report (Newport et al. 1959, p. 19) clearly states that

> A system of grading is intended to group the logs or trees in such a way that the total variation around the estimated averages for the groups (subpopulations) will be less than the variation without the grouping (whole population). The true averages for the total population of logs or trees are actually never known. How close the estimates are to the actual averages in each instance will depend upon the natural variability of the individual logs or trees in the sample and the number in the sample. If we assume that the range of sizes and the number of logs or

Table 8.—Summary of Selects and Better lumber yields (percent) of selected species of US Department of Agriculture Forest Service Factory Grade 1 logs (Hanks et al. 1980).[a]

Log diameter (inches)	YP (%)	RO (%)	WO (%)	SM (%)	HM (%)	BC (%)
13	14.4	40.1	29.7	36.8	32.0	56.7
14	20.8	43.0	43.8	47.0	40.3	55.1
15	17.0	43.7	30.5	50.3	39.4	60.3
16	24.4	40.6	39.4	46.3	34.1	54.5
17	19.3	50.6	36.6	43.8	37.3	56.5
18	23.5	47.3	25.0	57.3	40.6	57.6
19	23.7	54.0	27.9	49.2	35.7	62.3
20	29.6	50.5	37.9	59.4	42.4	58.9
21	25.7	45.9	37.7	55.3	44.4	63.7
22	17.6	51.1	36.8	28.0	33.0	65.1
23	22.1	53.2	30.6	70.1	51.0	0.0
24	21.8	48.0	30.6	21.1	59.6	67.0
25	34.0	57.0	—	15.2	41.0	59.9

[a] YP = yellow-poplar; RO = red oak; WO = white oak; SM = soft maple; HM = hard maple; BC = black cherry.

Table 9.—Summary of Selects and Better lumber yields (percent) of selected species of US Department of Agriculture Forest Service Factory Grade 2 logs (Hanks et al. 1980).[a]

Log diameter (inches)	YP (%)	RO (%)	WO (%)	SM (%)	HM (%)	BC (%)
10	5.8	14.4	4.5	26.0	9.0	29.8
11	4.3	15.7	9.9	13.3	11.2	14.9
12	6.4	16.1	8.6	19.5	12.0	23.3
13	6.6	12.8	7.8	19.1	10.4	21.7
14	7.4	20.8	8.8	22.5	12.2	28.8
15	10.2	21.5	11.7	26.7	16.3	27.9
16	10.3	23.9	16.9	22.9	13.9	25.8
17	8.4	21.9	13.2	20.4	17.2	27.6
18	12	30.1	11.6	23.8	15.3	30.3
19	18.3	21.3	15.8	38.1	23.1	23.6
20	8.2	23.6	13.3	60.2	22.6	29.9
21	10	17.3	17.3	52.8	28.9	50.7

[a] YP = yellow-poplar; RO = red oak; WO = white oak; SM = soft maple; HM = hard maple; BC = black cherry.

> trees in the sample to be used in testing or development of log or tree grades are adequate, our main concern can be directed toward the variability of logs or trees. This variability can be controlled within natural limits by grouping the logs or trees into grades (subpopulations). Therefore, the effectiveness of a grading system should be judged by the reduction in variability which occurs when it is used to segregate the logs or trees. From a statistical standpoint this is a problem in stratification rather than one of sampling distribution or application.

In most instances, the USDAFS Factory Log Grading system does not result in reducing variation in a way that yields a uniform, consistent outcome that provides industry with a system for procuring and confidently pricing logs of varying quality.

As noted earlier, the AHC at WVU in 2005 embarked on a research program to help hardwood sawmills better understand their log grades and lumber grade yields, in the context of the de facto industry log grading system, with the companion objective of empirically evaluating the de facto system as a possible candidate for a national hardwood grading system in the United States. It is clear from the Rast and Baumgras (1997) report that the de facto log grading system has superseded the USDAFS Hardwood Logs Grades in practice, but as one would expect, with the lack of coordination or general oversight, the de facto system has resulted in many permutations. Yet the basic notion of grading based on log diameter and clear sides remains intact. The opportunity certainly exists to expand on the de facto system to develop a consistent and reliable system that incorporates many basic tenets of the National Log Grading Committee report (Newport et al. 1959), since those basic tenets are as meaningful today as they were in the 1950s.

Part 3 of this series will provide, through the results of a mail survey of hardwood sawmills, a more detailed overview of the current status of the de facto hardwood log grading system and the variety of elements at play within that system. Follow-up articles will document the efforts the AHC-WVU will pursue in developing a new hardwood log grading system that better meets the needs of the hardwood industry.

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