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Institut de recherche sur les feuillus nordiques Inc.
Northern Hardwoods Research Institute Inc.

Mainstream grading systems for lumber boards and harvested logs

July
2018

Technical Note

Resource Characterization

INTRODUCTION

Petro (1990) mentions that for maximum yields and profits, a high ratio of high-quality products has to be extracted from a stand harvesting operation: veneer logs, sawlogs, and pulp logs. There are many factors and practices, both in the stand during harvesting and in the factory during processing, that may affect the value of the products. To ensure the correct assessment of product quality and value all across, standards are required and grading systems have been established to provide fair prices to the industry and its clients.

But what could determine quality and how does grading systems work in the hardwood industry? This technical note presents guidelines from the prevalent grading systems in the hardwood industry, being the National Hardwood Lumber Association grading rules (NHLA), and the Petro Log Classification is introduced. Links between the two systems will conclude this technical note.

HIGHLIGHTS

- **Sawlogs of poor quality, containing injuries or defects may produce poorer quality boards by NHLA standards, reducing the financial profits of the harvested stand.**
- **Assessing sawlogs by a Petro log class prior to sawing can estimate the output product by NHLA standards, since both are correlated.**

GRADING LUMBER BOARDS—NHLA

The NHLA has developed a grading system, to which forest industries turn to when assessing the quality of their products (and subsequent profits). Although it has been adopted in both United States' and Canadian's hardwood industries, it is based on the imperial measurement system. For the next few page, an overview of the NHLA method of grading a board will be given. Usually, the measure-

ments are made in feet (for length) times inches (for width). Such product will be called "units" throughout the examples. Thickness is not considered while grading the board, but can be used to find the volume of a board or of a bundle of lumber. Measurements for thickness of one board would be in quarter-inch fractions ($^{3}/_{4}$, $^{4}/_{4}$, $^{5}/_{4}$, $^{6}/_{4}$, $^{8}/_{4}$, $^{10}/_{4}$, $^{12}/_{4}$, $^{16}/_{4}$…).

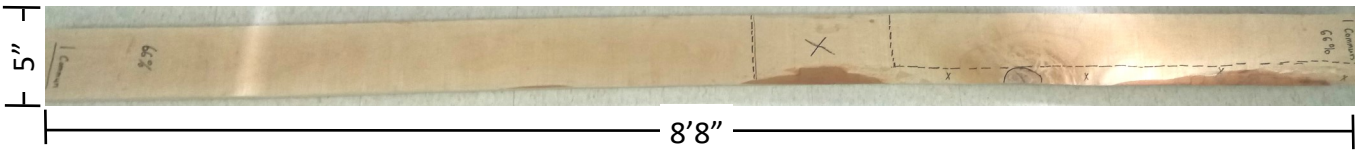
Steps for the NHLA lumber board grading method:

1. Find the poorest face of the board by doing a visual assessment.

Grading is usually made from the poorest face. As an example, the board measured in Step 2 has its poorest face visible. Inspection with NHLA standards is made by trained and certified graders.

2. Calculate the surface area of the board.

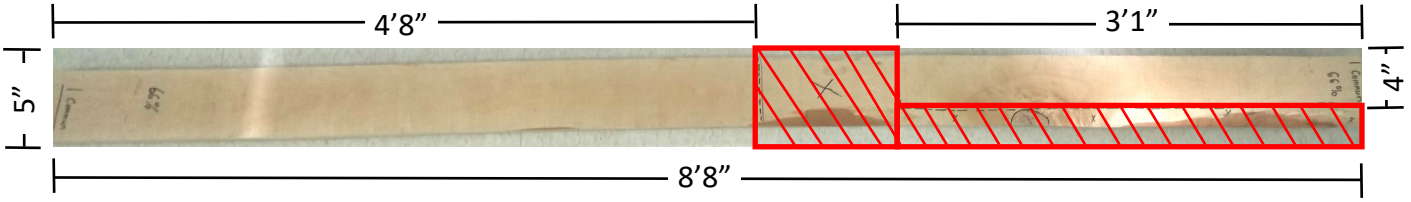
To calculate the surface area, multiply the length of the board (in feet) by its width (in inches). Inches in the length dimension can be divided by 12 to ease the calculations (as we did here: 8in becomes 0.66ft). Boards have to be over a certain minimum size to be classified, depending on grade (a list is available in Appendix A).



$$Length \times Width = 8'8" \times 5" = 8.66' \times 5" = 43.33 \text{ units} \quad (1)$$

3. Measure the clear cuttings of the board.

Wood free from defect in the board is called a clear cutting. Defects not admitted are: bark pockets, bird pecks, checks, decay or rot, unsound and sound knots, split, sticker stain, wane, worm holes, pith, and grub holes. To measure these clear cuttings, first eliminate every section containing defects (here in red). Then they have to be measured as in Step 2 (length by width) and added to each other ($C_1 + C_2 + … + C_n$ in equation 2). It should be noted that there exist minimum dimensions of clear cuttings per grade. If those minimum requirements are not fulfilled, the board could be downgraded. Again, Appendix A contains most of these specifications.



$$C_1 + C_2 + \cdots + C_n = (length \times width) + (length \times width) \ldots \quad (2)$$

$$(4'8'' \times 5'') + (3'1'' \times 4'') = (4.66' \times 5'') + (3.083' \times 4'') = 23.33 + 12.33 = 35.66\, units$$

4. Calculate the percentage of clear cuttings.

The percentage of lumber free from defects is defined by dividing the sum of the clear cuttings as in Step 3 by the total surface area of Step 2, then multiplied by 100.

$$\frac{Sum\ of\ the\ clear\ cuttings\ areas}{Total\ area\ of\ the\ board} \times 100 = \frac{35.66}{43.33} \times 100 \cong 0.823 \times 100 = 82.3\,\% \qquad (3)$$

5. Compare percentage of clear cutting to NHLA specs to determine grade

With this percentage in hand, it is now possible to assign a grade the lumber board. Table 1 summarizes the measurements of our example. Table 2 presents the required clear cutting percentage to attain for each grade. Exceptions and other specs may be required. Please refer to the NHLA rulebook, available online at https://issuu.com/nhla/docs/2015_rulebook_final, for the complete requirements and other rules not mentioned in this technical note. The reader should be reminded that inspection by NHLA standards should be done by certified graders.

Since the example board has 82% of clear cutting, it would fall in the 1 Common grade that includes board having 66% to 82% of clear cuttings.

The top row of Table 2 (in green - FAS/F1F/Select) consist of prime quality boards with no or minimal defect. They are also the most expensive due to their quality. Some companies may only work with certain grades (mostly 2A Common and greater), and some may also create their own grading system, while maintaining NHLA standards.

Characteristics of the Example Board	
Total surface area	43.33 units
Clear cutting area (no defects)	35.66 units
Percent clear cut available	82 %
NHLA Grade	1 Common

Table 1. Characteristics of the board used as example, and its grade by the NHLA standards.

NHLA Grade	Clear cut % Requirement
FAS / F1F / Select	83% to 100%
1 Common	66% to 82%
2A / 2B Common	50% to 65%
3A / 3B Common	20% to 49%

Table 2. NHLA Clear cut % requirements per grade. Not only the clear cut % is required, but board dimensions per grade have to be within a specific range (see Appendix A for most the requirements).

The NHLA rules and grades have been around since 1897 and revised periodically by a committee of experienced lumber-people, providing the forest industry with the best lumber specifications for their products.

Directly based on the NHLA lumber grading system, the Petro log classification has been developed by Petro and Calvert in 1976. Both of these grading share similar traits, such as minimal cutting sizes and distance between defects. The main purpose of the Petro classification is to grade sawlogs into three categories and, indirectly, give a sense of the expected quality level of the lumber output. Although it only involves the visible elements on the surface of the log and the end portions, the Petro classification gives an excellent idea of what to expect underneath the bark. This system is used mainly by research institutes in the United States and in Canada, and it is the common element to link sawlog grades to studies done in sawmills, where logs are sawn individually and the breakdown in NHLA board is evaluated.

During the next few pages, a step by step procedure is given on how to grade sawlogs with the Petro log classification. Measurements can be made either with imperial or metric systems. At NHRI Inc, a combined approach is used. Grading should only be made by experienced professionals and trained individuals.

STEPS FOR PETRO LOG CLASSIFICATION

1. Find the poorest face of the board by doing a visual assessment.

Logs can be divided in four faces. All faces must be visually assessed, and then the before-last poorest face will be used for grading — not the poorest. In the example of Figure 1, that *grading face would be number 4*, since face 1 seems to be the poorest, with less clear cutting length.

2. Measure the length of the log and the inside-bark small diameter.

In accordance to the NHRI approach, diameter will be measured in centimeters and length will be calculated in feet. In the example, *inside-bark small diameter is 30cm and total length is 8 feet.*

3. Determine and measure the clear cuttings.

Same as for the NHLA, all visible defects on the graded face are not included in clear cuttings. Defects can be, but are not limited to, bump, split, decay, knot, wormhole, bark distortion, and canker. When these are found on the log, they delimit the boundaries of clear cutting sections, and only the defect-free part of the log is measured. On face 4, the red circles represent the defects, so *the clear cutting length on face 4 is 6 feet 6 inches.* Note: some defects can be partly accepted in clear-cuttings so refer to the complete document for specific explanation.

4. **Calculate the clear cutting portions and the yield percentage.**

Minimal size and maximum number of clear cuttings are required depending on the grade. It is wise to check the complete guide for more details and other grade-dependant specs. In this example, the full clear cutting section contains the minimal requirement for its length 2 portions of 3 feet. To find the yield percentage, take the sum of the clear cutting sections divided by the total length of the log, then multiplied by 100 (as Step 4 of NHLA).

Characteristics of the Example Log (Graded on quadrant 4)	
Inside-bark diameter	30cm
Total length	8 ft
Clear cutting sections	6 ft 6 in
Clear cuttings portions	2
Yield	81 %
Petro Log grade	F2

Table 3: Summary of log example.

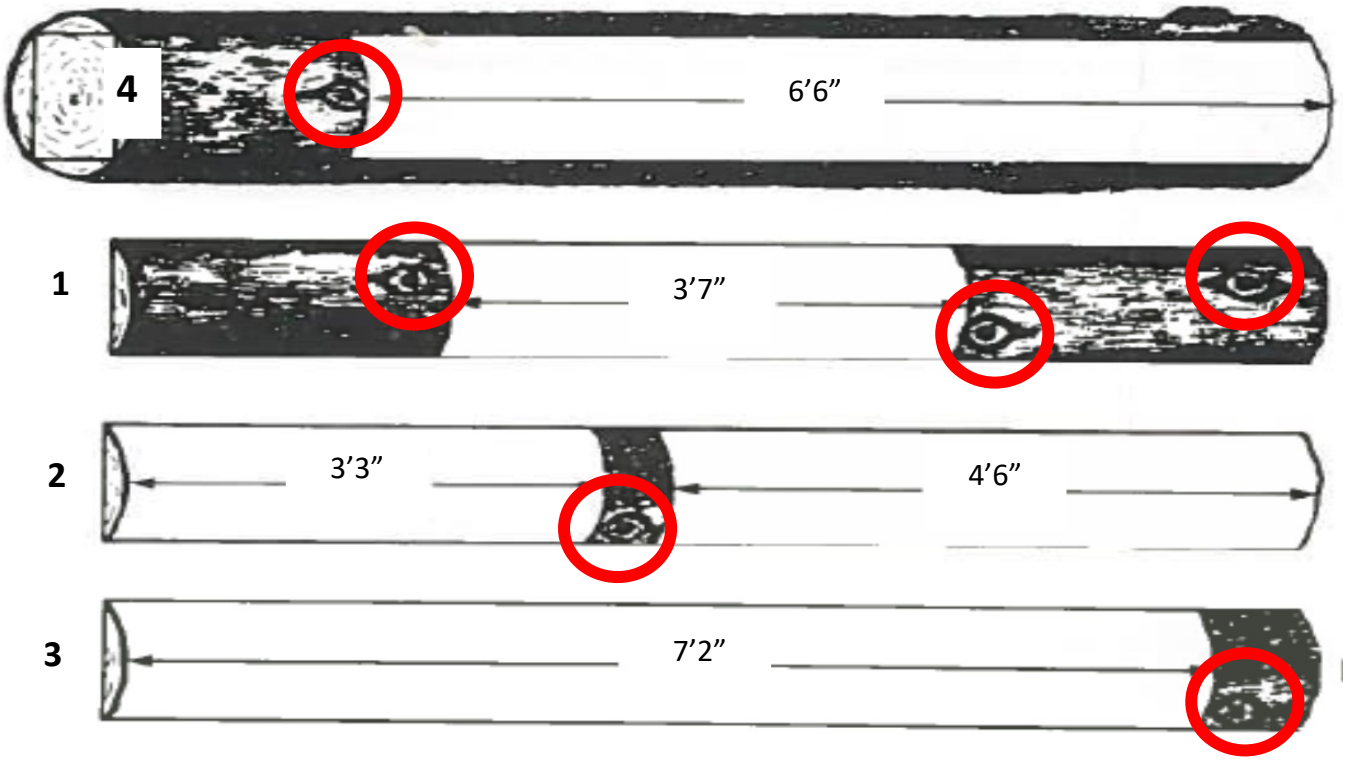


Figure 1: Log used as example for the Petro classification.

5. Grading.

We then compare the log's measurements of Table 3 to the Petro classification in Appendix B, containing the minimum requirements of each grade, and we find that the example is ranked as a F2 log. Sweeps, crooks, rot, and curves are also to taken into account when grading a log. Please refer to the complete guide for the exact specifications for each grade.

There exist three grade in the Petro Log Classification, identified as F1, F2 and F3. F1 logs are considered to be the best quality logs from the tree since they have a longer clear cutting face and less defects. F2 logs are still considered good logs containing defects and/or having smaller diameter. F3 logs have the most defects for their length and diameter, and they can be used for less aesthetic purposes...since hardwood is used primarily for appearance or non-structural wood.

NHLA AND PETRO LOG CLASSIFICATION

As it was previously stated, the Petro log Classification is based on the NHLA grading system. Evidently, the surface of the log may present knots, splits, or other defects, and these will be present to some extend underneath the bark as well at least for a few boards, as it is illustrated in Figure 2. Also, the minimum require measures for the clear cutting portions of the Petro log classification are identical to those of the NHLA (Figure 3).

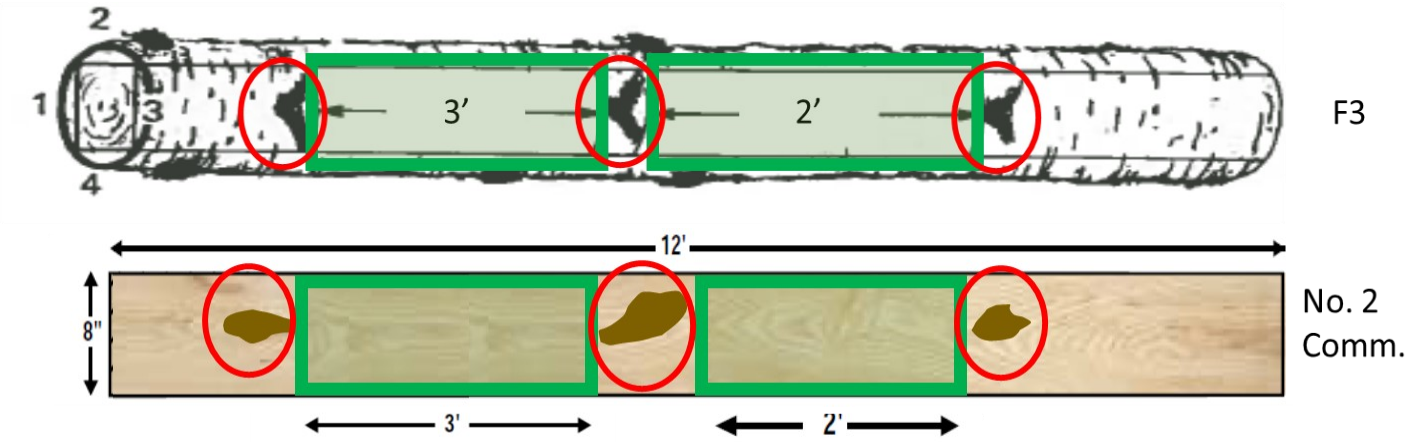


Figure 2: Visual comparison of Petro classes and NHLA grades specs regarding similar clear cutting sizes.

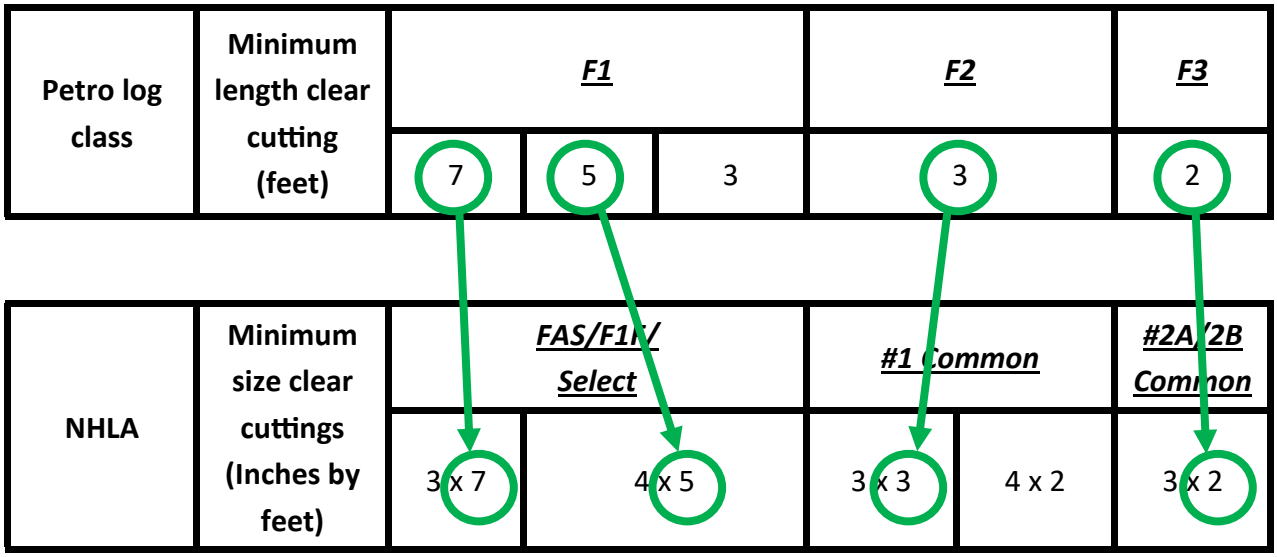


Figure 3: Technical comparison of Petro classes and NHLA grades specs regarding similar clear cutting sizes.

CONCLUSION

A diversity of benefits are provided by forests and trees, but the main goal of the forest industry is to harvest high-quality products that will have a competitive merchantable value. To achieve maximum profitability from a stand, bucking strategies should aim to produce sawlogs of good quality and have the least possible amount of defects, thus ranking high on the Petro log class. Indirectly, if the log's defects are limited, the grade of the lumber boards produced from those sawlogs could class high in the NHLA standards. Since hardwoods are used mostly for aesthetics and finishing purposes (veneers, cabinetry, furniture, flooring...), products should be appealing and be of the utmost quality, *virtually* free from any defects.

We do think that what is underneath the bark of a tree is often out of the industry's control, but forest managers and silviculturists may obtain the highest possible log quality by exercising thoughtful and punctual silvicultural procedures. For example, it is possible to control the amount of injuries and defects a tree can receive by managing the density of a stand. Sharad (2017) has demonstrated that stand density management can provide the right balance between accelerated growth and natural pruning to provide high-quality products. Petro (1990) mentions that proper and careful harvesting methods should always be kept in mind by both managers and operators, as to limit injuries from the machinery on standing trees not targeted for harvest for example. Trees that have been damaged may lose vigour, create imperfections, thus produce lower NHLA-grade lumber with lower returns.

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APPENDICES

Appendix A: Grading specifications summary of the National Hardwood Lumber Association (NHLA) - 2015, pp. 20-21. Grading should be done by NHLA certified graders only. COM = Common and SM = Surface measure. (Continues on next page).

	FAS	F1F	SELECT	#1 COM	#2A & 2B
Minimum Size Board	6” x 8’	Same as FAS for species being graded	4” x 6’	3” x 4’	3” x 4’
Minimum Size Cutting	4” x 5’ 3” x 7’	Better Face to Grade FAS Poor Face to Grade #1 Common		4” x 2’ 3” x 3’	3” x 2’
Basic Yield	SM x 10 83-1/3%			SM x 8 66-2/3%	SM x 6 50%
Formula to Determine Number of Cuts	$\frac{SM}{4}$ (4 max)			$\frac{SM + 1}{3}$ (5 max)	$\frac{SM}{2}$ (7 max)
SM Needed to Take Extra Cutting	6-15’ SM			3-10’ SM	2-7’ SM
Extra Yields Needed for Extra Cutting	SM x 11 91-2/3%			SM x 9 75%	SM x 8 66-2/3%
Special Yields	97% Rule - 2 cuts full widths any length; Pcs. 6’ & wider with 6-12’ SM SM x 11.64 for yields	97% Rule - On Better Face	97% Rule - On Better Face; 2’ x 3’ SM to be 100% clear of SM x 11 in one cutting	1’ SM - SM x 12 or 100% clear 2’ SM - SM x 9	1’ SM - SM x 8 #2A COM - Clear Cuttings #2B COM - Sound Cuttings

Appendices

Appendix A: (Continuation from previous page.)

	#3A COM	#3B COM	FAS Limits
Minimum Size Board	3" x 4'	3" x 4'	Pith = SM in inches Wane = 1/2 length Knot = 1/3 SM Warp = Entire board must be flat enough to S2S to S.S.T. Splits = Not to exceed 2 x SM or 12" whichever is greater. Splits shall not diverge 1" in 12". First Lineal Rule: Applies to both end of Board to contain not less than 50% clear wood, 25% sound wood.
Minimum Size Cutting	3" x 2'	Not Less than 1-1/2' wide containing 36 sq. inches.	
Basic Yield	SM x 4 33-1/3%	SM x 3 25%	
Formula to Determine Num-ber of Cuts	Unlimited	Unlimited Sound Cuttings	
SM Needed to Take Extra Cutting	——	——	
Extra Yields Need-ed for Extra Cutting	——	——	
Special Yields	#2A Common on Better Face and reverse side of cuttings sounds; will also qualify for 3A Common	——	

NOTE: This chart summarizes the main requirements for the standard grades. For complete information, consult the appropriate section of the NHLA Rule Book (2015). Companies can add grades to these ones.

Wane in FAS 1 FACE

FAS limitation applies to Better Face

#1 Common side: 1/3 W or 1/2 L Widest wane added together. Length can be on both edges.

Wane in Selects

Pcs. 6'' & Wider

FAS limitation applies to Better Face.
#1 Common Side: 1/3 W or 1/2 L Widest wane added together. Length can be on both edges.

Pcs. 4" & 5" Wide

1/3 W or 1/2 L applies to both faces.
Add widest wane together.
Add total length of wane from both edges.

APPENDICES

Appendix B: Petro Log Classification - Petro, F. J., & Calvert, W. W. (1976). *La classification des billes de bois franc destinées au sciage.* Ottawa: Forintek Canada Corp.

Quality Criteria		F1 log			F2 log				F3 log
Position of log		Butt log	Butt log and others		Butt log and others				Butt log and others
Minimum diameter (cm)		34-48	40-48	50+	28	30+			20+
Minimum length (ft)		10			10	8-9	10	12+	8+
Clear sections	Minimum length (ft)	7	5	3	3				2
	Number	2			2			3	Unlimited
	Yield (%)	83%			67%	75%	67%	67%	50%
Sweeps	Less than 1/4 small	15%			30%				50%
	More than 1/4 small	10%			20%				35%
	Decay and sweeps	40%			50%				50%

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