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A Classification System for Predicting Pallet Part Quality from Hardwood Cants

E. Paul Craft
Kenneth R. Whitenack, Jr.

The Authors

E. Paul Craft, research forester, received a B.S. degree in forestry from West Virginia University in 1951. From 1951 to 1961 he managed logging and milling operations and was a field representative for heavy construction and industrial equipment manufacturers. He joined the Northeastern Forest Experiment Station's Forestry Sciences Laboratory at Princeton, West Virginia, in 1962.

Kenneth R. Whitenack, mathematical statistician, received a B.S. degree in mathematics from Concord College, Athens, West Virginia, in 1968. He completed graduate courses at North Carolina State University and Virginia Polytechnic Institute and State University from 1968 to 1970. He joined the Northeastern Station at Princeton in 1967.

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Abstract

Producers who manufacture pallet parts from hardwood cants generally must purchase cants on the basis of existing structural timber grades that do not adequately reflect the quality of pallet parts produced from resawed cants. A system for classifying cants for pallet part production has been developed that more accurately reflects the parts grade mix that can be produced from each of the new cant classes. A formula is given to determine value relatives for each cant class.

Introduction

The early practice of the pallet industry for procuring hardwood raw material was to purchase stringer stock (mostly 2 by 4's) and low-grade random lumber for deckboards from sawmills. As the industry developed, this practice changed to the purchase of cants or lumber of specified dimensions, in multiples of sizes required for individual pallet parts. This material was then resawed into pallet parts.

In 1958 the National Wooden Pallet and Manufacturers Association (now the National Wooden Pallet & Container Association) published specifications which included a pallet and parts grading system that reflected the degree of strength and durability of four grades of commercial pallets. The pallet grades were based on the placement of various grades of parts in the pallet. The parts grades were based on the size, type, and distribution of defects that affect the strength and durability of the part.

Although this system provided a method of assuring overall pallet quality and performance, it did not include a method of predicting pallet part grade yield from cants. Existing structural cant grades (National Hardwood Lumber Association [NHLA] Rules) were developed for application to whole pieces; they were not intended to reflect the grade mix of parts resawed from the pieces. For the last 15 years, pallets have been produced by specifying the minimum quality of parts acceptable in the pallet. As a result, pallet producers who do not have markets for a variety of pallet grades develop surplus inventories of off-grade parts.

To help alleviate this situation, we experimented with a cant classification system (Interim) that is based on the same defect size, type, and distribution as the National Wooden Pallet & Container Association (NWPCA) parts grading rules (Appendix). This system enables a pallet producer to purchase grade classes of cants that will yield the grade mix of parts that more nearly meet the requirements for his operation, and thus help minimize the accumulation of off-grade parts.

This paper describes the system of classifying cants for pallet part production and provides the grade mix of parts produced from each cant class. It also compares the newly developed cant classes with two construction timber grades from NHLA rules and one grade used by some industry firms (Appendix). In this report, the latter three grades are referred to as "Present."

Procedure

Four- and six-foot-long bolts from each of three species groups (yellow-poplar—cucumber, birch—maple, and red—white—chestnut oak) were sawed into 4- by 4-inch and 4- by 6-inch cants. The cant width was dictated by the size of the bolt. No effort was made to balance the cant widths produced.

Bolts were processed until a minimum of 10 cants were produced for each of four cant classes in each length category and for each species group. The cant classes were developed from the NWPCA grading rules for industrial pallets. Each cant also was graded by specifications by Present rules.

Each cant was sawed into 1- by 4-inch pallet deckboards and 2- by 4-inch pallet stringers. The pallet parts were classified by a grading system based on the NWPCA pallet grading rules.

Results

A total of 295 cants were processed into parts. The cant distribution by classes was:

Classification system	Cant class			
	1	2	3	Below grade
	percent			
Interim	33	23	24	20
Present	24	66	5	5

Graded pallet part yields by interim cant classes were:

Cant class interim	Part grade yield (NWPCA)			
	1	2	3	Below grade
	percent			
1	59	23	8	10
2	33	23	29	15
3	10	19	37	34
Below grade	10	11	14	65

(See Table 1 for grade yields by species and length.)

Table 1.—Parts yields by NWPCA grades from cants classified by the interim grading system, in percent

Species	Interim cant class	Number of samples	Parts grade				Number of samples	Parts grade			
			1	2	3	Below grade		1	2	3	Below grade
		4-FOOT LENGTH					6-FOOT LENGTH				
Yellow-poplar	1	21	47	34	14	5	10	73	21	4	2
	2	13	40	28	26	6	10	18	36	32	14
	3	14	12	34	44	10	10	9	10	44	37
	Below grade	10	16	21	11	52	10	12	13	2	73
Maple	1	25	67	14	6	13	10	63	27	10	0
	2	10	46	21	25	8	10	19	33	23	25
	3	10	8	20	36	36	10	8	21	36	35
	Below grade	10	16	14	11	59	10	2	2	32	64
Oak	1	21	54	21	8	17	10	64	24	0	12
	2	15	38	10	32	20	10	36	14	36	14
	3	16	16	9	26	49	10	2	14	40	44
	Below grade	10	6	7	7	80	10	7	7	22	64
Total	1	67	56	23	9	12	30	67	24	4	5
	2	38	41	19	28	12	30	24	28	30	18
	3	40	13	21	35	31	30	7	15	40	38
	Below grade	30	13	14	10	63	30	7	8	17	68

Graded pallet part yields by Present cant grades were:

Cant grade Present	Part grade yield (NWPCA)			
	1	2	3	Below grade
	percent			
1	48	27	14	11
2	29	18	24	29
3	18	26	18	38
Below grade	3	3	14	80

Differences in parts yield between species and cant length could not be distinguished statistically for cants classified by the Present rules.

A series of statistical procedures were applied to determine the classification system that was more closely related to the quality of pallet materials within the cant. Results indicate the Interim system is more accurate by 33 percent. (The procedures and conclusions are given in the Appendix.)

Relative parts values generally applied in the pallet industry using Grade 3 value as the base are:

Below grade parts = 0.0
Grade 3 parts = 1.0
Grade 2 parts = 1.4
Grade 1 parts = 2.1

Where these relative values apply, the current value of each part by grade is determined by multiplying the current value of Grade 3 parts by the relative value of the appropriate part grade. For example: If Grade 3 parts are worth $125 per thousand board feet (M bf), the value for each part grade would be:

Part grade	*Relative value*	*Grade 3 value*	*Part value*
		dollars/M bf	
1	2.1	125	262.50
2	1.4	125	175
3	1.0	125	125
Below grade	0.0	125	0

These relative values were used to develop Table 2. To determine the value of parts from cants classified by the Interim system, the value of Grade 3 parts may be multiplied by the appropriate table value. For example, if the value of Grade 3 parts is $125 per M bf, the mean value of parts that could be sawed from 4-foot cants by class for all species combined is:

Interim cant class	*Table value*	*Grade 3 part value*	*Gross cant value*
		dollars/M bf	
1	1.584	125	198
2	1.383	125	172.88
3	0.880	125	110
Below grade	0.541	125	56.38

Where the relative parts values differ from the example, value tables can be developed by the formula:

$$\text{Cant Value Relative} = P_1 \cdot R_1 + P_2 \cdot R_2 + P_3 \cdot R_3 + P_4 \cdot R_4$$

For example:

If the parts price relatives are:

Grade 1 = 3.0
Grade 2 = 1.5
Grade 3 = 1.0
Below grade = 0.0,

The mean value relative for a No. 1 4-foot-long hardwood cant graded by the interim system is:

$$(.47)(3.0) + (.27)(1.5) + (.15)(1.0) + (.11)(0) = 1.965$$

If the value of Grade 3 parts is $70/M bf, the mean gross value of parts from No. 1 4-foot hardwood cants is $70 × 1.965 or $137.55/M bf.

Table 2.—Interim classification system value relatives[a]

Interim class	Length (feet)	Actual means (weighted)							
		N[b]	Poplar	N	Maple	N	Oak	M	All
1	4	21	1.566	25	1.673	21	1.497	67	1.584
1	6	10	1.888	10	1.798	10	1.668	30	1.785
2	4	13	1.472	10	1.487	15	1.238	38	1.383
2	6	10	1.198	10	1.075	10	1.276	30	1.183
3	4	14	1.192	10	0.771	16	0.675	40	0.880
3	6	10	0.753	10	0.831	10	0.665	30	0.750
Below grade	4	10	0.730	10	0.592	10	0.301	30	0.541
Below grade	6	10	0.437	10	0.403	10	0.488	30	0.443
All	4	58	1.310	55	1.279	62	1.029	175	1.201
All	6	40	1.069	40	1.027	40	1.024	120	1.040

[a] Value relatives based on the relation: Class 1 parts = 2.1; Class 2 parts = 1.4; Class 3 parts = 1.0; Below grade parts = 0. For other value relationships, tabular values are calculated by the formula: $P_1 \cdot R_1 + P_2 \cdot R_2 + P_3 \cdot R_3 + P_4 \cdot R_4$

[b] N = Number of samples.

Literature Cited

National Hardwood Lumber Association. **Rules for the measurement and inspection of hardwood and cypress lumber**. Chicago, IL: Nat. Hardwood Lumber Assoc., 1978. 115 p.

National Wooden Pallet and Manufacturers Association. **Specifications and grades for hardwood warehouse, permanent or returnable pallets**. Washington, DC: Nat. Wooden Pallet and Container Assoc., 1962. 18 p.

Appendix

Cant Quality Classification

Since no published pallet cant grading system is available, we devised interim quality classes for use in the study. The following summarizes minimum specifications for each of four classes of cants:

Class 1

Sawed knots. Maximum dimension 1/3 face width. Multiple knot dimensions additive if within 3 inches of each other. None over 1/2 inch in edges or end 3 inches.

Unsound knots and holes. Unsound or loose knots or holes may not exceed 1/6 width of cant face.

Cross grain. Not greater than 1:10 except in vicinity of knots and burls.

Split, shake, checks. Singly or in combination not to exceed 1/3 cant length, except 3 inches or less long are ignored.

Wane. May not exceed 1/2-inch width on any edge of the cant.

Manufacture. 75 percent of pieces must be at least of specified dimensions, and may not exceed 1/4-inch thickness in excess of specified dimension; 25 percent may be within − 1/8 and + 1/4 inch of specified dimension.

Class 2

Sound knots. Maximum dimension 1/2 face width. Dimensions of clustered knots additive if within 3 inches of each other. None over 1 inch in edges or end 3 inches.

Unsound knots or holes. Unsound knots, loose knots, or holes may not exceed 1/4 width of cant face.

Cross grain. Not greater than 1:6 except in vicinity of knots and burls.

Splits, checks, shake. Singly or in combination, may not exceed 1/2 of cant length. Those less than 3 inches long are ignored.

Wane. May not exceed ⅝-inch width on any edge of the cant.

Manufacture. 66-2/3 percent of pieces must be at least of specified dimensions, and may not exceed 1/4-inch thickness in excess of specified dimension; 33-1/3 percent of pieces may be within − 1/8 inch and + 1/4 inch of specified dimension.

Class 3

Sound knots. No size limitation.

Unsound knots and holes. Unsound knots, loose knots, or holes may not exceed 1/2 width of cant face.

Cross grain. No limitation.

Splits, checks, shake. Singly or in combination, may not exceed 3/4 of cant length; those less than 3 inches long are ignored.

Wane. May not exceed 3/4-inch width of any edge of the cant.

Manufacture. All pieces must be within − 1/8 inch and + 1/4 inch of specified dimension.

Below grade. Cants that do not meet Class 3 specification.

Interim Grading System

The interim pallet cant grading system has not been adopted by industry. Most cants currently are purchased by some variation of the following rules (Present).

Class 1

Sound end and faces 1/4-inch wane on not more than two faces.

Class 2

Sound-Square-Edge grade as defined in NHLA Rule Book, 1978, p. 74.

Class 3

Common Timbers & Industrial Blocking Grade as defined in NHLA Rule Book, 1978, p. 75.

Statistical Analysis for Value Relations

The mean value relative ($\overline{VR}$) for the entire sample was: $\overline{VR}$ = 1.135 with standard deviation (S) S = 0.6112. If the cants are now classified by Present rules, the following results are obtained:

Present class	No. cants	$\overline{VR}$	S
1	70	1.499	0.476
2	195	1.091	0.586
3	16	0.884	0.474
4 (Below grade)	14	0.214	0.368

An analysis of variance (ANOVA) with a Duncan's Multiple Range Test yields the following results:

1. No difference between Grades 2 and 3

2. Pooled standard deviation = 0.548

3. R^2 = 0.205

Classifying the same cants with the proposed system (Interim) yields the following results:

Interim class	No. cants	$\overline{VR}$	S
1	97	1.646	0.399
2	68	1.295	0.433
3	70	0.824	0.399
4 (Below grade)	60	0.492	0.457

Similarly, an ANOVA with a Duncan's Multiple Range Test performed yields these results:

1. All classes different

2. Pooled standard deviation = 0.419

3. R^2 = 0.535

A comparison of the two analyses reveals the following pertinent points:

1. The Interim system produces a more uniform distribution of the cants into classes. Note that with the Present system, 66 percent of all cants were grade 2 cants, only 5 percent were Grade 3, and another 5 percent were Grade 4.

2. The differences between adjacent mean value relatives for both systems are:

Classes	*Difference (Present)*	*Difference (Interim)*
1, 2	0.408	0.351
2, 3	0.207*	0.471
3, 4	0.670	0.332

*Not significant.

Note the more uniform spacing between the Interim system means.

3. The standard deviations for the Interim system are very consistent among classes. This is not true for the Present system. These are more variable with the largest standard deviation occurring in the Grade 2 cant class—the one that contains 66 percent of all cants. In fact, the standard deviation for this class (0.586) is nearly the same as the standard deviation with no grouping at all (0.6112).

The smallest standard deviation (0.368 in Grade 4) occurs in a class that contains only 5 percent of all cants.

Thus, the proposed system produces four distinct classes versus only three for the Present system. Further, the standard deviation is 23.5 percent smaller than that yielded by the Present system. This means that in using the proposed system (Interim) we can more accurately predict the value of the material within a group of cants and within significantly narrower limits.

Also noteworthy is that the Interim system of classification can explain 33 percent more of the variation among the value relatives than the Present system, i.e., 0.535 − 0.205 = 0.33 or 33 percent.

Errata Sheet for Research Paper NE-515

On page 4, column 3, paragraphs 2 and 3 should read:

The mean value relative for a No. 1 4-foot-long hardwood cant graded by the interim system is:

$$(.56)(3.0) + (.23)(1.5) + (.09)(1.0) + (.12)(0) = 2.115$$

If the value of Grade 3 parts is $70/M bf, the mean gross value of parts from No. 1 4-foot hardwood cants is $70 x 2.115 or $148.05/M bf.

Craft, E. Paul; Whitenack, Kenneth R., Jr. A classification system for predicting pallet part quality from hardwood cants. Broomall, PA: Northeast. For. Exp. Stn.; 1982; USDA For. Serv. Res. Pap. NE-515. 7 p.

A system for classifying cants for pallet part production was developed that more accurately predicts the pallet parts grade mix that can be sawed from cants than the structural timber grades that are now used. A formula is given to determine value relatives for each cant class.

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Keywords: Pallet cant classes; value relatives

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