ODC: 331

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THE QUALITY AND AVAILABILITY OF HARDWOOD LOGGING RESIDUE

Based on Developed Quality Levels

FOREST SERVICE RESEARCH PAPER NE-459
1980
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
NORTHEASTERN FOREST EXPERIMENT STATION
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MANUSCRIPT RECEIVED FOR PUBLICATION 27 DECEMBER 1979

Abstract

Hardwood logging residue was examined for salvageable quality material. Four quality levels (QL 1 to QL 4), based on four sets of specifications, were developed. The specifications used surface indicators, sweep, center decay, and piece size to determine quality. Twenty-six percent of the total logging residue (residue $\geq$ 4 inches in diameter outside bark at small end and $\geq$ 4 feet long, except if $\geq$ 2 feet long and $\geq$ 12 inches dob) from saw log only harvesting operations met the lowest of the four quality levels (QL 4). QL 4 could best be described as local use logs. The acceptability of residue at QL 4 increased to 36 percent if bolewood only was considered. Only 9 percent of the residue would be salvageable at the QL 1 level.

INTRODUCTION

FOREST MANAGERS are increasingly interested in achieving greater timber utilization. Logging residues are a major concern because of the large volumes generated annually. In West Virginia, for example, Martin (1975a) estimated that timber harvesting operations produce approximately 80 million cubic feet of residue per year. This is in material equal to or larger than 4 inches in diameter outside bark (dob) and 4 feet or longer.

Logging residue protects the site and acts as a nutrient bank for forest soil, and provides wildlife with shelter and food. While these are important uses, we may be approaching the time when some residue can be used commercially in lieu of harvested trees.

The feasibility of using logging residue depends on two factors: (1) the physical suitability of residue wood for different product uses; and (2) the value of products derived from residues versus the cost of recovery and processing. In 1977, I evaluated logging residue as a raw material for producing mine timbers (Timson 1978). The study on which this report is based was concerned with the suitability of residue wood where the physical requirements for acceptance were more stringent than the quality requirements for mine timbers.

Logging residue has become an accepted term, but what it encompasses depends on specific situations. Logging residue as used or referred to in this report is felled or knocked over material remaining on the site after a harvesting operation (see cover).

QUALITY LEVELS

In the mine timber study, hardwood logging residue was examined to find what percentage of the material remaining after a saw log only cutting operation was suitable for a specific product. For this study, no specific product requirements were used. Rather, four sets of specifications (quality levels) were developed to classify the residue wood.

The reason for the switch from studying residue from a specific to a general standpoint was the lack of even minimum specifications for raw materials used in making a given product. Through the use of the four quality specifications, a more general knowledge of residue quality could be obtained.

Potential users of the findings of this study can compare their raw material specifications with the quality levels used here. The readers' specification and quality levels of the study probably will not compare exactly. However, the reader can interpolate where his specifications lie among the four quality levels and interpolate approximately the percent of a given logging residue source that can be used in his specific case.

The quality levels (QL 1, 2, 3, 4) include two length classes, each containing two quality standards.

QL 1

Length: 4 to 5 feet.
Minimum diameter: 8 inches.
Surface: 2 or more clear faces full length of piece.
Defect indicators (other faces):
Seam—Acceptable if it can be confined to face edge.
Knots, bumps, etc.—diameter not to exceed face width.
Sweep: None.
Unsound end defects: $\leq$ 12-inches (dob)—none allowed.
$>$ 12 inches (dob)—allowed in center one-third of end diameter.

QL 2

Length: 4 to 5 feet.
Minimum diameter: 6 inches.
Surface: 2 or more faces with at least one clear cutting each.
Minimum length cutting—24 inches.
Defect indicators:
Seam—acceptable if it can be confined to face edge.
Knots, bumps, etc.—diameter not to exceed face width.
Sweep: None.
Unsound end defects: $\leq$ 12 inches (dob)—none allowed.
$>$ 12 inches (dob)—allowed in center one-half of end diameter.

QL 3

Length: 6 to 16 feet.
Minimum diameter: 8 inches.
Surface (second poorest face):
Minimum proportion clear—one-half.
Minimum length cutting—24 inches.
Maximum number cuttings—none.
Defect indicators:
Seam—acceptable if it can be confined to face edge.
Knots, bumps, etc.—diameter not to exceed face width.
Sweep: Absolute sweep, one-fourth of small end diameter.
Unsound end defects: $\leq$ 12 inches (dob)—none allowed.
$>$ 12 inches (dob)—allowed in center one-fourth of end diameter.

QL 4

Length: 6 to 16 feet.
Minimum diameter: 6 inches.
Surface (second poorest face):
Minimum proportion clear—
6 to 8 feet, one cutting.
8.5 to 16 feet, two cuttings.
Minimum length cutting—24 inches.
Maximum number cuttings—none.
Defect indicators:
Seam—acceptable if it can be confined to face edge.
Knots, bumps, etc.—diameter not to exceed face width.
Sweep: Absolute sweep, one-fourth of small end diameter.
Unsound end defects: $\leq$ 12 inches (dob)—none allowed.
13 to 18 inches (dob)—allowed in center one-fourth of end diameter.
$>$ 18 inches (dob)—allowed in center one-half of end diameter.

The QL specifications were not designed to meet a specified grading system. However, to help familiarize you with the specifications, the following comparisons can be made:

QL 1: The specifications are very close to those for Pennsylvania bolt grade 2 (Dunmire and others 1974). The most noticeable difference is that QL 1 has a lower diameter limit.

QL 2: This class is poorer in most respects than Pennsylvania bolt grade 3.

QL 3: This class is similar to factory grade 3 (Ostrander and others 1965). Minimum diameter and minimum length are less than grade 3 specifications.

QL 4: This is basically a local use log (Ostrander and others 1965) except that minimum diameter and minimum length do not meet minimum local use requirements.

THE STUDY

Logging residue was measured on 25 randomly selected areas within the Appalachian hardwood forest region (Fig. 1): 17 sample areas in West Virginia, 1 in Virginia, and 7 in Pennsylvania. Over 90 percent of the cutting sites were on private lands.

The selected areas had been cut for saw logs only. The cutting system used was a selection cut based on diameter limit, marked timber, or in some cases, the timber cutter's judgment.

One 1/2-acre circular plot was established on each sample area. In selecting plots, the field crew considered access, ease of identifying and measuring the residue (Fig. 2), and whether the volume of residue was sufficient to justify selecting that plot. Generally, we required at least 300 cubic feet of residue per acre to justify a given plot selection. However, very large concentrations of residue were avoided because of the difficulty in measuring and identifying the quality of individual pieces.

Figure 2.—The remains of a hardwood saw log cutting operation

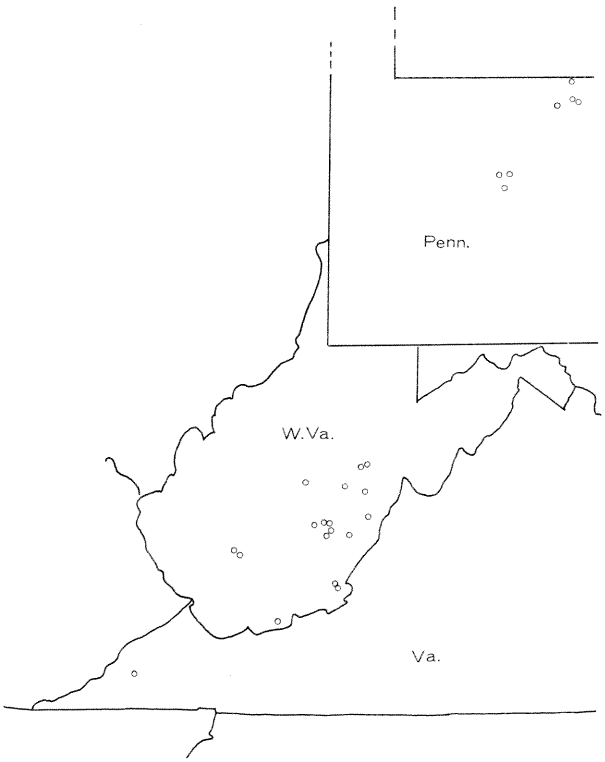

Figure 1.—Locations of selected areas for residue measurement

These selection criteria were suitable for the study since the objective was to determine the percentage of residue that would meet the quality level requirements. Because of the plot selection method, unbiased volume per acre estimates cannot be developed.

Within each plot, pieces of residue that met the following standards were measured:

- Equal to or greater than 4 feet long
- Equal to or greater than 4 inches in diameter outside bark (dob) small end
- Equal to or greater than 2 feet long if small end exceeded 12 inches in diameter
- Lie within plot boundary or pieces that had any portion crossing one-half of the plot boundary circumference (0° to 180°)—

pieces crossing the remainder of the boundary were ignored

It should be noted that sweep (crookedness), rot, or any external characteristics did not exclude any piece from being measured as part of the total residue.

For each piece of residue, the following was recorded:

- Species
- Position in tree
  Bolewood—main stem to a 4-inch outside bark (ob) top or to where the stem breaks up
  Limbwood—to a 4-inch (ob) small diameter
- Large and small end dob—to nearest 1/2 inch
- Length—to nearest 1/2 foot

After the above information was recorded, the same residue was reexamined to determine the parts of each piece that could be classified as being acceptable for one or more of the QL classes. For each section of residue acceptable by a QL class, the following was recorded:

- QL class
- Species
- Position in tree (description given above)
- Large and small end dob—to nearest 1/2 inch
- Length—to nearest 1/2 foot

In classifying a portion of a piece of residue for a given QL class, the longest length acceptable was given first priority except where more of the overall piece of residue could be used by considering shorter lengths and more sections. Also, the residue on each plot was classified for each QL class independent of the other QL classes. It was possible for any given piece of residue to meet the specification for more than one QL class.

In the office, the piece measurement information (length and diameter) was used to calculate total volume, each QL class volume, and designated subclass volumes within the QL classes. The percentage of acceptable residue by QL class was then calculated by dividing each QL class volume by total volume. The same procedure was used to develop percentages by species, bolewood or limbwood, and various size classes for each QL specification.

RESULTS

Statistical analysis showed no difference between the southern (West Virginia, Virginia) and the northern (Pennsylvania) sample areas, so stratification was discarded. The percentage of residue that met each of the four quality levels is shown in Tables 1 through 4.

Nine percent of hardwood logging residue met QL 1 standards of which one-third could be cut into 5-foot lengths. Twenty-four percent of the residue met QL 2 standards, half of which would make 5-foot bolts.

In the longer QL classes, 14 percent of the logging residue met QL 3 specifications, and 26 percent was acceptable as QL 4 material. In both cases, approximately 60 percent of these amounts was in acceptable pieces over 8 feet long.

Limbwood accounted for 32 percent of the total saw log harvesting residue (Table 5), but produced only 0.4 to 2.1 percent of the total acceptable material. Considering acceptable residue from limbwood only, 1 percent met QL 1 and QL 3 standards, 4 percent met QL 4 requirements, and 7 percent was acceptable as QL 2 material.

Bolewood residue (the remaining 68 percent) was of considerably higher quality. Up to 36 percent of this material met at least one of the four QL requirements. In the short wood classes, 12 percent of the bolewood residue met QL 1 standards and 32 percent was acceptable in the QL 2 class. In the long wood classes, 19 percent of the bolewood residue met QL 3 specifications and 36 percent was suitable for the QL 4 class.

The amount of acceptable residue by species ranged from 3 percent to about 50 percent. Beech, followed by birch, had the smallest percentage of acceptable material. On the high end of the acceptability scale was basswood followed by hickory, the yellow-poplar/cucumber/magnolia group, and black cherry (Tables 1-4). The order of these species remained constant over all four QL

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Table 1.—Percentage of logging residue useable at given quality levels and material measured (based on volumetric measure)

Quality Level 1

Species	Percent of measured residue useable at listed specs			Percent breakdown of quality level total			
	Total	4-ft lengths	5-ft lengths	Portion of QL 4 ft	Portion of 4 ft ≤ 10 in	Portion of QL 5 ft	Portion of 5 ft ≤ 10 in
				MATERIAL MEASURED—ALL			
Basswood	31	10	21	32	47	68	31
Hickory	16	11	5	71	39	29	38
Yellow-poplar/cucumber/ magnolia	12	6	6	47	33	53	54
Black cherry	10	8	2	83	59	17	72
Sugar maple	10	8	2	74	15	26	5
Red oak	8	6	2	73	45	27	57
Other hardwood	6	4	2	61	57	39	22
White oak	5	4	1	85	80	15	100
Red maple	4	4	0	88	11	12	100
Birch	4	4	0	100	0	0	0
Beech	3	2	1	58	26	42	14
All	9	6	3	64	36	36	40
				MATERIAL MEASURED—BOLEWOOD			
Basswood	37	12	25	32	47	68	31
Hickory	21	15	6	71	39	29	38
Yellow-poplar/cucumber/ magnolia	15	7	8	47	33	53	54
Black cherry	14	11	3	82	53	18	72
Sugar maple	16	12	4	74	15	26	5
Red oak	12	9	3	75	42	25	51
Other hardwood	10	6	4	57	50	43	22
White oak	6	5	1	84	77	16	100
Red maple	5	4	1	86	13	14	100
Birch	5	5	0	100	0	0	0
Beech	3	2	1	56	34	44	0
All	12	8	4	64	35	36	39

Table 2.—Percentage of logging residue useable at given quality levels and material measured (based on volumetric measure)

Quality Level 2

Species	Percent of measured residue useable at listed specs			Percent breakdown of quality level total			
	Total	4-ft lengths	5-ft lengths	Portion of QL 4 ft	Portion of 4 ft ≤ 10 in	Portion of QL 5 ft	Portion of 5 ft ≤ 10 in
				MATERIAL MEASURED—ALL			
Basswood	46	17	29	36	68	64	42
Hickory	36	20	16	55	39	45	74
Yellow-poplar/cucumber/ magnolia	36	16	20	44	50	56	66
Black cherry	33	18	15	56	67	44	68
Sugar maple	22	13	9	58	25	42	16
Red oak	24	12	12	50	66	50	66
Other hardwood	16	8	8	51	77	49	79
White oak	25	14	11	56	90	44	64
Red maple	16	10	6	62	39	38	69
Birch	13	11	2	81	11	19	100
Beech	11	5	6	44	47	56	41
All	24	12	12	51	52	49	58
				MATERIAL MEASURED—BOLEWOOD			
Basswood	53	20	33	37	68	63	41
Hickory	44	24	20	54	32	46	72
Yellow-poplar/cucumber/ magnolia	43	19	24	43	48	57	65
Black cherry	45	25	20	56	63	44	64
Sugar maple	30	17	13	56	20	44	15
Red oak	36	17	19	48	62	52	63
Other hardwood	25	12	13	48	72	52	74
White oak	33	19	14	59	89	41	56
Red maple	21	13	8	61	40	39	67
Birch	16	13	3	81	11	19	100
Beech	13	5	8	39	36	61	34
All	32	16	16	50	49	50	55

Table 3.—Percentage of logging residue useable at given quality levels and material measured (based on volumetric measure)

Quality Level 3

Species	Percent of measured residue useable at listed specs			Percent breakdown of quality level total			
	Total	6-to 8-ft lengths	8.5-to 16-ft lengths	Portion of QL—6 to 8 ft	Portion of 6 to 8 ft ≤ 10 in	Portion of QL—8.5 to 16 ft	Portion of 8.5 to 16 ft ≤ 10 in
				MATERIAL MEASURED—ALL			
Basswood	29	7	22	24	62	76	59
Hickory	26	12	14	45	23	55	50
Yellow-poplar/cucumber/ magnolia	21	7	14	33	62	67	63
Black cherry	21	8	13	40	60	60	69
Sugar maple	15	7	8	48	15	52	31
Red oak	12	6	6	47	55	53	53
Other hardwood	13	4	9	33	73	67	37
White oak	12	6	6	48	74	52	100
Red maple	7	2	5	23	22	77	57
Birch	8	3	5	35	100	65	0
Beech	4	2	2	37	49	63	0
All	14	6	8	39	47	61	52
				MATERIAL MEASURED—BOLEWOOD			
Basswood	35	8	27	24	62	76	59
Hickory	34	15	19	45	23	55	50
Yellow-poplar/cucumber/ magnolia	26	8	18	32	60	68	63
Black cherry	29	12	17	40	57	60	65
Sugar maple	22	10	12	47	11	53	31
Red oak	21	10	11	46	53	54	53
Other hardwood	20	5	15	27	64	73	37
White oak	18	9	9	50	74	50	74
Red maple	9	2	7	19	0	81	57
Birch	9	3	6	35	100	65	0
Beech	5	1	4	29	26	71	0
All	19	7	12	38	44	62	52

Table 4.—Percentage of logging residue useable at given quality levels and material measured (based on volumetric measure)

Quality Level 4

Species	Percent of measured residue useable at listed specs			Percent breakdown of quality level total			
	Total	6-to 8-ft lengths	8.5-to 16-ft lengths	Portion of QL—6 to 8 ft	Portion of 6 to 8 ft ≤ 10 in	Portion of QL—8.5 to 16 ft	Portion of 8.5 to 16 ft ≤ 10 in
				MATERIAL MEASURED—ALL			
Basswood	39	12	27	31	78	69	58
Hickory	38	19	19	50	45	50	64
Yellow-poplar/cucumber/ magnolia	36	12	24	34	55	66	69
Black cherry	34	13	21	39	69	61	76
Sugar maple	22	11	11	49	25	51	39
Red oak	25	14	11	56	67	44	71
Other hardwood	18	5	13	28	83	72	59
White oak	29	21	8	71	81	29	100
Red maple	32	8	24	26	57	74	25
Birch	15	9	6	58	46	42	24
Beech	11	6	5	57	42	43	48
All	26	11	15	44	57	56	57
				MATERIAL MEASURED—BOLEWOOD			
Basswood	46	14	32	31	78	69	58
Hickory	49	23	26	47	46	53	64
Yellow-poplar/cucumber/ magnolia	43	14	29	33	53	67	69
Black cherry	46	18	28	39	65	61	74
Sugar maple	31	14	17	46	20	54	39
Red oak	40	21	19	53	64	47	71
Other hardwood	30	8	22	26	76	74	60
White oak	43	30	13	69	80	31	100
Red maple	44	11	33	24	25	76	25
Birch	19	11	8	58	46	42	24
Beech	15	8	7	54	35	46	48
All	36	15	21	42	54	58	57

classes when all material was considered. When bolewood only was considered, there was a slight shifting of rank with different QL classes.

Table 5.—Percentage of bolewood and limbwood in Appalachian logging residue

Species	Bolewood	Limbwood
Basswood	85	15
Birch	81	19
Yellow-poplar/cucumber/ magnolia	81	19
Hickory	75	25
Red maple	73	27
Beech	68	32
Sugar maple	66	34
Black cherry	66	34
White oak	65	35
Red oak	59	41
Other hardwood	46	54
All	68	32

VOLUMES PER ACRE

Martin (1975a) reported that logging residue averaged 467 cubic feet to the acre. The areas measured included both clear and selection cuts for harvesting saw logs only or saw logs plus other products. In a followup study, Martin (1975b) found an average of 500 cubic feet per acre from 40 cutover areas (range: 90 to 2,600).

In the study of residues for mine timber production (Timson 1978), the areas sampled were selectively cut for saw log only harvesting operations. I found residue volumes ranging from 216 to 997 cubic feet per acre. Average volume per acre was 540 cubic feet. Total residue volumes on the current study plots averaged 657 cubic feet per acre (this is not necessarily representative of present volume due to plot selection method).

Therefore, if we use 500 cubic feet per acre as the total volume of residue left after a saw log only cutting operation, we can estimate the quality level yield for an average acre:

Quality class	Volume available from: Total residue	Bolewood only
	ft^3/acre	
1	45	41
2	120	109
3	70	65
4	130	122

Or, if we assume that each cubic foot of QL 1 through QL 4 wood would yield 5.5 board feet of sawed product, we can estimate the QL board-foot yield:

Quality class	Volume available from: Total residue	Bolewood only
	fbm/acre	
1	247	225
2	660	599
3	385	357
4	715	671

CONCLUSION

The amount of saw log harvesting residues that meets the specifications used in this study is limited. The least restrictive of the quality levels specified in this report allows material that is best described as "local use." Even at this level, 74 percent of the logging residue was unacceptable. Eighty-six percent would not meet factory grade 3 standards (similar to QL 3), and 91 percent would not be good enough for QL 1 specifications. Salvaging this class of material would require working through or around at least three times as much volume as could be recovered. Even if bolewood only is harvested, limbwood must be handled (Fig. 3).

Considering other sources that could supply the same product (Grade 3 lumber, trees removed in timber stand improvement, etc.) and taking into account the cost of handling, hardwood residue is not competitive. When cost, damage to the residual stand, competitive sources of supply, and material demand are considered, hardwood logging residue can best be used when extracted in the primary

Figure 3.—Large volume—little quality

harvesting operation and used for bulk products. The uses that come to mind are energy wood, chips, and pulpwood. There is another option for some of the residue—recycling in place.

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S. GOVERNMENT PRINTING OFFICE: 1980-603-111/10

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