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Characteristics of Residues in a Cable-Logged Area of Old-Growth Douglas-Fir

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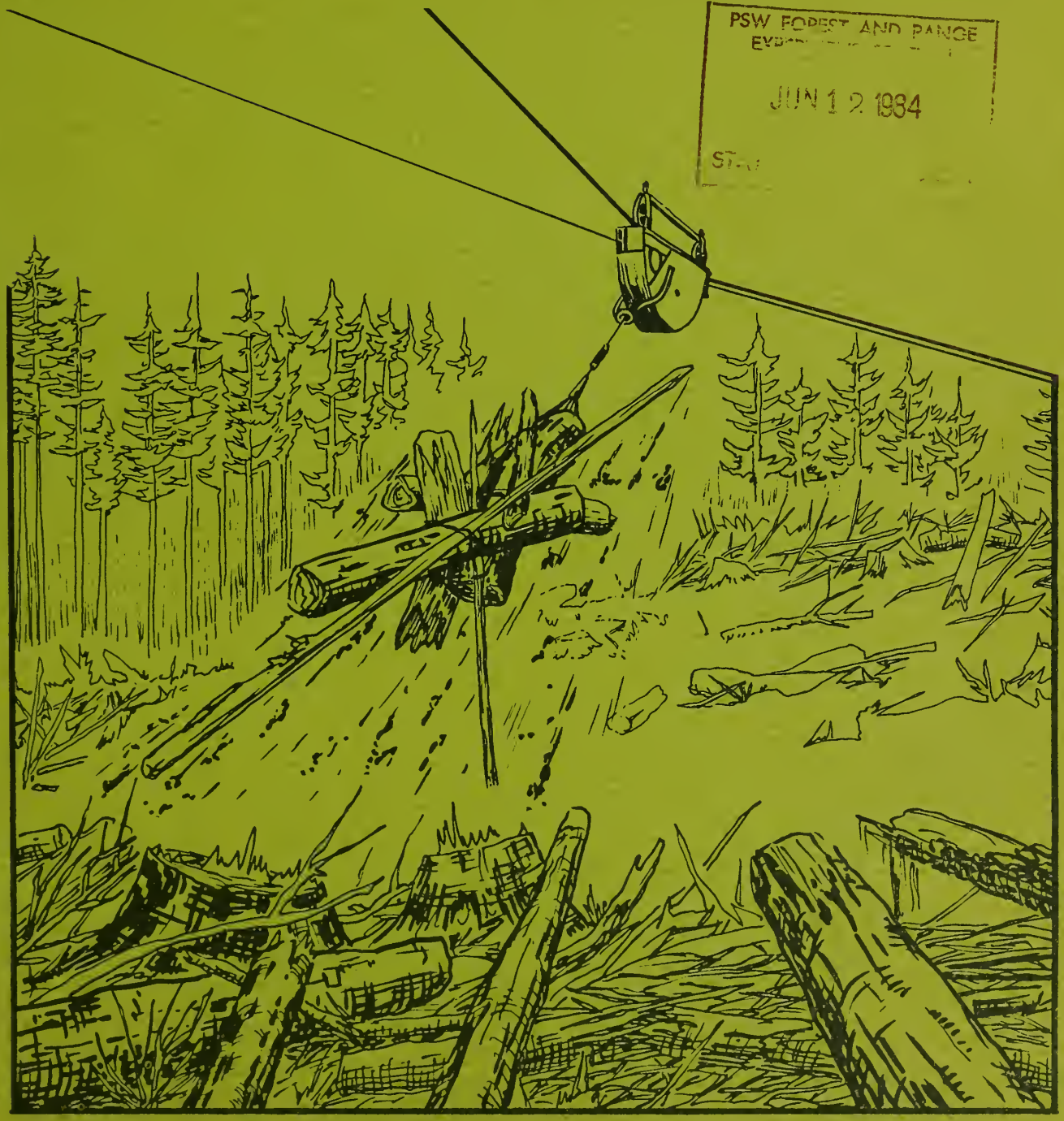

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Abstract

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The volume and character of woody material on the ground in four old-growth Douglas-fir cutting units in the Cascade Range in Oregon were determined before and after harvesting by cable and yarding of unutilized material (YUM). Total volume of residue increased after logging in all units. Coarse residues were reduced by YUM yarding. Small changes in the defect condition of the timber can drastically affect the amount and character of the residues remaining on the site. Modifying bucking procedures can result in the removal of a considerable volume of usable residue.

Keywords: Residue management, residue treatment, logging effects, cable logging, old-growth stands, Douglas-fir, *Pseudotsuga menziesii*, Oregon (Cascade Range), Cascade Range—Oregon.

Research Summary

The volume and character of woody material on the ground in four study units of old-growth Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii*) in Oregon were determined before and after harvesting by cable and yarding of unutilized material (YUM). Two silvicultural treatments (clearcut and partial cut) and two levels of YUM yarding were applied. Total volume of residue increased after logging in all study units but increased most in the clearcuts. Not all diameter classes of residue increased in volume after logging. As a group, the coarser, larger diameter residue decreased in volume after the harvesting operation. Yarding unutilized material appears to reduce the amount of large residue. Results, however, were not always consistent; some larger diameter classes of residue increased on each unit. Results further suggest that yarding unutilized material from small units with highly defective timber is less effective than from larger units containing timber that is nearly as defective or from larger units with timber that is much less defective.

The merchantable volume of logs removed from each unit was generally greater than the total volume of residue remaining on the unit and greater than the total unused volume of wood generated during the logging operation. In only one small unit with highly defective timber was the gross merchantable log volume removed less than either the gross volume of residue left on the ground or the total unused volume of wood generated. Results suggest that the amount and character of the residue remaining on a site depend heavily on the defective condition of the timber and can change drastically with small changes in amounts of defect.

From 34 to 56 percent of the residue remaining on units after harvesting had some potential for utilization. This was proportionately less than the volume of prelogging residue considered usable (38 to 71 percent of total residue per acre) because of the disproportionate large increase in the volume of unusable residue. The potential for utilization of residues (both natural and logging) was reduced as the direct result of harvesting activities and YUM yarding. A noticeable increase in the volume of slabs was recorded on all units. Most YUM either met or exceeded the minimum specifications for utilization. When combined with the gross volume of usable residue left on the ground, 35 to 65 percent of all residue was considered potentially usable.

The number of pieces of usable residue per acre (excluding YUM) increased in all units after harvesting, varying from three to nine times greater than the number before. Most of the increase was in shorter pieces in the smaller diameter classes.

Study results suggest that a considerable volume of the usable residue could have been removed by modifying the bucking procedures. Over 35 percent of the usable residue had been bucked from longer pieces. If left intact with the merchantable log or the YUM material, these pieces of residue could have been easily removed during the yarding operation.

Conversion Factors

1 inch = 2.54 centimeters
1 foot = 0.304 8 meter
1 acre = 0.404 686 2 hectare
1 cubic foot/acre = 0.069 972 5 cubic meter/hectare

1 pound (lb) = 0.453 6 kilogram
1 ton = 2,000 lb = 907.2 kilograms
1 bone-dry unit (BDU) of chips = 2,400 pounds

Species density (ovendry weight per green volume)
(Hartman, n.d., table E-1):
Coast Douglas-fir = 28.0 pounds per cubic foot
Western hemlock = 26.2 pounds per cubic foot

1 cubic-foot Douglas-fir = 0.011 666 6 BDU chips
1 cubic-foot western hemlock = 0.010 916 6 BDU chips

Higher heating values dry wood (Hartman, n.d., table G-1):
1 cubic-foot Douglas-fir = 249,000 British thermal units (Btu) per cubic foot
1 cubic-foot western hemlock = 204,000 Btu per cubic foot

Contents

Introduction

Land managers attempting to achieve the goals and objectives of multiple-use forestry need information on logging residue to plan optimum utilization of the resource, minimize risk of fire, and prepare for reforestation.

Information on residue was obtained from three timber sale areas in the Pansy Creek drainage on the Estacada Ranger District of the Mount Hood National Forest. Three aerial logging systems—balloon, helicopter, and skyline (cable)—were used to log these areas. The aim of these studies was to evaluate the performance of each system in attaining land management objectives. Residue left after logging is an important factor in this evaluation.

This report provides information on the amount and character of residues left in four units of the area logged by cable. The information is site specific and unique to specific logging conditions but can be used in evaluating the utilization potential of residues, fuel loadings, and the effects of changes in market conditions and contract requirements in timber sales, such as yarding of unutilized material (YUM).[1/] The character and volume of residues left in the balloon-logged area and in the helicopter-logged area were reported by Pong and Henley (1976, 1978).

Procedures

Terrain of the study area was steep and broken with slopes varying from 10 to 100 percent. Principal species in the area were old-growth coast Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii*) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.). Secondary species were western redcedar (*Thuja plicata* Donn ex D. Don), western white pine (*Pinus monticola* Dougl. ex D. Don), and true firs (*Abies* spp.).

Cruise volumes, logging specifications, and size of the four units are given in table 1.

1/ YUM is used for the yarding process (YUM yarding) and for the unutilized material that is yarded (YUM).

Table 1—Cruise data and logging specifications for 4 study units before cable logging, Pansy Creek drainage, Mount Hood National Forest

Study unit	Size	Cruise volume, Scribner rule: Gross	Net	Gross per acre	Net per acre	Defect	Cutting method	YUM[1/] specifications
	Acres	Thousand board feet				Percent		
1	9	467	259	52	29	44.5	Clearcut	12-inch diameter inside bark or larger on large end, 10 feet long or longer
2	41	1,433	861	35	21	39.9	Partial cut[2/]	
3	59	4,136	3,677	70	62	11.1	Clearcut	
4	138	8,146	7,104	61	51	15.6	Partial cut[3/]	8-inch diameter inside bark or larger on large end, 10 feet long or longer

1/ Yarding of unutilized material.

2/ About 50 percent of merchantable volume removed.

3/ About 65 percent of merchantable volume removed.

Logging specifications in the timber sale contract required that all logs that scaled one-third sound with a minimum net scale of 80 board feet be removed. These specifications applied to logs that were 6 inches and larger in diameter inside bark (d.i.b.) at the small end and at least 8 feet long. The contract also required yarding of unutilized materials according to specifications shown in table 1.

A planar intersect technique was used to inventory the downed woody residues. Woody pieces that intersect imaginary vertical sampling planes (each 200 feet long) dropped through the downed debris were tallied (Brown 1974, Van Wagner 1968). A systematic grid point sampling design, with random orientation of a sampling plane at each point, was used to inventory each unit (Howard and Ward 1972). At least 40 sample points were located in each unit. Pieces less than 3 inches in diameter were tallied as follows:

Diameter class (Inches)	Sampling plane (Feet)
0.25 to 0.99	6
1.0 to 2.99	10

Pieces 3 inches and larger were recorded by diameter to the nearest inch. A 200-foot sampling plane was used for these larger pieces.

Pieces qualifying for tally were downed woody material (twigs, stems, branches, and bolewood) from trees and shrubs. Slabs from shattered trees were recorded, as were twigs and branches deposited in and above the litter layer. But dead branches attached to boles of standing trees were not tallied, nor were cones, bark flakes, needles, leaves, grass, and forbs.

The size classes were chosen because they permit precise estimates of volume and they correspond to the standard moisture timelags used in the National Fire-Danger Rating System (Deeming and others 1972).

As each piece of residue 3 inches d.i.b. and larger was inventoried, the piece was classified according to its potential for utilization. Pieces less than 4 feet long were not considered usable and were classed as fuel. Pieces so decayed or splintered that they would not hold together if yarded were also classed as fuel. All others were placed in one of the following categories:

1. From a felled tree and bucked on at least one end.

2. From a felled tree and broken on both ends.

3. From prelogging (natural) residue (for example, dead and down windthrows) and bucked on at least one end.

4. From prelogging residue and broken on both ends.

Information on species, length, and soundness was obtained for each piece considered usable. Length was recorded to the nearest foot. Soundness or percentage of firmwood (proportion of wood usable for pulp chips) was estimated to the nearest 10 percent at the point of intersection with the sampling plane. Estimates of soundness were based on the proportion of the cross-sectional area that was sound and was judged usable for pulp chips. Decayed or excessively splintered material was considered unusable and was classed as fuel. The cross-sectional area at the sampling point was usually not visible, and soundness was estimated on the basis of surface and end characteristics of the piece and by a limited amount of sounding and chopping with hatchets.

These sampling procedures were used to inventory the natural residues on the unit before any harvesting activities and also the residues left after the yarding operations were completed. The logging residues were sampled after the required yarding of unutilized material was complete, but before any further treatment of the remaining slash.

Results

Total Residue Volume Increased After Harvesting

The gross volume of all residues on the ground increased in all four study units after the harvesting operation (table 2). The largest increases were in the clearcut units (1 and 3), where residue volumes increased 83 and 54 percent, respectively. A smaller increase was recorded in the partial cut units; 33 percent in unit 2 and 28 percent in unit 4. The volumes of residue before and after logging are presented in table 3 by diameter class. The proportion of total residue in each size class on each unit, before and after logging, is shown in figure 1.

Table 2—Average gross volume of usable and unusable residue, pieces of usable residue before and after cable logging, and gross volume of YUM 1/ and merchantable logs removed from 4 study units, Pansy Creek drainage, Mount Hood National Forest

Study unit and cutting method	Volume of residue			Pieces of usable residue	YUM	Yum plus usable residue	Volume of merchantable logs removed
	Usable	Unusable	Total				
	- -Cubic feet per acre- -			Number per acre	- - -Cubic feet per acre- - -		
Unit 1 (clearcut):							
Before logging	911	1,457	2,368	53	--	911	--
After logging	1,472	2,858	4,330	486	58	1,530	3,486
Unit 2 (partial cut):							
Before logging	1,737	693	2,430	133	--	1,737	--
After logging	1,528	1,698	3,226	436	553	2,081	5,265
Unit 3 (clearcut):							
Before logging	1,745	732	2,477	146	--	1,745	--
After logging	2,141	1,666	3,807	695	983	3,124	8,274
Unit 4 (partial cut):							
Before logging	1,552	1,113	2,665	110	--	1,552	--
After logging	1,814	1,595	3,409	725	692	2,506	9,732

1/ Yarding of unutilized material (removed during logging operation).

Table 3—Average gross volume of residue on 4 study units before and after cable logging, by diameter class, Pansy Creek drainage, Mount Hood National Forest

Diameter class	Unit 1		Unit 2		Unit 3		Unit 4	
	Before logging[1]	After logging[2]	Before logging[1]	After logging[2]	Before logging[1]	After logging[2]	Before logging[1]	After logging[2]
Inches	- - - - - - - - - - - - - - - - Cubic feet per acre - - - - - - - - - - - - - - - -							
0.26- 1.0	79.0	449.6	82.4	199.9	105.3	350.5	121.5	202.4
1.1 - 2.9	134.3	539.8	123.8	366.0	210.7	794.8	160.2	571.4
3.0 - 4.4	63.4	185.1	63.1	120.6	53.2	119.6	62.5	193.0
4.5 - 7.4	91.2	339.4	127.3	419.8	130.5	303.8	100.1	341.6
7.5 -10.4	253.8	288.9	224.9	341.5	217.9	623.0	298.7	419.5
10.5 -13.4	432.3	332.5	218.8	265.2	220.2	426.1	404.9	278.0
13.5 -16.4	651.4	297.7	288.1	276.0	311.9	346.4	257.8	307.3
16.5 -19.4	90.7	275.8	149.5	90.8	144.6	106.0	327.5	272.6
19.5 -22.4	306.4	224.7	195.4	175.8	277.8	342.7	270.9	162.9
22.5 -25.4	0	217.2	107.5	163.5	439.2	160.2	203.4	109.9
25.5 -28.4	73.1	128.6	157.7	0	97.1	0	87.2	68.1
28.5 -31.4	126.0	42.0	377.9	42.0	84.0	0	279.9	78.5
31.5 -34.4	0	50.8	0	104.7	101.7	0	0	107.9
34.5+	60.5	0	306.4	178.1	82.3	0	50.4	0
Slabs	5.7	957.8	7.6	482.4	1.1	234.5	40.0	296.0
Total[3]	2,367.9	4,329.9	2,430.3	3,226.3	2,477.4	3,807.4	2,664.9	3,409.0

1/ Dead and down material, which includes material not yardable, less than 10 percent sound, and less than 3 inches in diameter and 4 feet long.

2/ All down material, which includes material not yardable, less than 10 percent sound, and less than 3 inches in diameter and 4 feet long.

3/ Totals may be off because of rounding.

Coarse Residues Reduced by YUM Yarding

Not all diameter classes of residue increased in volume after logging; as a group, the large diameter residues decreased (table 3). The larger material also represented proportionately less of the total volume of residue remaining on each unit (fig. 1). This seems to suggest that YUM yarding had some impact in reducing the amount of large residue. Yarding unutilized material, however, did not give consistent results for all diameter classes of residue in all study units. Some classes increased in volume in each unit in spite of YUM yarding. Unit 1, in particular, registered increases in residue for several of the larger diameter classes (table 3). The low gross volume of YUM material removed from unit 1 (58 cubic feet per acre, table 2) indicates a buildup of larger residue. The volume of YUM removed from unit 2 was 553 cubic feet per acre; from unit 3, 983 cubic feet; and unit 4, 692 cubic feet. These results suggest that yarding unutilized material from a small unit with timber containing a large amount of defect (9 acres, 44.5 percent defect) is less effective than from a larger unit with almost as much defect in the timber (unit 2) and from larger units that have much less defective timber (units 3 and 4) (table 1). These results further suggest that much of the buildup of larger residue on unit 1 may have been in pieces not meeting the length requirement for YUM, and they were therefore left on the site.

The fact that the volume of large residue decreased for many diameter classes in all units after logging indicates that some of the prelogging residue had been removed during the logging operation. Removing this material as YUM probably accounted for much of this reduction; however, some reduction may also have resulted from the utilization of the sounder pieces of prelogging residue, especially the larger diameter material.

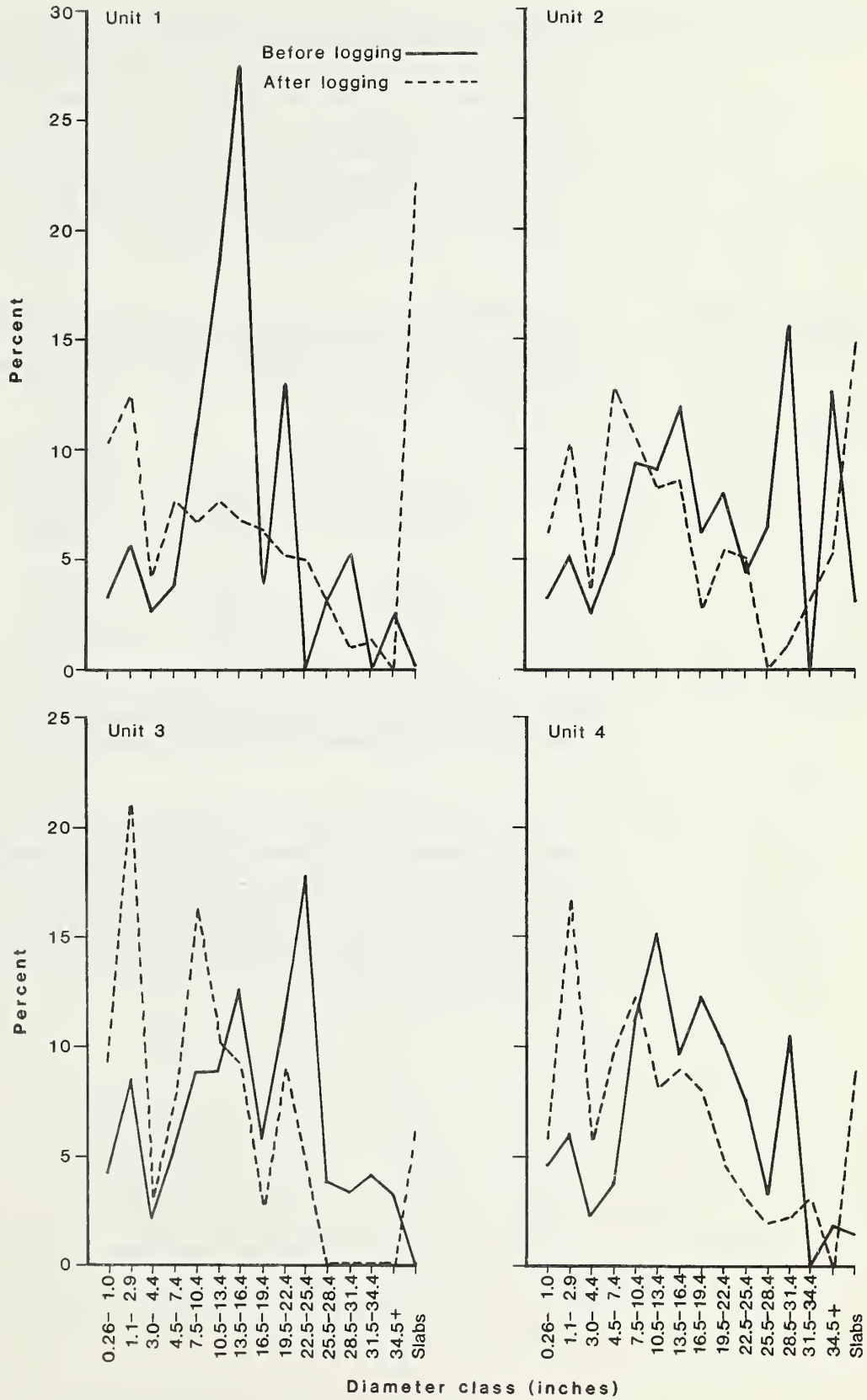

Figure 1.—Percent of total gross volume of residues in each diameter class and in slabs before and after cable logging on four study units, Pansy Creek drainage, Mount Hood National Forest.

The gross volume of merchantable logs removed from each unit during the cable logging operation, as tallied at the truck scale station, is presented in table 2. Except for unit 1, the merchantable volume of logs removed from each unit was greater than the total residue volume remaining on the unit and greater than the total unused wood volume (total logging residue plus YUM) generated during the logging operation. In unit 1, however, gross volume of merchantable logs removed was 3,486 cubic feet per acre. This was less than either the total gross volume of residue left on the ground (4,330 cubic feet per acre) or the total unused wood volume of 4,388 cubic feet per acre. The defective condition of the timber on unit 1 probably accounts for a major part of the low volume of merchantable logs.

Utilization Potential of Residues

Residue with some potential for utilization is defined as material that can be yarded without breaking up and is at least 10 percent sound, 3 inches and larger in diameter, and at least 4 feet long. The volume of prelogging residues meeting these specifications on each unit was:

Unit	Volume		Coefficient of variation
	(Cubic feet per acre)	(Percent of total)	(Percent)
1	911	38	89.7
2	1,737	71	112.4
3	1,745	70	99.8
4	1,552	58	97.8

These residues were not uniformly distributed on the units but were in scattered, sparse concentrations. This is evident from the high coefficients of variation recorded for the units.

The volume of prelogging residues by diameter and length classes for each unit is presented in tables 4-7. The larger and sounder natural residues were probably salvaged during the harvesting operation; some may have been removed as YUM and others left on the site. The decrease of usable residue after logging on unit 2 (table 2) strongly suggests that prelogging residue was removed from the units as salvage and/or YUM. Volumes of usable and unusable prelogging residues for each unit are shown in figure 2 and summarized in table 2.

Table 4—Average gross and net volumes of usable residue on study unit 1 before cable logging, by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest 1/

Diameter class	Length class (feet)								All classes	
	4.0-7.9		8.0-13.9		14.0-20.9		21.0+			
	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net
Inches	- - - - - - - - - - - - - - - - Cubic feet per acre - - - - - - - - - - - - - - - -									
3.0- 4.4	1.6	1.6	0	0	1.5	1.3	1.6	1.5	4.7	4.4
4.5- 7.4	1.7	1.0	6.7	5.0	3.4	2.4	9.7	9.2	21.5	17.6
7.5-10.4	6.0	3.6	7.7	5.8	13.6	7.7	49.7	46.4	76.9	63.4
10.5-13.4	6.7	4.0	20.2	20.2	33.6	26.2	26.9	22.8	87.3	73.2
13.5-16.4	0		35.8	27.5	60.5	55.9	102.6	71.9	198.9	155.3
16.5-19.4	0		15.1	12.1	15.1	12.1	0		30.2	24.2
19.5-22.4	18.7	18.7	18.7	18.7	18.7	18.7	175.8	125.3	231.8	181.3
22.5-25.4									0	
25.5-28.4	0		0		0		73.1	69.5	73.1	69.5
28.5-31.4	0		42.0	42.0	0		84.0	84.0	126.0	126.0
31.5-34.4									0	
34.5+	0		0		0		60.5	60.5	60.5	60.5
Slabs									0	
Total 2/	34.6	28.9	146.1	131.2	146.3	124.1	583.8	491.1	910.8	775.2

1/ Includes all dead and down material averaging at least 3 inches in diameter (inside bark) and 4 feet long, at least 10 percent sound, and yardable.

2/ Totals may be off because of rounding.

Table 5—Average gross and net volumes of usable residue on study unit 2 before cable logging, by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest [1/]

Diameter class	Length class (feet) 4.0-7.9 Gross	4.0-7.9 Net	8.0-13.9 Gross	8.0-13.9 Net	14.0-20.9 Gross	14.0-20.9 Net	21.0+ Gross	21.0+ Net	All classes Gross	All classes Net
Inches	-Cubic feet per acre-									
3.0- 4.4	5.2	1.4	9.5	4.7	6.4	3.1	2.7	0.9	23.7	10.2
4.5- 7.4	12.0	4.7	23.5	8.8	18.9	8.1	34.1	19.1	88.5	40.8
7.5-10.4	10.6	1.1	37.7	14.8	63.6	36.6	70.4	35.6	182.4	88.1
10.5-13.4	11.3	2.3	6.7	0	46.0	9.3	101.0	46.7	165.1	58.2
13.5-16.4	9.1	.9	54.1	10.2	61.7	5.6	78.7	46.4	203.7	63.2
16.5-19.4	0		0		30.2	10.6	68.8	22.7	89.1	33.3
19.5-22.4	0		45.2	9.0	22.6	2.3	127.6	43.9	195.4	55.2
22.5-25.4	0		0		26.9	26.9	80.6	26.9	107.5	53.7
25.5-28.4	31.5	31.5	0		0		126.1	44.1	157.7	75.7
28.5-31.4	0		42.0	8.4	0		167.9	67.2	209.9	75.6
31.5-34.4									0	
34.5+	82.3	24.7	0		0		224.1	119.1	306.4	143.8
Slabs	0		3.8	1.7	3.8	.8	0		7.6	2.4
Total [2/]	162.1	66.6	222.4	57.7	280.1	103.2	1,072.3	472.6	1,736.9	700.1

1/ Includes all dead and down material averaging at least 3 inches in diameter (inside bark) and 4 feet long, at least 10 percent sound, and yardable.

2/ Totals may be off because of rounding.

Table 6—Average gross and net volumes of usable residue on study unit 3 before cable logging, by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest [1/]

Diameter class	Length class (feet) 4.0-7.9 Gross	4.0-7.9 Net	8.0-13.9 Gross	8.0-13.9 Net	14.0-20.9 Gross	14.0-20.9 Net	21.0+ Gross	21.0+ Net	All classes Gross	All classes Net
Inches	-Cubic feet per acre-									
3.0- 4.4	12.3	6.1	6.5	4.6	7.6	5.0	2.2	0.9	28.6	16.5
4.5- 7.4	10.9	3.8	20.5	8.6	18.8	8.1	46.1	25.1	96.4	45.6
7.5-10.4	4.7	3.7	14.6	8.0	35.6	9.7	94.0	49.6	148.7	71.1
10.5-13.4	6.7	1.3	20.2	8.1	58.4	31.5	134.9	75.2	220.2	116.0
13.5-16.4	0		63.3	16.6	30.2	18.4	218.4	128.5	311.9	163.5
16.5-19.4	15.1	0	0		15.1	0	114.4	81.9	144.6	81.9
19.5-22.4	0		18.7	1.9	0		78.6	22.9	97.2	24.7
22.5-25.4	26.9	26.9	0		136.7	39.0	168.1	118.1	331.7	184.0
25.5-28.4	0		0		31.5	15.8	65.5	49.0	97.1	64.8
28.5-31.4	0		0		0		84.0	4.2	84.0	4.2
31.5-34.4	0		0		0		101.7	96.3	101.7	96.3
34.51+	0		0		0		82.3	8.2	82.3	8.2
Slabs	0		1.1	.1	0		0		1.1	.1
Total [2/]	76.6	41.8	144.5	47.8	334.0	127.5	1,190.2	660.0	1,745.3	877.1

1/ Includes all dead and down material averaging at least 3 inches in diameter (inside bark) and 4 feet long, at least 10 percent sound, and yardable.

2/ Totals may be off because of rounding.

Table 7—Average gross and net volumes of usable residue on study unit 4 before cable logging, by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest 1/

Diameter class	Length class (feet)									
	4.0-7.9		8.0-13.9		14.0-20.9		21.0+		All classes	
	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net
Inches	Cubic feet per acre									
3.0- 4.4	6.4	4.8	3.9	2.9	2.8	2.2	2.6	1.9	15.7	11.9
4.5- 7.4	8.1	5.6	11.9	6.9	11.4	9.1	26.7	20.5	58.1	42.0
7.5-10.4	2.5	2.5	23.4	13.5	47.1	34.0	119.4	82.5	192.3	132.5
10.5-13.4	11.2	5.6	20.6	8.6	27.1	21.3	136.4	81.5	195.3	117.0
13.5-16.4	0		37.5	15.8	32.8	14.2	126.6	93.2	196.9	123.1
16.5-19.4	12.6	7.6	0		37.8	31.5	126.0	103.3	176.3	142.3
19.5-22.4	0		15.5	12.4	0		130.9	100.7	146.5	113.1
22.5-25.4	22.4	0	0		22.4	6.7	69.1	43.3	113.9	50.0
25.5-28.4	0		0		0		87.2	68.9	87.2	68.9
28.5-31.4	0		0		35.0	28.0	244.9	213.4	279.9	241.4
31.5-34.4	0								0	0
34.5+	0		0		0		50.4	50.4	50.4	50.4
Slabs	0		34.1	17.7	5.9	5.3	0		40.0	23.1
Total 2/	63.2	26.0	146.9	77.9	222.3	152.3	1,120.0	859.5	1,552.4	1,115.8

1/ Includes all dead and down material averaging at least 3 inches in diameter (inside bark) and 4 feet long, at least 10 percent sound, and yardable.

2/ Totals may be off because of rounding.

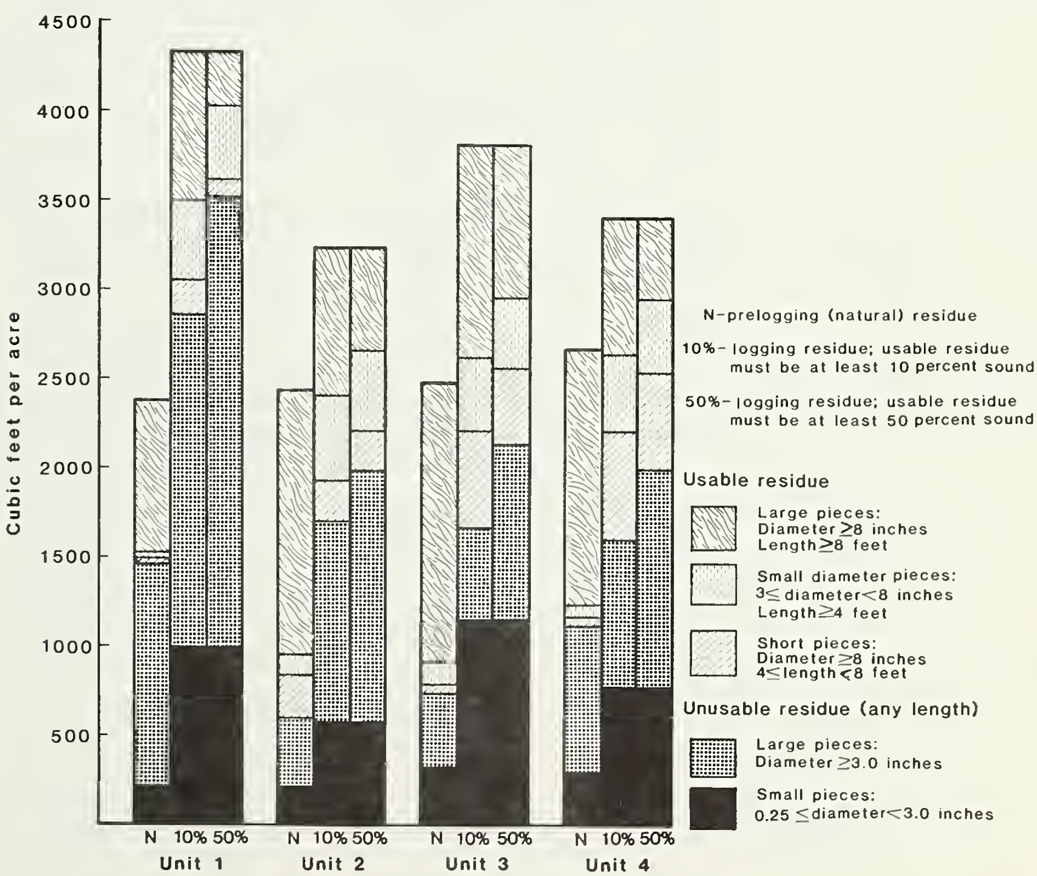

Figure 2.—Average gross volume of usable and unusable residues before and after cable logging on four study units, by soundness and size—Pansy Creek drainage, Mount Hood National Forest.

Much of the prelogging residue was defective; average soundness varied from 40 percent on unit 2 to 85 percent on unit 1 (table 8). After logging, soundness of usable residues averaged higher on three of the units (77 percent for units 2 and 3, and 78 percent for unit 4) but lower on unit 1 (57 percent) (tables 9-12). The salvage of the larger and sounder prelogging residues during the logging operation probably contributed to the reduction of the average soundness of the remaining residues on unit 1. The exceptionally low volume of YUM removed from unit 1 compared with the other units (table 2) was also a factor. Generally, the yarding of unutilized material would increase the average soundness of the material left on the logging site through the removal of defective, nonmerchantable logs. The highly defective condition of the usable residue left on unit 1 (table 9) suggests that only the sounder, less defective, nonmerchantable logs were removed during the YUM operation. The species composition and soundness data of the usable residues on each unit before the harvesting operation are presented in table 8; after the operation, in tables 9-12.

With the exception of unit 2, volume of usable residue increased on each unit after harvesting; however, compared with the proportions of the prelogging residues considered usable, the usable portion of the logging residues represents a smaller percentage of the total residue generated on each unit because of the disproportionately large increase in volume of unusable logging residues (table 2).

According to study specifications, the amount of residue remaining on each unit after logging that could have been used was:

Unit	Volume		Coefficient of variation
	(Cubic feet per acre)	(Percent of total)	(Percent)
1	1,472	34	70.0
2	1,528	47	65.9
3	2,141	56	62.8
4	1,814	53	73.8

The average gross and net volumes of usable logging residue remaining on each unit are shown by soundness and by diameter and length classes in tables 13-16. Volumes of usable and unusable residue by 10- and 50-percent soundness classes before and after logging are presented in figure 2, and a summary of volumes of each unit is given in table 2.

Table 8—Average gross and net volumes of usable residue on 4 study units before cable logging, by species, Pansy Creek drainage, Mount Hood National Forest 1/

Species	Gross volume	Net volume	Soundness	Proportion of total
	Cubic feet per acre		Percent	
Study unit 1:				
Douglas-fir	567.5	465.8	82.1	62.3
Western hemlock	258.7	230.7	89.2	28.4
Western redcedar	0			
Pines	59.9	56.2	93.9	6.6
Other softwoods	24.7	22.4	90.9	2.7
Hardwoods	0			
Total or average 2/	910.8	775.2	85.1	100.0
Study unit 2:				
Douglas-fir	547.4	199.6	36.5	31.5
Western hemlock	1,072.8	444.5	41.4	61.8
Western redcedar	97.2	50.0	51.5	5.6
Pines	4.9	.8	16.5	.3
Other softwoods	13.4	4.6	34.1	.8
Hardwoods	1.2	.6	50.0	.1
Total or average 2/	1,736.9	700.1	40.3	100.0
Study unit 3:				
Douglas-fir	1,174.0	563.8	48.0	67.3
Western hemlock	363.4	187.6	51.6	20.8
Western redcedar	130.9	102.3	78.1	7.5
Pines	0			
Other softwoods	77.0	23.5	30.5	4.4
Hardwoods	0			
Total or average 2/	1,745.3	877.1	50.3	100.0
Study unit 4:				
Douglas-fir	1,169.9	824.8	70.5	75.4
Western hemlock	309.2	231.8	75.0	19.9
Western redcedar	35.2	31.3	88.9	2.3
Pines	0			
Other softwoods	38.1	27.9	73.2	2.5
Hardwoods	0			
Total or average 2/	1,552.4	1,115.8	71.9	100.0

1/ Includes all dead and down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, at least 10 percent sound, and yardable.

2/ Totals may be off because of rounding.

Table 9—Average gross and net volumes of usable residue on study unit 1 after cable logging, by soundness category and species, Pansy Creek drainage, Mount Hood National Forest [1/]

Soundness category and species	Gross volume	Net volume	Soundness	Proportion of total
	Cubic feet per acre		- - - -Percent- - - -	
75+ percent sound:				
Douglas-fir	93.1	85.6	92.0	14.8
Western hemlock	184.4	178.5	96.8	29.4
Western redcedar	25.3	23.5	92.8	4.0
Pines	0			
Other softwoods	324.2	322.2	99.4	51.7
Hardwoods	0			
Total or average [2/]	627.0	609.8	97.3	100.0
50+ percent sound:				
Douglas-fir	170.7	126.9	74.3	21.0
Western hemlock	269.2	225.0	83.6	33.1
Western redcedar	32.4	28.4	87.7	4.0
Pines	0	--	--	--
Other softwoods	340.7	331.3	97.2	41.9
Hardwoods	0	--	--	--
Total or average [2/]	813.0	711.6	87.5	100.0
30+ percent sound:				
Douglas-fir	244.5	154.9	63.4	23.1
Western hemlock	416.3	271.2	65.1	39.3
Western redcedar	32.4	28.4	87.7	3.1
Pines	0			
Other softwoods	365.0	339.1	92.9	34.5
Hardwoods	0			
Total or average [2/]	1,058.2	793.6	75.0	100.0
10+ percent sound:				
Douglas-fir	253.9	156.5	61.6	17.3
Western hemlock	773.7	309.8	40.0	52.6
Western redcedar	32.4	28.4	87.7	2.2
Pines	0			
Other softwoods	411.8	347.1	84.3	28.0
Hardwoods	0			
Total or average [2/]	1,471.8	841.8	57.2	100.0

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 10—Average gross and net volumes of usable logging residue on study unit 2 after cable logging, by soundness category and species, Pansy Creek drainage, Mount Hood National Forest 1/

Soundness category and species	Gross volume	Net volume	Soundness	Proportion of total
	Cubic feet per acre		-Percent-	
75+ percent sound:				
Douglas-fir	261.0	252.7	96.8	26.4
Western hemlock	461.7	441.8	95.7	46.7
Western redcedar	99.3	89.0	89.6	10.0
Pines	4.7	3.7	80.0	.5
Other softwoods	64.6	64.0	99.1	6.5
Hardwoods	97.6	97.0	99.4	9.9
Total or average 2/	986.8	948.2	95.9	100.0
50+ percent sound:				
Douglas-fir	379.8	321.4	84.6	30.9
Western hemlock	549.3	495.9	90.3	44.6
Western redcedar	126.2	106.0	84.0	10.3
Pines	4.7	3.7	80.0	.4
Other softwoods	72.1	68.3	94.6	5.9
Hardwoods	98.8	97.7	98.9	8.0
Total or average 2/	1,230.8	1,092.9	88.6	100.0
30+ percent sound:				
Douglas-fir	446.3	343.3	76.9	31.6
Western hemlock	641.0	527.5	82.3	45.3
Western redcedar	129.6	107.3	82.8	9.2
Pines	4.7	3.7	80.0	.3
Other softwoods	92.5	76.2	82.4	6.5
Hardwoods	99.9	98.0	98.1	7.1
Total or average 2/	1,413.9	1,156.1	81.8	100.0
10+ percent sound:				
Douglas-fir	485.5	349.9	72.1	31.8
Western hemlock	700.0	538.2	76.9	45.8
Western redcedar	129.6	107.3	82.8	8.5
Pines	4.7	3.7	80.0	.3
Other softwoods	100.3	77.8	77.5	6.6
Hardwoods	107.9	99.4	92.1	7.1
Total or average 2/	1,528.0	1,176.4	77.0	100.0

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 11—Average gross and net volumes of usable logging residue on study unit 3 after cable logging, by soundness category and species, Pansy Creek drainage, Mount Hood National Forest 1/

Soundness category and species	Gross volume	Net volume	Soundness	Proportion of total
	Cubic feet per acre		- - - -Percent- - - -	
75+ percent sound:				
Douglas-fir	644.7	634.2	98.4	42.6
Western hemlock	786.2	767.2	97.6	52.0
Western redcedar	45.3	42.6	94.0	3.0
Pines	0			
Other softwoods	34.3	34.3	100.0	2.3
Hardwoods	2.4	2.4	100.0	.2
Total or average 2/	1,512.9	1,480.8	97.9	100.0
50+ percent sound:				
Douglas-fir	742.8	684.7	92.2	44.3
Western hemlock	850.0	804.1	94.6	50.7
Western redcedar	46.2	43.0	93.1	2.8
Pines	0			
Other softwoods	34.3	34.3	100.0	2.0
Hardwoods	2.4	2.4	100.0	.1
Total or average 2/	1,675.7	1,568.5	93.6	100.0
30+ percent sound:				
Douglas-fir	752.4	687.5	91.4	43.0
Western hemlock	891.6	18.7	91.8	51.0
Western redcedar	68.1	50.2	73.6	3.9
Pines	0			
Other softwoods	34.3	34.3	100.0	2.0
Hardwoods	2.4	2.4	100.0	.1
Total or average 2/	1,748.9	1,593.1	91.1	100.0
10+ percent sound:				
Douglas-fir	874.4	699.7	80.0	40.8
Western hemlock	1,161.9	856.7	73.7	54.3
Western redcedar	68.1	50.2	73.6	3.2
Pines	0			
Other softwoods	34.3	34.3	100.0	1.6
Hardwoods	2.4	2.4	100.0	.1
Total or average 2/	2,141.1	1,643.4	76.8	100.0

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 12—Average gross and net volumes of usable logging residue on study unit 4 after cable logging, by soundness category and species, Pansy Creek drainage, Mount Hood National Forest 1/

Soundness category and species	Gross volume	Net volume	Soundness	Proportion of total
	Cubic feet per acre		- - - -Percent- - - -	
75+ percent sound:				
Douglas-fir	520.8	508.0	97.6	42.3
Western hemlock	377.8	371.7	98.4	30.7
Western redcedar	85.6	83.2	97.2	7.0
Pines	3.0	3.0	100.0	.2
Other softwoods	242.0	228.5	94.4	19.7
Hardwoods	1.3	1.3	100.0	.1
Total or average 2/	1,230.3	1,195.6	997.2	100.0
50+ percent sound:				
Douglas-fir	607.1	555.1	91.4	42.6
Western hemlock	447.2	412.6	92.3	31.4
Western redcedar	85.6	83.2	97.2	6.0
Pines	3.0	3.0	100.0	.2
Other softwoods	279.5	251.3	89.9	19.6
Hardwoods	1.3	1.3	100.0	.1
Total or average 2/	1,423.5	1,306.4	91.8	100.0
30+ percent sound:				
Douglas-fir	691.7	587.8	85.0	41.6
Western hemlock	472.3	421.5	89.2	28.4
Western redcedar	89.4	84.3	94.3	5.4
Pines	3.0	3.0	100.0	.2
Other softwoods	404.0	296.9	73.5	24.3
Hardwoods	1.3	1.3	100.0	.1
Total or average 2/	1,661.6	1,394.7	83.9	100.0
10+ percent sound:				
Douglas-fir	736.8	595.9	80.9	40.6
Western hemlock	520.5	427.4	82.1	28.7
Western redcedar	89.4	84.3	94.3	4.9
Pines	3.0	3.0	100.0	.2
Other softwoods	462.6	304.9	65.9	25.5
Hardwoods	1.3	1.3	100.0	.1
Total or average 2/	1,813.5	1,416.7	78.1	100.0

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 13—Average gross and net volumes of usable residue on study unit 1 after cable logging, by soundness category and by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest [1/]

Soundness category and diameter class	Length class (feet)									
	4.0-7.9		8.0-13.9		14.0-20.9		21.0+		All classes	
	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net
Inches	-Cubic feet per acre-									
75+ percent sound:										
3.0- 4.4	42.5	42.1	32.0	31.9	32.9	32.7	12.7	12.6	120.1	119.3
4.5- 7.4	44.6	44.4	49.7	49.3	82.4	82.1	86.5	86.0	263.3	261.7
7.5-10.4	22.9	22.9	16.1	15.2	29.7	27.0	76.5	784.3	145.1	139.4
10.5-13.4	13.4	11.4	19.1	18.4	5.6	5.6	18.0	18.0	56.2	53.5
13.5-16.4	10.5	10.5	9.1	7.3	0		0		19.6	17.8
16.5-19.4									0	
19.5-22.4	22.6	18.1	0		0		0		22.6	18.1
22.5-25.4									0	
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4									0	
34.5+									0	
Slabs									0	
Total [2/]	156.5	149.4	126.0	122.1	150.7	147.4	193.7	190.9	627.0	609.8
50+ percent sound:										
3.0- 4.4	44.4	43.2	34.0	33.0	32.9	32.7	12.7	12.5	124.0	121.5
4.5- 7.4	50.9	47.9	53.1	51.1	87.0	84.8	89.9	87.6	281.0	271.4
7.5-10.4	22.9	22.9	22.1	18.7	32.7	28.5	89.2	80.7	166.8	150.8
10.5-13.4	31.4	22.9	19.1	18.4	19.1	14.4	38.2	28.1	107.8	83.8
13.5-16.4	22.4	16.5	18.3	11.9	0		0		40.7	28.4
16.5-19.4	0		13.5	8.1	0		13.5	8.1	27.0	16.2
19.5-22.4	22.6	18.1	0		20.6	10.3	22.6	11.3	65.7	39.5
22.5-25.4									0	
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4									0	
34.5+									0	
Slabs									0	
Total [2/]	194.7	171.4	160.0	141.2	192.3	170.6	266.0	228.4	813.0	711.6
30+ percent sound:										
3.0- 4.4	45.2	43.4	34.0	33.0	32.9	32.7	12.9	12.7	125.0	121.8
4.5- 7.4	54.4	49.0	53.1	51.1	87.0	84.8	91.6	88.3	286.1	273.2
7.5-10.4	22.9	22.9	25.1	19.9	53.0	34.9	89.2	80.7	190.1	158.4
10.5-13.4	47.2	28.4	31.4	22.1	34.8	19.9	46.0	31.2	159.5	101.7
13.5-16.4	22.4	16.5	27.4	14.6	0		30.2	9.1	80.1	40.2
16.5-19.4	0		13.5	8.1	32.0	9.6	28.6	12.6	74.0	30.3
19.5-22.4	22.6	18.1	0		20.6	10.3	22.6	11.3	65.7	39.6
22.5-25.4	0		0		0		26.9	8.1	26.9	8.1
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4	50.8	20.3	0		0		0		50.8	20.3
34.5+									0	
Slabs									0	
Total [2/]	265.4	198.6	184.5	148.9	260.3	192.1	348.0	254.0	1,058.2	79.36
10+ percent sound:										
3.0- 4.4	50.3	44.0	36.0	33.4	32.9	32.7	12.9	12.7	132.2	122.8
4.5- 7.4	57.2	49.6	58.2	51.5	93.9	85.6	97.9	89.2	307.2	275.9
7.5-10.4	44.0	24.8	47.1	22.2	60.6	35.2	92.2	81.3	244.0	163.5
10.5-13.4	55.1	29.2	58.4	24.1	83.2	24.5	46.0	31.2	242.8	109.1
13.5-16.4	22.4	16.5	57.7	15.8	35.8	4.8	30.2	9.1	146.2	46.1
16.5-19.4	0		28.6	8.1	62.2	12.6	84.2	19.5	174.9	40.2
19.5-22.4	22.6	18.1	0		20.6	10.3	43.2	15.4	86.3	43.8
22.5-25.4	0		29.2	5.8	0		26.9	8.1	56.0	13.9
25.5-28.4	0		0		0		31.5	6.3	31.5	6.3
28.5-31.4									0	
31.5-34.4	50.8	20.3	0		0		0		50.8	20.3
34.5+									0	
Slabs									0	
Total [2/]	302.5	202.5	315.2	160.9	389.2	205.6	465.0	272.8	1,471.8	841.8

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 14—Average gross and net volumes of usable logging residue on study unit 2 after cable logging, by soundness category and by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest 1/

Soundness category and diameter class	Length class (feet)									
	4.0-7.9		8.0-13.9		14.0-20.9		21.0+		All classes	
	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net
Inches	Cubic feet per acre									
75+ percent sound:										
3.0- 4.4	27.3	26.7	25.3	24.9	24.0	23.8	17.4	17.4	94.1	92.9
4.5- 7.4	45.4	44.3	88.4	87.1	81.4	78.9	99.7	98.4	315.1	308.7
7.5-10.4	24.3	22.0	75.5	71.7	53.8	52.9	49.6	47.5	203.2	194.0
10.5-13.4	24.7	24.1	21.3	21.3	23.7	20.6	24.8	22.7	94.5	88.7
13.5-16.4	0		21.1	18.1	10.5	10.5	30.2	26.0	61.8	54.6
16.5-19.4	28.6	25.6	47.1	45.4	0		15.1	13.6	90.8	84.6
19.5-22.4	18.7	18.7	0		0		22.6	18.1	41.2	36.7
22.5-25.4	26.9	26.9	0		0		0	0	26.9	26.9
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4									0	
34.5+	57.1	57.1	0		0		0		57.1	57.1
Slabs	.7	.7	3.3	3.3	0		0		4.0	4.0
Total 2/	253.7	246.0	282.1	271.8	193.4	186.7	259.6	243.7	988.8	948.2
50+ percent sound;										
3.0- 4.4	29.2	28.0	27.2	25.9	24.8	24.4	17.4	17.4	98.7	95.6
4.5- 7.4	57.3	51.4	95.8	91.3	87.7	82.5	110.6	104.5	351.4	329.7
7.5-10.4	34.0	27.4	95.1	83.9	66.0	60.9	59.4	53.1	254.5	225.3
10.5-13.4	24.7	24.1	39.3	33.3	37.1	30.0	30.5	26.1	131.6	113.4
13.5-16.4	18.3	11.0	30.2	24.5	22.4	17.7	39.4	32.4	110.3	85.5
16.5-19.4	28.6	25.6	47.1	45.4	0		15.1	13.6	90.8	84.6
19.5-22.4	18.7	18.7	0		37.3	20.5	22.6	18.1	78.6	57.2
22.5-25.4	26.9	26.9	26.9	13.4	0		0		53.7	40.3
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4									0	
34.5+	57.1	5.71	0		0		0		57.1	57.1
Slabs	.7	.7	3.3	3.3	0		0		4.0	4.0
Total 2/	295.6	270.8	365.0	320.9	275.3	236.0	295.0	265.2	1,230.8	1,092.9
30+ percent sound:										
3.0- 4.4	30.5	28.4	28.4	26.3	26.3	24.8	17.4	17.4	102.6	96.9
4.5- 7.4	60.8	52.8	102.0	93.3	90.0	83.3	111.8	104.9	354.6	334.3
7.5-10.4	40.0	29.5	109.1	89.5	75.3	64.2	62.4	54.3	286.8	237.5
10.5-13.4	31.4	26.1	52.8	38.0	51.7	35.1	36.1	27.8	172.0	126.8
13.5-16.4	18.3	11.0	30.2	24.5	22.4	17.7	39.4	32.4	110.3	85.5
16.5-19.4	28.6	25.6	47.1	45.4	0		15.1	13.6	90.8	84.6
19.5-22.4	18.7	18.7	0	0	37.3	20.5	59.9	33.0	115.9	72.2
22.5-25.4	26.9	26.9	26.9	13.4	0		56.0	16.8	109.8	57.1
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4									0	
34.5+	57.1	57.1	0		0		0		57.1	57.1
Slabs	.7	.7	3.3	3.3	0		0		4.0	4.0
Total 2/	313.0	276.7	399.8	333.6	303.0	245.6	398.1	300.2	1,413.9	1,156.1
10+ percent sound:										
3.0- 4.4	30.5	28.4	29.2	26.3	26.3	24.8	18.2	17.5	104.1	97.1
4.5- 7.4	64.7	53.6	103.2	93.5	92.3	83.5	111.8	104.9	372.0	335.6
7.5-10.4	47.6	31.1	112.1	90.1	75.3	64.2	62.4	54.3	297.4	239.6
10.5-13.4	31.4	26.1	52.8	38.0	78.7	40.5	36.1	27.8	199.0	132.2
13.5-16.4	18.3	11.0	40.7	27.4	31.6	18.6	60.5	34.5	151.1	91.5
16.5-19.4	28.6	25.6	47.1	45.4	0		15.1	13.6	90.8	84.6
19.5-22.4	18.7	18.7	0		37.3	20.5	59.9	33.0	115.9	72.2
22.5-25.4	26.9	26.9	26.9	13.4	26.9	5.4	56.0	16.8	136.6	62.5
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4									0	
34.5+	57.1	57.1	0		0		0		57.1	57.1
Slabs	.7	.7	3.3	3.3	0		0		4.0	4.0
Total 2/	324.6	279.1	415.2	337.4	368.3	257.5	419.9	302.4	1,528.0	1,176.4

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 15—Average gross and net volumes of usable logging residue on study unit 3 after cable logging, by soundness category and by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest [1/]

Soundness category and diameter class	Length class (feet)									
	4.0-7.9		8.0-13.9		14.0-20.9		21.0+		All classes	
	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net
Inches	- - - - - - - - - - - - - - - - Cubic feet per acre - - - - - - - - - - - - - - - -									
75+ percent sound:										
3.0- 4.4	46.0	45.5	30.8	30.6	20.3	20.1	7.9	7.8	104.9	104.0
4.5- 7.4	43.4	41.3	90.6	89.9	89.1	87.5	48.9	48.9	272.0	267.5
7.5-10.4	90.0	85.5	143.6	142.0	176.3	171.4	99.5	93.2	509.4	492.2
10.5-13.4	91.3	88.2	77.7	76.3	88.4	85.8	46.3	44.6	303.7	294.9
13.5-16.4	34.9	34.9	58.7	58.7	0		0		93.6	93.6
16.5-19.4	16.3	16.3	0		0		0		16.3	16.3
19.5-22.4	77.4	77.4	0		0		0		77.4	77.4
22.5-25.4									0	
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4									0	
34.5+									0	
Slabs	84.1	84.0	41.3	40.8	8.4	8.4	1.7	1.7	135.5	134.9
Total [2/]	483.4	473.1	442.7	438.2	382.5	373.2	204.3	196.2	1,512.9	1,480.8
50+ percent sound:										
3.0- 4.4	47.0	46.0	33.1	31.9	20.3	20.1	7.9	7.8	108.3	105.8
4.5- 7.4	46.1	42.7	96.9	93.3	93.3	90.1	48.9	48.9	285.2	275.0
7.5-10.4	90.0	85.5	149.3	144.8	179.9	173.3	99.5	93.2	518.7	496.8
10.5-13.4	91.3	88.2	94.0	86.0	88.4	85.8	46.3	44.6	320.0	304.6
13.5-16.4	49.4	45.0	58.7	58.7	0		11.1	5.5	119.1	109.3
16.5-19.4	16.3	16.3	0		0		18.3	9.2	34.7	25.5
19.5-22.4	77.4	77.4	0		27.4	13.7	27.4	13.7	132.1	104.7
22.5-25.4									0	
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4									0	
34.5+									0	
Slabs	101.7	93.6	45.9	43.1	8.4	8.4	1.7	1.7	157.7	146.9
Total [2/]	519.2	494.8	477.8	457.8	417.7	391.4	261.0	224.6	1,675.7	1,568.5
30+ percent sound:										
3.0- 4.4	48.1	46.3	34.0	32.2	21.2	20.5	7.9	7.8	111.1	106.7
4.5- 7.4	46.1	42.7	101.7	95.0	95.3	90.7	48.9	48.9	292.1	277.3
7.5-10.4	94.5	86.9	149.3	144.8	185.6	175.0	105.2	95.5	534.6	502.1
10.5-13.4	91.3	88.2	94.0	86.0	104.7	90.7	54.4	47.1	344.4	312.0
13.5-16.4	49.4	45.0	58.7	58.7	12.7	5.1	11.1	5.5	131.9	114.3
16.5-19.4	16.3	16.3	0		0		18.3	9.2	34.7	25.5
19.5-22.4	77.4	77.4	0		27.4	13.7	27.4	13.7	132.1	104.7
22.5-25.4									0	
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4									0	
34.5+									0	
Slabs	112.1	97.2	45.9	43.1	8.4	8.4	1.7	1.7	168.1	150.5
Total [2/]	535.2	500.1	483.5	459.7	455.3	404.0	274.8	229.3	1,478.9	1,593.1
10+ percent sound:										
3.0- 4.4	50.4	46.6	35.8	32.5	21.7	20.5	7.9	7.8	115.7	107.4
4.5- 7.4	46.1	42.7	104.4	95.3	95.3	90.7	48.9	48.9	294.8	277.6
7.5-10.4	117.7	89.2	166.8	146.6	208.2	177.8	110.8	96.0	603.4	509.6
10.5-13.4	91.3	88.2	111.7	88.7	119.6	92.9	69.4	48.6	392.1	318.4
13.5-16.4	95.3	51.8	80.9	60.9	12.7	5.1	23.8	6.8	212.7	124.6
16.5-19.4	16.3	16.3	36.6	7.3	0		36.6	11.0	89.6	34.7
19.5-22.4	102.3	79.8	27.4	5.5	50.0	15.9	50.0	15.9	229.6	117.2
22.5-25.4	0		0		29.9	3.0	0		29.9	3.0
25.5-28.4									0	
28.5-31.4									0	
31.5-34.4									0	
34.5+									0	
Slabs	117.1	97.7	45.9	43.1	8.4	8.4	1.7	1.7	173.1	151.0
Total [2/]	636.6	512.4	609.4	479.9	545.9	414.3	349.1	236.8	2,141.1	1,643.4

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 16—Average gross and net volumes of usable logging residue on study unit 4 after cable logging, by soundness category and by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest [1/]

Soundness category and diameter class	Length class (feet)								All classes	
	4.0-7.9		8.0-13.9		14.0-20.9		21.0+			
	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net
Inches	- - - - - - - - - - - - - - - - Cubic feet per acre - - - - - - - - - - - - - - - -									
75+ percent sound:										
3.0- 4.4	76.9	76.3	35.2	35.1	15.3	15.3	4.2	4.2	131.6	130.9
4.5- 7.4	91.2	90.2	71.4	70.6	55.4	53.0	40.0	39.0	258.0	252.9
7.5-10.4	73.0	71.9	105.0	102.3	31.7	30.2	13.6	12.6	223.3	216.9
10.5-13.4	60.9	60.9	43.9	42.8	7.9	6.3	14.6	13.9	127.3	123.9
13.5-16.4	49.9	49.9	19.6	19.6	10.5	9.4	31.6	25.3	111.6	104.2
16.5-19.4	75.8	74.1	15.1	15.1	0		0		90.9	89.2
19.5-22.4	20.6	20.6	22.6	20.3	0		0		43.2	40.9
22.5-25.4	24.7	22.2	0		0		0		24.7	22.2
25.5-28.4	68.1	68.1	0		0		0		68.1	68.1
28.5-31.4	0		39.2	39.2	0		0		39.2	39.2
31.5-34.4	107.9	102.5	0		0		0		107.9	102.5
34.5+									0	
Slabs	4.6	4.6	0		0		0		4.6	4.6
Total [2/]	653.4	641.3	352.1	345.1	120.8	114.3	104.0	94.9	1,230.3	1,195.6
50+ percent sound:										
3.0- 4.4	79.2	77.7	35.2	35.1	16.0	15.7	4.2	4.2	134.6	132.7
4.5- 7.4	101.9	96.3	76.5	73.2	60.6	55.9	40.0	39.0	279.0	264.4
7.5-10.4	92.0	84.5	115.6	108.5	52.1	42.4	13.6	12.6	273.4	248.0
10.5-13.4	66.6	63.7	56.3	50.1	7.9	6.3	14.6	13.9	145.3	134.1
13.5-16.4	59.0	56.3	37.9	30.6	19.6	14.9	43.5	32.4	160.1	134.2
16.5-19.4	75.8	74.1	15.1	15.1	0		0		90.9	89.2
19.5-22.4	43.2	31.9	22.6	20.3	0		0		65.7	52.2
22.5-25.4	24.7	22.2	29.2	14.6	0		0		53.8	36.8
25.5-28.4	68.1	68.1	0		0		0		68.1	68.1
28.5-31.4	0		39.2	39.2	0		0		39.2	39.2
31.5-34.4	107.9	102.5	0		0	0	0	0	107.9	102.5
34.5+									0	
Slabs	5.5	5.1	0		0		0		5.5	5.1
Total [2/]	723.8	682.3	427.6	386.8	156.2	135.3	115.9	102.1	1,423.5	1,306.4
30+ percent sound:										
3.0- 4.4	79.6	77.8	35.6	35.3	16.0	15.7	4.2	4.2	135.4	133.0
4.5- 7.4	104.2	97.2	82.1	75.2	160.6	55.9	40.0	39.0	286.9	267.4
7.5-10.4	106.5	88.8	128.0	113.5	58.9	44.7	17.4	13.7	310.7	260.7
10.5-13.4	73.3	66.4	64.1	52.4	7.9	6.3	21.3	16.6	166.6	141.8
13.5-16.4	59.0	56.3	37.9	30.6	31.6	18.5	55.5	36.0	184.0	141.4
16.5-19.4	75.8	74.1	32.0	21.9	13.5	5.4	28.6	10.1	149.8	111.4
19.5-22.4	43.2	31.9	22.6	20.3	20.6	8.2	0	0	86.3	60.4
22.5-25.4	24.7	22.2	29.2	14.6	0		26.9	10.7	80.7	47.5
25.5-28.4	68.1	68.1	0		0		0		68.1	68.1
28.5-31.4	0		39.2	39.2	0		39.2	15.7	78.5	54.9
31.5-34.4	107.9	102.5	0		0		0		107.9	102.5
34.5+									0	
Slabs	6.8	5.6	0		0		0		6.8	5.6
Total [2/]	748.9	690.9	470.7	403.0	209.0	154.8	233.1	146.0	1,661.6	1,394.7
10+ percent sound:										
3.0- 4.4	81.2	78.0	36.1	35.3	16.0	15.7	4.2	4.2	137.4	133.2
4.5- 7.4	110.5	98.5	84.4	75.7	60.6	55.9	42.3	39.5	297.7	269.6
7.5-10.4	133.2	92.0	128.0	113.5	72.0	46.0	20.4	14.0	353.5	265.4
10.5-13.4	80.0	67.1	69.8	53.6	7.9	6.3	27.0	17.2	184.6	144.2
13.5-16.4	59.0	56.3	70.9	35.1	31.6	18.5	66.0	36.1	227.4	148.0
16.5-19.4	75.8	74.1	32.0	21.9	13.5	5.4	28.6	10.1	149.8	111.4
19.5-22.4	43.2	31.9	22.6	20.3	20.6	8.2	20.6	4.1	106.9	64.5
22.5-25.4	24.7	22.2	29.2	14.6	0		26.9	10.7	80.7	47.5
25.5-28.4	68.1	68.1	0		0		0		68.1	68.1
28.5-31.4	0	0	39.2	39.2	0		39.2	15.7	78.5	54.9
31.5-34.4	107.9	102.5	0		0		0		107.9	102.5
34.5+									0	
Slabs	16.3	6.9	4.8	.5	0		0		21.0	7.4
Total [2/]	799.7	697.4	516.7	409.6	222.1	156.1	275.0	153.5	1,813.5	1,416.7

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

The utilization potential of the residue (natural and logging) was reduced as a result of the harvesting activities. Many pieces were broken and shattered when trees were felled and stem segments yarded. Slab volumes greatly increased in all units after logging (table 3 and fig. 1), indicating that shattering had occurred during the harvesting operations. Yarding of unutilized material also contributed to the increase in slab volume. In unit 1, more than 22 percent of the residue volume was in the form of slabs; in unit 2, 15 percent; in units 3 and 4, 6 and 8 percent. The defective condition of timber in units 1 and 2 (table 1) probably contributed heavily to the high generation of slabs in these units. According to study specifications, slab residues generated on units 1 and 2 (table 3) had little or no utilization potential (tables 13 and 14). In contrast, nearly 74 percent of the slab volume generated on unit 3 (table 3) could be used (table 15) and more than 7 percent on unit 4 (table 16); most of this volume was in pieces shorter than 14 feet.

Most of the YUM either met or exceeded the minimum specifications for utilization. When combined with the gross volume of usable residue left on the ground, the total potential usable residue for each unit was:

Unit	All residue	Total usable residue	
	(Cubic feet per acre)	(Cubic feet per acre)	(Percent of all residue)
1	4,388	1,530	35
2	3,779	2,081	55
3	4,790	3,124	65
4	4,101	2,506	61

Only in unit 1 was the volume of all residues (usable, unusable, and YUM) greater than the merchantable volume of logs removed (table 2). This anomaly is probably directly related to the decadent condition of the timber on unit 1, which produced only a small volume of YUM but an exceptionally large volume of unusable slabs (tables 3 and 13) and other residues (table 2). As on unit 1, the volume of slabs recorded on unit 2 (table 3) reflects the 39.9-percent defect in timber on this unit (table 1). Unlike unit 1, however, the merchantable volume of logs removed exceeded the volume of all residues remaining, even with an appreciable volume of YUM included. These data suggest that the amount and character of the residue remaining on a site depend heavily on the defective condition of the timber on that site and can change drastically with small changes in amounts of defect.

The piece count of usable residues per acre (excluding YUM) increased on all units after harvesting (table 2). Unit 1 had the largest increase with a piece count more than nine times greater per acre than that recorded prior to logging. The smallest increase occurred on unit 2 where the piece count more than tripled after logging. Most of the increases were in the shorter pieces in the smaller diameter classes. The number of pieces of usable residue per acre is summarized by soundness and by diameter and length classes for each unit before the logging operation (table 17) and after (tables 18-21).

Table 17—Average number of pieces per acre of usable residue on 4 study units before cable logging, by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest 1/

Diameter class	Length class (feet) 4.0-7.9	8.0-13.9	14.0-20.9	21.0+	All classes
Inches					
Study unit 1:					
3.0- 4.4	5	0	1	1	7
4.5- 7.4	2	3	1	2	8
7.5-10.4	3	2	2	4	11
10.5-13.4	2	2	3	1	8
13.5-16.4	0	2	3	3	9
16.5-19.4	0	1	1	0	1
19.5-22.4	2	1	1	3	6
22.5-25.4					0
25.5-28.4	0	0	1	1	1
28.5-31.4	0	1	0	1	1
31.5-34.4					0
34.5+					0
Slabs					0
Total 2/	12	12	11	17	53
Study unit 2:					
3.0- 4.4	11	11	5	1	28
4.5- 7.4	12	11	6	7	37
7.5-10.4	5	7	8	6	26
10.5-13.4	3	1	4	5	13
13.5-16.4	2	4	3	3	11
16.5-19.4	0	0	1	1	2
19.5-22.4	0	2	1	2	4
22.5-25.4	0	0	1	1	2
25.5-28.4	2	0	0	1	3
28.5-31.4	0	1	0	1	2
31.5-34.4					0
34.5+	2	0	0	1	2
Slabs	0	2	1	0	2
Total 2/	36	39	28	30	133
Study unit 3:					
3.0- 4.4	31	8	6	1	46
4.5- 7.4	11	10	6	9	36
7.5-10.4	2	3	5	8	18
10.5-13.4	2	2	5	7	16
13.5-16.4	0	5	2	7	14
16.5-19.4	2	0	1	3	5
19.5-22.4	0	1	0	1	2
22.5-25.4	2	0	3	2	6
25.5-28.4	0	0	1	1	1
28.5-31.4	0	0	0	1	1
31.5-34.4	0	0	0	1	1
34.5+					0
Slabs	0	1	0	0	1
Total 2/	48	30	26	41	146
Study unit 4:					
3.0- 4.4	16	5	2	1	25
4.5- 7.4	8	5	4	5	22
7.5-10.4	1	5	7	10	24
10.5-13.4	3	3	2	7	15
13.5-16.4	0	3	2	5	9
16.5-19.4	1	0	1	3	5
19.5-22.4	0	1	0	2	3
22.5-25.4	1	0	0	1	3
25.5-28.4	0	0	0	1	1
28.5-31.4	0	0	0	2	2
31.5-34.4					0
34.5+					0
Slabs	0	1	0	0	2
Total 2/	30	24	19	38	110

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, at least 10 percent sound, and yardable.

2/ Totals may be off because of rounding.

Table 18—Average number of pieces per acre of usable residue on study unit 1 after cable logging, by soundness category and by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest 1/

Soundness category and diameter class	Length class (feet) 4.0-7.9	8.0-13.9	14.0-20.9	21.0+	All classes
Inches					
75+ percent sound:					
3.0- 4.4	134	45	28	5	213
4.5- 7.4	51	27	27	16	121
7.5-10.4	10	3	4	6	23
10.5-13.4	3	2	1	1	7
13.5-16.4	2	1	0	0	2
16.5-19.4					0
19.5-22.4	2	0	0	0	2
22.5-25.4					0
25.5-28.4					0
28.5-31.4					0
31.5-34.4					0
34.5+					0
Slabs					0
Total 2/	202	78	60	29	369
50+ percent sound:					
3.0- 4.4	138	49	28	6	221
4.5- 7.4	58	28	29	16	131
7.5-10.4	10	5	5	7	26
10.5-13.4	8	2	2	2	14
13.5-16.4	3	2	0	0	5
16.5-19.4	0	1	0	0	1
19.5-22.4	2	0	1	0	2
22.5-25.4					0
25.5-28.4					0
28.5-31.4					0
31.5-34.4					0
34.5+					0
Slabs					0
Total 2/	219	87	63	32	401
30+ percent sound:					
3.0- 4.4	139	49	28	6	222
4.5- 7.4	61	28	29	16	134
7.5-10.4	10	6	8	7	30
10.5-13.4	11	4	3	2	20
13.5-16.4	3	2	0	1	7
16.5-19.4	0	1	1	1	2
19.5-22.4	2	0	1	0	2
22.5-25.4					0
25.5-28.4					0
28.5-31.4					0
31.5-34.4	2	0	0	0	2
34.5+					0
Slabs					0
Total 2/	228	90	68	34	420
10+ percent sound:					
3.0- 4.4	158	52	28	6	245
4.5- 7.4	65	31	31	17	144
7.5-10.4	20	11	9	7	47
10.5-13.4	13	7	6	2	29
13.5-16.4	3	5	2	1	11
16.5-19.4	0	2	2	2	5
19.5-22.4	2	0	1	1	3
22.5-25.4	0	1	0	0	1
25.5-28.4					0
28.5-31.4					0
31.5-34.4	2	0	0	0	2
34.5+					0
Slabs					0
Total 2/	263	109	77	37	486

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 19—Average number of pieces per acre of usable residue on study unit 2 after cable logging, by soundness category and by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest [1/]

Soundness category and diameter class	Length class (feet) 4.0-7.9	8.0-13.9	14.0-20.9	21.0+	All classes
Inches					
75+ percent sound:					
3.0- 4.4	75	37	19	8	139
4.5- 7.4	47	48	29	18	142
7.5-10.4	11	17	8	4	40
10.5-13.4	6	3	2	1	12
13.5-16.4	0	2	1	1	3
16.5-19.4	3	3	0	0	6
19.5-22.4	2	0	0	0	2
22.5-25.4	2	0	0	0	2
25.5-28.4					0
28.5-31.4					0
31.5-34.4					0
34.5+	2	0	0	0	2
Slabs	2	1	0	0	2
Total [2/]	148	110	58	33	350
50+ percent sound:					
3.0- 4.4	80	40	19	8	147
4.5- 7.4	56	53	31	20	159
7.5-10.4	16	22	9	5	52
10.5-13.4	6	5	3	1	16
13.5-16.4	3	3	1	1	8
16.5-19.4	3	3	0	0	6
19.5-22.4	2	0	1	0	3
22.5-25.4	2	1	0	0	2
25.5-28.4					0
28.5-31.4					0
31.5-34.4					0
34.5+	2	0	0	0	2
Slabs	2	1	0	0	2
Total [2/]	170	127	64	36	397
30+ percent sound:					
3.0- 4.4	84	42	20	8	153
4.5- 7.4	59	56	32	20	167
7.5-10.4	19	25	10	6	59
10.5-13.4	8	7	4	2	20
13.5-16.4	3	3	1	1	8
16.5-19.4	3	3	0	0	6
19.5-22.4	2	0	1	1	3
22.5-25.4	2	1	0	1	3
25.5-28.4					0
28.5-31.4					0
31.5-34.4					0
34.5+	2	0	0	0	2
Slabs	2	1	0	0	2
Total [2/]	181	136	68	38	424
10+ percent sound:					
3.0- 4.4	83	42	20	8	154
4.5- 7.4	62	57	32	20	171
7.5-10.4	22	25	10	6	63
10.5-13.4	8	7	5	2	22
13.5-16.4	3	3	2	2	10
16.5-19.4	3	3	0	0	6
19.5-22.4	2	0	1	1	3
22.5-25.4	2	1	1	1	3
25.5-28.4					0
28.5-31.4					0
31.5-34.4					0
34.5+	2	0	0	0	2
Slabs	2	1	0	0	2
Total [2/]	186	139	72	39	436

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 20—Average number of pieces per acre of usable residue on study unit 3 after cable logging, by soundness category and by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest [1/]

Soundness category and diameter class	Length class (feet) 4.0-7.9	8.0-13.9	14.0-20.9	21.0+	All classes
Inches					
75+ percent sound:					
3.0- 4.4	162	51	18	4	235
4.5- 7.4	45	45	28	9	127
7.5-10.4	41	32	25	9	107
10.5-13.4	24	11	8	2	45
13.5-16.4	6	6	0	0	12
16.5-19.4	3	0	0	0	3
19.5-22.4	6	0	0	0	6
22.5-25.4					0
25.5-28.4					0
28.5-31.4					0
31.5-34.4					0
34.5+					0
Slabs	40	7	1	0	48
Total [2/]	327	152	80	24	583
50+ percent sound:					
3.0- 4.4	168	54	18	4	244
4.5- 7.4	47	48	29	9	133
7.5-10.4	41	33	25	9	108
10.5-13.4	24	13	8	2	47
13.5-16.4	8	6	0	0	14
16.5-19.4	3	0	0	0	3
19.5-22.4	6	0	1	0	7
22.5-25.4					0
25.5-28.4					0
28.5-31.4					0
31.5-34.4					0
34.5+					0
Slabs	50	9	1	0	60
Total [2/]	347	163	82	24	616
30+ percent sound:					
3.0- 4.4	173	55	19	4	251
4.5- 7.4	47	51	30	9	137
7.5-10.4	43	33	26	9	111
10.5-13.4	24	13	9	2	48
13.5-16.4	8	6	1	0	15
16.5-19.4	3	0	0	0	3
19.5-22.4	6	0	1	0	7
22.5-25.4					0
25.5-28.4					0
28.5-31.4					0
31.5-34.4					0
34.5+					0
Slabs	56	9	1	0	66
Total [2/]	360	167	87	24	638
10+ percent sound:					
3.0- 4.4	180	57	19	4	260
4.5- 7.4	47	52	30	9	138
7.5-10.4	54	37	29	9	129
10.5-13.4	24	16	10	3	53
13.5-16.4	17	8	1	1	27
16.5-19.4	3	2	0	1	6
19.5-22.4	8	1	1	1	11
22.5-25.4	0	0	1	0	1
25.5-28.4					0
28.5-31.4					0
31.5-34.4					0
34.5+					0
Slabs	60	9	1	0	70
Total [2/]	393	182	92	28	695

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 21—Average number of pieces per acre of usable residue on study unit 4 after cable logging, by soundness category and by diameter and length classes, Pansy Creek drainage, Mount Hood National Forest [1/]

Soundness category and diameter class	Length class (feet)				
	4.0-7.9	8.0-13.9	14.0-20.9	21.0+	All classes
Inches					
75+ percent sound:					
3.0- 4.4	268	50	13	2	333
4.5- 7.4	96	40	17	8	161
7.5-10.4	31	26	5	1	63
10.5-13.4	16	7	1	1	25
13.5-16.4	8	2	1	1	12
16.5-19.4	10	1	0	0	11
19.5-22.4	1	1	0	0	2
22.5-25.4	1	0	0	0	1
25.5-28.4	3	0	0	0	3
28.5-31.4	0	1	0	0	1
31.5-34.4	3	0	0	0	3
34.5+					0
Slabs	8	0	0	0	8
Total [2/]	445	128	37	13	623
50+ percent sound:					
3.0- 4.4	273	50	13	2	338
4.5- 7.4	105	42	18	8	173
7.5-10.4	39	28	8	1	76
10.5-13.4	18	9	1	1	29
13.5-16.4	10	3	1	1	15
16.5-19.4	10	1	0	0	11
19.5-22.4	3	1	0	0	4
22.5-25.4	1	1	0	0	2
25.5-28.4	3	0	0	0	3
28.5-31.4	0	1	0	0	1
31.5-34.4	3	0	0	0	3
34.5+					0
Slabs	10	0	0	0	10
Total [2/]	475	136	41	13	665
30+ percent sound:					
3.0- 4.4	274	51	13	2	340
4.5- 7.4	106	45	18	8	177
7.5-10.4	46	30	9	1	86
10.5-13.4	19	9	1	1	30
13.5-16.4	10	3	2	2	17
16.5-19.4	10	2	1	1	14
19.5-22.4	3	1	0	0	4
22.5-25.4	1	1	0	0	2
25.5-28.4	3	0	0	0	3
28.5-31.4	0	1	0	0	1
31.5-34.4	3	0	0	0	3
34.5+					0
Slabs	12	0	0	0	12
Total [2/]	487	143	44	15	689
10+ percent sound:					
3.0- 4.4	279	52	13	2	346
4.5- 7.4	111	46	18	8	183
7.5-10.4	57	30	11	2	100
10.5-13.5	21	10	1	1	33
13.5-16.4	10	5	2	2	20
16.5-19.4	10	2	1	1	14
19.5-22.4	3	1	0	0	4
22.5-25.4	1	1	0	0	2
25.5-28.4	3	0	0	0	3
28.5-31.4	0	1	0	0	1
31.5-34.4	3	0	0	0	3
34.5+					0
Slabs	15	1	0	0	16
Total [2/]	513	150	46	16	725

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Specifications for yarding unutilized material (table 1) influenced the distribution of usable material remaining on the units. Minimum specifications for YUM on unit 4 included some residues that were excluded as YUM on units 1, 2, and 3. As expected, the smaller diameter specification for removing YUM from unit 4 resulted in a greater reduction in the percentage of material remaining in this size category, both in volume and piece count, for the site (table 22). Because YUM yarding removed the larger pieces of unutilized material from the logging site, the volume of usable residue remaining was predominantly in pieces not meeting YUM specifications.

Logging residue that was at least 50 percent sound, 8 inches and larger in diameter, and at least 8 feet long probably meets or exceeds specifications for pulp or utility logs. Volume of usable residue (tables 13-16 and fig. 1) and number of pieces (tables 18-21) meeting these specifications on each unit were:

Unit	Volume		Pieces	
	(Cubic feet per acre)	(Percent of usable residue)	(Number)	(Percent of usable residue)
1	309	21	25	5
2	572	37	55	13
3	856	40	97	14
4	467	26	57	8

These estimates do not include the YUM material meeting these specifications that was removed during the harvesting operation.

The volumes of usable logging residues on each unit by soundness and material handling class are presented in tables 23-26. About 80 percent of the gross volume of usable residue on unit 1 was from felled trees, nearly 62 percent on unit 2, 68 percent on unit 3, and 61 percent on unit 4. Almost 54 percent of these amounts was bucked from longer pieces on unit 1, 45 percent on unit 2, 42 percent on unit 3, and 46 percent on unit 4. The lower average soundness of usable residue from felled trees on unit 1 (table 23), compared with the soundness of the usable residue on units 2, 3, and 4 (tables 24-26), suggests that the decadent condition of the timber on unit 1 predisposed the trees to produce higher proportions of residue from felled trees and of residue bucked from longer pieces. Of the downed residue remaining on the unit, about 9 percent of the volume had been bucked from longer pieces on unit 1, 14 percent on unit 2, 6 percent on unit 3, and 19 percent on unit 4.

Of the usable residue on unit 1, nearly 45 percent was bucked; on unit 2, 33 percent; on unit 3, 30 percent; and on unit 4, 35 percent. For the four units combined, more than 35 percent of the usable residue volume was bucked from longer pieces. This class of residue could have been easily reduced in volume by modifying guidelines for bucking whereby the practices of long butting and bucking out submerchantable or defective segments and broken log ends are restricted. Material that would otherwise be bucked from longer pieces would be left intact and be yarded with the merchantable logs or with the YUM material. This procedure would minimize the volume of bole residue left on the site.

Table 22—Volume and pieces of usable residue on 4 study units after cable logging, by 2 size groups, Pansy Creek drainage, Mount Hood National Forest 1/

Residue size group	Study unit	Volume of usable residue per acre		Pieces of usable residue per acre	
		Within size group	Percent of total	Within size group	Percent of total
		Cubic feet		Number	
7.5-inch d.i.b. or larger on large end, 8 feet long or longer	1	837.5	56.9	57	11.7
	2	819.0	53.6	70	16.1
	3	1,134.8	53.0	121	17.4
	4	765.3	42.2	72	9.9
10.5-inch d.i.b. or larger on large end, 8 feet long or longer	1	637.3	43.3	30	6.2
	2	569.9	37.3	29	6.7
	3	648.8	30.3	46	6.6
	4	545.9	30.1	38	5.3

1/ Usable residue includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

Table 23—Average gross and net volumes of usable residue on study unit 1 after cable logging, by soundness category and material handling class, Pansy Creek drainage, Mount Hood National Forest 1/

Soundness category and material handling class	Gross volume	Net volume	Soundness	Proportion of total
	Cubic feet per acre		- - - -Percent- - - -	
75+ percent sound:				
Felled and bucked	310.4	307.4	99.0	49.5
Felled and broken	305.1	292.2	95.8	48.7
Down and bucked	0			
Down and broken	11.5	10.2	88.8	1.8
Total 2/	627.0	609.8	97.3	100.0
50+ percent sound:				
Felled and bucked	363.3	337.3	92.8	44.7
Felled and broken	359.2	323.3	90.0	44.2
Down and bucked	25.4	14.1	55.3	3.1
Down and broken	65.0	37.0	56.9	8.0
Total 2/	813.0	711.6	87.5	100.0
30+ percent sound:				
Felled and bucked	527.0	392.4	74.5	49.8
Felled and broken	414.4	341.8	82.5	39.2
Down and bucked	25.4	14.1	55.3	2.4
Down and broken	91.4	45.2	49.5	8.6
Total 2/	1,058.2	793.6	75.0	100.0
10+ percent sound:				
Felled and bucked	630.5	408.1	64.7	42.8
Felled and broken	541.8	358.7	66.2	36.8
Down and bucked	25.4	14.1	55.3	1.7
Down and broken	274.2	61.1	22.3	18.6
Total 2/	1,471.8	841.8	57.2	100.0

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 24—Average gross and net volumes of usable residue on study unit 2 after cable logging, by soundness category and material handling class, Pansy Creek drainage, Mount Hood National Forest 1/

Soundness category and material handling class	Gross volume	Net volume	Soundness	Proportion of total
	Cubic feet per acre		- - - -Percent- - - -	
75+ percent sound:				
Felled and bucked	385.4	379.7	98.5	39.0
Felled and broken	403.1	393.5	97.6	40.8
Down and bucked	46.3	39.2	84.8	4.7
Down and broken	154.1	135.8	88.1	15.6
Total 2/	988.8	948.2	95.9	100.0
50+ percent sound:				
Felled and bucked	419.6	397.5	94.7	34.1
Felled and broken	477.0	438.0	91.8	38.8
Down and bucked	55.1	44.4	80.6	4.5
Down and broken	279.1	213.0	76.3	22.7
Total 2/	1,230.8	1,092.9	88.8	100.0
30+ percent sound:				
Felled and bucked	420.8	398.0	94.6	29.8
Felled and broken	490.7	443.4	90.4	34.7
Down and bucked	61.8	46.4	75.1	4.4
Down and broken	440.6	268.4	60.9	31.2
Total 2/	1,413.9	1,156.1	81.8	100.0
10+ percent sound:				
Felled and bucked	423.1	398.2	94.1	27.7
Felled and broken	522.9	449.7	86.0	34.2
Down and bucked	80.5	48.9	60.8	5.3
Down and broken	501.6	279.5	55.7	32.8
Total 2/	1,528.0	1,176.4	77.0	100.0

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 25—Average gross and net volumes of usable residue on study unit 3 after cable logging, by soundness category and material handling class, Pansy Creek drainage, Mount Hood National Forest [1/]

Soundness category and material handling class	Gross volume	Net volume	Soundness	Proportion of total
	Cubic feet per acre		Percent	
75+ percent sound:				
Felled and bucked	589.3	588.5	99.9	39.0
Felled and broken	776.1	768.8	99.1	51.3
Down and bucked	6.9	5.8	84.8	.5
Down and broken	140.6	117.5	83.6	9.3
Total [2/]	1,512.9	1,480.8	97.9	100.0
50+ percent sound:				
Felled and bucked	600.4	594.1	98.9	35.8
Felled and broken	789.7	777.1	98.4	47.1
Down and bucked	25.2	15.0	59.5	1.5
Down and broken	260.3	182.4	70.1	15.5
Total [2/]	1,675.7	1,568.5	93.6	100.0
30+ percent sound:				
Felled and bucked	606.1	596.3	98.4	34.7
Felled and broken	796.4	779.0	97.8	45.5
Down and bucked	30.9	16.7	54.1	1.8
Down and broken	315.6	201.1	63.7	18.0
Total [2/]	1,748.9	1,593.1	91.1	100.0
10+ percent sound:				
Felled and bucked	606.1	596.3	98.4	28.3
Felled and broken	849.7	788.2	92.8	39.7
Down and bucked	37.7	18.1	47.9	1.8
Down and broken	647.6	240.7	37.2	30.2
Total [2/]	2,141.1	1,643.4	76.8	100.0

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Table 26—Average gross and net volumes of usable residue on study unit 4 after cable logging, by soundness category and material handling class, Pansy Creek drainage, Mount Hood National Forest 1/

Soundness category and material handling class	Gross volume	Net volume	Soundness	Proportion of total
	Cubic feet per acre		Percent	
75+ percent sound:				
Felled and bucked	495.5	488.0	98.5	40.3
Felled and broken	552.1	547.5	99.2	44.9
Down and bucked	85.6	77.2	90.2	7.0
Down and broken	97.2	82.9	85.3	7.9
Total 2/	1,230.3	1,195.6	97.2	100.0
50+ percent sound:				
Felled and bucked	504.6	493.5	97.8	35.4
Felled and broken	583.7	568.1	97.3	41.0
Down and bucked	94.7	82.7	87.3	6.7
Down and broken	240.5	162.2	67.4	16.9
Total 2/	1,423.5	1,306.4	91.8	100.0
30+ percent sound:				
Felled and bucked	504.6	493.5	97.8	30.4
Felled and broken	593.0	571.8	96.4	35.7
Down and bucked	133.9	98.3	73.4	8.1
Down and broken	430.0	231.0	53.7	25.9
Total 2/	1,661.6	1,394.7	83.9	100.0
10+ percent sound:				
Felled and bucked	504.6	493.5	97.8	27.8
Felled and broken	593.0	571.8	96.4	32.7
Down and bucked	133.9	98.3	73.4	7.4
Down and broken	582.0	253.0	43.5	32.1
Total 2/	1,813.5	1,416.7	78.1	100.0

1/ Includes all down material averaging at least 3.0 inches in diameter (inside bark) and 4.0 feet long, and yardable.

2/ Totals may be off because of rounding.

Conclusions

This investigation presents results based on a case study of a particular cable logging operation. Inferences that can be drawn from these results are unique to this study and may not necessarily apply to other cable operations. The information generated, however, can provide a basis on which forest land managers can evaluate logging operations for production of residue, its reduction, characteristics, volumes, and potential uses. Results of this study also give some indication of the fuel loading a land manager can expect from similar logging operations. The impact on the character and volume of the residue resulting from a change in utilization either from changes in the market or in logging requirements (for example, yarding unutilized material) can also be evaluated.

As expected, YUM yarding reduced the volume of large residue in the study units. The volume and distribution of pieces of usable residue were influenced by the contractual specifications for yarding unutilized material. The amount and character of the residue remaining on the sites were also influenced by the defect in the timber on the site; both changed drastically with a small change in amount of defect.

Results suggest that even with YUM yarding, a substantial volume of residue will still remain on the logging sites. Though much of this residue is usable according to our specifications, its removal and utilization will continue to be a problem for land managers. We found, however, that a considerable volume of the usable residue could have been removed if bucking procedures were modified. Much of the usable residue remaining on the site had been bucked from longer pieces. These could have been removed if left intact with the merchantable log or as part of the pieces removed as YUM.

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The volume and character of woody material on the ground in four old-growth Douglas-fir cutting units in the Cascade Range in Oregon were determined before and after harvesting by cable and yarding of unutilized material (YUM). Total volume of residue increased after logging in all units. Coarse residues were reduced by YUM yarding. Small changes in the defect condition of the timber can drastically affect the amount and character of the residues remaining on the site. Modifying bucking procedures can result in the removal of a considerable volume of usable residue.

Keywords: Residue management, residue treatment, logging effects, cable logging, old-growth stands, Douglas-fir, *Pseudotsuga menziesii,* Oregon (Cascade Range), Cascade Range—Oregon.

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