LOGGING RESIDUES UNDER DIFFERENT STAND AND HARVESTING CONDITIONS, ROCKY MOUNTAINS

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ABSTRACT

Volume and characteristics of logging residues from 34 harvest areas are presented. Clearcuts and partial cuts logged to conventional utilization levels and to close utilization levels are included. Residue volumes ranged from almost 3,600 ft^3/acre of wood 3-inches-plus down to about 550 ft^3/acre, depending on treatment. More than 60 percent of the residues were sound. A high proportion of residues were in pieces under 9 feet in length.

INTRODUCTION

Much of the merchantable-size timber in the Northern Rocky Mountain States is in mature and overmature stands. Consequently, timber harvesting in these stands over the next several decades will involve handling sizable volumes of material such as dead trees, down material, and small, understory trees that are part of most mature stands. The volume and utilization potential of this "residue"--material other than green saw logs--is of immediate interest to both the wood products industry and the land manager. To the industry this residue represents a potential source of wood fiber to help offset increasingly tight saw-log supplies. To the land manager, utilization of this material can reduce the costs of postharvest treatments.

This paper describes postharvest residues from 34 typical logging units in the Northern Rockies. Some of the units were logged to conventional utilization standards, other units or subunits were logged to more intensive utilization standards.

Volumes and characteristics of residues can vary considerably from those reported here. However, these initial data should provide a general idea of the amounts and characteristics of residues left after logging. In addition, we hope that this paper will stimulate managers to make their own evaluations of logging residues.

METHODS FOR ESTIMATING RESIDUE VOLUME

The methods used in estimating residue volumes are based on a planar intercept technique: the measuring of pieces of down material that pass through an imaginary vertical plane superimposed along a random bearing from a sample point (fig. 1). This procedure has been developed by the Northern Forest Fire Laboratory for measuring fuel loadings.[1,2] To this basic procedure we have added a more detailed description of characteristics that affect utilization potential: size of piece, species, defect, bark, and spiral grain (procedures on file at Forestry Sciences Laboratory, Missoula, Montana).

Sampling procedure in these studies has been to establish a grid of about 25 to 40 samples in each logging unit (units were generally about 20 to 50 acres in size). Each sample was a line consisting of several segments. Fine material up to 1-inch diameter was measured on a 6-foot segment of the line; larger material from 1- to 3-inch diameter was measured on a 10-foot segment; and material over 3-inch diameter was measured on a longer segment usually 35 or 50 feet in length, depending on the amount

[1]Brown, James K. 1971. A planar intersect method for sampling fuel volume and surface area. For. Sci. 17(1):96-102.

[2]Brown, James K. 1974. Handbook for inventorying down woody material. USDA For. Serv. Gen. Tech. Rep. INT-16, 24 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

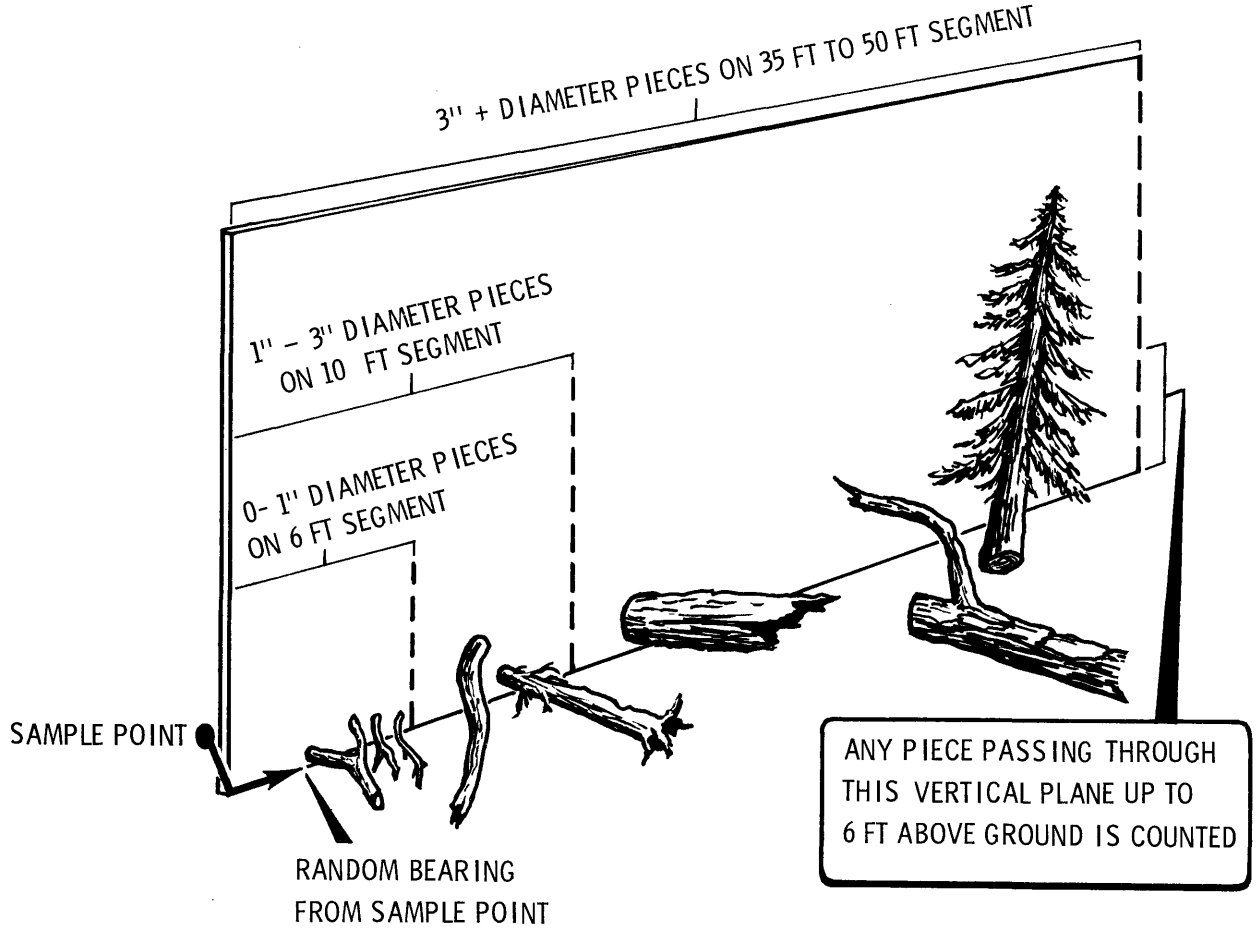

Figure 1.--Planar intercept layout.

of down material. A similar technique using a continuous transect line is also available,[3] but we have used the grid system because it better served other measurement needs of the studies.

Residue volumes were predicted by estimating the volume that would remain after logging, given the harvesting method and utilization level used on the area. This included (a) nonmerchantable material that was on the ground prior to harvest (not available on some areas), (b) cull and other nonmerchantable volume shown in the timber sale cruise data, and (c) volume of top boles from merchantable trees harvested, and from small stems, based on stand tables from sale cruise data. These predictions are compared to actual residues in tables that follow.

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[3]Howard, James O., and F. R. Ward. 1972. Measurement of logging residue--alternative applications of the line intersect method. USDA For. Serv. Res. Note PNW-183, 8 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

The data were punched onto cards and processed by computer through the Northern Forest Fire Laboratory. However, the formulas presented in Brown's "Handbook" are simple enough that the basic volume computations could be made with a desk calculator. The description of larger pieces in terms of utilization potential involved more complex computer procedures developed by Johnston, and these are on file at the Northern Forest Fire Laboratory.

AREAS STUDIED

Residue volumes were measured on logged units in mature lodgepole pine, Douglas-fir/larch, and mixed-conifer stands throughout Wyoming, Montana, and Idaho. On areas where intensive logging research was being done, both preharvest and postharvest residues were measured in detail. In other areas, preharvest measurements could not be made, but by piecing together timber-sale appraisal and other data we have developed an estimate of preharvest volumes. A variety of silvicultural prescriptions, harvesting systems, and utilization levels are represented by the study areas.

1. LOGGING RESIDUES – CLEARCUTS LOGGED

STUDY AREAS:

LODGEPOLE PINE STANDS

1. *Bridger-Teton National Forest, Wyoming.*--Mature lodgepole pine stands harvested with ground-skidding equipment. Green saw logs were removed to a 6-inch top diameter; remaining material piled and burned.

DOUGLAS-FIR/LARCH STANDS

1. *Lolo National Forest, Montana.*--Mature Douglas-fir/larch stands harvested with jammer and tractor-skidding equipment. Green saw logs were utilized from trees 9 inches d.b.h. and larger to an 8-inch top diameter; dead material 50 percent or more sound was removed; remaining material slashed.

2. *Coram Experimental Forest, Montana.*--Mature Douglas-fir/larch stands harvested with running skyline system under (1) block clearcut and (2) group selection clearcut prescriptions. Green and recently dead saw logs utilized from trees 7 inches d.b.h. and larger to a 6 inch top diameter with pieces one-third or more sound removed. Remaining material slashed.

MIXED-CONIFER STANDS

1. *North Idaho State lands.*--Mature mixed-conifer stands harvested with ground-skidding equipment. Logs utilized from trees 10 inches d.b.h. to a variable top diameter, depending on log length. Pieces one-third or more sound removed (minor variations in these specifications between units). Remaining material slashed.

TO CONVENTIONAL UTILIZATION STANDARDS

Figure 2.--Residue remaining after clearcut logged to conventional utilization standards, lodgepole pine.

RESIDUES REMAINING

	Preharvest volume		Predicted[1] residue,	Actual residue	
	Saw log	Total, 3 inches+	3 inches+	3 inches+	Fines
	M BF/a	*Ft^3/a*	*Ft^3/a*	*Ft^3/a*	*Tons/a*
LODGEPOLE PINE					
1	27.7	10,164	3,524	3,567	12.8
DOUGLAS-FIR/LARCH					
1	18.1	5,575	2,577	2,756	8.9
2	21.5	6,970	3,051	2,371	11.0
MIXED CONIFER					
1	24.0	[2]7,947+	[2]3,946+	3,141	10.6
AVERAGE, ALL	22.8	7,664	3,274	2,958	10.8

[1] Based on preharvest measurements and utilization specifications.
[2] Estimated from limited preharvest data; an undetermined volume of down material not included.

2. LOGGING RESIDUES – PARTIAL CUTS LOGGED 1

STUDY AREAS

DOUGLAS-FIR/LARCH STANDS

1. *Lolo National Forest overwood removal.*--Mature Douglas-fir/larch overwood harvested with jammer and tractor skidding. Green saw logs from trees 9 inches d.b.h. and larger were removed to an 8-inch top diameter; dead material 50 percent or more sound removed.

2. *Salmon National Forest overwood removal.*--Mature Douglas-fir/ponderosa pine overwood removed by helicopter.

3. *Lolo National Forest shelterwood.*--Mature Douglas-fir/larch was harvested with tractor and jammer skidding; selected shelterwood trees left; green saw logs from trees 9 inches d.b.h. and larger were removed to an 8 inch top diameter; dead material 50 percent or more sound removed.

4. *Coram Experimental Forest shelterwood.*--Mature Douglas-fir/larch harvested, with trees 7 inches d.b.h. and larger cut; green saw logs to 6-inch top diameter and dead material one-third or more sound removed.

MIXED CONIFER STANDS

1. *North Idaho State lands.*--Mixed-conifer stands about 60 to 100 years old were commercially thinned with ground-skidding equipment; about half of standing trees removed. Cut trees were 9 inches d.b.h. and larger; logs to 6-inch top removed; some dead material and cedar poles also removed.

TO CONVENTIONAL UTILIZATION STANDARDS

Figure 3.--A "turn" of logs coming to landing in a partial-cut, larch/Douglas-fir stand logged to conventional utilization standards.

	Preharvest volumes			Predicted[1] residue	Actual residue	
	Saw log	Cut volume	Total 3 inches+		3 inches+	Fines
	M BF/a	*M BF/a*	*Ft³/a*	*Ft³/a*	*Ft³/a*	*Tons/a*
DOUGLAS-FIR/LARCH						
1	27.7	10.7	6,611	1,328	1,532	8.8
2	- - - - - - - -not available- - - - - -				1,359	5.4
3	36.1	20.5	8,695	2,134	2,319	5.4
4	15.3	6.2	7,452	3,846	1,938	10.2
MIXED CONIFER						
1	[2]13.1	9.2	[2]4,362	1,518	2,860	8.7
AVERAGE, ALL	23.0	11.6	6,780	2,206	2,002	7.7

[1] Based on preharvest measurements and utilization specifications.

[2] Estimated from limited preharvest data; an undetermined amount of down material not included.

3. LOGGING RESIDUES – CLEARCUTS LOGGED TO

STUDY AREAS

LODGEPOLE PINE STANDS

1. *Bridger-Teton National Forest.*--Mature lodgepole pine was harvested using a feller-buncher, grapple skidder, and portable chipper. Green saw logs were removed to a 6-inch top diameter and all other material down to 3-inch diameter by 8-foot length was field-chipped.

2. *Bitterroot National Forest.*--An overmature, high-elevation stand was harvested using small, rubber-tired skidders, small crawler tractors, and horse skidding. Sound material 3-inch-plus diameter, live and dead, was removed for saw logs, houselogs, posts, and corral poles.

DOUGLAS-FIR/LARCH STANDS

1. *Coram Experimental Forest close log utilization.*--Mature stands harvested with running skyline. Trees 7 inches d.b.h. and larger were cut; all pieces green and dead, one-third or more sound, down to 3-inch diameter by 8-foot length removed. Understory protected in skidding.

2. *Coram Experimental Forest close tree and log utilization.*--Mature stands harvested with running skyline. Trees 5 inches d.b.h. and larger cut; all pieces dead and green, one-third or more sound, down to 3-inch diameter by 8-foot length removed. Understory slased for burning.

3. *Coram Experimental Forest fiber utilization.*--Mature stands harvested with running skyline. All stems 1-inch diameter and larger cut and removed; 1- to 5-inch diameter material was cut and bundled prior to logging to facilitate yarding.

CLOSE UTILIZATION STANDARDS

Figure 4.--Field chipping residue in lodgepole pine stand logged to close utilization standards.

	Preharvest volume				
	Saw log	Total 3 inches+	Predicted[1] residue	Actual residue 3 inches+	Actual residue Fines
	M BF/a	*Ft³/a*	*Ft³/a*	*Ft³/a*	*Tons/a*
LODGEPOLE PINE					
1	24.1	9,673	595	731	10.5
2	5.2	4,973	1,998	1,442	(not avail.)
DOUGLAS-FIR/LARCH					
1	20.3	7,534	2,362	1,424	11.1
2	22.0	8,137	2,835	1,983	11.5
3	13.6	6,297	2,630	1,214	8.3
AVERAGE, ALL	17.0	7,123	2,084	1,359	10.3

[1] Based on preharvest measurements and utilization specifications.

4. LOGGING RESIDUES – PARTIAL CUTS LOGGED

STUDY AREAS

DOUGLAS-FIR/LARCH STANDS

1. *Coram Experimental Forest close log utilization.*--Mature stands were harvested with skyline; shelterwood prescription with about half of overwood volume left. Trees 7 inches d.b.h. and larger were cut; all pieces green and dead, one-third or more sound, down to 3-inch diameter by 8-foot length removed. Understory protected.

2. *Coram Experimental Forest close tree and log utilization.*--Mature stands harvested with skyline; shelterwood prescription with about half of overwood volume left. Trees 5 inches d.b.h. and larger cut; pieces dead and green, one-third or more sound, down to 3-inch diameter by 8-foot length removed. Understory slashed for burning.

3. *Coram Experimental Forest close fiber utilization.*--Mature stands harvested with skyline; shelterwood prescription with about half of overwood volume left. All stems 1-inch diameter and larger cut and removed; 1- to 5-inch diameter material cut and bundled prior to logging to facilitate yarding.

MIXED-CONIFER STANDS

1. *North Idaho State lands commercial thinning.*--Small sawtimber stand thinned with ground-skidding equipment. About half of volume left; pieces down to 3-inch top diameter by 8-foot length removed.

TO CLOSE UTILIZATION STANDARDS

Figure 5.--Shelterwood cut with close utilization in larch/ Douglas-fir stand.

RESIDUES REMAINING

	Preharvest volume			Predicted[1] residue,	Actual residue	
	Total volume	Cut volume	Total 3 inches+	3 inches+	3 inches+	Fines
	M BF/a	*M BF/a*	*Ft³/a*	*Ft³/a*	*Ft³/a*	*Tons/a*
DOUGLAS-FIR/LARCH						
1	9.7	5.3	5,940	2,030	1,502	9.4
2	16.4	9.1	7,397	2,664	1,610	2.4
3	14.6	6.7	5,938	2,193	865	6.4
MIXED CONIFER						
1	16.3	8.0	3,620	620	548	6.4
AVERAGE, ALL	14.2	7.3	5,723	1,877	1,131	6.2

[1] Based on preharvest measurements and utilization specifications.

VOLUME OF RESIDUES

The volume of residues 3 inches and larger remaining after logging ranged from more than 3,567 ft^3/acre in a mature, lodgepole pine clearcut unit with conventional utilization, to 548 ft^3/acre in a young, mixed-conifer commercial thinning unit where "close" utilization was practiced (tables, pages 5, 7, 9, 11).

The volume of residues was largest in clearcut units with conventional utilization (average 2,958 ft^3/acre) and smallest in partial cuts with close utilization (average 1,131 ft^3/acre). It should be noted, however, that some individual areas with close utilization had as much residue as some areas with conventional utilization. This is because of differences in initial stand volumes and also because utilization specifications were not always followed exactly--both underutilization and overutilization occurred.

Residue under 3-inch diameter--"fines," measured in tons per acre--were heavier in the clearcut areas than in partial cuts. This is to be expected because in most clearcuts small stems and defective trees were knocked down or slashed after logging.

On the average, residue volumes were less than we had predicted, based on preharvest estimates of existing residues, and slash that would be created in logging:

Area	*Actual residues as percent of predicted*	
	Average	*Range*
Clearcut/conventional	91	72 to 107
Partial cut/conventional	91	50 to 188
Clearcut/close	65	46 to 123
Partial cut/close	61	39 to 88

The conventional utilization areas had residue volumes that were closest to our predictions. On close utilization areas the loggers removed even more than we had anticipated. However, this was mainly on the Coram study area, where most of the close utilization units were located. This was a closely monitored research study with some unusual logging requirements, and this probably led to more material being yarded than the specifications called for.

Variables such as habitat type, slope, logging equipment, and logging-layout specifications probably have some effect on residue volumes. However, there were not sufficient replications in the sample to draw any conclusions. (Data from individual logging units would be too lengthy to report here, but are on file at the Forestry Sciences Laboratory.)

CONDITION, SIZE, AND TYPE OF RESIDUES

In addition to volume, the soundness and size of pieces (along with species) determines the utilization potential of residues.

We sorted residues into four soundness or condition classes:

Crumbly rot--the piece could not be handled;

Solid rot--rotten, but it would hold together in yarding and handling;

Sound defect--no rot, but it has deformities, splits, etc., that prevent it from use as a roundwood product;

No defect--none of the above defects.

The actual volume of residues in different condition classes varied along with total volume; therefore proportions of residue in each class are used as a basis for comparison. We found that conventional utilization areas had much higher proportions of sound residues than did close utilization areas:

	Conventional *Percent*	*Close* *Percent*
Crumbly rot	20	40
Solid rot	19	33
Sound defect	11	10
No defect	50	17
	100	100

To the extent that it may be possible to retrieve all residues, close utilization appears to substantially increase the recovery of sound materials. From a practical standpoint, the feasibility of recovering more material depends partly on the size of the pieces. We have determined the size distribution of sound pieces from some (not all) of the study areas. Based on these areas, most of the sound volume is in pieces under 9 feet in length (about 9 feet is needed to square the ends and produce an 8-foot

stud log or a 100-inch pulp bolt). Conventional utilization units had a higher proportion of long lengths than did close utilization units:

Piece size, sound pieces / *Length, small-end diam.*	*Conventional* / *Percent of volume*	*Close* / *Percent of volume*
0 to 9 feet long		
3- to 6-inch diameter	37	45
6-inch-plus diameter	44	48
9 to 18 feet long		
3- to 6-inch diameter	9	4
6-inch-plus diameter	4	1
19-feet-plus long		
3- to 6-inch diameter	4	1
6-inch-plus diameter	2	1
	100	100

Sometimes managers are interested in knowing just how much green residue material is created in logging. On most units we identified residues as green (freshly created by harvesting operation) or dead. We found that nearly half the volume in conventional logging units is green, but only a small amount of green material was left in close utilization units:

	Dead / *Percent*	*Green* / *Percent*
Conventional utilization		
Partial cuts	56	44
Clearcuts	51	49
Close utilization	88	12

This was expected because although close utilization specifications for dead material varied somewhat, they always called for removal of sound green pieces down to 4- or 3-inch diameter.

SUMMARY AND DISCUSSION

This report presents the initial summaries of some of the basic residue data we have compiled to date. Additional detailed information on file, such as on bark volume, species, and product potential, remains to be analyzed, and will be published in future reports.

We have summarized highlights of this report in terms of questions we have been asked most frequently since we have begun quantifying residues.

1. *What volumes of residues remain after logging?*--This varies by species, utilization specifications, and a number of other factors. On the average we found about 35 percent of the initial cubic volume (3-inch-plus) of the stand remained as residue following conventional utilization; and about 20 percent of the initial volume where closer utilization was practiced (tables, pages 5, 7, 9, 11). In terms of actual volumes, clearcutting with conventional utilization averaged about 3,000 ft^3/acre of residues, and partial cutting with conventional utilization averaged about 2,000 ft^3/acre.

2. *Can residue volumes be predicted?*--Using standard timber-sale data, plus some additional preharvest measurements of down material we developed estimates that fairly accurately predicted residues in conventionally logged areas. Under close utilization, and under research study conditions, we generally overestimated the amount residue remaining. This was primarily because logging removed more than was called for in the specifications.

3. *What is the condition of logging residues?*--Condition varies with original stand conditions, but on the average, we found that under conventional utilization over 60 percent of the residue had no rotten defect. Nearly half the residue that had rot was solid enough to be handled and was potentially usable for pulp, fuel, or fiber products.

4. *Are residues recoverable and utilizable?*--A high proportion of residues appear to be sound enough for either fiber or roundwood-product use. Over 80 percent of the sound pieces are under 9 feet long, the current minimum length for products such as stud logs, pulp bolts, and house logs. Shorter pieces would be usable for fuel and fiber products, although yarding and handling them may pose some technical and economic problems. Developing logging procedures that would reduce breakage might be a partial solution.

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Benson, Robert E., and Cameron M. Johnston
1976. Logging residues under different stand and harvesting conditions, Rocky Mountains. USDA For. Serv. Res. Pap. INT-181, 15 p. Intermountain Forest & Range Experiment Station, Ogden, Utah 84401.

Volume and characteristics of logging residues from 34 harvest areas are presented. Clearcuts and partial cuts logged to conventional utilization levels and to close utilization levels are included. Residue volumes ranged from almost 3,600 ft^3/acre of wood 3-inches-plus down to about 550 ft^3/acre, depending on treatment. More than 60 percent of the residues were sound. A high proportion of residues were in pieces under 9 feet in length.

OXFORD: 332.3, 331, 432.16
KEYWORDS: logging, slash, fuels, harvest systems, residue

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field programs and research work units are maintained in:

Billings, Montana
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Logan, Utah (in cooperation with Utah State University)
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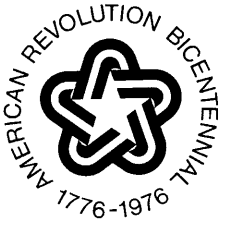
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