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Research Summary

Data collected on 20 logging operations in Utah in 1993 provided board-foot and cubic-foot conversion factors of log scale and factors to apply to harvest volume estimates to obtain removals estimates. The components of timber products and removals, obtained by application of these factors to the 1992 Utah timber harvest, are included. Additional findings, presented in table form, are the diameter distribution of trees removed from growing stock per thousand cubic ft of products and the volume of logging residue in pieces 6 ft and longer as a proportion of product volume. Survey methods and estimates of data reliability are also presented.

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Introduction

A study to develop factors for relating Utah's timber harvest to the standing forest inventory was conducted concurrently with the Statewide forest inventory in 1992. Two other concurrent studies, timber product output (McLain and others, in preparation) and fuelwood harvest (McLain 1997), provided estimates of log volumes harvested and delivered to primary wood processors and to residences burning firewood in 1992. Logging utilization, the subject of this bulletin, provides the factors to convert harvest estimates to standing inventory and thus facilitate the assessment of growth-to-cut relationships for the State. Other factors are used to convert reported harvest volumes received by primary wood processors into cubic feet so that products using different units of measurement, such as cords and board feet, can be readily combined. Additional factors, also to be applied to harvest volumes, provide estimates of the diameter class distribution of the harvest and the volume of residue in pieces 6 ft and longer.

Study Methods

The study was conducted in Utah using the sampling and measurement techniques designed by A. K. Wilson of the Forest Survey Project at the Intermountain Research Station from 1959 to 1960 (Wilson 1965). These techniques are described in the following two sections.

Sample Size and Distribution

Measurements were obtained in the summer of 1993 on 20 active sawlog and multiproduct logging operations located on timberland. These operations—the basic sample units—were distributed throughout the State; 15 of the operations were located on National Forests and five on State land. No logging operations occurring on private land were accessed. Measurements from 20 logging operations were deemed sufficient to achieve a standard error of the logging residue and product volume ratio (total net cubic-foot volume of logging residue divided by the total net volume of timber products) of 20 percent.

Data Collection

The study design prescribed four basic measurements to be obtained from each sample unit to compute removals and logging residue factors.

On each sample unit, 15 to 24 felled and bucked product trees with an average sample unit total net volume of about 3,700 bd ft (International ¼ inch rule) and a varying number of associated nonproduct trees were measured to obtain:

1. Product volume
2. Noninventory volume in products
3. Volume of logging residue from product trees
4. Volume of logging residue from nonproduct trees

All measured trees were categorized as poletimber, sawtimber, salvable dead, cull, or nontimber. Gross and net volumes in cubic feet and board feet (International ¼ inch rule and Scribner rule) were obtained by scaling. These measurements were correlated to obtain factors to apply to reported product volumes received by primary wood processors. Thus, all factors were calculated as proportions of product volume. No product volume from nontimber species was encountered on the logging operations sampled.

Study Results

The results of this study comprise cubic-foot to board-foot conversion factors, removals factors, removals volumes, logging residue volume in long pieces, and the diameter class distribution of trees harvested in 1992 on logging operations in Utah.

Log Scale Conversions

The following product volumes resulted from scaling the logs of the 390 product trees on the 20 logging operations measured.

	Product volume	
	Gross	Net
Cubic feet	12,558	12,256
Board feet, Scribner rule	65,280	63,205
Board feet, International ¼ inch rule	76,250	74,035

Table 1—Net product volume conversion factors for Utah, 1993.

1 cubic foot equals	5.1571	Board feet (Scribner rule)
1 cubic foot equals	6.0407	Board feet (International ¼ inch rule)
1 board foot equals (Scribner rule)	1.1714	Board feet (International ¼ inch rule)

The conversions appearing in table 1 were calculated using the net product volumes. These conversions are Statewide averages, reflecting the average conversion for the harvest of the product mix encountered on the 20 operations measured. Caution is recommended in applying these factors to State subdivisions or to harvests of a narrow range of products of small size, such as posts or fuelwood, or to sawlogs of exceptionally large diameters.

Removals Factors, Utah 1993

The factors in table 2 are applied to reported harvest volumes to estimate growing-stock and sawtimber removals from the inventory by logging (appendix A). In this publication "removals" is limited to harvesting. Factors are used to estimate the amount of growing-stock or sawtimber volume in the products and the amount of logging residue associated with the product volume. Removals is the sum of these volumes (fig. 1).

The growing-stock removals factor of 1.050 means that for every 100 cubic ft of logs from live trees harvested in Utah (table 2):

99.8 cubic ft of removals were in the logs
5.3 cubic ft of removals were residue
Total: 105.0 cubic ft were removed from the growing-stock inventory; sum is not exact due to rounding

Of the 5.3 cubic ft of removals that were residue:

4.3 cubic ft of residue came from the merchantable portion of the trees containing the 100 cubic ft of logs
1.0 cubic ft of residue was in trees knocked over or otherwise killed during the logging of the trees containing the 100 cubic ft

And 0.2 cubic ft of the 100 cubic ft was not growing stock removals. It came from the stumps and tops of growing-stock trees and from cull trees.

99.8 cubic ft of growing stock
0.2 cubic ft of noninventory product volume
Total: 100.0 cubic ft of product volume

For every 100 cubic ft of logs from salvable dead trees harvested in Utah, 1.0 cubic ft of residue was produced in trees knocked over while logging the 100 cubic ft.

The sawtimber removals factor of 0.942 means that for every 100 bd ft (Scribner rule) of logs from live trees harvested in Utah:

92.9 bd ft of sawtimber removals were in the logs
1.3 bd ft of sawtimber removals were residue
Total: 94.2 bd ft were removed from the sawtimber inventory

Of the 1.3 bd ft of sawtimber removals that were residue:

0.8 bd ft of residue came from the merchantable portion of the trees producing the 92.9 bd ft of removals in the logs
0.4 bd ft of residue was in trees knocked over or otherwise killed during the logging of the trees containing the 100 bd ft.

Total: 1.3 bd ft; sum is not exact due to rounding.

And 7.1 of the 100 bd ft were not sawtimber removals; this volume came from poletimber, the tops and stumps of sawtimber, and from cull trees.

92.9 bd ft of sawtimber
7.1 bd ft of noninventory product volume
Total: 100.0 bd ft of product volume

For every 100 bd ft of logs from salvable dead trees harvested in Utah, 0.4 bd ft of residue was produced in trees knocked over while logging the 100 bd ft.

As in the case of log scale conversions, the reader is cautioned to consider the appropriate use of these factors. For instance, harvesting operations in a stand of predominantly dead timber may well produce no residue.

Table 2—Removals factors in cubic and board feet, Utah, 1993.

Type of factor	Cubic feet	Board feet Scribner rule	Board feet International ¼ inch rule
Logging residue	0.053	0.013	0.013
Product tree residue	.043	.008	.009
Nonproduct tree residue	.010	.004	.004
Noninventory product volume	.002	.071	.080
Inventory product volume	.998	.929	.920
Growing-stock (cubic) or sawtimber (board feet) removals	1.050	.942	.933

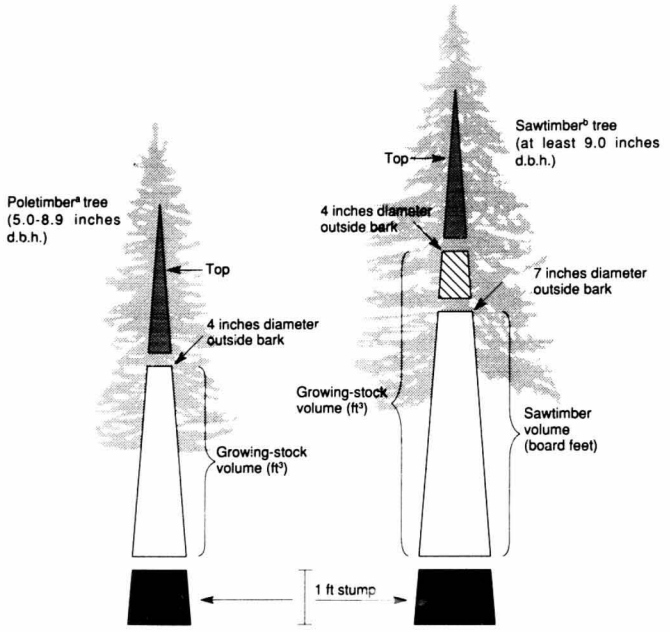

Figure 1—Stem sections of a poletimber and a sawtimber tree. Inventory volume comprises growing-stock volume in poletimber trees and both growing-stock and sawtimber volume in sawtimber trees. Noninventory volume is shaded. Roundwood products from the noninventory portion of tree stems are noninventory product volume. Board-foot volume from poletimber trees or from sections of sawtimber trees above the 7 inch top (cross-hatched) is also noninventory product volume.

[a]Softwoods; hardwoods, 5.0-10.9 inches d.b.h.
[b]Softwoods; hardwoods, at least 11.0 inches d.b.h.

Removals and Products

Table 3 exhibits estimates of roundwood products harvested in Utah in 1992 and the associated removals volume.

Roundwood products came from live trees (growing-stock and cull), salvable dead trees, and other sources (nontimber trees and nonforest land). The product volume from live trees comprises noninventory product volume and inventory product volume (growing-stock or sawtimber volume). The growing-stock and sawtimber volume in products plus the logging residue equals the growing-stock and sawtimber removals. In table 3 industrial roundwood products are subtotaled exclusive of fuelwood to simplify comparisons and analysis.

Estimates of industrial roundwood products were furnished by the primary wood processors who received logs harvested in Utah in 1992. Separate estimates were provided for products from live trees and salvable dead trees. The growing-stock and sawtimber removals component of the products, the noninventory product volume component, and the logging residue volume were estimated by applying factors from table 2 to the reported harvest volumes.

Table 3—Timber and fuelwood production and timber removals by source of material and product, Utah, 1992.

Products and additional removals	Product volume[a]				Noninventory product volume	Growing-stock removals
	Total	Live trees	Salvable dead trees	Other sources[b]		
	Thousand cubic feet					
Sawlogs[c]	10,174	7,763	2,411	—	16	7,747
Fiberwood	582	582	0	—	1	581
Posts and poles[d]	189	41	148	—	0	41
House logs[c]	1,588	204	1,384	—	0	204
Total	12,533	8,590	3,943	—	17	8,573
Fuelwood[e]	5,091	26	3,394	1,671	0	26
Logging residue[f]						494
Total	17,624	8,616	7,337	1,671	17	9,093
						Sawtimber removals
	Thousand board feet (Scribner rule)					
Sawlogs[c]	52,510	40,052	12,458	—	2,844	37,208
Fiberwood	3,000	3,000	0	—	213	2,787
Posts and poles[d]	—	—	—	—	—	—
House logs[c]	8,189	1,048	7,141	—	74	974
Total	63,699	44,100	19,599	—	3,131	40,969
Fuelwood[e]	17,637	134	17,503	—	10	124
Logging residue[f]	—	—	—	—	—	651
Total	81,336	44,234	37,102	—	3,141	41,744
	Thousand board feet (International ¼-inch rule)					
Sawlogs[c]	61,489	46,901	14,588	—	3,752	43,149
Fiberwood	3,513	3,513	0	—	281	3,232
Posts and poles[d]	—	—	—	—	—	—
House logs[c]	9,589	1,227	8,362	—	98	1,129
Total	74,591	51,641	22,950	—	4,131	47,510
Fuelwood[e]	20,659	157	20,502	—	12	144
Logging residue[f]	—	—	—	—	—	763
Total	95,250	51,798	43,452	—	4,143	48,417

[a]Sawlog, fiberwood, post and pole, and house log, volumes (McLain and others, in preparation). Fuelwood volumes (McLain 1997).
[b]No board-foot volume in other sources.
[c]Volumes reported in thousand board feet (Scribner rule). Cubic and board foot conversions are from logging utilization study (table 1).
[d]Posts and small poles were reported in number of pieces and their respective dimensions. The cubic volume was calculated using the dimension information. No posts or small poles met the minimum size for board foot scaling.
[e]Fuelwood volumes were reported in cords. Cords were converted to cubic feet at the rate of 80 cubic feet per cord. Table 1 factors were used to convert cubic volume to board-foot volume.
[f]Logging residue is associated with the harvest of industrial roundwood products. Logging residue associated with the fuelwood harvest is assumed to be zero.

Fuelwood estimates, obtained by sampling households and canvassing commercial fuelwood harvesters, were also separated into live and dead. A small volume fell into an additional category, other sources, which means nontimber species, or timber species from nonforest land. Because the logging utilization data were not collected from fuelwood harvesting operations, some adjustments were made to estimate growing-stock and sawtimber removals associated with fuelwood. The appropriate table 2 factors were used to estimate the growing-stock and sawtimber product volume, but residue was estimated to be zero. We assumed that all growing-stock and sawtimber volume in trees cut for fuelwood and trees killed by such logging went into the product. The fuelwood product volume from growing-stock trees was very small, less than 1 percent of the growing-stock removals generated by the industrial roundwood harvest.

Removals Factors, Then and Now

Table 4 compares the Utah removals, logging residue, and noninventory product volume factors from data collected in 1969 (Setzer 1973) to those from 1993. The differences, though not statistically significant, indicate that current timber harvesting removes

Table 4—Removal factors for Utah in 1969, compared to factors computed in 1993.

Factor	1969[a]	1993	Difference
Growing-stock removals (cubic)	1.068	1.050	(–0.018)
Logging residue (cubic)	.073	.053	(–.020)
Noninventory product volume (cubic)	.005	.002	(–.003)
Sawtimber removals (board feet, International ¼ inch rule)	.973	.933	(–.040)
Logging residue (board feet, International ¼ inch rule)	.026	.013	(–.013)
Noninventory product volume (board feet, International ¼ inch rule)	.053	.080	(+.027)

[a]Setzer 1973.

almost 2 percent less growing-stock volume and produces 2 percent less logging residue per unit of product volume than in 1969. This results from hauling more log volume to the wood processing plants relative to the growing-stock volume in the trees harvested or killed by harvesting. In other words, less wood is left (wasted?) in slash and stumps and more is manufactured into logs. Lower stumps were left and top logs were bucked at smaller diameters.

Current sawtimber removals per unit of product volume are about 4 percent less than in 1969. This results, partially, from increased efficiency in log manufacturing; less wood is left in the slash piles and in the stump. However, part resulted from harvesting poletimber. Noninventory product volume was 8 percent of product volume in 1992, a 2.7 percent increase over 1969. Over 75 percent of this noninventory product volume was the board-foot volume in logs from poletimber. An increase in poletimber harvest as a proportion of the total harvest automatically reduces the sawtimber removals factor; this gives the appearance of increased log manufacturing efficiency. This might mean that all of the 4 percent "gain" in board-foot log utilization was simply due to poletimber comprising a larger proportion of the 1992 harvest than the 1969 harvest. (See appendix A for factor computations.)

Logging Residue Volume in Pieces 6 Feet and Longer

Table 5 shows the factor used to estimate the cubic volume of logging residue from product trees in pieces 6 ft in length and longer to a 4 inch top, the proportion of product trees producing such residue, and the volume of residue at least 6 ft long produced in Utah in 1993. The factor, 0.034, means that residue volume in pieces 6 ft long and longer equals 3.4 percent of the product volume from live trees. In 1992, the industrial roundwood product volume from live trees (this excludes fuelwood) was estimated at 8.6 million cubic ft (table 3). Applying the factor to this volume (0.034 x 8.6) results in an estimate of 292,000 cubic ft of residue (table 5) in pieces 6 ft and longer left in the slash piles. Of course the desirability, given the focus on nutrient recycling, and the economic feasibility of capturing any or part of that wood volume for products, is questionable.

The proportion of live product trees measured in the study that produced residue in pieces 6 ft and longer, 56.4 percent (table 5), gives some indication of the degree of log utilization. The lower the proportion, the higher the utilization.

Diameter Class Distribution of Trees Harvested or Damaged

Table 6 gives information about the number of growing-stock trees and the growing-stock volume harvested or destroyed in each diameter class. Such information can be used when computing diameter class cutting rates to project residual inventory, growth, and yield. For example, in 1994, an estimated 1,469,000 growing-stock trees were in the 30 inch and larger diameter class and 102,007,000 growing-stock trees were in the 10 inch diameter class in Utah (O'Brien, in preparation). We estimate that 0.57 (30 inch and larger) diameter class trees are removed from the inventory for every 1,000 cubic ft of product volume; for 10 inch diameter class trees, the 1993 factor is 7.91 (table 6).

Table 5—Volume, proportion of harvest volume (factor), and proportion of product trees containing logging residue to a 4 inch top in pieces 6 ft and longer, Utah, 1992.

Residue volume in pieces 6 ft and longer (thousand cubic feet)	Factor[a] for residue volume in pieces 6 ft and longer	Proportion of product trees producing residue volume in pieces 6 ft and longer
292	0.034	0.564

[a]Apply to product volume, in cubic feet.

Table 6—Diameter at breast height (d.b.h.) class distribution of the number and volume of growing-stock trees removed from inventory through harvesting per 1,000 cubic ft of net product volume, Utah, 1993—with the number of trees removed in 1969 provided for comparison. The 1969 volume by d.b.h. class is unavailable.

D.b.h. class	Number of growing-stock trees		Volume of growing-stock trees in cubic feet
	1969[a]	1993	1993
6	1.69	1.14	2.69
8	1.21	4.90	35.66
10	1.21	7.91	108.44
12	4.12	5.47	110.72
14	2.42	4.90	130.06
16	3.15	3.10	109.99
18	3.15	1.47	69.19
20	1.45	1.22	74.33
22	1.69	.73	60.13
24	.48	.82	82.57
26	—	.73	90.49
28	—	.49	69.52
30+	1.94	.57	106.64
All classes[b]	28.32	34.51	1,050.42

[a]Setzer 1973.
[b]Data may not sum to totals due to truncating or rounding.

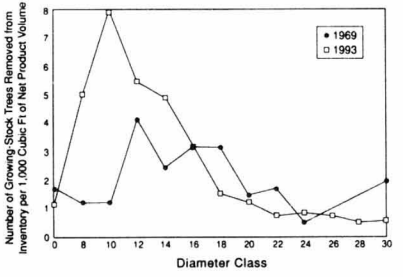

Figure 2—A comparison of the diameter class distribution of growing-stock trees removed from the inventory through harvesting per 1,000 cubic ft of net product volume, Utah, 1969 and 1993.

A harvest level of 8,590 M cubic ft, the estimated harvest from growing stock on Utah lands in 1992, would reduce the growing-stock inventory of 30 inch diameter class and larger trees by 4,896 (0.57 x 8,590) or 0.3 percent (4,896 divided by 1,469,000) and the 10 inch diameter class growing-stock inventory by 67,947 trees (7.91 x 8,590) or 0.07 percent (67,947 divided by 102,007,000). The information from the 1969 utilization study is provided in table 6 and in figure 2 for comparison. It is interesting, though hardly surprising, that in 1969 there were 1.94 30 inch and larger diameter class trees removed from inventory per thousand cubic feet of product volume, or over three times the 1993 estimated rate, and only 1.21 10 inch diameter class trees, less than one-sixth the 1993 rate.

Reliability of Estimates

The computation of the standard error of the various residue and utilization percentages employs the formula for the standard error of a ratio (Cochran 1963, p. 158), which may be stated:

$$S_R = \sqrt{\frac{\hat{R}^2}{n}\left[\frac{\sum_{i=1}^{n}(y_i-\bar{y})^2}{(n-1)\bar{y}^2} + \frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{(n-1)\bar{x}^2} - \frac{2\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{(n-1)\bar{y}\bar{x}}\right]}$$

where:

y = logging residues measured on an operation (net volume)

x = timber products measured on an operation (net volume)

$\hat{R} = \dfrac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i}$ = logging residues ratio

n = total number of operations sampled

$\bar{y} = \dfrac{\sum_{i=1}^{n} y_i}{n}$

$\bar{x} = \dfrac{\sum_{i=1}^{n} x_i}{n}$

$SE(\%) = \dfrac{S_R}{\hat{R}} \times 100$ = standard error of the ratio as a percentage of the ratio

Table 7 gives the achieved standard errors of the logging residue volume and product volume ratios and the standard errors as percentages of the ratios.

Table 7—Achieved standard errors of the logging residue volume and product volume ratios and the standard errors as percentages of the ratios.

	Standard error of the ratio (SR)	Standard error of the ratio as a percentage of the ratio (SE percent)
Cubic foot	0.0098	18.71
Board feet, Scribner rule	.0036	27.67
Board feet, International ¼ inch rule	.0037	26.82

Standard Forest Service Terminology

Cubic-foot / board-foot conversions—The cubic-foot volume in product logs compared to the board-foot volume in the same logs for selected log scales.

Cull tree—A live timber species tree that is less than one-third sound.

Forest land—Land at least 10 percent stocked by forest trees of any size, including lands that formerly had such tree cover and that will be naturally or artificially regenerated. The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width at least 120 ft wide to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if less than 120 ft wide.

Forest trees—Woody plants having a well-developed stem or stems, usually more than 12 ft in height at maturity, with a generally well-defined crown.

Gross product volume—The board-foot or cubic-foot volume of wood fiber in a product log(s).

Growing-stock product volume—The growing-stock volume in timber products such as sawlogs, posts, poles, pulpwood, fuelwood, and house logs.

Growing-stock removals (in this publication)—The growing-stock volume removed from inventory by harvesting. Consists of logging residue and the growing-stock volume of products.

Growing-stock trees (in this publication)—Live sawtimber trees and poletimber trees meeting specified standards of quality and vigor; excludes cull trees.

Growing-stock volume—Net cubic-foot volume in live poletimber-size and sawtimber-size growing-stock trees from a 1 ft stump to a minimum 4 inch top outside bark.

Industrial roundwood products—All timber products except fuelwood.

Inventory product volume—The growing-stock or sawtimber volume in timber products.

Logging residue—The unused growing-stock or sawtimber volume of trees cut or killed by logging and left in the woods.

Net product volume—The gross product volume less deductions for cull volume.

Noninventory product volume—The cubic volume of timber products that came from the upper stems (beyond the 4 inch top d.o.b.) or below the 1 ft high stumps of growing-stock product trees; the board-foot volume in timber products that came from poletimber trees, and from the upper stems (beyond the 7 inch or 9 inch top d.o.b.) and below the 1 ft high stump of sawtimber trees; the product volume from cull trees.

Non-National Forest lands—Lands not administered by the Forest Service, U.S. Department of Agriculture.

Nonproduct tree residue—The growing-stock or sawtimber volume of nonproduct trees cut, killed, or damaged while felling or skidding product trees. This volume is left in the woods. It is a component of slash.

Nonproduct trees—Those trees cut, killed, knocked down, or destroyed due to felling and skidding the product trees.

Nontimber tree—Other than timber species.

Other sources—Product volume from nontimber species (such as juniper and, in the West, oak) and trees harvested on nonforest land (such as urban streets, orchards, and windbreaks).

Poletimber tree—A live tree of timber species, at least 5 inches diameter at breast height (d.b.h.) but smaller than sawtimber size, containing at least one 8 ft bolt, and more than one-third sound.

Primary wood processors—Mills, plants, and yards receiving logs for processing into such products as studs, boards, lumber, fiberboard, plywood, utility and building poles, house logs, excelsior, pulp and paper, pulp chips, mine timbers, railroad ties, pilings, hop stakes, grape stakes, barrel staves, siding, paneling, and shakes. Primary wood processors include sawmills, fiberboard mills, plywood plants, house log plants, post and pole yards, post and pole treating plants, excelsior manufacturing plants, and pulp and paper mills.

Product tree residue—The unused growing-stock or sawtimber volume of product trees that is left in the woods.

Product trees—Trees felled for products such as sawlogs, posts, poles, pulpwood, fuelwood, or house logs.

Product volume—The cubic-foot or board-foot volume in timber products such as sawlogs, posts, poles, pulpwood, fuelwood, and house logs. Product volume comprises volume from salvable dead trees, other sources, and the noninventory and growing-stock (or sawtimber) volume from growing-stock trees.

Removals (in this publication)—The growing-stock and sawtimber volume removed from the inventory by harvesting. Consists of logging residue and the growing-stock and sawtimber volume of products.

Residual inventory (in this publication)—The growing-stock and sawtimber volume remaining after the inventory is reduced through removals due to harvest.

Salvable dead trees—Standing or down dead trees of timber species that are merchantable by regional standards.

Salvable dead volume—The cubic volume in dead poletimber-size and sawtimber-size trees of timber species from a 1 ft stump to a minimum 4 inch top d.o.b. The board-foot volume in dead sawtimber-size trees of timber species between a 1 ft high stump and a 7 inch d.o.b. top (softwoods) or 9 inch d.o.b. top (hardwoods).

Sawlog portion—That part of the bole of sawtimber trees between a 1 ft stump and the sawlog top.

Sawlog top—The portion on the bole of sawtimber trees above which a sawlog cannot be produced. The minimum sawlog top is 7 inches d.o.b. for softwoods and 9 inches d.o.b. for hardwoods.

Sawtimber product volume—The sawtimber volume in timber products.

Sawtimber removals (in this publication)—The sawtimber volume removed from inventory by harvesting. Consists of logging residue and the sawtimber volume of products.

Sawtimber tree—A live tree of timber species meeting regional size and defect specifications. A softwood tree must be at least 9 inches d.b.h. and a hardwood tree 11 inches d.b.h. The tree must be more than one-third sound.

Sawtimber volume—Net volume in board feet of the sawlog portion of live sawtimber trees.

Slash—The wood volume of cut or killed trees resulting from logging and left in the woods (not hauled out as timber products). Slash consists of logging residue (growing-stock and sawtimber volume) and noninventory volume (such as tree tops, limbs, cull trees, dead trees, and nontimber trees).

Timberland—Forest land where timber species make up at least 10 percent stocking.

Timber products—Roundwood products such as sawlogs, posts, poles, pulpwood, veneer logs, and house logs.

Timber removals—Same as "Removals."

Timber species—Trees traditionally used for industrial wood products. In the Rocky Mountains, these include only three hardwoods: birch, aspen, and cottonwood; and all softwood species except pinyon and juniper.

Total removals (associated with harvesting)—Comprises the growing-stock (or sawtimber) volume contained in products, the product tree logging residue, and the nonproduct tree logging residue.

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Appendix A—Removals Factors Formulas

The factors in table 2, derived from data collected on 20 logging operations, were calculated as follows:

Growing-stock removals factor (cubic)

Logging residue = Product tree residue factor + Nonproduct tree residue factor

Product tree residue = Product tree residue volume / Product volume from live trees

Nonproduct tree residue = Nonproduct tree residue volume / Product volume from live trees and salvable dead trees

Noninventory product volume = Noninventory product volume / Product volume from live trees

Inventory product volume = Inventory product volume / Product volume from live trees

or

Inventory product volume = 1—noninventory product volume factor

Growing-stock removals = Inventory product volume factor + Logging residue factor

Sawtimber removals factor (board feet)

Logging residue = Product tree residue factor + Nonproduct tree residue factor

Product tree residue = Product tree residue from sawlog sections of sawtimber trees / Product volume from live trees

Nonproduct-tree residue = Nonproduct-tree residue from the sawlog sections of sawtimber trees / Product volume from live trees and salvable dead trees

Noninventory product volume = Noninventory product volume from sawtimber trees + product volume from poletimber trees / Product volume from live trees

Inventory product volume = Sawtimber product volume / Product volume from live trees

or

Inventory product volume = 1—noninventory product volume factor

Sawtimber removals = Inventory product volume factor + Logging residue factor

McLain, William H. 1997. Logging utilization—Utah, 1993. Resour. Bull. INT-RB-90. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 9 p.

Reports results of a study of timber harvesting operations in Utah to derive factors used to estimate logging residue, growing-stock and sawtimber removals, diameter class distributions of harvests, and board-foot and cubic-foot conversions.

Keywords: timber removals, growing-stock removals, sawtimber removals, cubic-foot and board-foot conversions, logging residue