1997

Logging Utilization - Utah, 1993

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Logging Utilization—Utah, 1993

William H. McLain

The Author

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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 feet 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 total volume 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 to 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 such 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 described by A. K. Wilson of the Forest Survey Project at the Intermountain Research Station from 1959 to 1966 (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 an estimated error of the log 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 residuals 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 7,600 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

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 applying appendix A. In this publication removals is limited to logging of growing-stock and sawtimber volume in the products and the amount of logging residue associated with the product volume. Removals are the sum of these volumes (fig. 1).

The growing-stock removals factor of 1.05 means that for every 100 cubic ft of logs from live trees harvested in Utah (table 2):
109.8 cubic ft of removals were in the logs
5.3 cubic ft of removals were residue
Total: 115.1 cubic ft were removed from the growing-stock inventory; 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.

Removals

<table>
<thead>
<tr>
<th>Product Volume</th>
<th>Cubic Feet</th>
<th>Board Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross</td>
<td>12,558</td>
<td>65,260</td>
</tr>
<tr>
<td>Net</td>
<td>12,256</td>
<td>63,205</td>
</tr>
<tr>
<td>Cubic Feet</td>
<td>76,250</td>
<td>74,035</td>
</tr>
<tr>
<td>Board Feet</td>
<td>60,040</td>
<td>1,711</td>
</tr>
</tbody>
</table>

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 a harvest of a narrow range of products of small size, such as posts or fuelwood, or to sawlogs of exceptionally large diameters.

Study Results
The results of this study comprise cubic-foot to board-foot conversion factors, removals factors, removals and logging residue volume, logging residue volume in long pieces, and the diameter 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.

<table>
<thead>
<tr>
<th>Product Volume</th>
<th>Cubic Feet</th>
<th>Board Feet</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>Net</td>
<td>12,256</td>
<td>63,205</td>
</tr>
</tbody>
</table>

The sawtimber removals factor of 0.942 means that for every 100 bd ft of sawtimber 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 sawtimber 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 salvageable 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 future, harvesting operations in a stand of predominantly dead timber may well produce no residue.

<table>
<thead>
<tr>
<th>Type of factor</th>
<th>Cubic feet</th>
<th>Board feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross</td>
<td>12,558</td>
<td>65,260</td>
</tr>
<tr>
<td>Net</td>
<td>12,256</td>
<td>63,205</td>
</tr>
<tr>
<td>Cubic feet</td>
<td>76,250</td>
<td>74,035</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Type of factor</th>
<th>Cubic feet</th>
<th>Board feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross</td>
<td>12,558</td>
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</tr>
<tr>
<td>Net</td>
<td>12,256</td>
<td>63,205</td>
</tr>
<tr>
<td>Cubic feet</td>
<td>76,250</td>
<td>74,035</td>
</tr>
</tbody>
</table>

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

Removals Factors, Then and Now

Fuelwood estimates, obtained by sampling household and canning 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 products 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 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.

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

<table>
<thead>
<tr>
<th>Products and additional removals</th>
<th>Product volume*</th>
<th>Noninventory product volume</th>
<th>Growing-stock removals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live trees</td>
<td>10,174</td>
<td>7,763</td>
<td>2,411</td>
</tr>
<tr>
<td>Sawlogs</td>
<td>3,992</td>
<td>2,606</td>
<td>1,386</td>
</tr>
<tr>
<td>Fiberwood</td>
<td>3,000</td>
<td>2,606</td>
<td>1,386</td>
</tr>
<tr>
<td>Posts and poles</td>
<td>189</td>
<td>41</td>
<td>148</td>
</tr>
<tr>
<td>House logs</td>
<td>1,568</td>
<td>204</td>
<td>1,364</td>
</tr>
<tr>
<td>Total</td>
<td>12,533</td>
<td>8,590</td>
<td>3,943</td>
</tr>
<tr>
<td>Sawtimber removaees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuelwood</td>
<td>5,091</td>
<td>26</td>
<td>3,394</td>
</tr>
<tr>
<td>Loggin residue</td>
<td>17,824</td>
<td>8,616</td>
<td>7,337</td>
</tr>
<tr>
<td>Total</td>
<td>38,150</td>
<td>17,260</td>
<td>20,890</td>
</tr>
</tbody>
</table>

*Sawlog, fiberwood, post and pole, and house log, volumes (McLain and others, in preparation). Fuelwood volumes (McLain 1997).

No board-foot volume in other sources.

*Volume reported in thousand board feet (Scribner rule). Cubic and board foot conversions are from logging utilization study (table 1).

*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.

Fuelwood volumes were reported in cubic feet. 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.

* Logging residue is associated with the harvest of industrial roundwood products. Logging residue associated with the fuelwood harvest is assumed to be zero.
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 than in 1969. This results from hauling more log volume to the wood processing plants relative to the growing-stock volume than in 1969.

### 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).

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

\[
\text{SE} = \sqrt{\frac{1}{n} \sum \left(1 - \frac{y_i}{x_i}\right)^2 - \left(\frac{\sum y_i}{\sum x_i}\right)^2} \cdot \left(\frac{1}{n}\right)
\]

where:
- \(y\) = logging residues measured on an operation (net volume)
- \(x\) = timber products measured on an operation (net volume)

The formula for the standard error of the ratio is:

\[
\text{SE} = \sqrt{\frac{1}{n} \sum \left(1 - \frac{y_i}{x_i}\right)^2 - \left(\frac{\sum y_i}{\sum x_i}\right)^2} \cdot \left(\frac{1}{n}\right)
\]

### 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.
**Table 7** shows the achieved standard errors of the logging residue volume and product volume ratio and the standard errors as percentages of the ratios.

**Standard Forest Service Terminology**

- **Cubic-inch**/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 be classified 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.
- **Gross product volume**: The growing-stock volume in timber products such as sawlogs, posts, poles, pulpwod, fuelwood, and house logs.
- **Gross product volume**: The growing-stock volume of trees cut or killed by logging and left in the woods.
- **Gross growth stock volume**: The unused growing-stock or sawtimber volume of products.
- **Gross growth stock volume**: The cubic-foot or board-foot volume of timber products except fuelwood.
- **Inventory product volume**: The growing-stock or sawtimber volume in timber products.
- **Landing residue**: The unused growing-stock or sawtimber volume of trees cut or killed by logging and left in the woods.
- **Noninventory product volume**: The cubic volume of timber products that came from the upper stems (beyond the 4 inch top d.b.h.) 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.b.h.) 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 unused 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.
- **Non-timber tree**: Other than timber species.
- **Other sources**: Producing growing-stock non-timber species (such as juniper and, in the West, oak) and trees harvested on nonforest land (such as urban streets, orchards, and windbreaks).
- **Primary wood processors**: Mills, plants, and yards receiving logs for processing into products as studs, boards, lumber, fiberboard, plywood, utility and building poles, house logs, excelsior, pulp and paper, pulp chips, mine timber, railroad ties, pit logs, 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.

**References**


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)

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logging residue = Product tree residue factor + Nonproduct tree residue factor</td>
<td></td>
</tr>
<tr>
<td>Product tree residue = Product tree residue volume + Product volume from live trees</td>
<td></td>
</tr>
<tr>
<td>Nonproduct tree residue = Product volume from live trees and salvable dead trees</td>
<td></td>
</tr>
<tr>
<td>Noninventory product volume = Noninventory product volume factor</td>
<td></td>
</tr>
<tr>
<td>Inventory product volume = Inventory product volume factor</td>
<td></td>
</tr>
<tr>
<td>Logging residue factor = 1 — noninventory product volume factor</td>
<td></td>
</tr>
</tbody>
</table>

Sawtimber removals factor (board feet)

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logging residue = Product tree residue factor + Nonproduct tree residue factor</td>
<td></td>
</tr>
<tr>
<td>Product tree residue = Product tree residue from sawlog sections of sawtimber trees</td>
<td></td>
</tr>
<tr>
<td>Nonproduct-tree residue = Product volume from live trees of sawtimber trees and salvable dead trees</td>
<td></td>
</tr>
<tr>
<td>Noninventory product volume = Noninventory product volume from sawtimber trees + Product volume from poletimber trees</td>
<td></td>
</tr>
<tr>
<td>Inventory product volume = Sawtimber product volume + Product volume from live trees</td>
<td></td>
</tr>
<tr>
<td>Logging residue factor = 1 — noninventory product volume factor</td>
<td></td>
</tr>
</tbody>
</table>

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