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## Estimation of U.S. Timber Harvest Using Roundwood Equivalents

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**Abstract.**—This report details the procedure used to estimate the roundwood products portion of U.S. annual timber harvest levels by using roundwood equivalents. National-level U.S. forest products data published by trade associations and State and Federal Government organizations were used to estimate the roundwood equivalent of national roundwood products production. The procedure for estimating roundwood equivalent of roundwood products is to calculate the “roundwood equivalent” of solid wood products using recovery factors estimated from mill studies over the years. The procedure for estimating roundwood equivalent of products provides a simple technique for estimating the major portion of national timber harvest levels that is less expensive than conducting surveys and can be done on an annual basis. This technique provides a benchmark that can be used in conjunction with the Forest Inventory and Analysis survey approach, which helps ensure the accuracy of both methods. These national harvest levels were estimated by working backwards from U.S. national timber products production data using lumber recovery factors to derive the roundwood equivalent of harvest.

### Introduction

Federal law requires that the U.S. Department of Agriculture (USDA) maintain a current analysis of the demand and supply of resources from forest land and rangelands. Specifically, the Renewable Resources Planning Act (RPA) of 1976 and the Forest and Rangeland Renewable Resources Research Act of 1978 require development of periodic programs and assessments. The Research Act directs the Secretary of Agriculture to make and keep a comprehensive survey and analysis of present and

prospective conditions of and requirements for renewable resources of forest and range lands of the United States. The compilation of roundwood equivalents of harvest, defined as an estimate of the solid volume (i.e., total wood content) of a processed log in cubic units derived by multiplying the final products by product recovery factors, are computed in a spreadsheet. In the roundwood equivalent spreadsheet, the four major groupings of industrial roundwood uses (under headings “Industrial roundwood used for”) are (1) lumber, (2) plywood and veneer products, (3) pulpwood-based products, and (4) other. Each group contains more specific subcategories of products, which encompass all primary industrial wood and wood fiber products. The subcategories for lumber are softwood (SW) lumber, hardwood (HW) lumber, and pallets (produced at sawmills); plywood and veneer products are SW plywood, HW plywood, and laminated veneer lumber (LVL); pulpwood-based products are oriented strandboard (OSB), particleboard, hardboard, medium-density fiberboard (MDF) and insulation board, and pulp, paper and paperboard. In the pulpwood-based products category, the spreadsheet accounts only for estimated roundwood inputs, not wood residue inputs. Wood residue inputs are included as part of roundwood initially sent to sawmills or other mills that produce residue. The “other” category is composed of posts, poles, piling, and miscellaneous products. Apart from these categories, log and chip trade and fuel wood are also accounted for. The intent of the roundwood equivalent estimation is to calculate roundwood harvest on an annual basis or the roundwood equivalent of logs that actually get on the logging truck. This estimate of timber use differs from total harvest and removals from growing stock because the roundwood equivalent estimation does not include logging residues, which are left in the woods, or other removals, such as land clearing for development that may exclude timber output.

The procedure for estimating the roundwood equivalent of harvest is to back out the roundwood equivalent of products using recovery factors estimated from mill studies over the years.

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Table 1.—*Production of timber products, by major product, various years, 1965–2002 (million cubic feet, roundwood equivalent).<sup>a</sup>*

|                                        | 1965   | 1970   | 1976   | 1986   | 1988   | 1991   | 1996   | 2002   |
|----------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| All products                           | 12,276 | 14,702 | 13,580 | 18,328 | 18,736 | 18,823 | 17,268 | 16     |
| Industrial roundwood use               |        |        |        |        |        |        |        |        |
| Total                                  | 11,230 | 13,287 | 12,102 | 14,644 | 15,618 | 15,187 | 15,344 | 14,963 |
| Lumber                                 | 6,233  | 6,511  | 6,026  | 7,105  | 7,667  | 7,039  | 6,975  | 7,347  |
| Plywood and veneer                     | 1,070  | 1,197  | 1,466  | 1,598  | 1,598  | 1,267  | 1,281  | 1,067  |
| Pulpwood-based products                | 3,176  | 4,488  | 3,715  | 4,881  | 5,075  | 5,397  | 5,908  | 5,699  |
| Other industrial products <sup>b</sup> | 560    | 652    | 375    | 475    | 510    | 551    | 342    | 317    |
| Log exports <sup>d</sup>               | 191    | 438    | 520    | 585    | 767    | 602    | 422    | 388    |
| Pulpwood chip exports <sup>c</sup>     | 7      | 150    | 245    | 151    | 218    | 332    | 416    | 189    |
| Fuel wood                              | 1,038  | 1,265  | 1,232  | 3,533  | 2,901  | 3,636  | 1,924  | 1,520  |

<sup>a</sup> Howard (2003), 21.

<sup>b</sup> Includes cooperage logs, poles and piling, fence posts, hewn ties, round mine timbers, box bolts, excelsior bolts, chemical wood, shingle bolts, and miscellaneous items.

<sup>c</sup> Before 1989, pulpwood chips were not included in total production.

<sup>d</sup> Before 2000, pulpwood logs were not included in logs.

The timber harvest or roundwood equivalents associated with production, trade, and consumption of all wood-based products were computed for the entire United States from 1965 to 2002 (Howard 2003) based on product output data and average roundwood input coefficients by product category. Since 1991—the peak roundwood production year in the United States—when the production of roundwood was 18.8 billion ft<sup>3</sup>, roundwood harvest has declined steadily to 16.5 billion ft<sup>3</sup> in 2002 (table 1).

The Timber Demand and Technology Assessment Research Work Unit at the Forest Products Laboratory (FPL) has as part of its mission the development of historical U.S. timber production statistics. Historical statistics are developed to support USDA Forest Service RPA objectives, which are in part to produce U.S. timber harvest trends. The Timber Assessment Market Model (TAMM) (Adams and Haynes 1996) was developed and is used to produce national assessments of supply and demand trends for timber in support of RPA objectives. FPL's historical timber production statistics are used by TAMM to create a plausible baseline projection of future changes in the Nation's demand for timber products and in the domestic resource that supplies a substantial part of our timber requirements. Annual roundwood equivalent of harvest estimations is used to substantiate the accuracy of timber product output (TPO) for years in which TPO harvest data are published. Also, the 1998 Farm Bill charged the national FIA program with developing an annualized forest

inventory so that users would have current data for their planning and decisionmaking processes. The FPL procedure for estimating annual harvest helps accomplish the FIA program goal established in the Farm Bill by providing a complementary method for making reasonable annual national harvest estimates

## Methods

Each of the four major product categories has a subset of several primary product categories for a total of 15 product categories that enter into the computation for roundwood equivalent of harvest (table 2). The production data for each of the 15 product categories were collected from industry trade associations and government agencies. The USDA Forest Service has developed and kept up to date appropriate statistical series on timber, wood, and fiber products production since its inception (Johnson 2001). These statistics extend and complement data found in other RPA assessment reports (Haynes 2003). The 15 product categories are the basis for estimating the roundwood equivalent of harvest, which contributes to satisfying the RPA requirement by providing the historical data needed for long-term RPA projections.

Table 3 shows an example of roundwood equivalent calculation for lumber (2002 data) that illustrates the procedure for using product recovery factors and the computation of the roundwood

Table 2.—U.S. annual industrial wood product production, various years, 1965–2002.<sup>a</sup>

| Product                      |                                                | 1965   | 1970   | 1976   | 1986   | 1988   | 1991   | 1996   | 2002   |
|------------------------------|------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Softwood plywood             | Million ft <sup>2</sup> (3/8-in basis)         | 12,447 | 14,340 | 18,440 | 22,118 | 22,599 | 18,652 | 19,181 | 15,200 |
| Oriented strandboard         | Million ft <sup>2</sup> (3/8-in basis)         | NA     | NA     | NA     | 3,513  | 4,604  | 5,613  | 9,314  | 13,426 |
| Laminated veneer lumber      | Million ft <sup>2</sup> (3/8-in basis)         | NA     | NA     | NA     | 8      | 11     | 16     | 32     | 56     |
| Hardwood plywood and veneer  | Million ft <sup>2</sup> (3/8-in basis)         | 2,049  | 1,796  | 1,083  | 1,390  | 1,552  | 1,496  | 1,784  | 2,096  |
| Softwood lumber              | Million board feet                             | 29,295 | 27,530 | 30,600 | 35,273 | 38,130 | 33,161 | 33,266 | 35,831 |
| Hardwood lumber              | Million board feet                             | 9,440  | 8,330  | 7,977  | 10,477 | 11,741 | 11,168 | 12,488 | 11,750 |
| Lumber made at pallet plants | Thousands of short tons (product weight)       | 171    | 247    | 383    | 721    | 876    | 1,005  | 660    | 735    |
| Particleboard                | Million ft <sup>2</sup> (3/8-in basis)         | 753    | 1,731  | 3,189  | 3,603  | 3,829  | 3,772  | 4,459  | 4,414  |
| Hardboard                    | Million ft <sup>2</sup> (1/8-in basis)         | 2,921  | 4,384  | 6,785  | 5,822  | 5,118  | 4,895  | 5,280  | 2,919  |
| Medium-density fiberboard    | Million ft <sup>2</sup> (3/4-in basis)         | 75     | 127    | 280    | 781    | 939    | 958    | 1,246  | 1,621  |
| Pulp, paper, and board       | Thousand tons                                  | 40,489 | 48,719 | 54,993 | 70,905 | 76,587 | 79,427 | 90,381 | 89,687 |
| Other industrial products    | Million ft <sup>3</sup> (roundwood equivalent) | 560    | 652    | 375    | 475    | 510    | 551    | 342    | 317    |
| Insulating board             | Million ft <sup>2</sup> (1/2-in basis)         | 3,362  | 3,194  | 3,407  | 2,194  | 2,340  | 2,323  | 2,335  | 2,335  |
| Log exports                  | Million board feet (Scribner log scale)        | 1,195  | 2,741  | 3,250  | 3,656  | 4,798  | 3,761  | 2,636  | 2,428  |
| Fuel wood                    | Million ft <sup>3</sup> (roundwood equivalent) | 1,038  | 1,265  | 1,232  | 3,533  | 2,901  | 3,636  | 1,924  | 1,520  |

NA = Not available. <sup>a</sup> Howard (2003), 29.

Table 3.—Roundwood equivalent calculation for lumber example.

| Product  | Production level                    | Factor to convert production to roundwood requirement | Roundwood equivalent (million ft <sup>3</sup> ) |
|----------|-------------------------------------|-------------------------------------------------------|-------------------------------------------------|
| Softwood |                                     |                                                       |                                                 |
| Lumber   | 36,400 x 10 <sup>6</sup> board feet | 6.952 board feet/ft <sup>3</sup>                      | 5,236                                           |
| Pallets  | 40 x 10 <sup>6</sup> pallets        | 0.18 ft <sup>3</sup> /pallet                          | 7.2                                             |
| Hardwood |                                     |                                                       |                                                 |
| Lumber   | 11,800 x 10 <sup>6</sup> board feet | 5.74 board feet/ft <sup>3</sup>                       | 2,056                                           |
| Pallets  | 401 x 10 <sup>6</sup> pallets       | 0.12 ft <sup>3</sup> /pallet                          | 48.12                                           |
|          |                                     |                                                       | 7,347.3                                         |

Table 4.—*Product recovery factors, various years, 1965–2002.*<sup>a</sup>

| Product                      | Conversion factor units          | 1965    | 1970    | 1976    | 1986    | 1988    | 1991    | 1996    | 2002    |
|------------------------------|----------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| Softwood plywood             | ft <sup>3</sup> /ft <sup>2</sup> | 0.0753  | 0.0753  | 0.0757  | 0.0676  | 0.0656  | 0.0617  | 0.0586  | 0.0562  |
| Hardwood plywood and veneer  | ft <sup>3</sup> /ft <sup>2</sup> | 0.0651  | 0.0651  | 0.0651  | 0.0613  | 0.0598  | 0.0567  | 0.0544  | 0.0524  |
| Lumber                       |                                  |         |         |         |         |         |         |         |         |
| Softwood lumber              | ft <sup>3</sup> /board foot      | 6.400   | 6.400   | 6.438   | 6.734   | 6.828   | 6.952   | 6.952   | 6.952   |
| Hardwood lumber              | ft <sup>3</sup> /board foot      | 5.74    | 5.74    | 5.74    | 5.74    | 5.74    | 5.74    | 5.74    | 5.74    |
| Lumber made at pallet plants |                                  |         |         |         |         |         |         |         |         |
| Softwood                     |                                  | 0.35    | 0.35    | 0.35    | 0.35    | 0.31    | 0.25    | 0.18    | 0.18    |
| Hardwood                     |                                  | —       | —       | —       | —       | —       | —       | —       | —       |
| Laminated veneer lumber      | ft <sup>3</sup> /ft <sup>3</sup> | NA      | NA      | NA      | 2.16    | 2.10    | 1.98    | 1.87    | 1.80    |
| Oriented strandboard         | ft <sup>3</sup> /ft <sup>2</sup> | NA      | NA      | NA      | 0.06    | 0.06    | 0.05    | 0.05    | 0.05    |
| Particleboard                | ft <sup>3</sup> /ft <sup>2</sup> | 0.0083  | 0.0083  | 0.0083  | 0.0085  | 0.0086  | 0.0086  | 0.0088  | 0.0088  |
| Hardboard                    | ft <sup>3</sup> /ft <sup>2</sup> | 0.0012  | 0.0012  | 0.0012  | 0.0013  | 0.0013  | 0.0013  | 0.0013  | 0.0013  |
| Medium-density fiberboard    | ft <sup>3</sup> /ft <sup>2</sup> | 0.0075  | 0.0075  | 0.0075  | 0.0077  | 0.0077  | 0.0078  | 0.0078  | 0.0078  |
| Insulating board             | ft <sup>3</sup> /ft <sup>2</sup> | 0.00495 | 0.00495 | 0.00495 | 0.00506 | 0.00510 | 0.00513 | 0.00515 | 0.00515 |
| Log exports                  | ft <sup>3</sup> /board foot      | 0.02832 | 0.02832 | 0.02832 | 0.02832 | 0.02832 | 0.02832 | 0.02832 | 0.02832 |
| Other industrial products    |                                  | 1.0     | 1.0     | 1.0     | 1.0     | 1.0     | 1.0     | 1.0     | 1.0     |
| Pulpwood                     |                                  |         |         |         |         |         |         |         |         |
| Softwood                     | ft <sup>3</sup> /ton             | 81      | 81      | 81      | 84      | 84      | 84      | 84      | 84      |
| Hardwood                     | ft <sup>3</sup> /ton             | 78      | 78      | 78      | 78      | 78      | 78      | 78      | 78      |

NA = Not available. <sup>a</sup> Unpublished TAMM data.

equivalent of lumber. Note that this procedure changes slightly depending on the product that roundwood equivalents are being estimated for. Typically the difference is whether to multiply or divide the entity in the product column by the recovery factor.

The FPL roundwood equivalent estimates of harvest for all solid wood products (e.g., lumber, plywood, OSB) are based on product recovery factors (table 4). Product recovery factors are cubic feet volume measurements of roundwood produced per unit of solid wood product input (see table 2 for units). Some solid wood products in the FPL system have both SW and HW components, such as HW plywood. HW plywood is sometimes constructed with SW material as a core. In such cases, a roundwood proportion is used to estimate the roundwood equivalent of HW plywood in conjunction with the product recovery factor. The product recovery factors change over time to reflect changes in timber characteristics such as size, taper, and defect. Policy restrictions governing harvests, especially from public lands, have contributed to a difference in the average characteristics of harvested timber and timber making up the merchantable growing stock inventory. Changes in product recovery factors over time also reflect mill technology changes and market impacts (Spelter 2002). Fuel wood estimates for all but the most recent years are from TPO estimates. Preliminary estimates are made for recent years where TPO data are not available based on the U.S. Department of Energy (DOE) restricted energy consumption survey.

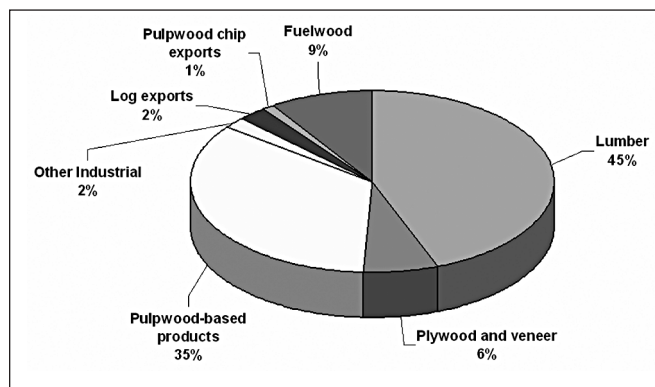
## Findings

U. S. harvest (or roundwood equivalent of production) decreased to 16.5 billion ft<sup>3</sup> in 2002, down slightly from 16.6 billion ft<sup>3</sup> a year earlier. The roundwood harvest peaked in 1991, when industrial roundwood production was 18.8 billion ft<sup>3</sup> (table 1). Lumber and pulpwood-based products by far make up the largest share (80 percent) of roundwood use (fig. 1). The 2002 level for timber harvest was estimated by converting the 15 solid wood products to cubic feet of roundwood using product recovery factors. Since 1986, the largest decline by far was in fuel wood production (– 2 billion ft<sup>3</sup>), followed by plywood (– 0.5 billion ft<sup>3</sup>); the largest gains were in pulpwood production (+ 0.8 billion ft<sup>3</sup>).

Fuel wood is the only product for which product recovery factors are not used to estimate roundwood equivalents. An indexing procedure is used to estimate and update the fuel wood component of estimated timber harvest. Historical TPO estimates are indexed to the DOE residential fuel wood use estimates starting in the base year, 1990. Linear interpolation between DOE residential fuel wood survey years is done to provide TPO household fuel wood use estimates. Timber harvest, or the roundwood equivalents associated with production and trade, is therefore the summation of all wood-based products for the entire United States. Roundwood equivalents plus the estimate for fuel wood are added and then compared with USDA Forest Service TPO estimates of annual U.S. timber harvest made at six points in time since 1952, and roundwood equivalents are evaluated as a proxy for annual timber harvest data in years when actual data are not available.

The lumber and engineered wood products sectors are the main contributors to the current harvest level. An estimated 48.0 billion board feet of SW lumber plus HWs were produced in the United States in 2002 (table 2). Lumber production climbed upward from 1965 to a peak in 1988 but then declined. The production of saw logs used in the domestic manufacture of lumber rose slightly in 2002 to 7.3 billion ft<sup>3</sup> (table 1), representing about 44 percent of total industrial roundwood production. Of the total timber harvested, 32 percent were processed to produce SW lumber, and 12 percent were processed to produce HW lumber.

Figure 1.—*Industrial roundwood use, 2002 (Howard 2003).*



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SW plywood production in 2002 was estimated at 15.2 billion ft<sup>2</sup> (3/8-in basis) based on data published by APA—The Engineered Wood Association (table 2). This figure represented about 9 percent of SW industrial roundwood production in 2002 (table 1). HW plywood production had fallen annually for three straight years to an estimated 2.0 billion ft<sup>2</sup> in 2002 (3/8-in basis). This 2002 level of production accounted for 2 percent of total HW industrial roundwood use.

Included in the pulpwood-based products category, total wood pulp, paper, and board production in U.S. mills in 2002 was estimated at 89.7 million tons based on data published by the American Forest and Paper Association (table 2). This excludes dissolving pulp and pulp produced for hardboard, MDF, and related products. In addition, OSB production was 13.4 million ft<sup>2</sup> (3/8-in basis), which represented 5.7 billion ft<sup>3</sup> of roundwood, or 35 percent of total industrial roundwood use (table 1).

According to estimates of the National Particleboard Association (table 2), production of particleboard in 2002 totaled 4.4 billion ft<sup>2</sup> (3/4-in basis). Production of MDF in 2002 was 1.6 billion ft<sup>2</sup> (3/4-in basis). Hardboard production in 2002 was estimated to be 2.9 billion ft<sup>2</sup> (1/8-in basis). Production of insulation board in 2002 was 2.3 billion ft<sup>2</sup> (1/2-in basis), or 857,000 tons. These subcategories are components of the pulpwood-based products category

Engineered wood products such as glulam, I-joists, and LVL are relatively new to the market, and production levels for these products are forecast to increase steadily. During 2002, glulam production was 321 million board feet, LVL production was 56 million ft<sup>3</sup>, and I-joist production was 756 million linear feet. Glulam and I-joists roundwood usage currently are not accounted for in terms of roundwood use, whereas LVL production is accounted for in the plywood and veneer category.

Total SW log exports decreased 10.1 percent during 2002. SW log exports from the Western United States continued a downward trend as Douglas fir log exports declined 3.8 percent in 2002. Log exports make up 2 percent of industrial roundwood use (fig. 1).

Production of miscellaneous or other industrial roundwood products, which includes cooperage logs, poles and piling, fence posts, mine timbers, and an assortment of other products such as hewn ties and box bolts, is estimated at 317 million ft<sup>3</sup> in 2002. This category represented 2 percent of industrial roundwood use, less than half the amount used in 1986. Production of round fuel wood in 2002 is estimated at 1.5 billion ft<sup>3</sup>.

## Conclusions

This effort to produce a complementary method for estimating annual harvest helps accomplish the goal set forward in the 1998 Farm Bill. The national FIA program was charged with developing an annualized forest inventory so that users would have current data for their planning and decisionmaking processes. The production of TPO estimates helps accomplish RPA national timber assessment objectives. The two concepts of timber harvest associated with roundwood products and roundwood equivalents of industrial timber removals are comparable. They are compared by the use of product recovery rates, which differ for each of the 15 solid wood product classes. The product recovery rates also change over time to reflect changes in the timber resource characteristics, technology, and markets. Shifting patterns of timber harvests have contributed to a change in the average characteristics of harvested timber and timber that make up the merchantable growing-stock inventory. Fuel wood is the only commodity for which product recovery rates are not used. Instead, an indexing procedure, which uses DOE estimates, is used to calculate household fuel wood use. Lumber is the largest product category for roundwood use, followed closely by pulpwood-based products. Precise breakdowns by species or ownership are not possible using the roundwood equivalent approach, even at the national level. This approach was specifically designed to perform aggregate national estimates.

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