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# Session IVB: Forcasting and Facilitating Adoption of Technological Innovations

## *USDA Forest Service Forecasting of Technological Change in Wood Products Processing*

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The USDA Forest Service is modeling technological change in U.S. wood products processing and use in order to more accurately project anticipated uses of, demand for, and supply of timber resources. This work is for the 1989 assessment that is being developed in response to the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 and related legislation. The technology forecasting effort includes identifying technological developments for making softwood lumber, panels, and fiber products and using models to evaluate the impact of their adoption on product recovery and processing costs. Other Forest Service efforts include forecasting the effect of technological change on harvesting costs and the rates of wood use in manufacturing and construction. These projections of product recovery, processing costs, harvesting costs, and wood end use rates are being incorporated into regional market models that project timber production, consumption, and prices in the United States over the next 50 years. The purpose of our paper is to display preliminary projections of product recovery and processing costs for softwood lumber, panels, paper, and paperboard and explain the technological reasons for these trends. To project recovery and costs we: 1) identified likely changes in technology; 2) formulated current and future mill designs that incorporate innovations and have specific recovery and cost characteristics; 3) developed projections of the mix of mill designs used for production through the year 2040; and 4) calculated recovery and costs resulting from the projected mix of mill designs.

The following projections include the effect of projected declines in the diameter of logs processed by sawmills and plywood mills. We project the average diameters will decline 23 percent between 1985 and 2040 in the Douglas-fir region and California, 13 percent in the ponderosa pine region and the Rocky Mountain region, and 4 percent in the South.

### Softwood lumber

Average softwood lumber recovery in the United States is just over 40 percent of the cubic volume processed, or a lumber recovery factor of 6.4 to 6.5 board feet lumber tally per cubic foot log scale (bf/ft.$^3$). With new processes and process enhancements, average recovery could exceed 7.3 bf/ft.$^3$ by 2040 and average more than 7.6 bf/ft.$^3$ in some regions. These figures take into consideration a projected decline in diameter of logs processed. They assume improvements in conventional sawmills, including improved scanning for log bucking, breakdown, trimming, and edging; wide adoption of computer-controlled process optimizers; narrow kerf saws and improved circular saw guides; and improved dry-kiln sensing and control that will decrease degrade. It is not difficult to notably increase these projections by assuming widespread use of touch sanding in place of planing or by assuming further improvement in computer software and breakdown equipment that would allow closer approach to theoretical highest yield for each log.

Projected increases vary sharply by region. Recovery increases by 21 to 24 percent in the South and ponderosa pine regions (Table 1), where log diameter decreases are limited. Recovery improvement is smallest in the Douglas-fir region (7%) and Pacific Southwest (9%) because of a projected 24-percent decline in average log diameter. Lumber recovery factors in 1985 ranged from 5.82 to 7.14; this figure narrows between 7.06 and 7.67 by 2040. The Douglas-fir region and the Pacific Southwest retain the highest recovery factors because log diameters, despite declines, remain relatively high and because the South is projected to retain a significant number of small, less efficient mills.

Softwood lumber processing costs are projected to decrease in all regions to 2040. Processing costs exclude wood costs and revenue from sale of residue. This departure from the upward trend in the 1970s is attributable to continued improvements in sawing technology and projected constant labor and energy costs. With labor and energy costs projected to remain constant, improvements in technology, including increased throughput rates, more

TABLE 1 – *Recovery factors for 1952, 1976, and 1986 with preliminary projections to 2040.*

| | Recovery factor data and projections | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1952 | 1976 | 1985 | 2000 | 2010 | 2020 | 2030 | 2040 |
| Softwood lumber (board feet lumber tally per cubic foot log scale) | | | | | | | | |
| South | 5.06 | 5.74 | 5.82 | 6.36 | 6.54 | 6.69 | 6.86 | 7.06 |
| Pacific Northwest | | | | | | | | |
| Douglas-fir subregion | 5.72 | 7.27 | 7.14 | 7.38 | 7.38 | 7.45 | 7.56 | 7.65 |
| Ponderosa pine subregion | 5.35 | 6.13 | 6.05 | 6.46 | 6.68 | 6.93 | 7.20 | 7.50 |
| Pacific Southwest | 6.25 | 6.89 | 7.06 | 7.13 | 7.25 | 7.38 | 7.53 | 7.67 |
| Rocky Mountains | | | | | | | | |
| Northern Rocky Mountains | 5.74 | 6.76 | 6.67 | 6.92 | 7.02 | 7.14 | 7.26 | 7.41 |
| Southern Rocky Mountains | 5.48 | 6.61 | 6.67 | 6.92 | 7.02 | 7.14 | 7.26 | 7.41 |
| Softwood plywood (square feet, 3/8-in. basis, per cubic foot log scale) | | | | | | | | |
| South | -- | 12.5 | 14.0 | 16.9 | 17.1 | 17.2 | 17.3 | 17.4 |
| Rocky Mountains | -- | 16.1 | 16.7 | 17.7 | 17.9 | 18.0 | 18.0 | 18.0 |
| Pacific Northwest | | | | | | | | |
| Douglas-fir subregion | 14.5 | 16.1 | 16.7 | 17.7 | 17.9 | 18.0 | 18.0 | 18.0 |
| Ponderosa pine subregion | 14.3 | 16.1 | 16.7 | 18.0 | 18.1 | 18.2 | 18.2 | 18.2 |
| Pacific Southwest | 14.5 | 16.1 | 16.7 | 17.7 | 17.9 | 18.0 | 18.0 | 18.0 |
| Oriented strandboard and waferboard (square feet, 3/8-in. basis, per cubic foot log scale) | | | | | | | | |
| North | -- | -- | 17.9 | 18.3 | 18.3 | 18.3 | 18.3 | 18.3 |
| South | -- | -- | 16.9 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 |
| Paper, paperboard, and related products[a] | | | | | | | | |
| Recycled wastepaper (tons per ton of paper and board | 0.32 | 0.20 | 0.23 | 0.23 | 0.24 | 0.25 | 0.25 | -- |
| Pulpwood (cords of wood per ton of paper and board | | | | | | | | |
| Hardwood average | -- | -- | 0.37 | 0.45 | 0.45 | 0.46 | 0.47 | 0.46 |
| North | -- | -- | 0.39 | 0.45 | 0.45 | 0.45 | 0.44 | 0.43 |
| South | -- | -- | 0.43 | 0.49 | 0.51 | 0.51 | 0.54 | 0.54 |
| West | -- | -- | 0.10 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| Softwood average | -- | -- | 0.85 | 0.74 | 0.71 | 0.68 | 0.66 | 0.65 |
| North | -- | -- | 0.23 | 0.16 | 0.16 | 0.16 | 0.16 | 0.15 |
| South | -- | -- | 1.50 | 0.96 | 0.92 | 0.89 | 0.88 | 0.87 |
| West | -- | -- | 1.72 | 1.64 | 1.61 | 1.61 | 1.60 | 1.61 |
| U.S. average | 1.08 | 1.20 | 1.21 | 1.18 | 1.16 | 1.14 | 1.13 | 1.11 |

[a] Paper and board figures under 1985 are for 1986.

than compensate for declining log diameters, which results in declining processing costs. The decline between 1985 and 2040 is the greatest in the South and ponderosa pine regions—24o 26 percent. Greater declines in log diameters in other regions result in smaller cost declines (Table 2).

### Softwood plywood

Softwood plywood product recovery factors have tended to increase as the focus of production has shifted from sanded items to commodity sheathing requiring lower grade veneer. Increased use of smaller but less defective second-growth timber has also helped boost recovery in terms of quantity. Currently, wood recovery in plywood mills averages close to 50 percent of the cubic volume of wood processed. Even higher recovery is projected despite the drop in average bolt diameters, which would tend to depress recovery. These increases average 16 percent (Table 1) and elevate recovery to over 55 percent. The principal reasons for the projected improvement are optimal log centering, minimal spin-out, more uniform veneer thicknesses, and reductions in shrinkage.

Processing costs are projected to decline. This development continues historical trends, interrupted briefly by rising energy costs in the 1970s, toward lower real plywood manufacturing costs. Enhancements to gluing technology should reduce glue consumption, while increased automation in veneer stacking, lay-up, and pressing, coupled with productivity boosting impacts of higher moisture gluing, panel compression controls, and radiofrequency redrying, reduce real labor costs. Processing costs are projected to fall by 4 to 7 percent in real terms over the next 55 years (Table 2).

### Oriented strandboard and waferboard

Nonveneered structural panel wood recoveries average between 55 and 60 percent (based on lasses of 2% for trimming log ends and log rejects, 8 to 12% for fines, 35 to 38% for panel densification, and 3% for panel trim). This is projected to increase slightly because of improved flakers that produce more acceptable sized particles and the advent of continuous presses, which would reduce trim loss (Table 1).

Significant reductions in waferboard manufacturing costs have occurred during the past 5 years because of savings in glue costs made possible by improved blenders. Resin dosages of liquid phenolic resins have declined from over 5 percent to less than 4 percent. Powdered resin dosages have also been reduced from 3 to 2 percent. Further potential for savings in this area is limited, so the projections of processing costs show more modest declines than those for plywood. The adoption of modern technology by remaining mills is expected to account for the bulk of the projected 4 percent improvement [Table 2).

TABLE 2. – *Processing costs for 1952, 1976, and 1986 with preliminary projections to 2040.*[a]

| | Recovery factor data and projections | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1952 | 1976 | 1985 | 2000 | 2010 | 2020 | 2030 | 2040 |
| Softwood lumber (1982 dollars per thosand board feet) | | | | | | | | |
| South | 60 | 89 | 89 | 79 | 77 | 74 | 70 | 68 |
| Pacific Northwest | | | | | | | | |
| Douglas-fir subregion | 100 | 112 | 130 | 131 | 117 | 116 | 102 | 100 |
| Ponderosa pine subregion | 77 | 100 | 117 | 108 | 103 | 98 | 92 | 87 |
| Pacific Southwest | 118 | 120 | 119 | 107 | 107 | 99 | 96 | 94 |
| Rocky Mountains | | | | | | | | |
| Northern Rocky Mountains | 68 | 105 | 113 | 111 | 111 | 107 | 103 | 94 |
| Southern Rocky Mountains | 112 | 114 | 125 | 111 | 111 | 107 | 103 | 94 |
| Softwood plywood (1982 dollars per thousand square feet, 3/8-in. basis) | | | | | | | | |
| South | -- | 91 | 82 | 81 | 81 | 80 | 80 | 79 |
| Pacific Northwest | | | | | | | | |
| Douglas-fir subregion | 123 | 110 | 103 | 99 | 98 | 97 | 97 | 96 |
| Ponderosa pine subregion | 120 | 95 | 92 | 88 | 88 | 87 | 87 | 86 |
| Pacific Southwest | -- | 110 | 103 | 99 | 98 | 97 | 97 | 96 |
| Oriented strandboard and waferboard (1982 dollars per thousand square feet. 3/8-in. basis) | | | | | | | | |
| North | -- | -- | 90 | 87 | 87 | 86 | 86 | 86 |
| South | -- | -- | 87 | 85 | 84 | 84 | 84 | 84 |
| Paper, paperboard, and related products[b] (1982 dollars per ton of paper or paperboard) | | | | | | | | |
| Newsprint | -- | -- | 368 | 367 | 365 | 363 | 361 | 361 |
| Unbleached kraft board | -- | -- | 173 | 169 | 166 | 162 | 159 | 158 |
| Semichemical board | -- | -- | 206 | 206 | 206 | 205 | 205 | 204 |
| Recycled board | -- | -- | 234 | 234 | 234 | 234 | 234 | 234 |
| Solid bleached board | -- | -- | 460 | 437 | 428 | 419 | 412 | 408 |

[a] Processing costs exclude wood cost and revenue from sale of mill residue.
[b] Paper and board figures under 1985 are for 1986.

## Paper, paperboard, and related products[1]

Consumption of pulpwood (roundwood and chips) per ton of paper, paperboard, and related products produced in the United States increased 10 percent from the mid-1950s to mid-1970s. During the past decade, consumption has been about 1.2 cords per ton of product. Between 1986 and 2040, pulpwood use per ton of products is projected to decline 8 percent, from 1.21 to 1.11 cords per ton (Table 1). The decline is due to projected increased use of high-yield mechanical pulps, increased use of recycled fiber, increased use of additives, and changes in product performance, all of which reduce fiber requirements.

A 24-percent increase is projected between 1986 and 2040 in consumption of hardwood pulpwood, and an equivalent decrease in consumption of softwood pulpwood is projected. This reflects a continuation of recent trends toward increased substitution of hardwood for softwood. The greatest relative decrease in softwood use is expected in the North—35 percent. The greatest increase in hardwood use is expected in the West—46 percent. Improvements allowing increased use of hardwoods include improved pressing technology, better refining, and improved sheet additives.

Recycled waste paper consumption per ton of product decreased from the 1950s to the mid-1970s but increased 5 percent in the past decade. Recycled fiber use per ton is expected to increase 10 percent over current levels as new technologies improve fiber recovery and product quality.

Processing costs are projected to decline 1 percent for newsprint and 2 percent for semichemical boards by 2040, while processing costs are projected to decline 8 percent for unbleached kraft and and 11 percent for solid bleached kraft board (Table 2). Processing costs for recycled board are projected to remain unchanged at 1986 levels. The cost decline for unbleached kraft board is due to adoption of wide-nip or high-impulse press sections, greater use of recycled fiber, and reduced energy consumption. For solid bleached board, the cost decline is due to improvements in bleaching technology and greater use of mechanical pulps.

[1] Includes wet machine board, construction paper, insulating board, and hardboard.