

Potential timber market impact of current wood utilization research

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Abstract

As part of the USDA Forest Service 1989 timber assessment, an analysis has been conducted of the potential impact of seven areas of current Forest Service wood utilization research on timber and wood products markets. Prices, consumption, total annual value, and present (discounted) value were all studied. Research on pulp, paper, and paperboard processing has by far the greatest long-term potential for altering prices, harvest/consumption, and value. However, the effects would not be felt until after 2010. By 2040, pulp and paper research may lead to softwood pulpwood consumption and sawlog harvest that are respectively one-third lower and one-sixth higher than the base case projections. The result would be a decrease in the present harvest value of sawtimber-pulpwood by \$2.4 billion (10⁹) (1982 \$U.S.) at a discount rate of 10 percent. The effects of solid wood product research would occur sooner and would generally increase softwood sawtimber price. The effect on solid wood product prices and consumption levels would vary. Research on design and performance of wood structures may increase the value of timber and wood products the most. The present value of sawtimber harvest and of wood products sales, at a 10 percent discount rate, may increase \$1.5 and \$2.6 billion, respectively.

In the USDA Forest Service, managers of wood utilization research are asked to justify their research in terms of its potential impact. The areas of concern vary widely, but the impact of research on timber and wood products markets is of particular interest to the Forest Service. This is because the public is interested in how utilization research may alter the relative adequacy of timber supplies, the health of the forest products industry, and the cost of wood products to consumers.

Approach

To evaluate the potential impact of current wood utilization research that is conducted in part by the Forest Service, we first identified seven Forest Service research areas that, if successful, would influence prices and consumption in timber markets:

1. Harvesting
2. Lumber, plywood, and veneer processing
3. Expanded use of timber bridges
4. Development of new or improved composite products using wood
5. Design and performance of wood structures
6. Development of improved adhesives from renewable resources
7. Pulp, paper, and paperboard processing

Scientists at the Forest Products Laboratory (FPL) and other regional USDA Forest Service research stations identified how successful completion of research-development-adoption efforts may alter timber processing or demand for timber products. With the exception of harvesting research, our analysis assumed complementary research and development would be done by universities and industry. In some cases, universities and industry are expected to contribute as much or more than the Forest Service in terms of basic and applied research. It is assumed that most engineering development will be done by industry.

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To reduce the uncertainty about the possible impact of research, we used the principle of decomposition: "decompose a complex problem (overall impact) into simpler problems." Decomposition has been shown to improve judgmental predictions and is of most value when uncertainty is high (1). For each research area (other than pulp, paper, and paperboard), scientists described how research would alter such technical factors as product recovery factors, processing costs, or rate of wood use in various end products, as well as the timing of such changes. We are confident that utilization research will have many notable impacts; this opinion is based in part on studies that show that past research has had an impact. Seven such studies are summarized in Chapter 10 of the 1989 Forest Service timber assessment (13). These expected technology changes were translated into sets of changes (one set for each research area) to the base case assumptions used to make timber market projections to 2040 with two econometric models: the Timber Assessment Market Model (TAMM) and the Hardwood Assessment Market Model (2).¹ We use TAMM to refer to both models.

The TAMM model was used to make timber market projections for the 1989 Resources Planning Act (RPA) forest and rangelands assessment (12). The sets of changes were used for simulation runs to project timber market conditions that reflect successful completion, development, and adoption of research in each research area. The TAMM projections of timber and wood product consumption and prices were then compared for the base case and the altered cases.

For pulp, paper, and paperboard research, we used the FPL Pulpwood Model to make market projections (6,7). Scientists estimated the technical characteristics (pulp yield and processing costs) of new ways to make various grades of paper, and they projected when industry would begin using these techniques. These new processes were inserted in the FPL Pulpwood Model to alter projections of pulpwood and paper-paperboard production and prices. Altered projections of pulpwood and paper-paperboard price and production were compared to the base case projections. Altered projections of pulpwood consumption were then inserted in the TAMM model, and the resulting sawtimber and solid product projections were compared to the TAMM base case projections.

We first describe the research being conducted in each area and the anticipated technology changes as implemented in TAMM or the FPL Pulpwood Model. We then discuss the potential impact of these research areas on timber and wood products prices, harvest/consumption levels, and total annual product value (price multiplied by volume).

¹Reasoning on the specific kinds, extent, and timing of changes is contained in "Changes in Forest Service Econometric Models to Evaluate the Impact of Current Wood Utilization Research," by K. Skog, unpublished background paper on file at the USDA Forest Serv., Forest Prod. Lab., Madison, Wis.

Research areas

Harvesting

Two kinds of harvesting research were evaluated for their potential impact on softwood sawtimber and veneer log harvesting: a) research on transferring analyses and ideas about the best types of existing equipment for various situations; and b) research on improving the efficiency of equipment and systems with new types of hardware or new designs. The effect of these changes on harvest costs was estimated using a harvest technology projection model developed by Bradley (3,4). To implement the effect of the first type of research activity, we increased the pace of change in the mix of harvesting systems used. The change is small; we assumed the base case system mix for the year 2001 would be achieved by 2000. For the second type of research activity, we estimated how cost efficiency could be improved in various equipment systems by 2040 with continued research by the Forest Service, universities, and industry. We assumed the Forest Service would produce about one-third of the efficiency gains (in rough proportion to total harvesting research expenditures). The harvesting model estimated that the combined effect of the two research activities, after accounting for projected changes in stand density and stem diameter, would reduce harvesting cost 5 to 7 percent by 2040 depending on the U.S. region.

Lumber, plywood, and veneer processing

We evaluated three activities that can improve lumber, plywood, and veneer processing: 1) the IMPROVE program; 2) research on using best-opening-face (BOF) concepts for hardwood lumber production; and 3) research on developing the automated lumber processing system (ALPS) for hardwood lumber (8).

The IMPROVE program, a technology transfer program developed by FPL for sawmill, veneer, and plywood industries, would speed up improvement in softwood lumber and plywood recovery, and reductions in processing costs. The program would also help increase hardwood lumber recovery, as we will describe later. As a result of such acceleration, we assumed improvements formerly estimated to occur by 2001 would occur by 2000. We estimated the effect of these changes on lumber and plywood recovery and costs by using softwood lumber and plywood technology projection models developed by Skog (10) and Spelter (13). By 2000, softwood lumber and plywood recoveries would increase an extra 0.3 and 0.5 percent, respectively, and softwood lumber and plywood processing costs would decrease an extra 0.5 and 0.1 percent, respectively.

With successful completion and adoption of BOF research to make hardwood lumber, as well as efforts through the IMPROVE program, we estimated that overall hardwood lumber recovery would increase at a rate of 1.6 percent per decade between 1985 and 2000, and 1.5 percent per decade between 2000 and 2040. In the base case, hardwood lumber recovery increases 1.0 percent per decade.

Implementation of ALPS would increase recovery of higher hardwood lumber grades by using tomography to scan for internal defects of logs and computers to aid in log breakdown. We estimated 10 percent of the lumber formerly graded as less than No. 1 Common would be upgraded to No. 1 Common, and 10 percent of the lumber formerly graded as No. 1 Common would be upgraded to other grades. We assumed this technology would be first used in 1995, and its use would increase gradually to 25 percent of lumber production by 2040. The slow pace of adoption is due to the expected high capital investment required and relatively small size of most hardwood mills. Implementation of ALPS would also decrease by 10 to 15 percent the amount of lumber needed to produce a given quantity of furniture parts by using computer vision and computer-controlled conventional or laser cutting. By 2040, we assumed 50 percent of furniture-part production would use this technology.

Expanded use of timber bridges

The Forest Service has undertaken a program for promoting the use of timber to replace thousands of small bridges in the United States each year. Roughly one-quarter million bridges are in need of eventual repair or replacement. Currently, less than 1,000 timber bridges are built each year. With improved, economical designs, we assumed that the annual construction of timber bridges could increase to 7,500 bridges by 1995 and continue at that level through 2040. An average bridge would use 1,300 ft.³ (36.8 m³) of wood, for a total of 9.75 × 10⁶ ft.³ (2.76 × 10⁶ m³) or 120 × 10⁶ board feet per year. We assumed 75 percent softwoods and 25 percent hardwoods are used. This extra production would be 0.19 and 0.33 percent of 1986 softwood and hardwood lumber production, respectively.

New or improved composite products

Research on composite products includes development of steam injection pressing for products like oriented strandboard (OSB), chemical treatments to improve dimensional stability and water resistance of composite panels, and composites of wood and nonwood materials (such as plastics) for many applications.

We assumed that by 2040, chemically treated OSB would substitute for 1) much plywood in foundations and concrete forms; 2) some plywood in single-family housing, slightly expanding the market for OSB; and 3) about half the lumber millwork in exterior applications. These changes amount to a relatively small shift from plywood and lumber to OSB-type products compared to the base case projections.

Research on wood-nonwood composites could yield products that pair wood with nonwood biomass, metal, plastics, glass, or synthetic fibers. Much current research is devoted to wood-plastic composites. These composites could substitute for existing wood products such as packaging (containers, cartons, pallets). Even though overall material use may increase with greater demand for a cheaper product, the wood input would decrease. Composites could substitute for nonwood

products such as auto and truck components and thus increase the use of wood. We assumed wood-plastic composites will have the widest use, and overall they will tend to increase wood use. This is based on current trends in composite applications. We used wood-plastic composites in auto or truck components as a proxy to indicate the overall net increase in wood use. Wood use in such composites could be 3.6 × 10⁶ ft.³ (1.0 × 10⁵ m³) by 2040, assuming 15 percent wood use in 30 percent of such auto or truck components.

Design and performance of wood structures

We evaluated 10 research activities in which the Forest Service participates that can improve the design and performance of wood structures:

1. Development of more reliable engineered wood structural components such as wood I-beams.
2. Improved design criteria for efficient and reliable structural connectors.
3. Accurate determination of effects of use conditions on structural components.
4. Improved resistance of wood products and assemblies to fire.
5. Improved techniques for rehabilitating wood structures.
6. Development of advanced design procedures to improve competitiveness of designs using wood relative to designs that use steel or concrete.
7. Improved adhesive-connected structural components.
8. Accurate assessment of structural lumber properties (aids in using advanced design concepts).
9. Flexible and precise nondestructive evaluation techniques to aid grading of lumber.
10. Development of grading that is independent of species in order to enhance use of diverse species.

Success in these research activities could 1) increase lumber and panel use for nonresidential structures; and 2) decrease lumber use and increase panel use per square foot of residential construction. For nonresidential structures, we assumed that by 2010 and thereafter, research will increase lumber, plywood, and OSB-waferboard use by 15 percent over levels in the base case by increasing the number of nonresidential buildings where wood is used. This increase accounts for the fact that advanced design procedures will reduce the wood used per square foot of floor area. For single and multifamily homes, we assumed this research will accelerate technology changes projected to occur at a slower pace in the base case. For single-family homes, lumber use will decrease 15 percent because of more efficient design (by 2010 rather than 2040), and structural panel thickness will increase (to provide needed strength with wider stud spacing) in floors, wall sheathing, and siding by an average of 7.5 to 12 percent by 2010. For multifamily homes, lumber use in floors will decrease slightly and average floor panel thickness will increase. Lumber use in roofs and walls is already quite efficient. The aggregate effect of

the research will be to increase both lumber and structural panel consumption above levels in the base case projections.

Adhesives from renewable resources

Adhesives developed from renewable resources, particularly tree components, would be cheaper than petroleum-based phenolic adhesives if oil prices increase substantially. If adhesives from renewable resources are not available, and if oil prices increase to \$50 per barrel (14) by 2020, we estimated increases in phenolic adhesive prices would increase plywood prices by 5 to 16 percent and OSB prices by 46 percent by 2020. (Note: All figures in this paper are expressed in terms of 1982 \$U.S.) Availability of economical adhesives from renewable resources would hold down such panel price increases.

Pulp, paper, and paperboard processing

Research on pulp, paper, and paperboard processing will include mechanical and peroxymonosulfate pulping, wastepaper recycling, production of newsprint, and development of FPL Spaceboard I.

Mechanical pulping. – Research on mechanical pulping for hardwoods in linerboard could lead to the use of pulp with yields of 85 to 95 percent compared to yields of 50 to 55 percent for conventional unbleached kraft pulp. With chemithermomechanical pulping (CTMP) and press-drying, linerboard could be made from 100 percent hardwoods with 80 percent yield by the year 2015. Mechanical pulping could also increase the use of hardwoods in making printing and writing papers.

Peroxymonosulfate pulping. – By 2010, research on peroxymonosulfate pulping may facilitate the increased use of hardwood in newsprint, unbleached kraft paperboard, solid bleached paperboard, printing and writing papers, packaging and industrial papers, and tissue. Peroxymonosulfate pulping may be able to produce a relatively high-yield pulp from 100 percent hardwoods that has improved bonding strength and higher brightness relative to other hardwood pulps. Peroxymonosulfate pulp could be used in combination with other pulps to make many grades of paper.

Wastepaper recycling. – By 2010 to 2015, research on wastepaper recycling may facilitate additional increases in use, or altered use, of recycled paper for newsprint, unbleached kraft paperboard, solid bleached paperboard, recycled paperboard, printing and writing paper, packaging and industrial paper, and tissue. To increase recycling, research is being done to develop a disk separation process to separate contaminants from recycled fiber, to improve the means to remove ink from printing and writing papers, and to

develop chemical and biological treatments to restore bonding strength to recycled fibers.

Production of newsprint. – Research on CTMP and biomechanical pulping (BMP) with press-drying may be successfully combined to make newsprint from 100 percent hardwoods. Mills using CTMP or BMP with press-drying may be possible beginning in 2015 and 2025, respectively. Combining CTMP with press-drying may achieve higher sheet strength, previously attainable only with softwoods. (Bleaching may be needed when using hardwood species.) Combining BMP with press-drying may increase strength and also retain optical properties for low- and medium-density hardwood species.

FPL Spaceboard I. – Through research, a new product, FPL Spaceboard I, could replace some corrugated fiberboard for boxes (9). Spaceboard is a sandwich of two or more pulp-molded structures. We assumed that manufacturing plants for Spaceboard I will be built near large cities by 2000; the plants will use 100 percent recycled corrugated containers as raw material. We estimated Spaceboard I may replace 25 percent of corrugated container board by 2040.

Findings

The diverse objectives of wood utilization research benefit a variety of interest groups, including forest landowners, loggers, product producers, and consumers. The limited set of measures used in our study clearly showed that the interest groups who gain vary from one research area to another. Our approach was similar to one used by Skog and Haynes (5,11) to evaluate past wood utilization research.

To measure market impact, we used the change in 1) timber and wood product prices; 2) harvest/consumption volume; 3) harvest/consumption deflated dollar value (price multiplied by volume); and 4) present (discounted) value of timber or product value. These measures clearly indicated gains or losses for some groups. For example, stumpage price or harvest volume increases that lead to increased value of harvest would be a gain to landowners, whereas price increases for final products would be a loss for consumers. But these measures do not clearly indicate gains or losses for producers. For example, a decrease in lumber price caused by reduced cost of timber may lead to a profit gain for producers, or the savings may be passed on to consumers, but a decrease in lumber price caused by reduced demand for lumber would lead to a profit loss.

For all research areas, change in price, harvest/consumption, and value were estimated for softwood and hardwood sawtimber, softwood and hardwood lumber, softwood plywood, and OSB-waferboard. These estimates were produced using TAMM model projections.² For pulp, paper, and paperboard research, changes in price of softwood pulpwood, and changes in production of softwood and hardwood pulpwood and selected grades of paper and paperboard were estimated. These estimates were made using the FPL Pulpwood Model.

In terms of the magnitude of impact, the research

²We compared long-term average price and consumption levels between the base case and altered cases to try to avoid observing the effects of technology differences on short-term business cycles generated in TAMM. Averages were taken for 9-year periods around 2000, 2010, 2020, and 2030.

areas fall into three categories: 1) research on harvesting, timber bridges, composite products, lumber, plywood, and veneer, which will cause less than 5 percent

change in price, harvest/consumption volume, and value through 2040 (Tables 1 and 2); 2) research on design and performance of wood structures and devel-

TABLE 1. — Potential impact of harvesting research and lumber, plywood, and veneer research on price, production level, and value of various types of lumber and wood products from 2000 to 2040.

Market characteristic and product ^a	Harvesting					Lumber, plywood, veneer				
	2000	2010	2020	2030	2040	2000	2010	2020	2030	2040
Difference from base case projection ^b										
----- (%) -----										
Price ^c										
SW sawtimber	* ^d	0.6	2.5	4.2	3.5	-0.8	0.9	1.2	2.2	1.3
HW sawtimber	NA	NA	NA	NA	NA	-0.2	-0.4	-0.6	-0.8	-1.0
SW lumber	0.2	-0.2	*	-0.2	-0.8	-0.3	0.2	0.2	*	-0.3
HW lumber	*	*	*	*	*	-0.2	-0.7	-1.1	-1.4	-1.7
SW plywood	*	-0.1	1.3	-0.6	0.5	-0.2	-0.6	1.9	-1.0	3.1
OSB-waferboard	*	0.1	*	-0.5	-1.9	0.3	0.2	-0.7	-1.0	-2.2
Harvest/consumption ^c										
SW sawtimber	0.1	0.2	0.2	0.4	0.2	-0.2	0.2	*	0.1	*
HW sawtimber	NA	NA	NA	NA	NA	-0.2	-0.5	-0.8	-0.9	-1.0
SW lumber	*	*	0.1	*	*	0.1	*	*	-0.1	-0.1
HW lumber	*	*	*	*	*	-0.2	-0.4	-0.7	-0.9	-1.0
SW plywood	*	*	-0.1	*	-0.2	0.1	0.2	-0.1	0.1	-0.4
OSB-waferboard	*	*	*	*	*	-0.1	-0.1	-0.5	*	*
Value	----- (million 1982 \$) -----									
SW sawtimber	3	59	231	413	357	-57	82	104	209	127
HW sawtimber	NA	NA	NA	NA	NA	-11	-35	-72	-116	-163
SW lumber	37	-39	3	-53	-201	-43	44	53	-5	-100
HW lumber	*	*	*	*	-1	-17	-59	-115	-117	-235
SW plywood	-1	-6	56	-30	18	-5	-18	82	-45	144
OSB-waferboard	1	1	1	-12	-49	3	2	-25	-24	-56

^a SW = softwood, HW = hardwood. NA = effect of reduced hardwood harvesting costs not estimated.

^b Positive value indicates the altered case is greater than the base case.

^c Sawtimber prices are for stumpage. Other prices are for delivered products.

^d * = value between -0.05 and 0.05.

^e Sawtimber volume is for U.S. harvest. Other volumes are for amounts consumed in the United States. Net imports from Canada may change and are included.

TABLE 2. — Potential impact of timber bridge and composites research on price, production level, and value of various types of lumber and wood products from 2000 to 2040.

Market characteristic and product ^a	Timber bridge technology transfer					Composites				
	2000	2010	2020	2030	2040	2000	2010	2020	2030	2040
Difference from base case projection ^b										
----- (%) -----										
Price ^c										
SW sawtimber	1.1	* ^d	1.0	1.3	0.7	0.5	0.7	-0.1	0.8	0.2
HW sawtimber	1.4	1.1	1.3	1.2	1.2	*	*	*	*	*
SW lumber	0.6	-0.6	0.3	-0.2	-0.8	0.2	-0.4	-0.4	-0.6	-1.0
HW lumber	1.8	3.3	3.2	3.0	3.0	*	*	*	*	*
SW plywood	0.2	-0.1	1.3	0.4	3.9	-0.2	-0.5	2.3	-1.6	-0.3
OSB-waferboard	0.2	0.3	-0.7	-1.3	-4.0	0.5	0.8	-0.4	0.4	-2.2
Harvest/consumption ^c										
SW sawtimber	0.1	-0.2	0.1	0.2	0.1	*	0.1	0.1	0.1	-0.1
HW sawtimber	2.5	2.0	1.8	1.6	1.5	*	*	*	*	*
SW lumber	0.2	0.4	0.2	0.3	0.4	-0.1	-0.1	-0.2	-0.2	*
HW lumber	2.5	2.0	1.8	1.6	1.5	*	*	*	*	*
SW plywood	*	*	*	*	-0.5	-0.1	-0.4	-1.0	-0.9	-1.6
OSB-waferboard	*	*	*	*	*	0.8	1.5	2.2	2.4	2.4
Value	----- (million 1982 \$) -----									
SW sawtimber	65	-12	91	91	84	0.5	0.8	*	0.9	0.2
HW sawtimber	121	131	168	194	218	*	*	*	*	*
SW lumber	143	-50	124	4	83	0.1	-0.5	-0.6	-0.8	-1.0
HW lumber	185	290	324	361	388	*	*	*	*	*
SW plywood	9	-3	58	19	179	-0.3	-0.9	1.2	-2.5	-1.9
OSB-waferboard	1	4	-15	-30	-102	1.2	2.3	1.7	2.8	0.1

^a SW = softwood, HW = hardwood.

^b Positive value indicates the altered case is greater than the base case.

^c Sawtimber prices are for stumpage. Other prices are for delivered products.

^d * = value between -0.05 and 0.05.

^e Sawtimber volume is for U.S. harvest. Other volumes are for amounts consumed in the United States. Net imports from Canada may change and are included.

TABLE 3. — Potential impact of research on engineered structures and adhesives price, production level, and value of various types of lumber and wood products from 2000 to 2040.

Market characteristic and product ^a	Engineered structures					Adhesives from renewable resources				
	2000	2010	2020	2030	2040	2000	2010	2020	2030	2040
Difference from base case projection ^b										
----- (%) -----										
Price ^c										
SW sawtimber	3.1	5.6	6.0	7.4	6.8	0.2	0.9	* ^d	1.5	1.2
HW sawtimber	*	-0.1	*	0.1	0.1	*	0.1	0.2	0.4	0.6
SW lumber	0.9	1.1	1.3	1.9	1.4	0.2	0.5	-0.2	-0.3	0.1
HW lumber	*	*	*	0.1	0.1	*	0.1	0.2	0.3	0.4
SW plywood	1.0	2.1	3.5	0.9	6.0	-1.8	-3.4	-3.5	-3.8	-3.9
OSB-waferboard	0.2	-0.8	0.5	-0.2	-0.1	-10.0	-15.0	-20.0	-19.0	-19.0
Harvest/consumption ^e										
SW sawtimber	0.3	0.5	0.1	0.3	0.1	*	-0.1	-0.2	-0.4	-0.6
HW sawtimber	*	*	*	-0.1	*	*	*	-0.1	-0.1	-0.2
SW lumber	0.7	1.4	1.5	1.6	1.7	-0.1	-0.2	-0.1	*	0.1
HW lumber	*	*	*	*	*	*	-0.1	-0.1	-0.1	-0.2
SW plywood	0.7	1.0	0.9	1.0	0.2	-0.6	-1.2	-1.4	-0.9	-0.5
OSB-waferboard	2.3	4.5	4.7	4.8	5.0	1.3	2.0	1.6	1.1	0.8
Value	----- (million 1982 \$) -----									
SW sawtimber	183	461	539	701	664	-13	-54	13	-100	-59
HW sawtimber	-1	-6	0	0	6	0	-3	-8	-18	-29
SW lumber	278	520	654	817	740	-27	-68	64	73	-32
HW lumber	0	3	2	4	3	0	0	7	13	21
SW plywood	67	137	204	93	331	-94	-221	-238	-249	-246
OSB-waferboard	37	71	110	104	127	-134	-304	-473	-513	-585

^a SW = softwood, HW = hardwood.

^b Positive value indicates the altered case is greater than the base case.

^c Sawtimber prices are for stumpage. Other prices are for delivered products.

^d * = value between -0.05 and 0.05.

^e Sawtimber volume is for U.S. harvest. Other volumes are for amounts consumed in the United States. Net imports from Canada may change and are included.

TABLE 4. — Potential impact of selected pulp, paper, and paperboard research on price, production level, and value of softwood and hardwood pulpwood from 2000 to 2040.

Market characteristic and product ^a	Pulp, paper, and paperboard				
	2000	2010	2020	2030	2040
Difference from base case projection ^b					
----- (%) -----					
Price ^c					
SW pulpwood	1.3	-0.6	-13.1	-7.2	-8.7
Harvest ^c /production					
SW pulpwood	-0.3	-1.0	-13.7	-20.1	-32.7
HW pulpwood	-0.5	0.4	-0.8	-1.9	-0.8
Value ^d	----- (million 1982 \$) -----				
SW pulpwood	39	-74	-1,304	-1,530	-2,459
HW pulpwood	-11	14	-30	-74	-353

^a SW = softwood, HW = hardwood.

^b Positive value indicates the altered case is greater than the base case.

^c Price change is from the portion of the FPL Pulpwood Model that takes into account technology changes in only the manufacture of chemical, solid bleached, and recycled paperboards. Harvest change is from combined estimates that take into account technology changes in the manufacture of all eight paper and paperboard grades.

^d Softwood pulpwood value change includes price change noted in table. Hardwood change assumes no change in hardwood prices.

opment of adhesives from renewable resources, which may change the price or consumption of some products by 5 to 20 percent by 2040 (Table 3); and 3) research on pulp, paper, and paperboard, which may decrease softwood pulpwood consumption 33 percent and increase softwood sawtimber harvest 17 percent by 2040 (Tables 4 and 5). A key difference between the first two categories and pulp and paper research is that the full

TABLE 5. — Potential impact of research on pulp, paper, and paperboard on price, production level, and value of various types of timber and wood products in the future.

Market characteristic and product ^a	Pulp, paper, and paperboard ^d				
	2000	2010	2020	2030	2040
Difference from base case projection ^b					
----- (%) -----					
Price ^c					
SW sawtimber	-6.1	2.5	-5.6	-29.0	-43.0
HW sawtimber	* ^d	-0.1	-0.1	-0.2	-2.0
SW lumber	-1.2	*	-4.1	-14.1	-37.9
HW lumber	*	-0.1	*	-0.1	-0.3
SW plywood	-2.3	0.8	-0.1	-10.7	-10.4
OSB-waferboard	0.3	*	0.4	-2.0	-5.2
Harvest/consumption ^e					
SW sawtimber	0.5	0.7	3.0	11.7	16.8
HW sawtimber	*	*	*	*	-0.1
SW lumber	0.5	0.5	1.0	3.0	4.7
HW lumber	*	0.1	*	0.1	0.1
SW plywood	0.7	0.2	0.2	1.7	1.8
OSB-waferboard	-0.4	-0.2	*	-0.1	-0.1
Value	----- (million 1982 \$) -----				
SW sawtimber	-307	240	-241	-1,873	-3,189
HW sawtimber	2	-3	-2	-8	-170
SW lumber	-133	108	-729	-2,690	-8,243
HW lumber	1	-1	-2	-5	-18
SW plywood	-62	44	4	-460	-474
OSB-waferboard	-1	-5	-10	-47	-135

^a SW = softwood, HW = hardwood.

^b Positive value indicates the altered case is greater than the base case.

^c Sawtimber prices are for stumpage. Other prices are for delivered products.

^d * = value between -0.05 and 0.05.

^e Sawtimber volume is for U.S. harvest. Other volumes are for amounts consumed in the United States. Net imports from Canada may change and are included.

effect of research in the first two categories is expected well before 2010, whereas the effect of pulp and paper research will not begin until 2010 to 2020. The research areas, except for pulp, paper, and paperboard, are expected to lead to higher softwood sawtimber prices, and, with the exception of adhesives and pulp, paper, and paperboard research, to generally higher softwood sawtimber harvest (Figs. 1 and 2).

The projected percentage of change in softwood sawtimber prices caused by the research areas is generally greater than the change in harvest volume (Figs. 1 and 2) because a large change in stumpage price is required to make a small change in stumpage supply; likewise, a large change in wood product price is required to make a small change in wood product demand. As a result, the increase in softwood sawtimber value caused by research in categories 1 and 2 would be caused primarily by increases in stumpage price and not increases in harvest volume. For example, harvesting research will increase softwood sawtimber price by up to 4.2 percent over the projection period (Table 1) but will increase sawtimber production by only a few tenths of a percent.

Research to produce adhesives from renewable re-

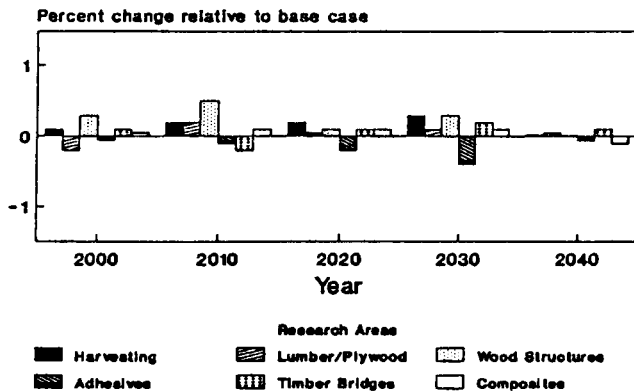


Figure 1. — Projected percentage of change in softwood sawtimber harvest resulting from selected current wood utilization research.

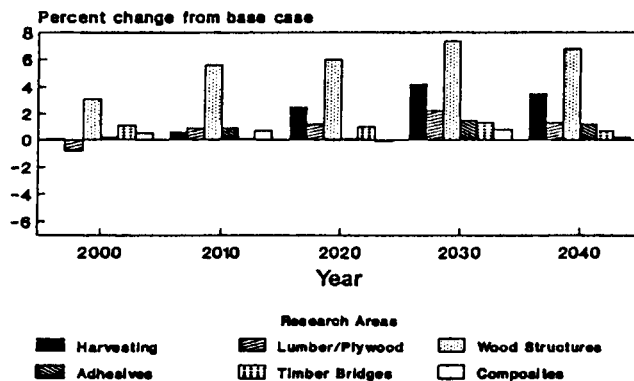


Figure 2. — Projected percentage of change in softwood sawtimber stumpage price resulting from selected current wood utilization research.

sources is notable because it may keep OSB-waferboard and plywood prices almost 20 and 3.9 percent lower, respectively, than the base case projections. These estimated price effects are greater than could actually be achieved because we assumed that the new adhesives could keep glue prices constant at current levels. With cheaper glues, OSB-waferboard consumption would increase by only 2 percent by 2040 relative to the base case. The increase is small because demand for panels is relatively unresponsive to changes in panel price.

The impacts of pulp, paper, and paperboard research stand out when compared to those of the other categories of research: 1) the effects are expected to occur further in the future (after 2010); 2) both pulpwood and sawtimber harvest and prices will be substantially affected; and 3) the potential changes in price, harvest/consumption, and value will be much greater. Softwood and hardwood pulpwood harvest may be 33 and 0.8 percent lower by 2040, respectively (Table 4). The 33 percent decrease in softwood pulpwood harvest is equal to 27 percent of the projected softwood sawtimber harvest in 2040. With lower pulpwood harvest, softwood sawtimber harvest would in-

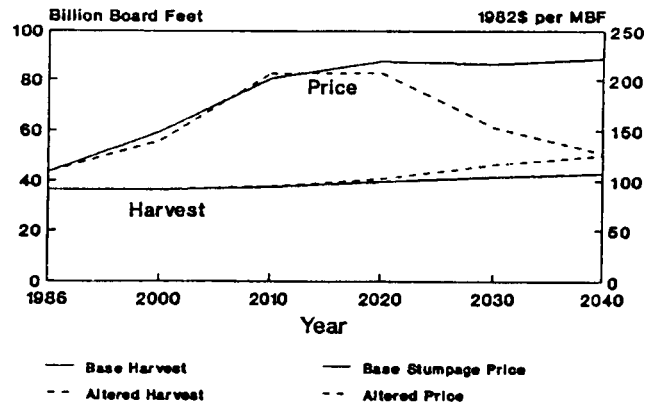


Figure 3. — Projected softwood sawtimber harvest and stumpage price, with and without successful completion and adoption of current pulp, paper, and paperboard research.

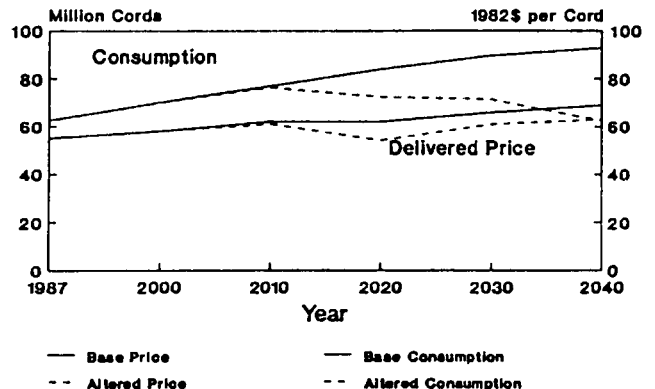


Figure 4. — Projected softwood pulpwood harvest and delivered price, with and without successful completion and adoption of current pulp, paper, and paperboard research.

TABLE 6. – Potential impact of research on present (discounted) value of timber and wood products from 1987 to 2040.

Research area	Product value (billion 1982 \$)						
	Sawtimber		All pulpwood	Lumber		SW plywood	OSB-waterboard
	SW ^a	HW ^a		SW	HW		
Present value at 4% discount rate							
Base case	136	86	94	413	110	94	33
Change in present value at 4% discount rate							
Harvesting	1.8	* ^b	--	-0.5	-0.1	-0.1	-0.1
Lumber, plywood	0.6	-0.7	--	-1.5	-1.2	-0.1	-0.2
Timber bridges	1.0	2.3	--	0.8	4.1	0.2	-0.2
Composites	0.5	*	--	1.1	*	-0.4	0.5
Wood structures	6.1	*	--	7.2	-0.1	1.7	1.0
Adhesives	-0.5	-0.1	--	-0.6	-0.1	2.5	4.6
Pulp and paper	-7.5	-0.1	-8.5	-10.8	-0.1	-1.6	-0.3
Percent value at 10% discount rate							
Base case	51	31	21	167	42	41	12
Change in present value at 10% discount rate							
Harvesting	0.2	*	--	*	*	*	*
Lumber, plywood	-0.1	-0.1	--	-0.1	-0.2	*	*
Timber bridges	0.3	0.7	--	0.5	1.1	0.1	*
Composites	0.2	*	--	-0.2	*	-0.1	0.1
Wood structures	1.5	*	--	1.9	*	0.5	0.3
Adhesives	-0.1	*	--	-0.2	*	-0.7	1.1
Pulp and paper	-1.4	*	-1.0	-1.1	*	-0.3	*

^a SW - softwood; HW - hardwood.

^b * - value is between -0.05 and 0.05.

crease by 16.8 percent by 2040 (Fig. 3). However, combined harvest would decline, overall, leading to lower prices for both softwood sawtimber and softwood pulpwood; prices may decline by 43 and 9 percent for softwood sawtimber and pulpwood, respectively (Figs. 3 and 4).

As shown in Tables 4 and 5, the potential decreases in harvest value – both for pulpwood and sawtimber – resulting from pulp, paper, and paperboard research are much greater than any potential increase in sawtimber harvest value caused by other research areas. The potential annual value decrease in pulpwood value alone, relative to the base case, would exceed \$1.3 billion (10⁹) by 2020 and \$2.8 billion by 2040 (-15% and -26%, respectively) (Table 4). The associated annual value decrease for softwood sawtimber would be \$0.2 billion by 2020 and \$3.2 billion by 2040 (-3% and -34%, respectively) (Table 5).

One purpose of wood utilization research has been to hold down the cost of timber used to make wood products as well as the cost of final products. One way to measure the value of such research is to calculate how much the research would reduce the present (discounted) value of timber or wood products relative to the base case over an extended period, say from 1987 to 2040. Presumably, investors would be willing to pay more for research that made a greater reduction in present value.

We calculated the change in present value that would be caused by different research areas using discount rates of 4 and 10 percent. If investors, public and private, consider the investment in research to be quite risky, they may demand a higher rate of return – say 10 percent. If they are confident of success, they

may be satisfied with a 4 percent return. At the 10 percent discount rate, research in two areas – lumber, plywood, and veneer research and pulp, paper, and paperboard research – would reduce the present value of sawtimber and pulpwood harvest, lumber, and panels (Table 6).

Harvesting research and composite research would benefit consumers by decreasing the present value of lumber and plywood slightly, and they would benefit timber owners by increasing the present value of timber harvest (Table 6). In the long run, softwood timber owners would also benefit from higher timber harvest revenues resulting from research on timber bridges, engineered structures, and lumber, plywood, and veneer (Tables 1 to 3).

The greatest increase in the present value of products is likely to come from research on the design and performance of wood structures and, to a lesser extent, from research and technology transfer for timber bridges. For wood structures research, the present value of sawtimber harvest and wood products sales, at the 10 percent discount rate, may increase \$1.5 and \$2.6 billion, respectively (Table 6).

Conclusions

Our analysis indicates that wood utilization research conducted in part by the Forest Service would benefit a wide variety of interest groups.

1. Consumers would benefit through lowered prices on solid wood products as a result of research on paper and paperboard; adhesives; lumber, plywood, and veneer processing; composites; and harvesting.

2. Owners of softwood sawtimber would benefit through increased harvesting revenue brought about

through research on wood structures, harvesting, timber bridges, composites, and lumber, plywood, and veneer.

3. Solid wood products manufacturers would benefit from research on wood structures and timber bridges, which could increase product demand, product prices, and production.

Research on pulp, paper, and paperboard processing has the greatest long-term potential for altering timber and wood product prices, harvest/consumption, and value. All solid wood products research that was evaluated in our study would increase softwood sawtimber price. Its effect on harvest/consumption levels would vary. The greatest increase in sawtimber and wood product value promises to come from research on design and performance of wood structures.

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