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RESOURCE POTENTIAL OF WOOD-BASED WASTES IN THE UNITED STATES

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Abstract

Large amounts of waste are generated in the United States annually. Although much of this material is indeed waste, an increasing share is becoming a valuable resource. Wood is usually thought of as a renewable, not a recyclable, resource. However, solid residues from primary timber processing facilities have been recycled into usable products for decades. Wooden pallets are recycled into new pallets or other wood products at an increasing rate, and wood waste from construction and demolition sites is becoming an important commodity. Wood from urban waste collection may too prove to be a valuable resource. The first step in developing waste wood into a viable resource is to quantify the amounts of waste wood available by source and type of material. There are three major sources of wood waste in the United States–municipal solid waste (MSW), new construction and demolition waste, and wood residues from primary timber manufacturing facilities. Included in MSW are pallets and yard waste. In this report, total amounts of waste generated, amounts of wood waste generated by type, and amounts of wood waste potentially available for recycling are quantified for each source of waste. Estimates are based on published waste generation volumes and rates, measures of economic activity, and trends in virgin wood use in specific markets. The report also identifies possible uses for each source of wood waste and includes recommendations for better utilizing this resource.

Introduction

Large amounts of waste are generated in the United States annually. Although much of this material is indeed waste, an increasing share is now a valuable resource. In the past, recycling was limited to a few commodity items such as metal, glass, and old newspapers. Today, such diverse items as plastic containers and film, used oil and oil filters, fluorescent lighting tubes, and aerosol spray cans are being recycled.

Solid wood, usually not included on any of these lists, should appear in all three. Wood residues from primary timber processing facilities have been recycled into usable products for decades. Wooden pallets are recycled into new pallets or other wood products at an increasing rate, and wood waste from construction and demolition sites is becoming an important commodity. Urban wood waste may soon be a valuable resource. The first step in developing solid wood waste into a viable resource is to quantify the amounts of wood waste available by source and type of material. There are three major sources of wood waste in the United States–municipal solid waste, new construction and demolition waste, and wood residues from primary timber manufacturing facilities. The purpose of this report is to estimate total amounts of waste generated, amounts of wood waste by type, and amounts of wood waste potentially recoverable by source of material. Wood waste from other, lesser sources are identified but not included in this analysis, nor are residues left in the woods from logging or cultural operations and other nonwood agricultural wastes. Also, it should be noted that this report deals exclusively with solid wood waste. Wood fiber used for paper and paperboard is not included.

Municipal Solid Waste

Municipal solid waste (MSW) is waste from residential, commercial, institutional and industrial sources. It includes waste such as durable goods, nondurable goods, containers and packaging food scraps, yard trimmings, and miscellaneous inorganic waste (14). Specific examples of MSW are appliances, automobile tires, newspapers, clothing, boxes, disposable tableware, office and classroom paper, wooden pallets, and cafeteria waste. MS W does not include waste from other sources, such as construction and demolition waste, automobiles, municipal sludge, combustion ash, and industrial process wastes that may, or may not, be disposed of in municipal waste landfills or incinerators.

An estimated 188 million metric tonnes ($\times 10^6$ t) (207 million shorttons [$\times 10^6$ tons]) of MSW were generated in the United States in 1993 (14) (Fig. 1). Since 1960 (with the exception of 1991), MSW generation has increased steadily from 80×10^6 t (88 tons). MSW generation is sensitive to overall economic conditions. Periods of eeonomic recession–either severe, or mild as in 1991–cause deviations of MSW from long-term trends. Between 1960 and 1993, MSW generation increased at an average annual rate of 2.6% per year. Since 1990, the rate has been just 1.5% per year compared to 2.8% per year for the period 1960 through 1990. Overall, MSW is projected to be 198×10^6 t (218×10^6 tons) by the year 2000. This represents an average annual increase of just 0.7% per year from 1993 through 2000. Thus, although total MSW is increasing, it is increasing at a

decreasing rate, and is expected to do so into the foreseeable future. Per capita MSW generation averaged 1.99 kg (4.39 lb) per person per day in 1993, an increase from 1.97 kg (4.35 lb) in 1990 and 1.21 kg (2.66 lb) in 1960. Trends in per capita generation closely followed total MSW generation from 1960 through 1990. Source reduction and recycling programs initiated in the late 1980s began to influence waste generation by 1990. Per capita generation began to plateau in the early 1990s; in 2000, it is expected to decrease (to 1.96 kg [4.32 lb]), for the first time since 1960.

A wide variety of products are included in the overall MSW generation figures. The wood waste and yard trimmings portion of MSW is examined here. Wood waste includes such items as wooden furniture and cabinets, pallets and containers, scrap lumber and panels from other than new constriction or demolition activities, and wood waste from manufacturing facilities. Wood waste does not include roundwood or unprocessed wood. Yard trimmings include leaves and grass clippings, brush, and tree trimmings and removals. The amounts and types generated, currently recovered for recycling, composting, or combustion and discarded determine the physical supply of solid wood waste that may be available for recovery from the municipal waste stream.

Wood

In 1993, 12.4×10^6 t (13.7×10^6 tons) of MSW wood waste was generated in the United States (14) (Table 1), nearly 7% of all MSW. Of this, 1.2×10^6 t (1.3×10^6 tons) was recovered for recycling or composting, and the rest was discarded. The discarded wood waste was sent to either combustion facilities or landfills. The exact proportion of discards that were combusted is available only for overall MSW, not for specific materials within the waste stream. Approximately 95% of all MSW combustion facilities burn either unprocessed mixed waste or processed mixed waste (refuse-derived fuel). In 1993, about 30.0×10^6 t (33.1×10^6 tons) of MSW was burned. Since wood waste accounts for about 10% of all combustible mixed MSW, about 3.0×10^6 t (3.3×10^6 tons) was burned in 1993. Also, some discarded wood waste was too contaminated, commingled with other waste, or otherwise unacceptable for recovery. Overall, about 60% of all discarded wood waste 6.7×10^6 t (7.4×10^6 tons) was considered to be recoverable in 1993 (2,3).

Yard Trimmings

Yard trimmings constituted the second largest single component of MSW in 1993 at 29.8×10^6 t (32.8×10^6 tons), or nearly 16% of all MSW (14). Of this, 5.9×10^6 t (6.5×10^6 tons) was recovered for recycling or composting, and the remainder (23.9×10^6 t [26.3×10^6 tons]) was discarded. A recent study detailed the generation and disposition of all urban tree and landscape residues, not just the proportion in the municipal waste stream (8). In 1993, 95% of all urban tree and landscape residues, by volume, was woody residues.

Table 1. Wood Waste Generated and Recoverable From Various Sources

Source	Generated 10^6 t	Generated (10^6 tons)	Recoverable 10^6 t	Recoverable (10^6 tons)	Recoverable %
Municipal solid waste					
Wood waste	12.4	(13.7)	6.7	(7.4)	54
Woody yard trimmings	28.2	(31.1)	13.6	(15.1)	48
Total	40.6	(44.8)	20.3	(22.5)	50
Construction & demolition					
New construction waste	6.1	(6.7)	5.4	(5.9)	88
Demolition waste	22.7	(25.0)	6.8	(7.5)	30
Total	28.8	(31.7)	12.2	(13.4)	42
Primary timber processing					
Bark residues	26.0	(28.7)	1.4	(1.5)	5
Wood residues	74.5	(82.1)	4.3	(4.7)	6
Total	100.5	(110.8)	5.7	(6.2)	6
Total wood waste	169.9	(187.3)	38.2	(42.1)	22

Therefore, about 28.2×10^6 t (31.1×10^6 tons) of woody residue was generated in MSW in 1993; 22.7×10^6 t (25.0×10^6 tons) was discarded. After combustion and allowance for unrecoverable material due to contamination, size, commingling with other materials, and cost of collection, about 13.6×10^6 t (15.0×10^6 tons) were considered to be available for recovery (60% of the total amount discarded (2,3)) (Table 1).

Total Solid Wood Waste

In 1993, half of all solid wood waste in MSW, or about 20.3×10^6 t (22.5×10^6 tons), was potentially recoverable (Table 1). It should be emphasized that although these amounts were deemed potentially available, many factors affect recoverability and usability, such as the size and condition of the material, extent of commingling with other types of waste, contamination and physical location of the material, and costs associated with acquiring, transporting, and processing the material into a useable raw material. Overall economic conditions and changing recycling rates will affect future supplies. Estimates of recoverable solid wood waste for 1993 are practical limits to overall supply given current recovery technology and costs, not exact amounts that were specifically available.

New Construction and Demolition Waste

New construction and demolition wastes are not a single form of waste, as often thought. These wastes originate from distinctly different sources, have different characteristics, and differ in their ease of separation, recoverability, and recyclability. New construction waste, particularly wood waste, originates from the construction, repair, and remodeling of single- and multifamily houses, and the construction of low-rise nonresidential buildings. Demolition waste originates at any site where a building or other structure is being demolished. New construction waste tends to be much cleaner than demolition waste and

consists of contemporary types of materials; demolition waste is usually more contaminated with foreign materials such as paints, fasteners, wall covering materials, and insulation, and typically contains a more diverse mix of materials. Many materials in demolition waste are no longer being widely used in new construction, which makes them potentially more difficult to recycle. New construction waste can be readily separated on the job site with little additional effort by the builder, whereas source separation of waste at the demolition site can be very time-consuming and costly. Demolition practices would have to be radically altered to achieve adequate source separation. For these reasons, new construction and demolition wastes were evaluated separately.

Although construction and demolition (C&D) waste recovery is increasing, little consistent information is available nationally for developing overall estimates of materials generation and recovery. Available data are limited to specific case studies that may or may not reflect overall national trends and vary widely. The C&D waste generation rates published in the past 25 years ranged from a low of 0.05 kg (0.12 lb) per person/day (19.9 kg [43.8 lb] per year) to 1.60 kg (3.52 lb) per person/day (582.6 kg [1,284.4 lb] per year) (11). Factors that affect C&D generation rates include new construction activity, type of structure, type of materials, demolition activity, type and age of structure being demolished, and extent to which materials are removed from structures for reuse or recycling prior to demolition. Because of variability in reported C&D waste generation rates and the many factors that affect them, information from specific case studies that could be linked to national levels of construction activity was used to estimate C&D waste generation in 1993. The resulting estimates, although not precise estimates of the size or extent of this waste stream, particularly regionally or locally, provide a good, overall view of the C&D waste resource.

New Construction Waste

New residential and nonresidential buildings, as well as nonbuilding construction, generates large amounts of waste annually. Information on the types and amounts of waste generated is sketchy and limited to anecdotes or a handful of case studies. Since nearly all new single-family and low-rise multifamily residential structures are based on traditional wood-frame building technology, information on this type of construction was used to develop estimates of wood waste generated and recoverable for new construction. Specific waste generation rates were obtained from a case study of the Portland, Oregon, metropolitan area (5). Although specific to the structures examined, the waste generation rates were typical of all new residential construction in 1993 because the individual structures examined had characteristics typical of all new residential construction. Information from this source was used to develop weighted average waste generation rates based on floor area built for new single-family and multifamily houses. These rates were then applied to total floor area of each type of structure built in the United States in 1993 to develop estimates of total waste generated for residential construction. Estimates were then adjusted to account for new nonresidential construction and residential repair/modeling. Waste from the production of mobile homes and manufactured housing was not included since it is a component of MSW.

An estimated 2,237 kg (4,931 lb) of solid wood waste, and 1,215 kg (2,678 lb) of paper and other waste were generated for the average 188.3 m^2 (2,027 ft^2) single-family house built in the Portland metropolitan area in 1993 (5). Wood waste was generated at 11.86 kg/m^2 (2.43 lb/ft^2) of finished floor area. Overall, an estimated 88% of the wood waste was considered

to be recoverable. New multifamily construction generated 619 kg (1,365 lb) of wood waste and 390 kg (860 lb) of other waste per living (apartment) unit. These amounts included not only materials generated per unit, but also prorated amounts for common areas like laundry rooms, lobbies, and recreational areas. Wood waste was generated at a rate of 7.42 kg/m^2 (1.52 lb/ft^2) of finished floor area; 88% of this material was also recoverable.

In 1993, 1,126,000 new single-family houses with an average 195 m^2 (2,095 ft^2) of floor area and 153,000 multifamily living units with an average 99 m^2 (1,065 ft^2) of floor area were built nationally (12). Applying the average wood waste generation rates per unit of floor area (5) resulted in an estimated 2.6×10^6 t (2.9×10^6 tons) of wood waste generated in 1993 for new single-family construction and 0.1×10^6 t (0.1×10^6 tons) for new multifamily construction (Fig. 2). Based on materials use factors (building material required per unit of finished floor area) for new residential construction (1,7), an estimated 27.1×10^6 t (29.9×10^6 tons) of wood products was required in 1993 for all new residential construction. Wood waste was about 10% of the wood used to build the structures.

Large amounts of wood products are required for residential repair and remodeling and new nonresidential construction annually, and these activities therefore generate large amounts of wood waste. Reliable information on the amounts of waste generated by these types of construction was not available. However, the types of materials and construction techniques typically used for residential repair and remodeling are used for new single-family construction as well. Therefore, waste generation estimates for residential repair and remodeling were based on waste generation rates for new single-family construction. Data on wood products use in 1991 for residential repair and remodeling (6) were updated to 1993 using expenditures data (13). Total wood products use was estimated to be 25.8×10^6 t (28.4×10^6 tons) and wood waste generated about 2.6×10^3 t (2.9×10^6 tons) in 1993 by residential repair and remodeling activities (Fig. 2).

Estimates of amounts of wood products used for new nonresidential construction in 1986 were used to estimate that used in 1993 (9). In 1993, about 8.6×10^6 t (9.5×10^6 tons) of wood products was used for new nonresidential construction and one-third of that used for new single-family construction (Fig. 2). The wood products and construction techniques typically used to build low-rise, light-frame nonresidential buildings such as stores and office buildings are similar to that used for new residential construction. Waste generation is also expected to be similar. Wood is not typically used as the primary construction material for larger nonresidential projects such as warehouses, high-rise buildings, and highways, and the building techniques are different. Information needed to estimate waste from such building activities was not available. However, since wood is not the primary building material for these larger nonresidential projects, total waste wood generation should not be greatly affected. In 1993, the combined use of wood products for residential repair/remodeling, and new nonresidential construction was about 27% greater than that for new residential construction (single-family and multifamily combined) and generated 25% more wood waste.

Wood waste generation for all new construction (new single- and multifamily residential, residential repair and remodeling, and new nonresidential) was estimated to be 6.1×10^6 t (6.7×10^6 tons) in 1993, with 5.4×10^6 t (5.9×10^6 tons) recoverable (Table 1). The percentage of new residential construction waste considered to be recoverable was used to

estimate recoverable amounts of wood waste from residential repair and remodeling and new nonresidential construction.

Demolition Waste

Demolition waste is the heterogeneous mixture of building materials generated by demolishing a building or other structure. It typically contains aggregate, concrete, wood, paper, metal, insulation, glass, and other contemporary building materials. Depending on the age and type of structure, it may also contain asbestos, lead-based finishes, mercury, polychlorinated biphenyl compounds (PCBs) or other contaminates. Estimates on the amounts of demolition waste generated have been made over the years. These estimates are usually for specific localities, typically include new construction waste, and are based on the size of the resident population. (Urban areas tend to generate more C&D waste per capita than suburban or rural areas.) The C&D waste generation rates were estimated by the California Waste Management Board and the New York Solid Waste Management Board for 1968 and 1991, respectively (11) (Fig. 3). Because of the consistency between the New York and Calfornia rates, and the relationship between population and waste generation, the New York C&D generation rates were used to estimate demolition waste generated in the United States in 1993.

To estimate demolition waste, total C&D waste was first estimated by annualizing the generation rates from the 1991 New York study and multiplying them by the size of the population living in metropolitan and nonmetropolitan statistical areas. The estimated amount of new construction waste was then subtracted, resulting in an estimated 43.8×10^6 t (48.3×10^6 tons) of demolition waste generated in 1993. Finally, information from a 1991 Metropolitan Toronto Waste Composition Study indicated that 52% of demolition waste being disposed of in metropolitan Toronto landfills was wood, and 48% was other materials (11). Application of these percentages resulted in an estimated 22.7×10^6 t (25.0×10^6 tons) of wood in demolition waste in the United States in 1993.

Recoverability of demolition waste is difficult to determine. The characteristics of demolition waste make it more difficult to recover and recycle than construction waste. Recycling operations are very sensitive to contamination. Entire loads of demolition waste are typically rejected if contaminated. About 15% of the wood, by weight (38% by volume), received at a Massachusetts demolition waste recycling facility is usable (4). These figures are for a specific operation producing a single product and are based on primary crushing of the incoming demolition waste to achieve uniform material size. Differences in treatment technology, products manufactured, and source of demolition waste affect the utilization rate. Based on an assumed overall 30% utilization rate, approximately 6.8×10^6 t (7.5×10^6 tons) of wood demolition waste was estimated to be recoverable in 1993 (Table 1).

Primary Timber Processing Mill Residues

Primary timber processing facilities in the United States generate large amounts of residues in such forms as bark, sawmill slabs and edging, sawdust, and peeler log cores. In 1991, an

estimated 26.0 × 10^6 dry t (28.7 × 10^6 tons) of bark and 74.5 × 10^6 dry t (82.1 × 10^6 tons) of wood residues were generated (Table 1) (10). Many mill residues arc being used to produce other products, primarily fiber products, nonstructural panels, and fuel. Only 5% of the bark (1.4 × 10^6 t [1.5 × 10^6 tons]) and 6% of the wood residue (4.3 x 10^6 t [4.7 x 10^6 tons]) were not used in 1991. This unused residue is all potentially recoverable. Overall lumber and plywood production changed little between 1991 and 1993. The 1991 mill residue data were therefore used as an estimate for 1993. As such, an estimated 5.7 × 10^6 t (6.2 × 10^6 tons) of bark and wood residue was available for recovery in 1993 (Table 1).

Other Sources

There are many other sources of waste wood, including chemically treated wood used for railroad crossties, switch ties and bridge timbers, telephone and utility poles, and pier and dock timbers, and untreated wood in the form of logging residues left in the woods, chipped brush and limbs resulting from maintenance of utility right-of-ways, and industrial waste wood outside the MSW stream. Some of this material is being reused, some is being burned, some is being disposed of in hazardous waste landfills, and much is being left on site. Chemical treatments and cost of collection make much of this material difficult to recover. The amounts of wood available from these other sources (with the exception of logging residues) are fairly small compared to that from MSW, C&D waste, and mills. For example, in 1993 a total of 12.3 × 10^6 railroad crossties was replaced. The replacement ties were all treated wood and had an estimated volume of 1.2 × 10^6 m^3 (491 × 10^6 board feet [BF]). Bridge and switch tie replacements constituted an additional 0.1 × 10^6 m^3 (44 × 10^6 BF). The combined volume was equivalent to nearly 0.8 × 10^6 t (0.9 × 10^6 tons) of ties replaced. If half the volume of wood in the removed ties were sound, then less than 0.5 × 10^6 t (0.5 × 10^6 tons) of wood would have been recoverable from all railroad tie replacements. This is approximately 10% of the recoverable wood residue from primary timber processing mills, the smallest of the three major sources of wood waste. Although wood from other sources may become a valuable resource in the future, they were not examined in our estimates because of their smaller volumes or obstacles to recovery.

Conclusions

An estimated 170 × 10^6 t (187 × 10^6 tons) of waste wood were generated in the United States in 1993 from MSW, new construction and demolition (C&D) waste, and primary timber processing facilities. Much of this waste was used to produce new products, was used for fuel, or was not suitable for other uses because of contamination or other physical characteristics. Of the total amount generated about 38 × 10^6 t (42 × 10^6 tons) or 22% was suitable for recovery. More than half of the recoverable waste wood was from MSW, about one-third from C&D wood waste, and the remainder from primary timber processing mill residues. Many technical and economic obstacles need to be overcome before much of the recoverable wood waste can be recycled. This is nevertheless a valuable resource, and it is playing an ever-increasing role in satisfying the demand for wood-baaed products. Advances are constantly being made in current utilization and new uses are being found. In

the forest products industry, for examp1e, furnish consisting of UP to half recycled construction waste, pallets, crating, and other wood waste is being used in a particleboard plant in Eugene, Oregon. Also, funding and siting are underway for a medium-density fiberboard (MDF) plant in Toronto, Canada, that will use urban and industrial wood waste exclusively. Six additional MDF plants of the same company are being considered for large metropolitan areas in the United States and Canada. The USDA Forest Service Recycling Initiative is aimed at developing uses for waste wood and paper, particularly building products for residential construction.

[1] The Forest Products Laboratory is maintained in cooperation with the University of Wisconsin. This article was written and prepared by U.S. Government employees on official time, and it is therefore in the public domain and not subject to copyright.

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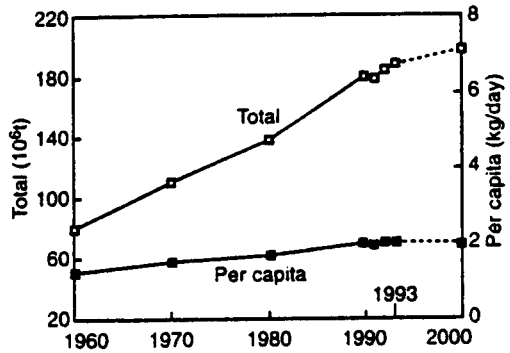

Figure 1. Total and per capita MSW generation, 1993.

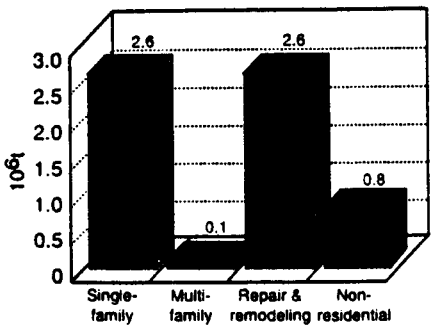

Figure 2. New construction wood waste generation, 1993.

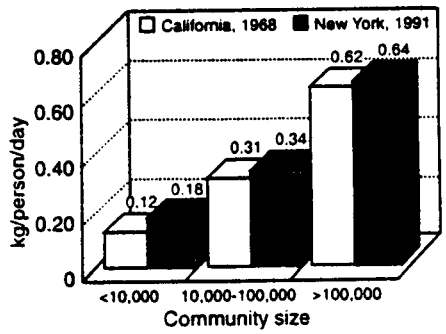

Figure 3. C&D waste generation rates for California and New York.

on recycled paper