

論文 (Original article)

Estimate of material recycling flow in the Japanese wood industry

MURATA Kohji^{1)*}, IKAMI Yuji¹⁾ and TONOSAKI Mario²⁾

Abstract

Concrete methods for estimating the amount of carbon stocked in wood used as housing, furniture, etc., have been discussed for the Second Commitment Period at the Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNCCC), because the capacity of carbon sinks by wood utilization can not be ignored in the global carbon circulation. Therefore, we have to establish a method for estimating the amounts of carbon stocked in wood products. In this study, we observed the material recycling flow in Japanese wood industry, in order to understand the amounts of material recycling of wood residues.

We estimated the volumes of wood residues generated at sawmills, plywood mills, wooden furniture factories, wooden pallet factories, packing factories, *precut* factories, and glue laminating factories and the volume of their material recycling based on several kinds of statistics and former studies and the result of questionnaire. In 2001, the total volume of the wood residues generated in Japanese wood industry was estimated 13.475 million m³, that is 5.054 million m³ at sawmills, 0.407 million m³ at plywood mills, 0.036 million m³ at wooden furniture factories, 0.006 million m³ at wooden pallet factories, 0.014 m³ at packing factories, 0.175 million m³ at *precut* factories, and 0.032 million m³ at glue laminating factories. The wood residues of 43% (5.724 million m³) were recycled as material for pulp and wood composites. The material recycled residues of 98% were generated at sawmills, plywood mills, and *precut* factories.

Key words : material recycle, wood residues, wood processing factory

1. INTRODUCTION

Since the dawn of the Industrial Revolution, the burning of fossil fuels has resulted in the massive emission of greenhouse gasses, such as carbon dioxide and methane, into the atmosphere, which in turn has resulted in global warming. The mitigation of global warming is one of the most serious issues for the global environment. In 1992, the United Nations Framework Convention on Climate Change (UNCCC) was established in order to consider what can be done to reduce global warming. The Kyoto Protocol, which has legally binding measures, was agreed to at the Third Conference of Parties (COP3) of UNCCC in 1997.

In the First Commitment Period (2008-2012), the Kyoto Protocol simply states that trees emit carbon in the atmosphere when they are cut down. However, the carbon is still fixed in the wood and is not emitted into the atmosphere until the wood is burned. Since the capacity of carbon sinks by wood utilization cannot be ignored in the global carbon circulation, concrete methods for estimating the volume of carbon stored in wood used as housing, furniture, etc., have been discussed at COP for the Second Commitment Period of the Kyoto Protocol (2013-2018). However, we still have to develop a method for estimating the volume of carbon stored in wood products. When we estimate the carbon stock in wood products, we have

to determine whether or not the output flow from these products would emit carbon, because the wood would still fix carbon if it is used as material.

In this study, we observed the material recycling flow in the Japanese wood industry in order to understand the volume of wood residues that is recycled at wood processing factories.

2. METHOD

We estimated the volumes of wood residues generated at sawmills, plywood mills, wooden furniture factories, wooden pallet factories, packing factories, *precut* factories, and glue laminating factories, which are on the output side of material recycling in the wood industry, and the volume of their material recycling based on several kinds of statistics and studies. When there were no statistics or literature, we gave a questionnaire to wood processing factories in order to estimate the volume of wood residue generation and material recycling. There are statistics on the volume of log consumption and the volume of lumber and plywood at sawmills and plywood mills. Also there are reports on the wood residue generated at sawmills, plywood mills, wooden furniture factories, *precut* factories, and glue laminating factories. However, there is no report on the wood residue generated at wooden pallet factories and packing factories so that we sent the questionnaire on volume

原稿受付：平成 17 年 9 月 9 日 Received Sep. 9, 2005 原稿受理：平成 17 年 12 月 22 日 Accepted Dec. 22, 2005

* Department of Wood Processing, Forestry and Forest Products Research Institute, 1 Matsunosato, Tsukuba, Ibaraki 305-8687, Japan, e-mail: saw@ffpri.affrc.go.jp

1) Department of Wood Processing, Forestry and Forest Products Research Institute(FFPRI)

2) Department of Wood Properties, Forestry and Forest Products Research Institute(FFPRI)

of lumber consumption, volume of products, and volume of each kind of wood residue to 26 wooden pallet factories (all members of Japan Pallet Association Wooden Pallet Division) and 100 packing factories (50 members of East Japan Packing Association and 50 members of West Japan Packing Association). The numbers of respondents were 12 from wooden pallet factories and 46 from packing factories, respectively. The estimated volume of recycled wood residues was also compared with the statistics of the volume of materials come from the wood industry into pulp mills, particleboard factories, and fiberboard factories.

3. RESULTS AND DISCUSSION

3.1 Sawmills

There are several reports on the residues generated at sawmills in Japan (HOWTEC, 1994, JAWIC, 1998, Ikami and Murata, 2003, Sawanobori *et al.*, 2004). The generation ratio of wood residues is a useful index for estimating the volume of wood residues, but it differs from one report to another. In this study, the generation ratio of wood residues reported by Ikami and Murata (Ikami and Murata, 2003) was used for estimating the volume of wood residues at sawmills, because the number of respondents was the largest among the reports and the data was most current. The volume of the wood residues was calculated using log volume handled by sawmills as described in "Report on Wood Supply and Demand 2001" (MAFF, 2002) and the generation ratio of wood residues.

Fig. 1 shows the flow of raw material, products, and wood

residues at sawmills in 2001. A total of 15.486 million m³ of lumber was sawn from 23.587 million m³ of logs (MAFF, 2002). The total volume of wood residues produced at sawmills was estimated at 9.811 million m³. The wood residues at sawmills were slabs, listings, thin boards, sawdust, planer shavings, chip dust, and bark. While most of them were used as chips, smaller lumber, livestock bedding, compost, soil conditioners, fuel and so on, some of them were burned or rejected. The volume of material recycling was estimated at 5.054 million m³ (4.852 million m³ of chips plus 0.202 million m³ of smaller lumber). The volume of burned wood is decreasing because the use of incinerators at factories is severely regulated in Japan.

3.2 Plywood mills

The generation ratio of wood residues in the report of Japan Wood-Products Information & Research Center (JAWIC, 1999) was used for estimating the volume of wood residues generated at plywood mills. The volume of wood residues at plywood mills was estimated in a similar manner.

Fig. 2 shows the flow of raw material, products, and wood residues at plywood mills in 2001. About 4.689 million m³ of logs were turned into 2.771 million m³ of plywood at plywood mills (MAFF, 2002). The wood residues generated at plywood mills included chain sawdust, log trims, peeled cores, green and dried veneer trims, plywood edges, and bark. The total volume of wood residues was estimated at 2.014 million m³ at plywood mills. The volume of material recycle was estimated at 407,000 m³ (chips). At plywood mills, the wood residues were mostly

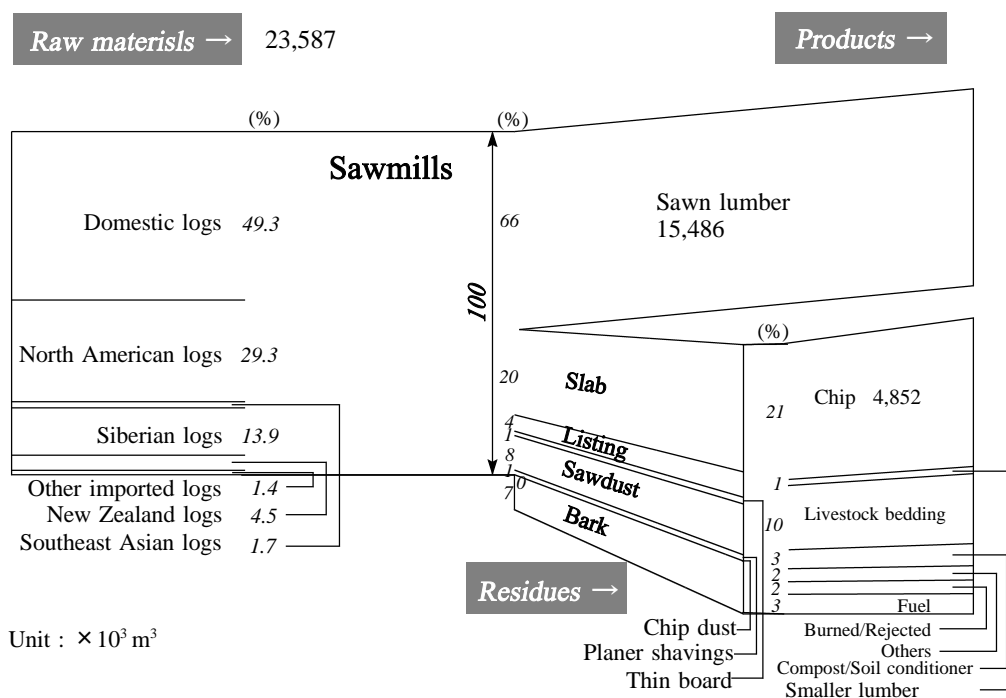


Fig. 1. Flow of raw materials, products, and wood residues at sawmills in 2001.

used as fuel for boilers to generate steam for veneer driers and hot presses. The volume of wood residues used for material recycling was less than that for thermal recycling.

3.3 Wooden furniture factories

Although there are no statistics on the volume of wood residues generated at wooden furniture factories, some estimates have been reported by the Wood-Products Information &

Research Center (JAWIC, 2003). They estimated the volume of wood residues at furniture factories using “Report on Textiles and Consumer Goods Statistics” (METI, 2002A), “Report on Census of Manufactures” (METI, 2002B), and the results of interviews and questionnaires.

Fig. 3 shows the flow of raw material, products, and wood residues at wooden furniture factories in 2001. An estimated 1.250 million m³ of sawn lumber and 0.872 million m³ of wood

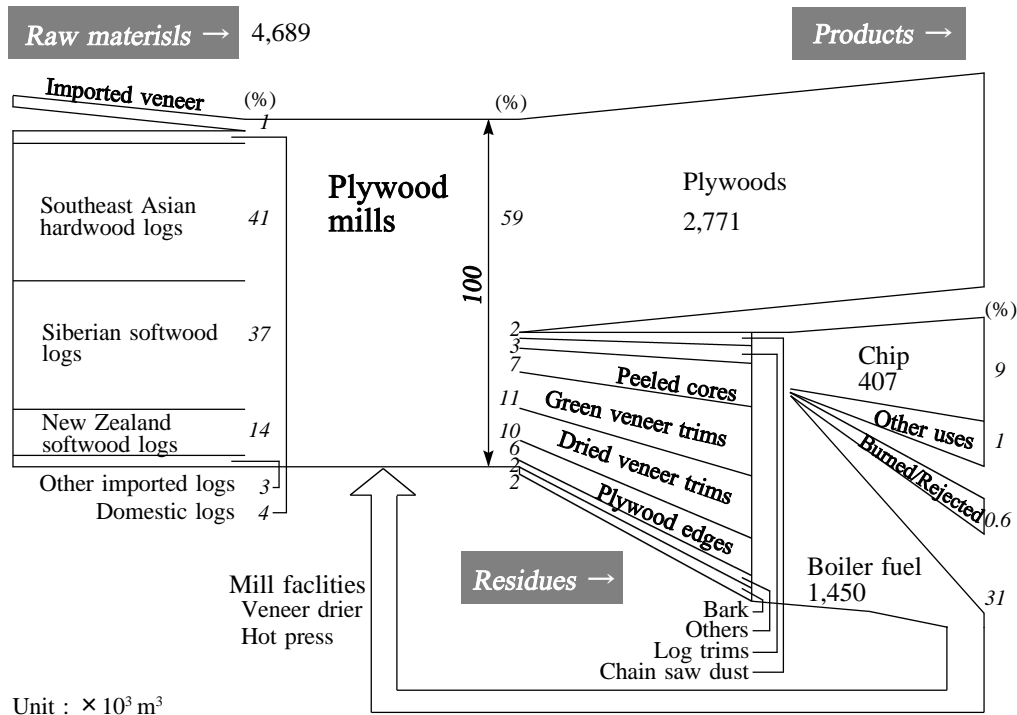


Fig. 2. Flow of raw materials, products, and wood residues at plywood in 2001.

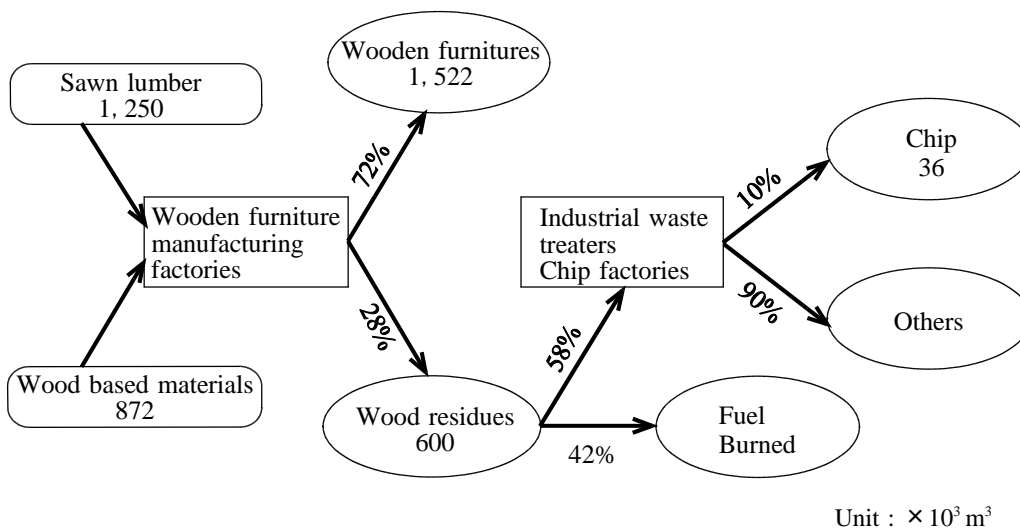


Fig. 3. Flow of raw materials, products, and wood residues at wooden furniture factories in 2001

based materials were used as raw materials at wooden furniture factories. The estimated volume of wood residues was 0.600 million m³. Of wood residues generated at wooden furniture factories, 58% was sold to industrial waste treaters or chip factories. The volume of material recycle was estimated at 0.036 million m³.

3.4 Wooden pallet factories

Since there are no statistics on wood consumption and wood residues generated at wooden pallet factories, we estimated the volume of wood consumption using the number of wooden pallets manufactured and mean wood volume per wooden pallet. The volume of wood residues was estimated using the results of questionnaires.

The numbers of wooden pallets manufactured in 2001 were estimated at 31.691 million of 1100×1100 mm pallet, 1.463 million of 1300×1100 mm pallet, 11.690 million of 1400×1100 mm pallet, 0.833 million of 1200×1000 mm pallet, and 1.020 million of other size pallets. The average wood volumes per pallet were 0.060 m³ for 1100×1100 mm pallet, 0.073 for 1300×1100 mm pallet, 0.077 for 1400×1100 mm pallet, 0.056 for 1400×1100 mm pallet, and 0.040 for other size pallets. Consequently, the total wood volume consumed was estimated at 3.004 million m³. Almost all wooden pallet factories buy piece lumber and only assemble it into wooden pallets, so that little wood residue is generated. We estimated the generating ratio of wood residues at wooden pallet factories to be 2%. The volumes of wood residues and material recycling were estimated at 60,000 and 6,000 m³, respectively.

3.5 Packing factories

We conducted a questionnaire on wood consumption and wood residues at packing factories in order to determine the volume of wood residues generated there. The results revealed that the generation ratio of listings and sawdust were 7% and 1.5%, respectively. We estimated the volume of wood consumption at 2 million m³ in 2001, and consequently estimated the volume of listings and sawdust at 0.140 million and 0.030 million m³, respectively. We assumed that 10% of the listings generated at packing factories were material-recycled. The volume of material recycling was estimated at 0.014 million m³.

3.5 *Precut* factories

Japanese carpenters had long *precut* various timber joints of building members at their shops instead of at the construction sites when they build wooden constructions. However, we scarcely call such cuttings "*precut*" now. "*Precut*" or "*machine precut*" in Japanese means machining timber joints of building members for Japanese conventional wooden house construction

(post and beam construction) at a factory instead of manual cutting by a carpenter at the carpenter's shop. The factory at which timber joints of the post and beam construction are machined is called a "*precut* factory" and the building members machined at a *precut* factory are called "*precut* lumber". Japanese conventional wooden houses, which are built with *precut* lumber, are called "*precut* houses" (Matsumura and Murata, 2005).

The generation ratio of wood residues listed in the report of the Japan Wood-Products Information & Research Center (JAWIC, 1999) was also used for estimating the volume of wood residues at *precut* factories. The volume of wood residues at *precut* factories was estimated similar to that of sawmills and plywood mills.

The generation ratio of listings, sawdust, and cutter shavings were reported to be 5%, 0.3%, and 2%, respectively (JAWIC, 1999). Since the estimated wood consumption at *precut* factories was 4,376 million m³, 0.219 million m³ of listings, 0.013 million m³ of sawdust, and 0.088 million m³ of cutter shavings were generated in 2001. We assumed that 80% of the listings generated at *precut* factories were material-recycled. The volume of material recycling was estimated at 0.175 million m³.

3.6 Glue laminating factories

Sawanobori, *et al.* (Sawanobori, *et al.*, 2004) estimated the volume of wood residues generated at glue laminating factories using the production volume aggregated by the Japan Laminated Wood Association and the results of questionnaires. The estimated amounts of listings and sawdust/cutter shavings were 0.101 million and 0.399 million m³, respectively. The volume of material recycle was 0.032 million m³, thus the ratio of material recycling was 6.4%

3.7 Recycling flow of wood residues in the wood industry

Fig.4 shows the estimated volume of wood residues generated by the wood industry, which was an estimated 13.475 million m³ in 2001. Eighty-eight percent of these residues were generated at sawmills and plywood mills. Of the total wood residues, 43% (5.724 million m³) were recycled as materials and the other 57% (7.751 million m³) were used for other purposes, or rejected or burned. Ninety-eight percent of the wood residues recycled as materials were generated at sawmills, plywood mills, and *precut* factories.

It was reported that 10.683 million m³ of domestic chips were consumed at pulp mills in 2001 (JPA, 2005); 41% of these chips, or 4.380 million m³, were manufactured from the residues generated by the wood industry (Anonymous, 2000). About 3.428 million m³ of chips were consumed at particleboard/fiberboard factories (HOWTEC, 2002) and 38% of those, or

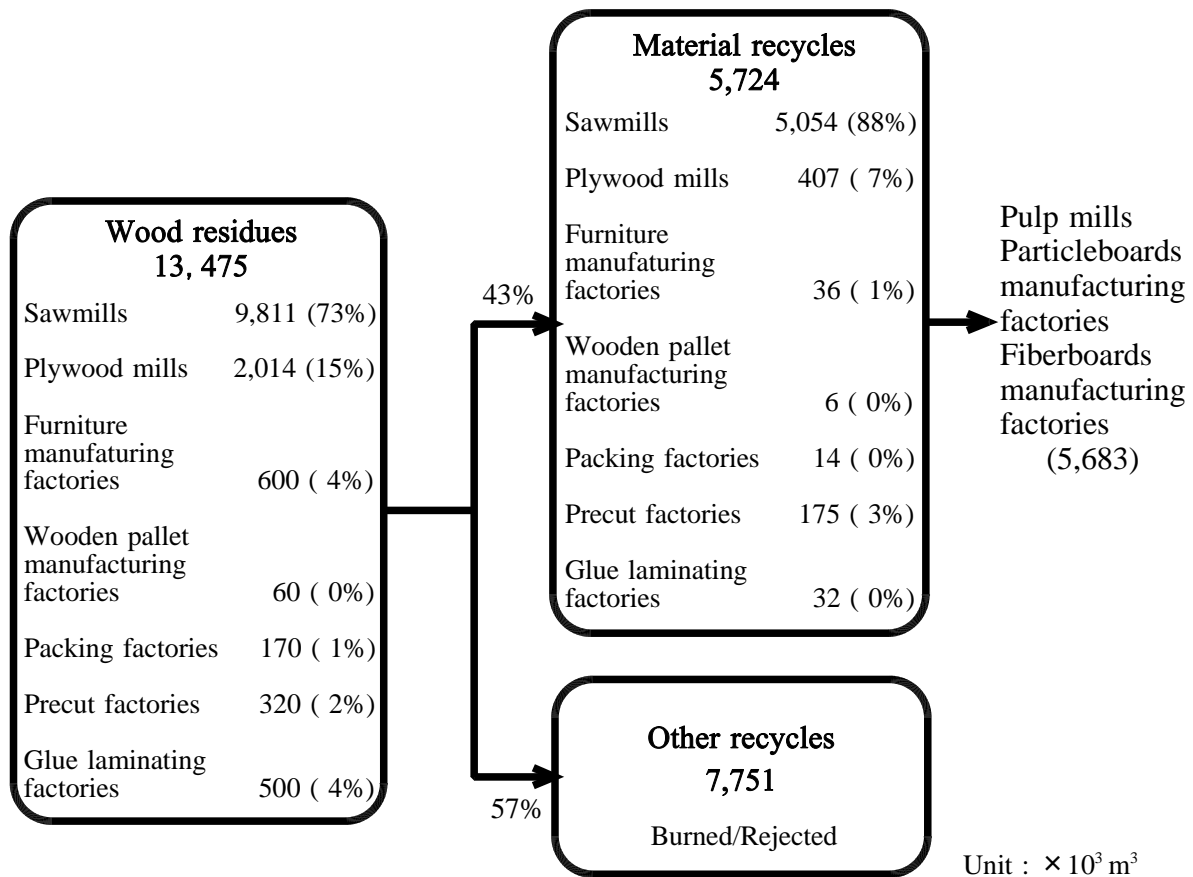


Fig. 4. Estimated volume of wood residues generated in wood industry in 2001.

1.303 million m^3 , were manufactured from residues generated by the wood industry (HOWTEC, 2001). Therefore, 5.683 million m^3 of chips manufactured from wood residues were used in pulp mills, particleboard factories, and fiberboard factories.

The volume of residues from the wood industry that were recycled as materials was estimated at 5.724 million m^3 and the volume of chips manufactured from wood residues generated by the wood industry and used in pulp mills, particleboard factories, and fiberboard factories was estimated at 5.683 million m^3 , for a difference of 0.041 m^3 . This difference is considered to be within the allowance.

4. CONCLUSION

In 2001, the total volume of the wood residues generated at sawmills, plywood mills, wooden furniture factories, wooden pallet factories, packing factories, *precut* factories, and glue laminating factories in Japan was estimated 13.475 million m^3 . The wood residues of 43% (5.724 million m^3) were recycled as material for pulp and wood composites. The material recycled residues of 98% were generated at sawmills, plywood mills, and *precut* factories. The volume of residues used in pulp mills, particleboard factories, and fiberboard factories was estimated

at 5.683 million m^3 , for a difference of 0.041 m^3 .

Acknowledgment

This study was financially supported by Research Project for Utilizing Advanced Technologies in Agriculture, Forestry and Fisheries of Agriculture, Forestry and Fisheries Research Council.

REFERENCES

- Anonymous (2000) Wood/Pulp Wood, J. of the Japan Paper Association, No. 616, 17-18.
- Ikami, Y. and Murata, K. (2003) Generation and Utilization of Wood Residues at Sawmills, *Bul. of FFPRI*, 2(2) 111-114.
- Japan Housing and Wood Technology Center (HOWTEC) (1994) *Report on Development of Recycling Technique of Wood Residues (I)*, Tokyo, Japan Housing and Wood Technology Center.
- Japan Housing and Wood Technology Center (HOWTEC) (2001) *Report on Census and Development of Reuse and Reject Technique of Wood Residues*, Tokyo, Japan Housing and Wood Technology Center.
- Japan Housing and Wood Technology Center (HOWTEC)

- (2002) *Status of Wood Supply and Demand and Wood Industry*, Tokyo, Japan Housing and Wood Technology Center.
- Japan Paper Association (JPA) (2005) *Pulp Handbook 2005*, Japan Paper Association.
- Japan Wood-Products Information & Research Center (JAWIC) (1998) *Chip Manufacturer Using Wood Residues as Raw Materials (No 1)*, Tokyo, Japan Wood-Products Information & Research Center.
- Japan Wood-Products Information & Research Center (JAWIC) (1999) *Chip Manufacturer Using Wood Residues as Raw Materials (No 2)*, Tokyo, Japan Wood-Products Information & Research Center.
- Japan Wood-Products Information & Research Center (JAWIC) (2003) *Report on Census of Environment Information in Wood Industry*, Tokyo, Japan Wood-Products Information & Research Center.
- Matsumura, Y., Murata, K. (2005) Analysis of *precut* industry in Japan, *Holz als Roh- und Werstoff*, **63**(1) 68-72.
- Ministry of Agriculture, Forestry and Fisheries (MAFF) (2002) *Report on Wood Supply and Demands 2001*, Tokyo, Ministry of Agriculture, Forestry and Fisheries.
- Ministry of Economy, Trade and Industry (METI) (2002A) *Report on Textiles and Consumer Goods Statistics*, Tokyo, Ministry of Economy, Trade and Industry, 2002.
- Ministry of Economy, Trade and Industry (METI) (2002B) *Report on Census on Manufactures*, Tokyo, Ministry of Economy, Trade and Industry.
- Sawanobori, S. et al.(2004) *Effective Utilization of Wood Residues*, Tokyo, Forest Policy Research Institute.

木材工業におけるマテリアルリサイクルフローの評価

村田 光司^{1)*}、伊神 裕司¹⁾、外崎 真理雄²⁾

要旨

世界の炭素循環を考えるにあたり、木材製品中に貯蔵されている炭素の量は無視することできない量であることから、気候変動枠組条約 (UNCCC) の締約国会議 (COP) において木製品に貯蔵されている炭素量を評価する具体的な方法が議論されており、その方法の確立が強く求められている。本研究では、木質廃材がマテリアルリサイクルされれば炭素放出とならないことから、木質廃材のマテリアルリサイクル量を把握するために、木材工業におけるマテリアルリサイクル量について検討した。

2001年に日本の木材工場において発生した木質廃材量は、文献およびアンケート調査結果より、製材工場で5,054千m³、合板工場で407千m³、木製家具工場で36千m³、木製パレット製造工場で6千m³、木箱・こん包工場で14千m³、プレカット工場で175千m³、集成材工場で32千m³の合計13,475千m³と推定された。このうちの43%(5,724千m³)がパルプ原料や木質ボード原料としてリサイクルされていると推定された。マテリアルリサイクルされている木質廃材の98%は、製材工場、合板工場、プレカット工場由来のものである。

キーワード：マテリアルリサイクル、木質廃材、木材加工工場

* 森林総合研究所 加工技術研究領域 〒 305-8687 茨城県つくば市松の里 1 e-mail: saw@ffpri.affrc.go.jp

1) 森林総合研究所 加工技術研究領域

2) 森林総合研究所 木材特性研究領域