Municipal Solid Waste (MSW) and Construction and Demolition (C&D) Wood Waste Generation and Recovery in the United States

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INTRODUCTION

The softwood and hardwood forests of the United States provide wood products that are used in many applications including: lumber and other building materials; furniture; pallets and other forms of containers and crating; posts and poles; and a wide-range of consumer goods. This wide array of products generates *waste wood*[1] when these products are disposed at the end of their useful lives. This waste wood is typically included in the categories of Municipal Solid Waste (MSW) and Construction & Demolition (C&D) wood, with the total amount generated in 2010 estimated at 70.6[2] million short tons;[3] this amount is difficult to track and may be understated.

In spite of significant improvements in wood waste utilization throughout the product channel over the last 75 years, a major amount of wood waste is still accruing at landfills across the country; in part simply due to the huge total volume used by American society. Residential construction contributes significantly to this volume. Phil Araman, Research Team Leader at the USDA Forest Service, Southern Research Station notes that in their recent research into wood C&D waste in new residential construction, for an average 2000 square foot home they have found about 5,100 pounds, or more than two and a half tons of wood waste is being generated, in spite of using factory made roof and floor trusses and LVL headers. At a projected one million housing starts per year in the U.S., this suggests C&D wood waste from residential construction alone at over five billion pounds annually. Thus, tracking and understanding the nature of wood waste is critical to development of plans to mitigate and/or utilize this volume.

In the past few years in the U.S, it has been estimated that 35% (12.1 million tons)[4] of the wood in the MSW stream is being recovered for products, an additional 16% (5.5 million tons) is combusted (nearly all for energy), and an additional 32% (11.1 million tons) is yet available for recovery (Table 1). For C&D wood in the U.S., 52% (19.1 million tons) is currently recovered, combusted for energy, or not usable, with 48% (17.3 million tons) yet available for recovery (Table 1). *In total, approximately 28.4 million tons of wood (11.1 + 17.3), in MSW and C&D debris streams, is estimated to be available yet for recovery*.

Table 1. Estimates for Wood Waste Recovery in the United States

	MSW Wood Waste	C&D Wood Waste
Recovered for products	35% (12.1 million tons)	52% (19.1 million tons)
Combusted *(e.g., for energy)*	16% (5.5 million tons)	
Not Usable Material	16% (5.5 million tons)	
Yet available for recovery	32% (11.1 million tons)	48% (17.3 million tons)

[1] This report (with updated statistics) relates to a longer investigation of wood reuse and recycling in North America. See Howe et al. 2013, available at: http://www.dovetailinc.org/report_pdfs/2013/wood_reuse_and_recycling/current_state_wood_reuse_recycling_namerica.pdf.

[2] 2,000 pounds = one short ton; unless otherwise noted, all references to tons in this report refer to 'short' tons.

[3] See Tables 7 and 10 for a derivation of the 70.6 million tons.

[4] This estimate is based on updated recovery rates as described in Falk and McKeever 2004.

Since wood is a significant portion of both MSW and C&D waste streams, and since wood can be reused for a host of products (e.g., energy, fiber, or chemical-based), its recovery presents a significant opportunity. Also, since most MSW and C&D waste streams are located near population centers, the opportunity for creating useful consumer products is high (pool of natural resources near markets).

Consequently, there is growing interest in a more complete understanding of the amount and types of MSW and C&D wood waste generated and recovered in the U.S. This information is essential to identifying the barriers and opportunities related to expanding and improving wood reuse and recycling. Unfortunately, precise, reliable, and current data on MSW and C&D wood is difficult to obtain. The data is dispersed among various governmental agencies and universities as well as private companies. Much of the data is not transparent and comes with various assumptions relating to waste definitions, measurement units, and survey formats. This leads to differences in volume estimates between studies.

This report provides an overview on recent research relating to the wood component of MSW and C&D waste streams in the United States. Comparisons are made between different studies and implications arising from differences between these studies are addressed. A summary of MSW and C&D wood recovery in the U.S., and recommendations for the future, are provided.

MUNICIPAL SOLID WASTE

Different Studies Result in Different Estimates for MSW

Currently, there are two often-cited sources (periodically updated) of MSW data in the U.S.—the Environmental Protection Agency (US EPA)[5] (in conjunction with Franklin Associates) and the *BioCycle* magazine/Columbia University Earth Engineering Center.[6] These organizations use different research methodologies resulting in different MSW estimates.

EPA

The EPA uses a *materials flow methodology*, which relies heavily on a mass balance approach.[7] Simply put, this methodology is based on production data (by weight) for the material and products in the waste stream. Using data gathered from industry associations, key businesses, and similar industry sources, and supported by government data from sources such as the Department of Commerce and the U.S. Census Bureau, the EPA estimates tons of materials and products generated, recycled, or discarded.[8] Other sources of data, such as waste characterizations and surveys performed by governments, industry, or the press, supplement these data.

[5] The EPA defines MSW as trash or garbage (from our homes, schools, hospitals, and businesses) that we use and then throw away, such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. (US EPA, 2014a).

[6] The most recent *BioCycle*/Columbia University report used 2008 data. Columbia University conducted its own study in 2013 using 2011 data (see Shin 2014).

[7] EPA MSW Characterization Methodology. See http://www.epa.gov/osw/nonhaz/municipal/pubs/06numbers.pdf.

[8] As done in previous EPA studies, combustion with energy recovery (wood and rubber tires are examples) is tallied as a separate category and not considered as reuse or recycling.

To estimate MSW generation, EPA adjusts production data by imports and exports from the U.S., where necessary. Also, allowances are made for the average life spans of different products. MSW not managed by recycling (including composting) or combustion is presumed landfilled.[9]

In 2012, the EPA estimated that Americans generated about 251 million tons of trash, nearly 4.4 lbs. per person per day.[10] Of this amount, nearly 87 million tons (34.5%) were recycled and composted, with more than an additional 29 million tons (almost 12%) combusted with energy recovery. Discards to landfills and other disposals totaled 135 million tons (54%). See Table 2. (A breakdown of the EPA-estimated wood component in MSW is detailed later in this report.)

Table 2. EPA Estimates of United States MSW Generation, Recycling/Composting, Combustion with Energy Recovery and Discards, 2012.

Year	MSW Generation *(Million tons)*	Recycled/ Composted *(Million tons)*	Combusted with Energy Recovery *(Million tons)*	Landfill (Discards) *(Million tons)*
2012	250.9	86.6	29.3	135.0

BioCycle/Columbia University

BioCycle/Columbia University also use a materials flow methodology for estimating MSW in the U.S. but with a different strategy or approach than EPA (Kaufman and Themelis 2009). Because most states have regulations requiring landfills and waste-to-energy (WTE) facilities to report tons received, *BioCycle*/Columbia University attempts to obtain disposal tonnage reports from the relevant regulatory authorities in each of the 50 states, with quantities expressed in short tons. Although recycling tons are typically not regulated, the same agencies tend to track these figures as well, although these numbers are less reliable than those provided for landfilled and WTE tonnages. Consequently, *BioCycle*/Columbia University conducts a survey of representatives of waste management departments of each state.

In order to allow for an "apples to apples" comparison, *BioCyle*/Columbia University researchers adjust (or attempt to adjust) reported state values to align with the EPA definition of MSW. A follow-up is then made with state officials to clarify misunderstandings and fill in missing data where possible. This iterative process attempts to characterize landfilled and WTE tons fairly accurately; however, questions still remain regarding the accuracy of the tonnage of material recycled.

The most recent joint *BioCycle*/Columbia University survey (using data from 2008) resulted in an estimate **56 percent greater** than the EPA estimate for the same year for total tons of MSW generated (see Table below).

[9] MSW, as defined by the EPA, does not include C&D debris, which is handled separately.

[10] Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2012. See http://www.epa.gov/osw/nonhaz/municipal/pubs/2012_msw_fs.pdf.

Table 3. Comparison of US EPA and *BioCycle*/Columbia University MSW Generation and Management Data (calendar year 2008) (from van Haaren et al. 2010).[11]

MSW Data	EPA/Franklin *(Million tons)*	*BioCycle*/Columbia Univ. *(Million tons)*
Total Generated	249.6	389.5
Total Recovery (recycling, composting, mulch)	82.9	93.8
Combustion with Energy Recovery	31.6	25.9
Discards to Landfills	135.1	269.8

Implications

By nature of their methodology, the U.S. EPA has a good working relationship with industry, and provides a reasonable picture of MSW *composition*. However, some solid wastes, such as food and yard wastes, are not amenable to EPA's material flow model (Tonjes and Greene 2012). *BioCycle*/Columbia University research demonstrates good relations with a network of state waste managers who have direct access to MSW generation and disposal data (Kaufman and Themelis, undated). The *BioCycle*/Columbia University researchers (for the 2008-data year) also note that they have been able to collect data directly from Material Recovery Facilities (MRFs) and compost facilities that are sometimes unwilling to share with government agencies due to privacy and competition concerns.

Other writers (Humes 2012), and the EPA itself, acknowledge that the EPA underestimates the total amount of MSW that is generated annually. One implication is that EPA numbers make it difficult to use the agency's tonnage estimates to plan for actual MSW management in practice (such as size of future landfills or estimates of greenhouse gas emissions). A second implication is that a combined effort (building on the strengths of each) between EPA and *BioCycle*/Columbia University would go a long way to reliably measuring MSW, and ultimately improving waste management practices in the U.S. (Fortunately, a collaborative effort has begun—see Shin 2014). *A third implication, is that underestimation of MSW, or uncertainty in the data, likely underestimates the amount of wood, or other specific materials, in the MSW stream.*

Wood in the MSW Stream

Table 4 highlights the EPA estimate of MSW in 2012. The estimated amount of "wood" in the MSW stream is 15.82 million tons with a total of 2.41 million tons recovered, for a recovery total of 15.2 percent. Yard trimmings, which include an unknown amount of green (wet) wood, are included in the table in a separate category. Also, the recovery amount does NOT include combustion for energy.

[11]As noted in an earlier footnote, 2008 (using data from this year) was the last year that BioCycle magazine participated in the Columbia University study. Consequently, the 2008-data year is the last year a direct comparison can be made with EPA estimates.

Table 4. EPA Estimates of U.S. Generation and Recovery of Materials in MSW, 2012 (in millions of short tons and percent of generation of each material).*

Material	Weight Generated *(Million tons)*	Weight Recovered *(Million tons)*	Recovery as Percent of Generation *(%)*
Paper and paperboard	68.62	44.36	64.6%
Glass	11.57	3.20	27.7%
Plastics	31.75	2.80	8.8%
Rubber and leather	7.53	1.35	17.9%
Textiles	14.33	2.25	15.7%
Wood	15.82	2.41	15.2%
Other materials	4.60	1.30	28.3%
Metals			
Steel	16.80	5.55	33.0%
Aluminum	3.58	0.71	19.8%
Other nonferrous metals**	2.00	1.36	68.0%
Total metals	**22.38**	**7.62**	**34.0%**
Total materials in products	**176.60**	**65.29**	**37.0%**
Other wastes			
Food, other***	36.43	1.74	4.8%
Yard trimmings	33.96	19.59	57.7%
Miscellaneous inorganic wastes	3.90	Negligible	Negligible
Total other wastes	**74.29**	**21.33**	**28.7%**
Total municipal solid waste	**250.89**	**86.62**	**34.5%**

*Source: US EPA 2014; includes waste from residential, commercial, and institutional sources.
** Includes lead from lead-acid batteries.
***Includes recovery of other MSW organics for composting.

A closer look at the "wood" component of the EPA estimate (15.82 million tons) is illustrated in Table 5 below.

Table 5. EPA Estimate of Generation and Recovery of Wood in U.S. MSW, 2012 (in millions of short tons and percent of generation of each product).

Product	Weight Generated *(Million tons)*	Weight Recovered *(Million tons)*	Recovery as Percent of Generation *(%)*
Wood (Durable Goods, e.g. furniture)	6.16	Negligible	Negligible
Wood (Containers and Packaging, e.g. pallets)	9.66	2.41	24.9%
Wood – Total*	15.82	2.41	15.2%

*Total for wood does NOT include combustion.
Table 4 adapted from US EPA 2014, Table 2.
Negligible = less than 5,000 tons or 0.05 percent.

Based on Table 5, wood-based durable goods (like furniture) entering the MSW stream have a near zero (negligible) recovery rate. Wood pallets (and related wood containers) are recovered at a rate of nearly 25 percent, excluding combustion for energy.

Unfortunately, EPA data is not collected in a fashion to allow for the breakdown of specific product categories relating to combustion with energy recovery. Table 6, however, provides EPA data on *all* combustion with energy recovery (which includes pallets and other wood wastes) for the MSW stream over a 52-year period.

Table 6. EPA Estimates of Generation, Materials Recovery, and Combustion to Energy of MSW – 1960 to 2012 (in millions of tons)*

Activity	1960	1970	1980	1990	2000	2012
Generation ***(Million tons)***	88.1	121.1	151.6	208.3	243.5	250.9
Total Materials Recovery ***(recycling and composting)*** ***(Million tons)***	5.6	8.0	14.5	33.2	69.5	86.6
Combustion with Energy Recovery (includes pallets)* ***(Million tons)***	*0.0*	*0.4*	*2.7*	*29.7*	*33.7*	*29.3*

*Table 6 adapted from US EPA 2014, Table 3.
**Includes combustion of MSW in mass burn or refuse-derived-fuel form, and combustion with energy recovery of source separated materials in MSW (e.g., wood pallets, tire-derived fuel)

U.S. Forest Service Estimates

The Forest Products Laboratory, a research unit of the U.S. Forest Service, provides estimates of wood waste including both MSW and C&D material. The Forest Service estimates are "anchored" on EPA estimates and a report (Whittier et al. 1995) on the woody component of yard trimmings.

Table 7 shows the distribution of 2010 MSW in various categories as estimated by the U.S. Forest Products Lab. The values for MSW recovered, combusted and not usable are derived from Falk and McKeever 2004. Values for MSW generated and available for recovery are from Falk, McKeever, and Sawka 2012.[12]

[12] Table 7 values for 2010 woody yard trimmings are presented as a 'green' weight and 'anchored' on 1993 data. Other studies, such as Bratkovich et al. 2011 and Nowak and Crane 2001, present urban tree weights and removals (derived) on a dry basis. Also, if annual urban tree removals average 1.5 percent or greater (based on total volume of the urban forest), then Table 7 likely underestimates the volume (generation) of woody yard trimmings.

Table 7. Forest Service Estimate of MSW Wood Generated, Recovered, Combusted, Not Usable, and Available for Recovery in the United States, 2010. (million metric tonnes/million short tons)*

Source	Generated *(tonnes/tons)*	Recovered *(tonnes/tons)*	Combusted *(tonnes/tons)*	Not Usable *(tonnes/tons)*	Available for Recovery *(tonnes/tons)*
Wood Component	14.4 tonnes / 15.8 tons	1.3 / 1.4	3.2 / 3.5	3.2 / 3.5	6.6 / 7.3
Woody Yard Trimmings**	16.7 / 18.4	9.6 / 10.6	1.7 / 1.9	1.8 / 2.0	3.6 / 4.0
Total MSW Wood	31.1 / 34.2	11.0 / 12.1	5.0 / 5.5	5.0 / 5.5	10.1 / 11.1

* Values may not total correctly due to rounding.
**Woody yard trimmings are about 55% wood and 45% herbaceous material (Falk et al. 2012)

The Forest Service estimate of total MSW wood generated includes *both* the wood component (using EPA data for 2010) and an estimate of woody yard trimmings (not included in the EPA estimate). **Consequently, the Forest Service estimate of 34.2 million short tons (31.1 million metric tonnes) is approximately double the EPA estimate of 15.8 million short tons (over 14.4 million metric tonnes) of MSW wood**.[13] Also, based on the values in the above table, 35% (12.1 million tons) of the wood in the MSW stream is recovered and 16% (5.5 million tons) is combusted for energy with an additional 32% (11.1 million tons) available for recovery.

Also, a 1998 study at Virginia Tech (Corr 2000), involved the Southern Research Station of the U.S. Forest Service, and sampled all state-licensed MSW and C&D landfills in the U.S. (except Alaska). This study found total volumes of MSW (239 million tons) in close agreement to EPA estimates for the same year (220 million tons). The Corr (2000) research estimated MSW landfills were comprised of 10.9% wood waste, up from 7.3% in 1995 (Araman et al. 1997). The 10.9% equates to over 26 million tons which is "in the ballpark" with the Forest Products Lab (Forest Service) 2010 estimate (26 vs. 34.2 million tons).

MSW Recap

The EPA MSW total generation values (tons) are well below the *BioCycle*/Columbia University numbers for the 2008-data year (the *BioCycle* estimates are 56% higher than EPA values). The 2012 EPA estimate (nearly 251 million tons) is also considerably below the Columbia University (Shin 2014) estimate for 2011 (389 million tons). Both EPA and *BioCycle*/Columbia University do not separate the woody component out of their woody yard trimmings category. Also, neither of these data sources includes combustion as either recovered or recycled wood.

The Forest Service estimate uses EPA data as the source for their "wood component" category of MSW. The wood component includes items such as wooden furniture and cabinets, pallets and containers, scrap lumber and wooden panels, and wood from manufacturing facilities. The Forest Service adds to the EPA estimate an approximation of woody yard trimmings and includes an estimate of wood combustion for energy recovery (see Table 8).

[13] As noted earlier, the EPA does NOT attempt to estimate the amount of *wood* in their yard trimmings material category.

The Virginia Tech study (1998 data), is "in line" with both the EPA estimate of total MSW and the Forest Service (Forest Products Lab) estimate of wood waste in the MSW debris stream.

Table 8. Comparison of MSW Estimates for Generation, Combustion, and Recovery from U.S. EPA, Columbia University and U.S. Forest Service (in million short tons).

	EPA (2012 data) ***(million tons)***	**Columbia (2011 data)** ***(million tons)***	**Forest Service (2010)** ***(million tons)***
MSW Generation: Total for ALL Components	250.9	389.5	249.9 *(using EPA 2010 data)*
Wood Component ***(Generation)***	15.82	Unknown	15.88 *(using EPA 2010 data)*
Woody Yard Trimmings ***(Generation)***	Unknown	Unknown	18.4 *(from Table 7)*
Wood Combustion ***(for energy)***	Unknown	Unknown	5.5 *(from Table 7)*
Wood Recovered ***(w/o combustion)***	2.41*	Unknown	12.1** *(from Table 7)*

*Excludes woody yard trimmings.
**Includes woody yard trimmings.

CONSTRUCTION & DEMOLITION

As noted earlier, C&D debris (including C&D wood) is excluded by the EPA in their definition of MSW. *BioCycle* and Columbia University research attempt to adopt EPA definitions; therefore, C&D is also technically excluded from their estimates.[14] Fortunately, the EPA does track C&D debris in a separate effort. The most recent EPA report (2009) is titled "Estimating 2003 Building-Related Construction and Demolition Materials Amounts" (using 2003 data).

EPA

The EPA estimate of C&D (2003 data) is based on national statistical data (U.S.) and typical waste generation during building construction, renovation, demolition or maintenance activities. Recovery estimates rely on 2003 data reported by state environmental agencies.

Table 9 reflects materials generated from *building* projects that occur as a result of normal daily life, not debris resulting from disasters. However, construction materials resulting from *rebuilding* efforts after a disaster are included in the table below.[15]

[14] Both *BioCycle* magazine (in pre-2010 research) and Columbia University (Shin 2014) attempt to exclude C&D debris from MSW studies. However, some C&D debris likely ends up in MSW landfills.
[15] In 2008 the EPA published *Planning for National Disaster Debris*, which discussed tools for forecasting disaster debris generation amounts. See: http://www.epa.gov/osw/conserve/imr/cdm/pubs/pndd.pdf.

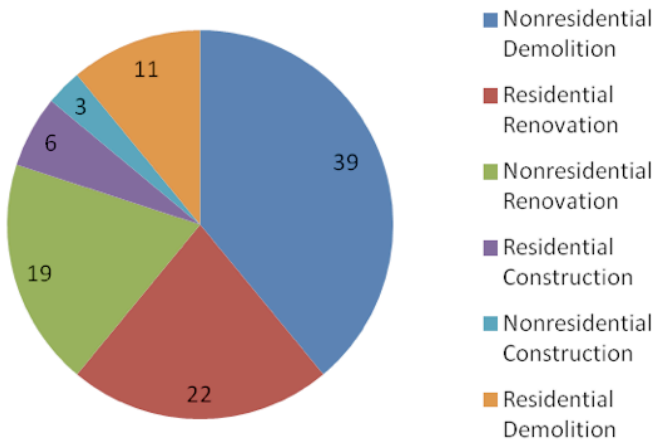
The EPA estimates the amount of C&D building-related materials for 2003 at 170 million tons, with 39 percent coming from residential and 61 percent from nonresidential sources. (As noted below, the Forest Service uses the total volume in the C&D waste stream to estimate the 'wood' component).

Table 9. EPA Estimated Amount of Building-Related C&D Materials Generated in the U.S. During 2003.*

Source	Residential		Nonresidential		Totals	
	Million Tons	*Percent*	*Million Tons*	*Percent*	*Million Tons*	*Percent*
Construction	10	15%	5	5%	15	9%
Renovation	38	57%	33	32%	71	42%
Demolition	19	28%	65	63%	84	49%
Totals	**67**	100%	**103**	100%	**170**	100%
Percent	39%		61%		100%	

*C&D managed on site should, in theory, be deducted from generation. Quantities managed on-site are unknown.
Note: Data rounded to the appropriate significant digits. Data may not add to totals shown.
(Source: U.S. EPA 2009)

Figure 1. Contribution to the C&D Materials Stream by Each Building Sector (per EPA)



Source: U.S. EPA 2009.

Figure 1 provides a percentage breakdown of the six building sectors that generate C&D materials. According to the EPA (2009) the largest sector is nonresidential demolition at 39 percent. Residential and nonresidential renovation materials make up 22 percent and 19 percent, respectively, followed by residential demolition at 11 percent. New construction represents 9 percent of total C&D materials (with the new construction divided between residential construction at 6 percent and nonresidential construction at 3 percent).

The EPA (2009) estimates that 48 percent of the 170 million tons of the C&D materials generated in 2003 were recovered, based on state-reported disposal and recovery data. This is a 23 percent increase from the 1996 estimate (although comparisons should be viewed with caution due to different methodologies in 1996 and 2003).

U. S. Forest Service Estimate of Waste Wood in C&D Materials

The U.S. Forest Service (Falk et al. 2012) estimates the generation of construction and demolition waste wood at 6.7 and 29.7 million tons, respectively, for 2010, for a total of 36.4 million tons *(*33.0 million metric tonnes*)* *(*Table 10). This is based on McKeever (2004), and Falk and McKeever (2004) methodology, and applied to 2010 economic drivers such as housing completions, value of nonresidential construction, and population change. An assumption of the Forest Service estimate is that 28% of the C&D waste stream is wood.[16]

[16] Falk and McKeever 2012, p.31.

Table 10. U.S. Forest Service Estimate of Construction and Demolition Waste Wood Generated, Recovered, Combusted or Not Usable, and Available for Recovery in the U.S., 2010* (million metric tonnes/million short tons)

Source	Generated *(tonnes/tons)*	Recovered, Combusted, Not usable *(tonnes/tons)*	Available for Recovery *(tonnes/tons)*
Construction Waste Wood	6.1 / 6.7	1.7 / 1.9	4.4 / 4.9
Demolition Waste Wood	26.9 / 29.7	15.6 / 17.2	11.3 / 12.5
Total, C&D	33.0 / 36.4	17.3 / 19.1	15.7 / 17.3

*Forest Service estimates based on updated demand drivers and estimated recovery rates.
Source: Falk et al. 2012.

Interestingly (and likely due to the recession), the 2010 construction waste wood estimate (6.7 million tons) is down from 2002 (11.6 million tons) and the demolition waste wood estimate is up (from 27.8 to 29.7 million tons). See Table 11.

Table 11. U.S. Forest Service and EPA Estimates of Construction and Demolition Wood Generated by Various Years and Sources (million metric tonnes/million short tons).

Generation Source	Forest Service, 2002 *(tonnes/tons)*	Forest Service, 2010 *(tonnes/tons)*	EPA, 2003 *(tonnes/tons)*
Construction Waste Wood	10.5 / 11.6	6.1 / 6.7	Unknown
Demolition Waste Wood	25.2 / 27.8	26.9 / 29.7	30.8* / 34.0*
Total, C&D Wood	35.7 / 39.4	33.0 / 36.4	Unknown

*Based on Forest Service assumption from case studies that 40% of demolition materials entering landfills are wood.

Other Studies of C&D Waste Wood

The Virginia Tech research (Corr 2000) estimated total C&D waste for 1998 at 40 million tons. This number, albeit five years earlier, is significantly below the EPA estimate (170 million tons in 2003).

Also, and at the other end of the scale, Cochran and Townsend (2010) estimated total C&D debris in the U.S. in 2002 between 671 and 858 million tons (using a materials flow analysis for ALL sectors including roads, bridges, utilities, etc.). However, in an "apples to apples" comparison with the EPA (building-related C&D debris only) the range was 154 (long service life) to 220 (short service life) million tons. Consequently, the Cochran and Townsend estimate is close to the EPA estimate of 170 million tons in 2003.

C&D Recap

The EPA reports that in 2003 (most recent data) approximately 170 million tons of material was generated in construction, renovation, and demolition projects; however, wood is not separated from other materials in this estimate. The Cochran and Townsend (2010) estimate, using a materials flow analysis, is "in line" with EPA estimates. Virginia Tech research results are significantly less than either

EPA or Cochran and Townsend. *BioCycle* magazine and/or Columbia University does not conduct research on C&D materials. The Forest Service estimates 36.4 million tons of C&D wood material was generated in 2010 with 19.1 million tons (52%) recovered, combusted, or not usable and 17.3 million tons (48%) available for recovery (Table 10).

Total Wood Waste Generation and Recovery

Regardless of the data collection methodology, or the entity conducting the research, there is clearly still a large amount of wood generated; **70.6 million tons is the current best estimate for the MSW and C&D waste streams** (34.2 + 36.4 million) (Tables 7 and 10). **The amount yet available for recovery in these waste streams is also significant at 28.4 million tons** (11.1 + 17.3 million) (Tables 7 and 10).

CONCLUSIONS

The amount of wood – chips, logs, pallets, boards, etc.– in the U.S. waste stream is large. Differences in estimates of wood waste volumes should not distract from the goal of pursuing increased wood recovery from the MSW and C&D waste streams.

Also, as elaborated upon in Howe *et. al* 2013, there are a host of strategies and recommendations to reducing wood waste before it finds its way into waste streams including: (1) funding market (product) development, (2) raising consumer awareness of wood recovery, and (3) encouraging green building (particularly of salvaged products such as flooring and doors). In a personal communication, researcher Phil Araman also noted that in some urban areas there have been companies set up to grind both tree waste and wood construction waste that do not show up in MSW or C&D data. This includes some pallet companies who are accepting some C&D wood waste and grinding it with the pallets they need to grind. Araman stated that, "this could be a way to increase wood recovery in major cities by going through pallet recyclers."

As noted above, the best estimate for a recoverable volume (currently not yet recovered) in the MSW and C&D waste streams is 28.4 million tons. To put this volume in perspective, approximately 90 Combined Heat and Power (CHP) plants the size of the St. Paul, Minnesota, CHP plant (65 megawatts of thermal energy and 25 megawatts of electricity)[17]could be built and operated across the U.S.

Finally, wood recovery from waste streams has many societal benefits. One benefit of using waste wood is that the action has a positive effect on the environment by sequestering carbon and reducing greenhouse gas emissions. A second benefit – although narrower in scope – is a higher wood recovery rate (post-consumer), which leads to a more positive public perception of the forest products sector.

THE BOTTOM LINE

Due to differences in study (report) years, various assumptions on generation and recovery, and differing methodologies and definitions, there are gaps in the 'wood waste data.' This leads to a lack of precision, reliability, and timeliness. The U.S. Forest Service anchors its estimate of the "wood component" for MSW on EPA estimates. Since the EPA estimate might be low (based on the huge difference with the

[17] The St. Paul, MN, CHP plant currently burns approximately 300,000 tons of wood chips per year.

BioCyle/Columbia University estimate), the Forest Service estimate, in turn, could also be low, leading to an underrepresentation of wood in the MSW stream. Also, the Forest Service should use more current estimates (rather than a 1995 report) of urban tree populations and removals to estimate woody yard trimmings.[18]Regardless, U.S. Forest Service (Forest Products Laboratory) estimates remain the best regarding MSW and C&D wood waste generation and recovery in the U.S. This is particularly true due to the Forest Service's inclusiveness of tallying woody materials (yard trimmings) in the waste stream, methodologies for updating past estimates, and timeliness of reporting.

An important finding of the Virginia Tech study was that only 33% of MSW landfills, and only 27% of C&D landfills, had the ability (in 1998) to recover wood (Bush et al. 2001). Although these percentages are likely higher (better) today, low recovery rates at U.S. landfills present a barrier to wood waste utilization.

The U.S. EPA and Columbia University need to collaborate on studies of U.S. municipal solid waste management. The EPA has developed strong partnerships with industry organizations leading to estimates of materials generated, recycled, or discarded; Columbia University (and *BioCycle* magazine in the past) has developed good relationships with a robust network of state waste managers who have direct access to MSW generation and disposal data. By working together (as was done on the Shin (2014) research through Columbia University), the two entities should be able to provide waste managers and policy makers with accurate data on estimates of MSW generation.

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[18] Examples include Bratkovich et al. 2011, and Nowak and Crane 2001.

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