

An Investigation of Wood Pallets Landfilled and Recovered at US Municipal Solid Waste Facilities

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The purpose of this research was to investigate the total number of pallets that end up in landfills in the United States as well as to gain a better understanding of the overall waste stream. This research was conducted by mailing all of the licensed Municipal Solid Waste (MSW) facilities in the continental United States a questionnaire that included the option to complete the survey online. The questionnaire that was sent to the landfills was built upon previous surveys conducted by researchers at Virginia Tech in both 1995 and 1998. The results indicated that an estimated 249 million tons of MSW was received at landfills nationwide. This was an increase from the 239 million tons of MSW in 1998. Only 13.1 million pallets were landfilled in 2016, which was over a 90% decrease from the 138 million pallets landfilled in 1998. At the same time, approximately 15.9 million pallets were recovered, repurposed, or reused at the surveyed MSW facilities, which was a decrease from the 22 million pallets recovered in 1998. The results of this research indicate that fewer pallets are making their way to landfills, and a greater proportion of pallets reaching MSW facilities are being recovered.

Keywords: Municipal solid waste; Wood pallets; Wood waste; Recycling

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INTRODUCTION

Municipal solid waste (MSW) is waste that has been generated by private residents, commercial businesses, restaurants, and public institutions such as schools and hospitals. The category does not include industrial, hazardous, or construction waste (United States Environmental Protection Agency 2016). Several organizations study the waste stream to gain a better understanding of the landfilling and recovery rates of certain materials. This information can be used to understand the effectiveness of recycling programs, the impact of waste regulations, and to predict waste generation rates in the future. The United States Environmental Protection Agency (EPA) utilizes material flow methodologies based on data provided by the U.S. Department of Commerce and trade organizations to quantify the materials and products that are being generated. This number is then adjusted to consider a variety of factors such as product lifetime, diversion, recovery rates, and imports/exports. The most recent EPA study estimated that 258.5 million tons of MSW was generated in 2014 (United States EPA 2016).

Other studies have relied on different methodologies or communicating directly with MSW facilities or state government waste agencies. Those studies resulted in estimates that were different than the EPA's estimates. For example, after the Earth Engineering Center (EEC) at Columbia University collected information from state waste management agencies, they estimated that 389 million tons of MSW was generated in

2013, which is over 100 million tons higher than the EPA's estimate for the same year (Themelis 2014). However, not all of the waste in the EEC's study was landfilled; much of it was recycled, composted, or incinerated before being buried in the landfill. The EEC report found that 29% of the MSW generated was either recycled or composted, 7.6% was sent to waste-to-energy (WTE) facilities, and only 63.5% was actually landfilled (Themelis 2014). It is important to further understand the type and amount of waste that is being produced, so efforts to minimize landfill volume through diversion techniques can be maximized.

One such instance is the case with wood pallets. It is estimated that 513 million pallets are produced each year and that there are 2.6 billion in use at any given time throughout the United States (Freedonia Group Inc. 2015; Gerber 2018). Several sources have estimated that 90 to 95% of all pallets are wooden pallets (White and Hamner 2005; Trebilcock 2013; Freedonia Group Inc. 2015). The manufacturing of pallets consumes more hardwood lumber than flooring, furniture, millwork, and cabinets combined (Johnson and Caldwell 2014). Historically, not much attention is paid to the end of life scenario. Once pallets reach the end of their useful service lives, many of them are presumably disposed of.

However, beginning in the 1990s, a movement began in the industry as operators saw the opportunities and the inherent value of untreated wood pallets. Pallet components are replaceable, so damaged pallets can be repaired and used again in the marketplace. Alternatively, heavily damaged pallets can be dismantled into their individual components, and then used in the repair of other pallets or constructed into a completely remanufactured pallet. This practice became increasingly popular, and the number of pallets sent to repair firms increased from 143 million in 1995 to 326 million in 2011 and has stayed consistent thereafter (Bush and Araman 2013; Gerber 2018).

Furthermore, when a pallet reaches the end of its useful lifespan, pallet recovery operations grind and sell biodegradable materials as mulch, animal bedding, or feedstock for biofuel. This practice is mirrored by MSW facilities that actively separate wood pallets from other MSW arriving at landfills. There were 32 million pallets recovered at MSW landfills in 1995 and 22 million in 1998 (Bush *et al.* 2001). Landfills that recover wooden pallets indicate a wide variety of uses: giving them away to residents, using them "as-is" for operations, grinding them into mulch to be sold or given away, used as material for composting, or for use within the facility as a road base or daily cover. Keeping pallets out of landfills helps to reduce the demand for virgin pallet lumber and to preserve landfill space while also generating economic activity. Despite this activity, research from Virginia Tech indicated that pallets made up 1.5% and 2.8% of all MSW landfilled by weight, in 1995 and 1998, respectively (Bush *et al.* 2001).

It has been several years since the previous study was performed to understand the amount of wood pallets entering MSW landfills. With the maturing of the recycling industry and the ongoing separation of wood pallets by MSW facilities, this study intended to reevaluate the effect of these practices on the volume of wood pallets entering landfills.

EXPERIMENTAL

This research utilized a 19-item questionnaire that was developed to help collect information about waste management from MSW facilities in the United States for the year 2016. Question types consisted of numerical responses, open-ended questions, closed-

ended multiple choice questions, and partially closed-ended questions containing an “other” option.

A mailed questionnaire with the option to complete it online was chosen as the main method of data collection. This method provided the ability to reach a diverse sample population at a low cost while still allowing time for the respondents to gather the necessary data to fill out the questionnaire (Dillman 2009). The design and content of the questionnaire were modeled after previous surveys conducted by researchers at Virginia Tech in 1995 and 1998 that investigated the same primary research topics. However, the wording and style of several of the questions were changed to be compatible with the online survey and/or in an attempt to improve the analysis based upon the recommendations for future research provided by the respondents of the previous surveys. The structure of this questionnaire followed a sequential development; it started by asking general questions about facility characteristics, waste received and landfilled, and tipping fees. It then moved on to the landfilling and recovery of wood and wood pallets. The types of waste received by the facilities were divided into four categories including normal waste landfilled, normal waste recovered, wood landfilled, and wood recovered. The wood waste categories were further divided into the following categories: pallets, crates, construction related wood, treated wood, yard waste, and other.

When deciding where to mail this questionnaire, MSW facility selection was based upon the state legislation of landfill classifications through information largely available in the public domain. Because most landfills are required to have permits, databases of permitted facilities are commonly published online by state regulatory agencies. Facility classification methodology can vary from state to state depending on the respective regulations around facility operating permit issuance. Thus, it was important to first delineate each state's classification scheme to determine which facilities to include in the sample population. Facilities that were included in this research study were chosen based on their matching the general description of a municipal solid waste facility as defined by the U.S. EPA. Hawaii and Alaska were not included in this research study due to the fact that their population characteristics were inconsistent with the continental United States (Bush *et al.* 2001). Before removing the facilities that indicated that they did not receive MSW from the list, the sample population consisted of 1,385 facilities.

The questionnaires were mailed in June of 2017 through the physical mail system to addresses compiled from state population databases along with the cover letter and prepaid, addressed return envelopes. A link was provided in the cover letter that offered the recipients the opportunity to fill out the survey through Qualtrics (Provo, UT, USA), an access-restricted, online-survey, software company. A temporary website was created at ‘www.vtlandfillsurvey.org’ to provide an easily accessible link to the Qualtrics survey. Each questionnaire had a unique identifier that allowed the recipients to gain one-time access to the online survey. A postcard was sent 10 business days after the initial questionnaire was mailed, reminding the facilities to fill out the survey. Then, 10 days after mailing the postcard, a second copy of the same questionnaire was sent to the facilities who had not yet returned a response. If email addresses were able to be found for any of the non-responding facilities, two reminder emails were sent out using MailChimp’s email distribution system (Atlanta, GA, USA) after the second mailed questionnaire.

Facilities were grouped into four regions, using the methodology of the U.S. Census Bureau, to help provide a higher level of detail and to allow comparison to the research studies from previous years. To extrapolate the facility results into a national estimate, several steps were taken to analyze the data. The mean facility tonnage was based only on

the facilities that responded to both questions number two and four. This mean was then multiplied by the total number of facilities to determine a national estimate. Each of the individual categories in question four were then summed together and divided by the total waste accepted by the respondents of question four to find the percentage of waste by category for all facilities. These percentages were applied to the national total waste estimate that had been calculated to determine total waste by category. These sums for each category were then compared by region to determine the percentage of waste per category for which each region was responsible. The percentage that each region made up of the total for all regions was multiplied by the total waste for each category to determine the amount of waste per category by region. This same methodology was followed for questions nine and eleven.

To determine the amount of wood landfilled and recovered by category, the same methodology was followed. All responses from the category of waste were added together, and the percentage of the total wood landfilled or recovered by the respondents was determined by dividing the sum total of categories by a particular category, for example, pallets landfilled. To determine the national total, the percentage of each category was multiplied by the total wood waste landfilled or recovered, which was reported in question four.

Non-response Bias

After the survey was completed, the nonresponding facilities were contacted to see whether there was a bias among the facilities that completed the survey compared to those that did not. Facilities were asked if the majority of the waste they received was MSW and to report the total tonnage of MSW received in 2016. Wilcoxon Signed Rank Test, the non-parametric version paired the student's t-tests using a $\alpha = 0.05$ significance level was used to compare the two populations using JMP[®] software (version 12, SAS Institute Inc., Cary, NC, USA).

RESULTS AND DISCUSSION

MSW Response Rate and Distribution

Overall, there were 1,385 MSW facilities surveyed, but 42 of the facilities indicated that they did not accept MSW. The adjusted population size was 1,343; the breakdown shows 106 in the Northeast, 525 in the South, 327 in the Midwest, and 385 in the West. The questionnaire received 173 responses resulting in a 12.9% response rate (14.2% from Northeast, 12.4% from South, 11.6% from Midwest, and 14.3% from West).

One simple test for skewness is to compare the median to the mean. With a mean of 185,077 tons and a median of 71,690 tons, the data were right-tail skewed. Similar distribution skewnesses were found in nearly every question's responses except for the question regarding tipping fees. This pattern indicated that there were more small facilities than large ones. Literature supports this hypothesis. In 2016, the Environmental Research and Education Foundation (EREF) found that 33% of landfills receive the majority of all waste (EREF 2013).

Mean Waste Received per Facility and Total Tonnage

The mean amount of waste received at each MSW facility in 2016 was 185,077 tons. This was an increase from the Virginia Tech studies of 1995 and 1998, which estimated 103,000 tons and 138,400 tons, respectively (Corr *et al.* 2000).

In 1976, the Resource Conservation and Recovery Act (RCRA) made building landfills more capital intensive and subjected them to more regulation. In 1993, amendments were made to the RCRA Subtitle D, which required all active municipal solid waste landfills to make expensive technological improvements to their facilities or exit the market by 1995 (Tomarelli 2008). In response, solid waste management companies started to build “mega-dumps” that utilized economies of scale for larger construction, longer lifespan, and greater service areas to reduce costs (Palmer 2011). Facilities that were previously unregulated often did not want to transition their facilities to meet the new requirements. This is shown by the decreasing number of landfills in the United States, which went from 2,829 in 1995 to 1,669 in 1998 and to 1,343 MSW facilities in 2016 (Corr *et al.* 2000). Although the total amount of waste generated decreased from 1995 to 2016 by 15%, the number of facilities decreased over 52%. This means that each facility is now capturing a larger portion of the total amount of waste generated (Corr *et al.* 2000).

When analyzed regionally, facilities in the South received a mean of 235,228 tons, which was over 9% more waste than the facilities in the Northeast that received the second highest amount of waste at 215,708 tons. Facilities in the West received a mean of 156,403 tons of waste, and facilities in the Midwest received the lowest amount of waste with a mean of 126,556 tons (Table 1). The Midwest also had the lowest amount of waste received per facility in both 1995 and 1998 at 73,200 tons and 109,500 tons, respectively. Facilities in the South received the most waste out of all of the regions in 1995 and 2016, while facilities in the Northeast received the most waste in 1998.

Table 1. Year-to-year Comparison of Mean Tonnage of Waste Received Per MSW Facility by Region for 1995, 1998, and 2016

	1995 (Tonnage)	1998 (Tonnage)	2016 (Tonnage)
All Regions	103,300	138,400	185,007
West	107,100	145,400	156,403
Midwest	73,200	109,500	126,556
Northeast	97,500	182,000	215,708
South	119,000	151,600	235,228

Facilities in all regions saw an increase in the mean tonnage of MSW received from 1995 to 1998 and from 1998 to 2016. However, the rate of increase varied regionally, possibly due to the differences in economic conditions, living standards, urbanization, and population (Kawai and Tasaki 2015). Additionally, every state has different landfill regulations, available space, and varied public response to the construction of new landfill sites. In 2011, Slate writer Brian Palmer found that Arkansas reported that it had over 600 years of landfill capacity available while Rhode Island and Massachusetts reported having less than 12 years capacity (Palmer 2011).

Smaller, highly populated states do not have as much land available, and they often resort to shipping their waste across state lines. For example, Virginia has private sanitary landfills that accepted several million tons of waste from other states in 2006. Shipping waste away from the source results in less being recorded where it was generated and more being recorded in the region that received it.

In 2013, it was estimated that approximately 90% of the waste received at landfills was generated within the state, and the remaining 10% was shipped across state lines (EREF 2013). The total estimate of waste received at MSW landfills nationally in this study was 248.6 million tons, representing an increase from 1998 (238.9 million tons) but a decrease from 1995 (293.0 million tons) (Table 2).

Table 2. Virginia Tech Estimates of Total Waste Received at MSW Facilities in the United States Along with the Number of MSW Facilities in 1995, 1998, (Corr *et al.* 2000) and 2016

	1995	1998	2016
Number of MSW Facilities	2,829	1,669	1,343
Virginia Tech (Total Waste Received) (Million Tonnage)	293.0	238.9	248.6

The 248.6 million tons of total waste landfilled in 2016 is close to the USEPA's most recent estimate of 258.5 million tons in 2014 (United States Environmental Protection Agency 2016). The historical results of the Virginia Tech and EPA methodologies were also similar. In 1998, the EPA estimated 223 million tons and the Virginia Tech study estimated just under 239 million tons. Meanwhile, in 1995, the EPA's estimate was 217 million tons and Virginia Tech's estimate was 293 million tons. Although, the numbers look similar, it is important to mention that the EPA estimated a total waste using a material flow methodology while Virginia Tech surveyed the waste that was received by landfills.

Received Waste by Category

Municipal solid waste facilities were asked to provide a breakdown of the types of waste received. The questionnaire included four options for types of waste received: (1) normal waste landfilled, (2) normal waste recovered, (3) wood landfilled, and (4) wood recovered. "Normal waste landfilled" included all types of MSW that were not either wood or recovered normal waste. "Normal waste recovered" was defined as any waste accepted by the facility that was not buried directly in the landfill, implying that it instead went through a recovery operation such as recycling, incineration, or composting. "Wood landfilled" was all wood, treated wood, wood products, woody yard waste, pallets, wooden packaging/crates, and wood from the construction and destruction of structures that was buried in the landfill. "Wood recovered" encompassed all the same categories as "wood landfilled" (except treated wood), but this wood went through recovery/recycling instead of being buried. The "wood landfilled" and "wood recovered" numbers utilized the mean tonnage received at each facility. The total national estimates for tonnage in each category were calculated by the percentage that the category made up of the total waste. The results to this question are presented in Table 3.

Table 3. Mean Waste and Total National Waste Received at Each MSW Facility by Category - Including Percent, by Category, of Total Waste Received at Landfills

Waste Category	Mean Waste Received Per Facility (Tonnage)	Total National Waste Received at Landfills (Tonnage)	Percent of Total National Waste Received at Landfills
Normal Waste Landfilled	156,994	210,842,000	84.83%
Normal Recovered	5,598	7,517,000	3.02%
Wood Landfilled	14,896	20,006,000	8.05%
Wood Recovered	7,590	10,193,000	4.10%

Landfilled Normal Waste

Overall, the amount of “normal waste landfilled” made up the largest portion of total waste received at 84.8%. Each facility received a mean of 156,994 tons of “normal waste landfilled” (Table 3). In 2014 the EPA estimated that approximately 52.6% of normal waste was landfilled (United States EPA 2016). This is significantly different from the results of this study. However, the EPA methodology considers all waste that was generated; this study only investigated the waste that arrived at landfills. Much of the EPA’s estimated total waste was actually diverted from the landfill prior to arrival. Another cause of this inflation may be that this study did not include an “other” options for separating out waste that is not MSW but that the surveyed facilities still processed and landfilled. “Other” types of waste include fly ash and treated sewage both of which the EPA would not consider in their estimates of MSW generated, but these types of waste could have been included in responses from the facilities in this study. This happens because many facilities are permitted to accept a wide variety of waste including, but not limited to, MSW. However, the “other” option was not included, in an effort to keep this questionnaire consistent with the previous Virginia Tech surveys.

As a regional total, the South had the highest amount of normal waste at 89.4 million tons while the West had the second highest amount with 63.1 million tons (Table 4). The Midwest and West landfilled 32.9 million and 25.4 million tons of normal waste, respectively.

Table 4. Mean Normal Waste Landfilled Per MSW Facility in 2016 by Region

	Mean Normal Waste Landfilled Per Facility (Tonnage)	Total Normal Waste Landfilled (Tonnage)
All Regions	156,994	210,842,000
Midwest	119,163	32,912,000
South	191,409	89,443,000
Northeast	176,907	25,431,000
West	118,572	63,056,000

Normal Waste Recovered

A total of 7.5 million tons of normal waste was recovered at MSW facilities within the United States in 2016 (Table 5). This number was significantly lower than the EPA's estimate of 89 million tons of recovered MSW and an additional 33 million tons combusted with energy recovery (United States EPA 2016). This was likely because questionnaires were not sent to Material Recovery Facilities (MRF) or transfer stations. Transfer stations often sort and send waste to MRFs. A MRF is a special type of transfer station that separates, processes, and consolidates recyclable materials for shipment to recovery facilities instead of landfills or other disposal sites (United States EPA 2002). Regionally, the South and the West captured over 82% of recovered normal waste at 3.1 and 3.0 million tons, respectively. The Northeast and the Midwest recovered 775,740 and 631,826 tons, respectively.

Table 5. Mean Normal Waste Recovered Per MSW Facility by Region

Region	Mean Normal Waste Recovered per Facility (Tonnage)	Total Normal Waste Recovered (Tonnage)
All Regions	5,598	7,517,000
Midwest	2,287	631,826
South	6,609	3,089,000
Northeast	5,396	775,740
West	5,681	3,021,000

Wood Landfilled

Overall, approximately 86.3% of MSW facilities accepted wood waste for landfilling in 2016. The Midwest, with 96.8% of their facilities accepting wood waste for landfilling, had the fewest restrictions, while the Northeast, with only 75% of their facilities accepting wood waste, had the most stringent. The South and West only accepted 89.5% and 82.5%, respectively.

The mean amount of wood waste landfilled per facility was 14,896 tons (Table 6). This is equivalent to approximately 8% of all waste (Table 7) and it was a 26% increase from the 1998 mean of 11,820 tons (Table 6). When the data were analyzed by region, landfills in the South, with a mean of 32,250 tons of wood waste landfilled per facility (which is 13.2% of all MSW received in the region), had the greatest amount of wood waste landfilled per facility. Facilities in the South received more on average waste than any other region in 2016, and the same trend holds for wood landfilled. The South also had the greatest proportion of all waste received being landfilled wood waste (Table 7). The West had the second highest mean of wood waste landfilled with 5,974 tons, and facilities in the Northeast received a slightly lower mean of 5,960 tons. Facilities in the Midwest landfilled a mean of 3,610 tons of wood waste, which made up just 2.9% of all waste received. When compared historically, all regions, except the South, experienced a large decrease in the mean amount of wood waste landfilled per facility. Out of the 20 facilities that landfill the most wood waste, 10 were in the South. These results indicate that the typical facility in the South receives more waste overall, and they landfill the greatest proportion of it.

Table 6. Mean Wood Waste Landfilled Per MSW Facility in 1995, 1998, and 2016

	Mean Wood Waste Landfilled Per Facility (Tonnage)		
	1995	1998	2016
All Regions	9,980	11,820	14,896
Midwest	5,939	7,600	3,610
South	11,127	14,700	32,250
Northeast	7,110	21,650	5,960
West	12,648	9,500	5,974

When compared to the historical values, the amount of wood waste landfilled as a proportion of total waste received at each facility decreased from 1998 in all regions except the South (Table 7). The Northeast saw the greatest reduction; their mean percentage dropped from 11.5% in 1998 to 3.2% in 2016.

Table 7. Percent of Overall Waste Received that was Landfilled Wood Waste in 1995, 1998, and 2016

	Percent of the Overall Waste Received that was Landfilled Wood		
	1995	1998	2016
All Regions	7.30%	10.90%	8.04%
Midwest	8.00%	8.90%	2.85%
South	6.00%	11.30%	13.16%
Northeast	6.60%	11.50%	3.15%
West	7.30%	12.20%	4.28%

Nationally, the total amount of wood waste landfilled in 2016 was approximately 20 million tons, which was a decrease from the estimates of 28.2 million in 1995 and 20.8 million in 1998 (Table 8). These results indicate that the overall amount of wood waste being landfilled in the continental United States has been trending downwards since 1995. Either less wood waste is being generated overall, or it is being diverted to other uses. The EPA estimated that a total of 11 million tons wood waste was generated, which is lower than the estimate of this study by approximately 9 million tons. One possible reason for this is that the EPA separates their estimates for wood waste from yard trimmings. When their estimates for the categories of yard trimmings and wood waste are combined, the total is approximately 21.8 million tons, which is much closer to this study's estimates (United States Environmental Protection Agency 2015). When compared to the Virginia Tech studies of previous years, the total 20 million tons of wood waste landfilled in 2016 shows a slight decrease from the previous estimates of 28.2 million tons in 1995 and 20.8 million tons in 1998 (Table 8).

Table 8. Total Wood Waste Landfilled by Region at MSW Facilities in 1995, 1998, and 2016

	Total Wood Waste Landfilled (Tonnage)		
	1995	1998	2016
All Regions	28,220,000	20,840,000	20,006,000
Midwest	3,154,000	3,025,000	997,112
South	11,780,000	10,422,000	15,070,000
Northeast	3,107,000	3,659,000	856,806
West	10,179,000	3,734,000	3,082,000

Regionally, the South landfilled 15.1 million tons of wood waste; this was 3.9 times higher than the West, which was the region with the second most amount of wood waste landfilled at just under 3.1 million tons (Table 8). In each of the past studies, the South landfilled the highest amount of wood, and it was the only region that had an increase in the amount of wood landfilled from 1998 to 2016. As previously discussed, the South contains some of the largest MSW facilities in the country, and it also has the highest number of landfills when compared to the other regions, which is why it has landfilled over 75% of the total national wood waste.

MSW Tipping Fees

Table 9 shows the mean tipping fees per ton, by region, for normal MSW, recovered wood and brush, and recovered pallets. The overall mean tipping fee for normal MSW in 2016 was \$49.92 per ton. Facilities in the Northeast charged the highest rates at \$61.83 per ton. This is likely because available landfill space in the Northeast is at a premium. The Northeast also has the lowest tipping fees for recovered wood and brush at \$23.94 per ton. Because of the desirability of keeping waste out of the landfills when space is limited, it makes sense that facilities in this region promote recovery. This study found that the Northeast region has the lowest percentage of facilities accepting wood waste for landfilling.

Table 9. Mean Tipping Fees in US Dollars (USD) Per Ton by Region for Normal MSW, Recovered Wood and Brush, and Recovered Pallets

	Normal MSW (\$/Ton)	Recovered Wood and Brush (\$/Ton)	Recovered Pallets (\$/Ton)
All Regions	\$49.92	\$30.73	\$33.62
Midwest	\$46.59	\$27.07	\$29.00
South	\$47.23	\$34.32	\$36.36
Northeast	\$61.83	\$23.94	\$41.00
West	\$50.96	\$29.98	\$30.21

When compared to historical values that have been adjusted to present values using the Consumer Price Index (CPI) of January 2016, the mean price of recovered wood and brush decreased from \$35.97 per ton in 1998 to \$30.73 per ton in 2016 (Table 10). The South had the highest tipping fees for recovered wood and brush. A possible explanation

for this may be that there is plenty of space in landfills in this region; therefore, they do not need to incentivize recovery. The reason that mean tipping fees for recovered wood and brush are higher than the mean tipping fees for recovered pallets in all regions is because many facilities do not have special rates for pallets, and thus they end up with the same rate as normal waste.

Table 10. Mean Tipping Fees in USD Per Ton for Recovered Wood and Brush Received at MSW Facilities in 1995, 1998, and 2016

	Mean Tipping Fee for Recovered Wood and Brush at MSW Facilities (\$/Ton)		
	1995	1998	2016
All Regions	\$36.78	\$35.97	\$30.73
Midwest	\$29.48	\$33.89	\$27.07
South	\$37.57	\$35.94	\$34.32
Northeast	\$51.17	\$49.53	\$23.94
West	\$31.02	\$33.19	\$29.98

Note: Historical values were adjusted using the CPI from January 2016

Wood Landfilled by Category

The MSW facilities that indicated, in question 4, that they landfilled wood waste were asked to estimate the breakdown of all wood waste landfilled into six different categories including: pallets, crates, construction related wood, treated wood, woody yard waste, and an “other” category meant for any wood waste received that could not be included in the other five categories. Of the 86.3% of facilities that landfilled wood waste, the mean tonnage of wood waste landfilled was 14,896 tons. The mean tonnage of each category per facility is presented in Table 11.

Table 11. Mean Tonnage and Percentage of Wood Waste Landfilled by Category Per MSW Facility In 2016

	Wood Waste Landfilled (%)	Mean Wood Waste Landfilled (Tons)
Pallets	1.80%	267
Crates	2.74%	407
Construction Related Wood	55.22%	8,225
Treated Wood	17.40%	2,591
Yard Waste	15.8%	2,354
Other	7.05%	1,050

Overall, construction-related wood made up the greatest portion of wood waste landfilled. Each facility landfilled a mean of 8,225 tons, which was equivalent to 55.2% of all wood waste landfilled. Regionally, the South and the Northeast had the highest amounts of this type of wood waste with 18,326 tons and 5,070 tons per facility, respectively (Table 12). The Midwest and the West reported lower values in this category of wood waste at 2,173 tons and 1,715 tons per facility, respectively. This highlights one of the common problems with attempting to quantify waste streams. It is possible that the construction-related wood waste being reported by MSW facilities should be classified as Construction

and Demolition (C&D) waste. Theoretically, this waste should be disposed of at different facilities or least quantified separately. While this does not cause a problem in methodologies that utilize facility-based data, it may be one of the main reasons that many of this study's estimates do not agree with the EPA estimates. A material flows method for MSW would not take C&D waste into account, and this mixing of waste streams could explain why several estimates from surveying the landfills directly were higher. The mixed nature of construction related debris makes it difficult to sort and process and/or it may not be as convenient for contractors to take it to a C&D facility.

Treated wood waste makes up the second largest portion of all wood waste landfilled with the facilities surveyed landfilling a mean of 2,571 tons per facility (Table 12). The South, with a mean of 5,742 tons per facility, was much higher than the other regions. Treated wood poses a challenge for some landfills because it is generally undesirable to have treated wood in mulch piles. While it is not classified as hazardous waste, many states have separate disposal sites for treated wood and prohibit the open burning of it (Connecticut Department of Energy and Environmental Protection 2017).

The mean tonnage for yard waste landfilled in all regions was 2,354 tons per facility. This was highest in the South and the West, with their facilities reporting means of 4,423 tons and 2,370 tons per facility, respectively. This was in stark contrast to the Northeast and the Midwest that reported a mean of 70 and 69 tons per facility, respectively. Regions with a lack of landfill space often develop curbside pickup programs to help divert this type of waste from being landfilled. Woody yard waste should be relatively easy to recover because it usually lacks metal fasteners and contaminants, so it could represent an opportunity to divert more wood waste from landfills.

Table 12. Regional Breakdown of Tons of Wood Waste Per MSW Facility that Landfilled Wood in 2016

Waste Type	All Regions	Midwest	South	Northeast	West
Pallets	267	190	513	186	37
Crates	407	182	817	149	164
Construction Wood	8,225	2,173	18,326	5,070	1,715
Treated Wood	2,591	567	5,742	215	1,275
Yard Waste	2,354	69	4,423	70	2,370
Other	1,050	429	2,373	271	233

Participants were also provided an "Other" category to account for any wood waste that was not included in one of the other categories. This "Other" category included wood products such as furniture and wood from various types of projects and activities. Facilities tracking wood waste in the South indicated that they landfilled a mean of 2,373 tons of "other" wood waste. Facilities in the Midwest, Northeast, and West reported much lower mean tonnages. Despite this, the tonnage of "other" wood waste was still higher than the pallets and crates categories of wood landfilled.

Overall, 75.8% of all MSW facilities indicated that they accepted pallets for landfilling in 2016. Over 90.3% of facilities in the Midwest indicated that they landfilled pallets. This was the highest of any region. Conversely, only 66.7% of facilities in the Northeast indicated that they landfilled pallets (Table 13). The number of facilities

landfilling pallets increased from 67.9% in 1995 to 83.7% 1998, but decreased to 75.83% by 2016. The increase from 1995 to 1998 could be explained by the enhanced facility requirements that the RCRA implemented in that time period.

Table 13. Percentage of MSW Facilities Accepting Pallets for Landfilling in 2016 by Region

	MSW Facilities Accepting Pallets for Landfilling		
	1995	1998	2016
All Regions	67.90%	83.70%	75.83%
Midwest	71.00%	86.80%	90.32%
South	63.60%	83.80%	76.79%
Northeast	55.90%	67.40%	66.70%
West	77.30%	86.10%	77.78%

Facilities that did not accept pallets for landfilling were given the opportunity, on the questionnaire, to explain why they do not or cannot. Respondents commonly indicated that they separate pallets to send them to a recovery area where they can be ground up, which is a desirable result. Several states, such as North Carolina, have bans on the landfilling of pallets. Grinding up the pallets saves landfill space, and some facilities indicated that by mixing it with other materials, such as bio-waste coming from the waste treatment plant, they achieve 40% greater compaction.

Each MSW facility that indicated they landfilled wood waste reported a mean of 267 tons of pallets per facility in 2016 (Table 14). Regionally, the South landfilled the highest mean tonnage of pallets per facility in 2016 at 513 tons. This was a decrease from the 1998 estimate of 1,535 tons and the 810 tons in 1995. The mean tonnage of landfilled pallets per facility in the South was 170% higher than the mean tonnage reported by facilities in the Midwest, which was the region with the second highest mean tonnage of pallets landfilled.

When compared to the results of previous Virginia Tech studies, 267 tons of pallets landfilled per facility was a 78.9% decrease from the 1,269 tons landfilled per facility in 1995 and a 76.9% decrease from the 1,158 tons of pallets landfilled in 1998. Facilities in all regions saw large decreases in the mean tonnage of pallets landfilled compared to the previous studies (Table 14).

Table 14. Mean Tonnage of Pallets Landfilled Per Facility in 1995, 1998, and 2016 by Region

	Mean Number of Pallets Landfilled Per MSW Facility by Region (Tonnage)		
	1995	1998	2016
All Regions	1,269	1,158	267
Midwest	1,322	663	190
South	810	1,535	513
Northeast	961	1,354	186
West	1,357	949	37

There were 13,095,000 pallets landfilled throughout the United States in 2016 (Table 15). This number was calculated by taking the percentage of total waste received that was pallets landfilled indicated by each respondent and multiplying it against the total waste generated. Then, the total landfilled pallet weight was divided by 50 lbs, which is an approximate weight of a 48 inch \times 40 inch standard wooden pallet, to calculate the number of pallets. Geber estimated that there were 513 million new pallets and 326 million repaired or refurbished pallets produced by pallet manufacturers and recyclers in 2016 in the United States (Gerber 2018). Therefore, the 13 million pallets landfilled represent only 1.6% of the total pallets produced in the United States in 2016.

Municipal solid waste facilities in the South landfilled over 9.2 million pallets, which was equivalent to 70.8% of all pallets landfilled in the United States in 2016. The Midwest and the Northeast had the second and third highest concentrations at 2 million and 1 million pallets, respectively. The West landfilled just 753,379, which was equivalent to just 5.8% of all pallets landfilled nationally. Clearly, the South landfills more pallets than any other region.

There are several possible explanations for this finding. Firstly, the South has more landfills that are also larger on average. This means more wood pallets could be flowing to them. Landfills in the South have abundant space and often import waste from outside states. This could lead to more wood pallets being sent to them and also makes it possible to keep low tipping fees for landfilling. These low tipping fees may deter customers from separating pallets from other waste before it is brought in to the landfill. Regional differences in economic activity that generate pallet waste could also cause a large difference between regions. For example, there are a high number of seaports in the South, which could lead to more pallet waste being generated in the transportation, loading, and unloading of goods shipped in and out of the region.

Table 15. Total Number of Pallets Landfilled in the United States in 2016 at MSW Facilities by Region

Total Number of Pallets Landfilled by Region			
	1995	1998	2016
All Regions	152,745,000	138,360,000	13,095,000
Midwest	26,490,000	28,910,000	2,032,000
South	90,215,000	40,180,000	9,274,000
Northeast	10,560,000	12,440,000	1,036,000
West	25,480,000	56,800,000	753,379

The results represent a sizable decrease in the number of pallets landfilled since the previous surveys were conducted in 1995 and 1998. It was estimated that 152.8 million pallets were landfilled in 1995 and 138.4 million in 1998 (Table 15). The findings of the current study indicate that there was a 90.5% decrease in the number of pallets being landfilled since 1998.

The decrease in the number of pallets landfilled can be attributed to several factors. During the challenging economic conditions brought about by the 2008 recession, businesses started looking for ways to save money. The amount companies were spending

on purchasing pallets received increased awareness. Thus, reusing pallets, selling them to recyclers, and buying recycled pallets all became strategies to help companies save money within their supply chain. In 2016, 326 million wooden pallets were recycled by pallet repair companies (Gerber 2018). This suggests that more pallets are being sent to pallet repair facilities, which are often operated by landfills, before they ever go to the landfill. This represents a major reason why fewer pallets went to landfills in 2016 than in previous years. In addition, several states have implemented bans on landfilling wood or pallets since the previous 1998 study. For example, North Carolina no longer allows pallets to be landfilled (Buehlmann *et al.* 2009). Another factor contributing to the decrease in landfilled pallets is the cultural shift towards a more intense emphasis on sustainability. This may have led to more pallet users taking the effort to separate pallets before bringing their waste to landfills. Overall, people are recognizing that pallets in nearly any condition still have value, and they can become a source of personal income or a cost savings within an organization. If pallets cannot be sold to pallet recyclers, such as in the case of small quantities or odd sizes of pallets, pallet recyclers recommend finding companies that produce mulch, looking on Craigslist to find pallet scavengers, or using old pallets in bonfires because of their low moisture content (Gruber Pallets 2017). Instead of being viewed as a disposable commodity, people are taking steps to extend the lives of pallets far beyond the purpose for which they were initially built. This can even include the use of discarded pallets for home improvement, crafting, or for reuse in new construction, such as wall paneling for coffee shops and breweries.

Wood Recovery

Over 62.4% of MSW landfill facilities in the United States operated recovery areas in 2016, and an additional 5.1% plan on adding this capability within the next two years. When analyzed regionally, most facilities operated wood recovery areas in the South (68.4%), while the Midwest operated the least with 55.2%. However, 10.3% of the facilities planned to add a wood recovery area in the Midwest, contrary to 0% in the South. When compared to historical results, these findings show that the percentage of facilities operating recovery areas in each region has nearly doubled (Table 16). This was likely due to the fact that more facilities are recognizing the opportunity for monetary savings through wood recovery, and they are choosing to add the equipment, labor, and facility space necessary to recover wood. There is also more legislation requiring wood recovery. Additionally, because the total number of MSW facilities has decreased since 1998, it is possible that those remaining in operation were newer, larger, more sophisticated, and more likely to already have the necessary equipment for wood recovery.

Table 16. Percent of Facilities Operating Wood Recovery Areas in 1995, 1998, and 2016 by Region

Historical Percentage of MSW Facilities Operating Wood Recovery Areas			
Region	1995	1998	2016
All Regions	37.9%	33.4%	62.4%
Midwest	30.8%	32.2%	55.2%
South	49.0%	49.0%	68.4%
Northeast	38.2%	45.5%	58.3%
West	27.0%	30.6%	61.4%

On average, MSW landfills recovered 7,589 tons of wood waste per facility in 2016 (Table 16). Facilities in the South recovered the most amount of wood with a mean of 14,513 tons per facility. The West had the second highest with a mean of 5,955 tons, while the Midwest and Northeast recovered 1,519 and 1,238 tons per facility, respectively. Historically, the overall mean tonnage of wood waste recovered per facility decreased by 51% from 1998. Additionally, every region except the South saw a decrease in the amount of wood recovered when compared to the previous studies.

Table 17. Mean Tonnage of Wood Recovered Per MSW Facility for 1995, 1998, and 2016 by Region

Mean Amount of Wood Recovered Per MSW Facility (Tonnage)			
Region	1995	1998	2016
All Regions	12,866	15,498	7,589
Midwest	21,536	35,037	1,519
South	3,418	5,748	14,513
Northeast	5,329	6,568	1,238
West	14,978	14,659	5,955

Overall, there were more than 10 million tons of wood recovered at MSW wood recovery facilities in 2016. This represents an increase from the estimate of 8.9 million tons in 1998 and only a slight decrease from the 10.3 million tons in 1995 (Table 18). The South was the only region that saw an increase in the tonnage of wood waste recovered, rising from 3.5 million tons in 1998 to nearly 6.9 million tons in 2016. Each of the other regions saw significant reductions in the amount of wood waste recovered when compared to the 1998 study.

Table 18. Total Wood Waste Recovered Per MSW Recovery Area in 1995, 1998, and 2016 by Region

Total Wood Recovered by Region (Tonnage)			
Region	1995	1998	2016
All Regions	10,320,000	8,932,000	10,019,000
Midwest	449,000	721,000	410,778
South	6,755,000	3,500,000	6,889,000
Northeast	730,000	506,000	156,311
West	2,386,000	4,205,000	2,737,000

When the total tonnage of wood recovered was considered in combination with the total tonnage wood landfilled, it can be seen that the overall amount of wood waste received at MSW landfills increased slightly from 29.7 million in 1998 to 30.2 million tons in 2016.

Wood Recovered by Category

Municipal solid waste facilities were asked to group the tonnage of wood waste recovered into one of five categories: pallets, crates, construction related wood, woody yard waste, and an “other” category for any wood not included in the any of the other four categories. Woody yard waste made up the largest portion of wood recovered by MSW facilities, with each facility recovering a mean of 6,444 tons (Table 19). This woody yard

waste was most likely ground into mulch for sale or pickup by local residents and businesses. The South, with each facility recovering a mean of 13,678 tons, and the West with a mean of 3,173 tons per facility, recovered much higher mean tonnages than the Midwest and Northeast where 960 tons and 639 tons of woody yard waste were recovered per facility, respectively. The frequency and radius of curbside pick-up programs and how the waste is processed may vary by region, but it would be expected that recovery for this category would return a high value because woody yard waste usually does not contain metal or other harmful contaminants, making it easy to chip and grind.

Approximately 486 tons of construction-related wood waste was recovered per facility in 2016. This was much less than the amount of construction related wood waste landfilled, previously shown to be 8,225 tons. The intermingled nature of construction debris makes it difficult to recover. Specialized equipment and labor are often required to do so successfully, especially for materials like wood that have lower value than easily extractable materials like metal (Goldstein 2006).

Table 19. Mean Tonnage of Wood Waste Recovered by Category Per Facility that had Wood Recovery Operations in 2016

Mean Amount of Recovered Wood Per MSW Facility by Category (Tonnage)					
Recovery Category	All Regions	Midwest	South	Northeast	West
Pallets	325	395	360	48	270
Crates	237	113	160	78	488
Construction Related Wood	486	19	402	288	1,073
Woody Yard Waste	6,444	960	13,678	639	3,173
Other	97	0	141	38	143

Nationally, just under 15.9 million pallets (1.9% of total pallets produced) were recovered in 2016, which was more than the 13 million pallets landfilled (Table 20). This was the first time that more pallets were recovered than landfilled since these studies began in 1995. The South and the West recovered the most with 6.1 million and 5.2 million pallets, respectively. The Midwest recovered 786,908 pallets and the Northeast recovered just 251,792 pallets. Every region, except the West, experienced a large decrease in the number of pallets recovered since 1998. When compared to previous studies, the 2016 estimate of 15.9 million pallets recovered represents a 50.3% decrease from the 32 million pallets recovered in 1995 and 27.6% decrease from the 22.1 million pallets recovered in 1998 (Table 20). The Midwest saw an 88.9% decrease in the number of pallets landfilled from 1998 to 2016 despite being the only region with an increase in the number of pallets recovered from 1995 to 1998.

Although both the numbers of pallets landfilled and those recovered have decreased since 1998, the number of pallets recovered was greater than the number of pallets landfilled for the first time since these studies began. When the number of pallets landfilled and recovered at MSW facilities was combined, the total decreased from 184.8 million in 1995 to 160.4 million in 1998, down to 29.0 million in 2016 (Table 21). The percentage of total pallets arriving at MSW facilities that were recovered as opposed to landfilled rose from 13.8% in 1998 to 54.8% in 2016. There is a positive finding for the state of wood and pallet recovery; it means that the industry is collectively diverting pallets from landfills

through reuse or recycling, and pallet users are sending fewer pallets to landfills. Moreover, landfills are doing a better job of recovering them than in previous years.

Table 21. Total Number of Pallets Recovered by Region at MSW Facilities in 1995, 1998, and 2016

Total Number of Pallets Recovered by Region			
	1995	1998	2016
All Regions	32,030,000	22,052,000	15,887,000
Midwest	2,460,000	7,146,000	786,908
South	19,400,000	8,218,000	6,116,000
Northeast	4,500,000	3,794,000	251,792
West	5,670,000	2,894,000	5,221,000

Table 21. Total Number of Pallets Received, Landfilled, and Recovered at MSW Landfills in 1995, 1998, and 2016 and Percent of Total Pallets Received from Recovered Pallets

	1995	1998	2016
Total Number of Pallets Received	184,775,000	160,412,000	28,982,081
Number of Pallets Landfilled	152,745,000	138,360,000	13,094,815
Number of Pallets Recovered	32,030,000	22,052,000	15,887,265
Recovery of Total Pallets Received (%)	17.3%	13.8%	54.8%

Wood Chip Sales

Facilities were asked to indicate the total tonnage and average price per ton for wood chips sold. While the previous surveys had asked for the specific uses chipped pallets were sold for, this questionnaire only asked for wood chips to be split into three use categories to improve the ease of response. These categories included wood chips sold for (1) residential use, (2) commercial use, and (3) “other” use. After receiving the results, the responses for all three categories were combined into one value due to the low number of respondents in each region. When all of the values were combined, the average ton of wood chips sold for \$14.81, and the facilities that sold wood chips sold an average of 1,660 tons per facility.

Respondents were given space to provide additional information while describing their wood chip sales. Many respondents indicated that they do not charge local residents for wood chips or mulch. Sometimes hardwood chips are separated for sale to the public, while softwood and pallet chips are used within the landfill operation. It is common to utilize wood chips for fuel, facility operations, as a material for daily cover, in road construction, or as an addition to composting mix. Several facilities indicated that it is possible to mix this ground wood waste with commercial food waste and then sell the compost.

Pallet Separation

Participants were asked if they separated pallets from other types of wood waste diverted to their recovery areas in 2016. If they did, they were provided three options to indicate why the pallets were being separated: (1) separated for repair/recycling, (2) separated to be sold to a pallet recycler, and (3) separated for other uses. If they selected other uses, a short response area was provided where they could further elaborate on why the pallets were being separated. Overall, 27.8% of wood recovery facilities indicated that they separated pallets from other wood waste. Of these, 92% of facilities that separated pallets for recovery did so for other uses. Only 4% separated them for repair and another 4% did so to sell them to pallet recyclers.

When asked to describe these other uses, respondents indicated several different answers. The most common reasons found for why the landfills separate pallets from other waste was either to give them away to local residents or to process them into wood chips. Respondents indicated a variety of uses for wood chips including being used for boiler fuel, composting, cover material, or as a wet weather road cover and turn around base. Several respondents indicated that when good quality pallets were received at their facilities, they are used to ship out universal waste such as e-waste and batteries. This is a benefit that discarded pallets can bring to landfills because it saves them the cost associated with purchasing new pallets. It also extends the useful life of the wood used to construct the pallets by keeping it out of the landfill longer.

Alternative Daily Cover

Wood waste can be ground and used in conjunction with other earthy materials as a way to meet landfills' regulatory requirements of alternative daily cover (ADC) to control odor, vectors, fires, litter, and scavenging (Fantell and Flannagan 2011). Approximately 22% of facilities indicated that they use recovered wood waste for ADC. Facilities that use recovered wood waste for ADC utilized a mean of 7,753 tons per facility in 2016. Facilities in the South utilized more recovered wood waste for ADC than any other region (14,927 tons). This suggests that it is an important part of their facility operations. Facilities in the Northeast used the lowest amount of ADC at their recovery areas with a mean of 1,046 tons per facility while facilities in the West utilized a mean 1,967 tons and facilities in the Midwest used 2,295 tons of recovered wood waste for ADC in 2016.

Pallets Sold at MSW Landfills

Facilities surveyed in this study were asked how many pallets they sold in 2016 and for what price. There was only one response to this question, and it indicated that the selling price was \$4.60 when a pallet was sold to a pallet recycler. This was higher than the present-day value of \$2.30 that the previous study found as the price for an individual pallet sold for reuse (using the CPI inflation method on the responses from January 1998).

Change in Volume of Pallets Received Over the Past Two Years

When asked how the volume of pallets received at their recovery facilities has changed over the past two years, 4% of respondents indicated that they have experienced an increase while 12% saw a decrease, 76% experienced no change at all, and 8% reported that their recovery facilities have been in operation for less than two years. The 4% of facilities that reported an increase in the volume of pallets over the past two years indicated a 2% mean increase. This is a large change from the 1998 study. In that study, the 27.2% of the facilities reporting an increase indicated a 21% mean increase. In 2016, the 12% of

facilities that indicated a decrease reported a mean of 39%, while in 1998, 9% of facilities indicated a mean decrease of 30%. The percentage of facilities indicating no change increased from 59.2% in 1998 to 76% in 2016.

The percentage of facilities experiencing a decrease in volume and mean percent change were similar in 1998 and 2016. However, there was a large decrease in the percent of facilities indicating an increase of pallet volume received at their recovery areas and a decrease in their mean percent increase. Additionally, there was an increase in the percentage of facilities indicating no change. All of this suggests that the overall number of pallets going to recovery areas is stabilizing or decreasing year to year.

Waste-to-energy Conversion

Participants in the survey were asked whether they converted waste that would otherwise be landfilled into energy through combustion or incineration. Just 14.6% of all facilities report operating a waste-to-energy conversion facility, through which they redirect an average of 24,000 tons of waste from the landfill. Respondents reported that over 53% of this converted waste is made of wood.

Non-Response Bias

The Wilcoxon Signed Rank Test, found that the non-responding population is not significantly different from the responding population (p -value = 0.55). Therefore, there was no significant response bias.

CONCLUSIONS

1. The total estimate for waste generated nationally for this study was 249 million tons, which was an increase from the 1998 estimate of 239 million tons but a decrease from the 1995 estimate of 293 million tons.
2. Regionally, the South receives the most waste per facility and has the greatest number of facilities, as well as the majority of recovered and landfilled wood.
3. The amount of wood waste received at MSW landfills increased 1.43% since 1998. However, the amount of wood waste landfilled decreased 4% while the amount of wood waste recovered increased 14.1%.
4. Overall, fewer pallets are going to landfills, and those that arrive are more likely to be recovered. Twenty-nine million pallets were received at MSW landfills in 2016. Of these, 13.1 million were landfilled and 15.9 million were recovered. This represents a 90.5% decrease in the number of pallets landfilled and a 28% decrease in the number recovered compared to the 1998 study.
5. Most facilities indicated that the volume of pallets received at recovery areas has not changed or has decreased in the past two years. When combined with the findings that the number of recovered pallets decreased 28% since 1998, this indicated that fewer pallets are going to recovery areas. With few facilities reporting an increase in the number of pallets received at recovery areas and 5.1% reporting that they added wood recovery areas in the past two years, it was extrapolated that most facilities that foresaw the benefits and had the ability to add a wood recovery area have done so since 1998.

- The results of this study indicate that 3.5% of all new pallets produced were transported to MSW landfills in 2016, but only 1.6% of all pallets produced were landfilled and 1.9% were recovered into other value adding products.

ACKNOWLEDGEMENTS

The funding for this research was provided by the National Wooden Pallet and Container Pallet Foundation of the Association and the United States Forest Service Southern Research Station.

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Article submitted: January 17, 2020; Peer review completed: July 12, 2020; Revised version received and accepted: September 30, 2020; Published: January 10, 2021.

DOI: 10.15376/biores.16.1.1496-1522

APPENDIX**Supplementary Information****Definition of Terms**

Recovered waste: Any waste that accepted by your facility that does not go directly into the landfill. Many facilities have a separate area for wood, woody yard waste, and pallets. This waste is commonly chipped for mulch or alternative daily cover.

Normal waste: Unsorted MSW waste.

Wood and Brush: Waste including all wood, treated wood, wood products, woody yard waste, pallets, wooden packaging and crates, and wood from destruction of structures.

Pallets: A flat shipping platform for use by forklifts in the transportation of goods.

Crates and wooden packaging: nailed or locked corner boxes, crates, barrels, baskets, carrier trays, chests, and reels.

Pallet Recycler: A business that collects used pallets for repair, stripping to individual components, or mulching.

- 1. This survey is intended for facilities that receive municipal solid waste. Do you accept municipal solid waste at your facility?**

Yes _____ *Please continue*

No _____ *Please stop here and return the questionnaire. Postage is prepaid.*

- 2. In which state is your facility located?**

State: _____

- 3. What is the estimated population that your facility serves?**

Number of people: _____

- 4. In 2016, approximately how much total waste (all types) was received at the municipal solid waste facility you operate?**

Total waste received (tons)	
-----------------------------	--

5. In 2016, what was the breakdown of the total waste received at your facility that was landfilled compared to the amount recovered for any other uses (recycling, daily cover, combustion, compost, etc.)? (Please estimate percentage or tonnage that passed through the scalehouse for the following categories.)

	Percentage		Tonnage
Landfilled – wood and brush		or	
Landfilled – normal waste			
Recovered – wood and brush			
Recovered – normal waste			
Total	100%		

6. In 2016, what were the average tipping fees for the following waste types received at your facility? (Leave categories blank if you do not have a tipping fee for that specific type of waste or answer what you would charge.)

	Tipping fee (\$/ton)
Landfilled normal waste	
Recovered wood and brush	
Recovered pallets	

7. In 2016, did your facility accept wood and wood products of any kind for landfilling?

- Yes
 No (please skip to question 20)

8. Do you accept wood pallets at your Municipal Solid Waste facility for landfilling as they are received? (I.e. without additional recovery processing such as grinding, chipping, incineration, or repair.)

- Yes
 No (please explain below)

Please explain why you do not accept pallets for landfilling as they are received:

9. In 2016, what were the estimated amounts of wood landfilled by the following categories? (Please fill out either tonnage landfilled or percentage of total wood landfilled.)

	Percentage	or	Tonnage
Pallets			
Crates or other wood packaging			
Construction related wood			
Treated Wood			
Woody yard waste (stumps, logs, brush, etc)			
% Other (furniture, household goods, etc.)			
Total	100%		

RECOVERY AND RECYCLING

10. Does your facility have the ability to recycle or repurpose wood, yard waste, or wood pallets? In other words, does your organization divert wood waste into a separate area for recovery?

- Yes...*Please continue with this section*
- No...*but we plan to within the next two years (please skip to question 17)*
- No...*and we do not plan to add any recovery operations (please skip to question 17)*

11. In 2016, approximately what was the breakdown by the following categories of wood and yard waste received at your recovery area? (Please answer either percentage or tons of total wood and yard waste processed.)

	Percentage	or	Tonnage
Pallets			
Crates or other wood packaging			
Construction related wood			
Woody yard waste (branches, logs, brush, etc.)			
Other (furniture, household goods, etc.)			
Total	100%		

12. In 2016, how much of the wood and yard waste received at your recovery area was used for alternative daily cover or facility operation?

Tons	
------	--

13. In 2016, what was the average selling price and amount of ground or chipped wood sold from your recovery area? (Please indicate the dollars per ton and the number of tons sold for each category.)

	\$/ton	and	Tonnage
Ground and sold for commercial use			
Ground and sold for residential use			
Sold for other uses			
Total	100%		

Please explain other uses wood diverted to your recovery area was sold for:

We did not sell this type of material to residents or businesses in 2016

14. In 2016, did you separate pallets from other types of wood waste diverted to your recovery area? (Please check all that apply.)

- Yes...we repair/recycle pallets
- Yes...we sell to a pallet recycler
- Yes...for other uses (please explain below)
- No (please skip to question 17)

Please describe other uses for separated pallets:

15. How has the volume of wood pallets recovered at your wood/yard waste recovery area changed over the past two years?

% Increase	
Or	
<input type="checkbox"/> % Decrease	<input type="checkbox"/>

- No change
- Our wood/yard waste recovery area has been in operation for fewer than two years.

- 16. In 2016, what was your average selling price for pallets and how many did you sell?** (Please indicate the average price per pallet sold and the number of pallets sold from each category and leave a section blank if you did not indicate that you do so in the question above.)

	\$/pallet		# of pallets
Repaired pallets		and	
Unrepaired sold to recycler			
Other uses			

We did not sell pallets in 2016

- 17. Does your facility convert any of the waste you receive to energy that would have otherwise been landfilled?**

Yes

No (*please skip to question 20*)

- 18. What was the tonnage of waste that your facility converted to energy that would have otherwise been landfilled?**

Tonnage	
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- 19. What estimated portion of the amount of waste stated in question 17 was wood?** (Please do not include paper or cardboard.)

% Wood Waste	
or	
Tonnage	

- 20. If you would like to receive a summary report of this study, please write your name and a valid mailing and/or email address or attach a business card so we can send it to you upon completion.**

Thank you for your participation. Your response will help a graduate student to finish his degree. After completing the survey to the best of your ability, please fold the booklet in half and place it in the 9" x 6" pre-paid return envelope. All responses are confidential.

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