

Wood Waste Processing and Utilization in Southeastern Michigan

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Executive summary

This project conducted a qualitative and quantitative study of wood waste processing and disposal yards in southeastern Michigan. The goal of the study was to characterize wood waste supply patterns and evaluate the recovery efficiency and potential alternatives. To achieve this goal, the network of Michigan State University extension agents was used in combination with the Michigan Department of Natural Resources processing facilities lists and local directories to establish a reliable list of wood collection and processing facilities operating in the 16 counties included in the study. Calls were made to all yards to confirm that they accept and use wood, with only those that also processed wood included in the study. A mail-in questionnaire survey was used to derive information on wood waste supply flows and sources to generate information necessary for characterizing facilities, and to identify product types and quantities produced by wood waste yards. Several yards were visited to validate trends obtained from the survey and generate additional technical information on processes and wood utilization patterns. Results of the study indicate that 180 wood waste yards were operating in the 16 counties included in the study. These yards employ an average of 6 employees per yard for a total of 1082 employees in the industry. The total volume of wood entering yards was quantified at 235 million cubic feet (5.3 million metric tons), mainly from land clearing and tree removal. The wood waste supply was used to produce a total of 71.8 million cubic feet (1.6 million tons) of new products (wood chips, mulches, firewood, etc...) which were mainly sold locally. The overall conversion rate was estimated at 30% for the entire industry, clearly indicating room for improvement. The industry was estimated to contribute about \$40 million to Michigan's economy. However, in the last few years, the housing slump and the overall economic downturn has seriously affected yards' activities by causing sharp reductions in wood supply from land clearing and tree removals going into wood waste processing facilities. The improvement of conversion rates and value-added product development at these processing facilities would require fundamental changes in the equipment, qualifications, and processes used by tree service companies in their field operations. Tree service companies, who are the first handlers of the wood resource, play a critical role in the identification, sorting, and preliminary processing of log material which was the highest potential for value-added products. In addition to traditional solid wood products, wood waste processing facilities should consider wood pellets as a viable alternative product. Other potential new products include wood composites (OSB, particleboard, and wood plastic composites), as well new biobased products such as feedstock for ethanol and syngas for biofuels production.

Introduction

Wood wastes include a large spectrum of wood products from primary and secondary processing such as bark, slabs, sawdust, chips, planer shavings, sander dust, end trims, used or scrapped pallets, and construction wood wastes. However, wood wastes also include logs, branches, and brush from urban tree removals and land clearing for construction, farming and industrial projects.

Large amounts of wood wastes, residues and solid wood are generated annually in the United States. According to McKeever (2003), in 2001 an estimated 234 million metric tons of residue was generated from traditional timber extraction, forest conversion to non-forest uses, primary processing, and demolition of buildings and structures. USDA Forest Service analysis reported that 104 million tons of woody residuals were available for recovery in the U.S., with wood and Municipal Solid Wastes (MSW) and construction and demolition debris streams comprising 28 million tons (McKeever 2003). Regional analysis indicates that the Midwest has 21.2 million tons of recoverable wastes including 2.2 million tons of MSW, 1.5 million tons from construction wastes, 2.6 million tons of demolition wastes, 5.6 million tons of logging residues, and 2.8 million tons of other types of woody residuals (McKeever 2003). A study of wood residue utilization in Pennsylvania indicated that round wood companies utilized or disposed of 120 million cubic feet (Murphy et al. 2007). The residues collected consisted of 20% bark, 45% coarse, and 35% fine residues (Murphy et al. 2007). Past study reports from several other states have reported large quantities of residues generated. Approximately 7.5 million tons were generated in Mississippi in 1994 (Short et al. 1996), 5 million tons in Wisconsin in 1992 (Hubing 1993), and 7.0 million tons in Louisiana in 1994 (De Hoop et al., 1994).

The situation in Michigan is very similar to national averages. A case study of Mid-Michigan Recycling (reported by the USDA Forest Service) revealed that the company recycles about 200,000 tons of urban wood annually by producing boiler fuel for the Genesee Power Station in Flint (Forest Products Laboratory, 2002). A recent study gives a more complete picture of the annual wood resource availability in southeastern Michigan, reporting that 7.5 million cubic yards of urban wood residues are generated annually in this region, with 58% of the material being discarded (Sherrill and MacFarlane, 2007).

The majority of wood waste recovery programs in Michigan and nationally are generally targeted towards low-end markets such as chips, and mulches, which pay the equivalent of \$0.25 for a recovered wood pallet, while higher-end markets using value-added products could pay 20 to 32 times as much for an equivalent amount of wood (Forest Products Laboratory, 2002). In Michigan, these residues have been traditionally mulched and used for bedding, compost or as fuel for energy cogeneration. However, a good proportion of wood waste ends up in landfills. A study conducted by the Forest Products Laboratory estimated that wood wastes accounted for about 17% of the total wastes received at municipal landfills in the United States (Forest Products Laboratory, 2002). In addition Sherrill and MacFarlane (2007) estimated that two million cubic yards of wood waste enters southeastern Michigan landfills each year.

Despite the high value-added potential of some of the removed material, the preferred processing method for all wood wastes going into disposal yards is still grinding for conversion into bedding material for landscape purposes or fuel for cogeneration. Several studies have shown that there are several value-added options for conversion of waste wood. For example, a manufacturer in North Carolina patented a process that converts end-trims, construction and demolition wastes, scrap pallets, and yard trimmings into top soil and compost (Alderman et al. 1999). Wood wastes have also been effectively converted into wood fuel pellets for use in residential stoves, or included as filler in the manufacturing of wood composites. Additionally, several USDA Forest Service publications also highlight case studies from local governments and private businesses across the county that have been successful in demonstrating creative and profitable uses for managing waste wood (Bratkovich, 2001; Cesa, et al. 2003; Forest Products Laboratory, 2002). A study conducted by Chow and Zhao (1992) indicated that Medium Density Fiberboards (MDF) manufactured from red lauan, white meranti ash, birch, oak, lindens, true firs, Douglas and larch achieved equal or better strength properties compared to service class hardboard and plywood. Haviarova et al (2001) manufactured and tested solid and laminated school desk frames from salvage woody residues, and concluded that strong and durable school furniture can be produced by small scale facilities from local woody material using low technology processes.

In Michigan, the wood disposal situation has drastically changed since the Emerald Ash Borer (EAB) infestation was discovered during the summer of 2002. The Michigan Department of Agriculture estimates that more than 25 million ash trees have been killed and more than 700 million trees are at risk due to the EAB infestation (McCullough and Siegert 2007; Nzokou et al. 2006). The EAB infestation has caused an increase in green wood going into the waste stream due to the removal of dead trees in cities and woodlots around the state. Several reports and field observations have indicated that significant amounts of Michigan's quality logs from removed ash and other tree species entered wood waste processing facilities and were converted into low value products.

To alleviate the negative impact of the EAB in the state, several research and extension efforts are being developed by the Southeast Michigan Resource and Development Council (SEMIRCD), Michigan State University (MSU), the Michigan Department of Natural Resources (DNR) and other partners to demonstrate and promote value-added utilization of resources with good potential. Although the early focus was on ash trees, other hardwood species available are also included in this effort. Ash wood is best known as the wood mostly used for sporting goods manufacturing, such as baseball bats in the United States. Ash has been used for tool handles and steam bending for armchairs and other curved products. Its relatively high strength, flexibility, light weight, shock absorbency and split resistance favor its uses in furniture making. Other uses of ash in the fabrication of value added products include lumber and veneer for furniture, paneling, flooring, interior joinery, cabinetry and pallets (Nzokou et al. 2006). If properly sorted and processed, quality logs currently going into disposal yards can be used for such value-added products.

An important necessary step in developing green wood or waste wood into a viable resource is to quantify the amounts that are available by source and type of material, analyze current production patterns, and identify the potential for alternative value-added

options. A clear understanding of factors that affect the production and utilization of wood in disposal yards is critical to maximizing the economic values of these resources. Several questions need to be answered in order to assess the full potential of this sector and to propose strategies to enhance the production of higher-value products:

- How many wood disposal yards operate in southeastern Michigan?
- How many of these yards accept logs?
- What types of products are produced from these logs?

The goal of this study is to assess resource flow patterns for waste and green wood entering recycling yards and landfills in southeastern Michigan and to evaluate the potential for a better use of these resources. The specific objectives are to:

- 1- Estimate the quantity of green wood and wood residues entering disposal and recycling yards in southeastern Michigan and to characterize their composition,
- 2- Quantify and characterize products exiting the yards, and
- 3- Conduct a technical study of model disposal yards, and estimate the economic potential of the various processing and product alternatives.

Survey Methods and Approaches

This study focused on 16 counties in southeastern Michigan. These 16 counties were also included in the wood waste generation survey study conducted by Sherrill and MacFarlane (2007). A survey methodology was developed to identify yards, collect data, quantify results, and make generalizations for the study area.

Study population

We first started by creating a list of disposal yards and wood waste processing facilities in the study area. The list was compiled by combining companies listed as such in the Michigan Department of Natural Resources database, the local telephone directory listings, and lists available from the SEMIRCD for disposal yards. A telephone call was made to each company on the list and those who reported not dealing with wood were removed. Wood collection sites that did not report doing any further processing in the telephone surveys were also removed from the list. The corrected list for each county was forwarded to MSU Extension county directors for validation and correction and the final target population for the study was established. A total of 180 yards were retained in the study from the 16 counties. The breakdown of yards per county is presented in Table 1.

Survey instrument and data collection

To estimate the quantity and types of resources entering the yards and the amount and value of products generated, a questionnaire was developed to gather the necessary data. The questionnaire was evaluated by the SEMIRCD and the DNR and pretested with two disposal yards to clarify the wording and include additional questions necessary to achieve the study's objectives. The questionnaire was mailed to the 180 facilities

identified in October 2007. A postcard reminder was mailed in March 2008 and a second questionnaire sent out to non-respondents in May 2008.

The first section of the questionnaire asked categorical questions to obtain basic information about the company. We also gathered information to identify the provenance of the woody material entering the yard, the type and characteristics of the manufacturing facility, the species processed, the number of employees, the product types, and total volumes produced in their facility. The second section of the questionnaire focused on types of products processed at the facility, current markets, the marketing strategy of the yard, as well as identifying bottlenecks to higher productivity. The full questionnaire is included as Appendix 1. Following the mailing survey, personal phone calls (14 total) were made to respondents who provided insufficient or unclear answers to fill gaps observed in the responses received.

Table 1: Number of surveys mailed and response rate by county

County	Mailed	Responded	Response rate
Genesee	20	5	25.0%
Ingham	12	3	25.0%
Jackson	6	1	16.7%
Lapeer	8	3	37.5%
Lenawee	4	0	0.0%
Livingston	11	4	36.4%
Macomb	15	5	33.3%
Monroe	6	2	33.3%
Oakland	36	10	27.8%
Saginaw	8	2	25.0%
Shiawassee	5	0	0.0%
St Clair	4	1	25.0%
Washtenaw	8	3	37.5%
Wayne	37	3	8.1%
	180	42	23.3%
Landfills and Disposal Facilities			24

The counties with the highest number of yards were Wayne (37), Oakland (36), Genesee (20), Macomb (15), Ingham (12) and Livingston (11). The response rate varied widely, with several counties having response rates well above 30% (Lapeer and Washtenaw 37.5%, Livingston 36.4%, Macomb and Monroe 33.3%). The average response rate for all counties was 23.3%, which is within range of typical response rates for survey studies. No positive response was received from any of the landfills that were contacted. A recent study indicated that 2 million cubic yards were disposed in landfills each year (Sherrill and MacFarlane 2007). However, all landfill employees contacted by phone indicated that they did not have any quantifiable amount of activities related to wood and declined to be included into the response to this survey. However, it is well known that many landfills use large quantities of wood as landfill cover, even though it is illegal under Michigan law to dispose of wood in landfills.

Estimation procedure

Companies were classified into types based on their size, equipment and processing capacity, and the number of employees. Companies responding to the survey that own any three combinations of large equipments including chipper, stump grinder, chip van, and truck with dump bed, and also had at least 10 full time employees were considered large processing facilities. All other respondents were classified as small processing facilities. Data collected from respondents was extrapolated to determine first, the quantities of wood waste entering yards, and second, the types and volumes of products processed from these yards. This extrapolation was conducted through a method previously used by Adelman et al. (1999) and Alderman et al. (2000)) summarized as follows:

1. The reported quantities (volumes, number, types) for each product (e.g., logs, brush, chips, bark, and sawdust) was divided by the reported number of employees of each respondent sample frame to calculate wood residues production per employee for each product type, as related to their equipment and processing facilities.
2. The average (mean) production per employee for each product type was multiplied by the determined total industry wide employment to generate an estimate of the total production.
3. Board footage, square footage, linear footage, tonnage production and consumption estimates, for each company were made by the same method.
4. By repeating these calculations for each sample frame and adding up, we were able to develop estimates for the entire region.

Yard visits

Field studies of seven yards were conducted to generate information to confirm resource flow patterns developed from the mail-in survey, quantify inputs and yields, and identify potential alternatives and bottlenecks. The initial study plan was to focus these studies to two specific yards. However, due to unforeseeable circumstances that delayed the beginning of the study, one of the two yards was out of business before the scheduled field visit. As consequence, an adjustment to the initial protocol was made and field visit extended to seven yards. These companies were selected based on their reported production patterns to cover the range of products generated from disposal yards.

During these visits, through a guided discussion with the owner or manager (see questions used in appendix 3), technical information including, the yard size, total number of employees, major equipments, type of wood products/residues accepted, and products produced recorded. This data was used for cross validation of the mail in survey data. No large disparity was observed between the face to face interviews data and mail in survey responses. Averages derived from the study were presented to yard owners and trends observed discussed and validated. Extended discussions were also conducted to assess their strategic vision for the future of wood wastes processing in Southeastern Michigan.

Characterization of wood waste processing facilities

The 180 yards identified and included in this study collectively provided 1082 full time employments. The average number of employees for a large yard was 7.5 employees, while a small yard typically employed only 4.8 employees (Table 2). About 78.5% of the large yards reported having their own field crews for logging and harvesting operations, while only 31% of smaller yards had their own field crews.

Table 2: Employment statistics

Characteristics	Large yard	Small yard	Total
Average number of employees per yard	7.5	4.8	
Estimated total number of employees all yards	440.0	582.0	1,082.0
% of businesses with own field crews	78.5%	31.0%	

The data clearly indicates that larger yards were more likely to have their own field crews, providing them with a more reliable resource of raw materials compared to smaller yards which depended more on drop-offs from other tree care companies.

The equipment ownership data for large and small yards are presented in Table 3. The most common equipment available in larger yards included chainsaws (100% response), log splitters (78.6%), trucks with dump bed (78.6%), whole tree chippers (64.3%), hand chipper (64.3%), stump grinders (57.1%), and forklifts (50%).

Table 3: Equipment ownership among wood disposal yards (according to yard size)

Equipment	Large	Small	Equipment	Large	Small
Aerial lift	0.00%	3.40%	Kiln/air-dry area	7.10%	3.40%
Backhoe	14.30%	10.30%	Loader	14.30%	13.80%
Band mill	7.10%	10.30%	Log splitter	78.60%	31.00%
Bulldozer	35.70%	6.90%	Portable mill	7.10%	10.30%
Chainsaws	100%	48.30%	PTO chipper	14.30%	3.40%
Chip van	42.90%	6.90%	Pup-dump	14.30%	0.00%
Chipper with chip box	42.90%	6.90%	Screener	0.00%	3.40%
Circular mill	7.10%	3.40%	Skidder	11.80%	0.00%
Coloring unit	0.00%	3.40%	Slabsaw	7.10%	0.00%
Denailer	0.00%	3.40%	Stump grinder	57.10%	17.20%
Edger	7.10%	3.40%	Stump grinder	7.10%	0.00%
Excavator	7.10%	0.00%	Truck scales	7.10%	0.00%
Fork lift	50.00%	24.10%	Truck with dump bed	78.60%	48.30%
Forwarder processor	0.00%	3.40%	Tub grinder	21.40%	0.00%
Hand chipper	64.30%	20.70%	Whole tree chipper	64.30%	0.00%
Horizontal grinder	7.10%	3.40%	Wood working equipment	14.30%	27.60%

Smaller yards were much less likely to own much wood processing equipment. The most commonly available equipment included chainsaws (48.3%), trucks with dump beds (48.3%), log splitters (31.0%), and wood working equipment (27.6%). The specific types of equipment often owned at small yards clearly indicate their tendency to be independent by maintaining the ability to deliver processed products (by having a truck with dump bed), producing other products such as firewood (with commonly owned log splitters) or creating solid wood products (using wood working equipment).

Raw material sourcing and supply

About two-thirds of the businesses surveyed (65.1%) reported using wood supplies originating from tree removals. The second most prominent wood sources came from land clearing (44.2%), followed by pallets and crates (16.3%) and mill wastes (11.6%)

Table 4: Characteristics of wood waste processing facilities in southeastern Michigan

	Waste types	% of business using this supply
Supply	Land clearing	44.2%
	Pallets/crates	16.3%
	Mill waste	11.6%
	Tree removals	65.1%

All companies interviewed reported being affected by the national economic conditions and the declines in new housing development (which result in declines in land clearing activities). As result, wood waste processing facilities have had to rely more on other tree removals for their supply of raw material.

A limited number of yards (12.2%) reported charging a tipping fee to accept wood wastes in their yards (Table 5). Companies with organized procedures for screening material arriving at their yards and charging fees seemed to be large well established facilities. The average tipping fee charged was \$14 per cubic foot for logs, \$18.67 for stumps, \$11 for brush and branches, and \$12.50 for pallets and scrap wood. The average price charged is affected by the difficulty in processing the material and by potential for converting the wood waste into useful salable products. Raw materials that are very difficult to process with low potential for salable products (such as stumps) are generally charged the highest fees, and material (such as brush and branches) that are easy to move around and process are charged the lowest fees. Logs were charged a medium fee because although they are generally converted into high-value products, the amount of energy needed for the conversion is also higher than other materials such as branches and pallets.

Table 5: Average tipping fee charged by wood waste yards (per cubic yard)

	% of businesses that charge a tipping fee for any material	Logs	Stumps	Brush and branches	Pallets and scrap wood
		Average	\$14.00	\$18.67	\$11.00
12.2	Min	\$10.00	\$13.00	\$10.00	\$10.00
	Max	\$18.00	\$25.00	\$13.00	\$15.00

Few yards (17.1%) reported regularly buying raw material for their processing facilities (Table 6). The three types of products purchased include logs (at the average price of \$3.32/cu ft), sawdust (at \$0.30/cu ft), and shredded bark at (\$0.72/ cu ft).

Table 6: Average price paid by wood waste yards for wood supply (per cubic foot)

% of businesses that buy materials		Average paid for logs per cu ft	Average paid for sawdust per cu ft	Average paid for shredded bark per cu ft
17.1	Mean	\$3.32	\$0.30	\$0.72
	Min	\$3.00	\$0.15	\$0.55
	Max	\$3.64	\$0.40	\$0.90

Yards willing to pay for raw material supply generally relied significantly more on tree removals for their supplies and had to provide financial incentives for tree service companies to travel extra miles to dump selected wood materials in their yards.

The estimate of the total materials going into wood waste processing facilities is summarized in Table 7. Wood chips, logs, branches and brush, mulch and stumps were the main categories from land clearing and tree removals.

Table 7: Source of supply of wood waste yards in southeastern Michigan

	<i>Types</i>	<i>Small</i>	<i>Large</i>	<i>Total</i>	<i>Total from source</i>	<i>Percentage of total supply</i>
Land clearing	Wood chips	2,323,346	25,832,749	28,156,095	143,139,730	60.86%
	Logs	155,382	67,357,723	67,513,105		
	Branches and brushes	1,908	39,868,241	39,870,149		
	Mulch	Nd	7,530,465	7,530,465		
	Stump	Nd	69,916	69,916		
	Source total	2,480,636	140,659,094	143,139,730		
Pallets	Scrap pallets	Nd	408,420	408,420	498,333	0.21%
	Wood chips from pallets	Nd	89,913	89,913		
	Source total	0	498,333	498,333		
Sawmill residues	Mixed	Nd	12,960,149	12,960,149	12,960,149	5.51%
Tree removals	Wood chips	2,375,271	36,579,861	38,955,132	78,582,152	33.41%
	Logs	249,291	3,801,489	4,050,781		
	Branches and brushes	2,726,578	32,204,589	4,931,168		
	Mulch	Nd	481,933	481,933		
	Stump	Nd	163,138	163,138		
	Source total	5,351,140	73,231,010	48,582,152		
Total wood supply		7,831,776	227,348,586	235,180,362	235,180,362	

The total volume of wood material entering processing facilities in southeastern Michigan was 235 million cu ft (5.3 million tons) coming from four primary sources: land clearing (143 million cu ft), tree removals (78.5 million cu ft), sawmill residues (12.9 million cu ft), and pallet materials (0.49 million cu ft). The comparison of the relative size of supply sources indicate that land clearing remains the major source of material for wood waste processing facilities, accounting for 60.86% of their total supply, followed by tree removals that contribute 33.41% of the total supply. Small residues account for 5.51% and pallet materials account for less than a quarter of a percent.

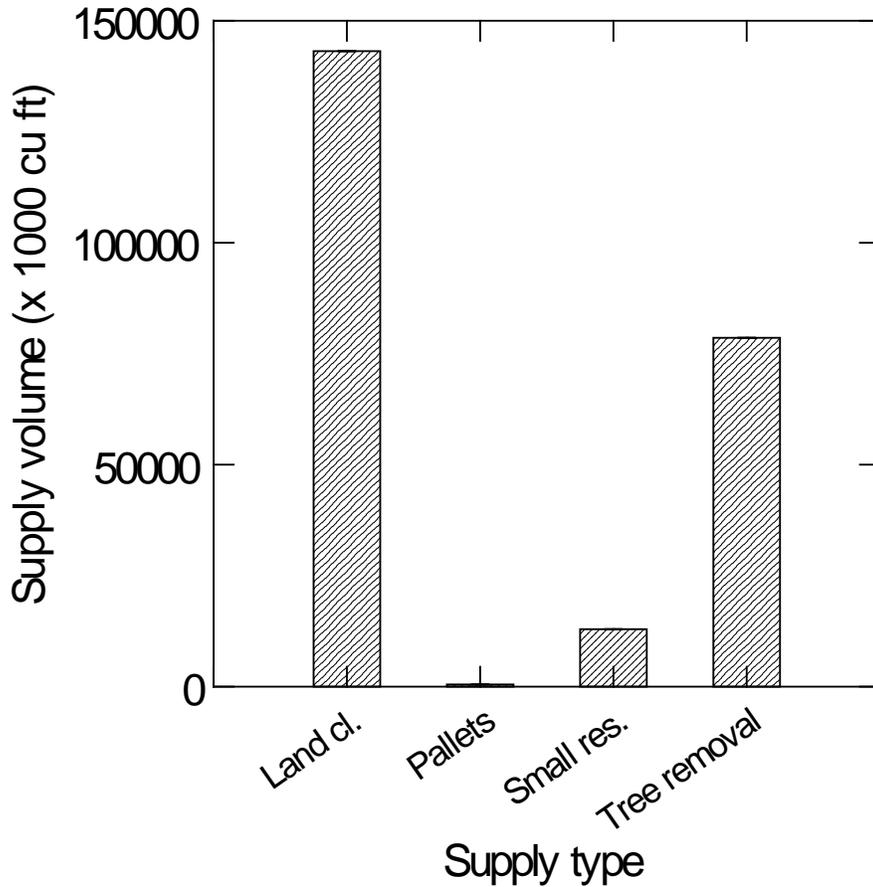


Figure 1: Wood waste supply in processing facilities in southeastern Michigan

Land clearing

A look into each of these major sources indicates that logs from land clearing (contributing 67.5 million cu ft) were the main form of material from this source used by wood waste processing facilities. Other major forms included branches and brush (39.8 million cu ft) and wood chips (28.1 million cu ft). Mulch contributed only 7.5 million cu ft and supplies delivered as stumps were negligible.

Analysis of land clearing sources (Figure 2) show that logs contributed a large proportion of wood supply from land clearing, contributing about 47% of the total supply for land clearing source. This is followed by banches and brushes, and wood chips that combine to make up about 47% of the land clearing source (Figure 2). Material from tree removals were essentially made up of wood chips and branches and brushes. For both supply sources, almost all of the material (99.8%) was collected in larger yards with only negligible amounts reported by smaller yards.

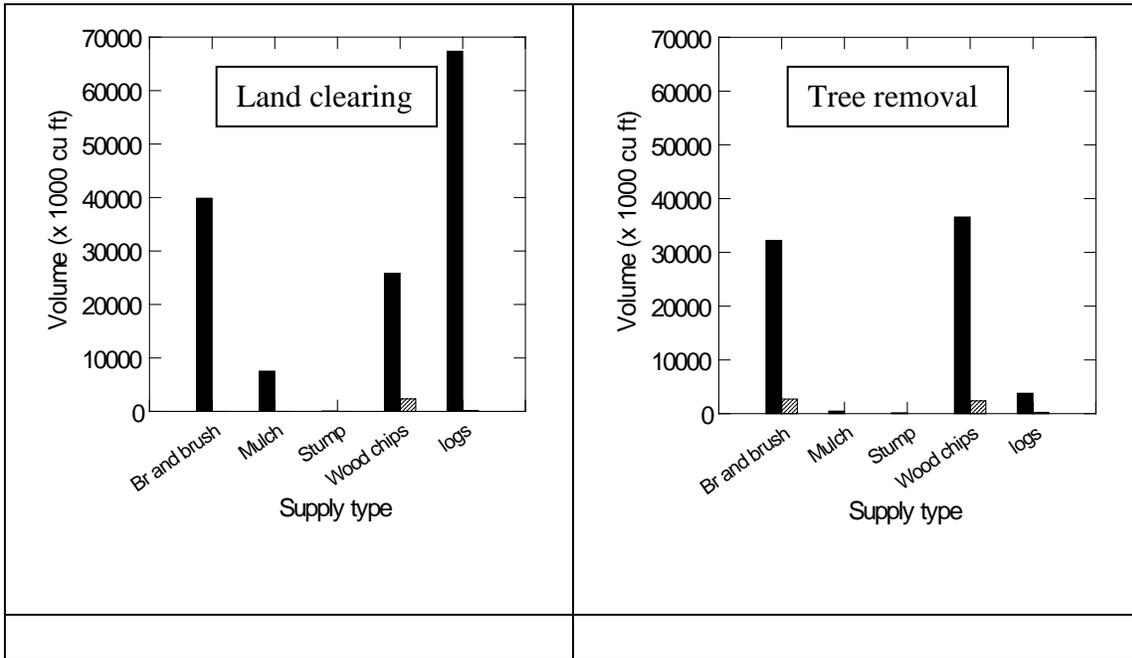


Figure 2: Breakdown of the raw material forms from land clearing and tree removal sources to wood waste processing facilities in southeastern Michigan. Black shaded bars are large yards and stripes are smaller facilities.

Tree removals

The other major source of wood supplies came from tree removals by tree service companies. The bulk of the supply from this source was delivered in the form of wood chips (38.9 million cu ft), followed by branches and brush (4.9 million cu ft), and logs (4 million cu ft).

Wood chips were the most important type of material supplied from tree removals contributing 49% of the total supplies from that source (Figure 2). Branches and brush were also very important, contributing about 44% of the total supply. Just 5% of the wood supply from tree removals was delivered to wood yards as logs. This is certainly a result of the limited ability of tree removal companies to handle logs as consequence of their lack of heavy lifting and trucking equipment.

An additional 2.9 million cu ft of material classified as sawmill residues was also supplied to wood waste processing facilities. The bulk of this material was generated from hardwood sawmills located in southern Michigan. These residues were made up of chips, sawdust, and bark material. Much of this material was purchased, as more than 17% of the respondents reported buying and using sawmill residues as part of their supply. The average price paid was \$0.30 per cu ft for sawdust, and \$0.72 per cu ft for shredded bark. Processing facilities paid an average of \$3.32 per cu ft when mill residues were supplied as logs. The higher price paid is due to the high return potential for logs compared to sawdust and shredded bark.

Pallets

While much less than the land clearing, tree removal, and sawmill residues sources, pallets do still contribute a significant amount of the wood waste channeled to processing facilities in southeastern Michigan. Most pallets manufactured in eastern United States are made with hardwoods, and over 500 million wood pallets are manufactured annually. Of these, more than 200 million are intended for one time use. The data from the current study indicate that pallets contributed 0.48 million cu ft to the total wood supply to processing facilities in southern Michigan. This volume corresponds to about 5.2 million pallets (1 pallet = 60 lbs, 1 ton = 44 cu ft) for the region, coming mainly from scrap pallets and chipped pallets from industrial wastes. The regional pallet volume corresponds to about 1% of the nationwide pallet production.

General trends

When looking at all wood sources, most logs entering the processing facilities are shipped to yards cut into small, easy-to-handle sizes. The survey results indicated that only 5% of the total volume of logs received (0.08 million tons) arrived in “millable” condition, that is, of timber quality with logs at least ten inches in diameter and at least eight feet long.

A large number of wood waste processing facilities (85%) reported a change in the volume of solid wood collected during the past few years, seeing a 75 to 85% decrease in wood supplies since 2001. The bulk of the decrease is reported to have occurred between 2005 and 2007, when facilities observed about a 50% drop in wood supply. The decrease was generally attributed to drops in land clearing activities for new construction caused by the slowdown in new housing development. Facilities reported receiving more industrial pallets and crates, and most of their woody debris as brush. Two other factors were identified as deterrents for the disposal of wood wastes to various yards in southern Michigan. These include the increase in imports of cheap wood composite pallets from various overseas sources and the creation of subsidized free disposal yards by the EAB eradication programs.

Production

Wood waste processing facilities were involved in the production of a number of wood products listed in Table 8. The most commonly produced commodities include wood

chips (generated by 51.2% of the facilities), firewood (48.8%), mulches (23.3%), lumber (23.4%), and sawlogs (13.9%). Other products of less significance were compost, pallets, finished wood products, industrial fuels, top soil, and playground material.

Table 8: Products generated by processing facilities in southeastern Michigan

	Product types	% of businesses
Products	Woodchips	51.1
	Firewood	48.8
	Mulch	23.2
	Lumber	23.2
	Sawlogs	13.9
	Compost	9.3
	Pallets	6.9
	Finished wood products	6.9
	Industrial Fuel	2.3
	topsoil	2.3
	Playground surfacing	2.3

All yards surveyed produced a combination of the products listed in Table 8. Larger yards generally combined wood chips, mulches, industrial fuels, and composts. Some also sorted good logs and marketed them as sawlogs. Some of the smaller yards also produced lumber and firewood.

The total production was 71.9 million cu ft (1.6 million tons), essentially made up of mulches (30.2 million cu ft or 42% of the total production), and woodchips (27.7 million cu ft or 38.6% of the total production) (Table 9).

Table 9: Estimated total production from wood waste yards (cu ft)

Type	Large	Small	Total	Percentage of total production
Mulch	24,183,767	6,013,906	30,197,674	42.0%
Woodchips	25,967,930	1,822,568	27,790,498	38.7%
Firewood	3,002,058	1,808,149	4,810,207	6.7%
Industrial Fuel	4,687,483	ND	4,687,483	6.5%
Logs	2,494,882	ND	2,494,882	3.5%
Compost	ND	1,309,051	1,309,051	1.8%
Sawn products	326,366	94,325	420,691	0.6%
PC&S	ND	183,402	183,402	0.3%
Total production	60,662,487	11,231,402	71,893,889	
Percentage	84.38%	15.62%		

Woodchips and mulches combined to represent 80.6% of the total production from yard processing facilities. Other products generated included firewood (4.8 million cu ft), industrial fuels (4.6 million cu ft), logs (2.5 million cu ft), and compost (1.3 million cu ft).

The breakdown by processing facility size indicates that about 84% of the total production comes from larger yards, while just 16% is produced in smaller yards (Figure 4). The larger production of larger yards correlates very well with the relative proportion of the total supply going into these yards. The data presented in Table 7 indicate that more than 95% of the wood wastes going into yards went into yards considered as large in this survey.

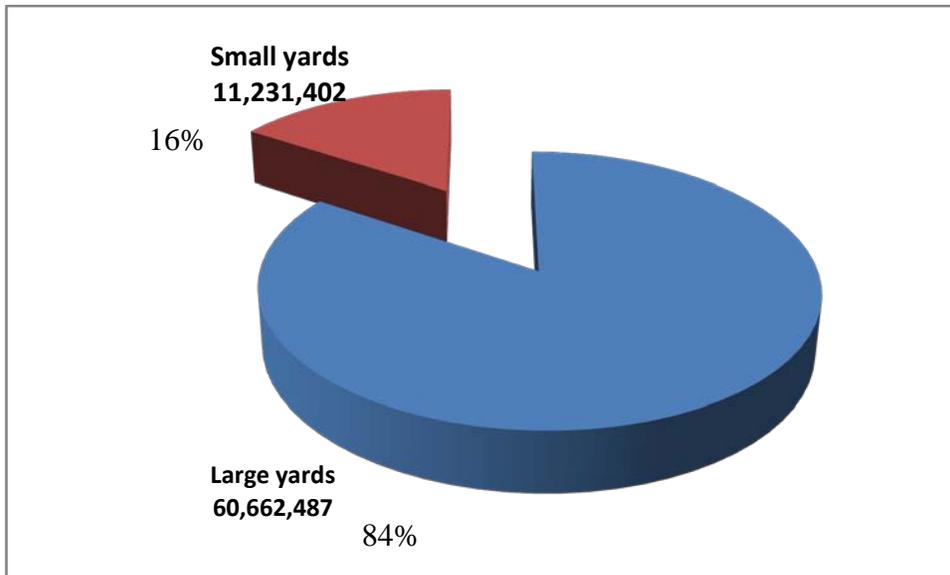


Figure 4: Total production from wood waste processing facilities in southeastern Michigan (in cu ft, by yard type)

The breakdown of the total production by yard size shows that the bulk of the wood chips and mulch production came from larger yards (Table 9). Most of the industrial fuels, and logs were also marketed from larger yards. The total production of firewood was more evenly distributed between larger and smaller yards (Table 9). The data also clearly indicated that the production from wood wastes processing facilities is predominantly geared towards landscape materials with mulch and wood chips accounting for 81% of the total production (Figure 5). Firewood and industrial fuels combine for 13% and logs represent only 3% of the total production.

Yard visits

Data collected from the various yards included in the field studies were generally in agreement with survey information. The general production and marketing scheme of most yards visited was largely skewed towards wood chips and mulches with only very limited potential for solid wood products. Owners interviewed indicated several reasons for low production and marketing of solid wood products, including the cutting down of logs into short unusable length during land clearing operations, the lack of interest from large owners to embark in primary processing, transportation issues, and the high cost for improving log processing in the field. However all owners visited are considering high value added markets for yard products, and three major product types mentioned are: the production pellets, exports of mulch and chips to value added markets in larger metropolitan areas and Canada, and production of fuel for home stoves. Some of the large owners also vehemently complained about the Emerald Ash Borer eradication program as responsible for the decline in the market.

Discussion and evaluation of economic impact and potential alternative products

The supply and production data shown in the sections above clearly indicate that wood waste processing facilities have a very important economic impact, creating more than 1,000 permanent jobs in the region, while also processing and marketing significant volumes of material necessary for southeast Michigan landscapes and energy plants. Based on product levels and average selling prices for the various products, the industry contributes about \$40 million into the local economy. However, for a better understanding of the full potential of wood waste processing facilities, a detailed evaluation of the industry is necessary.

Wood wastes supplied to processing facilities traditionally come from land clearing, tree removals, pallets, crates, and sawmill residues with the largest proportion coming from the first two sources listed. Consequently, these woods are harvested in conditions where land has been cleared for other purposes (land clearing) or in situations where trees are removed from the landscape because of reasons other than their use as wood product. Consequently trees are not pre-inspected or evaluated for their wood product potential before they are harvested and processed. Furthermore, tree removal companies that usually perform harvesting and processing operations in the field have no direct interest, incentive, or equipment to process and handle large logs in the field. As a result, logs are usually cut down into small pieces for ease in their handling, thereby limiting the amount of intact wood available for the highest-value products. Another difficulty in maximizing value-added potential arises from the uncertainty about the quantities and species any wood waste processing facility can expect to receive in any given period. These factors pose serious supply challenges to any yard wishing to specialize in the production of any high-end wood product.

As a practical measure, processing facilities try as best as they can to separate the material coming into yards. The most desirable option for high-value utilization of wood

waste is the reuse of wood as a building material or interior wood products. However, several barriers exist. Very little lumber-quality wood is available for reuse due to the fact that logs are processed into short pieces during harvesting operations. The total volume of timber quality logs coming into yards is currently too low (less than 5%) to justify any serious effort to develop solid wood products. It is conceivable that wood obtained from trees from woodlots cleared for construction and wood waste from arborists or salvage operations can be milled and used for such items as furniture, trim work, cabinetry, or flooring rather than cut into short logs and disposed for low-end uses. However, appropriate infrastructure, training, equipment, and markets will be necessary to change the current situation.

Based on our observations, it is possible to increase the relative proportion of quality logs going into yards from 5% to 30%. This will raise the total volume of good quality logs from 0.08 million tons to 0.48 million tons or 21 million cubic feet. Consequently, significant changes in the quality of products coming into yard will follow, potentially increasing the interest of yard owners and managers in new alternative products. Despite the current outlook, several processing facilities are looking to take advantage of the new market conditions by developing higher-value end products. The most commonly mentioned product was wood pellets for both the domestic market (fuel for home use) and for the export market to Canada.

Another option for reuse would be to divert high quality material towards the creation of engineered wood from the wood waste. Engineered wood is the term given to material derived from smaller pieces of wood that are bound together through a variety of glues, resins, and other chemicals to make a wood-like product. Engineered woods that can be considered in this situation include particleboard, OSB, and wood plastics composites. The technical process of manufacturing these composites with wood waste material from yards is certainly feasible if clean and premium materials are used. However, it would be helpful to evaluate success of manufacturing various types of wood composites using combinations of high and low quality material (wood, bark and species combinations) to study the possibility of recycling just lower value material from yards. In addition to the technical study, a cost benefit analysis would have to be conducted to fully assess the economic potential of using yard wastes for wood composite products.

With the growing international emphasis on bioeconomy, a potential market for wood waste is the conversion of wood chips to ethyl alcohol (ethanol) through conventional fermentation technologies. This can be done chemically, using acid hydrolysis or biochemically using enzymes. The resulting product must be purified and the alcohol distilled to concentrate it enough for use as a fuel. Biomass feedstock can also be used to produce biofuels. Thermal processes can also be used to convert the biomass directly to a synthesis gas (syngas) composed of carbon monoxide and hydrogen. Syngas can then be cleaned and used in commercial units to produce methanol. However, it is clear that wastes from processing yards would have to be combined with wood from other sources to supply this market. Therefore, clear standards about the properties and conditions of the raw material would need to be developed to maintain the efficiency of these biochemical processes.

Conclusion

The goal of this study was to assess the situation of wood waste resources in southeastern Michigan and to evaluate the potential for a better use of wood waste resources. The study identified a total of 180 wood wastes yards and 23 landfills operating in southern Michigan (16 counties). These yards employ an estimated 1,082 employees. Wood waste processing facilities in Michigan are usually small, family-owned businesses, employing an average of six employees per company. Most companies have been in operation for several years and have expanded as new markets developed.

The wood wastes supplied to processing facilities came from four major sources including land clearing (60%), tree removals (33.4 %), sawmill residues (5.5%) and waste pallets (0.2%). About 12% of the processing sites charge tipping fees, ranging from \$10 to \$25 per ton depending on the type of material. Some yards also paid for certain types of wood supplies including logs (\$3.32/cu ft), hardwood sawdust (\$0.30/cu ft) and shredded bark (\$0.72/cu ft). The total volume of wood waste supply going into yards in southeastern Michigan was evaluated at 235 millions cu ft, corresponding to 5.3 million tons for the entire region.

The total production from yards was 71.9 million cu ft, corresponding to 1.6 million tons. This corresponds to a conversion rate of about 30%. The low conversion rate is due to a combination of factors, including the composition of raw material coming into processing facilities, inappropriate or poor sorting procedures for incoming materials at entry point or throughout the yard, and low yield production practices. Major products generated include woodchips (38.6%), mulches (42%), wood for industrial fuel (6.5%), and firewood (6.7%). Other products include compost, logs, and sawn products. The survey showed that the bulk of this production (84%) came from large yards. However, the study also showed that smaller facilities (16% of the production) were more flexible and more likely to produce a more diverse product line.

Technical analyses conducted in the field coupled with survey responses indicated that less than 5% of the total volume of logs entering yards was of timber quality. The main bottleneck for the quality of log materials coming into yards results from the methods used by tree service companies in the field. Analysis conducted indicated that with proper equipment and training, the proportion of quality logs coming into wood waste processing facilities can be increased to 30% creating a large enough supply to justify a strategic shift towards value-added solid wood products. The data also show a very low conversion rate for products entering processing facilities, partly due to the lack of an efficient sorting and characterization of wood waste materials arriving at processing facilities for best potential utilization. Processing facilities could create a sorting mechanism at their gate that will determine the potential enduses for each load coming into the yard. Sawdust, sanderdust, and fines could be directed to production of products such as pellets for fuel, or industrial fuels. Bark, chips and other mixed residues could be processed for landscape products, while larger wood residues and logs are directed

towards the production of solid wood products such as trims, garden stakes, fence pickets, flower boxes, and flooring. Other value-added options include using some of the woody biomass for wood composites manufacturing, and using biomass as feedstock for the production of ethanol or syngas. It will obviously be very difficult for any single wood waste processing facility to integrate all these potential product lines into their unit. However, high level of wood waste utilization efficiency and yield can be achieved through the establishment of partnerships within the industry and with other potential partners. Such relationships will help identify and develop potential markets for value added products, and facilitate the transportation, storage, and marketing of value added products. Achieving greater value added utilization for wood wastes demands a realistic approach that combines market conditions, assembling all technological resources available, and educating stakeholders about the environmental and economical advantages of increasing the competitiveness of processing facilities operating in southeastern Michigan.

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Appendixes

Appendix 1

Questions for MSUE Country Extension Directors

Questions about Disposal yards and contact info

1. Are there any wood disposal yards in our county (any yards that accept and process unused mill waste and/or lumber otherwise destined for landfills i.e. from land clearing, urban tree removal, fuel reduction, habitat improvements, salvage or precommercial thinning operations)?
2. What is the name and address of each of these yards?
3. Can you provide contact info for the individual(s) responsible for the operation of these yards?
4. Can you give me a little background info on these yards (i.e. public or private? subsidized? When was it started? Was it originally subsidized through MDA emergency grants?)

General questions to help design the surveys

5. Do any of these yards produce high end (or value added) products as opposed to chips or dust for feedstock, fuel, lawn care animal bedding etc...
 - a. If so do all of these yards charge a tipping fee? Do any of them rely solely on selling product for income
 - b. If not do all of these yards charge a tipping fee? Do any of them rely solely on selling product for income
 - c. Do these high end products sell well? Is there a market specifically for them?

6. Do the yards typically use all of the wood entirely or is there often a significant amount of waste from them (i.e. processing residue or unacceptable wood).

7. Are these yards customers primarily local governments (state, city etc..) and industries? Do NIPFs constitute a significant portion?

8. Do you know how well records of transactions are kept at these facilities?
 - a. Are species and/or wood type known and recorded?

9. You have worked with these companies for much longer than I have, Is there any advice you can give me?

Appendix 2: Survey questionnaire for the study

Wood Waste Processing and Utilization in Southeastern Michigan

Please answer the following questions as accurately as you can. All of the information you provide will be kept strictly confidential.

General questions about this business

1. What county is your business located in? _____
2. How many full time employees does your business employ? _____
3. How many part time employees does your business employ? _____
4. What equipment does your business own? (in the space provided before each of the following equipment types please enter the number of that type owned)

_____ Chainsaw	_____ Band sawmill	_____ Circular sawmill
_____ Portable sawmill	_____ Whole tree chipper	_____ Hand fed chipper
_____ PTO chipper	_____ Chipper /w chip box	_____ Stump Grinder
_____ Tub grinder	_____ Horizontal Grinder	_____ Coloring unit
_____ Log splitter	_____ Box truck	_____ Truck /w dump bed
_____ Pup-dump	_____ Forklift	_____ Bulldozer
_____ Backhoe	_____ Truck Scales	

_____ Other, please specify _____

5. Does your business routinely rent any of the equipment mentioned in question 4 or pay another company for the services of the equipment.
Yes / No

6. What structures does your business own? (in the space provided before each of the following structure types please enter the number of that type owned)

_____ Yard	_____ Shed	_____ Office building	_____ Office
_____ Warehouse	_____ Retail Store	_____ Workshop	

_____ Other, please specify _____

7. What structures does your business rent? (in the space provided before each of the following structure types please enter the number of that type rented)

_____ Yard	_____ Shed	_____ Office building	_____ Office
_____ Warehouse	_____ Retail Store	_____ Workshop	

12. What products does your business produce from this wood? (check those that apply)

- A. Firewood
- B. Woodchips/Mulch
- C. Lumber
- D. Sawlogs
- E. Finished products (cabinetry, flooring, etc....)
- F. Pallets, Boxes, Skids and/or Dunnage
- G. Compost
- H. Other, please specify _____

13. a. Does your business measure the amount of unused wood waste that leaves it's property for disposal by the number of truckloads, by weight or by volume. (please circle all that apply)

Truckload / Weight / Volume

Other, please specify _____

Please fill out whichever of the following apply:

b. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100

- How many truckloads of this wood did your business remove in 2005? _____

c. **Weight** Please estimate the weight, in US tons, of this wood your business removed in 2005. _____

d. **Volume** Please estimate the number of cubic yards of this wood that your business removed in 2005. _____

e. **Other** Please estimate the amount of this wood that your business removed in 2005. _____

14. In what form does this unused wood leave your property? (check all that apply)

Woodchips Sawdust Cuttings/Side rippings Logs
 Miscellaneous tree parts Damaged wood parts or products
 Other, please specify _____

15. About what percentage of this waste is produced as a basic function of your businesses operation (i.e. sawmill waste)?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

16. a. About what percentage of this waste is wood that was unusable when your business received it?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

b. What are the three most common reasons that this wood was unusable?
(please check 3)

Chemical treatments Contains foreign objects
 Is a glued product such as plywood or fiberboard
 Paint Physical damage Rot Unusable species
 Received more than could be used
 Other, please specify _____

c. Of the three reasons you checked in question 16.b. which is the most common?

d. About what percentage of the total unused wood was the due to the reason you specified in question 16.c..

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

=====

The following sections correspond to the different categories in question 8 and are labeled A through F in the same manner. You may skip the sections that do not apply to you.

A. Wood from land clearing

17. From what kinds of businesses does your business you receive this wood from?

Tree services Construction contractors City foresters

Other, please specify _____

18. In what form do you receive this wood? (check all that apply)

Wood chips Logs Firewood

Other, please specify _____

19. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight, by number of face cords or by volume? (please circle all that apply)

Truckload / Weight / Face cords / Volume

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100

• How many truckloads of this wood did your business receive in 2005?

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

c. **Face Cords** Please estimate the number of face cords of this wood that your business received in 2005. _____

- d. **Volume** Please estimate the volume in cubic yards of this wood that your business received in 2005. _____
- e. **Other** Please estimate the amount of this wood that your business received in 2005. _____

20. What are the three most common tree species that you receive from this source?

- | | | | |
|--|---|-------------------------------------|----------------------------------|
| <input type="checkbox"/> Oak | <input type="checkbox"/> Hard Maple | <input type="checkbox"/> Soft Maple | <input type="checkbox"/> Ash |
| <input type="checkbox"/> Walnut | <input type="checkbox"/> Aspen | <input type="checkbox"/> Cottonwood | <input type="checkbox"/> Willow |
| <input type="checkbox"/> Black Locust | <input type="checkbox"/> Spruce | <input type="checkbox"/> Fir | <input type="checkbox"/> Pine |
| <input type="checkbox"/> Other Hardwood | <input type="checkbox"/> Other Softwood (Conifer) | | <input type="checkbox"/> Exotics |
| <input type="checkbox"/> ??I don't know?? | | | |
| <input type="checkbox"/> Other, please specify _____ | | | |

a. Of the three species that you marked above which is the most common?

b. Approximately what percent of the wood you receive is this species?

- | | | | | |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|
| <input type="checkbox"/> 0-10% | <input type="checkbox"/> 11-20% | <input type="checkbox"/> 21-30% | <input type="checkbox"/> 31-40% | <input type="checkbox"/> 41-50% |
| <input type="checkbox"/> 51-60% | <input type="checkbox"/> 61-70% | <input type="checkbox"/> 71-80% | <input type="checkbox"/> 81-90% | <input type="checkbox"/> 91-100% |

B. Reclaimed lumber

21. From what kinds of businesses does your business you receive this wood from?

- | | |
|--|---|
| <input type="checkbox"/> Construction contractors | <input type="checkbox"/> Landfills |
| <input type="checkbox"/> Recycling centers | <input type="checkbox"/> Demolition companies |
| <input type="checkbox"/> Other, please specify _____ | |

22. In what form do you receive this wood? (check all that apply)

- | | |
|--|--|
| <input type="checkbox"/> Wood chips | <input type="checkbox"/> Pallets, Boxes or Skids |
| <input type="checkbox"/> Lumber/Lumber fragments | |
| <input type="checkbox"/> Other, please specify _____ | |

23. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight, by board feet or by volume? (please circle all that apply)

Truckload / Weight / Board feet / Volume

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

• How many truckloads of this wood did your business receive in 2005?

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

c. **Board Feet** Please estimate the number of board feet of this wood that your business received in 2005. _____

d. **Volume** Please estimate the volume in cubic yards of this wood that your business received in 2005. _____

e. **Other** Please estimate the amount of this wood that your business received in 2005. _____

C. Pallets, Boxes, Skids and/or Dunnage

24. From what kinds of businesses does your business you receive this wood from?

____ Shipping companies ____ Other companies

____ Other, please specify _____

25. In what form do you receive this wood? (check all that apply)

___ Wood chips ___ Pallets, Boxes or Skids

___ Other, please specify _____

26. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight or by number of individual units?

Truckloads / Weight / Units

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

___ 0-<10 ___ 10-<20 ___ 20-<30 ___ 30-<40 ___ 40-<50
___ 50-<60 ___ 60-<70 ___ 70-<80 ___ 80-<90 ___ 90-<100

• How many truckloads of this wood did your business receive in 2005?

b. **Weight** Please estimate the weight, in US tons, of this wood your

business received in 2005. _____

c. **Units**

• Please estimate the number of used pallets that your

business received in 2005. _____

• Please estimate the number of used skids that your

business received in 2005. _____

• Please estimate the number of used boxes that your

business received in 2005. _____

d. **Other** Please estimate the amount of this wood that your business

received in 2005. _____

D. Sawmill waste

27. From what kinds of businesses does your business you receive this wood from?

___ Sawmills
___ Other, please specify _____

28. a. What kinds of sawmill waste does your business use, sell or give away?

___ Chips ___ Sawdust ___ Cuttings ___ Side rippings

b. If you marked more than one of the categories in question 21.a. which one is the primary sawmill waste type?

c. Approximately what percent of the wood you receive fits into the category you specified in question 21.b.?

___ 0-10% ___ 11-20% ___ 21-30% ___ 31-40% ___ 41-50%
___ 51-60% ___ 61-70% ___ 71-80% ___ 81-90% ___ 91-100%

29. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight or by volume? (please circle all that apply)

Truckload / Weight / Volume

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

___ 0-<10 ___ 10-<20 ___ 20-<30 ___ 30-<40 ___ 40-<50
___ 50-<60 ___ 60-<70 ___ 70-<80 ___ 80-<90 ___ 90-<100

- How many truckloads of this wood did your business receive in 2005?

b. **Weight** Please estimate the weight, in US tons, of this wood your

business received in 2005. _____

c. **Volume** Please estimate the number of cubic yards of this wood that your business received in 2005. _____

d. **Other** Please estimate the amount of this wood that your business received in 2005. _____

E. Tree removals

30. From what kinds of businesses does your business you receive this wood from?

____ Tree services ____ Construction contractors

____ Other, please specify _____

31. In what form do you receive this wood? (check all that apply)

____ Wood chips ____ Logs ____ Firewood

____ Other, please specify _____

32. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight, by number of face cords or by volume? (please circle all that apply)

Truckload / Weight / Face cords / Volume

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

- How many truckloads of this wood did your business receive in 2005?

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

- c. **Face Cords** Please estimate the number of face cords of this wood that your business received in 2005. _____
- d. **Volume** Please estimate the volume in cubic yards of this wood that your business received in 2005. _____
- e. **Other** Please estimate the amount of this wood that your business received in 2005. _____

33. What are the three most common tree species that you receive from this source?

- | | | | |
|--|---|-------------------------------------|----------------------------------|
| <input type="checkbox"/> Oak | <input type="checkbox"/> Hard Maple | <input type="checkbox"/> Soft Maple | <input type="checkbox"/> Ash |
| <input type="checkbox"/> Walnut | <input type="checkbox"/> Aspen | <input type="checkbox"/> Cottonwood | <input type="checkbox"/> Willow |
| <input type="checkbox"/> Locust | <input type="checkbox"/> Spruce | <input type="checkbox"/> Fir | <input type="checkbox"/> Pine |
| <input type="checkbox"/> Other Hardwood | <input type="checkbox"/> Other Softwood (Conifer) | | <input type="checkbox"/> Exotics |
| <input type="checkbox"/> ??I don't know?? | | | |
| <input type="checkbox"/> Other, please specify _____ | | | |

a. Of the three species that you marked above which is the most common?

b. Approximately what percent of the wood you receive is this species?

- | | | | | |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|
| <input type="checkbox"/> 0-10% | <input type="checkbox"/> 11-20% | <input type="checkbox"/> 21-30% | <input type="checkbox"/> 31-40% | <input type="checkbox"/> 41-50% |
| <input type="checkbox"/> 51-60% | <input type="checkbox"/> 61-70% | <input type="checkbox"/> 71-80% | <input type="checkbox"/> 81-90% | <input type="checkbox"/> 91-100% |

F. City tree removals

34. In what form do you receive this wood? (check all that apply)

- Wood chips Logs Firewood
- Other, please specify _____

35. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight, by number of face cords or by volume? (please circle all that apply)

Truckload / Weight / Face cords / Volume

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100

• How many truckloads of this wood did your business receive in 2005?

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

c. **Face Cords** Please estimate the number of face cords of this wood that your business received in 2005. _____

d. **Volume** Please estimate the volume in cubic yards of this wood that your business received in 2005. _____

e. **Other** Please estimate the amount of this wood that your business received in 2005. _____

36. What are the three most common tree species that you receive from this source?

Oak Hard Maple Soft Maple Ash
 Walnut Aspen Cottonwood Willow
 Locust Spruce Fir Pine
 Other Hardwood Other Softwood (Conifer) Exotics
 ??I don't know??
 Other, please specify _____

a. Of the three species that you marked above which is the most common?

b. Approximately what percent of the wood you receive is this species?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

=====

If you answered yes to question 9 above please fill out this section.

Waste Disposal

37. Does your business measure the amount of clean wood it receives by the number of truckloads, or by weight? (please circle all that apply)

Truckload / Weight

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

• How many truckloads of this wood did your business receive in 2005? _____

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

c. **Other** Please estimate the amount of this wood that your business received in 2005. _____

38. From what types of sources do you receive this wood?

____ Demolition ____ Tree services ____ City foresters ____ Haulers

39. a. Is any of this wood reused, sold or given back to the public? Yes / No

b. If so, approximately what percent is reused, sold or given away?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

=====
The following sections correspond to the different categories in question 10 and are labeled A through H in the same manner. Please fill out those that apply to your business and skip those that do not.

A. Firewood

40. a. How many face cords of firewood made from this wood did you sell in 2005? (a face cord is a 4x8ft stack of 16 inch long fire wood and is one third of a cord)

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

b. How many face cords of firewood made from this wood did you give away in 2005?

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

c. How many face cords of firewood made from this wood did you use personally in 2005?

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

41. To whom do you sell or give away this firewood? (check all that apply)

Homeowners Retailers
 Other, please specify _____

42. a. Approximately what percent of this firewood goes to individual Homeowners?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

b. Approximately what percent of this firewood goes to other businesses?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

c. Approximately what percent of this firewood goes to marshalling yards?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

d. Approximately what percent of this firewood goes to personal use?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

B. Woodchips/Mulch

43. a. How many cubic yards of mulch made from this source did you sell in 2005?

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

b. How many cubic yards of mulch made from this source did you give away in 2005?

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

c. How many cubic yards of mulch made from this source did you or your business use personally in 2005?

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

44. To whom do you sell or give this mulch? (check all that apply)

Homeowners landscaping services landscaping retailers

Other, please specify _____

45. a. Approximately what percent of this mulch goes to individual Homeowners?
- 0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%
- b. Approximately what percent of this mulch goes to other businesses?
- 0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%
- c. Approximately what percent of this mulch goes to marshalling yards?
- 0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%
- d. Approximately what percent of this mulch is used by you or your business?
- 0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%
-

C. Lumber

46. a. How many board feet yards of lumber made from this source did you sell in 2005?
- 0-<5,000 5000-<10,000 10,000-<15,000
 15,000-<20,000 20,000-<25,000 25,000-<30,000
 30,000-<35,000 35,000-<40,000 40,000-<45,000
 45,000-<50,000 50,000-<55,000 55,000-<60,000
 >60,000
- b. How many board feet of lumber made from this source did you give away in 2005?
- 0-<5,000 5000-<10,000 10,000-<15,000
 15,000-<20,000 20,000-<25,000 25,000-<30,000
 30,000-<35,000 35,000-<40,000 40,000-<45,000
 45,000-<50,000 50,000-<55,000 55,000-<60,000
 >60,000

- c. How many board feet yards of lumber made from this source did you or your business use personally in 2005?

0-<5,000 5000-<10,000 10,000-<15,000
 15,000-<20,000 20,000-<25,000 25,000-<30,000
 30,000-<35,000 35,000-<40,000 40,000-<45,000
 45,000-<50,000 50,000-<55,000 55,000-<60,000
 >60,000

47. To whom do you sell or give this product? (check all that apply)

Homeowners lumber retailers
 Wood product manufacturers
 Other, please specify _____

48. a. Approximately what percent of this lumber goes to individual Homeowners?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

- b. Approximately what percent of this lumber goes to other businesses?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

- c. Approximately what percent of this lumber goes to marshalling yards?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

- d. Approximately what percent of this lumber is used by you or your business?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

D. Sawlogs

49. What is the average diameter of the logs you sell or give to sawmills?

10-<12in 12-<14in 14-<16in 16-<18in
 18-<20in 20-<22in 22-<24in >24in

50. a. How many sawlogs from this source did you sell in 2005?

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

b. How many board sawlogs from this source did you give away in 2005?

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

c. How many sawlogs from this source did you or your business use personally in 2005?

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

E. Finished products

51. What finished products do you manufacture using this wood?

Flooring Cabinetry Furniture Fencing
 Doors Trim/Molding Arts & Crafts
 Other, please specify _____

52. a. How many board feet from this source were used to manufacture products that were sold in 2005?

0-<5,000 5000-<10,000 10,000-<15,000
 15,000-<20,000 20,000-<25,000 25,000-<30,000
 30,000-<35,000 35,000-<40,000 40,000-<45,000
 45,000-<50,000 50,000-<55,000 55,000-<60,000
 >60,000

b. How many board feet from this source were used to manufacture products that were given away in 2005?

0-<5,000 5000-<10,000 10,000-<15,000
 15,000-<20,000 20,000-<25,000 25,000-<30,000
 30,000-<35,000 35,000-<40,000 40,000-<45,000
 45,000-<50,000 50,000-<55,000 55,000-<60,000
 >60,000

c. How many board feet from this source were used to manufacture products that were used personally or by your business in 2005?

- | | | |
|---|---|---|
| <input type="checkbox"/> 0-<5,000 | <input type="checkbox"/> 5000-<10,000 | <input type="checkbox"/> 10,000-<15,000 |
| <input type="checkbox"/> 15,000-<20,000 | <input type="checkbox"/> 20,000-<25,000 | <input type="checkbox"/> 25,000-<30,000 |
| <input type="checkbox"/> 30,000-<35,000 | <input type="checkbox"/> 35,000-<40,000 | <input type="checkbox"/> 40,000-<45,000 |
| <input type="checkbox"/> 45,000-<50,000 | <input type="checkbox"/> 50,000-<55,000 | <input type="checkbox"/> 55,000-<60,000 |
| <input type="checkbox"/> >60,000 | | |

53. To whom do you sell or give your products? (check all that apply)

- Homeowners Retail outlets
 Other, please specify _____

54. a. Approximately what percent of your products go to individual consumers?

- | | | | | |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|
| <input type="checkbox"/> 0-10% | <input type="checkbox"/> 11-20% | <input type="checkbox"/> 21-30% | <input type="checkbox"/> 31-40% | <input type="checkbox"/> 41-50% |
| <input type="checkbox"/> 51-60% | <input type="checkbox"/> 61-70% | <input type="checkbox"/> 71-80% | <input type="checkbox"/> 81-90% | <input type="checkbox"/> 91-100% |

b. Approximately what percent of your products go to other businesses?

- | | | | | |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|
| <input type="checkbox"/> 0-10% | <input type="checkbox"/> 11-20% | <input type="checkbox"/> 21-30% | <input type="checkbox"/> 31-40% | <input type="checkbox"/> 41-50% |
| <input type="checkbox"/> 51-60% | <input type="checkbox"/> 61-70% | <input type="checkbox"/> 71-80% | <input type="checkbox"/> 81-90% | <input type="checkbox"/> 91-100% |

c. Approximately what percent of your product goes to marshalling yards?

- | | | | | |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|
| <input type="checkbox"/> 0-10% | <input type="checkbox"/> 11-20% | <input type="checkbox"/> 21-30% | <input type="checkbox"/> 31-40% | <input type="checkbox"/> 41-50% |
| <input type="checkbox"/> 51-60% | <input type="checkbox"/> 61-70% | <input type="checkbox"/> 71-80% | <input type="checkbox"/> 81-90% | <input type="checkbox"/> 91-100% |

d. Approximately what percent of your products are used by you or your business?

- | | | | | |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|
| <input type="checkbox"/> 0-10% | <input type="checkbox"/> 11-20% | <input type="checkbox"/> 21-30% | <input type="checkbox"/> 31-40% | <input type="checkbox"/> 41-50% |
| <input type="checkbox"/> 51-60% | <input type="checkbox"/> 61-70% | <input type="checkbox"/> 71-80% | <input type="checkbox"/> 81-90% | <input type="checkbox"/> 91-100% |

F. Pallets, Boxes, Skids and/or Dunnage

55. a. Please estimate how many pounds of these products made from this wood did you sell in 2005? (a face cord is a 4x8ft stack of 16 inch long fire wood and is one third of a cord)

- | | | | | |
|-----------------------------------|-----------------------------------|-----------------------------------|---------------------------------|----------------------------------|
| <input type="checkbox"/> 0-<10 | <input type="checkbox"/> 10-<20 | <input type="checkbox"/> 20-<30 | <input type="checkbox"/> 30-<40 | <input type="checkbox"/> 40-<50 |
| <input type="checkbox"/> 50-<60 | <input type="checkbox"/> 60-<70 | <input type="checkbox"/> 70-<80 | <input type="checkbox"/> 80-<90 | <input type="checkbox"/> 90-<100 |
| <input type="checkbox"/> 100-<150 | <input type="checkbox"/> 150-<200 | <input type="checkbox"/> 200-<250 | <input type="checkbox"/> >250 | |

- b. Please estimate how many pounds of these products made from this wood did you give away in 2005?

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

- c. Please estimate how many pounds of these products made from this wood did you use personally in 2005?

0-<10 10-<20 20-<30 30-<40 40-<50
 50-<60 60-<70 70-<80 80-<90 90-<100
 100-<150 150-<200 200-<250 >250

56. To whom do you sell or give away these products? (check all that apply)

Shipping companies Other businesses
 Other, please specify _____

57. a. Approximately what percent of these products go to other businesses?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

- b. Approximately what percent of these products go to marshalling yards?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

- c. Approximately what percent of these products go elsewhere?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

G. Compost

58. On average, what volume of woodchips does your company use to produce one cubic yard of compost?

59. a. How many cubic yards of compost made using this wood did you sell in 2005?

_____ 0-<10 _____ 10-<20 _____ 20-<30 _____ 30-<40 _____ 40-<50
_____ 50-<60 _____ 60-<70 _____ 70-<80 _____ 80-<90 _____ 90-<100
_____ 100-<150 _____ 150-<200 _____ 200-<250 _____ 250-<300
_____ 300-<350 _____ 350-<400 _____ 400-<450 _____ 450-<500
_____ 500-<600 _____ 600-<700 _____ 700-<800 _____ >800

b. How many cubic yards of compost made using this wood did you give away in 2005?

_____ 0-<10 _____ 10-<20 _____ 20-<30 _____ 30-<40 _____ 40-<50
_____ 50-<60 _____ 60-<70 _____ 70-<80 _____ 80-<90 _____ 90-<100
_____ 100-<150 _____ 150-<200 _____ 200-<250 _____ 250-<300
_____ 300-<350 _____ 350-<400 _____ 400-<450 _____ 450-<500
_____ 500-<600 _____ 600-<700 _____ 700-<800 _____ >800

c. How many cubic yards of compost made using this wood did you or your business use personally in 2005?

_____ 0-<10 _____ 10-<20 _____ 20-<30 _____ 30-<40 _____ 40-<50
_____ 50-<60 _____ 60-<70 _____ 70-<80 _____ 80-<90 _____ 90-<100
_____ 100-<150 _____ 150-<200 _____ 200-<250 _____ 250-<300
_____ 300-<350 _____ 350-<400 _____ 400-<450 _____ 450-<500
_____ 500-<600 _____ 600-<700 _____ 700-<800 _____ >800

60. To whom do you sell or give this compost? (check all that apply)

_____ Homeowners _____ landscaping services _____ landscaping retailers

_____ Other, please specify _____

61. a. Approximately what percent of this compost goes to individual Homeowners?

_____ 0-10% _____ 11-20% _____ 21-30% _____ 31-40% _____ 41-50%

___ 51-60% ___ 61-70% ___ 71-80% ___ 81-90% ___ 91-100%

b. Approximately what percent of this compost goes to other businesses?

___ 0-10% ___ 11-20% ___ 21-30% ___ 31-40% ___ 41-50%
___ 51-60% ___ 61-70% ___ 71-80% ___ 81-90% ___ 91-100%

c. Approximately what percent of this compost is used by you or your business?

___ 0-10% ___ 11-20% ___ 21-30% ___ 31-40% ___ 41-50%
___ 51-60% ___ 61-70% ___ 71-80% ___ 81-90% ___ 91-100%

H. Other

62. a. Approximately how many units from this wood were sold in 2005?

b. Approximately how many units from this wood were given away in 2005?

c. Approximately how many units from this wood were used personally or by your business in 2005?

63. To whom do you sell or give your products? (check all that apply)

___ Homeowners ___ Retailers ___ Service businesses

___ Other, please specify _____

64. a. Approximately what percent of your product goes to individual consumers?

___ 0-10% ___ 11-20% ___ 21-30% ___ 31-40% ___ 41-50%
___ 51-60% ___ 61-70% ___ 71-80% ___ 81-90% ___ 91-100%

b. Approximately what percent of your product goes to other businesses?

___ 0-10% ___ 11-20% ___ 21-30% ___ 31-40% ___ 41-50%
___ 51-60% ___ 61-70% ___ 71-80% ___ 81-90% ___ 91-100%

c. Approximately what percent of your product goes to marshalling yards?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

d. Approximately what percent of this product is used by you or your business?

0-10% 11-20% 21-30% 31-40% 41-50%
 51-60% 61-70% 71-80% 81-90% 91-100%

Appendix 3: Questions used during yard visits

1. What is the size of the yard? (sq ft, ac)
2. What is the total number of full time employees?
3. What is the total number of part time employees?
4. Do you own any equipment that is not in the yard at the moment?
5. About how much “waste” wood is processed by this yard every year?
6. What kinds of wood does this yard accept? (Ask about survey categories if they are not mentioned.)
 - a. About what percent of you overall supply is represented by each of these categories?
 - b. Our survey shows.... percent of supply from these categories. Do these numbers characterize your wood supply as well?
7. Has your wood supply pattern changed in the last few years? (if so) How?
8. How does the supply this year compare with the supply in 2005? 2006?
9. Is this change more or less the same across all wood supply types?
10. Did the introduction of tipping fees effect supply?
 - a. If so by approximately how much?
11. What types of companies bring the various types of wood you accept?
 - a. Are there any clear characteristics that these companies have in common? (such as company size)
 - b. Did either the types of companies or there characteristics change with the end of subsidies/introduction of tipping fees?
12. From how far away do companies typically bring wood from?
13. How far do companies seem to be willing to travel?
 - a. Do you think that they would be willing to travel further if there were no tipping fee? Did this distance change with the introduction of tipping fees?
 - b. What is the furthest that a company has traveled?
 - c. Where there extenuating circumstances involved?
 - d. Does it seem to you that the companies are just looking for somewhere to get rid of or dump the wood? Do you need to do something to motivate them to use your yard?

14. What do you feel is the most significant deterrent to companies using your yard? (the fee, travel time or costs, the hassle, don't know about your company)
15. Do you feel that your yard and services are sufficiently well known? or: Is lack of knowledge about your services a problem?
16. Approximately what percent of the total wood supply do these categories represent?
17. Is there a large amount of seasonal variation in your wood supply?
 - a. How much does wood supply increase/decrease in the winter?
 - b. Is the standing supply today typical for this time of year?
 - c. Is employment seasonal as well? What is employment at the peaks and throughout the season?
18. What tipping fees do you charge?
 - a. our survey shows Does this seem reasonable to you?
19. What products do you sell? (Ask about categories from the survey if they are not mentioned.)
 - a. Do you have a price list available? (if no) What is the average price charged for each of these products?
 - b. About what percent of you overall sales are represented by each of these products?
 - c. Our survey shows.... percent of supply from these categories. Do these numbers seem reasonable to you?
 - d. What limits the amount sold of the most valuable product you sell? (Consumer demand, wood supply, wood supply quality etc...)
 - I. (If value added products sold) what percent of logs received are converted to high value products.
 - II. What limits this amount?
20. What types of consumers buy your products?
 - a. (for businesses that sell value added products) why do you believe that consumers buy the products from you rather than conventional dealers?
21. For how long does wood typically stay in the yard from receiving to sale?
22. What do you think is the biggest obstacles to a more efficient waste wood utilization system?
23. Do you see any other problems in the business you are in that you would like to mention?
24. How have these supply changes affected your products?