CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN THE UNITED STATES: 1995 UPDATE

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CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN THE UNITED STATES: 1995 UPDATE

Executive Summary

FEATURES OF THIS REPORT

This report is the most recent in a series of reports released by the U.S. Environmental Protection Agency (EPA) characterizing municipal solid waste (MSW) in the United States. The report describes the national waste stream based on data collected from 1960 through 1994. This historical perspective is useful for establishing trends and highlighting changes that have occurred over the years, both in types of waste generated and in the ways they are managed. It does not, however, specifically address local and regional variations in the waste stream. Nevertheless, the data in this report can be used to develop approximate (but quick) estimates of MSW generation and composition in a defined area. Due to increased interest in the report over the years and the dynamic nature of the MSW field, EPA plans to provide annual updates of this report as a service to state and local MSW officials and other interested parties.

The report includes information on:

- MSW generation, recovery, and discards from 1960 to 1994
- Per capita generation and discard rates
- Residential/commercial portions of MSW generation
- Trends in MSW management, including recovery for recycling and composting, as well as combustion and landfilling, from 1960 to 1994
- The role of source reduction in MSW management
- Projections for MSW generation and management through 2010, including three scenarios for recovery
- An "Additional Perspectives" Chapter devoted to basic information on the potential climate change implications of various municipal waste management strategies.

REPORT HIGHLIGHTS

While the total amount of MSW generated annually continues to increase, the rate of this growth is slowing. Per capita MSW generation (the amount of MSW generated per person per day) is expected to remain constant at

4.4 pounds per person per day through the year 2000. The primary reason for this steady rate is that, while the per capita generation of the products and packaging component of MSW will continue to rise, efforts to keep yard trimmings out of the waste management system are beginning to have an effect. Recovery rates for recycling and composting continue to grow, and this year, for the first time, composting of food scraps has reached measurable proportions. As MSW generation continues to increase and recycling matures, however, source reduction as a management practice will be increasingly important.

1994 MSW Generation and Management

- A total of 209 million tons of MSW was generated in 1994. This reflects an increase of 3 million tons from 1993, when MSW generation was 206 million tons. This increase in total MSW generation is due largely to an increase in population.

- However, the per capita generation rate remained at 4.4 pounds per person per day, the same rate as 1993.

- The per capita discard rate (after recycling and composting) was 3.4 pounds per person per day in 1994, down from 3.5 pounds per person per day in 1993.

- Recycling and composting recovered 24 percent of MSW in 1994, up from 21 percent in 1993 and up from 17 percent in 1990. As a nation, during 1994 we quickly approached the goal of 25 percent recovery of MSW.

- An estimated 49 million tons of MSW were recovered in 1994, while 44 million tons were recovered in 1993.

- Recovery of paper and paperboard accounted for more than half (nearly 29 million tons) of total MSW recovery. Composting of yard trimmings contributed to the next largest fraction of total recovery at 7 million tons.

- For the first time, composting of food scraps reached measurable proportions at the national level. An estimated 3.4 percent of food scraps was composted (500,000 tons out of 14.1 million tons generated).

- Landfills managed 61 percent of MSW generated (127 million tons), and combustion facilities managed 15 percent of the total MSW generated (32.5 million tons).

Trends in MSW Generation and Management

- Annual MSW generation is expected to increase to 223 million tons in the year 2000 and 262 million tons in 2010. Natural population growth and

sustained long-term growth in the economy account for this projected increase.

- Per capita generation rates are projected to remain constant at 4.4 pounds per person per day to the year 2000. Projected decreases in per capita generation of yard trimmings during this time will be offset by increases in per capita generation associated with the discard of products and packaging.

- After the year 2000, per capita decreases in generation of yard trimmings are expected to plateau, while increases in per capita generation of products and packaging will continue, causing total MSW per capita generation rates to rise to 4.8 pounds per person per day by 2010.

- Achieving a decline in projected overall and per capita waste generation will require continued emphasis on source reduction activities, which prevent waste before it is generated. For example, State and local efforts to keep yard trimmings out of landfills are projected to result in a 25 percent decrease in yard trimmings generation (by the year 2000) from the 1994 estimate of 30.6 million tons. Primarily through the success of grasscycling and backyard composting programs, yard trimmings generation is projected to decrease to 23 million tons by 2000.

- Recovery from recycling and composting continues to show impressive growth. For the year 2000, three recovery scenarios ranging from 25 percent to 35 percent are presented. The range for the year 2010 is 30 percent to 40 percent. Achieving a 40 percent recovery rate nationwide would require recovery rates in the range of 50 percent for many material categories in MSW, including paper and paperboard, yard trimmings, metals, and glass.

- Combustion is expected to remain relatively unchanged through the year 2000.

- While the percentage of MSW being disposed of in landfills is decreasing, the actual tonnage is expected to increase to the year 2000. Landfilling is expected to continue to be the single most predominant MSW management method in future years.

- Preliminary research indicates that source reduction and recycling of MSW have significant potential to reduce greenhouse gas emissions and mitigate climate change.

DEFINITIONS AND METHODOLOGY

Municipal solid waste (MSW) includes wastes such as durable goods, nondurable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. Examples of waste from these categories include appliances, automobile tires, newspapers, clothing, boxes, disposable tableware, office and classroom paper, wood pallets, and cafeteria wastes. MSW does not include wastes from other sources, such as construction and demolition debris, automobile bodies, municipal sludges, combustion ash, and industrial process wastes that might also be disposed in municipal waste landfills or incinerators.

Source reduction activities reduce the amount or toxicity of wastes before they enter the municipal solid waste management system (see **Generation**). Reuse of products such as refillable glass bottles, reusable plastic food storage containers, or refurbished wood pallets are examples of source reduction.

Generation refers to the amount (weight or volume) of materials and products that enter the waste stream before recycling, composting, landfilling, or combustion takes place.

Recovery of materials means removing MSW from the waste stream for the purpose of recycling or composting. Recovery for recycling as defined for this report includes purchases of postconsumer recovered materials plus net exports of the materials. Recovery of yard trimmings includes diverting yard trimmings from disposal to a composting facility. For some materials, recovery for uses such as highway construction or insulation is considered recovery along with materials used in remanufacturing processes.

Combustion includes combustion of mixed MSW, fuel prepared from MSW, or a separated component of MSW (such as rubber tires), with or without energy recovery.

Discards include the municipal solid waste remaining after recycling and composting. These discards are usually combusted or disposed of in landfills, although some MSW is littered, stored, or disposed on site, particularly in rural areas.

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Methodology. There are two primary methods for conducting a waste characterization study. The first is a source-specific approach in which the individual components of the waste stream are sampled, sorted, and weighed. Although this method is useful for defining a local waste stream, extrapolating from a limited number of studies can produce a skewed or misleading picture if used for a nationwide characterization of waste. Atypical circumstances encountered during sampling or errors in the sample would be greatly magnified when expanded to represent the nation's entire waste stream. The second method, which is used in this report, is called the "material flows methodology." EPA's Office of Solid Waste and its predecessors in the Public Health Service sponsored work in the 1960s and early 1970s to develop the material flows methodology. This methodology is based on production data (by weight) for the materials and products in the waste stream, with adjustments for imports, exports, and product lifetimes.

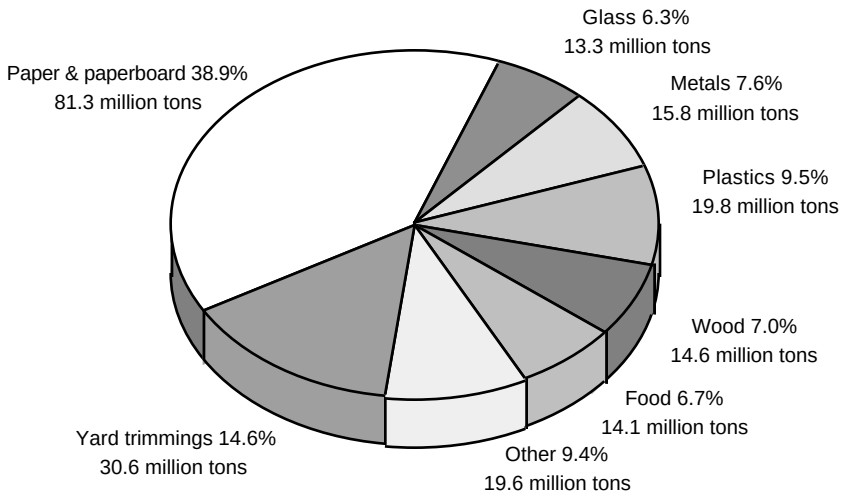
Note that when the report is updated, there are numerical discrepancies in waste generation, recovery, and discards from previous editions. These differences are due to revised estimates from source data (e.g., industry associations and federal agencies) made to the MSW characterization database.

MUNICIPAL SOLID WASTE IN 1994

Materials in MSW

In 1994, MSW generation totaled 209 million tons. Figure ES-1 provides a breakdown by weight of the materials generated in 1994. Paper and paperboard products made up the largest component of MSW generated (39 percent), and yard trimmings were the second largest component (15 percent). Glass, metals, plastics, wood, and food scraps each constituted between 6 and 10 percent of the total MSW generated. Other materials in MSW, such as rubber, leather, textiles, and miscellaneous wastes, made up approximately 9 percent of the MSW generated in 1994.

Figure ES-1. Materials generated in MSW by weight, 1994
(Total weight = 209.1 million tons)



In 1994, a portion of most materials in MSW were recycled or composted, as illustrated in Table ES-1. Each material category (except for food scraps and yard trimmings) is made up of many different products. Because some of these products are not recovered at all, the overall recovery rate for any particular material may be lower than recovery rates for some products within the material category.

Nonferrous metals (other than aluminum) have the highest recovery rate (66 percent), due to high rates of lead recovery from lead-acid batteries. Approximately 38 percent of aluminum is recovered, even though aluminum cans are recovered at rates above 65 percent. Likewise, the overall recovery rate for paper and paperboard is 35 percent, even though corrugated containers are recovered at rates above 55 percent.

Table ES-1

GENERATION AND RECOVERY OF MATERIALS IN MSW, 1994
(In millions of tons and percent of generation of each material)

	Weight Generated	Weight Recovered	Recovery as a Percent of Generation
Paper and paperboard	81.3	28.7	35.3%
Glass	13.3	3.1	23.4%
Metals			
Ferrous metals	11.5	3.7	32.3%
Aluminum	3.1	1.2	37.6%
Other nonferrous metals	1.2	0.8	66.1%
Total metals	15.8	5.7	35.9%
Plastics	19.8	0.9	4.7%
Rubber and Leather	6.4	0.5	7.1%
Textiles	6.6	0.8	11.7%
Wood	14.6	1.4	9.8%
Other materials	3.6	0.8	20.9%
Total Materials in Products	161.3	41.8	25.9%
Other Wastes			
Food Wastes	14.1	0.5	3.4%
Yard Trimmings	30.6	7.0	22.9%
Miscellaneous Inorganic Wastes	3.1	Neg.	Neg.
Total Other Wastes	47.8	7.5	15.7%
TOTAL MUNICIPAL SOLID WASTE	209.1	49.3	23.6%

Includes wastes from residential, commercial, and institutional sources.
Neg. = Less than 50,000 tons or 0.05 percent.
Numbers in this table have been rounded to the first decimal place.

Products in MSW

The products in MSW are grouped into three main categories: 1) durable goods (e.g., appliances); 2) nondurable goods (e.g., newspapers); and 3) containers and packaging (Figure ES-2). These product categories generally contain each type of MSW material, with some exceptions. The durable goods category contains no paper and paperboard. The nondurable goods category includes only small amounts of metals and essentially no glass or wood. The containers and packaging category includes only very small amounts of rubber, leather, and textiles.

Figure ES-2. Products generated in MSW by weight, 1994
(Total weight = 209.1 million tons)

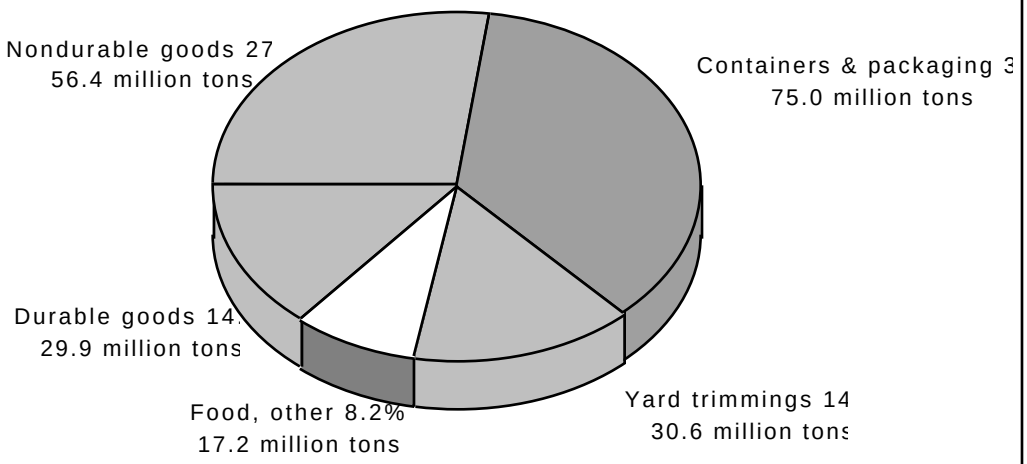


Table ES-2 shows the generation and recovery of the product categories in MSW, broken down by materials within each category. Overall, the materials in **durable goods** were recovered at a rate of approximately 15 percent in 1994. A large portion of non-ferrous metals were recovered from lead-acid batteries. Considerable amounts of ferrous metals were recovered from appliances in the durables category, and some rubber was recovered from tires.

Overall recovery in the **nondurable goods** category was approximately 22 percent in 1994. In this category, large amounts of newspapers, office papers, and some other paper products were recovered.

Recovery from the **containers and packaging** category is the highest of these categories—34 percent of generation. More than 55 percent of aluminum packaging was recovered in 1994 (mostly aluminum beverage cans), while more than 51 percent of steel packaging (mostly cans) was recovered. Paper and paperboard packaging recovery was estimated at 45 percent, with corrugated containers accounting for most of that tonnage. Approximately 26 percent of glass containers were recovered overall, while about 14 percent of wood packaging (mostly pallets) was recovered. About 8 percent of plastic containers and packaging was recovered in 1994, most of which was made up of soft drink, milk, and water bottles.

Table ES-2

GENERATION AND RECOVERY OF PRODUCTS IN MSW
BY MATERIAL, 1994
(In millions of tons and percent of generation of each product)

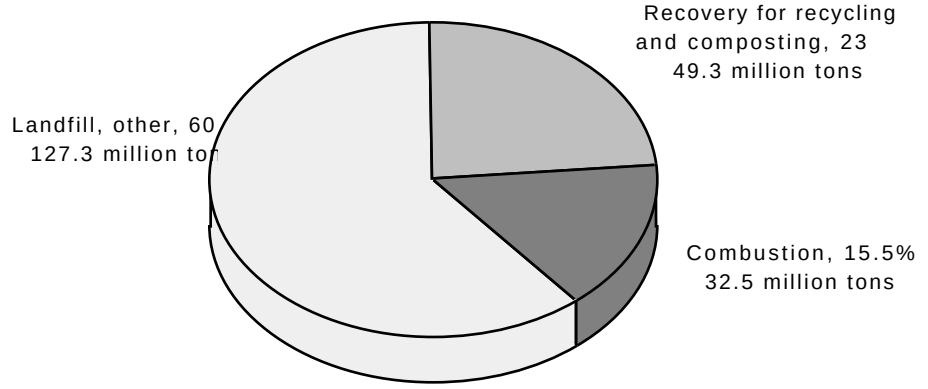
	Weight Generated	Weight Recovered	Recovery as a Percent of Generation
Durable goods			
Ferrous metals	8.4	2.1	25.2%
Aluminum	0.8	Neg.	Neg.
Other non-ferrous metals	1.2	0.8	66.1%
Total metals	10.4	2.9	28.0%
Glass	1.2	Neg.	Neg.
Plastics	5.6	0.2	3.6%
Rubber and leather	5.1	0.5	8.9%
Wood	4.4	Neg.	Neg.
Textiles	2.3	0.1	4.4%
Other materials	1.0	0.8	74.3%
Total durable goods	29.9	4.4	14.8%
Nondurable goods			
Paper and paperboard	43.5	11.6	26.8%
Plastics	4.7	Neg.	<1%
Rubber and leather	1.3	Neg.	Neg.
Textiles	4.2	0.7	16.4%
Other materials	2.8	Neg.	Neg.
Total nondurable goods	56.4	12.3	21.9%
Containers and packaging			
Steel	3.1	1.6	51.4%
Aluminum	2.1	1.2	55.0%
Total metals	5.2	2.8	52.9%
Glass	12.1	3.1	25.8%
Paper and paperboard	37.8	17.1	45.2%
Plastics	9.5	0.7	7.5%
Wood	10.2	1.4	14.0%
Other materials	0.2	Neg.	Neg.
Total containers and packaging	75.0	25.1	33.5%
Other wastes			
Food wastes	14.1	0.5	3.4%
Yard trimmings	30.6	7.0	22.9%
Miscellaneous inorganic wastes	3.1	Neg.	Neg.
Total other wastes	47.8	7.5	15.7%
TOTAL MUNICIPAL SOLID WASTE	209.1	49.3	23.6%

Includes wastes from residential, commercial, and institutional sources.
Neg. = less than 50,000 tons or 0.05 percent.
Numbers in this table have been rounded to the first decimal place.

Management of MSW

Figure ES-3 shows how much MSW was recycled, composted, combusted, and landfilled in 1994. Approximately 49 million tons, or 24 percent of MSW, was recycled and composted; an estimated 32 million tons, or 15 percent, was combusted (nearly all with energy recovery); and the remainder, 127 million tons (61 percent), was landfilled (small amounts may have been littered or self-disposed).

Figure ES-3. Management of MSW in U.S., 1994
(Total weight = 209.1 million tons)

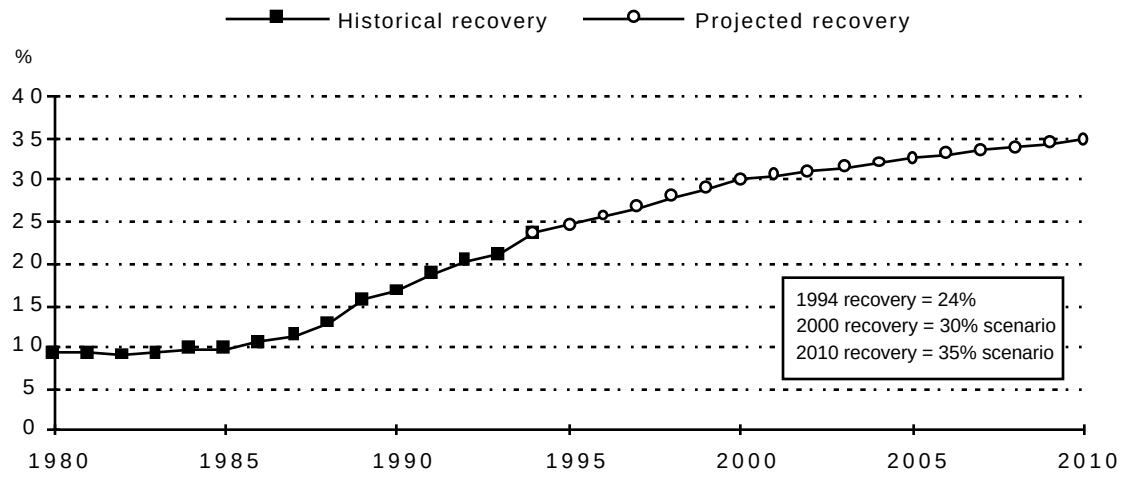


Recovery rates have increased steadily since the 1980s. After remaining constant at 9 to 10 percent in the early to mid-1980s, people nationwide began realizing that new approaches to solid waste management were needed. Recycling and composting rates increased from 13 percent in 1988 to 17 percent in 1990 to 24 percent in 1994 (Figure ES-4). For the year 2000, three recovery scenarios ranging from 25 percent to 35 percent are presented. The range for the year 2010 is 30 percent to 40 percent. Achieving a 40 percent recovery rate nationwide would require recovery rates in the range of 50 percent for many material categories in MSW, including paper and paperboard, yard trimmings, metals, and glass.

Residential and Commercial Sources of MSW

Sources of MSW, as characterized in this report, include both residential and commercial locations (commercial locations include schools, some industrial sites where packaging is generated, and businesses). Identifying sources where MSW is generated is important to developing management techniques, such as collection for disposal, recycling, or composting. Residential wastes

Figure ES-4. Recovery for recycling and composting, 1980 to 2010 (in percent of total MSW generation)



(including wastes from multi-family dwellings) are estimated to be 55 to 65 percent of total generation. Commercial wastes constitute between 35 and 45 percent. Local and regional factors such as climate and level of commercial activity contribute to these variations.

TRENDS IN MSW GENERATION AND MANAGEMENT

Generation of MSW has grown steadily from 88 million tons in 1960 to 209 million tons in 1994. The total amount of MSW generated is projected to be 223 million tons in 2000 and 262 million tons in 2010. Per capita generation of MSW increased from 2.7 pounds per person per day in 1960 to 4.4 pounds per person per day in 1994. This rate is expected to remain constant through the year 2000 based in large part on a projected decrease in the tonnage of yard trimmings entering the MSW management system, along with an increase in generation of consumer products and packaging. After 2000, the amount of yard trimmings diverted from disposal is expected to plateau. Achieving a decline in overall waste generation after 2000 hinges on continued emphasis on source reduction of all MSW.

Source Reduction activities include the design, manufacture, purchase, or use of materials (such as products and packaging) to reduce the amount or toxicity of materials before they enter the MSW management system. Source reduction activities include:

- Designing products or packaging to reduce the quantity of materials or the toxicity of the materials used.

- Reusing products or packaging already manufactured.

- Lengthening the life of products to postpone disposal.

- Managing non-product organic wastes (e.g., food scraps and yard trimmings) through on-site composting or other alternatives to disposal.

While most source reduction activities were not quantified in this report, calculations show that yard trimmings generation could be reduced significantly if current and planned state and local programs to reduce their disposal are implemented. While recycling and composting programs are continuing to decrease the amount of MSW that is disposed of, source reduction can help decrease MSW discards even more, by preventing waste before it is even generated.

Recovery (recycling and composting) has increased from approximately seven percent of MSW in 1960 to 24 percent by 1994. Much of the growth has occurred over the past five or six years. Projected scenarios for recovery are between 25 and 35 percent in 2000, and 30 to 40 percent in 2010. To achieve these recovery rates, some products will have to be recovered at rates of 50 percent or more. In addition, composting of yard trimmings will have to increase substantially.

For this report, EPA examined a range of recovery scenarios from 25 percent to 35 percent nationwide for the year 2000. For the year 2010, EPA examined recovery scenarios ranging from 30 percent to 40 percent. A mid-range projected scenario of 30 percent in the year 2000 and 35 percent in 2010 was used to illustrate the effects of recovery on future MSW management. To achieve this level of recovery, EPA assumed that local, state, and federal agencies would continue to emphasize recycling and composting as a priority; that industries would continue to make the necessary investments in recovery and utilization of materials; that state and local governments would continue to expand programs designed to keep yard trimmings out of landfills; and that most U.S. citizens would have access to some sort of recovery program and that they would be willing to participate.

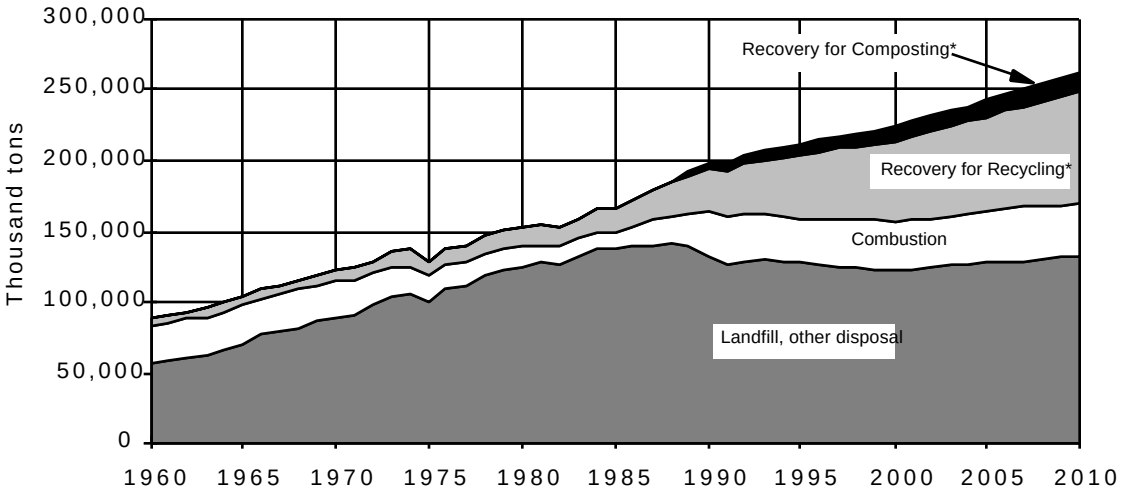
Combustion facilities handled an estimated 30 percent of MSW generated in 1960, mostly through incinerators with no energy recovery and no air pollution controls. In the 1960s and 1970s, combustion dropped steadily as old incinerators were closed, reaching a low of less than 10 percent by 1980. In 1990, approximately 16 percent of MSW was combusted. Between 1990 and 1994, combustion remained between 15 and 16 percent. All major new facilities have energy recovery and are designed to meet air pollution standards.

This report projects that tonnage of MSW combusted will remain relatively unchanged, particularly in terms of percentage of total MSW generation. By the year 2000, the tonnage is expected to increase from about 32 million tons (or 15 percent of total MSW generation) in 1994 to 34 million tons (15 percent of projected 2000 total MSW generation). For 2010, the tonnage of MSW combusted is projected to be 38 million tons (or 14 percent of projected 2010 total MSW generation). Combustion projections are based on an assumption that the current number of facilities will remain the same and that they will operate at around 85 percent of capacity. The projected tonnage increase in combustion is primarily due to an expected rise in the combustion of source-separated materials (e.g., wood and tires).

Landfill use fluctuates with changes in the use of alternative solid waste management methods. For example, when the use of combustion for MSW management declined and recovery rates were low, the amount of waste sent to landfills increased (Figure ES-5). Alternatively, when recovery and combustion of MSW increased, the percentage of MSW discarded in landfills declined. In 1960, approximately 62 percent of MSW was sent to landfills. This increased to 81 percent by 1980 as incineration declined, then decreased to an estimated 61 percent by 1994 due to moderate increases in incineration and dramatic increases in recovery.

Landfill tonnage is expected to decrease from 127 million tons (61 percent of generation) in 1994 to 122 million tons in 2000 (55 percent of generation). Significant diversion of yard trimmings from landfills is the primary reason for

Figure ES-5. Municipal solid waste management, 1960 to 2010



* Recovery scenarios of 30% in 2000 and 35% in 2010 used in this figure. Other scenarios are presented in the report.

this projection. The amount of waste disposed of in landfills is expected to increase in tonnage to 132 million tons by 2010, as diversion of yard trimmings from landfills plateaus and discards from products and packaging increases. However, as a percentage of total MSW generated, discards to landfills are projected to decline to 51 percent by 2010 due to increases in recovery.

ADDITIONAL PERSPECTIVES ON MSW

Global Climate Change

The manufacture and distribution of products and the subsequent management of solid waste can contribute to the formation of excess "greenhouse gases." Carbon dioxide, methane, and other gases form an atmospheric blanket around the planet's surface. These gases regulate the earth's temperature by trapping some of the sun's heat. This natural process is commonly referred to as the "greenhouse effect."

Human activities—in particular, the burning of fossil fuels (e.g., coal, oil, and wood)—and other factors appear to have increased the amount of greenhouse gases in the atmosphere. A buildup of these gases could raise global temperatures, setting off profound changes in the earth's climate and ecosystems, known as "global climate change." There is growing consensus that global climate change is occurring and will cause serious environmental dislocations.

Greenhouse gas emissions can be generated throughout the life cycle of a product, from its manufacture to its disposal. Source reduction and recycling activities can help reduce greenhouse gases because they 1) reduce the need to harvest or extract new raw materials; 2) eliminate the need to manufacture new products; 3) reduce the amount of energy required in manufacturing (through the use of recycled rather than virgin materials); and 4) prevent or divert waste from disposal (greenhouse gas emissions can be released when materials decompose in landfills or burn in combustors). Source reduction and recycling initiatives, as outlined in President Clinton's 1993 Climate Change Action Plan, will make a significant contribution to reducing greenhouse gas emissions.

Chapter 1

INTRODUCTION AND METHODOLOGY

BACKGROUND

This report is the most recent in a 20-year series of reports sponsored by the U.S. Environmental Protection Agency to characterize municipal solid waste (MSW) in the United States. Together with the previous reports, this report provides a historical database for a 34-year characterization (by weight) of the materials and products in MSW, with projections through the year 2010.

Management of the nation's municipal solid waste (MSW) continues to be a high priority issue for many communities as we near the turn of the century. Increasingly, the concept of integrated solid waste management—source reduction of wastes before they enter the waste stream, recovery of generated wastes for recycling and composting, and environmentally sound disposal through combustion facilities and landfills that meet current standards—is being used by communities as they plan for the future.

There are many regional variations that require each community to examine its own waste management needs. Such factors as local and regional availability of suitable landfill space, proximity of markets for recovered materials, population density, commercial and industrial activity, and climatic and groundwater variations all may motivate each community to make its own plans.

Identifying the components of the waste stream is an important step toward addressing the issues associated with the generation and management of municipal solid wastes. MSW characterizations, which analyze the quantity and composition of the municipal solid waste stream, involve estimating how much MSW is generated, recycled, combusted, and disposed of in landfills. By determining the makeup of the waste stream, waste characterizations also provide valuable data for setting waste management goals, tracking progress toward those goals, and supporting planning at the national, state, and local levels. For example, waste characterizations can be used to highlight opportunities for source reduction and recycling and provide information on any special management issues that should be considered.

Readers should note that this report characterizes the municipal solid waste stream of *the nation as a whole*. Local and regional variations are not addressed, but suggestions for use of the information in this report by local planners are included in Chapter 1.

HOW THIS REPORT CAN BE USED

The data in this report provide a nationwide picture of municipal solid waste generation and management. The historical perspective is particularly useful in establishing trends and highlighting the changes that have occurred over the years, both in types of wastes generated and in the ways they are managed. This perspective on MSW and its management is useful in assessing national solid waste management needs and policy. However, the report is of equal or greater value as a solid waste management planning tool for state and local governments and private firms.

A common error in using this report is to assume that *all* nonhazardous wastes are included. As shown later in this chapter, municipal solid waste as defined here does *not* include construction and demolition wastes, industrial process wastes, or a number of other wastes that may well go to a municipal waste landfill.

At the local or state level, the data in this report can be used to develop approximate (but quick) estimates of MSW generation in a defined area. That is, the data on generation of MSW per person nationally may be used to estimate generation in a city or other local area based on the population in that area. This can be of value when a "ballpark" estimate of MSW generation in an area is needed. For example, communities may use such an estimate to determine the potential viability of regional versus single community solid waste management facilities. This information can help define solid waste management planning areas and the planning needed in those areas. However, for communities making decisions where knowledge of the amount and composition of MSW is crucial, e.g., where a solid waste management facility is being sited, local estimates of the waste stream should be made.

Another useful feature of this report for local planning is the information provided on MSW trends. Changes over time in total MSW generation and the mix of MSW materials can affect the need for and use of various waste management alternatives. Observing trends in MSW generation can help in planning an integrated waste management system that includes facilities sized and designed for years of service.

While the national average data are useful as a checkpoint against local MSW characterization data, any differences between local and national data should be examined carefully. There are many possible reasons for these differences, for example:

- Scope of waste streams may differ. That is, a local landfill may be receiving construction and demolition wastes in addition to MSW, but this report addresses MSW only.

- Per capita generation of some products, such as newspapers and telephone directories, varies widely depending upon the average size of the publications. Typically, rural areas will generate less of these products on a per capita basis than urban areas.

- The level of commercial activity in a community will influence the generation rate of some products, such as office paper, corrugated boxes, wood pallets, and food wastes from restaurants.

- Variations in economic activity can affect waste generation in both the residential and the commercial sectors.

- Variations in climate and local waste management practices will greatly influence generation of yard trimmings. For instance, yard trimmings exhibit strong seasonal variations in most regions of the country. Also, the level of backyard composting in a region will affect generation of yard trimmings.

- Generation and discards of other products will be affected by local and state regulations and practices. Deposit laws, bans on landfilling of specific products, and variable rate pricing for waste collection are examples of practices that can influence a local waste stream.

While caution should be used in applying the data in this report, for some areas, the national breakdown of MSW by material may be the only such data available for use in comparing and planning waste management alternatives. Planning a curbside recycling program, for example, requires an estimate of household recyclables that may be recovered. If resources are not available to adequately estimate these materials by other means, local planners may turn to the national data. This is useful in areas that can reasonably be expected to have typical/average MSW generation or in areas where appropriate adjustments in the data can be made to account for local conditions.

In summary, the data in this report can be used in the following ways for local planning:

- to develop approximate estimates of total MSW generation in an area

- to check locally developed MSW data for accuracy and consistency

- to help estimate quantities of recyclables and other MSW components in an area

- to account for trends in total MSW generation and the generation of individual components.

MUNICIPAL SOLID WASTE IN PERSPECTIVE

Municipal Solid Waste Defined

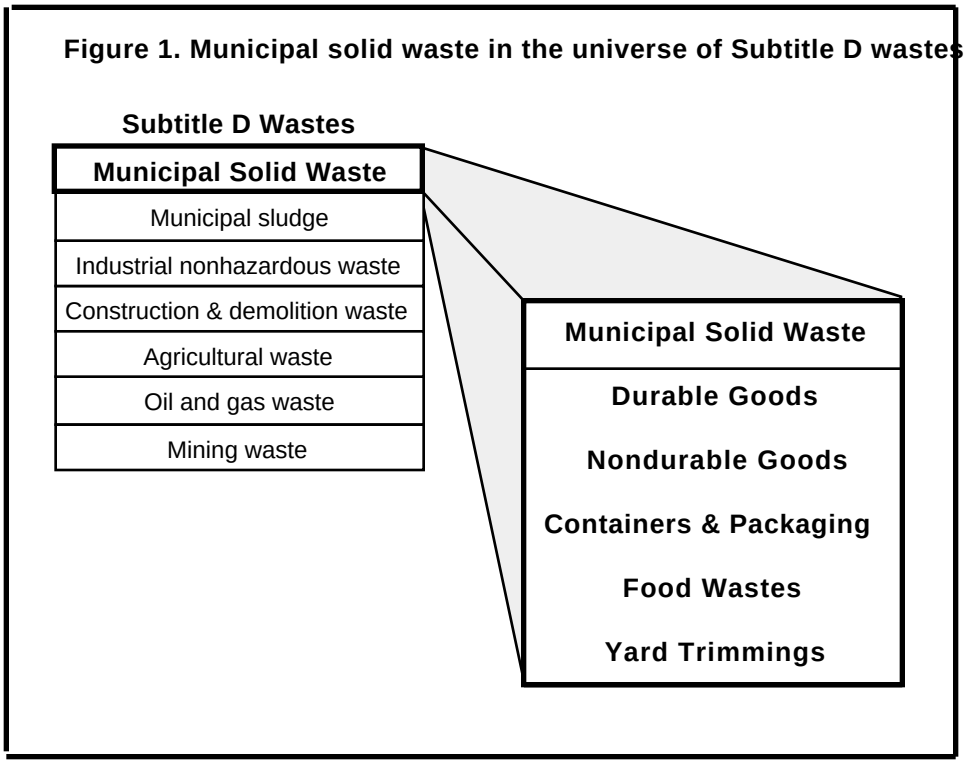
Municipal solid waste includes durable goods, nondurable goods, containers and packaging, food wastes and yard trimmings, and miscellaneous inorganic wastes (Figure 1). Municipal solid wastes characterized in this report come from residential, commercial, institutional, and industrial sources. Some examples of the types of MSW that come from each of the broad categories of sources are:

Sources and Examples	Example Products
Residential (single- and multi-family homes)	Newspapers, clothing, disposable tableware, food packaging, cans and bottles, food scraps, yard trimmings
Commercial (office buildings, retail and wholesale establishments, restaurants)	Corrugated boxes, food wastes, office papers, disposable tableware, paper napkins, yard trimmings
Institutional (schools, libraries, hospitals, prisons)	Cafeteria and restroom trash can wastes, office papers, classroom wastes, yard trimmings,
Industrial (packaging and administrative; *not* process wastes)	Corrugated boxes, plastic film, wood pallets, lunchroom wastes, office papers.

The material flows methodology used in this report does not readily lend itself to the quantification of wastes according to their source. For example, corrugated boxes may be unpacked and discarded from residences, commercial establishments such as grocery stores, institutions such as schools, or factories. The methodology estimates only the total quantity of such boxes generated, not their places of disposal or recovery for recycling.

Other Subtitle D Wastes

Some people assume that “municipal solid waste” must include everything that is landfilled in Subtitle D landfills. (Subtitle D of the Resource Conservation and Recovery Act deals with wastes other than the hazardous wastes covered under Subtitle C.) As shown in Figure 1, however, RCRA Subtitle D includes many kinds of wastes. It has been common practice to landfill wastes such as municipal sludge, nonhazardous industrial wastes, residue from automobile salvage operations, and construction and demolition wastes along



with MSW, but these other kinds of wastes *are not included in the estimates presented in this report.*

The Solid Waste Management Hierarchy

EPA's 1989 Agenda for Action endorsed the concept of integrated waste management, by which municipal solid waste is reduced or managed through several different practices, which can be tailored to fit a particular community's needs. The components of the hierarchy are:

- source reduction (including reuse of products and backyard composting of yard trimmings)
- recycling of materials (including composting)
- waste combustion (preferably with energy recovery) and landfilling.

With the exception of source reduction, this updated characterization report includes estimates of the quantities of MSW managed by each practice in the hierarchy.

METHODOLOGIES FOR CHARACTERIZING MUNICIPAL SOLID WASTE

The Two Methodologies

There are two basic approaches to estimating quantities of municipal solid waste. The first method, which is site-specific, involves sampling, sorting, and weighing the individual components of the waste stream. This method is useful in defining a local waste stream, especially if large numbers of samples are taken over several seasons. Results of sampling also increase the body of knowledge about variations due to climatic and seasonal changes, population density, regional differences, and the like. In addition, quantities of MSW components such as food and yard trimmings can only be estimated through sampling and weighing studies.

A disadvantage of sampling studies based on a limited number of samples is that they may be skewed and misleading if, for example, atypical circumstances were experienced during the sampling. These circumstances could include an unusually wet or dry season, delivery of some unusual wastes during the sampling period, or errors in the sampling methodology. Any errors of this kind will be greatly magnified when a limited number of samples are taken to represent a community's entire waste stream for a year. Magnification of errors could be even more serious if a limited number of samples was relied upon for making the national estimates of MSW. Also, extensive sampling would be prohibitively expensive for making the national estimates. An additional disadvantage of sampling studies is that they do not provide information about trends unless performed in a consistent manner over a long period of time.

The second approach to quantifying and characterizing the municipal solid waste stream—the method used for this report—utilizes a material flows approach to estimate the waste stream on a nationwide basis. In the late 1960s and early 1970s, EPA's Office of Solid Waste and its predecessors at the Public Health Service sponsored work that began to develop this methodology. This report represents the latest version of this database that has been evolving for over 20 years.

The material flows methodology is based on production data (by weight) for the materials and products in the waste stream. Adjustments are made for imports and exports and for diversions from MSW (e.g., for building materials made of plastic and paperboard). Adjustments are also made for the lifetimes of products. Finally, food wastes and yard trimmings and a small amount of miscellaneous inorganic wastes are accounted for by compiling data from a variety of waste sampling studies.

Definition of Terms

The material flows methodology produces an estimate of total municipal solid waste generation in the United States, by material categories and by product categories.

The term ***generation*** as used in this report refers to the weight of materials and products as they enter the waste management system from residential, commercial, institutional, and industrial sources and before materials recovery or combustion takes place. Preconsumer (industrial) scrap is not included in the generation estimates. Source reduction activities (e.g., backyard composting of yard trimmings) take place *ahead of* generation.

Source reduction activities reduce the amount or toxicity of wastes before they enter the municipal solid waste management system. Reuse of products such as refillable glass bottles, reusable plastic food storage containers, or refurbished wood pallets is counted as source reduction, not recycling.

Recovery of materials as estimated in this report includes products or yard trimmings removed from the waste stream for the purpose of recycling or composting. For recovered products, recovery equals reported purchases of postconsumer recovered material (e.g., glass cullet, old newspapers) plus net exports (if any) of the material. Thus, recovery of old corrugated containers (OCC) is the sum of OCC purchases by paper mills plus net exports of OCC. If recovery as reported by a data source includes converting or fabrication (preconsumer) scrap, the preconsumer scrap is *not* counted towards the recovery estimates in this report. For some materials, additional uses, such as glass used for highway construction or newspapers used to make insulation, are added into the recovery totals.

Combustion of MSW was estimated with and without energy recovery. Combustion with energy recovery is often called "waste-to-energy," while combustion without energy is called incineration in this report. Combustion of separated materials—wood, rubber from tires, paper, and plastics—is included in the estimates of combustion in this report.

Discards include the MSW remaining after recovery for recycling and composting. These discards would presumably be combusted or landfilled, although some MSW is littered, stored or disposed on-site, or burned on-site, particularly in rural areas. No good estimates for these other disposal practices are available, but the total amounts of MSW involved are presumed to be small.

MATERIALS AND PRODUCTS NOT INCLUDED IN THESE ESTIMATES

As noted earlier, other Subtitle D wastes (illustrated in Figure 1) are not included in these estimates, even though some may be managed along with

MSW (e.g., by combustion or landfilling). Household hazardous wastes, while generated as MSW with other residential wastes, are not identified separately in this report. Transportation equipment (including automobiles and trucks) is not included in the wastes characterized in this report.

One problem with the material flows methodology is that product residues associated with other items in MSW (usually containers) are not accounted for. These residues would include, for example, food left in a jar, detergent left in a box or bottle, dried paint in a can, etc. Some household hazardous wastes, e.g., pesticide left in a can, are also included among these product residues.

Certain other materials associated with products in MSW are often not accounted for because the appropriate data series have not yet been developed. These include, for example, inks and other pigments and some additives associated with plastic resins. Considerable additional research would be required to estimate these materials, which constitute a relatively small percentage of the waste stream.

Some adjustments are made in this report to account for packaging of imported goods, but there is little available documentation of these amounts.

PROJECTIONS

The projections of MSW generation to the year 2010 were not based on total quantities, but were aggregated from separate projections for each product and material. The projections are based on trend analysis of the 34-year historical database developed for each product, from information in government sources such as the ***Industrial Outlook*** published by the Department of Commerce, and, in some cases, best professional judgment. Based on correlations of MSW generation with population and Gross Domestic Product (GDP), the projections for most products were kept higher than projected population growth but lower than projected GDP growth. (See Chapter 5 of EPA report 530-R-94-042, ***Characterization of Municipal Solid Waste in the United States: 1994 Update***, for an explanation of the correlation of MSW generation with these demographic and economic factors.)

It should be emphasized that projections are not predictions. Projections are based on an assumption that there will be no unforeseen changes in current trends. Thus, the economy is assumed to remain stable and population trends are assumed to be as projected by the Bureau of the Census. Additional discussions of projection assumptions are included in Chapter 4.

OVERVIEW OF THIS REPORT

Following this introductory chapter, Chapter 2 presents the results of the municipal solid waste characterization (by weight). Estimates of MSW generation, recovery, and discards are presented in a series of tables, with discussion. Detailed tables and figures summarizing 1994 MSW generation, recovery, and discards of products in each material category are included.

In Chapter 3 of the report, estimates of 1994 MSW management by the various alternatives are summarized. These include recovery for recycling and composting, combustion, and landfilling. A discussion of source reduction is also included in Chapter 3.

Projections of municipal solid waste generation and management to the year 2010 are included in Chapter 4. Projections are made by material and by product. A discussion of assumptions and trends is included. In addition, there is a discussion of the potential effects of source reduction in this chapter.

Finally, Chapter 5 provides a brief explanation of the implications of various municipal solid waste management strategies on the "greenhouse effect" and climate change.

Chapter 1

REFERENCES

Darnay, A., and W.E. Franklin, ***The Role of Packaging in Solid Waste Management, 1966 to 1976.*** Public Health Service Publication No. 1855. U.S. Government Printing Office. 1969.

Franklin, W.E., and A. Darnay. ***The Role of Nonpackaging Paper in Solid Waste Management, 1966 to 1976.*** Public Health Service Publication No. 2040. U.S. Government Printing Office. 1971.

Darnay, A., and W.E. Franklin. ***Salvage Markets for Materials in Solid Wastes.*** Environmental Protection Publication SW-29c. U.S. Government Printing Office. 1972.

Franklin, W.E., et al. ***Base Line Forecasts of Resource Recovery 1972 to 1990.*** Midwest Research Institute for the U.S. Environmental Protection Agency. March 1975.

U.S. Environmental Protection Agency, Office of Solid Waste Management Programs. ***Second Report to Congress: Resource Recovery and Source Reduction*** (SW-122). 1974.

Smith, F.L., Jr. ***A Solid Waste Estimation Procedure: Material Flows Approach.*** U.S. Environmental Protection Agency (SW-147). May 1975.

U.S. Environmental Prot*ection Agency, Office of Solid Waste Management Programs.* ***Third Report to Congress: Resource Recovery and Source Reduction*** (SW-161). 1975.

U.S. Environmental Protection Agency, Office of Solid Waste Management Programs. ***Fourth Report to Congress: Resource Recovery and Waste Reduction*** (SW-600). 1977.

Franklin Associates, Ltd. ***Post-consumer Solid Waste and Resource Recovery Baseline.*** Prepared for the Resource Conservation Committee. May 16, 1979.

Franklin Associates, Ltd. ***Post-consumer Solid Waste and Resource Recovery Baseline: Working Papers.*** Prepared for the Resource Conservation Committee. May 16, 1979.

Resource Conservation Committee. ***Choices for Conservation: Final Report to the President and Congress*** (SW-779). July 1979.

Franklin Associates, Ltd. **Characterization of Municipal Solid Waste in the United States, 1960 to 2000**. U.S. Environmental Protection Agency. July 11, 1986.

Franklin Associates, Ltd. ***Characterization of Municipal Solid Waste in the United States, 1960 to 2000 (Update 1988)***. U.S. Environmental Protection Agency. March 30, 1988.

U.S. Environmental Protection Agency. ***Characterization of Municipal Solid Waste in the United States: 1990 Update.*** (EPA / SW-90-042). June 1990.

U.S. Environmental Protection Agency. ***Characterization of Municipal Solid Waste in the United States: 1992 Update.*** (EPA / 530-R-92-019). July 1992.

U.S. Environmental Protection Agency. ***Characterization of Municipal Solid Waste in the United States: 1994 Update.*** EPA / 530-R-94-042. November 1994.

U.S. Environmental Protection Agency, Municipal Solid Waste Task Force, Office of Solid Waste. ***The Solid Waste Dilemma: An Agenda for Action.*** February 1989.

U.S. Environmental Protection Agency, Office of Solid Waste. ***Subtitle D Study Phase I Report*** (EPA / 530-SW-054). October 1986.

Chapter 2

CHARACTERIZATION OF MUNICIPAL SOLID WASTE BY WEIGHT

INTRODUCTION

The tables and figures in this chapter present the results of the update of EPA's municipal solid waste characterization study through 1994. The data presented also incorporate revisions to previously reported data for 1993 and, in some instances, to data for earlier years. The revisions are generally due to revisions in the various source data series used to prepare this report.

The findings are presented in two ways: a breakdown of municipal solid waste (MSW) by material, and a breakdown by product (both by weight and by percentage of generation or discards). While some products, for example, paper towels, are made up of a single material—paper—other products, for example, rubber tires, contain more than one material, such as rubber, ferrous metals, and textiles. Thus the materials summary tables represent an aggregation of the materials that go into all the products in MSW. (Note that the totals for the materials and the products tables are the same.)

The summary tables and figures provide information on generation of each material and product, and recovery for recycling and composting (if any). Tables and figures displaying discards of materials and products after recovery for recycling and composting follow.

Recovery means that the materials have been removed from the municipal solid waste stream. Recovery of materials in products means that the materials are reported to have been purchased by an end-user or exported. For yard trimmings, recovery includes estimates of the trimmings delivered to a composting facility (not backyard composting). Under these definitions, residues from a materials recovery facility (a MRF) or other waste processing facility are counted as generation, since they are not purchased by an end-user. Residues from an end-user facility (e.g., sludges from a paper deinking mill) are considered to be industrial process wastes that are no longer part of the municipal solid waste stream.

Additional detail is provided for some of the materials and products in MSW that are of the most interest to planners: paper, glass, metals, plastics, and rubber and leather.

MATERIALS IN MUNICIPAL SOLID WASTE

Generation, recovery, and discards of materials in MSW, by weight and by percentage of generation or discards, are summarized in Tables 1 through 3. Following these tables, each material is discussed in detail.

Paper and Paperboard

By any measure, the many products made of paper and paperboard, taken collectively, are the largest component of MSW. The wide variety of products that comprise the paper and paperboard materials total is illustrated in Table 4 and Figures 2 and 3. In this report, these products are classified as either nondurable goods or as containers and packaging, with nondurable goods being the larger category.

Table 4

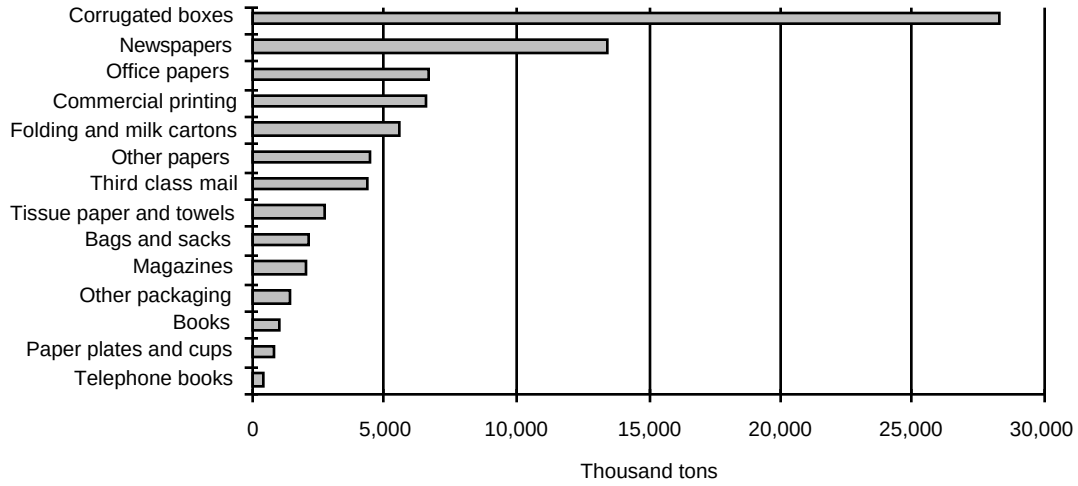
PAPER AND PAPERBOARD PRODUCTS IN MSW, 1994
(In thousands of tons and percent of generation)

Product Category	Generation (Thousands tons)	Recovery (Thousands tons)	Recovery (Percent of generation)	Discards (Thousands tons)
Nondurable Goods				
Newspapers				
Newsprint	11,100	5,090	45.9%	6,010
Groundwood inserts	2,440	1,040	42.6%	1,400
Total Newspapers	13,540	6,130	45.3%	7,410
Books	1,140	220	19.3%	920
Magazines	2,160	650	30.1%	1,510
Office Papers	6,770	2,880	42.5%	3,890
Telephone Directories	470	50	10.6%	420
Third Class Mail	4,400	610	13.9%	3,790
Other Commercial Printing	6,740	1,090	16.2%	5,650
Tissue Paper and Towels	2,860	Neg.	Neg.	2,860
Paper Plates and Cups	870	Neg.	Neg.	870
Other Nonpackaging Paper*	4,530	Neg.	Neg.	4,530
Total Paper and Paperboard Nondurable Goods	43,480	11,630	26.7%	31,850
Containers and Packaging				
Corrugated Boxes	28,420	15,710	55.3%	12,710
Milk Cartons	520	Neg.	Neg.	520
Folding Cartons	5,140	970	18.9%	4,170
Other Paperboard Packaging	300	Neg.	Neg.	300
Bags and Sacks	2,240	420	18.8%	1,820
Wrapping Papers	90	Neg.	Neg.	90
Other Paper Packaging	1,110	Neg.	Neg.	1,110
Total Paper and Paperboard Containers and Packaging	37,820	17,100	45.2%	20,720
Total Paper and Paperboard	81,300	28,730	35.3%	52,570

* Includes tissue in disposable diapers, paper in games and novelties, cards, etc.
Neg. = Less than 5,000 tons or 0.05 percent.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Figure 2. Paper and paperboard products generated in MSW, 1994

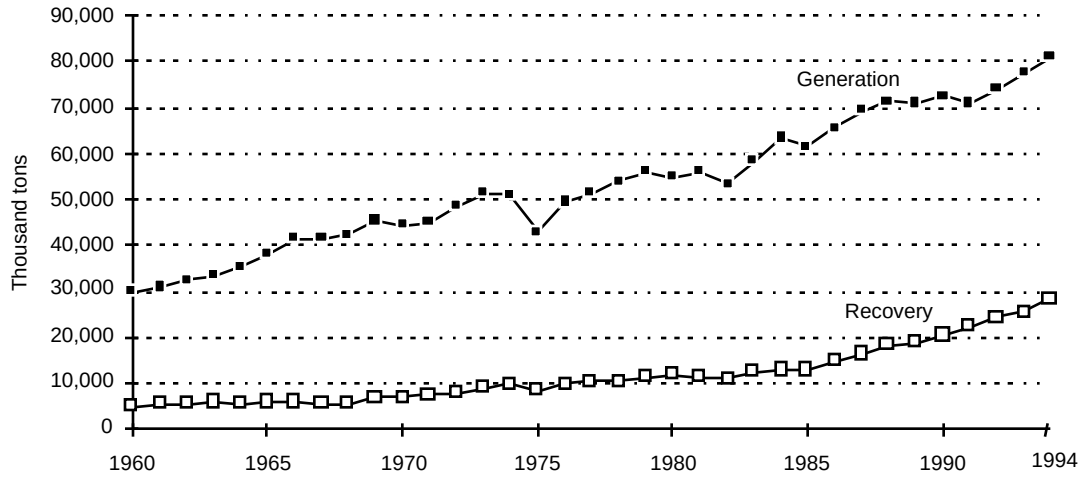


Total generation of paper and paperboard in MSW has grown steadily from 29.9 million tons in 1960 to 81.3 million tons in 1994 (Table 1). As a percentage of total MSW generation, paper represented 34.1 percent in 1960 (Table 1). The percentage has varied over time, but increased to 38.9 percent of total MSW generation in 1994.

(The sensitivity of paper products to economic conditions can be observed in Figure 3. The tonnage of paper generated in 1975—a severe recession year—was actually less than the tonnage in 1970, and the percentage of total generation was also less in 1975. Similar but less pronounced declines in paper generation can be seen in other recession years.)

Generation. Estimates of paper and paperboard generation are based on statistics published by the American Forest & Paper Association (AF&PA). These statistics include data on new supply (production plus net imports) of the various paper and paperboard grades that go into the products found in MSW. The AF&PA new supply statistics are adjusted to deduct converting scrap, which is generated when sheets of paper or paperboard are cut to make products such as envelopes or boxes. Converting scrap rates vary from product to product; the rates used in this report were developed as part of a 1992 report for the Recycling Advisory Council. Various deductions are also made to account for products diverted out of municipal solid waste, such as gypsum wallboard facings or toilet tissue.

Figure 3. Paper generation and recovery, 1960 to 1994



Recovery. Estimates of recovery of paper and paperboard products for recycling are based on annual reports of recovery published by AF&PA. The AF&PA reports include recovery of paper and paperboard purchased by U.S. paper mills, plus exports of recovered paper, plus a small amount estimated to have been used in other products such as animal bedding. Recovery as reported by AF&PA includes both preconsumer and postconsumer paper.

To estimate recovery of postconsumer paper products for this EPA report, estimates of recovery of converting scrap and returned overissue publications are deducted from the total recovery amounts reported by AF&PA. In earlier versions of this EPA report, a simplifying assumption that all converting scrap is recovered was made. For this update, however, various converting scrap recovery rates ranging from 70 percent to 98 percent were applied to the estimates for 1990 through 1994. The converting scrap recovery rates were developed for a 1992 report for the Recycling Advisory Council. Because converting scrap is deducted, the paper recovery rates presented in this report are always lower than the total recovery rates published by AF&PA.

When recovered paper is repulped, and often deinked, at a recycling paper mill, considerable amounts of sludge are generated in amounts varying from 5 percent to 35 percent of the paper feedstock. Since these sludges are generated at an industrial site, they are considered to be industrial process waste, not municipal solid waste; therefore they have been removed from the municipal waste stream.

Recovery of paper and paperboard for recycling is at the highest rate overall compared to all other materials in MSW. As Table 4 shows, 55.3 percent of all corrugated boxes were recovered for recycling in 1994. Newspapers were recovered at a rate of 45.3 percent, and office papers at 42.5 percent, with lesser percentages of other papers being recovered also. Approximately 28.7 million tons of postconsumer paper were recovered in 1994—35.3 percent of total generation.

Discards After Recovery. After recovery of paper and paperboard for recycling, discards were 52.6 million tons in 1994, or 32.9 percent of total MSW discards.

Glass

Glass is found in MSW primarily in the form of containers (Table 5 and Figures 4 and 5), but also in durable goods like furniture, appliances, and consumer electronics. In the container category, glass is found in beer and soft drink bottles, wine and liquor bottles, and bottles and jars for food, cosmetics, and other products. More detail on these products is included in the later section on products in MSW.

Generation. Glass accounted for 6.7 million tons of MSW in 1960, or 7.6 percent of total generation. Generation of glass continued to grow over the next two decades, but then glass containers were widely displaced by other materials, principally aluminum and plastics. Thus the tonnage of glass in MSW declined in the 1980s, from approximately 15.0 million tons in 1980 to 13.2 million tons in

Table 5

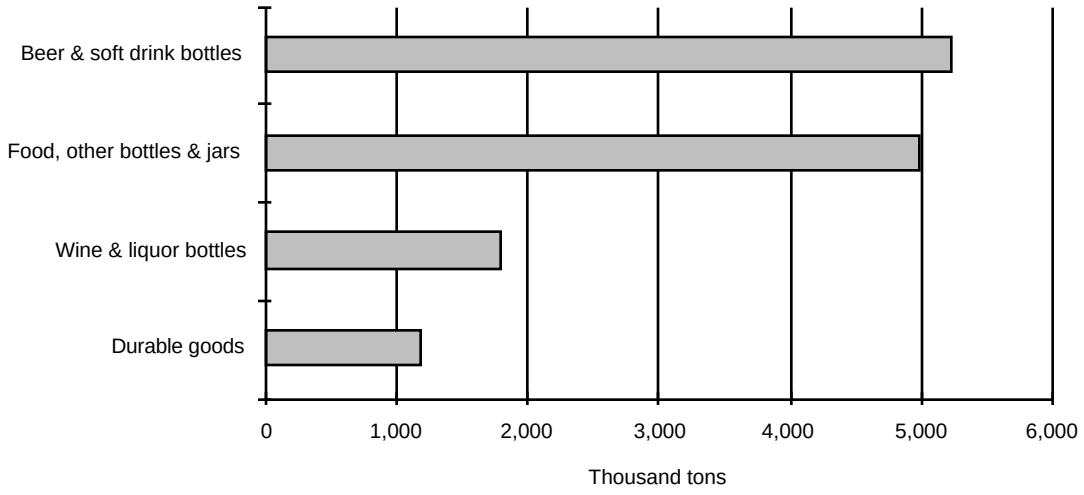
GLASS PRODUCTS IN MSW, 1994
(In thousands of tons and percent of generation)

Product Category	Generation (Thousand tons)	Recovery (Thousand tons)	Recovery (Percent of generation)	Discards (Thousand tons)
Durable Goods*	1,200	Neg.	Neg.	1,200
Containers and Packaging				
Beer and Soft Drink Bottles	5,250	1,650	31.4%	3,600
Wine and Liquor Bottles	1,820	470	25.8%	1,350
Food and Other Bottles and Jars	5,000	990	19.8%	4,010
Total Glass Containers	12,070	3,110	25.8%	8,960
Total Glass	13,270	3,110	23.4%	10,160

* Glass as a component of appliances, furniture, consumer electronics, etc.
Neg. = Less than 5,000 tons or 0.05 percent.
Details may not add to totals due to rounding.

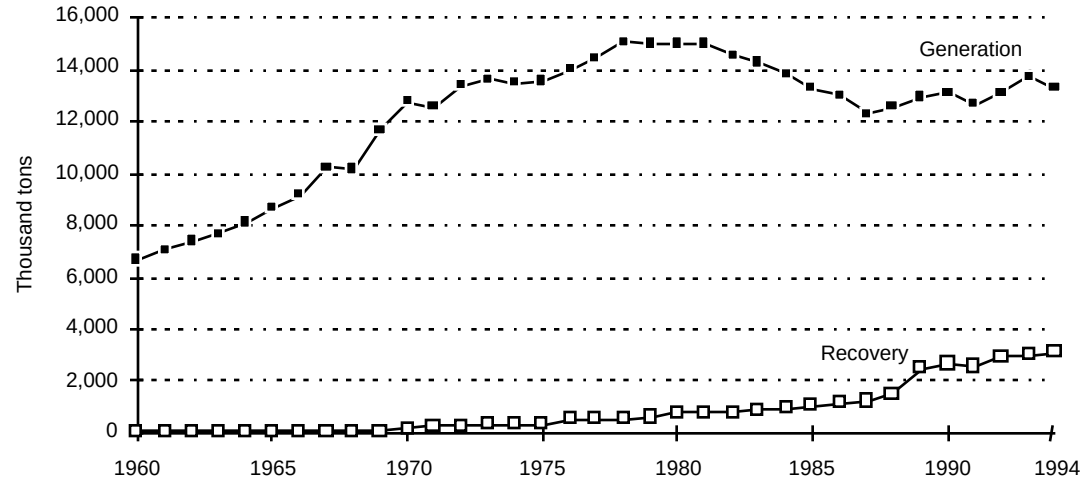
Source: Franklin Associates, Ltd.

Figure 4. Glass products generated in MSW, 1994



1985. Beginning about 1987, however, the decline in generation of glass containers reversed (Figure 5), and glass generation in 1994 was 13.3 million tons, about the same as the estimate for 1985. A decline in generation occurred in 1991, a recession year. Glass was 9.8 percent of MSW generation in 1980, declining to 6.3 percent in 1994.

Figure 5. Glass generation and recovery, 1960 to 1994



Recovery. Published estimates indicate 3.1 million tons of glass containers were recovered for recycling in 1994. Based on 1994 glass generation, an estimated 25.8 percent of glass containers was recovered for recycling, with a 23.4 percent recovery rate for all glass in MSW. Most of the recovered glass went into new glass containers, but a portion went to other uses such as fiberglass and glasphalt for highway construction. The Glass Packaging Institute reported a recovery rate of 37 percent for glass containers in 1994; this recovery rate includes an allowance for refilling of bottles. Since this EPA report classifies refilling as reuse (source reduction) rather than recovery for recycling, the recovery rate estimated for this report is 25.8 percent of glass containers.

Discards After Recovery. Recovery for recycling lowered discards of glass to 10.2 million tons in 1994 (6.4 percent of total MSW discards).

Ferrous Metals

By weight, ferrous metals are the largest category of metals in MSW (Figure 6 and Table 6). The largest quantities of ferrous metals in MSW are found in durable goods such as appliances, furniture, tires, and other miscellaneous durables. Containers and packaging are the other source of ferrous metals in MSW. Large quantities of ferrous metals are found in construction materials and in transportation products such as automobiles, locomotives, and ships, but these are not counted as MSW in this report.

Total generation and recovery of all metals in MSW are shown in Figure 7.

Figure 6. Metal products generated in MSW, 1994

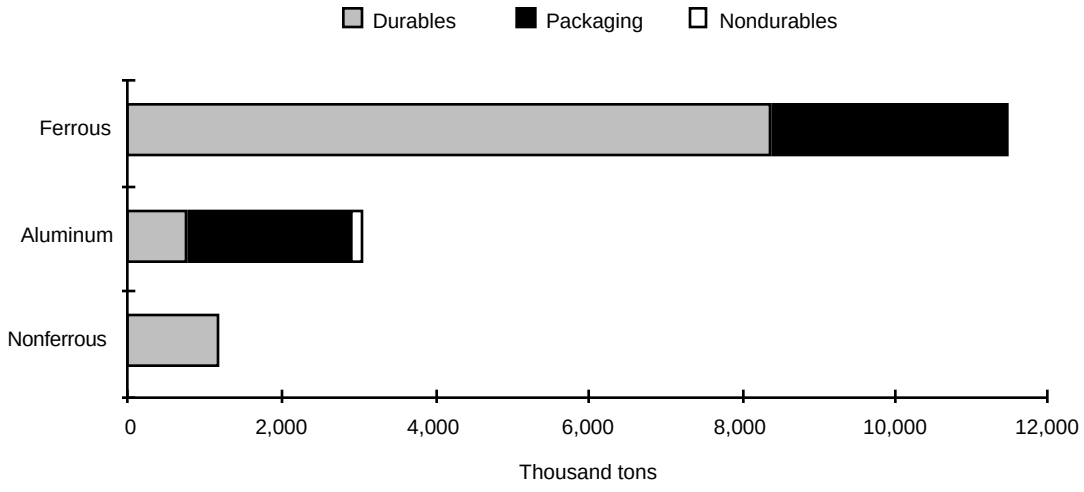


Table 6

METAL PRODUCTS IN MSW, 1994
(In thousands of tons and percent of generation)

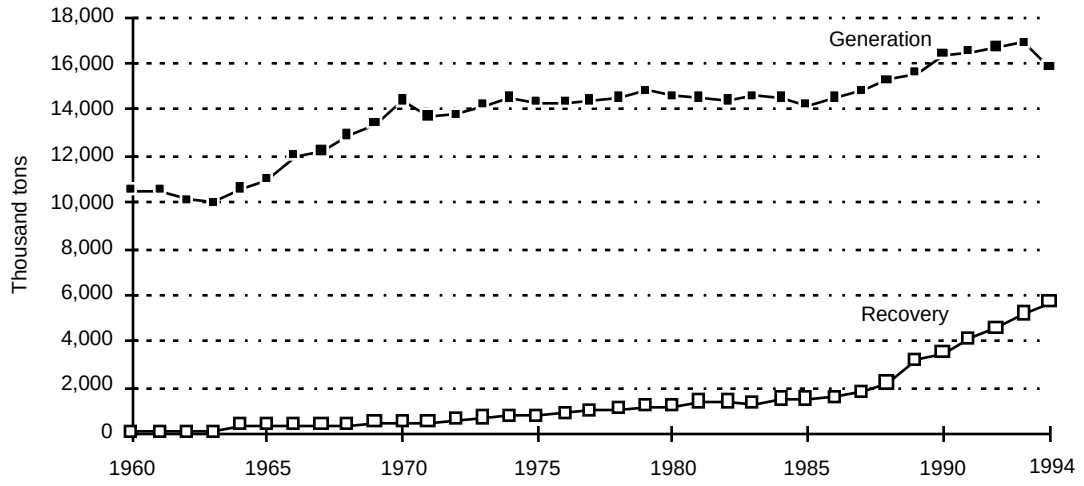
Product Category	Generation (Thousand tons)	Recovery (Thousand tons)	Recovery (Percent of generation)	Discards (Thousand tons)
Durable Goods				
Ferrous metals*	8,410	2,120	25.2%	6,290
Aluminum**	790	Neg.	Neg.	790
Lead†	860	800	93.0%	60
Other nonferrous metals‡	350	Neg.	Neg.	350
Total Metals in Durable Goods	10,410	2,920	28.0%	7,490
Nondurable Goods				
Aluminum	180	Neg.	Neg.	180
Containers and Packaging				
Steel				
Beer and soft drink cans	10	Neg.	53.1%	10
Food and other cans	2,920	1,550	53.1%	1,370
Other steel packaging	180	50	27.8%	130
Total Steel Packaging	3,110	1,600	51.4%	1,510
Aluminum				
Beer and soft drink cans	1,710	1,120	65.5%	590
Food and other cans	40	Neg.	7.0%	40
Foil and closures	340	30	8.8%	310
Total Aluminum Packaging	2,090	1,150	55.0%	940
Total Metals in Containers and Packaging	5,200	2,750	52.9%	2,450
Total Metals	15,790	5,670	35.9%	10,120
Ferrous	11,520	3,720	32.3%	7,800
Aluminum	3,060	1,150	37.6%	1,910
Other nonferrous	1,210	800	66.1%	410

* Ferrous metals in appliances, furniture, tires, and miscellaneous durables.
** Aluminum in appliances, furniture, and miscellaneous durables.
† Lead in lead-acid batteries.
‡ Other nonferrous metals in appliances and miscellaneous durables.
Neg. = Less than 5,000 tons or 0.05 percent.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

Generation. Approximately 10.0 million tons of ferrous metals were generated in 1960. Like glass, the tonnages grew during the 1960s and 1970s, but began to drop as lighter materials like aluminum and plastics replaced steel in many applications. Generation of ferrous metals did, however, increase to 12.7 million tons in 1993, then dropped to 11.5 million tons in 1994. The percentage of ferrous metals generation in MSW has declined from 11.3 percent in 1960 to 5.5 percent in 1994.

Recovery. The renewed emphasis on recovery and recycling in recent years has included ferrous metals. Recovery of ferrous metals from

Figure 7. Metals generation and recovery, 1960 to 1994



appliances ("white goods") was estimated to be approximately 72 percent of the total ferrous in appliances in 1994. Overall recovery of ferrous metals from durable goods (large and small appliances, furniture, and tires) was estimated to be 25.2 percent in 1994 (Table 6).

Steel beverage cans, food cans, and other cans were estimated to be recovered at a rate of 53.1 percent in 1994. Other steel packaging, such as steel strapping, was estimated to have been recovered at a rate of 27.8 percent in 1994.

Discards After Recovery. Discards of ferrous metals after recovery were 7.8 million tons in 1994, or 4.9 percent of total discards.

Aluminum

The largest source of aluminum in MSW is aluminum cans and other packaging (Table 6 and Figure 6). Other sources of aluminum (almost one-third of generation) are found in durable and nondurable goods.

Generation. In 1994, approximately 2.1 million tons of aluminum were generated as containers and packaging, while a total of approximately 1.0 million tons was found in durable and nondurable goods. The total—3.1 million tons—represented 1.5 percent of total MSW generation in 1994. Aluminum generation was only 360,000 tons (0.4 percent of MSW generation) in 1960.

Recovery. Aluminum beverage containers were recovered at a rate of 65.5 percent of generation in 1994, and 55.0 percent of all aluminum containers and packaging was recovered for recycling in 1994.

Discards After Recovery. In 1994, 1.9 million tons of aluminum were discarded in MSW after recovery, which was 1.2 percent of total MSW discards.

Other Nonferrous Metals

Other nonferrous metals (e.g., lead, copper, zinc) are found in durable products such as appliances, consumer electronics, etc. Lead in lead-acid batteries is the most prevalent nonferrous metal (other than aluminum) in MSW. (Note that only lead-acid batteries from passenger car and trucks and motorcycles are included. Lead-acid batteries used in large equipment or industrial applications are not included.)

Generation. Generation of other nonferrous metals in MSW totaled 1.2 million tons in 1994. Lead in batteries accounted for 860,000 tons of this amount. Generation of these metals has increased slowly, up from 160,000 tons in 1960. As a percentage of total generation, nonferrous metals have never exceeded one percent.

Recovery. Recovery of the other nonferrous metals was 800,000 tons in 1994, with most of this being lead recovered from batteries. It was estimated that 93 percent of battery lead was recovered in 1994.

Discards After Recovery. In 1994, 410,000 tons of nonferrous metals were discarded in MSW. Percentages of total discards remained less than one percent over the entire period.

Plastics

Plastics are a rapidly growing segment of MSW. Plastics are found in durable and nondurable goods and in containers and packaging, with the latter being the largest category of plastics in MSW (Figure 8 and Table 7).

In durable goods, plastics are found in appliances, furniture, casings of lead-acid batteries, and other products. (Note that plastics in transportation products generally are not included in this report.) As shown in Table 7, a wide range of resin types is found in durable goods. While some detail is provided in Table 7 for resins in durable goods, there are hundreds of different resin formulations used in appliances, carpets, and other durable goods; a complete listing is beyond the scope of this report.

Plastics are found in such nondurable products as disposable diapers, trash bags, cups, eating utensils, sporting and recreational equipment, shower curtains, etc. The plastic foodservice items are generally made of clear or foamed polystyrene, while trash bags are made of high-density polyethylene or low-density polyethylene. A wide variety of other resins are used in other nondurable goods.

Plastic resins are also used in a variety of container and packaging products such as polyethylene terephthalate (PET) soft drink bottles, high-density polyethylene (HDPE) bottles for milk and water, and a wide variety of other resin types used in other plastic containers, bags, sacks, wraps, lids, etc.

Generation. Data on plastics resin use in products is taken from the ***Modern Plastics*** annual statistical issue. The basic data are adjusted for fabrication losses and for net imports of plastic products to derive generation of plastics in the various products in MSW.

Plastics comprised an estimated 400,000 tons of MSW generation in 1960. The quantity grew steadily to 19.8 million tons in 1994 (Figure 9). As a percentage of MSW generation, plastics were less than one percent in 1960, increasing to 9.5 percent in 1994.

Recovery for Recycling. While overall recovery of plastics for recycling is relatively small—930,000 tons, or 4.7 percent of plastics generation in 1994 (Table 9)—recovery of some plastic containers is increasing. Plastic (polyethylene terephthalate) soft drink bottles and their base cups were recovered at a rate of 50.0 percent in 1994. Recovery of high-density polyethylene milk and water bottles was estimated at 29.8 percent in 1994. Significant recovery of plastics from lead-acid battery casings and from some other containers was also reported.

The primary source of data on plastics recovery is an annual survey conducted for the American Plastics Council (APC). There has been a change in the way APC reports plastics recovery data. In previous years, APC had reported the quantity of resin actually recycled after being cleaned and processed. The 1994 data reported by APC are recovery for recycling before processing. Thus, the plastics data are now more consistent with the data reported for the other materials.

Figure 8. Plastics products generated in MSW, 1994

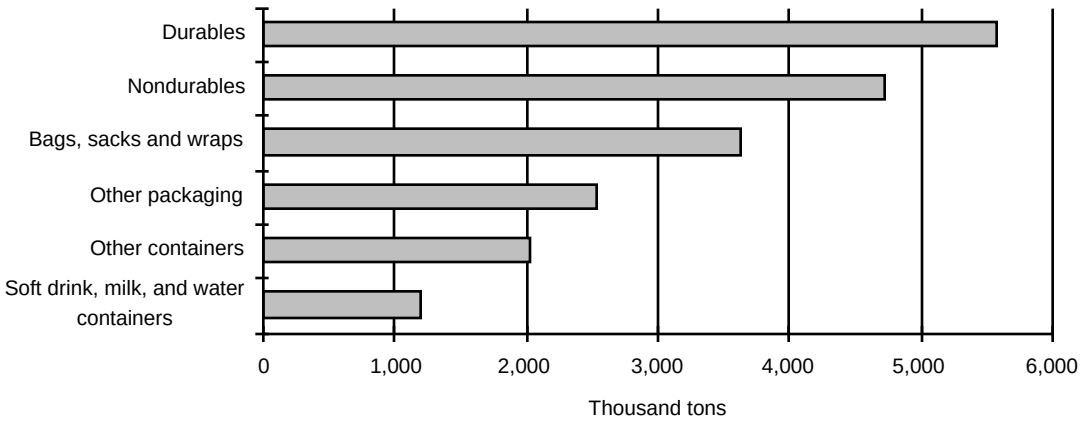
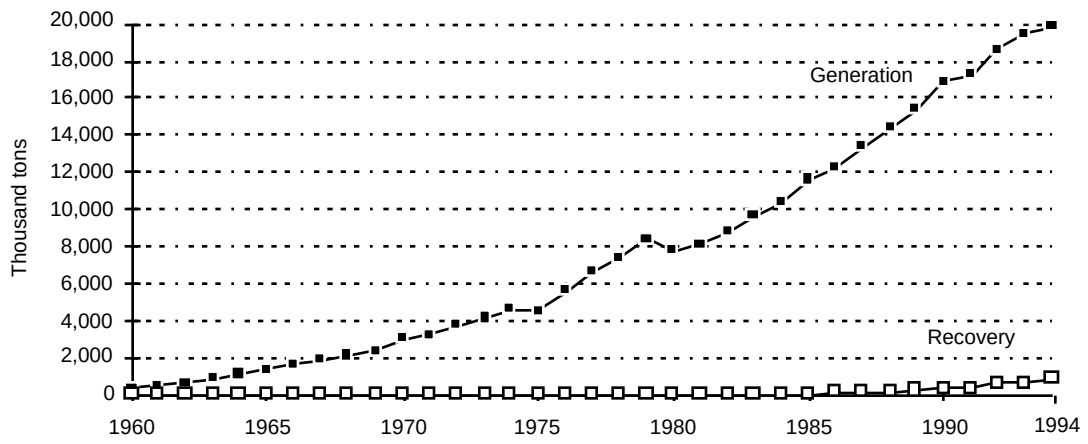


Figure 9. Plastics generation and recovery, 1960 to 1994



Discards After Recovery. Discards of plastics in MSW after recovery were 18.9 million tons, or 11.8 percent of total MSW discards.

Other Materials

Rubber and Leather. The predominant source of rubber in MSW is rubber tires from automobiles and trucks (Table 8). Other sources of rubber and leather include clothing and footwear and other miscellaneous durable and nondurable products. These other sources are quite diverse, including such items as gaskets on appliances, furniture, and hot water bottles, for example.

Generation. Generation of rubber and leather in MSW has shown slow growth over the years, increasing from 2.0 million tons in 1960 to 6.4 million tons in 1994. One reason for the relatively slow rate of growth is that tires have been made smaller and longer-wearing than in earlier years.

As a percentage of total MSW generation, rubber and leather has been about 3.0 percent for many years.

Recovery for Recycling. The only recovery for recycling identified in this category is rubber from tires, and that was estimated to be 450,000 tons (15.1 percent of rubber in tires in 1994) (Table 8). (This recovery estimate does not include tires retreaded or energy recovery from tires.) Overall, 7.1 percent of rubber and leather in MSW was recovered in 1994.

Discards After Recovery. Discards of rubber and leather after recovery were 5.9 million tons in 1994 (3.7 percent of total discards).

Table 8

RUBBER AND LEATHER PRODUCTS IN MSW, 1994
(In thousands of tons and percent of generation)

Product Category	Generation (Thousand tons)	Recovery (Thousand tons)	Recovery (Percent of generation)	Discards (Thousand tons)
Durable Goods				
Rubber Tires*	2,990	450	15.1%	2,540
Other Durables**	2,080	Neg.	Neg.	2,080
Total Rubber & Leather Durable Goods	5,070	450	8.9%	4,620
Nondurable Goods				
Clothing and Footwear	1,050	Neg.	Neg.	1,050
Other Nondurables	230	Neg.	Neg.	230
Total Rubber & Leather Nondurable Goods	1,280	Neg.	Neg.	1,280
Containers and Packaging	20	Neg.	Neg.	20
Total Rubber & Leather	6,370	450	7.1%	5,920

* Automobile and truck tires. Does not include other materials in tires.
** Includes carpets and rugs and other miscellaneous durables.
Neg. = Less than 5,000 tons or 0.05 percent.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Textiles. Textiles in MSW are found mainly in discarded clothing, although other sources were identified to be furniture, carpets, tires, footwear, and other nondurable goods such as sheets and towels.

Generation. An estimated 6.6 million tons of textiles were generated in 1994.

Recovery for Recycling and Discards. A significant amount of textiles is recovered for reuse, but the reused garments and wiper rags re-enter the waste stream eventually, so this is considered a diversion rather than recovery for recycling and, therefore, not included in the recovery for recycling estimates. Since data on elapsed time from recovery of textiles for reuse to final discard is limited, it was assumed that reused textiles re-enter the waste stream the same year that they are first discarded. It was estimated that 11.7 percent of textiles in clothing and items such as sheets and pillowcases was recovered for export or reprocessing in 1994 (770,000 tons) leaving discards of 5.8 million tons of textiles in 1994.

Wood. The sources of wood in MSW include furniture, miscellaneous durables (e.g., cabinets for electronic equipment), wood packaging (crates, pallets), and some other miscellaneous products.

Generation. Generation of wood in MSW was 14.6 million tons in 1994 (7.0 percent of total generation).

Recovery for Recycling and Discards. Recovery of wood pallets (usually by chipping) has been increasing along with recovery of other materials. It was estimated that 1.4 million tons of wood waste were recovered in 1994, leaving wood discards of 13.2 million tons (8.2 percent of total discards).

Other Products. Generation of "other product" waste is mainly associated with disposable diapers, which are discussed under the section on Products in Municipal Solid Waste. The only other significant source of materials in this category is the electrolytes and other materials associated with lead-acid batteries that are not classified as plastics or nonferrous metal.

Food Wastes

Food wastes included here consist of uneaten food and food preparation wastes from residences, commercial establishments (restaurants, fast food establishments), institutional sources such as school cafeterias, and industrial sources such as factory lunchrooms.

Generation. Obviously no production data are available for food wastes. Food wastes from residential and commercial sources were estimated using data from sampling studies in combination with demographic data on population, numbers of garbage disposers in homes, grocery store sales, restaurant sales, numbers of employees, and numbers of prisoners and students in institutions.

Generation of food wastes was estimated to be 14.1 million tons in 1994. The use of garbage disposals, which send food wastes to wastewater treatment systems rather than MSW, and use of prepared foods both at home and in food service establishments, affect the amount of food waste in MSW. (When foods are prepared and packaged off site, food preparation wastes are categorized as industrial wastes rather than MSW.)

Recovery. For the first time in this series of reports, a significant amount of food waste composting from commercial sources (about 500,000 tons) was identified in 1994. This amounted to 3.4 percent of food waste generation. As discussed in Chapter 3, composting of food wastes in backyard composting projects is classified as source reduction.

Discards. Discards of food wastes in 1994 were 13.6 million tons, or 8.5 percent of total MSW generation.

Yard Trimmings

Yard trimmings include grass, leaves, and tree and brush trimmings from residential, institutional, and commercial sources.

Generation. Generation of yard trimmings was estimated using sampling studies and population data. While in past years generation of yard trimmings had been increasing steadily as population and residential housing grew, in recent years there has been a new trend. That is banning of yard trimmings from landfills in some states. Because of this phenomenon, yard trimmings generation is shown to be declining. An estimated 30.6 million tons of yard trimmings were generated in MSW in 1994.

Recovery for Composting and Discards. Quantitative national information on composting of yard trimmings is difficult to obtain, but estimates were based on a literature search and data on numbers of composting programs. Removal of yard trimmings for composting was estimated to be 22.9 percent of generation in 1994 (7.0 million tons), leaving 23.6 million tons of yard trimmings to be discarded.

It should be noted that these estimates do not account for backyard composting by individuals or practices such as less bagging of grass wastes; since the yard trimming estimates are based on sampling studies at the landfill or transfer station, they are based on the quantities received there. These source reduction practices are discussed in Chapter 3.

Miscellaneous Inorganic Wastes

This relatively small category of MSW is also derived from sampling studies. It is not well defined and often shows up in sampling reports as “fines” or “other.” It includes soil, bits of concrete, stones, and the like.

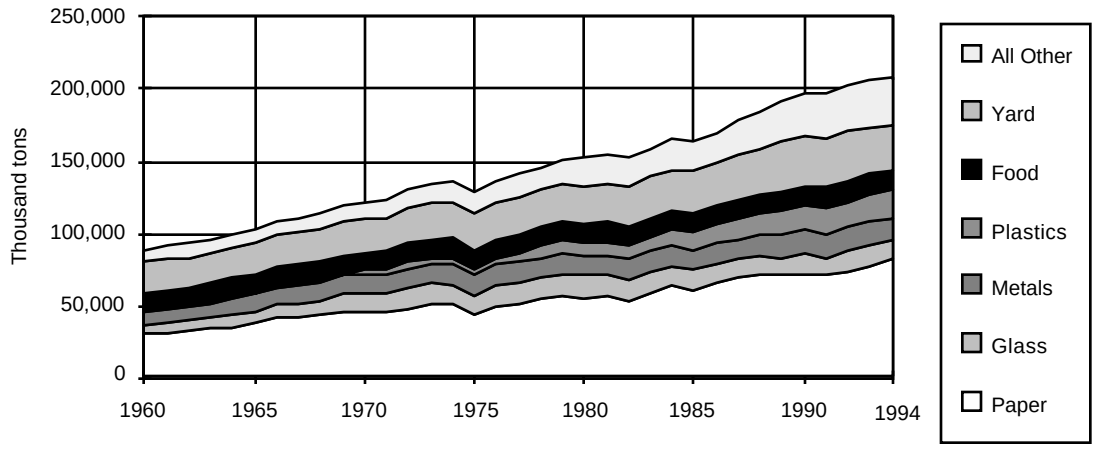
Generation. This category contributed an estimated 3.1 million tons of MSW in 1994.

Recovery and Discards. No recovery of these products was identified; discards are the same as generation.

Summary of Materials in Municipal Solid Waste

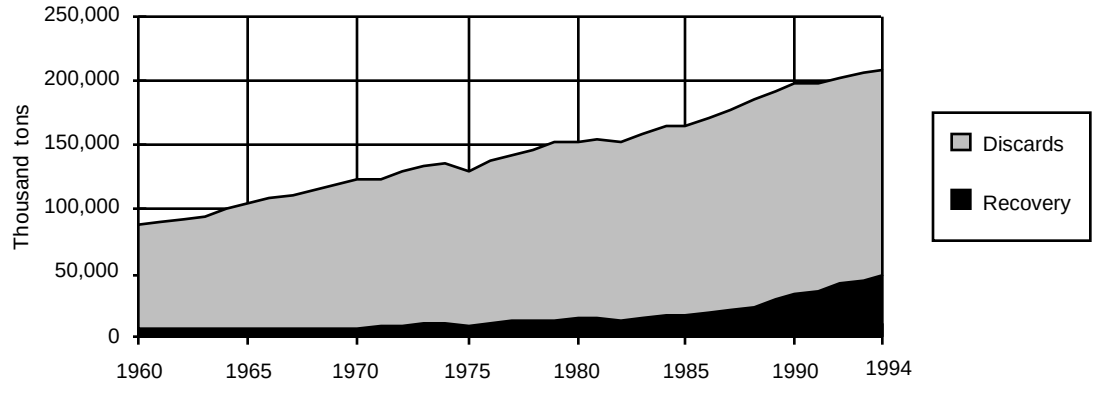
Generation. Changing quantities and composition of municipal solid waste generation are illustrated in Figure 10. Generation of MSW has grown steadily, from 87.8 million tons in 1960 to 209.1 million tons in 1994. Over the years, paper and paperboard has been the dominant material generated in MSW. Yard trimmings, the second largest component of MSW, have been declining as a percentage of MSW in recent years due to state and local legislated landfill bans

Figure 10. Generation of materials in MSW, 1960 to 1994



and increased emphasis on backyard composting and other source reduction measures such as use of mulching mowers. Metals have remained fairly constant as a source of MSW, while glass increased until the 1980s and has since declined or shown a slower rate of increase. Food wastes have remained fairly constant in terms of MSW tonnage. Plastics have increasingly been used in a variety of products and thus have been a rapidly growing component of MSW. In terms of tonnage contributed, they ranked third in 1994 (behind yard trimmings).

Figure 11. Materials recovery and discards of MSW, 1960 to 1994



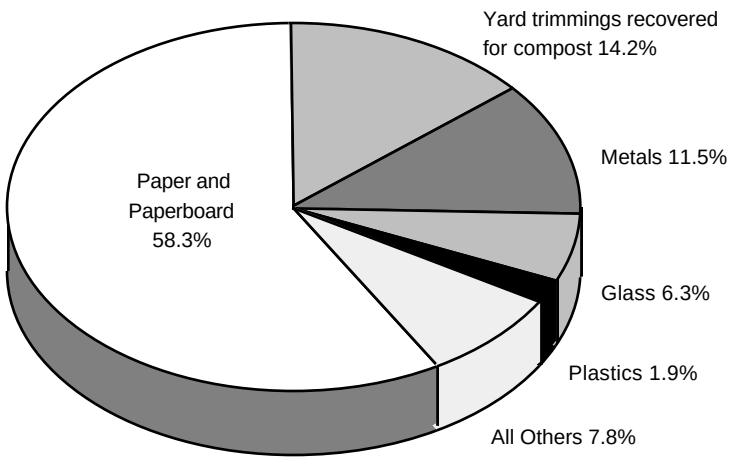
Recovery and Discards. The effect of recovery and composting on MSW discards is illustrated in Figure 11. Recovery of materials for recycling grew at a rather slow pace during most of the historical period covered by this data series, increasing only from 9.4 percent of generation in 1980 to 9.9 percent in 1985. Renewed interest in recycling and composting as solid waste management alternatives came about in the late 1980s, and the recovery rate in 1990 was estimated to be 16.7 percent of generation, increasing to 23.6 percent in 1994.

Estimated recovery and composting of materials are shown in Figure 12. In 1994, recovery of paper and paperboard dominated materials recovery at 58.2 percent of total tonnage recovered. Recovery of other materials, while generally increasing, contributes much less tonnage, reflecting in part the relatively smaller amounts of materials generated in those categories.

Figure 13 illustrates the effect of recovery of materials for recycling, including composting, on the composition of MSW discards. For example, paper and paperboard were 38.9 percent of MSW generated in 1994, but after recovery, paper and paperboard were 32.9 percent of discards.

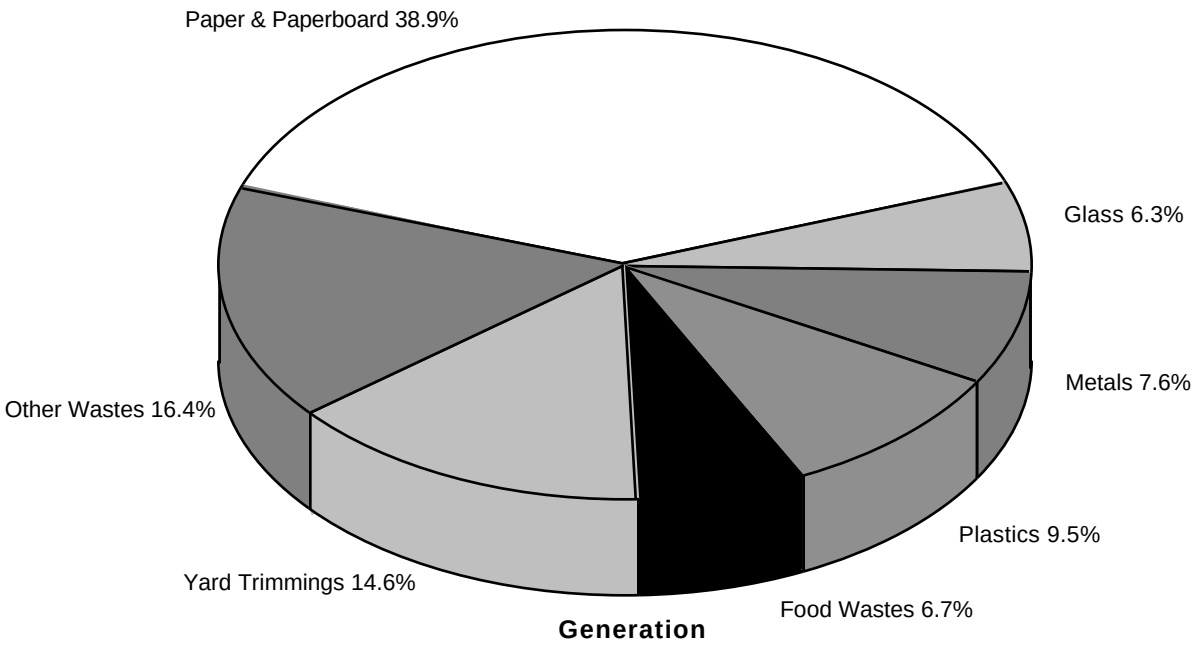
Materials that have little or no recovery exhibit a larger percentage of MSW discards compared to generation. For instance, food wastes were 6.7 percent of MSW generation in 1994, but 8.5 percent of discards.

Figure 12. Materials recovery*, 1994

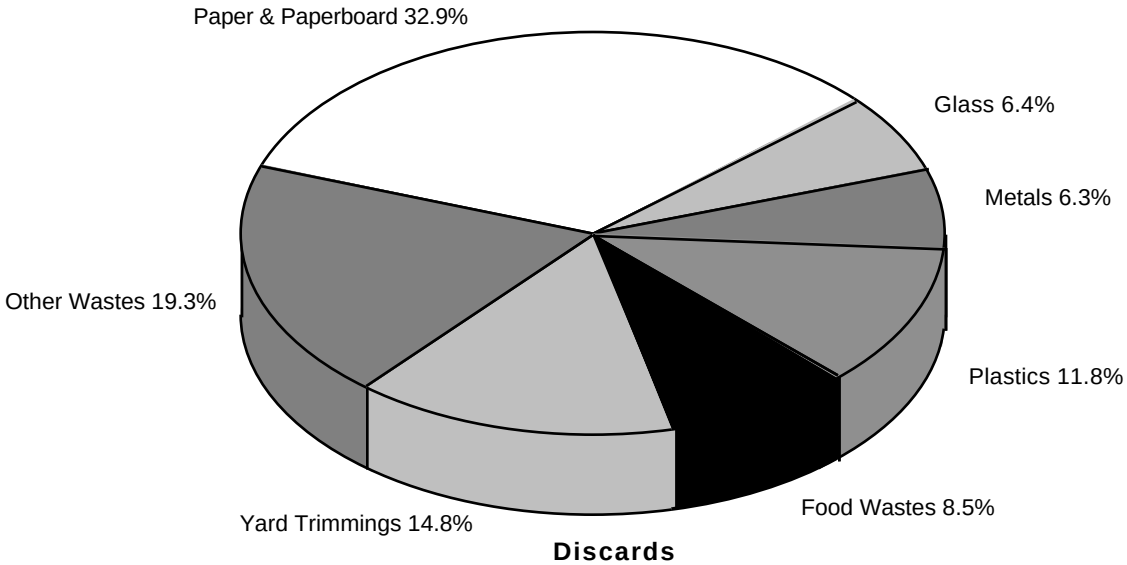


* In percent by weight of total recovery.

Figure 13. Materials generated and discarded in municipal solid waste, 1994
(in percent of total generation and discards)



Generation



Discards

PRODUCTS IN MUNICIPAL SOLID WASTE

Generation, recovery, and discards of products in municipal solid waste are shown in a series of tables in this section. (Note that the totals for these tables are the same as the previous series of tables for materials in MSW.) The products in MSW are categorized as durable goods, nondurable goods, and containers and packaging. Generation, recovery, and discards of these products are summarized in Tables 9 through 11. Each product category is discussed in more detail below, with detailed tables highlighting the products in each.

Durable Goods

Durable goods generally are defined as products having a lifetime of three years or more, although there are some exceptions. In this report, durable goods include large and small appliances, furniture and furnishings, carpets and rugs, rubber tires, lead-acid automotive batteries, and miscellaneous durables (e.g., luggage, consumer electronics) (see Tables 12 through 14).* These products are often called "oversize and bulky" in municipal solid waste management practice, and they are generally handled in a somewhat different manner than other components of MSW. That is, they are often picked up separately, and may not be mixed with other MSW at the landfill, combustor, or other waste management facility. Durable goods are made up of a wide variety of materials. In order of tonnage in MSW in 1994, these include: ferrous metals, plastics, rubber and leather, wood, textiles, other nonferrous metals (e.g., lead, copper), glass, and aluminum.

Generation of durable goods in MSW totaled 29.9 million tons in 1994 (14.3 percent of total MSW generation). After recovery for recycling, 25.5 million tons of durable goods remained as discards in 1994.

Major Appliances. Major appliances in MSW include refrigerators, washing machines, water heaters, etc. They are often called "white goods" in the trade. Data on unit production of appliances are taken from Appliance Manufacturer Annual Report. The unit data are converted to weight using various conversion factors developed over the years, plus data on the materials composition of the appliances. Adjustments are also made for the estimated lifetimes of the appliances, which range up to 20 years.

Generation of these products in MSW has increased very slowly; it was estimated to be 3.4 million tons in 1994 (1.6 percent of total MSW). In general, appliances have increased in quantity but not in average weight over the years. Ferrous metals are the predominant materials in major appliances, but other metals, plastics, glass, and other materials are also present.

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* Automobiles and other transportation equipment are not included in this report.

Data on recovery of ferrous metals from major appliances are taken from a survey conducted by the Steel Recycling Institute. Recovery of ferrous metals from shredded appliances was estimated to be 1.9 million tons in 1994, leaving 1.5 million tons of appliances to be discarded.

Small Appliances. This category includes items such as toasters, hair dryers, electric coffeepots, and the like. Information on shipments of small appliances was obtained from Department of Commerce data. Information on weights and materials composition of small appliances was obtained through interviews. It was estimated that 750,000 tons of small appliances were generated in 1994. A small amount of ferrous metals in small appliances may be recovered through magnetic separation, but no specific data on recovery were found.

Furniture and Furnishings. Data on sales of furniture and furnishings are provided by the Department of Commerce in dollars. These data are converted to tons using factors developed for this study over the years. Adjustments are made for imports and exports, and adjustments are made for the lifetimes of the furniture.

Generation of furniture and furnishings in MSW has increased from 2.2 million tons in 1960 to 7.5 million tons in 1994 (3.6 percent of total MSW). No significant recovery of materials from furniture was identified. Wood is the largest material category in furniture, with ferrous metals second. Plastics, glass, and other materials are also found in furniture.

Carpets and Rugs. An industry publication, ***Carpet and Rug Industrial Review***, publishes data on carpet sales in square yards. These data are converted to tons using various factors developed for this report. An estimated 2.3 million tons of carpets and rugs were generated in MSW in 1994, which was 1.1 percent of total generation.

A small amount of recycling of carpet fiber was identified—estimated to be 0.4 percent recovery in 1994.

Rubber Tires. The methodology for estimating generation of rubber tires for automobiles and trucks was revised in 1994; some of the data series used previously have been discontinued. The estimates are based on data on replacement tires purchased and vehicles deregistered as reported by the U.S. Department of Commerce. It is assumed that for each replacement tire purchased, a used tire enters the waste management system, and that tires on deregistered vehicles also enter the waste management system. Retreaded tires are treated as a diversion out of the waste stream; they are assumed to re-enter the waste stream after two years of use.

The quantities of tires in units are converted to weight and materials composition using factors developed for this series of reports. In addition to

rubber, tires include relatively small amounts of textiles and ferrous metals. Generation of rubber tires increased from 1.1 million tons in 1960 to 3.7 million tons in 1994 (1.8 percent of total MSW).

Data on 1994 recovery of rubber tires are taken from a scrap tire use/disposal study conducted by the Scrap Tire Management Council. Previous years were based on an EPA scrap tire market study, updated with information from ***Scrap Tire News***. Rubber recovery from tires has been small, but increasing in recent years. In 1994, an estimated 15.2 percent of tire rubber generated was recovered for recycling, leaving 3.1 million tons to be discarded. (Tires going to combustion facilities are included in the combustion estimates in Chapter 3.)

Lead-Acid Batteries. The methodology for estimating generation of lead-acid batteries was changed for the 1994 report to be similar to the methodology for rubber tires as described above. An estimated 1.7 million tons of lead-acid batteries from automobiles, trucks, and motorcycles were generated in MSW in 1994 (0.8 percent of total generation).

Data on recovery of batteries are provided by the Battery Council International. Recovery of batteries for recycling has fluctuated between 60 percent and 95 percent or higher; recovery has increased since 1980 as a growing number of communities have restricted batteries from disposal at landfills or combustors. In 1994, 93.7 percent of the lead in these batteries was recovered for recycling as well as substantial quantities of the polypropylene battery casings; so discards after recycling of these batteries were decreased to 110,000 tons in 1994. (Some electrolytes and other materials in batteries are removed from the municipal solid waste stream along with recovered lead and polypropylene; these materials are counted as "recovered" along with the recyclable materials.

Miscellaneous Durables. Miscellaneous durable goods include consumer electronics such as television sets, video cassette recorders, personal computers, luggage, sporting equipment, and the like. (Small appliances were included with miscellaneous durables in previous reports in this series, but are estimated separately in this report.) An estimated 10.6 million tons of these goods were generated in 1994, amounting to 5.0 percent of MSW generated. Small amounts of ferrous metals are estimated to be recovered from this category, decreasing discards to 10.2 million tons. In addition to ferrous metals, this category includes plastics, glass, rubber, wood, and other metals.

(Note: the decline in generation of miscellaneous durables between 1993 and 1994 is apparently due to a decline in sales during a recession earlier in the 1990s. Since there is a time lag before miscellaneous durables are assumed to be discarded, this shows up later as a decrease in generation. In actual practice, the discards of goods bought in a particular year undoubtedly are spread out over several years, but it is beyond the scope of this report to analyze this phenomenon.)

Nondurable Goods

The Department of Commerce defines nondurable goods as those having a lifetime of less than three years, and this definition was followed for this report to the extent possible.

Products made of paper and paperboard comprise the largest portion of nondurable goods. Other nondurable products include paper and plastic plates, cups, and other disposable food service products; disposable diapers; clothing and footwear; linens; and other miscellaneous products. (See Tables 15 through 17.)

Generation of nondurable goods in MSW was 56.4 million tons in 1994 (27.0 percent of total generation). Recovery of paper products in this category is quite significant, resulting in 12.3 million tons of nondurable goods recovered in 1994 (21.9 percent of nondurables generation). This means that 44.1 million tons of nondurable goods were discarded in 1994 (27.6 percent of total MSW discards).

Paper and Paperboard Products. Generation, recovery, and discards of paper and paperboard products in nondurable goods are summarized in Tables 15 through 17. A summary for 1994 was shown earlier in Table 4. Each of the paper and paperboard product categories in nondurable goods is discussed briefly below.

- Newspapers are by far the largest single component of the nondurable goods category, at 13.5 million tons generated in 1994 (6.5 percent of total MSW). In 1994, 45.3 percent of newspapers generated were recovered for recycling, leaving 7.4 million tons discarded (4.6 percent of total MSW discarded). Estimates of newspaper generation are broken down into newsprint (the majority of the weight of newspapers) and the groundwood* inserts (primarily advertising) that are a significant portion of the total weight of newspapers. This breakdown is shown in Table 4.

- Books amounted to approximately 1.1 million tons, or 0.5 percent of total MSW generation, in 1994. Recovery of books is not well documented, but it was estimated that approximately 220,000 tons of books were recovered in 1994. Books are made of both groundwood and chemical pulp.

- Magazines accounted for an estimated 2.2 million tons, or 1.0 percent of total MSW generation, in 1994. Like books, recovery of magazines is not

* Groundwood papers, like newsprint, are made primarily from pulp prepared by a mechanical process. The other major type of wood pulp is prepared by a chemical process. The nature of the pulp (groundwood vs. chemical) affects the potential uses for the recovered paper.

well documented. It was estimated that 650,000 tons of magazines were recovered in 1994. Magazines are predominately made of coated groundwood, but some uncoated groundwood and chemical pulps are also used.

- Many different kinds of papers are generated in offices. For this report, office-type paper estimates include the high grade papers such as copier paper, computer printout, stationery, etc. (6.8 million tons, or 3.2 percent of total MSW generation, in 1994). These papers are almost entirely made of uncoated chemical pulp, although some amounts of groundwood are also used. It should be noted that some of these office-type papers are generated at locations other than offices, including homes and institutions such as schools. Also, other kinds of papers (e.g., newspapers, magazines, and packaging) are generated in offices, but are accounted for in other categories. An estimated 2.9 million tons of office-type papers were recovered in 1994.

- Telephone directories were estimated to generate 470,000 tons (0.2 percent of total MSW) in 1994. These directories are made of groundwood. It was estimated that 50,000 tons of directories were recovered in 1994. The Yellow Pages Publishers Association (YPPA) has instituted a programs to encourage recovery of directories and has begun to collect and publish data on generation and recovery. The 1993 and 1994 data in this report are taken from YPPA data; therefore, there is some discontinuity with the data published for earlier years, which was estimated.

- Third-class mail includes catalogs and other direct bulk mailings; these amounted to 4.4 million tons, or 2.1 percent of MSW generation, in 1994. Both groundwood and chemical pulps are used in these mailings. It was estimated that 610,000 tons were recovered in 1994. The U.S. Postal Service is implementing a program to increase recovery of bulk mail in the future.

- Other commercial printing includes a wide range of paper items: brochures, reports, menus, invitations, etc. Both groundwood and chemical pulps are used in these varied items. Generation was estimated at 6.7 million tons, or 3.2 percent of MSW generation, in 1994, with recovery at 1.1 million tons.

- Tissue paper and towels include facial and sanitary tissues and napkins, but not bathroom tissue, which is nearly all diverted from MSW into the wastewater treatment system. Tissue products amounted to 2.9 million tons (1.4 percent of total MSW generation) in 1994. No significant recovery of tissue products was identified.

- Paper plates and cups include paper plates, cups, bowls, and other food service products used in homes, in commercial establishments like restaurants, and in institutional settings such as schools. Generation of these products was estimated at 870,000 tons (0.4 percent of total MSW generation) in 1994. No significant recovery of these products was identified.

- Other nonpackaging papers—including posters, photographic papers, cards and games, etc.—accounted for 4.5 million tons (2.1 percent of total MSW generation) in 1994. No significant recovery of these papers was identified.

Overall, generation of paper and paperboard products in nondurable goods was 43.5 million tons in 1994 (Table 4). While newspapers were recovered at the highest rate, other paper products, such as books, magazines, and office papers, were also recovered for recycling, and the overall recovery rate for paper in nondurables was 26.7 percent in 1994. Thus 31.9 million tons of paper in nondurables were discarded in 1994.

Plastic Plates and Cups. This category includes plastic plates, cups, glasses, dishes and bowls, hinged containers, and other containers used in food service at home, in restaurants and other commercial establishments, and in institutional settings such as schools. These items are made of polystyrene resin. An estimated 440,000 tons of these products were generated in 1994, or 0.2 percent of total MSW (see Table 15). An estimated 20,000 tons of these products were recovered for recycling in 1994.

Disposable Diapers. This category includes estimates of both infant diapers and adult incontinence products. Generation was estimated using data on sales of the products along with information on average weights and composition. An estimated 3.0 million tons of disposable diapers were generated in 1994, or 1.4 percent of total MSW generation. (This tonnage includes an adjustment for the urine and feces contained within the discarded diapers.) The materials portion of the diapers includes wood pulp, plastics (including the super-absorbent materials now present in most diapers), and tissue paper.

There has been some investigation of recycling/composting of disposable diapers, but no significant recovery was identified for 1994.

Clothing and Footwear. Generation of clothing and footwear was estimated to be 4.5 million tons in 1994 (2.1 percent of total MSW). Textiles, rubber, and leather are major materials components of this category, with some plastics present as well. Generation estimates for these products are based on sales data from the Department of Commerce along with data on average weights for each type of product included. Adjustments are made for net imports of these products based on Department of Commerce data.

The Council for Textile Recycling reports on recovery of textiles for exports, reprocessing, and reuse. Based on their data, it was estimated that 550,000 tons of textiles in clothing were recovered for export or recycling in 1994. (Reuse is not counted as recycling and is discussed in Chapter 3.)

Towels, Sheets, and Pillowcases. An estimated 0.8 million tons of towels, sheets, and pillowcases were generated in 1994. Generation was estimated using a methodology similar to that for clothing. An estimated 130,000 tons of these textiles were recovered in 1994.

Other Miscellaneous Nondurables. Generation of other miscellaneous nondurables was estimated to be 3.4 million tons in 1994 (1.6 percent of MSW). The primary material component of miscellaneous nondurables is plastics, although some aluminum, rubber, and textiles are also present. Typical products in miscellaneous nondurables include shower curtains and other household items, disposable medical supplies, novelty items, and the like.

Generation of plastic products in miscellaneous nondurables is taken from resin sales data published annually in ***Modern Plastics***. Generation of other materials in these nondurable products is estimated based on information in past reports in this series.

Containers and Packaging

Containers and packaging make up a major portion of MSW, amounting to 75.0 million tons of generation in 1994 (35.9 percent of total generation). Generation, recovery, and discards of containers and packaging are shown in detail in Tables 18 through 23.

There is substantial recovery of many container and packaging products, especially corrugated containers. In 1994, 33.5 percent of containers and packaging generated was recovered for recycling. Because of this recovery, containers and packaging comprised 31.2 percent of total MSW discards in 1994.

Containers and packaging in MSW are made of several materials: paper and paperboard, glass, ferrous metals, aluminum, plastics, wood, and small amounts of other materials. Each materials category is discussed separately below.

Glass Containers. Glass containers include beer and soft drink bottles, wine and liquor bottles, and bottles and jars for food, cosmetics, and other products. Generation of glass containers is estimated using Department of Commerce data. Adjustments are made for imports and exports of both empty glass containers and containers holding products, e.g., imported beer.

Generation of these glass containers was 12.1 million tons in 1994, or 5.8 percent of MSW generation (Tables 18 and 19). This is a decrease in generation compared to 1993.

The Glass Packaging Institute (GPI) reports a recovery rate for glass containers, but includes reuse of refillable bottles in the figure. Since refilling is defined as reuse rather than recycling in this report, the refilled bottles are not counted as recovery here. An estimated 3.1 million tons of glass containers were recovered for recycling in 1994, or 25.8 percent of generation. After recovery for recycling, glass container discards were 9.0 million tons in 1994, or 5.6 percent of total MSW discards.

Steel Containers and Packaging. Steel beer and soft drink cans, food and other cans, and other steel packaging (e.g., strapping), totaled 3.1 million tons in 1994 (1.5 percent of total generation), with most of that amount being “tin” cans for food (Tables 18 and 19). Generation estimates are based on data supplied by the Steel Recycling Institute (SRI), the American Iron and Steel Institute (AISI), and the Can Manufacturers Institute (CMI). Generation estimates include adjustments for imports and exports. Generation of steel containers and packaging had been declining in the 1970s and 1980s, but has been increasing in recent years.

Recovery data for steel containers and packaging were provided by the Steel Recycling Institute. An estimated 1.6 million tons of steel packaging were recovered in 1994, or 51.4 percent of generation. The SRI estimates include both recovery from residential sources and magnetic separation of steel cans at waste-to-energy facilities.

Aluminum Containers and Packaging. Aluminum containers and packaging include beer and soft drink cans, other cans, and foil and closures. Aluminum can generation is estimated based on data from the Can Manufacturers Institute and the Aluminum Association, while data on other aluminum packaging is based on Department of Commerce data. Total aluminum container and packaging generation in 1994 was 2.1 million tons, or 1.0 percent of total MSW generation.

Aluminum can recovery data comes from the Aluminum Association. Aluminum beer and soft drink cans were recovered at an estimated 65.5 percent rate in 1994. Recovery of all aluminum packaging was estimated to be 51.4 percent of total generation in 1994. After recovery for recycling, 940,000 tons of aluminum packaging were discarded in 1994. This represented 0.6 percent of MSW discards.

Paper and Paperboard Containers and Packaging. Corrugated boxes are the largest single product category of MSW at 28.4 million tons generated, or 13.6 percent of total generation, in 1994. Corrugated boxes also represent the largest single category of product recovery, at 15.7 million tons of recovery in 1994 (55.3 percent of boxes generated were recovered). After recovery, 12.7 million tons of corrugated boxes were discarded, or 8.0 percent of MSW discards in 1994.

Other paper and paperboard packaging in MSW includes milk cartons, folding boxes (e.g., cereal boxes, frozen food boxes, some department store boxes), bags and sacks, wrapping papers, and other paper and paperboard packaging. Overall, paper and paperboard containers and packaging totaled 37.8 million tons of MSW generation in 1994, or 18.0 percent of total generation.

While recovery of corrugated boxes is by far the largest component of paper packaging recovery, smaller amounts of other paper packaging products are recovered (estimated at 1.4 million tons in 1994). The overall recovery rate for paper and paperboard packaging in 1994 was 45.2 percent. Recovery of other paper packaging like folding boxes and sacks is mostly in the form of mixed papers.

Plastic Containers and Packaging. Many different plastic resins are used to make a variety of packaging products. Some of these include polyethylene terephthalate (PET) soft drink bottles—some with high-density polyethylene (HDPE) base cups, HDPE milk jugs, film products (including bags and sacks) made of low-density polyethylene (LDPE and LLDPE), and containers and other

packaging (including coatings, closures, etc.) made of polyvinyl chloride, polystyrene, polypropylene, and other resins.

Estimates of generation of plastic containers and packaging are based on data on resin sales by end use published annually by ***Modern Plastics***, a trade publication. Adjustments are made for imports and exports based on Department of Commerce data.

Plastic containers and packaging have exhibited rapid growth in MSW, with generation increasing from 120,000 tons in 1960 (0.1 percent of generation) to 9.5 million tons in 1994 (4.5 percent of generation). (Note: plastic packaging as a category in this report does not include single-service plates and cups and trash bags, which are classified as nondurable goods.)

Estimates of recovery of plastic products are based on data published annually by the American Plastics Council. Plastic soft drink bottles and base cups were estimated to have been recovered at a 50.0 percent rate in 1994. Recovery of plastic milk and water bottles was estimated to have been 29.8 percent of generation. Overall, recovery of plastic containers and packaging was estimated to be 7.5 percent in 1994. Discards of plastic containers and packaging were thus 8.8 million tons in 1994, or 5.5 percent of total discards. (As explained earlier in this chapter, the basis for reporting plastics recovery has been changed to be more consistent with the basis for other materials.)

Wood Packaging. Wood packaging includes wood crates and pallets (mostly pallets). Data on production of wood packaging (in units) is obtained from the Wooden Pallet and Container Association, and converted to weight using converting factors for wood. In 1994, 10.2 million tons of wood packaging were estimated to have been generated. Wood packaging was thus 4.9 percent of total generation in 1994.

There is increasing recovery of wood pallets, mostly by chipping to make products like mulch. The Wooden Pallet and Container Association provides data on recovery of wood pallets. It was estimated that 1.4 million tons of wood were recovered in this manner in 1994, or 14.0 percent of generation. This left 8.8 million tons discarded in 1994, or 5.5 percent of total MSW discards.

There is considerable reuse of wood pallets. Reuse was not counted as recycling in this chapter, but is accounted for when calculating wood pallet generation. Reuse of pallets is discussed further in the section on source reduction in Chapter 3.

Other Packaging. Estimates are included for some other miscellaneous packaging such as bags made of textiles, small amounts of leather, and the like. These latter quantities are not well documented, but were estimated to amount to 180,000 tons generated in 1994.

Summary of Products in Municipal Solid Waste

Changing quantities and composition of municipal solid waste generation by product category are illustrated in Figure 14. This figure shows graphically that generation of durable goods has increased very gradually over the years. Nondurable goods and containers and packaging have accounted for the large increases in MSW generation.

The materials composition of nondurable goods in 1994 is shown in Figure 15. Paper and paperboard made up 77.0 percent of nondurables in MSW generation, with plastics contributing 8.4 percent, and textiles 7.3 percent. Other materials contributed lesser percentages. After recovery for recycling, paper and paperboard were 72.2 percent of nondurable discards, with plastics being 10.7 percent, and textiles 7.8 percent.

The materials composition of containers and packaging in MSW in 1994 is shown in Figure 16. Paper and paperboard products made up 50.4 percent of containers and packaging generation, with glass second at 16.1 percent of containers and packaging generation by weight. Wood made up 13.6 percent of containers and packaging generation, while plastics were 12.6 percent.

Recovery for recycling makes a significant change, with paper and paperboard being 41.4 percent of containers and packaging discards after recovery takes place. Glass was 17.9 percent of discards of containers and packaging, plastics comprised 17.7 percent, and wood was 17.6 percent.

Some additional perspectives on products in municipal solid waste are included in other chapters of this report.

Figure 14. Generation of products in MSW, 1960 to 1994

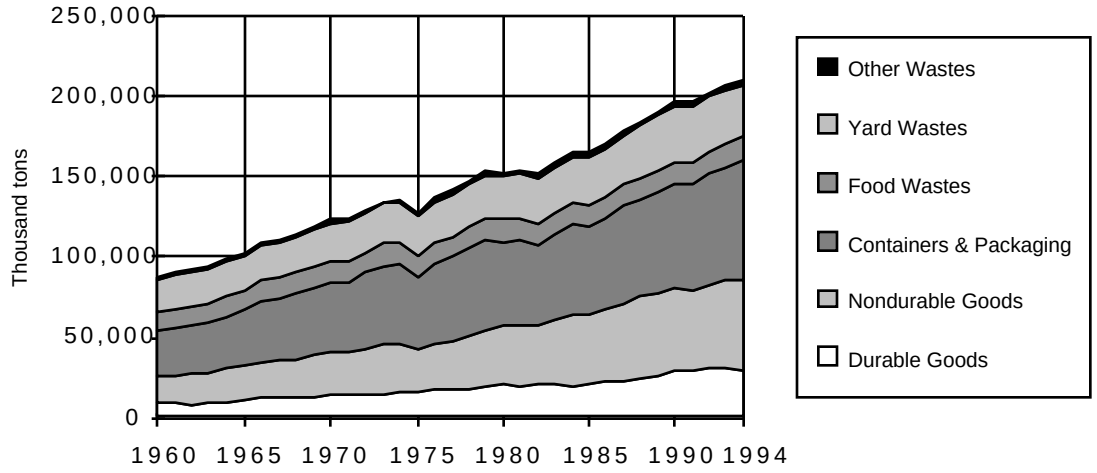
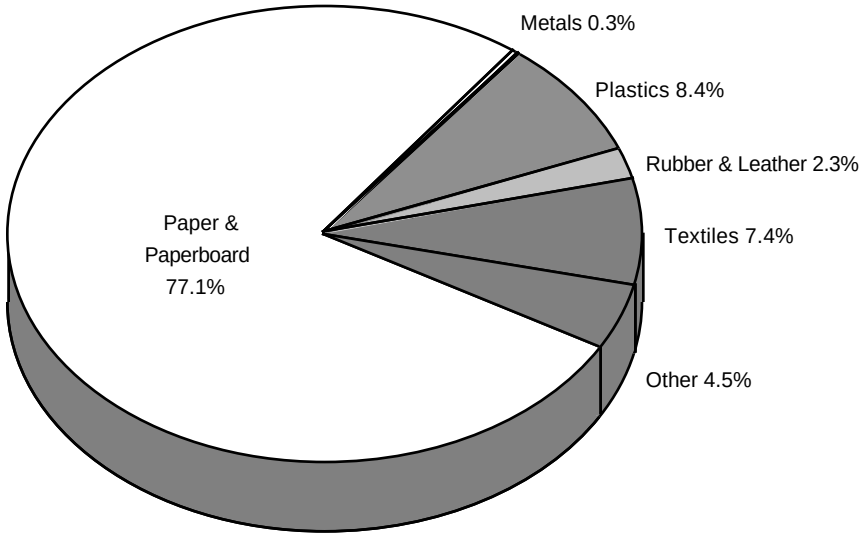
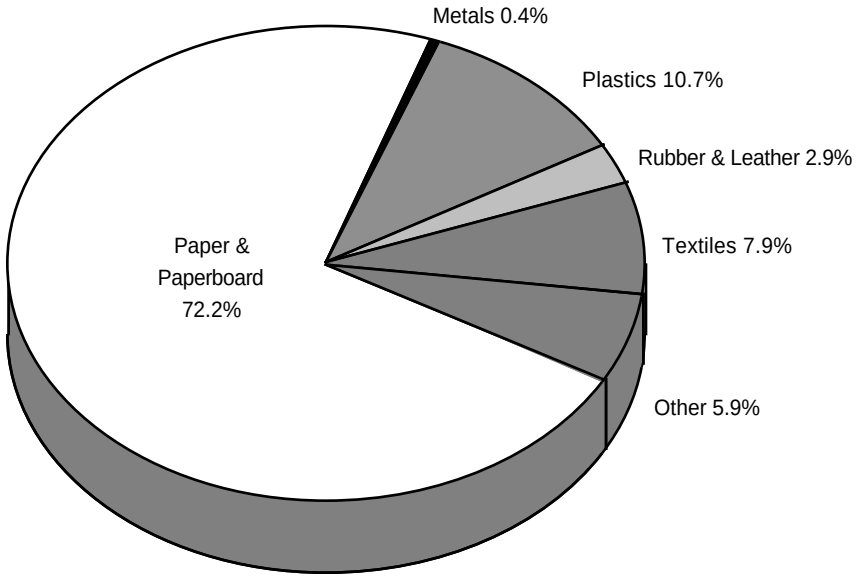


Figure 15. Nondurable goods generated and discarded in municipal solid waste, 1994
(in percent of total generation and discards)

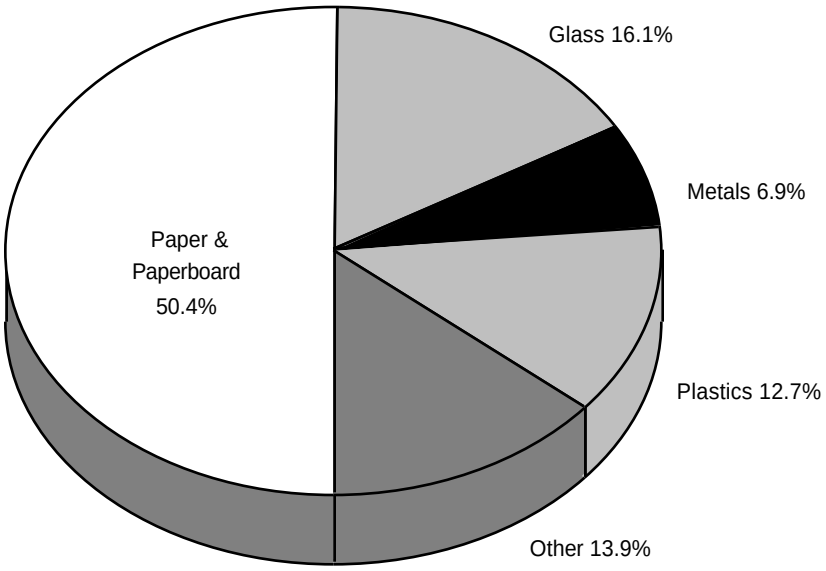


Generation

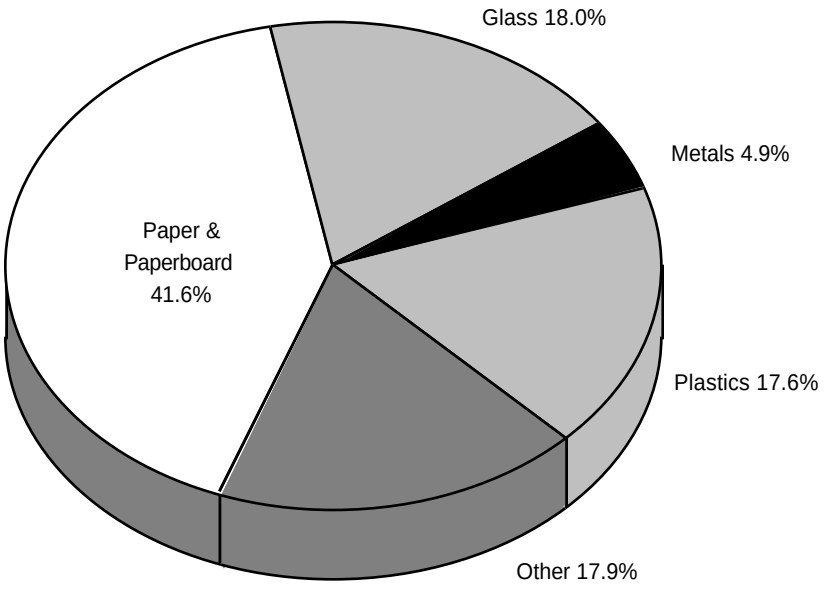


Discards

Figure 16. Containers and packaging generated and discarded in municipal solid waste, 1994
(in percent of total generation and discards)



Generation



Discards

Chapter 2

REFERENCES

GENERAL

U.S. Environmental Protection Agency. ***Characterization of Municipal Solid Waste in the United States: 1994 Update.*** EPA/530-R-94-042. November 1994.

U.S. Environmental Protection Agency. ***Characterization of Municipal Solid Waste in the United States: 1992 Update.*** EPA/530-R-92-019. July 1992.

U.S. Environmental Protection Agency. ***Characterization of Municipal Solid Waste in the United States: 1990 Update***. EPA/530-SW-90-042. June 1991.

Franklin, M.A. ***Characterization of Municipal Solid Waste in the United States, 1960 to 2000 (Update 1988)***. U.S. Environmental Protection Agency. EPA/530-SW-88-033. NTIS PB88-232780/WEP. March 1988.

Franklin, M.A. ***Characterization of Municipal Solid Waste in the United States, 1960 to 2000***. U.S. Environmental Protection Agency. REPT-15-3490-00. NTIS PB87-178323/WEP. July 1986.

ALUMINUM CONTAINERS AND PACKAGING

The Aluminum Association. ***Aluminum Statistical Review***. Various years.

Can Manufacturers Institute. ***Can Shipments Report.*** Various years.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports***. "Closures for Containers." MQ34H. Various years.

CARPETS AND RUGS

The Carpet and Rug Institute. ***Carpet & Rug Industry Review.*** Various years.

Personal communication with a representative of the Carpet and Rug Institute. February 14, 1992.

Rauch Associates, Inc. ***The Rauch Guide to the U.S. Adhesives and Sealants Industry.*** ISBN O-932157-05-X.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports***. "Carpets and Rugs." MA22Q. Various years.

FERROUS METAL CONTAINERS AND PACKAGING

American Iron and Steel Institute. ***Annual Statistical Report.*** Various years.

Can Manufacturers Institute. ***Can Shipments Report.*** Various years.

Personal communication with a representative of the Association of Container Reconditioning. June 1994.

Personal communication with a representative of the Steel Recycling Institute. July 1995.

Smith, F.L. ***A Solid Waste Estimation Procedure: Material Flows Approach.*** U.S. Environmental Protection Agency. EPA/530-SW-147. May 1974.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports***. "Closures for Containers." MQ34H. Various years.

FOOD WASTE

Food Manufacturers Institute. ***Composting Workbook.*** "Reducing Waste Disposal Costs: How to Evaluate the Benefits of Composting in the Supermarket Industry." Food Marketing Institute. 1994.

Grocery Committee on Solid Waste. ***Composting Task Force Report.*** October 24, 1991.

Hinshaw, Jane, and Ivan Braun. "Targeting Commercial Businesses for Recycling." ***Resource Recycling.*** November 1991.

Kunzler, Connie, Roe, Rebecca. "Food Service Composting Projects on the Rise." ***Biocycle.*** April 1995.

Newell, Ty, Elizabeth Markstahler, and Matthew Snyder. "Commercial Food Waste from Restaurants and Grocery Stores." ***Resource Recycling.*** February 1993.

Marion, James, New York State Department of Corrections. Presentation at the ***BioCycle*** conference. Philadelphia, Pennsylvania. 1994.

Savage, George M. "The History and Utility of Waste Characterization Studies." ***MSW Management.*** May/June 1994.

U.S. Department of Commerce, Bureau of the Census. ***Current Population Reports.*** Various years.

U.S. Department of Commerce, Bureau of the Census. "Combined Annual and Revised Monthly Retail Trade." ***Current Business Reports. BR/94-RV.***

U.S. Department of Commerce, Bureau of the Census. ***Statistical Abstract of the United States.*** Various years.

U.S. Department of Commerce. "Trends and Forecasts: Retail Sales." ***U.S. Industrial Outlook 1994.***

Walsh, Patrick, Wayne Pferdehirt, and Phil O'Leary. "Collection of Recyclables from Multifamily Housing and Businesses." ***Waste Age***. April 1993.

FURNITURE AND FURNISHINGS

U.S. Department of Commerce, Bureau of the Census. ***Census of Manufactures*** *and* ***Annual Survey of Manufactures***. Various years.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports.*** "Average Weight and Width of Broadwoven Fabrics (Gray)." MC-22T. November 1977.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports.*** "Office Furniture." MA-25H. Various years.

Smith, F.L. ***A Solid Waste Estimation Procedure: Material Flows Approach.*** U.S. Environmental Protection Agency. EPA/530-SW-147. May 1974.

GLASS CONTAINERS

Brewers Almanac. Various years.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports***. "Glass Containers." M32G. Various years.

U.S. Department of Commerce. ***U.S. Exports, Schedule B Commodity by Country - Domestic Merchandise***. FT 447.

U.S. Department of Commerce. ***U.S. Imports of Merchandise for Consumption***. FT 110 and FT 125.

Resource Recycling. ***Bottle/Can Recycling Update***. June 1995. Page 4.

LEAD-ACID BATTERIES

American Automobile Manufacturers Association. ***AAMA Motor Vehicle Facts and Figures.*** Various years.

Apotheker, Steve. "Batteries Power Secondary Lead Smelter Growth." ***Resource Recycling***. February 1990.

Apotheker, Steve. "Does Battery Recycling Need a Jump?" ***Resource Recycling***. February 1990.

Apotheker, Steve. "Get the Lead Out." ***Resource Recycling***. April 1991.

Battery Council International. ***Industry Statistics.*** Various years.

Battery Council International. ***National Recycling Rate Study.*** March 1995.

Franklin Associates, Ltd. ***Characterization of Products Containing Lead and Cadmium in Municipal Solid Waste in the United States, 1970 to 2000***. U.S. Environmental Protection Agency. EPA/530-SW-89-015A. NTIS PB89-151039/WEP. January 1989.

Motorcycle Industry Council, Inc. ***Motorcycle Statistical Annual***. Various years.

U.S. Department of Commerce. ***U.S. Industrial Outlook*** "Metals." Various years.

U. S. Department of Commerce. ***Statistical Abstract of the United States***. Various years.

MAJOR APPLIANCES

Appliance Magazine. Corcoran Communications. September 1983.

Appliance Manufacturer. Annual Industry Marketing Guide, March issue of various years.

Association of Home Appliance Manufacturers. ***Trends and Forecasts***. 1971 to 1988.

Electrical Merchandising. January 1951.

Gas Appliance Manufacturers Association. ***Statistical Highlights***. Various years.

National Industrial Pollution Control Council. ***The Disposal of Major Appliances***. June 1971.

Personal communication with a representative of Amana, Inc. November 1991.

Personal communication with a representative of Steel Recycling Institute. May 1994.

Purchasing Magazine. Cahner's Publications. January 15, 1987 and March 9, 1989.

U.S. Department of Commerce, Bureau of the Census. ***Census of Manufactures***. Various years.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports***. "Major Household Appliances." MA36F. Various years.

U.S. Department of Commerce, Bureau of the Census. ***Statistical Abstract of the United States***. Various years.

PAPER AND PAPERBOARD

American Forest & Paper Association, Paper Recycling Group. ***1995 Annual Statistical Summary Waste Paper Utilization***. April 1995.

American Forest & Paper Association. ***1994 Statistics of Paper, Paperboard & Wood Pulp***. September 1994.

American Forest & Paper Association. ***Monthly Statistical Report***. Various issues.

Franklin Associates, Ltd. ***Supply of and Recycling Demand for Office Waste Paper, 1990 to 1995***. National Office Paper Recycling Project. July 1991.

Franklin Associates, Ltd. ***Evaluation of Proposed New Recycled Paper Standards and Definitions***. Special Task Force on Standards and Definitions, Recycled Paper Committee, Recycling Advisory Council. January 27, 1992.

U.S. Postal Service. ***Annual Report of the Postmaster General: Fiscal Year 1994.***

"U.S. Portal Service to Recycle Undelivered Bulk Business Mail." ***Waste Age***. September 1994.

Yellow Pages Publishers Association. ***Yellow Pages Publishers Environmental Network: Progress Report for the Year 1994***. March 1, 1995. Also earlier editions of the same report.

PLASTICS

***Modern Plastics*.** Resin Statistics. January issue, various years.

R.W. Beck and Associates. "Postconsumer Plastics Recycling Rate Study for the American Plastics Council." Various years.

U.S. Department of Commerce. ***1994 U.S. Industrial Outlook.***

RUBBER

American Automobile Manufacturers Association. ***AAMA Motor Vehicle Facts and Figures.*** Various years.

National Petroleum News Market Facts. Mid-June issue. Various years.

McRee, Robert E. "Recap – Recapture: Incineration of Rubber for Energy Recovery" Presented at the Joint NTDRA/RMA International Symposium. Washington, DC. October 22, 1982.

Retreaders Journal. April 1987.

Scrap Tire Management Council. ***"1994 Scrap Tire Use/Disposal Study".*** Results published in ***Scrap Tire News.*** March 1995

U.S. Department of Commerce, Bureau of the Census. ***Census of Manufactures***. Industry series 30A-30. Various years.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports***. "Rubber Mechanical Goods." MA30C. Various years.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports***. "Rubber: Production, Shipments, and Stocks." MA30A. Various years.

U.S. Department of Commerce, Bureau of the Census. ***Statistical Abstract of the United States***. Various editions.

U.S. Department of Commerce. ***U.S. Industrial Outlook***. "Plastics and Rubber." Also earlier editions. Various years.

U.S. Department of Commerce, Bureau of the Census. ***U.S. Imports for Consumption.*** FT 247. Table 1. 1991.

U.S. Environmental Protection Agency. ***Markets for Scrap Tires***. EPA/530-SW-90-074A. October 1991.

TEXTILES AND FOOTWEAR

National Association of Hosiery Manufacturers. ***Fact Sheets***. Various years.

Riggle, David. "Tapping Textile Recycling." ***BioCycle***. February 1992.

Council for Textile Recycling. ***Textile Recycling Fact Sheet.***

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports.*** "Apparel." MA23A, MA23E, MA23G. Various years.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports.*** "Sheets, Towels and Pillowcases." MQ23X. Various years.

U.S. Department of Commerce, Bureau of the Census. ***Current Industrial Reports.*** MA31A, MA23E, MA23G, and MA23A. Various years.

U.S. Department of Commerce, Bureau of the Census. ***Statistical Abstract of the United States***. Various years.

WOOD PACKAGING

Personal communication with representative of the National Wooden Pallet and Container Association. June 1995.

Personal communication with representative of the U.S. Forestry Service Laboratory, Princeton, WV. December 1991.

Eshbach, Ovid, Ed. ***Handbook of Engineering Fundamentals***. Second Edition. John Wiley & Sons, Inc.

Personal communication with representative of Virginia Polytechnical Institute. December 1991.

Personal communication with representative of U.S. Department of Agriculture Forest Service, Forest Products Laboratory. December 1991.

Misner, Michael. "Cutting into Wood Waste Markets." ***Waste Age***. August 1991.

U.S. Department of Commerce. ***U.S. Industrial Outlook .*** "Wood Products." Various year.

U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. ***Wood Used in U.S. Manufacturing Industries, 1977***. December 1983.

YARD TRIMMINGS

The Role of Recycling in Integrated Solid Waste Management to the Year 2000. Franklin Associates, Ltd. Appendix J and Appendix K. Keep America Beautiful, Inc. September 1994.

Raymond Communications. "State Recycling Laws Update." 1994.

Savage, George M. “The History and Utility of Waste Characterization Studies.” ***MSW Management.*** May/June 1994.

Steuteville, Robert. “The State of Garbage in America, Part I.” ***Biocycle.*** April 1995.

Steuteville, Robert. “The State of Garbage in America, Part II.” ***Biocycle.*** May 1995.

“Yard Waste Legislation: Disposal Bans and Similar Bills as of July, 1993.” Composting Council. Fact Sheet. July 1993.

Chapter 3

MANAGEMENT OF MUNICIPAL SOLID WASTE

INTRODUCTION

EPA's tiered integrated waste management strategy includes the following components:

1. Source reduction (including reuse of products and backyard composting of yard trimmings)
2. Recycling of materials (including composting)
3. Waste combustion (preferably with energy recovery) and landfilling.

Characterization of historical municipal solid waste (MSW) management is a component of this report. Estimates of historical recovery of materials and yard trimmings for recycling and composting are presented in Chapter 2. Estimates of MSW combustion are presented in this chapter, and quantities of waste landfilled are estimated by subtracting combustion and recovery for recycling and composting from total MSW generation as estimated in Chapter 2.

While source reduction is not quantified as a line item in this report, a discussion of source reduction activities is included in this chapter. Source reduction activities have the effect of reducing MSW generation, while the other management alternatives deal with MSW once it is generated.

SOURCE REDUCTION

While the primary focus of this report is on generation of municipal solid waste and the ways in which the MSW is managed after it enters the waste stream, there is another aspect to waste management: source reduction. (Note that source reduction is often called "waste prevention.") EPA defines source reduction as "any change in the design, manufacturing, purchase, or use of materials or products (including packaging) to reduce the amount or toxicity before they become municipal solid waste. Prevention also refers to the reuse of products or materials." Thus, source reduction activities affect the waste stream before the point of generation. In this report, MSW is considered to have been generated if it is placed at curbside or in a receptacle such as a dumpster for pickup, or if it is taken by the generator to another site for disposal or other management alternative.

Many attempts have been made to measure and quantify source reduction activities. It is relatively easy to measure source reduction for a single product, such as a package, or for a specific location, such as an office. It is much more difficult to quantify source reduction on a national basis, and there is no

consensus at this time as to how this could be done. Some steps toward measuring source reduction have been identified; they include establishing a baseline, tracking that baseline, and accounting for major variables that impact generation rates. Variables that make accurate measurement difficult include economic factors, technical innovations, changing demographics, and climatic variations.

Source reduction measures encompass a very broad range of activities by private citizens, communities, commercial establishments, institutional agencies, and manufacturers and distributors. In general, source reduction activities include:

- Designing products or packages so as to reduce the quantity of materials or the toxicity of the materials used.
- Reducing amounts of products or packages used through modification of current practices.
- Reusing products or packages already manufactured.
- Lengthening the life of products to postpone disposal.
- Managing non-product organic wastes (food wastes, yard trimmings) through backyard composting or other on-site alternatives to disposal.

Product and Packaging Design for Source Reduction

Since source reduction of products and packages can save money through reducing materials and energy costs, manufacturers and packagers have been pursuing these activities for many years. Design for source reduction can take several approaches:

- A product or package can be reduced in size or made lighter. For example, soft drink packaging, regardless of material, has been reduced in weight over time (Table 24).

Table 24

REDUCTION IN WEIGHTS OF SOFT DRINK CONTAINERS, 1972 TO 1992
(In pounds per 100 containers)

Soft Drink Containers	1972	1992	Percent Change
One-way glass bottle (16 fluid ounce)	75.70	48.04	-36.5%
Steel can (12 fluid ounce)	10.50	7.19	-31.5%
Aluminum can (12 fluid ounce)	4.50	3.51	-22.0%
PET bottle (2 liter, one-piece)	14.60	11.95	-18.2%

Does not include weight of labels and caps. PET data for 1977 and 1992.
Source: Franklin Associates, Ltd.

- Materials substitution can make a product or package lighter. There has been a continuous trend of substitution of lighter materials such as plastics and aluminum for materials such as glass and steel. The substitution may often be a flexible package (such as a bag) instead of a rigid package (such as a box). For example, a brick pack for coffee made of an aluminum foil / plastic laminate reduces packaging by 85 percent compared to a steel coffee can.

  Another illustration of source reduction by materials substitution is shown in Table 25. This shows that over a 15-year period, weight of snack foods increased by over 42 percent, while weight of snack food packaging decreased by nearly 9 percent and pounds of packaging per 100 pounds of product decreased by over 36 percent. This decrease can be attributed primarily to a switch from rigid packaging (e.g., boxes) to flexible packaging (e.g., bags).

Table 25

COMPARISON OF SNACK FOOD PACKAGING, 1972 AND 1987

	1972	1987	Percent Change
Million pounds of product	11,028	15,731	+42.6%
Million pounds of packaging	1,243	1,134	-8.8%
Pounds packaging per 100 pounds of product	11.3	7.2	-36.0%
Thousand cubic yards of packaging	1,536	1,391	-9.4%

Does not include tertiary packaging (e.g., corrugated containers)
Source: Franklin Associates, Ltd.

- A product or package can be redesigned to reduce weight or volume. For example, a box used to package a tube or bottle can often be eliminated.

- Toxic materials in products or packaging can be replaced with non-toxic substitutes. Considerable efforts have been made in this area in the past few years. For example, vegetable-based inks are being substituted for petroleum-based inks.

Modifying Practices to Reduce Materials Use

Businesses and individuals can often modify their current practices to reduce the amounts of waste generated. In a business office, electronic mail can replace printed memoranda and data. Reports can be copied on both sides of the paper (duplexed).

Individuals (and businesses) can request removal from mailing lists to reduce the amount of mail received and discarded. When practical, products can be purchased in large sizes or in bulk to minimize the amount of packaging per unit of product. Concentrated products can also reduce packaging requirements; some of these products, such as fabric softeners and powdered detergent, are designed to be used with refillable containers.

Reuse of Products and Packages

Reuse of products and packages delays the time when the items must finally be discarded as waste. When a product is reused, presumably purchase and use of a new product is delayed, although this may not always be true.

Many of the products characterized for this report are reused in sizable quantities. The recovery of products and materials for recycling and composting as characterized in Chapter 2 does *not* include reuse of products, but reuse is discussed in this section.

Durable Goods. There is a long tradition of reuse of durable goods such as large and small appliances, furniture, and carpets. Often this is done informally as individuals pass on used goods to family members and friends. Other durable goods are donated to charitable organizations for resale or donation to needy families. Some communities and other organizations have facilitated exchange programs for citizens, and there are for-profit retail stores that deal in used furniture, appliances, and carpets. Other goods are resold by individuals at garage sales, flea markets, and the like. Borrowing and sharing items like tools can also reduce the number of products to be discarded ultimately. Except for tires, there is generally a lack of data on the volume of durable goods reused in the United States, and what the ultimate effect on MSW generation might be.

Nondurable Goods. While nondurable goods by their very nature are designed for short term use and disposal, there is considerable reuse of some items classified as nondurable. In particular, footwear, clothing, and other textile goods are often reused. Much of the reuse is accomplished through the same types of channels as those described above for durable goods. That is, private individuals, charitable organizations, and retail outlets (consignment shops) all facilitate reuse of discarded clothing and footwear. In addition, considerable amounts of textiles are reused as wiping cloths before being discarded.

Another often-cited source reduction measure is use of washable plates, cups, napkins, towels, diapers, etc. instead of the disposable variety. (This will reduce solid waste but will have other effects, such as increased water and energy use.) Other reusable items are available, for example: reusable air filters, reusable coffee filters, reconditioned printer cartridges, etc.

Containers and Packaging. Containers and packaging can be reused in two ways: they can be used again for their original purpose, or they can be used in other ways.

Glass bottles are a prime example of reuse of a container for its original purpose. Refillable glass beer and soft drink bottles can be collected, washed, and refilled for use again. Some years ago large numbers of refillable glass soft drink bottles were used, but these have largely been replaced by single-use glass bottles, plastic bottles and aluminum cans. Considerable numbers of beer bottles are collected for refilling, often by restaurants and taverns where the bottles can conveniently be collected and returned by the distributor. The Glass Packaging Institute estimates that refillable glass bottles achieve a rate of 8 trips (refillings) per bottle.

Another example in this category is the use of refurbished wood pallets for shipping palletized goods. The Wood Pallet and Container Association estimates that over 50 percent of wood pallets produced are reusable; the pallets are reused about four times per year, on average.

Many other containers and packages can be recycled but are not often reused. Some refillable containers (e.g., plastic laundry softener bottles) have been introduced; the original container can be refilled using concentrate in small packages. This practice can achieve a 75 percent source reduction in packaging. As another example, some grocery stores will allow customers to reuse grocery sacks, perhaps allowing a refund for each sack brought back for reuse. Also, many parcel shippers will take back plastic packaging “peanuts” for reuse.

Many ingenious reuses for containers and packaging are possible in the home. People reuse newspapers, boxes, bags, jars, jugs, and cans for many purposes around the house. There are no reliable estimates as to how these activities affect the waste stream.

Lengthening Product Life. Lengthening product life delays the time when the products enter the municipal waste stream. The responsibility for lengthening product life lies partly with manufacturers and partly with consumers. Products can be designed to last longer and be easier to repair. Since some of these design modifications may make products more expensive, at least initially, consumers must demand the products and be willing to pay for them to make the goal work. Consumers must also be willing to care for and repair products.

Management of Organic Wastes. Food wastes and yard trimmings combined made up 21.3 percent of MSW generation in 1994, so source reduction measures aimed at these products can have an important effect on waste generation. Composting is the usual method for source reducing these organic wastes. As defined in this report, composting of organic wastes after they are

taken to a central composting facility is a waste management activity comparable to recovery for recycling. Estimates for these composting activities are included in this Chapter 3.

Composting or other reduction management measures that take place at the point of generation (e.g., the yard of a home or business) is source reduction. Backyard composting of yard trimmings and some food wastes is not a new practice, but in recent years publicity and education programs have encouraged more people to participate. There also is a trend toward leaving grass clippings on lawns, sometimes through the use of mulching mowers.

Part of the impetus for source reduction of yard trimmings is the large number of state regulations discouraging landfilling or other disposal of yard trimmings. The Composting Council and other sources report that in 1992, 12 states (amounting to over 28 percent of the nation's population) had in effect legislation banning yard trimmings from landfills. By 1996, 23 states (amounting to over 50 percent of the nation's population) will have in effect legislation affecting disposal of yard trimmings. While data on amounts of yard trimmings received at disposal facilities is limited, there is considerable anecdotal evidence indicating that when these bans go into effect, people find ways to source reduce. This is discussed in more depth in Chapter 4.

SUMMARY OF HISTORICAL AND CURRENT MSW MANAGEMENT

Municipal solid waste generation has grown steadily (except for occasional decreases during recession years) from 87.8 million tons in 1960 to 209.1 million tons in 1994. The data presented in this chapter and Chapter 2 provide a perspective on the historical management of municipal solid waste. The study results are summarized in Table 26 and Figure 17.

Recovery for Recycling and Composting of Yard Trimmings

Recovery for recycling and composting had little effect on the total waste stream until the 1980s. Recovery was less than 10 percent of generation in the 1960s and 1970s. A strong emphasis on recovery for recycling, including composting, developed in the latter part of the 1980s, and total recovery reached an estimated 49.3 million tons, or 23.6 percent of generation, in 1994.

Mixed MSW Composting

Composting of yard trimmings is well established in many communities and was found to be increasing rapidly due to state-wide bans of yard trimmings in landfills and other local initiatives. Composting of mixed municipal wastes (e.g., by in-vessel units) is a developing technology in the United States. It was estimated that less than 400 thousand tons of mixed MSW were recovered for composting in 1994.

Combustion of Municipal Solid Waste

Most of the municipal solid waste combustion currently practiced in this country incorporates recovery of an energy product (generally steam or electricity). The resulting energy reduces the amount needed from other sources, and the sale of the energy helps to offset the cost of operating the facility. In past years, it was common to burn municipal solid waste in incinerators as a volume reduction practice; energy recovery became more prevalent in the 1970s.

Previous estimates of combustion with energy recovery were updated and expressed as a percentage of MSW generation (Table 26). Surveys by trade organizations such as the Integrated Waste Services Association (IWSA) were used as references for identifying operating combustion facilities.

In most cases the facilities have a stated daily capacity, but they normally operate at less than capacity over the course of a year. It was assumed for this report that throughput over a year of operation is 85 percent of rated capacity. While this is a conservative assumption, it has proven to be reasonably accurate over the years. (While new facilities are reporting operation at very high utilization rates, other facilities do not meet the same standards for annual throughput as compared to rated capacity.)

The surveys revealed that combustion of MSW increased rapidly between 1980 and 1990, with numerous new facilities coming into operation. The amount of MSW combusted has remained relatively constant since 1990. It was estimated that approximately 29.7 million tons of MSW were combusted with energy recovery in 1994. These estimates include facilities that mass burn mixed MSW without much pre-processing as well as those using fuel prepared from mixed MSW (usually called refuse-derived fuel). To provide a complete picture of historical MSW management, updates of the estimates of combustion without energy recovery were also made. The estimates indicate that MSW combustion without energy recovery dropped steadily throughout the entire study period, to about 1.3 million tons in 1994.

In addition to facilities combusting mixed MSW (processed or unprocessed), there is a small but growing amount of combustion of source separated MSW. In particular, there is considerable interest in using rubber tires as fuel in dedicated facilities or as fuel in cement kilns. In addition, there is combustion of wood wastes and some paper and plastic wastes, usually in boilers that already burn some other type of solid fuel. For this report, it was estimated that about 1.5 million tons of MSW were combusted in this manner in 1994, with tires contributing a majority of the total.

The total of all MSW combustion was an estimated 32.5 million tons, or 15.5 percent of MSW generation, in 1994.

Table 26

GENERATION, MATERIALS RECOVERY, COMPOSTING, COMBUSTION, AND DISCARDS OF MUNICIPAL SOLID WASTE, 1960 TO 1994
(In thousands of tons and percent of total generation)

	Thousands of Tons							
	1960	**1970**	**1980**	**1990**	**1991**	**1992**	**1993**	**1994**
Generation	87,820	122,600	152,350	197,100	196,770	202,950	206,450	209,080
Recovery for recycling	5,560	7,970	14,390	28,690	32,220	35,450	37,350	41,840
Recovery for composting*	Neg.	Neg.	Neg.	4,200	5,000	6,000	6,500	7,480
Total Materials Recovery	5,560	7,970	14,390	32,890	37,220	41,450	43,850	49,320
Discards after recovery	82,260	114,630	137,960	164,210	159,550	161,500	162,600	159,760
Combustion**	27,000	25,100	13,700	31,900	33,330	32,690	32,920	32,490
Discards to landfill, other disposal†	55,260	89,530	124,260	132,310	126,220	128,810	129,680	127,270

	Percent of Total Generation							
	1960	**1970**	**1980**	**1990**	**1991**	**1992**	**1993**	**1994**
Generation	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Recovery for recycling	6.3%	6.5%	9.4%	14.6%	16.4%	17.5%	18.1%	20.0%
Recovery for composting*	Neg.	Neg.	Neg.	2.1%	2.5%	3.0%	3.1%	3.6%
Total Materials Recovery	6.3%	6.5%	9.4%	16.7%	18.9%	20.4%	21.2%	23.6%
Discards after recovery	93.7%	93.5%	90.6%	83.3%	81.1%	79.6%	78.8%	76.4%
Combustion**	30.7%	20.5%	9.0%	16.2%	16.9%	16.1%	15.9%	15.5%
Discards to landfill, other disposal†	62.9%	73.0%	81.6%	67.1%	64.1%	63.5%	62.8%	60.9%

* Composting of yard trimmings and food wastes. Does not include mixed MSW composting or backyard composting. MSW composting estimated to be less than 400 thousand tons per year.
** Includes combustion of MSW in mass burn or refuse-derived fuel from, incineration without energy recovery, and combustion with energy recovery of source separated materials in MSW.
† Discards after recovery minus combustion.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Residues from Waste Management Facilities

Whenever municipal wastes are processed, residues will remain. For the purposes of this report, it is assumed that these residues are landfilled (although residues from combustion processes (ash) are often managed separately from other MSW).

Materials processing facilities (MRFs) and compost facilities generate some residues when processing various recovered materials. These residues include materials that are unacceptable to end users (e.g., broken glass, wet newspapers), other contaminants (e.g., products made of plastic resins that are not wanted by the end user), or dirt. While residue generation varies widely, 7 to 8 percent is probably typical for a MRF. Residues from a MRF or compost facility are generally landfilled.

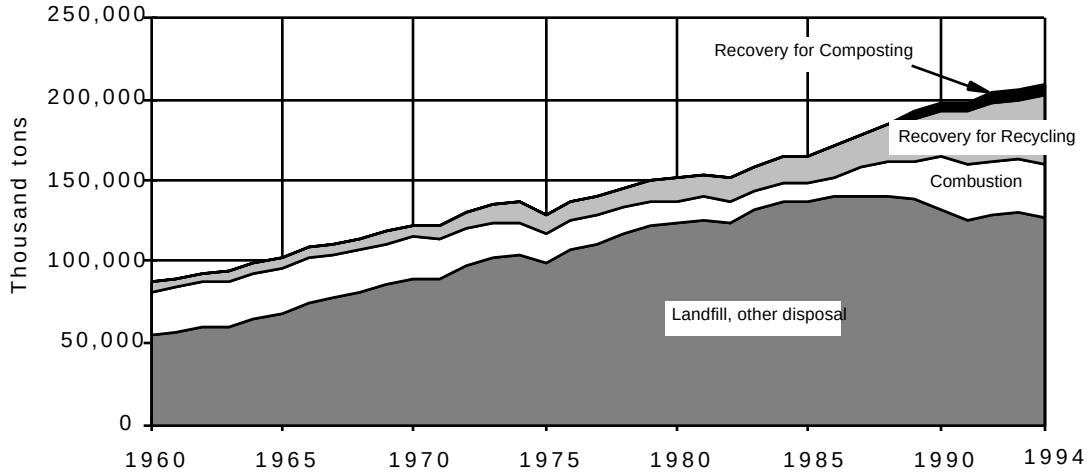
When municipal solid waste is combusted, a residue (usually called ash) is left behind. Years ago this ash was commonly disposed of along with municipal solid waste, but combustor ash is not counted as MSW in this report because it generally must be managed separately. As a general "rule of thumb," MSW combustor ash amounts to about 25 percent (dry weight) of unprocessed MSW input. This percentage will vary from facility to facility depending upon the types of waste input and the efficiency and configuration of the facility.

Summary

This summary provides some historical perspective on municipal solid waste management practices in the U.S. In the 1960s and early 1970s a large percentage of MSW was burned. The remainder was not usually landfilled as we define landfill in the 1990s; that is, it was not compacted and buried in cells with cover material added daily. In fact, much of this waste was "dumped" and often it was burned at the dump to reduce its volume.

As the old incinerators were closed down and landfills became more difficult and expensive to site, waste generation continued to increase. Materials recovery rates increased very slowly in this time period, and the burden on the nation's landfills grew dramatically. As Figure 17 graphically shows, discards of MSW to landfill or other disposal apparently peaked in the 1986-1987 period, then began to decline as materials recovery and combustion increased. Generation of MSW declined in 1991 (a recession year), but then continued to increase afterwards. Recovery of products and yard trimmings increased steadily, while combustion stayed nearly constant. As a result, discards to landfills were lower in 1994 than in 1993, accounting for 127.3 million tons or 60.9 percent of total generation.

Figure 17. Municipal Solid Waste Management, 1960 to 1994



Chapter 3

REFERENCES

GENERAL

U.S. Environmental Protection Agency. ***Characterization of Municipal Solid Waste in the United States: 1994 Update.*** EPA/530-R-94-042. November 1994.

U.S. Environmental Protection Agency. ***Characterization of Municipal Solid Waste in the United States: 1992 Update.*** EPA/530-R-92-019. July 1992.

U.S. Environmental Protection Agency. ***Characterization of Municipal Solid Waste in the United States: 1990 Update***. EPA/530-SW-90-042. June 1991.

U.S. Environmental Protection Agency, Municipal Solid Waste Task Force, Office of Solid Waste. ***The Solid Waste Dilemma: An Agenda for Action***. February 1989.

SOURCE REDUCTION

Brown, Kenneth. ***Source Reduction Now***. Minnesota Office of Waste Management. February 1993.

Compost Council. "Yard Waste Legislation: Disposal Bans and Similar Passed Bills as of July, 1993." Fact Sheet. July 1993.

Congress of the United States, Office of Technology Assessment. ***Green Products by Design: Choices for a Cleaner Environment***. OTA-E-541. October 1992.

Fishbein, Bette K., and Caroline Gelb. ***Making Less Garbage: A Planning Guide for Communities***. INFORM. 1992.

Franklin Associates, Ltd. ***The Role of Recycling in Integrated Solid Waste Management to the Year 2000***. Keep America Beautiful, Inc. 1994.

Rattray, Tom. "Source Reduction—An Endangered Species?" ***Resource Recycling***. November 1990.

Raymond Communications. ***State Recycling Laws Update.*** 1994.

Selke, Susan E. "Evaluating a Source Reduction Opportunity." ***Solid Waste & Power***. June 1991.

Steuteville, Robert. "The State of Garbage in America. Part II." ***Biocycle.*** May 1995.

U.S. Environmental Protection Agency. ***The Consumer's Handbook for Reducing Solid Waste***. EPA/530-K-92-003. August 1992.

U.S. Environmental Protection Agency. ***Waste Prevention Pays Off: Companies Cut Waste in the Workplace***. EPA/530-K-92-005. November 1993.

COMBUSTION

Integrated Waste Services Association. "High Court Rules Ash Not Exempt from Subtitle C Regulation." ***Update***. Summer 1994.

Kiser, Jonathan V.L., and John Menapace. "The 1995 IWSA Municipal Waste Combustion Directory Of United States Facilities." Integrated Waste Services Association. March 1995.

Kiser, Jonathan V.L. "The IWSA Municipal Waste Combustion Directory: 1993." Integrated Waste Services Association. February 1994.

Kiser, Jonathan V.L. "Municipal Waste Combustion in North America: 1992 Update." ***Waste Age***. November 1992.

Kiser, Jonathan V.L. "The 1992 Municipal Waste Combustion Guide." National Solid Wastes Management Association. February 1992.

Kiser, Jonathan V.L. "A Comprehensive Report on the Status of Municipal Waste Combustion." ***Waste Age***. November 1990.

Levy, Steven J. ***Municipal Waste Combustion Inventory***. U.S. Environmental Protection Agency, Office of Solid Waste, Municipal & Industrial Solid Waste Division. November 22, 1991.

National Solid Wastes Management Association. "The 1992 Municipal Waste Combustion Guide." ***Waste Age.*** November 1992.

"1991-1992 Energy-from-Waste Report." ***Solid Waste & Power***. HCI Publications. October 1991, December 1990.

"The 1991 Municipal Waste Combustion Guide." ***Waste Age***. November 1991.

Chapter 4

PROJECTIONS OF MSW GENERATION AND MANAGEMENT AND ADDITIONAL PERSPECTIVES

INTRODUCTION

This chapter includes projections of municipal solid waste generation and management for the years 2000 and 2010. It should be emphasized that these projections are not predictions. Recent efforts at source reduction are difficult to measure at a national level, but almost certainly are affecting MSW generation. No one can foresee with accuracy changes in the economy (e.g., booms and recessions), which also affect the municipal waste stream. In addition, it is difficult to predict which innovations and new products will affect the amounts and types of MSW discards. For example, there have long been predictions of the "paperless office" due to improvements in electronic communications, but in fact, facsimile machines, high-speed copiers, and personal computers have caused increasing amounts of paper to be generated in offices.

In spite of the limitations, it is useful to look at projections characterizing MSW based on past trends, since it is clear that the composition of the waste stream does change over time. New products (e.g., disposable products) are used, and materials are used in new ways (e.g., composite materials replace simpler products). Planners thus may choose to use different projections than those presented here, but anyone assuming that the current mix of materials in the waste stream will remain constant is disregarding the experience of the past.

OVERVIEW OF THIS CHAPTER

This chapter includes projections of municipal solid waste generation, recovery for recycling and composting, combustion, and landfill through the year 2010. Projections of total MSW recovery for recycling and composting are presented in three scenarios for the years 2000 and 2010—25 percent, 30 percent, and 35 percent. In making these projections, it was assumed that overall, products in MSW would continue to grow at a rate higher than population growth and lower than growth of Gross Domestic Product (GDP). (See Chapter 5 of EPA report 530-R-94-042, ***Characterization of Municipal Solid Waste in the United States: 1994 Update***, for an explanation of the correlation of MSW generation with these demographic and economic factors.)

It is important to note that the projections in this series of tables are also based on the assumption that there will continue to be a reduction in the generation of yard trimmings that enter the solid waste management system. These assumptions are explained later in this chapter. One result of this assumption is that the percentages of other products and materials in MSW are higher in future years than they would be if yard trimmings generation stayed constant or increased.

A summary table showing projected MSW generation, recovery at the mid-range scenario, and discards of MSW to combustion and landfill in 2000 and 2010 is included at the end of the chapter.

MATERIALS GENERATION IN MUNICIPAL SOLID WASTE

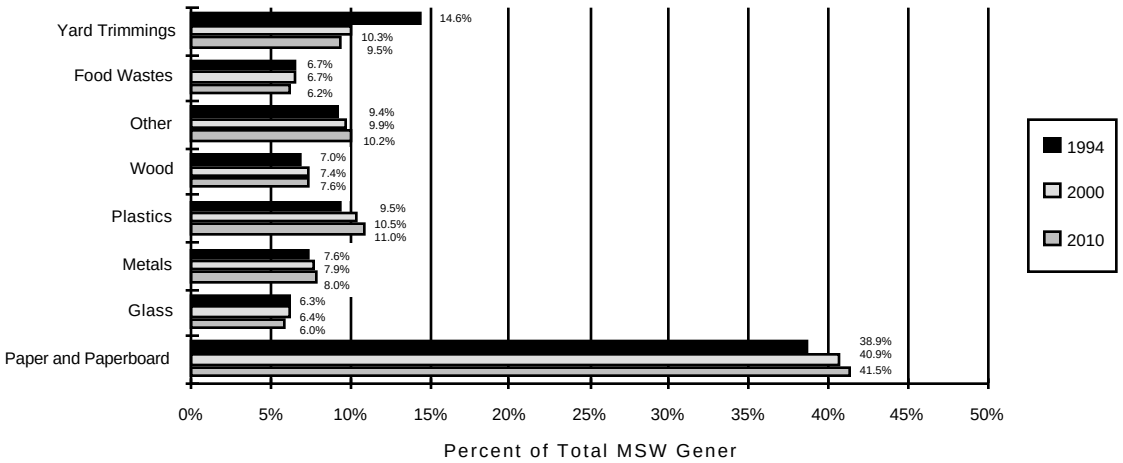
Projections of materials generated in MSW (by weight) are summarized in Figure 18 and, and a discussion of each material category follows.

Paper and Paperboard

Projections of paper and paperboard generation were based on past trends, with some slowing of growth projected for newsprint and paper packaging other than corrugated boxes. These grades of paper are showing the effects of decreased newspaper readership and some source reduction in packaging.

Paper and paperboard is projected to continue to be the dominant material in MSW, growing from a generation of 81.3 million tons in 1994 to 91.3 million tons and 108.9 million tons in 2000 and 2010, respectively. This would be 41.0 percent of MSW generation in 2000.

Figure 18. Materials generated in MSW: 1994, 2000, and 2010
(In percent of total MSW generation*)



* Total MSW generation (in thousand tons) for 1994 = 209,080; 2000 = 222,870; 2010 = 262,030.

Table 27

**PROJECTIONS OF MATERIALS GENERATED*
IN THE MUNICIPAL WASTE STREAM: 1994, 2000, AND 2010
(In thousands of tons and percent of total generation)**

	Thousands of tons			% of total		
Materials	**1994**	**2000**	**2010**	**1994**	**2000**	**2010**
Paper and Paperboard	81,300	91,260	108,860	38.9%	40.9%	41.5%
Glass	13,270	14,190	15,650	6.3%	6.4%	6.0%
Metals						
Ferrous	11,520	12,830	15,010	5.5%	5.8%	5.7%
Aluminum	3,060	3,510	4,300	1.5%	1.6%	1.6%
Other Nonferrous	1,210	1,350	1,660	0.6%	0.6%	0.6%
Total Metals	*15,790*	*17,690*	*20,970*	*7.6%*	*7.9%*	*8.0%*
Plastics	19,840	23,290	28,940	9.5%	10.5%	11.0%
Rubber and Leather	6,370	7,280	8,780	3.0%	3.3%	3.4%
Textiles	6,560	7,490	9,220	3.1%	3.4%	3.5%
Wood	14,590	16,490	19,930	7.0%	7.4%	7.6%
Other	3,590	4,000	4,790	1.7%	1.8%	1.8%
Total Materials in Products	161,310	181,690	217,140	77.2%	81.5%	82.9%
Other Wastes						
Food Wastes	14,070	14,900	16,300	6.7%	6.7%	6.2%
Yard Trimmings**	30,600	23,000	25,000	14.6%	10.3%	9.5%
Miscellaneous Inorganic Wastes	3,100	3,280	3,590	1.5%	1.5%	1.4%
Total Other Wastes	47,770	41,180	44,890	22.8%	18.5%	17.1%
Total MSW Generated	209,080	222,870	262,030	100.0%	100.0%	100.0%

* Generation before materials recovery or combustion.
** Yard trimmings based on source reduction scenario #2 described in Table 33.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

Glass

Glass products were a declining percentage of municipal solid waste during the 1970s and 1980s, with the 1990s showing a leveling off at approximately 6.5 percent of MSW generation. This recent trend is projected to continue, with the percentage of glass in MSW remaining fairly constant. Glass generation is projected to grow from 13.3 million tons in 1994 to 14.2 million tons and 15.7 million tons in 2000 and 2010, respectively. For 2000 this represents 6.4 percent of projected total MSW generation.

Ferrous Metals

Cans made of steel declined as a percentage of MSW in the 1970s and 1980s due to material substitution and light-weighting practices of can manufacturers. Since 1990, steel cans have been a relatively constant percent of MSW generation. On the other hand, more ferrous metals enter MSW as a component of durable goods than as containers. Since durable goods are an increasing component of MSW, ferrous metals in MSW were projected to increase from 11.5 million tons in 1994 to 12.8 million tons and 15.0 million tons in 2000 and 2010, respectively. The percentage of ferrous metals in MSW is projected to increase slightly, from 5.5 percent of total generation in 2000 to 5.7 percent in 2010.

Aluminum

Containers and packaging represent the primary source of aluminum in MSW, although some aluminum is present in durables and nondurables. Aluminum in MSW has grown, and the growth is projected to continue, to 3.5 million tons and 4.3 million tons in 2000 and 2010, respectively. Because of its light weight, aluminum represents a small percentage of MSW generation—1.5 percent in 1994 and a projected 1.6 percent in 2000 and 2010.

Other Nonferrous Metals

Other nonferrous metals (e.g., lead, copper, and zinc) are found in durable goods like appliances, furniture, and batteries. Lead-acid (automotive) batteries comprise the majority of this category. Generation of lead-acid batteries is projected to continue to increase, along with small increases in other nonferrous metals. Other nonferrous metals were estimated to be 1.2 million tons in 1994 and are projected to be 1.4 million tons and 1.7 million tons in 2000 and 2010, respectively. These metals are expected to continue to be less than one percent of total MSW generation.

Plastics

Generation of plastics in MSW has grown very rapidly in the past three decades. Plastics in MSW are projected to continue to increase both in tonnage (from 19.8 million tons in 1994 to 23.3 million tons and 28.9 million tons in 2000 and 2010, respectively) and in percentage of total MSW generation (from 9.5 percent of total in 1994 to 11.0 percent in 2010).

Wood Wastes

Wood wastes (in furniture and other durables and in pallets and other packaging) have been increasing in MSW. The tonnage of wood wastes generated is projected to grow from 14.6 million tons in 1994 to 16.5 million tons and 19.9 million tons in 2000 and 2010, respectively. The percentage of wood wastes is

projected to increase from 7.0 percent in 1994 to 7.6 percent of total MSW generation in 2010.

Other Materials

Other materials in MSW—including rubber, leather, and textiles—are projected to have modest growth in tonnage and nearly "flat" percentages of total MSW generation. Tonnage is projected to increase from 19.6 million tons in 1994 to 22.1 million tons and 26.4 million tons in 2000 and 2010, respectively.

Food Wastes

Sampling studies over a long period of time show food wastes to be a declining percentage of the waste stream. Per capita discards of food wastes have also been declining over time, which can be explained by the increased use of preprocessed food in homes, institutions, and restaurants, improved packaging, and by the increased use of garbage disposals, which put food wastes into wastewater systems rather than MSW. Therefore, the generation of food wastes was projected to grow at a slightly lower rate than population. The tonnage of food wastes is projected to increase from 14.1 million tons in 1994 to 14.9 million tons and 16.3 million tons in 2000 and 2010, respectively. The percentage of food wastes in total MSW would decline slightly, from 6.7 percent to 6.2 percent of total MSW generation.

Yard Trimmings

In earlier versions of this report, generation of yard trimmings* was estimated based on sampling studies, which showed a more or less constant generation on a per capita basis. (The definition of generation used here is the amount of yard trimmings that enter the solid waste management system, e.g., they are placed at the curb for collection or taken to a drop-off site.) Projections were made on the same basis. This methodology has now been revised because of changing trends in the management of yard trimmings in many parts of the country.

Although not well documented, there is evidence that where communities have charged separately for pickup of yard trimmings, or where disposal of yard trimmings in landfills has been banned, or other regulatory/educational measures have been taken, the amount of yard trimmings entering the system has greatly declined. In other words, source

* Although there are limited data available on the composition of yard trimmings, it is estimated that the average composition by weight is about 50 percent grass, 25 percent brush, and 25 percent leaves. These are "ballpark" numbers that will vary widely according to climate and region of the country.

reduction at the site of generation (e.g., residences) has been accomplished through backyard composting, leaving grass clippings on the lawn, and the like.

Using data published by the Composting Council as updated from more recent sources, legislation affecting yard trimmings disposal in landfills was tabulated. In 1992, 12 states accounting for over 28 percent of the nation's population had in effect legislation banning yard trimmings from landfills. Also, data compiled by ***BioCycle*** magazine indicates that there were about 3,000 composting facilities for yard trimmings in 1992. Using these facts, it was estimated that the effect of this legislation was that there was no increase in yard trimmings generated (e.g., entering the waste management system) between 1990 and 1992, and that there was a 6 percent annual decline in yard trimmings generation between 1992 and 1994.

The tabulation of existing legislation also shows that by 1996, 23 states including more than 50 percent of the nation's population will have legislation banning yard trimmings from landfills. Additional states have enacted less stringent measures. Therefore, it was projected that yard trimmings generation would be reduced by half between 1992 and 1996 in the states having legislation—a 25 percent reduction overall. This is a rather conservative assumption, because yard trimmings may well be reduced by more than half in these states. Finally, it was assumed that some additional legislation affecting generation of yard trimmings would be enacted between 1996 and 2000, and that yard trimmings would decline by 15 percent between 1996 and 2000. No additional legislation affecting yard trimmings was projected past 2000. For 2000 and 2010 projections, yard trimmings generation was adjusted to account for population growth rates (approximately one percent annually) projected by the U.S. Bureau of the Census.

Writing in May 1995, an editor of ***BioCycle*** magazine noted that there is a trend towards reduced regulations in the states, although existing programs are being continued. He noted that no states had passed comprehensive recycling laws or adopted diversion goals since the start of 1994, and some states were pushing back deadlines for goals already set but unachieved. Only one new state disposal ban on yard trimmings was passed in 1994, although several bans went into effect in 1994 and 1995, with few more already scheduled for 1996. The editor noted that strong markets, rather than state mandates appear to be the driving force behind increased recycling in 1995.

These assumptions yield a projection that generation of yard trimmings would decline from 30.6 million tons in 1994 to 23.0 million tons in 2000 (a 25 percent decrease compared to 1994). With no additional legislation affecting yard trimmings projected after 2000, and an increasing U.S. population, generation of yard trimmings is projected to increase to 25.0 million tons by 2010. In 1994 yard trimmings accounted for 14.6 percent of total MSW generation. Based on

projected generation, this will decline to 10.3 percent and 9.5 percent of total MSW generation in 2000 and 2010, respectively.

Projected Growth Rates for Materials in MSW

Projected growth rates by decade for the various materials generated in MSW are shown in Table 28. Projected population growth rates (from the Bureau of the Census) are included as well; the Bureau of the Census forecasts an approximately one percent annual growth of population from 1990 to 2000 with a decline in the growth rate (0.8 percent annual growth rate) from 2000 to 2010. Paper and paperboard, plastics, metals, and wood are all projected to increase faster than population, while glass and food wastes are projected to increase at about the same rate as population. Yard trimmings are projected to decline through 2000 due to source reduction efforts and landfill bans and then increase after 2000 due to population increases. Overall, municipal solid waste generation is projected to increase at a rate of 1.2 percent annually between 1990 and 2000. This rate would be higher if the projected decline in yard trimmings does not occur. For the period 2000 through 2010, the annual growth rate for municipal solid waste is projected to be 1.6 percent annually.

Table 28

AVERAGE ANNUAL RATES OF INCREASE (OR DECREASE)* OF GENERATION OF MATERIALS IN MSW (In annual percent by weight)

	1960-1970	1970-1980	1980-1990	1990-2000	2000-2010
Paper & Paperboard	4.0%	2.2%	2.8%	2.3%	1.8%
Glass	6.7%	1.6%	-1.3%	0.8%	1.0%
Metals	3.3%	0.2%	1.1%	0.8%	1.7%
Plastics	23.8%	9.7%	8.1%	3.3%	2.2%
Wood	3.4%	5.8%	5.2%	3.0%	1.9%
All Other Materials**	4.3%	4.2%	4.0%	2.3%	1.8%
Food Wastes	0.5%	0.2%	0.2%	1.2%	0.9%
Yard Trimmings	1.5%	1.7%	2.4%	-4.1%	0.8%
Total MSW	3.4%	2.2%	2.6%	1.2%	1.6%
Population^	1.3%	1.1%	0.9%	1.0%	0.8%

* Annual rates of increase or decrease calculated on 10-year end points.

** Rubber and leather, textiles, electrolytes in batteries, wood pulp and moisture in disposable diapers, miscellaneous inorganics.

^ Based on population estimates from U.S. Dept. of Commerce, Bureau of the Census.
Source: Franklin Associates, Ltd.

PRODUCT GENERATION IN MUNICIPAL SOLID WASTE

Projected generation of products in MSW (by weight) is summarized in Figure 19 and Table 29. All categories (except for yard trimmings) are projected to grow in tonnage. Containers and packaging are projected to remain the largest single category at over 37 percent of total generation, with nondurables being the second largest category of generation at 29 percent of total MSW generation. More detailed observations on the projected growth in the individual product categories follow.

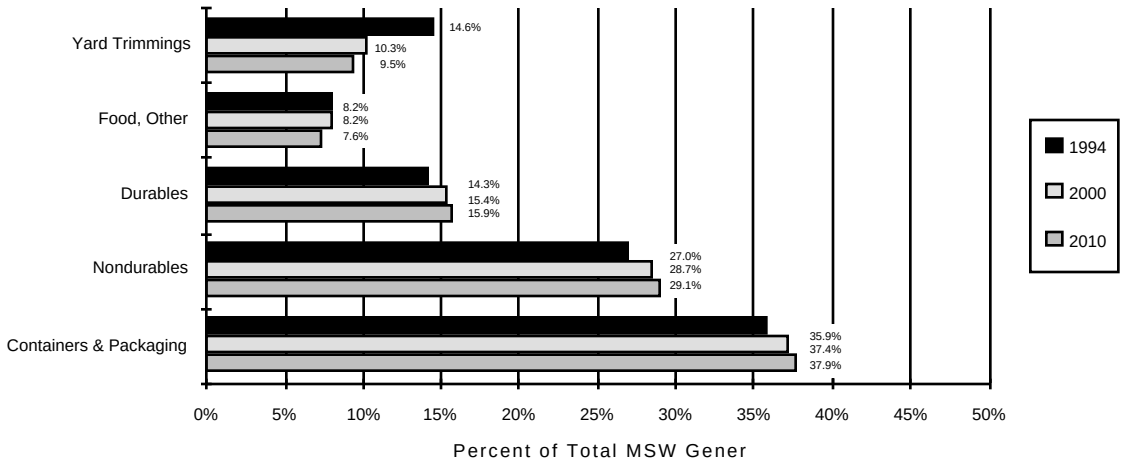
Durable Goods

Overall, durable goods are projected to increase in both tonnage and percent of total MSW generation (Table 30). The trends in generation of major appliances, carpet and rugs, and furniture and furnishings are well established by production numbers, since lifetimes of up to 20 years are assumed. Generation of rubber tires and lead-acid batteries is projected based on historical trends, which are generally exhibiting average rates of growth. Durable goods are projected to increase to 34.4 million tons and 41.7 million tons in 2000 and 2010, respectively. This represents a growth rate of about two percent annually for durable goods.

Nondurable Goods

Similar to durable goods, nondurable goods are projected to increase in both tonnage and percent of total MSW generation (Table 31). Generation of nondurable goods is projected to be 63.9 million tons and 76.2 million tons in

Figure 19. Products generated in MSW: 1994, 2000, and 2010
(In percent of total MSW generation*)



* Total MSW generation (in thousand tons) for 1994 = 209,080; 2000 = 222,870; 2010 = 262,030.

Table 29

**PROJECTIONS OF CATEGORIES OF PRODUCTS GENERATED*
IN THE MUNICIPAL WASTE STREAM: 1994, 2000, AND 2010
(In thousands of tons and percent of total generation)**

Products	Thousands of tons			% of total		
	1994	2000	2010	1994	2000	2010
Durable Goods *(Detail in Table 30)*	29,930	34,370	41,650	14.3%	15.4%	15.9%
Nondurable Goods *(Detail in Table 31)*	56,410	63,910	76,190	27.0%	28.7%	29.1%
Containers and Packaging *(Detail in Table 32)*	74,970	83,410	99,300	35.9%	37.4%	37.9%
Total Product Wastes **	161,310	181,690	217,140	77.2%	81.5%	82.9%
Other Wastes						
Food Wastes	14,070	14,900	16,300	6.7%	6.7%	6.2%
Yard Trimmings^	30,600	23,000	25,000	14.6%	10.3%	9.5%
Miscellaneous Inorganic Wastes	3,100	3,280	3,590	1.5%	1.5%	1.4%
Total Other Wastes	47,770	41,180	44,890	22.8%	18.5%	17.1%
Total MSW Generated	209,080	222,870	262,030	100.0%	100.0%	100.0%

* Generation before materials recovery or combustion.
** Other than food products.
^ Yard trimmings based on source reduction scenario #2 described in Table 33.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

2000 and 2010, respectively. Generation of nondurable goods is projected to grow approximately two percent annually, accounting for about 29 percent of total MSW generation in 2010.

Most of the nondurable paper products are projected to continue to grow at rates higher than population growth. Strong growth rates are projected for paper products such as office paper, paper used in commercial printing, and other nonpackaging paper. Newspaper generation is projected to increase to over 16 million tons in 2010, although the growth rate is expected to be lower than other paper products comprising nondurable goods.

Substitution of relatively light materials like aluminum and plastics for heavier materials like steel has occurred in durables like appliances and furniture as well as other products. Also, cars have become smaller and tires have been made longer-wearing, which tends to reduce the rate of increase at which tires are generated. It was projected that these trends will continue.

Clothing and footwear and other textiles also are projected to increase in tonnage.

Table 30

**PROJECTIONS OF PRODUCTS GENERATED*
IN THE MUNICIPAL WASTE STREAM: 1994, 2000, AND 2010
(WITH DETAIL ON DURABLE GOODS)
(In thousands of tons and percent of total generation)**

Products	Thousands of tons			% of total		
	1994	2000	2010	1994	2000	2010
Durable Goods						
Major Appliances	3,370	3,430	3,760	1.6%	1.5%	1.4%
Small Appliances	750	860	1,100	0.4%	0.4%	0.4%
Furniture and Furnishings	7,510	8,450	9,870	3.6%	3.8%	3.8%
Carpets and Rugs	2,320	2,610	3,180	1.1%	1.2%	1.2%
Rubber Tires	3,690	4,100	4,690	1.8%	1.8%	1.8%
Batteries, Lead-Acid	1,740	1,920	2,350	0.8%	0.9%	0.9%
Miscellaneous Durables	10,550	13,000	16,700	5.0%	5.8%	6.4%
Total Durable Goods	29,930	34,370	41,650	14.3%	15.4%	15.9%
Nondurable Goods *(Detail in Table 31)*	56,410	63,910	76,190	27.0%	28.7%	29.1%
Containers and Packaging *(Detail in Table 32)*	74,970	83,410	99,300	35.9%	37.4%	37.9%
Total Product Wastes*	161,310	181,690	217,140	77.2%	81.5%	82.9%
Other Wastes						
Food Wastes	14,070	14,900	16,300	6.7%	6.7%	6.2%
Yard Trimmings^	30,600	23,000	25,000	14.6%	10.3%	9.5%
Miscellaneous Inorganic Wastes	3,100	3,280	3,590	1.5%	1.5%	1.4%
Total Other Wastes	47,770	41,180	44,890	22.8%	18.5%	17.1%
Total MSW Generated	209,080	222,870	262,030	100.0%	100.0%	100.0%

* Generation before materials recovery or combustion.
** Other than food products.
^ Yard trimmings based on source reduction scenario #2 described in Table 33.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

Finally, other miscellaneous nondurables, which include many items made of plastics, have been growing historically and the growth is projected to continue, causing this category to continue to increase as a percentage of MSW generation.

Containers and Packaging

Containers and packaging is the largest single category of MSW, and this is projected to continue through 2010 (Table 32). Generation was 75.0 million tons in 1994, with an increase to 83.4 million tons and 99.3 million tons in 2000 and 2010, respectively. In percentage of total MSW, containers and packaging were 35.9 percent in 1994, with a projected increase to 37.9 percent in 2010. The average

Table 31

**PROJECTIONS OF PRODUCTS GENERATED*
IN THE MUNICIPAL WASTE STREAM: 1994, 2000, AND 2010
(WITH DETAIL ON NONDURABLE GOODS)
(In thousands of tons and percent of total generation)**

Products	Thousands of tons			% of total		
	1994	2000	2010	1994	2000	2010
Durable Goods *(Detail in Table 30)*	29,930	34,370	41,650	14.3%	15.4%	15.9%
Nondurable Goods						
Newspapers	13,540	14,600	16,300	6.5%	6.6%	6.2%
Books	1,140	1,290	1,650	0.5%	0.6%	0.6%
Magazines	2,160	2,500	3,000	1.0%	1.1%	1.1%
Office Papers	6,760	7,850	9,600	3.2%	3.5%	3.7%
Telephone Directories	470	4,960	5,760	0.2%	2.2%	2.2%
Third Class Mail	4,400	540	660	2.1%	0.2%	0.3%
Other Commercial Printing	6,740	7,820	9,550	3.2%	3.5%	3.6%
Tissue Paper and Towels	2,860	3,200	3,500	1.4%	1.4%	1.3%
Paper Plates and Cups	870	950	1,100	0.4%	0.4%	0.4%
Plastic Plates and Cups	440	490	600	0.2%	0.2%	0.2%
Trash Bags	910	1,140	1,510	0.4%	0.5%	0.6%
Disposable Diapers	2,980	3,340	3,980	1.4%	1.5%	1.5%
Other Nonpackaging Paper	4,480	5,100	6,300	2.1%	2.3%	2.4%
Clothing and Footwear	4,490	5,200	6,640	2.1%	2.3%	2.5%
Towels, Sheets, & Pillowcases	770	870	1,030	0.4%	0.4%	0.4%
Other Misc. Nondurables	3,400	4,060	5,010	1.6%	1.8%	1.9%
Total Nondurable Goods	56,410	63,910	76,190	27.0%	28.7%	29.1%
Containers and Packaging *(Detail in Table 32)*	74,970	83,410	99,300	35.9%	37.4%	37.9%
Total Product Wastes **	161,310	181,690	217,140	77.2%	81.5%	82.9%
Other Wastes						
Food Wastes	14,070	14,900	16,300	6.7%	6.7%	6.2%
Yard Trimmings^	30,600	23,000	25,000	14.6%	10.3%	9.5%
Miscellaneous Inorganic Wastes	3,100	3,280	3,590	1.5%	1.5%	1.4%
Total Other Wastes	47,770	41,180	44,890	22.8%	18.5%	17.1%
Total MSW Generated	209,080	222,870	262,030	100.0%	100.0%	100.0%

* Generation before materials recovery or combustion.
** Other than food products.
^ Yard trimmings based on source reduction scenario #2 described in Table 33.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

growth rate for containers and packaging through 2010 is projected to be 1.8 percent annually.

Tonnage of glass containers generated is projected to increase at a low rate. Glass containers are projected to continue to be a declining percentage of MSW generation (5.3 percent of total generation in 2010).

Table 32

PROJECTIONS OF PRODUCTS GENERATED*
IN THE MUNICIPAL WASTE STREAM: 1994, 2000, AND 2010
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In thousands of tons and percent of total generation)

	Thousands of tons			% of total		
Products	**1994**	**2000**	**2010**	**1994**	**2000**	**2010**
Durable Goods *(Detail in Table 30)*	29,930	34,370	41,650	14.3%	15.4%	15.9%
Nondurable Goods *(Detail in Table 31)*	56,410	63,910	76,190	27.0%	28.7%	29.1%
Containers and Packaging						
Glass Packaging						
Beer and Soft Drink Bottles	5,250	5,550	6,030	2.5%	2.5%	2.3%
Wine and Liquor Bottles	1,820	1,920	2,080	0.9%	0.9%	0.8%
Food and Other Bottles & Jars	5,000	5,280	5,740	2.4%	2.4%	2.2%
Total Glass Packaging	12,070	12,750	13,850	5.8%	5.7%	5.3%
Steel Packaging						
Beer and Soft Drink Cans	10	10	10	0.0%	0.0%	0.0%
Food and Other Cans	2,920	3,100	3,390	1.4%	1.4%	1.3%
Other Steel Packaging	180	190	210	0.1%	0.1%	0.1%
Total Steel Packaging	3,110	3,300	3,600	1.5%	1.5%	1.4%
Aluminum Packaging						
Beer and Soft Drink Cans	1,710	1,950	2,380	0.8%	0.9%	0.9%
Other Cans	40	40	50	0.0%	0.0%	0.0%
Foil and Closures	340	390	470	0.2%	0.2%	0.2%
Total Aluminum Pkg	2,090	2,380	2,900	1.0%	1.1%	1.1%
Paper & Paperboard Pkg						
Corrugated Boxes	28,420	32,400	40,300	13.6%	14.5%	15.4%
Milk Cartons	520	550	600	0.2%	0.2%	0.2%
Folding Cartons	5,140	5,490	6,120	2.5%	2.5%	2.3%
Other Paperboard Packaging	300	320	360	0.1%	0.1%	0.1%
Bags and Sacks	2,240	2,370	2,600	1.1%	1.1%	1.0%
Wrapping Papers	90	90	100	0.0%	0.0%	0.0%
Other Paper Packaging	1,110	1,170	1,290	0.5%	0.5%	0.5%
Total Paper & Board Pkg	37,820	42,390	51,370	18.1%	19.0%	19.6%
Plastics Packaging						
Soft Drink Bottles	640	740	900	0.3%	0.3%	0.3%
Milk Bottles	570	660	810	0.3%	0.3%	0.3%
Other Containers	2,060	2,360	2,900	1.0%	1.1%	1.1%
Bags and Sacks	1,590	1,830	2,230	0.8%	0.8%	0.9%
Wraps	2,080	2,390	2,930	1.0%	1.1%	1.1%
Other Plastics Packaging	2,550	2,920	3,580	1.2%	1.3%	1.4%
Total Plastics Packaging	9,490	10,900	13,350	4.5%	4.9%	5.1%
Wood Packaging	10,210	11,500	14,020	4.9%	5.2%	5.4%
Other Misc. Packaging	180	190	210	0.1%	0.1%	0.1%
Total Containers & Pkg	74,970	83,410	99,300	35.9%	37.4%	37.9%
Total Product Wastes**	161,310	181,690	217,140	77.2%	81.5%	82.9%
Other Wastes						
Food Wastes	14,070	14,900	16,300	6.7%	6.7%	6.2%
Yard Trimmings^	30,600	23,000	25,000	14.6%	10.3%	9.5%
Miscellaneous Inorganic Wastes	3,100	3,280	3,590	1.5%	1.5%	1.4%
Total Other Wastes	47,770	41,180	44,890	22.8%	18.5%	17.1%
Total MSW Generated	209,080	222,870	262,030	100.0%	100.0%	100.0%

* Generation before materials recovery or combustion.
** Other than food products.
^ Yard trimmings based on source reduction scenario #2 described in Table 33.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

Since 1990, steel cans have been a relatively constant percentage of MSW generation. Generation of steel containers and packaging is projected to increase at about the same rate as population through 2010. Steel packaging generation is expected to increase to 3.3 million tons and 3.6 million tons in 2000 and 2010, respectively. As a percentage of MSW generation, steel packaging is projected to be constant at about 1.5 percent of total generation.

Tonnage of aluminum packaging has been increasing steadily over the historical period, and this trend is projected to continue. Aluminum packaging is projected to increase to 2.4 million tons and 2.9 million tons in 2000 and 2010, respectively. Tonnage of other materials also increases, however, so aluminum stays at one percent of total generation in the projections.

Like other paper and paperboard products, overall generation of paper and paperboard packaging has been increasing rapidly. The increase is mostly in corrugated boxes, which are mainly used for shipping other products. Continued increases in generation of corrugated boxes are projected; tonnage of these boxes is projected to be 32.4 million tons in 2000, or 14.5 percent of total MSW generation. Other paper packaging is also projected to increase in tonnage, but as a percent of total MSW generation remain constant. All paper and paperboard packaging is projected to be 19.6 percent of total generation in 2010.

Plastics packaging has exhibited rapid historical growth, and the trends are projected to continue. Soft drink bottles, milk bottles, other containers, bags and sacks, wraps, and other packaging are all projected to follow the increasing trends. Generation of all plastics packaging is projected to be 10.9 million tons and 13.4 million tons in 2000 and 2010, respectively. This accounts for about 5 percent of total MSW generation.

The Effects of Yard Trimmings Source Reduction

As discussed earlier in this chapter, the apparent trend toward lower generation of yard trimmings (that is, a lower tonnage of yard trimmings entering the waste management system to go to composting facilities, landfill, or combustion facilities) has a marked effect on projections of total generation of MSW. As discussed earlier, over half of the U.S. population will live in states having regulations affecting disposal of yard trimmings by 1996, and some additional legislation is projected between 1996 and 2000. No additional legislation is projected after 2000, although adjustments for population increases were made for yard trimmings generation in 2000 and 2010.

Since dramatic source reduction of yard trimmings is a comparatively new phenomenon, data to support these projections are limited, although the data that are available tend to support the assumptions used. Due to current lack of hard data, three different scenarios for yard trimmings projections are shown to

Table 33

COMPARISON OF THREE SCENARIOS FOR SOURCE REDUCTION OF YARD TRIMMINGS: 2000 AND 2010
(In thousands of tons and percent of total generation)

	2000			2010		
	Generation (Thousand Tons)	% of Total MSW Generation	Avg. Annual % Increase in MSW Generation 1994-2000	Generation (Thousand Tons)	% of Total MSW Generation	Avg. Annual % Increase in MSW Generation 1994-2010
Scenario 1						
Yard trimmings constant since 1994						
Yard trimmings	30,600	13.3%	–	30,600	11.4%	–
Total MSW generation	230,470	100.0%	1.64%	267,630	100.0%	1.56%
Scenario 2						
Yard trimmings reduced*						
Yard trimmings	23,000	10.3%	–	25,000	9.5%	–
Total MSW generation	222,870	100.0%	1.07%	262,030	100.0%	1.42%
Scenario 3						
Yard Trimmings reduced further**						
Yard trimmings	15,300	7.1%	–	15,300	6.1%	–
Total MSW generation	215,170	100.0%	0.48%	252,330	100.0%	1.18%

* Assumes a 25 percent reduction in yard trimmings from 1994 generation for 2000 and an 18 percent reduction in yard trimmings from 1994 generation for 2010. (See text for assumptions.)

** Assumes a 50 percent reduction in yard trimmings from 1994 generation.

Source: Franklin Associates, Ltd.

present a range of possible outcomes (Table 33). The mid-range scenario (Scenario 2) is used for projections in this report.

For Scenario 1, it was assumed that there would be no further reduction in yard trimmings generation compared to generation in 1994 (i.e., yard trimmings remain at 30.6 million tons for 2000 and 2010). Scenario 2 was developed using the assumptions described earlier in this chapter. Assuming that generation of all other products and materials would not change from scenario to scenario, total projected MSW generation in 2000 would be 230.5 million tons under Scenario 1 compared to 222.9 million tons under Scenario 2. Yard trimmings would comprise 13.3 percent of total generation in Scenario 1, compared to 10.3 percent in Scenario 2. For 2010, total projected MSW generation would be 267.3 million tons under Scenario 1 compared to 262.0 million tons under Scenario 2. Under Scenario 2 yard trimmings are projected to be 9.5 percent of total MSW generation in 2010.

For a more optimistic scenario for yard trimmings reduction, it was assumed that yard trimmings generation could be reduced by 50 percent between 1994 and 2000 and remain at that level through 2010 (Scenario 3). Under this assumption, yard trimmings generation would be 15.3 million tons in both 2000

and 2010. Yard trimmings would be 7.1 percent and 6.1 percent of total MSW generation for 2000 and 2010, respectively.

For another perspective, Table 33 also shows the annual rates of increase of MSW generation for the time periods 1994-2000 and 1994-2010 under the various scenarios. If yard trimmings do not decrease (Scenario 1), MSW generation would increase an average of 1.64 percent annually from 1994 to 2000 and 1.56 percent annually from 1994 to 2010. Under Scenario 2 for yard trimmings reduction, the average annual rate of increase in MSW generation would be 1.1 percent from 1994 to 2000 and 1.4 percent from 1994 to 2010. Finally, under a 50 percent reduction in yard trimmings scenario, the increase in MSW generation would be 0.5 percent annually for 1994 to 2000 and 1.2 percent for 1994 to 2010. (Each scenario assumes that generation of other materials would increase by the amount shown in Table 27.)

It should be noted that a marked reduction in yard trimmings causes the percentages of all other products in the MSW stream to increase, even if their tonnages remain constant or decrease modestly.

PROJECTIONS OF MSW RECOVERY

Prior to the 1980s, rates of recovery for recycling increased slowly and thus projections were relatively easy to make. At this time, however, there is a high level of interest in municipal solid waste management in general, and in recycling and composting in particular. Government agencies at all levels are seeking ways to stimulate materials recovery. Local communities are adding materials recovery and recycling programs, but there is no accurate nationwide accounting system. In response to the demand for more recovery and more markets for recovered products, industry associations and individual companies have invested large amounts of money and effort in developing new recycling programs and products containing recovered materials.

Because of the rapidly changing situation and uncertainty in the available data, projections of materials recovery were made in scenarios that could achieve different rates of recovery in 2000 and 2010. Scenarios were developed for 25, 30, and 35 percent recovery rates in 2000 and 30, 35, and 40 percent recovery rates in 2010 (see Appendix B). These scenarios are based on recovery of postconsumer MSW and do not include industrial scrap. Also, composting of only food wastes and yard trimmings is included in these scenarios; estimates of composting of mixed MSW were not made for this report.

The recovery scenarios developed for this report describe sets of conditions that could achieve the selected range of recovery rates. The scenarios are not intended to predict exact recovery rates for any particular material; there are many ways in which a targeted overall recovery rate could be achieved. Especially at the state and local levels, differing circumstances mean that

recovery rates of a particular material could be higher or lower than those used to develop these scenarios.

Discussion of Assumptions

Some general assumptions and principles were used in making the recovery estimates:

- Recovery includes both recovery for recycling and for composting. Recovered materials are assumed to have been removed from the municipal waste stream.

- It was assumed that local, state, and federal agencies will continue to emphasize recycling and composting as MSW management alternatives.

- It was assumed that present state deposit laws will remain in place, but that no additional deposit legislation for containers would be enacted.

- It was assumed that affected industries will continue to emphasize recovery and recycling programs, and will make the necessary investments to achieve higher recycling rates.

- It was assumed that the current trend toward banning certain yard trimmings in landfills will continue to 2000, providing stimulus for composting programs and for source reduction of yard trimmings by citizens. No additional legislation affecting yard trimmings was projected past 2000.

- Based on the preceding assumptions, most U.S. citizens will have access to recovery options before 2000, which will often, in fact, be mandated. These options will include curbside collection, drop-off and buy-back centers, and, in some instances, mixed waste processing facilities. Recovery will continue to increase as more recovery systems come on-line.

- In spite of the factors encouraging more recovery as enumerated above, many areas of the U.S. are thinly populated and/or remote from ready markets for recovered materials; many of these areas also have adequate landfill capacity. Therefore, the overall recovery rate for the entire country may not reflect the higher rates achieved in communities where conditions are favorable for recycling and composting.

Scenarios for 2000

The range of projected recovery rates for materials in MSW under three recovery scenarios (25, 30, and 35 percent) in the year 2000 is shown in Table 34. (Details of the assumptions for individual products in MSW are in Appendix B.) Continued increases in recovery in every category will be required to reach the scenarios shown. To reach a recovery rate of 30 percent nationwide in 2000, 43 percent of all paper and paperboard, 27 percent of all glass, 44 percent of metals, and over 7 percent of all plastics in MSW would be recovered under this scenario. Forty percent of all yard trimmings would be recovered for composting under this scenario (not including backyard composting and other source reduction measures).

Table 34

PROJECTED GENERATION AND RANGES OF RECOVERY,* 2000
(In thousands of tons and percent of generation of each material)

Materials	2000 MSW Generation (thous tons)	Recovery						1994 MSW Recovery (%***)
		Thousand tons			% of generation			
		25%	30%	35%	25%	30%	35%	
Paper and Paperboard	91,260	33,280	39,440	43,340	36.5%	43.2%	47.5%	35.3%
Glass	14,190	3,440	3,830	5,100	24.2%	27.0%	35.9%	23.4%
Metals								
Ferrous	12,830	4,430	5,310	6,670	34.5%	41.4%	52.0%	32.3%
Aluminum	3,510	1,380	1,550	1,710	39.3%	44.2%	48.7%	37.6%
Other Nonferrous**	1,350	900	930	930	66.7%	68.9%	68.9%	66.1%
Total Metals	17,690	6,710	7,790	9,310	37.9%	44.0%	52.6%	35.9%
Plastics	23,290	1,170	1,690	2,500	5.0%	7.3%	10.7%	4.7%
Rubber & Leather	7,280	620	820	1,030	8.5%	11.3%	14.1%	7.1%
Clothing, Other Textiles	7,490	910	1,090	1,210	12.1%	14.6%	16.2%	11.7%
Wood	16,490	1,720	2,180	2,880	10.4%	13.2%	17.5%	9.8%
Yard Trimmings†	23,000	7,360	9,200	11,500	32.0%	40.0%	50.0%	22.9%
Food Wastes	14,900	510	830	1,130	3.4%	5.6%	7.6%	3.4%
Other Materials‡	7,280	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Totals	222,870	55,720	66,870	78,000	25.0%	30.0%	35.0%	23.6%

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
Does not include recovery for mixed MSW composting.
** Includes some nonferrous metals other than battery lead.
† Yard trimmings generation based on source reduction scenario #2 described in Table 33.
‡ Miscellaneous inorganic wastes, electrolytes in batteries, other miscellaneous.
*** From Table 2.
Neg. = Negligible (less than 5,000 tons or 0.05 percent)
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

To achieve a recovery rate of 35 percent nationwide in 2000, approximately 50 percent of all paper and paperboard, all metals, and yard trimmings would need to be recovered. Glass recovery would need to be 35 percent, and recovery of plastics, clothing and other textiles, and wood would each be about 15 percent of generation. Increased composting of food waste would also be required to reach this level of recovery nationwide.

Scenarios for 2010

The range of projected recovery rates for materials in MSW under three recovery scenarios (30, 35, and 40 percent) in the year 2010 is shown in Table 35. (Details of the assumptions for individual products in MSW are in Appendix B.) Recovery rates required for a 35 percent recovery rate nationwide are similar to those described in the 35 percent scenario for 2000. To reach a 40 percent recovery

Table 35

PROJECTED GENERATION AND RANGES OF RECOVERY,* 2010
(In thousands of tons and percent of generation of each material)

Materials	2010 Generation (thous tons)	Recovery: Thousand tons 30%	35%	40%	Recovery: % of generation 30%	35%	40%	1994 MSW Recovery (%***)
Paper and Paperboard	108,860	47,460	52,140	56,010	43.6%	47.9%	51.5%	35.3%
Glass	15,650	4,160	5,540	7,620	26.6%	35.4%	48.7%	23.4%
Metals								
Ferrous	15,010	6,000	7,650	8,790	40.0%	51.0%	58.6%	32.3%
Aluminum	4,300	1,880	2,120	2,170	43.7%	49.3%	50.5%	37.6%
Other Nonferrous**	1,660	1,140	1,140	1,140	68.7%	68.7%	68.7%	66.1%
Total Metals	20,970	9,020	10,910	12,100	43.0%	52.0%	57.7%	35.9%
Plastics	28,940	2,060	3,140	4,330	7.1%	10.9%	15.0%	4.7%
Rubber & Leather	8,780	940	1,170	1,640	10.7%	13.3%	18.7%	7.1%
Clothing, Other Textiles	9,220	1,380	1,530	1,920	15.0%	16.6%	20.8%	11.7%
Wood	19,940	2,660	3,500	4,910	13.3%	17.6%	24.6%	9.8%
Yard Trimmings†	25,000	10,000	12,500	13,750	40.0%	50.0%	55.0%	22.9%
Food Wastes	16,300	930	1,270	2,530	5.7%	7.8%	15.5%	3.4%
Other Materials‡	8,370	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Totals	262,030	78,610	91,700	104,810	30.0%	35.0%	40.0%	23.6%

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
Does not include recovery for mixed MSW composting.
** Includes some nonferrous metals other than battery lead.
† Yard trimmings generation based on source reduction scenario #2 described in Table 33.
‡ Miscellaneous inorganic wastes, electrolytes in batteries, other miscellaneous.
*** From Table 2.
Neg. = Negligible (less than 5,000 tons or 0.05 percent)
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

rate nationwide in 2010, 52 percent of all paper and paperboard, 49 percent of all glass, 58 percent of metals, and 15 percent of plastics would need to be recovered. Significant recovery of clothing, food, and wood wastes would also be required. Over 50 percent of all yard trimmings would be recovered for composting under this scenario.

PROJECTIONS OF MSW DISCARDS AFTER RECOVERY

Discards of municipal solid waste as defined for this report are those wastes remaining after recovery of materials for recycling and composting of yard trimmings. The remaining discards must be managed by combustion, landfilling, or some other means such as mixed waste composting or preparation of fuel products. The effects of projected recovery rates on the amounts and characteristics of municipal solid waste discards are illustrated in Table 36. (A 30 percent recovery scenario for 2000 and 35 percent recovery scenario for 2010 is shown as an example.)

This projected scenario of discards, which is based on substantial source reduction of yard trimmings and a 30 percent recovery rate for materials and products generated in 2000, shows a 2.4 percent decrease in MSW discards in 2000 as compared to 1994. Assuming a 35 percent recovery rate for materials and products generated in 2010, discards from 2000 to 2010 are projected to increase. This increase in discards occur (versus a decrease as shown from 1994 to 2000) because of the projected "flattening out" of the growth rate for recycling (23.6 percent to 30 percent in a six-year period from 1994 to 2000 versus 30 percent to 35 percent in a ten-year period from 2000 to 2010). Also, a reduction in the generation of yard trimmings between 1994 and 2000 is projected, whereas the reduction in generation from 2000 to 2010 is not expected to be as significant. This is based on the assumption that the majority of legislation banning yard trimmings from landfills will have occurred before 2000.

The materials composition of MSW discards is quite different from the materials composition of MSW generation (see Table 27), especially for materials that are recovered at higher rates. For example, paper and paperboard are projected to comprise 40.9 percent of MSW generation, but 33.2 percent of MSW discards, in 2000. Yard trimmings would decline from 14.6 percent of MSW generation to 10.3 percent of discards under this scenario in 2000. The percentages of other materials discards would likewise increase or decrease, depending upon their projected recovery rates.

Table 36

PROJECTIONS OF MATERIALS DISCARDED* IN MSW: 1994, 2000, AND 2010
(RECOVERY SCENARIOS ASSUMED: 30% IN 2000, 35% IN 2010)
(In thousands of tons and percent of total discards)

	Thousand tons			% of discards		
Materials	**1994**	**2000****	**2010^**	**1994**	**2000****	**2010^**
Paper and Paperboard	52,570	51,820	56,720	32.9%	33.2%	33.3%
Glass	10,160	10,360	10,110	6.4%	6.6%	5.9%
Metals						
Ferrous	7,800	7,520	7,360	4.9%	4.8%	4.3%
Aluminum	1,910	1,960	2,180	1.2%	1.3%	1.3%
Other Nonferrous	410	420	520	0.3%	0.3%	0.3%
Total Metals	*10,120*	*9,900*	*10,060*	*6.3%*	*6.3%*	*5.9%*
Plastics	18,910	21,600	25,800	11.8%	13.8%	15.1%
Rubber & Leather	5,920	6,460	7,610	3.7%	4.1%	4.5%
Clothing, Other Textiles	5,790	6,400	7,690	3.6%	4.1%	4.5%
Wood	13,160	14,310	16,430	8.2%	9.2%	9.6%
Yard Trimmings†	23,600	13,800	12,500	14.8%	8.8%	7.3%
Food Wastes	13,590	14,070	15,030	8.5%	9.0%	8.8%
Other Materials‡	5,940	7,280	8,380	3.7%	4.7%	4.9%
Totals	159,760	156,000	170,330	100.0%	100.0%	100.0%

* Discards after recovery for recycling and composting of yard trimmings.
** 30 percent recovery scenario assumed for 2000 (Table 34).
^ 35 percent recovery scenario assumed for 2010 (Table 35).
† Yard trimmings generation based on source reduction scenario #2 described in Table 33.
‡ Miscellaneous inorganic wastes, electrolytes in batteries, other miscellaneous.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

PROJECTIONS OF MSW COMBUSTION

Making projections of MSW combustion is somewhat difficult because of the many uncertainties affecting the planning and construction of new facilities. Several years are required to site and obtain permits for construction of new MSW combustion facilities. Projections of future waste-to-energy combustion capacity were based on facilities operating or reported under construction or in planning. Conversely, estimates were made to account for capacity that will be retired from service after 1994. Based on this analysis, MSW sent to waste-to-energy combustion facilities was projected to remain near the 1994 level (30 million tons) for 2000 and 2010.

While substantial amounts of MSW were burned without energy recovery in past years, most of these older facilities have been closed due to the costs of

implementing air pollution requirements. MSW destined for incinerators is projected to continue to decrease through 2010. Approximately one million tons of MSW is projected to be managed through incinerators after 1994.

Since there is increasing interest in combustion of certain source-separated components of MSW—especially tires, but also wood pallets, paper, and plastics—it was assumed that combustion of these materials would continue to increase.

Accounting for waste-to-energy combustion, incinerators, and combustion of source-separated components of MSW, combustion of MSW is projected to increase from 32.5 million tons in 1994 to 34 million tons of MSW in 2000. By 2010 MSW combustion is projected to increase to 38 million tons.

SUMMARY OF PROJECTED MSW MANAGEMENT

A summary of the projections is presented, with similar figures for 1994 included for contrast (Table 37). For the summary, a mid-range recovery scenario of 30 percent in 2000 and 35 percent in 2010 was used. A graphical illustration of the long-term trends is shown in Figure 20.

Table 37

GENERATION, RECOVERY, COMBUSTION, AND DISPOSAL OF MUNICIPAL SOLID WASTE: 1994, 2000, AND 2010 (RECOVERY SCENARIOS ASSUMED: 30% IN 2000, 35% IN 2010) (In thousands of tons and percent of total generation)

	Thousands of tons			% of generation		
	1994	2000	2010	1994	2000	2010
Generation	209,080	222,870	262,030	100.0%	100.0%	100.0%
Recovery for recycling	41,840	56,840	77,930	20.0%	25.5%	29.7%
Recovery for composting*	7,480	10,030	13,770	3.6%	4.5%	5.3%
Total materials recovery	49,320	66,870	91,700	23.6%	30.0%	35.0%
Discards after recovery	159,760	156,000	170,330	76.4%	70.0%	65.0%
Combustion**	32,490	34,000	38,000	15.5%	15.3%	14.5%
Landfill, other disposal	127,270	122,000	132,330	60.9%	54.7%	50.5%

* Composting of yard trimmings and food wastes. Does not include backyard composting.

** Combustion of MSW in mass burn or refuse derived form, incineration without energy recovery, and combustion with energy recovery of source separated materials in MSW.

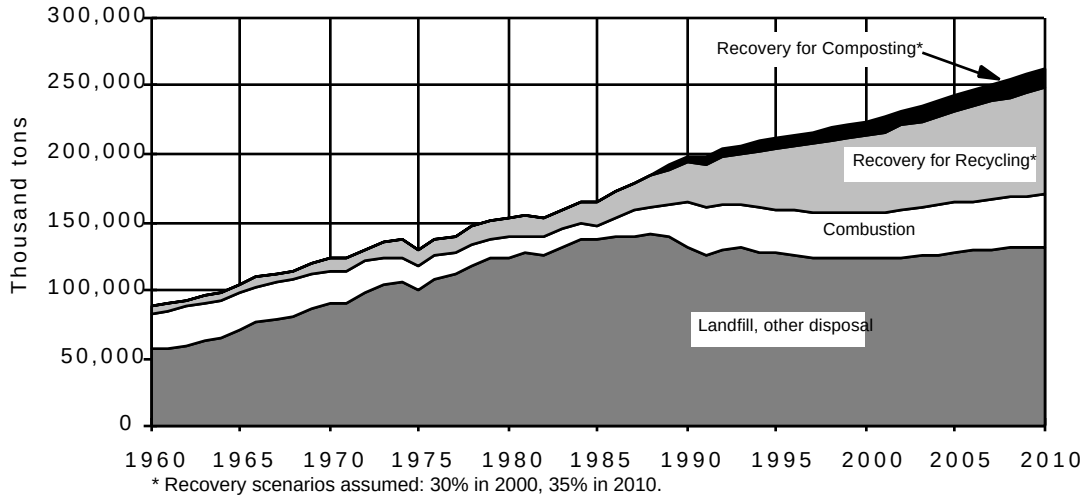
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

From 1994 to 2000, generation of MSW is projected to increase by 1.1 percent per year compared to 2.6 percent per year between 1980 and 1990. The generation of MSW is projected to increase by 1.6 percent per year between 2000 and 2010. As described earlier, source reduction of yard trimmings accounts for most of the decrease from 1994 to 2000 under the selected scenario.

The effect of the mid-range scenario for materials recovery for recycling and yard trimmings composting causes the discards of MSW to decline between 1994 and 2000, from 159.8 million tons in 1994 to 156.0 million tons in 2000. After deductions for combustion, discards to landfill and other disposal were 127.3 million tons in 1994, declining to 122.0 million tons in 2000. After deductions for recycling and combustion, discards to landfill and other disposal were projected to increase to 132.3 million tons in 2010.

Figure 20. Municipal Solid Waste Management, 1960 to 2010



* Recovery scenarios assumed: 30% in 2000, 35% in 2010.

ADDITIONAL PERSPECTIVES ON MUNICIPAL SOLID WASTE

In this section, the municipal solid waste (MSW) characterization data summarized in previous sections of the report are presented again from different perspectives. These are:

- Historical and projected MSW generation and management on a pounds per person per day basis
- Historical and projected MSW generation by material on a pounds per person per day basis

- A classification of 1994 MSW generation into residential and commercial components

- Historical and projected discards of MSW classified into organic and inorganic fractions

- A ranking of products and materials in 1994 MSW by tonnage generated and discarded.

Generation and Discards by Individuals

Municipal solid waste planners often think in terms of generation and discards on a per capita (per person) basis. Data on historical and projected MSW generation and management are presented on the basis of pounds per person per day in Table 38. The top line shows a steady increase in per capita generation of MSW, from 2.7 pounds per person per day in 1960 to 4.4 pounds per person per day in 1994, with a projection of 4.4 and 4.8 pounds per person per day in 2000 and 2010, respectively. The primary reason for the projected decline in growth of MSW generation is a decrease in yard trimmings entering the MSW management system.

The per capita discards represent the amount remaining after recovery for recycling and composting. Discards after recovery for recycling and composting grew from 2.5 pounds per person per day in 1960 to 3.6 pounds per person per day in 1990. Between 1990 and 1994, discards declined to 3.4 pounds per person per day due to increased recovery for recycling and composting. Under a 30 percent

Table 38

PER CAPITA GENERATION, MATERIALS RECOVERY, COMBUSTION, AND DISCARDS OF MUNICIPAL SOLID WASTE, 1960 TO 2010
(In pounds per person per day; population in thousands)

	1960	1970	1980	1990	1994	2000	2010
Generation	2.67	3.29	3.67	4.33	4.40	4.42	4.78
Recovery for recycling & composting	0.17	0.21	0.35	0.72	1.04	1.33	1.67
Discards after recovery	2.50	3.08	3.33	3.61	3.36	3.09	3.11
Combustion	0.82	0.67	0.33	0.70	0.68	0.67	0.69
Discards to landfill, other disposal	1.68	2.40	3.00	2.91	2.68	2.42	2.41
Resident Population (thousands)	179,979	203,984	227,255	249,402	260,341	276,241	300,431

Projections assume a substantial reduction of yard trimmings generation from 1994 to 2000, a 30% recovery scenario for 2000, a 35% recovery scenario for 2010, and a slight increase in net combustion of MSW.
Details may not add to totals due to rounding.
Population figures from Bureau of the Census, Current Population Reports.
Source: Franklin Associates, Ltd.

recovery scenario for 2000 and a 35 percent recovery scenario for 2010, this decline is projected to continue, to 3.1 pounds per person per day.

In 1994, an estimated 0.7 pounds per person per day of discards were managed through combustion, while the remainder—2.7 pounds per person per day—went to landfill or other disposal. The projection for 2000 and 2010 is that 0.7 pounds per person per day would continue to be combusted, and 2.4 pounds per person per day would be landfilled.

In Table 39, per capita generation of each material category characterized in this study is shown. Paper, plastics, textiles, and wood in MSW have grown on a per capita basis throughout the 34-year historical period, and this growth is projected to continue. Glass generation grew on a per capita basis during the earlier decades, but declined in the 1980s. Generation in the 1990s was lower on a per capita basis, and is projected to remain constant. Generation of metals and rubber and leather on a per capita basis also grew, then declined somewhat. Some growth in the per capita generation of these materials is projected to 2010.

Table 39

PER CAPITA GENERATION* OF MUNICIPAL SOLID WASTE, BY MATERIAL, 1960 TO 2010
(In pounds per person per day)

Materials	1960	1970	1980	1990	1994	2000	2010
Paper and paperboard	0.91	1.19	1.33	1.60	1.71	1.81	1.99
Glass	0.20	0.34	0.36	0.29	0.28	0.28	0.29
Metals	0.32	0.39	0.35	0.36	0.33	0.35	0.38
Plastics	0.01	0.08	0.19	0.37	0.42	0.46	0.53
Rubber and leather	0.06	0.09	0.11	0.14	0.13	0.14	0.16
Textiles	0.05	0.05	0.06	0.11	0.14	0.15	0.17
Wood	0.09	0.11	0.18	0.27	0.31	0.33	0.36
Other	0.00	0.02	0.06	0.07	0.08	0.08	0.09
Total Nonfood Products	1.65	2.28	2.64	3.21	3.40	3.60	3.96
Food wastes	0.37	0.34	0.31	0.29	0.30	0.30	0.30
Yard trimmings	0.61	0.62	0.66	0.77	0.64	0.46	0.46
Miscellaneous inorganic wastes	0.04	0.05	0.05	0.06	0.07	0.07	0.07
Total MSW Generated	2.67	3.29	3.67	4.33	4.40	4.42	4.78
Resident Population (thousands)	179,979	203,984	227,255	249,402	260,341	276,241	300,431

* Generation before materials or energy recovery.
Details may not add to totals due to rounding.
Source: Tables 1 and 27. Population figures from the Bureau of the Census, Current Population Reports.

Generation of food wastes has declined on a per capita basis due to increased processing of food before it enters the residential or commercial waste streams. Per capita generation of food wastes is projected to remain constant. Generation of yard trimmings on a per capita basis increased over a 30-year period, but has begun to decline for reasons discussed elsewhere in this report.

Overall, per capita generation of MSW increased throughout the 34-year study period. This increase is projected to continue, but at a much slower rate of growth, primarily because of the projected source reduction of yard trimmings.

Residential and Commercial Generation of MSW

The sources of MSW generation are of considerable interest to management planners. The material flows methodology does not lend itself well to a distinction as to sources of the materials because the data used are national in scope. However, a classification of products and materials by residential and commercial sources was first made for the 1992 update of this series of reports.

For purposes of this classification, residential waste was considered to come from both single family and multi-family residences. This is somewhat contrary to a common practice in MSW management to classify wastes collected from apartment buildings as commercial. The rationale used for this report is that the nature of residential waste is basically the same whether it is generated in a single or multi-family residence. (Yard trimmings are probably the primary exception, and this was taken into account.) Because of this approach, the percentage of residential waste shown here is higher than that often reported by waste haulers.

Commercial wastes for the purpose of this classification include MSW from retail and wholesale establishments; hotels; office buildings; airports and train stations; hospitals, schools, and other institutions; and similar sources. No industrial process wastes are included, but normal MSW such as packaging, cafeteria and washroom wastes, and office wastes from industrial sources are included. As is the case for the data in Chapter 2, construction and demolition wastes, sludges, ashes, automobile bodies, and other non-MSW wastes are not included.

The classification of MSW generation into residential and commercial fractions was made on a product-by-product basis (see Appendix C of EPA report 530-R-94-042, ***Characterization of Municipal Solid Waste in the United States: 1994 Update***). The 1994 tonnage generation of each product was allocated to residential or commercial sources on a “best judgment” basis; then the totals were aggregated. These are estimates for the nation as a whole, and should not be taken as representative of any particular region of the country.

A few revisions to the methodology were made for the current report based on estimates made in a 1994 report for Keep America Beautiful, which was

extensively reviewed by public and private sector experts in municipal solid waste management. Discards of major appliances and rubber tires were reassigned to the commercial sector rather than the residential sector because, while these products may be used in a residential setting, they tend to be collected and managed through the commercial sector.

Based on this analysis, a reasonable range for residential wastes would be 55 to 65 percent of total MSW generation, while commercial wastes probably range between 35 to 45 percent of total generation (Table 40).

Table 40

CLASSIFICATION OF MSW GENERATION INTO RESIDENTIAL AND COMMERCIAL FRACTIONS, 1994
(In thousands of tons and percent of total)

	Thousand tons	Percent of total
Residential Wastes	114,990 – 135,900	55.0% – 65.0%
Commercial Wastes	73,180 – 94,090	35.0% – 45.0%

Estimates are presented as a range because of wide variations across the country.
Source: Franklin Associates, Ltd

Organic/Inorganic Fractions of MSW Discards

The composition of MSW in terms of organic and inorganic fractions is of interest to planners of waste management facilities and others working with MSW. This characterization of MSW discards is shown in Table 41. (Discards were used instead of generation because discards enter the solid waste management system after recovery for recycling and composting.) The organic fraction of MSW has been increasing steadily since 1970, from 75 percent organics in 1970 to 85 percent in 1994.

It is interesting to note, however, that the percentage of MSW that is organics began to "level off" after 1992 because of the projected decline in yard trimmings discarded. This trend is projected to continue through 2000, with organics comprising 85 percent of total MSW discards in 2000. After 2000 projected increases in yard trimmings and other organic components of MSW, such as paper, are expected to cause the organic fraction to increase to approximately 86 percent of total MSW discards.

Ranking of Products in MSW by Weight

About 50 categories of products and materials are characterized as line items in the tables in Chapter 2. It is difficult when examining that set of tables to

Table 41

COMPOSITION OF MSW DISCARDS* BY ORGANIC AND INORGANIC FRACTIONS, 1960 TO 2010 (In percent of total discards)

Year	Organics**	Inorganics†
1960	77.8%	22.2%
1970	75.3%	24.7%
1980	78.3%	21.7%
1990	84.0%	16.0%
1991	84.0%	16.0%
1992	84.3%	15.7%
1993	84.3%	15.7%
1994	85.4%	14.6%
2000	84.9%	15.1%
2010	86.1%	13.9%

* Discards after materials recovery has taken place, and before combustion.
** Includes paper, plastics, rubber and leather, textiles, wood, food wastes, and yard trimmings.
† Includes glass, metals, and miscellaneous inorganics.
Details may not add to totals due to rounding.

Source: Tables 3 and 36.

see in perspective the relative tonnages generated or discarded by the different items. Therefore, Tables 42 and 43 were developed to illustrate this point.

In Table 42, the various products and materials are arranged in descending order by weight generated in 1994. Subtotals in the right-hand column group components together for further illustration. For example, only yard trimmings and corrugated boxes stand at the top of the list, with each generating over 10 percent of total MSW. Together these two items totaled 28.2 percent of MSW generated in 1994. The next seven components, each comprising 3 to 10 percent of total MSW generation, accounted for 33.2 percent of generation. Together these nine components accounted for over 61 percent of total MSW generated. The 17 items at the bottom of the list each amounted to less than one percent of generation in 1994; together they amounted to only 6.7 percent of total MSW generation.

A different perspective is provided in Table 43, which ranks products in MSW by weight discarded after recovery for recycling and composting. This table illustrates how recovery alters the products' rankings. For example, corrugated boxes, which ranked second highest in generation, ranked third in discards in 1994.

Table 42

GENERATION OF MUNICIPAL SOLID WASTE, 1994
ARRANGED IN DESCENDING ORDER BY WEIGHT
(In thousands of tons)

	Thousand tons	Percent of total	Percent subtotals
Components comprising > 10% of total MSW generation			
Yard trimmings	30,600	14.6%	
Corrugated boxes	28,420	13.6%	28.2%
Components comprising 3-10% of total MSW generation			
Food wastes	14,070	6.7%	
Newspapers	13,540	6.5%	
Miscellaneous durables	10,550	5.0%	
Wood packaging	10,210	4.9%	
Furniture and furnishings	7,510	3.6%	
Office-type papers	6,760	3.2%	
Other commercial printing	6,740	3.2%	33.2%
Components comprising 2-3% of total MSW generation			
Glass beer & soft drink bottles	5,250	2.5%	
Paper folding cartons	5,140	2.5%	
Glass food & other bottles	5,000	2.4%	
Clothing and footwear	4,490	2.1%	
Other nonpackaging paper	4,480	2.1%	
Third class mail	4,400	2.1%	13.8%
Components comprising 1-2% of total MSW generation			
Rubber tires	3,690	1.8%	
Miscellaneous nondurables	3,400	1.6%	
Major appliances	3,370	1.6%	
Steel cans and other packaging	3,110	1.5%	
Miscellaneous inorganic wastes	3,100	1.5%	
Disposable diapers	2,980	1.4%	
Tissue paper and towels	2,860	1.4%	
Other plastic packaging	2,550	1.2%	
Carpets and rugs	2,320	1.1%	
Paper bags and sacks	2,240	1.1%	
Magazines	2,160	1.0%	
Aluminum cans and other packaging	2,090	1.0%	
Plastic wraps	2,080	1.0%	
Plastic other containers	2,060	1.0%	18.2%
Components comprising < 1% of total MSW generation			
Glass wine & liquor bottles	1,820	0.9%	
Lead-acid batteries	1,740	0.8%	
Plastic bags and sacks	1,590	0.8%	
Books	1,140	0.5%	
Other paper packaging	1,110	0.5%	
Trash bags	910	0.4%	
Paper plates and cups	870	0.4%	
Towels, sheets, and pillowcases	770	0.4%	
Small appliances	750	0.4%	
Plastic soft drink bottles	640	0.3%	
Plastic milk bottles	570	0.3%	
Paper milk cartons	520	0.2%	
Telephone directories	470	0.2%	
Plastic plates and cups	440	0.2%	
Other paperboard packaging	300	0.1%	
Other miscellaneous packaging	180	0.1%	
Paper wraps	90	0.0%	6.7%
Total MSW Generation	209,080	100.0%	100.0%

Source: Chapter 2.

Table 43

DISCARDS OF MUNICIPAL SOLID WASTE, 1994
ARRANGED IN DESCENDING ORDER BY WEIGHT
(In thousands of tons)

	Thousand tons	Percent of total	Percent subtotals
Components comprising > 10% of total MSW discards			
Yard trimmings	23,600	14.8%	14.8%
Components comprising 3-10% of total MSW discards			
Food wastes	13,590	8.5%	
Corrugated boxes	12,710	8.0%	
Miscellaneous durables	10,240	6.4%	
Wood packaging	8,780	5.5%	
Furniture and furnishings	7,510	4.7%	
Newspapers	7,410	4.6%	
Other commercial printing	5,650	3.5%	41.2%
Components comprising 2-3% of total MSW discards			
Other nonpackaging paper	4,480	2.8%	
Paper folding cartons	4,180	2.6%	
Glass food & other bottles	4,010	2.5%	
Clothing and footwear	3,940	2.5%	
Office-type papers	3,880	2.4%	
Third class mail	3,790	2.4%	
Glass beer & soft drink bottles	3,600	2.3%	
Miscellaneous nondurables	3,400	2.1%	
Rubber tires	3,130	2.0%	21.5%
Components comprising 1-2% of total MSW discards			
Miscellaneous inorganic wastes	3,100	1.9%	
Disposable diapers	2,980	1.9%	
Tissue paper and towels	2,860	1.8%	
Other plastic packaging	2,540	1.6%	
Carpets and rugs	2,310	1.4%	
Plastic wraps	2,050	1.3%	
Plastic other containers	1,920	1.2%	
Paper bags and sacks	1,820	1.1%	
Plastic bags and sacks	1,550	1.0%	13.2%
Components comprising < 1% of total MSW discards			
Steel cans and other packaging	1,510	0.9%	
Magazines	1,510	0.9%	
Major appliances	1,460	0.9%	
Glass wine & liquor bottles	1,350	0.8%	
Other paper packaging	1,110	0.7%	
Aluminum cans and other packaging	940	0.6%	
Books	920	0.6%	
Trash bags	910	0.6%	
Paper plates and cups	870	0.5%	
Small appliances	750	0.5%	
Towels, sheets, and pillowcases	640	0.4%	
Paper milk cartons	520	0.3%	
Telephone directories	420	0.3%	
Plastic plates and cups	420	0.3%	
Plastic milk bottles	400	0.3%	
Plastic soft drink bottles	320	0.2%	
Other paperboard packaging	300	0.2%	
Other miscellaneous packaging	180	0.1%	
Lead-acid batteries	110	0.1%	
Paper wraps	90	0.1%	9.2%
Total MSW Discards	159,760	100.0%	100.0%

Source: Chapter 2.

Yard trimmings accounted for 14.8 percent of total MSW discards in 1994. Seven components, each representing 3 to 10 percent of total MSW discards, accounted for over 41 percent of discards. These components included; food wastes, corrugated boxes, miscellaneous durables, wood packaging, furniture and furnishings, newspapers, and other commercial printing. Together these eight components made up 56 percent of MSW discards in 1994. Twenty categories of discards were each less than one percent of the total; together these items totaled 9.2 percent of 1994 discards.

Chapter 4

REFERENCES

Alozie, Emmanuel C. "More Illegal Dumping in Missouri." ***Kansas City Star***. August 15, 1994.

Composting Council. "Yard Waste Legislation: Disposal Bans and Similar Passed Bills as of July, 1993." Fact Sheet. July 1993.

Conversation with a representative of a waste hauler. August 10, 1994.

Franklin Associates, Ltd. ***The Role of Recycling in Integrated Solid Waste Management to the Year 2000.*** Keep America Beautiful, Inc. September 1994.

Harrison-Ferris, Pamela. "Letters to the Editor." ***BioCycle***. July 1992.

Kiser, Jonathan V.L., and John Menapace. "The 1995 IWSA Municipal Waste Combustion Directory Of United States Facilities." Integrated Waste Services Association. March 1995.

Monk, Randall. "After the Ban." ***MSW Management***. September/October 1992.

Raymond Communication. ***State Recycling Laws Update.*** 1994.

Sheehan, Kathleen. "Yard Waste Composting—A Legislative Update." ***Waste Age***. February 1994.

Steuteville, Robert. "Measuring the Impact of Disposal Bans." ***BioCycle***. September 1994.

Steuteville, Robert. "The State of Garbage in America, Part II." ***BioCycle***. May 1995. Also earlier editions of the same ***BioCycle*** survey.

U.S. Department of Commerce. ***1994 Statistical Abstract of the United States.***

U.S. Department of Commerce, Bureau of the Census. ***Current Population Reports, National and State Population Estimates: 1990 to 1994.*** P25-1127. Issued July 1995.

U.S. Department of Commerce, Bureau of the Census. ***Current Population Reports, Population Projections of the U.S. by Age, Sex, Race, and Hispanic Origin: 1993 to 2050.*** P25-1104. Issued November 1993.

U.S. Environmental Protection Agency. ***Characterization of Municipal Solid Waste in the United States: 1994 Update.*** EPA/530-R-94-042. November 1994.

Chapter 5

CLIMATE CHANGE

This chapter provides an overview of the climate change implications of municipal solid waste. Specifically, this chapter will provide a brief explanation of the "greenhouse effect" and climate change, discuss the relationship of materials found in municipal solid waste to greenhouse gas emissions, and describe generally the impacts of various waste management strategies on greenhouse gas emissions.

INTRODUCTION

Climate change is a serious international environmental concern and one which is the subject of much ongoing research and debate. Carbon dioxide and other so-called greenhouse gases form a type of "atmospheric blanket" around the planet's surface, regulating the earth's temperature by trapping some of the sun's heat. This natural process is commonly referred to as the "greenhouse effect." However, many in the international scientific community believe that significant recent increases in carbon dioxide and other so-called greenhouse gases in the atmosphere are throwing the natural "greenhouse effect" seriously out of balance. Increased concentrations of greenhouse gases in the atmosphere are believed to stem, at least in part, from human activity, particularly the burning of fossil fuels (coal, oil, natural gas). There is growing consensus in the international scientific community that the buildup of carbon dioxide and other greenhouse gases in the atmosphere will lead to major climatic and environmental changes, including higher average surface temperatures, rising sea levels and inundation of coastal areas, and more frequent and severe storms.

In 1993 President Clinton announced a national plan to reduce emissions of greenhouse gases in the United States to 1990 levels by the year 2000. The plan, called the Climate Change Action Plan (CCAP), is based on the Framework Convention on Climate Change—an international agreement which challenges the industrial countries of the world to stabilize greenhouse gas concentrations in the atmosphere. The CCAP is a comprehensive plan which establishes a partnership between the Federal government, state and local governments, and the American business community to identify and implement voluntary strategies to reduce greenhouse gas emissions.

The major greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydro fluorocarbons (HFCs). Without the Action Plan, net emissions of these gases in the U.S. are projected to grow by about 7 percent between 1990 and 2000—from 1,462 million metric tons of carbon equivalent (MMTCE) to 1,568 MMTCE. To return U.S. greenhouse gas emission

to 1990 levels by the year 2000, the Action Plan calls for reductions of 108 MMTCE in the year 2000.

For purposes of the CCAP, all greenhouse gas emissions are calculated in terms of "carbon equivalents," which are derived from a measure of the global warming potential (GWP) for the greenhouse gas. For example, the greenhouse effect of one ton of methane is equivalent to that of 24.5 tons of carbon dioxide.

Carbon dioxide from the extraction of fossil energy production is the largest contributor to greenhouse gas emissions in the U.S. In 1990, net U.S. emissions of greenhouse gases were:

- carbon dioxide—1,237 MMTCE
- methane—166 MMTCE
- nitrous oxide—39 MMTCE
- hydro fluorocarbons—20 MMTCE.

The CCAP establishes over 50 new or expanded initiatives to reduce emissions from all sectors of the economy that emit greenhouse gases. These initiatives include projects which reduce greenhouse emissions through: the promotion of commercial, residential, and industrial energy efficiency; improved forestry practices; and recovery of methane and other greenhouse gases.

One of the initiatives established under CCAP is Action #16—"Accelerate Source Reduction, Pollution Prevention, and Recycling." This action directs the EPA, Department of Agriculture, and the Department of Energy to work together to promote source reduction, pollution prevention, and recycling of municipal solid waste. Source reduction and recycling initiatives as outlined in President Clinton's 1993 Climate Change Action Plan will make a significant contribution to reducing greenhouse gas emissions.

RELATIONSHIP OF MUNICIPAL SOLID WASTE TO GREENHOUSE EMISSIONS

What do source reduction, pollution prevention, and recycling of municipal solid waste have to do with rising sea levels and higher temperatures? Actually, a lot. For many wastes, what we dispose is the material that is left over after a long series of steps including: 1) extraction and processing of raw materials; 2) manufacture of products; 3) transportation of materials and products to markets; 4) use by consumers; and 5) waste management. We refer to this series of steps as the "life cycle."

At virtually every step along this "life cycle," the potential exists for greenhouse gas impacts. In its simplest terms, waste affects greenhouse gases through one, two, or all three of the following mechanisms:

1) Energy consumption (specifically, burning of fossil fuels) associated with making, transporting, and using the product or material that becomes a waste.

2) Methane emissions from landfills where the waste is disposed. (Methane is one of the most potent greenhouse gases.)

3) Carbon sequestration. Carbon sequestration refers to natural or man-made processes which remove carbon from the atmosphere and store it for long time periods or permanently.

The first two mechanisms—burning fossil fuels and emissions of methane from landfills—clearly add greenhouse gases to the atmosphere and contribute to global warming. The third mechanism—carbon sequestration—reduces greenhouse gas concentrations in the atmosphere by removing carbon dioxide from the atmosphere. Forests are one mechanism for sequestering carbon; growing more trees or cutting down fewer trees enables forests to remove more carbon dioxide from the atmosphere for a time.

GREENHOUSE GAS IMPACTS OF VARIOUS MUNICIPAL SOLID WASTE MATERIALS AND MANAGEMENT OPTIONS

Measuring the greenhouse gas impacts of municipal solid waste requires looking at the specific components of municipal solid waste and the various ways that municipal solid waste is managed. The following materials* comprise about 60 percent of municipal solid waste and have significant potential to affect greenhouse gas emissions depending on how they are managed:

- newspaper
- office paper
- corrugated cardboard
- aluminum cans
- steel cans
- HDPE (high-density polyethylene) plastic
- LDPE (low-density polyethylene) plastic
- PET (polyethylene terephthalate) plastic
- food waste
- yard trimmings.

* As of publication of this report, EPA has not begun to examine in detail the potential greenhouse gas implications of managing other components of municipal solid waste.

Each of these materials has different potential climate impacts depending on whether it is source reduced, recycled, composted, combusted, or landfilled. To determine the greenhouse gas effects of these options, one must look at the steps in the material life cycle that have the potential to affect greenhouse gas emissions as the material makes its way from a raw material to a waste. Key inputs to this analysis include:

- greenhouse gas emissions from extraction and processing of raw materials, manufacturing, transportation, and waste management;
- changes in carbon sequestration (i.e., in forests and landfills);
- opportunities for displacement of utility fossil fuels (due to energy recovery at landfills or combustors).

The potential for these effects must be examined at the following points in a product's life cycle:

- raw material acquisition (e.g., fossil fuel energy and other greenhouse gas emissions; any change in forest carbon sequestration);
- manufacturing (e.g., fossil fuel energy emissions);
- waste management (e.g., greenhouse gas emissions associated with combustion and landfilling, offset by any energy recovery and avoided utility emissions as well as any carbon sequestration in landfills).

Each of the major municipal waste management options and their major greenhouse gas implications are described briefly below:

Source Reduction. When a material is source reduced, some or all of it is not produced. As a result, for every unit of material not produced, greenhouse gas emissions associated with raw material acquisition, manufacturing, and waste management are avoided. In sum, there are no greenhouse gas emissions to count with source reduction. Moreover, if the material in question is a forest product, a "credit" is given for forest carbon sequestration in the case of source reduction; that is, for every ton of forest product not harvested, forest carbon sequestration increases (resulting in a *decrease* in greenhouse gas emissions). EPA's ongoing analysis of the climate impacts of source reduction apply to the source reduction strategies of material light weighting or reuse.

Recycling. When a material is recycled, it is used in place of virgin inputs in the manufacturing process. The greenhouse gas implications of recycling are the following: 1) avoided greenhouse gas emissions from raw

material acquisition (although transportation-related energy emissions resulting from the collection and transport of recycled materials are counted); 2) reduced greenhouse gas emissions in the manufacturing stage (because manufacturing with recycled inputs generally requires less energy than using virgin inputs); and 3) avoided greenhouse gas emissions at the waste management stage. As is the case with source reduction, if the material in question is a forest product and is recycled, "credit" is given for forest carbon sequestration: that is, for every ton of forest product not harvested, forest carbon sequestration increases (resulting in a corresponding *decrease* in greenhouse gas emissions).

Composting. When organic materials are composted, they decompose to humus (humic acid, fulvic acid, and humin) and CO_2. The materials that may be composted (e.g., leaves, grass, food waste, paper) are all originally produced by trees or other plants. International climate change protocols dictate that CO_2 emitted from these materials when they degrade is "biogenic CO_2," and is not counted in greenhouse gas emission inventories. Although composting may result in some production of methane due to anaerobic decomposition in the center of the compost pile, it is likely that the methane is oxidized to CO_2 before it escapes from the compost pile. Thus, very little if any greenhouse gas emissions are counted against composting.

Of course, emissions associated with materials acquisition and manufacturing of products that end up being composted (e.g., paper products) are counted in assessing the greenhouse gas impacts of composting.

Combustion. As is the case with composting, when a waste is combusted one must consider the greenhouse gas impacts associated with the raw materials acquisition and manufacturing of the material to be composted. In addition, one must consider the greenhouse gases associated with combustion itself. Two greenhouse gases are emitted when waste is combusted: CO_2 and N_2O. Non-biogenic CO_2 (e.g., CO_2 from plastics) is counted, but biogenic CO_2 is not. (See discussion above under **Composting**.) Because most waste combustors produce electricity that substitutes for utility-generated electricity, net greenhouse gas emissions associated with combustion are calculated by subtracting the utility greenhouse gas emissions avoided through the substitution of combustion-generated electricity from the total greenhouse gas emissions associated with combustion.

Landfilling. As with composting and combustion, greenhouse gas analysis of landfilling must consider any relevant greenhouse gas emissions associated with raw materials acquisition and manufacturing

of the material to be landfilled. Then, one must consider the specific greenhouse gas impacts of landfilling: e.g., methane emissions, avoided utility emissions, and landfill carbon sequestration. Methane is produced from the decomposition of organic matter in landfills and is one of the more potent greenhouse gases. Landfill methane is either released to the atmosphere, flared, or recovered for energy (i.e., electricity generation). Methane released to the atmosphere is counted as a greenhouse gas emission; methane recovered for energy represents a reduction in greenhouse gas emissions. Landfill carbon sequestration (carbon that does not degrade to CO_2 or CH_4 in a landfill and is stored long term in the landfill) also represents a decrease in greenhouse gas emissions.

EPA is currently undertaking a detailed analysis of climate impacts of various municipal solid waste management strategies. This work will be made available for public review and comment when a draft report is completed. Research to date indicates that source reduction and recycling of municipal solid waste can significantly reduce greenhouse gas emissions.

Appendix A

MATERIAL FLOWS METHODOLOGY

The material flows methodology is illustrated in Figures A-1 and A-2. The crucial first step is making estimates of the generation of the materials and products in MSW (Figure A-1).

DOMESTIC PRODUCTION

Data on domestic production of materials and products were compiled using published data series. U.S. Department of Commerce sources were used where available, but in several instances more detailed information on production of goods by end use is available from trade associations. The goal is to obtain a consistent historical data series for each product and/or material.

CONVERTING SCRAP

The domestic production numbers were then adjusted for converting or fabrication scrap generated in the production processes. Examples of these kinds of scrap would be clippings from plants that make boxes from paperboard, glass scrap (cullet) generated in a glass bottle plant, or plastic scrap from a fabricator of plastic consumer products. This scrap typically has a high value because it is clean and readily identifiable, and it is almost always recovered and recycled within the industry that generated it. Thus, converting/fabrication scrap is *not* counted as part of the postconsumer recovery of waste.

ADJUSTMENTS FOR IMPORTS/EXPORTS

In some instances imports and exports of products are a significant part of MSW, and adjustments were made to account for this.

DIVERSION

Various adjustments were made to account for diversions from MSW. Some consumer products are permanently diverted from the municipal waste stream because of the way they are used. For example, some paperboard is used in building materials, which are not counted as MSW. Another example of diversion is toilet tissue, which is disposed in sewer systems rather than becoming MSW.

In other instances, products are temporarily diverted from the municipal waste stream. For example, textiles reused as rags are assumed to enter the waste stream the same year the textiles are initially discarded.

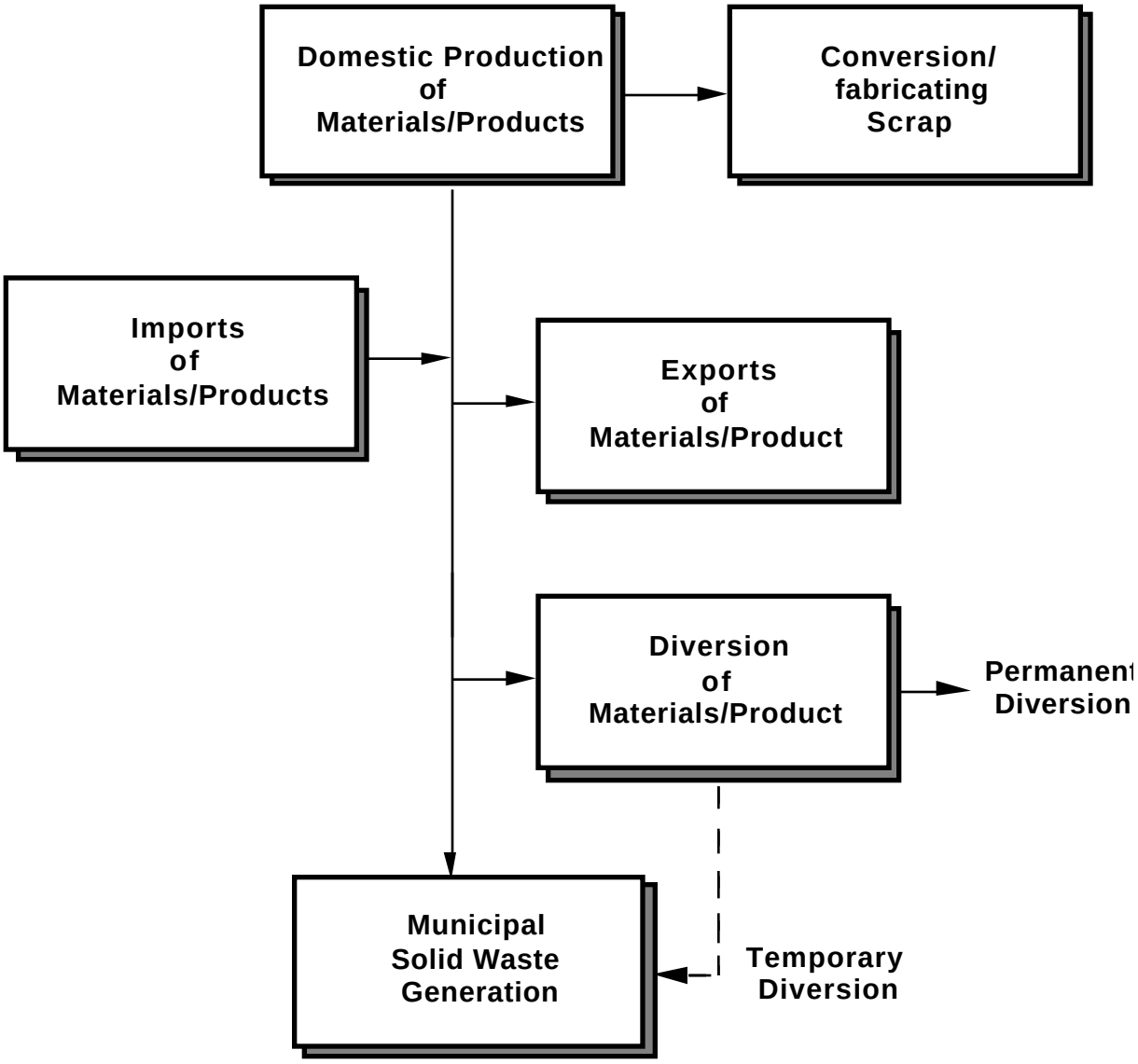


Figure A-1. Material flows methodology for estimating generation of products and materials in municipal solid waste.

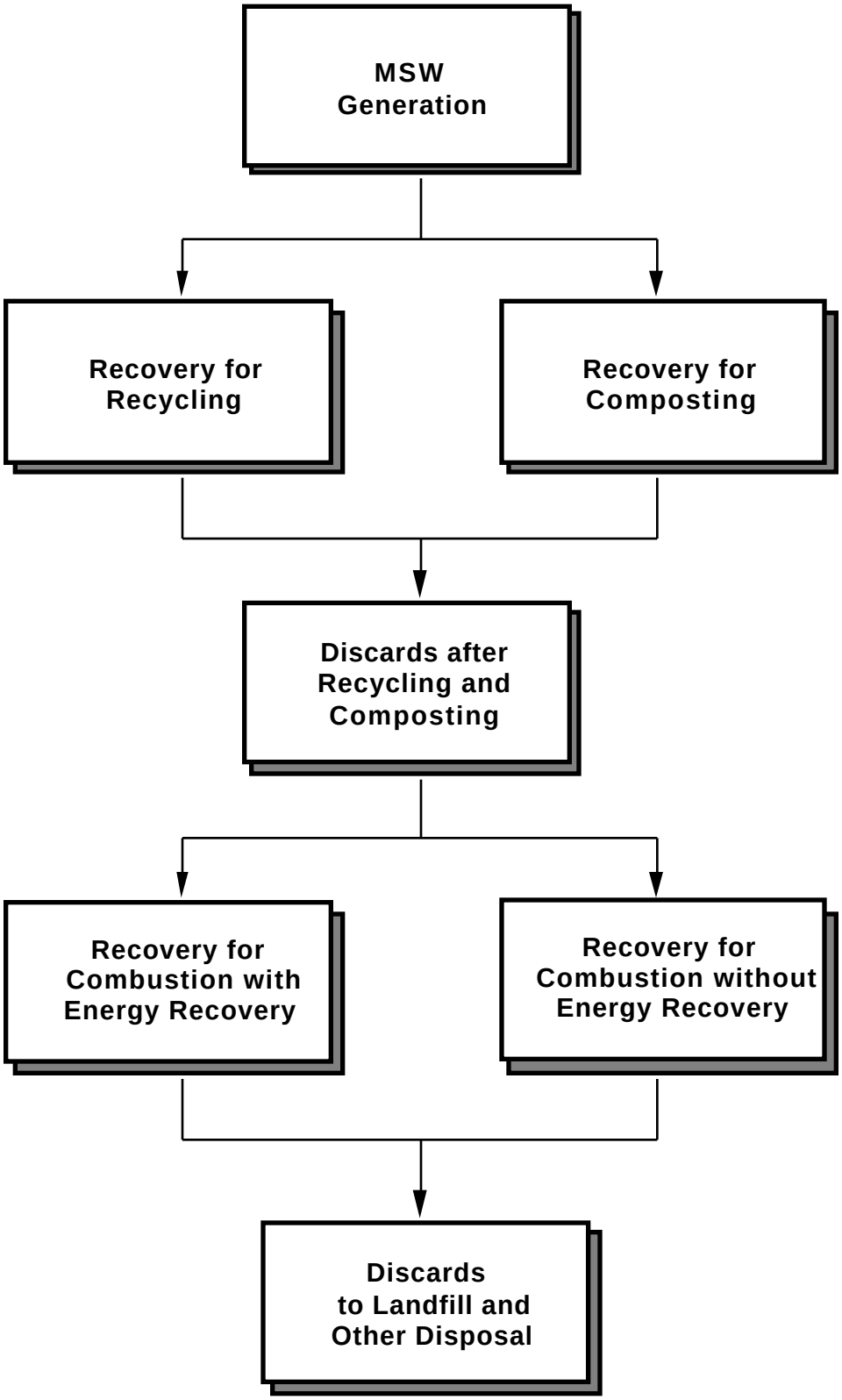


Figure A-2. Material flows methodology for estimating recovery and discards of municipal solid waste.

ADJUSTMENTS FOR PRODUCT LIFETIME

Some products (e.g., newspapers and packaging) normally have a very short lifetime; these products are assumed to be discarded in the same year they are produced. In other instances (e.g., furniture and appliances), products have relatively long lifetimes. Data on average product lifetimes are used to adjust the data series to account for this.

MUNICIPAL SOLID WASTE GENERATION AND DISCARDS

The result of these estimates and calculations is a material-by-material and product-by-product estimate of MSW generation, recovery, and discards.

Appendix B

RECOVERY SCENARIOS FOR 2000 AND 2010

Because of the rapidly changing situation and uncertainty in the available data, projections of materials recovery were made in scenarios that could achieve different rates of recovery in 2000 and 2010. Scenarios were developed for total MSW recovery rates of 25, 30, and 35 percent recovery rates in 2000; and 30, 35, and 40 percent recovery rates in 2010. These scenarios are based on recovery of postconsumer MSW and do not include industrial scrap. Also, estimates for composting of food wastes and yard trimmings are including in these scenarios.

The recovery scenarios developed for this report describe sets of conditions that could achieve the selected range of recovery rates. The scenarios are not intended to predict exact recovery rates for any particular material; there are many ways in which a selected overall recovery rate could be achieved.

Discussion of Assumptions

Some general assumptions and principles were used in making the recovery estimates:

- Recovery includes both recovery for recycling and for composting.
- It was assumed that local, state, and federal agencies will continue to emphasize recycling and composting as MSW management alternatives.
- It was assumed that there will be no new deposit laws for beverage containers, but that the present state deposit laws will remain in place.
- It was assumed that affected industries will continue to emphasize recovery and recycling programs, and will make the necessary investments to achieve higher recycling rates.
- It was assumed that the current trend toward banning certain yard trimmings in landfills will continue, providing stimulus for composting programs and for source reduction of yard trimmings by citizens.
- Based on the preceding assumptions, most U.S. citizens will have access to recovery options by 2000, which will often, in fact, be mandated. These options will include curbside collection, drop-off and buy-back centers, and composting facilities. Recovery will continue to increase as more recovery systems come on-line.

- In spite of the factors encouraging more recovery as enumerated above, many areas of the U.S. are thinly populated and/or remote from ready markets for recovered materials; many of these areas also have adequate landfill capacity. Therefore, the overall recovery rate for the entire country may not reflect the rates achieved in communities where conditions are favorable for recycling and composting.

The ranges of projected recovery assumptions for the various materials in MSW are shown for 2000 and 2010 in Table B-1 and Table B-2, respectively. Assumed recovery rates were based on existing recovery rates in 1994, with projected growth that seemed reasonably achievable nationwide for the period of time under consideration. Projections for each product in MSW were made separately, and the results were aggregated, with some minor adjustments to achieve the three selected scenarios for each year. Assumptions as to the projected recovery rates for specific products and materials were made in ranges. It is certainly possible (indeed, probable) that any given material will be recovered at higher or lower rates than those given here, but the scenarios illustrate how the selected recovery rates could be reached.

Table B-1

SCENARIOS FOR RECOVERY* OF MSW, 2000
(In thousands of tons and percent of generation)

Products	Generation	25% Recovery		30% Recovery		35% Recovery	
		Tons	%	Tons	%	Tons	%
Durable Goods							
Major Appliances (ferrous metals only)	2,697	1,942	72.0%	2,023	75.0%	2,023	75.0%
Rubber Tires	4,100	615	15.0%	820	20.0%	1,025	25.0%
Batteries, lead acid							
Nonferrous metals	946	899	95.0%	927	98.0%	927	98.0%
Plastics	90	86	95.0%	86	95.0%	86	95.0%
Misc. Durables (ferrous metals only)	4,075	326	8.0%	408	10.0%	611	15.0%
Other Durables	22,462	449	2.0%	898	4.0%	1,797	8.0%
Total Durable Goods	34,370	4,316	12.6%	5,161	15.0%	6,469	18.8%
Nondurable Goods							
Newspapers	14,600	6,862	47.0%	8,760	60.0%	9,490	65.0%
Books	1,290	258	20.0%	323	25.0%	387	30.0%
Magazines	2,500	750	30.0%	875	35.0%	1,000	40.0%
Office- type Papers	7,850	3,533	45.0%	3,925	50.0%	4,318	55.0%
Directories	540	81	15.0%	108	20.0%	135	25.0%
Third Class Mail	4,960	744	15.0%	992	20.0%	1,240	25.0%
Other Commercial Printing	7,820	1,408	18.0%	2,346	30.0%	2,737	35.0%
Textiles, Footwear	6,070	911	15.0%	1,093	18.0%	1,214	20.0%
Other Nondurables	18,280	91	0.5%	183	1.0%	548	3.0%
Total Nondurable Goods	63,910	14,637	22.9%	18,604	29.1%	21,069	33.0%
Containers and Packaging							
Glass Containers	12,750	3,443	27.0%	3,825	30.0%	5,100	40.0%
Steel Containers Pkg	3,300	1,815	55.0%	1,980	60.0%	2,244	68.0%
Aluminum Packaging	2,380	1,380	58.0%	1,547	65.0%	1,714	72.0%
Paper & Paperboard Packaging							
Corrugated Containers	32,400	18,144	56.0%	20,412	63.0%	22,032	68.0%
Other Packaging	9,990	1,499	15.0%	1,698	17.0%	1,998	20.0%
Total Paper & Board Pkg	42,390	19,643	46.3%	22,110	52.2%	24,030	56.7%
Plastics Packaging							
Soft Drink Bottles	735	368	50.0%	404	55.0%	441	60.0%
Milk Bottles	659	198	30.0%	231	35.0%	264	40.0%
Other Containers	2,363	189	8.0%	354	15.0%	591	25.0%
Other Plastics Packaging	7,143	143	2.0%	429	6.0%	571	8.0%
Total Plastics Packaging	10,900	897	8.2%	1,418	13.0%	1,867	17.1%
Wood Packaging	11,500	1,725	15.0%	2,185	19.0%	2,875	25.0%
Other Misc. Packaging	190	0	0.0%	0	0.0%	0	0.0%
Total Containers & Packaging	83,410	28,903	34.7%	33,065	39.6%	37,829	45.4%
Total Product Waste*	181,690	47,856	26.3%	56,830	31.3%	65,367	36.0%
Other Wastes							
Yard Trimmings†	23,000	7,360	32.0%	9,200	40.0%	11,500	50.0%
Food Wastes	14,900	507	3.4%	834	5.6%	1,132	7.6%
Other Wastes	3,280	0	0.0%	0	0.0%	0	0.0%
TOTAL MSW	222,870	55,722	25.0%	66,865	30.0%	77,999	35.0%

* Does not include recovery for mixed waste composting.
** Other than food products.
† Yard trimmings substantially reduced in this scenario.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

Table B-2

SCENARIOS FOR RECOVERY* OF MSW, 2010
(In thousands of tons and percent of generation)

Products	Generation	30% Recovery		35% Recovery		40% Recovery	
		Tons	%	Tons	%	Tons	%
Durable Goods							
Major Appliances (ferrous metals only)	2,957	2,218	75.0%	2,218	75.0%	2,218	75.0%
Rubber Tires	4,690	938	20.0%	1,173	25.0%	1,642	35.0%
Batteries, lead acid							
Nonferrous metals	1,158	1,135	98.0%	1,135	98.0%	1,135	98.0%
Plastics	111	105	95.0%	105	95.0%	105	95.0%
Misc. Durables (ferrous metals only)	5,234	523	10.0%	785	15.0%	1,309	25.0%
Other Durables	27,500	1,100	4.0%	2,200	8.0%	2,750	10.0%
Total Durable Goods	41,650	6,019	14.5%	7,616	18.3%	9,158	22.0%
Nondurable Goods							
Newspapers	16,300	9,780	60.0%	10,595	65.0%	11,084	68.0%
Books	1,650	413	25.0%	495	30.0%	578	35.0%
Magazines	3,000	1,050	35.0%	1,200	40.0%	1,500	50.0%
Office- type Papers	9,600	4,800	50.0%	5,280	55.0%	5,568	58.0%
Directories	660	132	20.0%	165	25.0%	198	30.0%
Third Class Mail	5,760	1,152	20.0%	1,440	25.0%	1,728	30.0%
Other Commercial Printing	9,550	2,865	30.0%	3,343	35.0%	3,820	40.0%
Textiles, Footwear	7,670	1,381	18.0%	1,534	20.0%	1,918	25.0%
Other Nondurables	22,000	220	1.0%	660	3.0%	1,100	5.0%
Total Nondurable Goods	76,190	21,792	28.6%	24,712	32.4%	27,493	36.1%
Containers and Packaging							
Glass Containers	13,850	4,155	30.0%	5,540	40.0%	7,618	55.0%
Steel Containers Pkg	3,600	2,160	60.0%	2,448	68.0%	2,520	70.0%
Aluminum Packaging	2,900	1,885	65.0%	2,117	73.0%	2,175	75.0%
Paper & Paperboard Packaging							
Corrugated Containers	40,300	25,389	63.0%	27,404	68.0%	28,210	70.0%
Other Packaging	11,070	1,882	17.0%	2,214	20.0%	3,321	30.0%
Total Paper & Board Pkg	51,370	27,271	53.1%	29,618	57.7%	31,531	61.4%
Plastics Packaging							
Soft Drink Bottles	901	496	55.0%	541	60.0%	586	65.0%
Milk Bottles	808	283	35.0%	323	40.0%	364	45.0%
Other Containers	2,895	434	15.0%	724	25.0%	869	30.0%
Other Plastics Packaging	8,746	525	6.0%	787	9.0%	1,312	15.0%
Total Plastics Packaging	13,350	1,737	13.0%	2,375	17.8%	3,130	23.4%
Wood Packaging	14,020	2,664	19.0%	3,505	25.0%	4,907	35.0%
Other Misc. Packaging	210	0	0.0%	0	0.0%	0	0.0%
Total Containers & Packaging	99,300	39,872	40.2%	45,603	45.9%	51,880	52.2%
Total Product Waste*	217,140	67,684	31.2%	77,930	35.9%	88,531	40.8%
Other Wastes							
Yard Trimmings†	25,000	10,000	40.0%	12,500	50.0%	13,750	55.0%
Food Wastes	16,300	929	5.7%	1,271	7.8%	2,527	15.5%
Other Wastes	3,590	0	0.0%	0	0.0%	0	0.0%
TOTAL MSW	262,030	78,613	30.0%	91,701	35.0%	104,808	40.0%

* Does not include recovery for mixed waste composting.

** Other than food products.

† Yard trimmings substantially reduced in this scenario.

Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.